A Biometric Study of Equids in the Roman World

Cluny Jane Johnstone

Thesis submitted for PhD

University of York
Department of Archaeology

September 2004

THESIS CONTAINS

VIDEO

CD

DVD

TAPE CASSETTE

Abstract

Arguably horses and their close relatives have been amongst the most important domestic mammals in the history of human development. Equids have provided benefits to humankind that other domestic mammals were unable to offer: – specifically their ability to be trained and ridden. Equids were particularly crucial to the expansion and success of the Roman Empire.

The equids studied for this thesis were the horse (*Equus caballus*), the donkey (*Equus asinus*) and their hybrid the mule (male donkey x female horse). The first major area of research focused on the discrimination of the bones of these equids. A new methodology, using discriminant function analysis on biometric data, was developed to enable the positive identification of these equids. This methodology was then applied to a large set of archaeological data to determine whether there was a real discrepancy in species proportions between the contemporaneous literature and the zooarchaeological record. It was discovered that the hitherto perceived difference was caused by identification problems and that mules were ubiquitous across the Empire.

Withers height estimations, shape index and log ratio calculations were carried out on the identified equid material to look at differences between various groups of data. It was established that Roman conquest had an effect on the physical appearance of horses in the Empire. This effect varied considerably and although improvements in size were universal the appearance of the Roman horses was found to vary according to the differences in the preceding Iron Age stock, corroborating the contemporaneous literature and art historical sources. It was also determined that the trade of, and use of, equids was evident from the presence of mules and donkeys in areas external to, but contemporaneous with, the Empire.

This study shows the potential of a synthetic biometric survey of a single family of animals, within geographic and temporal limits, once the problem of identification has been overcome.

Contents

List of figures

List of Tables

List of Appendix figures

List of Appendix tables

Acknowledgements

The primary acknowledgements I would like to make are to the Department of Archaeology, University of York for providing funding for this thesis in the form of a Departmental Scholarship and my supervisor Prof. Terry O'Connor for providing unfailing support, advice, criticism and sympathy throughout the duration of the project. I would also like to thank the other members of my thesis advisory panel, Dr James Barrett and Dr Dom Perring, for their enthusiasm for the project and criticism of my literary endeavours. I also thank my examiners (Geoff Bailey and Mark Maltby) for their constructive comments and dialogue during my *viva voce* examination.

In addition I would like to thank all the people who have helped me obtain data, either through allowing visits to their collection or sending data from published and unpublished works. These include Joris Peters, Angela Von den Driesch, Henriette Manhart, Joachim Wussow, Marjan Mashkour, Sheila Hamilton-Dyer, Keith Dobney, Umberto Albarella, Richard Sabin, Guido Breuer, Barbara Stopp, Andy Hammon, Roel Lauwerier, Anton Ervynck, Kevin Reilly, Ian Smith, Julie Bond, Annemiek Robeerst, Jane Richardson, Michael MacKinnon, Jean-Herve Yvinec and any others whom I have forgotten to include in this list!

Finally I would like to thank my husband Richard Chapman for his computer expertise that has extracted me from several holes, and also for his incredible patience and support during this somewhat stressful time, and to dedicate this thesis to him.

Author's Declaration

I declare that to the best of my knowledge any previously published material included here has been acknowledged as such and that the rest is my own work.

Chapter One – Introduction

1.1 Subject to be addressed

Arguably horses and their close relatives have been amongst the most important domestic mammals in the history of human development. Equids have provided benefits to humankind that other domestic mammals have been unable to offer, specifically their ability to be trained and ridden. This ability has influenced the later prehistory and history of most of the Old World, from the Assyrians, Egyptians and Scythians, through the Greek and Roman civilisations, to Genghis Khan, the European medieval feudal system and the Crusades; all have been aided by and have relied upon equids (Clutton-Brock 1992: Peters 1998). The more recent history of the European conquest of the New World was also successful because of horses.

In the introduction to the book *Equus: the horse in the Roman world* Hyland (1990: 1) states that:

> In many ways we are the inheritors of Roman expertise. With regard to the horse there are many links in the way we ride him, the equipment we use, the veterinary care he receives, his nutrition and general care. Most telling is the way he is trained, particularly for military use: his display of talent on the parade ground, the elaborate tack he carried, the very considerable weight of rider and armour under which he was expected to perform to optimum efficiency. Today many riders benefit from the methods used to train the Roman cavalryman and their mounts to a high degree of proficiency.

In addition to this, the practice of breeding animals to fulfil specific roles was initiated at this time and has continued down to the present day (Peters 1998). This process has resulted in the very great variety of equid breeds we have today, many of which have been bred for specific purposes, from the Shetland, Dales and Welsh ponies to the heavy draught horses and racing Thoroughbreds.

Equids were particularly crucial in the expansion and success of the Roman Empire. This was at least partly due to military foresight in making full use of the equids available, not only as cavalry but to move infantry from place to place and to provision the army both on campaign and at base. In addition to military use, equids were important in trade and communications both within the Empire and across its borders. Horses also played a part in providing entertainment for the populace in chariot races and other entertainment within the circuses and amphitheatres around the empire. 'Despite its complicated political and social structure the Roman Empire depended entirely on oxen, mules, donkeys and horses for all its land transport and postal service' (Clutton-Brock 1992: 118).

> Without its mule-borne baggage the legions would have found it virtually impossible to operate. As frontiers extended cavalry increasingly became a military arm in both size and importance. Without the racing fraternity and their passionate addiction to sport the circus would not have existed. Efficient transport haulage by land would have been non-existent, hampered and slowed to oxen pace. The cities' bakery mills would have lacked motive power and bread risen in price. Rapid communications, so vital in a military state, would have been absent (Hyland 1990: 2).

It has even been said (Clutton-Brock 1992) that a lack of horsepower was one factor in the eventual decline of the Empire, when better mounted 'barbarian' groups, more experienced in fighting from horseback, gained the upper hand.

Although a limited amount of information on these matters is available from contemporaneous literature, there are many aspects of Roman equids and their interactions with humans that remain unknown. These include such details as the sizes and shape/build of the equids of the Roman world, the movements of equids around the Empire and the ratio of horses, donkeys and mules used for different purposes in different areas. Many of these aspects may well have been considered common knowledge by the Roman authors and therefore not worthy of mention. Alternatively, some aspects may have been treated as secret, such as the breeding of chariot horses, or too specialised for general writers to concern themselves with. However, many of these aspects are of interest to archaeology and zooarchaeology as they can elucidate details of life in the Roman world that were previously unclear.

Some information has been gleaned from the archaeological record, but it is scattered throughout innumerable publications and archives, originating from countries in all parts of the former Empire. The aim of this project was to bring together what is currently known about equids in the Roman world and to extend that knowledge through further analysis of the zooarchaeological evidence.

Before going any further it would be beneficial to describe exactly which animals I will be dealing with in the course of this thesis. The horse family (Equidae) includes horses (*Equus caballus* L.), donkeys/asses (*Equus asinus* L.), half-asses (onager, khur and kiang *Equus hemionus* ssp.) and zebras (*Equus burchelli* etc), together with their hybrids. The taxonomic nomenclature of species that have extant wild and domestic forms is the subject of much debate. The issue is discussed in more detail in the terminology section (1.5) below, and the nomenclature used above and throughout this thesis is that recommended by the International Council for Zoological Nomenclature in an article in their Bulletin (Gentry *et al.* 1996).

In relation to the hybrids it is worth mentioning that the different species of Equidae have different diploid numbers of chromosomes, therefore their hybrid offspring have an odd number of chromosomes resulting in the vast majority of these animals being sterile because the odd number cannot be divided to make equal gametes. Domestic horses have a chromosome number of 64 and donkeys of 62, leading to mules having 63 chromosomes (Clutton-Brock 1992). Occasionally mules do produce offspring but this is such a rare occurrence that the Romans had a phrase *cum mula peperit,* 'when a mule foals', similar in usage to 'when pigs fly' and 'once in a blue moon' (Kay 2002).

In the context of the Roman Empire it is possible that the remains of all the species mentioned above could be found in archaeological assemblages dating to this period. However, half-asses and zebras, though sometimes tamed, have never been domesticated and the only likely way they would be found in Roman assemblages is as casualties from one of the many animal spectacles put on to entertain the public around the Empire but mostly in Rome. Wild horses and donkeys were also used in these spectacles (Hyland 1990). However, it is unlikely that any of these would be found in the vast proportion of archaeological assemblages from around the Empire and, taking this into account, they have been excluded from these investigations. Consequently, the following work is based on the main domestic equid species: horses, donkeys and the hybrid mules (Figure 1.1).

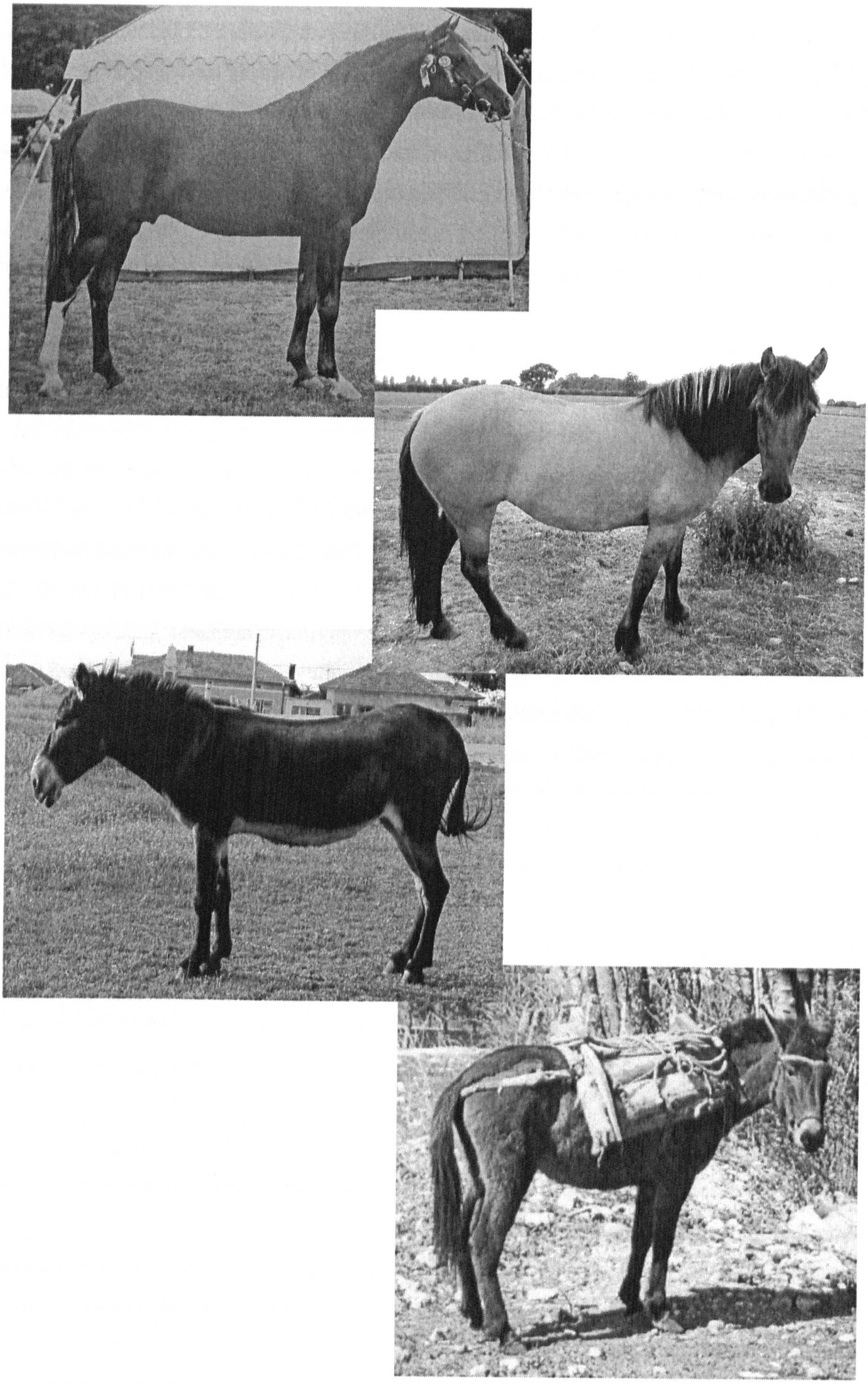


Figure 1.1 Pictures of modern equids. Clockwise from top left horse (Arabian), pony (Highland), mule and donkey. (Arabian from Archer 1992, Highland and donkey author's photos, mule courtesy of T. P. O'Connor)

1.2 Introduction to current research themes in studies of the Roman world

In 1888 Pitt-Rivers wrote 'it is next to impossible to give a continuous narrative of any archaeological investigation that is entirely free of bias; undue stress will be laid upon facts that seem to have an important bearing upon theories that are current at the time while others that might come to be considered of greater value afterwards are put in the background or not recorded' (quoted in Luff 1982).

Despite more than a century of archaeological investigations since Pitt-Rivers' statement, it is still true that current research themes, theoretical frameworks and methodologies play a major role in the way in which the discussion of archaeological material is targeted. Indeed in 1999 Goodman wrote that the choice of a framework for the discussion on Roman archaeology and literature studies is without doubt influenced by the taste and prejudices of the writer. This inevitably leads to bias in what is included and, perhaps more importantly, what is not included in any given publication. Goodman (1999) also suggests that, whilst new evidence often requires a shift in perception, this should be a matter for rejoicing rather than regret as new evidence invariably fits another piece into the puzzle, even if requiring the moving of other pieces first.

In addition, because of the time period over which books in particular are written and published, they are often slightly 'out of date' by the time they emerge. Journals are to some extent more current in terms of the research themes they address because the turn around time is quicker. Therefore, with the constraints just outlined, taking an overview from a selection of recently published books and current journals can give an impression of the current research themes pertaining to the sub-disciplines of archaeology. However, because of the diversity of these sub-disciplines within archaeology, there is inevitably great variety in the current research themes of each discipline. Therefore, the interaction of two or more disciplines can converge the current research themes and enhance the understanding of a particular topic by providing a fresh perspective on the evidence available.

It is hoped that the application of zooarchaeological techniques and evidence to the study of equids in the Roman World will bring about a better understanding of their role within the systems of the Empire. Conversely it is hoped that by integrating the information from Classical texts and archaeological knowledge of the Roman World into the results of the zooarchaeological analysis of equid remains, a better understanding of observed trends can be obtained.

It would not be practical to review all the current research themes in Roman archaeology, so this section has been limited to covering those themes that are considered most appropriate to the interpretation of the subject of the thesis. These include studies of the process of Romanisation (1.2.1), the degree of regionality in the Empire (1.2.2), discussion of frontier zones (1.2.3), the impact of the Empire on communities beyond the boundaries (1.2.4), the question of trade and supply to both the army and civilians (1.2.5) and the end of Roman rule (1.2.6). Many of these topics interrelate as would be expected for a series of themes essentially concerned with the same broad subject. During this section and the rest of Chapter 1, the areas of research that this project will attempt to address will be highlighted as bullet points with the heading 'Research aims'. The questions posed in this manner will be those that will be enlarged upon in Chapter 7, although not in a question and answer format but as a discussion of the issues.

1.2.1 Romanisation

Following the order outlined above, the first topic, 'Romanisation', is one that recurs as a research theme in the archaeology of the Roman period. Romanisation is usually the term used to describe the process of 'becoming Roman' when an area was conquered. Traditionally this has mostly been written about from the viewpoint of the conqueror changing Iron Age barbarians into civilised provincial Romans. The assumption that the Roman authority was the dominant force may be relevant in some areas, but needs careful thought before use (Barrett and Fitzpatrick 1989). Wells (2001) suggests that this is a one-sided view of what was actually a two-way process and that these same Iron Age societies were actually in the process of 'Romanising' themselves through contacts with Mediterranean cultures before conquest took place. Fitzpatrick (1989) also indicates that the indigenous elites adopted some aspects of 'Romanness' to their own advantage prior to conquest.

Wells (2001) argues that the conquest was only an intensification of interactions that had taken place for some time and therefore, that modern research should focus not just on the effects of conquest and imperial administration on indigenous peoples, but also on the active roles played by those peoples in the construction of the new colonial societies. Fitzpatrick (1989) also advocates this approach and suggests that the indigenous people played an important role in the integration of their communities into Roman Empire rather than receiving Roman contact passively.

These interactions probably took many forms, such as diplomatic relations, military alliances, mercenary service and trade and exchange, the last two being perhaps the most visible archaeologically (Fitzpatrick 1989). Aspects of trade and exchange are discussed below. The exact nature of these interactions varies widely through time and in different areas. In some cases these interactions took place prior to conquest, whilst in other areas these were ongoing interactions across a relatively stable frontier zone as discussed below. These different situations required diverse interactions to achieve the aims of the Empire, i.e. the expansion or stabilisation of frontiers.

Another aspect of Romanisation is the effect of veteran colonies on an area. These veteran colonies were founded deliberately to settle people loyal to Rome (i.e. ex-soldiers) in a newly conquered area to serve as a deterrent to rebellion. This was started in Italy but gradually spread to other parts of the Empire as conquest proceeded. Therefore the veteran colonies formed a focus for Romanisation within areas of the Empire (Goodman 1999). These colonies would have attracted trade, as the ex-soldiers, who would have become accustomed to the Roman way of life during their military service, formed a demand for Roman goods.

- **Research aims.** In the light of the above research theme, there are several areas that can be addressed in relation to equids. For instance, what effect did the Roman conquest of a particular area have on the physical appearance of horses in that area? Were any changes the result of a process that started pre-conquest and was continued afterwards and is therefore manifested as a gradual change? Alternatively, are there any detectable changes between immediately pre- and post-conquest horses suggesting a sudden change consequent upon the conquest?

1.2.2 Regionality

The next research theme is intimately related to the process of Romanisation in general as it is the study of regionality within the Empire. This is the study of differences between the degree and nature of Romanisation in different provinces. The study of regionality in the Roman Empire is the topic of a forthcoming conference session, making it a very current research theme. It is highly likely that the written sources overstate the degree to which the material culture and lifestyle in the provinces became 'Roman', because these authors were mostly based in the heart of the Empire and were themselves biased towards 'Romanness' (Wells 2001).

The word 'Romanisation' implies a standard process, and Wells (2001) argues that it is very clear from both the archaeological and epigraphic evidence that the differences between the conquered societies in various areas meant that the character of the interactions was different and therefore the process could not be standard. The archaeological evidence also shows a complex combination of indigenous traditions and elements introduced by the Roman military and administration, and which elements of each culture were combined depended on local needs and traditions. This means that the 'Roman citizens' of different provinces adopted the Mediterranean Roman traditions and culture in many ways and to a varied extent (Wells 2001). The pattern of change was different across different regions and each community experienced the changes differently. These differences are spelt out in the work of Goodman (1999), who devotes a chapter to each province (or group of similar provinces) to explain the politics and administration, the cultural makeup pre- and post-conquest and how the process of Romanisation manifested itself. It seems that the dominant aspect of these communities was diversity (Wells 2001), which is almost the opposite of the traditional view of uniformity across the Empire.

Recent studies (summarised in Goodman 1999 and Wells 2001) have shown that many communities did not adopt Roman styles as eagerly or as rapidly as others in their region did, either because they could not afford to do so, or in many cases, because they chose not to. Therefore, whilst the architecture of public buildings, and acquisition of portable material culture such as pottery and coins, display a remarkable degree of uniformity across the Empire, from Britain to North Africa, Spain to the Near East, it is important to bear in mind that this homogeneity was restricted to the elites of the provinces. And yet even in these aspects the details of the distribution of the items of portable material culture reveal that there are differences between regions. The opposite of this uniformity can often be seen in the exaggerated expression of regional identities in material culture and architecture amongst non-elites in many areas (Wells 2001). Indeed it has been demonstrated that in Upper Moesia there was an area within the Empire south of the frontier zone that was all but devoid of Roman presence (Whittaker 1989), and a similar lack of Romanisation has been observed in the uplands of northern England behind the frontier (Higham 1989). It may be the case that these areas lacked enough social stratification to be predisposed to Romanisation. In contrast, the southern and eastern areas of France were quickly and extensively Romanised. This was partly the readiness of the elite to adopt Roman culture and the opportunities offered in economic terms by the role of the region in redistributing goods to the frontier zones further north (Goodman 1999).

Wells (2001) suggests that the term 'Roman' should not be applied in the context of temperate Europe and that the term 'Romanisation' should not be used to describe the process of post-conquest interaction. In this thesis these terms will be used but with less rigidly defined meanings, namely 'Roman' to denote material belonging to the post-conquest period of archaeological sites and 'Romanisation' to denote any observed changes that could have been caused by interactions resulting from the conquest of an area.

- **Research aims.** In relation to this research theme there are two areas to be questioned within this study. Firstly, was there variation in the ratios of different equids throughout the Empire? And secondly, were there differences between the physical appearance of horses from diverse areas of the Roman Empire and were these characteristics consistent through time?

1.2.3 Frontiers

The third research theme is another that has regularly received attention and concerns the frontiers or boundaries of the Roman Empire. In the 19th and 20th centuries, in Britain and Germany in particular, the physical remains of boundaries represented by Hadrians Wall (Britain) and the *Limes* wall (Rhineland) were studied intensely. At this time the frontier was presented in the literature as an actual barrier, be it a wall or a river, that could be drawn as a line on a map. Another aspect was the influence that modren empire thinking had on the works of people such as Haverfield in Britain and Mommsen in Germany (quoted in wells 2001), where they tried to emphasise the order and organisation of the Romans in order to justify some of the aspects of those empires. Also in Germany, the division of the east and west after World War II influenced the writings from both sides of that divide about both sides of the Roman frontier (Wells 2001).

During this time the frontiers were seen as military defences, and whilst they were certainly military, careful examination of the positioning and nature of the boundaries has revealed that they were not particularly defensible in the traditional sense. They can be seen more as an aid to controlling the movement of people and goods rather than repelling invasions. The idea of the frontier zone containing the friendly kings was more for defence than the often fragmentary physical barriers.

The idea of a frontier is a difficult concept to study when the Roman civilisation had little or no conception of the idea, particularly during the republic and early empire (Fitzpatrick 1989). This ambiguity is illustrated by the tribes who signed treaties with Rome to become client or friendly nations. These tribes were legally speaking outside the Empire, but the degree of interference from Rome in their affairs suggests they were regarded as part of the territory.

Therefore, Rome considered them as within the boundaries in some respects and outside them in other respects, leading to great ambiguity in the definition of boundaries in this period (Hanson 1989). The concept of frontiers became more apparent during the Empire period as the horns of imperial expansion were withdrawn and more or less stable boundaries were established (Fulford 1989), to the extent that Aristeides writing in the 2nd century AD lays importance on the 'walls surrounding the Empire' (Hanson 1989).

Modern thought is turning towards the idea of the frontier being a 'zone' rather than a line at a barrier. This has been through comparison with other frontiers worldwide and in particular the western frontiers in 18th and 19th century USA and those of the British Empire elsewhere. These comparisons have elucidated the fact that the frontiers can be quite broad zones of intense interaction between the peoples living on both sides of the actual boundary line (Wells 2001). The dynamics of these well-documented, recent, frontier zones have allowed the archaeological evidence to be reassessed and better understood. For instance, the frontiers of the Roman Empire are now considered to be areas of interaction between cultures as well as the interface between the army and native opposition (Hanson 1989). These frontier zones may or may not include a marked boundary within them.

Although the frontier zones in the Rhineland and Britain are perhaps the best studied, other frontier zones did exist in the Roman Empire. These include the frontiers in North Africa and the Levant. The limited amount of study that has been carried out on these suggests that similarities existed between all the frontier zones, particularly in the effects of a heavy military presence (Goodman 1999). However, they are each unique in the manner in which the boundaries are defined and the effect they had on local populations on both sides of the frontier itself. In some respects the study of the regionality of the Empire encompasses the study of the frontier zones as it presents particular patterns on a regional level, therefore the research aims outlined above also apply here, as well as the one outlined below.

- **Research aim.** In this study, research into frontier zones brings forward the question of whether there were differences between the equids of different elements of society, i.e. those from military, urban and rural sites. This applies to other areas as well, but the frontier zones may show the concentration of military animals.

1.2.4 External contact

Related to the frontier zones are of course the areas beyond the boundaries of the empire, and the next research theme concerns the impact of the Roman Empire on these areas. The literary sources say next to nothing about trade or contact with those beyond the boundaries of the Empire except in the immediate frontier zone. However, it has become apparent from archaeological excavations that the extent of Roman influence was far greater than had previously been thought. The sources mention the use of tributes and gifts to the 'friendly kings' in the immediate frontier zone as a means of keeping them amenable and therefore helping protect the Roman boundary, and also the use the friendly kings made of these gifts to bolster their own position in society and hence maintain stability (Braund 1989). These gifts to friendly kings sometimes included horses, as mentioned by Caesar in relation to the Gauls. These gifts also took the form of permission to trade within the Empire and therefore acquire weapons and horses that were forbidden to those hostile to the Empire (Braund 1989; Hanson 1989).

Much of the influence the Empire had on the communities beyond the boundaries was through trade, so this links with another research theme, that of trade and supply, which is covered below. Indeed Wells (2001) maintains that trade with the peoples beyond the frontier was so important that without the foodstuff, raw material and other goods that were produced by these communities Rome would not have been able to maintain the military presence and urban centres in the frontier zones and, elsewhere in the Empire.

Different communities felt the influence of the Roman Empire in different ways. For those close to the boundaries, the intense interactions of the military frontier zone would have had a major impact on their lives, economies, traditions and social organisation (Wells 2001). The quantity of Roman products in the frontier zones suggests that the communities living in these areas favoured Roman products and went to some effort to acquire them. However, the distances involved suggest that no particular organisation of the trade need to have taken place: individual entrepreneurial merchants could have travelled into the areas to trade and farmers bringing goods to the military and urban centres could have traded within the Empire (Fulford 1989; Wells 2001). The political stability gained through the tribute system to friendly kings would have the added effect of allowing economic growth in the communities of the frontier zone by allowing agricultural surplus to be produced and trade to be established.

It is noticeable that the quality of the imported items is better the greater the distance from the borders, with larger quantities of everyday items in the frontier zones and the most exotic and valuable pieces at long distance such as in Denmark and Poland (Whittaker 1989, Fulford 1989, Wells 2001). This perhaps reflects the difficulties involved in long distance trade and therefore the fact that the status of the goods had to make this a worthwhile exercise.

- ❖ **Research aims.** Here the obvious question to ask is were there differences between horses within the Empire and those beyond, particularly areas with close contacts such as the Rhineland? Also, how far did any discernible Roman influence on the equine population extend beyond the Empire?

1.2.5 Trade and supply

Related to all of the research topics mentioned above is the question of the trade and supply of material goods and foodstuffs, amongst other items, within and beyond the Roman Empire. The concentration of troops in the Rhineland and the foundation of veteran colonies provided a huge boost to the economy and the Rhine itself became a trade route, protected by the Rhine fleet (Goodman 1999).

Regarding the Empire, a major concern of most who study trade and supply is the supply of the standing armies along the frontier zones mentioned above. There is much debate as to whether the armies could have been supplied from within the Empire either locally or long distance or whether there was trade externally for supplies. Turning first to supply from within the Empire, it is surmised that a specialised system of supply to army developed. Like supplies for Rome, the army could not afford to chance the vagaries of the harvest in local areas, grain **had** to be supplied by whatever means. Some of the long distance routes can be worked out from such things as the distribution of amphorae and other ceramics (Middleton 1979; Whittaker 1989). These studies suggest an organised gathering of supplies for the army and direct transportation, using the rivers of France as a major distribution network (Middleton 1979; Whittaker 1989). This work was undertaken by *negotiatores* (Whittaker 1989) and the transportation was done by specific fleets, either under contract to (*navicularii*) or belonging to the army (*classis Germanica* and *Brittanica*) (Middleton 1979).

Presumably mules and donkeys must have been kept for the transport of supplies along the short distances from the production sites to the rivers and the rivers to the forts, either to pull wagons or as pack animals. Donkey trains are mentioned in the context of ceramic transport from La Graufesenque to the Frontier as this site was on the route from the mining regions of Ruteni to Narbonne along a military route (Whittaker 1989). The transportation of the goods demanded as taxes was possibly also a tax requirement (Middleton 1979), so mules and donkeys must have been used at a local level for this transportation, at least to centralised collection points, i.e. river ports. During the conquest of Britain road transport must have been used to supply the army as the river and sea routes had yet to be secured (Middleton 1979). Tacitus refers to the above-mentioned tax demands of transportation in the British context in his account of *Agricola* (19.4 quoted in Middleton 1979).

Groenman-van Waateringe's (1989) study of the palaeobotanical evidence and agricultural practices in northern Europe has elucidated much about the supply of grain to the army. The army's preferred cereal was wheat but the soils and climate of much of the lower Rhineland, in particular, were not suited to wheat raising. Therefore, wheat must have been imported from outside the immediate hinterland of the frontier zone. In wheat producing areas, an increase in production and storage is denoted by the replacement of small square granaries with large buildings over 20m long. As previously stated this would have required equine transport at least at the local level.

The specialised army supply trade spilled over into civilian areas en route to a limited extent. Long distance trade was at least dependent, if not parasitic, on official supply lines (Middleton 1979). This suggests that little trade existed outside these mechanisms. However the extent of the evidence for trade amongst civilians indicates that this must have been sufficient to supply needs. Alternatively there may have been other trade routes or supply mechanisms that have yet to be established. Part of this may be the issue that many of the traded goods were part of what has been termed the archaeologically invisible import and export trade, i.e. those things that are perishable or for which there is no means of immediately identifying area of origin, unlike amphorae (Fitzpatrick 1989). Trade in equids, as mentioned in Livy and Caesar's *Bello Gallico*, or the use of equids in trade is one area that falls into this category.

This last issue of the trade in equids is one that leads onto the trade with areas outside the Empire, as this is what Caesar and Livy mention. Previously it has been suggested that trade across the borders was facilitated by the frontier being a zone where friendly societies could be traded with. This trade was one of the interactions that took place between Rome and external societies both prior to conquest and along frontier zones as mentioned above.

There is evidence of quite extensive trade with Gaul in the 2nd and 1st centuries BC and this has been shown (Fitzpatrick 1989) to have a been a complex and extensive network of contacts between Gaul and both Italy and Spain. In the frontier zones, the area east of the Rhine is well documented for the trade contacts that took place. The texts mention the purchase of livestock, in particular oxen and horses, as well as grain and amber from this area (Wells 2001). In addition to the Rhineland, the plains across the Danube and the lowlands of Scotland fulfilled this role (Whittaker 1989). Indeed, Whittaker (1989) suggests that one reason for the quite rapid retreat to Hadrian's Wall soon after setting out further north was the guarantee of supplies without the need for annexation.

The immediate frontier zone (i.e. within 60 miles of the boundary) has been discussed above so this section is confined to the longer distance contacts and trade. The presence of *terra sigillata* pottery, bronze wine equipment, wine and oil amphorae, olive stones, jewellery, glass vessels and coins in some quantity on many sites beyond this frontier zone hints at quite a considerable degree of trade interaction. The distribution of sites with such finds extends into Germany east of the Rhine, Denmark, Sweden, Poland and Moravia.

In the 60 to 240 mile zone (Wells 2001) it is evident that some communities changed their economies in order to benefit from trade with the Empire. Fedderesen Wierde is a good example, where the inhabitants intensified cattle production to trade meat and hides to the frontier zone (Wells 1996). Another reason for fairly intense trade in this zone is that many auxiliary soldiers returning to their homelands in this region brought Roman objects with them and stimulated a need for goods and material culture to continue the life they had become accustomed to.

At even greater distances (beyond 240 miles from the frontier) the most spectacular imports have been found in association with some of the largest and most complex commercial centres for supplying goods to the Roman provinces. These sites include Jakuszowice in southern Poland, where high quality imported Roman goods were traded for iron ore and other metals from the Holy Cross Mountains. In Denmark, the excavation of the 'Kings Hall' at Gudme (a very large aisled building) produced a staggering quantity of high quality Roman imports. The associated harbour site at Lundeborg seems to have been set up specifically for seasonal use in the summer when shipping was active.

In both these cases the associated cemetery sites show that most of these lavish imports were destined for the elite of these communities suggesting that the elites controlled production of the raw materials and craft items that the Romans wished to trade for. Another view is that because it was considerably cheaper to transport goods by sea than by land, supplies destined for areas east of the Rhine would most likely have been transported around Denmark to the Baltic coast of Germany, and therefore establishing trading posts and hence safe harbours en route was a sensible approach (Greene 1986).

Although trade undeniably took place, Goodman (1999) suggests that the imported artefacts did not greatly alter the established lifestyles of those beyond the boundaries of the Empire, but Wells (2001) suggests that many did take advantage of the economic opportunities as outlined above.

The issue of trade and supply seems initially not to be connected to the study of equids until it is remembered that equids were essential to the transport of people and goods across the Empire. Perhaps the most obvious form of equid transportation is the hauling of wagons. Until recently it was considered that the designs of Roman harness and the wagons themselves prevented efficient haulage by equids. However, recent work using replicas has shown that this was not the case and that equids were an efficient means of traction as long as the terrain was not difficult (Greene 1986). The discussion of the importance of rivers in long distance trade and the supply of garrisons (e.g. Middleton 1979) has tended to underestimate the use of mules as pack animals, particularly in areas of hilly terrain and over short distances (Greene 1986). In areas such as central Italy and Greece, mules were superior beasts of burden as a string of 20 mules could carry as much as five ox-drawn wagon loads. Donkeys were also commonly used as beasts of burden, often being bought with the load and sold along with it at the destination.

It is noticeable that there are many carvings from northern Gaul depicting the use of equid drawn wagons and from these it has been deduced that technical improvements in harnessing took place in this area. It is argued that the terrain in this area was ideal for wagon transport and that the agricultural surplus produced there must have been transported to markets where it could be sold for enough profit to allow the quantity and quality of the local villas to flourish (Greene 1986). This suggests that land transport must have been efficient; otherwise the profits would have been lost in the high cost of transportation. The distribution of representations of equid drawn wagons and pack animals is extremely uneven, being common in eastern France and neighbouring areas but totally absent from Britain and Spain. Whether this regionality is a result of differences in the means of transporting goods or differences in epigraphic habit is difficult to determine, however it can be said that generalisations about transport cannot be made because each region relied in different proportions on land or water borne systems, depending largely on geography.

- **Research aims.** With reference to the army supply routes, can these long distance trade routes be detected in equid remains, for instance are there concentrations of mules and/or donkeys at producer or military sites as the first and last stages of the transport routes? Research aims connected to long distance trade outside the empire are essentially the same as for those given in the section on contacts outside the Empire so will not be repeated here.

1.2.6 Roman / post-Roman transition

The last research theme to be discussed is the issue of the end of Roman rule. This is a 'hot topic' of current research focussing on the extent to which roman pottery traditions (amongst other studies) carried on after the official end of Roman administration in an area and whether lifestyles changed dramatically or went through another more gradual shift as at the beginning of the period. It is becoming apparent that the Roman pottery tradition did extend past the official end of Roman administration and therefore the chronology of many sites can now be extended by as much as another century (Whyman 2001; J. Gerrard *pers. comm.*). This later dating of pottery from late Roman / early post-Roman contexts is only just being understood and therefore it was not be possible to use the data from already published bone reports, that had used the more traditionally accepted pottery dates, to address this issue at present. However, the extended chronologies will allow this to become an interesting area to study in the future.

The research themes within Roman archaeology outlined above are those that it is thought this study will be able to contribute to. Hopefully by addressing the research aims highlighted here and below, a new perspective on these research themes from both the Roman archaeology and zooarchaeological viewpoints will be gained.

1.3 Roman equids in art and literature

There are a great many references to Roman equids in classical texts and art, revealing a lot of detail regarding some aspects but virtually no information on other aspects of equid use. It is also highly probable that many equids in art historical sources are not all that accurately portrayed. The second item is one worth considering further at this juncture. The portrayal of equids in Roman art may not be accurate for a number of reasons, such as political motivation, ineptitude of the artist and artistic licence. The first point really concerns such articles as public monuments, where the artist has an obligation to portray the subject in a manner pleasing to the person paying for the monument (Figure 1.2). For instance, this could result in the horses of a defeated army appearing either inferior to those of the Roman cavalry to show the superiority of Rome, or the opposite to show how brave and wonderful the army was in defeating them.

Figure 1.2 Statue of the Emperor Marcus Aurelius.

Ineptitude of the artist could be the result of unfamiliarity with the subject (as in the case of the representation of exotic animals) or a real lack of talent: either way the resulting images would not be an accurate reflection of equids at that time (see Figure 1.3 for examples of poor artistic quality and Figures 1.6 and 1.8 for examples of high quality). Artistic licence could take many forms, such as the enlarging of an equid that was central to a story, for instance in a mosaic depicting the legend of Pegasus. Equally the artist could reduce the size of the equids when they are not central to the image, so as not to detract from the main theme (Figure 1.4). In relation to equids, it has been noted (Raepseat 1982 quoted in Greene 1986) that, because horses were an expensive and prestigious commodity, they were shown on gravestones in situations where they were not used in real life in order to increase the apparent status of the deceased.

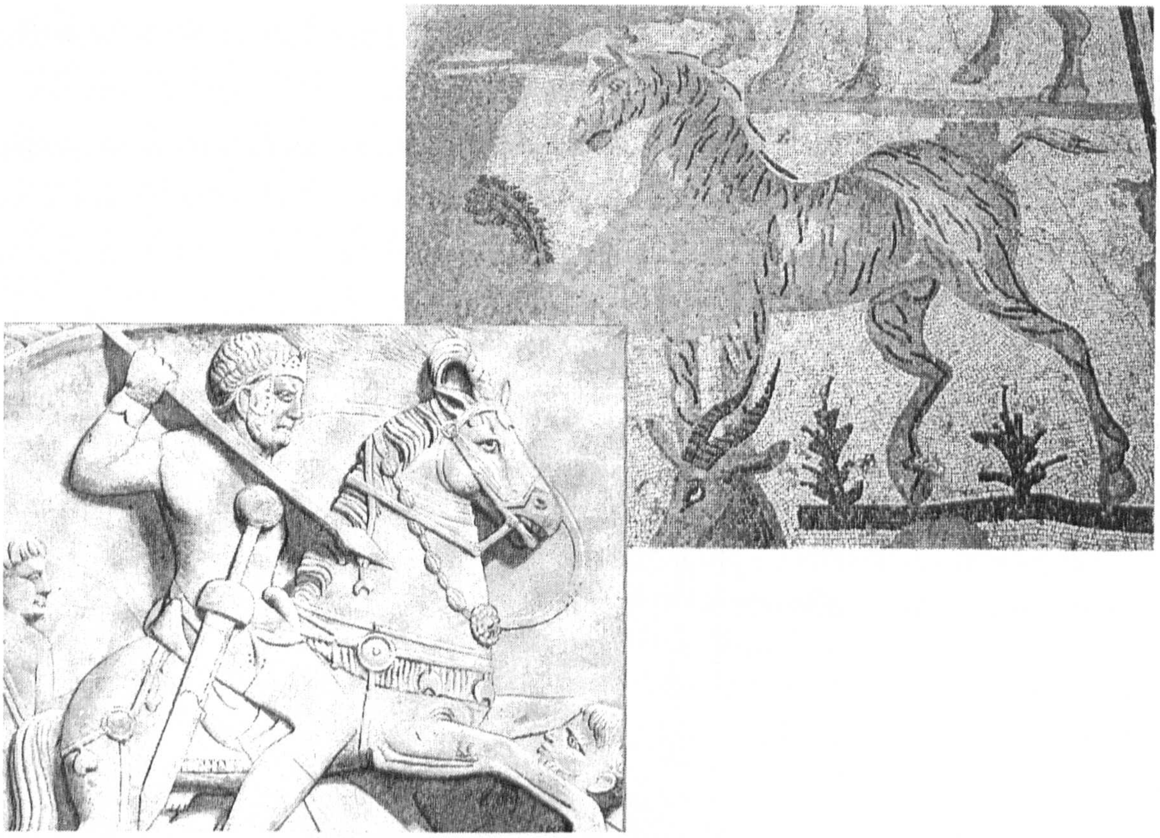


Figure 1.3 Examples of poor artistic quality. A zebra represented in a mosaic that is just a slightly stripy horse (top), and a carving of a cavalry man and his mount that is very oddly proportioned (bottom) (Mosaic from Ciurca undated; carving from Hyland 1990).

Figure 1.4 Example of artistic licence. This scene of mule-drawn balistae from Trajan's column shows the men at a larger scale than the animals to draw attention to the importance of the man rather than the mules (From Toynbee 1973).

In spite of all these arguments against the use of art historical sources as a means of understanding what Roman equids looked like, it is possible to make general statements by looking at many representations and removing the obvious outliers. Art historical sources can also give information about how equids were used in Roman society, and what species were used for what types of activities, which may help us to interpret the equid remains found on different types of archaeological site. Bearing in mind the considerations detailed above on the use of the art historical sources, there are a great many representations of equids in many Roman art forms. This plethora of depictions reflects the high standing horses had in the life, cult and customs of the Ancient World (Peters 1998). These images include statues, carved reliefs, tombstones, coins and mosaics (Toynbee 1973). Many of these are discussed below under the relevant section.

The snippets of information given in the contemporaneous literature are scattered throughout numerous documents covering a time span from the height of the Classical Greek civilisation to the end of the Roman Empire (*c.* 500 BC to *c.* AD 500). As with the art sources, there are inherent biases in literature too, because the understanding of the subject will colour the account given by each individual author. For instance many of the authors lived and wrote in Rome itself, or in Italy, therefore what is said about everyday life, economic factors and political administration cannot necessarily be taken as applying across the entire Empire (Goodman 1999), particularly given the great diversity mentioned in Section 1.2 above. In addition, did the author have a political motivation or other agenda for writing, or was it written for a particular audience? If this was the case then these biases need to be understood before a text can be used and interpreted (Wells 2001). In addition, the bias of those who wrote from Rome has a very 'us' and 'them' attitude to those beyond the boundaries of the Empire (Braund 1989). As the purpose of this thesis is not to analyse classical texts in detail, many of the quotes from Greek and Roman authors are derived from secondary sources. In particular the book by Hyland (1990), which draws together a great deal of information gleaned from ancient written sources, has been quoted extensively in the following pages.

The equids being studied here, horses, donkeys and mules, were used for a variety of purposes within the Roman world, which are generally separated according to species although there is some overlap. Horses were used as cavalry mounts, chariot racing, riding (transport and hunting) and occasionally pulling carriages (White 1970). Mules were mostly used for draught purposes (mostly road haulage but also for carriages), as pack animals (particularly in the army) and were occasionally ridden. Donkeys were used primarily for traction (turning mills and ploughing in areas of light soil) and as pack animals. The appearance of donkeys would have varied little, as is the case today, but both horses and mules would have shown considerable variation in appearance. Mules would have varied according to the type of mare used to breed from. Descriptions of mules are very scarce but descriptions of horses are much more prevalent.

1.3.1 Horses

Appearance

As a starting point in studying Roman equids it would perhaps be a good idea to use a contemporaneous description of the Roman 'ideal' horse. Both Columella and Pelagonius described this and the texts show remarkable similarities despite having been written three centuries apart. This could well be plagiarism (quite common in classical texts) but does show that over the three intervening centuries the ideal horse had not changed. Other writers, including Xenophon, Vegetius and Varro, also describe parts of the horse and most accounts agree as to the ideal to aim for. Columella's text reads as follows:

> Small head, dark eyes, wide-open nostrils, short upstanding ears; a neck which is soft and broad without being long, a thick mane which falls down on the right side; a broad chest covered with well-proportioned muscles, the shoulders big and straight; the flanks arched, the backbone double, the belly drawn in; the loins broad and sunken; the tail long and covered with bristling curly hair; the legs soft and tall and straight; the knee tapering and small but not turned inwards; the buttocks round, the haunches brawny and well-proportioned; the hoofs hard, high, hollow and round with moderately large coronets above them. The whole body must be so formed as to be large, tall, and erect, and also active in appearance and, in spite of its length, rounded as far as its shape allows. (Columella *r.r.* VI, 24, 2-3).

This ideal Roman horse is very close to modern descriptions of good conformation (e.g. Spooner 1990), with two exceptions. The first of these is the Roman preference for upright shoulders, which today is considered a fault as it gives the horse a somewhat vertical front leg action. This can be very showy but puts stress on the lower leg joints. The second point is the Roman liking of horses with small knees: again this puts extra stress on the joints of the lower leg and modern descriptions suggest they should be in proportion to the leg. Despite their limited understanding of anatomy and how conformation can affect performance, however, the Romans ideal horse would come close to modern expectations of a 'good' horse.

Peters (1998) gives a good account of coat colours and how some were considered good and others as useless. The *Mulomedicina Chironis* (quoted in Peters 1998) even describes the unscrupulous use of dyes and bleaches by horse traders to obtain a higher sale price for the animals! Generally a solid coat colour was preferred to a bi-coloured or roan (mixture of hair colours all over) one. White markings were also frowned upon. Of course there is no basis in truth that horses of a particular colour are better or worse than any others. However, where a deme exhibits a single or small range of colours and that deme is preferred for a particular use, it is easy to see that coat colour would be associated with other attributes.

Whilst this was the ideal to which Roman horse breeders aspired, there was still considerable variation between horses bred in different areas of the Empire. As discussed below (section 1.5) these are not breeds in the true sense of the word and will be termed demes. These demes seem to have had a relatively consistent appearance, which resulted from breeding within a limited gene pool over a substantial period of time. The improvement of local stock with imported stock was carried out in many areas, such as Gaul (Caesar: *De bello gallico*), even prior to the Roman period.

Most of the Roman authors who wrote about equids were concerned with their use in agriculture, their care from the veterinary perspective, their breeding and use in the chariot racing industry or their use to the military. Most of these authors were based in Italy and base their views of equids from other areas of the Empire on whether they were likely to be of use to the people undertaking each sphere of activity mentioned above. They generally showed favour for the demes that were useful in breeding certain types of animal for particular uses. Conversely, those demes that were considered of no value for breeding or use tended to be dismissed in no uncertain terms.

For instance, Varro (*r.r.*) indicates that three areas were renowned for good horses: Apulia, the Peloponnesus and Reate (where his own mule breeding stud farms were located). He also suggests that the best donkeys used for breeding mules come from Arcadia (Greece) and Reate. In addition to these areas, Vegetius (quoted in White 1970) suggests that cavalry horses were mostly barbarian horses from the Huns and Burgundians, those for the circus came from Cappodocia, Spain, Sicily and Africa, and those for riding came mostly from Persia, Armenia, Epirus and Sicily.

Many pieces of Roman and Greek literature contain descriptions of horses from different areas of the Empire. The names given to each deme generally refer to the area from which they originated and as this is the most comprehensible way of categorising the different groups. Figure 1.5 shows the demes described by classical authors together with a brief outline of that description. Most of the descriptions are taken from Hyland (1990) and their main uses from Peters (1998), which bring together the works of many classical authors.

- **Research aim.** From these descriptions there was evidently a great diversity of horses within the Roman Empire and detecting this in the archaeological record is one of the aims of this piece of research.

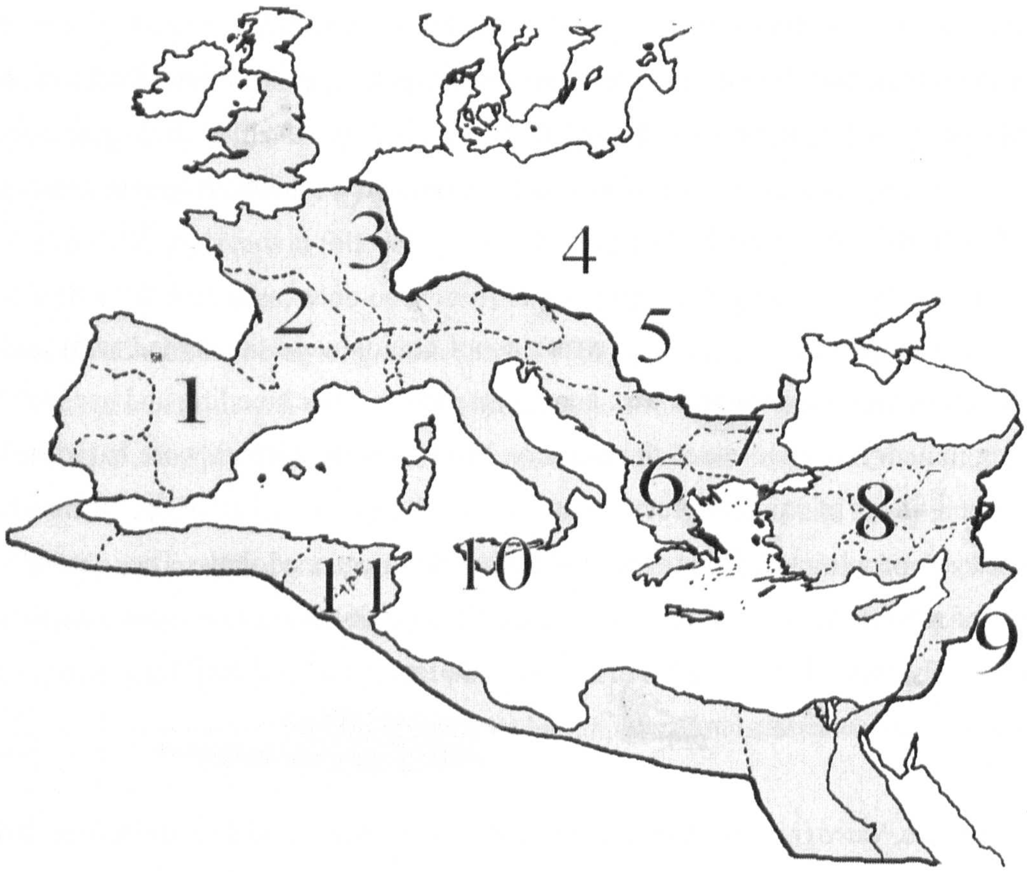


Figure 1.5 Map of the Roman Empire during the 2nd century AD showing the location of various horse demes as taken from the works of contemporaneous authors.

1) Spanish horses were used extensively by the military and also in racing. Oppian considered these horses to be small and 'weak-spirited' and whilst they were speedy over a short distance they had no stamina. A century later Nemesian considered them to have both courage and stamina, probably after the addition of Libyan blood during the middle of the 3rd century.

2) Gallic horses were considered to be small and ugly by Caesar (*B.G.* IV 2) when he

encountered them. However, the Gallic people had realised the potential for upgrading their stock using imported stallions prior to the Roman conquest. These improved animals were considered to be ideal cavalry mounts as they had great endurance and were bred for this purpose in large numbers.

3) The Germanic people had similarly small and ugly horses but Caesar (*B.G.* IV, 2) comments that were 'rendered capable of very hard work by daily exercise'. He also says that they were content with their own animals and did not import those of the Romans. Once the Romans had conquered they imported larger horses in numbers.

4) Vegetius described the Hunnish horses as eminently suitable for war, because although they were not pretty they were excellent mounts for soldiers who were not experienced horsemen as they were strong enough to carry the weight a long distance and were also easy to manage. They were tall and long in the body with thin belly and big bones. In more detail they had roman-noses, a narrow nose, broad jaw, strong and stiff neck, long and narrow bodies with a bent back and hollow flanks, strong cannons and dinner plate hooves. Vegetius also says that their temperament was moderate, they were calm, could endure wounds, were trainable, able to work hard, and could withstand cold and hunger.

5) Descriptions of Sarmation horses are scarce in the literature but Strabo tells us that they were small, fast and hard to manage, whilst Pliny the Elder indicates that they had great endurance.

6) Herodotus considered the Thessalian horses were the best in Greece but were no match for the Persian animals. However, the Persian invasion saw thousands of cavalry stationed in Thessaly and these horses left their mark on the local population. This went a long way to improving the local stock, so that by Roman times the Greek horses were considered one of the superior demes and were mainly used as cavalry mounts.

7) Thrace was producing 'huge' horses as early as the time of Homer (*Iliad*). Even given the fact that at that time most horses were pony-sized, these must have been substantial animals. Homer also comments that many were white in colour. Gratius Faliscus commented that they were 'easy keepers and excellent performers but with ugly necks and thin spine curving along their backs'. Evidence of the horse trade between Thrace and Greece and Persia is indicated by the description of large white horses from the latter two areas as well.

8) Because of the degree of crossbreeding between the Nisean, Median, Armenian and Cappadocian horses they are included as a group. The Cappodocian horses are mentioned particularly as good racehorses and also as good carriage horses.

9) Many classical authors rated the Parthian or Persian horses very highly. Oppian describes them as handsome, courageous, gentle to ride, obedient, swift, spirited, war-like and strong with small heads. Strabo describes them as the 'best and largest' and Nemesian calls them 'huge'. The Apadana frieze at Persepolis shows large, heavy, high crested, well-muscled animals with slightly convex head (in profile). This descriptions and depictions are close to the Roman ideal horse hence the favourable reports. The Persian horses were mainly used as riding animals.

10) Sicilian horses were particularly regarded as racehorses and also as riding animals, but little in the way of description seems to have survived.

11) The Libyan horses (Numidian/Libyan/African used as interchangeable terms) were considered by Livy to be small and ugly, but Nemisian and Strabo recognised them as being obedient, fast and with great powers of endurance. The reference to their small size may refer to their slender build rather than their height, as many were about 1400mm. They were highly regarded as cavalry mounts and were often used to impart endurance when improving other demes. They were also excellent carriage horses.

Breeding, training and caring for horses

The breeding of horses in the Roman period was carried out at two levels: the large studs owned by the state and wealthy landowners, and the small-scale landowner with one or two mares. Much of the material written about horse breeding is in relation to the large studs. However, the principles of breeding a horse are the same whether you have one or a hundred mares. As most large studs bred horses for a particular purpose, the characteristics of the mares and stallions would be chosen with this in mind. As has been discussed above, different areas bred horses with different characteristics more suited to one or another of the equestrian fields. In attempts to improve stock, stallions were frequently imported from other areas as the Romans thought the stallion was decisive in imparting physical characteristics to the offspring (Peters 1998), whereas the Greeks considered the attributes of the mare more important.

Columella (*r.r.* VI, 27) tells us that there were three types of horse breeding stock. The first was the noble stock (*materies generosa*) for breeding chariot-racing horses (and probably also ceremonial and military horses), the second (*materies mularis*) was the stock used for breeding mules (almost as highly rated as the noble stock) and thirdly the common stock (*materies vulgaris*). There were different husbandry regimes for breeding from these types of stock. For the common horses, the stallions ran free with the mares all year round. For the quality stock, supervised mating took place around the spring equinox, the stallion being kept indoors or far away at other times of the year.

Varro (*r.r.* II, 7) kept one stallion to every ten mares, whilst Columella (*r.r.* VI, 27, 9) suggested 15 to 20 mares to one stallion. A teaser stallion was often used to test a mare's readiness to mate (Columella). This is often still done today, particularly in thoroughbred breeding, so that the very valuable mare and stallion are not injured if the mare kicks out when not ready to mate. Columella (*r.r.* VI, 28) says a stallion can cover mares between the ages of 3 and 20. Pliny suggests 33 as the upper limit. Stallions were used to cover mares whilst still working as racehorses, they did not 'retire to stud' only after their working life was over, as modern racehorses do. For mares, Columella (*r.r.* VI, 28) says they could be bred from between 2 and 10 years, whilst Varro suggested 3 to 10 years (II, 7, 2). These figures (apart from Pliny) are relatively accurate as it is very hard to get an older mare in foal without modern drugs and a stallion begins to lose his fertility during his 20s (Hyland 1990). The principle of improving stock using a different stallion was understood, and a single stallion can influence a deme more quickly than one mare.

Varro (*r.r.* II, 7, 7) states that the foal is born on the tenth day of the twelfth month after conception. This is absolutely correct, as the gestation period of a horse is 335 to 346 days (Clutton-Brock

1992). Without modern drugs, the horse is not the most fertile of animals, only having a fertilisation success rate of about 60% (so even less resulting in live births), indicating why a foal was a very expensive commodity (Hyland 1990). Stallions were fed a high grain diet and first-rate fodder during the mating season. Mares were kept lean as they thought conception was difficult in overweight mares (found to have been true (Hyland 1990)). The working of mares in foal seems to have been a controversial subject, then as now. Virgil suggests they should be worked until the later stages, Varro says no work at all. It may be a question as today, of the size of the breeding establishment. Varro was exclusively breeding a large quantity of horses and mules - this was his job. But many small-scale breeders may have had to use their mares for agricultural work or riding, as today.

By the time of the Empire the Romans certainly knew about and undertook the castration of male horses to produce more amenable animals. Cato mentions geldings in the context of farming, and Varro (II, 7, 15) illustrates the reasons for gelding a horse as follows 'on the one hand, in the army, they want spirited horses, so on the other hand they prefer more docile ones for road service'. Occasionally the military had to geld a colt or stallion that was too unruly. The racing fraternity also preferred stallions, as the more aggressive nature of an entire horse is more suited to this situation, whilst for general riding and draught purposes the more placid nature of a gelding is more appropriate.

According to Strabo and Plato (quoted in Peters 1998) the Romans learnt about the castration of male horses from the Scythians, Sarmatians and Gauls. It was acknowledged that the first two peoples gelded horses to increase their submissiveness. The following statement about the Gallic tribe of the Cantheri shows unequivocally that they castrated their horses '*est enim cantherius equus, cui testiculi amputantur*' (Festus quoted in Peters 1998). At what date the Romans adopted the practice of gelding is unclear, but certainly Varro and Columella were knowledgeable about the procedure. The *Mulomedicina chironis* gives a detailed description of the procedure that is worth quoting in full:

> When you want to castrate an animal you must keep it away from food and drink for a day beforehand. Then lay it down and carefully bind its legs. Make a cut in the middle of the skin of the scrotum about double the size of a coin. Seize the underlying testicle and split the membrane covering it. Draw the testicle to the outside through this hole. Pinch the middle vein with the thumb and stroke the soft covering of the testicle until it tears or cut it off when it is thin. Pull the testicle from top to bottom and cut off the sperm cord near to the sack. In a similar manner remove the other testicle. Clean the testicle covering

carefully where the openings were made. If the wound becomes irritated or the pus does not drain out, clean it, wash it out and rub ground salt into it. If the cut does not close when left to itself, treat with wood tar and oil spreading the medicine in the opening with the fingers until it is healthy

Apart from the use of anaesthetics and antiseptics, the procedure is essentially the same as that carried out today. Apparently, they even used metal or wooden castration clips to stem the flow of blood (Peters 1998, fig 45). However, no scale is given in the illustration and certainly the larger of these clips appear more like a twitch, a device used to pinch the fleshy part of the horses nose to render it docile. If this instrument were indeed a twitch it could have been used to subdue the horse whilst the castration operation was carried out.

Today, castration is usually carried out when the colt is between six months and two years old, but Aspyrtos (*Corpus hippiatricorum Graecorum*: I, 99, 3, quoted in Peters 1998) suggests that in Roman times it was normal practice to leave this until four years old. The reasons given for this were that the testicles cannot been seen in a foal (modern data suggest they drop at around six months of age) and also the false assumption that castration would prevent the replacement of the milk teeth with permanent ones. The timing of the operation was based on the appearance of the canine teeth (at around four years). In addition it seems likely that waiting until an animal was four years old would allow an assessment of the horse's character and suitability for different areas of work. For instance, a stallion might suit the cavalry if it had the right conformation but if the conformation or temperament were not suited to military activity then castration could take place to tame the temperament and produce a carriage horse. This kind of assessment would be very difficult to make until the animal was fully grown and had been broken in and trained to some degree.

It seems that most horses were stabled only in cold damp weather conditions. This is perhaps borne out by the lack of archaeological evidence for stables. At least there are very few buildings that have been positively identified as such (see section 1.4.1 below). According to written sources stables were constructed in various forms. On Varro's estate the mares each had separate stalls, which were heated by brazier in winter (*r.r.* II, 7, 14). The house of Popidius Secundus, excavated in Pompeii, had stabling of four stalls, with masonry dividers, leading onto a court. At Mondeleia in Syria a stable with mangers and tie rings attached to the wall was found (Hyland 1990). They were also kept in groups, like in American ranch barns, according to Pelagonius in connection with racing stock. These different types are attested to by the fact that they were given different names, an *equile* was a proper stable i.e. a separate accommodation for one horse not tied up, whereas a *stabulum* was a stall where the horses would be tied to the wall at much closer intervals.

Concern for hoof care was also shown in the construction of stabling. Varro (*r.r.* II, 7, 10) recommends that a good floor be laid in all stables to keep the hoof from rotting, and Columella (*r.r.* VI, 30,2) states that it is of prime importance to keep a horse in a dry stable and recommends the use of wooden floors with chaff. Columella (*r.r.* VI, 31) also advises keeping a sick horse on a deep bed of straw or chaff. Bedding for horses in military camps (and elsewhere) is one of the areas for which we have virtually no records. A considerable quantity of bedding would have been required and disposing of such a large quantity of manure each day would have been an arduous task.

The feeding of horses is a bit of balancing act, between giving them enough energy to carry out the tasks required of them and yet not too much to cause them to be unruly. In the Roman world, for favoured equines nutrition was very good, but for those at the lower end of the scale it was a very different story. Obviously the best food for horses is their natural diet of grass. In fact, Columella (*r.r.* VI, 27,2) states that better pasture was required for the noble and mule-breeding stock, preferably well watered and at higher altitude. However, very few areas produce enough grass all year round to give working horses enough nutrients to remain in good health.

For this reason working horses are usually fed supplementary rations in the form of grains and pulses and dried plant fodder. Most of the classical veterinary and agricultural texts give a variety of recipes for horse feed, which have not changed much over time. Grains used were wheat and barley (oats were considered inferior). The grain species grown in Roman times were more varied than today and also had a significantly higher protein content (Reynolds 1979 quoted in Hyland 1990), which meant that less was needed for the horses. This means that the Roman army ration of 5 *librae* of barley (approximately 1.65 kg) per horse per day was probably sufficient, but would be considered too little today.

A variety of pulses was also fed, including horse beans (broad beans), chickpeas, kidney beans and sweet chestnuts. These are all very high in protein and are not generally used in horse feed today but only because most modern horses are not worked hard enough to burn off the energy these feeds give. Cato (*A.C.* XXVII and XXX) and Virgil both state that green foodstuffs included hay, vetch, fenugreek, clover, lucerne and tree leaves, including elm, poplar, oak, fig, willow and broom. Lucerne or alfalfa has a very high nutritional value and originally came from Media, where the Nisean horses were raised. This availability of very nutritious feed may be one reason why these horses were renowned for their size. Good nutrition would have enabled them to reach their full genetic potential (Chapter 2).

The Romans recognised the importance of feeding pregnant and lactating mares well in order to obtain a healthy foal (Varro *r.r.* II, 7, 10) and to give the foal a good start in the first few months of life, as the level and quality of feeding has a direct bearing on the adult size of an animal (see Chapter 2). Varro (*r.r.* II, 7 11-12) also gives instructions for feeding young stock: at five months they should be fed barley-meal ground with bran; as yearlings they should be fed barley and bran until they are weaned at about two years old; from three years they should be fed mixed forage and barley.

The fact that Roman horses seem to be larger than their Iron Age counterparts in many areas of the Empire may in part be due to the extensive trade network enabling most horse owners to obtain first class rations for their animals. This is probably particularly true for the studs breeding equids exclusively for the circus or the military. However, the lot of animals that ended up turning mills at the end of their working lives was probably not very good. Apuleius (*m.m.*) describes in detail the appalling condition of mill beasts, with running sores, mange, coughs and the like. Malnutrition amongst these animals was probably commonplace. It was cheaper to replace an animal that died than to feed it properly.

In addition to food, horses also require a large amount of water each day (donkeys are much more drought tolerant). This can be about 22 litres in normal conditions and more in hot weather. Also horses fed grain and hay rather than grass need more water. For this reason, grazing lands would need to be either close to water or the herds would be driven to water twice a day.

Caring for a horse to maintain its health and usefulness to humans is quite an exacting task. The various elements of this, including feeding and veterinary care, were well understood by the Romans, even if not always applied. Maintaining good hard hooves was of paramount importance, as the old proverb 'no hoof, no horse' was particularly applicable in a time when the horse was vital for every aspect of maintaining the Empire and were not shod with iron horseshoes as they are today. Mares and foals were often driven up into the mountains in the summer to get the foals feet accustomed to rocky conditions and to toughen their hooves.

Lucius (Apuleius *m.m.*) complains that his unshod hooves were worn down to the quick and that he had no shoes to protect his hooves from the hard edges of frozen ruts and broken ice. There are examples of hipposandals from all over the Roman Empire both made of iron (*Solea ferrea*) and rushes (*Solea spartea*). Hipposandals have a flat hoof-shaped base with vertical elements around which thongs or rope were attached, to keep the hipposandal on the hoof. It appears that pack and draught animals were mostly fitted with hipposandals when on difficult terrain, but riding and cavalry horses were not (Peters 1998), perhaps explaining the concern with hard hooves in the texts when choosing cavalry horses. It is interesting to note that nailed horseshoes were probably developed by peoples in northern Europe because of the softer ground they had to ride on. However, they were not generally in use until towards the end of the Empire or afterwards.

Horse grooms and stockmen were expected to know how to treat most minor complaints in horses, a vetinarian only being called in when really necessary. Many works have survived from classical times (Columella, Pelagonius, Vegetius, Varro and in the *Corpus hippiatricorum Graecorum* and the *Mulomedicina Chironis*) dealing in great detail with veterinary matters, suggesting the importance of horses and their health to the Roman population. Many of these contain fascinating remedies for a great variety of illnesses, and practical methods for treating lameness and other injuries. Similar remedies were still in use until the mid-20th century when more scientific methods and drugs were established.

Diseases recognised and treated included colic, coughs and poisonous bites. The classical works also contain general information on good management practices. These include the necessity of daily grooming. Arrian suggests 'massaging the legs and body as it strengthened the legs and rendered the skin supple, removing impurities and imparting lustre to the coat', and Columella (*r.r.* VI, 30, 2) says 'to massage a horse's back ... does more good than if you were to provide it most generously with food'. Both of these are in accord with modern thinking. Good horsemanship also meant ensuring that the horses did not fall ill from avoidable excesses. Varro, Columella and Pelagonius all say that most ailments are caused by cold, fatigue, drinking too much when hot after work or working too hard after prolonged idleness. Pelagonius suggests that strained muscles should be treated by swimming the horse in a pond, a treatment that seems to have been ignored until the late 20th century.

Many laws were passed regarding equines. For instance, it was an offence to beat a mare in foal and cause her to miscarry. This was, however, more to do with the fact that horses and mules were an expensive commodity and the laws were to protect property rather than animal rights, as can be seen from the reference to abuse of mill beasts.

Training a young horse is crucial to its future career, and as such was taken very seriously in the Roman world. The early training of young horses was undertaken in much the same way as it is today. Varro (*r.r.* II, 7, 12-13) suggests gradually introducing a three year old horse to a bit and bridle, working without a rider and then the gradually introducing of the weight of a saddle and rider, followed by ridden training. The acknowledged source of much information on the training of horses is Xenophon's The art of horsemanship (*p.h.*) and later authors, including Varro, used it extensively in their own works. In fact this treatise by Xenophon is still considered compulsory reading for those sitting British Horse Society examinations today (Hyland 1990).

Training the young horse on a lunge line and also by long reining are both attested to in literature and art. Aelian mentions running a horse round in circles (lunging) and long reining is seen on tombstones of cavalrymen (Hyland 1990, plate 1). In addition, Tacitus and others mention using a training ring (*gyrus*). This appears to have been a fenced-in circular area much like a modern round pen used for breaking in horses in America. The ridden training would depend on the purpose the horse was intended for, for instance training for the military (see below) would differ considerably from training of racehorses. Columella (*r.r.* VI, 29, 4) states that prospective race horses were broken in at three years old and raced a year later, whilst riding horses were broken at two (the opposite of current practice). Varro (*r.r.* II, 7, 15) commented that the experienced soldier would train his horse one way, the charioteer and circus rider another, while the horse that was used as a pack animal needed to be docile and was usually castrated.

It seems that many horses were sold after the initial breaking in was complete and the new owner would carry out the more specific training. For this reason Varro (*rr* II, 7,2-4), Pelagonius (quoted in Hyland 1990) and Xenophon (*p.h.* VIII, 1) recommend that a person buying a horse should be able to tell its age from the teeth; obviously horse dealers were as unscrupulous then as they are today!

> The horses being said to drop at thirty months first the middle teeth, two upper and as many lower; at the beginning of the fourth year they again cast, this time dropping the same number of those coming next those which they have lost; and the so-called canine teeth begin to grow. At the beginning of the fifth year they again shed two in each jaw in the same way, as at that time the animals has hollow front teeth which fill out in the six year so that in the seventh it usually has a full set of permanent teeth. It is said that there is no way of determining those which are older than this, except that when the teeth become prominent and the brows grey with hollows under them, they determine by looking at him that such a horse is sixteen years old (Varro *r.r.* II, 7,2-4).

The various descriptions of the ageing of horses from the replacement of the incisors are pretty accurate in modern terms, and it is also true when they state that after the age of seven it is very difficult to tell the age accurately. From studies of modern breeds (Peters 1998), the clasiically referenced timing seems closer to that observed in late maturing breeds, such as the Haflinger, rather than the early maturing breeds, such as the Thoroughbred, indicating that the Roman horses may have been of the slower maturing type. The suggestion was made that the wear on the teeth after seven years was more rapid than that observed in modern horses. The fact that these observations were made in the Mediterranean area, where fodder is coarser and dryer, suggests that tooth wear would be hastened under such conditions. Therefore the ageing of teeth from the amount of wear should only be applied to the area and conditions under which the observations were made (Peters 1998).

Military horses

The aspects of the Roman Empire about which most has been written, both contemporaneously and recently, are the emperors and the army. However, the subject of the cavalry, and in particular their horses, forms only a very small part of this vast literature. In addition, the baggage and draught animals, so vital to the operation of the army, are hardly mentioned at all. This is partly to do with the fact that until the later Empire, the cavalry only formed quite a small proportion of the army and was considered second rate. In the 3rd and 4th centuries AD they were more highly rated and formed approximately a third of the army. In Diocletian's time there were 70 cavalry vexillations, each of about 500 men in the eastern part of the Empire alone (Hyland 1990).

Equids in the Roman army fall into two categories, firstly the traction and baggage mules, packhorses and ponies, and secondly the chargers for the various levels in the hierarchy. These included the high ranking officers, legionary cavalry, cavalry *alae*, *cohortes equitatae* and possibly also speedy horses for scouts. Hyland (1990) suggests baggage animals may have varied according to the country in which they were working: eastern and Mediterranean areas using mules and large donkeys whilst more northerly areas may have employed indigenous ponies. Hyland (1990) suggests this would be because mules and donkeys do not do well in wet and cold conditions, whereas the native ponies were more adapted to the conditions in northern Europe. However, information in the literature on the baggage animals is very scarce so there are no clues regarding the likelihood of the above statement, but zooarchaeology may help to answer it (Section 1.4 and Chapters 6 and 7).

Turning to the cavalry horses the art historical sources depicting military horses are particularly numerous. However many of these are politically motivated carvings of Emperors (e.g. the statue of Marcus Aurelius Figure 1.2,) and their achievements (Trajan's column Figure 1.4). Yet many do show some of the characteristics of cavalry horses (Figure 1.6).

Figure 1.6 Base of Antoninus Pius' column showing cavalry ready for battle (above, from Hyland 1990) and Marcus Aurelius' column showing the Emperor reviewing the horse guard (below, from Speidel 1994).

The cavalry required horses with certain characteristics and these characteristics can be put together from the scraps of information spread throughout numerous texts. The duties a horse had to perform dictated the requirements regarding type, temperament, intelligence, conformation, age, training required and care bestowed. The *Codex Theodosianus* states that horses should 'meet certain requirements as to shape, stature and age' but does not say what these requirements were (Hyland 1990). Cavalry horses tended to be mostly stallions, but the list of remounts in the accounts of the *Cohors XX Palmyrenorum* at Duro Europus in 251 AD clearly indicates mares as well as stallions (Toynbee 1973). This document describes the horses' ages, colours, markings, brands, purchase prices and, in one instance, country of origin. It shows there was no standardisation as long as the animal was fit for the purpose, which included passing a veterinary examination (Hyland 1990).

Virgil (quoted in Hyland 1990: 79) states some of the qualities essential to a charger: 'how the animal from birth picks his feet up high; ... is the first to venture on to the highroad; to ford the menacing river; cross bridges; does not shy easily; has a proud carriage; gets excited at the sound of battle and is impatient to engage.' He also says that bay and roan horses were the toughest and white or light coloured horses were worst. This is to some extent true of their feet, as dark coloured hooves are stronger than pale ones. Age requirements seem to have been for animals mostly under seven and preferably 4 to 5 years old. This means they were mature enough to withstand the rigours of training and cavalry life and were also at the height of their physical strength but were young enough to be amenable to training and still be useful for breeding after a few years of service.

As for the size of cavalry horses, Hyland (1990:67) says that:

> 'the size of the horse does not have as great a bearing on its ability to carry weight as would at first appear, but its conformation does, and this also affects its durability ... The more compact the animal the greater its load-bearing capacity, and the short stocky breeds that still retain enough refinement to give a smooth ride and achieve sufficient speed are far more suited to the arena of war than the overlarge, lumbering, excessively heavy-fleshed animals ... At the other end of the scale ponies would also be unsuitable ... For a cavalryman riding without the benefit of a saddle, a pony's gait would be very tiring ... it would take too much of the troopers attention merely to stay aboard.'

To clarify this last statement, a pony is not just a small horse: they have different limb and body proportions (Section 1.5) and hence a slightly different way of moving.

Another piece of evidence regarding the size of cavalry horses is the fact that the cavalryman was expected to be able to vault onto his horse easily and cleanly and from either side whilst wearing armour and carrying weapons and also whilst the horse was running (Speidel 1994). Both Arrian and Vegetius state the importance of this and the fact that the cavalrymen practised using a wooden dummy horse (Davies 1969). This implies that the horses were of a size that vaulting onto them was relatively easy. Even though the cavalrymen had to be at least 1730 mm and preferably 1780 mm (from Vegetius), from personal experience this means a horse no bigger than about 1420 mm. The rations of barley and hay suggested for horses in the army (see below) would also be adequate to feed animals of 1220 to 1420 mm, particularly if they were 'good-doers' (Toynbee 1973).

The places that supplied cavalry horses changed through time as the nature and quantity of the cavalry altered. In Caesar's time (1st century BC) the cavalry mainly consisted of the native mounts, which the various auxiliary units brought with them, and specially purchased Spanish and Italian horses for the legionary officers (Hyland 1990). Where possible mounts were recruited along with the cavalrymen, rather than being issued to them later. This reflects the fact that at this time the cavalry was not a major part of the army and almost all cavalrymen were auxiliary troops from annexed and friendly native tribes. The Germanic peoples were particularly admired for their horsemanship, and Tacitus (*ger.*) says this was because they were taught to ride from a very early age and were therefore better than those who had to be taught in adulthood. The wide geographic span of the auxiliary units influenced the types of horses used. Also at this time the cavalry did not fight from horseback; they were used for reconnaissance, sending messages and as back up for the infantry (Clutton-Brock 1992).

In the later Empire, when the numbers of cavalry increased dramatically, military horses were specially bred. Imperial stud farms supplied horses for the army from the time of Emperor Theodosius and probably earlier (White 1970). Where the army got its horses from is not dealt with explicitly in any Roman histories. Many may have come from race horse studs: those that grew too small or too tall, showed no inclination to race, could not be trained in harness, or were just too slow to race. This explanation is borne out by the fact that areas that bred racehorses (Africa and Spain particularly) were also noted as areas from which cavalry mounts were obtained (Hyland 1990). By the time Vegetius wrote in the late 5th century AD, the horses used in the army were mostly those of the barbarian Huns and Burgundians. This reflects the stresses of the Roman Empire at the time and perhaps a shortfall in the supply of purpose bred animals.

The supply of enough horses for the cavalry and enough mules and donkeys for transport of military supplies around the Empire seems to have been a continual problem. This was in spite of measures such as demanding a stock of military horses as part of the regular taxes from North Africa (Clutton-Brock 1992). Hyland (1990: 77) gives a list of the means of acquiring horses, which shows that almost any way possible was used:

1) National contingents that brought their own horses with them

2) Requisition from large landowners

3) Levies on provinces

4) Tribute from client kingdoms

5) Taxes where the whole or part value of a beast was levied on individuals

6) Public services

7) Outright purchase from breeders and/or dealers

8) Imperial/army stud farms

9) Capture of enemy horses.

The cost of purchasing horses for the cavalry varied through time. The price paid by the troopers was fixed, whilst the market price was not, meaning that whilst the cost of a horse remained about half of the soldier's annual pay, the fixed price did not go up with pay increase or inflation. By the late 3rd century AD a horse only cost the soldier about one-seventh of his salary (Speidel 1994). From AD 139 to 251 auxiliary cohorts paid about 125 *denarii* each, whilst the troopers of the *alae,* who were expected to have better horses, paid more (Speidel 1994).

An idea of the numbers of horses (both cavalry mounts and baggage animals) in the army can be worked out from a variety of sources. At Hod Hill (Richmond in Toynbee 1973), a 1st century AD fort with a legionary cohort and a half *ala* of cavalry, it has been estimated that 82 equids were needed. This was worked out from the number of people in a half *ala* of cavalry and a legionary cohort. Thirty troop horses and four officer's remounts were required per *turma*, plus one baggage animal per officer and four per *turma*. The space in the stables (as previously discussed) suggests the presence of 84 animals, which agrees with the calculation. Even a small contingent attached to a *cohors equitata* would present considerable provisioning problems, with 120 plus animals needing to be fed. In Britain in AD122 there were four legions, 12 *alae quingenariae*, one *alae milliaria*, four *cohors equitatae milliariae*, 14 *cohors equitatae quingenariae*. According to the computations of Hyland (1990: 89) a total of 18,503 equids would have been needed for these units to function! This is a considerable number of equids to be fed.

Vegetius tells us that when the army was in camp, the horses were pastured outside when conditions allowed (Peters 1998), with guards posted 24 hours a day to prevent horse rustling. Baggage animals no doubt came under the same system. Meadowland and pasture were set aside for the military use. However, for a third to perhaps a half of the year, in most areas of the Empire, there ws not enough high-grade grass to feed horses adequately, particularly if they had to be kept off it to produce some hay during late spring and early summer. A horse needs around 4.5 kg (10 lb) of hay per day, which means that to feed all the military equines in Britain for 150 days (nearly half the year) it would take 12,500 tonnes of hay. In addition to this, the rations of 1.65 kg (3.5 lb) of grain per horse per day all year round would work out at 11,145 tonnes of grain. Given that crop yields were lower than today (probably about two tonnes per hectare for hay and 1.5 to 2.5 tonnes per hectare for wheat) (Hyland 1990), this would require around 6500 ha of pasture and around 5500 ha of arable land to produce horse fodder for the army alone.

The training of cavalry horses would have been quite a specialised activity and was probably delegated to those cavalrymen who had both an aptitude for the task and experience (Hyland 1990). Training and exercises were undertaken in the open as much as possible, but Vegetius mentions that covered halls were constructed in which the soldiers could carry out their training and exercises even in bad weather. 'In winter they constructed for the cavalry halls of tile or shingles, and halls like basilicas for the infantry' (Davies 1969). The preparation of a cavalry parade ground was described by Arrian 'They choose a site where the exercises are to be held that is flat and they work on it in addition. From the whole level field they demarcate the area in front of the platform into the shape of a square and dig the middle to an equal depth and break up the clods to obtain softness and springiness' (Davies 1969). The last part indicates that the Romans knew that a soft surface would benefit the horses whereas a hard surface would lead to leg injuries and lameness.

Several Classical authors, including Arrian, Onasander and Xenophon (*p.h.*), all state the need for horses to be exercised in jumping over ditches and leaping over walls, rushing up and springing off banks, and also galloping up and down hills and on a slope (Davies 1969). Xenophon (*p.h.*) goes on to explain how to train a horse to jump ditches and walls from scratch and how the rider's position changes when jumping and going up and down hills. The principles are exactly the same as are generally used today to train horses to jump. These kinds of training and exercises would obviously not have taken place on the exercise ground, as they did not contain ditches, walls and hills.

Arrian states 'the commander should ... arrange practice battles including pursuits, hand-to-hand struggles, and skirmishes; these manoeuvres should be held on the plains and around the base of hills as far as possible in broken country, as it is impossible to gallop at full speed either uphill or downhill' (Davies 1969). Xenophon (*p.h.*) also indicates that 'It is a correct principle to hold these equestrian exercises in different places and at different times, on occasions making the exercises long, on other occasions short. This is less irksome to the horse than that the exercises should always be in the same place and in the same routine' (Davies 1969). The second piece of advice is one that many modern riders could do with following, as a horse will easily get bored if asked to do the same routine everyday and will probably rebel in some way or get overexcited when asked to do something different.

Vegetius talks about the use of route marches as exercise and training for the troops:

> 'The infantry were ordered to march wearing their armour and equipped with all their weapons to and from the camp for ten (Roman) miles. Similarly the cavalry were also divided into troops, armed in the same way, and travelled the same distance, although in the equestrian exercise from time to time they pursued, from time to time retreated and made ready to charge back again. It was not only in the plains but also in hilly and difficult terrain that both arms of the service were compelled to ascend and descend so that they might never experience an incident while fighting that they had not as trained soldiers learnt by continual practice' (Davies 1969).

Vegetius also says that ' During the summer months every recruit without exception must learn to swim ... It is of the greatest advantage that not only the infantry but also the cavalry and even the horses and the soldier's servants should be exercised in swimming, in order that they might not be inexperienced in case of any necessity' (Davies 1969). Horses do swim very well naturally; the problem is training them to go into the water in the first place!

All these exercises would have kept both the horses and riders fit and ready for active service. They would also have accustomed the horses to many unfamiliar situations, so that when they encountered them in a battle situation the horses would not react in an adverse way. All of this is very sound in principle and in practice, showing that the Roman cavalry was as advanced in its warfare as the infantry was.

- **Research aims.** Did the Romans move large quantities of horses with the army or recruit local stock as they moved? Were the horses used by the military of a particular type of physical appearance?

Circus horses

The circus was the name given to the arena in which chariot racing took place, not to a travelling entertainment group. Therefore circus horses were those that took part in the chariot racing. Occasionally mounted races took place, but the majority of races were for two- or four-horse chariots (*biga* and *quadriga* respectively). Circus horses are perhaps the most often illustrated equids in the Roman period, and often written about. This is perhaps to do with the fact that the Romans (particularly those in major urban centres) were obsessed with racing, on a par with or surpassing modern football fanaticism. However, although there are many accounts of race days and autobiographies of charioteers, there is not nearly as much mention of the horses themselves. Many pictures of chariot horses are seen on mosaics and other decorative items in all areas of the Empire (Figure 1.7), both of individual horses and scenes of racing taking place (Toynbee 1973).

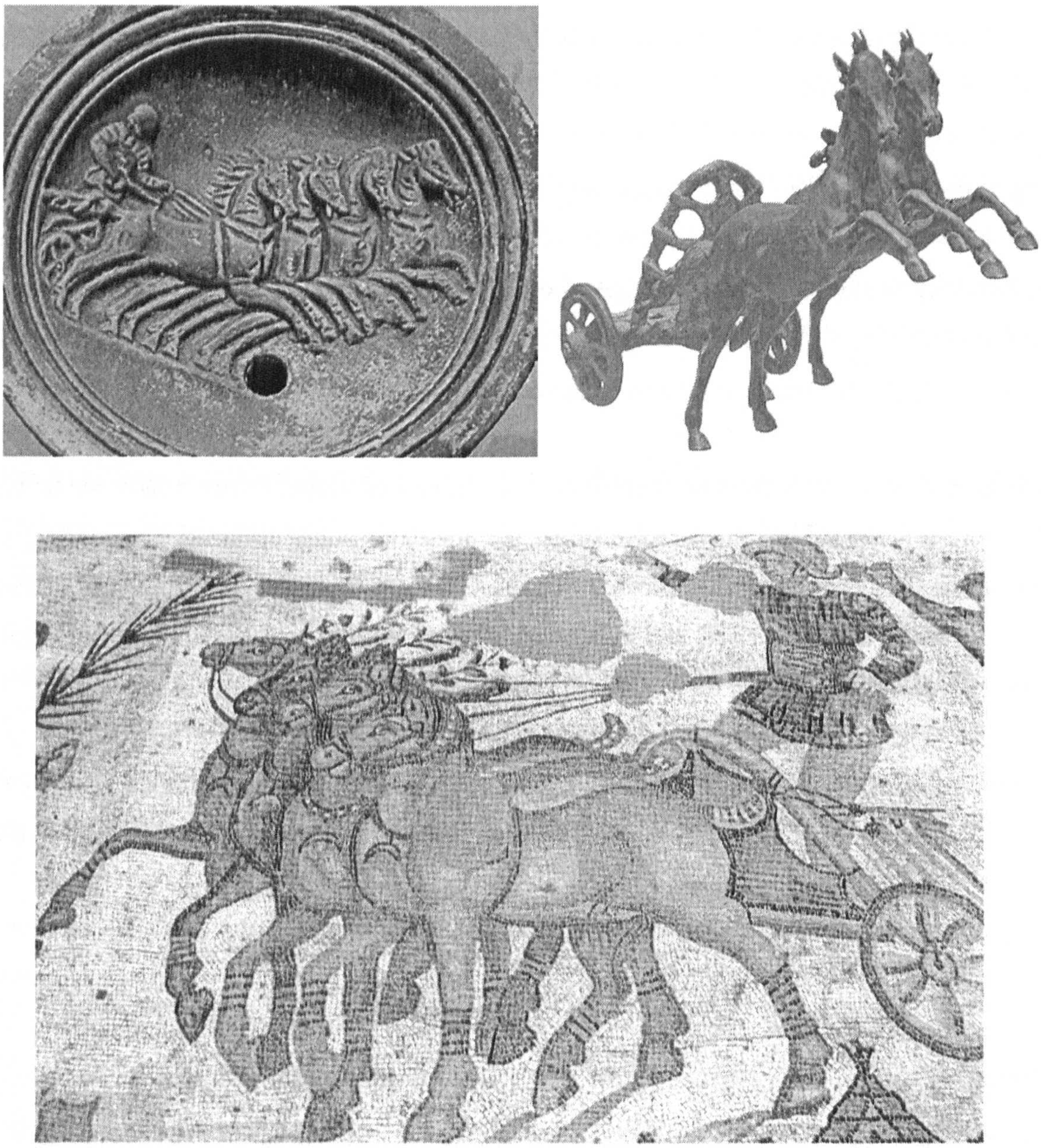


Figure 1.7 Examples of chariot horses depicted on a terracotta lamp, a bronze statuette (both from the British Museum, London website) and a mosaic (Ciurca undated).

The names of racehorses were often recorded on mosaics (Figure 1.8) and in the literature (Toynbee 1973). However, in autobiographies of charioteers only the name of one of the horses in their teams is mentioned. This is perhaps because the lead horse (the horse on the far left hand side when viewed from the chariot) was the one that had to do the most work in cornering and in leading the others during the races, which were run in an anticlockwise direction. Many names relate to the colour of the horse, for instance *Aureus* (golden), *Pupureus* (roan), *Ployeides* (dappled), *Glaucus* (grey), *Maculosus* (piebald) and *Roseus* (bay). Others relate to speed rather than appearance, *Celer* (Swift), *Volucer* (Flyer), *Sagitta* (Arrow), or strength *Adamus* (Cast-iron), and expected triumphs, *Victor*. Many were also named after gods and heroes, such as *Castor*, *Achillles*, *Diomedes* and *Pegasus*. Others were named almost as obscurely as some modern racehorses (Grizzly activewear, Sewmuch character, My legal eagle, Kathakali, etc.)! The list is almost endless and many examples are given in Toynbee (1973).

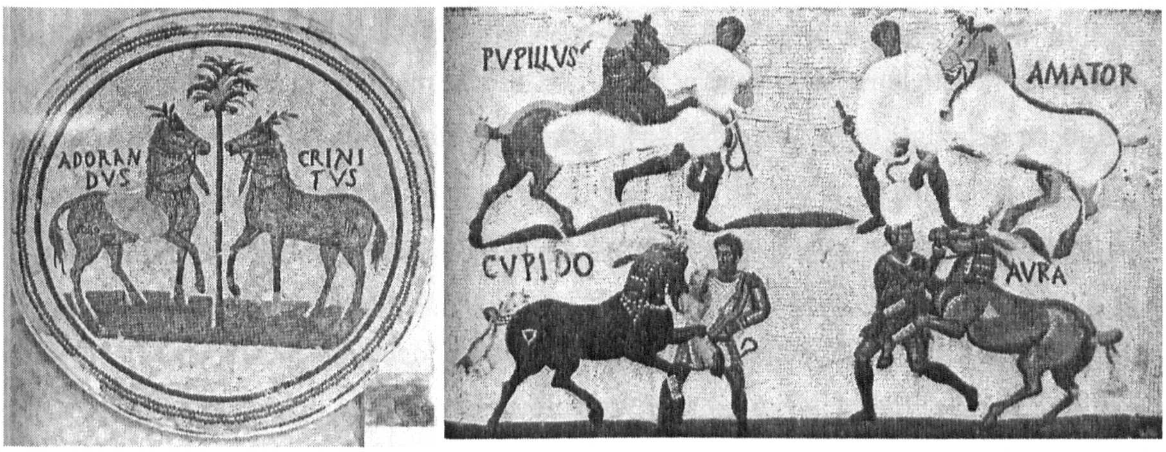


Figure 1.8 Two mosaics showing racehorses with their names (both from Hyland 1990)

One of the topics most often discussed in the literature is the areas from which good racehorses stemmed. Vegetius indicates that horses for the circus came from Cappodocia, Spain, Sicily and Africa. Gratius Faliscus in the 1st century AD suggests Sicilian and Mycenean horses were good, in addition to the Spanish and African ones. Oppian in the early 3rd century AD says that the Spanish horses were fast but had no endurance, whereas the Libyan (African) horses had good endurance. Sicilian and Cappodocian horses were also fast, whilst Tuscan and Cretan horses were rated but not as highly. Nemisian in the late 3rd century AD rates Cappodocian, Spanish and Greek horses highly. Many racehorse studs were established in Spain, including a number of Imperial studs raising horses for the Emperor's faction in Rome (White 1970).

Therefore in the early Empire African horses dominated the track whilst Cappodocian and, to a lesser extent, Spanish horses were dominant in the later Empire (Hyland 1990). This may have been the result of continual upgrading of the Spanish stock with African blood. This predominance of African horses in racing continues today, as all modern Thoroughbred racehorses can trace their ancestry back to three Arabian stallions imported into Britain in the 18th century AD. Similarly the Romans imported many horses by ship from North Africa (Clutton-Brock 1992).

As in modern Thoroughbred racing, in Roman tims the elite of society owned most of the horses and controlled the occurrence of races. Imperial studs were set up in Spain and Cappadocia to produce chariot horses that ran for the Emperors (White 1970). Often horses from these studs were retired back to them when their racing career was finished and allowed a peaceful retirement out to pasture. This was a far cry from working mills, as many ex-chariot horses ended up doing.

The number of mares needed to keep up the supply of chariot horses was four times that needed for thoroughbred racing today, partly because the mares were not bred every year and also because chariot horses did not have a long working life (White 1970). Chariot horses were nearly always stallions, although the names of a few racing mares are attested to. Their training started at the age of three but they were not raced until four or five years old (Hyland 1990).

A great deal of attention was given to veterinary matters concerning racehorses. Pelagonius' treatise on horse medicine is almost entirely devoted to treating chariot horses, probably because this was his main employment at one stage in his career. Because of the hard surface of the race tracks (to make the chariot wheels run smoothly), chariot horses tended to have a variety of leg problems; they also suffered back and shoulder problems from the strain of turning tight corners at speed (Hyland 1990). Pelagonius devotes several chapters to the cure of these ailments and also to treating eye injuries, bruises and cuts from accidents whilst racing.

Riding and carriage horses

Perhaps because these were considered as the 'common stock' by Columella (*r.r.*), riding and carriage horses are very infrequently mentioned in literary sources. Vegetius mentions that most horses for riding came from Persia, Armenia, Epirote and Sicily. Riding horses had three main purposes, the most obvious of which was getting a person from one place to another. In addition a horse was a status symbol, particularly for city dwellers with some degree of public office. The third purpose was for sport and leisure activities, such as hunting or riding around a country estate. Reasons for the lack of mention of carriage horses include the fact that there were very few carriages around and they only belonged to people of very high social rank (and usually women), and they were more usually drawn by mules (Casson 1994).

Because of the problems with mounted barbarian raiders in the later Empire, owning riding horses was restricted by law to the upper classes, aristocracy, veteran army officers and other wealthy citizens. This was also partly because horses were expensive animals to buy and keep (Casson 1994). Herdsmen were also allowed to own riding horses, but only in areas where rustling was not a problem (Hyland 1990). Apuleius (*m.m.*) mentions that wealthy people had mounting blocks outside their houses and rode 'Thessalian thoroughbreds' and 'Pedigreed Gallic cobs', amongst other types of horse. However, there is no description of what these looked like. Presumably the Thessalian thoroughbreds were the large horses bred in Greece, which were also favoured by the army. The term 'Gallic cob' probably refers to a more heavily built animal such as was described by Caesar when he mentioned Gallic draught horses.

Interestingly, Martial refers to gaited riding horses: 'the small Asturian horse who picked up his hooves in such regular time' apparently had a syncopated gait like the pace or rack, which provides a smoother ride that is ideal when you have no stirrups! The lack of stirrups meant that horses were not that comfortable to ride over long distances (Casson 1994). Pliny the Elder (quoted in Hyland 1990) describes some Spanish horses bred by the Gallic and Asturian tribes as Theldones, which 'do not have the normal gaits but a smooth trot, straightening the near and offside legs alternately from which they are taught to amble'. Many horses and ponies pace naturally and most can be taught to do so (Hyland 1990).

Arrian suggests that the best horses for hunting were those from Scythia and Illyria, which were considered uncouth and ugly (unlike the Thessalian, Sicilian and Peloponnesian horses) but could run after a stag and wear it down. This description implies that these were lean, tough endurance horses. Oppian suggests that stallions were more favoured for hunting as they were faster than mares. Gratius Faliscus suggests that bay or dun horses should be used. This is because horses of these colours tend to have harder hooves, which means they are able to cope better with hunting over any type of ground. Hunting scenes are depicted on mosaics (Toynbee 1973) and some of the most spectacular are from the villa of Piazza Armerina in Sicily (Ciurca undated), and from various buildings in North Africa (Figure 1.9). These show that hunting from horseback was undertaken, and that horses were also used to carry back the dead animals, as Highland ponies still do for stag hunts in Scotland.

Figure 1.9 Two scenes from mosaics showing hare hunting using horses and dogs (above El Jem, Tunisia from a website; below Piazza Armerina, Sicily, Ciurca undated).

Another major use of riding and carriage horses was as the mainstay of the *Cursus publicus:* the state postal and transport system (Casson 1994). Procopius says that about 40 horses were held at each major inn (*mansiones* and *stationes*), with less at the minor inns (*mutationes*). The inns were about 8 to12 miles apart along most major roads in the Empire, with a ratio of two minor to one major inn in most areas. This means that with over 53,000 miles of trunk road and about 4,800 stations, approximately 128,000 horses were in the service of the *Cursus publicus*. Although Procopius suggests these were horses, it is likely that a mistranslation of 'equids' has occurred and that many of these were actually mules, particularly as Casson (1994) refers to similar numbers of animals kept at the major inns *mansiones* but specifies a mixture of horses and mules.

It was expected that these animals would be replaced after only four years of service in the *Cursus publicus* because of the hard usage they received. As well as the public service there was also the private post-horse service, which probably had an almost equal number of horses, mules and oxen. The logistics of supplying this number of animals, and keeping them fed and cared for, was one of the major headaches for the bureaucrats of the Roman Empire, and, as in many such cases, the burden fell to the local citizens (Casson 1994).

❖ **Research aims.** Were there differences between the types of horses used by civilians and those of the army? Is there a connection between status/wealth of an individual/ settlement and the type of horses found there?

Horses in ceremonies and religion

Roman ceremonies almost always included some religious element, which is why the two topics have been treated as a single entity. The state kept a number of white horses for use on ceremonial occasions, such as religious feasts and military triumphs. The Emperor usually rode a white horse in triumphal processions because it stood out from other coloured animals. Indeed Trajan rode a white stallion upon his triumphal entry into Rome in AD 99 (Speidel 1994). Many of these may have come from the Imperial studs in Thrace, as these were noted as being huge and white. Those from the Imperial stud at Phrygia were also used in processions (Hyland 1990). Many rulers in later centuries have used white horses on ceremonial occasions for the same reason, including the use of the 'Windsor greys' to pull the Queen's carriage on state occasions in England.

The use of white horses in religious activities in other areas of the Roman Empire may have had something to do with the fact that in the wild a white prey animal is very rare. White animals tend to be killed before reaching adulthood because they have no natural camouflage. Tacitus in his treatise on the Germanic peoples (*Ger.*) gives an account of their use of white horses:

> ..the Germans also have a special method of their own – to try to obtain omens and warnings from horses. These horses are kept at the public expense in the sacred woods

> and groves… they are pure white and undefiled by any toil in the service of man. The priest and the king or the chief of state yoke them to a sacred chariot and walk beside them, taking note of their neighs and snorts. No kind of omen inspires greater trust, not only among the common people, but even among nobles and priests, who think they themselves are but the servants of the gods, whereas horses are privy to the gods' counsels.

In addition to this, horses were sometimes cremated along with their owner if that man was of sufficiently high status and esteem. Burial or cremation of the horse was carried on into the Migration Period in north-west Europe, as evidenced by the many archaeological finds of horse remains, such as those at Sutton-Hoo, UK (O'Connor 1994), and many in Hungary (Bökönyi 1974).

Great importance was also placed on the horse in Thracian culture, as shown by the many depictions of mounted heroes. In Thracian religion the horse played a prominent role, with white horses being sacrificed to the sun. The only votive tablets known from Thrace show depictions of Apollo on horseback (Hyland 1990). Herodotus (VII. 113) says that 'There are other links between Thracian and Persian horses: white horses were also sacred to the Persians and on occasion were sacrificed in propitiation to the Strymon'. These images may be linked to the worship of horses in Greek culture, where horses were considered to be deities in animal form (Peters 1998). Deities were also depicted with certain animals as a form of identification, for instance the god Silenus was always depicted riding on a donkey (Figure 1.10). This idea was carried through into the Roman pantheon where the twins Castor and Pollux (the protectors of Rome) were always depicted with horses (Figure 1.10).

The most obvious religious association between horses and religion is in the worship of the goddess Epona. She was originally an indigenous Celtic goddess, as indicated by her name which is related to the Celtic name for 'horse' (Wells 2001). Representations of Epona always show her either riding a horse or seated between two horses and sometimes with foals (Figure 1.10). Stone carvings, altars and other artefacts dedicated to her have been found in abundance from former Celtic provinces such as Gaul, the Rhineland and Britain, but have been found as far afield as the Danubian provinces and North Africa (Toynbee 1973). She was particularly revered by cavalry soldiers but was also celebrated in Rome, because of her other attributes of fertility and healing (Wells 2001) and her association with the Emperor's horse guard (Speidel 1994).

Although not directly linked to horses, cavalrymen, particularly those from Gaul, worshipped a set of goddesses known as the *Campestres* (Speidel 1994). The *Campestres* looked after cavalrymen whilst they were training rather than in a war situation, so they are associated with training areas rather than in camps (Davies 1969). Archaeological evidence for this practice is outlined below (Section 1.4.)

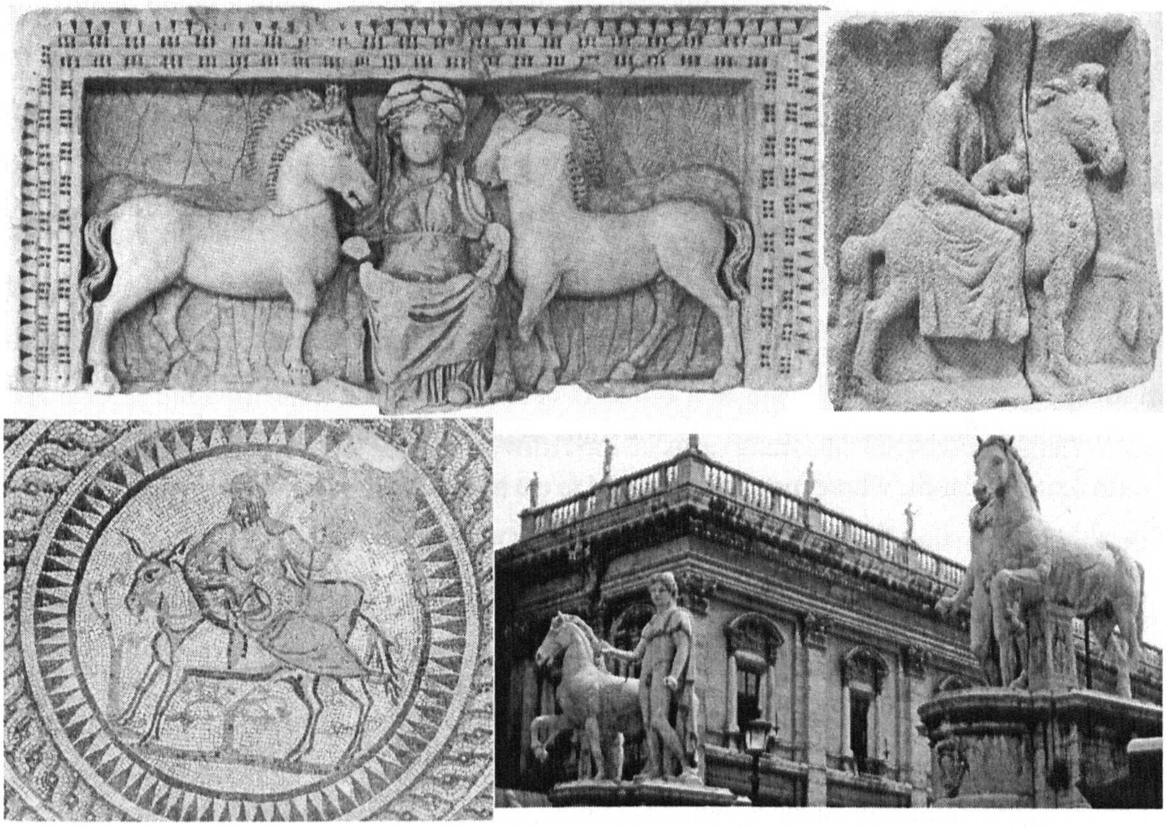


Figure 1.10 Clockwise from top left: Epona seated between two horses, Epona riding a pony, Castor and Pollux with horses, Silenus riding a donkey (from Speidel 1994, Toynbee 1973, website, Clutton-Brock 1992)

Horse transport

Horses appear to have been frequently transported across the Mediterranean in some numbers, as attested by the fact that African horses were prevalent in chariot racing and frequently used to upgrade Spanish and other demes of horses. Racehorses with the brands of their owners or breeders C. Sabinus and Sorothus are depicted on a mosaic in Barcelona, and both had their studs in Algeria, as evidenced to by other mosaics and inscriptions found there. Hyland (1990) states that it was quite common to move horses in specially constructed horse transport ships. A mosaic from Medeina in Tunisia shows a ship with three racehorses (*Ferox*, *Icarus* and *Cupido*) on board. The type of ship is described by the Latin inscription *Hippago* written underneath, followed by the Greek equivalent (Hyland 1990). A diagram of what a proposed horse transport ship may have looked like is given in Hyland (1990: 98).

Consumption of horsemeat

In most of the ancient literature, the consumption of horsemeat is not mentioned at all because horsemeat was not a normal part of the Roman diet. There are two possible reasons for this: either horsemeat was considered unclean, or there was some religious taboo against the consumption of horsemeat. It could have been a combination of the two, along the lines of the Jewish prohibition of pork consumption. It is presumed (Arbogast *et al.* 2002) that a 'religious' taboo against eating a noble animal reserved for war came from the Greek civilisation to that of Rome. Whatever the reason, it is clear that those who considered themselves Roman only consumed horsemeat in dire emergencies.

Instances of emergency situations are referred to in the literature, such as the wrecking of Germanicus' fleet in the North Sea: ' Some ships went down. Others more numerous, were cast onto remote islands, where men were obliged to eat horses washed up with them, or starved to death' (Tacitus *Ann.* II, 24, quoted in Peters 1998). During the revolt of Civilis 'all normal and emergency rations gave out. They had by now consumed the mules, horses and other animals which a desperate plight compels men to use as food, however unclean and revolting' (Tacitus *Hist.* IV, 60, quoted in Peters 1998).

Other exceptional circumstances included famine, such as encountered by Alexander the Great in India (*Q-C.* IX, 10 quoted in Arbogast *et al.* 2002). Pliny the Elder (*Nat. Hist.* XXVIII, 146, 265, quoted in Arbogast *et al.* 2002) says that it was forbidden to sacrifice horses and also that eating them would give you ulcers and that the meat was unclean. However, it is unclear why horses were regarded as such a repugnant foodstuff when the same man, Pliny the Elder, considered the meat of donkeys and onagers a delicacy.

Indeed there was a specific market for donkey meat in Athens, although it is unclear whether this was for the consumption of donkey meat as part of the normal diet or for the production of a multitude of medical remedies made using products from donkeys. Celse (quoted in Arbogast *et al.* 2002) records that asses milk was supposed to be an antidote for poisons, whilst donkey bones, preserved testicles, foetal membranes and male donkeys' hearts were also used in some medicines to control epileptic fits. Horse parts were apparantly not similarly employed in medicinal practices.

1.3.2 Mules

Mules are the result of a cross between a male donkey (jackass) and a female horse (mare) (as discussed below). A hinny is a cross between a male horse (stallion) and a female donkey (jenny). It is considered that the mule is generally stronger and more robust than a hinny. The reason for this is because the mule's dam (the mare) is larger than its sire (the jackass). When the cross is the other way, the resulting hinny will not be much larger than the donkey dam, because the size of the dam limits the size of the foetus (Clutton-Brock 1992). During the Roman period it seems that mules were bred more frequently than the hinny, as most of the Classical sources that mention hybrid equids are concerned with mules. Whilst Varro (*r.r.* II, 8, 6) mentions hinnies, in so far as to identify the parent animals and describe their appearance ('smaller than the mules, with ears like a horse but with mane and tail like those of an ass'), he then dismisses them as inferior to mules. Columella (*r.r.* VI, 38, 5) concurs with both the description and the assertion that hinnies are inferior to mules.

Varro (*r.r.* II, 8, 5) states that mules drew all vehicles on the road (see Figure 1.11 for examples). This may be an exaggeration but implies that a great many mules were bred and used. Clutton-Brock (1992) suggests that mules became the essential means of transport in the ancient world because it was found that the strong hybrids produced by breeding a male donkey with a female horse were the most powerful and resilient baggage animals for both peace and war. As was discussed briefly in the sections above on military and riding horses, mules were the primary baggage and draught animal of both the Roman army and the civilian *Cursus publicus*. Mules were an essential part of life to the Romans, being used for riding, ploughing, drawing carts and carrying baggage. Mules are seen drawing carts on coins, tombstones, other carvings and mosaics. Draught mules are depicted (Figure 1.4) on Trajan's and Marcus' columns and pack mules are also shown in military contexts on Trajan's column (Toynbee 1973). Mules were also used to bring home the spoils of the hunt.

Mules were not considered second-rate riding animals but could be difficult to ride (Figure 1.11). Martial mentions several types of mule, and a well-bred mule could set the purchaser back the price of a house. A spirited mule could give a lively ride to a gentleman of the upper classes. For timid riders who feared a lofty steed there was a breed of dwarf mule (Hyland 1990). The best mules were probably small horse size (14 to 15 hh), as the largest donkeys and mares were used and hybrid vigour would make them still larger.

Figure 1.11. Clockwise from top left: two-wheeled mule cart depicted on a mosaic, coin showing mule-drawn funeral carriages of the Empress Agrippina, carved relief of a mule-drawn carriage and a mosaic showing a mule throwing its rider! (top left from a website, others from Toynbee 1973).

Much of what has been said above regarding the breeding and care of horses also applies to mules, but are a few extra points that are worth making regarding mules in the Roman Empire. Varro owned a mule-breeding stud at Reate in Italy, so his information on the subject should be accurate. He says that mule breeding was very profitable but that it could cost 3 to 4,000 sesterces for a good jackass to breed from (*r.r.* II, 8, 3). This shows something of the economic importance of mules (or an unlikely rarity of donkeys). Varro (*r.r.* II, 8, 3) suggests that where there is no jackass available that has been reared on a mare (see below), one as handsome and heavy as possible should be bought from a good breeding area such as Reate in Italy or Arcadia in Greece.

Varro (*r.r.* II, 8, 2) also says that jackass foals destined to be used to breed mules were taken from their mother and reared on surrogate mares. This was because a mare's milk is more nutritious than jenny's, so the donkey foal would grow larger. Columella (*r.r.* VI, 37, 8) also writes about this practice but says that the reason was so that the foal became accustomed to horse behaviour patterns, so that it would respond to a mare in oestrus. Both explanations are rational and probably the combination worked in the jackass' favour. Xenophon (*P. h.* V, 8) claims that jackasses will not mate with mares because they have long manes, and that mares destined to breed mules must have their manes cut off. This erroneous belief has been perpetuated in other classical works and even in the 19th century AD was still being carried out (Peters 1998). Columella (*r.r.* VI, 36) suggests that a jackass reluctant to mate with a mare should be presented with a jenny first, which is then substituted for the mare when the jackass is aroused.

On the subject of choosing a jackass and mares for breeding mules, Columella is most specific, saying that they should be chosen with great care or the resulting offspring will be a failure. The mares (*r.r.* VI, 36, 2) should be 'big and handsome and well able to endure toil' so that she will impart both her good physical qualities and natural disposition to the mule foal. As for the jackass (*r.r.* VI, 36, 3), he says that good ones are hard to find, and often a good-looking jackass will produce poor offspring and *vice versa*, so choosing is difficult. Temperament is also important, and whilst a jackass of 'fierce passions' is desirable, sometimes he has to be harnessed to a mill to work off the energy in order to be manageable (*r.r.* VI, 37). Whilst both Columella and Varro indicated that wild jackasses could be used for breeding mules because of their large size, the resulting offspring were considered too unruly and a second generation jackass was then preferable. This was because it showed the spirit and agility of the grandsire (wild ass) and the form and tameness of the sire (Domestic x wild ass) (Peters 1998).

Mares used to breed mules were only put into foal every other year and only bred between the ages of 4 and 10 years, thereby producing only five mule foals each (Columella *r.r.* VI, 36, 2), another reason for the high cost of mules. Columella also indicates that the gestation period for a mare breeding a mule is slightly longer than usual, at just over a year (corroborated by with modern veterinary data; Clutton-Brock 1992), and that the foaling is often difficult. Jackasses should only be used for breeding mules after they are three years old (Columella *r.r.*). In order that a jackass could mate with a larger mare, the Romans built a ramp with cross bars, onto which the mare was tied at the lower end so that the donkey (who was of smaller stature) could walk up the ramp to mate (Columella *r.r.* VI, 37, 10).

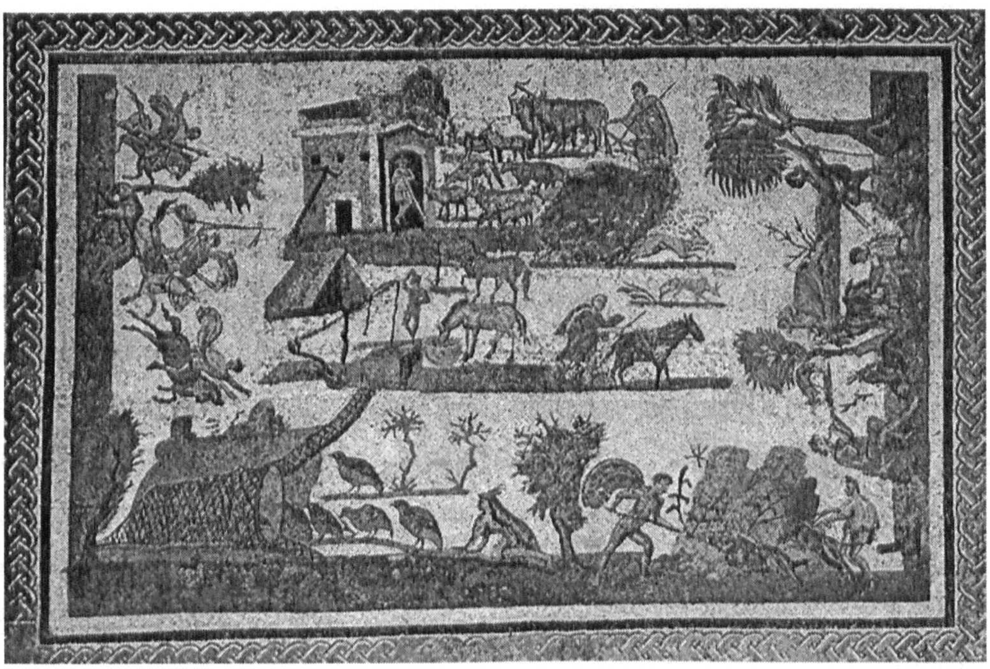
Mule foals were driven into mountainous regions in the summer to harden their hooves (Varro *r.r.* II, 8, 5). This was another economic consideration, as those with hard hooves would last longer unshod when working on hard road surfaces. Apparantly male mules were better at carrying pack-saddles but female mules were more nimble (Columella *r.r.* VI, 37, 11) and both 'step out well on a journey' and could be used for ploughing on light soil.

The appearance of the mules was also of concern to Columella (*r.r.* VI, 37, 6-7), who suggests that they should have 'ample stature, a strong neck and broad flanks, a vast and muscular chest, brawny thighs, solid legs and a black or spotted coat'. He seems to suggest that mules of other colours were inferior, particularly if they were mouse-coloured like donkeys.

1.3.3 Donkeys

The wild ancestors of the domestic donkey (*Equus asinus*) are the African asses. However, it is unclear whether one or more of the subspecies of *Equus africanus* contributed to the domestic donkeys of Roman times and today. Clutton-Brock (1999) argues that it is likely that at least two if not three subspecies were used. The Algerian wild ass *E. africanus atlanticus* (now extinct) has been identified on Roman mosaics from North Africa and was probably exterminated by the Romans. It may have been imported into Europe and used to breed from by the Romans. The mosaics depict it as having strongly marked long shoulder stripe and bars on the legs. *Equus africanus africanus,* the Nubian wild ass, has a clearly defined back stripe and a short but clear shoulder stripe but no bands on the legs. It is not possible to say which subspecies contributed most to present domestic donkeys; the Nubian ass was probably domesticated by the Egyptians, whilst it is probable that the Romans imported the Algerian ass. The Somali wild ass *E. africanus somaliensis* is quite large (can be over 1400 mm withers height). It does not have many much shoulder and back stripes but has very clear leg bars. Because of its size it seems likely that the Romans would have used this ass to breed bigger domestic donkeys and hence bigger mules. If the list of animals used in the spectacles in Rome is anything to go by, then the Roman Empire certainly accessed the Sub-Saharan wildlife so could have had access to these asses.

The domestic donkey is in some ways the 'Skoda' of the equine world: the butt of many unfounded jokes. This was true even in the Roman period as the novel 'The Golden Ass', written by Apuleius (*m.m.*), makes clear. In this book Lucius is accidentally turned into an donkey and the story relates all the trials and tribulations these beasts had to endure. Mostly the donkey's lot in life was a poor one, full of hard work and little reward. Cato (quoted in Hyland 1990) places these animals firmly in a niche as the beast of all work on a farm raising olives. The donkeys were used for rotating the mill for crushing the fruit, as well as hauling olives to the press, carting manure and so on. Donkeys could also be used for many other farm duties, including ploughing on light soil. Many of these activities are depicted on a mosaic from the Villa of the Laberii at Oudna in Tunisia (Figure 1.12).



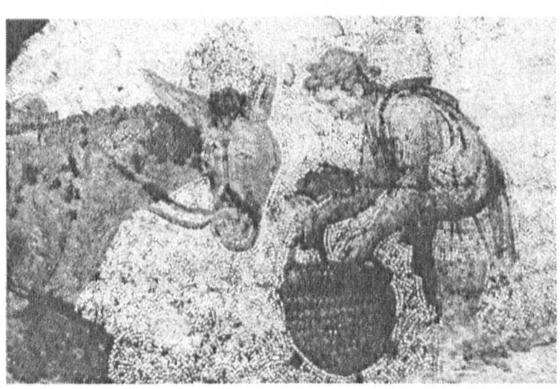


Figure 1.12. Scenes of daily life on a large farm from a mosaic in Oudna, Tunisia (above, from a website), and a humerous depiction of a donkey refusing food from a mosaic in Istanbul, Turkey (below, from Toynbee 1973).

Varro (*r.r.* II, 6, 5) states they were used as pack animals carrying panniers to carry oil, wine, grain and other merchandise. A donkey's load was calculated as 100 kg (225 lb), a mule as nearly twice that (Hyland 1990). Donkeys were also used for traction, ploughing in areas of light soil and more particularly turning mills (White 1970). Varro (*r.r.* II,VI, 5) suggests that herds of donkeys were not kept by estates, only the few required for work, and that traders assembled their own herds for pack trains as they needed them.

Mosaics often depict donkeys working mills or being beaten along under enormous loads. The crush of pack donkeys and mules in cities caused traffic jams, and tremendous pollution of road surfaces. Donkeys also contributed to noise pollution because they are very vocal, unlike horses (Hyland 1990).

Columella (*r.r.* VII, 1, 1-3) reiterates most of the information above, suggesting that as a beast of all work the donkey was second to none, not only because it can carry surprisingly large loads for its size but also because it can thrive on very little fodder and is rarely affected by disease. He particularly mentions that it can feed on leaves, thorns, twigs and chaff as well as conventional fodder. For these reasons, donkeys were considered to be one of the most significant working animals in the Mediterranean area (Peters 1998).

Ordinary donkeys were bred in large numbers all over the Empire, but on a small scale, unlike the vast mule studs of Varro. The best donkeys, used for breeding mules, came from the areas renowned for mule breeding, such as Reate in Italy (see section on mules above). Perhaps the mule-breeding studs also bred high-quality donkeys for their own use. It is mentioned in Columella (*r.r.* VII, 1) that donkeys bred in Arcadia were cheap and common in his times, whereas they were considered quite highly in Varro's time as he felt it quite an achievement to sell a jackass to the Arcadians. Small donkey demes were said to have come from Illyria, Thrace and Epeiros (Peters 1998).

On the subject of building up a breeding, herd Varro (*r.r.* II, 6, 2) suggests that animals of the correct age should be bought so that they have the maximum breeding life left in them (presumably around three years old, although this is not specified). They should be 'sturdy, sound in all parts, full bodies, and of good stock' and, as both parents contribute to the quality of the offspring, both should be chosen with care (*r.r.* II, 6, 4). This seems to be in contrast to the breeding of horses, where the stallion was considered to impart most of the quality to the foal. The pregnant jennies were not worked so that their offspring did not suffer. The young were not weaned until a year old, and then only partially. At three years old they were trained for whatever purpose was desired.

The treatment of illnesses in donkeys and mules seems to have been carried out in much the same way as for those of horses (Peters 1998) with a few exceptions noted by Columella (*r.r.* VI, 38). The castration of donkeys seems to have been carried out earlier in the animal's life and following a different method than that used for horses. Apsyrtos (*C.h.G* I, 99, 5, quoted in Peters 1998) indicates that donkeys were castrated at two years old by 'binding the testicles with linen, hold them firmly and cut obliquely. With this method no inflammation follows if the cut is treated with fire irons'. Perhaps the earlier age of castration, in relation to horses, reflects the use to which these animals were put. Only those destined for breeding would to be kept entire, as the use of donkeys as pack and draught animals meant they needed to be as tractable as possible. The earlier castration is undertaken, the less male behavioural characteristics have developed and the more docile the animal becomes. By extrapolation it is suggested here that mules may also have been castrated early for the same reasons.

1.4 Roman equids in archaeology and zooarchaeology

Archaeology can be defined as the study of the human past and of human behaviour through the collection, analysis and interpretation of the material remains left by those people (Wells 2001). Archaeology can, therefore, study periods from which no written records exist and can examine aspects of everyday life that are not mentioned in literature sources. The sub-discipline of zooarchaeology, the study of faunal remains from archaeological sites, started towards the end of the 19th century AD with the identification of animal bones together with some efforts to quantify the animals represented and find out what size they were. However, most advances in terms of the quantity and quality of information being gained from faunal remains have been made in the last 35 years. There are still wide discrepancies in the quality of information available in bone reports from different countries, and as a result of this much information has been lost.

Within the area covered by the Roman Empire, there is a long tradition of detailed bone reports from northern, central and eastern Europe in particular that allow comparison of sites and study of the socio-economic implications of the data. Unfortunately the core areas of the Empire around the Mediterranean are very poorly represented in the zooarchaeological literature for the Roman period, even though these areas have a good tradition of faunal analysis from earlier period sites.

There are many reports on bone assemblages from Roman sites that include small quantities of information on the equids, which will be used for the main data collection exercise of this thesis (see Chapter 5). In addition, there are a number of synthetic studies that bring together the information available in the site reports, mostly concentrating on particular regions. These include the extensive studies of Peters (1998) on the Roman animals of the Upper Rhineland area, Bökönyi's (1974) detailed analysis of animals in central and eastern Europe, including those of the Roman period, and the study of Arbogast *et al.* (2002) on horses in France through time. There are also smaller studies, such as those of Lauwerier (1988), and Lauwerier and Robeerst (2001) on Roman horses in the Netherlands, and the study undertaken by Luff (1982) for Roman Britain and the near continent that contain relevaent information. The following information was gleaned from the synthetic and smaller surveys and is presented under similar topic headings to the art and literature information presented in Section 1.3.

1.4.1 Mules and donkeys

Mules and donkeys are not often mentioned in a positive way in the zooarchaeological literature, as they are not often identified. Bökönyi (1974) states that donkeys were used by the Persians against the Scythians in the early 1st millenium BC, and that they were adopted by the Greeks in the last few centuries BC. According to Aristotle (*Hist.an.* VIII 162, quoted in Bökönyi 1974) the 2nd century BC asses in Illyria, Thracia and Eprirus were small. Bökönyi (1974) also mentions that there is zooarchaeological evidence that there were many donkeys in the Greek colonies around the Black Sea. In the Roman period Bökönyi states that asses were found at Cambodunum (Bavaria), Wurttemberg, Paris and Heidelberg as well as at Tac in Hungary.

According to Homer (*Iliad*, XXIV, 278, quoted in Bökönyi 1974), mules were first bred by the Mysians. Bökönyi (1974) suggests that mules were present in south-eastern Europe by the 7th century BC and were included in the Greek Olympic games during the 6th century BC. Mule breeding spread to central Europe via the Greek colonies on the Black Sea. Bökönyi (1974) states that these mules were quite big, i.e. similar in size to horses (although no actual figures are given). He also mentions that no mule bones had been found (or at least been identified) in Roman deposits from central Europe.

Peters (1998) states that mules are supposed to have arrived into the Rhine Danube area with the Roman army, and that this is attested to by the presence of five skeletons at Dangstetten (data from which were unfortunately not available for this study) that are presumed to be connected to the Alpine campaign of AD 15. A single mule, assumed to be a victim of battle of Varus in AD 9, was recovered from Kalkriese and must have been a pack animal with the army. Peters (1998) states that up until 1998 there is very little proof of the presence of mules other than these six, although a few scattered individuals are known. This is in contrast to the literature and art sources, where their stated great importance to the army suggests they were very numerous. Peters (1998) stresses that the problem lies in the fact that mules are only trivially osteologically different from horses. If the data on the numbers of mules from the recently researched equid skeletons from Weißenburg are anything to go by, there is a ratio of five horses to each mule indicating that many mules are 'missing' from other sites. The question of whether mules were bred in the western Rhine Danube province is not clearly answered, but the lack of donkeys may suggest that they were not bred there.

Therefore, whilst the remains of donkeys and mules have been found in small numbers on archaeological sites in many parts of the Empire, including Britain (Armitage and Chapman 1979) and Germany (von den Driesch and Cartajena 2001), there are vast numbers of mules in particular unaccounted for in the archaeological record.

- **Reasearch aim.** Because of the discrepancy between the contemporaneous and zooarchaeological literature it is imperative to find out whether the existing methodologies used by the zooarchaeologists effectively separate horses, donkeys and their hybrids. If not, can a methodology be constructed to identify the equids categorically, so that material that has hitherto been identified as 'horse' can be re-evaluated?

1.4.2 Horses

Appearance, size and shape

For Britain as a whole there have not been any extensive studies of the size and shape of Roman horses. In her study, Luff (1982) includes some information, mostly from south-eastern Britain. However, one problem with this work is that the 'Hands' measurement has been wrongly used (see Section 1.5.5) and no metric equivalents are quoted, therefore it is difficult to give figures for the estimated mean withers heights presented in that study. Relative sizes can be given, for instance in most cases the Roman horses are larger than the preceding Iron Age ones, with the exception of a few individuals.The studies of Johnstone (1996) and Johnstone and Albarella (2002) also indicate clear differences in height between pre- and post-(Roman)conquest horses in Britain.

Luff (1982) suggests that these larger individuals could be geldings, as the delayed epiphyseal fusion and hence elongated growth period could cause them to be taller. However, it is not mentioned whether these bones were also more slender, which might be another indicator of gelding. Luff (1982) also states that larger horses were present on civilian sites than on military ones, and again the suggestion is that this is perhaps as a result of stallions being used by army and geldings by the *Cursus Publicus* (as stated in Varro *r.r.* II, 7, 15). Luff does point out that not much work has been carried out on the effects of gelding on bone growth in horses, so these suggestions cannot be substantiated (see also Chapter 2).

Hyland (1990) suggests that the range of size of Roman horses was from about 1380 mm to 1540 mm, with a few smaller outliers (confirmed for Roman Britain in Johnstone 1996). Horses of this size were sufficiently large to operate efficiently and had smoother gaits than the small ponies. Modern horse breeds that cover this range include the Arabian, Quarter-horse and Morgan (which can be bigger), and larger ponies such as the Dales, Highland, Connemara, New Forest, Camargue and Haflinger. As discussed earlier, a more robust horse was preferred by the Romans, more like the pony breeds rather than the horses mentioned above.

Moving across the English Channel to look at the horses of France, the extensive study of Arbogast *et al.* (2002) gives quite detailed information on the heights of both Iron Age and Roman horses in Gaul. The mid- to late Iron Age horses were very small in comparison with all periods, both preceding and following. They were approximately 50 mm shorter on average, and some individuals were only about 1000 mm at the withers. These animals were also classed as 'gracile' or 'below average' based on metapodial shape indices (Arbogast *et al.* 2002). Caesar (*B.G*) recounts the gifting of horses to a Gallic king prior to conquest of the area, and the granting of permission to import more to use for breeding purposes to upgrade the native stock. These literature sources are borne out by the study of the horse bones from Gaul, which reveal that whilst most were from small individuals there were a few large, probably imported, animals.

The annexation of Gaul into the Roman Empire by Augustus (late 1st century BC), sees a marked increase in the size of the horses (Arbogast *et al.*(2002). Whilst small individuals arestill present, thereare vastly greater numbers of larger ones. However, the horses from one of the 1st century AD sites, Vertault, are probably not representative of the period because they are all male individuals and were sacrificial victims. In contrast the 2nd to 3rd centuries AD are better represented, with many more animals of middle height and fewer of the smallest individuals. There are also fewer 'gracile to average' individuals and many more robust ones, based on the metapodial indices. In late Roman times (4th to 5th centuries AD) there is a further reduction in numbers of the small individuals and a lifting of the lower end of the range and a corresponding increase in numbers but not height at the top end of the range (Arbogast *et al.* 2002).

It is difficult to trace changes in morphology of horses from the Iron Age to Roman periods in Gaul, mostly as a result of the lack of whole skeletons from Iron Age Gaul. In the Roman period it is most likely that a great diversity of forms of horses existed to suit different types of employment, for instance those for racing and hunting would have to be fast and have an aptitude for going in all types of terrain, respectively. The principal concern for the military horses was size, and this was achieved by importing Scythian-type horses via the Greeks, Persians and Spanish. Large horses permitted the army to conquer areas, but they always needed remounts, so large horses were imported to introduce selective breeding to Gallic peoples and supply the army with horses. This could be expected to impose a uniformity of size and shape across Gaul, but the size in particular differs between sites (Arbogast *et al.* 2002).

Moving across to the Netherlands there are two studies of relevance, the first (Lauwerier 1988) concerning the animals of the eastern river area (Rhine Delta) in Roman times, and the second (Lauwerier and Robeerst 2001) specifically concerning horses. From the first study there are a few general points tto be noted, but all the withers heights data from pre-Roman, Roman and native material have been combined to give an èaverage of 1434 mm (range 1240 to 1630 mm). It is stated (Lauwerier 1988) that the bones from military and villa sites gave the tallest values in the withers height calculations. It is also stated (Lauwerier 1988) that there was no increase in size through the Roman period, but there is no mention of the Iron Age/Roman transition period. In addition, the Roman eastern river area horses seem quite tall, in comparison with the native settlement at Rijswijk (1314 mm), and the Roman sites slightly further away at Valkenbrug (1406 mm) and Xanten (1375 mm).

The second study (Lauwerier and Robeerst 2001) uses the withers heights in a much more instructive way to highlight a number of differences between settlement type. The horses from the native settlements beyond the *Limes* boundary to the North are smaller (mean 1320 mm withers height) than those of villa and military settlements within the Roman Empire (1440 and 1420 mm respectively). Also rural settlements inside the *Limes* produced horses with a mean height between the two extremes and also a larger range of sizes. No trace of any exchange of large breeding animals to sites beyond the *Limes* could be found.

The authors (Lauwerier 1988; Lauwerier and Robeerst 2001) suggest that horse producers on the rural sites inside the *Limes* could have offered a wide range of sizes of horses as they had both native and Roman stock available to breed from. The army as consumer took the largest (either requisitioned or bought), as these best suited their purpose; therefore the rural producers used what was left. Villa sites also produced large horses and it is suggested that this fits with their more Romanised and wealthier status. The theory is put forward that the largest animals (over 1600 mm) could have come from renowned horse breeding areas such as Pannonia (Hungary).

Moving further up the Rhine, Peters' (1998) survey of the Rhine and Danube areas (mostly Germany, Austria and Switzerland) includes many analyses of the measurement data of the horses from late Iron Age, Roman and native settlements. In general the size of the horses appears to decrease from the early to late La Tène periods and then increases again in the Roman period, as was the pattern observed in the Gallic material. In the late La Tène period the mean withers height is only 1210 mm, similar to that for Gaul. Peters (1998) explains this lack of stature by suggesting that the same pastures were used constantly (overgrazing), that food was scarce in winter and that there was a general lack of interest in or knowledge of selective breeding amongst the Germanic peoples. This appears to contradict the references to the Germanic tribes' good horsemanship in the Classical sources; however, an ability to ride a horse well is not necessarily associated with an interest in breeding or raising horses.

As in Gaul, isolated occurrences of large horses north of the Alps in pre-Roman times are found, such as at the Manching oppidum site (Boessneck *et al.* 1971). However, these occurrences are once again all from sites known to have had contact with the Romans, so they could be traded goods, war booty or rewards for service. It is not clear if these large imports were crossed with small native ponies at this time or only after the Roman conquest of the area.

From early Imperial times, the larger horses are found in numbers on sites all over the western Rhine-Danube province (Peters 1998), suggesting that these animals were, at least initially, being imported, and then they were used for improving the native stock to supply the army with horses for initial conquest wars and then to secure the *Limes*. The mean withers height for the early Roman horses in the Rhine-Danube area is 1370 mm (Peters 1998). This figure is some 100 mm larger than the mean for horses from sites in Germany byond the *Limes* frontier of the Empire. Within the Empire animals under 1250 mm seem to be rare in the early Roman period and those that do exist are from sites with known contacts outside the Empire, either in border areas or along major trade routes. This is similar to the findings from Gaul (Arbogast *et al.* 2002).

In the mid-Roman period in the Rhineland the withers heights range from 1160 to 1530 mm, with a mean of 1390 mm based on just the metacarpals. If other bones are used, some larger individuals (i.e. over 1600 mm) are detected (Peters 1998). Therefore, most of the Roman 'horses' were in fact mid-large ponies (1200-1473 mm) and small horses (1473-1600 mm). Peters (1998) mentions at this point that the mules so far identified are generally taller that the horses, with a mean withers height of 1530 mm.

Peters (1998) also mentions some problems associated with the limb proportions of the studied horses. In the withers height calculations, the values estimated from the tibiae and radii tended to come out larger than from the other bones, so it was concluded that perhaps this was because the calculation factors were derived from modern horses which might not have same limb proportions as pre- and early historic ones. Peters (1998) does not, however, connect this difference in limb proportions amongst the 'equids' to problems with the identification of mule bones, even though he mentions at a later stage that mules do have different limb proportions.

The Iron Age Germanic tradition of sacrificing horses means that there are plenty of whole skeletons from this period to look at differences in limb proportions and build, but because of the process of Romanisation this practice died out, with the result thatthere are many fewer whole skeletons from the Roman period. However, the skeletons that are present show that there is little difference in proportions between the periods and that overall size does not affect these proportions.

In terms of build, positive allometric changes (i.e. as bone length increases, the breadth increases both absolutely **and** relatively) have been noted (Peters 1998) between the Iron Age and Roman horses, and also between native and Roman horses, but these were not statistically significant differences. Peters (1998) does note that the differences observed in the shape index results could be the result of genetic variability, but could also be a reflection of those individuals that were affected by nutritional deprivation. The suggestion is made that the Roman horses were more slender than those of the Iron Age, but Peters (1998) then goes on to suggest that this may be a product of the problem of mule identification, as the mules are much more slender overall. Therefore the results of build analyses must be questioned where identifications have not even been attempted.

Peters (1998) uses the heights and shape indices from various modern breeds as comparisons for the archaeological material. Modern 'walking' horses have a height range of 1550-1710 mm, and a mean shape index of 18.39 (range 16-21); thoroughbred racehorses have comparable withers heights but a more slender mean index of 15.89 (range 12-19) and the Belgian Coldblood (again of similar height) has a mean index of 21.6. The Roman horse bones mostly have a shape index of greater than 15.99 so are all relatively robustly built. From this evidence it suggested that the Roman horses were mostly more robust than the horses from both the preceding Iron Age and contemporaneous native settlements.

Moving further down the Danube and into eastern Europe, an extensive study of the animal remains found in sites from this region was undertaken by Bökönyi (1974). Information from Bökönyi (1974) is presented chronologically below, so discussion of the Iron Age horses of the area comes first. It is argued that there were two types of horse in the Iron Age, which possibly had different origins. The first group consisted of large and more robust horses, which have been termed the 'eastern group' whose remains are mostly found in the lower Danube region (Hungary, Romania, etc.) and a smaller 'western group' found mainly on sites in the upper Danube area (Austria, Switzerland and southern Germany). The eastern group has a mean withers height of 1355.2 mm, a metacarpal index of 15.24 and a metatarsal index of 11.59.

It is argued (Bökönyi 1974) that the Greek and Persian horses were derived from the eastern stock type as it is known that these peoples imported Scythian animals, the remains of which show that they were large and robust. These horses then influenced the Roman horses by being imported from Greece and Persia, and bred in whatever combination was required to breed horses for specific purposes. Large bodied animals with taller withers heights are found on many military sites and villas in the Roman period, but many rural settlements in the Danube region only have smaller horses. The Roman horses have a mean withers height of 1408.3 mm, a metacarpal shaft index of 15.05 and a metatarsal index of 11.91.

In discussion of the post-Roman migration period horse remains, Bökönyi (1974) talks about the sex of individuals, which is also relevant to the remains from Iron Age and Roman periods. He suggests separating mares and stallions using the presence of well-developed canines, but also adds caution as it is suggested, from modern data, that up to 22% of mares also have canines, although not usually well developed ones. It is also noted that a proportion of those individuals with well developed canines also had very long and slender metapodials which, it is suggested, could be the remains of geldings (Bökönyi 1974). It is suggested that this could be true if the metacarpal length is more than 23% of total length of forelimb with a shaft slenderness index of below 14.5 and if the metatarsal length is greater than 26.7% of the total hindlimb length with an index below 11.5%. This may be a good starting place but can obviously only be used where the total limb lengths are known (i.e. for whole skeletons or articulated limbs). In addition the possibility that the slenderness could be caused by malnutrition during growth or that these individuals could be mules is not discussed.

From the above summaries it can be seen that quite a lot of information is available on the size and shape of Roman horses across Europ,e but that there are a number of problems associated with material that cannot definitely be attributed to species, in particular, there are problems with assessing the size of the mules that could be contributing to the upper end of the withers height ranges and the lower end of the shaft slenderness figures.

- **Research aim.** If the separation of species (outlined in previous research aim) is achieved, then it will be possible to address the question of size and shape for identified bones separately, allowing a more accurate picture of the appearance of these animals to be constructed.

Horse care, training and hunting

One piece of evidence regarding the care of horses that can be deduced from archaeological sites, comprises the size and construction of stables. Indirectly this can give some idea of the size of the horses that occupied the stables. As mentioned above (Section 1.3.1) there were at least three types of stabling arrangement: loose boxes, with a single untied horse occupying each; stalls, with one or more animals tied to a wall between each partition; and the barn situation, with many animals loose in a larger area. The last of these allows the largest number of animals to be kept in the smallest space but is obviously unsuited to a mixed sex herd. The next best solution is the stall arrangement, where a few animals that get along together can be tied up in close proximity. The first arrangement is the way most horses are kept today, when space is not an issue, and is ideal for foaling mares and keeping stallions separate in a stud situation. In marching camps the military would probably have used picket lines: two stakes with a rope attached between them to which the horse could be tied on either side.

Unfortunately there are very few sites where excavated buildings have been positively identified as stables. Some of these are military sites, others civilian, but many excavated buildings cannot be attributed to any particular use. The difficulties of identifying a barn in which livestock were kept from any other type of barn, let alone where horses as opposed to other animals were kept, are obvious. In other cases buildings that once had partition walls, which could be used to identify stables, may not be able to yield such information as the partitions could easily have been constructed of perishable materials that do notpreserve.

Sites with buildings that have been identified as stables include Hod Hill (UK) (quoted in Toynbee 1973), Brough-on-Noe and The Lunt (UK) and Dormagen and Krefeld (Germany) (all quoted in Hyland 1990). These are all very different in plan and seem to have a small number of internal partitions, perhaps indicating that the horses were tied to the walls in a stall arrangement rather than in individual stables. This is unsurprising given the fact that space was usually at a premium but separation of the sexes would still have ben necessary. At Dormagen the areas between the

partitions measure 3.5 m square, which is the size of a modern loose box for one horse, however three horses who got on well together could be tethered to one wall.
At Hod Hill, a 1st century AD fort with a legionary cohort and a half *ala* of cavalry, the stables were excavated thoroughly (Richmond quoted in Toynbee 1973). Two types of stabling were uncovered, the first was partitioned into spaces 3.35 m x 3.65 m, the second into spaces 3.35 m x 5.5 m. The first type would allow three horses to be tethered to either side of the cross wall with a 1.8 m alley behind each group, in the second there would be two rows of three horses tethered to opposite walls with a 1.8 m alley between the rows.

These stables had a natural chalk floor in which the hoof scrapes were visible. The front hooves scraped about 45 cm from the cross wall and the hind ones about 90 cm behind the front ones. There were dung stains behind the hind hoof marks. The distance from the wall to the front hooves indicates that the wall must have been low enough for the horses to get their heads over, as the length of the head and neck on even a small pony is longer then 45 cm. The distance between the front and hind hooves is also quite small and suggests horses not much bigger than 1220 mm based on the measurement of several modern ponies (C. Johnstone unpublished data).

There is some archaeological evidence in Britain that the covered exercise halls for training cavalryman and their mounts, mentioned in Vegetius, were built at Inchtuthil, Chester, Newstead (later 2nd century AD fort), Haltonchesters, Brecon and Netherby. All forts had parade grounds outside, which were used to train and exercise all the troops, including the cavalry. Many of these have been identified archaeologically and some extend over 4 ha. All have been found on areas of flat ground outside the forts themselves, but sometimes quite some distance away. That these parade grounds were for cavalry training as well as for infantry is attested to by the finds of altars and inscriptions to the *Campestres*, deities concerned with horses and men in training situations rather than war (Davies 1969).

Luff (1982) suggests that, judging by the very small quantities of bones of wild species in assemblages from most Roman period sites, hunting was not a major occupation of soldiers, farmers or settlers in general, within or outside the Empire. However, this only proves that the kills did not end up being deposited with domestic rubbish, perhaps indicating that they were not eaten.It does not rule out the possibility that they were caught but not eaten. Villa sites show higher proportions of wild animals, as might be expected from higher status rural sites. However, there is no zooarchaeological evidence regarding whether hunting took place from horseback (as seen in the mosaics mentioned above) or the horses were simply used as a means of transport for the hunters and their kills (as also described above).

Consumption of horsemeat

Based on the assumption that there was a taboo on the eating of horsemeat because it was thought to be unclean, there should be no evidence of butchery on the horse bones from Roman sites. In many instances across the Empire this is indeed the case, and even where there is some evidence of butchery it cannot be linked conclusively to the consumption of horsemeat by people. For instance, Luff (1982) suggests that traces of butchery on horse bones could indicate removal of meat to feed to dogs. The butchery could also be a means of reducing a carcass to more manageable pieces for easier disposal in pits or ditches, particularly where these bones are found separately from the deposition of other domestic refuse.

In Roman Gaul it was noted that large deposits of horse bones were occasionally found on the edge of towns (Arbogast *et al.* 2002). This was probably just a specific place to dump dead horses, as there is evidence they decomposed in the open air and dogs had access to the cadavers. A dump at one site had separated vertebral columns and showed a deficit of small elements, indicating that this was a secondary deposition of horse cadavers from another source. Other areas where contained deposits of artisan waste where the use of parts of the tibiae, radii and metapodials of horses for the manufacture of bone pins was evidenced.

Lauwerier's (1988) study in the Netherlands showed that more horse bones were found in rural settlements than in urban ones, except deposits from urban ditches and cemeteries outside the settlement area. It is suggested that this is indicative of rubbish disposal patterns (as discussed above) and not the occurrence of horses in general. In addition, whilst there are some cut marks, it is indicative of skinning or carcass division prior to disposal rather than butchery for meat.

In Britain, where horses appear not to have been consumed in quantity in the preceding Iron Age, there was obviously not a great change in diet required to conform to Roman practices. However, in other parts of the Empire a very different story emerges.

Arbogast *et al.* (2002) demonstrate that the butchery of horses for meat was very prevalent in Iron Age Gaul, particularly in the Paris Basin area, but that the quantity varies widely across Gaul. On some sites it appears that the occupants raised horses primarily for meat consumption, as many of the remains were killed at around four years old, when the animals have grown to a stage where the most meat is gained for the least input (like the cattle in a beef economy). On other sites the consumption of horsemeat appears to be on a more *ad hoc* basis. The remains of older individuals have been recovered, suggesting that the animals were only consumed after having been used for riding, traction or some other purpose. On one site with a large amount of butchered horse bones, the quantification suggests that whilst horse is fourth on the species list in terms of numbers of fragments, it is second behind cattle in terms of meat yield (Arbogast *et al.* 2002).

Many of the butchered horse bones in Iron Age Gaul (Arbogast *et al.* 2002) were found amongst other domestic refuse and not separately buried, compared with those from the Roman period mentioned above. Many different butchery techniques were present, some indicating secondary use of the carcass, including the heating of heads (evidenced by burn damage to incisors), possibly indicative of brain removal and the longitudinal splitting of heads and metapodials, for brain and marrow extraction. Evidence for the jointing of carcasses was present, including halving the carcass by splitting down the vertebral column.

In the Roman period, the taboo against eating horse seems to have held in most parts of Gaul despite the previous large-scale consumption (Arbogast *et al.* 2002). In urban settings and *vici*, very few horse bones were found amongst the domestic refus,e suggesting a lack of consumption. More horse bones are found in the deposits from rural settlements over most of Roman Gaul, but even there butchery traces are rare in comparison with the Iron Age material. The exception to this is in northern Gaul, where traces of butchery are still quite evident, suggesting that the isolation of this area from major trade routes and military zones meant that Roman practices were less widely adhered to. By the 4th and 5th centuries AD hippophagy (eating of horses) had become prevalent again in northern France, either as a result of Germanic population incursion or of a return to Iron Age practices.

Peters (1998) repeats that horse bones are rare in settlement layers on archaeological sites of the Roman period because they do not usually from part of the butchery or domestic waste. It is pointed out that this has a bonus for zooarchaeologists: because the horses' bones were not generally butchered, they are well preserved, with complete lengths, so many withers heights can be calculated. The contrast between the consumption of horsemeat on Roman sites within the Empire and the native settlements beyond, and the north-west German coast in particular, is striking. Examination of material from sites like Feddersen Wierde (Reichstein 1991) in the latter category, show that horsemeat was an important foodstuff there. The presence of large numbers of horse bones, including those from young animals, many displaying butchery marks, from these native Germanic sites indicates that horse rearing and horsemeat consumption were undertaken on a relatively large scale. So although the Roman view was that horsemeat was unclean, to other groups such as the Celts and Germans, it was a natural part of the diet.

In relation to this, there are sites within the Empire where horse butchery is in evidence. These are generally military sites and it is thought that this can be attributed to the presence of Germanic auxiliary soldiers. These auxiliary units were not subject to the control of the Roman administrative system, so it is possible that these soldiers could have followed their native customs in terms of diet. At Weißenburg and other forts on the *Limes,* horsemeat was certainly consumed and indeed could have formed a substantial part of the diet. However, a connection to troops of Celtic or Germanic origin cannot always be made clearly. In contrast, in urban situations chop and cut marks are seldom found on horse bones and their interpretation where present can be ambiguous regarding to whether the meat was for human or canine consumption, or whether other products were being utilised rather than the meat. In some cases the consumption of horsemeat may also have had something to do with status, because more horse bones with cut marks were found in the poorer districts of Augusta Raurica, for instance, than in the more affluent areas. Therefore it seems that, except under certain circumstances, the Roman taboo against eating horses was mainly adhered to in the Rhine-Danube area.

Horses in ceremonies and religion

The interpretation of deposits as having a 'ritual significance' is one of the stock phrases used by archaeologists for deposits that are peculiar in some way, i.e. they have no apparent explanation in terms of the perceived ordinary economic or domestic life of a site. Sometimes these deposits are clearly associated with structures other than domestic dwellings that have a role in the public life of settlement, such as a temple. Other deposits are associated with ordinary domestic structures but are unexpected in their position and/or content. Some of these deposits are termed 'votive' deposits as they are considered to be offerings to deities to invoke blessings.

Examples of Iron Age and Roman votive deposits that contain horse bones come from wells, bogs and other watery places. The Roman examples of these well deposits seem to exist in areas where sacrifices in watery places were also made in the Iron Age. For instance in Germany, the sacrifice of horses that are then placed in bogs is well attested in the Iron Age (such as at Oberdorla) and the tradition continues into the Roman period, both in bogs and in wells. Many of these votive deposits in watery contexts contain either whole skeletons of horses, or just the heads, or heads and feet together. In Britain, there are similar deposits to those in Germany; for instance, in Roman Chelmsford (Luff 1982) a well near the site of the *mansio* contained several horse skulls at the bottom. Some of these were adults but there were also juvenile individuals. There were no obvious signs of butchery on the bones, and whilst most of the remains were skulls, some post-cranial bones were also present. More skulls and other bones were also found in an adjacent ditch.

Similar traditions of votive offerings in watery places seem to have taken place in the Netherlands. During excavation of the *Fossa Corbulonis* (Corbulo Canal, in Leiden-Roomburg), a deposit containing a bronze mask, unworn coins and a number of horse bones was recovered (Lauwerier and Robeerst 2001). The skull of an adult stallion of about 1360 mm withers height and the left hind leg of a much larger horse (about 1500 mm) were recovered all of which had been excessively heavily butchered. It is usually assumed that masks and helmets found in rivers were offerings from discharged soldiers giving thanks for protection during their military service. The offering of horse parts could have a similar significance if a cavalryman was giving thanks. The fact that the horse bones are heavily damaged might be paralleled in the deliberately smashed pottery and weapons rendered unfit for use found in other votive deposits.

Other instances of horse remains deposited in unusual places have been found in association with the construction of temples, other buildings and roads, and are termed 'foundation deposits'. These are considered to be offerings to the deities for good luck to be bestowed on the building. Examples occur in Britain (Luff 1982) and also in the Netherlands (Lauwerier and Robeerst 2001). The villa site of Druten and the settlements of Wijster and Heeten (beyond the *Limes*) in the Netherlands all had horse burials situated very close to buildings, and the burial pits could be seen to have been dug at the same time as the buildings foundations. Similar burials were found at the Germanic settlements at Raalte-Heeten, Leidenschendam De Leeuwenbergh and Wijster, but these were more closely associated with the entrances of the enclosures and farmyards. These have been interpreted as site offerings, perhaps a Germanic imitation along the lines of *suovetaurilia* to invoke blessing of the settlement itself at its inception.

Although there are not a vast number of horse burials in the Roman period, particularly in comparison with the following Migration and early medieval periods, there is a scattering present in most parts of Empire. Luff (1982) suggests that there is a slight concentration in the mid-Danube basin (west Hungary and east Austria) perhaps as a result of the preceding Iron Age and earlier horse burial traditions. In some cases there can be problems establishing whether a horse burial is a ritual deposit or just the disposal of a dead animal. This is partly because it is difficult to establish a cause of death. Arbogast *et al.* (2002) argue that on sites where hippophagy was practised, such as those of northern Gaul, the burial of a whole animal is more likely to be a ritual deposit, unless the animal died of a disease that made it unfit for consumption. The position of the burial in relation to buildings, and the posture of the skeleton in the burial environment, may help to differentiate the two hypotheses put forward above. However, on sites where horsemeat was not consumed it is particularly difficult to establish the significance of a horse burial (Lauwerier and Robeerst 2001).

The use of horses as sacrificial victims is implied in diverse forms of rituals in Gaul, particularly in the later Iron Age (last four centuries BC) and the Roman period (Arbogast *et al.* 2002). The remains of horses are found in funerary contexts of cemeteries and as sacrifices in sanctuaries and temple areas. It makes sense that horses were used as sacrifices when they were a source of meat, just as other food animals were used to bring fertility to the herds and prosperity to the owners. This then gives an explanation of their use in ritual meals (Lauwerier and Robeerst 2001).

The association of horse burials with those of humans hints strongly at a ritual element. In Britain and Gaul humans and horses were buried in the same pits (often thought to be ex-grain silos) from the 5th century BC (Grant 1984; Arbogast *et al.* 2002). However, the remains are not always directly associated with each other as they often occur on different levels within the pits, and sometimes the heads and limbs have been, manipulated i.e. the remains are not always articulated. By the 3rd century BC in Gaul the association is clearer and the deposition of the remains was simultaneous. The funerary rites obviously varied considerably across Gaul in the Iron Age, as the inclusion of horses was rare. Even in the areas where chariot burials were prevalent, the horses were not always included.

Evidence for the sacrifice of horses is plentiful from ditches defining the limits of Iron Age sanctuary sites (Arbogast *et al.* 2002). On some sites the remains show that the cadavers were deposited whole in the ditches and then left in the open air to decay. In the ditches of some sanctuary sites it is evident that the horse remains were a secondary deposit, as only the heads and legs were found, so the bodies must have been decomposing elsewhere and only parts were re-deposited in the ditches. Alternatively, this could represent the primary butchery waste left from a ritual meal. Archaeology is not able to say whether these slightly different depositions of horse remains were part of similar ritual practices or very different ones.

In the Netherlands there are examples of horses in Roman cemeteries, but it is often impossible to confirm if these were contemporaneous burials or whether the cemetery happened to be located on a site where the burial of horses (for whatever reason) happened to have taken place. Beyond the *Limes*, at the site of Wijster there is no doubt that the cemetery contained the contemporaneous deliberate burial of horses as well as people. The horses were buried in a vertical standing or kneeling position within their graves and the graves were in neat rows. This formalized burial position suggests that these were animals buried with some degree of ritual. A similar cemetery was found at Drantum in NW Germany, so perhaps this was a regional Germanic custom (Lauwerier and Robeerst 2001).

In Roman Gaul, temples were often put on top of the Iron Age ones but most likely with some modifications regarding the rites and practices of the associated religion. The large numbers of whole skeletons found on some of these sites indicate the sacrifice of non-food animals, i.e. there was no ritual meal. However, it could be argued (Arbogast *et al.* 2002) that these are the remains of horses that died of natural causes and were disposed of in a new way, all together in a ritual setting, but this seems unlikely given the numbers of animals deposited at the same time. Other animals are sometimes included in these deposits, particularly canines.

The remains from various sites show different population statistics; at some sites all the remains appear to be from young animals, whilst at others they appear to be all male. The method of deposition also varies, at some sites all the bodies were buried the same way round in pits together, at others they were buried individually; on some sites the scatter of bones suggest that open air decomposition took place, and on others it is suggested that partly decomposed heads and legs were subsequently buried in other places. This practice of horse sacrifice *en masse* seems to be confined to northern Gaul during the Roman period.

The absence of horse bones at Roman temple sites in the Netherlands has led Lauwerier and Robeerst (2001) to conclude that 'the horse did not play any part in sacrifices or ritual meals in any of these temples or complexes'. Perhaps the most extraordinary evidence for ritual use of horses comes from a collection of bones found in a pit at Houten-Tiellandt in the Netherlands. Eighty-seven bones from a single five year old mare were found together but not in articulation and most of these bones showed chopping and cutting marks of various sorts. Initially it was considered that the flesh had been stripped off to feed to dogs, but this would not leave the kinds of butchery traces in evidence. Also there was no trace of dog gnawing on any of the bones. 'This extremely concentrated ... consumption of such a large quantity of meat from an animal not normally eaten makes one suspect that these were the remains of a ritual meal' (Lauwerier and Robeerst 2001: 286). In addition, the large quantities of unbutchered horse bones from the rest of the site indicate that horses must have been an important component of the economy and may indicate horse breeding. Perhaps this ritual meal of horse was in honour of a horse-related deity.

As mentioned above (Section 1.3.1), cavalrymen worshipped a set of goddesses known as the *Campestres* whilst in a training situation (Davies 1969). Many altars dedicated to the *Campestres* have been found, located at cavalry exercise grounds rather than within forts. Examples have been found in Britain at Newstead, Castlehill, Cramond, Auchendavy and Benwell (Davies 1969).

1.5 Terminology

There is a group of terms in common usage in the zooarchaeological literature that are both ambiguous and quite often inappropriately used. In addition there is a further set of terms that it is appropriate to clarify at the outset of this research.

1.5.1 Breeds and demes

The most ambiguous word often used in association with domestic animals is 'breed', and it is often inappropriately applied to archaeological material. A breed of animal in the modern sense of the word is a group of animals that have shared, clearly defined characteristics in respect of size, conformation, action and in some cases also colour, resulting from human control of reproduction (Edwards 1993). Put another way 'a breed is a group of animals that has been selected by humans to possess a uniform appearance that is inheritable and distinguishes it from other groups of animals within the same species' (Clutton-Brock 1999: 40). In the case of horses and dogs, in particular, this is backed up by the existence of studbooks detailing all the ancestors of any individual registered as belonging to a particular breed. This means that the gene pool of any modern breed is very restricted as most studbooks have been in existence for no more than a couple of hundred years. Therefore any hybrids between breeds, or those animals without a pedigree, are not considered to belong to any breed. In view of these narrow definitions, it is entirely inappropriate to use the term breed to describe ancient groups of horses, the breeding of which is not known to have been controlled by humans in this way.

There are a number of alternative words that could be used to describe a group of animals within a species that have a similar appearance. These include 'type', 'race', 'variety', 'phenotype' and 'deme'. Amongst the equine community a 'type' of horse is one that has certain characteristics, like a breed, but does not have to have a pedigree. An example of this is the cob-type horse, a small (up to 15.1 hh), thickset horse with powerful shoulders and quarters and short strong limbs. It is useful for its weight-carrying ability rather than speed and is often used in harness as well as a riding animal (Edwards 1993). However, in biological circles 'type' is often used as an abbreviation for holotype, meaning the set of characteristics described from a single specimen used as the basis for classification of a genus or species (Lawrence 2000). Neither of these definitions is entirely what we are after and such variation in meaning is particularly confusing.

A 'race' is a 'group of individuals within a species, which forms a permanent and genetically distinguishable variety' (Lawrence 2000). A 'variety' is 'a taxonomic group below the species level'. Both of these can be, therefore, other words for a subspecies, which is not what a group of ancient horses constitutes. So both of these are also unsuitable for the purposes required here.

A 'phenotype' is defined in Henderson's dictionary of biological terms (Lawrence 2000) as '1) the visible or otherwise measurable physical and biochemical characteristics of an organism, resulting from the interaction of genotype and environment and 2) a group of individuals exhibiting the same phenotypic characters'. All modern breeds and types of horse are therefore phenotypes, as are all groups of ancient horses with shared appearances. However, this term has genetic connotations and the first part of the definition given above is the one most often used. Therefore, this is perhaps not the best term to use even if technically correct.

A 'deme' is 'an assemblage of individuals of a given taxon, usually qualified by a prefix e.g. ecodeme (a deme occupying a particular ecological habitat), gamodeme (a local population unit of a species within which breeding is completely random) or topodeme (a deme occupying a particular geographical area)' (Lawrence 2000). Whilst groups of ancient horses could in some ways be classed as both gamodemes and topodemes, the full definitions of these cannot be strictly applied. Therefore just the generic term can be used. The term 'deme' appears to be the most useful in terms of describing groups of ancient horses, as it has none of the connotations of a modern breed with its studbooks, or the confusion of meanings of the word type and is also not biased towards genetics or taxonomy. Therefore, throughout this work the word deme will be used to denote a group of equids with similarities in appearance.

1.5.2 Appearance and conformation

It has been mentioned above that horses and ponies have different conformation, with ponies having shorter legs in relation to the depth of the body. This is illustrated below in Figure 1.13. It can be seen that by rescaling the outline drawings of a typical pony breed (Exmoor), a typical light horse (Arab) and a typical heavy horse (Shire) to the same withers height that there are differences in proportion between the pony and the types of horse. In addition, a Lippizaner horse has been included as these are similar in proportion to the equestrian statues dating to the Roman period.

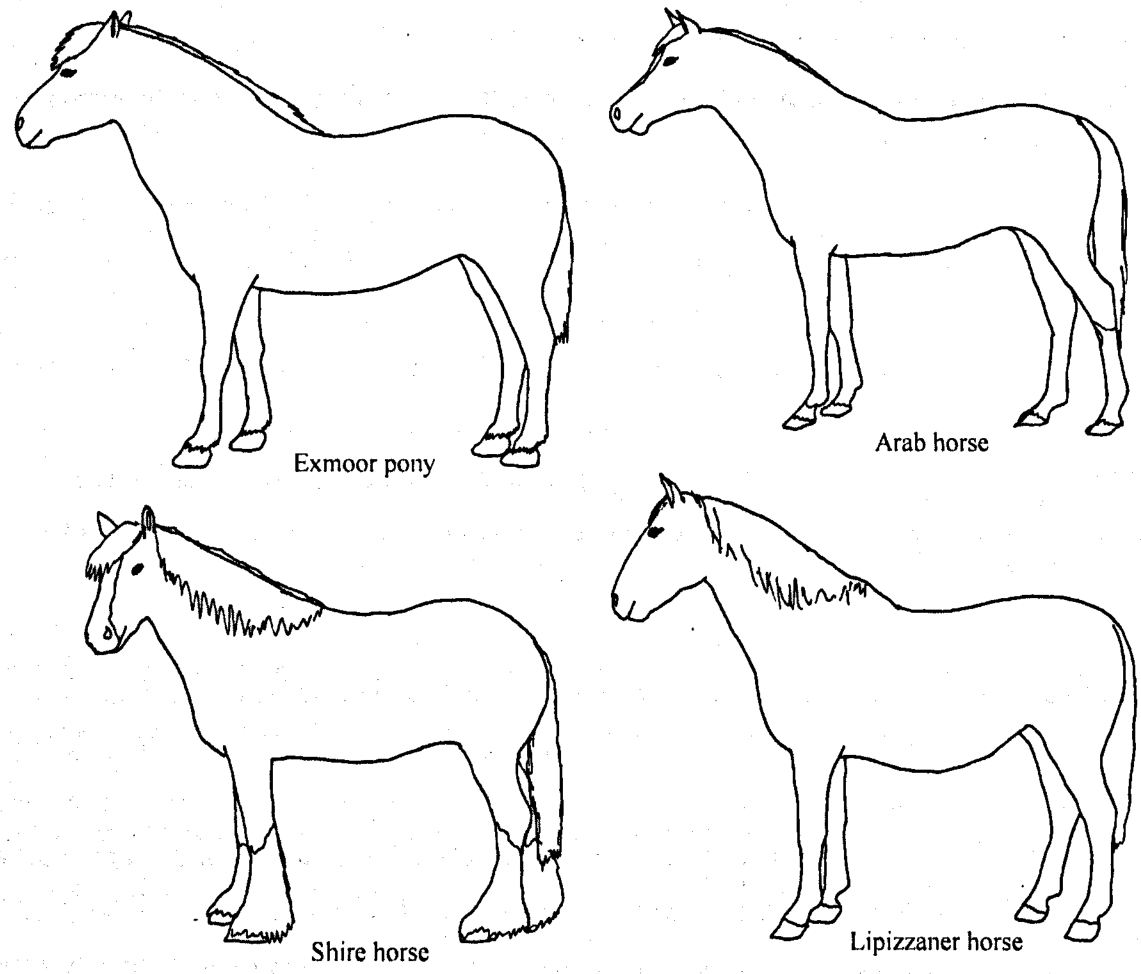


Figure 1.13 Line drawings of horse and pony breeds scaled to illustrate the differences between pony and horse conformation and between horse types (drawn by C. Johnstone).

1.5.3 Taxonomic nomenclature

The taxonomic nomenclature of domestic animals has been the subject of much debate (Clutton-Brock 1992, 1999; Uerpmann 1993), and a variety of forms is commonly used in zooarchaeological literature. In some cases a mixture of systems are used which further complicates the issue. There is also the problem that the wild and domestic forms of a species are not separate species in the genetic sense, as they produce fully fertile offspring when mated together. However, it is not practical to call the wild and domestic forms by the same name, as differentiation between the two is often crucial to zooarchaeological understanding. An example of the confusing situation is that both *Equus* f. domestic and *Equus caballus* have been used to denote domestic horses, whilst wild horses are usually termed *Equus przewalskii*. However, *Equus asinus* is often used to denote domestic as well as wild donkeys, although wild donkeys are sometimes given the additional suffix *somaliensis* or *africanus*.

There is not even no consistency within museums as to which system to use. This is particularly true with older specimens with labels that have not been updated since they were placed in the collection, often over a century ago. This can make secure identifications a little difficult when it is unclear whether two specimens are actually the same species or not.

Bohlken (1961 quoted in Clutton-Brock 1999) proposed one system that was accepted, mostly in Germany. His solution 'was to call the domestic form by the first available name for the wild species, followed by the linking word 'forma' (f.) and then by the earliest name, according to the rule of priority, for the domestic animal'. Using this system a domestic horse would be called *Equus ferus* f. *caballus*. Zeuner (1963 quoted in Gautier 1993) suggests a similar system to that of Bohlken, but adds 'f.d.' (forma domestica) between the species and subspecies names. Dennler de la Tour (1968 quoted in Gautier 1993) proposes that instead of 'forma' or '*forma domestica*' the word '*familiaris*' should be used to denote the domestic form. Under this system the horse would become *Equus ferus 'familiaris'*. This system allows for the naming of feral animals by using '*exfamiliaris*' which would mean that the mustangs of North America could be named *Equus ferus 'exfamiliaris' mustang*.

As can be seen all these are rather clumsy and long-winded systems, which have never really been accepted into mainstream zooarchaeological literature. They also suppose that all domestic animals are descended from a single known wild species, which is also a very debatable issue, particularly in reference to horses. To get around this problem Uerpmann (1993) proposed an entirely new system of nomenclature for domestic animals, which is based on a single word name written in italic capitals. This single word is mostly the Linnaean species name, hence a horse would just be *CABALLUS*. He goes on to suggest that breeds and types could be added to this name in the following form, *CABALLUS* 'Exmoor' for the Exmoor pony and *CABALLUS* t. cob (t = typus) for a cob-type horse. This system has some advantages as it is separate from the taxonomic system and its difficulties in relation to domestic animals, but is perhaps too radical to become commonly used, i.e. it has not come into general use and will not be used here.

Clutton-Brock (1992, 1999) suggests that the oldest name should be used for the domestic form and the next oldest name for the wild species. This is also the recommendation of the International Council for Zoological Nomenclature (Gentry *et al.* 1996). Following this system *Equus caballus* is used for the domestic horse and *Equus asinus* for the domestic donkey. The wild forms become *Equus ferus przewalskii* (wild horse) and *Equus africanus somaliensis* or *Equus africanus africanus* for wild donkeys (depending on the subspecies). As these seem to be the most commonly used (and by implication the most widely understood) Latin names for equids, as well as the officially recognised ones, they will be used throughout this work.

The naming of hybrids is perhaps even more debatable and often incorrect. The hybrids that concern us here are the mule and the hinny, both of which are crosses between horses and donkeys. The mule is the cross between a male donkey (jackass) and a female horse (mare) and its Latin name is *Equus asinus* x *Equus caballus:* the first part always being the sire. The hinny is a cross between a male horse (stallion) and a female donkey (jenny) and its Latin name is *Equus caballus* x *Equus asinus*.

1.5.4 Use of the term species

In relation to the taxonomic nomenclature of the equid species and their hybrids, it is awkward to have to refer to both species and hybrids when discussing the horses, donkeys and mules together. Therefore, throughout this thesis the term species will be used to denote both the true species (horses and donkeys) and the hybrid mules. Although it is acknowledged that this is not strictly zoologically accurate, the simplification will allow for less verbiage in the remainder of the text.

1.5.5 The measurement unit hands

Measurement of the height of horses, particularly in Britain, has traditionally been carried out in the unit of hands (hh), which according to Edwards (1993) has medieval origins. The measurement is taken from the ground to the withers, the slight upward protuberance of the vertebral spines at the base of the neck just in front of the saddle. One hand is equivalent to 4 inches, so therefore a horse that is said to be 15.1 hh is 15 multiples of four inches plus one inch: 61 inches or 1549.4 mm. The abbreviation 'hh' stands for hands high.

It needs to be stressed here that a measurement quoted as 14.2 hh means 14 hands and 2 inches high, and **not** 14.2 with a decimal point. Occasionally, workers have misunderstood the hands measurement, i.e. withers heights are quoted as 12.8 hands in Luff (1982) when this should be 12.3 hh as there are only 4 inches to each hand (see Section 1.5 and Chapter 3), so if a publication quotes a value of 14.5 hh, for example, it is wrong and perhaps the metric equivalent should looked at instead if this is given. The metric conversion of inches to millimetres gives a value of 25.4 mm to 1 inch, so one hand (4 inches) is 101.6 mm. These are the figures that will be used to calculate the withers height in Hands from the calculations based in mm.

Hands are the measurement cited widely in zooarchaeological literature for horse withers height (in addition to the metric values), because they are widely understood and used by those who deal with live horses and can therefore be compared with extant breeds, whose sizes are mostly quoted in hands. In this thesis, metric values for withers heights will mostly be quoted, as calculations will be carried out using bone measurements in millimetres. However, where appropriate hand measurements will also be given for clarity and comparative purposes.

1.5.6 Use of the terms Iron Age, Roman and External

In a similar way to the use of species outlined above to cover both true species and hybrids for simplification, the terms Iron Age, Roman and External will be used as outlined here. There is much debate about the use of these and other similar terms in the literature (e.g. Wells 2001) but it is felt that as long as the meaning of the terms, as they will be applied in a piece of work, are made clear at the beginning then, although perhaps not strictly correctly used, they will at least be understood.

In this research the term Iron Age will be used to describe any material dating to the last few centuries preceding the conquest of an area by the Romans. This will include any contemporaneous material from areas that were never conquered.

The term Roman will be used to describe any material dating to the period between the conquest of an area by the Romans and the official withdrawal of military and administrative support by Rome.

The term External will be used to describe any material dated to the same period of time as that of the Roman material but that comes from areas that were not conquered by the Romans, i.e. were external to the Roman Empire. It is acknowledged that this was still technically the Iron Age in these areas, but to avoid unnecessary confusion between two uses of the term Iron Age it is felt that the term External is more appropriate for this material.

1.6 How the subject is to be addressed

There are two main sections to the research project: the first deals with the issue of species and hybrid identification amongst the equid remains, and the second with the issue of appearance in terms of size and shape of these equids. To address the first issue a number of approaches were tried. Initially an assessment of the previously published methods of separation was carried out. To enable objective evaluation of the methods currently available, it was necessary to collect data from modern reference specimens of known species or hybrid in museum and other collections (see Chapter 5). The methods tested included the use of morphological characteristics (e.g. Armitage and Chapman 1979; Davis 1980) and biometrical techniques. The latter included the use of log-ratios (Eisenmann 1986; Eisenmann and Beckouche 1986) and multivariate analysis (Dive and Eisenmann 199; S. J. M. Davis, unpublished data) (see Chapter 4).

The next stage wall be to apply whichever methods of species separation was most appropriate to the archaeological data. The data for this primarily were collected from published information on equid bones recovered from archaeological sites across the Empire (see Chapter 5). The chosen methods were used to verify or contradict the few existing identifications of donkeys and mules in the zooarchaeological literature (Kunst 2000; von den Driesch and Cartajena 2001). Then the methods were applied to the main body of data recorded as 'horse' to check that mules and donkeys had not been included in this group. This forms the first part of the results in Chapter Six (Section 6.1).

The second area of research was carried out using the archaeological biometrical data mentioned above to investigate the size and shape of the Roman equids. Analyses included the use of withers height estimation, shape index calculation and log-ratio analysis (all methods outlined in Chapter 3). Although it was suspected that the smaller numbers of identified mule and donkey bones would prevent much statistically valid further work from being undertaken, the same analyses were applied to all three groups in order to form the basis for inter-species comparisons. In addition, intra-species comparisons were made between the equids of different periods, geographic areas and site types.

The results (Chapter 6) are split by analytical method (Sections 6.2 - 6.4) and then an overall summary (Section 6.5) brings them together. The results are then discussed (Chapter 7) in relation to the research aims and questions put forward above.

Chapter Two – Bone and skeletal biology

2.1 Introduction

The role of this chapter is to provide an understanding of the basic biology of the material to be used in this study, namely bone. The reasoning behind providing this is that there are a number of issues relating to the growth of bones and the skeleton that could affect the results of the study, or at least should be borne in mind when interpreting the results. The following sections look at bone as a biological substance, how individual bones and the whole skeleton grow under ideal conditions, and lastly factors that can affect that growth pattern. This section will include such issues as age, sex (including castration), nutrition, hormones and disease. These are necessarily dealt with relatively briefly, as whilst there is a vast veterinary literature dealing with these issues in minute biological detail, most of that detail is inappropriate to this study. Most of the information on the factors that affect growth in equids is concentrated on the horse, partly because the horse is a commercial animal and partly because there are far fewer donkeys and mules in existence (particularly in English-speaking countries).

2.2 What is bone?

Bone is the hard tissue that forms the internal skeletons of all members of the phylum Chordata and first appeared in the fossil record around 500 million years ago. Its structural roles include supporting the body against gravity, acting as a rigid lever system for muscular action, and providing protection for vital internal organs. In addition, bone is a metabolic tissue, serving as a repository for calcium and inducing marrow formation (Bouvier 1989). Cortical bone provides the mechanical and protective functions, whilst cancellous bone provides the metabolic function (Marks and Hermey 1996).

Bone is a living tissue that contains two main components, one organic and one inorganic. The main inorganic component of vertebrate bone is calcium phosphate in the form of hydroxyapatite (85%), $Ca_{10}(PO_4)_6(OH)_2$, together with calcium carbonate, $CaCO_3$ (10%). The organic component is composed of 95% collagen and 5% proteoglycans such as chondroitin-4-sulphate (Marks and Hermey 1996; Saladin 1998). Collagen is a fibrous protein consisting of aggregations of tropocollagen macro-molecules. Each of these comprises three polypeptide chains with a left-handed helical structure. These are twisted together to form a right-handed spiral. The complete amino acid sequence of this protein is extremely complex and somewhat variable. The three strands are hydrogen-bonded to each other internally and also to neighbouring fibrils

(Halstead 1974). Within the structure of bone, the inorganic compounds confer rigidity and hardness to the structure, whilst the organic material confers toughness, resilience and elasticity (Reitz and Wing 2000: 39). The structure is analogous to reinforced concrete. Like concrete, the minerals resist compression, whilst, like the steel reinforcement bars, the collagen resists tension (Saladin 1998).

There are four types of cell associated with bones, outlined below. (from Bouvier 1989, Halstead 1974, Marks & Hermey 1996, Saladin 1998)

1) Osteoblasts differentiate from osteogenic cells, which come from embryonic mesenchyme. They are typically cuboids, with a single nucleus at the opposite end to the extensive endoplasmic reticulum and a large Golgi apparatus. These structures are involved in protein production and secretion and they regulate mineralisation. Hence osteoblasts are the cells primarily responsible for bone production by collagen production and calcification.

2) Osteocytes are osteoblasts that have become trapped in the bone matrix as the bone grew. Their internal structure has changed and lost most of the cellular organelles and the cells become flattened with 'tentacles' going from them to neighbouring osteocytes through canaliculae in the bone structure. These tentacles provide a network through which substances can pass to repair and maintain the bone structure, which is the primary function of osteocytes.

3) Osteoclasts arise from the fusion of many monocytes (a type of white blood cell) and are, consequently, large cells with multiple nuclei. They also have a large Golgi apparatus and a characteristic ruffled membranous border. The primary function of osteoclasts is the resorption of bone. The ruffled border attaches to an area of bone to be resorbed, the Golgi apparatus produces lysosomes for breaking down bone structure, and particles of detached bone are taken inside the cell in vacuoles to be broken down further.

4) Bone-lining cells are flat, elongated, inactive cells with very few organelles. They cover bone surfaces that are not undergoing formation or resorption and may be precursors for osteoblasts.

There are two types of bones within the skeleton of a mammal classified according to the way in which they grow (Reitz and Wing 2000). Endochondral (cartilage replacement) bones are those that form indirectly by replacing a cartilage precursor and include most of the limb bones of mammals. Intramembranous (dermal) bones are those that form directly in the connective tissue of the epidermis and include most cranial elements of mammals. Both require a solid base and a well-developed vascular supply (Marks and Hermey 1996).

In addition there are many types of bone structure that can be present within a single bone. Those that are found in mammalian bone can be classified as immature (woven) bone, primary vascular (lamellar) bone, secondary lamellar (Haversian) bone, and plexiform (laminar) bone (Currey 1998). It should be noted that this is only one of several such classifications, one that suffices for this research.

Immature or woven bone has randomly orientated fine (about 0.1 μm diameter) collagen fibres. As well as being characteristic of young bone it is also found during the initial repair phases after injury to bone. Primary lamellar bone has precisely arranged collagen fibres and is commonly found in the long bones of adult mammals. The collagen and its associated mineral are arranged in sheets (lamellae) that encircle the longitudinal axis of the bone. The collagen fibres are much thicker than in woven bone (2-3 μm diameter) and are arranged in bundles, orientated the same way within small domains, but not throughout the lamella (Currey 1998).

Plexiform or laminar bone is found particularly in large mammals, whose bones have to grow rapidly in diameter (i.e. faster than lamellar bone can be laid down). Essentially, a scaffolding of woven bone is laid down, to be filled in later with lamellar bone. This creates alternating layers of parallel fibred, heavily mineralised woven bone and lamellar bone wrapped around the bone (Figure 2.1a). Sometimes these layers form around a blood vessel and look superficially like a Haversian system. However, these are termed primary osteones because they form as the bone grows, rather than replacing existing bone as Haversian systems do.

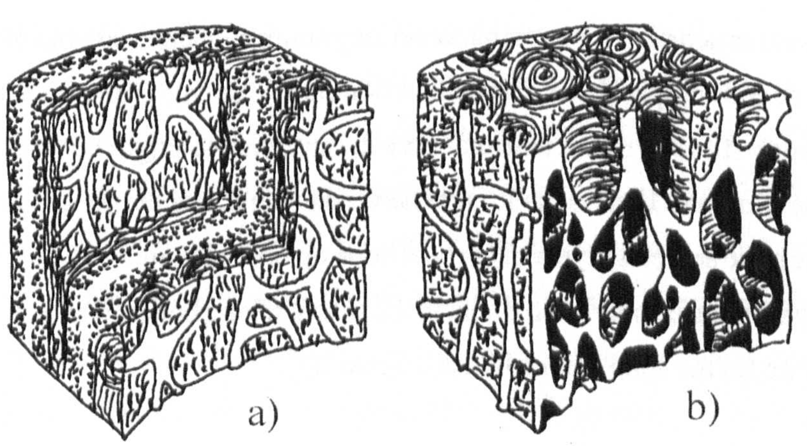


Figure 2.1. The structure of plexiform or laminar (a) and Secondary lamellar or Haversian bone (b) (C. Johnstone after Halstead 1974)

Secondary lamellar or Haversian bone is more complex than primary lamellar bone and contains Haversian systems (secondary osteons) (Figure 2.1b). Haversian systems, or osteons, are formed by osteoclasts (bone destroying cells) 'cutting' a cylindrical canal through the existing lamellae down the axis of the bone. These are then filled in by osteoblasts (bone manufacturing cells) with concentric lamellae around a central canal that can contain blood vessels and/or nerves (Currey 1998) (Figure 2.2). Haversian canal formation is a very variable process. In humans most long bones develop numerous Haversian canals, whereas in bovid long bones the laminar bone remains intact in most places with few Haversian systems, and in small mammals the bone most often stays as circumferential lamellar bone (Currey 1998). Haversian bone is less efficient than laminar bone because the vascular supply is not so good. It is also mechanically weaker for the same reasons. However, laminar bone is not so adaptable and it seems that Haversian bone is the usual form encountered after the initial period of growth (Halstead 1974).

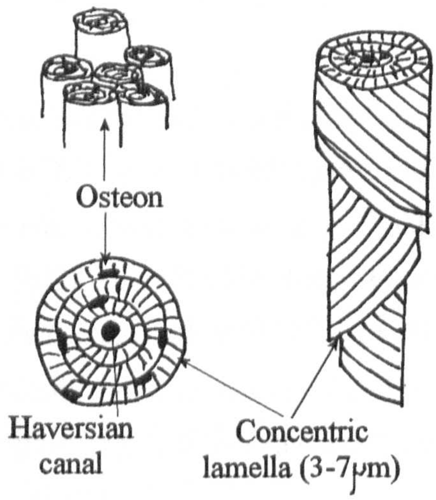


Figure 2.2. Microscopic structure of an osteon (C. Johnstone after Halstead 1974)

The mature bone structure of many mammalian long bones contains a combination of cancellous trabecular bone and compact bone. Cancellous bone has an open, porous or spongy appearance, made up of bony struts or trabeculae that give the structure strength but make it lighter than compact bone. Compact bone is made up of Haversian bone, and the periosteal membrane that surrounds the bone secretes layers of cortical bone on both the inner and outer surfaces of the cortex. Compact bone is most often found in the shafts of long bones, whereas cancellous bone is usually located at the ends of long bones (Figure 2.3).

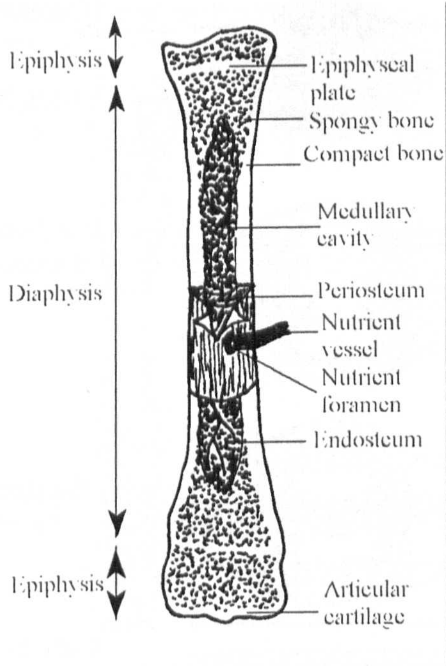


Figure 2.3. The structure of a typical long bone (C. Johnstone after Saladin 1998).

All bones can adapt and change according to circumstances. In an adult human, each year about 18% of the calcium in the bones is exchanged with that in the bloodstream, and at any one time about 5% of the skeleton is undergoing remodelling (Saladin 1998: 239). Many of the bony processes on the human skeleton are formed when a child begins to walk but can also adapt to changes in loading requirements through life. For instance, continued and extensive use of one muscle group will cause the bones to which these muscles are attached to become more robust to withstand the stress placed upon them. Examples of this include unequal humerus size in tennis players and heavily developed greater trochanter of the femur in weightlifters.

Bones can also repair themselves when injured. When a fracture happens the blood vessels are also broken and these bleed at the fracture site, forming a clot called a haematoma (Figure 2.4a). Blood vessels then grow into this soft (granulation) tissue, bringing macrophages to clean up the tissue debris, as well as osteoclasts, osteoblasts and fibroblasts. The fibroblasts then deposit collagen and chondroblasts produce patches of cartilage (Figure 2.4b). This resulting soft callus is subsequently mineralised by the osteoblasts and becomes a hard callus forming a collar around the periosteal and endosteal surfaces of the fracture, acting as splint. The callus persists for 3-4 months as the osteoclasts dissolve the necrotic bone and osteoblasts bridge the gap with spongy bone (Figure 2.4c). This is then remodelled into compact bone and eventually the callus is resorbed (Figure2.4d) (Halstead 1974). Even a severe fracture can be impossible to detect after a period of several months if the bones are realigned correctly at the time the fracture occurs.

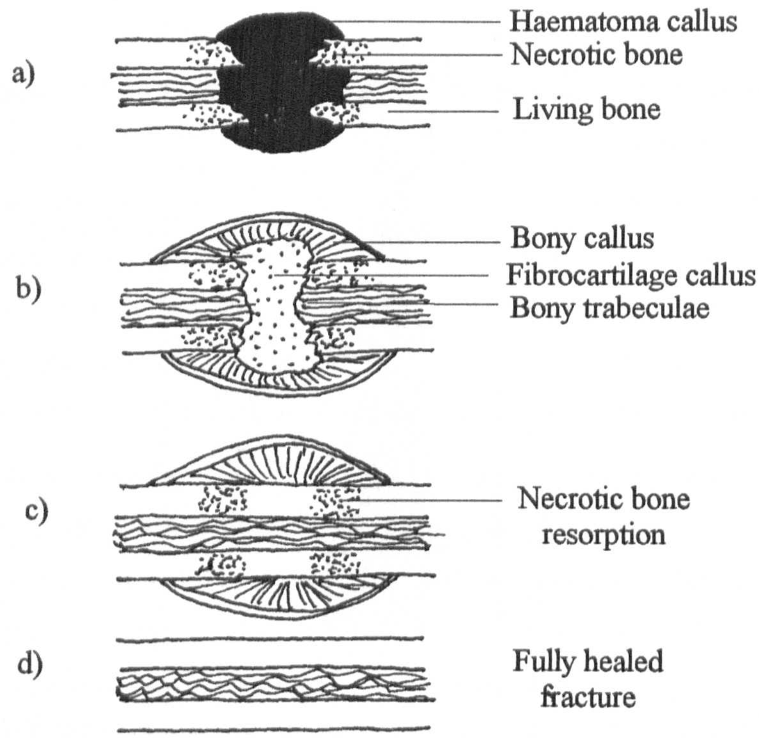


Figure 2.4. Stages in the healing of a bone fracture (C. Johnstone after Halstead 1974).

However, if the bones did not correctly align this would be detectable in archaeological bones as a deviation from the appearance of a normal bone. This deviation can take a variety of forms depending on where the fracture took place. In the context of this study, most types of non-aligned fracture are readily recognisable and measurements would not be taken on such a bone, however where a comminuted fracture takes place it is possible that the length of the bone ends up shorter, without appearing out of alignment. In this instance the resulting bone would not be recognised as a fracture case and could be measured, giving outlying values within a distribution. This type of fracture and consequent healing is, however, quite rare, particularly in equid bones, and therefore not all that likely to be found archaeologically.

Skeletal adaptations to a particular mode of locomotion should be mentioned here. In the case of horses the particular mode of locomotion of concern is running. This is the result of natural selection pressure on a prey species: the need to escape predators. Skeletal adaptations to running can be seen clearly in the limbs of horses (Figure 2.5). They have long straight elements, with the radius and ulna fused together (the latter also being reduced). The fibula is so reduced as to be almost absent. The metapodia (and phalanges) are reduced to a single functional element and are very elongated; and finally contact with the ground is only made with the tip of the third (or terminal) phalanx. Locomotion on the toes only is known as unguligrade. These adaptations give a greater rigidity to the joints of the long limbs and enable the animal to take longer strides and hence run faster (Figure 2.6).

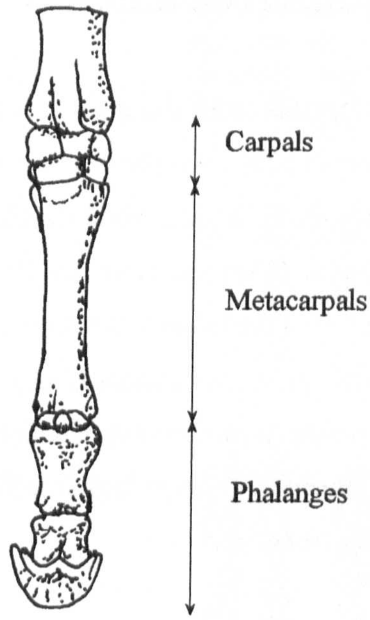


Figure 2.5. The lower forelimb of a horse showing the elongation of the metacarpals and the reduction to a single phalanx, giving a greater length of stride and hence speed.

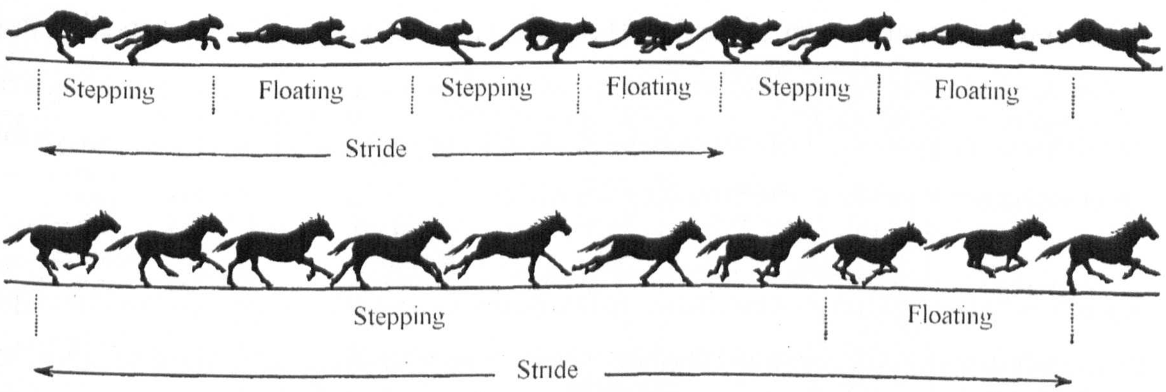


Figure 2.6. Illustration of the length of stride of a horse compared with that of a cheetah. On this evidence a horse should be the faster, but a more flexible spine generates the cheetah's extra speed (after Halstead 1974).

The swivelling action of the scapula also increases speed (Halstead 1974). Ungulates have suspensory ligaments that run from the posterior of the metapodials to the anterior of the terminal phalanx. When the toe is on the ground these are stretched, so that when the toe is lifted the ligament contracts, to give added impetus to the upward movement of the limb (Halstead 1974).

As the length of the leg is important in escaping prey, this is the reason that foals are born with very well developed limbs. At birth their legs are 73% of the length when adult, allowing them to run almost as fast as the adults from the moment they can stand. Moreover, because of the length of gestation (11 months) the foal is also quite mature at birth, allowing it to stand almost immediately and run within an hour of birth. These are very important adaptations for a prey species.

2.3 Bone growth under ideal conditions

The growth of the two types of bone, endochondral and intramembranous, is completely different. Intramembranous bones grow from a centre of ossification but do not have a cartilage precursor. 'Intramembranous ossification occurs during embryonic development by direct transformation of mesenchymal cells into osteoblasts' (Marks and Hermey 1996: 9). The mesenchyme forms a highly vascular sheet in the location of the future bone. Its cells enlarge and differentiate into osteoblasts, whilst some of the mesenchyme condenses into soft trabeculae. The osteoblasts then transform this into soft bone tissue, the trabeculae of which are subsequently thickened and mineralised. At the surfaces the trabeculae undergo further calcification to close up the gaps and convert to compact bone (Saladin 1998).

The bone grows outwards around the edges and growth ceases when it comes into contact with neighbouring bones. The joins between dermal bones are known as sutures and these continue to remodel and fuse after growth has ceased. This type of bone growth is found in the mammalian cranial vault, some facial bones and parts of the mandible and clavicle. For this reason it is not so important to study its growth in relation to an investigation regarding size and shape in archaeological equine material because the skull is rarely found intact enough for good analysis to take place, and there are no clavicles.

Endochondral growth, on the other hand, is of vital importance to this research as this is the type that occurs in bones with joints and that bear weight. 'Endochondral ossification is a method by which the unique properties of cartilage and bone are exploited to provide a mechanism for formation and growth of the skeleton' (Marks and Hermey 1996: 10). In foetal and neonatal individuals the bones are formed when 'condensed embryonic mesenchyme transforms into cartilage which reflects in both position and form the eventual bone to be found at the site' (Marks and Hermey 1996: 10). Ossification takes place as the individual grows.

Each bone has at least one centre of ossification within each cartilaginous precursor. For long bones the primary centre of ossification is located in the centre of the shaft or diaphysis (Figure 2.8a). Ossification of the diaphysis takes place here and occurs by the proliferation of chondrocyte columns, their hypertrophy and mineralisation (Figure 2.7). The persistence of the mineralised cartilage after the destruction of the cells acts as a scaffold for bone formation. Lengthwise growth progresses from the centre towards the ends of the bones, with resorption of the internal trabeculae to form the marrow cavity (Marks and Hermey 1996). Bone growth in diameter is achieved by the formation of bone on the outside of the diaphysis (periosteum) and resorption on the internal (endosteal) surface.

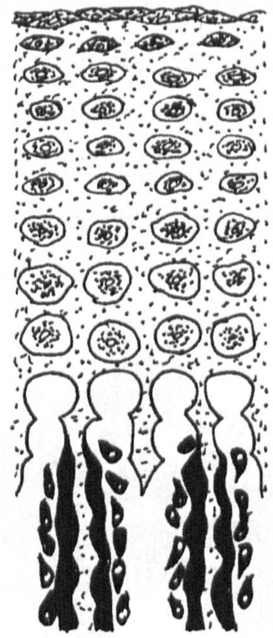


Figure 2.7. A schematic diagram of the process of cartilage mineralisation during bone formation (C. Johnstone after Halstead 1974).

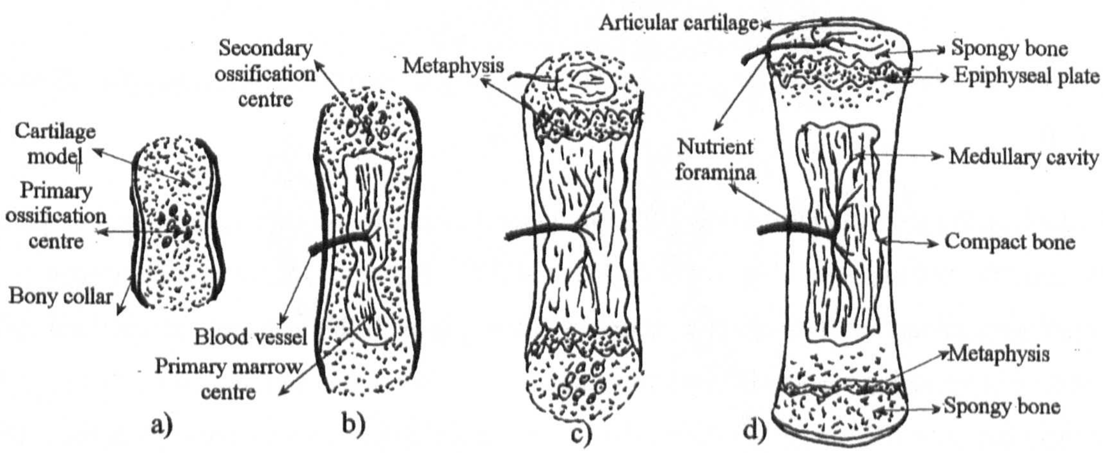


Figure 2.8. The sequence of ossification and bone growth in a mammalian long bone (C. Johnstone after Saladin 1998).

Secondary centres of ossification form at the ends and are called the epiphyses (Figure 2.8b). Growth takes place between the diaphysis and epiphyses in the cartilage disk that separates them, called the epiphyseal plate or metaphysis (Figure 2.8c) (McIlwraith 1996). Where the diaphysis meets the epiphysis it is flared outwards and is substantially wider than the centre of the shaft. This is called the periosteal collar and surrounds part of the growth plate cartilage. As the shaft lengthens a new periosteal collar is formed and the old one is remodelled to narrow it to the width of the shaft. This is achieved by resorption at the periosteal surface and formation on the endosteal surface (Marks and Hermey 1996) (Figure 2.9).

When the bone has reached adult size the cartilage of the epiphyseal plate stops growing and is replaced by bone, thus fusing the epiphyses and diaphysis (Figure 2.8d) (Halstead 1974; McIlwraith 1996). In some elements there are several epiphyses at one end of the bone, which fuse together prior to fusing to the shaft. In other elements (carpals and tarsals) growth occurs from a single centre of ossification with no epiphyses. The epiphyseal line is eventually completely remodelled away.

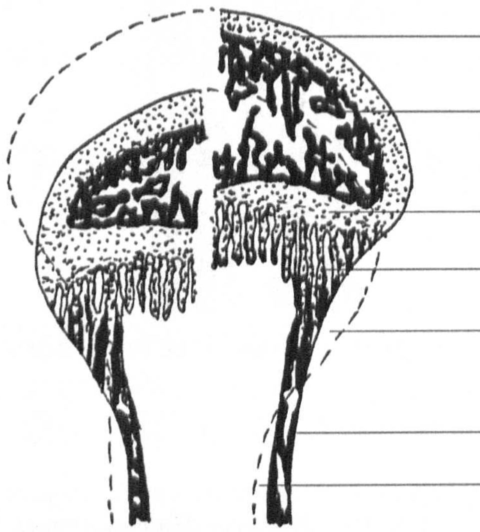


Figure 2.9. The process of lengthening bones during growth (C. Johnstone after Halstead 1974).

Regarding the growth of the whole skeleton rather than individual bones, there are two parts to the growth: one in pre- and the other in post-natal life. However, these should be seen as one continuous, rather than two separate, processes. 'During growth all organisms, except the simplest, not only increase in size but also undergo changes in form due to differential growth rate of their constituent parts' (Pálsson 1955: 430). Also 'in mammals having determinate growth, the external form changes continually during the period of growth, and as soon as the form becomes constant growth ceases' (Pálsson 1955). There is therefore a prescribed sequence to the growth of an animal that is well understood and will be described here.

There are two areas to discuss, firstly where bone growth fits into the overall growth pattern of a young animal, and, secondly, how skeletal growth proceeds. From conception to maturity there are a number of growth 'waves' that pass through the body, each causing a peak in growth rate of different parts and tissues of the body in turn. In terms of areas of the body, the head grows first, followed by the neck, thorax and loin. In terms of tissue development the brain and nervous tissue develop first followed by the bones, muscles and finally the fat reserves (Pálsson 1955). The appearance of a newborn foal reflects the fact the foetal growth has concentrated on the development of the head, central nervous system and bones. As post-natal growth occurs there is a shift from bone growth in the limbs towards the growth of muscles, particularly in the thorax and loin areas.

Also during foetal life the head seems disproportionately large in comparison with the rest of the body. In late foetal life the metapodials also grow considerably, giving the 'leggy' appearance of newborn animals. As post-natal growth proceeds, the wave of skeletal growth passes from the cranial vault down to the face and along the spine from head to tail, as well as up and down the legs from the metapodials (Figure 2.10). This is also reflected in the timings of epiphyseal closure, as given in Table 2.1. Because growth proceeds from the head backwards, the forequarters are better developed at birth than the hindquarters. As the foal grows a 'see-saw' effect can be observed between the height of the fore and hindquarters, as first the bones of the hind limb catch up with the growth of those in the forelimb and then the same thing happens with the muscle development.

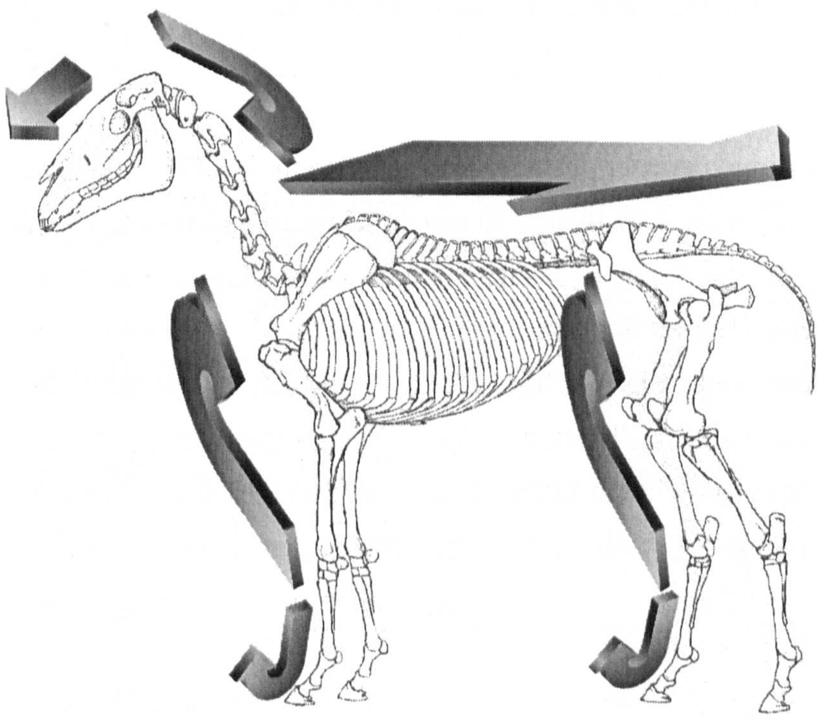


Figure 2.10. Horse skeleton with arrows showing the direction of the 'waves' of growth intensity as the skeleton matures (drawn by C. Johnstone).

In addition, the growth in length of the bones attains its maximum rate before the growth in thickness, meaning that once the maximum length is achieved the bones will still continue growing in diameter for a while after epiphyses have closed. This is also true of the body as a whole, with the height increasing least and width the most, with length of body and depth of chest intermediate in relation to the proportions at birth. Therefore at maturity the leg length is 1.38 x that at birth, whilst the width of the hips is 2.68 x that at birth, with depth of chest intermediate at 2.13 x the measurement at birth (Pálsson 1955).

2.4 Factors affecting bone growth

2.4.1 Age

Age and size are very closely linked in all species. However, in animals that have a determinate growth pattern (i.e. they reach adult size and stop growing) this only applies to immature individuals. There are two main age-related developments in animals with determinate growth patterns: remodelling to assume adult shape and size, and a reduction in bone porosity. It is important to highlight here that there are two types of 'age' when studying growth: physiological age and chronological age. Chronological age is the amount of time for which the animal has been alive. This is mostly measured in days/weeks/months/years since birth, although foetal life is sometimes included when studying the complete growth pattern of an animal. Physiological age is the stage of development that the individual has reached. This can vary considerably in relation to the chronological age of the individual, from conception to cessation of growth.

Foals are born at a much greater physiological age than many other animals as a result of their long gestation period, with their birth weight being around 10% of their adult weight (Pálsson 1955). Also the limbs of horses are so well developed at birth that very little length growth occurs below the hocks after birth, hence the phalanges (and to a lesser extent the metapodials) fuse early in life. At birth the leg length (ground to elbow) in a foal is 73% of the adult length and similarly the withers height is 60% of that achieved at maturity, indicating that the chest depth increases more than the leg length after birth (Pálsson 1955). Correspondingly the width of the chest and hindquarters develop to an even greater extent during postnatal growth. The reasons for this become clear when the sequence of growth is studied.

Studies have been carried out regarding whether the age of weaning affects bone growth and density in foals. Weaning is one of the most stressful events in a foal's life and often leads to a decrease in the growth rate. In particular, the loss of the calcium and protein from the mare's milk can reduce the rate of bone formation after weaning. By studying the bodyweight, withers height, metapodial circumference and bone density of foals weaned at 4.5 and 6 months, Warren *et al.* (1997) were able to establish that whilst weaning affected the weight gain of the foals initially, there was no difference between the early and late weaned groups after a few months. Growth in height and bone density of both groups remained unaffected by weaning. However, whilst the growth in metapodial circumference of both groups was affected by weaning, the early- weaned group was more severely affected, even at a few months after weaning (Warren *et al.* 1997). As the study did not follow the horses to maturity it is unclear whether this difference was still evident at maturity and would therefore affect the measurements of archaeological material.

As discussed above, epiphyseal closure is what limits the longitudinal length of the bones. The sequence in which the epiphyses fuse remains constant even when the exact chronological age at which they do so can be affected by nutrition, health, sex and individual variation. Table 2.1 gives the sequence and approximate timings of epiphyseal fusion based on the data of Silver (1969). These data are based on observations of modern horses (breed unspecified), and whilst Silver (1969) comments that horses have retained a slower skeletal development than other domestic animals, the timing of these closures may be less accurate in more 'primitive' breeds. In addition, these data are based on animals on a high plane of nutrition allowing optimum growth; a lower plane of nutrition can seriously delay epiphyseal fusion. Therefore, Table 2.1 should be used as a guide to the age of an individual, rather than providing absolute values.

Table 2.1. Sequence of epiphyseal fusion in horses and approximate ages at which this occurs (taken from Silver 1969)

Bone	**Epiphysis**	**Approximate age**
Metacarpal/metatarsal	Proximal	Pre-natal
1st phalanx	Distal	Pre-natal
2nd phalanx	Distal	Pre-natal
2nd Phalanx	Proximal	9-12 months
Scapula	Glenoid tuberosity	1 year
1st Phalanx	Proximal	13-15 months
Humerus	Distal	15-18 months
Radius	Proximal	15-18 months
Metacarpal	Distal	15-18 months
Metatarsal	Distal	16-20 months
Pelvis	Acetabulum	1 ½ -2 years
Tibia	Distal	20-24 months
Calcaneum	Tuber Calcis	3 years
Femur	Proximal	3-3 ½ years
Humerus	Proximal	3-3 ½ years
Femur	Distal	3-3 ½ years
Tibia	Proximal	3-3 ½ years
Ulna	Olecranon	3 ½ years
Radius	Proximal	3 ½ years

Whilst the current research is not directed towards unfused bones, it is possible that some bones from skeletally immature individuals will, inadvertently, be studied. This is because it will not be possible to tell entirely whether isolated finds of early fusing elements are from mature or immature individuals. Change can also take place after maturity has been reached by remodelling, and whilst this does not affect the length of the bones it leads to a greater robusticity. In addition, ossification of ligaments and tendons, exaggeration of muscle insertions and the obliteration of sutures, all take place after maturity is reached and can be a response to injury or stress or just advancing age. Therefore size distributions of relatively early fusing elements may show a 'tail' of smaller individuals that are not represented in the distribution of late-fusing elements in the same population.

The skulls of adult mammals are more elongated compared with those of juveniles, particularly in the facial region, due to the eruption of additional teeth. Independent verification of age of a whole skeleton can therefore be gained from studying the eruption and wear of the teeth. Whilst Table 2.2 gives the tooth eruption data for horses, Levine (1982) has found that there is very little variability between equid species; studies of zebras and onagers produced similar timings. Therefore it is not unreasonable to use this as a guide for donkeys and mules, in the absence of more accurate data. Upper and lower dentitions erupt at slightly different times, but these generally overlap, so the ranges given in Table 2.2 allow for this.

Table 2.2. Ages at which horse teeth erupt (from Levine 1982). Di = deciduous incisor, I = permanent incisor, C = canine, DP = deciduous premolar, P = permanent premolar, M = permanent molar

Tooth	Age at eruption	Tooth	Age at eruption
Di1	Prenatal-2m	Dp3	0-1 m
Di2	1-3m	Dp4	0-1 m
Di3	5-10m	P2	2.5-3.5 yrs
I1	2-3 yrs	P3	2.5-3.5 yrs
I2	3-4yrs	P4	3-4.5 yrs
I3	4-4.5 yrs	M1	7-12 m
C	4-5.5 yrs	M2	1.5-2 yrs
Dp2	0-1 m	M3	3-5 yrs

Once all the permanent dentition has erupted and is in wear, ageing the animal is more difficult. The ageing of horses from their incisors has been practised since ancient times, as the writings of Varro (*r.r.*) show (see Chapter 1) and this gives us a check on whether modern horses differ significantly from Roman ones in terms of rate of ageing. The slight drawback with this is that it is not always clear which tooth is being discussed in the ancient texts. Table 2.3 gives a description of the appearance of the incisors through the animal's life with a note on whether the modern and ancient sources agree; in general this is the case, indicating that the teeth erupted at similar ages in Roman times as they do now. This confirms Silver's (1969) comment (above) that the rate of development in the horse has not increased much in recent times. In addition, teeth evolution is generally slower than that of bones.

The later stages in an equid's life, 15 years onwards, are very variable and are determined to a great extent by the diet of the animal, a coarser diet leading to more rapid wear. These are the stages at which unscrupulous horse dealers will alter the teeth by burning false infundibula and filing the angle of the teeth to make the animals appear younger than thaey are, a practice that is seemingly as ancient as horse dealing (Varro *r.r.* and Columella *r.r.*)!

Table 2.3. Description of incisor eruption and wear in horses (from Silver 1969 and Webber 1991) with notes from Varro (r.r. *II, VII, 2-3). For abbreviations see Table 2.2*

Age	Description	Notes from Varro
Birth-5 months	Di1 erupt at birth, Di2 by 5months	
5-12 months	Di1 and Di2 in wear, Di3 erupt	
1-2 years	All Dis in wear	
2.5 years	Di1s lost, I1s erupt	Says the same
3 years	I1s in wear	
3.5 years	Di2s lost and I2s erupt, canines can erupt this early	Says beginning of 4th year
4 years	I2s in wear, canines erupt	Mentions canines
5 years	Di3s lost and replaced by I3s, canines can erupt this late	Says the same
6 years	Infundibulum on I1s becoming smaller	Mentions shrinking of hollows(infundibulum) in teeth
7 years	Infundibulum on I2s also smaller and '7year hook' on upper I3s	Says that this is the limit of accurately telling a horses age
8 years	Infundibulum small in all Is, '7year hook' going/gone	
10 years	'Galvayne's groove' appears at top of I3s, infundibula almost gone	
15 years	'Galvayne's groove' has reached halfway down I3s, infundibula gone, sometimes '7year hook' returns between 13 and 15 as occlusal surface of all Is becomes more triangular rather than oval as angle of teeth alters	Mentions teeth becoming prominent (i.e. angle changes) around this time
20 years	'Galvayne's groove' reaches occlusal surface of I3s, gaps appear at tops of teeth, where narrow roots are emerging	
25 years	'Galvayne's groove' gone	
30 years	All Is very sloping with triangular occlusal surfaces, obvious gaps at tops of teeth.	

It is unlikely that many horses lived beyond 20 years in the Roman period, as Varro (*r.r.)* does not mention what the teeth of aged animals looked like. Twenty is about the natural life expectancy of equids in general (Levine 1982), although some can live up to about 40 years. With modern horses, native ponies tend to live longer than the more refined horse breeds, perhaps because they mature more slowly, which in feral populations may be due to a low plane of nutrition. Roman horses are thought to have matured at a rate similar to the native ponies rather than Thoroughbred racehorses (Peters 1998).

In addition to looking at the wear on the incisors, the wear on the cheek teeth can also be used to determine age. This is a reasonable proposition for archaeological bones but it is not generally mentioned in classical texts because of the difficulties of looking at the cheek teeth in a live animal. The method of correlating the height of the tooth (and therefore degree of wear) with age was established by Levine (1982). The problems are that for loose teeth the tooth has to be anatomically identified correctly first and if you are lucky enough to have a whole mandible then the teeth have to be removed or a radiograph produced in order to measure them.

The height of the tooth (from the cemento-enamel junction at the roots to the occlusal surface) displays an exponential decay with increased age (Levine 1982). The rate of decay is fastest from when the tooth comes into wear until the age of around 10, and then the rate declines to almost no wear by around 17 years old. This means that in a 'natural' population with a life expectancy of 20, the teeth would last throughout the life of the individual (as would be expected). However, the method of Levine (1982) has another drawback; the wear curves are based on data from one size of horse (New Forest), so teeth from larger or smaller individuals cannot be directly compared with the curves as the measurements will be different. As it is usually impossible to know whether archaeological teeth are from that size of individual or not it makes the system inaccurate and it can therefore only be used as a general guide to the age of an individual.

Whilst it is possible to tell the age of archaeological horse material quite accurately up to the age of about 7 years by looking at both epiphyseal fusion and tooth eruption and wear, when all the epiphyses are closed and the teeth erupted it becomes much more difficult and subjective. However, in terms of how age affects bone growth this is not an issue as by that point bone growth has stopped, both longitudinally and in circumference, except in response to stress, injury or disease.

All these ageing methods are of most use when a whole skeleton is present, as a combination of the methods can usually estimate the age at death quite accurately. Therefore, if some bones (i.e. metapodials) are fused but others (i.e. femur) are not then the animal is not mature, and it is possible that circumferential growth of the early fusing bones has not fully progressed. However, if isolated metapodials are found, it is impossible to say if they are from an individual that is fully skeletally mature, which could cause problems in the interpretation of data from archaeological contexts. For instance, if slenderness indices (shaft breadth / length x 100) are produced for the metapodials, it is not possible to know whether very slender bones are from young individuals or from mature animals with slender limbs. It is hoped that this problem will (at least partly) be overcome by studying the proportions of the bones of fully mature whole skeletons and producing a range of variation for comparison with isolated finds.

All these ageing methods are based on horses and there appears to be no specific information available to compare the timing of epiphyseal closure and tooth eruption of donkeys and mules with those outlined above horses. Therefore, for this study it has been assumed that there is little difference, although it should be borne in mind that this might not be the case. Further work on this subject would require an extensive collection of complete skeletons with precisely known ages at death. Given the expense of obtaining such a collection a study of this nature is unlikely to occur, unless advances can be made in the use of X-rays for determining the state of epiphyseal fusion.

2.4.2 Sex

The identification of archaeological bones to male, female or castrate (gelding) is very difficult. If the jaws are present this is made easier as well-developed canines (or tushes) are present in all male equids (including geldings) but are rarely present in mares, and then usually in a reduced form. In horses the canines erupt at around 4 years old (Webber 1991). This is one way of distinguishing adult males from females, although it is not 100% reliable. In addition, the pelves of male and female equids differ, as they do for most mammals, in order to allow the female to give birth. However, it is very rare to find intact pelves in archaeological material, making this a less useful method of determining sex.

Moving on to the post-cranial skeleton (except the pelves), the way in which bone growth is affected by sex can provide us some clues. Sex can affect growth in two ways: the direct effect of the genetic sex of the individual and the indirect effect of sex hormones (see Sections 2.4.4).

In many mammals there is a noticeable difference in height and weight between males and females. This is termed sexual dimorphism and is quite easy to detect in a population of wild animals, where the degree of size variation between individuals is relatively small. However, in populations of domestic mammals the size differences due to sexual dimorphism can easily be masked by the size variation in diverse breeds or demes. This is particularly true for archaeological material where it is very difficult (if not impossible) to attribute individual bones to sex, and therefore size of the bones is the only method of separation.

In horses there is 'no appreciable difference between the sexes at birth nor up to 17 months, but thereafter males grow faster than females' (Pomeroy 1955). This faster growth however, is more related to gain in weight rather than height. Therefore, there is still not a great difference in height at maturity between entire males and females (Pomeroy 1955; von den Driesch and Boessneck 1974; Bartosiewicz *pers. comm.*). The question of the growth of castrates is an issue that has not been well studied in horses and may cause a further small degree of sexual dimorphism (see below). However, it is likely that the overlap between the three groups is still so great (extrapolated from Davis 2000 for sheep) that it is not likely to cause confusion when looking for differences between archaeologically determined groups in the results of the withers height analyses in this study. There are however, differences between stallions, mares and geldings in terms of bone robusticity and skeletal proportions (see below) that will be important to consider when analysing the results of shape index and log-ratio calculations (Sections 6.3 and 6.4).

Because different parts of the body do not grow at a uniform rate, the differences in size between sexes results in different body proportions. Some differences are caused indirectly by differences in metabolism during growth. Growth in males is affected by poor nutrition to a greater extent than in females, with castrates being intermediate (Pálsson 1955). This is due to the fact that colts (male horses under 3 years old) maintain a higher growth rate than fillies (female horses under 3 years old) from 12 months onwards (Breuer 1996), and therefore develop a greater robusticity by the time growth ceases. Entire males gain weight faster than females after weaning, but then proceed further in the development of the late maturing parts than the females. Pálsson (1955) suggests that stallions are not only larger in almost all body dimensions than mares, but all their measurements (except in the pelvic region) are better developed in proportion to the height at the withers. Females generally mature before males, hence the further development of the late maturing parts in stallions.

Castration reduces the difference between the sexes even further. From birth to 5 years the body measurements of geldings increase more than those of mares, the difference being greatest in the depth and width of the chest and smallest in the circumference of the metatarsals and knees and in the withers height. In addition, the bones of geldings do not develop to the same extent in thickness as an entire male, but the length growth is unretarded. Males castrated young do not develop secondary sex characters such as a crested neck and also do not attain the broad head, thick and heavy neck, or heavily muscled fore- and hindquarters that typify an entire male (Pálsson 1955).

There appears to have been very little experimental work carried out on the physiological effects of castration on horses, and almost none on the effects on the skeleton and its growth. This is most likely because the horse is very expensive to use as an experimental animal. The effects of castration on the skeletons of other domestic mammals have been studied and most of the following paragraphs are based on studies of sheep (and other animals) and the results extrapolated to horses.

It has been shown that testicular deficiency (mostly lack of testosterone production) seems to delay epiphyseal fusion and hence prolong the growth period and, conversely, the administration of testosterone causes earlier development of ossification centres and the premature closure of epiphyses (Davis 2000). The sequence of epiphyseal closure remains the same for entire males, females and castrates (as outlined above in Section 2.4.1) but the timing of the closures varies. From studies of sheep skeletons, Davis (2000) suggests that females fuse earliest, followed by entire males, and the castrates are much delayed. However, the lack of experimental work on horses means that it is not known whether this delay falls at the upper limit or extends outside the age range given in Table 2.1.

The age at which castration takes place determines to some extent what the effects on skeletal growth will be, because the increase in the length of the growth period will only affect those bones whose growth zones are still active at the time of castration (Davis 2000). For instance, if the animal is mature when gelded then obviously skeletal growth will not be affected, but perhaps remodelling due to a reduction in muscle mass as a result of the drop in testosterone levels could take place. However, as the modern practice is to geld between 6 and 12 months old (usually nearer 12 months, after the effects of weaning have been countered), prior to the colt becoming sexually active, then skeletal growth from that point on will be affected. In a colt gelded at 12 months this would mean that potentially all epiphyses except the glenoid tuberosity of the scapula and the proximal second phalanx could be affected, allowing a great deal of extra length growth in all the limb bones.

There are, however, individuals that are gelded later, and the changes that could still be possible in the growth pattern would be determined by the age at which the gelding took place. For instance, in a colt gelded at 2 ½ years of age the lower limbs would have already fused, so castration would only allow delayed fusion of the distal radius, proximal tibia and humerus and both ends of the femur. In the archaeological record it is difficult to know when castration took place because most bones are found as isolated elements, and even where a whole skeleton is present it would be impossible to determine whether the limb proportions were the result of gelding or the inherent characteristics of a deme.

Roman literature (Section 1.3.1) indicates that gelding took place when a horse was around 4 years old, at which time most of the epiphyses, with the exception of the vertebrae, are fused, and therefore the animal will have the appearance (and skeletal proportions) of a stallion (Peters 1998). In this research it therefore seems that the bones are most likely to exhibit entire male or female patterns of growth in the skeletons, even if some are from individuals gelded after growth had ceased, making it unlikely that sexual dimorphism will cause problems in the analysis of biometric data from horses of the Roman period. However, donkeys and mules may have been castrated earlier. Apsyrtos (quoted in Peters 1998) suggests that donkeys were castrated at two years of age, which would allow delayed fusion of the long bones mentioned above for castration at 2 ½ years (assuming that epiphyseal fusion takes place at similar ages in donkeys as in horses). Although no specific information is available for mules they may also have been castrated earlier than horses (Section 1.3.1).

The type of castration also affects the growth pattern of the skeleton. Two methods known to the Romans included crushing of the spermatic cord and surgical removal of testes. Under the first method, the production of testosterone will not be halted so the animal should grow like an entire stallion. Removing the testes, however, will halt testosterone production and the animal will grow more like a female but with differences due to the lack of oestrogen production (Section 2.4.4). Roman literature suggests both methods were used on animals, but it is unclear if both were practised on horses. Certainly surgical removal of testes was used on horses, as the process is described in great detail in both the *Mulomedicina chironis* and the *Corpus hippiatricorum Graecorum* (Sections 1.3.1 and 1.3.3). Therefore, if the males were castrated before long bone growth has ceased, the full effects of testicular deficiency would be detectable.

For sheep, Davis (2000) suggests that the best biometric separation of all three sex groups can be obtained by plotting bone length (Gl) against shaft slenderness (SD) for the metapodials. Although this does not produce clear-cut separation of the three groups, most of the specimens are in different regions of the graph. This means that whilst it is unlikely that individual bones can be attributed to sex, a plot of a sample of measurements should reveal whether all three groups are present or one is more abundant. It should be noted here that this was based on a single breed of sheep and that the picture becomes less clear if more than one breed is included in the sample, even to the point of reversing the groups (T. P. O'Connor *pers. comm.*). This method may also not be applicable to horses as the degree of sexual dimorphism is probably less than in sheep. However, it is impossible to know for sure unless a large, adequately aged and sexed collection of horse skeletons (preferably of a single breed) can be brought together for analysis. As can be seen in Chapter 5 many of the horse skeletons in reference collections have no age or sex data recorded and are of very varied breeds, so analysis of this method could not be carried out during this research.

Some of the measurements analysed by Davis (2000) for sheep showed no significant differences between the sex groups and were independent of age differences, and therefore would be useful as indicators of body size. These include HTC on the humerus, BFd on the metapodials and Bd on the tibia (see Chapter 3 for an explanation of the measurement codes). These measurements were taken on the equid bones for this research, but again the lack of an ideal collection of modern reference data precludes any analysis of whether the same measurements are also sex and age independent in equids.

2.4.3 Nutrition

Nutrition obviously plays a crucial role in growth, as it requires an increased level of many substances that are provided by the diet of an animal. A maintenance level of nutrition provides enough nutrient intake to maintain the body as it is. This level varies considerably between individuals as it depends on metabolic rate, size, sex, climate, reproductive status and the work expected of the animal (Pilliner 1992). A high plane of nutrition provides enough extra nutrients to allow for growth above the maintenance level. A low plane of nutrition does not provide enough nutrients for maintenance of the body, and the body will use reserves of fat and protein to keep going, resulting in weight loss. At the maintenance level it has been noted that whilst weight gain stops, skeletal growth continues (Pomeroy 1955; Duren 1996).

The critical nutrients required for growth in different animals are basically similar, i.e. energy, protein, minerals and vitamins. However, the specific nutrients needed for a balanced diet in various animals is very different (Duren 1996). Because horses vary so widely it is difficult to discuss their nutrient requirements as a whole, and the problem is compounded by the fact that a horse is an expensive experimental animal and little experimental work has thus been carried out on its nutrient requirements (Pilliner 1992). The exception to this is the Thoroughbred racehorse, but it is not a good analogue for archaeological horses.

The most critical nutrients for growth in young horses are energy, protein (lysine in particular), calcium, phosphorous, copper and zinc (Duren 1996). In the natural environment the horse has developed evolutionarily to be an efficient enough converter of food to allow it to survive the winter when forage is in short supply. However, under domestication the horse has been bred for performance and not for its efficiency of food conversion, with the result that highly refined horses such as thoroughbreds are far less efficient at converting food than the native ponies, leading to their nutrient intake having to be proportionately much higher (Pilliner 1992). Size in terms of nutrient requirements is more closely related to body weight than to height, for instance a 14.2 hh show pony weighs less than a 14.2 hh cob (Table 2.4). The approximate maintenance level of energy that is required by horses of different weights is given in megajoules (1 million joules) of digestible energy per day (Table 2.4). Table 2.4 also shows the extra requirement for maintenance during work. Light work is defined as an hour's walking up to an hour of fast trotting, cantering and some jumping per day; hard work is defined as more than an hour's cantering, galloping and jumping, racing and polo, and up to 100 km endurance work. The variation in these energy requirements depends on the individual horse (Pilliner 1992).

Table 2.4. Height, body weight and approximate nutrient requirements for different types of horses and ponies (from Pilliner 1992)

Height (mm)	Type	Bodyweight (kg)	Maintenance requirement (MJ/day)	Extra energy for light work (MJ/day)	Extra energy for hard work (MJ/day)
1020	Pony	200	25-32.5	0.4-10.5	25-43.5
1270	Pony	300	29-36	0.6-15.7	37-65
1320	Pony	350	36-44	0.7-18	43-76
1320	Foal/weanling	200	29-36	0.4-10.5	25-43.5
1420	Pony or yearling	400	44-52.5	0.8-20.9	50-87
1470	Pony	450	52.5-65	0.8-20.9	50-87
1470	Cob	500	52.5-65	1-26	63-109
1520	Hack	450	52.5-65	0.8-20.9	50-87
1630	Thoroughbred	550	62.5-75	1-26	63-109
1630	Hunter	600	62.5-75	1.3-31	75-130.5

In addition, horses require a certain level of protein intake for maintenance; at rest this is about 7.5-8% crude protein in the diet. Usually, if the energy requirements are being met, the protein level will also be adequate. The protein requirements for work are not much more than those at rest; for hard and fast work the amount only goes up to 10% crude protein in the diet (Pilliner 1992). The amino acid most important to growth is lysine, so the correct levels of this in the protein intake of young horses is vital. If the lysine level is met, then other necessary amino acid levels will usually also be available in sufficient quantities (Breuer 1996). Lysine is present in high concentrations in legumes, so concentrated feeds containing beans will contain adequate supplies. It is known that the Romans feed lucerne and beans (both legumes) to horses (Section 1.3.1), so it is likely that the lysine requirements of growing horses would have been met.

In terms of fodder, for most horses at rest and in light to medium work good quality hay can fulfil the dietary requirements for maintenance. One kilogram of good quality hay can provide about 8 MJ of energy (and enough protein), so that for a 1320 mm pony 4.5 to 5.5 kg of hay per day will be sufficient at rest, and similarly for a 1520 mm horse 6.5 to 8 kg of hay is enough (Pilliner 1992). However, as the rate or duration of work increases there comes a point when the horse cannot physically eat enough hay to provide the nutrients, and therefore supplementary feeding of higher energy and protein foods is necessary. For instance, a marching army cannot stop to allow the horses to graze, so supplementary feeding is essential and the Roman army certainly carried this out (see Section 1.3.1).

Nutrition of the mare during pregnancy and lactation, and the foal both before and after weaning, are very important for both the maintenance of the mare and the growth of the foal. During the 11 - month gestation there are two periods with different requirements. During the first 8 months the foetus grows very little and the mare requires no more nutrients than she would if not pregnant. However, during the last three months the foetus grows a considerable amount and the mare's energy requirement goes up to that of a horse in light to medium work, and the protein requirement to that of a horse in hard work. This means that the mare will most likely have to be fed concentrated feed in the last 3 months to bring the protein level up high enough. During lactation the energy requirements of the mare increase to the level of a horse in medium to hard work and the protein requirements are even higher than during late pregnancy, because the milk is high in protein (Pilliner 1992).

Table 2.5. The relationship between body weight and height during growth (from Pilliner 1992)

The nutrient requirements of growth change through time, particularly as the rate of growth slows

Breed	Age	Height (mm)	Weight (kg)
Pony	2 months	910	60
	4 months	1020	80
	9 months	1170	140
	12 months	1220	180
	3 years	1320	320
Thoroughbred	Birth	1020	50
	6-8 weeks	1120	90
	8-12 weeks	1220	140
	4-6 months	1320	200
	9-12 months	1470	350
	2-3 years	1570	450

towards maturity. Birth weight in very important in determining the horse's mature weight and a foal weighing less than 35 kg is unlikely to grow to more than 1520 mm high. At birth a foal is about 10% of its adult weight and should reach 50% of mature weight by weaning (Breuer 1996). By 12 months the young horse should achieve 60 to 70% of its mature weight and about 90% of its height (Pilliner 1992). Table 2.5 shows the relationship between body weight and height during growth.

The mare's milk will provide the ideal diet for a young foal, but as it gets older good pasture can provide significant amounts of nutrients (Breuer 1996). After weaning it is likely that the foal will require concentrated feed as well as hay or grass to provide enough protein to maintain the level of growth. This level of growth can be a gain of 1 kg per day from 3 to 6 months, then 0.5 kg per day until 12 months for a horse expected to mature at 450-500 kg (Pilliner 1992), which means a need for about 16% crude protein in the diet. Supplemental feed will therefore be at about 1% of body weight prior to weaning and around 3% afterwards (Breuer 1996). Because bone is one of the early maturing tissues, the foal requires a diet rich in protein and calcium (amongst other minerals and vitamins). As bone growth slows and is replaced by muscle growth, the young horse requires a more carbohydrate-rich diet. However, it is not good to allow growth to proceed too rapidly as this can lead to developmental problems such as are often seen in racing Thoroughbreds that have to been grown very fast to race at 2 years old (see Section 2.4.7).

Some information on the diet of young horses and also on the supplementary feeding of pregnant and lactating mares is given in the Roman literature (see Section 1.3.1) and this suggests that young horses, particularly those bred on the large stud farms, in the Roman period were probably adequately provided with the basic nutrients to sustain growth. Similarly, the variety and quantities of feedstuffs supplied to equids in work (see Section 1.3.1) suggests that at least those used by the army, as racehorses and by the upper strata of society were able to sustain nutrition and work to the level required. As with all societies, the lower strata may have had enough trouble feeding themselves let alone their animals, and the starving state of mill beasts described in several texts (see Section 1.3.1) attests to this fact.

Vitamins (particularly A, C, D and K) play significant roles in the development and maintenance of bone. Although not much work has been done on the sub-clinical effects of vitamin deficiencies (i.e. not severe enough to produce a 'disease'), they are known to retard growth (Pomeroy 1955). By looking at the ways each vitamin works, the effects of a deficiency can be implied. In cartilage vitamin A is required for the release of lysosomal enzymes and the extracellular digestion of glycoproteins, whilst in bone it increases the number and level of activity of osteoclasts. Therefore during growth vitamin A deficiency will impair the process of turning cartilage into bone and will also decrease the rate of remodelling, possibly resulting in oddly shaped bones. In adult bone a lack of osteoclast activity could lead to weakening of the bone, where necrosis occurs and cannot be removed and reformed.

Vitamin C is essential for the proper synthesis and aggregation of collagen, so a deficiency will lead to the production of fragile and weakly aggregated collagen fibrils and hence weak bone.

Vitamin D affects bone indirectly as it regulates the absorption of calcium and phosphate in the intestines and kidneys. Therefore vitamin D deficiency (rickets) causes a low concentration of calcium and phosphate ions in the plasma and hence calcification of cartilage cannot take place. Poorly mineralised bones are formed that cannot support the weight of the body, and they become characteristically bowed. Vitamin D may also promote bone resorption either alone or in conjunction with parathyroid hormone (PTH; see section 2.4.4).

Vitamin K is essential for the synthesis of osteocalcin, a phylogenetically variable protein that binds to hydroxyapatite crystals and to calcium phosphate. Osteocalcin is an essential part of the bone mineralisation process, so a vitamin K deficiency will detrimentally affect this process.

Minerals are also important for normal bone growth to occur, the most obvious being calcium. However, other minerals, such as phosphorus, copper and zinc, are also required. Calcium deficiency can lead to disease (see Section 2.4.7) and malformation or stunted growth of the whole skeleton, because it causes poor mineralization of bone. However, it is not just calcium that is critical, a balance between calcium and phosphorus has to be maintained for normal growth (Hintz 1996). An excess of phosphorus over calcium will interfere with calcium absorption, whereas a deficiency of phosphorus results in bone demineralisation (Duren 1996). It has been estimated that horses with a body weight of 500 to 600 kg need about 20 to 24 g of calcium per day for maintenance. Brood mares (same body weight) require 35 to 37 g per day in late pregnancy, and this increases to 50 to 56 g during early lactation. Young horses, 4 to 12 months old (expected to mature at 500 to 600 kg) need 36 to 45 g of calcium per day. Phosphorus requirements are less at 15 to18 g per day for maintenance, 23 to 28 g for pregnant mares, 23 to 28 g for mares during lactation and 24 to 30 g for weaned foals and yearlings.

The trace elements such as copper and zinc, although required in less quantity, are still vital for normal growth. Low copper intake can result in inferior collagen quality, biomechanically weak cartilage, decreased bone density and osteochondrosis legions (Hintz 1996). This is because the enzymes involved in elastin and collagen formation are dependant on copper (Duren 1996). It is estimated that around 50 to 80 mg per day are required for weaned foals and yearlings. Zinc is required by many metalloenzymes that are involved in protein and carbohydrate metabolism, so is vital for many areas of growth (Duren 1996). Weaned foals and yearlings require about 200 to 300 mg of zinc per day to maintain growth rates. Horses at pasture, with little or no supplementary feeding, will often lick the soil in certain areas in order to try and obtain the minerals that the grass is lacking.

Under-nutrition causes the physiological age of an individual to proceed at a slower rate than its chronological age. Therefore, in most cases, the body is able to 'catch up' growth after a period of malnutrition because the growth period has been extended. Animals show great flexibility in recovering, but if the period of malnutrition occurs early in life and is sufficiently prolonged and severe, it may result in permanent stunting of growth (Pomeroy 1955).

Restricted nutrition at any age does not just retard growth in general but affects different parts of the body and tissues differently. An animal's form can be controlled by changing the plane of nutrition at different stages of growth, a fact that has been exploited by the commercial meat industry to provide fat or lean animals for slaughter depending on current tastes (Pálsson 1955). It is even exploited by the Thoroughbred racing industry to some extent by ensuring that foals receive maximum nutrition during late foetal and early post-natal life to ensure the lower limbs reach their genetic potential in length and hence enhance their speed later on. This control of growth takes place within the wide limits imposed by genetic capacity on one hand and under-nutrition resulting in starvation on the other (Pálsson 1955).

In general (taken from Pálsson 1955: 475):
1) Malnutrition of the dam only affects the foetus in the later stages of pregnancy
2) During growth, the parts most affected by a period of malnutrition will be those at their highest growth intensity
3) A period of malnutrition at any age will affect the earliest maturing parts the least and the latest maturing ones the most
4) When the level is sub-maintenance, tissues are used for energy and protein in reverse maturing order, i.e. fat first, then muscle, then bone, and in the latest maturing regions of the body first (loin and pelvis)
5) Any part that has been retarded has great ability to recover once nutrition is increased, provided it has not gone on too long or at too severe a level

In view of these statements, the later developing growth in the thickness of the bones is retarded by poor nutrition to a greater extent than the early developing length growth. The length growth can be affected for example in the metapodials by a late foetal deprivation. This is because there is not enough time before the bone matures to catch-up the growth lost at that stage. The shape of the bones is more affected by different planes of nutrition than their weight. Early maturing distal limb bones are less affected than the later maturing proximal and girdle bones. In horses the length of the lower limb bones is more severely affected by late foetal deprivation because of the longer gestation period and therefore higher growth intensity of the bones at that stage than in other mammals.

Therefore, in summary, a constant high plane of nutrition means that nutrition ceases to be the limiting factor in growth: genetic potential is then the barrier. In terms of archaeological bones, the effects of malnutrition can be particularly hard to detect unless there are chronic shortages of particular parts of the diet leading to deficiency syndromes (see above) or the level of nutrition has been very low or maintained over a long period of time and the system has not recovered once the level is increased.

For whole skeletons it might be possible to suggest that abnormal limb proportions could be the result of malnutrition during growth. However, it would be difficult to differentiate between differences due to sexual dimorphism, inter-deme variation and malnutrition unless the effects were severe. For both whole skeletons and isolated bones, the fact that circumferential growth of bones is more severely affected by malnutrition than length growth may be detectable on archaeological bones. For instance, low values for the shape indices but no discernible differences in withers heights may indicate malnutrition during the growth period.

2.4.4 Hormones

Four hormones can influence skeletal growth: growth hormone, thyroid hormone, sex hormones and glucocorticoids. Growth hormone (Somatotropin) increases the synthesis of DNA (deoxy-ribonucleic acid), RNA (ribonucleic acid) and proteins, which leads to an increase in cartilage growth. It is released from the anterior pituitary gland and is controlled by the hypothalamus. Thyroid-stimulating hormone (also produced in the anterior pituitary gland) affects skeletal growth by promoting the differentiation and maturation of bone cells. Therefore the combination of growth hormone and thyroid-stimulating hormone maintains the rate and sequence of both endochondral and intramembranous bone formation (Bouvier 1989).

Too much or too little somatotropin can lead to acromegaly (gigantism) or pituitary dwarfism, respectively. This means that the individual is larger or smaller than usual but maintains the correct body and limb proportions (Bouvier 1989). Too little thyroid-stimulating hormone leads to thyroid dwarfism, in which the individual retains infantile body and limb proportions and is also mentally retarded; in less severe cases it just causes retardation in growth. Hyperthyroidism can lead to a loss of weight through an increased metabolic rate but also enhances growth of tissues (Pomeroy 1955).

Glucocorticoids (produced in the adrenal cortex) inhibit skeletal growth by decreasing DNA, RNA and protein synthesis. They may also interfere with mineralisation by impairing calcium absorption in the intestines. Hence they have the opposite effect to growth hormone (Bouvier 1989; Saladin 1998). Just prior to maturity the adrenal cortex increases in size, with the effect that the increased glucocorticoid production is responsible for bringing growth to a standstill (Pomeroy 1955).

Sex hormones are instrumental in causing the growth spurt that occurs at puberty in humans. Whilst the smooth growth curves suggest this spurt does not occur in ungulates (Pálsson 1955), sex hormones have other effects on growth. In females, oestrogen (produced in the ovaries) influences the epiphyseal plate closure at puberty and also maintains the skeletal mineral mass (Bouvier 1989). Therefore an excess of (or prolonged exposure to) oestrogen during growth can inhibit skeletal length growth by causing early ossification of the epipyseal cartilages (Pomeroy 1955). A lack of oestrogen during growth results in an increased bone growth over a prolonged period. Also, a lack of oestrogen after maturity can cause loss of bone mineral and lead to osteoporosis. Progesterone will also increase growth (Pomeroy 1955). Testosterone (produced in large amounts by the testes in males and small amounts by the ovaries in females) influences growth in both length and width of bones, by directly activating osteoblasts and chondroblasts and indirectly through its effect on muscle development (Bouvier 1989). However, testosterone has no effect on the rate of growth (Pomeroy 1955).

Hormones also have an influence on the turnover of skeletal tissues. Two hormones act in opposition to do this, parathyroid hormone (PTH) raises plasma calcium levels and calcitonin lowers it. PTH raises plasma calcium by increasing the rate of calcium reabsorption and hydroxylation of vitamin D in the kidneys. At high levels it also stimulates osteoclastic resorption of bone. Calcitonin depresses the activity of osteoclasts, resulting in lowered calcium levels and protection of the skeleton from excessive PTH activity. An imbalance in these hormones can cause either excessive resorption or formation of bone tissue during growth and adulthood (Bouvier 1989).

Once again, the effects of hormones on the growth of bones would be very hard to detect zooarchaeologically, unless the cases were particularly extreme. Even then the distinction between the effects of hormones and, for instance, vitamin or mineral deficiencies would be difficult to achieve.

2.4.5 Genetic potential

No matter how well the animal is fed there is a genetically set limit, past which an individual cannot grow. This is mostly determined by the size of the parents, and in particular the mother (see below). If a mare and stallion of equal height of the same breed, both of whom have been raised to their genetic potential, were mated, the resulting foal should mature at approximately the same size as the parents. However, when breeding a mare and jackass, the resulting mule foal will mature at the same size or taller than the dam. Joan Rawley (a mule breeder in Tennessee, USA) says that her mules, bred from a 1395 mm Spanish jackas and Paso Fino mares around 1520 mm, are slightly over 1520 mmh at maturity (J. Rawley *pers. comm.*). Following a question posed on their Internet forum, members of the British Mule Society (http://www.britishmulesociety.org.uk) suggest that mules can mature at up to 10 cm taller than their dam. This is most likely the result of hybrid vigour, although it is possible that the late-fusing epiphyses of mules close later than horses, giving a longer growth period. This would lead to a long and slender conformation of the late maturing bones such as the femur and tibia. This hypothesis cannot be tested at present because of the lack of mule skeletons available for study in reference collections (see Chapters 3 and 4).

When breeding horses, the size of the mare is of importance in allowing the genetic potential to be reached because the size of the dam limits the size of the foetus. The maternal influence can suppress the genetic influence of the male, so that birth can take place. For instance, when a Shetland pony is crossed with a Shire horse, the foal from the Shire mare is three times as large as that from the Shetland mare. Also each foal resembles a purebred foal of the dam's breed more than from the sire's. The differences decrease in post-natal life but do not disappear entirely (Pálsson 1955). Therefore to breed for maximum size, the largest stallions should be bred to the largest mares, and the offspring will be as large as the size of the dam allows.

The age of the mare can also have an influence on the offspring reaching its genetic potential. A young mare will produce a smaller foal than a mature mare. The reason is that when the mare is not fully mature, her nutritional needs for growth compete with those of the foetus, meaning that neither is receiving the maximum amount. Older mares also tend to produce smaller foals, particularly if they have been extensively bred from (Pálsson 1955). Varro (see Section 1.3.1) recommended that mares be bred from between the ages of three and ten years. In modern studs, three is also usually the minimum age but more often the mares are left until four as the body is more mature then. With modern stud practices, fertility and ease of conception in the mares can be kept into older age, allowing them to be usefully bred from for longer than in the past: into their teens is quite normal.

Genetic potential can be affected by many factors, mostly those that affect growth in general, but there are other factors relating to the dam that can stop a foal from reaching its genetic potential in terms of size. As has already been mentioned, the nutrition of the dam, particularly in the later stages of pregnancy and whilst lactating, can affect the growth of the foal, particularly in relation to the growth of its metapodials (see Section 2.4.3). In addition, nutrient restrictions of the growing horse can affect the expression of genetic potential in terms of size and structure. For instance, a low protein but high carbohydrate diet could change the composition of growth to more fat and less muscle or bone, resulting in an animal that does not reach its genetic potential in terms of height and muscle development but is obese (Breuer 1996).

Improved breeds have a proportionally more advanced state of development of the later maturing parts than their wild ancestors, the latter resembling a juvenile form of the improved breed. Early maturity and advanced development are inheritable characteristics provided the level of nutrition is sufficiently high. The evolution of horses has been along two lines: animals for speed and animals for draught. Thoroughbreds, bred for speed, have an increased leg length in proportion to the depth of the body, whilst draught horses have been bred along lines much more similar to those of beef cattle, breeding for more advanced development of the late maturing hindquarters (Pálsson 1955).

The inheritance of physical traits is one that the Roman writers hypothesised upon extensively but could know little of the science behind the process. This was because it was only in the 19th century AD that Charles Darwin published his *On the Origin of Species* and Gregor Mendel undertook his pioneering work on the inheritance of physical traits. And only in the 20th century AD were genes and DNA discovered: research continues in an attempt to fully understand them. Whilst the Greeks considered the mare's attributes paramount in imparting the physical characteristics to the offspring, the Romans thought it was the stallion. With modern knowledge it is, of course, now known that the offspring inherit a combination of characteristics from both parents. There are, however, some stallions that seem to regularly impart certain characteristics to their offspring, regardless of the characteristics of the mare (and *vice versa*), and these are termed 'pre-potent' (Mortimer 2004). It is also still true that a single stallion can more quickly change the characteristics of a group of horses than a mare, because it can produce more offspring per year than a mare. Therefore this was the standard method of breeding for a purpose or generally improving stock that the Romans employed, as it is today.

The inheritance of temperament is one that is much debated in relation to human children at present, with 'nature or nurture' comparisons being undertaken (Winston 2004). With horses it is generally acknowledged that a calm, placid mare, that is well used to being handled by, and willingly associates with, her human handlers, will produce a foal that is likewise not afraid of human contact. However, the temperament of the foal is also at least partly genetically determined; its reactions to danger and new situations are mostly governed by in-built reactions until learning allows modification of those reactions. In terms of horses for different uses, an inherently placid horse is desirable for general riding and draught use, whilst a fiery, reactive horse is more suited to the cavalry and a horse with a highly tuned 'flight' response will do well in racing. These characteristics were believed by the Romans to be inheritable and hence horses were bred accordingly.

2.4.6 Exercise

The effect of exercise on growth of the skeleton is something that probably does not receive the attention it should in modern literature except, in relation to modern racehorses. This is perhaps because it is presumed that those working in the field know that a horse should not be broken in and worked until it is mature enough. However, the term 'mature enough' may not relate to skeletal maturity. For instance, it is usual practice for horses (other than racehorses) to be broken in at three years of age (Knowles 1993), at which point their skeletons are not fully mature, although nearly so.

Modern racehorses are broken in at 18 months so that they can be raced at two years old. This is of course when the skeleton is quite immature, hence the weight limits for the jockeys and the use of very lightweight saddles, etc. Even with these restrictions it is quite often the case that racehorses suffer from skeletal defects resulting from overstressing the limbs during the growth period. For instance, fractures of the epiphyses are a regular occurrence, as are osteochondritis dessicans lesions caused by damage to the growing joint cartilages (Section 2.4.7).

However, Roman practice was to break in most equids at three years old, as it is today (aee Section 1.3.1). Roman racehorses were left until four years, because it was considered (quite correctly) that these animals should be more mature to withstand the extra strain in the circus. Therefore, it is unlikely that exercise relating to breaking in immature animals would be affecting the skeletal growth of Roman horses. The most likely cause of exercise affecting the skeleton would be the result of injury during work that resulted in a pathological change to the bones, and this is dealt with in Section 2.4.7 below.

Therefore, for the purposes of this study it is unlikely that changes caused by exercise would affect the measurements of limb bones, as most damage occurring during growth or afterwards would show up as a pathological case, and such bones would not usually be measured.

2.4.7 Disease and pathology

Bone disease in general is too large a topic to cover here. This section will be restricted to those diseases and conditions that affect the growth of bones or their size and shape, as these have relevance to this research. In many cases the aetiology of the diseases is poorly understood, making their prevention difficult and only allowing treatment of the symptoms even with modern veterinary advances. Therefore quite advanced cases are noted from many archaeological sites. Some of these diseases are thought to be attributable to poor diet and others to genetic mutations. Also included in this section are other pathological conditions seen on bones that result from some form of trauma.

Whilst the diseases and pathological conditions discussed below can drastically affect skeletal growth, and/or the size and shape of adult bones, in their more advanced forms, in general mild cases will not produce noticeable effects on the skeleton. In terms of this research, the more advanced cases of these conditions should have been noted as pathological by the zooarchaeologists working on the material and for that reason these bones will probably not have been measured and therefore will not bias the biometric sample. However, mild forms of these conditions are rather difficult to detect and so measured examples could affect a biometric sample, although these would be unlikely to introduce much bias as the measurements would not be sufficiently different from normal variation.

However, as Baker and Brothwell (1980) state, 'what is normal?', when studying the skeletons of domestic animals that have been selectively bred for particular characteristics, and may appear quite abnormal in relation to their wild ancestors. This is true of achondroplasia, the genetic form of dwarfism, where the head and trunk grow normally but the limbs are greatly shortened. In humans this is the most common form of dwarfism. Dexter cattle are often heterozygous for a form of achondroplasia, so an appreciable number of pure Dexter calves are homozygous achondroplastic dwarves or 'bulldog calves'. Dachshund dogs also have the classic appearance of achondroplastic dwarves, even though their short legs are now considered a breed characteristic rather than a deformity (Baker and Brothwell 1980). Whilst there does not seem to be any literature on this condition in equids, it is likely to occur occasionally, and if the resulting animal was viable there were at least two possible reactions to this in the past: the animal could be immediately killed as a 'monster' or kept as a curiosity.

Other hereditary conditions in horses are known and out of 23 listed by Roberts (1971, quoted but not listed in Baker and Brothwell 1980: 40), eight are considered to affect the skeleton. However, the prevalence of these conditions is unknown because this can only be determined by breeding experiments, which are slow and expensive in large animals such as horses (Baker and Brothwell 1980). Some of these conditions have been noted in archaeological specimens, and whilst they do not affect the measurements, they may be of some use in determining the possible movement of horses to different areas and the question of stock improvement, through the use of prevalence statistics.

The study of these non-metric traits is an area that is receiving more attention but still needs further research. One aspect of interest is consideration of the size, number and position of the nutrient foramina on certain elements. For instance, in cattle the regular recording of size and number of the mental foramina has elucidated some information on the movements of animals (Dobney *et al.* 1996). In equids, a likely candidate for further work appears to be the supra-orbital foramina. Eisenmann (1986) suggests that these could be used as a species determinant, and although this is unlikely (Section 4.3.1) their value in determining horse movements should be explored. Another non-metric trait found in horses is the presence of supernumerary incisors. These have an incidence of around 0.6% in modern horses (Colyer 1936 quoted in Baker and Brothwell 1980), but in the light of evidence that 8th century AD Hungarian folk tales ascribe magical powers to animals that possess these extra teeth, it would be worth considering if the prevalence varies across different time periods and geographic areas and could therefore be related to stock movements.

Baker and Brothwell (1980) wrote that 'the destructive effect of contagious diseases should not be underestimated' and yet this area has perhaps still not received the attention it deserves. In particular, whole skeletons recovered from a site should be studied more often and more carefully as possible evidence of an outbreak of an infectious disease in a particular community. This is particularly true where a number of skeletons of a single (or closely related) species are found in a single burial incident. For instance, Peters (1998) has suggested that the 35 horse and mule skeletons found together in one pit at Weißenburg/*Biriciana* (Germany) are most likely evidence of a fatal epidemic outbreak. The biometric aspects of the analysis of such skeletons will be unaffected by their cause of death, as most infectious diseases kill before changes to the bones can take place.

There are, of course, exceptions to every rule and one such disease is brucellosis. The *Brucella abortus* bacteria does not kill horses, nor cause the reproductive problems seen in cattle, but it does cause changes to the bones of the vertebrae. The cervical and lumbar intervertebral discs are gradually destroyed, resulting in the erosion of the vertebral bodies and the growth of exostoses, eventually leading to ankylosis of the spine.

Other infections that directly affect bones are those that, as a result of trauma or blood-borne agent, cause inflammation of the tissues of the bone itself. These are osteomyelitis (infection starting in the marrow cavity), osteoperiostitis (periosteal origin) and osteitis (cortical origin) (Baker and Brothwell 1980). Of these, the first two are the most commonly found and can result in large lesions that usually spread to involve all three sites if left untreated. Areas specifically at risk in horses are the spines of the thoracic vertebrae as a result of saddle sores; the metapodials as a result of knocks from opposing hooves; and the feet where laminitis has caused rotation of the pedal bone through the sole of the foot.

Other infections specific to horses include poll evil and fistulous withers, both diseases caused by infection of the *bursae* or voids near the atlas or first thoracic vertebrae, respectively, leading to infection of the surrounding bones. Even with modern veterinary care these infections are very difficult to treat because the pus cannot drain out easily (Baker and Brothwell 1980). Another problem is caused by infection involving the joints. As with osteomyelitis, etc., this is usually the result of a wound and can cause infection and necrosis of joint cartilage as well as swelling of the joint capsule, all of which lead to new cartilage and bone formations during the repair response.

As discussed abov,e nutrition plays a large role in the growth of the skeleton but there are also issues that relate to nutrition in mature individuals. One pathological condition of skeletal development that is sometimes associated with malnutrition but can also be the result of infectious disease is the production of Harris lines. These are lines of very dense bone, detectable using X-rays, running parallel to the epiphyseal fusion line. They occur when growth is slowed down for a significant period of time by any of the biologically stressful situations mentioned above (Baker and Brothwell 1980). The periods of stunted growth could lead to the shortening of the bone if the growth has not 'caught up' when more ideal conditions resumed.

Whilst oral pathology is not a topic that requires detailed discussion here, it is included because it can impinge on growth and skeletal maintenance through its effect on feeding. For instance, if the oral pathology is of such severity (either short term or prolonged) that feeding cannot take place adequately through pain, then the nutritional requirements of the individual could suffer and consequently this could affect the growth and maintenance of the bones, leading to all the problems associated with malnutrition outlined in Section 2.4.3.

Osteoporosis is a condition that affects horses as well as humans, and occurs when a lack of calcium in the diet causes a drop in the blood calcium, triggering a release of parathyroid hormones. This releases calcium from the bones in an attempt to maintain blood calcium levels to preserve normal nervous and muscle function. In the horse, as calcium is removed from the cranial bones, the fibrous connective tissue content increases and the head increases in size and appears swollen, hence 'big head disease'. Whilst it is uncommon to see such severe cases of calcium deficiency that result in big head today, it does appear occasionally (Hintz 1996). It is believed that less severe calcium deficiency in the limb bones (i.e. rickets) may result in a predisposition to lameness (Hintz 1996), probably as a result of the poor mineralization of the bones, enlarged joints and crooked long bones (Duren 1996).

Mild osteoporosis may not be detected on archaeological sites because often it affects all the bones when all the animals were raised in the same way. Therefore it appears 'normal' for that site (Baker and Brothwell 1980). Also, lightweight bones would, very often, be attributed to taphonomic processes rather than osteoporosis. In terms of biometric analyses, big head might result in anomalous cranium measurements being taken if the disease was not severe enough for easy recognition; however, at that stage the measurements are unlikely to be affected to any great extent.

There is a group of conditions and diseases that are commonly known in the veterinary literature as developmental orthopaedic diseases (DODs). These are a group of diseases that affect an animal whilst it is growing, either involving abnormalities in endochondral ossification, in bone lengthening or metabolic changes within the bone (McIlwraith 1996). Some of these resolve naturally, others only with the aid of advanced modern surgical techniques. This last group may, therefore, be detected archaeologically.

An eample of a DOD is epiphysitis, which manifests as pain and swelling at the growth plate. In horses this usually occurs in yearlings and foals around the distal epiphyses of the radius or the metapodials. Some cases have associated osteochondrosis (see below) but most do not. It can be associated with a high plane of nutrition, which has caused the diaphyses to outgrow the epiphyses, therefore a diet restriction will allow the joints to 'catch up' by slowing down growth in general (Pilliner 1992). Limiting the exercise of the horse helps to relieve the symptoms (McIlwraith 1996). Many cases resolve themselves with time and generally cease when the affected epiphysis fuses (McIlwraith 1996). As this condition usually resolves when growth ceases, it would not be detectable archaeologically (Baker and Brothwell 1980). Epiphyseal fractures can occur through trauma to the area where the cartilage is being calcified (McIlwraith 1996) and can result in sections of the epiphysis becoming displaced. These can still be seen after the bone has fused, as the displacement of a section of the epiphysis will still be evident.

Osteochondrosis is a defect in the endochondral ossification of the bones that can lead to several different specific conditions such as osteochondritis dissecans (OCD) and subchondral cystic lesions (SCL) (McIlwraith 1996). Both these conditions are caused when a restriction in the blood supply occurs in the cartilage precursor of the epiphysis, an abnormally thick layer of cartilage forms and some of this then undergoes necrosis, so the cartilage can then become detached from the bone through subsequent stresses, causing inflammation and pain (OCD) or can leave pits in the surface of the bone (SCL) (Figure 2.11) (Pilliner 1992; McIlwraith 1996). A number of other factors can contribute to the formation of these lesions, such as biomechanical stress, genetic predisposition, fast growth rate and nutritional imbalance, and therefore a multifactorial aetiology is generally accepted (McIlwraith 1996). There can be associated osteoarthritic lesions caused by incorrect use of the limb due to lameness.

In foals bred to grow quickly, the high plane of nutrition fed to these youngsters can increase the risk of OCD occurring. Low copper levels in the diet (Pilliner 1992) and imbalances in growth hormones have also been found to be exacerbating factors. It is most often found on the surfaces of the distal femur, distal tibia, proximal astragalus, distal metapodials and shoulder joint (Pilliner 1992; McIlwraith 1996). OCD can be recognised in archaeological material as a depression in the underlying bone.

Subchondral cystic lesions (SCL) occur in any joint, but are particularly associated with the limb joints, and in horses most commonly occur on the distal femur, and less commonly on the proximal tibia, distal metapodials, both ends of the radius and on the phalanges. There is some controversy as to whether they are caused by a trauma that starts the process or not (McIlwraith 1996). SCL are only treatable with surgery, meaning that many horses in the past with this condition would probably have been lame. In archaeological material these would be seen as a much deeper depression than OCD, where the hole in the surface is much smaller than the underlying cavity.

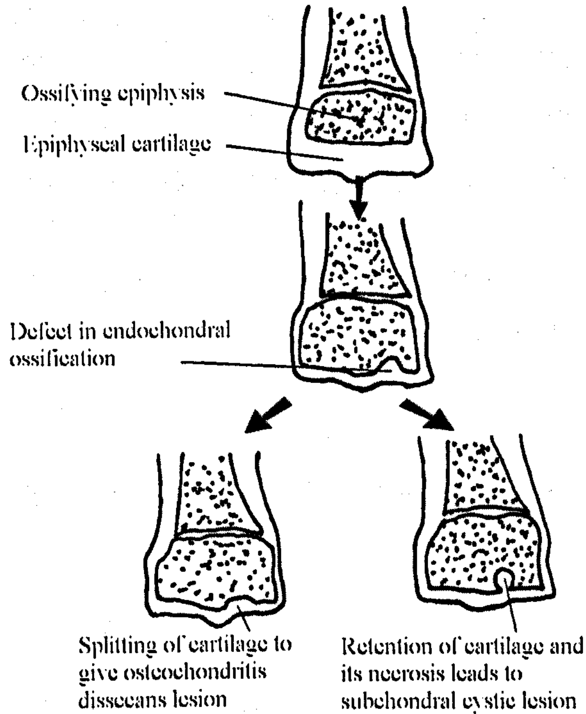


Figure 2.11. Formation of osteochondritis dissecans and subchondral cystic lesions (C.Johnstone after McIlwraith 1996).

Angular limb deformities (ALD) arise from uneven growth of the metaphysis or, less commonly, abnormalities of the cuboidal bones (carpals and tarsals). Abnormalities of the cuboidal bones are most often a problem with foetal development. After birth, the cuboid bones collapse because they are at an insufficient level of ossification to bear weight (McIlwraith 1996). It is unlikely that this condition would be found on archaeological material; however, it would be quite recognisable as it would not have been treated. ALD as a result of uneven growth (caused by unbalanced nutrition or hormones) of the metaphysis, most commonly involve the distal radius, metapodials and tibia. ALD can also be the result of crushing of the metaphysis by external trauma or excessive loading or exercise of the limb. This can lead to the early fusion of part of the epiphysis and therefore uneven growth (McIlwraith 1996).

Today, quite radical surgery is required to treat most cases of ALD, at sites other than the distal radius where it will usually correct itself (McIlwraith 1996). ALD would probably not have been treated in the past and could therefore be detectable in archaeological material, as bones with a lopsided appearance to the epiphyses. If the condition was not too severe then the animal would not be unduly affected in terms of movement. However associated osteoarthritis could well occur because of the uneven stress on the joints.

The next group of conditions are all associated with trauma and include fractures and dislocation as well as more minor incidents leading to the formation of haematomas. The latter are formed when a blood vessel under the periosteum is damaged and forms a blood clot between the surface of the bone and the periosteum, which then ossifies to form a smooth dense bony lump on the outer surface of the bone. Haematomas most usually form on bones where there is little surrounding soft tissue to protect the bone from knocks, such as the metapodials and skull. The lumps formed by haematoma should not be confused with the more regularly shaped dense bony nodules known as osteomata, which are benign bone tumours (Baker and Brothwell 1980). Dislocation of joints occurs in horses, but the muscle mass around most joints means that this is quite rare. The exception is dislocation of the hip joint, as evidenced by the formation of a false acetabulum on the pelvis to accommodate the femoral head on a few archaeological specimens (Baker and Brothwell 1980).

Fractures can occur in any place on the bone, including the epiphysis and the metaphysis. In growing bones, a fracture at the growth plate can lead to early fusion of the epiphysis as the repair process joins the two areas together, and hence the possibility of shortened bones. Sometimes the separation of the epiphysis can lead to a false joint between the epiphysis and metaphysis (Baker and Brothwell 1980). This is seen when a fracture of the femoral head occurs in horses (although the incidence of this is rare). Mid-shaft fractures of the long bones of horses are notoriously difficult to treat successfully, particularly in the upper limbs where the muscle mass is so great that straightening the fractured bone is almost impossible, particularly before anaesthetic and muscle relaxants were developed. Many horses sustaining a fracture would be put down immediately as their working lives would be over; perhaps this reflects the scarcity of identified fractures in the archaeological record. The metapodials are the most successfully treated, as evidenced by a well-healed fracture on a horse metatarsal from Skedemose (Sweden) (Baker and Brothwell 1980). This suggests that the animal must have been confined so that it could not move much until the fracture had healed, and that it was worth enough to the owner to allow it time to heal properly.

The last group of conditions to discuss are those that mostly affect mature and elderly individuals, namely degenerative conditions such as osteoarthritis, spavin, ringbone, navicular and spondylosis derformans. Although they can occur in younger animals as the result of a traumatic incident affecting the joints and soft tissues around them, these are mostly seen in older individuals as the result of general wear and tear on the joints. Osteoarthritis is caused by the degeneration of the joint cartilage leading to eburnation and grooving of the bone surfaces as well as bone growth around the margins of the joints known as exostoses. The presence of eburnation and grooving are the distinguishing features of osteoarthritis, compared with the following conditions (Baker and Brothwell 1980).

Spavin and ringbone are the names given to similar conditions affecting different joints of the limbs. Spavin affects the small tarsal bones and in extreme cases the proximal metatarsals as well. The joint capsule is affected and the formation of exostoses occurs between the tarsal bones, eventually leading to ankylosis of the joint. In ringbone, the inter-phalangeal joints are affected in the same manner, with high ringbone affecting the joint between the first and second phalanges and low ringbone the joint between the second and third phalanges. In both conditions the joint surface remains unaffected, so distinguishing them from osteoarthritis. Whilst the affected animals will be at least mildly lame, once the process of ankylosis is complete slow work can be resumed. Both conditions are thought to result from excessive stress on the joints concerned either through poor conformation not allowing the absorption of shock in the correct way, or as a result of too much fast work on hard surfaces (Baker and Brothwell 1980).

Navicular disease is peculiar to horses as far as can be determined. It is caused by the degeneration of the navicular bone, a sesamoid positioned at the posterior of the joint between the second and third phalanges. This disease should be easy to detect archaeologically because of the very characteristic way that the bone degenerates, but the navicular bone is not recovered very often, even from whole skeletons, perhaps due to poor familiarity with anatomy by the excavators or because those with navicular degeneration would be more vulnerable to taphonomic decay than healthy bone (Baker and Brothwell 1980). The condition causes severe and progressive lameness, but many animals would probably have been continued to be worked as there are no outward signs of the cause of the lameness.

As a slight deviation, another condition that causes foot lameness in horses is laminitis. This is a disease of the feet with a (still) unknown aetiology that causes inflammation of the lamellae holding the hoof horn to the third phalanx (pedal bone). If untreated it leads to the destruction of the lamellae, causing the pedal bone to drop downwards and even come through the sole of the hoof. In less advanced cases, the degeneration of the edges of the pedal bone is noted, where the blood supply has been disrupted and necrosis occurs. This bone degeneration is quite characteristic, but because of the bias against the preservation of third phalanges due to their porous nature, this disease is not often detected archaeologically despite its quite common occurrence in horse populations today. One exception to this comprises the four horse and two mule skeletons recovered from Künzing, Germany (von den Driesch and Cartajena 2001), which all exhibited chronic laminitis in at least two if not all four feet. It is surmised that these animals may have been put down because they were severely lame and hence unusable. However, it also suggests that they must have been used for a considerable length of time whilst they had laminitis for the hooves to have degenerated that far.

Ossification of ligaments and tendons occurs in horses, and is seen particularly in the ligamentum nuchae and the longissimus dorsi. This may be the result of using these animals for riding and traction, which places an abnormal stress on the structures. Extensive ossification can eventually lead to ankylosis of parts of the spine. Another condition that also causes this result is spondylosis deformans, where the destruction of the inter-vertebral discs and the eburnation of the vertebral bodies cause reactive exostoses to form around the margins, which eventually bridge the gaps between the vertebrae, leading to ankylosis. It might be expected that this kind of degeneration would be seen in the thoracic area as a result of bearing excessive weight in the saddle area, but it is mostly the lumbar region that appears to be affected (Baker and Brothwell 1980), perhaps in compensation for the weight further forward.

It is worth considering the consequences of the conditions outlined above. Many of the animals with these problems would have been lame to some degree, either temporarily or permanently, and yet from the advanced cases seen in the archaeological record these animals must have carried on being worked (Baker and Brothwell 1980). For some of the conditions, such as spavin and ringbone, the animal could still be used for slow work if it was rested until the bones had ankylosed, when the pain would have been less. It seems that when there was no obvious external cause for the lameness many owners may have just carried on using the animal regardless, either through ignorance of the discomfort the animal was in or because of a need to use the animal to earn a living.

Another aspect oto take into account is the indication that some animals, such as white horses, had a 'magico-religious significance and there may have been attempts to preserve the life of these at whatever costs' (Baker and Brothwell 1980). Wells (1972 quoted in Baker and Brothwell 1980) suggests that lame horses were specifically selected for burial with chieftains of the proto-Scythians of around 400 BC in Siberia, either just to get rid of unsound animals or to preserve the good ones. These gifts were supposed to represent things needed in the afterlife, so what the ghost chieftain thought of having a crippled horse with him in the afterlife is anyone's guess!

It has also been suggested that some Roman military stablemen kept severely lame animals alive in order to keep the rations allotted them so in order to feed other horses or sell the rations for a profit (Baker and Brothwell 1980). The disregard of equine welfare was not universal, as the many Roman veterinary texts give good advice on the diagnosis and treatment of conditions that cause lameness. For instance, Vegetius mentions both laminitis and navicular bone disease, and recommends various forms of treatment including paring down the foot to let out pus; further examples have been given in Section 1.3. However, it seems that where a profit or livelihood was at stake, the wellbeing of the animals may well have come second.

As stated at the beginning of this section, many of these diseases and pathological conditions would affect the measurements taken on archaeological bones, but the advanced cases should be recognised as pathological and subsequently not measured. It is hoped that the degree of inaccuracy resulting from the measurement of mild cases that are not recognised as abnormal is not likely to be outside the range of normal variation, and therefore should not unduly affect the results of this research. Individual cases that appeared to be outliers in any distribution wrere carefully checked with the original documentation to determine if pathology could be the cause.

Chapter Three – Methodology

This chapter contains information on the methods employed to gather and analyse the data on which this research is based. The first section (3.1) outlines the reasoning behind the choice of measurements to be taken on the equid bones and how they were taken, providing the necessary information for the work to be repeated or expanded upon in the future. Also included here is information on how the archaeological data were sourced.

The second section (3.2) looks at the database used to collate all the information for this study. The layout of the database and how to use it are outlined. The information contained in the database includes the measurement data, together with context and dating information for the archaeological material and bibliographic references for all data taken from published and grey literature sources, the details of which form Chapter 5.

Section 3.3 briefly outlines the analytical and statistical techniques employed to produce the information required to address the research questions outlined in Chapter One. This includes t-tests, withers height calculations, discriminant function analysis and the log-ratio technique (including the production of a standard to work from).

Section 3.4 is slightly different from the previous three, the aim being to outline the methods available for the withers height reconstruction of equids, and provide a critical evaluation of these methods. This involved a small amount of analytical work to test the available methods in order to be able to evaluate their potential fairly, in particular to determine whether the use of factors based on horse bones could also be used on donkeys and mules.

3.1 Measurement choice and collection

3.1.1 Measurement choice

The choice of measurements to be taken was based on three criteria: measurements that could be most useful in differentiating horses, donkeys and mules; those that could provide information on size and shape; and those that were the most commonly taken on archaeological material. The first two criteria overlap to a great extent as those measurements that provide information on size and shape are also most likely to be those that differentiate horses, donkeys and mules. The choice of measurements was based on an ideal situation where all bones were fully adult and were not influenced by the problems of post-fusion growth of bones (as outlined in Chapter 2). However, the possible presence of unideal data had to be taken into consideration when the data were analysed and the results interpreted.

In order to accommodate the third criterion it was necessary to use the measurement system outlined by von den Driesch (1976) in the publication, *A guide to the measurement of animal bones from archaeological sites*, rather than that put forward by Eisenmann (1986). Although the Eisenmann system is specifically designed to allow the separation of equid species, it is not widely used by zooarchaeologists, thereby limiting the data available from published sources. Therefore the more widely used, if less specific system, of von den Driesch (1976) was used, and the measurements chosen are given in Table 3.1. A few measurements were added to this list in order to give a more three-dimensional representation of some bones: these are denoted in Table 3.1 with an '*' and are explained in detail below.

Table 3.1. Summary of measurements used for this study. Taken from von den Driesch (1976) except those with an '' which are explained in more detail below*

Element	Code	Name	Description
Cranium	1	Total length	From akrocranoin-prosthion
	2	Condylobasal length	Aboral border of occiptal conyles - prosthion
	3	Basal length	Basion - Prosthion
	9	Upper neurocranium length	Akrokranion - supraorbitale
	10	Facial length	Supraorbitale - Prosthion
	22	Length of cheektooth row	Measured at alveolar margins
	23	Length of molars	Measured at alveolar margins on buccal side
	24	Length of premolars	Measured at alveolar margins on buccal side
	34	Greatest breadth of occipital condyles	
	38	Greatest breadth of neurocranium	Euryon - Euryon
	40	Least breadth between supra-orbital foramina	
	41	Greatest breadth of skull	Ectorbitale - Ectorbitale
	43	Facial breadth	Between the points of the intersection of the maxillo-jugal suture and the facial ridge on each side
	45	Greatest breadth of the muzzle	Outer borders of alveoli I3-I3
	48	Greatest palatal breadth	Outer borders of alveoli
	50	Basion height	Basion -highest point of skull in projection
Mandible	1	Length from the angle	Gonion caudale - infradentale
	4	Length of horizontal ramus	Aboral border of the alveolus of M3 - infradentale
	6	Length of cheektooth row	Measured at alveolar margins
	7	Length of molars	Measured at alveolar margins on buccal side
	8	Length of premolars	Measured at alveolar margins on buccal side
	16	Greatest breadth of the muzzle	Outer borders of alveoli I3-I3
	18	Smallest breadth of diastema	

	20	Middle height of vertical ramus	Gonion ventrale - deepest point of mandibular notch
	22a	Height of horizontal ramus behind M3	Aboral point of alveolus of M3 to basal border
	23	Breadth of two halves	Between most lateral points of Gonion laterale
Scapula	SLC	Smallest breadth of collum scapulae	
	GLP	Greatest length of processus articularis	
	LG	Length of glenoid	
	BG	Breadth of glenoid	
Humerus	GLC	Greatest length from caput	
	GLl	Greatest length of lateral part	From cranial part of the lateral tuberosity to the most distal point of the lateral border of the trochlea
	SD	Smallest breadth of diaphysis	Measured in medio-lateral plane
	Bd	Breadth of distal end	From most lateral to most medial prominent points
	BT	Breadth of trochlea	Measured in the middle from the cranial side including the outer borders of both the lateral and medial condyles
	HTC*	Height of the trochlea constriction	Measured at an angle to find the smallest height (see Figure 3.1c)
Radius	GL	Greatest length	
	Ll	Lateral length	From lateral border of proximal articular facet to lateral border of distal articular facet.
	Bp	Breadth of the proximal end	
	BFp	Breadth of the proximal articular facet	
	SD	Smallest shaft diameter	Measured in the medio-lateral plane
	Bd	Breadth of the distal end	
	BFd	Breadth of the distal articular facet	
	DFd*	Depth of the distal articular facet	Measured at right angles to BFd (see Figure 3.1b)
Metacarpal	GL	Greatest length	
	Ll	Lateral length	
	Bp	Breadth of the proximal end	
	Dp	Depth of the proximal end	
	SD	Smallest shaft diameter	Measured in the medio-lateral plane
	Bd	Breadth of the distal end	
	Dd	Depth of the distal end	
Femur	GL	Greatest length	
	GLC	Greatest length from caput	
	DC	Diameter of caput	Greatest diameter of caput
	Bp	Breadth of the proximal end	
	SD	Smallest shaft diameter	Measured in the medio-lateral plane
	Bd	Breadth of the distal end	

Tibia	GL	Greatest length	
	Ll	Lateral length	
	Bp	Breadth of the proximal end	
	SD	Smallest shaft diameter	Measured in the medio-lateral plane
	Bd	Breadth of the distal end	
	Dd	Depth of the distal end	At right angles to Bd, resting on two points on the anterior edge
Astragalus	GH	Greatest height	
	BFd	Breadth of distal articular facet	
Calcaneum	GL	Greatest length	
	GB	Greatest breadth	
	DS*	Depth of sustentaculum	See picture below (see Figure 3.1d)
Metatarsal		As metacarpal	
1st Phalanx	GL	Greatest length	Perpendicular not at an angle
	Bp	Breadth of the proximal end	
	Dp	Depth of the proximal end	
	SD	Smallest shaft diameter	Measured in the medio-lateral plane
	BFd	Breadth of the distal articular facet	
	DFd*	Depth of the distal end	Measured at right angles to BFd (see Figure 3.1a)

The following measurements are non-standard and are explained in full here: first phalanx DFd, radius DFd, humerus HTC, and calcaneum DS. The reason extra measurements were added was so that a three-dimensional picture of the bone could be built up. This was only done in cases where the resulting measurement could be taken consistently and accurately. These extra measurements were taken on the modern reference material; there was no comparable data in the archaeological literature. It is suggested here that these measurements are taken in the future, as they are used in determining species (see Chapter 4).

On the first phalanx, DFd stands for the depth of the distal articular facet, taken as shown in Figure 3.1a. One side of the callipers should touch both parts of the distal facet, as indicated by the arrows and should be at right angles to where BFd is taken. The DFd on the radius is taken in a similar way, at right angles to BFd as illustrated in Figure 3.1b. Only the widest part of the articular facet touches the callipers. If both touch the measurement is taken too much on the diagonal.

Measurement HTC (height of the trochlea constriction) is taken as shown in Payne and Bull (1988) for use on pig humeri. It is taken as the smallest diameter of the trochlea constriction, which in most cases means the callipers are at a diagonal to the shaft of the humerus, as shown in Figure 3.1c.

For the measurement on the calcaneum, DS is the depth of the sustentaculum. This is taken as shown in Figure 3.1d from the most lateral and posterior part of the sustentaculum to the most anterior 'nose' of the calcaneum. This means that the measurement is taken slightly diagonally to the axis of the bone.

All measurements taken by the author on the modern reference material were taken in one of three ways depending on the size of the measurement and its orientation. For measurements of less than 300 mm callipers were used, a set of dial callipers for less than 150 mm and larger Vernier scale callipers for those between 150 and 300 mm. Where the measurement exceeded 300 mm an improvised measuring box was employed. This consisted of a tape measure and two pieces of cardboard bent at right angles. The reason for using an improvised rather than 'real' measuring box was the need for a portable piece of equipment that could be used when travelling to visit reference collections abroad. This equipment was tested against a fixed measuring box in the laboratory and found to be accurate to within 2 mm. This was felt to be sufficiently accurate, as this is an error of less than 1% of the measurements and many of the subsequent analyses (such as withers height estimation) have relatively large calculation errors. Where the use of a measuring box was not possible (i.e. for certain skull measurements) the tape measure was used on its own. This means that measurements greater than 300 mm are quoted to the nearest 1 mm and those under 300 mm are given to 0.1 mm accuracy.

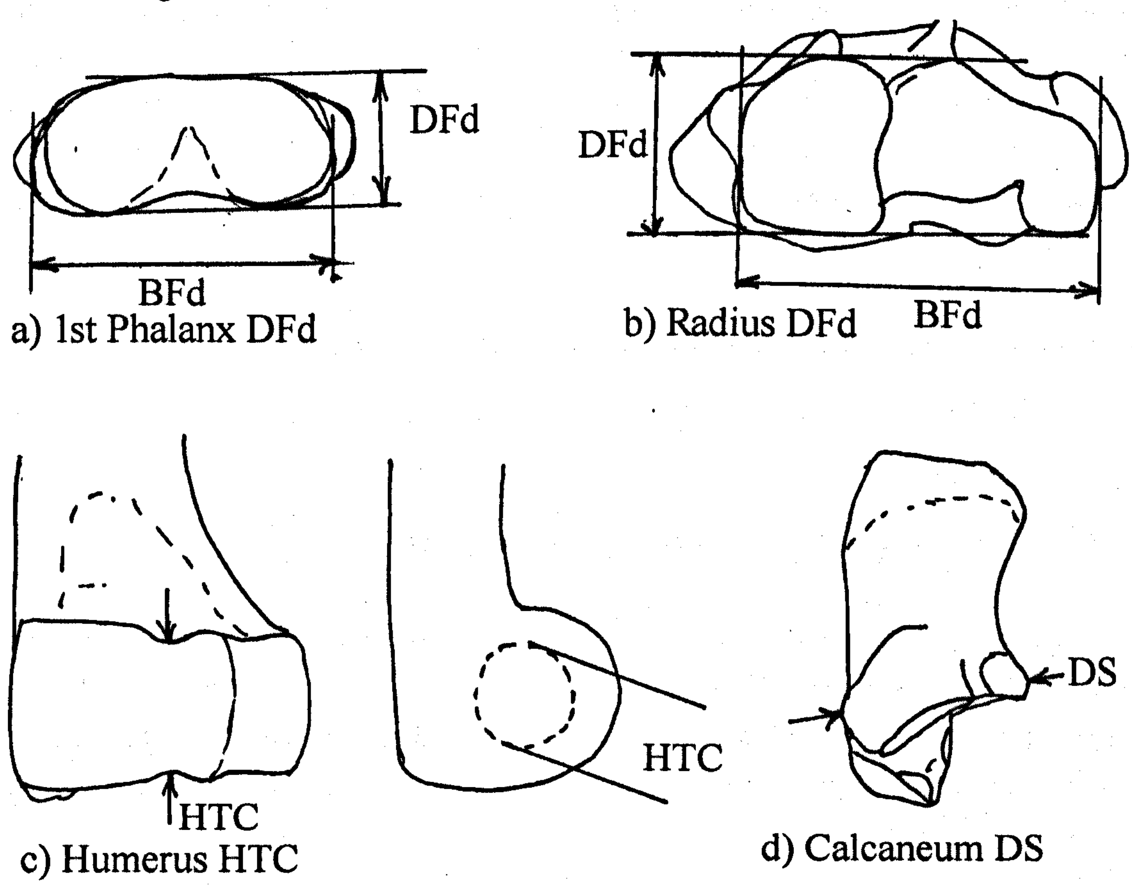


Figure 3.1. Illustrations of how the extra measurements were taken on the first phalanx, radius, humerus and calcaneum.

3.1.2 Data collection

Data were collected by the author from modern reference specimens of known species in laboratory and museum collections. The details of these collections and specimens are given in Chapter 5 and Appendix Table A1.

The collection of most archaeological data was not carried out first-hand but taken from published material because the time limits of a PhD thesis did not allow enough data to be collected personally by the author. Accuracy and consistency are very important factors in a study like this and many discussions have taken place about precision and intra- and inter-observer errors (Johnstone 1999; Reitz and Wing 2000). It is the major drawback to using published data. However, this was the only method of data collection available, so data from other workers have had to be taken on trust.

A problem with many older reports was that the von den Driesch (1976) system of measurement had not been used and/or how the measurements were taken was not fully explained. In these cases, only the measurements that could be equated fully with the von den Driesch (1976) equivalent from the descriptions given were included in the database.

Sources of archaeological data known to the author were collected first. This included material studied at first-hand and reports consulted in the process of writing up those sites. Secondarily, the bibliographies of these reports were studied for further sources of data. Where the raw measurement data were not present in the reports authors were contacted with requests for that data. In addition, colleagues in many countries were contacted concerning either their own work or reports they could provide copies of or references for. Requests for data were also placed on the ZOOARCH e-mail list and replies received. Periodically the data were analysed to check that a good geographic and temporal spread was being achieved. The data collection efforts were then targeted to fill gaps and expand 'thin patches'.

3.2 Database construction and structure

The database used to collect and store all the data for this project was constructed using Borland Paradox software (Version 7). This package was used because the author was already familiar with using it to construct databases and enter and extract data from them and at the start of the project it was supported on the University of York, (UK) internal network. Parts of the basic structure and some of the coding behind the user interface were taken from a bone recording database constructed by John Carrott and Debs Jaques for the Environmental Archaeology Unit, York, to whom I am indebted for teaching me how to use and adapt the original.

The database consists of a number of inter-linked forms and tables. The forms are the user interface, whilst the tables contain all the data entered by the user. The basic structure and forms of the database is shown in Figure 3.2. Each form is linked to the other forms joined to it as indicated by lines in Figure 3.2. These links are bi-directional i.e. the user can go forwards and backwards between forms. Each form has a series of buttons that perform tasks related to that form and its associated table and also take the user between forms in the database. If a record needs to be deleted for some reason then the 'delete current record' button is used. When all information has been entered for a site (in all forms) the 'next record' button is clicked. Some of the boxes (called fields) are automatically filled by the software, whilst others have 'lookup' tables (accessed by pressing the space bar) to enable consistent (and limited) information to be put into a field, and the remainder are used for plain text.

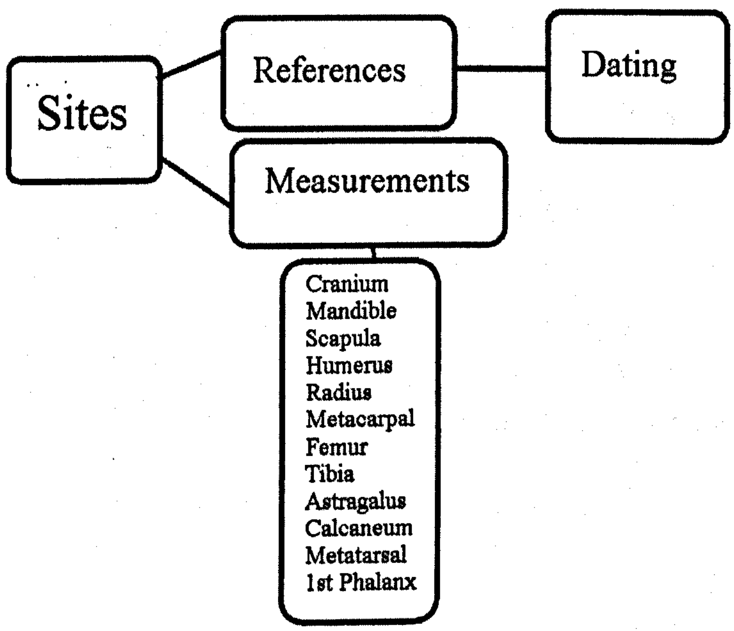


Figure 3.2. Flow diagram of database form structure

The Sites form (shown in Figure 3.3) is the starting point for entering data. This form requires general information about the site from which a particular bone assemblage was collected. The 'Site ID no.' field is an automatically generated integer so that number repetition cannot occur. The 'period' field has a lookup table, allowing only a limited number of periods to be entered. The rest of the fields are all plain text fields and are self-explanatory.

Following the flow chart in Figure 3.2, there are two possible directions can be taken. One is to fill in the References form (Figure 3.4), which has a number of fields and buttons similar to the Sites form, the software automatically carries across the 'Site ID no.' from the previous form, so it does not have to be entered manually. The bibliographic details are then entered into the remaining fields. The Dating form (Figure 3.5) can then be accessed and the phasing and dating information for the current site entered. Again the 'Site ID no.' is brought across automatically. On a multi-phase site the 'next record' button is used between each phase.

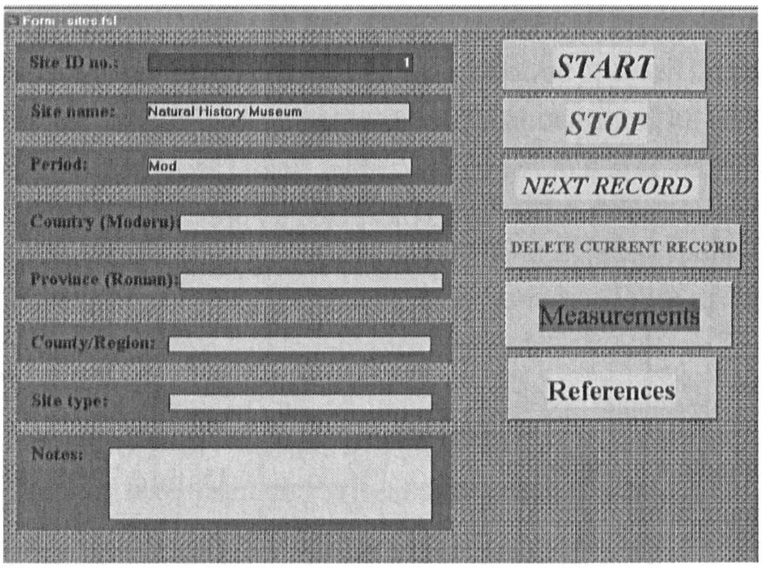


Figure 3.3. Layout and appearance of the Sites form.

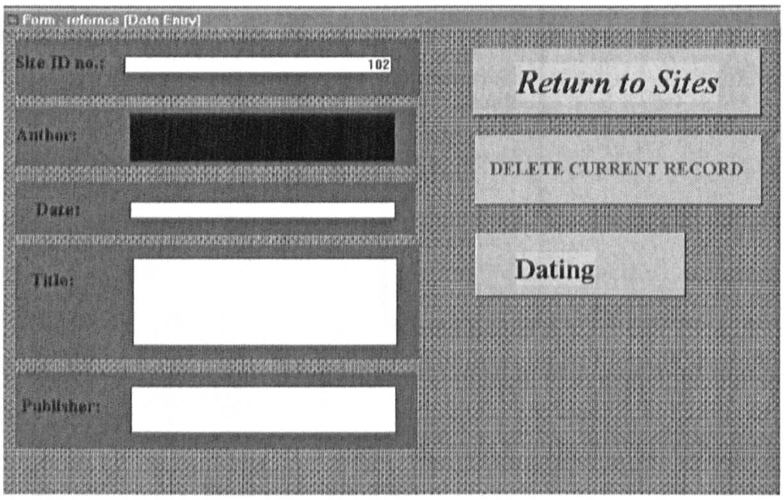


Figure 3.4. Layout and appearance of the References form.

By navigating back to the Sites form the second route can be taken using the 'Measurements' button, which brings up a menu containing a list of bone elements, one of which can then be selected. The sample form shown in Figure 3.6 is for the humerus. As before the 'Site ID no.' is brought across automatically. The measurement values are then typed in the correct column with the codes as given in Table 3.1 above. The measurements for all the specimens of that element can be typed by clicking the 'Next record' button between specimens.

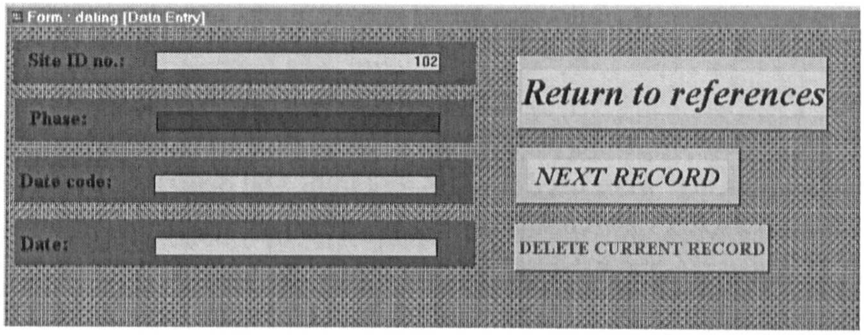
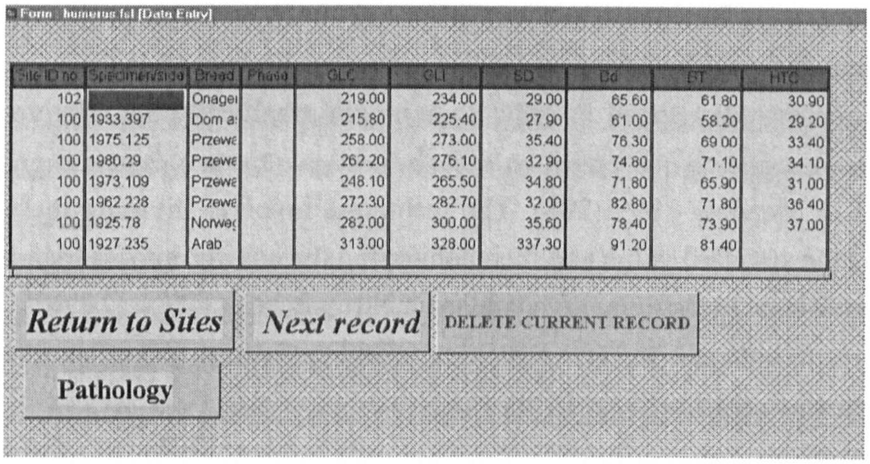


Figure 3.5. Layout and appearance of the Dating form.



Site ID no	Specimen/side	Breed	Phase	GLC	GLl	SD	Bd	BT	HTC
102		Onage		219.00	234.00	29.00	65.60	61.80	30.90
100	1933.397	Dom a		215.80	225.40	27.90	61.00	58.20	29.20
100	1975.125	Przewa		258.00	273.00	35.40	76.30	69.00	33.40
100	1980.29	Przewa		262.20	276.10	32.90	74.80	71.10	34.10
100	1973.109	Przewa		248.10	265.50	34.80	71.80	65.90	31.00
100	1962.228	Przewa		272.30	282.70	32.00	82.80	71.80	36.40
100	1925.78	Norweg		282.00	300.00	35.60	78.40	73.90	37.00
100	1927.235	Arab		313.00	328.00	337.30	91.20	81.40	

Figure 3.6. Layout and appearance of the Humerus form.

The tables that contain all the information entered via the forms also contain additional information that is generated by the computer. For instance, all the tables containing the measurements by element also have a field into which the name of the element is automatically recorded, and a bone ID number is also generated by the computer for each specimen. This last information is required when the data are analysed so that each record has a unique identifier. This is necessary so that repeated data (e.g. identical measurements) are not overlooked. The queries function is used to extract specific data from the database by asking questions of single tables or multiple linked tables.

3.3 Analytical techniques and statistics

The aim of this section is briefly to introduce some of the more complex analytical and statistical techniques that were used for this research. The descriptions will be limited to how the techniques were undertaken and applied, rather than a detailed account of the statistical formulae and principles on which the tests are based.

3.3.1 Log-ratio technique

This technique was first published by Simpson (1941) and was proposed for use on archaeological material by Meadow (1981) (although he termed it the log size index). 'The technique was developed in order to compare graphically the relative rather than absolute dimensions of a number of animals or groups of animals' (Simpson *et al.* 1960: 356, quoted in Meadow 1999: 288). The technique involves dividing the value of the specimen by the standard value and then converting the answer into its logarithm:

$\log_{10}$ (archaeological measurement / standard measurement).

A negative result indicates the archaeological specimen is from a smaller animal than the standard, and *vice versa*.

The standard can be the measurements of a single specimen or the means of the measurements from a group of specimens, either archaeological or modern. Eisenmann and Bekouche (1986) used the mean of the measurements of a sample of one particular species (the onager: *E. hemionus*) as the standard. The means of the other species were then tested against this. There are many ways of graphically displaying the results of this technique, depending on the exact nature of the data and what information is required from it. Eisenmann and Bekouche (1986) plotted the mean values of the measurements of different species against each other as line diagrams to see differences in the proportions of measurements from the standard (e.g. Figure 4.16). Other workers (e.g. Albarella 2002; Johnstone and Albarella 2002) have made histograms of the results to see if a sample is generally larger or smaller than the standard, and to detect changes in size through time. This will be the most usual display method in this research, as the technique will mostly be employed to detect differences in size between groups of data.

An advantage of this technique is that measurements from different elements can be pooled, once the log-ratio has been undertaken, because they are then directly comparable, thereby optimising the use of sparse data. It should be noted however, that the best results are obtained from pooling measurements in a single direction (e.g. all length measurements), rather than using all available measurements (e.g. lengths, breadths and depths) together (Davis 1996; Meadow 1999). Another advantage of this technique is a rescaling of the variance of the data. If the ratios of the specimens to the standard are taken without conversion to logarithms, the variance of the sample is substantially increased. The conversion to logarithmic values brings the variance back down to a level near that of the original data.

There is no published standard for calculating log-ratios of horse (or any equid) remains. Therefore a standard had to be established for use in this research. The original proposal was to use the mean values of the data obtained from modern Przewalski horses in reference collections. The reasoning behind this choice was that a reasonably large sample of Przewalski horses, including both males and females and a variety of ages, was available. There is very little variation in phenotype between Przewalski individuals and their physical appearance is reasonably widely known. However, it was discovered that Przewalski horses have significantly different limb proportions to those of domestic horses (see Section 3.4 below), making them unsuitable as a standard against which to compare archaeological domestic horses.

Therefore, a similar group of domestic horses was needed to construct a standard. A breed such as the Exmoor would be ideal as it also has little phenotypic variation (in pure-bred individuals). Although a collection of Exmoor individuals does exist in the laboratory at Cambridge University (Cambridge, UK), the keeper of that collection denied access to the author. Although Dr Marsha Levine has made use of the Cambridge Exmoor collection in published works, the biometric data have never been published. Therefore an important and potentially very useful dataset is unavailable for use by the zooarchaeological community.

As a result of this, it was decided to use the measurements of three Mongolian ponies from the collection at the Museum für Haustierkunde (Halle, Germany), as the standard for this research. The individuals (Numbers E mgl 1, E mgl 3 and E mgl 4) were all female, all of a similar size and aged about 15 years, 14 years and 16 years respectively. All were collected as part of Hagenbeck's expedition to Mongolia in 1901, and were adult at the time they were caught so the ages may be underestimated by a few years. Some pathological bones were noted in one individual, but only the left hock was involved so the measurements of the unaffected right hock were taken.

Table 3.2 gives the means of the measurements of the three Mongolian ponies for use as the standard against which to compare the archaeological material when using the log-ratio technique.

Table 3.2. The mean of the measurements of three Mongolian ponies for use as the standard in log ratio calculations.For codes see Table 3.1

Scapula	SLC	GLP	LG	BG				
	62.37	90.77	56.93	48.47				
Humerus	GLC	GLl	SD	Bd	BT	HTC		
	267.70	287.17	34.80	81.70	72.90	36.07		
Radius	Gl	Ll	Bp	BFp	SD	Bd	BFd	DFd
	316.33	298.67	79.87	71.13	35.60	74.47	62.17	36.13
Metacarpal	Gl	Ll	Bp	Dp	SD	Bd	Dd	
	216.17	207.03	47.17	32.17	31.40	44.70	35.30	
Femur	GL	GLC	DC	Bp	SD	Bd		
	383.00	349.67	57.63	114.67	39.57	92.03		
Tibia	GL	Ll	Bp	SD	Bd	Dd		
	337.33	306.33	95.50	40.23	71.63	45.23		
Astragalus	GH	BFd	**Calcaneum**	GL	GB			
	55.53	50.67		107.23	50.73			
Metatarsal	Gl	Ll	Bp	Dp	SD	Bd	Dd	
	258.07	249.17	48.70	44.33	30.63	47.27	36.90	
Phalanx 1	GL	Bp	Dp	SD	BFd	Dd		
(Fore)	82.20	54.97	36.00	34.60	42.80	24.37		
Phalanx 1	GL	Bp	Dp	SD	BFd	Dd		
(Hind)	78.30	53.67	38.07	33.47	41.00	24.27		
Phalanx 1	GL	Bp	Dp	SD	BFd	Dd		
(Both)	80.25	54.32	37.03	34.03	41.90	24.32		

3.3.2 Student's t-tests

Student's t-tests were used to determine the significance of observed differences between sets of data. These tests have been employed in a slightly unorthodox way because of the limitations of archaeological data. For instance, in some cases there was no guarantee that the specimens from a sample were completely independent (i.e. some bones could theoretically belong to the same individual). However, because t-tests require independence of data points, it was assumed for the present present research purposes. The exception to this was where the bones were obviously not independent, i.e. when a whole skeleton or articulated limb was analysed. In this case either a mean value calculated from all the bones or measurements from a single bone, taken as representative, were used, depending on the exact circumstances of the calculation.

The t-tests were carried out using Micrsoft Excel software. The data analysis tools in this software include several versions of the t-test; for this research the 'two samples: assuming equal variance' option was used. This is because the purpose was to test the difference between two datasets, both of which consist of measurement data, mostly from a single element, the variance of which is unlikely to be significantly different (Johnstone and Albarella 2002: 7). The test was usually only undertaken when the sample size was greater than 10, to limit the errors associated with small sample size. The degrees of freedom are not stated for each test but can be calculated from the summary tables given using the following formula: d.f = n - 1, where n is the number of cases.

3.3.3 Discriminant function analysis

Discriminant function analysis uses multiple variables to find the maximum separation between groups of data. It also quantifies the scale and direction of differences between pre-defined groups and the statistical significance of the discriminating functions produced (Baxter 2003). The software will also reclassify the known cases to test the validity of the discriminating criteria. This technique was used for the separation of horse, donkey and mule bones (see Chapter 4 for the results).

The discriminant function analysis was carried out using SPSS (version 10) software. In order that the methodology can be repeated, the following paragraph should allow other workers to obtain the same results, even if not using exactly the same software package. The analysis was undertaken for each element individually, using species as the grouping variable and the chosen measurements (see Section 3.1) as the independent variables. Output options were set to give case-by-case discriminant data, so that the identification result, posterior probability, and Mahalanobis distance for each individual specimen were obtained as well as a summary table. A plot of all cases was also produced using the first two canonical functions as the axes. SPSS automatically gives the Eigenvalues, chi-squared results, group centroids and standardised canonical discriminant function coefficients, but these may need to be requested in other software packages.

In addition, pair-wise analyses were carried out for each element, to test whether the species could be separated when only two were present. This was to test whether the small size of the dataset (particularly for mules) was limiting the success of the discriminating criteria when all three were analysed together. The same variables and output options were used for this analysis, as described in the last paragraph.

Once the best results for each element had been established using the modern data (Chapter 4), the methodology was applied to the archaeological data and a method of assessing the likelihood that the resulting identifications were correct was established. The first part was straightforward: the analyses were rerun with the archaeological data as ungrouped cases (i.e. outside the range of the grouping variables). The resulting plots show the archaeological points and the summary tables give the statistics and group membership for the archaeological specimens.

It was thought likely that there would be a spread of points, similar to those seen for the modern data, leading to 'grey areas' between the group centroids where the identifications may be less clear. In order to filter out the uncertain group attributions, the identification results were subjected to the following procedure in order to clarify which were most likely to be correct. To achieve this two additional statistics were analysed: the Mahalanobis distance from the centroid and the posterior probability of group membership. The standard deviation (SD) of the Mahalanobis distances from the centroid for the modern data was calculated so that a limit of 1 SD from the group centroid could be defined. Levels of identifications were then assigned to each case on the following basis.

- Definite identifications were assigned to those bones with a Mahalanobis distance within 1 SD of the group centroid and with a posterior probability of group membership higher than 0.8 (where 1 = certainty)
- Probable identifications were assigned where one of the above criteria was met
- Possible identifications were assigned where neither criterion was met.

3.3.4 Withers height calculations

The estimation of withers height from the length of bones is an established zooarchaeological method of comparing the size of animals, for example, between phases of a site or in comparison to modern breeds (Reitz and Wing 2000; O'Connor 2000). It also has the advantage of increasing the size of the sample that can be used by making measurements from different elements directly comparable (O'Connor 2000). The withers are the highest point of the shoulders, at the base of the neck; therefore withers height is sometimes also referred to as shoulder height, particularly for animals other than equids that have less prominent withers. Withers heights will mostly be quoted in millimetres throughout the results, with conversions to hands (see Section 1.5.5) where comparisons with modern breeds are made and elsewhere when approportiate.

The calculation of withers height from the length of the long bones is simply a process of multiplying the greatest (or lateral) length of the bone in question by a pre-determined factor, as discussed in more depth in Section 3.4. Once the withers height data have been calculated for each element they can be combined and then displayed in the same ways as other measurement data, for instance as histograms.

3.4 Critical evaluation of withers height calculation methods

Withers height calculations have been briefly introduced above. The aim of this section is to present an evaluation of the published methodologies and indicate which was the best to use for this research. Methods of calculating horse withers heights only arer evaluated. They cannot be used without modification on donkeys and mules. Because the latter have differently proportioned limbs to those of horses, factors calculated for use on horse bones may produce withers heights that are consistently too large or too small on certain elements. This problem will be addressed later in this section.

There are a number of issues relating to the calculation of the withers height from bone length that should be addressed before talking about the methods themselves. Many of these issues have been raised by von den Driesch and Boessneck (1974) and May (1985).

There are many factors that can influence the relationship of bone length to withers height in individuals, and include all the factors that can affect bone growth (see Chapter 2). In particular, sexual dimorphism and castration, body shape (pony/horse conformation, different breeds) and nutrition (individual and population differences) affect the relationship of the bone length to the withers height, or rather the proportional contribution that each element makes to the overall withers height.

For instance, if an individual experiences a period of poor nutrition during growth, then those bones that are already fused will not be affected but the growth of unfused bones could be stunted, resulting in different limb proportions compared with a well nourished individual (Section 2.3.3). The same kind of effect might be observed in castrated individuals, depending on the age at castration (Section 2.3.2). This may even be a human-influenced problem: for instance the oxen (castrated male cattle) of villagers in Bosnia were found to be bigger than the cows and bulls as a result of being better fed, since they were considered of more importance as working animals (von den Driesch and Boessneck 1974).

In addition to calculating withers heights from the major long bones, it has been attempted from other bones of the skeleton. Kiesewalter (1888) provided factors for calculating the withers height from the size of the vertebrae, pelvis, tarsus and first phalanx, as well as the long bones and skull. However, none of them is particularly reliable (von den Driesch and Boessneck 1974), either because the measurements are too small, which makes the errors of multiplication too great, or the measurements are not closely enough correlated will the withers height. Problems of accurately measuring a group of bones together (i.e. the tarsals) also cause errors. Sometimes a combination of these problems compounds the errors of the final calculation.

Several workers have tried to use the skull length to calculate withers height (Nehring 1884; Kiesewalter 1888; Vitt 1952). However, there are a number of problems with this calculation, such as which skull length measurement is used for the calculation where the descriptions are not particularly clear. The basilar length is used in Vitt's (1952) calculations, whilst the profile length is used with Kiesewalter's (1888) factors. Also, the skull length is not nearly as closely correlated with the withers height as the limb bone lengths. For example, the Arab horse has a naturally short head and the Przewalski a large one in comparison to overall size when compared with other breeds.

The calculation of withers height from skull length can give an indication of the size of the head of an individual in relation to overall size, and therefore the look of the animal as a whole. It is useful in comparing individuals from different sites or phases but is not a good measure of height on its own (von den Driesch and Boessneck 1974). May (1985) suggests that the use of a regression equation for the calculation of the withers height from the skull length is slightly more accurate than using a simple multiplication factor. However, it should still only be used with the above restrictions placed on the interpretation of results.

Another thing to bear in mind when calculating and interpreting the results of withers height estimations is the errors inherent in the calculation and possible range of variation in a population. The difference between the actual withers height and the estimated value has been estimated to be as much as 100 mm, with an average of 40 to 50 mm either side of the estimated value (Von den Driesch and Boessneck 1974; May 1985). May (1985) has also worked out that these calculation errors are not reduced when combinations of elements are used in the calculations instead of single elements, suggesting that this is about the limit to which the error can be reduced.

