The Application of Dental Anthropology to Population Dynamics, Economy and Health in the Prehispanic Canary Islands

By

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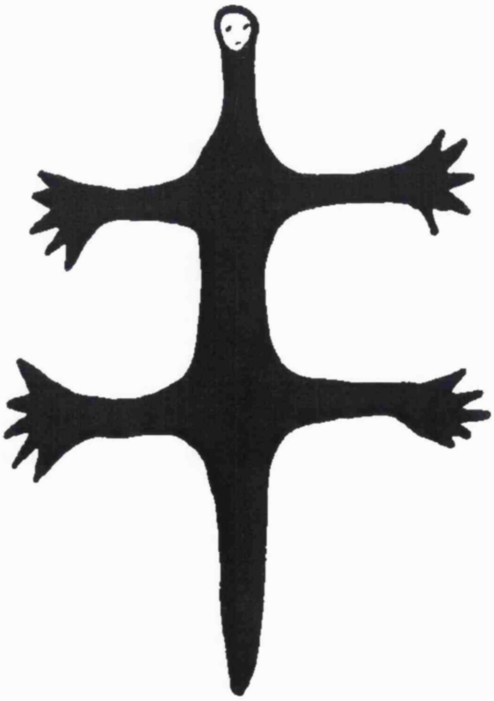
Abstract

This is a dental anthropology study of prehispanic (pre. 1400 AD) societies in the Canary Islands, comprising the analysis of morphology (ASUDAS dental scoring system) and pathology (dental caries and hypoplasia; cranial trauma) to examine population biology, diet, behaviour and health. The study was configured temporo-spatially, employed demographic variables, and was contextualised using archaeological, ecological and historical data. An MNI of 896 individuals was examined. Biologically, the Canarians appear to have been temporo-spatially homogenous; except for minor fluctuations probably caused by influxes from the mainland, the island populations were probably always socially interlinked and were not therefore a series of isolates as previously believed. The marked cultural diversity in the archipelago is therefore more likely to be the result of promulgating socio-political autonomy (at certain points at least) rather than involuntary socio-cultural isolation. Dental pathology suggested a diet intermediate between agriculture and foraging, with a relatively low caries rate that was probably linked to the consumption of dairy produce. There were minor differences between the sexes (the exact significance of this is unclear) and little evidence for temporal trends. While there was considerable variability in economic signatures, probably partially dictated by ecology and environment, there appears to have been considerable leeway in the manner that Native Canarians configured their lives. Populations were generally healthy, with the highest prevalence of hypoplasia being found in densely-populated islands that may have been vulnerable to economic stress linked to the islands' erratic climatic regime. All islands show a hypoplasia peak in late childhood and early adolescence, possibly reflecting social maturation/independence. Health did not differ conspicuously between the sexes, and there was no significant temporal trend in hypoplasia prevalence. Cranial trauma was very common and spatially variable in the Canarian archipelago, with higher overall prevalence in densely populated islands. Males possessed higher prevalence of trauma than females; there was no temporal trend. Judging from the appearance and distribution of the lesions, much of the trauma seems to have been caused by inter-personal conflict. This study provides an array of information concerning Native Canarian lifestyle and behaviour, and has implications for the development of Canarian archaeology, general island archaeology and also the study of how ecology and sociality can determine pattern and process in human adaptation.

To Charles and Judith Owens, for never giving up on me

> "The inhabitants are tall, and look upon themselves as noble, having none of the lower orders amongst them. They have barley, beans and grain of every sort. Everything grows there. They are great fishermen, and net (or hunt) very well. They go quite naked, save for a girdle of palm-leaves. Most of them print devices on their bodies, according to their various tastes, and wear their hair tied behind in the fashion of tresses. They are a handsome and well-formed people. Their women are very beautiful. They wear skins round the middle of the body. The people are well off for animals, such as hogs, goats, and sheep; there is also a kind of wild dog like a wolf, but small..."

(Boutier and Le Verrier 1405 [1872]: 130-131)



"Crawford's Lizard", Gran Canaria
From Martin de Guzman (1984)

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This thesis could not have been written without the assistance of individuals beyond number who have given of their time, energy and expertise to help me with the research and writing of the project. While I have tried to recognise all those who assisted me, I am sure that some worthies have slipped through the net, and to them I can but offer my sincerest apologies. Needless to say, while I have incorporated many ideas, data and background research into the opus, all mistakes contained therein are my own doing.

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1 Introduction

This is a dental anthropological study of ancient Canary Island populations in the period between the archipelago's colonisation and its invasion by European forces in the 14th-15th centuries AD. The archipelago's archaeological and historical significance, the aims of the project, the questions to be asked, and the appropriateness of dental anthropology for addressing the issues are all addressed here. A summary of the current works' chapter structure is also presented.

1.1 Background to the Canary Islands

The documentary history of early Canary Islands strikes many familiar notes in the annals of European colonial expansion. As in numerous other island groups occupied by European forces between the 14th and 18th centuries AD, the invaders found a series of societies seemingly well adapted to their various environments. Spanish and French invaders proceeded to plunder the islands of their resources, leading to the deterioration of Canarian society and the enslaving of its population, turning the archipelago into an outpost of the Spanish empire. As a result, relatively little is known of island life in the pre-European period. By being the first island group to be conquered by European forces, the Canaries assume additional importance for island archaeology and social/colonial studies by being something of a template for later European colonialism in the Pacific, the Americas and elsewhere (Crosby 1986: 78).

1.2 Approaches: History, Archaeology and Biological Anthropology

There has traditionally been a strong emphasis on historical sources in analyses of prehispanic Canarian populations. However, while these texts – written from the early 15th to mid 19th centuries AD – certainly have their uses, they have assumed an inappropriately dominant role in the analysis of ancient Canarian society. Given the large span of time between the archipelago's first definite and lasting occupation in the mid 1st millennium BC and the arrival of reliable chroniclers – at least 2000 years – it would seem that archaeology and physical anthropology may be of more utility in understanding the nature of prehispanic Canarian society. The Canaries have never lacked for enigmatic archaeological remains, and the significance of these artefacts – such as small step pyramids, superficially Egyptian-style mummification, highly variable ceramic traditions and spectacular rock art – have been argued over extensively since the 19th century (Mercer 1980; Martin de Guzman *et al.* 1994; Bethencourt *et al.* 1996; Steiner 1997). However, most approaches to the archaeological record have favoured an art-historical approach, while looting by amateur historians and early archaeologists has further detracted from investigations into the social dynamics of prehispanic Canarian life. Equally, while numerous physical anthropological studies have been carried out on the remains of Native Canarians, these have seldom strayed beyond typology or single specimen/island analyses (Falkenburger 1940; Schwidetzky 1963; Sanchez 1976, 1978, 1979; Sanchez *et al.* 1980; Sanchez and Brobeil 1991). Even in the most recent and sophisticated studies, individual islands are either examined as units (i.e. lumping all specimens from an entire island without reference to age or site of origin), or the entire archipelago is viewed as an insular appendix to Northwest Africa (Guatelli Steinberg *et al.* 2001). In both cases, little effort has been made to structure investigations with respect to temporo-spatial and demographic considerations, so little is really known about the social aspects of the extinct populations.

1.3 Methods and Approaches

This project employs spatial and chronological information in a pan-archipelagic bioarchaeological study of Canarian human settlement. While this is not the first time that dental anthropology has been used in the study of prehispanic Canarians, the project is unusual in combining population biology with life history indicators. The population biology indicators (dental morphology, supplemented by selected cranial non-metric traits) provide genetic information about group structure, while lifestyle variables (caries, enamel hypoplasia and cranial trauma) permit observations about economic practices, health and social life – such as dietary differences between males and females. Cultural priorities were pursued by focusing on the behavioural as well as the biological importance of physical characteristics, by considering socially important factors such as age and sex, and by using archaeologically-derived radiometric dates and spatial awareness in order to lend the study a temporo-spatial dimension. Environmental factors such as relief, topography, climate and ecology were all taken into account, both to set the scene and also to examine patterns of settlement in the archipelago. These parameters were also addressed in the context of a biogeographical analysis of non-human animals, in order to provide possible insights into human biology as evidenced by dental data. Selected contact-period histories were reviewed in order to assess the status of Canarian populations directly prior to their eradication/assimilation by the European sea powers. The general patterning of archaeological sites and artefacts was also assessed, in order to examine human society in terms of social, economic and temporal factors. The biogeographical, historical and archaeological data were assessed and compared with results derived from dental anthropology.

1.4 Aims and Motivations

The motives behind the current study were determined by shortfalls in traditional approaches, bioarchaeology's potential for the elucidation of ancient human behaviour, and the Canaries' potential for expanding the range of island archaeology's reference points. In the first instance it provides a social perspective and temporal structure to two thousand years of Native Canarian society, thus challenging what is currently a somewhat two-dimensional view of the pre-conquest populations. Secondly, the use of bioarchaeological approaches permits the detection of phenomena that have a direct impact on human beings, and which are therefore undetectable by traditional archaeological methods. Lastly, while it has become increasingly apparent that the settlement and use of islands is characterised by temporal and spatial diversity, the development of island archaeology may be hampered by the increasing prevalence of models based solely on highly specific Pacific or Mediterranean groups. For a variety of reasons, the Canaries have not received the attention they deserve from the mainstream discipline of island archaeology. For example, Broodbank's (2000) introduction to island archaeology refers to the Aleutians, the Caribbean, the Hawaiians, Polynesia, Melanesia, Easter Island, Malta and the Cyclades (amongst others), but makes only one reference to the Canary Islands (2000: 13) in connection with late mediaeval European expansion. However, this is not so much a case of neglect as a reflection of severely localised reporting as most Canary Island research is presented in archipelago-based journals, the relatively limited distribution of which has prevented the discipline from exploiting the Canaries' very evident potential for furthering the field of island archaeology. The basic layout of the various chapters in this project is presented below.

- Chapter two is a review of Canarian geological, geographical, ecological and biogeographical profiles, including a study of the Canaries in their wider island context. Implications for human settlement are also discussed, in addition to a critical review of the issues surrounding island population studies in general.

- Chapter three concerns the historical (Roman, Arab and late mediaeval) and archaeological evidence for Canarian human societies. Chronological issues concerning landfall and colonisation dates are critically discussed. A study of population size and demography in the contact period is also presented, along with a review of archaeological evidence for burial, and certain aspects of material culture. The question of biological/cultural origins is also covered, in addition to a summary of economic traditions (both historical and archaeological data) in the archipelago. Finally, an analytical study of the Canarian 'islandscape' was carried out, intended to elucidate how the island societies related to one another (if at all) both during the contact period and the more distant past, using material culture, archaeological data and a study of navigational/nautical technology and potential.

- Chapter four is a review of bioarchaeological methodologies for determining the nature of ancient population biology, health, diet and behaviour through the examination of human remains. Methods and systems used in the present study (dental anthropology recording system [ASUDAS], cranial trait recording system, dental caries recording system, hypoplasia recording system, cranial trauma recording system) are explained in further detail.

- Chapter five is divided into two sections. The first is a summary and critical review of extant works on Canarian bioarchaeology and biological anthropology, highlighting the areas upon which the current project focuses. The second section is a description of the materials used in this study, and a description of the individuals' age, sex and temporospatial context.

- The subsequent four chapters contain information on population biology (6), dental pathology (7), hypoplasia (8) and cranial trauma (9). The results are discussed in chapter 10.

2 Canarian Physical Environment

This chapter provides a general introduction to the Canarian archipelago. It also examines the archipelago's environmental parameters – configuration, geology, relief, topography and climate – and aims to assess how these may have affected human settlement and adaptation in the Canarian islandscape. A general comparison was carried out in order to compare size, form, relationships and ecology of the Canaries with that of other island groups. A survey of biogeographical information concerning the archipelago was conducted in order to establish how the islands' configuration and ecology have affected non-human animal settlement, with possible inferences for human settlement. It is hoped that this, when combined with historical and archaeological data, will provide one potential interpretative framework within which to assess the data derived from the dental anthropology study.

2.1 Archipelago Configuration

In basic terms, there are seven large islands and a scattering of small islets. Like the other groups comprising the Atlantic island group of Macaronesia – the Azores, Cape Verdes, Madeira and the Salvage Islands (none of which were colonised prior to the European invasions of the late mediaeval period) – the Canaries are a small and compact archipelago of relatively large islands. In this respect they are unlike most of the island-rich areas of the world such as Southwest Oceania and the Caribbean – which comprise island chains several thousand kilometres long – or single large islands such as Madagascar. While they are at the extreme western edge of the Mediterranean world (and have been described as part of the 'Mediterranean-Atlantic' [Chaunu 1979: 106]) they are nonetheless 'true' Oceanic islands which differ from the Cyclades, the Balearics and other Mediterranean groups in arising directly from the sea-floor and never having been attached to mainland coasts. The Canary Islands essentially constitute an insular appendix to North Africa and the Mediterranean region (see Plate 2.1). They are therefore unable to act as 'stepping stones from everywhere to everywhere else' (Broodbank 2000: 41) – unlike islands in the Eastern Mediterranean and the Caribbean – and cannot be used to reach any other destination (the American continent excepted, but this voyage does not appear to have been attempted before the end of the mediaeval period [but see Hristov nd.]). Even within the Atlantic they are somewhat unusual. While they appear to have arisen in the same manner as the Cape Verdes, Azores and other isolated island groups, their position relative to the African mainland has resulted in very different climatic, ecological and archaeological profiles.

Plate 2.1. Satellite Image of the Canary Islands and NW Africa (from www.visibleearth.nasa.com)
By: SeaWIFS Project/NASA/ORBPLATE. Satellite: OrbView 2. Date 4/24/1999. VE Record: 4896

2.2 Geology and Formation

Islands can be formed by tectonic activity associated with volcanism (e.g. the Antilles), intra-plate volcanism (e.g. Hawaii; the Marquesas), continental break-up (e.g. New Zealand) or partial post-glacial flooding of a dry land area (e.g. the Cyclades). Establishing the identity of island-forming processes is vitally important in providing a background for biogeographical and archaeological studies.

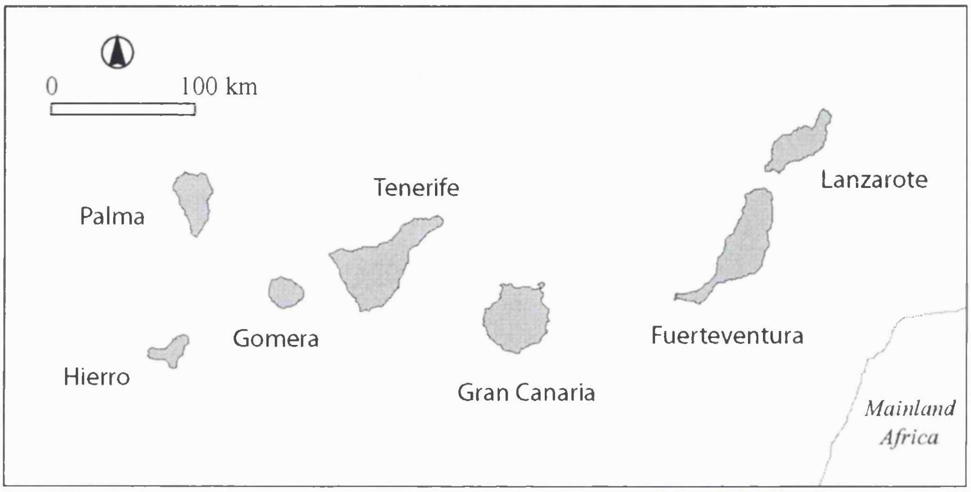

Plate 2.2. The Canarian Archipelago

The seven main islands are arranged in a 500km-long linear formation from E-W, and are accompanied by some small islets and rocks in the east (not shown in Plate 2.2.). Following bathymetric studies of the ocean floor, in collaboration with K-Ar dating of basement lavas (Quidelleur *et al* 2001) and volcanic stratigraphy (Ancochea *et al.* 1999), it is now generally agreed that the Canaries do in fact have a geologically brief history. The presence of volcanically uplifted Cretaceous sediments (Schmincke 1976:70) and late Tertiary shorelines on Lanzarote, Fuerteventura and Gran Canaria (Nunn 1994: 264) further suggest that the archipelago was never subject to the dynamic mountain-building processes that characterise the tectonically-associated islands of the Pacific. As the nearest plate margin (‘Mid-Atlantic Ridge’) is more than 2000km away, the genesis of the Canaries may instead be attributable to a ‘hot-spot’, an intra-plate extrusion of the lower mantle into the overlying lithosphere. As noted in a major review by Carracedo *et al.* (1998), however, the details of the hot-spot island-building process – and therefore island age and formation sequences – are far from clear. For example, while most intra-plate hotspot-derived chains – such as the Hawaiian Islands – have a more linear distribution describing the plate's route over the hotspot, the only partial linear form of the Canary Island archipelago cannot be so easily explained. Equally, their dates for basalt shield formation differ markedly from those provided by earlier authors such as Enghoff and Baez (1993). As the Carracedo *et al.* study (1998) is the most comprehensive recent review of Canarian volcanism, their dates for island formation have been provided here.

The oldest shield-stage formation dates are for islands towards the eastern end of the Canarian archipelago. Fuerteventura (20.6 mya) and Lanzarote (15.5 mya) are the oldest islands, followed by Gran Canaria (14.5 mya) and Gomera (12.0 mya). Tenerife's genesis is commonly dated to 7.5 mya, but this date does not reflect the full complexity of the islands' formation, in which three small islands formed between 7.4 and 11.6 mya were united by three distinct volcanic events between 3.5 and 0.2 mya (Brown *et al.* 2000: 1064). Gomera and the oldest Tenerife precursor are therefore roughly contemporary, shortly post-dating Gran Canaria, which was formed shortly after the eastern islands. A period of quiescence in Gomera's formation from 2.5 mya onwards coincides with the genesis of La Palma (2.0 mya) and Hierro (1.1 mya).

The Canaries have therefore never been linked with each other or with the African mainland. All animal and plant biota on the islands must therefore have arrived by sea, or by air.

2.3 Island Size, Elevation and Environment

Island area, height and environmental profile have major implications for settlement and colonisation patterns. A review of published data was therefore carried out to characterise individual islands, and to assess whether there are any perceptible groupings within the archipelago. The information thereby derived will be used in the discussion of biogeographical information.

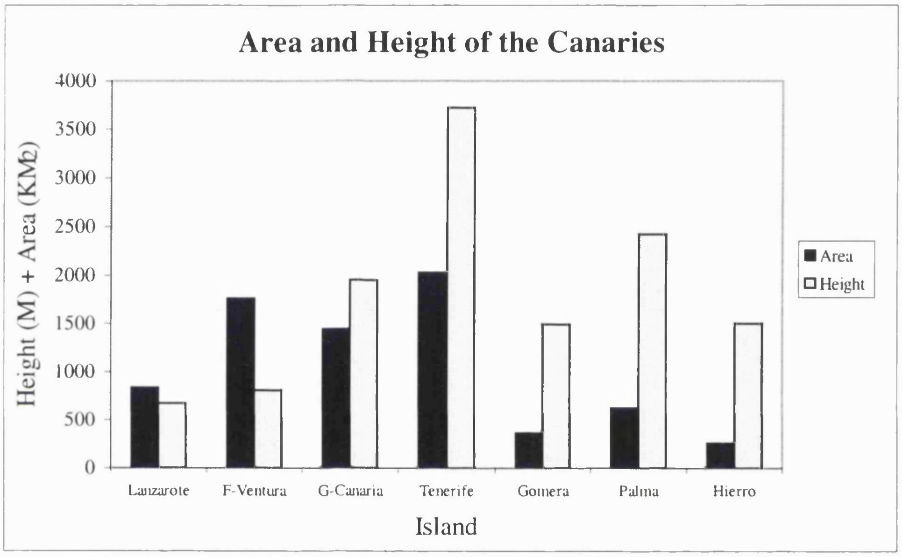

Fig 2.1. Area (KM^2) and Height (M) of the Canary Islands (E-W).

Island area (square kilometres) and maximum elevation (m) are provided in Fig. 2.1. The large islands are found in the east-centre of the archipelago, with smaller islands towards the western end of the group. With a combined area of 7499 km^2, the Canaries are amongst the largest of the Atlantic island clusters, and are individually (average area 1070 km^2) very much larger – but less numerous – than the majority of Oceanic islands in the Pacific or elsewhere (Williamson 1981: 1). The height of the principal islands is lowest in the East, rising sharply towards the middle of the group before dropping slightly towards the West. The smallest, western islands of La Palma, Gomera and El Hierro are all geologically modern, and therefore relatively high compared to the more ancient and eroded islands (Lanzarote and Fuerteventura) at the eastern end of the archipelago. Tenerife, the tallest island in the group, is comprised of three ancient islets joined together by a large active volcanic cone and lava massif (Brown *et al.* 2000). Island height is also related to rainfall figures (see Figs. 2.2 and 2.3). Elevation seems to be proportional to depth between islands, as the Canaries are seamounts with inter-island gulfs of never less than 1000m, and up to or exceeding 3000m, in depth (UN Island Directory Data).

There are six ancillary islets and rocks around Lanzarote and Fuerteventura, most probably the result of erosional processes. They are all small (between 0.5 and 36 square kilometres) and low-lying (<300m), and therefore do not possess ecological conditions substantially different from adjacent larger islands. Whereas the island of Lobos lies between the south coast of Lanzarote and the north coast of Fuerteventura, all the other islands are to the north of Lanzarote and therefore cannot be used to reach any other landmass. It should be noted that while these islets may prove to have been of economic importance to ancient Canarians – for the islets are major bird nesting sites – they are waterless and were therefore never inhabited by prehispanic groups.

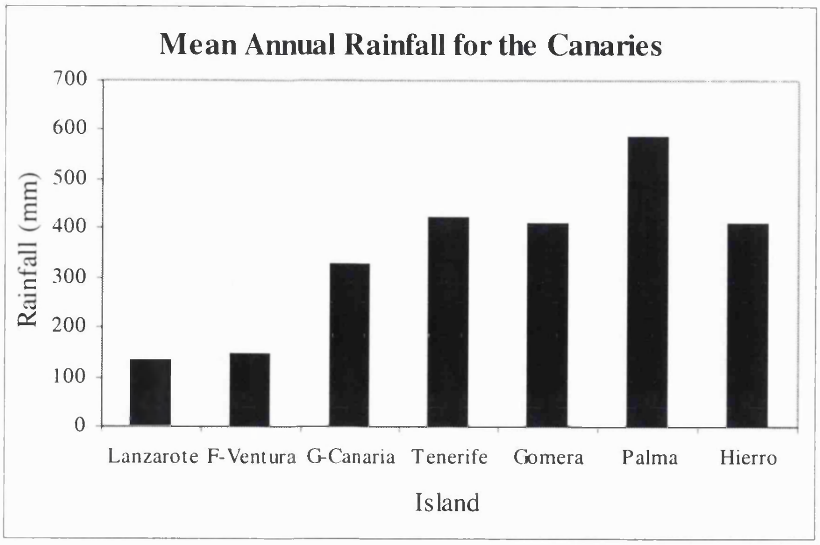

Fig 2.2. Mean Annual Rainfall Figures for the Canary Islands.

The combined mean rainfall figures for 1949-1967 are presented in Fig 2.2. As can be seen, the Canary Islands' position relative to the desiccated environment of North Africa and the cooling effect of the trade winds/gulf stream complex has given rise to marked levels of climatic variability within the archipelago. In general terms, the islands are climatically zoned according to their proximity to the mainland, and also their maximum elevation. The most easterly islands of Fuerteventura and Lanzarote are the flattest and the most proximate to the Sahara, and are therefore the most desiccated of the group. Towards the west the islands get progressively higher and further into the cooling Gulf Stream and trade winds complex, and are therefore increasingly lush and verdant. The central island of Gran Canaria possesses a temperate climate rather drier than the adjacent large and tall island of Tenerife. The western islands of El Hierro and La Gomera are high for their area, and possess rainfall comparable to that of Tenerife, whereas the wettest island in the archipelago is La Palma. It should be noted that these figures are only a guide. The effect of mean figures in this particular case is to obscure variability that needs to be considered when assessing palaeo-economic strategies, risk-taking and similar issues. Marzol Jaen (2000) deconstructed 'average' values for islands and periods by recording the amount of rainfall in as many parts of individual islands as possible, thus providing a more realistic picture of rainfall variability within the archipelago. The range of figures for individual islands is presented in figure 2.4. To add social significance to these figures, the minimum rainfall requirements for barley (200mm), wheat (300mm) and legume agriculture (350-400 mm – 400mm used for graphic comparison) have been included (figures from Garnsey 1995: 132).

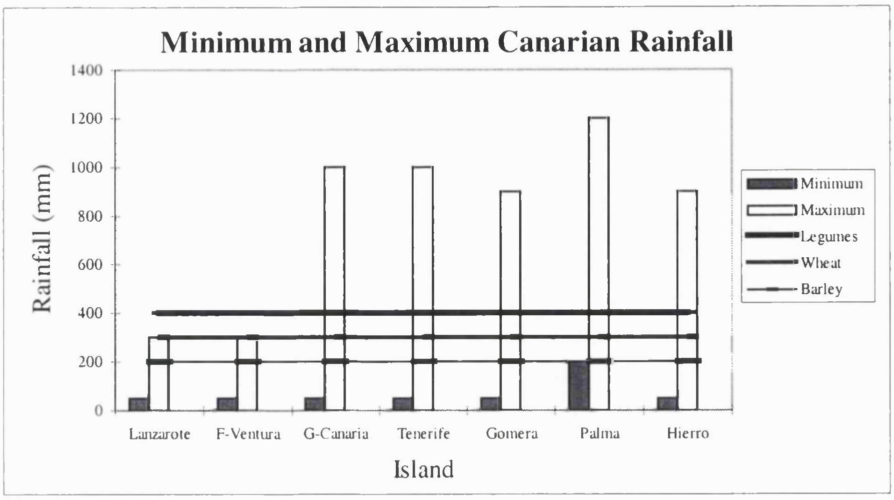

Fig.2.3. Minimum and Maximum Annual Rainfall Figures for the Canarian Archipelago

The rainfall range is extremely marked both within islands and throughout the archipelago. On very tall islands, desertic areas are those regions in the rain shadow of large peaks, the north and north-east aspects of which are well-irrigated by the Trade Winds (notably La Palma and Tenerife). All islands share similar minimum rainfall figures, with the exception of La Palma, which has the highest maximum and the highest minimum rainfall figures. While it is possible that sporadic low rainfall could be endured in the wetter islands, the marginal existence of populations in Fuerteventura and Lanzarote would be far more at threat by low rainfall. All the islands could cultivate barley in maximum rainfall years, but only La Palma could continue to do so in years of minimum rainfall. Again, all the islands – Lanzarote and Fuerteventura by a very narrow margin – could (and do) cultivate wheat in favourable years, but none could continue to do so in years of adversity. Legume cultivation would also be possible in years of high precipitation in all but the two easternmost islands (although lentil agriculture is sporadically attempted in Lanzarote – personal observation). All this seems to suggest that the margin for survival was narrower in Fuerteventura and Lanzarote, for even a minor drop off from maximum rainfall levels would preclude any cereal – much less legume – agriculture. An ecological study carried out by an association of architects, developers and engineers, assessing Lanzarote's rainfall between 1966/7 and 1985/6 provides a more detailed picture of inter-annual variability (figure 2.4).

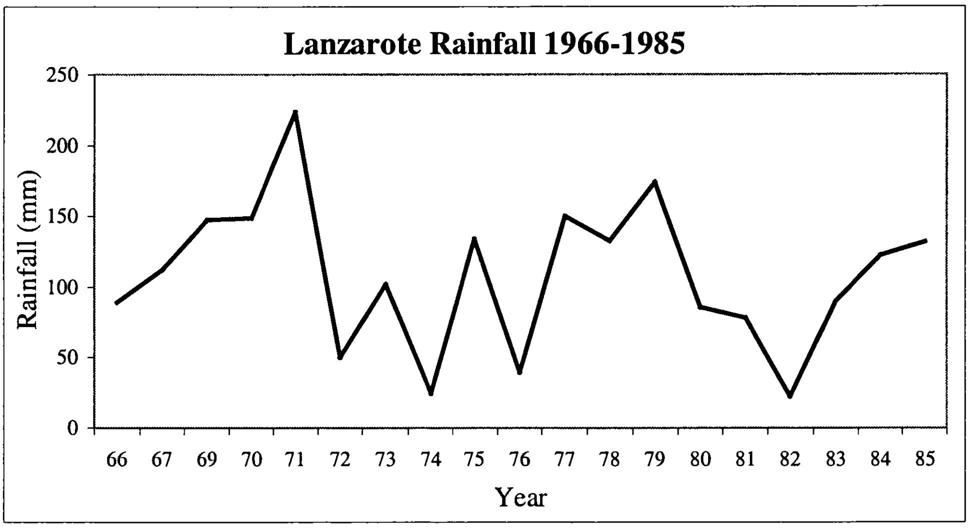

Fig.2.4. Rainfall oscillations in Lanzarote from 1966 to 1985

With an inter-annual range of 22.6mm to 223.7mm, the effect of rainfall fluctuations on ancient human populations must have been considerable. Even in the 1990's, rainfall had the power to utterly destroy crops and rural livelihoods, while similar episodes in the first half of the 20th century led to widespread famines, migrations and the consumption of marginal resources such as lizards (Martin Oval – pers. comm.). In fact, of all the years studied, only 1970-71 was adequate for the cultivation of barley (Garnsey 1995: 132). While climatic fluctuations may not always have been this severe – and there is some evidence that suggests increasing North African desiccation in the first millennium AD, in addition to environmental degradation brought about by the activities of humans and their commensals (Criado and Hansen 2002; Zoller *et al.* 2003) – the archipelago's location at the junction of dry Mediterranean/North African and Atlantic weather systems does suggest a turbulent climatic profile.

Studying the islands in their watery context is vital to appreciate the mechanics of colonisation and settlement history because all non-marine life forms – with the exception of birds, ocean-literate humans and human commensals – are completely at the whim of currents and winds when moving across water. The Canaries are situated in the Canary current, an anticyclonic North Atlantic current running NE-SW down the Atlantic seaboard. The Canarian archipelago essentially acts as an acceleration zone, diverting water through three main inter-insular channels. The main NE-SW channel within the island archipelago runs between the dry eastern islands and Gran Canaria, with weaker currents running between Gran Canaria and Tenerife and between Gomera and Hierro/Palma. The shadowing effect of the islands' bulk results in becalmed areas on their SW aspect, with resultant changes in water mixing and ecology (Santana Santana and Morales Matos 2000). The Canaries are situated in the eastern arm of the Trade Winds system. For most of the year, brisk winds blow down towards the islands from the North Atlantic from a NNE direction. The remainder of the year is made up of NE and ENE direction winds, with approximately 4% of wind originating from the NNW and E (Santana Santana and Morales Matos 2000).

In summary, the Canaries are characterised by high levels of climatic, environmental and ecological diversity. If it were not for the influx of cool winds and water from the north, it is likely that all the Canaries would resemble the desiccated islands of Lanzarote and Fuerteventura, and the neighbouring landmass of northwest Africa. Equally, the tall, western islands capture moisture from the Trade Winds, which also serve to keep the islands relatively cool and therefore temperate-Mediterranean in ecology (Marzol Jaen 2000). In keeping with the rain-shadow theory, the wettest parts of individual islands are invariably orientated towards the north and northeast. While low islands are less affected by the Trade Winds, the fact that the moistest – and biogeographically richest – parts of Lanzarote and Fuerteventura are the N-NE sea-cliffs indicates that even low-relief islands contain more ecological complexity than might be expected. In general terms, the Canaries are rather dry when compared to groups such as the Hawaiian Islands or the Antilles, and most closely resemble the desiccated environment of the Galapagos. As already stated, however, this tends to overshadow localised variability that may have profound effects on non-human and human colonisation and behaviour. Interplay between the Trade Winds, the Canary current, island elevation, relief patterning and proximity to the hot, dry environment of North Africa result in a mosaic patterning of environment and ecology that is unique to the Canarian archipelago.

2.4 Metric Study of Archipelago Configuration

Minimum distance between islands was measured using National Geographical Institute 1: 200.000 maps (Mapa Provincial de Las Palmas; Mapa Provincial de Santa Cruz de Tenerife), and are presented in table 2.1. Distances are rounded to the nearest km. However, these should only be treated as a rough guide. Island-mainland distances are derived from Enghoff and Baez (1993). The shortest route by which to describe a line through all the islands of the archipelago is highlighted. The main exception is the Gomera-Hierro/Palma link, where the linear arrangement of the islands gives way to an approximation of an isosceles triangle between these three members of the group. The shortest distance between the African mainland (Cape Juby, Morocco) and the Canarian archipelago (Fuerteventura) has also been highlighted.

	F-Ventura	G-Canaria	Tenerife	Gomera	Hierro	Palma	Mainland
Lanzarote	**11 km**	172 km	192 km	281 km	355 km	323 km	120 km
F-Ventura		**84 km**	147 km	221 km	288 km	275 km	**90 km**
G-Canaria			**46 km**	105 km	171 km	165 km	205 km
Tenerife				**28 km**	118 km	86 km	285 km
Gomera					**62 km**	**58 km**	320 km
Hierro						**67 km**	350 km
Palma							380 km

Table 2.1. Inter-island Distances in the Canarian Archipelago

The average distance between adjacent islands is c.50 km, with a range in distance to the nearest island of between 11 and 84 km, a range that would affect patterns of animal – including human – colonisation and inter-island travel. The shortest distance from the westernmost point of the African seaboard (Cape Juby, Morocco) to the easternmost tip of the Canarian archipelago (Fuerteventura) is 90 km. This is very similar to the most substantial break in the Canaries, between the dry eastern islands and the remaining five islands to the west (of which Gran Canaria is the easternmost). Gran Canaria is relatively close to Tenerife, but still appears to be an outlier in relation to the more homogenous Tenerife/Gomera/Hierro/Palma grouping. Within this grouping, Tenerife and Gomera are very close to one another, with another, more substantial division before reaching the equidistant islands of Hierro and Palma. It should be noted that these geographic divisions correspond to climatic zones within the archipelago, running from desertic to temperate/Mediterranean to Mediterranean/subtropical (see above). Inter-island distances are considerably greater than those of Mediterranean island groups such as the Cyclades (Broodbank 2000), but not unlike oceanic archipelagos such as the Galapagos (Weiner 1994), which the Canaries also resemble in size. The similarities and differences between the Canaries and other island groups are discussed in section 2.5.

2.5 Discussion – Canary Island Configuration and Comparisons

Finding an adequate analogy for the Canaries is remarkably difficult, as while there are many archipelagos that superficially resemble them in some aspects, their configuration has few close parallels. The factors defining island configuration are island size, the number of islands, archipelago size, inter-island distances, island-mainland relationships and ecology. The Canarian archipelago comprises seven large islands with scattered islets, thus more closely resembling the Galapagos (eleven islands) and the larger members of the Hawaiian group (eight islands) than oceanic arcs such as the Aleutians (c. 40 islands). With a combined land area of 7499 km^2, the Canaries are the largest islands in the Macaronesian group, and are physically similar to Pacific groups such as the Galapagos and Hawaii. While decidedly vertiginous in relative terms, the Canaries are not as tall as the Hawaiian Islands, and are most similar to the Galapagos, the Azores and the Greater Antilles. In terms of overall length (430km), the Canarian archipelago resembles the Galapagos (c. 400 km) and the Hawaiians (c. 550 km) rather than the Aleutians (c. 1500 km) or the closely grouped Seychelles (c. 90 km). The Canaries' closest Atlantic parallel in this respect is probably the Azores in terms of archipelago length (Azores; c.550 km) and number of islands (Azores; nine), although they are very different regarding island size and archipelago orientation. The Canarian archipelago is roughly linear in shape (but see section 2.2), thus resembling the larger Hawaiian Islands more than the elongated linearity of such Oceanic arcs as the Solomon Islands and the Aleutians, and the almost circular format of the Galapagos or the Comoros. Canarian inter-island distances are relatively large, and quite variable considering the small number of islands in the archipelago. In this they most closely resemble the Galapagos – which have an inter-island range of 10-90 km with most gaps not exceeding 30 to 40 km – and the large islands of Hawaii, which have a range from 15-110 km. In this respect they differ from elongated island arcs such as the Aleutians or the Lesser Antilles, which usually possess larger number of smaller islands with proportionally reduced inter-island distances. In summary, then, the Canaries most closely resemble Hawaii, the Galapagos and the Azores, although the fact that only the former of these was colonised prior to the mediaeval European expansion – therefore being potentially more analogous in 'human' terms – should be noted.

The Canarian archipelago constitutes an insular appendix to North Africa (or the Mediterranean – Chaunu 1976) rather than a truly 'isolated' archipelago such as Hawaii or the outlying reaches of Polynesia. At 90 km from the mainland, it is the most continentally proximate of all the Macaronesian islands, which may explain its relatively early inhabitation by humans when compared to other – more distant – members of the group (Crosby 1986). The Canaries are in fact somewhat unusually positioned. The few archipelagos that are similarly distanced from their respective mainlands – including the Comoros, the Ryukyus and the Laccadives – have nothing else in common with the Canarian group.

These findings have various implications for human settlement and behaviour. Geological findings confirm that there has never been a land bridge from the Canaries to the African mainland, and that all human groups must therefore have arrived by water. By being a small group of relatively large islands with some substantial distances between them, the Canaries are at once set aside from the class of very small, clustered islands (i.e. the Cyclades) that promote short-hop inter-island travel. Because of these distances, differences in relief and the position of the islands relative to the Trade Winds, ecological conditions are much more variable than might be expected for an archipelago of this size. This in turn created a range of economic and adaptive challenges for human groups, and determined the mechanics of the settlement process.

2.6 Biogeography – Methods and Practice

Simply defined, biogeography is the study of past and present distribution of biological species. While biogeographical research is global in scope, islands have always played an important role in biogeography since Darwin's groundbreaking work with Galapagos finches. This is because island biological communities are small (and therefore easy to survey) and typically possess low numbers of genera (thus facilitating the modelling of evolutionary trajectories). Immigration and emigration of species can therefore be easily estimated, while environmental perturbations are strongly felt by flora and fauna which either evolve faster, or rapidly become extinct in closed island environments (Lister 1995; Whittaker 1998). It is of course tempting to impose animal templates onto humans in order to examine colonisation and evolutionary trajectories, the extent to which biogeographical analyses of non-human animals can be used to model human settlement and spread is a matter of some debate.

2.6.1 The Application of Biogeography to Human Groups

The genesis of biogeography as applied to island archaeology is Evans' 1973 work, which claims that human populations inhabiting restricted island environments are immune to "...arbitrary cultural and ethnic change" (1973: 518) and that cultural and behavioural repertoires in bounded territories develop to their "logical conclusion" in the manner of biological organisms. This argument is based upon the observation of extraordinary island societies such as Rapa Nui and Temple period Malta, although the extent to which they are the cultural equivalent of peculiar island-based life forms – such as the Giant Moa, the Komodo Dragon or the Dodo – is difficult to demonstrate unequivocally. Finally, it was hoped that some sort of universal behavioural models could be derived from such studies, and transposed onto the seemingly more complex archaeological signatures left by humans in mainland environments. This rather extreme view was tempered in later work by Cherry (1981) and Keegan and Diamond (1987), who used sophisticated theoretical and physiological methods to model island colonisation and settlement patterns. The pros and cons of this approach are considered in section 2.9. However, while there are some doubts as to the appropriateness of applying biogeographical methods to humans, there can be no doubt that biogeographical approaches can operate as a heuristic approach for assessing general parameters of the human experience concerning colonisation and settlement.

2.7 Analytical Biogeography of the Canarian Archipelago

While it is true that purely biogeographical studies of human adaptation will miss a great deal of information, it would be unwise to reject biogeographical perspectives out of hand, for these – like research on history, archaeology and anthropology – also have their part to play in understanding the complexity of islandscapes. This section of the present study is a heuristic exploration of non-human colonisation data to assess whether anything useful can be derived about the human colonisation experience in the same area. This is of course a very crude measure of ecological adaptation of each group, but while the project cannot analyse the complexities of Canarian biogeography with the care and attention it deserves, it does pick up on certain significant factors that permit extrapolation of further details of the settlement process. With apologies to biogeographical purists, therefore, the intention of this study is to use non-human animal information as an interrogative strategy for the assessment of human colonisation and settlement potential (see Cherry 1981). This differs considerably from attempts to plot specifics of human movement through the analysis of morphological and genetic variance in their commensals – such as the use of pigs and rats (Allen *et al.* 2001; Flannery 1997; Matisoo-Smith and Allen 2001) to plot human colonisation of the Pacific, or mice and goats for human settlement of the Canary Islands (Castillo *et al.* 2001; Zoller *et al.* 2003) – in the absence of conclusive material culture links or human remains. In the present case, examining relationships of native species across the archipelago may provide a basis from which to assess potential constraints on human movement and behaviour. For this reason, the flora and fauna of the Canary Islands has been assessed to determine whether any patterns can be identified, and to compare this information with that derived from the study of dental anthropology described later in this project.

Like many other island groups or isolated landmasses, the animal and plant biota of the Canary Islands might be described as 'strategically impoverished'. Islands are often settled by limited number of genera – often represented by single species – and these may give rise to a range of species-level radiations into a range of econiches that differ from the ancestral condition. In Madagascar, for example, lemurid species have occupied all the niches usually occupied by animals ranging from birds (the Aye-Aye) to ungulates (the Sifaka). The Galapagos finches are a similarly celebrated example, having seemingly evolved from a generalised seed-eater into occupancy of a comprehensive suite of ecological niches (Weiner 1994). In the Canarian case, the relatively low numbers of genera has led to extravagant levels of speciation, and a consequent slew of biogeographical studies that aim to elucidate evolutionary processes at the species level. The non-volant animal biota is mainly comprised of invertebrates and reptiles (skinks, lizards and geckos). Currently, the largest mammals on the islands except for humans and goats/sheep are hedgehogs and rabbits, the latter at least having been introduced by European colonists in the 15th century (Pais Pais 1996; Martin Oval – pers. comm) although other mammals (such as *Mus Malpaisomys/canarionomys* – or 'lava mouse') once flourished in the archipelago (Barroso 1998).

The most consistent finding in this analysis was that endemism and variability were very high in the archipelago. According to a recent study by Juan *et al.* (2000), approximately 50% of the c.6500 terrestrial animal species are endemic to the archipelago. Of these, the vast majority (well over 90%) are invertebrates – especially beetles – with some birds and reptiles, and a very small number of mammals. Most

Canarian species and genera reviewed had extremely limited distributions, often within a specific ecological 'zone' on a single mountain or cliff-face (Kunkel 1982). While patterns of species diversity are not always clear, it seems that this is a function of the islands' physical relief and climatic heterogeneity. This is a function of both volcanic activity and human interference, which have led to population fragmentation and high levels of speciation throughout the archipelago. For example, organisms that differ at the specific – and often the generic – level may fill essentially identical econiches on adjacent mountaintops, while the proliferation of microclimates on the larger islands accentuates this 'continent in miniature' effect.

2.7.1 Evidence from Flora

Plant endemism is generally higher in Oceanic groups when compared to 'enclosed' (i.e. bounded by mainland shores, such as the Mediterranean or the Caribbean) archipelagos. Forty-five percent of Canarian flora is endemic to the archipelago (Whittaker 1998: 41), intermediate between that of the Hawaiian Islands (90%) and the Solomon Islands (1.1%), and is most similar to that of Mauritius (46.4%), according to the IPCC Island Biodiversity Report. Forty-eight percent of the endemics are restricted to a single island and 15% to two. Most studies of Canarian flora do not assess colonisation history. Indeed, reports on the archipelago's peculiarly enigmatic plant life typically focus upon unique endemic species, or upon floral elements that have conspecifics in remote regions such as Australia, East Africa and India (Juan *et al.* 2000). Diversity in plant life echoes faunal diversity (see below), being highest in large islands with large arrays of habitats (Tenerife), and with lower levels in drier (Lanzarote) or smaller (La Palma) islands. Prominent amongst the botanical studies that deal with colonisation history is the work of Hess *et al.* (2000), who examined the spread of the olive through the archipelago using DNA analysis. They propose a stepping-stone model from the Mediterranean to Fuerteventura in the East through to La Palma in the West, using an avian mechanism of dispersal. A study of the genus *Argyramthemum* indicates two major genetic lineages, which are restricted to the arid eastern archipelago and the dry coastlines of the western isles, and another which is found exclusively in western humid environments (Juan *et al.* 2000). In order to provide a wider view of plant affinities, the current author assessed distribution patterns of over 300 species of indigenous Canarian plants (data from Bramwell 1997). Single island endemics and species with an archipelago-wide distribution were removed from the analysis. Percentages of shared species between individual islands were then calculated, and the results are shown in table 2.2. The strongest links between pairs of islands have been highlighted.

	F-Ventura	G-Canaria	Tenerife	Gomera	Palma	Hierro
Lanzarote	**48**	9	5	4	4	2
	F-Ventura	**11**	6	5	4	6
		G-Canaria	**45**	**37**	38	36
			Tenerife	35	42	37
				Gomera	**43**	17
					Palma	**44**

Table 2.2. Plant Species Affinities (%) in the Canarian Archipelago.

Lanzarote and Fuerteventura were strongly related, and together were extremely divorced from the rest of the archipelago (i.e. relationships with other islands usually under 10%). The most strongly related island pairs (other than Lanzarote/Fuerteventura) were Gran Canaria-Tenerife (45%), La Palma-Hierro (44%) and La Palma-Gomera (43%). This pattern of linear relationships between adjacent islands constitutes a definitive E-W pattern. Affinities were therefore defined by spatial considerations, but the strength of the patterning suggests that climatic factors – between the dry islands in the east, the large central islands and the small western group – were equally if not more important.

In summary, the evidence available from botanical studies suggests that both direct linear dispersal and ecological parameters were of importance in determining floral colonisation of the archipelago. While dispersal through the archipelago may have taken place in a simple E-W trajectory, the strong contrasts in intra/inter-island ecology and inter-island distances seem to have played a major role in accelerating speciation into different environments and ecological niches.

2.7.2 Evidence from Fauna – General Considerations

There were no instances in which the fauna of any island resembled African mainland groups more than those from other islands in the archipelago. There are strong correlations between numbers of animal species and rainfall, as demonstrated by Enghoff and Baez's (1993) ecodiversity "scores" for the archipelago. Scores rose from 1 in Lanzarote/Fuerteventura to 4 in Gran Canaria, peaking at 6 in Tenerife before falling off slightly in the westernmost islands (3-5). The figures suggest that distance from the mainland and island area also appear to affect species diversity. Where comparisons could be made, Canarian species were most closely allied with North African and Mediterranean groups. As for the floral studies described above, the number of endemic species was such that most publications focus on intra-island variation. Exceptions to this rule – studies that reviewed species across more than one island – are summarised here.

2.7.3 Evidence from Invertebrates

Enghoff and Baez's (1993) study of 46 endemic Canarian millipede species across the archipelago found that ecological diversity was determined by distance from the main land, island area and – particularly – rainfall. The ancestral condition was a small body size suited to dry environments, later variability being the result of adaptations to new econiches. It is therefore likely that colonisation was from E to W, the eastern islands acting as a primary bridge from North Africa. Other species endemic to the eastern islands – such as the darkling beetle (Juan *et al.* 1998; Juan *et al.* 2000) – accentuate the biogeographical divide between the dry and temperate islands, while conspecifics illustrate similar boundaries between the central (Gran Canaria/Tenerife) and western (Gomera/Palma/Hierro) parts of the archipelago (Rees *et al.* 2001). Emerson *et al.*'s 2000 study of *Tarphius canariensis* suggests an origin in Southern Tenerife, followed by independent colonisations to Gran Canaria, La Palma and NE Tenerife. Emerson *et al.*'s (2000c) work on *Brachyderes rugatus* provides similar results; a monophyletic clade on Tenerife, La Palma and El Hierro, all distinct from Gran Canaria. Within the former group, Hierro and La Palma are sister-groups, more closely related to each other than to Tenerife. Kelly *et al.* (2001) reported few differences between intra- and inter-island variability in caddisfly populations. Brunton and Hurst (1998) propose a diffusion of brimstone butterflies from North Africa to Tenerife and Gomera, followed by another spread across to La Palma. It should, however, be remembered that volant species are less than perfect analogies for land-based organisms.

2.7.4 Evidence from Reptiles

Brown and Pestano (1998) examined mtDNA evolution in members of the genus *Chalcides* (skinks) in all the islands except for Lanzarote and La Palma. Skinks from the westernmost islands (Hierro and Gomera) were sister taxa most closely related to Tenerife, which in turn was linked to Gran Canaria. Fuerteventura was the most distantly related to the other islands, and showed only limited biological affinity with North African conspecifics. A stepping-stone model – related to the geological age of the islands – was supported. A fossilised Miocene snake vertebra from Lanzarote, the only such remains in the Canaries, provides tangential support for this assertion

(Barahona *et al.* 1998). This simple "island colonised as it emerges" pattern (Juan *et al.* 2000) contrasts with the more complex population history of the genus *Tarentola* (geckos). The high levels of genetic divergence in Canarian populations of the genus indicate a long-term extinction/replacement scenario, suggesting – as for the carabid beetles (see above – Emerson *et al.* 2000b) – a series of independent colonisation events from the African mainland.

2.7.5 General Trends from Invertebrates and Reptiles

The evidence is far from clear. What is suggested, however, is that species tend to cluster by ecological zone – desiccated/temperate/wet. For certain species – such as the millipedes – the fact that the original adaptation was for dry conditions suggests that there was an E-W radiation, and that adaptation to wet environments was a secondary occurrence. The strong affinity between the western islands at the expense of Tenerife, combined with their group homogeneity when compared with Gran Canaria or Lanzarote/Fuerteventura, would suggest correspondence with a E-W 'Stepping Stone' model, which happens to coincide with ecological 'zones' (i.e. *Chalcides*). The distribution of single-island or reduced-range endemics such as *Tarphius canariensis* or brimstone butterflies may be accurate reflections of colonisation patterns, or the result of extinction in desiccated islands and/or a re-colonisation (or back-colonisation) by western archipelago endemics. In either case, it would seem that while the general trend is for linear E-W colonisation, this scenario might be over-simplifying the issue.

2.7.6 Birds, Mammals and Reptiles: an Independent Study

Data from Mitchell-Jones *et al.*'s (1999) study of mammals, the UN review of Canarian biodiversity and the www.eurobirding.co.uk report on Canarian wildlife (focusing mainly on birds and reptiles) were examined in order to provide a measure of island affinities. It was anticipated that the wide range of genera sampled would reduce the chance of genus-specific bias, such as the relative ease with which birds can cross open stretches of water. It should be noted that the species used do not reflect the islands' total biodiversity. Ubiquitous species (i.e. mice), recently introduced species (i.e. rabbits) and single-island endemics were removed from the analysis, as these cannot be used to address the present question (it should be noted, however, that assessments of genetic variability within these species might provide useful information that cannot be acquired by morphological studies). The data were not weighted in the analysis, so all genera are treated alike. Inter-island affinity was assessed (see table 2.4) by counting the number of species common to a pair of islands, then calculating the number of shared species between the islands as a mean (percentage) measure of affinity. The results of this review are presented in table 2.3, where the strongest link that individual islands possess is highlighted. Islands are presented in E-W order.

Species	L	F	GC	T	G	P	H
Canary Shrew	■	■					
Houbara Bustard	■	■					
Cream-Coloured Courser	■	■					
Barbary Falcon	■	■					
Black-Bellied Sandgrouse	■	■					
East Canarian Gecko	■	■					
Haria Lizard	■	■	■				
Kuhl's Pipistrelle	■	■	■				
Algerian Hedgehog	■	■	■	■			
Blue Chaffinch			■	■			
Bolles' Pigeon			■	■		■	■
Savi's Pipistrelle			■	■	■	■	■
European Free-Tailed Bat			■	■	■	■	■
Canarian Kinglet				■	■	■	■
Canary Lizard				■	■	■	■
Madeira Pipistrelle				■	■	■	■
Laurel Pigeon				■	■	■	
Barbastelle (bat)				■	■		
Golden Skink				■	■		■
Leisler's Bat				■		■	
Canarian Gecko				■		■	■

Table 2.3. Mammal, Bird and Reptile Distribution in the Canary Islands.

	F-Ventura	G-Canaria	Tenerife	Gomera	Palma	Hierro
Lanzarote	100	19	5	0	0	0
F-Ventura		19	5	0	0	0
G-Canaria			25	13	19	19
Tenerife				38	36	38
Gomera					35	38
Palma						41

Table 2.4. Mammal, Bird and Reptile Relationships (%) Between the Canary Islands.

Lanzarote and Fuerteventura were identical (100%) in their mammal/bird/reptile profile, sharing only 19% of their species with Gran Canaria. This reflects the strong affinity with NW Africa, especially in terms of avian species and dry-island lizards. They have only 5% in common with Tenerife, and none with the remaining islands. Gran Canaria is linked to Tenerife (25%), a considerably stronger link than Gran Canaria to Lanzarote/Fuerteventura. Gran Canaria has more in common with Hierro and La Palma (19%) than with Gomera (13%). When compared with the weak links to the eastern islands, Tenerife has substantially stronger affinities with Gomera and Hierro (38%) and La Palma (36%). Gomera's strongest affinity is with Tenerife and Hierro (38%), against which La Palma falls out slightly (35%). However, the strongest similarity in the western archipelago is between La Palma and Hierro (41%). None of the islands west of Tenerife have any shared characteristics with Lanzarote and Fuerteventura, and only limited links with Gran Canaria. It is interesting to note that while Gran Canaria is quite strongly linked with Tenerife and La Palma/Hierro, it is rather less strongly affiliated with Gomera. There was generally more species diversity in the western end of the archipelago than the eastern islands. Lanzarote and Fuerteventura had many bird species in common with NW Africa, in addition to their own endemics (Canary shrew) and affinities with other islands (Gran Canaria and Tenerife – various bats and lizards). In the western islands, stronger links exist between Tenerife and the Gomera/Hierro/Palma triangle, but these affinities are not as strong as those that exist between the smaller islands. If Gran Canaria and Tenerife are removed (possessing 34% and 62% of the 21 species considered, respectively), no links at all exist between the eastern and western islands. This implies that the large islands operate as both resource pools and bridging points between more extreme ecozones, and that species radiations were more complex than a simple E-W 'colonised as they emerged' scenario (see above).

These findings are in approximate accordance with the only biogeographically oriented study of domestic animals so far carried out in the Canaries. Capote *et al.* (1998) conducted a morphological survey of modern goat morphology (no archaeological remains were used), and detected three "lineages" specific to Fuerteventura and Lanzarote ("Majorero"), La Palma ("Palmera") and Tenerife ("Tinerfeno" – divided into Southern and Northern lineages). Gran Canarian goats were a hybrid group (Hierro and Gomera were not analysed). Tenerife was apparently a central reservoir for the goats in the western end of the archipelago, with some Gran Canaria-Tenerife interchange. Zoller *et al.* (2003) have recently proposed that the arrival of goats (and therefore humans) in the islands be back-dated to between 5,000-10,000 years ago, so we may benefit from a reanalysis of the goat morphology data in order to derive more information about human settlement in the archipelago. This issue is addressed further in chapter 3.

2.8 Canarian Biogeographical and Configurational Clustering

Drawing the foregoing together in biogeographical terms, there are major differences between the apparent colonisation sequences and biological history in most of the animals reviewed, with a 'mosaic' of characteristics that often see more intra- than inter-insular differentiation (Juan *et al.* 2000). In western islands such as Tenerife – which comprises three ancient seamounts joined together by more recent volcanic activity – biological variability and diversity throughout the island has been strongly affected by complex geological history (Brown *et al.* 2000). The data suggests that – rather than an 'islands colonised as they emerge' scenario – the Canarian biome has been characterised by back-colonisation, re-colonisation, adaptation, extinction and replacement (see Juan *et al.* 2000).

Despite these evident complexities, however, a number of general points can be derived. Loosely, the results acquired echo the inter-island distances presented in table 2.1. The overall pattern is moderately consistent with the 'stepping stone' model that has frequently been invoked to explain pattern and process in Canarian biota distribution (Juan *et al.* 2000). Proximate islands usually share ecological profiles, thus possessing the strongest biogeographical links, while the strongest affinities are found between islands that are very close together (notably Lanzarote/Fuerteventura; Tenerife/Gomera). Simplistically, therefore, the results may be summarised as two contrasting poles – the dry and the wet islands – that overlap to provide mixed results towards the centre of the archipelago. However, this interpretation can be considerably improved upon. Lanzarote and Fuerteventura seem to be a homogenous unit, with few links to other islands. Gran Canaria has links to both Lanzarote/Fuerteventura and Tenerife, and is intermediate between the wetter western islands and the eastern archipelago arid zone. Tenerife is a central source pool, with the three smaller islands acting as varyingly-related satellites. Gomera is geographically and biogeographically proximate to Tenerife, whereas La Palma and Hierro are slightly more distant. Gomera has strong links with – and bridges – Tenerife and the westernmost islands.

However, the range of environments presented is far more complex. Four 'zones' – based upon distances, climate and biogeographical profile – are suggested in table 2.5.

Islands	Characteristics
Lanzarote and Fuerteventura	Desiccated; low-lying; easterly
Gran Canaria	Large; dry Mediterranean climate
Tenerife	Large; wetter; very diverse ecology
La Palma, Gomera and Hierro	Small; vertiginous; wettest

Table 2.5. Inter-Island Affinities 1

The affinities of Tenerife and Gomera are not unequivocal. Tenerife is rather similar to Gran Canaria in terms of size, biogeographical profile and apparent core-periphery role with smaller islands nearby (table 2.6).

Islands	Characteristics
Lanzarote and Fuerteventura	Desiccated; low-lying; easterly
Gran Canaria and Tenerife	Large; central ‘reservoir’ function
La Palma, Gomera and Hierro	Small; vertiginous; wet; westerly

Table 2.6. Inter-Island Affinities 2

Gomera, similarly, is in the same size group and ecodiversity category as the western islands, but is drier and therefore more similar to Tenerife than to La Palma and Hierro (Table 2.7).

Islands	Characteristics
Lanzarote and Fuerteventura	Desiccated; low-lying; easterly
Gran Canaria	Large; dry Mediterranean climate
Tenerife and Gomera	Proximate; similar ecology
La Palma and Hierro	Small; vertiginous; westerly; wettest

Table 2.7. Inter-Island Affinities 3

These divisions are appropriate for patterns of ecology, plant and animal distribution as discussed above. Whether or not they can be applied to archaeological and human remains will be explored in subsequent chapters.

2.9 Beyond Biogeography

Human biogeography’s central stance is that humans are animals, and that their behaviour can be modelled like any other species. This belief is not uncontentious, however. Clearly, all require certain conditions to engage upon sea-travel in the first instance, adequate resources to survive arrival in a new environment, reproductive success (and therefore a viable breeding population) and a certain amount of good luck against catastrophe (Broodbank 2000: 31). However, if one were to adhere to this rather reductive view, a considerable number of important differences between humans and other animals would be lost. The central issue is culture, which is a major determinant in humans' ability to overcome obstacles, through innovation and the adaptation of extant technologies to new challenges. Furthermore, Evans' (1973) notion of an island laboratory proves elusive, as it is only in exceptional circumstances that true 'experiments' can take place (i.e. the re-colonisation of Krakatau following it's eruption in the 19th century [Whittaker 1998: 77], or the experimental release of lizards into variable environments to assess their evolutionary modifications [Losos *et al.* 1997; Losos and de Queiroz 1997]). The supposition that the fundamental elements of human behaviour can be seen more clearly on islands than in mainland groups is misleading (Broodbank 2000: 30-32), as island human populations are just as distinctive as any other cultural group on biological, historical and social fronts. Finally, so long as negotiated space (i.e. deliberate isolation or incorporation with other islands or with mainland groups), mobility and voyaging can be demonstrated from the archaeological record, then clearly there are problems with applying biogeographical rules to the study of archaeological remains (Broodbank 2000).

There are several cases in which archaeological data have suggested complete isolation from external influence, followed by the "...exaggerated development" (Evans 1973: 519) of certain aspects of material culture. Prominent amongst these are the spectacular architectural achievements of Rapa Nui (Bahn and Flenley 1992) and Malta (Stoddart *et al.* 1993: 7). The agency behind these developments is, however, open to question, as it is not (purely) a function of 'isolation' as predicated under the biogeography model.