In addition to the calculation errors, there is also the problem of population variation. Von den Driesch and Boessneck (1974) suggest that a range of variation of 200 to 250 mm is normal for a modern breed or a confined prehistoric population. Therefore the overall range of variation can be much larger when one considers the possibility of cross-cultural contact and trade, such as across the boundaries of the Roman Empire. This is illustrated by the horse bones from Manching, Germany which show a great range of withers heights (1120 to 1480 mm), the largest individuals of which, it is argued, clearly show influence from the neighbouring Roman horse populations (Boessneck *et al.* 1971).

Therefore, when only a few bones are recovered from a site the sample may not represent the full range of variation of the population. This can then lead to misleading interpretations of the data. For instance, if few bones are recovered and all give tall (or short) withers height values, then a statement to the effect that horses on that site are large (or small) could be misleading. Sample size is something that has to be considered when interpreting the results of withers height reconstructions and the data placed in a wider context.

It should therefore be remembered that all reconstructed withers heights can only be estimates. The published methods are based on a limited number of individual skeletons from reference collections and will reflect the proportions of those individuals. The problem of a small sample not being representative of the whole population also applies here.

Moving on to a discussion of the specific methods, there are two established systems in the published literature for reconstructing the withers height of horses from the length of the long bones. The first of these is the system published by Kiesewalter (1888) and the second by Vitt (1952). Both methods have previously been evaluated by von den Driesch and Boessneck (1974), Ambros and Müller (1975) and May (1985) and, rather than repeat the work contained in those three papers, a summary of the findings will be presented here together with an overview of the two methods.

The Kiesewalter (1888) method uses a simple multiplication factor to obtain the estimated withers height from the length of the bone. The factors given in Table 3.3 are those quoted in von den Driesch and Boessneck (1974); they note that in Kiesewalter's (1888) original publication a mistake had been made with the factor for the humerus, which they corrected for their paper. To calculate the withers height from a single bone, the length of the bone (exactly which measurement is specified in the second column) is multiplied by the factor in the third column, the result being the withers height estimate. The unit of measurement of the calculated withers height will be the same as that used for the initial bone measurement.

Worked example using a modern Exmoor pony metacarpal: the lateral length 200.6 mm, when multiplied by the factor 6.41, produces an estimated withers height of 1285 mm (12.3 hh).

Table 3.3. Multiplication factors for calculating horse withers heights using the system of Kiesewalter (1888) as taken from von den Driesch and Boessneck (1974)

Element	Measurement to be used	Multiplication factor
Skull	Total length (1)	2.7
Scapula	Greatest length	4.28
Humerus	Greatest lateral length (GLl)	4.87
Radius	Lateral length (Ll)	4.34
Radius + Ulna	Greatest lateral length	3.40
Metacarpal	Lateral length (Ll)	6.41
Femur	Greatest length (GL)	3.51
Tibia	Lateral length (Ll)	4.36
Metatarsal	Lateral length (Ll)	5.33

Quoting the withers height to the nearest millimetre may be seen as spurious precision when the preceding comments on the accuracy of the method are taken into account. However, it is felt that this level of precision needs to be maintained for further analytical work, so that the results are presented as accurately as possible. Therefore, where a withers height is quoted to 1285 mm this should be read as 1285 ± ~50 mm. This is similar to ^{14}C dates that are quoted to a year, but with a ± error either specified or implied. In this instance, because the error is only an estimate (based on the figures given above from other workers' estimates), not a calculated figure, it is not systematically repeated on all the withers height estimates. The 80 mm ranges quoted in Vitt's (1952) work (Table 3.4) would therefore give an estimated ± figure of 40 mm, which is the lowest average figure suggested by the workers mentioned above.

However, because Kiesewalter's (1888) factors were not calculated from the living heights of individuals but were based on the estimation of the withers heights from mounted skeletons (as stated in von den Driesch and Boessneck 1974; Ambros and Müller 1975), they could underestimate the withers height of archaeological horses but will definitely not overestimate them. The reason they may underestimate the withers height is because no allowance is made for joint cartilage and synovial capsules, hooves and the ligaments, muscles and skin of the withers area. The accuracy of this method was tested by May (1985) and found to be as accurate as the method of Vitt (1952), which was based on living withers heights.

The method published by Vitt (1952) works on a slightly different principle. He published a table of values (reproduced as Table 3.4) that gives a range of estimated withers heights that corresponds to a range of greatest length measurements. It should be noted that Vitt's (1952) method works with the greatest length not the lateral length (see below).

Worked example using the same Exmoor bone as previously: this time using the greatest length of 210.0 mm. Looking along the metacarpal row in Table 3.4 to find the range containing 210.0 mm ('smaller than average' column 205 to 220 mm) and looking down to the last row gives a withers height range of 1280 to 1360 mm (12.2 to 13.2 hh). This shows that the estimate produced using Kiesewalter's (1888) method falls within the range from Vitt's (1952) data table.

Although giving a range for the withers height alleviates the problems of calculation errors discussed above, it has the disadvantage that further analytical work cannot be undertaken on the values. For instance, histograms of withers heights can only be constructed using the ranges defined in the table and little statistical analysis can be undertaken to illustrate differences between periods or sites, with the exception of frequency comparisons. For this reason Vitt's (1952) method as it stands was not well suited to the current research.

Table 3.4. Table of values for the greatest length of the bones and their corresponding withers height range (taken from Vitt 1952)

Element	Measurement to be used (all given in mm)	Lower limit	Very small	Small	Smaller than average
Skull	Basilar length	400	400-425	425-450	450-475
Humerus	Greatest length (GL)	230	230-250	250-270	270-290
Radius	Greatest length (GL)	270	270-290	290-310	310-330
Metacarpal	Greatest length (GL)	175	175-190	190-205	205-220
Femur	Greatest length (GL)	330	330-350	350-370	370-390
Tibia	Greatest length (GL)	285	285-305	305-325	325-345
Metatarsal	Greatest length (GL)	215	215-230	230-245	245-260
Withers height	**In mm**	**<1120**	**1120-1200**	**1200-1280**	**1280-1360**

Element	Average	Larger than average	Large	Very Large	Upper limit
Skull	475-500	500-525	525-550	550-575	575
Humerus	290-310	310-330	330-350	350-370	370
Radius	330-350	350-370	370-390	390-410	410
Metacarpal	220-235	235-250	250-265	265-280	280
Femur	390-410	410-430	430-450	450-470	470
Tibia	345-365	365-385	385-405	405-425	425
Metatarsal	260-275	275-290	290-305	305-320	320
Withers height	**1360-1440**	**1440-1520**	**1520-1600**	**1600-1680**	**1680**

A point that has caused confusion (and therefore wrong results) on many occasions is that the method of Vitt (1952) uses the greatest length whilst that of Kiesewalter (1888) uses the lateral length. A few cases where confusion has happened are quoted von den Driesch and Boessneck (1974) and May (1985). In addition, the author recently came across a poster at a conference (Lyublyanovics 2002) where the mistake occurred again. The poster claimed to have found particularly tall horses from the Roman site of Albertfalva (near Budapest, Hungary). However, the greatest length had been used in conjunction with Kiesewalter's factors. This meant that the withers heights were overestimated by as much as 130 mm (apart from the inherent errors of the method). Therefore, the Albertfalva horses were probably of a stature normal for the period rather than exceptionally large. This example illustrates the fact that because the greatest length can be as much as 25 mm longer than the lateral length, using GL with Kiesewalter's (1888) factors will overestimate the withers height (and *vice versa* using Ll in Vitt's (1952) table).

May (1985) discusses the issue of whether the withers height calculations are subject to allometry, i.e. whether the proportions of the limb elements to withers height are different in larger individuals than in smaller ones. This would mean that the withers height calculation is not linear and the use of simple multiplication factors would be inappropriate. To test this May (1985) used both linear and logarithmic regression equations of both

Kiesewalter's (1888) factors and the equations on which Vitt's (1952) table were based, to show that both methods produce very similar results that are close to the known withers height of the sample. Therefore, whilst there is a clear allometric (non-linear) relationship between bone length and withers height in mammals as a whole, horses occupy a short enough section of the curve that it approximates a straight line. Hence, allometry does not play a significant role in these calculations. This conclusion means that simple multiplication factors for estimating the withers height are quite satisfactory and produce results with acceptable error ranges.

Just as von den Driesch and Boessneck (1974) had to correct the Kiesewalter (1888) humerus factor, May (1985) adjusted all of the factors very slightly so that they are more accurate; this mainly involved using three decimal places rather than two. In addition, May (1985) tackled the problem of not being able to use the Vitt (1952) ranges for further work by calculating factors for use with the greatest length from the tables of Vitt. Table 3.5 below shows the two sets of corrected factors as given by May (1985). These are the factors that will be used for this research as it allows use to be made of published measurements where either the lateral length or greatest length were taken.

Table 3.5. Corrected factors for the determination of the withers height from the lateral lengths (based on Kiesewalter 1888) and greatest lengths (based on Vitt 1952) of the long bones, taken from May (1985).

Element	Factors using Ll	Factors using GL
Humerus	4.868	4.634
Radius	4.317	4.111
Metacarpal	6.403	6.102
Femur	3.501	3.501
Tibia	4.361	3.947
Metatarsal	5.331	5.239

Worked example using the same bone aspreviously: the lateral length (200.6 mm) gives a withers height of 1284 mm (12.3 hh) and the greatest length (210.0 mm) gives a withers height of 1281 mm (12.3 hh). A difference of only 3 mm in the calculated withers heights from the two measurements on the same bone shows the close agreement of the two methods. Other individuals tested showed up to 20 mm difference between the two estimated wither height values, suggesting a range of individual variation in the morphology of the bones. However, this difference falls within the inherent errors of the method and is such a small proportion of the overall height that it will not greatly affect any subsequent analytical work.

The measurements from the skull of the Exnoor individual used in the worked examples above wee then used to see if the skull is in proportion to the body. The basilar length of this individual is 462 mm. Using the regression equation of May (1985):

Withers height (WH) = (3.268 x basilar length) –194.82

WH = (3.268 x 462) – 194.82

WH = 1315.0 mm

This shows that the head of this Exmoor individual is only slightly larger than average in relation to its body size, and for this individual this way of calculating the withers height is relatively accurate. However on other modern skeletons the difference was far greater, underlining the statements made above that this method should only be used in conjunction with the limb bone estimates, not by itself.

When calculating the withers height from all the long bones of a single individual, Ambros and Müller (1975) state that a range of 70–80 mm in the estimates from the different elements is acceptable, but if it is greater than 100 mm it should be thought of as an extreme value and the possibility that the bones are not from the same individual should be considered. However, when the withers heights were calculated for all the long bones from the modern reference specimens that are known to be the same individuals the difference between almost all of the values was over 70 mm and many were over 100 mm (Table 3.6). This seems to contradict the argument of Ambros and Müller (1975) and therefore it is suggested here that, where a difference of more than 150 mm is calculated from the bones of an alleged single skeleton, the possibility that the bones are not from the same individual should be considered.

Table 3.6. The minimum, maximum, mean and difference (all in mm) for the calculated withers heights of modern horse reference specimens. Specimen no's from Table A1

Specimen Number	Breed	Mean	Min	Max	Difference
1927.235	Arab	1580.9	1515.9	1610.0	94.0
24.5.4.1	Arab	1524.6	1480.9	1543.7	62.7
37.1.26.10	Arab	1586.2	1543.4	1651.4	108.1
E arb 3	Arab	1468.8	1421.4	1514.0	92.5
H40	Arab pony	1478.8	1413.9	1528.1	114.2
1937.51	Pony	1000.1	953.8	1067.6	113.7
BZL1	Pony	1166.8	1086.7	1235.9	149.1
E pon 1	Pony	1369.1	1325.4	1425.9	100.5
LWH3	Pony	1234.6	1211.9	1259.2	47.3
BZL332	Exmoor	1334.0	1282.9	1382.5	99.6
1961/29	Icelandic	1280.9	1242.9	1305.6	62.7
E mgl 1	Mongolian	1334.0	1290.5	1367.9	77.4
E mgl 3	Mongolian	1318.6	1274.0	1352.5	78.6
E mgl 4	Mongolian	1348.5	1320.2	1402.0	81.8
H37	New Forest	1220.1	1165.6	1254.5	88.9
L2161	New Forest	1377.8	1338.7	1424.0	85.3
1925.78	Norwegian	1428.9	1396.9	1460.4	63.5
1911.145	Tonkin	1283.7	1244.6	1315.7	71.1
TPOC1	Welsh	1183.0	1140.8	1231.6	90.8
BZL135	Welsh A	1205.7	1160.5	1231.5	70.9

Table 3.7. Limb elements ranked from lowest to highest estimated withers height for the modern reference material. H=humerus, R=radius, MC=metacarpal, F=femur, T=tibia, MT=metatarsal.Specimen numbers from Table A1

Breed	Specimen no.	Lowest estimate				Highest estimate	
Przewalski	02.9.25.1	F	T	R	H	MT	MC
	07.5.15.1	F	H	T	R	MC	MT
	1929.37	F	T	H	R	MT	MC
	1953/147	F	T	H	R	MC	MT
	1962.228	F	T	R	MT	MC	H
	1973.109	F	MC	T	MT	R	H
	1973/237	F	T	H	R	MC	MT
	1975.125	F	R	T	MC	H	MT
	1980.29	F	T	R	MC	H	MT
	45.6.11.1	F	H	R	T	MC	MT
	E wld 1	F	T	R	H	MC	MT
	E wld 2	F	T	R	H	MC	MT
	E wld 4	F	R	H	T	MC	MT
	LMUprz11	F	R	T	MC	H	MT
	LMUprz13	F	R	T	H	MC	MT
Arabs	1927.235	F	T	R	H	MC	MT
	24.5.4.1	F	MC	T	MT	H	R
	37.1.26.10	R	F	T	H	MC	MT
	E arb 3	F	T	MC	R	MT	H
	H40	T	R	F	MT	H	MC
Ponies	1937.51	MC	MT	R	T	F	H
	BZL1	MC	MT	R	H	T	F
	E pon 1	MC	MT	R	F	H	T
	LWH3	R	T	MC	F	H	MT
	BZL332	MC	R	F	MT	T	H
	1961/29	F	R	MC	T	MT	H
	E mgl 1	R	MC	MT	T	F	H
	E mgl 3	R	F	MC	T	H	MT
	E mgl 4	R	MC	MT	T	F	H
	H37	MC	MT	R	T	F	H
	L2161	H	T	R	F	MC	MT
	1911.145	MC	F	MT	H	T	R
	TPOC1	T	F	R	MC	MT	H
	BZL135	MC	F	MT	R	H	T
Donkeys	1933.397	F	H	R	MT	MC	T
	1968/696	F	H	MC	R	T	MT
	47.7.16.6	MC	MT	H	F	R	T
	86.1756	F	H	MC	R	MT	T
	Ea 11	F	R	H	MC	T	MT
	Ea 12	F	MC	H	R	T	MT
	Ea 15	F	H	MC	MT	T	R
	M131	F	MC	H	MT	R	T
	1893.634	F	H	R	MT	R	T
	E abs wld1	F	H	R	MC	T	MT
	LMUass2	F	MT	MC	R	T	H
	LMUass3	F	MC	MT	H	R	T
Mules	1970/5	MC	MT	F	R	H	T
	1970/6	MC	F	R	MT	T	H
	1972/337	F	R	H	MC	MT	T
	1972/338	F	R	MC	MT	T	H
	Eml mlt 1	MC	R	H	F	MT	T
	LMUmule1	MT	MC	R	H	F	T
	LMUmule2	MT	MC	F	H	R	T

Another use of being able to analyse the withers height data further is that conclusions can be drawn about a particular population. For instance, if all the metapodials produce higher values than the other bones, then this part of the limb must have been elongated in that particular group of animals (von den Driesch and Boessneck 1974). This is something that will be considered when discussing the use of horse-derived factors on donkey and mule bones (see below) but is useful when comparing groups of horses from different sites, geographic areas or time periods.

The next problem to address is the use of horse-derived factors on donkey and mule bones. As a precursor to this, it was necessary to establish whether the factors were producing consistent results on all parts of the skeleton from the modern horse sample. This was done by calculating the withers heights for all elements, using both factors where possible, and then calculating the average for each element. The estimated withers heights from all elements were then ranked in ascending order for each specimen (Table 3.7).

For all the domestic horses there was a fairly random spread of the elements, suggesting that individual variation was playing the greatest role in determining which elements produced the highest and lowest withers height estimates. However, the Przewalski horses showed a very distinct pattern, with the lowest value always being estimated from the femur and the highest mostly from the metapodials. Using the same calculations on the horses and mules produced a less clear picture. However, the results did show that donkeys had quite long tibiae and radii, and short humeri and femora, although the metapodials were somewhat variable in length. The mules seemed to have relatively long tibiae and short metapodials but the other bones were somewhat variable.

In order to see if the observed differences in the relative lengths of the bones were significant a second analysis was undertaken. The greatest lengths of the bones were re-expressed as a percentage of the greatest length of the femur. Student's t-tests were then carried out between the values for each element for paired species. The results are given in Table 3.8. The Arab group was not included in this analysis because there were insufficient numbers for a statistically meaningful result to be obtained.

*Table 3.8. Results of t-tests on limb proportions of the modern reference material as a proportion of the femur. N = not significant, * = significant at 95% level, ** = significant at 99% level*

Test between	Humerus	Radius	Metacarpal	Tibia	Metatarsal
Przewalski and Ponies	*	**	**	*	**
Ponies and Donkeys	N	**	**	**	**
Ponies and Mules	N	*	N	**	N
Donkeys and Mules	N	*	**	N	*

The analysis showed that the most obvious differences observed between the groups were confirmed by the t-tests. The largest number of differences was between the wild and domestic horses. The longer metapodials (and to some extent also the zygopodium) of the wild horses are likely to be an adaptation for faster locomotion in response to the predator - prey relationship these animals would experience in the wild. It seems that the process of domestication has removed that particular selection pressure and domestic horses are now characterised by shorter metapodials and a differently proportioned stylopodium and zygopodium than their wild relatives. It is interesting to note that Arab horses which have been bred for speed (amongst other things), seem to be reverting back to the 'wild type' limb conformation (C. Johnstone, unpublished data), although this could not be rigorously tested because of the small sample size.

The observed difference between the ponies and the donkeys and mules was the elongation of the tibia in the latter groups. This was proven to be the case with the t-tests. However, there were highly significant differences between the ponies and donkeys on all elements except the humerus, suggesting that the proportions of both the metapodia and the zygopodia differ between donkeys and ponies. As might be expected from a hybrid, there were fewer differences between the ponies and mules than between the ponies and donkeys, but again the elongation of the zygopodium was evident. There were also a few significant differences between the donkeys and mules, most notably in the metapodials. However, the tibiae were not different. This suggests that the mules are inheriting their zygopodium conformation (particularly tibia) from the donkey sire and their metapodium conformation from the horse dam.

Because the withers height factors have been found to be less reliable for the femur than for the other elements, this is perhaps not the best element to use for limb proportion studies. The same analysis described above was repeated expressing the greatest length as a percentage of that of the humerus. The results of the t-tests on these comparisons are given in Table 3.9. It is immediately apparent that there are fewer differences between the elements and groups than shown in Table 3.8, suggesting that the difficulties outlined for the femur might indeed have been affecting these comparisons.

The consistent results between the two analyses are the difference between the lengths of the metatarsals for the Przewalski-pony comparison and the tibia for the pony-donkey comparison. As discussed above, the first of these differences (and the difference in femur length seen in Table 3.9) may be the result of a lack of selection pressure on the domestic animals. The pony-donkey tibia proportion differences suggest a real difference in limb proportions.

This work indicates that the horse-derived withers height factors would not give acceptable results for some donkey and mule elements. However, the difference between the minimum and maximum estimated withers heights for donkeys and mules was no greater than for those calculated for the ponies, as shown in Tables 3.8 and 3.9. This suggests that the discrepancies introduced by the limb conformation are of the same order as the inter-individual variation seen in horses and the errors of the estimation technique.

*Table 3.9. Results of t-tests on limb proportions of the modern reference material as a proportion of the humerus. N = not significant, * = significant at 95% level, ** = significant at 99% level*

Test between	Radius	Metacarpal	Femur	Tibia	Metatarsal
Przewalski and Ponies	N	N	*	N	**
Ponies and Donkeys	N	N	N	*	N
Ponies and Mules	N	N	N	N	N
Donkeys and Mules	N	N	N	N	N

For these reasons, the factors based on horse skeletal proportions were be used in this research on all isolated long bones except the femur of horses, because of the underestimation of the withers height observed in many cases. Taking into account all the analyses undertaken above, for donkeys and mules the horse-derived factors were considered sufficiently accurate to be used on all elements except the femur and tibia. Where whole or part skeletons were studied, all elements were used to calculate the withers height to establish if the limb proportions seen in the modern material also held true in the archaeological material, but only those also used for the isolated bones were used to calculate the mean withers height for that individual.

Although this is not the place to investigate this point further, it is suggested that an appropriate line of research would be to test a sample of zebra (*Equus burchelli*) measurements on the null hypothesis that they should show the same selection pressures and therefore limb conformation as the Przewalski horse. In addition, more Arab individuals and also Thoroughbred horses could be tested to see if their limb proportions conform to the 'speed' model.

3.5 Summary

The methods outlined in this chapter were used to address the research questions posed in Chapter 1. They should also allow another researcher to reproduce the work carried out for this research. The only part of the methodology not outlined here is the species identification methods. It was felt these merited a more detailed study and have, therefore, been accorded a chapter in their own right (Chapter 4).

Chapter 4 - Critical evaluation of methods of species separation

The importance of being able to distinguish between the different equine species and their hybrids, in order to shed some light on the distribution and use of the different species, has been highlighted in Chapter 1. The purpose of this chapter is to outline the methods currently available for the differential identification of equine species, to highlight the fact that this is not an easy task, to present an evaluation of which methods are most appropriate to the type of data to be used in this research, and, to show the development of a methodology for use in this research where none of those available proved suitable.

4.1 Dental morphology

The most frequently found elements in archaeological assemblages are usually teeth, both isolated and in their respective jaws. For this reason much time has been devoted to studying dental characteristics that will allow species level identification. Equids as a group have one of the more complex enamel fold patterns found in the animal kingdom. Therefore there is potentially a lot of detail in these patterns that can be used to differentiate species, but there are a few difficulties.

The morphology of the cheekteeth (3rd premolar (P3) to second molar (M2)) in equids is quite similar, making even an anatomical identification of an isolated tooth a problem. However, it is essential to do so, because there are minor differences in the enamel folds between teeth that could be confused with taxonomic characters. The molars are usually more reliable to identify to species (Davis 1980). There is also a lot of intra-species variation, which can lead to overlap between species. In addition, age-related changes to the occlusal surface of the teeth can lead to unclear enamel patterns and less certainty in identification. The degree of wear is an important factor: if too little enamel is exposed the pattern is not accurately discernible, and if the tooth is too worn the enamel pattern can become distorted (Davis 1980). For these reasons only the permanent dentitions with moderate wear are generally studied. Because the enamel fold structure in equid teeth is complicated, there are a number of terms used to describe the various features accurately. The nomenclature of these features varies in different publications, so Figures 4.1 and 4.2 show the terminology to be used in the current research.

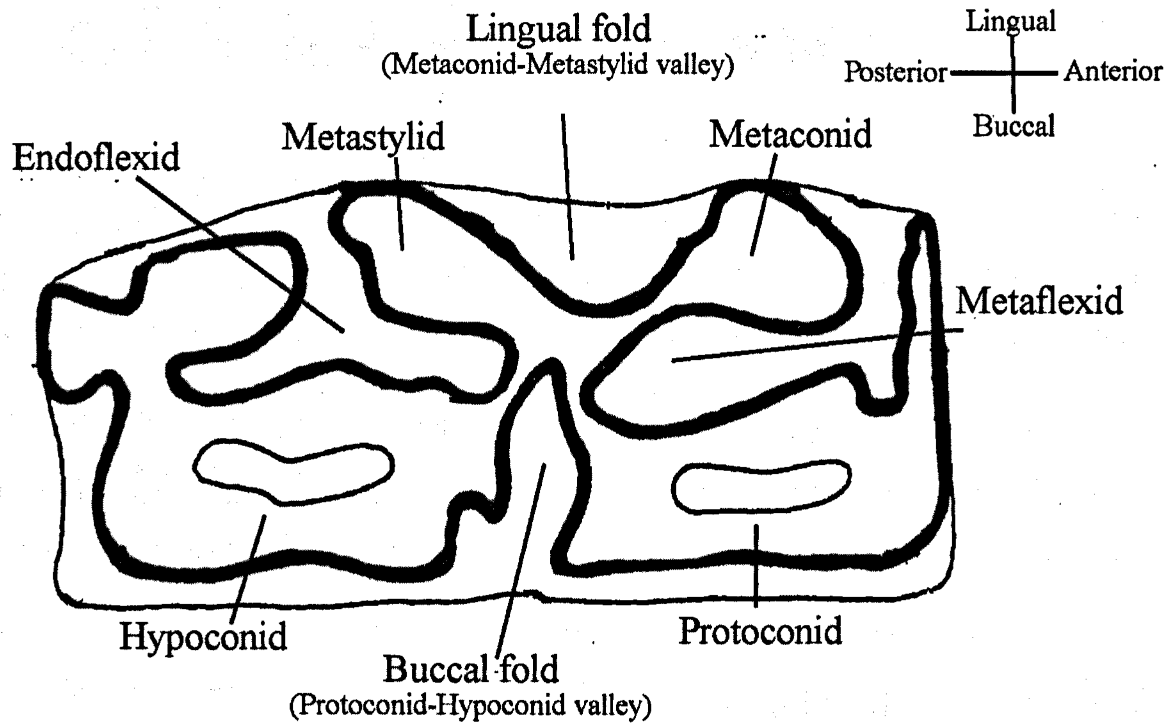


Figure 4.1. Nomenclature for the occlusal enamel patterns of equid mandibular teeth. The metastylid and metaconid are often referred together to as the 'double knot'.

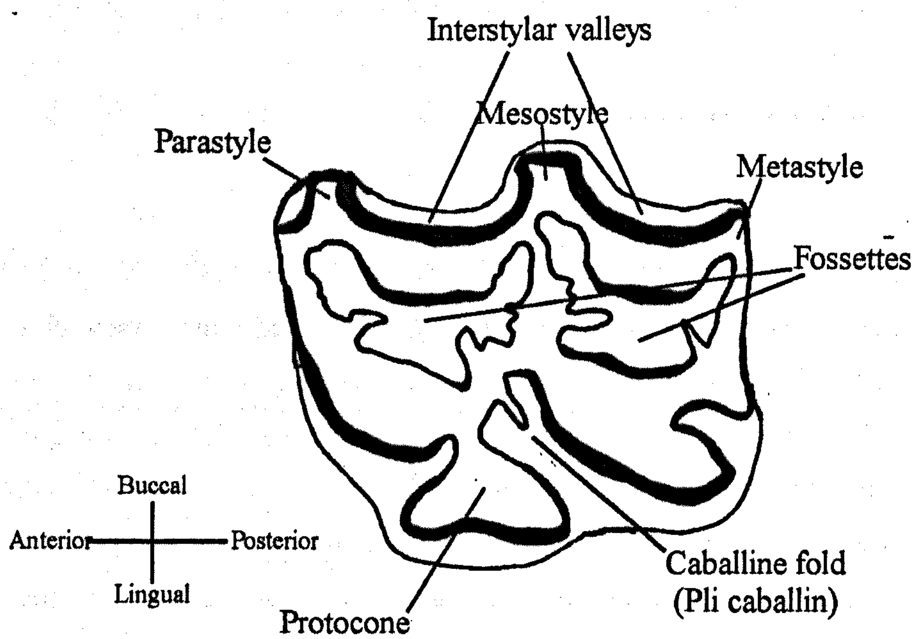


Figure 4.2. Nomenclature for the occlusal enamel patterns of equid maxillary teeth.

Table 4.1 of dental characteristics is a compilation of the work of various authors, including Davis (1980), Armitage and Chapman (1979), Uerpmann (2002) and Eisenmann (1986), detailing dental characteristics. These characteristics are illustrated in Figure 4.3.

Table 4.1. Enamel pattern characteristics used to identify horses, donkeys and mules

Characteristic	**Horse**	**Donkey**	**Mule**
Mandibular teeth			
Shape of lingual fold	U-shaped and deep (Figure 4.3a)	V-shaped but quite shallow (Figure 4.3b)	V-shaped but as deep as horses (Figure 4.3c)
Penetration of buccal fold	Partial penetration, the fold reaches the 'neck' made by the ento- and metaflexids (Figure 4.3a)	No penetration of fold into 'neck'(Figure 4.3b)	As much or more penetration than horses (Figure 4.3c)
Shape of 'double knot'	Asymmetrical, with posterior side appearing pointed and the anterior rounded (Figure 4.3a)	Nearly symmetrical, both sides rounded (Figure 4.3b)	Nearly symmetrical, more like donkey (Figure 4.3c)
Maxillary teeth			
Pli caballin (Caballine fold)	Usually well developed but can be absent (Figure 4.3d)	Usually absent (Figure 4.3e)	Intermittent or reduced (Figure 4.3f)
Interstylar profile	Deep and rounded U-shape with thick styles sometimes with dents in the top (Figure 4.3d)	Pronounced angles from columns to interstylar surfaces, forming a flat-based U shape (Figure 4.3e)	More like donkey (Figure 4.3f)
Protocone	Elongated, particularly posterior half with flattened inner surface and narrow shape. (Figure 4.3d)	Short and oval, both halves roughly equal length, lingual wall often concave (Figure 4.3e)	Smaller than horse, also less assymetrical (Figure 4.3f)
Fossette folds	Complex (Figure 4.3d)	Small and simple (Figure 4.3e)	Variable (Figure 4.3f)

In addition to the characteristics mentioned in Table 4.1, there is an additional feature of mule teeth that, although not always clear, is very useful when present. The mandibular P4 quite often looks substantially larger than the surrounding teeth (Uerpmann 2002). Although no work seems to have done on quantifying this, length and breadth measurements of this tooth in comparison with neighbouring teeth may provide significant results. This may be a product of hybrid vigour but only seems to affect this particular tooth.

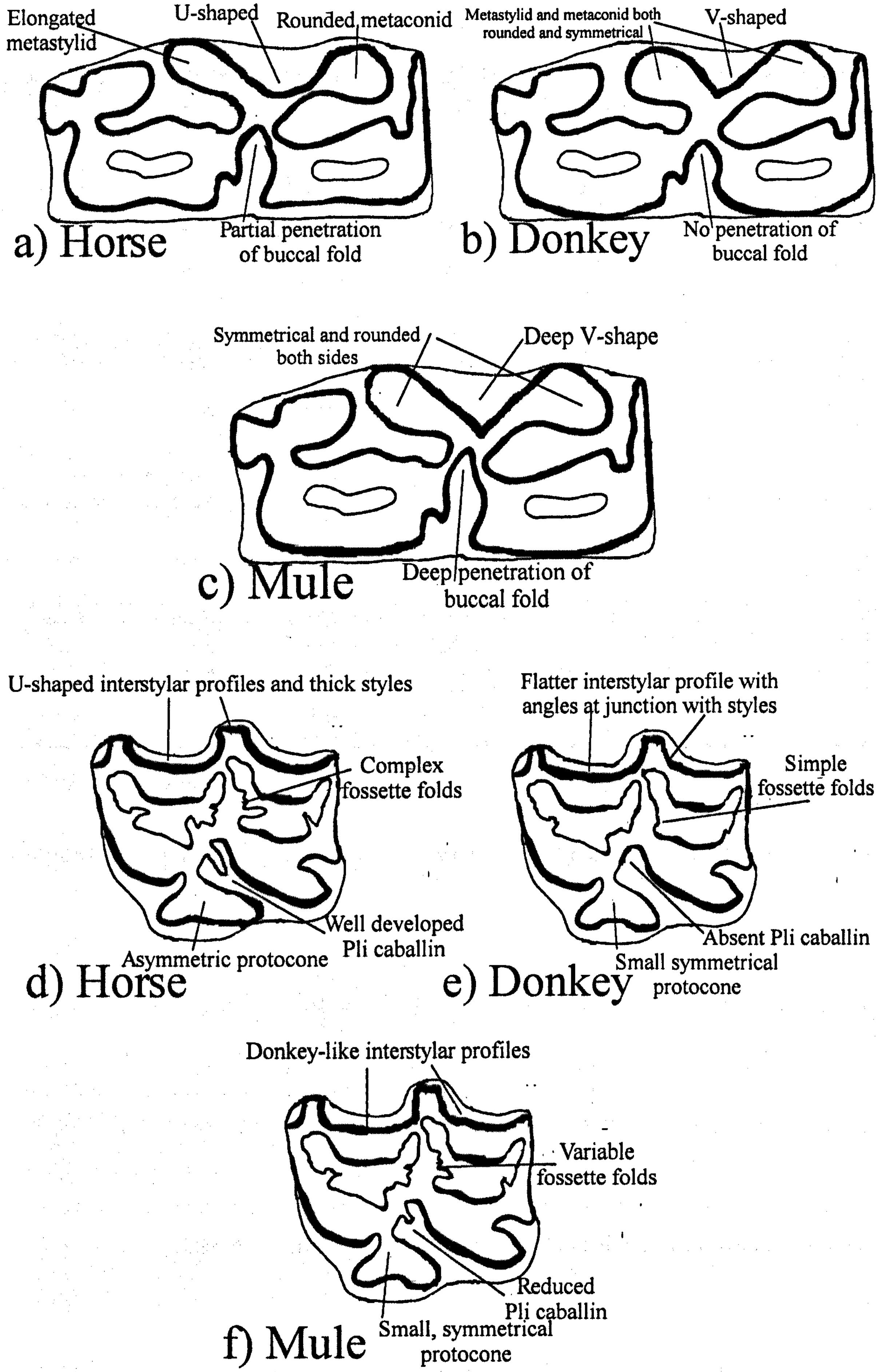


Figure 4.3. Enamel pattern characteristics used to identify horses, donkeys and mules

4.2 Dental biometry

The use of dental biometry to distinguish equid species has mostly been based on the morphological criteria outlined above. The inherent problems of anatomical identification of the tooth are still present, although Payne (1991) found that, because the variability of the enamel patterns within a population overlapped with the tooth row variability but species differentiation patterns barely overlapped, this was not as much of problem as had been first thought. However, the problem of tooth wear was found to affect the measurements of the morphological features quite considerably. For this reason it is recommended that teeth only just in wear and those with a great deal of wear are excluded from this kind of analysis.

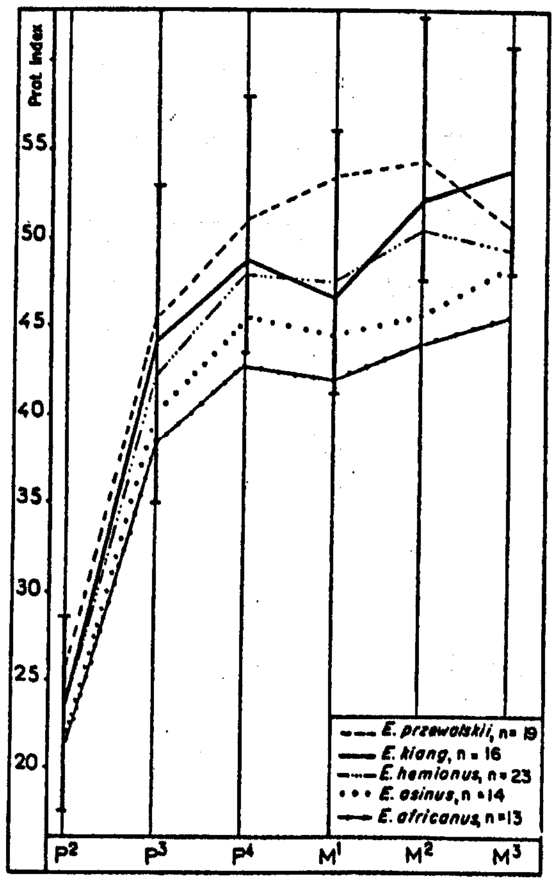


Figure 4.4. Mean protocone indices for the maxillary cheekteeth of donkeys, half-asses (hemiones) and wild horses (from Eisenmann 1986: 93, fig 18).

Eisenmann (1986) used a combination of morphology and measurements for discrimination. The overall size of the teeth is not enough to separate donkeys and horses, as the range of variation from both species overlaps quite considerably. However, the length of the protocone on the upper teeth shows quite a marked size difference between donkeys and horses. In addition, when the protocone index is calculated (LP x 100/OL, LP = protocone length, OL = occlusal length; see Figure 4.5 for measurements) there is frequently a difference between the P4 and M1 of horses and donkeys. The latter have a relatively long protocone on the P4 and short on the M1, whilst the reverse is true for wild horses (Figure 4.4).

Payne (1991) took the work of Eisenmann further by adding other measurements designed to quantify the differences highlighted in morphological studies (Table 4.1). These measurements are shown below (Fig 4.5).

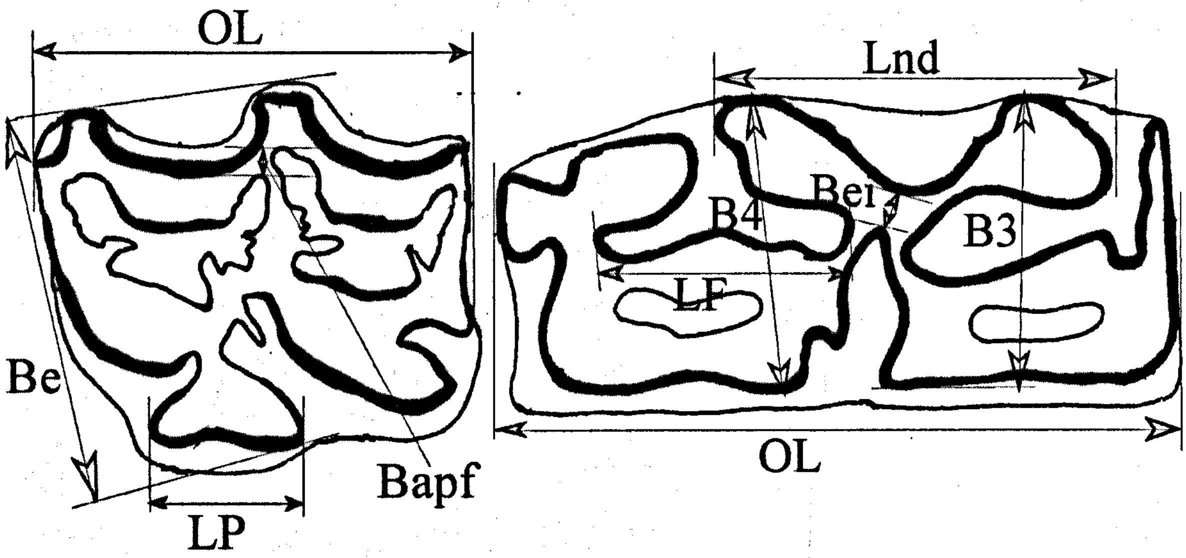


Figure 4.5. Measurements of equid maxillary (left) and mandibular (right) teeth, for which the codes are explained below (after Payne 1991: 135).

The codes are as follows: OL = occlusal length, measured from the approximate centres of the mesial and distal sides, including the external cement; Be = buccolingual length taken with one jaw of the calliper in contact with both the parastyle and mesostyle and the other on the protocone, including the enamel but not including the cement; Bapf = the distance the postfossette projects above the prefossette at right angles to OL (usually measured on enlarged photocopies); LP = greatest length of protocone including enamel; B3 = width from protoconid to metaconid at right angles to OL; B4 = width from hypoconid to metastylid at right angles to OL; Lnd = greatest length of double knot including enamel; LF = greatest length of postflexid including enamel; Bei = smallest distance between internal enamel of buccal sulcus and lingual sulcus.

In addition, Payne (1991: 136-7) gives a four-point scale for grading the development of the pli caballin and the degree of penetration of the buccal sulcus. Figure 4.6 shows the development of the caballine fold with. Similarly in the lower teeth, the penetration of the buccal sulcus is graded on a 4-point scale (Figure 4.7) based on the tip of the sulcus in relation to the post- and preflexids.

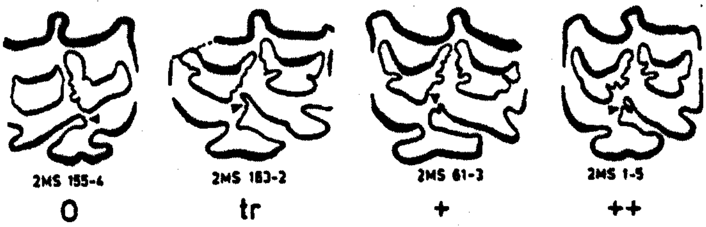


Figure 4.6. Illustration of the 4-point scale to record the development of the pli caballin. 0 = no fold at all; tr = trace; + = present; ++ = marked development (from Payne 1991:137).

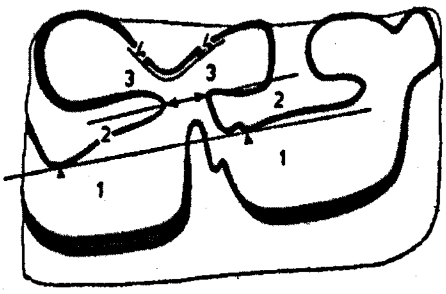


Figure 4.7. Illustration of the 4-point scale to record the penetration of the buccal sulcus. 1 = tip does not reach line joining buccal most parts of post- and preflexids; 2 = tip crosses line but does not reach line joining post- and preflexid at nearest points (as in this example); 3 = tip is across that line but more than 0.5 mm from lingual sulcus; 4 = tip is within 0.5 mm of lingual sulcus (from Payne 1991: 137).

These measurements can help identify a tooth anatomically, although Payne (1991: 139) points out that this is not always reliable, and there is some overlap between molars and premolars in terms of size and morphology, particularly for maxillary teeth.

These measurements allow a more objective way of describing the enamel patterns. It should then be possible to characterise the range of variation within a species using these measurements in combination with the known morphological characteristics (Table 4.1), and therefore to assign an unknown specimen to species on the basis of its measurements. Payne (1991: 163) says that 'equid teeth, are neither so uniform that single characteristics can be used to identify single teeth nor so variable that there is no purpose in trying to work with and identify collections of isolated teeth'. He goes on to say that the range of variation between species overlaps but that assemblages of teeth should be identifiable, even if individual specimens are not. Some more work needs to be undertaken on using these measurements in relation to mules, as most work has been done on separating donkeys, horses and half-asses (hemiones).

In conclusion, it seems that using a combination of dental morphology and biometry it should be possible to identify most teeth, both in jaws and isolated cases, to species with a reasonable degree of confidence. However, in terms of the current research, which is mainly based on published measurements, the identification of mules from teeth will not be easy. Usually only length and breadth measurements of teeth are routinely recorded for Roman equids, if at all, making it impossible to use the above methods.

4.3 Bone morphology

There is a serious problem with looking at the bone morphology of mules, as there appear to be very few mule skeletons in museum collections. There is one mounted (and therefore difficult to study) skeleton in the Natural History Museum in London (UK), two skulls in the Laboratoire d'Anatomie, Paris (France), one mounted skeleton in The Naturalis Museum, Leipzig (Netherlands), four complete skeletons in the Zoologische Statsammlung, Munich (Germany), a further four complete skeletons in the Institüt für Palaeoanatomie (also in Munich) and two specimens (one mounted, one un-mounted) in the Museum für Haustierkunde, Halle (Germany). Some of these skeletons are from mules bred using the particularly large donkeys of the Poitou breed, which means that they are not good comparative specimens for archaeological material. Appeals on the ZOOARCH e-mail list failed to locate any further specimens in Europe or indeed worldwide.

This lack of reference specimens seems to be extraordinary given the former abundance of mules in many countries of the world up until the advent of mechanised transport and beyond in many inaccessible and mountainous areas. This lack of reference material was highlighted as a major problem at the recent (January 2002) workshop on Equid identification held in Basel, Switzerland. It was agreed by all present that the procurement of mule skeletons should be a priority, particularly where information was available on the parent animals.

Most morphological work has been on separating horses, donkeys and hemiones (Eisenmann 1986; Lepetz 2002). Only one study has looked at the specific differences between horses and mules (Peters 1998).

4.3.1 Cranial morphology

Looking at the cranial morphology first, Table 4.2 gives a list of characteristics that can be used to differentiate horses and donkeys, and in some cases also mules. As can be seen, there are not many distinguishing characteristics when the cheekteeth are not present. There is also the problem that it is very rare to find complete skulls or mandibles in archaeological assemblages. The curvature of the incisor row seems to be a fairly reliable characteristic (see Figure 4.8, which shows the relative lengths of the diastema) as long as the animal is not so aged that the angle of the teeth has altered, giving them an elongated appearance with triangular occlusal surfaces.

Table 4.2. Summary of morphological characteristics of the cranium

Characteristic	Horse	Donkey	Mule	Reliability
Vomar length	Short	Long	Long	
Muzzle shape	Breadth at posterior I3 borders greater than that between inter-alveolar borders	Muzzle enlarged in the middle	Muzzle enlarged in middle	
Muzzle shape	Incisor row quite straight (Figure 4.8)	Incisor row very curved	Incisor row curved(Figure 4.8)	Age dependant, most reliable in young adult animals
Size of auditory meatus	Small	Large	Large?	
Position of orbits	Orientated for peripheral vision	Orientated for forward vision	Orientated for forward vision?	
Diastema length	Short (Figure 4.8)	Long?	Long (Figure 4.8)	

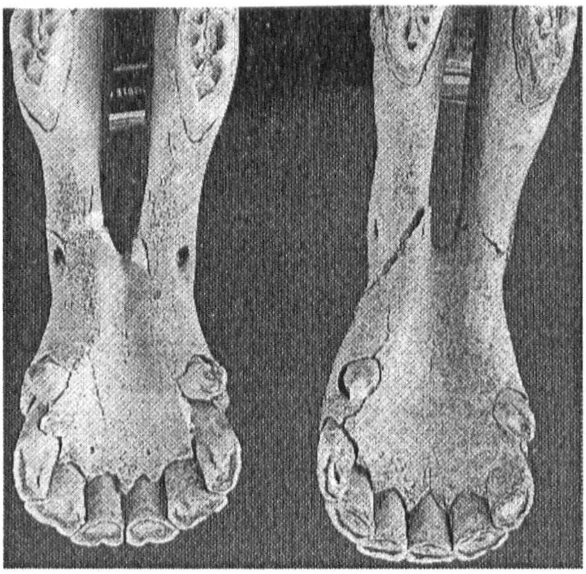


Figure 4.8. Horse (left) and mule (right) mandibles, showing relative lengths of diastema and curvature of the incisor row (from Kunst 2000).

For the purposes of this research, crania are unlikely to be of any great value in separating mules from horses and donkeys because of their scarcity in the archaeological record. Also the crania will not be very helpful in determining the size of the horses of the Roman world because the head is not necessarily proportionate to the size of the body (see Section 3.4). They will, however, help to build a picture of the look of the Roman horses when the skull size is compared with body size, and also determine the shape of the head.

Eisenmann (1986) investigated the possibility of using the number of supra-orbital foramina as a discriminating feature. Eisenmann (1986) suggests that half-asses can be distinguished from donkeys and horses by the fact that half asses generally have multiple supra-orbital foramina and asses and horses usually have single ones. From the specimens examined in museums for the current reasearch, this seems largely true except that the incidence of multiple foramina is substantially increased in Przewalski specimens. One explanation of this is that most Przewalski horses have been bred from a limited gene pool caused by the small number of animals captured prior to their extinction in the wild. This may have had the effect of increasing the incidence of some non-metric traits, including multiple supra-orbital foramina. This is therefore not a reliable way of differentiating equids but may have some value in looking at horse movement and breeding as a future line of research.

4.3.2 Post-cranial morphology

Moving on to post-cranial morphology, there are a number of characteristics that have been proposed for the separation of horses, donkeys and mules. The morphology of all three is very similar so many studies have tended to concentrate on the sizes of the bones, both individual elements and the relative lengths of the bones within the skeleton. The problem with morphological differentiation of equids has been highlighted on a number of occasions in the past, particularly with reference to horses, donkeys and half-asses on prehistoric sites in the Near East. More recently the problem of identification of hybrid animals has been highlighted, particularly with reference to mules. Several zooarchaeologists have been working on this problem.

Peters (1988) has published a number of criteria for the identification of mules, and the following descriptions and figures are taken from his work on skeletons in the collections of the Institüt für Palaeoanatomie and Zoologische Statsammlung, Munich (Germany). The bones that appear to show consistent differences are the scapula, radius, metacarpal, tibia and first phalanx. On the scapula (Figure 4.9) there is a noticeable ridge on the caudal edge at the distal end where the medial curve of the margo caudalis is strengthened. The collum scapulae is slightly twisted, such that the caudal half falls away towards the edge more sharply (as in deer).

The radius (Figure 4.10) shows two characteristics that differentiate mules and horses. In mules and donkeys the palmar side of the shaft is delineated from the distal articular surface by the crista transversa, which forms quite a deep sulcus or depression. In addition, the area of shaft above the distal articulation on the palmar side is slightly concave, whereas it is flat or slightly convex in horses. The rough area of bone on the medial and palmar side of the shaft distal to the ulna scar is much more pronounced in donkeys and mules than in horses. The sulcus on the border between the epiphysis and the diaphysis seems to be the clearest characteristic.

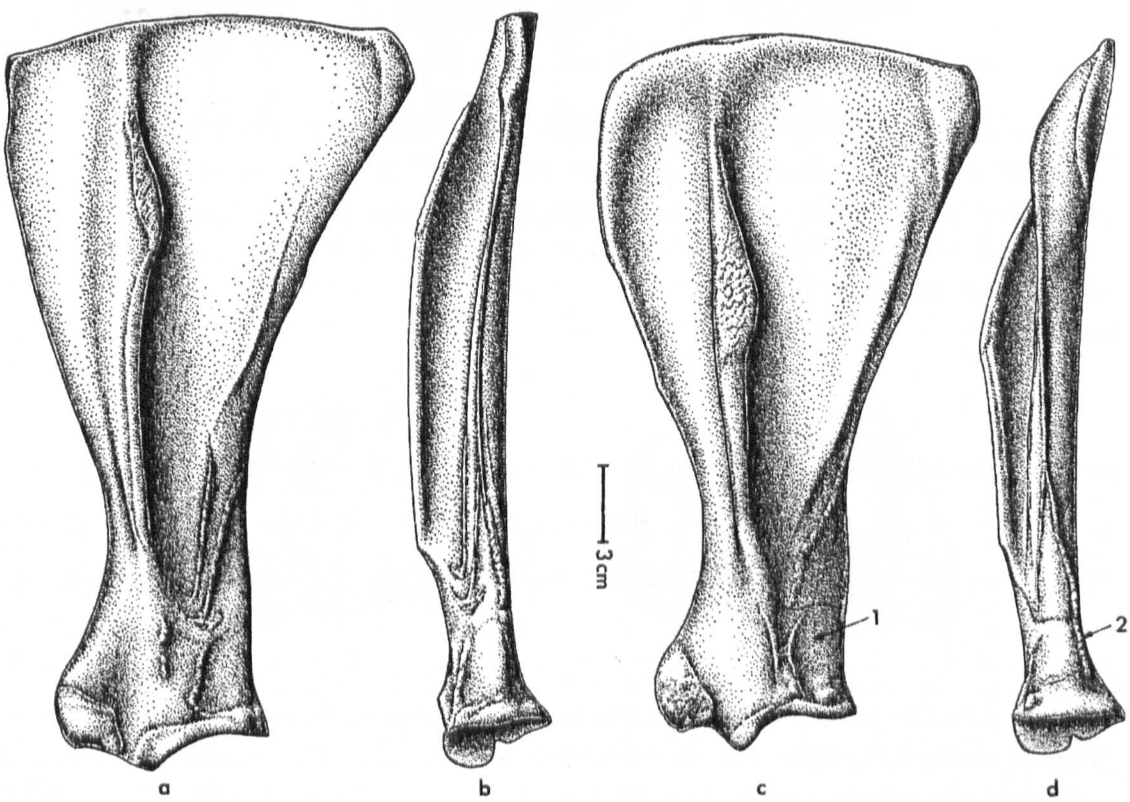


Figure 4.9. Morphological characteristics of the scapula. a-b) Horse scapula; c-d) mule scapula, in lateral and caudal views. Mule characteristics are the torsion of the collum scapulae (1) and the resulting pronounced strengthening of the caudal border (2) (from Peters 1988).

The distal end of the tibia (Figure 4.11) is characterised by an expansion of the medial half of the distal articulation in the medio-plantar direction. This means that viewed from the distal end the shape of the articular surface is more like a trapezium in mules and is rectangular in horses.

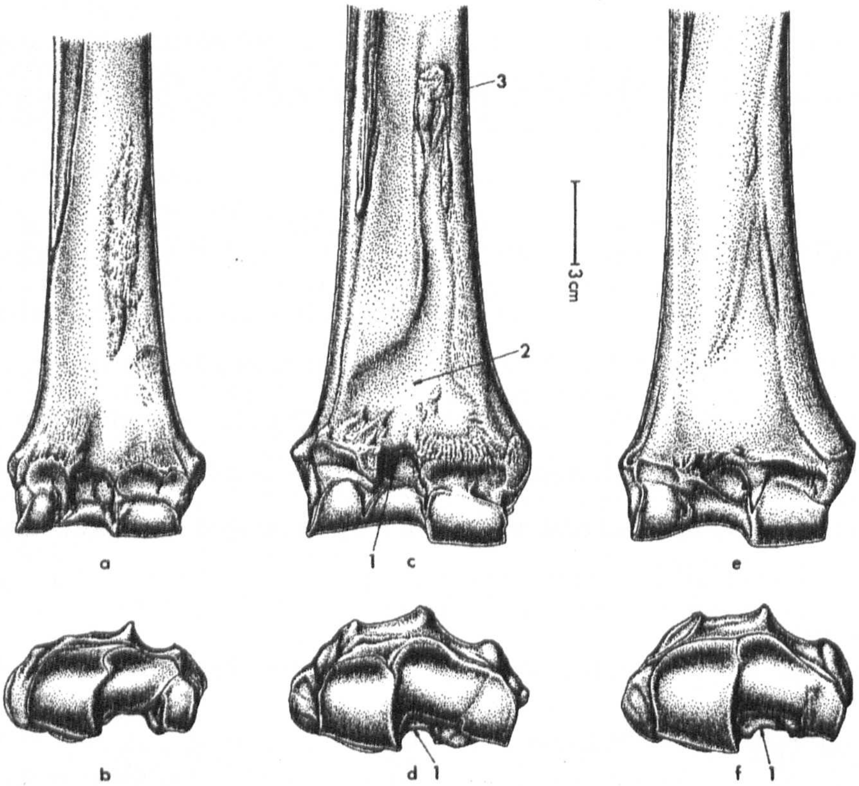


Figure 4.10 Morphological characteristics of the radius. a-b) Donkey radius; c-d) Mule radius; e-f) Horse radius, in palmar and distal views. Typical donkey and mule characteristics are the sulcus at the epiphyseal junction (1), the depression in the distal palmar area of the shaft (2) and the more pronounced muscle insertions below the ulnar scar (3) (from Peters 1988).

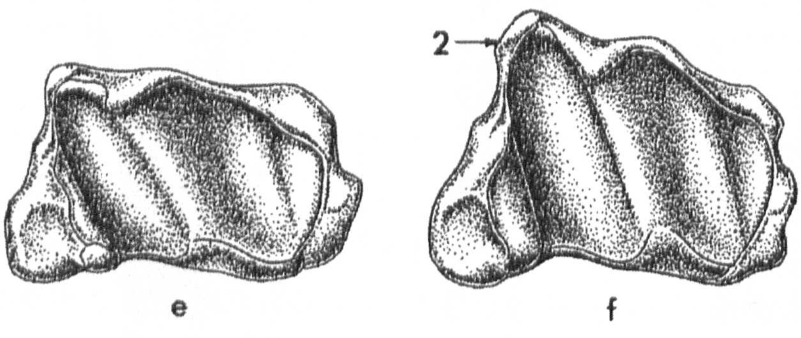


Figure 4.11 Morphological characteristics of the tibia. e) Horse tibia, f) mule tibia. The typical mule characteristic is the medio-plantar extension of the medial half of the distal articular surface, leading to a trapezoidal shape of the distal end (from Peters 1988).

The metacarpals of mules (Figure 4.12) are noticeably more slender then those of horses. As in the radius there is also a slight depression on the palmar side of the shaft above the distal articulation, which is hardly ever seen on horses and even then it is certainly not as pronounced as in mules. This depression gives the shaft a very slender appearance in the anterior-posterior plane at the distal end.

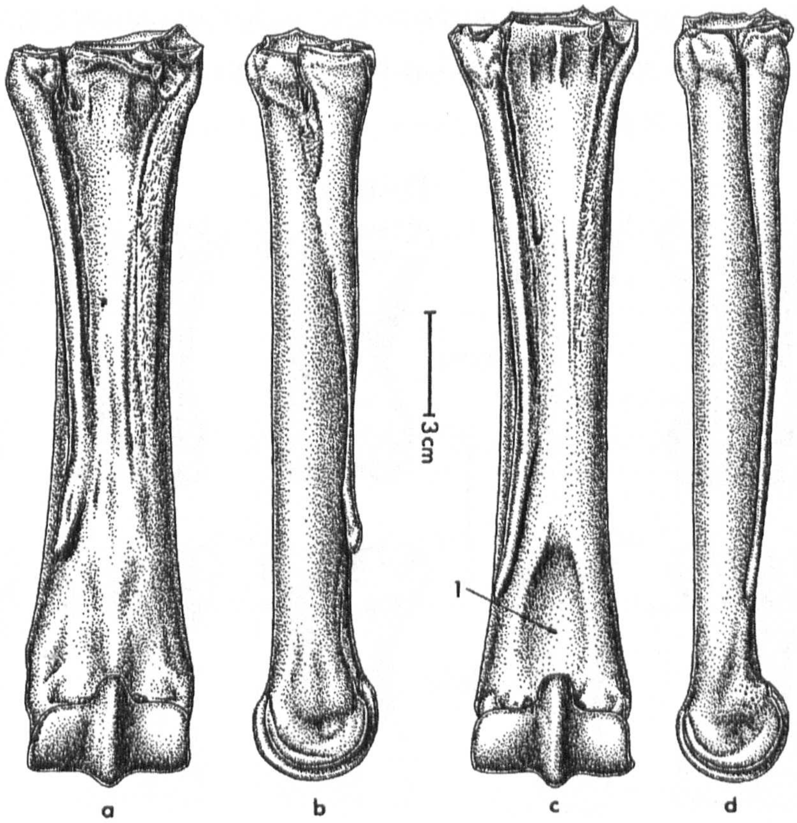


Figure 4.12 Morphological characteristics of the metacarpal. a-b) Horse metacarpal; c-d) Mule metacarpal, in palmar and medial views. The more slender appearance and also the depression on the distal palmar area of the shaft (1) distinguish mule metacarpals (from Peters 1988).

The first phalanges of mules are also more slender than those of horses. On the posterior surface the muscle insertions form a triangular shape that is much more prominent in mules than horses and also has a much more distinct ridge where the two scars join together at the distal end. This apex is placed more proximally on the bone in mules than in donkeys (Figure 4.13). This may be quite difficult to detect in archaeological material, because this is also a way of differentiating anterior and posterior phalanges in all equids (Eisenmann 1986).

In addition to these criteria, Lepetz (2002) has encountered other differences between the bones of horses and donkeys, where the mules appear to be more like donkeys. The descriptions that follow may not be entirely accurate as they were translated from French as the paper was being given. Despite numerous subsequent e-mails the author was unable to contact Sebastian Lepetz for further information and clarification. For the humerus (if the whole bone is present) the shaft shows more torsion in horses than in donkeys. This can be seen if the bone is placed on a flat surface with the lateral side downwards: in horse two parts of the proximal tuberosity rest on the surface, in donkey only one. If the bone is stood on its distal end, the shaft of the donkey bone is perpendicular to the distal end, whereas in horse it is at an angle.

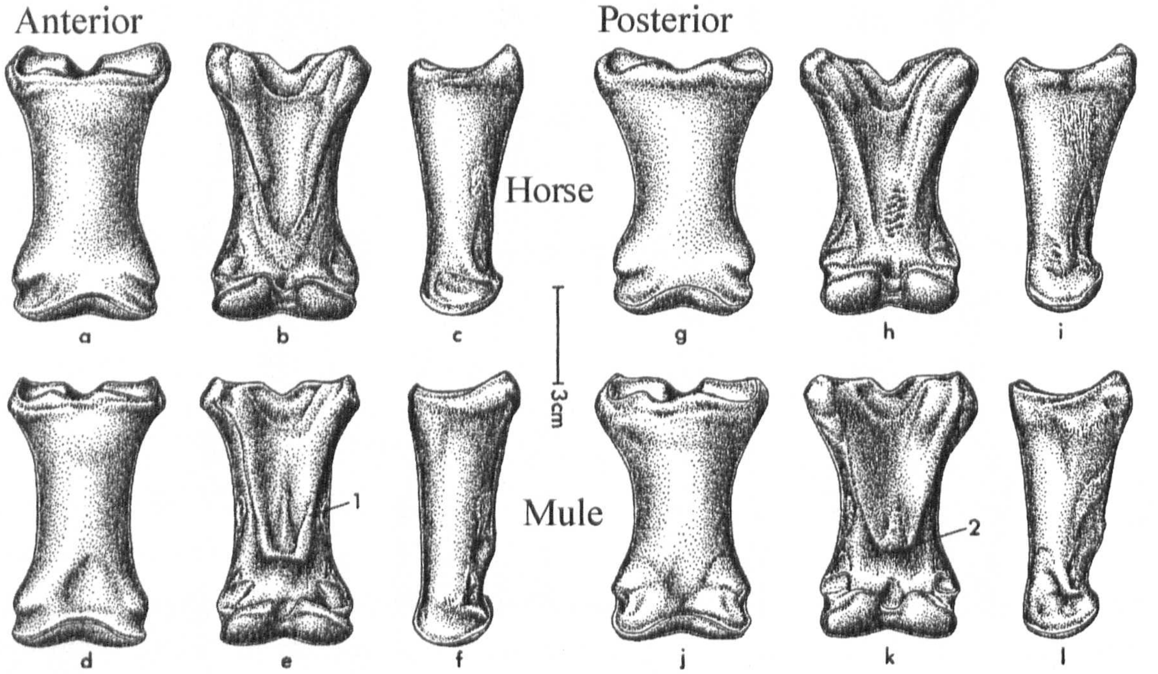


Figure 4.13. Morphological characteristics of the first phalanges. Horse (a-c, g-i) and Mule (d-f, j-l) first phalanges in dorsal, palmar and medial views. The slenderness, more pronounced palmar muscle scars (1) and position of the apex of these muscle scars (2) distinguish the mules (from Peters 1988).

On the radius, as well as the sulcus mentioned by Peters (1988), Lepetz (2002) has found that the whole bone is more curved in donkeys and mules than in horses. If the bone is laid on a flat surface on its anterior face, both the distal and proximal ends will touch the surface in horses (or at least very nearly), whereas in donkeys and mules it will rock quite considerably on the middle of the shaft. In addition to the depression on the distal, plantar side of the metacarpals, the proximal articulation is slightly different. In horses the articular surface is quite concave, whereas in donkeys and mules it is almost flat.

For the femur, it is once again the torsion of the shaft that seems to be important. When placed on a flat surface with the anterior face downwards, in horse the femur rests on the distal and proximal articular surfaces, but in donkey it rests on the distal articulation and the third trochanter with the femoral head off the surface. On the tibia, the lateral malleolus (the fused remnants of the fibula) of horses protrudes further distally than in the donkey when viewed from the posterior side. The distal articular facets in the astragalus have a distinct ridge separating them in the donkey, which is less marked in horses. Table 4.3 summarises all the morphological characteristics.

Table 4.3. Summary of differentiating characteristics of the post-cranial skeleton.

Element	Characteristic	Horse	Donkey	Mule
Scapula	Caudal ridge	Not present (Figure 4.9a,b)	Not present	Present (Figure 4.9c,d)
Humerus	Shaft	Twisted and at an angle to the distal end	Straight and perpendicular to distal end	Straight and perpendicular to distal end
Radius	Distal epiphyseal sulcus	Not present (Figure 4.10e,f)	Shallow sulcus sometimes present (Figure 4.10a,b)	Pronounced sulcus present (Figure 4.10c,d)
	Distal, palmar surface	Flat or convex (Figure 4.10e)	Concave (Figure 4.10a)	Concave (Figure 4.10c)
	Rough surface distal to ulna scar	Slight (Figure 4.10e)	Pronounced (Figure 4.10a)	Pronounced (Figure 4.10c)
	Anterior-posterior shaft curvature	Almost straight	Curved	Curved
Metacarpal	Distal, palmar depression	Not present (Figure 4.12a,b)	Shallow	Pronounced (Figure 4.12c,d)
	Proximal artculation	Concave	Almost flat	Almost flat
Femur	Twisting of shaft	Twisted	Straight	Straight
Tibia	Distal, medio-plantar expansion	Not present, rectangular shape (Figure 4.11e)		Present, trapezoidal shape (Figure 4.11f)
	Lateral malleolus	Protrudes distally	Less distal protrusion	Less distal protrusion
Astragalus	Distal articular ridge	Rounded	Sharp	
First phalanx	Muscle insertion triangle	Not prominent, apex indistinct (Figure 4.13a-f)		Prominent ridges and apex (Figure 4.13g-l)
	Position of apex	Near distal end	Near distal end	Higher up shaft

4.3.3 Limb proportions

The question of limb proportions has been partly addressed in Section 3.4 in relation to the use of horse-derived factors in withers height estimation. That work highlighted the fact that there was considerable variation in the proportions each element contributed within species and between species. The possibility that the differences observed between Przewalski horses and domestic ponies resulted from the lack of natural selection pressure on the domestic animals, leading to a reduction in metapodial length, was put forward. Similarly, the increased length of the metapodials of the Arab horses was suggested to be an artificial selection pressure for speed that resulted in a return to the 'wild' type of limb conformation.

The work of Duerst (1922, quoted in Peters 1998) showed that horses that primarily use one gait for their work have limbs with different proportions. For example, trotting horses have relatively short humeri and femora whilst racehorses have relatively long ones. The opposite is true of radii and tibiae. Horses that primarily walk, such as heavy horses, tend to have proportions inbetween the extremes. However, from the work of Duerst it is unclear whether these limb proportions were the result of a conscious choice of a conformation that was known to perform that particular job, or whether selective breeding for good trotting or racing horses has ended up with the conformation reflecting the use.

Environment can influence limb proportions, with desert animals having long metapodials and forest dwellers having shorter ones. This puts forward an alternative hypothesis for the differences between domestic ponies and Arab horses, the latter being originally desert animals. The phalanges of horses in areas with dry hard ground are more slender, in relation to length, than those in areas with softer ground (von den Driesch 1972, quoted in Peters 1998).

These differences in limb proportions could lead to problems with the use of the withers height estimation factors if there is sufficient differentiation of horses bred for specific purposes in the periods under consideration. However, Peters (1998) found that the skeletal proportions of pre- and early historical horses in Germany were undifferentiated or not sufficiently differentiated to be statistically different. Peters (1988) therefore used this fact to test whether donkeys and mules were present in assemblages, as it was thought their limb proportions were different. Table 4.4 gives the skeletal proportions of Roman horses and recent donkeys and mules (taken from Peters 1998). In comparison to donkeys, horses have a longer stylopodium and shorter zygopodium and metapodium. Mules fall inbetween in their proportions: the stylopodium is similar to horses, the zygopodium is more like those of donkeys, and the metapodium is proportionately shorter than both horses and donkeys.

Table 4.5 proves a compilation of the information available on the differences between the limb proportions of the three species considered in this study (taken from Eisenmann 1986; Groves 1986; Peters 1998). These observations echo the work carried out in the current research in Section 3.4 using slightly different methods. The concordance between different authors using different methods and arriving at the same solutions suggest that the results are not spurious and that differences in limb proportions do exist between the different species.

Table 4.4. The proportions of the larger limb bones expressed as a percentage of the sum of the greatest lengths (GL) of the respective elements (after Peters 1998: 155).

Element	**Humerus**		**Radius**		**Metacarpal**	
Number/percentage	**n**	**%**	**n**	**%**	**n**	**%**
Horse	13	34.0	52	39.5	137	26.5
Mule	8	33.8	8	39.9	8	26.3
Donkey	7	33.1	7	40.3	7	26.7
Element	**Femur**		**Tibia**		**Metatarsal**	
Horse	10	38.4	10	35.1	109	26
Mule	7	38.4	7	35.5	7	26.1
Donkey	7	37.8	7	35.5	7	26.7

Table 4.5 Relative lengths of elements within the respective limb

Element	**Horse**	**Donkey**	**Mule**
Scapula	Long	Short	
Humerus	Long	Short	Long
Radius	Short	Long	Long
Metacarpal	Short	Long	Short
Femur	Long	Short	Long
Tibia	Short	Long	Long
Metatarsal	Short	Long	Short
Third phalanx	Wider	Short & Narrow	Narrow

4.4 Bone microstructure

Dittman (2002) has investigated the possibility of using the histology of bone to determine species. The microstructure of bone is influenced by biomechanical properties such as locomotion and weight, such that differences in the way an animal uses its limbs can be seen in the histology of the bones themselves. Thin sections of bone were taken from the anterior side of the proximal metacarpal of five individuals of each of several equine species (Dittman 2002). The Haversian canals and osteons were then measured. The measurements taken were the minimum and maximum diameters, the area and the circumference. Using discriminant analysis the differences between most of the species and the hybrids were quite clear. Domestic horses and Przewalski horses were not distinguishable however, suggesting that they are too closely related and that their limb use is almost identical, which slightly contradicts the evidence of limb proportions as demonstrated in Section 3.4.

Although this technique seems to be a good proposition for separating donkeys, horses and mules from modern material there are a number of issues that would need to be considered before the technique was considered reliable. One of these issues is the question of age-related Haversian remodelling, which was not addressed in the original paper. The technique is also time consuming and expensive, and invasive and so not always suitable for use on archaeological material. Although the technique seems to work on modern reference material, it has not yet been tested on archaeological samples. It may be the case that the taphonomic degradation of the structure of the bone is too great for accurate measurement of the Haversian canals and osteons. This technique seems worth further investigation and could form part of future research but it is not considered further here.

4.5 Computed tomography

Computed tomography (CT) will only be mentioned briefly here because the equipment used to produce the results is specialised and usually only found in hospitals and medical or veterinary research laboratories. The technique involves using a CAT scanner to produce images of the cross-section of bones at various points along their length. From these images a measure of the thickness and density of the compact bone is obtained. These data, together with traditional osteometric data, are subjected to discriminant analysis. This produces results that has enabled separation of donkeys, horses and hybrids in >90% of cases (Artemiou 1999; Forstenpointner *et al.* 2002). However, when the method was tested on archaeological material it was found that the measure of density was far too variable to produce reliable results. The variability of the density of the compact bone in archaeological material is most likely to be affected by taphonomic factors as outlined in recent papers focusing on the porosity of bone (Turner-Walker *et al.* 2002 and Robinson *et al.* 2003). Further work is being undertaken to refine the technique without using density as a variable.

Cross-sectional morphology has also been used to study the differences between horses, donkeys and their hybrids (Kunst 1997a, 2002). It is known that the cross-sectional shape of a bone is closely related to the way the limb is used and its loading patterns. There are also known differences in gait and posture between horses and donkeys, so it was surmised that these differences should be detectable in cross-sectional area. The results indicated some degree of difference between species, but there was also great variability within species. This intra-species variability is likely to reflect the work the animals undertook during life and the conditions under which it took place, as is well known bones can change according to the stresses placed upon them.

Both of these techniques have yet to be explored fully and as a result their usefulness to the current research was limited. In addition, CAT scanners are scarce outside the institutions mentioned above and access to them is severely limited, so that this kind of analysis would be difficult to undertake without bringing material from many collections to one place for analysis.

4.6 DNA analysis

This relatively new field may in the future provide a definitive solution to the problem of hybrid identification. However, little work has been done on this particular problem and there are a number of difficulties that would need to be overcome before it would be a cost-effective means of discrimination. It should be remembered that all work on ancient DNA has to be based on the current state of knowledge of modern DNA (Brown 2001), so unless information is available on the genome of the species in question little work on the ancient DNA can be undertaken. A large amount of work has been undertaken on the genome of the domestic horse, including the determination of the entire mitochondral DNA (mDNA) sequence (Xu and Arnason 1994), and the nuclear genome is also being determined (Ellis 2001).

Previous studies on horse relationships have used a variety of molecular techniques including looking at protein polymorphisms, restriction enzyme analysis of mDNA, sections of the control region of mDNA and short sequences of 16S ribosomal RNA (rRNA) (Lister et al. 1998). Whilst it has been possible to find out that modern breeds of horse are different from each other using microsatellite analysis (Bjørnstad *et al.* 2000). Lister *et al.* (1998) found that they were unable to distinguish breeds using mDNA. Lister *et al.* (1998) were able to establish significant differences between horses, zebras and onagers, and that the genetic timeframe of the divergence of these species agrees with the fossil records. This ability to distinguish between different equid species has great potential for looking at the problems of differentiating horses and donkeys, and should also be able to determine their hybrids.

Whilst Lister *et al.* (1998) were unable to show breed types in the genetic information, they were able to establish that 'the amount of sequence divergence between modern horses is greater than could have arisen within the timescale of domestication', suggesting that domestic horses derive from wild stock distributed over an extensive enough geographic region to have contained a considerable pre-existing haplotype diversity (Lister *et al.* 1998: 275). They were also able to establish that the Przewalski horses originated from the same diverse genetic stock as domestic horses, but there was no conclusive evidence that they have either had a separate history since that time and are therefore a wild population, or that they are so similar to domestic breeds that they represent a feral population, leaving that question unresolved. This high degree of genetic diversity in horses from the point of domestication onwards may be a drawback to studying types of horses in ancient populations unless specific genes can be isolated that reflect aspects of phenotype such as height, build and coat colour.

One of the major problems with studying ancient DNA is the rate of DNA survival in ancient materials. For instance, water can induce breakage in the DNA strands that results in many small pieces of DNA being present (Brown 2001). These can than be subject to other forms of decay. The preservation of DNA in bone has been positively linked to the state of histological preservation (Colson *et al.* 1997). Therefore, taphonomic conditions that preserve the histological structure of bone (such as waterlogging) will also preserve the DNA. This can help in determining whether a sample is likely to be of use in a study of ancient DNA. Specific studies of post-mortem changes in the porosity of bone, caused by both loss of organic matter and microbial action (Turner-Walker *et al.* 2002; Robinson *et al.* 2003), have shown that the degree of porosity due to microbial action can be used to indicate the likelihood of DNA survival. The more microbial destruction has taken place, the higher the bone porosity and the lower the chances of DNA survival.

Colson *et al.* (1997) also found that age of the sample is not a discriminating factor in the preservation of DNA (at least not in the range of the 200-12,000 years of their study). This is corroborated by the work of Lister *et al.* (1998), who they were able to get amplifiable and recognisable DNA from 16-40,000 year old material from the Siberian permafrost and from 12,250 year old material from waterlogged deposits in Kents Cavern where, but not from more recent material from the dry environment of Bronze Age Botai, Kazakhstan. The three results Lister *et al.* (1998) did manage to obtain were from hundreds of amplifications carried out on over 50 samples, indicating that studies of ancient DNA will always be limited by the degree of preservation of the bones themselves.

Another problem that is particularly relevant to the question of determining horses, donkeys and hybrids is that much of the work, up to now, has concentrated on the mitochondrial DNA, which only reflects the maternal inheritance. It has been determined in several studies that only a limited number of maternal lines have contributed to the domestic horse gene pool (Jansen *et al.* 2002) and that the rate of mutation in these lines is so slow that differences in modern breeds often do not show up. This seems to contradict the statement of Lister *et al.* (1998) given above concerning the possible polyfocal domestication of the horse. However, Lister *et al.* (1998) only states, that there are more maternal lines than could have arisen from a single line of domestication, and that there was considerable rather than an enormous degree of diversity in those lines. Therefore the studies can be seen as pessimistic and optimistic views of the same situation.

The limited number of maternal lines in the horse would be a benefit in studying hybrids, as the degree of variation would be less, making positive identification of maternal horse inheritance easier. However, in studies of breed differences it is a major problem, as highlighted by Lister *et al.* (1998), because the movement of horses for cross-breeding has historically entailed mostly male individuals. The mitochondrial markers are unlikely to reflect this and could in fact underestimate the effect of cross-breeding. Jansen *et al.* (2002) have had more success differentiating breeds by studying the D-loop area of the mDNA. However, even their study showed that there is a great deal of overlap in types between breeds. Mitochondrial DNA is perhaps not the best part of the genome to study regarding differences and future work on nuclear DNA and Y-chromosome sequences may provide more useful information.

For the particular issue of hybrid identification, it may be that a combination of mDNA and Y-chromosome sequences would give better results. After all, nearly all living organisms inherit DNA from both parents (Brown 2001) and looking at one side only will not give a balanced picture. This is particularly relevant to the identification of mules because looking at either mDNA or Y chromosomes will only identify half the parentage, which will not distinguish the mules from the parent species on that side. Because mules are a hybrid, it may be possible to identify them by looking for the combination of 'horse' markers on the mDNA (maternal inheritance) and 'donkey' markers on the Y chromosome (paternal inheritance). However, this means that survival of sequencable fragments of both mDNA and Y-chromosomes in the same bone is crucial, which may not occur frequently enough for good results. This approach is still worth investigating in future research.

4.7 Bone biometry

Although the size of bones has been alluded to in Section 3.4 looking at the relative proportions of limb segments, this section will deal specifically with work that has been undertaken using measurements of individual bones. This includes work on simple measurement indices, log-ratio techniques and multivariate statistics. The measurements on which this work is based are explained in Chapter 3.

4.7.1 Bivariate plots

It was observed with museum specimens that the metapodials and first phalanges of donkeys and mules looked more slender than those of horses. A simple bivariate plot of shaft breadth against greatest length would therefore go some way to differentiating the species. Figures 4.14 and 4.15 show that the plots do to some extent separate the species, mainly because donkeys are generally significantly smaller in both dimensions than horses. The plots do not, however, distinguish mules from horses. Although the metapodials and first phalanges of mules are apparently visually more slender than those of horses, the difference is not great enough to separate them mathematically. This may be because the metapodials are particularly slender in the anterior-posterior plane (Figure 4.12) and less so in the medio-lateral plane that is measured using SD.

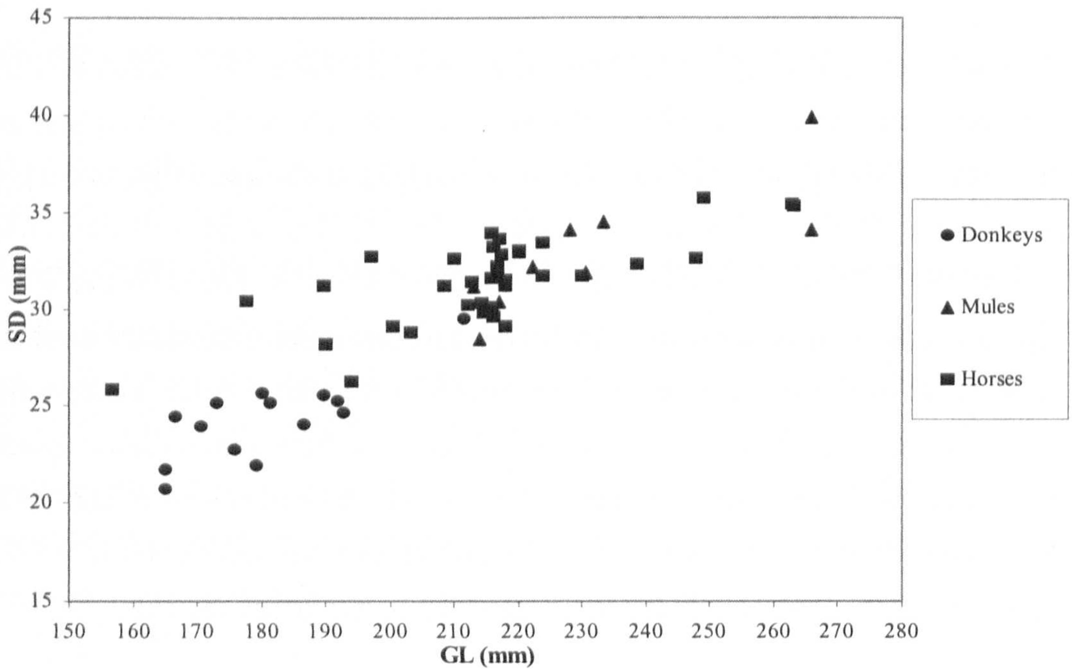


Figure 4.14. Scatterplot of greatest length (GL) against shaft diameter (SD) for modern metacarpals.

Another relatively simple technique that has been used to differentiate equids is estimated withers height. The working methods of this technique have been discussed in Chapter 3. Although estimated withers height can be used to distinguish between horses and donkeys, it cannot differentiate small ponies and donkeys because they are of similar height. Similarly, mules cannot be distinguished from large ponies and horses by height alone. In addition, there are the previously discussed problems of using horse-derived methods on donkeys and mules. As simple biometric methods do not separate the species and in particular cannot detect the hybrids it is necessary to use more complex methods.

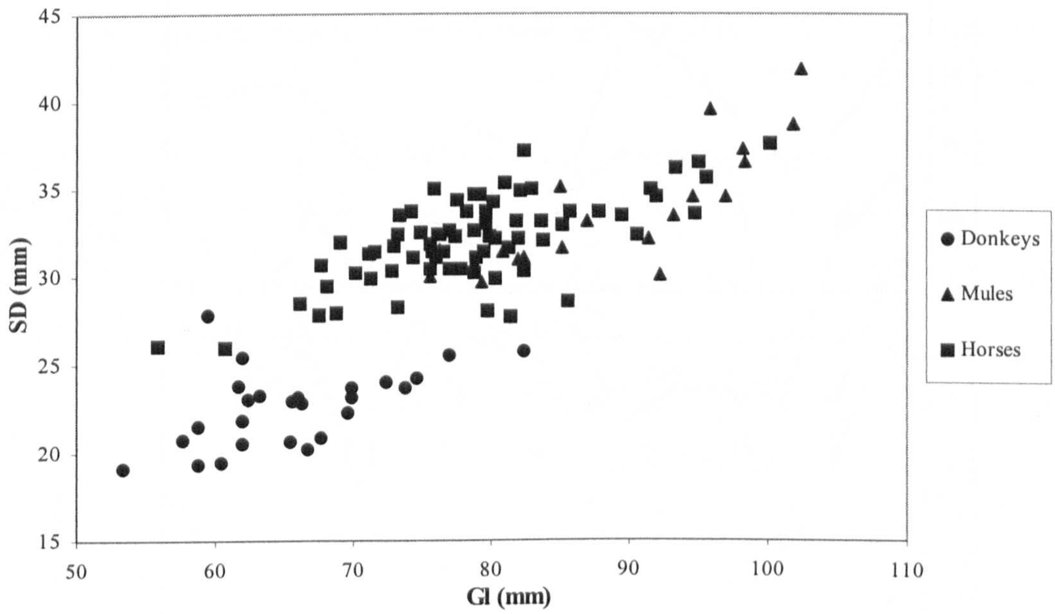


Figure 4.15. Scatterplot of greatest length (GL) against shaft diameter (SD) for the modern first phalanges.

4.7.2 Log-ratio technique

Véra Eisenmann has worked extensively on the problem of equid identifications. Together with colleagues she has written many papers on the subject, of which several are of particular relevance to this study (Eisenmann 1986; Eisenmann and Bekouche 1986; Dive and Eisenmann 1991). The log-ratio technique was used extensively in these works on equid identifications. The working of this system has been explained in Chapter 3.

It is necessary to reiterate the fact that Eisenmann uses a different measurement system to that employed by the majority of zooarchaeologists (Section 3.1). This has meant that whilst evaluating the possibility of using this technique in the current research, the nearest equivalent measurement to the more widely used von den Driesch (1976) system was used. With reference to the cranium first, all the species and hybrids were compared with the mean of a group of Onager (*Equus hemionus onager*) specimens. This illustrates well the differences between the major equine groups but as will be discussed below, is perhaps less applicable to this research. The conclusions that are drawn from the ratio diagrams comparing the horses, donkeys and hybrids are that horses have a short vomar bone, a narrow diastema in relation to the muzzle and a small auditory meatus; donkeys have broad supra-orbital crests, anteriorly placed orbits, long vomars, large auditory meati and a wider diastema in relation to the muzzle. Hybrids were determined to be more horse-like but have long vomars, and the muzzles have ass proportions (Eisenmann 1986).

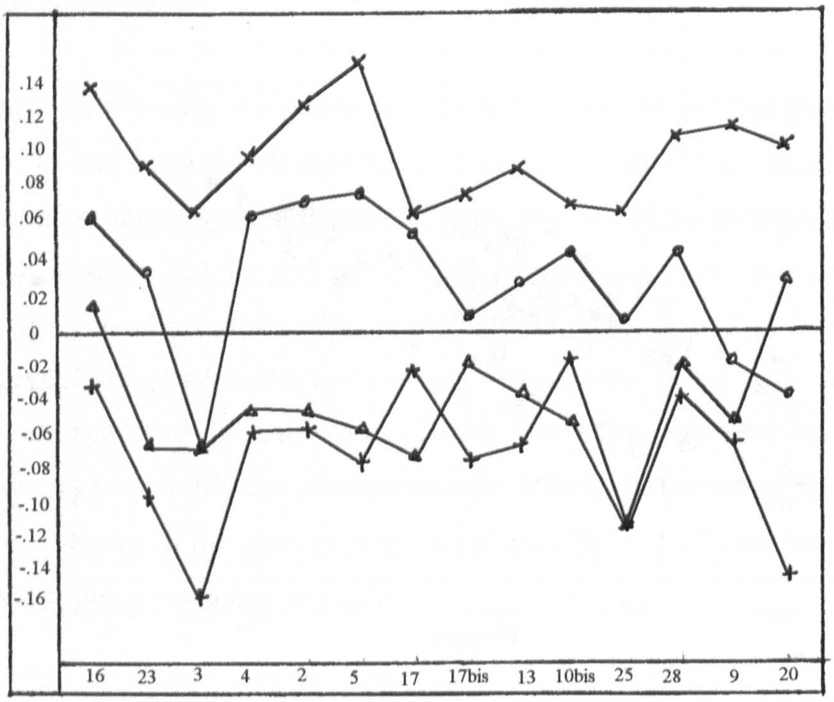


Figure 4.16. Log-ratio diagram of cranial measurements for ponies (+), Przewalski horses (x), donkeys (Δ) and mules (o) using onager as the standard and the Eisenmann system of measurement (after Eisenmann 1986).

The practice of comparing the horses, donkeys and hybrids to an onager standard has less relevance for this research, because the onager is quite different. Also, ratio diagrams are confusing and difficult to interpret clearly. For this reason it was decided that the work should be repeated using one of the equid samples relevant to this study as the standard and also using the measurement system of von den Driesch (1976).

Figure 4.17 shows the skull measurements of von den Driesch's (1976) system plotted using the mean of Przewalski horses as astandard. There are several interesting features of this graph. It shows that although the body sizes of the two domestic horse groups are very varied their heads are quite close in size, whilst donkeys have proportionately smaller heads and the mules have large heads. All the domestic horses have proportionately smaller cheek teeth (measurements 22-24) than those of the Przewalski horses, probably a factor of domestication. All the domestic animals show narrower muzzles (measurement 45), probably also a reduction in tooth size from the wild horses. However, mules and donkeys have a proportionately much narrower muzzle than all other categories, with the Arab horses coming a close second. One other interesting feature is the width of the occipital condyles, which are proportionately larger in domestic animals and much larger in mules and Arabs. There seems to be no anatomical significance behind these differences, and they are not strong enough to enable mule skulls to be separated from those of horses with any confidence. In addition, it is unlikely that the separation would be possible on incomplete skulls, which would preclude most archaeological specimens.

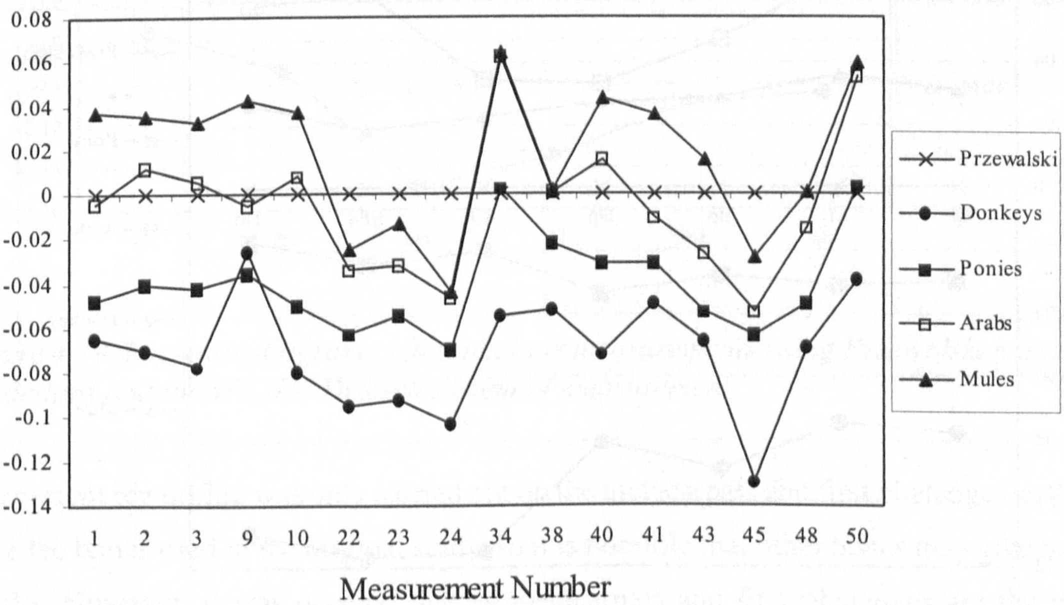


Figure 4.17. Log-ratio diagram of cranial measurements using Przewalski horses as the standard and the Von den Driesch (1976) system of measurement.

The log-ratio technique was originally also applied to the metacarpals (Eisenmann and Bekouche 1986) and the first phalanges (Dive and Eisenmann 1991). Therefore, it seemed appropriate that this work should be repeated using the current dataset and measurement system. Taking the metacarpals first of all, the measurements were again plotted against a Przewalskii standard.

Figure 4.18 shows that the donkeys are consistently much smaller than any of the other groups on all measurements, but particularly regarding the shaft and distal measurements. The two domestic horse groups have larger distal ends and smaller proximal ends than the Przewalski horses. Indeed the DP measurement (see Table 3.1 for definitions) seems to be proportionately quite a lot smaller. The mules show a very similar picture to the standard group, just slightly bigger, and the DP measurement is more similar to the standard than domestic horses. Again the visual slenderness of the mule metacarpals does not show up graphically. Indeed both the Arab and donkey groups show proportionately more slender shafts than the mules. From this it can be seen again that it is very difficult to separate mules from horses, and size is the main factor separating the donkeys. If the pony and Arab groups are combined their pattern is similar to that of the Arabs but overlapping in size with the mules (C. Johnstone, unpublished data), again demonstrating the problems of differentiating the two.

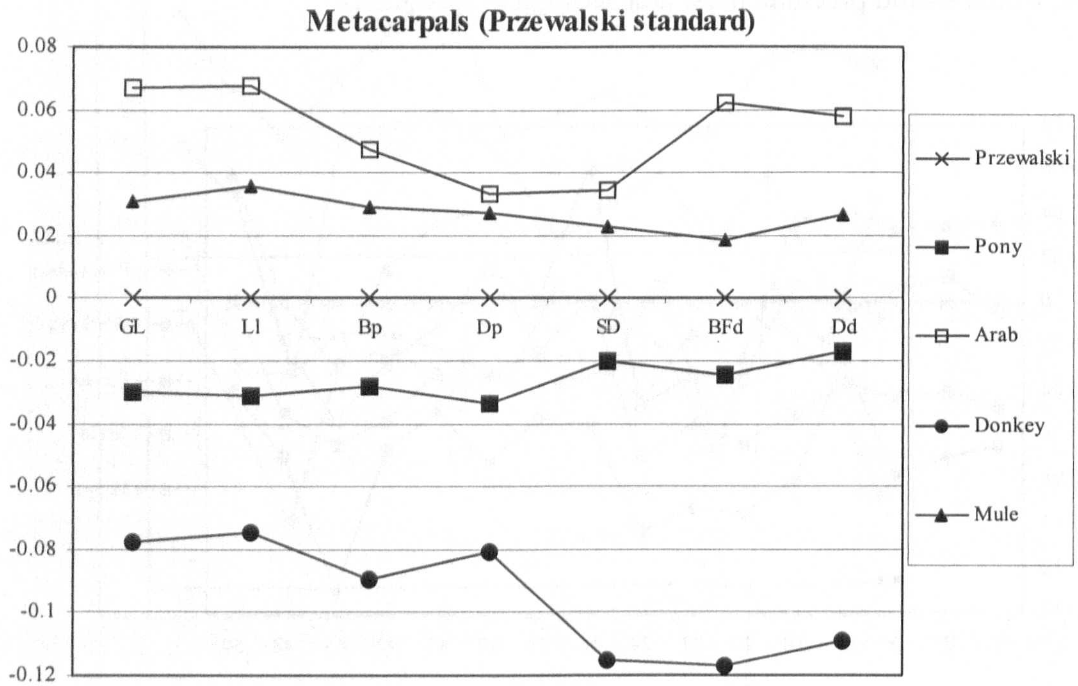


Figure 4.18. Log-ratio diagram of metacarpal measurements using Przewalski horses as a standard and the von den Driesch (1976) system of measurement.

The picture for the first phalanges is very similar (Figure 4.19). Once again the donkeys plot out slightly differently, showing a greater slenderness in the shaft than the other groups. Also the proximal end of the donkey phalanges is proportionately much narrower in the anterior-posterior plane than those of the ponies and Przewalski horses and slightly more so than the mules and Arabs. The mules are very similar to the Arab horses and not greatly different from the other horses: certainly not enough different to be able to separate them with confidence. This pattern stays the same if the pony and Arab data are combined.

As Figures 4.16-4.18 have shown, the log-ratio technique will allow the separation of donkeys from horses and mules, mostly on the basis of size but also on small morphometric characteristics. However, it is impossible to distinguish mules from horses with any degree of certainty. The original analysis using Eisenmann's (1986) measurement system seemed to be slightly more successful. However, the number of mules used in the original study was very small (two individuals) and therefore an inadequate sample. Even in the original study the differences were very slight.

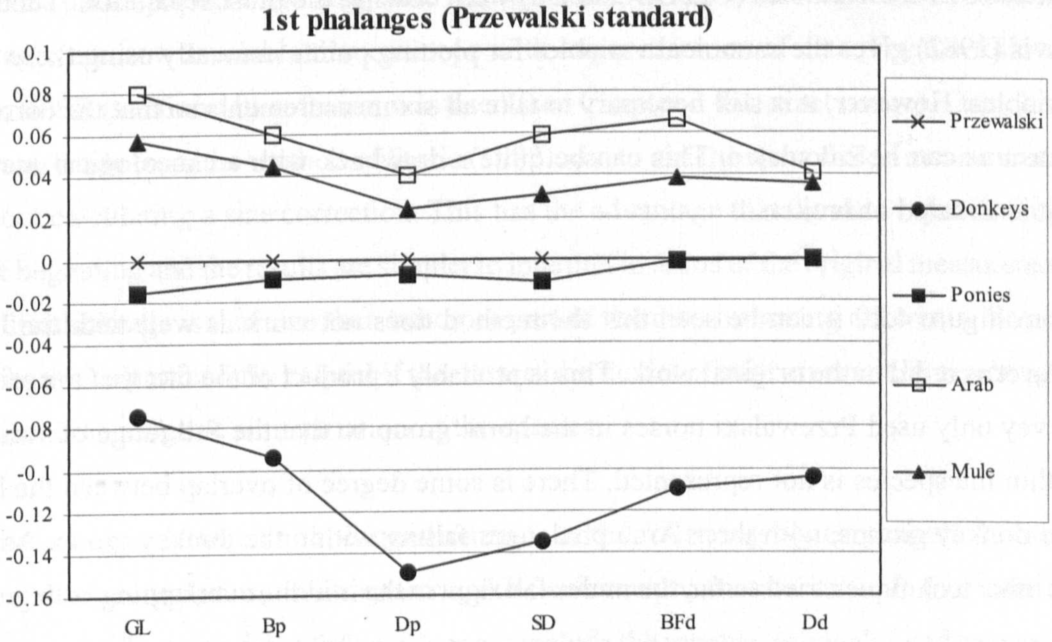


Figure 4.19. Log-ratio diagram of first phalanx measurements using Przewalski horses as a standard and the von den Driesch system of measurement.

The current reworking was only carried out on the metacarpals and first phalanges as these were the bones used in the original study, so it is possible that other bones may give better results. However, it was decided that as metacarpals and first phalanges are the most frequently occurring bones on archaeological sites it would be expedient to find a method for differentiating these bones.

4.7.3 Trivariate morphometric analysis

The basis of trivariate morphometric analysis is an unpublished paper by Davis (1982), which sets out the methodology. It was never taken further because the dataset was considered too small and the species separation was not 100% accurate (S. Davis *pers. comm.*). It was considered worthwhile to try the method with a larger sample and to include the mules, which were not included in the original work.

The method is based on the step-wise discriminant analysis of six measurements taken on the first phalanx. These measurements are GL, Bp, Dp, SD, Bd, and Dd which in the original paper (Davis 1982) were numbered 1–6 in that sequence. First of all a size correction measure was applied to the measurements, which was done by expressing the measurement as a percentage of the total of all six measurements. These size-corrected figures were put through step-wise discriminant analysis (Davis 1982), which calculated the canonical variables that were then used to plot the maximum separation of the groups. It was found that three of the variables (GL, SD and Dp) were causing the most separation. Therefore Davis (1982) gives the canonical variables for plotting points manually using these three variables. However, it is still necessary to take all six measurements so that the corrected measures can be calculated. This can be quite a drawback with archaeological material that is abraded or broken.

From Figure 4.20 it can be seen that the method does not work as well with the larger dataset as it did in the original work. This is probably a product of the fact that the original survey only used Przewalski horses in the horse group so that the full range of variation within the species is not represented. There is some degree of overlap between the horse and donkey groups, with three Arab phalanges falling within the donkey group. As with the other techniques tried so far, the mules fall right in the middle, overlapping both groups.

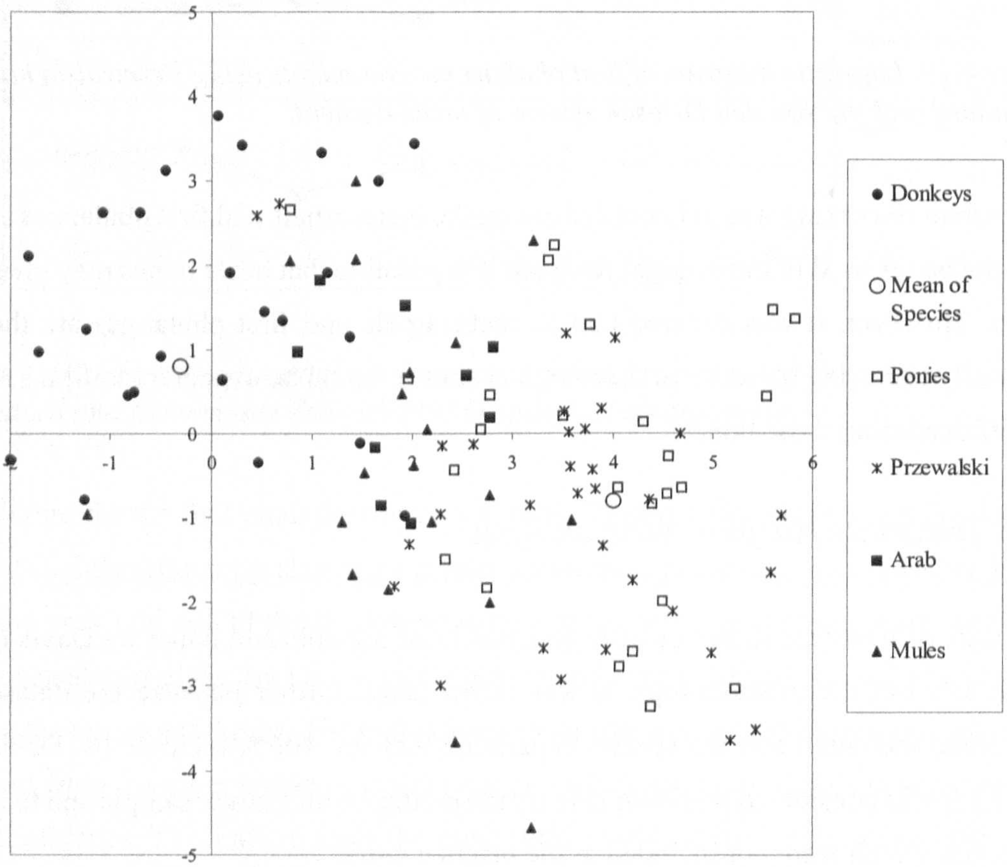


Figure 4.20. Trivariate method (after Davis 1982) of equid species determination using measurements of the first phalanx (Means taken from Davis 1982).

4.7.4 Discriminant function analysis

Davis' (1982) work was extended by applying multivariate methods to other bones and using more measurements. When the original work was undertaken (1982), computer statistics packages were less adaptable and less user friendly. More sophisticated software packages are now available that can cope with larger amounts of data. For the following work SPSS (version 10) software was used (see Chapter 3 for exact usage). One change that was made from the method of Davis (1982) was to use the unmodified measurements, without calculating a size correction. This has the advantage that the data input is simpler at the beginning and the results are simpler to interpret in terms of the original measurements. The disadvantage is that size then becomes part of the discriminating criteria, which may not always be particularly helpful if the dataset the model is built on is not large enough to represent the range of size variation of the species.

Analysis was undertaken on the measurements of the following bones: scapula, humerus, radius, metacarpal, femur, tibia, astragalus, calcaneum, metatarsal and first phalanx. However, the discussion that follows does not include the scapula, astragalus and calcaneum, because the analysis could only poorly discriminate the three groups using the few measurement variables available in each of these cases (C. Johnstone, unpublished data). In addition, although measurements of the skull and mandibles were taken on the modern specimens, it was decided that these were less likely to be of use in the work on archaeological material (due to poor preservation of these elements), and they were excluded from the analysis. The data used in the following analyses is given in Appendix Table A1a.

Initially pair-wise discriminant function analyses were carried out on all the elements to check whether the small sample size was affecting the results of the discriminant function analyses (see Chapter 3). These analyses showed that whilst the donkeys and mules were 100% distinguishable (Table 4.6) on all elements, the donkey-horse and mule-horse separations were not perfect on some elements.

Analysing the probabilities of group membership showed that even where the overall reclassification rate was lower, most individual cases still had a high probability of group membership (>80%). This result suggests that for most elements a larger sample (particularly of mules) would improve the prediction of group membership considerably. These results once again highlight the fact that the lack of mule reference material is a serious problem n researching the issue of identification.

Table 4.6. The % correct reclassification by element for the pair-wise analyses

Element	Donkey-mule	Mule-horse	Donkey-horse
Humerus	100	90.7	89.4
Radius	100	90.7	97.8
Metacarpal	100	73.3	100
Femur	100	82.6	95.9
Tibia	100	89.6	100
Metatarsal	100	81.6	100
First phalanx	100	76.7	100

The results of the discriminant function analyses of all three species are presented on the following pages on an element-by-element basis. The results for each element are described fully so that the limitations of the results can be understood. Table 4.7 gives a summary of the relevant statistics for each analysis.

Table 4.7. Element-by-element statistics from discriminant function analyses with all measurements

Element	Total no. of cases	% correct Reclassification	Chi-squared significance	
			Function 1	Function 2
Humerus	56	85.7	P = <.000	P =.005
Radius	55	87.3	P = <.000	P = <.000
Metacarpal	59	76.3	P = <.000	P =.096
Femur	58	81.0	P = <.000	P =.004
Tibia	62	91.9	P = <.000	P = <.000
Metatarsal	51	86.3	P = <.000	P =.013
First phalanx	112	82.1	P = <.000	P = <.000

Starting with the humerus, Figure 4.21 shows the results of the discriminant function analysis using all the measurements taken on this bone (see Table 3.1). The data points are particularly spread out over the whole area of the graph, with not much clustering around the group centroids (three-dimensional means), and a large area of overlap between the three groups. This may indicate that this element is rather variable within each species. The humerus certainly seems to form a very variable proportion of the front limb, as demonstrated for the withers height calculations (Chapter 3), which may be reflected in these results.

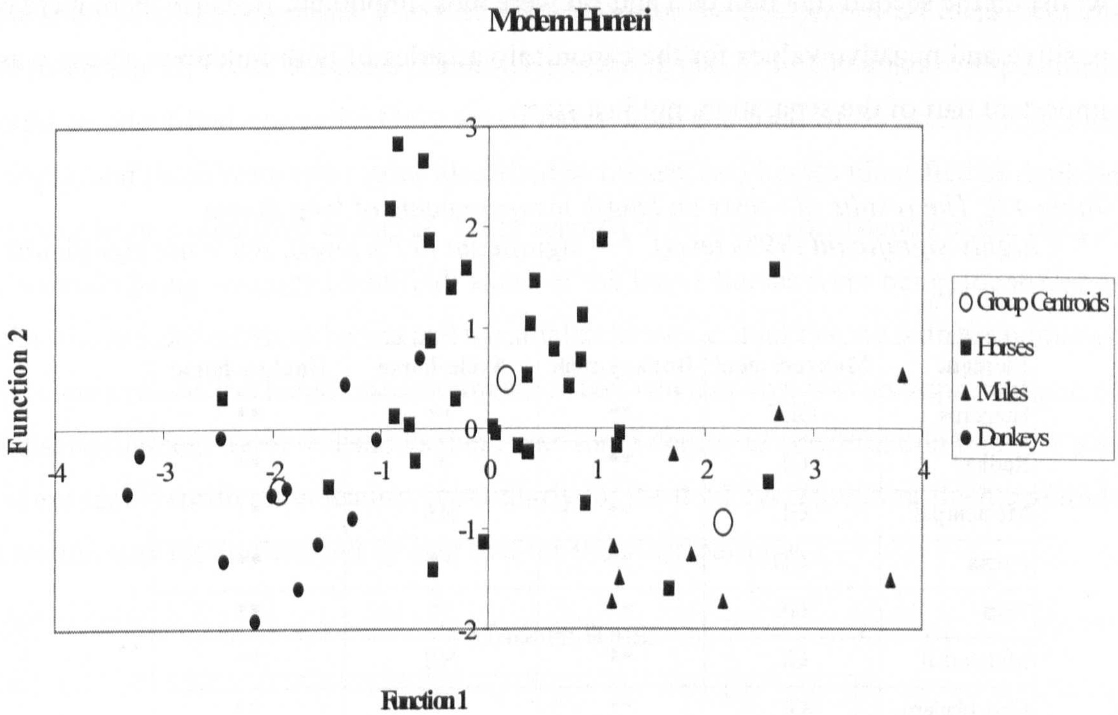


Figure 4.21. Discriminant function analysis of modern equid humerus measurements.

As would be expected from such a scatter of points the correct reclassification rate was quite low, 85.7%, meaning that 85 out of every 100 unknown cases would be correctly identified. Of the 56 cases analysed eight cases were wrongly identified, a single donkey as a horse, three horses as donkeys and a further two horses as mules. The confusion between horses and donkeys was far greater for the humerus than for any of the other elements, perhaps again reflecting the within-species variability of this bone.

In addition, the specimens that were wrongly identified seem to be the largest and/or smallest individuals, suggesting that size may be a significant factor in the identifications. In order to check whether this is true, t-tests were performed on the length measurements to see if the groups were significantly different in terms of size. The results for all the bones are shown in Table 4.8. As can be seen, the lengths of the humeri of all three groups were significantly different from each other, which may have bene contributing to the separation and causing outliers to be misidentified.

When chi-squared tests were performed, only the first function was significant (Table 4.7) indicating that most of the separation was done on the x-axis. This reflects the good donkey-mule pair-wise separation (Table 4.6) and the less good division of the horses from either.

On the first function, the measurements causing most of the separation were GLC and BT, whilst on the second function GLl and Bd were most important. Because there were both positive and negative values for the canonical variables of both functions, shape was an important part of the separation, not just size.

Table 4.8. The results of t-tests on length measurements of long bones.
*** = highly significant (99% level), * = significant (95% level), NS = not significant*

Element	Measurement	Donkey-mule	Mule-horse	Donkey-horse
Humerus	GLC	**	**	**
Radius	GL	**	*	**
Metacarpal	GL	**	NS	**
Femur	GL	**	**	**
Tibia	GL	**	**	**
Metatarsal	GL	**	NS	**
First phalanx	GL	**	**	**

Table 4.9. Best reclassification rate for the discriminant function analyses on each element and the measurements used to achieve that result.

Element	Total no. of cases	Best % correct Reclassification	Measurements used
Humerus	56	85.7	GLl GLC Bp SD Bd BT HTC (also without GLl, Bd or BT)
Radius	55	86.0	GL Ll BFp SD BFd
Metacarpal	59	81.4	GL Bp Dp SD Bd Dd (also without SD or Bp)
Femur	58	82.8	GL DC BP SD Bd
Tibia	62	91.9	GL Ll Bp SD Bd Dd (also without SD, Bd or Dd)
Metatarsal	51	86.5	GL Bp Dp SD Bd Dd (also without SD or Dd)
First phalanx	112	83.0	GL Bp SD BFd Dd (also without SD)

A method of refining the discrimination is to see if there are too many variables and this is clouding the issue. By dropping out measurements singly and in pairs it may be possible to achieve a better separation of species. When individual measurements were dropped from the analysis of the humerus, it was found that GLl, Bd or BT could be dropped from the analysis without adversely affecting the results (i.e. the reclassification rate stayed the same). Similarly GLl and Bd as a pair could be dropped from the analysis and the reclassification rate stayed the same (Table 4.9). This would be quite useful for archaeological material, where GLC and BT are more likely to be measurable than GLl and Bd, which are more affected by superficial abrasion of the bones. So although the rate of reclassification could not be improved in this case, more archaeological cases could be run through the revised analysis.

From the analysis of the radius measurements, Figure 4.22 shows a reasonably clear separation of all three groups. The reclassification for the analysis of all measurements was correct in 87.3 % of the cases (Table 4.7), meaning that 87 in 100 unknown specimens should be identified correctly. Only seven cases from the total of 55 were reclassified wrongly, and these were two mules identified as horses, two horses identified as donkeys and three horses identified as mules. There seemed to be some consistency in the sizes of the animals being wrongly identified; some of the larger horses were being identified as mules, the smaller mules as horses and the smaller horses as donkeys. As with the humerus, t-tests were run on the length measurements to test whether size was an important part of the discrimination. Table 4.8 shows there was some degree of confirmation that size was an important identification feature, particularly for the donkeys. However, the horse/mule separation was less influenced by size that for the other pairings.

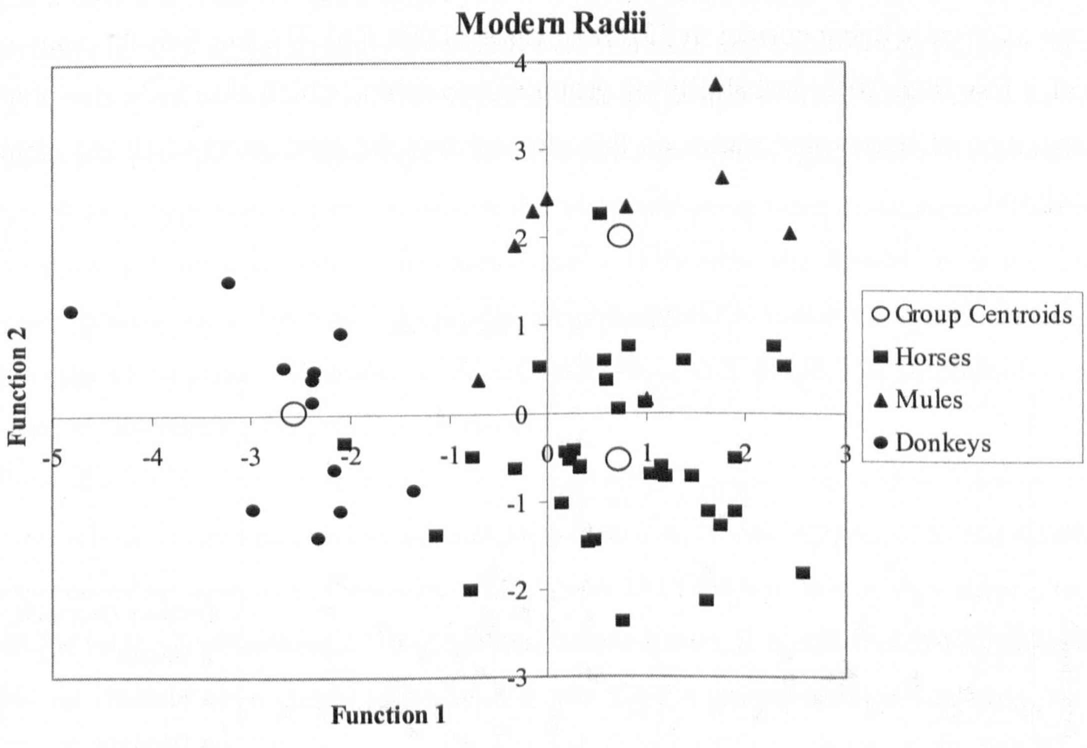


Figure 4.22. Discriminant function analysis of modern equid radius measurements.

Both functions gave highly significant results in the chi-squared tests (Table 4.7), indicating that both were contributing to the species separation. The separation of donkeys from horses and mules was mostly on the first function, and separation of mules from horses was mostly on the second function. The measurements that were contributing most to the separation were Bp, BFp and Bd for the first function, and GL, Bp and Bd and DFd for the second function. As with the humerus, the canonical variables of both functions showed both positive and negative values, indicating that shape was an important part of the separation.

A slight problem with the results from the radius was that they included one of the measurements devised by the author (DFd), which will not be available for most archaeological data. Rerunning the analysis without the DFd measurement resulted in a lower correct reclassification rate (82.5%). This was improved by also taking out the Bp and Bd measurements (86%; Table 4.9). Evidently the repetition of proximal and distal breadths was confusing the issue. This analysis, without Bp, Bd and DFd, was be used for the current research but measurement DFd should be taken for identification purposes in the future.

Taking the metacarpals next, the results were less good than with the previous two elements. Figure 4.23 shows that whilst the donkey metacarpals separated out well in a clearly defined group, the mules and horses did not separate particularly clearly. The pair-wise analyses reflected this, with the donkey identifications being completely correct but the horse-mule separation only being correct in 73.3% of cases (Table 4.6). For this pairing many cases had a less than 70% probability of group membership, which also indicated that the separation of horses and mules on this element was the least good of all the elements analysed.

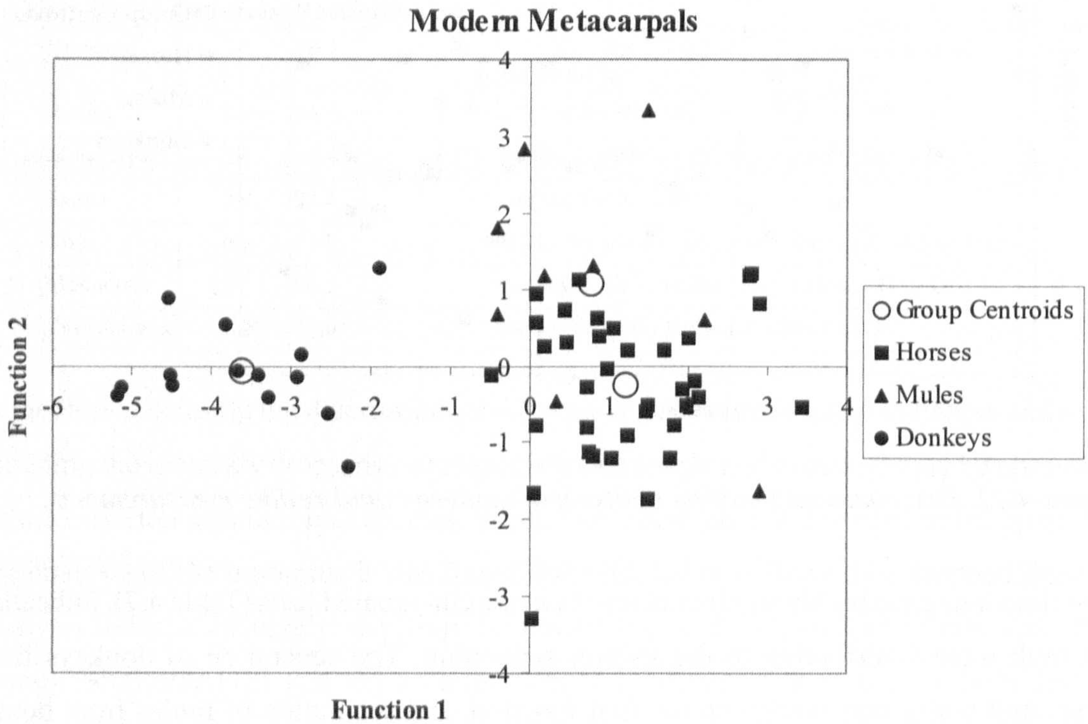


Figure 4.23. Discriminant function analysis of modern equid metacarpal measurements.

This problem was also evident in the overall reclassification rate of 76.3% using all the measurements (Table 4.7). This means that in an unknown sample only ¾ of metacarpals will be correctly identified as horse, donkey and mule. Of the 59 cases in the modern data set, 14 were reclassified incorrectly, 11 horses as mules and three mules as horses. The identification of donkeys was not a problem and again was size related on the basis of the t-tests (Table 4.8). However, the problem of separating horses and mules did not seem to be size related, as these misidentifications occured in both larger and smaller horses and mules. This was borne out by the t-tests, in which the mule-horse pairing gave a 'not significant' result (Table 4.8).

As with the humerus, only the first canonical function was highly significant (Table 4.7). This was again reflected in the way the points were spread on the plot, with most variation on the x-axis and little variation on the y-axis. Perhaps surprisingly the measurements that were causing most of the separation on both axes were GL and Ll, with Dp, SD and Dd on the x-axis and Bd on the y-axis. This suggests that the morphology of either the proximal articular facets or the distal trochlea (or both) is different in donkeys from both horses and mules. It also suggests that mules inherit the morphology of their metacarpals from the horse dam and are therefore more 'horse-like' (confirming the results from the limb proportion analyses in Section 3.4). As before, the canonical variables of both functions had a mix of positive and negative values, indicating that shape was important in the separation, supporting the previous evidence.

As the reclassification rate on the metacarpal was so low, it was imperative to test whether a selection of measurements would perform better than the whole set. Very surprisingly, given the heavy involvement of Ll in the separations above, it was found that by dropping Ll out on its own or in combination with Bp or SD the reclassification rate went up to 81.4% (Table 4.9). A slight improvement was also found if Gl was dropped (79.7%). These results will once again enable more archaeological data to be tested because often only one length measurement is taken. However, because the correct reclassification rate is still quite low, this element should probably not be used in the analysis of the archaeological material. This is a pity as complete metacarpals are one of the more frequently occurring elements in assemblages.

Now looking at the hind limb, the results of the analysis of all measurements of the femur are shown in Figure 4.24. The degree of scattering of the points was slightly less for the femur than the humerus, indicating a more uniform shape and size within species. However, none of the groups clustered around their respective group centroids and there was a large amount of overlap between the groups. The pair-wise analyses showed that donkeys and mules were completely separable and donkeys and horses almost so, whilst horses and mules were less clearly separated (Table 4.6). The probabilities of group membership were relatively high for both these last two pairs, again suggesting that the small dataset was hampering identification.

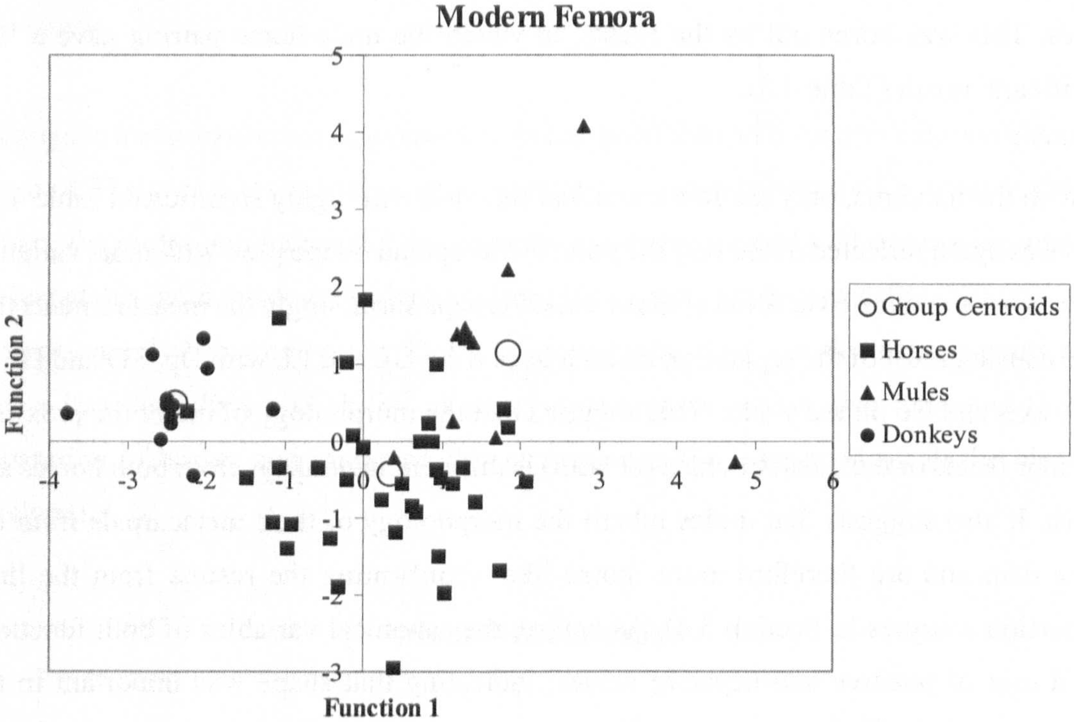


Figure 4.24. Discriminant function analysis of modern equid femur measurements.

The reclassification rate for all measurements on the femur was 81.0%, which was the second lowest value for the elements studied (Table 4.7). Eleven cases out of the total of 58 were wrongly attributed, two mules as a horses, three horses as donkeys and a further six horses as mules. Once again, there was a slight bias towards the larger horses being identified as mules, and the small ones as donkeys. This was confirmed in the t-tests on the lengths (Table 4.8), where all three pairs gave highly significant differences.

The first function was highly statistically significant (Table 4.7) and the second function was also significant (as was usual) but at a lower level ($P = 0.004$), indicating that most of the separation was occurring on the x-axis. This was less clear graphically than in previous figures, perhaps because of the greater degree of overlap in the groups. The measurements of GL and Bd were contributing most to the separation on the x-axis, whilst DC was causing the smaller amount of separation on the y-axis. On this element the loadings of the canonical coefficients were mostly positive, indicating that size may well have been contributing much more to the separation than had been the case for the other elements.

Once again the poor reclassification rate prompted further work to improve the success rate by taking measurements out the analysis. Taking out Bd on its own, the rate stayed the same (81.0%). Taking out Bp on its own or in combination with GLC improved the rate very slightly to 81.4%. The best result (Table 4.9) was achieved by taking out just GLC, resulting in a reclassification rate of 82.8%. However, this is still not a particularly good rate of correct reclassification, so this element should probably not be used in looking at the archaeological material. This will not be too much of a problem as whole femora are rare in archaeological assemblages.

As with the radius, the tibia (Figure 4.25) gave surprisingly good results. The separation of all three groups was good (although a few stray individuals were noted), the horses and donkeys forming quite tight clusters around the group centroids, whilst the mules were more widespread. The pair-wise analyses showed that the donkeys were 100% separable from both mules and horses and the mule horse separation was only slightly less good (Table 4.6). The probabilities of group membership were consistently high in all three pairs, suggesting that once again an increase in sample size would benefit the identification rate.

The reclassification rate for the analysis of all measurements was correct in 91.9% of cases, the best result of all the elements (Table 4.7). Of the 62 cases tested, only five were incorrectly identified: all five were horses identified as mules. As before the problem seemed to occur with the largest of the horses and this was strongly borne out by the results of the t-tests on the lengths, where there were highly significant differences between all three groups (Table 4.8).

The results of the chi-squared tests on the canonical functions showed that both were highly significant (Table 4.7). This was visible graphically (Figure 4.25), with the donkeys separating from the other two on the x-axis and the mules and horses separating on the y-axis. The measurements contributing the most to the first function were Bp Bd and Dd, and for the second function Ll and Bp were the most prominent. Although the t-tests showed that size was playing a significant role in the separation of species, the loadings of the canonical coefficients indicated that shape was at least as important, with a spread of positive and negative values.

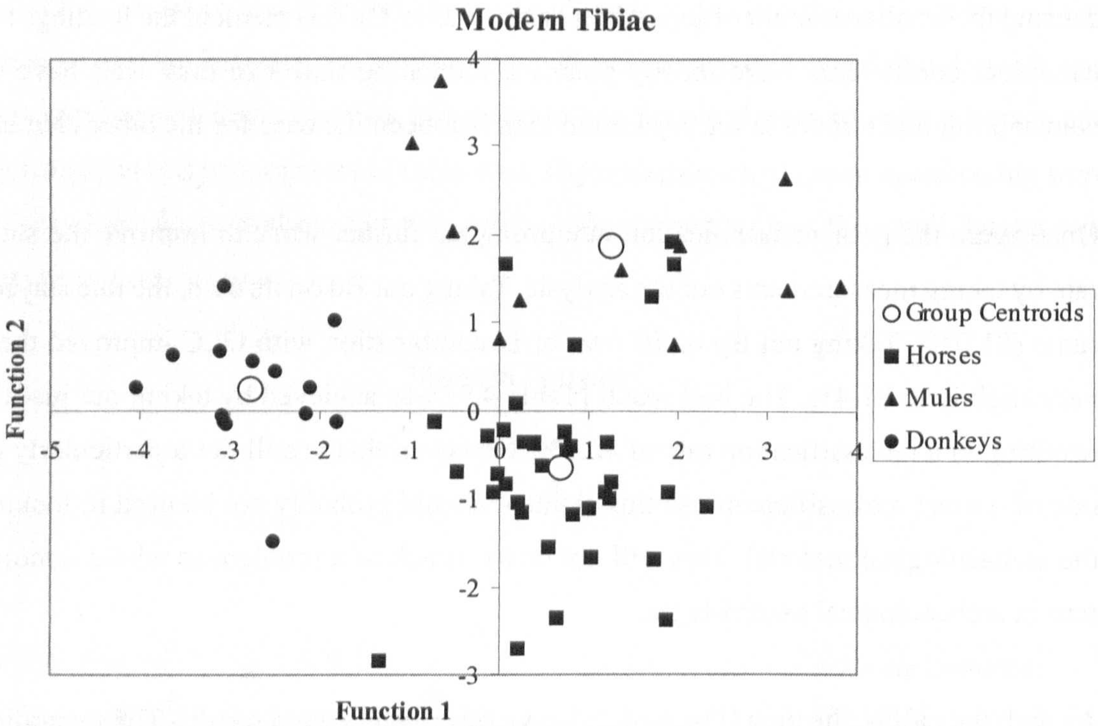


Figure 4.25. Discriminant function analysis of modern equid tibia measurements.

The reclassification ratewith tibiae was so good that there seemed little chance that removing measurements would improve matters, and this proved to be the case. However, the same rate could be achieved by removing SD, Bd or Dd individually (Table 4.9). As this element is most likely to produce accurate results, all these permutations of the analyses can be used on the archaeological material to maximise the results.

Given the poor results on the metacarpal, it was quite surprising that the metatarsal gave a far better reclassification rate and more obvious graphical separation of the species (Figure 4.26). As has been the case for most elements, the separation of the donkeys was quite clear-cut but the horse and mules much less so. The pair-wise analyses produced almost identical results to those of the tibia, with the donkeys giving 100% correct identifications from both horses and mules and the horses and mules giving a slightly lower rate (Table 4.6). The probabilities of group membership were slightly lower than for the tibia, but still high enough to suggest that, as was the case for all elements, a larger sample size would produce better results.

The reclassification value for the analysis of all measurements was 86.3 %, which is the third highest rate for the elements analysed (Table 4.7). From the total of 51 cases seven misidentifications occurred. A single donkey was identified as a mule, two mules as horses and four horses as mules. With this bone there was less uniformity in the size of the specimens being wrongly attributed and this is reflected in the t-tests on lengths. Whilst the donkeys were, as usual, highly significantly smaller than the horses and mules, there was no significant difference between the mules and horses (Table 4.8). This indicated that shape was playing a greater role than size in the identifications, particularly of horses and mules.

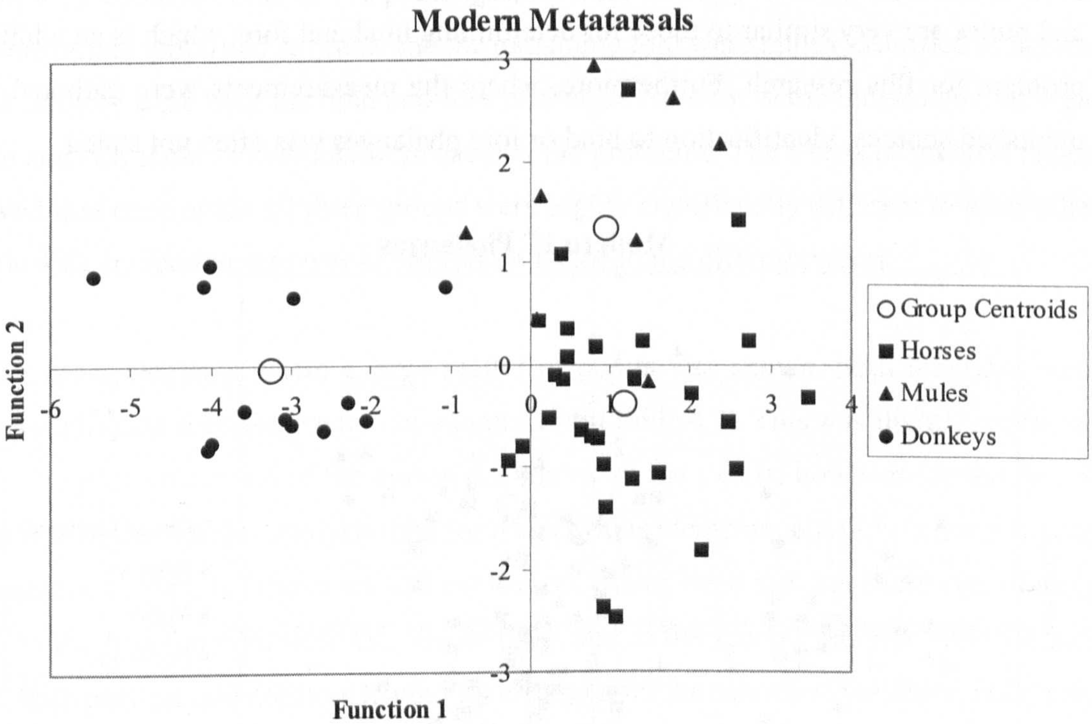


Figure 4.26. Discriminant function analysis of modern equid metatarsal measurements.

As with the metacarpals, only the first function (x-axis) gives a highly significant result with the chi-squared tests (Table 4.7), which was perhaps surprising given the degree of separation visible on the y-axis. The measurements contributing most to the separation on the first function were Bp and Bd, with GL and Bd on the second function. The spread of positive and negative loadings on the canonical variables confirmed that shape was playing an important role in the discrimination.

Although the reclassification rate was good, the analyses were still rerun without some measurements to try and improve the results. Taking Ll out individually produced the same rate (86.3%), and removing LL in combination with SD or Dd made a slight improvement to 86.5% (Table 4.9). As before this would allow more archaeological material to be studied, as many authors do not take both length measurements.

Figure 4.27 shows the results for the pooled data from both hind and fore first phalanges from the modern data set. The reason the phalanges were pooled is that for too many archaeological phalanges it would be impossible to assign them to hind or fore feet with sufficient accuracy. Sometimes it is difficult to do when they are known to be from the same individual, let alone when there is a great variety of shape and size in isolated finds. As stated above in the section on morphology, some of the differences that separate horses and mules are very similar to those for determining hind and fore, which is an additional problem for this research. Furthermore, where the measurements were gathered from published sources, identification to hind or fore phalanges was often not stated.

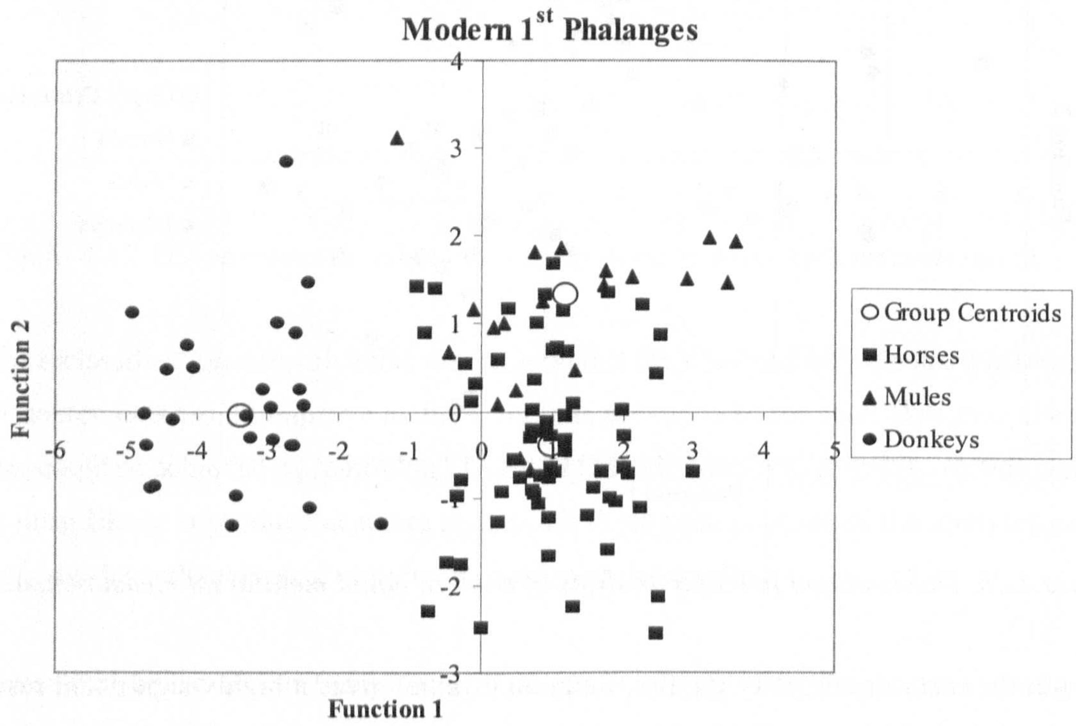


Figure 4.27. Discriminant function analysis of modern equid first phalanx measurements.

As in the trivariate analysis (Davis 1982; see section above), the donkeys formed a readily identifiable group towards the left side of the graph (Figure 4.27). In fact they were more clearly separated using the unmodified measurement data, suggesting that size alone is a factor in the identification of donkeys from horses (as has been discussed above). Unfortunately the distinction of horses and mules was less clear than using the method of Davis (1982), with both centroids close together and a large amount of overlap between the two groups. The pair-wise analyses were similar to the two preceding elements and reflected the visual separation, with donkeys being 100% identifiable from both horses and mules, but the horses and mules only having a correct reclassification rate of 76.7% (Table 4.6). The probabilities of group membership were quite good for all three pairings.

For this element, the poor separation of mules and horses in the pair-wise analyses suggests that even if a larger dataset were obtained, the differentiation of horses and mules would still be less good than with the other elements.

From the analysis of all the measurements, the correct reclassification rate was 82.1% (Table 4.7). From the total of 112 phalanges, 20 were wrongly reclassified cases of which 16 were horses identified as mules and the remaining four were mules identified as horses. Most of these were both the hind and fore phalanges from the same individuals, so eight horse and two mule individuals were causing the problems. The t-tests of greatest length showed that once again all three groups were highly significantly different to each other (Table 4.8), indicating size was an important factor in the differentiation.

Unlike other elements where a large scatter of points was shown, both functions were highly significant according to the chi-squared tests (Table 4.7). This was slightly surprising given the poor separation of the horses and mules on the y-axis; however the number of cases was higher for this analysis than for the previous elements, possibly influencing the chi-squared results. All the canonical coefficient values were low but those contributing most to the first function were GL, Bp and SD, and to the second function were GL and BFd. Both positive and negative loadings were given for the canonical variables, indicating that shape was playing a role in the separations as well as size.

Rerunning the analysis without some measurements resulted in slight improvements to the reclassification rate. Dropping out Dp resulted in the same rate (82.1%). Leaving out SD on its own or in combination with Dp resulted in a reclassification rate of 83% (Table 4.9). Because the reclassification rate was quite low, and because of the problems arising from combining hind and fore phalanges, this element should not be used for looking at archaeological material.

All the preceding analyses were carried out using whole bones. As the results were good for whole radii, tibiae and metatarsals, it was decided to analyse the measurements of these elements further. These further analyses were to investigate whether it was possible to get as good a differentiation with just the distal or proximal measurements of these elements, as these fragments are more commonly found in archaeological assemblages. Unfortunately, it seems that in all cases (C. Johnstone, unpublished data) the length measurements are crucial to the success of the discrimination as none of the analyses of proximal and distal measurements produced a correct reclassification rate above 70%.

4.8 Summary

For the study of equid material at first hand there seem to be many reliable morphological characteristics that will separate horses and donkeys, and a smaller number of features that will separate the mules from both. Whilst many existing biometric methods of separation will distinguish between donkeys and horses, they fail to separate the mules from the horses. The use of discriminant function analysis, as described above, seems to have potential for the differentiation of the bones of all three equids in the archaeological record. This capability is, however, limited by the fact that whole bones are required for an identification based on measurements alone to be reliable.

Many more sophisticated techniques such as studies of bone microstructure, computed tomography and DNA analysis, are all at the experimental stage, and whilst they show promise they are not at a stage that can be used reliably at present.

Given the fact that, for this study, most of the material cannot be studied at first hand, the most useful and reliable technique seems to be the use of discriminant function analysis on whole bones. Hence for nvestigation of archaeological material for this research, the method and analyses described above (Sections 3.3.3 and 4.7), for the radius, tibia and metatarsal, will be used to identify the equid remains.

Chapter Five – Materials

The aim of this chapter is to outline the materials studied in this research This includes the modern reference material used for the production of the species separation methodology (Chapter 4), establishing a standard for use in log-ratio analysis (Section 3.3.1) and evaluating the withers height calculations (Section 3.4). These data were collected first-hand by the C. Johnstone, following the methodology set out in Section 3.1.1, from collections across Europe.

The collection of most of the archaeological data was not carried out first-hand but taken from published material; the time limits of a PhD thesis did not allow enough data to be collected first-hand. The search for these data is outlined in Section 3.1.2 and the database into which all the data and information were entered is outlined in Section 3.2.

5.1 Modern reference material

Measurements were collected from specimens of known species to form a baseline against which the archaeological data could be compared, both for identification and analytical purposes (as described above). Table 5.1 lists the institutions where the reference material resided, together with information on the number of specimens measured. This is not the total number of specimens in that collection, as juvenile and incomplete skeletons were not measured for this study.

Table 5.1. Collections that supplied modern reference material

Collection	Code	Specimens measured
Birmingham Zooarchaeology Laboratory, Univ. of Birmingham, UK	BZL	3 *E. caballus*
British Museum (Natural History), London, UK	BMNH	7 *E. asinus*, 4 *E. caballus*, 3 *E. przewalski*
Museum National d'Histoire Naturelle, Paris, France	MNHN	2 *E. asinus*, 4 *E. caballus*, 5 *E. Przewalski*, 2 mules
Institut fur Paleoanatomie, Munich, Germany	LMU	2 *E. asinus*, 1 *E. caballus*, 2 *E. przewalski*, 6 mules
Zoologische Staatsammlung, Munich, Germany	ZSM	1 *E. asinus*, 1 *E. caballus*, 2 *E. przewalski*, 4 mules, 1 *E. hemionus onager.*
Royal (Dick) Veterinary School, Edinburgh, UK	RDVS	1 *E. przewalski*
Naturalis Museum, Leiden, Netherlands	NML	1 Mule
Museum für Haustierkunde, Halle, Germany	MHKH	4 *E. asinus*, 6 *E. caballus*, 3 *E. przewalski*, 2 mules, 3 hinnies
Sheila Hamilton-Dyer, private collection, UK	SHD	1 *E. asinus*, 1 *E. caballus*
Terry O'Connor, private collection, UK	TPOC	1 *E. caballus*
Keith Dobney, private collection, UK	KD	1 *E. hemionus onager*

A list of the individual specimens, their breed, age, sex and other details where known, is given in Appendix Table A1. As can be seen, much of this information is lacking for many of the specimens, particularly those collected a long time ago. With many museum collections the information has been lost, or was not collected in the first instance.

The number of horse skeletons from the various reference collections totaled 37, of which 21 were from domestic horses and 16 from Przewalski horses. The domestic horses included five Arab horses, two New Forest ponies, three Welsh ponies, four Mongolian ponies, single specimens of Icelandic, Norwegian and Exmoor ponies, and four ponies of unnamed breed. Of these, 31 were complete skeletons and six were part skeletons. One of the complete skeletons was a mounted specimen and hence not all the measurements could be taken. Several domestic horse breeds were initially chosen to represent the range of variation likely to be encountered in the archaeological material. However, the availability of skeletons in collections limited this to some extent, so small horses and ponies without breed details were also measured. Breeds such as Shetland ponies, Thoroughbred and Shire horses were not included as they were considered to be smaller or larger than anything likely to be present in the archaeological samples.

For the donkeys, 17 skeletons were measured, of which 10 were domestic (including two Poitou giant donkeys), two feral and five wild. Of these 14 were complete and three were incomplete. The numbers of mules was more limited, with only nine complete skeletons (one of which was mounted and therefore only limited measurements could be taken) and seven incomplete skeletons, of which four consisted of skulls only. In addition to these, three hinny and two onager skeletons were measured for comparison if needed.

5.2 Archaeological data

Archaeological measurement data were mostly collected from published sources together with information about the sites, such as dating, type of site and some context information. Further data were collected from various colleagues who made available unpublished material or more complete data than that which had been published. The site name and database-generated site number, together with references, are given in Table 5.2. Full bibliographic references are then given in the main bibliography and more information about the sites is contained in the gazetteer (Appendix Table A2). A map showing the approximate locations of these sites across the Roman Empire is given in Figure 5.1.

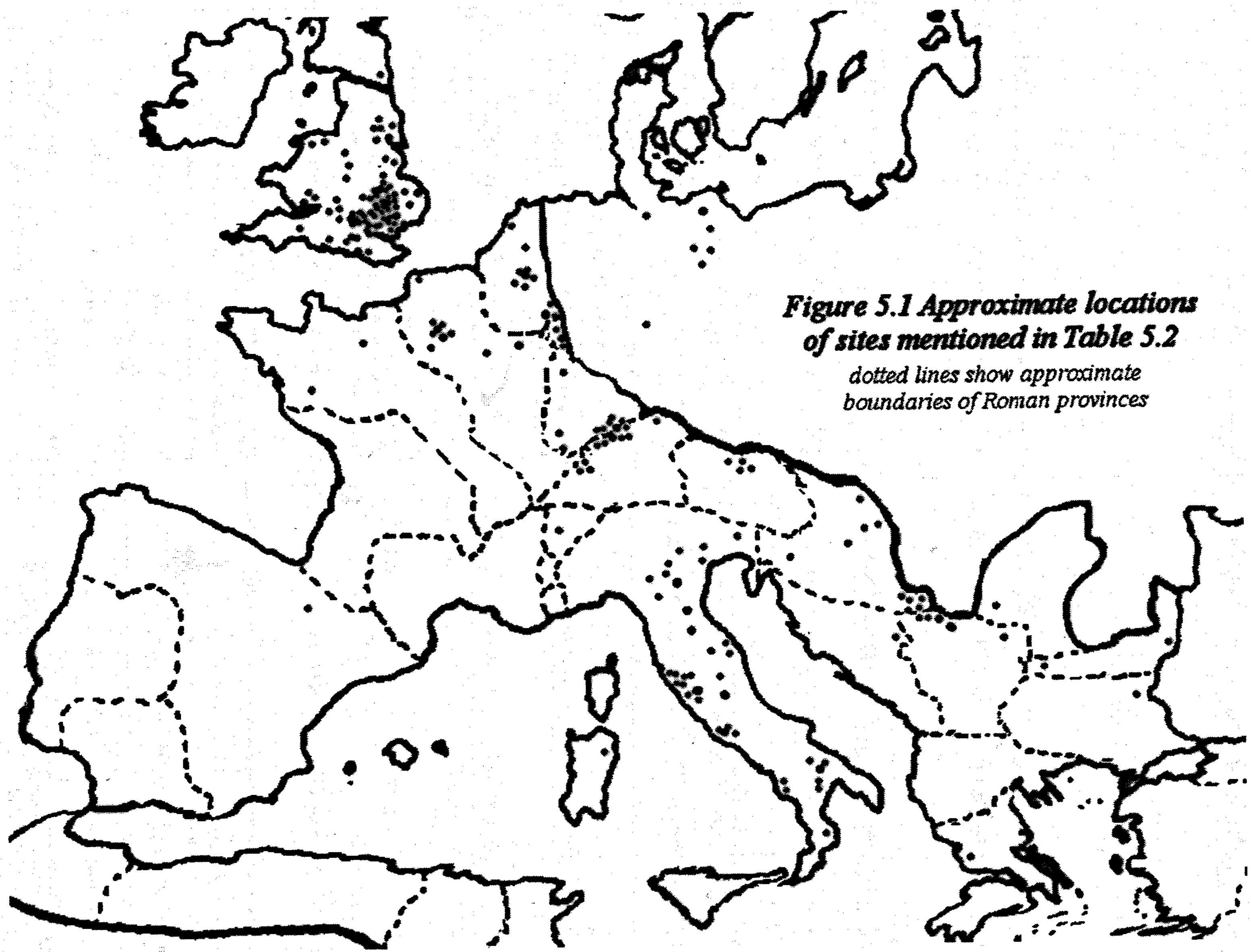


Figure 5.1 Approximate locations of sites mentioned in Table 5.2

dotted lines show approximate boundaries of Roman provinces

Table 5.2. Names of archaeological sites from which data was obtained together with references. Where full data was not published, source of data is given in square brackets [].

Site no.	Site name	Reference
3	Edix Hill	Davis 1995
4	Market Deeping	Albarella 1997
5	Beckford	Gilmore 1972
6	Wardy Hill	Davis 1999
7	Blackhorse Road	Legge *et al.* 1989
8	Hardingstone School	Gilmore 1969
9	Hardingstone enclosure	Gilmore 1969
10	Twywell	Harcourt 1975
11	Ivinghoe Beacon	Westley 1966
12	GA, Tanner Row	O'Connor 1988 [*pers. comm.*]
13	Wavendon Gate	Dobney and Jaques 1996
14	Lincoln	Dobney *et al.* 1996 [*pers. comm.*]
15	Scole-Dickleburgh	Baker 1998
16	Birdlip	Dobney and Jaques 1990
17	Great Holts Farm	Albarella 1997
18	Camulodunum	Jackson 1947
19	Scole	Jones 1977
20	Northchurch	Gebbels 1976
21	Skeleton Green	Ashdown and Evans 1981
22	Braughing	Ashdown and Evans 1977
23	Puckeridge	Croft 1979
24	Dunstable	Jones and Horne 1981
25	Redlands Farm	Davis 1997
26	Stonea	Barker 1976b
27	Lynch Farm	Wilson 1975
28	Longthorpe II	King 1987
29	Norman cross	Albarella 1997
30	Tort Hill East	Albarella 1997
31	Tort Hill West	Albarella 1997
32	Vinegar Hill	Albarella 1997
33	Longthorpe fortress	Marples 1974
34	Wall Mansio	Round 1992
35	Castricum-Oosterbuurt	Lauwerier and Laarman 1999
36	Egmond	Clason 1984
37	Kesteren 'De Prinsenhof'	Lauwerier and Hessing 1992 [*pers. comm.*]
38	Nijmegen	Lauwerier 1988 [*pers. comm.*]
39	Kesteren vicus	Lauwerier 1988 [*pers. comm.*]
40	Heteren	Lauwerier 1988 [*pers. comm.*]
41	Elst, temple	Lauwerier 1988 [*pers. comm.*]
42	Druten	Lauwerier 1988 [*pers. comm.*]
43	Elms Farm	Johnstone and Albarella 2002
44	Danebury	Grant 1984
45	Billingsgate	Armitage and Chapman 1979
46	E London RB Cemetary	[MOLAS database]
47	Beddington Sewage Farm	[MOLAS database]
48	Winchester Palace	[MOLAS database]
49	Buckingham Street	Jones 1982
50	Coldharbour Farm 90	Sadler 1990
51	Coldharbour Farm 97	Johnstone 1997
52	Magiovinium	Locker 1995
53	Ashville Trading Estate	Wilson *et al.* 1978
54	Thorpe Thewles	Rackham 1985
55	Brancaster 1974	Jones 1985
57	La Sagesse	Bourdillon 1990
58	Braintree	Smoothy 1993
59	Chichester cattlemarket	Levitan 1989
60	Narce	Barker 1976a
61	Vaste	Albarella 1995
62	Mola di Monte Gelato	King 1997
63	S. Giacomo	Albarella 1993
65	Carminiello ai Mannesi	King 1994

66	Settefinestre	King 1985
67	Ilchester,Church Street	Levitan 1994
68	Lutton/Huntingdon	Carrott et al. 1997
69	Thorley	Johnstone and Jaques 1999
70	Emilia	Farello 19
71	Piovego	Azzaroli 1980
72	Colle dei Cappuccini	Azzaroli 1979
73	Moie di Pollenza	Azzaroli 1979
74	Sovana	Azzaroli 1979
75	Marzabotto	Azzaroli 1979
76	Ansedonia	Azzaroli 1979
77	Grotto di Tibera	Azzaroli 1979
78	Cowbridge	Jones and Sadler 1996
79	Olbia	Manconi 1995
80	Friedland	Benecke 1991
81	Welsow	Benecke 1991
82	Genshagen	Müller 1996
83	Deutsch Wusterhausen	Müller 1996
85	Macon	Ayroles 1990
86	Dambron	Marinval-Vigne and Vigne 1982
87	Manching	Boessneck et al. 1971
88	Zwammerdam	van Wijngaarden-Bakker 1970
89	Jenstejn	Beech 1995
91	Whitton	Kinnes 1981
92	Feddersen Wierde	Reichstein 1991
93	Caerwent	Noddle 1983
96	Kunzing east vicus	von den Driesch and Cartajena 2001
97	Dee House	[I. Smith *pers. comm.*]
98	Prestatyn	Jones 1989
99	Mantles Green	Jones 1992
101	Chignall Roman Villa	Luff 1988
103	Newstead fort	Jones in prep [J. Bond *pers. comm.*]
104	Orton Hall Farm	King 1996
105	Mons Claudianus	Hamilton-Dyer 2001 [*pers. comm.*]

106	Abu Sha'ar	Van Neer and Sidebotham 2002
110	Nijmegen new excavations	[A. Robeerst *pers. comm.*]
112	Pompeii	[J. Richardson *pers. comm.*]
113	Southwark	Bendry 1999
114	Unterlaa	Czeika 2001
115	Bad Wimpfen	Frey 1991
116	Pommeroeul	Uytterschaut 1978
117	Pompeii stable	Genovese and Cocca 2000
118	Carnuntum	Kunst 1997b
119	Albertfalva	Lyublyanovics 2002
120	Basel-Gasfabrik	[G. Breuer and B. Stopp *pers. comm.*]
121	Soluthurn/Vigier	[G. Breuer *pers. comm.*]
122	Lousonna	Chaix 1980
123	Wroxeter Baths basilica	[A. Hammon *pers. comm.*]
124	Haddon	2000 Proc Cam ant soc
125	Castleford	Berg 1999 [*pers. comm.*]
126	Augusta Rauricorum Amphitheatre	Gradel 1989
127	Tortoreto-Fortellezza	Bökönyi 1991
128	Krefeld-Gellep	Nobis 1973
129	Lorenzberg Bei Epfach	Boessneck 1964
130	Msecke Zehrovice	Beech 1998
131	Radovesice	Peške 1993
132	Godmanchester	[R. Luff *pers comm*]
133	Colchester	[R. Luff [*pers comm*]
134	Butzbach	Habermehl 1959/60
135	Swestari	Nobis and Ninov 1986
136	Worth Matravers	Clark 2002
137	Magdelenska Gora	Bökönyi 1968
138	Brezje	Bökönyi 1968
139	Tapioszele	Bökönyi 1968
140	Sticna, Sentvid	Bökönyi 1968
141	Szentes-Vekerzug	Bökönyi 1968
142	Velemszentvid	Bökönyi 1968

143	Histria	Bökönyi 1968
144	Albertfalva	Bökönyi 1974
145	Jaszfelsozentgyorgy	Bökönyi 1974
146	Balatonaliga	Bökönyi 1974
147	Pilismarot I Watchtower	Bökönyi 1974
148	Szaszhalombatta	Bökönyi 1974
149	Helemba - Sziget	Bökönyi 1974
150	Acs - Vaspuszta	Bökönyi 1974
151	Gyor Szechenyi-Ter	Bökönyi 1974
152	Altino	Riedel 1985a [M. MacKinnon *pers. comm.*]
153	Aquileia forum	Riedel 1994 [M. MacKinnon *pers. comm.*]
154	Cerveteri	[M. MacKinnon *pers. comm.*]
155	Gravina 1	MacKinnon 1994, [*pers. comm.*]; Watson 1992
156	Invillino- Ibliglo	Storck and von den Driesch 1997 [M. MacKinnon *pers. comm.*]
157	Lugnano	MacKinnon 1998 [*pers. comm.*]
158	Matrice	Barker and Clark 1995 [M. MacKinnon *pers. comm.*]
159	Pompeii, Ganimede	Kokabi 1982 [M. MacKinnon *.pers. comm.*]
160	Pozzuolo	Riedel 1983-4 [M. MacKinnon *pers. comm.*]
161	San Giovanni	Assad 1986, MacKinnon 2001 [*pers. comm.*]
162	Santorsa, Vicenza	Cassoli and Tagliacozza 1991 [M. MacKinnon *pers. comm.*]
163	Settefinestre 2	King 1985 [M. MacKinnon *pers. comm.*]
164	Stufels	Riedel 1979, 1984 [M. MacKinnon *pers. comm.*]
165	Tarquinia	Bedini 1997 [M. MacKinnon *pers. comm.*]

166	Udine	Riedel 1990, 1993 [M. MacKinnon *pers. comm.*]
167	Via Gabina 10	Clark undated.[M. MacKinnon *pers. comm.*]
168	Volano	Riedel and Scarpa. 1988 [M. MacKinnon *pers. comm.*]
169	Rome, Aqua Marcia	De Grossi Mazzorin 1996 [M. MacKinnon *pers. comm*]
170	Castelrotto	Riedel 1985 [M. MacKinnon *pers. comm.*]
171	Mezzocorona	[M. MacKinnon *pers. comm.*]
172	Metaponto Panatello	[M. MacKinnon *pers. comm.*]
173	Paestum	[M. MacKinnon *pers. comm.*]
174	Abusina-Eining	Lipper, E. 1986
175	Sablonetum-Ellingen	von den Driesch and Liesau 1992
176	Oberdorla	Teichert1974
177	Champlieu	Yvinec 1983
178	Vitudurum-Oberwint-erthur	Morel 1991
179	Catterick CEU240	Meddens Undated
180	Catterick 434	Payne Undated
181	Barnsley Park	Noddle 1985
182	Frocester Court	Noddle 1979
183	Segontium	Noddle 1993
184	Chilgrove 1	Outen 1979
185	Shakenoak site C	Cram 1973
186	Shakenoak site K	Cram 1975
187	Hayton Fort	Canby 1977
188	Titelberg oppidum	Meniel 1993
189	Kassope	Friedl 1984
190	Breisach	Scmidt-Pauly 1980
191	Gunzburg - Gontia	Streitferdt 1972
192	Pfaffenhofen - Pons Aeni	Streitferdt 1972

193	Marzoll - Marciolae	Streitferdt 1972
194	Vemania	Piehler 1976
195	Kunzing-Quintana	Swegat 1976
196	Dormagen	Mennerich 1968
197	Froitzheim	Mennerich 1968
198	Gellep - Gelduba	Mennerich 1968
199	Hufingen	Sauer-Neubert 1968
200	Pfaffenhofen	von Houwald 1971
201	Wehringen	von Houwald 1971
202	Penzlin	Benecke 1989
203	Tac-Gorsium	Bökönyi 1984
204	Conchil	Yvinec Undated [*pers. comm.*]
205	Oberstimm	Stettmer 1997
206	Lauriacum	Müller 1967
207	Haus Burgel	Stein 2000
208	Colonia Ulpia Traiana	Waldmann 1966
209	Iatrus	Bartosiewicz and Choyke 1991
210	Freidorf	el Susi 1988
211	Castillar de Mendavia	Mariezkurrena 1986
212	Gournay	Meniel 1984
213	Beauvais	Meniel 1984
214	Compiegne	Meniel 1984
215	Ribemont	Meniel 1984
216	Variscourt	Maniel 1984
217	Soissons	Meniel 1984

5.3 Time frame and geographic areas covered

The following tables were compiled to illustrate the amount of data obtained from different time periods and geographic areas. Starting with the latter, Table 5.3 gives the number of sites and total number of measured bones collected for this study by modern country. This shows that whilst the greatest portion of the data comes from northern Europe, there are some data available for comparison with the Mediterranean, central and eastern Europe, and North Africa.

The spread of data by geographic area can be explained in two ways: firstly there is the question of the quantity of excavation and the quality of recovery on individual sites, and secondly there is the matter of taphonomic variation affecting the preservation of the bones themselves. The problems of recovery and taphonomic bias have been discussed in many publications (e.g. Lyman 1994; O'Connor 2000; Reitz and Wing 2000) and it is sufficient to just mention them here as factors to be considered. For each of the countries in Table 5.3 the extent to which each of these factors has affected the numbers of measurable bones varies considerably.

There is also the problem of accessibility of data to be considered. The variation in archaeological excavation and publication traditions between the countries covered in this research is considerable and as such has affected the ability to collect data from published sources. For instance, as a matter of course German site reports contain very detailed archives of almost all aspects of post-excavation analysis, including complete tables of raw measurement data from the bones, whereas those from Britain tend to favour summary tables rather than raw data.

Contacting authors directly to obtain data resulted in mixed success: some were very willing to share data whilst others seemed to be reluctant to do so, meaning that their data cannot be used by any other workers. One of the reasons for the small quantity of data from France was that although Sebastien Lepetz was known to hold a large database of equid measurements, he failed to reply to e-mail requests for reprints of his work and information from his database.

In addition there is the problem of accessing foreign language publications through the British library system, particularly those from former Eastern block countries and further afield in the Near East and Africa. The limitations of funding and time both precluded visits to libraries abroad, but this is a step that could be taken to expand the database for future research.

Table 5.3 Numbers of sites and numbers of measured bones by country.

Country	**No. Sites**	**No. bones**
Austria	3	228
Belgium	1	127
Britain	76	1212
Bulgaria	2	62
Czech Republic	3	27
Egypt	2	547
France	10	229
Germany	31	2773
Greece	1	131
Hungary	14	586
Italy	40	352
Luxemburg	1	5
Netherlands	10	486
Romania	2	12
Slovenia	2	36
Spain	1	11
Switzerland	4	138
Total	**203**	**6962**

It is interesting to note that although there appears to be a large volume of data from both Britain and Germany, the sites from which these data come are not evenly spaced across the countries but cluster quite considerably (Figure 5.1). This is also true for areas with less data such as the Netherlands, France and Hungary. This is most likely to have been caused by the nature of the opportunities for archaeological excavation and also the locations of research institutions and individuals whose publications were easily accessible.

The data can also be split into regions based on the Roman provinces, as defined by King (1999). Table 5.4 gives the name assigned to each region by King (1999), together with the modern countries that are included in that region and the total number of measurable bones collected from each. These regions were used to split the results of the various analyses into geographic areas for comparison. The reason for splitting the data according to the Roman provinces rather than by modern country is that the provinces each had a unique character, because of the interactions between the native peoples and Roman citizens (Section 1.2), which it is hoped can be detected in the results of the various analyses in Chapter 6.

Table 5.4. Geographic regions as defined by King (1999) together with information on the approximate Roman provinces and modern countries covered by that region and the number of measurable bones gathered for this study.

Region	Region name	Roman provinces covered	Modern countries covered	No. bones
A	Italy	Italia, Sicilia	Italy	352
B	Spain	Tarraconensis, Lusitania, Baetica	Spain	11
D	Gaul	Narbonensis, Aquitania, Lugdenensis, Belgica	France, Belgium, Luxemburg	361
E	Britain	Britannia	Britain	1209
F	Rhineland	Germania Inferior and Superior, Alpes, Raetia (west), Agri decumantes	The Netherlands, Germany, western Switzerland	3502
G	Danube and Balkans	Raetia (east), Noricum, Pannonia, Tres Daciae, Dalmatia, Moesia	eastern Switzerland, Austria, Hungary, Bulgaria, Romania	85
H	Greece	Thracia, Macedonia, Epirus, Achaea	Greece	131
K	Egypt	Aegyptus	Egypt	547

Moving on to splitting the bones by period, Table 5.5 shows the number of sites and number of bones by period, as defined in Section 1.5. The difference between the numbers of sites in Tables 5.4 and 5.5 is explained by the fact that some sites cover both the Iron Age and Roman periods so are counted in both categories in Table 5.5.

Table 5.5. Numbers of sites and numbers of measured bones by period

Period	No. sites	No. bones
Iron Age	69	1993
Roman	144	4187
External	8	782
Total	**221**	**6962**

Table 5.6 highlights the fact there were problems with the dating of many deposits. Although deposits had been identified as Roman, there was often no more specific dating available. Sometimes this was because the whole site had not been more accurately dated and sometimes the bone reports did not state which phase particular bones were from. In addition, there were deposits that were too widely dated (or came from the crossover period, 2nd – 3rd centuries AD) to be included in either the early (1st century BC – 2nd century AD) or late (3rd – 6th centuries AD) groups. There were also significantly fewer bones recovered from later Roman deposits than from the earlier ones, although it is possible that many of the 'Roman' dated bones could be from the later date categories. Table 5.6 shows that almost a third of the bones could not be dated more accurately than to the Roman period as a whole.

Table 5.6. Numbers of bones by date category within the Roman period (only includes major long bones

Date	No. bones
1st century BC	9
1st century BC - 1st century AD	30
1st century AD	417
1st - 2nd centuries AD	372
1st - 3rd centuries AD	235
2nd century AD	285
2nd - 3rd centuries AD	260
2nd - 4th centuries AD	63
3rd century AD	110
3rd - 4th centuries AD	206
4th century AD	236
4th - 5th centuries AD	44
4th - 6th centuries AD	1
5th century AD	24
5th - 6th centuries AD	47
6th century AD	6
6th - 7th centuries AD	29
Roman	936
Total	**3310**

Another way of looking at the data is by element, in order to observe any bias in element distribution across different periods. Appendix Table A3 gives the numbers of bones by element on a site-by-site basis, whilst Table 5.7 gives the numbers of bones for each element by period and Figure 5.2 shows this in the form of percentages. It can be seen that, as would be expected from taphonomic studies (Lyman 1994), the most robust elements (metapodials and phalanges) are best represented in all periods, with the astragalus, tibia and radius following next.

Table 5.7. Numbers of bones for each element by period (See Appendix Table A3 for explanation of element codes)

Period	**Cran**	**Mand**	**Scap**	**Hum**	**Rad**	**MC**	**Fem**	**Tib**	**Astr**	**Calc**	**MT**	**Phall**	**Total**
Iron Age	10	19	114	136	255	290	99	251	185	66	252	317	1994
Roman	68	103	272	324	530	667	199	523	275	127	621	477	4187
External	2	15	18	24	55	251	28	37	128	27	159	38	782
Total	**80**	**137**	**404**	**484**	**840**	**1208**	**326**	**811**	**588**	**220**	**1032**	**832**	**6963**

Whilst these results follow general taphonomic models, it should be remembered that these figures do not represent the whole picture as they only include the measurable bones from the site. However, it is usually the case that the bones most likely to survive intact are also those that most often can be measured. It is fortunate that the bones with a high survival rate that produce the highest numbers of bones are those that have proven to be most successful in differentiating horses, donkeys and mules (Chapter 4).

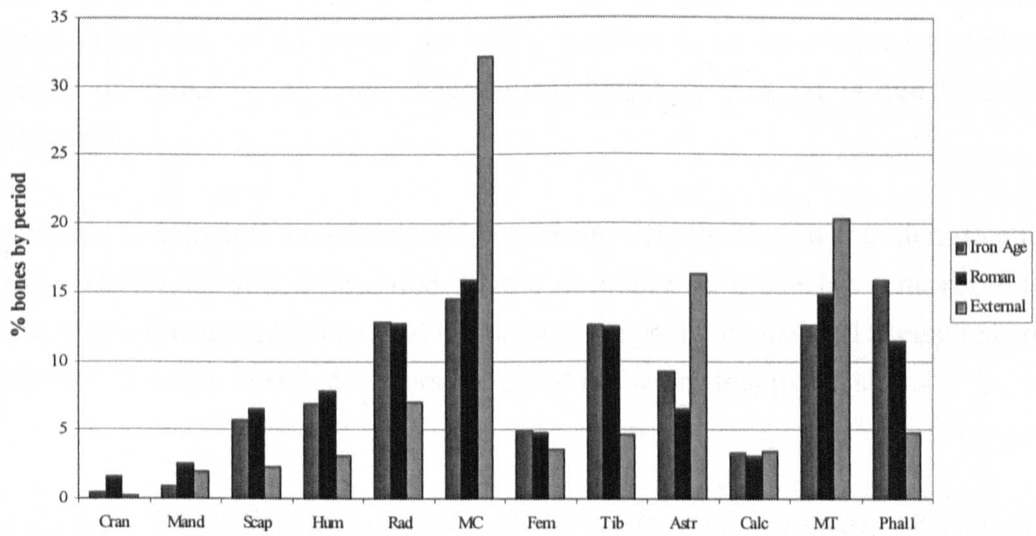


Figure 5.2. Percentages of bones for each element by period.

Another likely bias in this distribution is that introduced by post-excavation protocols. This is likely to affect the element distribution when only certain elements are routinely measured, or where, in combination with the taphonomic history, only certain measurements are taken. For instance, when only greatest lengths and shaft diameters are taken, this will severely limit the quantity of bones that will be included from that site in this study. This is usually why the numbers of bones available for analysis (Chapter 6) were lower than the numbers given in the tables and figures in this chapter: the relevant measurements were missing, either through fragmentation of the bones or a restrictive recording protocol.

Although there are still gaps and 'thin patches' in the dataset, the time that would have been spent on filling them further would not have been justified by the quantity of additional data, in the context of this research. However, for future research, targeting the collection of additional data towards these areas could enhance the results, by allowing more closely dated analysis of some of the inferences drawn here and giving sufficient numbers of cases for significance tests to be performed on differences observed but not currently able to be tested.

Chapter Six – Results of data analysis

This chapter presents the results from the various analyses undertaken on the archaeological dataset outlined in Chapter 5. The first analysis undertaken was the identification (where possible) of both complete skeletons and individual bones to species level following the methodology outlined in Chapter 4, and the results are given in Section 6.1. The estimated withers heights were then calculated using the methods and limitations outlined in Section 3.4 and utilising the identifications established in Section 6.1. The results of these analyses are given in Section 6.2. Shape indices were then determined, again making use of the previously established identifications, for the purpose of evaluating the build of the animals being studied (Section 6.3). Lastly log-ratio analysis was carried out on a more limited dataset in order to determine the size and shape of the horses of the Roman world in relation to a modern standard and to corroborate any results from the withers height and shape index analyses; these results are set out in Section 6.4. Finally, a summary drawing together the results of all the above-mentioned analyses, comparing them with modern equids, and providing a basis for the discussion in Chapter 7, is provided in Section 6.5.

6.1 Species identification

The aims of the analyses presented in this section were to use the methodology developed in Chapter 4 to corroborate or refute existing identifications of archaeological specimens based on morphological criteria of the teeth and post-cranial bones. Another aim was to identify to species as many as possible of those archaeological bones identified as equid. It was hoped that these results would then either confirm or contradict the hypothesis that the dearth of mules in the zooarchaeological literature thus far is due to issues of identification.

The analysis is split into two sections here, in the first looking at the identification of complete skeletons and articulated limbs, as many of these have morphological identifications already published, and the second analysing the isolated skeletal elements, the majority of which are cited as horse or equid in the original publications.

6.1.1 Species identification of skeletal elements from complete skeletons and articulated limbs

Various sites in the arcaheological dataset have produced complete skeletons and articulated limbs. It was decided to analyse these separately from the isolated bones. This was partly to provide a check that the methodology was producing usable and internally consistent results, to check previous identifications, and to give an idea of the proportion of species. Table 6.1 gives a list of the sites from which complete skeletons and articulated limbs were recovered, and more details of these sites are given in Appendix Table A2. Although the site of Mons Claudianus produced many limbs, many of the elements were not complete enough for this analysis and many consisted of lower limbs (metapodials downwards) that were also less useful for this analysis, so it was excluded. Most of the other sites listed in Table 6.1 produced whole skeletons, but again many elements were not complete enough for this analysis and were excluded. A total of 19 sites produced 71 skeletons or limbs for analysis.

Table 6.1. Archaeological sites from which complete equid skeletons and articulated limbs, with correct measurements for species identification, were recovered. L=late, M=mid, E=early

Site no.	Site name	Area	Site type	Date	No. skeletons/limbs
37	Kesteren De Prinsenhof	Rhineland	Cemetery	1st century AD	4
42	Druten	Rhineland	Villa	L 1st - E 2nd centuries AD	3
43	Elms Farm	Britain	Small urban	M3rd - M4th centuries AD	2
59	Chichester cattlemarket	Britain	Urban	Romano-British	2
67	Ilchester Church Street	Britain	Urban	L 3rd - 4th centuries AD	1
71	Piovego	Italy	Cemetery	?	1
92	Feddersen Wierde	Rhineland		1st - 5th centuries AD	5
96	Kunzing east Vicus	Rhineland	Cemetery	L 2nd -M 3rd centuries AD	6
105	Mons Claudianus	Egypt and N. Africa	Industrial	M 1st - M 2nd centuries AD	7
110	Nijmegen, new excavations	Rhineland	Urban	12 BC - L 1st centuries AD	4
114	Unterlaa	Rhineland	Urban	L 1st - 3rd centuries AD	12
115	Bad Wimpfen	Rhineland	Small urban	1st - 3rd centuries AD	2
117	Pompeii stable	Italy	Urban	1st century AD	2
118	Carnuntum	Rhineland	Military	E - M 3rd centuries AD	4
119	Albertflava	Danube and Balkans	Military	2nd - 3rd centuries AD	2
128	Krefeld-Gellep	Rhineland	Military	69 AD	6
135	Swestari	Danube and Balkans	Cemetery	Thracian L3rd century BC	5
141	Szentes-Vekerzug	Danube and Balkans	Cemetery	Iron Age	1
143	Histria	Danube and Balkans	Small urban	Iron Age	2

The analyses were run element-by-element, on all bones with enough measurements to produce accurate results. Detailed results on a case-by-case basis are given in Appendix Tables A4- A8. Levels of identifications were assigned as described in Section 3.3.3 for all bones analysed and are given in Table 6.2. In the subsequent figures in this section, open symbols represent the cases within 1 SD of the centroid, whilst black symbols are outside this range. The most numerous element was the metatarsal, which is one of the three most reliable elements for species identifications (Chapter 4). Hindlimb elements seemed to be more complete than those of the forelimb, at least in the middle and upper elements. The metacarpal was excluded from this analysis because of the poor identification rate.

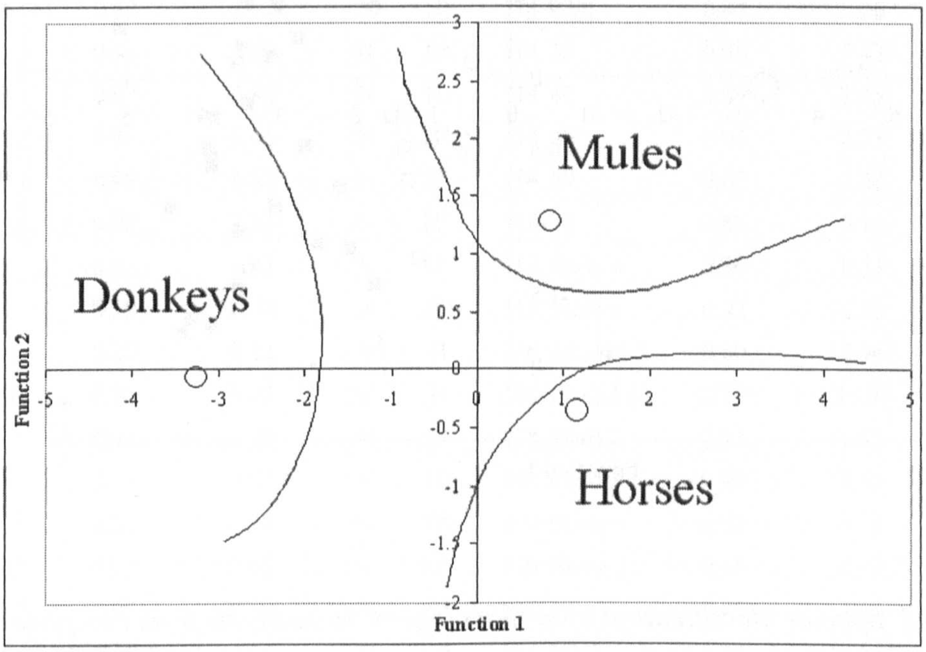


Figure 6.1. Group centroids and approximate ranges of the modern material for a typical element.

Figure 6.1 shows the approximate ranges of the modern material for a typical element. The areas inside the curves are where members of that group would normally be located. This will help clarify subsequent figures where the slightly 'abnormal' identifications lie. Figure 6.1 also illustrates that the mule and horse centroids are usually closer together than either is to the donkey centroid, showing the potential for a greater overlap between these two groups.

Looking in detail at the metatarsals, there were 47 analysable bones in total, all of which had the optimum measurements (Appendix Table A4). Figure 6.2 shows the results of the discriminant function analysis. There is a large cloud of points identified as horses in the bottom right quarter of the graph together with a few that merge with some identified as mules in the upper right quarter. The mule identifications are all quite far from the group centroid but are distributed evenly around it. The horse identifications are much more skewed away from the group centroid towards the bottom right corner of the graph. The donkey identifications are all a long way from the group centroid and are almost equidistant between the mule and donkey centroids.

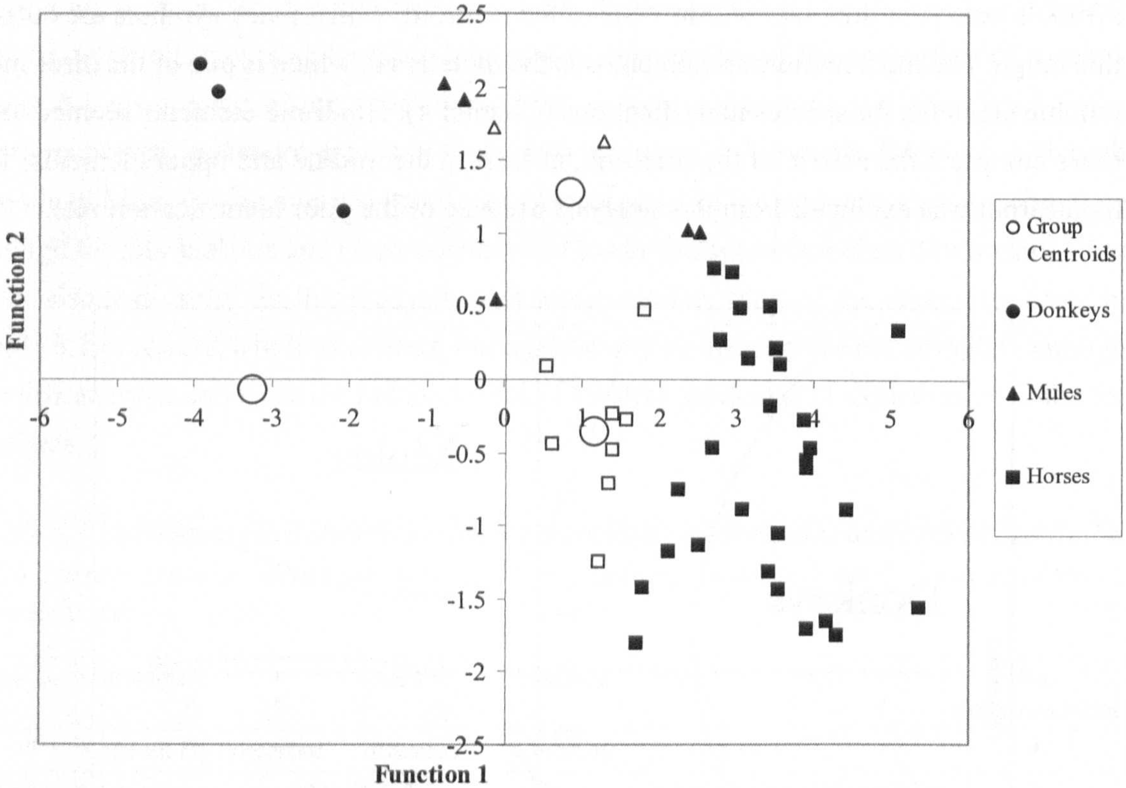


Figure 6.2. Species identification of archaeological metatarsals from complete skeletons and articulated limbs. Note the following conventions for this and subsequent figures: large open circle = group centroid; small solid symbols = identifications outside the 1 SD range; small open symbols = identifications within the 1 SD range.

In order to clarify the exact procedure for designating levels of identification, the results of this element will be explained in detail. There were two mules and eight horses within the 1 sd range, of which both mules and six of the horses also had high probabilities and were thus designated definite identifications (H or M). The two horses with lower probabilities were designated as probable horses (H*). The points outside the 1 SD range in the bottom right quadrant had high probabilities (as did two horse points, in the upper right quadrant) and were most likely to be horses, so these were also designated as probable horses. The two mules close together in the upper left quadrant were designated as probable mules (M*) because, again, although they were outside the 1 SD range they had high probabilities. Similarly, although the donkeys were a long way from the centroid, the probabilities are very high so they were designated probable identifications (D*). The horses above the zero line (except the two mentioned above) and the remaining three mules were all in ambiguous territory, both outside the 1 SD range and with low probabilities, so were designated as possible identifications (H? or M?). These results are summarised in Table 6.2, for ease of understanding the procedure. Full results for this and the other elements are given in the Appendix.

Table 6.2. Species identification of the metatarsals from complete archaeological skeletons and articulated limbs illustrating the procedure for determining the level of identification. ID = Identification

Site no.	Specimen	Probability	Mahalanobis distance	Within 1 SD	ID level	Site no.	Specimen	Probability	Mahalanobis distance	Within 1 SD	ID level
37	1.21	0.65	4.23	N	H?	110	179/16-25	0.95	3.88	N	H*
37	11.28	0.97	10.93	N	H*	114	18	0.93	3.19	N	M*
37	11.34	0.52	3.64	N	H?	114	23A	0.84	0.06	Y	H
37	2.27	0.94	7.59	N	H*	114	35	0.96	2.43	N	H*
42	1.18	0.67	5.88	N	H?	114	40	0.89	2.35	N	H*
42	12.4	0.98	5.96	N	H*	114	48	0.94	2.23	N	M*
43	6640	0.98	6.87	N	H*	114	49	0.62	2.40	N	M?
59	XXIII	0.90	7.38	N	H*	114	73	0.88	0.16	Y	H
59	XXIII	0.86	5.22	N	H*	115	Skele 4	0.86	0.31	Y	M
67	F267	0.99	18.91	N	H*	115	Skele 6	0.92	1.13	Y	M
92	skelett1L	0.80	0.17	Y	H	118	Maultier 1	0.60	2.94	N	M?
92	skelett1R	0.78	0.07	Y	H	118	Pferd 1	0.82	15.91	N	H*
96	1575/5	0.92	1.30	N	H*	118	Pferd 2	0.93	7.52	N	H*
96	1581	0.71	3.02	N	H?	118	Pferd 3	0.99	9.35	N	H*
96	1620	0.81	5.99	N	H*	119	Horse 1	0.97	6.18	N	H*
96	1641	0.92	7.83	N	H*	119	Horse 2	0.55	4.32	N	H?
96	1703	0.99	11.66	N	H*	135	1	0.97	1.50	N	H*
105	1486	1.00	5.39	N	D*	135	2	0.98	2.38	N	H*
105	1544	1.00	4.32	N	D*	135	3	0.95	0.79	Y	H
105	1719	0.94	2.84	N	D*	135	4	0.99	10.70	N	H*
105	549	0.79	0.31	Y	H	135	5	0.77	5.85	N	H?
105	604	0.62	1.44	N	M?	141	6	0.61	0.59	Y	H*
110	179/16-22	0.95	1.56	N	H*	143	P18	0.56	1.10	Y	H*
						143	P25	0.77	4.24	N	H?

The next element to be analysed was the tibia, as this gave the most accurate identifications on the modern material. There were 23 complete bones, of which 16 had the optimum measurements; the rest had the next best combination (Appendix Table A5). Figure 6.3 shows the results of the 16 optimum bones. As the other seven bones were subject to a slightly different analysis they could not be plotted on the same graph because the centroids were in slightly different places. This is because group centroids are specific to the parameters of the analysis. The points were arranged in similar ways around their group centroids as the metatarsals in Figure 6.2. The levels of identification and relevant statistics are given in Table 6.3. Of those bones displayed on Figure 6.3, there were nine horse and two mule definite identifications, two mule and one donkey probable identifications and two horse possible identifications. Amongst the tibiae not displayed on Figure 6.3 there were three positive identifications (two horse, one mule) and the three probable identifications (one each horse, donkey and mule), and a single horse possible identification.

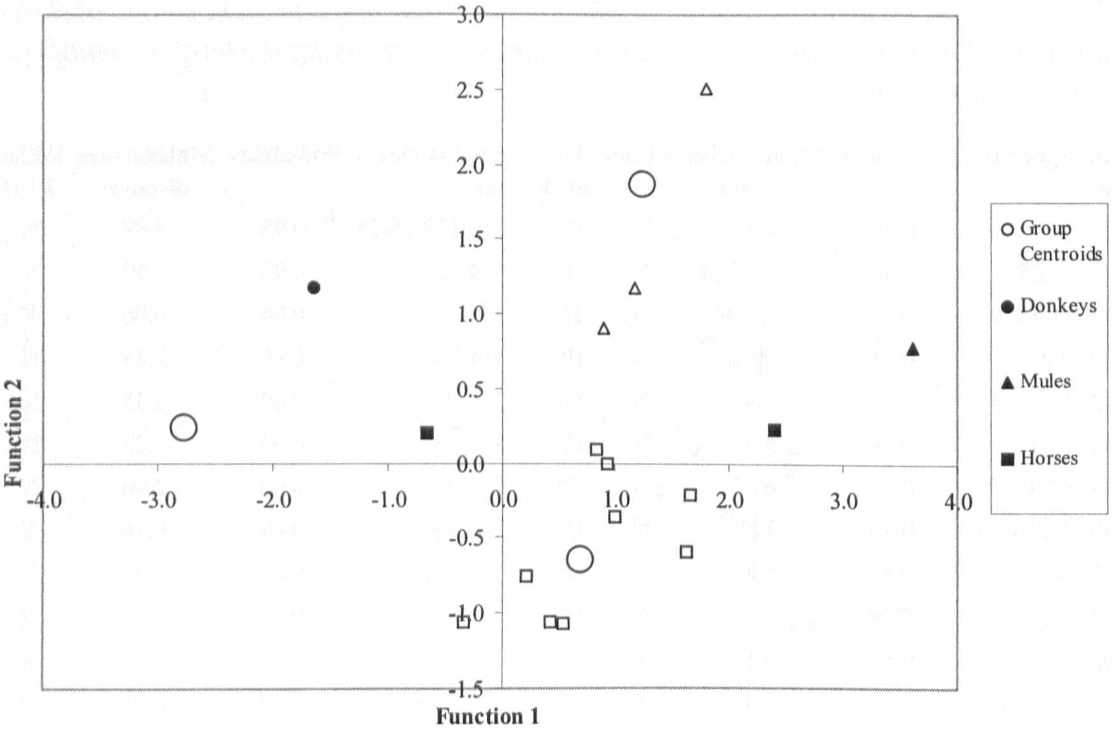


Figure 6.3. Species identification of tibiae from complete archaeologicalskeletons and articulated limbs

Table 6.3. Species identification of the tibiae from complete archaeological skeletons and articulated limbs illustrating the procedure for determining the level of identification

Site no.	Specimen	Probability	Mahalanobis distance	Within 1 SD	ID level
42	1.18	0.87	6.82	N	M*
42	12.2	0.91	4.21	N	H*
92	skelett2L	0.99	0.19	Y	H
92	skelett2R	0.97	0.22	Y	H
92	skelett1L	0.92	0.95	Y	H
92	skelett3L	0.75	1.15	Y	M*
105	600	0.93	2.14	N	D*
105	1108	0.98	1.47	N	D*
110	147/128-20	0.54	3.74	N	H?
114	23A	0.92	0.18	Y	H
114	68	0.66	2.52	N	H?
114	71	0.83	0.48	Y	H
118	Maultier 1	0.66	1.06	Y	M*
118	Pferd 1	0.99	0.72	Y	M
118	Pferd 2	0.80	0.58	Y	H
118	Pferd 3	0.84	1.14	Y	H
128	3510	0.73	2.21	N	H?
128	3573	0.98	0.87	Y	M
135	1	0.96	1.18	Y	H
135	2	0.99	0.23	Y	H
135	3	0.93	0.90	Y	H
135	4	0.93	0.18	Y	H
135	5	0.82	0.50	Y	M

Moving on to the third element, the radius, there were 21 radii, all with the optimum measurements for identification analysis. The results are shown in Figure 6.4 (and Appendix Table A6). As with the previous two elements the mules cluster around their centroid and the horses are spread away from the centroid into the right bottom quarter of the graph. All four of the mules were definite identifications. Whilst the single donkey was within 1 SD of the centroid, it had a low probability and was, therefore, only a probable identification. Amongst the horses there were five definite identifications, nine probable identifications and two possible identifications. The statistics used to obtain these identification levels are shown in Table 6.4.

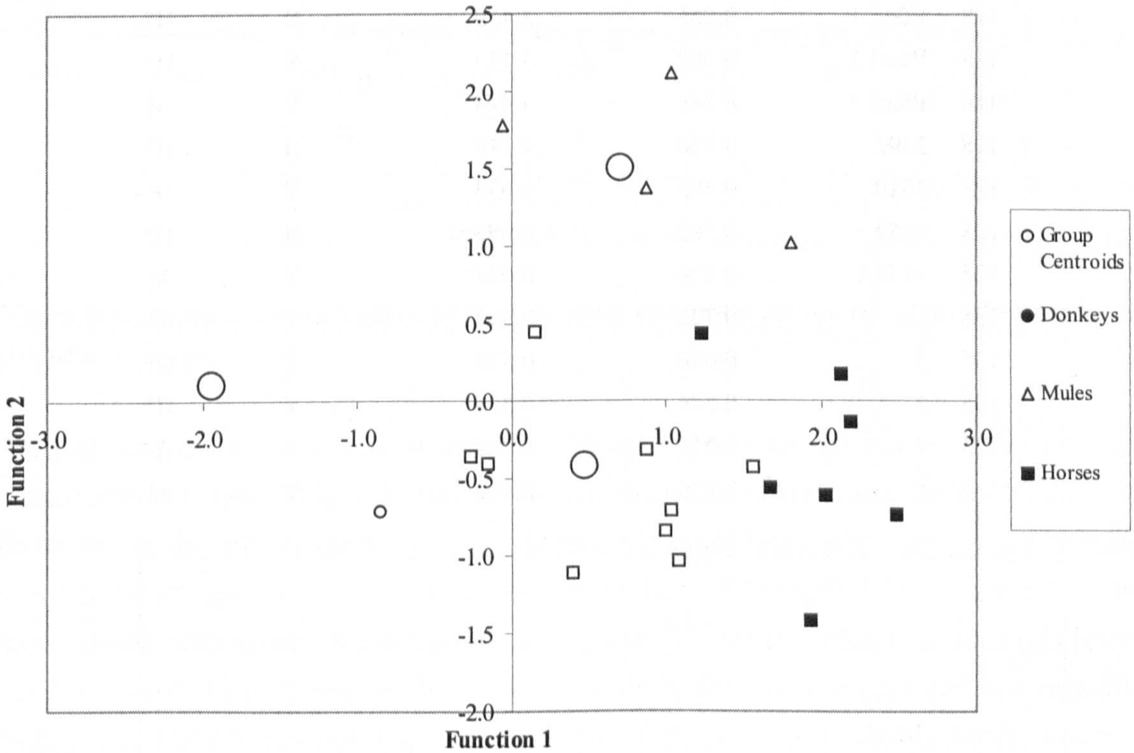


Figure 6.4. Species identification of radii from complete archaeological skeletons and articulated limbs.

The next element to undergo analysis was the humerus. There were 20 humeri with the optimum measurements and a single further case with one less measurement (Appendix Table A7). Figure 6.5 gives the results of the analysis on the 'optimum' bones and shows that the three group centroids are not as far apart as in the previous figures, which means that the areas covered by the 1 SD range overlap to a greater extent. The mule and horse centroids have 'swapped' places (Figure 6.5) with the mules in the bottom right and the horses at the top centre. Amongst the mules and horses, there were four positive identifications (all mules), ten probable identifications (six horse and four mule) and six possible identifications (five horse and one mule). There were no donkey identifications. The single bone not displayed on Figure 6.4 was identified as a possible mule.

Table 6.4. Species identification of the radii from complete archaeological skeletons and articulated limbs illustrating the procedure for determining the level of identification

Site no.	Specimen	Probability	Mahalanobis distance	Within 1 SD	ID level
43	6640	0.833	1.208	Y	H
43	6640	0.863	1.472	N	H*
92	skelett1L	0.941	0.762	Y	H
92	skelett1R	0.918	0.452	Y	H
92	skelett2R	0.927	0.489	Y	H
92	skelett3L	0.856	0.659	Y	M
110	147/128-15	0.716	3.043	N	H*
114	25	0.815	0.174	Y	H*
114	30	0.899	0.398	Y	H
118	Pferd 1	0.865	2.459	N	H*
118	Pferd 2	0.968	3.134	N	H*
118	Pferd 3	0.768	1.441	Y	M
128	3392	0.880	4.176	N	H*
128	3510	0.485	1.833	Y	D*
128	3557	0.583	3.093	N	H?
128	3577A	0.834	0.048	Y	M
135	1	0.738	0.392	Y	H*
135	2	0.698	0.539	Y	H*
135	3	0.526	0.835	Y	H*
135	4	0.515	1.289	N	H?
135	5	0.956	0.490	Y	M

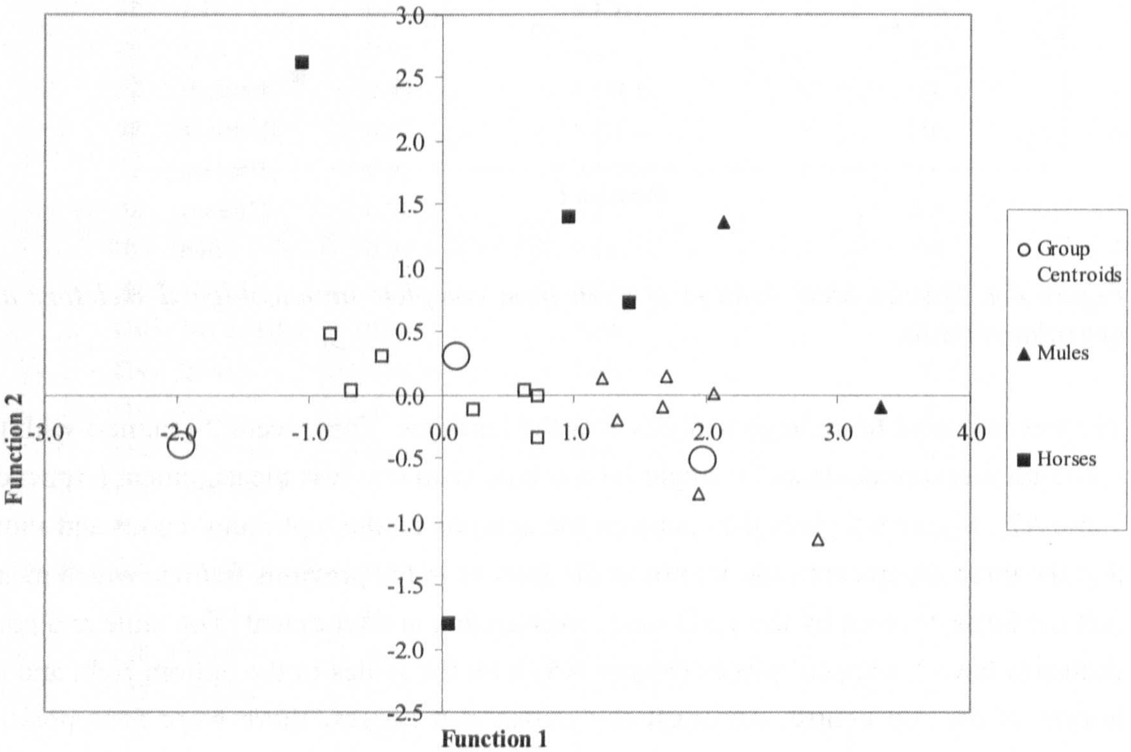


Figure 6.5. Species identification of humeri from complete archaeological skeletons and articulated limbs.

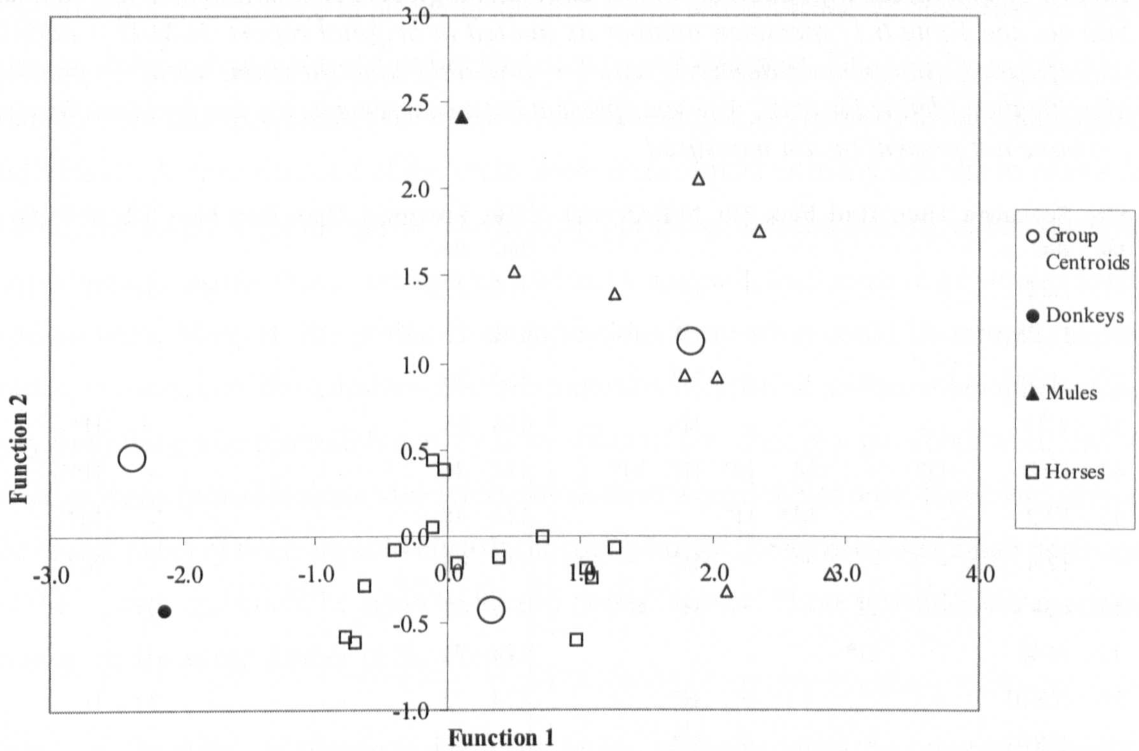


Figure 6.6. Species identification of femora from complete archaeological skeletons and articulated limbs.

The last element to be analysed was the femur. There were 24 bones with optimum measurements (Figure 6.6) and a further three with one less (Appendix Table A8). As with the humerus, the area covered by the 1 SD range is quite large, allowing greater overlap between the groups. However, this appears to be less of a problem here, as most of the bones cluster well around the centroids. There were 11 positive identifications (six horse and five mule), 12 probable (eight horse, three mule and one donkey) and one possible (mule). The three bones not displayed on Figure 6.6 were two probable horses and one probable mule.

Table 6.5 gives a summary of the identification (and level) of all analysed elements. It also gives an overall identification for individuals where there was more than one element to consider. Taking all the bones individually there was a total of 139 identifications, of which 94 were horses, 38 mules and seven donkeys. The numbers and percentages of these that were definite, probable and possible identifications are given in Table 6.6. The ratio of horses: mules: donkeys was 12.5:5.5:1. The low numbers of donkeys were to be expected as most of the data were from northern and eastern Europe. The ratio of horses to mules indicated that the mules had previously been misidentified in the archaeological record, so confirming literary sources.

Table 6.5. Species identification of complete archaeological skeletons and articulated limbs Site no. see Table 6.1, specimen number as quoted in original report. H/M/D = definite identification (horse/mule/donkey), with = probable identification, with? = possible identification (defined in text), + = bone present but measurements too few for identification, - = bone not present or not measured*

Site no.	Specimen no.	Hum	Rad	Fem	Tib	MT	Overall
37	1.21	+	+	+	+	H?	
37	11.28	-	-	+	+	H*	
37	11.34	+	+	+	+	H?	
37	2.27	-	-	+	-	H*	
42	1.18	H*	+	M	M*	H?	M*
42	12.2	-	+	M*	H*		
42	12.4	-	-	+	+	H*	
43	6640	-	H	-	+	H*	H*
43	6640	-	H*	-	-	+	
59	XXIII	+	+	+	+	H*	
59	XXIII	+	+	+	+	H*	
67	F267	-	-	+	+	H*	
71	N2	H*	+	+	+	+	
92	skelett1L	H*	H	H	H	H	H
92	skelett1R	H*	H	H*	+	H	H
92	skelett2L	-	+	H*	H	-	
92	skelett2R	H*	H	H	H	-	H
92	skelett3L	M*	M	H?	M*	+	M
96	1575/5	+	+	H*	+	H*	
96	1581	+	+	-	+	H?	
96	1620	M	+	H*	+	H*	H*
96	1632	M	-	M	+		M
96	1641	M*	+	M*	+	H*	M*
96	1703	M*	+	M	+	H*	M*
105	1486	-	-	-	-	D*	
105	1544	-	-	-	+	D*	
105	1719	-	-	-	-	D*	
105	549	-	-	-	-	H	
105	600	-	-	+	D*	-	
105	604	-	-	-	+	M?	
105	1108	-	-	-	D*	-	
110	147/128	M*	H*	+	H?	-	H?
110	1961/621--8	H?	-	-	-	-	
110	179/16-22	-	-	-	-	H*	
110	179/16-25	-	-	-	-	H*	
114	18	-	-	-	-	M*	
114	23A	-	-	H*	H	H	H
114	25	+	H	-	-	-	
114	30	+	H	-	-	-	
114	35	-	-	-	+	H*	
114	40	-	-	-	-	H*	
114	48	-	-	-	-	M*	
114	49	-	-	-	-	M?	
114	68	-	-	-	H?	-	
114	71	-	-	-	H	-	
114	73	-	-	-	-	H	
114	80L	-	-	H	-	-	
115	Skele 4	-	-	-	+	M	
115	Skele 6	+	-	-	-	M	
117	B	-	-	M*	+	+	
117	C	-	-	M?	+	+	
118	Maultier 1	-	-	H?	M*	M?	M*
118	Pferd 1	M*	H*	M	M	H*	M
118	Pferd 2	H*	H*	H*	H	H*	H
118	Pferd 3	M?	M*	H*	H	H*	H
119	Horse 1	+	-	+	+	H*	
119	Horse 2	+	-	+	+	H?	
128	3392	+	H*	-	-	+	
128	3510	-	D*	D*	H?	+	D*
128	3557	+	H?	+	+	+	
128	3559	-	-	M		+	
128	3573	+	+	+	M	+	
128	3577A	-	M	-	-	+	
135	1	H*	H	H	H	H*	H
135	2	H*	H*	H*	H	H*	H
135	3	H*	H*	H	H	H	H
135	4	M*	H?	M	H	H*	H*
135	5	M	M	H	M	H?	M
141	6	+	+	+	+	H*	
143	P18	-	-	-	-	H*	
143	P25	-	-	-	-	H?	

The proportion of definite to probable identifications is interesting. At one extreme, there were no definite donkey identifications but mostly probable ones. This may be an indication that there is a size discrepancy between the modern sample and some of the archaeological individuals. At the other end of the scale, there were almost as many definite as probable identifications amongst the mules. The high proportion of definite identifications suggests that, although the number of modern individuals was small, they seem to be similar to the Roman ones. Many of the probable identifications were what could be termed 'super' mules, i.e. ones that are exhibiting extreme mule characteristics, and are often quite a long way from the group centroid but away from either of the other groups. There were almost twice as many probable horse identifications as there were definite ones. However, as with the mules, many of them are unlikely to be anything except horses because of their positions on the figures, and could be again be termed 'super' horses. These possible discrepancies in size are discussed further in Section 6.5.

Table 6.6. Numbers and percentages of horse, mule and donkey identifications from complete archaeological skeletons and articulated limbs. Percentages were calculated as a percentage of the species total except in the last column where they were calculated as percentages of the total number of bones.

Species	Definite ID		Probable ID		Possible ID		Total	
	Number	%	Number	%	Number	%	Number	%
Horse	29	30.9	49	52.1	16	17.0	94	67.7
Mule	17	44.7	16	42.1	5	13.2	38	27.3
Donkey	0	0	6	85.7	1	14.3	7	5.0
Total	46	33.1	71	51.1	22	15.8	139	100

Looking in detail at the individual skeletons on a case-by-case basis, very few of the identifications were completely clear-cut with each element giving the same identification (even with varying levels of identification). However, there were equally few skeletons for which it is impossible to give an overall identification. There were a great many that fall in between these extremes and were identified to the probable level (Table 6.5). Skeletons 1 and 2 from Feddersen Wierde, skeleton 1632 from Kunzing, skeleton 23A from Unterlaa, skeleton Pferd2 from Carnuntum and skeletons 1 to 3 from Swestari are all examples of clear-cut identifications: they had consistent results across the elements present with either definite or probable levels of identification.

The most ambiguous cases were skeleton 1.18 from Druten, skeleton 147/128 from Nijmegen, skeletons Maultier1 and Pferd3 from Carnuntum and skeleton 4 from Swestari. In the case of Pferd3 from Carnuntum, there may be a case to argue that there are two animals represented, as the front limb indicated mule and the hindlimb horse. However, the report clearly shows a photograph (Kunst 1997b: 185, Abb 1) of the entire articulated skeleton in situ, refuting the above hypothesis. Clearly this individual has an ambiguous morphology. The other cases mentioned above also seem to have ambiguous morphologies and it is clear that in some cases it is just not possible to assign an accurate identification to those individuals using the methodology presented here. It also gives an indication of the confidence that can be applied to identifications based on single bones.

The rest of the skeletons with more than a single bone analysed were given probable overall identifications, as they were more consistent than the ambiguous individuals but not as consistent as the clear-cut identification. These include skeleton 6640 from Elms Farm, skeleton 3 from Feddersen Wierde, all the skeletons from Kunzing (except 1632), skeleton Pferd1 from Carnuntum, skeleton 3510 from Krefeld-Gellep and skeleton 5 from Swestari. All the rest of the individuals had only a single analysable bone and were thus identified only on that element, rather than overall.

Some of the identifications using this methodology confirmed the original identifications, whilst others contradicted. At Kunzing in Germany, there were six almost complete skeletons of which 1581 and 1620 had been identified as mules and the other four (1575/5, 1632, 1641, 1703) as horses, on the basis of their tooth morphology, in the original report (von den Driesch and Cartajena 2001). However, on the basis of their limb morphology 1632 is identified here as a definite mule, with 1641 and 1703 as probable mules and 1620 as a probable horse. 1575/5 is the only individual whose tooth morphology and limb morphology agree (horse probable identification). Only one bone (metatarsal) of 1581 was complete enough for analysis and was a possible horse identification.

One possible reason for the differences in identification could be that three of the animals were young (limb epiphyses closed but vertebral epiphyses open, so <5 years) and had therefore not finished the circumferential growth of the bones (see Chapter 2 for discussion of this issue). These are individuals 1575/5, 1581 and 1620. It was hoped that calculation of the shape indices for these individuals (Section 6.3 below) would elucidate this potential problem. It is also possible that the young age of these individuals meant that the enamel patterns were not fully in wear and could therefore have been misinterpreted. However, the other individuals were fully adult (8-12 years) and have still produced different identifications based on the teeth and the limbs.

At Carnuntum in Austria a further six skeletons were excavated, of which only four could be analysed using the current methodology. On the basis of both tooth morphology and visual differences in bone morphology, one mule and three horses were identified in the original report (Kunst 1997b). Using the current methodology Pferd 2 is confirmed as a definite horse and Pferd 3 as a probable horse. Maultier 1 was one of the ambiguous individuals, with an overall identification of possible mule, which at least partly confirms the visual identification. However, Pferd 1, whilst slightly inconsistent, has been given a probable mule identification overall. As this individual is fully adult (11years) it may therefore be another skeleton with ambiguous morphology.

Much of the equid assemblage from Mons Claudianus in Egypt was originally identified as donkey, aided by the fact that many articulated limbs were present, some with hooves and skin still intact (Hamilton-Dyer 2001). Most of the limbs were from the metapodials downwards so often only one analysable bone was present for the current analysis; therefore the identifications using the research method were are based on single elements. It is reassuring that most of the identifications are confirmed as probable donkeys. As has been discussed above, the probable status is due to the large distance of the individuals from the group centroids. The only anomaly between the original identifications and the new ones is individual 549, which was originally identified as a donkey but has been identified as a definite horse here. A possible mule (604) has also been identified, which does not help clarify its original unidentified status.

As has been stated earlier, more mules, both definite and probable, were found using this method than by using visual morphological characters. These include two probable identifications from rather unexpected sites. The first of these is skeleton 3 from Feddersen Wierde, for which three of its four analysable bones were identified as mule and the last as a possible horse. This is surprising as Feddersen Wierde is a Germanic settlement site, quite some distance beyond the *Limes* border of the Roman Empire. The possible significance of this will be discussed after the isolated bones have been analysed.

The second unexpected mule came from the Iron Age Thracian site of Swestari. Of the five bones of skeleton 5, three were definite mule identifications, one a definite horse and one a possible horse. The definite horse identification was on the femur, which is not as reliable as the top three elements. This mule identification is surprising because of its date of 3rd century BC, when Roman influence in this area was not known to have occurred. However, it is possible that contact with classical Greece could have resulted in the trading of donkeys or mules or the knowledge of their breeding.

The scarcity of donkeys amongst the European material is backed up by only a single find of a probable donkey at Krefeld Gellep in Germany. Skeleton 3510 had three analysable bones, of which two were identified as probable donkeys and one only a possible horse. This is the site of a battle between Roman forces and Batavian rebels in AD 69, so these equine casualties of war are likely to have military origins. The presence of a donkey and also three mules (3559, 3573 and 3577A) is therefore quite understandable.

6.1.2 Identification of isolated skeletal elements

The analysis of the isolated elements should build on the results from the skeleton and limbs. Although analyses were carried out on all the major long bones, only the results from the analysis of the three 'best' bones (tibia, radius, metatarsal) are considered here. This is because the remaining elements, whilst providing as many identifications as possible for the subsequent size and shape analyses, only replicate the results of the better elements without adding further information. The full results are shown in Appendix Tables A12-A14.

The metatarsals were most numerous; and the full results are given in Appendix Table A9. Because there were so many isolated metatarsals with optimum measurements (255) and others with the next best combination (19) it would have been impossible to see the results clearly if they were all displayed on a single graph. For this reason the results were split by region and in some cases also into pre- and post-(Roman) conquest phases. The regions and site types were based on the categories used by King (1999), as given in Chapter 5.

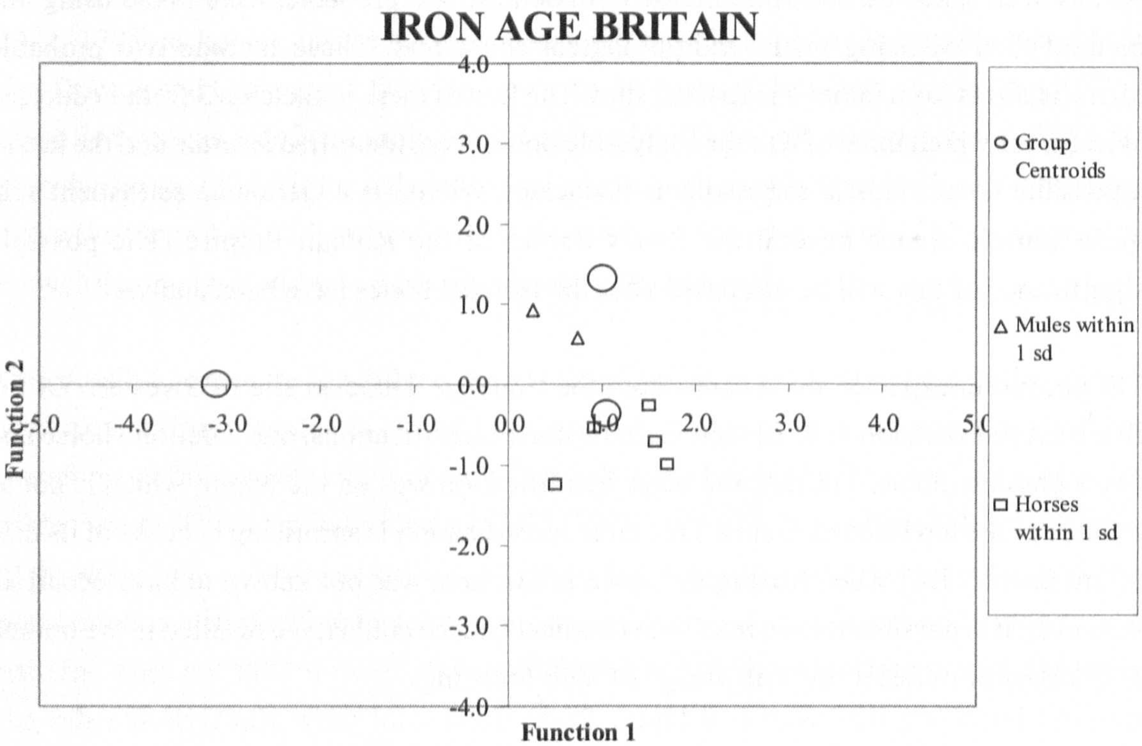


Figure 6.7. Species identifications of archaeological equid isolated metatarsals from Iron Age Britain.

Looking at Britain first of all, the data were split into pre- and post conquest phases (Figures 6.7. and 6.8) for clarity of presentation. All seven points in Figure 6.7 are within 1 SD of their group centroids and the horses in particular (all definite identifications) form a nice cluster around the centroid. The most surprising feature of these results is the presence of two mules, both of which are probable identifications due to a fairly low probability. Some possible explanations for the presence of mules in Iron Age Britain are discussed below. Moving on to post-conquest Britain (Figure 6.8), there were 21 analysable bones, of which 11 were definite identifications (nine horse and two mule), six were probable (one mule, one donkey and four horses) and four were possible (all horses). As has been the case on most of the previous figures, the horses spread away from the group centroid into the lower right quadrant of the graph, the mules cluster around the centroid and the donkey is some distance from the centroid but clearly separate from the other two groups. The probable donkey bone and most of the mules all came from sites in the Cambridgeshire/Norfolk area that were farmstead/villa and small town settlements. The only case associated with a military fort was from Castleford.

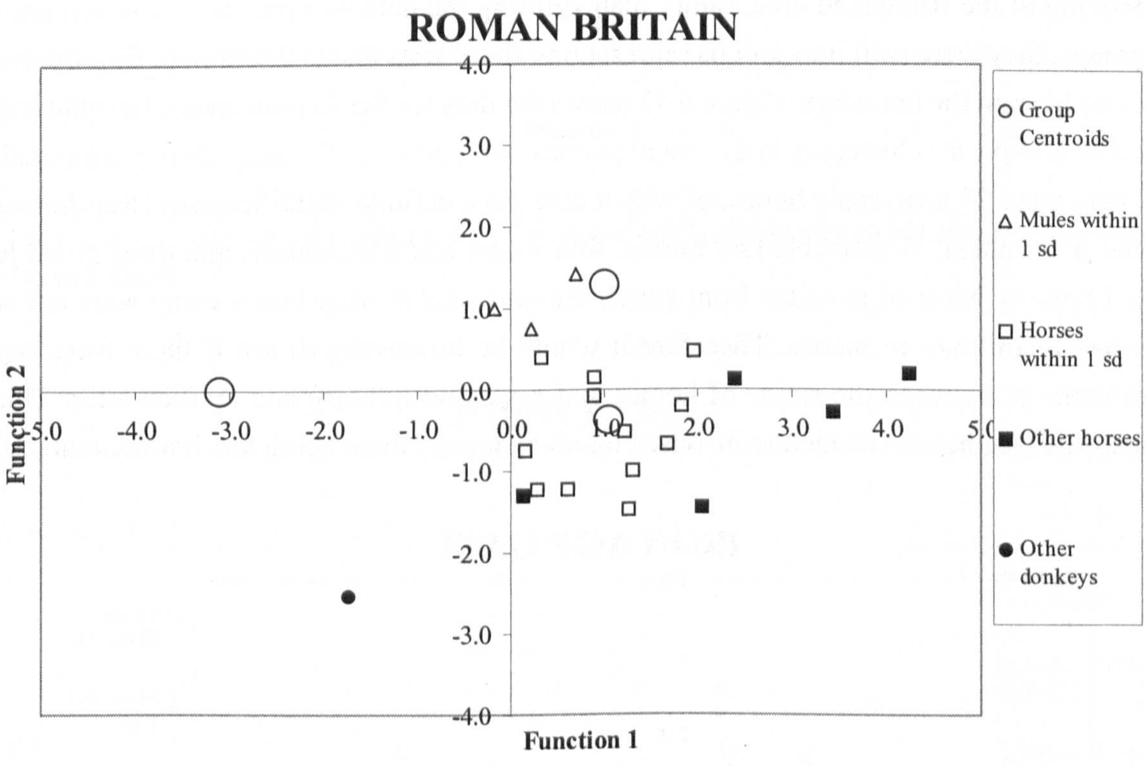


Figure 6.8. Species identifications of isolated archaeological equid metatarsals from Roman Britain

Moving across the Channel to Gaul, again the data were split into pre- and post-conquest groups. Figure 6.9 shows the pre-conquest data. The grouping of the points around the centroids is slightly more central for both the horse and mule groups, making the possibility of overlap between the groups somewhat greater. There were 21 analysable bones, of which nine were definite (eight horse and one mule), nine probable (five horse, three mule and one donkey) and three possible (two horses and one mule) identifications. As with the British data, the slightly surprising results were the presence of a few mules and a single donkey in pre-conquest material. The donkey came from Gournay, and the mules from

Gournay, Variscourt and Beauvais, all in the north-east of France and all Late Iron Age in date. The site of Gournay extends into the Roman period and the others both exist into the period when contact with Roman areas was entirely likely. Hence the presence of a donkey and some mules can be explained by the same hypotheses given for the British Iron Age material below.

There was a similar number (17) of analysable bones from Roman period Gaul and these are displayed on Figure 6.10. The positions of the groups around the centroids follow the usual pattern for this element. There were eight definite (six horses and two mules), seven probable (five horses and two mules) and two possible identifications (both horses). Three of the mule identifications were from Pommeroeul in Belgium, the fourth from Macon in France. Most of the horses were also from the site at Pommeroeul.

Moving to the Rhineland area, rather than splitting the data into pre- and post-conquest groups, they were split into groups representing those sites inside the Roman Empire and those beyond the boundary. Figure 6.11 shows the data for the Roman area. The mule and horse groups are clustering in the usual pattern, with almost all points clearly separated. There were 23 analysable bones, of which nine gave definite identifications (four horses and five mules), 11 probable (six horses, four mules and one donkey) and three possible (all horses). Most of the sites from which the mule and donkey bones came were either urban or military in nature. Therefore it would be interesting to see if there were any differences between the ratios of horses and mules on military and civilian sites. This analysis (see below) needed to be based on all elements, there being too few metatarsals.

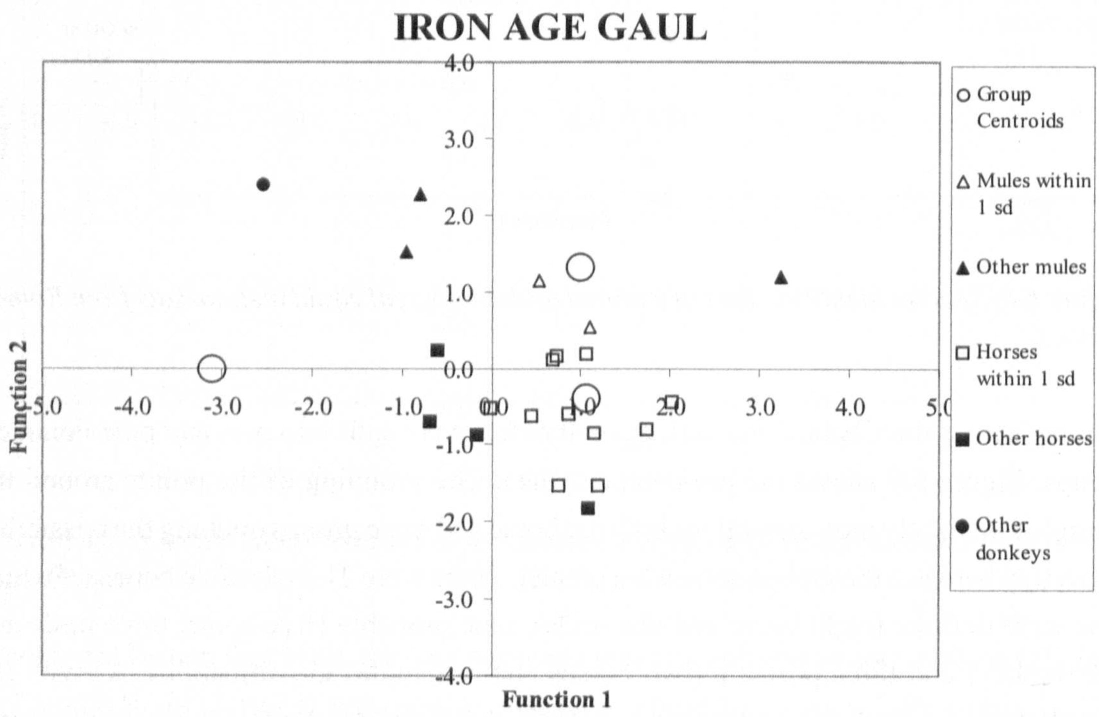


Figure 6.9. Species identifications of isolated archaeological equid metatarsals from Iron Age Gaul

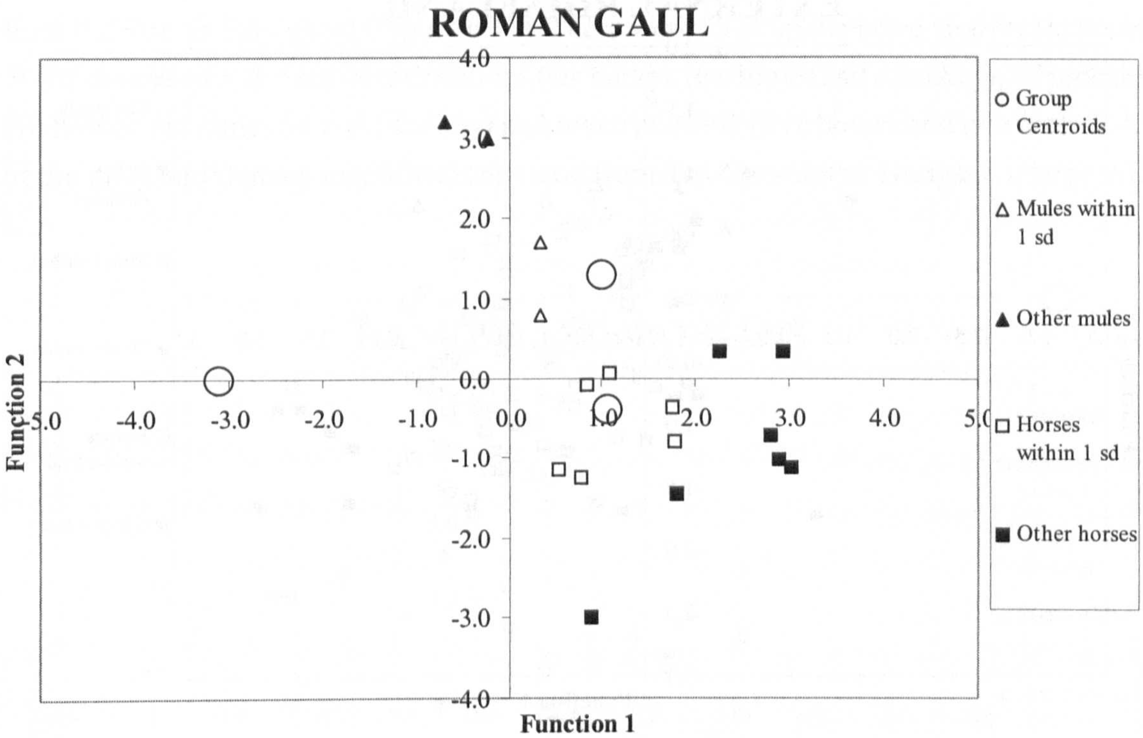


Figure 6.10. Species identifications of isolated archaeological equid metatarsals from Roman Gaul

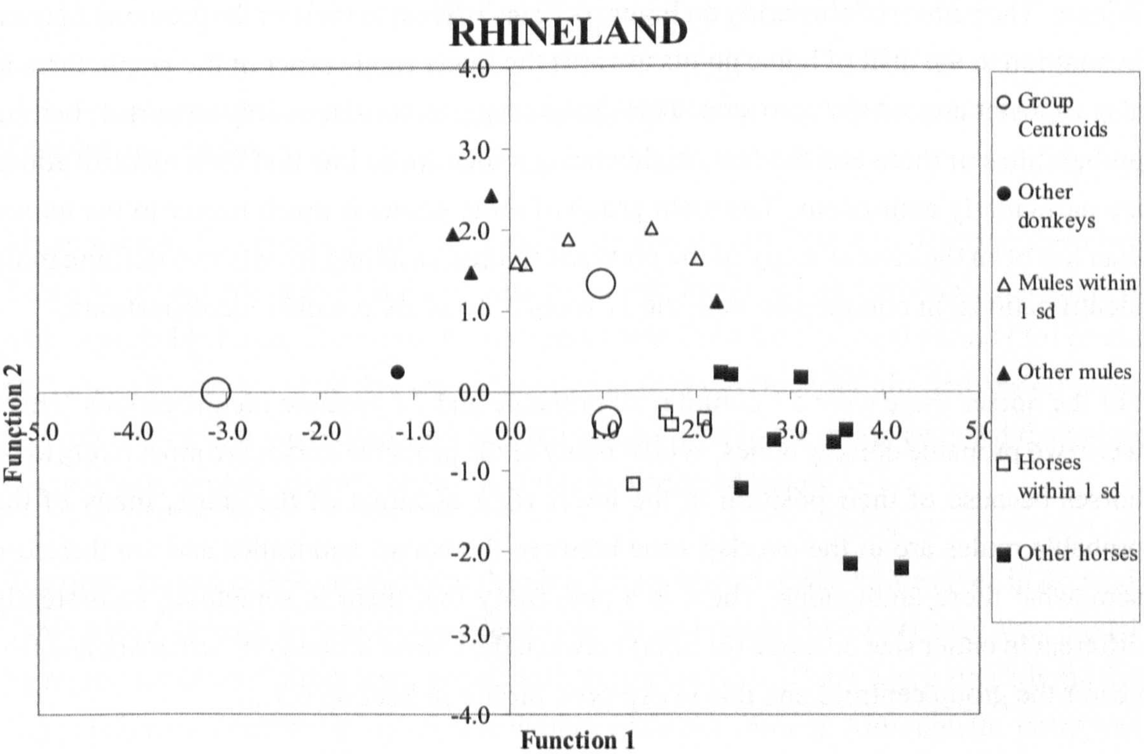


Figure 6.11. Species identifications of isolated archaeological equid metatarsals from the Roman Rhineland

EXTERNAL RHINELAND

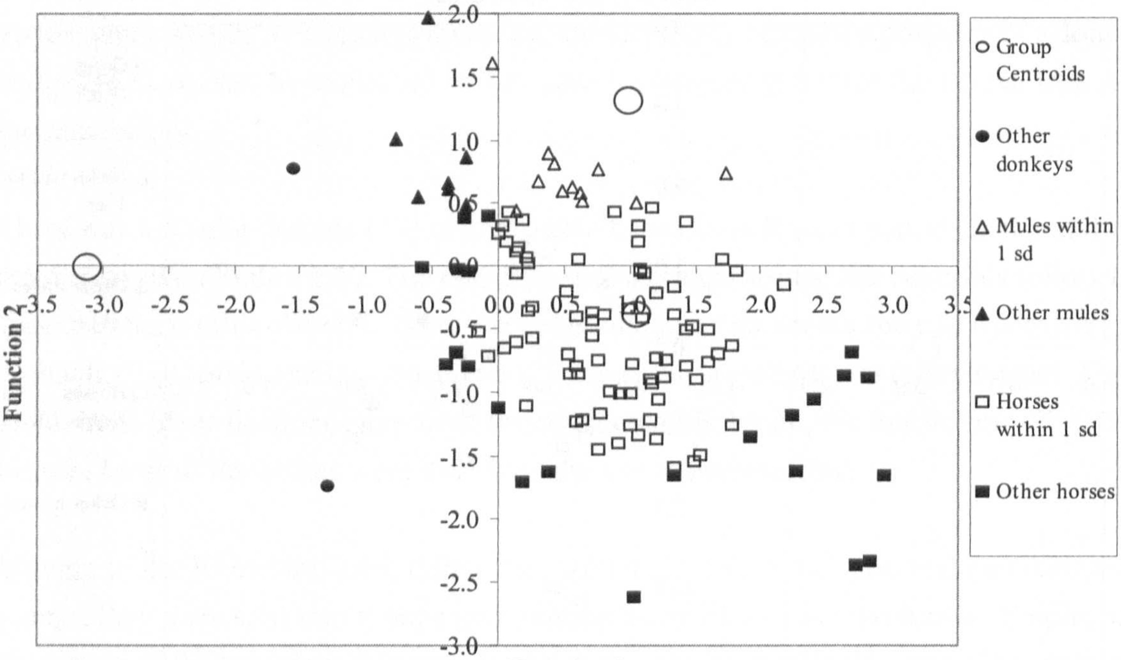


Figure 6.12. Species identifications of isolated archaeological equid metatarsals from the Rhineland beyond the Roman boundary

Figure 6.12 shows the results from the area beyond the Roman frontier along the Rhine. There were 122 analysable bones, most of which (98) were from the settlement at Feddersen Wierde. The pattern of clustering on Figure 6.12 is different to most of the previous figures. In addition to the drift of horse points towards the lower right corner of the graph, there is also a cluster around the zero area. This group seems to consist mainly of horses, but the probabilities of these and the few neighbouring mules are so low that their identifications are particularly ambiguous. The main group of mule points is much nearer to the horses than has been the case in many of the previous figures, resulting in only two definite mule identifications, in comparison with the 11 probable and six possible identifications.

For the horses there were 57 definite, 30 probable and 14 possible identifications. There were two probable donkey bones. Whilst many of the probable horses are most likely to be horses because of their position in the lower right quadrant of the graph, many of the probable mules are in the overlap zone between the horses and mules and are therefore somewhat more ambiguous. There is a possibility that there is something consistently different in either size or shape (or both) between the cluster around the zero mark and that nearer the group centroid and this is explored further in Section 6.1.3.

Figure 6.13 shows the results from the Danube and Balkans. The pre- and post-conquest material has been plotted on the same graph, as there were only three Iron Age bones, all of which were identified as horses (one definite and two probable, in the lower right quadrant).

The clustering follows the usual pattern and in particular is very similar to the material from the Roman Rhineland (Figure 6.11). There were 33 Roman period analysable bones, of which nine gave definite identifications (six horses, two mules and a donkey), 17 probable (10 horses, six mules and one donkey) and seven possible (five horses and two mules). All of the mule and donkey identifications came from Tac-Gorsium in Hungary, a large villa site.

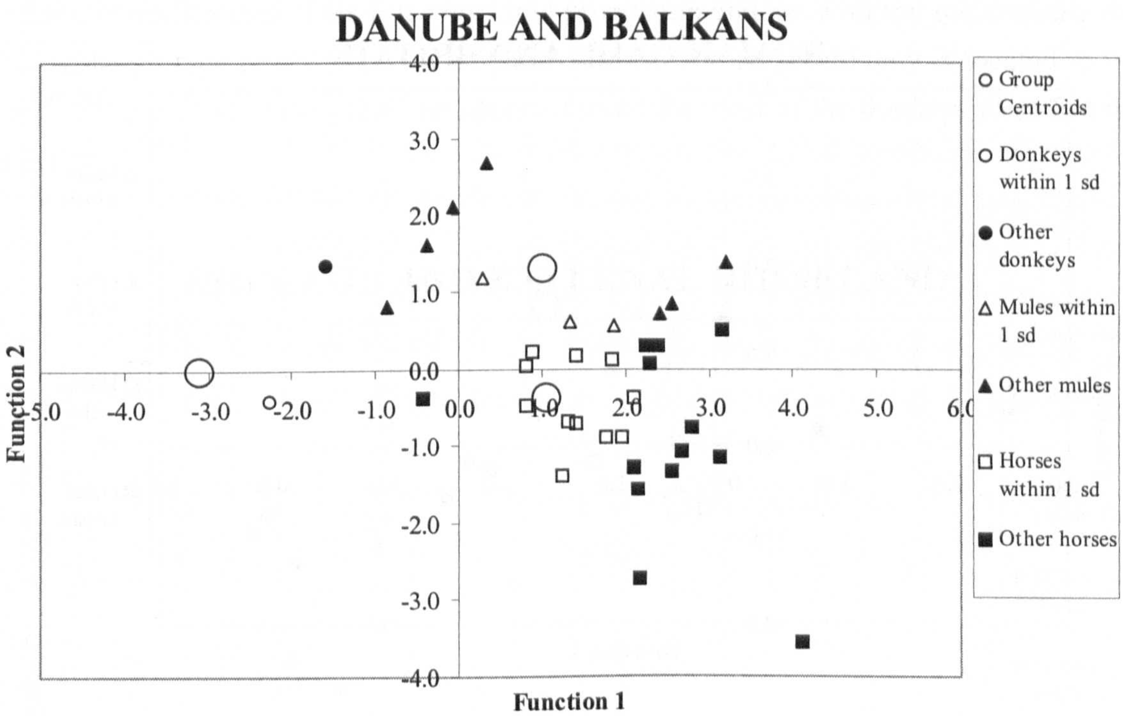


Figure 6.13. Species identifications of isolated archaeological equid metatarsals from the Danube and Balkans

There were so few points from Italy and Greece that it is sufficient to describe them here. There were two bones from Italy, of which one was identified as a probable mule and the other a probable horse. The bones from Greece came from the Classical period (3rd century BC) site of Kassope and all five were identified as donkeys (four definite and one probable). It is interesting that these donkeys clustered much closer to the group centroid than any of the previous donkey identifications, and this is discussed below.

The next element to be examined was the tibia. Comprehensive results are given in Appendix Table A10. Although there were considerably fewer analysable tibiae (49), they were grouped by region for ease of direct comparison with the metatarsals. There was a single bone from Egypt that was identified as a probable donkey (data not shown). Although the point was a long way from the group centroid, it had a high probability and this was consistent with the results on the metatarsals from this site (Mons Claudianus). Two bones from Italian sites were both identified as probable mules, as they were just into the overlap zone between horses and mules (data not shown).

For Britain and Gaul there were no complete Iron Age tibiae, so all the data plotted on Figure 6.14 are of Roman date. There were two bones from Britain, both identified as horses (one definite, one possible). Of the seven bones from Gaul a single definite horse identification was made, two probable identifications (one horse, one mule) and four possible (two horse, two mule). There seemed to be less clear differences between the horse and mule tibiae groups than there were on the metatarsals, in spite of the fact that the methodology produceed more accurate results on modern samples of this element.

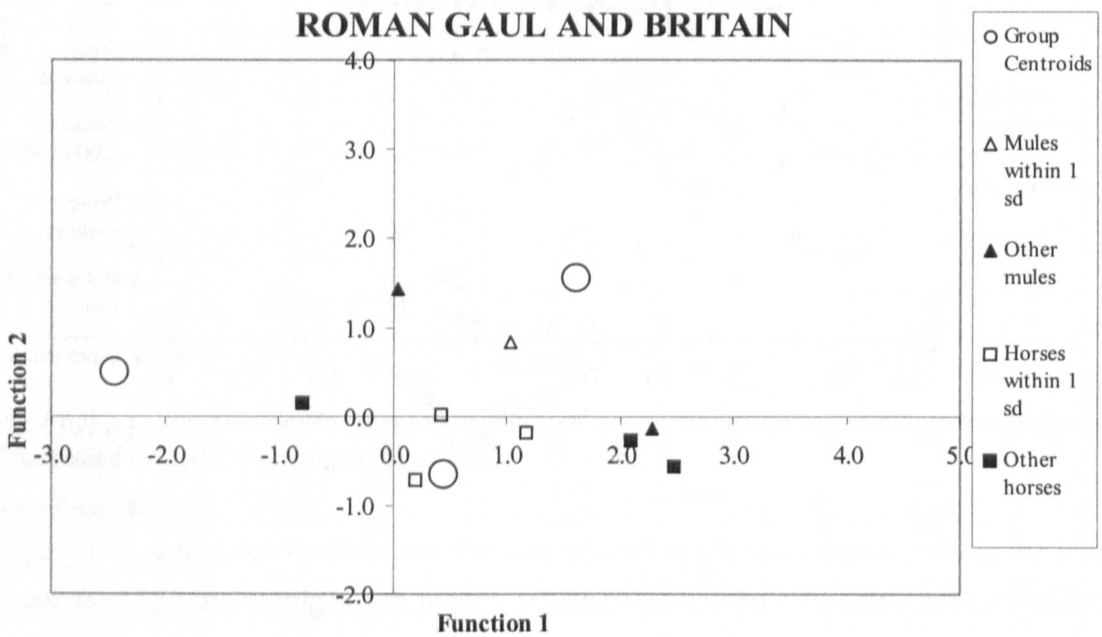


Figure 6.14 Species identifications of isolated archaeological equid tibiae from Roman Britain and Gaul.

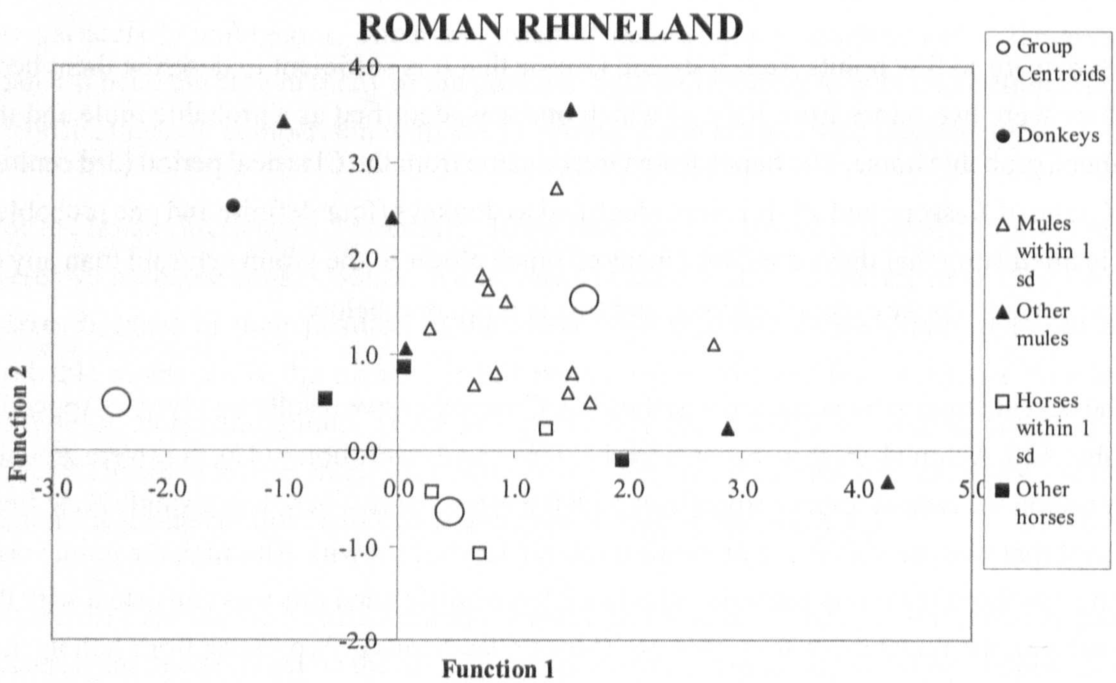


Figure 6.15. Species identifications of isolated archaeological equid tibiae from the Roman Rhineland

The only other area producing analysable tibiae was the Rhineland region. The results were split into two groups, those from pre-Roman and External Rhineland forming one group and, those from Roman deposits forming the other. Taking the Roman material first, Figure 6.15 show the results. There were 24 analysable bones, of which seven were definite identifications (two horses and five mules), 11 were probable (10 mules and one donkey) and six were possible identifications (four horses and two mules). A very high percentage of the tibiae from this region was identified as mules (17) and most (15) were probable or definite identifications. This is a very large proportion and, as with the metatarsals, any link with site type needs to be investigated further. The single donkey is located in the upper left quadrant of the graph, an apparent trend for most of the donkeys from Roman deposits.

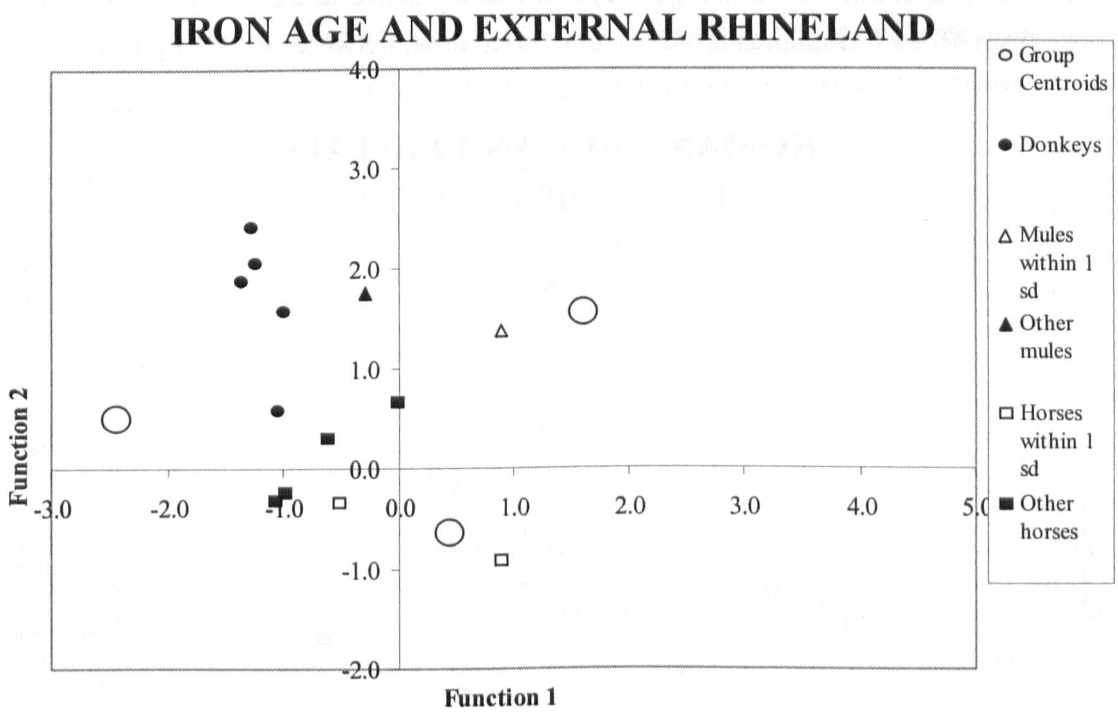


Figure 6.16. Species identification of isolated archaeological equid tibiae from Iron Age and External Rhineland

From Iron Age and External Rhineland (Figure 6.16), there were 13 analysable bones, of which three were definite identifications (two horses, one mule), three were probable (all donkeys) and the remaining seven were possible identifications (two donkeys, one mule and four horses). This was a particularly low level of identification, particularly as this is the most reliable element. As with the metatarsal, there seems to be a group of individuals around the zero point that is present on this graph but not present on the others. Most of these points are once again from Fedderesen Wierde, and they are discussed further below.

The last element to be analysed was the radius. There were a total of 98 analysable bones, all of which had the optimum measurements (Appendix Table A11). As with the two previous elements, the results were grouped by region so that they were directly comparable. Once again there were small numbers of bones from Italy and Egypt that are not illustrated here. Of the five bones from Mons Claudianus in Egypt, one probable donkey and four mules (one definite, one probable and two possible) were identified. The donkey was in a similar position on the graph (upper right quadrant) to those identified as donkeys on the other elements from this site. The mules were slightly more ambiguous and one was actually nearer the donkey centroid than the mule one.

Of the four bones from Italy, three were from the Punic site of Olbia. These clustered closely round the donkey centroid and were all identified as definite donkeys. The fourth bone was from Emilia (an Iron Age site) and was identified as a possible donkey; as with those from Mons Claudianus it was in an overlap area, between all three groups.

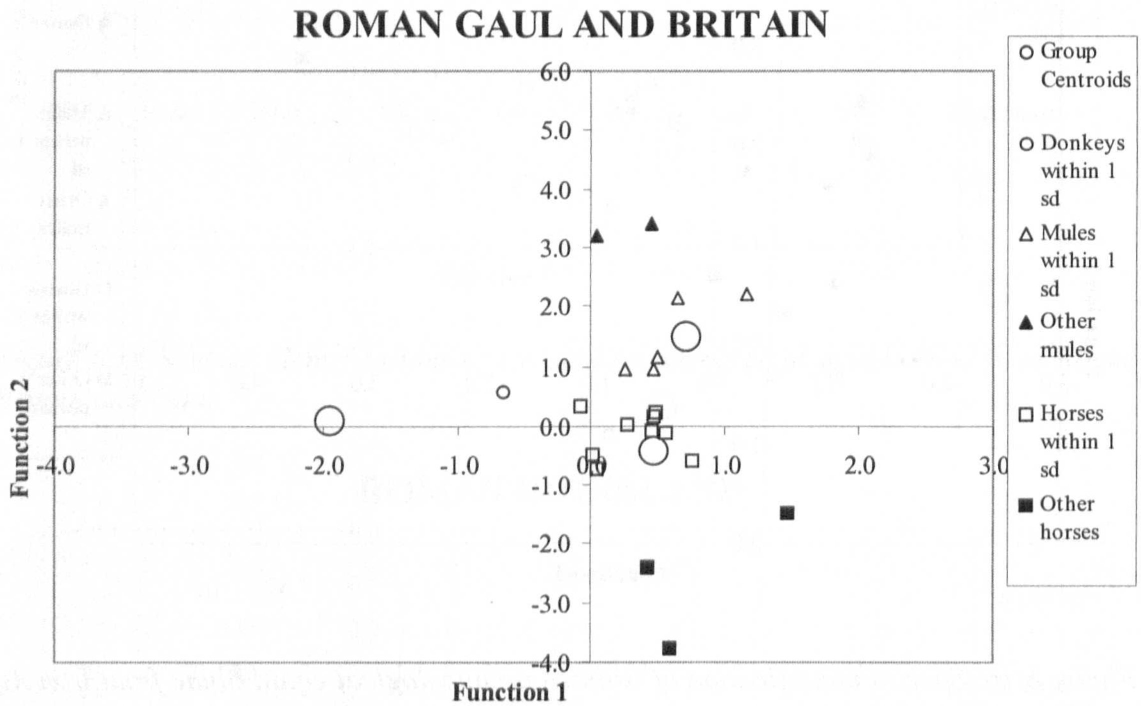


Figure 6.17 Species identifications of isolated archaeological equid radii from Roman Britain and Gaul

There were 20 radii from Britain and Gaul of which 19 were from Roman deposits (Figure 6.17) and one was Iron Age. This Iron Age radius was from Britain and was identified as a definite horse. There were four Roman bones from Britain, all of which were identified as horses (two definite and two probable). Amongst the 15 radii from Gaul there were four definite identifications (two horses and two mules), 10 probable identifications (four horses, five mules and one donkey) and one possible horse identification. The donkey is much closer to the other groups than has been the case on many of the previous figures and evidently the 1 SD area is quite large, hence the probable identification. As on some of the previous figures, some of the mules are situated well above the centroid, which once again may be showing a distinctive characteristic of Roman mules. The horses are spread typically around the centroid and into the bottom right quadrant of the graph.

Comparing the Roman bones from the Rhineland (Figure 6.18) which those of Britain and Gaul, there is a far greater concentration of bones in the overlap zone between the horses and mules and a greater spread to the right hand side of the graph in the Rhineland sample. From the total of 24 radii, there were only five definite identifications (two horses and three mules), a reflection of the greater number of bones in the overlap zone. Of the remaining bones 18 probable identifications (seven horses and eleven mules) and one possible horse identification were made. As with the mules from Gaul, there are a number of cases above the centroid, but there are also a large number in the overlap zone. For this area there are many more horses in the overlap zone, suggesting that the differences between the horses and mules in this area may be less pronounced than in previous cases.

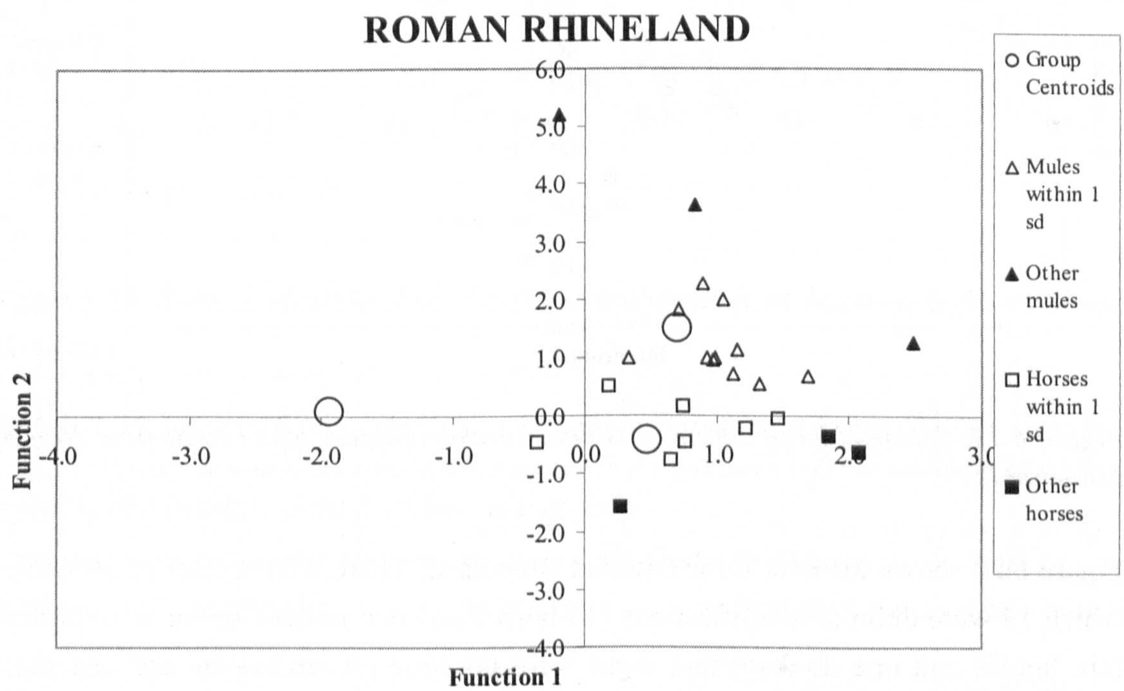


Figure 6.18. Species identification of isolated archaeological equid radii from Roman Rhineland

The Iron Age bones from the Rhineland area are shown in Figure 6.19. There was a total of 15 radii, of which only one was definitely identified (horse), seven were probable identifications (two horse, one mule and four donkeys) and seven were possible identifications (six horses and one mule).

These Iron Age bones produced a substantially different picture to the Roman bones (Figure 6.18) from the same area. The four probable donkey bones were all from the Manching

Oppidum. This is not too surprising as the site is only just pre-Roman and is known to have traded extensively with the Roman Empire. The two mules (one probable and the other possible) were also from Manching. These results are quite reassuring as they are identifying donkeys and mules where they could be expected to be present from other lines of evidence. One of the most striking features of Figure 6.19 is the position of the horses on the graph. Rather than the usual spread through the right lower quadrant, they are mostly bunched to the left of the zero line, into the overlap zone with the donkeys. Once again this may be question of size, which will be considered below.

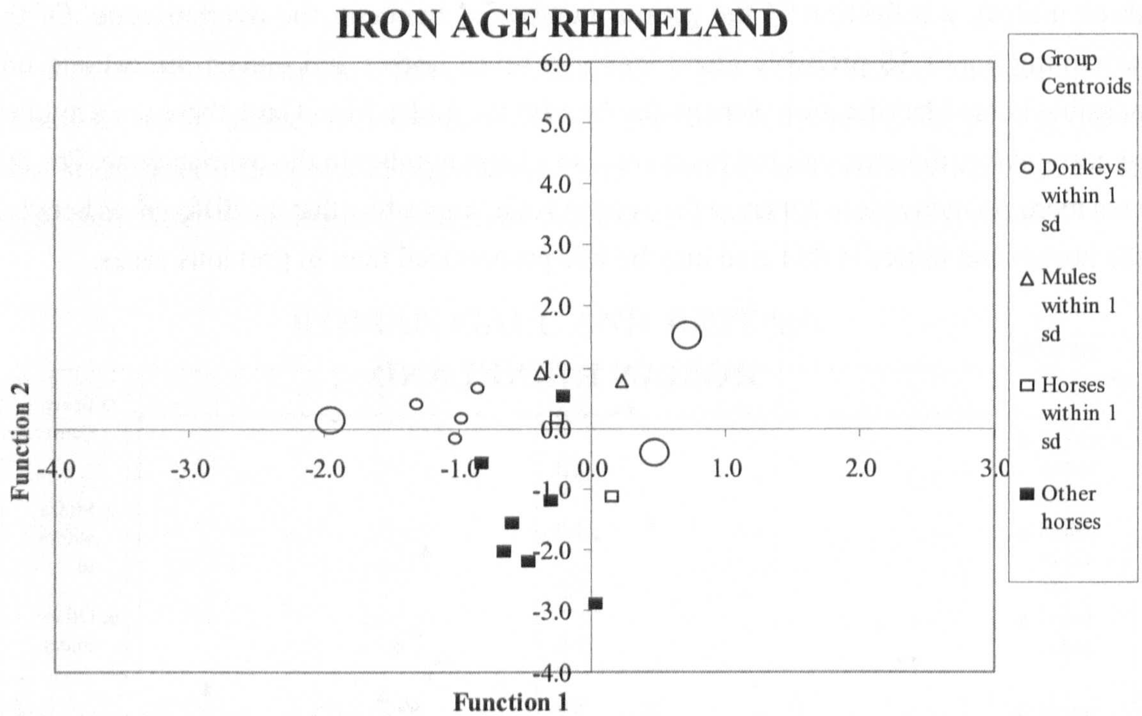


Figure 6.19. Species identification of isolated archaeological equid radii from Iron Age Rhineland

Figure 6.20 shows the data from External Rhineland. There were a total of 30 radii, of which 15 were definite identifications (13 horses and two mules), seven were probable (six horses and one donkey) and eight were possible (seven horses and one mule). Comparison of the External Rhineland data and Iron Age data (Figure 6.19) shows some similarities. Once again there are a number of horses that fall to the left of the zero line, overlapping with the donkey data: as before the small size of some of these animals may be contributing to this positioning. However, there is also a large number of horses spread in the usual pattern in the lower right quadrant of the graph, possibly indicating quite a range of size and shape in these animals. The two definite mules are well away from the overlap zone and indeed are in the position seemingly indicative of Roman mules.

The Roman period results from all three elements were also grouped by more accurate date categories to determine any chronological trends. However, there were no visual differences in the spread of points on each graph (data not shown), suggesting that the range of sizes and builds of the animals remained similar throughout the Roman period and therefore the results are only presented here in Table 6.7. This table again highlights the fact there is a problem with the dating of many deposits, as has been discussed previously (Chapter 5), and that there is more early Roman material than there is late.

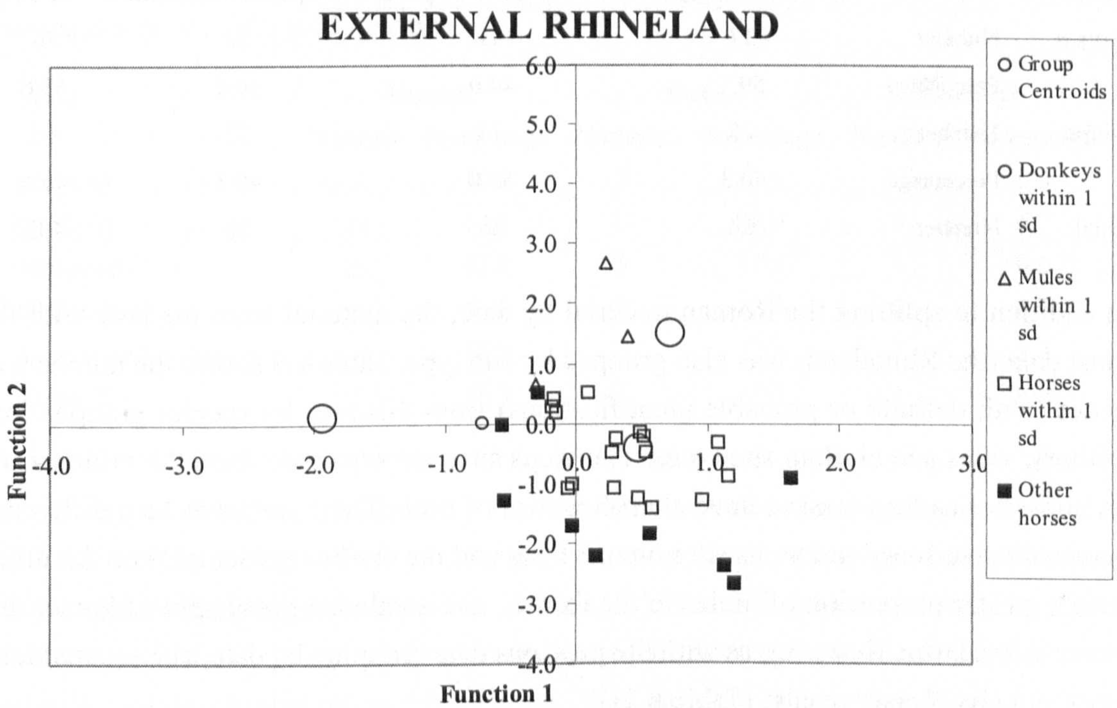


Figure 6.20. Species identification of isolated archaeological equid radii from External Rhineland.

Table 6.7. Numbers of horses, mules and donkeys by date for the Roman period. Data from metatarsals, tibiae and radii combined. Figures in parentheses refer to numbers of definite, probable and possible identifications, in that order

Species	1st- 2nd century AD	3rd - 4th century AD	Unspecified Roman	Total
Horses	46 (20,17,9)	15 (7,4,4)	37 (8,20,9)	98
Mules	29 (8,17,4)	15 (5,9,1)	30 (8,19,3)	74
Donkeys	3 (0,3,0)	0	4 (0,3,1)	7
Total	78	30	71	179

Table 6.8 shows that there is a slight difference in the proportions of mules to horses between the earlier and later periods. During the 1st and 2nd centuries AD there are only two-thirds as many mules as horses. Whilst there are far fewer bones dated to the 3rd and 4th centuries AD, there are slightly more mules than horses. In the unspecified and total categories the percentages marginally favour the horses but are again almost equal. These data hint that as the Roman Empire became more established in an area, the 'more Roman' use of mules increased. However, chi-squared tests performed on the results in Table 6.8

gave 'not significant' results (see Table 6.11 for test statistics), showing that observed differences between the periods were not statistically different.

Table 6.8. Numbers and percentages of horses and mules by date for the Roman period. Data from metatarsals, tibiae and radii combined. Only definite and probable identifications were used.

Species		1st- 2nd century AD	3rd - 4th century AD	Unspecified Roman	Total
Horses	Number	37	11	28	76
	Percentage	59.7	44.0	50.9	55.6
Mules	Number	25	14	27	66
	Percentage	40.3	56.0	49.1	46.4
Total	Number	62	25	55	142

In addition to splitting the Roman material by date, the material from the area with the most data (the Rhineland) was also grouped by site type. Table 6.9 shows the numbers of bones (with definite or probable identifications) from this area by species grouped into military, vicus and civilian site types. The vicus sites are separated from the military and civilian sites as they tend to have characteristics of both. There seems to be a difference between the military and vicus sites on one hand and the civilian settlements on the other, with a greater proportion of mules in the former, and an almost equal split of horses and mules in the latter. However, as with the previous data grouping by date, chi-squared tests gave 'not significant' results (Table 6.11).

Table 6.9. Numbers of horses and mules identified from military and civilian sites in the Rhineland area. Only definite and probable identifications were used.

	Military	Vicus	Civilian	Total
Mules	6	14	18	38
Horses	1	6	19	26
Donkeys		1	1	2
Total	**7**	**21**	**38**	**66**

As the Roman and Iron Age data had been separated it was quite easy to look at the differences in species proportions between these two periods. Looking at the Iron Age data (excluding the Greek site as being too different from the rest of the European sites), there was a ratio of 7.5 horses: 1.5 mules: 1 donkey. As most of the mules and donkeys were from late Iron Age sites with known contact with the Roman Empire, this was not unexpected, with horses predominating. In comparison with the Iron Age, the Roman period produced a ratio of 14 horses: 10.5 mules: 1donkey. This ratio showed an even higher proportion of mules than for the complete skeletons (12.5:5.5:1). This may be reflecting the difference in status between horses and mules, with some horses being treated as 'special' animals and accorded a separate burial whereas the mules were disposed of in any way possible.

Table 6.10. Numbers and percentages of Roman horses, mules and donkeys by area. Data from all elements combined. Only definite and probable identifications were used. Areas as defined in Section 5.3 (Table 5.4), letter codes shown in this table will be used subsequently in tables and figures.

Area	Horses		Mules		Donkeys	
	Number	Percentage	Number	Percentage	Number	Percentage
Italy (A)	3	60.0	2	40.0	-	0.0
Gaul (D)	29	64.4	13	28.9	3	6.7
Britain (E)	29	82.9	5	17.1	-	0.0
Rhineland (F)	56	52.8	45	42.4	5	4.7
Danube and Balkans (G)	56	58.9	36	37.9	3	3.2
Egypt (K)	4	36.4	3	27.3	4	36.4

Combining all the identification results for the Roman period and splitting the definite and probable data by area (see Chapter 5 for definitions of areas), some interesting differences in the species proportions were seen (Table 6.10). The Rhineland and the Danube and Balkans areas showed very similar percentages of all three species. Gaul was also similar but with a slightly higher proportion of horses then the other two species. Britain, however, showed a somewhat different picture, with a much higher proportion of horses and a correspondingly lower number of mules and no donkeys. When a chi-squared test was performed on these data the results showed there were highly significant differences between all of the areas and also between the four with the most data (Table 6.11). Although the numbers from Egypt were small the proportions of species were very different to all the other areas, and this probably reflects the fact that these data represents a single site of a type not found in the other areas: an industrial quarry.

*Table 6.11. Summary of chi-squared tests on identification data. N=not significant, *=significant (95% level), **=highly significant (99% level). For area abbrviations see Table 6.10.*

Chi-squared test on	For data see Table	Degrees of freedom	Probability	Significance
Differences in date	6.8	2	0.3667	N
Differences in site type (mules and horses only)	6.9	2	0.0947	N
Differences in area (all)	6.10	10	0.0001	**
Differences in area (DEFG only)	6.10	6	0.0326	**

6.1.3 Summary of species identification results

The results from running the identification analyses on the complete skeletons and limbs were not as clear-cut as had been hoped for. Taking all the bones individually there was a total of 139 identifications, of which 94 were horses, 38 mules and seven donkeys, which gave a ratio of horses: mules: donkeys of 12.5:5.5:1. However, within each specimen or limb very few of the identifications were completely clear-cut with each element giving the same identification. Indeed some cases had such a mix of identifications that they can be described as having ambiguous morphologies. It is therefore clear that in some cases it is just not possible to assign an accurate identification using the research methodology. This work on the complete skeletons and articulated limbs has highlighted the fact that identifications based on a single bone, with a 'possible' identification level, should be treated with caution and certainly not used as a definite identification.

For the isolated skeletal elements the data were split by period, so it is possible to discuss the Iron Age (including External) and Roman data separately. For the Iron Age data (excluding the Greek site as being too different from the rest of the European sites) there was a ratio of 7.5 horses: 1.5 mules: 1 donkey. In comparison, the Roman period produced a ratio of 14 horses: 10.5 mules: 1donkey. The difference in the proportion of mules between the two periods is striking and shows that the contemporaneous Roman literature is proving to be a better guide to relative species abundance than the zooarchaeological record thus far. This helps confirm the hypothesis that the lack of mules in the zooarchaeological literature is due to identification problems.

From the identification analyses undertaken it is possible to suggest that there are groups of individuals within each species with similar morphologies. For instance, there are two groups of donkeys, the first of which clusters around the group centroid, such as the material from the site of Kassope in Greece (3rd century BC), and must therefore be very similar to the modern material that the centroid was derived from. The second group clusters to the top left of each graph, and whilst they are unlikely to be anything other than donkeys because of their distance from the other species, they must have had slightly different characteristics to the majority of the modern sample. Most of the Roman donkeys fall into this cluster. It is quite possible that there is a slight size difference between the modern and archaeological samples that is causing this separation of individuals as most of the modern individuals were relatively small.

For the mules there are two noticeable clusters of individuals, one of which lies around the group centroid. A subset of this group lies slightly further away and towards or into the overlap zone with the horses. These for the most part have had to be identified as 'possible' mules. Two possible explanations can be put forward. Either these are mules that have morphologies at the horse end of the scale and are therefore genuinely difficult to identify, or this is an issue relating to the fact that the size of the bones may be important in the separation of horses and mules and this is masking some of the morphological differences. In most instances the second cluster is situated above the centroid, but some distance from it. These are what have been termed as the 'super' mules, and it is suggested that these are showing exaggerated mule characteristics, but the question of size cannot be discounted.

For the horses there are more clusters discernible. As with the other two species, there is a cluster around the group centroid that must therefore be very similar to the modern sample. There is also a subset of that group, which in most cases is situated above the centroid and therefore comes into the overlap zone with the mules. The same explanation put forward for the mules in this zone applies here too. The third cluster is more a drift of individuals that fills the space between the centroid and the lower right corner of the graph. These are 'super' horses, with either exaggerated horse characteristics or again slight differences in size from the modern sample. For both the 'super' mule and 'super' horse groups they are unlikely to be wrongly identified because the points are situated away from the overlap zones with the other species.

Two other groups of horse identifications may have similar explanations. The first is clustered around the zero area and therefore potentially in the overlap zones for all three species. This group seems to consist mainly of horses, but the probabilities of these and the few neighbouring mules are so low that their identifications are particularly ambiguous. The second is mostly bunched to the left of the zero line into the overlap zone with the donkeys. It is interesting that most of the individuals in the first group come from the site of Feddersen Wierde and the second group come from Manching. It is therefore a possibility that there is something internally consistent about these groups, in either size or shape (or both) that is causing these clusters. It also suggests that there are likely to be consistent differences in size or shape between these groups and the modern sample.

All the groups mentioned above that do not cluster around the group centroids may be explained by slight differences in size or shape, or both, from the modern samples. Analysis of withers heights, shape indices and log-ratios should help elucidate this.

Another interesting point to emerge from the analysis of the species identifications is that where the original workers had attempted identifications, this methodology confirms some of the identifications whilst contradicting others. In particular identifications based on tooth morphology alone seemed to contradict the limb morphology. In some cases the animals were young (limb epiphyses closed but vertebral epiphyses open, <5 years) and therefore may not have finished the circumferential growth of the bones (see Chapter 2 for discussion of this issue). It is hoped that the calculation of the shape indices for these individuals (Section 6.3 below) may shed some light on this potential problem. It is also possible that the young age of these individuals meant that the enamel patterns were not fully in wear and could therefore have been misinterpreted.

However, the other individuals were fully adult (8-12 years) and still had different identifications based on the teeth and the limbs. It is difficult to present an explanation for these ambiguous identifications other than the fact that maybe some individuals have such ambiguous morphology of both teeth and bones that a secure identification is impossible.

Looking at the distribution of mules and donkeys across time and space produced some unexpected results. The presence of donkeys and mules outside the Mediterranean basin in the Iron Age was not previously suspected, but can be explained satisfactorily on a site-by-site basis. For the mule from Swestari (3rd century BC, Thracian cemetery) it is possible that, whilst Roman influence in this area and time period is unlikely, potential contact with classical Greece could have resulted in the trading of donkeys or mules or the knowledge of their breeding.

For the mules and donkeys in Iron Age Britain and Gaul two possible explanations can be put forward. Most of the sites that these bones came from had a continuous occupation from the Iron Age, through conquest and into the Roman period. It is therefore possible that the bones came from contexts that were dated by residual artefacts and may actually be Roman in date. Alternatively, in the case of Thorpe Thewles and some of the sites in Gaul, there is known to have been extensive trade between the occupants of the sites and the Roman Empire before conquest, which could easily have included these animals as beasts of burden or as trade items in their own right. Neither of these hypotheses is immediately testable, so the presence of donkeys and mules in pre-conquest deposits must be considered a possibility.

In a similar way, the presence of donkeys and mules in areas beyond the borders of the Roman Empire was not previously suspected. Most of these individuals were from Feddersen Wierde and therefore the second explanation given for the Iron Age material applies equally well to this material.

For the Roman period the identifications were grouped by date to determine any chronological trend. No differences were discernible between the data from the earlier and later Roman periods, suggesting that the range of sizes and builds of the animals remained similar throughout the Roman period.

Combining all the identification results for the Roman period and splitting the definite and probable data by area showed some interesting differences in species proportions. The

Rhineland and the Danube and Balkans areas were very similar, with percentages of roughly 56% horses, 40 % mules and 4% donkeys. Gaul was also similar but with a slightly higher proportion of horses to the other two species. Britain, however, had a much higher proportion of horses and correspondingly lower number of mules. Chi-squared tests showed these differences were highly significant (Table 6.11). Although the numbers from Egypt were very small, the proportions of species were very different to all the other areas and this probably reflects the fact that the data represent a single site of a type not found in the other areas: an industrial quarry.

In addition to splitting the Roman material by date and area, the material from the area with the most data (the Rhineland) was also grouped by site type. There appeared to be a slight difference between the military and vicus sites on one hand and the civilian settlements on the other, with a greater proportion of mules in the former, and an almost equal split of horses and mules in the latter. However, chi-squared tests gave 'not significant' results (Table 6.11)

In other areas a few interesting observations could be made about the distribution of species and site types. In Britain most of the mules came from farmstead/villa and small town settlements rather than the urban centres or military sites. In the Danube and Balkans area all of the mule and donkey identifications come from Tac-Gorsium in Hungary, a large villa site. However, this last observation may just reflect the fact that the large Tac-Gorsium assemblage contributed most of the data for this area.

The aim of this section was to establish whether the lack of mules in the zooarchaeological literature was due to identification problems or to a real absence of the species. It is clear from the substantial numbers of mules presented here, identified using the research methodology, that the former is the case. Indeed, in this dataset, there are roughly two-thirds as many mules as there are horses, suggesting contemporaneous Roman literature provides a more accurate representation of relative species proportions than zooarchaeological literature.

6.2 Withers height estimation

6.2.1 Calculation of estimated withers height from complete skeletons and articulated limbs

The material outlined in Section 6.1.1 was also used for the withers height estimation analysis. As before, the complete skeletons and articulated limbs were analysed separately from the isolated bones, to provide a check that the methodology detailed in Chapter 3 is producing internally consistent results and that there are no major differences in limb proportions between the archaeological and modern material. Refer to Table 6.1 (above) and Appendix Table A2 for details of the sites from which complete skeletons and articulated limbs were recovered.

In order to provide as comprehensive a guide as possible to the withers heights of these individuals, additional elements were included, for which the length measurements were present but had not been used for the species identification work because other measurements were missing. For the main part of the analysis only data from those individuals identified to the definite or probable level have been used ('identified' bones). The individuals with possible identifications ('ambiguous' bones) have been kept separate, so that the data can be used to see if it is possible to clarify the identifications using the withers height in conjunction with the discriminant function analysis. Although withers height is a measure derived from bone length, the multiplication factors involved should amplify any differences between the groups and hence could aid identification.

The withers heights were calculated from the lengths of the major long bones using the factors given in Table 3.5. Where both length measurements were present the average of the two estimates was used. Detailed results of these calculations for all the skeletons and articulated limbs are given in Appendix Tables A15-20. To check the limb proportions of these individuals against those of the modern animals, the same procedure was used as described for the modern material in Section 3.4. The estimated withers height values were ranked from lowest to highest and these are shown in Table 6.12, grouped by identification level. As with the modern data the factors quoted for the femur were consistently underestimated the withers height for all three species, and the tibiae of the mules provided the highest values for the withers height. These observations confirm that the limb proportions of the modern and archaeological individuals are very similar, justifying the use of the quoted factors on this material.

Table 6.12. Limb elements ranked from lowest to highest estimated withers height for the archaeological skeletons and articulated limbs. H=humerus, R=radius, MC=metacarpal, F=femur, T=tibia, MT=metatarsal, ID = identification

Site no.	Site name	Specimen	ID level	Lowest					Highest
128	Krefeld-Gellep	3510	D*	F	T	MC	MT	H	R
135	Swestari	1	H	F	MC	H	R	T	MT
135	Swestari	3	H	F	MC	MT	T	H	R
92	Feddersen Wierde	skelett1L	H	F	R	MC	MT	T	H
135	Swestari	2	H	F	R	MC	T	H	MT
118	Carnuntum	Pferd 2	H	R	F	T	H	MC	MT
92	Feddersen Wierde	skelett2R	H		F	R	MC	T	H
92	Feddersen Wierde	skelett1R	H			F	R	MT	H
92	Feddersen Wierde	skelett2L	H			F	R	MC	T
118	Carnuntum	Pferd 3	H*	F	MT	H	MC	T	R
96	Kunzing east vicus	1620	H*	F	R	T	MC	H	MT
96	Kunzing east vicus	1575/5	H*	F	R	MC	MT	T	H
135	Swestari	4	H*	MC	F	MT	R	T	H
71	Piovego	N2	H*	R	MC	MT	T	H	F
59	Chichester cattlemarket	XXIII	H*		F	T	H	MC	MT
59	Chichester cattlemarket	XXIII	H*		F	T	MC	H	MT
141	Szentes-Vekerzug	6	H*		MC	H	R	MT	T
114	Unterlaa	23A	H*			F	MT	T	MC
37	Kesteren ‘De Prinsenhof’	11.28	H*				F	MT	T
43	Elms Farm	6640	H*				MT	R	MC
43	Elms Farm	6640	H*				MT	R	MC
128	Krefeld-Gellep	3392	H*				MT	R	MC
110	Nijmegen new excavations	147/128	H?		F	R	MC	MT	H
119	Albertfalva	Horse 2	H?		F	MC	MT	T	H
119	Albertfalva	Horse 1	H?		MC	F	T	MT	H
37	Kesteren ‘De Prinsenhof’	11.34	H?		R	F	MC	T	MT
37	Kesteren ‘De Prinsenhof’	1.21	H?				F	MT	T
96	Kunzing east vicus	1581	H?				R	MC	MT
128	Krefeld-Gellep	3557	H?				R	MC	MT
135	Swestari	5	M	F	MC	MT	R	H	T
118	Carnuntum	Pferd 1	M	R	MC	MT	F	H	T
128	Krefeld-Gellep	3573	M				MC	MT	T
42	Druten	1.18	M*	F	R	MC	T	MT	H
92	Feddersen Wierde	skelett3L	M*	MC	F	H	MT	R	T
96	Kunzing east vicus	1641	M*	MC	F	MT	T	H	R
96	Kunzing east vicus	1703	M*	MC	F	MT	R	H	T
96	Kunzing east vicus	1632	M*		F	R	T	MC	H
117	Pompeii stable	B	M*			F	T	MT	MC
118	Carnuntum	Maultier 1	M*				F	T	MT
117	Pompeii stable	C	M?			F	T	MT	MC

As proposed in the Section 3.4 and backed up by the evidence given above, it was decided that the femur would not be used to calculate the withers heights of isolated bones and would also not be used in further analyses of the withers heights of the skeletons and articulated limbs. In addition the withers height calculated from the tibia would only be used where the bones were identified as coming from horses. For the skeletons and articulated limbs the mean withers height was calculated from the appropriate elements and the results are given in Table 6.13. These results are also shown graphically as histograms (Figure 6.21).

Table 6.13. Mean estimated withers height calculated from the appropriate elements of the archaeological skeletons and articulated limbs

Site no.	Site name	Specimen no.	ID	Mean (mm)	Site no.	Site name	Specimen no.	ID	Mean (mm)
37	Kesteren De Prinsenhof	1.21	H?	1514.07	114	Unterlaa	25	H	1347.18
37	Kesteren De Prinsenhof	2.27	H*	1487.88	114	Unterlaa	30	H*	1341.81
37	Kesteren De Prinsenhof	11.28	H*	1471.55	114	Unterlaa	35	H*	1348.34
37	Kesteren De Prinsenhof	11.34	H?	1446.51	114	Unterlaa	40	H*	1378.74
42	Druten	1.18	M*	1521.54	114	Unterlaa	48	M*	1397.23
42	Druten	12.4	H*	1381.09	114	Unterlaa	49	M?	1461.94
43	Elms Farm	6640	H*	1409.61	114	Unterlaa	71	H	1368.83
43	Elms Farm	6640	H*	1412.22	114	Unterlaa	73	H	1312.67
59	Chichester cattlemarket	XXIII	H*	1462.22	114	Unterlaa	23A	H*	1343.17
59	Chichester cattlemarket	XXIII	H*	1463.00	115	Bad Wimpfen	Skele 4	M	1482.28
67	Ilchester,Church Street	F267	H*	1364.60	115	Bad Wimpfen	Skele 6	M	1404.32
71	Piovego	N2	H*	1348.99	117	Pompeii stable	B	M*	1437.43
92	Feddersen Wierde	skelett1L	H	1368.64	117	Pompeii stable	C	M?	
2	Feddersen Wierde	skelett1R	H	1371.71	118	Carnuntum	Maultier 1	M*	1496.55
92	Feddersen Wierde	skelett2L	H	1261.88	118	Carnuntum	Pferd 1	M	1533.18
92	Feddersen Wierde	skelett2R	H	1272.55	118	Carnuntum	Pferd 2	H	1437.81
92	Feddersen Wierde	skelett3L	M*	1377.23	118	Carnuntum	Pferd 3	H*	1444.32
96	Kunzing east vicus	1581	H?	1457.26	119	Albertfalva	Horse 1	H?	1439.04
96	Kunzing east vicus	1620	H*	1458.49	119	Albertfalva	Horse 2	H?	1577.34
96	Kunzing east vicus	1632	M*	1449.74	128	Krefeld-Gellep	3392	H*	1452.21
96	Kunzing east vicus	1641	M*	1437.27	128	Krefeld-Gellep	3510	D*	1186.92
96	Kunzing east vicus	1703	M*	1396.69	128	Krefeld-Gellep	3557	H?	1495.60
96	Kunzing east vicus	1575/5	H*	1402.54	128	Krefeld-Gellep	3559	M	1477.0
105	Mons Claudianus	549	H	1251.10	128	Krefeld-Gellep	3573	M	1449.08
105	Mons Claudianus	604	M?	1331.73	128	Krefeld-Gellep	3577A	M	1438.95
105	Mons Claudianus	1486	D*	1231.27	135	Swestari	1	H	1237.68
105	Mons Claudianus	1544	D*	1257.72	135	Swestari	2	H	1252.12
105	Mons Claudianus	1719	D*	1297.35	135	Swestari	3	H	1283.44
110	Nijmegen new excavations	147/128	H?	1514.15	135	Swestari	4	H*	1390.46
110	Nijmegen new excavations	179/16	H*	1241.67	135	Swestari	5	M	1502.04
110	Nijmegen new excavations	179/16	M*	1355.12	141	Szentes-Vekerzug	6	H*	1317.59
110	Nijmegen new excavations	1961/621	H?	1224.52	143	Histria	P18	H*	1440.73
114	Unterlaa	18	H	1386.35	143	Histria	P25	H?	1453.82

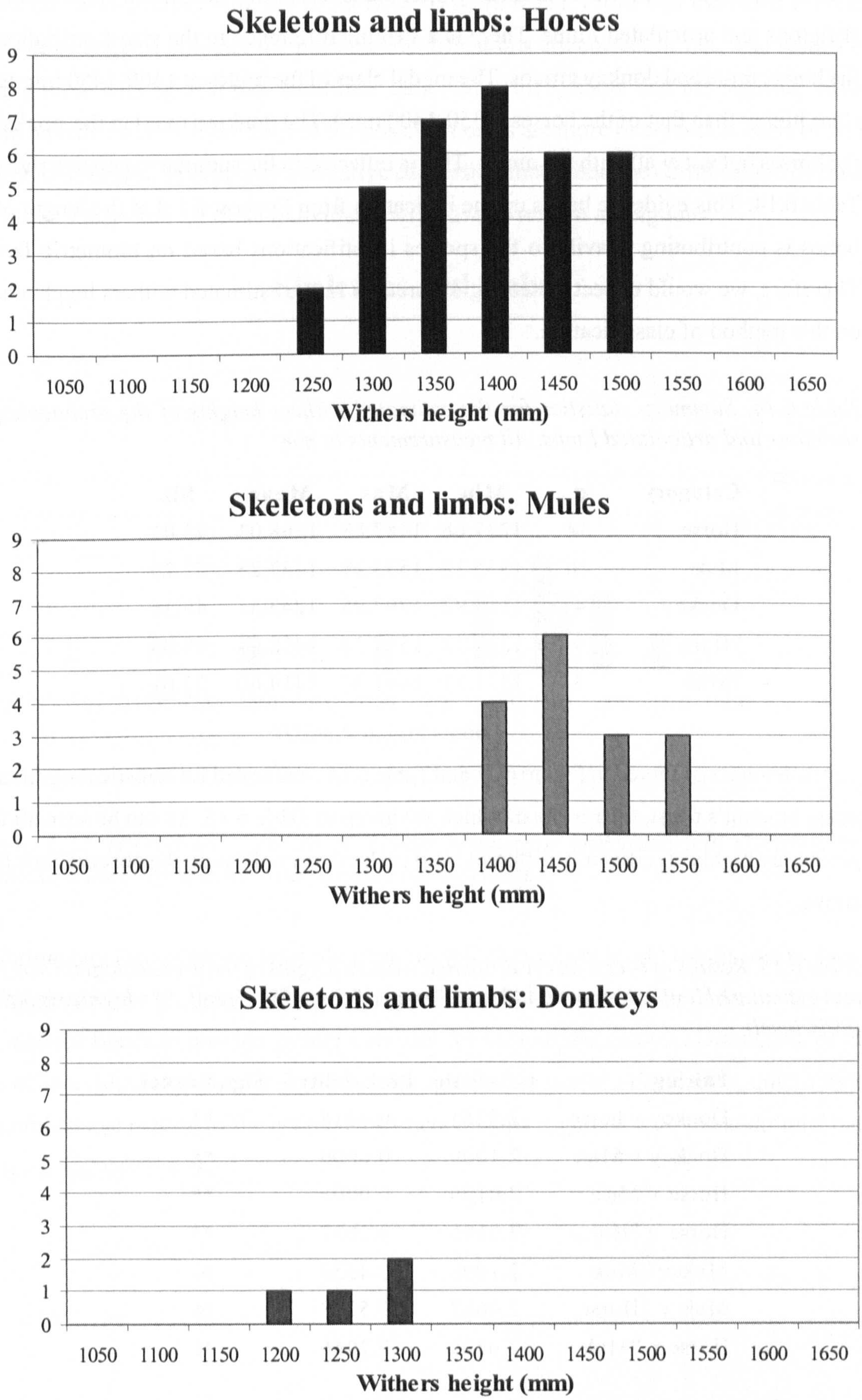


Figure 6.21. Histograms of estimated withers heights for all the archaeological skeletons and articulated limbs by species for the definite and probable identifications.

Figure 6.21 shows all the estimated withers heights for the 'identified' archaeological skeletons and articulated limbs. There is a striking difference in the size distributions of the horse, mule and donkey groups. The modal class of the mules at 1400-1450 mm is one class higher than that of the horses (1350-1400 mm). The donkeys overlap the smallest of the horses but not at all with the mules. This is reflected in the summary statistics shown in Table 6.14. This evidence backs up the indication from Section 6.1 that the length of the bones is contributing heavily to the species identifications based on biometric factors. Therefore, we would expect to see big differences in the estimated withers heights based on this method of classification.

Table 6.14. Summary statistics for the estimated withers heights of the archaeological skeletons and articulated limbs. All measurements in mm

Category	n	Min	Max	Mean	SD
Horse	34	1237.68	1487.88	1368.03	73.02
Mule	16	1355.12	1533.18	1447.23	52.29
Donkey	4	1186.92	1297.35	1243.31	46.38
?Horse	9	1224.52	1577.34	1458.04	98.09
?Mule	3	1331.73	1461.94	1414.60	72.01

The differences observed in Figure 6.21 and Table 6.14 were tested for statistical significance using Student's t-test, the results of which are given in Table 6.15. As can be seen all three groups are highly significantly different from each other, confirming the observations made above.

*Table 6.15. Results of t-tests on the estimated withers heights of the archaeological skeletons and articulated limbs. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	t statistic	Probability	Significance
Donkey v horse	2.0281	0.0018	**
Donkey v Mule	2.1009	0.0000	**
Horse v Mule	2.0106	0.0008	**
Horse v ?Horse	2.0195	0.0037	**
Mule v ?Mule	2.1098	0.4539	N
Mule v ?Horse	2.0687	0.5718	N
Horse v ?Mule	2.0301	0.2966	N

The results for the 'ambiguous' individuals are shown in Figure 6.22. Apart from the smallest possible horse and mule individuals, the rest fall at the upper end of the horse range and also overlap with the mule range (Figure 6.21). From this evidence it is not possible to suggest whether the possible identifications are correct or not. The results of testing these data against the 'identified' data (Table 6.15) show that the possible mules could be either mules or horses, but the possible horses are more likely on the basis of their height to be mules. This is only a tentative suggestion that cannot be corroborated by other means and therefore all these individuals will have to remain ambiguous.

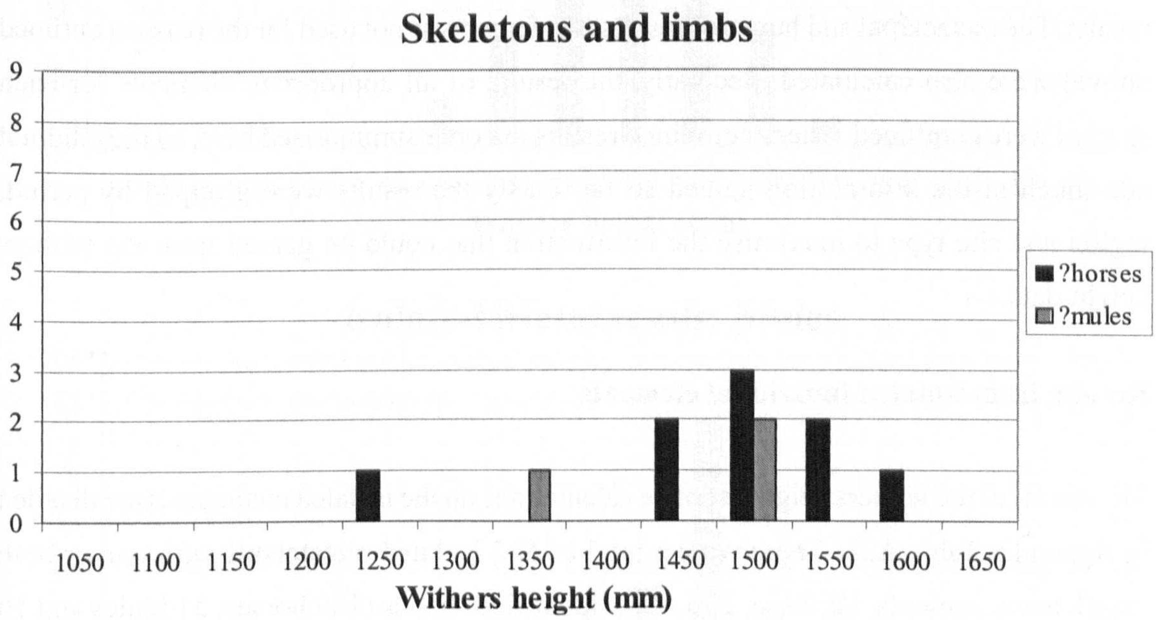


Figure 6.22. Histogram of estimated withers heights for archaeological skeletons and articulated limbs by species with possible identifications.

Unfortunately there were too few individuals to split the withers height results into regional, period or site type groupings. Therefore these data will be combined with the results from the isolated bones to provide greater numbers for meaningful analysis.Discussion of the size of individual skeletons will not provide any further useful information, until a more comprehensive picture of the estimated withers heights is gained with the additional data from the isolated bones.

6.2.2 Calculation of estimated withers height from isolated skeletal elements

This section contains the results of three analyses. Firstly, values for withers height from the isolated bones were calculated on an element-by-element basis to check internal consistency of results. The withers heights estimates were calculated for the same three elements as were used for the species identification (radius, tibia, metatarsal). These results are presented in some detail to show the working method and highlight aspects of the results. The metacarpal and humerus results (the femur was not used for the reasons outlined above) were also calculated. Secondly, the results of all appropriate elements for each species were combined. These combined results are only summarised here, as they did not add much to the information gained so far. Lastly the results were grouped by period, region and site type to maximise the information that could be gained from the withers height data.

Results from isolated individual elements

The results of the withers height estimate calculations on the isolated metatarsals are detailed in Appendix Table A21. There were a total of 585 isolated metatarsals with one or both length measurements. Of these, 236 were 'identified' bones (169 horses, 51 mules and 16 donkeys), and a further 38 'ambiguous' bones from the analysis in Section 6.1. The remaining 312 metatarsals were 'unknown'.

Figure 6.23 shows the histograms for the 'identified' bones. The difference in size between the species is very similar to that shown for the skeletons (Figure 6.21). However, the modal class for the horses is two groups smaller (1250-1300 mm) and that of the mules one class smaller (1350-1400 mm). This may be a reflection of the larger numbers of specimens involved. As with the skeletons, the mules as a group appear to be on average a little larger than the horse group. With this bone there is some overlap between all three groups, including overlap between the donkeys and mules. Of particular note are the quite substantial sizes at the upper end of the donkey range. This helps confirm earlier indications that larger donkeys were present in the archaeological sample that were not represented in the modern sample. This contradicts suggestions that the large donkeys are just misidentified mules or horses.

Table 6.16 shows the summary statistics for the metatarsals, showing the overlap between the ranges of the three 'identified' groups but also the clear separation of the three means. Testing this separation using t-tests showed that all three were highly significantly different (Table 6.17).

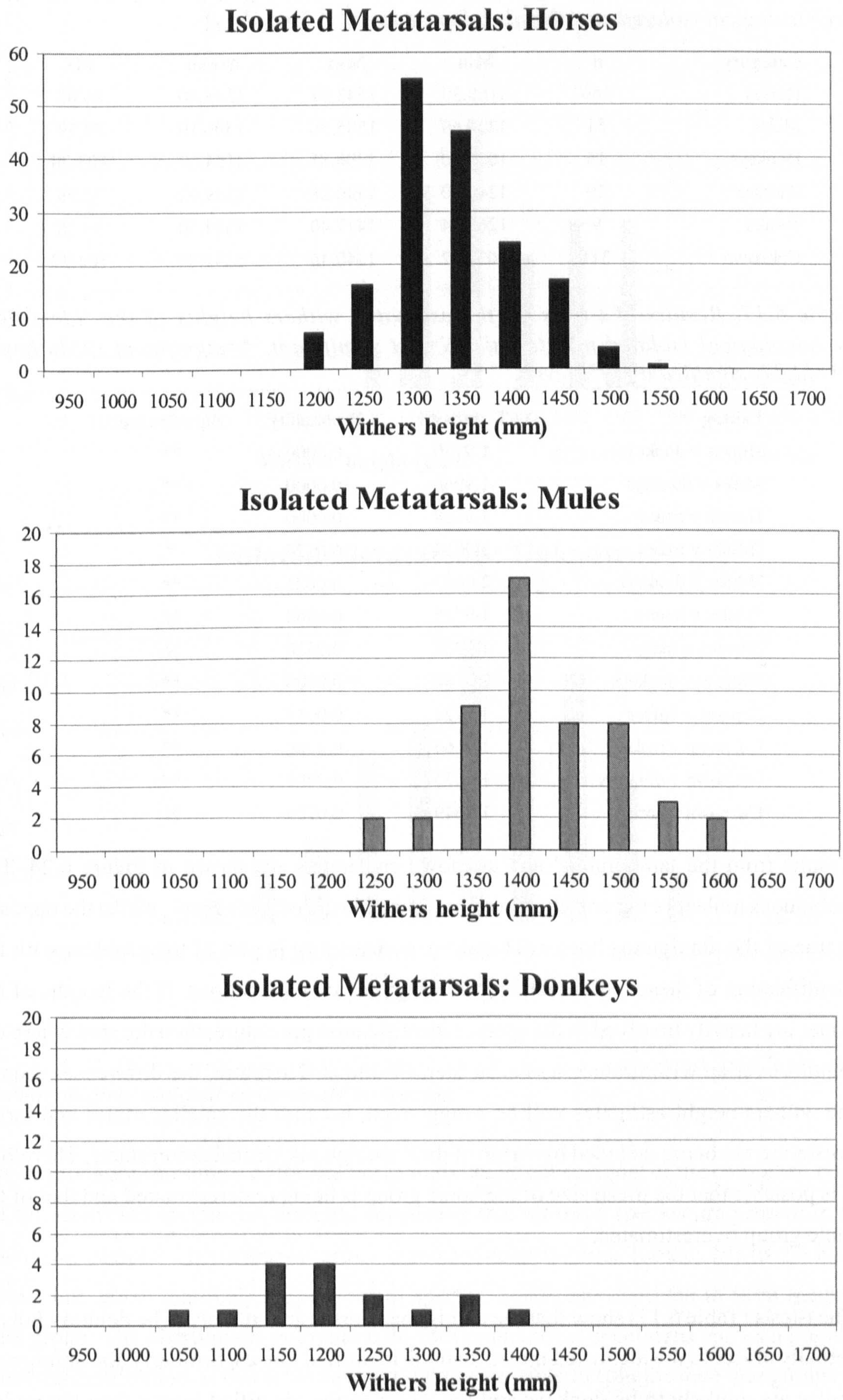


Figure 6.23. Histograms of estimated withers heights for the 'identified' archaeological isolated metatarsals by species.

Table 6.16. Summary statistics for the estimated withers heights (mm) of the 'identified' archaeological isolated metatarsals by species

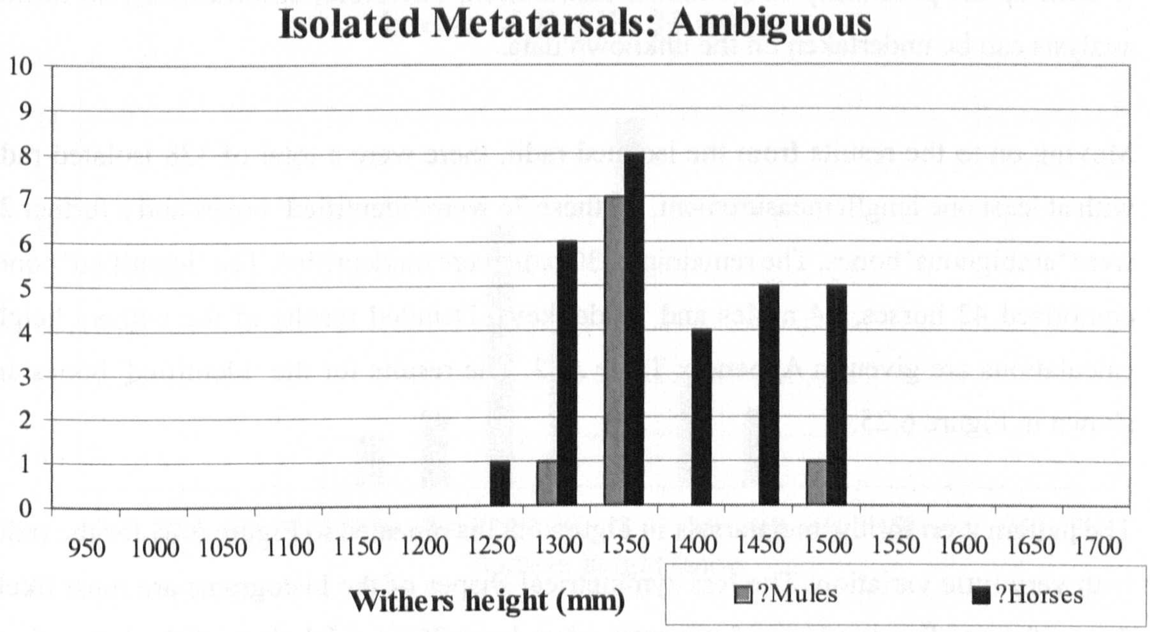
Category	n	Min	Max	Mean	SD
Horses	169	1168.30	1543.04	1315.40	66.02
Mules	51	1220.69	1585.36	1396.19	79.59
Donkeys	16	1033.10	1398.81	1194.02	103.30
?Horses	29	1249.50	1490.28	1359.92	78.98
?Mules	9	1267.84	1477.40	1324.50	59.28
Unknown	311	1037.32	1540.46	1331.44	104.37

*Table 6.17. Results of t-tests on the estimated withers heights of the 'identified' archaeological isolated metatarsals. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	T statisitic	Probability	Significance
Horses v donkeys	1.9730	0.0000	**
Mules v donkeys	1.9960	0.0000	**
Horses v mules	1.9708	0.0000	**
?Mules v mules	2.0017	0.0127	*
?Mules v donkeys	2.0687	0.0021	**
?Mules v horses	1.9735	0.6862	N
?Horses v mules	1.9908	0.0530	N
?Horses v donkeys	2.0167	0.0000	**
?Horses v horses	1.9721	0.0013	**
Unknown v mules	1.9666	0.0000	**
Unknown v donkeys	1.9673	0.0000	**
Unknown v horses	1.9649	0.0709	N

Results from the 'ambiguous' and unknown specimens are shown in Figure 6.24. The ambiguous mules are towards the lower end of the identified mule range, whilst the opposite is true of the ambiguous horses. Therefore, perhaps size is part of the problem with the identification of these individuals, reinforcing previous indications. If the lengths of the bones are heavily involved in the species identification procedure, then the area where the lengths overlap will produce less clear identifications. Therefore, the differences seen in the withers height estimates will be exaggerated, because the smaller mules and larger horses are not being included by virtue of their ambiguous identification status. Therefore, it is possible that the mean size of the horse group is being underestimated and that of the mule group overestimated.

The t-tests (Table 6.17) show that the ambiguous horses are unlikely to be donkeys but are actually closer to the identified mules than the identified horses. Similarly, the ambiguous mules are unlikely to be donkeys and are closer to the identified horses than the mules, although the number of ambiguous mules is small. These results strengthen the argument that size may be part of the problem with the identification of these individuals.



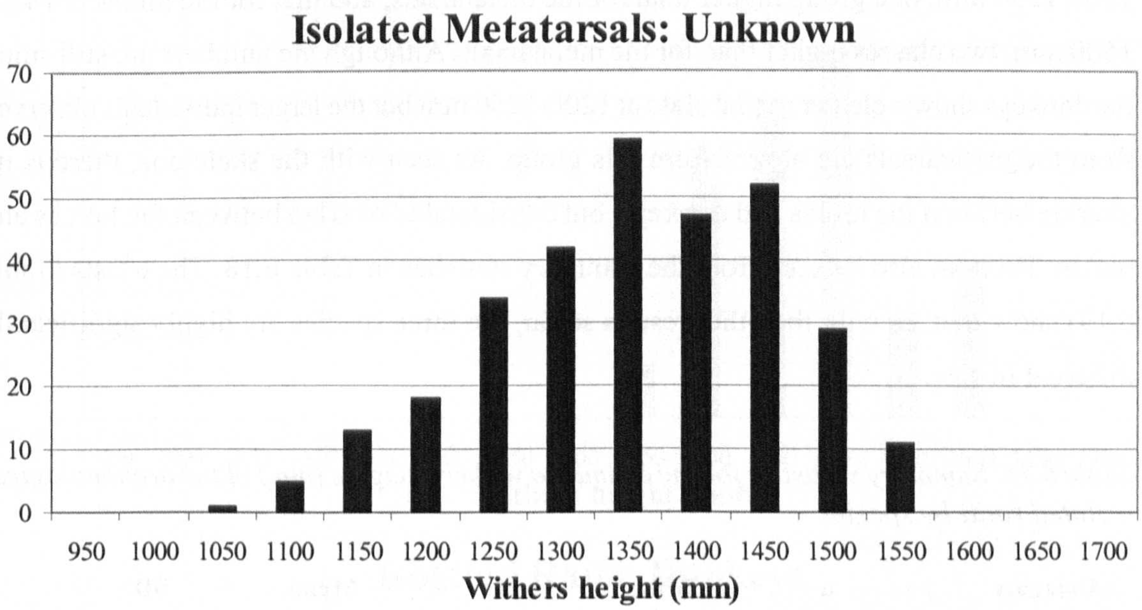


Figure 6.24. Histograms of estimated withers heights for the 'ambiguous' and 'unknown' archaeological isolated metatarsals by species.

Unsurprisingly, the spread of the unknown individuals covers most of the combined range of the identified specimens, strongly suggesting that all three species are present in the unknown sample. The unknown group is most similar (t-tests, Table 6.17) to the horse group but, given the likely proportions of species, horses are expected to form much of this group. The distribution in Figure 6.24 for the unknown specimens shows a possible bimodal distribution. If this is the case, it might be possible to split the data into groups for further analysis. To test this, the cumulative frequency distribution was plotted (data not shown) but, as the distribution showed an almost perfect sigma curve, there was no evidence to back up the possibility of a bimodal distribution. Therefore, unfortunately, no further analysis can be undertaken on the unknown data.

Moving on to the results from the isolated radii, there were a total of 328 isolated radii with at least one length measurement. Of these 76 were 'identified' bones and a further 22 were 'ambiguous' bones. The remaining 230 radii were unidentified. The 'identified' bones comprised 42 horses, 24 mules and 10 donkeys. Detailed results of the withers height calculations are given in Appendix Table A22. The results for the 'identified' bones are shown in Figure 6.25.

The pattern seen for the metatarsals in Figure 6.23 is repeated in Figure 6.25 for the radii, with very little variation. The less symmetrical shapes of the histograms are most likely due to the smaller numbers of specimens involved. The modal class of the horses is at 1300-1350 mm, one group higher than for the metatarsals, and that for the mules is 1450-1500 mm, two classes higher than for the metatarsals. Although the numbers are still small the donkeys show a clearer modal class at 1200-1250 mm but the larger individuals observed from the metatarsals are absent from this group. As seen with the skeletons, there is no overlap between the mules and donkeys, but considerable overlap between the horses and mules. This can also be seen from the summary statistics in Table 6.18. The t-tests (Table 6.19) show that, as with the other results so far, the three species are highly significantly different in size.

Table 6.18. Summary statistics for the estimated withers heights (mm) of the archaeological isolated radii by species

Category	n	Min	Max	Mean	SD
Horses	42	1138.24	1433.02	1288.02	73.40
Mules	24	1301.98	1580.40	1452.40	67.39
Donkeys	10	1040.85	1267.59	1177.83	92.55
?Horses	15	1124.52	1341.39	1252.36	75.85
?Mules	7	1284.45	1367.60	1316.39	25.72
Unknown	230	1023.64	1603.29	1321.04	96.71

The results for the 'ambiguous' and unknown specimens are shown in Figure 6.26. In this instance both the ambiguous mules and horses fall towards the lower end of their respective ranges, meaning that it is unlikely to be solely size that is playing a role in the identification problems. The t-tests (Table 6.19) show that the ambiguous horses are most likely to be horses with possibly also a few donkeys. There were too few ambiguous mules to apply t-tests to this group.

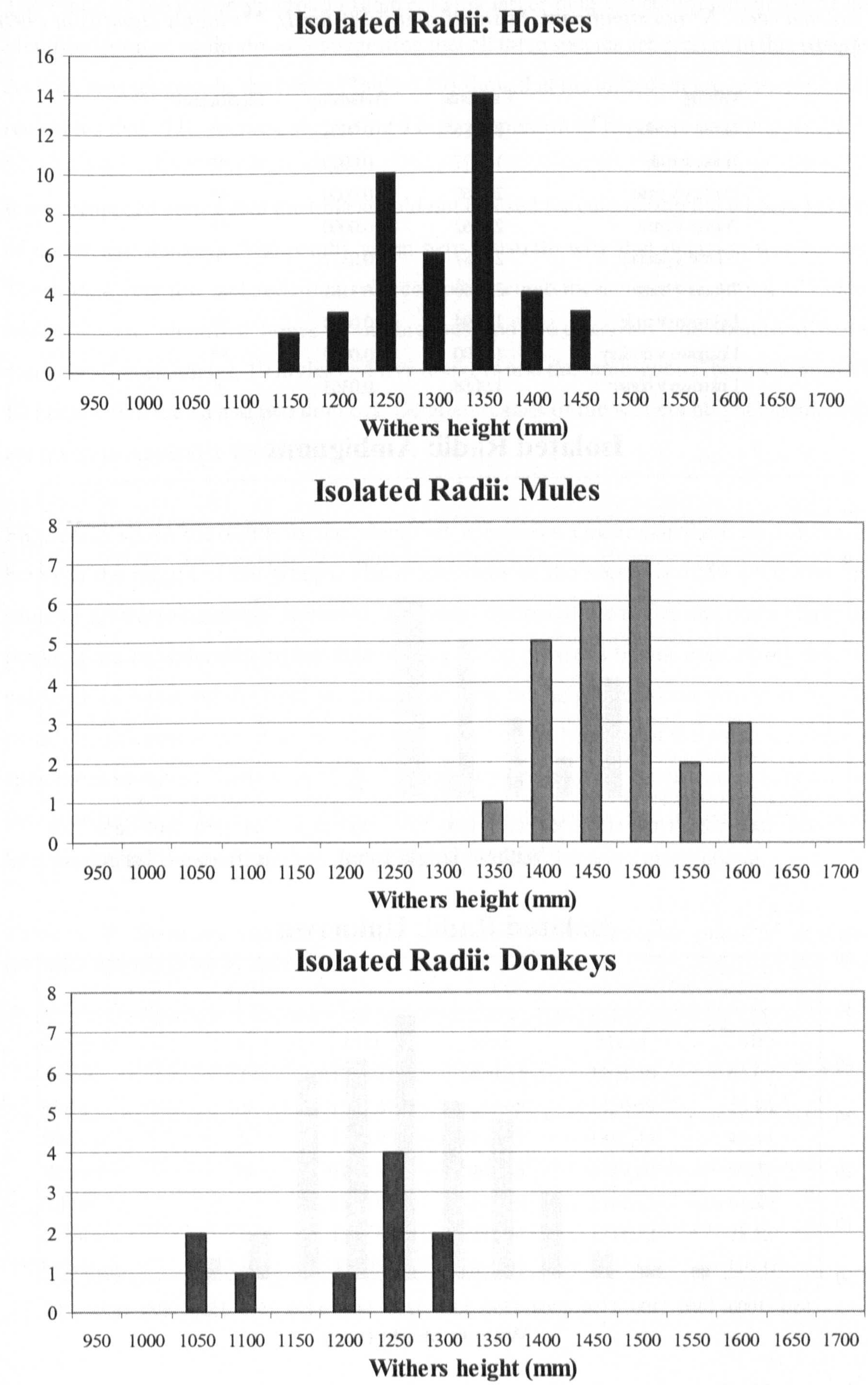
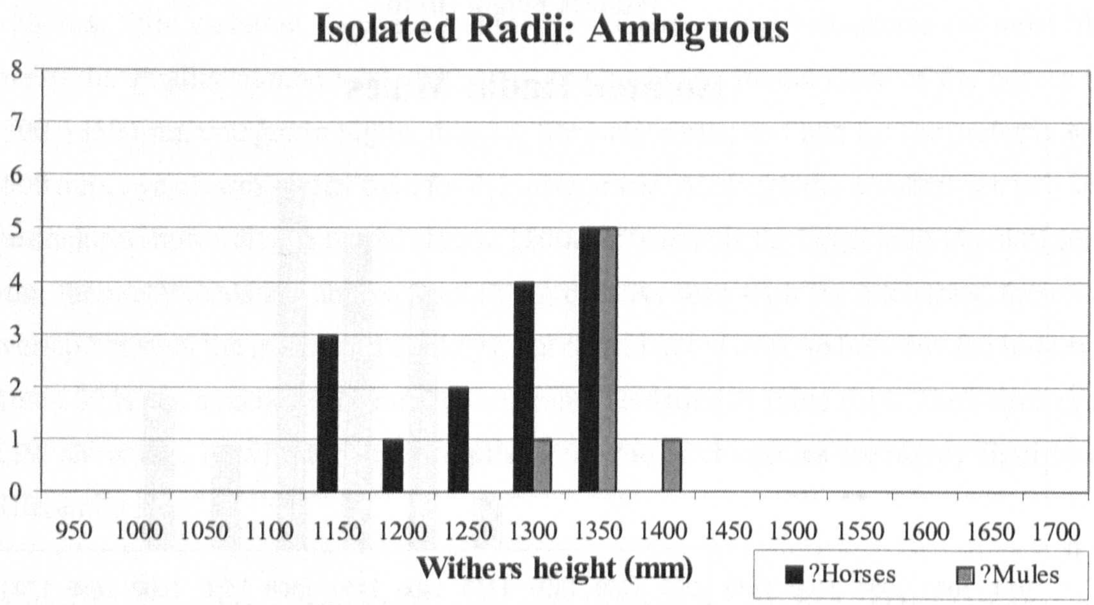


Figure 6.25. Histograms of estimated withers heights for the 'identified' archaeological isolated radii by species.

*Table 6.19. Results of t-tests on the estimated withers heights of all the archaeological isolated radii. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	T statistic	Probability	Significance
Horse v donkey	2.0086	0.0002	**
Horse v mule	1.9977	0.0000	**
Donkey v mule	2.0369	0.0000	**
?Horse v mule	2.0262	0.0000	**
?Horse v donkey	2.0687	0.0377	*
?Horse v horse	2.0040	0.1151	N
Unknown v mule	1.9694	0.0000	**
Unknown v donkey	1.9700	0.0000	**
Unknown v horse	1.9688	0.0363	*



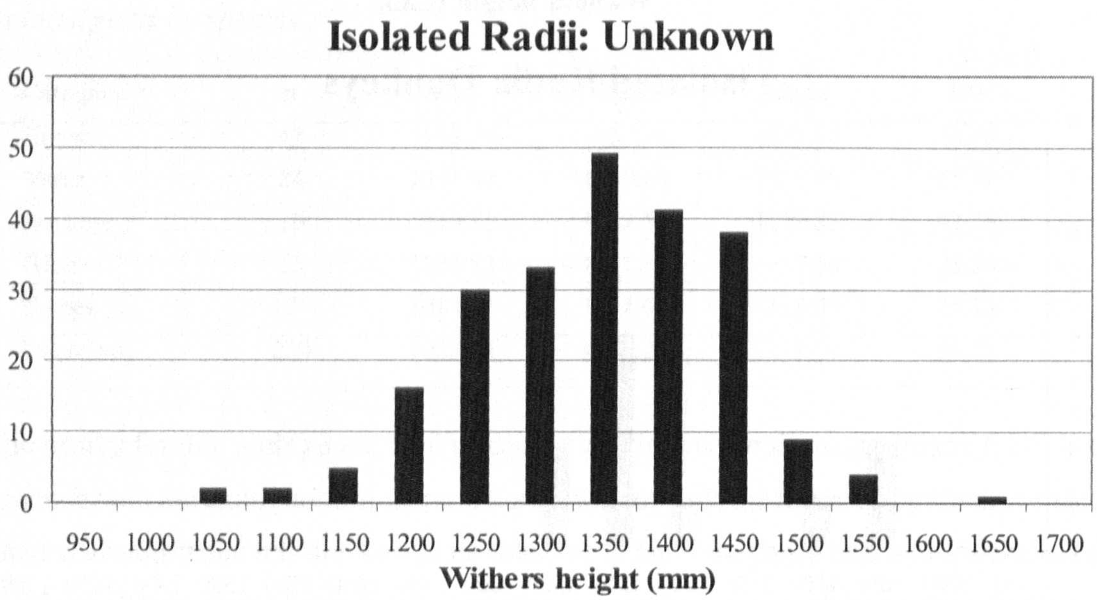


Figure 6.26. Histograms of estimated withers heights for the 'ambiguous' and 'unknown' archaeological isolated radii by species

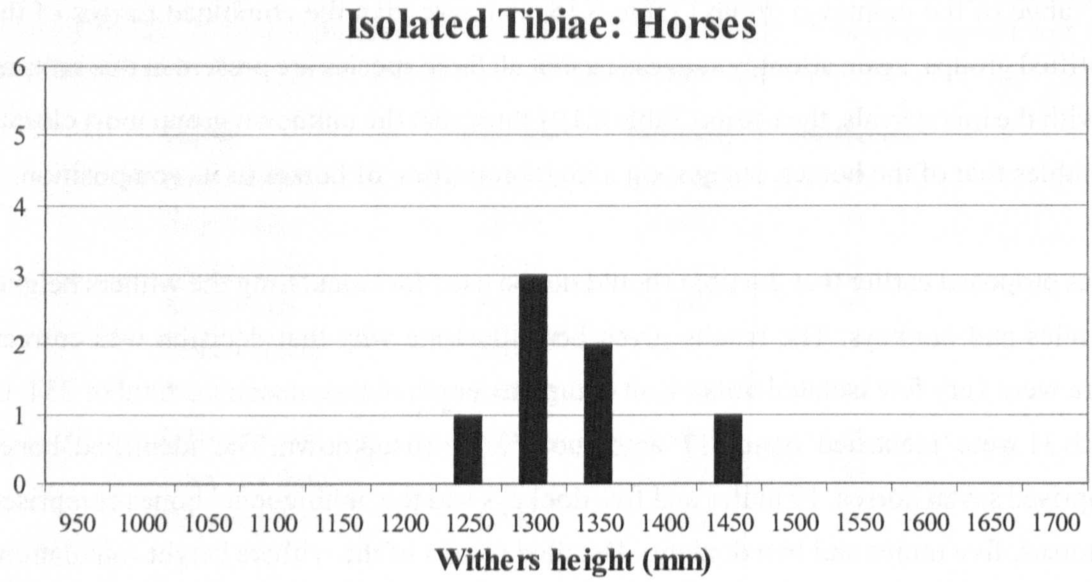
The range of the unknown group (Table 6.18) is larger than the combined ranges of the identified groups, again strongly suggesting that all three species are present in this sample. As with the metatarsals, the t-tests (Table 6.19) show that the unknown group most closely resembles that of the horses, suggesting a high proportion of horses in its composition.

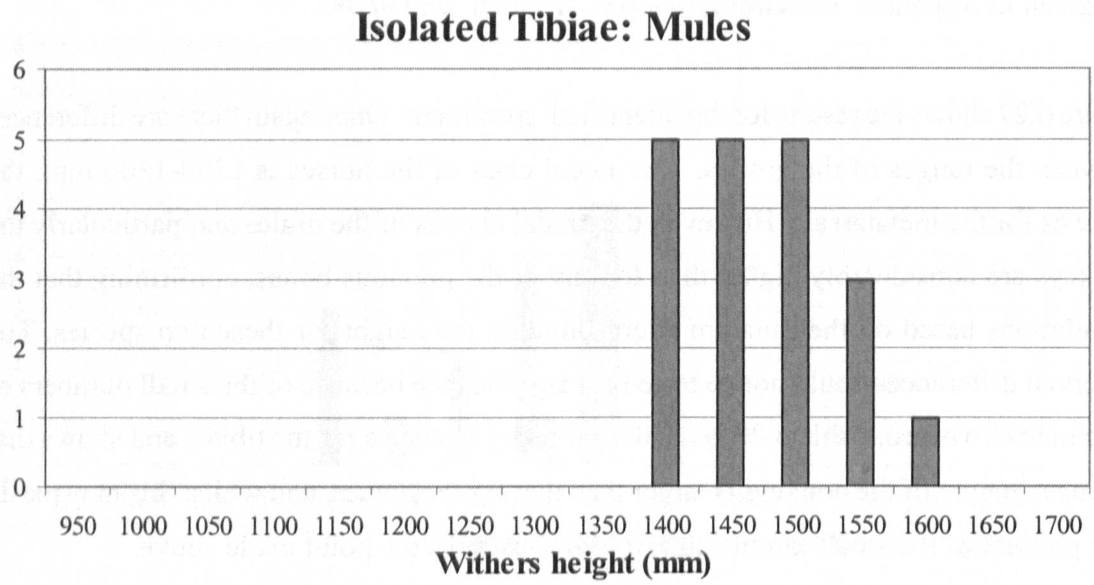
It was proposed earlier that the tibia should not be used for calculating the withers heights of mules and donkeys. The results given here illustrate why that decision was correct. There were very few isolated tibiae with complete length measurements, a total of 234, of which 31 were 'identified' bones, 17 'ambiguous' and 186 unknown. The 'identified' bones comprised seven horses, 19 mules and five donkeys and the 'ambiguous' bones comprised 10 horses, five mules and two donkeys. Detailed results of the withers height calculations are given in Appendix Table A23.

Figure 6.27 shows the results for the 'identified' specimens. Once again there are differences between the ranges of the groups. The modal class of the horses is 1250-1300 mm, the same as for the metatarsals. However, the modal classes of the mules and particularly the donkeys are considerably higher than for any of the previous bones, confirming that the calculations based on the tibia are overestimating the height for these two species. The observed differences could not be tested for significance because of the small numbers of specimens involved. Table 6.20 gives the summary statistics for the tibiae, and shows that the mean height of the donkeys is larger than that for the horses, and whilst this may partly be a product of the small sample size, it also illustrates the point made above.

Table 6.20. Summary statistics for the estimated withers heights (mm) of isolated archaeological tibiae by species

Category	**n**	**Min**	**Max**	**Mean**	**SD**
Horses	7	1223.31	1419.33	1304.28	64.00
Mules	19	1374.87	1553.65	1450.59	53.96
Donkeys	5	1310.91	1441.87	1361.44	49.45
?Horses	10	1156.48	1468.76	1323.80	99.31
?Mules	5	1319.90	1474.89	1407.33	61.29
?Donkeys	2	1262.69	1373.74	1318.22	78.53
Unknown	186	815.06	1636.01	1341.65	119.11





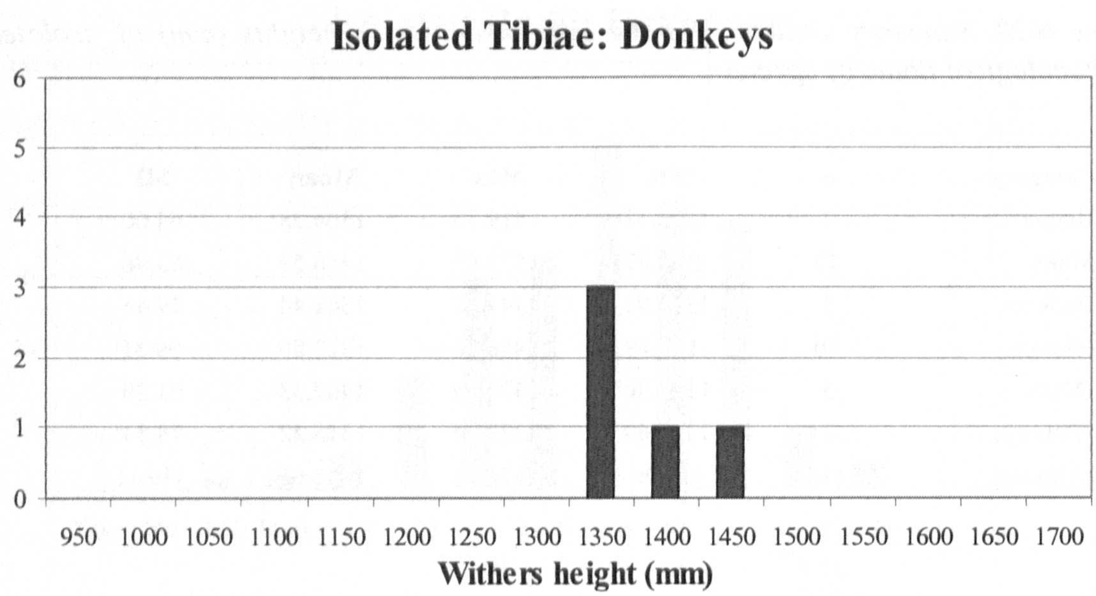


Figure 6.27. Histograms of estimated withers heights for the 'identified' archaeological isolated tibiae by species

Because of the inaccuracies of using the tibia for calculating the withers height of mules and donkeys there is no point showing the ambiguous or unknown specimens as it is even less likely than for the other elements that they can be identified further. The minimum value of the unknown specimens is extremely small but this value has been checked against the original publication and seems to be correct.

The results of the withers height calculations for the humerus and metacarpal are shown in Appendix Tables A24 and A25. The summary statistics are given in Tables 6.21 and 6.22 and the t-test results in Table 6.23. There were no t-test results for the humerus as the sample sizes were too small.

Table 6.21. Summary statistics for the estimated withers heights (mm) of the archaeological isolated humeri by species.

Category	n	Min	Max	Mean	SD
Horses	14	1291.48	1433.63	1343.01	50.15
Mules	6	1424.86	1584.53	1492.20	61.36
Donkeys	1			1003.78	
?Horses	3	1241.34	1426.32	1327.34	93.17
?Donkeys	2	1168.32	1254.97	1211.65	61.27
Unknown	43	1080.70	1606.44	1339.80	129.46

Table 6.22. Summary statistics for the estimated withers heights (mm) of the archaeological isolated metacarpals by species.

Category	n	Min	Max	Mean	SD
Horses	247	1043.44	1488.37	1282.08	74.46
Mules	38	1281.42	1601.78	1433.15	68.31
Donkeys	18	979.68	1507.19	1218.74	153.89
?Horses	66	1166.13	1507.19	1338.55	93.95
?Mules	26	1222.84	1586.52	1356.53	80.05
?Donkeys	10	1177.69	1310.29	1241.41	41.41
Unknown	389	950.08	1684.76	1312.05	101.53

As can be seen the results are very similar to those for the metatarsal and radius, with the exception of the far greater range of donkey sizes from the metacarpal. In fact both the largest and smallest donkey individuals were calculated from this bone. The range of the horses' measurements is also largest on this element, which may be a reflection of the larger sample size.

*Table 6.23. Results of t-tests on the estimated withers heights of the archaeological isolated metacarpals. N=not significant, *=significant (95% level), **=highly significant (99% level)*

Pairing	**T statistic**	**Probability**	**Significance**
Horses v Donkeys	1.969	0.0017	**
Horses v mules	1.968	0.0000	**
Donkeys v mules	2.005	0.0000	**
?Donkeys v donkeys	2.056	0.6541	N
?Donkeys v Mules	2.013	0.0000	**
?Donkeys v Horses	1.969	0.0876	N
?Mules v donkeys	2.018	0.0004	**
?Mules v mules	1.999	0.0001	**
?Mules v horses	1.969	0.0000	**
?Horses v donkeys	1.989	0.0001	**
?Horses v mules	1.983	0.0000	**
?Horses v horses	1.968	0.0000	**
Unknown v donkeys	1.966	0.0002	**
Unknown v mules	1.966	0.0000	**
Unknown v Horses	1.964	0.0001	**

In addition, the 'ambiguous' metacarpals are more ambiguous than their counterparts in the metatarsals and radii, as shown in the t-test results. Only the ambiguous donkeys are more likely to be donkeys or horses than mules; the ambiguous mules and horses could be any of the three. This may be a reflection of the lower identification rate from the discriminant function analysis, or of the larger sample size and greater overlap between the groups.

Results from combined elements

The appropriate results from each isolated element (i.e. without tibia for mules and donkeys) were pooled with the average estimates from the skeletons and limbs to produce the combined results discussed below. This produced a total of 697 'identified' and 189 'ambiguous' bones. The 'unknown' specimens were not included in any further analysis at this stage: the results would not be meaningful because of the differences already identified between the species. The 'identified' specimens comprised 513 horses, 135 mules and 49 donkeys; the 'ambiguous' specimens comprised 132 possible horses, 45 possible mules and 12 possible donkeys.

Figure 6.28 shows the combined results for the 'identified' specimens. Figure 6.28 highlights the differences already discussed between the three species, as do the summary statistics in Table 6.24. Of particular note is the large size range of the donkey specimens, and the generally larger size of the mules in comparison with horses. As expected the t-tests (Table 6.25) showed that the sizes of three species were highly significantly different.

Table 6.24. Summary statistics for the estimated withers heights (mm) of the combined archaeological results by species

Category	n	Min	Max	Mean	SD
Horses	513	1043.44	1543.04	1301.21	74.72
Mules	135	1220.69	1601.78	1426.21	74.76
Donkeys	49	979.68	1507.19	1199.74	121.14
?Horses	132	1124.52	1575.54	1340.26	98.38
?Mules	45	1222.84	1586.52	1347.75	72.27
?Donkeys	12	1168.32	1310.29	1236.45	43.34

Figure 6.29 shows the results for the combined 'ambiguous' specimens. The overlap between the three groups is much greater (Table 6.24), indicating that size must be playing a part in the discriminant function analysis identification process and that those that are within the overlap zones are harder to identify with confidence. The t-tests (Table 6.25) showed that whilst the 'ambiguous' donkeys were most likely to be donkeys there was a possibility some may be horses. However, the 'ambiguous' horses and mules could be a mixture of any or all of the three species, as the groups as a whole do not closely resemble any one species.

*Table 6.25. Results of t-tests on the estimated withers heights of the combined archaeological specimens. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	T statistic	Probability	Significance
Donkeys v horses	1.9642	0.0000	**
Donkeys v mules	1.9731	0.0000	**
Horses v mules	1.9636	0.0000	**
?Donkeys v donkeys	2.0010	0.3081	N
?Donkeys v mules	1.9765	0.0000	**
?Donkeys v horses	1.9645	0.0029	*
?Mules v donkeys	1.9861	0.0000	**
?Mules v mules	1.9734	0.0000	**
?Mules v horses	1.9642	0.0001	**
?Horses v donkeys	1.9733	0.0000	**
?Horses v mules	1.9690	0.0000	**
?Horses v horses	1.9637	0.0000	**

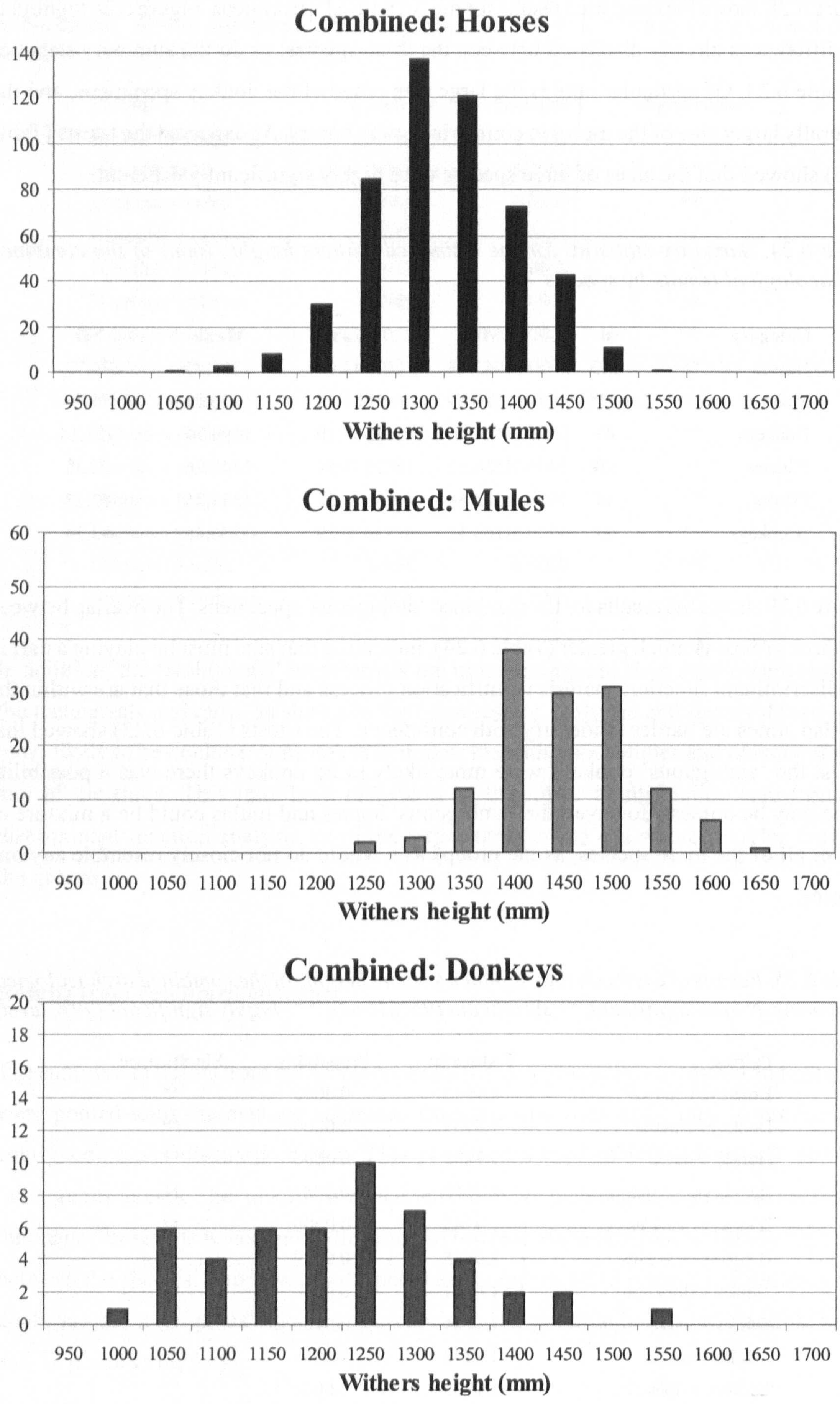


Figure 6.28. Histograms of estimated withers heights for the combined 'identified' archaeological specimens by species.

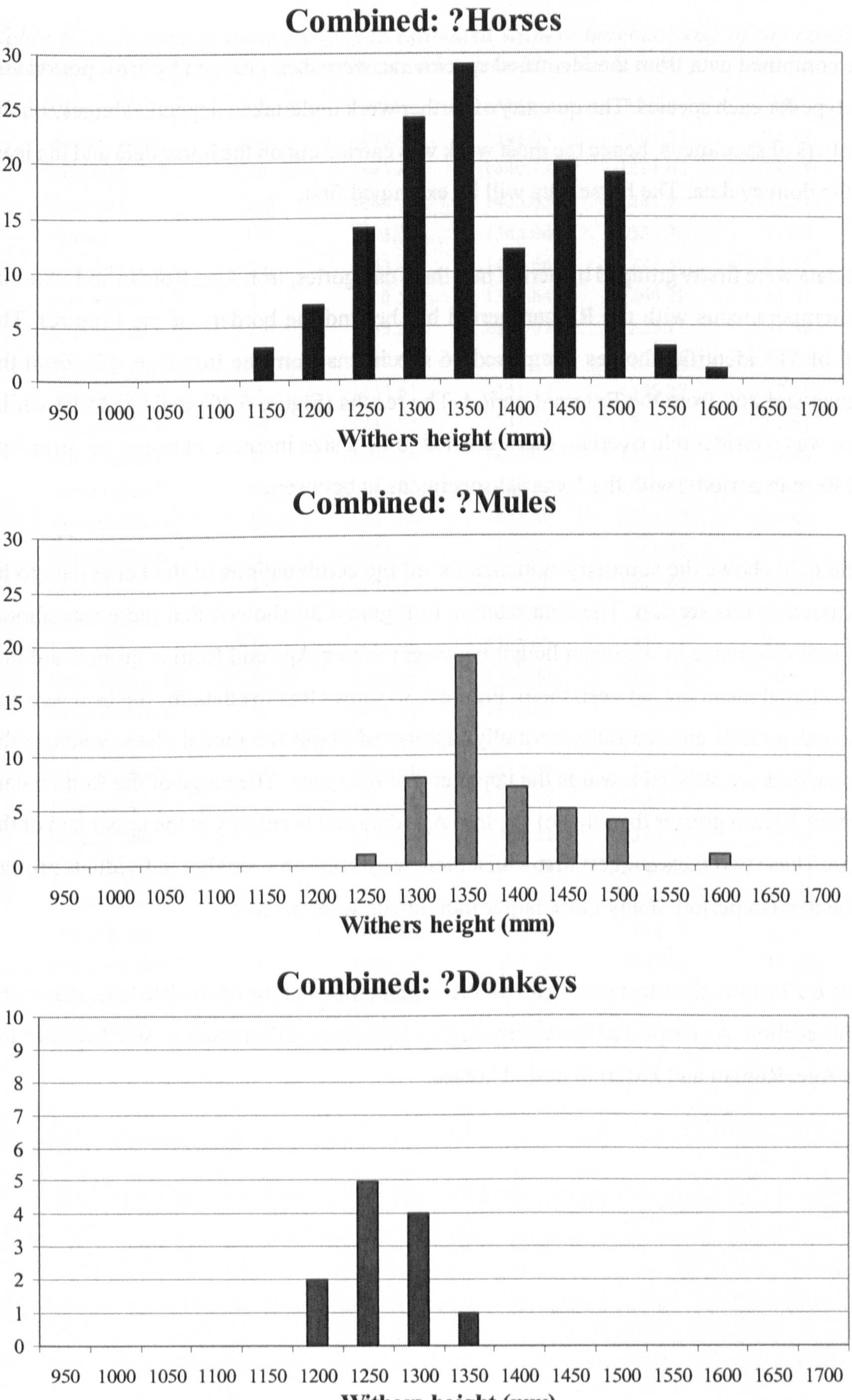


Figure 6.29. Histograms of estimated withers heights for the combined 'ambiguous' archaeological specimens by species.

Results from grouping the data by area, period and site type

The combined data from the identified specimens, were then grouped by area, period and site type for each species. The quantity of further work undertaken depended largely on the numbers of specimens; hence the most work was carried out on the horse data and the least on the donkey data. The horse data will be examined first.

The data were firstly grouped by period into three categories, Iron Age, Roman and External (contemporaneous with the Roman period but beyond the borders of the Empire). The total of 513 identified horses comprised 76 specimens from the Iron Age, 177 from the Roman and 260 from the External period. The results (Figure 6.30) indicated that whilst there was considerable overlap, there seemed to be a size increase between the Iron Age and Roman periods, with the External specimens in between.

Table 6.26 shows the summary statistics for all the combinations of the horse data to be discussed in this section. The data relating to Figure 6.30 showed that there was almost 100 mm difference in the mean height between the Iron Age and Roman groups and that the External mean lay between them. Figure 6.30 shows that the data for the Iron Age and External periods are centrally, normally distributed about the modal class, whereas the Roman data are skewed towards the upper end of the range. The range of the Roman data is about 50 mm greater than that of the Iron Age data and is entirely at the upper end of the range. These two facts suggest that whilst there were still some smaller individuals present in the Roman period, many more larger individuals were present.

Table 6.27 shows the t-test results for all the combinations of the horse data to be discussed in this section. As suspected there were highly significant differences in size between the Iron Age, Roman and External period horses.

Table 6.26. Summary statistics for the estimated withers heights (mm) of the combined identified' archaeological 'horses. Area codes defined in Table 6.10

Category	n	Min	Max	Mean	SD
Horses overall	513	1043.44	1543.04	1301.21	74.72
Iron Age	76	1043.44	1440.73	1251.60	78.63
External	260	1084.28	1433.63	1281.97	55.21
Roman	177	1098.36	1543.04	1350.76	71.00
Iron Age area D	29	1043.44	1415.66	1227.52	83.35
Iron Age area E	21	1110.56	1348.54	1260.29	61.71
Iron Age area F	12	1135.23	1368.07	1225.17	61.69
Iron Age area G	13	1202.09	1440.73	1308.22	78.10
Roman area A	3	1351.61	1451.20	1385.27	57.10
Roman area D	29	1246.85	1543.04	1341.74	60.61
Roman area E	29	1098.36	1463.00	1312.27	99.49
Roman area F	56	1178.22	1488.37	1364.48	67.19
Roman area G	56	1260.06	1477.40	1362.27	54.47
Roman area K	4	1251.10	1426.86	1316.32	76.38
Late IA D	23	1043.44	1379.05	1221.89	80.06
Late IA E	9	1110.56	1321.07	1222.20	62.08
Late IA F	12	1135.23	1368.07	1226.11	59.16
Early Roman D	29	1246.85	1543.04	1341.74	60.61
Early Roman E	12	1098.36	1435.49	1301.00	106.18
Early Roman F	22	1241.67	1487.88	1364.63	69.49
Late Roman E	14	1139.11	1412.22	1310.74	81.17
Late Roman F	17	1291.79	1488.37	1381.71	50.64
Military sites	12	1248.68	1452.21	1353.29	72.66
Vicus sites	13	1178.22	1469.09	1348.69	72.97
Urban sites	62	1241.67	1488.37	1358.15	51.10
Urban 2 sites	25	1246.85	1543.04	1344.19	65.11
Cemetery sites	4	1402.54	1487.88	1455.11	37.05
Villa sites	9	1299.80	1425.53	1375.96	43.74
Rural sites	12	1263.11	1477.40	1366.53	61.34

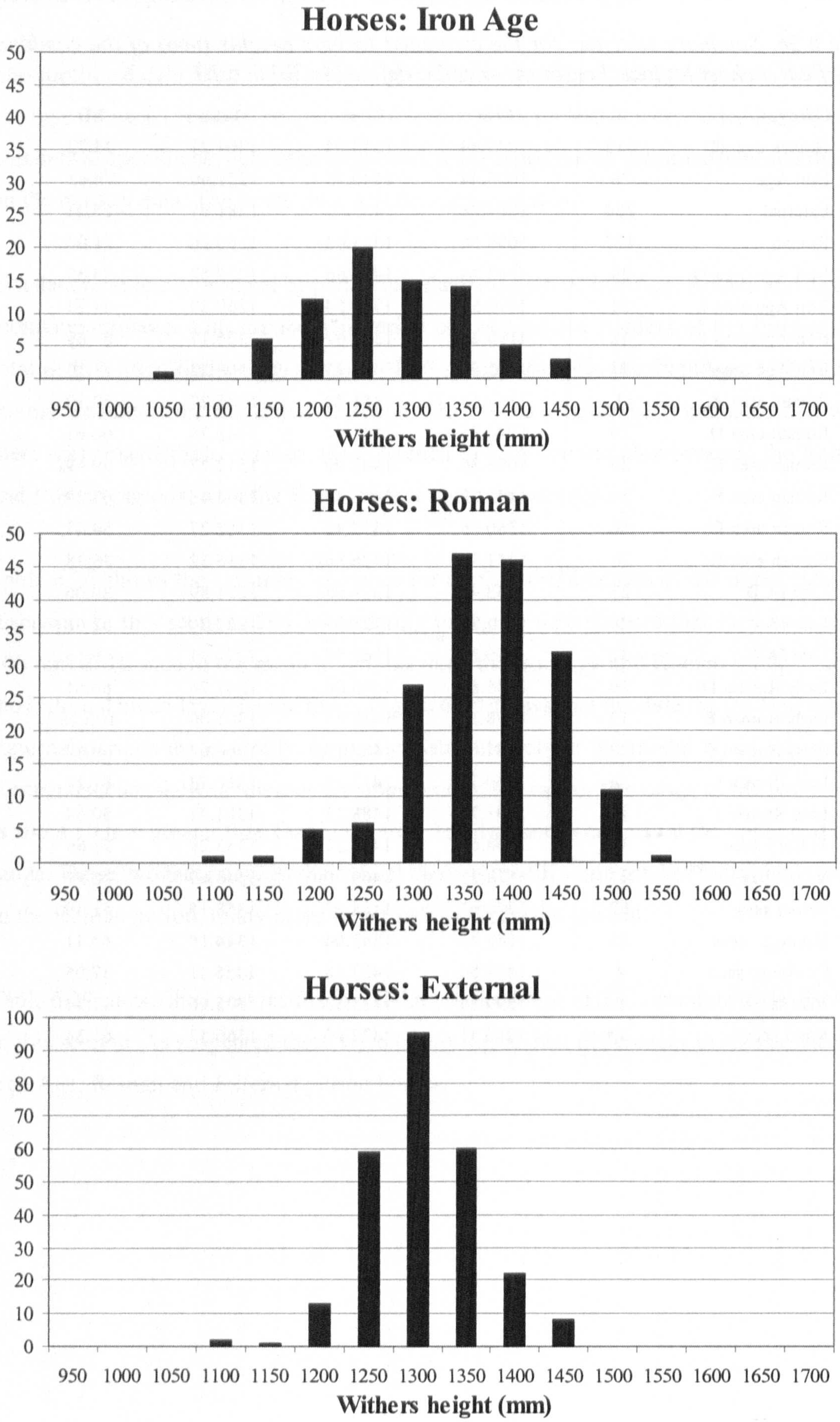


Figure 6.30. Histograms of estimated withers heights for the combined 'identified' archaeological horses by period.

*Table 6.27. Results of t-tests on the estimated withers heights of the combined archaeological horses. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	T statistic	Probability	Significance
Iron Age v External	1.9671	0.0002	**
Iron Age v Roman	1.9695	0.0000	**
External v Roman	1.9654	0.0000	**
Iron Age v Roman D	2.0032	0.0000	**
Iron Age v Roman E	2.0106	0.0397	*
Iron Age v Roman F	1.9966	0.0000	**
Iron Age v Roman G	1.9960	0.0043	**
Iron Age D v E	2.0106	0.1343	N
Iron Age D v F	2.0227	0.9303	N
Iron Age D v G	2.0211	0.0052	**
Iron Age E v F	2.0395	0.1259	N
Iron Age E v G	2.0369	0.0554	N
Iron Age F v G	2.0687	0.0075	**
Roman D v E	2.0032	0.1786	N
Roman D v F	1.9890	0.1303	N
Roman D v G	1.9890	0.1167	N
Roman E v F	1.9890	0.0052	**
Roman E v G	1.9890	0.0036	**
Roman F v G	1.9818	0.8489	N
Late Iron Age v Early Roman D	2.0086	0.0000	**
Late Iron Age v Early Roman E	2.0930	0.0625	N
Late Iron Age v Early Roman F	2.0369	0.0000	**
Early v Late Roman E	2.0639	0.7934	N
Early v Late Roman F	2.0262	0.3993	N
Late Roman E v F	2.0452	0.0058	**
Late Iron Age v Late Roman E	2.0796	0.0112	*
Late Iron Age D v E	2.0423	0.9917	N
Late Iron Age F v E	2.0930	0.9147	N
Late Iron Age F v D	2.0345	0.9025	N
Early Roman D v E	2.0227	0.1278	N
Early Roman D v F	2.0096	0.2158	N
Early Roman E v F	2.0369	0.0425	*
Military v Vicus	2.0687	0.8760	N
Military v Urban	1.9935	0.7798	N
Military v Urban 2	2.0301	0.7037	N
Military v Rural	2.0739	0.6345	N
Military v Villa	2.0930	0.4184	N
Vicus v Urban	1.9930	0.5766	N
Vicus v Urban 2	2.0281	0.8472	N
Vicus v Rural	2.0687	0.5168	N
Vicus v Villa	2.0860	0.3296	N
Rural v villa	2.0930	0.6997	N
Urban v Urban 2	1.9883	0.2906	N
Urban v Rural	1.9935	0.6166	N
Urban v Villa	1.9949	0.3245	N
Urban 2 v Villa	2.0369	0.1861	N
Urban 2 v Rural	2.0301	0.3268	N

In order to determine whether there are any differences between the horses from different geographic locations, the data was grouped by region. These regions are based on those of King (1999), the details of which can be found in Chapter 5. The grouping into Iron Age and Roman periods was continued through these analyses to determine whether there were differences in each region by period. As can be seen from the summary data (Table 6.26) there were very few specimens from both Italy and Egypt so these are not presented graphically and could not be used in the t-test analyses. Figure 6.31 presents the data for Iron Age Roman periods in Gaul, Britain, the Rhineland and the Danube and Balkans areas.

The first group of analyses were aimed at detecting any differences within each region between periods. In Gaul and the Rhineland there were very obvious size increases between the Iron Age and Roman periods: this size increase was much less obvious in Britain and the Danube and Balkans areas. Taking these area-by-area, the data from Gaul showed central normal distributions for both the Iron Age and Roman data, with modal classes of 1200-1250 and 1300-1350 mm respectively. There was a straightforward increase in size between the two periods with the smallest individuals being lost and larger individuals being gained. The range (Table 6.26) was also reduced in the Roman period. The t-tests (Table 6.27) showed that the size increase between the Iron Age and Roman periods in Gaul was highly significant.

Britain showed a rather different picture to that of Gaul. The Iron Age data showed a bias to the larger end of its range, with the modal class being the highest class in the range (1300-1350 mm), higher than for Gaul in the same period. The range was also considerably less wide than that from Gaul for the same period, whilst the mean was higher (Table 6.26). The Roman British data formed a less biased distribution, with a considerably wider range, particularly at the upper end. The slightly ragged appearance of the distribution is most likely due to small sample size. Whilst the modal class was exactly the same as that of the Iron Age data, the mean was somewhat higher. The t-test (Table 6.27) showed that there was a significant, but not highly significant, difference between the two periods in Britain, as would be expected for the less obvious changes.

The Rhineland area showed a pattern more similar to Gaul than to Britain. Whilst the numbers were quite small, the Iron Age period showed a centrally positioned normal distribution with a modal class of 1200-1250 mm. This is smaller than either Britain or Gaul, but the mean is not that different (Table 6.26). The Roman data were biased towards the upper end of its range, with a modal class of 1350-1400 mm, higher than the previous regions, and the mean was also higher. The t-test (Table 6.27) shows that there was a highly significant difference in size between the Iron Age and Roman periods in the Rhineland.

The Danube and Balkans area showed a similar picture to that from Britain, except that the sizes were greater in both periods. The Iron Age data had a similar narrow range to the British material but positioned two class intervals to the right, and in this case the modal class was the smallest of the range (1200-1250 mm). Whilst the modal class was the same as for Gaul and the Rhineland, the mean is the highest for the Iron Age material (Table 6.26). The Roman material from this region had a similar narrow range, but was more centrally distributed, with the modal class at 1350-1400 mm. The mean was similar to those of the other regions. Once again the t-test showed that there was a highly significant difference in size between the two periods in this region (Table 6.27).

Other t-tests (Table 6.27) were carried out to establish whether there were any differences between the regions by period. For the Iron Age material, there were no significant differences between the sizes of the horses in Britain, Gaul and the Rhineland. However the Danube and Balkans area horses were highly significantly larger than those from Gaul and the Rhineland. The Danube and Balkans material was not, however, different from the British material, suggesting that the British material is perhaps somewhat intermediate in size between the western and eastern European material. For the Roman material, there were no significant differences between Gaul and the other three regions or between the Rhine and Danube samples. However, the British horses were highly significantly smaller than those of both the Rhineland and Danube and Balkans areas. These differences between the periods and regions suggest that there was no great degree of uniformity in the horses of the Roman Empire, but that there was size improvement from the preceding Iron Age stock across the whole area.

As the dating of both the Iron Age and Roman data has thus far been very broad, the issue of stock improvement after inclusion in the Roman Empire is better served by comparing the late Iron Age and early Roman periods in each area. These periods have been taken as the first two centuries either side of the conquest of an area. Typically this equates to the 2nd – 1st centuries BC for the late Iron Age and 1st – 2nd centuries AD for the Early Roman material across the three areas being studied here. Only Britain, Gaul and the Rhineland could be studied as either the dating was too broad or the sample sizes insufficient from the other regions. Figure 6.32 shows these groupings.

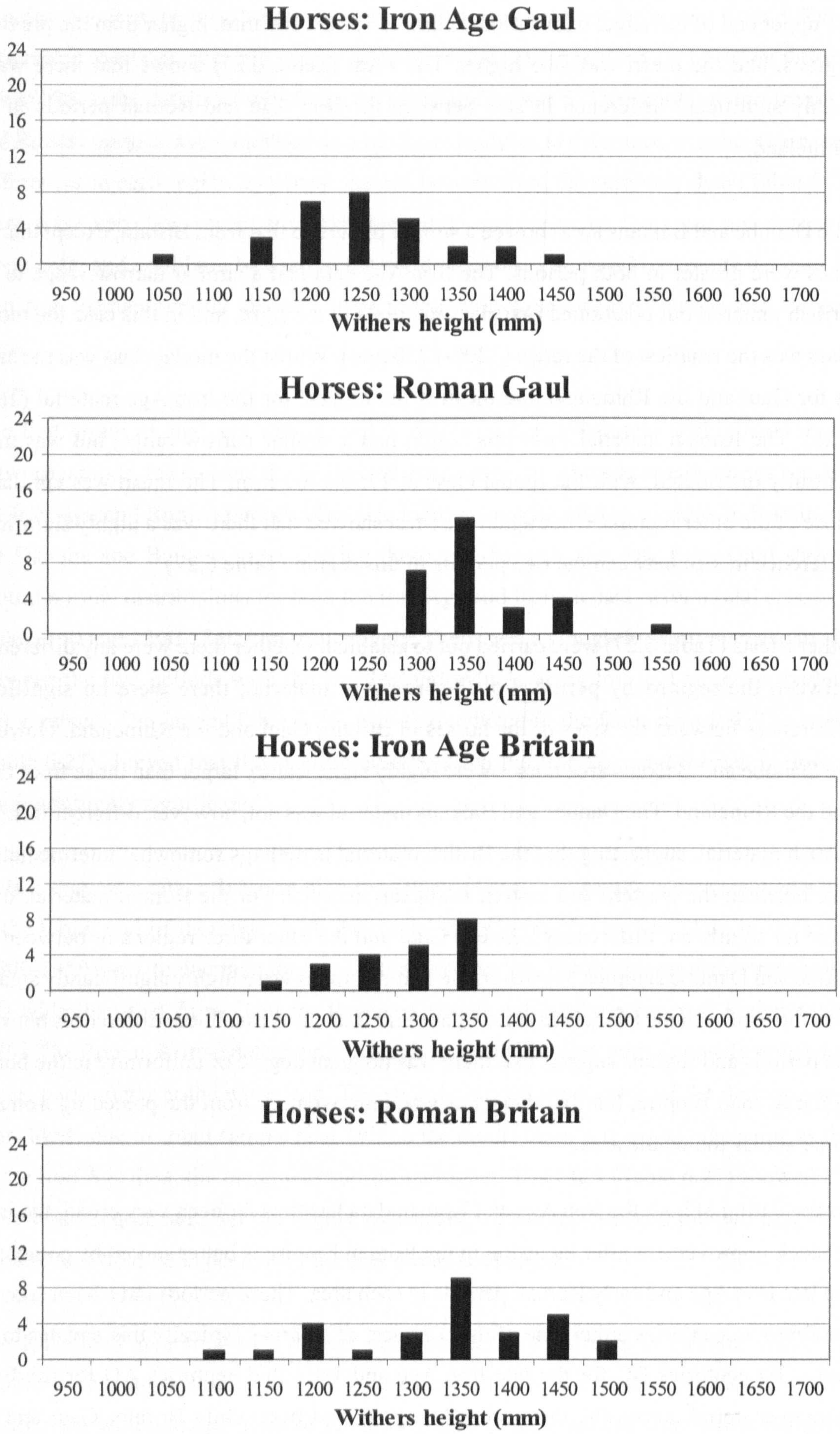


Figure 6.31. Histograms of estimated withers heights for the combined 'identified' archaeological horses by area and period.

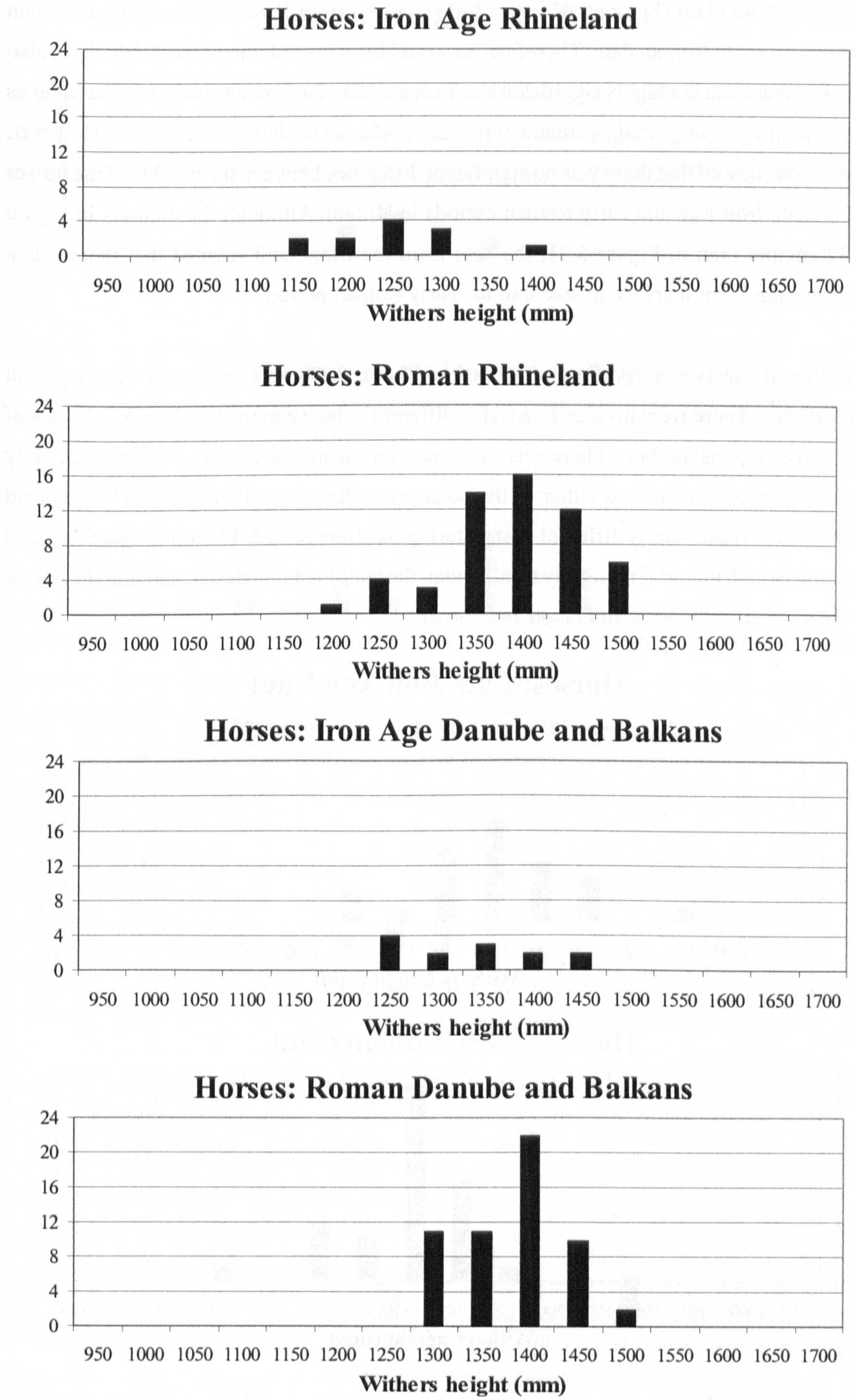
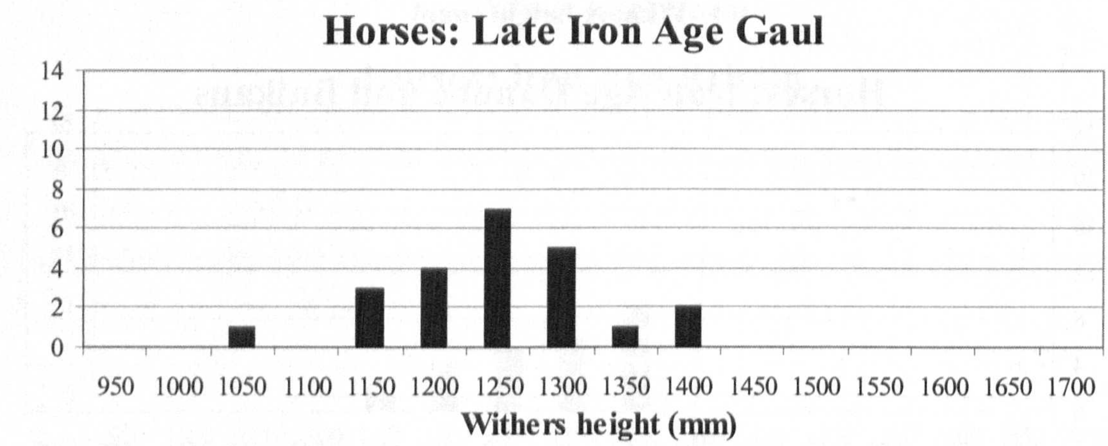


Figure 6.31 continued.

The data from Gaul (Figure 6.32) were little changed from Figure 6.31 as all the Roman data are of early Roman date. Therefore, as would be expected, the t-test (Table 6.27) also showed that there is a highly significant size increase after the Roman conquest. The samples for Britain were very small, as much of the data could not be dated more closely. However, the t-tests showed that there was no significant difference between the heights of the horses of the late Iron Age and early Roman periods in Britain. Although the datasets in Figure 6.32 smaller than in Figure 6.31, the data from the Rhineland showed that there was a highly significant increase in size into the early Roman period.

Additional t-tests were performed, as before (Table 6.27), to test for any inter-regional differences. There were no significant size differences between the late Iron Age horses of the three regions studied. There were also no significant differences between the early Roman horses of Gaul and either of the other areas; however, the British and Rhineland horses were significantly different in size during this time period. This once again suggests that the British material is slightly smaller than the continental material, and that the horses were smaller in the west and larger in the east.



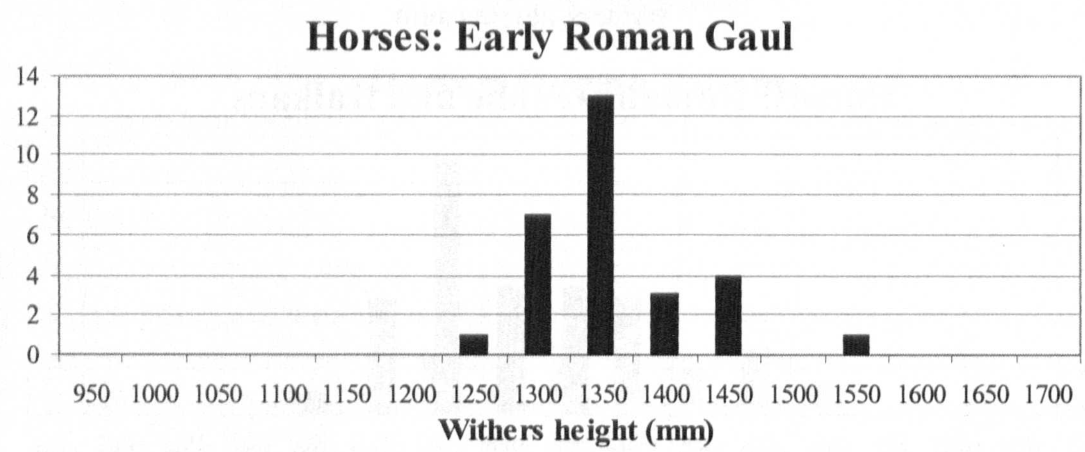


Figure 6.32. Histograms of estimated withers heights for the combined 'identified' archaeological late Iron Age and early Roman horses by area.

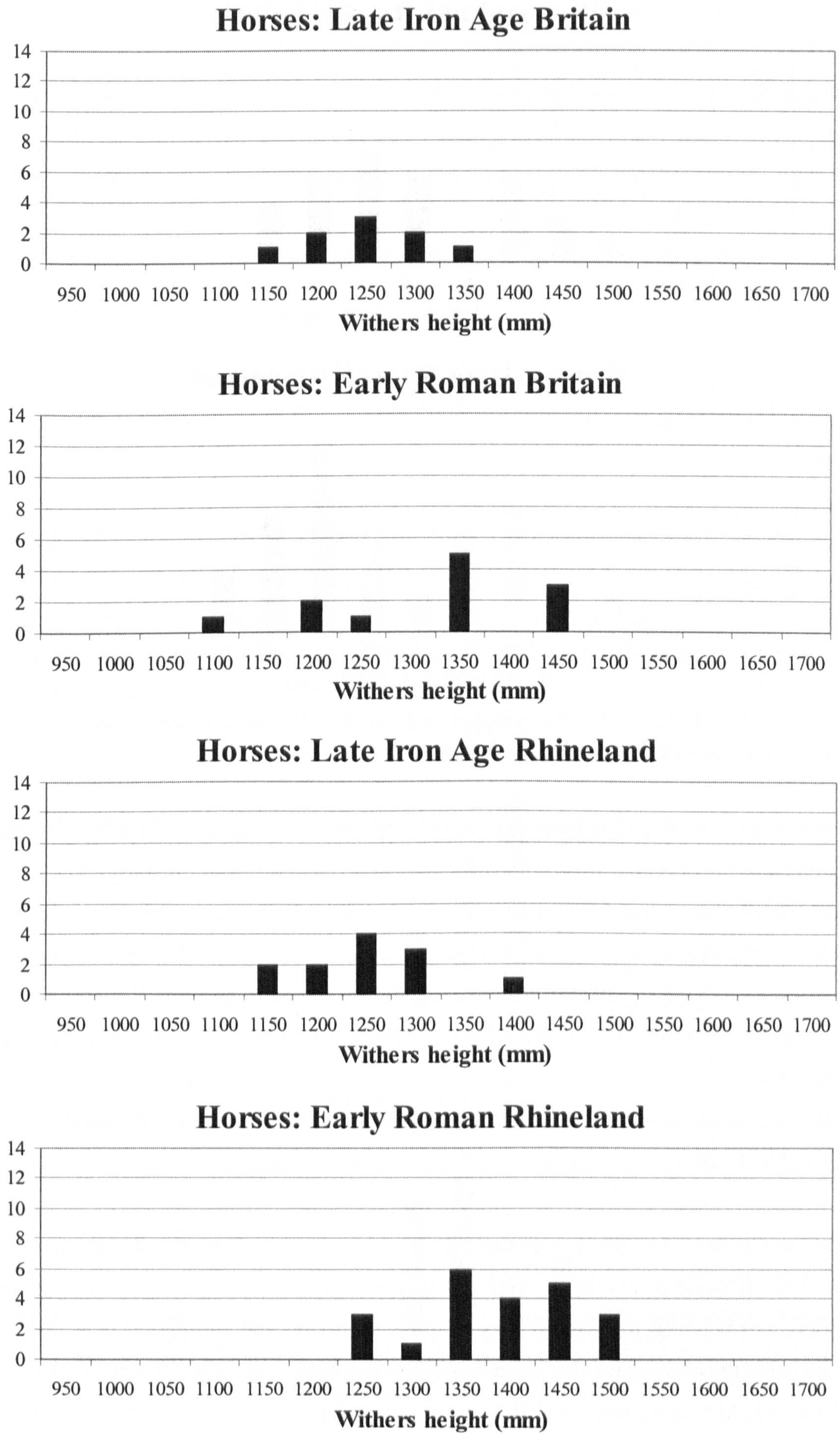


Figure 6.32. Continued

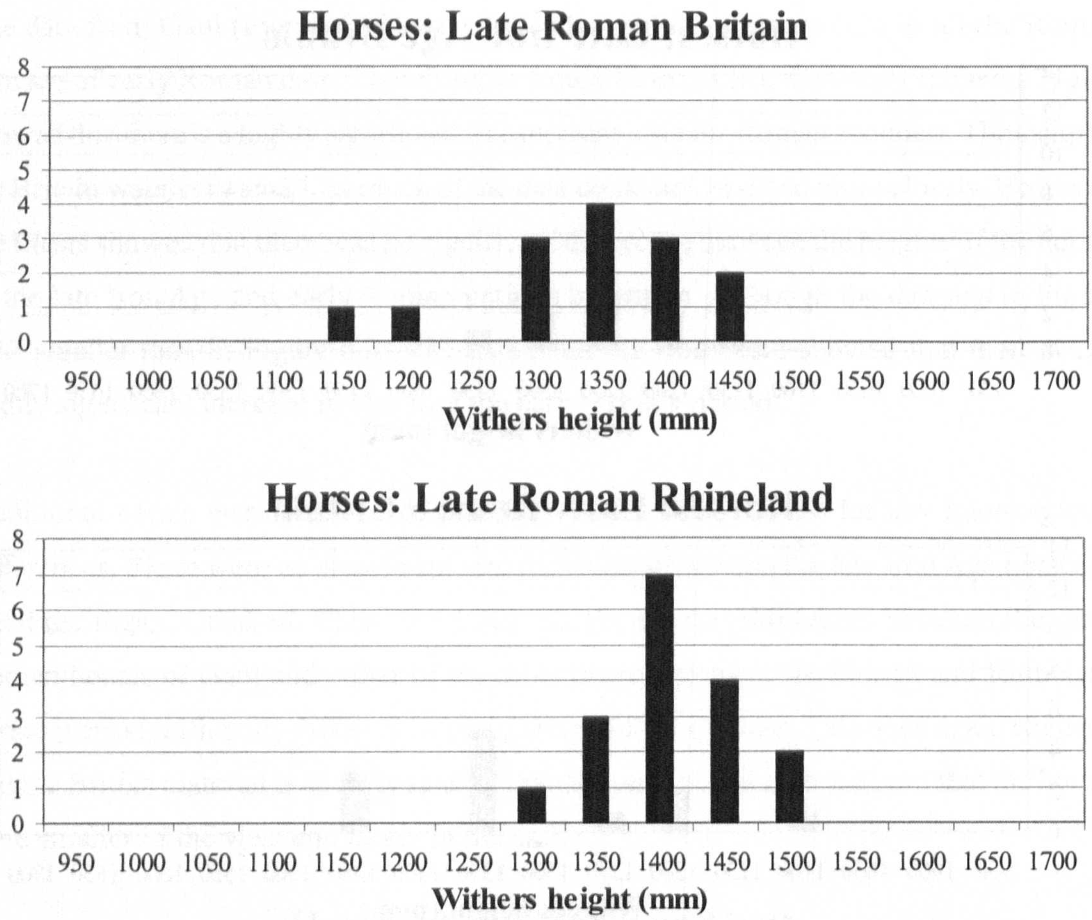


Figure 6.33. Histograms of estimated withers heights for the combined 'identified' archaeological late Roman horses by area.

Figure 6.33 shows the late Roman material (3rd century AD onwards) for Britain and the Rhineland (the only two areas with sufficient late Roman material for study). The range of both groups was reduced from that of the respective early Roman period (Figure 6.32 and Table 6.25) and also shows a more central distribution in both cases. Whilst t-tests suggested that there were no significant differences between the early and late Roman periods in each region (Table 6.26), the two regions were highly significantly different from each other. Also in Britain, the late Roman material was significantly different to that of the late Iron Age, suggesting that in Britain the improvement in the size of the horses was not immediately after the Roman conquest but at least 150 years later.

The next group of analyses was carried out using the data from the Roman periods of Gaul, the Rhineland and the Danube and Balkans combined. As there were no significant differences between the data of these regions by period and sub-period, it was deemed acceptable to combine the data to increase the sample size available. These analyses were to test whether there were any significant size differences between the horses deriving from different types of site. These site types were grouped on the basis of the categories set out by King (1999) and detailed in Chapter 5.

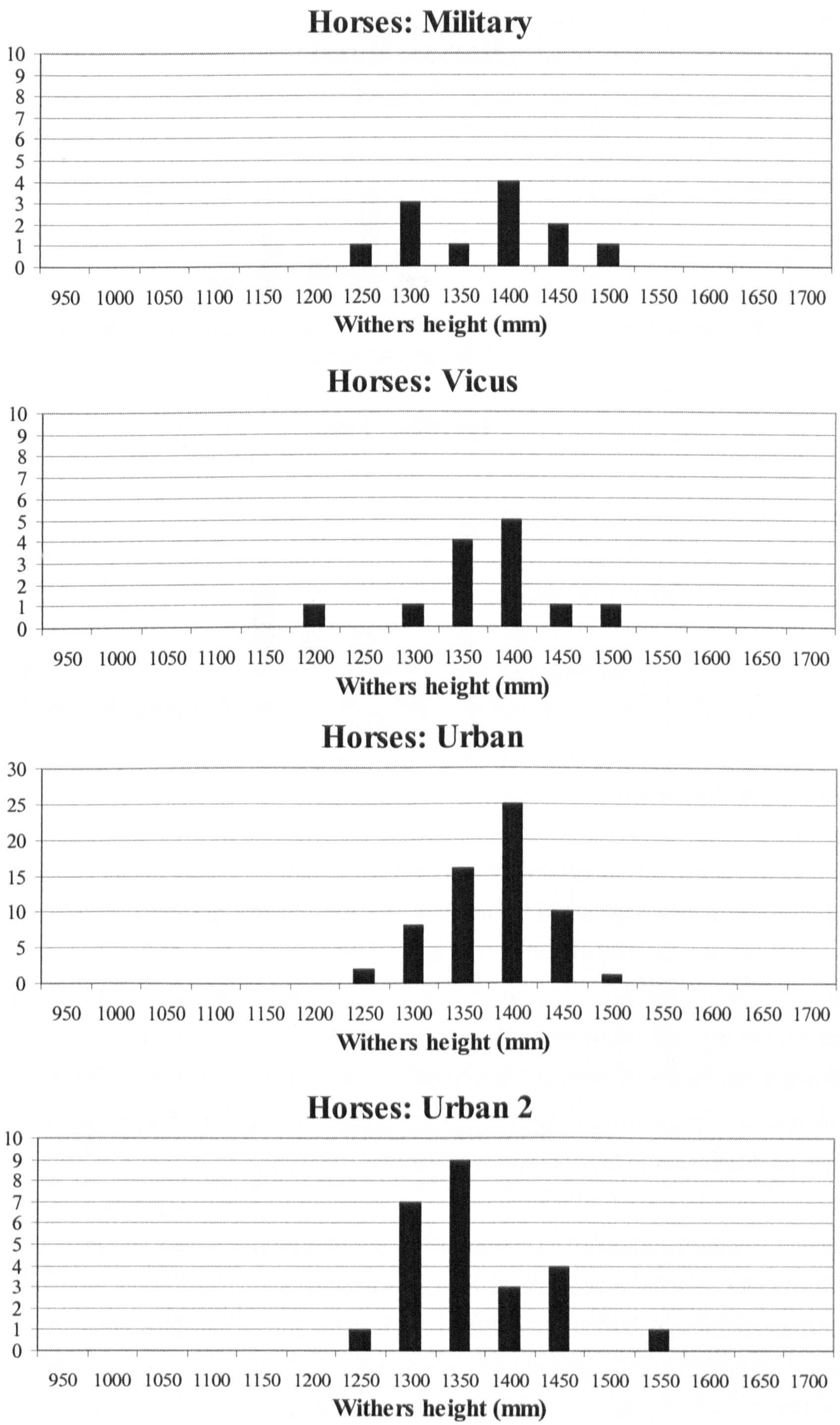
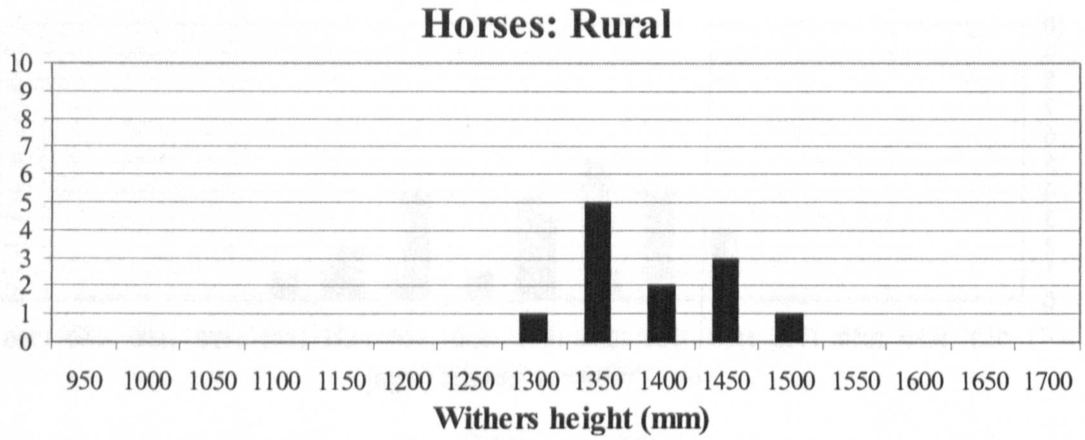


Figure 6.34. Histograms of estimated withers heights for the combined 'identified' archaeological horses by site type.



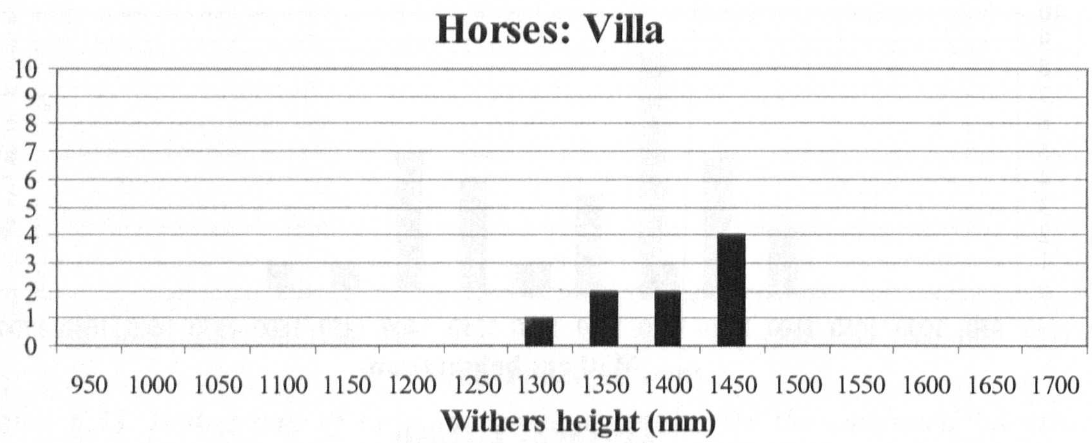


Figure 6.34. Continued.

There were apparently slight differences between the site types; the modal classes of the military, vicus and urban horses fell at 1350-1400 mm whereas the modal class of the villa horses was one class higher and the urban 2 (small town) and rural sites was one lower. However, the t-tests (Table 6.27) on these groupings showed that there were no significant differences between any of them. This may be a product of the small sample sizes and similar mean values of many of these groups (Table 6.26). Therefore, whilst there were differences between some of the regions in both the Iron Age and Roman periods, there were no differences in the horses from particular site types.

Having examined the horse data in some detail, the mule estimates were next to be analysed. Whilst there were fewer specimens, there were enough, particularly in the Roman period, for some useful analyses to be undertaken. As with the horses, the mules were first split by period to establish any differences between them. As expected, there were few mules attributed to Iron Age or External deposits, so most of the following analyses are based on the Roman data. There were a total of 135 identified mules, of which eight were Iron Age, 23 External and 104 Roman in date (Figure 6.35).

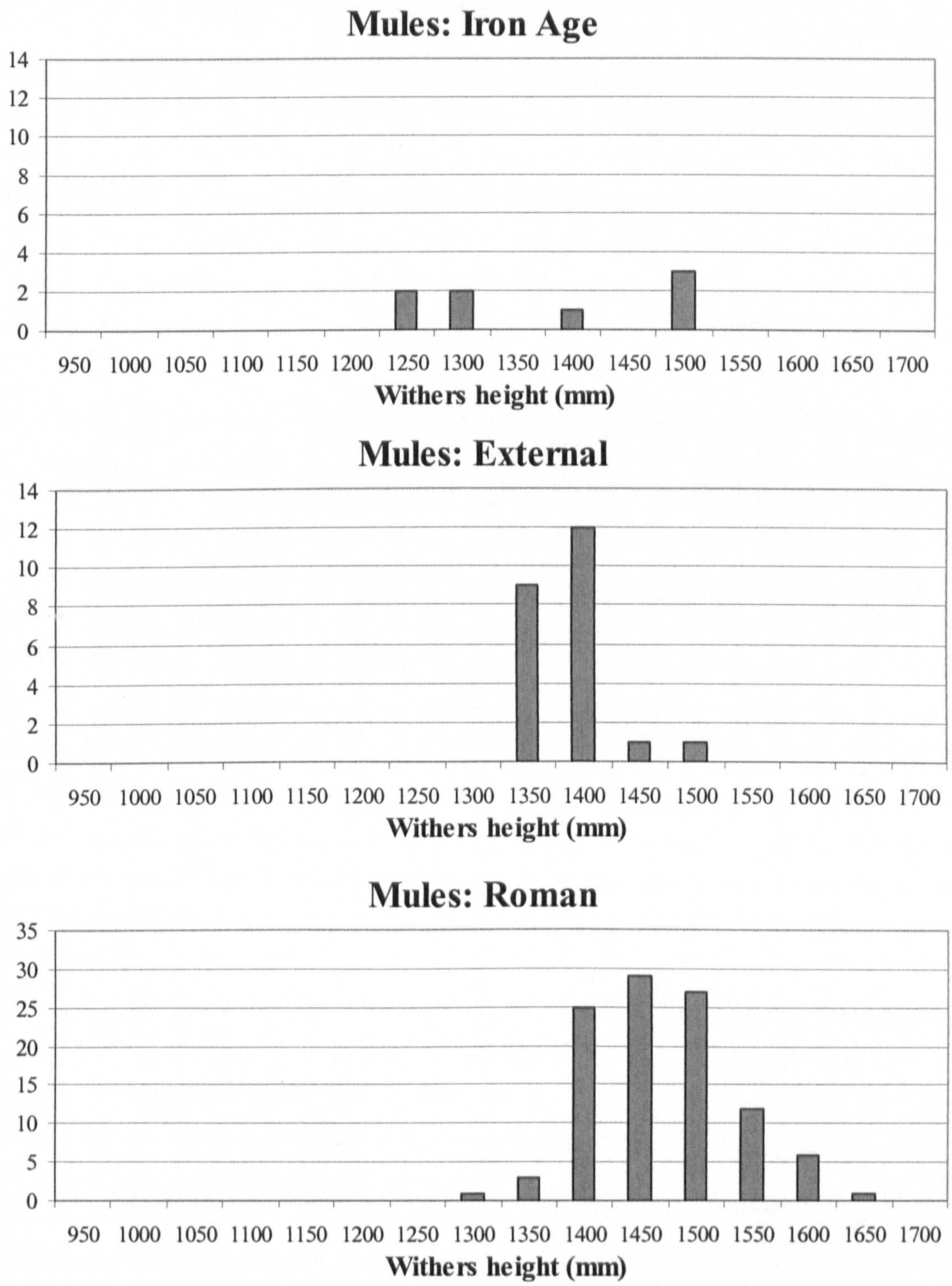


Figure 6.35. Histograms of estimated withers heights for the combined 'identified' archaeological mules by period

Figure 6.35 and Table 6.28 show that the Iron Age mules fall towards the lower end and the External mules fall within the range of the Roman mules. All of the groups' positions to the right side of the histograms reiterate the fact that the mules are on average taller than the contemporaneous horses. Table 6.29 shows the results of the t-tests on the mule data. Bearing in mind the small sample of Iron Age mules, the Roman mules were significantly taller than the other two groups, which were not significantly different from each other; this may be a consequence of breeding from larger horses.

Table 6.28. Summary statistics for the estimated withers heights (mm) of the combined 'identified' archaeological mules

Category	n	Min	Max	Mean	SD
Mules overall	135	1220.69	1601.78	1426.21	74.76
Iron Age	8	1220.69	1494.48	1355.60	118.63
External	23	1301.37	1499.00	1360.45	41.73
Roman	104	1281.42	1601.78	1446.19	64.71
Roman area A	2	1415.75	1429.39	1422.57	9.64
Roman area D	13	1356.19	1551.98	1443.54	65.56
Roman area E	5	1281.42	1452.28	1361.82	67.49
Roman area F	45	1326.45	1585.36	1449.70	50.76
Roman area G	36	1357.70	1601.78	1462.74	71.16
Roman area K	3	1319.78	1384.40	1362.82	37.27
Early Roman	30	1319.78	1551.98	1433.62	60.50
Mid Roman	26	1326.45	1585.36	1450.23	60.93
Late Roman	20	1281.42	1584.53	1459.99	79.70
Military sites	18	1320.23	1517.15	1449.35	54.14
Vicus sites	14	1360.30	1585.36	1456.80	60.71
Urban sites	42	1355.12	1601.78	1451.88	69.15
Urban 2 sites	13	1356.19	1551.98	1436.65	64.61
Villa sites	6	1281.42	1515.87	1415.22	84.91
Cemetary sites	4	1392.18	1493.12	1438.48	41.64
Industrial sites	3	1319.78	1384.40	1362.82	37.27
Rural sites	4	1442.63	1543.16	1482.73	47.96

*Table 6.29. Results of t-tests on the estimated withers heights of the combined archaeological mules. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	t statistic	Probability	Significance
Iron Agge v External	2.0452	0.8647	N
Iron Age v Roman	1.9818	0.0006	**
External v Roman	1.9791	0.0000	**
Roman areas D v F	2.0032	0.7201	N
Roman areas D v G	2.0117	0.3995	N
Roman areas F v G	1.9905	0.3393	N
Early v Mid Roman	2.0049	0.3115	N
Early v Late Roman	2.0106	0.1901	N
Mid v Late Roman	2.0154	0.6400	N
Military v Urban	2.0017	0.8907	N
Military v Urban 2	2.0452	0.5569	N
Military v Vicus	2.0423	0.7168	N
Urban v Vicus	2.0049	0.8135	N
Urban v Urban 2	2.0057	0.4844	N
Vicus v Urban 2	2.0595	0.4114	N

Following through the same order of grouping criteria as for the horses, the mules were next grouped by region. As before, there were too few specimens from Italy and Egypt, and this time also Britain, for graphical presentation to be useful. The results are summarised in Table 6.28. Figure 6.36 shows that the ranges of all three regions were very similar, and the distributions were also skewed towards the upper end of the range, particularly in Gaul and the Danube and Balkans areas. This may be a result of the smaller mules not being identified confidently. The t-tests (Table 6.29) between these regions showed that there were no significant differences in size between these mules.

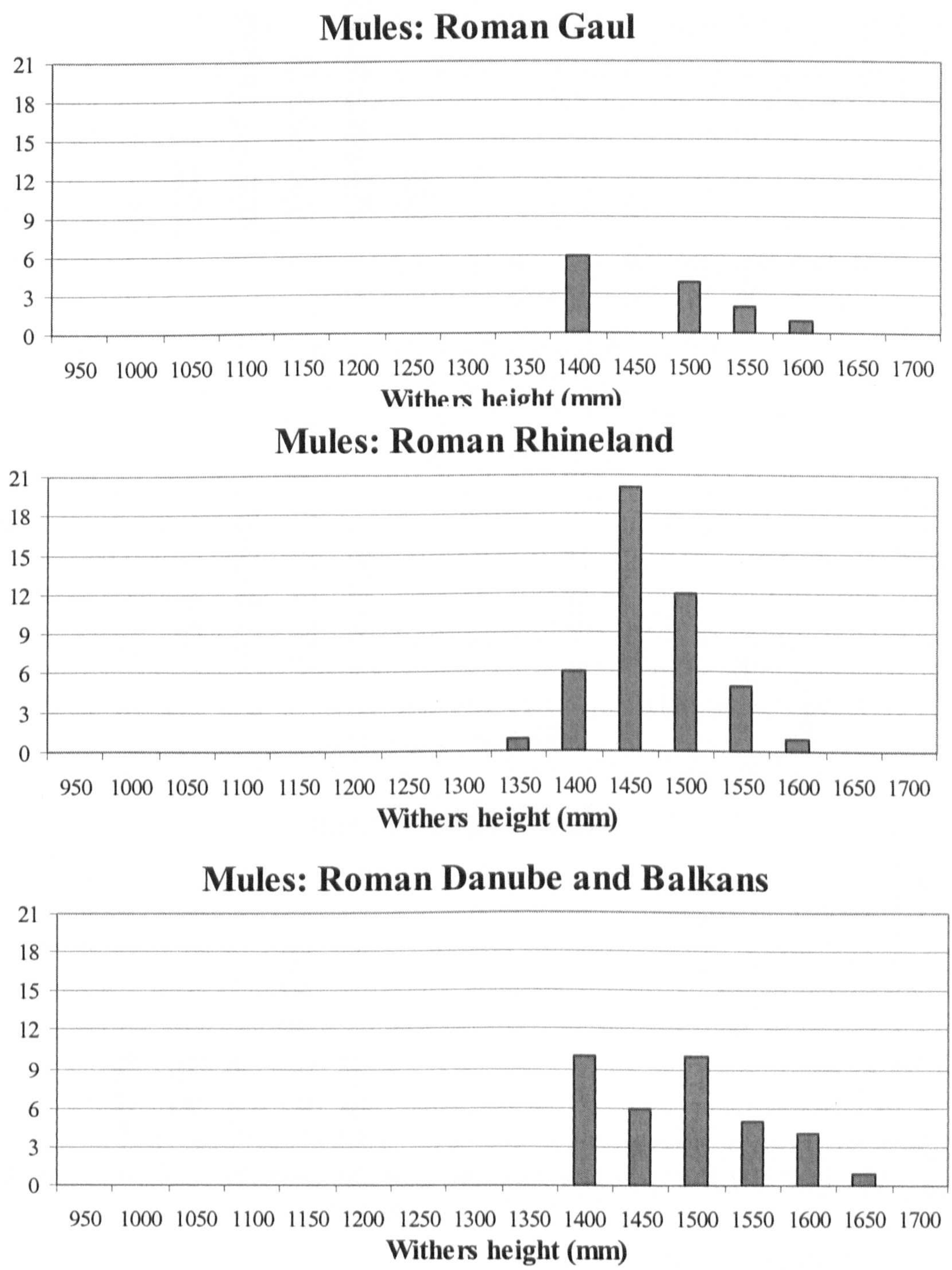


Figure 6.36. Histograms of estimated withers heights for the combined 'identified' archaeological Roman mules by area.

As there were no significant differences between the regions, the data were pooled to allow further comparisons to be made. Grouping the data by sub-periodin with the Roman period was undertaken next. Figure 6.37 shows that the range and distribution of the three sub-periods were very similar and this was confirmed in the t-test results (Table 6.29), with no significant differences detected.

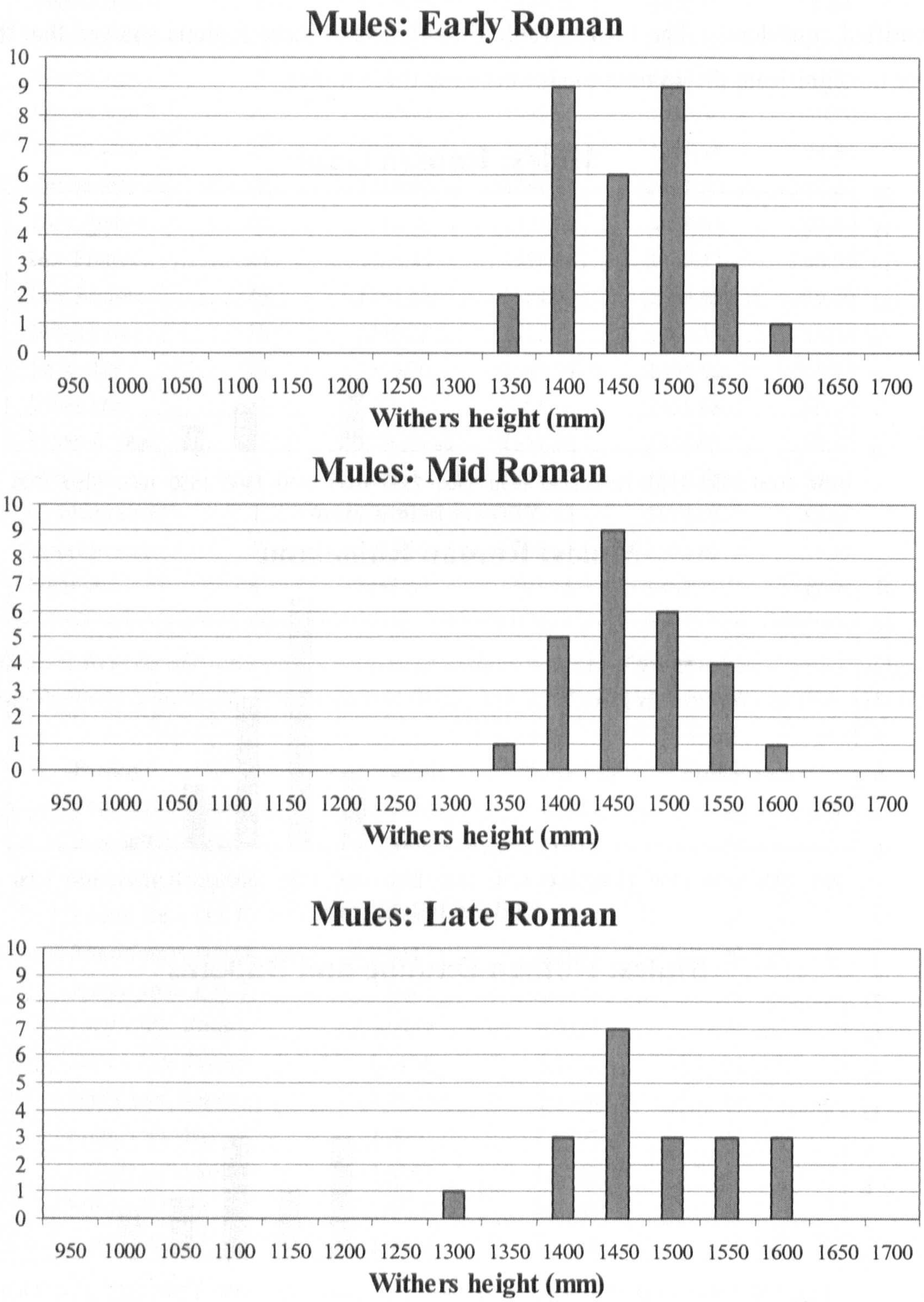


Figure 6.37. Histograms of estimated withers heights for the combined 'identified' archaeological Roman mules by sub-period.

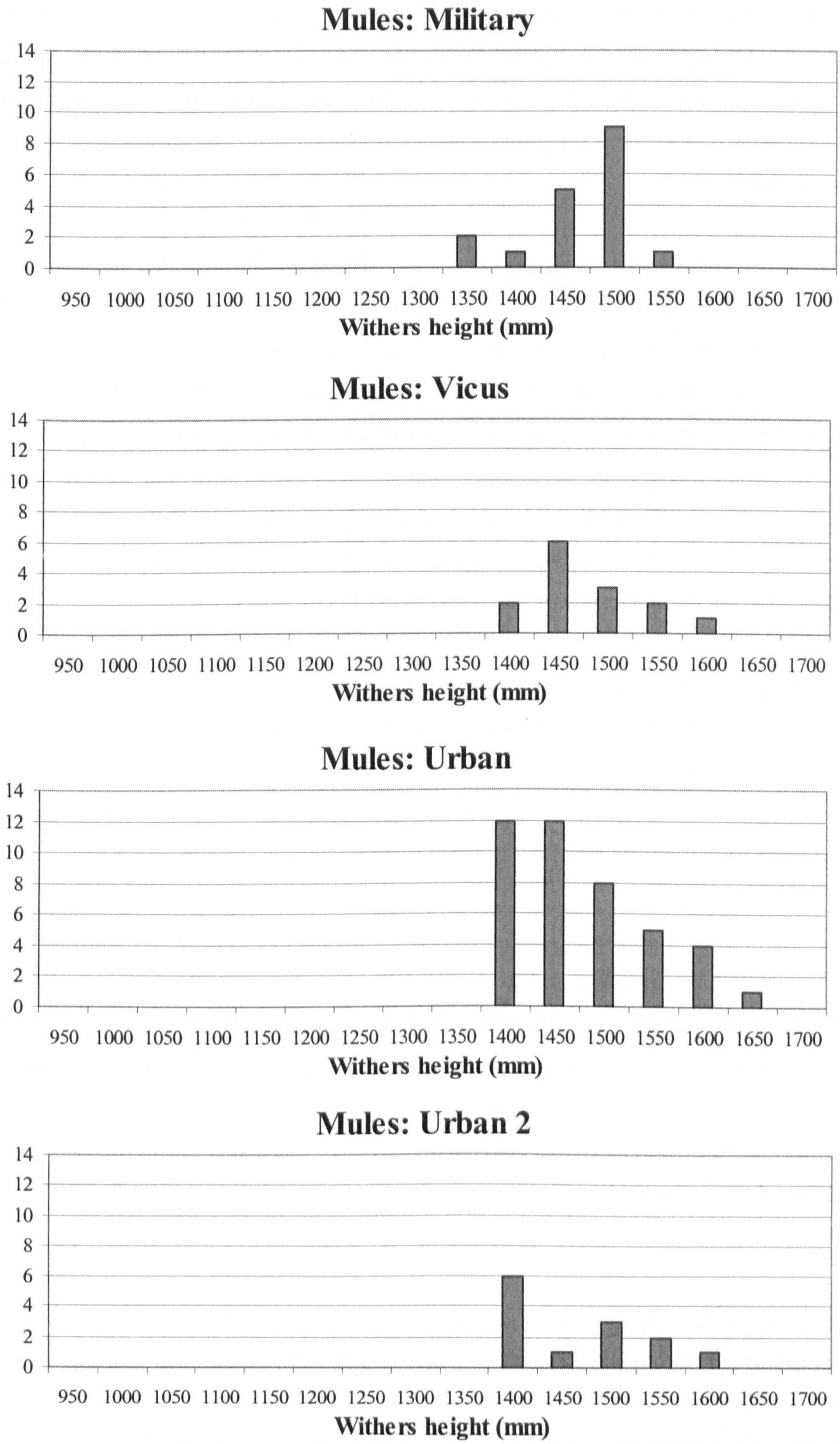


Figure 6.38. Histograms of estimated withers heights for the combined 'identified' archaeological Roman mules by site type.

Figure 6.38 shows the mule data grouped by site type; whilst there were subtle differences to be observed in the modal classes between the site types, there was very little difference in the range and mean of each group (Table 6.28). This was borne out by the results of the t-tests (Table 6.29), which suggested there were no significant differences between any of the site types.

This lack of significant differences between any of the grouping criteria suggests that the mules across the whole of the Roman Empire were remarkably consistent in size. This further suggests the possibility that mules were only bred in a few locations, perhaps under careful control of the Empire. This is in stark contrast to the horses, which seem to show much more regional variation and were therefore more likely to have been locally bred. The possible exception are the slightly smaller mules found in Britain, as seen from the summary statistics in Table 6.28, which, whilst the numbers are too small to be tested further, could possibly be the result of more local breeding, perhaps to avoid the expense of transporting these animals by sea from the continent.

Unfortunately the distribution of donkeys is so scarce in all the regions and periods that it is impossible from the current evidence to suggest where the mules may have been bred if the above hypothesis is correct. There were a total of 49 'identified' donkeys, of which 23 came from two Iron Age sites, one in Italy and the other in Greece. Of the remaining 26, nine were from External sites and 17 from Roman sites.

The first thing to note from Figure 6.39 is that the range of sizes from the donkeys is far greater in both the Iron Age and Roman material than for either the horses or the mules. The Iron Age data fall to the smaller end of the Roman range and the mean is also smaller, whilst the external material falls towards the centre and has an almost identical mean (Table 6.30). The t-tests (Table 6.31) showed that there was no significant differences between the Roman and External material but that there was a significant difference between the Iron Age material and the other two (bearing in mind the small sample of external data).

The data was split by period and by area, and the summary statistics are given in Table 6.30 as there are two few specimens to present graphically. The slightly larger mean size of the Iron Age donkeys from Gaul, Britain and the Rhineland may be indicative of the fact that they all came from very late Iron Age deposits, when contact with the Roman world was known to have occurred, whereas the material from Greece and Italy was much earlier in date.

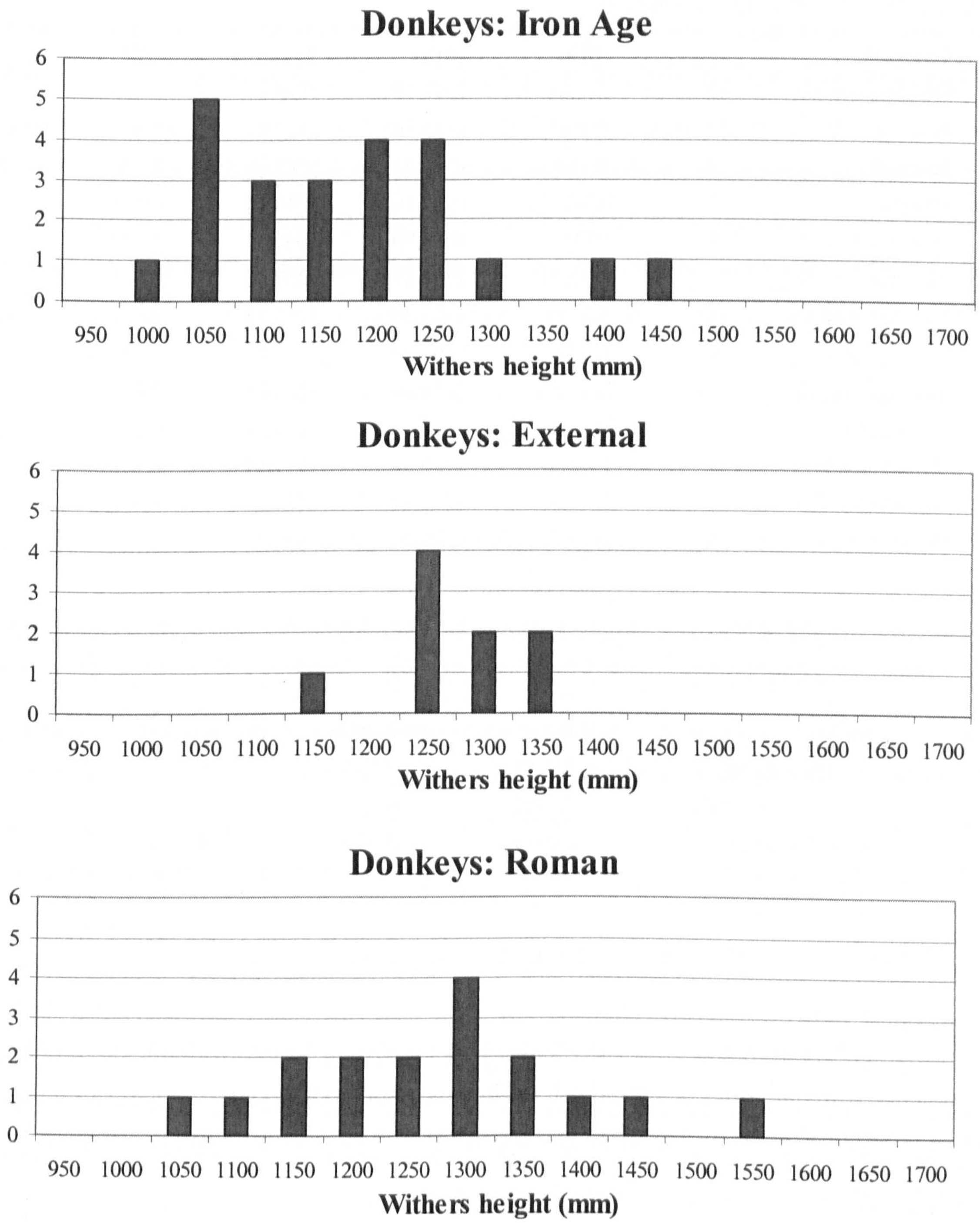


Figure 6.39. Histograms of estimated withers heights for the combined 'identified' archaeological donkeys by period.

Table 6.30. Summary statistics for the estimated withers heights (mm) of the combined 'identified' archaeological donkeys

Category	n	Min	Max	Mean	SD
Donkeys overall	49	979.68	1507.19	1199.74	121.14
Iron Age	23	979.68	1403.46	1144.81	114.61
External	9	1133.47	1344.33	1248.59	61.87
Roman	17	1030.37	1507.19	1248.19	125.99
Iron Age area A	6	979.68	1058.70	1031.11	32.11
Iron Age area D	2	1115.91	1398.81	1257.36	200.04
Iron Age area E	2	1110.56	1403.46	1257.01	207.11
Iron Age area F	4	1187.63	1267.59	1222.19	33.58
Iron Age area H	9	1019.03	1239.24	1136.28	74.88
Roman area D	3	1263.38	1507.19	1374.57	123.31
Roman area F	5	1030.37	1325.00	1179.87	125.99
Roman area G	3	1105.68	1346.42	1187.59	137.58
Roman area K	4	1231.27	1297.35	1256.70	29.24

*Table 6.31. Results of t-tests on the estimated withers heights of the combined archaeological donkeys. N=not significant, *=significant (95% level), **=highly significant (99% level).*

Pairing	t statistic	Probability	Significance
Iron Age v Roman	2.0244	0.0102	*
Iron Age v External	2.0423	0.0158	*
Roman v External	2.0639	0.9930	N

6.2.3 Summary of the results of withers height reconstruction

In summary, there are marked differences in the mean size of the horses, mules and donkeys as species, with the mules being largest, the horses in the middle and the donkeys smallest. There is overlap between the three groups and this may be contributing to some of the identification problems encountered in Section 6.1.

There are differences between the heights of the horses in the Iron Age in comparison with the Roman periods in the same regions, and this height increase occurs soon after the Roman conquest (with the exception of Britain, where it occurs later). There are also differences between the sizes of the horses in different regions during the Roman period, in particular the British material is smaller than the rest and there seems to be a slight height increase from west to east. Whilst there are slight visual differences between site types these are not significantly different. These differences suggest that local breeding of horses was perhaps the norm, and that no particular section of society (in terms of site type) had access to particular sizes of horses.

The mule data present a much more uniform size across the whole Roman Empire, in terms of date, region and site type. This suggests the possibility of centralised or controlled breeding of mules rather than localised production. The possible exception, although the numbers are too small to test, is Britain, where the mules appear to be slightly smaller. The small number of donkeys has meant that not much further information has been gained regarding the size of the donkeys by date or region. One observation, that cannot be tested, is that the donkeys found in the late Iron Age in Gaul, Britain and the Rhineland fit well within the sizes of Roman donkeys and may have arrived at these sites through trade or other contact with the Roman Empire.

6.2.4. Relation of withers height results to species identification issues

The modal class and mean withers height of the mules are higher than these of the horses. The donkeys overlap the smallest of the horses but not at all with the mules. Therefore, the withers height may be part of the problem with the identification of the ambiguous individuals, reinforcing previous indications that length is contributing heavily to the species identifications based on biometric factors. If the lengths of the bones are heavily involved in the species identification procedure, then the area where the lengths overlap will produce less clear identifications.

If this is the case, the differences seen in the withers height estimates will be exaggerated, because the smaller mules and larger horses are not being included by virtue of their ambiguous identification status. Therefore, it is possible that the mean size of the horse group is being underestimated and that of the mule group overestimated. Therefore, big differences in the estimated withers heights would be expected based on this method of classification.

One area of note is the quite substantial sizes at the upper end of the donkey range. This helps confirm earlier indications that larger donkeys are present in the archaeological sample that are not represented in the modern sample. This contradicts suggestions that the large donkeys are just misidentified mules or horses.

In order to determine if bone length (as seen in the withers height calculations) is influencing the outlying groups of identifications observed and commented on in Section 6.1.3, some further analysis of the data was necessary. The location of these outlying groups in relation to the 'standard' identification plot (see Figure 6.1) is shown in Figure 6.40. Groups 1, 2 and 7 correspond to the 'super' donkeys, mules and horses, respectively, as discussed in Section 6.1.3. Groups 3 and 4 represent the 'overlap' mules and horses, group 5 the 'zero' horses and group 6 the horses to the left of the zero line.

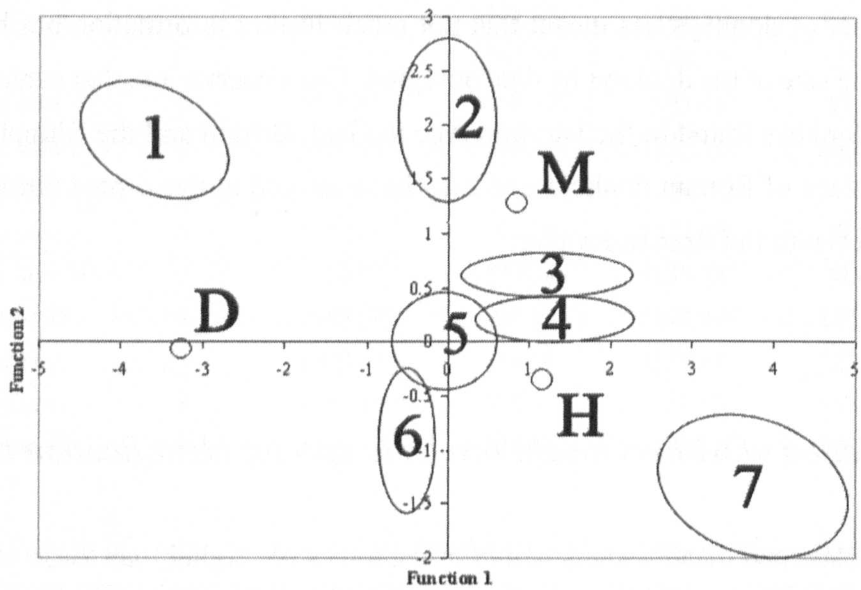


Figure 6.40. Areas on the 'standard' discriminant function plot where clusters of identifications occur.

Further analysis of the data consisted of splitting the range of the withers heights for each element by species into three equal portions. Individual bones falling in the smallest third were termed 'small', the middle third 'medium' and the largest third 'tall'. These results were then related to the groups outlined above according to where each bone was located on the identification plots in Section 2.1.

From this it was discovered that the length of the bones was playing a role in the determination of species and the characteristics of the clusters observed on the identification plots. As has been hypothesised, the overlap zone (areas 3 and 4 on Figure 6.40) between the horses and mules is where some of the tallest horses and shortest mules are to be found. The 'super' donkeys (area 1) are mostly tall, as are the 'super' mules (area 2). The 'super' horses (area 7), on the other hand, are mostly small to medium height. Both mules and horses in area 5, where the points cluster around the zero point, are mostly of medium height, whereas the horses to the left of the zero line (area 6) are small to medium in height. From this it can be seen that in general the observations put forward in the main part of the withers height analysis about the identification of some individuals can be backed up by the evidence presented here. It may be that when the shape index results are added to these data, a clearer picture of the characteristics of the clusters will emerge.

6.3. Calculation of shape indices

Shape indices were used to give an indication of the robusticity of a particular element. When compared with the withers height of an individual the shape index can indicate whether animal had slender or robust limbs in proportion to height. As the robusticity of the limbs is correlated with the relative weight of the animal, this will indicate whether the individual was, for instance, a short stocky pony or a tall slender horse.

For this section of the analysis the results are presented in a slightly different order and in different combinations. Because of the nature of the indices being calculated, the elements could not be combined, so the material from the skeletons and articulated limbs have been combined with the isolated elements to maximise the numbers of specimens available. There are many indices that could have been calculated on the bones. However, many would not mean very much in terms of size and shape of the individuals. Therefore a maximum of three indices was calculated on any one element, and in the majority of cases just one.

The most common index to be calculated on archaeological bones is the index of shaft breadth as a proportion of length, and is usually carried out on the metapodials. This gives a measure of the robusticity of the bones, which is taken as a proxy measure of the robusticity of the animal as a whole. Used in conjunction with the withers height estimations, a picture of the build of the animal can be obtained. As has been discussed in previous sections, the tibiae of mules seem disproportionately long in relation to the withers height in comparison with horses, and this index was used to determine whether the slenderness of the mule tibiae is similar to that of horses, and therefore the bones themselves, are larger or whether they are more slender or more robust.

In addition, indices of the articular breadths as a proportion of greatest length can be calculated. These will also give an indication of the robusticity of the bones, in terms of the size at the joint surfaces. If there are differences between the shaft breadth and articular indices, this may indicate different levels of nutrition during the growth period (Section 2.4.3), but could also highlight species and deme differences.

Index data can be presented in a number of ways to show different aspects of the data more clearly. Initially, histograms of the index values are used to show overall differences in robusticity between groups. Where warranted, the data from individual indices are also plotted as x-y scatter plots to show differences in size as well as shape. Where more than one index is calculated from a single bone, indices plotted against each other on scatter plots are used to show differences in bone morphology.

6.3.1. Calculation of the shape indices on metacarpals

Shaft breadth to greatest length index

The formula used here for the shaft breadth to greatest length index is SD/GL x 100. This expresses the shaft breadth as a percentage of the greatest length. As in the withers height estimations, the 'identified', 'ambiguous' and unknown specimens from the species identification work were treated separately.

A total of 775 metacarpals had both the GL and SD measurements, allowing the shaft breadth / greatest length index to be calculated. Of these 334 were 'identified', 110 'ambiguous' and 331 'unknown'. Examining the data for the identified specimens first, there were 267 horses, 48 mules and 19 donkeys. The results of calculating the shaft breadth index on these specimens are shown in Figures 6.41-6.43 and details of these results can be found in Appendix Table A26.

The pattern seen in Figure 6.41 for the 'identified' metacarpals shows that the mules and horses appear to be much more similar than in previous analyses, with the modal classes being exactly the same and the range of the mules falling within the range of the horses (Table 6.32). The donkeys are once again more slender than the horses. The t-tests (Table 6.33) back up this evidence, with the horses and mules showing no significant difference and the donkeys being highly significantly different to both the horses and mules.

Table 6.32. Summary statistics for the shaft breadth / greatest length index for the archaeological metacarpals

Category	n	Min	Max	Mean	SD
Horses	267	12.13	17.14	14.64	0.82
Mules	48	12.67	15.84	14.45	0.72
Donkeys	19	10.87	14.99	13.19	1.24
?Horses	73	11.92	16.83	14.45	1.05
?Mules	27	12.44	15.95	14.07	0.81
?Donkeys	10	12.66	14.13	13.11	0.45
Unknown	331	11.63	18.35	14.43	1.00

Table 6.33. Results of t-tests on the shaft breadth / greatest length index for the archaeological metacarpals

Pairing	t statistic	Probablilty	Significance
Donkeys v horses	1.9684	0.0000	**
Mules v horses	1.9676	0.1375	N
Donkeys v mules	1.9971	0.0000	**
Donkeys v ?donkeys	2.0518	0.8497	N
Horses v ?donkeys	1.9686	0.0000	**
Mules v ?donkeys	2.0032	0.0000	**
Mules v ?mules	1.9930	0.0416	*
Horses v ?mules	1.9681	0.0007	**
Donkeys v ?mules	2.0154	0.0056	**
Horses v ?horses	1.9670	0.0986	N
Donkeys v ?horses	1.9867	0.0000	**
Mules v ?horses	1.9801	0.9850	N
Mules v Unknown	1.9663	0.9062	N
Donkeys v unknown	1.9668	0.0000	**
Horses v unknown	1.9640	0.0070	**

Because of this lack of difference between the 'identified' horses and mules it is hardly surprising that the data from the 'ambiguous' horses and mules (Figure 6.42) are very similar to each other and to the 'identified' data for each species (Table 6.32). The t-tests revealed that the shape of the ambiguous mules is most like that of the mules, but the 'ambiguous' horses could be either horses or mules. The 'ambiguous' donkeys are most likely to be donkeys, reflecting Figure 6.42. The unknown material is shown in Figure 6.43 and as usual covers most of the range of all three species combined. However, in this instance the t-tests showed that the unknown group actually resembled the mules rather than the horses. This, however, is likely to be a reflection of the closeness of the horse and mule groups on this element.

Because results from different elements pooled together would be meaningless, the numbers of specimens available to study were less than they were for the withers height analyses, so fewer comparisons could be undertaken between the finer data groups.

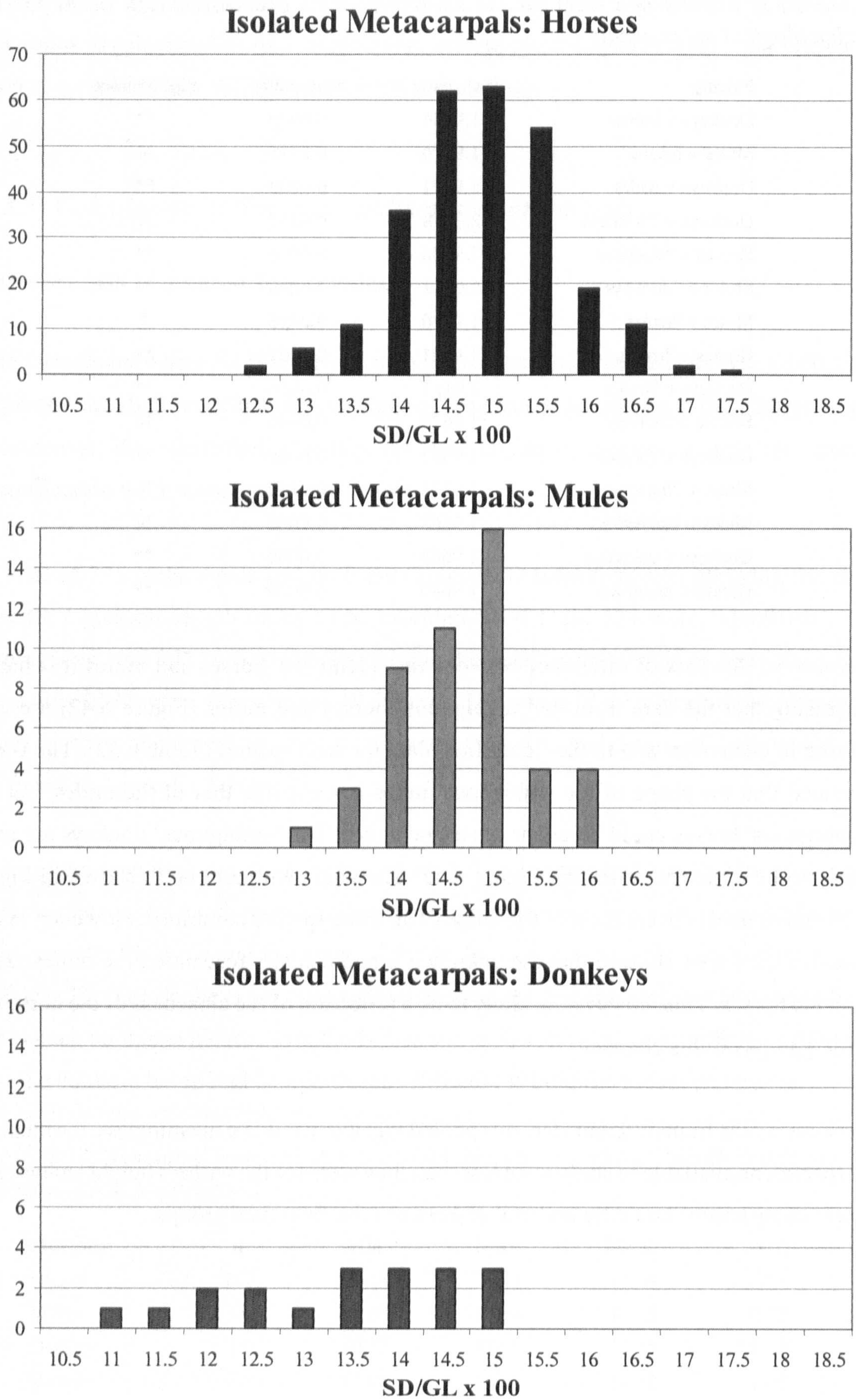


Figure 6.41. Histograms of shaft breadth / greatest length index for the 'identified' archaeological metacarpals.

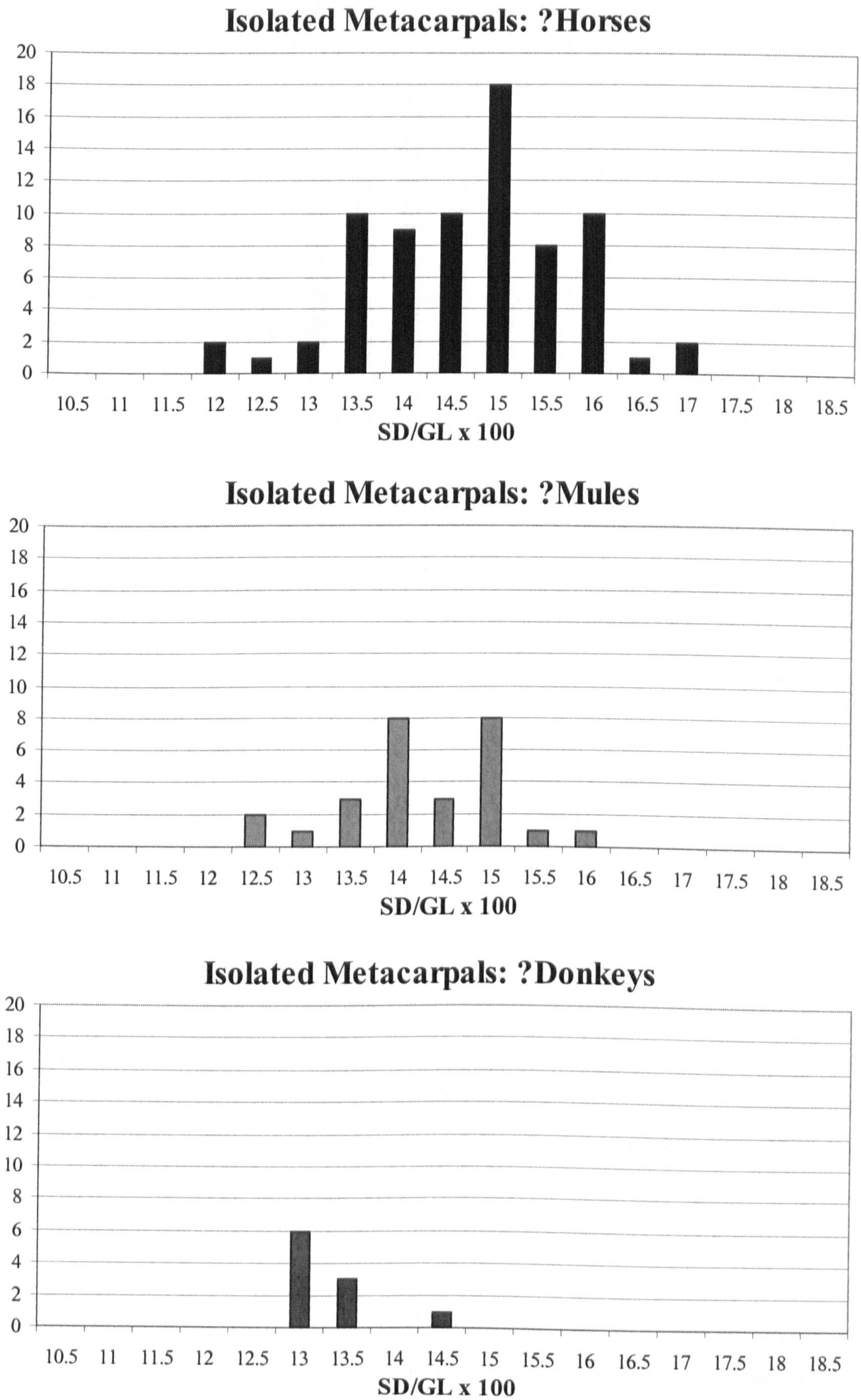


Figure 6.42. Histograms of shaft breadth / greatest length index for the 'ambiguous' archaeological metacarpals.

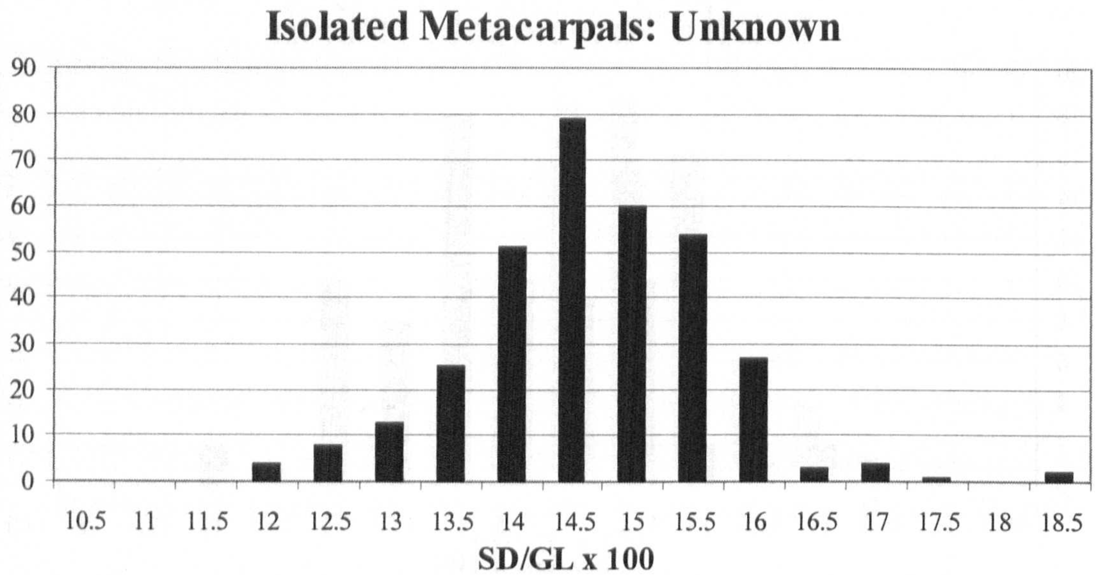


Figure 6.43. Histograms of shaft breadth / greatest length index for the 'unknown' archaeological metacarpals.

Table 6.34. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological horse metacarpals

Category	n	Min	Max	Mean	SD
Iron Age	44	13.44	16.84	14.86	0.65
Roman	81	12.13	16.89	15.01	0.78
External	142	12.64	17.14	14.36	0.78
Iron Age area D	16	13.79	16.84	14.87	0.70
Iron Agearea E	12	13.91	15.44	14.72	0.51
Iron Age area F	7	13.44	16.17	14.81	0.89
Iron Age area G	8	14.36	15.98	15.17	0.54
Roman area D	6	14.29	16.37	15.20	0.71
Roman area E	10	14.24	15.49	14.96	0.41
Roman area F	32	12.47	16.44	15.00	0.86
Roman area G	31	12.13	16.89	15.00	0.84
Military	10	14.14	16.29	14.90	0.61
Rural	3	15.08	15.51	15.35	0.24
Urban	47	12.13	16.89	15.07	0.80
Urban 2	7	14.24	16.37	14.92	0.73
Vicus	8	14.14	16.23	15.16	0.67
Villa	4	12.47	15.49	14.33	1.38

Examining the horse data, they were first split by period and the results are given in Figure 6.44. Figure 6.44 shows that the Roman horse metacarpals are most robust, followed by the Iron Age ones, with the most slender being the External metacarpals. Therefore, the larger number of External metacarpals may well be masking the robusticity of the Roman horses, and the average horse results (Figure 6.41) are consequently reduced to a level similar to that of the mule metacarpals. The ranges and means given in Table 6.34 reflect the modal classes and distributions seen in Figure 6.44. The t-tests (Table 6.35) showed that the External horses were highly significantly more slender than the Iron Age and Roman horses, but there was no significant difference between the Iron Age and Roman periods.

Splitting the data further into area groups, the Iron Age data were much as expected with the modal classes, means and ranges similar in all areas (Figure 6.45 and Table 6.34). The range and mean from the Danube and Balkans area were slightly higher than the other areas, but there were too few specimens to test the significance of this difference. There was no significant difference between the material from Gaul and from Britain (Table 6.35).

Table 6.35. Results of t-tests on the shaft breadth / greatest length index for the 'identified' archaeological horse metacarpals.

Pairing	t statistic	Probablilty	Significance
Iron Age v External	1.9729	0.0002	**
Iron Age v Roman	1.9794	0.2885	N
External v Roman	1.9708	0.0000	**
Roman areas E v F	2.0211	0.8728	N
Roman areas E v G	2.0227	0.8801	N
Roman areas F v G	1.9996	0.9861	N
Iron Age areas D v E	2.0555	0.5362	N
Iron Age v Roman area E	2.0860	0.2400	N
Military v Urban	2.0040	0.5261	N

The Roman material is shown in Figure 6.46 split by area. The modal classes of the three areas depicted are all the same, but the distributions are a little different. There is a hint of bimodality in the data from the Rhineland and there are very slender outliers in both the Rhineland and Danube and Balkans samples. The means are almost identical for all three areas (Table 6.34), so it is not surprising that the t-tests (Table 6.35) showed that there were no significant differences between them. Splitting the Roman horse data by site type once again produced small numbers of specimens in most categories. Figure 6.46 shows that there appears to be little difference between the modal classes and ranges of the material from different site types. As expected the t-tests (Table 6.35) showed there was no significant differences between the military and urban groups (the only ones with sufficient numbers to test), although this could be as a result of the small numbers of military specimens.

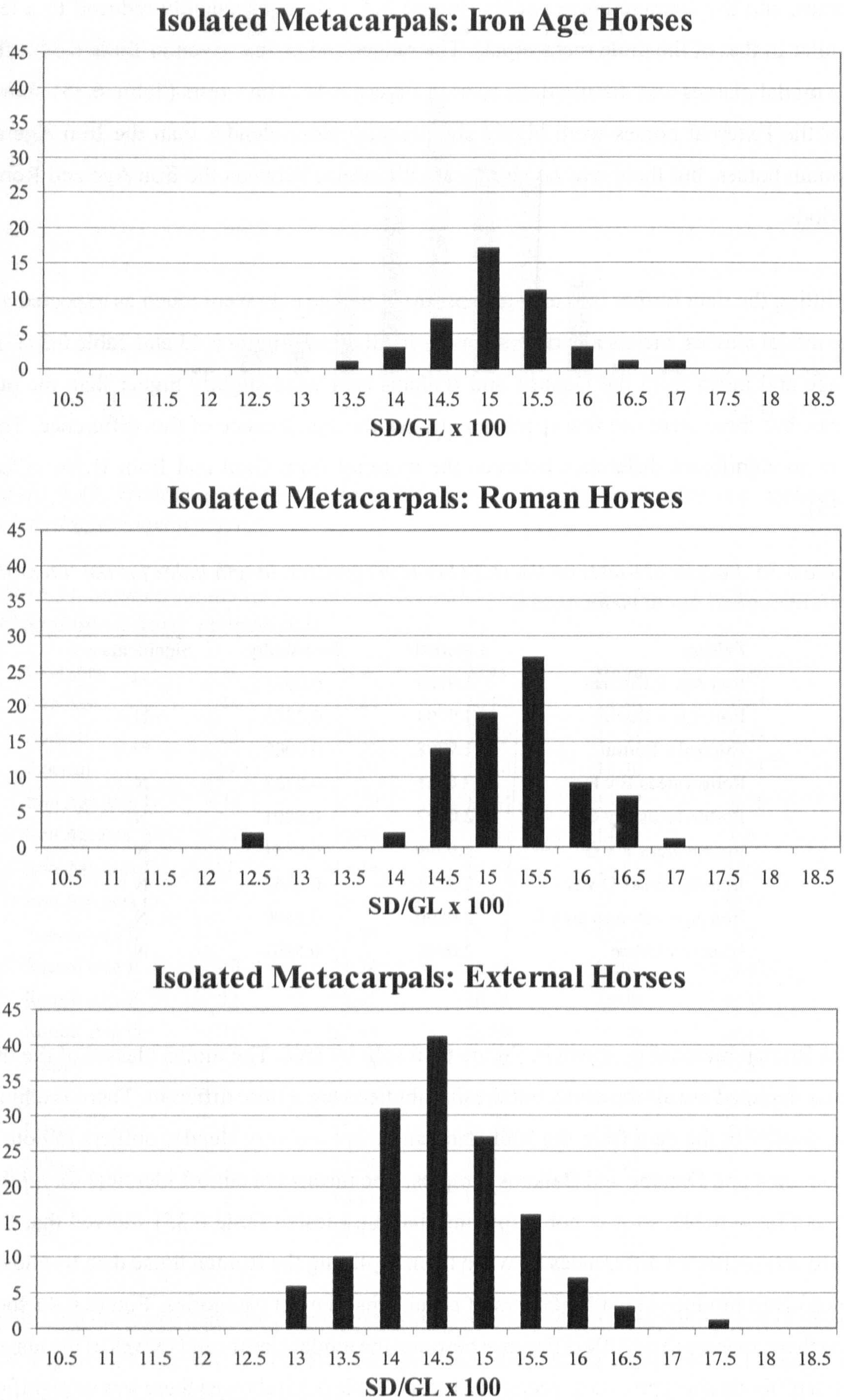


Figure 6.44. Histograms of shaft breadth / greatest length index for the 'identified' archaeological horse metacarpals by period.

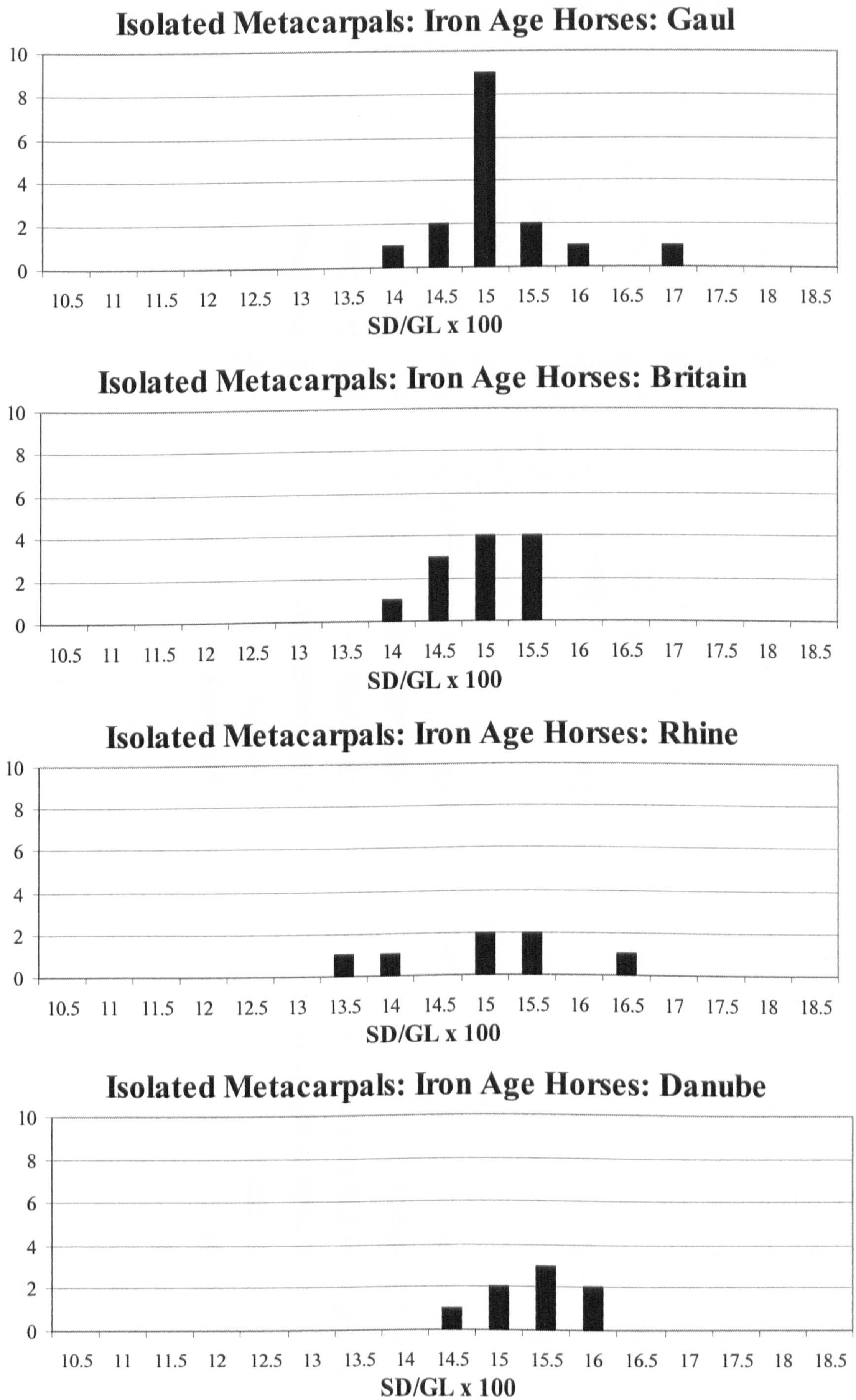


Figure 6.45. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Iron Age horse metacarpals by area

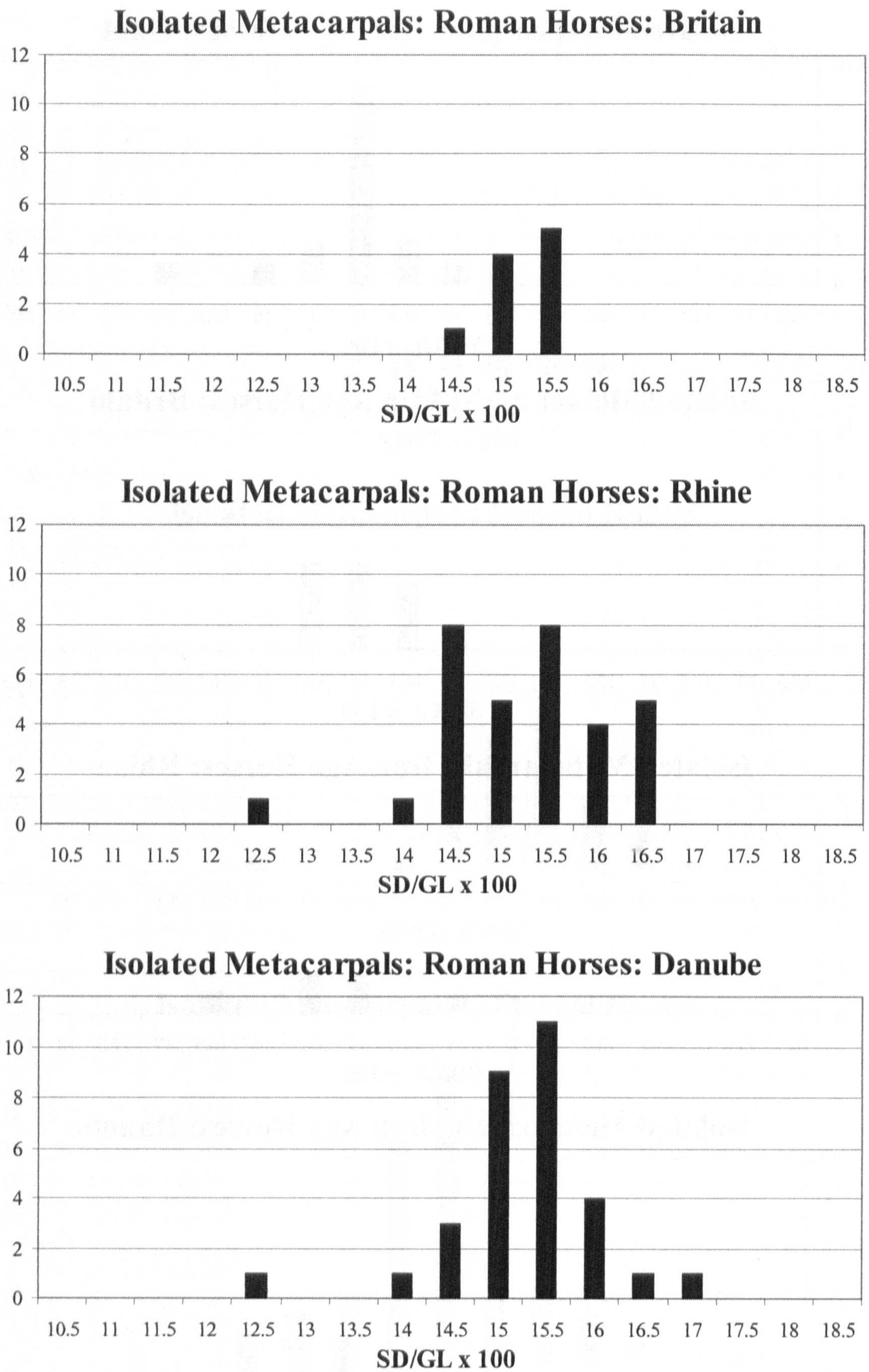


Figure 6.46. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Roman horse metacarpals by area.

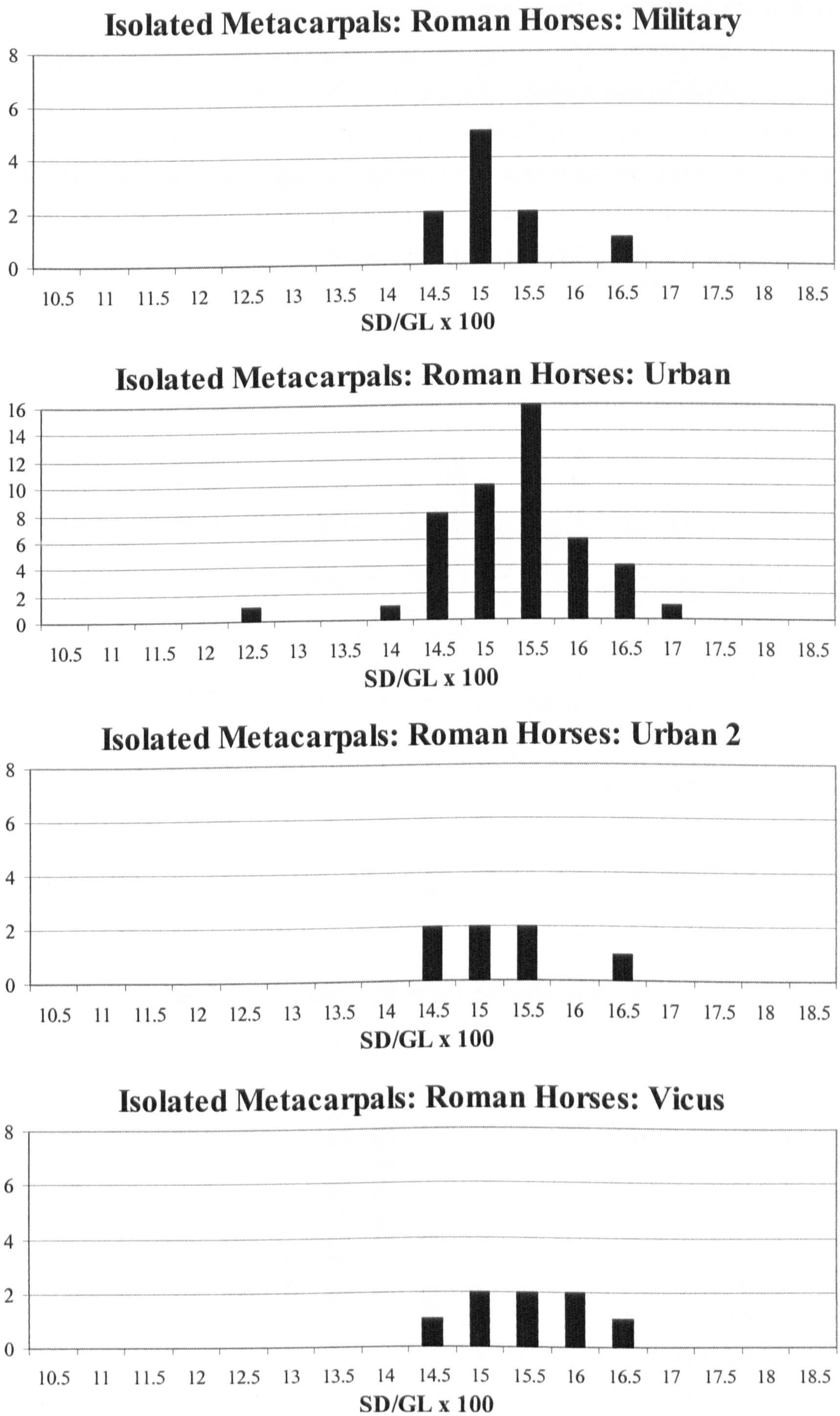


Figure 6.47. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Roman horse metacarpals by site type.

There were considerably fewer identified mules than there were horses, so less analysis could be undertaken. When the data was split by period, there were only one Iron Age mule and three External mules, so Figure 6.48 only shows the Roman data. When compared with the horse data for the same period it can be seen quite clearly that the mules were more slender than the horses. The t-test on these data (Table 6.37) showed that there were highly significant differences between the Roman mules and horses. This adds weight to the argument that the slender External horses are obscuring the robusticity of the Roman horses.

Table 6.36. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological mule metacarpals

Category	n	Min	Max	Mean	SD
Roman	44	13.05	15.84	14.52	0.67
External	3	12.67	13.93	13.37	0.64
Roman F	18	13.05	15.84	14.46	0.83
Roman G	22	13.64	15.50	14.54	0.50
Military	17	13.25	15.40	14.46	0.66
Urban	18	13.05	15.84	14.50	0.62
Villa	3	14.71	15.71	15.14	0.52

Table 6.37. Results of t-tests on the shaft breadth / greatest length index for the 'identified' archaeological mule metacarpals.

Pairing	t statistic	Probablilty	Significance
Roman areas F v G	2.0244	0.7129	N
Military v Urban	2.0345	0.8466	N
Roman horses v Roman mules	1.9794	0.0006	**

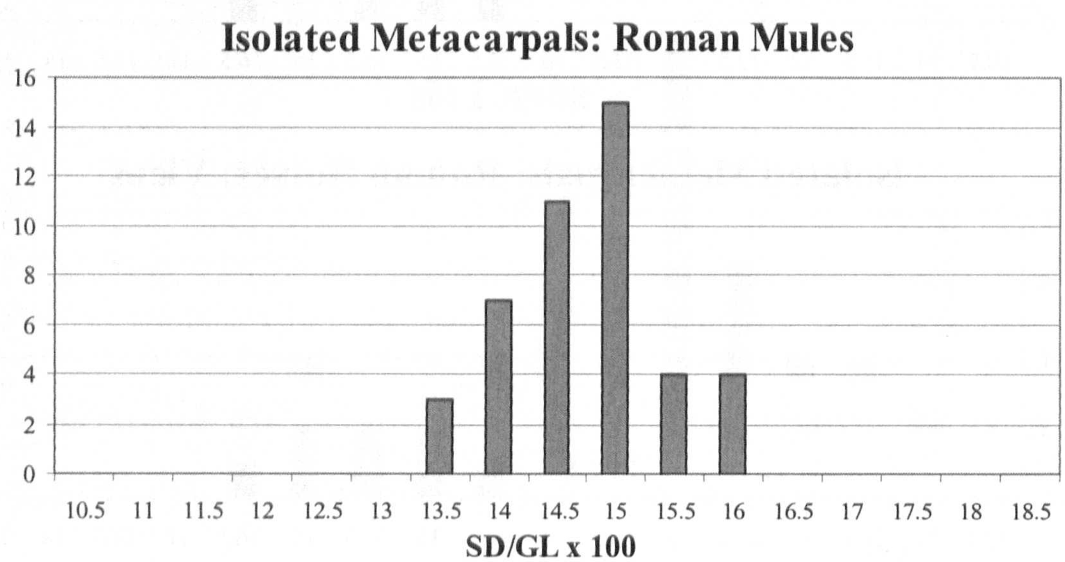
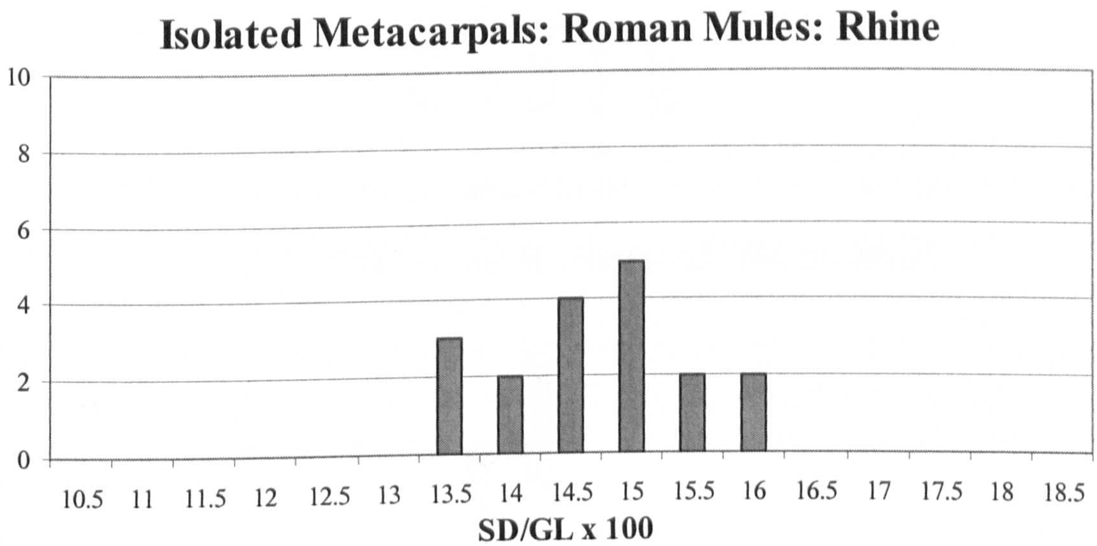


Figure 6.48. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Roman mule metacarpals.

Two areas produced enough mule metacarpals for graphical presentation and t-test analysis, the Rhineland and Danube and Balkans areas (Figure 6.49). There was little difference between the two areas except that the range shown by the Danube and Balkans material was quite narrow (Table 6.36). The t-tests (Table 6.37) confirmed that there was no significant difference between the two regions.



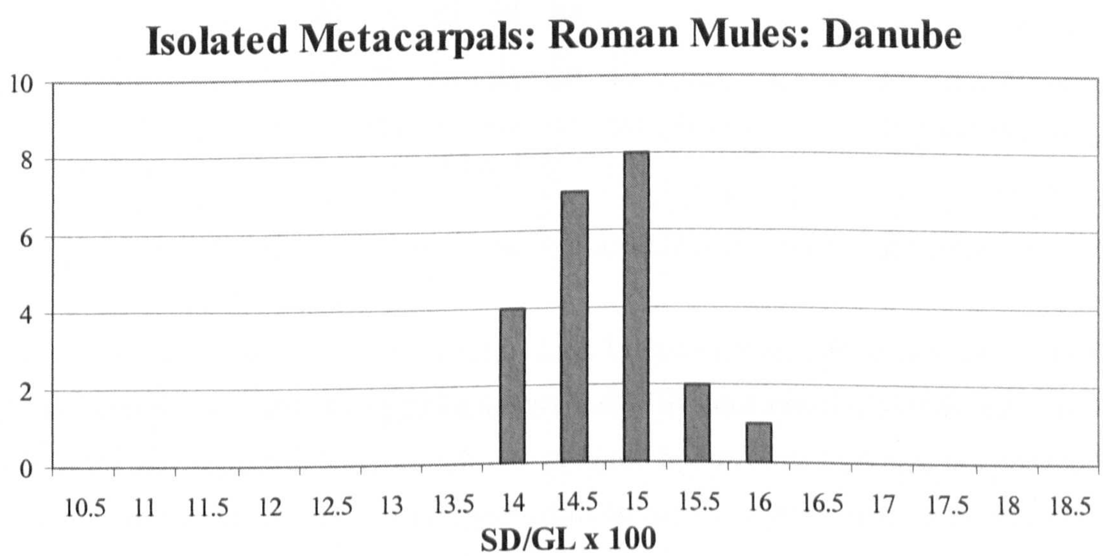
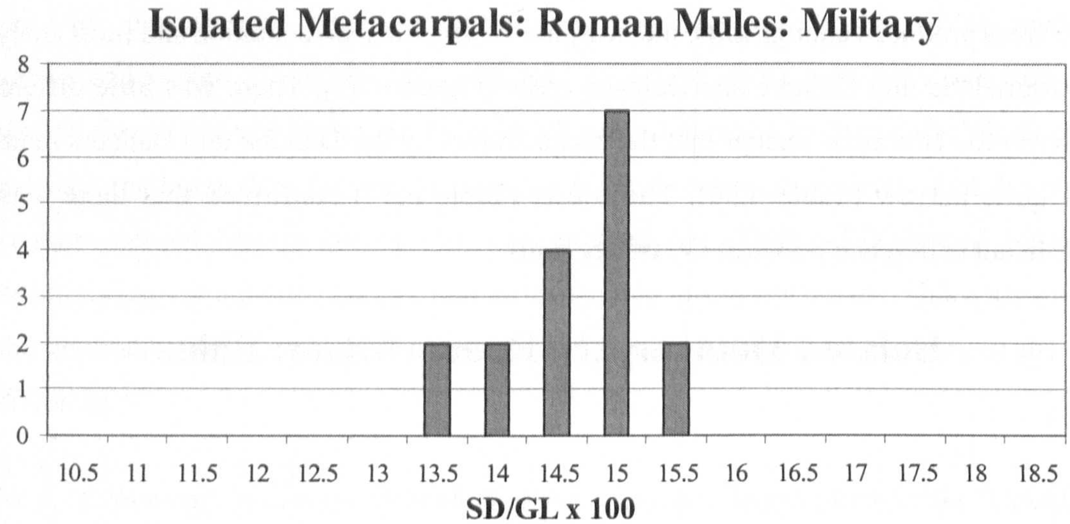


Figure 6.49. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Roman mule metacarpals by area.

Figure 6.50 shows the mule data split by site type and once again only two groups had enough material for further analysis. The modal classes were slightly different and the skew of the two distributions were opposite to each other. However, the ranges and means were very similar (Table 6.36), and therefore the t-tests showed that that once again there was no significant difference between the groups. From this evidence it suggests that there is a very widespread homogeneity in the mules across the Empire.



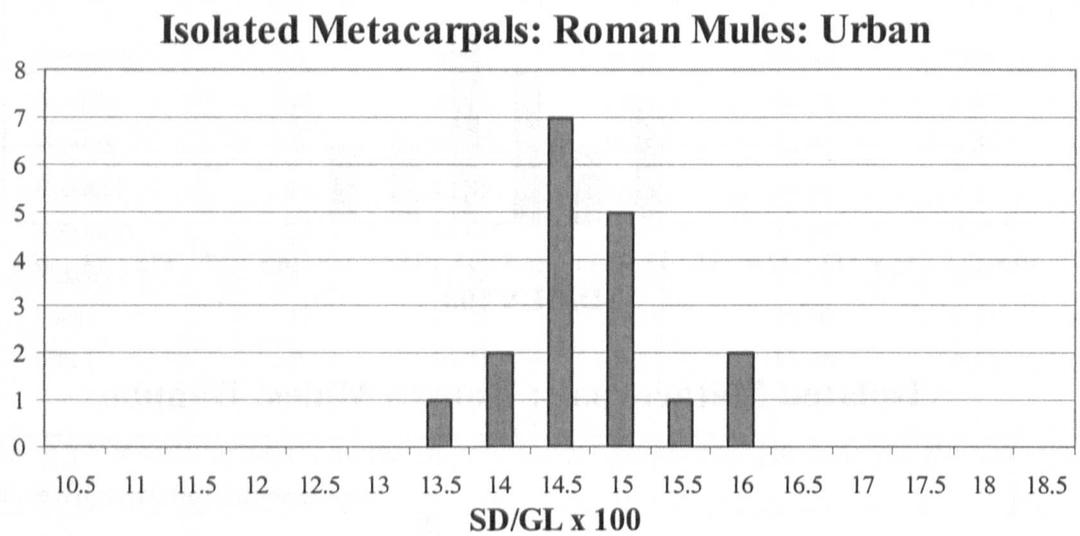


Figure 6.50. Histograms of shaft breadth / greatest length index for the 'identified' archaeological Roman mule metacarpals by site type

There were just sufficient numbers of donkey identifications to split the data by period, and the results are given in Table 6.38 (and Appendix Figure A1). There was little difference between the Iron Age and Roman donkeys, but the External donkeys were more slender than the other two groups. Unfortunately the groups were so dissimilar in terms of geographic location or site type little comment could be made on these differences. However, the slenderness of the External donkeys, horses and mules does lend credence to the idea that perhaps mule breeding was being carried out in areas external to the Empire using at least some local animals.

Table 6.38. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological donkey metacarpals

Category	n	Min	Max	Mean	SD
Iron Age	6	10.87	14.99	13.55	1.46
Roman	7	12.53	14.96	13.80	0.81
External	6	11.31	13.43	12.11	0.76

Proximal breadth to greatest length index

The use of articular breadth to greatest length indices (Bp/GL x 100) in combination with the shaft slenderness index can yield information on whether the bones are generally robust or slender (both indices giving high or low values, respectively) or are more robust or slender in the shaft in relation to the articular breadths. These variations can then be related to species differences, growth/nutritional problems and also possibly to deme diversity.

The results from the index of Bp/GL x 100 on the metacarpals were very similar in most respects to those shown for the shaft breadth index. As a result of this many of the figures have been placed in the Appendix to avoid unnecessary repeats within the text. A total of 723 metacarpals had both greatest length and proximal breadth measured. Of these 333 were 'identified' (267 horses, 47 mules, 19 donkeys), 110 were 'ambiguous' (73 ?horses, 27 ?mules and 10 ?donkeys) and the remaining 280 were unknown. Detailed results are given in Appendix Table A27.

Figure 6.51 shows the results for the 'identified' metacarpals, and the similarities with Figure 6.41 are striking. As before, the mules and horses appear very similar to each other, with the donkeys appearing more slender. However, unlike the shaft slenderness results (Table 6.33), there were highly significant differences between the mules and horses as well as between the other pairings (Table 6.40). This suggests that the mules have more slender proximal articulations in relation to length than the horses, and are therefore more slender overall than the horses.

Table 6.39. Summary statistics for the proximal breadth / greatest length index for the archaeological metacarpals

Category	n	Min	Max	Mean	SD
Horses	267	19.32	25.65	22.23	0.87
Mules	47	19.82	24.29	21.80	0.97
Donkeys	19	17.48	22.64	21.02	1.16
?Horses	73	19.57	25.38	22.02	0.96
?Mules	27	19.49	23.77	21.49	0.93
?Donkeys	10	20.30	22.27	21.46	0.64
Unknown	280	17.71	24.50	21.75	1.04

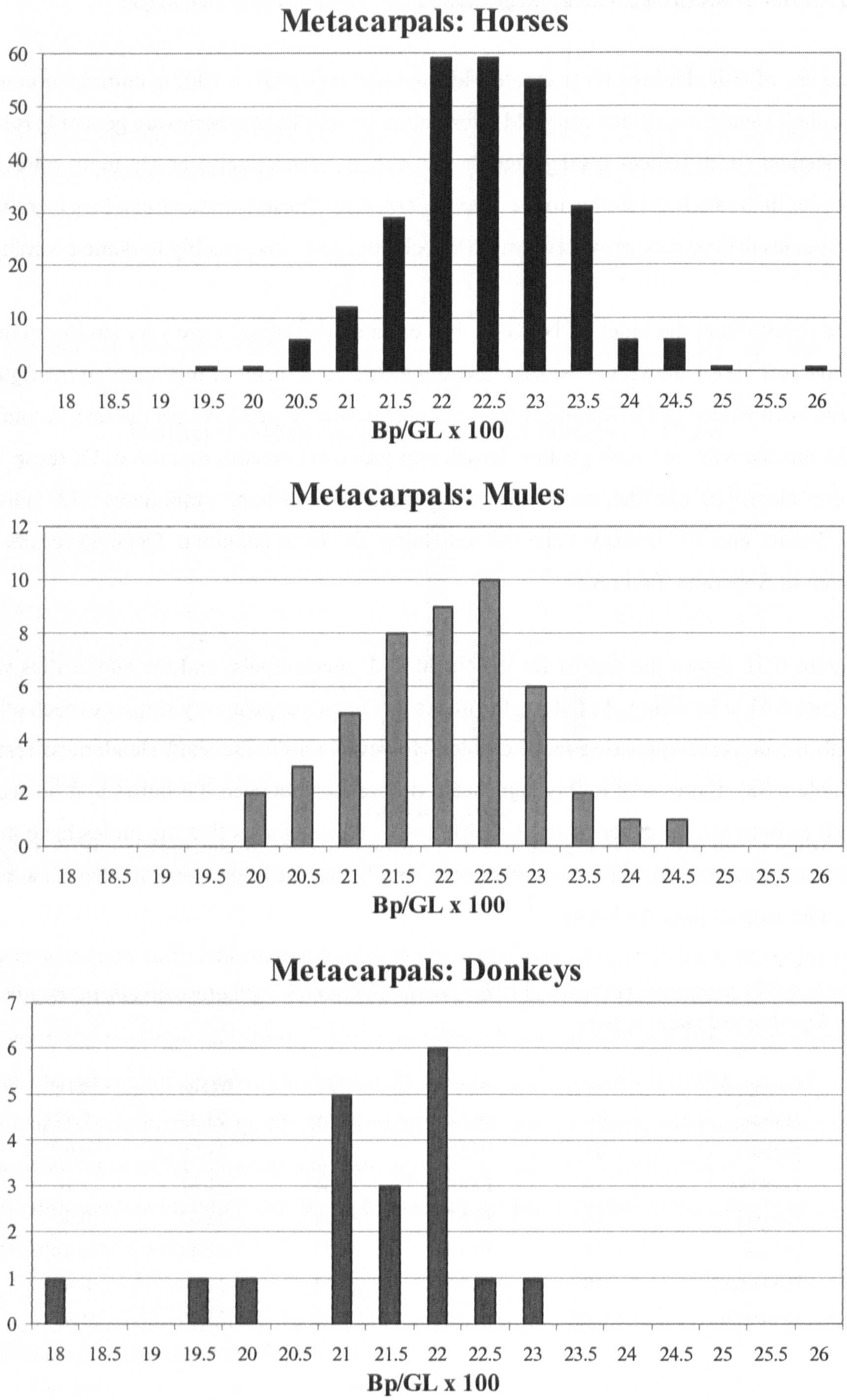


Figure 6.51. Histograms of proximal breadth / greatest length index for 'identified' archaeological metacarpals

Table 6.40. Results of t-tests on the proximal breadth / greatest length index for the archaeological metacarpals.

Pairing	t statistic	Probablilty	Significance
Donkeys v horses	1.9684	0.0000	**
Donkeys v mules	1.9977	0.0067	**
Horses v mules	1.9676	0.0027	**
Donkeys v ?donkeys	2.0518	0.2786	N
Horses v ?donkeys	1.9686	0.0060	**
Mules v ?donkeys	2.0040	0.2891	N
Donkeys v ?mules	2.0154	0.1343	N
Horses v ?mules	1.9681	0.0000	**
Mules v ?mules	1.9935	0.1781	N
Donkeys v ?horses	1.9867	0.0002	**
Horses v ?horses	1.9670	0.0814	N
Mules v ?horses	1.9803	0.2310	N
Donkeys v unknown	1.9680	0.0036	**
Horses v unknown	1.9643	0.0000	**
Mules v unknown	1.9673	0.7476	N

As with the shaft slenderness results, the similarities between the 'identified' horses and mules compounds the problems of identification for the 'ambiguous' specimens. Their results are very similar to each other and to the identified data for each species (Appendix Figure A2 and Table 6.39). The t-tests (Table 6.40) showed that there were slight differences between these results and those of the shaft slenderness index. The 'ambiguous' donkeys and mules were unlikely to be horses but both could be either donkeys or mules, and the 'ambiguous' horses could be either mules or horses. As has been the case in most of the previous analyses, the data for the unknown specimens cover the combined range of all three species (Appendix Figure A3). As with the shaft slenderness index, the t-tests (Table 6.40) indicated that the group is more like the mules than the horses, probably reflecting the closeness of the results for these two species rather than greater numbers of mules within the sample.

Examining the horse data by period, Figure 6.52 shows that there are subtle differences between the data for the shaft slenderness and proximal slenderness indices in these groups. Whilst Figure 6.44 showed that the Roman horses had the most robust shafts and the External horses the most slender, the data for the proximal breadth index show no significant difference between the groups, this being confirmed by the t-test results (Table 6.42). This suggests that the widths of the proximal joints of all these horses are very similar to each other but that the External specimens have proportionately more slender shafts. There are three possible explanations for this. Firstly, there could be genetic differences between these groups of animals, and the External horses are of a more slender limbed type than the other groups. Secondly it is possible that nutritional stress during growth could be responsible for producing bones with a proportionately more slender shaft (see Chapter 2). However, this would mean that the husbandry regime practised across several widely distributed sites and over a long period of time would have had to have been consistently affecting the growth rate of most individuals. The third possibility is that of sexual dimorphism, even though, as discussed in Chapter 2, equids display very little sexual dimorphism. The most likely candidate for relatively long slender metapodials would be geldings. However, it is unlikely that such a widely distributed group of bones would contain mostly castrates and the others mostly mares and/or stallions. Therefore it is unlikely that either sexual dimorphism or castration are the cause of the greater slenderness of these horses. As nutritional stress is unlikely to have consistently affected such large numbers of individuals it is more likely that genetic variation is the basis of the observed differences.

Table 6.41. Summary statistics for the proximal breadth / greatest length index for the 'identified' archaeological metacarpals

Category	**n**	**Min**	**Max**	**Mean**	**SD**
Iron Age horses	45	20.67	24.47	22.32	0.73
Roman horses	80	19.91	25.65	22.36	0.90
External horses	142	19.32	24.50	22.12	0.88
Roman mules	44	19.87	24.29	21.82	0.94
Iron Age donkeys	6	17.48	22.64	21.22	1.87
Roman donkeys	7	19.95	21.84	21.14	0.72
External donkeys	6	19.48	21.49	20.68	0.69
Iron Age D horses	16	20.67	24.47	22.14	0.90
Iron Age E horses	12	21.35	23.26	22.32	0.64
Iron Age F horses	7	21.63	23.26	22.47	0.60
Iron Age G horses	9	21.19	23.29	22.47	0.69
Roman D horses	6	21.84	23.81	22.63	0.70
Roman E horses	9	21.59	24.67	22.58	1.07
Roman F horses	31	20.46	25.65	22.39	1.04
Roman G horses	32	19.91	23.42	22.21	0.75
Roman F mules	18	20.33	23.11	21.69	0.83
Roman G mules	22	19.87	23.85	21.84	0.94

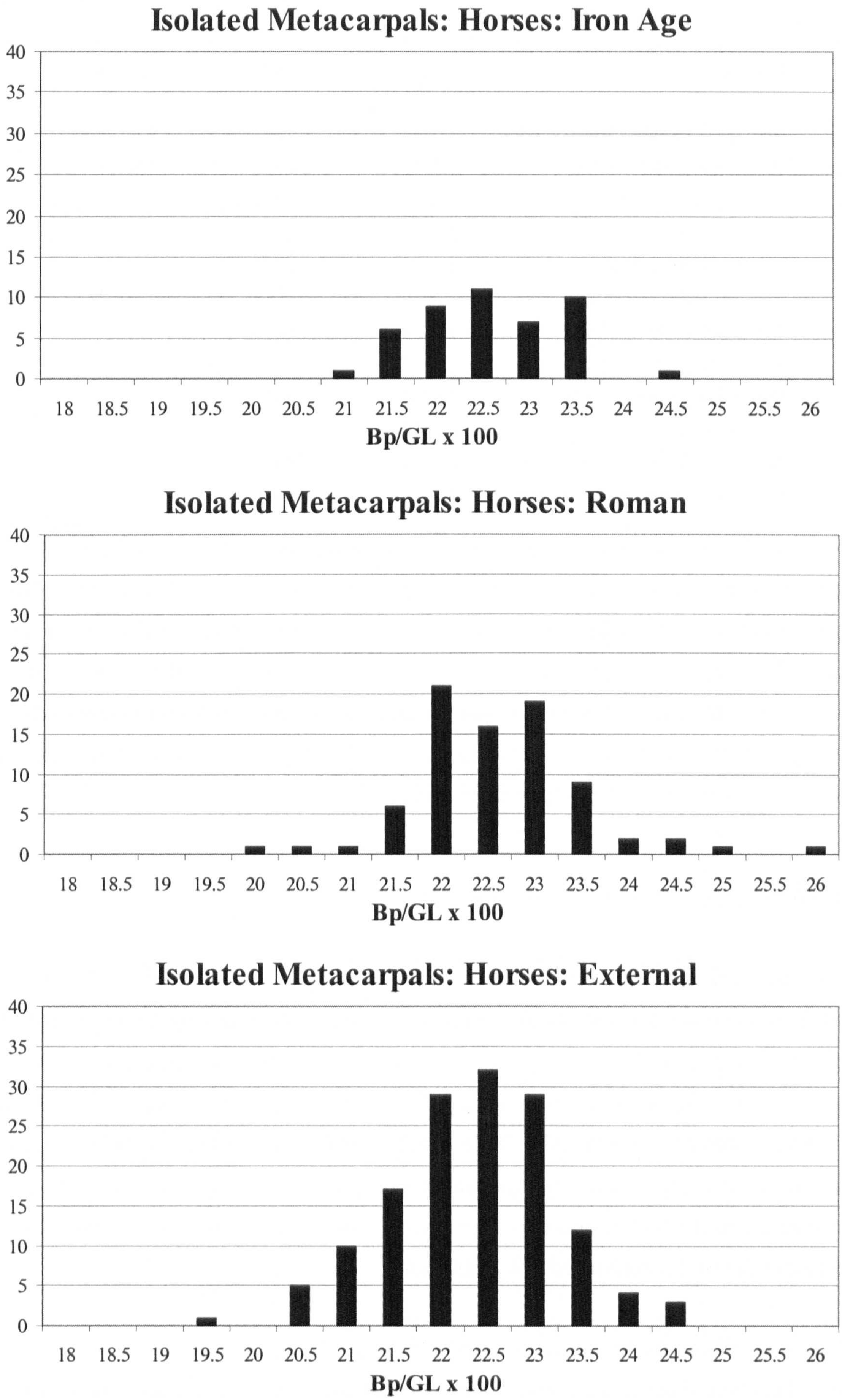


Figure 6.52. Histograms of proximal breadth / greatest length index for 'identified' archaeological horse metacarpals by period.

Table 6.42. Results of t-tests on the proximal breadth / greatest length index for the 'identified' archaeological metacarpals.

Pairing	t statistic	Probablilty	Significance
Iron Age v External	1.9729	0.1830	N
Iron Age v Roman	1.9794	0.7543	N
Roman v External	1.9708	1.6518	N
Roman Horses v Mules	1.9796	0.0020	**
Iron Age Horses areas D v E	2.0555	0.5699	N
Iron Age Horses areas D v G	2.0687	0.3507	N
Iron Age Horses areas E v G	2.0930	0.6008	N
Roman Horses areas E v F	2.0244	0.6410	N
Roman Horses areas E v G	2.0227	0.2519	N
Roman Horses areas F v G	1.9996	0.4433	N
Roman Mules areas F v G	2.0244	0.6038	N
Iron Age v Roman area E Horses	2.0930	0.4960	N
Iron Age v Roman area G Horses	2.0227	0.3599	N

When the horse data were split by period and by area (Appendix Figures A4 and A5), the Iron Age Gaul specimens appeared to be slightly more slender than those from other regions, but the t-tests (Table 6.42) showed there were no significant differences between any of the regions in either the Iron Age or the Roman period, and there were also no significant differences between the Iron age and Roman samples from those regions with enough data to test. The mules presented a similarly uniform picture, with no significant differences between areas (Appendix Figure A6).

Distal breadth to greatest length index

The distal breadth to greatest length index (Bd/GL x 100) gave some remarkably different results to the other two indices. A total of 760 metacarpals with both measurements was present. There were the same number and split of identified and 'ambiguous' specimens present as for the previous analysis, together with 317 unknown specimens. Detailed results are presented in Appendix Table A28. Figure 6.53 shows the results by species for the identified specimens and it is immediately apparent that there is a substantial difference between the horses and the other two species in their distal breadth indices. The results of the t-tests confirmed this (Table 6.44).

This suggests that the morphology of the distal end of the mule metacarpals more closely resembles that of the donkey whilst the proximal end is more like that of the horse. The shapes of mule hooves are more like those of the donkey (long and narrow) than the horse (almost round at the front). As this is related to the size of the articular surface, the width of the phalanges and hence the distal end of the metacarpal will also reflect any narrowness.

The 'ambiguous' specimens (Figure 6.54) show a similar pattern to the identified specimens but with a lesser degree of separation. This may be one of the factors affecting identification: those horses with smaller distal breadth measurements in relation to length and the broader mules are less clearly separable. The results of the t-tests confirmed these observations (Table 6.44) as whilst the ambiguous mules are most likely to be mules the 'ambiguous' horses could be any of the three species. These identification issues also affect the broader donkey metacarpals, where there is a clear overlap with the mules and also to some extent with the horses. The t-tests showed that the 'ambiguous 'donkeys were more similar to the horses and mules than to the donkeys.

Table 6.43. Summary statistics for the distal breadth / greatest length index for the archaeological metacarpals.

Category	n	Min	Max	Mean	SD
Horses	267	18.06	24.88	22.14	0.84
Mules	47	19.40	23.82	20.78	0.78
Donkeys	19	18.09	21.87	20.03	1.23
?Horses	73	19.60	22.68	21.52	0.67
?Mules	27	19.82	22.59	20.92	0.67
?Donkeys	10	19.97	22.42	21.12	0.79
Unknown	317	17.28	23.89	21.30	1.20

Table 6.44. Results of t-tests on the distal breadth / greatest length index for the archaeological metacarpals.

Pairing	t statistic	Probablilty	Significance
Donkeys v horses	1.9684	0.0000	**
Donkeys v mules	1.9977	0.0043	**
Horses v mules	1.9676	0.0000	**
?Donkeys v donkeys	2.0518	0.0179	*
?Donkeys v horses	2.0040	0.2224	N
?Donkeys v mules	2.0040	0.2224	N
?Mules v donkeys	2.0154	0.0029	**
?Mules v horses	1.9681	0.0000	**
?Mules v mules	1.9935	0.4387	N
?Horses v donkeys	1.9867	0.0000	**
?Horses v horses	1.9670	0.0000	**
?Horses v mules	1.9803	0.0000	**
Unknown v donkeys	1.9671	0.0000	**
Unknown v horses	1.9640	0.0000	**
Unknown v mules	1.9665	0.0042	**

The unknown specimens (Figure 6.55) show an interesting hint of bimodality, with a smaller group corresponding to the smaller donkey values and a larger group covering the horse - mule range. The t-tests showed that the unknown specimens as a group were unlike any of the three species, as would be expected from the much larger range and hint of bimodality. Although t-tests should only be applied to data with a normal distribution, they are being used here (and in cases further on) for consistency and comparability of results. Also, whilst the data appear possibly bi- or even poly-modal, the degree is slight and questionable.

Once again the horse data were examined first, and the split by period showed that there was no visible difference between the periods (Appendix Figure A7), confirmed by the summary statistics (Table 6.45) and t-tests (Table 6.46).

The Iron Age data (Figure 6.56) show that the horses from Gaul seem to be more slender in their distal dimensions than those from the other regions. Although the numbers are small, this is in part confirmed by the t-tests that suggest that there is a significant difference between the Gallic horses and their Danube - Balkans counterparts (Table 6.46). This difference was not observable in the Roman data (Appendix Figure A8) and indeed there were no significant differences between the areas at all in this period.

Table 6.45. Summary statistics for the distal breadth / greatest length index for the 'identified' archaeological metacarpals

Category	n	Min	Max	Mean	SD
Iron Age horses	45	18.06	23.35	22.00	0.93
Roman horses	80	19.60	24.21	22.24	0.80
External horses	142	20.40	24.88	22.13	0.84
Roman mules	44	19.40	23.82	20.78	0.79
Iron Age donkeys	6	18.09	21.87	20.34	1.40
Roman donkeys	7	18.10	21.58	19.53	1.29
External donkeys	6	19.30	21.54	20.32	0.96
Iron Age area D horses	16	20.79	23.16	21.50	0.58
Iron Age area E horses	12	18.06	23.30	22.12	1.38
Iron Age area F horses	7	21.17	23.25	22.35	0.74
Iron Age area G horses	9	21.84	23.35	22.43	0.53
Roman area D horses	6	21.92	23.81	22.71	0.78
Roman area E horses	9	21.57	23.44	22.44	0.58
Roman area F horses	31	20.66	24.08	22.01	0.78
Roman area G horses	32	19.60	24.21	22.30	0.84
Roman area F mules	18	19.40	23.82	20.65	1.02
Roman area G mules	22	19.83	21.62	20.78	0.56

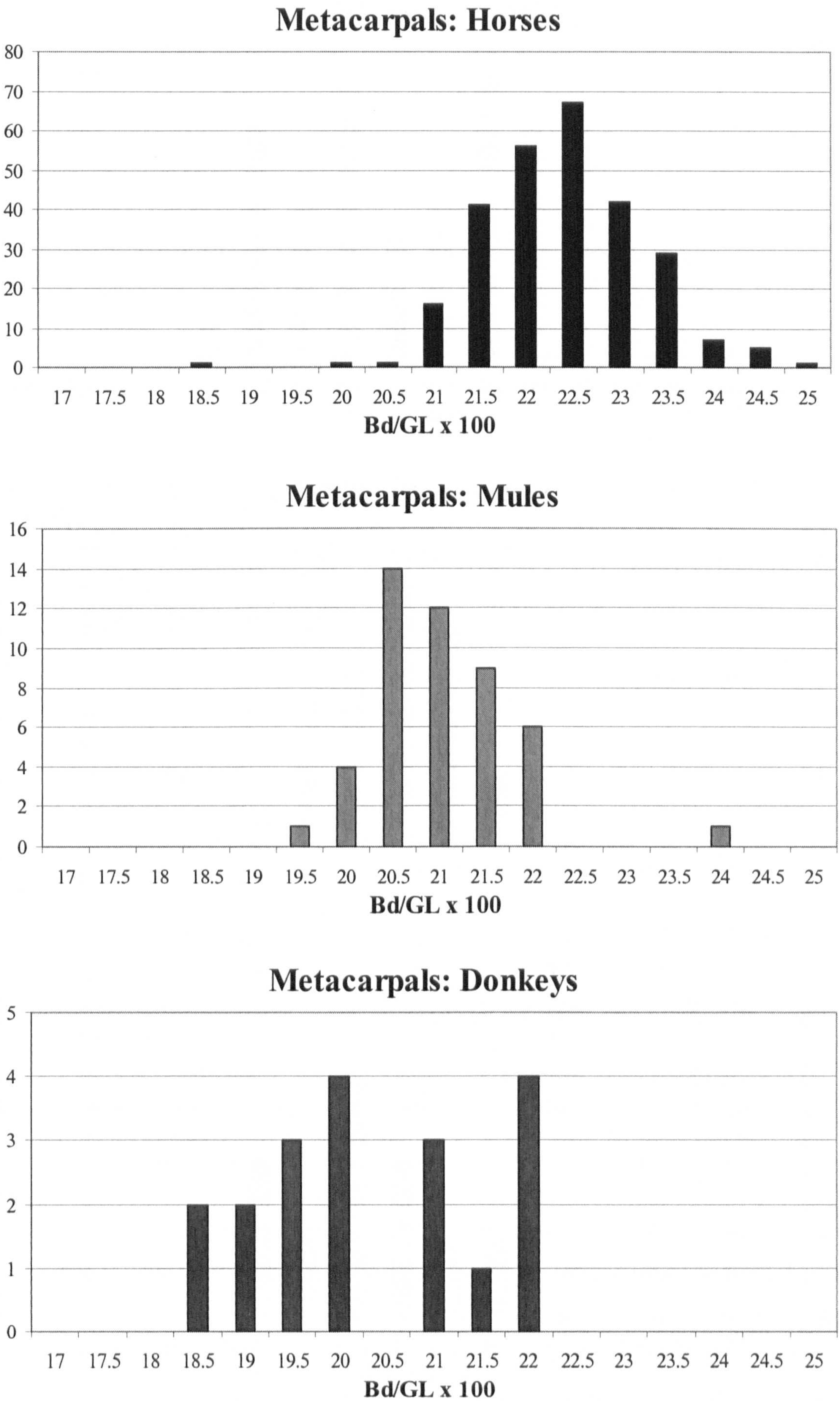
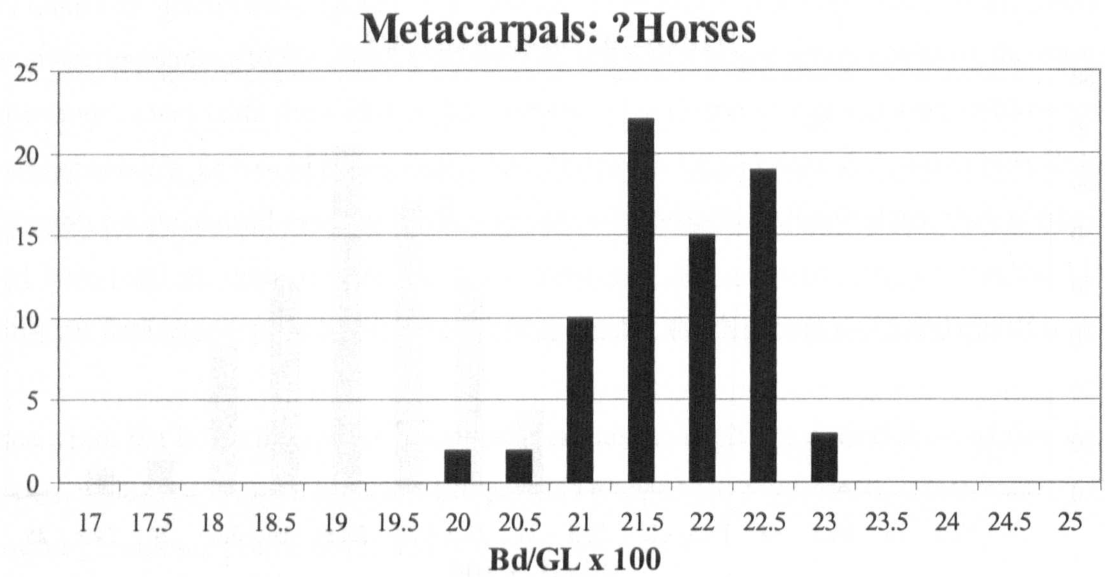
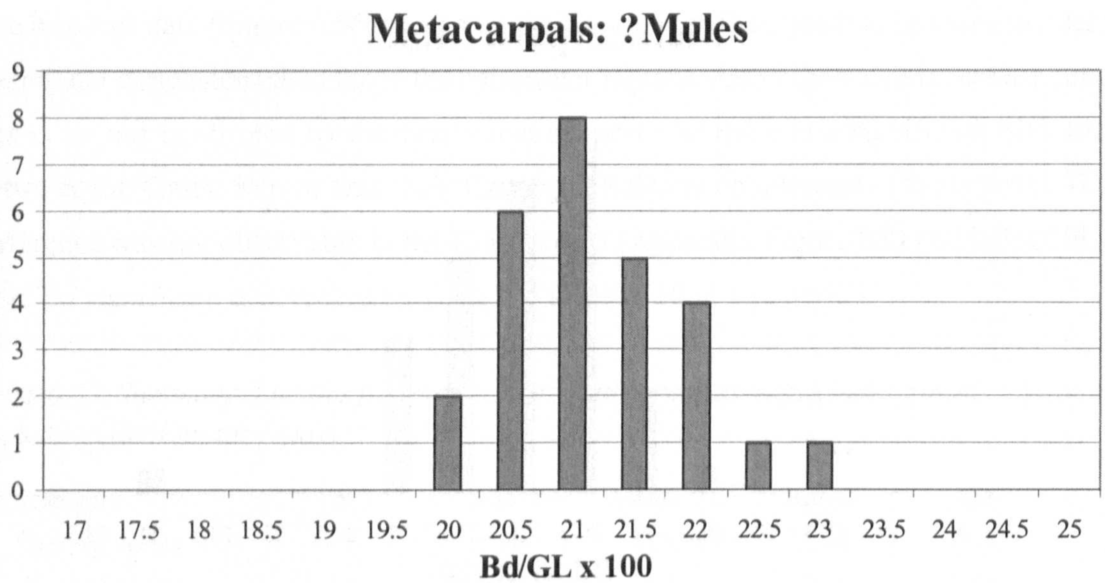


Figure 6.53. Histograms of distal breadth / greatest length index for 'identified' archaeological metacarpals.





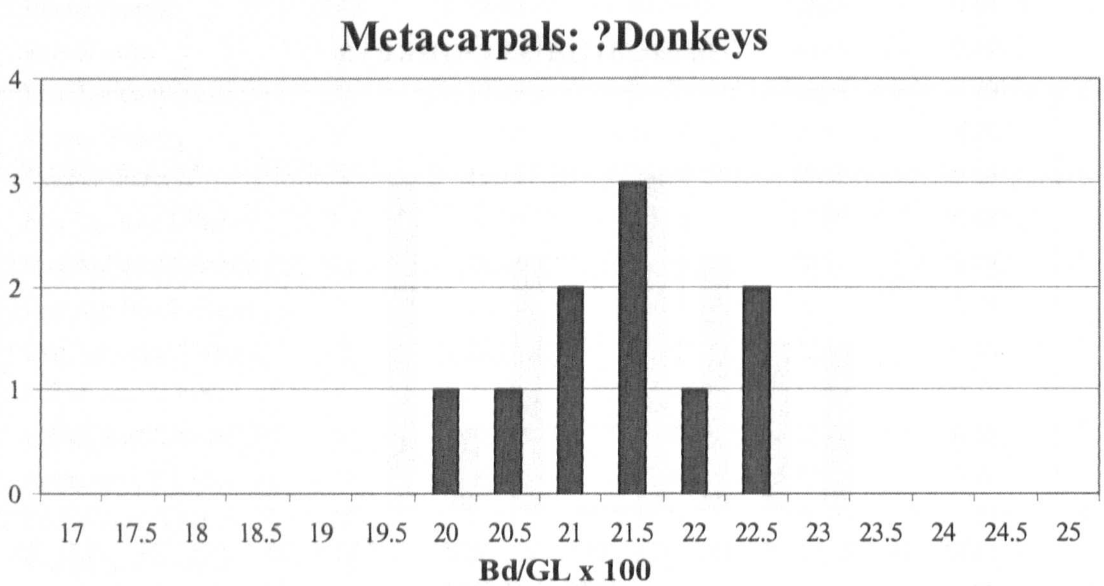


Figure 6.54. Histograms of distal breadth / greatest length index for 'ambiguous' archaeological metacarpals.

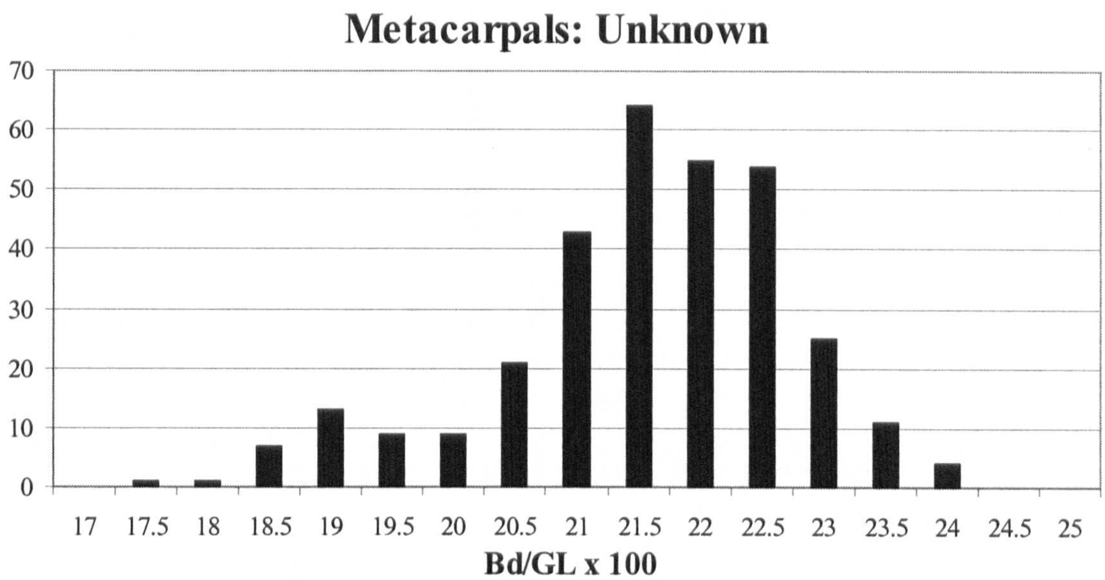


Figure 6.55. Histograms of distal breadth - greatest length index for unknown archaeological metacarpals.

Table 6.46. Results of t-tests on the distal breadth / greatest length index for the 'identified' archaeological metacarpals.

Pairing	t statistic	Probablilty	Significance
Iron Age v External horses	1.9729	0.3682	N
Iron Age v Roman horses	1.9794	0.1225	N
External v Roman horses	1.9708	0.3303	N
Roman horses v mules	1.9796	0.0000	**
Iron Age areas D v E horses	2.0555	0.1127	N
Iron Age areas D v G horses	2.0639	0.0009	**
Iron Age areas E v G horses	2.0860	0.6084	N
Roman areas E v F horses	2.0244	0.1366	N
Roman areas E v G horses	2.0227	0.6507	N
Roman areas F v G horses	1.9996	0.1583	N
Iron Age v Roman area E horses	2.0930	0.5289	N
Iron Age v Roman area G horses	2.0211	0.8244	N
Roman F v G mules	2.0244	0.6097	N

For the mules, the smaller number once again restricted the subsequent analyses. As with the difference between the species overall, the Roman horses and mules showed the same highly significant degree of separation (Table 6.46). The only other split of data that could be undertaken was the Roman period data by area (Appendix Figure A9). There were sufficient numbers in the Rhineland and Danube and Balkans areas for a t-test to be undertaken and the results showed that there was no significant difference between the areas. This all helps to confirm the uniformity of the mules across the Roman Empire.

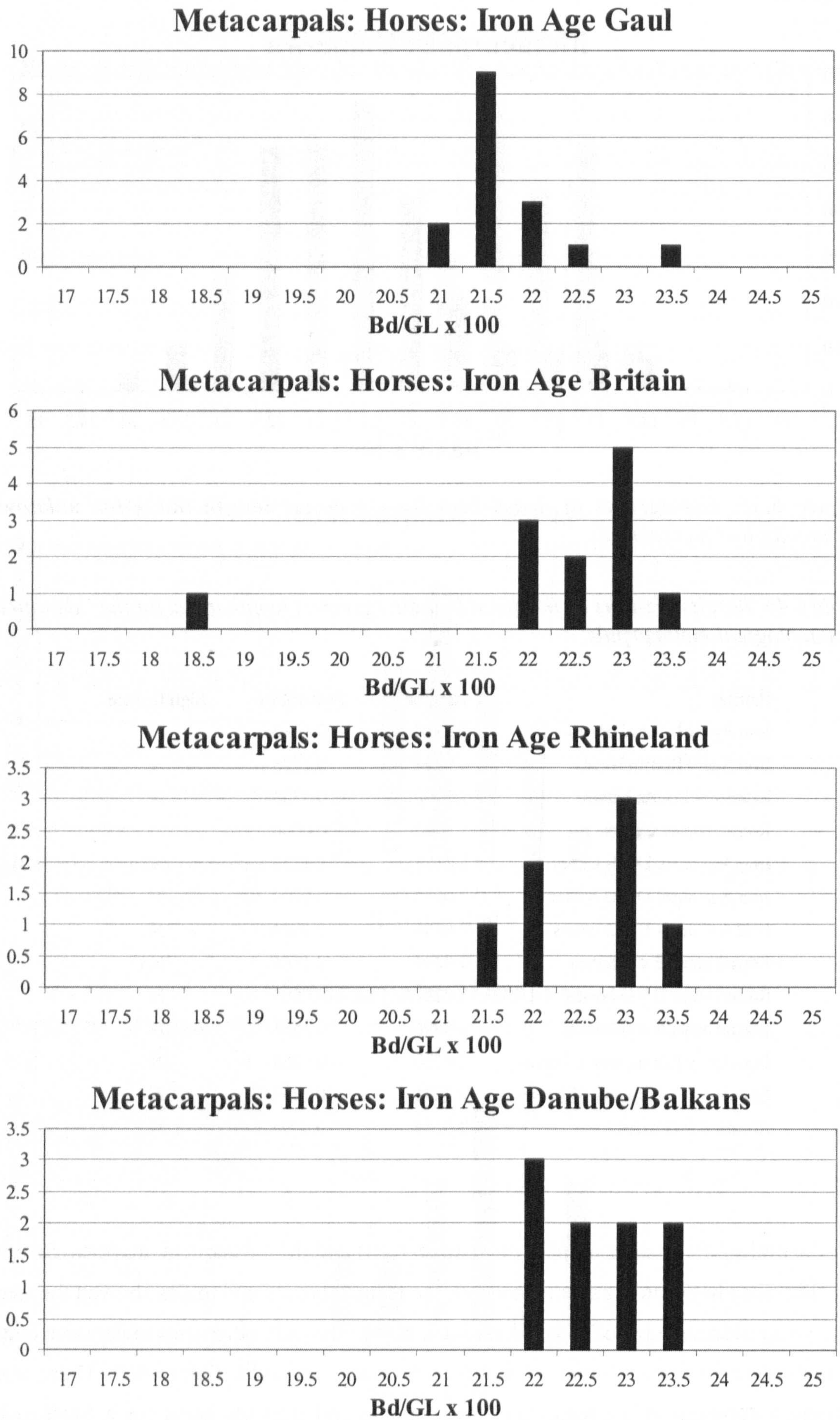


Figure 6.56. Histograms of distal breadth / greatest length index for 'identified' archaeological Iron Age horse metacarpals by area.

In summary, the calculation of the indices on the metacarpals has shown that there are several differences that can be used to both characterise the differences between the species and variations within species. The species differences are clearest using a combination of the indices, as each one individually does not show the whole picture. Visual inspection of the proximal breadth index indicated that there was very little variation between the species, but the t-tests showed that there were significant differences, with the horses most robust and the donkeys narrowest. The shaft breadth index however, indicated that when the data from all periods were lumped together there was no significant difference between the horses and mules but that the donkeys were considerably more slender than either. However, the Iron Age and Roman horse metacarpals were significantly more robust than both the External horses and the contemporaneous mules. Using the distal breadth index showed that the horses were much broader at this joint than either the donkeys or mules, and that all three were significantly different from each other.

Therefore horses (except the External horses) have more robust shafts and broader distal ends than mules and donkeys, and donkeys have more slender proximal and distal ends than either horses or mules. The very slender shafts of the External horses seem more likely to be due to genetic variation than to nutritional stress or sexual dimorphism. In general, the Roman and Iron Age horses and mules present a very uniform picture in terms of their shape indices, across time periods and geographic areas. The slight exception to this is the hint that the Iron Age Gallic horses are more slender in their articular breadths than those from other areas.

6.3.2. Calculation of shape indices on metatarsals

Shaft breadth to greatest length index

A total of 585 metatarsals had both the greatest length and shaft diameter measurements to allow analysis of the shaft breadth to greatest length (SD/GL x 100) to be undertaken. Of these 272 were 'identified', 47 'ambiguous' and 266 unknown. Examining the data for the identified specimens first, there were 193 horses, 62 mules and 17 donkeys. The results of calculating the shaft breadth index on these specimens are shown in Figures 6.56 - 59. Details of these results can be found in Appendix Table A29. Results that replicate the results from the metacarpals will not be illustrated in the text but in the Appendix.

In Figure 6.57 there is a clear difference between the modal index class of the horses and the other two species. The mule and donkey modal classes fall one class lower than the horses. The differences are less clearly borne out by the mean values (Table 6.47). However, because the standard deviations are so low, the t-tests performed on these data (Table 6.48), showed that the slenderness of the horse metatarsals was highly significantly different to both the mules and donkeys but the last two were not significantly different from each other. This is different to the metacarpals, where the horses and mules were not significantly different, although slight differences were observable in Figure 6.41. This suggests that whilst the mules take the length of their metapodials from the mare (Section 6.2), their slenderness is more akin to the jackass, and this is more marked in the hindlimb than the forelimb.

Table 6.47. Summary statistics for the shaft breadth / greatest length index for the archaeological metatarsals

Category	n	Min	Max	Mean	SD
Horses	193	9.56	14.40	11.44	0.76
Mules	62	9.40	12.37	10.99	0.74
Donkeys	17	9.12	11.93	10.63	0.72
?Horses	36	9.25	12.50	11.23	0.72
?Mules	11	9.92	11.80	10.54	0.64
Unknown	266	9.58	14.94	11.35	0.73

Table 6.48. Results of t-tests on the shaft breadth / greatest length index for the archaeological metatarsals.

Pairing	t statistic	Probablilty	Significance
Donkeys v mules	1.9913	0.0795	N
Donkeys v horses	1.9714	0.0000	**
Mules v horses	1.9694	0.0001	**
?horses v horses	1.9705	0.1283	N
?horses v donkeys	2.0076	0.0071	**
?horses v mules	1.9850	0.1259	N
?mules v mules	1.9939	0.0612	N
?mules v donkeys	2.0555	0.7290	N
?mules v horses	1.9718	0.0002	**
Unknown v horses	1.9652	0.1885	N
Unknown v donkeys	1.9684	0.0001	**
Unknown v mules	1.9673	0.0006	**

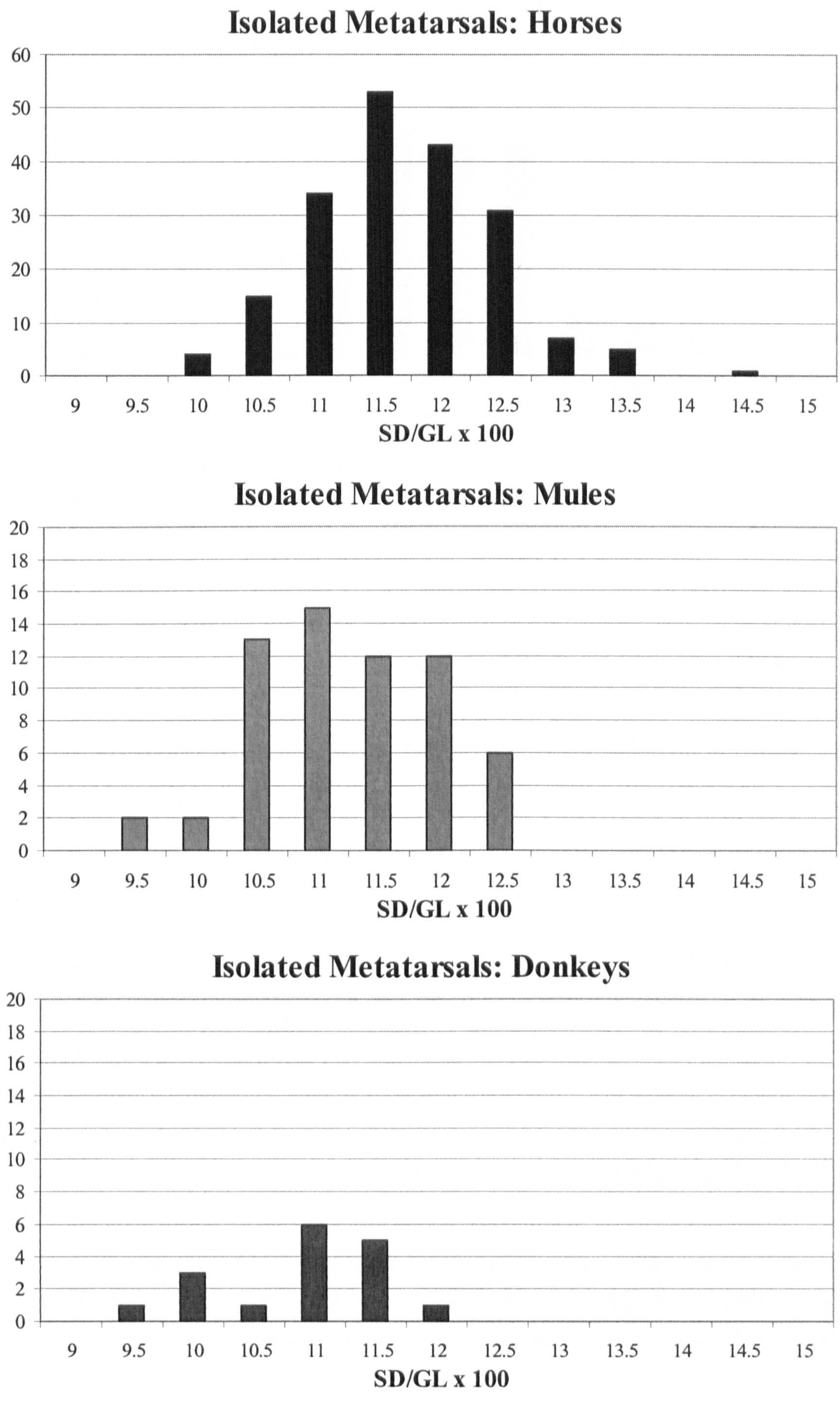


Figure 6.57. Histograms of shaft breadth / greatest length index for the 'identified' archaeological metatarsals.

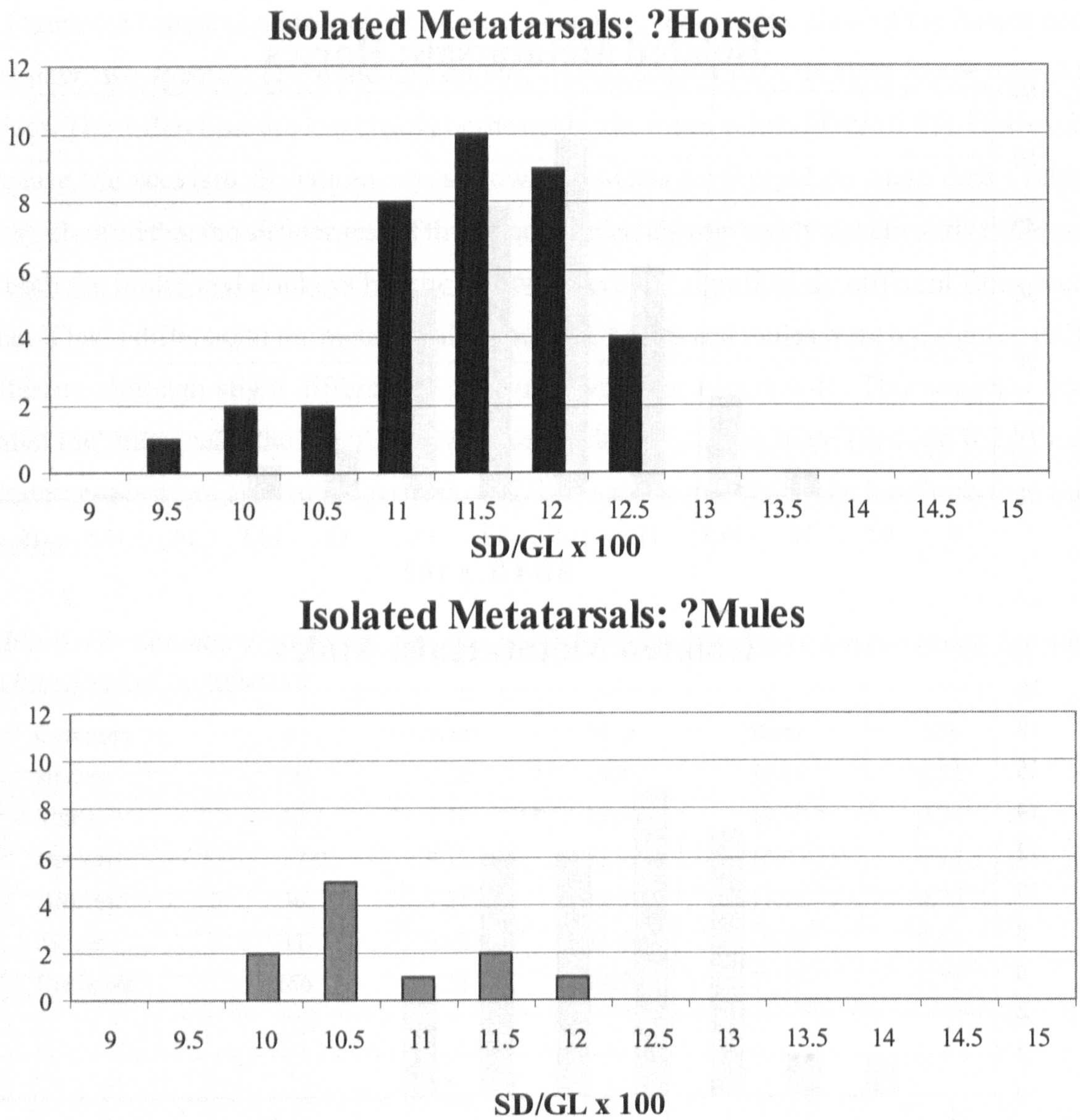


Figure 6.58. Histograms of shaft breadth / greatest length index for the 'ambiguous' archaeological metatarsals.

When we turn to the 'ambiguous' material, the pattern that emerges is different to that observed for the withers height estimations. Figure 6.58 shows that there is a clear separation of the modal classes of the 'ambiguous' horses and mules. Although the distribution of the 'ambiguous' horses is weighted towards the larger end of the scale, the substantial 'tail' produces a lower mean than for the identified horses. In this analysis it seems that maybe the confusion arises in the 'ambiguous' horses between slender horses and mules, and for the 'ambiguous' mules, between mules and donkeys. To test these slightly further, the same data were plotted on scatter plots with the identified material (Figure 6.59) to see if there was a consistent pattern of size and shape in the 'ambiguous' mules and horses.

Figure 6.59 shows that most of the horses fall towards the upper left side of the diagonal line drawn through the values where SD/GL = 11%. In contrast many of the mules fall to the lower right side of this line, confirming the indications seen in Figure 6.57 that the mules are more slender in the shaft than the horses. The 'ambiguous' mules are mostly falling at the smaller end of the range for the identified mules, in the area where it overlaps with the donkeys. This backs up the interpretation that the ambiguity is mostly one of size, as the smaller mule individuals are more like the donkeys in the slenderness of their metatarsals. In addition, the linear regression equations derived from the identified data in Figure 6.59 show that the gradient of the horse and mule 'best fit' lines are very similar but the intercept is lower for the mules, indicating generally more slender bones. The 'best fit' line for the donkeys has a much lower gradient and a higher intercept than either of the others, showing that the proportions of the donkey bones are different to the other two.

There is one group of 'ambiguous' horses at the larger end of the range that is perhaps 'ambiguous' because the individuals are tall and are being confused with the mules in this area, as stated previously. There are, however, a number of smaller 'ambiguous' horses that are also quite slender (SD/GL <11%), and these could easily be confused with the mules in this area on the slenderness of the shaft. However, there are also a number of 'identified' individuals in the same area so other aspects of shape must be playing a role in the identification. The t-tests (Table 6.48) showed that, as expected, the ambiguous horses are unlikely to be donkeys but could be either of the other two, and similarly the 'ambiguous' mules could be either mules or donkeys.

Figure 6.60 shows the results for the unknown specimens. As in the withers height analysis, the histogram covers nearly the same range as the combined identified material, with a bias towards the horse range. The t-tests (Table 6.48) backed up this observation. Of particular note are a few specimens with very large index values (greater than 13.5). Although these appear to be very robust specimens, a pathological cause for this robusticity cannot be ruled out from the data available.

As with the metacarpals, the numbers of specimens available to study were less than they were for the withers height analyses, because only results from a single element could be studied. Examining the data for the identified horses first of all, the data were grouped by period, area and site type, using the same categories as for the withers height analysis. Figure 6.61 shows the data split by period and is in some ways similar to the withers height analysis, with the Roman horses being more robust as well as taller than their Iron Age counterparts.

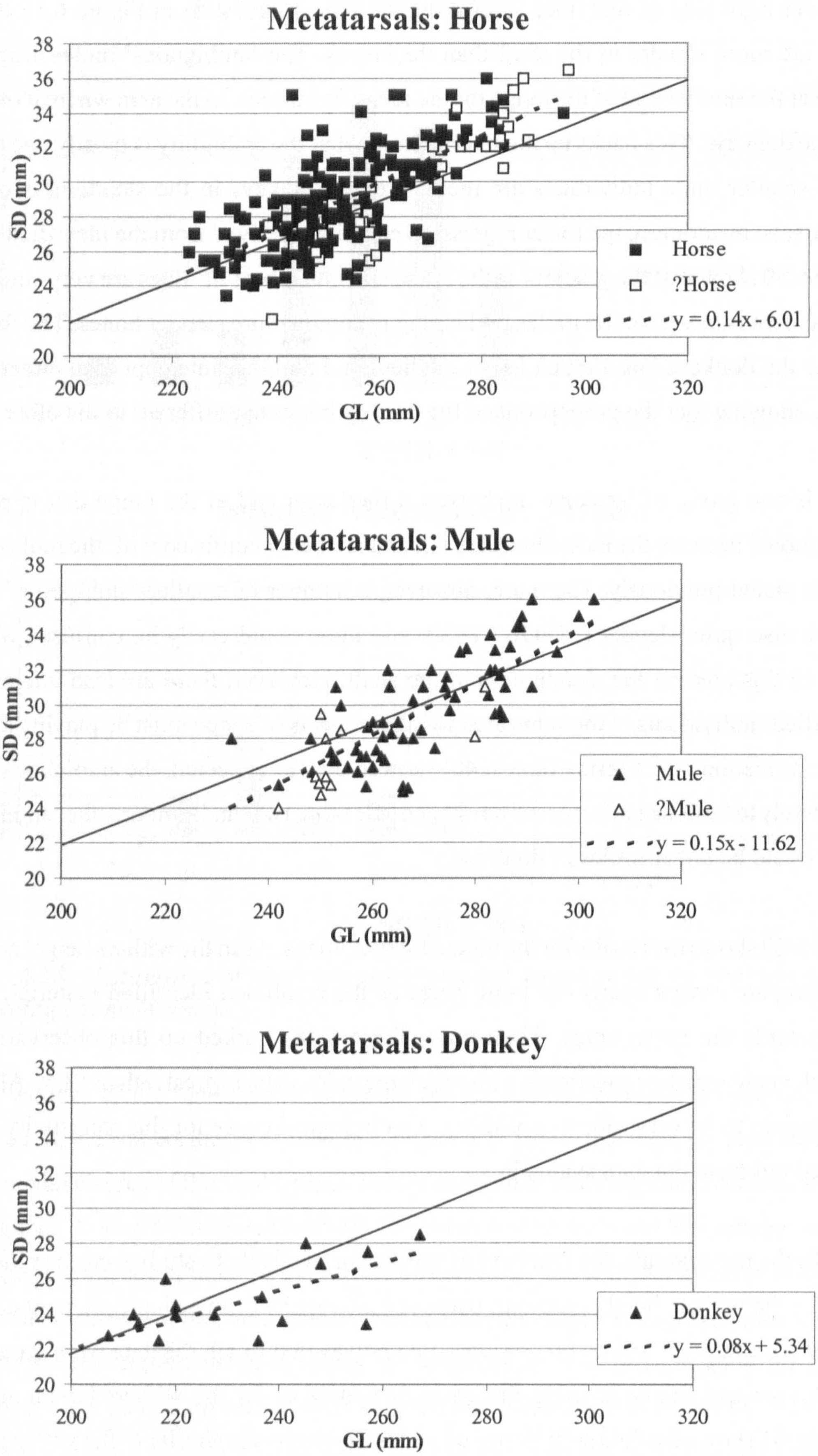


Figure 6.59. Scatter plots of shaft breadth against greatest length for the 'identified' and 'ambiguous' archaeological metatarsals. Solid diagonal lines show SD/GL = 11%.

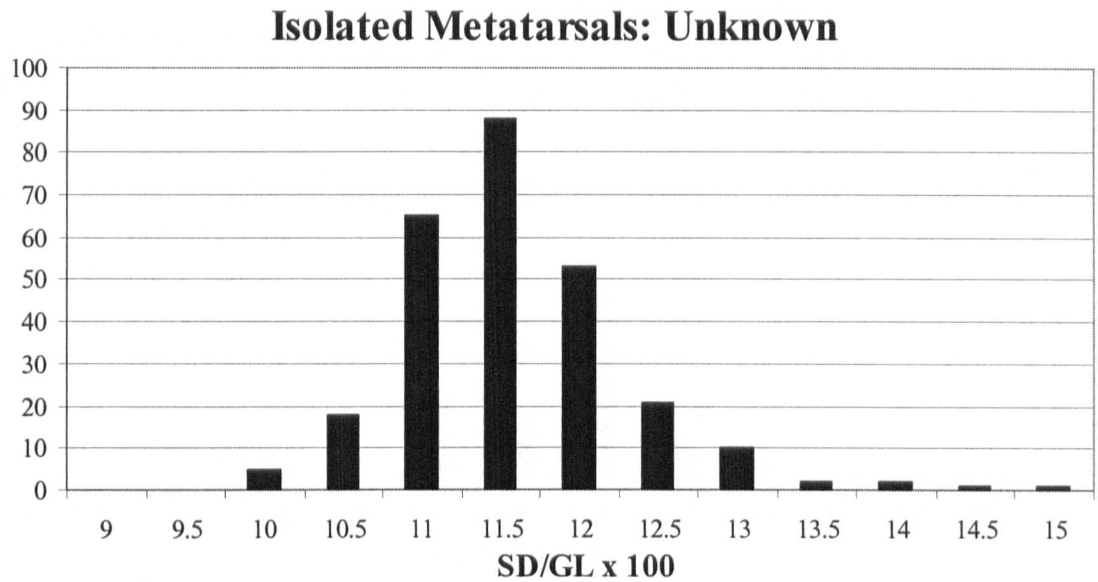


Figure 6.60. Histogram of shaft breadth / greatest length index for the 'unknown' archaeological metatarsals.

The External horses have very slender metatarsals in comparison with the Iron Age and Roman horses. This is reflected in the t-test results (Table 6.50), which showed that the External data are highly significantly different to both other periods and that the Iron Age and Roman data are significantly different from each other.

Table 6.49. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological horse metatarsals

Category	n	Min	Max	Mean	SD
Iron Age	30	10.32	13.31	11.52	0.63
Roman	71	10.10	14.40	11.83	0.69
External	92	9.56	13.29	11.11	0.70
Iron Age area D	13	10.32	12.44	11.48	0.55
Iron Age area E	8	10.60	12.37	11.39	0.58
Iron Age area G	9	10.83	13.31	11.70	0.81
Roman area D	12	10.40	12.13	11.42	0.50
Roman area E	15	11.11	13.29	11.87	0.59
Roman area F	18	10.81	12.81	11.91	0.60
Roman area G	23	10.61	14.40	12.03	0.79
Cemetery	5	11.30	12.22	11.69	0.43
Military	10	10.61	14.40	11.94	1.06
Rural	4	11.14	13.26	12.00	0.90
Urban	26	10.81	13.29	11.98	0.55
Urban 2	14	10.40	12.15	11.45	0.50
Vicus	4	11.05	12.81	12.09	0.86
Villa	7	11.11	12.53	11.89	0.48

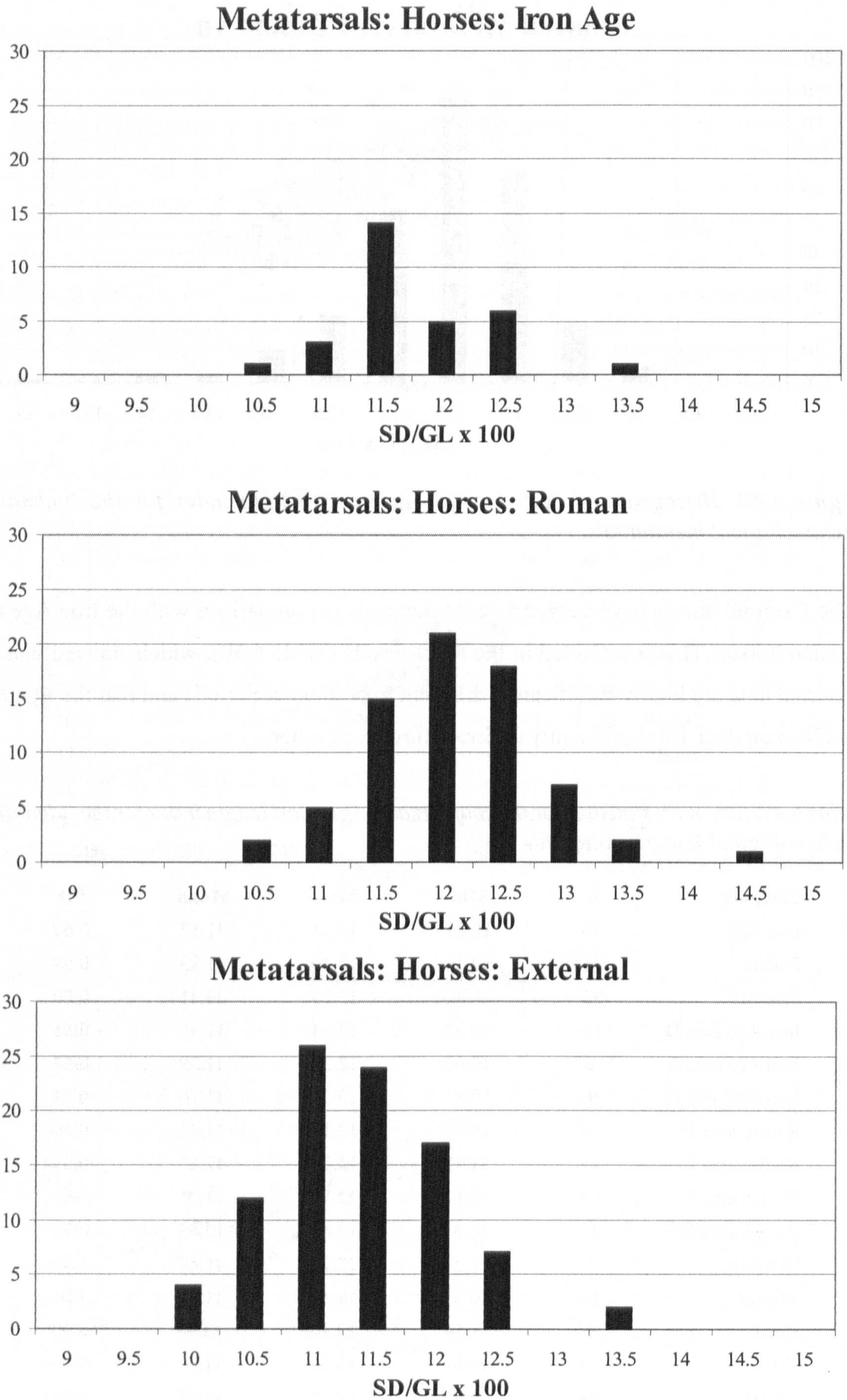


Figure 6.61. Histograms of the shaft breadth / greatest length index for the 'identified' archaeological horse metatarsals by period.

Table 6.50. Results of t-tests on the shaft breadth / greatest length index for the 'identified' archaeological horse metatarsals

Pairing	t statistic	Probablilty	Significance
Iron Age v External	1.9799	0.0047	**
Iron Age v Roman	1.9842	0.0358	*
External v Roman	1.9748	0.0000	**
Iron Age area D v E	2.0930	0.7145	N
Iron Age area D v G	2.0860	0.4662	N
Iron Age area E v G	2.1315	0.3846	N
Roman area D v E	2.0595	0.0442	*
Roman area D v F	2.0484	0.0262	*
Roman area D v G	2.0345	0.0199	*
Roman area E v G	2.0281	0.5045	N
Roman area E v F	2.0395	0.8585	N
Roman area F v G	2.0227	0.5851	N
Iron Age v Roman area D	2.0687	0.7593	N
Military v Urban	2.0345	0.8355	N
Military v urban 2	2.0739	0.1424	N
Urban v urban 2	2.0244	0.0051	**

The data for the Iron Age horses, split by region, gave low numbers of specimens: 13 for Gaul, eight for Britain and nine for the Danube and Balkans. The data are presented graphically in Appendix Figure A10 as there were no obvious differences between the regions. The t-tests (Table 6.50) also reflected this, with no significant differences between the regions, but it must be borne in mind that because the number of specimens is low these results are only an indication of the likely significance.

The numbers of specimens are slightly higher for the Roman data when split by area, and the results are given in Figure 6.62. The most noticeable difference between the regions is the distribution of the Gaul dataset. Although there is a bias towards the more robust individuals within the range, both the maximum and minimum values are lower than for the other three regions and the range is also narrower. This is reflected in the t-tests (Table 6.50) with the horses from Gaul being significantly different to those from the other three regions, which were not significantly different from each other. Interestingly, there is also no significant difference between the slenderness of the metatarsals of the Iron Age and Roman horses from Gaul. This might suggest that in Roman Gaul horses were being bred locally from stock that still retained the conformation of pre-conquest horses. Alternatively it could be the result of post-weaning malnutrition or sexual dimorphism. Discussion of this has been made earlier in reference to the External horse metacarpals and will be continued below.

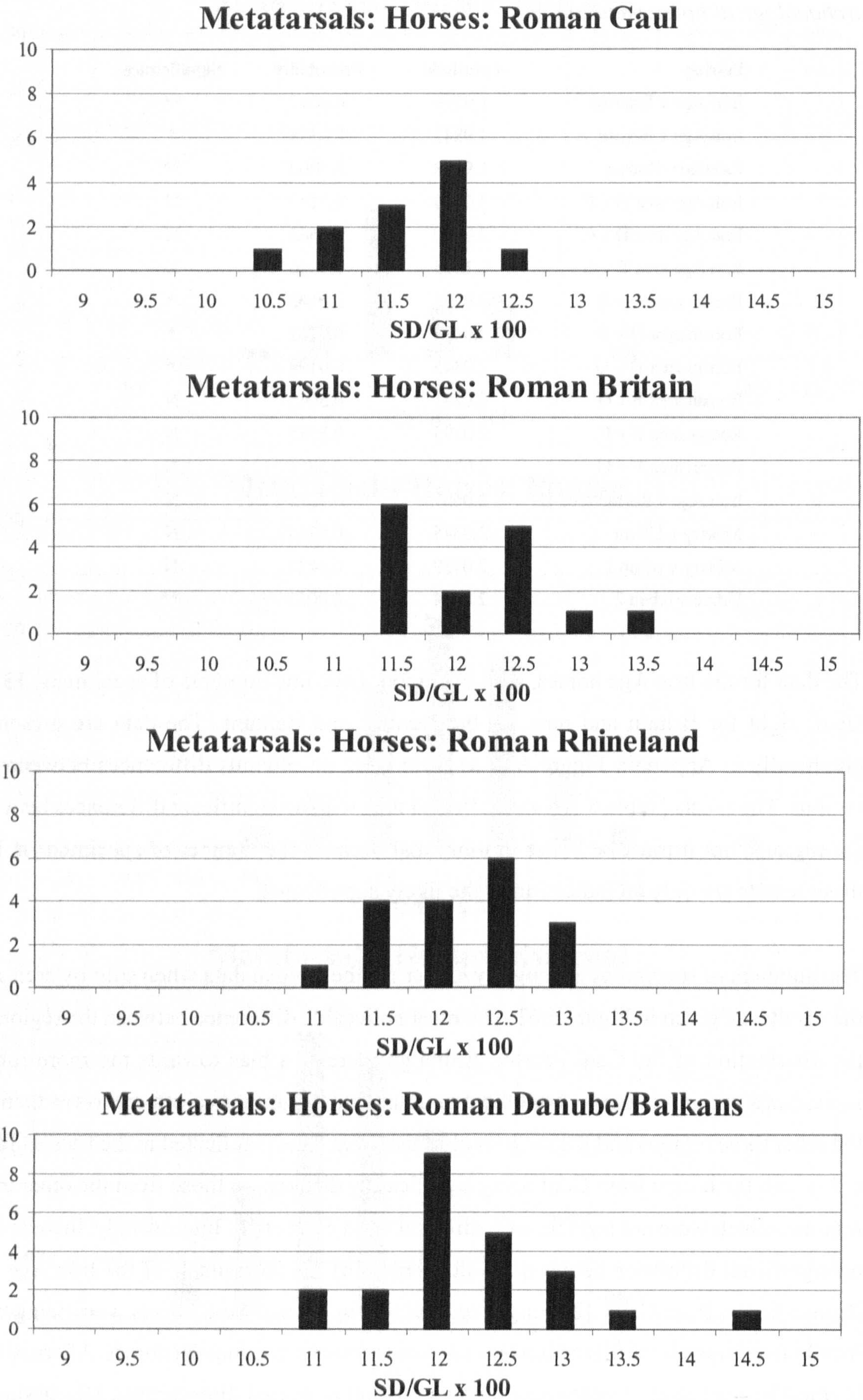


Figure 6.62. Histograms of the shaft breadth / greatest length index for the 'identified' Roman archaeological horse metatarsals by area.

Splitting the Roman horse data by site type again produced rather low numbers in each category but did produce some interesting results. Figure 6.62 shows that there are slight differences between the site types, particularly between the urban and urban 2 site types (large towns, and small towns respectively). This difference is reflected in the t-test results, with the urban and urban 2 groups being highly significantly different. The small numbers of the military specimens may be influencing the results, as they are not significantly different to either of the other two groups. The difference between the urban and urban 2 groups is that the urban 2 horses seem to be more slender limbed than their urban counterparts. This discernible difference is in contrast to the withers height analysis, which failed to show any differences between the site types. It is perhaps to be expected that the horses in the larger towns and cities were more robust (closer to the ideal Roman model, as discussed in Chapter 1) than those in the smaller towns.

From the analysis of the shaft breadth index of the metatarsals it seems that there are differences in limb slenderness between groups of horses that showed no differences in withers height. This suggests that the horses were not as homogeneous as the withers height data indicated.

The numbers of mules were considerably fewer than the horses and so the amount of grouping into smaller subsets that can be usefully achieved is also reduced. Splitting the mule data by period (Figure 6.64) shows that, as usual, there are very few Iron Age mules. Figure 6.64 also shows that the Roman and External data have opposite biases to their distributions, the Roman data being biased towards the more robust individuals and the External data towards the more slender limbed specimens. However, because the overall ranges and means are quite similar (Table 6.51), the t-tests showed that there was a significant difference at $P<0.05$ but not at $P<0.01$ (Table 6.52). This pattern of more slender limbed mules in the areas External to the Empire is the same as that seen for the horses. Two possible explanations for this can be put forward: either the mules were bred locally from local horses, or the mules that were used as pack animals going to these areas were not as robust as those used internally within the Empire.

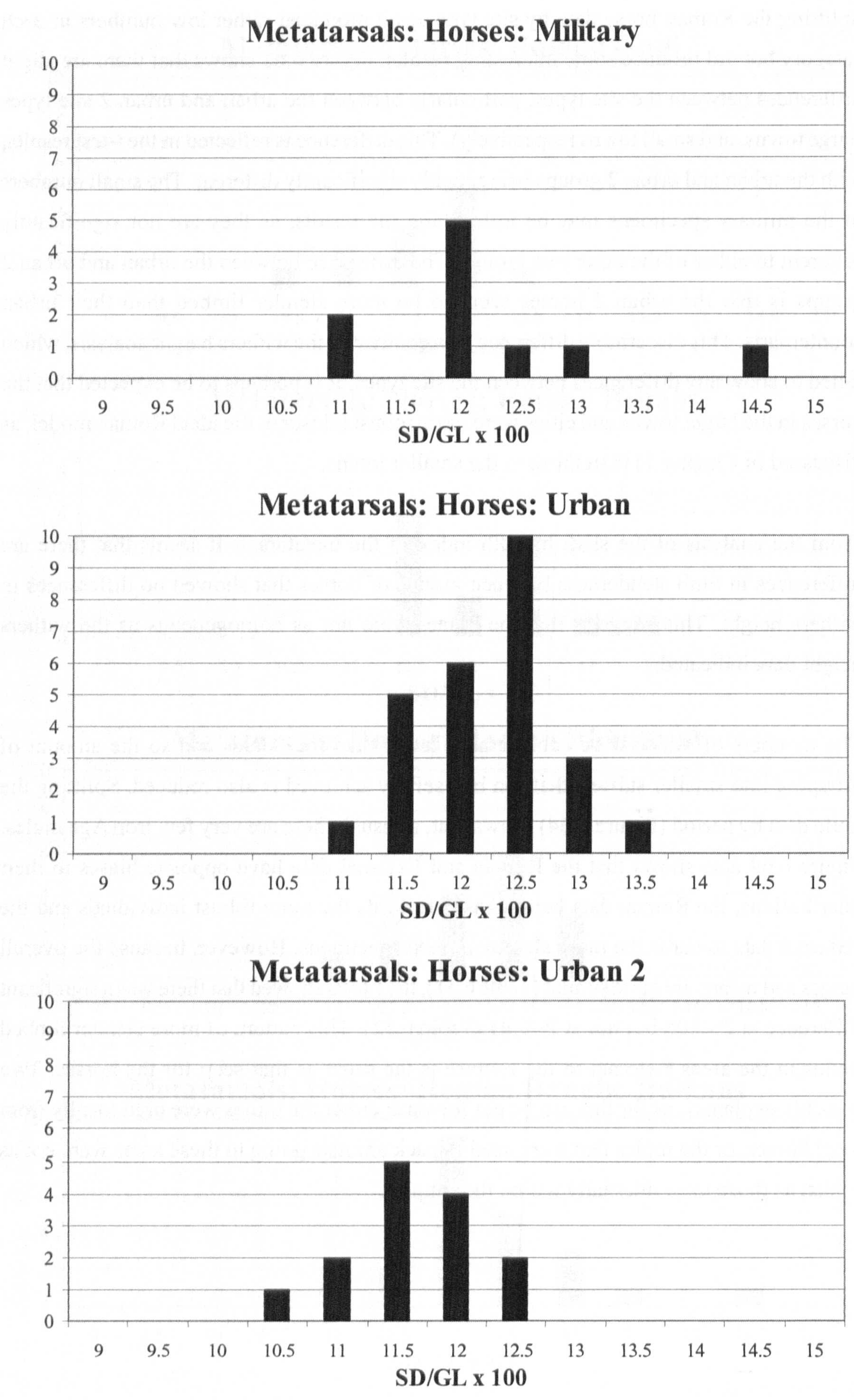


Figure 6.63. Histograms of the shaft breadth / greatest length index for the 'identified' archaeological Roman horse metatarsals by site type.

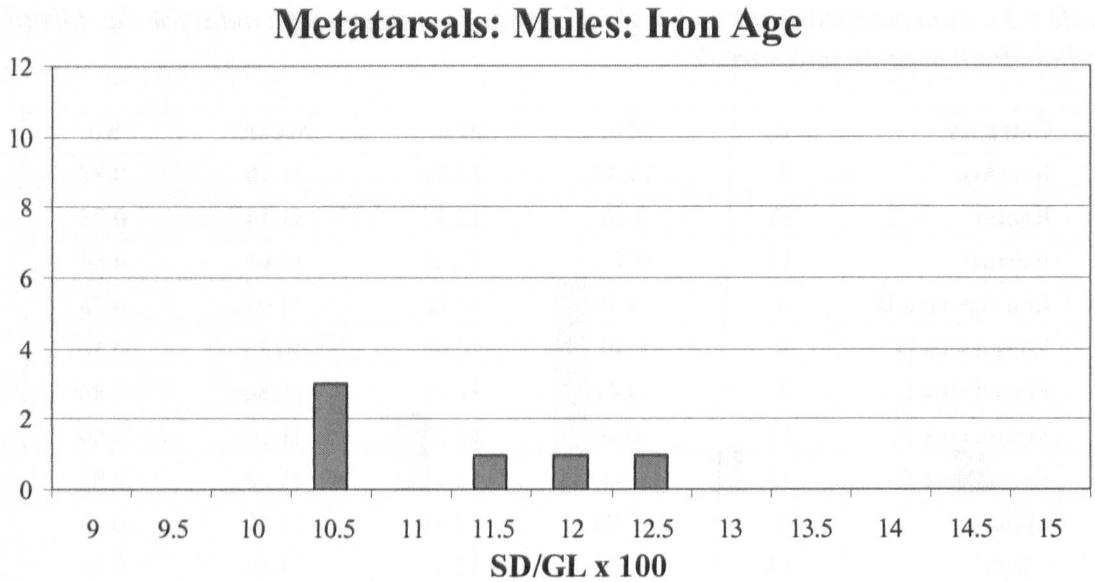
Table 6.51. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological mule metatarsals

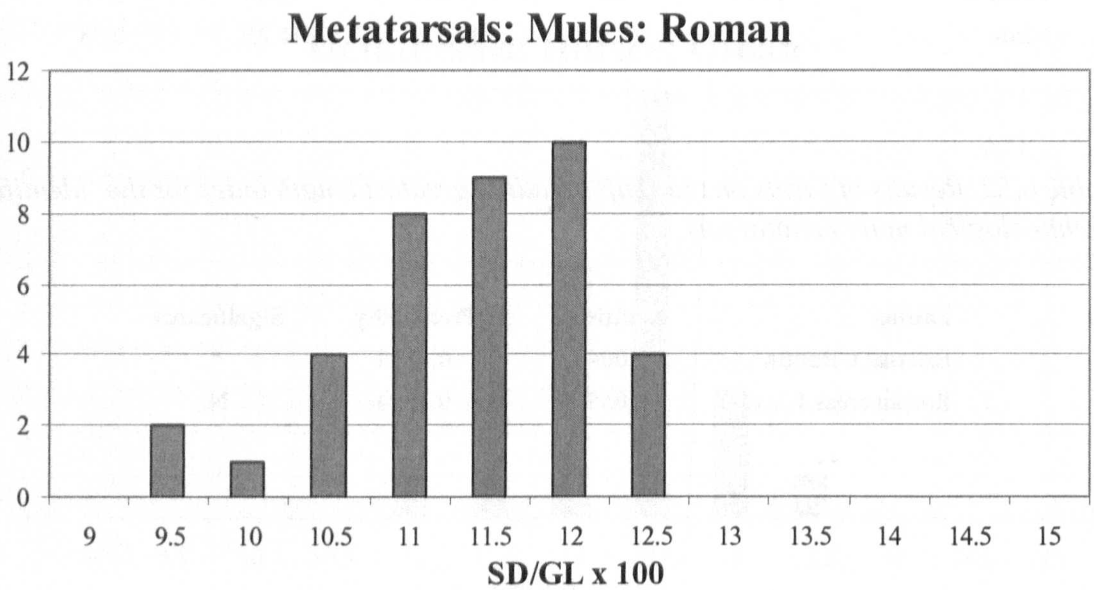
Category	n	Min	Max	Mean	SD
Iron Age	6	10.39	12.02	11.10	0.77
Roman	38	9.40	12.37	11.14	0.75
External	18	9.77	12.25	10.65	0.60
Iron Age area D	4	10.39	12.02	11.03	0.78
Roman area D	4	9.40	10.65	10.23	0.56
Roman area E	3	10.47	11.27	10.86	0.40
Roman area F	16	10.10	12.37	11.50	0.60
Roman area G	12	9.44	12.11	11.12	0.87
Military	6	10.83	12.01	11.45	0.41
Urban	14	9.44	12.11	11.16	0.84
Urban 2	4	9.40	11.27	10.44	0.78
Vicus	7	10.10	12.37	11.25	0.78

Table 6.52. Results of t-tests on the shaft breadth / greatest length index for the 'identified' archaeological mule metatarsals

Pairing	t statistic	Probablilty	Significance
External v Roman	2.0049	0.0198	*
Roman areas F v G	2.0555	0.1854	N

Grouping the Roman data by area again shows a similar pattern to that of the horses (Figure 6.65). Although the numbers of specimens are very small, the mules from Gaul seem to be slender limbed similar to the horses from the same region, and the same explanations for this difference probably apply here. The only areas where there were enough mules to test for significance were the Rhineland and Danube and Balkans areas, where no significant difference was found using t-tests (Table 6.52). The only site type containing more than a few mule specimens was the urban group (Figure 6.66). Therefore it was not possible to see if the trends observed for the horses were present in the mule data as well.





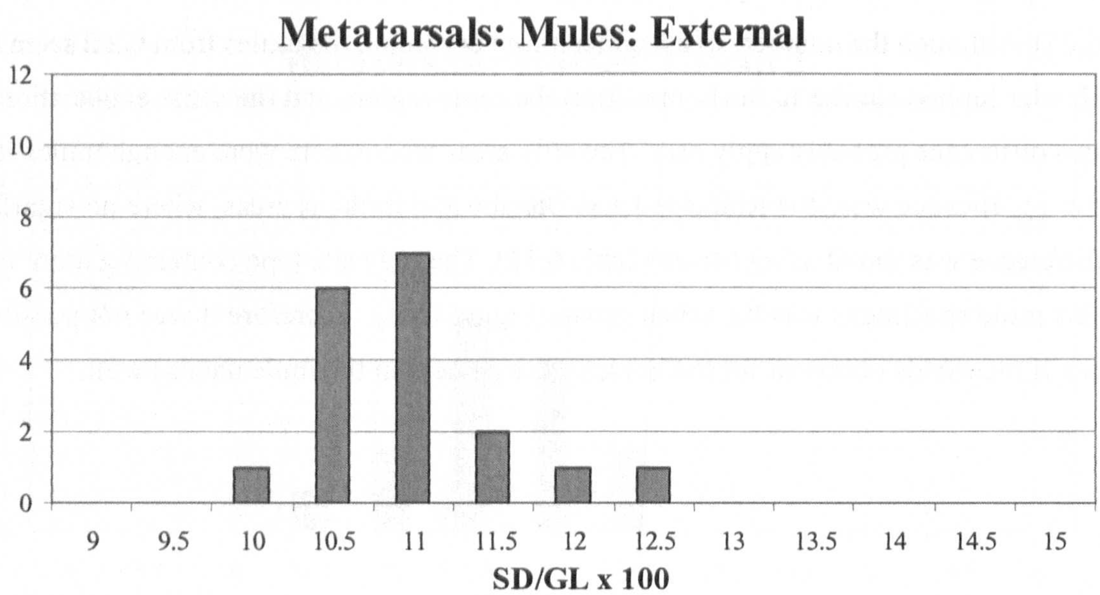


Figure 6.64. Histograms of the shaft breadth / greatest length index for the 'identified' archaeological mule metatarsals by period.

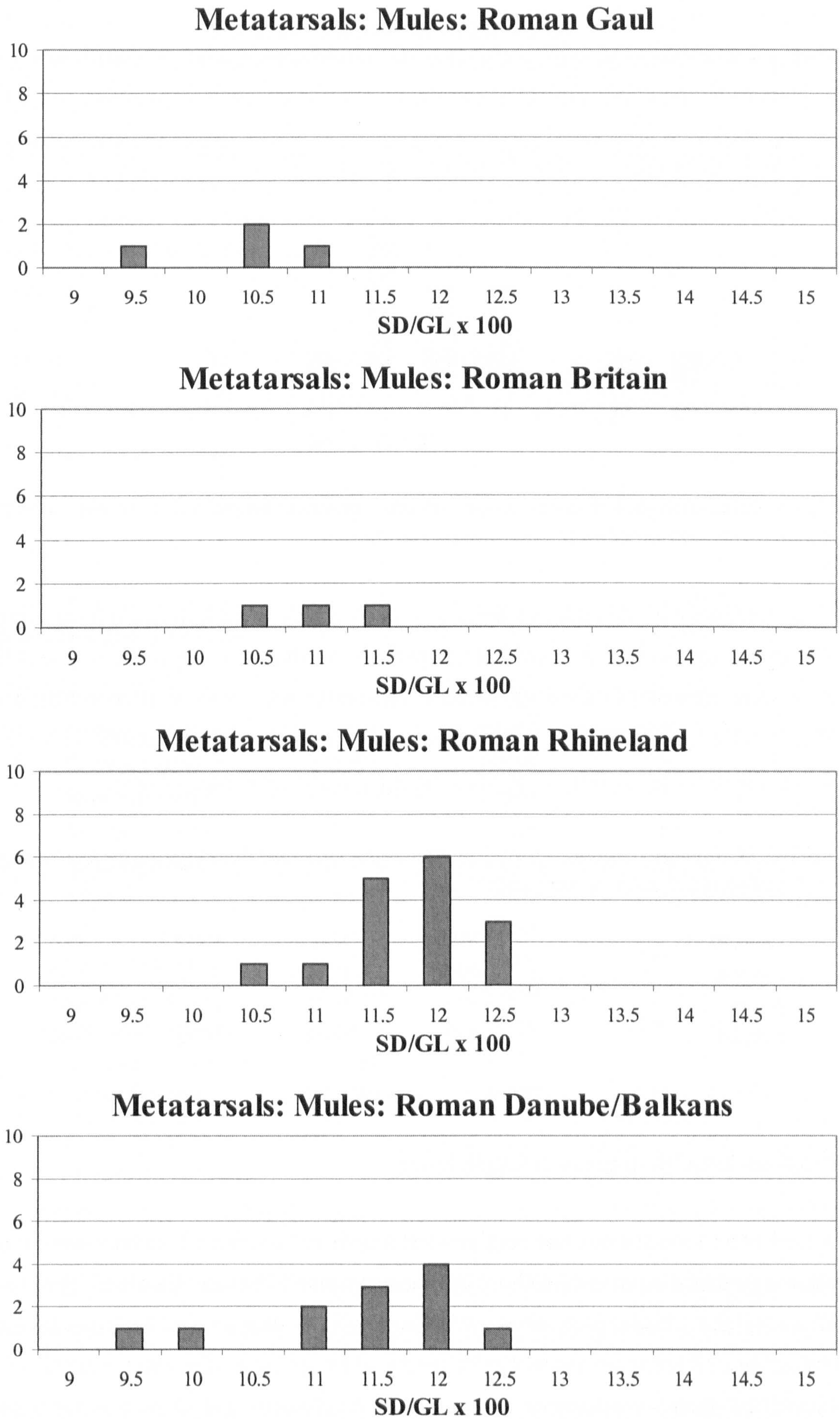


Figure 6.65. Histograms of the shaft breadth / greatest length index for the 'identified' Roman archaeological mule metatarsals by area.

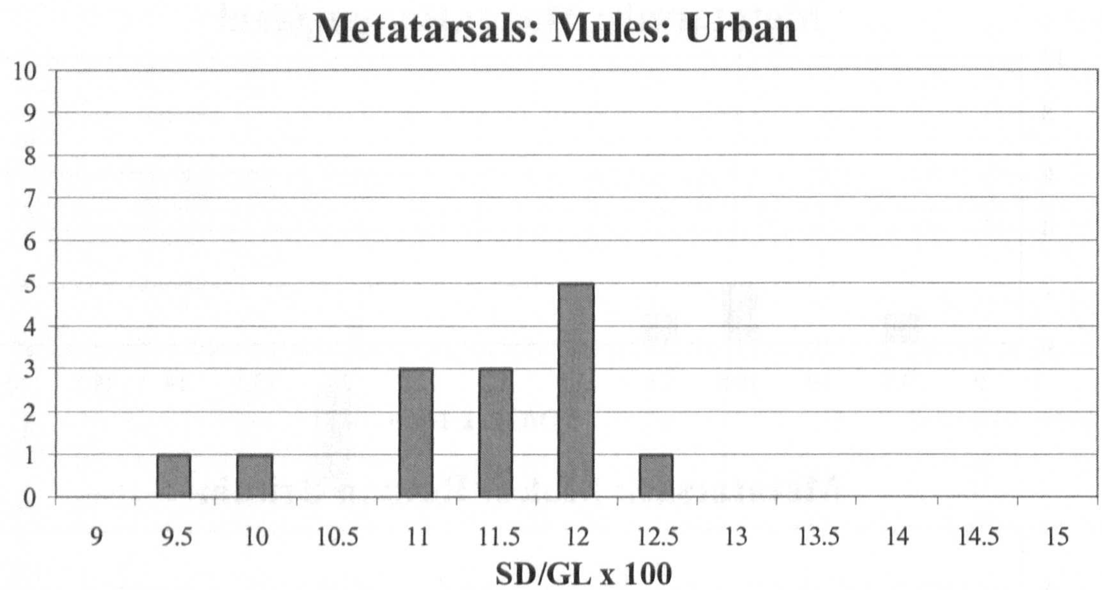


Figure 6.66. Histograms of the shaft breadth / greatest length index for the 'identified' Roman archaeological mule metatarsals by site type.

There were only 17 identified donkeys so very little further analysis could be undertaken. The results for the Iron Age and Roman periods are shown in Appendix Figure A11, as there were only two External specimens. The ranges were very similar and the means identical (Table 6.53). The small numbers precluded any t-tests being undertaken. No further data splits could be usefully undertaken because of the small sample size.

Table 6.53. Summary statistics for the shaft breadth / greatest length index for the 'identified' archaeological donkey metatarsals

Category	n	Min	Max	Mean	SD
Iron Age	7	9.85	11.14	10.65	0.44
Roman	8	9.53	11.43	10.65	0.67
External	2	9.12	11.93	10.52	1.99

Proximal breadth to greatest length index

A total of 553 metatarsals had both greatest length and proximal breadth measurements, allowing calculation of the Bp/Gl x 100 index. Of these 271 were 'identified' (192 horses, 62 mules and 17 donkeys), 47 were 'ambiguous' (36 ?horses and 11 ?mules) and the remaining 235 were unknown. Detailed results are given in Appendix Table A30. The 'identified' data are presented by species in Figure 6.67 and show that, as with the metacarpals, the mules are substantially more slender in their proximal index than the horses. This is also shown in the mean of each species (Table 6.54) and the t-tests (Table 6.55). The difference between the horses and mules is more pronounced with this index with the modal classes further apart than on the shaft slenderness index. As before, the donkeys are smaller than the other two species but overlap considerably with the mules.

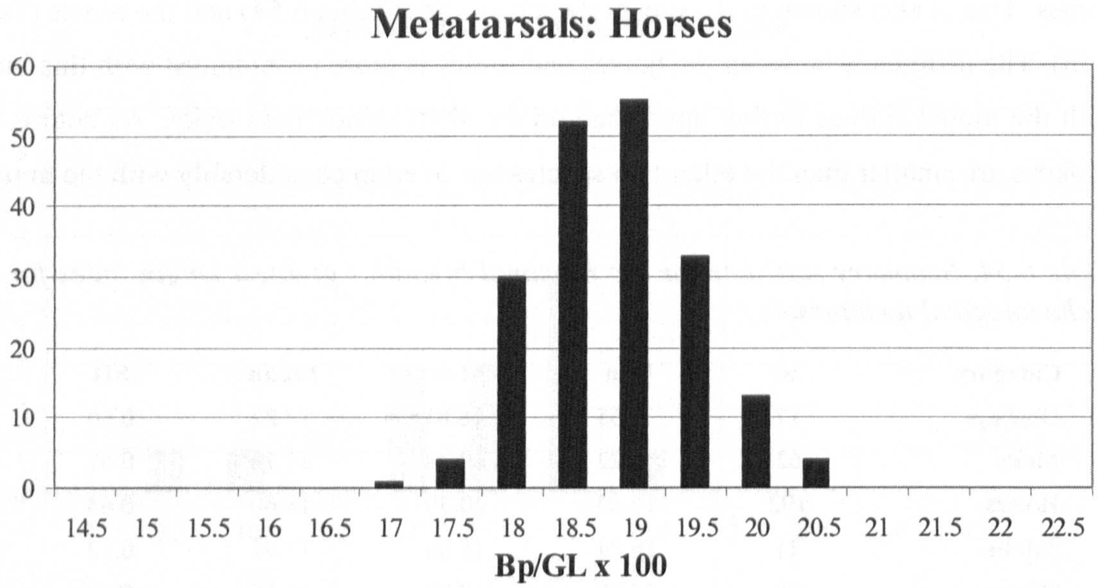
Table 6.54. Summary statistics for the proximal breadth / greatest length index for the archaeological metatarsals

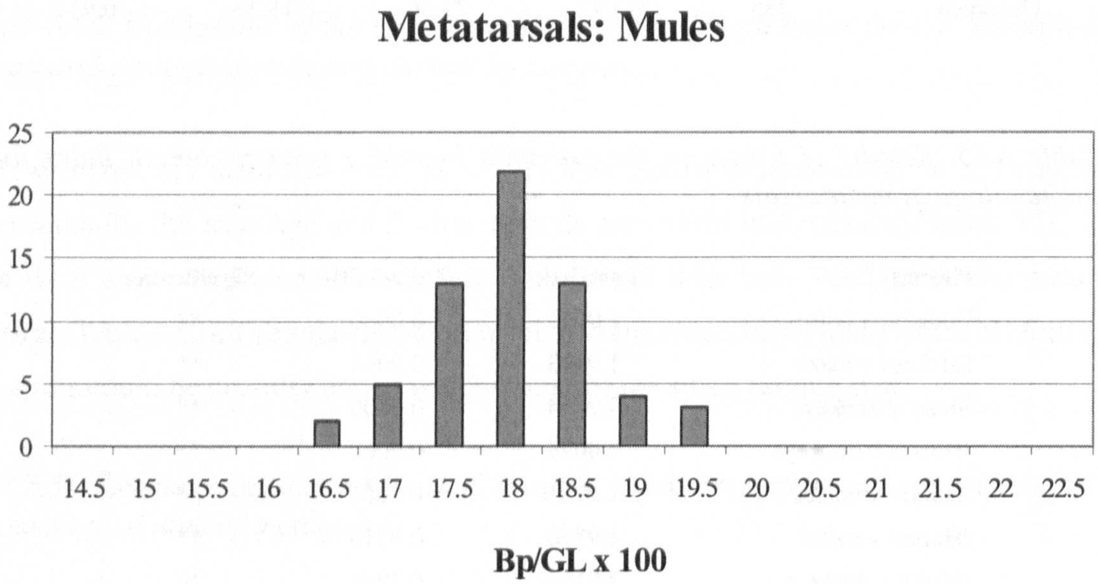
Category	n	Min	Max	Mean	SD
Donkeys	17	14.65	18.81	17.22	0.90
Mules	62	16.22	19.08	17.74	0.62
Horses	192	16.84	20.30	18.60	0.64
?Mules	11	16.74	18.00	17.47	0.42
?Horses	36	17.00	19.83	18.15	0.61
Unknown	235	15.97	21.86	18.33	0.93

Table 6.55. Results of t-tests on the proximal breadth / greatest length index for the archaeological metatarsals

Pairing	t statistic	Probability	Significance
Donkeys v horses	1.9715	0.0000	**
Donkeys v mules	1.9913	0.0069	**
Mules v donkeys	1.9694	0.0000	**
?Horses v donkeys	2.0076	0.0000	**
?Horses v horses	1.9705	0.0001	**
?Horses v mules	1.9850	0.0019	**
?Mules v donkeys	2.0555	0.3984	N
?Mules v horses	1.9718	0.0000	**
?Mules v mules	1.9939	0.1659	N
Unknown v donkeys	1.9695	0.0000	**
Unknown v horses	1.9656	0.0009	**
unknown v mules	1.9680	0.0000	**

The 'ambiguous' and 'unknown' specimens are shown in Figure 6.68, and once again the 'ambiguous' horses are towards the lower end of the horse range (Table 6.54). However, the 'ambiguous' mules fall towards the lower end of the mules range, and the t-tests (Table 6.55) reflect this, showing that they are most likely to be mules or donkeys rather than horses. The 'ambiguous' horses appear to be different to all three species in the t-tests.





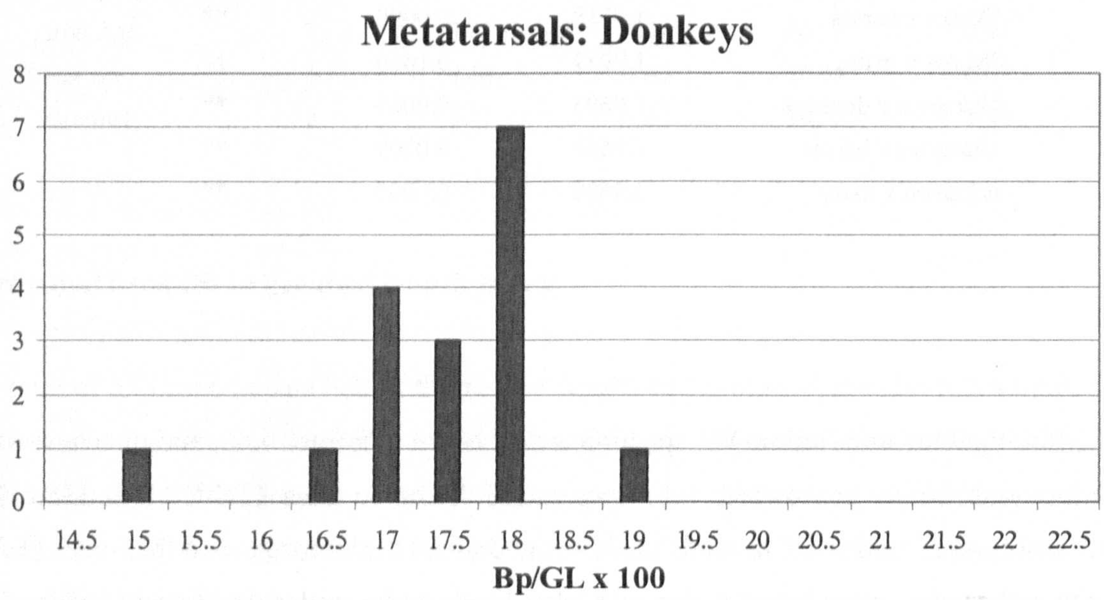
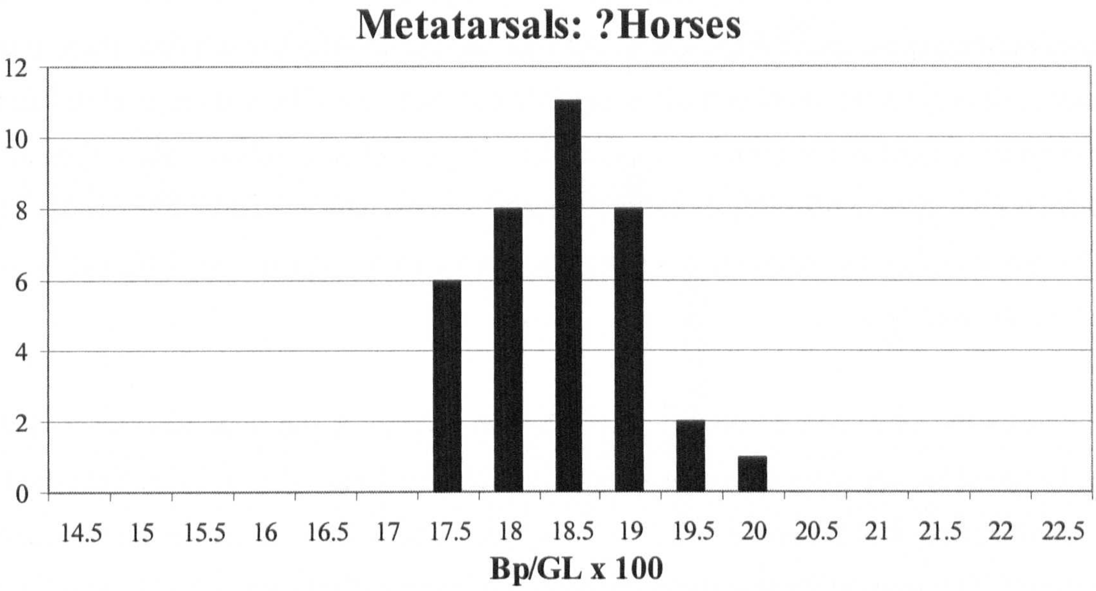
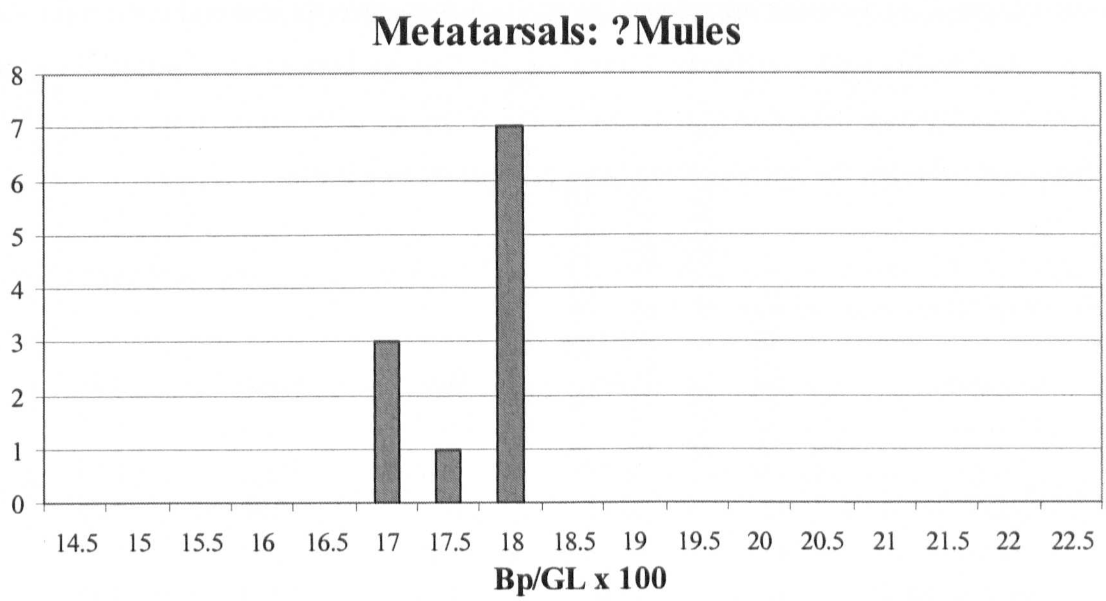


Figure 6.67. Histograms of proximal breadth / greatest length index for the 'identified' archaeological metatarsals.





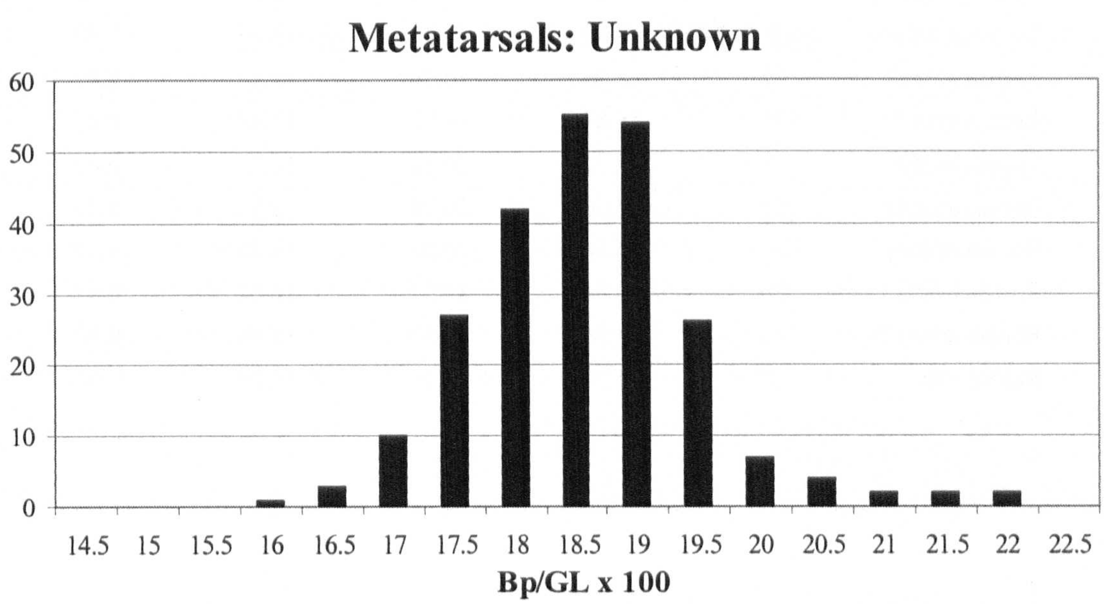


Figure 6.68. Histograms of proximal breadth / greatest length index for the 'ambiguous' and unknown archaeological metatarsals.

As usual the 'unknown' specimens cover the range displayed by all three species and mostly covering the mule-horse range. As with the shaft slenderness index, there were a number of very robust specimens. It is possible that these could be pathological specimens with both the shaft and proximal end affected, or they could be genuinely robust specimens. There is no way of confirming either hypothesis from the data available. The t-tests (Table 6.55) showed that, as usual, the unknown specimens were significantly different from all three individual species.

Analysing the horse data by period shows that, in contrast to the shaft slenderness index, the External horses were not more slender in their proximal breadth index than the Iron Age and Roman data (Figure 6.69). This is the same pattern that was seen in the metacarpals (Figure 6.52), suggesting that the morphology of the forelimbs and hindlimbs of all the archaeological horses were very similar to each other at the proximal end even if the shaft proportions were slightly different. Given the similarities between the groups on Figure 6.68 it is hardly surprising that the t-tests (Table 6.57) showed that there were no significant differences between the horses of the three periods on this index.

Table 6.56. Summary statistics for the proximal breadth / greatest length index for the 'identified' horse metatarsals

Category	n	Min	Max	Mean	SD
Iron Age	28	17.33	19.83	18.53	0.55
External	72	17.17	19.72	18.54	0.53
Roman	92	16.84	20.30	18.70	0.78
Iron Age area D	13	17.33	19.83	18.51	0.71
Iron Age area E	6	17.86	19.04	18.51	0.42
Iron Age area G	9	17.91	19.17	18.57	0.40
Roman area D	12	17.60	20.30	18.61	0.90
Roman area E	15	16.84	19.92	18.61	0.91
Roman area F	19	17.72	20.16	18.74	0.66
Roman area G	23	17.76	20.20	18.83	0.74
Roman military	9	17.76	20.20	18.88	1.07
Roman urban	26	16.84	19.72	18.62	0.67
Roman urban 2	18	17.54	20.30	18.66	0.87
Roman villa	7	17.80	20.16	18.79	0.96

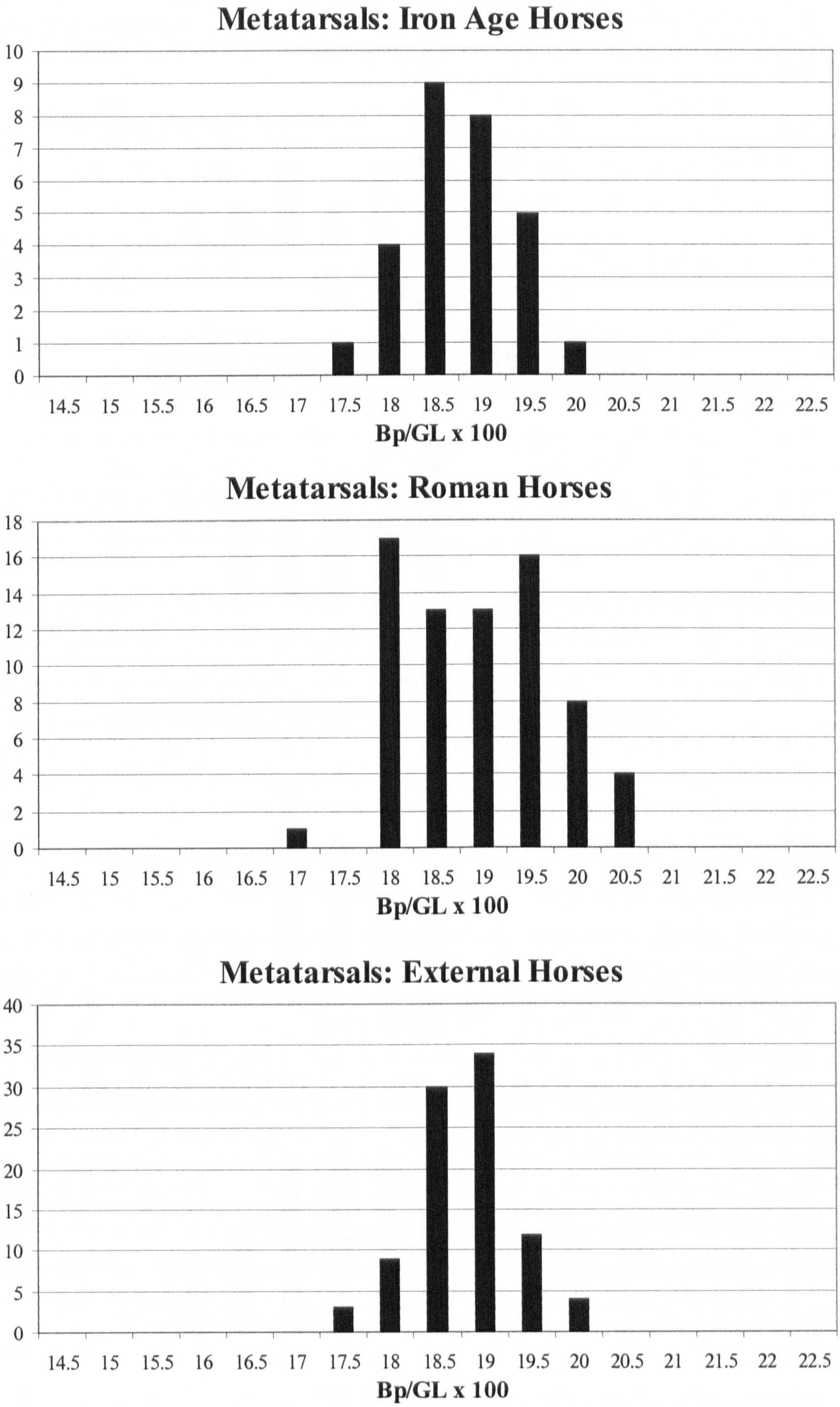


Figure 6.69. Histograms of proximal breadth / greatest length index for the 'identified' archaeological horse metatarsals by period.

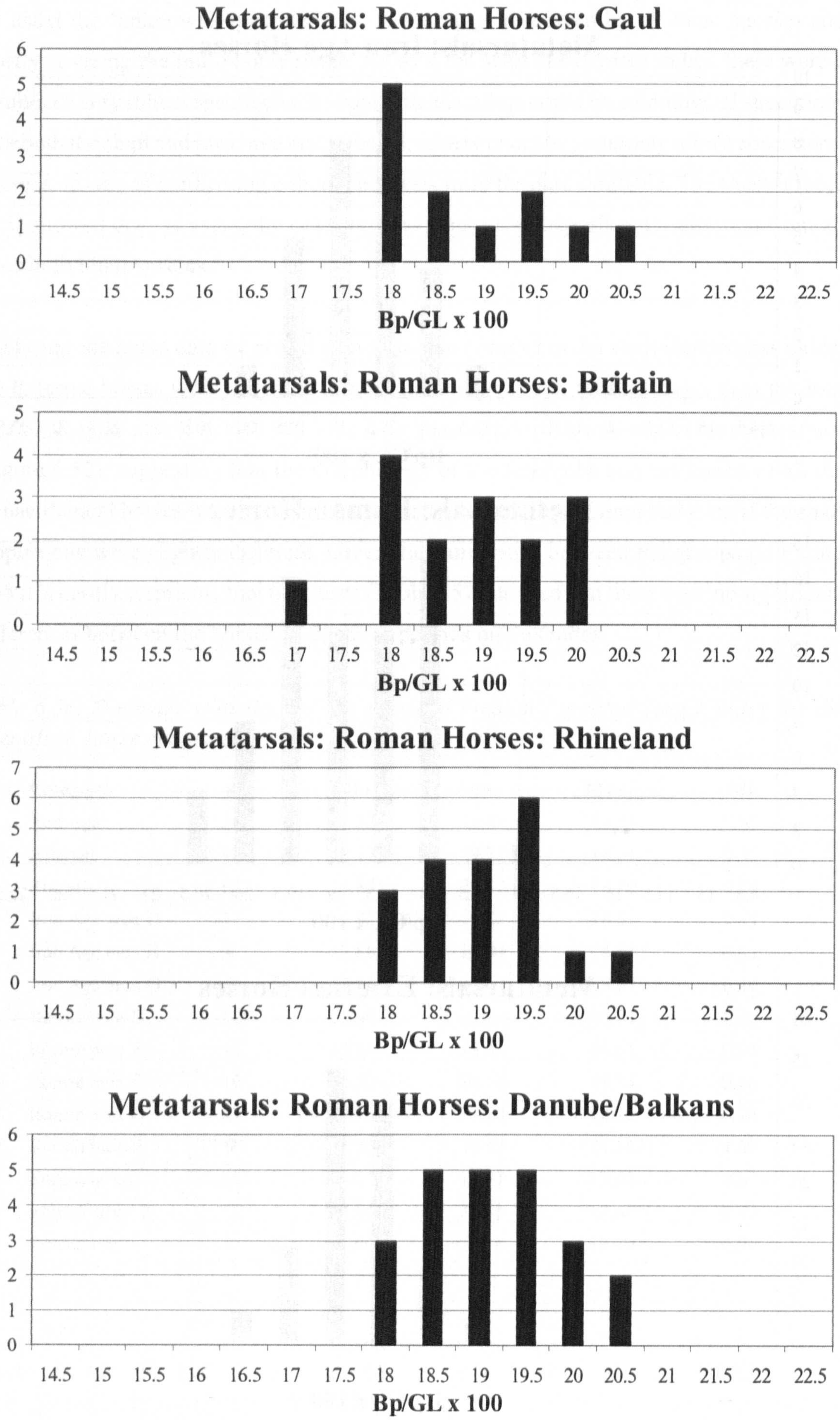


Figure 6.70. Histograms of proximal breadth / greatest length index for the 'identified' archaeological Roman horse metatarsals by area.

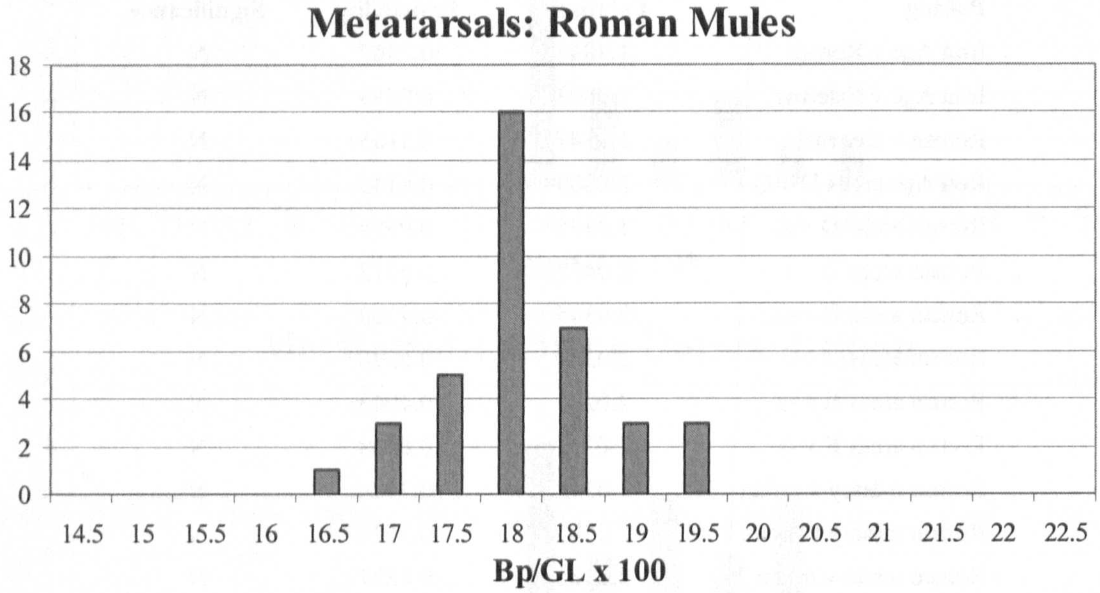
Table 6.57. Results of t-tests on the proximal breadth / greatest length index for the 'identified' archaaeological horse metatarsals

Pairing	t statistic	Probability	Significance
Iron Age v Roman	1.9845	0.2967	N
Iron Age v External	1.9803	0.9453	N
Roman v External	1.9747	0.1165	N
Iron Age areas D v G	2.0860	0.8145	N
Roman areas D v E	2.0595	0.9994	N
Roman areas D v F	2.0452	0.6372	N
Roman areas D v G	2.0345	0.4309	N
Roman areas E v F	2.0369	0.6220	N
Roman areas E v G	2.0281	0.4043	N
Roman areas F v G	2.0211	0.6708	N
Roman military v urban	2.0345	0.3984	N
Roman military v urban 2	2.0595	0.5620	N
Roman urban v urban 2	2.0181	0.8827	N

Dividing the periods by areas showed that there was a remarkable degree of consistency between all areas (Figure 6.70) and this was reflected in the t-tests where no significant differences were recorded between any of the areas (Table 6.57). This was in contrast to the shaft slenderness index, which indicated the Roman horses from Gaul were more slender than their counterparts in other areas. It was similar to the External data, where slender shafts were indicated but the proximal breadths were not correspondingly slender. The possible explanations given above for this variation are valid for the horses from Roman Gaul, as well as the External ones, namely nutritional stress or genetic variation (sexual dimorphism seems an unlikely cause in a sample from a variety of sites). In this case, neither explanation can be ruled out, as the numbers of individuals involved are too small.

The Roman period data split by site type showed a similar uniformity to the area data (Appendix Figure A12 and Table 6.57), once again mirroring the results given earlier for the metacarpals on this index. However, the shaft slenderness index on the metatarsals indicated that the urban 2 group individuals were more slender than their urban and military counterparts. This could, once again, reflect genetic variation or nutritional stress and the numbers are too small to rule out either option. However, the urban 2 group came from quite widely distributed sites, perhaps suggesting that genetic variation would be the more likely cause.

When the mule data were split by period, the results were slightly different to those of the horses. Figure 6.71 shows that the External mules seem more slender on this index than their Roman counterparts, unlike the horses where no discernable difference was detected. However, the t-tests (Table 6.59) showed that this difference was not statistically significant.



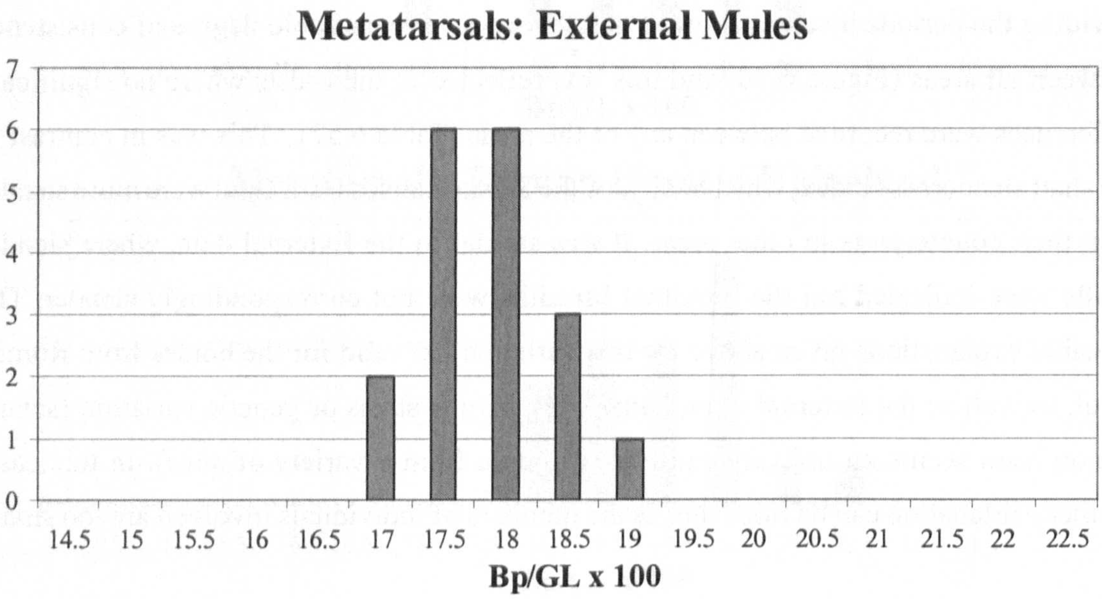


Figure 6.71. Histograms of proximal breadth / greatest length index for the 'identified' archaeological mule metatarsals by period.

As has been the case on most previous analyses of the mule data, splitting the proximal breadth data by area and by site type once again showed a remarkable uniformity across the groups (Appendix Figure A13 and A14). This was reflected in the t-test results (Table 6.59) where no significant differences were found. There were highly significant differences between the horses and mules of different periods and areas, confirming the results from analysis of the species groups as a whole.

Table 6.58. Summary statistics for the proximal breadth / greatest length index for the 'identified' archaeological mule metatarsals

Category	n	Min	Max	Mean	SD
Iron Age	6	16.22	18.45	17.69	0.88
External	18	16.54	18.58	17.60	0.51
Roman	38	16.42	19.08	17.82	0.63
Roman area F	16	16.75	19.08	18.02	0.72
Roman area G	12	16.95	18.17	17.69	0.39
Roman military	6	17.79	19.08	18.43	0.59
Roman Urban	14	16.75	18.55	17.59	0.51
Roman Urban 2	11	16.42	18.56	17.62	0.61

Table 6.59. Results of t-tests on the proximal breadth / greatest length index for the 'identified' archaeological mule metatarsals

Pairing	t statistic	Probability	Significance
Roman v External	2.0049	0.2030	N
Roman Horses v mules	1.9996	0.0022	**
Exernal Horses v mules	1.9822	0.0000	**
Roman areas F v G	2.0555	0.1633	N
Roman area F horses v mules	2.0345	0.0039	**
Roman area G horses v mules	2.0345	0.0000	**
Roman urban v urban 2	2.0687	0.9234	N

There were too few donkeys to represent graphically or to undertake t-test analyses, and as before the groups were too widely spread in time and location to allow meaningful comparison to take place. Table 6.60 is therefore just provided for completeness.

Table 6.60. Summary statistics for the proximal breadth / greatest length index for the 'identified' archaeological donkeys metatarsals

Category	n	Min	Max	Mean	SD
Iron Age	7	14.65	17.98	16.93	1.09
Roman	8	16.14	17.87	17.32	0.58

Distal breadth to greatest length index

A total of 559 metatarsals were available for analysis of distal breadth to greatest length (Bd/GL x 100) index. Of these 271 were 'identified' (193 horses, 61 mules and 17 donkeys), 47 were 'ambiguous' (36 ?horses and 11?mules) and 241 were 'unknown'. Detailed results are presented in Appendix Table A31. As with the metacarpals, the results of the distal breadth index on the metatarsals were quite different to the preceding index calculations. Figure 6.72 shows the results for the 'identified' specimens by species and shows that the slenderness of the mules is much more marked than on the shaft and proximal breadth indices. The donkeys were more slender still, unlike on the metacarpals where there was a greater degree of overlap between the mules and donkeys. This is reflected in the summary statistics (Table 6.61) and the t-tests (Table 6.62) where all three species are highly significantly different to each other. The explanation given for the metacarpals in terms of the distal limb morphology is also valid here, perhaps indicating that the mules are inheriting their distal limb morphology from the jackass rather than the mare, but are separated by size (inherited from the horse).

Table 6.61. Summary statistics for the distal breadth / greatest length index for the archaeological metatarsals

Category	n	Min	Max	Mean	Sd
Donkeys	17	14.65	18.35	16.11	1.03
Mules	61	15.49	19.58	17.31	0.79
Horses	193	16.88	21.40	18.57	0.63
?Mules	11	16.12	18.44	17.30	0.61
?Horses	36	16.47	18.92	17.95	0.58
Unknown	241	14.67	21.86	18.00	0.98

Table 6.62. Results of t-tests on the distal breadth / greatest length index for the archaeological metatarsals

Pairing	t statistic	Probablilty	Significance
Donkeys v horses	1.9714	0.0000	**
Mules v horses	1.9694	0.0000	**
Mules v donkeys	1.9917	0.0000	**
?Horses v donkeys	2.0076	0.0000	**
?Horses v horses	1.9705	0.0000	**
?Horses v mules	1.9852	0.0001	**
?Mules v donkeys	2.0555	0.0020	**
?Mules v horses	1.9718	0.0000	**
?Mules v mules	1.9944	0.9633	N
Unknown v donkeys	1.9693	0.0000	**
Unknown v horses	1.9655	0.0000	**
Unknown v mules	1.9679	0.0000	**

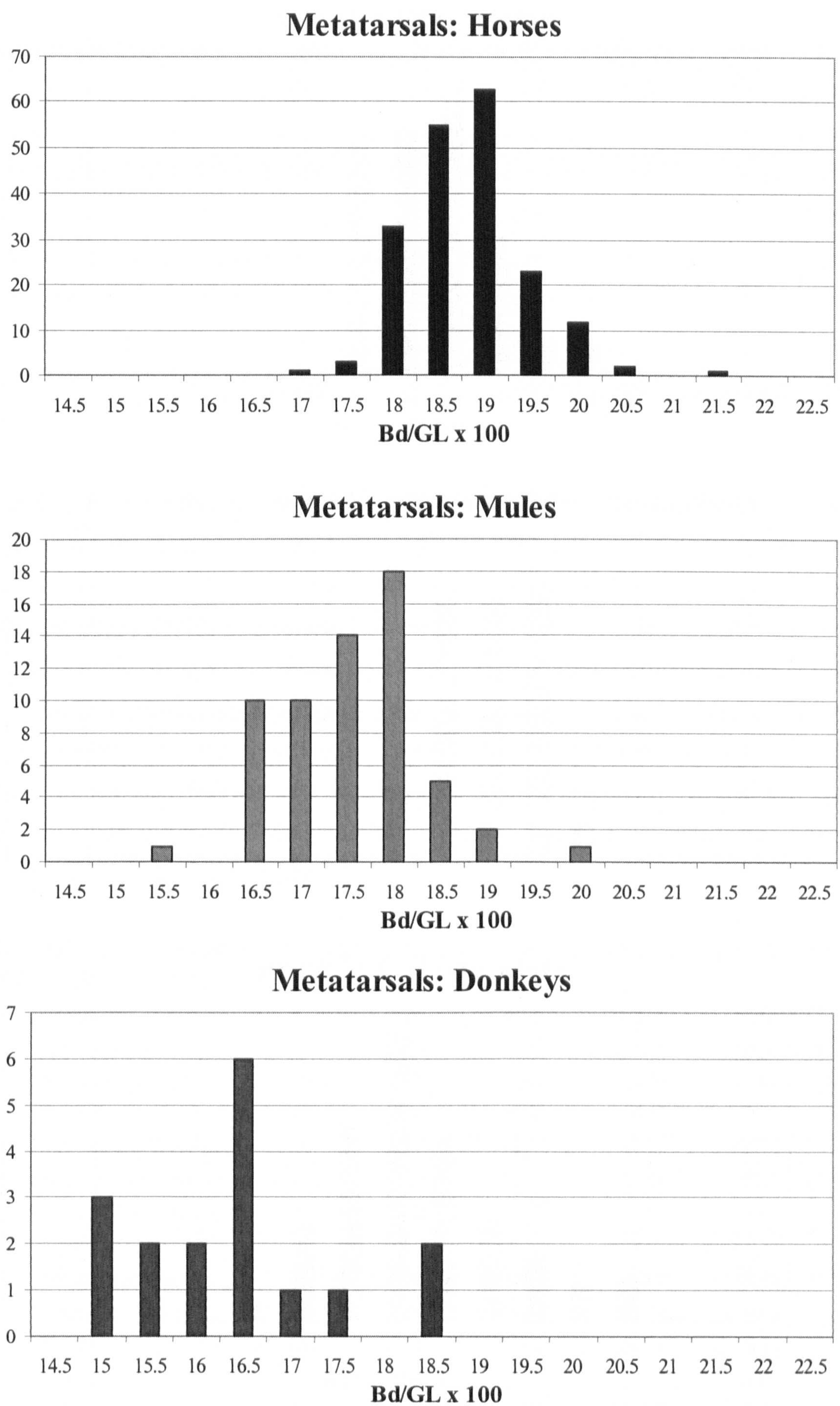
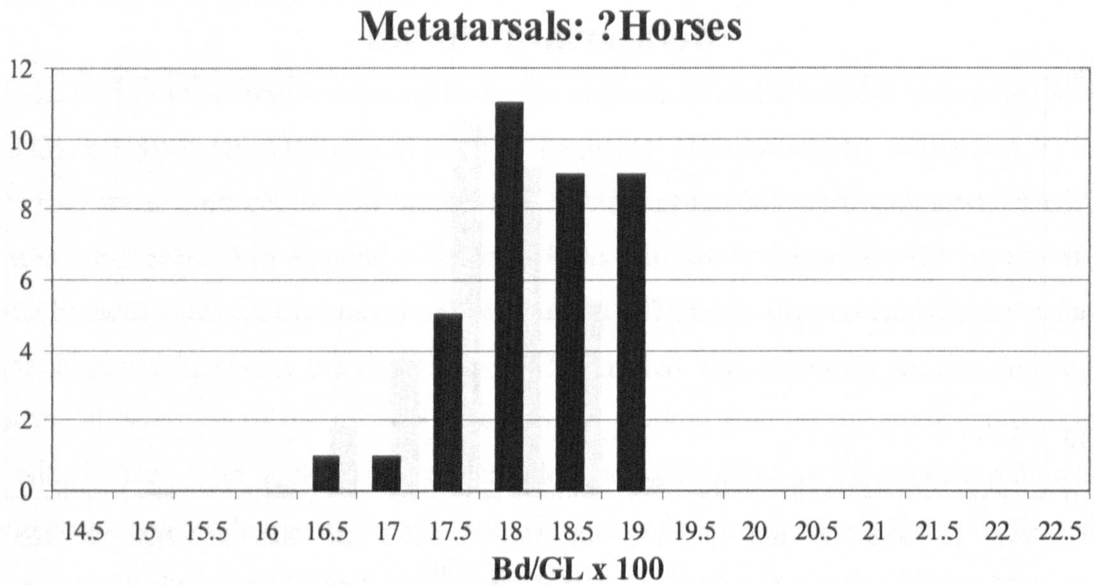
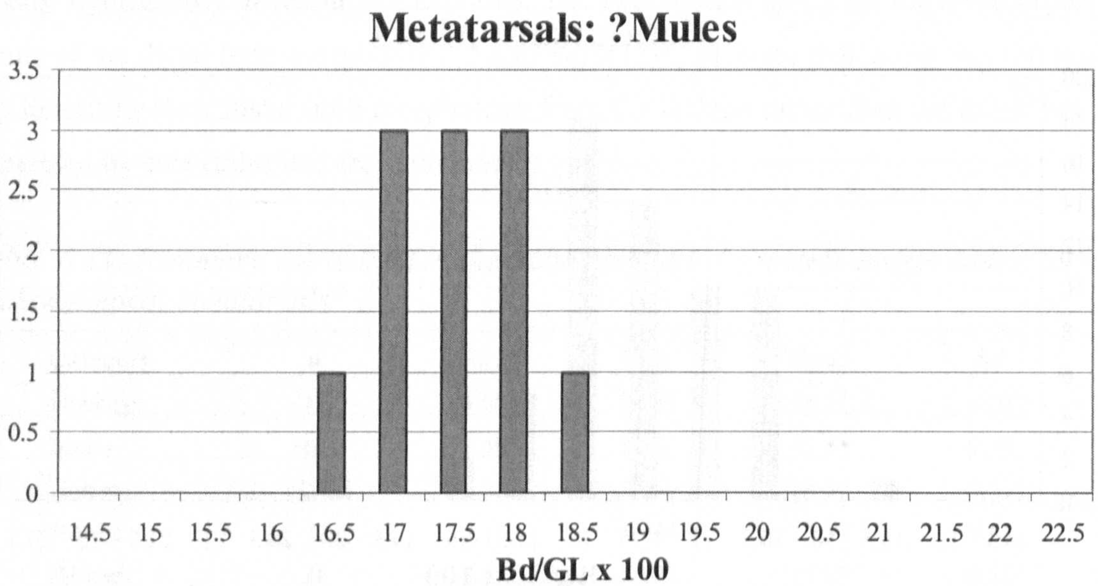


Figure 6.72. Histograms of distal breadth / greatest length index for the 'identified' archaeological metatarsals.





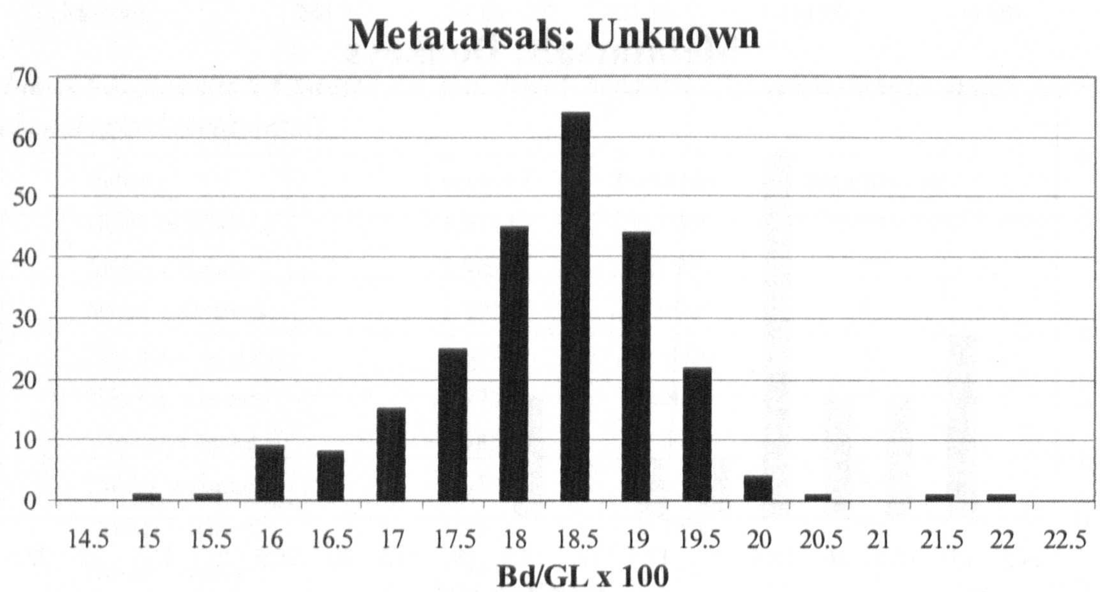


Figure 6.73. Histograms of distal breadth / greatest length index for the 'ambiguous' and 'unknown' archaeological metatarsals.

Figure 6.73 shows the results from the 'ambiguous' and 'unknown' specimens. As has been the case previously, the 'ambiguous' horses fall towards the lower end of the horse scale. However, the 'ambiguous' mules fall towards the middle of the mule range, suggesting that the distal breadth is not the factor confusing the identification of these individuals. The t-tests (Table 6.62) reflected these observations, with the 'ambiguous' mules most likely to be mules, and the 'ambiguous' horses being significantly different to all three species. As with the metacarpals, the distribution of the 'unknown' specimens showed a hint of bimodality, with the lower peak probably corresponding with donkeys. As expected, the 'unknown' specimens were significantly different as a group to the three species separately (explanation of the use of t-tests in this situation is given in the metacarpal section above).

Splitting the horse data into period groups (Figure 6.74) showed that there was a slight difference between the Iron Age horses and the other two groups. This was reflected in the t-tests (Table 6.64), where the Iron Age horses were significantly smaller than the External ones and highly significantly smaller than the Roman ones. This is in contrast to the results from the metacarpals on this index, which showed no significant difference between the periods. These results are also slightly different to those on the shaft index for this bone, where the External bones were the most slender and the Iron Age ones only slightly different to the Roman ones. This suggests that whilst the External metatarsals have slender shafts they have relatively wide distal breadths, whereas the Iron Age metatarsals have slightly slender shafts and distal breadths.

Table 6.63. Summary statistics for the distal breadth / greatest length index for the 'identified' archaeological horse metatarsals

Category	n	Min	Max	Mean	SD
Iron Age horses	28	16.88	20.35	18.29	0.66
Roman horses	73	17.46	21.40	18.70	0.68
External horses	92	17.53	19.92	18.55	0.55
Iron Age area D horses	13	16.02	18.75	17.87	0.68
Iron Age area E horses	6	16.88	18.26	17.94	0.53
Iron Age area G horses	9	18.03	20.35	18.84	0.63
Roman area D horses	12	17.90	19.55	18.61	0.50
Roman area E horses	17	17.46	20.35	18.63	0.71
Roman area F horses	18	17.69	19.91	18.68	0.60
Roman area G horses	23	17.86	21.40	18.84	0.79
Military horses	10	17.69	21.40	18.63	1.05
Urban horses	26	17.86	20.35	18.79	0.68
Urban 2 horses	18	17.89	19.55	18.64	0.52
Villa horses	7	17.46	19.58	18.76	0.71

Table 6.64. Results of t-tests on the distal breadth / greatest length index for the 'identified' archaeological horse metatarsals

Pairing	t statistic	Probablilty	Significance
Iron Age v External horses	1.9803	0.0394	*
Iron Age v Roman horses	1.9842	0.0063	**
External v Roman horses	1.9746	0.1057	N
Iron Age areas D v G	2.0860	0.0040	**
Roman areas D v E	2.0518	0.9385	N
Roman areas D v F	2.0484	0.7544	N
Roman areas D v G	2.0345	0.3778	N
Roman areas E v F	2.0345	0.8308	N
Roman areas E v G	2.0244	0.3991	N
Roman areas F v G	2.0227	0.4833	N
Iron Age v Roman area D	2.0687	0.0111	*
Iron Age v Roman area G	2.0423	0.9947	N
Military v urban	2.0322	0.6022	N
Military v urban 2	2.0555	0.9769	N
Urban v urban 2	2.0181	0.4445	N

The distal slenderness of the Iron Age horses as a group was revealed to be inconsistent across geographic areas (Figure 6.75). The Gallic horses were significantly more slender than those from the Danube and Balkans area (Table 6.64). The British Iron Age horses also appeared to be distally more slender but could not be tested because the numbers were too small. This distal slenderness of the Gallic horses was also picked up in the analysis of the metacarpals and in the shaft slenderness index of the metatarsals (the first was significantly different, the latter not).

However, when the Roman material was examined by area, no significant differences were visible between the groups (Appendix Figure A15) and this was reflected in the t-test results (Table 6.64). This contrasts with the shaft slenderness index, where the Roman horses from Gaul were visually and statistically more slender than other areas. This could suggest that in the case of the Roman horses from Gaul the shaft slenderness of the metatarsals may be more likely to be caused by nutritional stress rather than genetic variation, as in both articular breadth indices no significant difference between the areas could be detected. Similarly, there were no significant differences in distal breadth index between any of the Roman groups by site type (Appendix Figure A16 and Table 6.64), whereas the shaft breadth index showed differences between the Urban and Urban 2 classes (Table 6.50). As above, it seems that this difference in shaft but not articular breadths is more likely to have been caused by nutritional stress than genetic variation.

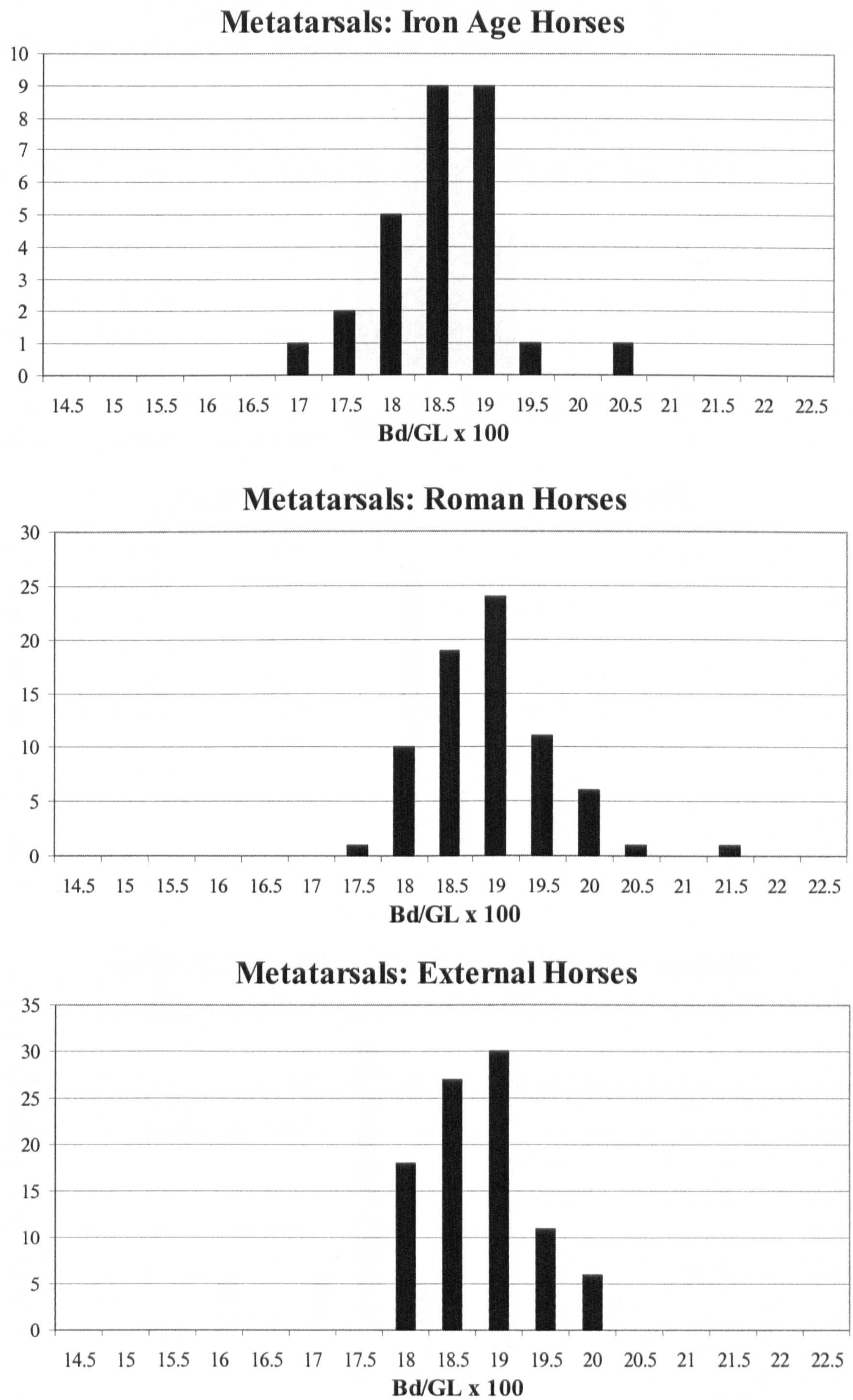
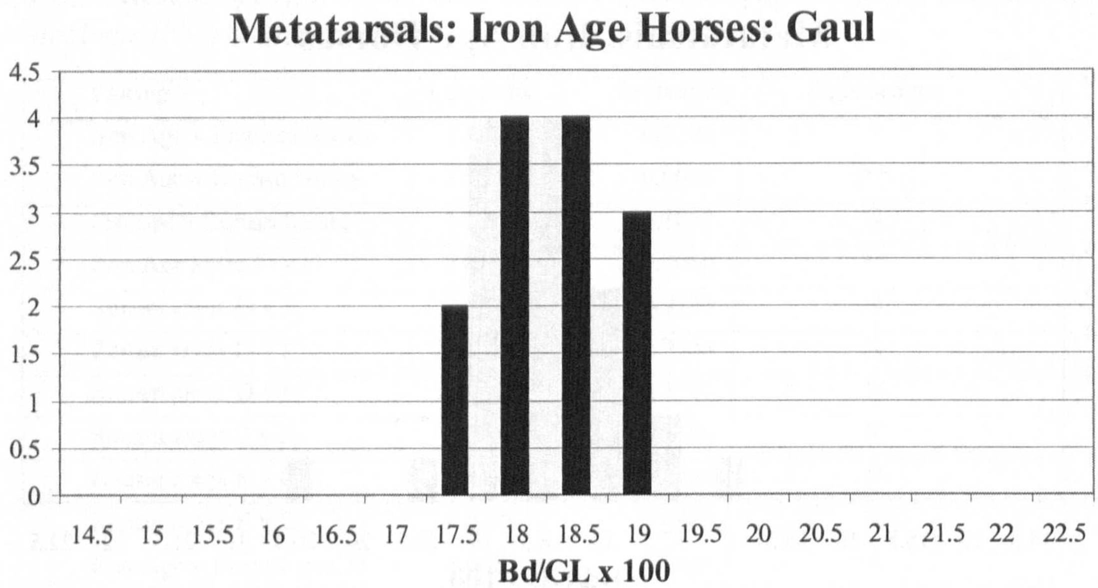
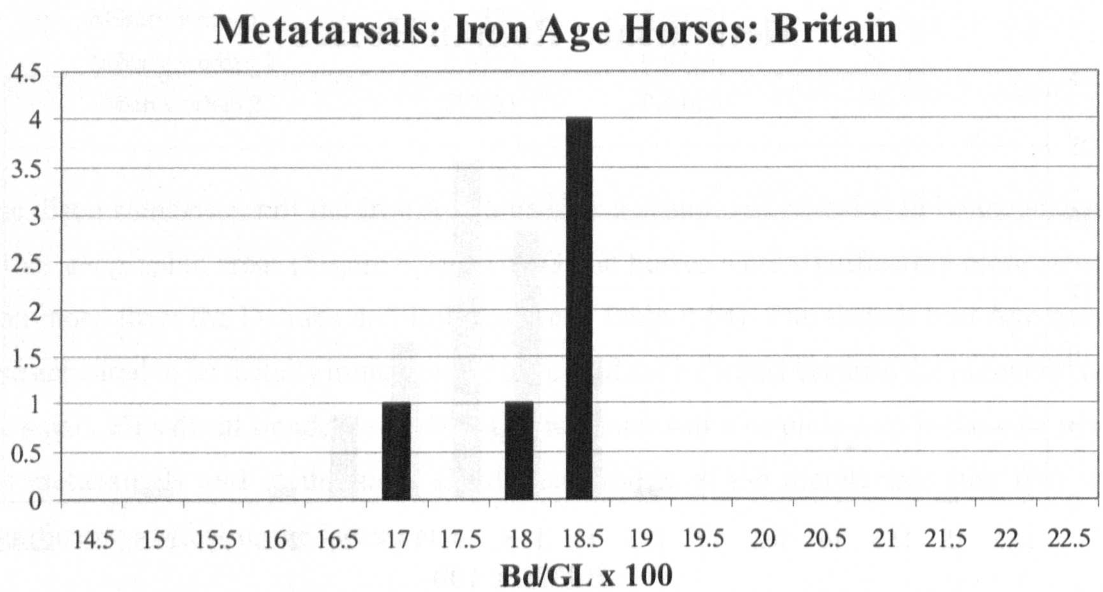


Figure 6.74. Histograms of distal breadth / greatest length index for the 'identified' archaeological horse metatarsals by period.





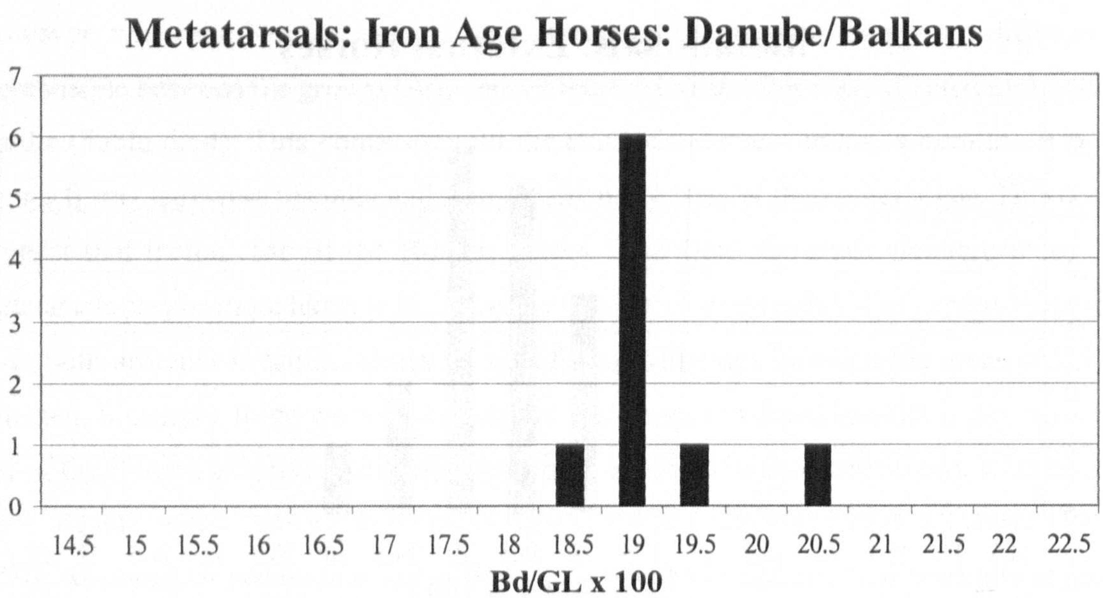


Figure 6.75. Histograms of distal breadth / greatest length index for the Iron Age 'identified' archaeological horse metatarsals by area.

As on most previous occasions, the mules showed a remarkable degree of homogeneity across time periods, geographic areas and site types (Appendix Figures A17-A19). The ranges and means (Table 6.65) showed just how similar the groups are, and the t-tests (Table 6.66) also reflected this, with no significant differences detectable between the groups. This was consistent with the results obtained from the most of the other indices on both the metatarsal and metacarpal and indeed the withers heights results. These very consistent results, in both height and build, across time and space is lending weight to the argument that there must have been either centralised breeding of mules or strict control over breeding in all areas of the Empire.

Table 6.65. Summary statistics for the distal breadth / greatest length index for the 'identified' archaeological mule metatarsals

Category	n	Min	Max	Mean	SD
Iron Age mules	6	16.02	18.06	17.47	0.78
Roman mules	37	15.49	19.58	17.23	0.88
External mules	18	16.03	18.34	17.42	0.57
Roman area F mules	15	16.28	19.58	17.42	0.88
Roman area G mules	12	16.28	18.97	17.45	0.90
Urban mules	14	16.28	18.34	17.26	0.74
Urban 2 mules	11	16.15	17.87	16.98	0.57

Table 6.66. Results of t-tests on the distal breadth / greatest length index for the 'identified' archaeological mule metatarsals

Pairing	t statistic	Probablilty	Significance
Roman v External mules	2.0057	0.4224	N
Roman horse v mules	1.9822	0.0000	**
External horses v mules	1.9822	0.0000	**
Roman areas F v G mules	2.0595	0.9276	N
Urban v urban 2 mules	2.0687	0.3050	N

As before the donkeys were too few to allow any further analysis and Table 6.67 is presented here for the sake of completeness.

Table 6.67. Summary statistics for the distal breadth / greatest length index for the 'identified' archaeological donkey metatarsals

Category	n	Min	Max	Mean	SD
Iron Age donkeys	7	14.65	16.14	15.69	0.61
Roman donkeys	8	14.83	18.02	16.16	1.10

The differences observed between the horses and mules on the shaft breadth and distal breadth indices suggest that a bivariate plot of these two indices may produce some degree of separation of the species. Figure 6.76 shows the results and there is indeed some degree of separation of the mules and horses. There is, however, still quite a range of overlap. A plot of the 'ambiguous' specimens (Figure 6.77) with their identified counterparts shows that, in the case of the mules, the 'ambiguous' specimens fall into the main body of identified material. Although a few of these are also in the overlap zone with the horses, it seems most likely that the mule identifications are correct. However, when the 'ambiguous' horses are examined, they mostly fall towards the mule overlap zone and in some cases look decidedly more like mules on these criteria. Therefore these 'ambiguous' horses should probably remain ambiguous, as there is no way of determining the correct identification.