Modern examples of this issue's complexity include the Ocracoke islanders (North Carolina, USA), who started to lose their highly distinctive accent and dialect as soon as a bridge was built to the mainland; however, this underwent a reversal in the subsequent generation, resulting in an even stronger accent and patois than had been noted prior to the bridge's construction. This was attributed to the original inhabitants' determination to be identified as 'real' Ocracokers, and to distinguish themselves from later incomers (Bryson 1998: 169). A similar phenomenon was noted in Martha's Vineyard where traditional pronunciations rallied unexpectedly after a long period of decline. This was attributed to natives returning to the island after working on the mainland, and adopting old speech forms as a means of distinguishing themselves from more recent – non-native – arrivals (Bryson 1998: 170). If further proof that the cultural process surrounding island 'isolation' is not purely mechanical were required, one need only consider what future archaeologists would make of cultural traditions in mid-late 20th century Cuba, when compared to neighbouring North or South America. Archaeological populations were just as diverse in their reactions to inner and outer worlds. For example, while Temple period Malta possessed the technology for close mainland links, contact was rejected in favour of what appears to have been a conscious effort to isolate the island from the outside world, with intensive architectural and infrastructure development (Grima 2001; Robb 2001). A highly contrasting motivation is that of the Rapa Nui Islanders – unable to leave their island and therefore had no reason to 'isolate' themselves further – whose investment in monumental architecture and art marked rivalry between warring tribes and an appeal for supernatural assistance in a time of adversity. Attitudes towards and relationships with the outside world – as well as internal dynamics – would therefore seem to be just as important as any crude measure of physical geography. It is necessary to bear this potentiality in mind when considering the implications of the biogeographical data, as a preliminary consideration before perusing the dental information.

3 History and Archaeology of the Canary Islands

The aim of this chapter is to present the basic characteristics of ancient Canarian society as they are currently understood, and to provide a cultural and economic background to the subsequent bioarchaeological study. This chapter summarises the historical sources pertaining to the Canary Islands from the 1st to the 15th centuries AD, with a brief history of Canarian archaeological investigation. All chronometric determinations for the archipelago are presented, along with discussion of their implications for human settlement of the islands. A summary of Canarian material culture and palaeoeconomy is also provided, including a study of how Canarian society was configured – in terms of inter-island contact and mobility – both before and during the European conquests.

3.1 Canarian 'History' and 'Prehistory'

The distinction between 'history' and 'prehistory' in the Canarian archipelago is somewhat blurred. Academics usually make this division at the point that the Canaries were first reached by Europeans in the 1300's and early 1400's. However, this is technically inconsistent as the Romans (Atoche Pena *et al.* 1995) and possibly earlier groups (Mederos Martin and Escribano Cobo 2002) visited the islands some 1500-2000 years previously. The term 'pre-European' has also been used, but this presupposes that the native Canarians had no link to Europe, a claim that has yet to be conclusively demonstrated. Further, if the Romans left some form of cultural or biological legacy (which seems plausible), it is in any case inaccurate. Finally, the term 'prehistory' is presumptuous in that it privileges the written word, and consigns such societies as can only be explored through archaeology and oral tradition as being an underdeveloped version of those which possess epigraphic records of their past. As recommended by Broodbank (2000: 11), therefore, the term 'prehistory' is avoided, clear distinctions being drawn between the fleeting Roman and the devastating 14th-15th century AD contact periods.

3.2. Roman and Arab Accounts of the Canary Islands

The only coherent account of Roman contact with the Canary Islands that has survived is that written by Pliny the Elder in 77AD. The entry refers to ‘the Isles of Bliss’ that lay some distance to the southwest, near to the coast of Mauritania (translation and annotation by Rackham 1842). While reliant on several accounts and therefore slightly confused, the source notes six islands discovered by Sebosus and Juba in the 1st century AD. They are named for their physical characteristics, including ‘Canaria’ for the dogs said to have lived there (the origin of the archipelago’s name), ‘Pluvialia’ for high rainfall and ‘Planasia’ for the flatness of the land. Owing to certain inconsistencies in the naming system – Planasia (supposedly Gran Canaria) is not especially flat, for example – it is possible that Rackham’s island nomenclature is in need of a review. The discovery of a Roman site on Lanzarote (in addition to various loose artefacts such as amphorae that are sometimes located on the seabed) has lent some veracity to these historical accounts (Atoche Pena *et al.* 1995).

While most authorities – notably Mercer (1980), Fernandez-Armesto (1982) and Tejera Gaspar and Aznar Vallejo (1992) – state that there is a 1200 year hiatus in textual references to the Canaries between the Romans and the Mediaeval period, there are some indications that Arab groups may also have come to the Canaries. Mederos Martin and Escribano Cobo (2002: 43) have assembled a number of Arabic sources that are claimed to refer to the Canary Islands, including works by Ibn Abd al-Munim (850-900), Al Bakri (died 1094), Al-Idrisi (1154) and Ibn Said al-Magribi (late 13th century), who referred to the islands (dubbed *al-Jadidat*) as a navigational reference point

(Mederos Martin and Escribano Cobo 2002: 42). Lopez Herrera (1978) cites an un-named source placing the Arab captain Ben-Farroukh in Gran Canaria in around 999 AD, establishing a political and trading alliance with the native leader Guanariga in a country that '...flourished in agriculture and other primitive industries' (1978: 94), and this late 1st millennium AD trade potentiality is echoed by Kelley and Boom (1992: 94). Abu Yahya al-Saih is said to have gone to these islands in order to convert the native populations, but further details are lacking (Mederos Martin and Escribano Cobo 2002: 42). The lack of detail is frustrating, and little was recorded about the appearance and traditions of the native populations. However, whatever the nature of the link, there was certainly some contact with the Arab empire as evidenced by (undated) Arabic graffiti on the eastern islands (Betancort 1995) and the appearance of certain Arabic words – including the number four *(arba)* and the name prefix '*Ben*' (son of) – in many contact period male names (Ossorio Acevedo 1996).

The Roman and Arabic references are of limited use to investigations of native Canarian society. While Pliny makes no specific mention of human populations on the islands, it is clear that humans had reached the archipelago by this date. This is demonstrated by the presence of dogs and the name 'Capraria', as goats and dogs are both human commensals and would also be unable to negotiate even the shortest stretch of water between the European/African seaboard without human intervention. This is substantiated by mention of '...traces of buildings' on Planasia (1855: 491) and '...a small temple...built of only a single stone' on Fuerteventura or Lanzarote (assuming that Rackham's identification of "Junonia" is correct). Whether or not the islands were in fact still inhabited at the moment the Romans arrived is uncertain from reading the historical sources, but an indigenous presence has been demonstrated archaeologically through the juxtaposition of Mediterranean and local ceramics on the 2nd century AD

Lanzarote site of El Bebedero (Atoche Pena *et al.* 1995). The Arabic sources suggest the presence of large and relatively complex societies on Gran Canaria at least, but supply few specifics about the people and their customs. It would appear that Arab contact with (and – presumably – influence upon) the Canaries was both limited and sporadic. Anecdotally, the earliest European sources do not suggest a particularly strong Arabic influence, as the Spanish and French forces – some of whom had probably confronted Moorish groups in Southern Europe and the Eastern Mediterranean (during the crusades) – are likely to have commented if the native Canarians bore a strong resemblance to Arabs. Furthermore, a number of traditions forbidden by the Koran were still very much in evidence on at least some of the islands in the 15th century, including consumption of pork (Bontier and le Verrier 1872: 74, 124) the absence of circumcision (da Recco, in Mercer 1980: 155) and the existence of figurative art (Zeuner 1960; Ucko 1960; Atoche Pena *et al.* 2001).

3.3. The Canaries in the Late Mediaeval Period – a Cautionary Note

In the 14th and 15th centuries, the Canaries came under European scrutiny (Tejera Gaspar and Aznar Vallejo 1992: 120), leading to forays and then invasions that were recorded in a series of accounts mainly concerned with military and strategic minutiae. This period is the main non-archaeological source of information about ancient Canarians, and these accounts have become 'the sacred texts of Canarian archaeology' (Atoche Pena 2001: 13). They have been exhaustively analysed since the 1800s in an effort to understand ancient Canarian society (Estevez 1992: 59), although many texts are in fact of questionable value. For example, the texts written by Torriani (1590), Frutuoso (1590), Alonso de Espinosa (1594) and Antonio de Viana (1604, in Martin de Guzman 1984) date to approximately a century after the last island had fallen to the French, and nearly three centuries after the first European forays into the archipelago.

One of the most widely used texts is even later, written by Friar Juan de Abreu de Galindo in 1632 (translated by George Glas in 1764). Additionally, the sporadic reappearance of similar pieces of information in various volumes suggests that facts were borrowed from earlier tomes; one example of this is Abreu de Galindo's reiteration of Espinosa's rather poetic prose style (Hooton 1925: 4). Continual cross-referencing, reiteration and reliance upon lost works all increase the danger of breeding factoids by recycling half-remembered, selective or inaccurate information, and it is therefore appropriate to exercise selectivity in choosing historic sources.

Emphasis is therefore placed on early accounts that have survived in original and unadulterated form, especially those written by da Recco (1341 – recorded in Hooton 1925, Mercer 1980 and Martin de Guzman 1984), and Bontier and le Verrier (written before 1420; 1872 reprint edited by R.H. Major). Relatively little is known about da Recco, other than the fact that he was the leader of a raiding mission despatched by the King of Portugal in 1341. Bontier (or 'Boutier') and le Verrier constituted Jean de Bethencourt's ecclesiastical retinue in the first decade of the 15th century, and wrote a fairly detailed account of the early years of the French conquest of the Canaries. Their obvious interest in the aboriginal Canarians – coupled with the expeditions' early date – makes this the most suitable text for the present purpose. Coverage of the later 15th century is patchy, but includes Azurara (returning to Europe from a slaving mission to the Western Sahara in 1443; see Mercer 1980: 180), Ca Da Mosto (writing in the mid 1450s – in Mercer 1980: 182) and various other minor references (Martin de Guzman 1984: 140).

3.4 Late Mediaeval Canarian History

The first mediaeval reference to the Canary Islands is Lancelotto Malocello's account of his 1336 visit to the island of Lanzarote, which was subsequently named after him. The Atlantic seaboard – including the islands – was beset by numerous slaving missions, such as the Sevillian mission to Lanzarote in 1399 that removed most of the 'royal' family and 170 other islanders (Mercer 1980: 163). In 1341, Niccoloso da Recco described either Lanzarote or Fuerteventura as 'a mass of uncultivated stony land...inhabited by naked men and women...like savages' (in Mercer 1980: 155). On Gran Canaria, they were greeted by large numbers of people wearing '...goatskins dyed saffron [yellow] or red' (Martin de Guzman 1984: 136). In the interior of the island they found stone houses roofed with wood – evidently large enough to contain twenty-five inhabitants – and gardens containing various fruits and cereals. Goats, sheep and 'wild pigs' were also found. The crew plundered several villages and temples, obtaining a range of goods including fat (from goats and seals), goatskins, wood, fish oil, clay, slaves and a stone statue of a naked man from '...a temple without paintings or ornamentation' (Martin de Guzman 1984: 137). The four native male Canarians captured were believed to be nobles, with long blonde hair, average stature ('...they do not exceed us in height' 1984: 137) and robust limbs, wearing skirts made of leather or palm-fronds. Their language did not resemble any of those on board the ship, and was described as '...lively and lilting, like Italian' (1984: 136).

The 1341 voyage triggered a race to exploit the archipelago. Various minor missions, raiding parties and accidental visitors arrived at the islands between 1342 and 1382, but it was not until 1402 that the colonisation began in earnest. The central protagonists were the French soldier and adventurer Gadifer de la Salle and the Norman courtier-landowner Jean de Bethencourt (Mercer 1980: 161). Lanzarote (1403), Fuerteventura

(1405) and Hierro (1405) all fell to the invading forces in the first decade of the 15th century, the remaining four islands falling in the 1480s (Gran Canaria 1483; Gomera 1488) and the 1490s (La Palma 1493; Tenerife 1496).

Lanzarote's population had been severely depleted by slavers prior to the arrival of Bethencourt's expedition in 1402-3. The few (~300) remaining individuals (known as Majos) were living in a polyandrous social system (male/female ratio 3:1) approximating to a chiefdom, dressed in plain skins (males) or leather tunics (females), and reliant upon a diet of barley bread, dairy products and meat (1872: 138). They were overrun, converted to Christianity, enslaved and deported, following a series of unlikely alliances between factions of both natives and invaders as de la Salle, Bethencourt and the Canarians battled for control of the archipelago.

The Fuerteventurans (Majoreros) lived in two main groups administered by separate leaders, and were described as being exceptionally athletic and of considerable stature, with long curly hair, simple leather clothing, flat shoes and an economic reliance upon pastoralism (ibid. 145, 148). They were also '...of a resolute character, very firm in their religion' and highly adept at guerrilla warfare, as the invading French forces were to discover to their cost from October 1403 onwards (ibid. 136). Although Bethencourt – having received royal sanction from Spain and thus successfully outmanoeuvring de la Salle – imported converted Lanzarote soldiers and trained them as archers, an attritional war of over thirteen months was required in order to induce the Fuerteventuran kings to surrender.

After the island fell, Bethencourt subsequently went to Gran Canaria to open trading negotiations with the ruler, en route to the western isles. Following an abortive attempt to storm the island, Bethencourt beat a hasty retreat to La Palma and Hierro in search of slaves. La Palmans (Beni-Hoare [Mercer 1980: 65]) were described as '…a fine people, who only live upon flesh' (Boutier and Le Verrier 1872: 127), although more precise details are lacking. Natives of Hierro (Bimbaches, or Beni-Bashir) are not extensively described in the chronicles, for even in the early 15th century this 'very fine race' had been severely deflated through unrecorded slaving missions (ibid. 123). Their economy was based upon grain, pigs, goats and sheep, and possibly upon the profusion of wild bird and terrestrial animal species also mentioned (ibid. 124). Bethencourt used the king of Hierro's brother – Augeron – to decoy the king and 111 of his retinue to a peace meeting, where they were enslaved. Their homesteads and agricultural lands were distributed amongst Bethencourt's Norman retinue, with their former owners as slave labour (ibid. 184).

The Bethencourt (i.e. Boutier and le Verrier) account ends in 1405, and so does not cover the invasions of Gran Canaria, Tenerife, Gomera or La Palma. Reporting is erratic from this point, and the quality of the information – especially considering that Canarian society had already been affected by the European presence – somewhat questionable. The 1420's to 1460's were characterised by internecine struggles, as Spain, France and Portugal sought administrative rights to the archipelago. The sequence of initial colonisation, settlement and conquest continued at different rates on each island.

Boutier and Le Verrier recorded relatively little about the Gomerans, who were apparently '…a tall people who speak the most remarkable of all the languages of the islands' (ibid. 127), and this may be a reference to the island's unique whistling language. Azurara (1443) described some Gomeran traditions, including their clothing

('...sacks into which men put themselves' Mercer 1980: 182), javelin fights, economy – goats, pigs, barley and wild roots – and casual attitudes towards sex (wives were lent to visitors, for example).

Gran Canaria proved to be more resilient than the smaller and less densely populated islands, and it took from 1461 to 1483 to completely subdue the Gran Canarians (Canarios). Bontier and le Verrier's account from the early days of the 15th century (1872: 130) reports that the native populations were very large, with seemingly complex social structures and a wide-ranging economy. They were tall, dressed in either palm-leaf girdles (males) or leather wraps (females), with long tied-back hair and a tendency to '...print devices on their bodies' (1872: 131). This is in approximate agreement with Bernaldez (1513 [describing a 1483 expedition] in Martin de Guzman 1984: 157), who reported that the Canarians were dressed in goatskin tunics, feathers and leather thongs/belts. Azurara (1451 – in Martin de Guzman 1984: 140-1) noted that Canarian society was governed by a 'king' and a 'duke' in addition to an administrative council – a hereditary elite – of 100-200. Society was highly divisive, as the elite were not permitted to converse with their 'inferiors' while certain groups – such as butchers – were essentially social outcasts. Other traditions such as bride fattening and the ruling elite's seigniorial rights were also noted. Azurara also reported a wide-ranging economy (agriculture, pastoralism and fishing), and that most Gran Canarians were attired in palm-leaf skirts. They used (and even shaved with) stone tools, obtained fire through wood friction, and fought a protracted guerrilla war against the Spanish using stones and staves. Ca Da Mosto substantiated some of these traditions (writing in 1455: in Martin de Guzman 1884: 141) along with further observations on body painting (or possibly tattooing), although much of his account of Gran Canarians focuses upon their considerable physical strength and agility.

On La Palma the population had already been deflated through slaving missions from the 1420s onwards. Boutier and le Verrier's earlier assertion that the La Palmans only lived on meat was not confirmed by Azurara (in Mercer 1980: 194), who claimed that their economy also included wild plants and milk, but not fish. Little other information is available about the islanders themselves, other than their large stature and remarkable physical strength.

Tenerife – the last island to fall to the Spanish – was the most populous and commercially valuable island in the archipelago. The early 1400s account by Boutier and Le Verrier is vague, stating only that the island was '...numerously inhabited by the hardiest race to be found in all these islands' (1872: 129) that had resisted both invasion and slaving missions. Azurara (1443, in Mercer 1980: 197-8) described the native populations (Guanches) as living in huts and caves, subsisting on an economy broadly similar to that of other islands (namely wheat, barley, sheep, goats and pigs) with strongly defined, warring territories that appeared when the overall ruler divided the island into 'menceyatos' and bestowed one upon each of his nine sons (Torriani 1590). The island was seemingly well peopled; the slaver Ca Da Mosto (1454) estimated the population at some 14-15000). The inhabitants dressed in animal skins and anointed their bodies with fat, and are reported to have worshipped a deity (Azurara 1443), celestial bodies (Ca Da Mosto 1454), a Madonna and Child figure washed up on the island in 1390-1400 and/or ancestral chiefs, according to different reports (Mercer 1980: 197). While the native groups enjoyed a series of victories over the unwieldy Spanish cavalry early in the campaign, their resistance was unexpectedly weakened by an unidentified 'plague' that decimated the Guanches and led to a series of defeats. The four Guanche chiefs eventually surrendered to the Spanish in September 1496.

3.4.1 'the sacred texts of Canarian archaeology'

These historical references have enjoyed a prominent role in reconstructions of ancient Canarian lifestyle. As with all such texts, however, it is important to ensure that inferences cast by contact-period histories are not automatically assumed to be representative of the Canarians throughout their history, as denying the past the potential to be substantially different from the time at which the histories were recorded has long been a problem in island archaeology (Broodbank 2000: 15). Calculations were carried out for the Canaries, taking the ballpark figure of 500 BC for first human habitation (Onrubia Pintado 1987; del Arco Aguilar *et al.* 1992: 74; Navarro Mederos 2001) and records kept by Bethencourt's retinue as the first available detailed historical source (disregarding the rather vague Roman references). All the historical information we possess therefore comes from a period lasting from 1402 to the Guanches' defeat in 1496, which constitutes only 4.7% of Canarian occupational history. It should be considered that recent discoveries by Zoller *et al.* (2003) may push back the date of initial colonisation to between 5,000 and 10,000 BP, so the amount of time covered by the histories would constitute between only 1.8% (5,000 BP) and 0.9% (10,000 BP) of Canarian human history (this early date is yet to be conclusively proven). In either case, however, it is clear that only the most tentative conclusions about ancient Canarian society can be drawn from the records of its destruction.

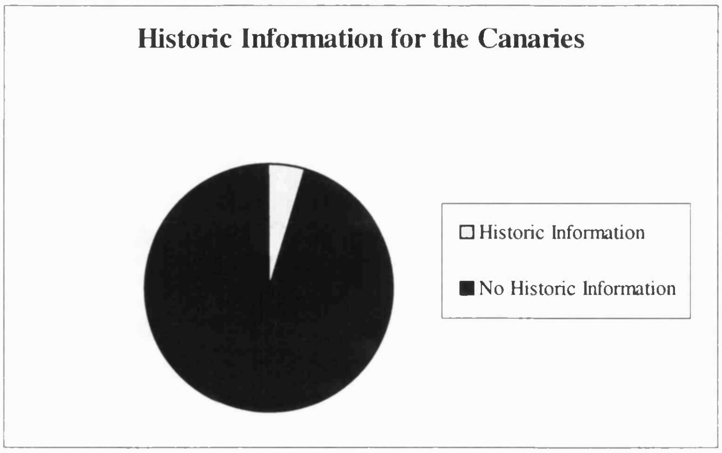

Figure 3.1. Proportion of Time Covered by Historical Sources in the Canaries

Chronological issues aside, the potentially misleading nature of historical sources should also be considered. None of the early historians were in any way dispassionate about their observations, and their frequent disdain for islanders' habits and customs may have induced them into exaggeration or misreporting. For example, it has been suggested that the Spanish and French chroniclers deliberately emphasised what they believed to be characteristics of cultural impoverishment in the Canarians, so as to '...justify the Castilian annexation, presenting it as a civilizing favour given by the Europeans' (Morales Mateos 2003: 2) The extent to which interference by Europeans may have affected islander behaviour is also relevant; it is likely that the smaller islands were particularly vulnerable to this, as population deflation occurred very quickly, often before the arrival of accomplished chroniclers. This aside, one should also consider the slaving missions that are known to have taken place but whose authors left no record of their activities (see Bontier and le Verrier 1872: 74, 75 and 123; Mercer 1980: 157-8). It is likely that the population decline and the inevitable social changes thus wrought would have significantly altered various aspects of human society on the islands, even as the first accounts were being written. Anything recorded about the Native Canarians from the early 16th century onwards is particularly suspect, as this was the period that saw the extinction of the Canary Islanders as a biocultural entity. In 1541 Girolamo Benzoni met one of the last Canary Islanders to have lived through the conquests. A La Palman man then in his 80s, he was establishing the sorry precedent of degradation and alcoholism that went on to define numerous aboriginal societies in the wake of Europe's burgeoning thallasocracies (Mercer 1980: 237). The validity of accounts concerning traditional Canarian life that were rendered by the few survivors, or their descendants, is therefore questionable at best. In summary, therefore, it should be noted that written histories of islands – while useful – should not be permitted to eclipse other avenues of investigation. So long as the prehistory/history dichotomy on the basis of the written word is avoided, there is no obstacle to accessing island 'history', of all periods, through the media of archaeology, physical anthropology or any other technique that assists in the search.

3.5 History of Archaeology in the Canary Islands

The development of Canarian archaeology and allied disciplines has profound implications for subsequent studies of archaeologically derived materials. Excavation methods determine the nature and condition of the material recovered. If collections rely primarily upon collected material – donated to the museum rather than being recovered from archaeological excavations – this necessarily constrains the level of information that can be derived from the remains. Equally, early excavations were often very unsystematic, thus affecting representation of elements, artefacts and all recovered material. Finally, the first work done on the material determines the intellectual climate, and – to a certain extent – defines future work. The development of Canarian archaeology must be considered in the light of socio-political and intellectual developments in mainland Spain, while taking into account the archipelago's geographical position and politics. A fuller coverage of these issues than is possible here can be derived from Mercer (1980), del Arco Aguilar *et al.* (1992), Tejera Gaspar (1992), Nowak (1994), Eddy (1995) and Martinez Navarrete (2001).

18th century interest in the archipelago was restricted to the collections of curiosities that are the basis of many modern Canarian museums. Intellectual approaches to pre-conquest Canarian history do not appear until the 19th century with Berthelot's *Antiquites Canariennes* (1879), followed by the development of institutions dedicated to investigating ancient Canarian lifestyle through historical sources (see above) and the collection/excavation of archaeological artefacts (Martinez Navarrete 2001: 1197) and human remains (some of which have since been dated and included in the present project). The 'gentleman archaeologist' approach persevered into the 20th century, leading to the unrecorded destruction of numerous sites. Spatial variability in material culture was explained in diffusionist terms, involving various 'obscure migrations' (Diego Cuscoy 1953: 15) determined by 'geographic fatalism' (Diego Cuscoy 1953: 31-2) and resulting in a panoply of genetically defined cultural groups both between and within islands (including a 'pure Neolithic' tradition on Tenerife and Gomera and two distinct groups – cave dwellers and cabin-dwellers – on La Palma). Excavation methods were primitive, and many of the remains collected during this period often have no context beyond area, or even island.

The late 20th century saw increased scientific input, radiometric dating and improved excavation techniques. Methodologies were also improved, with major projects such as Atoche Pena *et al.*'s (1995) careful excavation and analysis of El Bebedero (Lanzarote), Alberto Barroso *et al.*'s intra-site spatial analysis on Tenerife (1997) and Hernandez Perez's site report on the La Palma site of Belmaco (1999), along with numerous biological anthropology studies using methods ranging from protein analysis (Aufderheide *et al.* 1992a) to craniometry (Schwidetzky 1963) dental non-metrics (Bermudez de Castro 1985), diet (Delgado Darias 2001) and pathology (Rodriguez Martin 1992). However, most publications concerning prehispanic Canarians discuss isolated artefacts/human remains as reports (substantiated by discussions based primarily on historical information – see above) that are very island/area specific. This tendency to see the Canaries as seven individual entities rather than a potentially cohesive islandscape, while the continuing lack of protection for archaeological sites, amateur collecting, irregular island coverage and the absence of adequate temporo-spatial frameworks have all hampered the development of Canarian archaeology.

3.6 Canarian Chronology and Cultural Dynamics

It has been repeatedly claimed that ancient Canarians had a '...manifestly conservative character' (Luis Diego Cuscoy 1968a: 212, in del Arco Aguilar 1998), that their society and culture was caught in '...a Neolithic time warp' (Spence 2000: 1) and that '...the ethnobiological picture that they possessed in the 6th, 7th, 9th or 11th centuries is the same as when they arrived on the island and the same that was found by the Conquistadors in the 15th century' (Luis Diego Cuscoy 1968: 212, in del Arco Aguilar 1998). This assumption that contact-period Canarians are a convenient reflection of their antecedents is unproven, intellectually stifling, and threatens to impede methodological innovation as well as the development of Canarian archaeology as a discipline. It is therefore extremely important that chronometric information be sought for the archipelago, to enable the construction of adequate spatio-temporal networks and provide a much-needed time-depth perspective to Canarian archaeology.

There are several indications suggesting that Canarian culture was both spatially and temporally variable, and this is true both historically and archaeologically. To take a few text-derived examples for the contact period, the 'Menceyato' system of government and accompanying ancestor worship on Tenerife only appeared in the early/mid 15th century, as the previous system had seen the island ruled by a single leader (Mercer 1980: 197). Gran Canarians are reported to have netted fish in the first decade of the 15th century, but were using fishhooks (made from Spanish metal) by 1443. The Spanish were taken aback in 1468 when they attempted to invade Gran Canaria and were attacked by islanders wielding exact wooden copies of European metal weapons, left behind in an earlier raid (Mercer 1980: 186). Another example is the cult that sprang up around the Virgin and Child figure washed up on Tenerife in

1390-1400, as this is clearly outside the remit of ritual behaviour (such as the worship of celestial bodies) observed by Azurara and others.

Archaeological signatures also support behavioural dynamism, such as the clear cultural discontinuities in the ceramic traditions at El Bebedero (Atoche Pena *et al.* 1995), inter-period differences in burial practices on Lanzarote, Tenerife and Gran Canaria, and the major discontinuities in ceramic traditions on La Palma (Navarro Mederos 1998). Economic variability is also notable, such as the differences in economic signatures between the islands and inland/coastal sites (La Palma – Pais Pais 1996), sites hinting at over-exploitation of natural resources by a steady decrease in the size of gathered limpets through time at the La Palma site of El Tendal (Pais Pais 1996) and differing prevalence of external auditory exostoses (bony ear pathology caused by cold-water exposure, implying diving/swimming) between two major sites of different periods in Gran Canaria (Betancor Rodriguez and Velasco Vazquez 1998; personal observation). The significance of these indicators is certainly open to debate, but it would seem that the potential for understanding human history in the Canary Islands has not been fully exploited, as all archaeological phenomena pre-dating the 14th/15th centuries AD are usually 'lumped' into a single category without thought for the potential dynamics of Native Canarians throughout at least two millennia.

Finally, reliable dating – and appropriate utilisation of the information thereby derived – will enable the Canarians to be considered against the global range of ancient island societies. This provides a basis for assessing human adaptation and environmental impact, allowing us to establish whether Canarian society resembled the isolated, ancient and carefully balanced ecological adaptation of Australian aborigines, the shorter-term marginal sustainability of agricultural societies in the Eastern

Mediterranean (e.g. the Cyclades) or the ecological devastation and resulting social instability wrought by the relatively recent arrivals to New Zealand and Rapa Nui.

3.6.1. Dating: Problems with Materials, Coverage and Philosophy

Most Canarian (cave) sites have low levels of sedimentation (Hooton 1925: 358; Mercer 1980), and artefacts were 'gathered' rather than excavated from the 18th to the 20th centuries; relative dating systems are therefore virtually unknown for the Canaries. Even the most comprehensive available chronologies are essentially educated guesswork, as the few well-excavated sites with coherent sequences are rarely backed up by adequate radiometric evidence. This is problematic, as elucidating the details of Canarian human occupation – beyond simple inter-island comparisons (Navarro Mederos 1999) – will only achieve high levels of refinement if considered chronologically.

Radiometric evidence for pre-conquest Canarian sites is both sparse and unevenly distributed. There is a strong bias towards Gran Canaria and Tenerife, while the chronology of the other islands has been described as '...the great unknown' (del Arco Aguilar *et al.* 1992: 151). Table 3.1 provides the number of dates derived per island, and the number of sites that have been dated radiometrically.

Island	Dates	Sites Dated
Lanzarote	6	2
Fuerteventura	1	1
Gran Canaria	36	12
Tenerife	79	41
Gomera	1	1
La Palma	18	4
Hierro	7	3

Table 3.1. Number of Dates and Dated Sites for the Canarian Archipelago

Flagship sites also receive disproportionate attention. For example, over half of Gran Canarian dates pertain to a single site (Painted Cave, Galdar), while almost two-thirds of Tenerife's determinations relate to two large sites (Las Palomas and Roque Blanco) and over two thirds of La Palman dates pertain to the sites of Belmaco and Guinchos. Flamboyant sites are therefore over-researched, whereas smaller, less impressive settlements – vital in providing information about human mobility, land-use and other aspects of behaviour – are disregarded. In Lanzarote, only some 3% of known sites have been excavated, of which only 0.4% have been dated radiometrically (n=1 – de Balmin Behrmann *et al.* 1987: Atoche Pena *et al.* 1995).

Even where radiometric data does exist, it does not necessarily affect research agendas. Many major texts contain no radiometric information, include dates without applying them to the data, or otherwise fail to recognise the importance of temporal change and chronological issues. While this is not unreasonable in early works – when such information was not available – the tradition is still extant in major works as well as shorter reports, papers and textbooks. The reasons behind this are not clear, although it is possible that the emphasis on dichotomising history and prehistory at the point of European contact has overshadowed the importance of temporal variability in pre-conquest human behaviour, so that archaeology invariably plays a secondary role to history (Rodriguez Santana 1996: 446).

3.6.2 The Radiometric Evidence

Radiometric determinations for the archipelago are presented in tables 3.2 to 3.8. All dates are derived from information published between 1970 and 2003, and were compiled by the author. Site name, uncalibrated bp date, calibrated BC/AD dates and 2 sigma (2Σ) ranges have been provided where available. Laboratory references have been given where available, but if this was not provided the reference for the original article citing the date has been given. Consistency of reporting has been affected by the irregular manner in which the data was reported in the original publications. It should be noted that while this list is fairly comprehensive, some dates may inadvertently have been omitted. It is possible that other sites have been dated, but research articles are usually published in local journals, which typically have a very restricted distribution and effectively limit the spread of information. Most dates are C-14 determinations, except for two volcanological dates for Las Fuentes and Zanata (Tenerife) provided by del Arco Aguilar *et al.* (1997), an IRSL (luminescence) date range by Zoller *et al.* (2003) for a very early site on Lanzarote and a single palaeomagnetism date provided by Soler *et al.* (1987) for Roque de la Guerra (La Palma). Sources for tables 3.2 to 3.8 are as follows: Soler *et al.* (1987a); Museo Canario (unpublished material); Diego Cuscoy and Galand 1975; Instituto Espanol de Prehistoria (IEP) report 1978; del Arco Aguilar *et al.* 1992; Meco Cabrera 1992; del Arco Aguilar *et al.* 1997; Atoche Pena *et al.* 1995; Hernandez Perez 1999; Jimenez Gonzalez 1999; Mederos Martin and Escribano Cobo 2002. Tables are by island, arranged in E-W order. This is the most comprehensive review of dating-related material so far assembled for the Canarian archipelago.

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
Guatiza (IRSL Section)	-	-	-	3050-8050 BC	Zoller *et al.* 2003
El Bebedero 3	90	1635	420 AD	231-625 AD	GrN-19192/?
El Bebedero 4 – 5	60	1950	70 AD	50 BC-224 AD	GrN-15762/?
El Bebedero 4 (Base)	30	1840	215 AD	89-312 AD	GrN-15804/?
El Bebedero 4	140	1980	-	368 BC-382 AD	GrN-19194/?
El Bebedero 4	120	1895	120 AD	169 BC-414 AD	GrN-19195/?

Table 3.2. – Radiometric dating Evidence for Lanzarote

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
Villaverde	50	1070	-	-	Meco 1992
Villaverde II	50	1730	268/274/334 AD	219-425 AD	CSIC-556/C

Table 3.3. Radiometric Dating Evidence for Fuerteventura. Only 1/14 Fuerteventuran dates refers to human occupation layers at Villaverde. An unsubstantiated date from Meco Cabrera (1992) has been included for the purpose of comparison.

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
Arteara	-	-	-	3rd Century BC	Arco Aguilar *et al.*
Caserones Hse. 3	150	1890	120 AD	198BC-446AD	GAK-8064/M
Caserones House 4	-	730	-	-	Arco Aguilar *et al.*
Caserones House 4	-	980	-	-	Arco Aguilar *et al.*
Hormiguero	90	1740	260-330 AD	82-538 AD	GAK-8507H
Lomos Granados	100	1700	380 AD	118-597 AD	GAK-13035/M
Cuevas del Rey	60	1665	-	-	IEP 1978
Acusa	45	1520	-	-	IEP 1978
Acusa	60	1380	-	-	IEP 1978
Guayadeque	60	1410	-	-	IEP 1978
Guayadeque*	60	1120	-	-	IEP 1978
Majada de Altabaca	50	1180	-	-	J-Gonzalez 1999
Majada de Altabaca	50	700	-	-	J-Gonzalez 1999
El Roque, Guayedra	50	1180	-	-	J-Gonzalez 1999
Agaete (Malpais)	40	950	-	-	IEP 1978
La Guancha	60	875	-	-	IEP 1978
El Pajar	-	1470	-	-	Museo Canario
La Restinga	-	1030	-	-	Museo Canario
Ermita de San Anton X	70	920	-	1030 AD	SA99D2XI
Ermita de San Anton IX	50	750	-	1180 AD	SA99D1IX
Painted Cave CPG-10	100	1400	424 AD	423-869 AD**	LGQ-518
Painted Cave CPG-11	50	1310	647 AD	95 % interval	Gif-8870
Painted Cave CPG-12	50	1370	584 AD	95 % interval	Gif-8871
Painted Cave CPG-13	40	1380	601 AD	95 % interval	Gif-8872
Painted Cave CPG-14	60	1360	575 AD	95 % interval	Gif-8873
Painted Cave CPG-15	50	1140	775 AD	95 % interval	Gif-8874
Painted Cave CPG-16	70	1375	537 AD	95 % interval	Gif-8875
Painted Cave CPG-17	40	850	1051 AD	95 % interval	Gif-8876
Painted Cave CPG-18	50	1410	552 AD	95 % interval	Gif-8877
Painted Cave CPG-19	40	1440	549 AD	95 % interval	Gif-8878
Painted Cave CPG-20	110	1340	470 AD	95 % interval	Gif-8879
Painted Cave CPG-21	40	1120	811 AD	95 % interval	Gif-8880
Painted Cave CPG-22	30	1150	798 AD	95 % interval	Gif-8881
Painted Cave CPG-23	60	300	1465 AD	95 % interval	Gif-8882
Painted Cave CPG-24	90	915	950 AD	95 % interval	Gif-8883
Painted Cave CPG-25	50	1230	683 AD	95 % interval	Gif-8884
Painted Cave CPG-26	40	1270	673 AD	95 % interval	Gif-8885
Painted Cave CPG-27	40	1190	719 AD	95 % interval	Gif-8886
Painted Cave CPG-28	50	1270	668 AD	95 % interval	Gif-8887
Painted Cave CPG-29	50	1040	895 AD	95 % interval	Gif-8888
Painted Cave CPG-30	50	720	1213 AD	95 % interval	Gif-8889

Table 3.4. Radiometric Dating Evidence for Gran Canaria. *Jimenez Gonzalez (1999: 81) gives this date as 1220 +/- 60 BP.** Calibrated date from Jimenez Gonzalez 1997: 85

Site	+/-	BP	Range	(Lab.) Ref.
Los Cabezazos Level 2	45	1450 **	-	KN-601
Los Cabezazos Level 3	50	1450 **	-	KN-602
Los Cabezazos Lower Level	60	1280	-	CSIC-147
La Enladrillada	50	800	-	Del Arco *et al.* 1997
La Enladrillada	75	735	-	Del Arco *et al.* 1997
Los Guanches, Tegueste	81	2150	-	GX-18746
Los Guanches, Tegueste	65	2185	-	GX-19702
La Palmita (Palmilla)	110	1040	-	Del Arco *et al.* 1997
Risco de los Guanches	80	2150	-	GX-15960
Risco de los Guanches	65	2185	-	GX-15961
Risco del Perro	70	1005	-	GX-18741
La Florida	86	1260	-	GX-18742
Roque Blanco	70	1260	-	T-195
Roque Blanco	120	1380	-	T-195B
Roque Blanco	80	1230	-	T-195A
Roque Blanco	180	110	-	GX-15947
Roque Blanco	75	885	-	GX-15948
Roque Blanco	165	765	-	GX-15949
Roque Blanco	75	1065	-	GX-15950
Roque Blanco	135	665	-	GX-15951
Roque Blanco	95	755	-	GX-15955
Los Barros	90	910	-	E.II/GrN-13756
Quiquira	90	210	-	E.I/GrN-13755
Hoya Brunco	110	930	-	M-1055
Hoya Brunco*	100	780	-	M-1054
El Masape	77	636	-	GX-18743
Don Gaspar	80	1750	-	E.III/Gak-8066
Don Gaspar	110	1390	-	E.II/Gak-8067
Las Palomas Level VI	90	2200	-	Gak-15980
Las Palomas Level VI	140	1290	-	Gak-13089
Las Palomas Level IV	190	2010	-	Gak-13084
Las Palomas Level IV	100	2040	-	Gak-13088
Las Palomas Level III	160	960	-	Gak-15979
Las Palomas Level III	60	180	-	Gak-15973
Las Palomas Level III	230	6890	-	Gak-15976
Las Palomas Level II	120	2200	-	Gak-13087
Las Palomas Level II	70	1500	-	Gak-15974
Las Palomas Level II	140	1450	-	Gak-13083
Las Palomas Level II	120	1310	-	Gak-13086
Las Palomas Level II	70	950	-	Gak-15975
Las Palomas Level II	80	380	-	Gak-13085
Las Palomas Level II	730	5550	-	Gak-15977
Las Palomas Level II	690	5800	-	Gak-15978
Los Guanches (Icod) Level VII	160	2770	-	Gak-14599
Los Guanches (Icod) Level II	260	1720	-	Gak-14598
Los Guanches (Icod) Level XII	250	1700	-	Gak-14601
Los Guanches (Icod) Level XI	80	2400	-	Gak-14600
Las Fuentes	-	-	13th-14th C. AD	Del Arco *et al.* 1997
Zanata	-	-	5th-9th C. AD	Del Arco *et al.* 1997
Anaga	120	645	-	GX-15953
Bco. De Santos	83	580	-	GX-18744
Costa Hoya Fria	83	938	-	GX-18745

Table 3.5. Radiometric Dating Evidence for Tenerife. * - This sample is cited as being from both La Guancha (IEP 1978) and for Hoya Brunco (del Arco *et al.* 1997). ** - KN601 and KN 602 are dated to 1450 AD +/- 45 and 1450 AD +/- 50 respectively in del Arco Aguilar *et al* 1997, but both are dated to 1350 +/- 45 AD in the IEP report (1978). Both are referenced to the same author (Diego Cuscoy 1975).

Site	+/-	BP	2Σ Range	(Lab.) Ref.
El Chorrillo	81	693	-	GX-18748
Bco. Jagua	130	1465	-	GX-15958
Araya	128	745	-	GX-15945
Igueste	120	615	-	GX-15954
Malpais de la Candelaria	77	817	-	GX-18747
La Arena (I)	60	1800	-	CSIC-187/C
La Arena (III)	60	1970	-	CSIC-188/C
La Arena (IV)	60	2490	-	CSIC-189/C
Guargacho Level III	60	1260	-	CSIC-168
Uchova	72	1246	-	GX-18739
Barranco Pilon	165	795	-	GX-15946
Barranco del Infierno	51	670	-	GX-19697
Retamar/Ucazme	52	421	-	GX-19700
Adeje	120	595	-	GX-15952
Majagora	81	1092	-	GX-18740
Majagora	53	1278	-	GX-19693
Guia de Isora	70	540	-	GX-15962
Chafari, Las Canadas	-	-	12th-14th C. AD	Del Arco *et al.* 1997
Funerary Cave	75	1065	-	GX-15956
Funerary Cave	75	1155	-	GX-15957
Funerary Cave	80	2030	-	GX-15963
Funerary Cave	80	1900	-	GX-15964
Las Estacas Level II	60	2210	393-66BC	Beta-127.932
Las Estacas	70	1800	74-413 AD	Beta-127.931
Barranco Hondo @	60	1800	-	CSIC-187
Barranco Hondo @	60	1970	-	CSIC-188
Barranco Hondo @	60	2490	-	CSIC-189
RED-1 (Mummy)	80	1380	490-650 AD	Horne/Aufderheide 1992
Cueva del Tendal II	81	793	-	MAD-237
Cueva del Tendal II	87	951	-	MAD-236
Cueva del Tendal XV	97	921	-	MAD-237D
Cueva del Tendal XV	98	1049	-	TL-33
Cueva del Tendal VB	170	1875	-	MAD-371
Cueva del Tendal XXIX	209	2162	-	MAD-234
Cueva del Tendal XXX	180	2115	-	TL-37

Radiometric Dating Evidence for Tenerife (table 3.5. contd.).@ - These three dates are suspicious in that they are identical to those obtained for La Arena I, II and IV, which also have almost identical sample numbers. However, they have been included for the purpose of reference.

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
Fortaleza de Chipude	60	1480	600	436-666 AD	CSIC-195

Table 3.6. Radiometric Dating Evidence for La Gomera

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
La Lajura	60	1830	-	60-180 AD	Beta 128885
La Lajura	60	1740	-	150-270 AD	Beta 128884
La Lajura	-	1220	-	730 +/- 40 AD	Beta 128883
Area de el Golfo	-	1630	423 AD	412-436 AD	Martin/Cobo 2002
Area de el Golfo	-	1480	605 AD	565-625 AD	Martin/Cobo 2002
Hoyo de los Muertos	60	1200	-	-	CSIC 145
Hoyo de los Muertos **	60	1050	-	-	CSIC 144
Los Juaclos	-	-	-	3rd Century AD	Aguilar *et al.* 1992
Guinea	-	-	-	3rd Century AD	Aguilar *et al.* 1992

Table 3.7. Radiometric Dating Evidence for El Hierro. ** Based on charred pine board with Libyco-Berber inscription (Diego Cuscoy and Galand 1975).

Site	+/-	BP	Cal.	2Σ Range	(Lab.) Ref.
Cueva de la Palmera (IIIa)	90	2190	200 BC	401 BC-6 AD	GrN-13.753.M
Tendal (Level 5a Phase 1)	35	1650	415 AD	337-533 AD	GrN-13.663/C
Tendal (Level 5a Phase 1)	50	1590	445 AD	387-602 AD	GrN-13.665/C
Tendal (Level 4 Phase 2)	30	1605	435 AD	404-544 AD	GrN-13.661/C
Tendal (Level 3 Phase 2-3a)	50	1475	607 AD	461-662 AD	GrN-13.664/C
Tendal (Level 2 Phase 3)	70	1270	730/770 AD	650-956 AD	GrN-13662/C
Belmaco (Level 4 Phase 2) #	90	1320	680 AD	594-942 AD	GAK-8054/C
Belmaco (Level 4 Phase 2)	70	1150	890 AD	709-1020 AD	CSIC-257/C
Belmaco (Level 4 Phase 2)	70	1070	990 AD	818-1156 AD	CSIC-256/C
Belmaco (Level 3 Phase 3)	100	1160	890 AD	664-1037 AD	GAK-8053/C
Belmaco (Level 3 Phase 3) ***	50	980	1028 AD	982-1180 AD	CSIC-225/C
Belmaco (Level 1 Phase 4)	120	970	1030 AD	819-1286 AD	GAK-8052/C
Belmaco (Level 1 Phase 4)	70	930	1050-1160 AD	988-1275 AD	CSIC-254/C
Guinchos (Level 4) *	70	700	-	-	CSIC-193
Guinchos (Base Level 4) *	70	670	-	-	CSIC-191
Guinchos (Mid-low Level 3) *	70	600	-	-	CSIC-194
Guinchos (Mid/low Level 2) *	70	370	-	-	CSIC-190
Guinchos (Final Phase) *	70	260	-	-	CSIC-192
Roque de la Guerra **	-	-	-	50-100 AD	Soler *et al.* 1987

Table 3.8. Radiometric Dating Evidence for La Palma. * Soler *et al.* (1987) state that CSIC 190-194 are from Cueva del Humo, not Cueva de los Guinchos. ** The Soler *et al.* (1987) date is based upon palaeomagnetism; the authors are dissatisfied re its accuracy. *** This is given as CSIC 255 by Hernandez Perez 1999: 64. The date is the same. # This is listed as CSIC-257bp by Hernandez Perez 1999: 64. The date is the same.

3.6.3 Implications of the Dating Evidence

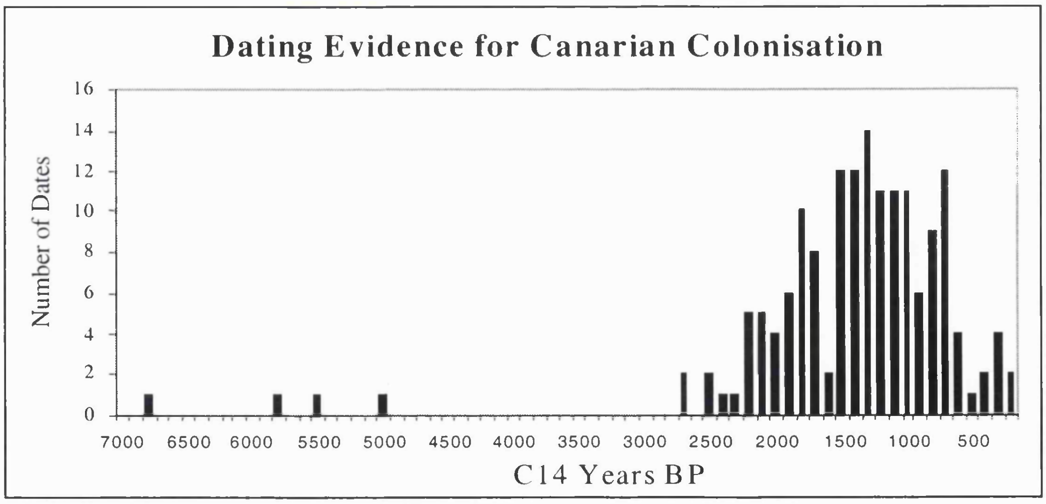

Figure 3.2. Dating Evidence for Canarian Colonisation

There is considerable controversy over the very early dates for the Canarian archipelago. Some of the very early dates for the archipelago (including Las Palomas, Tenerife, at 5500-6890 BP) were originally believed to have been derived from contaminated samples. The only independent verification of such an early colonisation event was the replacement of Fuerteventura's 'Lava Mouse' by the house mouse around

5,000BC (Castillo *et al.* 2001: 289-290), but while the species is certainly a human commensal, non-anthropogenic colonisation was also a possibility. However, suspicions of a very early human presence were recently confirmed by the discovery of goat bones dated to between 5,000 and 10,000 BP (Zoller *et al.* 2003) on Lanzarote, which – as goats could not have travelled to the islands unaided – are incontrovertible proof that humans visited the island at some point during this period. However, the discovery of donkey remains in the same horizon (Zoller Pers. Comm.) has cast doubt on these dates, given what is currently known about equid evolution in the Mediterranean region (Grigson 1993). Dating resolution of the very earliest Canarian landfalls is currently fairly poor, pending further luminescence work by Zoller and associates. However, we now know that while the Canarian chronology is not directly comparable with the 'deep time' chronologies of Melanesia and Australia (Smith 1995; Flannery 1994), it bears strong resemblances to landfall dates for various island societies in the Mediterranean and elsewhere (such as the Pitiussae [Bellard 1995]). While there is evidence of a human presence fairly early on, however, the very long hiatus between the early dates (derived primarily from IRSL and palaeontological profiles of human commensals) and well-dated, recognisable evidence of human settlement (late 1st millennium BC) is more puzzling. If Zoller *et al*'s dates are correct (2003), it may be that initial landfall and exploration was a tentative affair, with minimal colonisation of the new lands until later influxes and internal growth swelled the population, or, alternatively, that early settlers could not come to terms with the Canarian environment, resulting in colonisation failure. While the exact placing of the dates is unclear, it seems that the appearance of goats in the sedimentological section in Lanzarote resulted in considerable ecological damage (Zoller *et al.* 2003: 1305). If this devastation was very early (as claimed by Zoller *et al.*) it may have affected the rate of the human colonisation, as human groups may have perished or possibly abandoned the island, leaving the goats to their own destructive devices. The further implications for seafaring behaviour are discussed further in section 3.12.

The general trend is towards a low prevalence of dates prior to the BC/AD boundary (9%), then a rise up to 500AD (24%), a further rise up to 1000AD (42%), followed by a drop-off until 1500AD (25%). There is some variability between islands, although it is possible that this is an artefact of unequal coverage. Increased numbers of dates indicate both higher numbers of sites, and also larger sites (with various strata being tested individually). Although three categories – early <500AD; middle 501-1000 AD and late 1001-1500AD – were established in order to test the dental data for temporal trends, I advocate a fourth category of 'initial' human contact with the archipelago. The age range of this category is uncertain, although future finds and analyses will no doubt elucidate the details of the early contact process. When the dates were considered in more detail, and using the range trichotomy, the following trends are apparent: 1-500AD saw increased levels of activity, judging from superimposed horizons and cultural tradition change at El Bebedero on Lanzarote (Atoche Pena 1995), large burial sites in Hierro (La Lajura – human remains currently unavailable for study) and probably other sites that are currently undated. Some large and complex sites noted for Gran Canaria and Tenerife (including Gran Canaria's 'Painted Cave' site), and these two islands account for 57% of all sites during this period. Sparse occupation has also been noted for Villaverde Cave (Fuerteventura) and El Tendal (La Palma). The middle period (501 – 1000 AD) possesses almost twice as many dates as observed for the early phase, accounting for 42% of all Canarian dates. Large funerary (Guayadeque) and ritual (Painted Cave) sites on Gran Canaria, large funerary cave sites on Tenerife (Roque Blanco), Hierro and Gomera, along with continued habitation at El Tendal and El Belmaco (La Palma) and Villaverde (Fuerteventura) all pertain to the middle period.

A script on a funerary plank from El Hierro (one of the few inscriptions than can be dated) indicates some link with Libyco-Berberic groups. The late period (1001 AD – 1500 AD) sees a drop-off in site numbers in Tenerife and Gran Canaria, and some dates from La Palma. There was a cessation of activity at the ritual Painted Cave site (Gran Canaria), and further development of the Los Caserones habitation site. There was a continuation of funerary activity at Roque Blanco and Costa Hoya Fria (Tenerife) and probably Guayadeque (Gran Canaria). Habitation continued at Belmaco (La Palma), with many small sites known from Gran Canaria and Tenerife.

3.7 The Archaeological Evidence of Canarian Society

While desirable, an in-depth summary of Canarian material culture prior to the 14th century AD is impractical in light of this thesis's stated purpose. The Canarian archaeological record supports assertions of both cultural homogeneity and heterogeneity, for while some or all of the islands are linked by generalities (such as lack of metals, plain/slightly decorated ceramics and mummification), they are distinguished by specifics (including 'art and ritual' artefacts, mummification methods and extravagantly decorated ceramics) that seem to suggest higher levels of cultural diversity within the archipelago.

3.7.1 Settlement

Canarian populations of the contact period seem to have been structured approximately along the lines of chiefdoms, with 'kings' and ruling elites controlling individual areas. These were sometimes determined by ancestry (Tenerife) or by wealth (La Palma). Territories varied in size and number, and have been taken from Mercer (1980) and Bernaldez (1513: in Martin de Guzman 1984: 157); their areas have been calculated using the area figures from chapter 2.

Island	No. of Menceyatos	Mean Area
Lanzarote	1	800km^2
Fuerteventura	2	850km^2
Gran Canaria	1 (2?)	1444km^2 /722km^2
Tenerife	9	233 km^2
Gomera	4	100 km^2
La Palma	10	50km^2
Hierro	1	350 km^2

Table 3.9. Political Structures in the Contact-Period Canarian Archipelago

There was some variation in social structures, however, as Azurara (in Hooton 1925: 49) noted that Gran Canaria was governed by '...two kings and a duke' who were elected to their posts, in addition to two hundred 'knights' from a hereditary ruling class. La Palmans were more egalitarian, electing the richest (most sheep and goats) man in any one area as chief, while Gomerans ruled with a king and council, which Mercer interprets as evidence of a recently reunited island (1980: 182). Contact-period settlements are not usually described in detail. Small hamlets based on perhaps 5-10 family units are alluded to on Lanzarote and Fuerteventura, while group sizes on Gran Canaria and Tenerife seem to suggest rather larger settlements – perhaps of village size – based around clusters of stone-built structures (in scattered or conjoined form, or grouped into 'streets' – Atoche Pena and Ramirez Rodriguez 2001: 87) as well as caves. The western islands seem to have been settled in a manner similar to Lanzarote/Fuerteventura, with references to single individuals, small settlements and groups (extended families?) living predominantly in caves. The nature of earlier (i.e. archaeological) settlement patterns is equivocal, as sequencing of sites is currently impossible. Settlement sites include fortified summits, advanced cave dwellings, sunken houses, communal corrals, hollow cairns, granaries and cross-plan houses (dry-stone houses with cruciform, circular or quadrangular interiors and circular/oval exteriors). However, the vast majority of secular structures were simple caves, huts and corrals (Mercer 1980: 101). Large caves – possibly multi-period – are especially common on

Tenerife, while Gran Canarians often lived in complexes of natural and artificial caves (as well as in stone-built villages) that mainly date to the middle period (500-1000AD). Large caves – possible multi-period – are known from Tenerife, while cave complexes and clusters of artificial structures are more common on Gran Canaria. Caves and artificial structures sometimes appear to have been used for ritual purposes, notably the painted artificial caves at Galdar (Gran Canaria), and possibly the 'pyramids' of Guimar, Tenerife (although doubts have been expressed as to their age). The temporal trends are equivocal. However, it would not seem that the ancient Canarians were ever urbanised. The number of small, transient sites seems to suggest that village communities – or sections thereof – were sporadically mobile, perhaps living in a seasonal round or moving between resource catchments. The preponderance of sites were situated on or near the coast, with clusters of sites along water courses and near natural wells (if present).

3.7.2 Population Size of Pre-Conquest Canarian Groups

Population size in the pre-conquest period can only be crudely estimated. This is due to the low number of dated sites and the problems of distinguishing between spatial and temporal variability in population size indicators. However, it is possible to make rough estimates of population size at the time of European forays into the archipelago, using a combination of historical observations and extrapolation.

In general terms, the two large islands of the central archipelago were densely populated in the contact period, with sparser settlement in the drier islands towards the east and intermediate density in the small, wet, western islands. However, elucidating details about population size have been complicated by native Canarian social traditions, inadequate (or intentionally biased) historical reporting and population deflation through slavery. Calculations based on historical reports were carried out in order to produce general estimates of population size in the contact period, taking varying social and demographic factors into account. These results are shown in table 3.10 and are discussed below.

	Contact #1	Contact #2	Azurara	Azurara Revised	1590	1733
Lanz.	687-773	1000	360	240	1000	5184
Fuert.	980-1117	1500	480	320	1400	7498
GC	25000	12000	30000	20000	10000	30710
Ten.	30000	15000	36000	24000	21000	58618
Gom.	3500	3000	4200	2800	1600	4539
Pal.	2500	4000	3000	2000	6400	17581
Hie.	699-797	2500	72	48	2000	2201
Total	**63,366-63,687**	**39,000**	**74,112**	**49,408**	**43,400**	**126,331**

Table 3.10. Population Estimates by Island for contact period, 1443, 1590 and 1733. See text for further details

Assuming 'fighting men' to be young males, which constitute about 1/6 of an average population, the Azurara (1443, in Martin de Guzman 1984) account implies a population total of just over 74,000 individuals (column 3 of table 3.10). Note the contrast between the conquered (Lanzarote, Fuerteventura and Hierro) and the unconquered (Gran Canaria, Tenerife, La Palma and Gomera) islands. However, these figures do not consider the tradition of polyandry – which was noted for Lanzarote (Boutier and Le Verrier 1872) and possibly Gran Canaria (Torriani 1590: 161) where women had from three (Lanzarote) to five (Gran Canaria) husbands. This implies that there would have been a much lower number of females in these population groups, that fighting men would therefore have constituted more than 1/6 of the population, and that population size would therefore be overestimated. It is possible that this tradition was a response to preferential enslavement of one sex over the other, although this cannot be tested. There is also evidence to suggest that female infants were actively selected against through infanticide on Lanzarote and possibly Tenerife (Aguilar and Mederos 1987), thus reducing the proportion of females to males in the group. The data were therefore reprocessed to assume a standard relationship of three males to one female (the Lanzarote 3/1 figure was recorded in the early 15th century, and is therefore more likely to reflect actuality than the 5/1 figure recorded by Torriani in 1590), thus reducing totals to the figures in column 4 of table 3.10. In order to account for low populations on Lanzarote, Fuerteventura and Hierro (deflated by early slaving missions), population size was estimated using a mean of the population figures for 1590 and 1733 as a proxy for maximum non-industrial carrying capacity, taking into account the variable impact of slaving missions and technological advances. To produce the contact #1 figures, an average of polyandrous/non-polyandrous figures (see column 1 of table 3.10) is presented for all islands unaffected by slaving missions. The final plots are presented in figure 3.3.

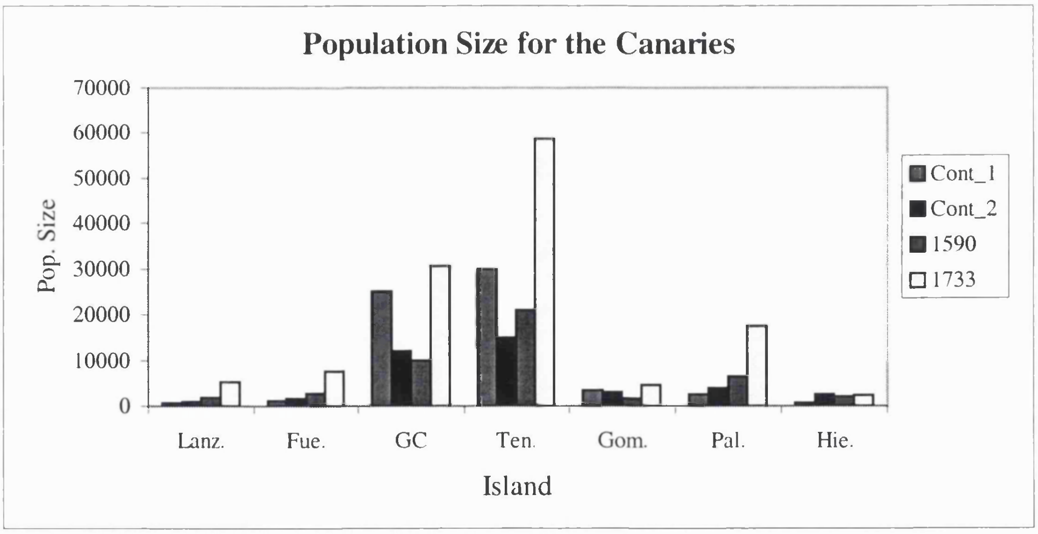

Figure. 3.3 Population Estimates by Island for contact period, 1443, 1590 and 1733

At just over 63,500 the revised estimate is about 10,000 lower than the crude estimate derived from Azurara's observations. These figures show that the population decreased on the largest and most fertile islands between the 15th century invasions and 1590. However, the population recovered to prehispanic levels after the introduction of industrial specialisation and intensification in the 17th and early 18th centuries. The constant increase in population figures from the contact, 1590 and 1733 dates on

Fuerteventura, Lanzarote, Gomera, La Palma and Hierro differs greatly from the levels on Gran Canaria and Tenerife. This disparity may, however, simply be the result of inaccurate reporting. Finally, the figures were used to calculate population density for the pre-contact period. In all cases, human population is highest and most dense in large temperate/wet islands. Population levels and density fall off sharply towards the east, reaching extremely low levels of population density in the desiccated islands. The western islands are intermediate in terms of population density.