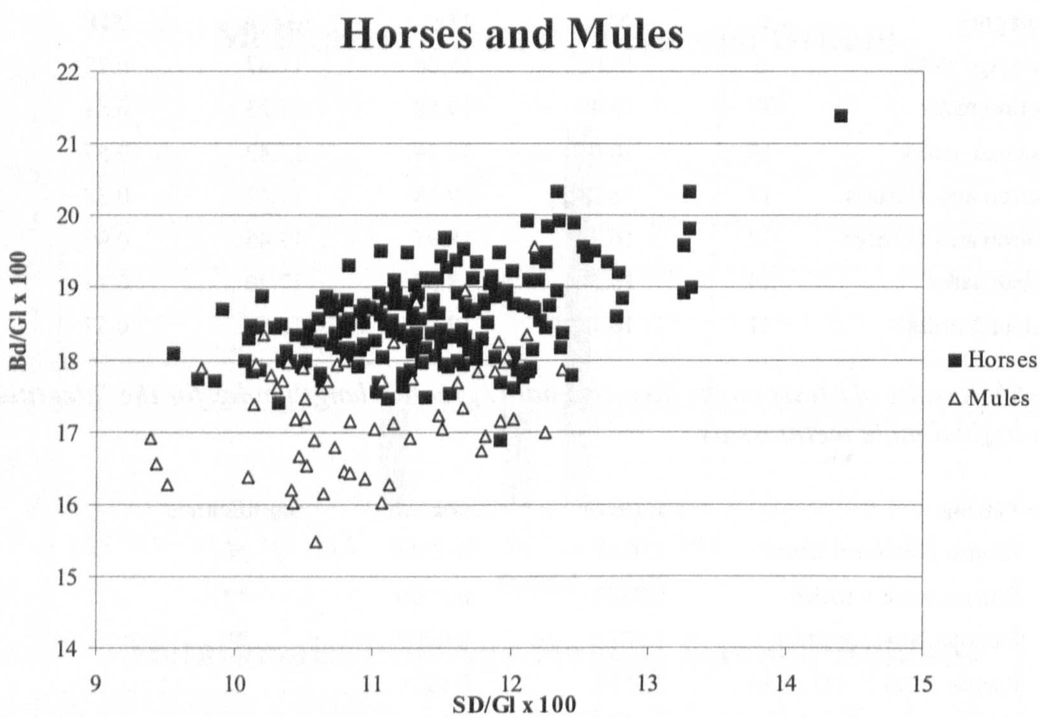


Figure 6.76. Scatter plot of SD/GL index against Bd/GL index for the 'identified' archaeological horses and mules.

When the 'unknown' specimens are analysed (Figure 6.78), it can be seen that they spread across the ranges of both the horses and the mules. However, there are a number of individuals towards the lower edge of the cluster that are most likely to be mules as they fall below the overlap zone. Similarly, the group of individuals towards the upper right corner of the graph are most likely to be horses as there are no identified mules in this region. These identifications must of course remain tentative, as there were too few measurements on these individuals for full discriminant function analysis of species to be carried out.

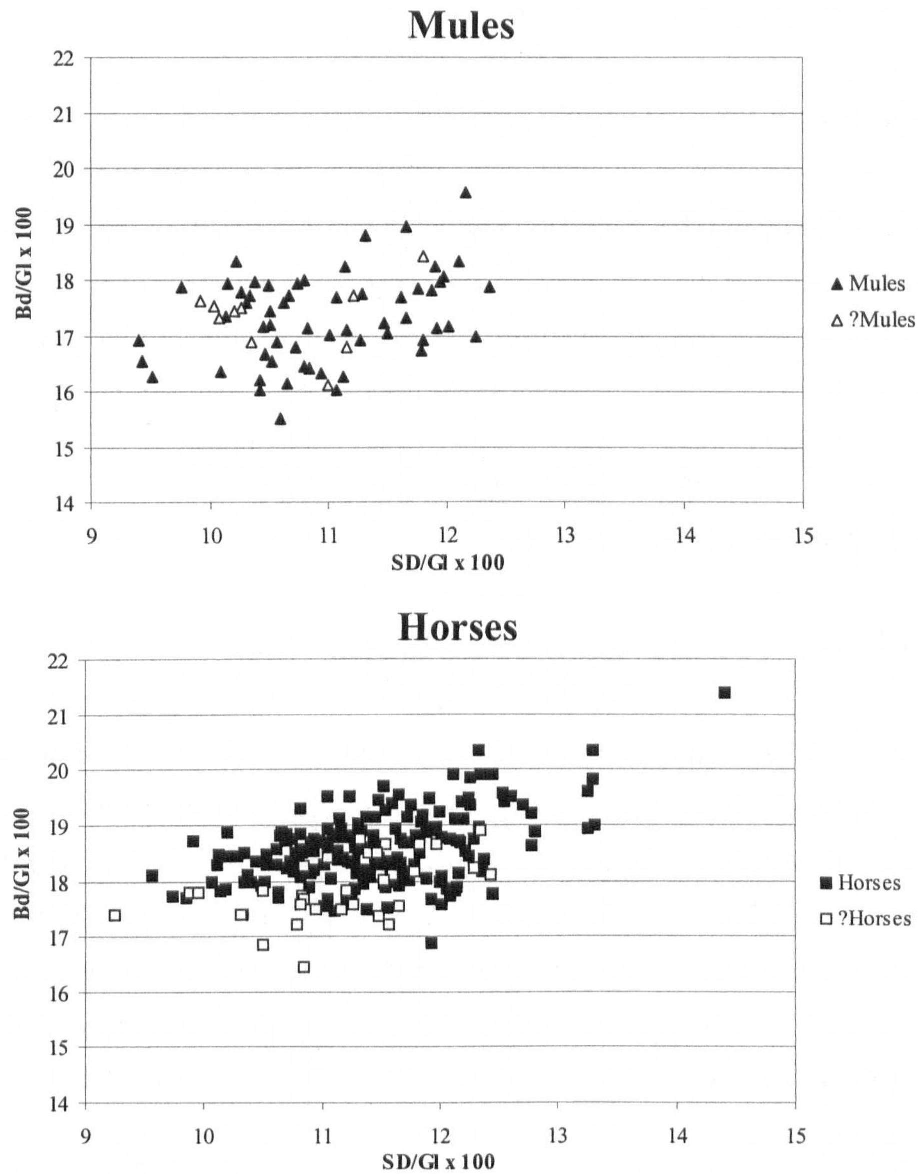


Figure 6.77. Scatter plot of SD/GL index against Bd/GL index for the 'identified' and 'ambiguous' archaeological horses and mules.

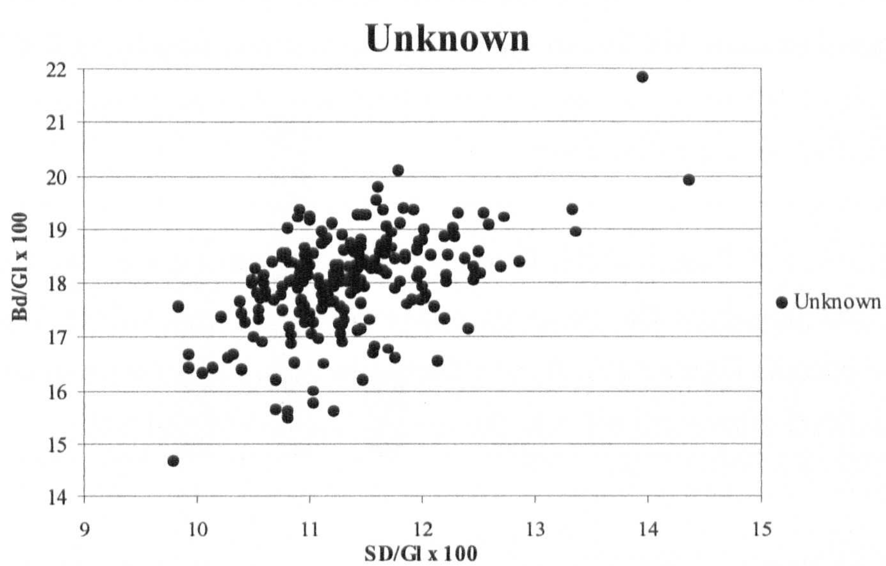


Figure 6.78. Scatter plot of SD/GL index against Bd/GL index for the unknown archaeological specimens.

6.3.3 Calculation of shape indices on tibiae

Whilst shape indices are more usually carried out on the metapodials, there is no reason for them not to be undertaken on other elements within the skeleton. In this research, the purpose of examining the shape indices on other bones is twofold: to see if the results are consistent with those on the metapodials, and to elucidate the shape differences between the species that are producing the identifications in the discriminant function analysis. In order to study the first of these questions it was necessary to calculate the same indices as were used on the metapodials in order to make direct comparisons.

Shaft breadth to greatest length index

There were 222 tibiae with the requisite measurements for the shaft diameter to greatest length (SD/GL x 100) index, including 53 'identified' bones (18 horses, 28 mules and seven donkeys), 13 'ambiguous' horses and 156 'unknown' specimens. Details of the results are given in Appendix Table A32. Figure 6.79 shows the results for the 'identified' tibiae, and it can be seen that the horses and mules are quite similar to each other and the donkeys are slightly more slender. The mule range is located slightly more to the left than the horse data (Table 6.68) and also the mule modal class is lower than that of the horses. These observations are, however, not borne out by the results of the t-tests (Table 6.69), which showed that there were no significant differences between any of the three species.

The 'ambiguous' horses and 'unknown' specimens are shown in Figure 6.80. The ambiguous horses were similar to both the identified horses and mules and this was reflected in the t-tests (Table 6.69), which showed there were no significant differences between either of these pairings. The same was true of the 'unknown' material, suggesting that this group mostly contains a mixture of horses and mules (and possibly also donkey,s as there were too few identified ones to test against).

The small numbers of tibiae available for this analysis meant that it was not possible to use many other data groupings. The exception to this was a comparison of the Roman horses and mules (Appendix Figure A20). These reflected the same pattern as the overall species, with no significant differences between the groups (Tables 6.68 and 6.69).

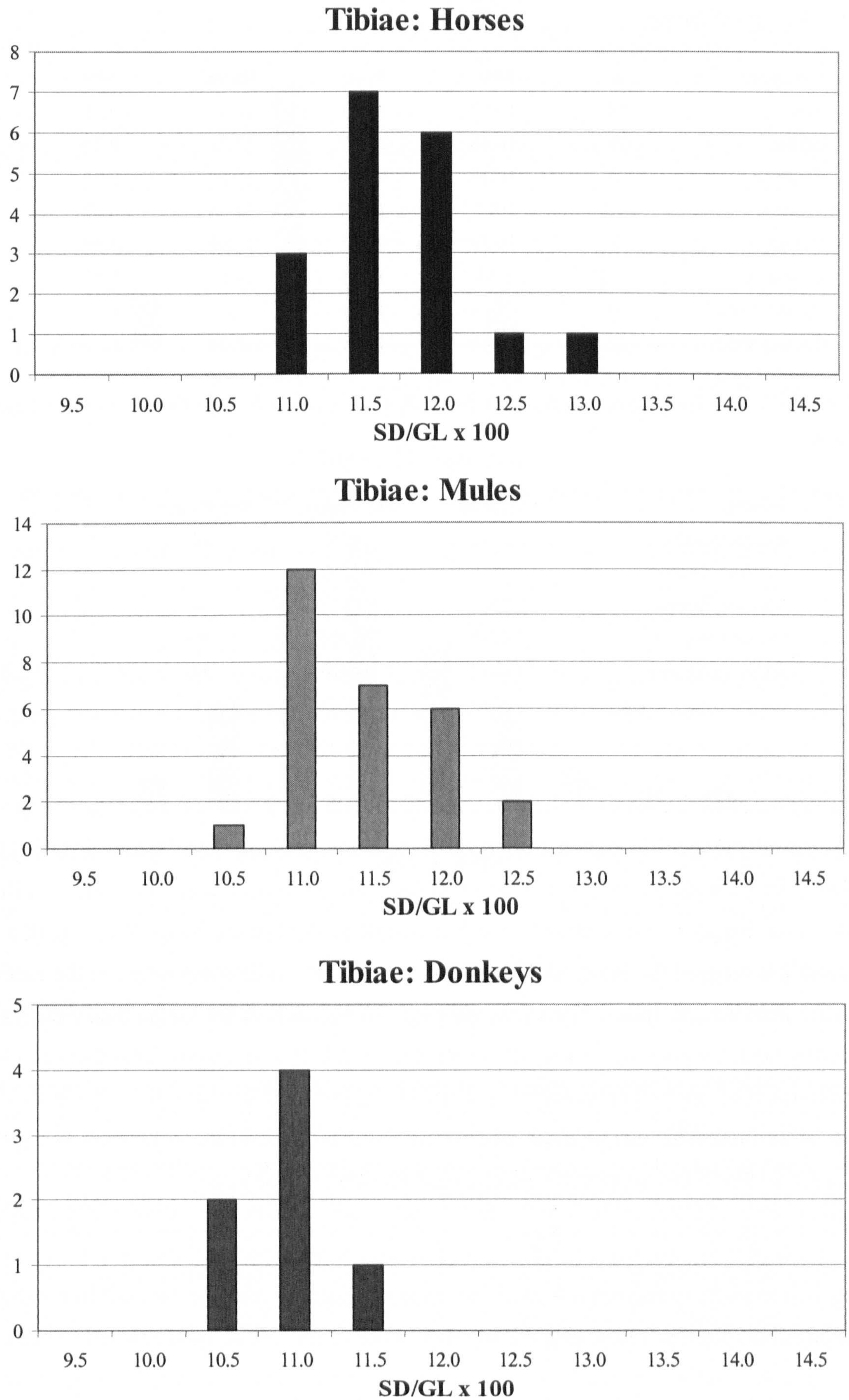


Figure 6.79. Histograms of shaft breadth / greatest length index for the 'identified' archaeological tibiae by species.

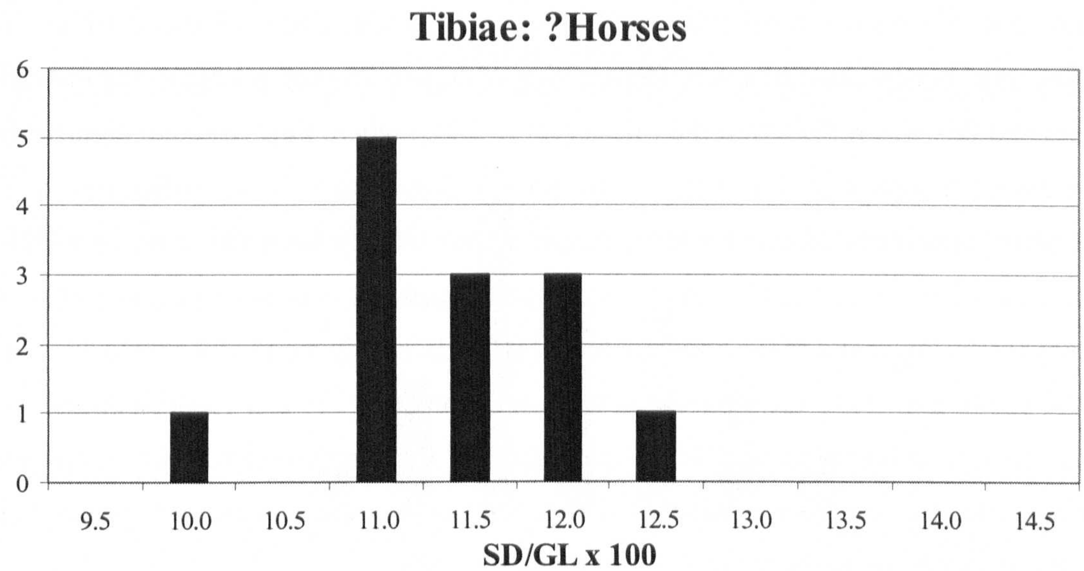
Table 6.68. Summary statistics for the shaft breadth-greatest length index for the archaeological tibiae

Category	n	Min	Max	Mean	SD
Horses	18	10.53	12.91	11.44	0.55
Mules	28	10.48	12.37	11.21	0.55
Donkeys	7	10.38	11.14	10.67	0.25
?Horses	13	9.97	12.28	11.18	0.62
?Mules	5	10.23	11.47	10.91	0.48
Unknown	156	9.83	14.46	11.37	0.87
Roman Horses	11	10.53	12.91	11.42	0.67
Roman Mules	25	10.48	12.37	11.24	0.56

Table 6.69. Results of t-tests on the shaft breadth-greatest length index for the archaeological tibiae

Pairing	t statistic	Probability	Significance
Horses v mules	2.0154	0.1737	N
Horses v ?horses	2.0452	0.2252	N
Mules v ?horses	2.0227	0.8617	N
Horses v unknown	1.9739	0.7490	N
Mules v unknown	1.9731	0.3499	N
Roman horses v mules	2.0322	0.4163	N

During the critical analysis of the withers heights methods, it was noted that the mules had significantly longer tibiae (as a proportion of the withers height) than the horses. Using the SD/GL index it should be possible to see if the mule tibiae are slender in relation to their additional length or are proportionately as robust as the horses. From Figure 6.78 it is possible to suggest the latter, as there were no significant differences between the species on the shaft breadth index. Therefore, although the mule tibiae are longer than their horse counterparts, they are also wider in the shaft diameter. It is suggested here that the shaft slenderness of the mule metatarsals is not followed through into the tibiae. This may be due to an increased muscle mass around the tibiae preventing the bone from being too slender so that it can support the mechanical stresses exerted upon it.



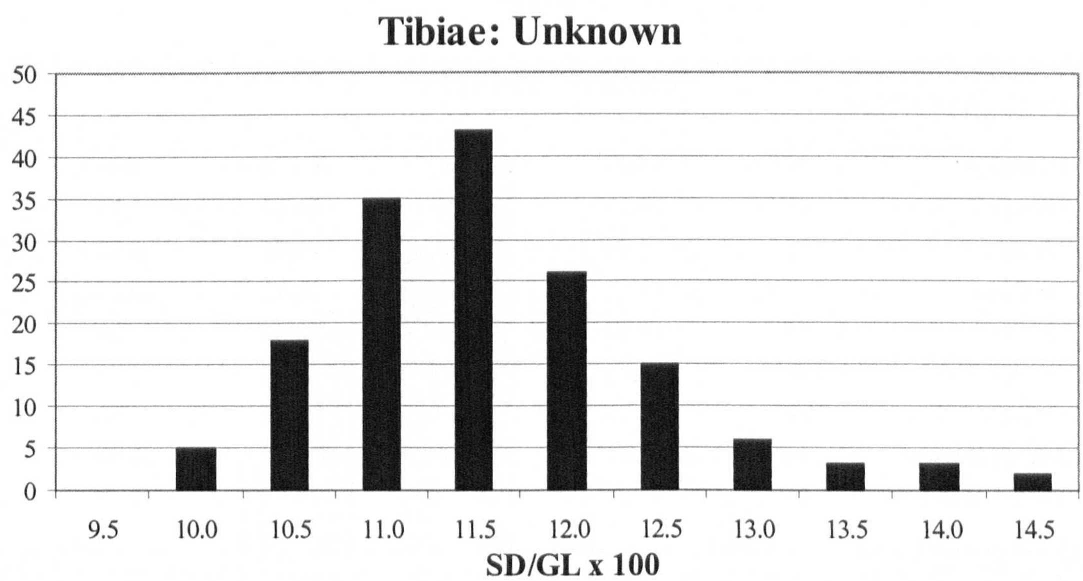


Figure 6.80. Histograms of shaft breadthv / greatest length index for the 'ambiguous' and 'unknown' archaeological tibiae by species.

Distal breadth to greatest length index

In contrast to the shaft slenderness index, the distal breadth / greatest length index (Appendix Table A33 and Figure 6.81) showed that there was a significant difference between the horses and mules (Table 6.71). Indeed the mules were more like the donkey tibiae. This reflected the results of the metapodials, where the distal ends of the mule bones were more slender than those of the horses. However, it did not reflect the picture given by the proximal end of the metapodials, as might be expected from the proximity of these two joint surfaces. The explanation for this could well lie in the length of the mule tibiae, as discussed above. If the proximal metatarsal and distal tibiae are of similar widths for the horses and mules, but the mule tibiae are proportionately longer than those of the horses, then the Bd/Gl index on the tibiae will appear more slender for the mules than for the horses.

Figure 6.82 shows the results for the 'ambiguous' horses and 'unknown' tibiae. The 'ambiguous' horses showed a very similar range (Table 6.70) and profile to the identified horses and this was reflected in the t-tests (Table 6.71), where they were not significantly different from each other but were significantly different from the identified mules. The 'unknown' specimens showed a large range, as has usually been the case. In addition, there was a hint of bimodality in the distribution, perhaps corresponding to mules and donkeys at the lower end of the scale and horses towards the upper end of the scale. However, as had previously been the case the overlap was too great for any identifications to be based on this evidence alone. The t-tests showed that the unknown specimens were significantly different from the identified horses but not from the mules, perhaps indicating that there may be more mules in the sample than horses.

Table 6.70. Summary statistics for the distal breadth / greatest length index for the archaeological tibiae

Category	n	Min	Max	Mean	SD
Horses	17	19.27	22.00	20.68	0.78
Mules	28	18.54	21.62	19.99	0.64
Donkeys	7	18.79	20.75	19.97	0.77
?Horses	13	18.54	21.62	20.52	0.80
?Mules	5	19.03	20.80	19.91	0.71
Unknown	161	17.72	23.77	20.16	1.03
Roman Horses	10	19.27	22.00	20.84	0.90
Roman Mules	25	18.54	21.62	19.99	0.61

Table 6.71. Results of t-tests on the distal breadth / greatest length index for the archaeological tibiae

Pairing	t statistic	Probability	Significance
Horses v mules	2.0167	0.0025	**
Horses v ?horses	2.0484	0.5927	N
Mules v ?horses	2.0227	0.0278	*
Horses v unknown	1.9735	0.0461	*
Mules v unknown	1.9727	0.3967	N
Roman horses v mules	2.0345	0.0029	**

Once again, due to the small sample size, further analyses were severely restricted. The Roman horses and Roman mules could be compared but no other groups (Appendix Figure 21). Surprisingly, given the results above for the species as a whole, there was no significant difference between these two groups, although visually they appeared very similar to Figure 6.81. This may well be due to the small sample size of the Roman horses. Additionally, the similarity between them could reflect an inheritance of the distal breadth morphology from the mare rather than the jackass, the opposite of what was suggested for the slenderness of the metapodials.

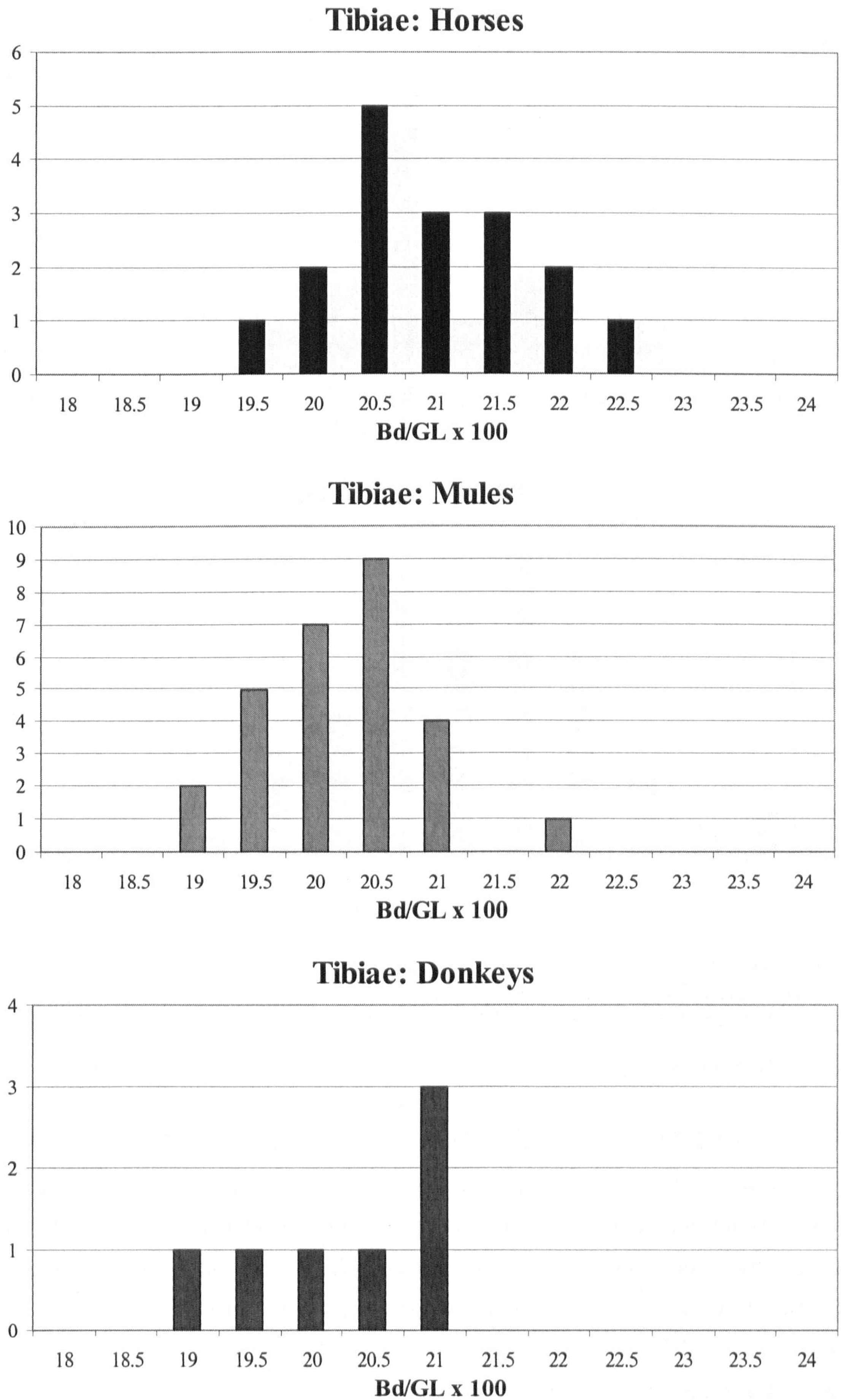
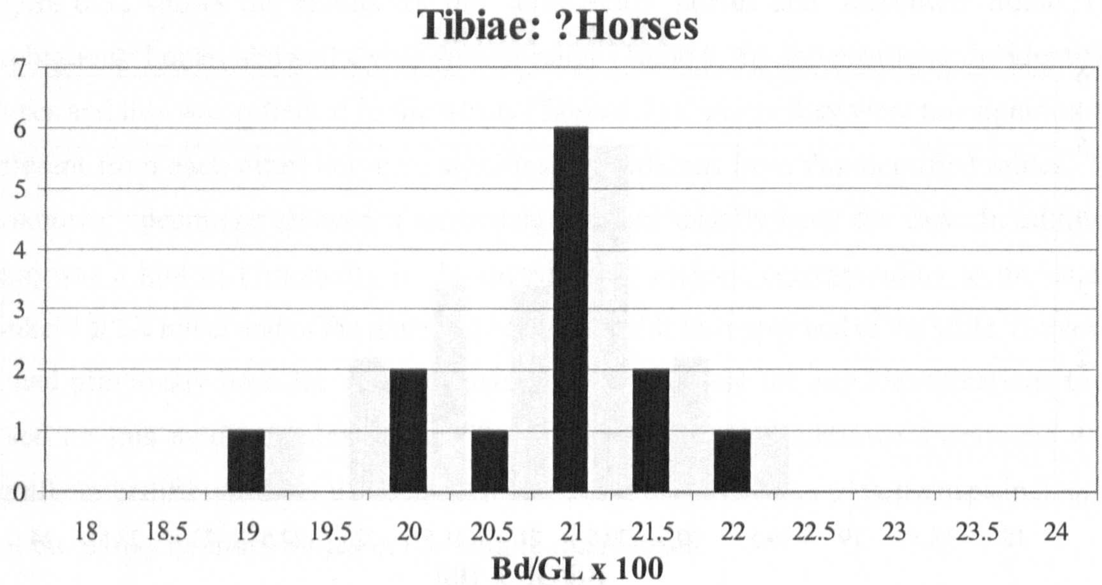


Figure 6.81. Histograms of distal breadth / greatest length index for the 'identified' archaeological tibiae by species.



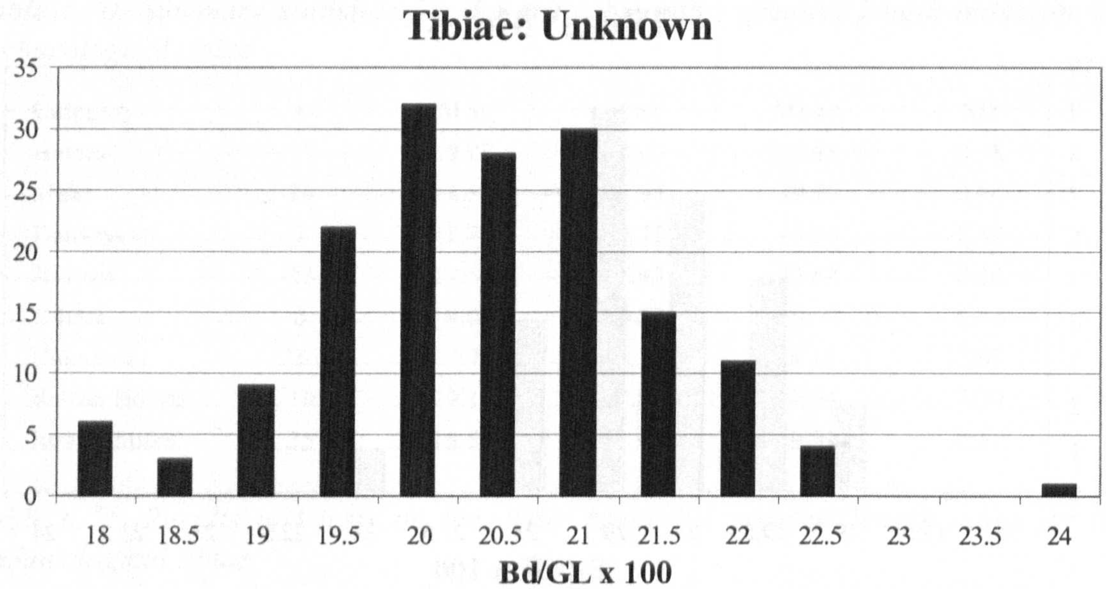


Figure 6.82. Histograms of distal breadth / greatest length index for the 'ambiguous' and 'unknown' archaeological tibiae by species.

Distal depth to distal breadth index

As there were qualitative differences in the distal morphology of the horse and mule tibiae, it was decided to try a slightly more unusual shape index to see if the visual differences were detectable biometrically. The index used was distal depth to distal breadth (Dd/Bd x 100) and the detailed results are given in Appendix Table A34 and Figures A22 and A23. Unfortunately the subtle morphological differences were not picked up by the gross measurement of distal breadth and depth, as there were no significant differences between the species (although the numbers were quite small). It is suggested that more refined measurements may be necessary to pick up the morphological differences between horses and mules.

6.3.4 *Calculation of shape indices on radii*

As with the tibiae, the purpose of calculating indices on the radii was twofold, to understand further the differences between the species and to comprehend more about any differences within the species by period or area.

Shaft breadth to greatest length index

There was a total of 305 radii that had both greatest length and shaft breadth measurements. Of these, 100 were 'identified' (57 horses, 32 mules and 11 donkeys), 24 were 'ambiguous' (17 horses and seven mules) and the remaining 181 were 'unknown' specimens. The results are shown in Figure 6.83 and Tables 6.72 and 73 (details in Appendix Table A35). As with the tibiae the results for the identified horses and mules were very similar, with the donkeys being slightly more slender. This was reflected in the t-tests, which showed that there was no significant difference between the horses and mules and highly significant differences between the donkeys and the other two species.

The results for the 'ambiguous' and 'unknown' specimens are shown in Figure 6.84. There were too few ambiguous mules to test for significant differences between pairings of species. However, the range and mean appeared very similar to those of the identified mules but also overlapped with the horses, so it is unlikely that they could be identified further on this basis. The 'ambiguous' horses were also within the range of both the identified horses and mules and this was mirrored in the t-tests, which suggested they were most likely to be mules but could be horses. The range of the unknown specimens overlapped the range of the combined species, with a bias towards the higher middle and higher end of the range. This was reflected in the t-tests, which suggested that the unknown specimens were unlikely to be donkeys but could be horses or mules.

Table 6.72. Summary statistics for the shaft breadth / greatest length index for the archaeological radii

Category	n	Min	Max	Mean	SD
Horses	57	10.40	12.68	11.28	0.55
Mules	32	10.08	12.12	11.09	0.52
Donkeys	11	9.93	11.00	10.47	0.32
?Horses	17	10.17	11.81	10.95	0.48
?Mules	7	10.34	12.08	11.13	0.71
Unknown	181	7.96	13.59	11.17	0.74
Iron Age horses	8	10.82	12.68	11.56	0.67
External horses	22	10.40	12.16	11.26	0.51
Roman horses	27	10.43	12.59	11.21	0.55
Roman mules	28	10.08	12.12	11.16	0.51

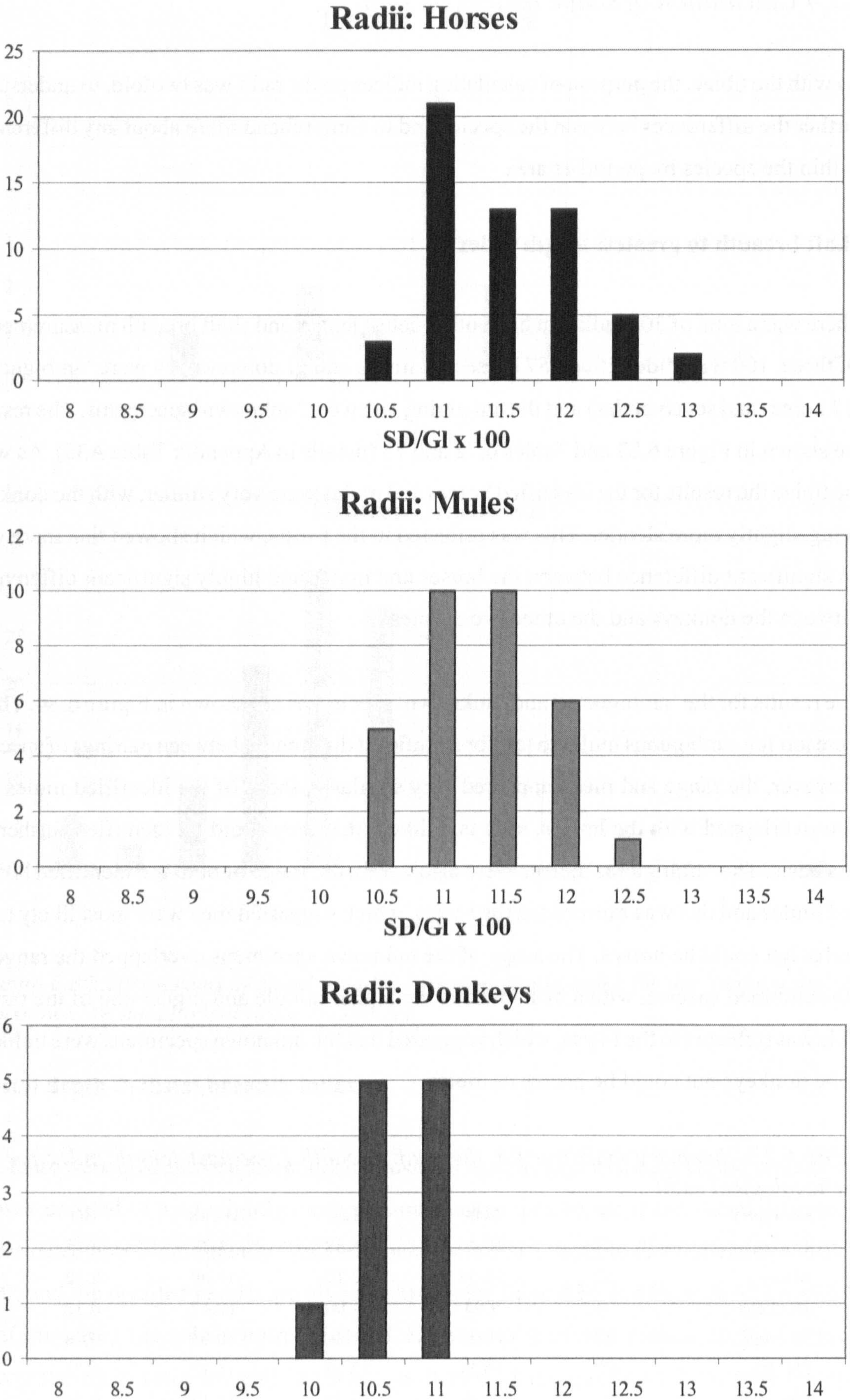


Figure 6.83. Histograms of shaft breadth / greatest length index for the 'identified' archaeological radii by species.

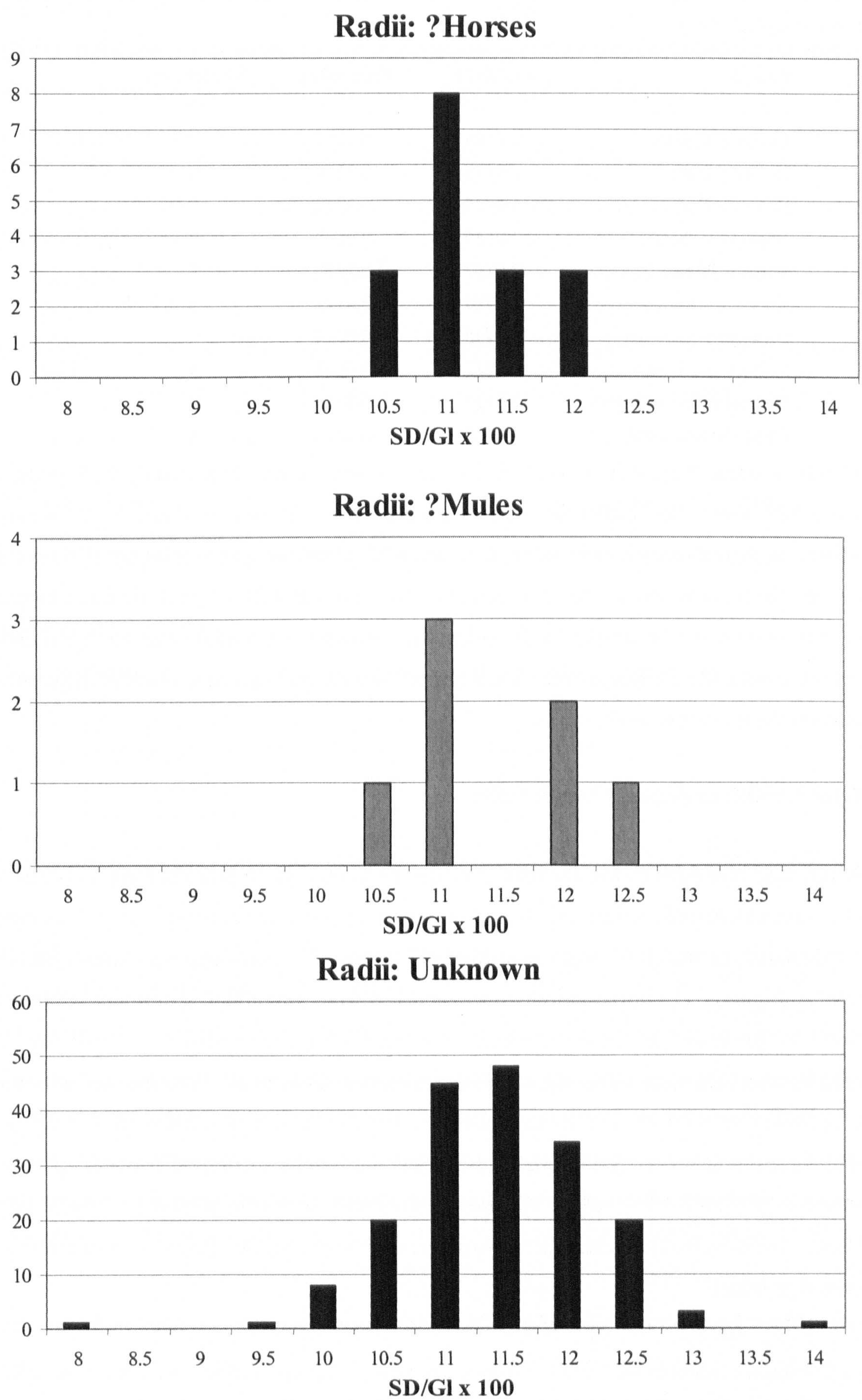


Figure 6.84. Histograms of shaft breadth-greatest length index for the 'ambiguous' and 'unknown' archaeological radii by species.

Table 6.73. Results of t-tests on the shaft breadth / greatest length index for the archaeological radii

Pairing	t statistic	Probability	Significance
Donkeys v horses	1.9966	0.0000	**
Donkeys v mules	2.0195	0.0007	**
Horses v mules	1.9876	0.1254	N
Horses v ?horses	1.9935	0.0318	*
Donkeys v ?horses	2.0555	0.0078	**
Mules v ?horses	2.0117	0.3629	N
Horses v unknown	1.9701	0.3175	N
Donkeys v unknown	1.9725	0.0024	**
Mules v unknown	1.9713	0.5678	N
External v Roman horses	2.0117	0.7415	N
Roman horses v mules	2.0057	0.7676	N

As with the tibiae, there were too few specimens to warrant much further analysis. Appendix Figure A24 shows the results for the identified horses split by period and the summary statistics and t-tests are given in Tables 6.72 and 6.73. There were no significant differences between the Roman and External horses (there were too few Iron Age individuals to test but they were visually similar to the other two periods). Also there was no significant difference between the Roman mules and horses, as was likely given the lack of difference between the species overall.

Distal breadth to greatest length index

Figures 6.85 and 6.86 shows the results of the distal breadth to greatest length (Bd/Gl x 100) index calculated on the radii. There was a total of 264 radii for which this index could be calculated, of which 91 were identified (53 horses, 29 mules and nine donkeys), 18 were 'ambiguous' (15 horses, three mules) and 155 were 'unknown' specimens. Detailed results are presented in Appendix Table A36. Examining the identified material first, it could be seen that there were slight visual differences between all three species, with the horses being most robust, the donkeys most slender and the mules in between. The ranges for all three (Table 6.74) overlapped, but the means were slightly different. This was reflected in the t-tests (Table 6.75), where all three species were shown to be highly significantly different from each other. It should be borne in mind, however, that the number of donkeys was rather small.

These results echoed those from the tibiae, where the shaft slenderness results between the horses and mules were not different, but those from the distal slenderness index were. Whilst the radius did not produce exaggerated withers height estimates, it is possible that a similar morphological explanation to that given for the tibiae can be used here. Namely, that the mule radii are more slender at their distal ends than those of the horses but that the shaft robusticity is similar in both, perhaps as a result of the physical need for strength for muscle attachment in the shaft area or a similar weight bearing requirement but slightly different joint function.

Table 6.74. Summary statistics for the distal breadth / greatest length index for the archaeological radii

Category	n	Min	Max	Mean	SD
Horses	53	20.97	23.97	22.54	0.69
Mules	29	20.33	23.05	21.96	0.64
Donkeys	9	20.22	22.08	21.22	0.68
?Horses	15	19.81	22.78	21.73	0.70
Unknown	155	17.69	25.00	22.00	1.07
Iron Age horses	7	21.31	23.30	22.65	0.65
External horses	22	21.50	23.97	22.86	0.69
Roman horses	24	20.97	23.41	22.22	0.57
Roman mules	25	20.33	23.05	22.05	0.59

Table 6.75. Results of t-tests on the distal breadth / greatest length index for the archaeological radii

Pairing	t statistic	Probability	Significance
Donkeys v horses	2.0003	0.0000	**
Donkeys v mules	2.0281	0.0051	**
Horses v mules	1.9901	0.0004	**
?Horses v mules	2.0181	0.2644	N
?Horses v donkeys	2.0739	0.0979	N
?Horses v horses	1.9966	0.0002	**
Unknown v mules	1.9731	0.8691	N
Unknwown v donkeys	1.9747	0.0340	*
Unknown v horses	1.9715	0.0007	**
External v Roman horses	2.0154	0.0013	**
Roman horses v mules	2.0117	0.3277	N

There were too few 'ambiguous' mules (three) to display graphically or to apply t-tests to. The 'ambiguous' horses are shown in Figure 6.86 and exhibited a lower range and modal class than the identified horses (Table 6.74), and this is shown in the t-tests (Table 6.75) where they were highly significantly different to the horses but not from either the mules or donkeys. This suggests that the slenderness of the distal end of these bones in relation to their lengths is perhaps one of the factors in the ambiguity of their identification.

As has often been the case previously, the 'unknown' specimens covered a wider range than the combined identified specimens (Table 6.74). The t-tests showed that the 'unknown' specimens were not significantly different from the mules but were from the other two species, suggesting that there may perhaps be a higher proportion of mules in this group than there has been on previous elements.

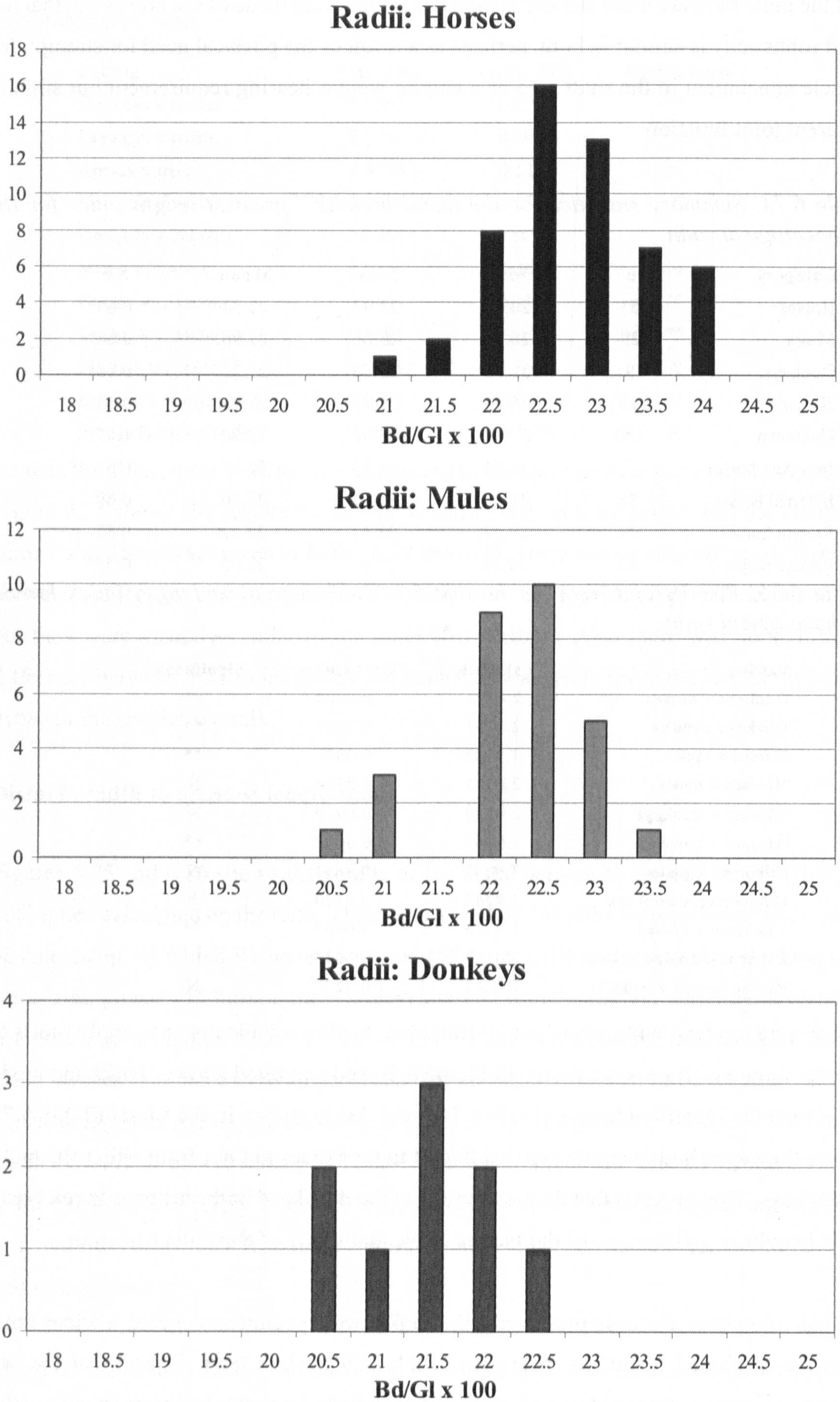
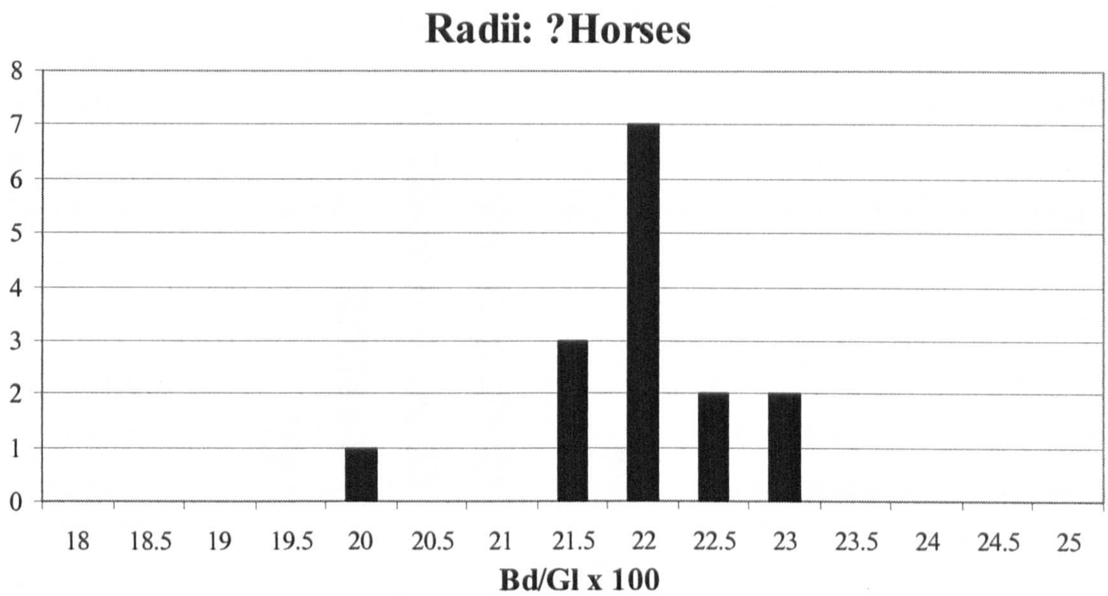


Figure 6.85. Histograms of distal breadth / greatest length index for the 'identified' archaeological radii by species.



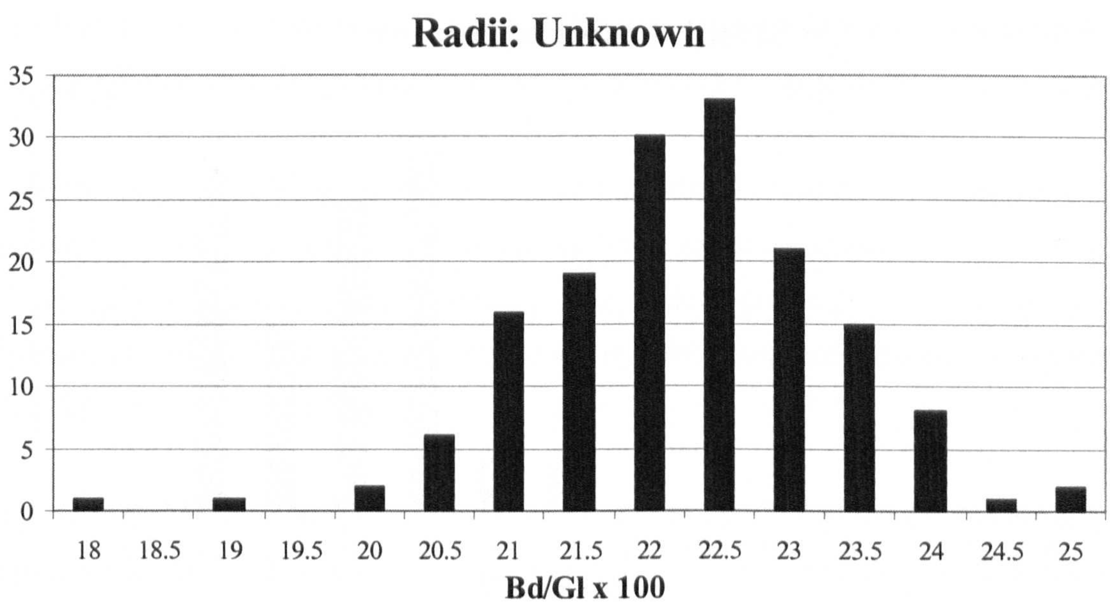
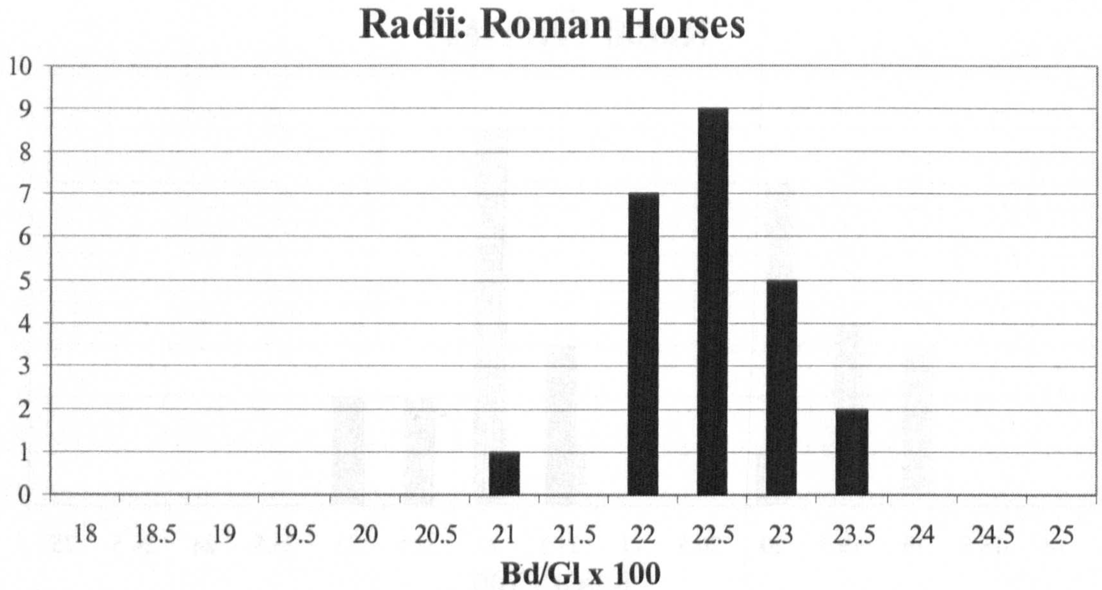


Figure 6.86. Histogram of distal breadth / greatest length index for the 'ambiguous' and 'unknown' archaeological radii by species.

Although the numbers were relatively small, the horse group could be split into period groups. Figure 6.87 shows that the Roman and External groups were slightly different to each other, with the External individuals appearing more robust than the Roman individuals. This result was borne out by the t-tests (Table 6.75), which showed that the two period groups were highly significantly different. This result was in direct contrast to the metapodials, where the External horses were significantly more slender than their Roman counterparts in most of the index results. A possible explanation may be that although the distal ends of the radii are larger, they are in proportion with the proximal metacarpals, which were also similar in all periods. This could therefore lend weight to the argument that nutritional stress in early life is affecting the metapodials of some individuals.



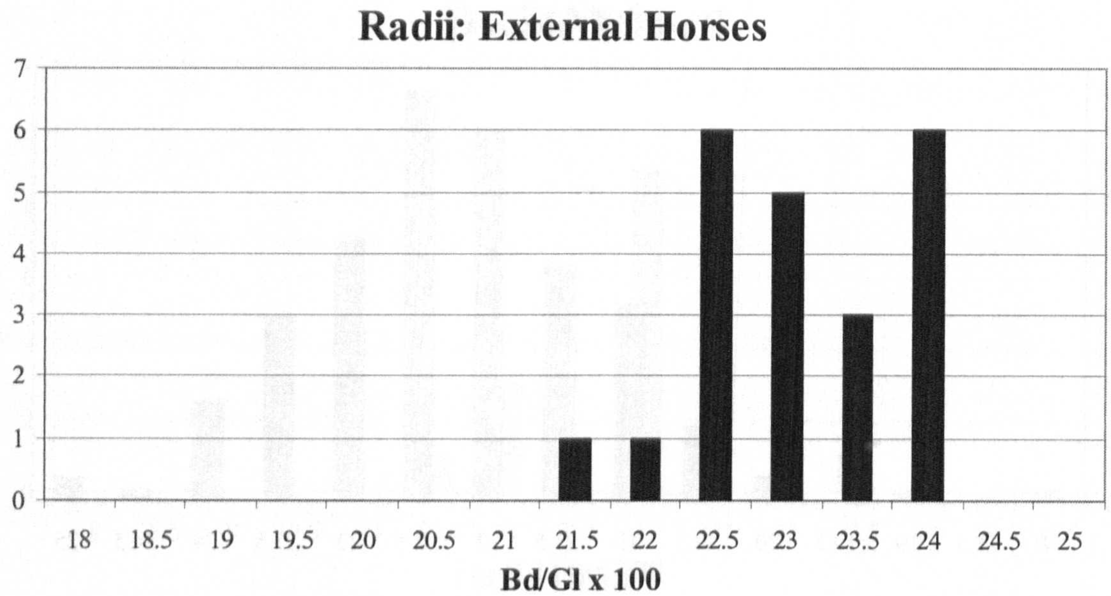


Figure 6.87. Histogram of distal breadth / greatest length index for the 'identified' archaeological horse radii by period

When the Roman horses and mules were compared (Appendix Figure A25 for Roman mules) it was found that there was no significant difference between them (Table 6.75). This suggests that the more robust External horses are influencing the results from the species as a whole. The higher values from the External horses were producing a higher range for the horses as a whole and therefore differences between the horses and mules were detectable. The lack of difference in the Roman horses and mules may suggest that the morphology of the radius is more influenced by the mare than the jackass, as was proposed above for the same index on the tibiae.

6.3.5 Summary of shape index analysis

There are two parts of the results of the shape indices that require summarising. Firstly the characteristics that clarify differences between the species and therefore may help with identification, and secondly those results that help us understand the similarities and differences within species.

Examining the species in terms of their shape indices showed that the metapodials were very similar to each other. The radius and tibia were also similar to each other but in some respects different to the metapodials. For all the indices calculated on the metapodials the donkeys were consistently the most slender of the three species. Similarly, on all the indices the mules were more slender than the horses. However, the degree of this difference changed: in particular, the differences were more marked on the metatarsal than the metacarpal, and were progressively more pronounced from the proximal to distal ends.

From these results a bivariate plot of the shaft and distal breadth indices plotted against each other goes some way to separating the horse and mule metatarsals (Figure 6.76). Whilst this does not give complete separation, it does give a good indication that the specimens could be mules if the points lie towards the bottom of the scatter and horses if they lie to the top right of the scatter.

It can be argued that the distal slenderness of the metapodials of the mules is a morphological characteristic inherited from the jackass. Both the fore and hind hooves of mules are more like those of donkeys and much narrower than those of horses. This characteristic translates into a narrow proximal third phalanx articular surface and hence narrow phalanges and distal metapodials.

The tibia and radius differ slightly from the metapodial pattern outlined above in several respects. Because of the poor taphonomic survival of the proximal ends of the bones (particularly the tibia) it was not possible to analyse the proximal breadth to greatest length index. The shaft index showed no significant difference between the mules and horses on either bone (the donkeys were more slender on the radius where there were sufficient numbers), whilst the distal index once again showed a noticeable slenderness of the mules in comparison with the horses (the donkeys were also more slender on the radius).

The slenderness of the distal end of the tibia and radius has to be related to skeletal anatomy. The mules are more slender than the horses at the proximal end of the metapodials; therefore, they should be similarly slender at the distal end of the zygopodium in order for the joints to align correctly. The lack of differentiation in the shaft slenderness could be related to the increased muscle mass around the bones of the zygopodium and therefore an increased need for mechanical strength or simply a matter of weight bearing.

Another aspect of the analysis of the shaft breadth index on the tibia in particular was the issue of the elongation of the tibia in relation to the withers height (as outlined in Chapter 3). Here the question was whether were the mule tibiae were more slender than the horse as well as proportionately longer. From the lack of difference between the mules and horses on the shaft breadth to greatest length index, it seems that the mule tibiae are as proportionately robust as the horses. The reason given above for this lack of differentiation, namely the need for mechanical strength in this area, may well not allow the tibia to be too slender.

In addition to the shaft and distal breadth indices, a distal depth to breadth ratio was calculated. This was desgined to pick up the differences in shape outlined by Peters (1998) and discussed in Chapter 4. However, these differences could not be picked up using distal breadth and distal depth measurements. This may partly be an effect of the small sample size available for this analysis, but may also be an indication that these measurements are not refined enough to pick out the morphological characteristics in enough detail.

The results from the shape indices can also give some indication of where the identification of 'ambiguous' individuals is failing. On the metapodials it generally seems to be the case that the 'ambiguous' horses are those that are more slender in their breadth dimensions in relation to length, hence they are more 'mule-like' in this respect. There are two areas where the 'ambiguous' mules are causing problems. Firstly, the more robust individuals are being confused with the horses, and secondly the overall smaller individuals are overlapping with the donkeys. The 'ambiguous' mules are mostly ambiguous in their proximal and shaft dimensions, as their distal indices fall in the middle of the range for the identified material. This perhaps indicates that the inheritance of the distal metapodial morphology is a relatively reliable characteristic.

Examination of the results to reveal similarities or differences within species was unfortunately hampered by the small numbers of specimens available for analysis. Therefore for most elements no further analysis was possible regarding the donkey bones and very little on the mules. In general, there were very few significant differences between the mule data by period, area or site type, confirming the previous observations that the mules appear to be very homogeneous across the Roman Empire. The exceptions to this were on the shaft breadth to greatest length index on the metatarsals, where the External mules were slightly more slender than the Roman ones and the mules from Roman Gaul also seemed slightly more slender than those from other areas, but were too few to test for significance. These results will be compared with those of the horses and discussed below.

The horses showed a little more variation than the mules, but still not a great deal. This was again partly due to the small sample sizes. In most of the analyses it was noted that, where there were differences by period, the Roman horses were generally more robust than their Iron Age and External counterparts. This was particularly true for the shaft indices of the metapodials but less so for the articular indices or the zygopodium. Three possible explanations for the slenderness of the shafts of the External metapodials can be considered. Firstly, it is possible that these individuals experienced nutritional deprivation during the period of time affecting the circumferential growth of the metapodials but not during longitudinal growth. Secondly, there may be some genetic basis for these individuals having more slender shafts to their metapodials. Thirdly, castration may cause the elongation of bones by delaying epiphyseal closure, and hence sexual dimorphism could be detected in this way. However, it is unlikely that a group of bones derived from several sites spread over a relatively wide geographic area would contain mostly geldings whilst the groups used for comparison contained mostly mares and/or stallions. In addition, the degree to which equids are sexually dimorphic is slight and the degree of bone elongation caused by castration is not fully known, therefore it is unlikely that this is the cause of the greater slenderness of these horses.

The first two explanations can both be argued for and against, making it unlikely that it will be possible to determine which is more likely. The large number of individuals affected perhaps argues that it is more likely that there is a genetic basis for this metapodial shaft slenderness than a temporally and geographically widespread husbandry regime that causes nutritional stress during the period of circumferential growth. However, one regime that would produce this pattern of nutritional stress is where the foals are weaned late (i.e. after their first winter) so their second winter will be the first 'on their own' in terms of nutrition. The period of circumferential growth of the metapodials, which occurs during an age range of 1½ to 2 years, would coincide with the second winter, if it is accepted that foaling occurs naturally around April-May each year. Given that most of these External horses were from Northern Europe, wintertime could easily cause nutritional stress if no supplementary fodder was available to the animals.

A second case where there were slender individuals is the distal breadth to greatest length index of both metapodials. Here the Iron Age horses from Gaul were more slender than their counterparts in other areas and also more slender than the Roman horses from the same area. Although both explanations given above could be used here, it is much less likely that nutritional stress would affect the distal articular breadth than it would the shaft breadth. As this result is restricted to one area, it seems more likely that the Iron Age horses from Gaul had slightly more slender distal limb morphology than their counterparts in other areas, which is likely to have been genetic in origin.

On the metatarsal shaft slenderness index there were also two cases where there were more slender individuals. Firstly the Roman horses from Gaul were more slender in their shafts than those from other areas, and secondly the Urban 2 (small town) group was more slender than the Urban counterparts. This is perhaps unsurprising as both groups originate mainly from a single site. Once again both arguments nutritional deprevation and genetic, can be put forward about the origin of this shaft slenderness. In this case it is impossible to suggest which explanation is more likely as the numbers do not preclude a single husbandry regime and as they are from a single site they could be genetically distinct.

When the radius and tibia were examined there were far fewer specimens even than for the metapodials, which severely limited the subsequent analyses. Two points of interest were, however, noted. Firstly, the distal breadth to greatest length index on the tibia showed that even though on the overall species analysis the mules were more slender than the horses, when the Roman animals were compared no significant difference was detected. Although the number of horses was relatively small, it is suggested that perhaps the Roman mules had inherited a robusticity in their tibiae from the generally more robust Roman horses. However, it is slightly odd that this is based on the dimensions of the distal tibia, when the proximal metatarsal showed the more usual pattern of slender mules.

Secondly, regarding the distal breadth to greatest length index of the radius, the External horses were more robust than their Roman counterparts, in contrast to all other elements and indices where a difference was detected. For obvious anatomical reasons the distal radius has to be in proportion to the proximal metacarpal, for which no significant differences were noted by period. This suggests that the distal radius of the External horses is a little more robust than expected. The general slenderness of the External metacarpals is perhaps making the contrast seem greater than it really is. If this is the case, this piece of evidence lends weight to the argument that nutritional stress is the most likely causal factor for the slender shafts of the External horse metapodials.

6.3.6. Relation of shape index results to species identification issues

In order to determine if the results of the shape indices could further characterise the outlying groups of identifications observed and commented on in Sections 6.1.3 and 6.2.4, some further analysis of the data was once again necessary. The location of these outlying groups in relation to the 'standard' identification plot (see Figure 6.1) is shown in Figure 6.88 and the definitions of the groups are as stated in Section 6.2.4. As with the withers heights, the range of the shape index results for each element by species was split into three equal portions. Individual bones falling in the smallest third were termed 'slender', the middle third 'average' and the largest third 'robust'. These results were then related to the groups outlined above according to where each bone was located on the identification plots in Section 2.1.

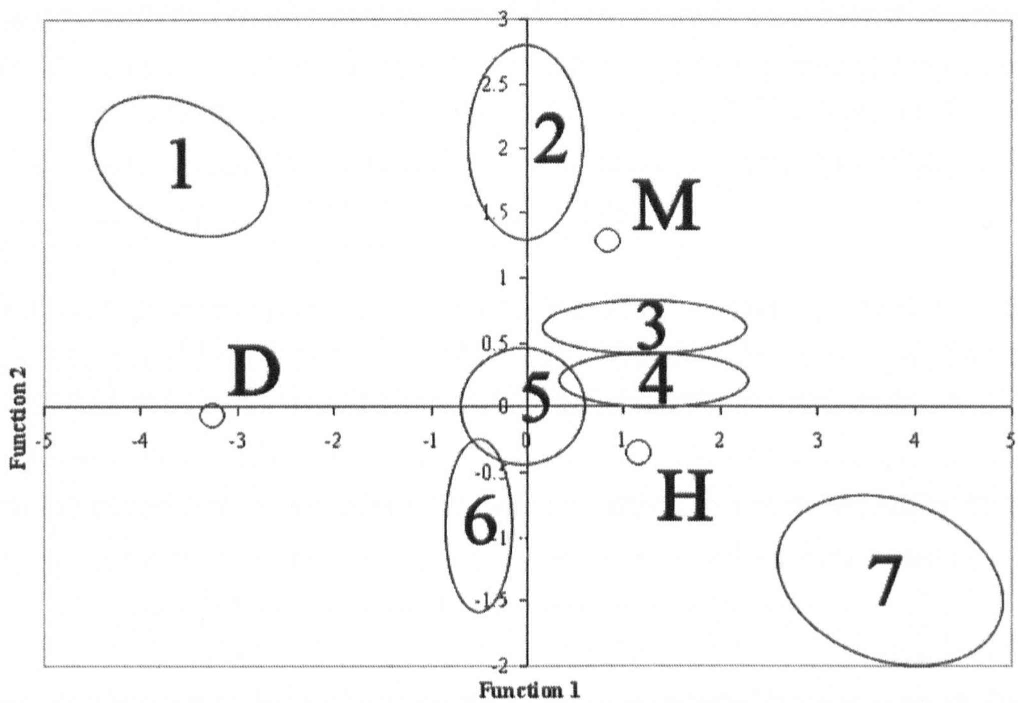


Figure 6.88. Areas on the 'average' discriminant function plot where clusters of identifications occur

As with the withers heights, it was discovered that the shape indices of the bones were playing a role in the determination of species and the characteristics of the identification clusters. The 'super' donkeys (area 1) have varied shape indices suggesting that length is more important in their separation. The 'super' mules (area 2) have average to robust shape indices, suggesting that although they are tall individuals they are also proportionately robust. On the other hand, the 'super' horses (area 7) have average to robust shape indices but this time linked with small stature.

The horses and mules in the overlap zone (areas 3 and 4) have average and mixed (respectively) shape indices, suggesting that the overlap in height and the similarity in robusticity are both contributing to the identification problems of these individuals. Both mules and horses in area 5, where the points cluster around the zero point, have slender to average shape indices, as do the horses to the left of the zero line (area 6). In general it seems that robusticity of the individuals is mostly reflected on the x-axis and height mostly on the y-axis of the identification plots. The characteristics of the clusters can, therefore, be roughly determined on this basis.

6.4. Calculation of log-ratios

The history and working of the log-ratio technique has been outlined in Chapter 3 so will not be repeated here. It is, however, worth mentioning that the length, breadth and depth measurements will be studied separately, as advocated by Davis (1996), so that differences within and between the three dimensions can be studied using the period, area and site type groups.

The original intention of this section was to include many of the measurements that could not be utilised in the preceding analyses and therefore increase the size of the dataset and enhance the results gained so far. However, several problems came to light during the previous analyses that meant that the scope of this section had to be scaled down. As stated above, one of the usual advantages of using this technique is that bones where only one or few measurements can be taken can be included in the analysis. However, it became clear that in this research it would not be possible to include more bones than had been used for the previous analyses because the bones have not been identified in Section 6.1. It would not be meaningful to compare 'unidentified' bones to the horse standard (Chapter 3), for example, when the bones could be from mules or donkeys.

This problem of comparing the measurements of the mules and donkeys to a horse standard is also relevant to the identified bones. If the mule measurements were compared to the horse standard, the results would be showing differences to that standard, which have nothing to do with the differences within the mules as a species and more to do with the differences between horses and mules. The same would be true of the donkeys. However, if the mule log-ratios were calculated using a mule standard and the horses using the horse standard, the two sets of results could not be compared to each other.

For these reasons it was decided that only the identified horse data would be studied for this section and the results would be used to confirm or contradict the evidence presented in the preceding sections, rather than as a separate set of results.

6.4.1 Log-ratio analysis of horse length measurements

The length measurements of the 'identified' horses were converted to log-ratio values using the Mongolian pony standard set out in Chapter 3. Where two lengths were present from the same bone, the mean of the two values was calculated to reduce the calculation errors caused by the values not being independent. However, the separate elements from the skeletons and limbs were left as multiple values, so some dependant values were included.

A total of 609 'identified' horse length measurements could be converted to log-ratios (including the mean values where two measurements from the same bone were taken). The detailed results of these calculations are given in the Appendix Table A37. The large number of lengths meant that the data could be split into most of the groups that have previously been studied. The period groups are shown in Figure 6.89. As was the case with the withers heights, there were highly significant differences between all three groups (Table 6.76), with the Roman horses having the longest bones and the Iron Age ones the shortest.

Table 6.76. Results of t-tests on the log-ratio length results for the 'identified' archaeological horses

Pairing	t statistic	Probability	Significance
Iron Age v External	1.9663	0.0010	**
Iron Age v Roman	1.9672	0.0000	**
External v Roman	1.9647	0.0000	**
Iron Age areas D V E	2.0129	0.2037	N
Iron Age areas D V F	2.0211	0.6218	N
Iron Age areas D V G	1.9977	0.0006	**
Iron Age areas E V F	2.0423	0.4668	N
Iron Age areas E V G	2.0049	0.0530	N
Iron Age areas F V G	2.0106	0.0130	*
Roman areas D V E	1.9939	0.9957	N
Roman areas D V F	1.9835	0.0079	**
Roman areas D V G	1.9837	0.0518	N
Roman areas E V F	1.9801	0.0106	*
Roman areas E V G	1.9803	0.0724	N
Roman areas F V G	1.9760	0.2179	N
Cemetery v military	2.0040	0.0512	N
Cemetery v rural	2.0395	0.0048	**
Cemetery v urban	1.9818	0.0002	**
Cemetery v urban2	1.9996	0.0003	**
Cemtery v villa	2.0452	0.0011	**
Military v villa	2.0086	0.5333	N
Military v rural	2.0066	0.6847	N
Military v urban	1.9782	0.2310	N
Military v urban2	1.9893	0.2692	N
Rural v urban	1.9824	0.7348	N
Rural v urban2	2.0017	0.6716	N
Rural v villa	2.0555	0.7995	N
Urban v urban2	1.9774	0.8444	N
Urban v villa	1.9828	0.9876	N
Urban2 v villa	2.0032	0.9220	N

In Figure 6.89 the distribution curves are less evenly bell-shaped than had previously been the case. In particular there were slight hints that the Roman data could be bimodal and the Iron Age data appeared bi- or possibly trimodal. As stated on previous occasions, the degree of polymodalism seemed to be slight and therefore t-tests were carried out for the sake of consistency of results. The polymodalism may be a product of the repeated data from the complete skeletons and limbs boosting the classes that they fall into. This presumes that the lengths of all the elements are in exactly the same proportions as the standard, for all the values to fall into such narrow class intervals. As this seems unlikely and because of the large numbers of cases involved, the less uniform pattern observed in these data may be real. Breaking the data down into smaller groups may help illuminate this issue.

In relation to the Mongolian pony standard, the External horses are clustered around the zero mark, indicating that in terms of bone length and hence height these two groups of animals are very similar. The Iron Age horses are much more spread out, two apparent groups falling either side of the zero mark. The majority are smaller than the pony standard and the minority are slightly larger than the standard. The Roman data are almost all substantially larger than the pony standard, as was expected from the withers height results.

Examining the Iron Age data in greater detail by splitting into periods, similar observations could be made about these results as were made for the withers heights split in the same way. Figure 6.90 shows that the material from Gaul has a particularly wide range, whilst the other three areas are more restricted. It is also noticeable that there is a slight west to east increase in the sizes of the horses. This was borne out by the t-tests (Table 6.76), where the Danube and Balkans material is significantly larger than the material from Gaul and the Rhineland and only misses by a fraction on the British material. This was also the pattern observed for the withers height data.

Splitting the Roman data into the same area categories produced similar results. Figure 6.91 shows that in this instance it is the British material that showed the widest range of variation. The horses from the Rhineland had the longest bones, which were significantly longer than both the material from Roman Gaul and Britain. The Danube and Balkans material missed being significantly larger than the same two areas by a very small fraction, but was definitely not different from the Rhineland data. In the withers height data the difference was only picked up with the British data, so the log-ratios have refined these observations a little. Therefore, whilst in the Iron Age there was a slight but gradual increase in size from east to west across Europe, in the Roman period there was a much more noticeable split between the northern and western areas and the more easterly ones. It is entirely possible that this could be attributed to the large military presence with all its supporting infrastructure along the Rhine - Danube frontier, which is less prominent in the more western and northern areas.

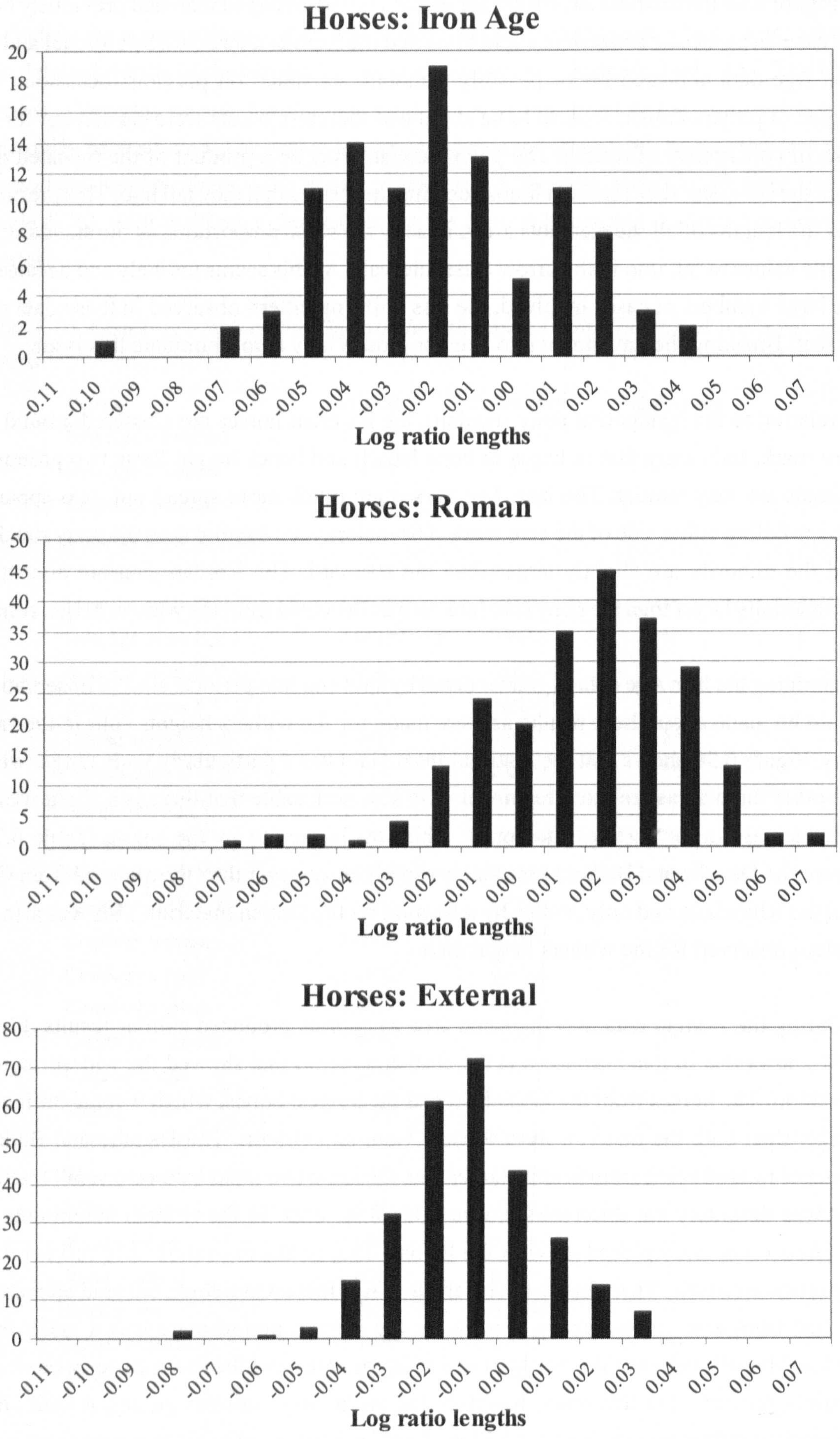


Figure 6.89. Histograms of the log-ratio length results from the 'identified' arcaeological horses split by period.

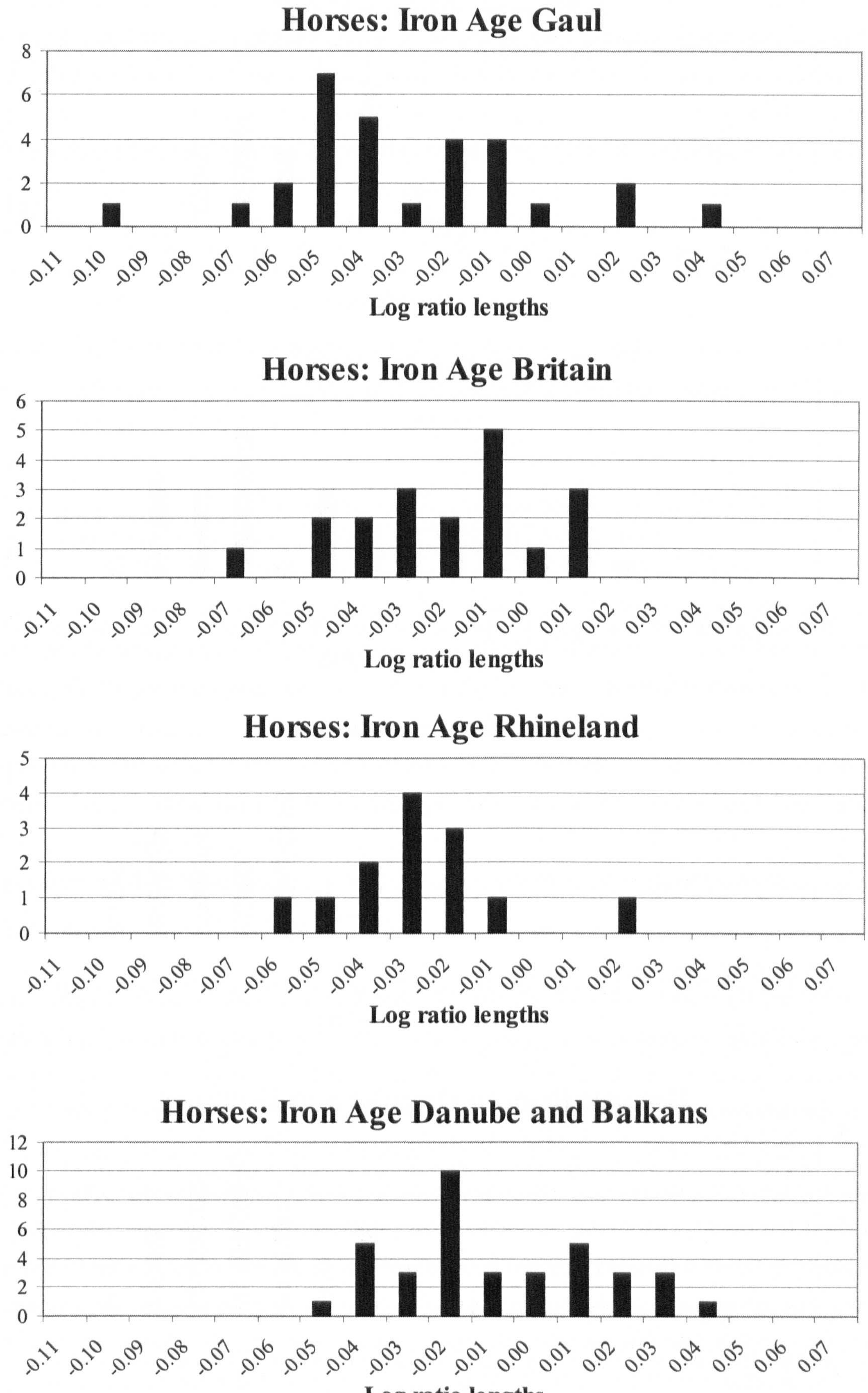


Figure 6.90. Histograms of the log-ratio length results from the 'identified' archaeological Iron Age horses split by area

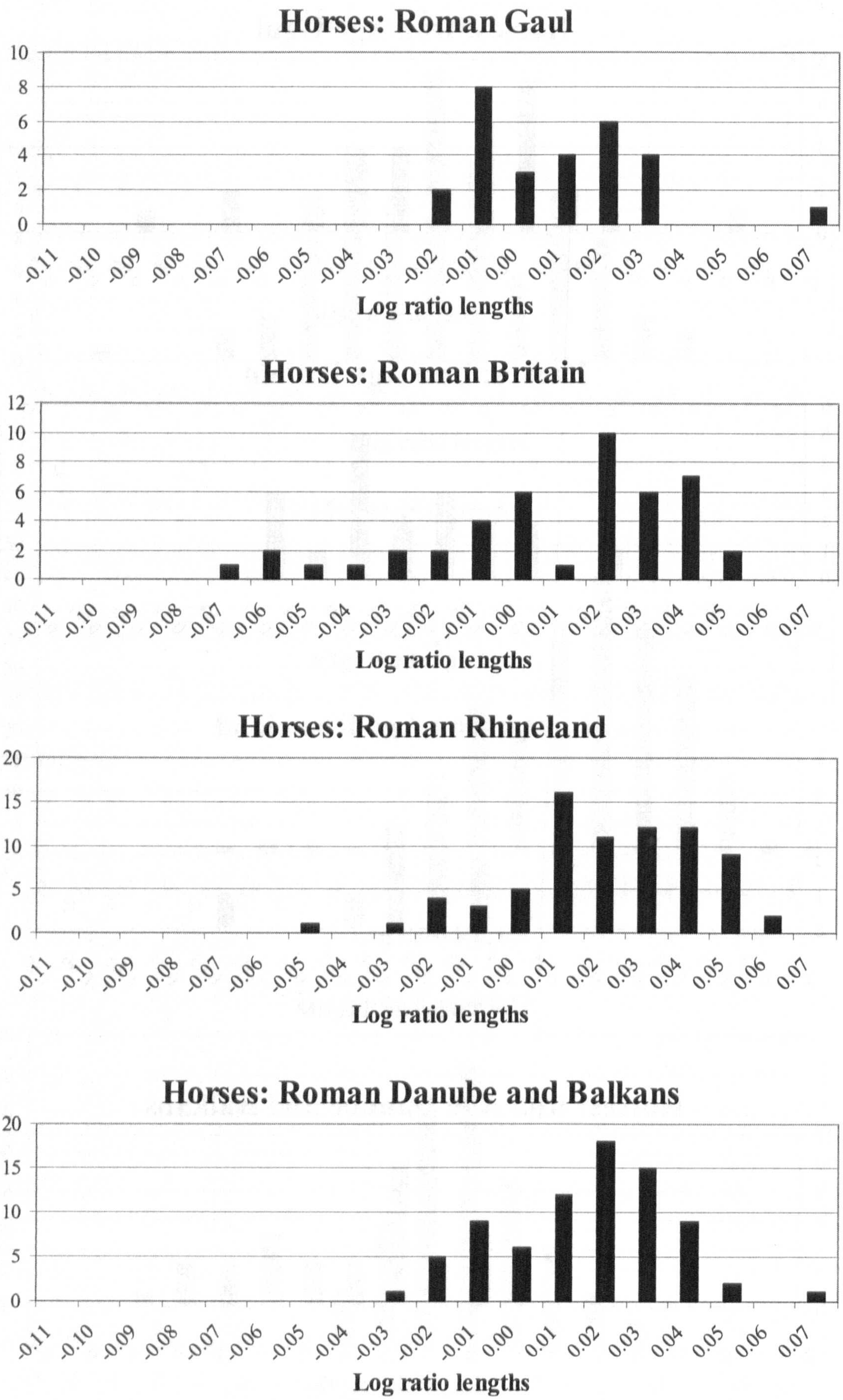


Figure 6.91. Histograms of the log-ratio length results from the 'identified' archaeological Roman horses split by area.

The Roman data were split by site type to see if the military presence was affecting the size of the horses from the more easterly areas. The results are given in Appendix Figure A26 and Table A37. Whilst the numbers of measurements were still in double figures for most groups, they were smaller than for the previous groups, which may have affected the results of the t-tests (Table 6.76). From the graphs it appeared that the military group were indeed larger than the others (with the exception of the cemetery group), but the t-tests showed that there were no significant differences between any groups except the remains from cemeteries. The numbers in that group were quite small and were mostly from a single site and a small number of complete skeletons, which undoubtedly biased the results to some degree. Therefore it seems that the military presence on the Rhine - Danube frontier was not the reason (at least not the sole reason) why the horses in these areas were larger than their counterparts from Roman Gaul and Britain.

6.4.2 Log-ratio analysis of horse breadth measurements

During the analysis of the shape indices it was noted that there appeared to be a large number of animals with slender shaft breadth indices in relation to the articular breadths. Hence, the hypothesis was put forward that it was more likely that these animals had suffered nutritional stress during limb bone growth than that they were genetically more slender than the other horses. For this reason the shaft breadth was not included in the log-ratio analysis to avoid any possible confusion of the results, as a consequence of a mixture of causal factors affecting the bones. Therefore only the articular breadth measurements were converted into log-ratios. As with the lengths, where two log-ratios were calculated on the same bone, a mean value was taken.

A total of 619 breadth measurements was converted to log-ratio values for the identified horses. The detailed results of these calculations are given in Appendix Table A38. Figure 6.92 presents the results by period. As before the three distributions were noticeably different. The hints of bimodality seen in the length data were still visible to some degree in the breadth data. This was particularly noticeable in the Iron Age data, where there was a larger peak of values below the zero line and a small peak in the positive zone. The Roman breadth data did not show the bimodality as much as the length data. There was however, a much greater range of values than previously, covering most of the Iron Age range and extending further into the positive values. In contrast the External data had a very narrow range and, as with the length data, clusters around the zero point. The differences between the periods were confirmed by the t-tests (Table 6.77), where all three results were highly significant.

Table 6.77. Results of t-tests on the log-ratio breadth results for the 'identified' archaeological horses

Pairing	t statistic	Probability	Significance
Iron Age v External	1.9662	0.0000	**
Iron Age v Roman	1.9670	0.0000	**
External v Roman	1.9646	0.0000	**
Iron Age areas D V E	2.0106	0.0721	N
Iron Age areas D V F	2.0211	0.5869	N
Iron Age areas D V G	1.9977	0.0140	*
Iron Age areas E V F	2.0369	0.3260	N
Iron Age areas E V G	2.0032	0.7857	N
Iron Age areas F V G	2.0106	0.1694	N
Roman areas D V E	1.9935	0.4943	N
Roman areas D V F	1.9835	0.0028	**
Roman areas D V G	1.9830	0.0092	**
Roman areas E V F	1.9799	0.0329	*
Roman areas E V G	1.9796	0.0531	N
Roman areas F V G	1.9757	0.9773	N

The differences seen in the Iron Age data when split by area in the length log-ratios were much less obvious when the breadth data were analysed (Figure 6.93). The only significant difference was between the data from Gaul and that from the Danube and Balkans area (Table 6.77), even though they look quite similar in Figure 6.93. This suggests that whilst the heights increase towards the east, the breadths do not. This indicates that the build of the eastern animals must have been slightly more slender in relation to height than those in the western areas. This contradicts the evidence from the shape indices, which suggested that the Iron Age Gallic horses were more slender limbed than their counterparts elsewhere.

The pattern that emerged from the length data in relation to the Roman horses by area was repeated in the breadth data. Figure 6.94 shows that, as with the Iron Age data the differences were less clear and the ranges were greater than for the length data. The t-tests (Table 6.77) confirmed that the same differences were present, namely that there was dissimilarity between the western and eastern areas, with the eastern horses having broader bones than those in the west. This means that the bones of the eastern horses were generally larger than those in the west rather than different in proportion.

In all areas except the Rhineland, there were hints of bimodality in the data, with the lower group clustering around the zero mark and the second in the positive values. This might suggest that the lower group contains individuals that are similar to the preceding Iron Age horses in that area, and larger horses may have been imported during the Roman period. This cannot be tested at present given the limitations of the dating of many of the sites (as discussed in Chapter 5) and the relatively small samples from each area. As was the case with the length data there were no discernible variations between any of the site type groups. Therefore the results are given in Appendix Figure A27.

These results corroborated those from the shape index results, which suggested that the lengths and breadths of the horse bones were in proportion to each other as there was very little variation in the shape indices between periods, areas and site types.

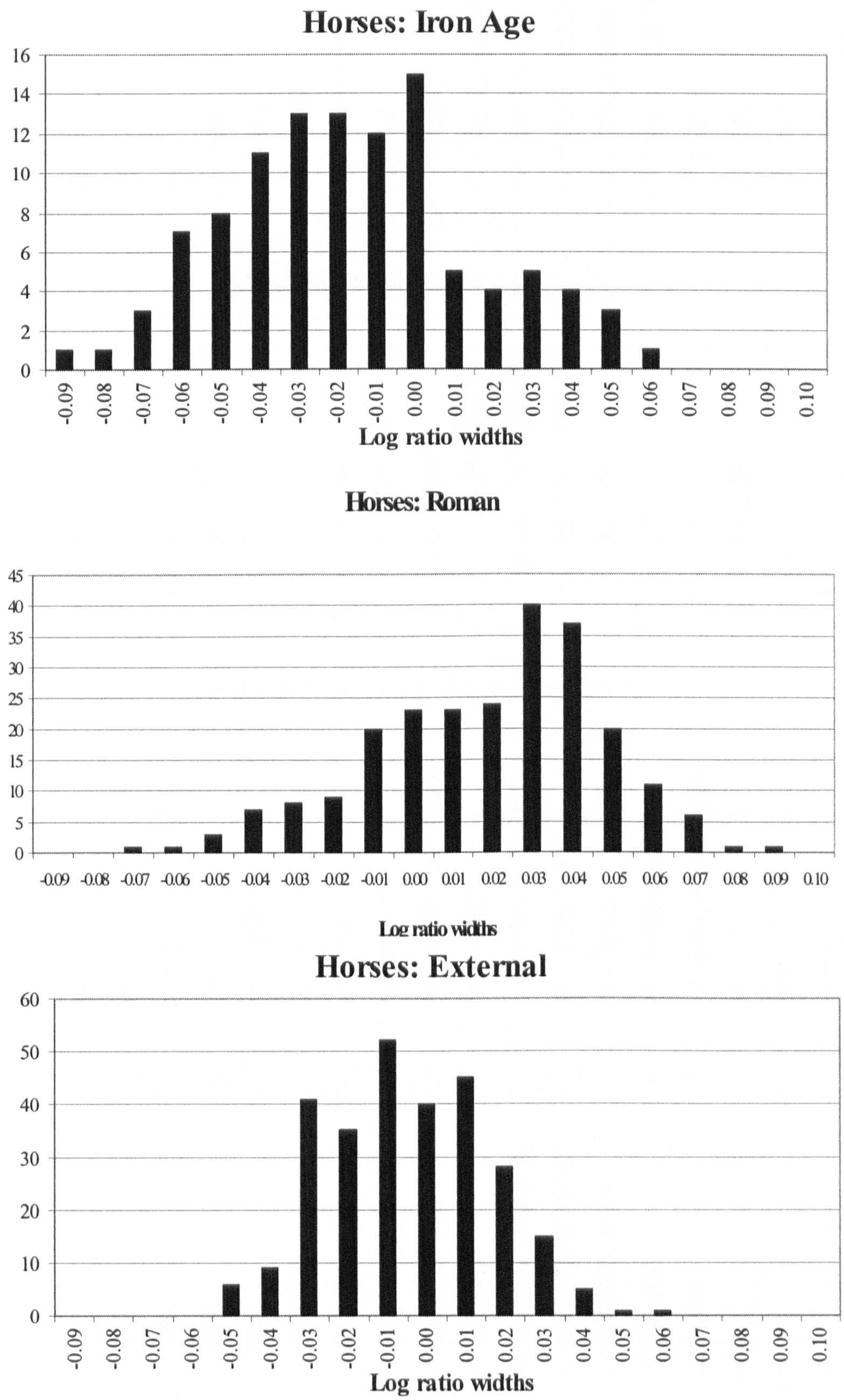


Figure 6.92 Histograms of the log-ratio breadth results from the 'identified' archaeological horses by period

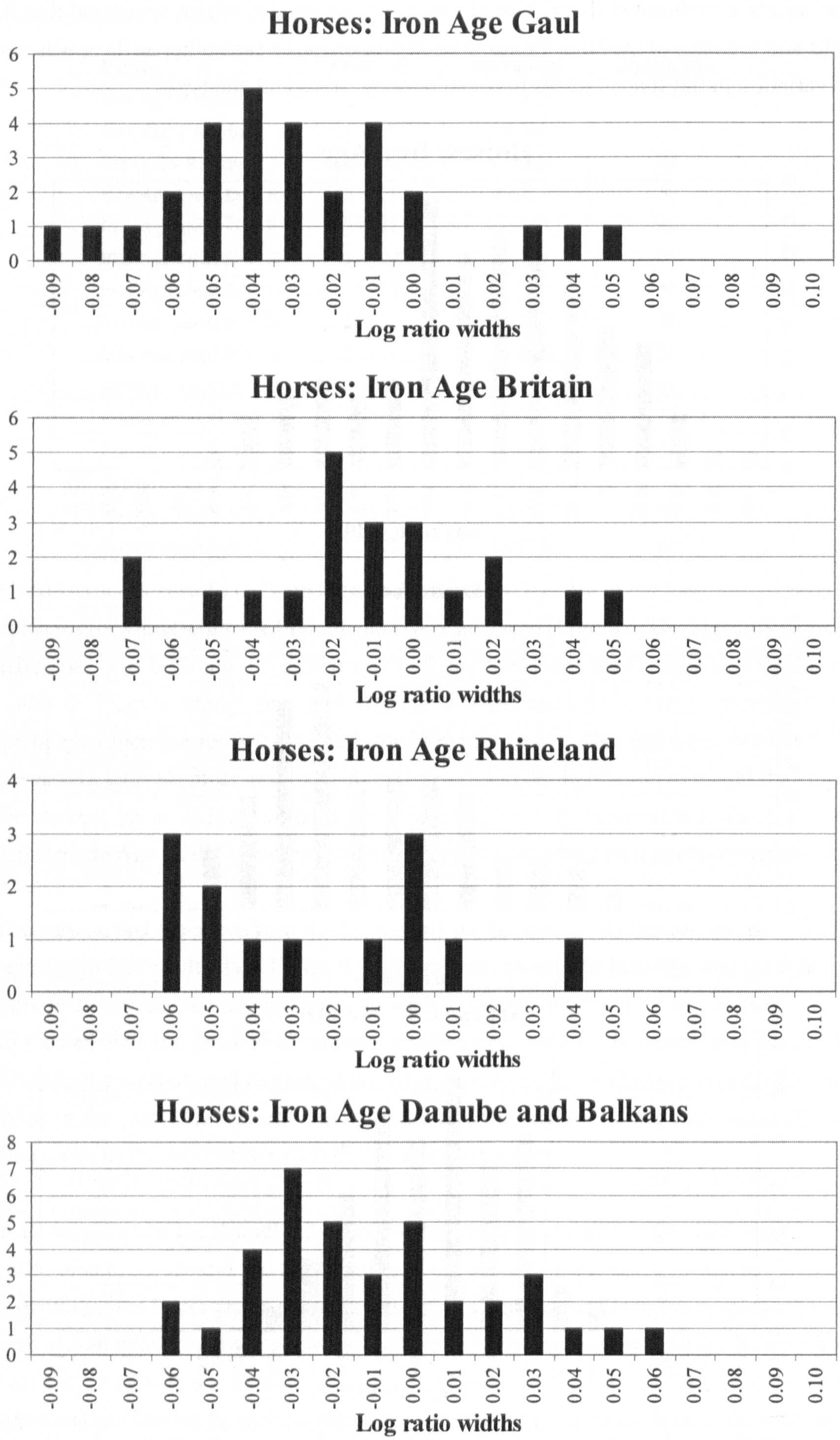


Figure 6.93 Histograms of the log-ratio breadth results from the 'identified' archaeological Iron Age horses by area

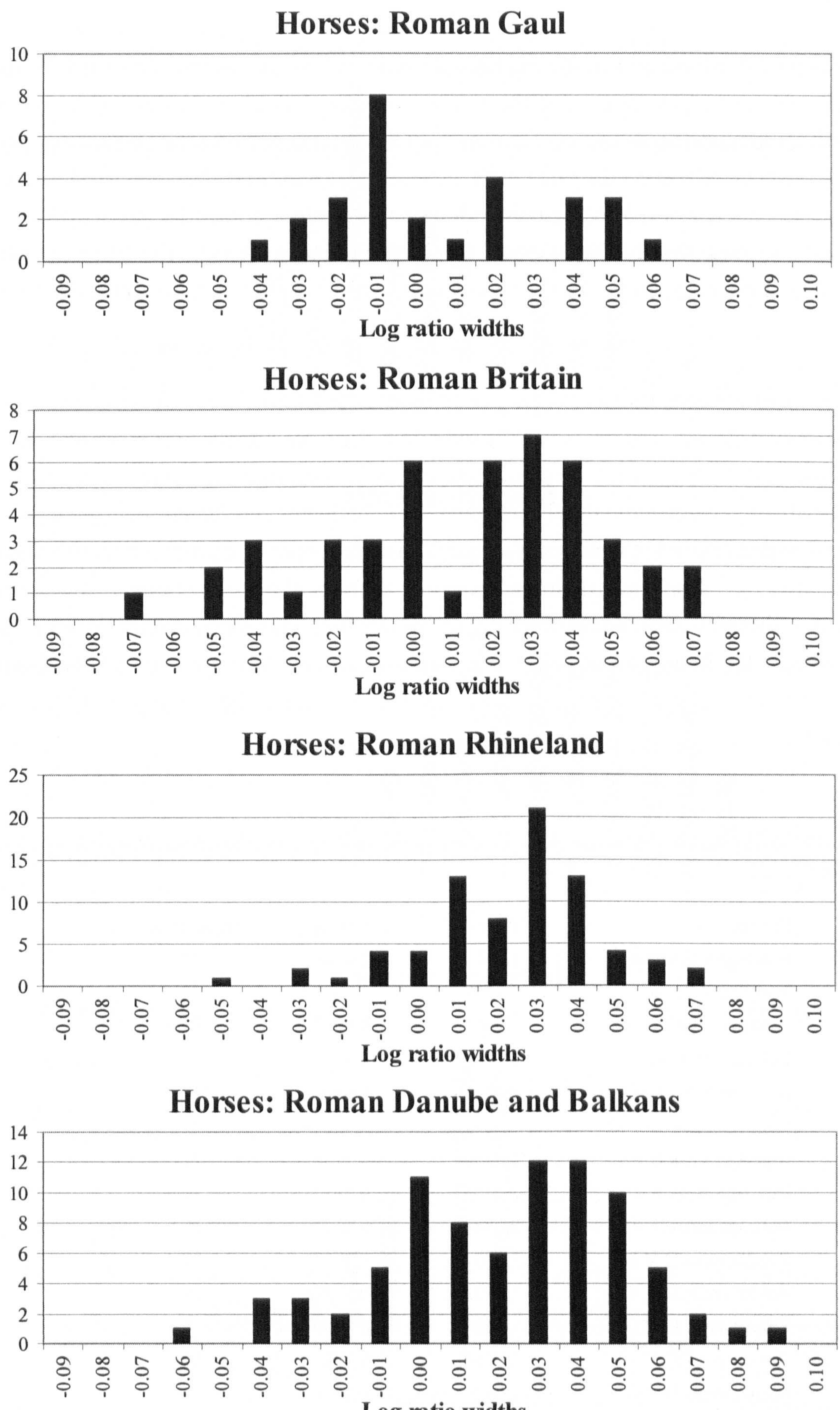


Figure 6.94. Histograms of the log-ratio breadth results from the 'identified' archaeological Roman horses by area

6.4.3 Log-ratio analysis of horse depth measurements

The aim of this third part of the log ratio analysis was to add another dimension to the results obtained so far, as none of the previous analyses had taken the depth (i.e. antero-posterior) measurements into account. As with the lengths and breadths, where two log-ratios were calculated on the same bone, a mean value was used. The total of 514 depth measurements converted to log-ratio values was slightly less than for the lengths and breadths, as fewer workers had originally recorded these measurements. The detailed results of the log-ratio calculations for the depth measurements are given in the Appendix Table A39.

Figure 6.95 presents the results by period, and as before the three distributions were noticeably different. The ranges of the data from the three periods was more like those observed for the breadths, with great variation in the Iron Age and Roman data and the External group much more tightly clustered. As in both previous dimensions, there was a hint of bimodality in both the Iron Age and Roman data, once again most strongly evident in the Iron Age. Also similarly to the preceding analyses, the t-tests (Table 6.78) showed that the observed differences were highly significant. This suggests that in all three dimensions the Roman horses were larger, indicating that whilst the Roman horses were taller they were proportionately no more robust than those in the Iron Age and External datasets.

Table 6.78. Results of t-tests on the log ratio depth results for the 'identified' archaeological horses

Pairing	t statistic	Probability	Significance
Iron Age v External	1.9672	0.0000	**
Iron Age v Roman	1.9689	0.0000	**
External v Roman	1.9655	0.0000	**
Iron Age areas D V E	2.0141	0.0147	*
Iron Age areas D V F	2.0262	0.0767	N
Iron Age areas D V G	2.0049	0.0000	**
Iron Age areas E V F	2.0555	0.7138	N
Iron Age areas E V G	2.0167	0.0932	N
Iron Age areas F V G	2.0301	0.0573	N
Roman areas D V E	2.0057	0.9759	N
Roman areas D V F	1.9935	0.0928	N
Roman areas D V G	1.9864	0.0157	*
Roman areas E V F	1.9883	0.1580	N
Roman areas E V G	1.9830	0.0224	*
Roman areas F V G	1.9794	0.2205	N

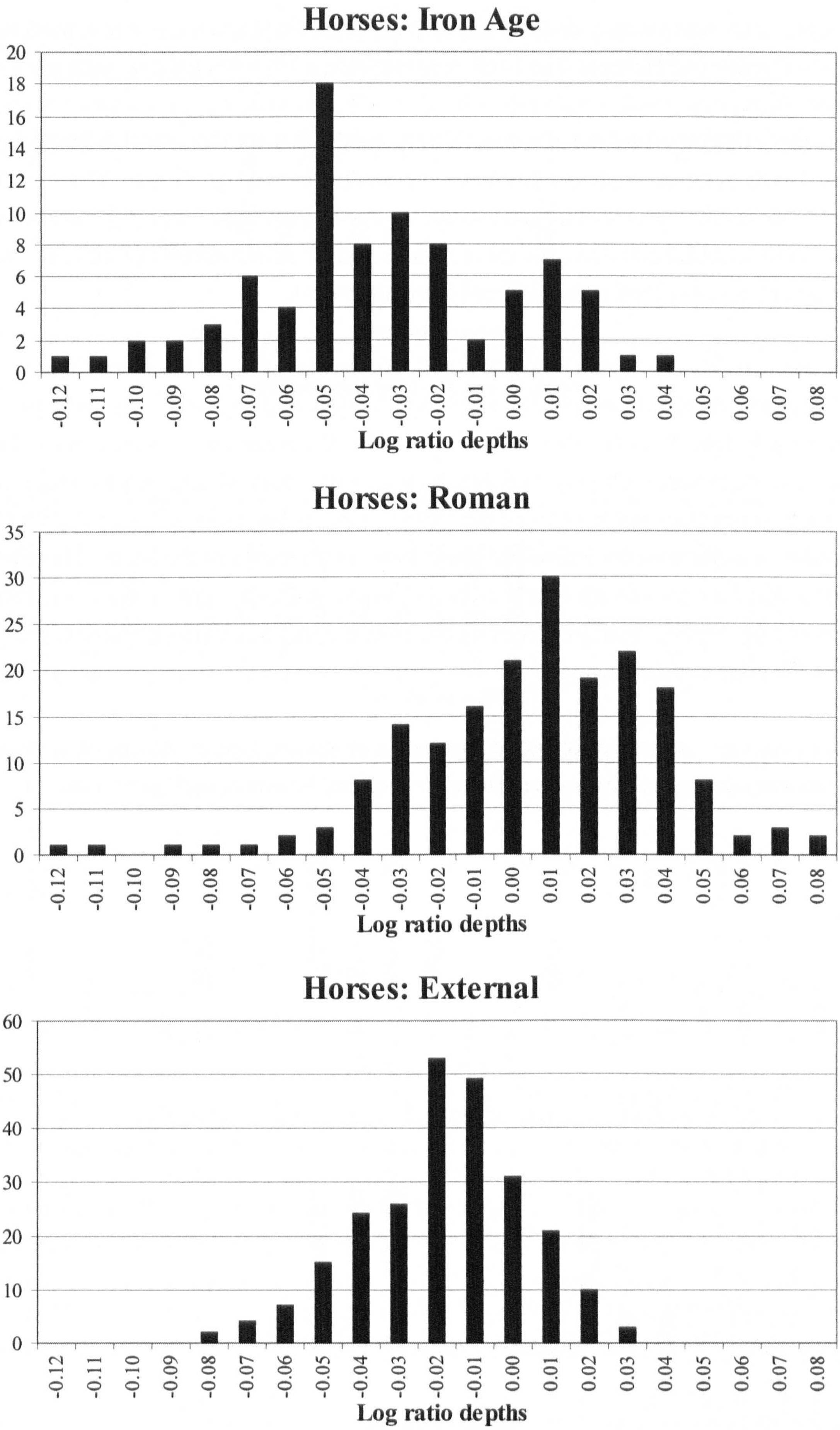


Figure 6.95 Histograms of the log-ratio depth results from the 'identified' archaeological horses by period.

The Iron Age data once again show some differences between areas. Figure 6.96 shows that the Gallic bones were noticeably less deep than their counterparts elsewhere, particularly in the Danube and Balkans. The t-test results (Table 6.78) reflected this, with the Gallic horses being significantly smaller than those from Britain and the Danube areas. It is slightly surprising that they were not also significantly smaller than the Rhineland individuals, but that dataset is rather small and this may have resulted in low significance. These findings reflect the results from the other dimensions, but also amplify them. The differences between the Gallic material and that from other regions seems to be most prominent in the depth measurements and least so in the breadth measurements.

The Roman data once again reflected mainly similarities between the areas (Figure 6.97). The ranges varied quite considerably between the areas, with a particularly wide spread in the British data. The observed similarity between the areas was reflected in the t-tests (Table 6.78), where no highly significant results were obtained, and only two significant ones: between Gaul and Britain and the Danube area. In this instance it is unlikely that the number of cases from the Rhineland was a factor in the results of the t-tests. Therefore, it seems that there are slight differences in the bone proportions of the horses from different areas of the Empire, with the depth measurements being less variable from west to east than the other two dimensions.

As in the previous two dimensions, the results of the site type comparisons showed no differences between them, so the results are confined to Appendix Figure A28.

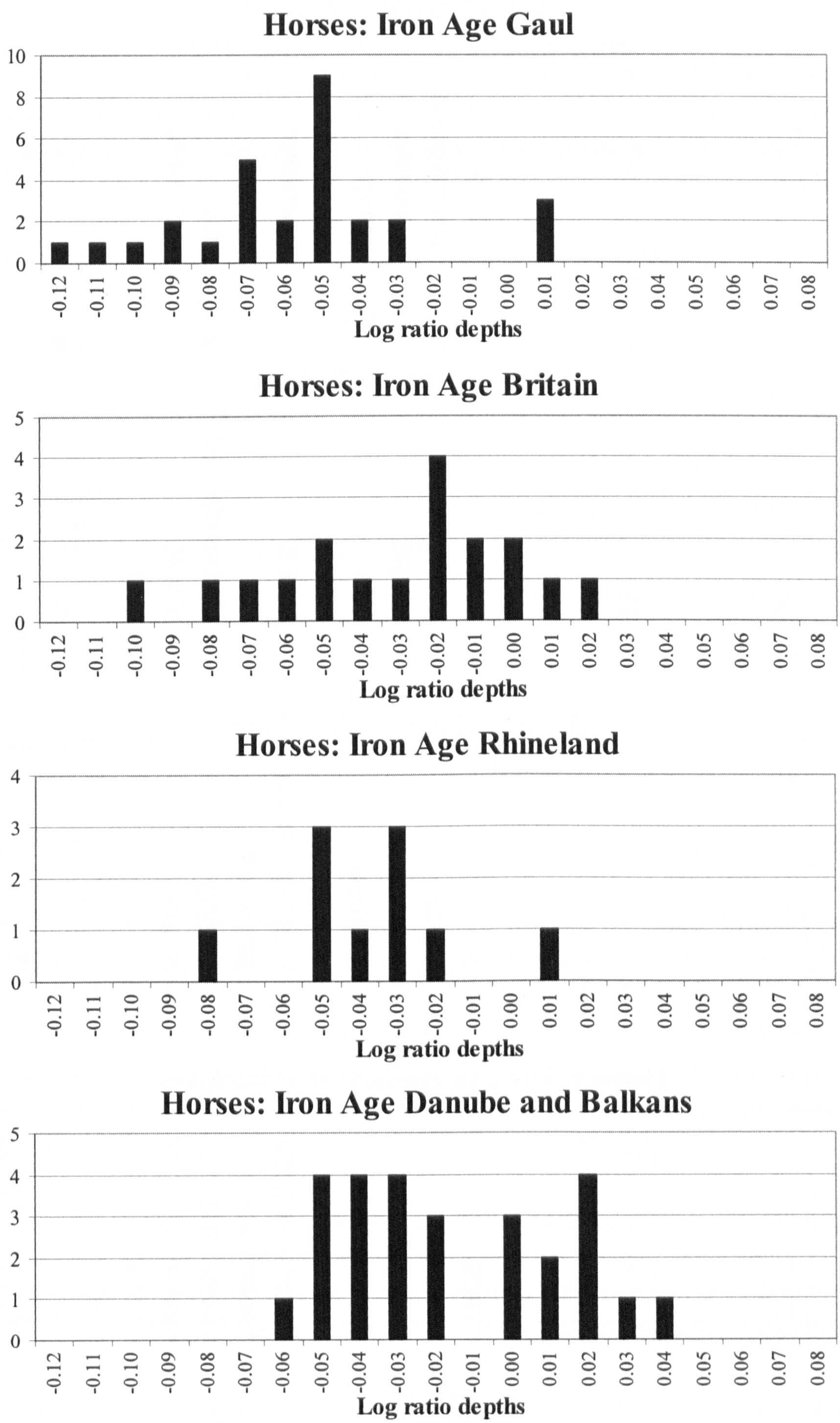


Figure 6.96 Histograms of the log-ratio depth results from the 'identified' archaeological Iron Age horses by area.

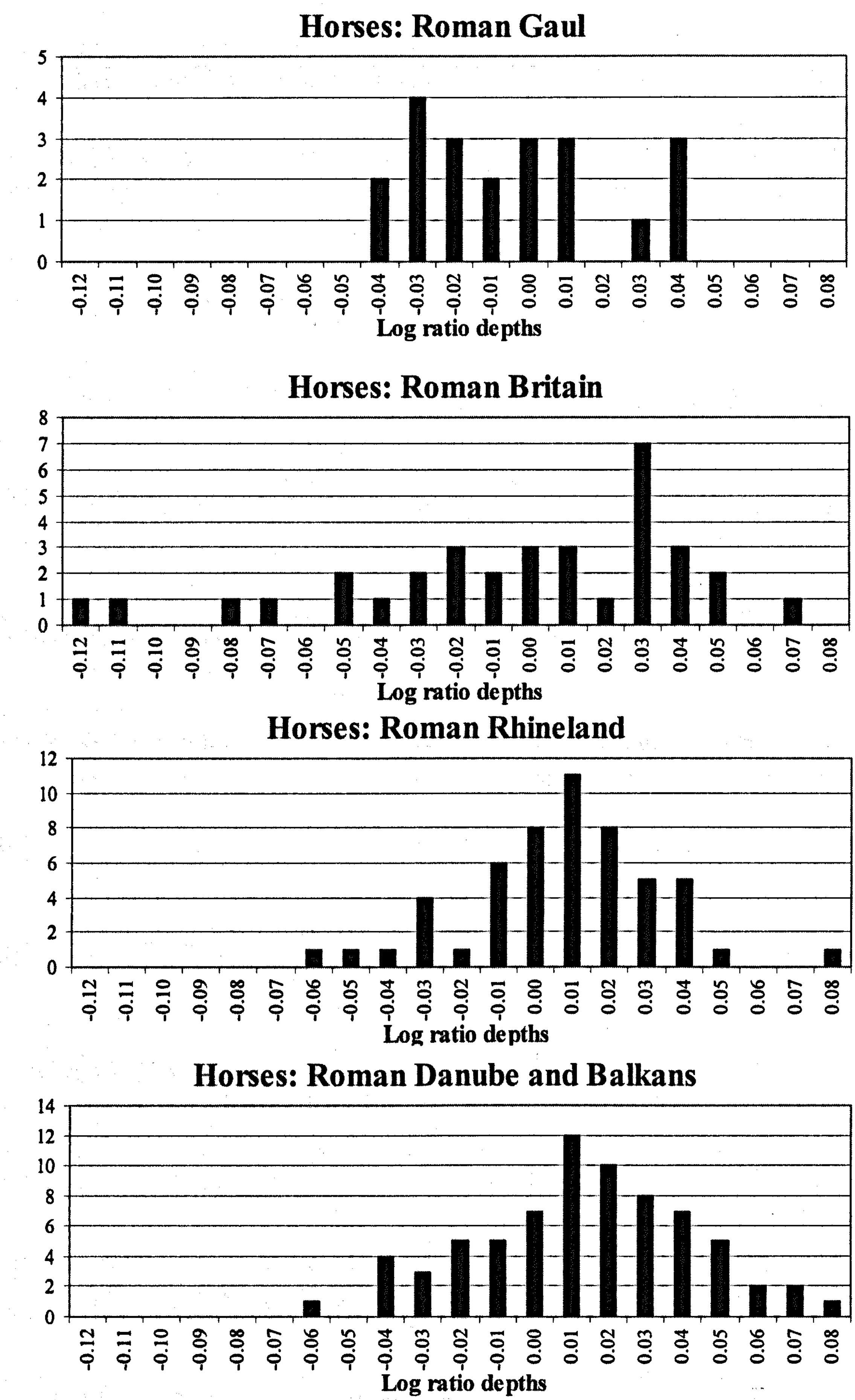


Figure 6.97 Histograms of the log-ratio depth results from the 'identified' archaeological Roman horses by area

6.4.4 Analysis of the combined horse log-ratio results

In order to compare directly the length, breadth and depth log -atios for the studied periods and areas, it is necessary to see the results together. For this purpose the means of each group of data, for all three dimensions, were calculated and plotted together on a single graph. This allows differences in the proportions of the bones between the various groups to be analysed.

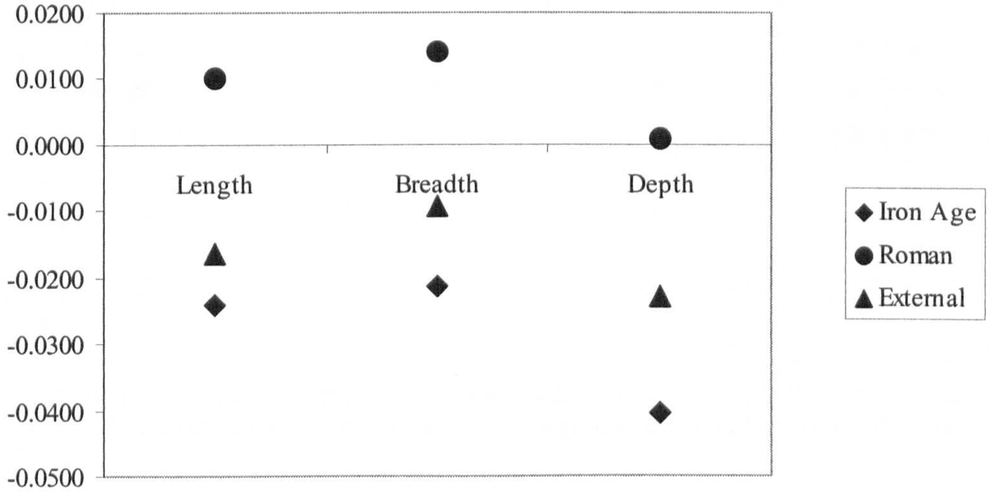


Figure 6.98. Graph of the mean values for the log-ratio calculations of the length, breadth and depth of the 'identified' archaeological horse measurements by period.

Figure 6.98 shows that the profiles of the three period groups are very similar to each other but are slightly different from the Mongolian pony standard (zero line). All three have larger breadths and smaller depths in relation to length than the standard animals. This could mean that the cross-sectional shape is different, so the cross-sectional area could be different from the standard and hence the weight-bearing capacity of the bones would also be different. However, because one measurement is larger and the other smaller it is difficult to say which direction that difference would take, if any. The positions of the three groups in relation to the zero mark (standard) confirm that the Iron Age and External horses are smaller than the Mongolian ponies and the Roman horses are larger.

Studying the Iron Age data by area (Figure 6.99) shows that there are more differences between the areas than were observed between the periods. All the log-ratio mean values fall below the zero line, as expected from the overall Iron Age means. The most strikingly different groups in terms of their proportions are the Gallic and Danube and Balkans datasets. The Danube area material shows much less deviation from the standard in terms of proportion than any of the other areas. The slight downward trend from the lengths to breadths is the opposite of what is seen in the other groups. The fact that both the breadths and depths of this group are smaller than the standard indicates that the weight-bearing capacity of these individuals is reduced, implying that they are of a slightly more slender build than the Mongolian ponies as well as being marginally smaller.

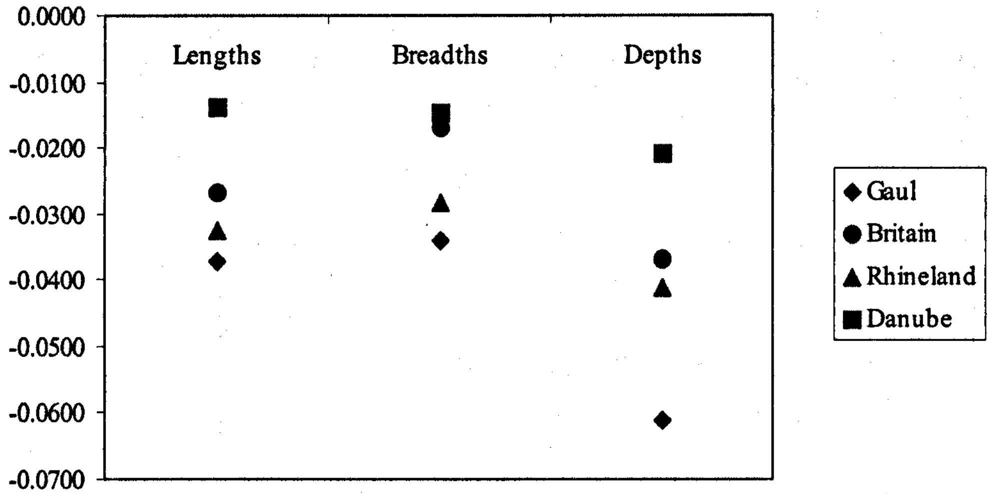


Figure 6.99. Graph of the mean values for the log-ratio calculations of the length, breadth and depth of the 'identified' archaeological Iron Age horse measurements by area.

In the case of the Gallic data, the markedly smaller size of the depth measurements in relation to the breadth means that the cross-sectional area of these bones is appreciably smaller than the standard (and the other areas). Therefore these individuals must have been of a more slender build than their counterparts elsewhere, as well as being slightly smaller in terms of height. The British and Rhineland material follows the pattern seen in the overall period groups, with the breadths slightly higher and the depths lower in relation to the lengths.

The Roman data also show interesting variation between the area groups (Figure 6.100). The data from Roman Gaul follow a similar pattern to that seen in the Iron Age data from the same region, with markedly smaller depth measurements in relation to the other two dimensions, although all dimensions are much larger. A similar comparison can be made with the British data, the proportionately higher values for the breadth measurements can be seen in both the Iron Age and Roman data, although again, the pure size is different.

The patterns of the Roman Rhineland and Danube and Balkans material show differences between these and the other two regions and also with their corresponding Iron Age datasets. In the case of the Roman Rhineland, the pattern more closely follows that of the Gallic horses than the preceding Iron Age in the region. The depth measurements are substantially smaller than the other two dimensions, once again suggesting that these animals are more slender in relation to their height than the standard Mongolian ponies. The Danube and Balkans dataset shows a marked rise in the breadth measurements in relation to both the lengths and depths in the Roman data. This is in contrast to the preceding Iron Age data and is in fact more like the pattern seen in the British data, although slightly more pronounced.

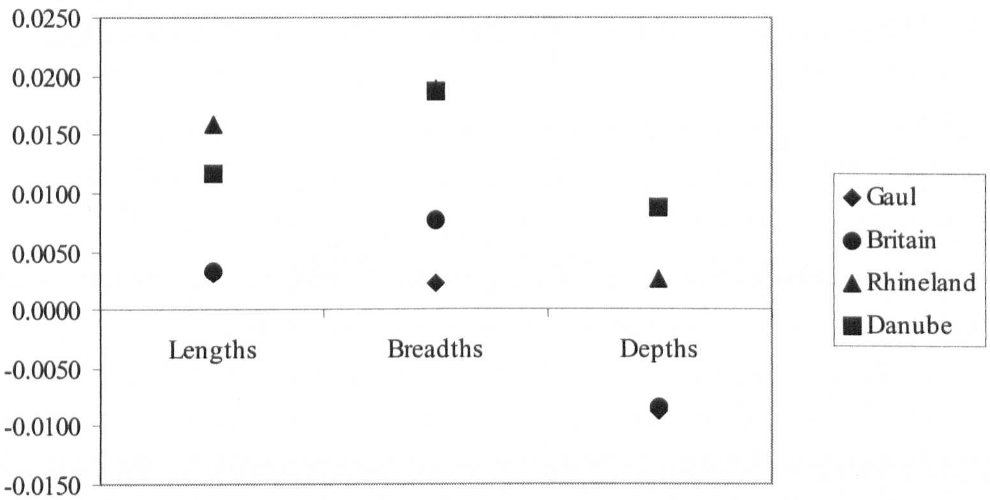


Figure 6.100. Graph of the mean values for the log-ratio calculations of the length, breadth and depth of the 'identified' archaeological Roman horse measurements by area.

Although no significant differences were detected between the Roman site type groups within the individual log-ratio analyses, when the three dimensions were put together some striking differences appeared (Figure 6.101). Whilst the number of measurements in some categories was quite small, they were all in double figures so it is suggested that these differences may not be solely a product of small sample sizes. One of the more noticeably different patterns was that of the cemetery data. Although it has been stated earlier that much of these data derived from a few individuals, it is still striking that these individuals are so much taller than the rest of the groups (as reflected in the length t-tests). What also becomes apparent in Figure 6.101 is that the bones are considerably more slender in both the breadths and depths than their counterparts from other site types. These animals were not only taller than the other groups but were also considerably more slender in their build, as the load-bearing cross-sectional area of the bones was greatly reduced.

The horses from the military and villa groups showed similarity in the proportions of the bones, with the military individuals being marginally larger all round. These two groups showed the 'usual' pattern of the breadths being larger and the depths smaller in relation to length, however the degree of slope in both parts of the graph is slightly greater than the overall Roman picture, suggesting that whilst the proportions are slightly different to the standard the overall build of the animals may not be much different. The urban group was similar to the last two groups in the proportions of lengths and breadths, but the depth measurements were larger, suggesting that these animals may have been of a more robust build than those from the military and villa sites.

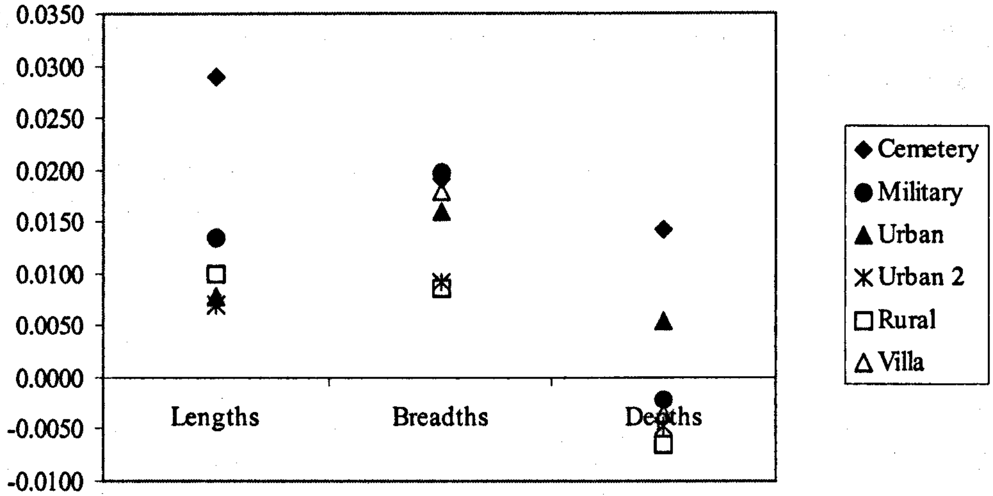


Figure 6.101. Graph of the mean values for the log-ratio calculations of the length, breadth and depth of the 'identified' archaeological Roman horse measurements by site type.

The last two groups were similar to each other but different from the other groups. The Urban 2 (small town) and rural material had similar length and depth measurements to the other groups but the breadth measurements were appreciably lower than the other groups, with almost the same values as the length measurements. This suggests that these animals were of similar proportions to the Mongolian ponies in the length and breadth measurements but were smaller in the depth measurements. Once again this suggests that these individuals may have been of a slightly more slender build than the Mongolian ponies and a slightly different, although not necessarily more slender, build to the other site type groups.

These log-ratio analyses have shown that whilst the individual dimensions of the bones may be similar to each other, the proportions they form can be markedly different. The analysis of the log-ratio data has enabled many of the previous observations to be confirmed, and a small amount of additional information appertaining to bone proportions and hence build has been added. The differences observed in the site type groups in particular have revealed additional information that would not be gathered from other analyses, chiefly because the sample sizes were too small.

6.5 Summary of results

6.5.1 Summary of results relating to species identifications

The results of applying the discriminant function analysis to the archaeological data (Section 6.1) showed that there had up to this point been a major problem with the identification of equids found on Roman sites. From new methodology developed in this research (the use of discriminant function analysis) it has been revealed that two-thirds as many mules as horses are present in the Roman assemblages studied, whereas the zooarchaeological literature had previously suggested that only a few mules were present.

The species ratio for the Roman material was 14:10.5:1 horses:mules:donkeys, in contrast with the Iron Age for which a ratio of 7.5:1.5:1 was established. When these data were split by area there were differences in the proportions: the Rhine and Danube and Balkans areas showed similar results to the overall figures, with horses forming about 56% of the identified equids and mules about 40%. In Gaul, the proportion of horses was higher and in Britain higher still. The most strikingly different results were from Egypt, where much higher proportions of donkeys and mules were noted. However, this is probably because most identifications were from the site of Mons Claudianus, an industrial quarry site unlike any of the sites in the other regions. Another factor in these differences may be that North Africa has the climate and conditions to which donkeys are adapted and horses are not.

The results from the complete skeletons and articulated limbs confirmed the usefulness of the methodological approach of assigning identification levels, as different elements of many individuals gave differing results. This meant that had identification levels not been assigned, the results for one individual could have been extremely confusing. However, those elements with 'possible' identifications were discounted and the overall identifications became clearer. There were still six individuals that could not be assigned to one species or another as their results were too varied. In contrast, eight individuals showed particularly clear-cut results, with most or all of the elements giving the same identification. With the 'ambiguous' results, there did not seem to be a bias towards horse or mule identifications with the complete skeletons and limbs. Therefore, it was presumed that no species bias would be introduced in the study of the isolated elements, as the wrong identifications would be evenly distributed.

In addition, there were a number of cases where the results of the identification using discriminant function analysis and that based on tooth and/or limb morphology had contradicted each other. It appears to be the case that using tooth morphology on its own can give a misleading identification, particularly in a relatively young individual where the enamel patterns on the teeth have not been fully developed through wear. Limb morphology in conjunction with tooth morphology seems to be a better approach, but perhaps a better combination of observed morphology and discriminant function analysis of the biometrics provides the best option for identification. It may still be the case that some individuals have such ambiguous characteristics that their identification is simply not possible.

Some of the reasons for the difficulties in the identification of were revealed during the analysis of the withers heights (Section 6.2) and shape indices (Section 6.3). The withers height analysis showed that there was a considerable degree of overlap in height between the horses and mules, and that many of the 'possible' identifications lay in this overlap zone in terms of height. Therefore, the smaller mules and larger horses were not being identified clearly. Similarly there was a small amount of overlap between the smaller horses and larger donkeys; however, this appeared to have been less of an identification issue as other characteristics, such as the slenderness of the bones, were sufficiently different to separate the horses and donkeys.

The results of the shape index analyses showed some differences between the species that were of some use in separating the species. These differences were noted on the metapodials and were most strongly evident on the metatarsal. The donkey metapodials were more slender than the mules and horses on all three indices calculated. The mules were more slender than the horses on the shaft and distal breadth indices, and were markedly more slender on the latter. This suggests that the distal limb morphology is inherited from the jackass and is not particularly variable across the mule population, unlike other characteristics. The bivariate plots of the shaft versus distal breadth indices went some way to separating the horses and mules. There is however, still a zone where there is overlap between the more slender horses and more robust mules.

During the identification analysis clusters of individuals were observed on the discriminant function plots. These are shown and numbered in Figures 6.40 and 6.88. Areas 1, 2 and 7 corresponded to what have been termed the 'super' donkeys, mules and horse,s respectively. These were the individuals that had very high probabilities of group membership but were outside the 1 SD range, indicating that they were unlikely to be any other species but differed in some way from the modern individuals. Areas 3 and 4 covered the overlap zone between the horses and mules, whilst area 5 covered the cluster of horses (and some mules) around the zero marks. Area 6 corresponded to the cluster of horses to the left of the zero mark.

Analysis of the withers height and shape index data for these groups revealed that there are certain size and shape characteristics to these clusters. The 'super' donkeys (area 1) are all tall donkey individuals (>1250 mm, varying slightly with element) but have quite varied robusticity, suggesting that the bone length is the defining characteristic of this group.

Similarly the 'super' mules (area 2) are also all tall individuals (>1480 mm approximately), but they also have relatively robust shape indices (definition of robust depends on element). The 'super' horses (area 7) show that they are different from the preceding two clusters in that they contain the smaller to medium height horses (<1400 mm approximately) but all have relatively robust shape indices, suggesting that the modern sample may not contain many of these more robust ponies.

As suspected from the withers height analysis, the overlap areas of mules and horses (areas 3 and 4, respectively) contained the shorter mules (<1400 mm approximately) and taller horses (>1400 mm approxately). The shape indices were not contributing so much to the identification problems as they had average or varied robusticity. The horses in area 5 around the zero mark had medium withers heights and slender robusticity, suggesting that the robusticity may be contributing to the identification issues of this cluster. Finally the cluster of horses to the left of the zero line (area 6) contained individuals with both smallish heights (<1280 mm approxately) and slender shape indices.

6.5.2 Summary of results relating to horses

This summary is based on the results from the 'identified' horses only (i.e. those with definite or probable identification status) and is presented as a series of bullet points relating to each of the period, area and site type categories that have been used to divide the data in Table 6.79 for ease of comparison.

The results of comparing the horses by overall period show the following.

- The Iron Age horses are smallest (mean withers height 1252 mm), followed by the External (1290 mm) and then the Roman horses (1351 mm).
- The shape indices on the metapodials confirm that the Roman horses are the most robust as well as the tallest, with the Iron Age horses in the middle and the External ones the most slender. This is most noticeable on the shaft index but is probably caused by nutritional stress during growth rather than genetic differences in conformation.
- The log-ratio analysis reveal that the Roman horses are bigger than the standard and the other periods in all three dimensions, the External horses clustering around the zero mark and the Iron Age horses showing hints of bimodality with a more numerous group below the zero and a smaller group above the zero mark. The Iron Age data show a wider range than the other two groups.

Splitting the Iron Age data into areas revealed the following.

- The Iron Age Gallic horses are different in several respects to those from other areas. They are almost the smallest in terms of withers heights (mean 1228 mm), and have the most slender metapodials Bd/GL index. In addition their log-ratio depth measurements are smaller than in other areas. This means that as well as being short the Gallic horsesaere also of slender build.

- The British Iron Age horses are similar to their Gallic counterparts but are taller (mean 1260 mm) and marginally more robust on the-log ratios.
- The mean height of the Iron Age horses from the Rhineland is slightly smaller than either of the preceding groups (1225 mm) but the range is much narrower than for the Gallic material. They are of similar robusticity, regarding the log-ratio analysis, to those from Britain.
- The horses from the Danube and Balkans areas are the largest in terms of withers height (mean 1308 mm). This size increase from the other regions is mirrored in the log-ratio data for the lengths (as would be expected). The breadths and depths however, do not get proportionately bigger, indicating that the eastern horses are more slender in relation to length than those from the other areas. Although the metapodials shaft and distal slenderness indices suggest they are more robust, this is based on small numbers.

Splitting the Roman data by area produces the following observations.

- The very small quantity of material from Italy did not allow much analysis to be undertaken. The mean withers height is 1385 mm.
- The material from Roman Gaul is small, in keeping with the preceding Iron Age data (mean withers height 1342 mm). The shaft slenderness index on the metatarsal shows that these are quite slender individuals. This is backed up by the log-ratio analysis, where all three dimensions are small. The combined results reveal that, similar to Iron Age, the proportionately small depths suggest these Gallic horses are certainly more slender limbed than those from other areas.
- The material from Britain produces the smallest mean withers height of all the areas (1312 mm) in the Roman period. The metapodials shaft slenderness indices are marginally smaller than others but all the areas are very similar. The log-ratio lengths and breadths are very similar to Gaul but the depths are greater, indicating that the British horses are more robust than their Gallic counterparts.
- The material from the Rhineland produces the largest mean withers height for the Roman period (1364 mm). In addition, this material produces the largest log-ratio length and breadth values. However, the depth values are proportionately small, like the Gallic material, so these horses are relatively slender limbed but slightly bigger overall.
- The Danube and Balkans area also produces a tall mean withers height (1362 mm). The metatarsal distal index produces quite a robust value but this is not significantly different. The log-ratio analysis produces larger values for all three dimensions, so

these horses are proportionately larger overall than those in the other regions and are certainly more robust limbed than those from Gaul and the Rhineland.

- As with the material from Italy there were very few remains from Egypt, and the mean withers height was 1316 mm.

Splitting Roman data by site type reveals the following.

- No differences are detected between site types using the withers heights, shape indices and single dimension log-ratios, mostly because there are too little data to test the significance of any observed variations. The combined log-ratio analysis however, picks up some interesting differences in bone proportions.
- Horses buried in cemetery contexts are much taller, but also proportionately more slender, than any of the other categories.
- The military and villa horses show very similar proportions to each other but the military animals are marginally larger all over.
- The horses from urban sites are a similar height to the preceding groups and the breadths were also similar but the depth measurements were larger suggesting more robust animals.
- The horses from the Urban 2 (Small town) and Rural sites were also similar to each other. Their length and depth measurements are similar to the preceding groups, but the breadth measurements are proportionately smaller than the other groups, suggesting that these animals are of a more slender build.

6.5.3 Summary of results relating to mules

As with the horses, this summary is based on the results from the 'identified' mules only (i.e. those with definite or probable identification status) and are summarised in Table 6.79. There are a number of general points concerning the mules that will be presented first to avoid repetition below.

- There were very few mules in the Iron Age or External periods, so most of the analysis is limited to the Roman period.
- The overall size and build of the mules across the geographic spread of the Roman Empire is remarkably uniform. They are mostly around 1450 mm in height, with shaft slenderness indices of around 14.5 (metacarpals) and 11.1 (metatarsals).

The results of comparing the mules by overall period show the following.

- Although there are very few mules dated to the Iron Age, they are smaller than those in the Roman period, with an average withers height of 1356 mm. Differences in the shape indices could not be tested because of the small numbers involved.
- The External mules are also smaller than their Roman contemporaries, with a mean withers height of 1361 mm. In addition their metatarsals have slender shaft indices.

This corroborates the findings from the External horses, where a similar pattern emerges, suggesting that these mules may have been locally raised and were subject to the same husbandry regime causing nutritional stress.

- The Roman mules have a mean withers height of 1446 mm and shape indices with values lower than the horses but more robust than the external mules.

Splitting the Roman data by area produced very uniform results. The following observations could be made about the slight differences.

- The mules from Roman Gaul are very similar to the overall picture for the Roman period, with a mean withers height of 1444 mm.
- The mules from roman britain are significantly smaller than their continental counterparts, with a mean withers height of only 1362 mm. This suggests the possibility that some local breeding of mules may have taken place in Britain and that the smaller local horses contributed to the smaller size of the mules.
- Mules from the Roman Rhineland and Danube and Balkans areas are close to the overall picture for the Roman period, with mean withers heights of 1450 and 1463 mm, respectively.

No differences in the mules between site types could be detected and the log-ratio analysis that revealed differences for the horses was not carried out on the mule data because of the lack of a standard and the smaller numbers of individuals concerned. If more data were to be collected in future this would be an area for further work.

6.5.4 Summary of results relating to donkeys

As with the mules, the numbers of identified individuals severely limited the amount of further analysis that could be undertaken on this material, as can be seen in Table 6.79. Also, the Iron Age and Roman material came from different areas of the Empire so were not directly comparable, therefore the differences observed should be read with this in mind.

- The Iron Age donkeys have a mean withers height of 1145 mm.
- The External donkeys are slightly larger with an average withers height of 1249 mm. As with the horses and mules, the metacarpals have slender shaft and proximal shape indices, possibly indicating local raising of these animals.
- The Roman donkeys have a similar withers height to the External ones, with a mean withers height of 1248 mm, they are, however, slightly more robust in the shape indices than their External counterparts.
- The Roman data split by area show that there are very few donkeys in most areas studied. The Gallic donkeys are quite large (mean 1375 mm) but there are only three individuals. The donkeys from the Rhineland have a smaller mean withers

height at 1180 mm and there are a few more individuals here. The donkeys from the Roman quarry at Mons Claudianus in Egypt have a mean withers height of 1257 mm, slightly higher than the average, but this might be expected as they probably bred or selected for their large size to allow greater loads to be carried.

Table 6.79 Summary of results of withers height, shape index and log-ratio analyses on the archaeological data

Category	**Withers Height**	**Metacarpal**			**Metatarsal**			**Log-ratios**		
		SD/GL	**BP/GL**	**BD/GL**	**SD/GL**	**BP/GL**	**BD/GL**	**Lengths**	**Breadths**	**Depths**
Horses	1301.2	14.6	22.2	22.1	11.4	18.6	18.6	-0.008	-0.003	-0.017
Iron Age	1251.6	14.9	22.3	22.0	11.5	18.5	18.3	-0.024	-0.021	-0.041
Roman	1350.8	15.0	22.4	22.2	11.8	18.5	18.7	0.010	0.014	0.001
External	1282.0	14.4	22.1	22.1	11.1	18.7	18.6	-0.016	-0.009	-0.023
Iron Age area D	1227.5	14.9	22.1	21.5	11.5	18.5	17.9	-0.037	-0.034	-0.061
Iron Age area E	1260.3	14.7	22.3	22.1	11.4	18.5	17.9	-0.027	-0.017	-0.037
Iron Age area F	1225.2	14.8	22.5	22.4				-0.033	-0.028	-0.041
Iron Age area G	1308.2	15.2	22.5	22.4	11.7	18.6	18.8	-0.014	-0.015	-0.021
Roman area D	1341.7	15.2	22.6	22.7	11.4	18.6	18.6	0.003	0.002	-0.009
Roman area E	1312.3	15.0	22.6	22.4	11.9	18.6	18.6	0.003	0.008	-0.008
Roman area F	1364.5	15.0	22.4	22.0	11.9	18.7	18.7	0.016	0.019	0.003
Roman area G	1362.3	15.0	22.2	22.3	12.0	18.8	18.8	0.012	0.019	0.009
Roman cemetary	1455.1				11.7			0.029	0.019	0.014
Roman miltary	1353.3	14.9			11.9	18.9	18.6	0.013	0.020	-0.002
Roman villa	1376.0	14.3			11.9	18.8	18.8	0.008	0.018	-0.004
Roman urban	1358.2	15.1			12.0	18.6	18.8	0.008	0.016	0.006
Roman urban 2	1344.2	14.9			11.5	18.7	18.6	0.007	0.009	-0.005
Roman vicus	1348.7	15.2			12.1					
Roman rural	1366.5	15.4			12.0			0.010	0.009	-0.007
Mules	1426.2	14.5	21.8	20.8	11.0	17.7	17.3			
Iron Age	1355.6				11.1	17.7	17.5			
Roman	1446.2	14.5	21.8	20.8	11.1	17.6	17.2			
External	1360.5	13.4			10.7	17.8	17.4			
Roman area D	1443.5				11.0					
Roman area E	1361.8				10.9					
Roman area F	1449.7	14.5	21.7	20.7	11.5	18.0	17.4			
Roman area G	1462.7	14.5	21.8	20.8	11.1	17.7	17.5			
Roman miltary	1449.4	14.5			11.5	18.4				
Roman villa	1415.2	15.1								
Roman urban	1451.9	14.5			11.2	17.6	17.3			
Roman urban 2	1436.7				10.4	17.6	17.0			
Roman vicus	1456.8				11.3					
Donkeys	1199.7	13.2	21.0	20.0	10.6	17.2	16.1			
Iron Age	1144.8	13.6	21.2		10.7	16.9	15.7			
Roman	1248.2	13.8	21.4		10.7	17.3	16.2			
External	1248.6	12.1	20.7		10.5					

6.5.5 Comparison between data from modern breeds and from the archaeological material

The same calculations performed on the archaeological data to determine height, shape indices and log-ratios (Table 6.79) were also carried out on the modern reference specimens (Table 6.80), so that comparisons between the archaeological data and known breeds could be carried out. These comparisons were only undertaken on the mean values for each period group in the archaeological material.

It was considered unprofitable to compare the modern mules to the archaeological ones, because of the small sample size and lack of detailed information for the modern specimens. In addition, analysis of the identification results has suggested that the archaeological mules showed a greater range than the modern specimens, with the 'super' mules being somewhat different to the modern specimens available. The archaeological donkeys were also not compared with the modern ones for similar reasons to the mules, and with the additional problem that there are not really different breeds of donkey. Although nominally geographic demes do exist these were not sufficiently represented in the modern sample to allow comparison to be undertaken.

The horse groups show quite similar results to each other, with minor variations expected between several breeds. The Przewalski horses appeared to be generally similar in build to the domestic ponies, despite the differences in limb proportions noted in Chapter 3. The Arab horse group appeared to be quite different to the ponies in many of their attributes. Apart from the obvious fact that they were all much taller than any of the ponies they were also taller than the mean values for the archaeological material (but not outside the ranges of that data). In addition the Arab horses had much more slender shaft indices than any of the ponies, although the epiphyseal indices were only slightly more slender. Because of the larger overall size, most of the log-ratio values for the horses were bigger than the standard, but some of the depth values were smaller, indicating that the bones of these horses were more slender overall than the ponies.

All three archaeological groups had mean values for their attributes similar to the ponies (both wild and domestic) and very different from the Arab horses. Although none of the means exactly matched any of the breeds included in the modern sample, there were some general similarities with various pony breeds. The mean values for the Iron Age horses suggested they were quite slender limbed as well as small. This was borne out by comparison with the modern breeds. The Iron Age horses had metapodial index proportions similar to those of the more slender built ponies in the modern sample, such as the Welsh and New Forest ponies, suggesting that their build would have been similar. The Iron Age mean height was towards the smaller end of the range shown by these modern breeds.

In contrast, the Roman means suggested that these horses were more robust as well as taller. This was illustrated by the comparison with the modern breeds, where the values were similar to the slightly larger and more robust ponies represented in the sample. These included the Exmoor and Mongolian ponies and the Przewalski horses. However, these were all quite small in terms of height and the Roman horses were larger but similarly proportioned.

The External horses were inbetween the Iron Age and Roman horses in most of their dimensions, so were harder to define in terms of the modern breeds. However the indices suggested that they were slender for their height in comparison with many of the modern pony specimens, as has been discussed above.

Table 6.80. Summary of results of withers height, shape index and log-ratio analyses on the modern reference data

Specimen no.	Breed	Withers heights	Metacarpal SD/GL	Metacarpal BP/GL	Metacarpal Bd/GL	Metatarsal SD/GL	Metatarsal BP/GL	Metatarsal Bd/GL	Log-ratio Lengths	Log-ratio Breadths	Log-ratio Depths
1927.235	Arab	1593.89	13.42	21.48	21.06				0.073	0.057	0.001
24.5.4.1	Arab	1533.29	13.17	20.84	21.49	11.05	16.76	17.47	0.058	0.031	-0.017
37.1.26.10	Arab	1594.59	13.48	21.43	20.48	10.95	18.67	17.66	0.073	0.063	0.008
E arb 3	Arab	1478.32	13.54	21.76	21.47	10.95	19.47	18.25	0.040	0.030	-0.046
H40	Arab pony	1477.72	14.34	21.81	21.69	10.07	19.30	18.74	0.041	0.045	-0.009
	Arab mean	**1535.56**	**13.59**	**21.46**	**21.24**	**10.75**	**18.55**	**18.03**	**0.06**	**0.05**	**-0.01**
1937.51	Pony	997.78	16.45	23.09	24.43	12.04	0.00	19.76	-0.126	-0.116	-0.175
BZL1	Pony	1152.97	17.11	23.02	23.07	12.60	0.00	18.72	-0.061	-0.066	-0.140
E pon 1	Pony	1367.09	15.48	23.82	22.49	12.31	18.41	18.64	0.010	0.011	-0.041
LWH3	Pony	1235.73	14.47	22.50	21.86	11.52	19.32	18.41	-0.034	-0.026	-0.088
BZL332	Pony Exmoor	1334.00	15.52	23.81	22.76	0.00	19.92	18.83	-0.001	0.011	-0.056
1961/29	Pony Icelandic	1341.87	14.96	21.63	21.73	12.12	17.58	17.98	-0.007	-0.036	-0.089
E mgl 1	Pony Mongolian	1348.46	14.62	21.03	19.23	11.82	18.29	18.99	0.002	-0.003	-0.053
E mgl 3	Pony Mongolian	1321.89	13.85	21.21	21.49	11.56	18.73	17.88	-0.005	-0.009	-0.058
E mgl 4	Pony Mongolian	1343.05	15.10	23.20	21.32	12.23	19.59	18.08	0.003	0.012	-0.044
H37	Pony New Forest	1213.49	14.79	22.00	20.42	11.50	18.67	17.96	-0.039	-0.061	-0.113
L2161	Pony New Forest	1376.05	13.78	22.57	20.87	11.09	18.84	17.28	0.013	0.014	-0.029
1925.78	Pony Norwegian	1439.62				11.54	19.29	18.79	0.025	0.017	-0.071
1911.145	Pony Tonkin	1289.01	14.12	22.39	21.80	14.72	17.85	18.33	-0.018	-0.031	-0.081
TPOC1	Pony Welsh	1187.79	13.51	22.89	21.19	10.34	19.14	18.36	-0.054	-0.055	-0.118
BZL135	Pony WelshA	1205.91	16.46	22.48	22.64	12.16	18.10	18.57	-0.045	-0.061	-0.104
	Pony mean	**1276.98**	**15.02**	**22.55**	**21.81**	**11.17**	**16.25**	**18.44**	**-0.02**	**-0.03**	**-0.08**
	Przewalski	1314.91	13.30	22.84	21.70	10.42	19.31	18.19	-0.011	-0.002	-0.078
02.9.25.1	Przewalski	1288.76	13.66	20.74	21.67	10.95	18.73	18.02	-0.021	-0.034	-0.100
07.5.15.1	Przewalski	1289.68	14.64	22.09	20.10	11.80	18.44	17.16	-0.019	-0.028	-0.080
1929.37	Przewalski	1279.84	14.46	21.40	20.11	11.70	18.52	17.45	-0.023	-0.039	-0.091
1953/147	Przewalski	1336.31	15.00	23.00	21.27	12.19	19.54	18.39	-0.004	0.009	-0.041
1962.228	Przewalski	1351.03	14.92	22.12	21.40	11.72	18.63	18.02	0.003	0.004	-0.045
1973.109	Przewalski	1237.84	16.60	23.15	22.39	13.25	19.77	18.37	-0.036	-0.039	-0.103
1973/237	Przewalski	1295.78	14.15	21.99	20.21	11.90	19.12	17.21	-0.017	-0.030	-0.076
1975.125	Przewalski	1322.60	15.36	22.81	21.89	12.56	19.41	17.38	-0.008	-0.012	-0.070
1980.29	Przewalski	1329.71	14.86	22.01	21.32	12.30	18.91	17.69	-0.004	-0.013	-0.070
45.6.11.1	Przewalski	1310.11	13.95	23.26	22.01	10.30	20.03	18.45	-0.013	-0.007	-0.051
E wld 1	Przewalski	1327.11	14.95	23.18	21.05	11.83	19.09	17.41	-0.007	-0.003	-0.071
E wld 2	Przewalski	1259.98	14.23	23.42	22.24	11.22	20.89	18.40	-0.029	-0.012	-0.075
E wld 4	Przewalski	1314.74	14.32	22.81	21.57	11.34	19.03	17.93	-0.009	-0.008	-0.057
LMUprz11	Przewalski	1300.96	14.76	21.95	21.71	12.06	19.39	17.67	-0.015	-0.018	-0.075
LMUprz13	Przewalski	1345.56	14.16	22.16	20.69	11.10	18.65	17.26	-0.001	-0.006	-0.063
	Przewalski mean	**1306.56**	**14.58**	**22.43**	**21.33**	**11.67**	**19.22**	**17.81**	**-0.01**	**-0.01**	**-0.07**

Chapter Seven – Discussion and conclusions

The aim of this chapter is to bring together the results obtained from the analyses in Chapter Six with the research aims outlined in Chapter One in order to discuss some possible explanations for the observed patterns in the data. The basis of this discussion will be the research questions outlined in Chapter One, but additional material will be brought under discussion when merited by the results of the analyses.

The first section will discuss the identification of species and the species proportions; the next section will look at the effects of Romanisation on the three species in terms of changes in size and shape; the third section will discuss the differences within the species within the Empire itself; the fourth section will look at the effects of Roman contact on the equids in areas External to the Empire; the fifth section presents ideas for further research. Finally the sixth section presents the conclusions.

7.1 Species identifications and proportions

7.1.1 Species identifications

The first aim of this project was to determine whether available methodologies could reliably discriminate the bones of horses, donkeys and mules. It was established in Chapter Four that this was not the case, and, therefore, a new methodology was developed. This was then applied to the archaeological data (Section 6.1) to determine whether the lack of mules in the zooarchaeological record hitherto was caused by lack of identification or real absence of the species.

As has already been stated (Section 6.5) the results of applying the new identification methodology (using discriminant function analysis) to the existing biometric data have shown that there has indeed been a problem with the identification of mules in the archaeological record except for a few isolated cases. From the biometric data it is possible to say that for every three horse bones there are approximately two mule bones in Roman period assemblages as a whole.

However, there are still a number of cases where the discriminant function analysis does not allow confident identification of the bones to species. There appears to be a number of factors that are causing this. There is the initial problem that there are insufficient numbers of modern reference mule specimens available for the discriminant function analysis to be 100% successful on the modern material. The separation of donkeys from both mules and horses does not appear to be a problem, but distinguishing mules from horses seems to be more difficult. The problem of lack of reference material is one that cannot be easily addressed without funds and facilities to acquire and prepare skeletons to use. In addition, acquiring mules may be relatively difficult from an ethical and legal perspective. Refining the methodology may have to wait until these issues can be resolved.

There appears to be greater variation in the archaeological material than is represented in the modern samples, leading to further difficulties in separating the species. The greater variation in the archaeological material is not surprising as the modern reference samples are restricted to certain breeds for the horses and by the numbers of specimens available for the mules (Section 5.1).

As far as the archaeological material is concerned, the main problem is the separation of some of the mules and horses. This problem is apparent not only in the isolated elements, but also in the analysis of complete skeletons where the different elements produced varied identifications. Some specimens were clear-cut, with consistent identifications across the elements, others were so mixed that an overall identification was not possible. There did not appear to be any bias in which elements produced which identifications, so it has been assumed that the morphology of each element varies slightly within the individuals. The variation in the mule bone morphology was perhaps to be expected because of the potential mix of characteristics from both parent species. The variation in the horses may be more to do with variation between different demes.

There were certainly clusters of identifications that could correspond to demes, although they were not particularly well defined. The clusters were actually more helpful, and perhaps more important, in defining some of the areas in which difficulties in identification can occur. All of these clusters were away from the group centroids, indicating differences in size and/or shape from the group of modern reference specimens rather than intermediate horse - mule traits. Analysis of the individuals in the areas of overlap between the positively identified groups showed that their withers heights were very similar. Hence the similar lengths of the bones may have been contributing to the 'ambiguous' identifications. The other clusters were around the zero mark: horses to the left of the zero line are distinguished by having slender shape indices, suggesting that the slenderness of these bones is contributing to the difficulties in obtaining positive identifications.

On the question of whether the clusters observed could be related to demes of horses, it is interesting to note that two of the clusters were formed mainly, but not exclusively, by cases from particular sites. In theory, a particular worker using slightly different measurements to others could cause this. However, as there was more than one site and worker involved in these groups this is unlikely to be the case. The individuals that made up the cluster around the zero mark came mostly from Feddersen Wierde (Reichstein 1991) and those to the left of the zero line from Manching (Boessneck *et al.* 1971). It is therefore possible that the inhabitants of these sites used local stock with the characteristics seen in the discriminant function analysis and that these animals were all of a consistent type and hence could be termed a deme. These were the only two sites for which particular characteristics were noted from the discriminant function analysis, and this is most likely the result of the very large numbers of bones available from these sites in comparison to all the other sites used in this analysis.

There were also three areas on the identification plots where the identifications were not in doubt but the distance from the centroid was greater than 1 SD. This resulted in these groups being termed 'super' horses, mules and donkeys, as they seemed to show exaggerated characteristics of each species. It is of course possible that some of these individuals could be from another species (e.g. onager) or hybrid that has not been included in the analysis; in particular there is the possibility that a few hinnies may be represented in the assemblages. The only way of testing this would be to extend the remit of the analysis and include hinnies in the discriminant function analysis. Once again there are the problems of obtaining modern specimens. There is no way of accurately predicting hinny morphology without modern reference specimens, but it could be argued that they would show more donkey characteristics than mules. However, documentary sources suggest that hinnies are likely to be very rare or non-existent in the assemblages under study for the current research.

At present it is assumed that the 'super' individuals are from the species already under discussion and therefore that their morphology varies slightly from that of the modern groups used for the initial species separation. From the withers height and shape index analyses on these individuals, it was determined that the 'super' donkeys were all tall individuals, taller than any of the individuals in the modern sample, which were all rather small. The 'super' mules were also all tall individuals and in addition were more robust than most of the modern reference individuals. Finding individuals in the archaeological assemblages with slightly different proportions to those of the modern reference sample is perhaps not surprising for mules, when the small size of the modern sample is probably insufficient to contain enough variation in mule morphologies. None the less, the discriminant function analysis classed the specimens as more mule-like than akin to horse or donkey. This suggests that they are unlikely to be hinnies or another equid species, as the identifications were not 'ambiguous'.

With the horses, the variation in the archaeological material is even greater than for the other two species. This is perhaps not surprising if the uses to which the animals were put are taken into consideration. The donkeys and mules were mainly used as pack and draught animals, whereas horses were mainly used for riding. The specialisation of horses for different areas of ridden activity demanded different physiques to achieve optimum performance (see Chapter 1) and this could have created the greater variation in morphologies seen in the species identification plots. The 'super' horses were more spread for the horses than they were for the mules and donkeys, as would be expected from the greater overall variation. Analysis of the withers heights and shape indices of the 'super' horses showed that they represented the smaller, more robust individuals.

The next item to discuss is the location in time and space of the identifications of donkeys and mules that had previously not been identified as such. It was expected at the outset that the mules would be found in predominantly Roman contexts, primarily because they are not mentioned as regularly in earlier (mainly Greek) literature or depicted as often in art historical sources, and this turned out to be the case. As will be shown below (Section 7.1.2), the numbers of mules increased dramatically from the Iron Age into the Roman period in all areas discussed in this research. In addition, it was expected that donkeys would be found predominantly in the areas surrounding the Mediterranean basin, as this is their natural habitat.

It was therefore something of a surprise to find that mules were present in Iron Age contexts from non-Mediterranean areas of the Empire. However, there are several plausible explanations for their presence. Many of these identifications came from sites with a continuous occupation record through the transition from Iron Age to Roman periods. Therefore it is possible that the deposits were dated by residual material and could be Roman in date. The only way of confirming or contradicting this would be to go back through the site archives to check the stratigraphy of individual contexts and this would not have been a profitable use of time during the current research. However, for future work this might be necessary in order to clarify points such as the date of the introduction of mules to Britain. Direct radiocarbon ($C^{14)}$ dating on the crucial specimens could be undertaken.

Another explanation could be that, many of the mule bones came from late Iron Age deposits on sites with known contacts and trade with the Roman Empire, which could easily have included these animals as beasts of burden or as trade items in their own right. As the discussion below on trade within and beyond the Empire will cover this in more detail, it is sufficient to mention here which sites produced mule bones from Iron Age deposits. Mules were identified from three sites in northern France: Beauvais, Gournay and Variscourt (Meniel 1984). The Oppidum at Manching (Boessneck *et al.* 1971) produced numerous mule and donkey identifications, although the dating of this site makes it contemporary with the presence of the Empire nearby so the results can be discussed regarding external contact.

A few donkey remains were also identified from Iron Age deposits outside the Mediterranean area. These included four from sites in Britain, three in northern France and the Manching Oppidum. Manching (Boessneck *et al.* 1971) and the northern French sites (Meniel 1984) have been discussed above concerning the mules identified from those assemblages, and explanations for the presence of donkeys can be argued along the same lines. Similarly, two of the sites from Britain had a continuous occupation sequence from the late Iron Age into the Roman period and the dating of the deposits could be questioned. The donkeys from Danebury (Grant 1984) come from the latest deposits on the site and as such fall into the category where the possibility of trade with the continent can be considered. Links have been demonstrated between the settlement at Danebury (Grant 1984) and that at Hengistbury Head, which was certainly trading with the continent.

Unexpected donkey and mule identifications were also observed from sites contemporaneous with, but outside the boundaries of, the Roman Empire. The most numerous identifications were made from the site at Feddersen Wierde (Reichstein 1991), where 18 mules (one skeleton and 17 isolated bones) and 10 donkeys (all isolated bones) were identified. As discussed in Section 1.2, trade beyond the boundaries of the Empire was extensive and included areas far further from the boundary than Feddersen Wierde. In addition it has been shown that the degree of interaction between the inhabitants of Feddersen Wierde and the Roman army in particular, was manifested in changes in the economy of the site as well as the appearance of traded goods. It is therefore perhaps not so surprising that donkeys and mules were found at this site. Further discussion of trade beyond the boundaries of the Empire, as relates to equids, will be undertaken below.

Within the boundaries of the Roman Empire, mules and donkeys were identified in varying quantities from all the geographic areas included in this research. The species proportions in the different areas are discussed in more detail in the next section, but in general the more northerly areas had fewest donkeys and mules, whilst Egypt had the highest, although this may be because of the special nature of the sites there, as discussed below. Areas with high concentrations of military sites, such as along the *Limes*, also had quite high numbers of mules. Possible reasons for these differences are discussed in Section 7.3.

In all the areas mentioned above, surprisingly low numbers of donkeys were identified and some suggestions on why this is the case are set out here. It was not likely to be a problem with the identification procedure, as for almost all elements the separation of the donkeys from the other species had a 100% confidence level. It may be reflecting the paucity of data from the Mediterranean and North African areas, where the largest numbers might be expected. This is backed up by the evidence that is included from this area, from the Classical Greek site at Kassope (Friedl 1984), the Punic site at Olbia (Manconi 1995) and the Roman Egyptian site at Mons Claudianus (Hamilton-Dyer 2001), all of which produced a preponderance of donkey remains.

The lack of donkeys in more northerly areas could also be a reflection of the environment; donkeys are ideally suited to hot dry conditions and would therefore perhaps not be expected to thrive outside the Mediterranean and North African area. There is another piece of evidence that backs up this argument: Aristotle (*hist an* VIII, 28 in Peters 1998) reports that donkeys did not occur in the Celtic and Scythian lands 'because they have bad winters'.

Alternatively, the lack of donkey identifications could be a manifestation of the data being mainly from urban and military contexts, and not the rural estates where many donkeys would have worked and where mules would have been bred. It is quite possible that a combination of these explanations could be contributing to the small numbers of donkeys identified from the dataset assembled for this thesis.

With all these donkey and mule identifications it is of course possible that because of the incomplete accuracy of the identification procedure, some of these were attributed to the wrong species. However, all of the identified cases were either from deposits within the Mediterranean area or from those dating to after the existence of the Roman state and its trade contacts. This suggests that it is entirely possible that mules and donkeys were traded either directly or indirectly as carriers of other goods from early Roman times onwards. The only exception to this is the Thracian site of Swestari (Nobis and Ninov 1986), where a single mule skeleton was identified. This can be explained by the presence of Classical

Greek colonies on the Black Sea coast with whom the Thracians traded, linking both to trade and the Mediterranean 'heartland' of these animals.

7.1.2 Species proportions

Discussion of the species proportions logically follows on from that of the species identifications. As already intimated above, there were differences in the species proportions between the main period groups and also within the Roman period between different geographic areas. As was expected, the ratio of mules to other species was higher in the Roman period than for the Iron Age period, and also higher than that for the contemporaneous External material. Data from all the Iron Age sites gave species proportions of 75% horses, 15% mules and 10% donkeys. The number of donkeys wa,s however, biased by the presence of the data from the Mediterranean sites where mostly donkey bones were recovered. If these were left out, the proportion of horses was even higher, as expected for this period.

The Roman period produced a ratio of 14 horses: 10.5 mules: 1 donkey (55%, 41% and 4%, respectively). As stated previously, this presents a very different picture to that from the zooarchaeological record before this research was undertaken. Prior to this research the identification of a mule bone was a rare occurrence, leading to the impression that mules were not numerous in Roman deposits, which was in turn at odds with the impression gained from the contemporaneous literature and art historical sources. On the basis of the information gained from the application of discriminant function analysis to the biometric data, it is suggested that, in general, it should be expected to find almost two-thirds as many mules as horses in Roman period bone assemblages.

The species proportions calculated from just the complete skeletons and articulated limbs showed an increase in the proportion of horses (12.5 horses: 5.5 mules: 1 donkey). It is thought that this may be reflecting a difference in status between the horses on one hand and the donkeys and mules on the other. This is manifested in the treatment of the remains after death, with some horses being treated as 'special' animals and accorded a separate burial whereas the mules and donkeys were disposed of in any way possible. The exception to this was the group of 35 equid skeletons (horses and mules) buried together as a single episode at Weißenburg (Peters 1998), where the interpretation of this deposit was casualties from a disease epidemic. The six skeletons from Künzing *vicus* (von den Driesch and

Cartejena 2001) deposited in a single pit could be interpreted in a similar fashion. The treatment of equid remains is discussed in Section 1.2 under ritual and religious use of horses and the consumption of horsemeat, neither of which is likely to be relevant to the cases just mentioned but could relate to other burials of individual or groups of skeletons. When the species proportion information was split by area, differences became apparent that require some thought and explanation. The Rhineland and Danube and Balkans areas showed similar results to the overall figures, with horses forming about 56% of identified equids and mules about 40%. In Gaul the proportion of horses was higher (64%) and in Britain higher still (82%). The most strikingly different results were from Egypt, where much higher proportions of donkeys and mules were noted, but the number of cases was rather small. There were insufficient equid remains from other areas to calculate meaningful species proportions.

The similarity of the Rhineland and Danube and Balkans areas to each other and to the overall proportion values is most likely to be a reflection of the large numbers of cases involved from these regions (particularly the Rhineland). It is probably the case that the overall values are reflecting the proportions for these regions. Although a number of different site types from the Rhineland contributed to the analysis, the majority were military and urban sites, which may be biasing the results to some extent. For instance, the extensive use of mules as baggage animals by the military may have increased the proportion of mules found on these sites. The small proportion of donkeys may be a reflection of this bias in site types, or environmental factors could be the cause, as discussed above. The site types from the Danube and Balkans areas were more mixed and yet were reflecting similar proportions of species, perhaps indicating that around 55% horses, 41% mules and 4% donkeys is a good average figure for the Roman period as whole.

There are a number of suggestions to explain the differences in proportions that appear in Gaul and Britain. Again there is the issue of sample size. The numbers from both regions were smaller than for the Rhineland and Danube and Balkans areas discussed above, and in the case of Gaul the sample was also biased by site type, as most of the data came from one urban 2 site. The small number of bones from Gaul was mostly the result of difficulties in obtaining data from published sources abroad and difficulties of dialogue with French colleagues. It is hoped that future research would incorporate a larger dataset and therefore it may be that the species proportions in Gaul would be more like those from the Rhineland and Danube and Balkans areas. Differences between Gaul and the Rhine-Danube frontier could be explained by the less strong military presence in Gaul in comparison with the

Limes area and the extensive use of the river systems rather than roads for the long distance transport of goods, as discussed in Section 1.2.

In addition, there is also the possibility that the small sample from Gaul is reflecting intraregional variation. Gaul varies widely in its climate from the Mediterranean south to the temperate north, and also in the Roman period it varied widely in its degree of Romanisation (Section 1.2). It is possible that the northern parts of Gaul (from where the data analysed derived) had different species proportions for reasons to do with climate and a lesser degree of Romanisation.

The sample from Britain was larger than that from Gaul and was also much more widely varied in terms of the site types from which it derived. It seems that the higher number of horses from this region is a genuine reflection of the species proportions present. As hinted at for Gaul, this may be to do with climate: donkeys (and perhaps also mules) are not so adapted to the British climate as horses. For Britain there is the additional factor that the province is an island. It was, therefore, perhaps not logistically viable to transport large quantities of mules and donkeys across the sea for use as baggage animals, and the indigenous ponies were used in this capacity instead. This may well be the case for the early post-conquest period, perhaps until donkeys were transported to establish mule breeding in Britain. Unfortunately, the dating of many of the deposits was not tight enough to allow analysis of the British data by sub-period to test this hypothesis.

The very different proportions of equids recovered from Egypt may have several explanations. The numbers of cases involved were very small and therefore could be biasing the results. All the identifications were from the site of Mons Claudianus (Hamilton-Dyer 2001), which is an industrial quarry site unlike any of the sites in the other regions, and this could be further biasing the results. Another factor in these differences may again be climatic conditions: donkeys and mules are adapted to the arid conditions of North Africa whereas horses are not. It seems, therefore, that the Egyptian material cannot really be compared with that from other areas for a number of unique reasons, although the preponderance of donkeys serves to verify the identification method.

From this evidence it appears that, although in some cases the small quantities of data available require caution in interpretation, there is a difference in the proportion of species found in different areas of the Roman Empire. These differences can be interpreted in a number of ways, including differences in site types from which the material derived, climatic conditions favouring particular species, and logistical difficulties in transporting animals across the sea. The collection of further data to eliminate some of the biases would allow a more detailed examination of the data to determine which of these factors are affecting which areas, and build a clearer picture of species proportions across the Empire.

7.2 Effects of Romanisation on the equid population

Definitions of the term Romanisation have been given in Chapter One so it suffices to repeat here that the term is only used as a convenient name to describe the changes that occurred as a result of the incorporation of an area into the Roman Empire. To determine the effects of Romanisation on the equine population, comparisons need to be made between pre- and post-conquest remains.

One of the effects of Romanisation has already been discussed, namely the spread of donkeys and mules throughout the area covered by the Empire. Whilst this process appears to have started prior to conquest in a number of areas, possibly though trade with the Empire, there are certainly more numerous mule remains in all areas in post-conquest deposits. The smaller quantities of donkey remains have been discussed above and it seems most likely that a combination of site-type bias in the dataset and climatic conditions across the Empire have contributed to this situation.

The more widespread presence of mules in the current datset perhaps indicates that this species was more adaptable to climatic conditions than donkeys, and that it is to be found on site types that occured regularly in this research. For instance, the contemporaneous literature sources suggest that the army primarily used mules as baggage animals and do not mention donkeys in the same context. This would make sense in terms of the greater carrying capacity of a single mule versus a single donkey. A combination of the fact that outside the Mediterranean area mules thrive better than donkeys and that they have a greater carrying capacity, perhaps favoured the use of mules and hence greater numbers have been found on sites in temperate Europe.

The process of Romanisation and afterwards the maintenance of the Empire was probably what precipitated the far greater need for mules as pack animals. They enabled the army to carry sufficient supplies for campaigns to expand territory and also enabled the maintenance of standing armies in border areas. There is no reason to believe that the preceding Iron

Age communities had a pressing need for pack mules, hence the numbers of mules would have been considerably smaller, to the extent that it can be argued that even the few mules that have been found were present only through trade with Roman contacts.

The following discussion is based on the data obtained from the analysis of the withers heights, shape indices and log-ratios of those cases that were calssed as identified or 'ambiguous', as detailed in Chapter Six. In most cases only four areas are discussed: Britain, Gaul, the Rhineland and the Danube and Balkans areas. This is because there were insufficient data from the remaining areas covered for significant results to be obtained. However, where individual cases are noteworthy, they will be included.

As has been discussed in Chapter 1, the differences between the Iron Age communities that became part of the Roman Empire showed pre-existing regional differences and those differences persisted after incorporation as Roman provinces. Therefore, it seems logical to discuss the regional differences noted in the equine populations of the Iron Age as they could have had a bearing on those of the post-conquest period in the same areas. As discussed in Section 6.5, the Iron Age horse mean values showed that they were similar in build to the Welsh ponies in the modern sample, although a little taller so the following descriptions can be visualised as deviations from this.

The smallest Iron Age horses in terms of withers height were those from the Rhineland area (1225 mm), closely followed by those from Gaul (1228 mm). As well as having the lowest mean values, the horses from the Rhineland area had the narrowest range of withers heights, suggesting a fairly uniform size of animal. This may be reflecting the fact that many of these animals originated from a single site (Manching, Reichstein 1991) and were likely to have all been locally bred and therefore similar in size. The small size of most of the horses from Manching was noted in the original site report, together with the observation that the few taller individuals could have been imported through trade with the Roman Empire (Boessneck *et al.* 1971). With the application of discriminant function analysis, some of these taller animals were probably mules, but this does not alter the suggestion that they were present as a result of Roman contact.

The horses from Iron Age Britain were taller, at about 1260 mm, and the tallest horses were from the Danube and Balkans, areas at about 1308 mm at the withers. The presence of tall horses from the Danube and Balkans areas in the Iron Age was perhaps to be expected given the contemporaneous accounts of the importation of large horses from these areas for breeding by the Greeks both in mainland Greece and the Near East. Although to modern eyes a horse of only 13 hh would be considered a middle-sized pony, in comparison with the rest of the Iron Age horses standing between 12 and 12.2 hh, the Danube and Balkans horses were indeed somewhat larger.

In terms of build, there are also significant differences between the Iron Age areas studied. The Gallic horses, as well as being of small stature were also of slender build. All the metapodial indices gave slender figures, but this was most noticeable on the distal breadth / greatest length index. This slenderness at the lower end of the limb suggests that the animals as a whole must have been of slender build in order to be in proportion. The British Iron Age horses, as well as being taller than their Gallic counterparts, were also more robust and this was particularly noticeable on the log-ratio measurements. This suggests that the British horses were bigger overall than those from Gaul, rather than being differently proportioned.

Although the Iron Age horses from the Rhineland were marginally the smallest in terms of height, the robusticity of the bones was similar to those from Britain, suggesting that these animals were of a more robust build than those from Britain and Gaul. As discussed above, the fact that most of these cases originated from a single site may be contributing to the narrow range of values for this group and hence their similarity of appearance. The opposite is true for the horses from the Iron Age Danube and Balkans region, where the height increased significantly, but the robusticity did not increase proportionately, indicating that these animals were slightly more slender relative to their height than those from the other regions. In absolute terms they were bigger all over, suggesting a degree of allometry (positive correlation between height and slenderness) in these measurements.

Having discussed the Iron Age horses, it is now time to discuss the changes that occurred as a result of the Roman conquest of the four best represented areas. Overall, there were significant differences between the Iron Age and Roman horses in both height and build. On average the Roman horses were taller than the Iron Age ones, with a mean of 1351 mm (13.2 hh). In addition, the build was considerably more robust, taking into account the data from both the shape index and log-ratio analyses. The overall appearance is similar to that seen in the Exmoor, Mongolian and Przewalski ponies from the modern sample: a fairly chunky middle-sized pony. Although the mean withers height was 1351 mm, there were many more larger individuals than in the Iron Age sample and the upper end of the range extended into what today would be considered, by height, horses rather than ponies.

However, the proportions of these larger individuals were not significantly different from the smaller ones. They were certainly not of build similar to the Arab horses included in the modern sample, which had particularly slender limbs. The Roman horses are of quite robust build, which suggests that many of the art historical representations of horses were relatively accurate in this respect, if not always regarding the relative sizes of horses and humans.

As well as the overall increases in height and robusticity, there were different degrees of change within and between the regions. For instance, although there was a significant size increase, the horses from Roman Gaul were still generally smaller than those from other regions (1342 mm) and also retained their slender build. This suggests that although there must have been some improvement of the local stock for the height to increase significantly, it was not undertaken to such a degree that the characteristics of the local stock were lost entirely.

Although the Iron Age British horses were relatively tall and robust in comparison with the period mean values, the Roman British horses were not. The mean Roman period withers height was 1312 mm (13 hh), an increase of only 50 mm from the Iron Age mean. The build of the Roman animals seems to have been similar to that of the preceding period horses. The Iron Age horses were relatively robust, so the Roman ones were nearer the means for the Roman period than was the case for the heights. The horses from Roman Britain, were therefore shorter but more robust than their Gallic counterparts.

The smaller degree of change in the Roman British material could be explained in a similar manner to the lack of mules; Britain is an island and therefore it was more difficult and costly to transport animals to Britain for breeding purposes. This is also reflected in the timing of the size increases in different areas. In all the continental areas studied, the size increase in the horses appears to have taken place almost immediately post-conquest, whereas in Britain it has been demonstrated that the size increase took place in the later Roman period, at least two centuries post-conquest. This slower pace of Romanisation of the equine population of Britain seems likely to have been the result of the logistical difficulties associated with an island, rather than any particular differences in the way in which the conquest and Romanisation of the province was undertaken.

The delayed size increase in the horses of Roman Britain is, however, in stark contrast to most other domestic mammals, which on many sites show (e.g. Elms Farm; Johnstone and Albarella 2002) a marked increase in size in the immediate post-conquest period. One possible explanation of this phenomenon is that the Iron Age horses of Britain were considered adequate for the immediate needs of the conquering army and the emergent province, whereas the meat-providing animals were not considered adequate and were improved at an earlier stage in order to satisfy the provisioning needs of the army. Alternatively, in the immediate post-conquest period the military needed to be able to control the food supply, so imported stock rather than relying on potentially hostile conquered peoples to provide for them. It is possible that horses were not considered such an important resource and did not require such close control.

In the Rhineland area, the Iron Age horses had the smallest mean height of the four areas, whereas the Roman mean withers height was the tallest of the four areas, at 1364.5 mm (13.2 hh). The robusticity also increased into the Roman period, but to a lesser extent than height, indicating that the Roman animals were of a slightly more slender build than their Iron Age counterparts and similar to the Roman Gallic horses. In some ways the Rhineland Roman horses changed the most from their Iron Age predecessors within the four main areas under discussion. It seems reasonable to relate this to the heavy military presence in the region and the contemporaneous accounts of how unsuitable the Germanic horses were to the Romans (e.g. Caesar, *B.G.* IV, 2).

The horses from the Roman period in the Danube and Balkans areas were also tall, with only a marginally smaller mean withers height of 1362.3 mm (13.2 hh), than the Rhineland horses. However, the log-ratio analysis in particular indicated that these animals were also proportionately robust. Therefore these animals were larger in all dimensions than those from other regions and would have appeared more robust, particularly when compared with those from Gaul. In terms of comparison with their Iron Age counterparts in the same area, the Roman horses were slightly taller but significantly more robustly built.

As suggested above, the differences in the Iron Age equine populations from the areas under study would have to some extent influenced the size and shape of the succeeding Roman horses. It has been shown that, although the Iron Age horse populations did influence the Roman ones, the changes observed between the two periods differ in the various areas studied. This suggests that the nature of the 'improvement' of the horses took different forms in different areas, perhaps partly dictated by the nature of the local horses at the time of conquest and probably also partly by the needs of the Roman officials, be that civilian or army. As discussed in Section 1.2, in most aspects of changes to material culture, economics and daily life, the process of Romanisation was not uniform across the Empire and can also be seen regarding the equid population.

7.3 Differences within the Empire

The differences commented on in relation to the process of Romanisation can also be applied to a discussion of differences within the Empire. Other lines of evidence, such as site type, chronological trends, the presence of frontier zones and the internal trade networks, can also be used to explain some of the observed differences.

One issue to discuss at this point is the unevenness of data coverage across the Empire. Difficulties in data collection include the lack of zooarchaeological studies in some areas and the lack of availability of data from others. The data collection problems encountered during this research are not confined to zooarchaeological data, Fitzpatrick (1989) highlights the lack of quantified data, in certain areas, in relation to wine amphorae and other ceramics. This means that there are inherent difficulties in the comparison of data, as the disproportionate representation between different areas of the Empire could lead to bias in the results of analyses based on that data. Only comparing areas for which enough data were available for statistical tests to be valid has, to some extent, countered this. Where observations are based on less data, this is made explicit in the text below.

7.3.1 Regionality

The question of regionality is one that has really only recently been discussed as a possibility. Hitherto, discussions of the Roman Empire have tended to focus on the uniformity of public architecture, and portable material culture throughout the Empire. However, many studies (e.g. Wells 2001) have now highlights that whilst overt displays of Romanisation were similar throughout the Empire, it is important to bear in mind that this homogeneity was mostly restricted to the elites, and that many of the aspects of daily life of the non-elites owed more to the preceding local Iron Age cultures and traditions than those of Rome.

Regional identities have already been shown to exist in the differences in size and shape of the horses across four areas of the Empire used in this research. The Roman horses show as many similarities as differences with the preceding Iron Age horses, and the differences between the Roman horses are equally varied.

The zooarchaeological evidence can be used on its own to demonstrate regionality in the horse population, and it is hard to make direct comparisons between the contemporaneous literature and the results of this research. The literary sources were mainly written about, and by people living in, the core areas of Empire around the Mediterranean, and this is one of the areas that suffers considerably from lack of zooarchaeological data. As described in Chapter One there are many limitations that have to be considered when applying observations in the contemporaneous literature to areas outside Italy.

The descriptions of horses from various parts of the Empire (see Figure 1.5) can be correlated with the results of the size and shape analyses carried out for this study. For instance, the descriptions of the Gallic and Germanic horses being small are certainly true of the pre-Roman period, as has been outlined in the section on Romanisation. Similarly the Danube and Balkans area horses were large, as is consistent with the descriptions of horses from these areas. For the North African and Spanish horses no zooarchaeological data were available, so no comparisons can be made.

In terms of the comparison with the 'Roman ideal horse', as described in Chapter 1 and relatively accurately depicted in Figure 1.2, the statue of Marcus Aurelius, the Gallic horses as a group appear to be furthest from this ideal, and those from the Danube and Balkans area the closest. The Rhineland horses were closest in terms of height but not in build, and the British ones *vice versa*. Whether the aim of Roman horse breeders was to fulfil the Roman ideal or just to produce animals that could adequately fulfil the tasks asked of them is of course something that cannot be ascertained, as the contemporaneous written sources do not tell us this explicitly.

It is argued here that the task of most horse breeders was simply to produce animals fit for use in whatever capacity was required of them, and as such local variation would not have mattered a great deal. There were of course exceptions to this, particularly those breeders producing horses for the chariot racing industry, where producing beautiful as well as functional horses was of paramount importance. There is no direct evidence of where these animals may have been deposited, but once their racing careers were over it is suspected they would have been sold on to work in mills, etc. This means they would be found amongst other equine remains and therefore be might not be distinguishable as a seperate deme.

In Chapter 1 it was argued that as well as specific studs producing mounts for the army, mounts were requisitioned in any way possible. Therefore, locally bred horses that fitted the criteria required by the army could have been requisitioned and would not necessarily have been required to be of an exactly uniform type. However, it can also be argued that if the army did take all the horses of a certain type, those that were left would have been those that were substandard in height or build. In most areas a mixture of military and civilian assemblages were included in the current dataset, so the overall appearance of the data would include all types of animal. The first explanation could, however, fit the material from Roman Gaul, where no military sites were included in the sample.

The degree of regionality indicated by the current dataset suggests that horse breeding was carried out throughout the Empire and that local stock was used in many instances, perhaps with limited importation of stallions to improve the stock. This would explain the differences encountered between the overall appearances of the horses from the various areas. It should, however, be remembered that these are generalisations based on the mean values and that within each group there may well be individuals covering a variety of heights and builds. These could include those that were closer to the Roman ideal, but in most cases it would be impossible to determine if these were bred locally or imported.

In contrast to horses, the discussion of regional differences in mules can be very brief as in most instances there were no detectable differences in the dataset between the size and shape of the mules from the four main areas studied. Because of the smaller sample sizes, it was not always possible to validate some of the possible differences statistically, but in those cases that were testable the differences did not appear to be significant.

The mean withers height of the mules from Roman deposits was 1446 mm (14.1 hh), significantly larger than the mean height of the horses. As has already been discussed in Section 6.2, there may be a slight bias in the discrepancy between these mean values, as the taller horses and shorter mules were not as clearly identifiable to species, leading to the possibility that only the taller mules and smaller horses contributed to the mean withers height estimates. Until the identification procedure can be refined to enable some of these more problematic individuals to be identified, the possible bias in withers heights should be borne in mind. However, it is suggested here that although it may be slightly exaggerated, the difference in heights is real. This suggestion is based on the knowledge that modern mule breeders expect their mules to mature at a height greater than that of the mares, and this has been estimated to be as much as 100 mm (1 hh). The difference observed in the mean withers heights of the Roman mules and horses comes very close to this figure (95.4 mm).

As discussed in Section 6.2 and relating to the discussions of mule breeding in Chapter 1, the mares used by the Romans to breed mules were considered superior to the run-of-the-mill horses of the Empire. This suggests that they were larger than average, and this in turn would lead to the production of tall mules. The discrepancy between the mean heights of the horses and the mules can be demonstrated to stem from a number of reasons, which at present cannot be separated but do indicate that it is real.

The horse height differences apparent in the various areas of the Empire are also apparent in the data for the mules, to a more pronounced degree. The variation between the areas analysed amounts to just over 100 mm, with the mules from Roman Britain having the smallest mean withers height (1362 mm) and those from the Danube and Balkans area the largest (1463 mm). The Gaul and Rhineland mules were similar in height and close to the overall mean.

The small size of the British mules is noteworthy, even though there were only five individuals. Whilst it is a little presumptuous to speculate on the possible reasons for their small size on the basis of only five individuals, it is perhaps justifiable because it is the same argument that has been used to explain the small number of mules and the small size of the horses in Roman Britain. The explanation offered is that the logistics of moving equines across the English Channel to Britain was not cost effective on a large scale, therefore the presence and small size of the mules may be the result of local mule breeding using imported jackasses and local mares (which have already been shown to be smaller than their continental counterparts). Although this is a tentative argument based on a small sample size, it incorporates and is consistent with all available evidence whilst not contradicting any of it.

Taking the argument that some of the tallest horses were used to breed mules, it is logical that the mules from the Danube and Balkans areas were the tallest given the fact that the horse withers height mean was almost the tallest. However, it is slightly surprising that the mules from the Rhineland were not equally tall. A possible explanation of this could lie in the different political/military situation in the two areas. The Rhineland was a heavily militarised zone, where perhaps mules were not bred but brought in with other supplies from a more widely dispersed area of the Empire. In contrast it is possible that the Danube and Balkans area, whilst having a military presence along the Danube itself, was not so heavily militarised further afield. Also in view of the excellence of the horses from this area, as acknowledged by the contemporaneous sources (see Figure 1.5), perhaps breeding mules from these horses was considered to be useful and profitable.

The shape indices of the mules indicate that they were consistently more slender than the horses regarding the Roman mean values and when split by area. This is one of the defining characteristics of mules in contrast to horses and is, therefore, unsurprising. Regarding differences within the values for the mules across the various areas within the Empire, there were only sufficient numbers to test for significance between the Rhineland and the Danube and Balkans areas, where no discernible differences were detected. Therefore, although the Danube mules were taller than those from the Rhineland, they were proportionately equally slender limbed.

The similarities between the mules across the Empire by far outweigh any differences and, in fact, the degree of uniformity is quite remarkable. There are a number of possible explanations for this. One suggestion is that the Roman mule breeders preferred to use the bigger mares to breed from and this would mean that all the ensuing mules would also be tall. If these mares were all of a particular type, i.e. close to the Roman ideal, then the mules' build would also be similar. However, the identification method may have excluded mules of 'outlying' size and shape, so tending towards a mean form.

A second explanation involves the idea of centralised rather than local breeding of mules. The diversity of the horse forms seems indicative of localised breeding from different base stock. The uniformity of the mules could be argude to be the result of the reverse, i.e very few breeders, possibly mostly in Italy, breeding the vast majority of mules to supply the needs of the army, the *Cursus publicus* and private merchants. This could be inferred from Varro's (*r.r.*) descriptions of his mule-breeding establishment, which was obviously an operation of some scale. The cost of good mares and jackasses and the requirement of a large estate with suitable grazing land would have prevented many citizens from breeding mules on a large scale. Whilst this would not have prevented individuals from breeding mules for their own use, perhaps the large-scale supply of mules was only carried out on large estates.

Another suggestion is that the uses to which most mules were put dictated that an animal with certain characteristics was required, in particular baggage animals for the army. Whilst there are references in the contemporaneous literature to the fact that the army had certain requirements regarding the horses selected for its use (Section 1.3.1 and Hyland 1990), no specific references to mules in the same context have survived but it is possible that specific height and weight carrying requirements had to be met for the mules to be used by the army. As the army was one of the main purchasers of mules, breeders would have aimed to produce mules to meet the army standards and would therefore have tried (and seem to have succeeded) to produce relatively uniform animals. The procurers of mules for the *Cursus publicus* could have exercised similar requirements, reinforcing the need for uniform animals.

The last suggestion could be considered as indirect control of mule breeding by the Roman authorities. Therefore another suggestion could be the direct control of mule breeding by the state, regulating the requirements of size and shape for mules and ensuring the mule breeders complied with these regulations. This could have taken the form of 'licensing' for the large mule-breeding establishments, such as that of the writer Varro (*r.r.*). The suggestion of direct control is perhaps a little extreme but there are indications that some control was exercised over the production of other goods. For instance, although the government supplied the army with food, it seems that it was up to individual forts to procure their own manufactured goods such as pottery, metalwork, leather goods, etc. Such goods were traded over vast distances, and whilst there is disagreement about degree of control by central government over pottery production and distribution, it seems likely that the large scale production sites in central Gaul and Rhineland were controlled in some way (Wells 2001). It is therefore possible that a similar degree of control was exercised over mule breeding.

It seems likely that the demands of the market would have dictated that the animals be able to carry a particular weight of baggage and hence breeders produced animals to fulfil those requirements by using the largest mares to produce the largest mules. The costs involved in this would have led to the control of the market by a limited number of large-scale breeding operations. Therefore, the direct control of mule breeding by the authorities may have been little more than the authority exercised by large-scale, wealthy mule breeders and landowners in their positions as senators or other official public posts.

From these various strands of evidence it can be seen that there was regionality in the equine population within the Roman Empire. The form this regionality took varies according to the species under discussion. The horses varied considerably between the areas of the Empire, both in terms of height and build, and there was also quite a wide range of variation within each area. In contrast, the mules showed a remarkable degree of uniformity between and within the four main areas under discussion, with the possible exception of Roman British mules. The differences in variation between the horses and mules can be explained in terms of local versus centralised breeding or in terms of a greater degree of selection of breeding stock for the mules than for the horses, or a combination of these.

7.3.2 Frontiers

Unfortunately, because the dataset was not as large as hoped, the question of whether the frontier zone equids had different characteristics to those from other areas of the Empire cannot be answered satisfactorily in specific terms. In general, there appear to be no greater differences between the equids from the Rhineland and the other areas, than between those other areas. This suggests that the variability of the horses overall could be masking any specific differences between those of the frontier zone and the other areas.

Differences in the equids that could be attributed to military or civilian site types will be dealt with in the section on social differences. There were insufficient numbers of cases to be able to split the site type data by area in order to determine if there were differences between the frontier zones and other areas.

The question of differences between the equines on either side of the borders in the frontier zones will be dealt with in Section 7.4 on detecting external contact in the equine population.

7.3.3 Trade and supply

A few of the issues of trade and supply in terms of the equine population of the Roman Empire have been touched upon in relation to the wide variation in size and shape of the horses and the contrasting uniformity of the mules. The logistical difficulties of transporting mules for baggage transport and stallions and jackasses for breeding to Britain have also been touched upon. This section aims to expand on these issues and raise a few other issues relating to equines in trade and supply within the Empire.

There are two main areas to discuss: the trade and supply of equines themselves and the use made of equines in the trade and supply of other goods. Discussion of the first issue falls into a number of parts relating to the breeding and movement of the different equines. Preceding sections have summarised the data relating to the representation of species and the size and shape differences between the various areas of the Empire. From this it has been suggested that horses appear to have been bred all over the Empire, using varying sizes and shapes of existing stock and improving one or more aspects from the preceding Iron Age stock. These changes indicate that at least some animals were imported into areas for the purpose of stock improvement. However, it is equally possible that the introduction of the principles of selective breeding could have caused the changes observed. Selective breeding is used here not to imply any knowledge or understanding of genetics, merely the observation that like begets like. It is, however, most likely that a combination of these factors was at work.

As discussed in Chapter 1, during the Republic and early Empire periods the practice of allowing the importation of stallions to areas outside the Empire was granted only to 'friendly kings' (Braund 1989) and other such favoured individuals. It was noted that this privilege was granted to various Gallic chiefs in the Republican period, with the express purpose of using these stallions to improve their own stock. It was also noted that prior to inclusion into the Empire the Gauls actively wanted to improve their horses, whilst the Germanic tribes did not. Therefore even in the late Iron Age, Roman horses were being used to improve stock, and the 'trade' or at least the 'gifting' of horses was established (Braund 1989). Post-conquest, the movement of horses would have been less restricted in terms of who had access to breeding animals and the demand for larger animals encouraging stock improvement and selective breeding.

The combination of the evidence provided by the written sources and that gained from the analysed zooarchaeological data show that changes certainly took place in the size and shape of the horses in areas that became part of the Roman Empire, and horses must have been moved around the Empire in order to facilitate this. The extent to which this took place, and the number of horses involved, is very hard to estimate. It is unlikely that there was a specific trade in breeding horses, but certainly the more affluent breeders went to some lengths to acquire quality breeding stock, as attested to by Varro (*r.r.*).

The breeding of horses on an Empire-wide scale means that there would not have been any great need to transport horses over long distances in most circumstances. The possible exceptions to this were the supply of horses to a rapidly advancing army on campaign, and the supply of horses to the racing industry. In the second instance, it has already been mentioned that horses from North Africa and Spain were favoured as chariot horses, and that those from North Africa were certainly shipped across the Mediterranean to Italy on a regular basis (Hyland 1990; Clutton-Brock 1992). It is suspected that the Spanish horses arrived by sea as well, this being the most efficient way of travelling horses over a long distance.

It is unclear whether the supply of high quality chariot horses over long distances was restricted to the amphitheatres of Rome and central Italy or whether they were also traded between amphitheatres across the Empire. This is one area where the contemporaneous written sources are particularly biased, by describing what was normal for Rome but neglect to tell us if the same applied across the Empire. Unfortunately, excavations of amphitheatres have not in general produced many animal remains, and where there have been horse remains they cannot be unequivocally linked to chariot racing, so it is not possible to be able to contrast the horses from Italy with those from the provinces. Indeed it is not even possible to illustrate the form that these horses took. Only those animals that actually died during the course of a race would be likely to be found near an amphitheatre. As mentioned before the majority would have probably been retired to other activities and thus would not be distinguishable from other horse remains.

It is suspected that the North African and Spanish bred horses were raced in their home areas as well as being brought to Rome and Italy and that the more northern and eastern provinces sourced their chariot horses at a more local level, particularly when it is considered that racing mania did not reach such a fever pitch in these provinces as it did in Rome and Italy. Once again, because of the lack of data and the almost impossible task of associating existing remains with racing, there is little chance that these theories can be proven in the immediate future.

Another suggestion that requires some consideration is the long distance supply of horses to the army on campaign. The supply needs of the army before a campaign and a standing army in a relatively stable environment could be met from recruitment of horses from local sources and from the specific studs set up to meet this need. However, the supply of remounts to replace those lost in action during a campaign, particularly one that was advancing fast into new territory, would have been more problematic. This would have involved the need for rapid transportation of horses to the frontline from sources some distance away. It may have been possible to take horses from the newly conquered areas, but this could not have been relied upon. A mechanism to supply from secure territory would have had to have been in place.

The problem with detecting rapid, long-distance transportation in the zooarchaeological record is that these were short-term incidents in the timeframe of the whole Empire, and as such are not easily detectable archaeologically. Whilst at least one battlefield site has been excavated (Krefeld-Gellep, Nobis 1973) and the equid remains analysed, it is most likely that these animals were brought with the army for the initial campaign. If remounts were brought in to replace casualties, they are not likely to be found in the same place. If they were different in terms of size or build, which might indicate a different place of procurement, it would be impossible to detect as the two sets of remains would either be indistinguishable or not found in the same place.

It appears that the movement of horses around the Empire is almost impossible to detect biometrically, except in terms of the appearance of improved stock in the various provinces. This is perhaps one area where some of the more advanced scientific methodologies may be able to shed some light. For instance, the detection of the presence of different levels of minerals and isotopes in the teeth of horses may be of use in elucidating the area in which that individual grew up, leading to the possibility of detecting horses that have moved a considerable distance.

In terms of the use of equids in the trade and supply of other goods, there are a few issues that can be discussed using the identification and size and shape data gathered in this research. As has been mentioned, one area that is of particular interest is the spread and proportion of mules across the Empire.The proportionately smaller numbers of mules from Roman Britain have been interpreted as being caused by the logistical difficulties of transporting mules across the sea, and the small size of those present as having been bred from the smaller local mares. Yet there is still the question of why there were not more mules, given the fact that the north of Britain was a military zone that required supply and this had to be done mostly by road because the rivers are not well placed for south to north transport (as suggested by Middleton 1979).

It seems slightly odd that pack horses instead of baggage mules carried out the road transport in Britain, when in all other areas the reverse seems to be true, for the very good reason that mules can carry larger loads per animal than horses. The logistical difficulties of transporting mules across the sea must have been very high for that cost to be offset by the increased expense of having to use larger numbers of ponies instead. Perhaps it is the case that goods transported by sea could be landed at any of a large number of identified Roman ports, and the distances required for transport over land were thus reduced considerably.

Apart from two mules from military contexts in the 1st century AD, the mules present in Roman Britain are all from the deposits dated to after the late 2nd century. Given the hypothesis above that mule breeding was in general linked to centralised wealthy estates, whose owners exerted influence over the supply of mules to the army and *Cursus publicus,* this may perhaps be linked to two factors. In the 2nd century in Britain the development of the fenlands in East Anglia, Lincolnshire and Cambridgeshire for agriculture was undertaken to supply the northern army garrisons along Hadrian's Wall (Middleton 1979). It is possible that mules were bred as transport for this more local supply network, rather than using the ports, as has been hypothesised for the supply of goods from the continent (e.g. Middleton 1979).

It is also possible that the development of wealthy villa sites in Britain in the 3rd and 4th centuries AD may have created the circumstances for the establishment of mule breeding on a more continental model, i.e. on large wealthy estates. However, as the number of identified mule bones involved is very small, these are just observations that could be tested in the future as new data become available.

The presence of many mules in the Rhineland has already been discussed briefly in Section 7.1.2 in terms of the highly militarised nature of the area. As discussed in some detail in Chapter One, the long distance supply of the military zone on the Rhine frontier from Gaul seems to have mostly been undertaken by river (Middleton 1979) but the final transfer would have needed mules, and this could also explain their presence in large numbers in this area. These water-borne supply routes from southern and central Gaul into the Rhineland explain the transport of commodities such as pottery and products transported in amphorae, which leave particularly visible, datable and traceable evidence in the archaeological record. However, there are other supplies, such as grain, that do not leave such a convenient trace in the archaeological record.

Groenman-van Waateringe's (1989) study of the palaeobotanical evidence and agricultural practices in northern Europe has elucidated much about the supply of grain to the army in the Rhineland frontier zone. It was established that the army preferred wheat to other cereals because it was better for making bread. However, the soils and climate of much of the lower Rhineland in particular were not suited to wheat raising, as they are better for barley. Therefore, wheat must have been imported from outside the immediate hinterland of the frontier zone. This is attested to by ships recovered from the Rhine that contained wheat as their cargo, as well as high proportions of wheat in paleaobotanical samples from fort sites (Groenman-van Waateringe 1989). In areas where wheat could be grown, such as northern Gaul, an increase in production is denoted by the replacement of small square granaries with large buildings over 20 m long (Groenman-van Waateringe 1989). This also suggests that the producers stored the grain for the army, and transport would have been required year round on a smaller scale rather than huge shipments at harvest time.

Although water-borne transport of grain has been noted, the transport of grain to and from the ships at either end of the journey would have required considerable numbers of equids, either carrying sacks or pulling carts.

This confirms the importance of beasts of burden in the military zone of the Rhineland. However, this evidence also suggests that mules are probably underrepresented in the, admittedly small, sample from Gaul. Future work needs to look at assemblages from rural sites of northern Gaul.

An exceptional site that did not provide enough data for statistically valid comparison but needs to be discussed as a noteworthy case, provides insight into perhaps the most outstanding use of equids as carriers of goods for trade. This is the porphyry quarry site of Mons Claudianus in Egypt (Hamilton Dyer 2001). It could be argued that this site only existed because vast numbers of equids were available to transport all the food and supplies to the workers in the settlement next to the quarry, and to transport the worked stone back to the coast for distribution around the Empire. Because of the special nature of the site, there were many more mules and donkeys present here than on the other site types analysed. A combination of the overwhelming need for baggage animals and the extreme climatic conditions of the area meant that horses were completely unsuited to the tasks required, and mules and donkeys dominate the assemblage. Horses were present, and were quite large, which may suggest that they were the mounts of the officers in charge of the site.

Comparison of what has been discovered from this research and the contemporaneous literature, regarding the use of equines in trade and supply, is limited by all the biases that have been mentioned previously. The problem of comparing the Mediterranean area with other areas of the Empire, which has been discussed on several previous occasions, means that the heavy use of donkeys as pack animals in Italy does not necessarily hold true for other areas of the Empire, particularly those further north. As has been shown, whilst donkeys were present in temperate Europe during the Roman period, they were not present in sufficient numbers to have carried the quantity of traded goods that have been found on sites around the Empire. The few sites analysed around the Mediterranean that have produced equine remains confirmed this to some extent, by producing more donkeys than the more northerly sites although this cannot be confirmed statistically.

The literature sources also mention the use of mules as baggage animals, particularly by the military, and this appears to be borne out by the results of this research. In the heavily militarised Rhineland area ,many mules were found, but they were also found in most of the other areas of the Empire, with the exception of Britain (as discussed above), suggesting that in areas outside the Mediterranean mules were the more important pack animal. Although this is not explicitly stated in the literature sources it is implied, so in this instance the archaeological data confirms the literature.

As has been discussed in Chapter One, it may well be the case that many of the aspects of the use of equines in trade and supply were considered too mundane for the ancient authors to bother writing about. There is thus very little written evidence that can be compared with the zooarchaeological data, so the results presented above represent new evidence on this subject.

7.3.4 Social differences

The research question to be answered here relates to whether it is possible to detect differences between the equids used by different sections of society, by comparing the equids from different types of site. It is acknowledged that by studying site types there will always be a slight mix of social classes represented, but some generalisations should be possible. However, as with Section 7.3.2 on the frontier zones within the Empire, there were not enough data when split into groups relating to site types for many statistically valid comparisons to be made.

The only analysis where enough data were present for meaningful comparison between site types was the log-ratio analysis of the horses. This analysis showed some interesting differences between the site types. In terms of differences between social classes, perhaps one of the best illustrations from the available data is the difference between the horses found in cemeteries and those from other contexts. There are two assumptions that have to be made here, firstly that the horses found in cemeteries were buried deliberately either with humans or on their own (and this is not always clear from the archaeological reports on these sites), and secondly that only those of wealthy status could afford to bury horses in this manner. It is therefore suggested that the upper echelons of society owned these horses.

As discussed in Section 6.4, the horses found in the cemetery sites were the tallest by some distance, as perhaps should be expected. However, they were of quite slender build, which is perhaps more of a surprise. If the horses belonging to the upper classes conformed more to the Roman 'ideal' horse, they should be of a more robust build. It must be remembered, however, that these observations are based on a relatively small number of individuals.

Other site types did show differences in the proportions of the log-ratio analyses of lengths, breadths and widths. For instance, the horses from the military and villa sites showed great similarity in their proportions, although the military horses were slightly larger. The urban horses were also similar but slightly more robust. In contrast, the horses from the urban 2 and rural sites were more slender.

It is necessary at this point to bear in mind the differences observed between the horses of the different areas of the Empire, as it may be that because the observed differences in the site types are based on small numbers, the results are biased by the areas from which they came. However, a few suggestions will be made regarding possible reasons for differences in the horses from different site types.

Any differences may be attributable to the various social classes that mainly occupied the various site types. For example the military needed a particular type of mount to meet its requirements so it might be expected that these horses would be different from others. However, it was observed that the horses from urban settlements and villas were of a somewhat similar type. As many urban centres started off as veteran colonies, perhaps it is not so surprising that there are few detectable differences in the types of equids found on these sites, the ex-soldiers using what they were used to as soldiers. As Wells (2001) suggests, military and urban centres were places where changes were taken up most quickly and thoroughly, partly because this is where the elite of society was based.

Villas were a distinctive new feature of the landscape in the Roman period and were associated with a new system of agricultural production and organisation. They were also associated with a new system of social organisation and many were a means of displaying wealth amongst the elite. However, the form of these villas and the wealth displayed in them varied considerably across the Empire, as most were owned and built by locals. Although it has generally been acknowledged that elites built these villas, it has been argued more recently (Wells 2001: 176) that many were built by those of more modest means. Some villa sites can be shown to have Iron Age precursors and so show the progressive addition of Roman features, such as colonnades and bathhouses. One at Oberndorf in Bavaria (Wells 2001) follows this pattern but also has unusual features in the weed flora and a high proportion of horse amongst the faunal remains, suggested to be indicative of interaction with a nearby fort.

At present the most confounding factor problem for interpretation of biometric data is the potentially problematic categorisation of sites as villas in the initial interpretation of a site. However, it appears that the sites categorised as villas in this research (based on the available archaeological interpretations) have produced horses that present a similar appearance to those from urban and military contexts. This in turn leads to the suggestion that the elite of society may well have been involved in these sites, as the horses appear to have been of a similar size and build to those from other types of site that could be considered high status.

According to Wells (2001), change in rural settings was both later and less pervasive than in urban and military contexts. This is at least partly confirmed by the evidence of the size and shape of the equids from these sites. The urban 2 (small town) and rural site categories produced the smallest and most slender horses when the log-ratio results were analysed. These animals could possibly be considered to be the least like the Roman 'ideal' horse of all the site type groups. This could be interpreted in terms of the social standing of the occupants of these site types, who perhaps did not have the means to purchase or breed the larger, more robust horses favoured by the elite.

In terms of the species proportions from different site types, there is once again the problem of only small numbers of bones for comparison between the groups. There is also the problem that the numbers of bones in some categories were inflated by the presence of skeletons; this was a particular problem with the cemetery sample. Taking this into account, the rural sample produced the highest proportion of horses of all the groups at 84.2%. The next was the cemetery sample at 66.7%, closely followed by the urban sample at 64.1%.

In terms of the social differences, there are probably different reasons behind these figures, although they appear similar. The high percentage of horses from the rural sites may be a reflection of comparative wealth, or in this case the lack of it, i.e. mules may have been expensive animals, for the reasons outlined in Chapter One, and therefore rural communities may not have been able to afford them but could afford locally bred horses.

The high proportion of horses in the cemetery group is also likely to be a reflection of wealth, with only rich individuals being able to afford to sacrifice a horse to place in a cemetery. The status attached to horses was greater than that of mules, so it is unlikely anyone rich enough to sacrifice an equine would want to be associated with a mule in this way. The mules that are present in cemetery sites may not be directly associated with human graves, but rather placed in the boundary ditches as a convenient means of disposing of a dead equine (Rielly 2000).

The proportion of horses and mules on the urban sites was close to that observed for the species proportions for the Roman period as a whole, and is perhaps what should be called 'normal'. The urban 2, villa and military sites all show less than 'normal' percentage of horses. The urban 2 and villa sites have very similar percentages, at around 55% horses and 40% mules, whilst the military sites have fewer horses than mules, at 42 and 50%, respectively. In terms of the social differences between these sites there are once again different explanations for the same proportions on different site types, but for these three site types the suggestions are all based around the transport of goods.

For the urban 2 sites, the most likely explanation is that many of these sites grew up as trading or market towns and as such mules would have been required to transport goods to and from the markets. For the villa sites, a similar explanation is feasible. Many of these villa estates were producer sites, requiring a means of transporting goods to the markets. In addition, as has been suggested a few times before, some of the villas were the main breeding centres for mules and, even if this was not the case for all, the wealth in these estates would have allowed the purchase of mules in quantity as required.

The military sites have the lowest percentage of horses and the highest of mules for all those discussed so far, and this can be explained by the need for transport of goods supplied to the army. As discussed in Chapter One many of the goods required by the army had to be transported over some distance, and mule trains carried out at least some of this transport. In addition, the army kept mules for transport of weapons and supplies when on campaign and, at least until the 2nd century, the cavalry was not considered as a major component of the army, so the number of horses needed as officers mounts was less than perhaps expected. It is perhaps not surprising to find the military sites have a high percentage of mules in comparison to the numbers of horses.

As discussed on several occasions, the species proportions from the industrial quarry site at Mons Claudianus in Egypt (Hamilton-Dyer 2001), is a special case because of the nature of the site. The proportions were almost the opposite of what was observed for rural sites, with many more mules and donkeys than on other site types. This is suggested to be the result of both the climatic conditions of the area and also the work that was required of the equines in and around the quarry.

Whilst the quantity of data for each of the site types was not as great as was hoped, there was enough for some differences to be noted that are probably related to social differences between the site types. For instance, the sizes and shapes of the horses from the military, urban and villa sites were all very similar, probably as a result of these site types containing similar sections of society. The villas and urban centres often contained many ex-soldiers as well as the civilian elite. In urban centres many classes of society were present, but, as has been discussed on many occasions, it is the remains left by the elite of society that tend to be most visible in the archaeological record, and this seems to be the case for the Roman horses.

The equids from the rural sites showed some features that might be expected from those belonging to the lower classes of society. The species proportions were heavily biased in favour of horses, possibly because of the cost of mules. The horses were amongst the smallest and most slender of the Roman horses, and were more like the preceding Iron Age horses in many cases, suggesting that the lower classes could not afford to import stallions to improve their stock. An alternative explanation is that in many areas the rural populations resisted Romanisation, so resisting use of mules and changing the local horse stock.

Another fact to emerge from the analysis of the data by site type was the concentration of mules on those sites involved in trade. This was most noticeable on the urban 2 and military sites, but was also noted on the villa sites. The exception to this was the urban sites, where more mules were expected. However, this may be a reflection of the nature of urban contexts, where it is often the case that equine remains are not found in contexts within the heart of urban areas, but rather on the fringes in ditches and refuse dumps. It is possible that the urban species proportions are biased by the context types represented.

7.3.5 Chronological trends

The question of chronological differences to be addressed here is not whether there were differences pre- and post-conquest, as that has already been addressed, but whether there were differences within the Roman period. Because the Roman Empire period spans approximately five centuries, in most of the areas covered in this research it should be possible to split the data into smaller chronological divisions and test for differences between them. However, in practice this was not possible in a large number of cases because of the poor temporal resolution on many sites, leaving a very small sample size of tightly dated material. Much of this section contains suggestions of what might be seen if dating issues are resolved and the dataset can be expanded.

A few facts could be elucidated from the small amount of tightly dated material. As discussed in the section on Romanisation, a size increase was seen to occur across the Empire after the Roman conquest, but this size change happened later in Britain than in the other areas studied. This was suggested to be a result of the Iron Age horses being relatively large and robust and the problem of the logistics of importing horses for the improvement of local stock.

The other area where there were enough data and good enough dating information to split the data into smaller time periods was the Rhineland. Here the data showed that whilst the size of the horses had increased in the immediate post-conquest period, there was no difference in withers height between the early and late Roman periods. This suggests that the initial improvement of stock was considered sufficient and that no further improvement took place through time.

Whilst the numbers of Roman mules were not sufficient to split into smaller time periods by area, overall there were just enough numbers. It was found that there was no difference in withers height between the early and late Roman periods. This is perhaps not surprising when there were very few discernible differences in the mules when split by any of the categories used in this study.

These were the only small pieces of information on any chronological differences within the Roman period that could be elucidated from the dataset as it stands at present. As indicated earlier (Chapter 5) this is mostly because of broad dating of the archaeological deposits from the Roman period. Part of the problem is that many of these sites were excavated a considerable time ago and the refinements made in dating techniques since those times have not been applied retrospectively, meaning that in many cases they are just described as Roman. Another problem is that even where the deposits have been dated more accurately, the small quantities of bones recovered have meant that the analysis was only merited by combining all the bones together, and the more accurate dating has not been reported in conjunction with the measurements.

If the dating issues can be resolved there are a number of areas where this dataset could yield information. It could be possible to detect the hypothesised delay between an area being conquered and the setting up of the official administration and building programme, etc. (see Chapter One). It is possible that this delay would be reflected in the improvement of stock and, more particularly, in the importation of larger animals. As well as detecting an overall size increase, there is also the possibility that a bimodal distribution could be detected early on, with a group of larger imported individuals and a more numerous group of smaller native ponies, before interbreeding produces individuals in between in size. However, this would require tight dating of deposits from the immediate post-conquest period in all areas.

There is also the possibility of detecting changes within an area as the frontier advanced and retreated through time. This would perhaps be most noticeable in northern England/ southern Scotland, in the areas east of the Rhine in Germany, and in Dacia, where the advance and retreat of the Empire took place on several occasions. Once again this would require very tight dating of the assemblages and it would perhaps be difficult to find enough material from such narrow time periods.

One area that has not been addressed much in this research is the issue of the decline of the Roman Empire. This is partly because there are very few well-dated transition period sites that have been excavated recently enough to benefit from the whole range of modern dating techniques available. The other reason was to place limits on the scope of this thesis, so that it was achievable in the time frame available. However, for future work it is worth mentioning some of the questions that could be addressed with a suitable Roman decline dataset.

The archaeological evidence suggests that the European frontier provinces became increasingly heterogeneous as they responded to the Roman presence, particularly in the 2nd and 3rd centuries AD (Wells 2001). Also, archaeologically we can see an end to major building programme and a reduction in the inhabited and fortified portions of towns in the 3rd century. In the Rhineland area few new villas were constructed and many existing ones were abandoned, yet in Britain most of the lavish villas were not constructed until the 4th century. In addition, the rural settlement patterns in many areas began to return to a more Iron Age character, with the reoccupation of hill forts in Britain and the return of Iron Age ritual practices in northern France (Wells 2001).

The raids into the Empire by outside groups disrupted the administration of many regions, as the focus of the officials was directed towards Rome. The withdrawal of troops from some areas and the movement of those troops into different areas to deal with particular threats was perhaps more reminiscent of the earlier periods of expansion, with less standing armies and therefore changes in the supply routes and requirements. In addition, troubled times always disrupt trade, particularly long distance trade, and reliance on local goods and produce becomes more prominent.

It is possible that many of these changes could be seen in the equine populations if the chronological evidence is good enough. For instance, the disruptions of trade routes could well result in a drop in the quantity of mules and donkeys found on urban and military sites. The disruption of administration systems, pre-occupation of many of the elite and the loss of high status villas in some areas might be reflected in loss of the breeding programme that were producing the larger improved horses seen through most of the Empire.

In the assemblages from a few sites in Britain where there is continuous occupation through the end of the Roman period, there are a few hints that the size of domestic animals decreases (Johnstone and Albarella 2002) after the official end of Roman rule, the withdrawal of troops and the breakdown of the administration and trade routes. Certainly the mean size of the horses in the early medieval period is smaller than in the Roman period in Britain (Johnstone 1996). This is also the case in the Hungarian area (Bökönyi 1974) although the difference is less noticeable, perhaps because of the history of horse breeding in this area. The timing of the size decrease in relation to the withdrawal of the Roman Empire is one of the questions that could be asked of the dataset of there was better dating resolution, as is whether the changing settlement patterns also change the character of the differences of the horses owned by different social groups. All these questions are possible lines of inquiry to be considered in future work.

7.4 Detecting the effects of external contact

The aim of this section is to discuss the effect that contacts with areas external to the Empire had on the equine population of those areas. Chapter One discussed that fact that contact is a two-way process and that effects could be detected on both sides of the boundaries. The first part of this section is concerned with the differences noted close to the boundary with the actions of campaigning and standing armies in these areas, and the second part will discuss the changes noted as a result of long distance trade.

Most of the sites in this research from outside the Empire were from the frontier zone, but in spite of this the largest number of the bones were from a single site (Feddersen Wierde, Reichstein 1991) much further away. At the analysis stage the distinction between the two areas was not made, so most of this discussion will focus on the differences between the equines within and without the Empire.

In many cases it is difficult to draw a clear distinction between the Iron Age settlements of areas that were never part of the Roman Empire prior to the existence of the Empire, and those that were technically still Iron Age settlements but contemporaneous with the Roman world. This is because the character of those settlements may have changed little, and the only traditional dating evidence was the existence of imported Roman goods. The use of scientific dating methods on these sites is now showing that there may have been little change in many of them, and the lack of Roman imports is not a clear indication of a pre-Roman Iron Age date. It is therefore possible that the current dataset is biased in favour of those sites for which contact with the Roman world had already been established through the presence of imported goods. Having said this, there are still differences between the equines from these sites and those from sites within the Empire that are worth discussing.

The species proportions of the External equids was similar to the that of the Iron Age ones but with an even greater emphasis on the horses, with a ratio of 21 horses : 2.5 mules : 1 donkey. This equates to percentages of 85.8%, 10.2% and 4.0%, respectively. The high proportion of horses was expected, as it was for the pre-Roman Iron Age material. Because of the contacts between the Roman and external sites, it was thought that perhaps there would be a greater presence of mules and donkeys on the external sites than for the Iron Age ones. However, this did not prove to be the case. The fact that they were present, if in small numbers, probably reflects some degree of contact with the Roman world.

The size and shape of the External horses showed more similarities with the Iron Age than the Roman horses, but there were differences. The mean withers height of the External horses was 1290 mm (12.3 hh), which was between that of the Iron Age (1252 mm) and the Roman horses (1351 mm). However, the shape indices on the metapodials showed that the External ones were the most slender, more so than the Iron Age horses. This was most noticeable on the shaft index and, as discussed in Section 6.3, this seems most likely to have been caused by nutritional stress during growth rather than genetic differences in conformation between horses from different areas and time periods.

The log-ratio analysis revealed the External horses clustered around the zero mark, and this suggests that they were of similar size and build to the Mongolian ponies used as the standard. This is slightly surprising given the relatively robust build of these ponies and the results of the shape indices given above. With this analysis the External horses were similar to the Iron Age ones, but more tightly clustered.

It seems that whilst the External horses were smaller and more slender than the Roman horses they were on average taller but more slender than the Iron Age horses. This may be reflection of the area from which these horses originated, i.e. the Rhineland, where (as discussed above) the Iron Age horses had the smallest mean withers height. However, the Iron Age horses from the Rhineland were relatively robust. This could suggest that between the two periods there was a change in husbandry regime that caused retardation of the circumferential growth of the metapodials. As discussed in Section 6.3 this could be the result of late weaning and subsequent second winters without adequate nutrition. However, these differences would need further investigation to be attributed to a single cause.

The mules from External sites were also smaller than their Roman contempories, with a mean withers height of 1361 mm. In addition, their metatarsals had slender shaft indices. This corroborates the results given above for the External horses, where a similar pattern emerged, suggesting that these mules may have been locally raised and were subject to the same husbandry regime causing nutritional stress. Alternatively, these individuals may have been 'second rate' mules that were being used by traders on private rather than state business. Again further investigation would be required to try and understand which of these explanations is more likely.

The small number of External donkeys had a slightly larger average withers height of 1249 mm than the Iron Age donkeys. However, as with the horses and mules, the metacarpals had slender shaft and proximal shape indices, again possibly indicating the local raising of these animals.

The differences between the External equids and those from both the preceding Iron Age and within the Roman Empire have a variety of explanations. Firstly there is the issue of regionality, as has been discussed in detail in Sections 7.2 and 7.3.1. The area covered by the assemblages studied is quite large and could therefore contain variation within itself, and does not overlap with much of the area covered by the Iron Age sites. This may partly be a problem with the dating of some of these sites, as eluded to earlier, and partly that the non-overlap was not discovered until after the data gathering stage of the research had been completed. For these reasons it cannot be determined whether the appearance of the underlying Iron Age horses in this area were similar to the Rhineland sites that have been analysed or similar to those from the subsequent External sites. Therefore it is hard to determine how much influence contact with the Roman Empire had on the appearance of equids in the area, but the presence of mules and donkeys can almost certainly be attributed to, and be used as evidence for, some form of contact.

7.4.1 Frontiers

The frontier areas have been discussed briefly from a standpoint within the Empire, and the issues relating to the supply of the standing armies in these areas and the differences that the heavy military presence in these areas made on the appearance and proportions of the various equids. It is now time to discuss the areas immediately outside the Empire and how the equids of these areas were affected by the presence of the Roman Empire. All the frontier zones of the Empire had different characteristics, as did the provinces, therefore it is not really possible to group them all together for the purposes of discussing contact beyond the various frontiers. For the purposes of this section, only the *Limes* frontier zone will be discussed, partly because most data were available for sites beyond this particular border and partly because it is the most extensively studied.

Because the External data were not split into different areas, as a result of the dominance of two assemblages and the paucity of data from other sites, there is little in the way of results that can be directly discussed. However, one of the large assemblages is from a site just beyond the *Limes*, in the frontier zone, so some discussion of these data can be undertaken. Possible questions for future research can be posed.

In Chapter One the issue of the supply of military garrisons on the Rhine-Danube frontier from 'friendly kings' and others in the frontier zones beyond the *Limes* was discussed(e.g. Wells 2001; Braund 1989; Hanson 1989). It was established that supplies were brought in from outside the boundaries of the Empire and that the frontier zone formed a kind of buffer zone and early warning system for the Empire. In addition, the societies in this zone received benefits from close association with the Empire, through the trade in prestige goods and the economic security afforded by the presence of the frontier.

Although there are fewer contemporaneous accounts of the interactions between the Empire and the communities in the frontier zone than there are of the associations with 'friendly kings' in the late Republic/early Empire period, it is possible that 'gifting' was employed in the later period as in the earlier. However, if the Germanic tribes of the frontier zones were of a similar mentality in relation to the improvement of their horses as they were in Caesar's (*B.G.*)accounts, then it seems likely that the frontier communities probably did not trade for horses. This is probably why the External horses were smaller and less robust than those from within the Empire.

However, the needs of the military meant that trade with these communities needed to take place, and the presence of mules and donkeys on these sites is not surprising as they would have been needed to transport goods in both directions. This is perhaps particularly noticeable because the distances involved are not great and the relevant rivers do not generally run in the right directions for efficient transport of goods.

The site previously mentioned as having produced a large bone assemblage is that of the Oppidum at Manching (Boessneck *et al.*1971). In the material dating to the period of time when Manching was beyond the borders of the Empire, but quite close to conquered territory, many donkey and mule bones were identified. Close contact with the Roman world is seen in many other lines of evidence from the site, for example imported goods, represented by fine ceramics, metalwork and coins, and archaeobotanical remains (Wells 1996: Küster, *pers. comm.*). These have been interpreted as indicating that the inhabitants of Manching emulated Roman ways and must have traded quite extensively with the Empire. Therefore, the presence of donkeys and mules can be interpreted as more evidence of this trade, and as evidence of the method of transport employed by the traders.

Although this hypothesis works for the site at Manching, this is a unique site in many ways and perhaps not typical of most frontier sites. However, the premise that the presence of donkeys and mules in the bone assemblages from these sites can be used as an indicator of trade with the Roman Empire can still be applied and perhaps a better idea of the extent of such trade could be established through further work in this area.

Another complication in the study of the frontier zones beyond the borders of the Empire, particularly in the Rhine area, is the fact that abortive attempts were made to incorporate further territory into the Roman Empire. These abortive military campaigns mean that there was the possibility of more direct contact between the inhabitants of these further territories and the Roman world than would exist through trade alone. It is therefore possible that equids involved in these military campaigns could have become incorporated into the lives of these communities through the military sphere rather than civilian trade. This is distinctly hypothetical, and would probably be difficult to prove without very close control of the chronology of sites in such areas.

7.4.2 Trade and supply

Evidence of long distance trade, particularly of raw materials, foodstuffs and so called 'prestige' goods, has been located on sites all over northern Europe as far away from the Mediterranean as Denmark, Sweden and Poland, from as early as the last few centuries BC (Wells 2001). In order to facilitate this trade transport was required, as has been stated earlier, and where sea or river transport was not possible land transport, probably utilising equid power, would have been used.

The trade of raw materials not available within the Empire was particularly vital to the Roman economy, and in some cases was so important that conquest of the source areas was undertaken. Metal ores, including precious metals such as gold but also more utilitarian metals such as iron, copper and tin, were transported over large distances and were traded from areas outside the Empire. Examples include the sites of Gera-Tinz in Thuringia, and the Holy Cross Mountains in Southern Poland where large-scale iron production can be linked to export to Roman sites (Wells 2001). This trade must have required many equids to transport such large quantities of heavy, bulky goods over long distances, where the rivers were not particularly close and did not run in the right direction.

The trade of other commodities such as amber may have been more in the nature of incidental trade whilst carrying out political affiliations. This could certainly be the case with trade in

Scandinavia. The Romans needed to be able to travel the seas around northern Denmark unhindered by pirates and to have safe harbours to use in bad weather, so it is possible that the trade of prestige Roman goods, such as fine drinking vessels and wine, with local elites in return for amber and other products may have been a kind of 'friendly king' arrangement with more emphasis on the political motives than the traded goods. For these reasons it is unlikely that equids were part of this trade, but as no sites of this nature were included in this research it cannot be ruled out as a possibility.

Another aspect of trade with communities external to the Empire was the supply of the army with agricultural produce. New agricultural settlements sprang up in response to the presence of Romans in the vicinity and, existing settlement expanded. Wells (1996) suggests that Feddersen Wierde is one of these settlements. The identification of mules and donkeys in the Feddersen Wierde assemblage initially appeared somewhat surprising, because the site was situated a long way from the boundary of the Empire and has in the past been considered as primarily an agrarian settlement that did not seem to have taken on Roman characteristics.

However, there now appears to have been a greater degree of trade between the inhabitants of the settlement and the Roman Empire than was previously thought. Whilst Roman goods such as *terra sigillata* pottery, glass beads and vessels, some coins and millstones have been found at Feddersen Wierde (Haarnagel 1975, quoted in Wells 1996), they do not occur in such quantity as they do at Manching (Boessneck *et al.*1971). It has therefore been suggested that these items may not have been the result of direct trade but a dispersion of goods between native communities, particularly as there was little evidence of what the inhabitants of Feddersen Wierde were producing for trade. However, analysis of the use of buildings themselves and the growth of the settlement has suggested that the community was involved in raising cattle on an increasingly large scale and that these cattle were traded to the Roman army garrisons along the *Limes* (Reichstein 1991; Wells 1996). This increasingly large scale of cattle production was possibly to supply leather as well as meat to the army on *Limes* (Wells 2001:146).

It seems most likely that the presence of donkeys at Feddersen Wierde (Reichstein 1991) was connected in some way to trade with the Roman Empire. Whether the mules were locally bred or were also traded could not be determined definitively from the current investigations. However, the shaft slenderness index and log-ratio analyses indicated that the mules and donkeys were smaller and more slender limbed than those from within the

Empire, as were the horses. This seems to suggest that the mules and donkeys could be the result of local breeding, as they appear to have been subjected to similar husbandry regimes resulting in limb slenderness cuased by malnutrition during particular stages of growth.

An alternative hypothesis is that these were 'second rate' mules and donkeys going to these areas for several, possibly connected, reasons. Firstly, there is the question of transport for the goods being traded for cattle at Feddersen Wierde (Reichstein 1991). There is relevant information on this subject in the novel The Golden Ass, where Apuleius (*m.m*) records the adventures of a man transformed into an ass by witchcraft before being returned to human form. Almost as soon as he has been turned into an ass he is stolen by a band of thieves who use him to transport their booty. When they have finished with him they sell him on to others to use. Later in the story he is just abandoned after he has fulfilled his purpose.

Even though, by and large, dishonest men carried out these transactions, the custom of selling on pack animals when they were no longer required seems to have been normal practice, and was probably undertaken by honest traders as well. The practical reason for selling the pack animals when they have delivered their loads is so the trader does not have to feed them on an 'empty' return journey where no profit would be gained. This could be linked to the fact that the return journey for the traders to Federsen Wierde was cattle. It would be more efficient to transport the cattle 'on the hoof' to the army bases than to transport carcasses, particularly given the distances involved.

A second hypothesis is the use of these pack animals as a foodstuff by the inhabitants of Feddersen Wierde (Reichstein 1991). There is evidence from many Germanic sites that horsemeat formed a regular part of the diet, and this can be seen in the assemblages from many settlement sites (Peters 1998: 148, 164). At Feddersen Wierde the meat weight figures suggest that horsemeat provided 22% of the diet of the inhabitants (Reichstein 1991; 243, table 94). Therefore, perhaps the unwanted (and perhaps second-rate) pack animals were sold or traded to the inhabitants of Feddersen Wierde for meat. There seems to be no evidence regarding whether donkey and mule flesh would have been eaten or not, but there is no reason to suspect it was treated differently to that of horse, particularly given the fact that the bones of all three equids were found in the same kinds of contexts on the site.

A combination of the evidence given above can be applied to the data from Feddersen Wierde (Reichstein 1991) to explain the somewhat unexpected presence of donkeys and mules in the faunal assemblage. If the trade between the Romans and the inhabitants of Feddersen Wierde was chiefly that of supplying the *Limes* garrisons with beef, perhaps the small quantity of Roman goods found at the settlement was the payment for the cattle. In addition, it is possible that perishable goods that have left no archaeological trace were traded. All these goods could have been brought in using donkeys and mules, which would then not have been necessary to transport cattle 'on the hoof' back to Roman territory. These beasts of burden would then have been surplus to requirements and could have been used as part of the payment or sold for additional profit. The inhabitants of Feddersen Wierde could then have consumed them as part of their normal dietary practice.

It has been possible to make such extensive hypotheses about Feddersen Wierde because such a large animal bone assemblage was recovered from the site, and extensive analysis was undertaken along the lines of the evidence cited here. Although these hypotheses have been applied to explain the presence (and somewhat slender build) of donkeys and mules at this one particular site, the same explanations can be applied to other sites beyond the *Limes*. The combination of evidence may have to be adjusted to the individual circumstances of a site, but the underlying relationships of trade and supply between the Roman Empire and the inhabitants of settlements, often at great distance from the *Limes* border, can still be utilised.

7.5 Areas for future research

This research has shown the potential for research into equids in the Roman world, but has also highlighted a number of areas where further research would be of benefit. The introduction of a new methodology for the discrimination of horse donkey and mules bones has been piloted here, but there are a number of areas where the accuracy of this methodology could be improved. Firstly, there is the problem that the sample of mules is too small, leading to a less than 100% accurate separation of mules and horses. There is also a lack of diversity in the donkey sample, leading to difficulties in ascertaining if the outlying donkey identifications are really donkeys or not. This research has highlighted the fact that there appear to be very few mule skeletons in reference collections in Europe and North America. This means that to overcome the difficulties outlined above and improve the methodology it would be necessary to obtain and prepare new mule skeletons. As the likely sources of mules are Africa, Asia and South America, obtaining skeletons has logistical and ethical considerations that would need to be addressed.

The methodology could also be expanded to include hinnies and even other equid species such as onagers and zebras. This would allow the technique to be applied to a wider range of assemblages containing equid bones, such as prehistoric sites in the Near East where there are frequently problems of differentiation between onagers, horse and donkeys. Expanding the technique to include these species would be less problematic as there are sufficient numbers of specimens already in reference collections across Europe.

As highlighted in Chapter Four there are a number of other methods and techniques of differentiation that it would be profitable to explore. The use of computed tomography may be worth exploring as being a non-destructive technique. Chemical analyses such as studies of ancient DNA and proteins would probably be are worthwhile. Some of the groundwork for DNA identification has already been undertaken, so it should be possible to continue this work, within the restrictions that any study of ancient DNA is subject to such as taphonomic problems. Recent studies of particular bone proteins have been useful in sheep/goat differentiation (M. Collins *pers. comm.*) so it is possible that this could be extended to other species. Because these techniques require destructive sampling and are relatively expensive to undertake, it is considered that an improved biometric technique would be of most use to zooarchaeologists on a day-to-day basis.

Other areas highlighted in this research that would benefit from further research include issues relating to the movement of stock. It is thought that isotope analysis could be used to detect animals that have died at a distance from where they were raised. This would aid the detection of animals imported for the improvement of stock or the breeding of hybrids. In addition, evidence of animals being moved around whilst being used for trade or for army requirements could be discovered.

The remaining areas for future study discussed here would all benefit from a larger and more tightly dated biometric dataset. It is possible that larger datasets could be accumulated for many of the areas highlighted without great difficulty, as limitations of the current research were time available for data collection and known sources of data. However, the question of more tightly dated material may have to wait until more recently excavated material is available for study, either at first hand or when published. In addition, it may be worth directly accessing some of the assemblages studied here so that further measurements can be taken on the equid bones, to allow further species identifications to be made and a greater volume of data made available for the other analyses.

Areas where more data would be helpful include the issue of regionality. In particular more data are needed from Italian sites to elucidate whether the descriptions of equids in the literary sources are nearer to Italian animals than to the areas studied so far. More data are also needed from Gaul, Greece, the Danube and Balkans area and Britain to establish more secure foundations for some of the observations that could not be tested statistically. An increase in the volume of data from these areas could help eliminate the biases of climatic variation and site type, amongst others. It would also be worthwhile expanding the dataset to include the Iberian peninsula, Near East and more of North Africa, as these were stated in the literary sources as being key areas of horse breeding in the Roman period. Other areas where more data would be beneficial are the frontier zones. Here it would be useful to study the effects of contact with the Roman world on frontier zones other than the part of the *Limes* on the Rhine, such as northern Britain, North Africa, the Danube *Limes* and the Near East.

A more closely controlled chronology is needed to detect changes through time within the Roman period. In some cases this may mean accessing original archives, utilising sites that have been excavated more recently and the possibility of direct dating (i.e. C^{14}) of particular bones of interest. In order to study changes in the equid population brought about by the end of the Roman period, dating techniques being developed using more refined studies of late Roman pottery may allow a better informed study of this period. Currently it is problematic to study this period because of the lack of available accurate dating, so further work may have to be postponed until the dating issues have been re-solved.

Data from a wider variety of site types, and in particular rural sites, would help elucidate some of the issues surrounding equids in relation to social differentiation. More data in this area would also aid an understanding of the use of mules to transport agricultural produce to river and sea ports. Examination of data from a larger number and greater variety of rural sites may also allow the detection of mule breeding, and thereby confirm or refute the suggestions made here about centralised and controlled mule breeding.

The issues of external contact and trade need to be explored further in terms of areas other than the Rhine - Danube border (as with the frontier zones discussed above). In addition, a more extensive survey of sites beyond the borders, both those that are known to have had contacts with the Roman world and those not previously considered to have had contact. It would be useful to include assemblages from external sites from both the Iron Age and Roman periods, and in particular those sites that are difficult to date because of their lack of visible trade goods that date them as belonging to the Roman period rather than the Iron Age. This also applies to sites within the Empire in less Romanised areas, such as north-western Gaul. Data from these sites could then be analysed for the presence of mules and donkeys as possible indicators of Roman dating and Roman contact.

Although this appears to be a long list of further research, it basically consists of two elements: work required to refine the methodology outlined here and associated identification procedures, and the collection of further, targeted, archaeological data collection to answer specific queries highlighted by this research.

7.6 Conclusions

The first aim of the project was to establish whether the existing methodologies used by zooarchaeologists effectively separate horses, donkeys and their hybrids. In Chapter Four it was established that this was not the case. Therefore a new methodology was developed using discriminant function analysis on biometric data, which could distinguish horses, donkeys and mules with about 80% accuracy in most instances. In addition a system for grading the likely success of an individual identification was established to eliminate the less certain identifications from the subsequent analyses.

Using the new methodology, archaeological material previously identified as 'horse' or 'equid' was re-evaluated to determine whether there was a real discrepancy in terms of species proportions between the contemporaneous literature and the zooarchaeological record. It was discovered that the hitherto perceived difference was due to identification problems.

The effective separation of horses, donkeys and mules was achieved, so it was possible to address the questions of size and shape for each species separately, allowing a more accurate picture of the appearance of these animals to be constructed. In addition, relative species proportions could be determined. The ratios of the three equids in different areas of the Empire varied considerably, probably as a result of a combination of climatic conditions, representation of site type and genuine differences in species proportions. The size and shape analyses carried out on the data for the separated species then allowed further research questions to be addressed.

It was established that the Roman conquest of a particular area had an effect on the physical appearance of horses in that area. In some areas these changes were the result of a process that started pre-conquest and continued afterwards, but the most profound changes were detectable changes between the immediate pre- and post-conquest periods. The amount of change and exactly how these changes were manifested seems to have varied greatly across the Empire. Although improvements in size were made almost universally, the appearance of the local pre-Roman stock was still evident in the form of the Roman period horses from these areas.

The differences in the Iron Age horse stock between the various areas studied here were still visible in the physical appearance of horses from diverse areas of the Roman Empire. This is in accordance with the great diversity of horses evident from contemporaneous written and art historical sources. Although exact descriptions could not be verified, general characteristics were shown to be relatively accurate. Unfortunately, because of a shortage of closely dated material, it was not possible to see if these characteristics were consistent through time, within the Roman period, or whether the horses from the various areas became more similar through time. In contrast to the horses, the mules displayed a remarkable degree of uniformity between the various regions, perhaps suggesting differences in breeding programmes from a localised one for the horses to a more centralised system for the mules.

It was initially hoped that it would be possible to establish whether there were differences between the equids from the frontier zones and those deeper within the Empire. However, as with the chronological trends, it was not possible to split the data this finely and still retain enough material for statistical analysis, so this question could not be answered satisfactorily. It was expected that the frontier zones would have show a concentration of military animal, but, as will be discussed below, it was difficult to characterise the military equines as a type distinct from civilian ones. It was noticeable that there was a higher proportion of mules along the Rhine - Danube frontier than in other areas, but this may be the result of bias in the numbers of specimens available for study.

Another research question related to the frontier zones was the question of trade and supply to various areas of the Empire, particularly military supply. Trade routes have been detected from finds for which it is easy to define the point of origin, such as amphorae and other ceramics. It was wondered whether the equid remains could also be used to detect trade routes and mechanisms. It has been discovered that there are certainly concentrations of mules at military and associated sites as the last stages of the transport chain. It was not possible to detect concentrations of mules at the producer end of the transport chain, mainly because assemblages from rural sites in the relevant areas were not plentiful.

The dilemma of whether the Romans moved large quantities of horses with the army or recruited local stock was equally difficult to determine due to small numbers of specimens available for study when the data were split into detailed categories. However, some of the analyses indicated that the horses used by the military were generally of a particular physical type, which was marginally different from that seen at other types of site. The same analyses showed that there were not necessarily differences between the types of horses used by civilians and those of the army, but there were more noticeable differences in the appearance of the horses and the species proportions between various site types on the basis of status and wealth. The higher status and apparently more wealthy sites had horses of a type closer to the Roman 'ideal', whereas those of lower status had horses closer to the preceding Iron Age types. This was not conclusive, however, as the differences were slight.

The final research aim related to the differences between horses within the Empire and those beyond, both those areas known to have had close contacts with the Empire and those at greater distance. It has been established that the presence of non-native equid species (mules and donkeys) within assemblages beyond the borders of the Empire in northern Europe may well be indicators of Roman trade. This seems to be the most discernible evidence of Roman influence on the equid population outside the Empire, as the size and shape of the horses in particular do not seem to have been influenced by the stock improvements that were discernible within the Empire. In terms of the spread of mules and donkeys, it appears that the influence of the Roman Empire extended many hundreds of miles from the frontiers, but to have been mostly effected through trade.

It is hoped that this study has shown the great potential for extracting information from a synthetic biometric survey of a single family of animals, once the problem of identification to species has been overcome.

References

Classical sources

Apuleius *Metamorphoses (m.m.)* - Adlington, W. (trans). 1996. Wordsworth classics of world literature. *Apuleius: The Golden Ass.* Ware, Herts: Wordsworth Editions Limited.

Caesar *De bello gallico (b.g.)* – Handford, S.A. (trans). 1982. Penguin Classics. *Caesar: The Conquest of Gaul.* London: Penguin Books.

Cato *De agri cultura (a.c.)* - Hooper, W. D. and Ash, H. B. (trans). 1935. Cato and Varro on agriculture. *Loeb Classical Library* **283**. Cambridge, Mass.: Harvard University Press.

Columella *Rei rusticae (r.r.)* – Forster, E. S. and Heffner, E. H. (trans). 1968. Columella on agriculture II: Books V-IX. *Loeb Classical Library* **407**. Cambridge, Mass.: Harvard University Press.

Tacitus *Agricola (agri)* - Mattingly, H. and Handford, S. A. (trans). 1970. Penguin Classics. *Tacitus: The Agricola and the Germania.* London: Penguin Books.

Tacitus *Germania (germ)* - Mattingly, H. and Handford, S. A. (trans). 1970. Penguin Classics. *Tacitus: The Agricola and the Germania.* London: Penguin Books.

Varro *Rerum rusticarum (r.r.)* - Hooper, W. D. and Ash, H. B. (trans). 1935. Cato and Varro on agriculture. *Loeb Classical Library* **283**. Cambridge, Mass.: Harvard University Press.

Xenophon. *Peri hippikés (p.h.)* - The art of horsemanship, pp. 295-363 in Marchant, E.C. and Bowersock, G.W. (trans). 1968. Xenophon VII. *Scripta Minora. Loeb Classical Library* **183**. Cambridge, Mass: Harvard University Press.

General references

Albarella, U. 1993. *The Fauna,* pp. 203-221, in Albarella, U., Ceglia, V. and Roberts, P.C. S. Giacoma degli schiavoni (Molise): an early fifth century AD deposit of pottery and animal bones from central Adriatic Italy. *Papers of the British School at Rome* **LXI**.

Albarella, U. 1995. Vaste, Fondo S. Antonio - I reperti faunistici dalle cisterne e dalla buca di scarico. pp. 289-304. *Studi di Antichita* **8.2**. Universita di Lecce, Dipartimento di beni culturali settore storico-archeologico.

Albarella, U. 1997. Iron Age and Roman animal bones excavated in 1996 from Norman Cross, Tort HIll East, Tort Hill West and Vinegar Hill, Cambridgeshire. *Ancient Monuments Laboratory Report* **108/97**. London: HBMC.

Albarella, U. 2002. 'Size matters': how and why biometry is still important in zooarchaeology, pp 51-62, in Dobney, K. and O'Connor, T. *Bones and the Man: Studies in Honour of Don Brothwell.* Oxford: Oxbow Books.

Ambros, C. and Müller, H-H. 1975. Zur Methode der Widerristhöhenberechnung aus den Längenmassen der Extremitätknochen beim Pferd, pp 45-50, in Clason, A. T. *Archaeozoological Studies.* Amsterdam: North Holland Publ. Comp.

Arbogast, R-M., Clavel, B., Lepetz, S., Méniel, P. and Yvinec, J-H. 2002. *Archéologie du Cheval: Des origins à la période moderne en France.* Paris: Editions Errance

Archer, R. 1992. *The Arabian horse.* London: J. A. Allen

Armitage, P. and Chapman, H. 1979. Roman mules. *The London Archaeologist* **3**, pp. 339-46, 359.

Artemiou, A. 1999. *Untersuchungen zur osteologie von Langknochen der Hinternextremität domestizierter Equiden unter besonderer berücksichtigung der Querschnittsmerkmale.* Unpublished dissertation: Institüt für Anatomie, Veterinärmedizinischen Universität Wien.

Ashdown, R. and Evans, C. 1977. *Animal remains,* pp. 58-62 in Partridge, C. Excavations and fieldwork at Braughing 1968-73. *Hertfordshire Archaeology* **5**.

Ashdown, R. and Evans, C. 1981. *Animal bones,* pp. 205-237 in Partridge, C. Skeleton Green: a late Iron Age and Romano-British site. *Britannia Monograph Series* **2**. London: Society for the Promotion of Roman Studies.

Assad, C. 1986. *Taphonomy of the faunal remains of a Roman rural farmsite: San Giovanni di Ruoti, Italy.* Unpublished MA Thesis: Texas A&M University.

Ayroles, P. 1990. La Faune de la nécropole Gallo-Romaine de la rue des Cordiers à Mâcon (Saône-et-Loire), pp. 115-121, in Barthelemy, A and Depierre, G. *La nécropole Gallo-Romaine des Cordiers à Mâcon.* Mâcon: Ministère de la culture.

Azzaroli, A. 1979. Su alcuni resti di cavalli protostorici dell'Italia centrale. *Studi Etruschi* **47**, pp. 231-236.

Azzarolli, A. 1980. Venetic horses from Iron Age burials at Padova. *Rivista di scienze preistoriche, Vol* **XXXV**, Fasc 1-2, pp. 281-308.

Baker, J. and Brothwell, D. R. 1980. *Animal diseases in Archaeology.* London: Academic Press.

Baker, P. 1998. The vertebrate remains from Scole-Dickleburgh, excavated in 1993 (Norfolk and Suffolk), A140 and A143 road improvement project. *Ancient Monuments Laboratory Report* **29/98**. London: HBMC

Barker, G. 1976a. Animal husbandry at Narce, pp. 295-307, in Potter, T.W. *A Faliscan Town in South Etruria: excavations at Narce 1966-71.* London: British School at Rome.

Barker, G. 1976b. *The animal bones,* pp. 46-48 + tables I-IV, in Potter, T.W.J. Excavations at Stonea, Cambs: Sites of the Neolithic, Bronze age and Roman periods. *Proceedings of the Cambridge Antiquarian Society* **LXVI.**

Barker, G. and Clark, G. 1995. The faunal data, pp. 143-76, in Barker, G. *The Biferno Valley Survey.* London: Leicester university Press.

Barrett, J. C. and Fitzpatrick, A. P. 1989. Introduction, pp. 9-13 in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity.* BAR International Series 471. Oxford: BAR.

Bartosiewicz, L. and Choyke, A. M. 1991. Animal remains from the 1970-1972 excavations of Iatrus (Krivina), Bulgaria. *Acta Archaeologica Academiae Scientiarum Hungaricae* **43**. Budapest: Akadémiai Kiadó.

Baxter, M. 2003. *Statistics in Archaeology.* London: Arnold.

Bedini, E. 1997. *I resti faunistici,* pp. 103-44, in Bonghi Jovino, M. and Chiaramonte, C. Tarquinia. Testimonianze archeologiche e ricostruzione storica. *Scavi sistematici nell'abitato (campagne 1982-1988).* Rome: L'ERMA di Bretschneider

Beech, M. 1995. The animal bones from the Hallstatt settlement of Jenstejn, Central Bohemia, Czech Republic, pp. 99-140, in Dreslerova, D. *A late Hallstatt settlement in Bohemia: Excavation at Jenstejn, 1984.* Prague: Institute of Archaeology CAS.

Beech, M. 1998. Animal bones from Mšecké Žehrovice, pp. 225-258, in Venclová, N. *Mšecke Žehrovice in Bohemia: Archaeologial background to a celtic hero 3rd-2nd C BC.* Prague: Kronos B.Y. Editions

Bendry, R. 1999. *A note on the identification of Donkey (Equus asinus L.) bones from Roman Southwark.* Unpublished report

Benecke, N. 1989. Die Tierknochenfunde aus einer germanischen Siedlung bei Penzlin, Kreis Waren. *Bodendenkmalpflege in Mecklenburg Jahrbuch 1988*, pp. 175-191.

Benecke, N. 1991. Untersuchungen an Tierknochenfunden aus zwei frühkaiserzeitlichen Siedlungen im Norden der DDR. *Bodendenkmalpflege in Mecklenburg Jahrbuch 1990*, pp. 53-68.

Berg, D. 1999. Animal bones, pp. 223-280, in Abramson, P., Berg, D. and Fossick, M.R. *Roman Castleford excavations 1974-85. Vol. 2. The Structural and Environmental Evidence.* West Yorkshire Archaeology Service.

Bjørnstad, G., Gunby, E. and Røed, K. H. 2000. Genetic structure of Norwegian horse breeds. *Journal of Animal Breeding and Genetics* **117**, pp. 307-317.

Boessneck, J. 1964. Die Tierknochen aus den grabungen 1954-1957 auf dem Lorenzberg bei Epfach. pp 213-261 + plates 71-83, in Werner J. *Studien zu Abodiacum - Epfach. München Beitrage Zur Vor- und Frühgeschichte* **7**.

Boessneck, J., von den Driesch, A., Meyer-Lempenau, U. and Weschler-von Ohlen, E. 1971. *Die Tierknochenfunde aus dem oppidum von Manching.* Wiesbaden: Franz Steiner Verlag GMBH.

Bohlken, H. 1961. Haustier und zoologische Systematik. *Zeitschrift für Tierzücht und Züchtungsbiloogie* **76**, pp. 107-113.

Bökönyi, S. 1968. Data on Iron Age horses of central and eastern Europe. *American School of Prehistoric research Peabody Museum Bulletin* **25**. Harvard.

Bökönyi, S. 1974. *History of Domestic mammals in Central and Eastern Europe.* Budapest: Akadémiai Kiadó.

Bökönyi, S. 1984. *Animal Husbandry and Hunting in Tác-Gorsium: the vertebrate fauna of a Roman town in Pannonia.* Budapest: Akadémiai Kiadó

Bökönyi, S. 1991. The ealiest occurence of Domestic Asses in Italy, pp. 217-225, in Meadow, R. H. and Uerpmann, H-P. *Equids in the Ancient World: Volume II.* Weisbaden: Dr Ludwig Reichert Verlag.

Bourdillon, J. 1990. The animal bones from La Sagesse (The Presbytery) 1988, Romsey, Hampshire. *Ancient Monuments Laboratory Report* **106/90**. London: HBMC.

Bouvier, M. 1989. The biology and composition of bone, pp. 2-13, in Cowin, S. C. *Bone Mechanics.* Boca Raton, Florida: CRC Press Inc.

Braund, D. 1989. Ideology, subsidies and trade: the ling of the northern frontier revisited, pp. 14-26, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity.* BAR International Series 471. Oxford: BAR.

Breuer, L. 1996. *Protein and energy requirements of growing horses.* Proceedings of short course on equine nutrition. Kentucky Equine Research.
http://www.ker.com/library/archive/proceedings/sc96/2/index.html

Brown, T. A. 2001. Ancient DNA, pp. 301-311, in Brothwell, D. R. and Pollard, A. M. *Handbook of Archaeological Sciences.* Chichester: J Wiley and Sons Ltd.

Canby, J. I. 1977. *The animal bones from Hayton: an illustration of the possibilities of bone studies.* Unpublished Dissertation for BA in Archaeology: University College, Cardiff.

Carrott, J., Dobney, K., Jaques, D., Johnstone, C., Large, F. and Worthy, D. 1997. Environmental evidence from excavations at various sites along the Lutton (Northamptonshire) to Huntingdon (Cambridgeshire) gas pipeline. *Reports from the Environmental Archaeology Unit, York* **97/42**.

Cassoli, P. F. and Tagliacozza, A. 1991. La Fauna degli scavi 1983-1986 a Santorsa, Vicenza (Eta del Ferro). *Preistoria Alpina* **25**. pp 165-216

Casson, L. 1994. *Travel in the Ancient World.* Baltimore: Johns Hopkins University Press.

Chaix, L. 1980. *La faune du vicus gallo-romain de Lousonna-Vidy (Vaud, Suisse) (fin du 1er siècle avant J.-C. - milieu du 3e siècle apres J.-C.),* pp. 168-193, in Kaenel, G., Klausener, M. and Fehlmann, S. Nouvelles recherche sur le vicus gallo-romain de Lousonna (Vidy/Lausanne). *Lousonna* **2** / *Cahiers d'archéologie romande* **18**. Lausanne.

Ciurca, S. Undated. *Mosaics of Villa 'Erculia' in Piazza Armerina.* Bologna: S. Lazzaro di Savena.

Clark, G. undated. *The faunal remains from two Roman Villas on the Via Gabina (Rome).* Unpublished report.

Clark, K. M. 2002. *Animal and bird bone,* pp. 59-67, in Graham, A. H., Hinton, D. A. and Peacock, D. P. S. Paper 1: The excavation of an iron age and Romano-British settlement in Hinton, D.A. (ed). *Purbeck papers. Southampton University Department of Archaeology Monograph* **4**. Oxford: Oxbow.

Clason, A.T. 1984. Dierlijke resten uit de Romeinse tijd pp.150-4 in Cordfunde, E. H. P. *Opgravingen in Egmond.* De Walburg Pers.

Clutton-Brock, J. 1992. *Horse Power.* London: British Museum (Natural History).

Clutton-Brock, J. 1999. *A Natural History of Domesticated Animals.* 2nd edition. Cambridge: Cambridge University Press.

Colson, I. B., Bailey, J. F., Vercauteren, M., Sykes, B. C. and Hedges, R. E. M. 1997. The preservation of ancient DNA and bone diagenesis. *Ancient Biomolecules* **1(2)**, pp. 109-117.

Cram, C. L. 1973. Animal bones, pp. 145-164, in Brodribb, A.C.C., Hands, A.R. and Walker, D.R. *Excavations at Shakenoak Farm, near Wilcote, Oxfordshire, Part IV: Site C.* Privately printed.

Cram, C. L. 1975. Animal Bones, pp. 117-160 + plate III-V, in Brodribb, A.C.C., Hands, A.R. and Walker, D.R. *Excavations at Shakenoak 1975.* Privately printed.

Croft, P. 1979. *The mammalian bones from feature 1,* pp.73-92, in Partridge, C. Excavations at Puckeridge and Braughing 1975-79. *Hertfordshire Archaeology* **7**.

Currey, J. D. 1998. Mechanical properties of vertebrate hard tissues. *Proceedings of the Institute of Mechanical Engineers* **212**, part H, pp. 399-411.

Czeika, S. 2001. Entsorgung von Tierkadavern im römerzeitlichen Unterlaa, Wien. pp 222-240 in *Fundort Wien: Berichte zur Archäologie* **4**. Forschungsgesellschaft Wiener Stadtarchaologie.

Davies, R.W. 1969. The training grounds of the Roman cavalry. *The Archaeological Journal* **CXXV**, pp.73-100.

Davis, S. J. 1980. Late Pleistocene and Holocene equid remains from Israel. *Zoological Journal of the Linnean Society* **70**, pp. 289-312.

Davis, S. 1982. A trivariate morphometric method to discriminate between first phalanges of *Equus hydruntinus, asinus/henionus* and *caballus*. Unpublished report.

Davis, S. J. M. 1999. Animal bones from the Iron Age site at Wardy Hill, Coveney, Cambridgeshire, 1991/92 excavations. *Ancient Monuments Laboratory Report* **47/99**. London: HBMC

Davis, S. J. M. 1995. Animal bones from the Iron Age site at Edix Hill, Barrington, Cambridgeshire, 1989-1991 excavations. *Ancient Monuments Laboratory Report* **54/95**. London: HBMC

Davis S. J. M. 1996. Measurements of a group of adult female Shetland sheep skeletons from a single flock: a baseline for zoo-archaeologists. *Journal of Archaeological Science* **23**, pp. 593-612.

Davis, S. J. M. 1997. Animal bones from the Roman site Redlands Farm, Stanwick, Northamptonshire. 1990 excavation. *Ancient Monuments Laboratory Report* **106/97**. London: HBMC

Davis S.J.M. 2000. The effect of castration and age on the development of the Shetland sheep skeleton and a metric comparison between the bones of males, females and castrates. *Journal of Archaeological Science* **27**, pp. 373-90.

De Grossi Mazzorin, J. 1996. Resti faunistici, pp. 203-14, in Volpe, R. *Aqua Marcia: Lo scavo di un tratto urbano*. Florence: Edizioni all'Insegna del Giglio

Dennler de la Tour, G. 1968. Zur Frage der Haustier-Nomenklatur. *Säugetierkundliche Mitteilungen* **16**. pp. 1-20.

Dittman, K. 2002. *Bone Microstructure*. Paper given at the workshop entitled 'Horse, Donkey and Co.' held in Basel, Switzerland, 23-24th January 2002.

Dive, J. and Eisenmann, V. 1991. Identification and discrimination of first phalanges from Pleistocene and modern *Equus*, wild and domestic, pp. 278-333, in Meadow, R. H. and Uerpmann, H-P. *Equids in the Ancient World: Volume II*. Weisbaden: Dr Ludwig Reichert Verlag.

Dobney, K. and Jaques D. 1990. Animal bones from excavations at Birdlip, Gloucestershire. *Ancient Monuments Laboratory Report* **36/90**. London: HBMC

Dobney, K .M. and Jaques, S.D. 1996. *The animal bones,* in Williams, R.J., Hart, P.J. and Williams, A.T.L. Wavendon Gate: A late Iron Age and Roman settlement in Milton Keynes. *Buckinghamshire Archaeological Society Monograph Series* **10**. Aylesbury: Buckinghamshire Archaeological Society.

Dobney, K., Jaques, D. and Irving, B. 1996. Of Butchers and Breeds. *Lincoln Archaeological Studies* **5**. Lincoln: CLAU

Dobney, K., Jaques, D. and Johnstone C. 1999. A protocol for recording animal remains from archaeological sites. *Reports from the Environmental Archaeology Unit, York* **99/15**. DRAFT VERSION.

von den Driesch, A. 1972. Osteoarchäologische Untersuchungen auf der Iberischen Halbinsel. *Studien über frühe Tierknochenfunde von der Iberischen Halbinsel* **3**. Munich: Unpublished LMU report.

von den Driesch, A. 1976. A guide to the measurement of animal bones from archaeological sites. *Peaboby Museum Bulletin* **1**, Cambridge Mass.: Harvard University.

von den Driesch, A. and Boessneck, J. 1974. Kritische Anmerkungen zur Widerristhöhenberechnung aus Längenmassen vor- und frühgeschichtlicher Tierknochen. *Säugetierkundliche Mitteilungen* **22**, pp. 325-48.

von den Driesch, A. and Cartajena, I. 2001. Geopfert oder verscharrt? Tierskelette aus dem Römischen Künzing, Lkr. Deggendorf. *Vorträge des 19. Niederbayerischen Archäologentages*, pp. 81-107. Rahden/ Westf.

von den Driesch, A. and Liesau, C. 1992. *Die Tierknochenfunde aus dem Römerkastell Sablonetum-Ellingen*. pp. 291-304, in Zanier, W. Das romische Kastell Ellingen. *Limesforschungen* **23**.

Duerst, J. U. 1922. *Die Beurteilung des Pferdes*. Stuttgart: Enke.

Duren, S. 1996. *Delivering Nutrients to Young, Growing Horses*. Proceedings of short course on equine nutrition. Kentucky Equine Research.
http://www.ker.com/library/archive/proceedings/sc96/3/index.html

Edwards, E. W. 1993. *Dorling Kindersley Handbooks: Horses*. London: Dorling Kindersley Limited.

Eisenmann, V. 1986. Comparative osteology of modern and fossil horses, half-asses and asses, pp. 67-116, in Meadow, R. H. and Uerpmann, H-P. *Equids in the Ancient World*. Weisbaden: Dr. Ludwig Reichert Verlag.

Eisenmann, V. and Beckouche, S. 1986. Identification and discrimination of metapodials from Pleistocene and modern *Equus*, wild and domestic, pp. 117-163, in Meadow, R. H. and Uerpmann, H-P.*Equids in the Ancient World*. Weisbaden: Dr. Ludwig Reichert Verlag.

Ellis, N. 2001. *Report on the IVth International Equine Gene Mapping Workshop 2001*. http://www.usyd.edu.au/su/rirdc/articles/genetics/genemap2.html

Farello, P. ?19??. L'Emilia dal VI al V Secolo A.C.: caccia e allevamento, pp. 209-233.

Fitzpatrick, A. P. 1989. The uses of Roman imperialism by the Celtic barbarians in the later Republic, pp. 27-54, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Forstenpointner, G., Kunst, G. K., Weissengruber, A. and Artemiou, A. 2002. *Investigations in the differentiation of equids (horse, donkey, hinny and mule) by means of computed tomography*. Paper given at the workshop entitled 'Horse, Donkey and Co.' held in Basel, Switzerland, 23-24th January 2002.

Frey, S. 1991. *Bad Wimpfen 1: Osteologishe untersuchungen an Schlact- und Siedlungsabfällen aus dem römischen Vicus von Bad Wimpfen*. Stuttgart: Konrad Theiss Verlag.

Friedl, H. 1984. *Tierknochen aus Kassope/Griechenland (4-1 Jh. v. Chr.)*. Munich: Diss. Med. Vet.

Fulford, M. 1989. Roman and barbarian: the economy of Roman frontier systems, pp. 81-95, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Gebbels, A. 1976. *Animal bones*, pp.48-51, in Neal, D.S. Northchurch, Boxmoor and Hemel Hempstead station: the excavation of three Roman buildings in the Bulbourne valley. *Hertfordshire Archaeology* **4**.

Genovese, A. and Cocca, T. 2000. Internal organistaion of an equine stable at Pompei. *Ibex Journal of Mountain. Ecology* **5** / *Anthropozoologica* **31**, pp. 119-123.

Gentry, A., Clutton-Brock, J. and Groves, C. P. 1996. Case 3010: Proposed conservation of usage of 15 mammal specific names based on the wild species which are antedated or contemporary with those based on domestic animals. *Bulletin of Zoological Nomenclature* **53(1)**, pp. 28-37.

Gilmore, F. 1969. The animal and human skeletal remains, pp.43-55, in Woods, P.J. *Excavations at Hardingstone, Northampton 1967-68*. Northampton: Northamptonshire County Council.

Gilmore, F. 1972. *Animal remains*, pp.18-27, in Oswald, A. Excavations at Beckford. *Transactions of the Worcestershire Archaeological Society, Third Series vol.* **3**. 1970-72.

Goodman, M. 1999. *The Roman World 44BC – AD180*. London: Routledge.

Gradel, E. 1989. Die Tierknochenfunde aus dem Amphitheater von Augusta Rauricorum (Grabungen 1982-86). *Jahresberichte aus Augst und Kaiseraugst* **10**, pp. 143-176.

Grant, A. 1984. *Animal husbandry*, pp. 496-547, in Cunliffe, B. Danebury: an Iron Age hillfort in Hampshire. Volume 2: the excavations, 1969-78: the finds. *CBA Research Report* **52**. London:CBA

Greene, K. 1986. *The Archaeology of the Roman Economy*. London: Batsford.

Groenman-van Waateringe, W. 1989. Food for soldiers, food for thought, pp. 96-107, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Groves, C. 1986. The taxonomy, distribution and adaptations of recent equids, pp.11-65, in Meadow, R. H. and Uerpmann, H-P. *Equids in the Ancient World*. Weisbaden: Dr. Ludwig Reichert Verlag

Habermehl, K-H. 1959/60. Die Tierknochen im römischen Lagerdorf Butzbach. *Saalburg-Jahrbuch* **18**, pp. 67-108.

Halstead, L. B. 1974. *Vertebrate Hard Tissues*. London: Wykeham Publications Ltd.

Hamilton-Dyer, S. 2001. Chapter 9 *The faunal remains*, pp. 251-301, in Peacock, D. P. S. and Maxfield, V. A. Mons Claudianus. Survey and excavation: vol 2 excavations part 1. *Institut Français d'Archéologie Orientale Documents de Fouilles* **42**. Cairo: IFAO.

Hanson, W. S. 1989. The nature and function of Roman frontiers, pp. 55-63, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Harcourt, R.A. 1975. *The animal bones*, pp. 88-9, in Jackson, D.A. An Iron Age site at Twywell, Northamptonshire. *Northamptonshire Archaeology* **10**.

Higham, N. J. 1989. Roman and native in England north of the Tees: acculturation and its limitations, pp. 153-174, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Hintz, H. F. 1996. *Mineral requirements of the horse: A historical perspective*. Proceedings of short course on equine nutrition. Kentucky Equine Research.
http://www.ker.com/library/archive/proceedings/sc96/1/index.html

Houwald, G. von. 1971. *Römische Tierknochenfunde aus Pfaffenhofen am Inn, Ldkr. Roseheim, und aus Wehringen, Ldkr. Schwadmünchen*. Munich: Diss. Med. Vet.

Hyland, A. 1990. *Equus: the Horse in the Roman World*. London: Batsford.

Jackson, J. W. 1947. *Mammalian remains*, pp. 350-354, in Hawkes, C. F. C. and Hull, M. R. Camulodunum: first report on excavations at Colchester 1930-39. *Reports. of the Research Committee of the Society of Antiquaries of London* **XIV**. Oxford: University Press.

Jansen, T., Forster, P., Levine, M. A., Oelke, H., Hurles., Renfre, C., Weber, J. and Olek, K. 2002. Mitochondrial DNA and the origins of the domestic horse. *Proceedings of the National Academy of Sciences of the USA* **99/16**, pp. 10905-10910. http://www.pnas.org/cgi/doi/10.1073/pnas.152330099

Johnstone, C. J. 1996. *How horses have changed in size and shape from the Iron Age to Medieval periods in Northern Europe*. Unpublished BSc Dissertation: University of Bradford.

Johnstone, C. J. 1997. Vertebrate remains from the Prehistoric site at Coldharbour Farm, Aylesbury, Buckinghamshire. *Reports from the Environmental Archaeology Unit, York* **97/3**

Johnstone, C. J. 1999. Looking a gift horse in the mouth: the problems of using archived and published biometrical data, pp. 48-50, in Anderson, S. *Current and recent research in Osteoarchaeology* **2**. Oxford: Oxbow Books.

Johnstone, C. J. and Albarella, U. 2002. The late Iron Age and Romano-British mammal and bird bone assemblage from Elms Farm, Heybridge, Essex. *Centre for Archaeology Reports* **45/2002**. English Heritage.

Johnstone, C. and Jaques, D. 1999. Vertebrate remains from Thorley, Hertfordshire. *Reports from the Environmental Archaeology Unit* **99/9**

Jones, E. V. and Horne, B. 1981. *Analysis of skeletal material*, pp. 69-73, in Mathews, C.L. A Romano-British inhumation cemetery at Dunstable. *Bedfordshire Archaeological Journal* **15**.

Jones, G. G. 1977. *Animal Bones*, pp. 209-13, in Rogerson, A. Excavations at Scole, 1973. *East Anglian Archaeology Report* **5**.

Jones, G. G. 1982. *The animal bones*, pp. 94-5, in Allen, D. Salvage excavations at 13-19 Buckingham Street and the Bull's Head redevelopement site, Aylesbury, in 1979 and 1980. *Records of Buckinghamshire* **24**.

Jones, G. G. 1985. *The animal bones from the 1974 excavations,* in Hinchliffe, J. Excavations at Brancaster 1974 and 1977. *East Anglian Archaeology Report* **23**. Norfolk Museums Service.

Jones, G. G. 1989. *The animal bones,* pp..211-221, in Blockley, K. Prestatyn 1984-5: An Iron Age and Romano-British Industrial site in North Wales. *BAR British series* **210**. Oxford: BAR.

Jones, G. G. 1992. *Animal bones*, pp. 173-174, Fiche 1 F1-G2, in Yeoman, P. A. and Stewart, I. J. A Romano-British Villa Estate at Mantles Green, Amersham, Buckinghamshire. *Records of Buckinghamshire* **34**. .

Jones, G. G. and Sadler, P. 1996. *The animal bones,* pp. 224-232, in Parkhouse, J. and Evans, E. Excavations in Cowbridge, South Glamorgan, 1977-88. *BAR British Series* **245**. Oxford: Tempus Reparatum/CADW

Kay, K. 2002. *Morocco's miracle mule.* http://news.bbc.co.uk/1/hi/sci/tech/2290491.stm accessed 14th March 2004.

Kiesewalter, L. 1888. *Skelettmessungen am Pferde als Beitrag zur theoretischen Grundlage der Beurteilungslehre des Pferdes*. Leipzig: Phil. Diss.

King, A. C. 1985. I resti animali;i mammiferi, i rettili e gli anfibi, pp. 278-300, in Ricci, A. (ed) *Settefinestre: una villa schiavistica nell'Etruria romana vol 2.* Modena: Panini

King, A. C. 1994. Mammiferi, pp.367-406, in Arthur, P. *Il complesso archeologico di Carminiello ai Mannesi, Napoli (Scavi 1983-1984).* Galatina: Congredo.

King, A. C. 1999. Meat diet in the Roman world: a regional inter-site comparison of the mammal bones. *Journal of Roman Archaeology* **12**, pp. 168-202.

King, A. C. 1997. *Mammal, reptile and amphibian bones,* pp.383-407, in Potter, T.W. and King, A.C. Excavations at the Mola di Monte Gelato: a Roman and medieval settlement in South Etruria. *Archaeological monographs of the British School at Rome* **11**. London: BSR/British Museum.

King, J. 1996. *The animal bones*, pp. 216-218, in Mackreth, D. F. Orton Hall Farm: a Roman and Early Anglo-Saxon farmstead. *East Anglian Archaeology report* **76**. EAA and Nene Valley Archaeological Trust.

King, J. M. 1987. *The animal bones,* pp.185-193, in Dannell, G. B. and Wild, J. P. Longthorpe II: The military works-depot: an episode in landscape history. *Britannia Monograph Series* **8**. London: Society for the Promotion of Roman Studies.

Kinnes, I. A. 1981. The animal bones, pp. 232-8, in Jarrett, M. G. and Wrathmell, S. *Whitton: an Iron Age and Roman Farmstead in South Glamorgan*. Cardiff: University of Wales Press.

Knowles, J. 1993. *The ABC of Breaking and Schooling horses*. London: J. A. Allen.

Kokabi, M. 1982. *Tierknochenfunde,* pp. 397-425, in Eschebach, H. *et al.* Die Casa di Ganimede in Pompeii VII 13,4. *Mitteilungen des Deutschen Archäologischen Instituts Roemische Abteilung* **89**.

Kunst, G. K. 1997a. Discrimination of long bones from domestic *Equus* cross-sectional geometry. *Journal of Morphology* **232**. pp. 282.

Kunst, G. K. 1997b. *Equidenskelette aus dem vorland des auxiliarkastelles Carnuntum*, pp. 183-218, in Kandler, M. Das Auxiliarkastell Carnuntum 2: Forschungen seit 1989. *Österreichsches Archäologisches Institut Sonderschriften Band* **30**. Vienna

Kunst, G. K. 2000. Archaeozoological evidence for equid use, sex structure and mortality in a Roman auxiliary fort (Carnuntum-Pteronell, Lower Austria). *Ibex Jounal of Mountain Ecology* **5**/*Anthropozoologica,* **31**. pp. 109-118.

Kunst, G. K. 2002. *Determination of domestic equids and diaphyseal morphology.* Paper given at the workshop entitled 'Horse, Donkey and Co.' held in Basel, Switzerland, 23-24th January 2002.

Lauwerier, R. C. G. M. 1988. Animals in Roman times in the Dutch eastern river area. *Nederlandse Oudheden* **12** / *Project Oostelijk Rivierengebied* **1**. Amersfoort: ROB.

Lauwerier, R. C. G. M. and Hessing, W. A. M. 1992. Men, horses and the Miss Blanche effect: Roman horse burials in a cemetery at Kesteren, the Netherlands. *Helinium* **XXXII/1-2**, pp.78-109.

Lauwerier, R. C. G. M. and Laarman, F. J. 1999. *Dierlijk Botmateriaal*, pp. 129-251, in Hagers, J-K.A. and Sier, M.M. Castricum-Oosterbuurt, bewoningssporen uit de Romeinse tijd en middeleeuwen. *ROB Rapportage Archeologische Monumentenzorg* **53**. Amersfoort: ROB

Lauwerier, R. C. G. M. and Robeerst, A. J. M. M. 2001. Horses in Roman times in the Netherlands, in Buitenhaus, H. and Prummel, W. (eds) *Animals and man in the past*. Groningen: ARC Publicatie **41**.

Lawrence. E. (ed). 2000. *Henderson's Dictionary of Biological Terms*. 12th edition. London: Prentice Hall.

Legge, A., Williams, J. and Williams, P. 1989. *Animal Remains*, pp. 90-95, in Moss-Eccardt, J. Archaeological investigations in the Letchworth area 1958-1974. *Proceedings of the Cambridge Antiquarian Society* **LXXVII**.

Lepetz, S. 2002. *Le cheval, l'-ne et les hybrides dans la moiti¾ nord de la France ' la p¾riode romaine.* Paper given at the workshop entitled 'Horse, Donkey and Co.' held in Basel, Switzerland, 23-24th January 2002.

Levine, M. A. 1982. *The use of crown height measurements and eruption-wear sequences to age horse teeth*, pp. 223-250, in Wilson, B., Grigson, C. and Payne, S. Ageing and Sexing Animal Bones from Arcaheological Sites. *BAR British Series* **109**.

Levitan, B. 1989. The vertebrate remains from Chichester cattlemarket, pp. 242-267, in Down, A. *Chichester Excavations VI*. Chichester: Phillimore

Levitan, B. 1994. *The vertebrate remains*, pp. 173-93 + 233-48, in Leach, P. Ilchester Volume 2: Archaeology, excavations and fieldwork to 1984. *Sheffield Excavation Reports* **2**. University of Sheffield

Lipper, E. 1986. Die Tierknochenfunde aus dem römischen Kastell Abusina-Eining, stadt Neustadt a.d. Donau, LKR. Kelheim *Bericht der Bayerischen Bodendenkmalpflege* **22/23** *1981/2*.

Lister, A. M., Kadwell, M., Kaagan, L. M., Jordan, W. C., Richards, M. B. and Stanley, H. F. 1998. Ancient and modern DNA in a study of horse domestication. *Ancient Biomolecules* **2**, pp. 267-280.

Locker, A. 1995. *A summary report on the animal bone*, pp. 57-9, in Hunn, A., Lawson, J. and Parkhouse, J. Investigations at Magiovinium 1990-1: The little Brickhill and Fenny Stratford by-passes. *Records of Buckinghamshire* **37**.

Luff, R-M. 1982. A Zooarchaeological Study of the Roman North-western Provinces. *BAR International Series* **137**. Oxford: BAR.

Luff, R. 1988. *The Faunal Remains*, pp. 122-125, in Clarke, C. P. Excavations to the south of Chignall Roman Villa, Essex 1977-8. *East Anglian Archaeology* **83**. Essex County Council.

Lyman, R. L. 1994. *Cambridge Manuals in Archaeology: Vertebrate taphonomy*. Cambridge: Cambridge University Press.

Lyublyanovics, K. 2002. *Size Variability in Roman Period Horses from hungary*. Poster and draft paper from ICAZ Conference 2002.

MacKinnon, M. 1994. *The faunal remains*, pp. 243-57, in Small, A. M. S. *et al.* A pit group of c 80-70 BC from Gravina di Puglia. *Publications of the British School at Rome* **62**.

MacKinnon, M. 1998. The faunal remains, pp. 533-94, in Soren, D. S. and Soren N. *Excavation of a Roman Villa and Late Infant Cemetery near Lugnano in Teverina, Italy*. Rome: L'ERMA di Bretschneider.

MacKinnon, M. 2001. The mammalian remains, pp. 1-169, in Mackinnon, M. *Excavations at San Giovanni di Ruoti. Vol 3. The plant and animal remains*. Toronto: University of Toronto Press.

Manconi, F. 1995. Equidi in Sardegna tra il II sec. a.C. e il VII sec. d.C. pp. 319-329 in Bellintani, P. *Collana di studi monografici del centro Plesano di study storici, archaeologici ed etnografici Rovigo*. Atti del I Convegno di Archeozoologia, Rovigo 5-7 marzo 1993. Rovigo: Padusa Quaderni n.1.

Mariezkurrena, K. 1986. La cabaña ganadera del Castillar de Mendavia (Navarra). *Munibe (anthrologia y Arqueologia)* **38**, pp. 119-169.

Marinval-Vigne, M-C. and Vigne, J-D. 1982. *Le matériel osseux - étude de la faune du dépotoir du IVe siècle de Dambron*, pp. 99-102, in Calvo, J-M and P. Le matériel d'un dépotoir du IVe siècle du site de la "Fosse-Dieppe", à Dambron (E.-et-L.). *Revue Archeologique du Loiret* **8**.

Marks, S. C. and Hermey, D. C. 1996. The structure of bone, pp. 3-14, in Bilezikian, J. P., Raisz, L. G. and Rodan, G. A. *Principles in Bone Biology*. London: Academic Press.

Marples, B. J. 1974. *Animal bones from the Roman fort at Longthorpe, near Peterborough*, pp.122-8, in Frere, S.S. and St Joseph, J.K. The Roman Fortress at Longthorpe. *Britannia* **5**.

May, E. 1985. Wideristhöhe und Langknochenmaße bei Pferd – ein immer noch aktuelles Problem. *Zeitschrift für Säugertierkunde* **50**, pp. 368-382.

McIlwraith, C. W. 1996. *The equine skeleton: how does bone grow and how do abnormalities in the developmental process affect soundness*? Proceedings of short course on equine nutrition. Kentucky Equine Research. http://www.ker.com/library/archive/proceedings/sc96/5/index.html

Meadow, R. H. 1981. Early animal domestication in South Asia: a first report of the faunal remains from Mehrgarh, Pakistan. pp. 143-179 in Härtel, H. *South Asian Archaeology 1979*. Berlin: Dietrich Reimer Verlag.

Meadow, R. H. 1999. The use of size index scaling techniques for research on archaeozoological collections from the Middle East, pp. 285-300 + figures 1-13, in Becker, C., Manhart, M., Peters, J. and Schibler, J. *Historia animalium ex ossibus: Beiträge zur Paläoanatomie, Archäologie, Ethnologie und Geschichte der Tiermedizin. Festschrit für Angela von den Driesch*. Rahden/Westfalen: Verlag Marie Leidorf GmbH.

Meddens, B. J. Undated. *Interim report on the animal bones from Catterick Bridge (CEU 240), North Yorkshire*. Unpublished archive report.

Meniel, P. 1984. *Contribution a l'histoire de l'elevage en Picardie: du Neolithique a la fin de l'age du fer*. Societe de Prehistoire du Nord et de Picardie. *Revue Archeologique de Picardie* **No. special 1984/50 F.**

Meniel, P. 1993. Les restes animaux de l'oppidum du Titelberg (Luxembourg) de La Tene finale au Gallo-Romaine precoce. *Archaeologi Mosellana* **2**, pp. 381-406.

Mennerich, G. 1968. *Römerzeitliche Tierknochen aus drei fundorten das Niederrheingebeits*. Munich: Diss. Med. Vet.

Middleton, P. 1979. Army surplus in Roman Gaul: an hypothesis for Roman Britain, pp. 81-97, in Burnham, B. C. and Johnson, H. B. *Invasion and response: the case for Roman Britain*. BAR British Series 73. Oxford: BAR.

Morel, P. 1991. *Untersuchung des osteologischen fundgutes aus dem vicus Viturdurum-Oberwinterthur*, pp. 79-176, Beiträge zum römischen Oberwinterthure-Vitudurum 5. *Berichte der Zürcher Denkmalpflege. Archäologische Monographien* **10**

Mortimer, C. 2004. Matchmaking for your mare. *Horse* **April 2004**, pp 88-91.

Müller, H-H. 1996. Archaozoologische Studien an zwei neun Faunenkmplexen der Römishen Kaiserzeit aus dem Land Brandenburg. *Veroffentlichungen des Brandenburgischen Landesmuseums für Ur- und*

Frühgeschichte **30**, pp.195-222.

Müller, R. 1967. *Die Tierknockenfunde aus den Spätrömischen siedlungsschichten von Lauriacum. II. Wild- und Haustierknochen ohne die Rinder.* Munich: Diss. Med. Vet.

Nehring, A. 1884. Fossile Pferd aus deutschen Diluvial-Ablagerungen und ihre Beziwhung zu lebenden Pferden. *Landwirtshaftliche Jahrbüch* Berlin, pp. 81-160.

Nobis, G 1973. Zur Frage römerzeitlicher hauspferde in Zentraleuropa. *Zeitschrift für Säugetierkunde* **38**, pp. 224-252.

Nobis, G. and Ninov, L. 1986. Archäologische Analyse einer Pferdebestattung aus der thrakischen Hügelnekropole Swestari (NO-Bulagrien). *Journal of Animal Breeding and Genetics* **103**, pp. 148-158.

Noddle, B. 1979. Frocester Court Roman Villa: The animal bones. *Transactions of the Bristol and Gloucestershire Archaeological Society* **97**, pp. 51-64 + plates IV-V.

Noddle, B. A. 1983. *The animal bones*, pp.63-7, in Casey, P. J. Caerwent (Venta Silurum): The excavation of the north-west corner tower and an analysis of the structural sequence of the defences. *Archaeologia Cambrensis* **132**

Noddle, B. 1985. *The Animal bones*, pp 82-96 in Webster, G. Fowler, P, Noddle, B. and Smith, L. The excavation of a Romano-British rural establishment at Barnsley Park, Gloucestershire, 1961-1979: Part III. *Trans. Bristol and Gloucs. Archaeol. Soc.* **103**. pp 73-100

Noddle, B. 1993. *Bones of larger mammals* pp.97-118. in Casey, P. J., Davies, J. L. and Evans, J. Excavations at Segontium (Caernarfon) Roman Fort, 1975-1979. *CBA Research Report* **90**. London: Council for British Archaeology

O'Connor, T. P. 1988. Bones from the General Accident site, Tanner Row. *The Archaeology of York* **15(2)**. 16-163 + plates III-VII. London: Council for British Archaeology

O'Connor, T. P. 1994. A horse skeleton from Sutton Hoo, Suffolk, U. K. *Archaeozoologia* **7/1**, pp. 29-37.

O'Connor, T. 2000. *The Archaeology of Animal Bones*. Stroud: Sutton.

Outen, A. 1979. *The Animal bones*, pp. 113-131, in Down, A. Chichester Excavations 4: the Roman villas at Chilgrove and Upmarden. Chichester: Phillimore.

Pálsson, H. 1955. Conformation and body composition, pp. 430-542, in Hammond, J. *Progress in the Physiology of Farm Animals Volume II*. London: Butterworths Scientific Publications

Payne, S. 1991. Early Holocene equids from Tall-I-Mushki (Iran) and Can Hasan III (Turkey). pp. 132-64, in Meadow, R. H. and Uerpmann, H-P. *Equids in the Ancient World: Volume II*. Weisbaden: Dr. Ludwig Reichert Verlag.

Payne, S. Undated. *Animal Bones from excavations in 1972 at Catterick Site 434, North Yorkshire*. Unpublished archive report.

Payne, S. and Bull, G. 1988. Components of variation in measurements of pig bones and teeth, and the use of measurements to distinguish wild from domestic pig remains. *Archaeozoologia* **2**, 12-65.

Peške, L. 1993. *Osteological analysis of the material from Radovesice (23): animal husbandry in the La Tène Period*, pp. 156-172, in Waldhauser, J. Die Hallstatt- und Latènezeitlichesiedlung mit gräberfeld bei Radovesice in Böhmen. Vol II Gutachten Auswertung. *Archeologicky vykum v Severnich Cechnach* **21**.

Peters, J. 1998. *Römische Tierhaltung und Tierzucht: eine Synthese aus archäozoologischer Untersuchung und schriftlich-bildlicher Überlieferung*. Passauer Universitätsschriften zu Archäologie Band 5. Rahden/ Westfalen: Verlag Marie Leidorf.

Piehler, W. 1976. *Die Knochenfunde aus dem spätrömishcen Kastell Vemania*. Munich: Diss. Med. Vet.

Pilliner, S. 1992. *Horse Nutrition and Feeding*. Oxford: Blackwell Scientific Publications.

Pomeroy, R. W. 1955. Live-weight growth, pp. 395-429, in Hammond, J. *Progress in the Physiology of Farm Animals Volume II*. London: Butterworths Scientific Publications

Rackham, D. J. 1985. An analysis and interpretation of the sample of animal bones from Thorpe Thewles, Cleveland. *Ancient Monuments Laboratory Report* **4567**. London: HBMC

Reichstein, H. 1991. *Die fauna des Germanischen dorfes Feddersen Wierde*. Teil 1 and Teil 2. Stuttgart: Franz Steiner Verlag.

Reitz, E. J. and Wing, E. S. 2000. *Zooarchaeology*. Cambridge: Cambridge University Press, Cambridge manuals in archaeology.

Riedel, A. 1979. Die Fauna einer frühmittelalterlichen Siedlung in Stufels bei Brixen. *Der Schlern* **53**, pp. 385-405.

Riedel, A. 1983-4. The fauna of the excavations of Pozzuolo del Friuli (1980-1983). *Atti del Museo Civico di Storia Artistica di Trieste* **14**, pp. 215-76.

Riedel, A. 1984. Die Fauna von zwei römischen Fundsatten im Brixen Gemeindegebeit. *Der Schlern* **58**, pp. 455-98.

Riedel, A. 1985a. Die fauna von Altino (Venetien) im Verhältnis zu den Faunen Nordostitaliens und der Alpenländer. *Razprave IV, Razreda SAZU* **26**, pp. 131-45.

Riedel, A. 1985b. The Fauna of the Iron Age site of Castelrotto (Verona). *Padusa* **21**, pp. 55-97.

Riedel, A. 1990. Bemerkungen über mittelalterliche Faunen Nordostitaliens, pp. 583, in Schibler, J., Sedlmeier, J. and Spychor, H.P. *Festschrift für Hans R. Stampfli*. Basel: Helbing and Lichtehahn.

Riedel, A. 1993. Tierknochenfunde aus den Ausgrabungen im Bereich de Schlosses con Udine (Friaul). *Aquileia Nostra* **64**, pp. 70-106.

Riedel, A. 1994. Roman animal bones from the area near the Forum of Aquilieia pp 583-91 in Verzar-Bass, M. (ed*). Scavi ad Aquileia I. L'area A est del Foro, rapporto degli scavi 1989-91*. Rome: Quasar.

Riedel, A. and Scarpa, G. 1988. Resti animali di un complesso produttivo di eta tardoromana a Volano. *Annali dei Musei Civici di Rovereto* **4**, pp. 37-54.

Rielly, K. 2000. *5.5 The animal bones*, pp. 64-65, in Mackinder, A. A Romano-British cemetery on Watling Street: excavations at 165 Great Dover Street, Southwark, London. *MoLAS Archaeology Studies Series* **4**. London: MoLAS.

Robinson, S., Nicholson, R. A., Pollard, A. M. and O'Connor, T.P. 2003. An evaluation of Nitrogen Porosity as a Technique for Predicting Taphonomic Durability in Animal Bone. *Journal of Archaeological Science* **30**, pp. 391-403.

Round, A. A. 1992. *Animal bones*, pp.70-1, in Round, A.A. Excavations on the Mansio site at Wall (Letocetum) Staffordshire, 1972-78 (Wall excavation report 14). *South Staffordshire Archaeological and Historical Society Trans*actions **XXXII** for 1990-1

Reynolds, P. J. 1979. *Iron Age Farm: The Butser Experiment*. London: British Museum Publications.

Sadler, P. 1990. *The animal bones*, pp. 100-103, in Stewart, I. J. Coldharbour Farm, Aylesbury, and archaeological investigation. *Records of Buckinghamshire* **32**, pp. 91-104.

Saladin, K. S. 1998. *Anatomy and Physiology: the Unity of Form and Function*. New York: WCB/McGraw-Hill.

Sauer-Neubert, A. 1968. *Tierknochenfunde aus der rőomischen Zivilsiedlung in Hüfingen (ldkrs. Donaueschingen). II. Wild- und Haustierknochen mit Ausnahme der Rinder.* Munich: Diss. Med. Vet.

Scmidt-Pauly, I. 1980. *Römerzeitliche und mittelalterliche Tierknochenfunde aus Breisach im Breisgau.* Munich: Diss. Med. Vet.

Silver, I. A. 1969. The ageing of domestic mammals, pp. 283-302, in Brothwell, D. and Higgs, E. *Science in Archaeology: A Survey of Progress and Research.* London: Thames and Hudson.

Simpson, G.G. 1941. *Explanation of ratio diagrams.* American Museum Novitates **1136**, pp. 23-25.

Simpson, G. G., Roe, A. and Lewontin, R.C. 1960. *Quantitative Zoology,* revised edition. New York: Harcourt, Brace and World.

Smoothy, M. D. 1993. *The animal bone,* pp.52-61. in Havis, R. Roman Braintree: excavations 1984-90. *Essex Archaeology and History* **24**, pp. 22-68.

Speidel, M. P. 1994. *Riding for Caesar: The Roman Emperors' Horse Guards.* London: Batsford.

Spooner, G. 1990. *The handbook of showing.* London: J. A. Allen

Stein, S. 2000. *Viehhaltung, Jagd und Fischfanf im 'Haus Burgel', einem spatäntiken Kastell am Niederrhein.* Munich: Diss. Med. Vet.

Stettmer, A. 1997. *Die Tierknochenfunde aus dem römischen Kastell Oberstimm, Ldkr. Ingolstadt/ Bayern (Grabungen 1994).* Munich: Diss. Med. Vet.

Storck, M. and von den Driesch, A. 1987. Tierknochenfunde aus Invillino-Ibligo in Friaul Italien, pp. 543-84, in Bierbrauer, V. *Invillino-Ibligo in Friaul 1: Die römische siedlung und das spatäntik-frühmittelalterliche castrum* Munich: C. H. Beck'sche.

Streitferdt, U. K. 1972. *Osteoarchäologische Untersuchungen an Tierknochenfunde aus vier Römischen Stationen im Suddeutschen Raum.* Munich: Diss. Med. Vet.

el Susi, G. 1988. Materialul faunistic din asezarea Daco-Romana de la Timisorar- 'Freidorf' (Jud. Timis). *Complexul Muzeal Judetean Bihor Oradea, Extras Din Crisia* **XVIII**.

Swegat, W. 1976. *Die Knochenfunde aus dem römischen Kastell Kunzing-Quintana.* Munich: Diss. Med. Vet.

Teichert, M. 1974. *Tierreste aus dem germanischen Opfermoor bei Oberdorla.* Weimar: Museum für ur- und frühgeschichte Thüringens

Toynbee, J. M. C. 1973. *Animals in Roman Life and Art.* London: Thames and Hudson.

Turner-Walker, G., Nielsen-Marsh, C. M., Syversen, U., Kars, H. and Collins, M. J. 2002. Sub-micron Spongiform Porosity is the Major Ultra-structural Alteration Occurring in Archaeological Bone. *International Journal of Osteoarchaeology* **12**, pp. 407-414.

Uerpmann, H-P. 1993. *Proposal for a separate nomenclature of domestic animals*, pp. 239-242, in Clason, A., Payne, S. and Uerpmann, H-P. Skeletons in her Cupboard: Festschrift for Juliet Clutton-Brock. *Oxbow Monograph* **34**. Oxford: Oxbow books.

Uerpmann, H-P. 2002. *Dental morphology of horses, donkeys and mules.* Contribution to the workshop entitled 'Horse, Donkey and Co.' held in Basel, Switzerland 23-24th January 2002.

Uytterschaut, H. 1978. *De Fauna van Gallo-Romeinse vindplaats to pommeroeul (provincie Henegouwen): wilfauna, gevogelte, hond en paard.* Unpublished MSc thesis: Laboratory of Palaeontology, University of Ghent (Belgium).

Van Neer, W. and Sidebotham, S. E. 2002. *Animal remains from the fourth-sixth century AD Military installation near Abu Sha'ar at the Red Sea coast (Egypt)*, pp. 171-195, in Jennerstrasse. Tides of the desert - Gezeiten der Wuste. *Africa Praehistoria* **14**. Cologne.

Vitt, V.O. 1952. Loshadi Pezyryksich kuganov. *Sovetskaja Archeologija* **16**, pp. 163-205.

Waldmann, K. 1966. *Die Knochenfunde aus der Colonia Ulpia Traiana einer römischen stadt dei Xanten am Niederrhein*. Munich: Diss. Med. Vet.

Warren, L. K., Lawrence, L. M., Griffin, A. S., Parker, A. L., Barnes, T. and Wright, D. 1997. *The effect of weaning age on foal growth and bone density*. Proceedings of short course on equine nutrition. Kentucky Equine Research. http://www.ker.com/library/archive/proceedings/sc97/07/index.html

Watson, J. P. N. 1992. The mammals, pp. 93-120, in Small, A. M. S. *An Iron Age and Roman republican settlement on Botromagno: Gravina di Puglia. Excavations of 1965-1974. Vol 1: The site*. London: Publications of the British School at Rome.

Webber, T. 1991. Mouths and Bits. *Threshold Picture Guide* **15**. Kenilworth: Threshold books.

Wells, P. S. 1996. Production within and beyond imperial boundaries: goods, exchange and power in Roman Europe. *Journal of World-Systems Research* **2 (13)**. 14 pages.
http://csf.colorado.edu/jwsr/archive/vol2/v2_nd.htm

Wells, P. S. 2001. *The Barbarians Speak: How the Conquered Peoples shaped Roman Europe*. Princeton: Princeton University Press.

Westley, B. 1966. *Bones from Ivinghoe Beacon*, pp. 252-260, in Cotton, M. A. and Frere, S. S. Ivinghoe Beacon excavations, 1963-5. *Records of Buckinghamshire* **XVIII**.

White, K. D. 1970. *Roman Farming*. London: Thames and Hudson.

Whittaker, C. R. 1989. Supplying the system: frontiers and beyond, pp. 64-80, in Barrett, J. C., Fitzpatrick, A. P. and Macinnes, L. *Barbarians and Romans in North-West Europe: from late Republic to late Antiquity*. BAR International Series 471. Oxford: BAR.

Whyman, M. 2001. *Late Roman Britain in Transition, AD300-500. A Ceramic Perspective from East Yorkshire*. Unpublished Dphil thesis: University of York.

van Wijngaarden-Bakker, L. H. 1970. Dierenresten uit het Castellum te Zwammerdam. pp. 274-78. *Helinium* **10**

Wilson, B., Hamilton, J., Bramwell, D. and Armitage, P. 1978. *The animal bones*, pp. 110-39, in Parrington, M. The excavation of an Iron Age settlement, Bronze Age ring-ditches and Roman features at Ashville Trading Estate, Abingdon, Oxfordshire 1974-76. *CBA Research Report* **28**. London: CBA and Oxfordshire Archaeological Unit.

Wilson, J. 1975. *The animal remains*, pp. 125-8, in Jones, R. The Romano-British farmstead and its cemetary at Lynch Farm, near Peterborough. *Northamptonshire Archaeology* **10**.

Winston, R. 2004. Seeing is believing. *The Guardian*. Wednesday 7th January 2004.
http://www.guardian.co.uk/parents/story/0,3605,1117383,00.html accessed 26/03/04.

Xu, X. and Arnason, U. 1994. The complete mitochondrial DNA sequence of the horse *Equus caballus*: extensive heteroplasmy of the control region. *Gene* **148**, pp. 357-362.

Yvinec, J-H. 1983. Les restes animaux du silo de Champlieu (Oise). *Revue Archéologique de Picardie* **no.1**, pp. 215-218.

Yvinec, J-H. Undated. *Étude archéozoologique du site de Conchil-Le temple*. Unpublished report

Zeuner, F. E. 1963. *Summary of the Symposium Man and Cattle*, pp. 158-66, in Mourant, A.E. and Zeuner, F. E. Man and Cattle: proceedings of a symposium on domestication at the Royal Anthropological Institute (London). *Occasional Paper* **18**.

Appendix

The Appendix contains figures and tables that are supplemantary to those contained within the text. A list of these figures and tables is given at the beginning of the thesis.

The figures mostly comprise additional material where the results were not considered of sufficient interest to be included in the main part of the text, but are useful for detailed comparison of results. The tables include more detailed information on the assemblages and sites from which data were extracted for this research and detailed lists of the results of the vairous analyses that were undertaken.

A CD containing the Paradox database in which data collected for this research were cllated is in the envelope attached to the inside of the back cover.

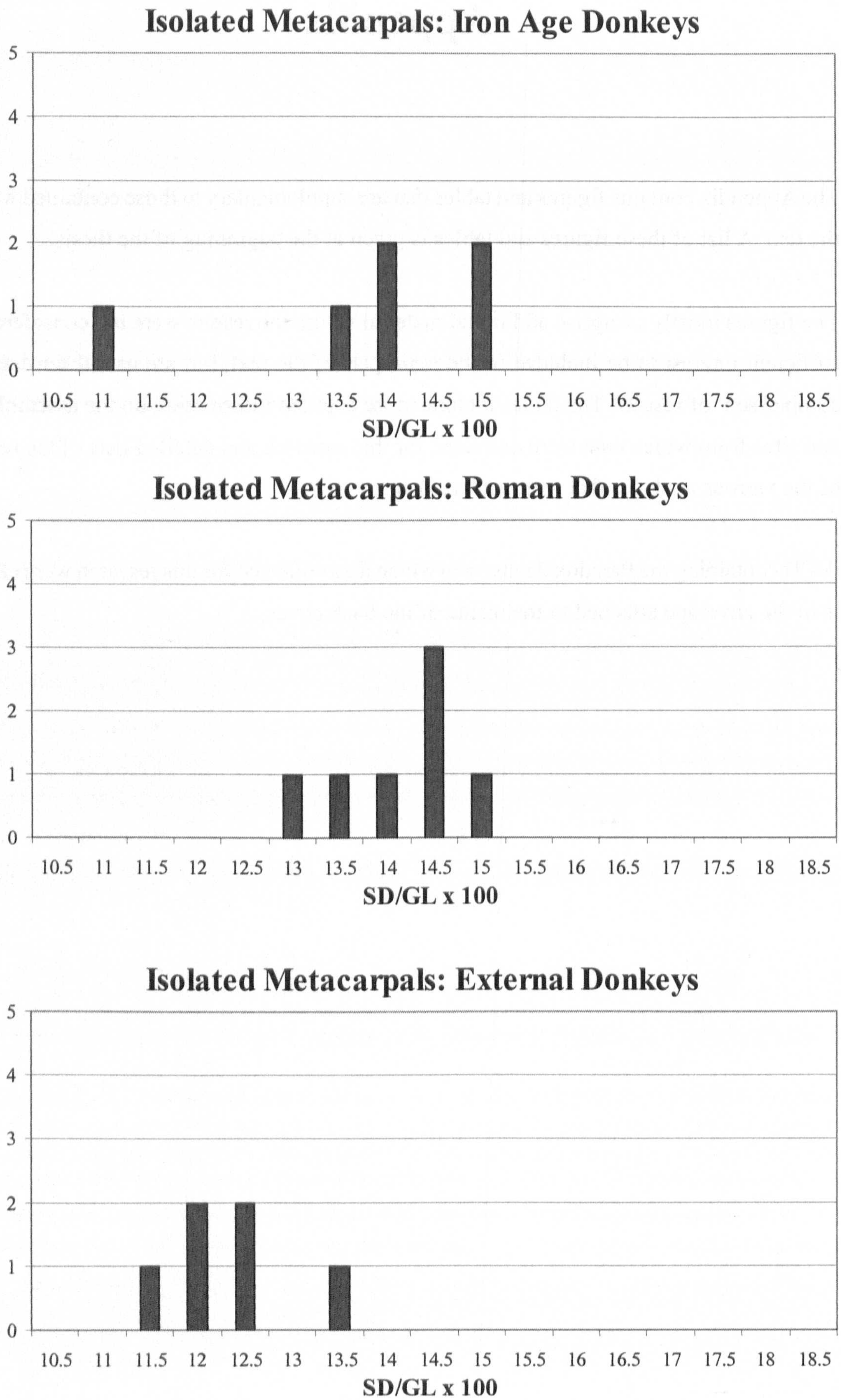


Figure A1. Histograms of shaft breadth to greatest length index for the 'identified' archaeological donkey metacarpals by period.

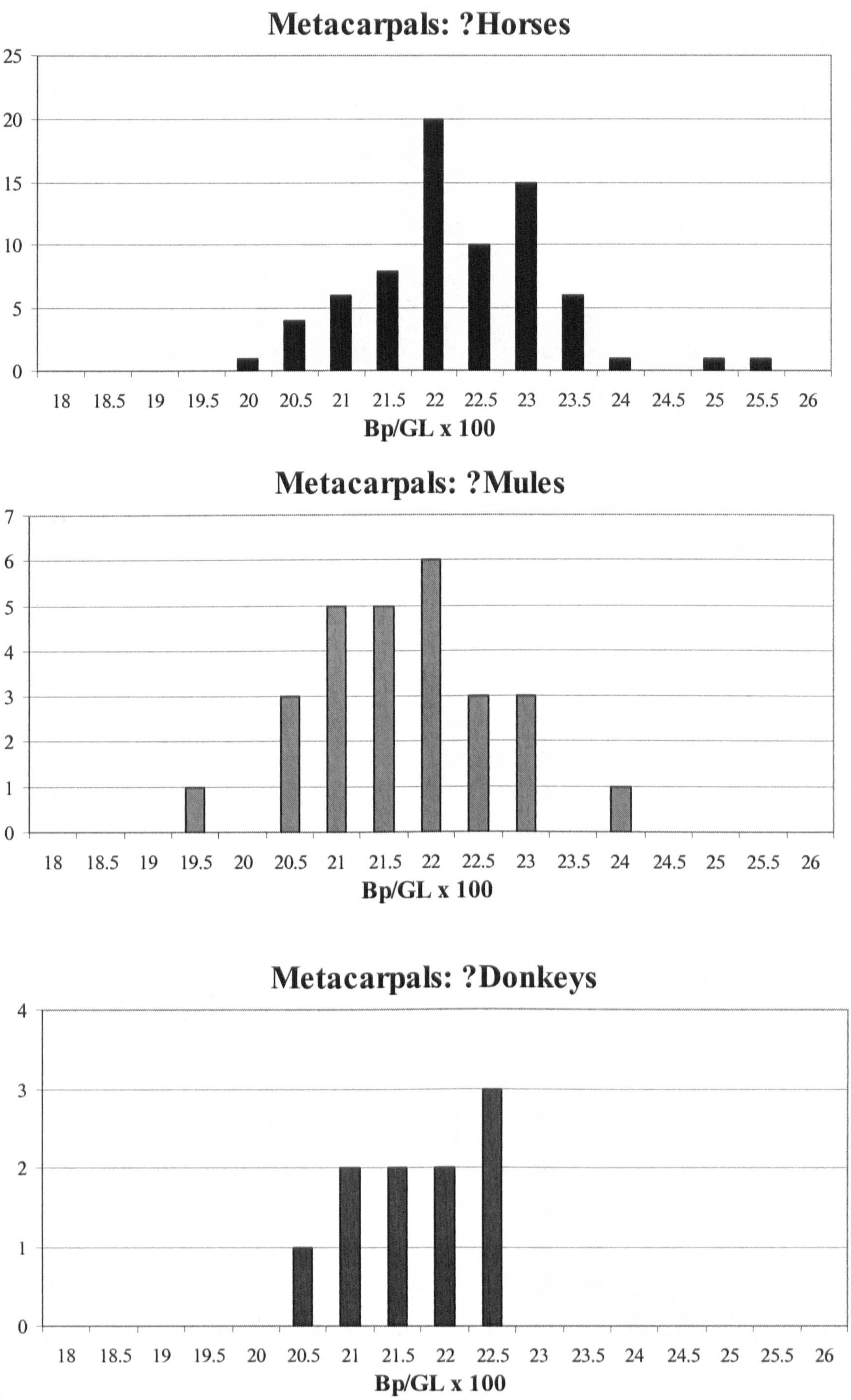


Figure A2. Histograms of proximal breadth to greatest length index for the 'ambiguous' archaeological metacarpals.

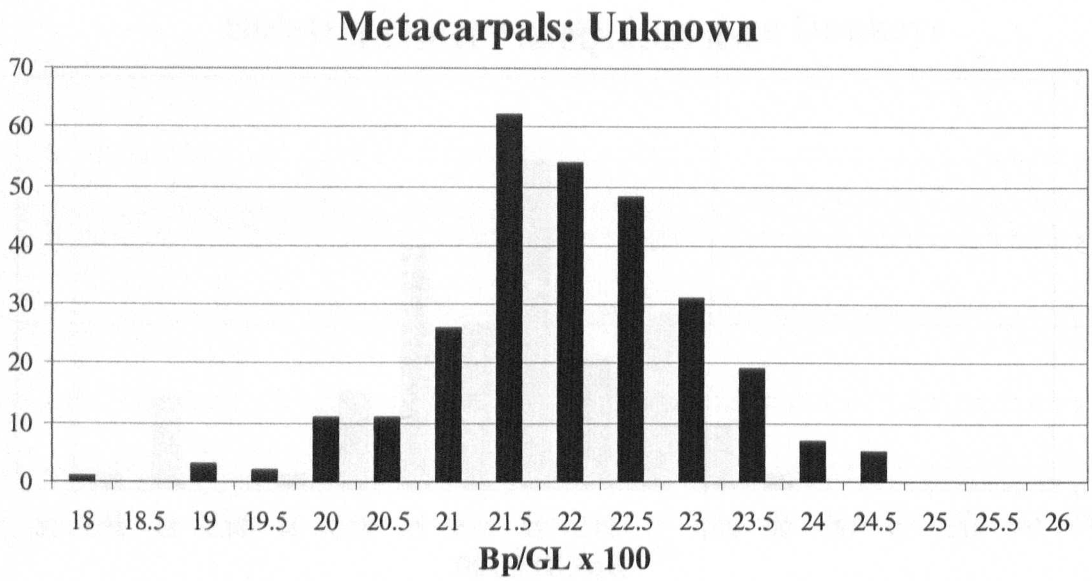
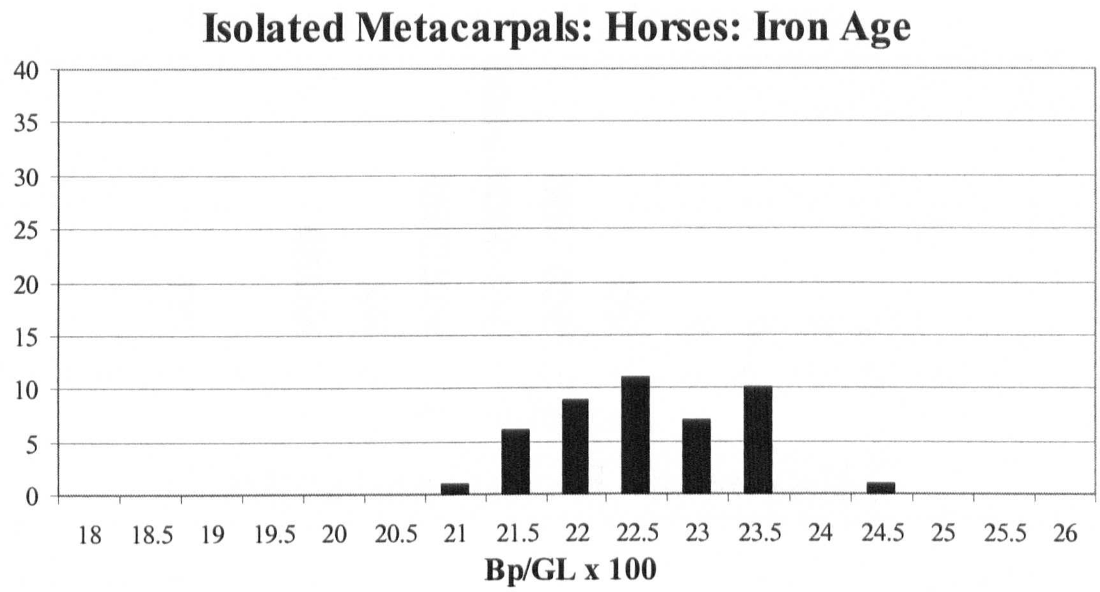
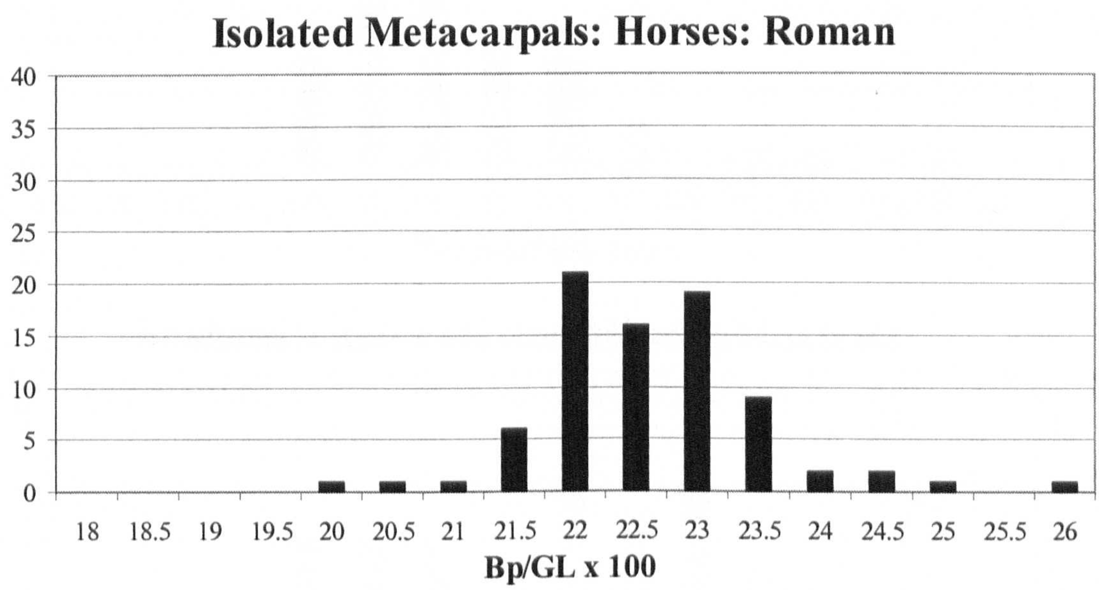


Figure A3. Histogram of proximal breadth to greatest length index for the 'unknown' archaeological metacarpals.





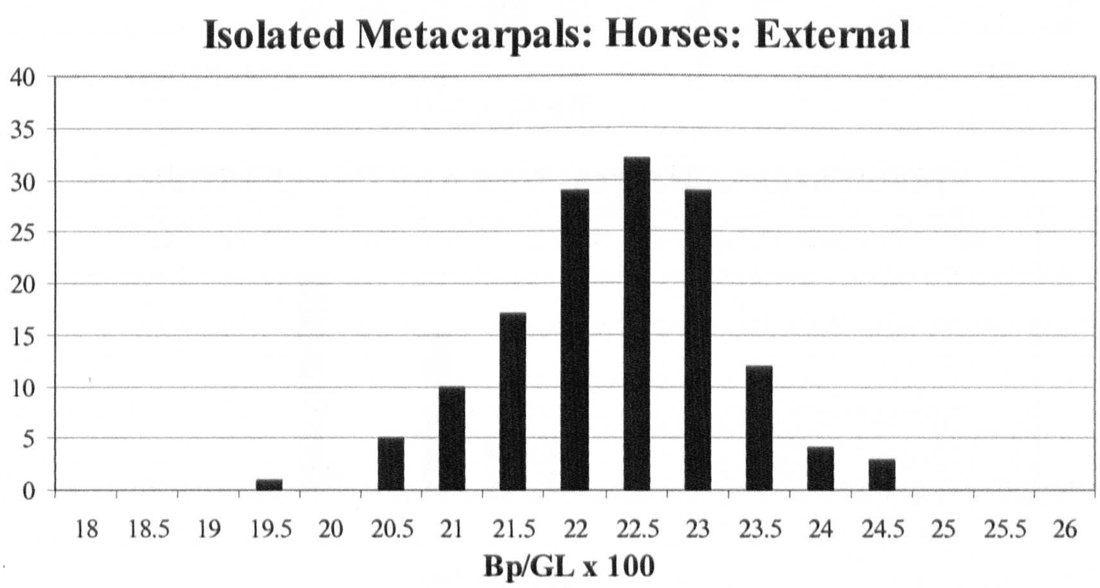


Figure A4. Histograms of proximal breadth to greatest length index for the 'identified' archaeological horse metacarpals by period.

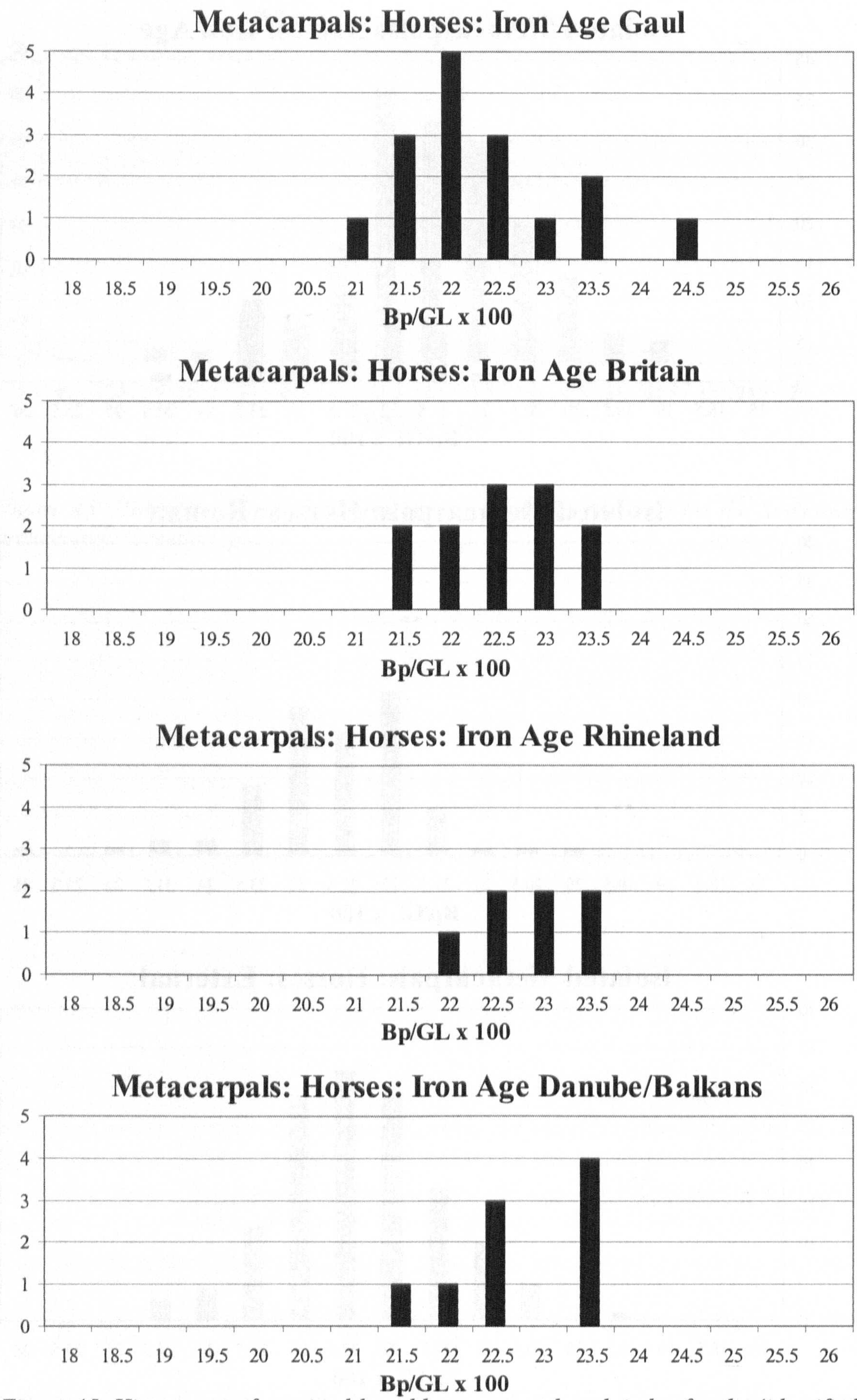
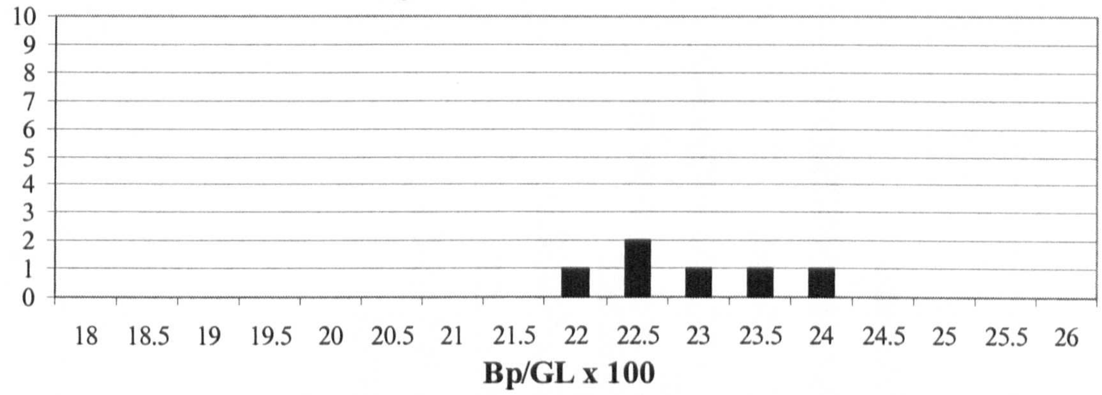
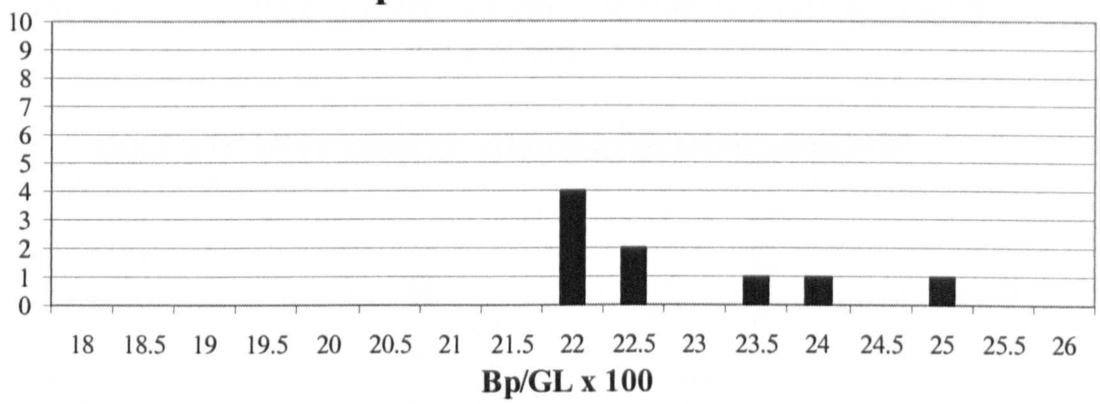


Figure A5. Histograms of proximal breadth to greatest length index for the 'identified' archaeological Iron Age and Roman horse metacarpals by area.

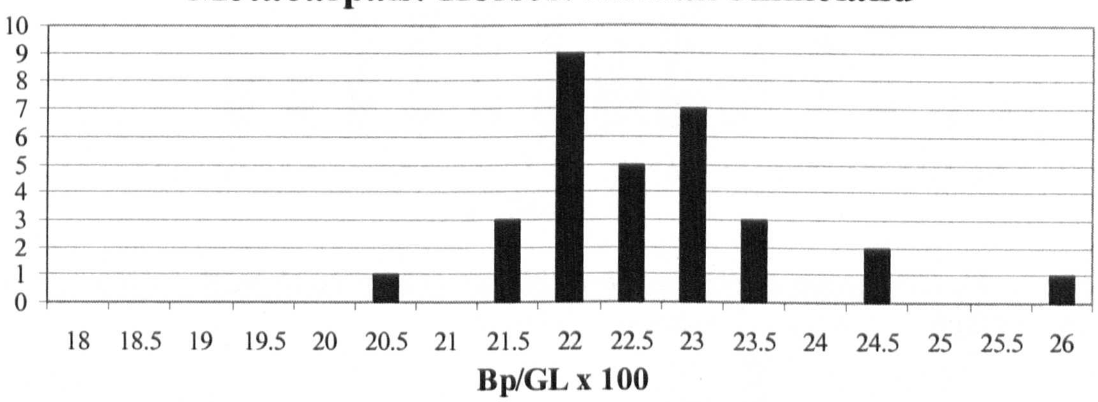
Metacarpals: Horses: Roman Gaul



Metacarpals: Horses: Roman Britain



Metacarpals: Horses: Roman Rhineland



Metacarpals: Horses: Roman Danube/Balkans

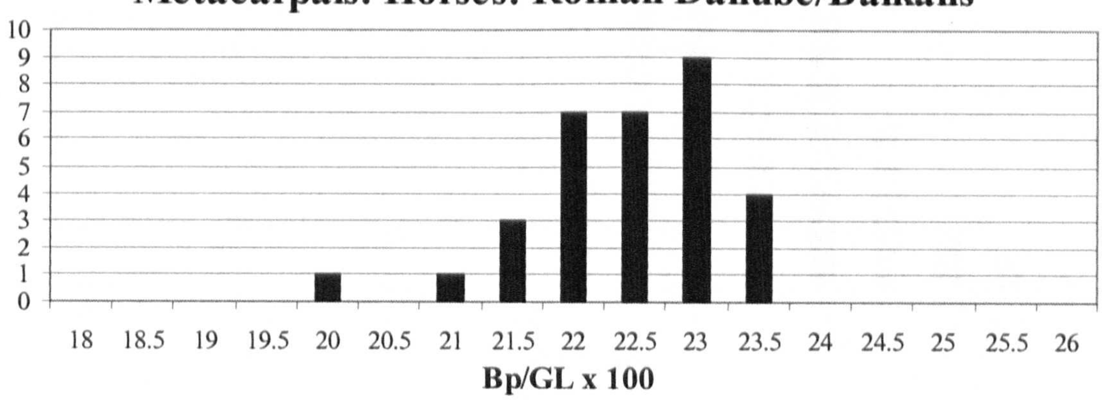
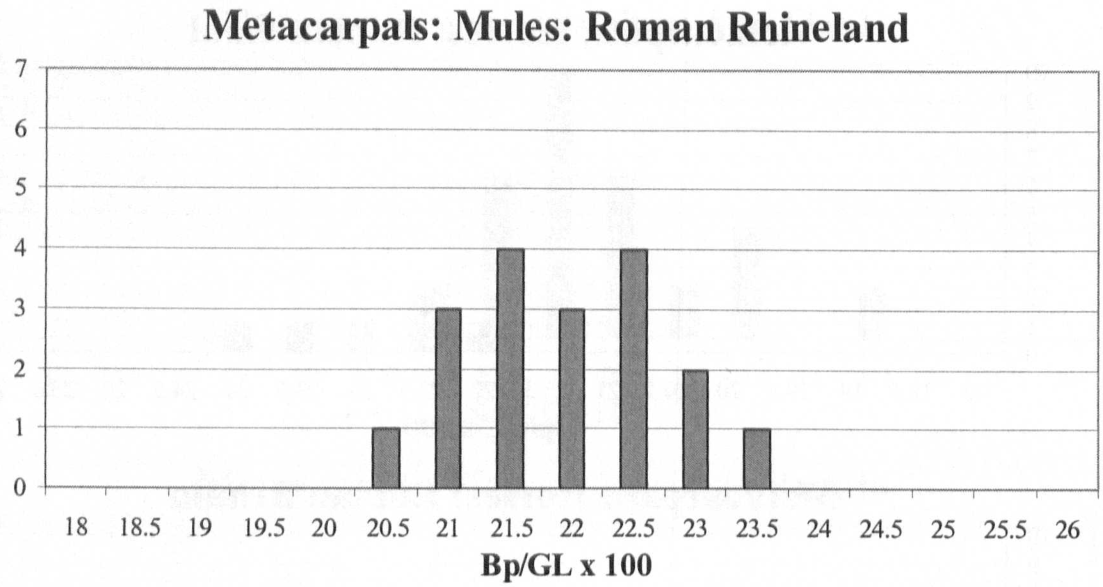


Figure A5 continued.



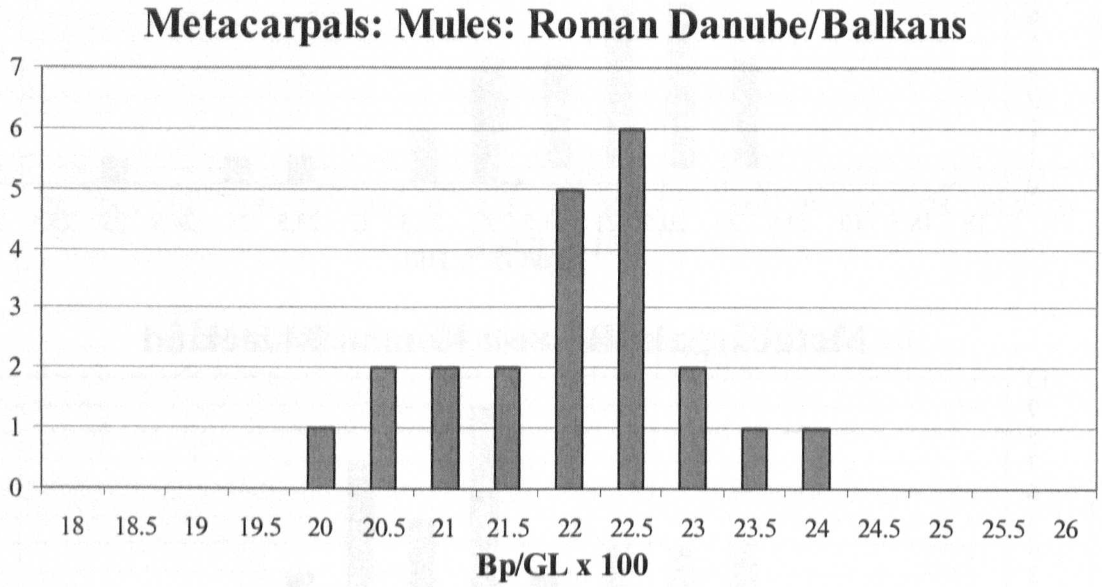


Figure A6. Histograms of proximal breadth to greatest length index for the 'identified' archaeological Roman mule metacarpals by area.

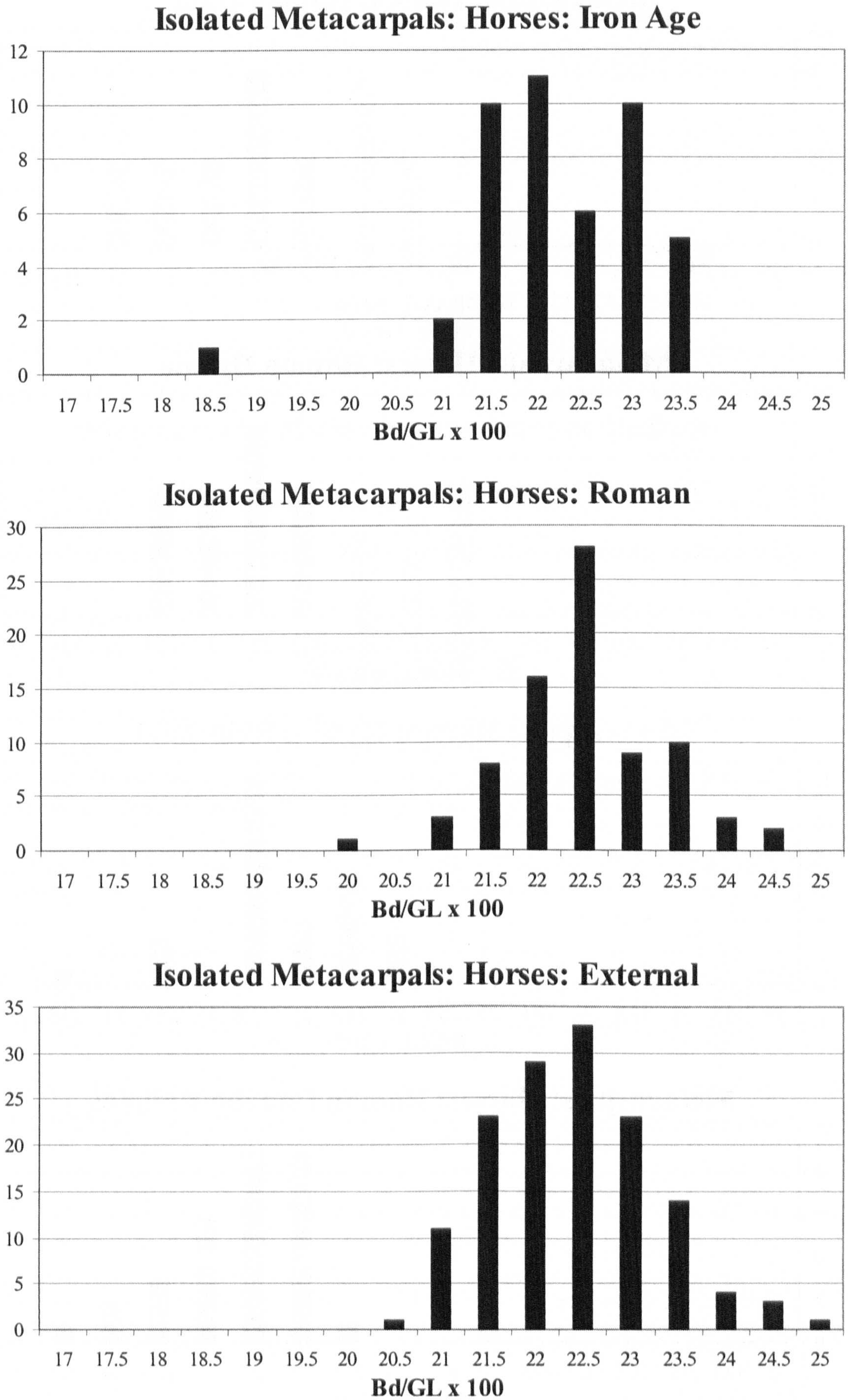


Figure A7. Histograms of distal breadth to greatest length index for the 'identified' archaeological horse metacarpals by period.

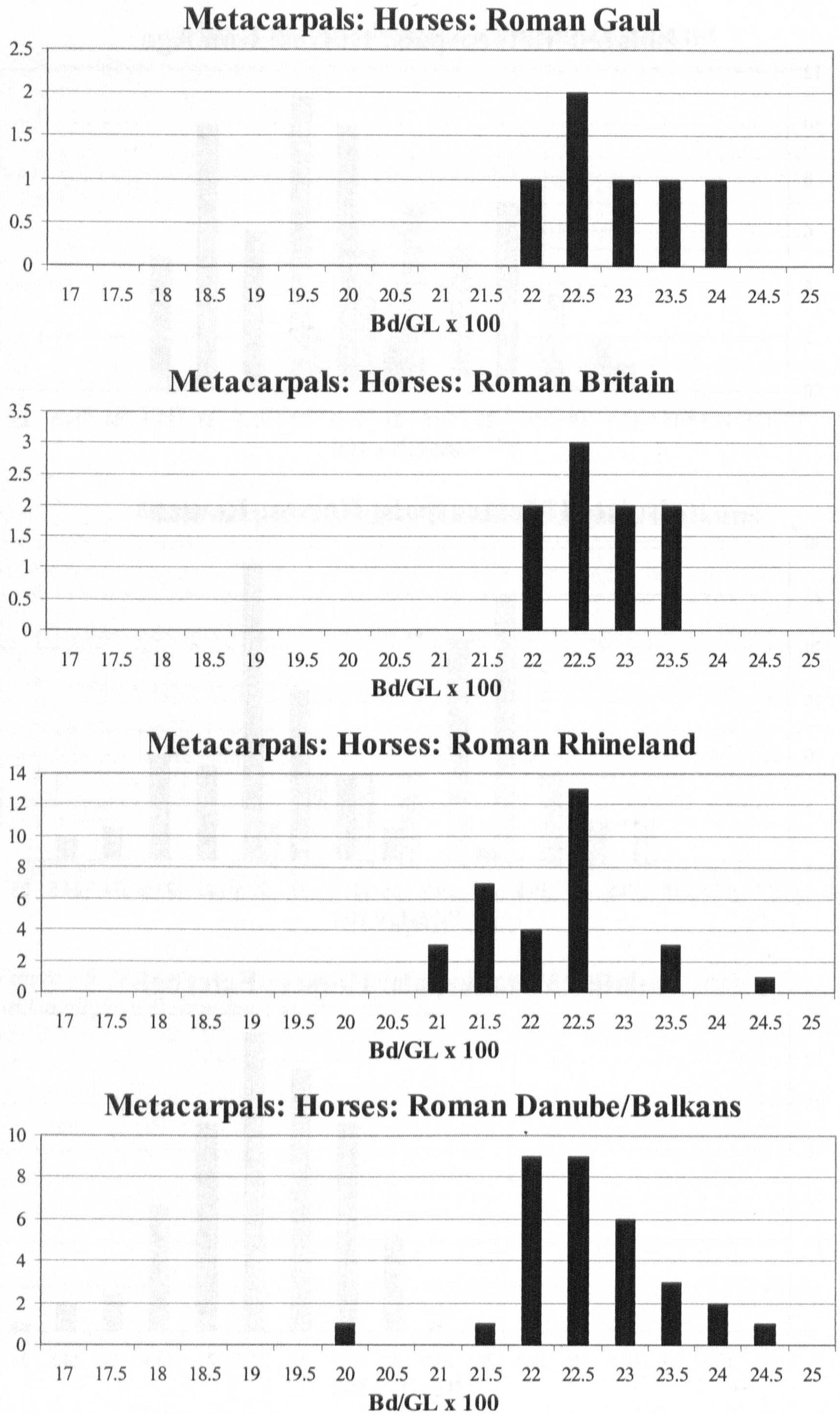
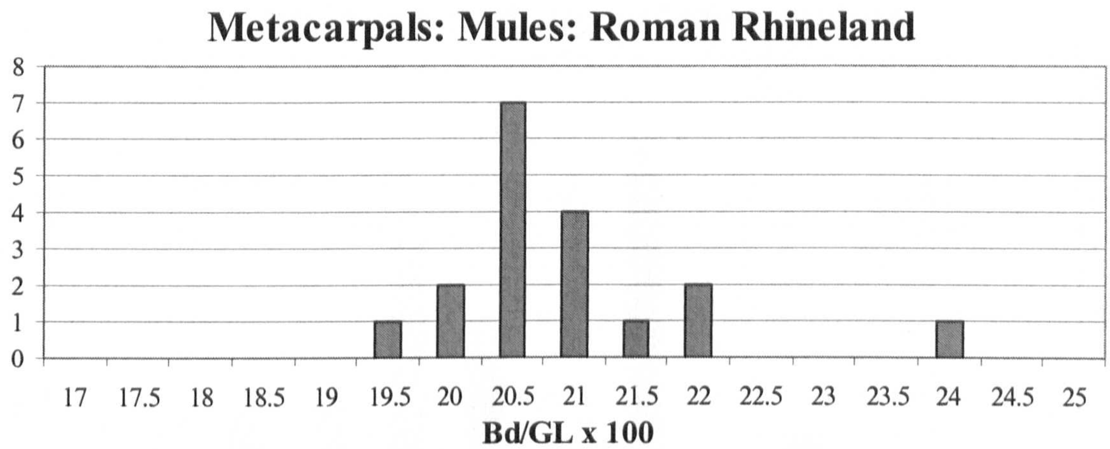


Figure A8. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman horse metacarpals by area.



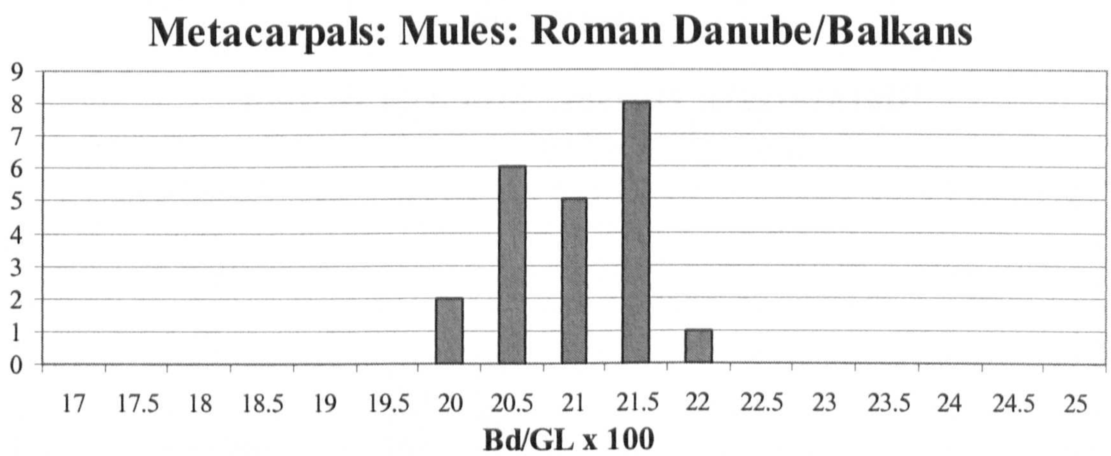


Figure A9. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman mule metacarpals by area.

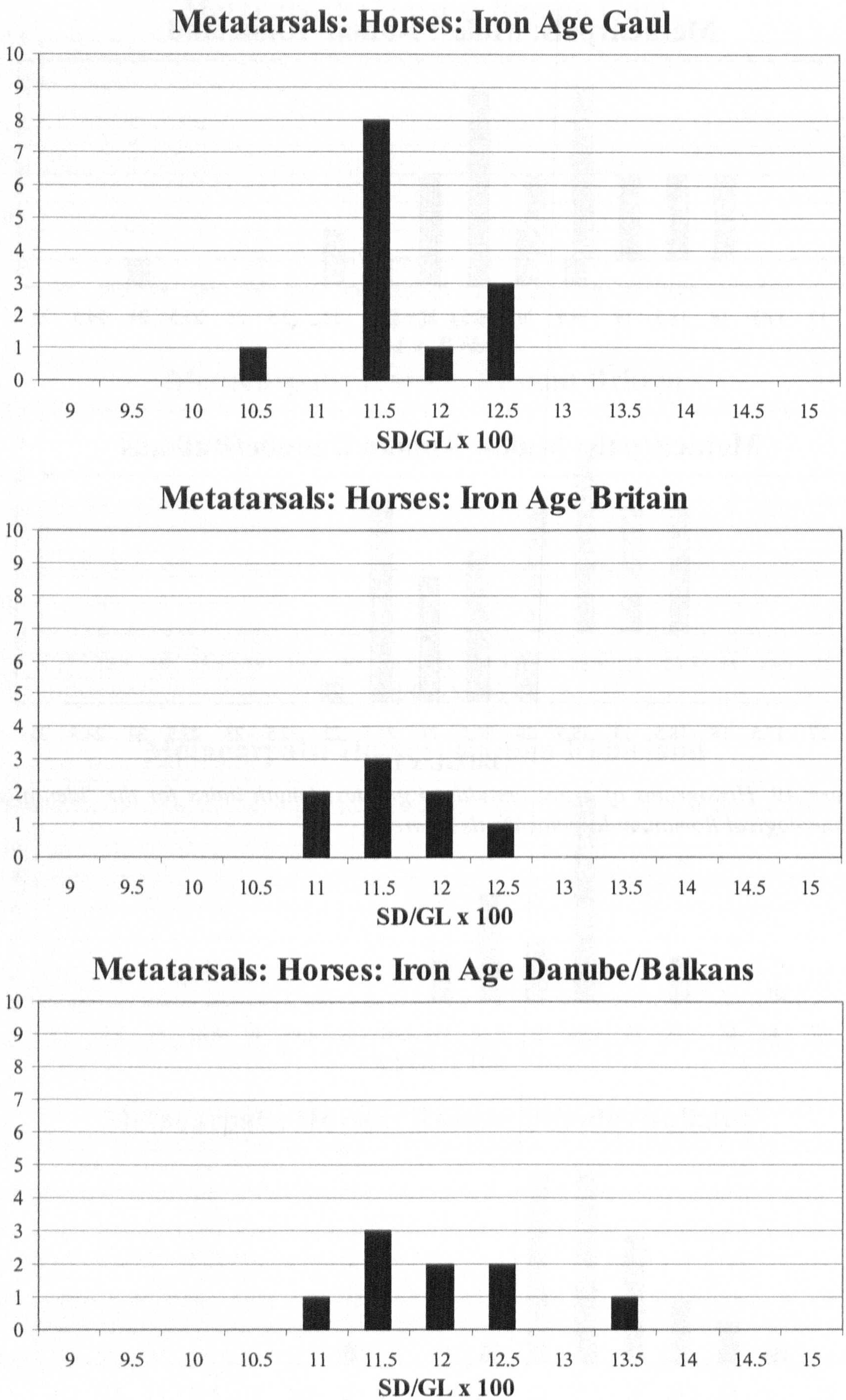
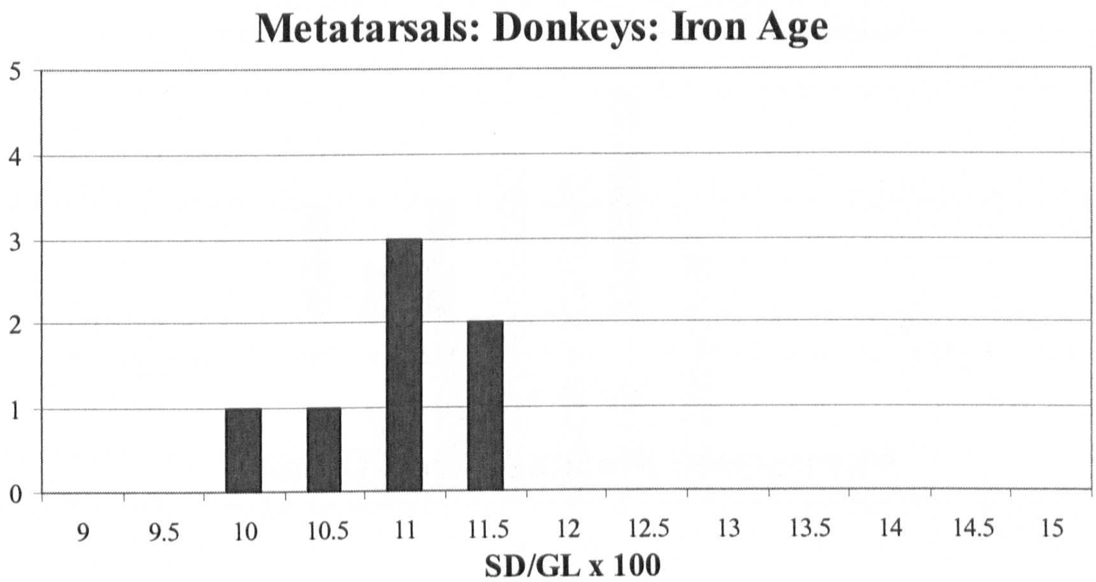


Figure A10. Histograms of shaft breadth to greatest length index for the 'identified' archaeological Iron Age horse metatarsals by area



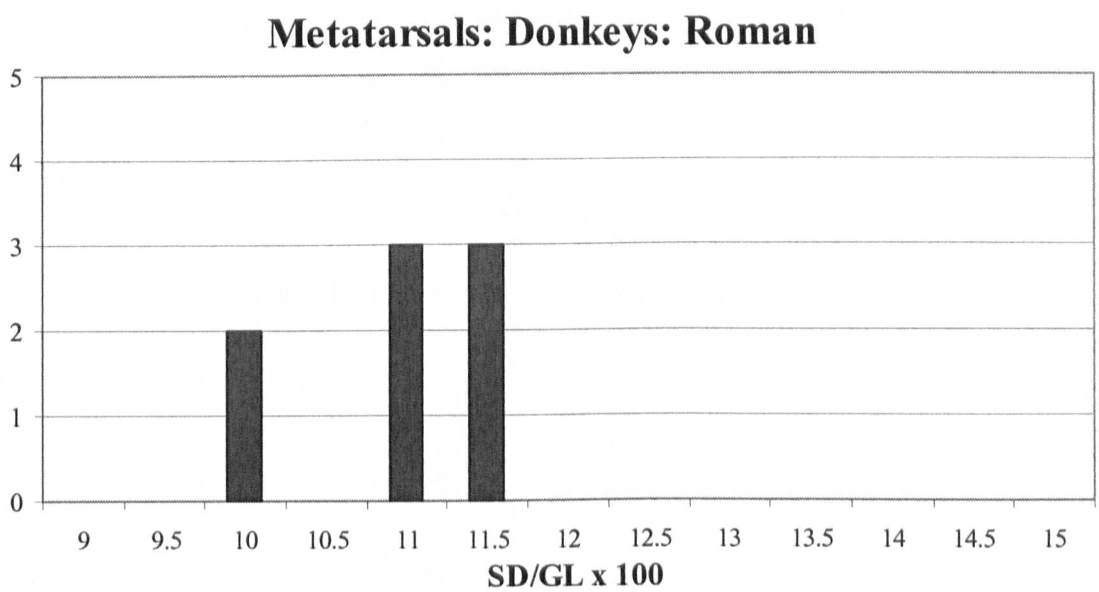


Figure A11. Histograms of shaft breadth to greatest length index for the 'identified' archaeological donkey metatarsals by period

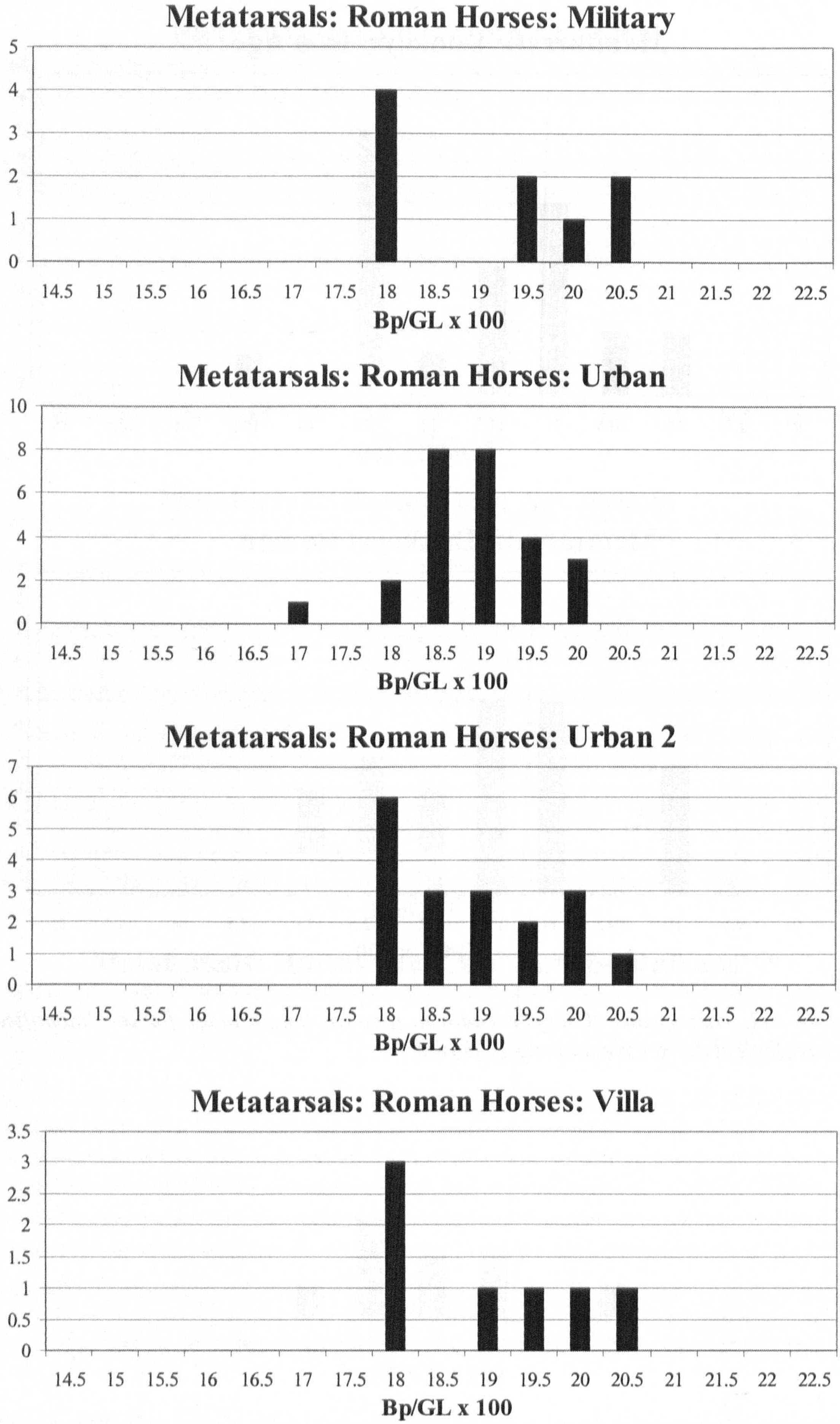
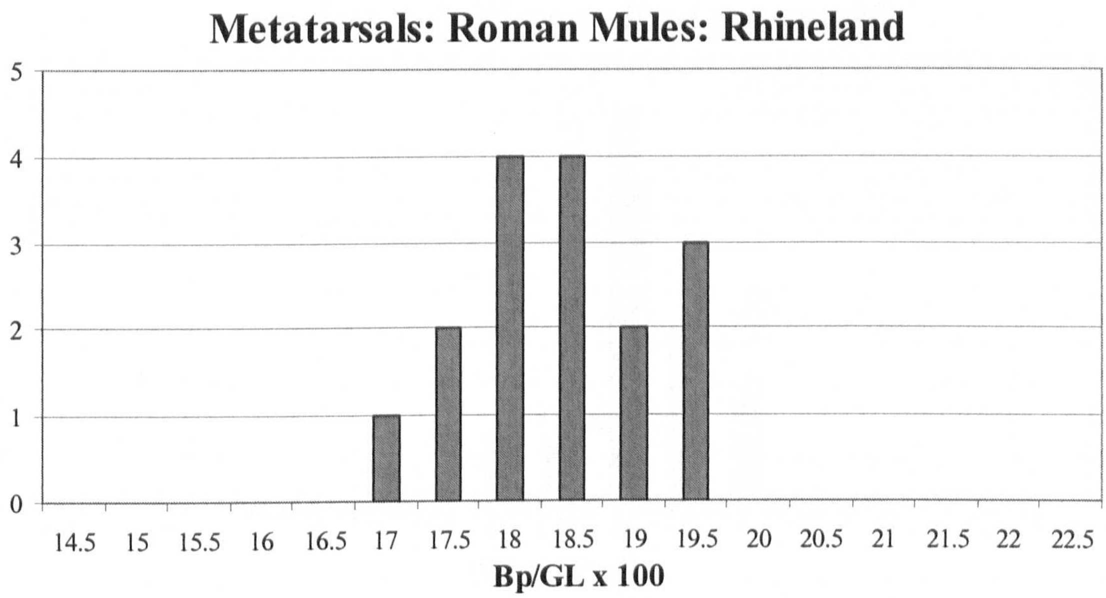


Figure A12. Histograms of proximal breadth to greatest length index for the 'identified' archaeological Roman horse metatarsals by site type.



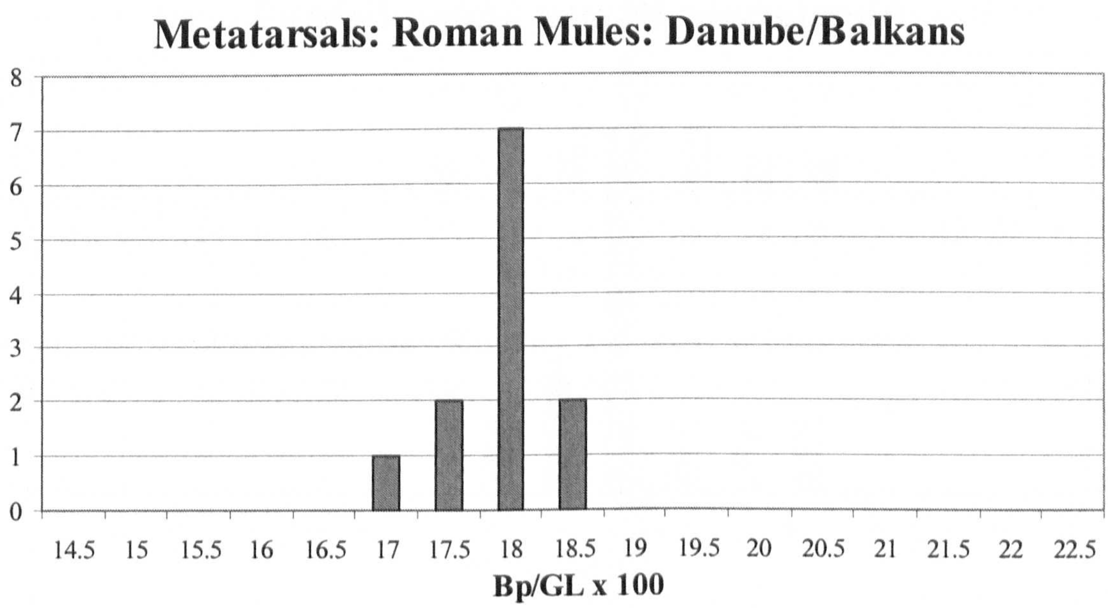
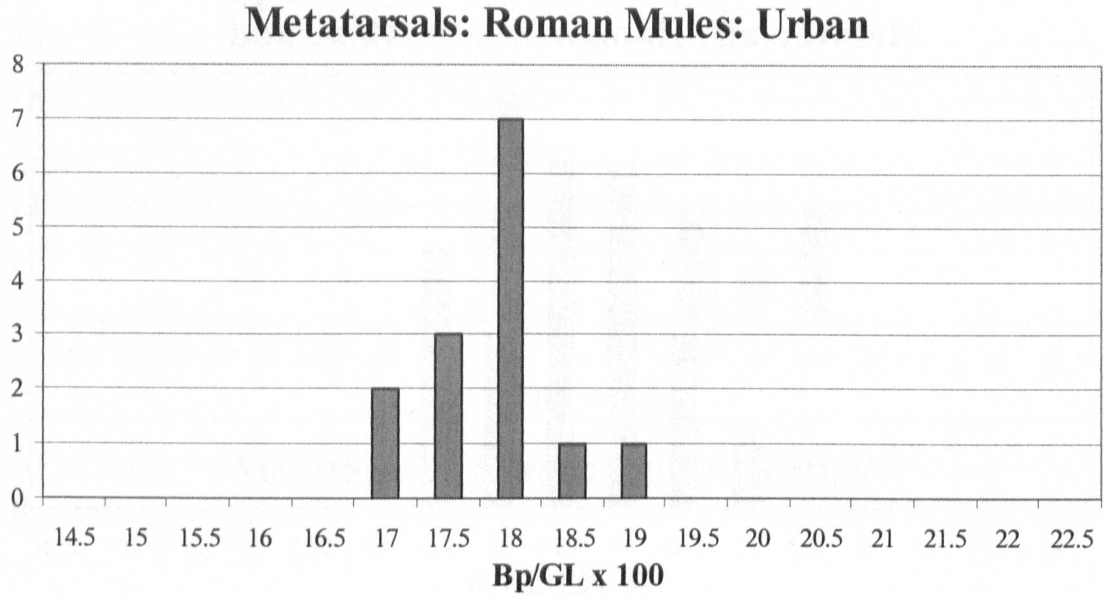


Figure A13. Histograms of proximal breadth to greatest length index for the 'identified' archaeological Roman mule metatarsals by area.



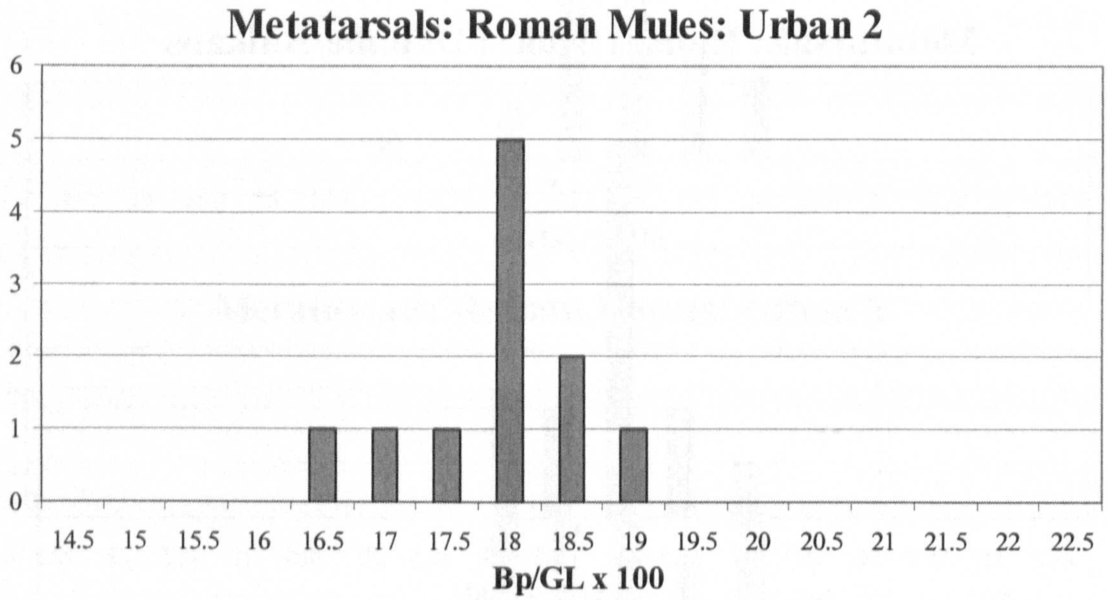


Figure A14. Histograms of proximal breadth to greatest length index for the 'identified' archaeological Roman mule metatarsals by site type.

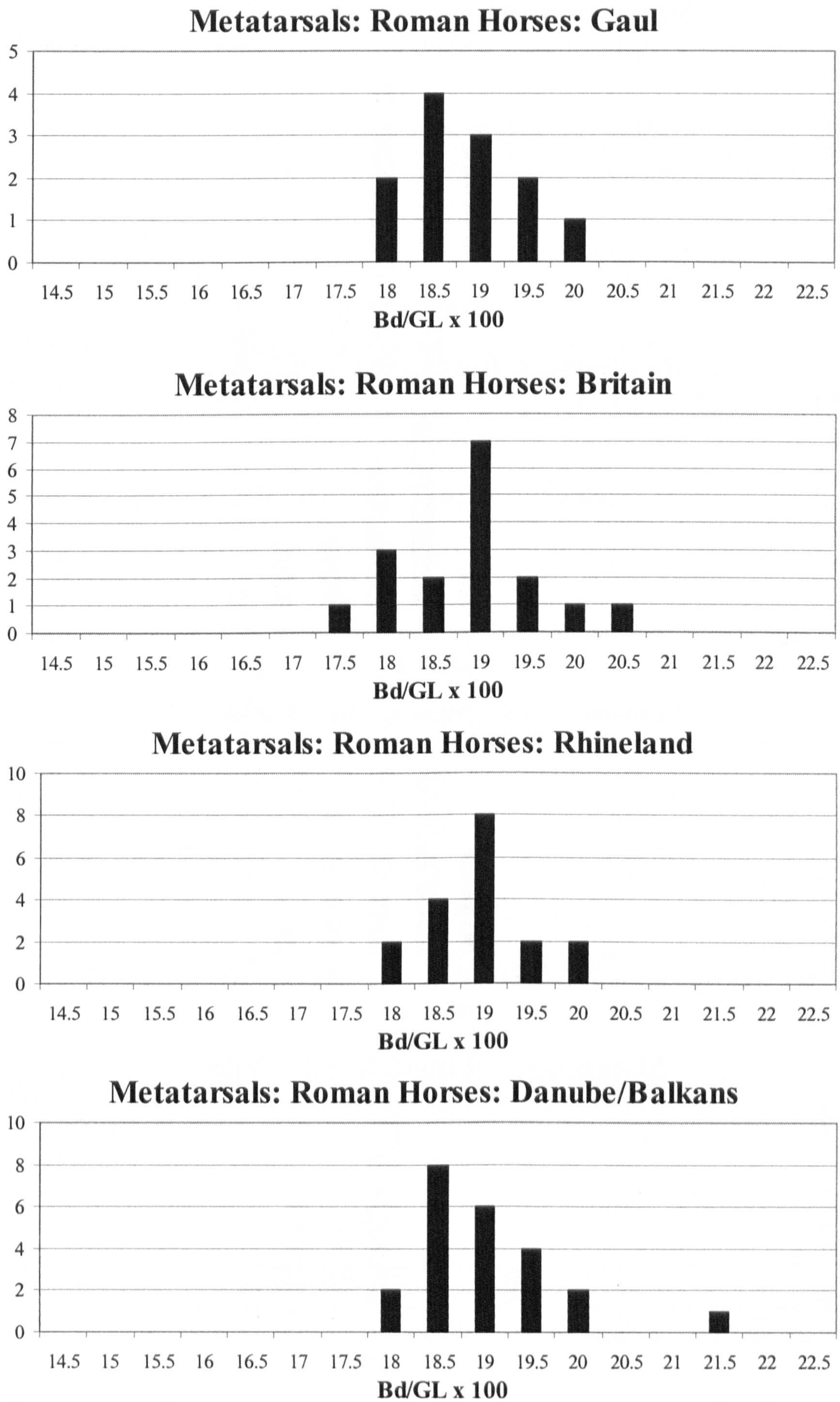


Figure A15. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman horse metatarsals by area.

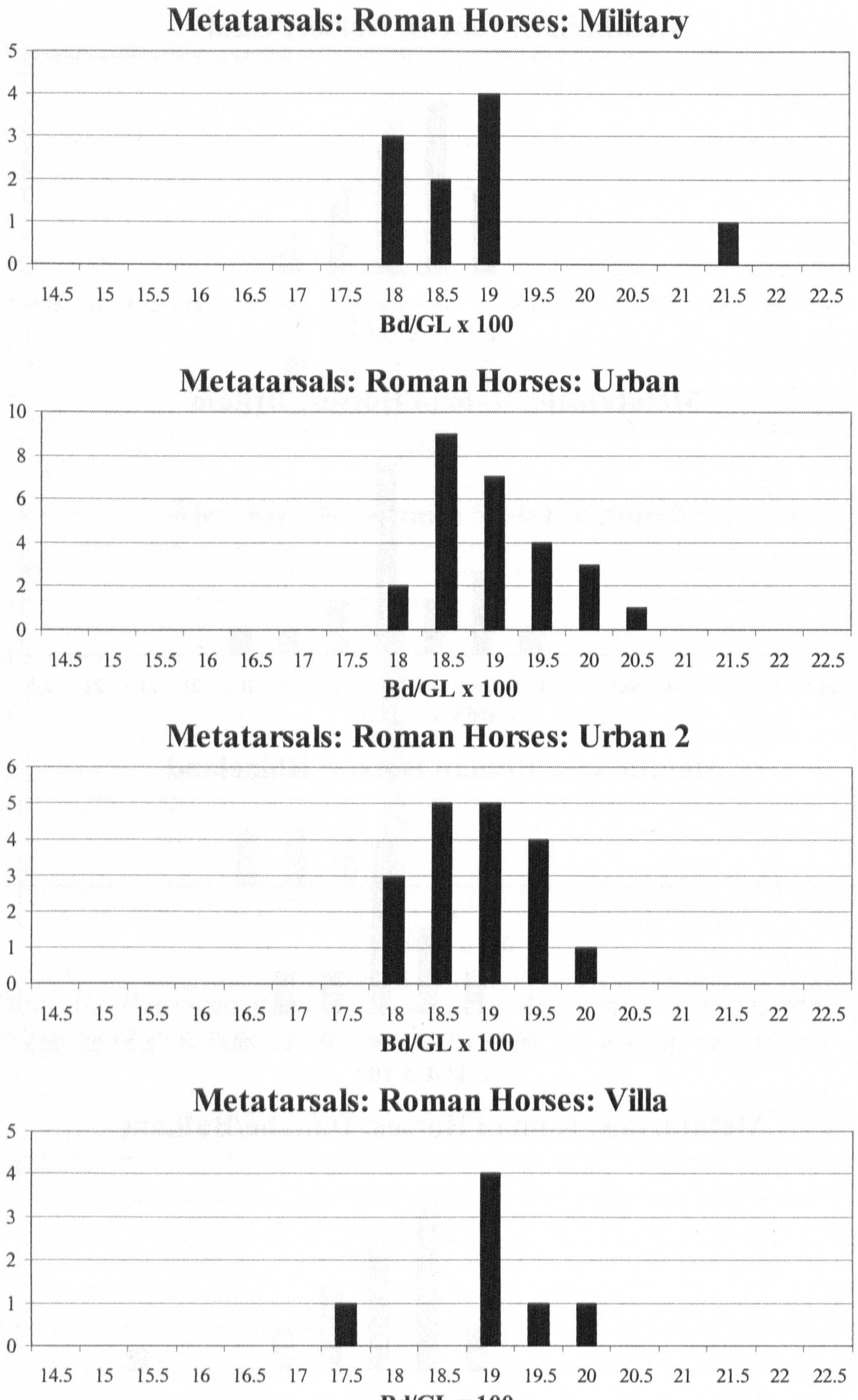


Figure A16. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman horse metatarsals by site type.

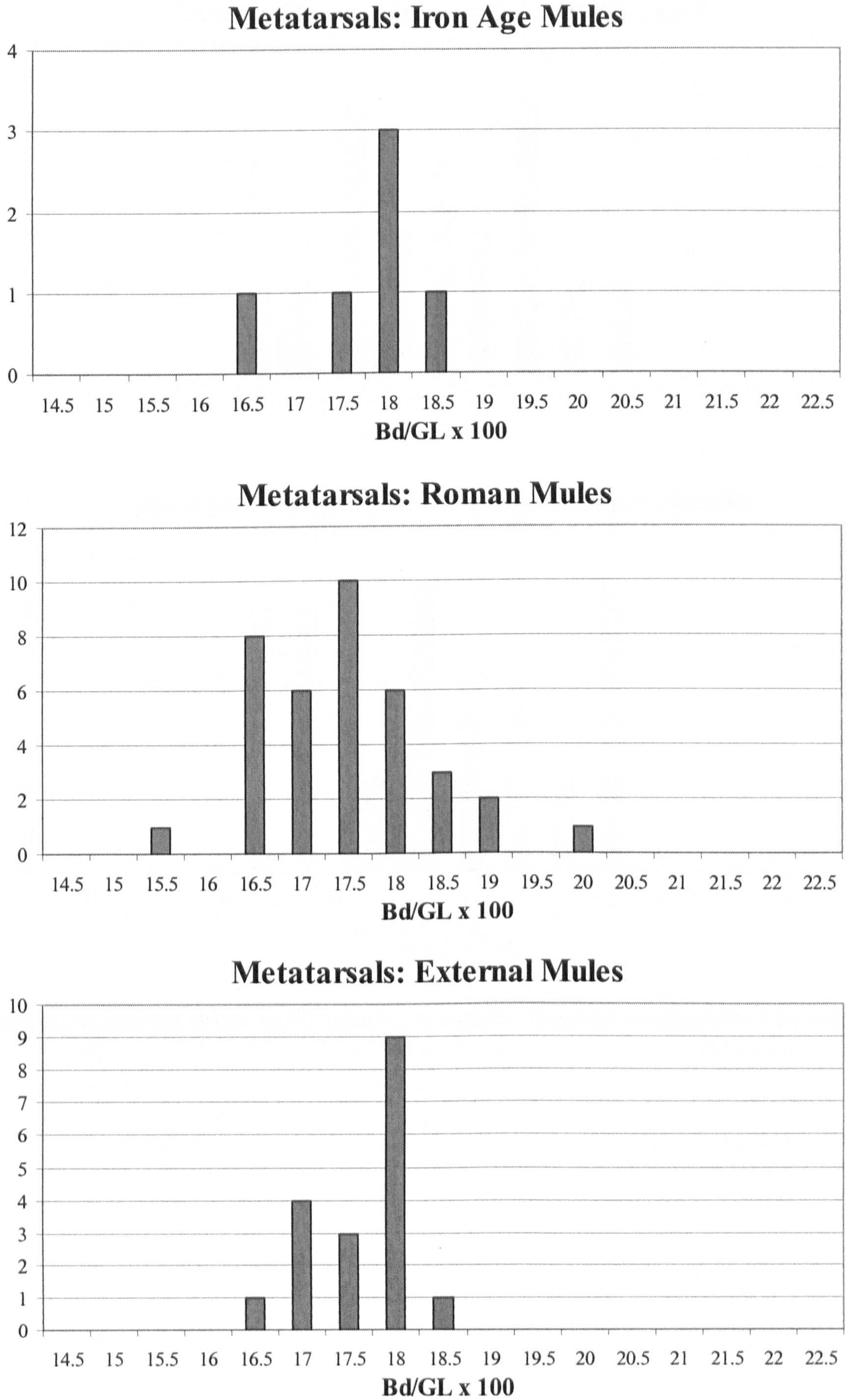
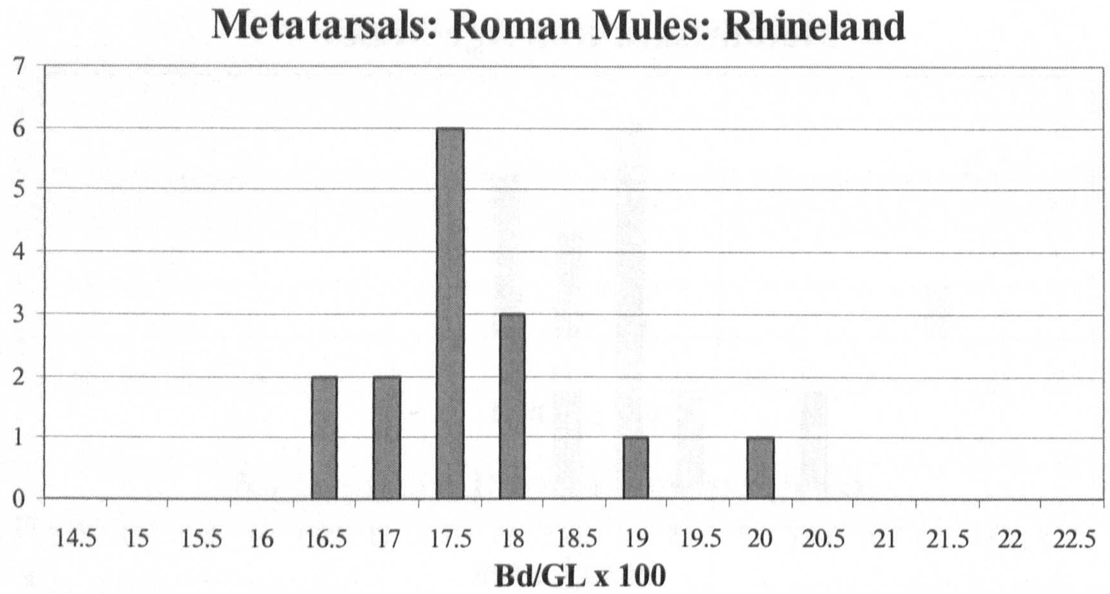


Figure A17. Histograms of distal breadth to greatest length index for the 'identified' archaeological mule metatarsals by period.



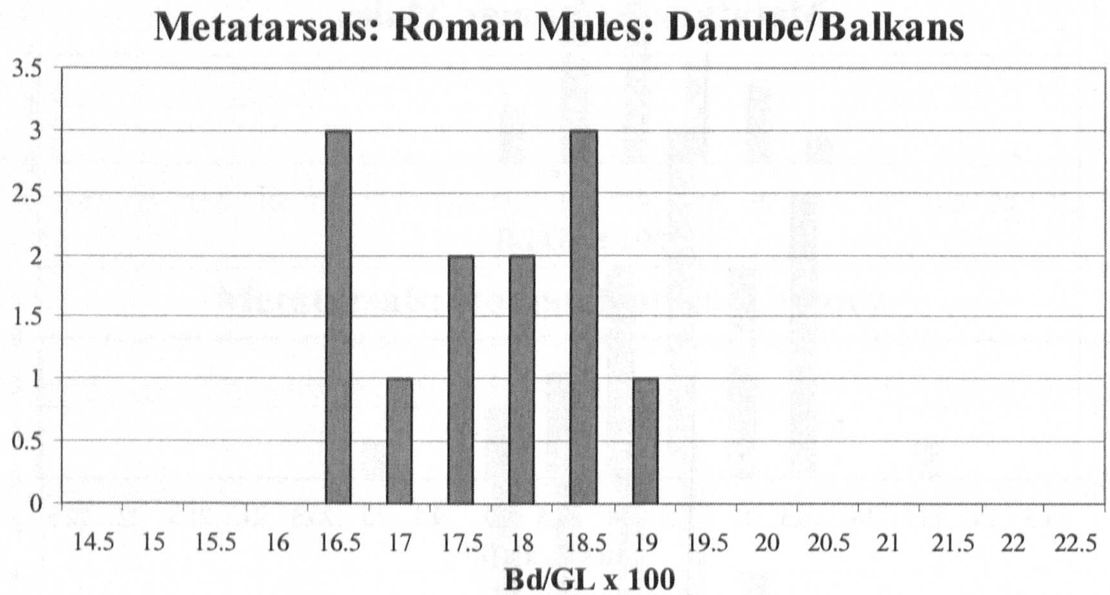
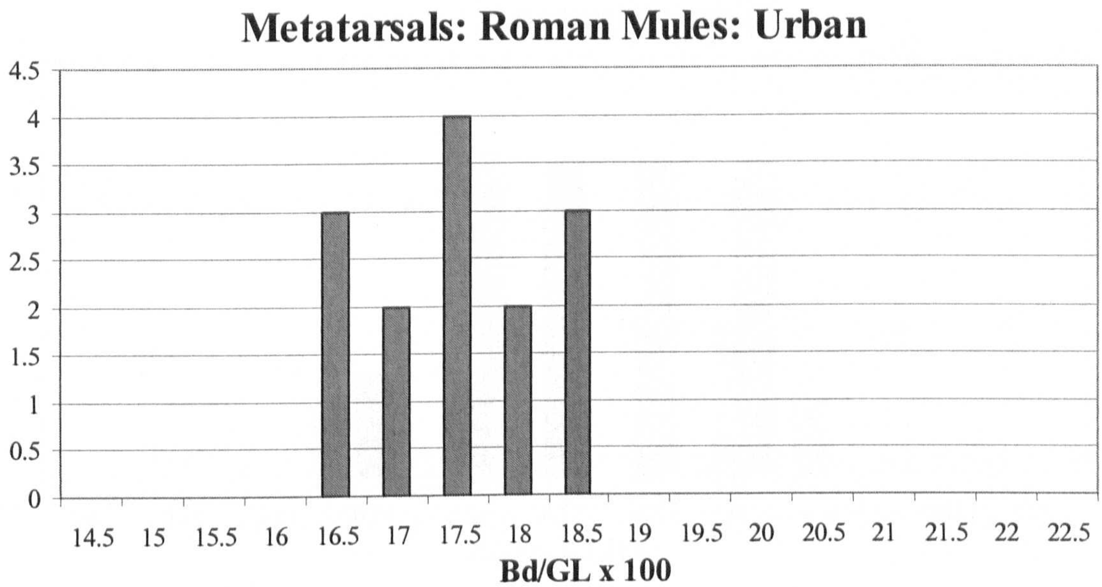


Figure A18. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman mule metatarsals by area.



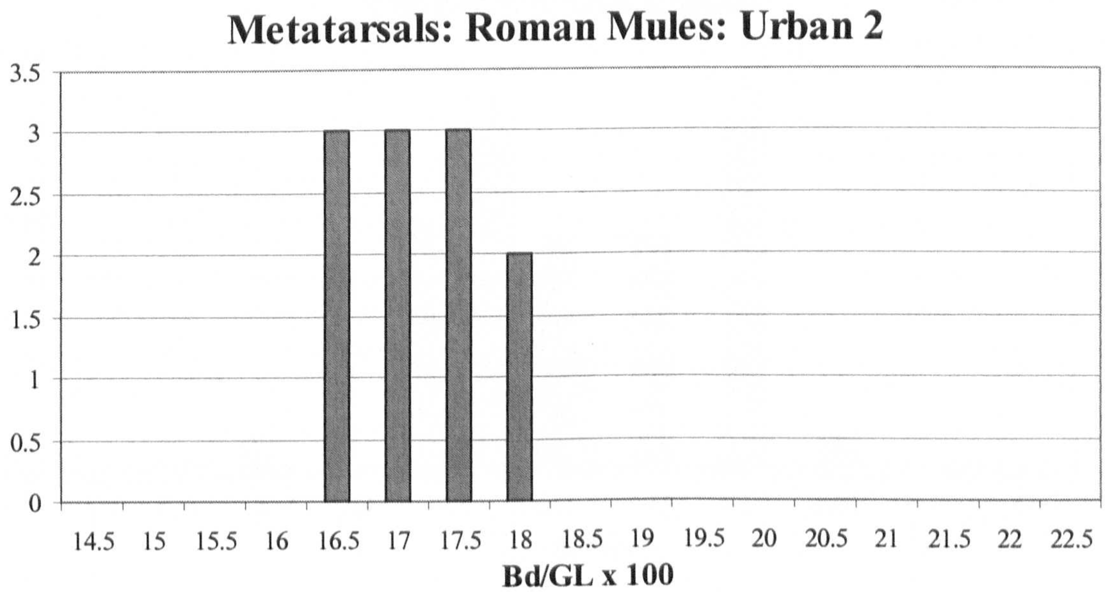
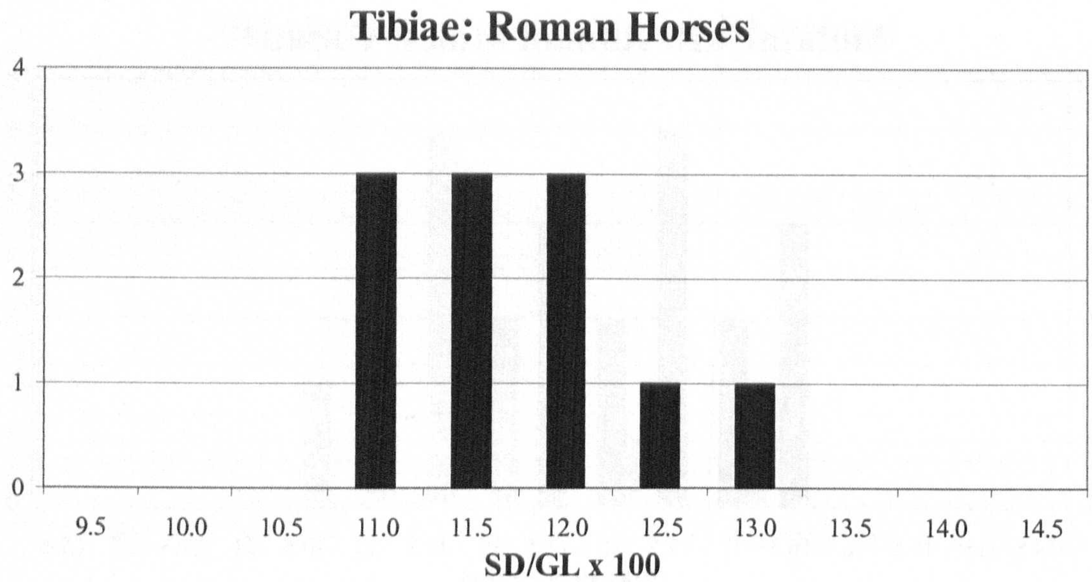


Figure A19. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman mule metatarsals by site type.



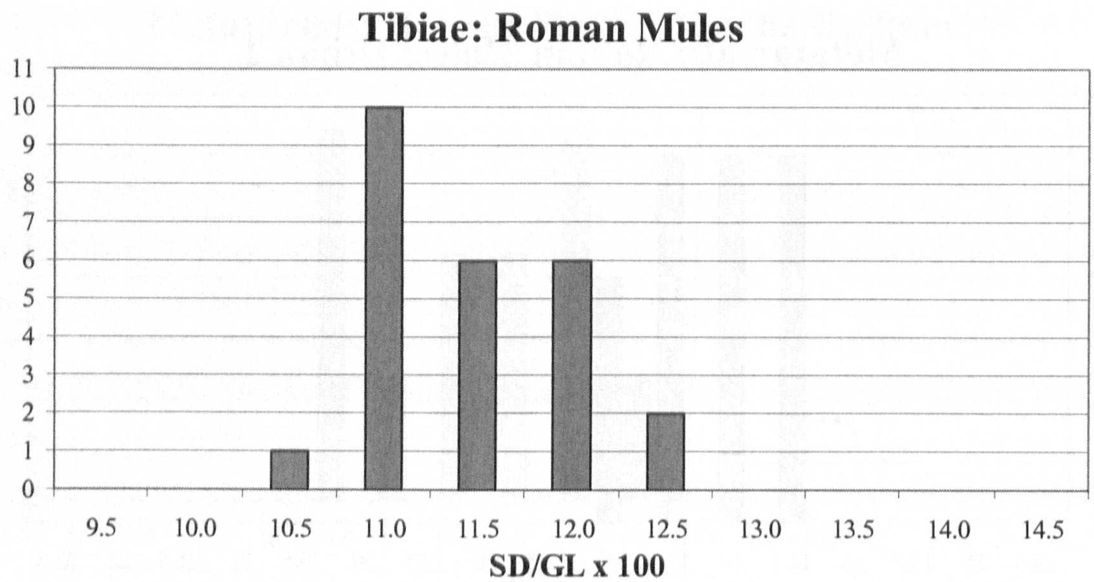
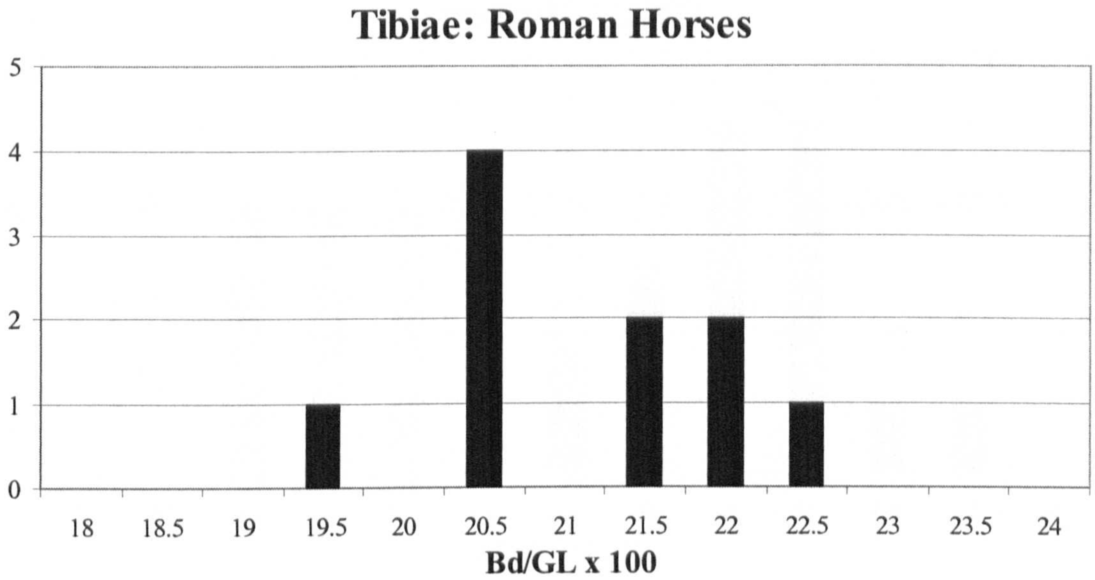


Figure A20. Histograms of shaft breadth to greatest length index for the 'identified' archaeological Roman horse and mule tibiae.



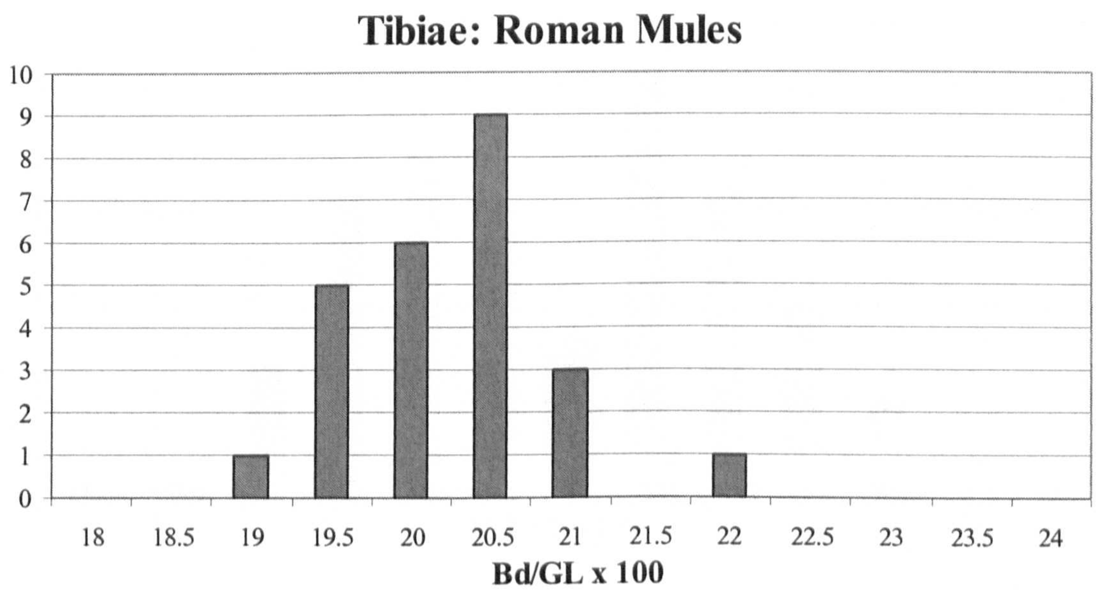


Figure A21. Histograms of distal breadth to greatest length index for the 'identified' archaeological Roman horse and mule tibiae.

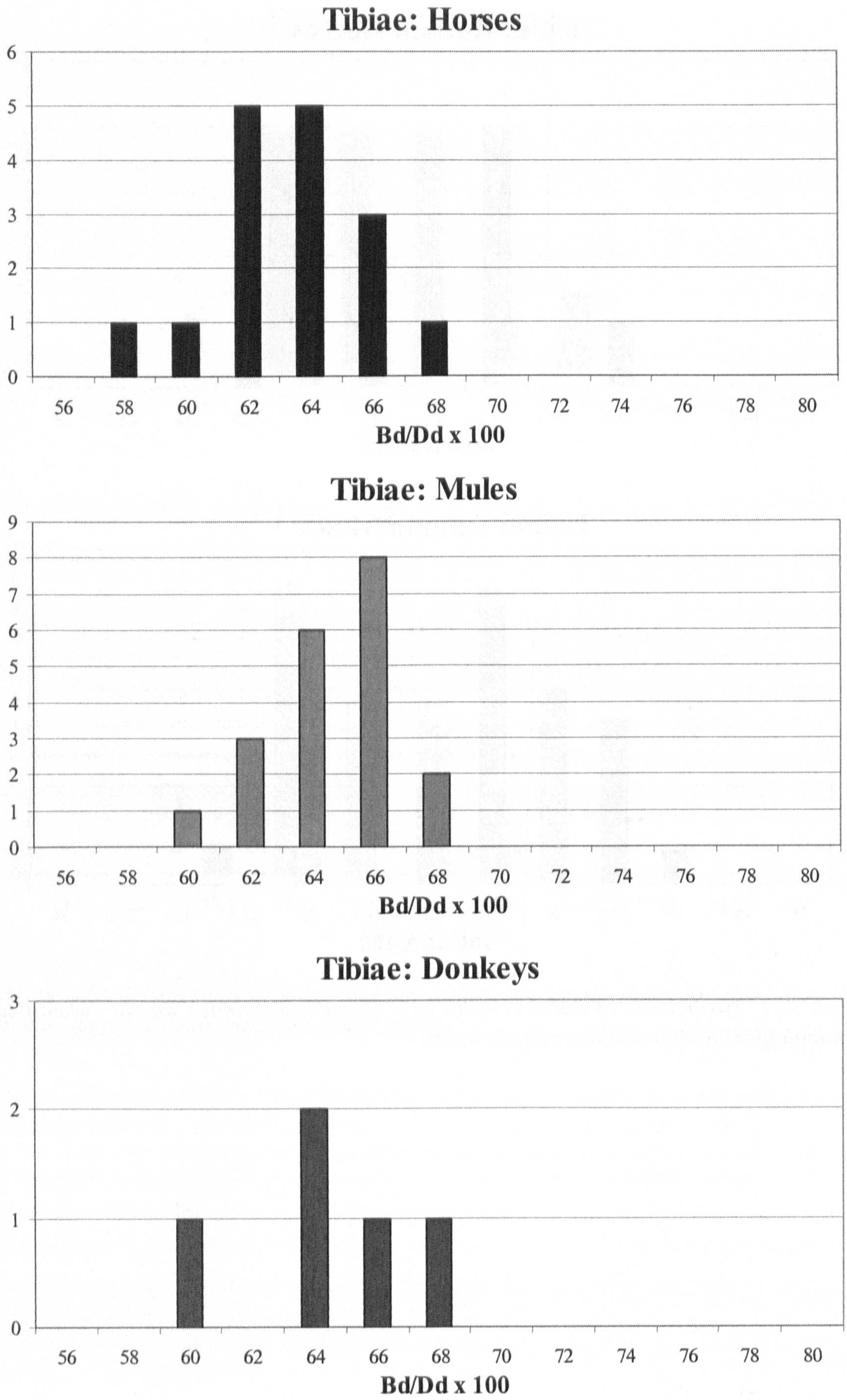
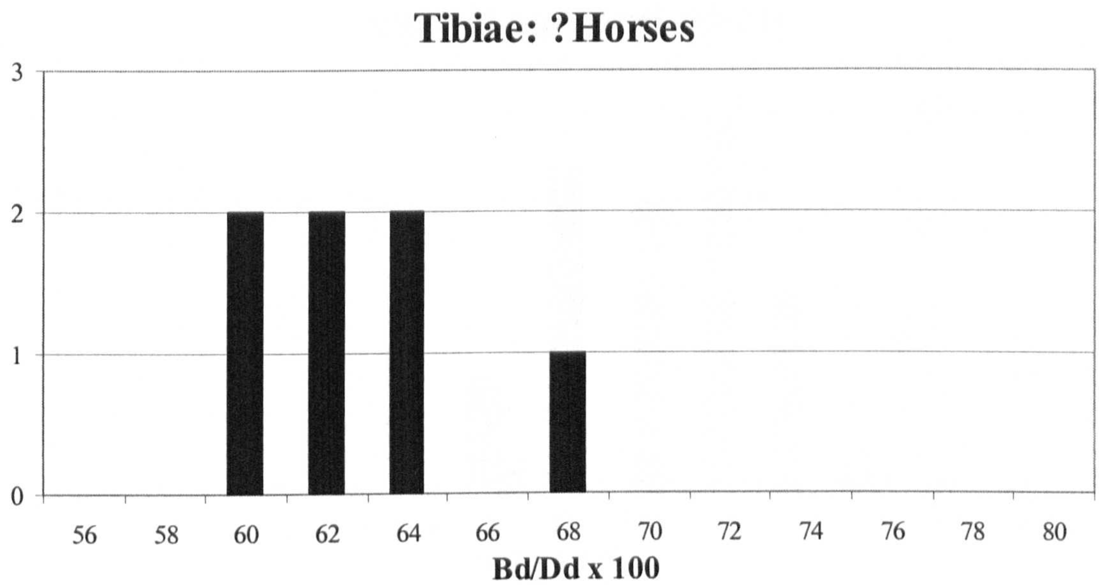


Figure A22. Histograms of distal depth to distal breadth index for the 'identified' archaeological tibiae by species.



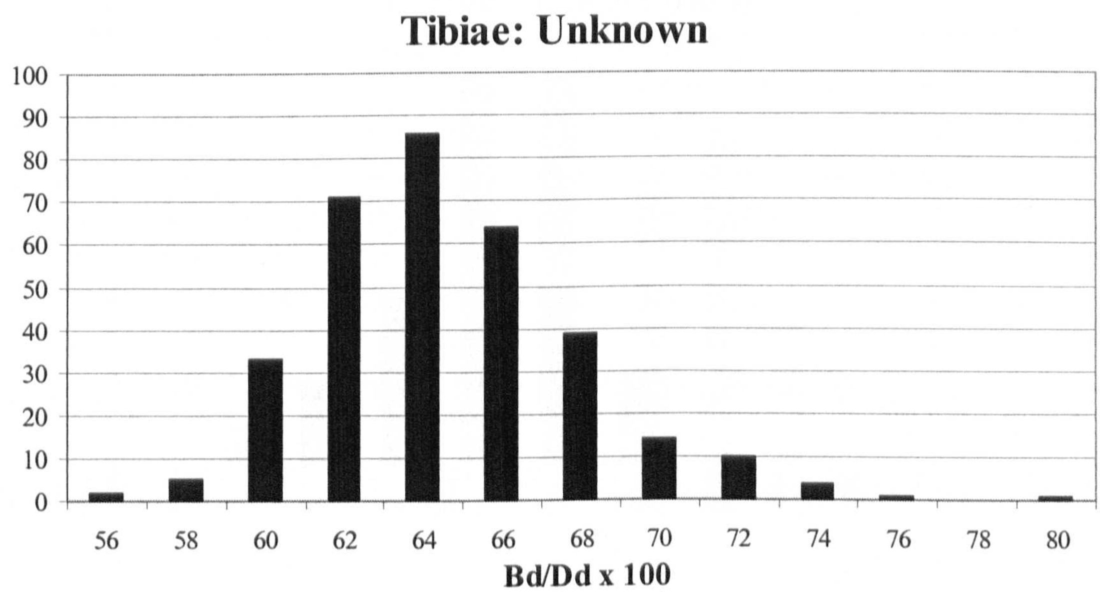
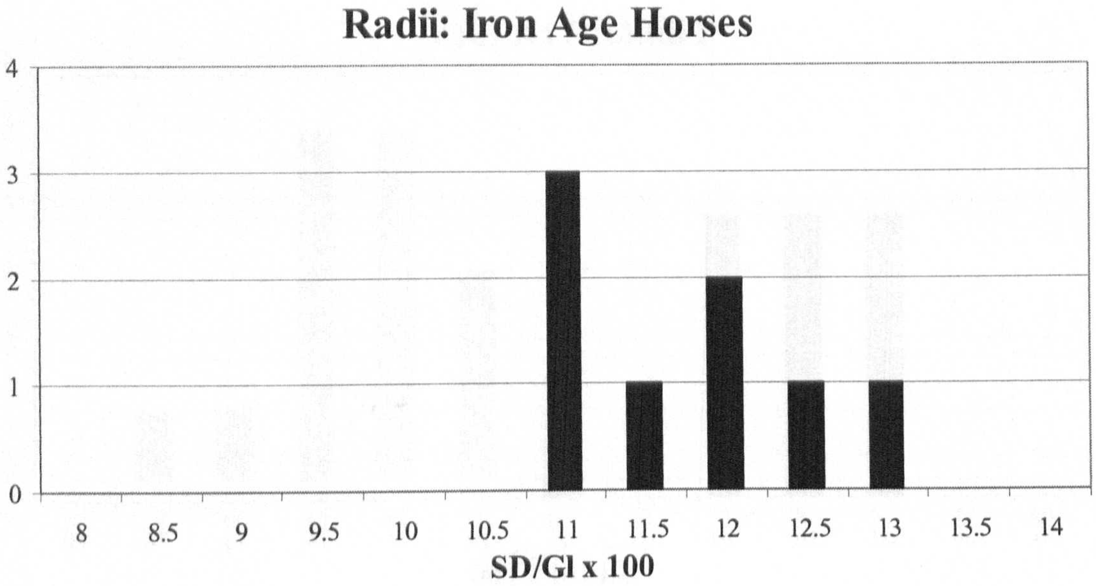
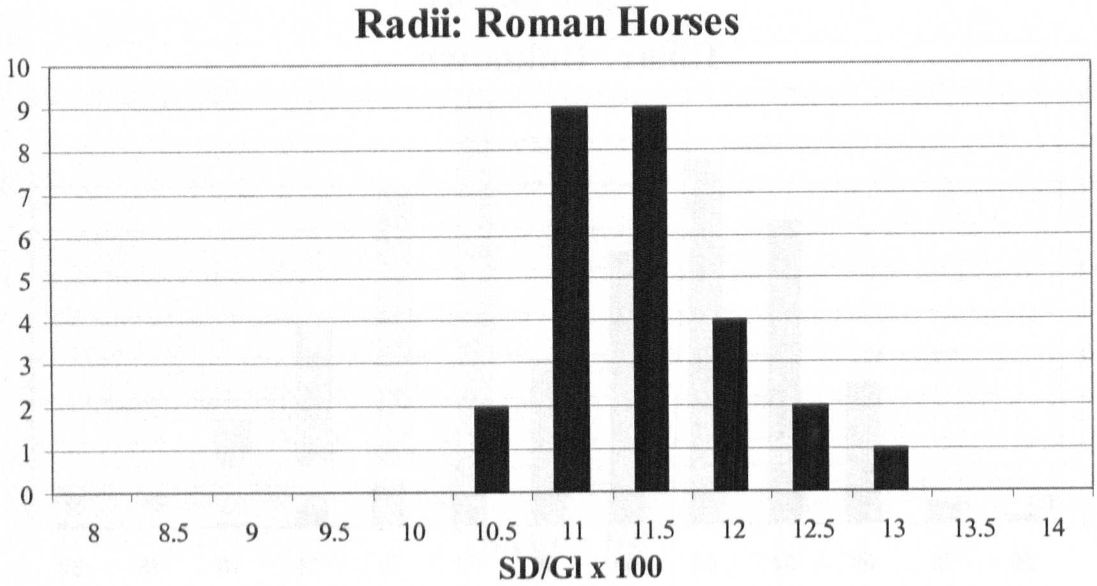


Figure A23. Histograms of distal depth to distal breadth index for the 'ambiguous' and 'unknown' archaeological tibiae by species.





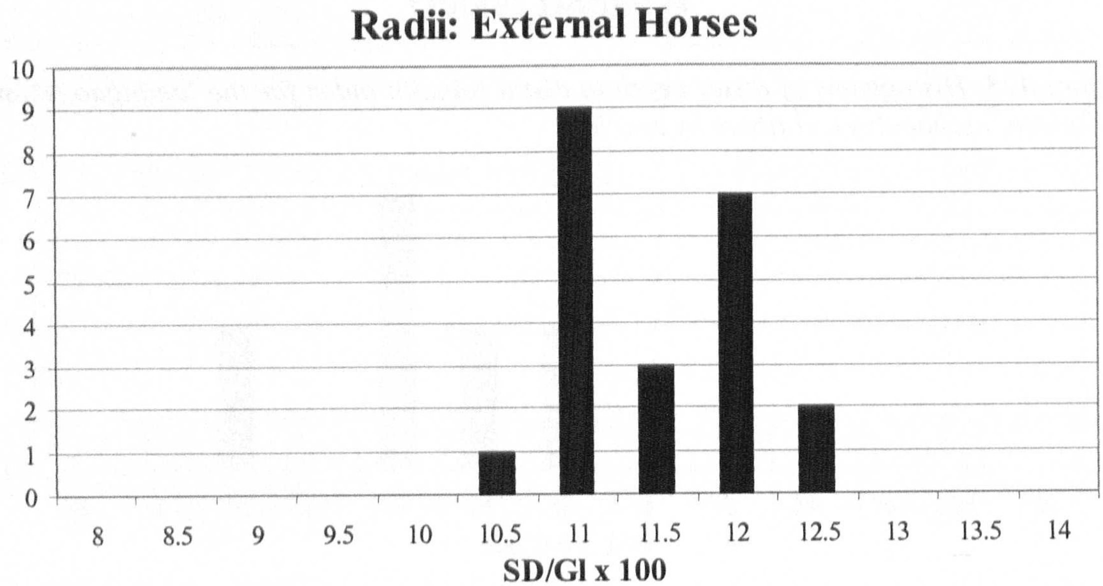
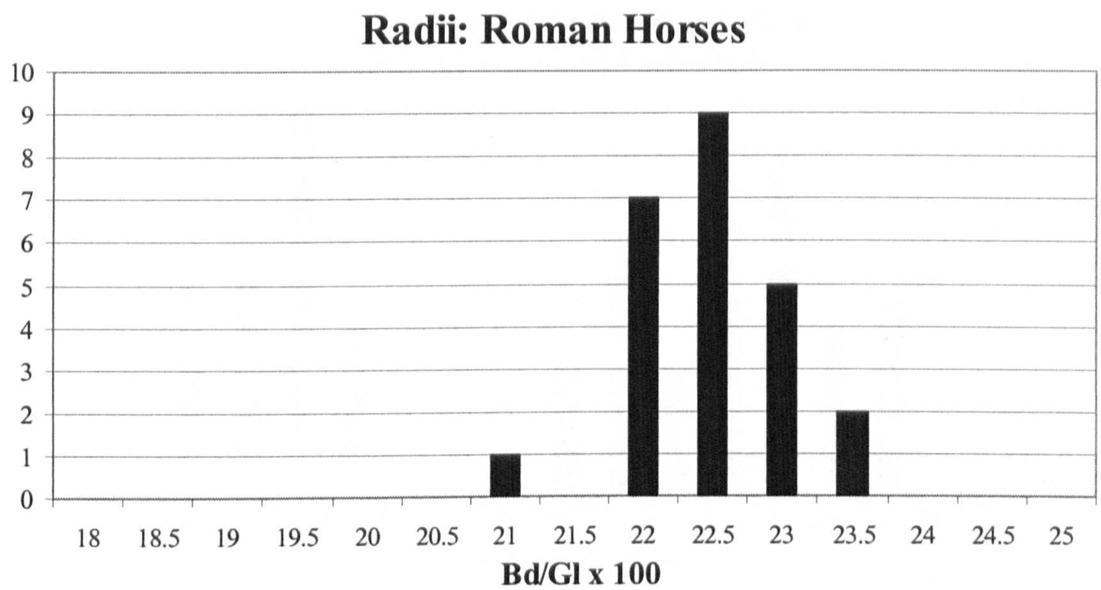


Figure A24. Histograms of shaft breadth to greatest length index for the'identified' archaeological horse radii by period.



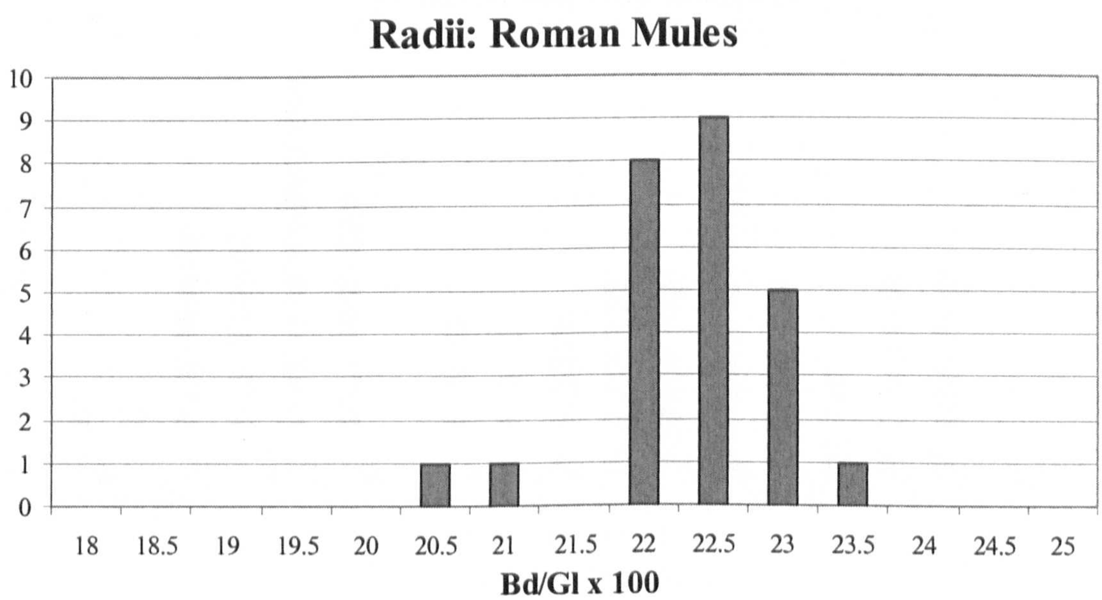


Figure A25. Histograms of distal breadth to greatest length index for the'identified' archaeological Roman horse and mule radii.

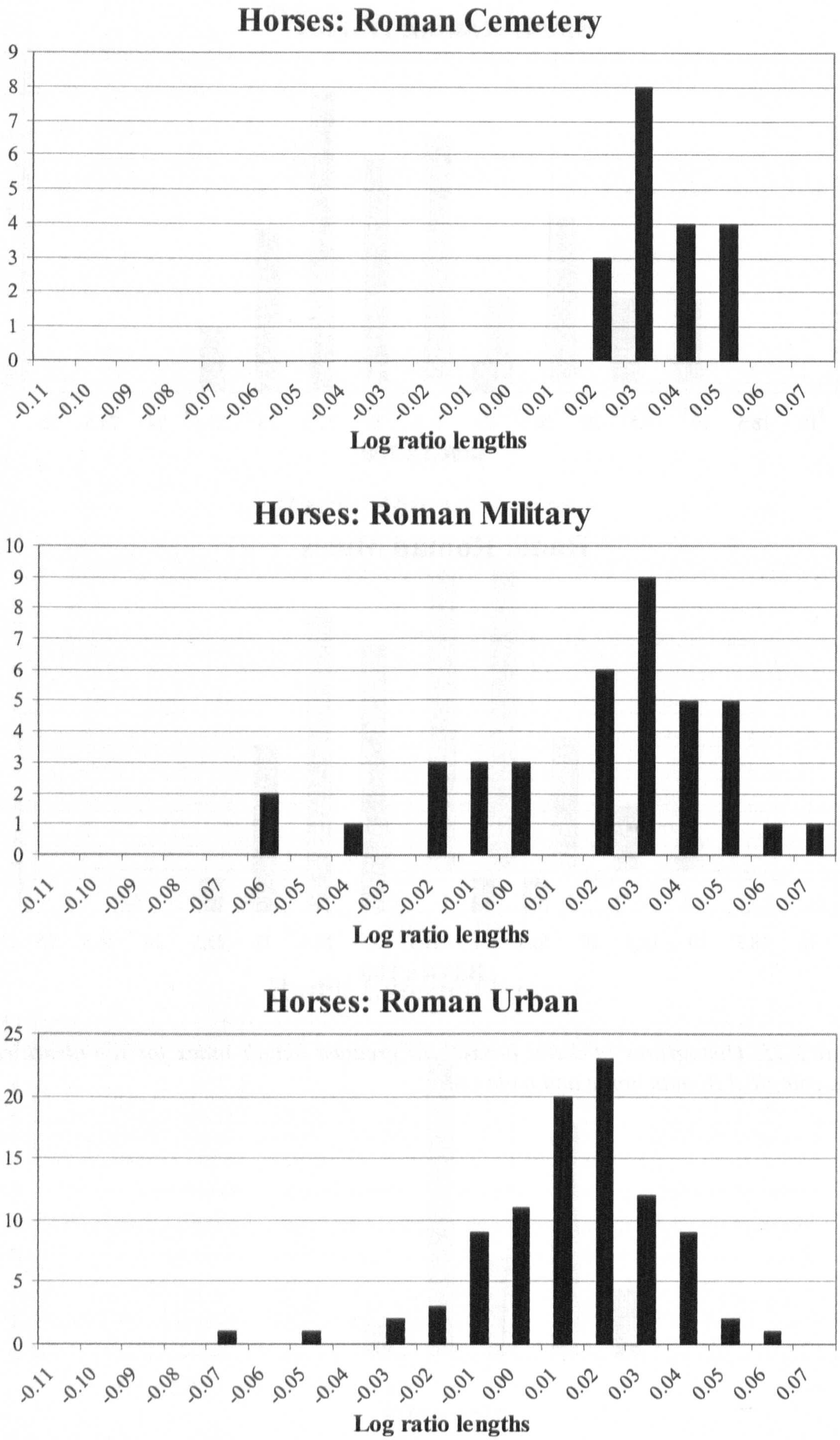


Figure A26. Histograms of log-ratio lengths for the 'identified' archaeological horses by site type.

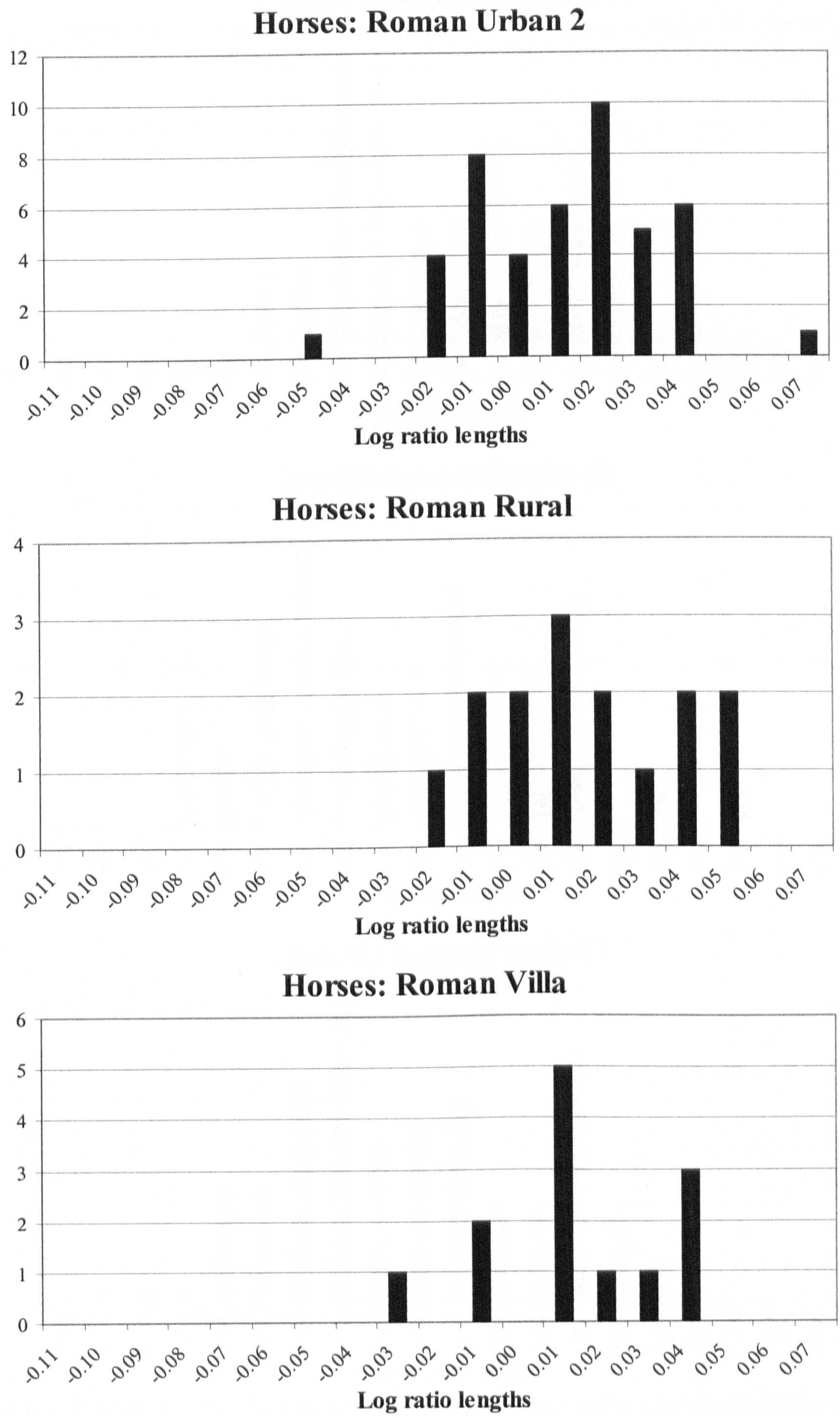
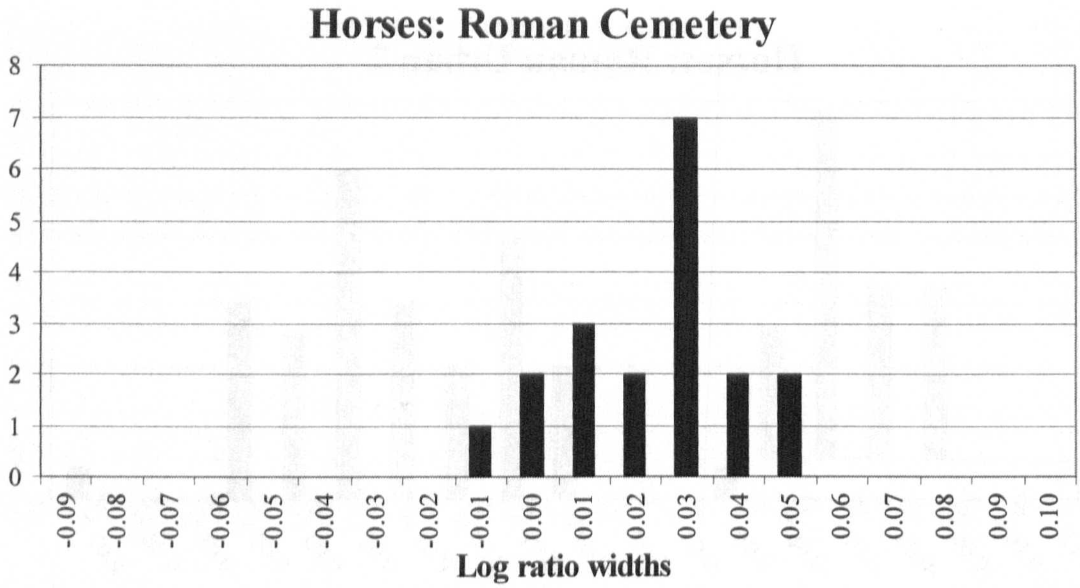
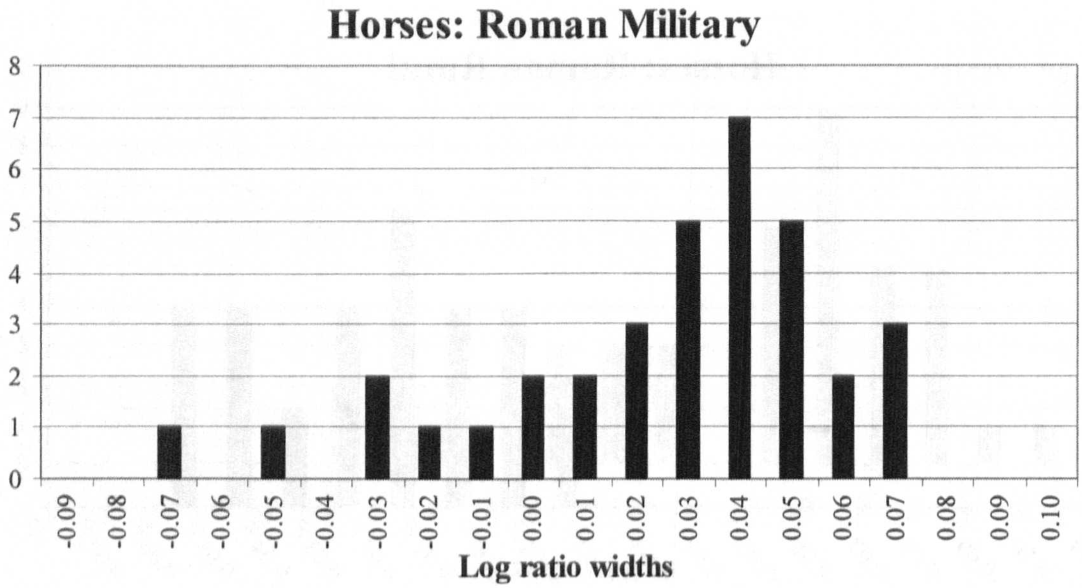


Figure A26 continueud.





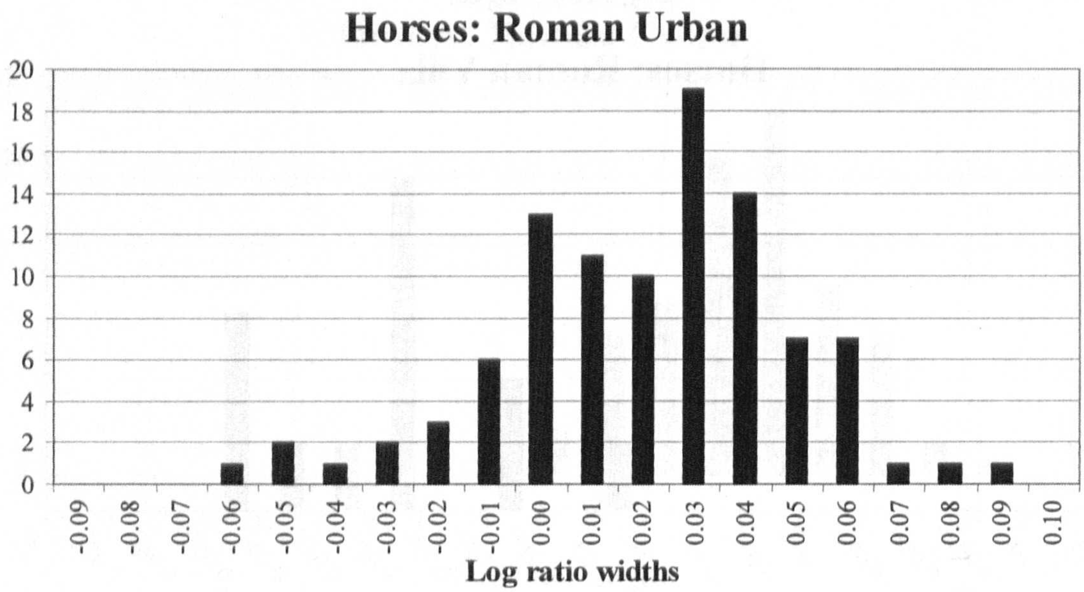
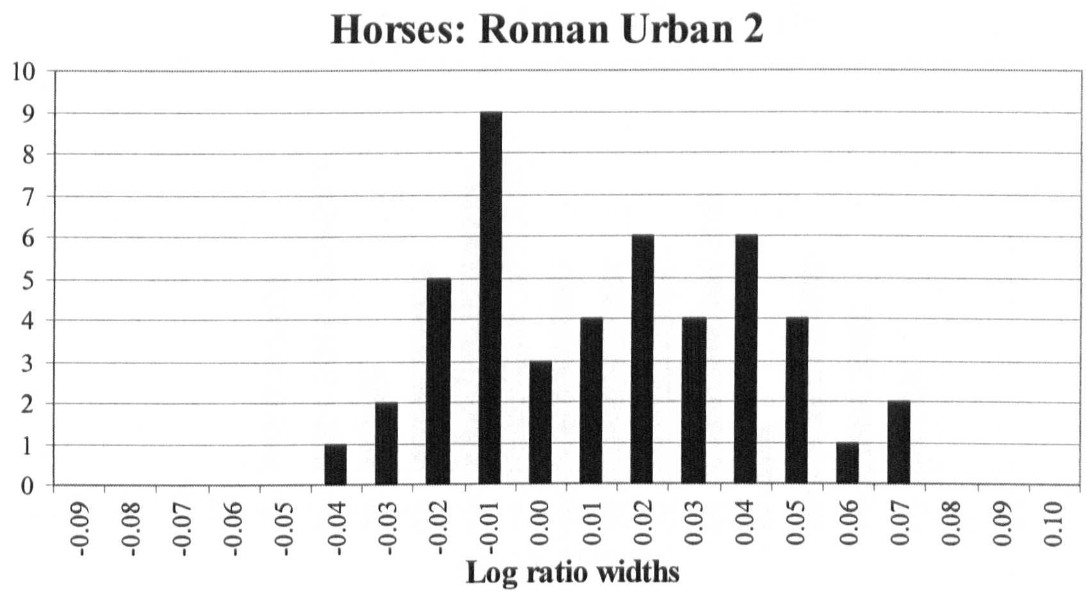
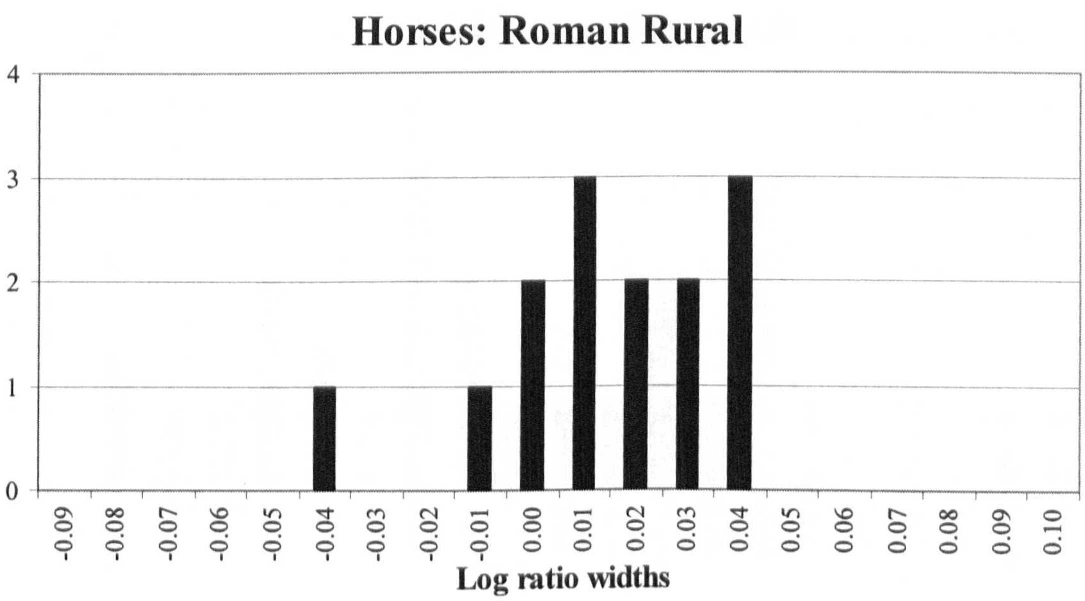


Figure A27. Histograms of log-ratio breadths for the 'identified' archaeological horses by site type





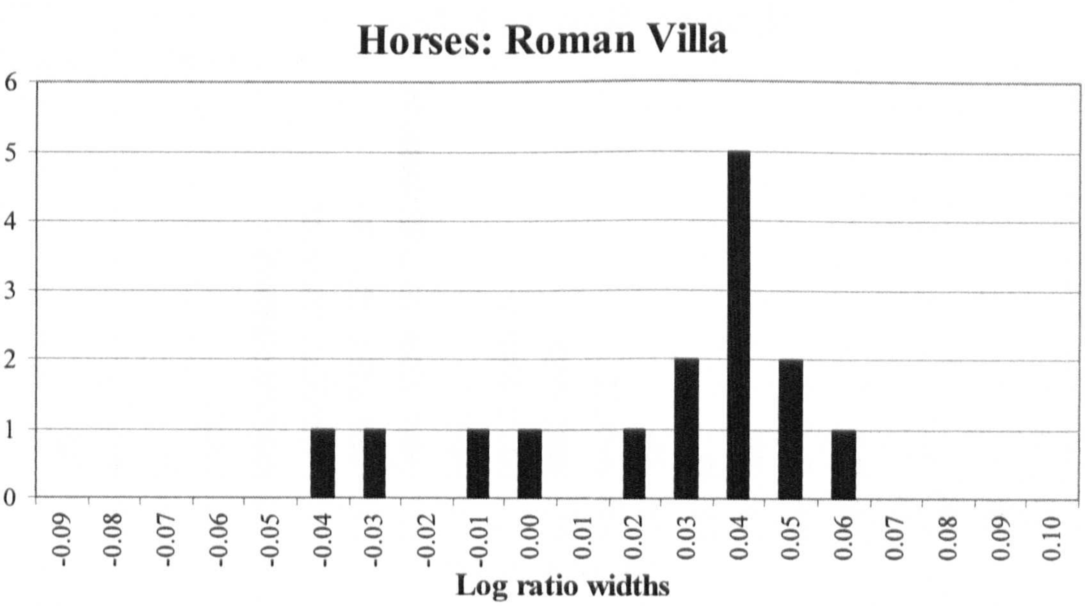


Figure A27 Continued.

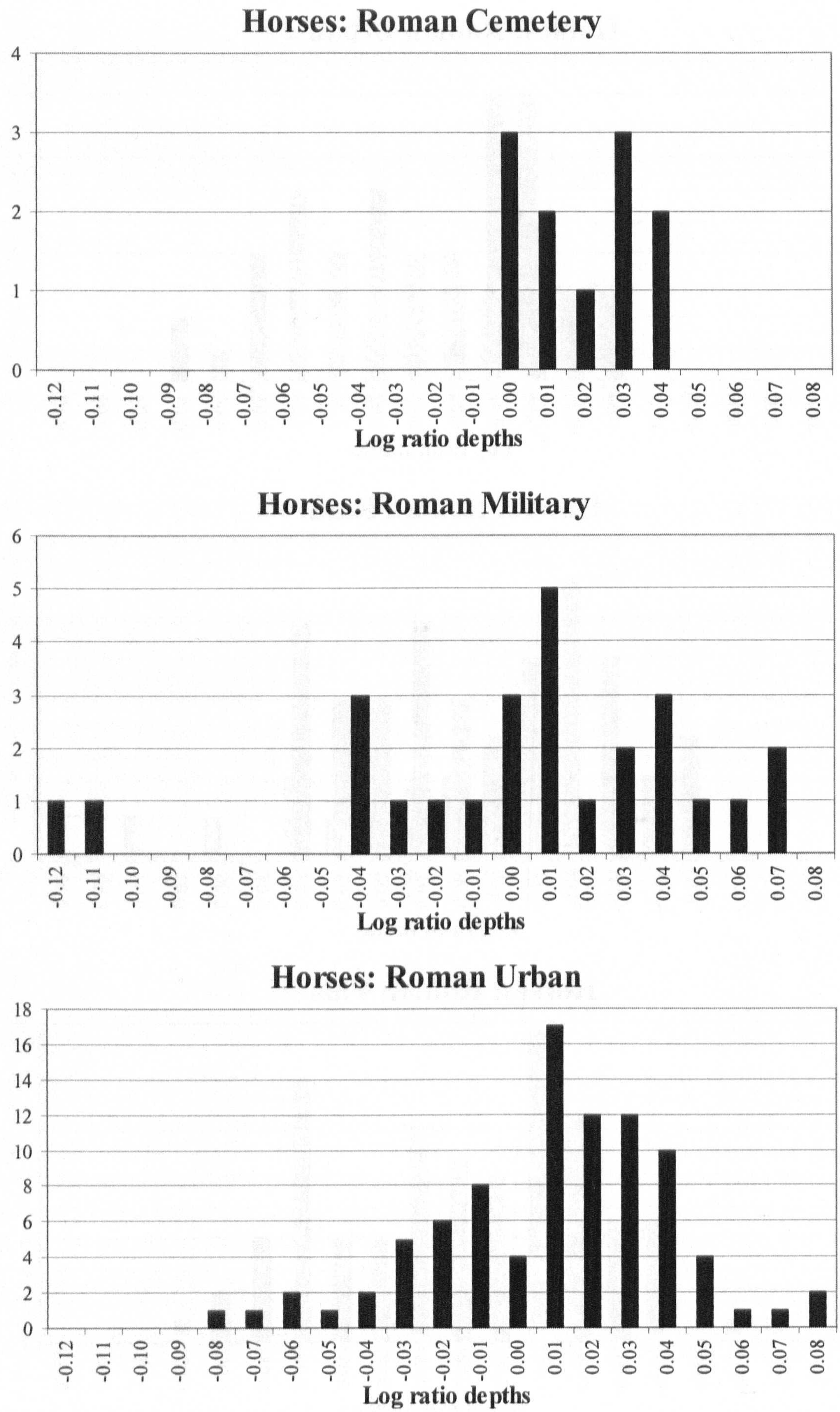
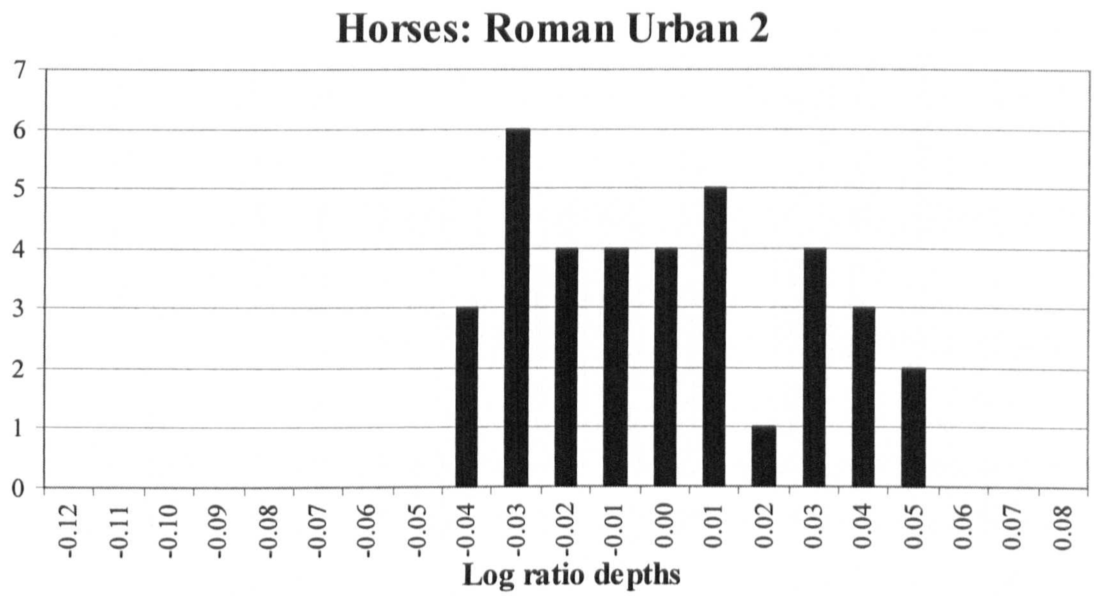


Figure A28. Histograms of log-ratio depths for the 'identified' archaeological horses by site type



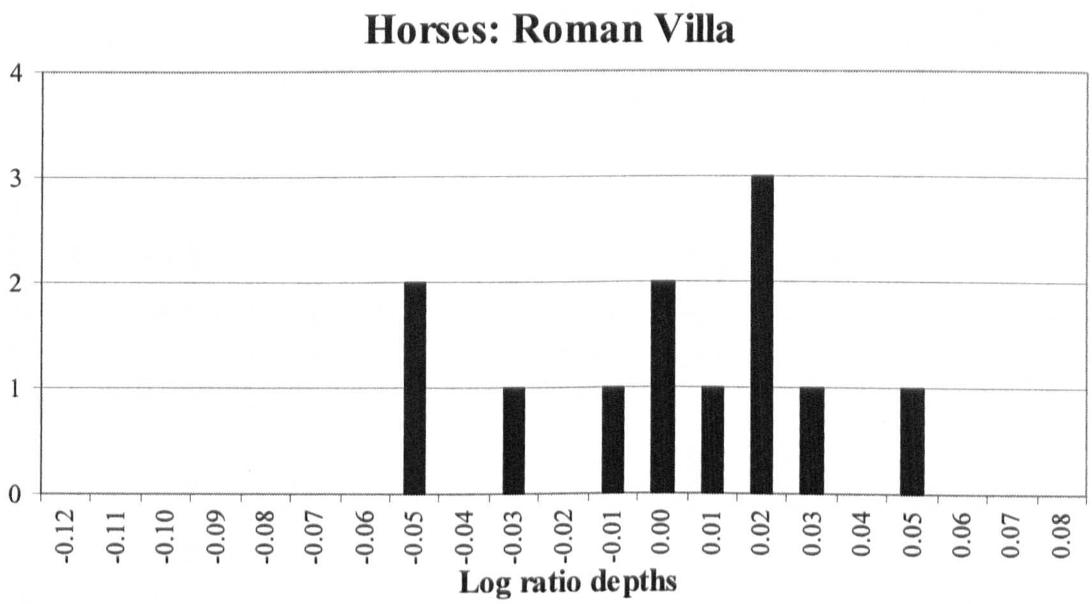


Figure A28 Continued.

Table A1. List of modern reference specimens with their details

Collection codes as specified in Table 5.1 in the main text. Information mostly taken from collection records. Where sex data were missing, this was estimated from the presence/absence of well-developed canine teeth. Missing age data was estimated from tooth eruption and wear.

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
BMNH	1947.7.16.6	*E. asinus*	Domestic	M	Old adult	Complete	From London zoo. Some joint pathology. Large canines. Slight abnormal wear on molars
BMNH	1986.1756	*E. asinus*	Domestic	M	?5-6 yrs	Complete	Long bones fused, M3's erupting, I3's still deciduous. Canines erupting.
BMNH	1899.3.14.18	*E. asinus*	Feral	F		Head and Lower limbs only	Collection of WRO Grant and H Forbes, came from Sartiau, Socotra Island, S.W. Arabia. I3's erputing, vestigial C, Upper P1 RHS. Long bones well fused but M3 only just in wear.
BMNH	1951.8.28.14	*E. asinus*	?Wild	M	Adult	Head and Lower limbs only	From Jebel Samaini, NW Oman. One label said *E.a.africanus*, other just said *E.asinus*.
BMNH	1960.11.10.4	*E. asinus*	?feral	M	Adult	Head and upper limbs only.	Collected by AT Hopwood, Africa. Abnormal wear on teeth, antemortem loss of upper P2. Vestigial canines only.
BMNH	1981.1338	*E. asinus*	Poitou	F	Adult	Complete	From Mr and Mrs Kingsley Lewis. Vestigial canines. Upper R P1. Has 7 properly formed upper cheek teeth each side! Infundibulums present on all incisors.
BMNH	1887.12.9.1	*E. asinus*	Poitou	F	Adult	Complete but damage to anterior skull and mandible	From CL Sutherland, Kent. Height 14-15 hh. Both upper P1 present.
BMNH	1924.5.41	*E. caballus*	Arab	M	30 yrs	Complete	"Dwarka", bred in Arabia by Great Anazrh tribe, imported to India by Gen Browne (director of remounts) as 4 yr old. In Britain he sired many prizewinners, sold to HRH Prince of Wales. 14.2 hh.
BMNH	1937.1.26.10	*E. caballus*	Arab	F	Adult	Complete	"Risala" bred by Lady Wentworth, Sussex. Has 17 thoracic and 6 lumbar vertebrae. No canines. Possibly R lower P1 cut off. Double supraorbital foramen both sides.
BMNH	H40	*E. caballus*	Arab	M	Adult	Complete	"Little Joker". Described as Arab pony.
BMNH	H37	*E. caballus*	New Forest	F	Adult	Complete	
BMNH	1907.5.15.1	*E. przewalski*		F	Young adult	Complete	Collected by Duke of Bedford in the Gobi Desert. I3's only just in wear.

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
BMNH	1945.6.11.1	*E. przewalski*		?	Adult	Complete	From Duke of Bedford, Wooburn Park. Label says M, but note in drawer suggests is F from Pelvic morphology and no C teeth. Double supraorbital foramen LHS only.
BMNH	1902.9.25.1	*E. przewalski*		F	Just adult	Complete	Collected by Duke of Bedford in the Gobi Desert. M3's unerupted, only I1's permanent. Vestigial C. Proximal femur only just fused.
TPOC	TPOC1	*E. caballus*	Welsh pony	F	c.6 yrs	Complete	Probably Welsh pit pony. Collected from Gelligaer Common, Mid Glamorgan. No canines. Unequal double supraorbital foramen both sides.
KD		*E. hemionus onager*		?M	Adult	Complete	Collected in ?Turkmenistan. Some pathology noted. Worn teeth, Canines present.
LMU	LMUmule1	Mule		F	Adult	Complete	From El officio, Cuevas del Almanzora. Slightly weathered appearance to some bones. Vestigial canines mandible only. Single large supraorbital foramen both sides.
LMU	LMUmule2	Mule		M	22 yrs	Complete	Gelding, known as "King". Canines present. Single large supraorbital foramen both sides.
LMU	LMUmule3	Mule		M	Adult	Limbs only	Gelding
LMU	LMUmule4	Mule		M	Adult	Part skeleton, most of limbs	Gelding. Very greasy specimen. Pathological exostoses on proximal Tibia and distal Femur and on medial side of all 3rd phalanges.
LMU	LMUmule5	Mule		F	Adult	Head and axial skeleton only	Vestigial lower canines. Lightly worn I3's. Single large supraorbital foramen both sides.
LMU	LMUmule6	Mule		F	Adult	Head and axial skeleton only	One vestigial lower canine. Has 7 cheekteeth in right maxilla. Molars abnormally worn. Single large supraorbital foramen both sides.
LMU	LMUwildass 3	*E. asinus africanus*	Nubian wild ass	M	6 yrs	Complete	From Hellabrunn Zoo, Munich. Bred in captivity. All canines present but not fully erupted. Incisors only lightly worn. Single large supraorbital foramen both sides.
LMU	LMUwildass 2	*E. asinus africanus*	Nubian wild ass	M	9 yrs	Complete	From Hellabrunn Zoo, Munich. Bred in captivity. All canines present. Single large supraorbital foramen both sides.
LMU	LWH3	*E. caballus*	Pony	?F		Complete	Vestigial lower canines suggests female. Has P1 upper left.
LMU	LMUprz13	*E. przewalski*		M	8 yrs	Complete	From Hellabrum Zoo, Munich. Born 10/6/1978, died 27/10/1986. From "Sindbad A" Line. 4 canines. Has 2 supraorbital foramen on left and 3 on the right.

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
LMU	LMUprz11	*E. przewalski*		F	21 yrs	Complete	"Mimosa". Born 28/5/1964 in Nurnberg zoo, sent to Prague zoo in 1967, ided 24/8/1985. No canines. Has 2 supraorbital foramen on left, single on right.
ZSM	1970/5	Mule		M	>15 yrs	Complete	From Mythilini, Lesbos, Greece. 4 canines. Has 2 supraorbital foramen on left, single on right. Very pathological hock joints, almost completely fused. From astragalus down to metatarsal affected with degenerative joint arthropathies and bridging of bones.
ZSM	1970/6	Mule		F	>17 yrs	Complete	From Mythilini, Lesbos, Greece. Vestigial lower canines. Single large supraorbital foramen both sides. Teeth very worn, most upper molars lost antemortem.
ZSM	1972/338	Mule		M	>10 yrs	Complete	From Lesbos, Greece. 4 large canines. P1 present both sides of maxilla. Antemortem loss of upper M2's. Single large supraorbital foramen both sides.
ZSM	1972/337	Mule		F	>>10 yrs	Complete	From Lesbos, Greece. No canines. Very worn teeth, antemortem loss of lower P2, others have abnormal wear. Pathological hock joints, tarsals fused to metatarsals. Vertebrae also fused in places.
ZSM	1968/696	*E. asinus*	Domestic	F	15 yrs	Complete	From Naxos, Greece. No canines. Single large supraorbital foramen both sides.
ZSM	1961/29	*E. caballus*	Icelandic pony	F	3 yrs	Complete	Imported from Iceland to Freiburg. Died 26/03/1961. Although only 3 ¼ yrs old all long bones are fused (prox femur only just). Adult I1's only. Vestigial canines. P1 present upper left. M3's erupting. DP4 still in place. Single large supraorbital foramen both sides.
ZSM	1973/237	*E. przewalski*		F	5/6 yrs	Complete	"Sinella" Born 10/6/1067, died 3/5/1973 in Hellabrunn Zoo Munich. Sire = Sidar, Dam = Sira. Has 2 supraorbital foramen on left and 3 on the right.
ZSM	1953/147	*E. przewalski*		M	16 yrs	Complete	"Neville" Born 9/5/1937 at Whipsnade, moved to Hellabrunn in 1938, died 6/7/1953. 4 canines. Single large supraorbital foramen both sides, one large, one small.
ZSM	1965/207	*E. hemionus onager*		M	6 yrs	Complete	"Ortiz" born in Hellabrun Zoo 29/6/1959, died 28/6/1965. Both parents, Olga and Otto, were caught in the wild in Central Iran. 4 canines. Both upper P1 present. Single large supraorbital foramen both sides.

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
MNHN	1893/634	*E. asinus africanus*		?M	Old Adult	Complete	White donkey of Egypt from the Menagerie, Paris. 4 canines. Abnormal wear on many teeth. Bony growth on lower edge of right mandible, below P3. Single supraorbital foramen both sides.
MNHN	1933.397	*E. asinus*	?domestic	F	Old Adult	Complete	African donkey (Abysinnia). Small canines. Single large supraorbital foramen both sides.
MNHN	17/543	Mule		?M	Adult	Head only	Not 100% sure if mule or hinny. 4 large canines. P1's present. Abnormal molar wear due to antermorten tooth loss. Single large supraorbital foramen both sides.
MNHN	1849/383	Mule		M	Adult	Head only	4 canines. Upper p1's present. Teeth worn. Has 2 supraorbital foramen on lft, one on right.
MNHN	1911/145	*E. caballus*	Pony du Tonkin	M	?7 yrs	Complete	From the Menagerie. 4 large canines. Abnormal wear on many teeth. Quite a lot of connective tissue remains so hard to measure. Single large supraorbital foramen both sides.
MNHN	1937/51	*E. caballus*	Pony	?F	Young adult	Complete	Pony from zoo at Vincennes. Weight 142 kg. Brain case opened. No canines. Supraorbital foramens joined to edge of orbit, i.e. notches not foramina.
MNHN	1927/235	*E. caballus*	Arab	M	Old adult	Complete	Arabian stallion, owned by General Cavaignac. Smallish canines. Abnormal wear on molars due to antemortem tooth loss. Single large supraorbital foramen both sides.
MNHN	1925/78	*E. caballus*	Norwegian	?M	Old adult	Part skeleton	Canines present. Abnormal wear on molars, very worn other teeth. Slight exostoses on hock joint and femur. Single large supraorbital foramen both sides.
MNHN	1929/037	*E. przewalski*		F	20 yrs	Post-cranial only	Born in Menagerie 12/6/1909.
MNHN	1962.228	*E. przewalski*		M	32 yrs	Complete	Abnormal wear on incisors. Molars so worn, roots show. Infection and bone growth around foramen on left side of face. Double supraorbital foramen both sides.
MNHN	1973.109	*E. przewalski*		F	16 yrs	Complete	No canines. Single large supraorbital foramen both sides.
MNHN	1980.29	*E. przewalski*		F	5 yrs	Complete	Bones only just fused. Vestigial lower canines. I3's only just in wear. Single supraorbital foramen on left, double on right.
MNHN	1975.125	*E. przewalski*		F	7 yrs	Complete	Vestigial lower canines. 7 yr hook on upper I3's. Single large supraorbital foramen both sides.
BZL	BZL1	*E. caballus*	Small pony	F	c.35 yrs	Limbs only	Rest of skeleton in AML collection (n. 3158). Born c. 1960, died 30/1/1995. Withers height c 125 cm. Slightly pathological metatarsals

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
BZL	BZL135	*E. caballus*	Welsh mountain pony (A)	F	25 yrs	Complete	Slightly pathological metatarsals.
BZL	BZL332	*E. caballus*	Exmoor	F	6 yrs	Head and right limbs only	Rest of skeleton in EAU York collection. Feral Exmoor mare, had 2-month-old foal at foot when put down due to injury to back and pelvis. Pathological metatarsals – ossified haematomas both sides.
NML		Mule	Mule	M	11-13 yrs	Whole skeleton	Mounted skeleton
SHD	M131	*E. asinus*	Domestic	M	Adult	Whole skeleton	Gelding. Culled due to severe laminitis. Upper and lower canines present. Upper wolf teeth present. Pathologies in hock joints. Wh about 11.3 hh.
SHD	L2161	*E. caballus*	New Forest	?	Adult	Almost whole	Right scapula and right hind phalanges missing
MHKH	Eml mlt 3	Mule	Mule	M	19 yrs	Whole skeleton	Stallion. Born 28/2/1902, died 30/5/1921. Grey coat colour. 4 canines present, upper L deformed and worn. Slight AW on molars. Single supra-orbital foramen both sides.
MHKH	Eml mlt 1	Mule	Mule	F	>10yrs	Whole skeleton	Mare. Mounted skeleton. Mounted WH = 123 cm. Vestigial lower canines. AW on lower P2s only. Single supra-orbital foramen both sides.
MHKH	Eml mlt 5	Mule	Mule	M	Elderly	Skull only	4 very large canines. Incisors and molars all very worn, AW on P2s and P3s. Single supra-orbital foramen both sides.
MHKH	Mhn mle 5	Hinny	Hinny	F	Adult	Post cranial only	Enhanced muscle insertions but no exostoses or other pathology.
MHKH	Mhn mle 10	Hinny	Hinny	M	25 yrs	Whole skeleton	Only post-cranials measured. Gelding called Hans, born 30/11/1901, died 20/1/1927. Worked under saddle in Halle. Stallion father was Ostpreusse breed.
MHKH	Mhn mle	Hinny	Hinny	F	28 yrs	Whole skeleton	Only post-cranials measured. Born 25/6/1897, died 3/7/1925. Stallion father was a Galisier horse (porzellauscheck). Hock joints pathological, exostoses but not degeneration.
MHKH	Ea abs wld 1	*E. asinus*	Wild Abyssinian Ass	F	Adult	Whole skeleton	Died 8/2/1894. No canines. Skull sutures still quite open. Single supra-orbital foramen both sides.
MHKH	Ea 15	*E. asinus*	Domestic	F	Adult	Whole skeleton	4 vestigial canines. Upper I's overshoot the lowers, slight AW. Very AW on molars, upper M3's and lower P2's lost antemortem, others have compensated. Single supra-orbital foramen both sides.
MHKH	Ea 11	*E. asinus*	Domestic	F	Adult	Whole skeleton	Vestigial lower canines. Single supra-orbital foramen both sides.
MHKH	Ea 12	*E. asinus*	Domestic	F	20 yrs	Whole skeleton	Born 21/10/1899, died 17/3/1919. 4 vestigial canines. Single supra-orbital foramen both sides.

Collection code	Accession code	Species	Breed	Sex	Age	Skeletal parts present	Other notes
MHKH	E pon 1	*E. caballus*	Pony	M	7 yrs	Whole skeleton	Born 1878, died 2/1/1885. 4 canines. AW on molars and incisors. Slightly undershot jaws. Single supra-orbital foramen both sides. Exostoses and joint degeneration in both hocks, one hind 3rd phalanx possibly laminitic.
MHKH	E arb 3	*E. caballus*	Arab	?	Adult	Post-cranial only	Patch of woven bone below femoral head on anterior surface, possibly infection. Also well healed and remodelled haematoma on anterior, proximal metatarsal shaft about 12 cm long, at least 1 cm of extra bone laid down.
MHKH	E mgl 4	*E. caballus*	Mongolian	F	>13 yrs	Whole skeleton	Post-cranials only measured. Grey coat colour. Arrived from Mongolia (Hagenbecks expedition) 23/11/1901, died 27/6/1914. Left hock joint exostoses and joint degeneration.
MHKH	E mgl 1	*E. caballus*	Mongolian	F	> 12 yrs	Whole skeleton	Post-cranials only measured. Dun coat colour. Arrived from Mongolia (Hagenbecks expedition) 23/11/1901, died 26/6/1913. Very large accessory metatarsals, deep in anterior-posterior direction, not pathological.
MHKH	E mgl 3	*E. caballus*	Mongolian	F	> 11 yrs	Whole skeleton	Post-cranials only measured. Brown/bay coat colour. Arrived from Mongolia (Hagenbecks expedition) 23/11/1901, died 30/7/1912.
MHKH	E wld 5	*E. Przewalskii x E. caballus*	Przewalski/ Mongolian cross	M	21 yrs	Whole skeleton	Called Theodor, born 11/2/1906, died 27/1/1927. Cross between Wild Przewalski (E wld 1) stallion and Mongolian pony mare (E mgl 1). Stuffed mounted exhibit is 131 cm WH.
MHKH	E wld 2	*E. przewalskii*		F	9 yrs	Whole skeleton	Caught as a foal in the wild in Mongolia (Hagenbecks expedition) in 1901, died 31/3/1910. Prague studbook number is BIJSK2. No canines. Single supra-orbital foramen both sides.
MHKH	E wld 4	*E. przewalskii*		F	9yrs	Whole skeleton	Born 8/5/1907, died 22/5/1916. Father is E wld 1 and mother E wld 2. Prague studbook number is Halle B. Vestigial lower canines. AW left M1's. Single supra-orbital foramen both sides.
MHKH	E wld 1	*E. przewalskii*		M	7 yrs	Whole skeleton	Caught as a foal in the wild in Mongolia (Hagenbecks expedition) in 1901, died 15/10/1908. Prague studbook number is BIJSK1. Mounted skeleton. 4 large canines. Has an extra lower I in front of the normal I2/I3 on both sides. Upper wolf teeth present. Single supra-orbital foramen both sides. Mounted WH = 125 cm.

Table A1a. Measurements taken from the modern reference specimens detailed in Table A1.

Measurement codes as given in Table 3.1

Skulls	Specimen no.	1	2	3	9	10	22	23	24	34	38	40	41	43	45	48	50
Przewalski	02.9.25.1	551.0	508.0	472.0	176.0	379.0			99.9	73.4	105.2	146.5	210.1	172.0	65.6	123.0	104.9
	07.5.15.1	523.0	505.0	477.0	165.0	370.0	189.4	85.9	102.1	75.5	115.6	140.3	203.9	176.8	69.9	134.5	99.5
	1953/147	566.0	532.0	506.0	184.5	383.0	169.6	82.6	94.0	77.7	119.4	150.5	232.9	190.4	70.8	133.8	106.8
	1962.228	580.0	524.0	504.0	186.7	392.0	161.0	77.3	85.1	83.3	102.2	147.1	212.5	178.4	79.6	122.0	102.4
	1973.109	533.0	494.0	471.0	181.4	358.0	171.8	80.1	96.0	76.9	101.7	125.2	200.2	181.6	68.4	128.0	90.9
	1973/237	546.0	520.0	494.0	179.7	376.0	178.4	82.5	100.7	76.2	115.2	134.2	216.8	184.6	72.2	134.8	93.6
	1975.125	563.0	517.0	495.0	191.5	373.0	184.9	86.4	100.6	77.0	110.1	138.6	213.2	193.2	71.7	132.3	98.7
	1980.29	569.0	517.0	491.0	182.7	385.0	193.6	90.0	105.9	79.6	109.1	150.1	214.8	192.8	69.4	133.6	95.5
	45.6.11.1	540.0	520.0	496.0	173.7	390.0	168.2	79.0	92.7	77.3	114.8	152.9	223.1	189.1	78.9	142.6	101.9
	E wld 1	537.0	500.0	484.0	176.0	333.0	177.1	81.8	102.0	74.8	117.1	146.7	218.4	185.0	73.1		94.3
	E wld 2	529.0	479.0	457.0	172.5	352.0	169.2	74.1	95.7	71.2	102.0	131.2	198.0	175.8	70.8	121.9	94.2
	E wld 4	563.0	496.0	475.0	183.3	370.0	182.4	82.4	103.0	74.4	110.1	156.7	224.0	187.1	73.1	128.9	100.0
	LMUprz11	532.0	507.0	484.0	177.0	371.0	157.2	73.6	84.7	71.8	108.7	134.7	206.1	185.9	64.9	135.6	96.7
	LMUprz13	560.0	510.0	485.0	186.5	367.0	182.3	82.3	104.1	79.6	115.5	142.5	222.1	179.7	73.2	132.0	103.1
Pony	1937.51	426.0	383.0	374.0	147.4	283.0	145.8	69.7	79.8	61.8	100.0	106.5	163.8	145.2	59.2	111.5	77.7
	E pon 1	542.0	488.0	472.0	176.7	371.0	158.5	78.6	79.5	81.8	113.0	136.9	204.7	170.9	60.9	121.6	100.8
	LWH3	485.0	458.0	433.0	158.1	320.0	150.5	72.9	83.0	78.3	108.8	135.7	201.5	167.7	61.4	121.4	97.8
	BZL332	509.0	489.0	462.0	176.5	349.0	178.8	82.3	98.7		109.5		210.0	167.0	69.2	118.8	111.0
	1961/29	515.0	480.0	455.0	174.0	356.0			98.9	73.3	109.1	143.4	208.8	173.6	64.1	129.8	97.2
	H37	473.0	444.0	420.0	169.0	301.0	141.1	65.7	75.3	74.3	93.8	120.2	198.0	156.1	58.8	107.1	94.0
	L2161	508.0	486.0	471.0	170.8	332.0	162.0	74.9	83.2	91.3	105.4	144.5	215.0	171.4	62.8	115.8	138.0
	1925.78	537.0	509.0	481.0	177.2	367.0	145.5	68.0	78.1	83.5	108.9	144.5	212.3	180.6	63.0	120.5	103.6
	1911.145	520.0	496.0	462.0	170.0	333.0	148.6	69.9	77.4	75.3	109.4	135.3	196.7	160.8	64.7	112.4	92.6
	TPOC1	447.0	429.0	406.0	153.5	304.0	145.1	67.0	80.9	71.7	96.9	128.4	196.0	144.4	55.9	110.3	85.2
	BZL135	455.0	445.0	410.0	147.3	320.0	144.2	68.2	78.7		99.2		182.3	153.0	59.5	117.9	97.0
Arab	24.5.4.1	535.0	527.0	491.0	178.8	370.0	163.8	75.3	91.0	80.6	107.3	155.7	202.6	174.9	62.6	127.7	110.5
	37.1.26.10	552.0	534.0	507.0	180.9	386.0	155.5	74.1	82.8	94.6	112.8	150.3	213.6	191.0	66.6	142.2	107.0
	1927.235	560.0	529.0	501.0	179.4	391.0	155.7	76.0	83.7	88.3	115.8	144.3	208.2	168.7	61.3	114.6	119.3
	H40	527.0	502.0	467.0	171.0	368.0	175.0	76.9	93.5	88.4	107.1	140.3	211.0	157.0	62.8	121.8	109.2

Skulls	Specimen no.	1	2	3	9	10	22	23	24	34	38	40	41	43	45	48	50
Donkey	1893.634	548.0	494.0	467.0	192.1	356.0	148.7	67.5	81.0	75.4	106.4	137.3	214.8	171.6	57.3	112.0	100.4
	1933.397	473.0	428.0	407.0	170.9	312.0	128.2	63.4	66.8	68.9	91.4	123.0	190.1	157.5	54.8	109.3	89.7
	1968/696	472.0	432.0	409.0	162.3	289.0	136.5	57.0	73.4	67.4	99.5	112.7	186.0	153.2	48.8	110.5	90.6
	47.7.16.6	470.0	450.0	388.0	171.0	295.0	136.3	69.6	71.8	68.7	91.8	120.1	183.4	151.8	54.1	113.7	87.3
	60.11.10.4	430.0		383.0	153.5	287.0	125.7	58.6	71.7	63.3	97.3	130.8	183.8	152.8	47.4	112.8	
	86.1756	410.0	395.0	370.0	152.7	281.1	148.0	63.9	85.2	60.9	92.2	116.1	180.2	140.1	52.1	108.4	84.5
	99.3.14.18	425.0	388.0	370.0	157.1	285.0	139.8	63.5	78.9	59.4	95.0	113.6	169.7	140.6	49.7	104.9	85.4
	Ea 11	508.0	451.0	425.0	172.4	336.0	140.5	65.0	77.1	69.6	98.0	123.5	199.0	161.9	54.5	112.2	91.7
	Ea 12	497.0	457.0	424.0	166.7	328.0	137.7	64.9	74.5	70.4	98.4	124.8	204.5	169.9	56.5	119.0	88.4
	Ea 15	466.0	388.0	377.0	160.3	288.0	142.1	73.3	71.5	67.0	101.5	111.7	176.9	151.5	49.8	108.5	84.2
	M131	475.0	445.0	428.0	184.0	310.0	140.5	66.4	75.0	70.6	98.0	128.3	197.7	165.6	50.3	107.7	95.8
	E abs wld1	486.0	421.0	399.0	168.6	320.0	149.3	68.1	83.5	61.3	99.4	109.4	194.3	148.0	55.9	109.9	84.3
	LMUass2	507.0	460.0	430.0	175.3	334.0	155.6	72.7	84.2	73.0	100.1	124.1	198.7	185.2	57.1	117.9	98.5
	LMUass3	461.0	428.0	404.0	184.3	303.0	147.8	68.0	82.2	66.1	102.1	118.5	194.3	160.3	55.8	116.2	93.3
	81.1338	608.0	564.0	530.0	210.0	400.0	188.7	96.5	91.4	86.9	108.8	150.0	247.8	200.0	68.0	130.9	116.9
	87.12.9.1	580.0	560.0	525.0	197.0	450.0	171.0	80.8	96.9	82.8	110.3	153.6	238.4	196.0		136.8	109.0
Mule	1849.383		558.0	537.0		437.0	169.7	80.6	90.4	87.4	116.4	253.0	236.6	187.0	68.2	128.3	
	1970/5	542.0	507.0	475.0	181.5	362.0	152.8	68.2	77.0	85.4	106.7	141.0	216.6	168.6	57.0	116.9	114.8
	1970/6	506.0	482.0	457.0	164.7	350.0	138.3	64.0	76.4	76.2	112.5	134.0	197.1	164.0	57.5	109.3	95.6
	1972/337	574.0	542.0	510.0	186.4	407.0	147.8	74.4	76.5	77.7	103.3	144.3	222.6	185.7	67.0	132.0	102.9
	1972/338	583.0	536.0	510.0	199.6	407.0	153.6	73.9	83.1	87.3	102.1	154.9	244.2	195.4	65.8	141.0	109.8
	A543	633.0	578.0	543.0	210.2	425.0	163.6	81.2	83.5	89.3	115.4	151.2	238.0	210.0	71.4	127.0	123.0
	Eml mlt 1	583.0	556.0	530.0	201.0		186.9	86.1	100.8	85.1	118.8	161.5	247.2	193.2	69.7	133.7	113.7
	Eml mlt 3	680.0	614.0	582.0	211.2	475.0	155.2	78.0	79.1	99.2	121.8	164.4	253.7	201.3	71.1	126.3	127.6
	Eml mlt 5	588.0	502.0	477.0	189.0	385.0	167.3	80.2	92.2	83.3	109.5	140.2	208.8	182.0	66.6	120.9	103.7
	LMUmule1	584.0	516.0	489.0	200.5	285.0	164.4	79.3	88.2	84.5	103.3	135.4	218.1	182.7	58.9	135.3	107.5
	LMUmule2	593.0	560.0	532.0	190.4	395.0	165.5	79.4	88.9	90.5	103.2	142.8	221.3	194.7	67.4	139.4	110.9
	LMUmule5	625.0	583.0	542.0	213.0	435.0	185.8	85.7	99.3	90.3	115.3	161.2	249.3	197.5	74.1	142.7	121.1
	LMUmule6	667.0	626.0	590.0	214.4	462.0	195.2	94.2	98.7	100.5	120.1	172.5	262.0	207.4	74.2	152.9	121.2
	Mule 1	615.2	568.4	546.1	214.9	434.0	174.8	80.4	100.6	101.8	105.8	151.7	236.8	196.4	68.4	131.2	121.1
Onager	1965/207	493.0	460.0	436.0	177.2	357.0	163.0	73.6	89.1	67.1	102.2	132.5	204.6	177.4	62.8	130.9	91.2
	KDonager	515.0	460.0	436.0	178.8	350.0	169.4	79.3	93.2	62.6	106.6	150.4	206.2	173.3	63.6	127.2	96.9

Mandibles	Specimen no.	1	4	6	7	8	16	18	20	22a	22c	23
Przewalski	02.9.25.1	403.0				93.2	63.2	37.4	206.3	99.8	56.6	119.4
	07.5.15.1	405.0	295.0	196.7	101.8	99.1	63.8	48.8	215.2	109.8	59.0	
	1953/147	436.0	302.0	173.4	87.0	90.0	66.9	48.9	227.9	105.4	61.6	167.0
	1962.228	439.0	299.0	162.2	84.5	77.9	71.9	363.4	199.0	93.0	60.8	156.6
	1973.109	406.0	288.0	175.9	90.0	86.9	62.9	35.4	209.5	99.8	51.6	158.0
	1973/237	426.0	306.0	189.2	91.6	96.5	61.9	39.5	224.2	110.5	60.0	156.5
	1975.1225	438.0	311.0	183.0	90.7	93.5	68.7	39.8	227.7	115.4	62.7	155.3
	1980.29	434.0	315.0	193.9	95.1	99.1	68.5	39.0	226.1	120.0	55.1	155.3
	45.6.11.1	436.0	300.0	174.4	91.5	85.4	75.0	41.6	204.1	93.4	51.7	143.1
	E wld 1	409.0	304.0	182.1	85.8	94.3	77.6	45.9	216.9	112.1	57.9	152.5
	E wld 2	390.0	280.0	176.5	83.0	93.4	67.3	47.2	206.0	101.6	52.1	140.5
	E wld 4	415.0	301.0	188.8	86.8	101.1	71.2	46.2	208.8	111.1	54.1	146.9
	LMUprz11	410.0	280.0	166.7	82.2	86.0	61.7	39.2	224.7	112.8	61.1	155.7
	LMUprz13	410.0	301.0	182.5	88.0	95.6	71.8	48.0	216.0	113.3	58.4	178.0
Pony	BZL332	396.0	284.0	184.5	88.9	94.9	65.9	45.7		102.9	52.2	143.1
	1961/29	403.0	197.0			96.0	59.5	42.0	208.3	108.9	55.7	151.9
	H37	357.0	250.0	146.2	72.7	72.7	53.3	35.5	165.3	80.2	37.9	128.4
	L2161	390.0	260.0	165.7	80.4	83.9	55.4	40.5	198.0	93.7	46.5	
	1925.78	409.0	281.0	155.0	80.4	73.3	56.3	31.6	211.6	103.3	53.8	158.8
	1937.51	333.0	228.1	152.4	71.5	80.8	55.2	36.9	153.9	76.3	38.4	128.3
	E pon 1	397.0	298.0	164.3	88.8	76.8	62.0	36.1	198.5	91.0	54.2	157.0
	1911.145	379.0	259.3	147.6	72.2	73.9	60.9	33.0	195.9	82.1	45.9	140.9
	TPOC1	345.0	243.0	148.2	72.6	76.0	57.0	32.8	161.8	77.7	42.3	121.1
	BZL135	356.0	253.0	148.7	74.6	74.6	58.3	35.0		78.9	41.9	128.4
	LWH3	375.0	257.0	156.1	175.9	81.3	57.2	35.1	197.0	93.8	51.8	140.8
Arab	1927.235	429.0	287.0	155.4	78.4	77.6	59.9	38.9	228.4	101.9	61.1	160.0
	24.5.4.1	420.0	297.0	176.2	93.0	82.5	55.6	33.2	222.1	97.8	52.4	127.7
	37.1.26.4	432.0	297.0	168.8	86.9	79.2	56.3	35.2	225.4	104.5	48.7	142.9
	H40	406.0	282.0	171.0	77.7	90.4	55.0	36.1	205.7	102.8	42.0	132.7

Mandibles	Specimen no.	1	4	6	7	8	16	18	20	22a	22c	23
Donkey	60.1.26.4	328.0	224.4	128.0	68.6	61.1	41.2	29.8	180.8	81.6	46.4	118.2
	1933.397	337.0	229.9	128.0	64.8	63.1	44.0	31.3	224.1	101.6	52.7	137.8
	47.7.16.6	330.0	238.3	138.0	75.3	65.4	45.3	35.3	185.5	85.1	41.8	135.5
	86.1756	312.0	231.5	146.9	74.6	75.5	47.0	32.1	156.6	81.0	44.7	107.6
	Ea 11	368.0	248.4	143.0	73.2	71.4	46.1	34.4	214.6	101.9	52.0	131.8
	Ea 12	358.0	237.1	140.0	71.5	69.1	48.3	37.8	201.0	93.2	58.2	101.5
	Ea 15	328.0	233.4	142.7	83.7	63.0	42.1	34.0	177.9	83.8	37.3	121.6
	M131	340.0	234.6	136.8	66.3	71.2	44.3	31.1	190.3	71.3	43.0	
	1968/696	345.0	235.0	139.9	71.6	70.4	40.0	34.3	188.9	86.6	47.0	121.1
	99.3.14.18	317.0	220.4	148.2	70.7	78.2	45.0	37.3	171.8	82.0	45.3	113.8
	E abs wld1	338.0	237.0	150.4	73.1	75.8	47.4	33.6	191.2	93.7	42.2	131.8
	1893.634	383.0	267.2	154.3	79.7	73.5	48.9	36.8	204.9	98.3	59.0	145.8
	LMUass2	365.0	260.0	150.4	78.6	77.0	45.9	34.4	200.8	94.8	53.2	139.0
	LMUass3	343.0	242.0	151.6	72.3	80.0	47.0	32.2	193.5	95.1	53.1	135.6
	81.1338	445.0	313.0	185.1	97.3	90.8	58.5	45.5	270.3	127.8	62.0	147.9
	87.12.9.1	425.0	295.0	168.2	87.7	80.5		38.6	266.0	120.3	61.3	131.4
Mule	1849.383	458.0	313.0	170.8	86.6	83.7	60.3	43.8	237.8	112.9	58.4	154.6
	A543	463.0	305.0	167.0	83.2	82.7		41.7	233.7	108.6	53.5	167.5
	Eml mlt 1	441.0	306.0	176.1	85.4	88.1	58.7	37.1	238.6	100.0	51.6	160.0
	Eml mlt 3	500.0	319.0	163.6	83.3	80.7	59.9	40.5	260.0	104.0	61.2	183.5
	Eml mlt 5	404.0	285.3	166.7	83.6	83.0	51.5	36.4	217.9	106.4	57.5	152.2
	Mule 1	452.2	300.0	178.2	87.0	89.9	61.3	40.4	229.3	102.3	52.0	144.5
	1970/5	405.0	265.0	143.5	71.3	72.0	49.4	31.6	211.1	87.5	50.6	152.3
	1970/6	392.0	247.0	144.8	72.4	71.7	52.3	38.7	203.8	84.9	45.6	151.4
	1972/337	443.0	284.0	150.7	78.6	73.7	52.5	34.1	224.1	89.1	41.9	156.4
	1972/338	455.0	300.0	155.8	79.0	77.8	54.0	36.4	236.5	110.8	55.5	156.6
	LMUmule1	412.0	279.1	169.9	85.9	82.6	48.1	346.0	236.4	114.5	55.8	
	LMUmule2	445.0	300.0	164.2	84.9	82.0	52.8	29.6	234.7	95.5	52.7	163.4
	LMUmule5	478.0	236.0	187.3	92.3	96.6	62.4	35.9	277.3	121.7	60.7	152.3
	LMUmule6	495.0	356.0	192.5	95.9	97.9	66.6	45.7	270.0	123.7	62.2	153.4
Onager	KD onager	378.0	257.0	163.4	78.5	86.0	60.1	38.3	203.8	102.9	54.6	128.0
	1965/207	391.0	273.0	162.3	77.7	83.5	58.4	36.6	201.0	98.5	57.0	135.0

Scapula	Specimen no.	SLC	GLP	LG	BG
Przewalski	02.9.25.1	57.4	83.1	55.0	44.1
	07.5.15.1	57.1	81.4	51.9	46.2
	1929.37	55.4	79.5	47.2	42.5
	1953/147	60.2	89.9	55.7	47.0
	1962.228	58.6	88.2	54.3	45.8
	1973.109	58.4	84.0	50.0	43.5
	1973/237	58.5	79.2	50.8	46.0
	1975.125	59.5	84.3	50.8	46.4
	1980.29	48.0	85.6	50.9	45.3
	45.6.11.1	61.8	90.8	55.3	49.2
	E wld 1	56.3	81.3	50.3	45.0
	E wld 2	55.8	81.4	51.6	46.8
	E wld 4	56.6	84.8	53.8	45.3
	LMUprz11	57.9	82.8	48.4	46.5
	LMUprz13	62.8	88.9	54.6	48.8
	RDVS	61.0	90.2	58.7	49.6
	E wld 5	60.4	87.2	54.7	47.0
Pony	1937.51	44.9	53.0	41.9	33.1
	BZL1	52.7	83.0	50.2	46.1
	E pon 1	61.0	93.8	59.0	56.7
	LWH3	55.1	79.3	51.0	44.6
	BZL332	62.9	96.7	56.9	48.1
	1961/29	58.7	84.6	51.8	43.1
	E mgl 1	64.9	88.1	53.9	47.1
	E mgl 3	59.8	87.4	56.8	47.8
	E mgl 4	62.4	96.8	60.1	50.5
	H37	48.4	79.2	50.4	41.3
	L2161	63.4	97.0	58.0	57.5
	1925.78	60.9	97.0	60.8	50.3
	1911.145	50.0	83.5	54.1	45.1
	TPOC1	49.9	79.0	49.5	39.5
	BZL135	53.4	79.9	50.3	40.6

	Specimen no.	SLC	GLP	LG	BG
Arab	1927.235	73.0	101.9	62.6	56.3
	24.5.4.1	71.0	112.7	60.1	51.0
	37.1.26.10	71.5	104.3	63.0	50.2
	E arb 3	64.8	94.7	57.3	47.8
	H40	65.3	100.0	63.2	51.3
Donkey	1933.397	46.7	70.6	45.5	38.4
	1968/696	43.7	65.2	43.8	31.9
	47.7.16.6	49.7	74.0	47.6	44.0
	60.11.10.4	44.7	60.7	40.5	36.9
	86.1756	39.0	60.0	40.0	31.4
	Ea 11	48.9	74.8	47.1	35.8
	Ea 12	43.1	68.8	44.6	42.7
	Ea 15	45.1	66.3	42.1	35.3
	M131	46.9	68.3	45.5	37.0
	1893.696	53.2	78.8	50.4	41.9
	E abs wld1	43.2	65.1	44.4	34.7
	LMUass2	48.5	72.2	46.6	39.7
	LMUass3	50.6	72.7	45.8	38.5
	81.1338	61.2	90.9	60.3	51.2
	87.12.9.1	57.2	92.1	58.7	51.0
Mule	1970/5	53.9	84.8	56.8	47.7
	1970/6	52.8	86.9	51.3	47.4
	1972/337	58.6	94.0	59.6	50.3
	1972/338	63.0	91.6	58.0	53.8
	Eml mlt 1	61.6	87.8	54.8	50.2
	Eml mlt 3	74.3	118.5	73.4	69.9
	LMUmule2	64.8	104.8	67.5	59.3
	LMUmule3	65.2	106.5	72.7	62.6
	LMUmule4	74.6	110.6	74.7	67.9
	Mule 1	67.8	101.8	64.5	56.9
Onager	KD onager	49.9	74.5	46.7	43.3
	1967/207	48.1	70.9	46.8	40.0

Humerus	Specimen no.	GLC	GLl	SD	Bd	BT	HTC
Przewalski	02.9.25.1	248.0	262.8	28.2	77.8	69.6	33.2
	07.5.15.1	242.7	257.6	33.7	75.4	66.4	32.1
	1929.37	243.0	256.4	30.6	69.1	66.4	31.5
	1953/147	257.5	273.7	32.5	78.6	79.6	35.9
	1962.228	272.3	282.7	32.0	82.8	71.8	36.4
	1973.109	248.1	265.5	34.8	71.8	65.9	31.0
	1973/237	247.5	261.8	32.7	74.4	64.0	32.6
	1975.125	258.0	273.0	35.4	76.3	69.0	33.4
	1980.29	262.2	276.1	32.9	74.8	71.1	34.1
	45.6.11.1	249.4	263.2	31.9	77.8	68.4	35.7
	E wld 1	248.0	272.0	33.5	81.5	72.8	
	E wld 2	242.1	255.7	31.6	79.4	68.3	33.8
	E wld 4	252.2	264.4	35.5	76.1	70.4	36.0
	RDVS	250.0		30.8	58.7	49.6	
	LMUprz11	257.8	270.1	34.9	77.4	68.8	32.9
	LMUprz13	261.5	272.9	34.4	78.1	79.2	34.9
	E wld 5	270.0	283.2	38.5	83.0	73.6	37.0
Pony	1937.51	205.9	219.3	26.6	62.7	55.8	28.6
	BZL1	234.0	244.0	27.1	66.9	60.8	30.3
	E pon 1	277.2	288.0	38.3	80.8	74.9	36.2
	LWH3	242.8	257.6	33.4	72.6	67.6	33.4
	BZL332	269.0	284.0	36.6	80.8	73.6	35.8
	1961/29	250.2	268.2	37.1	78.3	65.3	33.8
	E mgl 1	267.7	298.0	34.2	80.9	72.1	36.4
	E mgl 3	262.3	275.5	34.0	81.1	71.2	35.6
	E mgl 4	273.1	288.0	36.2	83.1	75.4	36.2
	H37	248.0	257.7	28.8	70.9	62.5	32.2
	L2161	271.0	275.0	32.6	78.1	75.4	39.7
	1925.78	282.0	300.0	35.6	78.4	73.9	37.0
	1911.145	256.5	266.5	28.2	74.8	71.0	33.9
	TPOC1	226.0	253.0	25.8	67.4	61.8	32.2
	BZL135	239.0	250.5	30.6	66.4	61.6	31.9

	Specimen no.	GLC	GLl	SD	Bd	BT	HTC
Arab	1927.235	313.0	328.0	337.3	91.2	81.4	
	24.5.4.1	302.0	316.0	31.0	88.6	78.2	40.4
	37.1.26.10	305.0	328.0	38.6	89.6	82.8	43.4
	E arb 3	287.0	311.0	33.3	81.2	87.5	36.2
	H40	282.0	312.0	36.8	87.0	79.6	42.5
Donkey	1933.397	215.8	225.4	27.9	61.0	58.2	29.2
	1968/696	220.1	231.5	22.8	60.5	52.7	21.6
	47.7.16.6	203.1	214.5	27.1	60.5	53.9	26.7
	60.11.10.4	190.9	210.5	28.4	58.4	54.3	25.4
	86.1756	191.9	202.1	24.2	56.0	51.7	26.8
	Ea 11	226.2	240.2	28.0	62.9	61.7	31.5
	Ea 12	217.3	227.1	28.2	63.2	57.8	32.2
	Ea 15	208.7	218.6	26.8	57.0	51.1	24.6
	M131	210.0	222.0	27.9	57.2	55.5	28.3
	1893.634	248.6	262.4	31.9	74.7	70.2	35.8
	E abs wld1	206.1	214.1	25.8	55.1	54.7	26.4
	LMUass2	233.0	250.8	28.5	70.0	65.2	32.7
	LMUass3	228.6	246.4	39.0	71.5	64.1	31.8
	81.1338	307.0	319.0	39.1	82.1	76.8	39.7
	87.12.9.1	286.0	300.0	34.7	83.0	76.5	36.7
Mule	1970/5	283.8	293.0	32.4	75.0	69.1	34.8
	1970/6	265.4	282.6	30.3	74.0	65.1	34.9
	1972/337	271.3	288.0	35.2	75.6	70.9	35.9
	1972/338	279.1	299.0	36.2	80.3	70.8	35.0
	Eml mlt 1	258.0	268.7	37.0	80.6	68.6	
	Eml mlt 3	326.0	352.0	45.6	101.6	89.0	45.3
	LMUmule1	269.7	285.3	33.5	76.4	69.1	36.3
	LMUmule2	292.0	304.0	40.2	84.7	80.8	40.9
	LMUmule3	317.0	344.0	37.0	89.1	81.5	40.3
	LMUmule4	313.0	344.0	45.1	97.0	90.4	43.4
	Mule	310.5	329.1	38.5	80.6	82.6	
Onager	KD onager	219.0	234.0	29.0	65.6	61.8	30.9
	1965/207	225.1	248.5	29.8	68.7	62.0	30.4

Radius	Specimen no.	GL	Ll	Bp	BFp	SD	Bd	BFd	DFd		Specimen no.	GL	Ll	Bp	BFp	SD	Bd	BFd	DFd
Przewalski	RDVS	311.0	295.8	79.2	72.4	33.8	73.6	62.2		**Arab**	1927.235	386.0	365.0	91.0	81.2	41.0	82.8	71.4	43.2
	02.9.25.1	309.0	293.8	76.5	67.4	68.1	57.5	33.8			24.5.4.1	374.0	359.0	86.5	79.8	37.7	78.3	65.2	40.1
	07.5.15.1	314.0	290.0	74.7	69.3	33.2	69.1	57.8	35.4		37.1.26.10	377.0	356.0	93.2	82.8	39.1	83.5	67.4	42.1
	1929.37	305.0	290.0	73.7	66.1	33.7	65.5	56.0	33.9		E arb 3	354.0	342.0	83.0	76.6	36.2	77.8	65.8	34.7
	1953/147	328.0	305.0	81.6	70.9	38.0	75.3	62.7	38.7		H40	349.0	333.7	87.6	79.4	37.9	80.3	67.7	39.5
	1962.228	325.0	302.0	79.3	73.0	35.3	71.6	61.3	38.2	**Donkey**	1933.397	269.7	254.2	64.6	57.6	31.8	60.1	49.0	29.5
	1973.109	305.0	287.0	72.3	65.2	36.1	67.4	56.0	32.0		1968/696	284.1	273.2	60.1	52.7	27.5	55.3	47.3	27.7
	1973/237	317.0	298.0	73.7	66.0	34.3	66.7	55.3	35.4		47.7.16.6	261.4	247.4	62.9	54.8	28.6	57.4	45.6	27.1
	1975.125	314.0	298.0	76.4	68.9	39.8	71.6	60.0	34.6		86.1756	247.4	238.9	58.2	52.5	26.0	52.2	43.5	25.7
	1980.29	319.0	302.0	76.2	70.5	37.5	70.5	59.4	33.3		99.3.14.18	247.7	236.4	54.0	49.9	24.9	49.4	41.6	24.3
	45.6.11.1	316.0	296.0	78.0	71.9	35.2	72.7	61.3	36.7		Ea 11	279.6	264.6	67.1	59.2	29.4	62.7	52.2	30.0
	E wld 1	318.0	302.0	77.7	70.4	38.0	74.1	51.4	35.6		Ea 12	269.9	255.6	66.2	58.1	31.3	61.8	49.9	29.4
	E wld 2	302.0	280.6	73.2	65.8	35.2	71.1	59.8	35.6		Ea 15	270.1	254.6	60.0	51.0	27.0	56.1	44.6	25.3
	E wld 4	314.0	293.0	76.6	69.2	37.0	71.7	60.7	36.2		M131		256.0	63.7	55.1	30.6	58.3	47.7	26.5
	LMUprz11	310.0	291.0	76.6	69.0	38.6	69.8	57.6	33.8		E abs wld1	263.0	249.0	58.7	53.0	27.1	53.8	44.0	25.2
	LMUprz13	322.0	302.0	77.9	68.8	37.9	71.4	58.1	36.0		LMUass2	296.0	277.1	72.0	63.0	32.8	69.3	55.6	31.0
	E wld 5	324.0	304.0	82.8	73.5	41.1	77.6	65.5	36.5		LMUass3	296.0	277.7	71.1	62.1	32.6	67.9	55.1	30.8
Pony	1937.51	242.7	227.3	59.3	54.1	28.8	54.5	47.0	27.6		1893.634	317.0	298.0	74.4	64.8	34.4	70.0	55.2	32.6
	BZL1	284.0	271.0	67.1	61.0	31.4	62.7	52.1	31.0		81.1338	377.0	359.0	85.3	75.4	42.4	84.8	66.5	39.3
	E pon 1	329.0	313.0	81.3	73.0	40.9	78.3	66.3	36.2		87.12.9.1	357.0	336.0	80.1	72.3	37.1	76.3	62.6	38.1
	LWH3	296.0	279.6	75.4	68.6	34.7	68.6	54.7	34.0	**Mule**	1970/5	332.0	319.0	73.8	67.7	34.7	70.5	56.7	34.7
	BZL332	319.0	300.0	80.9	75.4	37.6	76.0	62.5	34.7		1970/6	321.0	308.0	74.0	65.9	31.6	65.0	57.2	32.0
	1961/29	312.0	293.0	73.3	66.1	37.9	67.6	55.8	33.5		1972/337	341.0	324.0	77.1	71.2	38.2	73.4	60.1	35.0
	E mgl 1	317.0	296.0	79.7	70.1	31.7	75.8	62.1	36.7		1972/338	339.0	324.0	78.6	71.2	39.5	75.0	61.1	34.0
	E mgl 3	310.0	295.0	77.9	70.9	35.1	70.3	60.4	36.0		Eml mlt 1	320.0	301.0	76.9	69.9	36.2	71.5	62.0	34.8
	E mgl 4	322.0	305.0	82.0	72.4	40.0	77.3	64.0	35.7		LMUmule1	341.0	317.0	76.7	68.2	37.9	72.1	60.2	35.0
	H37	296.0	280.9	69.4	63.5	30.5	61.2	51.9	31.5		LMUmule2	366.0	350.0	85.1	79.0	40.2	79.1	66.2	35.8
	L2161	332.0	315.0	83.0	74.4	36.0	76.1	62.5	35.3		LMUmule3	406.0	376.0	89.7	81.4	41.9	83.7	67.2	41.0
	TPOC1	286.0	269.0	69.4	62.1	28.8	64.0	52.3	28.7		LMUmule4	396.0	371.0	98.0	88.7	47.7	96.9	77.1	44.4
	1911.145	324.0	301.0	72.4	66.7	31.2	66.4	56.6	34.7	**Onager**	KD onager	278.0	264.0	69.1	61.4	33.4	62.8	52.0	31.7
	BZL135	296.0	279.0	67.1	62.2	33.6	62.5	52.5	32.9		1965/207	300.0	277.0	67.9	62.1	33.1	63.0	50.7	29.3

Metacarpals	Specimen no.	GL	LL	Bp	Dp	SD	BFd	Dd
Przewalski	RDVS	218.0	206.0	49.8	33.8	29.0	47.3	36.1
	02.9.25.1	216.0	205.0	44.8	32.0	29.5	46.8	33.4
	07.5.15.1	215.9	209.1	47.7	29.7	31.6	43.4	34.4
	1929.4	217.8	210.1	46.6	30.6	31.5	43.8	33.0
	1953/147	220.0	210.0	50.6	35.1	33.0	46.8	37.1
	1962.2	223.8	214.9	49.5	34.3	33.4	47.9	37.2
	1973.1	197.0	189.2	45.6	30.9	32.7	44.1	31.5
	1973/237	214.2	205.4	47.1	31.1	30.3	43.3	33.4
	1975.1	216.1	209.0	49.3	30.9	33.2	47.3	34.3
	1980.3	216.7	209.0	47.7	31.9	32.2	46.2	34.4
	45.6.11.1	215.8	207.6	50.2	31.6	30.1	47.5	35.8
	E wld 1	220.0	211.0	51.0	33.0	32.9	46.3	31.2
	E wld 2	212.2	205.2	49.7	33.0	30.2	47.2	32.6
	E wld 4	217.9	212.2	49.7	31.9	31.2	47.0	34.7
	LMUprz11	212.8	204.4	46.7	33.0	31.4	46.2	34.8
	LMUprz13	223.8	215.6	49.6	34.4	31.7	46.3	35.3
	E wld 5	215.7	206.9	49.5	35.2	33.9	51.0	34.5
Pony	1937.5	156.8	148.5	36.2	24.6	25.8	38.3	25.4
	BZL1	177.7	170.1	40.9	27.4	30.4	41.0	29.3
	E pon 1	217.0	207.2	51.7	35.4	33.6	48.8	36.0
	LWH3	200.4	192.4	45.1	29.3	29.0	43.8	32.8
	BZL332	210.0	200.6	50.0	33.8	32.6	47.8	34.9
	1961/29	208.5	200.6	45.1	29.5	31.2	45.3	32.6
	E mgl 1	216.8	207.7	45.6	32.0	31.7	41.7	34.9
	E mgl 3	214.5	206.6	45.5	31.7	29.7	46.1	35.3
	E mgl 4	217.2	206.8	50.4	32.8	32.8	46.3	35.7
	H37	190.0	183.0	41.8	26.4	28.1	38.8	30.6
	L2161	230.0	221.0	51.9	33.8	31.7	48.0	36.5
	1911.1	203.2	195.1	45.5	29.7	28.7	44.3	34.5
	TPOC1	194.0	187.0	44.4	26.1	26.2	41.1	32.1
	BZL135	189.5	181.9	42.6	28.9	31.2	42.9	31.5

	Specimen no.	GL	LL	Bp	Dp	SD	BFd	Dd
Arab	1927.2	263.0	251.9	56.5	38.8	35.3	55.4	42.4
	24.5.4.1	247.6	238.0	51.6	31.4	32.6	53.2	39.1
	37.1.26.1	262.7	253.3	56.3	34.1	35.4	53.8	39.0
	E arb 3	238.5	229.8	51.9	35.2	32.3	51.2	36.7
	H40	249.0	240.0	54.3	35.9	35.7	54.0	39.0
Donkey	1933.4	181.5	175.8	40.6	27.3	25.1	36.5	26.2
	1968/696	186.5	181.9	36.8	24.9	24.0	33.8	24.3
	47.7.16.6	166.5	160.8	37.4	24.9	24.4	35.0	26.1
	86.2	165.2	161.1	36.7	25.3	21.7	32.2	24.2
	99.3.14.18	165.2	159.6	35.7	23.4	20.7	29.4	23.7
	Ea 11	191.7	185.8	43.1	28.4	25.2	37.4	29.9
	Ea 12	180.2	173.5	42.0	28.7	25.6	37.6	28.3
	Ea 15	173.0	168.7	35.5	25.2	25.1	32.7	24.1
	M131	175.9	168.7	37.2	28.5	22.7	34.8	26.3
	1893.6	211.6	204.4	48.5	31.1	29.4	40.1	31.3
	51.8.28.14	170.5	166.4	36.4	24.6	23.9	34.0	25.7
	E abs wld1	179.1	173.9	35.8	24.9	21.9	34.0	25.4
	LMUass2	192.6	186.0	44.3	31.2	24.6	40.0	29.7
	LMUass3	189.5	183.4	43.4	29.2	25.5	38.8	29.0
Mule	1970/5	217.1	210.5	48.2	31.2	30.4	44.5	33.0
	1970/6	213.8	205.1	43.5	29.5	28.4	44.4	33.5
	1972/337	230.5	222.6	50.8	33.0	31.9	43.9	34.7
	1972/338	228.1	219.5	48.6	31.4	34.1	47.1	34.8
	Eml mlt 1	213.0	202.2	46.7	30.7	31.2	47.6	35.6
	Eml mlt 3	265.8	256.1	63.1	46.9	39.9	57.2	42.8
	LMUmule1	222.2	216.5	50.1	32.4	32.2	45.7	34.6
	LMUmule2	233.3	224.9	54.8	36.7	34.5	49.2	36.4
	LMUmule3	266.0	257.4	57.8	39.4	34.1	52.8	40.1
	Mule 1		239.1	55.4		36.8	51.7	39.8
Onager	1965/207	215.4	210.7	46.9	27.3	27.6	39.6	29.6
	KD onager	216.0	209.0	47.9	30.9	26.6	40.2	30.6

Front first phalanx	Specimen no.	GL	Bp	Dp	SD	BFd	Dd
Przewalski	1953/147	85.2	50.7	32.9	36.8	42.9	25.3
	1973/237	77.0	50.1	30.4	38.2	37.3	22.2
	RDVS	82.4	53.8	30.3	34.7	45.0	
	02.9.25.1	81.4	49.4	27.7	35.3	39.0	23.2
	07.5.15.1	72.8	50.6	30.3	34.7	37.8	22.6
	1929.37	75.5	49.9	30.4	33.3	39.6	22.1
	1962.228	79.6	50.1	33.0	35.8	43.7	24.4
	1973.109	74.2	49.2	33.7	32.2	39.6	22.7
	1975.125	78.7	52.2	34.7	34.0	41.4	24.0
	1980.29	78.9	50.9	31.1	33.1	41.8	23.8
	45.6.11.1	74.9	53.2	32.5	36.4	40.1	24.0
	E wld 1	82.0	51.4	32.2	32.2	41.3	22.7
	E wld 2	73.4	51.7	33.5	34.6	40.4	23.3
	E wld 4	79.8	51.9	32.3	35.2	42.4	23.5
	LMUprz11	75.5	49.9	31.8	36.4	37.8	22.1
	LMUprz13	77.8	50.8	30.4	37.1	38.0	23.4
	E wld 5	82.1	53.9	34.9	36.4	43.8	23.8
Pony	1937.51	60.7	41.3	26.0	26.2	33.8	
	BZL1	70.1	46.0	30.2	31.9	40.5	20.8
	E pon 1	85.7	52.4	33.7	38.7	42.7	25.2
	LWH3	74.3	49.2	31.1	33.3	40.6	23.1
	BZL332	79.1	54.9	34.7	34.9	47.9	24.6
	1961/29	73.2	48.7	32.4	34.8	38.2	22.1
	E mgl 1	82.9	57.1	35.0	35.2	43.3	23.8
	E mgl 3	81.3	52.0	31.6	35.7	41.4	24.1
	E mgl 4	82.4	55.8	37.2	37.1	43.7	25.2
	H37	66.1	45.3	28.5	33.8	36.1	20.7
	L2161	87.8	53.6	33.7	37.0	44.6	24.9
	1911.145	80.3	47.7	29.9	34.4	41.5	23.5
	TPOC1	68.8	47.1	27.9	35.5	38.1	22.5
	BZL135	71.1	47.9	31.3	32.5	39.0	

	Specimen no.	GL	Bp	Dp	SD	BFd	Dd
Arab	1927.2	100.1	60.4	37.6	43.0	50.0	26.7
	24.5.4.1	90.5	57.3	32.4	41.6	44.8	25.1
	37.1.26.10	93.4	62.0	36.2	43.0	47.4	26.4
	E arb 3	92.0	54.5	34.6	37.0	47.1	23.4
	H40	91.5	58.7	35.0	38.3	47.6	25.4
Donkey	1933.4	69.8	38.8	23.2	27.2	34.1	19.1
	1968/696	69.6	36.2	22.3	25.5	30.9	17.0
	47.7.16.6	59.4	37.5	27.8	27.4	28.9	18.0
	86.2	62.0	20.9	25.4	35.3	30.4	17.8
	99.3.14.18	58.7	32.2	19.4	24.1	27.6	16.0
	Ea 12	66.0	40.3	23.1	30.0	34.1	19.7
	Ea 15	67.6	35.5	20.9	26.1	30.5	17.0
	M131	66.3	37.7	22.8	27.5	33.0	18.4
	1893.6	82.3	41.4	25.8	33.1	36.5	21.7
	51.8.28.14	62.0	35.5	21.8	25.9	31.2	18.8
	E abs wld1	66.6	34.8	20.2	26.1	31.4	16.6
	LMUass2	69.8	43.5	23.7	32.7	34.3	20.1
	LMUass3	73.7	43.6	23.7	34.0	34.0	20.2
	81.1	96.6	53.0	32.9	40.4	46.4	25.9
	87.12.9.1	84.2	51.7	30.3	35.9	39.1	24.8
Mule	1970/5	79.3	48.4	29.7	35.6	38.6	22.6
	1970/6	76.3	51.8	31.5	34.6	38.2	22.2
	1972/337	80.9	50.8	31.4	37.6	38.0	23.1
	1972/338	82.0	50.6	31.0	37.8	41.4	24.6
	Eml mlt 1	82.4	52.0	31.1	35.0	42.0	23.7
	Eml mlt 3	101.8	62.7	38.7	44.6	51.6	29.2
	LMUmule2	94.6	54.6	34.6	38.3	45.8	25.6
	LMUmule3	97.0	59.6	34.6	41.3	49.0	27.2
	LMUmule4	102.3	59.8	41.8	47.9	52.6	29.5
	Mule 1	98.3	58.2	36.5	38.4	49.0	26.7
Onager	KD onager	74.1	43.1	24.7	31.1	33.8	20.3
	1965/207	77.8	43.8	27.3	31.7	36.5	20.0

Femur	Specimen no.	GL	GLC	DC	Bp	SD	Bd
Przewalski	RDVS	309.0	356.0	35.1	85.2	52.4	108.8
	02.9.25.1	318.0	340.0	32.9	81.6	49.4	100.1
	07.5.15.1	319.0	355.0	34.6	83.1	51.3	106.5
	1929.37	315.0	350.0	38.7	83.3	48.9	95.0
	1953/147	334.0	359.0	38.4	91.2	56.5	110.2
	1962.228	345.0	368.0	38.4	92.9	54.7	119.0
	1973.109	316.0	341.0	40.1	82.0	52.0	99.0
	1973/237	324.0	353.0	31.7	84.7	52.3	101.9
	1975.125	333.0	360.0	40.8	84.1	55.0	103.9
	1980.29	343.0	366.0	39.7	90.4	55.6	103.8
	45.6.11.1	322.0	355.0	35.0	84.5	56.5	107.1
	E wld 1	334.0	368.0	39.8	86.3	53.7	106.3
	E wld 2	314.0	341.0	36.0	86.6	50.4	98.5
	E wld 4	332.0	363.0	41.1	86.6	54.6	105.4
	LMUprz11	323.0	357.0	38.8	84.5	53.8	104.3
	LMUprz13	331.0	362.0	37.8	82.8	52.1	112.3
	E wld 5	348.0	382.0	43.0	92.2	59.9	117.2
Pony	1937.51	265.2	289.0	29.8	67.8	40.2	82.0
	BZL1	306.0	353.0	31.0	79.0	45.0	99.3
	E pon 1	352.0	394.0	41.5	96.2	53.4	114.4
	LWH3	325.0	351.0	40.9	85.5	54.1	111.2
	BZL332	351.0	381.0	42.8	93.0	57.7	118.2
	1961/29	322.0	355.0	40.8	81.9	50.4	100.3
	E mgl 1	352.0	384.0	40.1	93.3	59.0	116.1
	E mgl 3	342.0	372.0	36.5	88.4	55.8	109.6
	E mgl 4	355.0	393.0	42.1	94.4	58.1	118.3
	H37	327.0	358.0	33.3	81.4	50.7	102.2
	L2161	348.0	396.0	39.6	95.5	60.3	115.3
	1925.78	372.0	399.0	39.0	95.7	57.9	119.0
	1911.145	319.0	359.0	30.3	84.7	51.3	102.4
	TPOC1	314.0	331.0	31.8	78.7	49.7	101.0
	BZL135	312.0	344.0	33.2	77.5	48.5	99.2

	Specimen no.	GL	GLC	DC	Bp	SD	Bd
Arab	1927.235	384.0	433.0	41.8	101.5	61.4	126.9
	24.5.4.1	392.0	423.0	39.3	97.2	60.0	120.3
	37.1.26.10	398.0	441.0	42.9	105.4	64.6	131.6
	E arb 3	372.0	406.0	38.2	91.9	55.4	114.6
	H40	376.0	424.0	38.8	101.0	60.5	126.4
Donkey	1933.397	279.3	302.0	27.9	70.7	43.1	89.6
	1968/696	297.0	319.0	26.3	71.2	42.0	89.6
	47.7.16.6	268.5	300.0	27.4	69.1	40.1	86.9
	60.11.10.4	250.0	277.9	28.8	64.4		84.8
	86.1756	251.5	275.3	26.3	67.4	37.4	79.5
	Ea 11	291.0	321.0	30.9	78.7	42.8	90.1
	Ea 12	286.0	308.0	29.9	74.6	42.7	92.0
	Ea 15	265.7	281.0	30.0	63.9	37.9	81.2
	M131	275.0	300.0	30.2	72.0	41.5	84.8
	1893.634	320.0	361.0	32.7	85.5	49.3	104.1
	E abs wld1	270.3	287.0	25.1	64.2	39.1	81.1
	LMUass2	295.0	329.0	29.2	80.2	45.3	94.5
	LMUass3	296.0	325.0	31.2	80.5	45.3	94.2
	81.1338	387.0	417.0	43.0	98.0	57.8	120.9
	87.12.9.1	371.0	407.0	40.2	95.6	54.7	120.1
Mule	1970/5	357.0	391.0	37.2	82.8	51.4	112.3
	1970/6	338.0	376.0	33.2	84.4	52.8	102.6
	1972/337	359.0	389.0	40.5	89.9	54.1	110.9
	1972/338	354.0	386.0	39.5	87.4	53.2	120.3
	Eml mlt 1	338.0	379.0	40.2	87.9	54.3	113.6
	Eml mlt 3	419.0	467.0	52.8	109.7	70.2	139.5
	LMUmule1	361.0	397.0	37.2	87.7	53.9	106.7
	LMUmule2	380.0	412.0	41.6	98.5	60.7	133.3
	LMUmule3			55.4	104.4		
	LMUmule4	399.0	437.0	55.0	117.3	67.0	131.6
	Mule 1	404.6	452.6	44.3	103.1	62.2	
Onager	KD onager	291.0	328.0	31.4	79.0	44.8	94.5
	1965/207	293.0	322.0	32.2	74.4	46.6	99.2

Tibia	Specimen no.	GL	Ll	Bp	SD	Bd	Dd
Przewalski		328.0	301.4	36.4	70.4	93.0	47.2
	02.9.25.1	318.0	293.1	36.5	64.6	85.5	41.3
	07.5.15.1	316.0	291.0	38.1	67.2	87.4	42.8
	1929.37	309.0	288.0	39.2	66.7	85.2	42.4
	1953/147	332.0	298.0	42.5	75.4	94.0	46.2
	1962.228	332.0	303.0	40.0	71.1	94.3	45.4
	1973.109	305.0	282.0	41.4	65.0	85.6	39.4
	1973/237	320.0	292.0	39.8	69.1	88.8	44.1
	1975.125	330.0	300.0	43.5	74.1	90.0	45.1
	1980.29	326.0	304.0	41.4	70.5	90.1	43.7
	45.6.11.1	330.0	302.0	38.5	69.0	92.1	45.0
	E wld 1	328.0	295.0	40.1	72.4	92.6	46.5
	E wld 2	307.0	278.0	40.2	70.3	92.0	44.6
	E wld 4	325.0	302.0	42.3	71.9	94.5	46.4
	LMUprz11	324.0	296.0	43.1	70.3	88.8	42.3
	LMUprz13	334.0	303.0	40.5	69.0	89.7	43.8
	E wld 5	337.0	309.0	46.5	77.0	97.9	47.1
Pony	1937.51	252.2	226.0	30.0	53.6	72.9	33.7
	BZL1	296.0	277.0	32.1	60.4	85.5	39.7
	E pon 1	359.0	329.0	43.6	74.2	95.3	52.1
	LWH3	313.0	279.0	39.0	66.6	90.2	40.1
	H37	314.0	289.8	33.5	62.0	84.6	39.2
	L2161	345.0	305.0	40.0	73.6	97.2	49.9
	BZL332	340.0	318.0	38.9	72.5	97.2	44.1
	1961/29	321.0	297.0	40.7	65.1	84.3	41.5
	E mgl 1	338.0	308.0	40.5	72.0	93.7	44.3
	E mgl 3	336.0	304.0	38.1	71.0	93.4	43.4
	E mgl 4	338.0	307.0	42.1	71.9	99.4	48.0
	1925.78	357.0	322.0	41.0	76.0	95.7	45.3
	1911.145	337.0	297.0	33.2	67.3	88.0	40.8
	TPOC1	293.0	258.0	30.2	62.9	86.0	38.6
	BZL135	308.0	286.0	35.2	63.2	83.7	41.9

Astragalus	Specimen no.	GH	BFd

	Specimen no.	GL	Ll	Bp	SD	Bd	Dd
Arab	1927.235	398.0	361.0	43.5	80.4	104.4	52.8
	24.5.4.1	387.0	352.0	40.1	75.8	100.0	48.2
	37.1.26.10	394.0	363.0	43.4	83.2	105.3	52.0
	E arb 3	369.0	336.0	39.7	77.2	98.4	48.7
	H40	357.0	325.3	39.6	79.9	100.0	49.8
Donkey	1933.397	285.0	261.5	33.4	56.6	72.7	37.6
	1968/696	297.0	279.0	28.6	55.8	70.4	36.2
	47.7.16.6	276.3	261.0	30.9	56.3	69.8	35.6
	60.11.10.4	252.0	241.0	31.2	53.9	71.1	35.6
	86.1756	265.8	253.4	27.8	52.1	67.3	33.1
	Ea 11	298.0	276.2	32.3	61.8	77.1	42.5
	Ea 12	282.3	261.6	31.5	60.1	77.2	42.6
	Ea 15	273.5	255.1	30.5	52.9	65.8	35.4
	M131	290.0	266.0	31.0	56.3	72.5	37.7
	99.3.14.18	257.0	247.3	27.0	49.6	62.2	31.8
	1893.634	331.0	303.0	35.3	68.2	83.6	43.9
	E abs wld1	276.5	257.1	28.7	51.0	67.3	34.2
	LMUass2	306.0	282.0	33.0	64.5	82.0	42.1
	LMUass3	312.0	282.0	34.0	65.3	82.0	44.0
	81.1338	404.0	380.0	42.4	77.6	98.2	52.2
	87.12.9.1	381.0	357.0	39.2	75.6	92.1	50.8
Mule	1970/5	368.0	336.0	37.0	66.2	86.9	47.4
	1970/6	356.0	301.0	34.0	67.2	85.7	42.0
	1972/337	364.0	338.0	39.4	72.0	92.4	51.8
	1972/338	368.0	334.0	41.3	71.2	94.0	46.8
	Eml mlt 1	341.0	350.0	37.5	70.8	91.0	44.4
	Eml mlt 3	415.0	377.0	49.4	88.6	115.7	59.3
	LMUmule1	361.0	328.0	38.2	72.3	91.5	45.3
	LMUmule2	392.0	358.0	45.3	75.6	104.4	49.4
	LMUmule3	417.0	388.0	45.0	82.5	110.1	54.0
	LMUmule4	418.0	381.0	51.1	97.7	119.8	63.6
	Mule 1	403.1	370.4	45.5	82.7	103.6	50.8
Onager	KD onager	308.0	277.0	37.1	64.6	83.8	46.1
	1965/207	313.0	288.0	35.9	60.9	81.4	41.8

Specimen no.	GH	BFd

Przewalski	RDVS	57.2	56.2
	02.9.25.1	53.0	46.4
	07.5.15.1	53.2	47.0
	1929.37	51.3	45.9
	1953/147	56.2	48.9
	1962.228	50.7	48.6
	1973.109	48.9	44.0
	1973/237	53.5	46.3
	1975.125	53.4	49.0
	1980.29	56.2	48.3
	45.6.11.1	57.5	49.0
	E wld 1		46.4
	E wld 2	50.3	48.1
	E wld 4	53.5	50.6
	LMUprz11	53.0	47.4
	LMUprz13	55.2	48.5
	E wld 5	56.7	47.8
Pony	BZL332	54.2	63.2
	1961/29	52.6	46.5
	E mgl 1	53.5	51.2
	E mgl 3	56.3	51.2
	E mgl 4	56.8	49.6
	H37	48.3	43.1
	L2161	61.4	53.2
	1925.78	60.3	51.4
	BZL1	45.5	50.8
	TPOC1	52.7	46.3
	BZL135	51.0	55.9
	1937.51	40.9	

Arab	1927.235	64.8	56.2
	24.5.4.1	62.8	50.8
	37.1.26.10	65.3	57.5
	E arb 3	60.5	52.9
	H40	64.1	52.9
Donkey	1933.397	46.1	38.5
	47.7.16.6	44.0	36.0
	86.1756	42.2	32.8
	Ea 12	50.9	39.7
	Ea 15	40.6	35.4
	M131	44.6	38.4
	1968/696	46.2	37.0
	99.3.14.18	39.6	33.3
	1893.634	56.3	46.8
	E abs wld1	40.9	34.9
	LMUass2	52.3	43.3
	LMUass3	50.4	43.4
	81.1338	61.6	50.8
	87.12.9.1	60.0	52.4
Mule	Eml mlt 1		49.0
	Eml mlt 3	70.9	59.2
	1970/5	58.3	
	1972/337	57.7	51.3
	1972/338	57.2	50.4
	LMUmule1	56.8	47.6
	LMUmule2	62.9	57.8
	LMUmule3	64.1	56.7
	LMUmule4	70.8	61.4
Onager	KD onager	51.6	43.8
	1965/207	51.8	43.4

Calcaneum	Specimen no.	GL	GB	DS
Przewalski	RDVS	104.2	52.0	
	02.9.25.1	98.6	48.7	56.8
	07.5.15.1	98.0	48.0	58.4
	1929.37	95.6	48.0	56.7
	1953/147	103.2	50.3	60.3
	1962.228	107.7	52.0	57.0
	1973.109	93.7	44.7	50.7
	1973/237	100.2	45.6	56.8
	1975.125	101.9	48.4	57.4
	1980.29	102.3	48.0	58.1
	45.6.11.1	110.7	51.2	59.8
	E wld 1	100.9	50.6	51.9
	E wld 2	95.5	46.5	56.7
	E wld 4	100.0	51.7	56.9
	LMUprz11	97.7	46.1	55.2
	LMUprz13	103.3	47.4	57.5
	E wld 5	106.0	53.1	59.3
Pony	BZL332	106.7	52.8	55.4
	1961/29	96.7	46.5	54.3
	E mgl 1	104.7	48.9	
	E mgl 3	107.6	49.6	62.1
	E mgl 4	109.4	53.7	
	H37	91.3	46.9	53.2
	L2161	111.0	50.8	58.3
	1925.78	118.6	54.4	63.1
	E pon 1	112.1		59.6
	BZL1	88.2	41.9	46.7
	1911.145	99.4	43.0	
	TPOC1	93.4	45.8	50.1
	BZL135	93.5	45.2	43.9
	1937.51	76.4	36.5	43.7

	Specimen no.	GL	GB	DS
Arab	1927.235	124.2	57.2	67.4
	24.5.4.1	117.2	52.4	63.0
	37.1.26.0	122.8	58.3	65.6
	E arb 3	115.4	55.5	62.9
	H40	114.9	53.3	64.3
Donkey	1933.397	84.8	41.0	45.6
	47.7.16.6	83.6	40.8	42.3
	86.1756	78.8	36.1	41.2
	Ea 11	88.4	44.3	49.1
	Ea 12	90.2	44.1	47.9
	Ea 15	80.0	36.7	39.8
	M131	84.0	42.1	45.0
	1968/696	86.5	40.3	44.7
	99.3.14.18	73.2	33.5	39.2
	1893.634	100.2	46.3	51.6
	E abs wld1	78.1	38.3	42.0
	LMUass2	93.4	42.9	48.9
	LMUass3	89.6	40.9	48.2
	81.1338	120.0	55.4	56.6
	87.12.9.1	112.2	56.2	56.8
Mule	Eml mlt 1	105.5	51.6	55.3
	Eml mlt 3	131.9	60.5	70.4
	Mule 1	126.5	62.0	53.9
	1970/5	109.6		
	1970/6	103.2	46.1	54.6
	1972/337	112.4		
	1972/338	110.7	50.9	57.3
	LMUmule1	104.7	49.1	54.8
	LMUmule2	121.3	56.3	65.2
	LMUmule3	126.2	56.7	69.7
	LMUmule4	131.4	61.4	73.9
Onager	KD onager	96.3	46.4	49.9
	1965/207	95.2	40.1	50.1

Metatarsal	Specimen no.	GL	Ll	Bp	Dp	SD	BFd	Dd
Przewalski	RDVS	260.0	252.0	50.2		27.1	47.3	37.1
	02.9.25.1	252.0	245.0	47.2	40.9	27.6	45.4	33.9
	07.5.15.1	255.9	250.0	47.2	42.9	30.2	43.9	35.3
	1929.37	253.8	247.0	47.0	42.1	29.7	44.3	34.4
	1953/147	262.6	255.2	51.3	43.9	32.0	48.3	38.5
	1962.228	263.6	255.8	49.1	45.1	30.9	47.5	37.5
	1973.109	236.2	228.1	46.7	40.0	31.3	43.4	32.2
	1973/237	256.3	247.2	49.0	41.9	30.5	44.1	35.1
	1975.125	261.2	254.1	50.7	43.1	32.8	45.4	34.4
	1980.29	261.8	253.1	49.5	42.8	32.2	46.3	
	45.6.11.1	259.1	251.1	51.9	47.2	26.7	47.8	36.8
	E wld 1	263.0	255.0	50.2	45.2	31.1	45.8	36.2
	E wld 2	253.2	243.5	52.9	42.2	28.4	46.6	33.7
	E wld 4	262.7	253.8	50.0	44.3	29.8	47.1	34.6
	LMUprz11	256.3	249.4	49.7	42.9	30.9	45.3	35.2
	LMUprz13	267.6	259.5	49.9	43.4	29.7	46.2	35.5
	E wld 5	260.5	252.6	50.1	45.5	32.0	49.3	35.1
Pony	1937.51	191.8	182.0			23.1	37.9	28.8
	BZL1	219.0	210.0		38.8	27.6	41.0	21.3
	E pon 1	255.9	247.6	47.1	44.7	31.5	47.7	37.3
	LWH3	242.2	234.4	46.8	37.8	27.9	44.6	35.1
	BZL332	257.0	249.0	51.2	44.3		48.4	36.2
	1961/29	249.1	344.4	43.8	41.2	30.2	44.8	34.3
	E mgl 1	258.0	247.7	47.2	42.5	30.5	49.0	35.6
	E mgl 3	259.5	252.4	48.6	44.9	30.0	46.4	36.7
	E mgl 4	256.7	247.4	50.3	45.6	31.4	46.4	38.4
	H37	226.0	221.0	42.2	37.2	26.0	40.6	32.1
	L2161	276.0	263.0	52.0	47.7	30.6	47.7	38.0
	1925.78	280.0	269.5	54.0		32.3	52.6	37.8
	1911.145	246.0	236.5	43.9		36.2	45.1	35.7
	TPOC1	232.0	225.0	44.4	38.4	24.0	42.6	33.4
	BZL135	231.0	226.0	41.8	37.7	28.1	42.9	32.1

	Specimen no.	GL	Ll	Bp	Dp	SD	BFd	Dd
Arab	1927.2		302.0	58.1	48.2	33.4	54.3	44.5
	24.5.4.1	296.0	285.3	49.6	51.9	32.7	51.7	39.7
	37.1.26.10	316.0	309.0	59.0	53.3	34.6	55.8	41.6
	E arb 3	285.0	278.0	55.5	42.6	31.2	52.0	39.2
	H40	286.0	278.0	55.2	47.5	28.8	53.6	40.4
Donkey	1933.4	214.7	207.9	38.8	36.5	24.5	35.2	27.9
	1968/696	227.5	224.7	38.5	31.2	22.4	33.2	26.2
	47.7.16.6	199.7	195.1	35.5	30.0	21.8	33.1	27.4
	86.2	200.4	195.8	35.7	31.7	20.7	32.2	25.2
	99.3.14.18	201.6	196.6	34.0	28.8	20.0	28.2	24.5
	Ea 11	228.2	222.9	42.4	37.7	24.5	36.2	31.1
	Ea 12	216.9	211.8	42.1	38.5	24.3	36.0	30.1
	Ea 15	204.6	200.7	36.1	29.9	22.7	31.1	23.9
	M131		207.0			23.0	34.9	27.7
	1893.6	247.5	243.0	43.5	38.6	28.7	40.2	32.2
	51.8.28.14	205.7	201.7	35.9	31.6	22.2	32.6	25.8
	E abs wld1	215.1	207.8	35.3	30.4	20.7	32.5	25.6
	LMUass2	225.7	220.8	42.1	39.7	23.3	39.6	30.7
	LMUass3	224.6	219.6	41.4	39.1	25.0	38.1	30.3
Mule	1970/5	260.1	256.8	44.4	42.0	26.5	44.1	33.4
	1970/6	256.9	249.1	44.3	39.8	26.4	44.1	35.7
	1972/337	275.8	264.1			28.9	43.9	35.5
	1972/338	269.7	263.1	47.3	40.6	30.1	46.3	36.4
	Eml mlt 1	260.0	249.5	48.8	39.0	29.5	45.4	35.1
	Eml mlt 3	311.0	298.0	58.6	55.4	36.2	51.3	43.0
	LMUmule1	259.8	252.8	48.1	44.5	28.9	45.5	35.7
	LMUmule2	274.0	267.6	53.0	50.5	32.6	50.1	38.7
	LMUmule3	316.0	308.0	56.1	53.3	34.3	54.2	41.3
	LMUmule4	314.0	306.0	59.7	59.4	35.7	56.4	45.4
	Mule 1		281.7	53.6	52.6	33.0	53.2	40.3
Onager	KD onager	250.0	242.0	42.4	34.8	26.7	38.5	31.5
	1965/207	246.2	241.4	39.6	36.6	26.6	38.6	30.2

Hind first phalanx	Specimen no.	GL	Bp	Dp	SD	BFd	Dd
Przewalski	1953/147	80.3	52.7	32.2	40.4	40.8	25.1
	1973/237	79.4	47.8	31.4	34.1	38.4	22.0
	RDVS	78.8	53.6	30.2	37.3	43.7	
	02.9.25.1	85.5	50.0	28.6	32.7	41.6	23.4
	07.5.15.1	76.9	50.0	32.6	34.0	38.8	22.9
	1929.37	71.3	50.2	29.9	35.7	37.3	21.7
	1962.228	76.1	51.0	32.4	39.1	42.4	23.6
	1973.109	71.5	48.0	31.4	33.4	37.7	22.4
	1975.125	75.8	51.5	35.0	36.8	40.2	24.2
	1980.29	76.5	52.3	31.4	35.0	40.5	24.2
	45.6.11.1	79.6	52.8	33.7	35.3	42.7	24.2
	E wld 1	76.0	50.1	31.1	34.4	38.8	23.5
	E wld 2	69.0	50.8	32.0	35.2	38.8	22.3
	E wld 4	77.4	51.7	32.3	37.0	40.9	23.3
	LMUprz11	78.8	49.5	32.6	33.2	39.4	22.3
	LMUprz13	83.7	50.5	32.1	36.5	40.1	23.7
	E wld 5	80.2	54.1	34.2	38.9	42.4	24.2
Pony	1937.51	55.9	37.5	26.1	26.0	34.5	
	BZL1	67.5	45.8	27.8	33.1	38.3	20.3
	E pon 1	81.8	52.4	33.1	38.1	40.1	24.3
	LWH3	72.9	49.9	31.7	36.0	39.1	23.6
	BZL332	77.5	55.5	34.4	37.7	46.4	25.2
	1961/29	76.2	49.0	32.4	32.4	39.3	22.3
	E mgl 1	78.2	55.1	33.7	37.2	41.8	24.1
	E mgl 3	75.7	51.6	31.4	38.0	39.6	24.2
	E mgl 4	81.0	54.3	35.3	39.0	41.6	24.5
	H37	68.0	44.3	29.5	30.9	37.1	20.5
	L2161	83.6	55.1	33.1	39.7	42.8	24.3
	1911.145	79.7	49.4	28.0	37.6	39.9	23.4
	TPOC1	73.2	47.5	28.3	30.6	39.0	21.9
	BZL135	67.6	47.6	30.7	34.7	39.9	23.5

	Specimen no.	GL	Bp	Dp	SD	BFd	Dd
Arab	1927.2	95.5	58.9	35.6	41.8	47.0	26.2
	24.5.4.1	94.7	57.1	33.6	41.4	46.4	25.9
	37.1.26.10	95.0	60.0	36.5	38.9	48.1	26.6
	H40	89.5	58.4	33.5	41.7	45.9	24.9
Donkey	1933.4	65.6	39.3	22.9	28.0	31.1	18.7
	1968/696	65.4	36.5	20.7	26.1	28.4	17.4
	47.7.16.6	63.2	37.0	23.3	27.2	31.2	18.5
	86.2	58.7	36.6	21.5	27.0	28.9	17.2
	99.3.14.18	53.4	31.6	19.1	24.1	24.7	15.3
	Ea 12	62.4	42.0	23.0	29.9	32.0	18.9
	Ea 15	62.0	35.5	20.5	26.6	27.7	16.4
	M131	61.7	37.8	23.8	28.4	30.0	18.6
	1893.6	77.0	43.3	25.5	32.9	35.0	20.7
	51.8.28.14	57.7	36.6	20.8	26.2	29.6	17.2
	E abs wld1	60.4	35.2	19.5	26.2	28.8	15.9
	LMUass2	72.4	42.4	24.0	32.7	37.1	20.8
	LMUass3	74.6	42.5	24.2	32.5	36.6	21.0
	81.1	91.0	54.4	32.2	40.3	43.2	24.4
	87.12.9.1	91.4	49.6	31.2	37.6	43.4	29.7
Mule	1970/5	85.2	48.1	31.6	34.8	41.8	23.4
	1970/6	78.7	49.9	30.8	33.3	38.9	22.5
	1972/337	85.0	51.5	35.1	34.3	40.7	23.2
	1972/338	86.9	50.5	33.2	36.2	44.1	25.2
	Eml mlt 1	75.6	52.0	30.0	37.1	40.4	23.7
	Eml mlt 3	98.2	64.6	37.3	46.1	48.4	28.0
	LMUmule2	91.4	56.3	32.2	42.0	45.1	26.2
	LMUmule3	93.2	61.5	33.5	43.7	46.3	27.0
	LMUmule4	95.9	61.5	39.6	48.0	48.9	28.9
	Mule 1	91.8	58.4	35.0	41.8	46.4	
Onager	KD onager	70.8	45.6	25.3	32.8	32.0	20.8
	1965/207	71.6	44.2	26.2	30.3	34.5	19.8

Table A2. A gazetteer of sites from which archaeological data were obtained, together with information on location, dating, site type and number of bones with measurements.

Site no.= the computer database generated number. Site name is mostly taken from the site report. Country and county/province are the geographic location according to Philips Atlas of the World. General period = IA for Iron Age, RO for Roman, IA+RO for both and NAT for Roman period beyond the Limes. Dating is in years BC and AD. No. phases = the number of phases the date range can be split into. Site type = the classification of the site according to King (1999). No. bones = number of bones whose biometric data have been entered in to the database. Notes = any comments on the site that are felt necessary.

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
3	Edix Hill	Britain	Cambs	Britannia	IA	150BC-AD50	1	Large settlement	6	
4	Market Deeping	Britain	Lincs	Britannia	IA		2	Settlement	10	
5	Beckford	Britain	Worcs	Britannia	IA		1	Enclosure	7	
6	Wardy Hill	Britain	Cambs	Britannia	IA		1	Settlement	4	
7	Blackhorse Road	Britain	Herts	Britannia	IA		1	Settlement	3	
8	Hardingstone School	Britain	Northants	Britannia	IA+RO	1st C AD	1	Industrial	7	
9	Hardingstone enclosure	Britain	Northants	Britannia	IA		1	Enclosure	8	
10	Twywell	Britain	Northants	Britannia	IA		1	Settlement	6	
11	Ivinghoe Beacon	Britain	Bucks	Britannia	IA	6th C BC		Hillfort	3	
12	GA, Tanner Row	Britain	York	Britannia	RO	E-LR	2	Urban vicus	3	
13	Wavendon Gate	Britain	Bucks	Britannia	IA+RO	1st C BC-4th C AD	5	Rural settlement	17	
14	Lincoln	Britain	Lincs	Britannia	RO	1st-4th C AD	5	Urban	25	
15	Scole-Dickleburgh	Britain	Norfolk/ Suffolk	Britannia	IA+RO	1st-4th C AD	3	Small town	75	
16	Birdlip	Britain	Gloucs	Britannia	IA	1st C BC-1st C AD	3	Farmstead	14	
17	Great Holts Farm	Britain	Essex	Britannia	RO	3rd/4th C AD	1	Villa	3	
18	Camulodunum	Britain	Essex	Britannia	IA+RO	1st C BC-65 AD	3	Military/ urban	16	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
19	Scole	Britain	Norfolk	Britannia	RO	2^{nd}-4^{th} C AD	1	?Villa	3	
20	Northchurch	Britain	Herts	Britannia	RO	2^{nd}-3^{rd} C AD	1	Villa	6	
21	Skeleton Green	Britain	Herts	Britannia	IA	1^{st} C AD	1	Settlement	6	
22	Braughing	Britain	Herts	Britannia	IA	1^{st} C AD	1	Oppidum	2	
23	Puckeridge	Britain	Herts	Britannia	IA	1^{st} C AD	1	Oppidum	7	
24	Dunstable	Britain	Beds	Britannia	RO	2^{nd} C AD	1	Cemetery	7	
25	Redlands Farm	Britain	Northants	Britannia	RO	2^{nd}-5^{th} C AD	2	Settlement	3	
26	Stonea	Britain	Cambs	Britannia	RO	2^{nd}-3^{rd} C AD	1	Settlement	2	
27	Lynch Farm	Britain	Cambs	Britannia	IA+RO	1^{st} c BC-4^{th} C AD	2	Farmstead	12	Occupation not continuous
28	Longthorpe II	Britain	Cambs	Britannia	IA+RO	1^{st}-2^{nd} C AD	4	Military/ Industrial	17	
29	Norman cross	Britain	Cambs	Britannia	RO	3^{rd}-4^{th} C AD	1	Rural Settlement	3	
30	Tort Hill East	Britain	Cambs	Britannia	RO	1^{st}-3rd C AD	2	Rural Settlement	9	
31	Tort HIll West	Britain	Cambs	Britannia	IA+RO	1^{st}-3^{rd} C AD	2	Rural Settlement	16	
32	Vinegar Hill	Britain	Cambs	Britannia	RO	3^{rd}-4^{th} C AD	1	Rural Settlement	3	
33	Longthorpe fortress	Britain	Cambs	Britannia	RO	44-62 AD	1	Military	1	
34	Wall Mansio	Britain	Staffs	Britannia	RO	?2^{nd} C AD	1	Military/ civilian	7	Mansio station ??road
35	Castricum-Oosterbuurt	Holland		Germania Inferior	RO	1^{st}-4^{th} C AD	2		59	
36	Egmond?	Holland		Germania Inferior	RO		1		14	
37	Kesteren 'De Prinsenhof'	Holland	Gelderland	Germania Inferior	RO	1^{st} C AD	1	Cemetary	112	
38	Nijmegen	Holland	Nijmegen	Germania Inferior	RO	1^{st} C BC – 4^{th} C AD	4	Military and Urban	124	
39	Kesteren vicus	Holland	Nijmegen	Germania Inferior	RO	1^{st}-3^{rd} C AD	1	Vicus	8	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
40	Heteren	Holland	Nijmegen		NAT	1^{st}–2^{nd} C AD	2	Settlement	17	
41	Elst, temple	Holland	Nijmegen	Germania Inferior	RO	1^{st}-3^{rd} C AD	1	Temple	1	
42	Druten	Holland	Nijmegen	Germania Inferior	IA+RO	1^{st} C BC – 2^{nd} C AD	2	Farmstead/Villa	125	
43	Elms Farm	Britain	Essex	Britannia	IA+RO	1^{st} C BC – 5^{th} C AD	5	Small town	93	
44	Danebury	Britain	Hants		IA	6^{th}-1^{st} C BC	4	Hillfort	205	
45	Billingsgate	Britain	London	Britannia	RO	2^{nd} C AD	1	Urban	1	
46	E London RB Cemetary	Britain	London	Britannia	RO	1^{st}-2^{nd} C AD	1	Cemetary	49	
47	Beddington Sewage Farm	Britain	London	Britannia	IA+RO	1^{st} C BC – 3^{rd} C AD	3	Urban	22	
48	Winchester Palace	Britain	Hants	Britannia	RO	1^{st} C AD	1		1	
49	Buckingham Street	Britain	Bucks	Britannia	RO	1^{st}-2^{nd} C AD	1	Rural Settlement	5	
50	Coldharbour Farm 90	Britain	Bucks		IA		1	Farmstead	3	
51	Coldharbour Farm 97	Britain	Bucks		IA		1	Farmstead	4	
52	Magiovinium	Britain	Bucks	Britannia	RO	1^{st}-4^{th} C AD	4	Military/ Urban	8	
53	Ashville Trading Estate	Britain	Oxon		IA		1	Settlement	6	
54	Thorpe Thewles	Britain	Cleveland	Britannia	IA+RO	1^{st} C BC – 1^{st} C AD	3	Rural Settlement	35	
55	Brancaster 1974	Britain	Norfolk	Britannia	RO	1^{st}-2^{nd} C AD	1	Military?	3	
57	La Sagesse	Britain	Hants		IA				10	
58	Braintree	Britain	Essex	Britannia	RO	2^{nd}-3^{rd} C AD	1	Small town	2	
59	Chichester cattlemarket	Britain	W. Sussex	Britannia	RO	??	1	Urban	21	
60	Narce	Italy	Etruria	Italia	IA	10^{th} C BC-8^{th} C BC	3	Rural Settlement	5	
61	Vaste	Italy	Puglia	Italia	RO	2^{nd} C BC	1		2	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
62	Mola di Monte Gelato	Italy	S. Etruria	Italia	RO	4^{th}-5^{th} C AD	1	Villa	1	
63	S. Giacomo	Italy	Molise	Italia	RO	5^{th} C AD	1	Villa	7	
64	Gravina	Italy		Italia	RO	4^{th}–2^{nd} C BC	2		13	
65	Carminiello ai Mamnesi	Italy	Napoli	Italia	RO	5^{th}-8^{th} C AD	2		4	
66	Settefinestre	Italy	Etruria	Italia	RO		5	Villa	12	
67	Ilchester,Church Street	Britain	Somerset	Britannia	RO	3^{rd}-4^{th} C AD	1	Urban	5	
68	Lutton/Huntingdon	Britain	Northants/ Cambs	Britannia	IA+RO	IA–4^{th} C AD	4	Rural Settlement	13	
69	Thorley	Britain	Herts	Britannia	IA+RO	MIA – 4^{th} C AD	3	Rural Settlement	12	
70	Emilia	Italy	Emilia?	Italia	IA+RO	6^{th}-5^{th} C BC	1		6	
71	Piovego	Italy	Padova	Italia	IA	6^{th} –5^{th} C BC	1	Cemetary	10	
72	Colle dei Cappuccini	Italy	Ancona	Italia	IA			Village	5	
73	Moie di Pollenza	Italy	Macerata	Italia	IA	9^{th}-6^{th} C BC	1	?Necropolis	1	
74	Sovana	Italy	Grosseto	Italia	IA	7^{th}-6^{th} C BC	1	Etruscan tomb	3	
75	Marzabotto	Italy	Bologna	Italia	IA	Etruscan	1	Settlement	3	
76	Ansedonia	Italy	Grosetto	Italia	RO		1	Villa	1	
77	Grotto di Tibera	Italy	Latina	Italia	RO	1^{st} C AD	1		9	
78	Cowbridge	Britain	S. Glamorgan	Britannia	RO	1^{st}-2^{nd} C AD	1	Urban	3	
79	Olbia	Italy	Sardinia	Italia	IA	2^{nd} C BC	1	Punic Settlement	20	
80	Friedland	Germany	Meclenburg-Varp..	Germania magna	NAT	2^{nd}-1^{st} C BC	1	Settlement	2	
81	Welsow	Germany	Brandenburg	Germania magna	NAT	2^{nd}-1^{st} C BC	1	Settlement	14	
82	Genshagen	Germany	Brandenburg	Germania magna	NAT	Empire	1	Settlement	3	
83	Deutsch Wusterhausen	Germany	Brandenburg	Germania magna	NAT	Empire	1	Settlement	7	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
85	Macon	France	Saone-et-Loire	?Aquitania	IA+RO	LIA-Gallo-Romaine	2	Cemetary	6	
86	Dambron	France	Eure-et-Loire	Lugdunensis	RO	4^{th} C AD	1	?	1	
87	Manching	Germany	Oberbayern	???	IA	1^{st} C BC	1	Oppidum	950	
88	Zwammerdam	Holland		Germania Inferior	RO		1	Military	7	
89	Jenstejn	Czech Republic	Bohemia		IA	Hallstatt C-La Tene A	1	Settlement	5	
91	Whitton	Britain	S. Glamorgan	Britannia	RO	1^{st}-4^{th} C AD	1	Farmstead	3	
92	Feddersen Wierde	Germany	Elbe-Weser-Drei..		NAT	1^{st} C BC – 5^{th} C AD	1	Settlement	575	
93	Caerwent	Wales		Britannia	RO	4^{th} C AD	1	Military	5	
96	Kunzing east vicus	Germany	Bayern	?Germania	RO	2^{nd}–3^{rd} C AD	1	Cemetary/ Mithraeum	74	
97	Dee House	Britain	Cheshire	Britannia	RO	2^{nd} C AD	1		3	
98	Prestatyn	Britain	N. Wales	Britannia	RO	1^{st}-2^{nd} C AD	1	Industrial	8	
99	Mantles Green	Britain	Bucks	Britannia	RO	3^{rd}-4^{th} C AD	1	Villa	5	
101	Chignall Roman Villa	England	Essex	Britannia	IA+RO	1^{st} C BC – 4^{th} C AD	4	Villa	5	
103	Newstead fort	Scotland		Britannia	RO	1^{st}-2^{nd} C AD	3	Military	11	
104	Orton Hall Farm	England	Nene Valley	Britannia	RO	1^{st}-6^{th} C AD	5	Farmstead	30	
105	Mons Claudianus	Egypt	E. Desert		RO	1^{st}-3^{rd} C AD	4	Industrial	544	
106	Abu Sha'ar	Egypt	Red Sea Coast		RO	4^{th}-5^{th} C AD	1	Military	3	
110	Nijmegen new excavations	Holland	Nijmegen		RO	12BC - 100AD	4	urban settlement	19	
112	Pompeii	Italy		Italia	RO	<79 AD	1	Urban	43	4 complete skeles from stable at back of 1 house
113	Southwark	Britain	London	Britannia	RO	180-190 AD	1	Urban	3	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
114	Unterlaa	Austria	Vienna		RO	End 1st to 3rd C AD	1	Urban	56	from roman Grubenhaus?! /pit.
115	Bad Wimpfen	Germany			RO	1-3rd C AD	1	Vicus	149	Some donkey bones.
116	Pommeroeul	Belgium	Henegouwen		RO	2nd C	1	?urban	127	Comes from a river deposit
117	Pompeii stable	Italy		Italia	RO	79 AD	1	Urban	22	Found inside stable from time of eruption
118	Carnuntum	Austria	Lower Austria	Pannonia	RO	1st half of 3rd C AD	1	Auxiliary fort	73	remains come from ditch around fort
119	Albertfalva	Hungary	Budapest	Pannonia	RO	2nd-3rd C AD	1	Auxiliary fort/Vicus	12	I hope these are accurate! NEEDS CLARIFICATION
120	Basel-Gasfabrik	Switzerland			IA	150-70 BC	1	Settlement?	80	Check site type
121	Soluthurn/Vigier	Switzerland			RO	1st - 3rd C AD	3	Vicus	48	
122	Lousonna	Switzerland	Vaud	Alpes graiae to poeniniae	RO	1st C BC - 3rd C AD	1	Vicus	1	
123	Wroxeter Baths basilica	Britain	Gloucestershire	Britannia	RO	L4th-E7th C AD	5	Urban	42	Very late Roman and post-roman, mostly after official withdrawal from Britain
124	Haddon	Britain		Britannia	RO		6		45	
125	Castleford	Britain	West Yorkshire		RO	71-400 AD	3	Fort	33	
126	Augusta Rauricorum Amphitheatre	Switzerland	Basel	Italia	RO	L 1st C - 5th C AD	6	Urban	9	Bones from Amphitheatre but mostly pre construction and post-abandonment
127	Tortoreto-Fortellezza	Italy	central Italy		IA	7th-6th C BC	1	Settlement	7	
128	Krefeld-Gellep	Germany			RO	69 AD	1	Battlefield	46	Cemetery presumed to be from battle with Batavians in 69AD (see Tacitus)
129	Lorenzberg Bei Epfach	Germany			RO	E 1st - 4th C AD	3		82	
130	Msecke Zehrovice	Czech republic	Bohemia		IA	3rd-2nd C BC	1	Settlement	3	
131	Radovesice	Czech republic	Bohemia		IA	3rd - 1st C BC	2	Settlement+Cemetery	19	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
132	Godmanchester	Britain		Britannia	RO	Needs checking	3	?Military	29	
133	Colchester	Britain	Essex	Britannia	RO	RB	1	Military/Urban	33	various sites in Colchester
134	Butzbach	Germany			RO	1st-3rd C AD	1	Vicus	32	
135	Swestari	Bulgaria	North east Bulgaria		IA	2nd half 3rd C BC	1	Cemetery	44	Thracian horse burials, 4 males, 1 mare, but doesn't say which are which.
136	Worth Matravers	Britain	Dorset	Britannia	IA+RO	LPRIA-MLR	2	Settlement	5	
137	Magdelenska Gora	Slovenia			IA	Hallstatt	1	Cemetery	29	Hallstatt period horse burials
138	Brezje		Krain		IA	Hallstatt	1		7	
139	Tapioszele	Hungary			IA	Scythian	1	Cemetery	1	Scythian cemetery
140	Sticna, Sentvid				IA	Hallstatt	1	Cemetery	2	
141	Szentes-Vekerzug	Hungary			IA	Hallstatt	1	Cemetery	11	
142	Velemszentvid		Szombathely?		IA	Hallstatt	1	Cemetery	5	
143	Histria	Roumania			IA	????	1	Urban	7	Says it is a greek colonial town on the black sea
144	Albertfalva	Hungary		Pannonia	RO	Roman	1	Fort	19	
145	Jaszfelsozentgyorgy	Hungary			IA	Scythian	1	Settlement	3	Scythian settlement
146	Balatonaliga	Hungary			RO	Roman	1	Settlement	10	
147	Pilismarot I Watchtower	Hungary			RO	L 4th C	1	Watchtower	4	
148	Szaszhalombatta	Hungary			RO	Roman	1	Camp	1	
149	Helemba - Sziget	Hungary			IA	Hallstatt	1	Settlement	6	Hallstatt A-B settlement
150	Acs - Vaspuszta	Hungary			RO	Roman	1	Fort	1	
151	Gyor Szechenyi-Ter	Hungary			RO	2nd C AD	1	Settlement	2	
152	Altino	Italy	N Italy	Italia	RO	4th/5th C AD	1	Urban	2	
153	Aquileia forum	Italy	N Italy	Italia	RO	2nd -5th C AD	1	Urban	40	
154	Cerveteri	Italy	Central Italy	Italia	RO	L6th-E5th c BC	1		3	
155	Gravina 1	Italy	South Italy	Italia	RO	M 2nd- E 1st C BC	1	Villa	13	
156	Invillino- Ibliglo	Italy	North Italy	Italia	RO	50 BC-5th C AD	3		40	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
157	Lugnano	Italy	Central Italy	Italia	RO	4th-5th C AD	1	Villa	6	
158	Matrice	Italy	Central Italy	Italia	RO	1st-5th C AD	2	Villa	2	
159	Pompeii, Ganimede	Italy	Central Italy	Italia	RO	6th c BC	1	Urban	1	
160	Pozzuolo	Italy	North Italy	Italia	RO	1st C BC - 1st C AD	1	Settlement	1	
161	San Giovanni	Italy	South Italy	Italia	RO	5th-6th C AD	1	Villa	33	
162	Santorsa, Vicenza	Italy	North Italy	Italia	IA	5th- 2nd C BC	1	Settlement	2	
163	Settefinestre 2	Italy	South Italy	Italia	RO	L 1st BC - 4th C AD	2	Villa	3	
164	Stufels	Italy	North Italy	Italia	RO	1st-5th C AD	2	Settlement	2	
165	Tarquinia	Italy	Central Italy	Italia	RO	6th- 2nd C	1	Urban	2	
166	Udine	Italy	North Italy	Italia	RO	4th-6th C AD	1	Settlement	2	
167	Via Gabina 10	Italy	Central Italy	Italia	RO	4th-5th C AD	1	Urban	7	grain warehouse
168	Volano	Italy	North Italy	Italia	RO	3rd-5th C AD	2	Rural	13	agriculture/craft production deposit
169	Rome, Aqua Marcia	Italy	Central Italy	Italia	RO	1st C BC- 1st C AD	1	Urban	2	
170	Castelrotto	Italy	North Italy, verona	Italia	IA	5th-4th C BC	1	Settlement	3	
171	Mezzocorona	Italy	North Italy	Italia	RO	1st-4th C AD	1		2	
172	Metaponto Panatello	Italy	South Italy	Italia	RO	Republic	1		3	
173	Paestum	Italy	South Italy	Italia	RO	Republic	1	Settlement	9	
174	Abusina-Eining	Germany	Kelheim	Raetia	RO	M2nd - M3rd C AD	1	Fort/Vicus	43	These bones from vicus
175	Sablonetum-Ellingen	Germany			RO	E 2nd - E 3rd C AD	1	Fort	18	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
176	Oberdorla	Germany	Muehlhausen		NAT	Latene - 4th C AD	1	Sacrificial bog	130	
177	Champlieu	France	Oise		IA	LPRIA	1	Settlement?	2	dating uncertain as to whether pre or post conquest but fauna suggests indigenous type.
178	Vitudurum-Oberwinterthur	Germany			RO	E 1st –E 2nd CAD	4	Vicus	23	tightly dated phases and mules
179	Catterick CEU240	Britain	N. Yorks	Britannia	RO	L2nd -4th C AD	2	Military/Vicus	17	
180	Catterick 434	Britain	N. Yorks	Britannia	RO	2nd - 4th C AD	2	Military/Vicus	8	
181	Barnsley Park	Britain	Gloucestershire	Britannia	RO	2nd-5th C AD	3	Rural settlement	24	in text says a donkey 3rd phal was found, but no photo or measurements
182	Frocester Court	Britain	Gloucestershire	Britannia	RO	1st - 5th C AD	2	Villa	21	
183	Segontium	Britain	Caernarfon	Britannia	RO	Flavian	5	Military	14	
184	Chilgrove 1	Britain	Sussex	Britannia	RO	L3rd-E4th C AD	1	Villa	10	
185	Shakenoak site C	Britain	Oxfordshire	Britannia	RO	c. 200 - 400AD	3	villa	10	
186	Shakenoak site K	Britain	Oxfordshire	Britannia	RO	before 200 AD - 400AD	3	villa	24	
187	Hayton Fort	Britain	E. Yorks	Britannia	RO	72-85 AD + 250-400 AD	2	Military	12	
188	Titelberg oppidum	Luxemburg			RO	LR	1	oppidum	5	
189	Kassope	Greece	Epirus	?Thessaly	IA	4th - 1st C BC	3	Urban	131	Although Have put IA/RO it is really classical Greece prior to roman invasion. Many donkeys identified
190	Breisach	Germany	Breisgau		RO	L3rd-4th C AD	1	?Fort	17	
191	Gunzburg - Gontia	Germany	Ulm, Schwaben	Raetia	RO	3rd-4th C AD	1	Fort	3	

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
192	Pfaffenhofen - Pons Aeni	Germany	Rosenheim, Oberbayern	Raetia	RO	M2nd-L3rd C AD	1	Settlement	54	settlement on crossing of 2 major roads, craft activities present.
193	Marzoll - Marciolae	Germany	Reichenhall, Oberbayern	Raetia	RO	E2nd-M3rd C AD	1	Villa	4	
194	Vemania	Germany	nr Kempton?	Raetia	RO	L3rd - end 4th C AD	1	Fort	10	Site is 4 km north of road from Bregenz to Kempton and 2 kn east of Isny.
195	Kunzing-Quintana	Germany	Deggendorf	Raetia?	RO	L1st-M3rd C AD	1	Fort	38	
196	Dormagen	Germany	Leverkusen, ?Oberbayern	Germania Inf.	RO	2nd-4th C AD?	1	Fort	12	Auxiliary Limes fort.
197	Froitzheim	Germany	Cologne	Germania Inf.	RO	L3rd - end 4th C AD	1	Enclosure?	15	
198	Gellep - Gelduba	Germany	Krefeld	Germania Inf.	RO	L1st-L4th C AD	1	Fort	60	Auxiliary limes fort
199	Hufingen	Germany	Donaueschingen		RO	RO	1	civilian settlement	262	near fort Brigobanne
200	Pfaffenhofen	Germany	Rosenheim	Raetia	RO	M2nd - M3rd C AD	1	Settlement	18	Settlement Pons aeni - see other notes about crossroads etc
201	Wehringen	Germany	Schwabmunchen	Raetia	RO	ML2nd C AD	1	Villa	14	
202	Penzlin	Germany	Waren	Germania Libera	NAT	ER	1	Germanic settlement	34	
203	Tac-Gorsium	Hungary		Pannonia	RO	RO	1	Urban	509	
204	Conchil	France	Calais?	Gallia	RO	20 BC – 4th C AD	4	Rural settlement	28	
205	Oberstimm	Germany	Bavaria	Raetia	RO	60 -122 AD	3	Fort		
206	Lauriacum	Austria	Upper austria	?Raetia	RO	3rd - 4th C AD	2	Fort and Urban		Z = urban, L = fort. donkeys present
207	Haus Burgel	Germany	Lower rhine	Germania inferior	RO	364-408 AD	1	fort		
208	Colonia Ulpia Traiana	Germany	near Xanten	Germania Inferior	RO	1st - 4th C AD	3	urban		

Site no.	Site name	Country	County/ province	Roman Province	General Period	Dating	No. Phases	Sitetype	No. Bones	Notes
209	Iatrus	Bulgaria	Lovech	Moesia Inferior	RO	M4th - L 5th C AD	4	Fort and Urban		Phase A is military, others are urban.
210	Freidorf	Romania	Timis	Dacia	RO	RO	1	Settlement?		
211	Castillar de Mendavia	Spain	Navarra		IA	IA	1	Settlement		
212	Gournay	France	Picardie		IA	La Tene final	1	Oppidum/Sanctuary		
213	Beauvais	France	Picardie		IA	La Tene final	1	settlement?		
214	Compiegne	France	Picardie		IA	MLIA	1	settlement?		
215	Ribemont	France	Picardie		IA	MLIA	1	??		
216	Variscourt	France	Picardie		IA	La Tene final	1	Oppidum		
217	Soissons	France	Picardie		IA	La Tene final	1	?cemetary		

Table A3. Numbers of bones by element by site.

Element codes are as follows: cran = cranium, mand = mandible, scap = scapula, hum = humerus, MC = metacarpal, fem = femur, tib = tibia, astr = astragalus, calc = calcaneum, MT = metatarsal, phal1 = phalanx 1

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phal1	Total
3	Edix Hill	Britain						3					1	2	6
4	Market Deeping	Britain				2	1	1		3			1	2	10
5	Beckford	Britain				1	1	1		1	1		1	1	7
6	Wardy Hill	Britain											4		4
7	Blackhorse Road	Britain						3							3
8	Hardingstone School	Britain					2	3					1	1	7
9	Hardingstone enclosure	Britain				1	3	1		3					8
10	Twywell	Britain				1	1	2		1			1		6
11	Ivinghoe Beacon	Britain				1		2							3
12	GA, Tanner Row	Britain			2		1								3
13	Wavendon Gate	Britain					6	7					4		17
14	Lincoln	Britain			5	2	2	5	1	2	2		6		25
15	Scole-Dickleburgh	Britain			6	5	8	9	4	9	12	1	8	13	75
16	Birdlip	Britain				2	1	5	1		2		3		14
17	Great Holts Farm	Britain				2				1					3
18	Camulodunum	Britain	3	1		3	1	3	2				3		16
19	Scole	Britain											2	1	3
20	Northchurch	Britain					1	3		2					6
21	Skeleton Green	Britain						1		3			2		6
22	Braughing	Britain								1				1	2
23	Puckeridge	Britain					2	2		1				2	7
24	Dunstable	Britain					1	1		1			2	2	7
25	Redlands Farm	Britain				1	1			1					3
26	Stonea	Britain			1								1		2
27	Lynch Farm	Britain				1	1	1	2	3	1		1	2	12
28	Longthorpe II	Britain				2	2	2	2	3		1	3	2	17
29	Norman cross	Britain				1							1	1	3
30	Tort Hill East	Britain				1	1	2		3			1	1	9
31	Tort HIll West	Britain				5		2		2	2		2	3	16

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
32	Vinegar Hill	Britain				1				1		1			3
33	Longthorpe fortress	Britain						1							1
34	Wall Mansio	Britain			3	1	1	1						1	7
35	Castricum-Oosterbuurt	Netherlands				3	8	17	2	14			15		59
36	Egmond?	Netherlands		1	11			1					1		14
37	Kesteren 'De Prinsenhof'	Netherlands	11	9	12	11	9	7	14	15			11	13	112
38	Nijmegen	Netherlands				21	20	21	14	24	2	1	13	8	124
39	Kesteren vicus	Netherlands				1		2					2	3	8
40	Heteren	Netherlands					1	2		5	2		3	4	17
41	Elst, temple	Netherlands												1	1
42	Druten	Netherlands			11	11	16	20	11	13	8	4	12	19	125
43	Elms Farm	Britain			4	4	14	11		11	9	3	19	18	93
44	Danebury	Britain			18	12	20	40	10	31	3	1	22	48	205
45	Billingsgate	Britain		1											1
46	E London RB Cemetary	Britain			4	3	7	5	4	9	2	6	2	7	49
47	Beddington Sewage Farm	Britain			2		6	7		1			6		22
48	Winchester Palace	Britain												1	1
49	Buckingham Street	Britain	1	1		1	1						1		5
50	Coldharbour Farm 90	Britain				1					1	1			3
51	Coldharbour Farm 97	Britain						3			1				4
52	Magiovinium	Britain				1		1		3			3		8
53	Ashville Trading Estate	Britain						3					3		6
54	Thorpe Thewles	Britain			2		7	3	5	5	2		7	4	35
55	Brancaster 1974	Britain						1		1				1	3
57	La Sagesse	Britain			1	1	2	3					1	2	10
58	Braintree	Britain											1	1	2
59	Chichester cattlemarket	Britain			2	2	2	2	2	2	2	2	2	3	21
60	Narce	Italy					1	1		2			1		5
61	Vaste	Italy				1							1		2
62	Mola di Monte Gelato	Italy												1	1
63	S. Giacomo	Italy					1	2		2		1	1		7
65	Carminiello ai Mannesi	Italy						2						2	4
66	Settefinestre	Italy			1		1	3			3		2	2	12

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
67	Ilchester,Church Street	Britain							2	1	1		1		**5**
68	Lutton/Huntingdon	Britain			3	1		2		2			5		**13**
69	Thorley	Britain			1	1	2	2		1	3		1	1	**12**
70	Emilia	Italy					1	1		2	1		1		**6**
71	Piovego	Italy	1	1		1	1	1	1	1			1	2	**10**
72	Colle dei Cappuccini	Italy						1	1	1	2				**5**
73	Moie di Pollenza	Italy						1							**1**
74	Sovana	Italy									1		1	1	**3**
75	Marzabotto	Italy								1				2	**3**
76	Ansedonia	Italy						1							**1**
77	Grotto di Tibera	Italy					1	3		1	2			2	**9**
78	Cowbridge	Britain				1	1						1		**3**
79	Olbia	Italy		1		2	4	1	5	2				5	**20**
80	Friedland	Germany												2	**2**
81	Welsow	Germany				3	3		1	2			3	2	**14**
82	Genshagen	Germany					1		1		1				**3**
83	Deutsch Wusterhausen	Germany				1		2			3			1	**7**
85	Macon	France				2		1					1	2	**6**
86	Dambron	France	1												**1**
87	Manching	Germany	2	9	47	69	120	128	39	116	114	39	115	152	**950**
88	Zwammerdam	Netherlands				1	3	1					2		**7**
89	Jenstejn	Czech Republic						1	1				1	2	**5**
91	Whitton	Britain				1	1	1							**3**
92	Feddersen Wierde	Germany	2	13	4	12	39	213	13	12	114	23	123	7	**575**
93	Caerwent	Britain							2	1			1	1	**5**
96	Kunzing east vicus	Germany	5	6	6	6	6	6	5	6	6	6	5	11	**74**
97	Dee House	Britain					1			1				1	**3**
98	Prestatyn	Britain			2		1				2		3		**8**
99	Mantles Green	Britain	1					2		2					**5**
101	Chignall Roman Villa	Britain											5		**5**
103	Newstead fort	Britain	2		2	1	2		1	1			1	1	**11**
104	Orton Hall Farm	Britain				1	3	4	5	6			5	6	**30**
105	Mons Claudianus	Egypt			47	41	70	77	24	68	52	28	57	80	**544**

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
106	Abu Sha'ar	Egypt					1	1						1	3
110	Nijmegen new excavations	Netherlands			3	3	1	4	1	1			2	4	19
112	Pompeii	Italy			4	4	4	4	3	4	4	4	4	8	43
113	Southwark	Britain				1	1	1							3
114	Unterlaa	Austria	4	3	2	4	3	5	4	5	7	3	8	8	56
115	Bad Wimpfen	Germany	5	3	6	14	26	23	5	17	5	5	12	28	149
116	Pommeroeul	Belgium	15	15	8	16	18	10	10	11	3	2	16	3	127
117	Pompeii stable	Italy			1	2	2	4	5	5			3		22
118	Carnuntum	Austria	5	5	8	5	6	8	6	5	5	5	5	10	73
119	Albertfalva	Hungary				2	1	2	2	2			3		12
120	Basel-Gasfabrik	Switzerland		4	2	5	8	10	5	13	10	4	6	13	80
121	Soluthurn/Vigier	Switzerland		3	3	6	2	2	7	4	5	2	8	6	48
122	Lousonna	Switzerland						1							1
123	Wroxeter Baths basilica	Britain				8	11	4		3	3	1	6	6	42
124	Haddon	Britain				5	2	6	1	5	9	1	9	7	45
125	Castleford	Britain			3	1	7	11	3	4			4		33
126	Augusta Rauricorum Amphit	Switzerland					1	1	1	3				3	9
127	Tortoreto-Fortellezza	Italy						1		2	1		3		7
128	Krefeld-Gellep	Germany				8	8	8	6	4			8	4	46
129	Lorenzberg Bei Epfach	Germany	1		3	4	9	12	2	13	9	2	14	13	82
130	Msecke Zehrovice	Czech republic			1								2		3
131	Radovesice	Czech republic			5	1	1	2	1			1	3	5	19
132	Godmanchester	Britain						15					14		29
133	Colchester	Britain				5	8	4	2	8			6		33
134	Butzbach	Germany			4	1	7	7		1	2	1	7	2	32
135	Swestari	Bulgaria			5	5	5	5	5	5	5	4	5		44
136	Worth Matravers	Britain					1	1		2			1		5
137	Magdelenska Gora	Slovenia	1	2	2	2	2	3	3	4	2	2	4	2	29
138	Brezje	Slovenia	1	2		1	1	1	1						7
139	Tapioszele	Hungary	1												1
140	Sticna, Sentvid				1					1					2
141	Szentes-Vekerzug	Hungary			1	1	1	1	1	1	1	1	1	2	11
142	Velemszentvid						3			2					5

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
143	Histria	Roumania						5					2		7
144	Albertfalva	Hungary	1					18							19
145	Jaszfelsozentgyorgy	Hungary					3								3
146	Balatonaliga	Hungary					1	4		1			4		10
147	Pilismarot I Watchtower	Hungary					1						3		4
148	Szaszhalombatta	Hungary					1								1
149	Helemba - Sziget	Hungary						1			2		3		6
150	Acs - Vaspuszta	Hungary						1							1
151	Gyor Szechenyi-Ter	Hungary								1			1		2
152	Altino	Italy									1		1		2
153	Aquileia forum	Italy					3	11					15	11	40
154	Cerveteri	Italy			1								1	1	3
155	Gravina 1	Italy			1	1	1	2		1			4	3	13
156	Invillino- Ibliglo	Italy			3	4	3	2	1	7	6	1	4	9	40
157	Lugnano	Italy					2	1		1		1	1		6
158	Matrice	Italy			1									1	2
159	Pompeii, Ganimede	Italy					1								1
160	Pozzuolo	Italy						1							1
161	San Giovanni	Italy			1		2	5		3	5	2	7	8	33
162	Santorsa, Vicenza	Italy												2	2
163	Settefinestre 2	Italy			1						2				3
164	Stufels	Italy						2							2
165	Tarquinia	Italy									2				2
166	Udine	Italy			1		1								2
167	Via Gabina 10	Italy					1			3	1		2		7
168	Volano	Italy				1	1	1	1	1	2	1	4	1	13
169	Rome, Aqua Marcia	Italy												2	2
170	Castelrotto	Italy			1		1							1	3
171	Mezzocorona	Italy					1						1		2
172	Metaponto Panatello	Italy						1		1			1		3
173	Paestum	Italy				1	2	3		1			1	1	9
174	Abusina-Eining	Germany				2	5	18	4	5	7	2			43
175	Sablonetum-Ellingen	Germany			4		6	1		5			1	1	18

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
176	Oberdorla	Germany			14	6	7	25	13	17	7	4	19	18	**130**
177	Champlieu	France					1					1			**2**
178	Vitudurum-Oberwinterthur	Germany		1	1	2	2	7		3	3		4		**23**
179	Catterick CEU240	Britain			2	1			3	2	5		4		**17**
180	Catterick 434	Britain				1	1			2	2		2		**8**
181	Barnsley Park	Britain			1	1	5	1		5			4	7	**24**
182	Frocester Court	Britain				2	4	5		5			3	2	**21**
183	Segontium	Britain			1		1	3		1			3	5	**14**
184	Chilgrove 1	Britain					5	2		2			1		**10**
185	Shakenoak site C	Britain					1			1	3	1	1	3	**10**
186	Shakenoak site K	Britain			1	3	1	4		4	1		3	7	**24**
187	Hayton Fort	Britain				1	1		1	3	1	1	2	2	**12**
188	Titelberg oppidum	Luxemburg			1		1			1	1		1		**5**
189	Kassope	Greece			7	6	17	14	4	10	12	2	23	36	**131**
190	Breisach	Germany	1	1	2	3		3		2	2		1	2	**17**
191	Gunzburg - Gontia	Germany		2									1		**3**
192	Pfaffenhofen - Pons Aeni	Germany	3	4	3	5	6	7	4	7	2	3	5	5	**54**
193	Marzoll - Marciolae	Germany			1			1		1				1	**4**
194	Vemania	Germany				1	4	2					2	1	**10**
195	Kunzing-Quintana	Germany	1	3	5	4	6	7	2	3	1		4	2	**38**
196	Dormagen	Germany			2			5	1	1			2	1	**12**
197	Froitzheim	Germany			2		3	5		1			1	3	**15**
198	Gellep - Gelduba	Germany		1		2			2		1		54		**60**
199	Hufingen	Germany		18	21	17	30	45	3	40	23	9	3	53	**262**
200	Pfaffenhofen	Germany				2	3	4		2			3	4	**18**
201	Wehringen	Germany		2	1		1	2	1	6	1				**14**
202	Penzlin	Germany		2		2	4	9		1	1		11	4	**34**
203	Tac-Gorsium	Hungary	7	19	36	34	78	98	9	72	38	19	99		**509**
204	Conchil	France			4	4	5	3	1	4			5	2	**28**
205	Oberstimm	Germany	3	1	1		2	2	3	1	1			2	**16**
206	Lauriacum	Austria		3	2	10	13	10	2	13	6	7	12	21	**99**
207	Haus Burgel	Germany				1		2	1	1					**5**
208	Colonia Ulpia Traiana	Germany			3		8	13	5	8	5		13	8	**63**

Site no	Name	Country	Cran	Mand	Scap	Hum	Rad	MC	Fem	Tib	Astr	Calc	MT	Phall	Total
209	Iatrus	Bulgaria			5		3	6	3				1		18
210	Freidorf	Romania						1						4	5
211	Castillar de Mendavia	Spain					2	2		2	1		3	1	11
212	Gournay	France	1		3	1	3	2	3	2	3	2	3	6	29
213	Beauvais	France	1		7	6	12	7	1	8			7		49
214	Compiegne	France			2	2	5	2	5	4	4	4	2	1	31
215	Ribemont	France				3	5	1	3	13	6	3	3	5	42
216	Variscourt	France			2		10	6		1	1		6	5	31
217	Soissons	France			1	1	1	1	1	1	1	1	1	1	10
Total			**80**	**137**	**404**	**484**	**840**	**1208**	**326**	**811**	**588**	**220**	**1032**	**832**	**6962**

Table A4 – Detailed information from discriminant function analysis of metatarsals from complete skeletons and articulated limbs

Site no	Site name	Bone no	Specimen	GL	Bp	Dp	SD	Bd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
37	Kesteren 'De Prinsenhof'	400	1.21	289	53.5	43.5	32.4	51.5	H	0.65	4.23	N	3.04	0.49	H?
37	Kesteren 'De Prinsenhof'	396	11.28	280	53.3	44.8	32.3	54	H	0.97	10.93	N	4.43	-0.89	H*
37	Kesteren 'De Prinsenhof'	395	11.34	285	50.8	42.9	33.2	50	H	0.52	3.64	N	2.71	0.77	H?
37	Kesteren 'De Prinsenhof'	398	2.27	284	54.1	43	34.7	51.6	H	0.94	7.59	N	3.91	-0.60	H*
42	Druten	373	1.18	288.8	52.1	45	34.5	51.9	H	0.67	5.88	N	3.43	0.51	H?
42	Druten	372	12.4	269.2	52.5	43	32.7	50.4	H	0.98	5.96	N	3.41	-1.31	H*
43	Elms Farm	350	6640	269	53.4	45.3	30.9	52.3	H	0.98	6.87	N	3.55	-1.44	H*
59	Chichester cattlemarket	294	XXIII	281.9	52	46	34.3	52.7	H	0.90	7.38	N	3.88	-0.28	H*
59	Chichester cattlemarket	295	XXIII	282.1	52.8	48.4	34.3	52.8	H	0.86	5.22	N	3.44	-0.17	H*
67	Ilchester,Church Street	284	F267	256.5	43.2	42.2	34.1	52.2	H	0.99	18.91	N	5.34	-1.56	H*
92	Feddersen Wierde	26	skelett1L	259	48.1	44.7	28	48.8	H	0.80	0.17	Y	1.57	-0.27	H
92	Feddersen Wierde	27	skelett1R	259.5	48.5	45	28.3	48.5	H	0.78	0.07	Y	1.40	-0.23	H
96	Kunzing east vicus	4	1575/5	266.5	51	40.7	32.2	47.3	H	0.92	1.30	N	2.23	-0.75	H*
96	Kunzing east vicus	3	1581	284	53.4	45	30.8	51.9	H	0.71	3.02	N	2.78	0.28	H?
96	Kunzing east vicus	5	1620	284	51.9	42.3	32.1	51.8	H	0.81	5.99	N	3.57	0.11	H*
96	Kunzing east vicus	2	1641	274	49.4	40.3	31	51.5	H	0.92	7.83	N	3.96	-0.47	H*
96	Kunzing east vicus	1	1703	263	50	42	32	51.5	H	0.99	11.66	N	4.28	-1.75	H*
105	Mons Claudianus	517	1486	236	38.1	34.2	22.5	35	D	1.00	5.39	N	-3.92	2.16	D*
105	Mons Claudianus	515	1544	240.5	40.6	36.6	23.6	36.2	D	1.00	4.32	N	-3.70	1.97	D*
105	Mons Claudianus	513	1719	248	43.5	35	26.9	37.8	D	0.94	2.84	N	-2.09	1.15	D*
105	Mons Claudianus	516	549	239.5	42.2	35.9	24.2	43.8	H	0.79	0.31	Y	0.62	-0.43	H
105	Mons Claudianus	511	604	254	45.2	42.8	28.5	44.3	M	0.62	1.44	N	-0.11	0.55	M?
110	Nijmegen new excavations	589	179/16-22	242.1	42.9	36.1	27.7	45.4	H	0.95	1.56	N	2.11	-1.18	H*
110	Nijmegen new excavations	590	179/16-25	263.1	48.9	39.9	29.2	49.6	H	0.95	3.88	N	3.06	-0.88	H*
114	Unterlaa	598	18	266	45.1	37.6	25.3	43.3	M	0.93	3.19	N	-0.79	2.02	M*
114	Unterlaa	599	23A	252	45.5	39.9	29.6	45.4	H	0.84	0.06	Y	1.38	-0.48	H
114	Unterlaa	600	35	258	48.6	41.1	31.6	47.6	H	0.96	2.43	N	2.51	-1.14	H*

Site no	Site name	Bone no	Specimen	GL	Bp	Dp	SD	Bd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
114	Unterlaa	601	40	263.5	47.6	39.2	29.8	48.4	H	0.89	2.35	N	2.69	-0.46	H*
114	Unterlaa	602	48	267	45.6	38.3	25.2	44.2	M	0.94	2.23	N	-0.52	1.91	M*
114	Unterlaa	603	49	280	48.8	38.8	28.1	49.6	M	0.62	2.40	N	2.36	1.03	M?
114	Unterlaa	604	73	251	46.5	41.5	29.3	46	H	0.88	0.16	Y	1.35	-0.71	H
115	Bad Wimpfen	613	Skele 4	284	49.8	48	33.1	49.2	M	0.86	0.31	Y	1.28	1.63	M
115	Bad Wimpfen	615	Skele 6	269.5	46.5	43	28.5	45.5	M	0.92	1.13	Y	-0.13	1.72	M
118	Carnuntum	639	Maultier 1	286.7	51	45.4	33.3	50.7	M	0.60	2.94	N	2.53	1.01	M?
118	Carnuntum	636	Pferd 1	300	54.5	48.2	35	56.9	H	0.82	15.91	N	5.09	0.34	H*
118	Carnuntum	637	Pferd 2	283.5	54	42.8	33	52.2	H	0.93	7.52	N	3.90	-0.54	H*
118	Carnuntum	638	Pferd 3	273.2	55.2	43.4	32.7	51.8	H	0.99	9.35	N	3.91	-1.71	H*
119	Albertfalva	641	Horse 1	272	52.3	41.8	31.8	50.8	H	0.97	6.18	N	3.55	-1.06	H*
119	Albertfalva	642	Horse 2	296.9	56.2	53.9	36.5	54.1	H	0.55	4.32	N	2.93	0.73	H?
135	Swestari	736	1	240	44	37.5	28	45	H	0.97	1.50	N	1.77	-1.42	H*
135	Swestari	737	2	240	46	39	29	45	H	0.98	2.38	N	1.69	-1.81	H*
135	Swestari	738	3	244	46	38	29	44	H	0.95	0.79	Y	1.21	-1.24	H
135	Swestari	739	4	263	49	42	35	50	H	0.99	10.70	N	4.17	-1.65	H*
135	Swestari	740	5	288	53	45	34.5	52	H	0.77	5.85	N	3.51	0.21	H?
141	Szentes-Vekerzug	746	6	254	46.5	45.5	27.5	47	H	0.61	0.59	Y	0.54	0.10	H*
143	Histria	747	P18	275	51	49	30.5	51	H	0.56	1.10	Y	1.79	0.48	H*
143	Histria	748	P25	277.5	50	45.5	32	51.8	H	0.77	4.24	N	3.16	0.15	H?

Table A5 – Detailed information from discriminant function analysis of tibiae from complete skeletons and articulated limbs

Site no	Site name	Bone no	Specimen	GL	Ll	Bp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
42	Druten	252	1.18	379.6	352.4	104.3	46.8	76.4	49.4	M	0.87	6.82	N	3.61	0.78	M*
42	Druten	251	12.2	374.2	337.1	107.1	48.3		52.6	H	0.91	4.21	N			H*
92	Feddersen Wierde	29	skelett2L	323.6	293	87.2	36.1	67.4	39.6	H	0.99	0.19	Y	0.55	-1.07	H
92	Feddersen Wierde	28	skelett2R	323.1	295	87.1	36.4	67.5	40.7	H	0.97	0.22	Y	0.22	-0.75	H
92	Feddersen Wierde	31	skelett1L	344.5	320.5	94		72.2	42.6	H	0.92	0.95	Y			H
92	Feddersen Wierde	27	skelett3L	355	326	92	39	71		M	0.75	1.15	Y			M*
105	Mons Claudianus	396	600	333	303	84	35.2	67.5	44.3	D	0.93	2.14	N	-1.64	1.17	D*
105	Mons Claudianus	403	1108	310	280	73.5		57.2	37.7	D	0.98	1.47	N			D*
110	Nijmegen new excavations	483	147/128-20	376.5	353.6	107.3	42.8	81.4	51.3	H	0.54	3.74	N	2.40	0.23	H?
114	Unterlaa	491	23A	332	306.6	87	37.7	66.9	38.8	H	0.92	0.18	Y	0.99	-0.36	H
114	Unterlaa	493	68	331	306.7	83.9	36.4	68.4	39.7	H	0.66	2.52	N	-0.66	0.21	H?
114	Unterlaa	494	71	347	313.7	92.2	37.6	70.7	43.6	H	0.83	0.48	Y	0.93	0.00	H
118	Carnuntum	533	Maultier 1	377	344	101.3	45.2	81.5	52.3	M	0.66	1.06	Y	0.90	0.90	M*
118	Carnuntum	530	Pferd 1	413	376.5	106	44.5	83.8	53.8	M	0.99	0.72	Y	1.81	2.51	M
118	Carnuntum	531	Pferd 2	364.5	332	101.7	42	80.2	51.6	H	0.80	0.58	Y	0.83	0.10	H
118	Carnuntum	532	Pferd 3	363.5	329	100	42	77.7	48.2	H	0.84	1.14	Y	1.65	-0.21	H
128	Krefeld-Gellep	574	3510	295	266	81	31.5	60.5		H	0.73	2.21	N			H?
128	Krefeld-Gellep	572	3573	378	349	98	44	73		M	0.98	0.87	Y			M
135	Swestari	598	1	321	281	85	37.5	68	41.5	H	0.96	1.18	Y	-0.33	-1.06	H
135	Swestari	599	2	321.5	285	86	36	66	40	H	0.99	0.23	Y	0.43	-1.05	H
135	Swestari	600	3	327	292	88	39	64	41	H	0.93	0.90	Y	1.63	-0.59	H
135	Swestari	601	4	355	322	97		77.5	47	H	0.93	0.18	Y			H
135	Swestari	602	5	382	350	100	43	80	49.5	M	0.82	0.50	Y	1.18	1.17	M

Table A6 – Detailed information from discriminant function analysis of radii from complete skeletons and articulated limbs

Site no	Site name	Bone no	Specimen	GL	Ll	BFp	SD	BFd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
43	Elms Farm	256	6640	339	329	77.7	37.9	65.5	H	0.833	1.208	Y	1.57	-0.42	H
43	Elms Farm	257	6640	346	327	77.6	37.1	64.9	H	0.863	1.472	N	1.68	-0.56	H*
92	Feddersen Wierde	30	skelett1L	325.5	311.5	73.9	35.2	60.7	H	0.941	0.762	Y	1.09	-1.03	H
92	Feddersen Wierde	29	skelett1R	326.5	311	73.4	35.3	60.7	H	0.918	0.452	Y	1.00	-0.83	H
92	Feddersen Wierde	27	skelett2R	305.1	291.6	69.4	34.5	59.3	H	0.927	0.489	Y	0.40	-1.11	H
92	Feddersen Wierde	26	skelett3L	342	325	70	35	59.5	M	0.856	0.659	Y	-0.06	1.78	M
110	Nijmegen new excavations	486	147/128-15	359.1	347	81.8	39.1	68.3	H	0.716	3.043	N	2.19	-0.13	H*
114	Unterlaa	494	25	329.7	313.6	73.1	36.1	61.6	H	0.815	0.174	Y	0.87	-0.31	H*
114	Unterlaa	495	30	327.1	312.7	73.7	36.4	61.2	H	0.899	0.398	Y	1.03	-0.70	H
118	Carnuntum	544	Pferd 1	349	328	79	40.2	67.1	H	0.865	2.459	N	2.03	-0.60	H*
118	Carnuntum	545	Pferd 2	328	312	77.4	41.3	66.7	H	0.968	3.134	N	1.93	-1.41	H*
118	Carnuntum	546	Pferd 3	368	349	79.9	40.6	68	M	0.768	1.441	Y	1.81	1.02	M
128	Krefeld-Gellep	583	3392	352	339	82	43	68	H	0.880	4.176	N	2.49	-0.73	H*
128	Krefeld-Gellep	589	3510	292	280	63	29	51	D	0.485	1.833	Y	-0.86	-0.70	D*
128	Krefeld-Gellep	585	3557	360	346	81	42	67	H	0.583	3.093	N	2.13	0.18	H?
128	Krefeld-Gellep	584	3577A	348	336	75	40	64	M	0.834	0.048	Y	0.88	1.37	M
135	Swestari	615	1	302	285	66	36.3	56.5	H	0.738	0.392	Y	-0.15	-0.40	H*
135	Swestari	616	2	305	287	66	33	57	H	0.698	0.539	Y	-0.26	-0.35	H*
135	Swestari	617	3	317	302	69	38	61	H	0.526	0.835	Y	0.15	0.44	H*
135	Swestari	618	4	339	323	75	43	64	H	0.515	1.289	N	1.23	0.43	H?
135	Swestari	619	5	364	349	77	39	68	M	0.956	0.490	Y	1.03	2.12	M

Table A7 – Detailed information from discriminant function analysis of humeri from complete skeletons and articulated limbs

Site no	Site name	Bone no	Specimen	GLC	GLl	SD	BT	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
42	Druten	159	1.18	299.1	316	385	79.1	H	0.83	6.71	N	-1.05	2.62	H*
71	Piovego	118	N2	268	283	33	72	H	0.65	0.47	Y	0.72	0.00	H?
92	Feddersen Wierde	28	skelett1L	268.5	290.2	31.7	74.3	H	0.70	0.33	Y	0.62	0.05	H?
92	Feddersen Wierde	27	skelett1R	268.3	290.3	31.9	73	H	0.59	0.79	Y	0.72	-0.34	H?
92	Feddersen Wierde	26	skelett2R	244.5	265.8	32.6	70.1	H	0.63	0.94	Y	-0.85	0.49	H*
92	Feddersen Wierde	25	skelett3L	267	282	34		M	0.75	3.54	N			M?
96	Kunzing east vicus	4	1575/5	284	295.5	35.8	74.3	M	0.76	0.27	Y	1.68	-0.09	M*
96	Kunzing east vicus	5	1620	292	305	35.5	77	M	0.86	0.29	Y	2.06	0.02	M
96	Kunzing east vicus	6	1632	287	304	38	74.2	M	0.90	0.07	Y	1.94	-0.77	M
96	Kunzing east vicus	2	1641	286	298	34.7	75.8	M	0.74	0.52	Y	1.71	0.15	M
96	Kunzing east vicus	1	1703	279	296.3	37	75.6	M	0.53	1.01	Y	1.21	0.13	M*
110	Nijmegen new excavations	325	147/128	302	317.1	35.7	84.6	M	0.70	3.52	N	2.13	1.35	M?
110	Nijmegen new excavations	323	1961/621	244.2	257.1	31.5	59.6	H	0.48	4.42	N	0.04	-1.80	H?
118	Carnuntum	369	Pferd 1	316	332	39.2	83	M	0.99	2.00	N	3.33	-0.10	M*
118	Carnuntum	370	Pferd 2	281.5	297.5	37.7	80.2	H	0.80	1.94	N	0.96	1.40	H*
118	Carnuntum	371	Pferd 3	283	292.5	34	76.4	H	0.50	1.89	N	1.41	0.73	H?
135	Swestari	422	1	241	253	30	65	H	0.62	0.71	Y	-0.69	0.03	H*
135	Swestari	423	2	247	258	33	67	H	0.75	0.31	Y	-0.46	0.31	H*
135	Swestari	424	3	257	267	35.4	67.5	H	0.76	0.19	Y	0.23	-0.11	H*
135	Swestari	425	4	279	295	39	74	M	0.65	0.52	Y	1.33	-0.20	M*
135	Swestari	426	5	299	310	36	74	M	0.99	1.15	Y	2.85	-1.14	M

Table A8 – Detailed information from discriminant function analysis of femora from complete skeletons and articulated limbs

Site no	Site name	Bone no	Specimen	GL	GLC	DC	Bp	SD	Bd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
42	Druten	122	1.18	426.5	378.5	60.1	125.4	43.6	99.9	M	0.91	0.09	Y	2.04	0.91	M
42	Druten	121	12.2	428.4	389.5	64.7	135.9	49.4	104.3	M	0.86	2.90	Y	2.89	-0.22	M*
92	Feddersen Wierde	31	skelett1L	374.5	340.2	54.7	115.1	39.2	91.6	H	0.87	0.14	Y	0.07	-0.15	H
92	Feddersen Wierde	30	skelett1R	375.4	338.2	53.7	115.5	39.6	92.2	H	0.76	0.96	Y	-0.12	0.44	H*
92	Feddersen Wierde	29	skelett2L	348.3	317.9	51.5	104.8	38.1	86.6	H	0.78	0.95	Y	-0.64	-0.28	H*
92	Feddersen Wierde	28	skelett2R	349.2	311.8	51.1	102.5	38.6	84.5	H	0.84	0.43	Y	-0.12	0.05	H
92	Feddersen Wierde	27	skelett3L	387	358	55	111	38		H	0.51	0.98	Y			H*
96	Kunzing east vicus	3	1575/5	394	362	57.3	115.5	40.6	92.9	H	0.59	1.00	Y	1.26	-0.07	H*
96	Kunzing east vicus	4	1620	405	368	57.3	118.7	39.9	100.3	H	0.77	0.79	Y	-0.03	0.39	H*
96	Kunzing east vicus	5	1632	401.5	360	56.5	123	41.5	92	M	0.88	0.04	Y	1.80	0.93	M
96	Kunzing east vicus	2	1641	400	369	54.9	116.6	41.3	96.2	M	0.71	1.94	Y	0.50	1.52	M*
96	Kunzing east vicus	1	1703	392.5	352	53	119.3	43.7	97	M	0.80	4.70	N	0.10	2.42	M*
114	Unterlaa	252	23B	366.2	339.3	54.8	109.2	41.7	87.4	H	0.71	0.60	Y	1.08	-0.24	H*
114	Unterlaa	254	80L	367	334	52	96.4	34.2	82.9	H	0.84	0.10	Y	0.38	-0.12	H
117	Pompeii stable	272	C	388	353	58	117	43	90.3	M	0.62	2.15	Y	2.10	-0.32	M?
117	Pompeii stable	273	B	392	353	56	119	41.5		M	0.61	0.59	Y			M*
118	Carnuntum	276	Pferd 1	455	422.5	61.3	126	42.6	104	M	0.98	0.67	Y	2.35	1.76	M
118	Carnuntum	277	Pferd 2	404	367.5	58.3	125.5	40.5	98	H	0.75	0.32	Y	0.71	0.00	H*
118	Carnuntum	278	Pferd 3	396	362	57.8	117	40.7	94.7	H	0.71	0.57	Y	1.05	-0.19	H*
118	Carnuntum	279	Maultier 1	394.5	375	58.5		47.5	102	H	0.55	1.04	Y			H*
128	Krefeld-Gellep	306	3510	325		46	103	29	78	D	0.93	0.86	N	-2.13	-0.43	D*
128	Krefeld-Gellep	302	3559	435		57	124	38.5	96	M	0.98	0.89	Y	1.89	2.06	M
135	Swestari	314	1	340	315.5	49.5	102.5	33	80	H	0.80	1.10	Y	-0.71	-0.61	H
135	Swestari	315	2	346	314	50.5	108	34	83	H	0.76	1.25	Y	-0.78	-0.58	H*
135	Swestari	316	3	355	326	51.5	105.5	37	86	H	0.82	0.66	Y	-0.41	-0.08	H
135	Swestari	317	4	390	357	55	120	44	93	M	0.87	0.40	Y	1.26	1.40	M
135	Swestari	318	5	407	377	60	120	41	99	H	0.83	0.45	Y	0.97	-0.60	H

Table A9 – Detailed information from discriminant function analysis of isolated metatarsals

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
5	Beckford	464	248	45	35		45	33	H	0.92	0.78	Y	1.69	-0.99	H
15	Scole-Dickleburgh	445	267.9	48.1	41.2	30.2	45.3	36.7	M	0.84	0.11	Y	0.69	1.43	M
21	Skeleton Green	431	235	38	33		40.5	32.5	M	0.69	0.69	Y	0.26	0.92	M
26	Stonea	427	225	42.2	34.6		39.1	25.3	D	0.89	8.26	N	-1.74	-2.54	D*
28	Longthorpe II	423	224	40	31	27	40	30	H	0.94	1.30	Y	0.29	-1.24	H
28	Longthorpe II	424	223	40	32	26	40	30	H	0.94	1.69	N	0.13	-1.30	H*
28	Longthorpe II	425	251	50	41	29	46	35	H	0.96	1.21	Y	1.26	-1.47	H
38	Nijmegen	379	271.4	46.2	40.2	32	45.4	35.7	M	0.92	0.43	Y	0.64	1.86	M
38	Nijmegen	380	258	46.8	39.3	27.9	46.6	35.1	H	0.79	0.41	Y	1.68	-0.29	H
38	Nijmegen	383	274.8	50	43.2	33.9	52.1	38.3	H	0.85	6.49	N	3.60	-0.49	H*
38	Nijmegen	384	274.6	46	39.7	31.6	46.8	36.9	M	0.93	0.75	Y	1.52	2.00	M
38	Nijmegen	385	260.2	50.7	41.3	32.4	51.8	37.8	H	0.99	13.07	N	4.18	-2.19	H*
38	Nijmegen	390	278.4	49.3	48.7	33.2	47.7	37	M	0.88	0.92	Y	0.08	1.60	M
39	Kesteren vicus	378	237.8	44.8	37.3	30.4	45.7	36.2	H	0.95	2.73	N	2.48	-1.22	H*
40	Heteren	374	285.6	50.3	42.1	29.3	50.8		M	0.69	2.40	N	2.38	1.24	M*
40	Heteren	376	251	43.8	39.1	28.8	43.6	33.3	H	0.52	1.32	Y	0.19	0.37	H?
42	Druten	364	248.1	46.9	40.7	30.3	46	34.6	H	0.94	0.67	Y	1.34	-1.16	H
42	Druten	365	272	47.1	49.1		46.2	36.5	M	0.91	2.96	N	-0.60	1.94	M*
42	Druten	366	258.3	46.9	38.7	29.7	46.8	37.2	H	0.61	1.88	N	2.28	0.22	H?
42	Druten	367	271.8	52.9	44	32.3	51.3	39.9	H	0.88	5.83	N	3.45	-0.65	H*
42	Druten	368	259.4	52.3	42.1	32.5	50.8	38.1	H	0.99	9.72	N	3.63	-2.13	H*
42	Druten	369	275	50.5	43.4	34.2	49.8	37.8	H	0.63	2.07	N	2.37	0.19	H?
43	Elms Farm	358	256	44.9	40.5	31.1	45.8	33.8	H	0.71	0.13	Y	0.89	-0.07	H
43	Elms Farm	359	234	41.8	34.6	27.9	39.5		H	0.77	2.32	N	-0.33	-0.64	H*
44	Danebury	322	242	45.7	36.7	28.2	44.2	35.2	H	0.89	0.39	Y	1.57	-0.73	H
44	Danebury	335	229	42	34.5	24.8	41.6	31.6	H	0.95	1.05	Y	0.50	-1.25	H
44	Danebury	338	251	47.8	40.8	28.5	45.1	35.2	H	0.84	0.04	Y	0.91	-0.54	H
44	Danebury	340	251.5	46.4	39.8	31.1	45.7	35.8	H	0.78	0.21	Y	1.49	-0.27	H
46	E London RB Cemetary	320	270.9	50.8	43.8	30.7	51.2	39.7	H	0.80	5.68	N	3.43	-0.27	H*
47	Beddington Sewage Farm	317	245	44.6	40	27.6	43.1	35.3	H	0.51	1.15	Y	0.33	0.40	H?
47	Beddington Sewage Farm	318	257	48.7	42		47	37.5	H	0.76	0.63	Y	1.82	-0.20	H

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
54	Thorpe Thewles	301	242	46.4	42.8	27.2	47.2	36.6	H	0.96	2.15	N	2.05	-1.46	H*
54	Thorpe Thewles	305	242	42.1	38.9	25.4	43.3	35.3	M	0.55	0.61	Y	0.73	0.57	M*
66	Settefinestre	285	277	49.5	41	33	54	38	H	0.94	14.55	N	4.80	-1.07	H*
68	Lutton/Huntingdon	279	286	52	45.4	35.3	54.1	40.9	H	0.65	10.56	N	4.25	0.20	H?
68	Lutton/Huntingdon	280	272	49	44	30.9	50	37.6	H	0.65	2.09	N	2.40	0.13	H?
68	Lutton/Huntingdon	283	254	47	41.7	28.3	47.1	35.7	H	0.88	0.48	Y	1.68	-0.67	H
81	Welsow	271	259.7	48.5	40.2	28.4	47.3	37.2	H	0.75	1.32	Y	2.18	-0.16	H
81	Welsow	272	247.5	44	35	26	411.7	32.4	H	0.54	1.54	Y	0.03	0.32	H?
81	Welsow	273	246	48.5	41.7	32.7	48.8	36.2	H	0.99	6.99	N	2.83	-2.35	H*
85	Macon	269	285	51	47.5	29.7	46.2	39	M	0.99	4.31	N	-0.22	2.99	M*
92	Feddersen Wierde	28	244.3	45.2	43.6	27.7	45.4	34.6	H	0.89	0.37	Y	0.60	-0.79	H
92	Feddersen Wierde	29	259.6	48.4	46.7	28.5	48.6	37	H	0.84	0.19	Y	1.48	-0.49	H
92	Feddersen Wierde	32	258.2	43.9	38.3	25.5	46	34.2	H	0.55	0.67	Y	1.42	0.34	H?
92	Feddersen Wierde	33	260.7	45.3	41.3	27.4	45.5	34.4	M	0.58	0.65	Y	0.56	0.63	M*
92	Feddersen Wierde	34	236	44.8	41.6	28.9	46	31.9	H	0.99	4.98	N	1.03	-2.62	H*
92	Feddersen Wierde	35	241.8	46	41.8	24.5	43.1	34.1	H	0.82	1.46	Y	-0.15	-0.53	H
92	Feddersen Wierde	36	247	43.5	43.1	28.6	45.3	34.3	H	0.75	0.33	Y	0.51	-0.19	H
92	Feddersen Wierde	37	257.4	49.7	46	28.7	49.2	36.7	H	0.96	1.68	N	1.91	-1.36	H*
92	Feddersen Wierde	38	239.7	43.5	39.8	25.5	45.1	33.9	H	0.93	0.50	Y	1.22	-1.07	H
92	Feddersen Wierde	39	250	45	40.2	24.8	42.3	33.3	M	0.51	3.17	N	-0.61	0.55	M?
92	Feddersen Wierde	40	270.7	50.5	45.7	30.6	51.5	37.6	H	0.92	3.37	N	2.82	-0.89	H*
92	Feddersen Wierde	41	241.6	44.4	41.6	29	46.5	34	H	0.97	1.56	Y	1.48	-1.56	H*
92	Feddersen Wierde	42	257.1	44.7	43.7	26.1	46.1	35.3	M	0.53	0.74	Y	0.65	0.52	M*
92	Feddersen Wierde	43	250.6	47.8	42.8	27.9	46.1	34.8	H	0.92	0.42	Y	0.93	-1.03	H
92	Feddersen Wierde	45	247.2	43.9	40.1	27.3	43.7	33.2	H	0.69	0.94	Y	0.13	-0.06	H*
92	Feddersen Wierde	46	271.3	48.3	47.5	29.6	49.2	36	H	0.61	0.34	Y	1.06	0.20	H*
92	Feddersen Wierde	47	249.1	42.2	42.1	25.8	43.9	33.1	M	0.52	2.20	N	-0.24	0.49	M?
92	Feddersen Wierde	48	247.5	43.3	43	29.2	46.5	35.7	H	0.75	0.13	Y	1.34	-0.17	H
92	Feddersen Wierde	49	269.2	52	46.9	30.4	49	36.3	H	0.88	0.14	Y	1.20	-0.73	H
92	Feddersen Wierde	50	239	42.2	38.9	22.1	41.6	32.1	H	0.60	2.78	N	-0.57	-0.01	H?
92	Feddersen Wierde	51	245.5	45.4	42.7	28.2	45.2	35	H	0.85	0.14	Y	0.72	-0.56	H
92	Feddersen Wierde	52	246.8	44.7	42.1	26.6	45.7	35.9	H	0.76	0.05	Y	1.20	-0.22	H

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
92	Feddersen Wierde	53	249.8	49.1	44.1	28.2	46.6	35.5	H	0.96	0.94	Y	1.07	-1.36	H
92	Feddersen Wierde	54	255.7	43.9	39.9	25.2	45.3	32.9	H	0.66	0.38	Y	0.61	0.05	H*
92	Feddersen Wierde	55	238.3	43	41.1	25.5	44.9	33.2	H	0.94	0.69	Y	0.78	-1.17	H
92	Feddersen Wierde	56	232.9	41.7	39.9	25.8	43.1		H	0.83	1.31	N	0.07	-0.69	H*
92	Feddersen Wierde	57	253.7	43.9	41.6	24.7	45	33	H	0.65	0.90	Y	0.22	0.06	H*
92	Feddersen Wierde	58	247.3	46	44.4	27.6	46.8	35.5	H	0.92	0.33	Y	1.18	-0.95	H
92	Feddersen Wierde	59	257.2	47	47	29.1	48.4	36.7	H	0.81	0.09	Y	1.34	-0.39	H
92	Feddersen Wierde	61	256	47	43.6	28.7	45.1	34.9	H	0.61	1.09	Y	0.15	0.15	H*
92	Feddersen Wierde	63	257.6	45	42.7	28.2	45.1	33.8	H	0.50	1.61	Y	0.08	0.42	H?
92	Feddersen Wierde	64	260.9	48.3	43.4	26.4	48.2	34.9	H	0.91	0.48	Y	1.51	-0.90	H
92	Feddersen Wierde	65	239.6	44.5	45.2	27.6	47.2	34.9	H	0.97	1.72	N	1.34	-1.67	H
92	Feddersen Wierde	66	259.3	44.3	43.9	28.7	45.9	34.5	M	0.60	0.87	Y	0.30	0.69	M*
92	Feddersen Wierde	67	262.3	47.2	45.5	26.8	48.1	38.8	M	0.61	0.85	Y	1.73	0.74	M*
92	Feddersen Wierde	68	247	45.5	42.6	28.3	47.3	34.2	H	0.97	1.48	Y	1.54	-1.50	H
92	Feddersen Wierde	69	234.2	41	36.5	24.1	43.2	31	H	0.95	0.94	Y	0.60	-1.24	H
92	Feddersen Wierde	70	249.5	45.9	42.3	26.5	45.6	33.6	H	0.90	0.42	Y	0.60	-0.86	H
92	Feddersen Wierde	71	262.7	50.6	48	31	49.4	37.9	H	0.88	0.49	Y	1.67	-0.70	H
92	Feddersen Wierde	72	259.4	46	43.1	27.9	47.1	35	H	0.71	0.11	Y	1.11	-0.06	H*
92	Feddersen Wierde	73	262.3	48.4	47.5	31.3	49.6	36.4	H	0.89	0.44	Y	1.60	-0.76	H
92	Feddersen Wierde	74	247.8	46.6	45	26.4	46.8	34	H	0.96	1.22	Y	0.77	-1.45	H
92	Feddersen Wierde	75	255.3	46.5	43.1	24.4	46.2	34.5	H	0.80	0.11	Y	0.72	-0.37	H
92	Feddersen Wierde	77	246.2	43.6	41	24.8	44.3	33	H	0.79	0.67	Y	0.23	-0.35	H
92	Feddersen Wierde	78	251.2	42.5	40.4	25.8	42.4	32.6	M	0.65	3.22	N	-0.77	1.01	M?
92	Feddersen Wierde	79	252.1	44.7	44.3	25.4	44.1	34.7	M	0.58	2.29	N	-0.37	0.67	M?
92	Feddersen Wierde	80	245	44.8	40.3	25.4	44.4	33.4	H	0.87	0.37	Y	0.53	-0.70	H
92	Feddersen Wierde	81	259.4	45.7	42.4	25.8	46.2	35.3	H	0.51	0.70	Y	0.88	0.43	H?
92	Feddersen Wierde	83	260.4	49.4	46.3	27.2	47.8	36.7	H	0.82	0.00	Y	1.10	-0.42	H
92	Feddersen Wierde	84	248.9	46.7	43.2	27.2	46.1	34.5	H	0.92	0.43	Y	0.85	-1.01	H
92	Feddersen Wierde	85	253.6	45.7	43.8	28.2	47	32.5	H	0.94	0.87	Y	0.64	-1.23	H
92	Feddersen Wierde	86	247	46.7	43.9	27.7	46.4	35.8	H	0.91	0.29	Y	1.15	-0.91	H
92	Feddersen Wierde	87	252.2	45.2	42.2	26.8	44.4		M	0.61	1.77	N	-0.25	0.52	M*
92	Feddersen Wierde	88	244.6	44.4	42.1	26.4	45	34.7	H	0.82	0.12	Y	0.71	-0.44	H

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
92	Feddersen Wierde	89	259.3	48.2	47.5	30.7	49.4	37.4	H	0.87	0.60	Y	1.78	-0.64	H
92	Feddersen Wierde	90	245.9	46.2	43	25.9	45.4	35.1	H	0.88	0.21	Y	0.76	-0.74	H
92	Feddersen Wierde	91	258.2	47.7	47.6	30	48.9	35.8	H	0.91	0.31	Y	1.26	-0.90	H
92	Feddersen Wierde	92	243.8	44.2	41.1	26.2	45.7	34.8	H	0.89	0.19	Y	1.28	-0.76	H
92	Feddersen Wierde	93	248.4	44.8	43.1	26.9	44.1	34.8	H	0.56	1.54	Y	-0.01	0.26	H?
92	Feddersen Wierde	95	242.2	46.3	43.8	25.9	45.4	33.3	H	0.97	1.99	N	0.38	-1.63	H
92	Feddersen Wierde	96	270.6	50.2	47.9	32	50.1	38.1	H	0.71	0.70	Y	1.82	-0.05	H*
92	Feddersen Wierde	98	256.6	43.1	41	23.4	42.3	30.2	D	0.81	3.06	N	-1.55	0.77	D*
92	Feddersen Wierde	99	241.7	44.9	42.8	25.4	43.5	32.8	H	0.84	2.24	N	-0.40	-0.78	H*
92	Feddersen Wierde	101	241.4	44.3	42.1	28	46.8	35.3	H	0.95	1.31	Y	1.77	-1.28	H
92	Feddersen Wierde	102	255.3	46.6	43.5	28.5	44.7	33.6	H	0.67	1.77	N	-0.23	-0.05	H?
92	Feddersen Wierde	103	258.1	48.4	43	27.1	46	37.2	H	0.56	0.51	Y	1.06	0.32	H?
92	Feddersen Wierde	104	239.6	44.3	40.5	28.8	45	33.7	H	0.95	0.77	Y	1.00	-1.26	H
92	Feddersen Wierde	105	257.1	47	44.5	27.5	48.1	36.2	H	0.84	0.32	Y	1.60	-0.52	H
92	Feddersen Wierde	107	243.6	46	42.3	28.4	44.5	33.3	H	0.93	1.24	Y	0.21	-1.12	H
92	Feddersen Wierde	109	258.1	47.2	43.7		47.7	35.6	H	0.84	0.16	Y	1.43	-0.51	H
92	Feddersen Wierde	110	241.7	43.7	40.1	27.2	44.3	33	H	0.90	0.47	Y	0.55	-0.86	H
92	Feddersen Wierde	111	256.7	48.1	43.6	27.7	44.2	35.1	H	0.50	2.29	N	-0.26	0.38	H?
92	Feddersen Wierde	113	244.4	45.9	42.9	27.8	44.4	34.6	H	0.84	0.66	Y	0.26	-0.58	H
92	Feddersen Wierde	114	248.6	48.4	45.4	26.6	45.3	34.2	H	0.92	1.67	N	-0.01	-1.13	H*
92	Feddersen Wierde	115	270.9	51.2	45	30.2	50.9	37.4	H	0.91	2.73	N	2.63	-0.88	H
92	Feddersen Wierde	116	262	47.3	42.7	28.1	44	36.7	M	0.88	1.16	Y	-0.04	1.60	M
92	Feddersen Wierde	117	255.7	47.1	44.2	26.8	45.8	34.3	H	0.78	0.62	Y	0.27	-0.33	H
92	Feddersen Wierde	118	240.4	44.9	40.5	25.3	44		H	0.80	1.38	N	0.01	-0.58	H*
92	Feddersen Wierde	119	252.3	46.4	45.1	28.3	46.3	35.2	H	0.81	0.21	Y	0.60	-0.41	H
92	Feddersen Wierde	120	255.2	46.3	42.9	26.4	45.2	36.3	M	0.56	0.67	Y	0.62	0.58	M*
92	Feddersen Wierde	121	242.9	45.3	42.3	26.9	43.8	33.4	H	0.86	1.39	Y	-0.08	-0.72	H
92	Feddersen Wierde	122	261.9	44.9	42.7	27	46.1	34.2	M	0.56	0.76	Y	0.49	0.59	M*
92	Feddersen Wierde	123	235.6	43	38.7	24	42.1	31.9	H	0.86	1.81	N	-0.23	-0.79	H*
92	Feddersen Wierde	124	247.5	45.2	41.9	25.6	44.5	33.1	H	0.85	0.90	Y	0.13	-0.62	H
92	Feddersen Wierde	125	249.9	47.4	44.2	26.7	47	35.1	H	0.95	0.71	Y	1.16	-1.22	H
92	Feddersen Wierde	126	250.6	44.9	42.1	28.1	44.6	34.1	H	0.67	0.84	Y	0.23	0.02	H*

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
92	Feddersen Wierde	127	239.6	43.9	38.9	26.4	43.8		H	0.86	0.60	Y	0.51	-0.76	H
92	Feddersen Wierde	128	263.6	48	44.3	28.3	47.3		M	0.54	0.59	Y	0.74	0.52	M*
92	Feddersen Wierde	129	232	44.1	41.7	25.1	44.8	35.3	H	0.96	1.01	Y	1.20	-1.38	H
92	Feddersen Wierde	130	249.8	43.8	41.9	25.5	43.3	33.8	M	0.56	2.36	N	-0.38	0.62	M?
92	Feddersen Wierde	131	236.1	45.8	41.1	24.4	43.7	32.7	H	0.97	2.51	N	0.19	-1.72	H*
92	Feddersen Wierde	132	248.4	43.4	40.2	26.1	42.7		M	0.68	2.80	N	-0.75	0.75	M*
92	Feddersen Wierde	134	247.8	46	44.4	27.1	46.5	35.5	H	0.89	0.15	Y	1.02	-0.78	H
92	Feddersen Wierde	135	248.2	44.6	40.6	25.6	43.2	32.8	H	0.66	1.97	N	-0.30	-0.03	H?
92	Feddersen Wierde	136	247	47.3	44.5	27.3	48.2	37.7	H	0.95	2.06	N	2.24	-1.19	H*
92	Feddersen Wierde	137	267.3	48.8	46.5	27.2	49.3	37.5	H	0.68	0.62	Y	1.70	0.05	H*
92	Feddersen Wierde	138	237.9	44	41.1	27.4	42.7	32.8	H	0.84	1.98	N	-0.32	-0.69	H*
92	Feddersen Wierde	139	260.3	44.8	41.3	26.4	45.2	34.4	M	0.66	0.56	Y	0.43	0.82	M*
92	Feddersen Wierde	140	249.9	45.2	42.9	26.8	45.9	36.1	H	0.70	0.13	Y	1.08	-0.02	H*
92	Feddersen Wierde	141	248.5	45.4	41.4	29.2	48.1		H	0.97	2.73	N	2.55	-1.25	H*
92	Feddersen Wierde	143	259	46.2	42.7	25.3	46.3	36.2	M	0.52	0.64	Y	1.05	0.51	M*
92	Feddersen Wierde	144	243.3	43.1	40	26.4	43	33.8	H	0.60	1.32	Y	0.05	0.19	H?
92	Feddersen Wierde	145	245.4	47.9	41.6	30.1	48.7	35.7	H	0.99	6.75	N	2.72	-2.38	H*
92	Feddersen Wierde	146	256.8	43.4	43.3	27.4	45.5	34.9	M	0.69	0.55	Y	0.38	0.90	M*
92	Feddersen Wierde	147	269.3	49.7	43.2	26.7	50.4	36.9	H	0.89	2.82	N	2.70	-0.70	H*
104	Orton Hall Farm	504	236	42	39	27	44	32	H	0.94	0.91	Y	0.61	-1.23	H
104	Orton Hall Farm	505	258	46	39	27	43	34	M	0.72	1.44	Y	-0.16	0.99	M
104	Orton Hall Farm	506	252	45	37	28	44	34	H	0.62	0.33	Y	0.89	0.16	H*
104	Orton Hall Farm	507	276	50	46	32	50	38	H	0.51	1.57	Y	1.96	0.48	H?
105	Mons Claudianus	509	272	52.1	40.6	33	48.5		H	0.93	3.02	N	2.85	-0.79	H*
105	Mons Claudianus	510	264.9	48.9	38.7	29	43.3		M	0.68	1.28	Y	-0.13	0.70	M
105	Mons Claudianus	512	253	43.2	31.5	26.8	39.2		M	0.74	2.97	N	-0.87	1.05	M*
115	Bad Wimpfen	605	276.3	52.6	46.6	32.4	50.2	37	H	0.83	0.48	Y	1.74	-0.45	H
115	Bad Wimpfen	606	264.3	48.1	44	29.2	49.2	36.7	H	0.81	1.09	Y	2.09	-0.37	H
115	Bad Wimpfen	616	207	37	32	22.8	33.8		D	1.00	0.67	Y	-2.90	-0.80	D
116	Pommeroeul	617	246	46	40	29	45	33	H	0.95	0.82	Y	0.77	-1.25	H
116	Pommeroeul	618	250	46	43	27	46	33	H	0.94	0.84	Y	0.53	-1.14	H
116	Pommeroeul	619	250	45	41	28	47	35	H	0.90	0.68	Y	1.77	-0.79	H

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
116	Pommeroeul	620	250	44	40	26	45	34	H	0.72	0.14	Y	0.83	-0.09	H
116	Pommeroeul	621	257	46	40	30	47	35	H	0.81	0.49	Y	1.75	-0.37	H
116	Pommeroeul	622	257	46	41	28	46	35	H	0.66	0.20	Y	1.08	0.06	H*
116	Pommeroeul	623	266	47	40	25	45	34	M	0.64	0.70	Y	0.34	0.79	M*
116	Pommeroeul	624	266	48	46	31	52	37	H	0.94	4.46	N	3.03	-1.13	H*
116	Pommeroeul	625	268	44	43	28	46	35	M	0.89	0.57	Y	0.35	1.69	M
116	Pommeroeul	626	271	55	50	31	51	38	H	0.96	1.68	N	1.80	-1.44	H*
116	Pommeroeul	627	271	54	49	32	51	32	H	1.00	6.81	N	0.89	-2.99	H*
116	Pommeroeul	628	272	53	49	33	52	40	H	0.89	3.21	N	2.81	-0.72	H*
116	Pommeroeul	629	281	52	47	32	52	40	H	0.58	4.03	N	2.93	0.33	H?
116	Pommeroeul	630	291	49	49	31	47	37	M	0.98	6.46	N	-0.70	3.20	M*
116	Pommeroeul	631	296	53	51	34	54	38	H	0.56	1.99	N	2.25	0.35	H*
121	Soluthurn/Vigier	650	285	49.9	45.6	31.7	46.4	36.7	M	0.97	2.64	N	-0.18	2.43	M*
121	Soluthurn/Vigier	651	276	49.7	47.1	30.4	47	37.3	M	0.87	0.71	Y	0.20	1.57	M
121	Soluthurn/Vigier	652	272.3	49.6	43.1	27.5	44.6	35.3	M	0.84	2.00	N	-0.41	1.46	M*
123	Wroxeter Baths basilica	659	265	50.1	49.3	30.4	49.4	37.2	H	0.84	0.04	Y	1.22	-0.51	H
123	Wroxeter Baths basilica	660	250.4	45.9	43.3	30.1	45.3	33.1	H	0.88	0.96	Y	0.15	-0.76	H
125	Castleford	673	274	52.9	51	35	51		H	0.88	1.67	N	2.45	-0.47	H*
125	Castleford	674	256	47.8	39.2		46.2	33.6	H	0.92	0.45	Y	1.30	-1.01	H
125	Castleford	675	252	44.9	39.1	27.3	43.2	34.6	M	0.63	0.93	Y	0.21	0.75	M*
134	Butzbach	729	284	51	47	34	53	39	H	0.65	4.60	N	3.12	0.17	H?
134	Butzbach	730	245	42	41	28	42	31	D	0.56	3.77	N	-1.19	0.23	D*
134	Butzbach	731	291	54	52	36	52	42	M	0.87	1.12	Y	2.01	1.61	M
134	Butzbach	732	281	52	48	36	53	38	H	0.87	3.23	N	2.83	-0.61	H*
134	Butzbach	735	303	54	51	36	54	39	M	0.74	1.55	N	2.22	1.10	M*
146	Balatonaliga	752	264	51	45	35	50	36	H	0.97	2.61	N	2.15	-1.56	H*
147	Pilismarot I Watchtower	753	245	43.5	39	26	45.5	34	H	0.88	0.24	Y	1.42	-0.71	H
147	Pilismarot I Watchtower	754	245	43.5	39.5	26.5	45.5	34	H	0.88	0.16	Y	1.32	-0.69	H
147	Pilismarot I Watchtower	755	243	49	44.5	35	52	37.5	H	1.00	19.45	N	4.12	-3.55	H*
149	Helemba - Sziget	756	231	44	41	28.5	47	34	H	1.00	6.75	N	2.16	-2.73	H*
149	Helemba - Sziget	757	253.5	46.5	43.5	28	48	37.5	H	0.81	1.11	Y	2.10	-0.38	H
149	Helemba - Sziget	758	254	45.5	43.5	28	47.5	37.5	H	0.66	0.88	Y	1.85	0.11	H*

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
151	Gyor Szechenyi-Ter	759	282	51	48	33.5	53.5	36	H	0.94	3.07	N	2.67	-1.06	H*
153	Aquileia forum	774	275	51	46.7	29.7	49.5	40	M	0.69	1.11	Y	1.99	0.95	M*
176	Oberdorla	804	266	44	42	28	44	34	M	0.92	2.75	N	-0.53	1.96	M*
176	Oberdorla	805	262	46	39	29	42		M	0.83	2.55	N	-0.76	1.31	M*
176	Oberdorla	806	260	49	41	31	46	35	H	0.79	0.01	Y	0.99	-0.34	H
176	Oberdorla	807	254	48	40	27	45	36	H	0.70	0.12	Y	1.08	-0.05	H*
176	Oberdorla	808	254	45	40	30	43	34	M	0.67	1.72	N	-0.24	0.86	M*
176	Oberdorla	810	253	47	37	31	43	36	M	0.63	0.34	Y	0.75	0.77	M
176	Oberdorla	811	253	47	44	31	49	37	H	0.93	2.29	N	2.40	-1.07	H*
176	Oberdorla	812	251	44	40	29	44	33	H	0.63	1.07	Y	0.14	0.11	H*
176	Oberdorla	813	251	44	41	28	44	34	M	0.50	1.50	Y	0.13	0.44	M?
176	Oberdorla	814	251	47	44	31	50	37	H	0.98	5.18	N	2.93	-1.66	H*
176	Oberdorla	815	250	47	44	30	45	34	H	0.85	1.08	Y	0.05	-0.65	H
176	Oberdorla	816	248	46	38	29	45	32	H	0.96	1.07	Y	0.92	-1.41	H
176	Oberdorla	817	246	48	40	30	47	36	H	0.97	3.05	N	2.27	-1.63	H*
176	Oberdorla	818	218	41	40	26	40	30	D	0.62	6.32	N	-1.29	-1.75	D*
188	Titelberg oppidum	849	256	49	42	30	49	38	H	0.93	3.77	N	2.89	-1.02	H*
189	Kassope	852	217	38.5	36	22.5	35	27	D	1.00	0.16	Y	-3.39	-0.29	D
189	Kassope	854	220	37	33	24.5	35		D	1.00	0.51	Y	-2.60	0.20	D
189	Kassope	858	198	29	26.5	19.5	29	21.5	D	1.00	3.10	N	-4.80	0.48	D*
189	Kassope	864	236.5	40.5	37.5	25	38	27	D	1.00	0.06	Y	-2.87	0.04	D
189	Kassope	865	220	38	32	24	35.5	25.5	D	1.00	0.55	Y	-2.74	-0.66	D
189	Kassope	866	231	39	37		36.5	29.5	D	1.00	1.41	Y	-2.85	1.15	D
189	Kassope	870	225	40	34		35.5	27.5	D	1.00	0.04	Y	-2.92	0.03	D
202	Penzlin	949	251.6	47.1	38.6	28.4	45.6	34.5	H	0.90	0.32	Y	1.43	-0.80	H
202	Penzlin	950	256	45.2	38.3	27.7	45	35	H	0.51	0.72	Y	1.17	0.45	H?
202	Penzlin	951	242	42	36.7	28	41.7	32.7	H	0.51	1.88	N	-0.08	0.39	H?
202	Penzlin	952	251.3	48.6	39.1	29	45	34.2	H	0.92	0.39	Y	1.01	-1.01	H
202	Penzlin	954	249	46.7	42	33	48.8	36.9	H	0.96	4.13	N	2.80	-1.41	H*
202	Penzlin	955	230.3	44	36.8	23.5	43.5	33.9	H	0.97	1.54	Y	1.34	-1.59	H
202	Penzlin	956	243.8	45.5	37.6	25.9	43.4	34.4	H	0.81	0.06	Y	0.81	-0.39	H
203	Tac-Gorsium	960	238.5	41.5	41.5	27.5	43	32	H	0.75	2.18	N	-0.43	-0.38	H?