The contact #2 test was carried out using the menceyato data (tribal division – see above for further details) in order to produce a second group of estimates for the islands and for comparison with the contact #1 figures. Azurara's estimate of total population size on Tenerife (15,000) was divided by the number of menceyatos to provide a rough estimate of 1,250-1,500 people per menceyato. This principle was transferred to the other islands using general controls based on island size and ecology, assuming less density for drier islands and lower numbers per menceyato for smaller islands; the results are presented in column 2 of table 3.10. The totals using this system are about 2/3 of the size of those derived using the former system, with a pooled total of around 39,000 individuals. While this is a somewhat crude test that does not take into account many of the Canarian social contingencies mentioned above, it substantiates the generalities of the more complex model, while producing a more modest population size.

These figures provide an approximate idea of population size in the late prehispanic era. However, this tells us nothing about original colonisation/landfall population size, or the rate of population growth through time. It seems likely that population levels were originally very low and increased through time – either from population growth or migration – and this is generally supported by the low number of archaeological sites early in the sequence. However, it should not be assumed that the size of the population in the 15th century was the highest it had ever been, or that growth was linear from point of first colonisation onwards. Indeed, the number of sites and the implied population size appears to have dropped in the late period directly prior to European arrival, with the major peak occurring in the middle period group. Resolution of this issue is of great importance to future studies of ancient Canarian lifestyle, population biology, cultural development and environmental impact.

3.7.3 Burial

Burial is an important aspect of any society, and in the present case particularly so as it determines the nature of the sample used in the study (see chapter 5). Historic accounts of burial practices relate that bodies were preserved to a greater or lesser extent (using various fillings and unguents), laid on biers made of wood or plant material, and placed in caves. In the 18th and early 19th centuries, European travellers reported hundreds of mummies stacked against the walls of major burial caves in Tenerife, while similar finds were reported by mid-late 19th century archaeological expeditions to Guayadeque (Gran Canaria). Some of these mummies have been recovered from burial caves in Gran Canaria and Tenerife, with evidence for evisceration, intentional desiccation, stuffing of the abdominal cavity (with materials such as sand, leather and various plants) finger/toe binding and embalming with fats/plant extracts (Rodriguez Martin 1999; Hooton 1925; Leyens 2000). The bodies were then sewn into multi-layered goatskin bags and/or rush matting, before being placed on their funerary biers and placed in caves. While mummification is best known on Gran Canaria and Tenerife, it also seems to have been employed on La Palma, Hierro and Gomera (although evidence is rather slimmer – Hooton 1925: 45). Partially mummified remains are known from Lanzarote and

Fuerteventura, but these may be the result of natural desiccation rather than intentional mummification (Hooton 1925: 45). Habitation caves were sometimes used to inter their late inhabitants (Mercer 1980), and there is archaeological evidence to assume that clusters of caves – such as Guayadeque – often had designated caves for habitation, and others for interments. The range of mortuary practices in the archaeological record hints at considerable cultural diversity in the archipelago, as mummies have been dated to the first half of the 1st millennium AD up until the contact period, running alongside many other methods of disposal. All the islands had a tradition of disposing of the dead in caves – from plain burials in Montana Mina cave in Lanzarote to enormous interment caves on Tenerife – in addition to cremations, tumulus burials and extended or crouched interments along cave walls or in the open (de Balbin Behrmann *et al.* 1987: 22; Galvan *et al.* 1998). Preliminary reports from La Lajura cave on Hierro (4th century AD) seem to suggest a large, multiple burial, with the human remains arranged in a manner suggestive of a mass grave (Velasco-Vazquez 2002). Cannibalism has also been noted, but the treatment of the bones does not suggest 'burial' *sensu stricto.* The remains in this study are derived from various forms of interment, and are currently held in Canarian and European museums. Most of the mummies and skeletons in caves had been plundered prior to their recovery by archaeologists or antiquarians, leading to a mixing of skeletal elements.

3.7.4 Material Culture

Certain characteristics of Canarian material culture are shared between several or all islands, although there are also numerous specifics that are unique to single islands. Distribution pattern significance is important if inter-island relationships are to be understood, and this is discussed in more detail below. In the present section, however, only the general groupings – lithic technology, ceramics, rock art and selected miscellaneous artefacts – of Canarian material culture are discussed.

Ancient Canarian society has been described as 'Neolithic', in that they did not possess metal technology (although some small copper artefacts have been recovered from a Roman site on Lanzarote – Atoche Pena 1995). Tools were flaked from phonolites, basalt and obsidian (where available) into blades, scrapers, denticulates, perforators and burins. Ground stone tools and other artefacts (saddle querns, mortars, grindstones and slingshots) have also been noted. Fragment representation seems to argue for curated technology, although site type may have affected artefact representation. Wooden artefacts are restricted to the central and – to a lesser extent – the western islands, and include spears/lances, spoons, bowls, combs, staves, 'bastones de mando' (ceremonial clubs/wands), funeral boards and, in one instance, a coffin.

Canarian ceramics are clearly related to the North African 'Mediterranean Neolithic' (Navarro Mederos 1999). All pottery from the Canaries is hand-coiled, although some imported (Roman) wheel-thrown vessels are known from the early period. Plain and minimally decorated specimens in an array of simple forms have been recovered from all islands, while more complex forms and decoration vary throughout the archipelago. Incision, combing, painting and stamping have all been noted. Incised designs are the most common form, and include 'dashing' (El Bebedero, Lanzarote), banding (Hierro, Gomera and La Palma) and completely invasive curvilinear designs/spirals (La Palma). Painted geometric abstract designs (Gran Canaria), combing and stamping (La Palma) are island-specific. Previous studies have tended to 'lump' island assemblages together without consideration of chronology, thus weakening ceramic vessels' potential for elucidating the cultural islandscape through time. However, recent work by Navarro

Mederos (1999) has gone some way towards rectifying this shortfall (see below). It is impossible to provide an appropriately detailed description of Canarian ceramic assemblages – however desirable – within the present project. Some of the more notable ceramic 'types' are presented in Plate 3.1 and 3.2, and are arranged by island. Heights of the vessels are provided in the footnotes, along with a brief description and findspot (if known). Rock art is common throughout the archipelago, ranging from Latinate, 'Punic-Inspired' and Libyo-Berberic text fragments (Atoche Pena and Ramirez Rodriguez 2001: 81 – see plate 3.3) to abstract (including circles, spirals, meandriforms and line grids), semi-abstract ('podomorfos' – foot-form designs; 'naviforms' – vaguely boat-like engravings), zoomorphic (see page 4) and anthropomorphic designs. Several spectacular ship engravings are also known, but are probably post-conquest (see section 3.10). Some Gran Canarian caves are decorated with painted motifs, colour washes and various alphabetical, geometric and figurative designs (Atoche Pena and Ramirez Rodriguez 2001: 79; Hernandez Rodriguez 1999). Small stone and ceramic sculptures – both zoomorphic and anthropomorphic – have been recovered from several of the islands, but are particularly common on Gran Canaria (Zeuner 1960; Ucko 1960). The importance of these artefacts – either engravings/paintings on rocks, or artistic heritage of iconic significance – means that they are very rarely dated.

Jewellery was made from shell (Fuerteventura and Gran Canaria), fish bone (La Palma) and ceramic beads (Tenerife). Bone (mainly from sheep and goats) was used to make a range of domestic items such as awls, needles and polishers, while horn was carved into ladles, spear-tips and fishhooks (Gomera and Tenerife; also made from bone on Fuerteventura and Tenerife). Gran Canarians produced fine basketwork, which was incorporated into mummy bundles as well as in the manufacture of containers, and even

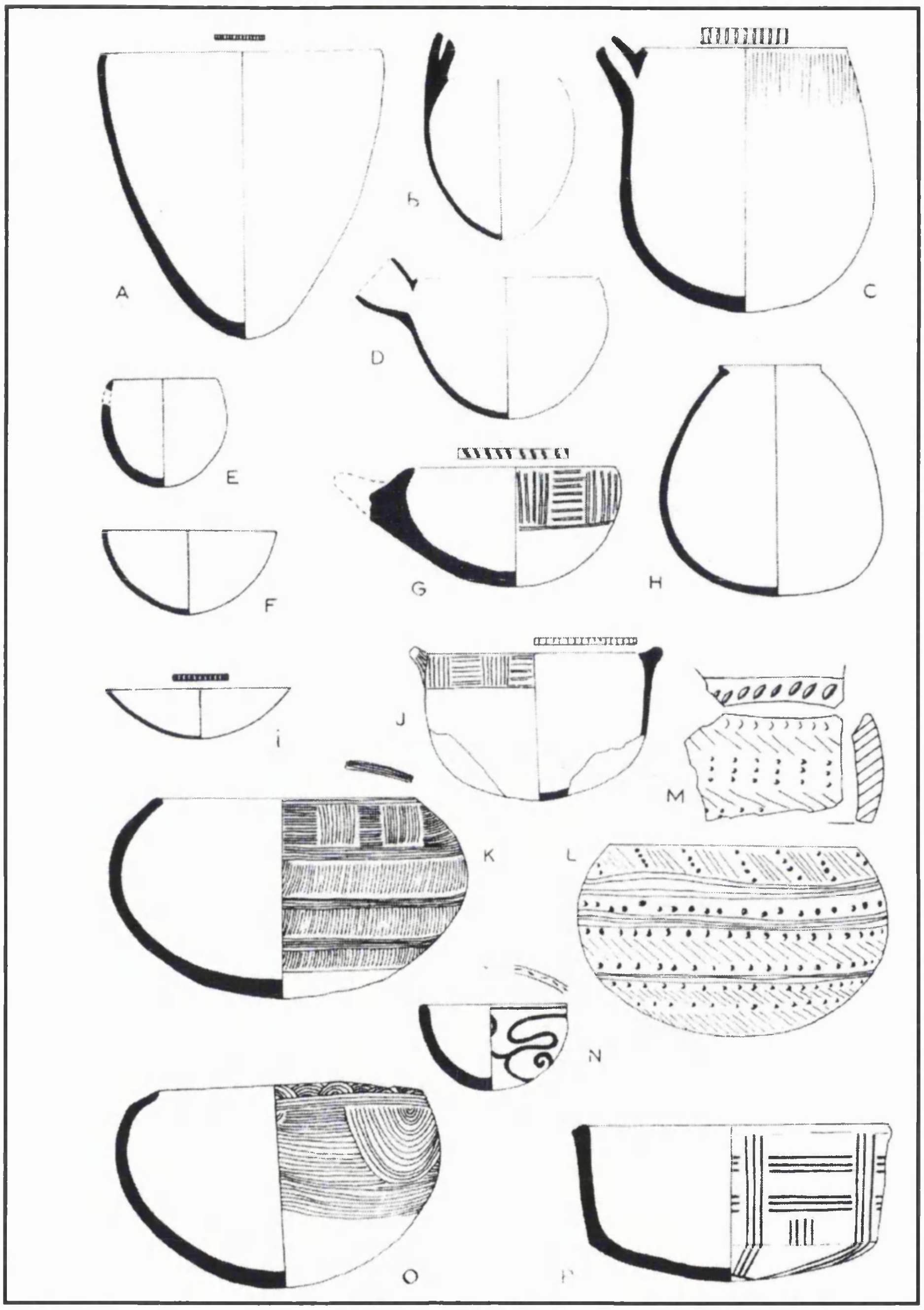

Plate 3.1. Western Canarian Ceramics (from Mercer 1980: 131)

Tenerife – A) Plain ovoid, Las Canadas [41cm]; B) Handled ovoid, Las Canadas [23cm]; C) Spouted globular pot, Arico [19cm]; D) Handle-spout vessel, Canada Blanca [15cm]; E) Globular vessel, La Guancha [14cm]; F) Bowl, Canada de la Mareta [5cm]; G) Scoop, Arico [6cm]; H) Pear-shaped vessel [33cm]; I) Bowl, Canada de la Mareta [5cm]; J) Lugged vessel, Canada de Pedro Mendez [25cm].

La Palma – K) Bowl [13cm]; L) Bowl, Barlovento; M) Bowl, Fuerteventura [4cm]; N) Bowl, Roque de la Campana; O) Bowl, site unknown [14cm]; P) Bowl, La Cucaracha [11cm].

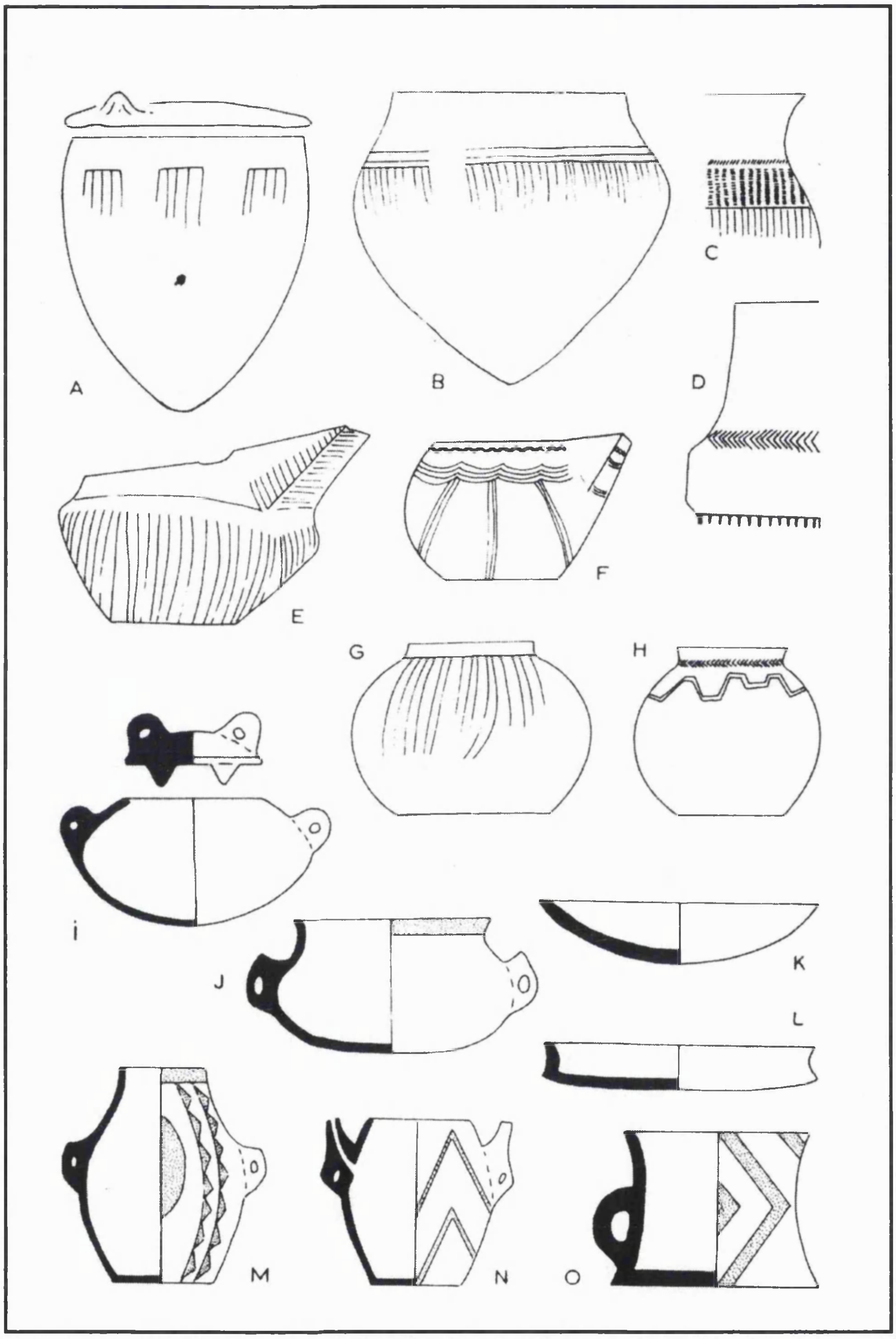

Plate 3.2. Eastern Canarian Ceramics (from Mercer 1980: 130)

Fuerteventura – A) Plain ovoid with travertine lid [75cm]; B/C) Shouldered ovoids (70cm); D) Collared ovoid; E/F) milking pots [19cm and 16cm].

Gran Canaria I) Globular vessel, Arguineguin [9cm]; J) Globular vessel, Galdar [10cm]; K) Bowl, Santa Brigida [4cm]; L) Bowl, Galdar [3cm]; M) Barrel-shaped vessel, Galdar [30cm]; N) Double-spouted vessel, Galdar [14cm]; O) Cup, Galdar [11cm].

twisted into rope. Very fine matting – almost resembling cloth, which is unknown for the prehispanic period – was also made in Gran Canaria. While leatherworking appears to have been virtually ubiquitous – used for clothing, bags, floor coverings, thin rope (thongs), slings (Gomera only, according to the historical sources) and the mummification process – most notable leather artefacts are restricted to Gran Canaria and Tenerife. However, it should be noted that during the 19th century it was common for inhabitants of the western isles to excavate leather artefacts from caves to manufacture harnesses for their beasts of burden (Mercer 1980).

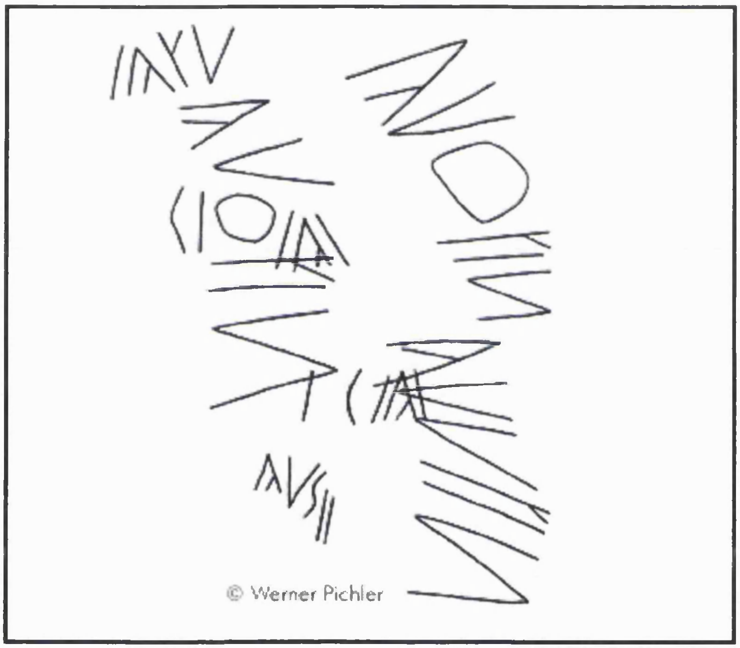

Plate 3.3. 'Latinate' Inscription, Cuchillete de Buenavista, Fuerteventura (www.almogaren.org/gallery/canarias.htm)

3.7.5 Origins

The origin of Canarian populations is hotly debated. However, as this project is less concerned with origins than the resolution of the archipelago's internal dynamics, full details cannot be presented here. Most of the current evidence is genetic and osteological, (see chapter 4). Historical and archaeological evidence for mainland affinities is equivocal, for while the Canaries have cultural links with various parts of NW Africa and further afield, the scale of variability both between and within islands has precluded any simple answer as to cultural affinities with the African or European mainlands. Historical information reveals little about population origins. Hooton's 1925 linguistic study suggests strong Berber affinities in Hierro, La Palma and Gran Canaria, rather weaker links in Lanzarote, Fuerteventura and Tenerife, and none in Gomera. Words unaffiliated to Berber were most common in Tenerife and Gomera and rather less common in Hierro and Gran Canaria, although the fairly high prevalence overall (from 37.5%-66.6%) would suggest a '...very strong linguistic substratum' (Hooton 1925: 18). Arabic words were most common in Lanzarote and Fuerteventura, and less so towards the west. Specific words sometimes suggest links with certain areas, such as the Fuerteventuran word *tamocen* (barley), which may be related to the Shluh Berber word *tumuzzen*, or the Palma populations' name for themselves (Beni Hoare), a tribe currently divided between the Sahara, the Middle Atlas and the Moroccan Sus (Mercer 1980: 65-66). Materially, there is little information about contact period Canary Islanders or their culture that betrays a specific origin. There would be a danger, furthermore, that affinity would be judged on the <u>absence</u> of evidence – metals, archery, cloth – that may not reflect the cultural proclivities of the settlement population (as demonstrated by the loss of cultural traditions in native Tasmanians – Flannery 1994: 266). Writing is a case in fact. While contact period Canarians had no form of writing, various inscriptions across the archipelago indicate that Canarian societies either possessed then lost the capacity to write, or that the contact-period Canarians are not representative of earlier – literate – groups. Furthermore, the juxtaposition of Libyo-Berberic (the antecedent of modern Tifinagh – Mercer 1980: 67), Libyo-Phoenician (Atoche Pena and Ramirez Rodriguez 2001: 43) and 'Latinate' inscriptions suggests that the ethnic makeup of Canarian society was more complex than a single colonisation and settlement event. The archaeological evidence has been interpreted in many ways, but there are few cultural artefacts in the Canaries that can be traced to specific origins.

On the basis of various Gran Canarian figurines, Zeuner (1960) suggested an Eastern Mediterranean Neolithic origin for the Canary Islanders. However, this was brusquely dismissed by Ucko (1960), who rejected Zeuner's methodology and suggested stylistic links with the Egyptian Predynastic period. Horne and Aufderheide (1992: 138) suggested that the absence of substantial evidence for seagoing and consumption of marine resources (determined by isotope analysis of mummified remains) indicates that the stem populations may have been an inland group unaccustomed to coastal living. Nowak (1994) – amongst others – claims that an inscription from Tenerife names a specific Berber group as the original colonists of the islands, but this has been refuted on linguistic and contextual fronts (see Eddy 1995). Mercer (1980) argued for late Roman colonisation of the archipelago, linked to the resolution of territorial debacles in NW Africa, although this does not explain early evidence for human activity in the islands that has since come to light. Various authors supported Ucko's work, claiming links with Egypt on the basis of 'pyramids' on Tenerife (Bethencourt *et al.* 1996) and an array of sculptures/jewellery (Atoche Pena and Ramirez Rodriguez 2001), although certain chronological and stylistic inconsistencies have not yet been resolved. For example, while Canarian mummies exhibit many of the characteristics of New Kingdom mummification practices, they were made over 1000 years later (Spence 2000). Equally, other than the Roman ceramics from El Bebedero (Lanzarote) and stray sea-bed finds, which have been traced to certain areas of the Mediterranean (Atoche Pena *et al.* 1995), there are few direct links with the Roman world. Arguments for Viking settlement of the archipelago (Spence 2000) are founded purely on the fair colouring of contact period Native Canarians, and are archaeologically unsubstantiated. While not expressly corroborated in this study, my personal contention is that while initial inhabitation may have occurred at a very early stage (Zoller *et al.* 2003) and again in the mid/late 1st millennium BC, extensive colonisation did not occur until the trend towards hyper-arid conditions in the Saharan region between 250BC and the early 1st millennium AD (Cremaschi 2002). The final collapse of the Garamantes kingdom in about 350AD – and the later movement of Islamic groups into the area (Cavalli-Sforza *et al.* 1994) – resulted in major population movements into Sub-Saharan areas and, possibly, the Canary Islands. Previously low Canarian population levels are certainly boosted during this period, and the possibility is beguiling. However, a detailed discussion of this possibility is beyond the range of this project, and will be covered elsewhere.

3.8 Canarian Economy

Knowledge of ancient Canarian economy is essential if the full implications of dental pathology are to be understood. Additionally, a review of economic behaviour will permit observations as to the manner in which native Canarians exploited and adapted to their varied island environments. Both the ecology of individual islands and the range of economic options thereby left open to the inhabitants fluctuate considerably (see chapter 2). In the present day, arable farming, fishing and pastoralism are still extant, but have lost ground to the boom of tourism. However, reconstructing prehispanic economy on the basis of modern observations are unlikely to be accurate, as innovations in irrigation and a climatic tendency towards aridification (even in recent years) have considerably altered the ecology of the archipelago.

3.8.1 Historical Approaches to Canarian Economy

The strong emphasis on historical information in reconstructions of ancient Canarian society has been discussed elsewhere (see above), and palaeoeconomy is no exception. Just as the material cultural repertoires of indigenous Canarians appear to have varied both temporally and spatially, it is extremely unlikely that economic behaviour remained static across time and space from first colonisation to the mediaeval period, and from one end of the archipelago to the other. There is nothing wrong with using historical information for the purpose of economic reconstruction, so long as potential shortcomings are appreciated. With this in mind, therefore, the main references to economic behaviour in the historical texts are summarised here.

Pliny the Elder refers to one of the islands (possibly Gomera – see Rackham 1842) as 'Capraria', implying that the island was inhabited by goats which must have been introduced intentionally. 'Enormous dogs' – for which the Canary Islands are named (i.e. *Canis*) – were also reported, although there is nothing outsized about the canid remains so far recovered from archaeological sites. Various fruits are also mentioned. No Arab references regarding Canarian economy are known, although Ben-Farroukh and his retinue are claimed to have received '...exquisite delicacies' from their Canarian hosts (Lopez Herrera 1978: 94). The late mediaeval references are now discussed by island from East to West.

Da Recco (1341 – in Mercer 1980: 155) noted 'goats and other beasts...' and animal fats on what was probably Fuerteventura. Bontier and Le Verrier (writing in the early 1400s) state that Fuerteventurans ate air-dried goat meat and cheese (1872: 135, 145, 148), while Lanzarote populations relied on a diet of barley bread, dairy products and meat (1872: 138). The apparent absence of bread from Fuerteventura is interesting, given the islands' proximity to one another. Pigs were absent from Lanzarote and Fuerteventura, and this may be a function of the desiccated ecology of the eastern end of the archipelago.

On his raiding trip to Gran Canaria, Da Recco (1341 – in Martin de Guzman 1984: 136) noted gardens containing figs, cabbages, vegetables, barley and other cereals, along with goats, sheep and 'wild pigs' (the presence of all these animals was confirmed by Boutier and Le Verrier). Maize/wheat were ground, roasted and eaten as flour (gofio). While not stated, fish must also have been exploited, as fish oil was one of the spoils plundered by the invaders. Boutier and Le Verrier confirm that fish were caught using a net. Later sources claim that harpooning by lamplight, fishing with hooks (made from Spanish iron) and poisoning of water using plants of the *Euphorbia* family (Viera – in Major 1872: 131) were also employed. Hunting – of unstated quarry – is also mentioned, as are figs and '...badly cultivated' cereals (1872: 133). Dogs are also mentioned, but whether they were used as food is not stated. The Gran Canarians '...lacked oxen, camels and donkeys' (Da Recco 1341: in Martin de Guzman 1984: 137), a fact that may undermine the apparent antiquity of donkey remains from Lanzarote (Zoller *et al.* 2003; Zoller Pers. Comm.). Bernaldez (1513 – in Martin de Guzman 1984: 156) corroborates the existence of sheep and goats, as well as cheese, butter and figs in around 1483.

Early economic references are lacking for Tenerife. Boutier and Le Verrier note that the land was '...good for all kinds of agriculture' (1872: 129), but details are lacking. Later sources mention wheat and barley, in addition to sheep, goats, dogs and pigs. Boutier and Le Verrier (1872: 128) reported 'small cattle' for Gomera (probably goats), but historical details as to Gomeran economy are very scanty. Azurara described a Gomeran diet (1443: Mercer 1980: 182) of goats, pigs, barley and wild roots. Boutier and Le Verrier described the La Palmans as '...a fine people, who only live upon flesh' (1872: 127) – presumably goats and sheep – like the Fuerteventurans. However, this assertion was not confirmed by Azurara (in Mercer 1980: 194), who claimed that their economy was also based on wild plants and milk, but not fish. Hierro economy was based upon grain, pigs, goats and sheep, and possibly upon the profusion of wild bird and terrestrial animal species also described (1872: 124). Wild bird consumption is recorded for Hierro (confirmed archaeologically by Rando *et al.* 1996; 1997) and Lanzarote (Torriani 1590). Boutier and Le Verrier state that '...lizards as large as cats, but harmless, although very hideous to look at' were found on Hierro (1872: 123-4), while later sources claim that they were used as food just as they were in times of hardship during the 20th century (Hooton 1925: 7; Martin Oval Pers. Comm.).

3.8.2 Zooarchaeology

Zooarchaeological approaches have only sporadically been applied in the archipelago. With some notable exceptions, such reports that exist are anecdotal, with little or no attempt to systematise observations across time and space. There is a pressing need for a reappraisal of Canarian palaeoeconomy, as the significance of diversity in excavated zooarchaeological material, which may reflect spatial economic differentiation or temporal variability, will remain wholly unclear until an adequate chronometric framework has been established. Most Canarian site reports note the presence of sheep/goats, pigs, fish, shellfish, birds, cats, dogs, lizards and rodents on archaeological sites. It should be noted that Canarian assemblages are very fragmented by both humans and dogs, rendering up to 70% of the remains unidentifiable (Pais Pais 1996: 431) and affecting species/element representation. Only a handful of sites have been well excavated and reported, and the results of these studies are summarised here.

'Palaeo-Canarian' sheep and goats – that have given rise to various archipelago-specific lineages (Capote *et al.* 1998) – share certain features with modern Sahel groups (Meco 1992a). The goat morphology data may benefit from reanalysis now that the eastern islands' initial colonisation date has been provisionally pushed back to between 5,000-10,000 BP (Zoller *et al.* 2003), as the genetic affinities of the goat populations may provide more information about the islands' deep past in the absence of suitably-dated archaeological sites. Goats have been reported for all islands, although their place within individual insular economies appears to have varied. They occupied a relatively prominent position amongst terrestrial prey groups, but are sometimes overshadowed by marine resources at sites situated near the sea (although the taphonomic durability of shells – and the relatively smaller economic value their contents would provide – should be considered). There is a distinct bias towards goats over sheep, (9:1 ratio at Villaverde, Fuerteventura – Meco Cabrera 1992: 130) but systematic differentiation between sheep and goats has only been attempted sporadically. The current author carried out age distribution studies for the La Palman sites of El Rincon (undated) and El Tendal (from 300-680AD), using data provided by Pais Pais (1996). A kill-off profile based on Payne's work on Anatolian samples (1973) has been generated from the data, but it should be noted that the definition is very poor owing to the low number of ageclasses used in the study.

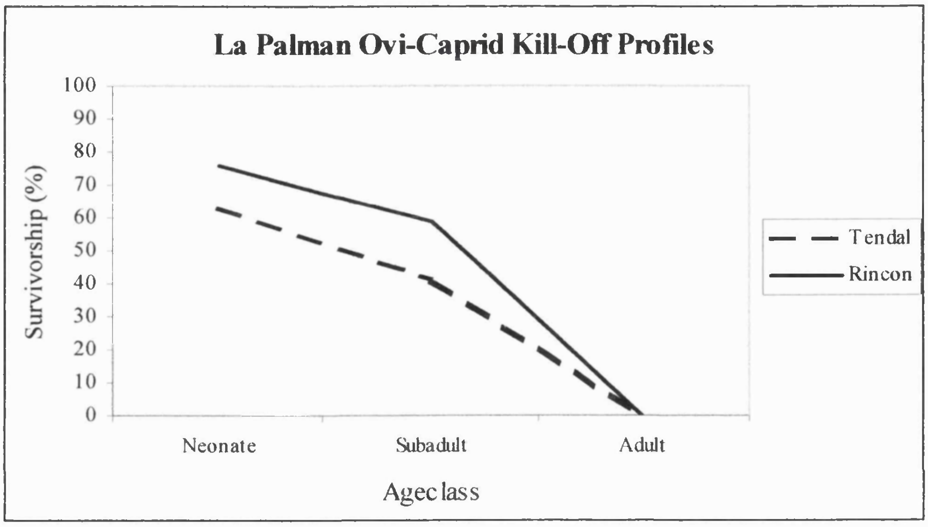

Figure. 3.4. La Palman Ovicaprid Kill-off Patterns. Data from Pais Pais 1996

Subadult kill-off is lower than neonate or adult specimens in all levels at both sites, suggesting a general reliance on milk rather than meat. However, the profile is not clear-cut – notably the high neonate and subadult kill-off for El Tendal – suggesting some form of mixed strategy or practices that are currently unclear. It should be noted that this is a very tentative introduction to a highly contentious issue, which deserves more profound analysis than is possible here.

Pig remains have been recovered in modest quantities from Gran Canaria and all western islands, and from the site of Villaverde on Fuerteventura (Meco 1994d). The fact that pigs were not present on either Lanzarote or Fuerteventura at the time of the conquest is interesting as it implies either a change of economic regime, or a trend towards increasing aridity that precluded the keeping of these heat-sensitive animals. Clay models of pigs have been recovered from archaeological sites on Gran Canaria.

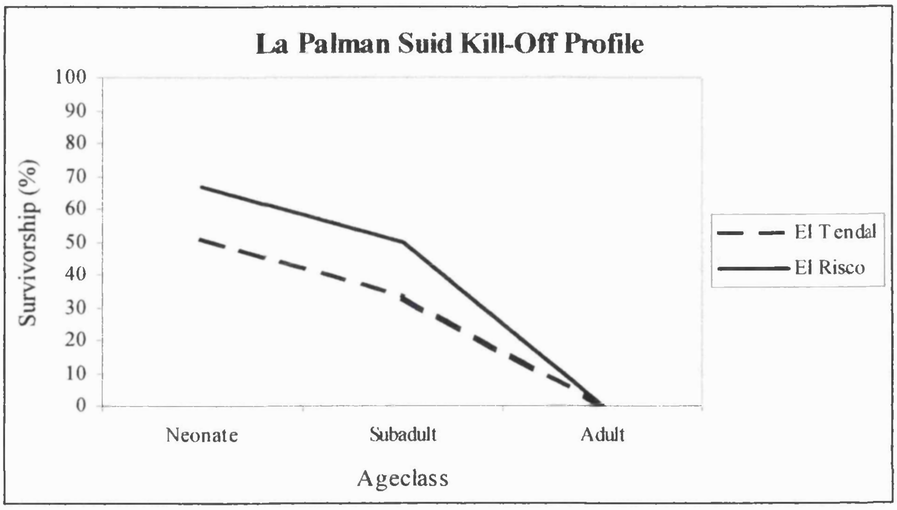

Figure.3.5. Suid (Pig) Kill-Off Patterns for La Palma. Data from Pais Pais (1996).

Pig remains are less common than those of goats/sheep. A preliminary test of data from El Tendal and El Risco (Pais Pais 1996 – see figure 3.5) shows a pattern strikingly similar to that shown for ovicaprids in figure 3.4. This is primarily attributable to the way in which the remains were aged, and underlines the need for further and more detailed analyses of zooarchaeological remains.

A cow metatarsal recovered from the La Palma site of El Tendal probably dates to the post-conquest period (Pais Pais 1996). Consumption of dogs has been claimed for the site of El Tendal, and also Tenerife (del Arco Aguilar 1987). Cats are also claimed to have constituted a minor dietary role in prehispanic La Palma (Pais Pais 1996), although most cats do not appear to have been consumed by humans. A clay model of a cat has been recovered from a site on Gran Canaria, and this is perhaps significant if the fact that all other animals thus modelled were definitely consumed by native Canarians (but see turtles, below) is considered. Canarian rabbits (a subgroup of North African species *Oryctolagus cuniculus* – Mitchell-Jones *et al.* 1999: 172-3) probably arrived on the islands with the conquest, and their occasional appearance in pre-conquest sites probably represents post-depositional disturbance and burrowing into archaeological layers rather than prehispanic diet (Martin Oval 1993). Previous reservations as to the possibility of Canarian cannibalism (Tejera Gaspar 1992: 78) have been challenged by Galvan *et al.*'s discovery of fragmented human remains bearing cut-marks and signs of disarticulation at the Tenerife site of Arenas 1 (1999: 308-317). The authors have suggested both cannibalism and ritual defleshing as possible causes. While this is currently an isolated case, it is possible that early excavators overlooked evidence – i.e. fragmentary bones – attesting to more widespread distribution of this tradition.

Three extinct species of rodents about the size of guinea pigs (genera *Carionomys* and *Malpaisomys*) have been recorded on archaeological sites on Tenerife, (Barroso 1998, Galvan *et al.* 1998: 323), Gran Canaria (Lopez Jurado and Lopez Martinez 1991) and Lanzarote (Martin Oval *et al.* 1998). Despite this association, however, it seems unlikely that these rodents played a significant role in indigenous diet. However, the decline and extinction of Tenerife's *Malpaisomys insularis* at approximately 1500-2000 years ago – like the earlier extinction of a similar species in Fuerteventura (c.5,000BC – see above) – may be linked to human activity, or that of their commensals (Castillo *et al.* 2001; Zoller *et al.* 2003). Remains of the monk seal (*Monachus cf. monachus*; eradicated completely by the late Mediaeval period) were found in the Fuerteventuran site of Villaverde (Meco 1992), but no significant reliance upon seals is apparent. Various turtle species – including the Green, Hawksbill, Loggerhead, Olive Ridley and Leatherback varieties – live in the Canarian region (Mattison 2001: 368-372), although their remains have not been reported from archaeological sites. Whether or not they were exploited is equivocal; turtles do not currently nest on the Canaries, but this may be a response to over-exploitation. If this is the case, it is odd that no remains have been reported on archaeological sites (either as food refuse or the use of tortoiseshell as personal adornment), although they may have been processed away from habitation areas, or may have escaped recognition by excavators. However, a clay model of a turtle has been recovered from a site on Gran Canaria, indicating that the Canarians were at least aware of this potential food resource. Cetaceans may have been consumed, but the few remains so far recovered – incorporated into structures in Lanzarote (Bethencourt and Bethencourt 1998: 10) – were probably scavenged from beaches in the north of the island, where dead creatures and other detritus have been cast up from the 2nd century AD (as noted by Pliny the Elder) to the present day.

Bird remains have been recovered from numerous sites in the Canaries, but constitute only a fraction of the vertebrate assemblage. The extreme frailty of bird bones is likely to succumb to taphonomic pressure and under-representation, particularly if – as suggested above – dogs were present on site. Rando *et al.* (1996) carried out a comprehensive analysis of bird bones from the site of El Tendal, with an MNI of 28 (considerably lower than mammals [n=93] and fish [n=105] MNIs from the same site). Most of the remains recovered pertain to land birds – notably pigeons – rather than to marine-based species, and these were exploited throughout the sequence. As there is no evidence for domestication (a single *Gallo gallo* specimen from La Palma probably post-dates the conquest), it is likely that humans were implicated in the disappearance of numerous bird species in the archipelago – including thirteen species of pigeons – particularly as most of these species are only known from archaeological sites.

With approximately 1583km of coastline (single island estimates: Lanzarote 230km; Fuerteventura 355km; Gran Canaria 270km; Tenerife 335km; Gomera 93km; La Palma 180km; Hierro 120km), the Canary Islanders had easy access to marine resources. Fish remains have been recovered from most archaeological sites in the Canaries, particularly those near the coast where they are usually the most common vertebrates. Current research suggests that exploitation varied considerably between islands and sites, although sophisticated fish-bone studies are unfortunately rare (but see Martin Oval *et al.* 1987 and Rodriguez Santana 1996). Martin Oval *et al.*'s (1987) data for Conchero de Guinea (Hierro) demonstrates a massive predominance of marine over terrestrial resources (83.9% vs. 16.1%), comprised mainly of parrotfish, moray eels and sea bream. Inland sites have proportionally less fish remains than sites on the coast, as indicated by the disparity between the La Palman sites of El Tendal (coastal: 37%) and El Rincon (inland: 0.01%). This trend is also true of the inland Gran Canarian site of Lomos Granados (1.3%: Martin Oval 1993) and Tenerife (Barroso 1999) at least. As fish vertebrae were turned into beads on inland La Palman sites (Pais Pais 1996), but not on the coast, it is possible that the status of marine resources increased according to distance from the sea. While recovery methods may be deficient, it is possible that the large size of most of the specimens recovered suggests that they were caught/speared rather than netted. This is substantiated by the discovery of bone fishhooks (from 6-20cm in length – Meneses Fernandez 1995) and harpoon heads at a number of sites, and also, perhaps, by the large number of aural cold-water pathologies contracted by the indigenous Canarians (see below). The exception is Gran Canaria, with a wide range of species including small fish such as blennies (Rodriguez Santana 1996: 446-7) that are unlikely to have been caught using harpoons/fishhooks, and may lend credence to historic references to the use of nets and natural narcotics (see above). Interestingly, the size of archaeological parrotfish exceeds that of modern examples, implying either selectivity in their capture, or subsequent over-fishing. Ideally, this assertion would be tested by examining the fish size data through time (which demonstrated a steady decrease in size on New Zealand [Flannery 1994: 244]) although the samples do not presently permit this. Thirty-one species were recovered from Gran Canarian sites, against 19 from Tenerife and 17 from La Palma (Rodriguez Santana 1996: 443). Rodriguez Santana (Ibid. 441) concluded that the vast majority of fish remains from selected Gran Canarian, Tenerife and La Palma sites pertained to species that adhered to shallow/coastal waters, which could be caught from the shore. This fact has been used to support the much-vaunted claim that Canarian groups were isolates, indisposed to nautical activity (see Mercer 1980: 17-26 for a discussion). This argument, which works well for the Lapita populations of Melanesia when compared to the earlier Papuan groups (Flannery 1994), is somewhat dubious, as shore-fishing may be viewed as optimisation of resources with minimal effort, rather than a manifestation of technological incapacity.

Marine shellfish are common on Canarian sites, notably in coastal areas. Assessing the importance of molluscs to Canarian populations is difficult owing to the high visibility of shells compared to other food remains, and the low calorific yield of molluscs relative to their overall weight/mass. Furthermore, there are few systematic studies of molluscs, which were often overlooked on earlier excavations. The most comprehensively analysed site is El Conchero de Guinea (El Hierro), containing 40,821 molluscs attributable to ten species. Eighty-seven percent of these were limpets, 12% whelks and a scattering of other species such as tusk shells (*Monodonta sp.*), sea urchins and red crabs. Prevalence was high even at the inland site of Lomos Granados (Martin Oval 1993), ranging between 73% and 100% in different levels and in stark contrast to the minimal prevalence of fish remains (see above). These sites may represent single events (such as ceremonial feasts: Gonzalez Anton *et al.* 1992b), or specialist exploitation of a sporadically available resource. In one of the rare continuous sequences of carefully assessed shell material, the La Palman site of El Tendal shows a distinct reduction in limpet size through time. This trend has been demonstrated for New Zealand (Flannery 1994: 244), and reflects exploitation of shellfish resources exceeding the species' carrying capacity (Pais Pais 1996).

Reptiles are plentiful in the Canarian archipelago, including *Gallotia* (lizards), *Tarentola* (geckos) and *Chalcides* (skinks). While all of these have appeared in zooarchaeological assemblages, their role, if any, in prehispanic diet remains uncertain. Only two major analyses of reptile remains have been conducted, at the undated Hierro site of El Guinea (Martin Oval *et al.* 1987) and the 3rd century AD funerary site of Lomos Granados in Gran Canaria (Martin Oval 1993). While the species concerned can attain a length of approximately 80-100cm, Martin Oval is hesitant to attribute their presence to human predation. Some of the five extant giant species of *Gallotia* were eaten historically (even during the 20th century) in times of hardship (Martin Oval pers. comm.), and some researchers believe that they were also exploited in the prehispanic period (Barroso 1998). The historic extinction of two other species in the giant lizard group may have been brought about by human predation, although the controversy over Canarian lacertid speciation and species recognition (Brown and Pestano 1998; Naca-Meyer *et. al.* 2003) has confused this issue.

3.8.3 Archaeobotany

Agriculture was supposedly widespread historically (see above), although chroniclers typically disagree on details (Hooton 1925). Most of the archaeological evidence for plant agriculture is indirect, including grindstones and mortars/pestles (which are common on Gran Canaria and Tenerife, but notably less so on the other islands), rock-cut granaries (Gran Canaria) and rock carvings of barley ears (Gran Canaria). Botanical evidence for cereal and plant consumption is limited as recovery methods were rather unrefined until recently. Exceptions include wheat grains in the stomach of an Acusa mummy and in various Gran Canarian ceramic vessels (Mercer 1980), although detailed information was not available prior to the development of rigorous archaeobotanical research by Morales Mateos *et al.* (2001). In the first major survey of its kind, the remains of lentils, wheat and barley were recovered from two levels (dating to the 11th and 12th centuries AD) of the Ermita de San Anton site, Gran Canaria. Fig seeds have also been recovered from sedimentary units (undated) and dental cavities (6-8th century) on Gran Canaria (Morales Mateos 2003), although fig exploitation may have been rather more widespread. Another recent discovery from the funerary site of La Lajura (Hierro) indicates that the Bimbaches were acquainted with vines and barley in the second to third centuries AD (no author 2002), although samples are currently not large and the possibility of contamination cannot be excluded. Other finds include Canary Palm kernels from the Painted Cave site (Gran Canaria) and a range of cereals from early 1st millennium AD sites in La Palma (Morales Mateos pers. comm.), although systematic examination of such remains in the Canarian islandscape is still in its infancy.

3.8.4 Collateral Evidence for Diet

Non-traditional methods have also been deployed to assess human diet in the Canaries; the nature of the archaeological record in the islands is such that human remains occupies a prominent position in such studies, hence the importance of the current study. Indirect evidence for marine resource exploitation has been obtained through study of external auricular exostoses (EAEs) in two prehistoric populations from Gran Canaria (Dutour and Onrubia Pintado 1991; Betancor Rodriguez and Velasco Vazquez 1998). This pathological condition – characterised by bony outgrowth proliferation in the auditory canal – has been clinically linked to cold-water contact with the eardrum. Using Kennedy's 1986 definitions of 'low' (<5%), 'medium' (6-20%) and 'high' (over 20%) EAE prevalence, the Canarian figure of between 65% and 88% is exceptionally high. This finding indicates that ancient Canarians were very aquatic – as noted by some historians (Ortiz 1526, in Martin de Guzman 1984: 161) – probably linked to subsistence, judging from the remains of marine resources on archaeological sites. This habit appeared early in life, affected both sexes, and persevered into maturity.

Histomorphometry (cross-sectional analysis) of trabecular bone mass can be used to assess levels of *in-vivo* protein consumption, while excessive carbohydrates cause osteoporotic conditions. A survey of remains from Hierro, Gran Canaria and Fuerteventura (Velasco Vazquez *et al.* 1999; Gonzalez Reimers *et al.* 2001) suggested that ancient Gran Canarians relied heavily on agricultural produce, and were less healthy (i.e. more osteoporotic) than the other two islands. Gonzalez-Reimers *et al.* (2001) also assessed the Barium/Strontium (Ba/Sr) ratio of Fuerteventurans and Gran

Canarians, concluding that the Fuerteventurans had a marine-rich diet and better osteological health than Gran Canarians. Radiography was used to ascertain Harris Line prevalence (longbone defects caused by physiological stress) in a Gran Canarian sample (Velasco Vazquez 1996). The high prevalence in the Gran Canarians (males 25%; females 21%) indicates developmental stress more consistent with an agricultural than hunter-gatherer economy (Larsen 1997), although comparative data is lacking.

The most wide-ranging analysis of dental pathology (Delgado Darias 2001) concluded that the inhabitants of ancient Guayadeque (Gran Canaria), with a crude caries rate of 17.31%, had an economy resembling that of agriculturists rather than the hunter-gatherers (0.07-0.71%) or mixed-economy (4.1%) groups (2001: 206). Most of the caritic lesions were on approximal (45.28%) and occlusal (32.08%) surfaces, with a slight bias towards female individuals (17.51% vs. 16.86%; corrected figures to include tooth loss 31.64% vs. 25.99%). Langsjoen's study of a Tenerife sample (1992) is not directly comparable, although certain trends are evident. All of the lesions observed (5% of teeth present) originated at the CEJ, and 96% of these were on the approximal surfaces. No smooth surface lesions were reported. Lesions in Tenerife specimens were typically restricted to the molars with minimal prevalence in the premolars and canines (Langsjoen 1992: 90), while the Gran Canarians were strongly affected in all tooth classes except for the incisors (Delgado Darias 2001: 204). Maxillary teeth were more frequently affected in Tenerife, mandibular teeth in Gran Canaria.

In both Gran Canaria and Tenerife occlusal wear was both severe and '...remarkable in its early onset' (Langsjoen 1992: 79). This was attributed to the quern stones used to grind cereals, as experimental results have indicated that grit may comprise up to 6.5% of total barley flour mass reduced in traditional Canarian querns (Langsjoen 1992: 85).

Prevalence of contact point destruction was therefore high in Tenerife at least – (Langsjoen 1992: 79) and variation in the figures was attributed to ecological diversity within the island (1992: 84). Finally, the crude caries rate for Tenerife's relatively well-watered north and the much drier south was 2.5/1, providing support for assertions of ecologically linked economic variability (1992: 85), although the manner in which the data were processed (i.e. with reference to period) is not clear.

Aufderheide *et al.*'s (1992) trace element analysis of Tenerife skeletal remains indicated strong reliance upon meat and dairy produce, with less reliance upon wild-caught and agricultural produce. There was also evidence for intra-insular regionalisation. These data are partly substantiated by Tieszen *et al.*'s survey of stable isotopes ^{13}C and ^{15}N (1992), suggesting that Tenerife diets consisted of '...animal inputs derived from a pastoral lifestyle' (1992: 47). The stable carbon isotope ratio ($d^{13}C$) was calculated for Tenerife mummy RED-1 (Horne and Aufderheide 1992: 138), indicating a dominant (68%) consumption of meat/dairy products and a lesser consumption of C3 class vegetable produce (probably barley: 32%). If marine resources were consumed, they were so rare that '...their effect is not chemically detectable' (1992: 138). Gonzalez Anton *et al.* (1992b) summarise recent work in ancient Canarian diet, postulating that the large shell middens that are relatively common in the islands may be attributable to sporadic feasting behaviour rather than reflecting a regular dietary component (1992b: 197). Regrettably, no chemical dietary evidence is available for the Gran Canarian mummified remains or Lanzarote/Fuerteventura specimens.

The evidence for ancient Canarian economy is therefore somewhat contradictory. There is little doubt that there was an agricultural element in most island economies, but the archipelago's ecological profiles do tend to suggest that dietary homogeneity was unlikely at best. Most of the compelling evidence for cereal agriculture comes from Gran Canaria and Tenerife, while other resources (notably marine produce) seem to have played a more dominant role in the economies of the western and eastern archipelago. Goats are essentially ubiquitous throughout the islands, although their resistance to dry and hostile conditions may have made them of increased importance to native groups on Lanzarote and Fuerteventura (as suggested by contact-period accounts of dried meat and secondary produce on the latter). It therefore behoves us to develop new ways of examining Canarian dietary affinity, and to consider how economy may have been affected by temporal, spatial and environmental factors.

3.9 The Canarian Islandscape – General Considerations

The ethnic, social and behavioural patterns of contact-period Canarians are too often assumed to be a conveniently fossilised representation of Canarians throughout their history, a common assumption with island groups (Broodbank 2000: 15). For the Canaries, we are therefore implying that human groups acted in the 14th/15th centuries AD as they had since their original colonisation of the islands at least two millennia earlier. While it is of course possible that the islands' human populations were socio-culturally conservative throughout their history, this must be demonstrated rather than assumed. Addressing this issue is only possible by examining variability within (and between) the archaeological and historical records, as while cultural conservatism is supported by technological, social and cultural stasis, it is disproved by innovation and spread. This section therefore deals with the relationships between islands in terms of cultural affiliation, considering both historical and archaeological information in order to determine their physical mobility through the archipelago, and – where possible – variability through time. While theories based on undated evidence may be anecdotal, it is sufficient to distinguish between the alternative models of stasis and dynamism.

Finally, establishing whether or not the ancient Canarians ever had the wherewithal for sea travel is of vital importance, as inter-island travel without sea-craft is impossible. Direct and indirect evidence for watercraft and oceanic travel was therefore sought.

The evidence gained from historical and archaeological sources will be compared with and contrasted against the following hypotheses:

1) Canarian human populations on each island were isolated from one another from the point of initial colonisation until the 14th-15th century AD, each having their unique cultural trajectories.

2) Canarian human populations continued to interact on an inter-island basis throughout their history, with a shared and dynamic cultural heritage.

3) The level of inter-island contact varied across time from the point of initial colonisation to the arrival of the European forces, with consequent variability in cultural affinity, and certain common elements shared between islands.

These hypotheses are potentially falsifiable on the basis of cultural heterogeneity levels in the archipelago, from highly heterogeneous (cultural isolation) to homogenous (dynamic inter-island relationships) historical and archaeological signatures.

3.10 Canarian Islandscapes – The Historical Evidence

Bontier and Le Verrier's initial description of the Canaries was '...islands inhabited by unbelievers of various habits and languages' (1872: 1), and this indication of linguistic heterogeneity (albeit with the assumption of interconnection) is substantiated by a reference to 'an interpreter, who knew the country and spoke the language of this island and the others' (1872: 74-5) and to the inhabitants of Gomera, described as 'a tall people who speak the most remarkable of all the languages of these islands (and) speak with their lips, as if they had no tongues' (1872: 127-8). This is confirmed by later authors, including Bernaldez (1513, discussing a 1483 visit to the Canaries) who commented that 'these seven islands have seven languages' (Bernaldez 1513 re 1483, in Martin de Guzman 1984: 157), and Lopez de Gomara (1552, in Martin de Guzman 1984: 159). However, the languages were either partly mutually comprehensible, or there was inter-island mobility, as Bethencourt took only three translators on his valedictory tour of the (seven) islands (1872: 189). The language(s) of the archipelago have been a source of controversy for some time, and require explication in the current study. Various proper names (as recorded in the 15th and early 16th centuries – in Ossorio Acevedo 1996) were reviewed for significant distribution of unusual prefixes such as Guay-, Yba- and Eche- in the contact period. While names demonstrated considerable endemism, distribution was sporadically widespread. None of the names examined was found in more than one island, and only rarely were prefixes common to all islands. There were strong affinities between Tenerife and Gomera/Hierro/Palma, Tenerife and Gomera, and Lanzarote and Fuerteventura. This is partially borne out by Hooton's 1925 work, which identified strong linguistic links from pure Berber words overlying a Berber 'substrate', and Arab words in the eastern archipelago. This supports contact between island modules (and between the archipelago and the mainland) in the period immediately prior to the European invasion, but not far-flung travel between the east and the west of the archipelago. The famous Canarian whistling language, which is currently restricted to Gomera, was noted in various forms (as battle cries and communication) on Tenerife and Gran Canaria during the last quarter of the 15th century (Palencia 1481, as quoted in Martin de Guzman 1984: 154).

Cultural and behavioural traditions echo this 'variations on a theme' patterning. For example, conduct towards women was controlled by rigid regulations on Gran Canaria and Lanzarote. However, there was a system of seigniorial rights for the social elite on Gran Canaria, while the Lanzarote 'royal' family permitted a 'princess' to bear the child of an early European visitor. This can be compared with the Gomerans, who were extremely informal regarding sex and would lend their wives to visitors. Weaponry was fairly uniform, although spears tipped with goat horn were only found in the western islands, while the sling was only found in Gomera (Hooton 1925). Some traditions were specific to individual islands, such as Lanzarote women's habit of feeding children 'with their mouths, and thus their under lips are longer than their upper ones' (Bontier and Le Verrier 1872: 139) as they were apparently unable to produce milk. Finally, Canarian economy was fairly similar throughout the archipelago, but possessed variations that may reflect either ecology (absence of pigs on drier islands) or cultural (dried meat, butter and cheese on Lanzarote, Fuerteventura and possibly Gran Canaria) tradition.

Evidence for at least limited inter-island mobility is supplied by a reference to the passage between Lanzarote and Lobos, which, while being 'only four leagues...is the most horrible passage to be found in these seas, according to the account of all who have tried it' (1872: 32, although it is possible that this refers to the accounts of fellow Europeans). Gadifer de la Salle, Bethencourt's colleague and, later, nemesis, is reported to have sailed into '...a large harbour between Feldes and Argonnez (Gran Canaria), where about five hundred Canarians came to speak to them, two and twenty of whom were persuaded to come to the vessel' (1872: 70) to trade and exchange. Their boat was large enough to hold 22 individuals (the size of a large war canoe, according to Johnstone 1980, Broodbank 2000), figs and 200 ducats' worth of 'Dragons' Blood' (Orchil – a lichen used to make dye). The coincidence in size between the vessel owned by the Canarians (capacity 22) and that later stolen from '...Guillame d'Auberbosc... (who) landed at a village called Arguyneguy (Arguinegin), in two boats, containing forty-five men' [1872: 182]) is striking, and it is possible that the boat had been stolen from the French. Regardless of the boats' potential prior ownership, however, the foregoing nonetheless indicates that the Canarians displayed considerable affinity with watercraft. This is substantiated by the statement that 'Peter the Canarian came to speak with them, and afterwards the son of Artamy, King of the country, and other Canarians, came in great numbers to the vessel, as they had done on former occasions' (1872: 116-7). As the inhabitants of Gran Canaria were said to 'look upon themselves as noble, having none of the lower orders amongst them' (1872: 130-1), it seems unlikely that high-status delegates and their retinues would have swum out to the vessels, and it is more probable that they came out in some form of sea-craft. Many other minor references also seem to support some form of maritime expertise, although it is sometimes difficult to distinguish between native Canarians and French soldiery acting with native Canarian support. For example, Jean de Bethencourt 'then sent Jean de Courtois and Guillame d'Andrac and the people of Lancerote (sic) and several others out to sea...and while they were out fishing with the line, sixty Canarians came down very sharply upon them' (1872: 146-7). A 1590 reference to ancient Gran Canarians by Torriani describes 'boats that they made from hollowed-out dragon trees, which they ballasted with stones, and they navigated with oars and with palm-leaf sails around the coast of the island; and they would go to Tenerife and to Fuerteventura to raid' (1999: 162). I would venture to suggest that the text has been embroidered, as no other source – even those dating from the very beginning of the conquest – have such detailed information about this apparently high level of seamanship. Dragon (*Dracaena drago*) trees, furthermore, are extremely slow-growing and of a rather porous texture that makes them less than ideal for nautical architecture. However, I would accept that the text was based on some knowledge of Canarian navigational expertise, for while the Canarians are known to have copied European technology (see 3.6), the likelihood of their developing dugout canoes from observations of European dinghies (or, possibly, larger vessels – see plate 3.4) seems remote indeed.

If the islands were indeed cultural isolates, there should have been no native knowledge of other islands. Boutier and le Verrier's statements that 'in those parts it (Tenerife) is pronounced to be one of the best islands there is' (1872: 129) and 'The island of Fuerteventure (sic), which we call Erbannie, as also do the people of the Grand Canary' (1872: 133) are therefore significant. Another reference detailing how Bethencourt sent 'an interpreter to the inhabitants of the island (Hierro), by name Augeron, who came from Gomera' to lure his brother 'the king of the island' and various of his retinue into slavery (1872: 183-4) seems to suggest that knowledge of other islands was sometimes sufficiently extensive to result in inter-island familial bonds and relationships. The chroniclers themselves seem uncertain as to the actual level of variation in the Canarian group, referring to them both as a single group ('you will nowhere meet with a finer or better formed race' 1872: 108) and also as a number of races ([Gran Canarians] as 'the hardiest race to be found in all these islands' (1872: 129). Their physical appearance, where noted, seems to have constituted variations on a theme, as they dressed in similar clothing (skins and plant materials, or sometimes naked), were of tall stature, with sporadic body adornment ('...most of them print devices on their bodies' ibid. 131) and long hair. A 1590 reference by Torriani (1999: 162) details how the Gran Canarians' inter-island travel by dugout canoe (see above) led to a spread of '...their language, and various customs, such as is said of the Fuerteventurans, who imitated the Canarians' way of doing justice'.