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
203	Tac-Gorsium	961	246	48.5	46.5	31	48		H	0.98	2.84	N	1.98	-1.83	H*
203	Tac-Gorsium	962	247	48.5	45	31	48	38	H	0.95	1.92	N	2.10	-1.29	H*
203	Tac-Gorsium	963	248	47.5	46.5	31.5	48	38	H	0.91	0.79	Y	1.78	-0.90	H
203	Tac-Gorsium	964	250	44	40.5	29.5	42	33	M	0.54	3.72	N	-0.87	0.82	M?
203	Tac-Gorsium	965	253	48	45.5	30	48.5	37.5	H	0.91	1.10	Y	1.96	-0.90	H
203	Tac-Gorsium	966	256	48	48.5	31	51	38	H	0.96	3.18	N	2.55	-1.34	H*
203	Tac-Gorsium	967	257	45	41.5	27.5	41.5	32.5	D	0.76	4.17	N	-1.61	1.37	D*
203	Tac-Gorsium	968	258.5	47	45	32	47.5		H	0.83	0.34	Y	1.75	-0.36	H
203	Tac-Gorsium	969	259	47	45.5	31.5	47	36.5	H	0.59	0.41	Y	0.88	0.23	H*
203	Tac-Gorsium	970	260	45	41	29	44.5	35	M	0.78	0.53	Y	0.28	1.19	M
203	Tac-Gorsium	974	262.5	50	45	32	51	38.5	H	0.94	4.93	N	3.14	-1.15	H*
203	Tac-Gorsium	975	263.5	47.5	43	31	47	37	M	0.56	0.59	Y	1.33	0.61	M*
203	Tac-Gorsium	976	264	47.5	44.5	31	48	36.5	H	0.62	0.44	Y	1.40	0.18	H*
203	Tac-Gorsium	978	266	50	46	30	47.5	36.5	H	0.67	0.24	Y	0.81	0.04	H*
203	Tac-Gorsium	979	267	52	47	31	48	36.5	H	0.83	0.07	Y	0.82	-0.49	H
203	Tac-Gorsium	981	270	48.5	50	31	46.5	37.5	M	0.87	2.02	N	-0.39	1.62	M*
203	Tac-Gorsium	983	270.5	50.5	48.5	32	50.5	40	H	0.59	1.88	N	2.24	0.29	H?
203	Tac-Gorsium	984	271.5	50	45.5	30	50	39	H	0.58	2.25	N	2.38	0.31	H?
203	Tac-Gorsium	985	271.5	53	47.5	32.5	51.5	39.5	H	0.90	3.18	N	2.79	-0.77	H*
203	Tac-Gorsium	987	277	49.5	47.5	33	50.5	38	M	0.53	1.34	Y	1.87	0.55	M*
203	Tac-Gorsium	990	282	50.5	49	31	52	39.5	M	0.58	2.36	N	2.41	0.71	M?
203	Tac-Gorsium	991	282.5	50.5	46	30.5	46.5	37	M	0.94	1.79	N	-0.08	2.10	M*
203	Tac-Gorsium	992	282.5	51	48.5	32	53	40.5	H	0.51	5.22	N	3.15	0.52	H?
203	Tac-Gorsium	993	283.5	54	51	32.5	52.5	40	H	0.68	1.76	N	2.30	0.05	H?
203	Tac-Gorsium	994	286	50.5	46	31	47	38.5	M	0.98	2.35	N	0.33	2.69	M*
203	Tac-Gorsium	995	289	52	50	35	53	40	M	0.63	2.68	N	2.56	0.83	M*
203	Tac-Gorsium	997	296	52	49	33	54	41	M	0.81	4.87	N	3.20	1.39	M*
203	Tac-Gorsium	1057	212	37.5	32	24	35	28	D	0.99	0.87	Y	-2.27	-0.41	D
209	Iatrus	1089	278.1	53.1	46.1	37.9	50.3	33.8	H	0.96	1.02	Y	1.24	-1.38	H
212	Gournay	1093	245	43	36	27	43	33.5	H	0.62	0.39	Y	0.73	0.15	H*
212	Gournay	1094	233	43	35	28	40	37	M	0.76	0.25	Y	0.53	1.14	M
212	Gournay	1095	267	48	41.5	28.5	40	33	D	0.98	6.16	N	-2.53	2.40	D*

Site no.	Site name	Bone no.	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
213	Beauvais	1096	233	41.5	35	28	41	31.5	H	0.82	1.16	Y	-0.02	-0.51	H
213	Beauvais	1097	247	45.5	35.5	25.5	43	35	H	0.62	0.33	Y	1.05	0.18	H*
213	Beauvais	1098	259	42	37.5	27	41.5	33	M	0.92	4.14	N	-0.79	2.27	M*
213	Beauvais	1099	249	48	37	28.5	45	35.5	H	0.90	0.63	Y	1.73	-0.80	H
213	Beauvais	1100	242	40.5	34	24	39	32	M	0.74	3.84	N	-0.95	1.52	M?
213	Beauvais	1101	225	39	31	28	40	31	H	0.86	0.41	Y	0.45	-0.61	H
213	Beauvais	1102	284	52	43.5	29.5	51	41	M	0.75	5.02	N	3.23	1.19	M*
214	Compiegne	1103	242	48	48	28.5	44	35.5	H	0.74	3.12	N	-0.69	-0.70	H?
214	Compiegne	1104	253	46.5	39	29	46.5	36	H	0.83	0.93	Y	2.02	-0.43	H
215	Ribemont	1105	226	42.5	35.5	25.5	42	32.5	H	0.97	1.39	Y	0.76	-1.53	H
215	Ribemont	1106	228	42	36.5	25.5	42	34.5	H	0.86	0.08	Y	0.87	-0.59	H
215	Ribemont	1107	232	46	38	28.5	43.5	34	H	0.98	2.05	N	1.07	-1.82	H*
216	Variscourt	1108	230	44.5	36.5	27	43	34	H	0.97	1.31	Y	1.19	-1.52	H
216	Variscourt	1109	231	43	36.5	26	41	32	H	0.88	1.69	N	-0.16	-0.86	H*
216	Variscourt	1110	232	43	35.5	26.5	42.6	34	H	0.90	0.22	Y	1.13	-0.85	H
216	Variscourt	1111	246	45	37	28	43	34.5	H	0.64	0.38	Y	0.69	0.11	H*
216	Variscourt	1112	249	43	34	27	41	30	H	0.51	3.10	N	-0.59	0.25	H?
216	Variscourt	1113	248	43	37.5	28	44	35	M	0.53	0.60	Y	1.10	0.54	M*
217	Soissons	1114	213	36	29.5	23.5	34		D	0.99	0.89	Y	-2.37	-0.37	D

Table A10 – Detailed information from discriminant function analysis of isolated tibiae

Site no.	Site name	Bone no.	GL	Ll	Bp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
38	Nijmegen	264	370	367.3	93.4	39.1	68.6	43.1	M	1.00	3.96	N	1.49	3.54	M*
38	Nijmegen	270	381	352.2	93.8	41.6	72.4	48.3	M	1.00	1.39	Y	1.38	2.71	M
38	Nijmegen	271	362.3	331.7	88.4	38.9	70.6	42.8	M	0.91	3.50	N	-0.06	2.40	M*
38	Nijmegen	272	364.6	337.7	85	40.6	71.7	42.1	M	0.55	10.28	N	-1.00	3.42	M?
38	Nijmegen	274	349.4	314.3	88.2	36.6	67.7	43.5	M	0.69	1.86	Y	0.28	1.25	M*
38	Nijmegen	277	335.8	303.4	94.5	40.7	72.8	45.9	H	0.97	0.25	Y	0.72	-1.07	H
42	Druten	247	372.6	337.1	100.3	43.5	73.6	47.4	M	0.84	3.37	N	2.88	0.23	M*
42	Druten	249	390.6	359	103.8	46.4	79.2	50.7	M	0.97	1.50	Y	2.75	1.09	M
46	E London RB Cemetary	192	346	316.2	95.5	42.5	68.8	45.5	H	0.63	4.11	N	2.47	-0.56	H?
46	E London RB Cemetary	196	359	326	98.5	40.4	78.3	48.4	H	0.83	0.45	Y	0.43	0.02	H
63	S. Giacomo	173	364	334	95.4	43.2	74.4	46.5	M	0.78	0.54	Y	1.20	0.95	M*
87	Manching	147	291	267	77.5	31	57		H	0.52	2.40	N	-1.07	-0.32	H?
87	Manching	152	312	287	85	33.5	65.5		H	0.55	2.22	N	-0.99	-0.24	H?
87	Manching	154	321	290	82	32	59.5		H	0.63	1.91	N	0.00	0.66	H?
92	Feddersen Wierde	33	338	324.1	88.8	36.8	71.2	41.2	D	0.76	3.25	N	-1.01	1.58	D?
92	Feddersen Wierde	35	325.3	310.9	82.1	36	61.9	39.4	M	0.66	3.63	N	-0.28	1.76	M?
92	Feddersen Wierde	36	317.7	299.5	86.3	33.9	65.5	39.4	H	0.61	2.06	N	-0.63	0.31	H?
92	Feddersen Wierde	37	339.7	320.4	86.6	36	70.5	40.9	D	0.92	3.10	N	-1.36	1.88	D*
92	Feddersen Wierde	38	314.1	294.8	82.8	35.2	64.5	41.2	D	0.69	1.94	N	-1.06	0.58	D?
105	Mons Claudianus	395	338	310	76.5	36.6	63.5	42	D	0.94	7.41	N	-1.67	3.10	D*
115	Bad Wimpfen	496	368.5	334.5	93.5	41	73	45	M	0.91	0.45	Y	0.94	1.56	M
116	Pommeroeul	513	323	290	89	34	66	42	H	0.96	0.07	Y	0.20	-0.71	H
116	Pommeroeul	514	324	292	85	36	67	41	H	0.56	2.19	N	-0.80	0.15	H?
116	Pommeroeul	515	327	300	89	35	63	42	H	0.78	0.73	Y	1.17	-0.19	H*
116	Pommeroeul	517	352	318	89	36	69	43	M	0.68	2.47	N	0.04	1.42	M?
116	Pommeroeul	518	373	335	98	41	77	45	M	0.70	0.85	Y	1.03	0.84	M*
116	Pommeroeul	519	373	336	103	44	79	47	H	0.59	2.86	N	2.10	-0.27	H?
116	Pommeroeul	520	375	337	103	43	78	48	M	0.54	3.34	N	2.29	-0.14	M?
118	Carnuntum	534	361	323	96.4	39.7	73.5	45.8	H	0.55	1.48	Y	1.29	0.23	H?
120	Basel-Gasfabrik	537	310.5	280	82.5	35.2	62.7	39.5	H	0.83	1.00	Y	-0.51	-0.35	H

Site no.	Site name	Bone no.	GL	Ll	Bp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
120	Basel-Gasfabrik	538	320.1	287.1	87.6	37.5	63.9	40	H	0.96	0.28	Y	0.90	-0.92	H
121	Soluthurn/Vigier	550	341	325	93	38.3	70	43.8	M	0.52	1.67	Y	0.66	0.69	M*
156	Invillino- Ibliglo	616	349	322.5	93	36.7	70		M	0.58	1.43	Y	0.69	0.79	M*
174	Abusina-Eining	634	388	351	107.5	48	78	48.5	M	0.89	10.60	N	4.27	-0.33	M*
176	Oberdorla	643	348	321	89	37	66	44	M	0.87	0.55	Y	0.89	1.38	M
176	Oberdorla	644	341	307	81	38	67	42	D	0.87	3.90	N	-1.24	2.05	D*
176	Oberdorla	646	334	310	80	35	64	40	D	0.86	5.06	N	-1.28	2.42	D*
192	Pfaffenhofen - Pons Aeni	701	360	328	90	41	70		M	0.91	0.69	Y	0.79	1.66	M
199	Hufingen	716	366.5	339.5	94	39.5	73		M	0.93	0.84	Y	0.73	1.81	M
199	Hufingen	717	366	330	88.5	38	75.5		D	0.91	5.20	N	-1.43	2.54	D*
199	Hufingen	718	358	323	92.5	42.5	75.5		H	0.52	2.44	N	0.05	0.86	H?
199	Hufingen	719	352	322.5	92	37.5	72		M	0.51	2.63	N	0.07	1.05	M?
201	Wehringen	758	333	303	87	37	69		H	0.53	2.60	N	-0.64	0.54	H?
201	Wehringen	759	340	305	93	38	72		H	0.93	0.07	Y	0.30	-0.44	H
205	Oberstimm	841	353	332	95.5	38.3	70	44	M	0.79	0.58	Y	1.51	0.80	M*
208	Colonia Ulpia Traiana	856	367	338	100	40.5	75.5		M	0.69	1.15	Y	1.67	0.49	M*
208	Colonia Ulpia Traiana	857	367	332	100.5	43	76.5		H	0.54	2.53	N	1.94	-0.10	H?
208	Colonia Ulpia Traiana	858	367	332	98	39	74		M	0.70	0.93	Y	1.48	0.60	M*
208	Colonia Ulpia Traiana	860	351	321	92	39	70		M	0.63	1.16	Y	0.85	0.80	M*

Table A11 – Detailed information from discriminant function analysis of isolated radii

Site no.	Site name	Bone no.	GL	Ll	BFp	SD	BFd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
46	E London RB Cemetary	228	324.5	309.3	70.9	35	59.4	H	0.74	0.11	Y	0.45	-0.08	H
47	Beddington Sewage Farm	221	307.6	256.4	64.8	32.8	55.3	H	0.98	3.89	N	0.42	-2.38	H*
47	Beddington Sewage Farm	224	278	263	68	29	56.5	H	0.99	11.15	N	0.59	-3.75	H*
69	Thorley	202	300	294	68.1	34.77	56.47	H	0.84	0.29	Y	0.03	-0.73	H
69	Thorley	203	319	304	71.63	37.68	60.45	H	0.88	0.11	Y	0.75	-0.59	H
70	Emilia	201	321	308	65.6	34	57.3	M	0.64	2.34	Y	-0.80	1.77	M?
79	Olbia	195	259.7	242.3	51.4	27.8	44.3	D	0.99	0.63	Y	-2.74	0.12	D
79	Olbia	196	253.4	240.9	50.2	26.7	42.8	D	1.00	1.22	Y	-3.04	0.21	D
79	Olbia	197	254.1	243	52.4	26.5	44.1	D	0.99	0.73	Y	-2.60	-0.44	D
87	Manching	162	273	261	63	31	52	H	0.84	4.06	N	-0.47	-2.19	H?
87	Manching	163	275	265	63	32	54	H	0.74	2.47	N	-0.59	-1.57	H?
87	Manching	164	276	264.5	65.5	30	53	H	0.96	6.45	N	0.02	-2.91	H*
87	Manching	167	289	275	62	31	54.5	D	0.62	0.94	Y	-1.02	-0.18	D*
87	Manching	168	291	276.5	65	32	55	H	0.81	1.25	N	-0.31	-1.21	H*
87	Manching	169	292	278	63	30	53	H	0.48	1.69	N	-0.82	-0.57	H?
87	Manching	170	293	282	61	31.5	50	D	0.78	0.47	Y	-1.31	0.38	D*
87	Manching	171	295.5	285	63	31	53.5	D	0.62	0.92	Y	-0.98	0.14	D*
87	Manching	176	301.5	285	67.5	34	57	H	0.90	0.63	Y	0.14	-1.14	H
87	Manching	179	309	293	64	31.5	54.5	D	0.52	1.49	Y	-0.85	0.66	D*
87	Manching	181	312.5	300	67	34	55	H	0.56	0.88	Y	-0.26	0.17	H?
87	Manching	184	316	303	67.5	35	57	H	0.46	1.35	N	-0.22	0.52	H?
87	Manching	185	318	303	67	34	59	M	0.48	1.53	Y	-0.39	0.92	M?
87	Manching	188	333.5	316	70.5	34.5	60	M	0.55	0.77	Y	0.22	0.77	M?
92	Feddersen Wierde	31	304.3	286.5	69.2	35	60.8	H	0.94	0.67	Y	0.47	-1.23	H
92	Feddersen Wierde	32	310.6	298.2	67	35.4	58.9	H	0.44	1.46	N	-0.29	0.53	H?
92	Feddersen Wierde	33	346.2	328.4	72.2	36	61.6	M	0.82	0.10	Y	0.39	1.45	M
92	Feddersen Wierde	34	320.1	305.9	68.8	37.8	57.9	H	0.49	1.01	Y	0.08	0.51	H?
92	Feddersen Wierde	35	304.8	292.3	70	35.4	58	H	0.96	1.00	Y	0.57	-1.41	H
92	Feddersen Wierde	36	303.9	288.3	72.7	32.7	61.4	H	1.00	5.69	N	1.20	-2.68	H*
92	Feddersen Wierde	37	290.7	280	66.6	31.5	54.7	H	0.91	1.91	N	-0.03	-1.70	H*
92	Feddersen Wierde	38	329.1	313.9	73.9	39	63	H	0.81	0.38	Y	1.08	-0.30	H

Site no.	Site name	Bone no.	GL	Ll	BFp	SD	BFd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
92	Feddersen Wierde	39	301	288.7	67.2	31.3	55.4	H	0.86	0.73	Y	-0.06	-1.08	H
92	Feddersen Wierde	40	316.7	301.6	66.7	64.6	57.5	M	0.97	1.59	Y	0.22	2.67	M
92	Feddersen Wierde	41	323.1	310.5	71.3	35.1	59.6	H	0.76	0.07	Y	0.49	-0.15	H
92	Feddersen Wierde	42	315.8	303.7	67.4	33.8	58.1	M	0.39	1.75	Y	-0.32	0.66	M?
92	Feddersen Wierde	43	317.1	298.9	67.3	33.7	56.8	H	0.58	0.77	Y	-0.16	0.20	H?
92	Feddersen Wierde	44	320.8	305.7	70.6	37.5	58.5	H	0.79	0.04	Y	0.51	-0.22	H
92	Feddersen Wierde	45	323.5	308.2	73.8	38.1	62.6	H	0.92	0.69	Y	1.16	-0.88	H
92	Feddersen Wierde	46	314.1	299.2	72.1	37.5	60.1	H	0.96	1.00	Y	0.96	-1.29	H
92	Feddersen Wierde	47	300.5	288.9	64.7	30.2	56.2	D	0.45	1.51	Y	-0.72	0.03	D*
92	Feddersen Wierde	48	302.4	285.3	71.9	35.1	61.9	H	0.99	4.31	N	1.12	-2.38	H*
92	Feddersen Wierde	50	321.6	305	70.8	35.1	58.8	H	0.85	0.01	Y	0.53	-0.47	H
92	Feddersen Wierde	52	281.6	267.8	66.3	33.9	57.2	H	0.96	3.33	N	0.15	-2.21	H*
92	Feddersen Wierde	53	334	313.9	75.9	40.6	63.8	H	0.93	1.58	N	1.63	-0.91	H*
92	Feddersen Wierde	54	303	288.1	67	32.4	54.8	H	0.86	0.61	Y	-0.04	-1.01	H
92	Feddersen Wierde	55	319.4	301.1	69.5	34.5	59.1	H	0.78	0.06	Y	0.30	-0.24	H
92	Feddersen Wierde	56	305.7	288.1	68.5	33.6	58.9	H	0.91	0.49	Y	0.29	-1.08	H
92	Feddersen Wierde	57	286.4	274.5	64	29.9	53.6	H	0.73	1.80	N	-0.55	-1.28	H?
92	Feddersen Wierde	58	301	284.9	69.4	33.5	58.5	H	0.97	2.04	N	0.56	-1.84	H*
92	Feddersen Wierde	61	311.5	297.6	69.3	34.8	59.3	H	0.83	0.05	Y	0.27	-0.49	H
92	Feddersen Wierde	62	317.7	303.5	67.8	34	57.3	H	0.50	1.11	Y	-0.17	0.42	H?
92	Feddersen Wierde	63	313.7	300.2	67.6	33.9	58	H	0.55	0.89	Y	-0.18	0.27	H?
105	Mons Claudianus	399	320	305	65.3	38.2	55.5	M	0.68	1.94	Y	-0.67	1.71	M?
105	Mons Claudianus	400	320	302	66	37	56	M	0.56	1.45	Y	-0.45	1.15	M?
105	Mons Claudianus	404	300	289	56.2	33	49.8	D	0.87	9.72	N	-2.57	3.16	D*
105	Mons Claudianus	414	338	319.5	67.9	38	59.2	M	0.91	1.90	Y	-0.38	2.36	M
105	Mons Claudianus	416	313	297	61.3	37.8	54.3	M	0.55	5.77	N	-1.45	2.56	M?
115	Bad Wimpfen	497	346	330	75.5	39.4	65	M	0.62	0.76	Y	1.12	0.74	M*
115	Bad Wimpfen	498	337.5	320	75.1	37.5	64	H	0.78	0.60	Y	1.22	-0.21	H*
115	Bad Wimpfen	499	373	355	71.5	45.2	65.6	M	1.00	14.51	N	-0.20	5.20	M*
115	Bad Wimpfen	500	331	315	70.8	38.3	61.9	M	0.66	0.41	Y	0.33	0.98	M*
115	Bad Wimpfen	505	349	330	75	38.1	65.7	M	0.72	0.34	Y	0.99	0.99	M
115	Bad Wimpfen	506	349	330.5	76.7	37.7	68.1	M	0.54	1.31	Y	1.33	0.54	M*

Site no.	Site name	Bone no.	GL	Ll	BFp	SD	BFd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
116	Pommeroeul	523	306	292	68	33	60	H	0.79	0.21	Y	0.02	-0.47	H
116	Pommeroeul	524	308	292	65	32	58	D	0.41	1.85	Y	-0.66	0.56	D*
116	Pommeroeul	525	320	307	70	35	59	H	0.69	0.24	Y	0.26	0.03	H*
116	Pommeroeul	526	323	308	68	35	53	H	0.54	0.87	Y	-0.09	0.33	H?
116	Pommeroeul	527	324	315	76	36	62	H	0.97	2.14	N	1.46	-1.49	H*
116	Pommeroeul	528	329	310	71	36	61	H	0.62	0.42	Y	0.48	0.24	H*
116	Pommeroeul	529	329	310	71	35	61	H	0.65	0.35	Y	0.46	0.17	H*
116	Pommeroeul	530	334	321	72	38	62	M	0.66	0.35	Y	0.46	0.97	M*
116	Pommeroeul	531	340	324	71	35	57	M	0.64	0.51	Y	0.25	0.96	M*
116	Pommeroeul	532	340	319	72	37	65	M	0.74	0.16	Y	0.50	1.17	M*
116	Pommeroeul	534	358	340	74	40	63	M	0.95	0.41	Y	0.65	2.14	M
116	Pommeroeul	535	362	337	71	39	63	M	0.99	3.30	N	0.04	3.19	M*
116	Pommeroeul	536	366	351	78	39	71	M	0.96	0.71	Y	1.17	2.21	M
116	Pommeroeul	537	377	360	75	38	63	M	0.99	3.63	N	0.45	3.39	M*
118	Carnuntum	543	384	366.5	84.2	43.6	71.2	M	0.87	3.18	N	2.48	1.29	M*
118	Carnuntum	547	379	360.5	76.5	43.5	67.3	M	1.00	4.56	N	0.83	3.64	M*
118	Carnuntum	548	363	345	76	42.3	64	M	0.94	0.35	Y	1.06	1.99	M
120	Basel-Gasfabrik	551	277.4	262.5	62.4	28.2	51.2	H	0.76	3.86	N	-0.65	-2.02	H?
129	Lorenzberg Bei Epfach	593	320	308	72	33.5	60	H	0.90	0.14	Y	0.66	-0.74	H
129	Lorenzberg Bei Epfach	595	297	283	68	34	57	H	0.95	1.38	N	0.28	-1.57	H*
174	Abusina-Eining	656	360	344	79	40.5	66	M	0.63	1.66	Y	1.70	0.68	M*
188	Titelberg oppidum	695	322	308	71	38	59	H	0.75	0.10	Y	0.55	-0.11	H
192	Pfaffenhofen - Pons Aeni	713	323	307	72	37	61	H	0.85	0.09	Y	0.77	-0.45	H
192	Pfaffenhofen - Pons Aeni	714	332	319	73	37	61	H	0.65	0.42	Y	0.75	0.18	H*
192	Pfaffenhofen - Pons Aeni	718	364	348	76	40	65.5	M	0.96	0.61	Y	0.90	2.26	M
195	Kunzing-Quintana	723	356	338	76	40	63.5	M	0.78	0.33	Y	1.16	1.15	M
199	Hufingen	732	348	332.5	79	38.5	67.5	H	0.80	1.88	N	1.84	-0.33	H*
199	Hufingen	734	347	330	79.5	40.5	67.5	H	0.87	2.59	N	2.06	-0.63	H*
199	Hufingen	737	349	336	75.5	37.5	63.5	M	0.70	0.37	Y	0.97	0.96	M*
200	Pfaffenhofen	762	326	311	70	35	60	H	0.49	0.98	Y	0.18	0.53	H?
200	Pfaffenhofen	763	344	327	76.5	40	64	H	0.71	1.14	Y	1.47	-0.03	H*
201	Wehringen	765	359	337	74	38.5	63	M	0.92	0.10	Y	0.72	1.82	M

Site no.	Site name	Bone no.	GL	Ll	BFp	SD	BFd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
202	Penzlin	766	301.5	289	65	32.7	55.4	H	0.50	1.24	N	-0.57	-0.01	H?
205	Oberstimm	853	304	289	65.5	33	53	H	0.68	0.69	Y	-0.36	-0.44	H*
206	Lauriacum	865	345	332	75	38.5	64.5	M	0.71	0.32	Y	0.93	0.99	M*

Table A12 – Detailed information from discriminant function analysis of isolated humeri

Site no.	Site name	Bone no.	GLC	GLl	SD	BT	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID
38	Nijmegen	175	277.4	292.7	35.7	74	M	0.58	0.77	Y	1.23	-0.06	M*
42	Druten	157	275	288.4	35.7	75.3	H	0.69	0.77	Y	0.91	0.64	H*
79	Olbia	116	197.7	206.2	25.3	55.4	D	0.98	2.01	N	-3.10	0.44	D*
87	Manching	107	300	307	36.5	76	M	0.96	0.58	Y	2.70	-0.29	M
92	Feddersen Wierde	29	245.6	270.6	30.4	69.2	H	0.61	0.76	Y	-0.63	-0.17	H*
92	Feddersen Wierde	30	258	286.4	33.4	72	H	0.72	0.59	Y	0.06	-0.47	H*
92	Feddersen Wierde	31	279.9	294.5	35.8	76.4	H	0.55	1.24	Y	1.20	0.52	H*
92	Feddersen Wierde	32	248.8	266.3	31.3	70.3	H	0.75	0.51	Y	-0.55	0.58	H*
92	Feddersen Wierde	33	259.1	278.1	32.3	72.2	H	0.82	0.00	Y	0.06	0.31	H
92	Feddersen Wierde	34	244.8	270.3	29.7	69.2	H	0.59	0.83	Y	-0.68	-0.17	H*
92	Feddersen Wierde	35	249	265.3	31	67.9	H	0.74	0.29	Y	-0.32	-0.03	H*
92	Feddersen Wierde	36	237.8	257.8	31.4	68.6	D	0.53	1.58	N	-1.22	0.61	D?
105	Mons Claudianus	258	252	270	30.3	64	H	0.50	3.29	N	0.29	-1.50	H?
105	Mons Claudianus	259	253	266	30.3	65.8	H	0.69	0.86	Y	0.16	-0.63	H*
105	Mons Claudianus	260	250.1	265.5	30.6	65.2	H	0.67	1.24	Y	0.01	-0.81	H*
105	Mons Claudianus	261	233	240	28.1	56.7	D	0.51	2.97	N	-0.56	-1.40	D?
116	Pommeroeul	353	255	275	33	71	H	0.80	0.08	Y	-0.14	0.16	H
116	Pommeroeul	354	277	293	32	75	H	0.50	1.12	Y	1.15	0.16	H?
116	Pommeroeul	355	275	291	33	75	H	0.60	0.78	Y	0.99	0.31	H*
116	Pommeroeul	356	287	300	35	75	M	0.84	0.10	Y	1.86	-0.23	M
116	Pommeroeul	358	240	255	30	68	H	0.58	1.43	Y	-1.02	0.71	H?
116	Pommeroeul	362	268	277	35	75	H	0.90	1.26	Y	0.38	1.39	Y
118	Carnuntum	372	306.2	325.5	41	75.8	M	1.00	3.20	N	3.25	-1.78	M*
192	Pfaffenhofen - Pons Aeni	472	301	317	38	80	M	0.93	0.55	Y	2.47	0.04	M
198	Gellep - Gelduba	478	265	268	35.5	74	H	0.94	2.31	N	0.18	1.82	H*
200	Pfaffenhofen	497	288	297	40	75	M	0.80	0.38	Y	1.86	0.09	M

Table A13 – Detailed information from discriminant function analysis of isolated femora

Site no	Site name	Bone no	GL	GLC	DC	Bp	SD	Bd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
38	Nijmegen	130	402.2	375	55.7	112.9	42.9	90.2	M	0.98	0.43	Y	2.31	1.57	M
38	Nijmegen	135	403.2	376.1	59	118.1	41.5	94	M	0.57	1.79	Y	1.83	-0.22	M*
46	E London RB Cemetary	101	396	361.4	57.3	124.7	44.6	94.5	M	0.81	0.18	Y	1.67	0.74	M
54	Thorpe Thewles	97	320.9	305	45.2	96.5	32.1	79.3	D	0.97	0.09	Y	-2.21	0.21	D
79	Olbia	86	262.4	247.5	33.9	76.3	24.4	61.8	D	1.00	2.87	N	-3.96	1.10	D*
87	Manching	78	350	317	50.5	101	32	81	H	0.87	0.78	Y	-0.51	-0.70	H
92	Feddersen Wierde	32	375.7	342.5	51.6	109.3	38.6	87.7	M	0.59	2.20	Y	0.36	1.32	M*
92	Feddersen Wierde	33	362.1	334.7	52	107.7	38	88.8	H	0.74	1.09	Y	-0.48	0.24	H*
92	Feddersen Wierde	34	360.5	329.1	49	96.7	33.1	83	H	0.57	2.27	N	-0.59	0.77	H?
92	Feddersen Wierde	35	344.3	315.7	47.1	98.4	34.4	83.4	D	0.87	1.15	N	-1.45	0.99	D*
92	Feddersen Wierde	36	362	327.6	52.7	112	37.7	87	H	0.87	0.21	Y	-0.01	-0.13	H
92	Feddersen Wierde	37	357.7	325.4	48	94.9	35.1	82.2	H	0.46	3.92	N	-0.36	1.43	H?
105	Mons Claudianus	199	365	331	46.5	130	38	80	M	0.98	5.65	N	0.70	3.21	M*
105	Mons Claudianus	200	340	315	47.3	96.3	32.6	80	D	0.64	1.55	N	-1.14	0.36	D?
115	Bad Wimpfen	256	409	384	58.2	112	39	93	M	0.64	1.12	Y	1.74	0.07	M*
116	Pommeroeul	261	377	344	49	112	39	88	M	0.82	5.96	N	-0.01	2.72	M*
116	Pommeroeul	262	388	354	49	105	36	86	M	0.93	5.04	N	0.38	2.83	M*
116	Pommeroeul	263	394	366	57	113	45	92	M	0.91	0.19	Y	2.14	0.81	M
116	Pommeroeul	265	404	375	58	128	44	95	M	0.87	0.13	Y	1.91	0.76	M
116	Pommeroeul	266	408	382	58	127	46	95	M	0.97	0.37	Y	2.41	1.32	M
116	Pommeroeul	269	430	392	60	122	42	91	M	0.99	4.15	Y	3.86	0.95	M
118	Carnuntum	280	379	347.5	56.1	114.5	37.5	90.5	H	0.94	0.20	Y	0.45	-0.85	H
120	Basel-Gasfabrik	284	333.5	310	46.4	96.7	30.6	79.4	D	0.89	0.52	Y	-1.76	0.10	D
208	Colonia Ulpia Traiana	382	404	365	68	126	41	95	H	0.99	24.71	N	3.07	-4.57	H*
187	Hayton Fort	347	400		59	132	44	97	M	0.53	1.27	Y	1.47	0.05	M*

Table A14 – Detailed information from discriminant function analysis of isolated metacarpals

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
15	Scole-Dickleburgh	578	205.4	43.9	30.8	27.8	42.3	34.1	H	0.62	2.08	N	-0.28	-0.33	H?
28	Longthorpe II	553	232	52	35	37	49	37	M	0.57	4.50	N	2.95	1.11	M?
37	Kesteren 'De Prinsenhof'	527	238	51.9	36	37.7	52.5	38.9	H	0.73	9.84	N	4.22	0.45	H?
38	Nijmegen	501	211.7	45.6	28.3	34.8	47.3	33.6	H	0.95	9.26	N	4.08	-1.08	H*
38	Nijmegen	502	236.8	49.6	33.5	30.9	47.4	33.8	M	0.86	3.35	N	-0.91	1.61	M*
38	Nijmegen	503	236.8	48	33.8	36.1	50.5	36.1	H	0.52	4.72	N	3.02	0.87	H?
38	Nijmegen	504	227.9	50.9	34.7	36.1	46.7	36.1	M	0.75	1.71	N	2.05	1.51	M*
38	Nijmegen	505	240.4	51.4	34.7	34.5	54	38.9	H	0.88	5.89	N	3.57	-0.48	H*
38	Nijmegen	506	221.5	49.9	33.1	35	48.9	35.2	H	0.75	2.44	N	2.70	-0.02	H?
38	Nijmegen	507	225.1	46.4	33	32.2	46	33.6	M	0.78	0.33	Y	0.27	1.19	M
38	Nijmegen	508	217.3	47.2	32.3	31.1	46.6	35.9	H	0.76	0.13	Y	1.49	-0.37	H
38	Nijmegen	509	226.9	49.4	33.2	32.6	48.6	36.2	H	0.66	0.45	Y	1.74	0.09	H*
38	Nijmegen	510	237.2	51.2	34.4	34.3	51.5	36.7	H	0.61	1.60	N	2.26	0.37	H?
38	Nijmegen	511	222.1	48.8	32.5	32.2	47.6	36.7	H	0.77	0.85	Y	2.08	-0.28	H
38	Nijmegen	514	215.9	46.5	32.1	31.8	46.2	33.1	H	0.54	0.38	Y	0.73	0.21	H?
38	Nijmegen	515	225.9	48.2	31.9	33.6	46.7	35.4	H	0.52	1.36	Y	1.97	0.59	H?
38	Nijmegen	519	215.8	47.2	31	33.2	46.3	34.7	H	0.78	1.41	Y	2.34	-0.22	H
42	Druten	478	236	48	32.6	31.6	48.3	36.7	M	0.54	0.39	Y	1.28	0.61	M?
42	Druten	483	220.3	50.1	32.2	33.6	49.4	35.9	H	0.89	3.23	N	2.87	-0.78	H*
42	Druten	485	231.8	52.2	32.3	32.7	50.2	38	H	0.86	2.60	N	2.73	-0.57	H*
42	Druten	489	241.7	55.6	35.6	32.2	53	37.3	H	0.58	0.18	Y	0.98	0.14	H?
42	Druten	490	232.6	47.6	31.7	29	49.6	34.5	H	0.61	1.13	Y	0.09	-0.17	H*
42	Druten	491	233.7	49.9	33.4	35	48.7	36.4	M	0.54	2.49	N	2.40	0.90	M?
42	Druten	492	235	49.9	32.7	31.6	49.7	36.8	H	0.65	0.23	Y	1.52	0.07	H?
42	Druten	495	224.2	48.5	32.7	32.9	51.2	35.5	H	0.90	2.50	N	2.59	-0.90	H*
43	Elms Farm	466	205.2	44.3	31	30.8	45.9	33.9	H	0.89	0.98	Y	1.69	-1.07	H
44	Danebury	427	193	43.2	27.7	28	43.2	31.8	H	0.95	2.78	N	0.85	-1.88	H*
44	Danebury	433	182	41.2	27.8	24.4	39.8	29.8	D	0.84	6.30	N	-1.62	-1.71	D*
44	Danebury	434	193	42.5	30	29.7	44	31.8	H	0.91	1.41	Y	1.03	-1.42	H

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
44	Danebury	436	197	44.4	30.6	26.9	43.5	31.2	H	0.52	5.70	N	-1.10	-1.02	H?
44	Danebury	437	230	40.2	33.3	25	41.6	32.5	D	1.00	6.98	N	-4.18	2.51	D*
44	Danebury	448	207	46.1	32.6	31.2	45	33.6	H	0.66	0.18	Y	0.73	-0.20	H
44	Danebury	457	207	45.4	30.8	30.7	45.3	33.8	H	0.84	0.33	Y	1.35	-0.78	H
44	Danebury	458	221	51.4	33.9	31.8	51.5	36.2	H	0.92	1.82	Y	2.01	-1.28	H
44	Danebury	460	200	42.7	28.7	29.2	44.7	32.4	H	0.93	1.66	Y	1.29	-1.52	H
46	E London RB Cemetary	420	216.5	48.2	32	32.2	47	32.6	H	0.58	0.28	Y	0.76	0.10	H?
47	Beddington Sewage Farm	413	190.5	43.1	30.5	27.5	42.3	30.5	H	0.62	4.94	N	-0.94	-0.99	H?
47	Beddington Sewage Farm	414	190.5	43	30.5	27.8	43.2	30.1	H	0.74	4.50	N	-0.75	-1.17	H?
47	Beddington Sewage Farm	416	213.3	42.9	28.8	27.7	42.4	31.5	M	0.53	3.96	N	-1.03	0.33	M?
47	Beddington Sewage Farm	419	198.4	42.4	30	29.1	42.9	33.2	H	0.84	0.62	Y	0.81	-0.95	H
51	Coldharbour Farm 97	410	215	47.2	31.1	29.9	48.3	34.8	H	0.91	1.22	Y	1.47	-1.30	H
51	Coldharbour Farm 97	411	207.9	46.8	30.9	32.1	47.3	32.6	H	0.88	0.84	Y	1.73	-0.95	H
51	Coldharbour Farm 97	412	217.7	49.1	32.8	33.4	49.9	34.8	H	0.89	2.06	N	2.47	-0.83	H*
54	Thorpe Thewles	404	203	46.6	32	29	46.4	34.6	H	0.92	1.77	Y	0.92	-1.55	H
54	Thorpe Thewles	405	182	42.3	28	25.8	41.3	30	H	0.86	6.78	N	-0.73	-2.03	H*
63	S. Giacomo	395	235	50.7	34.8	34.7	51.5	38.3	H	0.76	3.92	N	3.12	0.03	H?
66	Settefinestre	387	226	51	32	31	47	34	M	0.59	0.86	Y	0.09	0.47	M?
66	Settefinestre	389	189	39	26	25	35	24	D	1.00	2.48	N	-4.50	1.17	D*
79	Olbia	374	159.4	35.2	23.2	23.4	34.4	23.4	D	1.00	3.51	N	-2.73	-1.76	D*
83	Deutsch Wusterhausen	373	220	52.3	33.2	37.7	51.8	37.5	H	0.97	18.56	N	5.36	-1.19	H*
85	Macon	370	247	53	35.5	22.2	47	36	D	1.00	5.96	N	-5.31	1.59	D*
92	Feddersen Wierde	29	196.7	40.9	28.5	25.1	41.5	31.4	D	0.48	6.15	N	-1.25	-1.09	D?
92	Feddersen Wierde	30	213.8	47	32.9	31.6	47.9	33.6	H	0.75	0.05	Y	1.06	-0.45	H
92	Feddersen Wierde	32	196.1	42	28.3	27.1	40.9	31.2	H	0.68	3.37	N	-0.61	-0.74	H?
92	Feddersen Wierde	33	200.5	42.5	26.6	24.9	38.7	31	D	0.92	2.76	N	-1.86	-0.27	D*
92	Feddersen Wierde	34	203.5	45.6	31.4	31.3	49.4	36	H	0.99	10.83	N	3.46	-2.59	H*
92	Feddersen Wierde	35	207.5	44.7	31.5	26.4	43.6	33.1	D	0.60	4.56	N	-1.40	-0.40	D?
92	Feddersen Wierde	36	217.5	47.5	30.7	30.3	44.7	32.2	M	0.63	1.62	Y	-0.32	0.49	M*
92	Feddersen Wierde	37	198.1	42.7	29.4	28.7	40.8	31.1	H	0.52	2.88	N	-0.54	-0.10	H?
92	Feddersen Wierde	38	202.7	41.5	27.4	28.2	43.2	31.1	H	0.82	1.16	Y	0.36	-0.97	H
92	Feddersen Wierde	39	197.9	44.5	28	29.4	46.4	32.9	H	0.98	6.12	N	2.20	-2.48	H*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
92	Feddersen Wierde	40	215.3	45	31.7	27.6	45.6	34.8	H	0.68	1.94	N	-0.21	-0.52	H?
92	Feddersen Wierde	41	206.8	45	30.3	28.7	42	32.2	M	0.55	3.15	N	-0.75	0.22	M?
92	Feddersen Wierde	42	215.5	46.8	29.2	27.5	47.5	33.5	H	0.90	2.09	N	0.37	-1.45	H*
92	Feddersen Wierde	44	216.6	46.4	31.2	30.7	46	33.9	H	0.66	0.12	Y	0.83	-0.15	H*
92	Feddersen Wierde	45	209.8	43.8	29.9	30.5	43.3	31.5	M	0.54	1.04	Y	0.11	0.31	M?
92	Feddersen Wierde	47	210.7	48.3	33.4	30	46.3	33.3	H	0.59	1.94	N	-0.24	-0.23	H?
92	Feddersen Wierde	49	199	47.1	31.9	30.6	46.6	34.5	H	0.96	2.79	N	1.82	-1.77	H*
92	Feddersen Wierde	50	196	39.5	28.1	27.5	43.7	31.8	H	0.93	2.36	N	0.75	-1.72	H*
92	Feddersen Wierde	51	212.5	44.2	29.8	29.8	44.5	32.6	H	0.63	0.55	Y	0.42	-0.16	H*
92	Feddersen Wierde	53	202.9	43.4	28.7	26.1	43.7	30.6	D	0.44	6.07	N	-1.23	-0.99	D?
92	Feddersen Wierde	54	188.8	42.9	28	28.4	43.5	27.1	H	0.78	4.67	N	-0.71	-1.34	H*
92	Feddersen Wierde	55	205.1	47	32.5	29	46.5	34.8	H	0.89	1.40	Y	0.72	-1.34	H
92	Feddersen Wierde	56	202.9	43.5	28.1	28.7	43.5	32.2	H	0.85	0.89	Y	0.69	-1.06	H
92	Feddersen Wierde	57	210.9	44.6	31.8	28.8	45.4	35.8	H	0.83	0.43	Y	0.90	-0.85	H
92	Feddersen Wierde	60	202.9	44.3	30.9	29	46.2	33.3	H	0.91	1.59	Y	0.90	-1.48	H
92	Feddersen Wierde	61	203.8	46.9	30.8	27.9	44.9	33	H	0.81	2.65	N	-0.22	-1.11	H*
92	Feddersen Wierde	62	214.9	47.1	31.1	31.6	47.7	34.3	H	0.87	0.83	Y	1.85	-0.83	H
92	Feddersen Wierde	63	197.4	45.4	28.8	28.4	43.8	32.4	H	0.91	1.99	N	0.62	-1.55	H*
92	Feddersen Wierde	64	215.9	48	31.5	30.7	46.2	33.4	H	0.62	0.48	Y	0.48	-0.12	H*
92	Feddersen Wierde	65	206.7	48.3	32	31	45.7	34.3	H	0.82	0.26	Y	1.15	-0.75	H
92	Feddersen Wierde	67	202.4	45	30.8	28.6	45.1	28.7	D	0.63	4.41	N	-1.43	-0.39	D?
92	Feddersen Wierde	68	209.9	44.7	29.1	31	43.1	31.9	H	0.54	0.44	Y	0.64	0.18	H?
92	Feddersen Wierde	70	219.1	49.4	32.7	30.4	49	34.6	H	0.81	0.37	Y	0.82	-0.75	H
92	Feddersen Wierde	71	202.9	46.6	29.3	29.6	43.8	31.6	H	0.76	1.05	Y	0.24	-0.71	H
92	Feddersen Wierde	72	211.8	47.5	31.1	31.1	47.6	34.9	H	0.92	1.68	Y	2.00	-1.23	H
92	Feddersen Wierde	73	208.6	51.1	33.8	33.2	48.7	34.1	H	0.87	0.82	Y	1.79	-0.89	H
92	Feddersen Wierde	75	211.2	46.1	31	29.3	45.1	33.2	H	0.67	1.12	Y	0.10	-0.38	H*
92	Feddersen Wierde	76	215.2	47.6	30	25.8	46.2	33.1	H	0.47	5.93	N	-1.15	-1.02	H?
92	Feddersen Wierde	77	201.2	43.4	30.9	29.2	43.8	32.4	H	0.75	1.08	Y	0.20	-0.66	H
92	Feddersen Wierde	78	207.3	45.9	29.9	27.1	44.6	33	H	0.77	3.11	N	-0.43	-1.00	H?
92	Feddersen Wierde	79	215.8	45.1	29.5	29	46.7	33.8	H	0.85	0.58	Y	0.96	-0.98	H
92	Feddersen Wierde	80	199.5	41.3	27.5	23.5	42.4	29.7	D	0.99	2.96	N	-2.26	-1.24	D*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
92	Feddersen Wierde	81	204.3	44.9	30.7	29	43.1	32.9	H	0.65	1.49	Y	-0.06	-0.35	H*
92	Feddersen Wierde	82	207.4	45.2	28.9	25	44.3	32.6	H	0.49	6.50	N	-1.17	-1.28	H?
92	Feddersen Wierde	85	194	43.6	28.3	27.7	44.4	29.7	H	0.90	3.82	N	-0.15	-1.69	H*
92	Feddersen Wierde	86	211.2	47	31	30.9	46.6	34.4	H	0.87	0.62	Y	1.57	-0.91	H
92	Feddersen Wierde	87	193.3	43.3	27.7	27.4	42.7	31.8	H	0.93	2.82	N	0.45	-1.77	H*
92	Feddersen Wierde	88	204.5	42.7	29.4	27.7	43	30.5	H	0.43	4.75	N	-1.02	-0.27	H?
92	Feddersen Wierde	89	214.8	46.8	29.9	28	44.1	32.9	H	0.50	3.41	N	-0.69	-0.11	H?
92	Feddersen Wierde	90	217.1	49.1	32.2	31.2	46.8	35.4	H	0.75	0.03	Y	1.27	-0.38	H
92	Feddersen Wierde	91	201.6	42	27.2	29.1	43.3	31.2	H	0.86	0.74	Y	0.90	-1.06	H
92	Feddersen Wierde	92	216	46.6	31.2	28.3	46.3	33.8	H	0.69	1.80	Y	-0.15	-0.55	H*
92	Feddersen Wierde	93	204.6	45.5	30.1	30.4	45.8	34.4	H	0.94	2.07	Y	1.95	-1.44	H
92	Feddersen Wierde	94	209	46.3	32.6	31.8	48.8	34	H	0.92	1.64	Y	1.94	-1.25	H
92	Feddersen Wierde	95	215.8	45.9	32	29.9	45.5	33	M	0.53	1.74	Y	-0.20	0.21	M?
92	Feddersen Wierde	96	209.1	46.3	29.5	30	45.7	33.9	H	0.89	0.88	Y	1.45	-1.13	H
92	Feddersen Wierde	97	194	43.7	29.8	30.4	43.6	29.3	H	0.76	1.31	Y	0.12	-0.72	H
92	Feddersen Wierde	99	201.4	44	30.3	27.6	44	33.5	H	0.86	1.95	Y	0.17	-1.23	H
92	Feddersen Wierde	100	205.6	44.1	30.3	26.3	45.6	33.8	H	0.89	3.43	N	-0.11	-1.59	H*
92	Feddersen Wierde	101	206.6	44.4	30.1	25.2	44.5	29.7	D	1.00	1.19	Y	-2.54	-0.57	D
92	Feddersen Wierde	102	204.3	45.7	30.4	29.3	45.7	33.3	H	0.89	1.17	Y	0.90	-1.29	H
92	Feddersen Wierde	104	210.9	47.5	31.9	30.4	45.9	33.3	H	0.69	0.58	Y	0.40	-0.37	H*
92	Feddersen Wierde	105	211.1	47.1	31.6	30	47.7	33.9	H	0.88	0.83	Y	1.04	-1.14	H
92	Feddersen Wierde	106	214.2	46.3	32.5	30.9	46.1	33.8	H	0.61	0.36	Y	0.59	-0.05	H*
92	Feddersen Wierde	107	206.9	45.8	29.9	29	46	34.7	H	0.94	1.87	Y	1.44	-1.58	H
92	Feddersen Wierde	110	202.5	44.5	30.7	27.7	46.1	33.1	H	0.91	2.65	N	0.32	-1.64	H*
92	Feddersen Wierde	112	217	49	31.4	30.3	49.1	34.1	H	0.89	0.85	Y	1.19	-1.16	H
92	Feddersen Wierde	113	214.7	49.4	32.5	31.2	49.6	33.7	H	0.88	0.74	Y	1.24	-1.10	H
92	Feddersen Wierde	114	200.7	41.9	25.4	26.6	44.2	31.8	H	0.97	3.94	N	0.97	-2.22	H*
92	Feddersen Wierde	115	228.9	51.2	34.3	33.1	50.3	37.3	H	0.76	1.07	Y	2.19	-0.21	H
92	Feddersen Wierde	116	204.6	45.1	31.6	29.8	45.5	33.6	H	0.84	0.60	Y	0.81	-0.93	H
92	Feddersen Wierde	117	213.9	48.8	33.3	29.8	45.8	35.4	H	0.64	0.82	Y	0.25	-0.24	H*
92	Feddersen Wierde	118	211.9	48	30.1	31.6	47.7	33.7	H	0.92	1.69	Y	2.04	-1.20	H
92	Feddersen Wierde	119	206.5	46.4	31.8	30.3	46	33.2	H	0.80	0.48	Y	0.70	-0.77	H

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
92	Feddersen Wierde	120	210.8	46.4	32.4	29.3	46.5	34.2	H	0.78	0.86	Y	0.37	-0.74	H
92	Feddersen Wierde	121	207.8	45.2	31.3	30	44.7	33.9	H	0.75	0.24	Y	0.75	-0.51	H
92	Feddersen Wierde	122	207.6	44.1	28.7	27.3	44.4	33	H	0.84	1.84	Y	0.14	-1.14	H
92	Feddersen Wierde	123	202.4	43.8	28.4	27.6	43.2	33.7	H	0.89	1.46	Y	0.67	-1.35	H
92	Feddersen Wierde	124	198.3	44.6	29.6	28.3	42.9	32.7	H	0.83	1.54	Y	0.23	-1.07	H
92	Feddersen Wierde	125	208.1	48.6	33.6	30.8	48.2	36.5	H	0.94	2.22	N	1.93	-1.51	H*
92	Feddersen Wierde	126	196.5	45.9	29.6	27.2	41.8	31.7	H	0.60	4.66	N	-0.92	-0.82	H?
92	Feddersen Wierde	127	213.3	45.6	31.9	30.6	44.8	33.6	H	0.52	0.78	Y	0.37	0.17	H?
92	Feddersen Wierde	128	212.1	43.6	30.6	29.5	44.9	32	H	0.56	1.53	Y	-0.07	-0.06	H*
92	Feddersen Wierde	129	193.4	42.3	28.4	26	43.1	30.8	H	0.85	5.30	N	-0.63	-1.69	H*
92	Feddersen Wierde	130	199.1	43.3	30.9	28.6	46.3	32.3	H	0.93	2.34	N	0.63	-1.68	H*
92	Feddersen Wierde	131	199.9	41.1	27.2	22.6	41.3	29.1	D	1.00	0.94	Y	-3.06	-0.91	D
92	Feddersen Wierde	132	210	43.4	28.8	28.2	41.4	29	D	0.89	3.26	N	-1.96	0.89	D*
92	Feddersen Wierde	133	204.5	45.3	32.3	28.4	46.2	34.3	H	0.88	1.66	Y	0.42	-1.30	H
92	Feddersen Wierde	134	226.4	50	33.5	35.4	50.3	35.8	H	0.78	3.64	N	3.05	-0.04	H*
92	Feddersen Wierde	135	202.6	45.2	31.7	28.1	45.5	32.3	H	0.78	3.01	N	-0.39	-1.03	H?
92	Feddersen Wierde	136	207.9	46.1	28.8	29.4	45.7	33.3	H	0.91	1.22	Y	1.26	-1.34	H
92	Feddersen Wierde	137	214.1	45.6	30.8	28.5	45.2	32.7	H	0.56	2.63	N	-0.47	-0.21	H?
92	Feddersen Wierde	138	208.8	47	33.7	27.7	47	34.8	H	0.80	2.89	N	-0.33	-1.07	H*
92	Feddersen Wierde	139	204.9	48.3	30.8	29.9	47.3	35.6	H	0.97	4.18	N	2.11	-2.05	H*
92	Feddersen Wierde	140	197.2	42.7	28.9	25.9	44	30.2	H	0.57	6.62	N	-1.11	-1.46	H?
92	Feddersen Wierde	141	209.1	43.4	30	27.8	43.3	32.9	H	0.59	2.49	N	-0.42	-0.29	H?
92	Feddersen Wierde	142	205.2	44	30.3	30.2	44.4	33.9	H	0.84	0.36	Y	1.34	-0.82	H
92	Feddersen Wierde	143	206	46.9	30.6	29.4	42.4	33.5	H	0.57	1.42	Y	-0.03	-0.09	H*
92	Feddersen Wierde	146	215.6	42	29.4	24.9	42	30.7	D	1.00	0.79	Y	-2.91	0.62	D
92	Feddersen Wierde	147	210.8	49.1	32.3	30	47.7	34.2	H	0.86	0.86	Y	0.78	-1.09	H
92	Feddersen Wierde	148	196.5	42.8	28.6	27.1	43.3	30.7	H	0.83	3.67	N	-0.43	-1.32	H*
92	Feddersen Wierde	149	204.3	45.6	30.2	28.8	43.5	32.8	H	0.72	1.41	Y	0.02	-0.60	H
92	Feddersen Wierde	150	203.9	43.8	30.5	28.9	44.6	34	H	0.87	0.83	Y	0.89	-1.11	H
92	Feddersen Wierde	151	203.8	42.9	29.8	30.9	43.9	32.6	H	0.79	0.12	Y	1.31	-0.55	H
92	Feddersen Wierde	152	202.8	46.2	31.3	30.5	45.6	32.5	H	0.83	0.58	Y	0.78	-0.90	H
92	Feddersen Wierde	153	199.8	48.6	31.6	31.4	46.4	33.7	H	0.93	1.87	Y	1.72	-1.48	H

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
92	Feddersen Wierde	155	214.2	46.9	30.8	28.4	48.3	34.9	H	0.93	1.92	Y	1.04	-1.62	H
92	Feddersen Wierde	156	214.3	44.2	29.3	27.5	44.2	33.8	H	0.69	1.56	Y	-0.06	-0.51	H*
92	Feddersen Wierde	157	211.8	43.5	30.3	29.2	45.5	32.4	H	0.70	0.88	Y	0.24	-0.45	H
92	Feddersen Wierde	158	210.2	47.5	34.3	29.8	46.4	33.3	H	0.53	2.81	N	-0.52	-0.12	H?
92	Feddersen Wierde	159	211.7	46.8	33	29.9	46.4	33.4	H	0.63	1.36	Y	-0.01	-0.28	H*
92	Feddersen Wierde	160	203.3	46.3	33.9	30.6	47.8	33.9	H	0.89	1.01	Y	1.01	-1.24	H
92	Feddersen Wierde	161	219.2	46	31.5	27.4	45.4	33.2	M	0.37	5.11	N	-1.22	0.09	M?
92	Feddersen Wierde	162	206.1	48.7	30.1	30.4	45.1	33.6	H	0.86	0.54	Y	1.11	-0.98	H
92	Feddersen Wierde	164	210.3	48.7	32.6	30.3	46.1	33	H	0.63	1.38	Y	-0.02	-0.29	H*
92	Feddersen Wierde	165	204.5	46.4	31.4	27.3	43.7	32.5	H	0.39	5.51	N	-1.18	-0.50	H?
92	Feddersen Wierde	166	221.8	48.1	31	28.7	46.9	35.5	H	0.75	0.54	Y	0.51	-0.59	H
92	Feddersen Wierde	167	212.7	45.8	32.5	27.6	44.6	33.1	D	0.50	4.64	N	-1.35	0.07	D?
92	Feddersen Wierde	171	215.6	44.5	30.9	29.9	44.9	34.3	H	0.63	0.24	Y	0.69	-0.09	H*
92	Feddersen Wierde	172	213.7	46.8	32.6	30.1	46.7	34.4	H	0.73	0.37	Y	0.59	-0.46	H
92	Feddersen Wierde	174	197.6	43.4	29.4	30	44.6	31.2	H	0.89	1.02	Y	0.94	-1.23	H
92	Feddersen Wierde	175	203	46.1	31.8	30.7	50.5	36.1	H	0.99	12.40	N	3.36	-2.98	H*
92	Feddersen Wierde	176	205.9	43.3	280	27.5	42.3	32.2	H	0.71	1.93	Y	-0.18	-0.61	H
92	Feddersen Wierde	177	204.1	44.8	30.3	29.4	43.8	33	H	0.76	0.63	Y	0.47	-0.65	H
92	Feddersen Wierde	179	203.3	41.3	28.3	28.3	43.1	33.2	H	0.86	0.73	Y	0.92	-1.07	H
92	Feddersen Wierde	180	204.1	47.4	31	27.7	46	32.9	H	0.86	3.19	N	-0.21	-1.40	H*
92	Feddersen Wierde	181	219.1	49.2	32.8	30.2	48.5	34.9	H	0.78	0.35	Y	0.72	-0.65	H
92	Feddersen Wierde	182	192.4	43.4	28.9	29.6	43.6	32.2	H	0.94	2.14	N	1.40	-1.68	H*
92	Feddersen Wierde	183	208.3	45.6	30.2	28.7	45.6	32.9	H	0.82	1.23	Y	0.31	-0.97	H
92	Feddersen Wierde	185	204.9	45.2	30.4	27.5	43.3	31.4	D	0.40	5.25	N	-1.23	-0.32	D?
92	Feddersen Wierde	186	219.6	45	31.9	27.9	46.4	34.4	H	0.59	2.27	N	-0.35	-0.27	H?
92	Feddersen Wierde	187	200.2	43	28.9	25.9	41.2	31.6	D	0.61	4.74	N	-1.39	-0.58	D?
92	Feddersen Wierde	188	214.9	46.6	30.3	28.4	47.6	34.5	H	0.90	1.37	Y	0.86	-1.37	H
92	Feddersen Wierde	190	204.1	46.3	31.6	29.9	45.3	32.7	H	0.78	0.88	Y	0.36	-0.74	H
92	Feddersen Wierde	192	192.6	42.1	30.5	28.1	42.1	31.3	H	0.73	2.86	N	-0.43	-0.83	H?
92	Feddersen Wierde	193	202.6	45.6	30.7	29.5	43.9	32	H	0.70	1.40	Y	0.01	-0.53	H
92	Feddersen Wierde	194	208.9	46.3	31.4	28.9	43.4	31.9	M	0.51	4.10	N	-1.04	0.25	M?
92	Feddersen Wierde	195	187.7	41.5	28.4	27.8	43.5	32.4	H	0.97	4.58	N	1.26	-2.38	H*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
92	Feddersen Wierde	198	200	46	31.2	29.3	45.4	32.2	H	0.86	1.60	Y	0.30	-1.17	H
92	Feddersen Wierde	199	215.2	46.2	30.4	28.7	44.9	32.7	H	0.53	2.51	N	-0.42	-0.09	H?
92	Feddersen Wierde	201	205.5	44.5	30.8	30.9	48.3	33.3	H	0.96	3.13	N	2.10	-1.74	H*
92	Feddersen Wierde	203	205.6	46.6	31.5	29.1	46.1	33.4	H	0.85	1.29	Y	0.43	-1.12	H
92	Feddersen Wierde	204	213.5	48.1	31	29.8	44.8	34.3	H	0.66	0.54	Y	0.42	-0.26	H*
92	Feddersen Wierde	206	208.7	45.9	29.7	27.9	42.6	33.3	H	0.58	2.60	N	-0.46	-0.26	H?
92	Feddersen Wierde	207	219.7	46.4	31.7	29.2	47	33.7	H	0.62	1.32	Y	0.01	-0.23	H*
92	Feddersen Wierde	210	209.8	46.1	31.6	29	43.6	32.3	M	0.54	3.55	N	-0.89	0.25	M?
92	Feddersen Wierde	211	204.3	45.5	31.5	28.7	46.1	34.2	H	0.90	1.53	Y	0.75	-1.41	H
92	Feddersen Wierde	212	204.7	47.3	30.8	28.9	47	31.6	H	0.87	2.41	N	0.05	-1.33	H*
92	Feddersen Wierde	213	222.4	47.3	32.1	30.8	47.2	35.9	H	0.71	0.02	Y	1.29	-0.21	H
92	Feddersen Wierde	214	199.4	44.4	28.2	26.8	44.7	28.3	D	0.60	5.95	N	-1.36	-1.21	D?
92	Feddersen Wierde	215	200.6	47	32.1	30.8	48.2	35.3	H	0.98	5.71	N	2.48	-2.23	H*
92	Feddersen Wierde	216	210.9	46.6	33.2	31	47.2	35.6	H	0.85	0.52	Y	1.55	-0.84	H
92	Feddersen Wierde	217	190	42.4	27.4	26	42	30	H	0.83	5.61	N	-0.71	-1.70	H*
92	Feddersen Wierde	218	207.1	43.4	29.8	29.1	44.1	32.4	H	0.72	0.82	Y	0.29	-0.52	H
92	Feddersen Wierde	219	209.4	47.7	32.2	30	45.9	32.3	H	0.61	1.89	Y	-0.22	-0.29	H*
92	Feddersen Wierde	221	212.6	45.7	32.1	29.9	45.9	33	H	0.60	1.23	Y	0.05	-0.16	H
92	Feddersen Wierde	222	200.4	43.2	29.4	28.3	40.8	31.5	M	0.47	3.48	N	-0.70	-0.03	M?
92	Feddersen Wierde	224	210.4	44.8	30	29.8	46.6	34.5	H	0.92	1.46	Y	1.70	-1.32	H
92	Feddersen Wierde	225	211.4	45.3	30.2	29	42.4	30.9	M	0.51	4.60	N	-1.30	0.72	M?
92	Feddersen Wierde	226	302.1	44.3	28.9	26	44.9	30.4	H	0.51	6.65	N	-1.16	-1.38	H?
92	Feddersen Wierde	227	221.6	47.6	32	28	48.7	34.9	H	0.80	1.57	Y	0.10	-0.92	H
92	Feddersen Wierde	228	204.3	47.8	30.6	28.4	46.1	33.2	H	0.90	2.21	N	0.33	-1.48	H*
92	Feddersen Wierde	229	215.1	44	29.4	27.6	44.3	33.7	H	0.66	1.61	Y	-0.10	-0.42	H*
92	Feddersen Wierde	230	210	46.5	31.7	29	46.7	33.8	H	0.83	1.12	Y	0.40	-0.98	H
92	Feddersen Wierde	231	201.6	46.9	32.1	30.1	46.2	33.6	H	0.89	1.11	Y	0.95	-1.27	H
92	Feddersen Wierde	232	213.3	46.8	30.8	29.3	46.6	34.7	H	0.86	0.62	Y	0.99	-1.01	H
92	Feddersen Wierde	233	225.8	44	31.4	28.1	46.4	34.5	M	0.52	2.07	Y	-0.31	0.15	M?
92	Feddersen Wierde	234	219.7	48.2	33.7	30.9	50.3	35.7	H	0.88	0.76	Y	1.53	-1.03	H
92	Feddersen Wierde	235	209.5	46.1	30.7	28.8	43.8	33.9	H	0.66	1.21	Y	0.06	-0.36	H
92	Feddersen Wierde	236	196.5	40.8	27	29	40.5	29.2	H	0.61	1.86	Y	-0.21	-0.26	H*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
104	Orton Hall Farm	636	247	54	38	39	55	41	H	0.74	14.75	N	4.91	0.58	H?
104	Orton Hall Farm	637	210	51	37	33	46	34	M	0.71	1.01	Y	-0.15	0.79	M
104	Orton Hall Farm	638	238	50	36	35	52	36	M	0.57	1.18	Y	1.90	0.85	M*
104	Orton Hall Farm	639	226	50	33	35	52	39	H	0.97	14.60	N	4.81	-1.37	H*
113	Southwark	751	180	40.4	24.9	26.8	42.2	30.9	H	0.99	9.00	N	1.60	-3.21	H*
114	Unterlaa	752	225	48.9	32.6	33.1	46.9	34.4	M	0.59	0.20	Y	1.15	0.73	M*
114	Unterlaa	756	207.2	46.4	30.4	31.6	45	32.6	H	0.76	0.04	Y	1.21	-0.44	H
115	Bad Wimpfen	761	224.7	50	31.9	34.2	50.3	37	H	0.93	6.78	N	3.68	-0.90	H*
115	Bad Wimpfen	762	220.3	47.7	30.1	34.2	49.5	35	H	0.94	7.02	N	3.69	-1.02	H*
115	Bad Wimpfen	763	218.8	47.7	28.8	31.8	45.2	35.4	H	0.81	1.39	Y	2.32	-0.41	H
115	Bad Wimpfen	764	216	50.4	30.7	32.8	48	34.6	H	0.89	1.89	Y	2.38	-0.87	H
115	Bad Wimpfen	765	212.8	47	28.4	33.4	45.7	34.8	H	0.92	5.37	N	3.39	-0.85	H*
116	Pommeroeul	781	203	46	30	29	45	33	H	0.88	1.26	Y	0.66	-1.25	H
116	Pommeroeul	782	210	50	33	32	50	36	H	0.97	4.84	N	2.66	-1.85	H*
116	Pommeroeul	783	219	52	34	34	47	35	H	0.51	0.57	Y	1.40	0.48	H?
116	Pommeroeul	784	220	48	39	30	46	34	D	0.96	4.45	N	-2.41	1.76	D*
116	Pommeroeul	785	222	45	34	30	44	33	M	0.64	5.62	N	-1.46	1.66	M?
116	Pommeroeul	786	221	47	33	30	46	34	M	0.64	1.61	Y	-0.33	0.52	M*
116	Pommeroeul	787	224	50	33	33	51	36	H	0.90	2.44	N	2.58	-0.89	H*
116	Pommeroeul	788	226	52	35	37	53	36	H	0.89	7.13	N	3.81	-0.48	H*
116	Pommeroeul	789	240	52	35	32	52	36	M	0.54	0.38	Y	0.70	0.44	M?
116	Pommeroeul	790	241	50	33	33	51	36	H	0.52	0.86	Y	1.67	0.53	H?
118	Carnuntum	800	251	55	39.2	34.7	50.5	40.8	M	0.90	1.38	Y	1.21	2.15	M
118	Carnuntum	801	250	54.8	39.3	36.6	50.8	38	M	0.95	2.89	N	0.96	2.73	M*
118	Carnuntum	802	239	57	38	36.8	51.2	36.5	M	0.82	0.73	Y	1.38	1.68	M
118	Carnuntum	803	167.2	34.6	23.9	23.7	33	23.9	D	1.00	0.29	Y	-3.34	-0.56	D
120	Basel-Gasfabrik	806	205.1	46.4	29	31.4	46.6	33.8	H	0.96	4.15	N	2.59	-1.68	H*
120	Basel-Gasfabrik	807	185.2	40.8	25.7	24.9	39.2	30.1	H	0.78	6.18	N	-0.85	-1.71	H*
120	Basel-Gasfabrik	808	199.3	45.1	30.9	30.2	45.3	32	H	0.87	0.90	Y	0.79	-1.12	H
120	Basel-Gasfabrik	809	197.8	46	30.3	29.5	43.5	32.2	H	0.82	1.11	Y	0.35	-0.93	H
120	Basel-Gasfabrik	810	194.8	45	30.6	31.5	45.3	32.9	H	0.95	2.62	N	2.07	-1.58	H*
120	Basel-Gasfabrik	811	232.4	50.4	32.3	35.5	49	36.2	H	0.62	4.03	N	3.01	0.54	H?

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
120	Basel-Gasfabrik	812	208.5	45.1	29.8	30.8	43.2	32.4	H	0.57	0.41	Y	0.59	0.06	H?
120	Basel-Gasfabrik	813	206.6	45.5	28.7	28.9	44.9	32.6	H	0.87	0.99	Y	0.72	-1.14	H
121	Soluthurn/Vigier	816	241	49	34.8	32.6	47.1	36.8	M	0.90	1.12	Y	0.36	1.99	M
121	Soluthurn/Vigier	817	223.8	47.4	31.5	33.1	48.2	34.5	H	0.71	0.86	Y	2.06	-0.03	H
123	Wroxeter Baths basilica	819	216	48.7	33.6	33.9	47.5	34	H	0.62	0.40	Y	1.62	0.18	H?
123	Wroxeter Baths basilica	822	216.5	53.4	32.6	32.1	47.4	35.8	H	0.80	0.22	Y	1.52	-0.55	H
125	Castleford	830	194.2	42.4	29.8	29.8	44	32.6	H	0.93	1.66	Y	1.42	-1.50	H
125	Castleford	835	232	45.4	34.2	34.6	51.9	35.4	H	0.73	2.68	N	2.76	0.10	H?
125	Castleford	838	216	50.9	31.8	31.5	48.3	34.4	H	0.85	0.42	Y	1.40	-0.84	H
127	Tortoreto-Fortellezza	841	173.5	37.5	27	26	34.5	27	D	0.99	1.34	Y	-2.35	-0.17	D
131	Radovesice	863	202	45	30	29	46.5	38	H	0.99	10.44	N	3.22	-2.73	H*
134	Butzbach	885	191	49	34	31	46	32	H	0.88	1.71	Y	0.37	-1.29	H
134	Butzbach	886	225	52	36	34.5	48	34	M	0.80	0.25	Y	0.43	1.34	M
135	Swestari	891	200	44	29	31	45	32.5	H	0.93	1.95	Y	1.97	-1.38	H
135	Swestari	892	204	47	30	32	45	32	H	0.81	0.22	Y	1.39	-0.65	H
135	Swestari	893	206	45.5	31	30.5	45	32.5	H	0.74	0.35	Y	0.63	-0.51	H
135	Swestari	894	219	51	35	35	49.5	37.5	H	0.86	4.20	N	3.19	-0.44	H*
135	Swestari	895	244	56	36.5	36	53	39.5	H	0.62	4.19	N	3.04	0.55	H?
137	Magdelenska Gora	898	219	49	34	32	46.5	36	H	0.55	0.25	Y	1.08	0.25	H?
143	Histria	902	230	53	34	35	50.5	36	H	0.68	1.76	Y	2.41	0.19	H*
143	Histria	903	235	53.2	34	34	50	39	H	0.73	2.89	N	2.82	0.10	H?
143	Histria	906	225	50	33	34	51	37	H	0.92	5.29	N	3.37	-0.88	H*
144	Albertfalva	908	216	46	36	32	46.5	36	M	0.54	0.32	Y	0.79	0.47	M?
144	Albertfalva	914	245	53	39	36.5	52.5	38	M	0.80	1.49	Y	1.84	1.71	M
144	Albertfalva	915	240	55	37.5	36	50.5	39	M	0.69	1.94	Y	2.19	1.34	M
144	Albertfalva	918	237	48.5	37	34	47	35	M	0.96	3.97	N	-0.31	2.67	M*
144	Albertfalva	921	242	53	38.5	33	48	36	M	0.93	7.16	N	-1.23	2.76	M*
144	Albertfalva	923	220	45	31	32	46	34	H	0.59	0.30	Y	1.42	0.24	H?
146	Balatonaliga	925	207	45	31	32	47	35	H	0.94	3.83	N	2.77	-1.35	H*
146	Balatonaliga	926	218	48	32	33	46	35	H	0.63	0.58	Y	1.79	0.19	H?
149	Helemba - Sziget	929	197	45.5	32	29	46	32	H	0.89	2.40	N	0.16	-1.43	H*
150	Acs - Vaspuszta	930	227	48	32.5	33	48.5	37.5	H	0.80	2.60	N	2.77	-0.21	H*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
153	Aquileia forum	931	219.5	49.5	34.4	31.2	51	33.7	H	0.79	0.47	Y	0.66	-0.72	H
153	Aquileia forum	932	221	50.2	33.3	33.9	48.8	37.9	H	0.89	4.58	N	3.26	-0.62	H*
174	Abusina-Eining	966	247	55	38	37	51	39	M	0.84	2.76	N	2.19	1.99	M*
174	Abusina-Eining	967	242	52	35.5	34	49	36.5	M	0.87	0.59	Y	0.75	1.81	M
174	Abusina-Eining	969	241	52	33.5	35	51.5	37	H	0.61	3.02	N	2.73	0.50	H?
174	Abusina-Eining	970	240.5	52.5	34	34	49.5	38	M	0.57	1.52	Y	2.05	0.90	M*
174	Abusina-Eining	971	227.5	49	33	35	47	35	M	0.64	1.27	Y	1.95	1.10	M
174	Abusina-Eining	972	227	48.5	32	33.5	49	36	H	0.78	2.13	N	2.61	-0.15	H*
174	Abusina-Eining	973	216.5	45.5	31	31	42	34.5	M	0.73	0.19	Y	0.38	1.01	M
174	Abusina-Eining	974	236.5	51	35.5	35	50.5	37.5	M	0.52	2.31	N	2.33	0.81	M?
174	Abusina-Eining	975	234	50	36	31	46	35	M	0.76	6.44	N	-1.45	2.16	M*
174	Abusina-Eining	977	224	52	35	36.5	50	37.5	H	0.80	6.06	N	3.61	-0.02	H*
176	Oberdorla	987	226	47	32	30	46	31	M	0.50	5.43	N	-1.50	1.27	M?
176	Oberdorla	990	222	44	31	30	45	32	M	0.74	1.86	Y	-0.53	0.87	M
176	Oberdorla	992	214	48	31	33	49	35	H	0.95	4.80	N	3.06	-1.32	H*
176	Oberdorla	993	213	48	31	33	49	35	H	0.95	5.19	N	3.12	-1.40	H*
176	Oberdorla	994	210	46	30	31	43	32	M	0.56	0.77	Y	0.24	0.39	M?
176	Oberdorla	995	210	46	30	33	45	34	H	0.81	1.58	Y	2.40	-0.39	H
176	Oberdorla	996	210	44	32	30	45	32	M	0.50	2.00	Y	-0.23	0.10	M?
176	Oberdorla	997	210	48	31	32	46	33	H	0.76	0.06	Y	1.30	-0.44	H
176	Oberdorla	998	210	44	27	31	42	32	H	0.62	0.09	Y	1.19	0.06	H?
176	Oberdorla	999	210	51	32	34	49	36	H	0.96	7.33	N	3.54	-1.53	H*
176	Oberdorla	1001	208	447	31	29	44	34	H	0.70	1.09	Y	0.14	-0.49	H
176	Oberdorla	1002	207	40	29	32	47	33	H	0.95	4.77	N	3.02	-1.37	H*
176	Oberdorla	1003	202	47	30	34	45	28	H	0.55	0.37	Y	0.69	0.16	H?
176	Oberdorla	1004	201	43	27	28	41	32	H	0.76	1.07	Y	0.23	-0.70	H
176	Oberdorla	1005	193	42	28	30	42	31	H	0.87	0.65	Y	1.07	-1.04	H
176	Oberdorla	1006	179	42	28	29	42	29	H	0.95	3.26	N	0.57	-1.95	H*
176	Oberdorla	1008	177	40	29	29	43	29	H	0.96	3.99	N	0.73	-2.19	H*
178	Vitudurum-Oberwinterthur	1013	229	51.1	33.4	34.5	48.4	35.6	M	0.51	1.36	Y	1.94	0.68	M?
178	Vitudurum-	1015	220	50.1	33.3	31.1	48.3	35.2	H	0.72	0.08	Y	0.89	-0.36	H

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
	Oberwinterthur														
189	Kassope	1040	180	39.5	26.5	24.5	37.5	26.5	D	1.00	1.03	Y	-2.81	-0.79	D
189	Kassope	1044	167	36	24	23	33	25	D	1.00	0.68	Y	-3.32	-0.85	D
202	Penzlin	1129	200.8	42.3	27.6	29.2	41.5	31.3	H	0.72	0.58	Y	0.43	-0.47	H
202	Penzlin	1132	213.7	43.5	27	29.5	44	31.5	H	0.70	0.25	Y	0.66	-0.35	H
202	Penzlin	1133	213.3	43.3	29.1	27	42.6	31.3	D	0.63	4.11	N	-1.50	0.29	D?
202	Penzlin	1134	221.5	46.3	29.1	31.2	45	34.1	H	0.61	0.18	Y	1.35	0.13	H?
202	Penzlin	1136	198.5	43.4	28.7	29.6	42.6	30.9	H	0.76	0.81	Y	0.36	-0.66	H
202	Penzlin	1137	204.5	47	31.4	32.6	48.2	34.3	H	0.96	4.95	N	2.86	-1.67	H*
203	Tac-Gorsium	1138	206.5	46.5	34	33	50	34.5	H	0.95	3.61	N	2.59	-1.49	H*
203	Tac-Gorsium	1140	209	45.5	31.5	30.5	45	32.5	H	0.61	0.75	Y	0.30	-0.15	H*
203	Tac-Gorsium	1141	209	48.5	35.5	34	49.5	34.5	H	0.85	1.08	Y	2.09	-0.69	H
203	Tac-Gorsium	1143	218	46	36	32	47	36	M	0.54	0.31	Y	0.80	0.48	M?
203	Tac-Gorsium	1145	219	49.5	34	32	48	35	H	0.64	0.07	Y	0.98	-0.05	H*
203	Tac-Gorsium	1148	220	47	32	33	47.5	35.5	H	0.77	1.37	Y	2.33	-0.20	H
203	Tac-Gorsium	1149	220	50.5	36	34	51	36.5	H	0.84	1.54	Y	2.36	-0.54	H
203	Tac-Gorsium	1150	221	51	35.5	33.5	51	37	H	0.87	1.86	Y	2.43	-0.72	H
203	Tac-Gorsium	1151	222	48.5	35	32.5	49	37	H	0.74	0.47	Y	1.84	-0.20	H
203	Tac-Gorsium	1152	222	49.5	33.5	35.5	50.5	36	H	0.88	5.56	N	3.50	-0.49	H*
203	Tac-Gorsium	1153	222	50.5	37	37.5	50.5	38.5	H	0.82	8.80	N	4.11	0.04	H*
203	Tac-Gorsium	1154	222.5	46.5	31	31	45	34	M	0.61	0.27	Y	0.50	0.63	M*
203	Tac-Gorsium	1156	223	51	35	33.5	51.5	36	H	0.85	1.25	Y	2.20	-0.64	H
203	Tac-Gorsium	1157	223	49.5	35.5	34	49.5	38	H	0.79	2.42	N	2.71	-0.19	H*
203	Tac-Gorsium	1158	223	50	34.5	34	49	35	H	0.58	0.54	Y	1.65	0.30	H?
203	Tac-Gorsium	1160	224	51	37	32	50	35	M	0.57	1.03	Y	0.05	0.38	M?
203	Tac-Gorsium	1161	224	50	34.5	34.5	50	36	H	0.75	1.75	Y	2.46	-0.06	H
203	Tac-Gorsium	1163	225	50	37	32.5	46.5	35	M	0.88	2.27	N	-0.55	1.65	M*
203	Tac-Gorsium	1164	225	48	32	33	46	32	M	0.81	0.51	Y	0.17	1.33	M
203	Tac-Gorsium	1165	225.5	46	33	35.5	47.5	36	H	0.58	4.40	N	3.04	0.68	H?
203	Tac-Gorsium	1166	226	51	35	31.5	47	37.5	M	0.57	0.26	Y	0.73	0.54	M?
203	Tac-Gorsium	1167	226	50	36	34	48	35	M	0.75	0.03	Y	0.74	1.20	M
203	Tac-Gorsium	1168	226	49.5	35	34.5	50.5	37	H	0.78	2.59	N	2.76	-0.13	H*

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
203	Tac-Gorsium	1169	227	48.5	34.5	33	49	38	H	0.73	1.52	Y	2.37	-0.02	H
203	Tac-Gorsium	1170	227	51	36	36	50	38	H	0.70	4.39	N	3.18	0.31	H?
203	Tac-Gorsium	1171	227.5	53	35.5	32	47.5	37	M	0.65	0.23	Y	0.44	0.75	M*
203	Tac-Gorsium	1172	229	51	38	34	51	39.5	H	0.70	1.65	Y	2.39	0.09	H*
203	Tac-Gorsium	1173	229	48	36	34.5	50.5	37	H	0.62	1.85	Y	2.38	0.36	H*
203	Tac-Gorsium	1174	229	51	36	35.5	49.5	36.5	M	0.55	1.70	Y	2.12	0.86	M*
203	Tac-Gorsium	1175	229	51.5	37	35.5	52	37	H	0.69	2.11	Y	2.54	0.18	H*
203	Tac-Gorsium	1178	230	53.5	38	37	51.5	38.5	H	0.63	4.47	N	3.13	0.52	H?
203	Tac-Gorsium	1179	230.5	52.5	35	35.5	52.5	40	H	0.94	11.10	N	4.43	-0.86	H*
203	Tac-Gorsium	1180	231	48.5	36.5	33.5	48	38.5	M	0.65	0.68	Y	1.65	1.04	M
203	Tac-Gorsium	1181	231	50.5	34	33.5	50.5	37	H	0.74	1.41	Y	2.33	-0.06	H
203	Tac-Gorsium	1182	231.5	46	33	33.5	48	35	M	0.63	0.57	Y	1.57	0.97	M
203	Tac-Gorsium	1184	232	52	33	33	50	35	H	0.57	0.29	Y	1.34	0.26	H?
203	Tac-Gorsium	1185	232	52.5	36.5	33	51	39	H	0.71	0.75	Y	2.00	-0.02	H
203	Tac-Gorsium	1186	233.5	54.5	39	34.5	51.5	39.5	H	0.52	1.14	Y	1.87	0.56	H?
203	Tac-Gorsium	1187	235	51	34.5	33.5	53	36	H	0.76	0.88	Y	2.09	-0.23	H
203	Tac-Gorsium	1188	235	53	38	39	52	38.5	H	0.54	8.95	N	3.87	1.01	H?
203	Tac-Gorsium	1189	237	55.5	39	33	52.5	41	H	0.67	0.54	Y	1.82	0.07	H*
203	Tac-Gorsium	1190	237	48.5	34	33.5	50	35.5	M	0.62	0.38	Y	1.43	0.90	M
203	Tac-Gorsium	1191	237	55	38	36	56	39	H	0.89	5.58	N	3.50	-0.55	H*
203	Tac-Gorsium	1192	238	51	36	33	51	36	M	0.68	0.02	Y	0.73	0.93	M
203	Tac-Gorsium	1194	238.5	54	38	35.5	53	39	H	0.60	2.50	N	2.56	0.48	H?
203	Tac-Gorsium	1195	239	53.5	38.5	34.5	51	38	M	0.77	0.16	Y	1.08	1.35	M
203	Tac-Gorsium	1196	245	56.5	38	38	55	40.5	H	0.75	9.54	N	4.18	0.37	H?
203	Tac-Gorsium	1197	252.6	56	39	37.5	51	38.5	M	0.95	3.58	N	1.47	2.82	M*
203	Tac-Gorsium	1198	260	54.5	40	38	56	43	M	0.53	10.99	N	4.13	1.30	M?
203	Tac-Gorsium	1199	262.5	58	41	38	53	40	M	0.97	5.04	N	1.41	3.21	M*
204	Conchil	1236	215.3	47.7	30.3	33.4	47.2	35.5	H	0.91	4.54	N	3.20	-0.84	H*
204	Conchil	1237	217.5	47.5	30.4	32.8	48.1	35.6	H	0.92	4.24	N	3.07	-1.00	H*
205	Oberstimm	1239	215.5	43	32.5	27	39	32	D	1.00	5.29	N	-3.34	2.25	D*
205	Oberstimm	1240	239.5	49.5	36.5	32	48	35.5	M	0.93	3.69	N	-0.76	2.12	M*
207	Haus Burgel	1251	222	48	34	31.4	49	37.2	H	0.82	0.58	Y	1.84	-0.58	H

Site no	Site name	Bone no	GL	Bp	Dp	SD	Bd	Dd	SPSS ID	Probability	Mahalanobis distance	Within 1 sd	Function 1	Function 2	ID level
208	Colonia Ulpia Traiana	1254	240.5	52.5	36	35.5	52.5	38	H	0.59	3.11	N	2.73	0.56	H?
208	Colonia Ulpia Traiana	1255	235.5	53	37	35.5	52.5	39	H	0.72	3.67	N	3.02	0.18	H?
208	Colonia Ulpia Traiana	1256	231	52	35	34.5	58	37	H	0.99	12.21	N	4.10	-2.13	H*
208	Colonia Ulpia Traiana	1257	223	48.5	33	33.5	48	34	H	0.53	0.52	Y	1.42	0.43	H?
208	Colonia Ulpia Traiana	1258	222	54	36.5	35	52	37	H	0.86	2.44	N	2.68	-0.59	H*
208	Colonia Ulpia Traiana	1259	219.5	51.5	34	33.5	49	35	H	0.72	0.28	Y	1.68	-0.17	H
208	Colonia Ulpia Traiana	1260	218	50	32	34.5	50.5	37	H	0.97	10.61	N	4.17	-1.46	H*
208	Colonia Ulpia Traiana	1262	216	49	34	35	348	36	H	0.79	2.97	N	2.87	-0.14	H*
208	Colonia Ulpia Traiana	1263	203	46.5	30.5	28	43.5	32.5	H	0.68	3.09	N	-0.55	-0.68	H?
208	Colonia Ulpia Traiana	1264	201	48.5	32	32.5	46.5	33	H	0.89	1.02	Y	1.73	-1.07	H
209	Iatrus	1266	233.1	54.1	35.6	34.9	54	37.8	H	0.89	4.17	N	3.15	-0.67	H*
209	Iatrus	1270	181.2	39.1	28.2	25.5	34.1	25.6	D	1.00	1.69	Y	-4.19	1.06	D
212	Gournay	1275	203	47	29	29	44.5	33.5	H	0.91	1.39	Y	1.01	-1.41	H
212	Gournay	1276	194	43.5	28	29	40.5	31.5	H	0.77	0.91	Y	0.32	-0.70	H
213	Beauvais	1277	202	45	27.5	30	42	32	H	0.78	0.19	Y	0.94	-0.62	H
213	Beauvais	1278	226	52	31.5	33.5	50	36.5	H	0.90	3.73	N	3.01	-0.79	H*
213	Beauvais	1279	237	53	33	35	50	37.5	H	0.64	3.42	N	2.88	0.43	H?
213	Beauvais	1280	193	40.5	26	25.5	39	29.5	D	0.61	4.98	N	-1.38	-0.75	D?
213	Beauvais	1281	207	45	26.5	30.5	44	33	H	0.92	1.84	Y	2.12	-1.19	H
213	Beauvais	1282	200	44	27.5	28.5	42.5	32.5	H	0.88	1.04	Y	0.81	-1.20	H
213	Beauvais	1283	184	39.5	25	27.5	39.5	29	H	0.90	2.47	N	0.29	-1.55	H*
214	Compiegne	1284	232	51	32	32	49	37	H	0.72	0.60	Y	1.92	-0.12	H
215	Ribemont	1286	190	46.5	27	32	44	33.5	H	0.99	10.70	N	3.58	-2.43	H*
216	Variscourt	1287	188	40	26	27.5	40	31	H	0.91	1.93	Y	0.64	-1.53	H
216	Variscourt	1288	208	43	25.5	33	45	32	H	0.94	6.16	N	3.46	-1.16	H*
216	Variscourt	1289	182	39	24.5	27.5	39	28.5	H	0.91	2.54	N	0.28	-1.57	H*
216	Variscourt	1290	192	42	25	29	40.5	30	H	0.89	1.04	Y	0.95	-1.24	H
216	Variscourt	1291	189	43	26.5	27.5	40	30.5	H	0.86	2.48	N	-0.03	-1.27	H*
216	Variscourt	1292	224	49.5	31	32.5	48	37	H	0.87	2.79	N	2.78	-0.61	H*
217	Soissons	1293	171	37	22.5	25	37.5	28	H	0.97	6.85	N	0.07	-2.63	H*

Table A15 – Results of withers height calculations on the Humeri from the complete skeletons and articulated limbs

WH-K = withers height estimate from Kiesewalter's factors

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GLl	WH-K
42	Druten	159	1.18	F	RO	M*	316	1538.29
59	Chichester cattlemarket	123	XXIII	E	RO	H*	301.9	1469.65
59	Chichester cattlemarket	124	XXIII	E	RO	H*	302.4	1472.08
71	Piovego	118	N2	A	IA	H*	283	1377.64
92	Feddersen Wierde	25	skelett3L	F	EXT	M*	282	1372.78
92	Feddersen Wierde	26	skelett2R	F	EXT	H	265.8	1293.91
92	Feddersen Wierde	27	skelett1R	F	EXT	H	290.3	1413.18
92	Feddersen Wierde	28	skelett1L	F	EXT	H	290.2	1412.69
96	Kunzing east vicus	1	1703	F	RO	M*	296.3	1442.39
96	Kunzing east vicus	2	1641	F	RO	M*	298	1450.66
96	Kunzing east vicus	4	1575/5	F	RO	H*	295.5	1438.49
96	Kunzing east vicus	5	1620	F	RO	H*	305	1484.74
96	Kunzing east vicus	6	1632	F	RO	M	304	1479.87
110	Nijmegen new excavations	323	1961/621	F	RO	H?	257.1	1251.56
110	Nijmegen new excavations	325	147/128	F	RO	H?	317.1	1543.64
118	Carnuntum	369	Pferd 1	G	RO	M	332	1616.18
118	Carnuntum	370	Pferd 2	G	RO	H	297.5	1448.23
118	Carnuntum	371	Pferd 3	G	RO	H	292.5	1423.89
119	Albertfalva	374	Horse 1	G	RO	H?	311.1	1514.43
119	Albertfalva	375	Horse 2	G	RO	H?	335.8	1634.67
128	Krefeld-Gellep	403	3510	F	RO	D*	247	1202.40
135	Swestari	422	1	G	IA	H	253	1231.60
135	Swestari	423	2	G	IA	H	258	1255.94
135	Swestari	424	3	G	IA	H	267	1299.76
135	Swestari	425	4	G	IA	H*	295	1436.06
135	Swestari	426	5	G	IA	M	310	1509.08
141	Szentes-Vekerzug	431	6	G	IA	H*	270	1314.36

Table A16 – Results of withers height calculations on the Radii from the complete skeletons and articulated limbs

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
37	Kesteren 'De Prinsenhof'	308	11.34	F	RO	H?	345		1418.30		1418.30
42	Druten	282	1.18	F	RO	M*	367		1508.74		1508.74
43	Elms Farm	256	6640	E	RO	H*	339	329	1393.63	1420.29	1406.96
43	Elms Farm	257	6640	E	RO	H*	346	327	1422.41	1411.66	1417.03
71	Piovego	200	N2	A	IA	H*	319		1311.41		1311.41
92	Feddersen Wierde	30	skelett1L	F	EXT	H	325.5	311.5	1338.13	1344.75	1341.44
92	Feddersen Wierde	29	skelett1R	F	EXT	H	326.5	311	1342.24	1342.59	1342.41
92	Feddersen Wierde	28	skelett2L	F	EXT	H	304.4	290.6	1251.39	1254.52	1252.95
92	Feddersen Wierde	27	skelett2R	F	EXT	H	305.1	291.6	1254.27	1258.84	1256.55
92	Feddersen Wierde	26	skelett3L	F	EXT	M*	342	325	1405.96	1403.03	1404.49
96	Kunzing east vicus	3	1581	F	RO	H?	347.5		1428.57		1428.57
96	Kunzing east vicus	5	1620	F	RO	H*	345.5		1420.35		1420.35
96	Kunzing east vicus	6	1632	F	RO	M	345		1418.30		1418.30
96	Kunzing east vicus	2	1641	F	RO	M*	356.5		1465.57		1465.57
96	Kunzing east vicus	1	1703	F	RO	M*	347		1426.52		1426.52
96	Kunzing east vicus	4	1575/5	F	RO	H*	338		1389.52		1389.52
110	Nijmegen new excavations	486	147/128	F	RO	H?	359.1	347	1476.26	1498.00	1487.13
114	Unterlaa	494	25	G	RO	H*	329.7	313.6	1355.40	1353.81	1354.60
114	Unterlaa	495	30	G	RO	H	327.1	312.7	1344.71	1349.93	1347.32
118	Carnuntum	544	Pferd 1	G	RO	M	349	328	1434.74	1415.98	1425.36
118	Carnuntum	545	Pferd 2	G	RO	H	328	312	1348.41	1346.90	1347.66
118	Carnuntum	546	Pferd 3	G	RO	H	368	349	1512.85	1506.63	1509.74
128	Krefeld-Gellep	583	3392	F	RO	H*	352	339	1447.07	1463.46	1455.27
128	Krefeld-Gellep	589	3510	F	RO	D*	292	280	1200.41	1208.76	1204.59
128	Krefeld-Gellep	585	3557	F	RO	H?	360	346	1479.96	1493.68	1486.82
128	Krefeld-Gellep	584	3577A	F	RO	M	348	336	1430.63	1450.51	1440.57
135	Swestari	615	1	G	IA	H	302	285	1241.52	1230.35	1235.93
135	Swestari	616	2	G	IA	H	305	287	1253.86	1238.98	1246.42
135	Swestari	617	3	G	IA	H	317	302	1303.19	1303.73	1303.46
135	Swestari	618	4	G	IA	H*	339	323	1393.63	1394.39	1394.01
135	Swestari	619	5	G	IA	M	364	349	1496.40	1506.63	1501.52
141	Szentes-Vekerzug	624	6	G	IA	H*	320		1315.52		1315.52

Table A17 – Results of withers height calculations on the Metacarpals from the complete skeletons and articulated limbs

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
37	Kesteren 'De Prinsenhof'	523	11.34	F	RO	H?	235		1433.97		1433.97
42	Druten	493	1.18	F	RO	M*	248.1		1513.91		1513.91
43	Elms Farm	469	6640	E	RO	H*	230	224	1403.46	1434.27	1418.87
43	Elms Farm	468	6640	E	RO	H*	231	224	1409.56	1434.27	1421.92
59	Chichester cattlemarket	398	XXIII	E	RO	H*	242		1476.68		1476.68
59	Chichester cattlemarket	397	XXIII	E	RO	H*	240		1464.48		1464.48
71	Piovego	381	N2	A	IA	H*	217		1324.13		1324.13
92	Feddersen Wierde	26	skelett2R	F	EXT	H	206.3		1258.84		1258.84
92	Feddersen Wierde	27	skelett2L	F	EXT	H	205.7		1255.18		1255.18
92	Feddersen Wierde	28	skelett1L	F	EXT	H	221.8		1353.42		1353.42
92	Feddersen Wierde	25	skelett3L	F	EXT	M*	221		1348.54		1348.54
96	Kunzing east vicus	1	1703	F	RO	M*	219.6		1340.00		1340.00
96	Kunzing east vicus	2	1641	F	RO	M*	229		1397.36		1397.36
96	Kunzing east vicus	3	1581	F	RO	H?	238.5		1455.33		1455.33
96	Kunzing east vicus	4	1575/5	F	RO	H*	228		1391.26		1391.26
96	Kunzing east vicus	5	1620	F	RO	H*	239.4		1460.82		1460.82
96	Kunzing east vicus	6	1632	F	RO	M	237.8		1451.06		1451.06
110	Nijmegen new excavations	741	179/16-24	F	RO	H*	200	193.5	1220.40	1238.98	1229.69
110	Nijmegen new excavations	742	179/16-27	F	RO	H*	220.1	211.8	1343.05	1356.16	1349.60
110	Nijmegen new excavations	743	1961/621-2	F	RO	H?	194.9	188.3	1189.28	1205.68	1197.48
110	Nijmegen new excavations	744	147/128-21	F	RO	H?	246.5	237.3	1504.14	1519.43	1511.79
114	Unterlaa	753	23	G	RO	H	225	217.9	1372.95	1395.21	1384.08
114	Unterlaa	754	25	G	RO	H*	217.5	211.2	1327.19	1352.31	1339.75
114	Unterlaa	755	30	G	RO	H	217	210.6	1324.13	1348.47	1336.30
117	Pompeii stable	793	B	A	RO	M*	234	226	1427.87	1447.08	1437.47
117	Pompeii stable	794	C	A	RO	M?	239	230	1458.38	1472.69	1465.53
118	Carnuntum	796	Pferd 1	G	RO	M	249	240.5	1519.40	1539.92	1529.66
118	Carnuntum	797	Pferd 2	G	RO	H	239.5	231	1461.43	1479.09	1470.26
118	Carnuntum	798	Pferd 3	G	RO	H*	233	224.5	1421.77	1437.47	1429.62
119	Albertfalva	804	Horse 1	G	RO	H?	228.1		1391.87		1391.87
119	Albertfalva	805	Horse 2	G	RO	H?	251.8		1536.48		1536.48
128	Krefeld-Gellep	844	3392	F	RO	H*	238	230.5	1452.28	1475.89	1464.08
128	Krefeld-Gellep	850	3510	F	RO	D*	190	182	1159.38	1165.35	1162.36
128	Krefeld-Gellep	845	3557	F	RO	H?	242	236	1476.68	1511.11	1493.90
128	Krefeld-Gellep	847	3573	F	RO	M	231	222	1409.56	1421.47	1415.51
128	Krefeld-Gellep	848	3577A	F	RO	M	235	225	1433.97	1440.68	1437.32
135	Swestari	891	1	G	IA	H	200	192	1220.40	1229.38	1224.89
135	Swestari	892	2	G	IA	H	204	196	1244.81	1254.99	1249.90
135	Swestari	893	3	G	IA	H	206	198	1257.01	1267.79	1262.40
135	Swestari	894	4	G	IA	H*	219	210.5	1336.34	1347.83	1342.08
135	Swestari	895	5	G	IA	M	244	235	1488.89	1504.71	1496.80
141	Szentes-Vekerzug	901	6	G	IA	H*	210		1281.42		1281.42

Table A18 – Results of withers height calculations on the Femora from the complete skeletons and articulated limbs

WH = withers height estimate (Vitt's and Kiesewalter's factors are the same)

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	WH
37	Kesteren 'De Prinsenhof'	141	11.34	F	RO	H?	407	1424.91
37	Kesteren 'De Prinsenhof'	142	11.28	F	RO	H*	407	1424.91
37	Kesteren 'De Prinsenhof'	147	2.27	F	RO	H*	407	1424.91
37	Kesteren 'De Prinsenhof'	150	1.21	F	RO	H?	411	1438.91
42	Druten	121	12.2	F	RO	H?	428.4	1499.83
42	Druten	122	1.18	F	RO	M*	426.5	1493.18
59	Chichester cattlemarket	91	XXIII	E	RO	H*	394.9	1382.54
59	Chichester cattlemarket	92	XXIII	E	RO	H*	399.2	1397.60
71	Piovego	88	N2	A	IA	H*	420	1470.42
92	Feddersen Wierde	27	skelett3L	F	EXT	M	387	1354.89
92	Feddersen Wierde	28	skelett2R	F	EXT	H	349.2	1222.55
92	Feddersen Wierde	29	skelett2L	F	EXT	H	348.3	1219.40
92	Feddersen Wierde	30	skelett1R	F	EXT	H	375.4	1314.28
92	Feddersen Wierde	31	skelett1L	F	EXT	H	374.5	1311.12
96	Kunzing east vicus	1	1703	F	RO	M	392.5	1374.14
96	Kunzing east vicus	2	1641	F	RO	M	400	1400.40
96	Kunzing east vicus	3	1575/5	F	RO	H*	394	1379.39
96	Kunzing east vicus	4	1620	F	RO	H*	405	1417.91
96	Kunzing east vicus	5	1632	F	RO	M	401.5	1405.65
110	Nijmegen new excavations	246	147/128	F	RO	H?	416	1456.42
114	Unterlaa	252	23B	G	RO	H	366.2	1282.07
114	Unterlaa	254	80L	G	RO	H	367	1284.87
117	Pompeii stable	272	C	A	RO	M?	388	1358.39
117	Pompeii stable	273	B	A	RO	M*	392	1372.39
118	Carnuntum	276	Pferd 1	G	RO	M	455	1592.96
118	Carnuntum	277	Pferd 2	G	RO	H	404	1414.40
118	Carnuntum	278	Pferd 3	G	RO	H	396	1386.40
118	Carnuntum	279	Maultier 1	G	RO	M*	394.5	1381.14
119	Albertfalva	282	Horse 1	G	RO	H?	402.2	1408.10
119	Albertfalva	283	Horse 2	G	RO	H?	433.1	1516.28
128	Krefeld-Gellep	302	3559	F	RO	M	435	1522.94
128	Krefeld-Gellep	306	3510	F	RO	D*	325	1137.83
135	Swestari	314	1	G	IA	H	340	1190.34
135	Swestari	315	2	G	IA	H	346	1211.35
135	Swestari	316	3	G	IA	H	355	1242.86
135	Swestari	317	4	G	IA	H*	390	1365.39
135	Swestari	318	5	G	IA	M	407	1424.91

Table A19 – Results of withers height calculations on the Tibiae from the complete skeletons and articulated limbs

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
37	Kesteren 'De Prinsenhof'	294	1.21	F	RO	H?	388		1531.44		1531.44
37	Kesteren 'De Prinsenhof'	289	11.28	F	RO	H*	374		1476.18		1476.18
37	Kesteren 'De Prinsenhof'	288	11.34	F	RO	H?	365		1440.66		1440.66
42	Druten	252	1.18	F	RO	M*	379.6	352.4	1498.28	1536.82	1517.55
42	Druten	251	12.2	F	RO	H?	374.2	337.1	1476.97	1470.09	1473.53
42	Druten	250	12.4	F	RO	H*	342.5		1351.85		1351.85
59	Chichester cattlemarket	176	XXIII	E	RO	H*	361.2		1425.66		1425.66
59	Chichester cattlemarket	177	XXIII	E	RO	H*	364.2		1437.50		1437.50
67	Ilchester,Church Street	170	F267	E	RO	H*	351		1385.40		1385.40
71	Piovego	164	N2	A	IA	H*	347		1369.61		1369.61
92	Feddersen Wierde	29	skelett2L	F	EXT	H	323.6	293	1277.25	1277.77	1277.51
92	Feddersen Wierde	28	skelett2R	F	EXT	H	323.1	295	1275.28	1286.50	1280.89
92	Feddersen Wierde	31	skelett1L	F	EXT	H	344.5	320.5	1359.74	1397.70	1378.72
92	Feddersen Wierde	27	skelett3L	F	EXT	M	355	326	1401.19	1421.69	1411.44
96	Kunzing east vicus	6	1620	F	RO	H*	364.5		1438.68		1438.68
96	Kunzing east vicus	7	1632	F	RO	M*	366		1444.60		1444.60
96	Kunzing east vicus	3	1641	F	RO	M*	364		1436.71		1436.71
96	Kunzing east vicus	2	1703	F	RO	M*	367		1448.55		1448.55
96	Kunzing east vicus	5	1575/5	F	RO	H*	354		1397.24		1397.24
105	Mons Claudianus	396	600	K	RO	D*	333	303	1314.35	1321.38	1317.87
105	Mons Claudianus	403	1108	K	RO	D*	310	280	1223.57	1221.08	1222.33
110	Nijmegen new excavations	483	147/128-20	F	RO	H?	376.5	353.6	1486.05	1542.05	1514.05
114	Unterlaa	491	23A	G	RO	H	332	306.6	1310.40	1337.08	1323.74
114	Unterlaa	493	68	G	RO	H?	331	306.7	1306.46	1337.52	1321.99
114	Unterlaa	494	71	G	RO	H	347	313.7	1369.61	1368.05	1368.83
115	Bad Wimpfen	511	Skele 4	F	RO	M	354		1397.24		1397.24
117	Pompeii stable	526	B	A	RO	M*	360		1420.92		1420.92
117	Pompeii stable	527	C	A	RO	M?	360		1420.92		1420.92
118	Carnuntum	533	Maultier 1	G	RO	M*	377	344	1488.02	1500.18	1494.10
118	Carnuntum	530	Pferd 1	G	RO	M	413	376.5	1630.11	1641.92	1636.01
118	Carnuntum	531	Pferd 2	G	RO	H	364.5	332	1438.68	1447.85	1443.27
118	Carnuntum	532	Pferd 3	G	RO	H	363.5	329	1434.73	1434.77	1434.75
119	Albertfalva	535	Horse 1	G	RO	H?	361		1424.87		1424.87
119	Albertfalva	536	Horse 2	G	RO	H?	401		1582.75		1582.75
128	Krefeld-Gellep	574	3510	F	RO	D*	295	266	1164.37	1160.03	1162.20
128	Krefeld-Gellep	572	3573	F	RO	M	378	349	1491.97	1521.99	1506.98
135	Swestari	598	1	G	IA	H	321	281	1266.99	1225.44	1246.21
135	Swestari	599	2	G	IA	H	321.5	285	1268.96	1242.89	1255.92
135	Swestari	600	3	G	IA	H	327	292	1290.67	1273.41	1282.04
135	Swestari	601	4	G	IA	H*	355	322	1401.19	1404.24	1402.71
135	Swestari	602	5	G	IA	M	382	350	1507.75	1526.35	1517.05
141	Szentes-Vekerzug	610	6	G	IA	H*	341		1345.93		1345.93

Table A20 – Results of withers height calculations on the Metatarsals from the complete skeletons and articulated limbs

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
37	Kesteren 'De Prinsenhof'	400	1.21	F	RO	H?	289		1514.07		1514.07
37	Kesteren 'De Prinsenhof'	396	11.28	F	RO	H*	280		1466.92		1466.92
37	Kesteren 'De Prinsenhof'	395	11.34	F	RO	H?	285		1493.12		1493.12
37	Kesteren 'De Prinsenhof'	398	2.27	F	RO	H*	284		1487.88		1487.88
42	Druten	373	1.18	F	RO	M*	288.8	288.4	1513.02	1537.46	1525.24
42	Druten	372	12.4	F	RO	H*	269.2		1410.34		1410.34
43	Elms Farm	350	6640	E	RO	H*	269	262	1409.29	1396.72	1403.01
43	Elms Farm	351	6640	E	RO	H*	268	261	1404.05	1391.39	1397.72
59	Chichester cattlemarket	294	XXIII	E	RO	H*	281.9		1476.87		1476.87
59	Chichester cattlemarket	295	XXIII	E	RO	H*	282.1		1477.92		1477.92
67	Ilchester,Church Street	284	F267	E	RO	H*	256.5		1343.80		1343.80
71	Piovego	276	N2	A	IA	H*	260		1362.14		1362.14
92	Feddersen Wierde	26	skelett1L	F	EXT	H	259		1356.90		1356.90
92	Feddersen Wierde	27	skelett1R	F	EXT	H	259.5		1359.52		1359.52
92	Feddersen Wierde	25	skelett3L	F	EXT	M*	264		1383.10		1383.10
96	Kunzing east vicus	4	1575/5	F	RO	H*	266.5		1396.19		1396.19
96	Kunzing east vicus	3	1581	F	RO	H?	284		1487.88		1487.88
96	Kunzing east vicus	5	1620	F	RO	H*	284		1487.88		1487.88
96	Kunzing east vicus	2	1641	F	RO	M	274		1435.49		1435.49
96	Kunzing east vicus	1	1703	F	RO	M	263		1377.86		1377.86
105	Mons Claudianus	517	1486	K	RO	D*	236	230	1236.40	1226.13	1231.27
105	Mons Claudianus	515	1544	K	RO	D*	240.5	235.5	1259.98	1255.45	1257.72
105	Mons Claudianus	513	1719	K	RO	D*	248	243	1299.27	1295.43	1297.35
105	Mons Claudianus	516	549	K	RO	H	239.5	234	1254.74	1247.45	1251.10
105	Mons Claudianus	511	604	K	RO	M?	254	250	1330.71	1332.75	1331.73
110	Nijmegen new excavations	589	179/16-22	F	RO	H*	242.1	232.4	1268.36	1238.92	1253.64
110	Nijmegen new excavations	590	179/16-25	F	RO	H*	263.1	251.9	1378.38	1342.88	1360.63
114	Unterlaa	598	18	G	RO	M*	266	258.7	1393.57	1379.13	1386.35
114	Unterlaa	599	23A	G	RO	H	252	248.2	1320.23	1323.15	1321.69
114	Unterlaa	600	35	G	RO	H*	258	252.3	1351.66	1345.01	1348.34
114	Unterlaa	601	40	G	RO	H*	263.5	258.3	1380.48	1377.00	1378.74
114	Unterlaa	602	48	G	RO	M*	267	261.8	1398.81	1395.66	1397.23
114	Unterlaa	603	49	G	RO	M?	280	273.3	1466.92	1456.96	1461.94
114	Unterlaa	604	73	G	RO	H	251	245.8	1314.99	1310.36	1312.67
115	Bad Wimpfen	613	Skele 4	F	RO	M	284	277	1487.88	1476.69	1482.28
115	Bad Wimpfen	615	Skele 6	F	RO	M	269.5	262	1411.91	1396.72	1404.32
117	Pompeii stable	634	B	A	RO	M*	275	269	1440.73	1434.04	1437.38
117	Pompeii stable	635	C	A	RO	M?	275	268	1440.73	1428.71	1434.72
118	Carnuntum	639	Maultier 1	G	RO	M*	286.7	279.7	1502.02	1491.08	1496.55
118	Carnuntum	636	Pferd 1	G	RO	M	300	291	1571.70	1551.32	1561.51
118	Carnuntum	637	Pferd 2	G	RO	H	283.5	276.5	1485.26	1474.02	1479.64
118	Carnuntum	638	Pferd 3	G	RO	H	273.2	265.6	1431.29	1415.91	1423.60
119	Albertfalva	641	Horse 1	G	RO	H*	272		1425.01		1425.01
119	Albertfalva	642	Horse 2	G	RO	H?	296.9		1555.46		1555.46
128	Krefeld-Gellep	680	3392	F	RO	H*	277	267	1451.20	1423.38	1437.29
128	Krefeld-Gellep	687	3510	F	RO	D*	227.5	218.5	1191.87	1164.82	1178.35
128	Krefeld-Gellep	681	3557	F	RO	H?	288	282	1508.83	1503.34	1506.09

Site no	Site name	Bone no	Specimen	Area	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
128	Krefeld-Gellep	683	3559	F	RO	M	283	276	1482.64	1471.36	1477.00
128	Krefeld-Gellep	684	3573	F	RO	M	283		1482.64		1482.64
135	Swestari	736	1	G	IA	H	240	233	1257.36	1242.12	1249.74
135	Swestari	737	2	G	IA	H	240	234	1257.36	1247.45	1252.41
135	Swestari	738	3	G	IA	H	244	236.5	1278.32	1260.78	1269.55
135	Swestari	739	4	G	IA	H*	263	258.3	1377.86	1377.00	1377.43
135	Swestari	740	5	G	IA	M	288	280	1508.83	1492.68	1500.76
141	Szentes-Vekerzug	746	6	G	IA	H*	254		1330.71		1330.71
143	Histria	747	P18	G	IA	H*	275		1440.73		1440.73
143	Histria	748	P25	G	IA	H?	277.5		1453.82		1453.82

Table A21 – Results of withers height calculations on the isolated Metatarsals

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
3	Edix Hill	466	E	IA		261		1367.38		1367.38
4	Market Deeping	465	E	IA	H	251		1314.99		1314.99
5	Beckford	464	E	IA		248		1299.27		1299.27
6	Wardy Hill	460	E	IA			245.6		1309.29	1309.29
6	Wardy Hill	461	E	IA			231.7		1235.19	1235.19
6	Wardy Hill	462	E	IA			219.7		1171.22	1171.22
6	Wardy Hill	463	E	IA			218.6		1165.36	1165.36
8	Hardingstone School	459	E	IA+RO		243		1273.08		1273.08
10	Twywell	458	E	IA		238		1246.88		1246.88
13	Wavendon Gate	454	E	IA+RO		263.3	257	1379.43	1370.07	1374.75
13	Wavendon Gate	455	E	IA+RO		285	276	1493.12	1471.36	1482.24
14	Lincoln	449	E	RO		255.9	251.3	1340.66	1339.68	1340.17
14	Lincoln	451	E	RO		296	283.8	1550.74	1512.94	1531.84
14	Lincoln	452	E	RO		282.7	269.7	1481.07	1437.77	1459.42
14	Lincoln	453	E	RO		273.7	267.9	1433.91	1428.17	1431.04
15	Scole-Dickleburgh	440	E	IA+RO		254.4		1332.80		1332.80
15	Scole-Dickleburgh	442	E	IA+RO		239	234	1252.12	1247.45	1249.79
15	Scole-Dickleburgh	443	E	IA+RO		267.3		1400.38		1400.38
15	Scole-Dickleburgh	444	E	IA+RO		205.7		1077.66		1077.66
15	Scole-Dickleburgh	445	E	IA+RO	M	267.9		1403.53		1403.53
15	Scole-Dickleburgh	446	E	IA+RO		284.8		1492.07		1492.07
15	Scole-Dickleburgh	447	E	IA+RO		249	242	1304.51	1290.10	1297.31
16	Birdlip	437	E	IA		205		1074.00		1074.00
18	Camulodunum	434	E	IA+RO		244		1278.32		1278.32
18	Camulodunum	435	E	IA+RO		255		1335.95		1335.95
18	Camulodunum	436	E	IA+RO		260		1362.14		1362.14
19	Scole	432	E	RO		293		1535.03		1535.03
19	Scole	433	E	RO		246		1288.79		1288.79
21	Skeleton Green	431	E	IA	M*	235		1231.17		1231.17
24	Dunstable	428	E	RO		227		1189.25		1189.25
24	Dunstable	429	E	RO		278		1456.44		1456.44
26	Stonea	427	E	RO	D*	225		1178.78		1178.78
27	Lynch Farm	426	E	IA+RO		280		1466.92		1466.92
28	Longthorpe II	423	E	IA+RO	H	224		1173.54		1173.54
28	Longthorpe II	424	E	IA+RO	H*	223		1168.30		1168.30
28	Longthorpe II	425	E	IA+RO	H	251		1314.99		1314.99

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
35	Castricum-Oosterbuurt	410	F	RO		260		1362.14		1362.14
35	Castricum-Oosterbuurt	411	F	RO		267.71		1402.53		1402.53
35	Castricum-Oosterbuurt	412	F	RO		265		1388.34		1388.34
35	Castricum-Oosterbuurt	414	F	RO		266		1393.57		1393.57
35	Castricum-Oosterbuurt	417	F	RO		256.72		1344.96		1344.96
35	Castricum-Oosterbuurt	418	F	RO		264.17		1383.99		1383.99
37	Kesteren 'De Prinsenhof'	392	F	RO		274		1435.49		1435.49
37	Kesteren 'De Prinsenhof'	394	F	RO		270		1414.53		1414.53
37	Kesteren 'De Prinsenhof'	396	F	RO		280		1466.92		1466.92
37	Kesteren 'De Prinsenhof'	399	F	RO		269		1409.29		1409.29
37	Kesteren 'De Prinsenhof'	401	F	RO		280		1466.92		1466.92
38	Nijmegen	379	F	RO	M	271.4		1421.86		1421.86
38	Nijmegen	380	F	RO	H	258		1351.66		1351.66
38	Nijmegen	381	F	RO		279.8	273.3	1465.87	1456.96	1461.42
38	Nijmegen	382	F	RO		278.6	271	1459.59	1444.70	1452.14
38	Nijmegen	383	F	RO	H*	274.8	270.8	1439.68	1443.63	1441.66
38	Nijmegen	384	F	RO	M	274.6		1438.63		1438.63
38	Nijmegen	385	F	RO	H*	260.2		1363.19		1363.19
38	Nijmegen	390	F	RO	M	278.4		1458.54		1458.54
39	Kesteren vicus	378	F	RO	H*	237.8	242.4	1245.83	1292.23	1269.03
40	Heteren	374	F	NAT	M*	285.6	281.7	1496.26	1501.74	1499.00
40	Heteren	376	F	NAT	H?	251	247	1314.99	1316.76	1315.87
42	Druten	364	F	IA+RO	H	248.1		1299.80		1299.80
42	Druten	365	F	IA+RO	M*	272	267.2	1425.01	1424.44	1424.73
42	Druten	366	F	IA+RO	H?	258.3	255.2	1353.23	1360.47	1356.85
42	Druten	367	F	IA+RO	H*	271.8	267.7	1423.96	1427.11	1425.53
42	Druten	368	F	IA+RO	H*	259.4	255	1359.00	1359.41	1359.20
42	Druten	369	F	IA+RO	H?	275	270.8	1440.73	1443.63	1442.18
42	Druten	370	F	IA+RO		279.8	275.6	1465.87	1469.22	1467.55
43	Elms Farm	344	E	IA+RO		264		1383.10		1383.10
43	Elms Farm	346	E	IA+RO		270		1414.53		1414.53
43	Elms Farm	348	E	IA+RO		242		1267.84		1267.84
43	Elms Farm	349	E	IA+RO		267		1398.81		1398.81
43	Elms Farm	352	E	IA+RO		252	246	1320.23	1311.43	1315.83
43	Elms Farm	354	E	IA+RO		286		1498.35		1498.35
43	Elms Farm	355	E	IA+RO		254	241	1330.71	1284.77	1307.74
43	Elms Farm	357	E	IA+RO		258	251	1351.66	1338.08	1344.87
43	Elms Farm	358	E	IA+RO	H	256	246	1341.18	1311.43	1326.31
43	Elms Farm	359	E	IA+RO	H*	234	231	1225.93	1231.46	1228.69
44	Danebury	322	E	IA	H	242		1267.84		1267.84
44	Danebury	324	E	IA		246		1288.79		1288.79
44	Danebury	326	E	IA		233		1220.69		1220.69
44	Danebury	327	E	IA		226		1184.01		1184.01
44	Danebury	328	E	IA		228		1194.49		1194.49
44	Danebury	329	E	IA		237		1241.64		1241.64
44	Danebury	330	E	IA		231		1210.21		1210.21
44	Danebury	332	E	IA		235		1231.17		1231.17
44	Danebury	333	E	IA		251		1314.99		1314.99
44	Danebury	334	E	IA		218		1142.10		1142.10
44	Danebury	335	E	IA	H	229		1199.73		1199.73
44	Danebury	337	E	IA		248		1299.27		1299.27
44	Danebury	338	E	IA	H	251		1314.99		1314.99
44	Danebury	339	E	IA		231		1210.21		1210.21
44	Danebury	340	E	IA	H	251.5		1317.61		1317.61
44	Danebury	341	E	IA		250		1309.75		1309.75
44	Danebury	342	E	IA		245		1283.56		1283.56

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
46	E London RB Cemetary	320	E	RO	H*	270.9	263.4	1419.25	1404.19	1411.72
47	Beddington Sewage Farm	314	E	IA+RO		246.6	239.7	1291.94	1277.84	1284.89
47	Beddington Sewage Farm	317	E	IA+RO	H?	245	236	1283.56	1258.12	1270.84
47	Beddington Sewage Farm	318	E	IA+RO	H	257	248.3	1346.42	1323.69	1335.06
49	Buckingham Street	312	E	RO			251		1338.08	1338.08
52	Magiovinium	309	E	RO			256		1364.74	1364.74
52	Magiovinium	310	E	RO			278		1482.02	1482.02
52	Magiovinium	311	E	RO			246		1311.43	1311.43
53	Ashville Trading Estate	306	E	IA			249.5		1330.08	1330.08
53	Ashville Trading Estate	307	E	IA			258		1375.40	1375.40
53	Ashville Trading Estate	308	E	IA			233		1242.12	1242.12
54	Thorpe Thewles	301	E	IA+RO	H*	242		1267.84		1267.84
54	Thorpe Thewles	305	E	IA+RO	M*	242		1267.84		1267.84
57	La Sagesse	297	E	IA		224.5	220.5	1176.16	1175.49	1175.82
58	Braintree	296	E	RO		250.5		1312.37		1312.37
63	S. Giacomo	291	A	RO		284	281	1487.88	1498.01	1492.94
66	Settefinestre	285	A	RO	H*	277		1451.20		1451.20
68	Lutton/Huntingdon	279	E	IA+RO	H?	286	277	1498.35	1476.69	1487.52
68	Lutton/Huntingdon	280	E	IA+RO	H?	272	268	1425.01	1428.71	1426.86
68	Lutton/Huntingdon	282	E	IA+RO		259	250	1356.90	1332.75	1344.83
68	Lutton/Huntingdon	283	E	IA+RO	H	254	246	1330.71	1311.43	1321.07
70	Emilia	277	A	IA+RO		213.5	209	1118.53	1114.18	1116.35
74	Sovana	275	A	IA		252		1320.23		1320.23
81	Welsow	271	F	NAT	H	259.7		1360.57		1360.57
81	Welsow	272	F	NAT	H?	247.5		1296.65		1296.65
81	Welsow	273	F	NAT	H*	246		1288.79		1288.79
85	Macon	269	D	IA+RO	M*	285		1493.12		1493.12
87	Manching	212	F	IA		225	221.5	1178.78	1180.82	1179.80
87	Manching	213	F	IA		224	222	1173.54	1183.48	1178.51
87	Manching	214	F	IA		223	220	1168.30	1172.82	1170.56
87	Manching	215	F	IA		222.5	220	1165.68	1172.82	1169.25
87	Manching	216	F	IA		218	215	1142.10	1146.17	1144.13
87	Manching	217	F	IA		217	214	1136.86	1140.83	1138.85
87	Manching	218	F	IA		217	214	1136.86	1140.83	1138.85
87	Manching	219	F	IA		232	229	1215.45	1220.80	1218.12
87	Manching	220	F	IA		231	229	1210.21	1220.80	1215.50
87	Manching	221	F	IA		231	228.5	1210.21	1218.13	1214.17
87	Manching	222	F	IA		231	228	1210.21	1215.47	1212.84
87	Manching	223	F	IA		231	227.5	1210.21	1212.80	1211.51
87	Manching	224	F	IA		228		1194.49		1194.49
87	Manching	225	F	IA		228	224.5	1194.49	1196.81	1195.65
87	Manching	226	F	IA		227	224	1189.25	1194.14	1191.70
87	Manching	227	F	IA		226.5	223.5	1186.63	1191.48	1189.06
87	Manching	228	F	IA		226	223	1184.01	1188.81	1186.41
87	Manching	229	F	IA		236.5	233.5	1239.02	1244.79	1241.91
87	Manching	230	F	IA		236.5	232.5	1239.02	1239.46	1239.24
87	Manching	231	F	IA		236	234	1236.40	1247.45	1241.93
87	Manching	232	F	IA		236	233	1236.40	1242.12	1239.26
87	Manching	233	F	IA		236	233	1236.40	1242.12	1239.26
87	Manching	234	F	IA		234	231	1225.93	1231.46	1228.69
87	Manching	235	F	IA		233.5	230	1223.31	1226.13	1224.72
87	Manching	236	F	IA		233	229.5	1220.69	1223.46	1222.08
87	Manching	237	F	IA		232.5	229	1218.07	1220.80	1219.43
87	Manching	238	F	IA		232.5	229	1218.07	1220.80	1219.43
87	Manching	239	F	IA		243.5	241	1275.70	1284.77	1280.23
87	Manching	240	F	IA		242	240	1267.84	1279.44	1273.64

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
87	Manching	241	F	IA		242	239	1267.84	1274.11	1270.97
87	Manching	242	F	IA		240	238	1257.36	1268.78	1263.07
87	Manching	243	F	IA		240	236	1257.36	1258.12	1257.74
87	Manching	244	F	IA		239	236	1252.12	1258.12	1255.12
87	Manching	245	F	IA		239	235.5	1252.12	1255.45	1253.79
87	Manching	246	F	IA		239	235	1252.12	1252.79	1252.45
87	Manching	247	F	IA		237.5	235	1244.26	1252.79	1248.52
87	Manching	248	F	IA		237	233	1241.64	1242.12	1241.88
87	Manching	249	F	IA		250	246.5	1309.75	1314.09	1311.92
87	Manching	250	F	IA		250	246.5	1309.75	1314.09	1311.92
87	Manching	251	F	IA		249.5	246	1307.13	1311.43	1309.28
87	Manching	252	F	IA		247.5		1296.65		1296.65
87	Manching	253	F	IA		247	243	1294.03	1295.43	1294.73
87	Manching	254	F	IA		246.5	241.5	1291.41	1287.44	1289.43
87	Manching	255	F	IA		245.5	242	1286.17	1290.10	1288.14
87	Manching	256	F	IA		245	242	1283.56	1290.10	1286.83
87	Manching	257	F	IA		244.5	241	1280.94	1284.77	1282.85
87	Manching	258	F	IA		244	241	1278.32	1284.77	1281.54
87	Manching	259	F	IA		251	247.5	1314.99	1319.42	1317.21
87	Manching	260	F	IA		288	286	1508.83	1524.67	1516.75
87	Manching	261	F	IA		283.5	279	1485.26	1487.35	1486.30
87	Manching	262	F	IA		273	270	1430.25	1439.37	1434.81
87	Manching	263	F	IA		271	267.5	1419.77	1426.04	1422.91
87	Manching	264	F	IA		271	266	1419.77	1418.05	1418.91
87	Manching	265	F	IA		260	257	1362.14	1370.07	1366.10
87	Manching	266	F	IA		255	251.5	1335.95	1340.75	1338.35
87	Manching	267	F	IA		253	249	1325.47	1327.42	1326.44
87	Manching	268	F	IA		252.5	249	1322.85	1327.42	1325.13
88	Zwammerdam	152	F	RO		273	265	1430.25	1412.72	1421.48
88	Zwammerdam	153	F	RO		277	267	1451.20	1423.38	1437.29
92	Feddersen Wierde	28	F	NAT	H	244.3		1279.89		1279.89
92	Feddersen Wierde	29	F	NAT	H	259.6		1360.04		1360.04
92	Feddersen Wierde	30	F	NAT		251		1314.99		1314.99
92	Feddersen Wierde	31	F	NAT		247.1		1294.56		1294.56
92	Feddersen Wierde	32	F	NAT	H?	258.2		1352.71		1352.71
92	Feddersen Wierde	33	F	NAT	M*	260.7		1365.81		1365.81
92	Feddersen Wierde	34	F	NAT	H*	236		1236.40		1236.40
92	Feddersen Wierde	35	F	NAT	H	241.8		1266.79		1266.79
92	Feddersen Wierde	36	F	NAT	H	247		1294.03		1294.03
92	Feddersen Wierde	37	F	NAT	H*	257.4		1348.52		1348.52
92	Feddersen Wierde	38	F	NAT	H	239.7		1255.79		1255.79
92	Feddersen Wierde	39	F	NAT	M?	250		1309.75		1309.75
92	Feddersen Wierde	40	F	NAT	H*	270.7		1418.20		1418.20
92	Feddersen Wierde	41	F	NAT	H*	241.6		1265.74		1265.74
92	Feddersen Wierde	42	F	NAT	M*	257.1		1346.95		1346.95
92	Feddersen Wierde	43	F	NAT	H	250.6		1312.89		1312.89
92	Feddersen Wierde	44	F	NAT		258.8		1355.85		1355.85
92	Feddersen Wierde	45	F	NAT	H*	247.2		1295.08		1295.08
92	Feddersen Wierde	46	F	NAT	H*	271.3		1421.34		1421.34
92	Feddersen Wierde	47	F	NAT	M?	249.1		1305.03		1305.03
92	Feddersen Wierde	48	F	NAT	H	247.5		1296.65		1296.65
92	Feddersen Wierde	49	F	NAT	H	269.2		1410.34		1410.34
92	Feddersen Wierde	50	F	NAT	H?	239		1252.12		1252.12
92	Feddersen Wierde	51	F	NAT	H	245.5		1286.17		1286.17
92	Feddersen Wierde	52	F	NAT	H	246.8		1292.99		1292.99
92	Feddersen Wierde	53	F	NAT	H	249.8		1308.70		1308.70

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
92	Feddersen Wierde	54	F	NAT	H*	255.7		1339.61		1339.61
92	Feddersen Wierde	55	F	NAT	H	238.3		1248.45		1248.45
92	Feddersen Wierde	56	F	NAT	H*	232.9		1220.16		1220.16
92	Feddersen Wierde	57	F	NAT	H*	253.7		1329.13		1329.13
92	Feddersen Wierde	58	F	NAT	H	247.3		1295.60		1295.60
92	Feddersen Wierde	59	F	NAT	H	257.2		1347.47		1347.47
92	Feddersen Wierde	60	F	NAT		249.5		1307.13		1307.13
92	Feddersen Wierde	61	F	NAT	H*	256		1341.18		1341.18
92	Feddersen Wierde	62	F	NAT		255.3		1337.52		1337.52
92	Feddersen Wierde	63	F	NAT	H?	257.6		1349.57		1349.57
92	Feddersen Wierde	64	F	NAT	H	260.9		1366.86		1366.86
92	Feddersen Wierde	65	F	NAT	H	239.6		1255.26		1255.26
92	Feddersen Wierde	66	F	NAT	M*	259.3		1358.47		1358.47
92	Feddersen Wierde	67	F	NAT	M*	262.3		1374.19		1374.19
92	Feddersen Wierde	68	F	NAT	H	247		1294.03		1294.03
92	Feddersen Wierde	69	F	NAT	H	234.2		1226.97		1226.97
92	Feddersen Wierde	70	F	NAT	H	249.5		1307.13		1307.13
92	Feddersen Wierde	71	F	NAT	H	262.7		1376.29		1376.29
92	Feddersen Wierde	72	F	NAT	H*	259.4		1359.00		1359.00
92	Feddersen Wierde	73	F	NAT	H	262.3		1374.19		1374.19
92	Feddersen Wierde	74	F	NAT	H	247.8		1298.22		1298.22
92	Feddersen Wierde	75	F	NAT	H	255.3		1337.52		1337.52
92	Feddersen Wierde	76	F	NAT		253.6		1328.61		1328.61
92	Feddersen Wierde	77	F	NAT	H	246.2		1289.84		1289.84
92	Feddersen Wierde	78	F	NAT	M?	251.2		1316.04		1316.04
92	Feddersen Wierde	79	F	NAT	M?	252.1		1320.75		1320.75
92	Feddersen Wierde	80	F	NAT	H	245		1283.56		1283.56
92	Feddersen Wierde	81	F	NAT	H?	259.4		1359.00		1359.00
92	Feddersen Wierde	82	F	NAT		246.6		1291.94		1291.94
92	Feddersen Wierde	83	F	NAT	H	260.4		1364.24		1364.24
92	Feddersen Wierde	84	F	NAT	H	248.9		1303.99		1303.99
92	Feddersen Wierde	85	F	NAT	H	253.6		1328.61		1328.61
92	Feddersen Wierde	86	F	NAT	H	247		1294.03		1294.03
92	Feddersen Wierde	87	F	NAT	M*	252.2		1321.28		1321.28
92	Feddersen Wierde	88	F	NAT	H	244.6		1281.46		1281.46
92	Feddersen Wierde	89	F	NAT	H	259.3		1358.47		1358.47
92	Feddersen Wierde	90	F	NAT	H	245.9		1288.27		1288.27
92	Feddersen Wierde	91	F	NAT	H	258.2		1352.71		1352.71
92	Feddersen Wierde	92	F	NAT	H	243.8		1277.27		1277.27
92	Feddersen Wierde	93	F	NAT	H?	248.4		1301.37		1301.37
92	Feddersen Wierde	94	F	NAT		247.1		1294.56		1294.56
92	Feddersen Wierde	95	F	NAT	H	242.2		1268.89		1268.89
92	Feddersen Wierde	96	F	NAT	H*	270.6		1417.67		1417.67
92	Feddersen Wierde	97	F	NAT		237.6		1244.79		1244.79
92	Feddersen Wierde	98	F	NAT	D*	256.6		1344.33		1344.33
92	Feddersen Wierde	99	F	NAT	H*	241.7		1266.27		1266.27
92	Feddersen Wierde	100	F	NAT		255.3		1337.52		1337.52
92	Feddersen Wierde	101	F	NAT	H	241.4		1264.69		1264.69
92	Feddersen Wierde	102	F	NAT	H?	255.3		1337.52		1337.52
92	Feddersen Wierde	103	F	NAT	H?	258.1		1352.19		1352.19
92	Feddersen Wierde	104	F	NAT	H	239.6		1255.26		1255.26
92	Feddersen Wierde	105	F	NAT	H	257.1		1346.95		1346.95
92	Feddersen Wierde	106	F	NAT		258.2		1352.71		1352.71
92	Feddersen Wierde	107	F	NAT	H	243.6		1276.22		1276.22
92	Feddersen Wierde	108	F	NAT		242.5		1270.46		1270.46
92	Feddersen Wierde	109	F	NAT	H	258.1		1352.19		1352.19

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
92	Feddersen Wierde	110	F	NAT	H	241.7		1266.27		1266.27
92	Feddersen Wierde	111	F	NAT	H?	256.7		1344.85		1344.85
92	Feddersen Wierde	112	F	NAT		256		1341.18		1341.18
92	Feddersen Wierde	113	F	NAT	H	244.4		1280.41		1280.41
92	Feddersen Wierde	114	F	NAT	H*	248.6		1302.42		1302.42
92	Feddersen Wierde	115	F	NAT	H	270.9		1419.25		1419.25
92	Feddersen Wierde	116	F	NAT	M	262		1372.62		1372.62
92	Feddersen Wierde	117	F	NAT	H	255.7		1339.61		1339.61
92	Feddersen Wierde	118	F	NAT	H*	240.4		1259.46		1259.46
92	Feddersen Wierde	119	F	NAT	H	252.3		1321.80		1321.80
92	Feddersen Wierde	120	F	NAT	M*	255.2		1336.99		1336.99
92	Feddersen Wierde	121	F	NAT	H	242.9		1272.55		1272.55
92	Feddersen Wierde	122	F	NAT	M*	261.9		1372.09		1372.09
92	Feddersen Wierde	123	F	NAT	H*	235.6		1234.31		1234.31
92	Feddersen Wierde	124	F	NAT	H	247.5		1296.65		1296.65
92	Feddersen Wierde	125	F	NAT	H	249.9		1309.23		1309.23
92	Feddersen Wierde	126	F	NAT	H*	250.6		1312.89		1312.89
92	Feddersen Wierde	127	F	NAT	H	239.6		1255.26		1255.26
92	Feddersen Wierde	128	F	NAT	M*	263.6		1381.00		1381.00
92	Feddersen Wierde	129	F	NAT	H	232		1215.45		1215.45
92	Feddersen Wierde	130	F	NAT	M?	249.8		1308.70		1308.70
92	Feddersen Wierde	131	F	NAT	H*	236.1		1236.93		1236.93
92	Feddersen Wierde	132	F	NAT	M*	248.4		1301.37		1301.37
92	Feddersen Wierde	133	F	NAT		250.9		1314.47		1314.47
92	Feddersen Wierde	134	F	NAT	H	247.8		1298.22		1298.22
92	Feddersen Wierde	135	F	NAT	H?	248.2		1300.32		1300.32
92	Feddersen Wierde	136	F	NAT	H*	247		1294.03		1294.03
92	Feddersen Wierde	137	F	NAT	H*	267.3		1400.38		1400.38
92	Feddersen Wierde	138	F	NAT	H*	237.9		1246.36		1246.36
92	Feddersen Wierde	139	F	NAT	M*	260.3		1363.71		1363.71
92	Feddersen Wierde	140	F	NAT	H*	249.9		1309.23		1309.23
92	Feddersen Wierde	141	F	NAT	H*	248.5		1301.89		1301.89
92	Feddersen Wierde	142	F	NAT		233		1220.69		1220.69
92	Feddersen Wierde	143	F	NAT	M*	259		1356.90		1356.90
92	Feddersen Wierde	144	F	NAT	H?	243.3		1274.65		1274.65
92	Feddersen Wierde	145	F	NAT	H*	245.4		1285.65		1285.65
92	Feddersen Wierde	146	F	NAT	M*	256.8		1345.38		1345.38
92	Feddersen Wierde	147	F	NAT	H*	269.3		1410.86		1410.86
93	Caerwent	24	E	RO		215		1126.39		1126.39
98	Prestatyn	483	E	RO		243	240.5	1273.08	1282.11	1277.59
101	Chignall Roman Villa	497	E	IA+RO		242		1267.84		1267.84
101	Chignall Roman Villa	498	E	IA+RO		198		1037.32		1037.32
101	Chignall Roman Villa	499	E	IA+RO		234		1225.93		1225.93
101	Chignall Roman Villa	500	E	IA+RO		204		1068.76		1068.76
101	Chignall Roman Villa	501	E	IA+RO		212		1110.67		1110.67
104	Orton Hall Farm	504	E	RO	H	236		1236.40		1236.40
104	Orton Hall Farm	505	E	RO	M	258		1351.66		1351.66
104	Orton Hall Farm	506	E	RO	H*	252		1320.23		1320.23
104	Orton Hall Farm	507	E	RO	H?	276		1445.96		1445.96
104	Orton Hall Farm	508	E	RO		215		1126.39		1126.39
105	Mons Claudianus	509	K	RO	H*	272	268	1425.01	1428.71	1426.86
105	Mons Claudianus	510	K	RO	M	264.9	259	1387.81	1380.73	1384.27
105	Mons Claudianus	512	K	RO	M*	253	246.5	1325.47	1314.09	1319.78
105	Mons Claudianus	514	K	RO		242	235	1267.84	1252.79	1260.31
105	Mons Claudianus	518	K	RO		227.6	220	1192.40	1172.82	1182.61
105	Mons Claudianus	519	K	RO			234.1		1247.99	1247.99

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
112	Pompeii, Sarno Baths	593	A	RO		215.5		1129.00		1129.00
112	Pompeii, Sarno Baths	594	A	RO		275.5		1443.34		1443.34
112	Pompeii, Sarno Baths	595	A	RO		274		1435.49		1435.49
112	Pompeii, Sarno Baths	596	A	RO		335		1755.07		1755.07
114	Unterlaa	597	F	RO			273.2		1456.43	1456.43
115	Bad Wimpfen	605	F	RO	H	276.3	268.1	1447.54	1429.24	1438.39
115	Bad Wimpfen	606	F	RO	H	264.3	257.7	1384.67	1373.80	1379.23
115	Bad Wimpfen	607	F	RO		264.2	257.6	1384.14	1373.27	1378.70
115	Bad Wimpfen	608	F	RO		262	257	1372.62	1370.07	1371.34
115	Bad Wimpfen	609	F	RO			285.3		1520.93	1520.93
115	Bad Wimpfen	613	F	RO		284	277	1487.88	1476.69	1482.28
115	Bad Wimpfen	614	F	RO		278	270.5	1456.44	1442.04	1449.24
115	Bad Wimpfen	615	F	RO		269.5	262	1411.91	1396.72	1404.32
115	Bad Wimpfen	616	F	RO	D	207	203	1084.47	1082.19	1083.33
116	Pommeroeul	617	D	RO	H	246	240	1288.79	1279.44	1284.12
116	Pommeroeul	618	D	RO	H	250		1309.75		1309.75
116	Pommeroeul	619	D	RO	H	250	239	1309.75	1274.11	1291.93
116	Pommeroeul	620	D	RO	H	250	241	1309.75	1284.77	1297.26
116	Pommeroeul	621	D	RO	H	257	248	1346.42	1322.09	1334.26
116	Pommeroeul	622	D	RO	H*	257	245	1346.42	1306.10	1326.26
116	Pommeroeul	623	D	RO	M*	266	255	1393.57	1359.41	1376.49
116	Pommeroeul	624	D	RO	H*	266	258	1393.57	1375.40	1384.49
116	Pommeroeul	625	D	RO	M	268	257	1404.05	1370.07	1387.06
116	Pommeroeul	626	D	RO	H*	271	263	1419.77	1402.05	1410.91
116	Pommeroeul	627	D	RO	H*	271	264	1419.77	1407.38	1413.58
116	Pommeroeul	628	D	RO	H*	272	263	1425.01	1402.05	1413.53
116	Pommeroeul	629	D	RO	H?	281	272	1472.16	1450.03	1461.10
116	Pommeroeul	630	D	RO	M*	291		1524.55		1524.55
116	Pommeroeul	631	D	RO	H*	296	288	1550.74	1535.33	1543.04
118	Carnuntum	640	F	RO		291	284.7	1524.55	1517.74	1521.14
119	Albertfalva	643	G	RO		251.3		1316.56		1316.56
120	Basel-Gasfabrik	644	F	IA		225	221	1178.78	1178.15	1178.46
120	Basel-Gasfabrik	645	F	IA		220	216.5	1152.58	1154.16	1153.37
121	Soluthurn/Vigier	650	F	RO	M*	285	277.5	1493.12	1479.35	1486.23
121	Soluthurn/Vigier	651	F	RO	M	276	267.8	1445.96	1427.64	1436.80
121	Soluthurn/Vigier	652	F	RO	M*	272.3	267.8	1426.58	1427.64	1427.11
121	Soluthurn/Vigier	654	F	RO		284.2	277	1488.92	1476.69	1482.81
121	Soluthurn/Vigier	655	F	RO		280		1466.92		1466.92
121	Soluthurn/Vigier	656	F	RO		272		1425.01		1425.01
121	Soluthurn/Vigier	657	F	RO			269.8		1438.30	1438.30
123	Wroxeter Baths basilica	658	E	RO		261.5		1370.00		1370.00
123	Wroxeter Baths basilica	659	E	RO	H	265		1388.34		1388.34
123	Wroxeter Baths basilica	660	E	RO	H	250.4		1311.85		1311.85
124	Haddon	664	E	IA+RO		246	244	1288.79	1300.76	1294.78
124	Haddon	665	E	IA+RO		261	260	1367.38	1386.06	1376.72
124	Haddon	666	E	IA+RO		261	260	1367.38	1386.06	1376.72
124	Haddon	667	E	IA+RO		239	237	1252.12	1263.45	1257.78
124	Haddon	668	E	IA+RO		250	247	1309.75	1316.76	1313.25
124	Haddon	669	E	IA+RO		254	251	1330.71	1338.08	1334.39
124	Haddon	670	E	IA+RO		253	250	1325.47	1332.75	1329.11
125	Castleford	673	E	RO	H*	274		1435.49		1435.49
125	Castleford	674	E	RO	H	256		1341.18		1341.18
125	Castleford	675	E	RO	M*	252		1320.23		1320.23
127	Tortoreto-Fortellezza	677	A	IA		205		1074.00		1074.00
128	Krefeld-Gellep	685	F	RO		272		1425.01		1425.01
129	Lorenzberg Bei Epfach	689	F	RO		294	289	1540.27	1540.66	1540.46

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
129	Lorenzberg Bei Epfach	690	F	RO		272	267	1425.01	1423.38	1424.19
129	Lorenzberg Bei Epfach	691	F	RO		268	264	1404.05	1407.38	1405.72
129	Lorenzberg Bei Epfach	695	F	RO		258	253	1351.66	1348.74	1350.20
129	Lorenzberg Bei Epfach	696	F	RO		251	246	1314.99	1311.43	1313.21
129	Lorenzberg Bei Epfach	699	F	RO		256	252.5	1341.18	1346.08	1343.63
129	Lorenzberg Bei Epfach	700	F	RO		253.5	251	1328.09	1338.08	1333.08
130	Msecke Zehrovice	704	G	IA		274	265.1	1435.49	1413.25	1424.37
132	Godmanchester	708	E	RO		275		1440.73		1440.73
132	Godmanchester	709	E	RO		280		1466.92		1466.92
132	Godmanchester	710	E	RO		251		1314.99		1314.99
132	Godmanchester	711	E	RO		273		1430.25		1430.25
132	Godmanchester	712	E	RO		271		1419.77		1419.77
132	Godmanchester	713	E	RO		259.9		1361.62		1361.62
132	Godmanchester	715	E	RO		266		1393.57		1393.57
132	Godmanchester	716	E	RO		265		1388.34		1388.34
132	Godmanchester	717	E	RO		243		1273.08		1273.08
132	Godmanchester	720	E	RO		270		1414.53		1414.53
132	Godmanchester	721	E	RO		270		1414.53		1414.53
133	Colchester	723	E	RO		269		1409.29		1409.29
133	Colchester	724	E	RO		253.5		1328.09		1328.09
133	Colchester	725	E	RO		263		1377.86		1377.86
133	Colchester	727	E	RO		212		1110.67		1110.67
133	Colchester	728	E	RO		233		1220.69		1220.69
134	Butzbach	729	F	RO	H?	284	280	1487.88	1492.68	1490.28
134	Butzbach	730	F	RO	D*	245		1283.56		1283.56
134	Butzbach	731	F	RO	M	291	285	1524.55	1519.34	1521.94
134	Butzbach	732	F	RO	H*	281	275	1472.16	1466.03	1469.09
134	Butzbach	735	F	RO	M*	303	297	1587.42	1583.31	1585.36
137	Magdelenska Gora	742	G	IA		255		1335.95		1335.95
137	Magdelenska Gora	743	G	IA		260		1362.14		1362.14
137	Magdelenska Gora	744	G	IA		252.5		1322.85		1322.85
137	Magdelenska Gora	745	G	IA		248		1299.27		1299.27
146	Balatonaliga	749	G	RO		265		1388.34		1388.34
146	Balatonaliga	752	G	RO	H*	264		1383.10		1383.10
147	Pilismarot I Watchtower	753	G	RO	H	245		1283.56		1283.56
147	Pilismarot I Watchtower	754	G	RO	H	245		1283.56		1283.56
147	Pilismarot I Watchtower	755	G	RO	H*	243		1273.08		1273.08
149	Helemba - Sziget	756	G	IA	H*	231		1210.21		1210.21
149	Helemba - Sziget	757	G	IA	H	253.5		1328.09		1328.09
149	Helemba - Sziget	758	G	IA	H*	254		1330.71		1330.71
151	Gyor Szechenyi-Ter	759	G	RO	H*	282		1477.40		1477.40
153	Aquileia forum	773	A	RO		271	164.5	1419.77	876.95	1148.36
153	Aquileia forum	774	A	RO	M*	275	266	1440.73	1418.05	1429.39
153	Aquileia forum	775	A	RO		280	271	1466.92	1444.70	1455.81
155	Gravina 1	777	A	RO		242		1267.84		1267.84
155	Gravina 1	778	A	RO		214		1121.15		1121.15
156	Invillino- Ibliglo	781	A	RO		273	266	1430.25	1418.05	1424.15
156	Invillino- Ibliglo	782	A	RO		272	265	1425.01	1412.72	1418.86
156	Invillino- Ibliglo	783	A	RO		263	255	1377.86	1359.41	1368.63
156	Invillino- Ibliglo	784	A	RO		254	247.5	1330.71	1319.42	1325.06
157	Lugnano	785	A	RO		230		1204.97		1204.97
161	San Giovanni	790	A	RO		270.2		1415.58		1415.58
167	Via Gabina 10	794	A	RO		270		1414.53		1414.53
175	Sablonetum-Ellingen	802	F	RO		282.5	277	1480.02	1476.69	1478.35
176	Oberdorla	803	F	NAT		277	269	1451.20	1434.04	1442.62
176	Oberdorla	804	F	NAT	M*	266	260	1393.57	1386.06	1389.82

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
176	Oberdorla	805	F	NAT	M*	262	256	1372.62	1364.74	1368.68
176	Oberdorla	806	F	NAT	H	260	252	1362.14	1343.41	1352.78
176	Oberdorla	807	F	NAT	H*	254	246	1330.71	1311.43	1321.07
176	Oberdorla	808	F	NAT	M*	254	246	1330.71	1311.43	1321.07
176	Oberdorla	810	F	NAT	M	253	248	1325.47	1322.09	1323.78
176	Oberdorla	811	F	NAT	H*	253	243	1325.47	1295.43	1310.45
176	Oberdorla	812	F	NAT	H*	251	244	1314.99	1300.76	1307.88
176	Oberdorla	813	F	NAT	M?	251	243	1314.99	1295.43	1305.21
176	Oberdorla	814	F	NAT	H*	251	241	1314.99	1284.77	1299.88
176	Oberdorla	815	F	NAT	H	250	245	1309.75	1306.10	1307.92
176	Oberdorla	816	F	NAT	H	248	242	1299.27	1290.10	1294.69
176	Oberdorla	817	F	NAT	H*	246	239	1288.79	1274.11	1281.45
176	Oberdorla	818	F	NAT	D*	218	211	1142.10	1124.84	1133.47
178	Vitudurum-Oberwinterthur	822	F	RO		243.5		1275.70		1275.70
178	Vitudurum-Oberwinterthur	823	F	RO		281	271	1472.16	1444.70	1458.43
179	Catterick CEU240	826	E	RO		255		1335.95		1335.95
179	Catterick CEU240	827	E	RO		255		1335.95		1335.95
179	Catterick CEU240	829	E	RO		268.4		1406.15		1406.15
180	Catterick 434	830	E	RO		258		1351.66		1351.66
180	Catterick 434	831	E	RO		263		1377.86		1377.86
181	Barnsley Park	832	E	RO		250		1309.75		1309.75
181	Barnsley Park	833	E	RO		250		1309.75		1309.75
182	Frocester Court	836	E	RO		243		1273.08		1273.08
182	Frocester Court	837	E	RO		230		1204.97		1204.97
183	Segontium	839	E	RO		250		1309.75		1309.75
183	Segontium	840	E	RO		290		1519.31		1519.31
185	Shakenoak site C	843	E	RO		242		1267.84		1267.84
186	Shakenoak site K	845	E	RO		270		1414.53		1414.53
188	Titelberg oppidum	849	D	RO	H*	256	247	1341.18	1316.76	1328.97
189	Kassope	852	H	IA	D	217		1136.86		1136.86
189	Kassope	854	H	IA	D	220		1152.58		1152.58
189	Kassope	858	H	IA	D*	198	193	1037.32	1028.88	1033.10
189	Kassope	864	H	IA	D	236.5	232.5	1239.02	1239.46	1239.24
189	Kassope	865	H	IA	D	220	216.5	1152.58	1154.16	1153.37
189	Kassope	866	H	IA	D	231	228	1210.21	1215.47	1212.84
189	Kassope	870	H	IA	D	225	222	1178.78	1183.48	1181.13
192	Pfaffenhofen - Pons Aeni	875	F	RO		259	250	1356.90	1332.75	1344.83
192	Pfaffenhofen - Pons Aeni	876	F	RO		268	260	1404.05	1386.06	1395.06
192	Pfaffenhofen - Pons Aeni	877	F	RO		270	260.5	1414.53	1388.73	1401.63
192	Pfaffenhofen - Pons Aeni	879	F	RO		285	277	1493.12	1476.69	1484.90
194	Vemania	881	F	RO		263		1377.86		1377.86
195	Kunzing-Quintana	882	F	RO		288	280	1508.83	1492.68	1500.76
195	Kunzing-Quintana	883	F	RO		284	277	1487.88	1476.69	1482.28
195	Kunzing-Quintana	884	F	RO		258	249	1351.66	1327.42	1339.54
195	Kunzing-Quintana	885	F	RO		249	240	1304.51	1279.44	1291.98
199	Hufingen	889	F	RO		277	270.5	1451.20	1442.04	1446.62
199	Hufingen	890	F	RO		272.5	264.5	1427.63	1410.05	1418.84
199	Hufingen	891	F	RO		272	265.5	1425.01	1415.38	1420.19
199	Hufingen	892	F	RO		271	263	1419.77	1402.05	1410.91
199	Hufingen	893	F	RO		264	256	1383.10	1364.74	1373.92
199	Hufingen	894	F	RO		264	257.5	1383.10	1372.73	1377.91
199	Hufingen	895	F	RO		262.5	256	1375.24	1364.74	1369.99
199	Hufingen	896	F	RO		259	252.5	1356.90	1346.08	1351.49
199	Hufingen	897	F	RO		257.5	249.5	1349.04	1330.08	1339.56

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
199	Hufingen	898	F	RO		251	244	1314.99	1300.76	1307.88
199	Hufingen	899	F	RO		249	241	1304.51	1284.77	1294.64
199	Hufingen	915	F	RO		293.5	286.5	1537.65	1527.33	1532.49
199	Hufingen	916	F	RO		277		1451.20		1451.20
199	Hufingen	917	F	RO		272	265.5	1425.01	1415.38	1420.19
199	Hufingen	918	F	RO		267	260.5	1398.81	1388.73	1393.77
199	Hufingen	919	F	RO		266	258	1393.57	1375.40	1384.49
199	Hufingen	920	F	RO		263.5	254	1380.48	1354.07	1367.28
199	Hufingen	921	F	RO		259	251.5	1356.90	1340.75	1348.82
199	Hufingen	922	F	RO		253	247.5	1325.47	1319.42	1322.44
200	Pfaffenhofen	943	F	RO		274	268	1435.49	1428.71	1432.10
200	Pfaffenhofen	944	F	RO		284	275	1487.88	1466.03	1476.95
200	Pfaffenhofen	945	F	RO		262		1372.62		1372.62
201	Wehringen	946	F	RO		259	251	1356.90	1338.08	1347.49
202	Penzlin	949	F	NAT	H	251.6	243.6	1318.13	1298.63	1308.38
202	Penzlin	950	F	NAT	H?	256	248.5	1341.18	1324.75	1332.97
202	Penzlin	951	F	NAT	H?	242	234.8	1267.84	1251.72	1259.78
202	Penzlin	952	F	NAT	H	251.3	243.1	1316.56	1295.97	1306.26
202	Penzlin	953	F	NAT		240	233	1257.36	1242.12	1249.74
202	Penzlin	954	F	NAT	H*	249	242	1304.51	1290.10	1297.31
202	Penzlin	955	F	NAT	H	230.3	223.4	1206.54	1190.95	1198.74
202	Penzlin	956	F	NAT	H	243.8	237	1277.27	1263.45	1270.36
203	Tac-Gorsium	960	G	RO	H?	238.5		1249.50		1249.50
203	Tac-Gorsium	961	G	RO	H*	246		1288.79		1288.79
203	Tac-Gorsium	962	G	RO	H*	247		1294.03		1294.03
203	Tac-Gorsium	963	G	RO	H	248		1299.27		1299.27
203	Tac-Gorsium	964	G	RO	M?	250		1309.75		1309.75
203	Tac-Gorsium	965	G	RO	H	253		1325.47		1325.47
203	Tac-Gorsium	966	G	RO	H*	256		1341.18		1341.18
203	Tac-Gorsium	967	G	RO	D*	257		1346.42		1346.42
203	Tac-Gorsium	968	G	RO	H	258.5		1354.28		1354.28
203	Tac-Gorsium	969	G	RO	H*	259		1356.90		1356.90
203	Tac-Gorsium	970	G	RO	M	260		1362.14		1362.14
203	Tac-Gorsium	971	G	RO		260		1362.14		1362.14
203	Tac-Gorsium	972	G	RO		262		1372.62		1372.62
203	Tac-Gorsium	973	G	RO		262		1372.62		1372.62
203	Tac-Gorsium	974	G	RO	H*	262.5		1375.24		1375.24
203	Tac-Gorsium	975	G	RO	M*	263.5		1380.48		1380.48
203	Tac-Gorsium	976	G	RO	H*	264		1383.10		1383.10
203	Tac-Gorsium	977	G	RO		265		1388.34		1388.34
203	Tac-Gorsium	978	G	RO	H*	266		1393.57		1393.57
203	Tac-Gorsium	979	G	RO	H	267		1398.81		1398.81
203	Tac-Gorsium	980	G	RO		270		1414.53		1414.53
203	Tac-Gorsium	981	G	RO	M*	270		1414.53		1414.53
203	Tac-Gorsium	982	G	RO		270		1414.53		1414.53
203	Tac-Gorsium	983	G	RO	H?	270.5		1417.15		1417.15
203	Tac-Gorsium	984	G	RO	H?	271.5		1422.39		1422.39
203	Tac-Gorsium	985	G	RO	H*	271.5		1422.39		1422.39
203	Tac-Gorsium	986	G	RO		275		1440.73		1440.73
203	Tac-Gorsium	987	G	RO	M*	277		1451.20		1451.20
203	Tac-Gorsium	988	G	RO		277		1451.20		1451.20
203	Tac-Gorsium	989	G	RO		280		1466.92		1466.92
203	Tac-Gorsium	990	G	RO	M?	282		1477.40		1477.40
203	Tac-Gorsium	991	G	RO	M*	282.5		1480.02		1480.02
203	Tac-Gorsium	992	G	RO	H?	282.5		1480.02		1480.02
203	Tac-Gorsium	993	G	RO	H?	283.5		1485.26		1485.26

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
203	Tac-Gorsium	994	G	RO	M*	286		1498.35		1498.35
203	Tac-Gorsium	995	G	RO	M*	289		1514.07		1514.07
203	Tac-Gorsium	996	G	RO		292		1529.79		1529.79
203	Tac-Gorsium	997	G	RO	M*	296		1550.74		1550.74
203	Tac-Gorsium	1056	G	RO		203.5		1066.14		1066.14
203	Tac-Gorsium	1057	G	RO	D	212		1110.67		1110.67
204	Conchil	1059	D	RO		256.8	246.5	1345.38	1314.09	1329.73
204	Conchil	1060	D	RO		256	245.5	1341.18	1308.76	1324.97
204	Conchil	1061	D	RO		273.5		1432.87		1432.87
204	Conchil	1062	D	RO		268		1404.05		1404.05
204	Conchil	1063	D	RO		255		1335.95		1335.95
206	Lauriacum	1072	F	RO		260	255	1362.14	1359.41	1360.77
206	Lauriacum	1073	F	RO		288	282	1508.83	1503.34	1506.09
206	Lauriacum	1075	F	RO		213	208	1115.91	1108.85	1112.38
208	Colonia Ulpia Traiana	1076	F	RO		278.5	272	1459.06	1450.03	1454.55
208	Colonia Ulpia Traiana	1077	F	RO		276.5	271	1448.58	1444.70	1446.64
208	Colonia Ulpia Traiana	1078	F	RO		272	268	1425.01	1428.71	1426.86
208	Colonia Ulpia Traiana	1079	F	RO		271.5	267	1422.39	1423.38	1422.88
208	Colonia Ulpia Traiana	1080	F	RO		270.5	266	1417.15	1418.05	1417.60
208	Colonia Ulpia Traiana	1081	F	RO		267	265	1398.81	1412.72	1405.76
208	Colonia Ulpia Traiana	1082	F	RO		266	263	1393.57	1402.05	1397.81
208	Colonia Ulpia Traiana	1083	F	RO		266	261	1393.57	1391.39	1392.48
209	Iatrus	1089	G	RO	H	278.1		1456.97		1456.97
211	Castillar de Mendavia	1090	B	IA		262.5	258	1375.24	1375.40	1375.32
211	Castillar de Mendavia	1091	B	IA		257	251	1346.42	1338.08	1342.25
211	Castillar de Mendavia	1092	B	IA		255	250	1335.95	1332.75	1334.35
212	Gournay	1093	D	IA	H*	245		1283.56		1283.56
212	Gournay	1094	D	IA	M	233		1220.69		1220.69
212	Gournay	1095	D	IA	D*	267		1398.81		1398.81
213	Beauvais	1096	D	IA	H	233		1220.69		1220.69
213	Beauvais	1097	D	IA	H*	247		1294.03		1294.03
213	Beauvais	1098	D	IA	M*	259		1356.90		1356.90
213	Beauvais	1099	D	IA	H	249		1304.51		1304.51
213	Beauvais	1100	D	IA	M?	242		1267.84		1267.84
213	Beauvais	1101	D	IA	H	225		1178.78		1178.78
213	Beauvais	1102	D	IA	M*	284		1487.88		1487.88
214	Compiegne	1103	D	IA	H?	242		1267.84		1267.84
214	Compiegne	1104	D	IA	H	253		1325.47		1325.47
215	Ribemont	1105	D	IA	H	226		1184.01		1184.01
215	Ribemont	1106	D	IA	H	228		1194.49		1194.49
215	Ribemont	1107	D	IA	H*	232		1215.45		1215.45
216	Variscourt	1108	D	IA	H	230		1204.97		1204.97
216	Variscourt	1109	D	IA	H*	231		1210.21		1210.21
216	Variscourt	1110	D	IA	H	232		1215.45		1215.45
216	Variscourt	1111	D	IA	H*	246		1288.79		1288.79
216	Variscourt	1112	D	IA	H?	249		1304.51		1304.51
216	Variscourt	1113	D	IA	M*	248		1299.27		1299.27
217	Soissons	1114	D	IA	D	213		1115.91		1115.91

Table A22 – Results of withers height calculations on the isolated Radii

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
4	Market Deeping	358	E	IA		324		1331.96		1331.96
5	Beckford	357	E	IA		294		1208.63		1208.63
8	Hardingstone School	355	E	IA+RO		299		1229.19		1229.19
8	Hardingstone School	356	E	IA+RO		293		1204.52		1204.52
10	Twywell	351	E	IA		322		1323.74		1323.74
13	Wavendon Gate	344	E	IA+RO		347	337	1426.52	1454.83	1440.67
13	Wavendon Gate	345	E	IA+RO		321		1319.63		1319.63
13	Wavendon Gate	346	E	IA+RO		328	303	1348.41	1308.05	1328.23
13	Wavendon Gate	349	E	IA+RO		344		1414.18		1414.18
14	Lincoln	343	E	RO		290		1192.19		1192.19
15	Scole-Dickleburgh	334	E	IA+RO		325.2		1336.90		1336.90
15	Scole-Dickleburgh	339	E	IA+RO		283.2		1164.24		1164.24
15	Scole-Dickleburgh	341	E	IA+RO		288.1		1184.38		1184.38
18	Camulodunum	332	E	IA+RO		280		1151.08		1151.08
23	Puckeridge	329	E	IA		320		1315.52		1315.52
23	Puckeridge	330	E	IA		308		1266.19		1266.19
24	Dunstable	328	E	RO		349		1434.74		1434.74
28	Longthorpe II	325	E	IA+RO		315		1294.97		1294.97
30	Tort Hill East	323	E	RO		325		1336.08		1336.08
35	Castricum-Oosterbuurt	315	F	RO		330		1356.63		1356.63
35	Castricum-Oosterbuurt	319	F	RO		311		1278.52		1278.52
37	Kesteren 'De Prinsenhof'	312	F	RO		358		1471.74		1471.74
38	Nijmegen	285	F	RO		336.1		1381.71		1381.71
38	Nijmegen	288	F	RO		320.3		1316.75		1316.75
38	Nijmegen	289	F	RO		324.6		1334.43		1334.43
38	Nijmegen	290	F	RO		326.7		1343.06		1343.06
38	Nijmegen	291	F	RO		325.9		1339.77		1339.77
38	Nijmegen	292	F	RO		332.7		1367.73		1367.73
38	Nijmegen	294	F	RO		338		1389.52		1389.52
38	Nijmegen	295	F	RO		332.8		1368.14		1368.14
38	Nijmegen	296	F	RO		365		1500.52		1500.52
38	Nijmegen	301	F	RO		369.6		1519.43		1519.43
38	Nijmegen	304	F	RO		330.5		1358.69		1358.69
42	Druten	269	F	IA+RO		354.8		1458.58		1458.58
42	Druten	275	F	IA+RO		330.4		1358.27		1358.27
42	Druten	278	F	IA+RO		360		1479.96		1479.96
43	Elms Farm	254	E	IA+RO		351		1442.96		1442.96
43	Elms Farm	266	E	IA+RO		296	280	1216.86	1208.76	1212.81
43	Elms Farm	267	E	IA+RO		358		1471.74		1471.74
44	Danebury	235	E	IA		314.5		1292.91		1292.91
44	Danebury	236	E	IA		274		1126.41		1126.41
44	Danebury	237	E	IA		295.5		1214.80		1214.80
44	Danebury	238	E	IA		293		1204.52		1204.52
44	Danebury	240	E	IA		312		1282.63		1282.63
44	Danebury	241	E	IA		300		1233.30		1233.30
44	Danebury	242	E	IA		287		1179.86		1179.86
44	Danebury	243	E	IA		277		1138.75		1138.75
44	Danebury	244	E	IA		312.5		1284.69		1284.69
44	Danebury	245	E	IA		286		1175.75		1175.75
44	Danebury	247	E	IA		305		1253.86		1253.86

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
44	Danebury	248	E	IA		300		1233.30		1233.30
44	Danebury	249	E	IA		300		1233.30		1233.30
44	Danebury	250	E	IA		324.9		1335.66		1335.66
44	Danebury	253	E	IA		307		1262.08		1262.08
46	E London RB Cemetary	228	E	RO	H	324.5	309.3	1334.02	1335.25	1334.63
46	E London RB Cemetary	230	E	RO		345	329.7	1418.30	1423.31	1420.80
47	Beddington Sewage Farm	221	E	IA+RO	H*	307.6	256.4	1264.54	1106.88	1185.71
47	Beddington Sewage Farm	224	E	IA+RO	H*	278	263	1142.86	1135.37	1139.11
49	Buckingham Street	220	E	RO			304		1312.37	1312.37
54	Thorpe Thewles	217	E	IA+RO		289.9		1191.78		1191.78
57	La Sagesse	211	E	IA		323	311	1327.85	1342.59	1335.22
66	Settefinestre	204	A	RO		333		1368.96		1368.96
69	Thorley	202	E	IA+RO	H	300	294	1233.30	1269.20	1251.25
69	Thorley	203	E	IA+RO	H	319	304	1311.41	1312.37	1311.89
70	Emilia	201	A	IA+RO	M?	321	308	1319.63	1329.64	1324.63
77	Grotto di Tibera	199	A	RO		324		1331.96		1331.96
78	Cowbridge	198	E	RO		297		1220.97		1220.97
79	Olbia	195	A	IA	D	259.7	242.3	1067.63	1046.01	1056.82
79	Olbia	196	A	IA	D	253.4	240.9	1041.73	1039.97	1040.85
79	Olbia	197	A	IA	D	254.1	243	1044.61	1049.03	1046.82
87	Manching	162	F	IA	H?	273	261	1122.30	1126.74	1124.52
87	Manching	163	F	IA	H?	275	265	1130.53	1144.01	1137.27
87	Manching	164	F	IA	H*	276	264.5	1134.64	1141.85	1138.24
87	Manching	165	F	IA		279.5	267	1149.02	1152.64	1150.83
87	Manching	166	F	IA		287.5	274	1181.91	1182.86	1182.39
87	Manching	167	F	IA	D*	289	275	1188.08	1187.18	1187.63
87	Manching	168	F	IA	H*	291	276.5	1196.30	1193.65	1194.98
87	Manching	169	F	IA	H?	292	278	1200.41	1200.13	1200.27
87	Manching	170	F	IA	D*	293	282	1204.52	1217.39	1210.96
87	Manching	171	F	IA	D*	295.5	285	1214.80	1230.35	1222.57
87	Manching	172	F	IA		297.5	283.5	1223.02	1223.87	1223.45
87	Manching	174	F	IA		298	284	1225.08	1226.03	1225.55
87	Manching	176	F	IA	H	301.5	285	1239.47	1230.35	1234.91
87	Manching	177	F	IA		306	296	1257.97	1277.83	1267.90
87	Manching	179	F	IA	D*	309	293	1270.30	1264.88	1267.59
87	Manching	181	F	IA	H?	312.5	300	1284.69	1295.10	1289.89
87	Manching	182	F	IA			299		1290.78	1290.78
87	Manching	183	F	IA		313.5	299.5	1288.80	1292.94	1290.87
87	Manching	184	F	IA	H?	316	303	1299.08	1308.05	1303.56
87	Manching	185	F	IA	M?	318	303	1307.30	1308.05	1307.67
87	Manching	186	F	IA		326	308.5	1340.19	1331.79	1335.99
87	Manching	187	F	IA		326.5	309	1342.24	1333.95	1338.10
87	Manching	188	F	IA	M?	333.5	316	1371.02	1364.17	1367.60
88	Zwammerdam	66	F	RO		310	305	1274.41	1316.69	1295.55
88	Zwammerdam	67	F	RO		340	325	1397.74	1403.03	1400.38
88	Zwammerdam	68	F	RO		348	340	1430.63	1467.78	1449.20
92	Feddersen Wierde	31	F	NAT	H	304.3	286.5	1250.98	1236.82	1243.90
92	Feddersen Wierde	32	F	NAT	H?	310.6	298.2	1276.88	1287.33	1282.10
92	Feddersen Wierde	33	F	NAT	M	346.2	328.4	1423.23	1417.70	1420.47
92	Feddersen Wierde	34	F	NAT	H?	320.1	305.9	1315.93	1320.57	1318.25
92	Feddersen Wierde	35	F	NAT	H	304.8	292.3	1253.03	1261.86	1257.45
92	Feddersen Wierde	36	F	NAT	H*	303.9	288.3	1249.33	1244.59	1246.96
92	Feddersen Wierde	37	F	NAT	H*	290.7	280	1195.07	1208.76	1201.91
92	Feddersen Wierde	38	F	NAT	H	329.1	313.9	1352.93	1355.11	1354.02
92	Feddersen Wierde	39	F	NAT	H	301	288.7	1237.41	1246.32	1241.86
92	Feddersen Wierde	40	F	NAT	M	316.7	301.6	1301.95	1302.01	1301.98

Site no	Site name	Bone no	Region	Period	ID level	GL	LI	WH-V	WH-K	WH-M
92	Feddersen Wierde	41	F	NAT	H	323.1	310.5	1328.26	1340.43	1334.35
92	Feddersen Wierde	42	F	NAT	M?	315.8	303.7	1298.25	1311.07	1304.66
92	Feddersen Wierde	43	F	NAT	H?	317.1	298.9	1303.60	1290.35	1296.97
92	Feddersen Wierde	44	F	NAT	H	320.8	305.7	1318.81	1319.71	1319.26
92	Feddersen Wierde	45	F	NAT	H	323.5	308.2	1329.91	1330.50	1330.20
92	Feddersen Wierde	46	F	NAT	H	314.1	299.2	1291.27	1291.65	1291.46
92	Feddersen Wierde	47	F	NAT	D*	300.5	288.9	1235.36	1247.18	1241.27
92	Feddersen Wierde	48	F	NAT	H*	302.4	285.3	1243.17	1231.64	1237.40
92	Feddersen Wierde	49	F	NAT		317.1	303.2	1303.60	1308.91	1306.26
92	Feddersen Wierde	50	F	NAT	H	321.6	305	1322.10	1316.69	1319.39
92	Feddersen Wierde	51	F	NAT		306.6	291.1	1260.43	1256.68	1258.56
92	Feddersen Wierde	52	F	NAT	H*	281.6	267.8	1157.66	1156.09	1156.88
92	Feddersen Wierde	53	F	NAT	H*	334	313.9	1373.07	1355.11	1364.09
92	Feddersen Wierde	54	F	NAT	H	303	288.1	1245.63	1243.73	1244.68
92	Feddersen Wierde	55	F	NAT	H	319.4	301.1	1313.05	1299.85	1306.45
92	Feddersen Wierde	56	F	NAT	H	305.7	288.1	1256.73	1243.73	1250.23
92	Feddersen Wierde	57	F	NAT	H?	286.4	274.5	1177.39	1185.02	1181.20
92	Feddersen Wierde	58	F	NAT	H*	301	284.9	1237.41	1229.91	1233.66
92	Feddersen Wierde	59	F	NAT		314.1	298.7	1291.27	1289.49	1290.38
92	Feddersen Wierde	60	F	NAT		316.6		1301.54		1301.54
92	Feddersen Wierde	61	F	NAT	H	311.5	297.6	1280.58	1284.74	1282.66
92	Feddersen Wierde	62	F	NAT	H?	317.7	303.5	1306.06	1310.21	1308.14
92	Feddersen Wierde	63	F	NAT	H?	313.7	300.2	1289.62	1295.96	1292.79
98	Prestatyn	375	E	RO		295	282	1212.75	1217.39	1215.07
103	Newstead fort	387	E	RO		344		1414.18		1414.18
103	Newstead fort	388	E	RO		355		1459.41		1459.41
104	Orton Hall Farm	389	E	RO		311		1278.52		1278.52
104	Orton Hall Farm	390	E	RO		334		1373.07		1373.07
104	Orton Hall Farm	391	E	RO		340		1397.74		1397.74
105	Mons Claudianus	392	K	RO		350		1438.85		1438.85
105	Mons Claudianus	393	K	RO		340	288	1397.74	1243.30	1320.52
105	Mons Claudianus	394	K	RO		333		1368.96		1368.96
105	Mons Claudianus	395	K	RO		330		1356.63		1356.63
105	Mons Claudianus	396	K	RO		325		1336.08		1336.08
105	Mons Claudianus	397	K	RO		323		1327.85		1327.85
105	Mons Claudianus	398	K	RO		321		1319.63		1319.63
105	Mons Claudianus	399	K	RO	M?	320	305	1315.52	1316.69	1316.10
105	Mons Claudianus	400	K	RO	M?	320	302	1315.52	1303.73	1309.63
105	Mons Claudianus	401	K	RO		310	295.1	1274.41	1273.95	1274.18
105	Mons Claudianus	402	K	RO		309		1270.30		1270.30
105	Mons Claudianus	403	K	RO		301		1237.41		1237.41
105	Mons Claudianus	404	K	RO	D*	300	289	1233.30	1247.61	1240.46
105	Mons Claudianus	405	K	RO		300		1233.30		1233.30
105	Mons Claudianus	406	K	RO			290		1251.93	1251.93
105	Mons Claudianus	414	K	RO	M	338	319.5	1389.52	1379.28	1384.40
105	Mons Claudianus	415	K	RO		318	304	1307.30	1312.37	1309.83
105	Mons Claudianus	416	K	RO	M?	313	297	1286.74	1282.15	1284.45
105	Mons Claudianus	417	K	RO		300	285	1233.30	1230.35	1231.82
105	Mons Claudianus	418	K	RO		300		1233.30		1233.30
105	Mons Claudianus	419	K	RO			325		1403.03	1403.03
105	Mons Claudianus	420	K	RO			275		1187.18	1187.18
112	Pompeii, Sarno Baths	492	A	RO		338		1389.52		1389.52
115	Bad Wimpfen	497	F	RO	M*	346	330	1422.41	1424.61	1423.51
115	Bad Wimpfen	498	F	RO	H*	337.5	320	1387.46	1381.44	1384.45
115	Bad Wimpfen	499	F	RO	M*	373	355	1533.40	1532.54	1532.97
115	Bad Wimpfen	500	F	RO	M*	331	315	1360.74	1359.86	1360.30

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
115	Bad Wimpfen	501	F	RO			313		1351.22	1351.22
115	Bad Wimpfen	505	F	RO	M	349	330	1434.74	1424.61	1429.67
115	Bad Wimpfen	506	F	RO	M*	349	330.5	1434.74	1426.77	1430.75
115	Bad Wimpfen	507	F	RO			304.5		1314.53	1314.53
116	Pommeroeul	523	D	RO	H	306	292	1257.97	1260.56	1259.27
116	Pommeroeul	524	D	RO	D*	308	292	1266.19	1260.56	1263.38
116	Pommeroeul	525	D	RO	H*	320	307	1315.52	1325.32	1320.42
116	Pommeroeul	526	D	RO	H?	323	308	1327.85	1329.64	1328.74
116	Pommeroeul	527	D	RO	H*	324	315	1331.96	1359.86	1345.91
116	Pommeroeul	528	D	RO	H*	329	310	1352.52	1338.27	1345.39
116	Pommeroeul	529	D	RO	H*	329	310	1352.52	1338.27	1345.39
116	Pommeroeul	530	D	RO	M*	334	321	1373.07	1385.76	1379.42
116	Pommeroeul	531	D	RO	M*	340	324	1397.74	1398.71	1398.22
116	Pommeroeul	532	D	RO	M*	340	319	1397.74	1377.12	1387.43
116	Pommeroeul	533	D	RO		342	320	1405.96	1381.44	1393.70
116	Pommeroeul	534	D	RO	M	358	340	1471.74	1467.78	1469.76
116	Pommeroeul	535	D	RO	M*	362	337	1488.18	1454.83	1471.51
116	Pommeroeul	536	D	RO	M	366	351	1504.63	1515.27	1509.95
116	Pommeroeul	537	D	RO	M*	377	360	1549.85	1554.12	1551.98
116	Pommeroeul	538	D	RO			323		1394.39	1394.39
116	Pommeroeul	539	D	RO			333		1437.56	1437.56
117	Pompeii stable	541	A	RO		352		1447.07		1447.07
117	Pompeii stable	542	A	RO		322		1323.74		1323.74
118	Carnuntum	543	F	RO	M*	384	366.5	1578.62	1582.18	1580.40
118	Carnuntum	544	F	RO		349	328	1434.74	1415.98	1425.36
118	Carnuntum	545	F	RO		328	312	1348.41	1346.90	1347.66
118	Carnuntum	546	F	RO		368	349	1512.85	1506.63	1509.74
118	Carnuntum	547	F	RO	M*	379	360.5	1558.07	1556.28	1557.17
118	Carnuntum	548	F	RO	M	363	345	1492.29	1489.37	1490.83
120	Basel-Gasfabrik	551	F	IA	H?	277.4	262.5	1140.39	1133.21	1136.80
123	Wroxeter Baths basilica	564	E	RO		333.5		1371.02		1371.02
124	Haddon	572	E	IA+RO		301	290	1237.41	1251.93	1244.67
124	Haddon	573	E	IA+RO		334	323	1373.07	1394.39	1383.73
125	Castleford	574	E	RO		305		1253.86		1253.86
125	Castleford	575	E	RO		364		1496.40		1496.40
125	Castleford	576	E	RO		342		1405.96		1405.96
125	Castleford	578	E	RO		342		1405.96		1405.96
129	Lorenzberg Bei Epfach	590	F	RO		346		1422.41		1422.41
129	Lorenzberg Bei Epfach	593	F	RO	H	320	308	1315.52	1329.64	1322.58
129	Lorenzberg Bei Epfach	595	F	RO	H*	297	283	1220.97	1221.71	1221.34
131	Radovesice	599	G	IA		296	281	1216.86	1213.08	1214.97
133	Colchester	600	E	RO		332		1364.85		1364.85
133	Colchester	602	E	RO		343		1410.07		1410.07
133	Colchester	603	E	RO		313		1286.74		1286.74
133	Colchester	605	E	RO		335		1377.19		1377.19
133	Colchester	606	E	RO		321		1319.63		1319.63
134	Butzbach	608	F	RO		352		1447.07		1447.07
136	Worth Matravers	620	E	IA+RO		319		1311.41		1311.41
137	Magdelenska Gora	621	G	IA		332		1364.85		1364.85
137	Magdelenska Gora	622	G	IA		313		1286.74		1286.74
138	Brezje	623	G	IA		335		1377.19		1377.19
141	Szentes-Vekerzug	624	G	IA		320		1315.52		1315.52
142	Velemszentvid	625	G	IA		330		1356.63		1356.63
142	Velemszentvid	627	G	IA		345		1418.30		1418.30
145	Jaszfelsozentgyorgy	630	G	IA		355		1459.41		1459.41
146	Balatonaliga	631	G	RO		317		1303.19		1303.19

Site no	Site name	Bone no	Region	Period	ID level	GL	LI	WH-V	WH-K	WH-M
147	Pilismarot I Watchtower	633	G	RO		338		1389.52		1389.52
148	Szaszhalombatta	634	G	RO		313		1286.74		1286.74
156	Invillino- Ibliglo	639	A	RO		343	329	1410.07	1420.29	1415.18
161	San Giovanni	645	A	RO		353.2		1452.01		1452.01
173	Paestum	652	A	RO		331		1360.74		1360.74
173	Paestum	653	A	RO		322		1323.74		1323.74
174	Abusina-Eining	654	F	RO		335	320	1377.19	1381.44	1379.31
174	Abusina-Eining	655	F	RO		347.5	330	1428.57	1424.61	1426.59
174	Abusina-Eining	656	F	RO	M*	360	344	1479.96	1485.05	1482.50
176	Oberdorla	665	F	NAT		346	324	1422.41	1398.71	1410.56
176	Oberdorla	666	F	NAT		307	292	1262.08	1260.56	1261.32
176	Oberdorla	667	F	NAT		285	272	1171.64	1174.22	1172.93
177	Champlieu	672	D	IA		280		1151.08		1151.08
178	Vitudurum-Oberwinterthur	673	F	RO		314		1290.85		1290.85
178	Vitudurum-Oberwinterthur	674	F	RO		332		1364.85		1364.85
181	Barnsley Park	676	E	RO		275		1130.53		1130.53
181	Barnsley Park	677	E	RO		334		1373.07		1373.07
182	Frocester Court	681	E	RO		390		1603.29		1603.29
182	Frocester Court	682	E	RO		350		1438.85		1438.85
182	Frocester Court	683	E	RO		313		1286.74		1286.74
182	Frocester Court	684	E	RO		303		1245.63		1245.63
184	Chilgrove 1	687	E	RO		308		1266.19		1266.19
186	Shakenoak site K	693	E	RO		323		1327.85		1327.85
187	Hayton Fort	694	E	RO		287.5		1181.91		1181.91
188	Titelberg oppidum	695	D	RO	H	322	308	1323.74	1329.64	1326.69
189	Kassope	701	H	IA		250		1027.75		1027.75
189	Kassope	702	H	IA		249		1023.64		1023.64
189	Kassope	705	H	IA		273		1122.30		1122.30
189	Kassope	706	H	IA		270		1109.97		1109.97
189	Kassope	712	H	IA		294.5	281	1210.69	1213.08	1211.88
192	Pfaffenhofen - Pons Aeni	713	F	RO	H	323	307	1327.85	1325.32	1326.59
192	Pfaffenhofen - Pons Aeni	714	F	RO	H*	332	319	1364.85	1377.12	1370.99
192	Pfaffenhofen - Pons Aeni	717	F	RO		355	342	1459.41	1476.41	1467.91
192	Pfaffenhofen - Pons Aeni	718	F	RO	M	364	348	1496.40	1502.32	1499.36
195	Kunzing-Quintana	723	F	RO	M	356	338	1463.52	1459.15	1461.33
199	Hufingen	732	F	RO	H*	348	332.5	1430.63	1435.40	1433.02
199	Hufingen	733	F	RO		348	331	1430.63	1428.93	1429.78
199	Hufingen	734	F	RO	H*	347	330	1426.52	1424.61	1425.56
199	Hufingen	735	F	RO		343	325	1410.07	1403.03	1406.55
199	Hufingen	736	F	RO		332	315	1364.85	1359.86	1362.35
199	Hufingen	737	F	RO	M*	349	336	1434.74	1450.51	1442.63
199	Hufingen	738	F	RO			325		1403.03	1403.03
200	Pfaffenhofen	762	F	RO	H?	326	311	1340.19	1342.59	1341.39
200	Pfaffenhofen	763	F	RO	H*	344	327	1414.18	1411.66	1412.92
201	Wehringen	765	F	RO	M	359	337	1475.85	1454.83	1465.34
202	Penzlin	766	F	NAT	H?	301.5	289	1239.47	1247.61	1243.54
203	Tac-Gorsium	770	G	RO		307		1262.08		1262.08
203	Tac-Gorsium	771	G	RO		320		1315.52		1315.52
203	Tac-Gorsium	772	G	RO		323		1327.85		1327.85
203	Tac-Gorsium	773	G	RO		323.5		1329.91		1329.91
203	Tac-Gorsium	774	G	RO		325		1336.08		1336.08
203	Tac-Gorsium	775	G	RO		325		1336.08		1336.08
203	Tac-Gorsium	776	G	RO		326		1340.19		1340.19
203	Tac-Gorsium	777	G	RO		330.5		1358.69		1358.69
203	Tac-Gorsium	778	G	RO		333		1368.96		1368.96
203	Tac-Gorsium	779	G	RO		335		1377.19		1377.19

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
203	Tac-Gorsium	780	G	RO		336		1381.30		1381.30
203	Tac-Gorsium	781	G	RO		337		1385.41		1385.41
203	Tac-Gorsium	782	G	RO		340		1397.74		1397.74
203	Tac-Gorsium	783	G	RO		342		1405.96		1405.96
203	Tac-Gorsium	784	G	RO		343		1410.07		1410.07
203	Tac-Gorsium	785	G	RO		343		1410.07		1410.07
203	Tac-Gorsium	786	G	RO		346		1422.41		1422.41
203	Tac-Gorsium	787	G	RO		347		1426.52		1426.52
203	Tac-Gorsium	788	G	RO		348		1430.63		1430.63
203	Tac-Gorsium	789	G	RO		352		1447.07		1447.07
203	Tac-Gorsium	790	G	RO		352		1447.07		1447.07
203	Tac-Gorsium	791	G	RO		376		1545.74		1545.74
203	Tac-Gorsium	845	G	RO		260		1068.86		1068.86
204	Conchil	848	D	RO		323		1327.85		1327.85
204	Conchil	849	D	RO		324		1331.96		1331.96
204	Conchil	850	D	RO		318		1307.30		1307.30
204	Conchil	851	D	RO		349		1434.74		1434.74
204	Conchil	852	D	RO		336		1381.30		1381.30
205	Oberstimm	853	F	RO	H*	304	289	1249.74	1247.61	1248.68
205	Oberstimm	854	F	RO		345	326	1418.30	1407.34	1412.82
206	Lauriacum	865	F	RO	M*	345	332	1418.30	1433.24	1425.77
208	Colonia Ulpia Traiana	868	F	RO		347	328	1426.52	1415.98	1421.25
208	Colonia Ulpia Traiana	869	F	RO		342	324	1405.96	1398.71	1402.34
208	Colonia Ulpia Traiana	870	F	RO		339		1393.63		1393.63
208	Colonia Ulpia Traiana	871	F	RO		335	321	1377.19	1385.76	1381.47
208	Colonia Ulpia Traiana	872	F	RO		335		1377.19		1377.19
208	Colonia Ulpia Traiana	873	F	RO		324	312	1331.96	1346.90	1339.43
208	Colonia Ulpia Traiana	874	F	RO		320	304	1315.52	1312.37	1313.94
209	Iatrus	876	G	RO		315.2		1295.79		1295.79
212	Gournay	881	D	IA		303		1245.63		1245.63
212	Gournay	882	D	IA		320		1315.52		1315.52
212	Gournay	883	D	IA		302		1241.52		1241.52
213	Beauvais	884	D	IA		301		1237.41		1237.41
213	Beauvais	885	D	IA		306		1257.97		1257.97
213	Beauvais	886	D	IA		290		1192.19		1192.19
213	Beauvais	887	D	IA		286		1175.75		1175.75
213	Beauvais	888	D	IA		316		1299.08		1299.08
213	Beauvais	889	D	IA		321		1319.63		1319.63
213	Beauvais	890	D	IA		292		1200.41		1200.41
214	Compiegne	896	D	IA		315		1294.97		1294.97
214	Compiegne	897	D	IA		331		1360.74		1360.74
214	Compiegne	898	D	IA		313		1286.74		1286.74
214	Compiegne	899	D	IA		310		1274.41		1274.41
215	Ribemont	901	D	IA		321		1319.63		1319.63
215	Ribemont	902	D	IA		293		1204.52		1204.52
215	Ribemont	903	D	IA		299		1229.19		1229.19
215	Ribemont	904	D	IA		323		1327.85		1327.85
215	Ribemont	905	D	IA		318		1307.30		1307.30
216	Variscourt	906	D	IA		291		1196.30		1196.30
216	Variscourt	907	D	IA		295		1212.75		1212.75
216	Variscourt	908	D	IA		336		1381.30		1381.30
216	Variscourt	909	D	IA		304		1249.74		1249.74
216	Variscourt	910	D	IA		300		1233.30		1233.30
217	Soissons	916	D	IA		262		1077.08		1077.08

Table A23 – Results of withers height calculations on the isolated Tibiae

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
5	Beckford	349	E	IA		314		1239.36		1239.36
10	Twywell	345	E	IA		316		1247.25		1247.25
14	Lincoln	343	E	RO		311	282.9	1227.52	1233.73	1230.62
15	Scole-Dickleburgh	339	E	IA+RO		340		1341.98		1341.98
15	Scole-Dickleburgh	342	E	IA+RO		344.6		1360.14		1360.14
24	Dunstable	325	E	RO		322		1270.93		1270.93
27	Lynch Farm	322	E	IA+RO		366		1444.60		1444.60
27	Lynch Farm	323	E	IA+RO		317		1251.20		1251.20
28	Longthorpe II	318	E	IA+RO		325		1282.78		1282.78
28	Longthorpe II	319	E	IA+RO		387		1527.49		1527.49
28	Longthorpe II	320	E	IA+RO		332		1310.40		1310.40
35	Castricum-Oosterbuurt	301	F	RO		350		1381.45		1381.45
35	Castricum-Oosterbuurt	307	F	RO		343		1353.82		1353.82
37	Kesteren 'De Prinsenhof'	283	F	RO		346		1365.66		1365.66
37	Kesteren 'De Prinsenhof'	289	F	RO		374		1476.18		1476.18
37	Kesteren 'De Prinsenhof'	292	F	RO		378		1491.97		1491.97
37	Kesteren 'De Prinsenhof'	296	F	RO		376		1484.07		1484.07
38	Nijmegen	262	F	RO		372		1468.28		1468.28
38	Nijmegen	263	F	RO		379.1	343.4	1496.31	1497.57	1496.94
38	Nijmegen	264	F	RO	M*	370	367.3	1460.39	1601.80	1531.09
38	Nijmegen	270	F	RO	M	381	352.2	1503.81	1535.94	1519.88
38	Nijmegen	271	F	RO	M*	362.3	331.7	1430.00	1446.54	1438.27
38	Nijmegen	272	F	RO	M?	364.6	337.7	1439.08	1472.71	1455.89
38	Nijmegen	274	F	RO	M*	349.4	314.3	1379.08	1370.66	1374.87
38	Nijmegen	275	F	RO		376.5		1486.05		1486.05
38	Nijmegen	277	F	RO	H	335.8	303.4	1325.40	1323.13	1324.27
38	Nijmegen	279	F	RO		411.6		1624.59		1624.59
42	Druten	245	F	IA+RO		344		1357.77		1357.77
42	Druten	246	F	IA+RO		352		1389.34		1389.34
42	Druten	247	F	IA+RO	M*	372.6	337.1	1470.65	1470.09	1470.37
42	Druten	249	F	IA+RO	M	390.6	359	1541.70	1565.60	1553.65
42	Druten	250	F	IA+RO		342.5		1351.85		1351.85
42	Druten	251	F	IA+RO		374.2	337.1	1476.97	1470.09	1473.53
42	Druten	252	F	IA+RO		379.6	352.4	1498.28	1536.82	1517.55
43	Elms Farm	238	E	IA+RO		356	338	1405.13	1474.02	1439.58
44	Danebury	200	E	IA		294		1160.42		1160.42
44	Danebury	202	E	IA		292		1152.52		1152.52
44	Danebury	205	E	IA		311		1227.52		1227.52
44	Danebury	208	E	IA		303.5		1197.91		1197.91
44	Danebury	209	E	IA		305		1203.84		1203.84
44	Danebury	214	E	IA		295		1164.37		1164.37
44	Danebury	219	E	IA		303		1195.94		1195.94
44	Danebury	222	E	IA		322.5		1272.91		1272.91
44	Danebury	224	E	IA		321.5		1268.96		1268.96
44	Danebury	225	E	IA		342.7		1352.64		1352.64
44	Danebury	226	E	IA		316.4		1248.83		1248.83
44	Danebury	228	E	IA		308		1215.68		1215.68
44	Danebury	229	E	IA		329		1298.56		1298.56
46	E London RB Cemetary	192	E	RO	H?	346	316.2	1365.66	1378.95	1372.31
46	E London RB Cemetary	196	E	RO	H	359	326	1416.97	1421.69	1419.33
46	E London RB Cemetary	198	E	RO		311.5	287.8	1229.49	1255.10	1242.29

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
52	Magiovinium	186	E	RO			364		1587.40	1587.40
52	Magiovinium	187	E	RO			350		1526.35	1526.35
52	Magiovinium	188	E	RO			354		1543.79	1543.79
54	Thorpe Thewles	181	E	IA+RO		319.9		1262.65		1262.65
54	Thorpe Thewles	182	E	IA+RO		320.9		1266.59		1266.59
54	Thorpe Thewles	184	E	IA+RO		299.9		1183.71		1183.71
63	S. Giacomo	172	A	RO		342		1349.87		1349.87
63	S. Giacomo	173	A	RO	M*	364	334	1436.71	1456.57	1446.64
68	Lutton/Huntingdon	169	E	IA+RO		340	304	1341.98	1325.74	1333.86
69	Thorley	167	E	IA+RO		313	285	1235.41	1242.89	1239.15
71	Piovego	164	A	IA		347		1369.61		1369.61
72	Colle dei Cappuccini	163	A	IA		329		1298.56		1298.56
77	Grotto di Tibera	161	A	RO		369		1456.44		1456.44
79	Olbia	160	A	IA		255.6		1008.85		1008.85
81	Welsow	158	F	NAT		206.5		815.06		815.06
87	Manching	147	F	IA	H?	291	267	1148.58	1164.39	1156.48
87	Manching	148	F	IA		295	276	1164.37	1203.64	1184.00
87	Manching	149	F	IA		302	273	1191.99	1190.55	1191.27
87	Manching	150	F	IA		310	280	1223.57	1221.08	1222.33
87	Manching	151	F	IA		311	285	1227.52	1242.89	1235.20
87	Manching	152	F	IA	H?	312	287	1231.46	1251.61	1241.54
87	Manching	153	F	IA		319	293	1259.09	1277.77	1268.43
87	Manching	154	F	IA	H?	321	290	1266.99	1264.69	1265.84
87	Manching	155	F	IA		336	306	1326.19	1334.47	1330.33
92	Feddersen Wierde	32	F	NAT		335.1	319.5	1322.64	1393.34	1357.99
92	Feddersen Wierde	33	F	NAT	D?	338	324.1	1334.09	1413.40	1373.74
92	Feddersen Wierde	34	F	NAT		329.7	310.4	1301.33	1353.65	1327.49
92	Feddersen Wierde	35	F	NAT	M?	325.3	310.9	1283.96	1355.83	1319.90
92	Feddersen Wierde	36	F	NAT	H?	317.7	299.5	1253.96	1306.12	1280.04
92	Feddersen Wierde	37	F	NAT	D*	339.7	320.4	1340.80	1397.26	1369.03
92	Feddersen Wierde	38	F	NAT	D?	314.1	294.8	1239.75	1285.62	1262.69
93	Caerwent	26	E	RO		320		1263.04		1263.04
96	Kunzing east vicus	2	F	RO		367		1448.55		1448.55
96	Kunzing east vicus	3	F	RO		364		1436.71		1436.71
96	Kunzing east vicus	5	F	RO		354		1397.24		1397.24
96	Kunzing east vicus	6	F	RO		364.5		1438.68		1438.68
96	Kunzing east vicus	7	F	RO		366		1444.60		1444.60
103	Newstead fort	383	E	RO		333.5		1316.32		1316.32
104	Orton Hall Farm	384	E	RO		360		1420.92		1420.92
104	Orton Hall Farm	385	E	RO		356		1405.13		1405.13
104	Orton Hall Farm	386	E	RO		332		1310.40		1310.40
104	Orton Hall Farm	387	E	RO		304		1199.89		1199.89
104	Orton Hall Farm	388	E	RO		354		1397.24		1397.24
104	Orton Hall Farm	389	E	RO		347		1369.61		1369.61
105	Mons Claudianus	390	K	RO		372		1468.28		1468.28
105	Mons Claudianus	391	K	RO		350		1381.45		1381.45
105	Mons Claudianus	392	K	RO		350		1381.45		1381.45
105	Mons Claudianus	393	K	RO		345		1361.72		1361.72
105	Mons Claudianus	394	K	RO		345		1361.72		1361.72
105	Mons Claudianus	395	K	RO	D*	338	310	1334.09	1351.91	1343.00
105	Mons Claudianus	397	K	RO		333		1314.35		1314.35
105	Mons Claudianus	398	K	RO		333		1314.35		1314.35
105	Mons Claudianus	399	K	RO		330		1302.51		1302.51
105	Mons Claudianus	400	K	RO		330		1302.51		1302.51
105	Mons Claudianus	401	K	RO		326.7		1289.48		1289.48
105	Mons Claudianus	402	K	RO		320		1263.04		1263.04

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
112	Pompeii, Sarno Baths	489	A	RO		345.5		1363.69		1363.69
114	Unterlaa	490	F	RO		335		1322.25		1322.25
115	Bad Wimpfen	496	F	RO	M	368.5	334.5	1454.47	1458.75	1456.61
115	Bad Wimpfen	497	F	RO		345		1361.72		1361.72
115	Bad Wimpfen	498	F	RO			327		1426.05	1426.05
116	Pommeroeul	513	D	RO	H	323	290	1274.88	1264.69	1269.79
116	Pommeroeul	514	D	RO	H?	324	292	1278.83	1273.41	1276.12
116	Pommeroeul	515	D	RO	H*	327	300	1290.67	1308.30	1299.48
116	Pommeroeul	516	D	RO		344		1357.77		1357.77
116	Pommeroeul	517	D	RO	M?	352	318	1389.34	1386.80	1388.07
116	Pommeroeul	518	D	RO	M*	373	335	1472.23	1460.94	1466.58
116	Pommeroeul	519	D	RO	H?	373	336	1472.23	1465.30	1468.76
116	Pommeroeul	520	D	RO	M?	375	337	1480.13	1469.66	1474.89
116	Pommeroeul	521	D	RO		381	345	1503.81	1504.55	1504.18
116	Pommeroeul	522	D	RO		392		1547.22		1547.22
117	Pompeii stable	529	A	RO		348		1373.56		1373.56
118	Carnuntum	530	F	RO		413	376.5	1630.11	1641.92	1636.01
118	Carnuntum	531	F	RO		364.5	332	1438.68	1447.85	1443.27
118	Carnuntum	532	F	RO		363.5	329	1434.73	1434.77	1434.75
118	Carnuntum	533	F	RO		377	344	1488.02	1500.18	1494.10
118	Carnuntum	534	F	RO		361	323	1424.87	1408.60	1416.74
119	Albertfalva	535	G	RO		361.1		1425.26		1425.26
119	Albertfalva	536	G	RO		401		1582.75		1582.75
120	Basel-Gasfabrik	537	F	IA	H	310.5	280	1225.54	1221.08	1223.31
120	Basel-Gasfabrik	538	F	IA	H	320.1	287.1	1263.43	1252.04	1257.74
120	Basel-Gasfabrik	541	F	IA		296.4	270.2	1169.89	1178.34	1174.12
121	Soluthurn/Vigier	550	F	RO	M*	341	325	1345.93	1417.33	1381.63
121	Soluthurn/Vigier	551	F	RO		359	341	1416.97	1487.10	1452.04
121	Soluthurn/Vigier	552	F	RO		340		1341.98		1341.98
121	Soluthurn/Vigier	553	F	RO		355		1401.19		1401.19
124	Haddon	557	E	IA+RO		322	293	1270.93	1277.77	1274.35
124	Haddon	559	E	IA+RO		318	290	1255.15	1264.69	1259.92
124	Haddon	560	E	IA+RO		360	329	1420.92	1434.77	1427.84
125	Castleford	562	E	RO		363		1432.76		1432.76
125	Castleford	563	E	RO		363		1432.76		1432.76
127	Tortoreto-Fortellezza	569	A	IA		295		1164.37		1164.37
129	Lorenzberg Bei Epfach	578	F	RO		355		1401.19		1401.19
129	Lorenzberg Bei Epfach	581	F	RO		345		1361.72		1361.72
133	Colchester	589	E	RO		320		1263.04		1263.04
133	Colchester	593	E	RO		332		1310.40		1310.40
133	Colchester	594	E	RO		279		1101.21		1101.21
134	Butzbach	597	F	RO		394		1555.12		1555.12
137	Magdelenska Gora	605	G	IA		342		1349.87		1349.87
137	Magdelenska Gora	606	G	IA		335		1322.25		1322.25
137	Magdelenska Gora	607	G	IA		335		1322.25		1322.25
142	Velemszentvid	611	G	IA		352		1389.34		1389.34
142	Velemszentvid	612	G	IA		356		1405.13		1405.13
146	Balatonaliga	613	G	RO		363		1432.76		1432.76
151	Gyor Szechenyi-Ter	614	G	RO		385		1519.60		1519.60
156	Invillino- Ibliglo	616	A	RO	M*	349	322.5	1377.50	1406.42	1391.96
156	Invillino- Ibliglo	617	A	RO		348		1373.56		1373.56
161	San Giovanni	625	A	RO		277.3		1094.50		1094.50
172	Metaponto Panatello	631	A	RO		369		1456.44		1456.44
173	Paestum	632	A	RO		339.5		1340.01		1340.01
174	Abusina-Eining	633	F	RO		391	356	1543.28	1552.52	1547.90
174	Abusina-Eining	634	F	RO	M*	388	351	1531.44	1530.71	1531.07

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
174	Abusina-Eining	635	F	RO		367		1448.55		1448.55
174	Abusina-Eining	636	F	RO		352	319	1389.34	1391.16	1390.25
176	Oberdorla	643	F	NAT	M	348	321	1373.56	1399.88	1386.72
176	Oberdorla	644	F	NAT	D*	341	307	1345.93	1338.83	1342.38
176	Oberdorla	645	F	NAT	D*	335	298	1322.25	1299.58	1310.91
176	Oberdorla	646	F	NAT		334	310	1318.30	1351.91	1335.10
176	Oberdorla	647	F	NAT		320	292	1263.04	1273.41	1268.23
176	Oberdorla	648	F	NAT		319	292	1259.09	1273.41	1266.25
176	Oberdorla	649	F	NAT		318	284	1255.15	1238.52	1246.84
176	Oberdorla	650	F	NAT		317		1251.20		1251.20
176	Oberdorla	651	F	NAT		314		1239.36		1239.36
178	Vitudurum-Oberwinterthur	660	F	RO		343		1353.82		1353.82
178	Vitudurum-Oberwinterthur	661	F	RO		339		1338.03		1338.03
181	Barnsley Park	667	E	RO		340		1341.98		1341.98
181	Barnsley Park	668	E	RO		355		1401.19		1401.19
182	Frocester Court	673	E	RO		304		1199.89		1199.89
182	Frocester Court	674	E	RO		316		1247.25		1247.25
186	Shakenoak site K	682	E	RO		317		1251.20		1251.20
192	Pfaffenhofen - Pons Aeni	701	F	RO	M	360	328	1420.92	1430.41	1425.66
199	Hufingen	715	F	RO		368	334.5	1452.50	1458.75	1455.63
199	Hufingen	716	F	RO	M	366.5	339.5	1446.58	1480.56	1463.57
199	Hufingen	717	F	RO	D*	366	330	1444.60	1439.13	1441.87
199	Hufingen	718	F	RO	H?	358	323	1413.03	1408.60	1410.81
199	Hufingen	719	F	RO	M?	352	322.5	1389.34	1406.42	1397.88
199	Hufingen	720	F	RO		348	321.5	1373.56	1402.06	1387.81
199	Hufingen	721	F	RO		345	316.5	1361.72	1380.26	1370.99
199	Hufingen	722	F	RO			320.5		1397.70	1397.70
201	Wehringen	758	F	RO	H?	333	303	1314.35	1321.38	1317.87
201	Wehringen	759	F	RO	H	340	305	1341.98	1330.11	1336.04
203	Tac-Gorsium	765	G	RO		336		1326.19		1326.19
203	Tac-Gorsium	766	G	RO		336		1326.19		1326.19
203	Tac-Gorsium	767	G	RO		338		1334.09		1334.09
203	Tac-Gorsium	768	G	RO		339		1338.03		1338.03
203	Tac-Gorsium	769	G	RO		340		1341.98		1341.98
203	Tac-Gorsium	770	G	RO		340		1341.98		1341.98
203	Tac-Gorsium	771	G	RO		342		1349.87		1349.87
203	Tac-Gorsium	772	G	RO		345		1361.72		1361.72
203	Tac-Gorsium	773	G	RO		354		1397.24		1397.24
203	Tac-Gorsium	774	G	RO		365		1440.66		1440.66
203	Tac-Gorsium	775	G	RO		372		1468.28		1468.28
203	Tac-Gorsium	776	G	RO		383		1511.70		1511.70
203	Tac-Gorsium	777	G	RO		387		1527.49		1527.49
203	Tac-Gorsium	778	G	RO		406		1602.48		1602.48
204	Conchil	837	D	RO		347.5	324	1371.58	1412.96	1392.27
204	Conchil	839	D	RO		357		1409.08		1409.08
205	Oberstimm	841	F	RO	M*	353	332	1393.29	1447.85	1420.57
208	Colonia Ulpia Traiana	856	F	RO	M*	367	338	1448.55	1474.02	1461.28
208	Colonia Ulpia Traiana	857	F	RO	H?	367	332	1448.55	1447.85	1448.20
208	Colonia Ulpia Traiana	858	F	RO	M*	367	332	1448.55	1447.85	1448.20
208	Colonia Ulpia Traiana	859	F	RO		365	330	1440.66	1439.13	1439.89
208	Colonia Ulpia Traiana	860	F	RO	M*	351	321	1385.40	1399.88	1392.64
208	Colonia Ulpia Traiana	861	F	RO		346		1365.66		1365.66
208	Colonia Ulpia Traiana	862	F	RO			338		1474.02	1474.02
212	Gournay	866	D	IA		312		1231.46		1231.46
212	Gournay	867	D	IA		315		1243.31		1243.31
213	Beauvais	868	D	IA		284		1120.95		1120.95

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
213	Beauvais	869	D	IA		300		1184.10		1184.10
213	Beauvais	870	D	IA		300		1184.10		1184.10
213	Beauvais	871	D	IA		320		1263.04		1263.04
213	Beauvais	872	D	IA		309		1219.62		1219.62
214	Compiegne	876	D	IA		348		1373.56		1373.56
215	Ribemont	880	D	IA		308		1215.68		1215.68
215	Ribemont	881	D	IA		320		1263.04		1263.04
215	Ribemont	882	D	IA		328		1294.62		1294.62
215	Ribemont	883	D	IA		319		1259.09		1259.09
215	Ribemont	884	D	IA		319		1259.09		1259.09
215	Ribemont	885	D	IA		331		1306.46		1306.46
215	Ribemont	886	D	IA		305		1203.84		1203.84
215	Ribemont	887	D	IA		313		1235.41		1235.41
216	Variscourt	893	D	IA		315		1243.31		1243.31
217	Soissons	894	D	IA		277		1093.32		1093.32

Table A24 – Results of withers height calculations on the isolated Humeri

WH-K = withers height estimate from Kiesewalter's factors

Site no	Site name	Bone no	Region	Period	ID level	GLl	WH-K
5	Beckford	226	E	IA		261	1270.55
18	Camulodunum	209	E	IA+RO		260	1265.68
18	Camulodunum	210	E	IA+RO		250	1217.00
18	Camulodunum	211	E	IA+RO		250	1217.00
28	Longthorpe II	205	E	IA+RO		255	1241.34
28	Longthorpe II	206	E	IA+RO		278	1353.30
34	Wall Mansio	196	E	RO		228	1109.90
35	Castricum-Oosterbuurt	195	F	RO		264.8	1289.05
37	Kesteren 'De Prinsenhof'	182	F	RO		300	1460.40
37	Kesteren 'De Prinsenhof'	183	F	RO		313	1523.68
38	Nijmegen	175	F	RO	M*	292.7	1424.86
42	Druten	157	F	IA+RO	H*	288.4	1403.93
44	Danebury	137	E	IA		250	1217.00
44	Danebury	139	E	IA		252	1226.74
44	Danebury	140	E	IA		250.2	1217.97
44	Danebury	142	E	IA		257	1251.08
49	Buckingham Street	129	E	RO		255	1241.34
52	Magiovinium	127	E	RO		300	1460.40
79	Olbia	116	A	IA	D*	206.2	1003.78
87	Manching	107	F	IA	M	307	1494.48
88	Zwammerdam	38	F	RO		305	1484.74
91	Whitton	37	E	RO		285	1387.38
92	Feddersen Wierde	29	F	NAT	H*	270.6	1317.28
92	Feddersen Wierde	30	F	NAT	H*	286.4	1394.20
92	Feddersen Wierde	31	F	NAT	H*	294.5	1433.63
92	Feddersen Wierde	32	F	NAT	H*	266.3	1296.35
92	Feddersen Wierde	33	F	NAT	H	278.1	1353.79
92	Feddersen Wierde	34	F	NAT	H*	270.3	1315.82
92	Feddersen Wierde	35	F	NAT	H*	265.3	1291.48
92	Feddersen Wierde	36	F	NAT	D?	257.8	1254.97
103	Newstead fort	256	E	RO		246	1197.53
105	Mons Claudianus	258	K	RO	H?	270	1314.36
105	Mons Claudianus	259	K	RO	H*	266	1294.89

Site no	Site name	Bone no	Region	Period	ID level	GLl	WH-K
105	Mons Claudianus	260	K	RO	H*	265.5	1292.45
105	Mons Claudianus	261	K	RO	D?	240	1168.32
112	Pompeii, Sarno Baths	330	A	RO		275	1338.70
116	Pommeroeul	351	D	RO		255	1241.34
116	Pommeroeul	353	D	RO	H	275	1338.70
116	Pommeroeul	354	D	RO	H?	293	1426.32
116	Pommeroeul	355	D	RO	H*	291	1416.59
116	Pommeroeul	356	D	RO	M	300	1460.40
116	Pommeroeul	358	D	RO	H?	255	1241.34
116	Pommeroeul	362	D	RO	H	277	1348.44
117	Pompeii stable	368	A	RO		277.7	1351.84
118	Carnuntum	372	F	RO	M*	325.5	1584.53
124	Haddon	397	E	IA+RO		263	1280.28
124	Haddon	398	E	IA+RO		251	1221.87
128	Krefeld-Gellep	405	F	RO		328	1596.70
128	Krefeld-Gellep	406	F	RO		330	1606.44
128	Krefeld-Gellep	408	F	RO		295	1436.06
134	Butzbach	421	F	RO		300	1460.40
137	Magdelenska Gora	427	G	IA		280	1363.04
137	Magdelenska Gora	428	G	IA		263	1280.28
176	Oberdorla	441	F	NAT		292	1421.46
181	Barnsley Park	451	E	RO		310	1509.08
182	Frocester Court	453	E	RO		280	1363.04
192	Pfaffenhofen - Pons Aeni	472	F	RO	M	317	1543.16
198	Gellep - Gelduba	478	F	RO	H*	268	1304.62
200	Pfaffenhofen	497	F	RO	M	297	1445.80
203	Tac-Gorsium	501	G	RO		282	1372.78
203	Tac-Gorsium	502	G	RO		287	1397.12
203	Tac-Gorsium	503	G	RO		288	1401.98
203	Tac-Gorsium	504	G	RO		289	1406.85
203	Tac-Gorsium	505	G	RO		311	1513.95
203	Tac-Gorsium	506	G	RO		328	1596.70
212	Gournay	550	D	IA		253	1231.60
215	Ribemont	558	D	IA		254	1236.47
215	Ribemont	559	D	IA		261	1270.55
217	Soissons	562	D	IA		222	1080.70

Table A25 – Results of withers height calculations on the isolated Metacarpals

WH-V = withers height estimate from Vitt's factors, WH-K = withers height estimate from Kiesewalter's factors, WH-M = mean withers height

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
3	Edix Hill	604	E	IA		201.5		1229.55		1229.55
4	Market Deeping	603	E	IA		208		1269.22		1269.22
5	Beckford	602	E	IA		187		1141.07		1141.07
7	Blackhorse Road	599	E	IA		221.4		1350.98		1350.98
7	Blackhorse Road	600	E	IA		204		1244.81		1244.81
7	Blackhorse Road	601	E	IA		202.7		1236.88		1236.88
8	Hardingstone School	596	E	IA+RO		191		1165.48		1165.48
8	Hardingstone School	597	E	IA+RO		207		1263.11		1263.11
8	Hardingstone School	598	E	IA+RO		210		1281.42		1281.42
9	Hardingstone enclosure	595	E	IA		236		1440.07		1440.07
10	Twywell	593	E	IA		206		1257.01		1257.01
10	Twywell	594	E	IA		198		1208.20		1208.20
11	Ivinghoe Beacon	591	E	IA		190		1159.38		1159.38
11	Ivinghoe Beacon	592	E	IA		212		1293.62		1293.62
13	Wavendon Gate	585	E	IA+RO		234.7	220	1432.14	1408.66	1420.40
13	Wavendon Gate	589	E	IA+RO		220	210	1342.44	1344.63	1343.54
13	Wavendon Gate	590	E	IA+RO		199.6	193.9	1217.96	1241.54	1229.75
14	Lincoln	579	E	RO		223.9	215.9	1366.24	1382.41	1374.32
14	Lincoln	580	E	RO		196.3	189	1197.82	1210.17	1203.99
14	Lincoln	581	E	RO		241.4	231.4	1473.02	1481.65	1477.34
14	Lincoln	582	E	RO		184.9		1128.26		1128.26
14	Lincoln	583	E	RO		239.6		1462.04		1462.04
15	Scole-Dickleburgh	573	E	IA+RO		226.6		1382.71		1382.71
15	Scole-Dickleburgh	574	E	IA+RO		220.1		1343.05		1343.05
15	Scole-Dickleburgh	577	E	IA+RO		232.3		1417.49		1417.49
15	Scole-Dickleburgh	578	E	IA+RO	H?	205.4		1253.35		1253.35
16	Birdlip	567	E	IA		204.1	197.9	1245.42	1267.15	1256.29
16	Birdlip	568	E	IA		211	203.1	1287.52	1300.45	1293.99
16	Birdlip	569	E	IA		202	194	1232.60	1242.18	1237.39
18	Camulodunum	562	E	IA+RO		195		1189.89		1189.89
18	Camulodunum	563	E	IA+RO		195		1189.89		1189.89
18	Camulodunum	564	E	IA+RO		198		1208.20		1208.20
20	Northchurch	561	E	RO		260		1586.52		1586.52
23	Puckeridge	557	E	IA		212.5		1296.68		1296.68
24	Dunstable	555	E	RO		224		1366.85		1366.85
27	Lynch Farm	554	E	IA+RO		220		1342.44		1342.44
28	Longthorpe II	553	E	IA+RO	M?	232		1415.66		1415.66
30	Tort Hill East	550	E	RO		228		1391.26		1391.26
30	Tort Hill East	551	E	RO		202		1232.60		1232.60
33	Longthorpe fortress	547	E	RO		243.5		1485.84		1485.84
34	Wall Mansio	546	E	RO		215		1311.93		1311.93
35	Castricum-Oosterbuurt	529	F	RO		209.12		1276.05		1276.05
35	Castricum-Oosterbuurt	530	F	RO		228.33		1393.27		1393.27
35	Castricum-Oosterbuurt	531	F	RO		228.61		1394.98		1394.98
35	Castricum-Oosterbuurt	532	F	RO		220.64		1346.35		1346.35
35	Castricum-Oosterbuurt	533	F	RO		219.28		1338.05		1338.05
35	Castricum-Oosterbuurt	534	F	RO		219.93		1342.01		1342.01
35	Castricum-Oosterbuurt	535	F	RO		219.23		1337.74		1337.74
35	Castricum-Oosterbuurt	536	F	RO		220		1342.44		1342.44
35	Castricum-Oosterbuurt	537	F	RO		210.24		1282.88		1282.88

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
35	Castricum-Oosterbuurt	539	F	RO		221		1348.54		1348.54
35	Castricum-Oosterbuurt	540	F	RO		211		1287.52		1287.52
35	Castricum-Oosterbuurt	542	F	RO		212.21		1294.91		1294.91
35	Castricum-Oosterbuurt	543	F	RO		217.63		1327.98		1327.98
35	Castricum-Oosterbuurt	544	F	RO		231		1409.56		1409.56
35	Castricum-Oosterbuurt	545	F	RO		225.12		1373.68		1373.68
36	Egmond?	528	F	RO		220.5		1345.49		1345.49
37	Kesteren 'De Prinsenhof'	525	F	RO		217		1324.13		1324.13
37	Kesteren 'De Prinsenhof'	526	F	RO		231		1409.56		1409.56
37	Kesteren 'De Prinsenhof'	527	F	RO	H?	238		1452.28		1452.28
38	Nijmegen	501	F	RO	H*	211.7		1291.79		1291.79
38	Nijmegen	502	F	RO	M*	236.8		1444.95		1444.95
38	Nijmegen	503	F	RO	H?	236.8		1444.95		1444.95
38	Nijmegen	504	F	RO	M*	227.9	224.9	1390.65	1440.03	1415.34
38	Nijmegen	505	F	RO	H*	240.4	235.8	1466.92	1509.83	1488.37
38	Nijmegen	506	F	RO	H?	221.5	218.9	1351.59	1401.62	1376.60
38	Nijmegen	507	F	RO	M	225.1	222.3	1373.56	1423.39	1398.47
38	Nijmegen	508	F	RO	H	217.3	213.7	1325.96	1368.32	1347.14
38	Nijmegen	509	F	RO	H*	226.9	223.7	1384.54	1432.35	1408.45
38	Nijmegen	510	F	RO	H?	237.2	234.4	1447.39	1500.86	1474.13
38	Nijmegen	511	F	RO	H	222.1	217.7	1355.25	1393.93	1374.59
38	Nijmegen	514	F	RO	H?	215.9		1317.42		1317.42
38	Nijmegen	515	F	RO	H?	225.9		1378.44		1378.44
38	Nijmegen	518	F	RO		220.8		1347.32		1347.32
38	Nijmegen	519	F	RO	H	215.8		1316.81		1316.81
38	Nijmegen	520	F	RO		213.5		1302.78		1302.78
40	Heteren	496	F	NAT		198.3		1210.03		1210.03
40	Heteren	497	F	NAT		233.1		1422.38		1422.38
42	Druten	478	F	IA+RO	M?	236		1440.07		1440.07
42	Druten	480	F	IA+RO		226.2		1380.27		1380.27
42	Druten	481	F	IA+RO		226		1379.05		1379.05
42	Druten	482	F	IA+RO		241.4		1473.02		1473.02
42	Druten	483	F	IA+RO	H*	220.3		1344.27		1344.27
42	Druten	484	F	IA+RO		223.8		1365.63		1365.63
42	Druten	485	F	IA+RO	H*	231.8		1414.44		1414.44
42	Druten	489	F	IA+RO	H?	241.7		1474.85		1474.85
42	Druten	490	F	IA+RO	H*	232.6		1419.33		1419.33
42	Druten	491	F	IA+RO	M?	233.7		1426.04		1426.04
42	Druten	492	F	IA+RO	H?	235		1433.97		1433.97
42	Druten	495	F	IA+RO	H*	224.2		1368.07		1368.07
43	Elms Farm	465	E	IA+RO		217		1324.13		1324.13
43	Elms Farm	466	E	IA+RO	H	205.2	197.6	1252.13	1265.23	1258.68
43	Elms Farm	467	E	IA+RO		235	228	1433.97	1459.88	1446.93
43	Elms Farm	470	E	IA+RO		235		1433.97		1433.97
43	Elms Farm	472	E	IA+RO		191		1165.48		1165.48
43	Elms Farm	473	E	IA+RO		210		1281.42		1281.42
43	Elms Farm	474	E	IA+RO		190.9		1164.87		1164.87
44	Danebury	426	E	IA		193.9		1183.18		1183.18
44	Danebury	427	E	IA	H*	193		1177.69		1177.69
44	Danebury	428	E	IA		227		1385.15		1385.15
44	Danebury	432	E	IA		240		1464.48		1464.48
44	Danebury	433	E	IA	D*	182		1110.56		1110.56
44	Danebury	434	E	IA	H	193		1177.69		1177.69
44	Danebury	435	E	IA		208		1269.22		1269.22
44	Danebury	436	E	IA	H?	197		1202.09		1202.09
44	Danebury	437	E	IA	D*	230		1403.46		1403.46

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
44	Danebury	438	E	IA		190		1159.38		1159.38
44	Danebury	439	E	IA		187		1141.07		1141.07
44	Danebury	440	E	IA		191		1165.48		1165.48
44	Danebury	441	E	IA		209		1275.32		1275.32
44	Danebury	442	E	IA		200		1220.40		1220.40
44	Danebury	443	E	IA		192		1171.58		1171.58
44	Danebury	444	E	IA		201		1226.50		1226.50
44	Danebury	445	E	IA		204		1244.81		1244.81
44	Danebury	446	E	IA		172		1049.54		1049.54
44	Danebury	447	E	IA		188		1147.18		1147.18
44	Danebury	448	E	IA	H	207		1263.11		1263.11
44	Danebury	449	E	IA		187		1141.07		1141.07
44	Danebury	450	E	IA		201.5		1229.55		1229.55
44	Danebury	453	E	IA		182		1110.56		1110.56
44	Danebury	454	E	IA		240		1464.48		1464.48
44	Danebury	455	E	IA		206		1257.01		1257.01
44	Danebury	456	E	IA		212		1293.62		1293.62
44	Danebury	457	E	IA	H	207		1263.11		1263.11
44	Danebury	458	E	IA	H	221		1348.54		1348.54
44	Danebury	459	E	IA		217		1324.13		1324.13
44	Danebury	460	E	IA	H	200		1220.40		1220.40
44	Danebury	462	E	IA		228		1391.26		1391.26
44	Danebury	464	E	IA		209		1275.32		1275.32
46	E London RB Cemetary	420	E	RO	H?	216.5	207.2	1321.08	1326.70	1323.89
46	E London RB Cemetary	421	E	RO		224.5	216.5	1369.90	1386.25	1378.07
47	Beddington Sewage Farm	413	E	IA+RO	H?	190.5	184.3	1162.43	1180.07	1171.25
47	Beddington Sewage Farm	414	E	IA+RO	H?	190.5	182.7	1162.43	1169.83	1166.13
47	Beddington Sewage Farm	415	E	IA+RO		201.5	193.6	1229.55	1239.62	1234.59
47	Beddington Sewage Farm	416	E	IA+RO	M?	213.3	204.7	1301.56	1310.69	1306.13
47	Beddington Sewage Farm	417	E	IA+RO		210	200.2	1281.42	1281.88	1281.65
47	Beddington Sewage Farm	418	E	IA+RO		271	261.2	1653.64	1672.46	1663.05
47	Beddington Sewage Farm	419	E	IA+RO	H	198.4	188.8	1210.64	1208.89	1209.76
51	Coldharbour Farm 97	410	E	IA	H	215	203.4	1311.93	1302.37	1307.15
51	Coldharbour Farm 97	411	E	IA	H	207.9	200	1268.61	1280.60	1274.60
51	Coldharbour Farm 97	412	E	IA	H*	217.7	208	1328.41	1331.82	1330.11
52	Magiovinium	409	E	RO			221		1415.06	1415.06
53	Ashville Trading Estate	406	E	IA			208		1331.82	1331.82
53	Ashville Trading Estate	407	E	IA			231		1479.09	1479.09
53	Ashville Trading Estate	408	E	IA			204		1306.21	1306.21
54	Thorpe Thewles	404	E	IA+RO	H	203		1238.71		1238.71
54	Thorpe Thewles	405	E	IA+RO	H*	182		1110.56		1110.56
55	Brancaster 1974	402	E	RO		231	222.7	1409.56	1425.95	1417.76
57	La Sagesse	399	E	IA		203	195	1238.71	1248.59	1243.65
57	La Sagesse	400	E	IA		216	207	1318.03	1325.42	1321.73
57	La Sagesse	401	E	IA		209	200.5	1275.32	1283.80	1279.56
63	S. Giacomo	395	A	RO	H?	235	229	1433.97	1466.29	1450.13
66	Settefinestre	387	A	RO	M?	226	222	1379.05	1421.47	1400.26
66	Settefinestre	388	A	RO	D*	234		1427.87		1427.87
66	Settefinestre	389	A	RO		189		1153.28		1153.28
70	Emilia	382	A	IA+RO		202	198.5	1232.60	1271.00	1251.80
72	Colle dei Cappuccini	380	A	IA		209		1275.32		1275.32
73	Moie di Pollenza	379	A	IA		218		1330.24		1330.24
76	Ansedonia	378	A	RO		158		964.12		964.12
77	Grotto di Tibera	375	A	RO		198		1208.20		1208.20
77	Grotto di Tibera	376	A	RO		255		1556.01		1556.01
77	Grotto di Tibera	377	A	RO		231		1409.56		1409.56

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
79	Olbia	374	A	IA	D*	159.4	154.1	972.66	986.70	979.68
83	Deutsch Wusterhausen	373	F	NAT	H*	220	210	1342.44	1344.63	1343.54
85	Macon	370	D	IA+RO	D*	247		1507.19		1507.19
87	Manching	309	F	IA		180	176.5	1098.36	1130.13	1114.24
87	Manching	310	F	IA		181.5	178.5	1107.51	1142.94	1125.22
87	Manching	311	F	IA		184	191	1122.77	1222.97	1172.87
87	Manching	312	F	IA		184	182.5	1122.77	1168.55	1145.66
87	Manching	313	F	IA		185	182	1128.87	1165.35	1147.11
87	Manching	314	F	IA		185.5	183.5	1131.92	1174.95	1153.44
87	Manching	315	F	IA		186	183	1134.97	1171.75	1153.36
87	Manching	316	F	IA		186.5	183	1138.02	1171.75	1154.89
87	Manching	317	F	IA		188.5	186	1150.23	1190.96	1170.59
87	Manching	318	F	IA		191.5	188.5	1168.53	1206.97	1187.75
87	Manching	319	F	IA		191.5	189	1168.53	1210.17	1189.35
87	Manching	320	F	IA		192	188	1171.58	1203.76	1187.67
87	Manching	321	F	IA		192	188	1171.58	1203.76	1187.67
87	Manching	322	F	IA		192	188.5	1171.58	1206.97	1189.27
87	Manching	323	F	IA		192	189	1171.58	1210.17	1190.88
87	Manching	324	F	IA		193	189	1177.69	1210.17	1193.93
87	Manching	325	F	IA		193	189.5	1177.69	1213.37	1195.53
87	Manching	326	F	IA		193	189.5	1177.69	1213.37	1195.53
87	Manching	327	F	IA		193	190	1177.69	1216.57	1197.13
87	Manching	328	F	IA		193	190	1177.69	1216.57	1197.13
87	Manching	329	F	IA		193.5	191	1180.74	1222.97	1201.86
87	Manching	330	F	IA		194	191	1183.79	1222.97	1203.38
87	Manching	331	F	IA		194.5	191.5	1186.84	1226.17	1206.51
87	Manching	332	F	IA		195	191.5	1189.89	1226.17	1208.03
87	Manching	333	F	IA		195	191.5	1189.89	1226.17	1208.03
87	Manching	334	F	IA		195.5	193.5	1192.94	1238.98	1215.96
87	Manching	335	F	IA		196	194	1195.99	1242.18	1219.09
87	Manching	336	F	IA		198	195	1208.20	1248.59	1228.39
87	Manching	337	F	IA		198.5	196.5	1211.25	1258.19	1234.72
87	Manching	338	F	IA		199	194.5	1214.30	1245.38	1229.84
87	Manching	339	F	IA		199	194.5	1214.30	1245.38	1229.84
87	Manching	340	F	IA		199.5	196	1217.35	1254.99	1236.17
87	Manching	341	F	IA		199.5	197	1217.35	1261.39	1239.37
87	Manching	342	F	IA		200	197	1220.40	1261.39	1240.90
87	Manching	343	F	IA		200.5	197.5	1223.45	1264.59	1244.02
87	Manching	344	F	IA		200.5	199	1223.45	1274.20	1248.82
87	Manching	345	F	IA		201		1226.50		1226.50
87	Manching	346	F	IA		201	197.5	1226.50	1264.59	1245.55
87	Manching	347	F	IA		201	197.5	1226.50	1264.59	1245.55
87	Manching	348	F	IA		202	199	1232.60	1274.20	1253.40
87	Manching	349	F	IA		203	199	1238.71	1274.20	1256.45
87	Manching	350	F	IA		204	200.5	1244.81	1283.80	1264.30
87	Manching	351	F	IA		207.5	204	1266.17	1306.21	1286.19
87	Manching	352	F	IA		208	204.5	1269.22	1309.41	1289.31
87	Manching	353	F	IA		208.5	205	1272.27	1312.62	1292.44
87	Manching	354	F	IA		208.5	206	1272.27	1319.02	1295.64
87	Manching	355	F	IA		209	206	1275.32	1319.02	1297.17
87	Manching	356	F	IA		211	207	1287.52	1325.42	1306.47
87	Manching	357	F	IA		211.5	208	1290.57	1331.82	1311.20
87	Manching	358	F	IA		212.5	209.5	1296.68	1341.43	1319.05
87	Manching	359	F	IA		213.5	210	1302.78	1344.63	1323.70
87	Manching	360	F	IA		213.5	210	1302.78	1344.63	1323.70
87	Manching	361	F	IA		213.5	210.5	1302.78	1347.83	1325.30

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
87	Manching	362	F	IA		216	212.5	1318.03	1360.64	1339.33
87	Manching	363	F	IA		216	213	1318.03	1363.84	1340.94
87	Manching	364	F	IA		219	215.5	1336.34	1379.85	1358.09
87	Manching	365	F	IA		220	217	1342.44	1389.45	1365.95
87	Manching	366	F	IA		226.5	223.5	1382.10	1431.07	1406.59
87	Manching	367	F	IA		228.5	223.5	1394.31	1431.07	1412.69
87	Manching	368	F	IA		231	227	1409.56	1453.48	1431.52
87	Manching	369	F	IA		244	240	1488.89	1536.72	1512.80
88	Zwammerdam	241	F	RO		232	226	1415.66	1447.08	1431.37
89	Jenstejn	240	G	IA		208.3		1271.05		1271.05
91	Whitton	237	E	RO		229		1397.36		1397.36
92	Feddersen Wierde	29	F	NAT	D?	196.7		1200.26		1200.26
92	Feddersen Wierde	30	F	NAT	H	213.8		1304.61		1304.61
92	Feddersen Wierde	31	F	NAT		201.1		1227.11		1227.11
92	Feddersen Wierde	32	F	NAT	H?	196.1		1196.60		1196.60
92	Feddersen Wierde	33	F	NAT	D*	200.5		1223.45		1223.45
92	Feddersen Wierde	34	F	NAT	H*	203.5		1241.76		1241.76
92	Feddersen Wierde	35	F	NAT	D?	207.5		1266.17		1266.17
92	Feddersen Wierde	36	F	NAT	M*	217.5		1327.19		1327.19
92	Feddersen Wierde	37	F	NAT	H?	198.1		1208.81		1208.81
92	Feddersen Wierde	38	F	NAT	H	202.7		1236.88		1236.88
92	Feddersen Wierde	39	F	NAT	H*	197.9		1207.59		1207.59
92	Feddersen Wierde	40	F	NAT	H?	215.3		1313.76		1313.76
92	Feddersen Wierde	41	F	NAT	M?	206.8		1261.89		1261.89
92	Feddersen Wierde	42	F	NAT	H*	215.5		1314.98		1314.98
92	Feddersen Wierde	43	F	NAT		202.3		1234.43		1234.43
92	Feddersen Wierde	44	F	NAT	H*	216.6		1321.69		1321.69
92	Feddersen Wierde	45	F	NAT	M?	209.8		1280.20		1280.20
92	Feddersen Wierde	46	F	NAT		214.3		1307.66		1307.66
92	Feddersen Wierde	47	F	NAT	H?	210.7		1285.69		1285.69
92	Feddersen Wierde	48	F	NAT		191.3		1167.31		1167.31
92	Feddersen Wierde	49	F	NAT	H*	199		1214.30		1214.30
92	Feddersen Wierde	50	F	NAT	H*	196		1195.99		1195.99
92	Feddersen Wierde	51	F	NAT	H*	212.5		1296.68		1296.68
92	Feddersen Wierde	52	F	NAT		208.4		1271.66		1271.66
92	Feddersen Wierde	53	F	NAT	D?	202.9		1238.10		1238.10
92	Feddersen Wierde	54	F	NAT	H*	188.8		1152.06		1152.06
92	Feddersen Wierde	55	F	NAT	H	205.1		1251.52		1251.52
92	Feddersen Wierde	56	F	NAT	H	202.9		1238.10		1238.10
92	Feddersen Wierde	57	F	NAT	H	210.9		1286.91		1286.91
92	Feddersen Wierde	58	F	NAT		210.1		1282.03		1282.03
92	Feddersen Wierde	59	F	NAT		205.9		1256.40		1256.40
92	Feddersen Wierde	60	F	NAT	H	202.9		1238.10		1238.10
92	Feddersen Wierde	61	F	NAT	H*	203.8		1243.59		1243.59
92	Feddersen Wierde	62	F	NAT	H	214.9		1311.32		1311.32
92	Feddersen Wierde	63	F	NAT	H*	197.4		1204.53		1204.53
92	Feddersen Wierde	64	F	NAT	H*	215.9		1317.42		1317.42
92	Feddersen Wierde	65	F	NAT	H	206.7		1261.28		1261.28
92	Feddersen Wierde	66	F	NAT		197.3		1203.92		1203.92
92	Feddersen Wierde	67	F	NAT	D?	202.4		1235.04		1235.04
92	Feddersen Wierde	68	F	NAT	H?	209.9		1280.81		1280.81
92	Feddersen Wierde	69	F	NAT		195.1		1190.50		1190.50
92	Feddersen Wierde	70	F	NAT	H	219.1		1336.95		1336.95
92	Feddersen Wierde	71	F	NAT	H	202.9		1238.10		1238.10
92	Feddersen Wierde	72	F	NAT	H	211.8		1292.40		1292.40
92	Feddersen Wierde	73	F	NAT	H	208.6		1272.88		1272.88

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
92	Feddersen Wierde	74	F	NAT		202.3		1234.43		1234.43
92	Feddersen Wierde	75	F	NAT	H*	211.2		1288.74		1288.74
92	Feddersen Wierde	76	F	NAT	H?	215.2		1313.15		1313.15
92	Feddersen Wierde	77	F	NAT	H	201.2		1227.72		1227.72
92	Feddersen Wierde	78	F	NAT	H?	207.3		1264.94		1264.94
92	Feddersen Wierde	79	F	NAT	H	215.8		1316.81		1316.81
92	Feddersen Wierde	80	F	NAT	D*	199.5		1217.35		1217.35
92	Feddersen Wierde	81	F	NAT	H*	204.3		1246.64		1246.64
92	Feddersen Wierde	82	F	NAT	H?	207.4		1265.55		1265.55
92	Feddersen Wierde	83	F	NAT		212.6		1297.29		1297.29
92	Feddersen Wierde	84	F	NAT		205.2		1252.13		1252.13
92	Feddersen Wierde	85	F	NAT	H*	194		1183.79		1183.79
92	Feddersen Wierde	86	F	NAT	H	211.2		1288.74		1288.74
92	Feddersen Wierde	87	F	NAT	H*	193.3		1179.52		1179.52
92	Feddersen Wierde	88	F	NAT	H?	204.5		1247.86		1247.86
92	Feddersen Wierde	89	F	NAT	H?	214.8		1310.71		1310.71
92	Feddersen Wierde	90	F	NAT	H	217.1		1324.74		1324.74
92	Feddersen Wierde	91	F	NAT	H	201.6		1230.16		1230.16
92	Feddersen Wierde	92	F	NAT	H*	216		1318.03		1318.03
92	Feddersen Wierde	93	F	NAT	H	204.6		1248.47		1248.47
92	Feddersen Wierde	94	F	NAT	H	209		1275.32		1275.32
92	Feddersen Wierde	95	F	NAT	M?	215.8		1316.81		1316.81
92	Feddersen Wierde	96	F	NAT	H	209.1		1275.93		1275.93
92	Feddersen Wierde	97	F	NAT	H	194		1183.79		1183.79
92	Feddersen Wierde	98	F	NAT		207.1		1263.72		1263.72
92	Feddersen Wierde	99	F	NAT	H	201.4		1228.94		1228.94
92	Feddersen Wierde	100	F	NAT	H*	205.6		1254.57		1254.57
92	Feddersen Wierde	101	F	NAT	D	206.6		1260.67		1260.67
92	Feddersen Wierde	102	F	NAT	H	204.3		1246.64		1246.64
92	Feddersen Wierde	103	F	NAT		208.4		1271.66		1271.66
92	Feddersen Wierde	104	F	NAT	H*	210.9		1286.91		1286.91
92	Feddersen Wierde	105	F	NAT	H	211.1		1288.13		1288.13
92	Feddersen Wierde	106	F	NAT	H*	214.2		1307.05		1307.05
92	Feddersen Wierde	107	F	NAT	H	206.9		1262.50		1262.50
92	Feddersen Wierde	108	F	NAT		212.2		1294.84		1294.84
92	Feddersen Wierde	109	F	NAT		218.7		1334.51		1334.51
92	Feddersen Wierde	110	F	NAT	H*	202.5		1235.66		1235.66
92	Feddersen Wierde	111	F	NAT		205.1		1251.52		1251.52
92	Feddersen Wierde	112	F	NAT	H	217		1324.13		1324.13
92	Feddersen Wierde	113	F	NAT	H	214.7		1310.10		1310.10
92	Feddersen Wierde	114	F	NAT	H*	200.7		1224.67		1224.67
92	Feddersen Wierde	115	F	NAT	H	228.9		1396.75		1396.75
92	Feddersen Wierde	116	F	NAT	H	204.6		1248.47		1248.47
92	Feddersen Wierde	117	F	NAT	H*	213.9		1305.22		1305.22
92	Feddersen Wierde	118	F	NAT	H	211.9		1293.01		1293.01
92	Feddersen Wierde	119	F	NAT	H	206.5		1260.06		1260.06
92	Feddersen Wierde	120	F	NAT	H	210.8		1286.30		1286.30
92	Feddersen Wierde	121	F	NAT	H	207.8		1268.00		1268.00
92	Feddersen Wierde	122	F	NAT	H	207.6		1266.78		1266.78
92	Feddersen Wierde	123	F	NAT	H	202.4		1235.04		1235.04
92	Feddersen Wierde	124	F	NAT	H	198.3		1210.03		1210.03
92	Feddersen Wierde	125	F	NAT	H*	208.1		1269.83		1269.83
92	Feddersen Wierde	126	F	NAT	H?	196.5		1199.04		1199.04
92	Feddersen Wierde	127	F	NAT	H?	213.3		1301.56		1301.56
92	Feddersen Wierde	128	F	NAT	H*	212.1		1294.23		1294.23
92	Feddersen Wierde	129	F	NAT	H*	193.4		1180.13		1180.13

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
92	Feddersen Wierde	130	F	NAT	H*	199.1		1214.91		1214.91
92	Feddersen Wierde	131	F	NAT	D	199.9		1219.79		1219.79
92	Feddersen Wierde	132	F	NAT	D*	210		1281.42		1281.42
92	Feddersen Wierde	133	F	NAT	H	204.5		1247.86		1247.86
92	Feddersen Wierde	134	F	NAT	H*	226.4		1381.49		1381.49
92	Feddersen Wierde	135	F	NAT	H?	202.6		1236.27		1236.27
92	Feddersen Wierde	136	F	NAT	H	207.9		1268.61		1268.61
92	Feddersen Wierde	137	F	NAT	H?	214.1		1306.44		1306.44
92	Feddersen Wierde	138	F	NAT	H*	208.8		1274.10		1274.10
92	Feddersen Wierde	139	F	NAT	H*	204.9		1250.30		1250.30
92	Feddersen Wierde	140	F	NAT	H?	197.2		1203.31		1203.31
92	Feddersen Wierde	141	F	NAT	H?	209.1		1275.93		1275.93
92	Feddersen Wierde	142	F	NAT	H	205.2		1252.13		1252.13
92	Feddersen Wierde	143	F	NAT	H*	206		1257.01		1257.01
92	Feddersen Wierde	144	F	NAT		218		1330.24		1330.24
92	Feddersen Wierde	145	F	NAT		212.7		1297.90		1297.90
92	Feddersen Wierde	146	F	NAT	D	215.6		1315.59		1315.59
92	Feddersen Wierde	147	F	NAT	H	210.8		1286.30		1286.30
92	Feddersen Wierde	148	F	NAT	H*	196.5		1199.04		1199.04
92	Feddersen Wierde	149	F	NAT	H	204.3		1246.64		1246.64
92	Feddersen Wierde	150	F	NAT	H	203.9		1244.20		1244.20
92	Feddersen Wierde	151	F	NAT	H	203.8		1243.59		1243.59
92	Feddersen Wierde	152	F	NAT	H	202.8		1237.49		1237.49
92	Feddersen Wierde	153	F	NAT	H	199.8		1219.18		1219.18
92	Feddersen Wierde	154	F	NAT		209.9		1280.81		1280.81
92	Feddersen Wierde	155	F	NAT	H	214.2		1307.05		1307.05
92	Feddersen Wierde	156	F	NAT	H*	214.3		1307.66		1307.66
92	Feddersen Wierde	157	F	NAT	H	211.8		1292.40		1292.40
92	Feddersen Wierde	158	F	NAT	H?	210.2		1282.64		1282.64
92	Feddersen Wierde	159	F	NAT	H*	211.7		1291.79		1291.79
92	Feddersen Wierde	160	F	NAT	H	203.3		1240.54		1240.54
92	Feddersen Wierde	161	F	NAT	M?	219.2		1337.56		1337.56
92	Feddersen Wierde	162	F	NAT	H	206.1		1257.62		1257.62
92	Feddersen Wierde	163	F	NAT		212.3		1295.45		1295.45
92	Feddersen Wierde	164	F	NAT	H*	210.3		1283.25		1283.25
92	Feddersen Wierde	165	F	NAT	H?	204.5		1247.86		1247.86
92	Feddersen Wierde	166	F	NAT	H	221.8		1353.42		1353.42
92	Feddersen Wierde	167	F	NAT	D?	212.7		1297.90		1297.90
92	Feddersen Wierde	168	F	NAT		207.7		1267.39		1267.39
92	Feddersen Wierde	169	F	NAT		230.8		1408.34		1408.34
92	Feddersen Wierde	170	F	NAT		223.9		1366.24		1366.24
92	Feddersen Wierde	171	F	NAT	H*	215.6		1315.59		1315.59
92	Feddersen Wierde	172	F	NAT	H	213.7		1304.00		1304.00
92	Feddersen Wierde	173	F	NAT		230		1403.46		1403.46
92	Feddersen Wierde	174	F	NAT	H	197.6		1205.76		1205.76
92	Feddersen Wierde	175	F	NAT	H*	203		1238.71		1238.71
92	Feddersen Wierde	176	F	NAT	H	205.9		1256.40		1256.40
92	Feddersen Wierde	177	F	NAT	H	204.1		1245.42		1245.42
92	Feddersen Wierde	178	F	NAT		210.4		1283.86		1283.86
92	Feddersen Wierde	179	F	NAT	H	203.3		1240.54		1240.54
92	Feddersen Wierde	180	F	NAT	H*	204.1		1245.42		1245.42
92	Feddersen Wierde	181	F	NAT	H	219.1		1336.95		1336.95
92	Feddersen Wierde	182	F	NAT	H*	192.4		1174.02		1174.02
92	Feddersen Wierde	183	F	NAT	H	208.3		1271.05		1271.05
92	Feddersen Wierde	184	F	NAT		212.7		1297.90		1297.90
92	Feddersen Wierde	185	F	NAT	D?	204.9		1250.30		1250.30

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
92	Feddersen Wierde	186	F	NAT	H?	219.6		1340.00		1340.00
92	Feddersen Wierde	187	F	NAT	D?	200.2		1221.62		1221.62
92	Feddersen Wierde	188	F	NAT	H	214.9		1311.32		1311.32
92	Feddersen Wierde	189	F	NAT		212.6		1297.29		1297.29
92	Feddersen Wierde	190	F	NAT	H	204.1		1245.42		1245.42
92	Feddersen Wierde	191	F	NAT		198.1		1208.81		1208.81
92	Feddersen Wierde	192	F	NAT	H?	192.6		1175.25		1175.25
92	Feddersen Wierde	193	F	NAT	H	202.6		1236.27		1236.27
92	Feddersen Wierde	194	F	NAT	M?	208.9		1274.71		1274.71
92	Feddersen Wierde	195	F	NAT	H*	187.7		1145.35		1145.35
92	Feddersen Wierde	196	F	NAT		203.5		1241.76		1241.76
92	Feddersen Wierde	197	F	NAT		208.7		1273.49		1273.49
92	Feddersen Wierde	198	F	NAT	H	200		1220.40		1220.40
92	Feddersen Wierde	199	F	NAT	H?	215.2		1313.15		1313.15
92	Feddersen Wierde	200	F	NAT		211.2		1288.74		1288.74
92	Feddersen Wierde	201	F	NAT	H*	205.5		1253.96		1253.96
92	Feddersen Wierde	202	F	NAT		230.1		1404.07		1404.07
92	Feddersen Wierde	203	F	NAT	H	205.6		1254.57		1254.57
92	Feddersen Wierde	204	F	NAT	H*	213.5		1302.78		1302.78
92	Feddersen Wierde	205	F	NAT		203.1		1239.32		1239.32
92	Feddersen Wierde	206	F	NAT	H?	208.7		1273.49		1273.49
92	Feddersen Wierde	207	F	NAT	H*	219.7		1340.61		1340.61
92	Feddersen Wierde	208	F	NAT		214.2		1307.05		1307.05
92	Feddersen Wierde	209	F	NAT		208.6		1272.88		1272.88
92	Feddersen Wierde	210	F	NAT	M?	209.8		1280.20		1280.20
92	Feddersen Wierde	211	F	NAT	H	204.3		1246.64		1246.64
92	Feddersen Wierde	212	F	NAT	H*	204.7		1249.08		1249.08
92	Feddersen Wierde	213	F	NAT	H	222.4		1357.08		1357.08
92	Feddersen Wierde	214	F	NAT	D?	199.4		1216.74		1216.74
92	Feddersen Wierde	215	F	NAT	H*	200.6		1224.06		1224.06
92	Feddersen Wierde	216	F	NAT	H	210.9		1286.91		1286.91
92	Feddersen Wierde	217	F	NAT	H*	190		1159.38		1159.38
92	Feddersen Wierde	218	F	NAT	H	207.1		1263.72		1263.72
92	Feddersen Wierde	219	F	NAT	H*	209.4		1277.76		1277.76
92	Feddersen Wierde	220	F	NAT		204.9		1250.30		1250.30
92	Feddersen Wierde	221	F	NAT	H	212.6		1297.29		1297.29
92	Feddersen Wierde	222	F	NAT	M?	200.4		1222.84		1222.84
92	Feddersen Wierde	223	F	NAT		213.5		1302.78		1302.78
92	Feddersen Wierde	224	F	NAT	H	210.4		1283.86		1283.86
92	Feddersen Wierde	225	F	NAT	M?	211.4		1289.96		1289.96
92	Feddersen Wierde	226	F	NAT	H?	202.1		1233.21		1233.21
92	Feddersen Wierde	227	F	NAT	H	221.6		1352.20		1352.20
92	Feddersen Wierde	228	F	NAT	H*	204.3		1246.64		1246.64
92	Feddersen Wierde	229	F	NAT	H*	215.1		1312.54		1312.54
92	Feddersen Wierde	230	F	NAT	H	210		1281.42		1281.42
92	Feddersen Wierde	231	F	NAT	H	201.6		1230.16		1230.16
92	Feddersen Wierde	232	F	NAT	H	213.3		1301.56		1301.56
92	Feddersen Wierde	233	F	NAT	M?	225.8		1377.83		1377.83
92	Feddersen Wierde	234	F	NAT	H	219.7		1340.61		1340.61
92	Feddersen Wierde	235	F	NAT	H	209.5		1278.37		1278.37
92	Feddersen Wierde	236	F	NAT	H*	196.5		1199.04		1199.04
99	Mantles Green	623	E	RO		221	213	1348.54	1363.84	1356.19
99	Mantles Green	624	E	RO		239	231	1458.38	1479.09	1468.74
104	Orton Hall Farm	636	E	RO	H?	247		1507.19		1507.19
104	Orton Hall Farm	637	E	RO	M	210		1281.42		1281.42
104	Orton Hall Farm	638	E	RO	M*	238		1452.28		1452.28

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
104	Orton Hall Farm	639	E	RO	H*	226		1379.05		1379.05
105	Mons Claudianus	640	K	RO		230	220	1403.46	1408.66	1406.06
105	Mons Claudianus	641	K	RO		227.8	219.2	1390.04	1403.54	1396.79
105	Mons Claudianus	642	K	RO		226.8	220.2	1383.93	1409.94	1396.94
105	Mons Claudianus	643	K	RO		225.1	214.9	1373.56	1376.00	1374.78
105	Mons Claudianus	644	K	RO		221.9	215.8	1354.03	1381.77	1367.90
105	Mons Claudianus	645	K	RO		220	216	1342.44	1383.05	1362.74
105	Mons Claudianus	646	K	RO		216.2	210.9	1319.25	1350.39	1334.82
105	Mons Claudianus	647	K	RO		216	211	1318.03	1351.03	1334.53
105	Mons Claudianus	648	K	RO		215		1311.93		1311.93
105	Mons Claudianus	649	K	RO		214		1305.83		1305.83
105	Mons Claudianus	650	K	RO		211.2	205.8	1288.74	1317.74	1303.24
105	Mons Claudianus	651	K	RO		211	203.4	1287.52	1302.37	1294.95
105	Mons Claudianus	652	K	RO		210.4	204.3	1283.86	1308.13	1296.00
105	Mons Claudianus	653	K	RO		208		1269.22		1269.22
105	Mons Claudianus	654	K	RO		206	201	1257.01	1287.00	1272.01
105	Mons Claudianus	655	K	RO		205.7	198.7	1255.18	1272.28	1263.73
105	Mons Claudianus	656	K	RO		205	203	1250.91	1299.81	1275.36
105	Mons Claudianus	657	K	RO		205	195	1250.91	1248.59	1249.75
105	Mons Claudianus	658	K	RO		204.8	199.5	1249.69	1277.40	1263.54
105	Mons Claudianus	659	K	RO		204	198	1244.81	1267.79	1256.30
105	Mons Claudianus	660	K	RO		204	197	1244.81	1261.39	1253.10
105	Mons Claudianus	661	K	RO		202	195	1232.60	1248.59	1240.59
105	Mons Claudianus	662	K	RO		200	194.5	1220.40	1245.38	1232.89
105	Mons Claudianus	663	K	RO		197.5	191.6	1205.15	1226.81	1215.98
105	Mons Claudianus	664	K	RO		194	187.8	1183.79	1202.48	1193.14
105	Mons Claudianus	665	K	RO		192	186	1171.58	1190.96	1181.27
105	Mons Claudianus	666	K	RO		192	186	1171.58	1190.96	1181.27
105	Mons Claudianus	667	K	RO		191	185	1165.48	1184.56	1175.02
105	Mons Claudianus	668	K	RO			195		1248.59	1248.59
106	Abu Sha'ar	717	K	RO		203.5	196	1241.76	1254.99	1248.37
112	Pompeii, Sarno Baths	747	A	RO		235		1433.97		1433.97
112	Pompeii, Sarno Baths	750	A	RO		268.5		1638.39		1638.39
113	Southwark	751	E	RO	H*	180		1098.36		1098.36
114	Unterlaa	752	F	RO	M*	225	218.1	1372.95	1396.49	1384.72
114	Unterlaa	756	F	RO	H	207.2	199.1	1264.33	1274.84	1269.59
115	Bad Wimpfen	758	F	RO		239	232	1458.38	1485.50	1471.94
115	Bad Wimpfen	759	F	RO		236.5	228.2	1443.12	1461.16	1452.14
115	Bad Wimpfen	760	F	RO		225	217.9	1372.95	1395.21	1384.08
115	Bad Wimpfen	761	F	RO	H*	224.7	216.3	1371.12	1384.97	1378.04
115	Bad Wimpfen	762	F	RO	H*	220.3	211.8	1344.27	1356.16	1350.21
115	Bad Wimpfen	763	F	RO	H	218.8	211.3	1335.12	1352.95	1344.04
115	Bad Wimpfen	764	F	RO	H	216	207.7	1318.03	1329.90	1323.97
115	Bad Wimpfen	765	F	RO	H*	212.8	205.6	1298.51	1316.46	1307.48
115	Bad Wimpfen	779	F	RO		163	157	994.63	1005.27	999.95
115	Bad Wimpfen	780	F	RO		154	150	939.71	960.45	950.08
116	Pommeroeul	781	D	RO	H	203	196	1238.71	1254.99	1246.85
116	Pommeroeul	782	D	RO	H*	210	203	1281.42	1299.81	1290.61
116	Pommeroeul	783	D	RO	H?	219	211	1336.34	1351.03	1343.69
116	Pommeroeul	784	D	RO	D*	220	213	1342.44	1363.84	1353.14
116	Pommeroeul	785	D	RO	M?	222	215	1354.64	1376.65	1365.64
116	Pommeroeul	786	D	RO	M*	221	213	1348.54	1363.84	1356.19
116	Pommeroeul	787	D	RO	H*	224	216	1366.85	1383.05	1374.95
116	Pommeroeul	788	D	RO	H*	226	220	1379.05	1408.66	1393.86
116	Pommeroeul	789	D	RO	M?	240	232	1464.48	1485.50	1474.99
116	Pommeroeul	790	D	RO	H?	241	234	1470.58	1498.30	1484.44

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
117	Pompeii stable	792	A	RO		239	231	1458.38	1479.09	1468.74
117	Pompeii stable	795	A	RO		231	225	1409.56	1440.68	1425.12
118	Carnuntum	800	F	RO	M	251	243	1531.60	1555.93	1543.77
118	Carnuntum	801	F	RO	M*	250	243.7	1525.50	1560.41	1542.96
118	Carnuntum	802	F	RO	M	239	231	1458.38	1479.09	1468.74
118	Carnuntum	803	F	RO	D	167.2	162.5	1020.25	1040.49	1030.37
120	Basel-Gasfabrik	806	F	IA	H*	205.1	196.9	1251.52	1260.75	1256.14
120	Basel-Gasfabrik	807	F	IA	H*	185.2	178.1	1130.09	1140.37	1135.23
120	Basel-Gasfabrik	808	F	IA	H	199.3	191.2	1216.13	1224.25	1220.19
120	Basel-Gasfabrik	809	F	IA	H	197.8	190.3	1206.98	1218.49	1212.73
120	Basel-Gasfabrik	810	F	IA	H*	194.8	187.5	1188.67	1200.56	1194.62
120	Basel-Gasfabrik	811	F	IA	H?	232.4	222.8	1418.10	1426.59	1422.35
120	Basel-Gasfabrik	812	F	IA	H?	208.5	202.1	1272.27	1294.05	1283.16
120	Basel-Gasfabrik	813	F	IA	H	206.6	198.5	1260.67	1271.00	1265.83
120	Basel-Gasfabrik	814	F	IA		198		1208.20		1208.20
121	Soluthurn/Vigier	816	F	RO	M	241	231.6	1470.58	1482.93	1476.76
121	Soluthurn/Vigier	817	F	RO	H	223.8	214.8	1365.63	1375.36	1370.50
122	Lousonna	818	F	RO		229.2	218.8	1398.58	1400.98	1399.78
123	Wroxeter Baths basilica	819	E	RO	H?	216		1318.03		1318.03
123	Wroxeter Baths basilica	821	E	RO	H	211.5		1290.57		1290.57
123	Wroxeter Baths basilica	822	E	RO	H	216.5		1321.08		1321.08
124	Haddon	823	E	IA+RO		215	213	1311.93	1363.84	1337.88
124	Haddon	824	E	IA+RO		198	194	1208.20	1242.18	1225.19
124	Haddon	825	E	IA+RO		205.1		1251.52		1251.52
124	Haddon	826	E	IA+RO		205	202	1250.91	1293.41	1272.16
124	Haddon	827	E	IA+RO		245	244	1494.99	1562.33	1528.66
124	Haddon	828	E	IA+RO		202	198	1232.60	1267.79	1250.20
125	Castleford	830	E	RO	H	194.2		1185.01		1185.01
125	Castleford	834	E	RO		247		1507.19		1507.19
125	Castleford	835	E	RO	H?	232		1415.66		1415.66
125	Castleford	838	E	RO	H	216		1318.03		1318.03
127	Tortoreto-Fortellezza	841	A	IA	D	173.5		1058.70		1058.70
128	Krefeld-Gellep	846	F	RO		203		1238.71		1238.71
129	Lorenzberg Bei Epfach	851	F	RO		243	233	1482.79	1491.90	1487.34
129	Lorenzberg Bei Epfach	855	F	RO		227	219	1385.15	1402.26	1393.71
129	Lorenzberg Bei Epfach	861	F	RO		208	200	1269.22	1280.60	1274.91
129	Lorenzberg Bei Epfach	862	F	RO		195	188	1189.89	1203.76	1196.83
131	Radovesice	863	G	IA	H*	202	194	1232.60	1242.18	1237.39
132	Godmanchester	865	E	RO		234		1427.87		1427.87
132	Godmanchester	867	E	RO		214		1305.83		1305.83
132	Godmanchester	869	E	RO		222		1354.64		1354.64
132	Godmanchester	870	E	RO		222.2		1355.86		1355.86
132	Godmanchester	871	E	RO		210		1281.42		1281.42
132	Godmanchester	872	E	RO		229.9		1402.85		1402.85
132	Godmanchester	873	E	RO		221		1348.54		1348.54
132	Godmanchester	874	E	RO		211.3		1289.35		1289.35
132	Godmanchester	878	E	RO		234		1427.87		1427.87
133	Colchester	880	E	RO		202		1232.60		1232.60
133	Colchester	881	E	RO		203		1238.71		1238.71
133	Colchester	882	E	RO		206		1257.01		1257.01
133	Colchester	883	E	RO		234		1427.87		1427.87
134	Butzbach	884	F	RO		231	227	1409.56	1453.48	1431.52
134	Butzbach	885	F	RO	H	191	186	1165.48	1190.96	1178.22
134	Butzbach	886	F	RO	M	225	222	1372.95	1421.47	1397.21
136	Worth Matravers	896	E	IA+RO		202.3		1234.43		1234.43
137	Magdelenska Gora	897	G	IA		211		1287.52		1287.52

Site no	Site name	Bone no	Region	Period	ID level	GL	LI	WH-V	WH-K	WH-M
137	Magdelenska Gora	898	G	IA	H?	219		1336.34		1336.34
137	Magdelenska Gora	899	G	IA		214.5		1308.88		1308.88
141	Szentes-Vekerzug	901	G	IA		210		1281.42		1281.42
143	Histria	902	G	IA	H*	230		1403.46		1403.46
143	Histria	903	G	IA	H?	235		1433.97		1433.97
143	Histria	904	G	IA		221		1348.54		1348.54
143	Histria	905	G	IA		229		1397.36		1397.36
143	Histria	906	G	IA	H*	225		1372.95		1372.95
144	Albertfalva	908	G	RO	M?	216		1318.03		1318.03
144	Albertfalva	912	G	RO		245		1494.99		1494.99
144	Albertfalva	913	G	RO		240		1464.48		1464.48
144	Albertfalva	914	G	RO	M	245		1494.99		1494.99
144	Albertfalva	915	G	RO	M	240		1464.48		1464.48
144	Albertfalva	918	G	RO	M*	237		1446.17		1446.17
144	Albertfalva	919	G	RO		227		1385.15		1385.15
144	Albertfalva	920	G	RO		223		1360.75		1360.75
144	Albertfalva	921	G	RO	M*	242		1476.68		1476.68
144	Albertfalva	923	G	RO	H?	220		1342.44		1342.44
144	Albertfalva	924	G	RO		233		1421.77		1421.77
146	Balatonaliga	925	G	RO	H*	207		1263.11		1263.11
146	Balatonaliga	926	G	RO	H?	218		1330.24		1330.24
146	Balatonaliga	927	G	RO		219		1336.34		1336.34
149	Helemba - Sziget	929	G	IA	H*	197		1202.09		1202.09
150	Acs - Vaspuszta	930	G	RO	H*	227		1385.15		1385.15
153	Aquileia forum	931	A	RO	H	219.5	213	1339.39	1363.84	1351.61
153	Aquileia forum	932	A	RO	H*	221	212	1348.54	1357.44	1352.99
153	Aquileia forum	933	A	RO		228		1391.26		1391.26
153	Aquileia forum	934	A	RO		238	231	1452.28	1479.09	1465.68
156	Invillino- Ibliglo	948	A	RO		234	225	1427.87	1440.68	1434.27
156	Invillino- Ibliglo	949	A	RO		213	204	1299.73	1306.21	1302.97
161	San Giovanni	955	A	RO		276.1		1684.76		1684.76
161	San Giovanni	956	A	RO		241.8		1475.46		1475.46
161	San Giovanni	957	A	RO		215.3		1313.76		1313.76
164	Stufels	959	A	RO		187.5		1144.13		1144.13
172	Metaponto Panatello	962	A	RO		240		1464.48		1464.48
173	Paestum	963	A	RO		222		1354.64		1354.64
173	Paestum	965	A	RO		208		1269.22		1269.22
174	Abusina-Eining	966	F	RO	M*	247	238.5	1507.19	1527.12	1517.15
174	Abusina-Eining	967	F	RO	M	242	234.5	1476.68	1501.50	1489.09
174	Abusina-Eining	968	F	RO		241.5	233.5	1473.63	1495.10	1484.37
174	Abusina-Eining	969	F	RO	H?	241	231.5	1470.58	1482.29	1476.44
174	Abusina-Eining	970	F	RO	M*	240.5	233	1467.53	1491.90	1479.72
174	Abusina-Eining	971	F	RO	M	227.5	220	1388.21	1408.66	1398.43
174	Abusina-Eining	972	F	RO	H*	227	220	1385.15	1408.66	1396.91
174	Abusina-Eining	973	F	RO	M	216.5	208	1321.08	1331.82	1326.45
174	Abusina-Eining	974	F	RO	M?	236.5	226.5	1443.12	1450.28	1446.70
174	Abusina-Eining	975	F	RO	M*	234	227	1427.87	1453.48	1440.67
174	Abusina-Eining	976	F	RO		231		1409.56		1409.56
174	Abusina-Eining	977	F	RO	H*	224	216	1366.85	1383.05	1374.95
174	Abusina-Eining	978	F	RO			215		1376.65	1376.65
175	Sablonetum-Ellingen	984	F	RO		209	203	1275.32	1299.81	1287.56
176	Oberdorla	986	F	NAT		228	222	1391.26	1421.47	1406.36
176	Oberdorla	987	F	NAT	M?	226	218	1379.05	1395.85	1387.45
176	Oberdorla	988	F	NAT		226		1379.05		1379.05
176	Oberdorla	989	F	NAT		224		1366.85		1366.85
176	Oberdorla	990	F	NAT	M	222	216	1354.64	1383.05	1368.85

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
176	Oberdorla	991	F	NAT		219	211	1336.34	1351.03	1343.69
176	Oberdorla	992	F	NAT	H*	214	205	1305.83	1312.62	1309.22
176	Oberdorla	993	F	NAT	H*	213	204	1299.73	1306.21	1302.97
176	Oberdorla	994	F	NAT	M?	210	206	1281.42	1319.02	1300.22
176	Oberdorla	995	F	NAT	H	210	204	1281.42	1306.21	1293.82
176	Oberdorla	996	F	NAT	M?	210	202	1281.42	1293.41	1287.41
176	Oberdorla	997	F	NAT	H	210	201	1281.42	1287.00	1284.21
176	Oberdorla	998	F	NAT	H?	210	201	1281.42	1287.00	1284.21
176	Oberdorla	999	F	NAT	H*	210	202	1281.42	1293.41	1287.41
176	Oberdorla	1000	F	NAT		209	202	1275.32	1293.41	1284.36
176	Oberdorla	1001	F	NAT	H	208	199	1269.22	1274.20	1271.71
176	Oberdorla	1002	F	NAT	H*	207	200	1263.11	1280.60	1271.86
176	Oberdorla	1003	F	NAT	H?	202	196	1232.60	1254.99	1243.80
176	Oberdorla	1004	F	NAT	H	201	193	1226.50	1235.78	1231.14
176	Oberdorla	1005	F	NAT	H	193	187	1177.69	1197.36	1187.52
176	Oberdorla	1006	F	NAT	H*	179	171	1092.26	1094.91	1093.59
176	Oberdorla	1007	F	NAT		193		1177.69		1177.69
176	Oberdorla	1008	F	NAT	H*	177	170	1080.05	1088.51	1084.28
178	Vitudurum-Oberwinterthur	1011	F	RO		225	214	1372.95	1370.24	1371.60
178	Vitudurum-Oberwinterthur	1013	F	RO	M?	229	218	1397.36	1395.85	1396.61
178	Vitudurum-Oberwinterthur	1015	F	RO	H	220	209	1342.44	1338.23	1340.33
178	Vitudurum-Oberwinterthur	1016	F	RO		214	203.5	1305.83	1303.01	1304.42
181	Barnsley Park	1018	E	RO		227		1385.15		1385.15
182	Frocester Court	1019	E	RO		210		1281.42		1281.42
182	Frocester Court	1020	E	RO		220		1342.44		1342.44
183	Segontium	1024	E	RO		220		1342.44		1342.44
184	Chilgrove 1	1028	E	RO		227		1385.15		1385.15
184	Chilgrove 1	1029	E	RO		205		1250.91		1250.91
186	Shakenoak site K	1030	E	RO		200		1220.40		1220.40
186	Shakenoak site K	1031	E	RO		213		1299.73		1299.73
189	Kassope	1040	H	IA	D	180		1098.36		1098.36
189	Kassope	1044	H	IA	D	167		1019.03		1019.03
190	Breisach	1049	F	RO		226.5	217.5	1382.10	1392.65	1387.38
190	Breisach	1050	F	RO		233	227	1421.77	1453.48	1437.62
192	Pfaffenhofen - Pons Aeni	1053	F	RO		217	209	1324.13	1338.23	1331.18
192	Pfaffenhofen - Pons Aeni	1055	F	RO		236	226	1440.07	1447.08	1443.58
192	Pfaffenhofen - Pons Aeni	1057	F	RO		240.5	232	1467.53	1485.50	1476.51
193	Marzoll - Marciolae	1058	F	RO		212.5	205.5	1296.68	1315.82	1306.25
195	Kunzing-Quintana	1061	F	RO		217	208.5	1324.13	1335.03	1329.58
195	Kunzing-Quintana	1062	F	RO		215	208	1311.93	1331.82	1321.88
195	Kunzing-Quintana	1063	F	RO		214	206.5	1305.83	1322.22	1314.02
196	Dormagen	1068	F	RO		235	226	1433.97	1447.08	1440.52
196	Dormagen	1069	F	RO		227.5	221	1388.21	1415.06	1401.63
196	Dormagen	1070	F	RO		211.5	204.5	1290.57	1309.41	1299.99
197	Froitzheim	1073	F	RO		227		1385.15		1385.15
197	Froitzheim	1074	F	RO		225	214	1372.95	1370.24	1371.60
197	Froitzheim	1075	F	RO		224	218	1366.85	1395.85	1381.35
199	Hufingen	1078	F	RO		239	230.5	1458.38	1475.89	1467.13
199	Hufingen	1079	F	RO		229	219	1397.36	1402.26	1399.81
199	Hufingen	1080	F	RO		228.5	219	1394.31	1402.26	1398.28
199	Hufingen	1081	F	RO		228.5	221.5	1394.31	1418.26	1406.29
199	Hufingen	1082	F	RO		227.5	220.5	1388.21	1411.86	1400.03
199	Hufingen	1083	F	RO		227	217	1385.15	1389.45	1387.30
199	Hufingen	1084	F	RO		225		1372.95		1372.95
199	Hufingen	1085	F	RO		223	214	1360.75	1370.24	1365.49
199	Hufingen	1086	F	RO		220		1342.44		1342.44

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
199	Hufingen	1099	F	RO		239.5	228.5	1461.43	1463.09	1462.26
199	Hufingen	1100	F	RO		233	224.5	1421.77	1437.47	1429.62
199	Hufingen	1101	F	RO		233	224.5	1421.77	1437.47	1429.62
199	Hufingen	1102	F	RO		226	218.5	1379.05	1399.06	1389.05
199	Hufingen	1103	F	RO		224	217.5	1366.85	1392.65	1379.75
199	Hufingen	1104	F	RO		223	214	1360.75	1370.24	1365.49
199	Hufingen	1105	F	RO		222	214.5	1354.64	1373.44	1364.04
199	Hufingen	1106	F	RO		222		1354.64		1354.64
199	Hufingen	1107	F	RO		219.5		1339.39		1339.39
199	Hufingen	1108	F	RO		218		1330.24		1330.24
199	Hufingen	1109	F	RO		217		1324.13		1324.13
199	Hufingen	1110	F	RO		213	205.5	1299.73	1315.82	1307.77
200	Pfaffenhofen	1123	F	RO		218	210.5	1330.24	1347.83	1339.03
200	Pfaffenhofen	1124	F	RO		227	220.5	1385.15	1411.86	1398.51
200	Pfaffenhofen	1125	F	RO		232	224.5	1415.66	1437.47	1426.57
201	Wehringen	1127	F	RO		234	225.5	1427.87	1443.88	1435.87
202	Penzlin	1129	F	NAT	H	200.8	192	1225.28	1229.38	1227.33
202	Penzlin	1130	F	NAT		215.3	207.5	1313.76	1328.62	1321.19
202	Penzlin	1131	F	NAT		194.2		1185.01		1185.01
202	Penzlin	1132	F	NAT	H	213.7	205	1304.00	1312.62	1308.31
202	Penzlin	1133	F	NAT	D?	213.3	206	1301.56	1319.02	1310.29
202	Penzlin	1134	F	NAT	H?	221.5	213.1	1351.59	1364.48	1358.04
202	Penzlin	1136	F	NAT	H	198.5	190.5	1211.25	1219.77	1215.51
202	Penzlin	1137	F	NAT	H*	204.5	196	1247.86	1254.99	1251.42
203	Tac-Gorsium	1138	G	RO	H*	206.5		1260.06		1260.06
203	Tac-Gorsium	1139	G	RO		208		1269.22		1269.22
203	Tac-Gorsium	1140	G	RO	H*	209		1275.32		1275.32
203	Tac-Gorsium	1141	G	RO	H	209		1275.32		1275.32
203	Tac-Gorsium	1142	G	RO		216.5		1321.08		1321.08
203	Tac-Gorsium	1143	G	RO	M?	218		1330.24		1330.24
203	Tac-Gorsium	1144	G	RO		218		1330.24		1330.24
203	Tac-Gorsium	1145	G	RO	H*	219		1336.34		1336.34
203	Tac-Gorsium	1146	G	RO		219		1336.34		1336.34
203	Tac-Gorsium	1147	G	RO		219		1336.34		1336.34
203	Tac-Gorsium	1148	G	RO	H	220		1342.44		1342.44
203	Tac-Gorsium	1149	G	RO	H	220		1342.44		1342.44
203	Tac-Gorsium	1150	G	RO	H	221		1348.54		1348.54
203	Tac-Gorsium	1151	G	RO	H	222		1354.64		1354.64
203	Tac-Gorsium	1152	G	RO	H*	222		1354.64		1354.64
203	Tac-Gorsium	1153	G	RO	H*	222		1354.64		1354.64
203	Tac-Gorsium	1154	G	RO	M*	222.5		1357.70		1357.70
203	Tac-Gorsium	1155	G	RO		223		1360.75		1360.75
203	Tac-Gorsium	1156	G	RO	H	223		1360.75		1360.75
203	Tac-Gorsium	1157	G	RO	H*	223		1360.75		1360.75
203	Tac-Gorsium	1158	G	RO	H?	223		1360.75		1360.75
203	Tac-Gorsium	1159	G	RO		224		1366.85		1366.85
203	Tac-Gorsium	1160	G	RO	M?	224		1366.85		1366.85
203	Tac-Gorsium	1161	G	RO	H	224		1366.85		1366.85
203	Tac-Gorsium	1162	G	RO		225		1372.95		1372.95
203	Tac-Gorsium	1163	G	RO	M*	225		1372.95		1372.95
203	Tac-Gorsium	1164	G	RO	M	225		1372.95		1372.95
203	Tac-Gorsium	1165	G	RO	H?	225.5		1376.00		1376.00
203	Tac-Gorsium	1166	G	RO	M?	226		1379.05		1379.05
203	Tac-Gorsium	1167	G	RO	M	226		1379.05		1379.05
203	Tac-Gorsium	1168	G	RO	H*	226		1379.05		1379.05
203	Tac-Gorsium	1169	G	RO	H	227		1385.15		1385.15

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
203	Tac-Gorsium	1170	G	RO	H?	227		1385.15		1385.15
203	Tac-Gorsium	1171	G	RO	M*	227.5		1388.21		1388.21
203	Tac-Gorsium	1172	G	RO	H*	229		1397.36		1397.36
203	Tac-Gorsium	1173	G	RO	H*	229		1397.36		1397.36
203	Tac-Gorsium	1174	G	RO	M*	229		1397.36		1397.36
203	Tac-Gorsium	1175	G	RO	H*	229		1397.36		1397.36
203	Tac-Gorsium	1176	G	RO		229		1397.36		1397.36
203	Tac-Gorsium	1177	G	RO		230		1403.46		1403.46
203	Tac-Gorsium	1178	G	RO	H?	230		1403.46		1403.46
203	Tac-Gorsium	1179	G	RO	H*	230.5		1406.51		1406.51
203	Tac-Gorsium	1180	G	RO	M	231		1409.56		1409.56
203	Tac-Gorsium	1181	G	RO	H	231		1409.56		1409.56
203	Tac-Gorsium	1182	G	RO	M	231.5		1412.61		1412.61
203	Tac-Gorsium	1183	G	RO		232		1415.66		1415.66
203	Tac-Gorsium	1184	G	RO	H?	232		1415.66		1415.66
203	Tac-Gorsium	1185	G	RO	H	232		1415.66		1415.66
203	Tac-Gorsium	1186	G	RO	H?	233.5		1424.82		1424.82
203	Tac-Gorsium	1187	G	RO	H	235		1433.97		1433.97
203	Tac-Gorsium	1188	G	RO	H?	235		1433.97		1433.97
203	Tac-Gorsium	1189	G	RO	H*	237		1446.17		1446.17
203	Tac-Gorsium	1190	G	RO	M	237		1446.17		1446.17
203	Tac-Gorsium	1191	G	RO	H*	237		1446.17		1446.17
203	Tac-Gorsium	1192	G	RO	M	238		1452.28		1452.28
203	Tac-Gorsium	1193	G	RO		238		1452.28		1452.28
203	Tac-Gorsium	1194	G	RO	H?	238.5		1455.33		1455.33
203	Tac-Gorsium	1195	G	RO	M	239		1458.38		1458.38
203	Tac-Gorsium	1196	G	RO	H?	245		1494.99		1494.99
203	Tac-Gorsium	1197	G	RO	M*	252.6		1541.37		1541.37
203	Tac-Gorsium	1198	G	RO	M?	260		1586.52		1586.52
203	Tac-Gorsium	1199	G	RO	M*	262.5		1601.78		1601.78
204	Conchil	1236	D	RO	H*	215.3	208	1313.76	1331.82	1322.79
204	Conchil	1237	D	RO	H*	217.5		1327.19		1327.19
205	Oberstimm	1239	F	RO	D*	215.5	208.5	1314.98	1335.03	1325.00
205	Oberstimm	1240	F	RO	M*	239.5	233	1461.43	1491.90	1476.66
206	Lauriacum	1241	F	RO		227	218	1385.15	1395.85	1390.50
206	Lauriacum	1247	F	RO		228	219	1391.26	1402.26	1396.76
207	Haus Burgel	1251	F	RO	H	222		1354.64		1354.64
208	Colonia Ulpia Traiana	1253	F	RO		248.5	243	1516.35	1555.93	1536.14
208	Colonia Ulpia Traiana	1254	F	RO	H?	240.5	235	1467.53	1504.71	1486.12
208	Colonia Ulpia Traiana	1255	F	RO	H?	235.5	230	1437.02	1472.69	1454.86
208	Colonia Ulpia Traiana	1256	F	RO	H*	231	225	1409.56	1440.68	1425.12
208	Colonia Ulpia Traiana	1257	F	RO	H?	223	217.5	1360.75	1392.65	1376.70
208	Colonia Ulpia Traiana	1258	F	RO	H*	222	217	1354.64	1389.45	1372.05
208	Colonia Ulpia Traiana	1259	F	RO	H	219.5	214	1339.39	1370.24	1354.82
208	Colonia Ulpia Traiana	1260	F	RO	H*	218	213	1330.24	1363.84	1347.04
208	Colonia Ulpia Traiana	1261	F	RO		217	212.5	1324.13	1360.64	1342.39
208	Colonia Ulpia Traiana	1262	F	RO	H*	216	211	1318.03	1351.03	1334.53
208	Colonia Ulpia Traiana	1263	F	RO	H?	203	198.5	1238.71	1271.00	1254.85
208	Colonia Ulpia Traiana	1264	F	RO	H	201	197.5	1226.50	1264.59	1245.55
209	Iatrus	1266	G	RO	H*	233.1		1422.38		1422.38
209	Iatrus	1270	G	RO	D	181.2		1105.68		1105.68
210	Freidorf	1272	G	RO		227.5	217	1388.21	1389.45	1388.83
211	Castillar de Mendavia	1273	B	IA		202	194	1232.60	1242.18	1237.39
212	Gournay	1275	D	IA	H	203		1238.71		1238.71
212	Gournay	1276	D	IA	H	194		1183.79		1183.79
213	Beauvais	1277	D	IA	H	202		1232.60		1232.60

Site no	Site name	Bone no	Region	Period	ID level	GL	Ll	WH-V	WH-K	WH-M
213	Beauvais	1278	D	IA	H*	226		1379.05		1379.05
213	Beauvais	1279	D	IA	H?	237		1446.17		1446.17
213	Beauvais	1280	D	IA	D?	193		1177.69		1177.69
213	Beauvais	1281	D	IA	H	207		1263.11		1263.11
213	Beauvais	1282	D	IA	H	200		1220.40		1220.40
213	Beauvais	1283	D	IA	H*	184		1122.77		1122.77
214	Compiegne	1284	D	IA	H	232		1415.66		1415.66
214	Compiegne	1285	D	IA		203		1238.71		1238.71
215	Ribemont	1286	D	IA	H*	190		1159.38		1159.38
216	Variscourt	1287	D	IA	H	188		1147.18		1147.18
216	Variscourt	1288	D	IA	H*	208		1269.22		1269.22
216	Variscourt	1289	D	IA	H*	182		1110.56		1110.56
216	Variscourt	1290	D	IA	H	192		1171.58		1171.58
216	Variscourt	1291	D	IA	H*	189		1153.28		1153.28
216	Variscourt	1292	D	IA	H*	224		1366.85		1366.85
217	Soissons	1293	D	IA	H*	171		1043.44		1043.44

Table A26. – Results of the calculation of the shaft breadth to greatest length index on the Metacarpals

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
3	Edix Hill	IA	E	rural	604			201.5	30.3	15.04
4	Market Deeping	IA	E	rural	603			208.0	30.1	14.47
7	Blackhorse Road	IA	E	rural	599			221.4	28.4	12.83
7	Blackhorse Road	IA	E	rural	600			204.0	31.1	15.25
7	Blackhorse Road	IA	E	rural	601			202.7	31.4	15.49
10	Twywell	IA	E	rural	593			206.0	30.0	14.56
10	Twywell	IA	E	rural	594			198.0	28.0	14.14
14	Lincoln	RO	E	urb	579			223.9	34.4	15.36
14	Lincoln	RO	E	urb	580			196.3	27.4	13.96
15	Scole-Dickleburgh	RO	E	urb2	573			226.6	31.6	13.95
15	Scole-Dickleburgh	RO	E	urb2	574			220.1	34.1	15.49
15	Scole-Dickleburgh	RO	E	urb2	577			232.3	39.4	16.96
15	Scole-Dickleburgh	RO	E	urb2	578		H?	205.4	27.8	13.53
18	Camulodunum	RO	E	urb	562			195.0	28.0	14.36
18	Camulodunum	RO	E	urb	563			195.0	28.0	14.36
18	Camulodunum	RO	E	urb	564			198.0	31.0	15.66
20	Northchurch	RO	E	villa	561			260.0	31.5	12.12
27	Lynch Farm	RO	E	villa	554			220.0	32.0	14.55
28	Longthorpe II	RO	E	mil	553		M?	232.0	37.0	15.95
30	Tort Hill East	RO	E	rural	550			228.0	32.1	14.08
30	Tort Hill East	RO	E	rural	551			202.0	28.4	14.06
35	Castricum-Oosterbuurt	RO	F	oth	529			209.1	31.8	15.19
35	Castricum-Oosterbuurt	RO	F	oth	530			228.3	31.8	13.92
35	Castricum-Oosterbuurt	RO	F	oth	531			228.6	31.7	13.88
35	Castricum-Oosterbuurt	RO	F	oth	532			220.6	31.2	14.15
35	Castricum-Oosterbuurt	RO	F	oth	533			219.3	31.6	14.39
35	Castricum-Oosterbuurt	RO	F	oth	534	1		219.9	30.5	13.87
35	Castricum-Oosterbuurt	RO	F	oth	535	1		219.2	31.4	14.32
35	Castricum-Oosterbuurt	RO	F	oth	536			220.0	31.7	14.40
35	Castricum-Oosterbuurt	RO	F	oth	537			210.2	30.9	14.71
35	Castricum-Oosterbuurt	RO	F	oth	539			221.0	29.2	13.21
35	Castricum-Oosterbuurt	RO	F	oth	540			211.0	30.5	14.44
35	Castricum-Oosterbuurt	RO	F	oth	542			212.2	28.4	13.39
35	Castricum-Oosterbuurt	RO	F	oth	543			217.6	29.5	13.55
35	Castricum-Oosterbuurt	RO	F	oth	544			231.0	31.5	13.63
35	Castricum-Oosterbuurt	RO	F	oth	545			225.1	32.4	14.41
36	Egmond?	RO	F	oth	528			220.5	31.0	14.06
37	Kesteren 'De Prinsenhof'	RO	F	cem	522	11-36		235.0	37.5	15.96
37	Kesteren 'De Prinsenhof'	RO	F	cem	523	11-34	H?	235.0	35.0	14.89
37	Kesteren 'De Prinsenhof'	RO	F	cem	525	1-24		217.0	34.2	15.76
37	Kesteren 'De Prinsenhof'	RO	F	cem	526	1-11		231.0	35.8	15.50
37	Kesteren 'De Prinsenhof'	RO	F	cem	527	1-6	H?	238.0	37.7	15.84
38	Nijmegen	RO	F	urb	501		H*	211.7	34.8	16.44
38	Nijmegen	RO	F	urb	502		M*	236.8	30.9	13.05
38	Nijmegen	RO	F	urb	503		H?	236.8	36.1	15.24
38	Nijmegen	RO	F	urb	504		M*	227.9	36.1	15.84
38	Nijmegen	RO	F	urb	505		H*	240.4	34.5	14.35
38	Nijmegen	RO	F	urb	506		H?	221.5	35.0	15.80
38	Nijmegen	RO	F	urb	507		M	225.1	32.2	14.30
38	Nijmegen	RO	F	urb	508		H	217.3	31.1	14.31

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
38	Nijmegen	RO	F	urb	509		H*	226.9	32.6	14.37
38	Nijmegen	RO	F	urb	510		H?	237.2	34.3	14.46
38	Nijmegen	RO	F	urb	511		H	222.1	32.2	14.50
38	Nijmegen	RO	F	urb	514		H?	215.9	31.8	14.73
38	Nijmegen	RO	F	urb	515		H?	225.9	33.6	14.87
38	Nijmegen	RO	F	urb	518			220.8	34.0	15.40
38	Nijmegen	RO	F	urb	519		H	215.8	33.2	15.38
38	Nijmegen	RO	F	urb	520			213.5	32.3	15.13
40	Heteren	NAT	F	rural	496			198.3	29.9	15.08
40	Heteren	NAT	F	rural	497			233.1	36.0	15.44
42	Druten	RO	F	villa	478		M?	236.0	31.6	13.39
42	Druten	RO	F	villa	481			226.0	31.9	14.12
42	Druten	RO	F	villa	482			241.4	28.4	11.76
42	Druten	RO	F	villa	483		H*	220.3	33.6	15.25
42	Druten	RO	F	villa	484			223.8	36.1	16.13
42	Druten	RO	F	villa	485		H*	231.8	32.7	14.11
42	Druten	RO	F	villa	489		H?	241.7	32.2	13.32
42	Druten	RO	F	villa	490		H*	232.6	29.0	12.47
42	Druten	RO	F	villa	491		M?	233.7	35.0	14.98
42	Druten	RO	F	villa	492		H?	235.0	31.6	13.45
42	Druten	RO	F	villa	493	1.18	M*	248.1	37.2	14.99
42	Druten	IA	F	villa	495		H*	224.2	32.9	14.67
43	Elms Farm	RO	E	urb2	465			217.0	31.7	14.61
43	Elms Farm	RO	E	urb2	466		H	205.2	30.8	15.01
43	Elms Farm	RO	E	urb2	467			235.0	32.5	13.83
43	Elms Farm	RO	E	urb2	468	6640	H*	231.0	32.9	14.24
43	Elms Farm	RO	E	urb2	469	6640	H*	230.0	33.5	14.57
43	Elms Farm	RO	E	urb2	470			235.0	32.5	13.83
43	Elms Farm	IA	E	urb2	472			191.0	29.0	15.18
43	Elms Farm	IA	E	urb2	473			210.0	30.6	14.57
43	Elms Farm	IA	E	urb2	474			190.9	28.8	15.09
44	Danebury	IA	E	rural	427		H*	193.0	28.0	14.51
44	Danebury	IA	E	rural	433		D*	182.0	24.4	13.41
44	Danebury	IA	E	rural	434		H	193.0	29.7	15.39
44	Danebury	IA	E	rural	436		H?	197.0	26.9	13.65
44	Danebury	IA	E	rural	437		D*	230.0	25.0	10.87
44	Danebury	IA	E	rural	438			190.0	25.3	13.32
44	Danebury	IA	E	rural	439			187.0	25.9	13.85
44	Danebury	IA	E	rural	443			192.0	27.8	14.48
44	Danebury	IA	E	rural	444			201.0	28.7	14.28
44	Danebury	IA	E	rural	445			204.0	28.8	14.12
44	Danebury	IA	E	rural	446			172.0	26.2	15.23
44	Danebury	IA	E	rural	448		H	207.0	31.2	15.07
44	Danebury	IA	E	rural	449			187.0	25.8	13.80
44	Danebury	IA	E	rural	453			182.0	27.2	14.95
44	Danebury	IA	E	rural	455			206.0	30.4	14.76
44	Danebury	IA	E	rural	457		H	207.0	30.7	14.83
44	Danebury	IA	E	rural	458		H	221.0	31.8	14.39
44	Danebury	IA	E	rural	460		H	200.0	29.2	14.60
46	E London RB Cemetary	RO	E	cem	420		H?	216.5	32.2	14.87
46	E London RB Cemetary	RO	E	cem	421			224.5	33.4	14.88
47	Beddington Sewage Farm	RO	E	urb	413		H?	190.5	27.5	14.44
47	Beddington Sewage Farm	RO	E	urb	414		H?	190.5	27.8	14.59
47	Beddington Sewage Farm	RO	E	urb	415			201.5	31.2	15.48
47	Beddington Sewage Farm	RO	E	urb	416		M?	213.3	27.7	12.99
47	Beddington Sewage Farm	RO	E	urb	417			210.0	29.7	14.14

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
47	Beddington Sewage Farm	RO	E	urb	418			217.0	29.0	13.36
47	Beddington Sewage Farm	IA	E	urb	419		H	198.4	29.1	14.67
51	Coldharbour Farm 97	IA	E	villa	410		H	215.0	29.9	13.91
51	Coldharbour Farm 97	IA	E	villa	411		H	207.9	32.1	15.44
51	Coldharbour Farm 97	IA	E	villa	412		H	217.7	33.4	15.34
54	Thorpe Thewles	IA	E	rural	404		H	203.0	29.0	14.29
54	Thorpe Thewles	IA	E	rural	405		H*	182.0	25.8	14.18
55	Brancaster 1974	RO	E	mil	402			231.0	28.0	12.12
57	La Sagesse	IA	E	oth	399			203.0	29.9	14.73
57	La Sagesse	IA	E	oth	400			216.0	30.7	14.21
57	La Sagesse	IA	E	oth	401			209.0	30.9	14.78
59	Chichester cattlemarket	RO	E	urb	397	XXIII	H*	240.4	36.7	15.27
59	Chichester cattlemarket	RO	E	urb	398	XXIII	H*	242.0	37.2	15.37
63	S. Giacomo	RO	A	villa	395		H?	235.0	34.7	14.77
66	Settefinestre	RO	A	villa	387		M?	226.0	31.0	13.72
66	Settefinestre	RO	A	villa	388		D*	234.0	35.0	14.96
66	Settefinestre	RO	A	villa	389			189.0	25.0	13.23
70	Emilia	IA	A	oth	382			202.0	28.5	14.11
71	Piovego	IA	A	cem	381	N2	H*	217.0	31.0	14.29
72	Colle dei Cappuccini	IA	A	rural	380			209.0	31.0	14.83
73	Moie di Pollenza	IA	A	cem	379			218.0	36.0	16.51
76	Ansedonia	RO	A	villa	378			158.0	29.0	18.35
77	Grotto di Tibera	RO	A	oth	375	15.3		198.0	26.0	13.13
77	Grotto di Tibera	RO	A	oth	376	15.2		255.0	39.0	15.29
77	Grotto di Tibera	RO	A	oth	377	15.1		231.0	39.0	16.88
79	Olbia	IA	A	rural	374		D*	159.4	23.4	14.68
83	Deutsch Wusterhausen	NAT	F	rural	373		H*	220.0	37.7	17.14
85	Macon	RO	D	cem	370		D*	247.0	32.2	13.04
87	Manching	IA	F	rural	309			180.0	27.5	15.28
87	Manching	IA	F	rural	310			181.5	23.5	12.95
87	Manching	IA	F	rural	311			184.0	28.0	15.22
87	Manching	IA	F	rural	312			184.0	25.5	13.86
87	Manching	IA	F	rural	313			185.0	26.5	14.32
87	Manching	IA	F	rural	314			185.5	29.0	15.63
87	Manching	IA	F	rural	315			186.0	34.0	18.28
87	Manching	IA	F	rural	316			186.5	26.5	14.21
87	Manching	IA	F	rural	317			188.5	26.5	14.06
87	Manching	IA	F	rural	318			191.5	29.0	15.14
87	Manching	IA	F	rural	319			191.5	28.0	14.62
87	Manching	IA	F	rural	320			192.0	27.0	14.06
87	Manching	IA	F	rural	321			192.0	25.5	13.28
87	Manching	IA	F	rural	322			192.0	27.5	14.32
87	Manching	IA	F	rural	323			192.0	26.5	13.80
87	Manching	IA	F	rural	324			193.0	28.5	14.77
87	Manching	IA	F	rural	325			193.0	26.5	13.73
87	Manching	IA	F	rural	326			193.0	26.5	13.73
87	Manching	IA	F	rural	327			193.0	30.0	15.54
87	Manching	IA	F	rural	328			193.0	28.5	14.77
87	Manching	IA	F	rural	329			193.5	28.0	14.47
87	Manching	IA	F	rural	330			194.0	28.0	14.43
87	Manching	IA	F	rural	331			194.5	29.5	15.17
87	Manching	IA	F	rural	332			195.0	30.0	15.38
87	Manching	IA	F	rural	333			195.0	29.0	14.87
87	Manching	IA	F	rural	334			195.5	30.5	15.60
87	Manching	IA	F	rural	335			196.0	29.0	14.80
87	Manching	IA	F	rural	336			198.0	27.5	13.89

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
87	Manching	IA	F	rural	337			198.5	29.5	14.86
87	Manching	IA	F	rural	338			199.0	28.0	14.07
87	Manching	IA	F	rural	339			199.0	28.5	14.32
87	Manching	IA	F	rural	340			199.5	27.0	13.53
87	Manching	IA	F	rural	341			199.5	29.5	14.79
87	Manching	IA	F	rural	342			200.0	30.5	15.25
87	Manching	IA	F	rural	343			200.5	31.5	15.71
87	Manching	IA	F	rural	344			200.5	30.0	14.96
87	Manching	IA	F	rural	345			201.0	28.5	14.18
87	Manching	IA	F	rural	346			201.0	28.5	14.18
87	Manching	IA	F	rural	347			201.0	30.0	14.93
87	Manching	IA	F	rural	348			202.0	30.0	14.85
87	Manching	IA	F	rural	349			203.0	31.0	15.27
87	Manching	IA	F	rural	350			204.0	29.0	14.22
87	Manching	IA	F	rural	351			207.5	28.0	13.49
87	Manching	IA	F	rural	352			208.0	31.0	14.90
87	Manching	IA	F	rural	353			208.5	29.5	14.15
87	Manching	IA	F	rural	354			208.5	29.5	14.15
87	Manching	IA	F	rural	355			209.0	29.5	14.11
87	Manching	IA	F	rural	356			211.0	27.5	13.03
87	Manching	IA	F	rural	357			211.5	29.5	13.95
87	Manching	IA	F	rural	358			212.5	32.0	15.06
87	Manching	IA	F	rural	359			213.5	30.0	14.05
87	Manching	IA	F	rural	360			213.5	31.5	14.75
87	Manching	IA	F	rural	361			213.5	30.5	14.29
87	Manching	IA	F	rural	362			216.0	33.5	15.51
87	Manching	IA	F	rural	363			216.0	31.5	14.58
87	Manching	IA	F	rural	365			220.0	31.0	14.09
87	Manching	IA	F	rural	366			226.5	34.0	15.01
87	Manching	IA	F	rural	367			228.5	34.5	15.10
87	Manching	IA	F	rural	368			231.0	34.0	14.72
87	Manching	IA	F	rural	369			244.0	35.0	14.34
92	Feddersen Wierde	NAT	F	rural	25	skelett3L	M	221.0	28.0	12.67
92	Feddersen Wierde	NAT	F	rural	26	skelett2R	H	206.3	30.6	14.83
92	Feddersen Wierde	NAT	F	rural	27	skelett2L	H	205.7	29.8	14.49
92	Feddersen Wierde	NAT	F	rural	28	skelett1L	H	221.8	30.2	13.62
92	Feddersen Wierde	NAT	F	rural	29		D?	196.7	25.1	12.76
92	Feddersen Wierde	NAT	F	rural	30		H	213.8	31.6	14.78
92	Feddersen Wierde	NAT	F	rural	31			201.1	31.1	15.46
92	Feddersen Wierde	NAT	F	rural	32		H?	196.1	27.1	13.82
92	Feddersen Wierde	NAT	F	rural	33		D*	200.5	24.9	12.42
92	Feddersen Wierde	NAT	F	rural	34		H*	203.5	31.3	15.38
92	Feddersen Wierde	NAT	F	rural	35		D?	207.5	26.4	12.72
92	Feddersen Wierde	NAT	F	rural	36		M*	217.5	30.3	13.93
92	Feddersen Wierde	NAT	F	rural	37		H?	198.1	28.7	14.49
92	Feddersen Wierde	NAT	F	rural	38		H	202.7	28.2	13.91
92	Feddersen Wierde	NAT	F	rural	39		H*	197.9	29.4	14.86
92	Feddersen Wierde	NAT	F	rural	40		H?	215.3	27.6	12.82
92	Feddersen Wierde	NAT	F	rural	41		M?	206.8	28.7	13.88
92	Feddersen Wierde	NAT	F	rural	42		H*	215.5	27.5	12.76
92	Feddersen Wierde	NAT	F	rural	43			202.3	25.3	12.51
92	Feddersen Wierde	NAT	F	rural	44		H*	216.6	30.7	14.17
92	Feddersen Wierde	NAT	F	rural	45		M?	209.8	30.5	14.54
92	Feddersen Wierde	NAT	F	rural	47		H?	210.7	30.0	14.24
92	Feddersen Wierde	NAT	F	rural	48			191.3	29.6	15.47
92	Feddersen Wierde	NAT	F	rural	49		H*	199.0	30.6	15.38