3.10.1 Summary – Canarian Mobility in the Contact Period

European references to Canarian sea-travel are oblique and often must be implied from the sharing of certain cultural traditions that are unlikely to have arisen independently. This may be a result of reporting bias, as early commentaries on the Canaries lacked the detail and accuracy of later voyages in the Caribbean (Columbus 1492 – in Chaunu 1979: 158) and Oceania/Australia (e.g. Eyre 1845, cited in Flannery 1994: 271). However, strong nautical traditions would have constituted a real strategic and military presence, and it is likely that the French chroniclers would have commented if such had been the case (as in later reports by Torriani [1590], amongst others). In any case, it does seem that previous claims for complete insular isolation (i.e. Kelley and Boom 1992: 84), during the contact period at least, are incorrect. The contact-period Canary Islands only lack historical evidence for seafaring traditions when they are compared to more flamboyantly nautical and better-described regions such as Oceania and the Caribbean. Judging from the foregoing, there can be little doubt that the islanders enjoyed some degree of mobility, at least between geographically proximate islands, although details as to craft and travel networks are still lacking. The two large central islands were probably aware of each other, but were more closely involved with the groups of peripheral islands at their respective ends of the archipelago. These smaller islands seem to have had some form of interconnection, as evidenced by the many references in the earlier sources. Given the large population size of Gran Canaria and

Tenerife in the 15th century, it is possible that these islands formed a high-population core to the archipelago, while the peripheral groups, affected by restricted resources and small size, were involved in inter-island mobility for the purpose of exchange. Evidence for inter-island connections prior to the contact period must be sought, to put this possibility and its alternatives into perspective.

3.11 Canarian Islandscapes: the Archaeological Evidence

Traditionally, the high levels of cultural heterogeneity in the archipelago – coupled with the dearth of chronometric data – has led to claims of 'isolation' between the islands, thus implying that no evidence exists to link any members of the archipelago. However, it is likely that by deliberately focusing upon the most flamboyant remains, the differences between individual island cultures have been exaggerated. While fascinating in themselves, therefore, the social significance of unique archaeological entities, such as the painted caves of Gran Canaria, the pyramids of Tenerife or the spectacular meandriform rock-art of La Palma, can only be understood when the human islandscape is better understood. For this reason, only relatively widespread material culture forms will be analysed in this section. It should be noted that it is not intended to provide an exhaustive discussion of Canarian material culture, and that only evidence of cultural affinity, defined as similarities between islands and periods, will be sought.

There have been few systematic multi-island assessments of Canarian ceramics. Exceptions include work by Abercromby (1914), who stressed the uniformity of Canarian ceramics, and Diego Cuscoy (1953), who deemed inter-island differences to be representative of meaningful cultural divisions. The most comprehensive review by Navarro Mederos (1999) strikes a balance between these views, but can offer only tentative conclusions regarding relationships between them over time.

The La Palma sequence is by far the most comprehensive framework for the Canarian archipelago. By contrast, ceramics from Gomera, Hierro and Fuerteventura have no internal subdivisions, while Tenerife sequences have no temporal foundation (i.e. the 1-2-3 phase sequence is arbitrary). As Navarro Mederos's analysis of ceramics from Lanzarote is restricted to early remains from a single site (El Bebedero), it is probable that the island's full range of variability has not been sufficiently explored. The ceramics of Gran Canaria are so extraordinary that their internal and external relationships are almost completely obscure. Nevertheless, certain trends are apparent.

Plain or slightly-decorated bowls and pots are widespread; stylistic affinities between early remains from La Palma and Lanzarote (2nd century AD – Atoche Pena 1995), Hierro, Gomera and certain phases in the Tenerife sequence (de Balbin Behrmann 1987: 26) suggest a common tradition rooted in the North African Mediterranean Neolithic. Links are strongest between proximate islands, such as the Gomera/Hierro/La Palma triangle. Whereas the 'core-periphery' model works relatively well for Tenerife and the western islands, Gran Canaria has no apparent links with adjacent islands. Affinities are strongest early in the sequence, followed by increased diversity through time (for La Palma, Gran Canaria and – to a lesser extent – Tenerife, Hierro and Gomera). La Palma phase 4 diverges sharply from other islands and periods through possession of *sillons d'impression* pottery-stamping and other major stylistic variants. Navarro Mederos (1999) believes that this transition was associated with population migrations from the Sahara (represented by sites such as Hogar, Mouydir and Tassili) in the 11th century AD). This apparent cultural discontinuity may be a real reflection of population migration and change, a result of other islands' poorer stratigraphies and chronologies, or possibly a remnant of Canarian archaeologists' traditional preference for explaining innovation through diffusion rather than *in situ* development (Mercer 1980: 24). For example, while not seemingly used to decorate pottery vessels, Gran Canarian sites often produce 'pintaderas' – stamps made from ceramic. If La Palman potters lacked the tradition of painting pots, then it is possible that they used pottery stamps (which may have been traded from other islands) instead. The position of Gran Canarian ceramics is in itself a major issue, for while the appearance of painted and composite forms in the Canaries is not surprising given their proximity to Northern Africa (particularly Mauritania), the restriction of this tradition to a single island is harder to understand. It may suggest late contact with the mainland that did not spread to other islands before the European invasion, an expression of craft specialisation suited to a rich and populous environment, or a period of isolation leading to an acceleration of stylistic evolution.

While there are problems with the datasets, the ceramics indicate that a single colonisation and subsequent isolation model is unlikely to be an accurate interpretation of ancient Canarian social history. It is certainly true that the islands were linked in the early period, judging from pan-archipelago ceramic affinities (c. 2nd century AD). It is also unlikely that other (presumably later) affinities in ceramic structure and decoration between Tenerife, Gomera, Hierro and La Palma can have arisen independently. This, taken in addition to the contact period evidence described above, would suggest that inter-island contact was strong in the first half of the 1st millennium AD, but that this lessened through time without ever ceasing completely. The uniqueness of certain ceramic traditions in Gran Canaria and La Palma is interesting, as these depart from the majority of island assemblages. In conclusion, therefore, Canarian human populations varied considerably in their intensity and duration of inter-island contact. From a shared background, it seems that individual island populations developed distinctive cultural trajectories that were fundamentally similar yet superficially distinct. However, the differences are not so marked that a conclusion of subsequent total separation can be invoked. Finally, it would seem that at least some cultural transformations took place, and while the only strong evidence for this is entailed in Gran Canaria and the late stages of La Palma (phase 4), it is possible that the slightly confused sequences of the other islands are concealing similarly notable cultural discontinuities.

There are numerous other strands of evidence to support both homogeneity and heterogeneity in the pre-conquest Canarian islandscape. For example, structures were relatively modest on Lanzarote, Fuerteventura and the western islands. Large buildings, including cruciform houses and 'pyramids' (Guimar, Tenerife: Spence 2000), are only really known from Tenerife and Gran Canaria, although there are some structural similarities in design between Gran Canaria buildings and those at the Lanzarote site of Zonzamas. Caves were used for habitational, funerary and 'ritual' functions in all the islands, although only Gran Canarians created artificial caves and granaries. There was considerable mortuary practice variability in the archipelago. Whereas mummification is known for both Gran Canaria and Tenerife (and, to a lesser extent, the western islands), this tradition is absent from Lanzarote and Fuerteventura, where the dead were interred in single or multiple burials in caves, lava tubes or in the open. Large tumulus interments are known for early sites in Gran Canaria, while mass cave burials are common on Tenerife and Hierro. More unusual mortuary practices include cremation (only known for La Palma and Tenerife: de Balbin Behrmann *et al.* 1987: 22) and cannibalism (Tenerife only, but possibly more widely: Galvan *et al.* 1998).

Some artistic designs and patterns are island specific, such as the meandriform spirals from La Palma, while designs such as the 'podomorfos' ('footforms', said to represent sandaled feet [Atoche Pena and Ramirez Rodriguez 2001: 83]) have been found throughout the archipelago. Gran Canaria is the only island to have produced extensive cave painting (including repeating motifs, geometric designs and colour washes) and a range of alphabetical and figurative designs (ibid. 79). Libyo-Berberic inscriptions have been found in fragmentary form throughout the archipelago, but are very common on El Hierro, while 'Punic-inspired' inscriptions (ibid. 81) are common on Fuerteventura and Lanzarote. Small stone and ceramic sculptures, both zoomorphic and anthropomorphic, have been recovered from several of the islands, but are particularly common on Gran Canaria (ceramic) and Lanzarote/Fuerteventura (stone). Ceramic stamps ('pintaderas') are known for Gran Canaria, although ceramics decorated with stamped designs are only found on La Palma. While more work is required on lithic traditions, there appears to be some variation between islands such as Fuerteventura and Gran Canaria (Galvan Santos and Hernandez Gomez 1993), in terms of materials and knapping technique. Fishhooks were made from bone on Fuerteventura (Bethencourt and Bethencourt 1998: 10) and Tenerife (Hooton 1925: 35), overlapping with a horn fishhook tradition in Tenerife and the western islands (ibid. 35). Finally, simple jewellery shows some signs of cultural heterogeneity in the archipelago, with ceramic beads on Tenerife, bone and shell disks on Fuerteventura and Gran Canaria, widespread fish vertebrae beads that are especially common on the western islands, and composite forms (leather headbands decorated with shell beads) on Gran Canaria.

Overall, there is a distinct impression of cultural heterogeneity in the archipelago, in terms of differentiation in cultural artefacts and traditions, and the greatest differentiation is in those artefacts that are linked with decoration or other non-essential activities (i.e. rock art). Items such as fishhooks have a widespread range, and although different methods of manufacture (and possibly use, judging from palaeoichthyological profiles) seem to have applied to different islands, there is evidence for internal development from a more homogenous cultural base. Dating the period of these phenomena is impossible, owing to the manner in which the material was collected, although a general pattern of cohesion between the eastern islands and the western islands as separate groups, each of which was linked to the nearest large, central island (Gran Canaria to the east, Tenerife to the west) which in turn had tentative links with each other. The new dates for the islands (Zoller *et al.* 2003) have expanded the chronological depth of the archipelago's colonisation, and hint at further complexity that is yet to be fully understood.

3.12 Archaeological Evidence for Seacraft and Navigation

At least some of the islands were able to support self-sufficient populations. This, in addition to the substantial inter-island distances (most of which exceed the 10/20/40km 'interaction zones' cited as thresholds for single-day travel by paddle-powered canoe or longboat [Broodbank 2000: 260]), suggests that individual island groups would have been able to avoid regular or intense contact if so desired. Cultural diversity between islands has previously been explained in terms of inability to broach water gaps, or an inability to develop the required technological innovations required for regular inter-island voyaging. However, cultural diversity in the Canarian islandscape could also be the result of an intentional stance against external influence, with differing 'isolation' according to fluctuating economic, technological or socio-political motives. Choosing between these alternatives is a central investigation priority in Canarian archaeology.

There is no direct evidence for boats in the Canarian archaeological record. While this has been interpreted as a lack of technological facility for their manufacture, the discovery of a 6th-8th century wooden coffin from Gran Canaria that strongly resembles a dugout canoe implies that the ancient Canarians did in fact possess the requisite skills for boat-building (Mercer 1980: 17). The arrival of sufficient numbers of people to generate, over the long term, large populations in the Canaries (in addition to the various human commensals discussed above) would seem to suggest that the native Canarians were *au fait* with substantial seacraft for at least part of the colonisation sequence, and this would seem logical if the nautical and navigational contrasts between the Atlantic and the Mediterranean are considered, as the ocean beyond the 'Pillars of Hercules...was a very different and far less agreeable world' (Johnstone 1980: 76) that would seem to demand vessels of ocean-going calibre. However, even modern yachts are unable to negotiate the Canary Current for much of the year, and Europe-bound sailors are regularly stranded in the archipelago. By contrast, small vessels ('pateras') bearing illegal immigrants from NW Africa are often able to reach Fuerteventura or Lanzarote on the currents alone, or with minimal rowing/sailing effort. The fact that any floating item on the Atlantic seaboard can potentially reach the Canary Islands, but even complex boats of the 21st century AD are often unable to negotiate the return journey has powerful implications for the development of ancient Canarian society.

The controversy over the Canaries' earliest colonisation makes determining the nature/appearance of the settlers' watercraft fraught with difficulty. While arguments for small vessels such as bark canoes, dugout canoes and skin boats can be supported historically and implied archaeologically, there is a dearth of direct evidence for large boats in the archipelago, with the exception of perforated, curved planks from Hierro that were used as funerary tableaux (Diego Cuscoy and Galand 1975: 12) but which seem reminiscent of ships' timbers. The appearance of the house mouse in Fuerteventura around 5,000 BC (perhaps contemporaneously with the arrival of goats on Lanzarote – Zoller *et al.* 2003) is reminiscent of *Rattus praetor*'s first appearance in New Ireland around 1,000 BC. As this species is essentially inedible, it is very unlikely to have been intentionally introduced by the Lapita colonists, therefore suggesting that Lapita watercraft (which are archaeologically unknown) were sufficiently large to be infested by the species without the humans' knowledge (Flannery 1994: 168). The house mice may therefore be the best evidence yet to suggest that sizeable seacraft visited the islands fairly early in their human history. Whether the settlement was continuous or punctuated is, however, uncertain.

Engravings of boats sometimes appear in rock art panels, including 'galleys' (Atoche Pena and Ramirez Rodriguez 2001: 84 – see plate 3.4) and sail-less, oar-powered vessels resembling the 'hippoi' of the 1st millennium BC Atlantic seaboard (Johnstone 1980: 93). However, there is no guarantee that these carvings reflect pre-mediaeval naval architecture (de Balbin Behrmann *et al.* 1987: 34), and they are neither as consistent nor as clearly depicted as Neolithic engravings from Northern Europe (Johnstone 1980) or the Early Bronze Age engravings of longboats and other seacraft in the Cyclades (Broodbank 2000: 98).

At least some of the native Canarians would have to have possessed sufficient nautical experience to handle watercraft capable of transporting sizeable numbers of humans in addition to goats, sheep, pigs, dogs and cats. However, the temporal distribution of this expertise and technological capacity is debateable. It is not necessary to invoke very large, complex boats for the whole of the Canarian colonisation sequence (although they appear to have been present at some point), and a voyage-return system (which would, intuitively, have resulted in the transmission of extensive cultural signatures) does not appear to have occurred. It seems likely that there was a sequence of smaller colonisation events through time, adding to the extant human populations and possibly explaining the high levels of cultural heterogeneity in the archipelago, although this topic requires further study.

3.13 Summary: Mobility in the Prehispanic Period

When compared against the three hypotheses posited above (section 3.9), the Canaries most closely fit hypothesis three, in that their cultural heritage reflects a general common ancestry, but that this developed into distinctive styles on individual islands without the cessation of inter-island contact and travel. While precise patterns and processes cannot be derived from what is essentially a rather fragmentary dataset, it is evident that contacts between the islands – and with the mainland – were at least apparent if not common. There are indications that contact fluctuated through time, as demonstrated by the strong cultural (ceramic) links that existed between La Palma and Tenerife, followed by abrupt stylistic divergence. Networks are not clear: however, just as for the biogeographical profiles discussed above, general affinity patterns can be detected. Tenerife has a relatively strong albeit fluctuating relationship with La Palma, Gomera and Hierro, and also tentative links with Fuerteventura. The island of La Palma demonstrates affinities with other western isles in earlier periods – and also with the eastern island of Lanzarote – and is highly culturally distinctive for the later part of the archaeological sequence. Gran Canaria stands in relative isolation from the remainder of the archipelago.

As there were clear links between the islands at the time of the European takeover, it would seem that the capacity for oceanic travel was never lost in the archipelago, and persisted to a greater or lesser extent from the point of original colonisation onwards. This scheme roughly emulates that derived from the biogeographical study. Exceptions include the fact that there are stronger cultural links between distant islands, and that there is far less to characterise the dry eastern islands of Fuerteventura and Lanzarote as a unit. Island isolation on the scale of Rapa Nui or Temple-Period Malta is thus not supported for the Canary Islands, whereas as a group they were less incorporated than many eastern Mediterranean groups.

The overall pattern is unlikely to have been produced simply by a single E-W settlement (*contra* Guatelli-Steinberg *et al.* 2001), as the strength of the cultural links would be minute, and stylistic heterogeneity (i.e. between islands) far stronger, if further inter-island contact were not made after initial colonisation. I would therefore suggest that the archipelago was settled by a variety of currently unidentified social/ethnic groups at certain points in the period spanning ?5,000-500 BC, followed by an increased volume of immigration into the archipelago from the 1st century BC to the 7th century AD. During this time, a loose network of navigational routes linked the islands, and distinctive cultural artefacts – such as ceramics or artistic works – were not a major item of trade, exchange or diffusion. Individual societies may therefore have indulged in relatively frequent voyages to other islands, yet maintained highly specific cultural repertoires that functioned as intentioned political or socioeconomic markers that set them apart from their neighbours (internal variability is also likely, although difficult to demonstrate with the available data). Relating the exact mechanism behind the palimpsest of cultural similarities and dissimilarities is beyond the range of this thesis, but the bare facts serve to demonstrate the sea-going capacity of prehispanic Canarian peoples throughout their history. Testing the validity of these proposals, and examining the nature of human links between the islands, will be assessed using dental anthropology in section 6.

3.14 General Summary – Culture and History in the Canary Islands

The Canaries were occupied by agrarian and probably pastoral populations over a period of several millennia, resulting in a group of island populations with a wide range of social and cultural traditions reflecting their complex colonisation history. Various cultural signatures have linked the Canaries with various parts of NW Africa and southern Europe, although these will achieve little significance for Canarian colonisation history until a more complex temporo-spatial network is in place. However, NW Africa and the Atlantic seaboard would certainly appear to be the most likely area for Native Canarian origins (see chapter 5).

While Canarian chronology is currently less than refined, it is apparent that individual island cultures were interconnected by networks that were the vector for transmission of cultural traditions, although some islands – at certain points in their history at least – appear to have deliberately shunned overt external influence and contact. The fact that the island cultures were fairly homogeneous at the time of their discovery by European thassalocracies in the late mediaeval period tends to imply that inter-island contact was the rule rather than the exception. It is evident that there were several population moves into the archipelago, incorporating/assimilating earlier groups, reaching previously uncolonised islands and (re)establishing contact within the group, for one would intuitively expect rather higher levels of cultural diversity between islands if they had been absolute isolates for up to 7,000 years.

Economically, the islands were essentially variations on a theme, with reliance upon goats/sheep and pigs, in addition to wild-caught resources where available. Preliminary archaeological evidence suggests that exploitation of the latter had a detrimental effect on natural resources, with marked reduction of fish, shellfish and bird stocks on certain islands. The nature of exploitation may reflect population size, which appears to have increased markedly in the late 1st millennium AD.

Canarian cultural history and archaeology is of considerable importance to an ever-expanding range of disciplines. In addition to the fields of mediaeval history, island archaeology and Mediterranean archaeology, it now seems possible that the archipelago's archaeological heritage may be of relevance to earlier periods, with enormously powerful implications for the development of voyaging, exploration and cultural expansion. However, while it is necessary to assess the islands' past in order to maximise their potential for each of these fields, it must not be forgotten that Canarian heritage is sufficiently important to stand scrutiny on its own terms and not merely as an adjunct to other fields. It is therefore necessary to carry out temporo-spatial analyses of Canarian archaeology in order to develop a more coherent picture of the archipelago's colonisation and settlement histories, and it is hoped that the present project makes a contribution towards this goal.

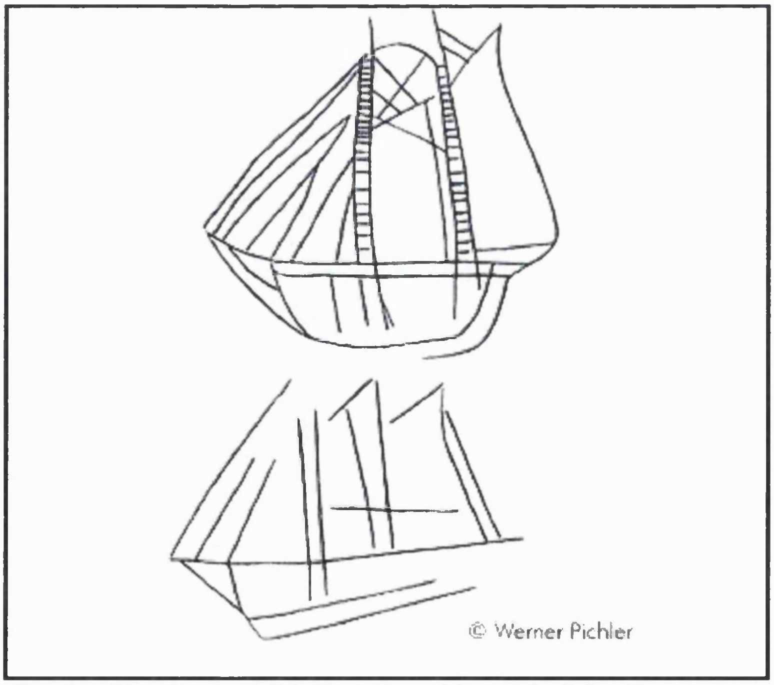

Plate 3.4. ?Post-Conquest Ship Engravings, Morro de la Galea, Fuerteventura (www.almogaren.org/gallery/canarias.htm)

4 The Scope of Bioarchaeology

Bioarchaeology as currently defined (Larsen 1997: 1) is a fusion of biological anthropology techniques and archaeological agendas, combined with a range of scientific disciplines such as genetics, microscopy and biochemistry, dedicated to understanding the biology and lifestyle of human groups in the past. The analysis of ancient human remains is often neglected in the wider realm of archaeological science, but can bring a completely new dimension to the study of ancient human populations (White and Folkens 1991; Buikstra and Ubelaker 1994; Bass 1995). Appropriate application of biological principles to the study of archaeologically-derived human remains may provide information to refute or support extant theories based on cultural information, or, in many cases, provide information not obtainable by other means. The types of information that can be obtained through bioarchaeological analysis include palaeodemography (ancient demographic structure), population biology (biological/genetic affinity within and between groups) and life history (lifestyle variables such as growth, health and diet determined by behaviour or environmental interactions). The present study includes both population biology and life history data.

4.1 Demographic Information

Age and sex information can add a social dimension to bioarchaeological studies. While less relevant for population biology studies, certain life-history indicators must be used in the context of age if they are to have any significance (i.e. caries – Hillson 2000). Equally, life history indicators may differ according to sex, denoting differences in social status, practices or traditions and thus strengthening theoretical perspectives such as the archaeology of gender. However, this study does not carry out a detailed palaeodemographic survey (see Waldron 1994), owing to both the nature of the materials available and the intended directions of the project. The ageing and sexing methods used are briefly described here; for fuller details see work by Lovejoy *et al.* (1985), White and Folkens (1991), Buikstra and Ubelaker (1994) and Bass (1995), and references therein.

4.1.2 Age Information

The materials were aged using dental wear, cranial suture closure and dental development (where applicable). While postcranial methodologies (pubic symphysis and auricular surface) were used where available, this was usually impossible owing to the nature of the materials in most Canarian collections (see Buikstra and Ubelaker 1994 for further details on ageing systems). Estimating age through observation of dental wear is contentious as the obvious link between increasing age and increasing wear can be blurred through variability in diet, food texture and social practices which should all be taken into account. It was therefore considered wise to calculate an approximate 'wear rate', calculated per site or population by observing the extent of wear between early and later erupting teeth, and to treat Lovejoy's (1985) assertion of uniformly applicable wear standards with suspicion (Walker 1978). As for the cranial suture closure technique (see below), therefore, the dental wear findings are not as strong in isolation as they would be if incorporated into a multi-factorial age determination process (Lovejoy *et al.* 1985). Cranial sutures describe fusion lines between the cranial bones, which obliterate with increasing age (Buikstra and Ubelaker 1994). Although the system has been demonstrated to be effective in various studies (Lovejoy *et al.* 1985; Meindl and Lovejoy 1985), suspicions as to its accuracy have also been expressed (Key *et al.* 1994). While cranial sutures were used, therefore, these were always viewed as inferior to 1) pelvic ageing systems and 2) dental wear – used together where possible to provide a multifactorial age (Lovejoy *et al.* 1985) – and were essentially ignored if the two latter were present.

Materials were classed using an eight-ranked system from young subadult (0.5-10 years) to old (50+ years), as laid out in table 4.1. If a specific age could not be determined, an adult (code 8) vs. subadult (code 3) dichotomy was used. This system was designed with the material used in the study in mind, but reflects the general characteristics of bioarchaeological ageing system classifications (see White and Folkens 1991, Buikstra and Ubelaker 1994, Bass 1995 and references therein for further details). In some tests, the categories were simplified to provide more general ageclasses categories, increasing sample size and therefore the strength of the test results (see 'Amended Ageclass' column of table 4.1).

Ageclass	Code	Amended Ageclass
Young Subadult: 0.5-10 years	1	Subadult
Older Subadult: 11-18 years	2	Subadult
Subadult: age unknown	3	-
Young Adult: 19-25 years	4	Young Adult
Older Adult: 26-35 years	5	Older Adult
Mature Adult: 36-50 years	6	Mature/Old
Old: 50+ years	7	Mature/Old
Adult: age unknown	8	-

Table 4.1 – Ageclass Information

The extra ageclass (young adults 19-25 years) was added to the traditional (Buikstra and Ubelaker 1994) ageclasses on the basis of the large number of individuals that would otherwise have fallen into the 19-35 years group. These individuals tended to fall into one of two groups: marked M1 wear and low M2 wear, as opposed to very high wear on both molars and M3 (if present). The distinction was so clear that it was thought justifiable to split the 'young adult' ageclass into 'young' and 'older' groups.

4.1.3 Sex Information

Owing to the nature of the materials, sexing was based primarily upon cranial remains. The standards for sexing skulls are well established, and mainly pertain to increased robusticity and size in males, along with some allometry (sex-based shape differences). Most areas of the skull show sexual dimorphism, particularly the frontal, the cranial base, the face and the jaws. Postcranial sexing techniques (where used) involved overall size (especially the longbones) and shape variability of the pelvis that are mainly related to obstetric considerations. These methods have been extensively discussed elsewhere (Bass 1995; White and Folkens 1992; Larsen 1997 etc), and do not require further explication here.

While five sex categories were used when scoring the material in order to allow increased refinement and room for uncertainty ('probably male' and 'probably female' categories) these were reduced to three in order to increase sample size and facilitate analysis. However, the original scoring still exists for future, more refined work. As assigning sex to immature remains is somewhat problematic due to the non-linear way in which the skeleton matures and develops (Buikstra and Ubelaker 1994), this was not done for individuals under the age of about 15 years. However, late adolescent individuals (16-18 years of age) preserved sufficiently diagnostic anatomy to be tentatively sexed.

Sex	Code
Male (including 'probably male')	1
Unknown (including most subadults)	2
Female (including 'probably female')	3

Table 4.2. Sex Groups

4.2 Population Biology

Population biology studies are based upon ascertaining biological affinity within or between groups or individuals. While this can be done using mtDNA or Y-Chromosome data, this is often inappropriate for use on archaeological specimens owing to financial considerations, preservation problems and the impracticality of destructively sampling ancient specimens. For this reason, morphometric assessment of osteological (especially cranial) and dental remains is an accepted means of measuring genetic affinity, based upon the common assumption that closely related populations will be more similar than distantly linked groups (Darwin 1859; Weiner 1994). Metric (interval), nominal and ordinal data from human skeletal remains has therefore been sought in order to elucidate ancient population movements, gene flow and human variability (Carlson and Van Gerven 1977).

4.2.1. Methods in Population Biology Studies

Craniometry (Howells 1973; Mizoguchi 1986; Kouchi 1986; Lahr 1996), odontometrics (Kieser 1996) and the observation of non-metric variants of the cranial and postcranial skeleton (Berry and Berry 1967; Ossenberg 1986; Sutter and Mertz 2004) have been deployed in a number of studies to identify biological relationships at all levels from familial to the regional. However, the most widely used system is based on the dentition, scoring the presence, size and shape of biologically significant cusps and other dental variants as a basis for population studies. While there are various scoring schemes, the most widely used is the Arizona State University Dental Anthropology System (ASUDAS).

4.2.2 The ASUDAS

The ASUDAS has been used in numerous archaeological contexts. For example, it confirmed the existence of familial links in a multiple burial at Upper Palaeolithic Dolni Vestonice (Alt *et al.* 1997), and has identified the affinities of ancient groups (i.e. the Alaskan Inuit and Arizona Pima Indians [Bang and Hasund, 1971; 1973; Scott *et al.*, 1983]) that often cannot otherwise be established. Anthropological enigmas such as the affinities of the Ainu have also been resolved with the help of the ASUDAS (Turner and Hanihara 1977). The system has also provided details of population history, such as the genetic subdivisions of ancient Europe (Coppa *et al.* 2001), or population migrations in

A-C group Nubia (i.e. Johnson and Lovell 1995). The ASUDAS is even effective on a continental scale, such as the application of dental evidence to Native American groups, which (when compared with genetic and linguistic analyses) confirmed an eastern Asian origin for Amerindian populations (Greenberg *et al.* 1986), while Scott and Turner's (1997: 288-307) study created global-scale dendrograms for human dental variability.

A combination of dental and cranial systems was used in the present project. Craniometrics were rejected for several reasons. This was partly due to the fact that cranial shape is as much affected by environmental factors – nutrition, level of exercise and age – as by genetic makeup (White and Folkens 1991; O'Loughlin 2004), and that archaeologically-derived cranial remains are usually in poor condition, thus affecting both the accuracy of measurements and the number of measurements that can be taken. However, the primary reason was that while there is a formidable body of work to support the use of craniometry to examine biological affinity (Howells 1973; Sjovold 1977; Krogman and Iscan 1986; Hauser and De Stefano 1989; Saunders 1989; Lahr 1996, amongst many others), the author was discouraged from utilising cranial techniques owing to it's associations with race-based Social Darwinism in the 19th and early 20th centuries. Teeth, by contrast, do not remodel through life, and once formed are unchanging except for mechanical attrition. While they may be affected by physiological stress during development, such disturbances are often recognisable as hypoplastic defects (Wood 1996). These lesions can also provide information on childhood development and health, while the age at which the metabolic insult was sustained can be estimated from the position of the defects on the tooth crowns (Larsen 1997). Even if morphology is obscured through masticatory activity, some life-history information, such as diet, can be derived from study of dental pathology. Archaeologically, teeth survive better than bones due to their small size and robust structure. There is little stigma attached to teeth, as dental anthropology was developed in the last thirty years along the strict guidelines of population biology and genetics. Certain cranial non-metric variants (Berry and Berry 1967) were also recorded in order to provide population biology results in the event of worn or missing teeth, and to test the ASUDAS results. As remodelling (cranial synostosis – age-related fusion of the sutures [Brasili *et al.* 1999]) can conceal minor morphological characteristics, ageclasses were controlled in these tests.

4.3 Life History

Life history variables are determined by environmental, socioeconomic and behavioural factors, rather than genetic affinities. There are methods for investigating diet (dental wear, caries patterns, isotopic analysis and trabecular bone geometry), body size (osteometry and anatomical modelling), health (palaeopathology, genetics and enamel hypoplasia), activity levels (articulation pathology and cross-sectional geometry) demography (age/sex-specific morphology, or degenerative change) and trauma. Such studies assume a higher level of resolution when combined with temporospatial and demographic (age/sex) information. As this project focuses on the human aspects of Canarian colonisation and settlement, research focused upon diet, health and interpersonal violence as indicators of island adaptation. It was decided to take advantage of recent work by Hillson (2000, 2001) and focus upon dental caries rather than isotopic or trace element analysis. Enamel hypoplasia was used to assess childhood health (Hillson 1996; Dean and Reid 2000), while the prevalence of trauma was also assessed by location on the cranium, sex, age, period and island ecology (a potentially important consideration for the ecologically diverse Canaries).

4.3.1 Diet

There are many ways in which diet in ancient populations can be explored, but most of these, such as isotopic analysis and trace element studies, are either destructive or too time-consuming for a study of this size. Caries was therefore used as a proxy, as it has long been recognised that variability in caries prevalence patterns accompany major transitions in human economic history (see below). However, it is equally apparent that caries' potential for explaining dietary changes has been hampered by inappropriate recording methods, and it was not until the recent development of a more sophisticated system by Hillson (2000, 2001) that such a study became truly viable.

A host of clinical/experimental and observational studies has conclusively demonstrated that plaque bacteria fermentation of dietary carbohydrate (sugars and starches) plays a major role in the development of caries through the demineralisation and destruction of dental tissues (Hillson 2000), exacerbated by factors including attrition, age and periodontal disease. Comparative studies of the great apes (relatively high in frugivorous species such as chimpanzees, and rare in folivores such as gorillas) and Plio-Pleistocene hominids (uncommon in Australopithecines and Paranthropines: Hillson 1996; Larsen 1997: 64-7). Caries continues at low prevalence throughout the Palaeolithic (Bartsiokas and Day 1993; Trinkaus *et al.* 2000) and Mesolithic, rising sharply in prevalence following the development of cereal agriculture, and therefore starch ingestion, in the Near East (Larsen 1997). Levels fluctuated across time and space until a pronounced prevalence jump in 19th century western Europe, then other regions, following increased availability of refined sugars (Hillson 1996; 2000). Dental caries has been used to ascertain dietary trends in a range of ancient cultures, including Turner's (1979) detection of agricultural practice in the Jomon culture of Japan, which had previously been proposed on the basis of cultural artefacts. The sensitivity of teeth to factors that define major trends in dietary proclivity supports the use of caries in the analysis of economic and, by extension, ecological adaptation of ancient human groups.

4.3.2 Health

Ancient health can be studied using palaeopathology, genetics and non-specific indicators of physiological health. As the samples to be studied are museum specimens, histological or genetic tests were inappropriate. Equally, palaeopathological studies often fail to examine populational trends and potential social impact, in favour of exploring the detailed anatomical and historical profile of ancient disease in isolated archaeological cases. In any case, morphological, histological and genetic studies require perusal of many parts of the skeleton, which is impossible with most collections of Canarian human remains.

Physiological health indicators are non-specific indicators of systemic stress. As such, they offer a more general view of health during physical development, and provide information concerning physiological insult prevalence, such as fevers, starvation or large-scale infections, from before birth to adolescence (these are over and above 'stress indicators' that may occur at any point during life; see Ribot and Roberts 1996). These insults affect development of the individual, leaving internal or external markings in the longbones (Harris Lines) and teeth (enamel hypoplasia). It was decided to use the hypoplasia-scoring system proposed by Hillson (2000, 2001), and to ally this with developmental age data from histological and radiographic studies of odontogenesis (see Hillson 1996 for a summary).

Dental enamel hypoplasia has been noted – and associated with illness or physiological stress – since the 18th and 19th centuries (Bunon 1746 and Zsigmondy 1893, in Hillson

1996: 165). However, details of the enamel growth process were less clear until relatively recently. Hypoplasia (or DDEs: Dental Defects of Enamel) is characterised by banding, furrowing, 'stepping' and pitting of dental enamel, caused by physiological disturbances sustained during odontogenesis (i.e. the first few years of life). As dental enamel is formed only once and is not turned over or replaced, this record of development is indelible once formed (Fischer and Noren 1988). Enamel hypoplasia therefore has considerable potential for deriving information on human health, with implications for social organisation, economy and stratification in the past. Because of the way enamel is laid down, the position of the lesion on the tooth crown can pinpoint the age (within certain parameters) at which the physiological insults were sustained. This in turn can be interpreted using frameworks based upon the sexes, or other socially significant groupings. There is considerable controversy over dental development (Dean and Reid 2000) and the precise causes of hypoplastic lesions; however, as a general measure it is certainly adequate for carrying out basic observations on systemic health in ancient populations, and it is on this basis that the system was adopted.

4.4 Trauma and Inter-Personal Violence

Physical injury corresponds with lifestyle in the same manner as dental pathology or other life history indicators. Some injury patterns are highly specific, such as the 'parry' or defence fracture that characterises the deflection of a blow aimed at the head (Webb 1989). Other fractures are less diagnostic, and are usually described in terms of pattern, extent of healing and other factors such as the presence/absence of limb shortening, defleshing/breakage (e.g. cannibalism; White 1992) and additional clues such as projectile points (Ubelaker 1978). As with dental systems (see above) it is inappropriate to claim that fracture patterns are a direct measure of anything as intangible as social dynamics, behaviour or aggression. However, it is possible to draw general conclusions ancient lifestyles (particularly if demographic and chronological issues are considered) in the manner of modern forensic investigations of human remains.

While the 'Standards' (Buikstra and Ubelaker 1994) contain a pro-forma for recording fractures, it is not as formalised as other systems for recording dental morphology/pathology or cranial variables. It is therefore necessary to constantly devise innovative recording systems in order to explain a phenomenon known to be inherent in a population, or to test for different behaviours of potential relevance to the group. For example, the warring nature of contact-period Maori groups (Flannery 1997: 246-8) or Easter Islanders (Flannery 1997: 256-7) has been confirmed osteologically in the high prevalence of traumatic injury on human remains from the islands (O'Gorman pers. comm.; Larsen 1997: 139-140; personal observation). In the present case, it was necessary to develop a cranial-only system (due to the nature of the materials) that would enable distinctions to be drawn between accidental injury and trauma caused by inter-personal violence.

Studies of modern groups establish parameters for the explanation of archaeological remains, such as how the injuries of domestic violence victims differ from those of pugilists, or those who participate in rugged outdoor activity. Webb's 1989 study of Australian aborigines demonstrates clear diversity in fracture prevalence, indicating higher levels of physical activity among males (broken limbs) and higher prevalence of 'battering' (1989: 140) marks in females, with some indication that the trends were related to ecology. Trauma prevalence and patterning can also provide an extra insight into ancient behaviour that is not available by other methods. Examples include Trinkaus' (1995) analysis of Neanderthal lifestyle and trauma, warfare in Amerindian groups (Lovejoy and Heiple 1981), the impact of European colonists on indigenous populations (Shermis 1984; Larsen 1997) and general investigations of lifestyle in archaeological populations, such as the relative status of males and females (Jurmain and Bellifemine 1997; Jurmain and Kilgore 1998).

4.5 The Human Dentition: Form, Structure and Heredity

Dental form is extremely variable, ranging from the baleen of plankton eaters to the grinding teeth of herbivores and the carnassials of carnivores, and reflects ecological adaptation. As occlusal crown morphology and relief can be used to differentiate animal groups at the population, species and genus level, they are therefore the '...centerpiece in many comparative populational and evolutionary studies' (White and Folkens 1991: 101). Intra-species morphological variability is the basis of the ASUDAS.

4.5.1. Human Dental Form

Human teeth comprise a crown and a root, divided by the cemento-enamel-junction (CEJ). The root and the crown core are made of dentine, containing a pulp cavity bearing nerves and a blood supply. The crown is capped with an ≤2mm thick layer of enamel, which is important for bioarchaeologists as it is the hardest substance in the human body and regularly survives in the archaeological record. The root is held in the jaw by the periodontal ligament, connecting to a coat of dental cement (Hillson 1996: 148-206). A cross-section through a human tooth is presented in plate 4.1.

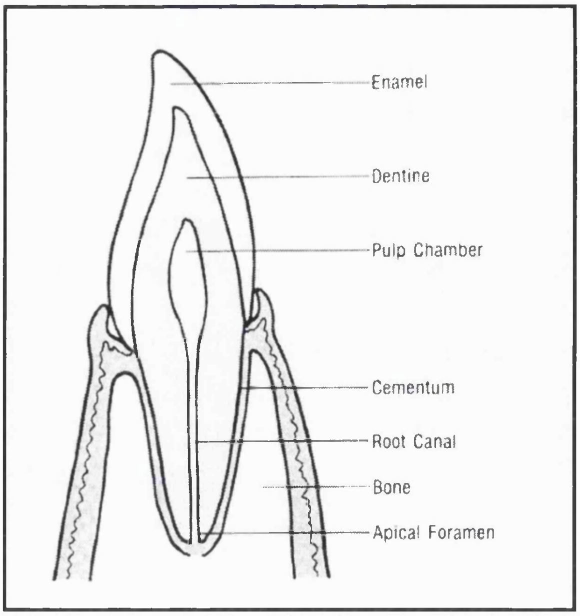

Plate 4.1. Cross Sectional Anatomy of a Human Tooth
From White and Folkens 1991: 104

Humans are heterodont, and therefore have several forms of tooth reflecting their dietary proclivities. A full discussion of dental morphology may be found in Steele and Bramblett (1988), Turner *et al.* (1991), White and Folkens (1992), Hillson (1996) and Scott and Turner (1997). The human dentition is divided into a cutting and slicing module (incisors), a puncture crushing module (canines; premolars) and a grinding/reduction module (molars), all of which are highly variable in numerous aspects of their morphology. Teeth are discussed in reference to the orientation of each of their surfaces in the mouth, as laid out in plate 4.2.

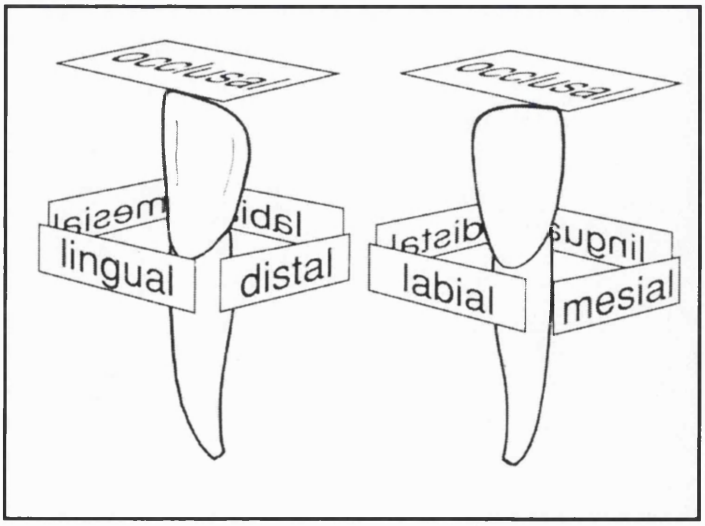

Plate 4.2. Tooth Orientation Nomenclature
From White and Folkens 1991: 104

The FDI (Fédération Dentaire Internationale) system uses double numbering; the first denoting jaw quadrants (permanent 1-4; deciduous 5-8), the second number denoting tooth 'number' as counted from the midline (see table 4.3. – standard abbreviations are also presented). This method was employed for the present project.

Tooth	Upper Right	Upper Left	Lower Left	Lower Right
1st Incisor	11 (UI1)	21 (UI1)	31 (LI1)	41 (LI1)
2nd Incisor	12 (UI2)	22 (UI2)	32 (LI2)	42 (LI2)
Canine	13 (UC)	23 (UC)	33 (LC)	43 (LC)
1st Premolar	14 (UP1)	24 (UP1)	34 (LP1)	44 (LP1)
2nd Premolar	15 (UP2)	25 (UP2)	35 (LP2)	45 (LP2)
1st Molar	16 (UM1)	26 (UM1)	36 (LM1)	46 (LM1)
2nd Molar	17 (UM2)	27 (UM2)	37 (LM2)	47 (LM2)
3rd Molar	18 (UM3)	28 (UM3)	38 (LM3)	48 (LM3)

Table 4.3. - FDI Dental Numbering System

4.5.2 Heredity of Dental Characteristics

'It is almost axiomatic that tooth development in general and dental morphology in particular are under strong hereditary control' (Scott and Turner 1997:131).

The ASUDAS is a recording system designed to score the presence/absence or extent of development of dental morphological traits, which are assumed to be hereditary, and therefore a reliable measure of biological affinity. Consequently, it is important to understand the manner in which dental form is inherited, and the extent to which morphology can be relied upon to accurately reflect populational history. While researchers have long been passively aware that dental morphology is under genetic control, most anthropologists were prepared to accept the self-evident phenotypic conservatism of the dentition without investigating its genetic basis. Anthropologists assumed from the outset that dental variables had a simple mode of inheritance, and used pedigree analysis (i.e. familial and twin studies) to examine phenotypic trait expression and create heredity models. While treating dental characteristics as discontinuous variables provided a certain amount of heredity data from a wide range of populations, it became increasingly clear (i.e. Turner 1971) that variable expression was a major feature of dental nonmetric traits, and that modifying genes and environmental scenarios were involved. The failure of simple inheritance models to explain irregular heredity patterns and the range of expression of the characteristics has led to the development of the threshold model (for quasi-continuous variants), which is regularly invoked to explain expression variability for morphological characteristics in the dentition. In this model, a physiological threshold marks the point where a genotypic character becomes part of the phenotype (i.e. physically present). A trait may be present genotypically, but possess insufficient penetrance to be expressed phenotypically. Individuals who do not possess a morphological (i.e. phenotypic) trait are identical phenotypically, but may be different distances from the physiological threshold and therefore be different genotypically. The nature of the threshold model allowed dental non-metric variants to be perceived as discontinuous variables (Sofaer 1970). As discontinuous traits with a genotype/phenotype threshold, variable phenotypic expression of a given trait 'was not only explained but predicted, given the tenets of the threshold model' (Scott and Turner 1997: 161). Although categories of morphological expression are artificial, in the sense that phenotypic traits grade imperceptibly into each other without recourse to discrete forms, categorisation of quasi-continuous variants as expression grades allows both standardisation and quantification of dental morphology for the purposes of population biology studies.

4.6 Morphological Traits Employed in the Present Study

The ASUDAS is based upon 'scoring' the presence/absence or degree of expression of minor morphological variants of the dentition, and using the distribution of such traits to assess biological relatedness between human populations. While there are 100+ dental traits, not all have been adequately defined. The typical trait suite in recent odontographies comprises 35 variables, most of which are represented by plaster plaques to aid identification (Turner *et al.* 1991). The ASUDAS traits laid out in Turner *et al.* (1991) and Scott and Turner (1997) were recorded for the present analysis, with the exception of Tomes' Root, torsomolar angle and rocker jaw. These traits were excluded because their strong dependence on environmental factors (such as age, sex, tooth loss and muscular development) makes them imperfect indicators of biological affinity, and also because the recording systems used to score them are unreliable. The very high levels of tooth loss and often poor condition of the Canarian gnathic remains also counted against the use of these traits. Two additional non-standard characteristics – metopic suture and sutural bone patterns – were recorded in order to increase the amount of biological information obtainable from damaged or edentulous specimens.

4.6.1 Non-Dental Traits

The non-metric cranial traits were employed in a supportive role, as teeth were often either lost *post-mortem*, or so worn as to obscure crown morphology. The bony traits refer to the fusion lines of cranial vault bones (metopic suture; sutural bones) and to bony proliferations of the jaws (palatine and mandibular tori). Owing to the non-standard nature of the traits and the lack of extensive comparative information, the sutural traits can only be used in a Canarian context for intra-archipelago comparisons. Studies by Moorrees *et al.* (1957) and Suzuki and Sakai (1960) suggest that the mandibular torus (bony protuberances sometimes arising on the lingual aspect of the mandible) is under genetic control. Mandibular tori usually occur in the premolar-molar region, and are typically bilateral but unequal in size. Considerable regionalisation has been demonstrated for the trait, which is particularly common in the Inuit. The ASU system advocates a four-grade scoring scale from 0 (absent) to 3 (marked [>5mm elevation]), scoring the strongest expression per individual (Turner *et al.* 1991). The palatine torus is a bony exostosis (ridge) running along the median-line of the maxilla

(Brothwell 1981). Certain authors believe any genetic influence to be weak (Lahr 1996), and any regionalism of trait prevalence to be irrelevant, although there are several studies suggesting its utility as a population biology indicator (El Najjar 1978, in Hillson 1996). A 5-grade system from absent to extremely large was employed. Metopic sutures trace the frontal bone's central fusion line, which is usually obliterated in childhood but sometimes persists into adulthood. There is little standardisation in this trait, which is not used in the ASUDAS. Trace (glabellar area only – coded '1') and full (from nasion to bregma – coded '2') expressions were therefore recorded, depending on extent of intrusion onto the frontal bone. These categories were adopted in line with published work on non-metric cranial variation (Berry and Berry 1967; White and Folkens 1991). Nineteen sutural bone variants were recorded, referring to the number (single or multiple) and combination (sites affected) of sutural bones on the coronal, sagittal and lambdoid sutures. While ossicles are a prominent aspect of cranial non-metric traits studies (Berry and Berry 1967), there is so much variation of expression that trait standardisation is difficult. Various permutations were tested in the analytical stage; the final subdivisions used an absent/bregma/lambda trichotomy. In table 4.4, the shaded categories are those that were used in the final analysis (i.e. containing bregma/lambda scores).

Code	Site	Code	Site
0	Absent	10	Lambda and Right ½ of Lambdoid Suture
1	Bregma	11	Lambda and Left ½ of Lambdoid Suture
2	Lambda	12	Sagittal and Bilateral Lambdoid Sutures
3	Bregma and Lambda	13	Sagittal and Lambdoid Sutures, and Lambda
4	Left ½ of Lambdoid Suture	14	Sagittal Suture
5	Right ½ of Lambdoid Suture	15	Bregma and Left Lambdoid Suture
6	Bilateral Lambdoid Suture	16	Bregma and Right ½ of Lambdoid Suture
7	Lambda and Bilateral Lambdoid Suture	17	Right Half of Coronal Suture
8	Bregma and Bilateral Lambdoid Suture	18	Left Half of Coronal Suture
9	Bregma, Lambda and Bilateral Lambdoid Suture	19	Coronal and Lambdoid Sutures

Table 4.4. Sutural bone non-metric trait definitions

4.6.2 Non-Metric Root Traits

Dental anthropology has traditionally focused on morphology of the crown rather than the root complex. Since the 1970's, however, attention has been paid to radicular number and form (Ackerman *et al.* 1973), which is often used in ASUDAS-based population biology studies (Turner 1981; Scott and Turner 1997). All tooth root numbers were recorded. The study adopted standard guidelines for recording tooth root morphology (Turner 1981; Turner *et al.* 1991; Scott and Turner 1997).

Developmental grooving of the tooth root may '...partition the cross-sectional area into two or more 'unseparated' rootlike divisions termed radicals' (Turner *et al.*, 1991: 20). The number of developmental grooves, and the number of radicals thus produced, is deemed by the ASU system to be a nonmetric trait worthy of consideration in attempts to assess population affinity in the archaeological record. Scott and Turner (1997) do not mention radical number as a trait in its own right, except for in the context of defining the six-category morphology of Tomes' Root (not used in the current study).

4.6.3 Gross Dental Differentiation

Congenitally absent (agenesis) or supernumerary (polygenesis) teeth are also considered to be non-metric traits. Polygenesis occurs in approximately 1.9% of humans, is almost five times as common in the maxilla as the mandible, and usually occurs in the vicinity of either the incisors or the third. Agenesis – by contrast – is fairly common in humans, with third molars, lateral incisors and second premolars absent in up to 30% of individuals (Scott and Turner 1997). As long as precautions are taken (such as examining adjacent teeth for wear facets) the chances of incorrectly distinguishing loss from congenital absence are substantially reduced (Scott and Turner 1997). Radiography can also be used, but is impractical for large-scale studies.

4.6.4 Dental Traits

The morphological characteristics (over and above those mentioned above) scored by the ASUDAS have been extensively discussed elsewhere in the literature, and it is unnecessary to repeat the basic anatomical and morphological information. A summary of the traits, the teeth where they may be found, germane references and the geographical areas where the trait is most prevalent (where available) are presented in table 4.5. Further discussion of dental traits in a global context may be found in Turner *et al.* (1991), White and Folkens (1991), Powell (1993), Hillson (1996), Larsen (1997) and Scott and Turner (1997).

Trait	Tooth	References	Region
Shovelling	All Anterior	Hrdlicka 1920; Moorees 1957	E.Asia/Sino-America
Winging	UI1	Escobar *et al.* 1976	Sino-America/Pacific
Double Shovelling	UI/UC/UP	Scott and Turner 1997	Sino-America
Labial Convexity	UI1	Nichol *et al.* 1984	Sino-America
Interruption Groove	UI1/UI2	Scott and Turner 1997	Sino-America
Tuberculum Dentale	UI1/UI2/UC	Lasker 1950	-
UI2 Variants	UI2	Turner 1991; Scott and Turner 1997	-
Mesial Canine Ridge	UC	Scott and Turner 1997	Subsaharan Africa
Distal Accessory Ridge	UC/LC	Scott and Turner 1997	-
Paracone/Protocone Access. Ridges	UP1/2	Scott and Turner 1997	-
Mesial/Distal Accessory Cusps	UP1/2	Scott and Turner 1997	-
Distosagittal Ridge	UP1	Morris *et al.* 1978	Sino-America
Three-Cusped Premolars	UP1	Turner *et al.* 1991	Sino-America
Odontomes	Premolars	Turner *et al.* 1991	Sino-America
Lingual Cusp Variants	LP1-2	Hillson 1996	-
Agenesis	UM3	Scott and Turner 1997	-
Metacone (C3)	UM1-3	Scott and Turner 1997	-
Hypocone (C4)	UM1-3	Bang and Hasund 1973	Sino-America; Eurasia
Metaconule (C5)	UM1-3	Harris and Bailit 1980	West Africa; Pacific
Carabelli's Trait	UM1-3	Bang and Hasund 1972; Scott 1980	-
Parastyle	UM1-3	Scott and Turner 1997	-
Mes. Marginal Acc. Tubercles	UM1-3	Kanazawa *et al.* 1990	-
Enamel Extensions	UM1-3	Lasker 1950	Sino-America
Reduced M3	UM3	Turner *et al.* 1991	-
Cusp Number (=4)	LM1-3	Scott and Turner 1997	Western Eurasia
Groove Pattern (=Y)	LM1-3	Hellman 1928; Morris 1970	Sub-Saharan Africa
Deflecting Wrinkle	LM1-3	Swindler and Ward 1988	Sino-America
Distal Trigonid Crest (DTC)	LM1-3	Turner *et al.* 1991	East Asia/Americas
Anterior Fovea	LM1-3	Scott and Turner 1997	-
Protostylid	LM1-3	Scott and Turner 1997	-
Hypoconulid (C5)	LM1-3	Scott and Turner 1997	-
Entoconulid (C6)	LM1-3	Townsend *et al.* 1990	West Africa
Meteconulid (C7)	LM1-3	Scott and Turner 1997	West Africa

Table 4.5. ASUDAS Dental Traits Scored for the Present Study

4.6.5 Refined ASUDAS System

The manner in which discontinuous series of trait expressions are subdivided into 'present' and 'absent' categories affects the results of ASUDAS-based population biology studies. The breakpoints and the trait suite used are usually revised with reference to the geographical area concerned; for this reason, not all the traits summarised in table 4.5 were used in the final analysis. Studies by Irish (1993; 2000), Irish and Turner (1990) and Guatelli Steinberg *et al.* (2001) have established parameters, ranges of variability and appropriate breakpoints for the African continent, and these studies were the source of the trait suite used in the present work (table 4.6.).

TOOTH	TRAIT	BREAKPOINT
UI1	SHOVEL	+ = ASU 2-6
UI1	DOUBLE SHOVEL	+ = ASU 2-6
UI1	LABIAL CONVEXITY	+ = ASU 2-4
UI1	WINGING	+ = ASU 1
UI2	INTERRUPTION GROOVE	+ = ASU +
UI2	UI2 FORM	+ = ASU 'P' + 'R'
UI2	TUBERCULUM DENTALE	+ = ASU 2-6
UC	'BUSHMAN CANINE' (MAR)	+ = ASU 1-3
UC	DISTAL ACCESSORY RIDGE	+ = ASU 2-5
UP1	ROOT NUMBER	+ = ASU 2+
UP1/2_LP1/2	ODONTOME	+ = ASU +
UM1	CARABELLI'S CUSP	+ = ASU 2-7
UM1	METACONULE	+ = ASU 2-5
UM1	ENAMEL EXTENSION	+ = ASU 1-3
UM2	HYPOCONE	+ = ASU 3-5
UM2	ROOT NUMBER	+ = ASU 3+
UM3	PARASTYLE	+ = ASU 1-5
UM3	AGENESIS	+ = ASU -
LC	ROOT NUMBER	+ = ASU 2+
LP2	LINGUAL CUSP	+ = ASU 2-9
LM1	CUSP NUMBER	+ = ASU 6+
LM1	ANTERIOR FOVEA	+ = ASU 2-4
LM1	DEFLECTING WRINKLE	+ = ASU 2-3
LM1	C1-C2 CREST	+ = ASU +
LM1	PROTOSTYLID	+ = ASU 1-6
LM1	CUSP 7	+ = ASU 2-4
LM1	ROOT NUMBER	+ = ASU 3+
LM2	CUSP NUMBER	+ = ASU 5+
LM2	GROOVE PATTERN	+ = ASU 'Y'
LM2	ROOT NUMBER	+ = ASU 2+
MANDIBLE	MANDIBULAR TORUS	+ = ASU 2-3
MAXILLA	MAXILLARY TORUS	+ = ASU 2-3

Table 4.6. Revised ASUDAS Trait Suite; Adapted from Irish (2000)

4.7 Dental Caries

The assumption of this section of the project is that dental caries reflects dietary affinity, and it is therefore necessary to examine the association between food types and dental caries.

4.7.1. Experimental Diet/Caries Correlations

The cariogenic potential of various diets has been calculated in both humans and laboratory animals using 'Stephan Curves' that plot plaque fluid pH against elapsed time (Hillson 1996: 276-7). These figures show that the consumption of sucrose and sweetened foods leads to a precipitous drop in pH below pH5.5 (leading to demineralisation), although there is considerable diversity according to sugar type (glucose and maltose, but especially sucrose), food consistency and frequency of ingestion. Whereas pH can recover fairly fast following a single dosage of sugar, repeated dosages further depress plaque pH. Starches are differently configured, as the molecules are unable to penetrate plaque and are broken down into maltose by salivary and bacterial enzymes. pH decrease is thus less precipitous and slower with starch-rich foods (i.e. bread, pasta and potatoes), and has a less detrimental effect on the teeth. These are therefore less cariogenic than sugary foods, although experimental studies indicate that foods combining starches and sugars are highly cariogenic (Hillson 1996: 269). Proteins and fats, including all meat and dairy products, are less cariogenic than carbohydrates, hence the virtual absence of caries in pre-agricultural populations and modern hunter-gatherers (Bartsiokas and Day 1993; Larsen 1997: 64-68). Dairy products in particular appear to have a retardant effect on caries, and may be partially responsible for the quiescence of caritic lesions that can remain unchanged for years without increasing in size or affecting dental integrity (Hillson 1996: 279).

4.7.2. Caries Trends

The manner in which caries attacks the teeth is determined by the morphology of the differerent 'sites' at which it can occur, and involves surface texture (enamel vs. dentine/root), enamel surface relief (occlusal detail/pit formation vs. smooth surfaces), and proximity to other dental surfaces (mesial/distal faces vs. buccal/lingual faces). Caries is strongly related to age, alveolar resorption and of course diet (both in terms of physical consistency and chemical composition/breakdown). Work by Sullivan *et al.* (1989), Cook (1990), Murphy (1993), Hillson (1996; 2001), Sakashita *et al.* (1997), Buikstra and Ubelaker (1994) and Larsen (1997) demonstrates that caries prevalence decreases from the molars to the premolars, then the anterior dentition, and tends to be more common in the lower than the upper teeth. The most frequently affected features are the pits and the occlusal surface detail, followed by the contact points of the postcanines, while lesions are comparatively uncommon on .the buccal, labial and lingual smooth enamel surfaces (of all teeth, but particularly the canines and incisors). Caries of the occlusal surface is common in childhood and early adulthood, while contact and root surface caries becomes more common with increasing age. Females typically have more caries than males in any one age group, partly owing to the fact that their teeth erupt earlier and are thus exposed to caritic attack for longer (Hillson 1996: 281-2).