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	50		H*	196.0	27.5	14.03
92	Feddersen Wierde	NAT	F	rural	51		H*	212.5	29.8	14.02
92	Feddersen Wierde	NAT	F	rural	52			208.4	28.6	13.72
92	Feddersen Wierde	NAT	F	rural	53		D?	202.9	26.1	12.86
92	Feddersen Wierde	NAT	F	rural	54		H*	188.8	28.4	15.04
92	Feddersen Wierde	NAT	F	rural	55		H	205.1	29.0	14.14
92	Feddersen Wierde	NAT	F	rural	56		H	202.9	28.7	14.14
92	Feddersen Wierde	NAT	F	rural	57		H	210.9	28.8	13.66
92	Feddersen Wierde	NAT	F	rural	60		H	202.9	29.0	14.29
92	Feddersen Wierde	NAT	F	rural	61		H*	203.8	27.9	13.69
92	Feddersen Wierde	NAT	F	rural	62		H	214.9	31.6	14.70
92	Feddersen Wierde	NAT	F	rural	63		H*	197.4	28.4	14.39
92	Feddersen Wierde	NAT	F	rural	64		H*	215.9	30.7	14.22
92	Feddersen Wierde	NAT	F	rural	65		H	206.7	31.0	15.00
92	Feddersen Wierde	NAT	F	rural	66			197.3	27.5	13.94
92	Feddersen Wierde	NAT	F	rural	67		D?	202.4	28.6	14.13
92	Feddersen Wierde	NAT	F	rural	68		H?	209.9	31.0	14.77
92	Feddersen Wierde	NAT	F	rural	69			195.1	27.7	14.20
92	Feddersen Wierde	NAT	F	rural	70		H	219.1	30.4	13.87
92	Feddersen Wierde	NAT	F	rural	71		H	202.9	29.6	14.59
92	Feddersen Wierde	NAT	F	rural	72		H	211.8	31.1	14.68
92	Feddersen Wierde	NAT	F	rural	73		H	208.6	33.2	15.92
92	Feddersen Wierde	NAT	F	rural	75		H*	211.2	29.3	13.87
92	Feddersen Wierde	NAT	F	rural	76		H?	215.2	25.8	11.99
92	Feddersen Wierde	NAT	F	rural	77		H	201.2	29.2	14.51
92	Feddersen Wierde	NAT	F	rural	78		H?	207.3	27.1	13.07
92	Feddersen Wierde	NAT	F	rural	79		H	215.8	29.0	13.44
92	Feddersen Wierde	NAT	F	rural	80		D*	199.5	23.5	11.78
92	Feddersen Wierde	NAT	F	rural	81		H*	204.3	29.0	14.19
92	Feddersen Wierde	NAT	F	rural	82		H?	207.4	25.0	12.05
92	Feddersen Wierde	NAT	F	rural	83			212.6	31.1	14.63
92	Feddersen Wierde	NAT	F	rural	84			205.2	27.4	13.35
92	Feddersen Wierde	NAT	F	rural	85		H*	194.0	27.7	14.28
92	Feddersen Wierde	NAT	F	rural	86		H	211.2	30.9	14.63
92	Feddersen Wierde	NAT	F	rural	87		H*	193.3	27.4	14.17
92	Feddersen Wierde	NAT	F	rural	88		H?	204.5	27.7	13.55
92	Feddersen Wierde	NAT	F	rural	89		H?	214.8	28.0	13.04
92	Feddersen Wierde	NAT	F	rural	90		H	217.1	31.2	14.37
92	Feddersen Wierde	NAT	F	rural	91		H	201.6	29.1	14.43
92	Feddersen Wierde	NAT	F	rural	92		H*	216.0	28.3	13.10
92	Feddersen Wierde	NAT	F	rural	93		H	204.6	30.4	14.86
92	Feddersen Wierde	NAT	F	rural	94		H	209.0	31.8	15.22
92	Feddersen Wierde	NAT	F	rural	95		M?	215.8	29.9	13.86
92	Feddersen Wierde	NAT	F	rural	96		H	209.1	30.0	14.35
92	Feddersen Wierde	NAT	F	rural	97		H	194.0	30.4	15.67
92	Feddersen Wierde	NAT	F	rural	98			207.1	32.2	15.55
92	Feddersen Wierde	NAT	F	rural	99		H	201.4	27.6	13.70
92	Feddersen Wierde	NAT	F	rural	100		H*	205.6	26.3	12.79
92	Feddersen Wierde	NAT	F	rural	101		D	206.6	25.2	12.20
92	Feddersen Wierde	NAT	F	rural	102		H	204.3	29.3	14.34
92	Feddersen Wierde	NAT	F	rural	103			208.4	29.7	14.25
92	Feddersen Wierde	NAT	F	rural	104		H*	210.9	30.4	14.41
92	Feddersen Wierde	NAT	F	rural	105		H	211.1	30.0	14.21
92	Feddersen Wierde	NAT	F	rural	106		H*	214.2	30.9	14.43
92	Feddersen Wierde	NAT	F	rural	107		H	206.9	29.0	14.02
92	Feddersen Wierde	NAT	F	rural	108			212.2	30.7	14.47

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	109			218.7	27.0	12.35
92	Feddersen Wierde	NAT	F	rural	110		H*	202.5	27.7	13.68
92	Feddersen Wierde	NAT	F	rural	111			205.1	29.6	14.43
92	Feddersen Wierde	NAT	F	rural	112		H	217.0	30.3	13.96
92	Feddersen Wierde	NAT	F	rural	113		H	214.7	31.2	14.53
92	Feddersen Wierde	NAT	F	rural	114		H*	200.7	26.6	13.25
92	Feddersen Wierde	NAT	F	rural	115		H	228.9	33.1	14.46
92	Feddersen Wierde	NAT	F	rural	116		H	204.6	29.8	14.57
92	Feddersen Wierde	NAT	F	rural	117		H*	213.9	29.8	13.93
92	Feddersen Wierde	NAT	F	rural	118		H	211.9	31.6	14.91
92	Feddersen Wierde	NAT	F	rural	119		H	206.5	30.3	14.67
92	Feddersen Wierde	NAT	F	rural	120		H	210.8	29.3	13.90
92	Feddersen Wierde	NAT	F	rural	121		H	207.8	30.0	14.44
92	Feddersen Wierde	NAT	F	rural	122		H	207.6	27.3	13.15
92	Feddersen Wierde	NAT	F	rural	123		H	202.4	27.6	13.64
92	Feddersen Wierde	NAT	F	rural	124		H	198.3	28.3	14.27
92	Feddersen Wierde	NAT	F	rural	125		H*	208.1	30.8	14.80
92	Feddersen Wierde	NAT	F	rural	126		H?	196.5	27.2	13.84
92	Feddersen Wierde	NAT	F	rural	127		H?	213.3	30.6	14.35
92	Feddersen Wierde	NAT	F	rural	128		H*	212.1	29.5	13.91
92	Feddersen Wierde	NAT	F	rural	129		H*	193.4	26.0	13.44
92	Feddersen Wierde	NAT	F	rural	130		H*	199.1	28.6	14.36
92	Feddersen Wierde	NAT	F	rural	131		D	199.9	22.6	11.31
92	Feddersen Wierde	NAT	F	rural	132		D*	210.0	28.2	13.43
92	Feddersen Wierde	NAT	F	rural	133		H	204.5	28.4	13.89
92	Feddersen Wierde	NAT	F	rural	134		H*	226.4	35.4	15.64
92	Feddersen Wierde	NAT	F	rural	135		H?	202.6	28.1	13.87
92	Feddersen Wierde	NAT	F	rural	136		H	207.9	29.4	14.14
92	Feddersen Wierde	NAT	F	rural	137		H?	214.1	28.5	13.31
92	Feddersen Wierde	NAT	F	rural	138		H*	208.8	27.7	13.27
92	Feddersen Wierde	NAT	F	rural	139		H*	204.9	29.9	14.59
92	Feddersen Wierde	NAT	F	rural	140		H?	197.2	25.9	13.13
92	Feddersen Wierde	NAT	F	rural	141		H?	209.1	27.8	13.30
92	Feddersen Wierde	NAT	F	rural	142		H	205.2	30.2	14.72
92	Feddersen Wierde	NAT	F	rural	143		H*	206.0	29.4	14.27
92	Feddersen Wierde	NAT	F	rural	144			218.0	32.1	14.72
92	Feddersen Wierde	NAT	F	rural	145			212.7	29.0	13.63
92	Feddersen Wierde	NAT	F	rural	146		D	215.6	24.9	11.55
92	Feddersen Wierde	NAT	F	rural	147		H	210.8	30.0	14.23
92	Feddersen Wierde	NAT	F	rural	148		H*	196.5	27.1	13.79
92	Feddersen Wierde	NAT	F	rural	149		H	204.3	28.8	14.10
92	Feddersen Wierde	NAT	F	rural	150		H	203.9	28.9	14.17
92	Feddersen Wierde	NAT	F	rural	151		H	203.8	30.9	15.16
92	Feddersen Wierde	NAT	F	rural	152		H	202.8	30.5	15.04
92	Feddersen Wierde	NAT	F	rural	153		H	199.8	31.4	15.72
92	Feddersen Wierde	NAT	F	rural	154			209.9	29.3	13.96
92	Feddersen Wierde	NAT	F	rural	155		H	214.2	28.4	13.26
92	Feddersen Wierde	NAT	F	rural	156		H*	214.3	27.5	12.83
92	Feddersen Wierde	NAT	F	rural	157		H	211.8	29.2	13.79
92	Feddersen Wierde	NAT	F	rural	158		H?	210.2	29.8	14.18
92	Feddersen Wierde	NAT	F	rural	159		H*	211.7	29.9	14.12
92	Feddersen Wierde	NAT	F	rural	160		H	203.3	30.6	15.05
92	Feddersen Wierde	NAT	F	rural	161		M?	219.2	27.4	12.50
92	Feddersen Wierde	NAT	F	rural	162		H	206.1	30.4	14.75
92	Feddersen Wierde	NAT	F	rural	164		H*	210.3	30.3	14.41
92	Feddersen Wierde	NAT	F	rural	165		H?	204.5	27.3	13.35

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	166		H	221.8	28.7	12.94
92	Feddersen Wierde	NAT	F	rural	167		D?	212.7	27.6	12.98
92	Feddersen Wierde	NAT	F	rural	168			207.7	26.4	12.71
92	Feddersen Wierde	NAT	F	rural	169			230.8	32.1	13.91
92	Feddersen Wierde	NAT	F	rural	170			223.9	31.7	14.16
92	Feddersen Wierde	NAT	F	rural	171		H*	215.6	29.9	13.87
92	Feddersen Wierde	NAT	F	rural	172		H	213.7	30.1	14.09
92	Feddersen Wierde	NAT	F	rural	173			230.0	30.5	13.26
92	Feddersen Wierde	NAT	F	rural	174		H	197.6	30.0	15.18
92	Feddersen Wierde	NAT	F	rural	175		H*	203.0	30.7	15.12
92	Feddersen Wierde	NAT	F	rural	176		H	205.9	27.5	13.36
92	Feddersen Wierde	NAT	F	rural	177		H	204.1	29.4	14.40
92	Feddersen Wierde	NAT	F	rural	178			210.4	27.6	13.12
92	Feddersen Wierde	NAT	F	rural	179		H	203.3	28.3	13.92
92	Feddersen Wierde	NAT	F	rural	180		H*	204.1	27.7	13.57
92	Feddersen Wierde	NAT	F	rural	181		H	219.1	30.2	13.78
92	Feddersen Wierde	NAT	F	rural	182		H*	192.4	29.6	15.38
92	Feddersen Wierde	NAT	F	rural	183		H	208.3	28.7	13.78
92	Feddersen Wierde	NAT	F	rural	184			212.7	30.4	14.29
92	Feddersen Wierde	NAT	F	rural	185		D?	204.9	27.5	13.42
92	Feddersen Wierde	NAT	F	rural	186		H?	219.6	27.9	12.70
92	Feddersen Wierde	NAT	F	rural	187		D?	200.2	25.9	12.94
92	Feddersen Wierde	NAT	F	rural	188		H	214.9	28.4	13.22
92	Feddersen Wierde	NAT	F	rural	189			212.6	29.8	14.02
92	Feddersen Wierde	NAT	F	rural	190		H	204.1	29.9	14.65
92	Feddersen Wierde	NAT	F	rural	191			198.1	24.3	12.27
92	Feddersen Wierde	NAT	F	rural	192		H?	192.6	28.1	14.59
92	Feddersen Wierde	NAT	F	rural	193		H	202.6	29.5	14.56
92	Feddersen Wierde	NAT	F	rural	194		M?	208.9	28.9	13.83
92	Feddersen Wierde	NAT	F	rural	195		H*	187.7	27.8	14.81
92	Feddersen Wierde	NAT	F	rural	196			203.5	28.4	13.96
92	Feddersen Wierde	NAT	F	rural	197			208.7	28.0	13.42
92	Feddersen Wierde	NAT	F	rural	198		H	200.0	29.3	14.65
92	Feddersen Wierde	NAT	F	rural	199		H?	215.2	28.7	13.34
92	Feddersen Wierde	NAT	F	rural	200			211.2	28.7	13.59
92	Feddersen Wierde	NAT	F	rural	201		H*	205.5	30.9	15.04
92	Feddersen Wierde	NAT	F	rural	202			230.1	32.8	14.25
92	Feddersen Wierde	NAT	F	rural	203		H	205.6	29.1	14.15
92	Feddersen Wierde	NAT	F	rural	204		H*	213.5	29.8	13.96
92	Feddersen Wierde	NAT	F	rural	205			203.1	29.0	14.28
92	Feddersen Wierde	NAT	F	rural	206		H?	208.7	27.9	13.37
92	Feddersen Wierde	NAT	F	rural	207		H*	219.7	29.2	13.29
92	Feddersen Wierde	NAT	F	rural	208			214.2	29.0	13.54
92	Feddersen Wierde	NAT	F	rural	209			208.6	29.8	14.29
92	Feddersen Wierde	NAT	F	rural	210		M?	209.8	29.0	13.82
92	Feddersen Wierde	NAT	F	rural	211		H	204.3	28.7	14.05
92	Feddersen Wierde	NAT	F	rural	212		H*	204.7	28.9	14.12
92	Feddersen Wierde	NAT	F	rural	213		H	222.4	30.8	13.85
92	Feddersen Wierde	NAT	F	rural	214		D?	199.4	26.8	13.44
92	Feddersen Wierde	NAT	F	rural	215		H*	200.6	30.8	15.35
92	Feddersen Wierde	NAT	F	rural	216		H	210.9	31.0	14.70
92	Feddersen Wierde	NAT	F	rural	217		H*	190.0	26.0	13.68
92	Feddersen Wierde	NAT	F	rural	218		H	207.1	29.1	14.05
92	Feddersen Wierde	NAT	F	rural	219		H*	209.4	30.0	14.33
92	Feddersen Wierde	NAT	F	rural	220			204.9	31.5	15.37
92	Feddersen Wierde	NAT	F	rural	221		H	212.6	29.9	14.06

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	222		M?	200.4	28.3	14.12
92	Feddersen Wierde	NAT	F	rural	223			213.5	30.4	14.24
92	Feddersen Wierde	NAT	F	rural	224		H	210.4	29.8	14.16
92	Feddersen Wierde	NAT	F	rural	225		M?	211.4	29.0	13.72
92	Feddersen Wierde	NAT	F	rural	226		H?	302.1	36.0	11.92
92	Feddersen Wierde	NAT	F	rural	227		H	221.6	28.0	12.64
92	Feddersen Wierde	NAT	F	rural	228		H*	204.3	28.4	13.90
92	Feddersen Wierde	NAT	F	rural	229		H*	215.1	27.6	12.83
92	Feddersen Wierde	NAT	F	rural	230		H	210.0	29.0	13.81
92	Feddersen Wierde	NAT	F	rural	231		H	201.6	30.1	14.93
92	Feddersen Wierde	NAT	F	rural	232		H	213.3	29.3	13.74
92	Feddersen Wierde	NAT	F	rural	233		M?	225.8	28.1	12.44
92	Feddersen Wierde	NAT	F	rural	234		H	219.7	30.9	14.06
92	Feddersen Wierde	NAT	F	rural	235		H	209.5	28.8	13.75
92	Feddersen Wierde	NAT	F	rural	236		H*	196.5	29.0	14.76
96	Kunzing east vicus	RO	F	cem	1	1703	M*	219.6	34.3	15.62
96	Kunzing east vicus	RO	F	cem	2	1641	M*	229.0	33.3	14.54
96	Kunzing east vicus	RO	F	cem	3	1581	H?	238.5	33.7	14.13
96	Kunzing east vicus	RO	F	cem	4	1575/5	H*	228.0	34.8	15.26
96	Kunzing east vicus	RO	F	cem	5	1620	H*	239.4	33.4	13.95
96	Kunzing east vicus	RO	F	cem	6	1632	M	237.8	33.1	13.92
99	Mantles Green	RO	E	villa	623			221.0	33.4	15.11
99	Mantles Green	RO	E	villa	624			239.0	28.1	11.76
104	Orton Hall Farm	RO	E	villa	636		H?	247.0	39.0	15.79
104	Orton Hall Farm	RO	E	villa	637		M	210.0	33.0	15.71
104	Orton Hall Farm	RO	E	villa	638		M*	238.0	35.0	14.71
104	Orton Hall Farm	RO	E	villa	639		H*	226.0	35.0	15.49
105	Mons Claudianus	RO	K	ind	640			230.0	29.2	12.70
105	Mons Claudianus	RO	K	ind	641			227.8	30.7	13.48
105	Mons Claudianus	RO	K	ind	642			226.8	28.8	12.70
105	Mons Claudianus	RO	K	ind	643			225.1	31.2	13.86
105	Mons Claudianus	RO	K	ind	644			221.9	29.9	13.47
105	Mons Claudianus	RO	K	ind	645			220.0	28.8	13.09
105	Mons Claudianus	RO	K	ind	646			216.2	28.3	13.09
105	Mons Claudianus	RO	K	ind	647	826		216.0	28.0	12.96
105	Mons Claudianus	RO	K	ind	648	143		215.0	25.0	11.63
105	Mons Claudianus	RO	K	ind	649			214.0	27.2	12.71
105	Mons Claudianus	RO	K	ind	650			211.2	29.5	13.97
105	Mons Claudianus	RO	K	ind	651	851		211.0	30.0	14.22
105	Mons Claudianus	RO	K	ind	652	1497		210.4	28.0	13.31
105	Mons Claudianus	RO	K	ind	654			206.0	28.2	13.69
105	Mons Claudianus	RO	K	ind	655			205.7	27.9	13.56
105	Mons Claudianus	RO	K	ind	656			205.0	27.2	13.27
105	Mons Claudianus	RO	K	ind	657	792		205.0	26.9	13.12
105	Mons Claudianus	RO	K	ind	658			204.8	29.7	14.50
105	Mons Claudianus	RO	K	ind	659			204.0	28.5	13.97
105	Mons Claudianus	RO	K	ind	660			204.0	26.5	12.99
105	Mons Claudianus	RO	K	ind	661			202.0	24.9	12.33
105	Mons Claudianus	RO	K	ind	662	180		200.0	25.2	12.60
105	Mons Claudianus	RO	K	ind	663			197.5	24.9	12.61
105	Mons Claudianus	RO	K	ind	664	286		194.0	26.7	13.76
105	Mons Claudianus	RO	K	ind	665			192.0	24.3	12.66
105	Mons Claudianus	RO	K	ind	666			192.0	24.9	12.97
105	Mons Claudianus	RO	K	ind	667			191.0	28.3	14.82
106	Abu Sha'ar	RO	K	mil	717			203.5	24.8	12.19
110	Nijmegen new excavations	RO	F	urb	741	179/16-24	H*	200.0	28.4	14.20

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
110	Nijmegen new excavations	RO	F	urb	742	179/16-27	H*	220.1	33.1	15.04
110	Nijmegen new excavations	RO	F	urb	743	1961/621-2	H?	194.9	30.2	15.50
110	Nijmegen new excavations	RO	F	urb	744	147/128-21	H?	246.5	34.1	13.83
112	Pompeii, Sarno Baths	RO	A	urb	747	A		235.0	33.8	14.38
112	Pompeii, Sarno Baths	RO	A	urb	748	B		236.5	32.2	13.62
112	Pompeii, Sarno Baths	RO	A	urb	749	C		237.3	35.4	14.92
112	Pompeii, Sarno Baths	RO	A	urb	750	D		268.5	32.4	12.07
113	Southwark	RO	E	urb	751		H*	180.0	26.8	14.89
114	Unterlaa	RO	G	urb	752	22B	M*	225.0	33.1	14.71
114	Unterlaa	RO	G	urb	753	23	H	225.0	27.3	12.13
114	Unterlaa	RO	G	urb	754	25	H*	217.5	33.8	15.54
114	Unterlaa	RO	G	urb	755	30	H	217.0	33.2	15.30
114	Unterlaa	RO	G	urb	756	32		207.2	31.6	15.25
115	Bad Wimpfen	RO	F	urb2	758			239.0	35.5	14.85
115	Bad Wimpfen	RO	F	urb2	759			236.5	36.9	15.60
115	Bad Wimpfen	RO	F	urb2	760			225.0	34.5	15.33
115	Bad Wimpfen	RO	F	urb2	761		H*	224.7	34.2	15.22
115	Bad Wimpfen	RO	F	urb2	762		H*	220.3	34.2	15.52
115	Bad Wimpfen	RO	F	urb2	763		H	218.8	31.8	14.53
115	Bad Wimpfen	RO	F	urb2	764		H	216.0	32.8	15.19
115	Bad Wimpfen	RO	F	urb2	765		H*	212.8	33.4	15.70
115	Bad Wimpfen	RO	F	urb2	779			163.0	21.3	13.07
115	Bad Wimpfen	RO	F	urb2	780			154.0	21.8	14.16
116	Pommeroeul	RO	D	urb2	781	248-1	H	203.0	29.0	14.29
116	Pommeroeul	RO	D	urb2	782	238	H*	210.0	32.0	15.24
116	Pommeroeul	RO	D	urb2	783	B	H?	219.0	34.0	15.53
116	Pommeroeul	RO	D	urb2	784	348	D*	220.0	30.0	13.64
116	Pommeroeul	RO	D	urb2	785	271-1	M?	222.0	30.0	13.51
116	Pommeroeul	RO	D	urb2	786	271-2	M*	221.0	30.0	13.57
116	Pommeroeul	RO	D	urb2	787	17-1	H*	224.0	33.0	14.73
116	Pommeroeul	RO	D	urb2	788	328	H*	226.0	37.0	16.37
116	Pommeroeul	RO	D	urb2	789	198	M?	240.0	32.0	13.33
116	Pommeroeul	RO	D	urb2	790	17-2	H?	241.0	33.0	13.69
117	Pompeii stable	RO	A	urb	793	B	M*	234.0	34.4	14.70
117	Pompeii stable	RO	A	urb	794	C	M?	239.0	35.6	14.90
118	Carnuntum	RO	G	mil	796	Pferd 1	M	249.0	37.2	14.94
118	Carnuntum	RO	G	mil	797	Pferd 2	H	239.5	35.4	14.78
118	Carnuntum	RO	G	mil	798	Pferd 3	H*	233.0	33.3	14.29
118	Carnuntum	RO	G	mil	799	Pferd 4		245.5	32.2	13.12
118	Carnuntum	RO	G	mil	800		M	251.0	34.7	13.82
118	Carnuntum	RO	G	mil	801		M*	250.0	36.6	14.64
118	Carnuntum	RO	G	mil	802		M	239.0	36.8	15.40
118	Carnuntum	RO	G	mil	803		D	167.2	23.7	14.17
119	Albertfalva	RO	G	mil	804	Horse 1	H?	228.1	36.2	15.87
119	Albertfalva	RO	G	mil	805	Horse 2	H?	251.8	37.8	15.01
120	Basel-Gasfabrik	IA	F	rural	806		H*	205.1	31.4	15.31
120	Basel-Gasfabrik	IA	F	rural	807		H*	185.2	24.9	13.44
120	Basel-Gasfabrik	IA	F	rural	808		H	199.3	30.2	15.15
120	Basel-Gasfabrik	IA	F	rural	809		H	197.8	29.5	14.91
120	Basel-Gasfabrik	IA	F	rural	810		H*	194.8	31.5	16.17
120	Basel-Gasfabrik	IA	F	rural	811		H?	232.4	35.5	15.28
120	Basel-Gasfabrik	IA	F	rural	812		H?	208.5	30.8	14.77
120	Basel-Gasfabrik	IA	F	rural	813		H	206.6	28.9	13.99
121	Soluthurn/Vigier	RO	F	urb2	816		M	241.0	32.6	13.53

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
121	Soluthurn/Vigier	RO	F	urb2	817		H	223.8	33.1	14.79
122	Lousonna	RO	F	urb2	818			229.2	34.8	15.18
123	Wroxeter Baths basilica	RO	E	urb	819		H?	216.0	33.9	15.69
123	Wroxeter Baths basilica	RO	E	urb	822		H	216.5	32.1	14.83
124	Haddon	RO	E	oth	823			215.0	31.0	14.42
124	Haddon	RO	E	oth	824			198.0	30.5	15.40
124	Haddon	RO	E	oth	825			205.1	32.7	15.94
124	Haddon	RO	E	oth	826			205.0	30.0	14.63
124	Haddon	RO	E	oth	827			245.0	38.6	15.76
124	Haddon	RO	E	oth	828			202.0	30.6	15.15
125	Castleford	RO	E	mil	830		H	194.2	29.8	15.35
125	Castleford	RO	E	mil	834			247.0	36.9	14.94
125	Castleford	RO	E	mil	835		H?	232.0	34.6	14.91
125	Castleford	RO	E	mil	838		H	216.0	31.5	14.58
127	Tortoreto-Fortellezza	IA	A	rural	841		D	173.5	26.0	14.99
128	Krefeld-Gellep	RO	F	mil	843	3392	H*	238.0	35.0	14.71
128	Krefeld-Gellep	RO	F	mil	844	3392	H*	238.0	36.0	15.13
128	Krefeld-Gellep	RO	F	mil	845	3557	H?	242.0	38.0	15.70
128	Krefeld-Gellep	RO	F	mil	846	3424		203.0	28.0	13.79
128	Krefeld-Gellep	RO	F	mil	847	3573	M	231.0	34.0	14.72
128	Krefeld-Gellep	RO	F	mil	848	3577A	M	235.0	35.0	14.89
128	Krefeld-Gellep	RO	F	mil	849	3577B		233.0	35.0	15.02
128	Krefeld-Gellep	RO	F	mil	850	3510	D*	190.0	27.0	14.21
129	Lorenzberg Bei Epfach	RO	F	oth	851			243.0	35.0	14.40
129	Lorenzberg Bei Epfach	RO	F	oth	861			208.0	29.0	13.94
129	Lorenzberg Bei Epfach	RO	F	oth	862			195.0	27.0	13.85
131	Radovesice	IA	G	rural	863		H*	202.0	29.0	14.36
132	Godmanchester	RO	E	mil	865			234.0	32.4	13.85
132	Godmanchester	RO	E	mil	867			214.0	32.6	15.23
132	Godmanchester	RO	E	mil	870			222.2	33.6	15.12
132	Godmanchester	RO	E	mil	871			210.0	32.3	15.38
132	Godmanchester	RO	E	mil	872			229.9	34.3	14.92
132	Godmanchester	RO	E	mil	873			221.0	34.5	15.61
132	Godmanchester	RO	E	mil	874			211.3	30.1	14.25
132	Godmanchester	RO	E	mil	878			234.0	33.5	14.32
133	Colchester	RO	E	urb	880			202.0	28.2	13.96
133	Colchester	RO	E	urb	881			203.0	30.0	14.78
133	Colchester	RO	E	urb	882			206.0	29.6	14.37
133	Colchester	RO	E	urb	883			234.0	34.5	14.74
134	Butzbach	RO	F	urb2	884			231.0	31.5	13.64
134	Butzbach	RO	F	urb2	885		H	191.0	31.0	16.23
134	Butzbach	RO	F	urb2	886		M	225.0	34.5	15.33
135	Swestari	IA	G	cem	891	1	H	200.0	31.0	15.50
135	Swestari	IA	G	cem	892	2	H	204.0	32.0	15.69
135	Swestari	IA	G	cem	893	3	H	206.0	30.5	14.81
135	Swestari	IA	G	cem	894	4	H*	219.0	35.0	15.98
135	Swestari	IA	G	cem	895	5	M	244.0	36.0	14.75
136	Worth Matravers	RO	E	rural	896			202.3	29.2	14.43
137	Magdelenska Gora	IA	G	cem	897	IV, 43		211.0	30.0	14.22
137	Magdelenska Gora	IA	G	cem	898	V, 29, I	H?	219.0	32.0	14.61
137	Magdelenska Gora	IA	G	cem	899	V, 29, II		214.5	30.0	13.99
141	Szentes-Vekerzug	IA	G	cem	901	6		210.0	32.0	15.24
143	Histria	IA	G	urb2	902	P1	H*	230.0	35.0	15.22
143	Histria	IA	G	urb2	903	P2	H?	235.0	34.0	14.47
143	Histria	IA	G	urb2	904	P3		221.0	33.0	14.93
143	Histria	IA	G	urb2	905	P4		229.0	32.1	14.02

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
143	Histria	IA	G	urb2	906	P12	H*	225.0	34.0	15.11
144	Albertfalva	RO	G	mil	908		M?	216.0	32.0	14.81
144	Albertfalva	RO	G	mil	912			245.0	30.5	12.45
144	Albertfalva	RO	G	mil	913			240.0	33.5	13.96
144	Albertfalva	RO	G	mil	914		M	245.0	36.5	14.90
144	Albertfalva	RO	G	mil	915		M	240.0	36.0	15.00
144	Albertfalva	RO	G	mil	918		M*	237.0	34.0	14.35
144	Albertfalva	RO	G	mil	919			227.0	33.0	14.54
144	Albertfalva	RO	G	mil	920			223.0	34.0	15.25
144	Albertfalva	RO	G	mil	921		M*	242.0	33.0	13.64
144	Albertfalva	RO	G	mil	923		H?	220.0	32.0	14.55
144	Albertfalva	RO	G	mil	924			233.0	36.0	15.45
146	Balatonaliga	RO	G	rural	925	574c	H*	207.0	32.0	15.46
146	Balatonaliga	RO	G	rural	926	607c	H?	218.0	33.0	15.14
146	Balatonaliga	RO	G	rural	927	610d		219.0	35.0	15.98
149	Helemba - Sziget	IA	G	rural	929		H*	197.0	29.0	14.72
150	Acs - Vaspuszta	RO	G	mil	930		H*	227.0	33.0	14.54
153	Aquileia forum	RO	A	urb	931		H	219.5	31.2	14.21
153	Aquileia forum	RO	A	urb	932		H*	221.0	33.9	15.34
153	Aquileia forum	RO	A	urb	933			228.0	33.7	14.78
153	Aquileia forum	RO	A	urb	934			238.0	31.4	13.19
156	Invillino- Ibligo	RO	A	oth	948			234.0	33.5	14.32
156	Invillino- Ibligo	RO	A	oth	949			213.0	33.5	15.73
161	San Giovanni	RO	A	villa	956			241.8	33.0	13.65
161	San Giovanni	RO	A	villa	957			215.3	31.4	14.58
164	Stufels	RO	A	rural	959			187.5	30.0	16.00
173	Paestum	RO	A	rural	963			222.0	31.5	14.19
173	Paestum	RO	A	rural	965			208.0	31.0	14.90
174	Abusina-Eining	RO	F	mil	966		M*	247.0	37.0	14.98
174	Abusina-Eining	RO	F	mil	967		M	242.0	34.0	14.05
174	Abusina-Eining	RO	F	mil	968			241.5	36.0	14.91
174	Abusina-Eining	RO	F	mil	969		H?	241.0	35.0	14.52
174	Abusina-Eining	RO	F	mil	970		M*	240.5	34.0	14.14
174	Abusina-Eining	RO	F	mil	971		M	227.5	35.0	15.38
174	Abusina-Eining	RO	F	mil	972		H*	227.0	33.5	14.76
174	Abusina-Eining	RO	F	mil	973		M	216.5	31.0	14.32
174	Abusina-Eining	RO	F	mil	974		M?	236.5	35.0	14.80
174	Abusina-Eining	RO	F	mil	975		M*	234.0	31.0	13.25
174	Abusina-Eining	RO	F	mil	976			231.0	37.5	16.23
174	Abusina-Eining	RO	F	mil	977		H*	224.0	36.5	16.29
175	Sablonetum-Ellingen	RO	F	mil	984			209.0	32.0	15.31
176	Oberdorla	NAT	F	cem	986			228.0	31.0	13.60
176	Oberdorla	NAT	F	cem	987		M?	226.0	30.0	13.27
176	Oberdorla	NAT	F	cem	988			226.0	34.0	15.04
176	Oberdorla	NAT	F	cem	989			224.0	35.0	15.63
176	Oberdorla	NAT	F	cem	990		M	222.0	30.0	13.51
176	Oberdorla	NAT	F	cem	991			219.0	31.0	14.16
176	Oberdorla	NAT	F	cem	992		H*	214.0	33.0	15.42
176	Oberdorla	NAT	F	cem	993		H*	213.0	33.0	15.49
176	Oberdorla	NAT	F	cem	994		M?	210.0	31.0	14.76
176	Oberdorla	NAT	F	cem	995		H	210.0	33.0	15.71
176	Oberdorla	NAT	F	cem	996		M?	210.0	30.0	14.29
176	Oberdorla	NAT	F	cem	997		H	210.0	32.0	15.24
176	Oberdorla	NAT	F	cem	998		H?	210.0	31.0	14.76
176	Oberdorla	NAT	F	cem	999		H*	210.0	34.0	16.19
176	Oberdorla	NAT	F	cem	1000			209.0	32.0	15.31

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
176	Oberdorla	NAT	F	cem	1001		H	208.0	29.0	13.94
176	Oberdorla	NAT	F	cem	1002		H*	207.0	32.0	15.46
176	Oberdorla	NAT	F	cem	1003		H?	202.0	34.0	16.83
176	Oberdorla	NAT	F	cem	1004		H	201.0	28.0	13.93
176	Oberdorla	NAT	F	cem	1005		H	193.0	30.0	15.54
176	Oberdorla	NAT	F	cem	1006		H*	179.0	29.0	16.20
176	Oberdorla	NAT	F	cem	1007			193.0	29.0	15.03
176	Oberdorla	NAT	F	cem	1008		H*	177.0	29.0	16.38
178	Vitudurum-Oberwinterthur	RO	F	urb2	1013		M?	229.0	34.5	15.07
178	Vitudurum-Oberwinterthur	RO	F	urb2	1015		H	220.0	31.1	14.14
178	Vitudurum-Oberwinterthur	RO	F	urb2	1016			214.0	31.7	14.81
181	Barnsley Park	RO	E	rural	1018			227.0	31.0	13.66
182	Frocester Court	RO	E	villa	1019			210.0	33.0	15.71
182	Frocester Court	RO	E	villa	1020			220.0	35.0	15.91
183	Segontium	RO	E	mil	1024			220.0	33.0	15.00
184	Chilgrove 1	RO	E	villa	1028			227.0	34.0	14.98
184	Chilgrove 1	RO	E	villa	1029			205.0	30.5	14.88
186	Shakenoak site K	RO	E	villa	1030			200.0	30.0	15.00
186	Shakenoak site K	RO	E	villa	1031			213.0	30.0	14.08
189	Kassope	IA	H	urb	1040		D	180.0	24.5	13.61
189	Kassope	IA	H	urb	1044		D	167.0	23.0	13.77
190	Breisach	RO	F	mil	1049			226.5	31.0	13.69
190	Breisach	RO	F	mil	1050			233.0	32.0	13.73
192	Pfaffenhofen - Pons Aeni	RO	F	rural	1053			217.0	34.5	15.90
192	Pfaffenhofen - Pons Aeni	RO	F	rural	1055			236.0	34.0	14.41
192	Pfaffenhofen - Pons Aeni	RO	F	rural	1057			240.5	34.5	14.35
193	Marzoll - Marciolae	RO	F	villa	1058			212.5	31.5	14.82
195	Kunzing-Quintana	RO	F	mil	1061			217.0	31.5	14.52
195	Kunzing-Quintana	RO	F	mil	1062			215.0	30.0	13.95
195	Kunzing-Quintana	RO	F	mil	1063			214.0	30.0	14.02
196	Dormagen	RO	F	mil	1068			235.0	38.2	16.26
196	Dormagen	RO	F	mil	1069			227.5	35.2	15.47
196	Dormagen	RO	F	mil	1070			211.5	37.0	17.49
197	Froitzheim	RO	F	rural	1074			225.0	32.5	14.44
197	Froitzheim	RO	F	rural	1075			224.0	32.0	14.29
199	Hufingen	RO	F	rural	1078			239.0	37.0	15.48
199	Hufingen	RO	F	rural	1079			229.0	33.5	14.63
199	Hufingen	RO	F	rural	1080			228.5	34.0	14.88
199	Hufingen	RO	F	rural	1081			228.5	35.0	15.32
199	Hufingen	RO	F	rural	1082			227.5	30.5	13.41
199	Hufingen	RO	F	rural	1083			227.0	35.5	15.64
199	Hufingen	RO	F	rural	1084			225.0	32.5	14.44
199	Hufingen	RO	F	rural	1085			223.0	33.0	14.80
199	Hufingen	RO	F	rural	1099			239.5	36.5	15.24
199	Hufingen	RO	F	rural	1100			233.0	32.0	13.73
199	Hufingen	RO	F	rural	1101			233.0	34.0	14.59
199	Hufingen	RO	F	rural	1102			226.0	33.5	14.82
199	Hufingen	RO	F	rural	1103			224.0	31.0	13.84
199	Hufingen	RO	F	rural	1104			223.0	32.0	14.35
199	Hufingen	RO	F	rural	1105			222.0	33.0	14.86
199	Hufingen	RO	F	rural	1106			222.0	32.0	14.41
199	Hufingen	RO	F	rural	1107			219.5	32.5	14.81
199	Hufingen	RO	F	rural	1108			218.0	31.0	14.22
199	Hufingen	RO	F	rural	1109			217.0	34.0	15.67
199	Hufingen	RO	F	rural	1110			213.0	30.0	14.08
200	Pfaffenhofen	RO	F	rural	1123			218.0	31.0	14.22

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
200	Pfaffenhofen	RO	F	rural	1124			227.0	35.0	15.42
200	Pfaffenhofen	RO	F	rural	1125			232.0	35.0	15.09
201	Wehringen	RO	F	villa	1127			234.0	34.5	14.74
202	Penzlin	NAT	F	rural	1129		H	200.8	29.2	14.54
202	Penzlin	NAT	F	rural	1130			215.3	32.6	15.14
202	Penzlin	NAT	F	rural	1131			194.2	28.4	14.62
202	Penzlin	NAT	F	rural	1132		H	213.7	29.5	13.80
202	Penzlin	NAT	F	rural	1133		D?	213.3	27.0	12.66
202	Penzlin	NAT	F	rural	1134		H?	221.5	31.2	14.09
202	Penzlin	NAT	F	rural	1136		H	198.5	29.6	14.91
202	Penzlin	NAT	F	rural	1137		H*	204.5	32.6	15.94
203	Tac-Gorsium	RO	G	urb	1138		H*	206.5	33.0	15.98
203	Tac-Gorsium	RO	G	urb	1139			208.0	31.0	14.90
203	Tac-Gorsium	RO	G	urb	1140		H*	209.0	30.5	14.59
203	Tac-Gorsium	RO	G	urb	1141		H	209.0	34.0	16.27
203	Tac-Gorsium	RO	G	urb	1142			216.5	34.0	15.70
203	Tac-Gorsium	RO	G	urb	1143		M?	218.0	32.0	14.68
203	Tac-Gorsium	RO	G	urb	1144			218.0	33.0	15.14
203	Tac-Gorsium	RO	G	urb	1145		H*	219.0	32.0	14.61
203	Tac-Gorsium	RO	G	urb	1146			219.0	34.5	15.75
203	Tac-Gorsium	RO	G	urb	1148		H	220.0	33.0	15.00
203	Tac-Gorsium	RO	G	urb	1149		H	220.0	34.0	15.45
203	Tac-Gorsium	RO	G	urb	1150		H	221.0	33.5	15.16
203	Tac-Gorsium	RO	G	urb	1151		H	222.0	32.5	14.64
203	Tac-Gorsium	RO	G	urb	1152		H*	222.0	35.5	15.99
203	Tac-Gorsium	RO	G	urb	1153		H*	222.0	37.5	16.89
203	Tac-Gorsium	RO	G	urb	1154		M*	222.5	31.0	13.93
203	Tac-Gorsium	RO	G	urb	1155			223.0	32.0	14.35
203	Tac-Gorsium	RO	G	urb	1156		H	223.0	33.5	15.02
203	Tac-Gorsium	RO	G	urb	1157		H*	223.0	34.0	15.25
203	Tac-Gorsium	RO	G	urb	1158		H?	223.0	34.0	15.25
203	Tac-Gorsium	RO	G	urb	1159			224.0	30.0	13.39
203	Tac-Gorsium	RO	G	urb	1160		M?	224.0	32.0	14.29
203	Tac-Gorsium	RO	G	urb	1161		H	224.0	34.5	15.40
203	Tac-Gorsium	RO	G	urb	1162			225.0	26.5	11.78
203	Tac-Gorsium	RO	G	urb	1163		M*	225.0	32.5	14.44
203	Tac-Gorsium	RO	G	urb	1164		M	225.0	33.0	14.67
203	Tac-Gorsium	RO	G	urb	1165		H?	225.5	35.5	15.74
203	Tac-Gorsium	RO	G	urb	1166		M?	226.0	31.5	13.94
203	Tac-Gorsium	RO	G	urb	1167		M	226.0	34.0	15.04
203	Tac-Gorsium	RO	G	urb	1168		H*	226.0	34.5	15.27
203	Tac-Gorsium	RO	G	urb	1169		H	227.0	33.0	14.54
203	Tac-Gorsium	RO	G	urb	1170		H?	227.0	36.0	15.86
203	Tac-Gorsium	RO	G	urb	1171		M*	227.5	32.0	14.07
203	Tac-Gorsium	RO	G	urb	1172		H*	229.0	34.0	14.85
203	Tac-Gorsium	RO	G	urb	1173		H*	229.0	34.5	15.07
203	Tac-Gorsium	RO	G	urb	1174		M*	229.0	35.5	15.50
203	Tac-Gorsium	RO	G	urb	1175		H*	229.0	35.5	15.50
203	Tac-Gorsium	RO	G	urb	1177			230.0	36.0	15.65
203	Tac-Gorsium	RO	G	urb	1178		H?	230.0	37.0	16.09
203	Tac-Gorsium	RO	G	urb	1179		H*	230.5	35.5	15.40
203	Tac-Gorsium	RO	G	urb	1180		M	231.0	33.5	14.50
203	Tac-Gorsium	RO	G	urb	1181		H	231.0	33.5	14.50
203	Tac-Gorsium	RO	G	urb	1182		M	231.5	33.5	14.47
203	Tac-Gorsium	RO	G	urb	1183			232.0	32.0	13.79
203	Tac-Gorsium	RO	G	urb	1184		H?	232.0	33.0	14.22

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
203	Tac-Gorsium	RO	G	urb	1185		H	232.0	33.0	14.22
203	Tac-Gorsium	RO	G	urb	1186		H?	233.5	34.5	14.78
203	Tac-Gorsium	RO	G	urb	1187		H	235.0	33.5	14.26
203	Tac-Gorsium	RO	G	urb	1188		H?	235.0	39.0	16.60
203	Tac-Gorsium	RO	G	urb	1189		H*	237.0	33.0	13.92
203	Tac-Gorsium	RO	G	urb	1190		M	237.0	33.5	14.14
203	Tac-Gorsium	RO	G	urb	1191		H*	237.0	36.0	15.19
203	Tac-Gorsium	RO	G	urb	1192		M	238.0	33.0	13.87
203	Tac-Gorsium	RO	G	urb	1194		H?	238.5	35.5	14.88
203	Tac-Gorsium	RO	G	urb	1195		M	239.0	34.5	14.44
203	Tac-Gorsium	RO	G	urb	1196		H?	245.0	38.0	15.51
203	Tac-Gorsium	RO	G	urb	1197		M*	252.6	37.5	14.85
203	Tac-Gorsium	RO	G	urb	1198		M?	260.0	38.0	14.62
203	Tac-Gorsium	RO	G	urb	1199		M*	262.5	38.0	14.48
204	Conchil	RO	D	rural	1236		H*	215.3	33.4	15.51
204	Conchil	RO	D	rural	1237		H*	217.5	32.8	15.08
205	Oberstimm	RO	F	mil	1239		D*	215.5	27.0	12.53
205	Oberstimm	RO	F	mil	1240	limb	M*	239.5	32.0	13.36
206	Lauriacum	RO	F	oth	1241			227.0	33.5	14.76
206	Lauriacum	RO	F	oth	1247			228.0	32.5	14.25
207	Haus Burgel	RO	F	mil	1251		H	222.0	31.4	14.14
208	Colonia Ulpia Traiana	RO	F	urb	1253			248.5	41.5	16.70
208	Colonia Ulpia Traiana	RO	F	urb	1254		H?	240.5	35.5	14.76
208	Colonia Ulpia Traiana	RO	F	urb	1255		H?	235.5	35.5	15.07
208	Colonia Ulpia Traiana	RO	F	urb	1256		H*	231.0	34.5	14.94
208	Colonia Ulpia Traiana	RO	F	urb	1257		H?	223.0	33.5	15.02
208	Colonia Ulpia Traiana	RO	F	urb	1258		H*	222.0	35.0	15.77
208	Colonia Ulpia Traiana	RO	F	urb	1259		H	219.5	33.5	15.26
208	Colonia Ulpia Traiana	RO	F	urb	1260		H*	218.0	34.5	15.83
208	Colonia Ulpia Traiana	RO	F	urb	1261			217.0	29.5	13.59
208	Colonia Ulpia Traiana	RO	F	urb	1262		H*	216.0	35.0	16.20
208	Colonia Ulpia Traiana	RO	F	urb	1263		H?	203.0	28.0	13.79
208	Colonia Ulpia Traiana	RO	F	urb	1264		H	201.0	32.5	16.17
209	Iatrus	RO	G	oth	1270		D	181.2	25.5	14.07
210	Freidorf	RO	G	rural	1272			227.5	32.5	14.29
211	Castillar de Mendavia	IA	B	rural	1273			202.0	32.0	15.84
212	Gournay	IA	D	cem	1275		H	203.0	29.0	14.29
212	Gournay	IA	D	cem	1276		H	194.0	29.0	14.95
213	Beauvais	IA	D	rural	1277		H	202.0	30.0	14.85
213	Beauvais	IA	D	rural	1278		H*	226.0	33.5	14.82
213	Beauvais	IA	D	rural	1279		H?	237.0	35.0	14.77
213	Beauvais	IA	D	rural	1280		D?	193.0	25.5	13.21
213	Beauvais	IA	D	rural	1281		H	207.0	30.5	14.73
213	Beauvais	IA	D	rural	1282		H	200.0	28.5	14.25
213	Beauvais	IA	D	rural	1283		H*	184.0	27.5	14.95
214	Compiegne	IA	D	rural	1284		H	232.0	32.0	13.79
214	Compiegne	IA	D	rural	1285			203.0	32.0	15.76
215	Ribemont	IA	D	oth	1286		H*	190.0	32.0	16.84
216	Variscourt	IA	D	rural	1287		H	188.0	27.5	14.63
216	Variscourt	IA	D	rural	1288		H*	208.0	33.0	15.87
216	Variscourt	IA	D	rural	1289		H*	182.0	27.5	15.11
216	Variscourt	IA	D	rural	1290		H	192.0	29.0	15.10
216	Variscourt	IA	D	rural	1291		H*	189.0	27.5	14.55
216	Variscourt	IA	D	rural	1292		H*	224.0	32.5	14.51
217	Soissons	IA	D	cem	1293		H*	171.0	25.0	14.62

Table A27. – Results of the calculation of the proximal breadth to greatest length index on the Metacarpals

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
5	Beckford	IA	E	rural		602		187.0	40.0	21.39
7	Blackhorse Road	IA	E	rural		599		221.4	45.0	20.33
7	Blackhorse Road	IA	E	rural		600		204.0	45.6	22.35
7	Blackhorse Road	IA	E	rural		601		202.7	47.7	23.53
8	Hardingstone School	IA	E	ind		596		191.0	46.0	24.08
8	Hardingstone School	IA	E	ind		597		207.0	42.0	20.29
8	Hardingstone School	IA	E	ind		598		210.0	46.0	21.90
9	Hardingstone enclosure	IA	E	rural		595		236.0	45.0	19.07
10	Twywell	IA	E	rural		593		206.0	44.0	21.36
13	Wavendon Gate	RO	E	rural		585		234.7	44.9	19.13
13	Wavendon Gate	RO	E	rural		589		220.0	48.5	22.05
13	Wavendon Gate	IA	E	rural		590		199.6	48.1	24.10
14	Lincoln	RO	E	urb		579		223.9	49.0	21.88
14	Lincoln	RO	E	urb		580		196.3	43.0	21.91
14	Lincoln	RO	E	urb		581		241.4	52.9	21.91
14	Lincoln	RO	E	urb		582		184.9	41.5	22.44
15	Scole-Dickleburgh	RO	E	urb2		573		226.6	48.6	21.45
15	Scole-Dickleburgh	RO	E	urb2		578	H?	205.4	43.9	21.37
16	Birdlip	IA	E	villa		567		204.1	40.8	19.99
16	Birdlip	IA	E	villa		568		211.0	44.4	21.02
16	Birdlip	IA	E	villa		569		202.0	44.3	21.93
23	Puckeridge	IA	E	rural		557		212.5	50.0	23.53
27	Lynch Farm	RO	E	villa		554		220.0	47.0	21.36
28	Longthorpe II	RO	E	mil		553	M?	232.0	52.0	22.41
35	Castricum-Oosterbuurt	RO	F	oth		529		209.1	44.5	21.27
35	Castricum-Oosterbuurt	RO	F	oth		530		228.3	50.7	22.20
35	Castricum-Oosterbuurt	RO	F	oth		531		228.6	50.8	22.23
35	Castricum-Oosterbuurt	RO	F	oth		532		220.6	49.4	22.38
35	Castricum-Oosterbuurt	RO	F	oth		533		219.3	48.9	22.30
35	Castricum-Oosterbuurt	RO	F	oth	1	534		219.9	47.4	21.53
35	Castricum-Oosterbuurt	RO	F	oth	1	535		219.2	47.3	21.58
35	Castricum-Oosterbuurt	RO	F	oth		536		220.0	49.1	22.32
35	Castricum-Oosterbuurt	RO	F	oth		539		221.0	50.4	22.80
35	Castricum-Oosterbuurt	RO	F	oth		540		211.0	47.7	22.61
35	Castricum-Oosterbuurt	RO	F	oth		542		212.2	44.9	21.15
35	Castricum-Oosterbuurt	RO	F	oth		543		217.6	46.6	21.39
35	Castricum-Oosterbuurt	RO	F	oth		544		231.0	48.3	20.90
35	Castricum-Oosterbuurt	RO	F	oth		545		225.1	47.7	21.18
36	Egmond?	RO	F	oth		528		220.5	43.5	19.73
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-36	522		235.0	43.7	18.60
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-34	523	H?	235.0	52.9	22.51
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-24	525		217.0	46.5	21.43
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-6	527	H?	238.0	51.9	21.81
38	Nijmegen	RO	F	urb		501	H*	211.7	45.6	21.54
38	Nijmegen	RO	F	urb		502	M*	236.8	49.6	20.95
38	Nijmegen	RO	F	urb		503	H?	236.8	48.0	20.27
38	Nijmegen	RO	F	urb		504	M*	227.9	50.9	22.33
38	Nijmegen	RO	F	urb		505	H*	240.4	51.4	21.38
38	Nijmegen	RO	F	urb		506	H?	221.5	49.9	22.53
38	Nijmegen	RO	F	urb		507	M	225.1	46.4	20.61
38	Nijmegen	RO	F	urb		508	H	217.3	47.2	21.72

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
38	Nijmegen	RO	F	urb		509	H*	226.9	49.4	21.77
38	Nijmegen	RO	F	urb		510	H?	237.2	51.2	21.59
38	Nijmegen	RO	F	urb		511	H	222.1	48.8	21.97
38	Nijmegen	RO	F	urb		514	H?	215.9	46.5	21.54
38	Nijmegen	RO	F	urb		515	H?	225.9	48.2	21.34
38	Nijmegen	RO	F	urb		519	H	215.8	47.2	21.87
40	Heteren	NAT	F	rural		496		198.3	44.3	22.34
42	Druten	RO	F	villa		478	M?	236.0	48.0	20.34
42	Druten	RO	F	villa		480		226.2	51.7	22.86
42	Druten	RO	F	villa		482		241.4	51.2	21.21
42	Druten	RO	F	villa		483	H*	220.3	50.1	22.74
42	Druten	RO	F	villa		484		223.8	46.9	20.96
42	Druten	RO	F	villa		485	H*	231.8	52.2	22.52
42	Druten	RO	F	villa		489	H?	241.7	55.6	23.00
42	Druten	RO	F	villa		490	H*	232.6	47.6	20.46
42	Druten	RO	F	villa		491	M?	233.7	49.9	21.35
42	Druten	RO	F	villa		492	H?	235.0	49.9	21.23
42	Druten	RO	F	villa	1.18	493	M*	248.1	52.8	21.28
42	Druten	IA	F	villa		495	H*	224.2	48.5	21.63
43	Elms Farm	RO	E	urb2		466	H	205.2	44.3	21.59
43	Elms Farm	RO	E	urb2	6640	469	H*	230.0	53.9	23.43
44	Danebury	IA	E	rural		427	H*	193.0	43.2	22.38
44	Danebury	IA	E	rural		433	D*	182.0	41.2	22.64
44	Danebury	IA	E	rural		434	H	193.0	42.5	22.02
44	Danebury	IA	E	rural		436	H?	197.0	44.4	22.54
44	Danebury	IA	E	rural		437	D*	230.0	40.2	17.48
44	Danebury	IA	E	rural		440		191.0	41.2	21.57
44	Danebury	IA	E	rural		442		200.0	44.3	22.15
44	Danebury	IA	E	rural		448	H	207.0	46.1	22.27
44	Danebury	IA	E	rural		454		240.0	42.5	17.71
44	Danebury	IA	E	rural		457	H	207.0	45.4	21.93
44	Danebury	IA	E	rural		458	H	221.0	51.4	23.26
44	Danebury	IA	E	rural		459		217.0	46.5	21.43
44	Danebury	IA	E	rural		460	H	200.0	42.7	21.35
46	E London RB Cemetary	RO	E	cem		420	H?	216.5	48.2	22.26
46	E London RB Cemetary	RO	E	cem		421		224.5	49.8	22.18
47	Beddington Sewage Farm	RO	E	urb		413	H?	190.5	43.1	22.62
47	Beddington Sewage Farm	RO	E	urb		414	H?	190.5	43.0	22.57
47	Beddington Sewage Farm	RO	E	urb		415		201.5	44.0	21.84
47	Beddington Sewage Farm	RO	E	urb		416	M?	213.3	42.9	20.11
47	Beddington Sewage Farm	RO	E	urb		417		210.0	45.7	21.76
47	Beddington Sewage Farm	RO	E	urb		418		271.0	50.8	18.75
47	Beddington Sewage Farm	IA	E	urb		419	H	198.4	42.4	21.37
51	Coldharbour Farm 97	IA	E	villa		410	H	215.0	47.2	21.95
51	Coldharbour Farm 97	IA	E	villa		411	H	207.9	46.8	22.51
51	Coldharbour Farm 97	IA	E	villa		412	H*	217.7	49.1	22.55
54	Thorpe Thewles	IA	E	rural		404	H	203.0	46.6	22.96
54	Thorpe Thewles	IA	E	rural		405	H*	182.0	42.3	23.24
57	La Sagesse	IA	E	oth		399		203.0	44.0	21.67
57	La Sagesse	IA	E	oth		400		216.0	47.5	21.99
57	La Sagesse	IA	E	oth		401		209.0	45.7	21.87
59	Chichester cattlemarket	RO	E	urb	XXIII	397	H*	240.4	51.9	21.59
59	Chichester cattlemarket	RO	E	urb	XXIII	398	H*	242.0	53.1	21.94
63	S. Giacomo	RO	A	villa		395	H?	235.0	50.7	21.57
66	Settefinestre	RO	A	villa		387	M?	226.0	51.0	22.57
66	Settefinestre	RO	A	villa		389	D*	189.0	39.0	20.63

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
70	Emilia	IA	A	oth		382		202.0	43.2	21.39
71	Piovego	IA	A	cem	N2	381	H*	217.0	49.0	22.58
72	Colle dei Cappuccini	IA	A	rural		380		209.0	48.5	23.21
73	Moie di Pollenza	IA	A	cem		379		218.0	53.0	24.31
76	Ansedonia	RO	A	villa		378		158.0	35.0	22.15
77	Grotto di Tibera	RO	A	oth	15.3	375		198.0	42.0	21.21
77	Grotto di Tibera	RO	A	oth	15.2	376		255.0	51.0	20.00
77	Grotto di Tibera	RO	A	oth	15.1	377		231.0	50.0	21.65
79	Olbia	IA	A	rural		374	D*	159.4	35.2	22.08
83	Deutsch Wusterhausen	NAT	F	rural		373	H*	220.0	52.3	23.77
85	Macon	RO	D	cem		370	D*	247.0	53.0	21.46
87	Manching	IA	F	rural		309		180.0	40.0	22.22
87	Manching	IA	F	rural		310		181.5	42.0	23.14
87	Manching	IA	F	rural		311		184.0	41.5	22.55
87	Manching	IA	F	rural		312		184.0	40.5	22.01
87	Manching	IA	F	rural		313		185.0	41.0	22.16
87	Manching	IA	F	rural		314		185.5	43.5	23.45
87	Manching	IA	F	rural		315		186.0	38.5	20.70
87	Manching	IA	F	rural		316		186.5	40.0	21.45
87	Manching	IA	F	rural		317		188.5	42.0	22.28
87	Manching	IA	F	rural		318		191.5	43.5	22.72
87	Manching	IA	F	rural		319		191.5	42.0	21.93
87	Manching	IA	F	rural		320		192.0	41.0	21.35
87	Manching	IA	F	rural		321		192.0	42.0	21.88
87	Manching	IA	F	rural		322		192.0	42.0	21.88
87	Manching	IA	F	rural		323		192.0	42.0	21.88
87	Manching	IA	F	rural		324		193.0	42.0	21.76
87	Manching	IA	F	rural		325		193.0	41.5	21.50
87	Manching	IA	F	rural		326		193.0	42.0	21.76
87	Manching	IA	F	rural		327		193.0	41.0	21.24
87	Manching	IA	F	rural		328		193.0	44.5	23.06
87	Manching	IA	F	rural		329		193.5	41.0	21.19
87	Manching	IA	F	rural		330		194.0	43.0	22.16
87	Manching	IA	F	rural		331		194.5	41.5	21.34
87	Manching	IA	F	rural		332		195.0	43.5	22.31
87	Manching	IA	F	rural		333		195.0	45.5	23.33
87	Manching	IA	F	rural		334		195.5	43.0	21.99
87	Manching	IA	F	rural		335		196.0	47.0	23.98
87	Manching	IA	F	rural		336		198.0	45.0	22.73
87	Manching	IA	F	rural		337		198.5	42.5	21.41
87	Manching	IA	F	rural		338		199.0	44.0	22.11
87	Manching	IA	F	rural		339		199.0	45.5	22.86
87	Manching	IA	F	rural		340		199.5	41.0	20.55
87	Manching	IA	F	rural		341		199.5	44.0	22.06
87	Manching	IA	F	rural		342		200.0	42.0	21.00
87	Manching	IA	F	rural		343		200.5	47.0	23.44
87	Manching	IA	F	rural		344		200.5	46.0	22.94
87	Manching	IA	F	rural		345		201.0	41.5	20.65
87	Manching	IA	F	rural		346		201.0	42.0	20.90
87	Manching	IA	F	rural		347		201.0	44.0	21.89
87	Manching	IA	F	rural		348		202.0	45.0	22.28
87	Manching	IA	F	rural		349		203.0	45.0	22.17
87	Manching	IA	F	rural		350		204.0	45.0	22.06
87	Manching	IA	F	rural		351		207.5	46.0	22.17
87	Manching	IA	F	rural		352		208.0	46.0	22.12
87	Manching	IA	F	rural		353		208.5	48.0	23.02

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
87	Manching	IA	F	rural		354		208.5	47.0	22.54
87	Manching	IA	F	rural		355		209.0	48.0	22.97
87	Manching	IA	F	rural		356		211.0	42.5	20.14
87	Manching	IA	F	rural		357		211.5	44.0	20.80
87	Manching	IA	F	rural		358		212.5	45.5	21.41
87	Manching	IA	F	rural		360		213.5	45.5	21.31
87	Manching	IA	F	rural		361		213.5	45.5	21.31
87	Manching	IA	F	rural		362		216.0	49.0	22.69
87	Manching	IA	F	rural		363		216.0	47.5	21.99
87	Manching	IA	F	rural		364		219.0	45.0	20.55
87	Manching	IA	F	rural		365		220.0	48.0	21.82
87	Manching	IA	F	rural		366		226.5	48.0	21.19
87	Manching	IA	F	rural		367		228.5	52.0	22.76
87	Manching	IA	F	rural		368		231.0	50.0	21.65
89	Jenstejn	IA	G	rural		240		208.3	47.7	22.90
91	Whitton	RO	E	villa	1	237		229.0	49.0	21.40
92	Feddersen Wierde	NAT	F	rural	skelett2R	26	H	206.3	46.9	22.73
92	Feddersen Wierde	NAT	F	rural	skelett2L	27	H	205.7	47.1	22.90
92	Feddersen Wierde	NAT	F	rural	skelett1L	28	H	221.8	48.8	22.00
92	Feddersen Wierde	NAT	F	rural		29	D?	196.7	40.9	20.79
92	Feddersen Wierde	NAT	F	rural		30	H	213.8	47.0	21.98
92	Feddersen Wierde	NAT	F	rural		31		201.1	43.4	21.58
92	Feddersen Wierde	NAT	F	rural		32	H?	196.1	42.0	21.42
92	Feddersen Wierde	NAT	F	rural		33	D*	200.5	42.5	21.20
92	Feddersen Wierde	NAT	F	rural		34	H*	203.5	45.6	22.41
92	Feddersen Wierde	NAT	F	rural		35	D?	207.5	44.7	21.54
92	Feddersen Wierde	NAT	F	rural		36	M*	217.5	47.5	21.84
92	Feddersen Wierde	NAT	F	rural		37	H?	198.1	42.7	21.55
92	Feddersen Wierde	NAT	F	rural		38	H	202.7	41.5	20.47
92	Feddersen Wierde	NAT	F	rural		39	H*	197.9	44.5	22.49
92	Feddersen Wierde	NAT	F	rural		40	H?	215.3	45.0	20.90
92	Feddersen Wierde	NAT	F	rural		41	M?	206.8	45.0	21.76
92	Feddersen Wierde	NAT	F	rural		42	H*	215.5	46.8	21.72
92	Feddersen Wierde	NAT	F	rural		43		202.3	45.0	22.24
92	Feddersen Wierde	NAT	F	rural		44	H*	216.6	46.4	21.42
92	Feddersen Wierde	NAT	F	rural		45	M?	209.8	43.8	20.88
92	Feddersen Wierde	NAT	F	rural		46		214.3	45.8	21.37
92	Feddersen Wierde	NAT	F	rural		47	H?	210.7	48.3	22.92
92	Feddersen Wierde	NAT	F	rural		48		191.3	44.9	23.47
92	Feddersen Wierde	NAT	F	rural		49	H*	199.0	47.1	23.67
92	Feddersen Wierde	NAT	F	rural		50	H*	196.0	39.5	20.15
92	Feddersen Wierde	NAT	F	rural		51	H*	212.5	44.2	20.80
92	Feddersen Wierde	NAT	F	rural		52		208.4	44.2	21.21
92	Feddersen Wierde	NAT	F	rural		53	D?	202.9	43.4	21.39
92	Feddersen Wierde	NAT	F	rural		54	H*	188.8	42.9	22.72
92	Feddersen Wierde	NAT	F	rural		55	H	205.1	47.0	22.92
92	Feddersen Wierde	NAT	F	rural		56	H	202.9	43.5	21.44
92	Feddersen Wierde	NAT	F	rural		57	H	210.9	44.6	21.15
92	Feddersen Wierde	NAT	F	rural		58		210.1	45.9	21.85
92	Feddersen Wierde	NAT	F	rural		59		205.9	48.0	23.31
92	Feddersen Wierde	NAT	F	rural		60	H	202.9	44.3	21.83
92	Feddersen Wierde	NAT	F	rural		61	H*	203.8	46.9	23.01
92	Feddersen Wierde	NAT	F	rural		62	H	214.9	47.1	21.92
92	Feddersen Wierde	NAT	F	rural		63	H*	197.4	45.4	23.00
92	Feddersen Wierde	NAT	F	rural		64	H*	215.9	48.0	22.23
92	Feddersen Wierde	NAT	F	rural		65	H	206.7	48.3	23.37

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
92	Feddersen Wierde	NAT	F	rural		66		197.3	41.5	21.03
92	Feddersen Wierde	NAT	F	rural		67	D?	202.4	45.0	22.23
92	Feddersen Wierde	NAT	F	rural		68	H?	209.9	44.7	21.30
92	Feddersen Wierde	NAT	F	rural		70	H	219.1	49.4	22.55
92	Feddersen Wierde	NAT	F	rural		71	H	202.9	46.6	22.97
92	Feddersen Wierde	NAT	F	rural		72	H	211.8	47.5	22.43
92	Feddersen Wierde	NAT	F	rural		73	H	208.6	51.1	24.50
92	Feddersen Wierde	NAT	F	rural		74		202.3	42.1	20.81
92	Feddersen Wierde	NAT	F	rural		75	H*	211.2	46.1	21.83
92	Feddersen Wierde	NAT	F	rural		76	H?	215.2	47.6	22.12
92	Feddersen Wierde	NAT	F	rural		77	H	201.2	43.4	21.57
92	Feddersen Wierde	NAT	F	rural		78	H?	207.3	45.9	22.14
92	Feddersen Wierde	NAT	F	rural		79	H	215.8	45.1	20.90
92	Feddersen Wierde	NAT	F	rural		80	D*	199.5	41.3	20.70
92	Feddersen Wierde	NAT	F	rural		81	H*	204.3	44.9	21.98
92	Feddersen Wierde	NAT	F	rural		82	H?	207.4	45.2	21.79
92	Feddersen Wierde	NAT	F	rural		84		205.2	42.3	20.61
92	Feddersen Wierde	NAT	F	rural		85	H*	194.0	43.6	22.47
92	Feddersen Wierde	NAT	F	rural		86	H	211.2	47.0	22.25
92	Feddersen Wierde	NAT	F	rural		87	H*	193.3	43.3	22.40
92	Feddersen Wierde	NAT	F	rural		88	H?	204.5	42.7	20.88
92	Feddersen Wierde	NAT	F	rural		89	H?	214.8	46.8	21.79
92	Feddersen Wierde	NAT	F	rural		90	H	217.1	49.1	22.62
92	Feddersen Wierde	NAT	F	rural		91	H	201.6	42.0	20.83
92	Feddersen Wierde	NAT	F	rural		92	H*	216.0	46.6	21.57
92	Feddersen Wierde	NAT	F	rural		93	H	204.6	45.5	22.24
92	Feddersen Wierde	NAT	F	rural		94	H	209.0	46.3	22.15
92	Feddersen Wierde	NAT	F	rural		95	M?	215.8	45.9	21.27
92	Feddersen Wierde	NAT	F	rural		96	H	209.1	46.3	22.14
92	Feddersen Wierde	NAT	F	rural		97	H	194.0	43.7	22.53
92	Feddersen Wierde	NAT	F	rural		98		207.1	48.6	23.47
92	Feddersen Wierde	NAT	F	rural		99	H	201.4	44.0	21.85
92	Feddersen Wierde	NAT	F	rural		100	H*	205.6	44.1	21.45
92	Feddersen Wierde	NAT	F	rural		101	D	206.6	44.4	21.49
92	Feddersen Wierde	NAT	F	rural		102	H	204.3	45.7	22.37
92	Feddersen Wierde	NAT	F	rural		104	H*	210.9	47.5	22.52
92	Feddersen Wierde	NAT	F	rural		105	H	211.1	47.1	22.31
92	Feddersen Wierde	NAT	F	rural		106	H*	214.2	46.3	21.62
92	Feddersen Wierde	NAT	F	rural		107	H	206.9	45.8	22.14
92	Feddersen Wierde	NAT	F	rural		110	H*	202.5	44.5	21.98
92	Feddersen Wierde	NAT	F	rural		112	H	217.0	49.0	22.58
92	Feddersen Wierde	NAT	F	rural		113	H	214.7	49.4	23.01
92	Feddersen Wierde	NAT	F	rural		114	H*	200.7	41.9	20.88
92	Feddersen Wierde	NAT	F	rural		115	H	228.9	51.2	22.37
92	Feddersen Wierde	NAT	F	rural		116	H	204.6	45.1	22.04
92	Feddersen Wierde	NAT	F	rural		117	H*	213.9	48.8	22.81
92	Feddersen Wierde	NAT	F	rural		118	H	211.9	48.0	22.65
92	Feddersen Wierde	NAT	F	rural		119	H	206.5	46.4	22.47
92	Feddersen Wierde	NAT	F	rural		120	H	210.8	46.4	22.01
92	Feddersen Wierde	NAT	F	rural		121	H	207.8	45.2	21.75
92	Feddersen Wierde	NAT	F	rural		122	H	207.6	44.1	21.24
92	Feddersen Wierde	NAT	F	rural		123	H	202.4	43.8	21.64
92	Feddersen Wierde	NAT	F	rural		124	H	198.3	44.6	22.49
92	Feddersen Wierde	NAT	F	rural		125	H*	208.1	48.6	23.35
92	Feddersen Wierde	NAT	F	rural		126	H?	196.5	45.9	23.36
92	Feddersen Wierde	NAT	F	rural		127	H?	213.3	45.6	21.38

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
92	Feddersen Wierde	NAT	F	rural		128	H*	212.1	43.6	20.56
92	Feddersen Wierde	NAT	F	rural		129	H*	193.4	42.3	21.87
92	Feddersen Wierde	NAT	F	rural		130	H*	199.1	43.3	21.75
92	Feddersen Wierde	NAT	F	rural		131	D	199.9	41.1	20.56
92	Feddersen Wierde	NAT	F	rural		132	D*	210.0	43.4	20.67
92	Feddersen Wierde	NAT	F	rural		133	H	204.5	45.3	22.15
92	Feddersen Wierde	NAT	F	rural		134	H*	226.4	50.0	22.08
92	Feddersen Wierde	NAT	F	rural		135	H?	202.6	45.2	22.31
92	Feddersen Wierde	NAT	F	rural		136	H	207.9	46.1	22.17
92	Feddersen Wierde	NAT	F	rural		137	H?	214.1	45.6	21.30
92	Feddersen Wierde	NAT	F	rural		138	H*	208.8	47.0	22.51
92	Feddersen Wierde	NAT	F	rural		139	H*	204.9	48.3	23.57
92	Feddersen Wierde	NAT	F	rural		140	H?	197.2	42.7	21.65
92	Feddersen Wierde	NAT	F	rural		141	H?	209.1	43.4	20.76
92	Feddersen Wierde	NAT	F	rural		142	H	205.2	44.0	21.44
92	Feddersen Wierde	NAT	F	rural		143	H*	206.0	46.9	22.77
92	Feddersen Wierde	NAT	F	rural		144		218.0	49.9	22.89
92	Feddersen Wierde	NAT	F	rural		146	D	215.6	42.0	19.48
92	Feddersen Wierde	NAT	F	rural		147	H	210.8	49.1	23.29
92	Feddersen Wierde	NAT	F	rural		148	H*	196.5	42.8	21.78
92	Feddersen Wierde	NAT	F	rural		149	H	204.3	45.6	22.32
92	Feddersen Wierde	NAT	F	rural		150	H	203.9	43.8	21.48
92	Feddersen Wierde	NAT	F	rural		151	H	203.8	42.9	21.05
92	Feddersen Wierde	NAT	F	rural		152	H	202.8	46.2	22.78
92	Feddersen Wierde	NAT	F	rural		153	H	199.8	48.6	24.32
92	Feddersen Wierde	NAT	F	rural		154		209.9	47.1	22.44
92	Feddersen Wierde	NAT	F	rural		155	H	214.2	46.9	21.90
92	Feddersen Wierde	NAT	F	rural		156	H*	214.3	44.2	20.63
92	Feddersen Wierde	NAT	F	rural		157	H	211.8	43.5	20.54
92	Feddersen Wierde	NAT	F	rural		158	H?	210.2	47.5	22.60
92	Feddersen Wierde	NAT	F	rural		159	H*	211.7	46.8	22.11
92	Feddersen Wierde	NAT	F	rural		160	H	203.3	46.3	22.77
92	Feddersen Wierde	NAT	F	rural		161	M?	219.2	46.0	20.99
92	Feddersen Wierde	NAT	F	rural		162	H	206.1	48.7	23.63
92	Feddersen Wierde	NAT	F	rural		163		212.3	46.0	21.67
92	Feddersen Wierde	NAT	F	rural		164	H*	210.3	48.7	23.16
92	Feddersen Wierde	NAT	F	rural		165	H?	204.5	46.4	22.69
92	Feddersen Wierde	NAT	F	rural		166	H	221.8	48.1	21.69
92	Feddersen Wierde	NAT	F	rural		167	D?	212.7	45.8	21.53
92	Feddersen Wierde	NAT	F	rural		168		207.7	43.2	20.80
92	Feddersen Wierde	NAT	F	rural		170		223.9	49.2	21.97
92	Feddersen Wierde	NAT	F	rural		171	H*	215.6	44.5	20.64
92	Feddersen Wierde	NAT	F	rural		172	H	213.7	46.8	21.90
92	Feddersen Wierde	NAT	F	rural		174	H	197.6	43.4	21.96
92	Feddersen Wierde	NAT	F	rural		175	H*	203.0	46.1	22.71
92	Feddersen Wierde	NAT	F	rural		176	H	205.9	43.3	21.03
92	Feddersen Wierde	NAT	F	rural		177	H	204.1	44.8	21.95
92	Feddersen Wierde	NAT	F	rural		179	H	203.3	41.3	20.31
92	Feddersen Wierde	NAT	F	rural		180	H*	204.1	47.4	23.22
92	Feddersen Wierde	NAT	F	rural		181	H	219.1	49.2	22.46
92	Feddersen Wierde	NAT	F	rural		182	H*	192.4	43.4	22.56
92	Feddersen Wierde	NAT	F	rural		183	H	208.3	45.6	21.89
92	Feddersen Wierde	NAT	F	rural		184		212.7	47.8	22.47
92	Feddersen Wierde	NAT	F	rural		185	D?	204.9	45.2	22.06
92	Feddersen Wierde	NAT	F	rural		186	H?	219.6	45.0	20.49
92	Feddersen Wierde	NAT	F	rural		187	D?	200.2	43.0	21.48

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
92	Feddersen Wierde	NAT	F	rural		188	H	214.9	46.6	21.68
92	Feddersen Wierde	NAT	F	rural		190	H	204.1	46.3	22.68
92	Feddersen Wierde	NAT	F	rural		191		198.1	41.8	21.10
92	Feddersen Wierde	NAT	F	rural		192	H?	192.6	42.1	21.86
92	Feddersen Wierde	NAT	F	rural		193	H	202.6	45.6	22.51
92	Feddersen Wierde	NAT	F	rural		194	M?	208.9	46.3	22.16
92	Feddersen Wierde	NAT	F	rural		195	H*	187.7	41.5	22.11
92	Feddersen Wierde	NAT	F	rural		196		203.5	44.8	22.01
92	Feddersen Wierde	NAT	F	rural		198	H	200.0	46.0	23.00
92	Feddersen Wierde	NAT	F	rural		199	H?	215.2	46.2	21.47
92	Feddersen Wierde	NAT	F	rural		200		211.2	45.4	21.50
92	Feddersen Wierde	NAT	F	rural		201	H*	205.5	44.5	21.65
92	Feddersen Wierde	NAT	F	rural		203	H	205.6	46.6	22.67
92	Feddersen Wierde	NAT	F	rural		204	H*	213.5	48.1	22.53
92	Feddersen Wierde	NAT	F	rural		205		203.1	47.2	23.24
92	Feddersen Wierde	NAT	F	rural		206	H?	208.7	45.9	21.99
92	Feddersen Wierde	NAT	F	rural		207	H*	219.7	46.4	21.12
92	Feddersen Wierde	NAT	F	rural		209		208.6	43.7	20.95
92	Feddersen Wierde	NAT	F	rural		210	M?	209.8	46.1	21.97
92	Feddersen Wierde	NAT	F	rural		211	H	204.3	45.5	22.27
92	Feddersen Wierde	NAT	F	rural		212	H*	204.7	47.3	23.11
92	Feddersen Wierde	NAT	F	rural		213	H	222.4	47.3	21.27
92	Feddersen Wierde	NAT	F	rural		214	D?	199.4	44.4	22.27
92	Feddersen Wierde	NAT	F	rural		215	H*	200.6	47.0	23.43
92	Feddersen Wierde	NAT	F	rural		216	H	210.9	46.6	22.10
92	Feddersen Wierde	NAT	F	rural		217	H*	190.0	42.4	22.32
92	Feddersen Wierde	NAT	F	rural		218	H	207.1	43.4	20.96
92	Feddersen Wierde	NAT	F	rural		219	H*	209.4	47.7	22.78
92	Feddersen Wierde	NAT	F	rural		220		204.9	45.0	21.96
92	Feddersen Wierde	NAT	F	rural		221	H	212.6	45.7	21.50
92	Feddersen Wierde	NAT	F	rural		222	M?	200.4	43.2	21.56
92	Feddersen Wierde	NAT	F	rural		223		213.5	44.2	20.70
92	Feddersen Wierde	NAT	F	rural		224	H	210.4	44.8	21.29
92	Feddersen Wierde	NAT	F	rural		225	M?	211.4	45.3	21.43
92	Feddersen Wierde	NAT	F	rural		226	H?	202.1	44.3	21.92
92	Feddersen Wierde	NAT	F	rural		227	H	221.6	47.6	21.48
92	Feddersen Wierde	NAT	F	rural		228	H*	204.3	47.8	23.40
92	Feddersen Wierde	NAT	F	rural		229	H*	215.1	44.0	20.46
92	Feddersen Wierde	NAT	F	rural		230	H	210.0	46.5	22.14
92	Feddersen Wierde	NAT	F	rural		231	H	201.6	46.9	23.26
92	Feddersen Wierde	NAT	F	rural		232	H	213.3	46.8	21.94
92	Feddersen Wierde	NAT	F	rural		233	M?	225.8	44.0	19.49
92	Feddersen Wierde	NAT	F	rural		234	H	219.7	48.2	21.94
92	Feddersen Wierde	NAT	F	rural		235	H	209.5	46.1	22.00
92	Feddersen Wierde	NAT	F	rural		236	H*	196.5	40.8	20.76
96	Kunzing east vicus	RO	F	cem	1703	1	M*	219.6	50.5	23.00
96	Kunzing east vicus	RO	F	cem	1641	2	M*	229.0	50.4	22.01
96	Kunzing east vicus	RO	F	cem	1581	3	H?	238.5	51.7	21.68
96	Kunzing east vicus	RO	F	cem	1575/5	4	H*	228.0	50.6	22.19
96	Kunzing east vicus	RO	F	cem	1620	5	H*	239.4	51.5	21.51
96	Kunzing east vicus	RO	F	cem	1632	6	M	237.8	52.4	22.04
104	Orton Hall Farm	RO	E	villa		636	H?	247.0	54.0	21.86
104	Orton Hall Farm	RO	E	villa		637	M	210.0	51.0	24.29
104	Orton Hall Farm	RO	E	villa		638	M*	238.0	50.0	21.01
104	Orton Hall Farm	RO	E	villa		639	H*	226.0	50.0	22.12
105	Mons Claudianus	RO	K	ind		640		230.0	48.0	20.87

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
105	Mons Claudianus	RO	K	ind		641		227.8	49.1	21.55
105	Mons Claudianus	RO	K	ind		642		226.8	52.0	22.93
105	Mons Claudianus	RO	K	ind		643		225.1	48.3	21.46
105	Mons Claudianus	RO	K	ind		644		221.9	51.9	23.39
105	Mons Claudianus	RO	K	ind		645		220.0	49.6	22.55
105	Mons Claudianus	RO	K	ind		646		216.2	46.1	21.32
105	Mons Claudianus	RO	K	ind		650		211.2	45.0	21.31
105	Mons Claudianus	RO	K	ind	851	651		211.0	45.8	21.71
105	Mons Claudianus	RO	K	ind	1497	652		210.4	44.5	21.15
105	Mons Claudianus	RO	K	ind		654		206.0	44.1	21.41
105	Mons Claudianus	RO	K	ind		655		205.7	40.8	19.83
105	Mons Claudianus	RO	K	ind		656		205.0	45.0	21.95
105	Mons Claudianus	RO	K	ind	792	657		205.0	40.0	19.51
105	Mons Claudianus	RO	K	ind		658		204.8	46.2	22.56
105	Mons Claudianus	RO	K	ind		659		204.0	46.6	22.84
105	Mons Claudianus	RO	K	ind		660		204.0	44.8	21.96
105	Mons Claudianus	RO	K	ind		661		202.0	44.2	21.88
105	Mons Claudianus	RO	K	ind	180	662		200.0	40.5	20.25
105	Mons Claudianus	RO	K	ind		663		197.5	39.4	19.95
105	Mons Claudianus	RO	K	ind	286	664		194.0	38.7	19.95
105	Mons Claudianus	RO	K	ind		665		192.0	38.9	20.26
105	Mons Claudianus	RO	K	ind		666		192.0	39.2	20.42
105	Mons Claudianus	RO	K	ind		667		191.0	40.1	20.99
106	Abu Sha'ar	RO	K	mil		717		203.5	43.6	21.43
110	Nijmegen new excavations	RO	F	urb	179/16-24	741	H*	200.0	45.0	22.50
110	Nijmegen new excavations	RO	F	urb	179/16-27	742	H*	220.1	48.9	22.22
110	Nijmegen new excavations	RO	F	urb	1961/621-2	743	H?	194.9	42.7	21.91
110	Nijmegen new excavations	RO	F	urb	147/128-21	744	H?	246.5	56.4	22.88
112	Pompeii, Sarno Baths	RO	A	urb	A	747		235.0	52.2	22.21
112	Pompeii, Sarno Baths	RO	A	urb	B	748		236.5	49.8	21.06
112	Pompeii, Sarno Baths	RO	A	urb	D	750		268.5	50.6	18.85
113	Southwark	RO	E	urb		751	H*	180.0	40.4	22.44
114	Unterlaa	RO	G	urb	22B	752	M*	225.0	48.9	21.73
114	Unterlaa	RO	G	urb	23	753	H	225.0	44.8	19.91
114	Unterlaa	RO	G	urb	25	754	H*	217.5	49.3	22.67
114	Unterlaa	RO	G	urb	30	755	H	217.0	47.4	21.84
114	Unterlaa	RO	G	urb	32	756	H	207.2	46.4	22.39
115	Bad Wimpfen	RO	F	urb2		758		239.0	50.5	21.13
115	Bad Wimpfen	RO	F	urb2		759		236.5	56.2	23.76
115	Bad Wimpfen	RO	F	urb2		761	H*	224.7	50.0	22.25
115	Bad Wimpfen	RO	F	urb2		762	H*	220.3	47.7	21.65
115	Bad Wimpfen	RO	F	urb2		763	H	218.8	47.7	21.80
115	Bad Wimpfen	RO	F	urb2		764	H	216.0	50.4	23.33
115	Bad Wimpfen	RO	F	urb2		765	H*	212.8	47.0	22.09
115	Bad Wimpfen	RO	F	urb2		779		163.0	35.0	21.47
115	Bad Wimpfen	RO	F	urb2		780		154.0	32.8	21.30
116	Pommeroeul	RO	D	urb2	248-1	781	H	203.0	46.0	22.66
116	Pommeroeul	RO	D	urb2	238	782	H*	210.0	50.0	23.81
116	Pommeroeul	RO	D	urb2	B	783	H?	219.0	52.0	23.74
116	Pommeroeul	RO	D	urb2	348	784	D*	220.0	48.0	21.82
116	Pommeroeul	RO	D	urb2	271-1	785	M?	222.0	45.0	20.27
116	Pommeroeul	RO	D	urb2	271-2	786	M*	221.0	47.0	21.27
116	Pommeroeul	RO	D	urb2	17-1	787	H*	224.0	50.0	22.32
116	Pommeroeul	RO	D	urb2	328	788	H*	226.0	52.0	23.01
116	Pommeroeul	RO	D	urb2	198	789	M?	240.0	52.0	21.67
116	Pommeroeul	RO	D	urb2	17-2	790	H?	241.0	50.0	20.75

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
117	Pompeii stable	RO	A	urb	A	792		239.0	55.1	23.05
117	Pompeii stable	RO	A	urb	B	793	M*	234.0	53.0	22.65
117	Pompeii stable	RO	A	urb	C	794	M?	239.0	56.8	23.77
117	Pompeii stable	RO	A	urb	D	795		231.0	50.0	21.65
118	Carnuntum	RO	G	mil	Pferd 1	796	M	249.0	56.3	22.61
118	Carnuntum	RO	G	mil	Pferd 2	797	H	239.5	54.5	22.76
118	Carnuntum	RO	G	mil	Pferd 3	798	H*	233.0	51.3	22.02
118	Carnuntum	RO	G	mil	Pferd 4	799		245.5	52.5	21.38
118	Carnuntum	RO	G	mil		800	M	251.0	55.0	21.91
118	Carnuntum	RO	G	mil		801	M*	250.0	54.8	21.92
118	Carnuntum	RO	G	mil		802	M	239.0	57.0	23.85
118	Carnuntum	RO	G	mil		803	D	167.2	34.6	20.69
119	Albertfalva	RO	G	mil	Horse 1	804	H?	228.1	57.9	25.38
119	Albertfalva	RO	G	mil	Horse 2	805	H?	251.8	61.9	24.58
120	Basel-Gasfabrik	IA	F	rural		806	H*	205.1	46.4	22.62
120	Basel-Gasfabrik	IA	F	rural		807	H*	185.2	40.8	22.03
120	Basel-Gasfabrik	IA	F	rural		808	H	199.3	45.1	22.63
120	Basel-Gasfabrik	IA	F	rural		809	H	197.8	46.0	23.26
120	Basel-Gasfabrik	IA	F	rural		810	H*	194.8	45.0	23.10
120	Basel-Gasfabrik	IA	F	rural		811	H?	232.4	50.4	21.69
120	Basel-Gasfabrik	IA	F	rural		812	H?	208.5	45.1	21.63
120	Basel-Gasfabrik	IA	F	rural		813	H	206.6	45.5	22.02
121	Soluthurn/Vigier	RO	F	urb2		816	M	241.0	49.0	20.33
121	Soluthurn/Vigier	RO	F	urb2		817	H	223.8	47.4	21.18
122	Lousonna	RO	F	urb2		818		229.2	49.3	21.51
123	Wroxeter Baths basilica	RO	E	urb		819	H?	216.0	48.7	22.55
123	Wroxeter Baths basilica	RO	E	urb		821		211.5	48.0	22.70
123	Wroxeter Baths basilica	RO	E	urb		822	H	216.5	53.4	24.67
125	Castleford	RO	E	mil		830	H	194.2	42.4	21.83
125	Castleford	RO	E	mil		834		247.0	58.3	23.60
125	Castleford	RO	E	mil		835	H?	232.0	45.4	19.57
125	Castleford	RO	E	mil		838	H	216.0	50.9	23.56
127	Tortoreto-Fortellezza	IA	A	rural		841	D	173.5	37.5	21.61
128	Krefeld-Gellep	RO	F	mil	3392	843		238.0	55.0	23.11
128	Krefeld-Gellep	RO	F	mil	3392	844	H*	238.0	54.0	22.69
128	Krefeld-Gellep	RO	F	mil	3557	845	H?	242.0	53.0	21.90
128	Krefeld-Gellep	RO	F	mil	3424	846		203.0	40.0	19.70
128	Krefeld-Gellep	RO	F	mil	3573	847	M	231.0	50.0	21.65
128	Krefeld-Gellep	RO	F	mil	3577A	848	M	235.0	54.0	22.98
128	Krefeld-Gellep	RO	F	mil	3510	850	D*	190.0	41.5	21.84
129	Lorenzberg Bei Epfach	RO	F	oth		851		243.0	55.5	22.84
129	Lorenzberg Bei Epfach	RO	F	oth		861		208.0	44.5	21.39
129	Lorenzberg Bei Epfach	RO	F	oth		862		195.0	39.0	20.00
131	Radovesice	IA	G	rural		863	H*	202.0	45.0	22.28
132	Godmanchester	RO	E	mil		867		214.0	46.7	21.82
132	Godmanchester	RO	E	mil		870		222.2	47.0	21.15
132	Godmanchester	RO	E	mil		871		210.0	44.5	21.19
132	Godmanchester	RO	E	mil		872		229.9	47.0	20.44
132	Godmanchester	RO	E	mil		874		211.3	47.5	22.48
132	Godmanchester	RO	E	mil		878		234.0	50.8	21.71
133	Colchester	RO	E	urb		880		202.0	44.0	21.78
133	Colchester	RO	E	urb		881		203.0	46.0	22.66
133	Colchester	RO	E	urb		882		206.0	44.4	21.55
134	Butzbach	RO	F	urb2		884		231.0	49.0	21.21
134	Butzbach	RO	F	urb2		885	H	191.0	49.0	25.65
134	Butzbach	RO	F	urb2		886	M	225.0	52.0	23.11

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
135	Swestari	IA	G	cem	1	891	H	200.0	44.0	22.00
135	Swestari	IA	G	cem	2	892	H	204.0	47.0	23.04
135	Swestari	IA	G	cem	3	893	H	206.0	45.5	22.09
135	Swestari	IA	G	cem	4	894	H*	219.0	51.0	23.29
135	Swestari	IA	G	cem	5	895	M	244.0	56.0	22.95
137	Magdelenska Gora	IA	G	cem	IV, 43	897		211.0	46.0	21.80
137	Magdelenska Gora	IA	G	cem	V, 29, I	898	H?	219.0	49.0	22.37
137	Magdelenska Gora	IA	G	cem	V, 29, II	899		214.5	48.0	22.38
141	Szentes-Vekerzug	IA	G	cem	6	901	H*	210.0	44.5	21.19
143	Histria	IA	G	urb2	P1	902	H*	230.0	53.0	23.04
143	Histria	IA	G	urb2	P2	903	H?	235.0	53.2	22.64
143	Histria	IA	G	urb2	P4	905		229.0	51.0	22.27
143	Histria	IA	G	urb2	P12	906	H*	225.0	50.0	22.22
144	Albertfalva	RO	G	mil		908	M?	216.0	46.0	21.30
144	Albertfalva	RO	G	mil		912		245.0	49.0	20.00
144	Albertfalva	RO	G	mil		913		240.0	53.0	22.08
144	Albertfalva	RO	G	mil		914	M	245.0	53.0	21.63
144	Albertfalva	RO	G	mil		915	M	240.0	55.0	22.92
144	Albertfalva	RO	G	mil		918	M*	237.0	48.5	20.46
144	Albertfalva	RO	G	mil		919		227.0	47.5	20.93
144	Albertfalva	RO	G	mil		920		223.0	51.0	22.87
144	Albertfalva	RO	G	mil		921	M*	242.0	53.0	21.90
144	Albertfalva	RO	G	mil		923	H?	220.0	45.0	20.45
144	Albertfalva	RO	G	mil		924		233.0	51.0	21.89
146	Balatonaliga	RO	G	rural	574c	925	H*	207.0	45.0	21.74
146	Balatonaliga	RO	G	rural	607c	926	H?	218.0	48.0	22.02
149	Helemba - Sziget	IA	G	rural		929	H*	197.0	45.5	23.10
150	Acs - Vaspuszta	RO	G	mil		930	H*	227.0	48.0	21.15
153	Aquileia forum	RO	A	urb		931	H	219.5	49.5	22.55
153	Aquileia forum	RO	A	urb		932	H*	221.0	50.2	22.71
153	Aquileia forum	RO	A	urb		934		238.0	50.4	21.18
156	Invillino- Ibligio	RO	A	oth		948		234.0	49.5	21.15
156	Invillino- Ibligio	RO	A	oth		949		213.0	44.0	20.66
161	San Giovanni	RO	A	villa		956		241.8	53.4	22.08
161	San Giovanni	RO	A	villa		957		215.3	43.0	19.97
173	Paestum	RO	A	rural		963		222.0	46.0	20.72
174	Abusina-Eining	RO	F	mil		966	M*	247.0	55.0	22.27
174	Abusina-Eining	RO	F	mil		967	M	242.0	52.0	21.49
174	Abusina-Eining	RO	F	mil		968		241.5	51.5	21.33
174	Abusina-Eining	RO	F	mil		969	H?	241.0	52.0	21.58
174	Abusina-Eining	RO	F	mil		970	M*	240.5	52.5	21.83
174	Abusina-Eining	RO	F	mil		971	M	227.5	49.0	21.54
174	Abusina-Eining	RO	F	mil		972	H*	227.0	48.5	21.37
174	Abusina-Eining	RO	F	mil		973	M	216.5	45.5	21.02
174	Abusina-Eining	RO	F	mil		974	M?	236.5	51.0	21.56
174	Abusina-Eining	RO	F	mil		975	M*	234.0	50.0	21.37
174	Abusina-Eining	RO	F	mil		977	H*	224.0	52.0	23.21
175	Sablonetum-Ellingen	RO	F	mil		984		209.0	46.7	22.34
176	Oberdorla	NAT	F	cem		986		228.0	49.0	21.49
176	Oberdorla	NAT	F	cem		987	M?	226.0	47.0	20.80
176	Oberdorla	NAT	F	cem		988		226.0	52.0	23.01
176	Oberdorla	NAT	F	cem		989		224.0	49.0	21.88
176	Oberdorla	NAT	F	cem		990	M	222.0	44.0	19.82
176	Oberdorla	NAT	F	cem		991		219.0	46.0	21.00
176	Oberdorla	NAT	F	cem		992	H*	214.0	48.0	22.43
176	Oberdorla	NAT	F	cem		993	H*	213.0	48.0	22.54

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
176	Oberdorla	NAT	F	cem		994	M?	210.0	46.0	21.90
176	Oberdorla	NAT	F	cem		995	H	210.0	46.0	21.90
176	Oberdorla	NAT	F	cem		996	M?	210.0	44.0	20.95
176	Oberdorla	NAT	F	cem		997	H	210.0	48.0	22.86
176	Oberdorla	NAT	F	cem		998	H?	210.0	44.0	20.95
176	Oberdorla	NAT	F	cem		999	H*	210.0	51.0	24.29
176	Oberdorla	NAT	F	cem		1000		209.0	44.0	21.05
176	Oberdorla	NAT	F	cem		1001	H	208.0	44.7	21.49
176	Oberdorla	NAT	F	cem		1002	H*	207.0	40.0	19.32
176	Oberdorla	NAT	F	cem		1003	H?	202.0	47.0	23.27
176	Oberdorla	NAT	F	cem		1004	H	201.0	43.0	21.39
176	Oberdorla	NAT	F	cem		1005	H	193.0	42.0	21.76
176	Oberdorla	NAT	F	cem		1006	H*	179.0	42.0	23.46
176	Oberdorla	NAT	F	cem		1008	H*	177.0	40.0	22.60
178	Vitudurum-Oberwinterthur	RO	F	urb2		1011		225.0	49.9	22.18
178	Vitudurum-Oberwinterthur	RO	F	urb2		1013	M?	229.0	51.1	22.31
178	Vitudurum-Oberwinterthur	RO	F	urb2		1015	H	220.0	50.1	22.77
178	Vitudurum-Oberwinterthur	RO	F	urb2		1016		214.0	47.3	22.10
181	Barnsley Park	RO	E	rural		1018		227.0	49.0	21.59
182	Frocester Court	RO	E	villa		1019		210.0	48.0	22.86
182	Frocester Court	RO	E	villa		1020		220.0	52.0	23.64
183	Segontium	RO	E	mil		1024		220.0	49.0	22.27
184	Chilgrove 1	RO	E	villa		1028		227.0	54.5	24.01
184	Chilgrove 1	RO	E	villa		1029		205.0	44.0	21.46
186	Shakenoak site K	RO	E	villa		1030		200.0	49.0	24.50
186	Shakenoak site K	RO	E	villa		1031		213.0	44.0	20.66
189	Kassope	IA	H	urb		1040	D	180.0	39.5	21.94
189	Kassope	IA	H	urb		1044	D	167.0	36.0	21.56
190	Breisach	RO	F	mil		1049		226.5	48.0	21.19
190	Breisach	RO	F	mil		1050		233.0	50.5	21.67
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1053		217.0	48.0	22.12
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1055		236.0	50.0	21.19
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1057		240.5	52.0	21.62
193	Marzoll - Marciolae	RO	F	villa		1058		212.5	46.5	21.88
195	Kunzing-Quintana	RO	F	mil		1061		217.0	44.0	20.28
195	Kunzing-Quintana	RO	F	mil		1062		215.0	44.5	20.70
195	Kunzing-Quintana	RO	F	mil		1063		214.0	44.5	20.79
196	Dormagen	RO	F	mil		1068		235.0	54.0	22.98
196	Dormagen	RO	F	mil		1069		227.5	52.0	22.86
196	Dormagen	RO	F	mil		1070		211.5	50.0	23.64
197	Froitzheim	RO	F	rural		1074		225.0	50.0	22.22
197	Froitzheim	RO	F	rural		1075		224.0	48.0	21.43
199	Hufingen	RO	F	rural		1078		239.0	54.0	22.59
199	Hufingen	RO	F	rural		1079		229.0	53.0	23.14
199	Hufingen	RO	F	rural		1080		228.5	51.0	22.32
199	Hufingen	RO	F	rural		1081		228.5	51.5	22.54
199	Hufingen	RO	F	rural		1082		227.5	49.0	21.54
199	Hufingen	RO	F	rural		1083		227.0	50.0	22.03
199	Hufingen	RO	F	rural		1085		223.0	51.0	22.87
199	Hufingen	RO	F	rural		1099		239.5	55.5	23.17
199	Hufingen	RO	F	rural		1100		233.0	49.5	21.24
199	Hufingen	RO	F	rural		1101		233.0	52.5	22.53
199	Hufingen	RO	F	rural		1102		226.0	49.5	21.90
199	Hufingen	RO	F	rural		1103		224.0	48.0	21.43
199	Hufingen	RO	F	rural		1104		223.0	47.5	21.30
199	Hufingen	RO	F	rural		1105		222.0	46.0	20.72

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
199	Hufingen	RO	F	rural		1106		222.0	46.0	20.72
199	Hufingen	RO	F	rural		1107		219.5	47.0	21.41
199	Hufingen	RO	F	rural		1108		218.0	44.0	20.18
199	Hufingen	RO	F	rural		1109		217.0	50.0	23.04
199	Hufingen	RO	F	rural		1110		213.0	44.0	20.66
200	Pfaffenhofen	RO	F	rural		1123		218.0	50.0	22.94
200	Pfaffenhofen	RO	F	rural		1124		227.0	51.0	22.47
200	Pfaffenhofen	RO	F	rural		1125		232.0	51.0	21.98
201	Wehringen	RO	F	villa		1127		234.0	52.5	22.44
202	Penzlin	NAT	F	rural		1129	H	200.8	42.3	21.07
202	Penzlin	NAT	F	rural		1131		194.2	43.4	22.35
202	Penzlin	NAT	F	rural		1132	H	213.7	43.5	20.36
202	Penzlin	NAT	F	rural		1133	D?	213.3	43.3	20.30
202	Penzlin	NAT	F	rural		1134	H?	221.5	46.3	20.90
202	Penzlin	NAT	F	rural		1136	H	198.5	43.4	21.86
202	Penzlin	NAT	F	rural		1137	H*	204.5	47.0	22.98
203	Tac-Gorsium	RO	G	urb		1138	H*	206.5	46.5	22.52
203	Tac-Gorsium	RO	G	urb		1139		208.0	42.0	20.19
203	Tac-Gorsium	RO	G	urb		1140	H*	209.0	45.5	21.77
203	Tac-Gorsium	RO	G	urb		1141	H	209.0	48.5	23.21
203	Tac-Gorsium	RO	G	urb		1142		216.5	49.0	22.63
203	Tac-Gorsium	RO	G	urb		1143	M?	218.0	46.0	21.10
203	Tac-Gorsium	RO	G	urb		1144		218.0	44.0	20.18
203	Tac-Gorsium	RO	G	urb		1145	H*	219.0	49.5	22.60
203	Tac-Gorsium	RO	G	urb		1147		219.0	47.0	21.46
203	Tac-Gorsium	RO	G	urb		1148	H	220.0	47.0	21.36
203	Tac-Gorsium	RO	G	urb		1149	H	220.0	50.5	22.95
203	Tac-Gorsium	RO	G	urb		1150	H	221.0	51.0	23.08
203	Tac-Gorsium	RO	G	urb		1151	H	222.0	48.5	21.85
203	Tac-Gorsium	RO	G	urb		1152	H*	222.0	49.5	22.30
203	Tac-Gorsium	RO	G	urb		1153	H*	222.0	50.5	22.75
203	Tac-Gorsium	RO	G	urb		1154	M*	222.5	46.5	20.90
203	Tac-Gorsium	RO	G	urb		1155		223.0	48.5	21.75
203	Tac-Gorsium	RO	G	urb		1156	H	223.0	51.0	22.87
203	Tac-Gorsium	RO	G	urb		1157	H*	223.0	49.5	22.20
203	Tac-Gorsium	RO	G	urb		1158	H?	223.0	50.0	22.42
203	Tac-Gorsium	RO	G	urb		1160	M?	224.0	51.0	22.77
203	Tac-Gorsium	RO	G	urb		1161	H	224.0	50.0	22.32
203	Tac-Gorsium	RO	G	urb		1163	M*	225.0	50.0	22.22
203	Tac-Gorsium	RO	G	urb		1164	M	225.0	48.0	21.33
203	Tac-Gorsium	RO	G	urb		1165	H?	225.5	46.0	20.40
203	Tac-Gorsium	RO	G	urb		1166	M?	226.0	51.0	22.57
203	Tac-Gorsium	RO	G	urb		1167	M	226.0	50.0	22.12
203	Tac-Gorsium	RO	G	urb		1168	H*	226.0	49.5	21.90
203	Tac-Gorsium	RO	G	urb		1169	H	227.0	48.5	21.37
203	Tac-Gorsium	RO	G	urb		1170	H?	227.0	51.0	22.47
203	Tac-Gorsium	RO	G	urb		1171	M*	227.5	53.0	23.30
203	Tac-Gorsium	RO	G	urb		1172	H*	229.0	51.0	22.27
203	Tac-Gorsium	RO	G	urb		1173	H*	229.0	48.0	20.96
203	Tac-Gorsium	RO	G	urb		1174	M*	229.0	51.0	22.27
203	Tac-Gorsium	RO	G	urb		1175	H*	229.0	51.5	22.49
203	Tac-Gorsium	RO	G	urb		1176		229.0	50.5	22.05
203	Tac-Gorsium	RO	G	urb		1178	H?	230.0	53.5	23.26
203	Tac-Gorsium	RO	G	urb		1179	H*	230.5	52.5	22.78
203	Tac-Gorsium	RO	G	urb		1180	M	231.0	48.5	21.00
203	Tac-Gorsium	RO	G	urb		1181	H	231.0	50.5	21.86

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bp	Index
203	Tac-Gorsium	RO	G	urb		1182	M	231.5	46.0	19.87
203	Tac-Gorsium	RO	G	urb		1184	H?	232.0	52.0	22.41
203	Tac-Gorsium	RO	G	urb		1185	H	232.0	52.5	22.63
203	Tac-Gorsium	RO	G	urb		1186	H?	233.5	54.5	23.34
203	Tac-Gorsium	RO	G	urb		1187	H	235.0	51.0	21.70
203	Tac-Gorsium	RO	G	urb		1188	H?	235.0	53.0	22.55
203	Tac-Gorsium	RO	G	urb		1189	H*	237.0	55.5	23.42
203	Tac-Gorsium	RO	G	urb		1190	M	237.0	48.5	20.46
203	Tac-Gorsium	RO	G	urb		1191	H*	237.0	55.0	23.21
203	Tac-Gorsium	RO	G	urb		1192	M	238.0	51.0	21.43
203	Tac-Gorsium	RO	G	urb		1194	H?	238.5	54.0	22.64
203	Tac-Gorsium	RO	G	urb		1195	M	239.0	53.5	22.38
203	Tac-Gorsium	RO	G	urb		1196	H?	245.0	56.5	23.06
203	Tac-Gorsium	RO	G	urb		1197	M*	252.6	56.0	22.17
203	Tac-Gorsium	RO	G	urb		1198	M?	260.0	54.5	20.96
203	Tac-Gorsium	RO	G	urb		1199	M*	262.5	58.0	22.10
204	Conchil	RO	D	rural		1236	H*	215.3	47.7	22.16
204	Conchil	RO	D	rural		1237	H*	217.5	47.5	21.84
205	Oberstimm	RO	F	mil		1239	D*	215.5	43.0	19.95
205	Oberstimm	RO	F	mil	limb	1240	M*	239.5	49.5	20.67
206	Lauriacum	RO	F	oth		1241		227.0	47.0	20.70
206	Lauriacum	RO	F	oth		1247		228.0	48.0	21.05
207	Haus Burgel	RO	F	mil		1251	H	222.0	48.0	21.62
208	Colonia Ulpia Traiana	RO	F	urb		1253		248.5	55.0	22.13
208	Colonia Ulpia Traiana	RO	F	urb		1254	H?	240.5	52.5	21.83
208	Colonia Ulpia Traiana	RO	F	urb		1255	H?	235.5	53.0	22.51
208	Colonia Ulpia Traiana	RO	F	urb		1256	H*	231.0	52.0	22.51
208	Colonia Ulpia Traiana	RO	F	urb		1257	H?	223.0	48.5	21.75
208	Colonia Ulpia Traiana	RO	F	urb		1258	H*	222.0	54.0	24.32
208	Colonia Ulpia Traiana	RO	F	urb		1259	H	219.5	51.5	23.46
208	Colonia Ulpia Traiana	RO	F	urb		1260	H*	218.0	50.0	22.94
208	Colonia Ulpia Traiana	RO	F	urb		1261		217.0	50.0	23.04
208	Colonia Ulpia Traiana	RO	F	urb		1262	H*	216.0	49.0	22.69
208	Colonia Ulpia Traiana	RO	F	urb		1263	H?	203.0	46.5	22.91
208	Colonia Ulpia Traiana	RO	F	urb		1264	H	201.0	48.5	24.13
209	Iatrus	RO	G	oth		1270	D	181.2	39.1	21.58
210	Freidorf	RO	G	rural		1272		227.5	48.5	21.32
211	Castillar de Mendavia	IA	B	rural		1273		202.0	44.0	21.78
212	Gournay	IA	D	cem		1275	H	203.0	47.0	23.15
212	Gournay	IA	D	cem		1276	H	194.0	43.5	22.42
213	Beauvais	IA	D	rural		1277	H	202.0	45.0	22.28
213	Beauvais	IA	D	rural		1278	H*	226.0	52.0	23.01
213	Beauvais	IA	D	rural		1279	H?	237.0	53.0	22.36
213	Beauvais	IA	D	rural		1280	D?	193.0	40.5	20.98
213	Beauvais	IA	D	rural		1281	H	207.0	45.0	21.74
213	Beauvais	IA	D	rural		1282	H	200.0	44.0	22.00
213	Beauvais	IA	D	rural		1283	H*	184.0	39.5	21.47
214	Compiegne	IA	D	rural		1284	H	232.0	51.0	21.98
215	Ribemont	IA	D	oth		1286	H*	190.0	46.5	24.47
216	Variscourt	IA	D	rural		1287	H	188.0	40.0	21.28
216	Variscourt	IA	D	rural		1288	H*	208.0	43.0	20.67
216	Variscourt	IA	D	rural		1289	H*	182.0	39.0	21.43
216	Variscourt	IA	D	rural		1290	H	192.0	42.0	21.88
216	Variscourt	IA	D	rural		1291	H*	189.0	43.0	22.75
216	Variscourt	IA	D	rural		1292	H*	224.0	49.5	22.10
217	Soissons	IA	D	cem		1293	H*	171.0	37.0	21.64

Table A28. – Results of the calculation of the distal breadth to greatest length index on the Metacarpals

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
3	Edix Hill	IA	E	rural		604		201.5	45.2	22.43
4	Market Deeping	IA	E	rural		603		208.0	47.0	22.6
5	Beckford	IA	E	rural		602		187.0	44.0	23.53
7	Blackhorse Road	IA	E	rural		599		221.4	43.4	19.6
7	Blackhorse Road	IA	E	rural		601		202.7	36.4	17.96
8	Hardingstone School	RO	E	ind		596		191.0	42.0	21.99
8	Hardingstone School	RO	E	ind		597		207.0	43.0	20.77
8	Hardingstone School	RO	E	ind		598		210.0	45.0	21.43
9	Hardingstone enclosure	IA	E	rural		595		236.0	43.0	18.22
10	Twywell	IA	E	rural		593		206.0	46.0	22.33
10	Twywell	IA	E	rural		594		198.0	42.0	21.21
13	Wavendon Gate	RO	E	rural		585		234.7	48.4	20.62
13	Wavendon Gate	RO	E	rural		589		220.0	45.5	20.68
13	Wavendon Gate	IA	E	rural		590		199.6	45.9	23
14	Lincoln	RO	E	urb		579		223.9	46.3	20.68
14	Lincoln	RO	E	urb		580		196.3	40.5	20.63
14	Lincoln	RO	E	urb		581		241.4	51.4	21.29
14	Lincoln	RO	E	urb		582		184.9	41.8	22.61
14	Lincoln	RO	E	urb		583		239.6	51.6	21.54
15	Scole-Dickleburgh	RO	E	urb2		573		226.6	45.5	20.08
15	Scole-Dickleburgh	RO	E	urb2		574		220.1	47.8	21.72
15	Scole-Dickleburgh	RO	E	urb2		577		232.3	46.8	20.15
15	Scole-Dickleburgh	RO	E	urb2		578	H?	205.4	42.3	20.59
16	Birdlip	IA	E	villa		567		204.1	44.1	21.61
16	Birdlip	IA	E	villa		568		211.0	43.1	20.4
16	Birdlip	IA	E	villa		569		202.0	46.3	22.92
20	Northchurch	RO	E	villa		561		260.0	47.0	18.08
23	Puckeridge	IA	E	rural		557		212.5	45.5	21.41
27	Lynch Farm	RO	E	villa		554		220.0	49.0	22.27
28	Longthorpe II	RO	E	mil		553	M?	232.0	49.0	21.12
30	Tort Hill East	RO	E	rural		550		228.0	51.9	22.76
30	Tort Hill East	RO	E	rural		551		202.0	43.4	21.49
35	Castricum-Oosterbuurt	RO	F	oth		529		209.1	45.0	21.51
35	Castricum-Oosterbuurt	RO	F	oth		530		228.3	49.8	21.82
35	Castricum-Oosterbuurt	RO	F	oth		531		228.6	49.5	21.64
35	Castricum-Oosterbuurt	RO	F	oth		532		220.6	48.7	22.09
35	Castricum-Oosterbuurt	RO	F	oth		533		219.3	49.0	22.33
35	Castricum-Oosterbuurt	RO	F	oth	1	534		219.9	47.4	21.57
35	Castricum-Oosterbuurt	RO	F	oth	1	535		219.2	47.8	21.8
35	Castricum-Oosterbuurt	RO	F	oth		537		210.2	47.0	22.36
35	Castricum-Oosterbuurt	RO	F	oth		539		221.0	48.9	22.14
35	Castricum-Oosterbuurt	RO	F	oth		540		211.0	47.6	22.55
35	Castricum-Oosterbuurt	RO	F	oth		542		212.2	45.0	21.18
35	Castricum-Oosterbuurt	RO	F	oth		543		217.6	48.0	22.07
35	Castricum-Oosterbuurt	RO	F	oth		544		231.0	50.5	21.84
35	Castricum-Oosterbuurt	RO	F	oth		545		225.1	49.6	22.03
36	Egmond?	RO	F	oth		528		220.5	44.0	19.95
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-36	522		235.0	55.0	23.4
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-34	523	H?	235.0	51.1	21.74
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-24	525		217.0	47.0	21.66
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-11	526		231.0	52.5	22.73

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-6	527	H?	238.0	52.5	22.06
38	Nijmegen	RO	F	urb		501	H*	211.7	47.3	22.34
38	Nijmegen	RO	F	urb		502	M*	236.8	47.4	20.02
38	Nijmegen	RO	F	urb		503	H?	236.8	50.5	21.33
38	Nijmegen	RO	F	urb		504	M*	227.9	46.7	20.49
38	Nijmegen	RO	F	urb		505	H*	240.4	54.0	22.46
38	Nijmegen	RO	F	urb		506	H?	221.5	48.9	22.08
38	Nijmegen	RO	F	urb		507	M	225.1	46.0	20.44
38	Nijmegen	RO	F	urb		508	H	217.3	46.6	21.45
38	Nijmegen	RO	F	urb		509	H*	226.9	48.6	21.42
38	Nijmegen	RO	F	urb		510	H?	237.2	51.5	21.71
38	Nijmegen	RO	F	urb		511	H	222.1	47.6	21.43
38	Nijmegen	RO	F	urb		514	H?	215.9	46.2	21.4
38	Nijmegen	RO	F	urb		515	H?	225.9	46.7	20.67
38	Nijmegen	RO	F	urb		519	H	215.8	46.3	21.46
38	Nijmegen	RO	F	urb		520		213.5	44.2	20.7
40	Heteren	NAT	F	rural		497		233.1	50.2	21.54
42	Druten	RO	F	villa		478	M?	236.0	48.3	20.47
42	Druten	RO	F	villa		480		226.2	49.3	21.79
42	Druten	RO	F	villa		481		226.0	50.5	22.35
42	Druten	RO	F	villa		482		241.4	49.3	20.42
42	Druten	RO	F	villa		483	H*	220.3	49.4	22.42
42	Druten	RO	F	villa		484		223.8	46.1	20.6
42	Druten	RO	F	villa		485	H*	231.8	50.2	21.66
42	Druten	RO	F	villa		489	H?	241.7	53.0	21.93
42	Druten	RO	F	villa		490	H*	232.6	49.6	21.32
42	Druten	RO	F	villa		491	M?	233.7	48.7	20.84
42	Druten	RO	F	villa		492	H?	235.0	49.7	21.15
42	Druten	RO	F	villa	1.18	493	M*	248.1	50.3	20.27
42	Druten	IA	F	villa		495	H*	224.2	51.2	22.84
43	Elms Farm	RO	E	urb2		465		217.0	46.9	21.61
43	Elms Farm	RO	E	urb2		466	H	205.2	45.9	22.37
43	Elms Farm	RO	E	urb2		467		235.0	50.5	21.49
43	Elms Farm	RO	E	urb2	6640	468		231.0	51.9	22.47
43	Elms Farm	RO	E	urb2	6640	469	H*	230.0	52.0	22.61
43	Elms Farm	RO	E	urb2		470		235.0	50.5	21.49
43	Elms Farm	IA	E	urb2		473		210.0	47.5	22.62
43	Elms Farm	IA	E	urb2		474		190.9	39.8	20.85
44	Danebury	IA	E	rural		426		193.9	43.0	22.18
44	Danebury	IA	E	rural		427		193.0	43.2	22.38
44	Danebury	IA	E	rural		428	H*	227.0	41.0	18.06
44	Danebury	IA	E	rural		432		240.0	44.7	18.63
44	Danebury	IA	E	rural		433	D*	182.0	39.8	21.87
44	Danebury	IA	E	rural		434	H	193.0	44.0	22.8
44	Danebury	IA	E	rural		435		208.0	46.8	22.5
44	Danebury	IA	E	rural		436	H?	197.0	43.5	22.08
44	Danebury	IA	E	rural		437	D*	230.0	41.6	18.09
44	Danebury	IA	E	rural		439		187.0	39.4	21.07
44	Danebury	IA	E	rural		441		209.0	44.0	21.05
44	Danebury	IA	E	rural		442		200.0	44.6	22.3
44	Danebury	IA	E	rural		443		192.0	42.5	22.14
44	Danebury	IA	E	rural		444		201.0	44.2	21.99
44	Danebury	IA	E	rural		445		204.0	43.7	21.42
44	Danebury	IA	E	rural		446		172.0	41.0	23.84
44	Danebury	IA	E	rural		448	H	207.0	45.0	21.74
44	Danebury	IA	E	rural		449		187.0	42.8	22.89

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
44	Danebury	IA	E	rural		450		201.5	44.5	22.08
44	Danebury	IA	E	rural		453		182.0	42.1	23.13
44	Danebury	IA	E	rural		455		206.0	45.6	22.14
44	Danebury	IA	E	rural		457	H	207.0	45.3	21.88
44	Danebury	IA	E	rural		458	H	221.0	51.5	23.3
44	Danebury	IA	E	rural		459		217.0	46.1	21.24
44	Danebury	IA	E	rural		460	H	200.0	44.7	22.35
44	Danebury	IA	E	rural		462		228.0	41.1	18.03
46	E London RB Cemetary	RO	E	cem		420	H?	216.5	47.0	21.71
46	E London RB Cemetary	RO	E	cem		421		224.5	49.3	21.96
47	Beddington Sewage Farm	RO	E	urb		413	H?	190.5	42.3	22.2
47	Beddington Sewage Farm	RO	E	urb		414	H?	190.5	43.2	22.68
47	Beddington Sewage Farm	RO	E	urb		415		201.5	45.0	22.33
47	Beddington Sewage Farm	RO	E	urb		416	M?	213.3	42.4	19.88
47	Beddington Sewage Farm	IA	E	urb		419	H	198.4	42.9	21.62
51	Coldharbour Farm 97	IA	E	villa		410	H	215.0	48.3	22.47
51	Coldharbour Farm 97	IA	E	villa		411	H	207.9	47.3	22.75
51	Coldharbour Farm 97	IA	E	villa		412	H*	217.7	49.9	22.92
54	Thorpe Thewles	IA	E	rural		404	H	203.0	46.4	22.86
54	Thorpe Thewles	IA	E	rural		405	H*	182.0	41.3	22.69
57	La Sagesse	IA	E	oth		399		203.0	42.5	20.94
57	La Sagesse	IA	E	oth		400		216.0	44.1	20.42
57	La Sagesse	IA	E	oth		401		209.0	44.1	21.1
59	Chichester cattlemarket	RO	E	urb	XXIII	397	H*	240.4	52.9	22
59	Chichester cattlemarket	RO	E	urb	XXIII	398	H*	242.0	52.2	21.57
63	S. Giacomo	RO	A	villa		395	H?	235.0	51.5	21.91
66	Settefinestre	RO	A	villa		387	M?	226.0	47.0	20.8
66	Settefinestre	RO	A	villa		388		234.0	48.0	20.51
66	Settefinestre	RO	A	villa		389	D*	189.0	35.0	18.52
71	Piovego	IA	A	cem	N2	381	H*	217.0	48.0	22.12
72	Colle dei Cappuccini	IA	A	rural		380		209.0	44.5	21.29
73	Moie di Pollenza	IA	A	cem		379		218.0	49.0	22.48
76	Ansedonia	RO	A	villa		378		158.0	33.0	20.89
77	Grotto di Tibera	RO	A	oth	15.3	375		198.0	39.0	19.7
77	Grotto di Tibera	RO	A	oth	15.2	376		255.0	51.0	20
77	Grotto di Tibera	RO	A	oth	15.1	377		231.0	47.0	20.35
79	Olbia	IA	A	rural		374	D*	159.4	34.4	21.58
83	Deutsch Wusterhausen	NAT	F	rural		373	H*	220.0	51.8	23.55
85	Macon	RO	D	cem		370	D*	247.0	47.0	19.03
87	Manching	IA	F	rural		309		180.0	40.0	22.22
87	Manching	IA	F	rural		310		181.5	40.0	22.04
87	Manching	IA	F	rural		311		184.0	41.0	22.28
87	Manching	IA	F	rural		312		184.0	39.5	21.47
87	Manching	IA	F	rural		313		185.0	39.5	21.35
87	Manching	IA	F	rural		314		185.5	43.0	23.18
87	Manching	IA	F	rural		315		186.0	39.0	20.97
87	Manching	IA	F	rural		316		186.5	40.0	21.45
87	Manching	IA	F	rural		317		188.5	41.5	22.02
87	Manching	IA	F	rural		318		191.5	42.0	21.93
87	Manching	IA	F	rural		319		191.5	40.0	20.89
87	Manching	IA	F	rural		320		192.0	41.0	21.35
87	Manching	IA	F	rural		321		192.0	40.0	20.83
87	Manching	IA	F	rural		322		192.0	41.0	21.35
87	Manching	IA	F	rural		323		192.0	40.0	20.83
87	Manching	IA	F	rural		324		193.0	42.0	21.76
87	Manching	IA	F	rural		325		193.0	41.0	21.24

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
87	Manching	IA	F	rural		326		193.0	40.0	20.73
87	Manching	IA	F	rural		327		193.0	40.0	20.73
87	Manching	IA	F	rural		328		193.0	43.0	22.28
87	Manching	IA	F	rural		329		193.5	41.0	21.19
87	Manching	IA	F	rural		330		194.0	42.0	21.65
87	Manching	IA	F	rural		331		194.5	40.5	20.82
87	Manching	IA	F	rural		332		195.0	41.0	21.03
87	Manching	IA	F	rural		333		195.0	43.0	22.05
87	Manching	IA	F	rural		334		195.5	43.5	22.25
87	Manching	IA	F	rural		335		196.0	45.0	22.96
87	Manching	IA	F	rural		336		198.0	43.0	21.72
87	Manching	IA	F	rural		337		198.5	42.0	21.16
87	Manching	IA	F	rural		338		199.0	44.0	22.11
87	Manching	IA	F	rural		339		199.0	44.0	22.11
87	Manching	IA	F	rural		340		199.5	42.5	21.3
87	Manching	IA	F	rural		341		199.5	43.5	21.8
87	Manching	IA	F	rural		342		200.0	44.0	22
87	Manching	IA	F	rural		343		200.5	45.5	22.69
87	Manching	IA	F	rural		344		200.5	44.5	22.19
87	Manching	IA	F	rural		346		201.0	43.0	21.39
87	Manching	IA	F	rural		348		202.0	45.0	22.28
87	Manching	IA	F	rural		349		203.0	43.0	21.18
87	Manching	IA	F	rural		350		204.0	43.0	21.08
87	Manching	IA	F	rural		351		207.5	42.0	20.24
87	Manching	IA	F	rural		352		208.0	47.5	22.84
87	Manching	IA	F	rural		353		208.5	45.0	21.58
87	Manching	IA	F	rural		354		208.5	44.5	21.34
87	Manching	IA	F	rural		355		209.0	45.0	21.53
87	Manching	IA	F	rural		356		211.0	41.0	19.43
87	Manching	IA	F	rural		357		211.5	43.5	20.57
87	Manching	IA	F	rural		358		212.5	46.0	21.65
87	Manching	IA	F	rural		359		213.5	44.0	20.61
87	Manching	IA	F	rural		360		213.5	46.0	21.55
87	Manching	IA	F	rural		361		213.5	45.0	21.08
87	Manching	IA	F	rural		362		216.0	50.5	23.38
87	Manching	IA	F	rural		363		216.0	46.0	21.3
87	Manching	IA	F	rural		364		219.0	47.0	21.46
87	Manching	IA	F	rural		365		220.0	45.5	20.68
87	Manching	IA	F	rural		366		226.5	48.0	21.19
87	Manching	IA	F	rural		367		228.5	51.0	22.32
87	Manching	IA	F	rural		368		231.0	48.5	21
87	Manching	IA	F	rural		369		244.0	50.0	20.49
91	Whitton	RO	E	villa	1	237		229.0	49.5	21.62
92	Feddersen Wierde	NAT	F	rural	skelett3L	25		221.0	46.0	20.81
92	Feddersen Wierde	NAT	F	rural	skelett2R	26	H	206.3	46.5	22.54
92	Feddersen Wierde	NAT	F	rural	skelett2L	27	H	205.7	46.1	22.41
92	Feddersen Wierde	NAT	F	rural	skelett1L	28	H	221.8	48.3	21.78
92	Feddersen Wierde	NAT	F	rural		29	D?	196.7	41.5	21.1
92	Feddersen Wierde	NAT	F	rural		30	H	213.8	47.9	22.4
92	Feddersen Wierde	NAT	F	rural		31		201.1	43.5	21.63
92	Feddersen Wierde	NAT	F	rural		32	H?	196.1	40.9	20.86
92	Feddersen Wierde	NAT	F	rural		33	D*	200.5	38.7	19.3
92	Feddersen Wierde	NAT	F	rural		34	H*	203.5	49.4	24.28
92	Feddersen Wierde	NAT	F	rural		35	D?	207.5	43.6	21.01
92	Feddersen Wierde	NAT	F	rural		36	M*	217.5	44.7	20.55
92	Feddersen Wierde	NAT	F	rural		37	H?	198.1	40.8	20.6

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		38	H	202.7	43.2	21.31
92	Feddersen Wierde	NAT	F	rural		39	H*	197.9	46.4	23.45
92	Feddersen Wierde	NAT	F	rural		40	H?	215.3	45.6	21.18
92	Feddersen Wierde	NAT	F	rural		41	M?	206.8	42.0	20.31
92	Feddersen Wierde	NAT	F	rural		42	H*	215.5	47.5	22.04
92	Feddersen Wierde	NAT	F	rural		43		202.3	42.6	21.06
92	Feddersen Wierde	NAT	F	rural		44	H*	216.6	46.0	21.24
92	Feddersen Wierde	NAT	F	rural		45	M?	209.8	43.3	20.64
92	Feddersen Wierde	NAT	F	rural		46		214.3	49.0	22.87
92	Feddersen Wierde	NAT	F	rural		47	H?	210.7	46.3	21.97
92	Feddersen Wierde	NAT	F	rural		48		191.3	44.9	23.47
92	Feddersen Wierde	NAT	F	rural		49	H*	199.0	46.6	23.42
92	Feddersen Wierde	NAT	F	rural		50	H*	196.0	43.7	22.3
92	Feddersen Wierde	NAT	F	rural		51	H*	212.5	44.5	20.94
92	Feddersen Wierde	NAT	F	rural		53	D?	202.9	43.7	21.54
92	Feddersen Wierde	NAT	F	rural		54	H*	188.8	43.5	23.04
92	Feddersen Wierde	NAT	F	rural		55	H	205.1	46.5	22.67
92	Feddersen Wierde	NAT	F	rural		56	H	202.9	43.5	21.44
92	Feddersen Wierde	NAT	F	rural		57	H	210.9	45.4	21.53
92	Feddersen Wierde	NAT	F	rural		58		210.1	45.8	21.8
92	Feddersen Wierde	NAT	F	rural		59		205.9	47.9	23.26
92	Feddersen Wierde	NAT	F	rural		60	H	202.9	46.2	22.77
92	Feddersen Wierde	NAT	F	rural		61	H*	203.8	44.9	22.03
92	Feddersen Wierde	NAT	F	rural		62	H	214.9	47.7	22.2
92	Feddersen Wierde	NAT	F	rural		63	H*	197.4	43.8	22.19
92	Feddersen Wierde	NAT	F	rural		64	H*	215.9	46.2	21.4
92	Feddersen Wierde	NAT	F	rural		65	H	206.7	45.7	22.11
92	Feddersen Wierde	NAT	F	rural		66		197.3	42.7	21.64
92	Feddersen Wierde	NAT	F	rural		67	D?	202.4	45.1	22.28
92	Feddersen Wierde	NAT	F	rural		68	H?	209.9	43.1	20.53
92	Feddersen Wierde	NAT	F	rural		69		195.1	43.4	22.25
92	Feddersen Wierde	NAT	F	rural		70	H	219.1	49.0	22.36
92	Feddersen Wierde	NAT	F	rural		71	H	202.9	43.8	21.59
92	Feddersen Wierde	NAT	F	rural		72	H	211.8	47.6	22.47
92	Feddersen Wierde	NAT	F	rural		73	H	208.6	48.7	23.35
92	Feddersen Wierde	NAT	F	rural		74		202.3	44.7	22.1
92	Feddersen Wierde	NAT	F	rural		75	H*	211.2	45.1	21.35
92	Feddersen Wierde	NAT	F	rural		76	H?	215.2	46.2	21.47
92	Feddersen Wierde	NAT	F	rural		77	H	201.2	43.8	21.77
92	Feddersen Wierde	NAT	F	rural		78	H?	207.3	44.6	21.51
92	Feddersen Wierde	NAT	F	rural		79	H	215.8	46.7	21.64
92	Feddersen Wierde	NAT	F	rural		80	D*	199.5	42.4	21.25
92	Feddersen Wierde	NAT	F	rural		81	H*	204.3	43.1	21.1
92	Feddersen Wierde	NAT	F	rural		82	H?	207.4	44.3	21.36
92	Feddersen Wierde	NAT	F	rural		83		212.6	46.9	22.06
92	Feddersen Wierde	NAT	F	rural		84		205.2	44.2	21.54
92	Feddersen Wierde	NAT	F	rural		85	H*	194.0	44.4	22.89
92	Feddersen Wierde	NAT	F	rural		86	H	211.2	46.6	22.06
92	Feddersen Wierde	NAT	F	rural		87	H*	193.3	42.7	22.09
92	Feddersen Wierde	NAT	F	rural		88	H?	204.5	43.0	21.03
92	Feddersen Wierde	NAT	F	rural		89	H?	214.8	44.1	20.53
92	Feddersen Wierde	NAT	F	rural		90	H	217.1	46.8	21.56
92	Feddersen Wierde	NAT	F	rural		91	H	201.6	43.3	21.48
92	Feddersen Wierde	NAT	F	rural		92	H*	216.0	46.3	21.44
92	Feddersen Wierde	NAT	F	rural		93	H	204.6	45.8	22.39
92	Feddersen Wierde	NAT	F	rural		94	H	209.0	48.8	23.35

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		95	M?	215.8	45.5	21.08
92	Feddersen Wierde	NAT	F	rural		96	H	209.1	45.7	21.86
92	Feddersen Wierde	NAT	F	rural		97	H	194.0	43.6	22.47
92	Feddersen Wierde	NAT	F	rural		99	H	201.4	44.0	21.85
92	Feddersen Wierde	NAT	F	rural		100	H*	205.6	45.6	22.18
92	Feddersen Wierde	NAT	F	rural		101	D	206.6	44.5	21.54
92	Feddersen Wierde	NAT	F	rural		102	H	204.3	45.7	22.37
92	Feddersen Wierde	NAT	F	rural		103		208.4	45.4	21.79
92	Feddersen Wierde	NAT	F	rural		104	H*	210.9	45.9	21.76
92	Feddersen Wierde	NAT	F	rural		105	H	211.1	47.7	22.6
92	Feddersen Wierde	NAT	F	rural		106	H*	214.2	46.1	21.52
92	Feddersen Wierde	NAT	F	rural		107	H	206.9	46.0	22.23
92	Feddersen Wierde	NAT	F	rural		108		212.2	49.3	23.23
92	Feddersen Wierde	NAT	F	rural		110	H*	202.5	46.1	22.77
92	Feddersen Wierde	NAT	F	rural		111		205.1	43.8	21.36
92	Feddersen Wierde	NAT	F	rural		112	H	217.0	49.1	22.63
92	Feddersen Wierde	NAT	F	rural		113	H	214.7	49.6	23.1
92	Feddersen Wierde	NAT	F	rural		114	H*	200.7	44.2	22.02
92	Feddersen Wierde	NAT	F	rural		115	H	228.9	50.3	21.97
92	Feddersen Wierde	NAT	F	rural		116	H	204.6	45.5	22.24
92	Feddersen Wierde	NAT	F	rural		117	H*	213.9	45.8	21.41
92	Feddersen Wierde	NAT	F	rural		118	H	211.9	47.7	22.51
92	Feddersen Wierde	NAT	F	rural		119	H	206.5	46.0	22.28
92	Feddersen Wierde	NAT	F	rural		120	H	210.8	46.5	22.06
92	Feddersen Wierde	NAT	F	rural		121	H	207.8	44.7	21.51
92	Feddersen Wierde	NAT	F	rural		122	H	207.6	44.4	21.39
92	Feddersen Wierde	NAT	F	rural		123	H	202.4	43.2	21.34
92	Feddersen Wierde	NAT	F	rural		124	H	198.3	42.9	21.63
92	Feddersen Wierde	NAT	F	rural		125	H*	208.1	48.2	23.16
92	Feddersen Wierde	NAT	F	rural		126	H?	196.5	41.8	21.27
92	Feddersen Wierde	NAT	F	rural		127	H?	213.3	44.8	21
92	Feddersen Wierde	NAT	F	rural		128	H*	212.1	44.9	21.17
92	Feddersen Wierde	NAT	F	rural		129	H*	193.4	43.1	22.29
92	Feddersen Wierde	NAT	F	rural		130	H*	199.1	46.3	23.25
92	Feddersen Wierde	NAT	F	rural		131	D	199.9	41.3	20.66
92	Feddersen Wierde	NAT	F	rural		132	D*	210.0	41.4	19.71
92	Feddersen Wierde	NAT	F	rural		133	H	204.5	46.2	22.59
92	Feddersen Wierde	NAT	F	rural		134	H*	226.4	50.3	22.22
92	Feddersen Wierde	NAT	F	rural		135	H?	202.6	45.5	22.46
92	Feddersen Wierde	NAT	F	rural		136	H	207.9	45.7	21.98
92	Feddersen Wierde	NAT	F	rural		137	H?	214.1	45.2	21.11
92	Feddersen Wierde	NAT	F	rural		138	H*	208.8	47.0	22.51
92	Feddersen Wierde	NAT	F	rural		139	H*	204.9	47.3	23.08
92	Feddersen Wierde	NAT	F	rural		140	H?	197.2	44.0	22.31
92	Feddersen Wierde	NAT	F	rural		141	H?	209.1	43.3	20.71
92	Feddersen Wierde	NAT	F	rural		142	H	205.2	44.4	21.64
92	Feddersen Wierde	NAT	F	rural		143	H*	206.0	42.4	20.58
92	Feddersen Wierde	NAT	F	rural		144		218.0	47.9	21.97
92	Feddersen Wierde	NAT	F	rural		145		212.7	46.3	21.77
92	Feddersen Wierde	NAT	F	rural		146	D	215.6	42.0	19.48
92	Feddersen Wierde	NAT	F	rural		147	H	210.8	47.7	22.63
92	Feddersen Wierde	NAT	F	rural		148	H*	196.5	43.3	22.04
92	Feddersen Wierde	NAT	F	rural		149	H	204.3	43.5	21.29
92	Feddersen Wierde	NAT	F	rural		150	H	203.9	44.6	21.87
92	Feddersen Wierde	NAT	F	rural		151	H	203.8	43.9	21.54
92	Feddersen Wierde	NAT	F	rural		152	H	202.8	45.6	22.49

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		153	H	199.8	46.4	23.22
92	Feddersen Wierde	NAT	F	rural		154		209.9	46.4	22.11
92	Feddersen Wierde	NAT	F	rural		155	H	214.2	48.3	22.55
92	Feddersen Wierde	NAT	F	rural		156	H*	214.3	44.2	20.63
92	Feddersen Wierde	NAT	F	rural		157	H	211.8	45.5	21.48
92	Feddersen Wierde	NAT	F	rural		158	H?	210.2	46.4	22.07
92	Feddersen Wierde	NAT	F	rural		159	H*	211.7	46.4	21.92
92	Feddersen Wierde	NAT	F	rural		160	H	203.3	47.8	23.51
92	Feddersen Wierde	NAT	F	rural		161	M?	219.2	45.4	20.71
92	Feddersen Wierde	NAT	F	rural		162	H	206.1	45.1	21.88
92	Feddersen Wierde	NAT	F	rural		163		212.3	45.4	21.38
92	Feddersen Wierde	NAT	F	rural		164	H*	210.3	46.1	21.92
92	Feddersen Wierde	NAT	F	rural		165	H?	204.5	43.7	21.37
92	Feddersen Wierde	NAT	F	rural		166	H	221.8	46.9	21.15
92	Feddersen Wierde	NAT	F	rural		167	D?	212.7	44.6	20.97
92	Feddersen Wierde	NAT	F	rural		168		207.7	43.9	21.14
92	Feddersen Wierde	NAT	F	rural		169		230.8	48.4	20.97
92	Feddersen Wierde	NAT	F	rural		170		223.9	46.4	20.72
92	Feddersen Wierde	NAT	F	rural		171	H*	215.6	44.9	20.83
92	Feddersen Wierde	NAT	F	rural		172	H	213.7	46.7	21.85
92	Feddersen Wierde	NAT	F	rural		173		230.0	46.7	20.3
92	Feddersen Wierde	NAT	F	rural		174	H	197.6	44.6	22.57
92	Feddersen Wierde	NAT	F	rural		175	H*	203.0	50.5	24.88
92	Feddersen Wierde	NAT	F	rural		176	H	205.9	42.3	20.54
92	Feddersen Wierde	NAT	F	rural		177	H	204.1	43.8	21.46
92	Feddersen Wierde	NAT	F	rural		178		210.4	46.5	22.1
92	Feddersen Wierde	NAT	F	rural		179	H	203.3	43.1	21.2
92	Feddersen Wierde	NAT	F	rural		180	H*	204.1	46.0	22.54
92	Feddersen Wierde	NAT	F	rural		181	H	219.1	48.5	22.14
92	Feddersen Wierde	NAT	F	rural		182	H*	192.4	43.6	22.66
92	Feddersen Wierde	NAT	F	rural		183	H	208.3	45.6	21.89
92	Feddersen Wierde	NAT	F	rural		185	D?	204.9	43.3	21.13
92	Feddersen Wierde	NAT	F	rural		186	H?	219.6	46.4	21.13
92	Feddersen Wierde	NAT	F	rural		187	D?	200.2	41.2	20.58
92	Feddersen Wierde	NAT	F	rural		188	H	214.9	47.6	22.15
92	Feddersen Wierde	NAT	F	rural		189		212.6	44.0	20.7
92	Feddersen Wierde	NAT	F	rural		190	H	204.1	45.3	22.2
92	Feddersen Wierde	NAT	F	rural		191		198.1	42.4	21.4
92	Feddersen Wierde	NAT	F	rural		192	H?	192.6	42.1	21.86
92	Feddersen Wierde	NAT	F	rural		193	H	202.6	43.9	21.67
92	Feddersen Wierde	NAT	F	rural		194	M?	208.9	43.4	20.78
92	Feddersen Wierde	NAT	F	rural		195	H*	187.7	43.5	23.18
92	Feddersen Wierde	NAT	F	rural		196		203.5	43.1	21.18
92	Feddersen Wierde	NAT	F	rural		197		208.7	43.9	21.03
92	Feddersen Wierde	NAT	F	rural		198	H	200.0	45.4	22.7
92	Feddersen Wierde	NAT	F	rural		199	H?	215.2	44.9	20.86
92	Feddersen Wierde	NAT	F	rural		201	H*	205.5	48.3	23.5
92	Feddersen Wierde	NAT	F	rural		202		230.1	48.1	20.9
92	Feddersen Wierde	NAT	F	rural		203	H	205.6	46.1	22.42
92	Feddersen Wierde	NAT	F	rural		204	H*	213.5	44.8	20.98
92	Feddersen Wierde	NAT	F	rural		206	H?	208.7	42.6	20.41
92	Feddersen Wierde	NAT	F	rural		207	H*	219.7	47.0	21.39
92	Feddersen Wierde	NAT	F	rural		208		214.2	45.0	21.01
92	Feddersen Wierde	NAT	F	rural		210	M?	209.8	43.6	20.78
92	Feddersen Wierde	NAT	F	rural		211	H	204.3	46.1	22.56
92	Feddersen Wierde	NAT	F	rural		212	H*	204.7	47.0	22.96

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		213	H	222.4	47.2	21.22
92	Feddersen Wierde	NAT	F	rural		214	D?	199.4	44.7	22.42
92	Feddersen Wierde	NAT	F	rural		215	H*	200.6	48.2	24.03
92	Feddersen Wierde	NAT	F	rural		216	H	210.9	47.2	22.38
92	Feddersen Wierde	NAT	F	rural		217	H*	190.0	42.0	22.11
92	Feddersen Wierde	NAT	F	rural		218	H	207.1	44.1	21.29
92	Feddersen Wierde	NAT	F	rural		219	H*	209.4	45.9	21.92
92	Feddersen Wierde	NAT	F	rural		221	H	212.6	45.9	21.59
92	Feddersen Wierde	NAT	F	rural		222	M?	200.4	40.8	20.36
92	Feddersen Wierde	NAT	F	rural		223		213.5	43.9	20.56
92	Feddersen Wierde	NAT	F	rural		224	H	210.4	46.6	22.15
92	Feddersen Wierde	NAT	F	rural		225	M?	211.4	42.4	20.06
92	Feddersen Wierde	NAT	F	rural		226	H?	202.1	44.9	22.22
92	Feddersen Wierde	NAT	F	rural		227	H	221.6	48.7	21.98
92	Feddersen Wierde	NAT	F	rural		228	H*	204.3	46.1	22.56
92	Feddersen Wierde	NAT	F	rural		229	H*	215.1	44.3	20.6
92	Feddersen Wierde	NAT	F	rural		230	H	210.0	46.7	22.24
92	Feddersen Wierde	NAT	F	rural		231	H	201.6	46.2	22.92
92	Feddersen Wierde	NAT	F	rural		232	H	213.3	46.6	21.85
92	Feddersen Wierde	NAT	F	rural		233	M?	225.8	46.4	20.55
92	Feddersen Wierde	NAT	F	rural		234	H	219.7	50.3	22.89
92	Feddersen Wierde	NAT	F	rural		235	H	209.5	43.8	20.91
92	Feddersen Wierde	NAT	F	rural		236	H*	196.5	40.5	20.61
96	Kunzing east vicus	RO	F	cem	1703	1	M*	219.6	52.3	23.82
96	Kunzing east vicus	RO	F	cem	1641	2	M*	229.0	49.7	21.7
96	Kunzing east vicus	RO	F	cem	1581	3	H?	238.5	51.8	21.72
96	Kunzing east vicus	RO	F	cem	1575/5	4	H*	228.0	47.1	20.66
96	Kunzing east vicus	RO	F	cem	1620	5	H*	239.4	51.3	21.43
96	Kunzing east vicus	RO	F	cem	1632	6	M	237.8	49.3	20.73
99	Mantles Green	RO	E	villa		623		221.0	46.4	21
104	Orton Hall Farm	RO	E	villa		636	H?	247.0	55.0	22.27
104	Orton Hall Farm	RO	E	villa		637	M	210.0	46.0	21.9
104	Orton Hall Farm	RO	E	villa		638	M*	238.0	52.0	21.85
104	Orton Hall Farm	RO	E	villa		639	H*	226.0	52.0	23.01
105	Mons Claudianus	RO	K	ind		640		230.0	43.4	18.87
105	Mons Claudianus	RO	K	ind		641		227.8	46.9	20.59
105	Mons Claudianus	RO	K	ind		642		226.8	42.9	18.92
105	Mons Claudianus	RO	K	ind		643		225.1	43.5	19.32
105	Mons Claudianus	RO	K	ind		644		221.9	44.6	20.1
105	Mons Claudianus	RO	K	ind		645		220.0	43.0	19.55
105	Mons Claudianus	RO	K	ind		646		216.2	40.2	18.59
105	Mons Claudianus	RO	K	ind	826	647		216.0	39.0	18.06
105	Mons Claudianus	RO	K	ind		649		214.0	39.8	18.6
105	Mons Claudianus	RO	K	ind		650		211.2	43.9	20.79
105	Mons Claudianus	RO	K	ind	851	651		211.0	41.3	19.57
105	Mons Claudianus	RO	K	ind	1497	652		210.4	40.5	19.25
105	Mons Claudianus	RO	K	ind		654		206.0	38.2	18.54
105	Mons Claudianus	RO	K	ind		655		205.7	38.0	18.47
105	Mons Claudianus	RO	K	ind		656		205.0	41.8	20.39
105	Mons Claudianus	RO	K	ind	792	657		205.0	38.7	18.88
105	Mons Claudianus	RO	K	ind		658		204.8	41.2	20.12
105	Mons Claudianus	RO	K	ind		659		204.0	42.6	20.88
105	Mons Claudianus	RO	K	ind		660		204.0	39.0	19.12
105	Mons Claudianus	RO	K	ind		661		202.0	37.4	18.51
105	Mons Claudianus	RO	K	ind	180	662		200.0	39.0	19.5
105	Mons Claudianus	RO	K	ind		663		197.5	37.2	18.84

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
105	Mons Claudianus	RO	K	ind	286	664		194.0	36.7	18.92
105	Mons Claudianus	RO	K	ind		665		192.0	34.8	18.13
105	Mons Claudianus	RO	K	ind		666		192.0	36.2	18.85
105	Mons Claudianus	RO	K	ind		667		191.0	36.6	19.16
106	Abu Sha'ar	RO	K	mil		717		203.5	38.3	18.82
110	Nijmegen new excavations	RO	F	urb	179/16-24	741	H*	200.0	44.2	22.1
110	Nijmegen new excavations	RO	F	urb	179/16-27	742	H*	220.1	48.5	22.04
110	Nijmegen new excavations	RO	F	urb	1961/621-2	743	H?	194.9	38.2	19.6
110	Nijmegen new excavations	RO	F	urb	147/128-21	744	H?	246.5	55.5	22.52
112	Pompeii, Sarno Baths	RO	A	urb	A	747		235.0	53.3	22.68
112	Pompeii, Sarno Baths	RO	A	urb	B	748		236.5	52.7	22.28
112	Pompeii, Sarno Baths	RO	A	urb	C	749		237.3	52.3	22.04
112	Pompeii, Sarno Baths	RO	A	urb	D	750		268.5	49.8	18.55
113	Southwark	RO	E	urb		751	H*	180.0	42.2	23.44
114	Unterlaa	RO	G	urb	22B	752	M*	225.0	46.9	20.84
114	Unterlaa	RO	G	urb	23	753	H	225.0	44.1	19.6
114	Unterlaa	RO	G	urb	25	754	H*	217.5	47.8	21.98
114	Unterlaa	RO	G	urb	30	755	H	217.0	48.0	22.12
114	Unterlaa	RO	G	urb	32	756	H	207.2	45.0	21.72
115	Bad Wimpfen	RO	F	urb2		759		236.5	53.5	22.62
115	Bad Wimpfen	RO	F	urb2		760		225.0	51.2	22.76
115	Bad Wimpfen	RO	F	urb2		761	H*	224.7	50.3	22.39
115	Bad Wimpfen	RO	F	urb2		762	H*	220.3	49.5	22.47
115	Bad Wimpfen	RO	F	urb2		763	H	218.8	45.2	20.66
115	Bad Wimpfen	RO	F	urb2		764	H	216.0	48.0	22.22
115	Bad Wimpfen	RO	F	urb2		765	H*	212.8	45.7	21.48
115	Bad Wimpfen	RO	F	urb2		779		163.0	30.0	18.4
115	Bad Wimpfen	RO	F	urb2		780		154.0	30.8	20
116	Pommeroeul	RO	D	urb2	248-1	781	H	203.0	45.0	22.17
116	Pommeroeul	RO	D	urb2	238	782	H*	210.0	50.0	23.81
116	Pommeroeul	RO	D	urb2	B	783	H?	219.0	47.0	21.46
116	Pommeroeul	RO	D	urb2	348	784	D*	220.0	46.0	20.91
116	Pommeroeul	RO	D	urb2	271-1	785	M?	222.0	44.0	19.82
116	Pommeroeul	RO	D	urb2	271-2	786	M*	221.0	46.0	20.81
116	Pommeroeul	RO	D	urb2	17-1	787	H*	224.0	51.0	22.77
116	Pommeroeul	RO	D	urb2	328	788	H*	226.0	53.0	23.45
116	Pommeroeul	RO	D	urb2	198	789	M?	240.0	52.0	21.67
116	Pommeroeul	RO	D	urb2	17-2	790	H?	241.0	51.0	21.16
117	Pompeii stable	RO	A	urb	B	793	M*	234.0	49.0	20.94
117	Pompeii stable	RO	A	urb	C	794	M?	239.0	54.0	22.59
118	Carnuntum	RO	G	mil	Pferd 1	796	M	249.0	53.4	21.45
118	Carnuntum	RO	G	mil	Pferd 2	797	H	239.5	53.0	22.13
118	Carnuntum	RO	G	mil	Pferd 3	798	H*	233.0	50.5	21.67
118	Carnuntum	RO	G	mil	Pferd 4	799		245.5	50.2	20.45
118	Carnuntum	RO	G	mil		800	M	251.0	50.5	20.12
118	Carnuntum	RO	G	mil		801	M*	250.0	50.8	20.32
118	Carnuntum	RO	G	mil		802	M	239.0	51.2	21.42
118	Carnuntum	RO	G	mil		803	D	167.2	33.0	19.74
119	Albertfalva	RO	G	mil	Horse 1	804	H?	228.1	49.1	21.53
119	Albertfalva	RO	G	mil	Horse 2	805	H?	251.8	56.8	22.56
120	Basel-Gasfabrik	IA	F	rural		806	H*	205.1	46.6	22.72
120	Basel-Gasfabrik	IA	F	rural		807	H*	185.2	39.2	21.17
120	Basel-Gasfabrik	IA	F	rural		808	H	199.3	45.3	22.73
120	Basel-Gasfabrik	IA	F	rural		809	H	197.8	43.5	21.99
120	Basel-Gasfabrik	IA	F	rural		810	H*	194.8	45.3	23.25
120	Basel-Gasfabrik	IA	F	rural		811	H?	232.4	49.0	21.08

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
120	Basel-Gasfabrik	IA	F	rural		812	H?	208.5	43.2	20.72
120	Basel-Gasfabrik	IA	F	rural		813	H	206.6	44.9	21.73
120	Basel-Gasfabrik	IA	F	rural		814		198.0	46.8	23.64
121	Soluthurn/Vigier	RO	F	urb2		816	M	241.0	47.1	19.54
121	Soluthurn/Vigier	RO	F	urb2		817	H	223.8	48.2	21.54
123	Wroxeter Baths basilica	RO	E	urb		819	H?	216.0	47.5	21.99
123	Wroxeter Baths basilica	RO	E	urb		821		211.5	48.6	22.98
123	Wroxeter Baths basilica	RO	E	urb		822	H	216.5	47.4	21.89
124	Haddon	RO	E	oth		823		215.0	49.8	23.16
124	Haddon	RO	E	oth		824		198.0	47.3	23.89
124	Haddon	RO	E	oth		826		205.0	46.0	22.44
124	Haddon	RO	E	oth		827		245.0	51.6	21.06
124	Haddon	RO	E	oth		828		202.0	43.2	21.39
125	Castleford	RO	E	mil		830	H	194.2	44.0	22.66
125	Castleford	RO	E	mil		835	H?	232.0	51.9	22.37
125	Castleford	RO	E	mil		838	H	216.0	48.3	22.36
127	Tortoreto-Fortellezza	IA	A	rural		841	D	173.5	34.5	19.88
128	Krefeld-Gellep	RO	F	mil	3392	843		238.0	50.0	21.01
128	Krefeld-Gellep	RO	F	mil	3392	844	H*	238.0	53.0	22.27
128	Krefeld-Gellep	RO	F	mil	3557	845	H?	242.0	53.5	22.11
128	Krefeld-Gellep	RO	F	mil	3424	846		203.0	40.0	19.7
128	Krefeld-Gellep	RO	F	mil	3573	847	M	231.0	50.0	21.65
128	Krefeld-Gellep	RO	F	mil	3577A	848	M	235.0	48.0	20.43
128	Krefeld-Gellep	RO	F	mil	3577B	849		233.0	51.0	21.89
128	Krefeld-Gellep	RO	F	mil	3510	850	D*	190.0	41.0	21.58
129	Lorenzberg Bei Epfach	RO	F	oth		851		243.0	54.0	22.22
129	Lorenzberg Bei Epfach	RO	F	oth		855		227.0	49.5	21.81
129	Lorenzberg Bei Epfach	RO	F	oth		861		208.0	43.0	20.67
129	Lorenzberg Bei Epfach	RO	F	oth		862		195.0	41.5	21.28
131	Radovesice	IA	G	rural		863	H*	202.0	46.5	23.02
132	Godmanchester	RO	E	mil		865		234.0	49.5	21.15
132	Godmanchester	RO	E	mil		867		214.0	46.4	21.68
132	Godmanchester	RO	E	mil		870		222.2	47.4	21.33
132	Godmanchester	RO	E	mil		871		210.0	43.1	20.52
132	Godmanchester	RO	E	mil		872		229.9	48.1	20.92
132	Godmanchester	RO	E	mil		873		221.0	50.4	22.81
132	Godmanchester	RO	E	mil		874		211.3	45.2	21.39
132	Godmanchester	RO	E	mil		878		234.0	50.5	21.58
133	Colchester	RO	E	urb		881		203.0	44.4	21.87
133	Colchester	RO	E	urb		882		206.0	46.3	22.48
133	Colchester	RO	E	urb		883		234.0	51.7	22.09
134	Butzbach	RO	F	urb2		885	H	191.0	46.0	24.08
134	Butzbach	RO	F	urb2		886	M	225.0	48.0	21.33
135	Swestari	IA	G	cem	1	891	H	200.0	45.0	22.5
135	Swestari	IA	G	cem	2	892	H	204.0	45.0	22.06
135	Swestari	IA	G	cem	3	893	H	206.0	45.0	21.84
135	Swestari	IA	G	cem	4	894	H*	219.0	49.5	22.6
135	Swestari	IA	G	cem	5	895	M	244.0	53.0	21.72
136	Worth Matravers	RO	E	rural		896		202.3	42.9	21.21
137	Magdelenska Gora	IA	G	cem	V, 29, I	898	H?	219.0	46.5	21.23
141	Szentes-Vekerzug	IA	G	cem	6	901	H*	210.0	46.0	21.9
143	Histria	IA	G	urb2	P1	902	H*	230.0	50.5	21.96
143	Histria	IA	G	urb2	P2	903	H?	235.0	50.0	21.28
143	Histria	IA	G	urb2	P12	906	H*	225.0	51.0	22.67
144	Albertfalva	RO	G	mil		908	M?	216.0	46.5	21.53
144	Albertfalva	RO	G	mil		914	M	245.0	52.5	21.43

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
144	Albertfalva	RO	G	mil		915	M	240.0	50.5	21.04
144	Albertfalva	RO	G	mil		918	M*	237.0	47.0	19.83
144	Albertfalva	RO	G	mil		921	M*	242.0	48.0	19.83
144	Albertfalva	RO	G	mil		923	H?	220.0	46.0	20.91
146	Balatonaliga	RO	G	rural	574c	925	H*	207.0	47.0	22.71
146	Balatonaliga	RO	G	rural	607c	926	H?	218.0	46.0	21.1
149	Helemba - Sziget	IA	G	rural		929	H*	197.0	46.0	23.35
150	Acs - Vaspuszta	RO	G	mil		930	H*	227.0	48.5	21.37
153	Aquileia forum	RO	A	urb		931	H	219.5	51.0	23.23
153	Aquileia forum	RO	A	urb		932	H*	221.0	48.8	22.08
153	Aquileia forum	RO	A	urb		933		228.0	45.7	20.04
153	Aquileia forum	RO	A	urb		934		238.0	46.4	19.5
156	Invillino- Ibliglo	RO	A	oth		948		234.0	50.0	21.37
156	Invillino- Ibliglo	RO	A	oth		949		213.0	47.0	22.07
161	San Giovanni	RO	A	villa		955		276.1	47.7	17.28
161	San Giovanni	RO	A	villa		956		241.8	49.2	20.35
164	Stufels	RO	A	rural		959		187.5	43.3	23.09
173	Paestum	RO	A	rural		963		222.0	45.5	20.5
174	Abusina-Eining	RO	F	mil		966	M*	247.0	51.0	20.65
174	Abusina-Eining	RO	F	mil		967	M	242.0	49.0	20.25
174	Abusina-Eining	RO	F	mil		968		241.5	50.0	20.7
174	Abusina-Eining	RO	F	mil		969	H?	241.0	51.5	21.37
174	Abusina-Eining	RO	F	mil		970	M*	240.5	49.5	20.58
174	Abusina-Eining	RO	F	mil		971	M	227.5	47.0	20.66
174	Abusina-Eining	RO	F	mil		972	H*	227.0	49.0	21.59
174	Abusina-Eining	RO	F	mil		973	M	216.5	42.0	19.4
174	Abusina-Eining	RO	F	mil		974	M?	236.5	50.5	21.35
174	Abusina-Eining	RO	F	mil		975	M*	234.0	46.0	19.66
174	Abusina-Eining	RO	F	mil		976		231.0	50.5	21.86
174	Abusina-Eining	RO	F	mil		977	H*	224.0	50.0	22.32
176	Oberdorla	NAT	F	cem		987	M?	226.0	46.0	20.35
176	Oberdorla	NAT	F	cem		990	M	222.0	45.0	20.27
176	Oberdorla	NAT	F	cem		991		219.0	46.5	21.23
176	Oberdorla	NAT	F	cem		992	H*	214.0	49.0	22.9
176	Oberdorla	NAT	F	cem		993	H*	213.0	49.0	23
176	Oberdorla	NAT	F	cem		994	M?	210.0	43.0	20.48
176	Oberdorla	NAT	F	cem		995	H	210.0	45.0	21.43
176	Oberdorla	NAT	F	cem		996	M?	210.0	45.0	21.43
176	Oberdorla	NAT	F	cem		997	H	210.0	46.0	21.9
176	Oberdorla	NAT	F	cem		998	H?	210.0	42.0	20
176	Oberdorla	NAT	F	cem		999	H*	210.0	49.0	23.33
176	Oberdorla	NAT	F	cem		1000		209.0	44.0	21.05
176	Oberdorla	NAT	F	cem		1001	H	208.0	44.0	21.15
176	Oberdorla	NAT	F	cem		1002	H*	207.0	47.0	22.71
176	Oberdorla	NAT	F	cem		1003	H?	202.0	45.0	22.28
176	Oberdorla	NAT	F	cem		1004	H	201.0	41.0	20.4
176	Oberdorla	NAT	F	cem		1005	H	193.0	42.0	21.76
176	Oberdorla	NAT	F	cem		1006	H*	179.0	42.0	23.46
176	Oberdorla	NAT	F	cem		1008	H*	177.0	43.0	24.29
178	Vitudurum-Oberwinterthur	RO	F	urb2		1011		225.0	48.1	21.38
178	Vitudurum-Oberwinterthur	RO	F	urb2		1013	M?	229.0	48.4	21.14
178	Vitudurum-Oberwinterthur	RO	F	urb2		1015	H	220.0	48.3	21.95
181	Barnsley Park	RO	E	rural		1018		227.0	44.0	19.38
182	Frocester Court	RO	E	villa		1019		210.0	45.0	21.43
182	Frocester Court	RO	E	villa		1020		220.0	47.0	21.36
183	Segontium	RO	E	mil		1024		220.0	48.0	21.82

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
184	Chilgrove 1	RO	E	villa		1028		227.0	50.0	22.03
184	Chilgrove 1	RO	E	villa		1029		205.0	43.0	20.98
186	Shakenoak site K	RO	E	villa		1030		200.0	45.0	22.5
189	Kassope	IA	H	urb		1040	D	180.0	37.5	20.83
189	Kassope	IA	H	urb		1044	D	167.0	33.0	19.76
190	Breisach	RO	F	mil		1049		226.5	45.5	20.09
190	Breisach	RO	F	mil		1050		233.0	48.0	20.6
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1053		217.0	49.0	22.58
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1055		236.0	51.0	21.61
192	Pfaffenhofen - Pons Aeni	RO	F	rural		1057		240.5	52.0	21.62
193	Marzoll - Marciolae	RO	F	villa		1058		212.5	46.5	21.88
195	Kunzing-Quintana	RO	F	mil		1061		217.0	46.0	21.2
195	Kunzing-Quintana	RO	F	mil		1063		214.0	43.0	20.09
196	Dormagen	RO	F	mil		1068		235.0	54.0	22.98
196	Dormagen	RO	F	mil		1069		227.5	51.0	22.42
196	Dormagen	RO	F	mil		1070		211.5	48.5	22.93
197	Froitzheim	RO	F	rural		1073		227.0	49.0	21.59
197	Froitzheim	RO	F	rural		1074		225.0	50.0	22.22
197	Froitzheim	RO	F	rural		1075		224.0	48.0	21.43
199	Hufingen	RO	F	rural		1078		239.0	51.0	21.34
199	Hufingen	RO	F	rural		1079		229.0	52.5	22.93
199	Hufingen	RO	F	rural		1080		228.5	46.5	20.35
199	Hufingen	RO	F	rural		1081		228.5	51.0	22.32
199	Hufingen	RO	F	rural		1082		227.5	46.0	20.22
199	Hufingen	RO	F	rural		1083		227.0	50.0	22.03
199	Hufingen	RO	F	rural		1084		225.0	46.0	20.44
199	Hufingen	RO	F	rural		1085		223.0	51.0	22.87
199	Hufingen	RO	F	rural		1086		220.0	46.0	20.91
199	Hufingen	RO	F	rural		1099		239.5	53.5	22.34
199	Hufingen	RO	F	rural		1100		233.0	49.0	21.03
199	Hufingen	RO	F	rural		1101		233.0	53.0	22.75
199	Hufingen	RO	F	rural		1102		226.0	50.5	22.35
199	Hufingen	RO	F	rural		1103		224.0	44.0	19.64
199	Hufingen	RO	F	rural		1104		223.0	46.5	20.85
199	Hufingen	RO	F	rural		1105		222.0	47.0	21.17
199	Hufingen	RO	F	rural		1106		222.0	46.5	20.95
199	Hufingen	RO	F	rural		1107		219.5	50.0	22.78
199	Hufingen	RO	F	rural		1108		218.0	41.5	19.04
199	Hufingen	RO	F	rural		1109		217.0	50.0	23.04
199	Hufingen	RO	F	rural		1110		213.0	45.5	21.36
200	Pfaffenhofen	RO	F	rural		1123		218.0	47.0	21.56
200	Pfaffenhofen	RO	F	rural		1124		227.0	49.0	21.59
200	Pfaffenhofen	RO	F	rural		1125		232.0	50.0	21.55
202	Penzlin	NAT	F	rural		1129	H	200.8	41.5	20.67
202	Penzlin	NAT	F	rural		1130		215.3	47.0	21.83
202	Penzlin	NAT	F	rural		1132	H	213.7	44.0	20.59
202	Penzlin	NAT	F	rural		1133	D?	213.3	42.6	19.97
202	Penzlin	NAT	F	rural		1134	H?	221.5	45.0	20.32
202	Penzlin	NAT	F	rural		1136	H	198.5	42.6	21.46
202	Penzlin	NAT	F	rural		1137	H*	204.5	48.2	23.57
203	Tac-Gorsium	RO	G	urb		1138	H*	206.5	50.0	24.21
203	Tac-Gorsium	RO	G	urb		1139		208.0	44.0	21.15
203	Tac-Gorsium	RO	G	urb		1140	H*	209.0	45.0	21.53
203	Tac-Gorsium	RO	G	urb		1141	H	209.0	49.5	23.68
203	Tac-Gorsium	RO	G	urb		1142		216.5	50.0	23.09
203	Tac-Gorsium	RO	G	urb		1143	M?	218.0	47.0	21.56

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
203	Tac-Gorsium	RO	G	urb		1145	H*	219.0	48.0	21.92
203	Tac-Gorsium	RO	G	urb		1147		219.0	48.0	21.92
203	Tac-Gorsium	RO	G	urb		1148	H	220.0	47.5	21.59
203	Tac-Gorsium	RO	G	urb		1149	H	220.0	51.0	23.18
203	Tac-Gorsium	RO	G	urb		1150	H	221.0	51.0	23.08
203	Tac-Gorsium	RO	G	urb		1151	H	222.0	49.0	22.07
203	Tac-Gorsium	RO	G	urb		1152	H*	222.0	50.5	22.75
203	Tac-Gorsium	RO	G	urb		1153	H*	222.0	50.5	22.75
203	Tac-Gorsium	RO	G	urb		1154	M*	222.5	45.0	20.22
203	Tac-Gorsium	RO	G	urb		1155		223.0	47.5	21.3
203	Tac-Gorsium	RO	G	urb		1156	H	223.0	51.5	23.09
203	Tac-Gorsium	RO	G	urb		1157	H*	223.0	49.5	22.2
203	Tac-Gorsium	RO	G	urb		1158	H?	223.0	49.0	21.97
203	Tac-Gorsium	RO	G	urb		1160	M?	224.0	50.0	22.32
203	Tac-Gorsium	RO	G	urb		1161	H	224.0	50.0	22.32
203	Tac-Gorsium	RO	G	urb		1163	M*	225.0	46.5	20.67
203	Tac-Gorsium	RO	G	urb		1164	M	225.0	46.0	20.44
203	Tac-Gorsium	RO	G	urb		1165	H?	225.5	47.5	21.06
203	Tac-Gorsium	RO	G	urb		1166	M?	226.0	47.0	20.8
203	Tac-Gorsium	RO	G	urb		1167	M	226.0	48.0	21.24
203	Tac-Gorsium	RO	G	urb		1168	H*	226.0	50.5	22.35
203	Tac-Gorsium	RO	G	urb		1169	H	227.0	49.0	21.59
203	Tac-Gorsium	RO	G	urb		1170	H?	227.0	50.0	22.03
203	Tac-Gorsium	RO	G	urb		1171	M*	227.5	47.5	20.88
203	Tac-Gorsium	RO	G	urb		1172	H*	229.0	51.0	22.27
203	Tac-Gorsium	RO	G	urb		1173	H*	229.0	50.5	22.05
203	Tac-Gorsium	RO	G	urb		1174	M*	229.0	49.5	21.62
203	Tac-Gorsium	RO	G	urb		1175	H*	229.0	52.0	22.71
203	Tac-Gorsium	RO	G	urb		1176		229.0	49.0	21.4
203	Tac-Gorsium	RO	G	urb		1177		230.0	50.5	21.96
203	Tac-Gorsium	RO	G	urb		1178	H?	230.0	51.5	22.39
203	Tac-Gorsium	RO	G	urb		1179	H*	230.5	52.5	22.78
203	Tac-Gorsium	RO	G	urb		1180	M	231.0	48.0	20.78
203	Tac-Gorsium	RO	G	urb		1181	H	231.0	50.5	21.86
203	Tac-Gorsium	RO	G	urb		1182	M	231.5	48.0	20.73
203	Tac-Gorsium	RO	G	urb		1183		232.0	50.0	21.55
203	Tac-Gorsium	RO	G	urb		1184	H?	232.0	50.0	21.55
203	Tac-Gorsium	RO	G	urb		1185	H	232.0	51.0	21.98
203	Tac-Gorsium	RO	G	urb		1186	H?	233.5	51.5	22.06
203	Tac-Gorsium	RO	G	urb		1187	H	235.0	53.0	22.55
203	Tac-Gorsium	RO	G	urb		1188	H?	235.0	52.0	22.13
203	Tac-Gorsium	RO	G	urb		1189	H*	237.0	52.5	22.15
203	Tac-Gorsium	RO	G	urb		1190	M	237.0	50.0	21.1
203	Tac-Gorsium	RO	G	urb		1191	H*	237.0	56.0	23.63
203	Tac-Gorsium	RO	G	urb		1192	M	238.0	51.0	21.43
203	Tac-Gorsium	RO	G	urb		1193		238.0	52.0	21.85
203	Tac-Gorsium	RO	G	urb		1194	H?	238.5	53.0	22.22
203	Tac-Gorsium	RO	G	urb		1195	M	239.0	51.0	21.34
203	Tac-Gorsium	RO	G	urb		1196	H?	245.0	55.0	22.45
203	Tac-Gorsium	RO	G	urb		1197	M*	252.6	51.0	20.19
203	Tac-Gorsium	RO	G	urb		1198	M?	260.0	56.0	21.54
203	Tac-Gorsium	RO	G	urb		1199	M*	262.5	53.0	20.19
204	Conchil	RO	D	rural		1236	H*	215.3	47.2	21.92
204	Conchil	RO	D	rural		1237	H*	217.5	48.1	22.11
205	Oberstimm	RO	F	mil		1239	D*	215.5	39.0	18.1
205	Oberstimm	RO	F	mil	limb	1240	M*	239.5	48.0	20.04

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID level	GL	Bd	Index
206	Lauriacum	RO	F	oth		1241		227.0	50.5	22.25
206	Lauriacum	RO	F	oth		1247		228.0	50.0	21.93
207	Haus Burgel	RO	F	mil		1251	H	222.0	49.0	22.07
208	Colonia Ulpia Traiana	RO	F	urb		1253		248.5	53.0	21.33
208	Colonia Ulpia Traiana	RO	F	urb		1254	H?	240.5	52.5	21.83
208	Colonia Ulpia Traiana	RO	F	urb		1255	H?	235.5	52.5	22.29
208	Colonia Ulpia Traiana	RO	F	urb		1256	H*	231.0	48.0	20.78
208	Colonia Ulpia Traiana	RO	F	urb		1257	H?	223.0	48.0	21.52
208	Colonia Ulpia Traiana	RO	F	urb		1258	H*	222.0	52.0	23.42
208	Colonia Ulpia Traiana	RO	F	urb		1259	H	219.5	49.0	22.32
208	Colonia Ulpia Traiana	RO	F	urb		1260	H*	218.0	50.5	23.17
208	Colonia Ulpia Traiana	RO	F	urb		1261		217.0	45.5	20.97
208	Colonia Ulpia Traiana	RO	F	urb		1262	H*	216.0	48.0	22.22
208	Colonia Ulpia Traiana	RO	F	urb		1263	H?	203.0	43.5	21.43
208	Colonia Ulpia Traiana	RO	F	urb		1264	H	201.0	46.5	23.13
209	Iatrus	RO	G	oth		1270	D	181.2	34.1	18.82
210	Freidorf	RO	G	rural		1272		227.5	47.5	20.88
211	Castillar de Mendavia	IA	B	rural		1273		202.0	43.5	21.53
212	Gournay	IA	D	cem		1275	H	203.0	44.5	21.92
212	Gournay	IA	D	cem		1276	H	194.0	40.5	20.88
213	Beauvais	IA	D	rural		1277	H	202.0	42.0	20.79
213	Beauvais	IA	D	rural		1278	H*	226.0	50.0	22.12
213	Beauvais	IA	D	rural		1279	H?	237.0	50.0	21.1
213	Beauvais	IA	D	rural		1280	D?	193.0	39.0	20.21
213	Beauvais	IA	D	rural		1281	H	207.0	44.0	21.26
213	Beauvais	IA	D	rural		1282	H	200.0	42.5	21.25
213	Beauvais	IA	D	rural		1283	H*	184.0	39.5	21.47
214	Compiegne	IA	D	rural		1284	H	232.0	49.0	21.12
214	Compiegne	IA	D	rural		1285		203.0	45.0	22.17
215	Ribemont	IA	D	oth		1286	H*	190.0	44.0	23.16
216	Variscourt	IA	D	rural		1287	H	188.0	40.0	21.28
216	Variscourt	IA	D	rural		1288	H*	208.0	45.0	21.63
216	Variscourt	IA	D	rural		1289	H*	182.0	39.0	21.43
216	Variscourt	IA	D	rural		1290	H	192.0	40.5	21.09
216	Variscourt	IA	D	rural		1291	H*	189.0	40.0	21.16
216	Variscourt	IA	D	rural		1292	H*	224.0	48.0	21.43
217	Soissons	IA	D	cem		1293	H*	171.0	37.5	21.93

Table A29. – Results of the calculation of the shaft breadth to greatest length index on the Metatarsals

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
3	Edix Hill	IA	E	rural	466			261.0	28.8	11.03
4	Market Deeping	IA	E	rural	465		H	251.0	26.6	10.60
10	Twywell	IA	E	rural	458			238.0	26.0	10.92
14	Lincoln	RO	E	urb	449			255.9	27.9	10.90
14	Lincoln	RO	E	urb	451			296.0	34.9	11.79
14	Lincoln	RO	E	urb	452			282.7	37.7	13.34
15	Scole-Dickleburgh	RO	E	urb2	440			254.4	28.4	11.16
15	Scole-Dickleburgh	RO	E	urb2	442			239.0	25.9	10.84
15	Scole-Dickleburgh	RO	E	urb2	443			267.3	31.2	11.67
15	Scole-Dickleburgh	RO	E	urb2	444			205.7	27.8	13.51
15	Scole-Dickleburgh	RO	E	urb2	445		M	267.9	30.2	11.27
15	Scole-Dickleburgh	RO	E	urb2	446			284.8	31.2	10.96
15	Scole-Dickleburgh	RO	E	urb2	447			249.0	27.4	11.00
18	Camulodunum	RO	E	urb	434			244.0	27.0	11.07
18	Camulodunum	RO	E	urb	435			255.0	30.0	11.76
18	Camulodunum	RO	E	urb	436			260.0	29.0	11.15
19	Scole	RO	E	villa	432			293.0	33.0	11.26
19	Scole	RO	E	villa	433			246.0	28.0	11.38
27	Lynch Farm	RO	E	villa	426			280.0	32.0	11.43
28	Longthorpe II	RO	E	mil	423		H	224.0	27.0	12.05
28	Longthorpe II	RO	E	mil	424		H*	223.0	26.0	11.66
28	Longthorpe II	RO	E	mil	425		H	251.0	29.0	11.55
35	Castricum-Oosterbuurt	RO	F	oth	405			275.0	30.5	11.09
35	Castricum-Oosterbuurt	RO	F	oth	406			256.6	27.7	10.80
35	Castricum-Oosterbuurt	RO	F	oth	407			273.4	30.7	11.22
35	Castricum-Oosterbuurt	RO	F	oth	408			272.4	31.7	11.63
35	Castricum-Oosterbuurt	RO	F	oth	409			260.3	29.8	11.46
35	Castricum-Oosterbuurt	RO	F	oth	410			260.0	28.9	11.11
35	Castricum-Oosterbuurt	RO	F	oth	411			267.7	29.2	10.90
35	Castricum-Oosterbuurt	RO	F	oth	412			265.0	27.6	10.42
35	Castricum-Oosterbuurt	RO	F	oth	414			266.0	29.7	11.15
35	Castricum-Oosterbuurt	RO	F	oth	417			256.7	27.7	10.79
35	Castricum-Oosterbuurt	RO	F	oth	418			264.2	30.2	11.43
37	Kesteren 'De Prinsenhof'	RO	F	cem	392	HKKO-35		274.0	32.5	11.86
37	Kesteren 'De Prinsenhof'	RO	F	cem	393	11-36		265.0	32.1	12.11
37	Kesteren 'De Prinsenhof'	RO	F	cem	394	11-35		270.0	34.0	12.59
37	Kesteren 'De Prinsenhof'	RO	F	cem	395	11-34	H?	285.0	33.2	11.65
37	Kesteren 'De Prinsenhof'	RO	F	cem	396	11-28	H*	280.0	32.3	11.54
37	Kesteren 'De Prinsenhof'	RO	F	cem	398	2-27	H*	284.0	34.7	12.22
37	Kesteren 'De Prinsenhof'	RO	F	cem	399	1-23		269.0	34.4	12.79
37	Kesteren 'De Prinsenhof'	RO	F	cem	400	1-21	H?	289.0	32.4	11.21
37	Kesteren 'De Prinsenhof'	RO	F	cem	401	1-11		280.0	32.6	11.64
38	Nijmegen	RO	F	urb	379		M	271.4	32.0	11.79
38	Nijmegen	RO	F	urb	380		H	258.0	27.9	10.81
38	Nijmegen	RO	F	urb	381			279.8	32.4	11.58
38	Nijmegen	RO	F	urb	383		H*	274.8	33.9	12.34
38	Nijmegen	RO	F	urb	384		M	274.6	31.6	11.51
38	Nijmegen	RO	F	urb	385		H*	260.2	32.4	12.45
38	Nijmegen	RO	F	urb	390		M	278.4	33.2	11.93
39	Kesteren vicus	RO	F	urb2	378		H*	237.8	30.4	12.78

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
40	Heteren	NAT	F	rural	374		M*	285.6	29.3	10.26
40	Heteren	NAT	F	rural	376		H?	251.0	28.8	11.47
42	Druten	RO	F	villa	364		H	248.1	30.3	12.21
42	Druten	RO	F	villa	366		H?	258.3	29.7	11.50
42	Druten	RO	F	villa	367		H*	271.8	32.3	11.88
42	Druten	RO	F	villa	368		H*	259.4	32.5	12.53
42	Druten	RO	F	villa	369		H?	275.0	34.2	12.44
42	Druten	RO	F	villa	370			279.8	30.1	10.76
42	Druten	RO	F	villa	372	12.4	H*	269.2	32.7	12.15
42	Druten	RO	F	villa	373	1.18	M*	288.8	34.5	11.95
43	Elms Farm	RO	E	urb2	344			264.0	35.3	13.37
43	Elms Farm	RO	E	urb2	348			242.0	26.9	11.12
43	Elms Farm	RO	E	urb2	349			267.0	31.4	11.76
43	Elms Farm	RO	E	urb2	350	6640	H*	269.0	30.9	11.49
43	Elms Farm	RO	E	urb2	351	6640	H*	268.0	30.5	11.38
43	Elms Farm	RO	E	urb2	352			252.0	32.4	12.86
43	Elms Farm	RO	E	urb2	354			286.0	34.1	11.92
43	Elms Farm	RO	E	urb2	355			254.0	29.7	11.69
43	Elms Farm	RO	E	urb2	357			258.0	32.3	12.52
43	Elms Farm	RO	E	urb2	358		H	256.0	31.1	12.15
43	Elms Farm	IA	E	urb2	359		H*	234.0	27.9	11.92
44	Danebury	IA	E	rural	322		H	242.0	28.2	11.65
44	Danebury	IA	E	rural	326			233.0	26.6	11.42
44	Danebury	IA	E	rural	328			228.0	26.2	11.49
44	Danebury	IA	E	rural	329			237.0	26.0	10.97
44	Danebury	IA	E	rural	330			231.0	24.5	10.61
44	Danebury	IA	E	rural	333			251.0	30.0	11.95
44	Danebury	IA	E	rural	334			218.0	24.9	11.42
44	Danebury	IA	E	rural	335		H	229.0	24.8	10.83
44	Danebury	IA	E	rural	338		H	251.0	28.5	11.35
44	Danebury	IA	E	rural	339			231.0	23.2	10.04
44	Danebury	IA	E	rural	340		H	251.5	31.1	12.37
44	Danebury	IA	E	rural	341			250.0	27.4	10.96
44	Danebury	IA	E	rural	342			245.0	27.3	11.14
46	E London RB Cemetary	RO	E	cem	320		H*	270.9	30.7	11.33
47	Beddington Sewage Farm	RO	E	urb	314			246.6	30.4	12.33
47	Beddington Sewage Farm	RO	E	urb	317		H?	245.0	27.6	11.27
54	Thorpe Thewles	RO	E	rural	301		H*	242.0	27.2	11.24
54	Thorpe Thewles	IA	E	rural	305		M*	242.0	25.4	10.50
57	La Sagesse	IA	E	oth	297			224.5	26.9	11.98
58	Braintree	RO	E	urb2	296			250.5	28.2	11.26
59	Chichester cattlemarket	RO	E	urb	294	XXIII	H*	281.9	34.3	12.17
59	Chichester cattlemarket	RO	E	urb	295	XXIII	H*	282.1	34.3	12.16
63	S. Giacomo	RO	A	villa	291			284.0	33.5	11.80
66	Settefinestre	RO	A	villa	285		H*	277.0	33.0	11.91
67	Ilchester,Church Street	RO	E	urb	284	F267	H*	256.5	34.1	13.29
68	Lutton/Huntingdon	RO	E	rural	279		H?	286.0	35.3	12.34
68	Lutton/Huntingdon	RO	E	rural	280		H?	272.0	30.9	11.36
68	Lutton/Huntingdon	RO	E	rural	282			259.0	29.2	11.27
68	Lutton/Huntingdon	RO	E	rural	283		H	254.0	28.3	11.14
70	Emilia	IA	A	oth	277			213.5	23.4	10.96
71	Piovego	IA	A	cem	276	N2		260.0	29.0	11.15
74	Sovana	IA	A	cem	275			252.0	26.0	10.32
81	Welsow	NAT	F	rural	271		H	259.7	28.4	10.94
81	Welsow	NAT	F	rural	272		H?	247.5	26.0	10.51
81	Welsow	NAT	F	rural	273		H*	246.0	32.7	13.29

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
85	Macon	RO	D	cem	269		M*	285.0	29.7	10.42
87	Manching	IA	F	rural	212			225.0	25.0	11.11
87	Manching	IA	F	rural	213			224.0	28.5	12.72
87	Manching	IA	F	rural	214			223.0	24.0	10.76
87	Manching	IA	F	rural	215			222.5	25.5	11.46
87	Manching	IA	F	rural	216			218.0	24.5	11.24
87	Manching	IA	F	rural	217			217.0	24.5	11.29
87	Manching	IA	F	rural	218			217.0	23.0	10.60
87	Manching	IA	F	rural	219			232.0	28.0	12.07
87	Manching	IA	F	rural	220			231.0	27.0	11.69
87	Manching	IA	F	rural	221			231.0	25.0	10.82
87	Manching	IA	F	rural	222			231.0	26.5	11.47
87	Manching	IA	F	rural	223			231.0	27.0	11.69
87	Manching	IA	F	rural	224			228.0	26.0	11.40
87	Manching	IA	F	rural	225			228.0	25.0	10.96
87	Manching	IA	F	rural	226			227.0	26.0	11.45
87	Manching	IA	F	rural	227			226.5	23.5	10.38
87	Manching	IA	F	rural	228			226.0	25.5	11.28
87	Manching	IA	F	rural	229			236.5	26.5	11.21
87	Manching	IA	F	rural	230			236.5	26.0	10.99
87	Manching	IA	F	rural	231			236.0	27.0	11.44
87	Manching	IA	F	rural	232			236.0	29.0	12.29
87	Manching	IA	F	rural	233			236.0	25.0	10.59
87	Manching	IA	F	rural	234			234.0	27.0	11.54
87	Manching	IA	F	rural	235			233.5	27.0	11.56
87	Manching	IA	F	rural	236			233.0	25.5	10.94
87	Manching	IA	F	rural	237			232.5	27.0	11.61
87	Manching	IA	F	rural	238			232.5	25.0	10.75
87	Manching	IA	F	rural	239			243.5	30.0	12.32
87	Manching	IA	F	rural	240			242.0	26.5	10.95
87	Manching	IA	F	rural	241			242.0	26.0	10.74
87	Manching	IA	F	rural	242			240.0	27.0	11.25
87	Manching	IA	F	rural	243			240.0	25.0	10.42
87	Manching	IA	F	rural	244			239.0	23.5	9.83
87	Manching	IA	F	rural	245			239.0	27.0	11.30
87	Manching	IA	F	rural	246			239.0	25.5	10.67
87	Manching	IA	F	rural	247			237.5	26.0	10.95
87	Manching	IA	F	rural	248			237.0	25.0	10.55
87	Manching	IA	F	rural	249			250.0	29.0	11.60
87	Manching	IA	F	rural	250			250.0	28.5	11.40
87	Manching	IA	F	rural	251			249.5	27.0	10.82
87	Manching	IA	F	rural	252			247.5	27.5	11.11
87	Manching	IA	F	rural	253			247.0	26.0	10.53
87	Manching	IA	F	rural	254			246.5	25.0	10.14
87	Manching	IA	F	rural	255			245.5	28.0	11.41
87	Manching	IA	F	rural	256			245.0	29.0	11.84
87	Manching	IA	F	rural	257			244.5	30.0	12.27
87	Manching	IA	F	rural	258			244.0	27.5	11.27
87	Manching	IA	F	rural	260			288.0	33.0	11.46
87	Manching	IA	F	rural	261			283.5	33.0	11.64
87	Manching	IA	F	rural	262			273.0	34.0	12.45
87	Manching	IA	F	rural	263			271.0	28.5	10.52
87	Manching	IA	F	rural	264			271.0	32.5	11.99
87	Manching	IA	F	rural	265			260.0	27.5	10.58
87	Manching	IA	F	rural	266			255.0	30.5	11.96
87	Manching	IA	F	rural	267			253.0	28.5	11.26

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
87	Manching	IA	F	rural	268			252.5	27.5	10.89
92	Feddersen Wierde	NAT	F	rural	26	skelett1R	H	259.5	28.3	10.91
92	Feddersen Wierde	NAT	F	rural	27	skelett1L	H	259.0	28.0	10.81
92	Feddersen Wierde	NAT	F	rural	28		H	244.3	27.7	11.34
92	Feddersen Wierde	NAT	F	rural	29		H	259.6	28.5	10.98
92	Feddersen Wierde	NAT	F	rural	30			251.0	27.0	10.76
92	Feddersen Wierde	NAT	F	rural	31			247.1	27.6	11.17
92	Feddersen Wierde	NAT	F	rural	32		H?	258.2	25.5	9.88
92	Feddersen Wierde	NAT	F	rural	33		M*	260.7	27.4	10.51
92	Feddersen Wierde	NAT	F	rural	34		H*	236.0	28.9	12.25
92	Feddersen Wierde	NAT	F	rural	35		H	241.8	24.5	10.13
92	Feddersen Wierde	NAT	F	rural	36		H	247.0	28.6	11.58
92	Feddersen Wierde	NAT	F	rural	37		H*	257.4	28.7	11.15
92	Feddersen Wierde	NAT	F	rural	38		H	239.7	25.5	10.64
92	Feddersen Wierde	NAT	F	rural	39		M?	250.0	24.8	9.92
92	Feddersen Wierde	NAT	F	rural	40		H*	270.7	30.6	11.30
92	Feddersen Wierde	NAT	F	rural	41		H*	241.6	29.0	12.00
92	Feddersen Wierde	NAT	F	rural	42		M*	257.1	26.1	10.15
92	Feddersen Wierde	NAT	F	rural	43		H	250.6	27.9	11.13
92	Feddersen Wierde	NAT	F	rural	44			258.8	28.4	10.97
92	Feddersen Wierde	NAT	F	rural	45		H*	247.2	27.3	11.04
92	Feddersen Wierde	NAT	F	rural	46		H*	271.3	29.6	10.91
92	Feddersen Wierde	NAT	F	rural	47		M?	249.1	25.8	10.36
92	Feddersen Wierde	NAT	F	rural	48		H	247.5	29.2	11.80
92	Feddersen Wierde	NAT	F	rural	49		H	269.2	30.4	11.29
92	Feddersen Wierde	NAT	F	rural	50		H?	239.0	22.1	9.25
92	Feddersen Wierde	NAT	F	rural	51		H	245.5	28.2	11.49
92	Feddersen Wierde	NAT	F	rural	52		H	246.8	26.6	10.78
92	Feddersen Wierde	NAT	F	rural	53		H	249.8	28.2	11.29
92	Feddersen Wierde	NAT	F	rural	54		H*	255.7	25.2	9.86
92	Feddersen Wierde	NAT	F	rural	55		H	238.3	25.5	10.70
92	Feddersen Wierde	NAT	F	rural	56		H*	232.9	25.8	11.08
92	Feddersen Wierde	NAT	F	rural	57		H*	253.7	24.7	9.74
92	Feddersen Wierde	NAT	F	rural	58		H	247.3	27.6	11.16
92	Feddersen Wierde	NAT	F	rural	59		H	257.2	29.1	11.31
92	Feddersen Wierde	NAT	F	rural	60			249.5	27.3	10.94
92	Feddersen Wierde	NAT	F	rural	61		H*	256.0	28.7	11.21
92	Feddersen Wierde	NAT	F	rural	62			255.3	27.1	10.61
92	Feddersen Wierde	NAT	F	rural	63		H?	257.6	28.2	10.95
92	Feddersen Wierde	NAT	F	rural	64		H	260.9	26.4	10.12
92	Feddersen Wierde	NAT	F	rural	65		H	239.6	27.6	11.52
92	Feddersen Wierde	NAT	F	rural	66		M*	259.3	28.7	11.07
92	Feddersen Wierde	NAT	F	rural	67		M*	262.3	26.8	10.22
92	Feddersen Wierde	NAT	F	rural	68		H	247.0	28.3	11.46
92	Feddersen Wierde	NAT	F	rural	69		H	234.2	24.1	10.29
92	Feddersen Wierde	NAT	F	rural	70		H	249.5	26.5	10.62
92	Feddersen Wierde	NAT	F	rural	71		H	262.7	31.0	11.80
92	Feddersen Wierde	NAT	F	rural	72		H*	259.4	27.9	10.76
92	Feddersen Wierde	NAT	F	rural	73		H	262.3	31.3	11.93
92	Feddersen Wierde	NAT	F	rural	74		H	247.8	26.4	10.65
92	Feddersen Wierde	NAT	F	rural	75		H	255.3	24.4	9.56
92	Feddersen Wierde	NAT	F	rural	76			253.6	26.3	10.37
92	Feddersen Wierde	NAT	F	rural	77		H	246.2	24.8	10.07
92	Feddersen Wierde	NAT	F	rural	78		M?	251.2	25.8	10.27
92	Feddersen Wierde	NAT	F	rural	79		M?	252.1	25.4	10.08
92	Feddersen Wierde	NAT	F	rural	80		H	245.0	25.4	10.37

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	81		H?	259.4	25.8	9.95
92	Feddersen Wierde	NAT	F	rural	82			246.6	25.1	10.18
92	Feddersen Wierde	NAT	F	rural	83		H	260.4	27.2	10.45
92	Feddersen Wierde	NAT	F	rural	84		H	248.9	27.2	10.93
92	Feddersen Wierde	NAT	F	rural	85		H	253.6	28.2	11.12
92	Feddersen Wierde	NAT	F	rural	86		H	247.0	27.7	11.21
92	Feddersen Wierde	NAT	F	rural	87		M*	252.2	26.8	10.63
92	Feddersen Wierde	NAT	F	rural	88		H	244.6	26.4	10.79
92	Feddersen Wierde	NAT	F	rural	89		H	259.3	30.7	11.84
92	Feddersen Wierde	NAT	F	rural	90		H	245.9	25.9	10.53
92	Feddersen Wierde	NAT	F	rural	91		H	258.2	30.0	11.62
92	Feddersen Wierde	NAT	F	rural	92		H	243.8	26.2	10.75
92	Feddersen Wierde	NAT	F	rural	93		H?	248.4	26.9	10.83
92	Feddersen Wierde	NAT	F	rural	95		H	242.2	25.9	10.69
92	Feddersen Wierde	NAT	F	rural	96		H*	270.6	32.0	11.83
92	Feddersen Wierde	NAT	F	rural	97			237.6	24.9	10.48
92	Feddersen Wierde	NAT	F	rural	98		D*	256.6	23.4	9.12
92	Feddersen Wierde	NAT	F	rural	99		H*	241.7	25.4	10.51
92	Feddersen Wierde	NAT	F	rural	100			255.3	26.8	10.50
92	Feddersen Wierde	NAT	F	rural	101		H	241.4	28.0	11.60
92	Feddersen Wierde	NAT	F	rural	102		H?	255.3	28.5	11.16
92	Feddersen Wierde	NAT	F	rural	103		H?	258.1	27.1	10.50
92	Feddersen Wierde	NAT	F	rural	104		H	239.6	28.8	12.02
92	Feddersen Wierde	NAT	F	rural	105		H	257.1	27.5	10.70
92	Feddersen Wierde	NAT	F	rural	106			258.2	27.9	10.81
92	Feddersen Wierde	NAT	F	rural	107		H	243.6	28.4	11.66
92	Feddersen Wierde	NAT	F	rural	108			242.5	24.7	10.19
92	Feddersen Wierde	NAT	F	rural	110		H	241.7	27.2	11.25
92	Feddersen Wierde	NAT	F	rural	111		H?	256.7	27.7	10.79
92	Feddersen Wierde	NAT	F	rural	112			256.0	28.8	11.25
92	Feddersen Wierde	NAT	F	rural	113		H	244.4	27.8	11.37
92	Feddersen Wierde	NAT	F	rural	114		H*	248.6	26.6	10.70
92	Feddersen Wierde	NAT	F	rural	115		H	270.9	30.2	11.15
92	Feddersen Wierde	NAT	F	rural	116		M	262.0	28.1	10.73
92	Feddersen Wierde	NAT	F	rural	117		H	255.7	26.8	10.48
92	Feddersen Wierde	NAT	F	rural	118		H*	240.4	25.3	10.52
92	Feddersen Wierde	NAT	F	rural	119		H	252.3	28.3	11.22
92	Feddersen Wierde	NAT	F	rural	120		M*	255.2	26.4	10.34
92	Feddersen Wierde	NAT	F	rural	121		H	242.9	26.9	11.07
92	Feddersen Wierde	NAT	F	rural	122		M*	261.9	27.0	10.31
92	Feddersen Wierde	NAT	F	rural	123		H*	235.6	24.0	10.19
92	Feddersen Wierde	NAT	F	rural	124		H	247.5	25.6	10.34
92	Feddersen Wierde	NAT	F	rural	125		H	249.9	26.7	10.68
92	Feddersen Wierde	NAT	F	rural	126		H*	250.6	28.1	11.21
92	Feddersen Wierde	NAT	F	rural	127		H	239.6	26.4	11.02
92	Feddersen Wierde	NAT	F	rural	128		M*	263.6	28.3	10.74
92	Feddersen Wierde	NAT	F	rural	129		H	232.0	25.1	10.82
92	Feddersen Wierde	NAT	F	rural	130		M?	249.8	25.5	10.21
92	Feddersen Wierde	NAT	F	rural	131		H*	236.1	24.4	10.33
92	Feddersen Wierde	NAT	F	rural	132		M*	248.4	26.1	10.51
92	Feddersen Wierde	NAT	F	rural	134		H	247.8	27.1	10.94
92	Feddersen Wierde	NAT	F	rural	135		H?	248.2	25.6	10.31
92	Feddersen Wierde	NAT	F	rural	136		H*	247.0	27.3	11.05
92	Feddersen Wierde	NAT	F	rural	137		H*	267.3	27.2	10.18
92	Feddersen Wierde	NAT	F	rural	138		H*	237.9	27.4	11.52
92	Feddersen Wierde	NAT	F	rural	139		M*	260.3	26.4	10.14

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
92	Feddersen Wierde	NAT	F	rural	140		H*	249.9	26.8	10.72
92	Feddersen Wierde	NAT	F	rural	141		H*	248.5	29.2	11.75
92	Feddersen Wierde	NAT	F	rural	142			233.0	26.8	11.50
92	Feddersen Wierde	NAT	F	rural	143		M*	259.0	25.3	9.77
92	Feddersen Wierde	NAT	F	rural	144		H?	243.3	26.4	10.85
92	Feddersen Wierde	NAT	F	rural	145		H*	245.4	30.1	12.27
92	Feddersen Wierde	NAT	F	rural	146		M*	256.8	27.4	10.67
92	Feddersen Wierde	NAT	F	rural	147		H*	269.3	26.7	9.91
96	Kunzing east vicus	RO	F	cem	1	1703	M*	263.0	32.0	12.17
96	Kunzing east vicus	RO	F	cem	2	1641	M*	274.0	31.0	11.31
96	Kunzing east vicus	RO	F	cem	3	1581	H?	284.0	30.8	10.85
96	Kunzing east vicus	RO	F	cem	4	1575/5	H*	266.5	32.2	12.08
96	Kunzing east vicus	RO	F	cem	5	1620	H*	284.0	32.1	11.30
98	Prestatyn	RO	E	ind	483			243.0	26.7	10.99
104	Orton Hall Farm	RO	E	villa	504		H	236.0	27.0	11.44
104	Orton Hall Farm	RO	E	villa	505		M	258.0	27.0	10.47
104	Orton Hall Farm	RO	E	villa	506		H*	252.0	28.0	11.11
104	Orton Hall Farm	RO	E	villa	507		H?	276.0	32.0	11.59
104	Orton Hall Farm	RO	E	villa	508			215.0	30.0	13.95
105	Mons Claudianus	RO	K	ind	509		H*	272.0	33.0	12.13
105	Mons Claudianus	RO	K	ind	510		M	264.9	29.0	10.95
105	Mons Claudianus	RO	K	ind	511	604	M?	254.0	28.5	11.22
105	Mons Claudianus	RO	K	ind	512	905	M*	253.0	26.8	10.59
105	Mons Claudianus	RO	K	ind	513	1719	D*	248.0	26.9	10.85
105	Mons Claudianus	RO	K	ind	514	813		242.0	23.7	9.79
105	Mons Claudianus	RO	K	ind	515	1544	D*	240.5	23.6	9.81
105	Mons Claudianus	RO	K	ind	516	549	H	239.5	24.2	10.10
105	Mons Claudianus	RO	K	ind	517	1486	D*	236.0	22.5	9.53
105	Mons Claudianus	RO	K	ind	518	2489		227.6	25.1	11.03
110	Nijmegen new excavations	RO	F	urb	589	179/16-22	H*	242.1	27.7	11.44
110	Nijmegen new excavations	RO	F	urb	590	179/16-25	H*	263.1	29.2	11.10
112	Pompeii, Sarno Baths	RO	A	urb	593	A		215.5	32.2	14.94
112	Pompeii, Sarno Baths	RO	A	urb	594	B		275.5	30.7	11.14
112	Pompeii, Sarno Baths	RO	A	urb	595	C		274.0	30.0	10.95
114	Unterlaa	RO	G	urb	598	18	M*	266.0	25.3	9.51
114	Unterlaa	RO	G	urb	599	23A	H	252.0	29.6	11.75
114	Unterlaa	RO	G	urb	600	35	H*	258.0	31.6	12.25
114	Unterlaa	RO	G	urb	601	40	H*	263.5	29.8	11.31
114	Unterlaa	RO	G	urb	602	48	M*	267.0	25.2	9.44
114	Unterlaa	RO	G	urb	603	49	M?	280.0	28.1	10.04
114	Unterlaa	RO	G	urb	604	73	H	251.0	29.3	11.67
115	Bad Wimpfen	RO	F	urb2	605		H	276.3	32.4	11.73
115	Bad Wimpfen	RO	F	urb2	606		H	264.3	29.2	11.05
115	Bad Wimpfen	RO	F	urb2	607			264.2	31.0	11.73
115	Bad Wimpfen	RO	F	urb2	608			262.0	33.0	12.60
115	Bad Wimpfen	RO	F	urb2	613	Skele 4	M	284.0	33.1	11.65
115	Bad Wimpfen	RO	F	urb2	614	Skele 5		278.0	28.4	10.22
115	Bad Wimpfen	RO	F	urb2	615	Skele 6	M	269.5	28.5	10.58
115	Bad Wimpfen	RO	F	urb2	616		D	207.0	22.8	11.01
116	Pommeroeul	RO	D	urb2	617	348-1	H	246.0	29.0	11.79
116	Pommeroeul	RO	D	urb2	618	224-1	H	250.0	27.0	10.80
116	Pommeroeul	RO	D	urb2	619	348-2	H	250.0	28.0	11.20
116	Pommeroeul	RO	D	urb2	620	17-1	H	250.0	26.0	10.40
116	Pommeroeul	RO	D	urb2	621	63	H	257.0	30.0	11.67
116	Pommeroeul	RO	D	urb2	622	251	H*	257.0	28.0	10.89
116	Pommeroeul	RO	D	urb2	623	80	M*	266.0	25.0	9.40

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
116	Pommeroeul	RO	D	urb2	624	306	H*	266.0	31.0	11.65
116	Pommeroeul	RO	D	urb2	625	32	M	268.0	28.0	10.45
116	Pommeroeul	RO	D	urb2	626	222	H*	271.0	31.0	11.44
116	Pommeroeul	RO	D	urb2	627	238	H*	271.0	32.0	11.81
116	Pommeroeul	RO	D	urb2	628	248-1	H*	272.0	33.0	12.13
116	Pommeroeul	RO	D	urb2	629	274	H?	281.0	32.0	11.39
116	Pommeroeul	RO	D	urb2	630	17-2	M*	291.0	31.0	10.65
116	Pommeroeul	RO	D	urb2	631	248-2	H*	296.0	34.0	11.49
118	Carnuntum	RO	G	mil	636	Pferd 1	M	300.0	35.0	11.67
118	Carnuntum	RO	G	mil	637	Pferd 2	H	283.5	33.0	11.64
118	Carnuntum	RO	G	mil	638	Pferd 3	H*	273.2	32.7	11.97
118	Carnuntum	RO	G	mil	639	Maultier 1	M*	286.7	33.3	11.61
118	Carnuntum	RO	G	mil	640			291.0	34.9	11.99
119	Albertfalva	RO	G	mil	641	Horse 1	H?	272.0	31.8	11.69
119	Albertfalva	RO	G	mil	642	Horse 2	H?	296.9	36.5	12.29
119	Albertfalva	RO	G	mil	643	Horse 3		251.3	36.1	14.37
120	Basel-Gasfabrik	IA	F	rural	644			225.0	24.6	10.93
120	Basel-Gasfabrik	IA	F	rural	645			220.0	25.0	11.36
121	Soluthurn/Vigier	RO	F	urb2	650		M*	285.0	31.7	11.12
121	Soluthurn/Vigier	RO	F	urb2	651		M	276.0	30.4	11.01
121	Soluthurn/Vigier	RO	F	urb2	652		M*	272.3	27.5	10.10
121	Soluthurn/Vigier	RO	F	urb2	654			284.2	31.8	11.19
121	Soluthurn/Vigier	RO	F	urb2	655			280.0	32.3	11.54
121	Soluthurn/Vigier	RO	F	urb2	656			272.0	31.8	11.69
123	Wroxeter Baths basilica	RO	E	urb	658			261.5	29.5	11.28
123	Wroxeter Baths basilica	RO	E	urb	659		H	265.0	30.4	11.47
123	Wroxeter Baths basilica	RO	E	urb	660		H	250.4	30.1	12.02
124	Haddon	RO	E	oth	664			246.0	27.9	11.34
124	Haddon	RO	E	oth	665			261.0	29.8	11.42
124	Haddon	RO	E	oth	666			261.0	29.8	11.42
124	Haddon	RO	E	oth	667			239.0	27.7	11.59
124	Haddon	RO	E	oth	668			250.0	26.9	10.76
124	Haddon	RO	E	oth	669			254.0	28.5	11.22
124	Haddon	RO	E	oth	670			253.0	28.6	11.30
125	Castleford	RO	E	mil	673		H*	274.0	35.0	12.77
125	Castleford	RO	E	mil	675		M*	252.0	27.3	10.83
127	Tortoreto-Fortellezza	IA	A	rural	677			205.0	23.0	11.22
128	Krefeld-Gellep	RO	F	mil	680	3392	H*	277.0	33.0	11.91
128	Krefeld-Gellep	RO	F	mil	681	3557	H?	288.0	36.0	12.50
128	Krefeld-Gellep	RO	F	mil	682	3559	M	284.0	32.0	11.27
128	Krefeld-Gellep	RO	F	mil	683	3559	M	283.0	32.0	11.31
128	Krefeld-Gellep	RO	F	mil	684	3573	M	283.0	34.0	12.01
128	Krefeld-Gellep	RO	F	mil	685	3575		272.0	33.0	12.13
128	Krefeld-Gellep	RO	F	mil	687	3510	D*	227.5	24.0	10.55
129	Lorenzberg Bei Epfach	RO	F	oth	689			294.0	31.0	10.54
129	Lorenzberg Bei Epfach	RO	F	oth	690			272.0	30.0	11.03
129	Lorenzberg Bei Epfach	RO	F	oth	691			268.0	31.5	11.75
129	Lorenzberg Bei Epfach	RO	F	oth	695			258.0	29.0	11.24
129	Lorenzberg Bei Epfach	RO	F	oth	696			251.0	30.7	12.23
129	Lorenzberg Bei Epfach	RO	F	oth	699			256.0	31.0	12.11
129	Lorenzberg Bei Epfach	RO	F	oth	700			253.5	29.0	11.44
130	Msecke Zehrovice	IA	G	rural	704			274.0	32.0	11.68
132	Godmanchester	RO	E	mil	708			275.0	30.8	11.20
132	Godmanchester	RO	E	mil	709			280.0	29.4	10.50
132	Godmanchester	RO	E	mil	711			273.0	33.3	12.20
132	Godmanchester	RO	E	mil	713			259.9	28.9	11.12

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
132	Godmanchester	RO	E	mil	715			266.0	29.3	11.02
132	Godmanchester	RO	E	mil	716			265.0	30.5	11.51
132	Godmanchester	RO	E	mil	717			243.0	27.0	11.11
132	Godmanchester	RO	E	mil	720			270.0	32.3	11.96
132	Godmanchester	RO	E	mil	721			270.0	33.8	12.52
133	Colchester	RO	E	urb	723			269.0	31.8	11.82
133	Colchester	RO	E	urb	724			253.5	32.2	12.70
133	Colchester	RO	E	urb	725			263.0	29.8	11.33
133	Colchester	RO	E	urb	727			212.0	24.0	11.32
134	Butzbach	RO	F	urb2	729		H?	284.0	34.0	11.97
134	Butzbach	RO	F	urb2	730		D*	245.0	28.0	11.43
134	Butzbach	RO	F	urb2	731		M	291.0	36.0	12.37
134	Butzbach	RO	F	urb2	732		H*	281.0	36.0	12.81
134	Butzbach	RO	F	urb2	735		M*	303.0	36.0	11.88
135	Swestari	IA	G	cem	736	1	H	240.0	28.0	11.67
135	Swestari	IA	G	cem	737	2	H	240.0	29.0	12.08
135	Swestari	IA	G	cem	738	3	H	244.0	29.0	11.89
135	Swestari	IA	G	cem	739	4	H*	263.0	35.0	13.31
135	Swestari	IA	G	cem	740	5	M	288.0	34.5	11.98
137	Magdelenska Gora	IA	G	cem	742	IV, 43		255.0	27.5	10.78
137	Magdelenska Gora	IA	G	cem	743	V, 29, I		260.0	27.5	10.58
137	Magdelenska Gora	IA	G	cem	744	V, 29, II		252.5	27.0	10.69
137	Magdelenska Gora	IA	G	cem	745	V, 29, III		248.0	26.5	10.69
141	Szentes-Vekerzug	IA	G	cem	746	6	H*	254.0	27.5	10.83
143	Histria	IA	G	urb2	747	P18	H*	275.0	30.5	11.09
143	Histria	IA	G	urb2	748	P25	H?	277.5	32.0	11.53
146	Balatonaliga	RO	G	rural	749	575a		265.0	29.0	10.94
146	Balatonaliga	RO	G	rural	752	620c	H*	264.0	35.0	13.26
147	Pilismarot I Watchtower	RO	G	mil	753		H	245.0	26.0	10.61
147	Pilismarot I Watchtower	RO	G	mil	754		H	245.0	26.5	10.82
147	Pilismarot I Watchtower	RO	G	mil	755		H*	243.0	35.0	14.40
149	Helemba - Sziget	IA	G	rural	756		H*	231.0	28.5	12.34
149	Helemba - Sziget	IA	G	rural	757		H	253.5	28.0	11.05
149	Helemba - Sziget	IA	G	rural	758		H*	254.0	28.0	11.02
151	Gyor Szechenyi-Ter	RO	G	rural	759		H*	282.0	33.5	11.88
153	Aquileia forum	RO	A	urb	773			271.0	30.0	11.07
153	Aquileia forum	RO	A	urb	774		M*	275.0	29.7	10.80
153	Aquileia forum	RO	A	urb	775			280.0	30.6	10.93
155	Gravina 1	RO	A	villa	777			242.0	26.2	10.83
156	Invillino- Ibligo	RO	A	oth	781			273.0	31.0	11.36
156	Invillino- Ibligo	RO	A	oth	782			272.0	30.0	11.03
156	Invillino- Ibligo	RO	A	oth	783			263.0	30.0	11.41
156	Invillino- Ibligo	RO	A	oth	784			254.0	30.5	12.01
176	Oberdorla	NAT	F	cem	803			277.0	33.0	11.91
176	Oberdorla	NAT	F	cem	804		M*	266.0	28.0	10.53
176	Oberdorla	NAT	F	cem	805		M*	262.0	29.0	11.07
176	Oberdorla	NAT	F	cem	806		H	260.0	31.0	11.92
176	Oberdorla	NAT	F	cem	807		H*	254.0	27.0	10.63
176	Oberdorla	NAT	F	cem	808		M*	254.0	30.0	11.81
176	Oberdorla	NAT	F	cem	809			253.0	26.0	10.28
176	Oberdorla	NAT	F	cem	810		M	253.0	31.0	12.25
176	Oberdorla	NAT	F	cem	811		H*	253.0	31.0	12.25
176	Oberdorla	NAT	F	cem	812		H*	251.0	29.0	11.55
176	Oberdorla	NAT	F	cem	813		M?	251.0	28.0	11.16
176	Oberdorla	NAT	F	cem	814		H*	251.0	31.0	12.35
176	Oberdorla	NAT	F	cem	815		H	250.0	30.0	12.00

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
176	Oberdorla	NAT	F	cem	816		H	248.0	29.0	11.69
176	Oberdorla	NAT	F	cem	817		H*	246.0	30.0	12.20
176	Oberdorla	NAT	F	cem	818		D*	218.0	26.0	11.93
178	Vitudurum-Oberwinterthur	RO	F	urb2	822			243.5	28.1	11.54
178	Vitudurum-Oberwinterthur	RO	F	urb2	823			281.0	33.5	11.92
179	Catterick CEU240	RO	E	mil	826			255.0	27.6	10.82
179	Catterick CEU240	RO	E	mil	829			268.4	28.1	10.47
180	Catterick 434	RO	E	mil	830			258.0	29.0	11.24
180	Catterick 434	RO	E	mil	831			263.0	29.5	11.22
181	Barnsley Park	RO	E	rural	832			250.0	27.0	10.80
181	Barnsley Park	RO	E	rural	833			250.0	26.0	10.40
182	Frocester Court	RO	E	villa	836			243.0	26.0	10.70
182	Frocester Court	RO	E	villa	837			230.0	25.0	10.87
183	Segontium	RO	E	mil	839			250.0	27.0	10.80
183	Segontium	RO	E	mil	840			290.0	31.0	10.69
185	Shakenoak site C	RO	E	villa	843			242.0	29.0	11.98
186	Shakenoak site K	RO	E	villa	845			270.0	32.0	11.85
188	Titelberg oppidum	RO	D	rural	849		H*	256.0	30.0	11.72
189	Kassope	IA	H	urb	852		D	217.0	22.5	10.37
189	Kassope	IA	H	urb	854		D	220.0	24.5	11.14
189	Kassope	IA	H	urb	858		D*	198.0	19.5	9.85
189	Kassope	IA	H	urb	864		D	236.5	25.0	10.57
189	Kassope	IA	H	urb	865		D	220.0	24.0	10.91
192	Pfaffenhofen - Pons Aeni	RO	F	rural	875			259.0	29.5	11.39
192	Pfaffenhofen - Pons Aeni	RO	F	rural	876			268.0	31.5	11.75
192	Pfaffenhofen - Pons Aeni	RO	F	rural	877			270.0	32.5	12.04
192	Pfaffenhofen - Pons Aeni	RO	F	rural	879			285.0	33.0	11.58
194	Vemania	RO	F	mil	881			263.0	29.0	11.03
195	Kunzing-Quintana	RO	F	mil	882			288.0	34.5	11.98
195	Kunzing-Quintana	RO	F	mil	883			284.0	29.5	10.39
195	Kunzing-Quintana	RO	F	mil	884			258.0	31.0	12.02
195	Kunzing-Quintana	RO	F	mil	885			249.0	29.5	11.85
199	Hufingen	RO	F	rural	889			277.0	27.5	9.93
199	Hufingen	RO	F	rural	890			272.5	34.0	12.48
199	Hufingen	RO	F	rural	891			272.0	30.5	11.21
199	Hufingen	RO	F	rural	892			271.0	30.0	11.07
199	Hufingen	RO	F	rural	893			264.0	30.0	11.36
199	Hufingen	RO	F	rural	894			264.0	30.0	11.36
199	Hufingen	RO	F	rural	895			262.5	32.0	12.19
199	Hufingen	RO	F	rural	896			259.0	32.5	12.55
199	Hufingen	RO	F	rural	897			257.5	30.0	11.65
199	Hufingen	RO	F	rural	898			251.0	30.0	11.95
199	Hufingen	RO	F	rural	899			249.0	27.0	10.84
199	Hufingen	RO	F	rural	915			293.5	31.0	10.56
199	Hufingen	RO	F	rural	916			277.0	34.5	12.45
199	Hufingen	RO	F	rural	917			272.0	28.5	10.48
199	Hufingen	RO	F	rural	918			267.0	26.5	9.93
199	Hufingen	RO	F	rural	919			266.0	29.0	10.90
199	Hufingen	RO	F	rural	920			263.5	29.0	11.01
199	Hufingen	RO	F	rural	921			259.0	28.0	10.81
199	Hufingen	RO	F	rural	922			253.0	29.0	11.46
200	Pfaffenhofen	RO	F	rural	943			274.0	34.0	12.41
200	Pfaffenhofen	RO	F	rural	944			284.0	31.0	10.92
200	Pfaffenhofen	RO	F	rural	945			262.0	30.0	11.45
201	Wehringen	RO	F	villa	946			259.0	28.5	11.00
202	Penzlin	NAT	F	rural	949		H	251.6	28.4	11.29

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
202	Penzlin	NAT	F	rural	950		H?	256.0	27.7	10.82
202	Penzlin	NAT	F	rural	951		H?	242.0	28.0	11.57
202	Penzlin	NAT	F	rural	952		H	251.3	29.0	11.54
202	Penzlin	NAT	F	rural	953			240.0	26.0	10.83
202	Penzlin	NAT	F	rural	954		H*	249.0	33.0	13.25
202	Penzlin	NAT	F	rural	955		H	230.3	23.5	10.20
202	Penzlin	NAT	F	rural	956		H	243.8	25.9	10.62
203	Tac-Gorsium	RO	G	urb	960		H?	238.5	27.5	11.53
203	Tac-Gorsium	RO	G	urb	961		H*	246.0	31.0	12.60
203	Tac-Gorsium	RO	G	urb	962		H*	247.0	31.0	12.55
203	Tac-Gorsium	RO	G	urb	963		H	248.0	31.5	12.70
203	Tac-Gorsium	RO	G	urb	964		M?	250.0	29.5	11.80
203	Tac-Gorsium	RO	G	urb	965		H	253.0	30.0	11.86
203	Tac-Gorsium	RO	G	urb	966		H*	256.0	31.0	12.11
203	Tac-Gorsium	RO	G	urb	967		D*	257.0	27.5	10.70
203	Tac-Gorsium	RO	G	urb	968		H	258.5	32.0	12.38
203	Tac-Gorsium	RO	G	urb	969		H*	259.0	31.5	12.16
203	Tac-Gorsium	RO	G	urb	970		M	260.0	29.0	11.15
203	Tac-Gorsium	RO	G	urb	971			260.0	30.5	11.73
203	Tac-Gorsium	RO	G	urb	972			262.0	30.5	11.64
203	Tac-Gorsium	RO	G	urb	974		H*	262.5	32.0	12.19
203	Tac-Gorsium	RO	G	urb	975		M*	263.5	31.0	11.76
203	Tac-Gorsium	RO	G	urb	976		H*	264.0	31.0	11.74
203	Tac-Gorsium	RO	G	urb	977			265.0	30.0	11.32
203	Tac-Gorsium	RO	G	urb	978		H*	266.0	30.0	11.28
203	Tac-Gorsium	RO	G	urb	979		H	267.0	31.0	11.61
203	Tac-Gorsium	RO	G	urb	980			270.0	31.0	11.48
203	Tac-Gorsium	RO	G	urb	981		M*	270.0	31.0	11.48
203	Tac-Gorsium	RO	G	urb	982			270.0	30.5	11.30
203	Tac-Gorsium	RO	G	urb	983		H?	270.5	32.0	11.83
203	Tac-Gorsium	RO	G	urb	984		H?	271.5	30.0	11.05
203	Tac-Gorsium	RO	G	urb	985		H*	271.5	32.5	11.97
203	Tac-Gorsium	RO	G	urb	986			275.0	30.0	10.91
203	Tac-Gorsium	RO	G	urb	987		M*	277.0	33.0	11.91
203	Tac-Gorsium	RO	G	urb	988			277.0	32.0	11.55
203	Tac-Gorsium	RO	G	urb	989			280.0	33.5	11.96
203	Tac-Gorsium	RO	G	urb	990		M?	282.0	31.0	10.99
203	Tac-Gorsium	RO	G	urb	991		M*	282.5	30.5	10.80
203	Tac-Gorsium	RO	G	urb	992		H?	282.5	32.0	11.33
203	Tac-Gorsium	RO	G	urb	993		H?	283.5	32.5	11.46
203	Tac-Gorsium	RO	G	urb	994		M*	286.0	31.0	10.84
203	Tac-Gorsium	RO	G	urb	995		M*	289.0	35.0	12.11
203	Tac-Gorsium	RO	G	urb	996			292.0	31.0	10.62
203	Tac-Gorsium	RO	G	urb	997		M*	296.0	33.0	11.15
203	Tac-Gorsium	RO	G	urb	1056			203.5	19.5	9.58
203	Tac-Gorsium	RO	G	urb	1057		D	212.0	24.0	11.32
204	Conchil	RO	D	rural	1059			256.8	32.6	12.69
204	Conchil	RO	D	rural	1060			256.0	31.7	12.38
204	Conchil	RO	D	rural	1061			273.5	30.4	11.12
204	Conchil	RO	D	rural	1062			268.0	31.9	11.90
204	Conchil	RO	D	rural	1063			255.0	31.5	12.35
206	Lauriacum	RO	F	oth	1072			260.0	30.0	11.54
206	Lauriacum	RO	F	oth	1073			288.0	32.0	11.11
206	Lauriacum	RO	F	oth	1075			213.0	23.0	10.80
208	Colonia Ulpia Traiana	RO	F	urb	1076			278.5	32.0	11.49
208	Colonia Ulpia Traiana	RO	F	urb	1077			276.5	31.0	11.21

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
208	Colonia Ulpia Traiana	RO	F	urb	1078			272.0	29.5	10.85
208	Colonia Ulpia Traiana	RO	F	urb	1079			271.5	29.0	10.68
208	Colonia Ulpia Traiana	RO	F	urb	1080			270.5	31.0	11.46
208	Colonia Ulpia Traiana	RO	F	urb	1081			267.0	31.5	11.80
208	Colonia Ulpia Traiana	RO	F	urb	1082			266.0	32.5	12.22
208	Colonia Ulpia Traiana	RO	F	urb	1083			266.0	31.0	11.65
211	Castillar de Mendavia	IA	B	rural	1090			262.5	30.0	11.43
211	Castillar de Mendavia	IA	B	rural	1091			257.0	28.0	10.89
211	Castillar de Mendavia	IA	B	rural	1092			255.0	28.7	11.25
212	Gournay	IA	D	cem	1093		H*	245.0	27.0	11.02
212	Gournay	IA	D	cem	1094		M	233.0	28.0	12.02
212	Gournay	IA	D	cem	1095		D*	267.0	28.5	10.67
213	Beauvais	IA	D	rural	1096		H	233.0	28.0	12.02
213	Beauvais	IA	D	rural	1097		H*	247.0	25.5	10.32
213	Beauvais	IA	D	rural	1098		M*	259.0	27.0	10.42
213	Beauvais	IA	D	rural	1099		H	249.0	28.5	11.45
213	Beauvais	IA	D	rural	1100		M?	242.0	24.0	9.92
213	Beauvais	IA	D	rural	1101		H	225.0	28.0	12.44
213	Beauvais	IA	D	rural	1102		M*	284.0	29.5	10.39
214	Compiegne	IA	D	rural	1103		H?	242.0	28.5	11.78
214	Compiegne	IA	D	rural	1104		H	253.0	29.0	11.46
215	Ribemont	IA	D	oth	1105		H	226.0	25.5	11.28
215	Ribemont	IA	D	oth	1106		H	228.0	25.5	11.18
215	Ribemont	IA	D	oth	1107		H*	232.0	28.5	12.28
216	Variscourt	IA	D	rural	1108		H	230.0	27.0	11.74
216	Variscourt	IA	D	rural	1109		H*	231.0	26.0	11.26
216	Variscourt	IA	D	rural	1110		H	232.0	26.5	11.42
216	Variscourt	IA	D	rural	1111		H*	246.0	28.0	11.38
216	Variscourt	IA	D	rural	1112		H?	249.0	27.0	10.84
216	Variscourt	IA	D	rural	1113		M*	248.0	28.0	11.29
217	Soissons	IA	D	cem	1114		D	213.0	23.5	11.03

Table A30. – Results of the calculation of the proximal breadth to greatest length index on the Metatarsals

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
5	Beckford	IA	E	rural		464		248.0	45.0	18.15
10	Twywell	IA	E	rural		458		238.0	38.0	15.97
13	Wavendon Gate	RO	E	rural		454		263.3	48.2	18.31
13	Wavendon Gate	RO	E	rural		455		285.0	50.2	17.61
14	Lincoln	RO	E	urb		449		255.9	50.4	19.70
14	Lincoln	RO	E	urb		451		296.0	52.1	17.60
14	Lincoln	RO	E	urb		452		282.7	57.6	20.37
14	Lincoln	RO	E	urb		453		273.7	52.7	19.25
15	Scole-Dickleburgh	RO	E	urb2		442		239.0	41.4	17.32
15	Scole-Dickleburgh	RO	E	urb2		444		205.7	44.2	21.49
15	Scole-Dickleburgh	RO	E	urb2		445	M	267.9	48.1	17.95
15	Scole-Dickleburgh	RO	E	urb2		446		284.8	54.7	19.21
16	Birdlip	IA	E	villa		437		205.0	43.4	21.17
19	Scole	RO	E	villa		432		293.0	55.0	18.77
19	Scole	RO	E	villa		433		246.0	47.0	19.11
21	Skeleton Green	IA	E	rural		431		235.0	38.0	16.17
26	Stonea	RO	E	rural		427		225.0	42.2	18.76
27	Lynch Farm	RO	E	villa		426		280.0	48.0	17.14
28	Longthorpe II	RO	E	mil		423		224.0	40.0	17.86
28	Longthorpe II	RO	E	mil		424	H	223.0	40.0	17.94
28	Longthorpe II	RO	E	mil		425	H*	251.0	50.0	19.92
35	Castricum-Oosterbuurt	RO	F	oth		405	H	275.0	49.4	17.98
35	Castricum-Oosterbuurt	RO	F	oth		406		256.6	47.2	18.41
35	Castricum-Oosterbuurt	RO	F	oth		407		273.4	51.4	18.80
35	Castricum-Oosterbuurt	RO	F	oth		408		272.4	54.7	20.09
35	Castricum-Oosterbuurt	RO	F	oth		409		260.3	48.9	18.80
35	Castricum-Oosterbuurt	RO	F	oth		410		260.0	47.6	18.30
35	Castricum-Oosterbuurt	RO	F	oth		412		265.0	48.1	18.15
35	Castricum-Oosterbuurt	RO	F	oth		414		266.0	43.9	16.52
35	Castricum-Oosterbuurt	RO	F	oth		417		256.7	47.7	18.59
35	Castricum-Oosterbuurt	RO	F	oth		418		264.2	44.9	16.99
37	Kesteren 'De Prinsenhof'	RO	F	cem	HKKO-35	392		274.0	50.7	18.50
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-35	394		270.0	52.0	19.26
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-34	395	H?	285.0	50.8	17.82
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-28	396	H*	280.0	53.3	19.04
37	Kesteren 'De Prinsenhof'	RO	F	cem	2-27	398	H*	284.0	54.1	19.05
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-23	399		269.0	51.0	18.96
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-21	400	H?	289.0	53.5	18.51
38	Nijmegen	RO	F	urb		379	M	271.4	46.2	17.02
38	Nijmegen	RO	F	urb		380	H	258.0	46.8	18.14
38	Nijmegen	RO	F	urb		381		279.8	52.2	18.66
38	Nijmegen	RO	F	urb		383	H*	274.8	50.0	18.20
38	Nijmegen	RO	F	urb		384	M	274.6	46.0	16.75
38	Nijmegen	RO	F	urb		385	H*	260.2	50.7	19.49
38	Nijmegen	RO	F	urb		390	M	278.4	49.3	17.71
39	Kesteren vicus	RO	F	urb2		378	H*	237.8	44.8	18.84
40	Heteren	NAT	F	rural		374	M*	285.6	50.3	17.61
40	Heteren	NAT	F	rural		376	H?	251.0	43.8	17.45
42	Druten	RO	F	villa		364	H	248.1	46.9	18.90
42	Druten	RO	F	villa		365		272.0	47.1	17.32

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
42	Druten	RO	F	villa		366	H?	258.3	46.9	18.16
42	Druten	RO	F	villa		367	H*	271.8	52.9	19.46
42	Druten	RO	F	villa		368	H*	259.4	52.3	20.16
42	Druten	RO	F	villa		369	H?	275.0	50.5	18.36
42	Druten	RO	F	villa		370		279.8	51.8	18.51
42	Druten	RO	F	villa	12.4	372	H*	269.2	52.5	19.50
42	Druten	RO	F	villa	1.18	373	M*	288.8	52.1	18.04
43	Elms Farm	RO	E	urb2	6640	350	H*	269.0	53.4	19.85
43	Elms Farm	RO	E	urb2	6640	351	H*	268.0	52.9	19.74
43	Elms Farm	RO	E	urb2		355		254.0	43.7	17.20
43	Elms Farm	RO	E	urb2		357		258.0	51.0	19.77
43	Elms Farm	RO	E	urb2		358	H	256.0	44.9	17.54
43	Elms Farm	IA	E	urb2		359	H*	234.0	41.8	17.86
44	Danebury	IA	E	rural		322	H	242.0	45.7	18.88
44	Danebury	IA	E	rural		330		231.0	39.9	17.27
44	Danebury	IA	E	rural		332		235.0	43.0	18.30
44	Danebury	IA	E	rural		335	H	229.0	42.0	18.34
44	Danebury	IA	E	rural		338	H	251.0	47.8	19.04
44	Danebury	IA	E	rural		340	H	251.5	46.4	18.45
46	E London RB Cemetary	RO	E	cem		320	H*	270.9	50.8	18.75
47	Beddington Sewage Farm	RO	E	urb		314		246.6	47.0	19.06
47	Beddington Sewage Farm	RO	E	urb		317	H?	245.0	44.6	18.20
47	Beddington Sewage Farm	RO	E	urb		318		257.0	48.7	18.95
54	Thorpe Thewles	RO	E	rural		301	H*	242.0	46.4	19.17
54	Thorpe Thewles	IA	E	rural		305	M*	242.0	42.1	17.40
57	La Sagesse	IA	E	oth		297		224.5	40.5	18.04
58	Braintree	RO	E	urb2		296		250.5	43.7	17.45
59	Chichester cattlemarket	RO	E	urb	XXIII	294	H*	281.9	52.0	18.45
59	Chichester cattlemarket	RO	E	urb	XXIII	295	H*	282.1	52.8	18.72
66	Settefinestre	RO	A	villa		285	H*	277.0	49.5	17.87
67	Ilchester,Church Street	RO	E	urb	F267	284	H*	256.5	43.2	16.84
68	Lutton/Huntingdon	RO	E	rural		279	H?	286.0	52.0	18.18
68	Lutton/Huntingdon	RO	E	rural		280	H?	272.0	49.0	18.01
68	Lutton/Huntingdon	IA	E	rural		283	H	254.0	47.0	18.50
70	Emilia	RO	A	oth		277		213.5	39.0	18.27
71	Piovego	IA	A	cem	N2	276		260.0	49.0	18.85
74	Sovana	IA	A	cem		275		252.0	43.0	17.06
81	Welsow	NAT	F	rural		271	H	259.7	48.5	18.68
81	Welsow	NAT	F	rural		272	H?	247.5	44.0	17.78
81	Welsow	NAT	F	rural		273	H*	246.0	48.5	19.72
85	Macon	RO	D	cem		269	M*	285.0	51.0	17.89
87	Manching	IA	F	rural		212		225.0	39.5	17.56
87	Manching	IA	F	rural		213		224.0	42.5	18.97
87	Manching	IA	F	rural		214		223.0	40.0	17.94
87	Manching	IA	F	rural		215		222.5	40.5	18.20
87	Manching	IA	F	rural		216		218.0	37.0	16.97
87	Manching	IA	F	rural		217		217.0	39.0	17.97
87	Manching	IA	F	rural		218		217.0	38.5	17.74
87	Manching	IA	F	rural		219		232.0	41.0	17.67
87	Manching	IA	F	rural		220		231.0	45.5	19.70
87	Manching	IA	F	rural		221		231.0	42.5	18.40
87	Manching	IA	F	rural		222		231.0	45.0	19.48
87	Manching	IA	F	rural		223		231.0	41.5	17.97
87	Manching	IA	F	rural		224		228.0	44.5	19.52
87	Manching	IA	F	rural		225		228.0	41.0	17.98
87	Manching	IA	F	rural		226		227.0	40.5	17.84

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
87	Manching	IA	F	rural		227		226.5	40.0	17.66
87	Manching	IA	F	rural		228		226.0	41.5	18.36
87	Manching	IA	F	rural		229		236.5	42.5	17.97
87	Manching	IA	F	rural		230		236.5	46.0	19.45
87	Manching	IA	F	rural		231		236.0	44.5	18.86
87	Manching	IA	F	rural		232		236.0	44.0	18.64
87	Manching	IA	F	rural		233		236.0	43.0	18.22
87	Manching	IA	F	rural		234		234.0	42.0	17.95
87	Manching	IA	F	rural		235		233.5	41.0	17.56
87	Manching	IA	F	rural		236		233.0	43.0	18.45
87	Manching	IA	F	rural		237		232.5	43.0	18.49
87	Manching	IA	F	rural		238		232.5	41.5	17.85
87	Manching	IA	F	rural		239		243.5	45.0	18.48
87	Manching	IA	F	rural		240		242.0	42.0	17.36
87	Manching	IA	F	rural		241		242.0	44.0	18.18
87	Manching	IA	F	rural		242		240.0	42.5	17.71
87	Manching	IA	F	rural		243		240.0	45.0	18.75
87	Manching	IA	F	rural		244		239.0	41.5	17.36
87	Manching	IA	F	rural		245		239.0	44.0	18.41
87	Manching	IA	F	rural		246		239.0	47.0	19.67
87	Manching	IA	F	rural		247		237.5	45.0	18.95
87	Manching	IA	F	rural		248		237.0	42.5	17.93
87	Manching	IA	F	rural		249		250.0	48.5	19.40
87	Manching	IA	F	rural		250		250.0	46.0	18.40
87	Manching	IA	F	rural		251		249.5	44.5	17.84
87	Manching	IA	F	rural		252		247.5	47.0	18.99
87	Manching	IA	F	rural		253		247.0	45.5	18.42
87	Manching	IA	F	rural		254		246.5	42.0	17.04
87	Manching	IA	F	rural		255		245.5	44.0	17.92
87	Manching	IA	F	rural		256		245.0	46.0	18.78
87	Manching	IA	F	rural		257		244.5	49.0	20.04
87	Manching	IA	F	rural		258		244.0	44.5	18.24
87	Manching	IA	F	rural		260		288.0	54.0	18.75
87	Manching	IA	F	rural		261		283.5	53.0	18.69
87	Manching	IA	F	rural		262		273.0	50.5	18.50
87	Manching	IA	F	rural		263		271.0	51.0	18.82
87	Manching	IA	F	rural		265		260.0	50.0	19.23
87	Manching	IA	F	rural		266		255.0	48.5	19.02
87	Manching	IA	F	rural		267		253.0	50.0	19.76
87	Manching	IA	F	rural		268		252.5	46.0	18.22
92	Feddersen Wierde	NAT	F	rural	skelett1R	26	H	259.5	48.5	18.69
92	Feddersen Wierde	NAT	F	rural	skelett1L	27	H	259.0	48.1	18.57
92	Feddersen Wierde	NAT	F	rural		28	H	244.3	45.2	18.50
92	Feddersen Wierde	NAT	F	rural		29	H	259.6	48.4	18.64
92	Feddersen Wierde	NAT	F	rural		30		251.0	44.3	17.65
92	Feddersen Wierde	NAT	F	rural		31		247.1	45.7	18.49
92	Feddersen Wierde	NAT	F	rural		32	H?	258.2	43.9	17.00
92	Feddersen Wierde	NAT	F	rural		33	M*	260.7	45.3	17.38
92	Feddersen Wierde	NAT	F	rural		34	H*	236.0	44.8	18.98
92	Feddersen Wierde	NAT	F	rural		35	H	241.8	46.0	19.02
92	Feddersen Wierde	NAT	F	rural		36	H	247.0	43.5	17.61
92	Feddersen Wierde	NAT	F	rural		37	H*	257.4	49.7	19.31
92	Feddersen Wierde	NAT	F	rural		38	H	239.7	43.5	18.15
92	Feddersen Wierde	NAT	F	rural		39	M?	250.0	45.0	18.00
92	Feddersen Wierde	NAT	F	rural		40	H*	270.7	50.5	18.66
92	Feddersen Wierde	NAT	F	rural		41	H*	241.6	44.4	18.38

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		42	M*	257.1	44.7	17.39
92	Feddersen Wierde	NAT	F	rural		43	H	250.6	47.8	19.07
92	Feddersen Wierde	NAT	F	rural		45	H*	247.2	43.9	17.76
92	Feddersen Wierde	NAT	F	rural		46	H*	271.3	48.3	17.80
92	Feddersen Wierde	NAT	F	rural		47	M?	249.1	42.2	16.94
92	Feddersen Wierde	NAT	F	rural		48	H	247.5	43.3	17.49
92	Feddersen Wierde	NAT	F	rural		49	H	269.2	52.0	19.32
92	Feddersen Wierde	NAT	F	rural		50	H?	239.0	42.2	17.66
92	Feddersen Wierde	NAT	F	rural		51	H	245.5	45.4	18.49
92	Feddersen Wierde	NAT	F	rural		52	H	246.8	44.7	18.11
92	Feddersen Wierde	NAT	F	rural		53	H	249.8	49.1	19.66
92	Feddersen Wierde	NAT	F	rural		54	H*	255.7	43.9	17.17
92	Feddersen Wierde	NAT	F	rural		55	H	238.3	43.0	18.04
92	Feddersen Wierde	NAT	F	rural		56	H*	232.9	41.7	17.90
92	Feddersen Wierde	NAT	F	rural		57	H*	253.7	43.9	17.30
92	Feddersen Wierde	NAT	F	rural		58	H	247.3	46.0	18.60
92	Feddersen Wierde	NAT	F	rural		59	H	257.2	47.0	18.27
92	Feddersen Wierde	NAT	F	rural		60		249.5	43.7	17.52
92	Feddersen Wierde	NAT	F	rural		61	H*	256.0	47.0	18.36
92	Feddersen Wierde	NAT	F	rural		62		255.3	47.4	18.57
92	Feddersen Wierde	NAT	F	rural		63	H?	257.6	45.0	17.47
92	Feddersen Wierde	NAT	F	rural		64	H	260.9	48.3	18.51
92	Feddersen Wierde	NAT	F	rural		65	H	239.6	44.5	18.57
92	Feddersen Wierde	NAT	F	rural		66	M*	259.3	44.3	17.08
92	Feddersen Wierde	NAT	F	rural		67	M*	262.3	47.2	17.99
92	Feddersen Wierde	NAT	F	rural		68	H	247.0	45.5	18.42
92	Feddersen Wierde	NAT	F	rural		69	H	234.2	41.0	17.51
92	Feddersen Wierde	NAT	F	rural		70	H	249.5	45.9	18.40
92	Feddersen Wierde	NAT	F	rural		71	H	262.7	50.6	19.26
92	Feddersen Wierde	NAT	F	rural		72	H*	259.4	46.0	17.73
92	Feddersen Wierde	NAT	F	rural		73	H	262.3	48.4	18.45
92	Feddersen Wierde	NAT	F	rural		74	H	247.8	46.6	18.81
92	Feddersen Wierde	NAT	F	rural		75	H	255.3	46.5	18.21
92	Feddersen Wierde	NAT	F	rural		76		253.6	45.4	17.90
92	Feddersen Wierde	NAT	F	rural		77	H	246.2	43.6	17.71
92	Feddersen Wierde	NAT	F	rural		78	M?	251.2	42.5	16.92
92	Feddersen Wierde	NAT	F	rural		79	M?	252.1	44.7	17.73
92	Feddersen Wierde	NAT	F	rural		80	H	245.0	44.8	18.29
92	Feddersen Wierde	NAT	F	rural		81	H?	259.4	45.7	17.62
92	Feddersen Wierde	NAT	F	rural		82		246.6	43.6	17.68
92	Feddersen Wierde	NAT	F	rural		83	H	260.4	49.4	18.97
92	Feddersen Wierde	NAT	F	rural		84	H	248.9	46.7	18.76
92	Feddersen Wierde	NAT	F	rural		85	H	253.6	45.7	18.02
92	Feddersen Wierde	NAT	F	rural		86	H	247.0	46.7	18.91
92	Feddersen Wierde	NAT	F	rural		87	M*	252.2	45.2	17.92
92	Feddersen Wierde	NAT	F	rural		88	H	244.6	44.4	18.15
92	Feddersen Wierde	NAT	F	rural		89	H	259.3	48.2	18.59
92	Feddersen Wierde	NAT	F	rural		90	H	245.9	46.2	18.79
92	Feddersen Wierde	NAT	F	rural		91	H	258.2	47.7	18.47
92	Feddersen Wierde	NAT	F	rural		92	H	243.8	44.2	18.13
92	Feddersen Wierde	NAT	F	rural		93	H?	248.4	44.8	18.04
92	Feddersen Wierde	NAT	F	rural		95	H	242.2	46.3	19.12
92	Feddersen Wierde	NAT	F	rural		96	H*	270.6	50.2	18.55
92	Feddersen Wierde	NAT	F	rural		98	D*	256.6	43.1	16.80
92	Feddersen Wierde	NAT	F	rural		99	H*	241.7	44.9	18.58
92	Feddersen Wierde	NAT	F	rural		100		255.3	43.8	17.16

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		101	H	241.4	44.3	18.35
92	Feddersen Wierde	NAT	F	rural		102	H?	255.3	46.6	18.25
92	Feddersen Wierde	NAT	F	rural		103	H?	258.1	48.4	18.75
92	Feddersen Wierde	NAT	F	rural		104	H	239.6	44.3	18.49
92	Feddersen Wierde	NAT	F	rural		105	H	257.1	47.0	18.28
92	Feddersen Wierde	NAT	F	rural		106		258.2	44.1	17.08
92	Feddersen Wierde	NAT	F	rural		107	H	243.6	46.0	18.88
92	Feddersen Wierde	NAT	F	rural		108		242.5	42.7	17.61
92	Feddersen Wierde	NAT	F	rural		109		258.1	47.2	18.29
92	Feddersen Wierde	NAT	F	rural		110	H	241.7	43.7	18.08
92	Feddersen Wierde	NAT	F	rural		111	H?	256.7	48.1	18.74
92	Feddersen Wierde	NAT	F	rural		112		256.0	42.4	16.56
92	Feddersen Wierde	NAT	F	rural		113	H	244.4	45.9	18.78
92	Feddersen Wierde	NAT	F	rural		114	H*	248.6	48.4	19.47
92	Feddersen Wierde	NAT	F	rural		115	H	270.9	51.2	18.90
92	Feddersen Wierde	NAT	F	rural		116	M	262.0	47.3	18.05
92	Feddersen Wierde	NAT	F	rural		117	H	255.7	47.1	18.42
92	Feddersen Wierde	NAT	F	rural		118	H*	240.4	44.9	18.68
92	Feddersen Wierde	NAT	F	rural		119	H	252.3	46.4	18.39
92	Feddersen Wierde	NAT	F	rural		120	M*	255.2	46.3	18.14
92	Feddersen Wierde	NAT	F	rural		121	H	242.9	45.3	18.65
92	Feddersen Wierde	NAT	F	rural		122	M*	261.9	44.9	17.14
92	Feddersen Wierde	NAT	F	rural		123	H*	235.6	43.0	18.25
92	Feddersen Wierde	NAT	F	rural		124	H	247.5	45.2	18.26
92	Feddersen Wierde	NAT	F	rural		125	H	249.9	47.4	18.97
92	Feddersen Wierde	NAT	F	rural		126	H*	250.6	44.9	17.92
92	Feddersen Wierde	NAT	F	rural		127	H	239.6	43.9	18.32
92	Feddersen Wierde	NAT	F	rural		128	M*	263.6	48.0	18.21
92	Feddersen Wierde	NAT	F	rural		129	H	232.0	44.1	19.01
92	Feddersen Wierde	NAT	F	rural		130	M?	249.8	43.8	17.53
92	Feddersen Wierde	NAT	F	rural		131	H*	236.1	45.8	19.40
92	Feddersen Wierde	NAT	F	rural		132	M*	248.4	43.4	17.47
92	Feddersen Wierde	NAT	F	rural		134	H	247.8	46.0	18.56
92	Feddersen Wierde	NAT	F	rural		135	H?	248.2	44.6	17.97
92	Feddersen Wierde	NAT	F	rural		136	H*	247.0	47.3	19.15
92	Feddersen Wierde	NAT	F	rural		137	H*	267.3	48.8	18.26
92	Feddersen Wierde	NAT	F	rural		138	H*	237.9	44.0	18.50
92	Feddersen Wierde	NAT	F	rural		139	M*	260.3	44.8	17.21
92	Feddersen Wierde	NAT	F	rural		140	H*	249.9	45.2	18.09
92	Feddersen Wierde	NAT	F	rural		141	H*	248.5	45.4	18.27
92	Feddersen Wierde	NAT	F	rural		143	M*	259.0	46.2	17.84
92	Feddersen Wierde	NAT	F	rural		144	H?	243.3	43.1	17.71
92	Feddersen Wierde	NAT	F	rural		145	H*	245.4	47.9	19.52
92	Feddersen Wierde	NAT	F	rural		146	M*	256.8	43.4	16.90
92	Feddersen Wierde	NAT	F	rural		147	H*	269.3	49.7	18.46
96	Kunzing east vicus	RO	F	cem	1703	1	M*	263.0	50.0	19.01
96	Kunzing east vicus	RO	F	cem	1641	2	M*	274.0	49.4	18.03
96	Kunzing east vicus	RO	F	cem	1581	3	H?	284.0	53.4	18.80
96	Kunzing east vicus	RO	F	cem	1575/5	4	H*	266.5	51.0	19.14
96	Kunzing east vicus	RO	F	cem	1620	5	H*	284.0	51.9	18.27
98	Prestatyn	RO	E	ind		483		243.0	45.1	18.56
104	Orton Hall Farm	RO	E	villa		504	H	236.0	42.0	17.80
104	Orton Hall Farm	RO	E	villa		505	M	258.0	46.0	17.83
104	Orton Hall Farm	RO	E	villa		506	H*	252.0	45.0	17.86
104	Orton Hall Farm	RO	E	villa		507	H?	276.0	50.0	18.12
104	Orton Hall Farm	RO	E	villa		508		215.0	47.0	21.86

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
105	Mons Claudianus	RO	K	ind		509	H*	272.0	52.1	19.15
105	Mons Claudianus	RO	K	ind		510	M	264.9	48.9	18.46
105	Mons Claudianus	RO	K	ind	604	511	M?	254.0	45.2	17.80
105	Mons Claudianus	RO	K	ind	905	512	M*	253.0	43.2	17.08
105	Mons Claudianus	RO	K	ind	1719	513	D*	248.0	43.5	17.54
105	Mons Claudianus	RO	K	ind	813	514		242.0	40.2	16.61
105	Mons Claudianus	RO	K	ind	1544	515	D*	240.5	40.6	16.88
105	Mons Claudianus	RO	K	ind	549	516	H	239.5	42.2	17.62
105	Mons Claudianus	RO	K	ind	1486	517	D*	236.0	38.1	16.14
110	Nijmegen new excavations	RO	F	urb	179/16-22	589	H*	242.1	42.9	17.72
110	Nijmegen new excavations	RO	F	urb	179/16-25	590	H*	263.1	48.9	18.59
112	Pompeii, Sarno Baths	RO	A	urb	A	593		215.5	40.8	18.93
112	Pompeii, Sarno Baths	RO	A	urb	B	594		275.5	50.3	18.26
112	Pompeii, Sarno Baths	RO	A	urb	C	595		274.0	48.1	17.55
112	Pompeii, Sarno Baths	RO	A	urb	D	596		335.0	54.4	16.24
114	Unterlaa	RO	G	urb	18	598	M*	266.0	45.1	16.95
114	Unterlaa	RO	G	urb	23A	599	H	252.0	45.5	18.06
114	Unterlaa	RO	G	urb	35	600	H*	258.0	48.6	18.84
114	Unterlaa	RO	G	urb	40	601	H*	263.5	47.6	18.06
114	Unterlaa	RO	G	urb	48	602	M*	267.0	45.6	17.08
114	Unterlaa	RO	G	urb	49	603	M?	280.0	48.8	17.43
114	Unterlaa	RO	G	urb	73	604	H	251.0	46.5	18.53
115	Bad Wimpfen	RO	F	urb2		605	H	276.3	52.6	19.04
115	Bad Wimpfen	RO	F	urb2		606	H	264.3	48.1	18.20
115	Bad Wimpfen	RO	F	urb2		607		264.2	47.2	17.87
115	Bad Wimpfen	RO	F	urb2	Skele 4	613	M	284.0	49.8	17.54
115	Bad Wimpfen	RO	F	urb2	Skele 5	614		278.0	50.2	18.06
115	Bad Wimpfen	RO	F	urb2	Skele 6	615	M	269.5	46.5	17.25
115	Bad Wimpfen	RO	F	urb2		616	D	207.0	37.0	17.87
116	Pommeroeul	RO	D	urb2	348-1	617	H	246.0	46.0	18.70
116	Pommeroeul	RO	D	urb2	224-1	618	H	250.0	46.0	18.40
116	Pommeroeul	RO	D	urb2	348-2	619	H	250.0	45.0	18.00
116	Pommeroeul	RO	D	urb2	17-1	620	H	250.0	44.0	17.60
116	Pommeroeul	RO	D	urb2	63	621	H	257.0	46.0	17.90
116	Pommeroeul	RO	D	urb2	251	622	H*	257.0	46.0	17.90
116	Pommeroeul	RO	D	urb2	80	623	M*	266.0	47.0	17.67
116	Pommeroeul	RO	D	urb2	306	624	H*	266.0	48.0	18.05
116	Pommeroeul	RO	D	urb2	32	625	M	268.0	44.0	16.42
116	Pommeroeul	RO	D	urb2	222	626	H*	271.0	55.0	20.30
116	Pommeroeul	RO	D	urb2	238	627	H*	271.0	54.0	19.93
116	Pommeroeul	RO	D	urb2	248-1	628	H*	272.0	53.0	19.49
116	Pommeroeul	RO	D	urb2	274	629	H?	281.0	52.0	18.51
116	Pommeroeul	RO	D	urb2	17-2	630	M*	291.0	49.0	16.84
116	Pommeroeul	RO	D	urb2	248-2	631	H*	296.0	53.0	17.91
117	Pompeii stable	RO	A	urb	A	633		283.0	51.0	18.02
117	Pompeii stable	RO	A	urb	B	634		275.0	50.0	18.18
117	Pompeii stable	RO	A	urb	C	635		275.0	51.0	18.55
118	Carnuntum	RO	G	mil	Pferd 1	636	M	300.0	54.5	18.17
118	Carnuntum	RO	G	mil	Pferd 2	637	H	283.5	54.0	19.05
118	Carnuntum	RO	G	mil	Pferd 3	638	H*	273.2	55.2	20.20
118	Carnuntum	RO	G	mil	Maultier 1	639	M*	286.7	51.0	17.79
118	Carnuntum	RO	G	mil		640		291.0	55.6	19.11
119	Albertfalva	RO	G	mil	Horse 1	641	H?	272.0	52.3	19.23
119	Albertfalva	RO	G	mil	Horse 2	642	H?	296.9	56.2	18.93
119	Albertfalva	RO	G	mil	Horse 3	643		251.3	52.3	20.81
120	Basel-Gasfabrik	IA	F	rural		644		225.0	38.0	16.89

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
120	Basel-Gasfabrik	IA	F	rural		645		220.0	40.6	18.45
121	Soluthurn/Vigier	RO	F	urb2		650	M*	285.0	49.9	17.51
121	Soluthurn/Vigier	RO	F	urb2		651	M	276.0	49.7	18.01
121	Soluthurn/Vigier	RO	F	urb2		652	M*	272.3	49.6	18.22
121	Soluthurn/Vigier	RO	F	urb2		654		284.2	49.6	17.45
123	Wroxeter Baths basilica	RO	E	urb		659	H	265.0	50.1	18.91
123	Wroxeter Baths basilica	RO	E	urb		660	H	250.4	45.9	18.33
125	Castleford	RO	E	mil		673	H*	274.0	52.9	19.31
125	Castleford	RO	E	mil		674		256.0	47.8	18.67
125	Castleford	RO	E	mil		675	M*	252.0	44.9	17.82
127	Tortoreto-Fortellezza	IA	A	rural		677		205.0	37.5	18.29
128	Krefeld-Gellep	RO	F	mil	3392	680	H*	277.0	49.5	17.87
128	Krefeld-Gellep	RO	F	mil	3557	681	H?	288.0	53.5	18.58
128	Krefeld-Gellep	RO	F	mil	3559	682	M	284.0	53.0	18.66
128	Krefeld-Gellep	RO	F	mil	3559	683	M	283.0	54.0	19.08
128	Krefeld-Gellep	RO	F	mil	3573	684	M	283.0	54.0	19.08
128	Krefeld-Gellep	RO	F	mil	3510	687	D*	227.5	40.5	17.80
129	Lorenzberg Bei Epfach	RO	F	oth		689		294.0	51.0	17.35
129	Lorenzberg Bei Epfach	RO	F	oth		690		272.0	48.0	17.65
129	Lorenzberg Bei Epfach	RO	F	oth		691		268.0	50.0	18.66
129	Lorenzberg Bei Epfach	RO	F	oth		695		258.0	48.0	18.60
129	Lorenzberg Bei Epfach	RO	F	oth		696		251.0	47.0	18.73
129	Lorenzberg Bei Epfach	RO	F	oth		699		256.0	44.5	17.38
129	Lorenzberg Bei Epfach	RO	F	oth		700		253.5	46.0	18.15
130	Msecke Zehrovice	IA	G	rural		704		274.0	52.6	19.20
132	Godmanchester	RO	E	mil		708		275.0	51.6	18.76
132	Godmanchester	RO	E	mil		709		280.0	53.3	19.04
132	Godmanchester	RO	E	mil		711		273.0	48.1	17.62
132	Godmanchester	RO	E	mil		712		271.0	50.0	18.45
132	Godmanchester	RO	E	mil		713		259.9	45.4	17.47
132	Godmanchester	RO	E	mil		715		266.0	44.0	16.54
132	Godmanchester	RO	E	mil		716		265.0	48.6	18.34
132	Godmanchester	RO	E	mil		717		243.0	46.8	19.26
132	Godmanchester	RO	E	mil		720		270.0	49.2	18.22
132	Godmanchester	RO	E	mil		721		270.0	51.0	18.89
133	Colchester	RO	E	urb		723		269.0	51.8	19.26
133	Colchester	RO	E	urb		724		253.5	49.1	19.37
133	Colchester	RO	E	urb		725		263.0	49.1	18.67
134	Butzbach	RO	F	urb2		729	H?	284.0	51.0	17.96
134	Butzbach	RO	F	urb2		730	D*	245.0	42.0	17.14
134	Butzbach	RO	F	urb2		731	M	291.0	54.0	18.56
134	Butzbach	RO	F	urb2		732	H*	281.0	52.0	18.51
134	Butzbach	RO	F	urb2		735	M*	303.0	54.0	17.82
135	Swestari	IA	G	cem	1	736	H	240.0	44.0	18.33
135	Swestari	IA	G	cem	2	737	H	240.0	46.0	19.17
135	Swestari	IA	G	cem	3	738	H	244.0	46.0	18.85
135	Swestari	IA	G	cem	4	739	H*	263.0	49.0	18.63
135	Swestari	IA	G	cem	5	740	M	288.0	53.0	18.40
137	Magdelenska Gora	IA	G	cem	IV, 43	742		255.0	45.0	17.65
137	Magdelenska Gora	IA	G	cem	V, 29, II	744		252.5	47.0	18.61
137	Magdelenska Gora	IA	G	cem	V, 29, III	745		248.0	46.0	18.55
141	Szentes-Vekerzug	IA	G	cem	6	746	H*	254.0	46.5	18.31
143	Histria	IA	G	urb2	P18	747	H*	275.0	51.0	18.55
143	Histria	IA	G	urb2	P25	748	H?	277.5	50.0	18.02
146	Balatonaliga	RO	G	rural	575a	749		265.0	48.0	18.11
146	Balatonaliga	RO	G	rural	620c	752	H*	264.0	51.0	19.32

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
147	Pilismarot I Watchtower	RO	G	mil		753	H	245.0	43.5	17.76
147	Pilismarot I Watchtower	RO	G	mil		754	H	245.0	43.5	17.76
147	Pilismarot I Watchtower	RO	G	mil		755	H*	243.0	49.0	20.16
149	Helemba - Sziget	IA	G	rural		756	H*	231.0	44.0	19.05
149	Helemba - Sziget	IA	G	rural		757	H	253.5	46.5	18.34
149	Helemba - Sziget	IA	G	rural		758	H*	254.0	45.5	17.91
151	Gyor Szechenyi-Ter	RO	G	rural		759	H*	282.0	51.0	18.09
153	Aquileia forum	RO	A	urb		773		271.0	47.8	17.64
153	Aquileia forum	RO	A	urb		774	M*	275.0	51.0	18.55
153	Aquileia forum	RO	A	urb		775		280.0	51.0	18.21
155	Gravina 1	RO	A	villa		777		242.0	42.0	17.36
156	Invillino- Ibliglo	RO	A	oth		781		273.0	47.5	17.40
156	Invillino- Ibliglo	RO	A	oth		782		272.0	50.0	18.38
156	Invillino- Ibliglo	RO	A	oth		783		263.0	48.0	18.25
156	Invillino- Ibliglo	RO	A	oth		784		254.0	48.5	19.09
157	Lugnano	RO	A	villa		785		230.0	47.0	20.43
161	San Giovanni	RO	A	villa		790		270.2	50.6	18.73
161	San Giovanni	RO	A	villa		792		231.0	50.0	21.65
167	Via Gabina 10	RO	A	urb		794		270.0	43.3	16.04
175	Sablonetum-Ellingen	RO	F	mil		802		282.5	52.5	18.58
176	Oberdorla	NAT	F	cem		803		277.0	52.0	18.77
176	Oberdorla	NAT	F	cem		804	M*	266.0	44.0	16.54
176	Oberdorla	NAT	F	cem		805	M*	262.0	46.0	17.56
176	Oberdorla	NAT	F	cem		806	H	260.0	49.0	18.85
176	Oberdorla	NAT	F	cem		807	H*	254.0	48.0	18.90
176	Oberdorla	NAT	F	cem		808	M*	254.0	45.0	17.72
176	Oberdorla	NAT	F	cem		809		253.0	52.0	20.55
176	Oberdorla	NAT	F	cem		810	M	253.0	47.0	18.58
176	Oberdorla	NAT	F	cem		811	H*	253.0	47.0	18.58
176	Oberdorla	NAT	F	cem		812	H*	251.0	44.0	17.53
176	Oberdorla	NAT	F	cem		813	M?	251.0	44.0	17.53
176	Oberdorla	NAT	F	cem		814	H*	251.0	47.0	18.73
176	Oberdorla	NAT	F	cem		815	H	250.0	47.0	18.80
176	Oberdorla	NAT	F	cem		816	H	248.0	46.0	18.55
176	Oberdorla	NAT	F	cem		817	H*	246.0	48.0	19.51
176	Oberdorla	NAT	F	cem		818	D*	218.0	41.0	18.81
178	Vitudurum-Oberwinterthur	RO	F	urb2		822		243.5	41.7	17.13
178	Vitudurum-Oberwinterthur	RO	F	urb2		823		281.0	54.4	19.36
179	Catterick CEU240	RO	E	mil		826		255.0	47.5	18.63
179	Catterick CEU240	RO	E	mil		827		255.0	46.7	18.31
179	Catterick CEU240	RO	E	mil		829		268.4	47.3	17.62
181	Barnsley Park	RO	E	rural		832		250.0	43.0	17.20
181	Barnsley Park	RO	E	rural		833		250.0	46.0	18.40
182	Frocester Court	RO	E	villa		836		243.0	43.0	17.70
182	Frocester Court	RO	E	villa		837		230.0	41.0	17.83
183	Segontium	RO	E	mil		839		250.0	43.0	17.20
183	Segontium	RO	E	mil		840		290.0	49.0	16.90
185	Shakenoak site C	RO	E	villa		843		242.0	45.0	18.60
188	Titelberg oppidum	RO	D	rural		849	H*	256.0	49.0	19.14
189	Kassope	IA	H	urb		852	D	217.0	38.5	17.74
189	Kassope	IA	H	urb		854	D	220.0	37.0	16.82
189	Kassope	IA	H	urb		858	D*	198.0	29.0	14.65
189	Kassope	IA	H	urb		864	D	236.5	40.5	17.12
189	Kassope	IA	H	urb		865	D	220.0	38.0	17.27
189	Kassope	IA	H	urb		866		231.0	39.0	16.88
189	Kassope	IA	H	urb		870		225.0	40.0	17.78

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
192	Pfaffenhofen - Pons Aeni	RO	F	rural		875		259.0	48.0	18.53
192	Pfaffenhofen - Pons Aeni	RO	F	rural		876		268.0	50.5	18.84
192	Pfaffenhofen - Pons Aeni	RO	F	rural		877		270.0	51.5	19.07
192	Pfaffenhofen - Pons Aeni	RO	F	rural		879		285.0	53.0	18.60
195	Kunzing-Quintana	RO	F	mil		882		288.0	51.5	17.88
195	Kunzing-Quintana	RO	F	mil		883		284.0	49.5	17.43
195	Kunzing-Quintana	RO	F	mil		884		258.0	48.5	18.80
195	Kunzing-Quintana	RO	F	mil		885		249.0	48.0	19.28
199	Hufingen	RO	F	rural		889		277.0	46.5	16.79
199	Hufingen	RO	F	rural		890		272.5	51.5	18.90
199	Hufingen	RO	F	rural		891		272.0	49.5	18.20
199	Hufingen	RO	F	rural		892		271.0	51.0	18.82
199	Hufingen	RO	F	rural		893		264.0	49.5	18.75
199	Hufingen	RO	F	rural		894		264.0	48.5	18.37
199	Hufingen	RO	F	rural		895		262.5	50.0	19.05
199	Hufingen	RO	F	rural		896		259.0	50.0	19.31
199	Hufingen	RO	F	rural		897		257.5	47.0	18.25
199	Hufingen	RO	F	rural		898		251.0	45.0	17.93
199	Hufingen	RO	F	rural		899		249.0	48.5	19.48
199	Hufingen	RO	F	rural		915		293.5	55.0	18.74
199	Hufingen	RO	F	rural		916		277.0	51.5	18.59
199	Hufingen	RO	F	rural		917		272.0	49.5	18.20
199	Hufingen	RO	F	rural		918		267.0	47.5	17.79
199	Hufingen	RO	F	rural		919		266.0	47.0	17.67
199	Hufingen	RO	F	rural		920		263.5	51.0	19.35
199	Hufingen	RO	F	rural		921		259.0	46.0	17.76
199	Hufingen	RO	F	rural		922		253.0	46.5	18.38
200	Pfaffenhofen	RO	F	rural		943		274.0	51.0	18.61
201	Wehringen	RO	F	villa		946		259.0	47.0	18.15
202	Penzlin	NAT	F	rural		949	H	251.6	47.1	18.72
202	Penzlin	NAT	F	rural		950	H?	256.0	45.2	17.66
202	Penzlin	NAT	F	rural		951	H?	242.0	42.0	17.36
202	Penzlin	NAT	F	rural		952	H	251.3	48.6	19.34
202	Penzlin	NAT	F	rural		953		240.0	41.6	17.33
202	Penzlin	NAT	F	rural		954	H*	249.0	46.7	18.76
202	Penzlin	NAT	F	rural		955	H	230.3	44.0	19.11
202	Penzlin	NAT	F	rural		956	H	243.8	45.5	18.66
203	Tac-Gorsium	RO	G	urb		960	H?	238.5	41.5	17.40
203	Tac-Gorsium	RO	G	urb		961	H*	246.0	48.5	19.72
203	Tac-Gorsium	RO	G	urb		962	H*	247.0	48.5	19.64
203	Tac-Gorsium	RO	G	urb		963	H	248.0	47.5	19.15
203	Tac-Gorsium	RO	G	urb		964	M?	250.0	44.0	17.60
203	Tac-Gorsium	RO	G	urb		965	H	253.0	48.0	18.97
203	Tac-Gorsium	RO	G	urb		966	H*	256.0	48.0	18.75
203	Tac-Gorsium	RO	G	urb		967	D*	257.0	45.0	17.51
203	Tac-Gorsium	RO	G	urb		968	H	258.5	47.0	18.18
203	Tac-Gorsium	RO	G	urb		969	H*	259.0	47.0	18.15
203	Tac-Gorsium	RO	G	urb		970	M	260.0	45.0	17.31
203	Tac-Gorsium	RO	G	urb		974	H*	262.5	50.0	19.05
203	Tac-Gorsium	RO	G	urb		975	M*	263.5	47.5	18.03
203	Tac-Gorsium	RO	G	urb		976	H*	264.0	47.5	17.99
203	Tac-Gorsium	RO	G	urb		977		265.0	46.0	17.36
203	Tac-Gorsium	RO	G	urb		978	H*	266.0	50.0	18.80
203	Tac-Gorsium	RO	G	urb		979	H	267.0	52.0	19.48
203	Tac-Gorsium	RO	G	urb		980		270.0	48.5	17.96
203	Tac-Gorsium	RO	G	urb		981	M*	270.0	48.5	17.96

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
203	Tac-Gorsium	RO	G	urb		982		270.0	51.0	18.89
203	Tac-Gorsium	RO	G	urb		983	H?	270.5	50.5	18.67
203	Tac-Gorsium	RO	G	urb		984	H?	271.5	50.0	18.42
203	Tac-Gorsium	RO	G	urb		985	H*	271.5	53.0	19.52
203	Tac-Gorsium	RO	G	urb		987	M*	277.0	49.5	17.87
203	Tac-Gorsium	RO	G	urb		988		277.0	50.0	18.05
203	Tac-Gorsium	RO	G	urb		989		280.0	51.5	18.39
203	Tac-Gorsium	RO	G	urb		990	M?	282.0	50.5	17.91
203	Tac-Gorsium	RO	G	urb		991	M*	282.5	50.5	17.88
203	Tac-Gorsium	RO	G	urb		992	H?	282.5	51.0	18.05
203	Tac-Gorsium	RO	G	urb		993	H?	283.5	54.0	19.05
203	Tac-Gorsium	RO	G	urb		994	M*	286.0	50.5	17.66
203	Tac-Gorsium	RO	G	urb		995	M*	289.0	52.0	17.99
203	Tac-Gorsium	RO	G	urb		997	M*	296.0	52.0	17.57
203	Tac-Gorsium	RO	G	urb		1056		203.5	36.0	17.69
203	Tac-Gorsium	RO	G	urb		1057	D	212.0	37.5	17.69
204	Conchil	RO	D	rural		1059		256.8	46.4	18.07
204	Conchil	RO	D	rural		1060		256.0	44.6	17.42
204	Conchil	RO	D	rural		1061		273.5	49.7	18.17
204	Conchil	RO	D	rural		1063		255.0	49.6	19.45
206	Lauriacum	RO	F	oth		1072		260.0	49.5	19.04
206	Lauriacum	RO	F	oth		1073		288.0	53.0	18.40
206	Lauriacum	RO	F	oth		1075		213.0	37.0	17.37
208	Colonia Ulpia Traiana	RO	F	urb		1076		278.5	52.5	18.85
208	Colonia Ulpia Traiana	RO	F	urb		1077		276.5	50.5	18.26
208	Colonia Ulpia Traiana	RO	F	urb		1078		272.0	50.5	18.57
208	Colonia Ulpia Traiana	RO	F	urb		1079		271.5	49.5	18.23
208	Colonia Ulpia Traiana	RO	F	urb		1080		270.5	51.0	18.85
208	Colonia Ulpia Traiana	RO	F	urb		1081		267.0	52.5	19.66
208	Colonia Ulpia Traiana	RO	F	urb		1082		266.0	49.5	18.61
208	Colonia Ulpia Traiana	RO	F	urb		1083		266.0	48.5	18.23
211	Castillar de Mendavia	IA	B	rural		1091		257.0	47.0	18.29
211	Castillar de Mendavia	IA	B	rural		1092		255.0	44.5	17.45
212	Gournay	IA	D	cem		1093	H*	245.0	43.0	17.55
212	Gournay	IA	D	cem		1094	M	233.0	43.0	18.45
212	Gournay	IA	D	cem		1095	D*	267.0	48.0	17.98
213	Beauvais	IA	D	rural		1096	H	233.0	41.5	17.81
213	Beauvais	IA	D	rural		1097	H*	247.0	45.5	18.42
213	Beauvais	IA	D	rural		1098	M*	259.0	42.0	16.22
213	Beauvais	IA	D	rural		1099	H	249.0	48.0	19.28
213	Beauvais	IA	D	rural		1100	M?	242.0	40.5	16.74
213	Beauvais	IA	D	rural		1101	H	225.0	39.0	17.33
213	Beauvais	IA	D	rural		1102	M*	284.0	52.0	18.31
214	Compiegne	IA	D	rural		1103	H?	242.0	48.0	19.83
214	Compiegne	IA	D	rural		1104	H	253.0	46.5	18.38
215	Ribemont	IA	D	oth		1105	H	226.0	42.5	18.81
215	Ribemont	IA	D	oth		1106	H	228.0	42.0	18.42
215	Ribemont	IA	D	oth		1107	H*	232.0	46.0	19.83
216	Variscourt	IA	D	rural		1108	H	230.0	44.5	19.35
216	Variscourt	IA	D	rural		1109	H*	231.0	43.0	18.61
216	Variscourt	IA	D	rural		1110	H	232.0	43.0	18.53
216	Variscourt	IA	D	rural		1111	H*	246.0	45.0	18.29
216	Variscourt	IA	D	rural		1112	H?	249.0	43.0	17.27
216	Variscourt	IA	D	rural		1113	M*	248.0	43.0	17.34
217	Soissons	IA	D	cem		1114	D	213.0	36.0	16.90

Table A31. – Results of the calculation of the distal breadth to greatest length index on the Metatarsals

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
3	Edix Hill	IA	E	rural		466		261.0	48.4	18.54
4	Market Deeping	IA	E	rural		465	H	251.0	45.6	18.17
5	Beckford	IA	E	rural		464		248.0	45.0	18.15
8	Hardingstone School	IA	E	ind		459		243.0	43.0	17.70
10	Twywell	IA	E	rural		458		238.0	42.0	17.65
13	Wavendon Gate	RO	E	rural		454		263.3	49.2	18.69
13	Wavendon Gate	RO	E	rural		455		285.0	51.7	18.14
14	Lincoln	RO	E	urb		449		255.9	46.9	18.33
14	Lincoln	RO	E	urb		451		296.0	59.5	20.10
14	Lincoln	RO	E	urb		452		282.7	54.7	19.35
14	Lincoln	RO	E	urb		453		273.7	51.1	18.67
15	Scole-Dickleburgh	RO	E	urb2		440		254.4	44.9	17.65
15	Scole-Dickleburgh	RO	E	urb2		443		267.3	49.6	18.56
15	Scole-Dickleburgh	RO	E	urb2		445	M	267.9	45.3	16.91
15	Scole-Dickleburgh	RO	E	urb2		447		249.0	43.4	17.43
16	Birdlip	IA	E	villa		437		205.0	40.3	19.66
19	Scole	RO	E	villa		433		246.0	46.0	18.70
21	Skeleton Green	IA	E	rural		431		235.0	40.5	17.23
26	Stonea	RO	E	rural		427		225.0	39.1	17.38
27	Lynch Farm	RO	E	villa		426		280.0	48.0	17.14
28	Longthorpe II	RO	E	mil		423	H	224.0	40.0	17.86
28	Longthorpe II	RO	E	mil		424	H*	223.0	40.0	17.94
28	Longthorpe II	RO	E	mil		425	H	251.0	46.0	18.33
35	Castricum-Oosterbuurt	RO	F	oth		405		275.0	49.4	17.97
35	Castricum-Oosterbuurt	RO	F	oth		406		256.6	48.8	19.01
35	Castricum-Oosterbuurt	RO	F	oth		407		273.4	50.1	18.33
35	Castricum-Oosterbuurt	RO	F	oth		408		272.4	50.6	18.58
35	Castricum-Oosterbuurt	RO	F	oth		409		260.3	49.0	18.82
35	Castricum-Oosterbuurt	RO	F	oth		410		260.0	48.7	18.73
35	Castricum-Oosterbuurt	RO	F	oth		411		267.7	47.9	17.90
35	Castricum-Oosterbuurt	RO	F	oth		414		266.0	47.8	17.98
35	Castricum-Oosterbuurt	RO	F	oth		417		256.7	47.7	18.57
35	Castricum-Oosterbuurt	RO	F	oth		418		264.2	49.0	18.53
37	Kesteren 'De Prinsenhof'	RO	F	cem	HKKO-35	392		274.0	48.2	17.59
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-34	395	H?	285.0	50.0	17.54
37	Kesteren 'De Prinsenhof'	RO	F	cem	11-28	396	H*	280.0	54.0	19.29
37	Kesteren 'De Prinsenhof'	RO	F	cem	2-27	398	H*	284.0	51.6	18.17
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-21	400	H?	289.0	51.5	17.82
37	Kesteren 'De Prinsenhof'	RO	F	cem	1-11	401		280.0	52.4	18.71
38	Nijmegen	RO	F	urb		379	M	271.4	45.4	16.73
38	Nijmegen	RO	F	urb		380	H	258.0	46.6	18.06
38	Nijmegen	RO	F	urb		381		279.8	47.1	16.83
38	Nijmegen	RO	F	urb		383	H*	274.8	52.1	18.96
38	Nijmegen	RO	F	urb		384	M	274.6	46.8	17.04
38	Nijmegen	RO	F	urb		385	H*	260.2	51.8	19.91
38	Nijmegen	RO	F	urb		390	M	278.4	47.7	17.13
39	Kesteren vicus	RO	F	urb2		378	H*	237.8	45.7	19.22
40	Heteren	NAT	F	rural		374	M*	285.6	50.8	17.79
40	Heteren	NAT	F	rural		376	H?	251.0	43.6	17.37
42	Druten	RO	F	villa		364	H	248.1	46.0	18.54

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
42	Druten	RO	F	villa		365		272.0	46.2	16.99
42	Druten	RO	F	villa		366	H?	258.3	46.8	18.12
42	Druten	RO	F	villa		367	H*	271.8	51.3	18.87
42	Druten	RO	F	villa		368	H*	259.4	50.8	19.58
42	Druten	RO	F	villa		369	H?	275.0	49.8	18.11
42	Druten	RO	F	villa	12.4	372	H*	269.2	50.4	18.72
42	Druten	RO	F	villa	1.18	373	M*	288.8	51.9	17.97
43	Elms Farm	RO	E	urb2		344		264.0	50.0	18.94
43	Elms Farm	RO	E	urb2		348		242.0	42.7	17.64
43	Elms Farm	RO	E	urb2		349		267.0	44.3	16.59
43	Elms Farm	RO	E	urb2	6640	350	H*	269.0	52.3	19.44
43	Elms Farm	RO	E	urb2	6640	351	H*	268.0	51.3	19.14
43	Elms Farm	RO	E	urb2		352		252.0	46.4	18.41
43	Elms Farm	RO	E	urb2		358	H	256.0	45.8	17.89
43	Elms Farm	IA	E	urb2		359	H*	234.0	39.5	16.88
44	Danebury	IA	E	rural		322	H	242.0	44.2	18.26
44	Danebury	IA	E	rural		324		246.0	46.3	18.82
44	Danebury	IA	E	rural		326		233.0	42.0	18.03
44	Danebury	IA	E	rural		328		228.0	42.0	18.42
44	Danebury	IA	E	rural		329		237.0	43.6	18.40
44	Danebury	IA	E	rural		330		231.0	41.2	17.84
44	Danebury	IA	E	rural		333		251.0	46.8	18.65
44	Danebury	IA	E	rural		334		218.0	40.8	18.72
44	Danebury	IA	E	rural		335	H	229.0	41.6	18.17
44	Danebury	IA	E	rural		338	H	251.0	45.1	17.97
44	Danebury	IA	E	rural		339		231.0	37.7	16.32
44	Danebury	IA	E	rural		340	H	251.5	45.7	18.17
44	Danebury	IA	E	rural		341		250.0	46.6	18.64
46	E London RB Cemetary	RO	E	cem		320	H*	270.9	51.2	18.90
47	Beddington Sewage Farm	RO	E	urb		317	H?	245.0	43.1	17.59
47	Beddington Sewage Farm	RO	E	urb		318		257.0	47.0	18.29
54	Thorpe Thewles	RO	E	rural		301	H*	242.0	47.2	19.50
54	Thorpe Thewles	IA	E	rural		305	M*	242.0	43.3	17.89
57	La Sagesse	IA	E	oth		297		224.5	39.7	17.68
58	Braintree	RO	E	urb2		296		250.5	45.3	18.08
59	Chichester cattlemarket	RO	E	urb	XXIII	294	H*	281.9	52.7	18.69
59	Chichester cattlemarket	RO	E	urb	XXIII	295	H*	282.1	52.8	18.72
63	S. Giacomo	RO	A	villa		291		284.0	51.2	18.03
66	Settefinestre	RO	A	villa		285	H*	277.0	54.0	19.49
67	Ilchester,Church Street	RO	E	urb	F267	284	H*	256.5	52.2	20.35
68	Lutton/Huntingdon	RO	E	rural		279	H?	286.0	54.1	18.92
68	Lutton/Huntingdon	RO	E	rural		280	H?	272.0	50.0	18.38
68	Lutton/Huntingdon	RO	E	rural		282		259.0	45.5	17.57
68	Lutton/Huntingdon	RO	E	rural		283	H	254.0	47.1	18.54
71	Piovego	IA	A	cem	N2	276		260.0	49.0	18.85
74	Sovana	IA	A	cem		275		252.0	42.0	16.67
81	Welsow	NAT	F	rural		271	H	259.7	47.3	18.21
81	Welsow	NAT	F	rural		272	H?	247.5	41.7	16.85
81	Welsow	NAT	F	rural		273	H*	246.0	48.8	19.84
85	Macon	RO	D	cem		269	M*	285.0	46.2	16.21
87	Manching	IA	F	rural		212		225.0	40.0	17.78
87	Manching	IA	F	rural		213		224.0	43.0	19.20
87	Manching	IA	F	rural		214		223.0	40.0	17.94
87	Manching	IA	F	rural		215		222.5	40.0	17.98
87	Manching	IA	F	rural		216		218.0	39.5	18.12
87	Manching	IA	F	rural		217		217.0	41.0	18.89

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
87	Manching	IA	F	rural		218		217.0	38.5	17.74
87	Manching	IA	F	rural		219		232.0	43.0	18.53
87	Manching	IA	F	rural		220		231.0	44.0	19.05
87	Manching	IA	F	rural		221		231.0	42.5	18.40
87	Manching	IA	F	rural		222		231.0	44.5	19.26
87	Manching	IA	F	rural		223		231.0	42.0	18.18
87	Manching	IA	F	rural		225		228.0	41.5	18.20
87	Manching	IA	F	rural		226		227.0	40.0	17.62
87	Manching	IA	F	rural		227		226.5	40.0	17.66
87	Manching	IA	F	rural		228		226.0	39.0	17.26
87	Manching	IA	F	rural		229		236.5	43.0	18.18
87	Manching	IA	F	rural		230		236.5	45.5	19.24
87	Manching	IA	F	rural		231		236.0	44.0	18.64
87	Manching	IA	F	rural		232		236.0	44.5	18.86
87	Manching	IA	F	rural		233		236.0	42.5	18.01
87	Manching	IA	F	rural		234		234.0	43.0	18.38
87	Manching	IA	F	rural		235		233.5	39.0	16.70
87	Manching	IA	F	rural		236		233.0	42.0	18.03
87	Manching	IA	F	rural		237		232.5	42.5	18.28
87	Manching	IA	F	rural		238		232.5	43.0	18.49
87	Manching	IA	F	rural		239		243.5	47.0	19.30
87	Manching	IA	F	rural		240		242.0	42.5	17.56
87	Manching	IA	F	rural		241		242.0	43.0	17.77
87	Manching	IA	F	rural		242		240.0	44.0	18.33
87	Manching	IA	F	rural		243		240.0	41.5	17.29
87	Manching	IA	F	rural		244		239.0	42.0	17.57
87	Manching	IA	F	rural		245		239.0	44.5	18.62
87	Manching	IA	F	rural		246		239.0	44.0	18.41
87	Manching	IA	F	rural		247		237.5	44.0	18.53
87	Manching	IA	F	rural		248		237.0	41.5	17.51
87	Manching	IA	F	rural		249		250.0	49.5	19.80
87	Manching	IA	F	rural		250		250.0	46.5	18.60
87	Manching	IA	F	rural		251		249.5	45.0	18.04
87	Manching	IA	F	rural		253		247.0	44.0	17.81
87	Manching	IA	F	rural		254		246.5	40.5	16.43
87	Manching	IA	F	rural		255		245.5	45.0	18.33
87	Manching	IA	F	rural		256		245.0	47.5	19.39
87	Manching	IA	F	rural		257		244.5	46.5	19.02
87	Manching	IA	F	rural		258		244.0	44.0	18.03
87	Manching	IA	F	rural		259		251.0	44.0	17.53
87	Manching	IA	F	rural		260		288.0	52.0	18.06
87	Manching	IA	F	rural		261		283.5	53.0	18.69
87	Manching	IA	F	rural		262		273.0	50.0	18.32
87	Manching	IA	F	rural		263		271.0	49.5	18.27
87	Manching	IA	F	rural		264		271.0	51.0	18.82
87	Manching	IA	F	rural		265		260.0	44.0	16.92
87	Manching	IA	F	rural		266		255.0	47.5	18.63
87	Manching	IA	F	rural		267		253.0	46.0	18.18
87	Manching	IA	F	rural		268		252.5	48.5	19.21
92	Feddersen Wierde	NAT	F	rural	skelett1R	26	H	259.5	48.5	18.69
92	Feddersen Wierde	NAT	F	rural	skelett1L	27	H	259.0	48.8	18.84
92	Feddersen Wierde	NAT	F	rural		28	H	244.3	45.4	18.58
92	Feddersen Wierde	NAT	F	rural		29	H	259.6	48.6	18.72
92	Feddersen Wierde	NAT	F	rural		30		251.0	43.9	17.49
92	Feddersen Wierde	NAT	F	rural		31		247.1	43.9	17.77
92	Feddersen Wierde	NAT	F	rural		32	H?	258.2	46.0	17.82

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		33	M*	260.7	45.5	17.45
92	Feddersen Wierde	NAT	F	rural		34	H*	236.0	46.0	19.49
92	Feddersen Wierde	NAT	F	rural		35	H	241.8	43.1	17.82
92	Feddersen Wierde	NAT	F	rural		36	H	247.0	45.3	18.34
92	Feddersen Wierde	NAT	F	rural		37	H*	257.4	49.2	19.11
92	Feddersen Wierde	NAT	F	rural		38	H	239.7	45.1	18.82
92	Feddersen Wierde	NAT	F	rural		39	M?	250.0	42.3	16.92
92	Feddersen Wierde	NAT	F	rural		40	H*	270.7	51.5	19.02
92	Feddersen Wierde	NAT	F	rural		41	H*	241.6	46.5	19.25
92	Feddersen Wierde	NAT	F	rural		42	M*	257.1	46.1	17.93
92	Feddersen Wierde	NAT	F	rural		43	H	250.6	46.1	18.40
92	Feddersen Wierde	NAT	F	rural		44		258.8	45.0	17.39
92	Feddersen Wierde	NAT	F	rural		45	H*	247.2	43.7	17.68
92	Feddersen Wierde	NAT	F	rural		46	H*	271.3	49.2	18.13
92	Feddersen Wierde	NAT	F	rural		47	M?	249.1	43.9	17.62
92	Feddersen Wierde	NAT	F	rural		48	H	247.5	46.5	18.79
92	Feddersen Wierde	NAT	F	rural		49	H	269.2	49.0	18.20
92	Feddersen Wierde	NAT	F	rural		50	H?	239.0	41.6	17.41
92	Feddersen Wierde	NAT	F	rural		51	H	245.5	45.2	18.41
92	Feddersen Wierde	NAT	F	rural		52	H	246.8	45.7	18.52
92	Feddersen Wierde	NAT	F	rural		53	H	249.8	46.6	18.65
92	Feddersen Wierde	NAT	F	rural		54	H*	255.7	45.3	17.72
92	Feddersen Wierde	NAT	F	rural		55	H	238.3	44.9	18.84
92	Feddersen Wierde	NAT	F	rural		56	H*	232.9	43.1	18.51
92	Feddersen Wierde	NAT	F	rural		57	H*	253.7	45.0	17.74
92	Feddersen Wierde	NAT	F	rural		58	H	247.3	46.8	18.92
92	Feddersen Wierde	NAT	F	rural		59	H	257.2	48.4	18.82
92	Feddersen Wierde	NAT	F	rural		61	H*	256.0	45.1	17.62
92	Feddersen Wierde	NAT	F	rural		63	H?	257.6	45.1	17.51
92	Feddersen Wierde	NAT	F	rural		64	H	260.9	48.2	18.47
92	Feddersen Wierde	NAT	F	rural		65	H	239.6	47.2	19.70
92	Feddersen Wierde	NAT	F	rural		66	M*	259.3	45.9	17.70
92	Feddersen Wierde	NAT	F	rural		67	M*	262.3	48.1	18.34
92	Feddersen Wierde	NAT	F	rural		68	H	247.0	47.3	19.15
92	Feddersen Wierde	NAT	F	rural		69	H	234.2	43.2	18.45
92	Feddersen Wierde	NAT	F	rural		70	H	249.5	45.6	18.28
92	Feddersen Wierde	NAT	F	rural		71	H	262.7	49.4	18.80
92	Feddersen Wierde	NAT	F	rural		72	H*	259.4	47.1	18.16
92	Feddersen Wierde	NAT	F	rural		73	H	262.3	49.6	18.91
92	Feddersen Wierde	NAT	F	rural		74	H	247.8	46.8	18.89
92	Feddersen Wierde	NAT	F	rural		75	H	255.3	46.2	18.10
92	Feddersen Wierde	NAT	F	rural		77	H	246.2	44.3	17.99
92	Feddersen Wierde	NAT	F	rural		78	M?	251.2	42.4	16.88
92	Feddersen Wierde	NAT	F	rural		79	M?	252.1	44.1	17.49
92	Feddersen Wierde	NAT	F	rural		80	H	245.0	44.4	18.12
92	Feddersen Wierde	NAT	F	rural		81	H?	259.4	46.2	17.81
92	Feddersen Wierde	NAT	F	rural		83	H	260.4	47.8	18.36
92	Feddersen Wierde	NAT	F	rural		84	H	248.9	46.1	18.52
92	Feddersen Wierde	NAT	F	rural		85	H	253.6	47.0	18.53
92	Feddersen Wierde	NAT	F	rural		86	H	247.0	46.4	18.79
92	Feddersen Wierde	NAT	F	rural		87	M*	252.2	44.4	17.61
92	Feddersen Wierde	NAT	F	rural		88	H	244.6	45.0	18.40
92	Feddersen Wierde	NAT	F	rural		89	H	259.3	49.4	19.05
92	Feddersen Wierde	NAT	F	rural		90	H	245.9	45.4	18.46
92	Feddersen Wierde	NAT	F	rural		91	H	258.2	48.9	18.94
92	Feddersen Wierde	NAT	F	rural		92	H	243.8	45.7	18.74

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural		93	H?	248.4	44.1	17.75
92	Feddersen Wierde	NAT	F	rural		94		247.1	44.3	17.93
92	Feddersen Wierde	NAT	F	rural		95	H	242.2	45.4	18.74
92	Feddersen Wierde	NAT	F	rural		96	H*	270.6	50.1	18.51
92	Feddersen Wierde	NAT	F	rural		97		237.6	42.9	18.06
92	Feddersen Wierde	NAT	F	rural		98	D*	256.6	42.3	16.48
92	Feddersen Wierde	NAT	F	rural		99	H*	241.7	43.5	18.00
92	Feddersen Wierde	NAT	F	rural		101	H	241.4	46.8	19.39
92	Feddersen Wierde	NAT	F	rural		102	H?	255.3	44.7	17.51
92	Feddersen Wierde	NAT	F	rural		103	H?	258.1	46.0	17.82
92	Feddersen Wierde	NAT	F	rural		104	H	239.6	45.0	18.78
92	Feddersen Wierde	NAT	F	rural		105	H	257.1	48.1	18.71
92	Feddersen Wierde	NAT	F	rural		107	H	243.6	44.5	18.27
92	Feddersen Wierde	NAT	F	rural		109		258.1	47.7	18.48
92	Feddersen Wierde	NAT	F	rural		110	H	241.7	44.3	18.33
92	Feddersen Wierde	NAT	F	rural		111	H?	256.7	44.2	17.22
92	Feddersen Wierde	NAT	F	rural		113	H	244.4	44.4	18.17
92	Feddersen Wierde	NAT	F	rural		114	H*	248.6	45.3	18.22
92	Feddersen Wierde	NAT	F	rural		115	H	270.9	50.9	18.79
92	Feddersen Wierde	NAT	F	rural		116	M	262.0	44.0	16.79
92	Feddersen Wierde	NAT	F	rural		117	H	255.7	45.8	17.91
92	Feddersen Wierde	NAT	F	rural		118	H*	240.4	44.0	18.30
92	Feddersen Wierde	NAT	F	rural		119	H	252.3	46.3	18.35
92	Feddersen Wierde	NAT	F	rural		120	M*	255.2	45.2	17.71
92	Feddersen Wierde	NAT	F	rural		121	H	242.9	43.8	18.03
92	Feddersen Wierde	NAT	F	rural		122	M*	261.9	46.1	17.60
92	Feddersen Wierde	NAT	F	rural		123	H*	235.6	42.1	17.87
92	Feddersen Wierde	NAT	F	rural		124	H	247.5	44.5	17.98
92	Feddersen Wierde	NAT	F	rural		125	H	249.9	47.0	18.81
92	Feddersen Wierde	NAT	F	rural		126	H*	250.6	44.6	17.80
92	Feddersen Wierde	NAT	F	rural		127	H	239.6	43.8	18.28
92	Feddersen Wierde	NAT	F	rural		128	M*	263.6	47.3	17.94
92	Feddersen Wierde	NAT	F	rural		129	H	232.0	44.8	19.31
92	Feddersen Wierde	NAT	F	rural		130	M?	249.8	43.3	17.33
92	Feddersen Wierde	NAT	F	rural		131	H*	236.1	43.7	18.51
92	Feddersen Wierde	NAT	F	rural		132	M*	248.4	42.7	17.19
92	Feddersen Wierde	NAT	F	rural		133		250.9	41.2	16.42
92	Feddersen Wierde	NAT	F	rural		134	H	247.8	46.5	18.77
92	Feddersen Wierde	NAT	F	rural		135	H?	248.2	43.2	17.41
92	Feddersen Wierde	NAT	F	rural		136	H*	247.0	48.2	19.51
92	Feddersen Wierde	NAT	F	rural		137	H*	267.3	49.3	18.44
92	Feddersen Wierde	NAT	F	rural		138	H*	237.9	42.7	17.95
92	Feddersen Wierde	NAT	F	rural		139	M*	260.3	45.2	17.36
92	Feddersen Wierde	NAT	F	rural		140	H*	249.9	45.9	18.37
92	Feddersen Wierde	NAT	F	rural		141	H*	248.5	48.1	19.36
92	Feddersen Wierde	NAT	F	rural		142		233.0	44.9	19.27
92	Feddersen Wierde	NAT	F	rural		143	M*	259.0	46.3	17.88
92	Feddersen Wierde	NAT	F	rural		144	H?	243.3	43.0	17.67
92	Feddersen Wierde	NAT	F	rural		145	H*	245.4	48.7	19.85
92	Feddersen Wierde	NAT	F	rural		146	M*	256.8	45.5	17.72
92	Feddersen Wierde	NAT	F	rural		147	H*	269.3	50.4	18.72
96	Kunzing east vicus	RO	F	cem	1703	1	M*	263.0	51.5	19.58
96	Kunzing east vicus	RO	F	cem	1641	2	M*	274.0	51.5	18.80
96	Kunzing east vicus	RO	F	cem	1581	3	H?	284.0	51.9	18.27
96	Kunzing east vicus	RO	F	cem	1575/5	4	H*	266.5	47.3	17.75
96	Kunzing east vicus	RO	F	cem	1620	5	H*	284.0	51.8	18.24

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
98	Prestatyn	RO	E	ind		483		243.0	44.1	18.15
104	Orton Hall Farm	RO	E	villa		504	H	236.0	44.0	18.64
104	Orton Hall Farm	RO	E	villa		505	M	258.0	43.0	16.67
104	Orton Hall Farm	RO	E	villa		506	H*	252.0	44.0	17.46
104	Orton Hall Farm	RO	E	villa		507	H?	276.0	50.0	18.12
104	Orton Hall Farm	RO	E	villa		508		215.0	47.0	21.86
105	Mons Claudianus	RO	K	ind		509	H*	272.0	48.5	17.83
105	Mons Claudianus	RO	K	ind		510	M	264.9	43.3	16.35
105	Mons Claudianus	RO	K	ind	604	511	M?	254.0	44.3	17.44
105	Mons Claudianus	RO	K	ind	905	512	M*	253.0	39.2	15.49
105	Mons Claudianus	RO	K	ind	1719	513	D*	248.0	37.8	15.24
105	Mons Claudianus	RO	K	ind	813	514		242.0	35.5	14.67
105	Mons Claudianus	RO	K	ind	1544	515	D*	240.5	36.2	15.05
105	Mons Claudianus	RO	K	ind	549	516	H	239.5	43.8	18.29
105	Mons Claudianus	RO	K	ind	1486	517	D*	236.0	35.0	14.83
105	Mons Claudianus	RO	K	ind	2489	518		227.6	35.9	15.77
110	Nijmegen new excavations	RO	F	urb	179/16-22	589	H*	242.1	45.4	18.75
110	Nijmegen new excavations	RO	F	urb	179/16-25	590	H*	263.1	49.6	18.85
112	Pompeii, Sarno Baths	RO	A	urb	A	593		215.5	41.8	19.40
112	Pompeii, Sarno Baths	RO	A	urb	B	594		275.5	51.8	18.80
112	Pompeii, Sarno Baths	RO	A	urb	C	595		274.0	47.4	17.30
112	Pompeii, Sarno Baths	RO	A	urb	D	596		335.0	52.0	15.52
114	Unterlaa	RO	G	urb	18	598	M*	266.0	43.3	16.28
114	Unterlaa	RO	G	urb	23A	599	H	252.0	45.4	18.02
114	Unterlaa	RO	G	urb	35	600	H*	258.0	47.6	18.45
114	Unterlaa	RO	G	urb	40	601	H*	263.5	48.4	18.37
114	Unterlaa	RO	G	urb	48	602	M*	267.0	44.2	16.55
114	Unterlaa	RO	G	urb	49	603	M?	280.0	49.6	17.71
114	Unterlaa	RO	G	urb	73	604	H	251.0	46.0	18.33
115	Bad Wimpfen	RO	F	urb2		605	H	276.3	50.2	18.17
115	Bad Wimpfen	RO	F	urb2		606	H	264.3	49.2	18.62
115	Bad Wimpfen	RO	F	urb2		607		264.2	50.0	18.93
115	Bad Wimpfen	RO	F	urb2		608		262.0	50.0	19.08
115	Bad Wimpfen	RO	F	urb2	Skele 4	613	M	284.0	49.2	17.32
115	Bad Wimpfen	RO	F	urb2	Skele 5	614		278.0	48.3	17.37
115	Bad Wimpfen	RO	F	urb2	Skele 6	615	M	269.5	45.5	16.88
115	Bad Wimpfen	RO	F	urb2		616	D	207.0	33.8	16.33
116	Pommeroeul	RO	D	urb2	348-1	617	H	246.0	45.0	18.29
116	Pommeroeul	RO	D	urb2	224-1	618	H	250.0	46.0	18.40
116	Pommeroeul	RO	D	urb2	348-2	619	H	250.0	47.0	18.80
116	Pommeroeul	RO	D	urb2	17-1	620	H	250.0	45.0	18.00
116	Pommeroeul	RO	D	urb2	63	621	H	257.0	47.0	18.29
116	Pommeroeul	RO	D	urb2	251	622	H*	257.0	46.0	17.90
116	Pommeroeul	RO	D	urb2	80	623	M*	266.0	45.0	16.92
116	Pommeroeul	RO	D	urb2	306	624	H*	266.0	52.0	19.55
116	Pommeroeul	RO	D	urb2	32	625	M	268.0	46.0	17.16
116	Pommeroeul	RO	D	urb2	222	626	H*	271.0	51.0	18.82
116	Pommeroeul	RO	D	urb2	238	627	H*	271.0	51.0	18.82
116	Pommeroeul	RO	D	urb2	248-1	628	H*	272.0	52.0	19.12
116	Pommeroeul	RO	D	urb2	274	629	H?	281.0	52.0	18.51
116	Pommeroeul	RO	D	urb2	17-2	630	M*	291.0	47.0	16.15
116	Pommeroeul	RO	D	urb2	248-2	631	H*	296.0	54.0	18.24
117	Pompeii stable	RO	A	urb	A	633		283.0	50.0	17.67
117	Pompeii stable	RO	A	urb	B	634		275.0	48.0	17.45
117	Pompeii stable	RO	A	urb	C	635		275.0	48.0	17.45
118	Carnuntum	RO	G	mil	Pferd 1	636	M	300.0	56.9	18.97

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
118	Carnuntum	RO	G	mil	Pferd 2	637	H	283.5	52.2	18.41
118	Carnuntum	RO	G	mil	Pferd 3	638	H*	273.2	51.8	18.96
118	Carnuntum	RO	G	mil	Maultier 1	639	M*	286.7	50.7	17.68
118	Carnuntum	RO	G	mil		640		291.0	52.2	17.94
119	Albertfalva	RO	G	mil	Horse 1	641	H?	272.0	50.8	18.68
119	Albertfalva	RO	G	mil	Horse 2	642	H?	296.9	54.1	18.22
119	Albertfalva	RO	G	mil	Horse 3	643		251.3	50.1	19.94
120	Basel-Gasfabrik	IA	F	rural		644		225.0	39.6	17.60
120	Basel-Gasfabrik	IA	F	rural		645		220.0	41.1	18.68
121	Soluthurn/Vigier	RO	F	urb2		650	M*	285.0	46.4	16.28
121	Soluthurn/Vigier	RO	F	urb2		651	M	276.0	47.0	17.03
121	Soluthurn/Vigier	RO	F	urb2		652	M*	272.3	44.6	16.38
121	Soluthurn/Vigier	RO	F	urb2		655		280.0	48.5	17.32
121	Soluthurn/Vigier	RO	F	urb2		656		272.0	45.6	16.76
123	Wroxeter Baths basilica	RO	E	urb		658		261.5	44.2	16.90
123	Wroxeter Baths basilica	RO	E	urb		659	H	265.0	49.4	18.64
123	Wroxeter Baths basilica	RO	E	urb		660	H	250.4	45.3	18.09
124	Haddon	IA	E	oth		664		246.0	44.5	18.09
124	Haddon	RO	E	oth		665		261.0	50.3	19.27
124	Haddon	RO	E	oth		666		261.0	50.3	19.27
124	Haddon	RO	E	oth		667		239.0	46.7	19.54
124	Haddon	RO	E	oth		668		250.0	46.4	18.56
124	Haddon	RO	E	oth		670		253.0	44.3	17.51
125	Castleford	RO	E	mil		673	H*	274.0	51.0	18.61
125	Castleford	RO	E	mil		674		256.0	46.2	18.05
125	Castleford	RO	E	mil		675	M*	252.0	43.2	17.14
127	Tortoreto-Fortellezza	IA	A	rural		677		205.0	32.0	15.61
128	Krefeld-Gellep	RO	F	mil	3392	680	H*	277.0	49.0	17.69
128	Krefeld-Gellep	RO	F	mil	3557	681	H?	288.0	53.5	18.58
128	Krefeld-Gellep	RO	F	mil	3559	682	M	284.0	48.5	17.08
128	Krefeld-Gellep	RO	F	mil	3559	683	M	283.0	49.0	17.31
128	Krefeld-Gellep	RO	F	mil	3575	685		272.0	45.0	16.54
128	Krefeld-Gellep	RO	F	mil	3510	687	D*	227.5	41.0	18.02
129	Lorenzberg Bei Epfach	RO	F	oth		689		294.0	51.0	17.35
129	Lorenzberg Bei Epfach	RO	F	oth		690		272.0	47.0	17.28
129	Lorenzberg Bei Epfach	RO	F	oth		691		268.0	48.0	17.91
129	Lorenzberg Bei Epfach	RO	F	oth		695		258.0	47.0	18.22
129	Lorenzberg Bei Epfach	RO	F	oth		696		251.0	46.5	18.53
129	Lorenzberg Bei Epfach	RO	F	oth		699		256.0	45.0	17.58
129	Lorenzberg Bei Epfach	RO	F	oth		700		253.5	47.0	18.54
130	Msecke Zehrovice	IA	G	rural		704		274.0	51.5	18.80
132	Godmanchester	RO	E	mil		708		275.0	52.6	19.13
132	Godmanchester	RO	E	mil		709		280.0	47.6	17.00
132	Godmanchester	RO	E	mil		711		273.0	47.4	17.36
132	Godmanchester	RO	E	mil		713		259.9	42.8	16.47
132	Godmanchester	RO	E	mil		715		266.0	45.4	17.07
132	Godmanchester	RO	E	mil		716		265.0	48.6	18.34
132	Godmanchester	RO	E	mil		717		243.0	46.1	18.97
132	Godmanchester	RO	E	mil		720		270.0	50.7	18.78
132	Godmanchester	RO	E	mil		721		270.0	49.1	18.19
133	Colchester	RO	E	urb		725		263.0	47.4	18.02
133	Colchester	RO	E	urb		728		233.0	42.0	18.03
134	Butzbach	RO	F	urb2		729	H?	284.0	53.0	18.66
134	Butzbach	RO	F	urb2		730	D*	245.0	42.0	17.14
134	Butzbach	RO	F	urb2		731	M	291.0	52.0	17.87
134	Butzbach	RO	F	urb2		732	H*	281.0	53.0	18.86

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
134	Butzbach	RO	F	urb2		735	M*	303.0	54.0	17.82
135	Swestari	IA	G	cem	1	736	H	240.0	45.0	18.75
135	Swestari	IA	G	cem	2	737	H	240.0	45.0	18.75
135	Swestari	IA	G	cem	3	738	H	244.0	44.0	18.03
135	Swestari	IA	G	cem	4	739	H*	263.0	50.0	19.01
135	Swestari	IA	G	cem	5	740	M	288.0	52.0	18.06
137	Magdelenska Gora	IA	G	cem	V, 29, I	743		260.0	47.0	18.08
141	Szentes-Vekerzug	IA	G	cem	6	746	H*	254.0	47.0	18.50
143	Histria	IA	G	urb2	P18	747	H*	275.0	51.0	18.55
143	Histria	IA	G	urb2	P25	748	H?	277.5	51.8	18.67
146	Balatonaliga	RO	G	rural	620c	752	H*	264.0	50.0	18.94
147	Pilismarot I Watchtower	RO	G	mil		753	H	245.0	45.5	18.57
147	Pilismarot I Watchtower	RO	G	mil		754	H	245.0	45.5	18.57
147	Pilismarot I Watchtower	RO	G	mil		755	H*	243.0	52.0	21.40
149	Helemba - Sziget	IA	G	rural		756	H*	231.0	47.0	20.35
149	Helemba - Sziget	IA	G	rural		757	H	253.5	48.0	18.93
149	Helemba - Sziget	IA	G	rural		758	H*	254.0	47.5	18.70
151	Gyor Szechenyi-Ter	RO	G	rural		759	H*	282.0	53.5	18.97
153	Aquileia forum	RO	A	urb		773		271.0	46.0	16.97
153	Aquileia forum	RO	A	urb		774	M*	275.0	49.5	18.00
153	Aquileia forum	RO	A	urb		775		280.0	49.5	17.68
155	Gravina 1	RO	A	villa		777		242.0	41.2	17.02
155	Gravina 1	RO	A	villa		778		214.0	34.0	15.89
156	Invillino- Ibligio	RO	A	oth		781		273.0	50.0	18.32
156	Invillino- Ibligio	RO	A	oth		782		272.0	43.5	15.99
156	Invillino- Ibligio	RO	A	oth		783		263.0	47.0	17.87
156	Invillino- Ibligio	RO	A	oth		784		254.0	45.0	17.72
161	San Giovanni	RO	A	villa		790		270.2	48.5	17.95
161	San Giovanni	RO	A	villa		792		231.0	49.2	21.30
167	Via Gabina 10	RO	A	urb		794		270.0	47.8	17.70
176	Oberdorla	NAT	F	cem		804	M*	266.0	44.0	16.54
176	Oberdorla	NAT	F	cem		805	M*	262.0	42.0	16.03
176	Oberdorla	NAT	F	cem		806	H	260.0	46.0	17.69
176	Oberdorla	NAT	F	cem		807	H*	254.0	45.0	17.72
176	Oberdorla	NAT	F	cem		808	M*	254.0	43.0	16.93
176	Oberdorla	NAT	F	cem		809		253.0	42.0	16.60
176	Oberdorla	NAT	F	cem		810	M	253.0	43.0	17.00
176	Oberdorla	NAT	F	cem		811	H*	253.0	49.0	19.37
176	Oberdorla	NAT	F	cem		812	H*	251.0	44.0	17.53
176	Oberdorla	NAT	F	cem		813	M?	251.0	44.0	17.53
176	Oberdorla	NAT	F	cem		814	H*	251.0	50.0	19.92
176	Oberdorla	NAT	F	cem		815	H	250.0	45.0	18.00
176	Oberdorla	NAT	F	cem		816	H	248.0	45.0	18.15
176	Oberdorla	NAT	F	cem		817	H*	246.0	47.0	19.11
176	Oberdorla	NAT	F	cem		818	D*	218.0	40.0	18.35
178	Vitudurum-Oberwinterthur	RO	F	urb2		823		281.0	54.4	19.36
179	Catterick CEU240	RO	E	mil		827		255.0	43.6	17.10
180	Catterick 434	RO	E	mil		831		263.0	47.2	17.95
181	Barnsley Park	RO	E	rural		832		250.0	39.0	15.60
181	Barnsley Park	RO	E	rural		833		250.0	41.0	16.40
182	Frocester Court	RO	E	villa		836		243.0	38.0	15.64
182	Frocester Court	RO	E	villa		837		230.0	38.0	16.52
183	Segontium	RO	E	mil		840		290.0	47.0	16.21
185	Shakenoak site C	RO	E	villa		843		242.0	44.0	18.18
186	Shakenoak site K	RO	E	villa		845		270.0	50.0	18.52
188	Titelberg oppidum	RO	D	rural		849	H*	256.0	49.0	19.14