4.7.3. Economic Associations

As stated above, there is a wealth of evidence hinting at the discipline's potential for understanding ancient human dietary proclivities. These range from the decreased prevalence of caries in sugar-rationed populations in Japan, Norway and the Isle of Man in WWII, to the very low prevalence of caries in ancient hominids and modern hunter-gatherer groups. The general trends concerning patterns of caries infestation in the crown/root complex (see above) may be an agriculturist adaptation, as studies of Australian Aboriginal and !Kung San hunter-gatherers, who are reliant upon meat and vegetable produce, indicate a virtual absence of crown caries in younger individuals with increasing prevalence of root caries relatively late in life (Hillson 1996; 2000: 263). This pattern is examined further in section 4.7.4.

4.7.4. Recording systems

While archaeological site reports often comment on caries in skeletal series, the level of refinement does not typically exceed a count of the total number of carious teeth (usually, but not necessarily [Vives 1992], by morphological class) in a given sample or chronological period. Despite a fairly long history of investigation, therefore, archaeological caries research has yet to achieve its potential for elucidating ancient lifestyles. Additionally, techniques used in modern epidemiological studies, such as the DMF (decayed; missing; filled) system proposed by Klein *et al.* (1938: see Hillson 1996: 279), are inappropriate for archaeological remains, or fail to address the full complexity of caritic infestation (for example, between initiation sites). Lesion counts in which only ‘cavities’ are scored are likewise less than effective, as they ignore the fact that caries is a pathological process rather than an absolute expression (unlike the ASUDAS) so that mild expressions or missing teeth are not counted. Prior to Hillson’s system, the most refined dental caries recording system regularly in use is that proposed by Turner *et al.* (1991), in which nine crown sites (occlusal, buccal, lingual, mesial and distal, and combinations thereof) could be scored per tooth. However, this system does not consider the possibility of recording the incidence of caries anywhere except for the crown, and has no means for recording the severity of caritic lesions. Equally, the fact that caries can manifest itself in forms other than distinct lesions (Hillson 1996, 2000, 2001; Larsen 1997) is not accounted for. Some of these problems were recognised by

Buikstra and Ubelaker (1994), such as the prevalence of root caries and 'smooth surface' caries, but the full range of variation in the severity of caritic affliction and the number of sites where lesions could appear was not considered.

Recent studies by Hillson (2000; 2001) have indicated that subdividing the tooth into its constituent components and sites, viewing caries as a process, and incorporating the study of dental wear, chipping and enamel hypoplasia can achieve a far higher level of sophistication in the recording of dental caries. It therefore improves upon earlier methods that either fail to differentiate between tooth classes and sites, or use a simplistic affected/unaffected dichotomy. In the case of hunters and gatherers, for example, levels of dental wear are typically extremely high, thus eradicating the occlusal fissure systems of postcanine teeth at a relatively early age, causing accelerated eruption of the roots that in turn become susceptible to caries. In an agricultural context, by contrast, the lower levels of wear make it increasingly likely that the caritic process will be able to attack from the fissure system, assisted by the 'sticky' nature of carbohydrate-rich foodstuffs.

4.8 The Hillson Method

Whereas Buikstra and Ubelaker (1994) advocate a total of 224 sites per full dentition, the Hillson system's total of 568 sites, to include a comprehensive assessment of root exposure and enamel hypoplasia, by far exceeds all previous efforts in terms of methodological refinement (see table 4.7). Economic regime and dietary associations are still a matter for debate, but all evidence has so far indicated that Hillson's new system constitutes a powerful analytical tool for determining dietary proclivities in the past.

Caries Sites	Incisors	Canines	Premolars	Molars	Totals
Occlusal Caries Sites	0	0	8	12	20
Dentine Caries Sites	16	8	16	24	64
Pit Caries Sites	8*	4*	0	12 (+)	24
Contact Caries Sites	12	8	12	20	52
Buccal Caries Sites	8	4	4	12	28
Lingual Caries Sites	8	4	4	12	28
Root Caries Sites	32	16	32	48	128
Measurement Sites	32	16	32	48	128
Hypoplasia Sites	24	12	24	36	96
Total	140 (+)	72 (+)	132	224 (+)	568

Table 4.7. Scoring of Dental Sites According to Hillson (2000).
* - some populations also possess 'pit' features on the anterior dentition

These sites/observations are in addition to macromorphological assessment of periapical activity, which cannot easily be scored due to the high level of anatomical and pathological complexity in the gingival area. The codes used for each scoring category are summarised below.

4.8.1 Status Codes

All teeth are scored for presence/absence. As the system is engineered to record the impact of caries and dental pathology, there are numerous codes to record the exact position, stage of eruption or 'gross gross' caries status, if the tooth is present, or, if lost, the extent to which the individual recovered from dental avulsion prior to death. Teeth are therefore present (0), affected by different grades of 'gross gross' caries (7, 8), partially erupted (14) or anomalously erupted (15). If absent, distinctions are drawn between unerupted (from impaction, agenesis or young age [13]), *post-mortem* loss (10) and *ante-mortem* loss occurring shortly before (11) and well before (12) death. Gross gross caries is defined as a lesion that has completely destroyed the tooth in question, thus concealing the initiation site (Hillson 2001: 253). The status recording system was combined with the ASUDAS codes, so that agenesis of third molars and second incisors (see above) was calculated from the prevalence of '13' codes in those individuals that had reached dental maturity.

4.8.2 Dental Wear

Hillson recommends that dental wear be recorded and combined with caries data to interpret the nature of ancient diets, using Smith's 1984 system. As currently understood, wear constitutes one of the two central characteristics that can be used to separate hunter-gatherer (high wear; low prevalence of caries) and agriculturist (low wear; high prevalence of caries) groups (see Larsen 1997). Wear rate can be calculated from the extent of wear in fully erupted teeth at specific points in dental development, especially in relation to the differences in molar wear. This assumed an additional importance in the present study because many specimens had to be aged on the basis of their dental wear (see above). While Buikstra and Ubelaker (1994) have criticised the accuracy of the Smith method, which will probably be replaced by more sophisticated successors, it is the most widely used system currently available.

Stage	Incisors and Canines	Premolars	Molars
0	No Wear	No Wear	No Wear
1	Polished; small facets	Polished; small facets	Polished; small facets
2	Dentine point/line	Cusp blunting; dentine pinpoints	Cusp blunting
3	Distinct dentine lines/points	Cusp removal	Cusp removal; pinpoint dentine
4	Non-linear dentine exposure	At least 1 large dentine exposure on 1 cusp	Several discrete dentine patches
5	Large dentine exposure	Two dentine areas (may be joined)	Two patches coalesced
6	Rim thin but still intact	Coalesced dentine areas	Patch coalescence
7	Rim lost on 1 or 2 sides	Full dentine exposure; partial rim loss	Enamel fragments; rim intact
8	Crown assumes form of roots	Crown form = root form	Rim loss; crown = root form

Table 4.8. Dental wear scoring system, based on Smith (1984).

4.8.3 Occlusal Surface Caries (OSC)

OSC describes caries of the occlusal surface fissure systems of the premolars and molars, which are particularly prone to accumulating food in societies with a low rate of occlusal attrition (wear). The process is scored from absent (0), to staining in the occlusal fissures (1, 2), cavitation (3, 5, 6) and gross coronal caries (7, 8). Extent of penetration is defined by enamel-only (1, 2, 3), dentine (5, 7) and pulp (6, 8), while breadth of affliction is either restricted to vertical penetration from the occlusal surface (1, 2, 3, 4, 5, 6) or gross cavitation, where the caries incorporates other sites or breaks out of the buccal/lingual or mesial/distal side of the tooth (7, 8). OSC is more common in the lower than upper teeth, appears more frequently in the molars than the premolars and is particularly associated with deep occlusal fissuring. It can only be scored if the occlusal surface detail is still extant (i.e. not worn away) or there is evidence that the caries originated in the fissure system and is not related to AFDC (see below).

4.8.4 Pit Site Caries (PSC)

Pit caries can only be scored on teeth with morphological 'pit' forms in the enamel, which are synonymous with ASUDAS scored for marked shovelling and protostylids. It is affected by caries in the same general manner as OSC, but is only worn away by attrition rather later in life. PSC demonstrates the same pattern of attack as OSC, from staining (1, 2) to cavitation of the enamel (3), dentine (5, 7) and pulp (6, 8). Multi-site dentine-only (7) and pulp-penetrating gross caries scores (8) are the same as for OSC. Intuitively, prevalence is likely to be increased in populations with carbohydrate-rich diets (as with OSC).

4.8.5 Occlusal Attrition Facet Dentine Caries (AFDC)

When occlusal enamel is worn away, the exposed dentine and pulp cavity may become affected by caries. This process may affect all teeth worn beyond a certain level, and is not restricted to morphological type. Penetration of the dentine surface seems to be a less regularised process than penetration of the enamel, as Hillson (2001) only notes three grades of expression from staining (4), to cavitation (5) and affliction of the pulp cavity (6). Hillson also cites a code for an exposed pulp cavity without caritic infestation (8), which is distinct from the '0' (absent) score. AFDC can usually be differentiated from an OSC penetrating through the enamel and into the dentine on the basis of the shape and size of the lesion, and its location on the tooth surface.

4.8.6 Occlusal Attrition Facet Edge Chipping and Caries (AFDECC)

Diets including substantial inclusions such as grit result in both accelerated dental wear and chipping of the enamel rim around dentine exposures. It is therefore vital that *ante-mortem* chipping (2) be differentiated from *post-mortem* damage (1). Hillson provides additional codes for chipped teeth with associated carious lesions (3), as well as gross caries of the un-chipped attrition facet enamel rim (7 [dentine only], 8 [pulp chamber]).

4.8.7 Mesial/Distal Attrition Scores (MAS/DAS)

Hillson (2001) ascertained that the contact points on the proximal (or 'approximal') and distal ends of the tooth, in abutting adjacent teeth, are therefore prone to caries. Wear caused by inter-dental attrition can affect the manner in which this process takes place. The sites can be unworn (0), or possess enamel-only (1), small dentine (2) or large dentine (3) exposures. An additional code (4) describes a tooth that has been worn down to root level, so that the contact point is destroyed. In order to facilitate analysis (and in consultation with Hillson), both mesial (MAS) and distal (DAS) attrition and caries scores (see below) were combined for the present study.

4.8.8 Mesial/Distal Contact Area Caries (MCAC/DCAC)

Dental contact areas may be susceptible to caries, in line with approximal wear and morphology. Just as there is a distinction drawn between enamel and dentine infestation on the occlusal surface (see above), different scores exist for caries affecting the enamel (1, 2, 3), the dentine (4, 5, 7) or the pulp cavity (6, 8). A further distinction is drawn between small lesions that penetrate the dentine through the enamel (3) and those that directly affect the dentine attrition facet (4), although there is no such distinction for the larger lesions (5, 6, 7). Finally, caritic lesions can be either single (1, 2, 3, 4, 5, 6,) or multi-site (7, 8). In this study, contact point caries affected teeth with large, closely abutting approximal surfaces (i.e. the postcanine dentition) more frequently than smaller, narrower teeth (i.e. the anterior dentition). Because teeth typically increase in size distally, distal caries was slightly more common than mesial examples. However, this difference was not deemed to be significant, so mesial/distal sites were combined into 'contact points' (Hillson pers. comm.).

4.8.9 Mesial/Distal Root Surface Caries (MRSC/DRSC)

Root surface caries (lesions below the CEJ) differs markedly from coronal caries, for whereas the crown is dentine covered by enamel, the roots are dentine coated with dental cement. Root caries is therefore akin to occlusal dentine caries, as they cannot be affected in young individuals, and are only exposed after considerable wear (direct exposure of occlusal dentine; over-eruption of the tooth resulting in root exposure) or gum disease. The root surface/crown caries ratio is therefore higher in groups with high levels of attrition (i.e. hunter gatherers), as occlusal surface detail and dentine caries sites would be worn away before they could properly take hold, whereas the roots would be exposed relatively early in life and therefore be more prone to cariogenesis. Both mesial and distal root caries follow an identical scoring system, from dark staining (1) to shallow cavities (5) and pulp chamber penetration (6). Multi-site gross caries scores (7 – dentine; 8 – pulp) were reserved for lesions crossing the CEJ to enamel surfaces, approximal attrition facets or contact areas. Mesial and distal root caries were scored separately but can be combined for analysis, as in the present case.

4.8.10 Buccal/Lingual Smooth Surface Caries (BSSC/LSSC)

The vertical, enamel-coated sides of the teeth may be affected by caries, but this is somewhat uncommon unless the enamel is breached, or the individual in question had an extremely cariogenic diet (Hillson pers. comm.). It is important to note that smooth surface caries is differentiated from pit, facet and occlusal surface forms, as the cariogenic process would necessarily take a very different route in each of these sites. The scoring scales are similar to those used for scoring occlusal surface caries, from enamel-only (1, 2, 3), dentine (5, 7) and pulp (6, 8) penetrating forms. Again, a dichotomy can be drawn between single (1, 2, 3, 5, 6) and multiple (7, 8) site forms. While Hillson does not make specific proviso against scoring caries in the Carabelli's feature of the upper molars (buccal parastyle formations being the only upper molar 'pit' forms recognised by the Hillson system), caries prevalence in these features was not scored as 'smooth surface' forms. It might be advisable to include an upper molar buccal/lingual pit site dichotomy in future studies.

4.8.11 Buccal/Lingual Root Caries (BRC/LRC)

Buccal and lingual root surface caries are scored in the same manner as mesial and distal sites, from staining (1) to cavitation (5), pulp chamber penetration (6) and multi-site gross caries scores (7: dentine; 8: pulp).

4.8.12 Alveolar Exposure

Hillson recommends that the alveolar exposure of the roots on all aspects of the tooth be measured, from the CEJ to the alveolar margin, as eruption is often continuous (particularly in high wear groups). If hunter-gatherers are indeed more prone to this condition that agriculturists, this may be a valuable diagnostic tool in identifying economic affinity. In any case, ascertaining differences in age-related alveolar exposure between groups provides at least general information about dietary behaviour. In the present case, a scaled dental probe was used to record alveolar exposure to the nearest millimetre. It became evident during the study that increased alveolar exposure (over 2mm, which is the norm for non-pathological young adults) was associated with aggravated or irregular dental wear, large caritic lesions and periapical activity, and that these characteristics were usually associated with increasing age. In the final study, the results were profiled (i.e. the full range of alveolar exposure figures was examined) and then grouped in order to facilitate the analysis of the results. The groupings used were absent (0-1mm), normal (2-3mm), moderate (4-7mm) and marked (8mm+).

4.9 Dental Enamel Hypoplasia (DEH)

Dental enamel hypoplasia is known to be an indicator of systemic health during odontogenesis. The most common forms are furrow defects, seen on the faces of the teeth as a change in the perikyma groove (PKG) spacing (from 1-20 lines) forming a narrow trough encircling the tooth's circumference (Hillson 2000: 251). These are particularly common on the anterior dentition, but are also found on the cheek teeth. Plane form defects involve the absence of entire layers of enamel matrix (Hillson 2000: 252), and with a prominent enamel step. Finally, pitted defects, ranging from large, well spaced pits in broad bands, to small, closely-packed examples in narrow banding, may form a pitted lesion around the tooth's circumference. Even with full medical histories, it is hard to relate hypoplasia with any specific affliction (although experimental studies have indicated links with conditions including anaemia, rickets, chickenpox, measles and pneumonia [Hillson 1996: 166]), thus further complicating the interpretation of archaeological material. It is therefore best described as a general index of childhood health rather than an indicator of a specific illness (Hillson 1996: 168). However, it has been claimed that syphilis leaves highly distinct markings on the incisors and molars, which can be differentiated from normal hypoplastic lesions (Hillson *et al.* 1998).

4.9.1 Hypoplasia Recording Systems

Because there is disagreement over the forms and causes of hypoplasia, and even how to define 'normal' perikymata spacing, recording systems are also very contentious. Previous studies, which did not have access to current information concerning tooth crown development, have made assumptions about the significance of hypoplastic lesions, and the manner in which they should be scored. For example, it is often assumed that the size of a lesion is directly related to the severity of the physiological insult that caused it (Darnforth *et al.* 1993; Durray 1996; Palubeckaite *et al.* 2002); this not only unproven, but also fails to address the increasingly evident (non-linear) ontogenetic complexity of dental microstructures (Hillson 2000: 252; Hillson and Bond 1997; Antoine *et al.* 1999). The validity of measurements from the crown surface to lesions – aiming to establish the age at which the defect was caused – are thus questionable. The selection of the Hillson/Smith technique was predicated on the fact that while general age ranges could be presented for socialisation of the current project, the age group information could be re-processed at any future date if age range accuracy were shown to be in some way deficient.

It would be impossible, for example, to undertake a histological study of Canarian museum collections (such as that conducted by Hillson *et al.* [1999] on Spitalfields data), while a simple 'affected tooth' count would not allow socially significant factors, such as the age at which lesions were sustained, to be calculated. Hillson (1996) advocates dividing the tooth crown into three sections and scoring each section for presence/absence of three forms of hypoplastic defect (linear; banding [aka 'pitting'; i.e. a band of pitted defects]; plane-form). However, this system was devised with reference to the recording of caries, and the author does not claim a high degree of accuracy in correspondence between these sections and specific chronological ages. Indeed, very precise age matches of this sort cannot be carried out without the use of cross-sectional techniques (Antoine 2001). While a developmental study by Dean and Reid (2001) has improved resolution, their system is restricted to the anterior dentition (incisors and canines) that rarely survives in archaeological collections. The project therefore employed a combination of Hillson's recording systems (1996) and Smith's estimates for formation times (1991). The Dean and Reid system was used to score the exact location of hypoplastic lesions on the anterior teeth, but the data were not considered in the present study. While different tables exist for males and females, as females are slightly precocious in their crown formation and eruption times, there is a general consensus that differences are not particularly significant (Hillson 1996: 131) and that the figures can be safely averaged. Hillson (1996) uses seven general age groups to examine temporal distribution of hypoplastic defects, but refuses to assign them a specific age range for developmental timing, in order to highlight the often extreme variability of dental formation times. The system was therefore combined with the Smith data so that the full range of developmental variability in the human dentition can be appreciated, while providing ballpark formation times in order to add a social element to the project. Each tooth was divided into occlusal, contact and cervical sections. The occlusal band was identified with cusp completion, the contact (intermediate) area with outline completion to 50% of crown formation, with the cervical area representing the remaining period until crown completion. The approximated ranges and the sections of the teeth developing within those categories are presented in table 4.9.

Group	Teeth	Age (Smith 1991)
A	Occlusal UI1, LI1, UM1, LM1	0.1 - 0.8
B	Occlusal LI2; Contact UI1, LI1, UM1, LM1	0.8 - 1.3
C	Occlusal UC, LC; Contact UI1, LI1, LI2; Cervical UM1, LM1	0.6 - 2.5
D	Occlusal UI2, UP1/2, LP1/2, UM2, LM2; Contact UC, LC; Cervical UI1, LI1, LI2	1.6 - 4.3
E	Contact UC, LC, UP1/2, LP1/2, UM2, LM2; Cervical UI2	1.6 - 5.4
F	Cervical UC, LC, UP1/2, LP1/2, UM2, LM2	3.4 - 6.6
G	Occlusal, Contact and Cervical Sections of UM3 and LM3	9.5 - 12.6

Table 4.9. Hillson (1996) Age-Group System with Inferred Age Ranges (Smith 1991)

As recommended by Hillson (1996), lesions were not scored unless a match could be made, so as to prevent confusing systemic lesions with evidence of localised disturbance. However, due to the bad preservation of many specimens, it was not always possible to practice this safeguard. While Hillson's age group system covers the spectrum of odontogenesis from birth to early adolescence, it is necessary to refine the ages at which the developments take place if this study is to have any significant social implications. Note that while early-forming teeth (specifically the first molars and the first incisors) show little variability in terms of formation time, later groups (premolars; second and third molars) are notably more variable (Smith 1991; Hillson 1996), and are presumably under rather less rigid genetic control. Age groups D and E are particularly problematic in this regard (figure 4.1), which is based on the table 4.9. Third molars possess their own age group category (G).

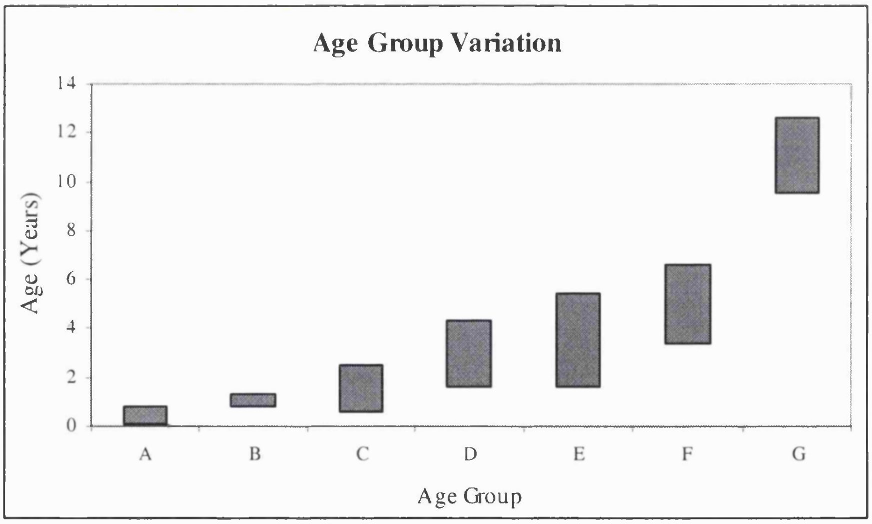

Figure 4.1. Dental Formation Timing, by Age Group

4.9.2 Hypoplasia Applications

The realisation that hypoplasia is a relatively sensitive indicator of systemic health has led to a plethora of investigations into human lifestyle in the past, despite the controversy over methods and approaches (see above). Profiling of modern populations has provided a basic framework for the interpretation of dental enamel hypoplasia in ancient groups, enabling the study of the health impacts of trends in human socio-economic history. In addition to numerous site- and population-specific analyses, hypoplasia prevalence patterns have been used to compare lifestyle in hominid subspecies, suggesting that Upper Palaeolithic (modern human) infants were more physiologically stressed than, and weaned differently from, Neanderthal populations (i.e. Skinner 1996). Webb (1989) profiled ancient Australian aboriginal populations and found a low overall prevalence with a peak in very young children that dropped away sharply into adolescence. Further, hypoplasia was rare in arid areas (which could only have supported transient occupation) and higher in lusher areas that may have seen more sedentary lifestyles (Webb 1989). More complex social modelling is also possible in the field of contact biology, such as Santos and Coimbra's (1999) use of enamel hypoplasia to assess the detrimental impact of 'national society' on the Tupi-Monde Amerindians of Brazilian Amazonia. The relatively low prevalence of DDEs in rural or mobile groups when compared to sedentary/agricultural populations appears to support Larsen's assertion that human health was severely impacted upon by the transition to agriculture in the Near Eastern Neolithic, in response to increasingly crowded and unsanitary living conditions (1997: 52). Human health suffered further with the increased overcrowding that accompanied urbanisation and industrialisation, and this is seen at all times in human history (such as Wood's 1996 study of evolving social stratification in colonial Americans). The rare cases where agricultural populations have adopted nomadic hunting and gathering in response to social or ecological pressures, such as the aridification of western India in the 1st millennium BC (Lukacs and Walimbe 1998), see an exact reversal of this trend, with apparent improvements in human physiological health. These generalities have strong implications for the present study, for the Canaries are ecologically diverse, while there is substantial evidence to suggest that their human populations were equally variable with regard to population size, density, economy and behaviour.

4.9.3 Revised Hypoplasia Recording Systems

As previously noted, it is important that the number of hypoplastic events is not overestimated, as the same physiological insult would be recorded in several separate teeth and thus apparent prevalence would be increased if the lesions were scored separately then added. The data were therefore assessed for tooth preservation and duplication, and individuals screened in order to provide estimates for overall hypoplasia prevalence. Representative 'index' teeth, in other words teeth sensitive to hypoplasia, with relatively well-established formation times (see below) and/or with respectable sample sizes, were chosen from each age group. It was realised that occlusal sections of the tooth (i.e. ageclasses A [M1] and D [M2]) – which are highly prone to destruction through wear, in addition to possessing widely-spaced perikymata and externally invisible appositional enamel – were imperfect devices for scoring hypoplasia, but were nonetheless preferable to using the anterior teeth, which were usually lost *post-mortem*. As stated above, the age ranges are unacceptably large if the study is to accurately reflect socially relevant patterns in hypoplasia prevalence. Therefore, teeth with very wide age ranges were not used, with the exception of LM3, which is the only tooth able to provide a measure of systemic health in early adolescence (Hillson 1996: 136-7). Because the formation chronology for this tooth is so erratic, an affected/unaffected dichotomy was used (pooling all three sections of the tooth). It should be noted that this method was deemed undesirable, but unfortunately inevitable in light of the tooth's formative peculiarities. Rather than subsuming all the teeth into the Hillson age groups, it was decided to take the specific ages for just the teeth used (rather than an age-group average) and use this as the age estimate for the time at which the lesion occurred. This obviates the need to expand the age ranges according to the number of teeth in each category. The estimates were arrived at in consultation with Smith (1991), Hillson (1996) and references therein. The corrected and refined figures are shown in table 4.10. and figure 4.2.

Group	Tooth	Section	Age (Smith 1991)	Refined Age
A	LM1	Occlusal	0.1 - 0.9	0.2-0.9
B	LM1	Contact	0.9 - 1.3	0.9-1.3
C	LM1	Cervical	0.6 - 2.5	1.8-2.5
D	LM2	Occlusal	1.6 - 4.3	3.6-4.9
E	LM2	Contact	1.6 - 5.4	5.1-6.1
F	LM2	Cervical	3.4 - 6.6	5.9-6.8
G	LM3	All	9.5 - 12.6	9.9-12.6

Table 4.10. Refined Age Estimates for Dental Enamel Hypoplasia

The total affected scores per age group were profiled for island, period, sex and region, and for appropriate permutations thereof.

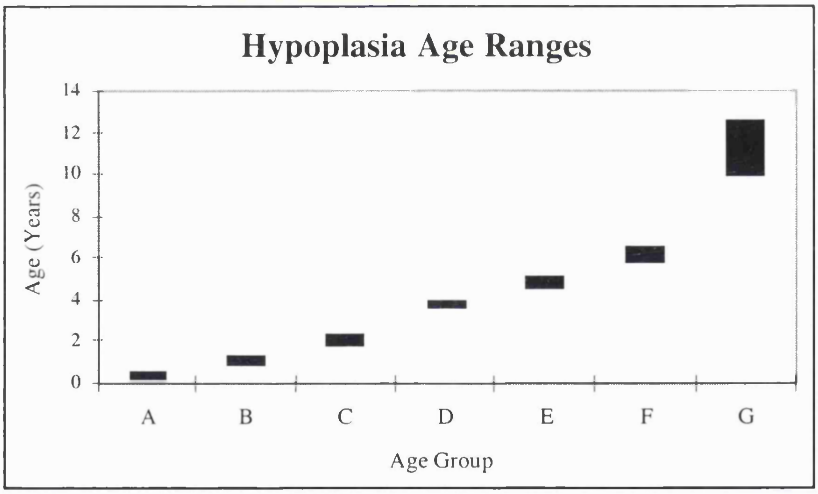

Figure 4.2. Refined Age Ranges Covered by Hypoplasia Recording System

4.10 Cranial Pathology and Trauma

There are few conventions for the scoring of traumatic lesions, and it is usually necessary to design recording systems around the sample in question or the query being addressed. In the Canaries' case, it was necessary to devise a system that was solely cranial (owing to cranial/postcranial disassociation in collections) and that was sensitive to the positioning of trauma. The system was also designed with reference to certain aspects of historically attested behaviour, to include stone throwing, stave fighting and the use of slingshots, to investigate whether these traditions were reflected as pathological markers, and if their prevalence was governed by temporal or spatial factors (Bontier and le Verrier 1872; Torriani 1590).

While (cranial) trauma prevalence may allow an intriguing glimpse into ancient lifestyles, it is important to note that such patterns are an imperfect measure of any social tradition. Once details of the recording system have been clarified, the interpretation of the results is partly speculative, as healed lesions (and the vast majority of archaeological specimens fall into this category) cannot be assigned to a particular cause in most cases. However, despite this shortfall, trauma does provide a general notion of lifestyle, be it activity levels, conflict or accidental injury, and while it is preferable to interpret the whole body for trauma trends diagnostic of certain sorts of injury (Shermis 1984), cranial patterns also have their role to play in the interpretation of ancient lifestyle.

Cranial pathology was scored using a 9-zone system, comprising the left and right halves of the frontal, the left and right parietals, the left and right maxillae, the left and right zygomatics and the pyriform aperture. The mandible was not scored, as no evidently affected remains were recovered. These regions are represented in plate 4.3. Please note that, in order to clarify the image, the left and right frontals are not labelled. This system roughly resembles that used by Webb (1989), but is designed to derive more refined information concerning trauma location. The data were scored so that comparisons per individual, per site and per side could all be calculated, in addition to the inter-period, inter-sex and inter-island variables that are standard procedure for the present project.

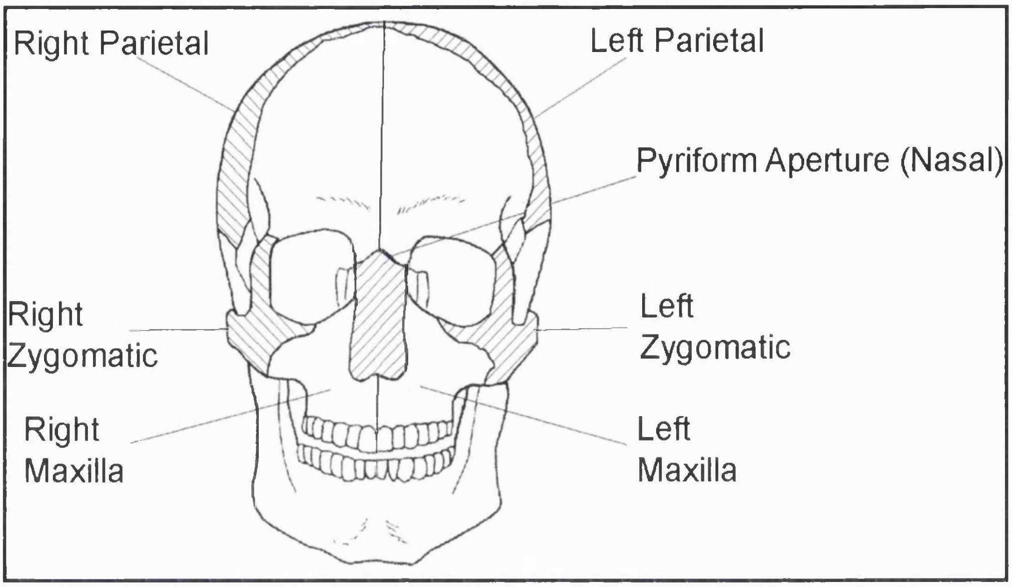

Plate 4.3. 'Sites' for Scoring Cranial Trauma

Care was taken to ensure than lesions were not confused with advanced periostitis caused by soft tissue infection, or cystic activity. The number of lesions per area was also recorded, as some individuals had up to three lesions per 'zone'. Owing to the size of the study, lesions were not measured. The project also followed up on work by Lukacs (1995) that examined tooth loss in relation to the traditional Canarian stave-fighting game 'Juego de Palo'. Tooth loss figures, particularly of the anterior portion of the dental arcade, were also considered in terms of trauma and personal injury.

4.11 Summary

This project aims to combine the best of traditional and innovative techniques in bioarchaeological research methods. By combining population biology and life history indicators, these offer the analytical power to interpret both genetic and behavioural information, so as to provide a more holistic contribution to our understanding of human society in the ancient Canary Islands. Incorporating chronological information (see chapters 3 and 5) enhances bioarchaeological methodology's potential for elucidating Canarian society, permitting the demarcation of temporally determined genetic and behavioural trends in this group of island societies.

5 Previous Work and Samples in the Canary Islands

This chapter is divided into a critical survey of previous work on Canarian human remains (section 5.1), and a detailed inventory , including summaries of age, sex, island and period data, of the materials used in the present study (section 5.2).

5.1 Biological Anthropology in the Canarian Archipelago

Biological anthropologists have subjected Canarian skeletal and mummified material to a battery of tests in an attempt to assess biological affinity, health, stature and diet, although until very recently "research in this important field of Canarian prehistory has not been as brilliant as might have been hoped" (Rodriguez Martin 1998: 284). Many studies in this field are basic reports, usually associated with anecdotal contact period historical information, that often suffer from incomplete coverage, poor material selection and a lack of internal (i.e. chronological or demographic) structure. This situation, and the international profile of Canarian biological anthropology, has recently been much improved by several publications on osteology/pathology (i.e. Betancor Rodriguez and Velasco Vazquez 1998; Velasco Vazquez *et al.* 1999; Machado Yanes and Martin Rodriguez 2000), dental anthropology (i.e. Guatelli Steinberg *et al.* 2001; Delgado Darias 2001) and genetics (i.e. Moral *et al.* 1997). The physical characteristics of Canarian populations, based on historical and bioarchaeological information, are presented by topic (and critically assessed) below.

5.1.1 Historical Descriptions of Native Canarians' Physical Characteristics

There are no native-written accounts of physical appearance, apart from some anthropomorphic carvings (see plates 5.5, 10.1 and 11.1). Historical descriptions of Native Canarians have been heavily relied upon in most past attempts to identify the origins and physical characteristics of ancient Canarian populations. However, the period during which these historical observations were made is only a small fraction of the Canaries' occupational history (see 3.4.1), and, furthermore, it is inappropriate to assume that mediaeval assessments of physical characteristics – such as height or skin colour – are directly relevant to modern standards. Equally, some descriptions of physical appearance are either ludicrous or highly ambiguous (Mercer 1980), although certain facts can be reliably derived. It is clear that the native Canarians were fairly light-skinned, suggesting that they were North African or European in origin, rather than sub-Saharan. Native Canarian stature appears to exceed that of the chroniclers in most cases, although there seems to have been some inter- and intra-island variation in terms of both stature and colouration (Hooton 1925: 5). There is no apparent pattern to this variability (and little consistency to be expected from the chroniclers), although there is a general tendency towards darker colouring in the eastern archipelago and southern Tenerife, with fairer hair and skin in the western islands and northern Tenerife (Bontier and Le Verrier 1872). Stature variability does not appear to be significant (the characteristics of clothing, adornment and other traditions are discussed in chapter 3). However, there is little more to be derived from the historical sources, and it is therefore necessary to consult the bioarchaeological record of the archipelago.

5.1.2 Biological Origins and Genetics

Population biology affinities are perhaps the most extensively explored subfield of Canarian physical anthropology. Most early work in the Canaries categorised human groups as finite morphological 'types' with 'admixture' being invoked to explain diversity. Quatrefagues, Hamy, Fuste, Berthelot and Verneau claimed that the archipelago contained a range of morphological classes, including "Pure Guanches", "Cro-Magnoids", "Semites (Mediterranoids)", "Orientaloids", "Euroafricans", "Armenoids", "Brachycephalics", "Berbers", "Arabs" and "Pure Arabs". Links were tenuous, and included Upper Palaeolithic remains from the Dordogne (Berthelot 1879: 128) and various North African and European populations. Interestingly, and despite the complete absence of dating evidence available at the time, Verneau claimed that the first Canarians were unrelated to 15th century Canarian populations, concluding that admixture had taken place after initial colonisation as "Semitic" elements entered the archipelago (Berthelot 1879: 128). Fuste (1959 – see Martin de Guzman 1984) claimed that the majority of Canarian populations dated to the desiccation of the Sahara and the spread of Islam, and that this explained certain morphological characteristics, such as light coloured eyes and hair, which are still present in many present-day Canarians. Schwidetzky (1963) proposed that ancient Canarians were descended from Mechta Afalou, Mesolithic North African and Capsian groups (although these populations predate Canarian occupation by several millennia). She used measurements and a physiognomic study of extant Canary Islanders to divide the remains of ancient Canarians into Cromagnoid (~ European) and Mediterranoid (~ African) groups, and believed this distinction to be a biological reflection of status (1963: 151-174). Despite her flagrant racial overtones, Schwidetzky's theory has proven to be remarkably resilient, and persisted virtually unaltered for several decades in standard Canarian archaeology textbooks. While now erased from mainstream Canarian academia, her work, remarkably, can still be found in some non-specialist introductory texts.

Dental morphology analyses by Bermudez de Castro Risueno (1985; 1989b) refuted both these and earlier findings, confirming an African link but stating that the Mesolithic and Neolithic groups previously claimed as Canarian predecessors were in fact more distantly related to Canarians than Northern African recent/modern and protohistoric populations (1985: 472). This was substantiated in dental studies by Irish (1993) and Guatelli Steinberg *et al.* (2002), who claimed that the Canarians were related to the Berbers – a loose association of Northern African subgroups (i.e. Kabyle; Shawia), derived from Capsian Mesolithic populations and their Neolithic descendants (Cavalli-Sforza *et al.* 1994: 172) – and a number of other Maghreb groups from Algeria and Morocco. Research by Cavalli-Sforza *et al.* (1994) placed the Canary Islanders in the group also containing Tunisians, Libyans, Berbers, Moroccans, Bedouin and Egyptians. A principal components analysis placed them closest to Algerians and Moroccans, but further from Arab groups, suggesting that Canarian occupation probably occurred prior to the 7th century AD. This has been broadly substantiated by Maca-Meyer *et. al.* (2004), who analysed ancient DNA from Canarian remains and concluded that the Berbers are probably amongst the closest extant ancestor stock for the Canarians, but that the populational complexity of NW Africa obscured the links with the mainland after "...the migratory wave to the Canary Islands" (2004: 155). Specific dates for the population's appearance in the archipelago are still lacking (see section 3), although Garcia-Villareal *et al.*'s (2000) study of Leu708Pro Wilson gene prevalence in the Canaries suggests that the original carriers arrived in the archipelago 56 generations ago, translating as either 1120 or 1680 years ago (880AD or 330 AD) using generation estimates of 20 and 30 years. Genetic bottlenecking has also been claimed on the basis of congenital malformations in a Tenerife sample (Rodriguez Martin 1992: 72-3), thought to be a direct reflection of endogamy and inbreeding brought about by isolation. A similar claim has been made for elevated levels of ankylosing spondylitis in Tenerife (Garcia Garcia and Gonzalez Garcia 1992). It should be noted that archaeological studies may be moiré appropriate than genetic studies of modern Canarians due to the complex post-conquest history of the islands. There is historical evidence for very large numbers of slaves and slavers (Cabrera 1982) passing through the islands throughout the late mediaeval and early modern periods. Following several failed uprisings, huge numbers of Guanche males were executed, their wives and families exported or taken as concubines and slaves to wealthy new arrivals from Spain and Portugal (Mercer 1980: 235-7). Slavery was still occurring in sufficient volume in the late 1500s to severely reduce population levels on the eastern islands at least (Torriani 1590; see chapter 3), thus further endangering the validity of genetic studies of modern Canarian populations. Salo *et al.* (1992) have pioneered the use of ancient mummy DNA to overcome this problem, but results have not yet been forthcoming.

Studies of intra-archipelago variability have reported both homogeneity (Irish 1993; Guatelli-Steinberg *et al.* 2002) and heterogeneity (i.e. Bermudez de Castro 1985; 1989) in genetic/morphological profiles (Owens 2003). However, both sampling techniques and methodologies are in doubt, as the characters used in studies claiming heterogeneity were often of dubious significance, whereas those arguing for homogeneity have often neglected to consider sampling problems (i.e. temporal variability) in their analyses. Bermudez de Castro used dental morphology (1985; 1989) to propose major differences between Gran Canaria and Tenerife (other islands not being significantly different), with marked inter-site variability on each of these islands. Irish (1993) and Guatelli-Steinberg *et al.* (2002) found no significant differences between (or within) island dental samples, although the data were pooled per island and not considered on a temporal basis. Inter-island heterogeneity has also been proposed between the north and south of Tenerife (Martin Oval 1992) on the basis of non-metric cranial trait variability, although the lack of chronometric data likewise imperils these conclusions. Findings regarding temporal trends are very limited, although preliminary observations carried out by the current author while collecting the Lanzarote data suggest some form of discontinuity between the tall and extremely robust specimens of Montana Mina and the short, gracile individual from Guanapay. However, the lack of chronometric information has prevented extensive exploration of temporal variability.

5.1.3 Stature

Garcia Talavera studied stature in ancient Tenerife individuals (1992: 71), using tibio-femoral ratios on a sample of 547 femora and tibiae (MNI 367). He concluded that they were "...quite tall for their time", with a male height of 170.5cm (approximately 5'8") and a female stature of 156.5cm (5'2-5'3"), and that these heights were comparable to North African Cromagnoid groups. While attempts were made to assess stature by various factors (coast/inland; north/south; by '*menceyato*' [contact-period political districts]) no significant relationships were found. It should be noted that age correction factors were not used in this study, and that the use of the 'white race' formula is – of course – equivocal. Aufderheide *et al.* (1992b) analysed mummified material from Tenerife and calculated heights of 171 +/- 4.4cm for males and 164 +/- 4.8cm for females; these high figures were believed to reflect mummified individuals' elevated social status. However, there is little evidence to back up the mummification/status link, and in any case there are several much shorter mummified male individuals from Tenerife, as measured by the current author (Cambridge University specimen: 151-155cm) and by Horne and Aufderheide (162.39 +/- 2.99cm [1992: 135]).

5.1.4 Life Span

Dietary factors are a major determinant of health and lifestyle, some of which are presented in chapter 4. Life expectancy figures vary according to author and method used, but were generally reasonable for pre-industrial groups. Most people expired in the 3rd-4th decade of life (mean 29.3 years) in Aufderheide *et al.*'s study (1992b: 114), which is substantiated by Langsjoen's sample where almost half of the population expired between 19 and 30 years and a further 29% between 31 and 45 (1992: 88).

5.1.5 Health and Illness

Both specific and general indicators have provided information about ancient health in the archipelago, although surveys of Canarian material are usually site/island-specific. Guayadeque (Gran Canaria) enamel hypoplasia was common compared to the Tenerife sample analysed by Dominguez (see below), with 28.26% of individuals affected, mainly in the 3-3.5 and 3.5-4.5 years age. While lesions were measured in order to establish the severity of each systemic disturbance, the results are not reported here as recent work by Hillson and Bond (1997) has called this method into question. Differences between male and female prevalence were not significant. Dominguez (1997 – in Delgado Darias 2001) examined hypoplastic lesions in a Tenerife sample, where the low prevalence (4.19% of males and 2.82% of females) suggested an "absence of nutritional deprivations and systemic illnesses" in the group (1997: 242, in Darias 2001: 241). Kelley and Boom (1992) examined Harris Lines (radio-opaque lines circling the metaphyses of longbones, believed by some to represent physiological stress [Larsen 1997: 40-42) in a sample of 146 tibiae from Tenerife. Males were less affected than females (2.6 lines vs. 4.2 lines per individual), while stress peaks occurred between 7-10 years and were particularly strong between 9 and 10 years of age. It should be noted, however, that the reliability of Harris lines as indicators of systemic stress has been called into question (Larsen 1997: 43; medcyclopaedia nd.).

A host of observations on specific pathologies has also been carried out, including a number of genetically and behaviourally-induced conditions. Genetic afflictions include *Talipes equinovirus* (club foot), spondylolysis, incomplete cervical vertebra fusion, atlas occipitalisation, hydrocephalus, oxycephaly, turricephaly and scaphocephaly (rare craniosynostoses brought about by premature fusion of the cranial sutures). The relatively high prevalence of these generally rare conditions (particularly on Tenerife) implies isolated genetic trajectories, but is uninformative about lifestyle or population biology (Aufderheide and Rodriguez Martin 1998: 54-75). The sporadic presence of the ankylosing spondylitis (AS) is interesting, as this genetic condition, which is characterised by very specific form of joint surface erosion and other lesions, is rare in all groups except for Caucasians, and therefore supports a North African or European origin for the Canarians (1998: 102-3). This link was confirmed by Garcia Garcia and Gonzalez Garcia (1992), who added that the elevated prevalence of the AS gene in modern Canarians also implies considerable genetic bottlenecking. Serious infectious diseases such as syphilis, leprosy and tuberculosis are absent, so (insofar as skeletal pathology can ascertain) the Canarians were relatively healthy. The fact that diffuse idiopathic skeletal hyperostosis (DISH) – a spinal condition especially common in late sedentary societies – is also absent, tends to support a generally healthful, low-density population pattern for indigenous groups (Aufderheide and Rodriguez Martin 1998: 99, 121, 154, 121-130). Rodriguez Martin's (1992) analysis of 395 Tenerife adults found high prevalence (<50%) of degenerative disease (osteoarthroses), with distinct differences between males (elbow, knee and shoulder) and females (hip and sacroiliac joint) that are believed to reflect sex-based lifestyle variability in a challenging terrain (Aufderheide and Rodriguez Martin 1998: 97). Ankylosing spondylitis has also vbeen found (Garcia Garcia and Gonzalez Garcia 1992). Further examples of a very active lifestyle include traumatic dislocations and longbone fractures (see below). Rodriguez Martin believes that these pathologies indicate a pastoralist society with some agricultural and hunter/gatherer activity, with high physicality and stress (particularly in males) from a relatively early age. Finally, anthracotic pigment and pulmonary fibrosis was found in the lungs of both adult and subadult mummies from Tenerife, suggesting smoke inhalation in confined spaces (Aufderheide *et al.* 1992b).

5.1.6 Trauma

Rodriguez Martin (1992) examined trauma in a Tenerife sample, concluding that <20% of individuals were affected with cranial trauma, with a male/female ratio of 2.6:1. There appears to be some regionalisation within Tenerife, with fewer traumas in the well-watered north (2%) than the desiccated south (9%), and it is possible that this reflects some competition for resources (Notman 1992; Aufderheide and Rodriguez Martin 1998: 24-5) or perhaps elite/non-elite differentiation. The ecological argument is supported by Kelley and Smeenk (1992: 201), although their methods, materials and reported figures differ somewhat (south: 29.8%; north: 9%). It is unfortunate, however, that the temporal variable was not employed, as this would have provided an added dimension to the studies. Kelley and Smeenk (1992) addressed the Tenerife population's supposed bellicosity by locational analysis, treating cranial trauma as a measure of social *stasis*. The consistency of spatial prevalence (90% on the frontal and parietal, rare on the facial bones), size (0.9-4.2cm) and shape (predominantly circular or elliptical) all suggest that accidents were not the predominant cause. The authors believe that slingshot stones (and possibly hand-held bolas: Rodriguez Martin 1999) were responsible for most of these lesions, as bare-knuckle fighting and clubbing leave less localised trauma and are especially common on the facial skeleton (Shermis 1984). This is supported in part by Aufderheide and Rodriguez Martin's review, which shows very low prevalence of sharp-edged weapon injuries, with more gross crushing injuries, penetrating wounds and linear fractures (1998: 23). It is possible that the slicing wounds relate to conflict in the contact period, as there is no evidence for sufficiently large bladed weapons in the archaeological record (although stone adzes may have been involved). Approximately 17% of the lesions were classified as *perimortem* or fatal (1998: 25). The sex bias – 80% male and 20% female – is also striking, and may reflect the more active (or, perhaps, bellicose) role that men appear to have played in everyday life (see 5.1.5, above). These lesions rarely affected subadults but were very common in younger (40%) and older (26%) adults; this tends to provide support for claims of interpersonal violence in Canarian groups. Total postcranial trauma prevalence was less than 1%, and occurred most commonly in the ulna and the fibula/tibia, with males being more affected than females by a ratio of 2.5:1. The trauma patterns substantiate the pathology data, possibly indicating a society with a highly active lifestyle and marked levels of physical trauma, which Rodriguez Martin believes to be linked to moving across uneven terrain in the execution of a pastoral lifestyle (1992: 69-70). All healed Canarian postcranial fractures were misaligned (Aufderheide and Rodriguez Martin 1998: 22). Notman's radiological survey of Tenerife mummies (1992) identified a large number of longbone fractures (femoral and tibial shafts; scapulae), leading to assertions of a "warlike" disposition amongst these groups (1992: 102). Notman also claims that the high prevalence of identical traumatic lesions in the lateral femoral condyles suggests some form of intentional incapacitation, and that this is further evidence of the islanders' warlike behaviour.

5.1.7 Summary – Ancient Canarian Biological Anthropology

The ancient Canarians appear to have been derived from North African populations of the pre-Islamic period, although input from later groups cannot be discounted at the present time. The populations were fairly tall and generally healthy, but appear to have had a very active lifestyle with severe deterioration of joints and postcranial trauma. The very high level of cranial trauma and the appearance of the lesions suggest some level of interpersonal confrontation and combat. Health and activity varied between the sexes, with increased levels of certain forms of activity and trauma in males, and some evidence for higher levels of developmental stress in females (Rodriguez-Martin 1992: 59-70). While the general biological characteristics of Canarian populations are fairly well understood, neglect of social and dynamic issues means that complex bioarchaeological questions – such as chronological genetic and lifestyle variable change, or populational perspectives on health and illness – cannot be addressed. It is hoped that the present project will contribute towards rectification of this shortfall.

5.2 Materials in the Present Study

This study is based upon observation of skeletal and mummified human remains from museum collections in the Instituto Canario de Paleopatologia y Bioantropologia (Tenerife), the Museo Canario (Las Palmas, Gran Canaria), the Museo Arqueologico Castillo de San Gabriel (Arrecife, Lanzarote), the Musee de L'Homme (Paris, France), the British Museum of Natural History (London, UK) and the Duckworth collection (Cambridge, UK). The study involved an MNE (Minimum Number of Elements) of 1096 specimens (mandibles and maxillae), with an MNI (Minimum Number of Individuals) of 896, from 62 sites in the archipelago. Maps showing the location of some of the sites (not all could be located) are presented below in plates 5.1 to 5.3.

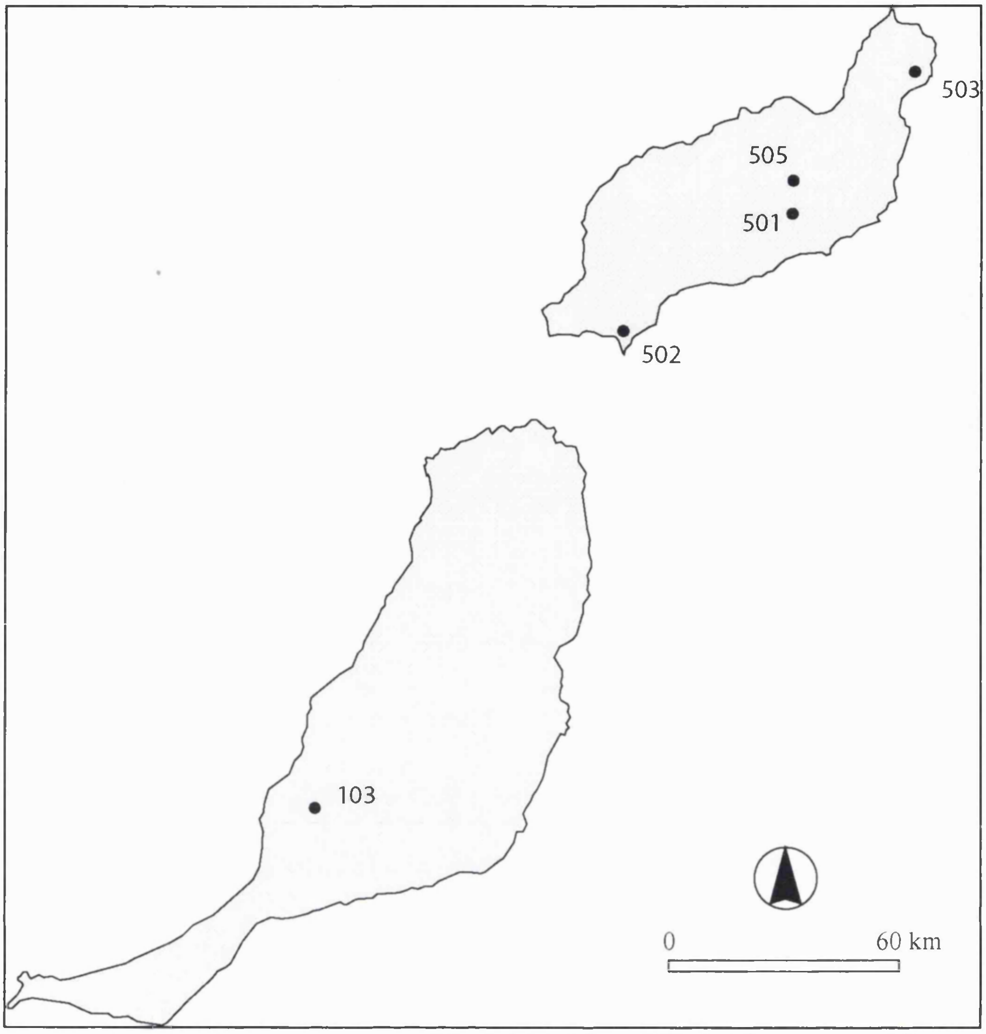

Plate 5.1. Location of Sites on Lanzarote and Fuerteventura

Site Name	Site Code	Sample Size	Date
Unknown	100	10	-
Cueva de Rio Palmas	101	1	-
Punta Becerra	102	4	-
Cueva de la Montana de Cardon	103	5	-
Valle del Jerugo	104	1	-

Table 5.1 Fuerteventura (Island 1) Sites

Site Name	Site Code	Sample Size	Date
Unknown	500	0	-
Montana Mina	501	13	EARLY
San Marcial de Rubicon	502	1	-
Jameos del Agua	503	1	-
Chifletera	504	1	-
Guanapay	505	1	LATE

Table 5.2 Lanzarote (Island 5) Sites

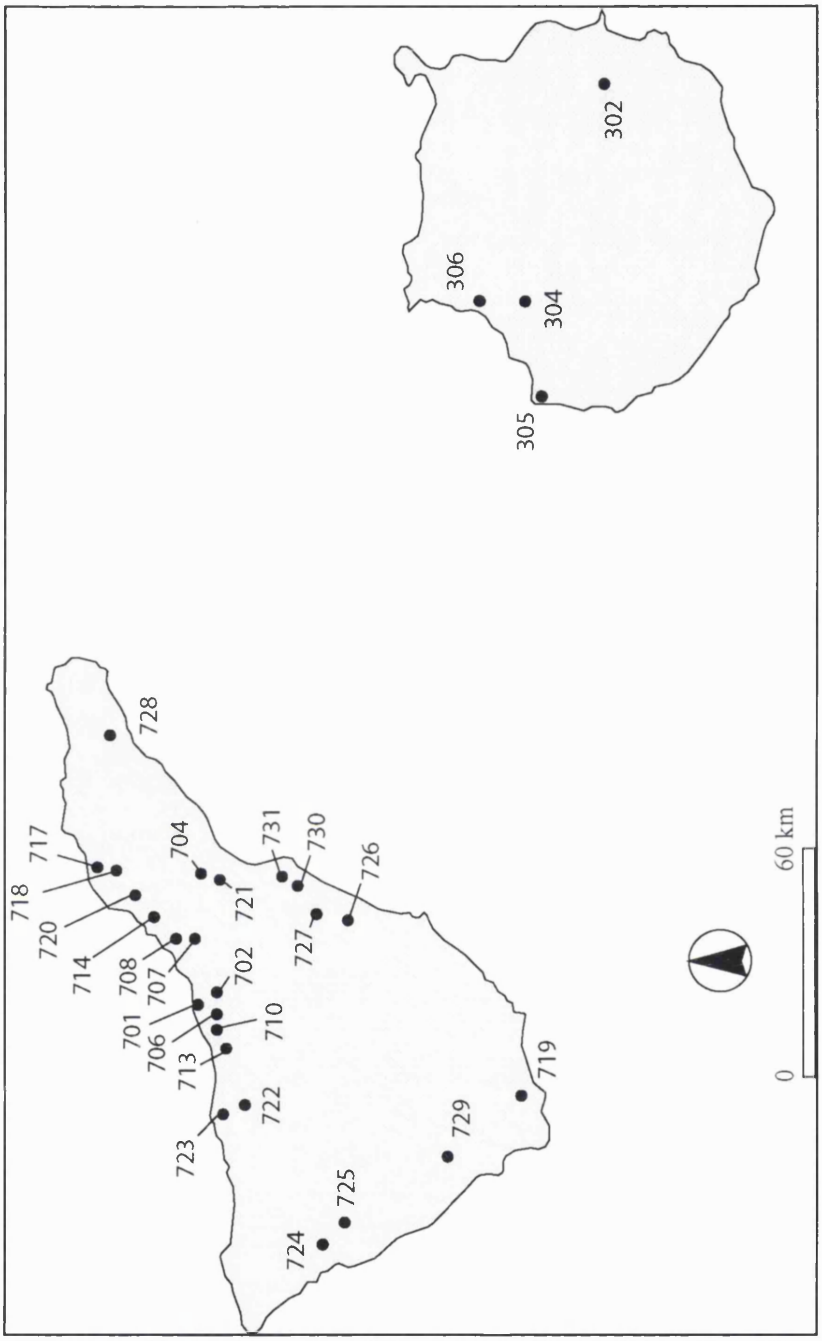

Plate 5.2. Location of Sites on Gran Canaria (Island 3) and Tenerife (Island 7)

Site	Code	Sample	Date
Unknown	300	0	-
Tumulus de la Isleta	301	8	1043 and 1213 BP
Guayadeque	302	245	1410 and 1120 +/- 60 BP
El Agujero	303	5	-
Acusa	304	18	1520 +/- 45 and 1380 +/- 60 BP
Los Caserones	305	4	1890 +/- 150 BP
Agaete	306	1	950 +/- 40 BP
Cuevas del Rey	307	1	1665 +/- 60 BP
La Guancha	308	20	875 +/- 60 BP

Table 5.3 Gran Canarian (Island 3) Sites

Site Name	Code	Sample	Date
Unknown	700	1	-
Playa de Martinez Cave, Orotava	701	8	-
La Paz Cave, Orotava	702	5	-
La Guerra Cave	703	1	-
Santa Cruz de la Laguna	704	2	-
Puerto de la Madera	705	6	-
Ancon, Orotava	706	5	-
Rio del Castillo, Sauzal	707	8	1505 +/- 80 BP
Cueva del Puertito, Sauzal	708	12	EARLY
Costa Hoya Fria	709	84	938 +/- 83 and 1395 +/- 80 BP
Roque Blanco, Orotava	710	6	1380 +/- 120 and 665 +/- 135 BP
Masape	711	37	636 +/- 77 BP
Becerril	712	54	1160 +/- 105 BP
La Florida (La Orotava)	713	25	1298 +/- 86 BP
Risco del Perro, La Matanza	714	11	1005 +/- 70 BP
Anaga (Yac. Des.)	715		645 +/- 120 BP
Anaga (Yac. Des.)	716		1065 +/- 75
Cueva del Guanche, Tegueste	717	153	1311 +/- 81 and 1341 +/- 59 BP
La Enladrillada, Tegueste	718	21	800 +/- 50 and 735 +/- 75 BP
Uchova (San Miguel de Abona)	719	68	1246 +/- 72 BP
Risco de Los Guanches, Tacoronte	720	7	2150 +/- 80 and 2185 +/- 65 BP
La Palmita, Tejina, La Laguna	721	20	1040 +/- 110 BP
Hoya Brunco, La Guancha	722	7	930 +/- 110 and 780 +/- 100 BP
El Masape (San Juan de la Rambla)	723		636 +/- 77 BP
El Retamar (Guia de Isora)	724	4	421 +/- 52 BP
Majagora (Guia de Isora)	725	17	1092 +/- 81 and 1278 +/- 53 BP
Igueste de la Candelaria (Candelaria)	726		615 +/- 120 BP
Barranco Cruz de las Animas (El Rosario)	727	17	1080 +/- 110 BP
Anaga, Sta, Cruz (Mummy)	728	1	1065 +/- 75 BP
Barranco del Infierno, Adeje (Mummy)	729	1	530 +/- 135 BP
Barranco de Santos, Sta. Cruz (Mummy)	730	1	1110 +/- 164 BP
Cueva de Guerra, Santa Cruz	731	1	-
(Cambridge Mummy)	732	1	LATE

Table 5.4. Contd. Tenerife (Island 7) Sites

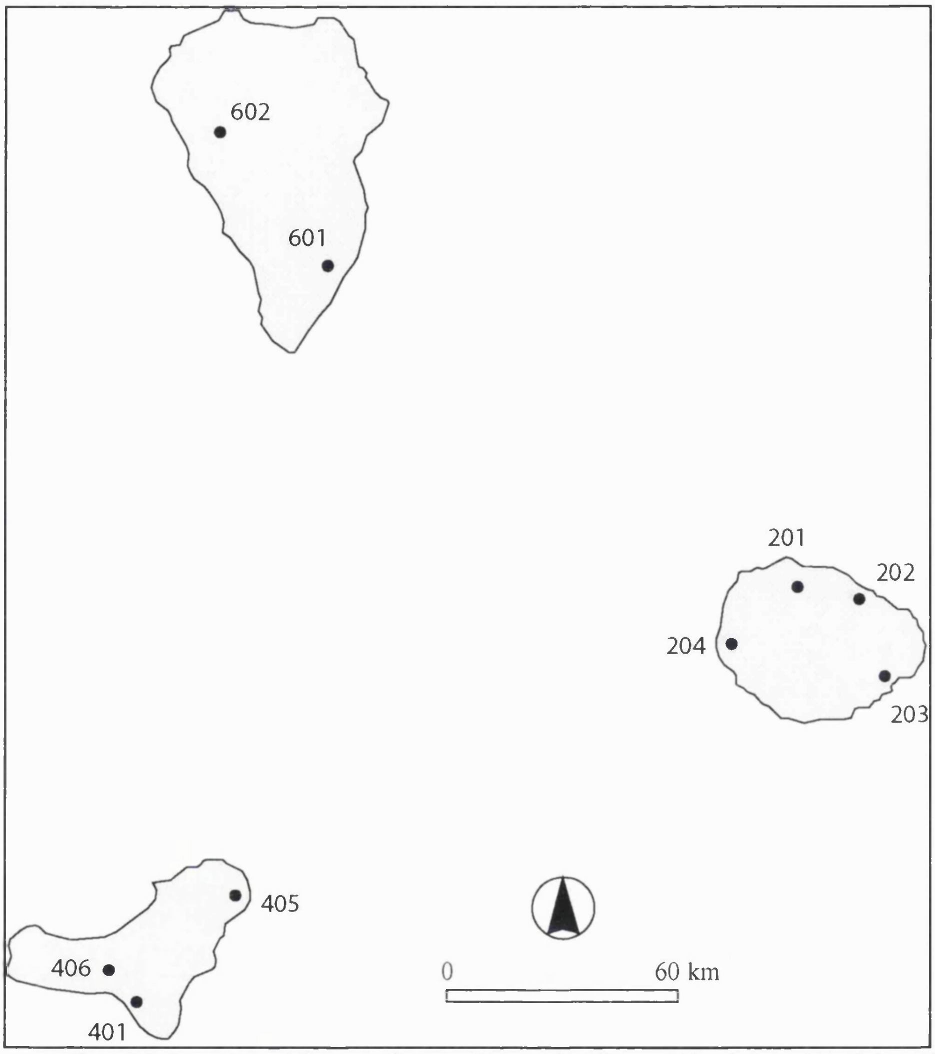

Plate 5.3. Location of Sites on Gomera (Island 2), Hierro (Island 4) and La Palma (Island 6)

Gomera	Site Code	Sample Size	Date
Unknown	200	0	-
Valle Hermosa	201	1	-
Agulo	202	1	-
San Sebastian	203	4	-
Valle Gran Rey	204	33	-
Tejeriguete	205	17	-
Hierro	**Site Code**	**Sample Size**	**Date**
Unknown	400	0	-
Lajiar	401	3	-
Barranco de la Guerra	402	14	-
Pozo de la Ballena	403	3	-
Tablon (Letreros)	404	58	-
Tamaduste	405	1	-
El Julan	406	3	-
La Palma	**Site Code**	**Sample Size**	**Date**
Unknown	600	0	-
San Juan Belmaco	601	1	930-1320 BP
Tijarafe	602	1	-

Table 5.5. Gomera, Hierro and La Palma Sites

5.2.1 Preservation and Representation of Skeletal Elements

Although complete skeletons have been recovered in Canarian archaeological excavations, the fact that most of these were curated by element rather than individual led to added complications in sexing and ageing of individuals (see below). Post-excavation association/mixing of maxillae and mandibles from different individuals caused additional problems (questionable pairings were divided and the elements assessed separately).