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
189	Kassope	IA	H	urb		852	D	217.0	35.0	16.13
189	Kassope	IA	H	urb		854	D	220.0	35.0	15.91
189	Kassope	IA	H	urb		858	D*	198.0	29.0	14.65
189	Kassope	IA	H	urb		864	D	236.5	38.0	16.07
189	Kassope	IA	H	urb		865	D	220.0	35.5	16.14
189	Kassope	IA	H	urb		866		231.0	36.5	15.80
189	Kassope	IA	H	urb		870		225.0	35.5	15.78
192	Pfaffenhofen - Pons Aeni	RO	F	rural		875		259.0	47.0	18.15
192	Pfaffenhofen - Pons Aeni	RO	F	rural		876		268.0	49.5	18.47
192	Pfaffenhofen - Pons Aeni	RO	F	rural		877		270.0	48.0	17.78
192	Pfaffenhofen - Pons Aeni	RO	F	rural		879		285.0	52.5	18.42
195	Kunzing-Quintana	RO	F	mil		883		284.0	49.5	17.43
195	Kunzing-Quintana	RO	F	mil		884		258.0	49.0	18.99
195	Kunzing-Quintana	RO	F	mil		885		249.0	46.0	18.47
199	Hufingen	RO	F	rural		889		277.0	45.5	16.43
199	Hufingen	RO	F	rural		890		272.5	49.5	18.17
199	Hufingen	RO	F	rural		891		272.0	48.0	17.65
199	Hufingen	RO	F	rural		892		271.0	49.0	18.08
199	Hufingen	RO	F	rural		893		264.0	49.5	18.75
199	Hufingen	RO	F	rural		894		264.0	47.0	17.80
199	Hufingen	RO	F	rural		895		262.5	49.5	18.86
199	Hufingen	RO	F	rural		896		259.0	50.0	19.31
199	Hufingen	RO	F	rural		897		257.5	47.0	18.25
199	Hufingen	RO	F	rural		898		251.0	45.5	18.13
199	Hufingen	RO	F	rural		899		249.0	45.0	18.07
199	Hufingen	RO	F	rural		915		293.5	52.0	17.72
199	Hufingen	RO	F	rural		916		277.0	50.0	18.05
199	Hufingen	RO	F	rural		917		272.0	49.0	18.01
199	Hufingen	RO	F	rural		918		267.0	44.5	16.67
199	Hufingen	RO	F	rural		919		266.0	46.5	17.48
199	Hufingen	RO	F	rural		920		263.5	50.5	19.17
199	Hufingen	RO	F	rural		921		259.0	44.5	17.18
199	Hufingen	RO	F	rural		922		253.0	41.0	16.21
200	Pfaffenhofen	RO	F	rural		943		274.0	47.0	17.15
200	Pfaffenhofen	RO	F	rural		944		284.0	55.0	19.37
200	Pfaffenhofen	RO	F	rural		945		262.0	45.0	17.18
201	Wehringen	RO	F	villa		946		259.0	47.5	18.34
202	Penzlin	NAT	F	rural		949	H	251.6	45.6	18.12
202	Penzlin	NAT	F	rural		950	H?	256.0	45.0	17.58
202	Penzlin	NAT	F	rural		951	H?	242.0	41.7	17.23
202	Penzlin	NAT	F	rural		952	H	251.3	45.0	17.91
202	Penzlin	NAT	F	rural		953		240.0	40.5	16.88
202	Penzlin	NAT	F	rural		954	H*	249.0	48.8	19.60
202	Penzlin	NAT	F	rural		955	H	230.3	43.5	18.89
202	Penzlin	NAT	F	rural		956	H	243.8	43.4	17.80
203	Tac-Gorsium	RO	G	urb		960	H?	238.5	43.0	18.03
203	Tac-Gorsium	RO	G	urb		961	H*	246.0	48.0	19.51
203	Tac-Gorsium	RO	G	urb		962	H*	247.0	48.0	19.43
203	Tac-Gorsium	RO	G	urb		963	H	248.0	48.0	19.35
203	Tac-Gorsium	RO	G	urb		964	M?	250.0	42.0	16.80
203	Tac-Gorsium	RO	G	urb		965	H	253.0	48.5	19.17
203	Tac-Gorsium	RO	G	urb		966	H*	256.0	51.0	19.92
203	Tac-Gorsium	RO	G	urb		967	D*	257.0	41.5	16.15
203	Tac-Gorsium	RO	G	urb		968	H	258.5	47.5	18.38
203	Tac-Gorsium	RO	G	urb		969	H*	259.0	47.0	18.15
203	Tac-Gorsium	RO	G	urb		970	M	260.0	44.5	17.12

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
203	Tac-Gorsium	RO	G	urb		971		260.0	48.5	18.65
203	Tac-Gorsium	RO	G	urb		972		262.0	49.0	18.70
203	Tac-Gorsium	RO	G	urb		973		262.0	49.0	18.70
203	Tac-Gorsium	RO	G	urb		974	H*	262.5	51.0	19.43
203	Tac-Gorsium	RO	G	urb		975	M*	263.5	47.0	17.84
203	Tac-Gorsium	RO	G	urb		976	H*	264.0	48.0	18.18
203	Tac-Gorsium	RO	G	urb		978	H*	266.0	47.5	17.86
203	Tac-Gorsium	RO	G	urb		979	H	267.0	48.0	17.98
203	Tac-Gorsium	RO	G	urb		981	M*	270.0	46.5	17.22
203	Tac-Gorsium	RO	G	urb		983	H?	270.5	50.5	18.67
203	Tac-Gorsium	RO	G	urb		984	H?	271.5	50.0	18.42
203	Tac-Gorsium	RO	G	urb		985	H*	271.5	51.5	18.97
203	Tac-Gorsium	RO	G	urb		986		275.0	50.0	18.18
203	Tac-Gorsium	RO	G	urb		987	M*	277.0	50.5	18.23
203	Tac-Gorsium	RO	G	urb		989		280.0	51.0	18.21
203	Tac-Gorsium	RO	G	urb		990	M?	282.0	52.0	18.44
203	Tac-Gorsium	RO	G	urb		991	M*	282.5	46.5	16.46
203	Tac-Gorsium	RO	G	urb		992	H?	282.5	53.0	18.76
203	Tac-Gorsium	RO	G	urb		993	H?	283.5	52.5	18.52
203	Tac-Gorsium	RO	G	urb		994	M*	286.0	47.0	16.43
203	Tac-Gorsium	RO	G	urb		995	M*	289.0	53.0	18.34
203	Tac-Gorsium	RO	G	urb		997	M*	296.0	54.0	18.24
203	Tac-Gorsium	RO	G	urb		1057	D	212.0	35.0	16.51
204	Conchil	RO	D	rural		1059		256.8	47.0	18.30
204	Conchil	RO	D	rural		1060		256.0	47.3	18.48
206	Lauriacum	RO	F	oth		1072		260.0	47.5	18.27
206	Lauriacum	RO	F	oth		1073		288.0	50.5	17.53
206	Lauriacum	RO	F	oth		1075		213.0	33.0	15.49
208	Colonia Ulpia Traiana	RO	F	urb		1076		278.5	50.0	17.95
208	Colonia Ulpia Traiana	RO	F	urb		1077		276.5	50.0	18.08
208	Colonia Ulpia Traiana	RO	F	urb		1078		272.0	50.0	18.38
208	Colonia Ulpia Traiana	RO	F	urb		1079		271.5	48.0	17.68
208	Colonia Ulpia Traiana	RO	F	urb		1080		270.5	50.5	18.67
208	Colonia Ulpia Traiana	RO	F	urb		1081		267.0	51.0	19.10
208	Colonia Ulpia Traiana	RO	F	urb		1082		266.0	48.0	18.05
208	Colonia Ulpia Traiana	RO	F	urb		1083		266.0	51.5	19.36
211	Castillar de Mendavia	IA	B	rural		1090		262.5	48.0	18.29
211	Castillar de Mendavia	IA	B	rural		1091		257.0	46.0	17.90
211	Castillar de Mendavia	IA	B	rural		1092		255.0	44.0	17.25
212	Gournay	IA	D	cem		1093	H*	245.0	43.0	17.55
212	Gournay	IA	D	cem		1094	M	233.0	40.0	17.17
212	Gournay	IA	D	cem		1095	D*	267.0	40.0	14.98
213	Beauvais	IA	D	rural		1096	H	233.0	41.0	17.60
213	Beauvais	IA	D	rural		1097	H*	247.0	43.0	17.41
213	Beauvais	IA	D	rural		1098	M*	259.0	41.5	16.02
213	Beauvais	IA	D	rural		1099	H	249.0	45.0	18.07
213	Beauvais	IA	D	rural		1100	M?	242.0	39.0	16.12
213	Beauvais	IA	D	rural		1101	H	225.0	40.0	17.78
213	Beauvais	IA	D	rural		1102	M*	284.0	51.0	17.96
214	Compiegne	IA	D	rural		1103	H?	242.0	44.0	18.18
214	Compiegne	IA	D	rural		1104	H	253.0	46.5	18.38
215	Ribemont	IA	D	oth		1105	H	226.0	42.0	18.58
215	Ribemont	IA	D	oth		1106	H	228.0	42.0	18.42
215	Ribemont	IA	D	oth		1107	H*	232.0	43.5	18.75
216	Variscourt	IA	D	rural		1108	H	230.0	43.0	18.70
216	Variscourt	IA	D	rural		1109	H*	231.0	41.0	17.75

Site no	Site name	Period	Region	Site type	Specimen	Bone no	ID	GL	Bd	Index
216	Variscourt	IA	D	rural		1110	H	232.0	42.6	18.36
216	Variscourt	IA	D	rural		1111	H*	246.0	43.0	17.48
216	Variscourt	IA	D	rural		1112	H?	249.0	41.0	16.47
216	Variscourt	IA	D	rural		1113	M*	248.0	44.0	17.74
217	Soissons	IA	D	cem		1114	D	213.0	34.0	15.96

Table A32. – Results of the calculation of the shaft breadth to greatest length index on the Tibiae

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
10	Twywell	IA	E	rural	345			316.0	35.0	11.08
14	Lincoln	RO	E	urb	343			311.0	31.8	10.23
15	Scole-Dickleburgh	RO	E	urb2	339			340.0	34.1	10.03
15	Scole-Dickleburgh	RO	E	urb2	342			344.6	42.7	12.39
27	Lynch Farm	RO	E	villa	322			366.0	48.0	13.11
27	Lynch Farm	IA	E	villa	323			317.0	37.0	11.67
28	Longthorpe II	RO	E	mil	318			325.0	47.0	14.46
28	Longthorpe II	RO	E	mil	319			387.0	54.0	13.95
28	Longthorpe II	RO	E	mil	320			332.0	46.0	13.86
35	Castricum-Oosterbuurt	RO	F	oth	301	1		350.0	37.5	10.71
35	Castricum-Oosterbuurt	RO	F	oth	307			343.0	36.7	10.71
37	Kesteren 'De Prinsenhof'	RO	F	cem	283	HKKO-35		346.0	40.9	11.82
37	Kesteren 'De Prinsenhof'	RO	F	cem	286	11-36		365.0	44.5	12.19
37	Kesteren 'De Prinsenhof'	RO	F	cem	288	11-34		365.0	41.5	11.37
37	Kesteren 'De Prinsenhof'	RO	F	cem	289	11-28		374.0	42.8	11.44
37	Kesteren 'De Prinsenhof'	RO	F	cem	292	6-28		378.0	42.1	11.14
37	Kesteren 'De Prinsenhof'	RO	F	cem	294	1-21		388.0	45.3	11.68
37	Kesteren 'De Prinsenhof'	RO	F	cem	296	1-11		376.0	43.2	11.49
38	Nijmegen	RO	F	urb	262			372.0	41.4	11.13
38	Nijmegen	RO	F	urb	263			379.1	40.5	10.68
38	Nijmegen	RO	F	urb	264		M*	370.0	39.1	10.57
38	Nijmegen	RO	F	urb	270		M	381.0	41.6	10.92
38	Nijmegen	RO	F	urb	271		M*	362.3	38.9	10.74
38	Nijmegen	RO	F	urb	272		M?	364.6	40.6	11.14
38	Nijmegen	RO	F	urb	274		M*	349.4	36.6	10.48
38	Nijmegen	RO	F	urb	275			376.5	41.4	11.00
38	Nijmegen	RO	F	urb	277		H	335.8	40.7	12.12
42	Druten	RO	F	villa	245			344.0	38.5	11.19
42	Druten	RO	F	villa	246			352.0	37.6	10.68
42	Druten	RO	F	villa	247		M*	372.6	43.5	11.67
42	Druten	RO	F	villa	249		M	390.6	46.4	11.88
42	Druten	RO	F	villa	250	12.4		342.5	45.1	13.17
42	Druten	RO	F	villa	251	12.2	H*	374.2	48.3	12.91
42	Druten	RO	F	villa	252	1.18	M*	379.6	46.8	12.33
43	Elms Farm	IA	E	urb2	238			356.0	43.8	12.30
44	Danebury	IA	E	rural	205			311.0	33.2	10.68
44	Danebury	IA	E	rural	214			295.0	32.1	10.88
44	Danebury	IA	E	rural	219			303.0	34.0	11.22
44	Danebury	IA	E	rural	222			322.5	37.2	11.53
44	Danebury	IA	E	rural	224			321.5	36.4	11.32

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
44	Danebury	IA	E	rural	228			308.0	34.9	11.33
44	Danebury	IA	E	rural	229			329.0	34.3	10.43
46	E London RB Cemetary	RO	E	cem	192		H?	346.0	42.5	12.28
46	E London RB Cemetary	RO	E	cem	196		H	359.0	40.4	11.25
46	E London RB Cemetary	RO	E	cem	198			311.5	36.6	11.75
54	Thorpe Thewles	RO	E	rural	181			319.9	32.3	10.10
54	Thorpe Thewles	IA	E	rural	182			320.9	38.9	12.12
54	Thorpe Thewles	IA	E	rural	184			299.9	33.6	11.20
59	Chichester cattlemarket	RO	E	urb	176	XXIII		361.2	44.6	12.35
59	Chichester cattlemarket	RO	E	urb	177	XXIII		364.2	44.5	12.22
63	S. Giacomo	RO	A	villa	172			342.0	38.8	11.35
63	S. Giacomo	RO	A	villa	173		M*	364.0	43.2	11.87
67	Ilchester,Church Street	RO	E	urb	170	F267		351.0	45.0	12.82
68	Lutton/Huntingdon	RO	E	rural	169			340.0	34.7	10.21
69	Thorley	RO	E	rural	167			313.0	40.1	12.80
71	Piovego	IA	A	cem	164	N2		347.0	37.0	10.66
72	Colle dei Cappuccini	IA	A	rural	163			329.0	35.0	10.64
77	Grotto di Tibera	RO	A	oth	161	15.1		369.0	38.0	10.30
79	Olbia	IA	A	rural	160			255.6	26.6	10.41
81	Welsow	NAT	F	rural	158			206.5	28.4	13.75
87	Manching	IA	F	rural	147		H?	291.0	31.0	10.65
87	Manching	IA	F	rural	148			295.0	33.0	11.19
87	Manching	IA	F	rural	149			302.0	33.0	10.93
87	Manching	IA	F	rural	150			310.0	35.0	11.29
87	Manching	IA	F	rural	151			311.0	32.5	10.45
87	Manching	IA	F	rural	152		H?	312.0	33.5	10.74
87	Manching	IA	F	rural	153			319.0	32.0	10.03
87	Manching	IA	F	rural	154		H?	321.0	32.0	9.97
87	Manching	IA	F	rural	155			336.0	35.0	10.42
92	Feddersen Wierde	NAT	F	rural	27	skelett3L	M	355.0	39.0	10.99
92	Feddersen Wierde	NAT	F	rural	28	skelett2R	H	323.1	36.4	11.27
92	Feddersen Wierde	NAT	F	rural	29	skelett2L	H	323.6	36.1	11.16
92	Feddersen Wierde	NAT	F	rural	32			335.1	35.6	10.62
92	Feddersen Wierde	NAT	F	rural	33		D?	338.0	36.8	10.89
92	Feddersen Wierde	NAT	F	rural	34			329.7	36.4	11.04
92	Feddersen Wierde	NAT	F	rural	35		M?	325.3	36.0	11.07
92	Feddersen Wierde	NAT	F	rural	36		H?	317.7	33.9	10.67
92	Feddersen Wierde	NAT	F	rural	37		D*	339.7	36.0	10.60
92	Feddersen Wierde	NAT	F	rural	38		D?	314.1	35.2	11.21
96	Kunzing east vicus	RO	F	cem	2	1703	M	367.0	42.0	11.44
96	Kunzing east vicus	RO	F	cem	3	1641	M	364.0	39.7	10.91
96	Kunzing east vicus	RO	F	cem	5	1575/5		354.0	40.7	11.50
96	Kunzing east vicus	RO	F	cem	6	1620	H*	364.5	42.4	11.63
96	Kunzing east vicus	RO	F	cem	7	1632	M	366.0	43.0	11.75
103	Newstead fort	RO	E	mil	383			335.0	36.7	10.96
104	Orton Hall Farm	RO	E	villa	384			360.0	46.0	12.78
104	Orton Hall Farm	RO	E	villa	385			356.0	50.0	14.04
104	Orton Hall Farm	RO	E	villa	386			332.0	44.0	13.25
104	Orton Hall Farm	RO	E	villa	387			304.0	38.0	12.50
104	Orton Hall Farm	RO	E	villa	388			354.0	46.0	12.99
104	Orton Hall Farm	RO	E	villa	389			347.0	45.0	12.97
105	Mons Claudianus	RO	K	ind	390			372.0	38.6	10.38
105	Mons Claudianus	RO	K	ind	391	665		350.0	38.1	10.89
105	Mons Claudianus	RO	K	ind	392			350.0	36.0	10.29
105	Mons Claudianus	RO	K	ind	393			345.0	37.6	10.90
105	Mons Claudianus	RO	K	ind	394	662		345.0	37.5	10.87

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
105	Mons Claudianus	RO	K	ind	395	717	D*	338.0	36.6	10.83
105	Mons Claudianus	RO	K	ind	396	600	D*	333.0	35.2	10.57
105	Mons Claudianus	RO	K	ind	397	855		333.0	36.2	10.87
105	Mons Claudianus	RO	K	ind	398	854		333.0	37.2	11.17
105	Mons Claudianus	RO	K	ind	399			330.0	34.9	10.58
105	Mons Claudianus	RO	K	ind	400			330.0	36.2	10.97
105	Mons Claudianus	RO	K	ind	401			326.7	38.0	11.63
105	Mons Claudianus	RO	K	ind	402			320.0	36.0	11.25
110	Nijmegen new excavations	RO	F	urb	483	147/128-20	H?	376.5	42.8	11.37
112	Pompeii, Sarno Baths	RO	A	urb	489	D		345.5	38.0	11.00
114	Unterlaa	RO	G	urb	490	21		335.0	37.3	11.13
114	Unterlaa	RO	G	urb	491	23A	H	332.0	37.7	11.36
114	Unterlaa	RO	G	urb	493	68	H?	331.0	36.4	11.00
114	Unterlaa	RO	G	urb	494	71	H	347.0	37.6	10.84
115	Bad Wimpfen	RO	F	urb2	496		M	368.5	41.0	11.13
115	Bad Wimpfen	RO	F	urb2	497			345.0	41.0	11.88
115	Bad Wimpfen	RO	F	urb2	511	Skele 4		354.0	39.1	11.05
116	Pommeroeul	RO	D	urb2	513	348	H	323.0	34.0	10.53
116	Pommeroeul	RO	D	urb2	514	17-1	H?	324.0	36.0	11.11
116	Pommeroeul	RO	D	urb2	515	238	H*	327.0	35.0	10.70
116	Pommeroeul	RO	D	urb2	516	224		344.0	34.0	9.88
116	Pommeroeul	RO	D	urb2	517	32	M?	352.0	36.0	10.23
116	Pommeroeul	RO	D	urb2	518	373	M*	373.0	41.0	10.99
116	Pommeroeul	RO	D	urb2	519	294	H?	373.0	44.0	11.80
116	Pommeroeul	RO	D	urb2	520	294-2	M?	375.0	43.0	11.47
116	Pommeroeul	RO	D	urb2	521	198		381.0	40.0	10.50
116	Pommeroeul	RO	D	urb2	522	17-2		392.0	39.0	9.95
117	Pompeii stable	RO	A	urb	526	B		360.0	39.0	10.83
117	Pompeii stable	RO	A	urb	527	C		360.0	40.0	11.11
117	Pompeii stable	RO	A	urb	529	E		348.0	40.0	11.49
118	Carnuntum	RO	G	mil	530	Pferd 1	M	413.0	44.5	10.77
118	Carnuntum	RO	G	mil	531	Pferd 2	H	364.5	42.0	11.52
118	Carnuntum	RO	G	mil	532	Pferd 3	H	363.5	42.0	11.55
118	Carnuntum	RO	G	mil	533	Maultier 1	M*	377.0	45.2	11.99
118	Carnuntum	RO	G	mil	534		H?	361.0	39.7	11.00
119	Albertfalva	RO	G	mil	535	Horse 1		361.1	42.0	11.63
119	Albertfalva	RO	G	mil	536	Horse 2		401.0	48.1	12.00
120	Basel-Gasfabrik	IA	F	rural	537		H	310.5	35.2	11.34
120	Basel-Gasfabrik	IA	F	rural	538		H	320.1	37.5	11.72
120	Basel-Gasfabrik	IA	F	rural	541			296.4	30.4	10.26
121	Soluthurn/Vigier	RO	F	urb2	550		M*	341.0	38.3	11.23
121	Soluthurn/Vigier	RO	F	urb2	551			359.0	40.8	11.36
121	Soluthurn/Vigier	RO	F	urb2	552			340.0	37.0	10.88
121	Soluthurn/Vigier	RO	F	urb2	553			355.0	40.0	11.27
125	Castleford	RO	E	mil	562			363.0	43.5	11.98
125	Castleford	RO	E	mil	563			363.0	43.5	11.98
127	Tortoreto-Fortellezza	IA	A	rural	569			295.0	32.0	10.85
128	Krefeld-Gellep	RO	F	mil	572	3573	M	378.0	44.0	11.64
128	Krefeld-Gellep	RO	F	mil	574	3510	D*	295.0	31.5	10.68
129	Lorenzberg Bei Epfach	RO	F	oth	578			355.0	40.0	11.27
129	Lorenzberg Bei Epfach	RO	F	oth	581			345.0	37.0	10.72
133	Colchester	RO	E	urb	589			320.0	37.0	11.56
133	Colchester	RO	E	urb	593			332.0	38.0	11.45
133	Colchester	RO	E	urb	594			279.0	32.0	11.47
135	Swestari	IA	G	cem	598	1	H	321.0	37.5	11.68
135	Swestari	IA	G	cem	599	2	H	321.5	36.0	11.20

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
135	Swestari	IA	G	cem	600	3	H	327.0	39.0	11.93
135	Swestari	IA	G	cem	602	5	M	382.0	43.0	11.26
137	Magdelenska Gora	IA	G	cem	605	V, 29, I		342.0	34.0	9.94
137	Magdelenska Gora	IA	G	cem	606	V, 29, II		335.0	33.5	10.00
137	Magdelenska Gora	IA	G	cem	607	V, 29, III		335.0	36.0	10.75
141	Szentes-Vekerzug	IA	G	cem	610	6		341.0	37.0	10.85
142	Velemszentvid	IA	G	cem	611	54.448.1		352.0	43.0	12.22
142	Velemszentvid	IA	G	cem	612	54.448.2		356.0	38.5	10.81
146	Balatonaliga	RO	G	rural	613	621a		363.0	42.0	11.57
151	Gyor Szechenyi-Ter	RO	G	rural	614			385.0	48.0	12.47
156	Invillino- Ibliglo	RO	A	oth	616		M*	349.0	36.7	10.52
156	Invillino- Ibliglo	RO	A	oth	617			348.0	36.5	10.49
173	Paestum	RO	A	rural	632			339.5	38.0	11.19
174	Abusina-Eining	RO	F	mil	633			391.0	42.0	10.74
174	Abusina-Eining	RO	F	mil	634		M*	388.0	48.0	12.37
174	Abusina-Eining	RO	F	mil	635			367.0	42.0	11.44
176	Oberdorla	NAT	F	cem	643		M	348.0	37.0	10.63
176	Oberdorla	NAT	F	cem	644		D*	341.0	38.0	11.14
176	Oberdorla	NAT	F	cem	645			335.0	43.0	12.84
176	Oberdorla	NAT	F	cem	646		D*	334.0	35.0	10.48
176	Oberdorla	NAT	F	cem	647			320.0	39.0	12.19
176	Oberdorla	NAT	F	cem	648			319.0	39.0	12.23
176	Oberdorla	NAT	F	cem	649			318.0	39.0	12.26
176	Oberdorla	NAT	F	cem	650			317.0	34.0	10.73
176	Oberdorla	NAT	F	cem	651			314.0	35.0	11.15
178	Vitudurum-Oberwinterthur	RO	F	urb2	660			343.0	39.4	11.49
178	Vitudurum-Oberwinterthur	RO	F	urb2	661			339.0	39.5	11.65
186	Shakenoak site K	RO	E	villa	682			317.0	36.0	11.36
192	Pfaffenhofen - Pons Aeni	RO	F	rural	701		M	360.0	41.0	11.39
199	Hufingen	RO	F	rural	715			368.0	40.5	11.01
199	Hufingen	RO	F	rural	716		M	366.5	39.5	10.78
199	Hufingen	RO	F	rural	717		D*	366.0	38.0	10.38
199	Hufingen	RO	F	rural	718		H?	358.0	42.5	11.87
199	Hufingen	RO	F	rural	719		M?	352.0	37.5	10.65
199	Hufingen	RO	F	rural	720			348.0	38.0	10.92
199	Hufingen	RO	F	rural	721			345.0	42.0	12.17
201	Wehringen	RO	F	villa	758		H?	333.0	37.0	11.11
201	Wehringen	RO	F	villa	759		H	340.0	38.0	11.18
203	Tac-Gorsium	RO	G	urb	765			336.0	37.5	11.16
203	Tac-Gorsium	RO	G	urb	766			336.0	39.0	11.61
203	Tac-Gorsium	RO	G	urb	767			338.0	39.5	11.69
203	Tac-Gorsium	RO	G	urb	768			339.0	39.0	11.50
203	Tac-Gorsium	RO	G	urb	769			340.0	39.5	11.62
203	Tac-Gorsium	RO	G	urb	770			340.0	38.5	11.32
203	Tac-Gorsium	RO	G	urb	771			342.0	40.0	11.70
203	Tac-Gorsium	RO	G	urb	772			345.0	39.5	11.45
203	Tac-Gorsium	RO	G	urb	773			354.0	42.5	12.01
203	Tac-Gorsium	RO	G	urb	774			365.0	41.5	11.37
203	Tac-Gorsium	RO	G	urb	775			372.0	44.0	11.83
203	Tac-Gorsium	RO	G	urb	776			383.0	45.0	11.75
203	Tac-Gorsium	RO	G	urb	777			387.0	43.0	11.11
203	Tac-Gorsium	RO	G	urb	778			406.0	48.0	11.82
204	Conchil	RO	D	rural	837			347.5	41.0	11.80
204	Conchil	RO	D	rural	839			357.0	44.4	12.44
205	Oberstimm	RO	F	mil	841		M*	353.0	38.3	10.85
208	Colonia Ulpia Traiana	RO	F	urb	856		M*	367.0	40.5	11.04

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	SD	Index
208	Colonia Ulpia Traiana	RO	F	urb	857		H?	367.0	43.0	11.72
208	Colonia Ulpia Traiana	RO	F	urb	858		M*	367.0	39.0	10.63
208	Colonia Ulpia Traiana	RO	F	urb	859			365.0	39.5	10.82
208	Colonia Ulpia Traiana	RO	F	urb	860		M*	351.0	39.0	11.11
208	Colonia Ulpia Traiana	RO	F	urb	861			346.0	38.0	10.98
213	Beauvais	IA	D	rural	868			284.0	31.5	11.09
213	Beauvais	IA	D	rural	869			300.0	29.5	9.83
213	Beauvais	IA	D	rural	870			300.0	34.0	11.33
213	Beauvais	IA	D	rural	871			320.0	35.0	10.94
213	Beauvais	IA	D	rural	872			309.0	31.5	10.19
214	Compiegne	IA	D	rural	876			348.0	38.0	10.92
215	Ribemont	IA	D	oth	880			308.0	36.0	11.69
215	Ribemont	IA	D	oth	881			320.0	35.0	10.94
215	Ribemont	IA	D	oth	882			328.0	34.0	10.37
215	Ribemont	IA	D	oth	883			319.0	36.0	11.29
215	Ribemont	IA	D	oth	884			319.0	35.5	11.13
215	Ribemont	IA	D	oth	885			331.0	38.5	11.63
215	Ribemont	IA	D	oth	886			305.0	35.0	11.48
215	Ribemont	IA	D	oth	887			313.0	33.0	10.54
216	Variscourt	IA	D	rural	893			315.0	36.5	11.59
217	Soissons	IA	D	cem	894			277.0	29.0	10.47

Table A33. – Results of the calculation of the distal breadth to greatest length index on the Tibiae

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	Bd	Index
5	Beckford	IA	E	rural	349			314.0	60.0	19.11
10	Twywell	IA	E	rural	345			316.0	56.0	17.72
14	Lincoln	RO	E	urb	343			311.0	61.5	19.77
15	Scole-Dickleburgh	RO	E	urb2	339			340.0	64.4	18.94
15	Scole-Dickleburgh	RO	E	urb2	342			344.6	75.3	21.85
27	Lynch Farm	RO	E	villa	322			366.0	70.0	19.13
27	Lynch Farm	IA	E	villa	323			317.0	57.0	17.98
28	Longthorpe II	RO	E	mil	319			387.0	84.0	21.71
28	Longthorpe II	RO	E	mil	320			332.0	65.0	19.58
35	Castricum-Oosterbuurt	RO	F	oth	301	1		350.0	69.3	19.79
35	Castricum-Oosterbuurt	RO	F	oth	307			343.0	73.0	21.27
37	Kesteren 'De Prinsenhof'	RO	F	cem	286	11-36		365.0	77.4	21.21
37	Kesteren 'De Prinsenhof'	RO	F	cem	288	11-34		365.0	75.9	20.79
37	Kesteren 'De Prinsenhof'	RO	F	cem	289	11-28		374.0	78.3	20.94
37	Kesteren 'De Prinsenhof'	RO	F	cem	292	6-28		378.0	77.0	20.37
37	Kesteren 'De Prinsenhof'	RO	F	cem	294	6-21		388.0	79.4	20.46
37	Kesteren 'De Prinsenhof'	RO	F	cem	296	1-11		376.0	77.8	20.69
38	Nijmegen	RO	F	urb	262			372.0	69.5	18.68
38	Nijmegen	RO	F	urb	263			379.1	76.3	20.13
38	Nijmegen	RO	F	urb	264		M*	370.0	68.6	18.54
38	Nijmegen	RO	F	urb	270		M	381.0	72.4	19.00
38	Nijmegen	RO	F	urb	271		M*	362.3	70.6	19.49
38	Nijmegen	RO	F	urb	272		M?	364.6	71.7	19.67
38	Nijmegen	RO	F	urb	274		M*	349.4	67.7	19.38

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	Bd	Index
38	Nijmegen	RO	F	urb	275			376.5	73.5	19.52
38	Nijmegen	RO	F	urb	277		H	335.8	72.8	21.68
42	Druten	RO	F	villa	245			344.0	71.7	20.84
42	Druten	RO	F	villa	246			352.0	74.0	21.02
42	Druten	RO	F	villa	247		M*	372.6	73.6	19.75
42	Druten	RO	F	villa	249		M	390.6	79.2	20.28
42	Druten	RO	F	villa	250	12.4		342.5	81.4	23.77
42	Druten	RO	F	villa	252	1.18	M*	379.6	76.4	20.13
43	Elms Farm	IA	E	urb2	238			356.0	80.1	22.50
44	Danebury	IA	E	rural	200			294.0	57.5	19.56
44	Danebury	IA	E	rural	205			311.0	60.0	19.29
44	Danebury	IA	E	rural	208			303.5	63.6	20.96
44	Danebury	IA	E	rural	209			305.0	63.6	20.85
44	Danebury	IA	E	rural	214			295.0	59.2	20.07
44	Danebury	IA	E	rural	219			303.0	62.2	20.53
44	Danebury	IA	E	rural	222			322.5	66.5	20.62
44	Danebury	IA	E	rural	224			321.5	66.5	20.68
44	Danebury	IA	E	rural	225			342.7	67.7	19.75
44	Danebury	IA	E	rural	226			316.4	61.5	19.44
44	Danebury	IA	E	rural	228			308.0	63.2	20.52
46	E London RB Cemetary	RO	E	cem	192		H?	346.0	68.8	19.88
46	E London RB Cemetary	RO	E	cem	196		H	359.0	78.3	21.81
46	E London RB Cemetary	RO	E	cem	198			311.5	60.3	19.36
54	Thorpe Thewles	RO	E	rural	181			319.9	62.9	19.66
54	Thorpe Thewles	IA	E	rural	182			320.9	68.2	21.25
54	Thorpe Thewles	IA	E	rural	184			299.9	59.2	19.74
59	Chichester cattlemarket	RO	E	urb	176	XXIII		361.2	79.9	22.12
59	Chichester cattlemarket	RO	E	urb	177	XXIII		364.2	80.1	21.99
63	S. Giacomo	RO	A	villa	172			342.0	61.0	17.84
63	S. Giacomo	RO	A	villa	173		M*	364.0	74.4	20.44
67	Ilchester,Church Street	RO	E	urb	170	F267		351.0	77.0	21.94
68	Lutton/Huntingdon	RO	E	rural	169			340.0	66.5	19.56
69	Thorley	RO	E	rural	167			313.0	62.6	20.00
71	Piovego	IA	A	cem	164	N2		347.0	71.0	20.46
72	Colle dei Cappuccini	IA	A	rural	163			329.0	63.0	19.15
77	Grotto di Tibera	RO	A	oth	161	15.1		369.0	71.0	19.24
79	Olbia	IA	A	rural	160			255.6	50.5	19.76
81	Welsow	NAT	F	rural	158			206.5	45.2	21.89
87	Manching	IA	F	rural	147		H?	291.0	57.0	19.59
87	Manching	IA	F	rural	149			302.0	58.5	19.37
87	Manching	IA	F	rural	150			310.0	61.0	19.68
87	Manching	IA	F	rural	151			311.0	62.0	19.94
87	Manching	IA	F	rural	152		H?	312.0	65.5	20.99
87	Manching	IA	F	rural	153			319.0	62.5	19.59
87	Manching	IA	F	rural	154		H?	321.0	59.5	18.54
87	Manching	IA	F	rural	155			336.0	69.0	20.54
92	Feddersen Wierde	NAT	F	rural	27	skelett3L	M	355.0	71.0	20.00
92	Feddersen Wierde	NAT	F	rural	28	skelett2R	H	323.1	67.5	20.89
92	Feddersen Wierde	NAT	F	rural	29	skelett2L	H	323.6	67.4	20.83
92	Feddersen Wierde	NAT	F	rural	31	skelett1L		344.5	72.2	20.96
92	Feddersen Wierde	NAT	F	rural	32			335.1	71.1	21.22
92	Feddersen Wierde	NAT	F	rural	33		D?	338.0	71.2	21.07
92	Feddersen Wierde	NAT	F	rural	34			329.7	66.0	20.02
92	Feddersen Wierde	NAT	F	rural	35		M?	325.3	61.9	19.03
92	Feddersen Wierde	NAT	F	rural	36		H?	317.7	65.5	20.62
92	Feddersen Wierde	NAT	F	rural	37		D*	339.7	70.5	20.75

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	Bd	Index
92	Feddersen Wierde	NAT	F	rural	38		D?	314.1	64.5	20.53
96	Kunzing east vicus	RO	F	cem	2	1703	M	367.0	74.5	20.30
96	Kunzing east vicus	RO	F	cem	3	1641	M	364.0	72.6	19.95
96	Kunzing east vicus	RO	F	cem	5	1575/5		354.0	72.0	20.34
96	Kunzing east vicus	RO	F	cem	6	1620	H*	364.5	73.3	20.11
96	Kunzing east vicus	RO	F	cem	7	1632	M	366.0	74.6	20.38
103	Newstead fort	RO	E	mil	383			335.0	70.3	20.99
104	Orton Hall Farm	RO	E	villa	384			360.0	65.0	18.06
104	Orton Hall Farm	RO	E	villa	385			356.0	70.0	19.66
104	Orton Hall Farm	RO	E	villa	386			332.0	67.0	20.18
104	Orton Hall Farm	RO	E	villa	387			304.0	61.0	20.07
104	Orton Hall Farm	RO	E	villa	388			354.0	67.0	18.93
104	Orton Hall Farm	RO	E	villa	389			347.0	69.0	19.88
105	Mons Claudianus	RO	K	ind	391	665		350.0	69.4	19.83
105	Mons Claudianus	RO	K	ind	393			345.0	65.4	18.96
105	Mons Claudianus	RO	K	ind	394	662		345.0	68.5	19.86
105	Mons Claudianus	RO	K	ind	395	717	D*	338.0	63.5	18.79
105	Mons Claudianus	RO	K	ind	396	600	D*	333.0	67.5	20.27
105	Mons Claudianus	RO	K	ind	398	854		333.0	63.8	19.16
105	Mons Claudianus	RO	K	ind	399			330.0	58.8	17.82
105	Mons Claudianus	RO	K	ind	401			326.7	64.2	19.65
105	Mons Claudianus	RO	K	ind	402			320.0	65.3	20.41
105	Mons Claudianus	RO	K	ind	403	1108		310.0	57.2	18.45
110	Nijmegen new excavations	RO	F	urb	483	147/128-20	H?	376.5	81.4	21.62
112	Pompeii, Sarno Baths	RO	A	urb	489	D		345.5	71.5	20.69
114	Unterlaa	RO	G	urb	490	21		335.0	70.5	21.04
114	Unterlaa	RO	G	urb	491	23A	H	332.0	66.9	20.15
114	Unterlaa	RO	G	urb	493	68	H?	331.0	68.4	20.66
114	Unterlaa	RO	G	urb	494	71	H	347.0	70.7	20.37
115	Bad Wimpfen	RO	F	urb2	496		M	368.5	73.0	19.81
115	Bad Wimpfen	RO	F	urb2	497			345.0	72.3	20.96
115	Bad Wimpfen	RO	F	urb2	511	Skele 4		354.0	70.3	19.86
116	Pommeroeul	RO	D	urb2	513	348	H	323.0	66.0	20.43
116	Pommeroeul	RO	D	urb2	514	17-1	H?	324.0	67.0	20.68
116	Pommeroeul	RO	D	urb2	515	238	H*	327.0	63.0	19.27
116	Pommeroeul	RO	D	urb2	516	224		344.0	67.0	19.48
116	Pommeroeul	RO	D	urb2	517	32	M?	352.0	69.0	19.60
116	Pommeroeul	RO	D	urb2	518	373	M*	373.0	77.0	20.64
116	Pommeroeul	RO	D	urb2	519	294	H?	373.0	79.0	21.18
116	Pommeroeul	RO	D	urb2	520	294-2	M?	375.0	78.0	20.80
116	Pommeroeul	RO	D	urb2	521	198		381.0	76.0	19.95
117	Pompeii stable	RO	A	urb	526	B		360.0	74.0	20.56
117	Pompeii stable	RO	A	urb	527	C		360.0	74.0	20.56
117	Pompeii stable	RO	A	urb	529	E		348.0	68.0	19.54
118	Carnuntum	RO	G	mil	530	Pferd 1	M	413.0	83.8	20.29
118	Carnuntum	RO	G	mil	531	Pferd 2	H	364.5	80.2	22.00
118	Carnuntum	RO	G	mil	532	Pferd 3	H	363.5	77.7	21.38
118	Carnuntum	RO	G	mil	533	Maultier 1	M*	377.0	81.5	21.62
118	Carnuntum	RO	G	mil	534		H?	361.0	73.5	20.36
119	Albertfalva	RO	G	mil	535	Horse 1		361.1	74.8	20.71
119	Albertfalva	RO	G	mil	536	Horse 2		401.0	80.3	20.02
120	Basel-Gasfabrik	IA	F	rural	537		H	310.5	62.7	20.19
120	Basel-Gasfabrik	IA	F	rural	538		H	320.1	63.9	19.96
120	Basel-Gasfabrik	IA	F	rural	541			296.4	59.6	20.11
121	Soluthurn/Vigier	RO	F	urb2	550		M*	341.0	70.0	20.53
121	Soluthurn/Vigier	RO	F	urb2	551			359.0	69.3	19.30

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	Bd	Index
121	Soluthurn/Vigier	RO	F	urb2	552			340.0	72.0	21.18
121	Soluthurn/Vigier	RO	F	urb2	553			355.0	76.0	21.41
124	Haddon	IA+RO	E	oth	557			322.0	66.0	20.50
124	Haddon	IA+RO	E	oth	559			318.0	68.4	21.51
124	Haddon	IA+RO	E	oth	560			360.0	71.0	19.72
125	Castleford	RO	E	mil	562			363.0	77.8	21.43
125	Castleford	RO	E	mil	563			363.0	77.8	21.43
127	Tortoreto-Fortellezza	IA	A	rural	569			295.0	56.0	18.98
128	Krefeld-Gellep	RO	F	mil	572	3573	M	378.0	73.0	19.31
128	Krefeld-Gellep	RO	F	mil	574	3510	D*	295.0	60.5	20.51
129	Lorenzberg Bei Epfach	RO	F	oth	578			355.0	73.0	20.56
129	Lorenzberg Bei Epfach	RO	F	oth	581			345.0	70.0	20.29
133	Colchester	RO	E	urb	589			320.0	66.0	20.63
133	Colchester	RO	E	urb	593			332.0	67.0	20.18
133	Colchester	RO	E	urb	594			279.0	55.0	19.71
135	Swestari	IA	G	cem	598	1	H	321.0	68.0	21.18
135	Swestari	IA	G	cem	599	2	H	321.5	66.0	20.53
135	Swestari	IA	G	cem	600	3	H	327.0	64.0	19.57
135	Swestari	IA	G	cem	601	4		355.0	77.5	21.83
135	Swestari	IA	G	cem	602	5	M	382.0	80.0	20.94
137	Magdelenska Gora	IA	G	cem	605	V, 29, I		342.0	65.0	19.01
137	Magdelenska Gora	IA	G	cem	606	V, 29, II		335.0	64.0	19.10
137	Magdelenska Gora	IA	G	cem	607	V, 29, III		335.0	68.0	20.30
141	Szentes-Vekerzug	IA	G	cem	610	6		341.0	64.5	18.91
142	Velemszentvid	IA	G	cem	611	54.448.1		352.0	72.5	20.60
142	Velemszentvid	IA	G	cem	612	54.448.2		356.0	73.0	20.51
151	Gyor Szechenyi-Ter	RO	G	rural	614			385.0	73.0	18.96
156	Invillino- Ibliglo	RO	A	oth	616		M*	349.0	70.0	20.06
156	Invillino- Ibliglo	RO	A	oth	617			348.0	70.0	20.11
161	San Giovanni	RO	A	villa	625			277.3	52.0	18.75
174	Abusina-Eining	RO	F	mil	633			391.0	75.5	19.31
174	Abusina-Eining	RO	F	mil	634		M*	388.0	78.0	20.10
176	Oberdorla	NAT	F	cem	643		M	348.0	66.0	18.97
176	Oberdorla	NAT	F	cem	644		D*	341.0	67.0	19.65
176	Oberdorla	NAT	F	cem	646		D*	334.0	64.0	19.16
176	Oberdorla	NAT	F	cem	647			320.0	64.0	20.00
176	Oberdorla	NAT	F	cem	648			319.0	63.0	19.75
176	Oberdorla	NAT	F	cem	649			318.0	64.0	20.13
176	Oberdorla	NAT	F	cem	650			317.0	60.0	18.93
176	Oberdorla	NAT	F	cem	651			314.0	60.0	19.11
178	Vitudurum-Oberwinterthur	RO	F	urb2	660			343.0	71.1	20.73
178	Vitudurum-Oberwinterthur	RO	F	urb2	661			339.0	70.7	20.86
181	Barnsley Park	RO	E	rural	667			340.0	70.0	20.59
181	Barnsley Park	RO	E	rural	668			355.0	71.0	20.00
182	Frocester Court	RO	E	villa	673			304.0	54.0	17.76
182	Frocester Court	RO	E	villa	674			316.0	67.0	21.20
186	Shakenoak site K	RO	E	villa	682			317.0	62.0	19.56
192	Pfaffenhofen - Pons Aeni	RO	F	rural	701		M	360.0	70.0	19.44
199	Hufingen	RO	F	rural	715			368.0	77.0	20.92
199	Hufingen	RO	F	rural	716		M	366.5	73.0	19.92
199	Hufingen	RO	F	rural	717		D*	366.0	75.5	20.63
199	Hufingen	RO	F	rural	718		H?	358.0	75.5	21.09
199	Hufingen	RO	F	rural	719		M?	352.0	72.0	20.45
199	Hufingen	RO	F	rural	720			348.0	74.0	21.26
199	Hufingen	RO	F	rural	721			345.0	71.5	20.72
201	Wehringen	RO	F	villa	758		H?	333.0	69.0	20.72

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	GL	Bd	Index
201	Wehringen	RO	F	villa	759		H	340.0	72.0	21.18
203	Tac-Gorsium	RO	G	urb	765			336.0	65.5	19.49
203	Tac-Gorsium	RO	G	urb	766			336.0	68.0	20.24
203	Tac-Gorsium	RO	G	urb	767			338.0	74.5	22.04
203	Tac-Gorsium	RO	G	urb	768			339.0	73.5	21.68
203	Tac-Gorsium	RO	G	urb	769			340.0	74.0	21.76
203	Tac-Gorsium	RO	G	urb	770			340.0	69.0	20.29
203	Tac-Gorsium	RO	G	urb	771			342.0	74.0	21.64
203	Tac-Gorsium	RO	G	urb	772			345.0	70.0	20.29
203	Tac-Gorsium	RO	G	urb	773			354.0	72.5	20.48
203	Tac-Gorsium	RO	G	urb	774			365.0	70.0	19.18
203	Tac-Gorsium	RO	G	urb	775			372.0	76.0	20.43
203	Tac-Gorsium	RO	G	urb	776			383.0	79.0	20.63
203	Tac-Gorsium	RO	G	urb	777			387.0	77.0	19.90
203	Tac-Gorsium	RO	G	urb	778			406.0	80.0	19.70
204	Conchil	RO	D	rural	837			347.5	69.7	20.06
204	Conchil	RO	D	rural	839			357.0	79.4	22.24
205	Oberstimm	RO	F	mil	841		M*	353.0	70.0	19.83
208	Colonia Ulpia Traiana	RO	F	urb	856		M*	367.0	75.5	20.57
208	Colonia Ulpia Traiana	RO	F	urb	857		H?	367.0	76.5	20.84
208	Colonia Ulpia Traiana	RO	F	urb	858		M*	367.0	74.0	20.16
208	Colonia Ulpia Traiana	RO	F	urb	860		M*	351.0	70.0	19.94
208	Colonia Ulpia Traiana	RO	F	urb	861			346.0	66.0	19.08
212	Gournay	IA	D	cem	866			312.0	63.0	20.19
212	Gournay	IA	D	cem	867			315.0	60.0	19.05
213	Beauvais	IA	D	rural	868			284.0	52.0	18.31
213	Beauvais	IA	D	rural	869			300.0	54.0	18.00
213	Beauvais	IA	D	rural	870			300.0	59.0	19.67
213	Beauvais	IA	D	rural	871			320.0	64.0	20.00
213	Beauvais	IA	D	rural	872			309.0	61.5	19.90
214	Compiegne	IA	D	rural	876			348.0	71.0	20.40
215	Ribemont	IA	D	oth	880			308.0	65.5	21.27
215	Ribemont	IA	D	oth	881			320.0	64.5	20.16
215	Ribemont	IA	D	oth	882			328.0	63.0	19.21
215	Ribemont	IA	D	oth	883			319.0	62.0	19.44
215	Ribemont	IA	D	oth	884			319.0	67.0	21.00
215	Ribemont	IA	D	oth	885			331.0	68.5	20.69
215	Ribemont	IA	D	oth	886			305.0	65.0	21.31
215	Ribemont	IA	D	oth	887			313.0	61.0	19.49
216	Variscourt	IA	D	rural	893			315.0	68.0	21.59
217	Soissons	IA	D	cem	894			277.0	57.0	20.58

Table A34. – Results of the calculation of the distal depth to distal breadth index on the Tibiae

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
5	Beckford	IA	E	rural	349			60.0	38.0	63.33
9	Hardingstone enclosure	IA	E	rural	346			55.0	33.0	60.00
9	Hardingstone enclosure	IA	E	rural	347			61.0	37.0	60.66
9	Hardingstone enclosure	IA	E	rural	348			60.0	38.0	63.33
14	Lincoln	RO	E	urb	343			61.5	39.8	64.72
14	Lincoln	RO	E	urb	344			63.7	38.9	61.07
15	Scole-Dickleburgh	RO	E	urb2	334			65.3	37.5	57.43
15	Scole-Dickleburgh	RO	E	urb2	339			64.4	38.8	60.25
15	Scole-Dickleburgh	RO	E	urb2	340			69.3	45.9	66.23
15	Scole-Dickleburgh	RO	E	urb2	341			70.1	43.1	61.48
21	Skeleton Green	IA	E	rural	328			62.0	39.0	62.90
21	Skeleton Green	IA	E	rural	329			59.0	39.0	66.10
22	Braughing	IA	E	rural	327			60.0	35.5	59.17
23	Puckeridge	IA	E	rural	326			63.0	39.5	62.70
28	Longthorpe II	RO	E	mil	319			84.0	51.0	60.71
28	Longthorpe II	RO	E	mil	320			65.0	41.0	63.08
38	Nijmegen	RO	F	urb	259			72.4	45.9	63.40
38	Nijmegen	RO	F	urb	262			69.5	42.9	61.73
38	Nijmegen	RO	F	urb	263			76.3	44.8	58.72
38	Nijmegen	RO	F	urb	264		M*	68.6	43.1	62.83
38	Nijmegen	RO	F	urb	265			71.8	46.2	64.35
38	Nijmegen	RO	F	urb	266			72.8	42.8	58.79
38	Nijmegen	RO	F	urb	267			78.6	47.6	60.56
38	Nijmegen	RO	F	urb	268			73.9	45.5	61.57
38	Nijmegen	RO	F	urb	270		M	72.4	48.3	66.71
38	Nijmegen	RO	F	urb	271		M*	70.6	42.8	60.62
38	Nijmegen	RO	F	urb	272		M?	71.7	42.1	58.72
38	Nijmegen	RO	F	urb	274		M*	67.7	43.5	64.25
38	Nijmegen	RO	F	urb	275			73.5	47.7	64.90
38	Nijmegen	RO	F	urb	277		H	72.8	45.9	63.05
38	Nijmegen	RO	F	urb	278			87.0	49.6	57.01
40	Heteren	NAT	F	rural	256			65.0	39.5	60.77
42	Druten	RO	F	villa	241			78.5	48.4	61.66
42	Druten	RO	F	villa	242			73.8	45.0	60.98
42	Druten	RO	F	villa	243			75.3	45.1	59.89
42	Druten	RO	F	villa	245			71.7	43.8	61.09
42	Druten	RO	F	villa	246			74.0	46.2	62.43
42	Druten	RO	F	villa	247		M*	73.6	47.4	64.40
42	Druten	RO	F	villa	248			70.3	43.2	61.45
42	Druten	RO	F	villa	249		M	79.2	50.7	64.02
42	Druten	RO	F	villa	250	12.4		81.4	50.5	62.04
42	Druten	RO	F	villa	252	1.18	M*	76.4	49.4	64.66
43	Elms Farm	RO	E	urb2	230			59.1	36.4	61.59
43	Elms Farm	RO	E	urb2	231			67.6	42.4	62.81
43	Elms Farm	RO	E	urb2	232			74.9	46.5	62.08
43	Elms Farm	RO	E	urb2	234	6640		70.7	43.9	62.09
43	Elms Farm	RO	E	urb2	235			69.2	44.7	64.60
43	Elms Farm	RO	E	urb2	236			59.9	36.9	61.60
43	Elms Farm	RO	E	urb2	237			67.5	41.3	61.19
43	Elms Farm	IA	E	urb2	238			80.1	50.2	62.67

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
43	Elms Farm	IA	E	urb2	239			61.2	33.8	55.23
44	Danebury	IA	E	rural	199			57.6	37.6	65.28
44	Danebury	IA	E	rural	200			57.5	36.4	63.30
44	Danebury	IA	E	rural	201			60.4	38.2	63.25
44	Danebury	IA	E	rural	203			62.2	37.8	60.77
44	Danebury	IA	E	rural	204			59.8	35.4	59.20
44	Danebury	IA	E	rural	205			60.0	37.7	62.83
44	Danebury	IA	E	rural	206			63.2	41.2	65.19
44	Danebury	IA	E	rural	207			63.8	39.3	61.60
44	Danebury	IA	E	rural	208			63.6	40.0	62.89
44	Danebury	IA	E	rural	209			63.6	38.8	61.01
44	Danebury	IA	E	rural	210			60.2	37.2	61.79
44	Danebury	IA	E	rural	211			64.3	39.2	60.96
44	Danebury	IA	E	rural	212			61.7	38.2	61.91
44	Danebury	IA	E	rural	213			60.7	38.2	62.93
44	Danebury	IA	E	rural	214			59.2	39.8	67.23
44	Danebury	IA	E	rural	215			60.7	38.2	62.93
44	Danebury	IA	E	rural	216			63.6	39.2	61.64
44	Danebury	IA	E	rural	217			64.3	42.1	65.47
44	Danebury	IA	E	rural	218			71.0	41.7	58.73
44	Danebury	IA	E	rural	220			60.7	38.4	63.26
44	Danebury	IA	E	rural	221			64.0	40.5	63.28
44	Danebury	IA	E	rural	222			66.5	41.7	62.71
44	Danebury	IA	E	rural	223			63.7	39.1	61.38
44	Danebury	IA	E	rural	224			66.5	43.2	64.96
44	Danebury	IA	E	rural	225			67.7	43.3	63.96
44	Danebury	IA	E	rural	226			61.5	37.5	60.98
44	Danebury	IA	E	rural	227			59.5	37.6	63.19
44	Danebury	IA	E	rural	228			63.2	38.0	60.13
46	E London RB Cemetary	RO	E	cem	190			77.1	48.7	63.16
46	E London RB Cemetary	RO	E	cem	192		H?	68.8	45.5	66.13
46	E London RB Cemetary	RO	E	cem	194			64.9	39.6	61.02
46	E London RB Cemetary	RO	E	cem	195			76.2	49.0	64.30
46	E London RB Cemetary	RO	E	cem	196		H	78.3	48.4	61.81
46	E London RB Cemetary	RO	E	cem	197			67.3	44.3	65.82
47	Beddington Sewage Farm	RO	E	urb	189			59.7	37.0	61.98
54	Thorpe Thewles	RO	E	rural	181			62.9	37.3	59.30
54	Thorpe Thewles	IA	E	rural	183			56.7	37.1	65.43
54	Thorpe Thewles	IA	E	rural	184			59.2	36.7	61.99
59	Chichester cattlemarket	RO	E	urb	176	XXIII		79.9	49.1	61.45
59	Chichester cattlemarket	RO	E	urb	177	XXIII		80.1	47.6	59.43
60	Narce	IA	A	rural	174			63.0	43.6	69.21
60	Narce	IA	A	rural	175			65.7	38.6	58.75
63	S. Giacomo	RO	A	villa	172			61.0	42.0	68.85
63	S. Giacomo	RO	A	villa	173		M*	74.4	46.5	62.50
67	Ilchester,Church Street	RO	E	urb	170	F267		77.0	46.0	59.74
68	Lutton/Huntingdon	RO	E	rural	168			59.0	38.9	65.93
68	Lutton/Huntingdon	RO	E	rural	169			66.5	41.5	62.41
69	Thorley	RO	E	rural	167			62.6	34.8	55.61
70	Emilia	IA	A	oth	166			65.2	39.4	60.43
79	Olbia	IA	A	rural	159			50.7	29.5	58.19
79	Olbia	IA	A	rural	160			50.5	30.2	59.80
81	Welsow	NAT	F	rural	157			66.5	41.7	62.71
81	Welsow	NAT	F	rural	158			45.2	32.0	70.80
92	Feddersen Wierde	NAT	F	rural	28	skelett2R	H	67.5	40.7	60.30
92	Feddersen Wierde	NAT	F	rural	29	skelett2L	H	67.4	39.6	58.75

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
92	Feddersen Wierde	NAT	F	rural	30	skelett1R		72.6	42.5	58.54
92	Feddersen Wierde	NAT	F	rural	31	skelett1L		72.2	42.6	59.00
92	Feddersen Wierde	NAT	F	rural	32			71.1	45.3	63.71
92	Feddersen Wierde	NAT	F	rural	33		D?	71.2	41.2	57.87
92	Feddersen Wierde	NAT	F	rural	34			66.0	43.5	65.91
92	Feddersen Wierde	NAT	F	rural	35		M?	61.9	39.4	63.65
92	Feddersen Wierde	NAT	F	rural	36		H?	65.5	39.4	60.15
92	Feddersen Wierde	NAT	F	rural	37		D*	70.5	40.9	58.01
92	Feddersen Wierde	NAT	F	rural	38		D?	64.5	41.2	63.88
96	Kunzing east vicus	RO	F	cem	2	1703	M	74.5	48.2	64.70
96	Kunzing east vicus	RO	F	cem	3	1641	M	72.6	45.1	62.12
96	Kunzing east vicus	RO	F	cem	4	1581		78.8	48.4	61.42
96	Kunzing east vicus	RO	F	cem	5	1575/5		72.0	45.8	63.61
96	Kunzing east vicus	RO	F	cem	6	1620	H*	73.3	48.0	65.48
96	Kunzing east vicus	RO	F	cem	7	1632	M	74.6	48.1	64.48
103	Newstead fort	RO	E	mil	383			70.3	42.4	60.31
104	Orton Hall Farm	RO	E	villa	384			65.0	47.0	72.31
104	Orton Hall Farm	RO	E	villa	385			70.0	46.0	65.71
104	Orton Hall Farm	RO	E	villa	386			67.0	43.0	64.18
104	Orton Hall Farm	RO	E	villa	387			61.0	36.0	59.02
104	Orton Hall Farm	RO	E	villa	388			67.0	44.0	65.67
104	Orton Hall Farm	RO	E	villa	389			69.0	42.0	60.87
105	Mons Claudianus	RO	K	ind	391	665		69.4	45.6	65.71
105	Mons Claudianus	RO	K	ind	393			65.4	45.0	68.81
105	Mons Claudianus	RO	K	ind	394	662		68.5	43.8	63.94
105	Mons Claudianus	RO	K	ind	395	717	D*	63.5	42.0	66.14
105	Mons Claudianus	RO	K	ind	396	600	D*	67.5	44.3	65.63
105	Mons Claudianus	RO	K	ind	398	854		63.8	42.8	67.08
105	Mons Claudianus	RO	K	ind	399			58.8	40.0	68.03
105	Mons Claudianus	RO	K	ind	402			65.3	42.7	65.39
105	Mons Claudianus	RO	K	ind	403	1108		57.2	37.7	65.91
105	Mons Claudianus	RO	K	ind	413			61.2	40.0	65.36
105	Mons Claudianus	RO	K	ind	415			58.4	40.2	68.84
105	Mons Claudianus	RO	K	ind	416	1036		59.9	40.5	67.61
105	Mons Claudianus	RO	K	ind	417	1031		57.3	37.2	64.92
105	Mons Claudianus	RO	K	ind	418			79.1	47.9	60.56
105	Mons Claudianus	RO	K	ind	419			69.8	46.2	66.19
105	Mons Claudianus	RO	K	ind	420			56.8	36.2	63.73
105	Mons Claudianus	RO	K	ind	422	953		61.0	42.5	69.67
105	Mons Claudianus	RO	K	ind	424			58.0	38.5	66.38
105	Mons Claudianus	RO	K	ind	425			63.5	45.6	71.81
105	Mons Claudianus	RO	K	ind	426	890		59.8	38.9	65.05
105	Mons Claudianus	RO	K	ind	427	872		69.9	45.2	64.66
105	Mons Claudianus	RO	K	ind	429			63.0	39.6	62.86
105	Mons Claudianus	RO	K	ind	430	783		61.2	43.5	71.08
105	Mons Claudianus	RO	K	ind	433	607		72.5	46.0	63.45
105	Mons Claudianus	RO	K	ind	434			59.1	39.4	66.67
105	Mons Claudianus	RO	K	ind	435			68.0	47.0	69.12
105	Mons Claudianus	RO	K	ind	440			62.6	38.3	61.18
105	Mons Claudianus	RO	K	ind	441			64.2	40.4	62.93
105	Mons Claudianus	RO	K	ind	442			72.1	45.5	63.11
105	Mons Claudianus	RO	K	ind	443			65.3	44.2	67.69
105	Mons Claudianus	RO	K	ind	444			68.7	45.1	65.65
105	Mons Claudianus	RO	K	ind	447			63.0	39.6	62.86
105	Mons Claudianus	RO	K	ind	448			56.0	39.4	70.36
105	Mons Claudianus	RO	K	ind	451			58.9	38.2	64.86

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
105	Mons Claudianus	RO	K	ind	452			64.1	40.7	63.49
105	Mons Claudianus	RO	K	ind	453			57.3	38.0	66.32
105	Mons Claudianus	RO	K	ind	454			57.5	40.9	71.13
105	Mons Claudianus	RO	K	ind	455	137		66.2	44.5	67.22
110	Nijmegen new excavations	RO	F	urb	483	147/128-20	H?	81.4	51.3	63.02
112	Pompeii, Sarno Baths	RO	A	urb	486	A		73.0	46.8	64.11
112	Pompeii, Sarno Baths	RO	A	urb	487	B		74.4	48.6	65.32
112	Pompeii, Sarno Baths	RO	A	urb	488	C		69.7	45.2	64.85
112	Pompeii, Sarno Baths	RO	A	urb	489	D		71.5	46.1	64.48
114	Unterlaa	RO	G	urb	490	21		70.5	42.9	60.85
114	Unterlaa	RO	G	urb	491	23A	H	66.9	38.8	58.00
114	Unterlaa	RO	G	urb	492	35		69.2	41.8	60.40
114	Unterlaa	RO	G	urb	493	68	H?	68.4	39.7	58.04
114	Unterlaa	RO	G	urb	494	71	H	70.7	43.6	61.67
115	Bad Wimpfen	RO	F	urb2	496		M	73.0	45.0	61.64
115	Bad Wimpfen	RO	F	urb2	497			72.3	45.0	62.24
115	Bad Wimpfen	RO	F	urb2	499			74.0	46.5	62.84
115	Bad Wimpfen	RO	F	urb2	501			74.7	45.5	60.91
115	Bad Wimpfen	RO	F	urb2	502			71.7	44.5	62.06
115	Bad Wimpfen	RO	F	urb2	503			81.5	50.0	61.35
115	Bad Wimpfen	RO	F	urb2	506			69.3	43.5	62.77
115	Bad Wimpfen	RO	F	urb2	507			81.0	49.0	60.49
115	Bad Wimpfen	RO	F	urb2	509			74.5	47.0	63.09
115	Bad Wimpfen	RO	F	urb2	510			70.0	43.3	61.86
115	Bad Wimpfen	RO	F	urb2	511	Skele 4		70.3	44.5	63.30
116	Pommeroeul	RO	D	urb2	513	348	H	66.0	42.0	63.64
116	Pommeroeul	RO	D	urb2	514	17-1	H?	67.0	41.0	61.19
116	Pommeroeul	RO	D	urb2	515	238	H*	63.0	42.0	66.67
116	Pommeroeul	RO	D	urb2	516	224		67.0	43.0	64.18
116	Pommeroeul	RO	D	urb2	517	32	M?	69.0	43.0	62.32
116	Pommeroeul	RO	D	urb2	518	373	M*	77.0	45.0	58.44
116	Pommeroeul	RO	D	urb2	519	294	H?	79.0	47.0	59.49
116	Pommeroeul	RO	D	urb2	520	294-2	M?	78.0	48.0	61.54
116	Pommeroeul	RO	D	urb2	521	198		76.0	47.0	61.84
116	Pommeroeul	RO	D	urb2	523	271		75.0	45.0	60.00
118	Carnuntum	RO	G	mil	530	Pferd 1	M	83.8	53.8	64.20
118	Carnuntum	RO	G	mil	531	Pferd 2	H	80.2	51.6	64.34
118	Carnuntum	RO	G	mil	532	Pferd 3	H	77.7	48.2	62.03
118	Carnuntum	RO	G	mil	533	Maultier 1	M*	81.5	52.3	64.17
118	Carnuntum	RO	G	mil	534		H?	73.5	45.8	62.31
119	Albertfalva	RO	G	mil	535	Horse 1		74.8	50.0	66.84
119	Albertfalva	RO	G	mil	536	Horse 2		80.3	52.2	65.01
120	Basel-Gasfabrik	IA	F	rural	537		H	62.7	39.5	63.00
120	Basel-Gasfabrik	IA	F	rural	538		H	63.9	40.0	62.60
120	Basel-Gasfabrik	IA	F	rural	539			63.9	39.8	62.28
120	Basel-Gasfabrik	IA	F	rural	540			64.8	38.5	59.41
120	Basel-Gasfabrik	IA	F	rural	541			59.6	37.8	63.42
120	Basel-Gasfabrik	IA	F	rural	543			56.3	33.6	59.68
120	Basel-Gasfabrik	IA	F	rural	544			57.0	35.0	61.40
121	Soluthurn/Vigier	RO	F	urb2	550		M*	70.0	43.8	62.57
121	Soluthurn/Vigier	RO	F	urb2	551			69.3	45.6	65.80
121	Soluthurn/Vigier	RO	F	urb2	552			72.0	42.5	59.03
121	Soluthurn/Vigier	RO	F	urb2	553			76.0	44.6	58.68
123	Wroxeter Baths basilica	RO	E	urb	554			71.8	46.0	64.07
123	Wroxeter Baths basilica	RO	E	urb	555			70.8	42.4	59.89
123	Wroxeter Baths basilica	RO	E	urb	556			79.2	48.5	61.24

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
125	Castleford	RO	E	mil	562			77.8	48.1	61.83
125	Castleford	RO	E	mil	563			77.8	48.1	61.83
125	Castleford	RO	E	mil	564			66.8	40.5	60.63
125	Castleford	RO	E	mil	565			62.3	39.6	63.56
126	Augusta Rauricorum Amphit	RO	F	urb	566			68.0	42.8	62.94
126	Augusta Rauricorum Amphit	RO	F	urb	567			72.4	45.9	63.40
126	Augusta Rauricorum Amphit	RO	F	urb	568			53.1	39.5	74.39
127	Tortoreto-Fortellezza	IA	A	rural	569			56.0	41.0	73.21
127	Tortoreto-Fortellezza	IA	A	rural	570			51.0	35.5	69.61
135	Swestari	IA	G	cem	598	1	H	68.0	41.5	61.03
135	Swestari	IA	G	cem	599	2	H	66.0	40.0	60.61
135	Swestari	IA	G	cem	600	3	H	64.0	41.0	64.06
135	Swestari	IA	G	cem	601	4		77.5	47.0	60.65
135	Swestari	IA	G	cem	602	5	M	80.0	49.5	61.88
136	Worth Matravers	IA	E	rural	603			58.9	35.9	60.95
136	Worth Matravers	RO	E	rural	604			72.8	46.0	63.19
137	Magdelenska Gora	IA	G	cem	605	V, 29, I		65.0	43.0	66.15
137	Magdelenska Gora	IA	G	cem	606	V, 29, II		64.0	38.0	59.38
137	Magdelenska Gora	IA	G	cem	607	V, 29, III		68.0	45.0	66.18
141	Szentes-Vekerzug	IA	G	cem	610	6		64.5	41.5	64.34
142	Velemszentvid	IA	G	cem	611	54.448.1		72.5	46.0	63.45
142	Velemszentvid	IA	G	cem	612	54.448.2		73.0	48.5	66.44
151	Gyor Szechenyi-Ter	RO	G	rural	614			73.0	49.0	67.12
157	Lugnano	RO	A	villa	623			50.3	40.0	79.52
161	San Giovanni	RO	A	villa	625			52.0	34.9	67.12
161	San Giovanni	RO	A	villa	626			72.1	42.8	59.36
167	Via Gabina 10	RO	A	urb	627			70.6	42.8	60.62
167	Via Gabina 10	RO	A	urb	629			72.0	44.1	61.25
168	Volano	RO	A	rural	630			70.6	44.7	63.31
174	Abusina-Eining	RO	F	mil	633			75.5	48.0	63.58
174	Abusina-Eining	RO	F	mil	634		M*	78.0	48.5	62.18
174	Abusina-Eining	RO	F	mil	637			50.0	36.0	72.00
175	Sablonetum-Ellingen	RO	F	mil	639			75.5	47.5	62.91
175	Sablonetum-Ellingen	RO	F	mil	640			75.0	43.5	58.00
175	Sablonetum-Ellingen	RO	F	mil	641			70.6	44.0	62.32
175	Sablonetum-Ellingen	RO	F	mil	642			66.0	41.0	62.12
176	Oberdorla	NAT	F	cem	643		M	66.0	44.0	66.67
176	Oberdorla	NAT	F	cem	644		D*	67.0	42.0	62.69
176	Oberdorla	NAT	F	cem	646		D*	64.0	40.0	62.50
176	Oberdorla	NAT	F	cem	647			64.0	42.0	65.63
176	Oberdorla	NAT	F	cem	648			63.0	42.0	66.67
176	Oberdorla	NAT	F	cem	649			64.0	41.0	64.06
176	Oberdorla	NAT	F	cem	650			60.0	38.0	63.33
176	Oberdorla	NAT	F	cem	651			60.0	37.0	61.67
176	Oberdorla	NAT	F	cem	653			70.0	42.0	60.00
176	Oberdorla	NAT	F	cem	654			65.0	42.0	64.62
176	Oberdorla	NAT	F	cem	655			65.0	41.0	63.08
178	Vitudurum-Oberwinterthur	RO	F	urb2	660			71.1	43.5	61.18
178	Vitudurum-Oberwinterthur	RO	F	urb2	661			70.7	45.6	64.50
178	Vitudurum-Oberwinterthur	RO	F	urb2	662			72.5	45.3	62.48
179	Catterick CEU240	RO	E	mil	663			63.3	40.0	63.19
188	Titelberg oppidum	RO	D	rural	688			67.0	42.0	62.69
189	Kassope	IA	H	urb	689			59.5	39.0	65.55
189	Kassope	IA	H	urb	690			57.0	39.0	68.42
189	Kassope	IA	H	urb	691			53.0	37.0	69.81
189	Kassope	IA	H	urb	692			49.0	33.0	67.35

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
189	Kassope	IA	H	urb	693			64.0	40.5	63.28
189	Kassope	IA	H	urb	694			62.0	41.5	66.94
189	Kassope	IA	H	urb	695			56.5	39.0	69.03
189	Kassope	IA	H	urb	696			55.0	37.0	67.27
189	Kassope	IA	H	urb	697			54.5	34.0	62.39
189	Kassope	IA	H	urb	698			53.0	38.5	72.64
190	Breisach	RO	F	mil	699			61.5	39.5	64.23
190	Breisach	RO	F	mil	700			71.0	46.0	64.79
203	Tac-Gorsium	RO	G	urb	765			65.5	43.0	65.65
203	Tac-Gorsium	RO	G	urb	766			68.0	44.0	64.71
203	Tac-Gorsium	RO	G	urb	767			74.5	44.5	59.73
203	Tac-Gorsium	RO	G	urb	768			73.5	44.0	59.86
203	Tac-Gorsium	RO	G	urb	769			74.0	45.0	60.81
203	Tac-Gorsium	RO	G	urb	770			69.0	43.5	63.04
203	Tac-Gorsium	RO	G	urb	771			74.0	47.0	63.51
203	Tac-Gorsium	RO	G	urb	772			70.0	42.5	60.71
203	Tac-Gorsium	RO	G	urb	773			72.5	45.5	62.76
203	Tac-Gorsium	RO	G	urb	774			70.0	47.0	67.14
203	Tac-Gorsium	RO	G	urb	775			76.0	47.0	61.84
203	Tac-Gorsium	RO	G	urb	776			79.0	53.0	67.09
203	Tac-Gorsium	RO	G	urb	777			77.0	49.0	63.64
203	Tac-Gorsium	RO	G	urb	778			80.0	54.0	67.50
203	Tac-Gorsium	RO	G	urb	781			56.5	40.0	70.80
203	Tac-Gorsium	RO	G	urb	782			63.0	38.0	60.32
203	Tac-Gorsium	RO	G	urb	783			63.5	40.0	62.99
203	Tac-Gorsium	RO	G	urb	784			65.0	40.0	61.54
203	Tac-Gorsium	RO	G	urb	785			66.0	42.5	64.39
203	Tac-Gorsium	RO	G	urb	786			66.5	43.5	65.41
203	Tac-Gorsium	RO	G	urb	787			67.0	43.0	64.18
203	Tac-Gorsium	RO	G	urb	788			67.5	44.0	65.19
203	Tac-Gorsium	RO	G	urb	789			68.0	45.5	66.91
203	Tac-Gorsium	RO	G	urb	790			68.0	45.5	66.91
203	Tac-Gorsium	RO	G	urb	791			69.0	46.0	66.67
203	Tac-Gorsium	RO	G	urb	792			69.0	46.5	67.39
203	Tac-Gorsium	RO	G	urb	793			69.5	43.0	61.87
203	Tac-Gorsium	RO	G	urb	794			69.5	45.0	64.75
203	Tac-Gorsium	RO	G	urb	795			69.5	45.0	64.75
203	Tac-Gorsium	RO	G	urb	796			70.0	44.0	62.86
203	Tac-Gorsium	RO	G	urb	797			70.0	45.0	64.29
203	Tac-Gorsium	RO	G	urb	798			70.0	45.0	64.29
203	Tac-Gorsium	RO	G	urb	799			70.0	47.0	67.14
203	Tac-Gorsium	RO	G	urb	800			70.0	47.0	67.14
203	Tac-Gorsium	RO	G	urb	801			70.0	50.0	71.43
203	Tac-Gorsium	RO	G	urb	802			70.5	44.5	63.12
203	Tac-Gorsium	RO	G	urb	803			70.5	46.0	65.25
203	Tac-Gorsium	RO	G	urb	804			71.0	44.0	61.97
203	Tac-Gorsium	RO	G	urb	805			71.0	45.0	63.38
203	Tac-Gorsium	RO	G	urb	806			71.0	46.5	65.49
203	Tac-Gorsium	RO	G	urb	807			71.5	45.5	63.64
203	Tac-Gorsium	RO	G	urb	808			71.5	47.5	66.43
203	Tac-Gorsium	RO	G	urb	809			72.0	45.5	63.19
203	Tac-Gorsium	RO	G	urb	810			72.0	47.0	65.28
203	Tac-Gorsium	RO	G	urb	811			72.5	45.0	62.07
203	Tac-Gorsium	RO	G	urb	812			72.5	45.5	62.76
203	Tac-Gorsium	RO	G	urb	813			72.5	46.0	63.45
203	Tac-Gorsium	RO	G	urb	814			72.5	46.0	63.45

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Bd	Dd	Index
203	Tac-Gorsium	RO	G	urb	815			73.0	45.0	61.64
203	Tac-Gorsium	RO	G	urb	816			73.0	48.0	65.75
203	Tac-Gorsium	RO	G	urb	817			73.0	50.0	68.49
203	Tac-Gorsium	RO	G	urb	818			73.5	47.0	63.95
203	Tac-Gorsium	RO	G	urb	819			75.0	50.0	66.67
203	Tac-Gorsium	RO	G	urb	820			75.5	47.0	62.25
203	Tac-Gorsium	RO	G	urb	821			75.5	47.0	62.25
203	Tac-Gorsium	RO	G	urb	822			75.5	48.5	64.24
203	Tac-Gorsium	RO	G	urb	823			76.0	48.0	63.16
203	Tac-Gorsium	RO	G	urb	824			76.0	52.5	69.08
203	Tac-Gorsium	RO	G	urb	825			76.0	49.0	64.47
203	Tac-Gorsium	RO	G	urb	826			77.0	47.0	61.04
203	Tac-Gorsium	RO	G	urb	827			77.0	53.0	68.83
203	Tac-Gorsium	RO	G	urb	828			77.5	50.0	64.52
203	Tac-Gorsium	RO	G	urb	829			79.0	49.0	62.03
203	Tac-Gorsium	RO	G	urb	830			79.0	50.0	63.29
203	Tac-Gorsium	RO	G	urb	831			80.0	53.5	66.88
203	Tac-Gorsium	RO	G	urb	832			82.0	48.0	58.54
203	Tac-Gorsium	RO	G	urb	833			83.5	55.0	65.87
203	Tac-Gorsium	RO	G	urb	835			50.0	36.0	72.00
203	Tac-Gorsium	RO	G	urb	836			52.0	38.0	73.08
204	Conchil	RO	D	rural	837			69.7	43.1	61.84
204	Conchil	RO	D	rural	838			66.6	40.0	60.06
204	Conchil	RO	D	rural	839			79.4	51.3	64.61
205	Oberstimm	RO	F	mil	841		M*	70.0	44.0	62.86
207	Haus Burgel	RO	F	mil	855			77.9	47.9	61.49
211	Castillar de Mendavia	IA	B	rural	864			63.5	36.0	56.69
211	Castillar de Mendavia	IA	B	rural	865			61.0	41.0	67.21
212	Gournay	IA	D	cem	866			63.0	39.0	61.90
212	Gournay	IA	D	cem	867			60.0	38.0	63.33
213	Beauvais	IA	D	rural	868			52.0	35.0	67.31
213	Beauvais	IA	D	rural	869			54.0	34.0	62.96
213	Beauvais	IA	D	rural	870			59.0	35.0	59.32
213	Beauvais	IA	D	rural	871			64.0	38.5	60.16
213	Beauvais	IA	D	rural	872			61.5	37.0	60.16
213	Beauvais	IA	D	rural	873			51.0	34.0	66.67
213	Beauvais	IA	D	rural	874			54.0	36.0	66.67
213	Beauvais	IA	D	rural	875			50.0	36.0	72.00
214	Compiegne	IA	D	rural	876			71.0	42.0	59.15
215	Ribemont	IA	D	oth	880			65.5	41.0	62.60
215	Ribemont	IA	D	oth	881			64.5	38.5	59.69
215	Ribemont	IA	D	oth	882			63.0	41.5	65.87
215	Ribemont	IA	D	oth	883			62.0	40.0	64.52
215	Ribemont	IA	D	oth	884			67.0	40.0	59.70
215	Ribemont	IA	D	oth	885			68.5	45.0	65.69
215	Ribemont	IA	D	oth	886			65.0	37.5	57.69
215	Ribemont	IA	D	oth	887			61.0	37.5	61.48
215	Ribemont	IA	D	oth	888			63.0	41.0	65.08
215	Ribemont	IA	D	oth	889			62.0	41.0	66.13
215	Ribemont	IA	D	oth	890			64.5	40.0	62.02
215	Ribemont	IA	D	oth	891			60.0	40.0	66.67
215	Ribemont	IA	D	oth	892			64.5	40.0	62.02
216	Variscourt	IA	D	rural	893			68.0	41.0	60.29
217	Soissons	IA	D	cem	894			57.0	34.0	59.65

Table A35. – Results of the calculation of the shaft breadth to greatest length index on the Radii

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
4	Market Deeping	IA	E	rural	358			324.0	33.2	10.25
10	Twywell	IA	E	rural	351			322.0	36.0	11.18
14	Lincoln	RO	E	urb	343			290.0	28.3	9.76
15	Scole-Dickleburgh	RO	E	urb2	334			325.2	37.2	11.44
15	Scole-Dickleburgh	RO	E	urb2	339			283.2	31.4	11.09
15	Scole-Dickleburgh	RO	E	urb2	341			288.1	31.5	10.93
28	Longthorpe II	RO	E	mil	325			315.0	40.0	12.70
30	Tort Hill East	RO	E	rural	323			325.0	34.3	10.55
35	Castricum-Oosterbuurt	RO	F	oth	315			330.0	38.2	11.58
35	Castricum-Oosterbuurt	RO	F	oth	319			311.0	31.9	10.26
37	Kesteren 'De Prinsenhof'	RO	F	cem	307	11-36		349.0	39.5	11.32
37	Kesteren 'De Prinsenhof'	RO	F	cem	308	11-34		345.0	38.8	11.25
37	Kesteren 'De Prinsenhof'	RO	F	cem	312	1-11		358.0	41.7	11.65
38	Nijmegen	RO	F	urb	285			336.1	41.9	12.47
38	Nijmegen	RO	F	urb	288			320.3	35.7	11.15
38	Nijmegen	RO	F	urb	289			324.6	36.7	11.31
38	Nijmegen	RO	F	urb	290			326.7	38.3	11.72
38	Nijmegen	RO	F	urb	291			325.9	35.1	10.77
38	Nijmegen	RO	F	urb	292			332.7	34.1	10.25
38	Nijmegen	RO	F	urb	294			338.0	37.9	11.21
38	Nijmegen	RO	F	urb	295			332.8	38.3	11.51
38	Nijmegen	RO	F	urb	296			365.0	39.7	10.88
38	Nijmegen	RO	F	urb	301			369.6	43.4	11.74
38	Nijmegen	RO	F	urb	304			330.5	36.1	10.92
42	Druten	RO	F	villa	269			354.8	40.2	11.33
42	Druten	RO	F	villa	275			330.4	36.5	11.05
42	Druten	RO	F	villa	278			360.0	42.3	11.75
42	Druten	RO	F	villa	282	1.18	M*	367.0	43.6	11.88
43	Elms Farm	RO	E	urb2	254			351.0	41.3	11.77
43	Elms Farm	RO	E	urb2	256	6640	H*	346.0	37.1	10.72
43	Elms Farm	RO	E	urb2	257	6640	H*	339.0	37.9	11.18
43	Elms Farm	IA	E	urb2	267			358.0	42.4	11.84
44	Danebury	IA	E	rural	237			295.5	33.2	11.24
44	Danebury	IA	E	rural	238			293.0	30.2	10.31
44	Danebury	IA	E	rural	241			300.0	31.2	10.40
44	Danebury	IA	E	rural	242			287.0	32.4	11.29
44	Danebury	IA	E	rural	244			312.5	33.5	10.72
44	Danebury	IA	E	rural	247			305.0	35.6	11.67
44	Danebury	IA	E	rural	248			300.0	30.6	10.20
44	Danebury	IA	E	rural	249			300.0	34.9	11.63
44	Danebury	IA	E	rural	253			307.0	35.6	11.60
46	E London RB Cemetary	RO	E	cem	228		H	324.5	35.0	10.79
46	E London RB Cemetary	RO	E	cem	230			345.0	38.5	11.16
47	Beddington Sewage Farm	RO	E	urb	221		H*	307.6	32.8	10.66
47	Beddington Sewage Farm	RO	E	urb	224		H*	278.0	29.0	10.43
54	Thorpe Thewles	IA	E	rural	217			289.9	28.7	9.90
57	La Sagesse	IA	E	oth	211			323.0	35.3	10.93
66	Settefinestre	RO	A	villa	204			333.0	36.0	10.81
69	Thorley	RO	E	rural	202		H	300.0	34.8	11.59
69	Thorley	IA	E	rural	203		H	319.0	37.7	11.81

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
70	Emilia	RO	A	oth	201		M?	321.0	34.0	10.59
71	Piovego	IA	A	cem	200	N2		319.0	36.0	11.29
77	Grotto di Tibera	RO	A	oth	199	15.1		324.0	39.0	12.04
78	Cowbridge	RO	E	urb	198			297.0	31.0	10.44
79	Olbia	IA	A	rural	195		D	259.7	27.8	10.70
79	Olbia	IA	A	rural	196		D	253.4	26.7	10.54
79	Olbia	IA	A	rural	197		D	254.1	26.5	10.43
87	Manching	IA	F	rural	162		H?	273.0	31.0	11.36
87	Manching	IA	F	rural	163		H?	275.0	32.0	11.64
87	Manching	IA	F	rural	164		H*	276.0	30.0	10.87
87	Manching	IA	F	rural	166			287.5	32.0	11.13
87	Manching	IA	F	rural	167		D*	289.0	31.0	10.73
87	Manching	IA	F	rural	168		H*	291.0	32.0	11.00
87	Manching	IA	F	rural	169		H?	292.0	30.0	10.27
87	Manching	IA	F	rural	170		D*	293.0	31.5	10.75
87	Manching	IA	F	rural	171		D*	295.5	31.0	10.49
87	Manching	IA	F	rural	176		H	301.5	34.0	11.28
87	Manching	IA	F	rural	177			306.0	32.0	10.46
87	Manching	IA	F	rural	179		D*	309.0	31.5	10.19
87	Manching	IA	F	rural	181		H?	312.5	34.0	10.88
87	Manching	IA	F	rural	183			313.5	31.5	10.05
87	Manching	IA	F	rural	184		H?	316.0	35.0	11.08
87	Manching	IA	F	rural	185		M?	318.0	34.0	10.69
87	Manching	IA	F	rural	186			326.0	34.5	10.58
87	Manching	IA	F	rural	187			326.5	35.0	10.72
87	Manching	IA	F	rural	188		M?	333.5	34.5	10.34
92	Feddersen Wierde	NAT	F	rural	26	skelett3L	M	342.0	35.0	10.23
92	Feddersen Wierde	NAT	F	rural	27	skelett2R	H	305.1	34.5	11.31
92	Feddersen Wierde	NAT	F	rural	29	skelett1R	H	326.5	35.3	10.81
92	Feddersen Wierde	NAT	F	rural	30	skelett1L	H	325.5	35.2	10.81
92	Feddersen Wierde	NAT	F	rural	31		H	304.3	35.0	11.50
92	Feddersen Wierde	NAT	F	rural	32		H?	310.6	35.4	11.40
92	Feddersen Wierde	NAT	F	rural	33		M	346.2	36.0	10.40
92	Feddersen Wierde	NAT	F	rural	34		H?	320.1	37.8	11.81
92	Feddersen Wierde	NAT	F	rural	35		H	304.8	35.4	11.61
92	Feddersen Wierde	NAT	F	rural	36		H*	303.9	32.7	10.76
92	Feddersen Wierde	NAT	F	rural	37		H*	290.7	31.5	10.84
92	Feddersen Wierde	NAT	F	rural	38		H	329.1	39.0	11.85
92	Feddersen Wierde	NAT	F	rural	39		H	301.0	31.3	10.40
92	Feddersen Wierde	NAT	F	rural	40		M	316.7	34.6	10.93
92	Feddersen Wierde	NAT	F	rural	41		H	323.1	35.1	10.86
92	Feddersen Wierde	NAT	F	rural	42		M?	315.8	33.8	10.70
92	Feddersen Wierde	NAT	F	rural	43		H?	317.1	33.7	10.63
92	Feddersen Wierde	NAT	F	rural	44		H	320.8	37.5	11.69
92	Feddersen Wierde	NAT	F	rural	45		H	323.5	38.1	11.78
92	Feddersen Wierde	NAT	F	rural	46		H	314.1	37.5	11.94
92	Feddersen Wierde	NAT	F	rural	47		D*	300.5	30.2	10.05
92	Feddersen Wierde	NAT	F	rural	48		H*	302.4	35.1	11.61
92	Feddersen Wierde	NAT	F	rural	49			317.1	35.1	11.07
92	Feddersen Wierde	NAT	F	rural	50		H	321.6	35.1	10.91
92	Feddersen Wierde	NAT	F	rural	51			306.6	33.0	10.76
92	Feddersen Wierde	NAT	F	rural	52		H*	281.6	33.9	12.04
92	Feddersen Wierde	NAT	F	rural	53		H*	334.0	40.6	12.16
92	Feddersen Wierde	NAT	F	rural	54		H	303.0	32.4	10.69
92	Feddersen Wierde	NAT	F	rural	55		H	319.4	34.5	10.80
92	Feddersen Wierde	NAT	F	rural	56		H	305.7	33.6	10.99

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
92	Feddersen Wierde	NAT	F	rural	57		H?	286.4	29.9	10.44
92	Feddersen Wierde	NAT	F	rural	58		H*	301.0	33.5	11.13
92	Feddersen Wierde	NAT	F	rural	61		H	311.5	34.8	11.17
92	Feddersen Wierde	NAT	F	rural	62		H?	317.7	34.0	10.70
92	Feddersen Wierde	NAT	F	rural	63		H?	313.7	33.9	10.81
96	Kunzing east vicus	RO	F	cem	1	1703	M	347.0	40.5	11.67
96	Kunzing east vicus	RO	F	cem	2	1641	M	356.5	36.6	10.27
96	Kunzing east vicus	RO	F	cem	3	1581		347.5	38.7	11.14
96	Kunzing east vicus	RO	F	cem	4	1575/5		338.0	39.1	11.57
96	Kunzing east vicus	RO	F	cem	5	1620	H*	345.5	39.4	11.40
96	Kunzing east vicus	RO	F	cem	6	1632	M	345.0	41.1	11.91
103	Newstead fort	RO	E	mil	387			344.0	36.7	10.67
103	Newstead fort	RO	E	mil	388			355.0	42.1	11.86
104	Orton Hall Farm	RO	E	villa	389			311.0	35.0	11.25
104	Orton Hall Farm	RO	E	villa	390			334.0	42.0	12.57
104	Orton Hall Farm	RO	E	villa	391			340.0	40.0	11.76
105	Mons Claudianus	RO	K	ind	392			350.0	39.0	11.14
105	Mons Claudianus	RO	K	ind	394			333.0	38.5	11.56
105	Mons Claudianus	RO	K	ind	395			330.0	35.0	10.61
105	Mons Claudianus	RO	K	ind	396			325.0	33.3	10.25
105	Mons Claudianus	RO	K	ind	397			323.0	37.0	11.46
105	Mons Claudianus	RO	K	ind	398	595		321.0	39.4	12.27
105	Mons Claudianus	RO	K	ind	399		M?	320.0	38.2	11.94
105	Mons Claudianus	RO	K	ind	400		M?	320.0	37.0	11.56
105	Mons Claudianus	RO	K	ind	401			310.0	31.6	10.19
105	Mons Claudianus	RO	K	ind	402			309.0	33.5	10.84
105	Mons Claudianus	RO	K	ind	403			301.0	37.0	12.29
105	Mons Claudianus	RO	K	ind	404		D*	300.0	33.0	11.00
105	Mons Claudianus	RO	K	ind	405			300.0	33.4	11.13
105	Mons Claudianus	RO	K	ind	414		M	338.0	38.0	11.24
105	Mons Claudianus	RO	K	ind	415			318.0	38.8	12.20
105	Mons Claudianus	RO	K	ind	416		M?	313.0	37.8	12.08
105	Mons Claudianus	RO	K	ind	417			300.0	30.0	10.00
105	Mons Claudianus	RO	K	ind	418			300.0	33.0	11.00
110	Nijmegen new excavations	RO	F	urb	486	147/128-15	H?	359.1	39.1	10.89
112	Pompeii, Sarno Baths	RO	A	urb	491	C		331.0	36.2	10.94
112	Pompeii, Sarno Baths	RO	A	urb	492	D		338.0	39.0	11.54
114	Unterlaa	RO	G	urb	494	25	H	329.7	36.1	10.95
114	Unterlaa	RO	G	urb	495	30	H	327.1	36.4	11.13
115	Bad Wimpfen	RO	F	urb2	497		M*	346.0	39.4	11.39
115	Bad Wimpfen	RO	F	urb2	498		H*	337.5	37.5	11.11
115	Bad Wimpfen	RO	F	urb2	499	?female	M*	373.0	45.2	12.12
115	Bad Wimpfen	RO	F	urb2	500		M*	331.0	38.3	11.57
115	Bad Wimpfen	RO	F	urb2	505		M	349.0	38.1	10.92
115	Bad Wimpfen	RO	F	urb2	506		M*	349.0	37.7	10.80
116	Pommeroeul	RO	D	urb2	523	251	H	306.0	33.0	10.78
116	Pommeroeul	RO	D	urb2	524	248-1	D*	308.0	32.0	10.39
116	Pommeroeul	RO	D	urb2	525	248-2	H*	320.0	35.0	10.94
116	Pommeroeul	RO	D	urb2	526	248-3	H?	323.0	35.0	10.84
116	Pommeroeul	RO	D	urb2	527	248-4	H*	324.0	36.0	11.11
116	Pommeroeul	RO	D	urb2	528	248-5	H*	329.0	36.0	10.94
116	Pommeroeul	RO	D	urb2	529	248-6	H*	329.0	35.0	10.64
116	Pommeroeul	RO	D	urb2	530	17-1	M*	334.0	38.0	11.38
116	Pommeroeul	RO	D	urb2	531	271	M*	340.0	35.0	10.29
116	Pommeroeul	RO	D	urb2	532	294-1	M*	340.0	37.0	10.88
116	Pommeroeul	RO	D	urb2	533	348		342.0	37.0	10.82

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
116	Pommeroeul	RO	D	urb2	534	294-2	M	358.0	40.0	11.17
116	Pommeroeul	RO	D	urb2	535	17-2	M*	362.0	39.0	10.77
116	Pommeroeul	RO	D	urb2	536	248-7	M	366.0	39.0	10.66
116	Pommeroeul	RO	D	urb2	537	17-3	M*	377.0	38.0	10.08
117	Pompeii stable	RO	A	urb	541	A		352.0	35.2	10.00
117	Pompeii stable	RO	A	urb	542	E		322.0	35.8	11.12
118	Carnuntum	RO	G	mil	543		M*	384.0	43.6	11.35
118	Carnuntum	RO	G	mil	544	Pferd 1	M	349.0	40.2	11.52
118	Carnuntum	RO	G	mil	545	Pferd 2	H	328.0	41.3	12.59
118	Carnuntum	RO	G	mil	546	Pferd 3	H	368.0	40.6	11.03
118	Carnuntum	RO	G	mil	547		M*	379.0	43.5	11.48
118	Carnuntum	RO	G	mil	548		M	363.0	42.3	11.65
119	Albertfalva	RO	G	mil	549	Horse 3		383.1	41.0	10.70
120	Basel-Gasfabrik	IA	F	rural	551		H?	277.4	28.2	10.17
123	Wroxeter Baths basilica	RO	E	urb	564			333.5	40.0	11.99
124	Haddon	IA+RO	E	oth	573			334.0	33.6	10.06
125	Castleford	RO	E	mil	574			305.0	32.6	10.69
125	Castleford	RO	E	mil	575			364.0	39.7	10.91
125	Castleford	RO	E	mil	576			342.0	41.7	12.19
128	Krefeld-Gellep	RO	F	mil	582	3392	H*	350.0	43.0	12.29
128	Krefeld-Gellep	RO	F	mil	583	3392	H*	352.0	43.0	12.22
128	Krefeld-Gellep	RO	F	mil	584	3577A	M	348.0	40.0	11.49
128	Krefeld-Gellep	RO	F	mil	585	3557	H?	360.0	42.0	11.67
128	Krefeld-Gellep	RO	F	mil	589	3510	D*	292.0	29.0	9.93
129	Lorenzberg Bei Epfach	RO	F	oth	590			346.0	42.0	12.14
129	Lorenzberg Bei Epfach	RO	F	oth	593		H	320.0	33.5	10.47
129	Lorenzberg Bei Epfach	RO	F	oth	595		H*	297.0	34.0	11.45
133	Colchester	RO	E	urb	600			332.0	40.0	12.05
133	Colchester	RO	E	urb	602			343.0	40.0	11.66
135	Swestari	IA	G	cem	615	1	H	302.0	36.3	12.02
135	Swestari	IA	G	cem	616	2	H	305.0	33.0	10.82
135	Swestari	IA	G	cem	617	3	H	317.0	38.0	11.99
135	Swestari	IA	G	cem	618	4	H*	339.0	43.0	12.68
135	Swestari	IA	G	cem	619	5	M	364.0	39.0	10.71
136	Worth Matravers	RO	E	rural	620			319.0	38.9	12.19
137	Magdelenska Gora	IA	G	cem	621	V, 29, I		332.0	34.0	10.24
137	Magdelenska Gora	IA	G	cem	622	V, 29, II		313.0	34.0	10.86
138	Brezje	IA	G	oth	623	VI,1-2,I		335.0	41.0	12.24
141	Szentes-Vekerzug	IA	G	cem	624	6		320.0	36.0	11.25
142	Velemszentvid	IA	G	cem	625	54.448.1		330.0	34.5	10.45
142	Velemszentvid	IA	G	cem	627	54.448.3		345.0	36.5	10.58
145	Jaszfelsozentgyorgy	IA	G	rural	630	62.1.81		355.0	41.0	11.55
146	Balatonaliga	RO	G	rural	631	574b		317.0	36.0	11.36
147	Pilismarot I Watchtower	RO	G	mil	633			338.0	40.5	11.98
148	Szaszhalombatta	RO	G	mil	634	54.1.2		313.0	35.0	11.18
156	Invillino- Ibliglo	RO	A	oth	639			343.0	38.7	11.28
161	San Giovanni	RO	A	villa	645			353.2	38.6	10.93
173	Paestum	RO	A	rural	652			331.0	37.5	11.33
173	Paestum	RO	A	rural	653			322.0	34.5	10.71
174	Abusina-Eining	RO	F	mil	654			335.0	40.5	12.09
174	Abusina-Eining	RO	F	mil	655			347.5	39.0	11.22
174	Abusina-Eining	RO	F	mil	656		M*	360.0	40.5	11.25
176	Oberdorla	NAT	F	cem	665			346.0	33.0	9.54
176	Oberdorla	NAT	F	cem	666			307.0	38.0	12.38
176	Oberdorla	NAT	F	cem	667			285.0	30.0	10.53
178	Vitudurum-Oberwinterthur	RO	F	urb2	673			314.0	35.7	11.37

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
178	Vitudurum-Oberwinterthur	RO	F	urb2	674			332.0	34.9	10.51
181	Barnsley Park	RO	E	rural	676			275.0	32.0	11.64
181	Barnsley Park	RO	E	rural	677			334.0	40.0	11.98
182	Frocester Court	RO	E	villa	681			390.0	37.0	9.49
182	Frocester Court	RO	E	villa	682			350.0	36.0	10.29
184	Chilgrove 1	RO	E	villa	687			308.0	37.0	12.01
186	Shakenoak site K	RO	E	villa	693			323.0	40.0	12.38
187	Hayton Fort	RO	E	mil	694			287.5	31.5	10.96
188	Titelberg oppidum	RO	D	rural	695		H	322.0	38.0	11.80
189	Kassope	IA	H	urb	701			250.0	29.5	11.80
189	Kassope	IA	H	urb	702			249.0	28.0	11.24
189	Kassope	IA	H	urb	705			273.0	28.0	10.26
189	Kassope	IA	H	urb	706			270.0	28.0	10.37
189	Kassope	IA	H	urb	712			294.5	32.0	10.87
192	Pfaffenhofen - Pons Aeni	RO	F	rural	713			323.0	37.0	11.46
192	Pfaffenhofen - Pons Aeni	RO	F	rural	714		H*	332.0	37.0	11.14
192	Pfaffenhofen - Pons Aeni	RO	F	rural	717			355.0	42.0	11.83
192	Pfaffenhofen - Pons Aeni	RO	F	rural	718		M	364.0	40.0	10.99
195	Kunzing-Quintana	RO	F	mil	723		M	356.0	40.0	11.24
199	Hufingen	RO	F	rural	732		H*	348.0	38.5	11.06
199	Hufingen	RO	F	rural	733			348.0	38.5	11.06
199	Hufingen	RO	F	rural	734		H*	347.0	40.5	11.67
199	Hufingen	RO	F	rural	735			343.0	37.5	10.93
199	Hufingen	RO	F	rural	736			332.0	37.5	11.30
199	Hufingen	RO	F	rural	737		M*	349.0	37.5	10.74
200	Pfaffenhofen	RO	F	rural	762		H?	326.0	35.0	10.74
200	Pfaffenhofen	RO	F	rural	763		H*	344.0	40.0	11.63
201	Wehringen	RO	F	villa	765		M	359.0	38.5	10.72
202	Penzlin	NAT	F	rural	766		H?	301.5	32.7	10.85
203	Tac-Gorsium	RO	G	urb	770			307.0	38.5	12.54
203	Tac-Gorsium	RO	G	urb	771			320.0	43.5	13.59
203	Tac-Gorsium	RO	G	urb	772			323.0	37.5	11.61
203	Tac-Gorsium	RO	G	urb	773			323.5	35.0	10.82
203	Tac-Gorsium	RO	G	urb	774			325.0	34.0	10.46
203	Tac-Gorsium	RO	G	urb	775			325.0	40.5	12.46
203	Tac-Gorsium	RO	G	urb	776			326.0	37.0	11.35
203	Tac-Gorsium	RO	G	urb	777			330.5	35.0	10.59
203	Tac-Gorsium	RO	G	urb	778			333.0	41.0	12.31
203	Tac-Gorsium	RO	G	urb	779			335.0	33.0	9.85
203	Tac-Gorsium	RO	G	urb	780			336.0	40.0	11.90
203	Tac-Gorsium	RO	G	urb	781			337.0	38.5	11.42
203	Tac-Gorsium	RO	G	urb	782			340.0	36.5	10.74
203	Tac-Gorsium	RO	G	urb	783			342.0	38.5	11.26
203	Tac-Gorsium	RO	G	urb	784			343.0	37.0	10.79
203	Tac-Gorsium	RO	G	urb	785			343.0	37.0	10.79
203	Tac-Gorsium	RO	G	urb	786			346.0	37.5	10.84
203	Tac-Gorsium	RO	G	urb	787			347.0	39.0	11.24
203	Tac-Gorsium	RO	G	urb	788			348.0	41.5	11.93
203	Tac-Gorsium	RO	G	urb	789			352.0	39.0	11.08
203	Tac-Gorsium	RO	G	urb	790			352.0	43.0	12.22
203	Tac-Gorsium	RO	G	urb	791			376.0	43.0	11.44
203	Tac-Gorsium	RO	G	urb	845			260.0	29.5	11.35
204	Conchil	RO	D	rural	848			323.0	39.8	12.32
204	Conchil	RO	D	rural	850			318.0	35.8	11.26
204	Conchil	RO	D	rural	851			349.0	42.2	12.09
205	Oberstimm	RO	F	mil	853		H*	304.0	33.0	10.86

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
205	Oberstimm	RO	F	mil	854			345.0	37.5	10.87
206	Lauriacum	RO	F	oth	865		M*	345.0	38.5	11.16
208	Colonia Ulpia Traiana	RO	F	urb	868			347.0	39.0	11.24
208	Colonia Ulpia Traiana	RO	F	urb	869			342.0	39.5	11.55
208	Colonia Ulpia Traiana	RO	F	urb	870			339.0	27.0	7.96
208	Colonia Ulpia Traiana	RO	F	urb	871			335.0	39.5	11.79
208	Colonia Ulpia Traiana	RO	F	urb	872			335.0	36.5	10.90
208	Colonia Ulpia Traiana	RO	F	urb	874			320.0	38.0	11.88
209	Iatrus	RO	G	oth	876			315.2	37.5	11.90
213	Beauvais	IA	D	rural	884			301.0	29.0	9.63
213	Beauvais	IA	D	rural	885			306.0	29.5	9.64
213	Beauvais	IA	D	rural	886			290.0	33.0	11.38
213	Beauvais	IA	D	rural	887			286.0	32.5	11.36
213	Beauvais	IA	D	rural	888			316.0	35.0	11.08
213	Beauvais	IA	D	rural	889			321.0	33.0	10.28
213	Beauvais	IA	D	rural	890			292.0	32.0	10.96
214	Compiegne	IA	D	rural	896			315.0	36.0	11.43
214	Compiegne	IA	D	rural	897			331.0	36.0	10.88
214	Compiegne	IA	D	rural	898			313.0	39.0	12.46
214	Compiegne	IA	D	rural	899			310.0	34.0	10.97
215	Ribemont	IA	D	oth	901			321.0	35.0	10.90
215	Ribemont	IA	D	oth	902			293.0	30.0	10.24
215	Ribemont	IA	D	oth	903			299.0	31.5	10.54
215	Ribemont	IA	D	oth	904			323.0	35.0	10.84
215	Ribemont	IA	D	oth	905			318.0	37.0	11.64
216	Variscourt	IA	D	rural	906			291.0	34.0	11.68
216	Variscourt	IA	D	rural	907			295.0	31.0	10.51
216	Variscourt	IA	D	rural	908			336.0	38.0	11.31
216	Variscourt	IA	D	rural	909			304.0	32.0	10.53
216	Variscourt	IA	D	rural	910			300.0	35.0	11.67
217	Soissons	IA	D	cem	916			262.0	29.0	11.07

Table A36. – Results of the calculation of the distal breadth to greatest length index on the Radii

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
8	Hardingstone School	RO	E	ind	355			299.0	64.0	21.40
8	Hardingstone School	RO	E	ind	356			293.0	63.0	21.50
13	Wavendon Gate	RO	E	rural	344			347.0	76.0	21.90
13	Wavendon Gate	RO	E	rural	346			328.0	72.2	22.01
13	Wavendon Gate	RO	E	rural	349			344.0	76.6	22.27
14	Lincoln	RO	E	urb	343			290.0	61.0	21.03
15	Scole-Dickleburgh	RO	E	urb2	334			325.2	70.7	21.74
15	Scole-Dickleburgh	RO	E	urb2	339			283.2	66.6	23.52
23	Puckeridge	IA	E	rural	329			320.0	60.5	18.91
23	Puckeridge	IA	E	rural	330			308.0	63.5	20.62
28	Longthorpe II	RO	E	mil	325			315.0	65.0	20.63
35	Castricum-Oosterbuurt	RO	F	oth	315			330.0	78.6	23.81
35	Castricum-Oosterbuurt	RO	F	oth	319			311.0	67.6	21.74
37	Kesteren 'De Prinsenhof'	RO	F	cem	307	11-36		349.0	78.3	22.44
37	Kesteren 'De Prinsenhof'	RO	F	cem	308	11-34		345.0	77.0	22.32
37	Kesteren 'De Prinsenhof'	RO	F	cem	312	1-11		358.0	81.2	22.68
38	Nijmegen	RO	F	urb	285			336.1	78.2	23.27
38	Nijmegen	RO	F	urb	288			320.3	67.2	20.98
38	Nijmegen	RO	F	urb	289			324.6	66.5	20.49
38	Nijmegen	RO	F	urb	290			326.7	74.2	22.71
38	Nijmegen	RO	F	urb	291			325.9	72.4	22.22
38	Nijmegen	RO	F	urb	292			332.7	70.5	21.19
38	Nijmegen	RO	F	urb	294			338.0	74.9	22.16
38	Nijmegen	RO	F	urb	295			332.8	77.8	23.38
38	Nijmegen	RO	F	urb	296			365.0	82.3	22.55
38	Nijmegen	RO	F	urb	304			330.5	68.2	20.64
42	Druten	RO	F	villa	269			354.8	74.0	20.86
42	Druten	RO	F	villa	278			360.0	79.8	22.17
42	Druten	RO	F	villa	282	1.18	M*	367.0	81.4	22.18
43	Elms Farm	RO	E	urb2	254			351.0	79.4	22.62
43	Elms Farm	RO	E	urb2	256	6640	H*	346.0	75.4	21.79
43	Elms Farm	RO	E	urb2	257	6640	H*	339.0	76.9	22.68
43	Elms Farm	IA	E	urb2	266			296.0	63.7	21.52
43	Elms Farm	IA	E	urb2	267			358.0	75.4	21.06
44	Danebury	IA	E	rural	248			300.0	66.0	22.00
46	E London RB Cemetary	RO	E	cem	228		H	324.5	71.4	22.00
46	E London RB Cemetary	RO	E	cem	230			345.0	75.0	21.74
47	Beddington Sewage Farm	RO	E	urb	221		H*	307.6	64.5	20.97
47	Beddington Sewage Farm	RO	E	urb	224		H*	278.0	63.1	22.70
54	Thorpe Thewles	IA	E	rural	217			289.9	61.9	21.35
57	La Sagesse	IA	E	oth	211			323.0	68.6	21.24
66	Settefinestre	RO	A	villa	204			333.0	66.0	19.82
69	Thorley	RO	E	rural	202		H	300.0	66.8	22.27
71	Piovego	IA	A	cem	200	N2		319.0	69.0	21.63
77	Grotto di Tibera	RO	A	oth	199	15.1		324.0	76.0	23.46
78	Cowbridge	RO	E	urb	198			297.0	66.0	22.22
79	Olbia	IA	A	rural	195		D	259.7	52.5	20.22
79	Olbia	IA	A	rural	196		D	253.4	51.7	20.40
79	Olbia	IA	A	rural	197		D	254.1	54.0	21.25
87	Manching	IA	F	rural	162		H?	273.0	60.0	21.98

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
87	Manching	IA	F	rural	163		H?	275.0	61.0	22.18
87	Manching	IA	F	rural	164		H*	276.0	62.0	22.46
87	Manching	IA	F	rural	165			279.5	61.0	21.82
87	Manching	IA	F	rural	166			287.5	62.5	21.74
87	Manching	IA	F	rural	167		D*	289.0	63.0	21.80
87	Manching	IA	F	rural	168		H*	291.0	66.5	22.85
87	Manching	IA	F	rural	169		H?	292.0	62.5	21.40
87	Manching	IA	F	rural	170		D*	293.0	62.0	21.16
87	Manching	IA	F	rural	171		D*	295.5	65.0	22.00
87	Manching	IA	F	rural	172			297.5	68.5	23.03
87	Manching	IA	F	rural	174			298.0	68.0	22.82
87	Manching	IA	F	rural	176		H	301.5	69.5	23.05
87	Manching	IA	F	rural	177			306.0	61.5	20.10
87	Manching	IA	F	rural	179		D*	309.0	64.0	20.71
87	Manching	IA	F	rural	181		H?	312.5	67.5	21.60
87	Manching	IA	F	rural	183			313.5	64.0	20.41
87	Manching	IA	F	rural	184		H?	316.0	69.0	21.84
87	Manching	IA	F	rural	185		M?	318.0	69.0	21.70
87	Manching	IA	F	rural	186			326.0	67.0	20.55
87	Manching	IA	F	rural	187			326.5	68.5	20.98
87	Manching	IA	F	rural	188		M?	333.5	71.5	21.44
92	Feddersen Wierde	NAT	F	rural	26	skelett3L	M	342.0	71.5	20.91
92	Feddersen Wierde	NAT	F	rural	27	skelett2R	H	305.1	72.1	23.63
92	Feddersen Wierde	NAT	F	rural	28	skelett2L		304.4	72.4	23.78
92	Feddersen Wierde	NAT	F	rural	29	skelett1R	H	326.5	73.7	22.57
92	Feddersen Wierde	NAT	F	rural	30	skelett1L	H	325.5	72.8	22.37
92	Feddersen Wierde	NAT	F	rural	31		H	304.3	67.9	22.31
92	Feddersen Wierde	NAT	F	rural	33		M	346.2	71.5	20.65
92	Feddersen Wierde	NAT	F	rural	34		H?	320.1	70.4	21.99
92	Feddersen Wierde	NAT	F	rural	35		H	304.8	70.3	23.06
92	Feddersen Wierde	NAT	F	rural	36		H*	303.9	70.2	23.10
92	Feddersen Wierde	NAT	F	rural	37		H*	290.7	65.8	22.64
92	Feddersen Wierde	NAT	F	rural	38		H	329.1	78.6	23.88
92	Feddersen Wierde	NAT	F	rural	39		H	301.0	64.7	21.50
92	Feddersen Wierde	NAT	F	rural	40		M	316.7	70.9	22.39
92	Feddersen Wierde	NAT	F	rural	41		H	323.1	71.5	22.13
92	Feddersen Wierde	NAT	F	rural	42		M?	315.8	69.1	21.88
92	Feddersen Wierde	NAT	F	rural	43		H?	317.1	67.4	21.26
92	Feddersen Wierde	NAT	F	rural	44		H	320.8	72.4	22.57
92	Feddersen Wierde	NAT	F	rural	45		H	323.5	76.8	23.74
92	Feddersen Wierde	NAT	F	rural	46		H	314.1	69.0	21.97
92	Feddersen Wierde	NAT	F	rural	47		D*	300.5	64.3	21.40
92	Feddersen Wierde	NAT	F	rural	48		H*	302.4	72.5	23.97
92	Feddersen Wierde	NAT	F	rural	49			317.1	68.1	21.48
92	Feddersen Wierde	NAT	F	rural	50		H	321.6	72.3	22.48
92	Feddersen Wierde	NAT	F	rural	51			306.6	69.8	22.77
92	Feddersen Wierde	NAT	F	rural	52		H*	281.6	67.1	23.83
92	Feddersen Wierde	NAT	F	rural	53		H*	334.0	79.1	23.68
92	Feddersen Wierde	NAT	F	rural	54		H	303.0	68.0	22.44
92	Feddersen Wierde	NAT	F	rural	55		H	319.4	72.9	22.82
92	Feddersen Wierde	NAT	F	rural	56		H	305.7	67.9	22.21
92	Feddersen Wierde	NAT	F	rural	57		H?	286.4	60.4	21.09
92	Feddersen Wierde	NAT	F	rural	58		H*	301.0	69.0	22.92
92	Feddersen Wierde	NAT	F	rural	59			314.1	67.5	21.49
92	Feddersen Wierde	NAT	F	rural	60			316.6	68.8	21.73
92	Feddersen Wierde	NAT	F	rural	61		H	311.5	71.8	23.05

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
92	Feddersen Wierde	NAT	F	rural	62		H?	317.7	71.6	22.54
92	Feddersen Wierde	NAT	F	rural	63		H?	313.7	68.5	21.84
96	Kunzing east vicus	RO	F	cem	1	1703	M	347.0	76.5	22.05
96	Kunzing east vicus	RO	F	cem	2	1641	M	356.5	77.0	21.60
96	Kunzing east vicus	RO	F	cem	3	1581		347.5	79.2	22.79
96	Kunzing east vicus	RO	F	cem	4	1575/5		338.0	72.8	21.54
96	Kunzing east vicus	RO	F	cem	5	1620	H*	345.5	78.6	22.75
96	Kunzing east vicus	RO	F	cem	6	1632	M	345.0	76.4	22.14
103	Newstead fort	RO	E	mil	388			355.0	81.7	23.01
104	Orton Hall Farm	RO	E	villa	389			311.0	66.0	21.22
104	Orton Hall Farm	RO	E	villa	390			334.0	71.0	21.26
104	Orton Hall Farm	RO	E	villa	391			340.0	72.0	21.18
110	Nijmegen new excavations	RO	F	urb	486	147/128-15	H?	359.1	81.8	22.78
112	Pompeii, Sarno Baths	RO	A	urb	491	C		331.0	74.0	22.36
112	Pompeii, Sarno Baths	RO	A	urb	492	D		338.0	77.2	22.84
114	Unterlaa	RO	G	urb	494	25	H	329.7	73.4	22.26
114	Unterlaa	RO	G	urb	495	30	H	327.1	72.9	22.29
115	Bad Wimpfen	RO	F	urb2	497		M*	346.0	77.9	22.51
115	Bad Wimpfen	RO	F	urb2	498		H*	337.5	74.3	22.01
115	Bad Wimpfen	RO	F	urb2	500		M*	331.0	72.4	21.87
115	Bad Wimpfen	RO	F	urb2	505		M	349.0	76.2	21.83
115	Bad Wimpfen	RO	F	urb2	506		M*	349.0	77.2	22.12
116	Pommeroeul	RO	D	urb2	523	251	H	306.0	70.0	22.88
116	Pommeroeul	RO	D	urb2	524	248-1	D*	308.0	68.0	22.08
116	Pommeroeul	RO	D	urb2	525	248-2	H*	320.0	70.0	21.88
116	Pommeroeul	RO	D	urb2	526	248-3	H?	323.0	64.0	19.81
116	Pommeroeul	RO	D	urb2	527	248-4	H*	324.0	70.0	21.60
116	Pommeroeul	RO	D	urb2	528	248-5	H*	329.0	71.0	21.58
116	Pommeroeul	RO	D	urb2	529	248-6	H*	329.0	71.0	21.58
116	Pommeroeul	RO	D	urb2	530	17-1	M*	334.0	77.0	23.05
116	Pommeroeul	RO	D	urb2	531	271	M*	340.0	74.0	21.76
116	Pommeroeul	RO	D	urb2	532	294-1	M*	340.0	75.0	22.06
116	Pommeroeul	RO	D	urb2	533	348		342.0	75.0	21.93
116	Pommeroeul	RO	D	urb2	534	294-2	M	358.0	79.0	22.07
116	Pommeroeul	RO	D	urb2	535	17-2	M*	362.0	80.0	22.10
116	Pommeroeul	RO	D	urb2	536	248-7	M	366.0	83.0	22.68
116	Pommeroeul	RO	D	urb2	537	17-3	M*	377.0	78.0	20.69
117	Pompeii stable	RO	A	urb	542	E		322.0	73.5	22.83
118	Carnuntum	RO	G	mil	543		M*	384.0	84.3	21.95
118	Carnuntum	RO	G	mil	544	Pferd 1	M	349.0	78.8	22.58
118	Carnuntum	RO	G	mil	545	Pferd 2	H	328.0	76.8	23.41
118	Carnuntum	RO	G	mil	546	Pferd 3	H	368.0	82.2	22.34
118	Carnuntum	RO	G	mil	547		M*	379.0	84.0	22.16
118	Carnuntum	RO	G	mil	548		M	363.0	83.3	22.95
119	Albertfalva	RO	G	mil	549	Horse 3		383.1	79.1	20.65
120	Basel-Gasfabrik	IA	F	rural	551		H?	277.4	59.9	21.59
125	Castleford	RO	E	mil	578			342.0	77.4	22.63
129	Lorenzberg Bei Epfach	RO	F	oth	590			346.0	79.0	22.83
129	Lorenzberg Bei Epfach	RO	F	oth	593		H	320.0	71.0	22.19
129	Lorenzberg Bei Epfach	RO	F	oth	595		H*	297.0	68.5	23.06
133	Colchester	RO	E	urb	600			332.0	76.0	22.89
133	Colchester	RO	E	urb	602			343.0	76.0	22.16
133	Colchester	RO	E	urb	603			313.0	69.0	22.04
133	Colchester	RO	E	urb	605			335.0	74.0	22.09
133	Colchester	RO	E	urb	606			321.0	74.0	23.05
135	Swestari	IA	G	cem	615	1	H	302.0	69.0	22.85

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
135	Swestari	IA	G	cem	616	2	H	305.0	65.0	21.31
135	Swestari	IA	G	cem	617	3	H	317.0	72.0	22.71
135	Swestari	IA	G	cem	618	4	H*	339.0	79.0	23.30
135	Swestari	IA	G	cem	619	5	M	364.0	79.0	21.70
136	Worth Matravers	RO	E	rural	620			319.0	71.5	22.41
137	Magdelenska Gora	IA	G	cem	621	V, 29, I		332.0	73.0	21.99
137	Magdelenska Gora	IA	G	cem	622	V, 29, II		313.0	69.0	22.04
138	Brezje	IA	G	oth	623	VI,1-2,I		335.0	75.0	22.39
141	Szentes-Vekerzug	IA	G	cem	624	6		320.0	69.0	21.56
142	Velemszentvid	IA	G	cem	625	54.448.1		330.0	73.5	22.27
145	Jaszfelsozentgyorgy	IA	G	rural	630	62.1.81		355.0	83.0	23.38
146	Balatonaliga	RO	G	rural	631	574b		317.0	70.0	22.08
147	Pilismarot I Watchtower	RO	G	mil	633			338.0	78.5	23.22
148	Szaszhalombatta	RO	G	mil	634	54.1.2		313.0	68.0	21.73
161	San Giovanni	RO	A	villa	645			353.2	74.2	21.01
173	Paestum	RO	A	rural	653			322.0	73.0	22.67
174	Abusina-Eining	RO	F	mil	654			335.0	76.5	22.84
174	Abusina-Eining	RO	F	mil	655			347.5	77.0	22.16
174	Abusina-Eining	RO	F	mil	656		M*	360.0	81.5	22.64
176	Oberdorla	NAT	F	cem	666			307.0	70.0	22.80
176	Oberdorla	NAT	F	cem	667			285.0	63.0	22.11
177	Champlieu	IA	D	rural	672			280.0	58.2	20.79
178	Vitudurum-Oberwinterthur	RO	F	urb2	673			314.0	70.9	22.58
178	Vitudurum-Oberwinterthur	RO	F	urb2	674			332.0	72.5	21.84
181	Barnsley Park	RO	E	rural	676			275.0	67.0	24.36
181	Barnsley Park	RO	E	rural	677			334.0	75.0	22.46
182	Frocester Court	RO	E	villa	681			390.0	69.0	17.69
182	Frocester Court	RO	E	villa	682			350.0	72.0	20.57
182	Frocester Court	RO	E	villa	683			313.0	63.0	20.13
182	Frocester Court	RO	E	villa	684			303.0	62.0	20.46
184	Chilgrove 1	RO	E	villa	687			308.0	68.0	22.08
186	Shakenoak site K	RO	E	villa	693			323.0	76.0	23.53
187	Hayton Fort	RO	E	mil	694			287.5	71.5	24.87
189	Kassope	IA	H	urb	701			250.0	54.0	21.60
189	Kassope	IA	H	urb	702			249.0	55.0	22.09
189	Kassope	IA	H	urb	705			273.0	58.0	21.25
189	Kassope	IA	H	urb	706			270.0	57.5	21.30
192	Pfaffenhofen - Pons Aeni	RO	F	rural	713			323.0	72.0	22.29
192	Pfaffenhofen - Pons Aeni	RO	F	rural	714		H*	332.0	73.0	21.99
192	Pfaffenhofen - Pons Aeni	RO	F	rural	717			355.0	81.0	22.82
192	Pfaffenhofen - Pons Aeni	RO	F	rural	718		M	364.0	80.0	21.98
195	Kunzing-Quintana	RO	F	mil	723		M	356.0	78.0	21.91
199	Hufingen	RO	F	rural	732		H*	348.0	78.0	22.41
199	Hufingen	RO	F	rural	733			348.0	79.5	22.84
199	Hufingen	RO	F	rural	734		H*	347.0	79.5	22.91
199	Hufingen	RO	F	rural	737		M*	349.0	76.5	21.92
200	Pfaffenhofen	RO	F	rural	762		H?	326.0	72.5	22.24
200	Pfaffenhofen	RO	F	rural	763		H*	344.0	76.0	22.09
201	Wehringen	RO	F	villa	765		M	359.0	73.0	20.33
202	Penzlin	NAT	F	rural	766		H?	301.5	65.6	21.76
203	Tac-Gorsium	RO	G	urb	770			307.0	73.0	23.78
203	Tac-Gorsium	RO	G	urb	772			323.0	71.5	22.14
203	Tac-Gorsium	RO	G	urb	773			323.5	68.5	21.17
203	Tac-Gorsium	RO	G	urb	774			325.0	72.0	22.15
203	Tac-Gorsium	RO	G	urb	775			325.0	77.0	23.69
203	Tac-Gorsium	RO	G	urb	776			326.0	74.0	22.70

Site no	Site name	Period	Region	Site type	Bone no	Specimen	ID	Gl	SD	Index
203	Tac-Gorsium	RO	G	urb	777			330.5	77.0	23.30
203	Tac-Gorsium	RO	G	urb	778			333.0	74.0	22.22
203	Tac-Gorsium	RO	G	urb	779			335.0	69.5	20.75
203	Tac-Gorsium	RO	G	urb	780			336.0	71.5	21.28
203	Tac-Gorsium	RO	G	urb	781			337.0	74.0	21.96
203	Tac-Gorsium	RO	G	urb	782			340.0	70.0	20.59
203	Tac-Gorsium	RO	G	urb	783			342.0	74.0	21.64
203	Tac-Gorsium	RO	G	urb	784			343.0	75.0	21.87
203	Tac-Gorsium	RO	G	urb	785			343.0	74.0	21.57
203	Tac-Gorsium	RO	G	urb	786			346.0	76.5	22.11
203	Tac-Gorsium	RO	G	urb	787			347.0	76.0	21.90
203	Tac-Gorsium	RO	G	urb	788			348.0	79.0	22.70
203	Tac-Gorsium	RO	G	urb	789			352.0	73.0	20.74
203	Tac-Gorsium	RO	G	urb	790			352.0	82.0	23.30
203	Tac-Gorsium	RO	G	urb	791			376.0	82.5	21.94
203	Tac-Gorsium	RO	G	urb	845			260.0	58.0	22.31
205	Oberstimm	RO	F	mil	853		H*	304.0	65.5	21.55
205	Oberstimm	RO	F	mil	854			345.0	74.0	21.45
206	Lauriacum	RO	F	oth	865		M*	345.0	76.5	22.17
208	Colonia Ulpia Traiana	RO	F	urb	869			342.0	81.5	23.83
208	Colonia Ulpia Traiana	RO	F	urb	871			335.0	80.0	23.88
209	Iatrus	RO	G	oth	876			315.2	68.1	21.61
212	Gournay	IA	D	cem	881			303.0	66.0	21.78
212	Gournay	IA	D	cem	883			302.0	66.0	21.85
213	Beauvais	IA	D	rural	884			301.0	66.0	21.93
213	Beauvais	IA	D	rural	885			306.0	62.0	20.26
213	Beauvais	IA	D	rural	886			290.0	65.0	22.41
213	Beauvais	IA	D	rural	887			286.0	63.0	22.03
213	Beauvais	IA	D	rural	888			316.0	79.0	25.00
213	Beauvais	IA	D	rural	889			321.0	64.0	19.94
213	Beauvais	IA	D	rural	890			292.0	64.0	21.92
214	Compiegne	IA	D	rural	896			315.0	70.0	22.22
214	Compiegne	IA	D	rural	897			331.0	74.0	22.36
214	Compiegne	IA	D	rural	898			313.0	72.0	23.00
214	Compiegne	IA	D	rural	899			310.0	69.0	22.26
215	Ribemont	IA	D	oth	901			321.0	72.5	22.59
215	Ribemont	IA	D	oth	902			293.0	62.0	21.16
215	Ribemont	IA	D	oth	903			299.0	65.0	21.74
215	Ribemont	IA	D	oth	904			323.0	74.5	23.07
215	Ribemont	IA	D	oth	905			318.0	74.0	23.27
216	Variscourt	IA	D	rural	906			291.0	68.0	23.37
216	Variscourt	IA	D	rural	907			295.0	61.0	20.68
216	Variscourt	IA	D	rural	908			336.0	69.5	20.68
216	Variscourt	IA	D	rural	909			304.0	65.0	21.38
216	Variscourt	IA	D	rural	910			300.0	70.0	23.33
217	Soissons	IA	D	cem	916			262.0	55.0	20.99

Table A37. – Results of the calculation of log ratios on the horse length measurements

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
5	M/Ts	IA	E	rural	464		H	248.0		-0.017		-0.017
28	M/Ts	RO	E	mil	423		H	224.0		-0.061		-0.061
28	M/Ts	RO	E	mil	424		H*	223.0		-0.063		-0.063
28	M/Ts	RO	E	mil	425		H	251.0		-0.012		-0.012
37	Fem	RO	F	cem	142	11-28	H*	407.0		0.026		0.026
37	Fem	RO	F	cem	147	2-27	H*	407.0		0.026		0.026
37	Tib	RO	F	cem	289	11-28	H*	374.0		0.045		0.045
37	M/Ts	RO	F	cem	396	11-28	H*	280.0		0.035		0.035
37	M/Ts	RO	F	cem	398	2-27	H*	284.0		0.042		0.042
38	Tib	RO	F	urb	277		H	335.8	303.4	-0.002	-0.004	-0.003
38	M/Ts	RO	F	urb	380		H	258.0		0.000		0.000
38	M/Ts	RO	F	urb	383		H*	274.8	270.8	0.027	0.036	0.032
38	M/Ts	RO	F	urb	385		H*	260.2		0.004		0.004
38	M/Cs	RO	F	urb	501		H*	211.7		-0.009		-0.009
38	M/Cs	RO	F	urb	505		H*	240.4	235.8	0.046	0.057	0.051
38	M/Cs	RO	F	urb	508		H	217.3	213.7	0.002	0.014	0.008
38	M/Cs	RO	F	urb	509		H*	226.9	223.7	0.021	0.034	0.027
38	M/Cs	RO	F	urb	511		H	222.1	217.7	0.012	0.022	0.017
38	M/Cs	RO	F	urb	519		H	215.8		-0.001		-0.001
39	M/Ts	RO	F	urb2	378		H*	237.8	242.4	-0.036	-0.012	-0.024
42	Hum	RO	F	villa	157		H*	275.0	288.4	0.012	0.002	0.007
42	Tib	RO	F	villa	250	12.4	H*	342.5		0.007		0.007
42	M/Ts	RO	F	villa	364		H	248.1		-0.017		-0.017
42	M/Ts	RO	F	villa	367		H*	271.8	267.7	0.023	0.031	0.027
42	M/Ts	RO	F	villa	368		H*	259.4	255.0	0.002	0.010	0.006
42	M/Cs	RO	F	villa	483		H*	220.3		0.008		0.008
42	M/Cs	RO	F	villa	485		H*	231.8		0.030		0.030
42	M/Cs	RO	F	villa	490		H*	232.6		0.032		0.032
42	M/Cs	IA	F	villa	495		H*	224.2		0.016		0.016
43	Rad	RO	E	urb2	256	6640	H*	346.0	327.0	0.039	0.039	0.039
43	Rad	RO	E	urb2	257	6640	H*	339.0	329.0	0.030	0.042	0.036
43	M/Ts	RO	E	urb2	350	6640	H*	269.0	262.0	0.018	0.022	0.020
43	M/Ts	RO	E	urb2	351	6640	H*	268.0	261.0	0.016	0.020	0.018
43	M/Ts	RO	E	urb2	358		H	256.0	246.0	-0.003	-0.006	-0.005
43	M/Ts	IA	E	urb2	359		H*	234.0	231.0	-0.043	-0.033	-0.038
43	M/Cs	RO	E	urb2	466		H	205.2	197.6	-0.023	-0.020	-0.021
43	M/Cs	RO	E	urb2	468	6640	H*	231.0	224.0	0.029	0.034	0.032
43	M/Cs	RO	E	urb2	469	6640	H*	230.0	224.0	0.027	0.034	0.031
44	M/Ts	IA	E	rural	322		H	242.0		-0.028		-0.028
44	M/Ts	IA	E	rural	335		H	229.0		-0.052		-0.052
44	M/Ts	IA	E	rural	338		H	251.0		-0.012		-0.012
44	M/Ts	IA	E	rural	340		H	251.5		-0.011		-0.011
44	M/Cs	IA	E	rural	427		H*	193.0		-0.049		-0.049
44	M/Cs	IA	E	rural	434		H	193.0		-0.049		-0.049
44	M/Cs	IA	E	rural	438		H	190.0		-0.056		-0.056
44	M/Cs	IA	E	rural	457		H	207.0		-0.019		-0.019
44	M/Cs	IA	E	rural	458		H	221.0		0.010		0.010
44	M/Cs	IA	E	rural	460		H	200.0		-0.034		-0.034
46	Tib	RO	E	cem	196		H	359.0	326.0	0.027	0.027	0.027
46	Rad	RO	E	cem	228		H	324.5	309.3	0.011	0.015	0.013

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
46	M/Ts	RO	E	cem	320		H*	270.9	263.4	0.021	0.024	0.023
47	Rad	RO	E	urb	221		H*	307.6	256.4	-0.012	-0.066	-0.039
47	Rad	RO	E	urb	224		H*	278.0	263.0	-0.056	-0.055	-0.056
47	M/Ts	RO	E	urb	318		H	257.0	248.3	-0.002	-0.002	-0.002
47	M/Cs	IA	E	urb	419		H	198.4	188.8	-0.037	-0.040	-0.039
51	M/Cs	IA	E	villa	410		H	215.0	203.4	-0.002	-0.008	-0.005
51	M/Cs	IA	E	villa	411		H	207.9	200.0	-0.017	-0.015	-0.016
51	M/Cs	IA	E	villa	412		H*	217.7	208.0	0.003	0.002	0.003
54	M/Ts	RO	E	rural	301		H*	242.0		-0.028		-0.028
54	M/Cs	IA	E	rural	404		H	203.0		-0.027		-0.027
54	M/Cs	IA	E	rural	405		H*	182.0		-0.075		-0.075
59	Fem	RO	E	urb	91	XXIII	H*	394.9		0.013		0.013
59	Fem	RO	E	urb	92	XXIII	H*	399.2		0.018		0.018
59	Hum	RO	E	urb	123	XXIII	H*		301.9		0.022	0.022
59	Hum	RO	E	urb	124	XXIII	H*		302.4		0.022	0.022
59	Tib	RO	E	urb	176	XXIII	H*	361.2		0.030		0.030
59	Tib	RO	E	urb	177	XXIII	H*	364.2		0.033		0.033
59	M/Ts	RO	E	urb	294	XXIII	H*	281.9		0.038		0.038
59	M/Ts	RO	E	urb	295	XXIII	H*	282.1		0.039		0.039
59	M/Cs	RO	E	urb	397	XXIII	H*	240.4		0.046		0.046
59	M/Cs	RO	E	urb	398	XXIII	H*	242.0		0.049		0.049
66	M/Ts	RO	A	villa	285		H*	277.0		0.031		0.031
67	Fem	RO	E	urb	89	F267	H*		361.0		0.014	0.014
67	Fem	RO	E	urb	90	F267	H*		361.0		0.014	0.014
67	Tib	RO	E	urb	170	F267	H*	351.0		0.017		0.017
67	M/Ts	RO	E	urb	284	F267	H*	256.5		-0.003		-0.003
68	M/Ts	RO	E	rural	283		H	254.0	246.0	-0.007	-0.006	-0.006
69	Rad	RO	E	rural	202		H	300.0	294.0	-0.023	-0.007	-0.015
69	Rad	IA	E	rural	203		H	319.0	304.0	0.004	0.008	0.006
71	Fem	IA	A	cem	88	N2	H*	420.0	334.0	0.040	-0.020	0.010
71	Tib	IA	A	cem	164	N2	H*	347.0		0.012		0.012
71	Rad	IA	A	cem	200	N2	H*	319.0		0.004		0.004
71	M/Ts	IA	A	cem	276	N2	H*	260.0		0.003		0.003
71	M/Cs	IA	A	cem	381	N2	H*	217.0		0.002		0.002
81	M/Ts	NAT	F	rural	271		H	259.7		0.003		0.003
81	M/Ts	NAT	F	rural	273		H*	246.0		-0.021		-0.021
83	M/Cs	NAT	F	rural	373		H*	220.0	210.0	0.008	0.006	0.007
87	Fem	IA	F	rural	78		H	350.0	317.0	-0.039	-0.043	-0.041
87	Rad	IA	F	rural	164		H*	276.0	264.5	-0.059	-0.053	-0.056
87	Rad	IA	F	rural	168		H*	291.0	276.5	-0.036	-0.033	-0.035
87	Rad	IA	F	rural	176		H	301.5	285.0	-0.021	-0.020	-0.021
92	Hum	NAT	F	rural	26	skelett2R	H	244.5	265.8	-0.039	-0.034	-0.036
92	M/Cs	NAT	F	rural	26	skelett2R	H	206.3		-0.020		-0.020
92	M/Ts	NAT	F	rural	26	skelett1R	H	259.5		0.002		0.002
92	M/Cs	NAT	F	rural	27	skelett2L	H	205.7		-0.022		-0.022
92	Rad	NAT	F	rural	27	skelett2R	H	305.1	291.6	-0.016	-0.010	-0.013
92	M/Ts	NAT	F	rural	27	skelett1L	H	259.0		0.002		0.002
92	Hum	NAT	F	rural	27	skelett1R	H	268.3	290.3	0.001	0.005	0.003
92	Fem	NAT	F	rural	28	skelett2R	H	349.2	311.8	-0.040	-0.050	-0.045
92	M/Ts	NAT	F	rural	28		H	244.3		-0.024		-0.024
92	Tib	NAT	F	rural	28	skelett2R	H	323.1	295.0	-0.019	-0.016	-0.018
92	Rad	NAT	F	rural	28	skelett2L	H	304.4	290.6	-0.017	-0.012	-0.014
92	Hum	NAT	F	rural	28	skelett1L	H	268.5	290.2	0.001	0.005	0.003
92	M/Cs	NAT	F	rural	28	skelett1L	H	221.8		0.011		0.011
92	Fem	NAT	F	rural	29	skelett2L	H	348.3	317.9	-0.041	-0.041	-0.041
92	Hum	NAT	F	rural	29		H*	245.6	270.6	-0.037	-0.026	-0.032

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
92	Tib	NAT	F	rural	29	skelett2L	H	323.6	293.0	-0.018	-0.019	-0.019
92	M/Ts	NAT	F	rural	29		H	259.6		0.003		0.003
92	Rad	NAT	F	rural	29	skelett1R	H	326.5	311.0	0.014	0.018	0.016
92	Fem	NAT	F	rural	30	skelett1R	H	375.4	338.2	-0.009	-0.014	-0.012
92	Hum	NAT	F	rural	30		H*	258.0	286.4	-0.016	-0.001	-0.009
92	M/Cs	NAT	F	rural	30		H	213.8		-0.005		-0.005
92	Rad	NAT	F	rural	30	skelett1L	H	325.5	311.5	0.012	0.018	0.015
92	Rad	NAT	F	rural	31		H	304.3	286.5	-0.017	-0.018	-0.017
92	Fem	NAT	F	rural	31	skelett1L	H	374.5	340.2	-0.010	-0.012	-0.011
92	Tib	NAT	F	rural	31	skelett1L	H	344.5	320.5	0.009	0.020	0.014
92	Hum	NAT	F	rural	31		H*	279.9	294.5	0.019	0.011	0.015
92	Hum	NAT	F	rural	32		H*	248.8	266.3	-0.032	-0.033	-0.032
92	Fem	NAT	F	rural	33		H*	362.1	334.7	-0.024	-0.019	-0.022
92	Hum	NAT	F	rural	33		H	259.1	278.1	-0.014	-0.014	-0.014
92	M/Ts	NAT	F	rural	34		H*	236.0		-0.039		-0.039
92	Hum	NAT	F	rural	34		H*	244.8	270.3	-0.039	-0.026	-0.033
92	M/Cs	NAT	F	rural	34		H*	203.5		-0.026		-0.026
92	Hum	NAT	F	rural	35		H*	249.0	265.3	-0.031	-0.034	-0.033
92	M/Ts	NAT	F	rural	35		H	241.8		-0.028		-0.028
92	Rad	NAT	F	rural	35		H	304.8	292.3	-0.016	-0.009	-0.013
92	Fem	NAT	F	rural	36		H	362.0	327.6	-0.024	-0.028	-0.026
92	M/Ts	NAT	F	rural	36		H	247.0		-0.019		-0.019
92	Rad	NAT	F	rural	36		H*	303.9	288.3	-0.017	-0.015	-0.016
92	Rad	NAT	F	rural	37		H*	290.7	280.0	-0.037	-0.028	-0.032
92	M/Ts	NAT	F	rural	37		H*	257.4		-0.001		-0.001
92	M/Ts	NAT	F	rural	38		H	239.7		-0.032		-0.032
92	M/Cs	NAT	F	rural	38		H	202.7		-0.028		-0.028
92	Rad	NAT	F	rural	38		H	329.1	313.9	0.017	0.022	0.019
92	M/Cs	NAT	F	rural	39		H*	197.9		-0.038		-0.038
92	Rad	NAT	F	rural	39		H	301.0	288.7	-0.022	-0.015	-0.018
92	M/Ts	NAT	F	rural	40		H*	270.7		0.021		0.021
92	M/Ts	NAT	F	rural	41		H*	241.6		-0.029		-0.029
92	Rad	NAT	F	rural	41		H	323.1	310.5	0.009	0.017	0.013
92	M/Cs	NAT	F	rural	42		H*	215.5		-0.001		-0.001
92	M/Ts	NAT	F	rural	43		H	250.6		-0.013		-0.013
92	M/Cs	NAT	F	rural	44		H*	216.6		0.001		0.001
92	Rad	NAT	F	rural	44		H	320.8	305.7	0.006	0.010	0.008
92	M/Ts	NAT	F	rural	45		H*	247.2		-0.019		-0.019
92	Rad	NAT	F	rural	45		H	323.5	308.2	0.010	0.014	0.012
92	Rad	NAT	F	rural	46		H	314.1	299.2	-0.003	0.001	-0.001
92	M/Ts	NAT	F	rural	46		H*	271.3		0.022		0.022
92	Rad	NAT	F	rural	48		H*	302.4	285.3	-0.020	-0.020	-0.020
92	M/Ts	NAT	F	rural	48		H	247.5		-0.018		-0.018
92	M/Cs	NAT	F	rural	49		H*	199.0		-0.036		-0.036
92	M/Ts	NAT	F	rural	49		H	269.2		0.018		0.018
92	M/Cs	NAT	F	rural	50		H*	196.0		-0.043		-0.043
92	Rad	NAT	F	rural	50		H	321.6	305.0	0.007	0.009	0.008
92	M/Ts	NAT	F	rural	51		H	245.5		-0.022		-0.022
92	M/Cs	NAT	F	rural	51		H*	212.5		-0.007		-0.007
92	Rad	NAT	F	rural	52		H*	281.6	267.8	-0.051	-0.047	-0.049
92	M/Ts	NAT	F	rural	52		H	246.8		-0.019		-0.019
92	M/Ts	NAT	F	rural	53		H	249.8		-0.014		-0.014
92	Rad	NAT	F	rural	53		H*	334.0	313.9	0.024	0.022	0.023
92	M/Cs	NAT	F	rural	54		H*	188.8		-0.059		-0.059
92	Rad	NAT	F	rural	54		H	303.0	288.1	-0.019	-0.016	-0.017
92	M/Ts	NAT	F	rural	54		H*	255.7		-0.004		-0.004

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
92	M/Ts	NAT	F	rural	55		H	238.3		-0.035		-0.035
92	M/Cs	NAT	F	rural	55		H	205.1		-0.023		-0.023
92	Rad	NAT	F	rural	55		H	319.4	301.1	0.004	0.004	0.004
92	M/Ts	NAT	F	rural	56		H*	232.9		-0.045		-0.045
92	M/Cs	NAT	F	rural	56		H	202.9		-0.028		-0.028
92	Rad	NAT	F	rural	56		H	305.7	288.1	-0.015	-0.016	-0.015
92	M/Cs	NAT	F	rural	57		H	210.9		-0.011		-0.011
92	M/Ts	NAT	F	rural	57		H*	253.7		-0.007		-0.007
92	Rad	NAT	F	rural	58		H*	301.0	284.9	-0.022	-0.020	-0.021
92	M/Ts	NAT	F	rural	58		H	247.3		-0.019		-0.019
92	M/Ts	NAT	F	rural	59		H	257.2		-0.001		-0.001
92	M/Cs	NAT	F	rural	60		H	202.9		-0.028		-0.028
92	M/Cs	NAT	F	rural	61		H*	203.8		-0.026		-0.026
92	Rad	NAT	F	rural	61		H	311.5	297.6	-0.007	-0.002	-0.004
92	M/Ts	NAT	F	rural	61		H*	256.0		-0.003		-0.003
92	M/Cs	NAT	F	rural	62		H	214.9		-0.003		-0.003
92	M/Cs	NAT	F	rural	63		H*	197.4		-0.039		-0.039
92	M/Cs	NAT	F	rural	64		H*	215.9		-0.001		-0.001
92	M/Ts	NAT	F	rural	64		H	260.9		0.005		0.005
92	M/Ts	NAT	F	rural	65		H	239.6		-0.032		-0.032
92	M/Cs	NAT	F	rural	65		H	206.7		-0.019		-0.019
92	M/Ts	NAT	F	rural	68		H	247.0		-0.019		-0.019
92	M/Ts	NAT	F	rural	69		H	234.2		-0.042		-0.042
92	M/Ts	NAT	F	rural	70		H	249.5		-0.015		-0.015
92	M/Cs	NAT	F	rural	70		H	219.1		0.006		0.006
92	M/Cs	NAT	F	rural	71		H	202.9		-0.028		-0.028
92	M/Ts	NAT	F	rural	71		H	262.7		0.008		0.008
92	M/Cs	NAT	F	rural	72		H	211.8		-0.009		-0.009
92	M/Ts	NAT	F	rural	72		H*	259.4		0.002		0.002
92	M/Cs	NAT	F	rural	73		H	208.6		-0.015		-0.015
92	M/Ts	NAT	F	rural	73		H	262.3		0.007		0.007
92	M/Ts	NAT	F	rural	74		H	247.8		-0.018		-0.018
92	M/Cs	NAT	F	rural	75		H*	211.2		-0.010		-0.010
92	M/Ts	NAT	F	rural	75		H	255.3		-0.005		-0.005
92	M/Cs	NAT	F	rural	77		H	201.2		-0.031		-0.031
92	M/Ts	NAT	F	rural	77		H	246.2		-0.020		-0.020
92	M/Cs	NAT	F	rural	79		H	215.8		-0.001		-0.001
92	M/Ts	NAT	F	rural	80		H	245.0		-0.023		-0.023
92	M/Cs	NAT	F	rural	81		H*	204.3		-0.025		-0.025
92	M/Ts	NAT	F	rural	83		H	260.4		0.004		0.004
92	M/Ts	NAT	F	rural	84		H	248.9		-0.016		-0.016
92	M/Cs	NAT	F	rural	85		H*	194.0		-0.047		-0.047
92	M/Ts	NAT	F	rural	85		H	253.6		-0.008		-0.008
92	M/Ts	NAT	F	rural	86		H	247.0		-0.019		-0.019
92	M/Cs	NAT	F	rural	86		H	211.2		-0.010		-0.010
92	M/Cs	NAT	F	rural	87		H*	193.3		-0.049		-0.049
92	M/Ts	NAT	F	rural	88		H	244.6		-0.023		-0.023
92	M/Ts	NAT	F	rural	89		H	259.3		0.002		0.002
92	M/Ts	NAT	F	rural	90		H	245.9		-0.021		-0.021
92	M/Cs	NAT	F	rural	90		H	217.1		0.002		0.002
92	M/Cs	NAT	F	rural	91		H	201.6		-0.030		-0.030
92	M/Ts	NAT	F	rural	91		H	258.2		0.000		0.000
92	M/Ts	NAT	F	rural	92		H	243.8		-0.025		-0.025
92	M/Cs	NAT	F	rural	92		H*	216.0		0.000		0.000
92	M/Cs	NAT	F	rural	93		H	204.6		-0.024		-0.024
92	M/Cs	NAT	F	rural	94		H	209.0		-0.015		-0.015

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
92	M/Ts	NAT	F	rural	95		H	242.2		-0.028		-0.028
92	M/Cs	NAT	F	rural	96		H	209.1		-0.014		-0.014
92	M/Ts	NAT	F	rural	96		H*	270.6		0.021		0.021
92	M/Cs	NAT	F	rural	97		H	194.0		-0.047		-0.047
92	M/Cs	NAT	F	rural	99		H	201.4		-0.031		-0.031
92	M/Ts	NAT	F	rural	99		H*	241.7		-0.028		-0.028
92	M/Cs	NAT	F	rural	100		H*	205.6		-0.022		-0.022
92	M/Ts	NAT	F	rural	101		H	241.4		-0.029		-0.029
92	M/Cs	NAT	F	rural	102		H	204.3		-0.025		-0.025
92	M/Ts	NAT	F	rural	104		H	239.6		-0.032		-0.032
92	M/Cs	NAT	F	rural	104		H*	210.9		-0.011		-0.011
92	M/Cs	NAT	F	rural	105		H	211.1		-0.010		-0.010
92	M/Ts	NAT	F	rural	105		H	257.1		-0.002		-0.002
92	M/Cs	NAT	F	rural	106		H*	214.2		-0.004		-0.004
92	M/Ts	NAT	F	rural	107		H	243.6		-0.025		-0.025
92	M/Cs	NAT	F	rural	107		H	206.9		-0.019		-0.019
92	M/Ts	NAT	F	rural	109		H	258.1		0.000		0.000
92	M/Ts	NAT	F	rural	110		H	241.7		-0.028		-0.028
92	M/Cs	NAT	F	rural	110		H*	202.5		-0.028		-0.028
92	M/Cs	NAT	F	rural	112		H	217.0		0.002		0.002
92	M/Ts	NAT	F	rural	113		H	244.4		-0.024		-0.024
92	M/Cs	NAT	F	rural	113		H	214.7		-0.003		-0.003
92	M/Cs	NAT	F	rural	114		H*	200.7		-0.032		-0.032
92	M/Ts	NAT	F	rural	114		H*	248.6		-0.016		-0.016
92	M/Ts	NAT	F	rural	115		H	270.9		0.021		0.021
92	M/Cs	NAT	F	rural	115		H	228.9		0.025		0.025
92	M/Cs	NAT	F	rural	116		H	204.6		-0.024		-0.024
92	M/Cs	NAT	F	rural	117		H*	213.9		-0.005		-0.005
92	M/Ts	NAT	F	rural	117		H	255.7		-0.004		-0.004
92	M/Ts	NAT	F	rural	118		H*	240.4		-0.031		-0.031
92	M/Cs	NAT	F	rural	118		H	211.9		-0.009		-0.009
92	M/Cs	NAT	F	rural	119		H	206.5		-0.020		-0.020
92	M/Ts	NAT	F	rural	119		H	252.3		-0.010		-0.010
92	M/Cs	NAT	F	rural	120		H	210.8		-0.011		-0.011
92	M/Ts	NAT	F	rural	121		H	242.9		-0.026		-0.026
92	M/Cs	NAT	F	rural	121		H	207.8		-0.017		-0.017
92	M/Cs	NAT	F	rural	122		H	207.6		-0.018		-0.018
92	M/Ts	NAT	F	rural	123		H*	235.6		-0.040		-0.040
92	M/Cs	NAT	F	rural	123		H	202.4		-0.029		-0.029
92	M/Cs	NAT	F	rural	124		H	198.3		-0.037		-0.037
92	M/Ts	NAT	F	rural	124		H	247.5		-0.018		-0.018
92	M/Cs	NAT	F	rural	125		H*	208.1		-0.017		-0.017
92	M/Ts	NAT	F	rural	125		H	249.9		-0.014		-0.014
92	M/Ts	NAT	F	rural	126		H*	250.6		-0.013		-0.013
92	M/Ts	NAT	F	rural	127		H	239.6		-0.032		-0.032
92	M/Cs	NAT	F	rural	128		H*	212.1		-0.008		-0.008
92	M/Cs	NAT	F	rural	129		H*	193.4		-0.048		-0.048
92	M/Ts	NAT	F	rural	129		H	232.0		-0.046		-0.046
92	M/Cs	NAT	F	rural	130		H*	199.1		-0.036		-0.036
92	M/Ts	NAT	F	rural	131		H*	236.1		-0.039		-0.039
92	M/Cs	NAT	F	rural	133		H	204.5		-0.024		-0.024
92	M/Ts	NAT	F	rural	134		H	247.8		-0.018		-0.018
92	M/Cs	NAT	F	rural	134		H*	226.4		0.020		0.020
92	M/Ts	NAT	F	rural	136		H*	247.0		-0.019		-0.019
92	M/Cs	NAT	F	rural	136		H	207.9		-0.017		-0.017
92	M/Ts	NAT	F	rural	137		H*	267.3		0.015		0.015

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
92	M/Ts	NAT	F	rural	138		H*	237.9		-0.035		-0.035
92	M/Cs	NAT	F	rural	138		H*	208.8		-0.015		-0.015
92	M/Cs	NAT	F	rural	139		H*	204.9		-0.023		-0.023
92	M/Ts	NAT	F	rural	140		H*	249.9		-0.014		-0.014
92	M/Ts	NAT	F	rural	141		H*	248.5		-0.016		-0.016
92	M/Cs	NAT	F	rural	142		H	205.2		-0.023		-0.023
92	M/Cs	NAT	F	rural	143		H*	206.0		-0.021		-0.021
92	M/Ts	NAT	F	rural	145		H*	245.4		-0.022		-0.022
92	M/Cs	NAT	F	rural	147		H	210.8		-0.011		-0.011
92	M/Ts	NAT	F	rural	147		H*	269.3		0.018		0.018
92	M/Cs	NAT	F	rural	148		H*	196.5		-0.041		-0.041
92	M/Cs	NAT	F	rural	149		H	204.3		-0.025		-0.025
92	M/Cs	NAT	F	rural	150		H	203.9		-0.025		-0.025
92	M/Cs	NAT	F	rural	151		H	203.8		-0.026		-0.026
92	M/Cs	NAT	F	rural	152		H	202.8		-0.028		-0.028
92	M/Cs	NAT	F	rural	153		H	199.8		-0.034		-0.034
92	M/Cs	NAT	F	rural	155		H	214.2		-0.004		-0.004
92	M/Cs	NAT	F	rural	156		H*	214.3		-0.004		-0.004
92	M/Cs	NAT	F	rural	157		H	211.8		-0.009		-0.009
92	M/Cs	NAT	F	rural	159		H*	211.7		-0.009		-0.009
92	M/Cs	NAT	F	rural	160		H	203.3		-0.027		-0.027
92	M/Cs	NAT	F	rural	162		H	206.1		-0.021		-0.021
92	M/Cs	NAT	F	rural	164		H*	210.3		-0.012		-0.012
92	M/Cs	NAT	F	rural	166		H	221.8		0.011		0.011
92	M/Cs	NAT	F	rural	171		H*	215.6		-0.001		-0.001
92	M/Cs	NAT	F	rural	172		H	213.7		-0.005		-0.005
92	M/Cs	NAT	F	rural	174		H	197.6		-0.039		-0.039
92	M/Cs	NAT	F	rural	175		H*	203.0		-0.027		-0.027
92	M/Cs	NAT	F	rural	176		H	205.9		-0.021		-0.021
92	M/Cs	NAT	F	rural	177		H	204.1		-0.025		-0.025
92	M/Cs	NAT	F	rural	179		H	203.3		-0.027		-0.027
92	M/Cs	NAT	F	rural	180		H*	204.1		-0.025		-0.025
92	M/Cs	NAT	F	rural	181		H	219.1		0.006		0.006
92	M/Cs	NAT	F	rural	182		H*	192.4		-0.051		-0.051
92	M/Cs	NAT	F	rural	183		H	208.3		-0.016		-0.016
92	M/Cs	NAT	F	rural	188		H	214.9		-0.003		-0.003
92	M/Cs	NAT	F	rural	190		H	204.1		-0.025		-0.025
92	M/Cs	NAT	F	rural	193		H	202.6		-0.028		-0.028
92	M/Cs	NAT	F	rural	195		H*	187.7		-0.061		-0.061
92	M/Cs	NAT	F	rural	198		H	200.0		-0.034		-0.034
92	M/Cs	NAT	F	rural	201		H*	205.5		-0.022		-0.022
92	M/Cs	NAT	F	rural	203		H	205.6		-0.022		-0.022
92	M/Cs	NAT	F	rural	204		H*	213.5		-0.005		-0.005
92	M/Cs	NAT	F	rural	207		H*	219.7		0.007		0.007
92	M/Cs	NAT	F	rural	211		H	204.3		-0.025		-0.025
92	M/Cs	NAT	F	rural	212		H*	204.7		-0.024		-0.024
92	M/Cs	NAT	F	rural	213		H	222.4		0.012		0.012
92	M/Cs	NAT	F	rural	215		H*	200.6		-0.032		-0.032
92	M/Cs	NAT	F	rural	216		H	210.9		-0.011		-0.011
92	M/Cs	NAT	F	rural	217		H*	190.0		-0.056		-0.056
92	M/Cs	NAT	F	rural	218		H	207.1		-0.019		-0.019
92	M/Cs	NAT	F	rural	219		H*	209.4		-0.014		-0.014
92	M/Cs	NAT	F	rural	221		H	212.6		-0.007		-0.007
92	M/Cs	NAT	F	rural	224		H	210.4		-0.012		-0.012
92	M/Cs	NAT	F	rural	227		H	221.6		0.011		0.011
92	M/Cs	NAT	F	rural	228		H*	204.3		-0.025		-0.025

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
92	M/Cs	NAT	F	rural	229		H*	215.1		-0.002		-0.002
92	M/Cs	NAT	F	rural	230		H	210.0		-0.013		-0.013
92	M/Cs	NAT	F	rural	231		H	201.6		-0.030		-0.030
92	M/Cs	NAT	F	rural	232		H	213.3		-0.006		-0.006
92	M/Cs	NAT	F	rural	234		H	219.7		0.007		0.007
92	M/Cs	NAT	F	rural	235		H	209.5		-0.014		-0.014
92	M/Cs	NAT	F	rural	236		H*	196.5		-0.041		-0.041
96	Fem	RO	F	cem	3	1575/5	H*	394.0	362.0	0.012	0.015	0.014
96	M/Ts	RO	F	cem	4	1575/5	H*	266.5		0.014		0.014
96	M/Cs	RO	F	cem	4	1575/5	H*	228.0		0.023		0.023
96	Fem	RO	F	cem	4	1620	H*	405.0	368.0	0.024	0.022	0.023
96	Rad	RO	F	cem	4	1575/5	H*	338.0		0.029		0.029
96	Tib	RO	F	cem	5	1575/5	H*	354.0		0.021		0.021
96	Hum	RO	F	cem	5	1620	H*	292.0	305.0	0.038	0.026	0.032
96	Rad	RO	F	cem	5	1620	H*	345.5		0.038		0.038
96	M/Ts	RO	F	cem	5	1620	H*	284.0		0.042		0.042
96	M/Cs	RO	F	cem	5	1620	H*	239.4		0.044		0.044
96	Tib	RO	F	cem	6	1620	H*	364.5		0.034		0.034
104	M/Ts	RO	E	villa	504		H	236.0		-0.039		-0.039
104	M/Ts	RO	E	villa	506		H*	252.0		-0.010		-0.010
104	M/Cs	RO	E	villa	639		H*	226.0		0.019		0.019
105	Hum	RO	K	ind	259		H*	253.0	266.0	-0.025	-0.033	-0.029
105	Hum	RO	K	ind	260		H*	250.1	265.5	-0.030	-0.034	-0.032
105	M/Ts	RO	K	ind	509		H*	272.0	268.0	0.023	0.032	0.027
110	M/Ts	RO	F	urb	589	179/16-22	H*	242.1	232.4	-0.028	-0.030	-0.029
110	M/Ts	RO	F	urb	590	179/16-25	H*	263.1	251.9	0.008	0.005	0.007
110	M/Cs	RO	F	urb	741	179/16-24	H*	200.0	193.5	-0.034	-0.029	-0.032
110	M/Cs	RO	F	urb	742	179/16-27	H*	220.1	211.8	0.008	0.010	0.009
113	M/Cs	RO	E	urb	751		H*	180.0		-0.080		-0.080
114	Fem	RO	G	urb	252	23B	H	366.2	339.3	-0.019	-0.013	-0.016
114	Fem	RO	G	urb	254	80L	H	367.0	334.0	-0.019	-0.020	-0.019
114	Tib	RO	G	urb	491	23A	H	332.0	306.6	-0.007	0.000	-0.003
114	Tib	RO	G	urb	494	71	H	347.0	313.7	0.012	0.010	0.011
114	Rad	RO	G	urb	494	25	H	329.7	313.6	0.018	0.021	0.020
114	Rad	RO	G	urb	495	30	H	327.1	312.7	0.015	0.020	0.017
114	M/Ts	RO	G	urb	599	23A	H	252.0	248.2	-0.010	-0.002	-0.006
114	M/Ts	RO	G	urb	600	35	H*	258.0	252.3	0.000	0.005	0.003
114	M/Ts	RO	G	urb	601	40	H*	263.5	258.3	0.009	0.016	0.012
114	M/Ts	RO	G	urb	604	73	H	251.0	245.8	-0.012	-0.006	-0.009
114	M/Cs	RO	G	urb	753	23	H	225.0	217.9	0.017	0.022	0.020
114	M/Cs	RO	G	urb	754	25	H	217.5	211.2	0.003	0.009	0.006
114	M/Cs	RO	G	urb	755	30	H	217.0	210.6	0.002	0.007	0.005
114	M/Cs	RO	G	urb	756	32	H	207.2	199.1	-0.018	-0.017	-0.018
115	Rad	RO	F	urb2	498		H*	337.5	320.0	0.028	0.030	0.029
115	M/Ts	RO	F	urb2	605		H	276.3	268.1	0.030	0.032	0.031
115	M/Ts	RO	F	urb2	606		H	264.3	257.7	0.010	0.015	0.012
115	M/Cs	RO	F	urb2	761		H*	224.7	216.3	0.017	0.019	0.018
115	M/Cs	RO	F	urb2	762		H*	220.3	211.8	0.008	0.010	0.009
115	M/Cs	RO	F	urb2	763		H	218.8	211.3	0.005	0.009	0.007
115	M/Cs	RO	F	urb2	764		H	216.0	207.7	0.000	0.001	0.001
115	M/Cs	RO	F	urb2	765		H*	212.8	205.6	-0.007	-0.003	-0.005
116	Hum	RO	D	urb2	353	294-1	H	255.0	275.0	-0.021	-0.019	-0.020
116	Hum	RO	D	urb2	355	B	H*	275.0	291.0	0.012	0.006	0.009
116	Tib	RO	D	urb2	513	348	H	323.0	290.0	-0.019	-0.024	-0.021
116	Tib	RO	D	urb2	515	238	H*	327.0	300.0	-0.014	-0.009	-0.011
116	Rad	RO	D	urb2	523	251	H	306.0	292.0	-0.014	-0.010	-0.012

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
116	Rad	RO	D	urb2	525	248-2	H*	320.0	307.0	0.005	0.012	0.008
116	Rad	RO	D	urb2	527	248-4	H*	324.0	315.0	0.010	0.023	0.017
116	Rad	RO	D	urb2	528	248-5	H*	329.0	310.0	0.017	0.016	0.017
116	Rad	RO	D	urb2	529	248-6	H*	329.0	310.0	0.017	0.016	0.017
116	M/Ts	RO	D	urb2	617	348-1	H	246.0	240.0	-0.021	-0.016	-0.019
116	M/Ts	RO	D	urb2	618	224-1	H	250.0		-0.014		-0.014
116	M/Ts	RO	D	urb2	619	348-2	H	250.0	239.0	-0.014	-0.018	-0.016
116	M/Ts	RO	D	urb2	620	17-1	H	250.0	241.0	-0.014	-0.014	-0.014
116	M/Ts	RO	D	urb2	621	63	H	257.0	248.0	-0.002	-0.002	-0.002
116	M/Ts	RO	D	urb2	622	251	H*	257.0	245.0	-0.002	-0.007	-0.005
116	M/Ts	RO	D	urb2	624	306	H*	266.0	258.0	0.013	0.015	0.014
116	M/Ts	RO	D	urb2	626	222	H*	271.0	263.0	0.021	0.023	0.022
116	M/Ts	RO	D	urb2	627	238	H*	271.0	264.0	0.021	0.025	0.023
116	M/Ts	RO	D	urb2	628	248-1	H*	272.0	263.0	0.023	0.023	0.023
116	M/Ts	RO	D	urb2	631	248-2	H*	296.0	288.0	0.060	0.063	0.061
116	M/Cs	RO	D	urb2	781	248-1	H	203.0	196.0	-0.027	-0.024	-0.026
116	M/Cs	RO	D	urb2	782	238	H*	210.0	203.0	-0.013	-0.009	-0.011
116	M/Cs	RO	D	urb2	787	17-1	H*	224.0	216.0	0.015	0.018	0.017
116	M/Cs	RO	D	urb2	788	328	H*	226.0	220.0	0.019	0.026	0.023
118	Fem	RO	G	mil	277	Pferd 2	H	404.0	367.5	0.023	0.022	0.022
118	Fem	RO	G	mil	278	Pferd 3	H	396.0	362.0	0.014	0.015	0.015
118	Fem	RO	G	mil	280		H	379.0	347.5	-0.005	-0.003	-0.004
118	Hum	RO	G	mil	370	Pferd 2	H	281.5	297.5	0.022	0.015	0.019
118	Hum	RO	G	mil	371	Pferd 3	H	283.0	292.5	0.024	0.008	0.016
118	Tib	RO	G	mil	531	Pferd 2	H	364.5	332.0	0.034	0.035	0.034
118	Tib	RO	G	mil	532	Pferd 3	H	363.5	329.0	0.032	0.031	0.032
118	Rad	RO	G	mil	545	Pferd 2	H	328.0	312.0	0.016	0.019	0.017
118	Rad	RO	G	mil	546	Pferd 3	H	368.0	349.0	0.066	0.068	0.067
118	M/Ts	RO	G	mil	637	Pferd 2	H	283.5	276.5	0.041	0.045	0.043
118	M/Ts	RO	G	mil	638	Pferd 3	H	273.2	265.6	0.025	0.028	0.026
118	M/Cs	RO	G	mil	797	Pferd 2	H	239.5	231.0	0.045	0.048	0.046
118	M/Cs	RO	G	mil	798	Pferd 3	H	233.0	224.5	0.033	0.035	0.034
119	Fem	RO	G	mil	282	Horse 1	H*	402.2		0.021		0.021
119	Hum	RO	G	mil	374	Horse 1	H*		311.1		0.035	0.035
119	Tib	RO	G	mil	535	Horse 1	H*	361.1		0.030		0.030
119	M/Ts	RO	G	mil	641	Horse 1	H*	272.0		0.023		0.023
119	M/Cs	RO	G	mil	804	Horse 1	H*	228.1		0.023		0.023
120	Tib	IA	F	rural	537		H	310.5	280.0	-0.036	-0.039	-0.038
120	Tib	IA	F	rural	538		H	320.1	287.1	-0.023	-0.028	-0.025
120	M/Cs	IA	F	rural	806		H*	205.1	196.9	-0.023	-0.022	-0.022
120	M/Cs	IA	F	rural	807		H*	185.2	178.1	-0.067	-0.065	-0.066
120	M/Cs	IA	F	rural	808		H	199.3	191.2	-0.035	-0.035	-0.035
120	M/Cs	IA	F	rural	809		H	197.8	190.3	-0.039	-0.037	-0.038
120	M/Cs	IA	F	rural	810		H*	194.8	187.5	-0.045	-0.043	-0.044
120	M/Cs	IA	F	rural	813		H	206.6	198.5	-0.020	-0.018	-0.019
121	M/Cs	RO	F	urb2	817		H	223.8	214.8	0.015	0.016	0.016
123	M/Ts	RO	E	urb	659		H	265.0		0.012		0.012
123	M/Ts	RO	E	urb	660		H	250.4		-0.013		-0.013
123	M/Cs	RO	E	urb	822		H	216.5		0.001		0.001
125	M/Ts	RO	E	mil	673		H*	274.0		0.026		0.026
125	M/Ts	RO	E	mil	674		H	256.0		-0.003		-0.003
125	M/Cs	RO	E	mil	830		H	194.2		-0.047		-0.047
125	M/Cs	RO	E	mil	838		H	216.0		0.000		0.000
128	Rad	RO	F	mil	582	3392	H*	350.0	338.0	0.044	0.054	0.049
128	Rad	RO	F	mil	583	3392	H*	352.0	339.0	0.046	0.055	0.051
128	M/Ts	RO	F	mil	680	3392	H*	277.0	267.0	0.031	0.030	0.030

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
128	M/Cs	RO	F	mil	843	3392	H*	238.0	231.0	0.042	0.048	0.045
128	M/Cs	RO	F	mil	844	3392	H*	238.0	230.5	0.042	0.047	0.044
129	Rad	RO	F	oth	593		H	320.0	308.0	0.005	0.013	0.009
129	Rad	RO	F	oth	595		H*	297.0	283.0	-0.027	-0.023	-0.025
131	M/Cs	IA	G	rural	863		H*	202.0	194.0	-0.029	-0.028	-0.029
134	M/Ts	RO	F	urb2	732		H*	281.0	275.0	0.037	0.043	0.040
134	M/Cs	RO	F	urb2	885		H	191.0	186.0	-0.054	-0.047	-0.050
135	Fem	IA	G	cem	314	1	H	340.0	315.5	-0.052	-0.045	-0.048
135	Fem	IA	G	cem	315	2	H	346.0	314.0	-0.044	-0.047	-0.045
135	Fem	IA	G	cem	316	3	H	355.0	326.0	-0.033	-0.030	-0.032
135	Fem	IA	G	cem	317	4	H*	390.0	357.0	0.008	0.009	0.008
135	Hum	IA	G	cem	422	1	H	241.0	253.0	-0.046	-0.055	-0.050
135	Hum	IA	G	cem	423	2	H	247.0	258.0	-0.035	-0.047	-0.041
135	Hum	IA	G	cem	424	3	H	257.0	267.0	-0.018	-0.032	-0.025
135	Hum	IA	G	cem	425	4	H*	279.0	295.0	0.018	0.012	0.015
135	Tib	IA	G	cem	598	1	H	321.0	281.0	-0.022	-0.037	-0.030
135	Tib	IA	G	cem	599	2	H	321.5	285.0	-0.021	-0.031	-0.026
135	Tib	IA	G	cem	600	3	H	327.0	292.0	-0.014	-0.021	-0.017
135	Tib	IA	G	cem	601	4	H*	355.0	322.0	0.022	0.022	0.022
135	Rad	IA	G	cem	615	1	H	302.0	285.0	-0.020	-0.020	-0.020
135	Rad	IA	G	cem	616	2	H	305.0	287.0	-0.016	-0.017	-0.017
135	Rad	IA	G	cem	617	3	H	317.0	302.0	0.001	0.005	0.003
135	Rad	IA	G	cem	618	4	H*	339.0	323.0	0.030	0.034	0.032
135	M/Ts	IA	G	cem	736	1	H	240.0	233.0	-0.032	-0.029	-0.030
135	M/Ts	IA	G	cem	737	2	H	240.0	234.0	-0.032	-0.027	-0.029
135	M/Ts	IA	G	cem	738	3	H	244.0	236.5	-0.024	-0.023	-0.024
135	M/Ts	IA	G	cem	739	4	H*	263.0	258.3	0.008	0.016	0.012
135	M/Cs	IA	G	cem	891	1	H	200.0	192.0	-0.034	-0.033	-0.033
135	M/Cs	IA	G	cem	892	2	H	204.0	196.0	-0.025	-0.024	-0.024
135	M/Cs	IA	G	cem	893	3	H	206.0	198.0	-0.021	-0.019	-0.020
135	M/Cs	IA	G	cem	894	4	H*	219.0	210.5	0.006	0.007	0.006
141	Hum	IA	G	cem	431	6	H*		270.0		-0.027	-0.027
141	Tib	IA	G	cem	610	6	H*	341.0		0.005		0.005
141	Rad	IA	G	cem	624	6	H*	320.0		0.005		0.005
141	M/Ts	IA	G	cem	746	6	H*	254.0		-0.007		-0.007
141	M/Cs	IA	G	cem	901	6	H*	210.0		-0.013		-0.013
143	M/Ts	IA	G	urb2	747	P18	H*	275.0		0.028		0.028
143	M/Cs	IA	G	urb2	902	P1	H*	230.0		0.027		0.027
143	M/Cs	IA	G	urb2	906	P12	H*	225.0		0.017		0.017
146	M/Ts	RO	G	rural	752	620c	H*	264.0		0.010		0.010
146	M/Cs	RO	G	rural	925	574c	H*	207.0		-0.019		-0.019
147	M/Ts	RO	G	mil	753		H	245.0		-0.023		-0.023
147	M/Ts	RO	G	mil	754		H	245.0		-0.023		-0.023
147	M/Ts	RO	G	mil	755		H*	243.0		-0.026		-0.026
149	M/Ts	IA	G	rural	756		H*	231.0		-0.048		-0.048
149	M/Ts	IA	G	rural	757		H	253.5		-0.008		-0.008
149	M/Ts	IA	G	rural	758		H*	254.0		-0.007		-0.007
149	M/Cs	IA	G	rural	929		H*	197.0		-0.040		-0.040
150	M/Cs	RO	G	mil	930		H*	227.0		0.021		0.021
151	M/Ts	RO	G	rural	759		H*	282.0		0.039		0.039
153	M/Cs	RO	A	urb	931		H	219.5	213.0	0.007	0.012	0.009
153	M/Cs	RO	A	urb	932		H*	221.0	212.0	0.010	0.010	0.010
174	M/Cs	RO	F	mil	972		H*	227.0	220.0	0.021	0.026	0.024
174	M/Cs	RO	F	mil	977		H*	224.0	216.0	0.015	0.018	0.017
176	M/Ts	NAT	F	cem	806		H	260.0	252.0	0.003	0.005	0.004
176	M/Ts	NAT	F	cem	807		H*	254.0	246.0	-0.007	-0.006	-0.006

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
176	M/Ts	NAT	F	cem	811		H*	253.0	243.0	-0.009	-0.011	-0.010
176	M/Ts	NAT	F	cem	812		H*	251.0	244.0	-0.012	-0.009	-0.011
176	M/Ts	NAT	F	cem	814		H*	251.0	241.0	-0.012	-0.014	-0.013
176	M/Ts	NAT	F	cem	815		H	250.0	245.0	-0.014	-0.007	-0.011
176	M/Ts	NAT	F	cem	816		H	248.0	242.0	-0.017	-0.013	-0.015
176	M/Ts	NAT	F	cem	817		H*	246.0	239.0	-0.021	-0.018	-0.019
176	M/Cs	NAT	F	cem	992		H*	214.0	205.0	-0.004	-0.004	-0.004
176	M/Cs	NAT	F	cem	993		H*	213.0	204.0	-0.006	-0.006	-0.006
176	M/Cs	NAT	F	cem	995		H	210.0	204.0	-0.013	-0.006	-0.009
176	M/Cs	NAT	F	cem	997		H	210.0	201.0	-0.013	-0.013	-0.013
176	M/Cs	NAT	F	cem	999		H*	210.0	202.0	-0.013	-0.011	-0.012
176	M/Cs	NAT	F	cem	1001		H	208.0	199.0	-0.017	-0.017	-0.017
176	M/Cs	NAT	F	cem	1002		H*	207.0	200.0	-0.019	-0.015	-0.017
176	M/Cs	NAT	F	cem	1004		H	201.0	193.0	-0.032	-0.030	-0.031
176	M/Cs	NAT	F	cem	1005		H	193.0	187.0	-0.049	-0.044	-0.047
176	M/Cs	NAT	F	cem	1006		H*	179.0	171.0	-0.082	-0.083	-0.082
176	M/Cs	NAT	F	cem	1008		H*	177.0	170.0	-0.087	-0.086	-0.086
178	M/Cs	RO	F	urb2	1015		H	220.0	209.0	0.008	0.004	0.006
188	Rad	RO	D	rural	695		H	322.0	308.0	0.008	0.013	0.011
188	M/Ts	RO	D	rural	849		H*	256.0	247.0	-0.003	-0.004	-0.004
192	Rad	RO	F	rural	713		H	323.0	307.0	0.009	0.012	0.011
192	Rad	RO	F	rural	714		H*	332.0	319.0	0.021	0.029	0.025
198	Hum	RO	F	mil	478		H*	265.0	268.0	-0.004	-0.030	-0.017
199	Rad	RO	F	rural	732		H*	348.0	332.5	0.041	0.047	0.044
199	Rad	RO	F	rural	734		H*	347.0	330.0	0.040	0.043	0.042
200	Rad	RO	F	rural	763		H*	344.0	327.0	0.036	0.039	0.038
201	Tib	RO	F	villa	759		H	340.0	305.0	0.003	-0.002	0.001
202	M/Ts	NAT	F	rural	949		H	251.6	243.6	-0.011	-0.010	-0.010
202	M/Ts	NAT	F	rural	952		H	251.3	243.1	-0.012	-0.011	-0.011
202	M/Ts	NAT	F	rural	954		H*	249.0	242.0	-0.016	-0.013	-0.014
202	M/Ts	NAT	F	rural	955		H	230.3	223.4	-0.049	-0.047	-0.048
202	M/Ts	NAT	F	rural	956		H	243.8	237.0	-0.025	-0.022	-0.023
202	M/Cs	NAT	F	rural	1132		H	213.7	205.0	-0.005	-0.004	-0.005
202	M/Cs	NAT	F	rural	1136		H	198.5	190.5	-0.037	-0.036	-0.037
202	M/Cs	NAT	F	rural	1137		H*	204.5	196.0	-0.024	-0.024	-0.024
203	M/Ts	RO	G	urb	961		H*	246.0		-0.021		-0.021
203	M/Ts	RO	G	urb	962		H*	247.0		-0.019		-0.019
203	M/Ts	RO	G	urb	963		H	248.0		-0.017		-0.017
203	M/Ts	RO	G	urb	965		H	253.0		-0.009		-0.009
203	M/Ts	RO	G	urb	966		H*	256.0		-0.003		-0.003
203	M/Ts	RO	G	urb	968		H	258.5		0.001		0.001
203	M/Ts	RO	G	urb	969		H*	259.0		0.002		0.002
203	M/Ts	RO	G	urb	974		H*	262.5		0.007		0.007
203	M/Ts	RO	G	urb	976		H*	264.0		0.010		0.010
203	M/Ts	RO	G	urb	978		H*	266.0		0.013		0.013
203	M/Ts	RO	G	urb	979		H	267.0		0.015		0.015
203	M/Ts	RO	G	urb	985		H*	271.5		0.022		0.022
203	M/Cs	RO	G	urb	1138		H*	206.5		-0.020		-0.020
203	M/Cs	RO	G	urb	1140		H*	209.0		-0.015		-0.015
203	M/Cs	RO	G	urb	1141		H	209.0		-0.015		-0.015
203	M/Cs	RO	G	urb	1145		H*	219.0		0.006		0.006
203	M/Cs	RO	G	urb	1148		H	220.0		0.008		0.008
203	M/Cs	RO	G	urb	1149		H	220.0		0.008		0.008
203	M/Cs	RO	G	urb	1150		H	221.0		0.010		0.010
203	M/Cs	RO	G	urb	1151		H	222.0		0.012		0.012
203	M/Cs	RO	G	urb	1152		H*	222.0		0.012		0.012

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	GL or GlC	Ll or GLl	Log1	Log2	Mean Log
203	M/Cs	RO	G	urb	1153		H*	222.0		0.012		0.012
203	M/Cs	RO	G	urb	1156		H	223.0		0.014		0.014
203	M/Cs	RO	G	urb	1157		H*	223.0		0.014		0.014
203	M/Cs	RO	G	urb	1161		H	224.0		0.015		0.015
203	M/Cs	RO	G	urb	1168		H*	226.0		0.019		0.019
203	M/Cs	RO	G	urb	1169		H	227.0		0.021		0.021
203	M/Cs	RO	G	urb	1172		H*	229.0		0.025		0.025
203	M/Cs	RO	G	urb	1173		H*	229.0		0.025		0.025
203	M/Cs	RO	G	urb	1175		H*	229.0		0.025		0.025
203	M/Cs	RO	G	urb	1179		H*	230.5		0.028		0.028
203	M/Cs	RO	G	urb	1181		H	231.0		0.029		0.029
203	M/Cs	RO	G	urb	1185		H	232.0		0.031		0.031
203	M/Cs	RO	G	urb	1187		H	235.0		0.036		0.036
203	M/Cs	RO	G	urb	1189		H*	237.0		0.040		0.040
203	M/Cs	RO	G	urb	1191		H*	237.0		0.040		0.040
204	M/Cs	RO	D	rural	1236		H*	215.3	208.0	-0.002	0.002	0.000
204	M/Cs	RO	D	rural	1237		H*	217.5		0.003		0.003
205	Rad	RO	F	mil	853		H*	304.0	289.0	-0.017	-0.014	-0.016
207	M/Cs	RO	F	mil	1251		H	222.0		0.012		0.012
208	Fem	RO	F	urb	382		H*	404.0	365.0	0.023	0.019	0.021
208	M/Cs	RO	F	urb	1256		H*	231.0	225.0	0.029	0.036	0.032
208	M/Cs	RO	F	urb	1258		H*	222.0	217.0	0.012	0.020	0.016
208	M/Cs	RO	F	urb	1259		H	219.5	214.0	0.007	0.014	0.011
208	M/Cs	RO	F	urb	1260		H*	218.0	213.0	0.004	0.012	0.008
208	M/Cs	RO	F	urb	1262		H*	216.0	211.0	0.000	0.008	0.004
208	M/Cs	RO	F	urb	1264		H	201.0	197.5	-0.032	-0.020	-0.026
212	M/Ts	IA	D	cem	1093		H*	245.0		-0.023		-0.023
212	M/Cs	IA	D	cem	1275		H	203.0		-0.027		-0.027
212	M/Cs	IA	D	cem	1276		H	194.0		-0.047		-0.047
213	M/Ts	IA	D	rural	1096		H	233.0		-0.044		-0.044
213	M/Ts	IA	D	rural	1097		H*	247.0		-0.019		-0.019
213	M/Ts	IA	D	rural	1099		H	249.0		-0.016		-0.016
213	M/Ts	IA	D	rural	1101		H	225.0		-0.060		-0.060
213	M/Cs	IA	D	rural	1277		H	202.0		-0.029		-0.029
213	M/Cs	IA	D	rural	1278		H*	226.0		0.019		0.019
213	M/Cs	IA	D	rural	1281		H	207.0		-0.019		-0.019
213	M/Cs	IA	D	rural	1282		H	200.0		-0.034		-0.034
213	M/Cs	IA	D	rural	1283		H*	184.0		-0.070		-0.070
214	M/Ts	IA	D	rural	1104		H	253.0		-0.009		-0.009
214	M/Cs	IA	D	rural	1284		H	232.0		0.031		0.031
215	M/Ts	IA	D	oth	1105		H	226.0		-0.058		-0.058
215	M/Ts	IA	D	oth	1106		H	228.0		-0.054		-0.054
215	M/Ts	IA	D	oth	1107		H*	232.0		-0.046		-0.046
215	M/Cs	IA	D	oth	1286		H*	190.0		-0.056		-0.056
216	M/Ts	IA	D	rural	1108		H	230.0		-0.050		-0.050
216	M/Ts	IA	D	rural	1109		H*	231.0		-0.048		-0.048
216	M/Ts	IA	D	rural	1110		H	232.0		-0.046		-0.046
216	M/Ts	IA	D	rural	1111		H*	246.0		-0.021		-0.021
216	M/Cs	IA	D	rural	1287		H	188.0		-0.061		-0.061
216	M/Cs	IA	D	rural	1288		H*	208.0		-0.017		-0.017
216	M/Cs	IA	D	rural	1289		H*	182.0		-0.075		-0.075
216	M/Cs	IA	D	rural	1290		H	192.0		-0.051		-0.051
216	M/Cs	IA	D	rural	1291		H*	189.0		-0.058		-0.058
216	M/Cs	IA	D	rural	1292		H*	224.0		0.015		0.015
217	M/Cs	IA	D	cem	1293		H*	171.0		-0.102		-0.102

Table A38. – Results of the calculation of log ratios on the horse breadth measurements

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
5	M/Ts	IA	E	rural	464		H	45.0	45.0		-0.034	-0.021		-0.028
28	M/Ts	IA	E	mil	423		H	40.0	40.0		-0.085	-0.073		-0.079
28	M/Ts	RO	E	mil	424		H*	40.0	40.0		-0.085	-0.073		-0.079
28	M/Ts	IA	E	mil	425		H	50.0	46.0		0.011	-0.012		0.000
37	Fem	RO	F	cem	142	11-28	H*	121.7	96.3		0.026	0.020		0.023
37	Fem	RO	F	cem	147	2-27	H*	114.3	92.2		-0.001	0.001		0.000
37	M/Ts	RO	F	cem	396	11-28	H*	53.3	54.0		0.039	0.058		0.049
37	Tib	RO	F	cem	289	11-28	H*	102.4	78.3		0.030	0.039		0.034
38	M/Cs	RO	F	urb	501		H*	45.6	47.3		-0.015	0.025		0.005
38	M/Cs	RO	F	urb	505		H*	51.4	54.0		0.037	0.082		0.060
38	M/Cs	RO	F	urb	508		H	47.2	46.6		0.000	0.018		0.009
38	M/Cs	RO	F	urb	509		H*	49.4	48.6		0.020	0.036		0.028
38	M/Cs	RO	F	urb	511		H	48.8	47.6		0.015	0.027		0.021
38	M/Cs	RO	F	urb	519		H	47.2	46.3		0.000	0.015		0.008
38	M/Ts	RO	F	urb	380		H	46.8	46.6		-0.017	-0.006		-0.012
38	M/Ts	RO	F	urb	383		H*	50.0	52.1		0.011	0.042		0.027
38	M/Ts	RO	F	urb	385		H*	50.7	51.8		0.017	0.040		0.029
38	Tib	RO	F	urb	277		H	94.5	72.8		-0.005	0.007		0.001
39	M/Ts	RO	F	urb2	378		H*	44.8	45.7		-0.036	-0.015		-0.025
42	Fem	RO	F	villa	119	12.4	H*		96.4			0.020		0.020
42	Hum	RO	F	villa	157		H*		85.0	75.3		0.017	0.014	0.016
42	M/Cs	RO	F	villa	483		H*	50.1	49.4		0.026	0.043		0.035
42	M/Cs	RO	F	villa	485		H*	52.2	50.2		0.044	0.050		0.047
42	M/Cs	RO	F	villa	490		H*	47.6	49.6		0.004	0.045		0.025
42	M/Cs	IA	F	villa	495		H*	48.5	51.2		0.012	0.059		0.036
42	M/Ts	RO	F	villa	364		H	46.9	46.0		-0.016	-0.012		-0.014
42	M/Ts	RO	F	villa	367		H*	52.9	51.3		0.036	0.036		0.036
42	M/Ts	RO	F	villa	368		H*	52.3	50.8		0.031	0.031		0.031
42	M/Ts	RO	F	villa	372	12.4	H*	52.5	50.4		0.033	0.028		0.030
42	Tib	RO	F	villa	250	12.4	H*	105.9	81.4		0.045	0.056		0.050
43	M/Cs	RO	E	urb2	466		H	44.3	45.9		-0.027	0.012		-0.008
43	M/Cs	RO	E	urb2	468	6640	H*		51.9			0.065		0.065
43	M/Cs	RO	E	urb2	469	6640	H*	53.9	52.0		0.058	0.066		0.062
43	M/Ts	RO	E	urb2	350	6640	H*	53.4	52.3		0.040	0.044		0.042
43	M/Ts	RO	E	urb2	351	6640	H*	52.9	51.3		0.036	0.036		0.036
43	M/Ts	RO	E	urb2	358		H	44.9	45.8		-0.035	-0.014		-0.025
43	M/Ts	IA	E	urb2	359		H*	41.8	39.5		-0.066	-0.078		-0.072
43	Rad	RO	E	urb2	256	6640	H*	85.4	75.4		0.029	0.005		0.017
43	Rad	RO	E	urb2	257	6640	H*	84.8	76.9		0.026	0.014		0.020
43	Tib	RO	E	urb2	234	6640	H*	90.1	70.7		-0.025	-0.006		-0.015
44	M/Cs	IA	E	rural	427		H*	43.2	43.2		-0.038	-0.015		-0.027
44	M/Cs	IA	E	rural	434		H	42.5	44.0		-0.045	-0.007		-0.026
44	M/Cs	IA	E	rural	448		H	46.1	45.0		-0.010	0.003		-0.004
44	M/Cs	IA	E	rural	457		H	45.4	45.3		-0.017	0.006		-0.005
44	M/Cs	IA	E	rural	458		H	51.4	51.5		0.037	0.061		0.049
44	M/Cs	IA	E	rural	460		H	42.7	44.7		-0.043	0.000		-0.022
44	M/Ts	IA	E	rural	322		H	45.7	44.2		-0.028	-0.029		-0.028
44	M/Ts	IA	E	rural	335		H	42.0	41.6		-0.064	-0.055		-0.060
44	M/Ts	IA	E	rural	338		H	47.8	45.1		-0.008	-0.020		-0.014
44	M/Ts	IA	E	rural	340		H	46.4	45.7		-0.021	-0.015		-0.018
46	M/Ts	RO	E	cem	320		H*	50.8	51.2		0.018	0.035		0.027

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
46	Rad	RO	E	cem	228		H	76.7	71.4		-0.018	-0.018		-0.018
46	Tib	RO	E	cem	196		H	98.5	78.3		0.013	0.039		0.026
47	M/Cs	IA	E	urb	419		H	42.4	42.9		-0.046	-0.018		-0.032
47	M/Ts	RO	E	urb	318		H	48.7	47.0		0.000	-0.002		-0.001
47	Rad	RO	E	urb	221		H*	71.0	64.5		-0.051	-0.062		-0.057
47	Rad	RO	E	urb	224		H*	72.9	63.1		-0.040	-0.072		-0.056
51	M/Cs	IA	E	villa	410		H	47.2	48.3		0.000	0.034		0.017
51	M/Cs	IA	E	villa	411		H	46.8	47.3		-0.003	0.025		0.011
51	M/Cs	IA	E	villa	412		H*	49.1	49.9		0.017	0.048		0.033
54	M/Cs	IA	E	rural	404		H	46.6	46.4		-0.005	0.016		0.005
54	M/Cs	IA	E	rural	405		H*	42.3	41.3		-0.047	-0.034		-0.041
54	M/Ts	RO	E	rural	301		H*	46.4	47.2		-0.021	-0.001		-0.011
59	Fem	RO	E	urb	91	XXIII	H*	122.5	92.7		0.029	0.003		0.016
59	Fem	RO	E	urb	92	XXIII	H*	120.6	94.7		0.022	0.012		0.017
59	Hum	RO	E	urb	123	XXIII	H*		80.4	74.8		-0.007	0.011	0.002
59	Hum	RO	E	urb	124	XXIII	H*		81.9	72.7		0.001	-0.001	0.000
59	M/Cs	RO	E	urb	397	XXIII	H*	51.9	52.9		0.042	0.073		0.057
59	M/Cs	RO	E	urb	398	XXIII	H*	53.1	52.2		0.051	0.067		0.059
59	M/Ts	RO	E	urb	294	XXIII	H*	52.0	52.7		0.028	0.047		0.038
59	M/Ts	RO	E	urb	295	XXIII	H*	52.8	52.8		0.035	0.048		0.042
59	Rad	RO	E	urb	208	XXIII	H*	83.9			0.021			0.021
59	Rad	RO	E	urb	209	XXIII	H*	83.9	82.0		0.021	0.042		0.032
59	Tib	RO	E	urb	176	XXIII	H*	97.0	79.9		0.007	0.047		0.027
59	Tib	RO	E	urb	177	XXIII	H*	96.0	80.1		0.002	0.049		0.025
66	M/Ts	RO	A	villa	285		H*	49.5	54.0		0.007	0.058		0.032
67	Fem	RO	E	urb	89	F267	H*		97.0			0.023		0.023
67	Fem	RO	E	urb	90	F267	H*	117.0	97.2		0.009	0.024		0.016
67	M/Ts	RO	E	urb	284	F267	H*	43.2	52.2		-0.052	0.043		-0.004
67	Tib	RO	E	urb	170	F267	H*	99.5	77.0		0.018	0.031		0.025
68	M/Ts	RO	E	rural	283		H	47.0	47.1		-0.015	-0.002		-0.008
69	Rad	RO	E	rural	202		H	73.5	66.8		-0.036	-0.047		-0.042
69	Rad	IA	E	rural	203		H	76.9			-0.017			-0.017
71	Fem	IA	A	cem	88	N2	H*	112.0			-0.010			-0.010
71	Hum	IA	A	cem	118	N2	H*		82.0	72.0		0.002	-0.005	-0.002
71	M/Cs	IA	A	cem	381	N2	H*	49.0	48.0		0.017	0.031		0.024
71	M/Ts	IA	A	cem	276	N2	H*	49.0	49.0		0.003	0.016		0.009
71	Rad	IA	A	cem	200	N2	H*	76.0	69.0		-0.022	-0.033		-0.027
71	Tib	IA	A	cem	164	N2	H*	96.0	71.0		0.002	-0.004		-0.001
81	M/Ts	NAT	F	rural	271		H	48.5	47.3		-0.002	0.000		-0.001
81	M/Ts	NAT	F	rural	273		H*	48.5	48.8		-0.002	0.014		0.006
83	M/Cs	NAT	F	rural	373		H*	52.3	51.8		0.045	0.064		0.054
87	Fem	IA	F	rural	78		H	101.0	81.0		-0.055	-0.055		-0.055
87	Rad	IA	F	rural	164		H*	70.0	62.0		-0.057	-0.080		-0.068
87	Rad	IA	F	rural	168		H*	71.0	66.5		-0.051	-0.049		-0.050
87	Rad	IA	F	rural	176		H	72.5	69.5		-0.042	-0.030		-0.036
92	Fem	NAT	F	rural	28	skelett2R	H	102.5	84.5		-0.049	-0.037		-0.043
92	Fem	NAT	F	rural	29	skelett2L	H	104.8	86.6		-0.039	-0.026		-0.033
92	Fem	NAT	F	rural	30	skelett1R	H	115.5	92.2		0.003	0.001		0.002
92	Fem	NAT	F	rural	31	skelett1L	H	115.1	91.6		0.002	-0.002		0.000
92	Fem	NAT	F	rural	33		H*	107.7	88.8		-0.027	-0.016		-0.021
92	Fem	NAT	F	rural	36		H	112.0	87.0		-0.010	-0.024		-0.017
92	Hum	NAT	F	rural	26	skelett2R	H		73.6	70.1		-0.045	-0.017	-0.031
92	Hum	NAT	F	rural	27	skelett1R	H		75.1	73.0		-0.037	0.001	-0.018
92	Hum	NAT	F	rural	28	skelett1L	H		75.6	74.3		-0.034	0.008	-0.013
92	Hum	NAT	F	rural	29		H*		71.1	69.2		-0.060	-0.023	-0.041
92	Hum	NAT	F	rural	30		H*		74.4	72.0		-0.041	-0.005	-0.023

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
92	Hum	NAT	F	rural	31		H*		80.3	76.4		-0.008	0.020	0.006
92	Hum	NAT	F	rural	32		H*		73.2	70.3		-0.048	-0.016	-0.032
92	Hum	NAT	F	rural	33		H		73.7	72.2		-0.045	-0.004	-0.024
92	Hum	NAT	F	rural	34		H*		70.0	69.2		-0.067	-0.023	-0.045
92	Hum	NAT	F	rural	35		H*		70.0	67.9		-0.067	-0.031	-0.049
92	M/Cs	NAT	F	rural	26	skelett2R	H	46.9	46.5		-0.002	0.017		0.007
92	M/Cs	NAT	F	rural	27	skelett2L	H	47.1	46.1		-0.001	0.013		0.006
92	M/Cs	NAT	F	rural	28	skelett1L	H	48.8	48.3		0.015	0.034		0.024
92	M/Cs	NAT	F	rural	30		H	47.0	47.9		-0.002	0.030		0.014
92	M/Cs	NAT	F	rural	34		H*	45.6	49.4		-0.015	0.043		0.014
92	M/Cs	NAT	F	rural	38		H	41.5	43.2		-0.056	-0.015		-0.035
92	M/Cs	NAT	F	rural	39		H*	44.5	46.4		-0.025	0.016		-0.005
92	M/Cs	NAT	F	rural	42		H*	46.8	47.5		-0.003	0.026		0.011
92	M/Cs	NAT	F	rural	44		H*	46.4	46.0		-0.007	0.012		0.003
92	M/Cs	NAT	F	rural	49		H*	47.1	46.6		-0.001	0.018		0.009
92	M/Cs	NAT	F	rural	50		H*	39.5	43.7		-0.077	-0.010		-0.043
92	M/Cs	NAT	F	rural	51		H*	44.2	44.5		-0.028	-0.002		-0.015
92	M/Cs	NAT	F	rural	54		H*	42.9	43.5		-0.041	-0.012		-0.027
92	M/Cs	NAT	F	rural	55		H	47.0	46.5		-0.002	0.017		0.008
92	M/Cs	NAT	F	rural	56		H	43.5	43.5		-0.035	-0.012		-0.023
92	M/Cs	NAT	F	rural	57		H	44.6	45.4		-0.024	0.007		-0.009
92	M/Cs	NAT	F	rural	60		H	44.3	46.2		-0.027	0.014		-0.006
92	M/Cs	NAT	F	rural	61		H*	46.9	44.9		-0.002	0.002		0.000
92	M/Cs	NAT	F	rural	62		H	47.1	47.7		-0.001	0.028		0.014
92	M/Cs	NAT	F	rural	63		H*	45.4	43.8		-0.017	-0.009		-0.013
92	M/Cs	NAT	F	rural	64		H*	48.0	46.2		0.008	0.014		0.011
92	M/Cs	NAT	F	rural	65		H	48.3	45.7		0.010	0.010		0.010
92	M/Cs	NAT	F	rural	70		H	49.4	49.0		0.020	0.040		0.030
92	M/Cs	NAT	F	rural	71		H	46.6	43.8		-0.005	-0.009		-0.007
92	M/Cs	NAT	F	rural	72		H	47.5	47.6		0.003	0.027		0.015
92	M/Cs	NAT	F	rural	73		H	51.1	48.7		0.035	0.037		0.036
92	M/Cs	NAT	F	rural	75		H*	46.1	45.1		-0.010	0.004		-0.003
92	M/Cs	NAT	F	rural	77		H	43.4	43.8		-0.036	-0.009		-0.023
92	M/Cs	NAT	F	rural	79		H	45.1	46.7		-0.019	0.019		0.000
92	M/Cs	NAT	F	rural	81		H*	44.9	43.1		-0.021	-0.016		-0.019
92	M/Cs	NAT	F	rural	85		H*	43.6	44.4		-0.034	-0.003		-0.019
92	M/Cs	NAT	F	rural	86		H	47.0	46.6		-0.002	0.018		0.008
92	M/Cs	NAT	F	rural	87		H*	43.3	42.7		-0.037	-0.020		-0.029
92	M/Cs	NAT	F	rural	90		H	49.1	46.8		0.017	0.020		0.019
92	M/Cs	NAT	F	rural	91		H	42.0	43.3		-0.050	-0.014		-0.032
92	M/Cs	NAT	F	rural	92		H*	46.6	46.3		-0.005	0.015		0.005
92	M/Cs	NAT	F	rural	93		H	45.5	45.8		-0.016	0.011		-0.003
92	M/Cs	NAT	F	rural	94		H	46.3	48.8		-0.008	0.038		0.015
92	M/Cs	NAT	F	rural	96		H	46.3	45.7		-0.008	0.010		0.001
92	M/Cs	NAT	F	rural	97		H	43.7	43.6		-0.033	-0.011		-0.022
92	M/Cs	NAT	F	rural	99		H	44.0	44.0		-0.030	-0.007		-0.019
92	M/Cs	NAT	F	rural	100		H*	44.1	45.6		-0.029	0.009		-0.010
92	M/Cs	NAT	F	rural	102		H	45.7	45.7		-0.014	0.010		-0.002
92	M/Cs	NAT	F	rural	104		H*	47.5	45.9		0.003	0.012		0.007
92	M/Cs	NAT	F	rural	105		H	47.1	47.7		-0.001	0.028		0.014
92	M/Cs	NAT	F	rural	106		H*	46.3	46.1		-0.008	0.013		0.003
92	M/Cs	NAT	F	rural	107		H	45.8	46.0		-0.013	0.012		0.000
92	M/Cs	NAT	F	rural	110		H*	44.5	46.1		-0.025	0.013		-0.006
92	M/Cs	NAT	F	rural	112		H	49.0	49.1		0.017	0.041		0.029
92	M/Cs	NAT	F	rural	113		H	49.4	49.6		0.020	0.045		0.033
92	M/Cs	NAT	F	rural	114		H*	41.9	44.2		-0.051	-0.005		-0.028

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
92	M/Cs	NAT	F	rural	115		H	51.2	50.3		0.036	0.051		0.043
92	M/Cs	NAT	F	rural	116		H	45.1	45.5		-0.019	0.008		-0.006
92	M/Cs	NAT	F	rural	117		H*	48.8	45.8		0.015	0.011		0.013
92	M/Cs	NAT	F	rural	118		H	48.0	47.7		0.008	0.028		0.018
92	M/Cs	NAT	F	rural	119		H	46.4	46.0		-0.007	0.012		0.003
92	M/Cs	NAT	F	rural	120		H	46.4	46.5		-0.007	0.017		0.005
92	M/Cs	NAT	F	rural	121		H	45.2	44.7		-0.019	0.000		-0.009
92	M/Cs	NAT	F	rural	122		H	44.1	44.4		-0.029	-0.003		-0.016
92	M/Cs	NAT	F	rural	123		H	43.8	43.2		-0.032	-0.015		-0.024
92	M/Cs	NAT	F	rural	124		H	44.6	42.9		-0.024	-0.018		-0.021
92	M/Cs	NAT	F	rural	125		H*	48.6	48.2		0.013	0.033		0.023
92	M/Cs	NAT	F	rural	128		H*	43.6	44.9		-0.034	0.002		-0.016
92	M/Cs	NAT	F	rural	129		H*	42.3	43.1		-0.047	-0.016		-0.032
92	M/Cs	NAT	F	rural	130		H*	43.3	46.3		-0.037	0.015		-0.011
92	M/Cs	NAT	F	rural	133		H	45.3	46.2		-0.018	0.014		-0.002
92	M/Cs	NAT	F	rural	134		H*	50.0	50.3		0.025	0.051		0.038
92	M/Cs	NAT	F	rural	136		H	46.1	45.7		-0.010	0.010		0.000
92	M/Cs	NAT	F	rural	138		H*	47.0	47.0		-0.002	0.022		0.010
92	M/Cs	NAT	F	rural	139		H*	48.3	47.3		0.010	0.025		0.017
92	M/Cs	NAT	F	rural	142		H	44.0	44.4		-0.030	-0.003		-0.017
92	M/Cs	NAT	F	rural	143		H*	46.9	42.4		-0.002	-0.023		-0.013
92	M/Cs	NAT	F	rural	147		H	49.1	47.7		0.017	0.028		0.023
92	M/Cs	NAT	F	rural	148		H*	42.8	43.3		-0.042	-0.014		-0.028
92	M/Cs	NAT	F	rural	149		H	45.6	43.5		-0.015	-0.012		-0.013
92	M/Cs	NAT	F	rural	150		H	43.8	44.6		-0.032	-0.001		-0.017
92	M/Cs	NAT	F	rural	151		H	42.9	43.9		-0.041	-0.008		-0.025
92	M/Cs	NAT	F	rural	152		H	46.2	45.6		-0.009	0.009		0.000
92	M/Cs	NAT	F	rural	153		H	48.6	46.4		0.013	0.016		0.015
92	M/Cs	NAT	F	rural	155		H	46.9	48.3		-0.002	0.034		0.016
92	M/Cs	NAT	F	rural	156		H*	44.2	44.2		-0.028	-0.005		-0.017
92	M/Cs	NAT	F	rural	157		H	43.5	45.5		-0.035	0.008		-0.014
92	M/Cs	NAT	F	rural	159		H*	46.8	46.4		-0.003	0.016		0.006
92	M/Cs	NAT	F	rural	160		H	46.3	47.8		-0.008	0.029		0.011
92	M/Cs	NAT	F	rural	162		H	48.7	45.1		0.014	0.004		0.009
92	M/Cs	NAT	F	rural	164		H*	48.7	46.1		0.014	0.013		0.014
92	M/Cs	NAT	F	rural	166		H	48.1	46.9		0.008	0.021		0.015
92	M/Cs	NAT	F	rural	171		H*	44.5	44.9		-0.025	0.002		-0.012
92	M/Cs	NAT	F	rural	172		H	46.8	46.7		-0.003	0.019		0.008
92	M/Cs	NAT	F	rural	174		H	43.4	44.6		-0.036	-0.001		-0.019
92	M/Cs	NAT	F	rural	175		H*	46.1	50.5		-0.010	0.053		0.022
92	M/Cs	NAT	F	rural	176		H	43.3	42.3		-0.037	-0.024		-0.031
92	M/Cs	NAT	F	rural	177		H	44.8	43.8		-0.022	-0.009		-0.016
92	M/Cs	NAT	F	rural	179		H	41.3	43.1		-0.058	-0.016		-0.037
92	M/Cs	NAT	F	rural	180		H*	47.4	46.0		0.002	0.012		0.007
92	M/Cs	NAT	F	rural	181		H	49.2	48.5		0.018	0.035		0.027
92	M/Cs	NAT	F	rural	182		H*	43.4	43.6		-0.036	-0.011		-0.023
92	M/Cs	NAT	F	rural	183		H	45.6	45.6		-0.015	0.009		-0.003
92	M/Cs	NAT	F	rural	188		H	46.6	47.6		-0.005	0.027		0.011
92	M/Cs	NAT	F	rural	190		H	46.3	45.3		-0.008	0.006		-0.001
92	M/Cs	NAT	F	rural	193		H	45.6	43.9		-0.015	-0.008		-0.011
92	M/Cs	NAT	F	rural	195		H*	41.5	43.5		-0.056	-0.012		-0.034
92	M/Cs	NAT	F	rural	198		H	46.0	45.4		-0.011	0.007		-0.002
92	M/Cs	NAT	F	rural	201		H*	44.5	48.3		-0.025	0.034		0.004
92	M/Cs	NAT	F	rural	203		H	46.6	46.1		-0.005	0.013		0.004
92	M/Cs	NAT	F	rural	204		H*	48.1	44.8		0.008	0.001		0.005
92	M/Cs	NAT	F	rural	207		H*	46.4	47.0		-0.007	0.022		0.007

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
92	M/Cs	NAT	F	rural	211		H	45.5	46.1		-0.016	0.013		-0.001
92	M/Cs	NAT	F	rural	212		H*	47.3	47.0		0.001	0.022		0.011
92	M/Cs	NAT	F	rural	213		H	47.3	47.2		0.001	0.024		0.012
92	M/Cs	NAT	F	rural	215		H*	47.0	48.2		-0.002	0.033		0.016
92	M/Cs	NAT	F	rural	216		H	46.6	47.2		-0.005	0.024		0.009
92	M/Cs	NAT	F	rural	217		H*	42.4	42.0		-0.046	-0.027		-0.037
92	M/Cs	NAT	F	rural	218		H	43.4	44.1		-0.036	-0.006		-0.021
92	M/Cs	NAT	F	rural	219		H*	47.7	45.9		0.005	0.012		0.008
92	M/Cs	NAT	F	rural	221		H	45.7	45.9		-0.014	0.012		-0.001
92	M/Cs	NAT	F	rural	224		H	44.8	46.6		-0.022	0.018		-0.002
92	M/Cs	NAT	F	rural	227		H	47.6	48.7		0.004	0.037		0.021
92	M/Cs	NAT	F	rural	228		H*	47.8	46.1		0.006	0.013		0.010
92	M/Cs	NAT	F	rural	229		H*	44.0	44.3		-0.030	-0.004		-0.017
92	M/Cs	NAT	F	rural	230		H	46.5	46.7		-0.006	0.019		0.006
92	M/Cs	NAT	F	rural	231		H	46.9	46.2		-0.002	0.014		0.006
92	M/Cs	NAT	F	rural	232		H	46.8	46.6		-0.003	0.018		0.007
92	M/Cs	NAT	F	rural	234		H	48.2	50.3		0.009	0.051		0.030
92	M/Cs	NAT	F	rural	235		H	46.1	43.8		-0.010	-0.009		-0.009
92	M/Cs	NAT	F	rural	236		H*	40.8	40.5		-0.063	-0.043		-0.053
92	M/Ts	NAT	F	rural	26	skelett1R	H	48.5	48.5		-0.002	0.011		0.005
92	M/Ts	NAT	F	rural	27	skelett1L	H	48.1	48.8		-0.005	0.014		0.004
92	M/Ts	NAT	F	rural	28		H	45.2	45.4		-0.032	-0.018		-0.025
92	M/Ts	NAT	F	rural	29		H	48.4	48.6		-0.003	0.012		0.005
92	M/Ts	NAT	F	rural	34		H*	44.8	46.0		-0.036	-0.012		-0.024
92	M/Ts	NAT	F	rural	35		H	46.0	43.1		-0.025	-0.040		-0.032
92	M/Ts	NAT	F	rural	36		H	43.5	45.3		-0.049	-0.018		-0.034
92	M/Ts	NAT	F	rural	37		H*	49.7	49.2		0.009	0.017		0.013
92	M/Ts	NAT	F	rural	38		H	43.5	45.1		-0.049	-0.020		-0.035
92	M/Ts	NAT	F	rural	40		H*	50.5	51.5		0.016	0.037		0.026
92	M/Ts	NAT	F	rural	41		H*	44.4	46.5		-0.040	-0.007		-0.024
92	M/Ts	NAT	F	rural	43		H	47.8	46.1		-0.008	-0.011		-0.009
92	M/Ts	NAT	F	rural	45		H*	43.9	43.7		-0.045	-0.034		-0.040
92	M/Ts	NAT	F	rural	46		H*	48.3	49.2		-0.004	0.017		0.007
92	M/Ts	NAT	F	rural	48		H	43.3	46.5		-0.051	-0.007		-0.029
92	M/Ts	NAT	F	rural	49		H	52.0	49.0		0.028	0.016		0.022
92	M/Ts	NAT	F	rural	51		H	45.4	45.2		-0.030	-0.019		-0.025
92	M/Ts	NAT	F	rural	52		H	44.7	45.7		-0.037	-0.015		-0.026
92	M/Ts	NAT	F	rural	53		H	49.1	46.6		0.004	-0.006		-0.001
92	M/Ts	NAT	F	rural	54		H*	43.9	45.3		-0.045	-0.018		-0.032
92	M/Ts	NAT	F	rural	55		H	43.0	44.9		-0.054	-0.022		-0.038
92	M/Ts	NAT	F	rural	56		H*	41.7	43.1		-0.067	-0.040		-0.054
92	M/Ts	NAT	F	rural	57		H*	43.9	45.0		-0.045	-0.021		-0.033
92	M/Ts	NAT	F	rural	58		H	46.0	46.8		-0.025	-0.004		-0.015
92	M/Ts	NAT	F	rural	59		H	47.0	48.4		-0.015	0.010		-0.003
92	M/Ts	NAT	F	rural	61		H*	47.0	45.1		-0.015	-0.020		-0.018
92	M/Ts	NAT	F	rural	64		H	48.3	48.2		-0.004	0.008		0.002
92	M/Ts	NAT	F	rural	65		H	44.5	47.2		-0.039	-0.001		-0.020
92	M/Ts	NAT	F	rural	68		H	45.5	47.3		-0.030	0.000		-0.015
92	M/Ts	NAT	F	rural	69		H	41.0	43.2		-0.075	-0.039		-0.057
92	M/Ts	NAT	F	rural	70		H	45.9	45.6		-0.026	-0.016		-0.021
92	M/Ts	NAT	F	rural	71		H	50.6	49.4		0.017	0.019		0.018
92	M/Ts	NAT	F	rural	72		H*	46.0	47.1		-0.025	-0.002		-0.013
92	M/Ts	NAT	F	rural	73		H	48.4	49.6		-0.003	0.021		0.009
92	M/Ts	NAT	F	rural	74		H	46.6	46.8		-0.019	-0.004		-0.012
92	M/Ts	NAT	F	rural	75		H	46.5	46.2		-0.020	-0.010		-0.015
92	M/Ts	NAT	F	rural	77		H	43.6	44.3		-0.048	-0.028		-0.038

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
92	M/Ts	NAT	F	rural	80		H	44.8	44.4		-0.036	-0.027		-0.032
92	M/Ts	NAT	F	rural	83		H	49.4	47.8		0.006	0.005		0.006
92	M/Ts	NAT	F	rural	84		H	46.7	46.1		-0.018	-0.011		-0.015
92	M/Ts	NAT	F	rural	85		H	45.7	47.0		-0.028	-0.002		-0.015
92	M/Ts	NAT	F	rural	86		H	46.7	46.4		-0.018	-0.008		-0.013
92	M/Ts	NAT	F	rural	88		H	44.4	45.0		-0.040	-0.021		-0.031
92	M/Ts	NAT	F	rural	89		H	48.2	49.4		-0.004	0.019		0.007
92	M/Ts	NAT	F	rural	90		H	46.2	45.4		-0.023	-0.018		-0.020
92	M/Ts	NAT	F	rural	91		H	47.7	48.9		-0.009	0.015		0.003
92	M/Ts	NAT	F	rural	92		H	44.2	45.7		-0.042	-0.015		-0.028
92	M/Ts	NAT	F	rural	95		H	46.3	45.4		-0.022	-0.018		-0.020
92	M/Ts	NAT	F	rural	96		H*	50.2	50.1		0.013	0.025		0.019
92	M/Ts	NAT	F	rural	99		H*	44.9	43.5		-0.035	-0.036		-0.036
92	M/Ts	NAT	F	rural	101		H	44.3	46.8		-0.041	-0.004		-0.023
92	M/Ts	NAT	F	rural	104		H	44.3	45.0		-0.041	-0.021		-0.031
92	M/Ts	NAT	F	rural	105		H	47.0	48.1		-0.015	0.008		-0.004
92	M/Ts	NAT	F	rural	107		H	46.0	44.5		-0.025	-0.026		-0.025
92	M/Ts	NAT	F	rural	109		H	47.2	47.7		-0.014	0.004		-0.005
92	M/Ts	NAT	F	rural	110		H	43.7	44.3		-0.047	-0.028		-0.038
92	M/Ts	NAT	F	rural	113		H	45.9	44.4		-0.026	-0.027		-0.026
92	M/Ts	NAT	F	rural	114		H*	48.4	45.3		-0.003	-0.018		-0.011
92	M/Ts	NAT	F	rural	115		H	51.2	50.9		0.022	0.032		0.027
92	M/Ts	NAT	F	rural	117		H	47.1	45.8		-0.015	-0.014		-0.014
92	M/Ts	NAT	F	rural	118		H*	44.9	44.0		-0.035	-0.031		-0.033
92	M/Ts	NAT	F	rural	119		H	46.4	46.3		-0.021	-0.009		-0.015
92	M/Ts	NAT	F	rural	121		H	45.3	43.8		-0.031	-0.033		-0.032
92	M/Ts	NAT	F	rural	123		H*	43.0	42.1		-0.054	-0.050		-0.052
92	M/Ts	NAT	F	rural	124		H	45.2	44.5		-0.032	-0.026		-0.029
92	M/Ts	NAT	F	rural	125		H	47.4	47.0		-0.012	-0.002		-0.007
92	M/Ts	NAT	F	rural	126		H*	44.9	44.6		-0.035	-0.025		-0.030
92	M/Ts	NAT	F	rural	127		H	43.9	43.8		-0.045	-0.033		-0.039
92	M/Ts	NAT	F	rural	129		H	44.1	44.8		-0.043	-0.023		-0.033
92	M/Ts	NAT	F	rural	131		H*	45.8	43.7		-0.027	-0.034		-0.030
92	M/Ts	NAT	F	rural	134		H	46.0	46.5		-0.025	-0.007		-0.016
92	M/Ts	NAT	F	rural	136		H*	47.3	48.2		-0.013	0.008		-0.002
92	M/Ts	NAT	F	rural	137		H*	48.8	49.3		0.001	0.018		0.010
92	M/Ts	NAT	F	rural	138		H*	44.0	42.7		-0.044	-0.044		-0.044
92	M/Ts	NAT	F	rural	140		H*	45.2	45.9		-0.032	-0.013		-0.023
92	M/Ts	NAT	F	rural	141		H*	45.4	48.1		-0.030	0.008		-0.011
92	M/Ts	NAT	F	rural	145		H*	47.9	48.7		-0.007	0.013		0.003
92	M/Ts	NAT	F	rural	147		H*	49.7	50.4		0.009	0.028		0.018
92	Rad	NAT	F	rural	27	skelett2R	H	77.5	72.1		-0.013	-0.014		-0.014
92	Rad	NAT	F	rural	28	skelett2L	H	77.6	72.4		-0.013	-0.012		-0.012
92	Rad	NAT	F	rural	29	skelett1R	H	81.5	73.7		0.009	-0.005		0.002
92	Rad	NAT	F	rural	30	skelett1L	H	80.0	72.8		0.001	-0.010		-0.005
92	Rad	NAT	F	rural	31		H	74.8	67.9		-0.028	-0.040		-0.034
92	Rad	NAT	F	rural	35		H	77.5	70.3		-0.013	-0.025		-0.019
92	Rad	NAT	F	rural	36		H*	79.7	70.2		-0.001	-0.026		-0.013
92	Rad	NAT	F	rural	37		H*	70.6	65.8		-0.054	-0.054		-0.054
92	Rad	NAT	F	rural	38		H	85.3	78.6		0.029	0.023		0.026
92	Rad	NAT	F	rural	39		H	72.6	64.7		-0.041	-0.061		-0.051
92	Rad	NAT	F	rural	41		H	78.8	71.5		-0.006	-0.018		-0.012
92	Rad	NAT	F	rural	44		H	76.0	72.4		-0.022	-0.012		-0.017
92	Rad	NAT	F	rural	45		H	80.9	76.8		0.006	0.013		0.009
92	Rad	NAT	F	rural	46		H	78.6	69.0		-0.007	-0.033		-0.020
92	Rad	NAT	F	rural	48		H*	78.8	72.5		-0.006	-0.012		-0.009

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
92	Rad	NAT	F	rural	50		H	76.3	72.3		-0.020	-0.013		-0.016
92	Rad	NAT	F	rural	52		H*	72.1	67.1		-0.044	-0.045		-0.045
92	Rad	NAT	F	rural	53		H*	83.1	79.1		0.017	0.026		0.022
92	Rad	NAT	F	rural	54		H	73.9	68.0		-0.034	-0.039		-0.037
92	Rad	NAT	F	rural	55		H	75.9	72.9		-0.022	-0.009		-0.016
92	Rad	NAT	F	rural	56		H	76.0	67.9		-0.022	-0.040		-0.031
92	Rad	NAT	F	rural	58		H*	74.6	69.0		-0.030	-0.033		-0.031
92	Rad	NAT	F	rural	61		H	74.5	71.8		-0.030	-0.016		-0.023
92	Tib	NAT	F	rural	28	skelett2R	H	87.1	67.5		-0.040	-0.026		-0.033
92	Tib	NAT	F	rural	29	skelett2L	H	87.2	67.4		-0.039	-0.026		-0.033
92	Tib	NAT	F	rural	30	skelett1R	H	92.9	72.6		-0.012	0.006		-0.003
92	Tib	NAT	F	rural	31	skelett1L	H	94.0	72.2		-0.007	0.003		-0.002
96	Fem	RO	F	cem	3	1575/5	H*	115.5	92.9		0.003	0.004		0.004
96	Fem	RO	F	cem	4	1620	H*	118.7	100.3		0.015	0.037		0.026
96	Hum	RO	F	cem	4	1575/5	H*			74.3			0.008	0.008
96	Hum	RO	F	cem	5	1620	H*			77.0			0.024	0.024
96	M/Cs	RO	F	cem	4	1575/5	H*	50.6	47.1		0.030	0.023		0.027
96	M/Cs	RO	F	cem	5	1620	H*	51.5	51.3		0.038	0.060		0.049
96	M/Ts	RO	F	cem	4	1575/5	H*	51.0	47.3		0.020	0.000		0.010
96	M/Ts	RO	F	cem	5	1620	H*	51.9	51.8		0.028	0.040		0.034
96	Rad	RO	F	cem	4	1575/5	H*	81.5	72.8		0.009	-0.010		-0.001
96	Rad	RO	F	cem	5	1620	H*	85.2	78.6		0.028	0.023		0.026
96	Tib	RO	F	cem	5	1575/5	H*	96.9	72.0		0.006	0.002		0.004
96	Tib	RO	F	cem	6	1620	H*	99.3	73.3		0.017	0.010		0.013
104	M/Cs	RO	E	villa	639		H*	50.0	52.0		0.025	0.066		0.045
104	M/Ts	RO	E	villa	504		H	42.0	44.0		-0.064	-0.031		-0.048
104	M/Ts	RO	E	villa	506		H*	45.0	44.0		-0.034	-0.031		-0.033
105	Hum	RO	K	ind	259		H*			65.8			-0.045	-0.045
105	Hum	RO	K	ind	260		H*			65.2			-0.048	-0.048
105	M/Ts	RO	K	ind	509		H*	52.1	48.5		0.029	0.011		0.020
105	M/Ts	RO	K	ind	516	549	H	42.2	43.8		-0.062	-0.033		-0.048
110	M/Cs	RO	F	urb	741	179/16-24	H*	45.0	44.2		-0.020	-0.005		-0.013
110	M/Cs	RO	F	urb	742	179/16-27	H*	48.9	48.5		0.016	0.035		0.026
110	M/Ts	RO	F	urb	589	179/16-22	H*	42.9	45.4		-0.055	-0.018		-0.036
110	M/Ts	RO	F	urb	590	179/16-25	H*	48.9	49.6		0.002	0.021		0.011
113	M/Cs	RO	E	urb	751		H*	40.4	42.2		-0.067	-0.025		-0.046
114	Fem	RO	G	urb	252	23B	H	109.2	87.4		-0.021	-0.022		-0.022
114	Fem	RO	G	urb	254	80L	H	96.4	82.9		-0.075	-0.045		-0.060
114	Hum	RO	G	urb	333	25	H		78.5	73.5		-0.017	0.004	-0.007
114	Hum	RO	G	urb	334	30	H		78.5	74.6		-0.017	0.010	-0.004
114	M/Cs	RO	G	urb	753	23	H	44.8	44.1		-0.022	-0.006		-0.014
114	M/Cs	RO	G	urb	754	25	H	49.3	47.8		0.019	0.029		0.024
114	M/Cs	RO	G	urb	755	30	H	47.4	48.0		0.002	0.031		0.017
114	M/Cs	RO	G	urb	756	32	H	46.4	45.0		-0.007	0.003		-0.002
114	M/Ts	RO	G	urb	599	23A	H	45.5	45.4		-0.030	-0.018		-0.024
114	M/Ts	RO	G	urb	600	35	H*	48.6	47.6		-0.001	0.003		0.001
114	M/Ts	RO	G	urb	601	40	H*	47.6	48.4		-0.010	0.010		0.000
114	M/Ts	RO	G	urb	604	73	H	46.5	46.0		-0.020	-0.012		-0.016
114	Rad	RO	G	urb	494	25	H	78.8	73.4		-0.006	-0.006		-0.006
114	Rad	RO	G	urb	495	30	H	80.3	72.9		0.002	-0.009		-0.003
114	Tib	RO	G	urb	491	23A	H	87.0	66.9		-0.040	-0.030		-0.035
114	Tib	RO	G	urb	492	35	H*		69.2			-0.015		-0.015
114	Tib	RO	G	urb	494	71	H	92.2	70.7		-0.015	-0.006		-0.010
115	M/Cs	RO	F	urb2	761		H*	50.0	50.3		0.025	0.051		0.038
115	M/Cs	RO	F	urb2	762		H*	47.7	49.5		0.005	0.044		0.025
115	M/Cs	RO	F	urb2	763		H	47.7	45.2		0.005	0.005		0.005

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
115	M/Cs	RO	F	urb2	764		H	50.4	48.0		0.029	0.031		0.030
115	M/Cs	RO	F	urb2	765		H*	47.0	45.7		-0.002	0.010		0.004
115	M/Ts	RO	F	urb2	605		H	52.6	50.2		0.033	0.026		0.030
115	M/Ts	RO	F	urb2	606		H	48.1	49.2		-0.005	0.017		0.006
115	Rad	RO	F	urb2	498		H*	81.3	74.3		0.008	-0.001		0.003
116	Hum	RO	D	urb2	353	294-1	H		77.0	71.0		-0.026	-0.011	-0.019
116	Hum	RO	D	urb2	355	B	H*		79.0	75.0		-0.015	0.012	-0.001
116	Hum	RO	D	urb2	362	233	H		87.0	75.0		0.027	0.012	0.020
116	M/Cs	RO	D	urb2	781	248-1	H	46.0	45.0		-0.011	0.003		-0.004
116	M/Cs	RO	D	urb2	782	238	H*	50.0	50.0		0.025	0.049		0.037
116	M/Cs	RO	D	urb2	787	17-1	H*	50.0	51.0		0.025	0.057		0.041
116	M/Cs	RO	D	urb2	788	328	H*	52.0	53.0		0.042	0.074		0.058
116	M/Ts	RO	D	urb2	617	348-1	H	46.0	45.0		-0.025	-0.021		-0.023
116	M/Ts	RO	D	urb2	618	224-1	H	46.0	46.0		-0.025	-0.012		-0.018
116	M/Ts	RO	D	urb2	619	348-2	H	45.0	47.0		-0.034	-0.002		-0.018
116	M/Ts	RO	D	urb2	620	17-1	H	44.0	45.0		-0.044	-0.021		-0.033
116	M/Ts	RO	D	urb2	621	63	H	46.0	47.0		-0.025	-0.002		-0.014
116	M/Ts	RO	D	urb2	622	251	H*	46.0	46.0		-0.025	-0.012		-0.018
116	M/Ts	RO	D	urb2	624	306	H*	48.0	52.0		-0.006	0.041		0.018
116	M/Ts	RO	D	urb2	626	222	H*	55.0	51.0		0.053	0.033		0.043
116	M/Ts	RO	D	urb2	627	238	H*	54.0	51.0		0.045	0.033		0.039
116	M/Ts	RO	D	urb2	628	248-1	H*	53.0	52.0		0.037	0.041		0.039
116	M/Ts	RO	D	urb2	631	248-2	H*	53.0	54.0		0.037	0.058		0.047
116	Rad	RO	D	urb2	523	251	H	75.0	70.0		-0.027	-0.027		-0.027
116	Rad	RO	D	urb2	525	248-2	H*	77.0	70.0		-0.016	-0.027		-0.021
116	Rad	RO	D	urb2	527	248-4	H*	81.0	70.0		0.006	-0.027		-0.010
116	Rad	RO	D	urb2	528	248-5	H*	77.0	71.0		-0.016	-0.021		-0.018
116	Rad	RO	D	urb2	529	248-6	H*	78.0	71.0		-0.010	-0.021		-0.016
116	Tib	RO	D	urb2	513	348	H	89.0	66.0		-0.031	-0.036		-0.033
116	Tib	RO	D	urb2	515	238	H*	89.0	63.0		-0.031	-0.056		-0.043
118	Fem	RO	G	mil	277	Pferd 2	H	125.5	98.0		0.039	0.027		0.033
118	Fem	RO	G	mil	278	Pferd 3	H	117.0	94.7		0.009	0.012		0.011
118	Fem	RO	G	mil	280		H	114.5	90.5		-0.001	-0.007		-0.004
118	Hum	RO	G	mil	370	Pferd 2	H		87.0	80.2		0.027	0.041	0.034
118	Hum	RO	G	mil	371	Pferd 3	H		80.0	76.4		-0.009	0.020	0.006
118	M/Cs	RO	G	mil	797	Pferd 2	H	54.5	53.0		0.063	0.074		0.068
118	M/Cs	RO	G	mil	798	Pferd 3	H	51.3	50.5		0.036	0.053		0.045
118	M/Ts	RO	G	mil	637	Pferd 2	H	54.0	52.2		0.045	0.043		0.044
118	M/Ts	RO	G	mil	638	Pferd 3	H	55.2	51.8		0.054	0.040		0.047
118	Rad	RO	G	mil	545	Pferd 2	H	82.3	76.8		0.013	0.013		0.013
118	Rad	RO	G	mil	546	Pferd 3	H	90.2	82.2		0.053	0.043		0.048
118	Tib	RO	G	mil	531	Pferd 2	H	101.7	80.2		0.027	0.049		0.038
118	Tib	RO	G	mil	532	Pferd 3	H	100.0	77.7		0.020	0.035		0.028
119	Fem	RO	G	mil	282	Horse 1	H*	124.0	98.2		0.034	0.028		0.031
119	Hum	RO	G	mil	374	Horse 1	H*		79.5			-0.012		-0.012
119	M/Cs	RO	G	mil	804	Horse 1	H*	57.9	49.1		0.089	0.041		0.065
119	M/Ts	RO	G	mil	641	Horse 1	H*	52.3	50.8		0.031	0.031		0.031
119	Tib	RO	G	mil	535	Horse 1	H*	116.2	74.8		0.085	0.019		0.052
120	M/Cs	IA	F	rural	806		H*	46.4	46.6		-0.007	0.018		0.005
120	M/Cs	IA	F	rural	807		H*	40.8	39.2		-0.063	-0.057		-0.060
120	M/Cs	IA	F	rural	808		H	45.1	45.3		-0.019	0.006		-0.007
120	M/Cs	IA	F	rural	809		H	46.0	43.5		-0.011	-0.012		-0.011
120	M/Cs	IA	F	rural	810		H*	45.0	45.3		-0.020	0.006		-0.007
120	M/Cs	IA	F	rural	813		H	45.5	44.9		-0.016	0.002		-0.007
120	Tib	IA	F	rural	537		H	82.5	62.7		-0.064	-0.058		-0.061
120	Tib	IA	F	rural	538		H	87.6	63.9		-0.037	-0.050		-0.044

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
121	M/Cs	RO	F	urb2	817		H	47.4	48.2		0.002	0.033		0.017
123	M/Cs	RO	E	urb	822		H	53.4	47.4		0.054	0.025		0.040
123	M/Ts	RO	E	urb	659		H	50.1	49.4		0.012	0.019		0.016
123	M/Ts	RO	E	urb	660		H	45.9	45.3		-0.026	-0.018		-0.022
125	M/Cs	RO	E	mil	830		H	42.4	44.0		-0.046	-0.007		-0.027
125	M/Cs	RO	E	mil	838		H	50.9	48.3		0.033	0.034		0.033
125	M/Ts	RO	E	mil	673		H*	52.9	51.0		0.036	0.033		0.034
125	M/Ts	RO	E	mil	674		H	47.8	46.2		-0.008	-0.010		-0.009
128	M/Cs	RO	F	mil	843	3392	H*	55.0	50.0		0.067	0.049		0.058
128	M/Cs	RO	F	mil	844	3392	H*	54.0	53.0		0.059	0.074		0.066
128	M/Ts	RO	F	mil	680	3392	H*	49.5	49.0		0.007	0.016		0.011
129	Rad	RO	F	oth	593		H	79.0	71.0		-0.005	-0.021		-0.013
129	Rad	RO	F	oth	595		H*	74.5	68.5		-0.030	-0.036		-0.033
131	M/Cs	IA	G	rural	863		H*	45.0	46.5		-0.020	0.017		-0.002
134	M/Cs	RO	F	urb2	885		H	49.0	46.0		0.017	0.012		0.014
134	M/Ts	RO	F	urb2	732		H*	52.0	53.0		0.028	0.050		0.039
135	Fem	IA	G	cem	314	1	H	102.5	80.0		-0.049	-0.061		-0.055
135	Fem	IA	G	cem	315	2	H	108.0	83.0		-0.026	-0.045		-0.035
135	Fem	IA	G	cem	316	3	H	105.5	86.0		-0.036	-0.029		-0.033
135	Fem	IA	G	cem	317	4	H*	120.0	93.0		0.020	0.005		0.012
135	Hum	IA	G	cem	422	1	H		69.0	65.0		-0.073	-0.050	-0.062
135	Hum	IA	G	cem	423	2	H		75.0	67.0		-0.037	-0.037	-0.037
135	Hum	IA	G	cem	424	3	H		75.0	67.5		-0.037	-0.033	-0.035
135	Hum	IA	G	cem	425	4	H*		82.0	74.0		0.002	0.007	0.004
135	M/Cs	IA	G	cem	891	1	H	44.0	45.0		-0.030	0.003		-0.014
135	M/Cs	IA	G	cem	892	2	H	47.0	45.0		-0.002	0.003		0.001
135	M/Cs	IA	G	cem	893	3	H	45.5	45.0		-0.016	0.003		-0.006
135	M/Cs	IA	G	cem	894	4	H*	51.0	49.5		0.034	0.044		0.039
135	M/Ts	IA	G	cem	736	1	H	44.0	45.0		-0.044	-0.021		-0.033
135	M/Ts	IA	G	cem	737	2	H	46.0	45.0		-0.025	-0.021		-0.023
135	M/Ts	IA	G	cem	738	3	H	46.0	44.0		-0.025	-0.031		-0.028
135	M/Ts	IA	G	cem	739	4	H*	49.0	50.0		0.003	0.024		0.014
135	Rad	IA	G	cem	615	1	H	74.0	69.0		-0.033	-0.033		-0.033
135	Rad	IA	G	cem	616	2	H	73.0	65.0		-0.039	-0.059		-0.049
135	Rad	IA	G	cem	617	3	H	75.0	72.0		-0.027	-0.015		-0.021
135	Rad	IA	G	cem	618	4	H*	83.5	79.0		0.019	0.026		0.022
135	Tib	IA	G	cem	598	1	H	85.0	68.0		-0.051	-0.023		-0.037
135	Tib	IA	G	cem	599	2	H	86.0	66.0		-0.046	-0.036		-0.041
135	Tib	IA	G	cem	600	3	H	88.0	64.0		-0.036	-0.049		-0.042
135	Tib	IA	G	cem	601	4	H*	97.0	77.5		0.007	0.034		0.020
141	Hum	IA	G	cem	431	6	H*		71.0			-0.061		-0.061
141	M/Cs	IA	G	cem	901	6	H*	44.5	46.0		-0.025	0.012		-0.006
141	M/Ts	IA	G	cem	746	6	H*	46.5	47.0		-0.020	-0.002		-0.011
141	Rad	IA	G	cem	624	6	H*	77.0	69.0		-0.016	-0.033		-0.025
141	Tib	IA	G	cem	610	6	H*		64.5			-0.046		-0.046
143	M/Cs	IA	G	urb2	902	P1	H*	53.0	50.5		0.051	0.053		0.052
143	M/Cs	IA	G	urb2	906	P12	H*	50.0	51.0		0.025	0.057		0.041
143	M/Ts	IA	G	urb2	747	P18	H*	51.0	51.0		0.020	0.033		0.027
146	M/Cs	RO	G	rural	925	574c	H*	45.0	47.0		-0.020	0.022		0.001
146	M/Ts	RO	G	rural	752	620c	H*	51.0	50.0		0.020	0.024		0.022
147	M/Ts	RO	G	mil	753		H	43.5	45.5		-0.049	-0.017		-0.033
147	M/Ts	RO	G	mil	754		H	43.5	45.5		-0.049	-0.017		-0.033
147	M/Ts	RO	G	mil	755		H*	49.0	52.0		0.003	0.041		0.022
149	M/Cs	IA	G	rural	929		H*	45.5	46.0		-0.016	0.012		-0.002
149	M/Ts	IA	G	rural	756		H*	44.0	47.0		-0.044	-0.002		-0.023
149	M/Ts	IA	G	rural	757		H	46.5	48.0		-0.020	0.007		-0.007

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
149	M/Ts	IA	G	rural	758		H*	45.5	47.5		-0.030	0.002		-0.014
150	M/Cs	RO	G	mil	930		H*	48.0	48.5		0.008	0.035		0.022
151	M/Ts	RO	G	rural	759		H*	51.0	53.5		0.020	0.054		0.037
153	M/Cs	RO	A	urb	931		H	49.5	51.0		0.021	0.057		0.039
153	M/Cs	RO	A	urb	932		H*	50.2	48.8		0.027	0.038		0.033
174	M/Cs	RO	F	mil	972		H*	48.5	49.0		0.012	0.040		0.026
174	M/Cs	RO	F	mil	977		H*	52.0	50.0		0.042	0.049		0.045
176	M/Cs	NAT	F	cem	992		H*	48.0	49.0		0.008	0.040		0.024
176	M/Cs	NAT	F	cem	993		H*	48.0	49.0		0.008	0.040		0.024
176	M/Cs	NAT	F	cem	995		H	46.0	45.0		-0.011	0.003		-0.004
176	M/Cs	NAT	F	cem	997		H	48.0	46.0		0.008	0.012		0.010
176	M/Cs	NAT	F	cem	999		H*	51.0	49.0		0.034	0.040		0.037
176	M/Cs	NAT	F	cem	1001		H	44.7	44.0		-0.023	-0.007		-0.015
176	M/Cs	NAT	F	cem	1002		H*	40.0	47.0		-0.072	0.022		-0.025
176	M/Cs	NAT	F	cem	1004		H	43.0	41.0		-0.040	-0.038		-0.039
176	M/Cs	NAT	F	cem	1005		H	42.0	42.0		-0.050	-0.027		-0.039
176	M/Cs	NAT	F	cem	1006		H*	42.0	42.0		-0.050	-0.027		-0.039
176	M/Cs	NAT	F	cem	1008		H*	40.0	43.0		-0.072	-0.017		-0.044
176	M/Ts	NAT	F	cem	806		H	49.0	46.0		0.003	-0.012		-0.005
176	M/Ts	NAT	F	cem	807		H*	48.0	45.0		-0.006	-0.021		-0.014
176	M/Ts	NAT	F	cem	811		H*	47.0	49.0		-0.015	0.016		0.000
176	M/Ts	NAT	F	cem	812		H*	44.0	44.0		-0.044	-0.031		-0.038
176	M/Ts	NAT	F	cem	814		H*	47.0	50.0		-0.015	0.024		0.004
176	M/Ts	NAT	F	cem	815		H	47.0	45.0		-0.015	-0.021		-0.018
176	M/Ts	NAT	F	cem	816		H	46.0	45.0		-0.025	-0.021		-0.023
176	M/Ts	NAT	F	cem	817		H*	48.0	47.0		-0.006	-0.002		-0.004
178	M/Cs	RO	F	urb2	1015		H	50.1	48.3		0.026	0.034		0.030
188	M/Ts	RO	D	rural	849		H*	49.0	49.0		0.003	0.016		0.009
192	Rad	RO	F	rural	713		H	79.0	72.0		-0.005	-0.015		-0.010
192	Rad	RO	F	rural	714		H*	82.0	73.0		0.011	-0.009		0.001
198	Hum	RO	F	mil	478		H*		81.0	74.0		-0.004	0.007	0.001
199	Rad	RO	F	rural	732		H*	88.0	78.0		0.042	0.020		0.031
199	Rad	RO	F	rural	734		H*	86.5	79.5		0.035	0.028		0.032
200	Rad	RO	F	rural	763		H*	88.0	76.0		0.042	0.009		0.025
201	Tib	RO	F	villa	759		H	93.0	72.0		-0.012	0.002		-0.005
202	M/Cs	NAT	F	rural	1129		H	42.3	41.5		-0.047	-0.032		-0.040
202	M/Cs	NAT	F	rural	1132		H	43.5	44.0		-0.035	-0.007		-0.021
202	M/Cs	NAT	F	rural	1136		H	43.4	42.6		-0.036	-0.021		-0.029
202	M/Cs	NAT	F	rural	1137		H*	47.0	48.2		-0.002	0.033		0.016
202	M/Ts	NAT	F	rural	949		H	47.1	45.6		-0.015	-0.016		-0.015
202	M/Ts	NAT	F	rural	952		H	48.6	45.0		-0.001	-0.021		-0.011
202	M/Ts	NAT	F	rural	954		H*	46.7	48.8		-0.018	0.014		-0.002
202	M/Ts	NAT	F	rural	955		H	44.0	43.5		-0.044	-0.036		-0.040
202	M/Ts	NAT	F	rural	956		H	45.5	43.4		-0.030	-0.037		-0.033
203	M/Cs	RO	G	urb	1138		H*	46.5	50.0		-0.006	0.049		0.021
203	M/Cs	RO	G	urb	1140		H*	45.5	45.0		-0.016	0.003		-0.006
203	M/Cs	RO	G	urb	1141		H	48.5	49.5		0.012	0.044		0.028
203	M/Cs	RO	G	urb	1145		H*	49.5	48.0		0.021	0.031		0.026
203	M/Cs	RO	G	urb	1148		H	47.0	47.5		-0.002	0.026		0.012
203	M/Cs	RO	G	urb	1149		H	50.5	51.0		0.030	0.057		0.043
203	M/Cs	RO	G	urb	1150		H	51.0	51.0		0.034	0.057		0.046
203	M/Cs	RO	G	urb	1151		H	48.5	49.0		0.012	0.040		0.026
203	M/Cs	RO	G	urb	1152		H*	49.5	50.5		0.021	0.053		0.037
203	M/Cs	RO	G	urb	1153		H*	50.5	50.5		0.030	0.053		0.041
203	M/Cs	RO	G	urb	1156		H	51.0	51.5		0.034	0.061		0.048
203	M/Cs	RO	G	urb	1157		H*	49.5	49.5		0.021	0.044		0.033

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
203	M/Cs	RO	G	urb	1161		H	50.0	50.0		0.025	0.049		0.037
203	M/Cs	RO	G	urb	1168		H*	49.5	50.5		0.021	0.053		0.037
203	M/Cs	RO	G	urb	1169		H	48.5	49.0		0.012	0.040		0.026
203	M/Cs	RO	G	urb	1172		H*	51.0	51.0		0.034	0.057		0.046
203	M/Cs	RO	G	urb	1173		H*	48.0	50.5		0.008	0.053		0.030
203	M/Cs	RO	G	urb	1175		H*	51.5	52.0		0.038	0.066		0.052
203	M/Cs	RO	G	urb	1179		H*	52.5	52.5		0.046	0.070		0.058
203	M/Cs	RO	G	urb	1181		H	50.5	50.5		0.030	0.053		0.041
203	M/Cs	RO	G	urb	1185		H	52.5	51.0		0.046	0.057		0.052
203	M/Cs	RO	G	urb	1187		H	51.0	53.0		0.034	0.074		0.054
203	M/Cs	RO	G	urb	1189		H*	55.5	52.5		0.071	0.070		0.070
203	M/Cs	RO	G	urb	1191		H*	55.0	56.0		0.067	0.098		0.082
203	M/Ts	RO	G	urb	961		H*	48.5	48.0		-0.002	0.007		0.002
203	M/Ts	RO	G	urb	962		H*	48.5	48.0		-0.002	0.007		0.002
203	M/Ts	RO	G	urb	963		H	47.5	48.0		-0.011	0.007		-0.002
203	M/Ts	RO	G	urb	965		H	48.0	48.5		-0.006	0.011		0.002
203	M/Ts	RO	G	urb	966		H*	48.0	51.0		-0.006	0.033		0.013
203	M/Ts	RO	G	urb	968		H	47.0	47.5		-0.015	0.002		-0.007
203	M/Ts	RO	G	urb	969		H*	47.0	47.0		-0.015	-0.002		-0.009
203	M/Ts	RO	G	urb	974		H*	50.0	51.0		0.011	0.033		0.022
203	M/Ts	RO	G	urb	976		H*	47.5	48.0		-0.011	0.007		-0.002
203	M/Ts	RO	G	urb	978		H*	50.0	47.5		0.011	0.002		0.007
203	M/Ts	RO	G	urb	979		H	52.0	48.0		0.028	0.007		0.018
203	M/Ts	RO	G	urb	985		H*	53.0	51.5		0.037	0.037		0.037
204	M/Cs	RO	D	rural	1236		H*	47.7	47.2		0.005	0.024		0.014
204	M/Cs	RO	D	rural	1237		H*	47.5	48.1		0.003	0.032		0.017
205	Rad	RO	F	mil	853		H*	71.0	65.5		-0.051	-0.056		-0.053
207	M/Cs	RO	F	mil	1251		H	48.0	49.0		0.008	0.040		0.024
208	Fem	RO	F	urb	382		H*	126.0	95.0		0.041	0.014		0.027
208	M/Cs	RO	F	urb	1256		H*	52.0	48.0		0.042	0.031		0.037
208	M/Cs	RO	F	urb	1258		H*	54.0	52.0		0.059	0.066		0.062
208	M/Cs	RO	F	urb	1259		H	51.5	49.0		0.038	0.040		0.039
208	M/Cs	RO	F	urb	1260		H*	50.0	50.5		0.025	0.053		0.039
208	M/Cs	RO	F	urb	1262		H*	49.0	48.0		0.017	0.031		0.024
208	M/Cs	RO	F	urb	1264		H	48.5	46.5		0.012	0.017		0.015
212	M/Cs	IA	D	cem	1275		H	47.0	44.5		-0.002	-0.002		-0.002
212	M/Cs	IA	D	cem	1276		H	43.5	40.5		-0.035	-0.043		-0.039
212	M/Ts	IA	D	cem	1093		H*	43.0	43.0		-0.054	-0.041		-0.048
213	M/Cs	IA	D	rural	1277		H	45.0	42.0		-0.020	-0.027		-0.024
213	M/Cs	IA	D	rural	1278		H*	52.0	50.0		0.042	0.049		0.045
213	M/Cs	IA	D	rural	1281		H	45.0	44.0		-0.020	-0.007		-0.014
213	M/Cs	IA	D	rural	1282		H	44.0	42.5		-0.030	-0.022		-0.026
213	M/Cs	IA	D	rural	1283		H*	39.5	39.5		-0.077	-0.054		-0.065
213	M/Ts	IA	D	rural	1096		H	41.5	41.0		-0.069	-0.062		-0.066
213	M/Ts	IA	D	rural	1097		H*	45.5	43.0		-0.030	-0.041		-0.035
213	M/Ts	IA	D	rural	1099		H	48.0	45.0		-0.006	-0.021		-0.014
213	M/Ts	IA	D	rural	1101		H	39.0	40.0		-0.096	-0.073		-0.084
214	M/Cs	IA	D	rural	1284		H	51.0	49.0		0.034	0.040		0.037
214	M/Ts	IA	D	rural	1104		H	46.5	46.5		-0.020	-0.007		-0.014
215	M/Cs	IA	D	oth	1286		H*	46.5	44.0		-0.006	-0.007		-0.007
215	M/Ts	IA	D	oth	1105		H	42.5	42.0		-0.059	-0.051		-0.055
215	M/Ts	IA	D	oth	1106		H	42.0	42.0		-0.064	-0.051		-0.058
215	M/Ts	IA	D	oth	1107		H*	46.0	43.5		-0.025	-0.036		-0.030
216	M/Cs	IA	D	rural	1287		H	40.0	40.0		-0.072	-0.048		-0.060
216	M/Cs	IA	D	rural	1288		H*	43.0	45.0		-0.040	0.003		-0.019
216	M/Cs	IA	D	rural	1289		H*	39.0	39.0		-0.083	-0.059		-0.071

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Bp	Bd	BT	Log1	Log2	Log3	Mean Log
216	M/Cs	IA	D	rural	1290		H	42.0	40.5		-0.050	-0.043		-0.047
216	M/Cs	IA	D	rural	1291		H*	43.0	40.0		-0.040	-0.048		-0.044
216	M/Cs	IA	D	rural	1292		H*	49.5	48.0		0.021	0.031		0.026
216	M/Ts	IA	D	rural	1108		H	44.5	43.0		-0.039	-0.041		-0.040
216	M/Ts	IA	D	rural	1109		H*	43.0	41.0		-0.054	-0.062		-0.058
216	M/Ts	IA	D	rural	1110		H	43.0	42.6		-0.054	-0.045		-0.050
216	M/Ts	IA	D	rural	1111		H*	45.0	43.0		-0.034	-0.041		-0.038
217	M/Cs	IA	D	cem	1293		H*	37.0	37.5		-0.105	-0.076		-0.091

Table A39. – Results of the calculation of log ratios on the horse depth measurements

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
5	M/Ts	IA	E	rural	464		H	35.0	33.0	-0.103	-0.049	-0.076
28	M/Ts	RO	E	mil	423		H	31.0	30.0	-0.155	-0.090	-0.123
28	M/Ts	RO	E	mil	424		H*	32.0	30.0	-0.142	-0.090	-0.116
28	M/Ts	RO	E	mil	425		H	41.0	35.0	-0.034	-0.023	-0.028
37	M/Ts	RO	F	cem	396	11-28	H*	44.8	41.1	0.005	0.047	0.026
38	M/Cs	RO	F	urb	501		H*	28.3	33.6	-0.056	-0.021	-0.039
38	M/Cs	RO	F	urb	505		H*	34.7	38.9	0.033	0.042	0.038
38	M/Cs	RO	F	urb	508		H	32.3	35.9	0.002	0.007	0.005
38	M/Cs	RO	F	urb	509		H*	33.2	36.2	0.014	0.011	0.012
38	M/Cs	RO	F	urb	511		H	32.5	36.7	0.004	0.017	0.011
38	M/Cs	RO	F	urb	519		H	31.0	34.7	-0.016	-0.007	-0.012
38	M/Ts	RO	F	urb	380		H	39.3	35.1	-0.052	-0.022	-0.037
38	M/Ts	RO	F	urb	383		H*	43.2	38.3	-0.011	0.016	0.002
38	M/Ts	RO	F	urb	385		H*	41.3	37.8	-0.031	0.010	-0.010
38	Tib	RO	F	urb	277		H		45.9		0.006	0.006
39	M/Ts	RO	F	urb2	378		H*	37.3	36.2	-0.075	-0.008	-0.042
42	M/Cs	RO	F	villa	483		H*	32.2	35.9	0.000	0.007	0.004
42	M/Cs	RO	F	villa	485		H*	32.3	38.0	0.002	0.032	0.017
42	M/Cs	RO	F	villa	490		H*	31.7	34.5	-0.006	-0.010	-0.008
42	M/Cs	IA	F	villa	495		H*	32.7	35.5	0.007	0.002	0.005
42	M/Ts	RO	F	villa	364		H	40.7	34.6	-0.037	-0.028	-0.033
42	M/Ts	RO	F	villa	367		H*	44.0	39.9	-0.003	0.034	0.015
42	M/Ts	RO	F	villa	368		H*	42.1	38.1	-0.022	0.014	-0.004
42	M/Ts	RO	F	villa	372	12.4	H*	43.0	41.2	-0.013	0.048	0.017
42	Tib	RO	F	villa	250	12.4	H*		50.5		0.048	0.048
43	M/Cs	RO	E	urb2	466		H	31.0	33.9	-0.016	-0.018	-0.017
43	M/Cs	RO	E	urb2	468	6640	H*	36.5	38.8	0.055	0.041	0.048
43	M/Cs	RO	E	urb2	469	6640	H*	36.2	39.1	0.051	0.044	0.048
43	M/Ts	RO	E	urb2	350	6640	H*	45.3	40.0	0.009	0.035	0.022
43	M/Ts	RO	E	urb2	351	6640	H*		39.4		0.028	0.028
43	M/Ts	RO	E	urb2	358		H	40.5	33.8	-0.039	-0.038	-0.039
43	M/Ts	IA	E	urb2	359		H*	34.6		-0.108		-0.108
43	Tib	RO	E	urb2	234	6640	H*		43.9		-0.013	-0.013
44	M/Cs	IA	E	rural	427		H*	27.7	31.8	-0.065	-0.045	-0.055
44	M/Cs	IA	E	rural	434		H	30.0	31.8	-0.030	-0.045	-0.038
44	M/Cs	IA	E	rural	448		H	32.6	33.6	0.006	-0.021	-0.008
44	M/Cs	IA	E	rural	457		H	30.8	33.8	-0.019	-0.019	-0.019

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
44	M/Cs	IA	E	rural	458		H	33.9	36.2	0.023	0.011	0.017
44	M/Cs	IA	E	rural	460		H	28.7	32.4	-0.050	-0.037	-0.043
44	M/Ts	IA	E	rural	322		H	36.7	35.2	-0.082	-0.020	-0.051
44	M/Ts	IA	E	rural	335		H	34.5	31.6	-0.109	-0.067	-0.088
44	M/Ts	IA	E	rural	338		H	40.8	35.2	-0.036	-0.020	-0.028
44	M/Ts	IA	E	rural	340		H	39.8	35.8	-0.047	-0.013	-0.030
46	M/Ts	RO	E	cem	320		H*	43.8	39.7	-0.005	0.032	0.013
46	Tib	RO	E	cem	196		H		48.4		0.029	0.029
47	M/Cs	IA	E	urb	419		H	30.0	33.2	-0.030	-0.027	-0.028
47	M/Ts	RO	E	urb	318		H	42.0	37.5	-0.023	0.007	-0.008
51	M/Cs	IA	E	villa	410		H	31.1	34.8	-0.015	-0.006	-0.010
51	M/Cs	IA	E	villa	411		H	30.9	32.6	-0.017	-0.035	-0.026
51	M/Cs	IA	E	villa	412		H*	32.8	34.8	0.008	-0.006	0.001
54	M/Cs	IA	E	rural	404		H	32.0	34.6	-0.002	-0.009	-0.005
54	M/Cs	IA	E	rural	405		H*	28.0	30.0	-0.060	-0.071	-0.065
54	M/Ts	RO	E	rural	301		H*	42.8	36.6	-0.015	-0.004	-0.009
59	M/Cs	RO	E	urb	397	XXIII	H*	32.7		0.007		0.007
59	M/Cs	RO	E	urb	398	XXIII	H*	34.0	39.2	0.024	0.046	0.035
59	M/Ts	RO	E	urb	294	XXIII	H*	46.0	40.4	0.016	0.039	0.028
59	M/Ts	RO	E	urb	295	XXIII	H*	48.4	40.4	0.038	0.039	0.039
59	Tib	RO	E	urb	176	XXIII	H*		49.1		0.036	0.036
59	Tib	RO	E	urb	177	XXIII	H*		47.6		0.022	0.022
66	M/Ts	RO	A	villa	285		H*	41.0	38.0	-0.034	0.013	-0.011
67	M/Ts	RO	E	urb	284	F267	H*	42.2	27.8	-0.021	-0.123	-0.072
67	Tib	RO	E	urb	170	F267	H*		46.0		0.007	0.007
68	M/Ts	RO	E	rural	283		H	41.7	35.7	-0.027	-0.014	-0.020
81	M/Ts	NAT	F	rural	271		H	40.2	37.2	-0.042	0.004	-0.019
81	M/Ts	NAT	F	rural	273		H*	41.7	36.2	-0.027	-0.008	-0.017
83	M/Cs	NAT	F	rural	373		H*	33.2	37.5	0.014	0.026	0.020
87	Fem	IA	F	rural	78		H	50.5		-0.057		-0.057
92	Fem	NAT	F	rural	28	skelett2R	H	51.1		-0.052		-0.052
92	Fem	NAT	F	rural	29	skelett2L	H	51.5		-0.049		-0.049
92	Fem	NAT	F	rural	30	skelett1R	H	53.7		-0.031		-0.031
92	Fem	NAT	F	rural	31	skelett1L	H	54.7		-0.023		-0.023
92	Fem	NAT	F	rural	33		H*	52.0		-0.045		-0.045
92	Fem	NAT	F	rural	36		H	52.7		-0.039		-0.039
92	M/Cs	NAT	F	rural	26	skelett2R	H	30.7	33.8	-0.020	-0.019	-0.020
92	M/Cs	NAT	F	rural	27	skelett2L	H	30.3	33.9	-0.026	-0.018	-0.022
92	M/Cs	NAT	F	rural	28	skelett1L	H	32.9	35.8	0.010	0.006	0.008
92	M/Cs	NAT	F	rural	30		H	32.9	33.6	0.010	-0.021	-0.006
92	M/Cs	NAT	F	rural	34		H*	31.4	36.0	-0.011	0.009	-0.001
92	M/Cs	NAT	F	rural	38		H	27.4	31.1	-0.070	-0.055	-0.062
92	M/Cs	NAT	F	rural	39		H*	28.0	32.9	-0.060	-0.031	-0.045
92	M/Cs	NAT	F	rural	42		H*	29.2	33.5	-0.042	-0.023	-0.032
92	M/Cs	NAT	F	rural	44		H*	31.2	33.9	-0.013	-0.018	-0.015
92	M/Cs	NAT	F	rural	49		H*	31.9	34.5	-0.004	-0.010	-0.007
92	M/Cs	NAT	F	rural	50		H*	28.1	31.8	-0.059	-0.045	-0.052
92	M/Cs	NAT	F	rural	51		H*	29.8	32.6	-0.033	-0.035	-0.034
92	M/Cs	NAT	F	rural	54		H*	28.0	27.1	-0.060	-0.115	-0.088
92	M/Cs	NAT	F	rural	55		H	32.5	34.8	0.004	-0.006	-0.001
92	M/Cs	NAT	F	rural	56		H	28.1	32.2	-0.059	-0.040	-0.049
92	M/Cs	NAT	F	rural	57		H	31.8	35.8	-0.005	0.006	0.001
92	M/Cs	NAT	F	rural	60		H	30.9	33.3	-0.017	-0.025	-0.021
92	M/Cs	NAT	F	rural	61		H*	30.8	33.0	-0.019	-0.029	-0.024
92	M/Cs	NAT	F	rural	62		H	31.1	34.3	-0.015	-0.012	-0.014
92	M/Cs	NAT	F	rural	63		H*	28.8	32.4	-0.048	-0.037	-0.043

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
92	M/Cs	NAT	F	rural	64		H*	31.5	33.4	-0.009	-0.024	-0.017
92	M/Cs	NAT	F	rural	65		H	32.0	34.3	-0.002	-0.012	-0.007
92	M/Cs	NAT	F	rural	70		H	32.7	34.6	0.007	-0.009	-0.001
92	M/Cs	NAT	F	rural	71		H	29.3	31.6	-0.041	-0.048	-0.044
92	M/Cs	NAT	F	rural	72		H	31.1	34.9	-0.015	-0.005	-0.010
92	M/Cs	NAT	F	rural	73		H	33.8	34.1	0.021	-0.015	0.003
92	M/Cs	NAT	F	rural	75		H*	31.0	33.2	-0.016	-0.027	-0.021
92	M/Cs	NAT	F	rural	77		H	30.9	32.4	-0.017	-0.037	-0.027
92	M/Cs	NAT	F	rural	79		H	29.5	33.8	-0.038	-0.019	-0.028
92	M/Cs	NAT	F	rural	81		H*	30.7	32.9	-0.020	-0.031	-0.025
92	M/Cs	NAT	F	rural	85		H*	28.3	29.7	-0.056	-0.075	-0.065
92	M/Cs	NAT	F	rural	86		H	31.0	34.4	-0.016	-0.011	-0.014
92	M/Cs	NAT	F	rural	87		H*	27.7	31.8	-0.065	-0.045	-0.055
92	M/Cs	NAT	F	rural	90		H	32.2	35.4	0.000	0.001	0.001
92	M/Cs	NAT	F	rural	91		H	27.2	31.2	-0.073	-0.054	-0.063
92	M/Cs	NAT	F	rural	92		H*	31.2	33.8	-0.013	-0.019	-0.016
92	M/Cs	NAT	F	rural	93		H	30.1	34.4	-0.029	-0.011	-0.020
92	M/Cs	NAT	F	rural	94		H	32.6	34.0	0.006	-0.016	-0.005
92	M/Cs	NAT	F	rural	96		H	29.5	33.9	-0.038	-0.018	-0.028
92	M/Cs	NAT	F	rural	97		H	29.8	29.3	-0.033	-0.081	-0.057
92	M/Cs	NAT	F	rural	99		H	30.3	33.5	-0.026	-0.023	-0.024
92	M/Cs	NAT	F	rural	100		H*	30.3	33.8	-0.026	-0.019	-0.022
92	M/Cs	NAT	F	rural	102		H	30.4	33.3	-0.025	-0.025	-0.025
92	M/Cs	NAT	F	rural	104		H*	31.9	33.3	-0.004	-0.025	-0.014
92	M/Cs	NAT	F	rural	105		H	31.6	33.9	-0.008	-0.018	-0.013
92	M/Cs	NAT	F	rural	106		H*	32.5	33.8	0.004	-0.019	-0.007
92	M/Cs	NAT	F	rural	107		H	29.9	34.7	-0.032	-0.007	-0.020
92	M/Cs	NAT	F	rural	110		H*	30.7	33.1	-0.020	-0.028	-0.024
92	M/Cs	NAT	F	rural	112		H	31.4	34.1	-0.011	-0.015	-0.013
92	M/Cs	NAT	F	rural	113		H	32.5	33.7	0.004	-0.020	-0.008
92	M/Cs	NAT	F	rural	114		H*	25.4	31.8	-0.103	-0.045	-0.074
92	M/Cs	NAT	F	rural	115		H	34.3	37.3	0.028	0.024	0.026
92	M/Cs	NAT	F	rural	116		H	31.6	33.6	-0.008	-0.021	-0.015
92	M/Cs	NAT	F	rural	117		H*	33.3	35.4	0.015	0.001	0.008
92	M/Cs	NAT	F	rural	118		H	30.1	33.7	-0.029	-0.020	-0.025
92	M/Cs	NAT	F	rural	119		H	31.8	33.2	-0.005	-0.027	-0.016
92	M/Cs	NAT	F	rural	120		H	32.4	34.2	0.003	-0.014	-0.005
92	M/Cs	NAT	F	rural	121		H	31.3	33.9	-0.012	-0.018	-0.015
92	M/Cs	NAT	F	rural	122		H	28.7	33.0	-0.050	-0.029	-0.039
92	M/Cs	NAT	F	rural	123		H	28.4	33.7	-0.054	-0.020	-0.037
92	M/Cs	NAT	F	rural	124		H	29.6	32.7	-0.036	-0.033	-0.035
92	M/Cs	NAT	F	rural	125		H*	33.6	36.5	0.019	0.015	0.017
92	M/Cs	NAT	F	rural	128		H*	30.6	32.0	-0.022	-0.043	-0.032
92	M/Cs	NAT	F	rural	129		H*	28.4	30.8	-0.054	-0.059	-0.057
92	M/Cs	NAT	F	rural	130		H*	30.9	32.3	-0.017	-0.039	-0.028
92	M/Cs	NAT	F	rural	133		H	32.3	34.3	0.002	-0.012	-0.005
92	M/Cs	NAT	F	rural	134		H*	33.5	35.8	0.018	0.006	0.012
92	M/Cs	NAT	F	rural	136		H	28.8	33.3	-0.048	-0.025	-0.037
92	M/Cs	NAT	F	rural	138		H*	33.7	34.8	0.020	-0.006	0.007
92	M/Cs	NAT	F	rural	139		H*	30.8	35.6	-0.019	0.004	-0.008
92	M/Cs	NAT	F	rural	142		H	30.3	33.9	-0.026	-0.018	-0.022
92	M/Cs	NAT	F	rural	143		H*	30.6	33.5	-0.022	-0.023	-0.022
92	M/Cs	NAT	F	rural	147		H	32.3	34.2	0.002	-0.014	-0.006
92	M/Cs	NAT	F	rural	148		H*	28.6	30.7	-0.051	-0.061	-0.056
92	M/Cs	NAT	F	rural	149		H	30.2	32.8	-0.027	-0.032	-0.030
92	M/Cs	NAT	F	rural	150		H	30.5	34.0	-0.023	-0.016	-0.020

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
92	M/Cs	NAT	F	rural	151		H	29.8	32.6	-0.033	-0.035	-0.034
92	M/Cs	NAT	F	rural	152		H	31.3	32.5	-0.012	-0.036	-0.024
92	M/Cs	NAT	F	rural	153		H	31.6	33.7	-0.008	-0.020	-0.014
92	M/Cs	NAT	F	rural	155		H	30.8	34.9	-0.019	-0.005	-0.012
92	M/Cs	NAT	F	rural	156		H*	29.3	33.8	-0.041	-0.019	-0.030
92	M/Cs	NAT	F	rural	157		H	30.3	32.4	-0.026	-0.037	-0.032
92	M/Cs	NAT	F	rural	159		H*	33.0	33.4	0.011	-0.024	-0.006
92	M/Cs	NAT	F	rural	160		H	33.9	33.9	0.023	-0.018	0.003
92	M/Cs	NAT	F	rural	162		H	30.1	33.6	-0.029	-0.021	-0.025
92	M/Cs	NAT	F	rural	164		H*	32.6	33.0	0.006	-0.029	-0.012
92	M/Cs	NAT	F	rural	166		H	31.0	35.5	-0.016	0.002	-0.007
92	M/Cs	NAT	F	rural	171		H*	30.9	34.3	-0.017	-0.012	-0.015
92	M/Cs	NAT	F	rural	172		H	32.6	34.4	0.006	-0.011	-0.003
92	M/Cs	NAT	F	rural	174		H	29.4	31.2	-0.039	-0.054	-0.046
92	M/Cs	NAT	F	rural	175		H*	31.8	36.1	-0.005	0.010	0.002
92	M/Cs	NAT	F	rural	176		H	27.9	32.2	-0.062	-0.040	-0.051
92	M/Cs	NAT	F	rural	177		H	30.3	33.0	-0.026	-0.029	-0.028
92	M/Cs	NAT	F	rural	179		H	28.3	33.2	-0.056	-0.027	-0.041
92	M/Cs	NAT	F	rural	180		H*	31.0	32.9	-0.016	-0.031	-0.023
92	M/Cs	NAT	F	rural	181		H	32.8	34.9	0.008	-0.005	0.002
92	M/Cs	NAT	F	rural	182		H*	28.9	32.2	-0.047	-0.040	-0.043
92	M/Cs	NAT	F	rural	183		H	30.2	32.9	-0.027	-0.031	-0.029
92	M/Cs	NAT	F	rural	188		H	30.3	34.5	-0.026	-0.010	-0.018
92	M/Cs	NAT	F	rural	190		H	31.6	32.7	-0.008	-0.033	-0.020
92	M/Cs	NAT	F	rural	193		H	30.7	32.0	-0.020	-0.043	-0.031
92	M/Cs	NAT	F	rural	195		H*	28.4	32.4	-0.054	-0.037	-0.046
92	M/Cs	NAT	F	rural	198		H	31.2	32.2	-0.013	-0.040	-0.027
92	M/Cs	NAT	F	rural	201		H*	30.8	33.3	-0.019	-0.025	-0.022
92	M/Cs	NAT	F	rural	203		H	31.5	33.4	-0.009	-0.024	-0.017
92	M/Cs	NAT	F	rural	204		H*	31.0	34.3	-0.016	-0.012	-0.014
92	M/Cs	NAT	F	rural	207		H*	31.7	33.7	-0.006	-0.020	-0.013
92	M/Cs	NAT	F	rural	211		H	31.5	34.2	-0.009	-0.014	-0.011
92	M/Cs	NAT	F	rural	212		H*	30.8	31.6	-0.019	-0.048	-0.033
92	M/Cs	NAT	F	rural	213		H	32.1	35.9	-0.001	0.007	0.003
92	M/Cs	NAT	F	rural	215		H*	32.1	35.3	-0.001	0.000	0.000
92	M/Cs	NAT	F	rural	216		H	33.2	35.6	0.014	0.004	0.009
92	M/Cs	NAT	F	rural	217		H*	27.4	30.0	-0.070	-0.071	-0.070
92	M/Cs	NAT	F	rural	218		H	29.8	32.4	-0.033	-0.037	-0.035
92	M/Cs	NAT	F	rural	219		H*	32.2	32.3	0.000	-0.039	-0.019
92	M/Cs	NAT	F	rural	221		H	32.1	33.0	-0.001	-0.029	-0.015
92	M/Cs	NAT	F	rural	224		H	30.0	34.5	-0.030	-0.010	-0.020
92	M/Cs	NAT	F	rural	227		H	32.0	34.9	-0.002	-0.005	-0.004
92	M/Cs	NAT	F	rural	228		H*	30.6	33.2	-0.022	-0.027	-0.024
92	M/Cs	NAT	F	rural	229		H*	29.4	33.7	-0.039	-0.020	-0.030
92	M/Cs	NAT	F	rural	230		H	31.7	33.8	-0.006	-0.019	-0.013
92	M/Cs	NAT	F	rural	231		H	32.1	33.6	-0.001	-0.021	-0.011
92	M/Cs	NAT	F	rural	232		H	30.8	34.7	-0.019	-0.007	-0.013
92	M/Cs	NAT	F	rural	234		H	33.7	35.7	0.020	0.005	0.013
92	M/Cs	NAT	F	rural	235		H	30.7	33.9	-0.020	-0.018	-0.019
92	M/Cs	NAT	F	rural	236		H*	27.0	29.2	-0.076	-0.082	-0.079
92	M/Ts	NAT	F	rural	26	skelett1R	H	45.0	37.0	0.007	0.001	0.004
92	M/Ts	NAT	F	rural	27	skelett1L	H	44.7	36.6	0.004	-0.004	0.000
92	M/Ts	NAT	F	rural	28		H	43.6	34.6	-0.007	-0.028	-0.018
92	M/Ts	NAT	F	rural	29		H	46.7	37.0	0.023	0.001	0.012
92	M/Ts	NAT	F	rural	34		H*	41.6	31.9	-0.028	-0.063	-0.045
92	M/Ts	NAT	F	rural	35		H	41.8	34.1	-0.026	-0.034	-0.030

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
92	M/Ts	NAT	F	rural	36		H	43.1	34.3	-0.012	-0.032	-0.022
92	M/Ts	NAT	F	rural	37		H*	46.0	36.7	0.016	-0.002	0.007
92	M/Ts	NAT	F	rural	38		H	39.8	33.9	-0.047	-0.037	-0.042
92	M/Ts	NAT	F	rural	40		H*	45.7	37.6	0.013	0.008	0.011
92	M/Ts	NAT	F	rural	41		H*	41.6	34.0	-0.028	-0.036	-0.032
92	M/Ts	NAT	F	rural	43		H	42.8	34.8	-0.015	-0.025	-0.020
92	M/Ts	NAT	F	rural	45		H*	40.1	33.2	-0.044	-0.046	-0.045
92	M/Ts	NAT	F	rural	46		H*	47.5	36.0	0.030	-0.011	0.010
92	M/Ts	NAT	F	rural	48		H	43.0	35.7	-0.013	-0.014	-0.014
92	M/Ts	NAT	F	rural	49		H	46.9	36.3	0.024	-0.007	0.009
92	M/Ts	NAT	F	rural	51		H	42.7	35.0	-0.016	-0.023	-0.020
92	M/Ts	NAT	F	rural	52		H	42.1	35.9	-0.022	-0.012	-0.017
92	M/Ts	NAT	F	rural	53		H	44.1	35.5	-0.002	-0.017	-0.010
92	M/Ts	NAT	F	rural	54		H*	39.9	32.9	-0.046	-0.050	-0.048
92	M/Ts	NAT	F	rural	55		H	41.1	33.2	-0.033	-0.046	-0.039
92	M/Ts	NAT	F	rural	56		H*	39.9		-0.046		-0.046
92	M/Ts	NAT	F	rural	57		H*	41.6	33.0	-0.028	-0.049	-0.038
92	M/Ts	NAT	F	rural	58		H	44.4	35.5	0.001	-0.017	-0.008
92	M/Ts	NAT	F	rural	59		H	47.0	36.7	0.025	-0.002	0.012
92	M/Ts	NAT	F	rural	61		H*	43.6	34.9	-0.007	-0.024	-0.016
92	M/Ts	NAT	F	rural	64		H	43.4	34.9	-0.009	-0.024	-0.017
92	M/Ts	NAT	F	rural	65		H	45.2	34.9	0.008	-0.024	-0.008
92	M/Ts	NAT	F	rural	68		H	42.6	34.2	-0.017	-0.033	-0.025
92	M/Ts	NAT	F	rural	69		H	36.5	31.0	-0.084	-0.076	-0.080
92	M/Ts	NAT	F	rural	70		H	42.3	33.6	-0.020	-0.041	-0.031
92	M/Ts	NAT	F	rural	71		H	48.0	37.9	0.035	0.012	0.023
92	M/Ts	NAT	F	rural	72		H*	43.1	35.0	-0.012	-0.023	-0.018
92	M/Ts	NAT	F	rural	73		H	47.5	36.4	0.030	-0.006	0.012
92	M/Ts	NAT	F	rural	74		H	45.0	34.0	0.007	-0.036	-0.015
92	M/Ts	NAT	F	rural	75		H	43.1	34.5	-0.012	-0.029	-0.021
92	M/Ts	NAT	F	rural	77		H	41.0	33.0	-0.034	-0.049	-0.041
92	M/Ts	NAT	F	rural	80		H	40.3	33.4	-0.041	-0.043	-0.042
92	M/Ts	NAT	F	rural	83		H	46.3	36.7	0.019	-0.002	0.008
92	M/Ts	NAT	F	rural	84		H	43.2	34.5	-0.011	-0.029	-0.020
92	M/Ts	NAT	F	rural	85		H	43.8	32.5	-0.005	-0.055	-0.030
92	M/Ts	NAT	F	rural	86		H	43.9	35.8	-0.004	-0.013	-0.009
92	M/Ts	NAT	F	rural	88		H	42.1	34.7	-0.022	-0.027	-0.025
92	M/Ts	NAT	F	rural	89		H	47.5	37.4	0.030	0.006	0.018
92	M/Ts	NAT	F	rural	90		H	43.0	35.1	-0.013	-0.022	-0.017
92	M/Ts	NAT	F	rural	91		H	47.6	35.8	0.031	-0.013	0.009
92	M/Ts	NAT	F	rural	92		H	41.1	34.8	-0.033	-0.025	-0.029
92	M/Ts	NAT	F	rural	95		H	43.8	33.3	-0.005	-0.045	-0.025
92	M/Ts	NAT	F	rural	96		H*	47.9	38.1	0.034	0.014	0.024
92	M/Ts	NAT	F	rural	99		H*	42.8	32.8	-0.015	-0.051	-0.033
92	M/Ts	NAT	F	rural	101		H	42.1	35.3	-0.022	-0.019	-0.021
92	M/Ts	NAT	F	rural	104		H	40.5	33.7	-0.039	-0.039	-0.039
92	M/Ts	NAT	F	rural	105		H	44.5	36.2	0.002	-0.008	-0.003
92	M/Ts	NAT	F	rural	107		H	42.3	33.3	-0.020	-0.045	-0.032
92	M/Ts	NAT	F	rural	109		H	43.7	35.6	-0.006	-0.016	-0.011
92	M/Ts	NAT	F	rural	110		H	40.1	33.0	-0.044	-0.049	-0.046
92	M/Ts	NAT	F	rural	113		H	42.9	34.6	-0.014	-0.028	-0.021
92	M/Ts	NAT	F	rural	114		H*	45.4	34.2	0.010	-0.033	-0.011
92	M/Ts	NAT	F	rural	115		H	45.0	37.4	0.007	0.006	0.006
92	M/Ts	NAT	F	rural	117		H	44.2	34.3	-0.001	-0.032	-0.017
92	M/Ts	NAT	F	rural	118		H*	40.5		-0.039		-0.039
92	M/Ts	NAT	F	rural	119		H	45.1	35.2	0.007	-0.020	-0.007

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
92	M/Ts	NAT	F	rural	121		H	42.3	33.4	-0.020	-0.043	-0.032
92	M/Ts	NAT	F	rural	123		H*	38.7	31.9	-0.059	-0.063	-0.061
92	M/Ts	NAT	F	rural	124		H	41.9	33.1	-0.024	-0.047	-0.036
92	M/Ts	NAT	F	rural	125		H	44.2	35.1	-0.001	-0.022	-0.011
92	M/Ts	NAT	F	rural	126		H*	42.1	34.1	-0.022	-0.034	-0.028
92	M/Ts	NAT	F	rural	127		H	38.9		-0.057		-0.057
92	M/Ts	NAT	F	rural	129		H	41.7	35.3	-0.027	-0.019	-0.023
92	M/Ts	NAT	F	rural	131		H*	41.1	32.7	-0.033	-0.052	-0.043
92	M/Ts	NAT	F	rural	134		H	44.4	35.5	0.001	-0.017	-0.008
92	M/Ts	NAT	F	rural	136		H*	44.5	37.7	0.002	0.009	0.005
92	M/Ts	NAT	F	rural	137		H*	46.5	37.5	0.021	0.007	0.014
92	M/Ts	NAT	F	rural	138		H*	41.1	32.8	-0.033	-0.051	-0.042
92	M/Ts	NAT	F	rural	140		H*	42.9	36.1	-0.014	-0.010	-0.012
92	M/Ts	NAT	F	rural	141		H*	41.4		-0.030		-0.030
92	M/Ts	NAT	F	rural	145		H*	41.6	35.7	-0.028	-0.014	-0.021
92	M/Ts	NAT	F	rural	147		H*	43.2	36.9	-0.011	0.000	-0.006
92	Tib	NAT	F	rural	28	skelett2R	H		40.7		-0.046	-0.046
92	Tib	NAT	F	rural	29	skelett2L	H		39.6		-0.058	-0.058
92	Tib	NAT	F	rural	30	skelett1R	H		42.5		-0.027	-0.027
92	Tib	NAT	F	rural	31	skelett1L	H		42.6		-0.026	-0.026
96	Fem	RO	F	cem	3	1575/5	H*	57.3		-0.002		-0.002
96	Fem	RO	F	cem	4	1620	H*	57.3		-0.002		-0.002
96	M/Cs	RO	F	cem	4	1575/5	H*	34.6	37.7	0.032	0.029	0.030
96	M/Cs	RO	F	cem	5	1620	H*	34.6	37.8	0.032	0.030	0.031
96	M/Ts	RO	F	cem	4	1575/5	H*	40.7	38.8	-0.037	0.022	-0.008
96	M/Ts	RO	F	cem	5	1620	H*	42.3	40.3	-0.020	0.038	0.009
96	Tib	RO	F	cem	5	1575/5	H*		45.8		0.005	0.005
96	Tib	RO	F	cem	6	1620	H*		48.0		0.026	0.026
104	M/Cs	RO	E	villa	639		H*	33.0	39.0	0.011	0.043	0.027
104	M/Ts	RO	E	villa	504		H	39.0	32.0	-0.056	-0.062	-0.059
104	M/Ts	RO	E	villa	506		H*	37.0	34.0	-0.078	-0.036	-0.057
105	M/Ts	RO	K	ind	509		H*	40.6		-0.038		-0.038
105	M/Ts	RO	K	ind	516	549	H	35.9		-0.092		-0.092
110	M/Cs	RO	F	urb	741	179/16-24	H*	27.6	32.3	-0.067	-0.039	-0.053
110	M/Cs	RO	F	urb	742	179/16-27	H*	31.6	36.9	-0.008	0.019	0.006
110	M/Ts	RO	F	urb	589	179/16-22	H*	36.1	34.3	-0.089	-0.032	-0.060
110	M/Ts	RO	F	urb	590	179/16-25	H*	39.9	37.5	-0.046	0.007	-0.019
113	M/Cs	RO	E	urb	751		H*	24.9	30.9	-0.111	-0.058	-0.085
114	Fem	RO	G	urb	252	23B	H	54.8		-0.022		-0.022
114	Fem	RO	G	urb	254	80L	H	52.0		-0.045		-0.045
114	Hum	RO	G	urb	333	25	H	35.5		-0.007		-0.007
114	Hum	RO	G	urb	334	30	H	35.2		-0.011		-0.011
114	M/Cs	RO	G	urb	753	23	H	30.1	34.2	-0.029	-0.014	-0.021
114	M/Cs	RO	G	urb	754	25	H	32.3	33.6	0.002	-0.021	-0.010
114	M/Cs	RO	G	urb	755	30	H	32.2	33.5	0.000	-0.023	-0.011
114	M/Cs	RO	G	urb	756	32	H	30.4	32.6	-0.025	-0.035	-0.030
114	M/Ts	RO	G	urb	599	23A	H	39.9	34.0	-0.046	-0.036	-0.041
114	M/Ts	RO	G	urb	600	35	H*	41.1	34.5	-0.033	-0.029	-0.031
114	M/Ts	RO	G	urb	601	40	H*	39.2	36.8	-0.053	-0.001	-0.027
114	M/Ts	RO	G	urb	604	73	H	41.5	34.3	-0.029	-0.032	-0.030
114	Rad	RO	G	urb	494	25	H		36.5		0.004	0.004
114	Rad	RO	G	urb	495	30	H		35.2		-0.011	-0.011
114	Tib	RO	G	urb	491	23A	H		38.8		-0.067	-0.067
114	Tib	RO	G	urb	492	35	H*		41.8		-0.034	-0.034
114	Tib	RO	G	urb	494	71	H		43.6		-0.016	-0.016
115	M/Cs	RO	F	urb2	761		H*	31.9	37.0	-0.004	0.020	0.008

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
115	M/Cs	RO	F	urb2	762		H*	30.1	35.0	-0.029	-0.004	-0.016
115	M/Cs	RO	F	urb2	763		H	28.8	35.4	-0.048	0.001	-0.023
115	M/Cs	RO	F	urb2	764		H	30.7	34.6	-0.020	-0.009	-0.015
115	M/Cs	RO	F	urb2	765		H*	28.4	34.8	-0.054	-0.006	-0.030
115	M/Ts	RO	F	urb2	605		H	46.6	37.0	0.022	0.001	0.011
115	M/Ts	RO	F	urb2	606		H	44.0	36.7	-0.003	-0.002	-0.003
116	M/Cs	RO	D	urb2	781	248-1	H	30.0	33.0	-0.030	-0.029	-0.030
116	M/Cs	RO	D	urb2	782	238	H*	33.0	36.0	0.011	0.009	0.010
116	M/Cs	RO	D	urb2	787	17-1	H*	33.0	36.0	0.011	0.009	0.010
116	M/Cs	RO	D	urb2	788	328	H*	35.0	36.0	0.037	0.009	0.023
116	M/Ts	RO	D	urb2	617	348-1	H	40.0	33.0	-0.045	-0.049	-0.047
116	M/Ts	RO	D	urb2	618	224-1	H	43.0	33.0	-0.013	-0.049	-0.031
116	M/Ts	RO	D	urb2	619	348-2	H	41.0	35.0	-0.034	-0.023	-0.028
116	M/Ts	RO	D	urb2	620	17-1	H	40.0	34.0	-0.045	-0.036	-0.040
116	M/Ts	RO	D	urb2	621	63	H	40.0	35.0	-0.045	-0.023	-0.034
116	M/Ts	RO	D	urb2	622	251	H*	41.0	35.0	-0.034	-0.023	-0.028
116	M/Ts	RO	D	urb2	624	306	H*	46.0	37.0	0.016	0.001	0.009
116	M/Ts	RO	D	urb2	626	222	H*	50.0	38.0	0.052	0.013	0.033
116	M/Ts	RO	D	urb2	627	238	H*	49.0	32.0	0.043	-0.062	-0.009
116	M/Ts	RO	D	urb2	628	248-1	H*	49.0	40.0	0.043	0.035	0.039
116	M/Ts	RO	D	urb2	631	248-2	H*	51.0	38.0	0.061	0.013	0.037
116	Tib	RO	D	urb2	513	348	H		42.0		-0.032	-0.032
116	Tib	RO	D	urb2	515	238	H*		42.0		-0.032	-0.032
118	Fem	RO	G	mil	277	Pferd 2	H	58.3		0.005		0.005
118	Fem	RO	G	mil	278	Pferd 3	H	57.8		0.001		0.001
118	Fem	RO	G	mil	280		H	56.1		-0.012		-0.012
118	M/Cs	RO	G	mil	797	Pferd 2	H	36.0	37.1	0.049	0.022	0.035
118	M/Cs	RO	G	mil	798	Pferd 3	H	35.8	36.5	0.046	0.015	0.030
118	M/Ts	RO	G	mil	637	Pferd 2	H	42.8	38.2	-0.015	0.015	0.000
118	M/Ts	RO	G	mil	638	Pferd 3	H	43.4	38.2	-0.009	0.015	0.003
118	Tib	RO	G	mil	531	Pferd 2	H		51.6		0.057	0.057
118	Tib	RO	G	mil	532	Pferd 3	H		48.2		0.028	0.028
119	M/Cs	RO	G	mil	804	Horse 1	H*	41.2	37.0	0.107	0.020	0.064
119	M/Ts	RO	G	mil	641	Horse 1	H*	41.8	38.1	-0.026	0.014	-0.006
119	Tib	RO	G	mil	535	Horse 1	H*		50.0		0.044	0.044
120	M/Cs	IA	F	rural	806		H*	29.0	33.8	-0.045	-0.019	-0.032
120	M/Cs	IA	F	rural	807		H*	25.7	30.1	-0.098	-0.069	-0.083
120	M/Cs	IA	F	rural	808		H	30.9	32.0	-0.017	-0.043	-0.030
120	M/Cs	IA	F	rural	809		H	30.3	32.2	-0.026	-0.040	-0.033
120	M/Cs	IA	F	rural	810		H*	30.6	32.9	-0.022	-0.031	-0.026
120	M/Cs	IA	F	rural	813		H	28.7	32.6	-0.050	-0.035	-0.042
120	Tib	IA	F	rural	537		H		39.5		-0.059	-0.059
120	Tib	IA	F	rural	538		H		40.0		-0.053	-0.053
121	M/Cs	RO	F	urb2	817		H	31.5	34.5	-0.009	-0.010	-0.010
123	M/Cs	RO	E	urb	822		H	32.6	35.8	0.006	0.006	0.006
123	M/Ts	RO	E	urb	659		H	49.3	37.2	0.046	0.004	0.025
123	M/Ts	RO	E	urb	660		H	43.3	33.1	-0.010	-0.047	-0.029
125	M/Cs	RO	E	mil	830		H	29.8	32.6	-0.033	-0.035	-0.034
125	M/Cs	RO	E	mil	838		H	31.8	34.4	-0.005	-0.011	-0.008
125	M/Ts	RO	E	mil	673		H*	51.0		0.061		0.061
125	M/Ts	RO	E	mil	674		H	39.2	33.6	-0.053	-0.041	-0.047
131	M/Cs	IA	G	rural	863		H*	30.0	38.0	-0.030	0.032	0.001
134	M/Cs	RO	F	urb2	885		H	34.0	32.0	0.024	-0.043	-0.009
134	M/Ts	RO	F	urb2	732		H*	48.0	38.0	0.035	0.013	0.024
135	Fem	IA	G	cem	314	1	H	49.5		-0.066		-0.066
135	Fem	IA	G	cem	315	2	H	50.5		-0.057		-0.057

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
135	Fem	IA	G	cem	316	3	H	51.5		-0.049		-0.049
135	Fem	IA	G	cem	317	4	H*	55.0		-0.020		-0.020
135	M/Cs	IA	G	cem	891	1	H	29.0	32.5	-0.045	-0.036	-0.040
135	M/Cs	IA	G	cem	892	2	H	30.0	32.0	-0.030	-0.043	-0.036
135	M/Cs	IA	G	cem	893	3	H	31.0	32.5	-0.016	-0.036	-0.026
135	M/Cs	IA	G	cem	894	4	H*	35.0	37.5	0.037	0.026	0.031
135	M/Ts	IA	G	cem	736	1	H	37.5	34.0	-0.073	-0.036	-0.054
135	M/Ts	IA	G	cem	737	2	H	39.0	33.0	-0.056	-0.049	-0.052
135	M/Ts	IA	G	cem	738	3	H	38.0	34.5	-0.067	-0.029	-0.048
135	M/Ts	IA	G	cem	739	4	H*	42.0	40.0	-0.023	0.035	0.006
135	Tib	IA	G	cem	598	1	H		41.5		-0.037	-0.037
135	Tib	IA	G	cem	599	2	H		40.0		-0.053	-0.053
135	Tib	IA	G	cem	600	3	H		41.0		-0.043	-0.043
135	Tib	IA	G	cem	601	4	H*		47.0		0.017	0.017
141	M/Cs	IA	G	cem	901	6	H*	33.5		0.018		0.018
141	M/Ts	IA	G	cem	746	6	H*	45.5	34.5	0.011	-0.029	-0.009
141	Tib	IA	G	cem	610	6	H*		41.5		-0.037	-0.037
143	M/Cs	IA	G	urb2	902	P1	H*	34.0	36.0	0.024	0.009	0.016
143	M/Cs	IA	G	urb2	906	P12	H*	33.0	37.0	0.011	0.020	0.016
143	M/Ts	IA	G	urb2	747	P18	H*	49.0	37.0	0.043	0.001	0.022
146	M/Cs	RO	G	rural	925	574c	H*	31.0	35.0	-0.016	-0.004	-0.010
146	M/Ts	RO	G	rural	752	620c	H*	45.0	36.0	0.007	-0.011	-0.002
147	M/Ts	RO	G	mil	753		H	39.0	34.0	-0.056	-0.036	-0.046
147	M/Ts	RO	G	mil	754		H	39.5	34.0	-0.050	-0.036	-0.043
147	M/Ts	RO	G	mil	755		H*	44.5	37.5	0.002	0.007	0.004
149	M/Cs	IA	G	rural	929		H*	32.0	32.0	-0.002	-0.043	-0.022
149	M/Ts	IA	G	rural	756		H*	41.0	34.0	-0.034	-0.036	-0.035
149	M/Ts	IA	G	rural	757		H	43.5	37.5	-0.008	0.007	-0.001
149	M/Ts	IA	G	rural	758		H*	43.5	37.5	-0.008	0.007	-0.001
150	M/Cs	RO	G	mil	930		H*	32.5	37.5	0.004	0.026	0.015
151	M/Ts	RO	G	rural	759		H*	48.0	36.0	0.035	-0.011	0.012
153	M/Cs	RO	A	urb	931		H	34.4	33.7	0.029	-0.020	0.004
153	M/Cs	RO	A	urb	932		H*	33.3	37.9	0.015	0.031	0.023
174	M/Cs	RO	F	mil	972		H*	32.0	36.0	-0.002	0.009	0.003
174	M/Cs	RO	F	mil	977		H*	35.0	37.5	0.037	0.026	0.031
176	M/Cs	NAT	F	cem	992		H*	31.0	35.0	-0.016	-0.004	-0.010
176	M/Cs	NAT	F	cem	993		H*	31.0	35.0	-0.016	-0.004	-0.010
176	M/Cs	NAT	F	cem	995		H	30.0	34.0	-0.030	-0.016	-0.023
176	M/Cs	NAT	F	cem	997		H	31.0	33.0	-0.016	-0.029	-0.023
176	M/Cs	NAT	F	cem	999		H*	32.0	36.0	-0.002	0.009	0.003
176	M/Cs	NAT	F	cem	1001		H	31.0	34.0	-0.016	-0.016	-0.016
176	M/Cs	NAT	F	cem	1002		H*	29.0	33.0	-0.045	-0.029	-0.037
176	M/Cs	NAT	F	cem	1004		H	27.0	32.0	-0.076	-0.043	-0.059
176	M/Cs	NAT	F	cem	1005		H	28.0	31.0	-0.060	-0.056	-0.058
176	M/Cs	NAT	F	cem	1006		H*	28.0	29.0	-0.060	-0.085	-0.073
176	M/Cs	NAT	F	cem	1008		H*	29.0	29.0	-0.045	-0.085	-0.065
176	M/Ts	NAT	F	cem	806		H	41.0	35.0	-0.034	-0.023	-0.028
176	M/Ts	NAT	F	cem	807		H*	40.0	36.0	-0.045	-0.011	-0.028
176	M/Ts	NAT	F	cem	811		H*	44.0	37.0	-0.003	0.001	-0.001
176	M/Ts	NAT	F	cem	812		H*	40.0	33.0	-0.045	-0.049	-0.047
176	M/Ts	NAT	F	cem	814		H*	44.0	37.0	-0.003	0.001	-0.001
176	M/Ts	NAT	F	cem	815		H	44.0	34.0	-0.003	-0.036	-0.019
176	M/Ts	NAT	F	cem	816		H	38.0	32.0	-0.067	-0.062	-0.064
176	M/Ts	NAT	F	cem	817		H*	40.0	36.0	-0.045	-0.011	-0.028
178	M/Cs	RO	F	urb2	1015		H	33.3	35.2	0.015	-0.001	0.007
188	M/Ts	RO	D	rural	849		H*	42.0	38.0	-0.023	0.013	-0.005

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
188	Rad	RO	D	rural	695		H		36.0		-0.002	-0.002
202	M/Cs	NAT	F	rural	1129		H	27.6	31.3	-0.067	-0.052	-0.059
202	M/Cs	NAT	F	rural	1132		H	27.0	31.5	-0.076	-0.049	-0.063
202	M/Cs	NAT	F	rural	1136		H	28.7	30.9	-0.050	-0.058	-0.054
202	M/Cs	NAT	F	rural	1137		H*	31.4	34.3	-0.011	-0.012	-0.012
202	M/Ts	NAT	F	rural	949		H	38.6	34.5	-0.060	-0.029	-0.045
202	M/Ts	NAT	F	rural	952		H	39.1	34.2	-0.055	-0.033	-0.044
202	M/Ts	NAT	F	rural	954		H*	42.0	36.9	-0.023	0.000	-0.012
202	M/Ts	NAT	F	rural	955		H	36.8	33.9	-0.081	-0.037	-0.059
202	M/Ts	NAT	F	rural	956		H	37.6	34.4	-0.072	-0.030	-0.051
203	M/Cs	RO	G	urb	1138		H*	34.0	34.5	0.024	-0.010	0.007
203	M/Cs	RO	G	urb	1140		H*	31.5	32.5	-0.009	-0.036	-0.023
203	M/Cs	RO	G	urb	1141		H	35.5	34.5	0.043	-0.010	0.016
203	M/Cs	RO	G	urb	1145		H*	34.0	35.0	0.024	-0.004	0.010
203	M/Cs	RO	G	urb	1148		H	32.0	35.5	-0.002	0.002	0.000
203	M/Cs	RO	G	urb	1149		H	36.0	36.5	0.049	0.015	0.032
203	M/Cs	RO	G	urb	1150		H	35.5	37.0	0.043	0.020	0.032
203	M/Cs	RO	G	urb	1151		H	35.0	37.0	0.037	0.020	0.029
203	M/Cs	RO	G	urb	1152		H*	33.5	36.0	0.018	0.009	0.013
203	M/Cs	RO	G	urb	1153		H*	37.0	38.5	0.061	0.038	0.049
203	M/Cs	RO	G	urb	1156		H	35.0	36.0	0.037	0.009	0.023
203	M/Cs	RO	G	urb	1157		H*	35.5	38.0	0.043	0.032	0.037
203	M/Cs	RO	G	urb	1161		H	34.5	36.0	0.030	0.009	0.019
203	M/Cs	RO	G	urb	1168		H*	35.0	37.0	0.037	0.020	0.029
203	M/Cs	RO	G	urb	1169		H	34.5	38.0	0.030	0.032	0.031
203	M/Cs	RO	G	urb	1172		H*	38.0	39.5	0.072	0.049	0.061
203	M/Cs	RO	G	urb	1173		H*	36.0	37.0	0.049	0.020	0.035
203	M/Cs	RO	G	urb	1175		H*	37.0	37.0	0.061	0.020	0.041
203	M/Cs	RO	G	urb	1179		H*	35.0	40.0	0.037	0.054	0.045
203	M/Cs	RO	G	urb	1181		H	34.0	37.0	0.024	0.020	0.022
203	M/Cs	RO	G	urb	1185		H	36.5	39.0	0.055	0.043	0.049
203	M/Cs	RO	G	urb	1187		H	34.5	36.0	0.030	0.009	0.019
203	M/Cs	RO	G	urb	1189		H*	39.0	41.0	0.084	0.065	0.074
203	M/Cs	RO	G	urb	1191		H*	38.0	39.0	0.072	0.043	0.058
203	M/Ts	RO	G	urb	961		H*	46.5		0.021		0.021
203	M/Ts	RO	G	urb	962		H*	45.0	38.0	0.007	0.013	0.010
203	M/Ts	RO	G	urb	963		H	46.5	38.0	0.021	0.013	0.017
203	M/Ts	RO	G	urb	965		H	45.5	37.5	0.011	0.007	0.009
203	M/Ts	RO	G	urb	966		H*	48.5	38.0	0.039	0.013	0.026
203	M/Ts	RO	G	urb	968		H	45.0		0.007		0.007
203	M/Ts	RO	G	urb	969		H*	45.5	36.5	0.011	-0.005	0.003
203	M/Ts	RO	G	urb	974		H*	45.0	38.5	0.007	0.018	0.012
203	M/Ts	RO	G	urb	976		H*	44.5	36.5	0.002	-0.005	-0.002
203	M/Ts	RO	G	urb	978		H*	46.0	36.5	0.016	-0.005	0.006
203	M/Ts	RO	G	urb	979		H	47.0	36.5	0.025	-0.005	0.010
203	M/Ts	RO	G	urb	985		H*	47.5	39.5	0.030	0.030	0.030
204	M/Cs	RO	D	rural	1236		H*	30.3	35.5	-0.026	0.002	-0.012
204	M/Cs	RO	D	rural	1237		H*	30.4	35.6	-0.025	0.004	-0.010
207	M/Cs	RO	F	mil	1251		H	34.0	37.2	0.024	0.023	0.023
208	Fem	RO	F	urb	382		H*	68.0		0.072		0.072
208	M/Cs	RO	F	urb	1256		H*	35.0	37.0	0.037	0.020	0.029
208	M/Cs	RO	F	urb	1258		H*	36.5	37.0	0.055	0.020	0.038
208	M/Cs	RO	F	urb	1259		H	34.0	35.0	0.024	-0.004	0.010
208	M/Cs	RO	F	urb	1260		H*	32.0	37.0	-0.002	0.020	0.009
208	M/Cs	RO	F	urb	1262		H*	34.0	36.0	0.024	0.009	0.016
208	M/Cs	RO	F	urb	1264		H	32.0	33.0	-0.002	-0.029	-0.016

Site no	Element	Period	Area	Site type	Bone no	Specimen	ID	Dc or HTC or Dp	Dd	Log1	Log2	Mean Log
212	M/Cs	IA	D	cem	1275		H	29.0	33.5	-0.045	-0.023	-0.034
212	M/Cs	IA	D	cem	1276		H	28.0	31.5	-0.060	-0.049	-0.055
212	M/Ts	IA	D	cem	1093		H*	36.0	33.5	-0.090	-0.042	-0.066
213	M/Cs	IA	D	rural	1277		H	27.5	32.0	-0.068	-0.043	-0.055
213	M/Cs	IA	D	rural	1278		H*	31.5	36.5	-0.009	0.015	0.003
213	M/Cs	IA	D	rural	1281		H	26.5	33.0	-0.084	-0.029	-0.057
213	M/Cs	IA	D	rural	1282		H	27.5	32.5	-0.068	-0.036	-0.052
213	M/Cs	IA	D	rural	1283		H*	25.0	29.0	-0.110	-0.085	-0.097
213	M/Ts	IA	D	rural	1096		H	35.0	31.5	-0.103	-0.069	-0.086
213	M/Ts	IA	D	rural	1097		H*	35.5	35.0	-0.096	-0.023	-0.060
213	M/Ts	IA	D	rural	1099		H	37.0	35.5	-0.078	-0.017	-0.048
213	M/Ts	IA	D	rural	1101		H	31.0	31.0	-0.155	-0.076	-0.116
214	M/Cs	IA	D	rural	1284		H	32.0	37.0	-0.002	0.020	0.009
214	M/Ts	IA	D	rural	1104		H	39.0	36.0	-0.056	-0.011	-0.033
215	M/Cs	IA	D	oth	1286		H*	27.0	33.5	-0.076	-0.023	-0.049
215	M/Ts	IA	D	oth	1105		H	35.5	32.5	-0.096	-0.055	-0.076
215	M/Ts	IA	D	oth	1106		H	36.5	34.5	-0.084	-0.029	-0.057
215	M/Ts	IA	D	oth	1107		H*	38.0	34.0	-0.067	-0.036	-0.051
216	M/Cs	IA	D	rural	1287		H	26.0	31.0	-0.092	-0.056	-0.074
216	M/Cs	IA	D	rural	1288		H*	25.5	32.0	-0.101	-0.043	-0.072
216	M/Cs	IA	D	rural	1289		H*	24.5	28.5	-0.118	-0.093	-0.106
216	M/Cs	IA	D	rural	1290		H	25.0	30.0	-0.110	-0.071	-0.090
216	M/Cs	IA	D	rural	1291		H*	26.5	30.5	-0.084	-0.063	-0.074
216	M/Cs	IA	D	rural	1292		H*	31.0	37.0	-0.016	0.020	0.002
216	M/Ts	IA	D	rural	1108		H	36.5	34.0	-0.084	-0.036	-0.060
216	M/Ts	IA	D	rural	1109		H*	36.5	32.0	-0.084	-0.062	-0.073
216	M/Ts	IA	D	rural	1110		H	35.5	34.0	-0.096	-0.036	-0.066
216	M/Ts	IA	D	rural	1111		H*	37.0	34.5	-0.078	-0.029	-0.054
217	M/Cs	IA	D	cem	1293		H*	22.5	28.0	-0.155	-0.101	-0.128