Plate 5.4. Male Mummy from Tenerife
Duckworth Collection, University of Cambridge

The MNI may therefore be higher than stated. Preservation varied considerably both within and between collections, ranging from intact mummified bodies (see Plate 5.4) to individual mandibles/maxillae or fragments of calvarium. Imperfect collection and curation methods have compounded damage caused by taphonomic forces, which may also account for the relatively low number of individuals in fragile age/sex classes (i.e. female, subadult or aged) recovered.

5.2.2 Recording Standards for Skeletal Remains

Badly provenanced and undated materials have limited the social value of previous studies of Canarian bioarchaeology. Therefore in this study the ideal was to only score individuals that could be fitted into the intended temporo-spatial framework (Owens 2001). For example, although conservative estimates place the ICPB (Tenerife) collections at some 30,000 individuals (Martin Oval, pers. comm.), the lack of provenance and dating evidence severely reduced the size of the sample. The 'Yacimiento Desconocido' (site unknown) data were ignored, unless there was radiometric information accompanying the remains. While it was possible to be selective on the large islands, the scarcity of human remains from Gomera, Hierro, Fuerteventura, Lanzarote and La Palma meant that undated (and often unprovenanced) specimens had to be used.

5.2.3 Sample Size

The total MNI of 896 – based on 1096 dentitions – is intermediate between those used in previous studies of prehistoric Canarian populations by Bermudez de Castro 1989 (3210 dentitions – MNI=1492) and Guatelli Steinberg *et al.* 2001 (n=397) but is unusual in using these specimens to address both biological and social questions in an archipelago-wide temporospatial framework. Sample size varied considerably between sites and islands, in accordance with taphonomy, the agendas of early archaeologists and actual pre-conquest population size. The smallest island sample was La Palma (n=2), with small numbers of specimens on Fuerteventura (n=21) and Lanzarote (n=17). Rather larger groups were recorded from Hierro (n=82) and Gomera (n=55), the large majority of specimens coming from Tenerife (n=581) and Gran Canaria (n=338). Only six mummies were available for scoring.

5.2.4 Demography in Bioarchaeological Studies

While recognising Lahr's argument that sex and age data are not always necessary for population biology profiles (1996), it is a *sine qua non* for socially-oriented bioarchaeological investigations. While the ASUDAS is unaffected by age and only weakly affected by sex (Scott and Turner 1997: 105-109), explication of life-history variables such as childhood health (enamel hypoplasia), diet (caries) and other indicators (i.e. trauma; disease) can acquire added social significance when considered in terms of sex and age. However, using skeletal material to examine the demography of past populations is fraught with difficulty, as it has long been recognised that the age/sex structure of an osteoarchaeological sample is rarely representative of the original population from which it came (Waldron 1994). Firstly, social practices may dictate that methods for disposal of the dead are reliant upon sex, age or status, leading to misrepresentation in the archaeological record. Secondly, burial environments and retrieval methods may adversely affect the samples, impacting more strongly on certain age (subadults; old individuals) and sex (females) groups and thus skewing the sample. Finally, it should be noted that the aesthetic sensibilities of early collectors and excavators might have led to bias towards certain sectors of the population. Therefore, while age and sex profiles will be discussed, this is only done as a background to the dental study and should therefore be viewed as preliminary.

5.2.5 Age and Sex Composition of the Canarian Sample

The remains were sexed using craniofacial shape, size and proportions, notably the supraorbital torus, glabella, gonion, pyriform aperture, occiput, mastoid processes and palate (White and Folkens 1991; Buikstra and Ubelaker 1994: 17-20; Bass 1995 – see sections 4.1.2 and 4.8.2). Postcranial anatomy (particularly the pelvis) was used where available. A 5-class system was used, from 'definitely male' to 'definitely female', with 'probably male', 'probably female' and 'unknown' categories (as advised by Buikstra and Ubelaker 1994: 21). This was reduced to a 3-class system (male; unknown; female) in order to simplify the final analyses and to maximise sample size, although the five-class data has been retained for future study. Individuals were aged using dental eruption and wear, cranial suture closure and postcranial anatomy (auricular surface; pubic symphysis) where available. Pelvic methods were favoured over dental wear, which in turn was favoured over cranial suture closure. It was decided to adopt the general age assessment guidelines laid down by Buikstra and Ubelaker (young 20-34 years; middle 35-49 years; old 50+ years: 1994: 36), and to refine this slightly by the addition of an extra age category that was obtained by dividing the large 'young adult' category into younger and older adult groups (see section 4.1.2). The total list of ageclasses used was therefore young subadults (0-10), older subadults (10-18), 'subadult' (age unknown), young adults (19-25), older adults (26-35), mature adults (36-50), old adults (50+) and 'adult' (age unknown). The addition of the extra ageclass was deemed to be justified because of the pattern in which the data 'fell' when each specimen was allocated a specific age in years as recommended by Lovejoy *et al.* (1985) and the distribution was examined. As before, in order to maximise sample size, these categories were sometimes reduced to a four-stage system by combining the younger/older subadult ageclasses and the mature/old ageclasses. Reliability testing of sexing and ageing techniques was carried out using a sample of 30 Canarian specimens from Tenerife (10), Gran Canaria (10), Gomera (5) and Hierro (5) in the Musee de L'Homme (Paris), chosen at random within islands. The specimens (all cranial) were scored for age and sex, and then re-scored two days later without reference to the original results. It was not possible to use another researcher to confirm the results at the time the test was carried out. When using the 5-ranked system for sexing, attribution matched identically in 19/30 (63.3%) cases. However, when the results were recalculated with reference to the 3-ranked system (i.e. the 'probably male' and 'probably female' categories were collapsed into the 'male' and 'female' categories) this figure increased to 28/30 (93.3%). Misattribution was most common in late adolescents and very aged specimens, while young/older/mature adults were typically very dimorphic. The ageing results showed a strike rate of 17/30 (56.7%) using the 8-class system, and a refined rate of 23/30 (76.7%) when recalculated with reference to the 4-class system. The rate of positive sexing is very high, exceptionally so considering that only cranial remains were used in this test (see Lovejoy *et al* 1985), and reflects the marked dimorphism in Canarian groups (Rodriguez-Martin 1992). The ageing rate is respectable considering that pubic symphysis, auricular surfaces and other age-linked postcranial anatomical sites were not available for study, although it does underline the importance of curating skeletal remains by individual rather than by element (a traditional approach that has severely affected the range of options open to students of Canarian physical anthropology). A breakdown of the sample is presented in table 5.6.

Ageclass	Male	Unknown	Female	Total
Young Subadult	0	48	0	48
Older Subadult	16	19	9	44
Subadult (Age Unknown)	0	1	0	1
Young Adult	244	8	101	353
Older Adult	182	9	123	314
Mature Adult	115	4	66	185
Old Adult	50	5	37	92
Adult (Age Unknown)	33	4	22	59
Total	640	98	358	1096

Table 5.6 Total numbers of dentitions analysed in this study, by sex and ageclass

When divided by sex, 640/1096 dentitions were male, 358/1096 female and 98/1096 unsexed (table 5.6). The minimum number of individuals represented by these remains was 505 males (56.4%), 303 females (33.8%) and 88 specimens (9.8%) of unknown sex. 73.9% of the unsexed class were subadults. While these results demonstrate a very high rate of success in assigning sex, especially considering the fact that postcranial data were not usually available (see White and Folkens 1991: 323), it should be remembered that the levels of sexual dimorphism in the sample are unusually high (Rodriguez Martin 1992), possibly due to the fact there may have been fairly notable behavioural differences between the sexes (male craniae were very robust when compared to females). The sample, considered by island and by sex, is presented in table 5.7 and figure 5.1. See chapter 4 for further discussion of the sexing process.

Island	Male	Unknown	Female	N
Lanzarote	12	0	5	17
Fuerteventura	13	4	4	21
Gran Canaria	165	31	142	338
Tenerife	373	51	157	581
Gomera	33	9	13	55
La Palma	0	0	2	2
Hierro	44	3	35	82
Total	640	98	358	1096

Table 5.7. Total numbers of dentitions analysed, by sex and island

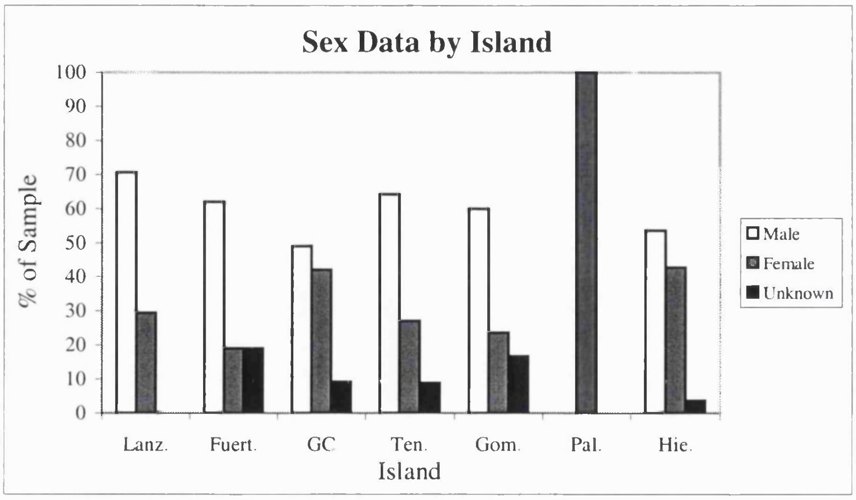

Figure 5.1. Canarian Sample by Sex and Island

Eighty percent of individuals originate in the two main islands of the central archipelago (Gran Canaria and Tenerife), with 4.2% from the eastern islands (Lanzarote and Fuerteventura) and 15.5% from the western portion of the archipelago (La Palma, Gomera and Hierro). Except for La Palma (two females and no males), there were more males than females in all the island samples. Proportions ranged from approximately equal (Gran Canaria) to heavily male-orientated (Tenerife). Most of the unsexed remains are subadults.

The ageclass data figures see the following archipelago averages (table 5.8): 9.2% subadult individuals, increasing into the young (31.4%) to older (28.1%) adult ageclasses before declining into the mature (16.7%) and old (8.9%) adult groups. To provide an added social dimension, the sex and age data were combined to examine how males and females differed in terms of age-at-death, and the standard and cumulative profiles for combined sexes, males only and females only are presented in figures 5.2 and 5.3.

Ageclass	Male	Unknown	Female	Sample
Young Subadult	0	46	0	46
Older Subadult	11	18	8	37
Subadult (Age Unknown)	0	1	0	1
Young Adult	192	7	82	281
Older Adult	140	6	106	252
Mature Adult	92	3	55	150
Old ('senile')	42	4	34	80
Adult (Age Unknown)	28	3	18	49
Total	505	88	303	896

Table 5.8 Sample by sex and ageclass

Individuals that could not be aged were not included, while young subadults – that cannot be sexed with any certainty – were only presented in the pooled sample. For purposes of graphic representation, the male and female young subadult figures were set at 2.5% each (half of the pooled sexes figure) in the cumulative graph.

Ageclass	Combined	Cumulative	Male	Cumulative	Female	Cumulative
Young Subadult	5.1	5.1	-	-	-	-
Older Subadult	4.1	9.2	2.2	2.2	2.6	2.6
Young Adult	31.4	40.6	38.0	40.2	27.1	29.7
Older Adult	28.1	68.7	27.7	67.9	35.0	64.7
Mature Adult	16.7	85.4	18.2	86.1	18.2	82.9
Old ('senile')	8.9	94.3	8.3	94.4	5.9	88.8

Table 5.7 Die-off percentage values, by ageclass and sex (for graphs)

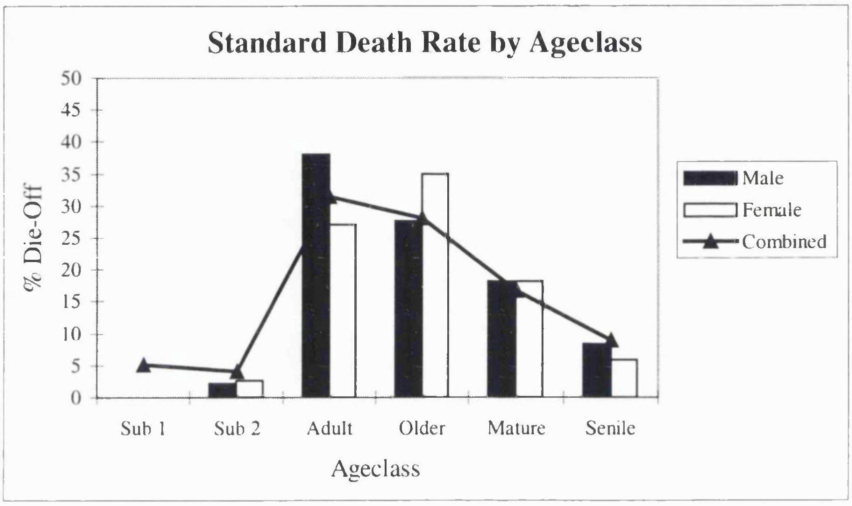

Figure 5.2. Standard Graph of Canarian Sample by Sex and Ageclass

The cumulative death curve is modelled on the ovicaprid kill-off curve originally proposed by Payne (1973).

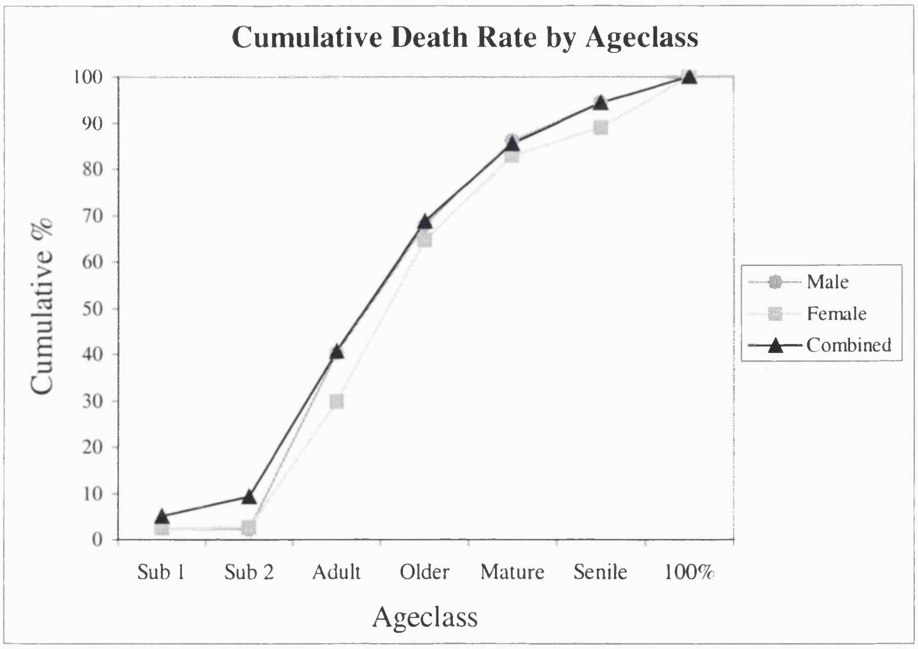

Figure 5.3. Cumulative Graph of Canarian Sample by Ageclass and Sex

Age-at-death figures were approximately equal between males and females in the sample. There were more young adult male specimens (38% vs. 27.1%), an increased number of older adult female specimens (35% vs. 27.7%) and parity (18.2%-18.2%) in maturity. There were more males (8.9%) than females (5.9%) in the 'old' ageclass, although this may be an artefact of preservation. While there is little difference between younger and older subadults, there were more specimens below the age of 10 than between 11 and 18. At increased resolution, it seems that the vast majority of 'young subadults' were between 2 and 5 years of age.

5.2.6 The Canarian Sample by Period

The issues surrounding chronology and dating in the Canaries have already been discussed (see chapter 3). Of the few available dates, many presented in recent work were carried out on human remains (or on samples from sites containing them) so a fair number of radiometric determinations were collated for the present purpose. Tenerife has the largest number of dated sites, falling away towards the peripheral islands, while the Gran Canaria sample is well dated, but only pertains to a handful of large and important sites. Where possible, date ranges or estimates, acquired in consultation with Canarian researchers, have been provided. These were employed during analysis to add a temporal aspect to the project. To facilitate analysis, the age ranges were divided into early (0 BC/AD-500 AD), middle (501-1000 AD) and late (1001-1500 AD), as well as an undated group. These dates were arrived at in consultation with the distribution of radiometric dates for the archipelago as a whole (see chapter 3).

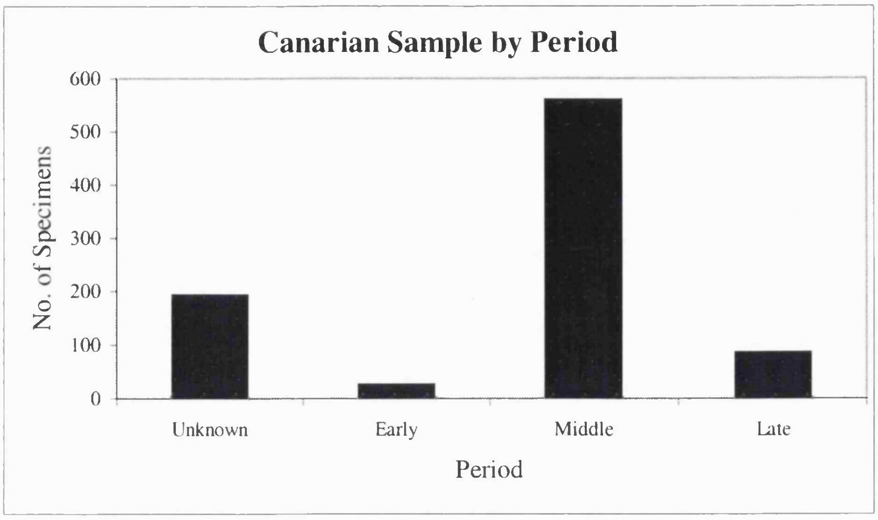

Figure 5.4. Pooled Canarian Sample by Period

Most individuals, and the largest sites, are from the middle period (62.3%), with only 3% from the early period and 9.6% from the late period (figure 5.4 and table 5.8). Twenty-one and a half percent of the specimens were undated, and most of these are from Gomera and Hierro (although all island samples include at least a few undated specimens). While these results generally indicate small numbers in the early period, a marked increase in the middle group and a decrease into the later period, it should be noted that the age and sex distribution of a skeletal sample is an imperfect indicator of demography in the source population (Waldron 1994). The island samples break down by ageclass as shown in figure 5.5. Younger and older subadults and mature and old adults were combined into 'subadult' and 'mature' ageclasses for comparative purposes.

Island	Unknown	Early	Middle	Late	Sample
Lanzarote	3	13	0	1	17
Fuerteventura	21	0	0	0	21
Gran Canaria	3	20	191	16	230
Tenerife	28	27	368	69	492
Gomera	56	0	0	0	56
La Palma	1	0	1	0	2
Hierro	81	0	0	0	81
Total	193	27	560	86	899

Table 5.8 Sample by Period and by Island

Ageclass	Lanz.	F'ventura	GC	Tenerife	Gomera	Palma	Hierro	N
Subadult #1	0	3	16	22	4	0	1	46
Subadult #2	1	2	10	17	4	0	3	37
Subadult (?)	0	0	0	1	0	0	0	1
Young Adult	3	10	55	180	19	0	14	281
Older Adult	3	4	69	140	17	0	20	253
Mature Adult	3	1	45	57	9	1	34	150
Old	0	1	29	41	1	0	8	80
Adult (?)	7	0	6	32	2	1	1	49
Total	17	21	230	490	56	2	81	897

Table 5.11. Ageclasses by Island

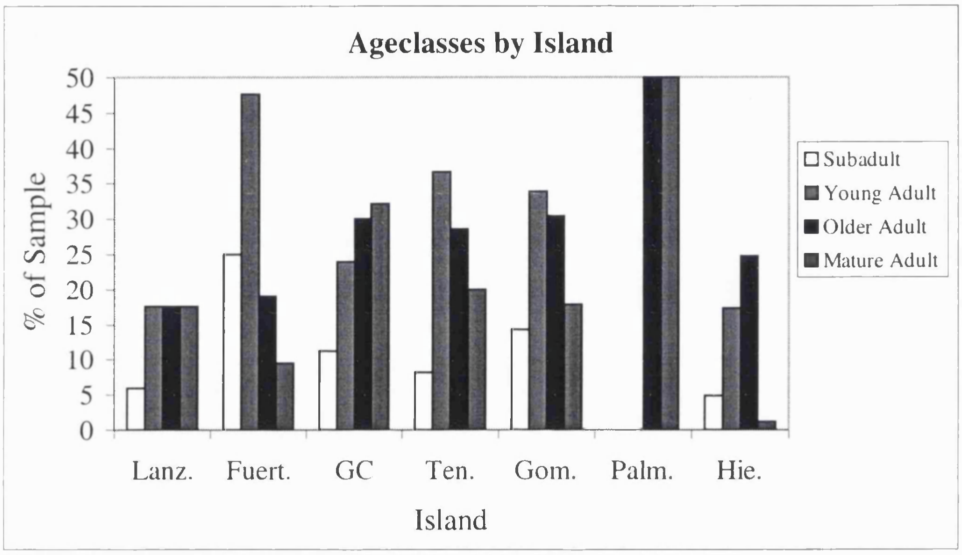

Figure 5.5. Grouped Ageclasses by Island

In the islands with significant samples there were distinct differences in ageclass representation. The greatest proportion of subadult remains was found in Fuerteventura and Gomera, followed by Gran Canaria, Lanzarote and Gomera. Older specimens were most common in Gran Canaria, followed by Tenerife and Gomera. Individuals from Lanzarote and Fuerteventura were mainly young, while only a very small proportion of Hierro individuals were in the mature/old ageclass. Most of Lanzarote's population appear to have died in young adulthood, although samples are not large. The basic data are presented below

Ageclass	Unknown	Early	Middle	Late
Subadults	11.2	15.4	9.6	5.2
Young Adults	32.1	7.7	33.3	39
Older Adults	24.6	28.8	31.2	33.8
Mature/Old	32.1	28.8	25.9	22.1

Table 5.12 Ageclass by Period

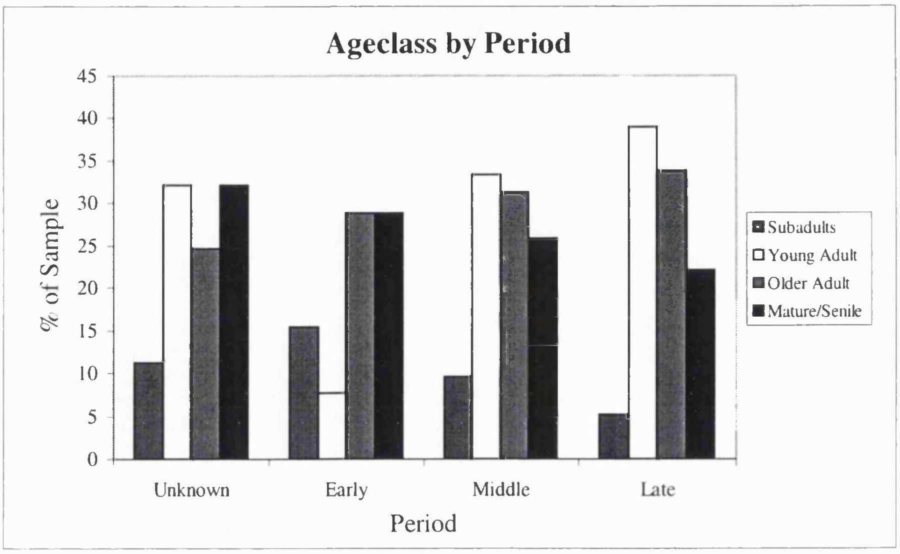

Figure 5.6. Ageclasses by Period

When considered by period, the general trend is a decrease in subadult death and an increase in young-older adult deaths. In accordance with this, there was a decrease in the number of mature/old specimens (see table 5.12). The undated sample sees an intermediate number of subadults, a peak in young adults and a very high proportion of individuals in the mature/old ageclass. While these results are of dubious worth in isolation, there is clearly potential for future studies of human palaeodemography in the Canarian archipelago.

	Lanz.	F'ventura	GC	Tenerife	Gomera	Palma	Hierro
Unknown	17.6	100	1.3	5.7	100	50	100
Early	76.5	0	8.7	5.5	0	0	0
Middle	0	0	83	74.8	0	50	0
Late	5.9	0	7	14	0	0	0

Table 5.13 Samples by Period and Island (%)

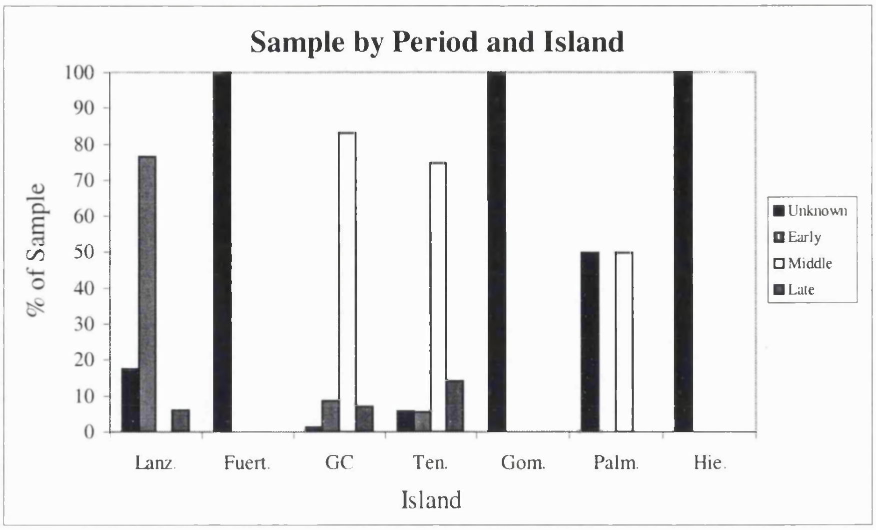

Figure 5.7 Sample by Period and Island (%)

Finally, the sample was considered by island and period, which emulated the general temporal trend discussed above. Note the peaks of undated materials in Fuerteventura, Gomera and Hierro (and La Palma, although the sample is small). In all islands for which there is multi-period information, the middle period sample is much larger than those from the early and late periods. The exception (Lanzarote) peaks in the early period, although this is partly attributable to small sample size. This pattern is also dependent upon the accuracy of the current author's attribution of Montana Mina to the early period, and Guanapay to the late group. These sites have not been radiometrically dated, but are evidently different in terms of burial tradition, associated artefacts and physical attributes of the human remains (personal observation). In Guanapay's case, the burial comprised a single, extremely gracile individual, buried in the open with grave offerings that included, significantly, a metal knife. This has been interpreted (Aguilar 1976) as a late period burial (Native Canarians in contact with European traders or forces), although it is possible that it in fact dates to the very earliest group of Native Canarians that interacted with Roman groups in the 2^{nd} century AD (Atoche Pena *et al.* 1995). Montana Mina, by comparison, is a multiple cave burial of extremely robust individuals without associated grave goods. The current author has interpreted these as the remains of early Canarians, possibly from the first half of the 1st millennium AD ('early' period). These findings are tentative, and are subject to review.

5.2.7 Discussion

At 896 individuals (1096 jaws), sample size is respectable considering the size of the archipelago and sample sizes for most previous projects, and is sufficiently large to address the issue at hand. While island coverage is somewhat uneven for a number of historical and archaeological reasons, the fact that all of the islands are represented, unlike many extant studies that focus on only one site or island, adds value to any conclusions reached concerning human adaptation in this highly diverse islandscape. It is of course also possible that the small sample sizes for some of the islands reflect actual population size in the pre-conquest period. Equally, both sexes (males 505; females 303) and all ageclasses (subadults 9.2%; young adults 31.4%; older adults 28.1%; mature 16.7%; old 8.9%) are represented, allowing testing for inter-sex and age-related pathology/life history characteristics. It would be unwise to make any generalisations about ancient Canarian populations on the basis of overall figures, particularly if the sampling problems are considered (Waldron 1994). The subadult figures are particularly striking, as such low childhood mortality would be virtually unprecedented in bioarchaeological samples (infancy being a time of high mortality for most populations [White and Folkens 1992: 373]) and it is therefore possible that dead subadults were either dealt with differently from adults, or were passed over by collectors. However, certain points can be derived. Life expectancy appears to have been relatively good, with most of the population dying in their thirties and forties. More males than females died in early adulthood, while females caught up in older adulthood. The sexes are roughly equal in the oldest two ageclasses, although the number of females to survive into maturity/senility is interesting in light of the smaller number of females in the population as a whole. The temporal trend towards large sample sizes in the middle period (62.3%) is of interest in attempting to model patterns of island colonisation and settlement, as is the large proportion of remains from the central two islands in the archipelago (80%). The temporal trend in longevity is interesting, as it suggests an early population with fairly high infant mortality, but considerable portions of the population surviving into maturity/senility. This then changes into the intermediate group, with increasing mortality of young adults, decreasing child mortality and less people surviving into the oldest ageclasses, and this trend is continued into the late period. The extent to which this is a true reflection of ancient lifestyle (or an artefact of preservation/taphonomy) is currently unclear, and it is hoped that the underlying causes of these trends, be it changes in economy, diet or social behaviour, will be better understood as a result of the present study.

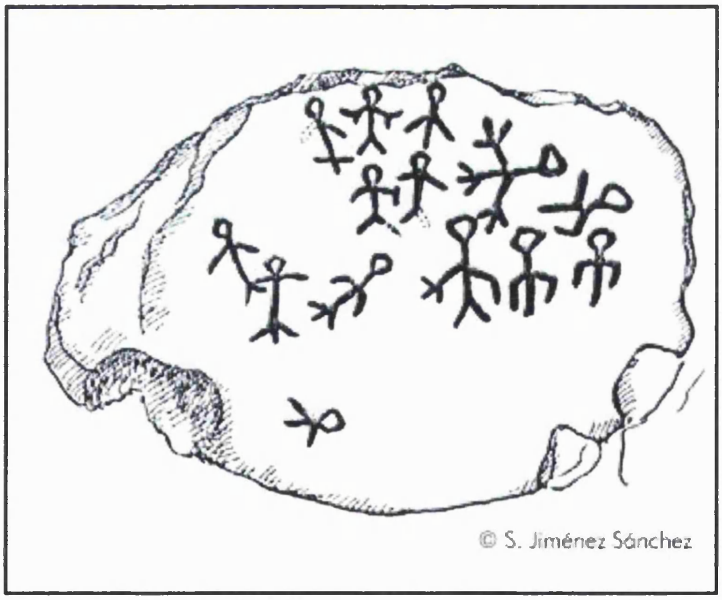

Plate 5.5. Group of Anthropomorphic Figures, Majada Alta, Gran Canaria (www.almogaren.org/gallery/canarias.htm)

6 – Population Biology Results and Statistics

The dental and cranial morphology data are summarised here. The basic characteristics of the data, and comparative reports where applicable (ASUDAS only), are outlined for all islands and periods. Chi-Squared tests were run to assess the variability of the samples by island and by period, using predicted figures (to fulfil the null hypothesis) to examine the distribution of the data points. The internal temporal variability of individual islands with large dated samples (Gran Canaria and Tenerife) was also assessed.

6.1 ASUDAS Data

The ASUDAS data were assessed in the manner laid out in chapter 4. Table 6.1. details the complete multi-period (grouped) profile of these traits that characterise the islands as a unit, as well as by-period prevalence. This elucidates the difference in approach between standard regional profiling and more socially orientated population history of geographically restricted areas. By-island counts and percentage values are presented in addition to Chi-Squared statistic results in appendix 2.

Trait	Unknown %	Early %	Middle %	Late %	Total %	Count
UI1 WINGING	28.6	0.0	6.3	7.7	10.5	4/38
UI1 SHOVEL	0.0	50.0	46.2	15.4	28.1	9/32
UI1 D_SHOVEL	0.0	0.0	14.3	0.0	5.7	2/35
UI1 LAB_CON	50.0	0.0	35.7	35.7	36.1	13/36
UI2 INT_GROOVE	17.6	50.0	18.2	15.4	19.4	13/67
UI2 FORM	6.3	0.0	5.6	14.3	7.0	5/71
UI2 *T_DENTALE*	33.3	100.0	52.4	87.5	54.8	23/42
UC_MAR	0.0	0.0	7.7	75.0	11.4	4/35
UC_DAR	23.5	0.0	31.3	20.0	28.2	11/39
UP1 ROOT	37.7	100.0	60.0	75.0	71.4	45/93
PREM_ODONT	1.8	6.3	0.3	1.1	0.9	4/431
UM1_CARABELLI	18.8	28.6	45.1	41.7	34.1	61/179
UM1_C5	19.6	57.1	25.0	27.2	24.8	37/149
UM1 ENAM_EXT	9.5	9.5	16.6	21.1	14.4	40/277
UM2 C4	72.4	90.9	83.1	88.2	80.4	193/240
UM2 ROOT	92.2	87.5	95.0	87.5	93.2	206/221
UM3 P'STYLE	5.6	25.0	2.5	6.6	4.3	9/208
UM3 AGENESIS	15.3	10.0	12.6	8.1	12.9	59/456
LC ROOT	5.3	0.0	4.7	0.0	4.4	5/114
LP2 LING_CUSP	53.8	100.0	83.3	94.1	80.0	112/140
LM1 CUSP	2.0	41.7	2.6	0.0	3.6	13/361
LM1 A_FOVEA	17.4	66.6	15.4	25.0	19.3	31/161
LM1 D_WRINKLE	10.0	75.0	35.3	100.0	34.4	11/32
LM1 DTC	0.0	0.0	1.3	0.0	1.0	2/209
LM1 P'STYLID	24.1	38.5	26.8	26.0	26.6	113/425
LM1 C7	9.0	0.0	8.8	15.4	9.0	36/401
LM1 ROOT	2.9	0.0	0.8	0.0	1.2	6/512
LM2 CUSP	23.2	55.5	28.8	25.8	28.0	117/418
LM2 GROOVE	31.6	36.4	24.3	12.9	25.2	107/425
LM2 ROOT	97.0	87.5	95.2	100.0	96.6	454/470
MAND_TORUS	0.0	5.3	1.8	0.0	1.6	10/626
MAX_TORUS	0.7	0.0	3.2	4.8	2.4	12/500

Table 6.1. ASU Data for the Canaries (% values and sample size)

6.2 General and Regional Comparisons

While this project does not intend to investigate regional affinities on a large scale, it is appropriate to make some general comparisons. Data from Irish and Turner's 1990 study of Nubian dental origins and dispersals (and also Turner and Markowitz 1990) was combined with the current author's Canarian sample in order to provide a wider perspective on Canary Island population biology. The comparative samples are presented in table 6.2.

Group	Age	Sample
West Africa	19th-20th Century AD	71
Christian	550-1350 AD	18
X-Group	350-550 AD	39
Meroitic	100 BC – 350 AD	91
Pleistocene	12000-18000 BP	57
Canary Islands	100 BC – 1400 AD	626

Table 6.2. Samples Used for Basic ASU Comparisons

The basic comparisons are presented in table 6.3. The Canarian data has been divided by period (undated; early; middle; late).

Trait	W'Af	Chr'an	X'G	Mer'	Plei'	Undated	Early	Middle	Late
UI1_Wing	7.4	11.1	7.1	13.9	32.0	28.6	0.0	6.3	7.7
UI1_Shov	52.6	0.0	33.3	42.4	59.1	0.0	50.0	46.2	15.4
UI1 D'Shov	0.0	12.5	14.3	4.9	0.0	0.0	0.0	14.3	0.0
UI2 Int'Gr	13.0	50.0	57.1	38.6	16.0	17.6	50.0	18.2	15.4
UI2 *T_D*	25.0	12.5	50.0	41.0	38.9	33.3	100.0	52.4	87.5
UC_MR	32.4	28.6	10.0	32.6	22.6	0.0	0.0	7.7	75.0
UM2_C4	87.5	72.7	87.5	77.9	92.6	72.4	90.9	83.1	88.2
UM1 C5	32.4	16.7	22.2	11.1	28.6	19.6	57.1	25.0	27.2
UM1 Carab	58.3	77.8	46.2	58.9	46.2	18.8	28.6	45.1	41.7
UM3 P'style	2.0	0.0	7.7	0.0	0.0	4.2	0.0	1.7	0.0
UM1 En'Ext	37.5	8.3	11.5	14.0	60.0	9.5	9.5	16.6	21.1
UP1 Root	64.4	63.6	70.4	52.6	71.4	37.7	100.0	60.0	75.0
UM2 Root	87.7	100.0	87.0	82.5	72.0	92.2	87.5	95.0	87.5
UI2 Form	3.1	0.0	0.0	2.0	3.1	6.3	0.0	5.6	14.3
UM3 Agen.	1.5	7.7	20.0	7.6	0.0	15.3	10.0	12.6	8.1
LC DAR	61.9	0.0	0.0	6.9	71.4	8.3	0.0	27.0	0.0
LP2 L'Cusp	79.5	100.0	100.0	87.8	93.3	53.8	100.0	83.3	94.1
LM1 A'fov	-	28.6	70.0	40.0	-	17.4	66.6	15.4	25.0
LM2_G've	25.0	33.3	10.0	10.7	59.3	31.6	36.4	24.3	12.9
LM1 Cusp	35.3	12.5	11.8	6.9	30.0	2.0	41.7	2.6	0.0
LM2 C5	83.3	1.0	14.3	33.3	93.9	75.0	55.6	30.2	26.2
LM1_DW	60.0	0.0	15.4	7.0	30.0	10.0	75.0	35.3	100.0
LM1_DTC	0.0	0.0	0.0	4.9	0.0	0.0	0.0	1.3	0.0
LM1_P'Lid	20.0	30.0	31.8	49.3	28.6	24.1	38.5	26.8	26.0
LM1 C7	30.2	0.0	14.3	2.4	3.6	9.0	0.0	8.8	15.4
LM1 Root	0.0	-	-	-	15.6	2.9	0.0	0.8	0.0
LM2 Root	95.7	87.5	89.5	89.1	86.1	97.0	87.5	95.2	100.0
Pal'Tor	1.4	7.7	14.7	11.1	9.1	0.7	0.0	3.2	4.8

Table 6.3.Regional Comparisons of ASU Data (% values and sample size)

Based on basic visual inspection, the Canary Islands resemble the West African sample, followed by the X-Group, the Pleistocene sample, the Meroitic group and the Christian sample. The Canaries' apparent affinity with the X-Group is interesting, as the period coincides with an apparent increase in population size in the mid first millennium AD. The West African similarity is surprising in light of the Canaries' historic association with Northern Africa (see chapters 4 and 5). The Meroitic group has links with the earlier stage of Canarian occupation, while the Pleistocene group's affinity with the Canarian sample may be grounded in that groups' ancestral role in many North African populations (Irish and Turner 1990). The weak link to the Christian group may be partly attributable to small sample size in Irish's study. The Canaries lie with the Western Eurasian and Sub-Saharan groups if considered on a global scale. Data on selected traits from Scott and Turner (1997: 179-234) were used for more specific comparisons. Percentage values were derived from the survey data and compared with the Canarian figures. Certain traits could not be compared if definitions or breakpoints were different, and these have been omitted. The three major areas with potential for Canarian colonisation – North Africa, Western Europe and West Africa – were included as comparatives, in addition to a North-Western USA outgroup. The closest affinity was highlighted. The columns were then arranged in decreasing order of affinity. The absence of comparative data for certain North African traits should be noted.

Trait	Canaries	W.Europe	W.Africa	N.Africa	NW USA
UI1_Wing	10.5	7	18	8	37
UI1_Shovel	28.1	2	8	8	88
UI1 D_Shovel	5.7	4	4	8	57
UI2 Int_Gr	19.4	42	10	32	68
UC Mesial Ridge	11.4	4	29	6	1
Odontome	0.6	0.5	0	0.3	7
UM1 Carabelli's	34.1	27	22	-	7
UM1 C5	24.8	12	62	18	21
UM1 Enamel Ext.	14.4	4	0	3	50
4-Cusped LM1	3.6	7.5	0	-	0
4-Cusped LM2	28	72	12	65	3
LM2 Y-Groove	25.2	28	32	30	12
LM1_C7	9	5	44	8	8
LM1 D_Wrink	34.4	5	17	8	37
LM1 DTC	1	6	0	4	8
3-Root UM2	93.2	58	82	78	44
2-Root LC	4.4	5.5	0	2.5	0
3-Root LM1	1.2	1.5	7	1.5	17

Table 6.4. General Comparisons of the Canaries and Africa/USA

These percentage values ally the Canaries with Western Europe (8/18), while affinities with North and West Africa were slightly weaker (6/18 and 5/18). This indicates either that the input of (North) Africans to ancient Canarians has been overestimated, or that the sampling is in some way non-representative (see above). While beguiling, these figures are at best crude regional approximations of genetic relationships in the Mediterranean Atlantic. As this avenue of research does not lie specifically within the remit of the current project, it is proffered solely as an avenue for further investigation of the issue. In order to understand the nature of Canarian populations, however, it is necessary to focus attention within the archipelago, and to consider the importance of temporal and spatial factors.

6.3 Population Biology Traits by Period and Island (Dental)

The data are arranged by tooth type or cranial region, and then tested by island and by chronological period. Each of the two larger, dated island samples (Gran Canaria and Tenerife) was tested for internal temporal variability. Chi Squared tests were carried out for all groupings in the sample. The results are presented in appendix 2, while summary data are presented in table 6.5 (dental traits; significantly variable results [P ≤ .05] have been highlighted).

Trait	Island	Period	GC/Period	Ten/Period
UI1_Wing	.231	.891	.515	.576
UI1_Shov	.477	.734	.564	-
UI1 D'Shov	.987	.364	.275	-
UI1 Lab_Con	.430	.652	.592	.248
UI2 Int'Gr	.569	.459	.379	.157
UI2 Form	.404	.651	.421	-
UI2 *T_D*	.333	.087	.065	.157
UC_MAR	**.005**	**.000**	-	**.028**
UC_DAR	.281	.397	.574	.490
UP1 Root	.240	.129	.652	.467
Odontome	.933	.116	.126	-
UM1 Carab	**.000**	**.006**	.306	.595
UM1 C5	.860	.195	.223	.905
UM1 En'Ext	.160	.344	.242	**.010**
UM2_C4	**.000**	.160	.733	.376
UM2 Root	.981	.430	.192	.712
UM3 P'style	.666	.137	.063	1.000
UM3 Agen.	.566	.758	.294	.573

Table 6.5. Chi-Squared Test Results for Dental Non-Metric Traits

Trait	Island	Period	GC/Period	Ten/Period
LC_Root	.775	.889	-	.808
LP2 L'Cusp	**.000**	**.002**	.697	.229
LM1 Cusp	.094	**.000**	**.000**	**.001**
LM1 A'fov	.379	**.002**	**.013**	**.007**
LM1_DW	.179	.100	.343	.325
LM1_DTC	.805	.876	.823	-
LM1_P'Lid	**.025**	.750	.467	.322
LM1 C7	.518	.441	.068	.740
LM1 Root	.140	.324	.855	.948
LM2 Cusp	.076	.211	.275	.572
LM2_G've	.289	.166	**.037**	.052
LM2 Root	.835	.370	.572	**.003**
Pal'Tor	.767	**.003**	**.002**	.547
Mand_Tor	.191	.128	.855	.502

Table 6.5. Contd.

6.4 Spatial Trends in the Canarian Sample – Dental Traits

Assessing the strength of links between pooled island samples provides a general measure of archipelago social networks and patterning. However, the potential for covering over potentially valuable temporally-induced trends within individual islands should also be considered (see below). Only 5/32 traits considered in this test demonstrated significant inter-island variability, and it is therefore evident that the islands were characterised by homogeneity rather than heterogeneity, and that the human groups thereupon probably emanated from the same general populational base complex. This is in accord with earlier work claiming that island populations were essentially unchanging across space (Guatelli Steinberg *et al.* 2001); the small proportion of spatially variable traits in the Canarian sample does not suggest the levels of variability seen in various NW African groups studied by Irish (2000) and Irish and Turner (1990), and it was therefore decided not to carry out MMD (Mean Measure of Divergence) tests, as these would inevitably support homogeneity for Canarian groups, and in any case regional comparisons of this sort lie outside the directives of this project's remit. However, it is important to assess directional trends in the data that may support transitions in population biology in order to determine whether there were any more subtle signs of population biology transitions as humans moved between islands, or between the archipelago and the mainland. The spatially variable traits are presented in figures 6.1 to 6.5.

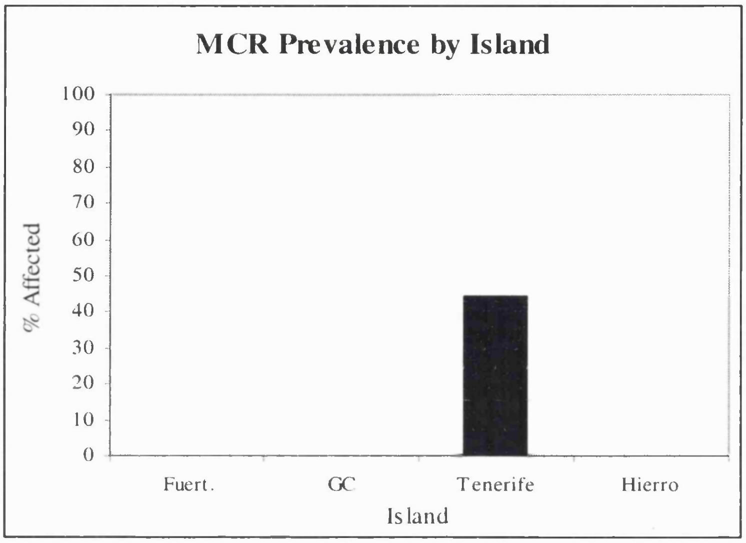

Figure 6.1. MCR Prevalence by Island

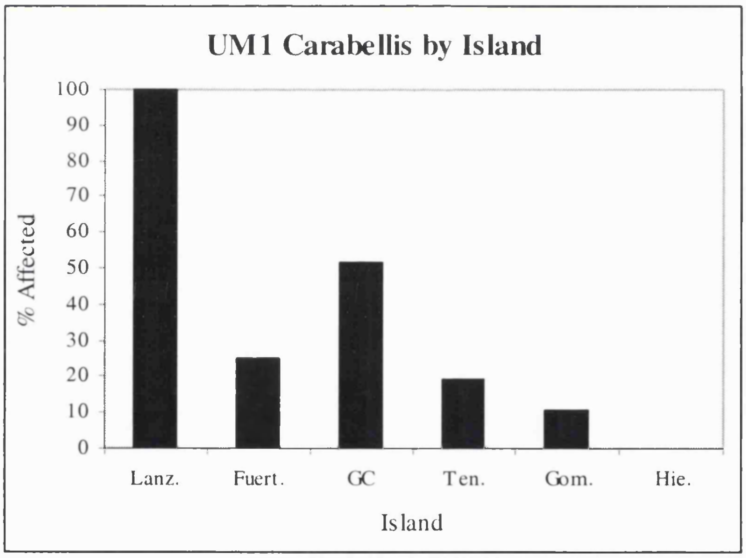

Figure 6.2. UM1 Carabelli's Prevalence by Island

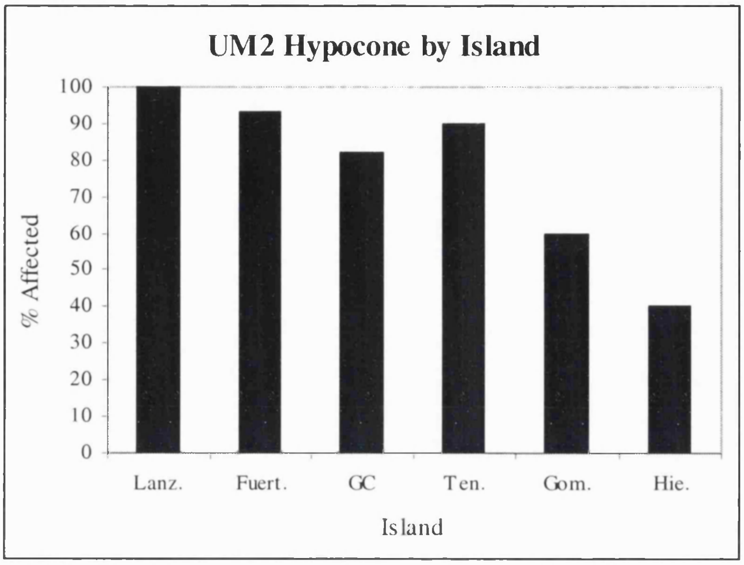

Figure 6.3. UM2 Hypocone Prevalence by Island

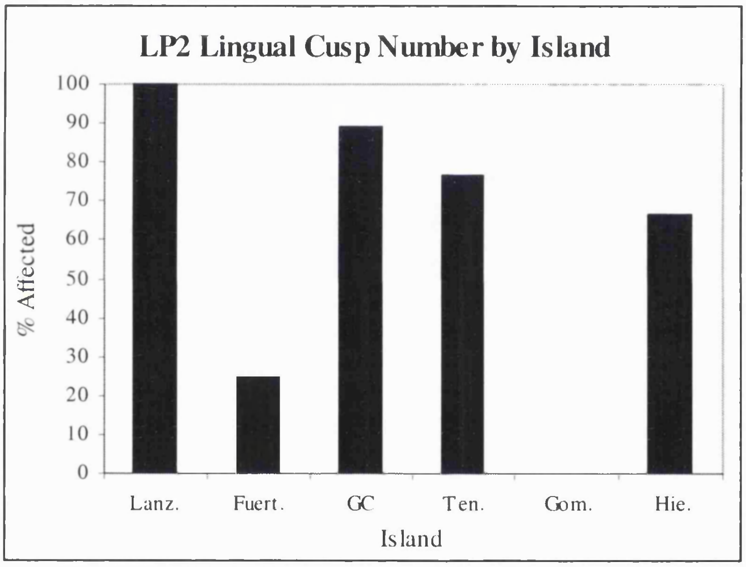

Figure 6.4. LP2 Lingual Cusp Number Prevalence by Island

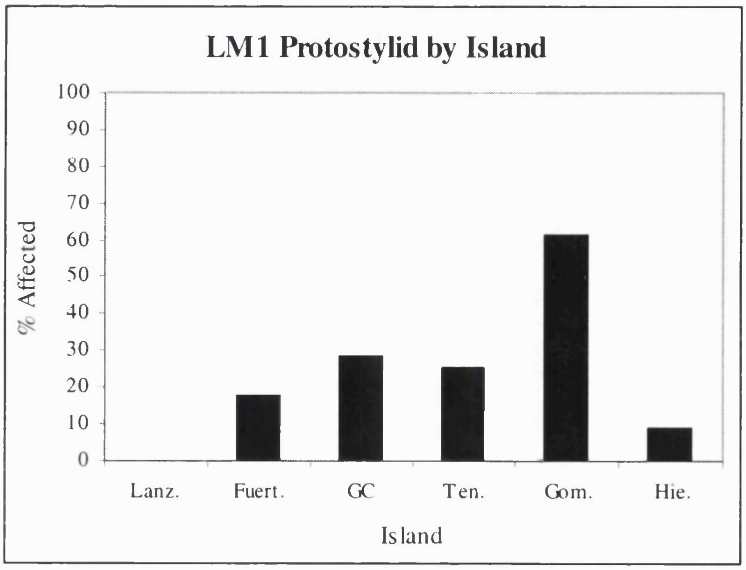

Figure 6.5. LM1 Protostylid Prevalence by Island

While Tenerife stood out as the only island with mesial canine ridges, spatial patterning was decidedly irregular. Gran Canarian prevalence of Carabelli's cusp was significantly higher than was expected under the null hypothesis, as was the Lanzarote count (but small samples). Gomera and Hierro stand out again in possessing a lower prevalence of UM2 hypocones when the counts were compared against the predicted model. LP2 lingual cusp prevalence peaks in Gran Canaria, standing out against the traits' low prevalence or absence in Gomera and Fuerteventura. Gomera was also notable in terms of high LM1 protostylid prevalence, compared to which the remaining islands were essentially homogeneous, fitting the null hypothesis model. Interpreting the implications of this patterning is fraught with difficulty as the temporal component of the study must also be considered.

6.5 Temporal Trends in the Canarian Sample – Dental Traits

As 26 of the 32 traits used in the analysis did not demonstrate any significant temporal flux, it is evident that the Canary Islands are relatively homogenous in terms of population stability along this particular part of the Canarian sequence (recent determinations of Canarian human occupation beyond 3000BC will force a rethink of the human timescale – see Zoller *et al* 2003). It is therefore evident that the same general population sources were responsible for island colonisation (i.e. NW Africa), although more comprehensive sampling of African populations is required before the specific geographical origin can be ascertained. In the context of the present project, the most important aspect of dental differentiation is the strength with which it reflects temporal demarcations in population biology in the islands. The fact that 6/32 traits displayed significant variability between periods indicates some temporal flux, genetic isolation or uneven (i.e. incomplete/partial) resettlement of the archipelago after the initial colonisation took place. The six significantly variable traits are represented graphically in figures 6.6 to 6.11. The implications of the temporal trend data is discussed further below.

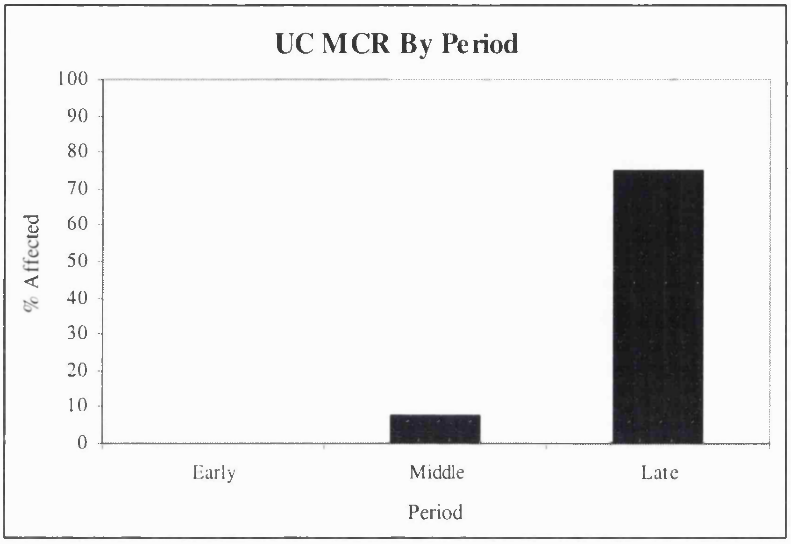

Figure 6.6. UC MCR Prevalence by Period

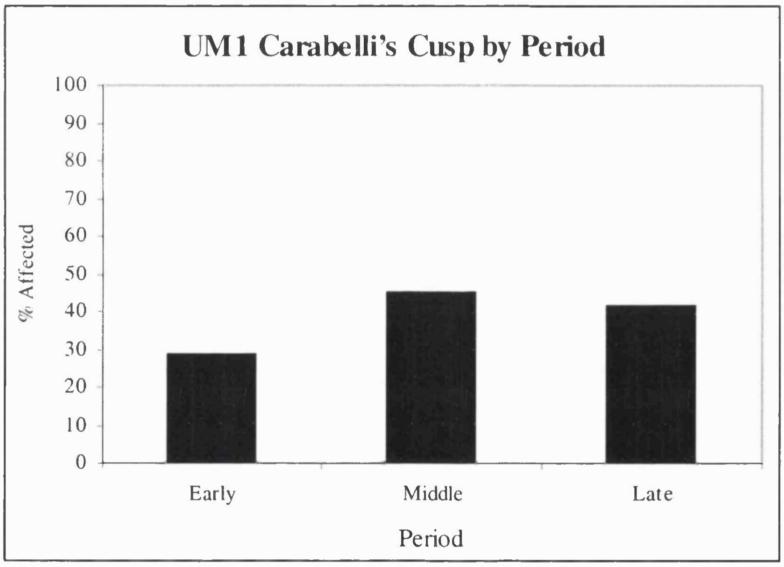

Figure 6.7. UM1 Carabelli's Cusp Prevalence by Period

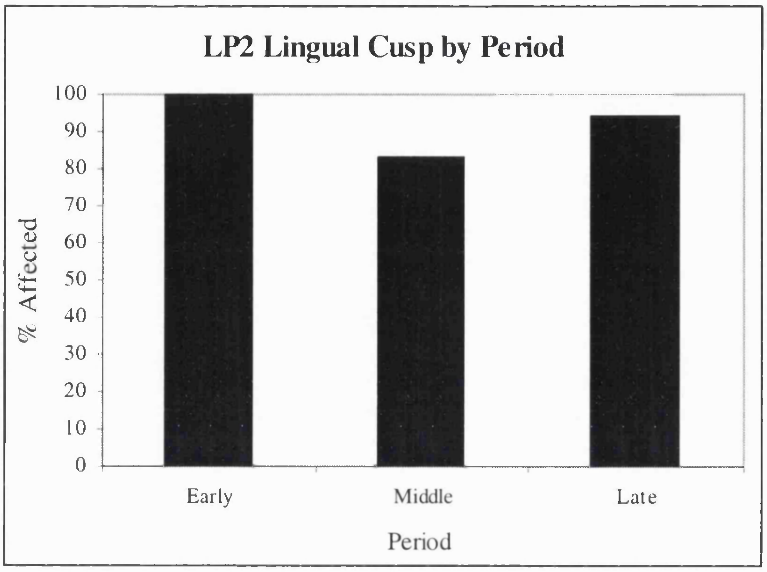

Figure 6.8. LP2 Lingual Cusp Number Prevalence by Period

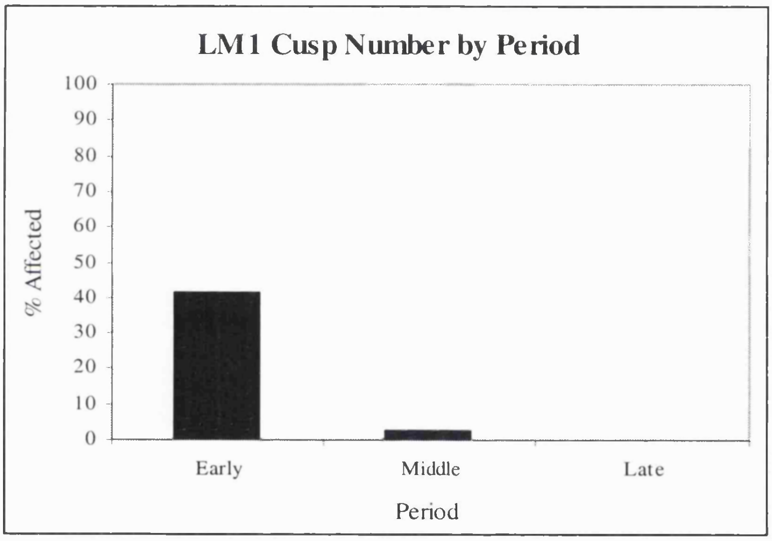

Figure 6.9. LM1 Cusp Number Prevalence by Period

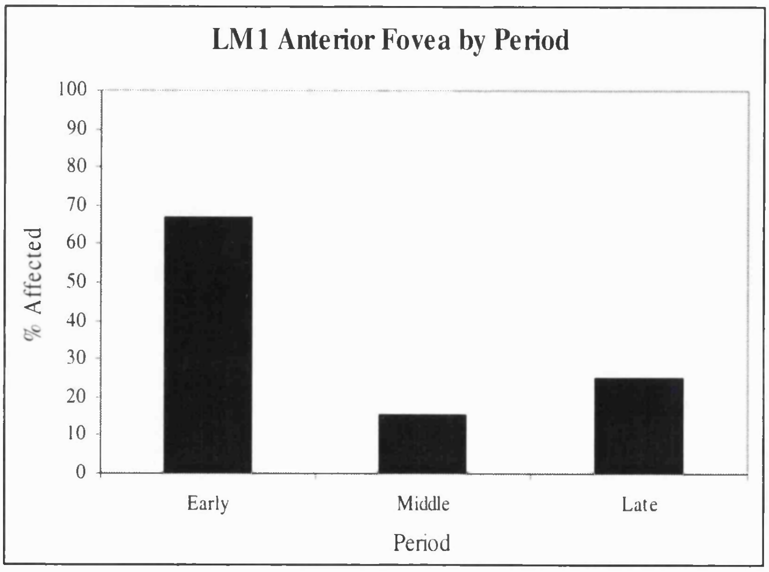

Figure 6.10. LM1 Anterior Fovea Prevalence by Period

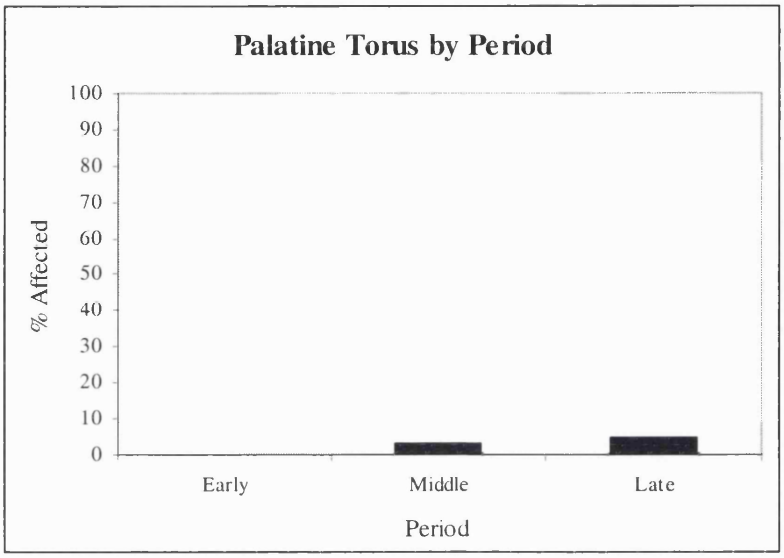

Figure 6.11. Palatine Torus Prevalence by Period

The sudden appearance of mesial canine ridges in the middle/late period (Tenerife only) marks a major discontinuity between the early and middle/late – and particularly between the early and late – period groups (P = .000). While this may hint at influence from Sub-Saharan groups at this date (Scott and Turner 1997: 190) the important aspect for the present study is the traits' abrupt appearance – and therefore some form of biological discontinuity – at some point after the archipelago's original colonisation. It should be considered, however, that the high wear levels in Canarian groups have reduced the total sample size available for this test. UM1 Carabelli's cusp was significantly more common in the middle and late periods than was expected under the constraints of the null hypothesis, exceeding the low prevalence in the early group (P = .006). This was accompanied by a commensurate rise in the prevalence of LP2 lingual cusps (P = .002) and a marked drop in LM1 cusp number (P = .000) and LM1 anterior fovea (P = .002). These trends are accompanied by the appearance of the palatine torus prevalence into the middle period group (absent in the early period), followed by a sharp rise into the late period sample (P = .003). The central trend as indicated by these figures is that there was a divide between the early and the middle periods, and this is in agreement with the archaeological data that indicate a proliferation of sites – and particularly large sites – in the middle period. While continuity is certainly supported by the preponderance of dental traits, there seems to have been some form of accompanying interruption to the genetic characteristics of the Canary Islanders. There were also some indications that while there were more general resemblances between the middle and late groups, the late sample – including traits such as the mesial canine ridge – was sometimes highly distinct from both earlier groups.

6.6 Gran Canaria and Tenerife Dental Morphology by Period

The nature of the dataset militates against comparisons of individual islands along chronological trajectories. Furthermore, as the previous section indicates, most of the variability in the archipelago appears to be from the larger islands to their smaller satellites. It was therefore decided to analyse the internal temporal variability of Gran Canaria and Tenerife – where samples were of reasonable size – and to see how this varied through time. Undated samples were not analysed. Chi-Squared tests were carried out as before, and the data are displayed in table 6.5. The islands are discussed separately in section 6.6.1 (Gran Canaria) and 6.6.2 (Tenerife).

6.6.1 Gran Canarian Internal Variability (Dental Traits)

Four of the 32 traits assessed demonstrated significant internal variability within the Gran Canarian sample. As before, consequently, there is no basis for postulating major populational changes in the island through time, although these minor deviations in the sequence may have implications for lower-level populational movements. The significantly variable traits are presented graphically in figures 6.12 to 6.15.

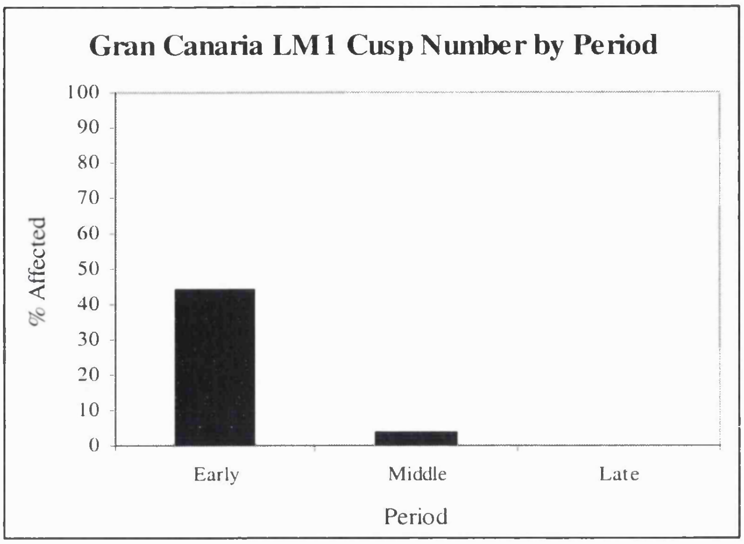

Figure 6.12. Gran Canarian LM1 Cusp Number Prevalence by Period

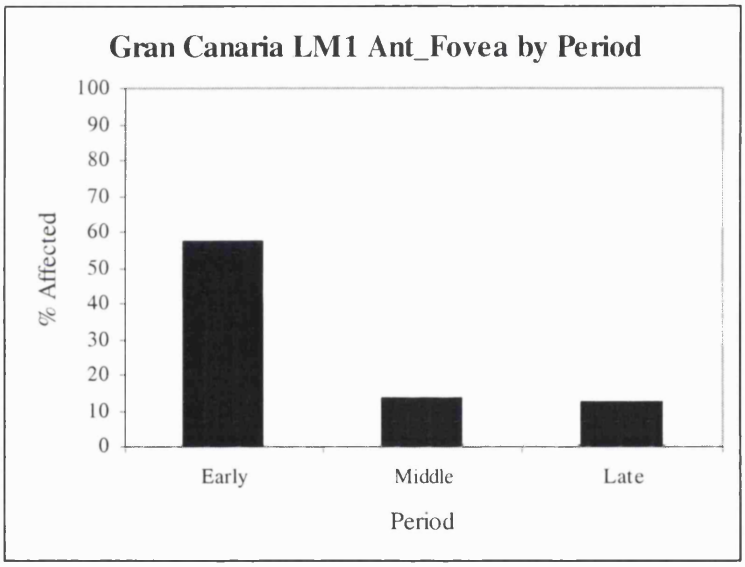

Figure 6.13. Gran Canarian Anterior Fovea Prevalence by Period

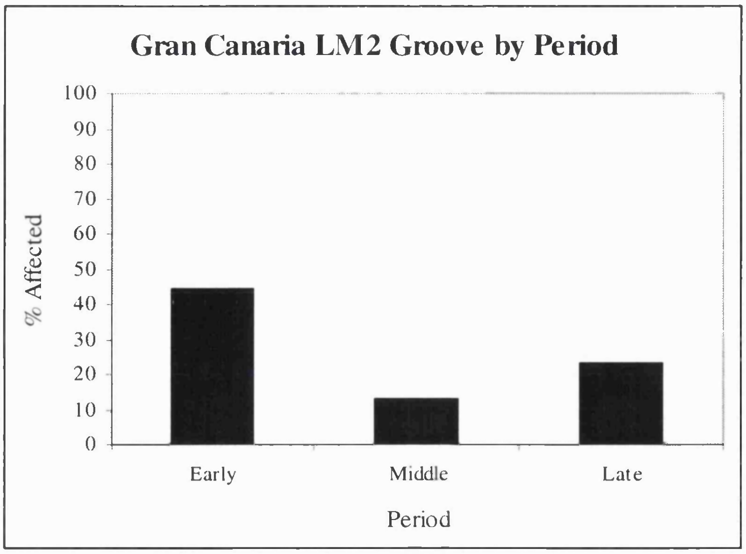

Figure 6.14. Gran Canarian LM2 Groove Pattern Prevalence by Period

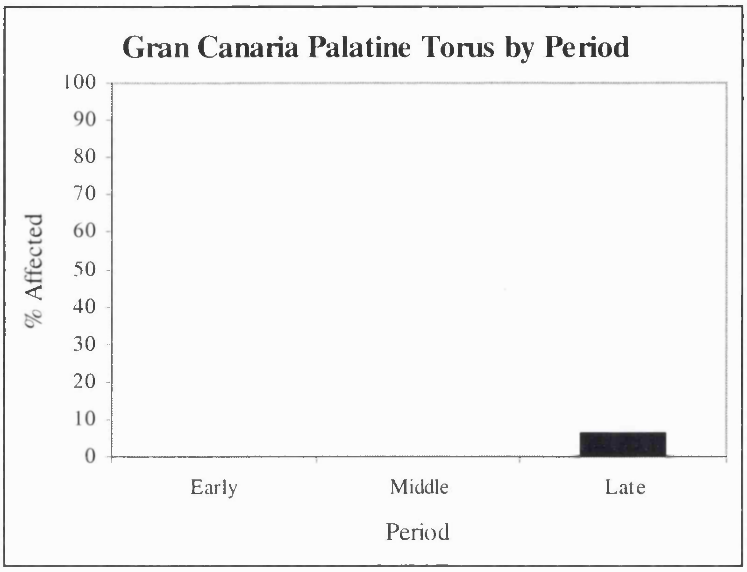

Figure 6.15. Gran Canarian Palatine Torus Prevalence by Period

Two of the five traits (LM1 cusp number; LM1 anterior fovea) were shared with both Tenerife/period and pooled islands/period. LM1 cusp number (P = .001), LM1 anterior fovea (P = .013) and LM2 groove pattern (P = .037) exceeded the null hypothesis prediction in the early sample, dropping off sharply into the middle and late groups. The palatine torus (P = .002) was absent in the early and middle groups, appearing suddenly in the late period sample. Except for the latter case, therefore, the middle and late periods were relatively homogenous, demarcating a departure from the population biology of the early period sample.

6.6.2 Tenerife Internal Variability (Dental Traits)

Five of the 32 traits assessed in the Tenerife sample yielded significantly variable Chi-Squared test results when considered by period, thus constituting another example of low-level variability through time as demonstrated for Gran Canaria (see above). As before, the significantly variable traits are presented graphically below (figures 6.16 to 6.20).

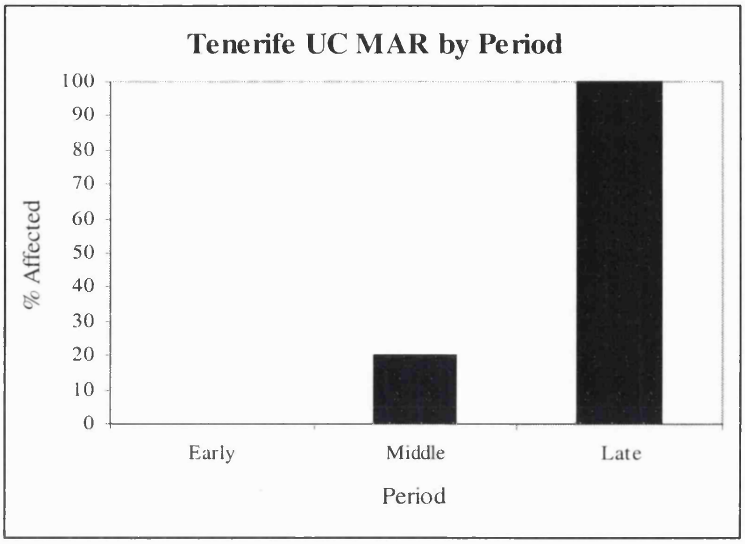

Figure 6.16. Tenerife UC MAR Prevalence by Period

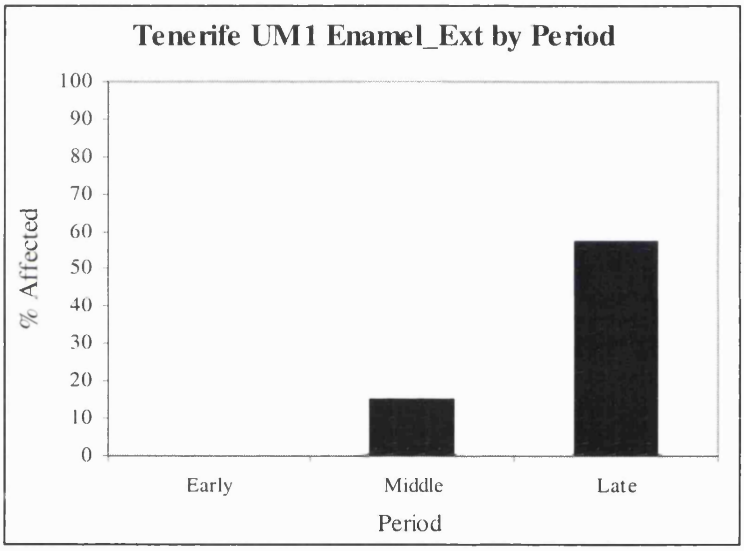

Figure 6.17. Tenerife UM1 Enamel Extension Prevalence by Period

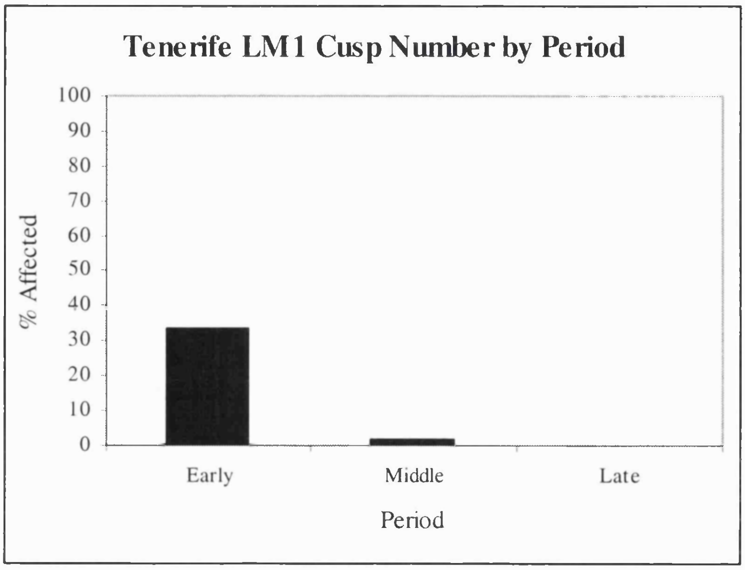

Figure 6.18. Tenerife LM1 Cusp Number Prevalence by Period

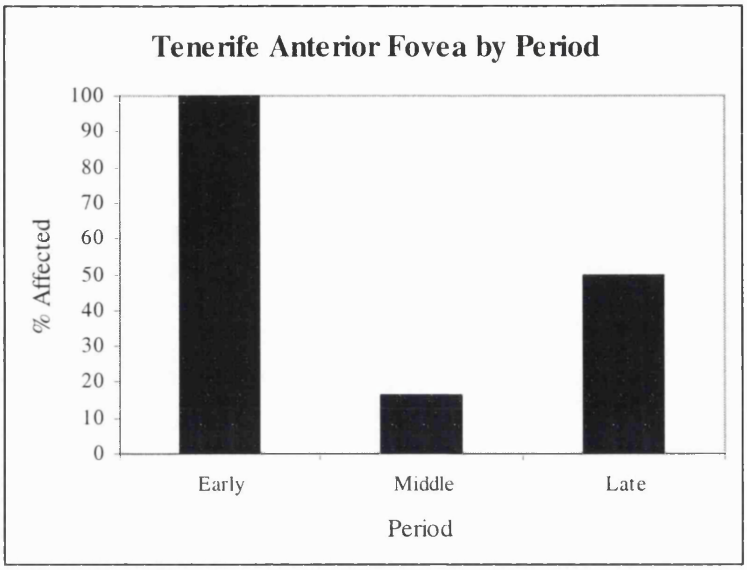

Figure 6.19 Tenerife LM1 Anterior Fovea Prevalence by Period

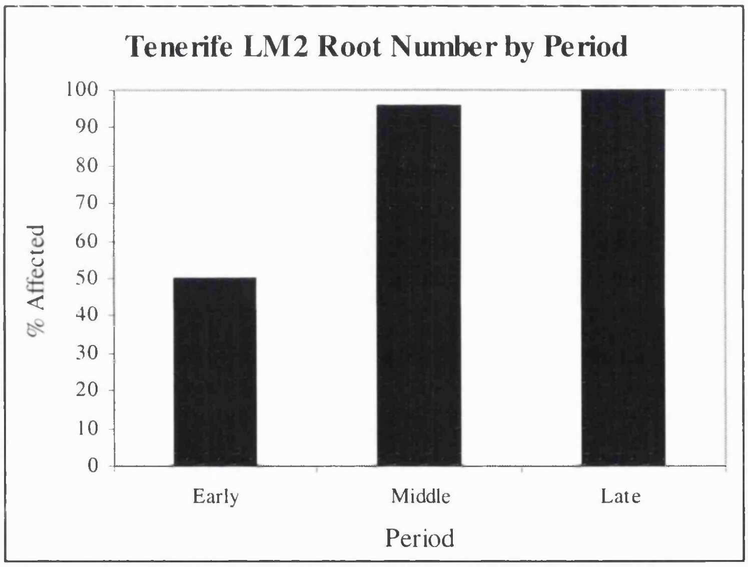

Figure 6.20 Tenerife LM2 Root Number Prevalence by Period

Tenerife's possession of UC MCR ('Bushman Canine'), which is unique in the archipelago, has already been covered above. Analysis of this trait's distribution therefore produced significant Chi-Squared test results for island and for period (see above), as well as for Tenerife's internal temporal variability (P = .028). This trait was prevalent in low numbers in the middle period and then much more so in the late period sample. UM1 enamel extensions (P = .010) follow a similar pattern, while LM1 cusp number (P = .001) and LM1 anterior fovea (P = .007) emulates the Gran Canarian sample by dropping in frequency from the early to the middle/late period groups. This indicates some discontinuity between the early and the middle/late groups, in addition to population biology changes from the middle to the late periods. The geographical specificity of one of these traits (UC MCR) poses a new set of challenges to dental anthropology studies of the ancient Canarians.

6.6.3 Tenerife and Gran Canaria – Summary

Of the 32 traits tested, only four were significantly variable on Gran Canaria and five on Tenerife. The fact that so few traits were affected (about 12-15% of the total trait suite) indicates that major genetic perturbations were not characteristic for these islands, or alternatively that influxes and inter-island movement has been disguised by the native populations' common genetic base area (i.e. NW Africa). The implications of these findings are discussed further below.

6.7 Cranial Non-Metric Variants and Profiles

Cranial non-metric traits were examined in order to ascertain whether they supported the dental evidence. Metopic suture and palatine/mandibular tori are standard traits with accepted scoring systems. The breakpoint in this case was 0/1 (mildest expression of the trait – see chapter 4 for further details). The ossicle traits scored are non-standard (see chapter 4). While the maxillary torus scoring system is duplicated from the dental study, the other traits have not previously been used to elucidate Canarian population biology. Breakpoints were created for all traits in order to facilitate analysis, as numerous variants were scored (for example, 19 cranial ossicle variants). Torus breakpoints were adapted (see chapter 4). All breakpoints are presented in table 6.6.

Trait	Subsumed Codes
Mandibular Torus	1, 2, 3
Maxillary Torus	1, 2, 3, 4
Bregmatic Ossicle	1, 15, 16
Lambda Ossicle	2, 7, 8, 10, 11
Lambdoid Ossicles	4, 5, 6,
Sagittal Ossicles	12, 14
Metopic Suture	1, 2

Table 6.6 Breakpoints for Cranial Traits

Ossicle breakpoints were altered to facilitate analysis between 'absence' (total absence, the presence of lambdoid bones, sagittal bones and coronal bones) and 'presence' (presence of bregmatic and lambda ossicles). As with the ASUDAS, sex was not deemed to be a significant factor. Age was considered insofar that very young individuals display high visibility of sutural characteristics, while cranial synostosis may obliterate sutural variants. Very old individuals – where the sutures could not be seen – were therefore excluded, as were any individuals where weathering or cranial trauma had impaired clarity. Very young individuals (ageclass 1) were also excluded, as the *Sutura interfrontalis* may not normally close until the eighth year of life (Buikstra and Ubelaker 1994: 87). Chi-Squared tests were carried out on the cranial data in the same manner as the dental data (see above). The traits were all examined to profile the archipelago, with all islands and periods combined in order to provide a crude measure of trait prevalence.

Trait	% Value	Sample
Mandibular Torus	15.2	95/626
Maxillary Torus	21.2	106/500
Metopic Suture	43.8	216/493
Bregmatic Ossicle	0.4	2/483
Lambda Ossicle	20.3	98/483
Lambdoid Ossicles	20.3	98/483
Sagittal Ossicles	1.9	9/483

Table 6.7 Basic Cranial Trait Data for the Canaries

Metopism was the most common trait for the group as a whole (43.8%), followed by mild forms of maxillary tori (21.2%) and lambdoid and lambda sutural bones (both 20.3%). The rarest traits were bregmatic ossicles (0.4%) and sagittal suture ossicles (1.9%).

6.7.1 Spatial Trends (Cranial Traits)

Simple comparisons of inter-insular cranial variant prevalence were carried out, in order to identify general spatial trends in the archipelago. Percentage and sample size figures are presented for each island in table 6.8 (tori and metopism) and 6.9 (ossicles). Bar charts are not shown.

Island	M_TOR	N	P_TOR	N	METOP	N
Lanzarote	42.9	3/7	0	0/1	50.0	5/10
Fuerteventura	9.1	1/11	0	0/20	63.2	12/19
Gran Canaria	15.5	27/174	17.3	38/220	55.2	122/221
Tenerife	16.8	63/375	33.8	47/139	42.6	55/129
Gomera	4.0	1/25	34.3	12/35	18.9	7/37
La Palma	0	0/1	12.5	1/8	0	0/1
Hierro	0	0/33	10.3	8/78	19.7	15/76
Total	15.2	95/626	21.2	106/500	43.8	216/493

Table 6.8 Prevalence of Tori and Metopism by Island

Island	Bregma	N	Lambda	N	Lambdoid	N	Sagittal	N
Lanzarote	0	0/17	22.2	4/17	11.1	2/17	0	0/17
Fuerteventura	0	0/30	23.5	7/30	17.6	5/30	5.9	2/30
Gran Canaria	0.5	2/385	20.9	80/385	15.8	61/385	2.8	11/385
Tenerife	0.8	2/220	27.7	61/220	25	55/220	0.8	2/220
Gomera	0	0/66	18.9	12/66	29.7	20/66	0	0/66
La Palma	0	0/2	100.0	2/2	0	0/2	0	0/2
Hierro	0	0/133	13.2	18/133	22.4	30/133	1.3	2/133
Total	0.4	3/850	20.3	173/850	20.3	173/850	1.9	16/850

Table 6.9 Prevalence of Ossicles by Island

6.7.2 General Data – Temporal Trends (Cranial Traits)

The island comparisons were then subdivided by period, in order to identify temporal trends in cranial non-metric trait distribution. The simple trends – based on 2894 observations – are presented in table 6.10 and figure 6.21.

Trait	Unknown	Early	Middle	Late	N
Mandibular Torus	2.2	10.5	18.6	11.3	626
Palatine Torus	14.8	7.7	23	40.5	500
Metopic Suture	29.3	59.3	49.1	51.3	493
Bregmatic Ossicle	0	0	0	5.3	269
Lambda Ossicle	24.3	27.3	27	35.7	365
Lambdoid Ossicles	28.2	20	24.7	40	365
Sagittal Ossicles	2.3	0	3.9	5.3	276

Table 6.10 Cranial Non-Metric Trends by Period: Basic Data

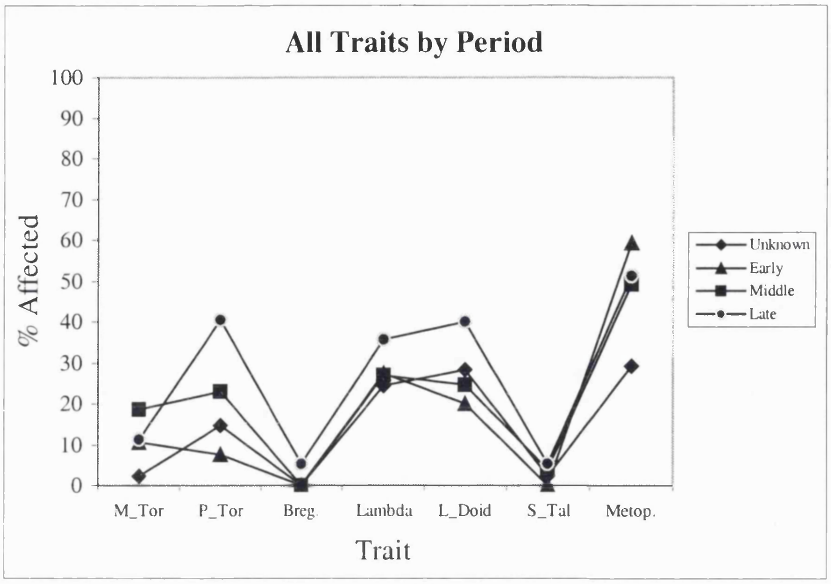

Figure 6.21 Cranial Non-Metric Trends by Period

The most striking point that can be observed from the chronometric data is the relative consistency of profiles through time. In all cases, the most distinctive period (as decreed by extent of deviation from the other period profile lines) is the late period group. Palatine tori and metopism appear to be the most variably-occurring traits. The significance of this variability is addressed further below.

6.7.3 Statistical Analysis of Spatial Distribution (Cranial Traits)

As before, Chi-Squared tests were carried out on the spatial data in order to assess the nature and strength of links between islands. The statistical workings are presented in appendix 2. In order to facilitate the analysis, the ossicle data were reworked to produce a present/absence dichotomy on the bregmatic ossicle, as this feature was common, easily visible and typically unaffected by taphonomic pressures. This was repeated for sections 6.7.4-6.7.8. The spatial, temporal and single-island data are all presented in table 6.11. Significantly variable traits have been highlighted.

Trait	Island	Period	GC/Period	Ten/Period
Mandibular Torus	**.032**	.215	**.049**	**.005**
Palatine Torus	**.000**	**.006**	**.014**	.692
Cranial Ossicle	.295	.738	.395	1.000
Metopism	**.000**	.607	.891	.526

Table 6.11. Chi-Squared Test Results for Spatial Distribution of Cranial Traits

Of the four traits examined, three (mandibular torus, palatine torus and metopism) were significantly variable when considered by island. The percentage figures for the significantly variable traits are presented graphically in figures 6.22 to 6.24.

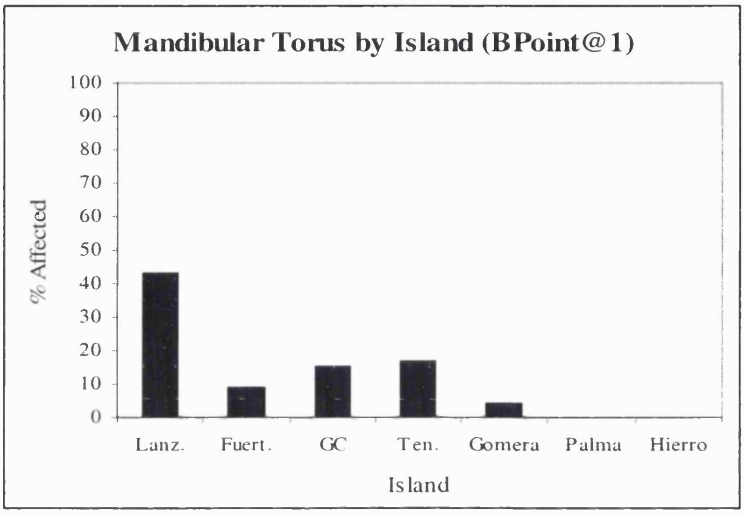

Figure 6.22. Spatial Distribution of Mandibular Torus

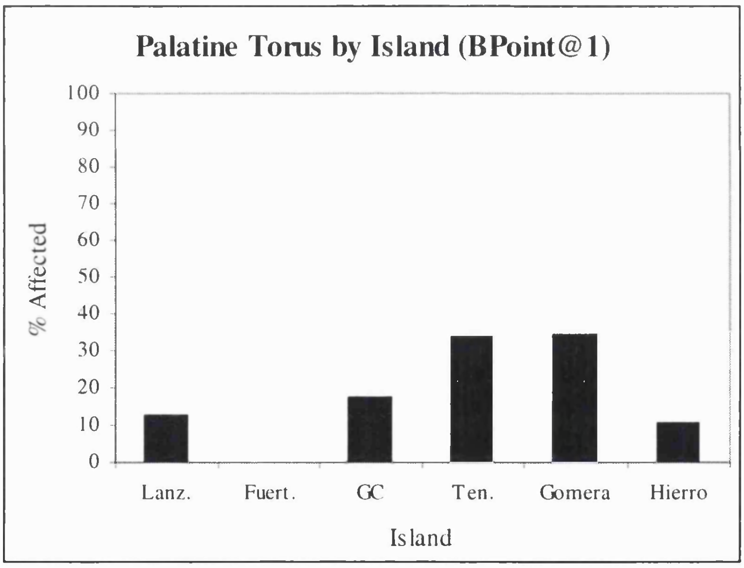

Figure 6.23. Spatial Distribution of Palatine Torus

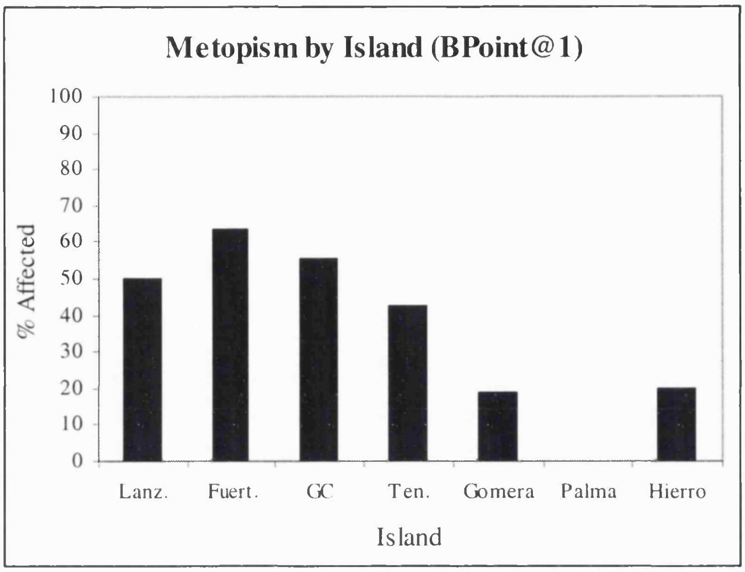

Figure 6.24. Spatial Distribution of Metopism

Spatial patterns of cranial trait distribution were highly irregular. Mandibular torus variability (P = .032) was attributable to Lanzarote and Tenerife's high prevalence of the trait, and its low prevalence or absence in all other islands. Palatine tori (P = .000) were common on the adjacent islands of Gomera and Tenerife, where the count exceeded that predicted by the null hypothesis. All other islands dropped below their predicted figures. Metopism (P = .000) was especially common in the eastern islands (including Gran Canaria) and tailed off towards the west, and is thus essentially similar to the mandibular torus results and an antimere of the palatine torus profile. In general terms, the central islands of the archipelago resemble one another, while the peripheral islands are more variable in their population biology profiles. As before, there were no major, strong directional trends indicating large-scale population changes or movements, further suggesting that the populations were relatively homogeneous. However, the relevance of this variability cannot be fully addressed without reference to the temporal data (see below).

6.7.4 Statistical Analysis of Temporal Distribution (Cranial Traits)

As before, Chi-Squared tests were carried out on the temporal data in order to assess the nature and strength of links between periods. The statistical workings are presented in appendix 2.

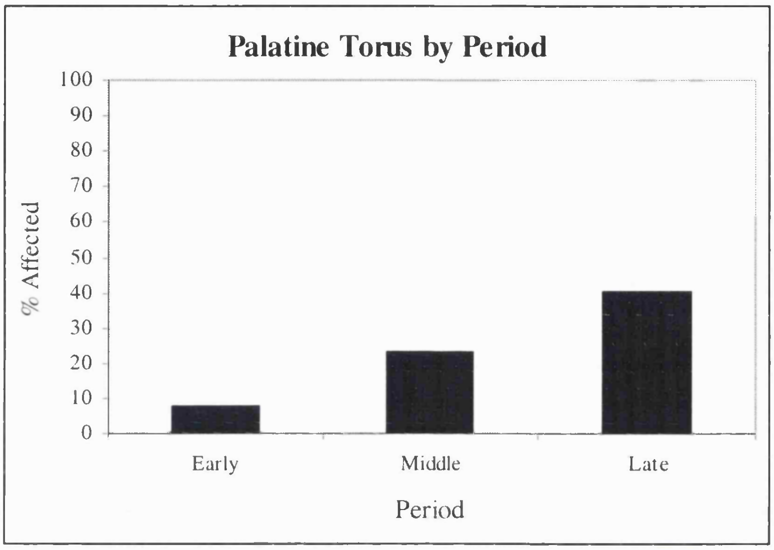

Figure 6.25. Palatine Torus Prevalence by Period

Only one trait – palatine torus – demonstrated any temporal variability when the islands were pooled (P = .006). The major transition is between the early and the middle/late periods, which sees a steady increase in the prevalence of the trait, which exceeds that predicted by the null hypothesis.

6.7.5 Single Island Statistical Analyses by Period (Cranial Traits)

Chi-Squared tests were carried out on the Gran Canarian and Tenerife data in order to assess the nature and extent of temporal flux in population biology within single islands with respectably-sized samples. The statistical workings are presented in appendix 2.

6.7.5.1 Gran Canaria by Period (Cranial Traits)

Two of the four traits tested – mandibular torus (P = .049) and palatine torus (P = .014) varied significantly between periods within the Gran Canarian sample. The data have already been presented (see also appendix 2), and are shown graphically in figures 6.26 and 6.27.

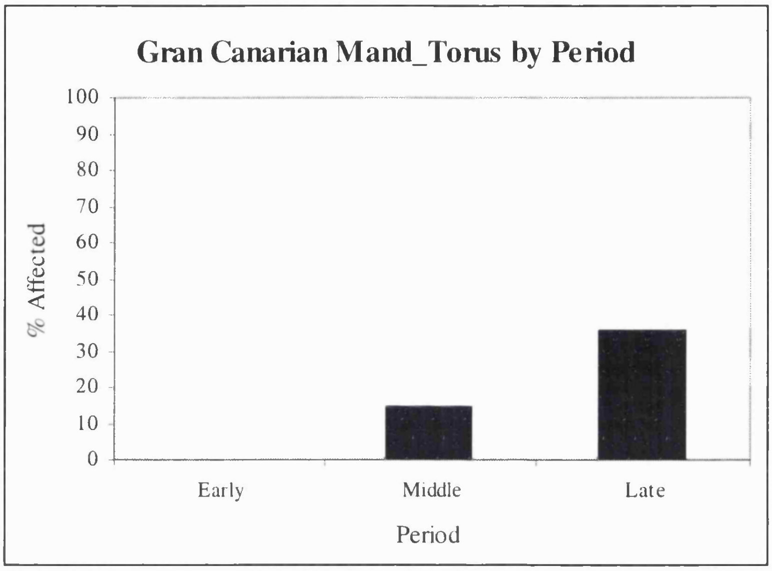

Figure 6.26. Gran Canaria Mandibular Torus Prevalence by Period

Mandibular tori was absent in the early group, first appearing in the middle period then increasing markedly into the late period sample. Palatine torus prevalence increased through time, also with a marked peak in the late period group.

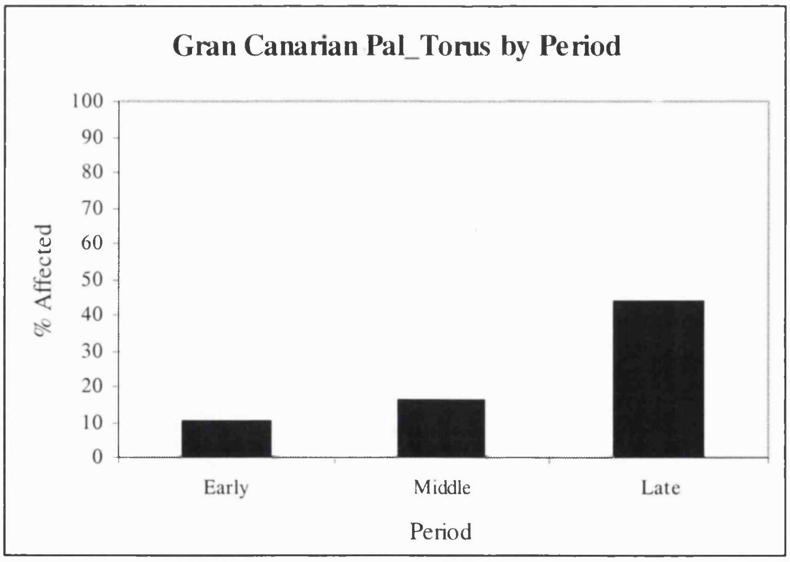

Figure 6.27. Gran Canaria Palatine Torus Prevalence by Period

In both cases, however, the main differences occurred between the middle and the late period samples, perhaps indicating some population biology discontinuity in the centuries directly prior to the European invasion.

6.7.5.2 Tenerife by Period (Cranial Traits)

Mandibular tori showed significant variability in the Tenerife sample (P = .005), with a sharp peak of prevalence – considerably exceeding the constraints of the null hypothesis – in the middle period sample when compared to the early and late periods.

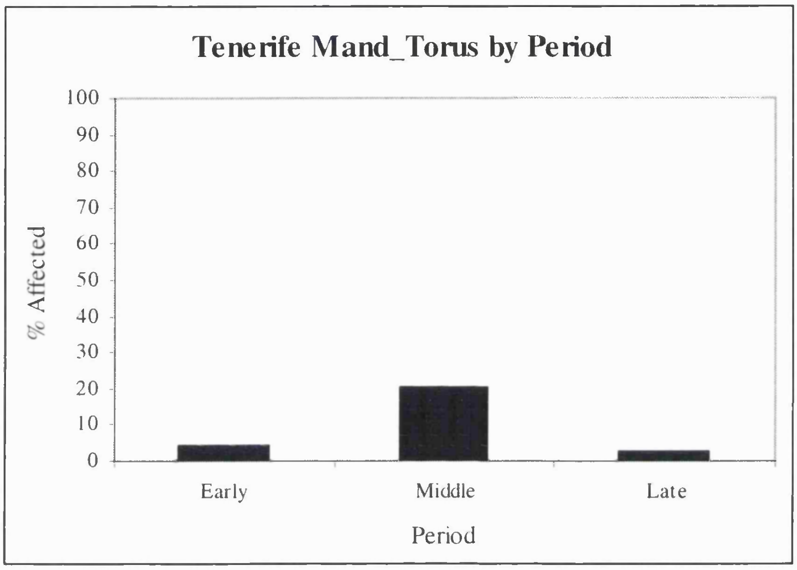

Figure 6.28. Gran Canaria Palatine Torus Prevalence by Period

This is in accord with dental evidence indicating an early/middle period discontinuity – particularly the mesial canine ridge ('Bushman Canine'[see above]) – but is unusual in being a single peak with no particular similarity with earlier or later groups.

6.7.6 Summary

In all, the Canarian dental and cranial evidence suggest homogeneity of the populations through time, but with minor variations suggestive of population discontinuity that was probably related to low-level immigration into the archipelago in the middle and late periods. The external source is proposed mainly on the basis of the MCR data, as most of the inter-island data (although the scarcity of eastern and western samples, especially those with dates, imperils the strength of these conclusions) demonstrates low variability levels overall. That said, there are some indications for regionalisation within the archipelago, although the trends are not particularly strong. If the islands had been isolates throughout their history (i.e. from first colonisation onwards) one would have expected to see higher levels of internal heterogeneity in the archipelago, as island groups were squeezed into genetic bottlenecks. In the event, however, the fact that there were few differences in the groups goes against the assertion that the islands saw a single colonisation (Guatelli Steinberg *et al.* 2001) or that, once colonised, the islands were completely cut off from one another in the traditional 'island laboratories' manner (Evans 1973). It seems likely that the island populations were biologically, and therefore socially, connected throughout at least some of their history, and that the genetic data therefore suggest a relatively homogenous population that must have used watercraft to travel between islands with relative frequency.

6.7.7 Postscript

Since completion of this thesis, basic MMD tests were carried out in the dental morphology data. Although these findings are preliminary and subject to change, it would appear that the western islands are the most unusual of the group, while the rest of the archipelago is fairly homogenous. It is possible that this is an expression of some double-wave colonisation process in which the first group settled across the islands, while the second did not reach the end of the archipelago. This may in turn be the cause of the highly unusual material culture in the islands of Hierro, Gomera and La Palma, as evidence of their longer 'isolation' and cultural evolution. At the time of writing, these results were being processed for publication.

7 – Caries

The caries data were assessed in a number of ways, using criteria defined in earlier chapters. The first consideration was age, as caries prevalence is age-reliant and therefore cannot be assessed without reference to this factor. The teeth were grouped (according to their morphology and age at eruption) and the ageclasses merged (see chapter 4), in order to provide a more general measure of cariogenic profiles in the populations under assessment, and also to increase sample size and thus strengthen any assertions made on the basis of the results. The divisions are upper anterior, lower anterior, upper premolars and lower premolars; each molar, both upper and lower, was considered separately. Ageclasses 3 (unaged subadult) and 8 (unaged adult) were removed, and ageclasses 1+2 (subadults), 4 (young adults), 5 (older adults) and 6+7 (mature/old) were combined. Sex, period and island data were all considered, in addition to regional subdivisions of the archipelago as proposed in chapter 2.

Chi-Squared tests (CSTs) were carried out on the caries data, to detect the essential trends of the sample where applicable. Much of the data is also presented graphically as percentage or standard prevalence figures. While summaries of the data are presented in the text, the full workings are presented in appendix 3.

All forms of lesions described in Hillson's (2001) research were detected, to a greater or lesser extent, in the Canarian sample. In general terms (but see below for further details) wear was high, thus preventing extensive caritic infestation of the occlusal surfaces. Where present, these lesions were most common in young adults (in whom the occlusal surface detail had not yet been worn away) in Gran Canaria, Tenerife and Gomera (see plate 7.1, below).

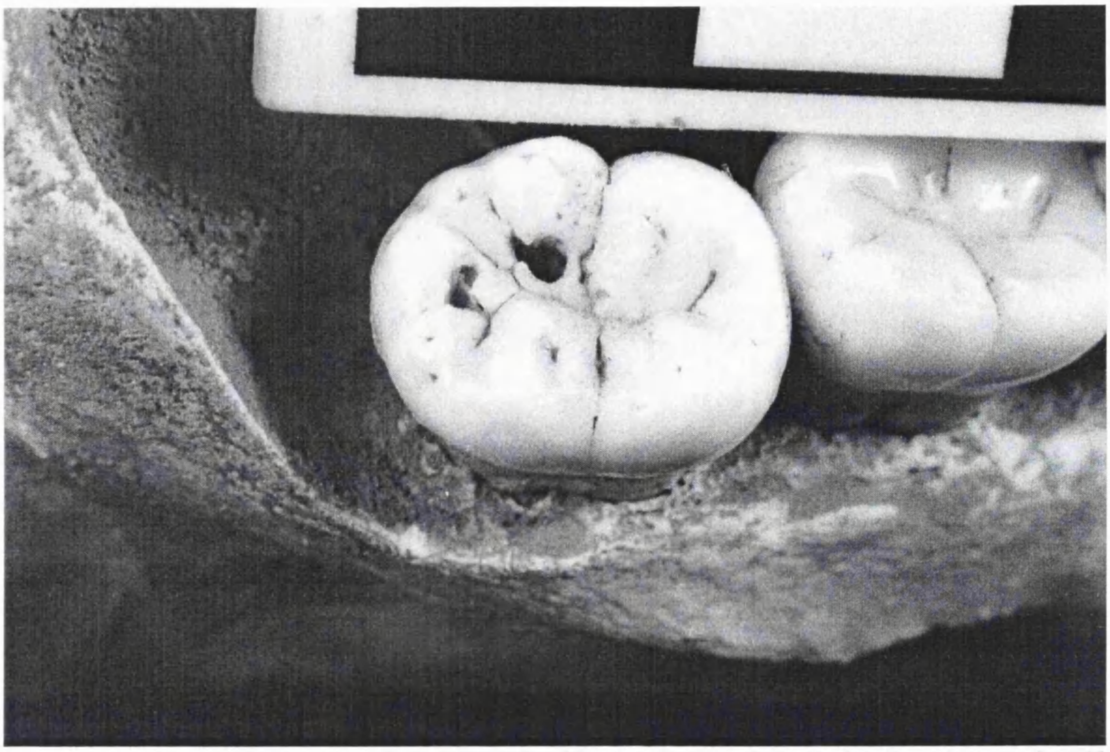

Plate 7.1. Lower Left M3 Occlusal Surface Caries; Young Adult from Gomera (MDH)

Older specimens exhibited often extreme forms of wear, which exposed the pulp cavities and led to occlusal dentine facet caries (plate 7.2). The other major form of caries in the Canarian sample, contact point caries (plate 7.3), was therefore primarily restricted to younger individuals and those with less marked wear.

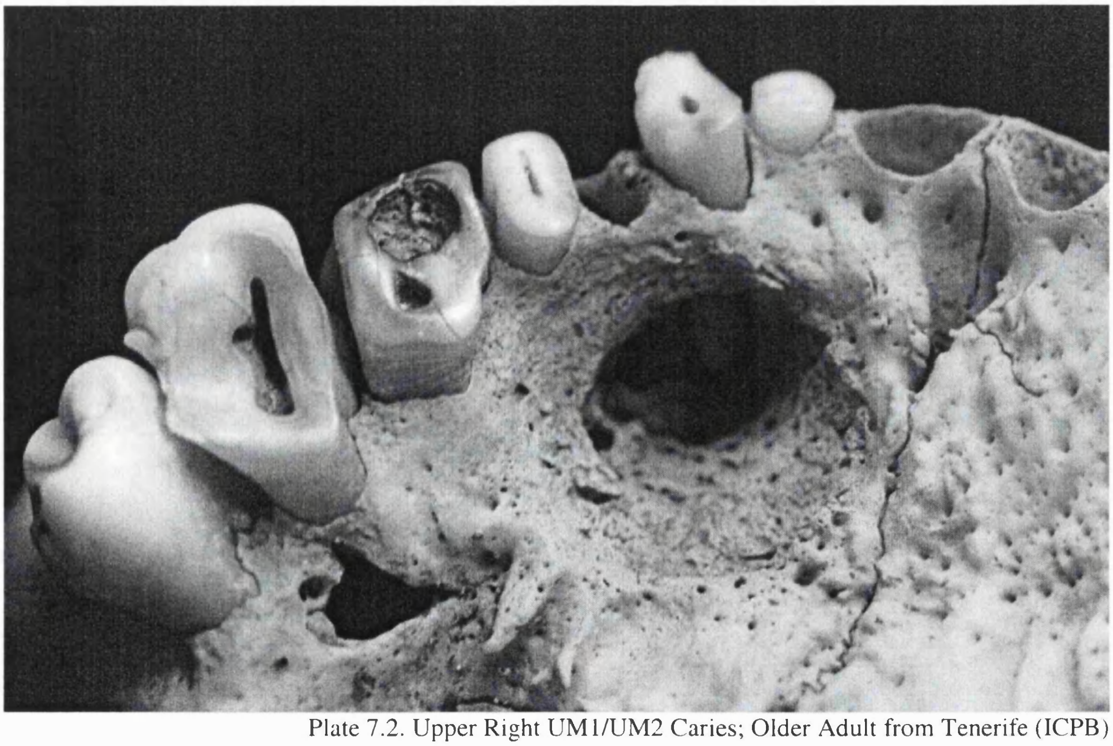

Plate 7.2. Upper Right UM1/UM2 Caries; Older Adult from Tenerife (ICPB)

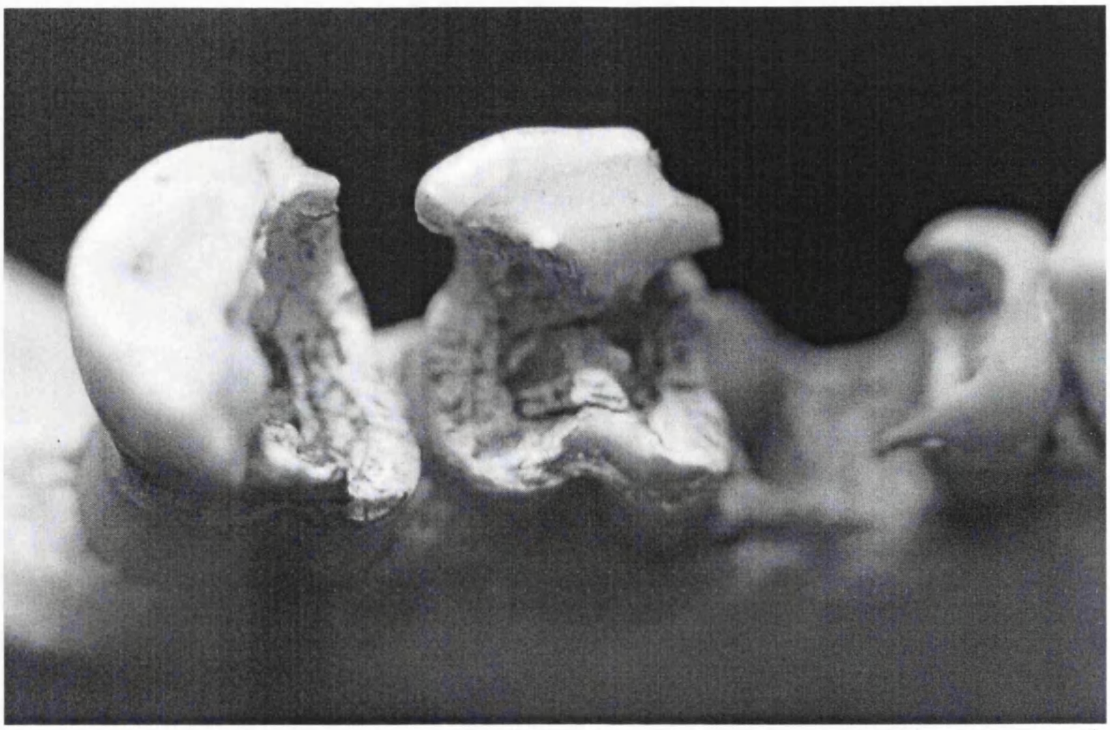

Plate 7.3. Multiple Lower Molar Caries; Older Adult, Tenerife

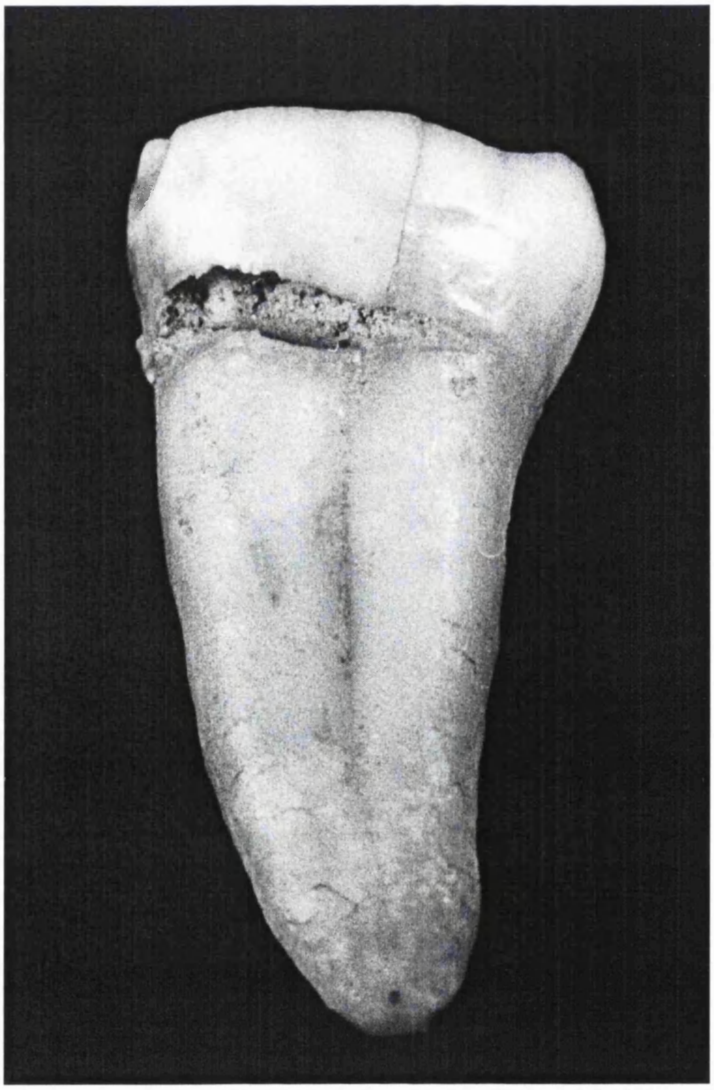

Plate 7.4. Root Surface Caries, Young Adult Upper Premolar (Gomera)

The final main caries category concerned the tooth roots, particularly the approximal (mesial and distal) surfaces, and were particularly associated with elevated wear levels. Plate 7.4 illustrates a fairly typical young adult example; older specimens typically possessed larger lesions that sometimes incorporated the CEJ and the contact points.

7.1 Basic Ageclass Trends – Pooled Teeth

Firstly, the ageclass categories were tested in order to establish whether there was any trend in terms of caries (all forms) prevalence with increasing age when all the teeth were pooled. The "all_car" variable was used, based on a simple presence/absence of carious lesions per tooth, regardless of location or extent of penetration. This serves as a general measure of caries prevalence, as a background for more complex, site-specific tests. While Hillson (2001) has pointed out that affected/unaffected dichotomies for caries studies, whether tooth specific or not, are of limited use for establishing dietary traditions, simple figures of this sort make the Canarian sample comparable with extant studies in a wider context (i.e. Larsen 1997: Langsjoen 1992; Delgado Darias 2001 etc).

The preliminary test confirmed a very strong relationship between increasing age and basic caries prevalence (P = .000) when all tooth types were pooled. Caries affected 9.4% of the subadult group, 24% of the young adults, 26.5% of the older adults and 18.8% of the mature/old group. This latter drop in prevalence figures reflects the high levels of tooth loss – and also the loss of caries 'sites' through pronounced levels of wear – that characterise most Canarian populations.

The caries trend data, as maxillary and mandibular dentitions, are presented in figures 7.1 and 7.2.

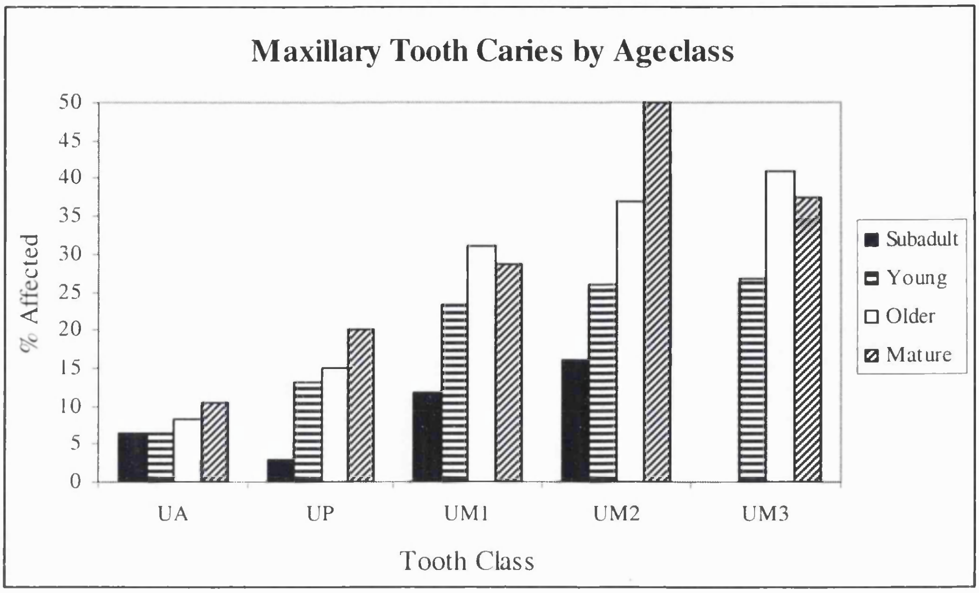

Figure 7.1. Maxillary Caries by Toothclass and Ageclass

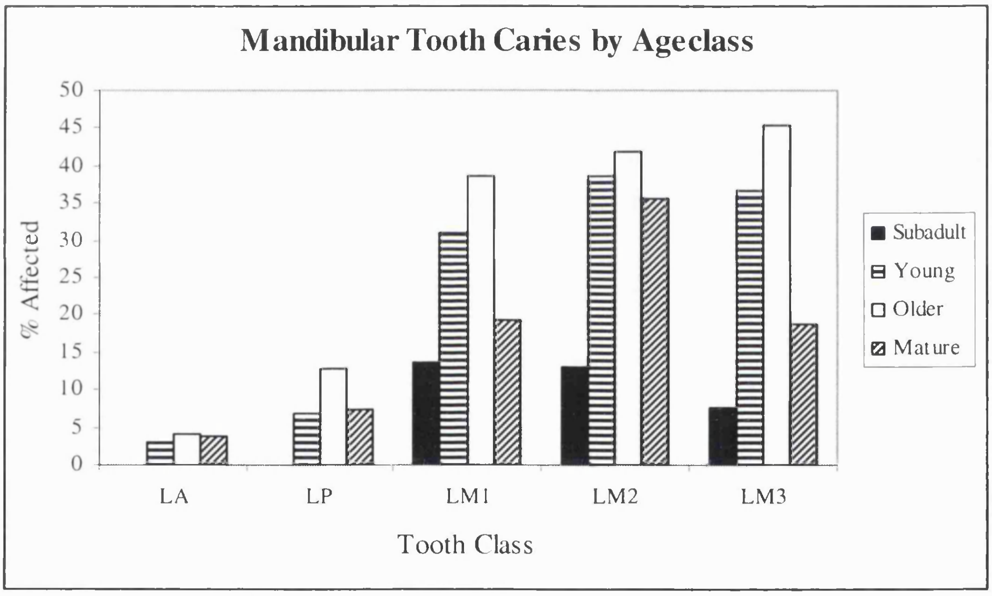

Figure 7.2. Mandibular Caries by Toothclass and Ageclass

These data were reconfigured to demonstrate the extent of penetration of the tooth by the carious process, and are presented in figures 7.3 (maxillary) and 7.4 (mandibular). So far individuals or caries sites have been profiled, regardless of affliction severity (penetration). This analysis groups the various sites as follows: occlusal surface; occlusal dentine; smooth surface; contact points; contact roots; buccolingual roots. These groupings are based upon caries prevalence similarities, so sites that differ widely in terms of caries prevalence were not grouped together. 'Penetration' was determined by whether the lesion had affected the enamel, the dentine or the pulp. Codes were adapted in Excel before being transferred into SPSS.

Sites	Enamel	Dentine	Pulp
Occlusal Surface	1; 2; 3	5; 7	6; 8
Pit Sites	1; 2; 3	5; 7	6; 8
Occlusal Dentine	-	4; 5	6 •
Smooth Surface	1; 2; 3;	5; 7	6; 8
Contact Points	1; 2; 3	4; 5; 7	6; 8
Contact Roots	-	1; 5; 7	6; 8
Buccolingual Roots	-	1; 5; 7	6; 8

Table 7.1. Penetration Caries System

- An '8' code denotes an exposed pulp chamber unaffected by caries.

Please note that these figures are intended to provide a general summary of dental caries in the sample. The exact figures upon which they are based are presented in tabular format in sections 7.2-7.5.

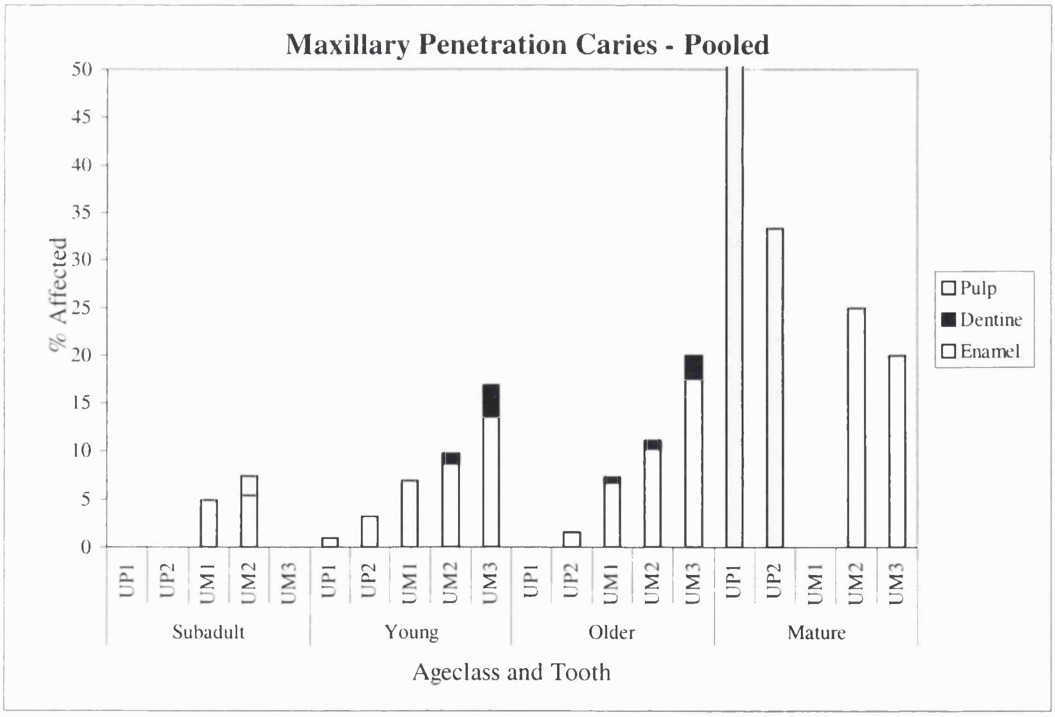

Figure 7.3. Maxillary OSC Caries by Toothclass and Ageclass

Subadult postcanine occlusal surface caries was limited to UM1-2, and LM1-2-3 (figure 7.3). Cases were most common in the enamel (4%), followed by the pulp (.9%) and dentine (.3%). The enamel breakdown was: UM1 4.9%; UM2 5.4%; LM1 3.4%; LM2 7.4%; LM3 3.8%, with 1.9% of LM2's affected by dentine caries. A single case of pulp caries was noted for UM2. All postcanine teeth except for LP1 were affected by caries in the young adult category, which also sees a decrease in penetration from enamel to pulp (10.1%-0.9%-0.5%). UM2 (8.7%), UM3 (13.5%), LM2 (15.8%) and LM3 (17.5%) were the most commonly affected by enamel caries, while all lower molars (0.2%; 1.1%; 2.2%) and UM2-3 (1.0%; 3.4%) were affected by dentine caries.

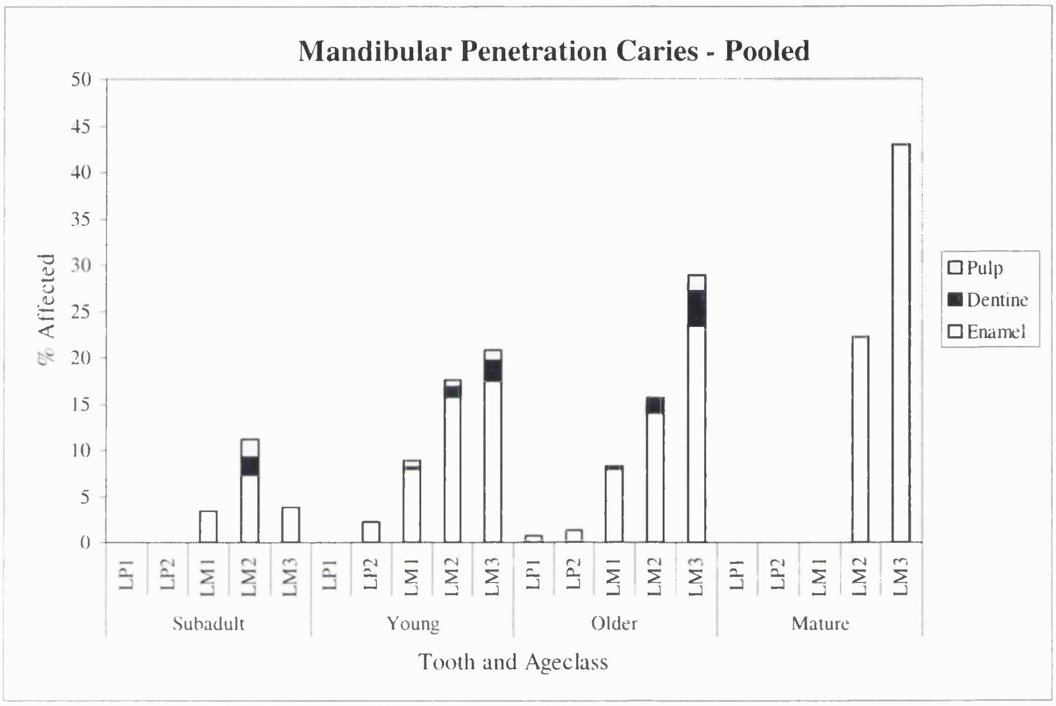

Figure 7.4. Mandibular OSC Caries by Tooth and Ageclass

Only LM1-3 (0.7%; 0.7%; 1.1%) were affected by pulp caries in the young adult group. All teeth with the exception of UP1 were affected by enamel caries in the older adults group, while only the molars (upper and lower) were affected by dentine caries and only LM2 affected by pulp infestation: overall figures were similar to those of young adults (10.2% > 1.2% > 0.2%). The dropping UM1/LM1 figures (6.7% and 8.0%) reflect the loss of occlusal detail, while UM3/LM3 (17.5% and 23.4%) are more frequently affected by enamel caries. Upper and lower dentine caries are approximately even, but slightly more common in the lower teeth. Overall figures for mature and old individuals see a slight rise in enamel caries (11.9%) with an absence of dentine caries and 3% of pulp cavities affected. Second and third upper and lower molars (25% and 20% vs.

22.2% and 42.9%) are the only teeth affected. These figures reflect high tooth loss in the younger ageclasses.

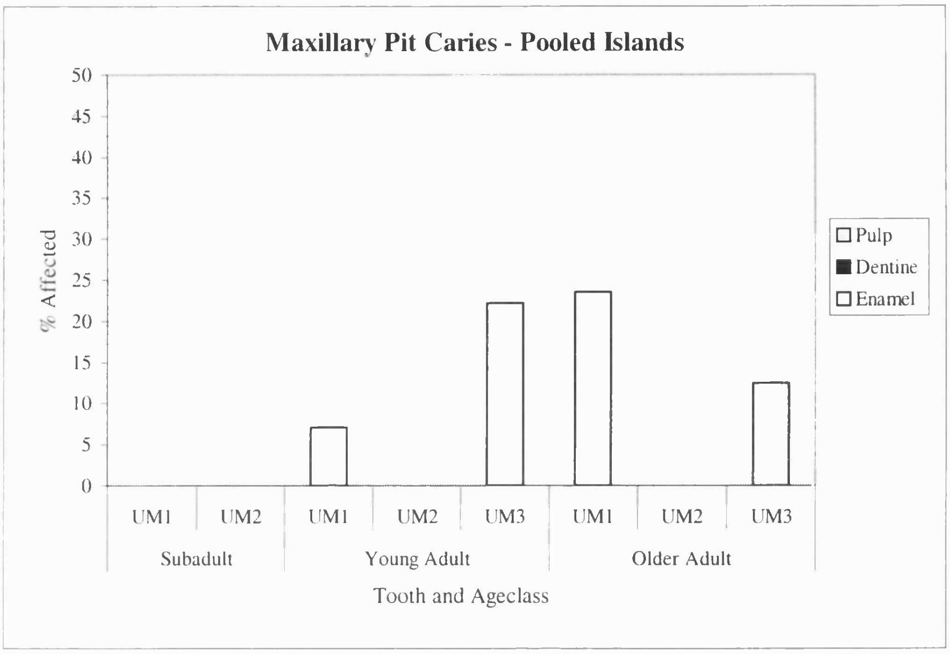

Figure 7.5. Maxillary Pit Site Penetration Caries by Ageclass – Pooled Islands

Pit caries was recorded on upper and lower molars (figs. 7.5 and 7.6). As the pit forms themselves were relatively uncommon on the upper teeth (fig. 7.5), caries were also somewhat rare in subadults (3.3%), rising into the young adult (15.7%), older adult (14.6%) and mature/old (20%) ageclasses. However, no dentine/pulp forms were noted.

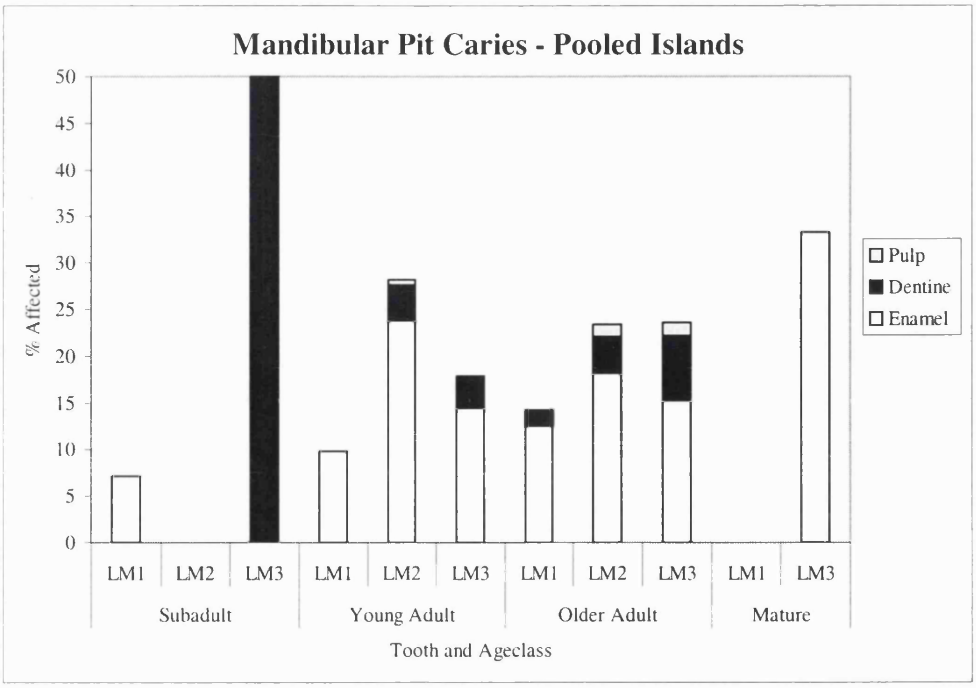

Figure 7.6. Mandibular Pit Site Penetration Caries by Ageclass – Pooled Islands

In the mandibular dentition, by contrast (fig 7.6), pit caries – in all forms of severity – were considerably more common. The high peak of dentine caries in subadulthood refers to impacted teeth, while severe forms were mainly found in the older adult group. By the mature ageclass, the pit sites had for the most part been worn away, while high levels of tooth loss led to a higher proportion of individuals having enamel caries.

Occlusal dentine caries (figure 7.7) prevalence rose from subadults to adults and older adults (1.7%-2.2%-3.6%), with a relative increase in pulp caries and a decrease of dentine forms in the older group. Low prevalence of pulp caries was noted for young adults (0.2%) and older adults (0.8%) only. Prevalence was higher in the mandibular dentition, and was particularly common in LM2-3. The most commonly-affected maxillary tooth was UM3.

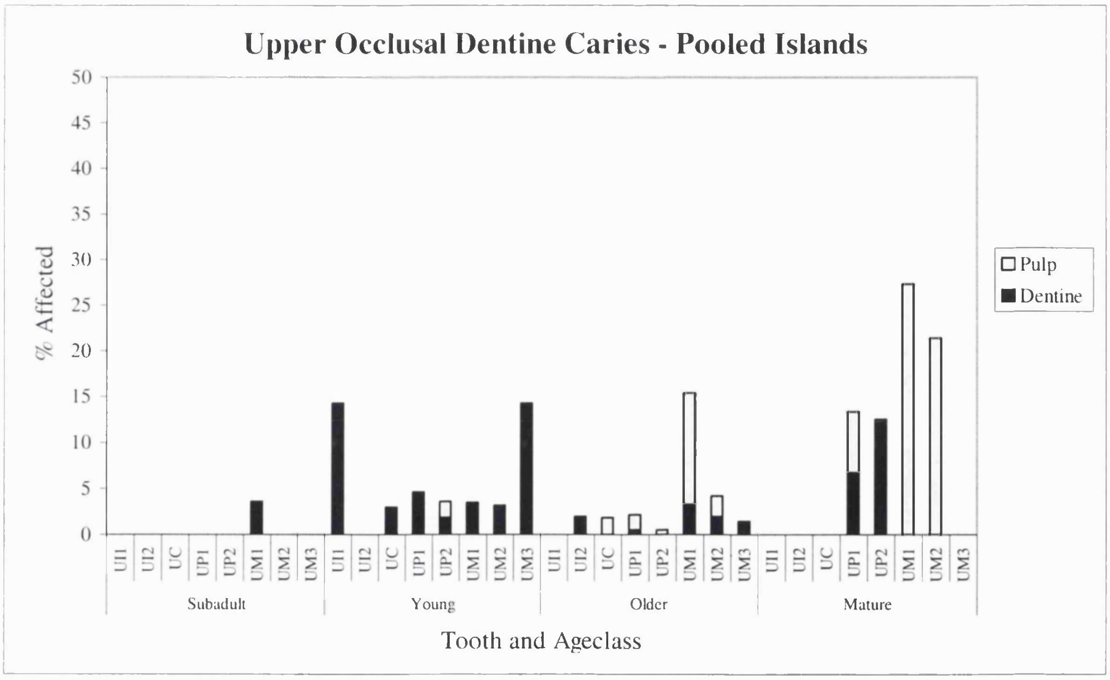

Figure 7.7. Maxillary Occlusal Dentine Penetration Caries by Ageclass – Pooled Islands

Subadult occlusal dentine caries was noted for UM1 (3.6%) only. High prevalence of dentine caries of the anterior dentition in the young adult ageclass is partly attributable to small sample size (i.e. 14.3% in UI1; 3% in UC). With the notable exception of UM3 (14.3%), dentine caries was uncommon in the postcanine dentition (from 1.8% to

4.6%). Older adult caries figures are similar to those of younger adults, and do not rise substantially until the mature/old ageclass. Maxillary caries is more common than mandibular caries, and occur as frequently in the premolars as the molars. In general terms, pulp caries only affects the oldest group where many teeth have been lost and the caries has an opportunity to penetrate the pulp cavity in the absence of occlusal wear.

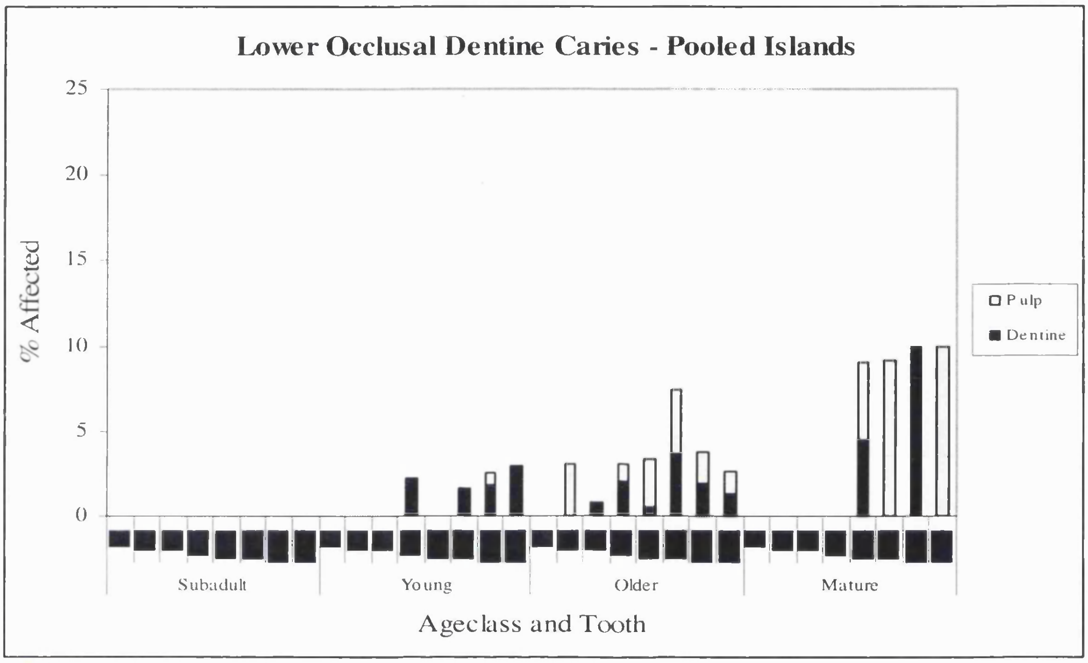

Figure 7.8. Mandibular Occlusal Dentine Penetration Caries by Ageclass – Pooled Islands

Contact point caries (figures 7.9 and 7.10) was restricted to the enamel in subadults (3.3% of total dentition), and was limited to UM1 (5.3%), LM1 (6.9%) and LM2 (2.9%). Most young adult contact point caries were also enamel-only (6.8% of pooled sample). All teeth except UI1, LI1 and LI2 were affected, but prevalence was fairly low in the anterior teeth (i.e. UC 2%). The upper postcanines were less commonly affected than the mandibular teeth, but with high prevalence in the upper premolars (9% and 5.1%). Lower premolar caries was uncommon (LP1 3.2%; LP2 0.7%), compared to LM1 (13%), LM2 (10.3%) and LM3 (5.9%).

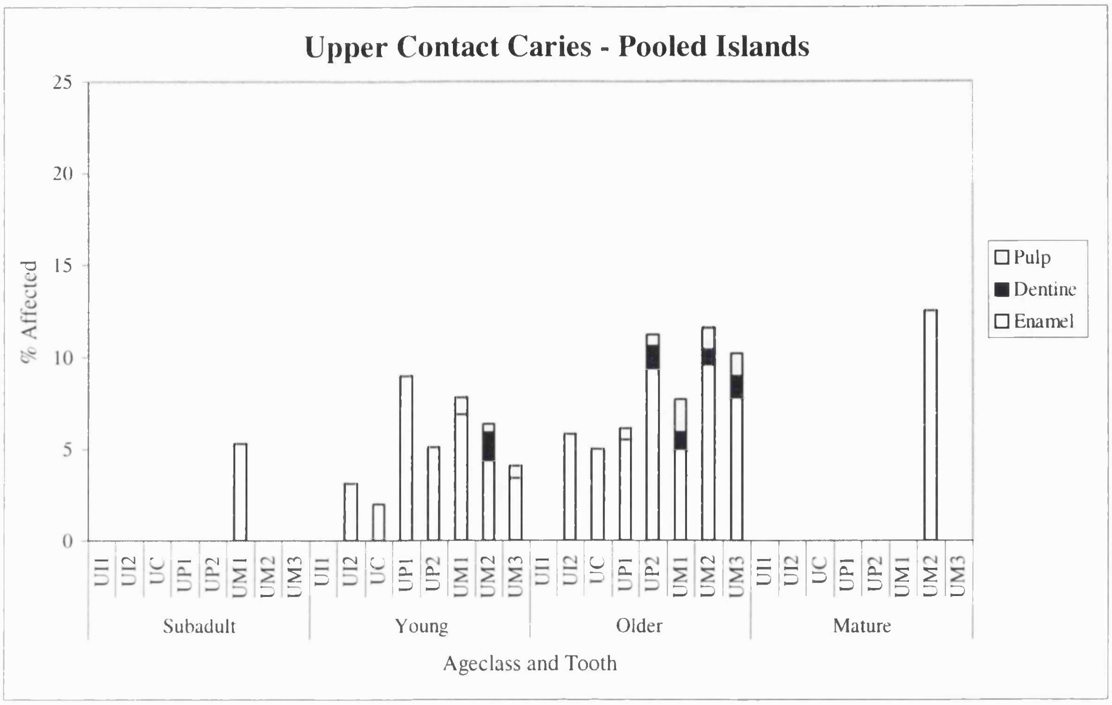

Figure 7.9. Maxillary Contact Surface Penetration Caries by Ageclass – Pooled Islands

Contact caries affecting the dentine was rare (0.6%), restricted to UM2 (1.5%), LM1 (1.4%) and LM2 (1.2%). Pulp cavity caries occurred sporadically in the upper molars (UM1 0.9%; UM2 0.5%; UM3 0.7%) and LM1/3 (0.5% and 0.3%). Older adult contact point caries affected the enamel (5.7%) than the dentine (2.2%) or pulp cavity (1%).

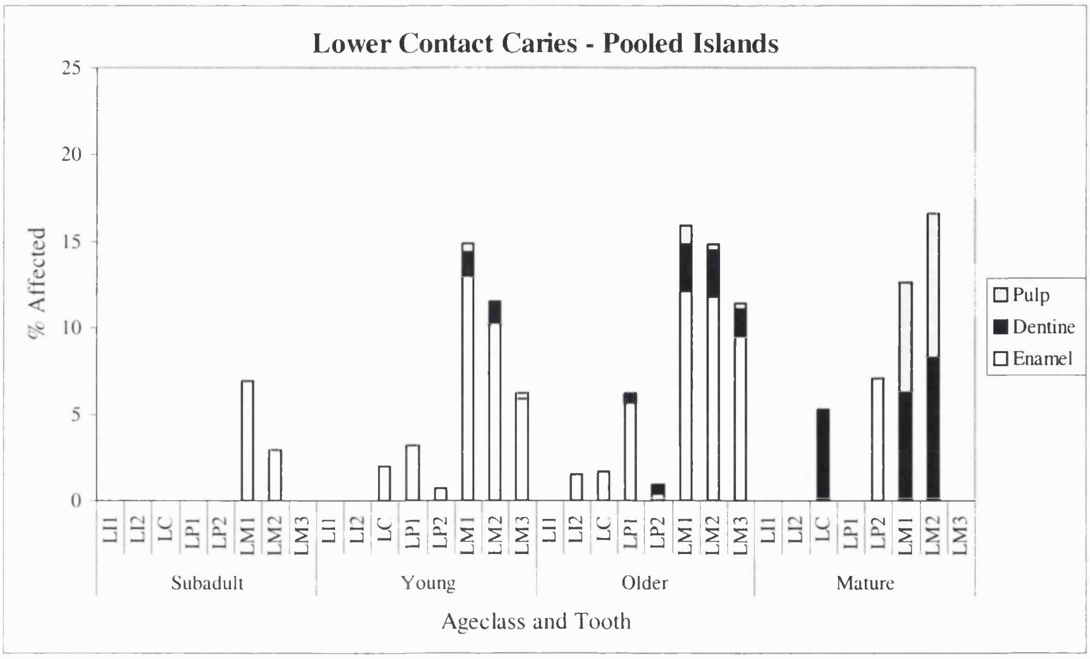

Figure 7.10. Mandibular Contact Surface Penetration Caries by Ageclass – Pooled Islands

Upper tooth prevalence was low in the anterior section (0%-5.8%-5%), higher in the premolars (5.5%-9.4%) and highest in the molars (5%-9.6%-7.8%). Lesions were less common in the lower anterior dentition (LI1-LC 0%-1.5%-1.7%) and the premolars (LP1-2 5.7% and 0.4%) and high in the molars (LM1-3 12.1%-11.8%-9.5%). Dentine caries was present at low levels in all teeth from UP2 distally (1.2%-0.9%-0.8%-1.2%) and from LP1 distally (0.5%-0.5%-2.7%-2.7%-1.6%), while pulp caries was more widespread in the upper (UP1 0.6%; UP2 0.6%; UM1 1.8%; UM2 1.2%; UM3 1.2%) than lower (LM1 1.1%; LM2 0.3%; LM3 0.3%). Tooth loss and wear was such that caries levels in the mature/old group were low. Enamel caries was restricted to UM2 (12.5%) and LP2 (7.1%), while dentine caries was found in LC (5.3%), LM1 (6.3%) and LM2 (8.3%). Pulp cavity caries was limited to LM1 (6.3%) and LM2 (8.3%). As noted above, older individuals had more severe lesions in response to tooth loss and destruction of the contact points.

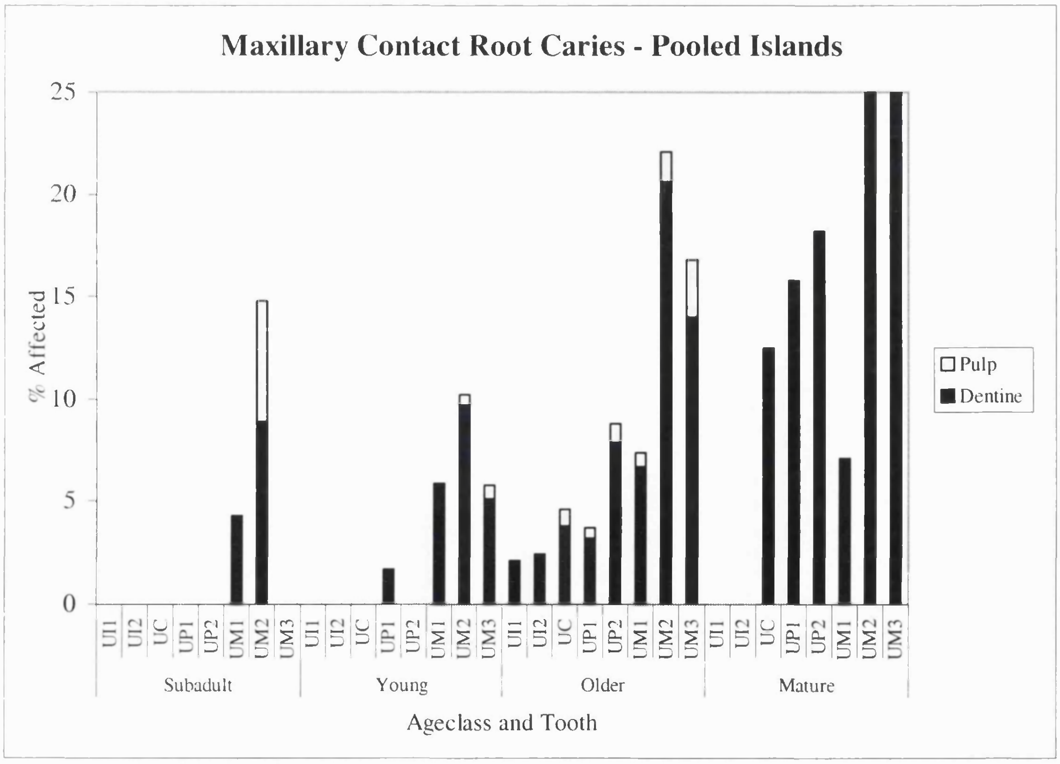

Figure 7.11. Maxillary Contact Root Penetration Caries by Ageclass – Pooled Islands

Contact root caries (figs. 7.11 and 7.12) was rare in subadulthood, occurring in UM1 (4.3%), UM2 (8.9%) and LM1 (2.8%). Pulp cavity caries was limited to UM2. Young adult contact root caries was slightly more common than in the subadult group. The lower dentition was affected in the anterior (LC 0.8%), premolar (LP1 2.8%; LP2 2%) and molar (LM1-3: 9.9%, 6.7% and 7%), while the UP1 (1.7%) and the upper molars (UM1-3 5.9%, 9.7% and 5.1%) were affected. Pulp cavity forms were rare in the upper dentition (0.5% of UM2s and 0.7% of UM3s), and slightly more common in the lower teeth from LP2 distally (0.7%; o.5%; 1.3% and 0.3%). The distinction between the upper and lower teeth was not as marked as for coronal caries forms.

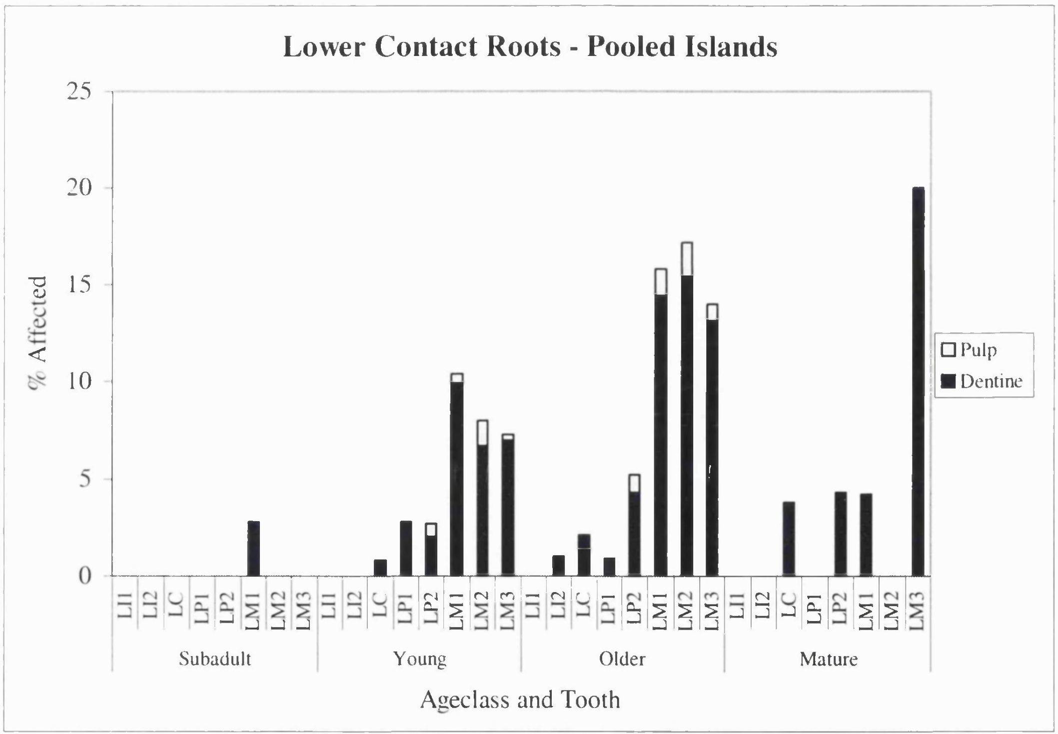

Figure 7.12. Mandibular Contact Root Penetration Caries by Ageclass – Pooled Islands

Older adults were strongly affected by approximal root surface caries, with a total of 9.3% of all teeth afflicted (see figs. 7.11 and 7.12). This is likely to be a reflection of extreme wear bringing about continuous eruption and thus exposing the roots to caritic attack. All the upper teeth were affected, and all the lower teeth except for LI1. The anterior teeth and the premolars were seldom afflicted in the lower jaw (LI1-LP2 0%, 1%, 2.1%, 0.9%, 4.3%), followed by a jump into the molar group (LM1-3 14.4%, 15.4% and 13.1%). There was a distal increase from UI1-UM1 (2.1%, 2.4%, 3.8%, 3.2%, 7.9%, 6.7%), followed by a more substantial jump from UM2-3 (20.6%, 14%). Pulp cavity caries was generally uncommon (1% of pooled teeth). They were more common in the upper than lower dentition, commencing in UC > distally (0.8%, 0.5%, 0.9%, 0.7%, 1.5% and 2.8%), but only present in LP2 > distally (0.9%, 1.4%, 1.8% and 0.9%). While figures for caries prevalence in the mature/old group are high, this is a reflection of high tooth loss levels rather than true cariogenesis in the ageclass. Mild forms were most common in the upper dentition from UC > distally (12.5%, 15.8%, 18.2%, 7.1%, 25%, 25%), while lower tooth forms were both less frequent, and affected less teeth (LC 3.8%, LP2 4.3%, LM1 4.2%, LM3 20%) than their maxillary counterparts. No pulp forms were observed.

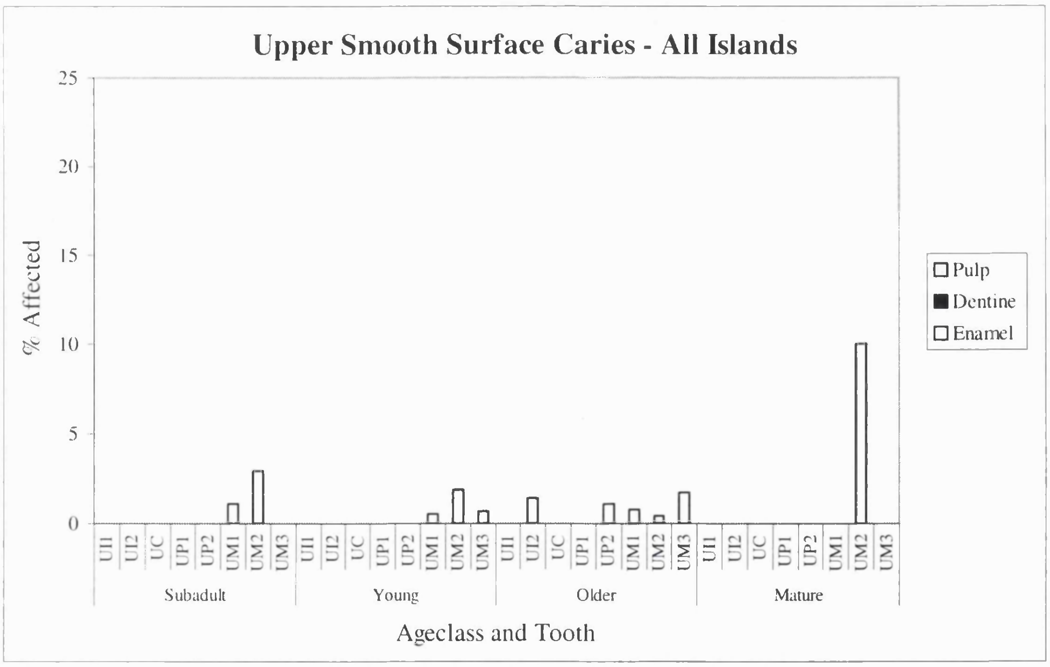

Figure 7.13. Maxillary Smooth Surface Penetration Caries by Ageclass – Pooled Islands

Smooth surface caries were rare for the group as a whole (figs. 7.13 and 7.14). Only mild forms were noted, associated with enamel cracks, very high gum-lines with associated calculus, and hypoplastic defects. However, the caries never assumed cavity form, consisting of dark staining. These were observed in subadults, including 2.1% of UM1s, 2.9% of UM2s and 2.1% of LM1s. The upper molars (UM1-3 0.5%, 1.9% and

0.7%), the lower canines (1.7%) and the lower molars (0.2%, 0.9% and 1.1%) were all affected with smooth surface enamel caries in the younger adult ageclass. Lower teeth (LI2 1.1%, LC 1.5%, LP1 0.9%, LP2 1.9%, LM1 0.5%, LM2 0.3%, LM3 1.9%) were more frequently affected than upper teeth (UI2 1.4%, UP2 1.1%, UM1 0.8%, 1.9%) in the older adult ageclass, which were also affected with dentine (0.6% of LM3s) and pulp cavity (0.4% of UM2s, 0.3% of LM3s) caries. UM2s (10%) were the only teeth affected with enamel smooth surface caries in the mature/old ageclass. Overall, however, these lesions were somewhat serendipitous, linked with abnormal tooth position or morphology/pathology (i.e. hypoplasia, enamel cracks).

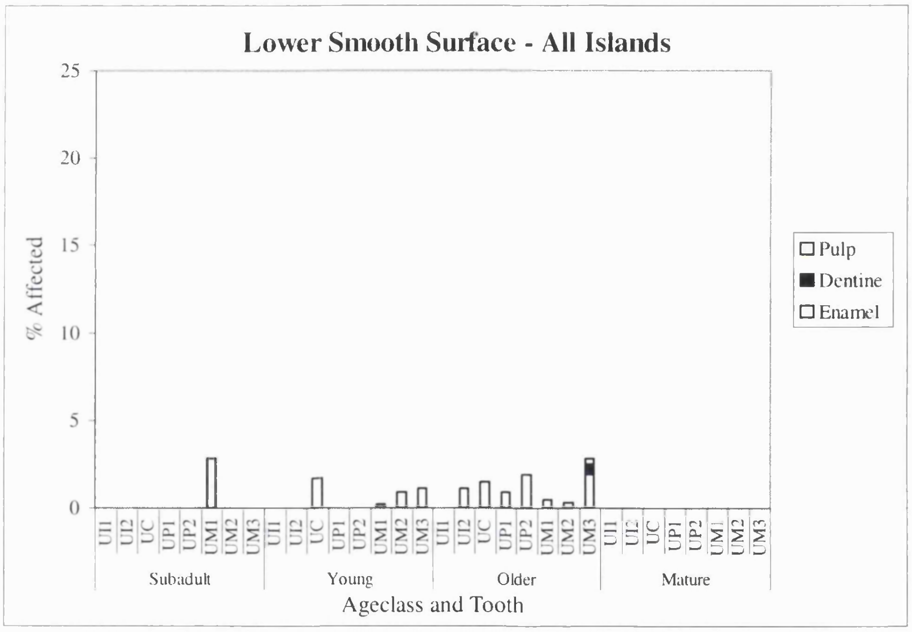

Figure 7.14. Mandibular Smooth Surface Penetration Caries by Ageclass – Pooled Islands

Buccal/lingual root surface caries (figs. 7.15 and 7.16) was found in UP2 (11.1%), UM2 (2.9%) and LM1 (2.8%) in the subadult ageclass. No dentine or pulp caries were noted. Young adult buccal/lingual caries prevalence increased from UI2 > distally (2.4%, 3.3%, 2.6%, 2.9%, 3.1%, 3.8%, 4.1%), but was more irregular in the lower dentition from LC > distally (1.6%, 2.1%, 0.6%, 3.2%, 2.4%, 6.1%).

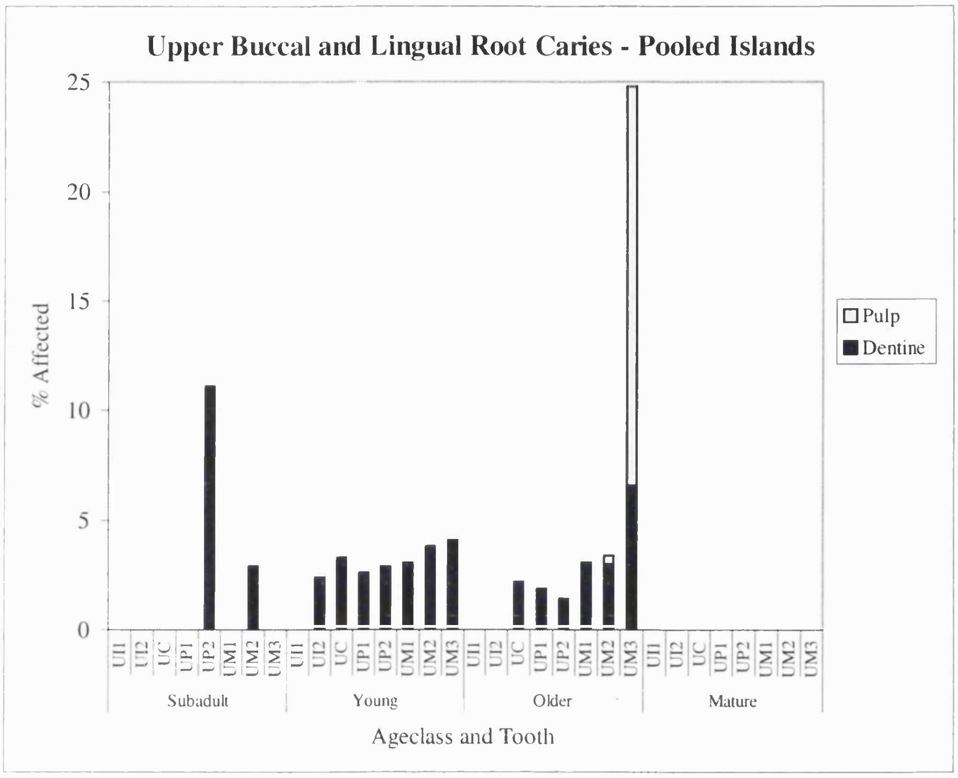

Figure 7.15. Maxillary Buccal/Lingual Root Penetration Caries by Ageclass – Pooled Islands

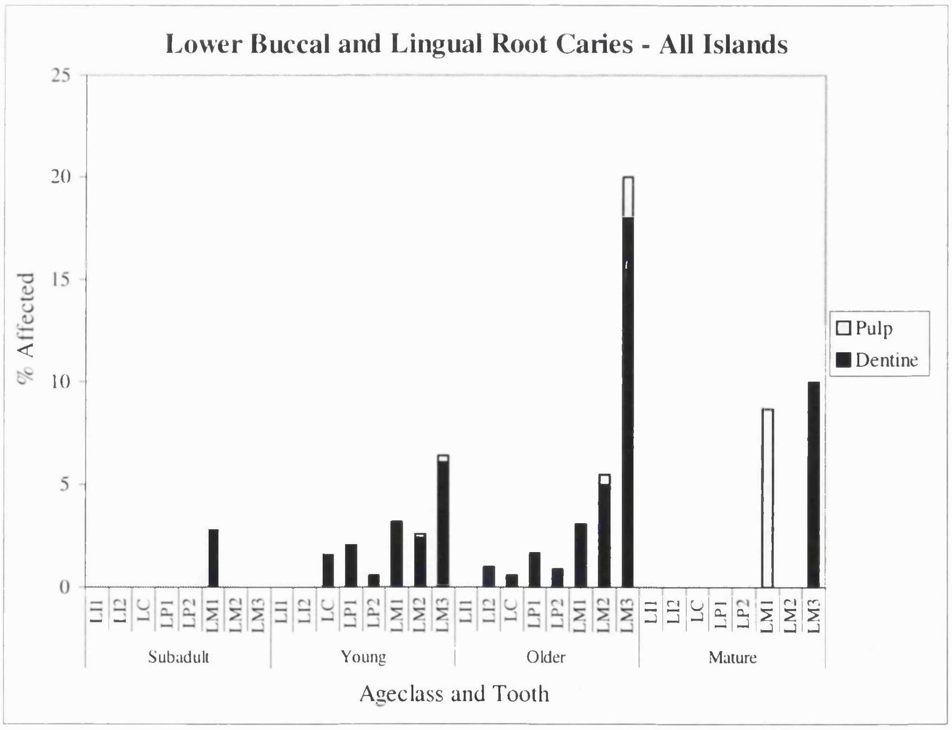

Figure 7.16. Mandibular Buccal/Lingual Root Penetration Caries by Ageclass – Pooled Islands

Lower second (0.2%) and third (0.3%) molars were also affected with pulp cavity caries. Older adult pathology was more common in the lower (0%-18%) than upper (0%-6.6%) dentition, and was particularly high in the third molars (UM3 6.6%; LM3

18%). Pulp cavity caries was restricted to upper (0.4% and 18.2%) and lower (0.5% and 2%) second and third molars. Ten percent of LM3s were affected in the mature/old ageclass, while 8.7% of LM1s were affected with pulp cavity caries. As before, there was not a great deal of disparity between the upper and lower dentitions, as prevalence appears to be directly linked to high levels of wear that leave the tooth roots exposed.

7.2 Social Trends – Sex and Period

It is important that the social aspects of caries prevalence be assessed in addition to standard spatial studies. For this reason, a series of tests was carried out to examine the inter-sex and inter-period distribution of caries. Firstly, teeth, islands and ageclasses were pooled in order to provide a basic measure of caries prevalence, on the basis that the materials described in chapter 5 do not suggest any major differences in age-at-death between the sexes. These results are presented in table 7.2.

	Absent	Present	%	N
Male	3353	983	22.7	4336
Unsexed	356	64	15.2	420
Female	1499	608	28.9	2107
Total	5208	1655	24.1	6863

Table 7.2. Total Caries Count by Sex

In this test, the sexes were close in terms of caries prevalence, although females were slightly more affected than males. The unsexed group – mainly comprising subadults – was considerably less strongly affected by cariogenesis. The next part of the process involved breaking the teeth down into their components (see chapter 4) to assess whether this resulted in any change in the results already observed. The results are presented in table 7.3.

Caries Type	Male	%	Unsexed	%	Female	%	N
Occlusal Surface	272/2947	9.2	24/346	6.9	228/1447	15.8	4740
Pit Caries	81/511	15.9	4/46	8.7	49/212	23.1	769
Occlusal Dentine	102/3062	3.3	7/146	4.8	72/1498	4.7	4706
Contact Points	292/3698	7.9	23/297	7.7	174/1842	9.4	5837
Contact Roots	315/4208	7.5	21/304	6.9	198/2072	9.6	6584
Buccal/Lingual Surfaces	33/3963	0.8	6/311	1.9	11/1931	0.6	6205
Buccal/Lingual Roots	127/4236	2.9	4/304	1.3	66/2079	3.1	6639
Total	1222/22625	5.4	89/1754	5.1	798/9655	8.3	35480

Table 7.3. Caries Count by Site and Sex

These values support the findings in the pooled sample, with increased female prevalence in all but buccal/lingual smooth surface caries. It is possible that this pattern reflects some behavioural difference related to physical trauma (see chapter 9 for further details). The LM1 data were assessed in order to test for differences in caries prevalence between the sexes. Basic studies – without considering age – were carried out on a by-tooth basis, and on a by site basis. These data are presented in tables 7.4 and 7.5.

	Absent	Present	%	N
Male	451	200	30.7%	651
Unsexed	60	16	21.1%	76
Female	153	101	39.8%	254
Total	664	317	32.3%	981

Table 7.4. LM1 Caries by Sex (Pooled Samples)

Chi-squared tests were carried out on the pooled Canarian sample, examining the prevalence of caries within the young and older adult sample. These groups were chosen because sex could be easily assigned in most cases, and because samples were substantial.

Caries Type	Male	%	Unsexed	%	Female	%	N
Occlusal Surface	44/531	8.1	0/71	0	23/218	10.6	820
Pit Caries	12/135	8.9	3/22	13.6	8/62	12.9	219
Occlusal Dentine	26/620	4.2	3/30	10	10/239	4.2	889
Contact Points	74/589	12.6	9/57	15.8	46/236	19.5	882
Contact Roots	72/642	11.2	4/60	6.7	39/354	15.4	956
Buccal/Lingual Surfaces	1/618	0.2	2/56	3.6	2/247	0.5	921
Buccal/Lingual Roots	21/643	3.3	2/58	3.4	8/254	3.2	955
Total	250/3778	6.6	22/354	6.2	136/1610	8.4	5642

Table 7.5. LM1 Caries by Sex and Specific Site

Tooth Class	Pearson Chi-Square
Upper Anterior	.187
Upper Premolars	.474
Upper M1	.644
Upper M2	.048
Upper M3	.178
Lower Anterior	.112
Lower Premolars	.966
Lower M1	.001
Lower M2	.000
Lower M3	.000

Table 7.6. Inter-Sex Trends in Caries Prevalence

All the teeth with significantly variable caries prevalence between the sexes are postcanine, and 3/4 are mandibular. This therefore indicates that anterior dentition caries – which was uncommon (see 7.1) – was therefore fairly equal between the sexes. When consulting the expected vs. observed counts for the sexes (i.e. the observed figures' affinity with the parameters of the null hypothesis) females had a higher prevalence of UM2, LM1, LM2 and LM3 caries than males, indicating either girls' precocious dental eruption (Hillson 1996: 125), or a difference in dietary patterns. However, the inter-sex differences in terms of formation/eruption are not exceptional, so the fact that female caries prevalence is higher in nearly all parts of the tooth (i.e. root surface caries as well as crown forms) seems disproportionate. It is possible that females ate more cariogenic produce than men, in addition to grinding their teeth down faster (thus resulting in exposure of the roots through continuous eruption), possibly owing to the high grit content in prehispanic Canarian flour. However, it is also important to assess the spatial and temporal components of caries distribution.

7.3 Basic Period Trends – Pooled Teeth

A basic pooled tooth test was carried out to examine temporal variability in the data. The sample numbers are provided in tables 7.8 and 7.9.

	Absent	Present	%	N
Early	296	77	20.6%	373
Middle	3237	1195	27%	4432
Late	597	109	15.4%	706
Total	5208	1655	24.1%	6863

Table 7.7. Basic Caries Prevalence in Pooled Teeth by Period

Caries Type	Early	%	Middle	%	Late	%	N
Occlusal Surface	21/234	9	440/3258	13.5	29/453	6.4	4740
Pit Caries	8/36	22.2	93/500	18.6	10/54	18.5	769
Occlusal Dentine	15/248	6	106/3051	3.5	17/489	3.5	4706
Contact Points	15/315	4.8	396/3822	10.4	30/616	4.9	5837
Contact Roots	28/343	8.2	375/4264	8.8	27/685	3.8	6584
Buccal/Lingual Surfaces	0/321	0	30/4075	0.7	2/654	0.3	6205
Buccal/Lingual Roots	4/338	1.2	106/4288	2.5	17/691	2.5	6639
Total	91/1835	5	1546/23258	6.6	132/3642	3.6	35480

Table 7.8. Contd. Caries Prevalence by Site and Period – Pooled Teeth

There was a marked increase in occlusal surface caries prevalence in the middle period (13.5%) when compared to the early and late groups. The same pattern characterised contact point caries, with a peak in the middle group (10.4%) compared to both other periods. By contrast, the late period prevalence of contact root surface caries was lower (3.6%) than both the early and the middle period. In order to control for age, the young adult group was analysed by period using "all_car", and accounting for tooth class. A summary of the results is presented in table 7.9.

Tooth Class	Pearson Chi-Square
Upper Anterior	.025
Upper Premolars	.034
Upper M1	.075
Upper M2	.878
Upper M3	.274
Lower Anterior	.753
Lower Premolars	.399
Lower M1	.421
Lower M2	.078
Lower M3	.009

Table 7.9. Chi-Squared Test Results for Caries Prevalence in Younger Adults by Period

Early period upper anterior caries was notably higher than would be expected under the terms of the null hypothesis. Prevalence of upper premolar and LM3 caries was high in the middle period but low in the late period sample. The test was repeated using the older adult sample; a summary of the results is presented in table 7.10.

Tooth Class	Pearson Chi-Square
Upper Anterior	.000
Upper Premolars	.024
Upper M1	.135
Upper M2	.311
Upper M3	.622
Lower Anterior	.133
Lower Premolars	.426
Lower M1	.726
Lower M2	.156
Lower M3	.439

Table 7.10. Chi-Squared Test Results for Caries Prevalence in Older Adults by Period

Upper anterior and premolar caries was high (i.e. exceeded the bounds of the null hypothesis) in the early period and was very low or absent in the late sample. Like the younger adult group, however, the fact that only 2/10 (young adults 3/10) tooth groups provided significant variability between periods would seem to suggest that there were no major economic transitions. The internal variability (by period and by sex) of Gran Canaria and Tenerife was assessed for trends, as these islands possess the largest and best-dated samples in the archipelago. As the number of subadult and mature/old individuals was rather low, only the young and older adults were examined. The basic ('all_car') presence/absence dichotomy was used.

Tooth Class	Pearson Chi-Square
Upper Anterior	.001
Upper Premolars	.121
Upper M1	.299
Upper M2	.203
Upper M3	.125
Lower Anterior	.654
Lower Premolars	.875
Lower M1	.939
Lower M2	.357
Lower M3	.088

Table 7.11. Chi-Squared Test Results for Gran Canarian Younger Adult Caries Prevalence by Period

Tooth Class	Pearson Chi-Square
Upper Anterior	.000
Upper Premolars	.095
Upper M1	.121
Upper M2	.095
Upper M3	.060
Lower Anterior	.521
Lower Premolars	.319
Lower M1	.777
Lower M2	.168
Lower M3	.145

Table 7.12. Chi-Squared Test Results for Tenerife Older Adult Caries Prevalence by Period

In both the younger and older group the early period upper anterior dentition was significantly more affected with caries than either of the other periods. In general terms, however, there was homogeneity of economic traditions so far as can be determined from the dental evidence. As there was very little variability overall, it was decided that carrying out more complex analyses would not be useful. The site-specific analysis (as laid out by Hillson 2001) was carried out on younger and older adults for the pooled island sample. The results are presented below (tables 7.13 and 7.14).

Tooth Class	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
Upper Anterior	-	-	.000	.512			
Upper Premolars	.465	-	.103	.087	.664		
Upper M1	.765	.708	.600	.680	.459		.525
Upper M2	.808		.870	.828	.553	.092	.733
Upper M3	.633			.917	.787		.705
Lower Anterior	-	-		.727			.735
Lower Premolars	.585	-	.315	.757	.735		.638
Lower M1	.029	.794	.000	.734	.313	.909	.552
Lower M2	.141	.137	.085	.911	.312	.821	.734
Lower M3	.505	.030	.041	.352	.365	.678	.525

Table 7.13. Chi-Squared Test Results for Younger Adult Caries Prevalence by Period

When tested in this manner, only a low proportion of caries forms was temporally variable at a significant ($P \leq .05$) level, and this is consistent with the pooled caries data. The early period saw the highest prevalence of LM1 occlusal surface caries and UA occlusal dentine caries, the middle period was characterised by high prevalence of LM3 pit caries, and the late group was noted for high prevalence of LM1 and LM3 occlusal dentine caries. Judging from these tests, it appears that Canarian economy was charac-

Tooth Class	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
Upper Anterior	-	-	.849	.000	.596		.883
Upper Premolars	.000	-	.066	.663	.494	.932	.775
Upper M1	.740		.179	.897	.730		.324
Upper M2	.210		.882	.967	.178	.907	.920
Upper M3	.204		.855	.994	.868	.924	.002
Lower Anterior	-	-	.910	.583	.494	.573	.831
Lower Premolars	.066	-	.473	.660	.771	.829	.745
Lower M1	.256	.168	.509	.451	.427	.814	.801
Lower M2	.377	.653	.513	.380	.419	.899	.851
Lower M3	.633	.963	.882	.037	.942	.876	.187

Table 7.14. Chi-Squared Test Results for Older Adult Caries Prevalence by Period

terised by homogeneity rather than heterogeneity, for if agriculture had appeared suddenly in the islands (or if the groups had adopted hunting and gathering from a previously agricultural tradition) there would have been stronger traits in the material. While it is therefore apparent that the Canaries as a whole were temporally stable, the spatial patterning (i.e. the profiles of individual islands) remains to be determined.

7.4 Inter-Island Trends – Pooled Teeth

A crude inter-island caries rate was calculated from the pooled tooth data. Tooth class, age and sex were not considered, on the basis that distributions were roughly equal (see chapter 5) and that this test would serve only as a very general indicator of cariogenesis (Larsen 1997: 69). However, in order to refine the approach, the caries site data (i.e. occlusal surface, pit, etc) was incorporated into the test. The data presented are therefore the total number of lesions against the total number of sites (see figure 7.17). The data are presented in table 7.15 and figure 7.17.

	F'Ventura	Gomera	GC
Occ_Surf	1.3% (2/156)	4.6% (10/219)	14.2% (292/2061)
Pit	0 (0/13)	27.3% (9/33)	18.5% (53/287)
Occ_Dent	0.9% (1/111)	6.5% (14/214)	2.7% (51/1886)
Cont_Surf	1.7% (3/174)	7.4% (20/269)	7.7% (195/2534)
Cont_Rt	3.4% (6/175)	8.2% (29/354)	5.9% (160/2706)
BL_Surf	1.1% (2/176)	1.6% (5/307)	0.4% (10/2627)
BL_Rt	5.1% (9/176)	4.2% (15/359)	1.5% (42/2702)
Mean	2.3% (23/981)	5.8% 102/1755	5.4% (803/14803)

Table 7.15. Crude Caries Rate by Site and Island

	Hierro	Lanzarote	La Palma	Tenerife
Occ_Surf	9.1% (19/235)	2.9% (1/35)	-	9.8% (200/2034)
Pit	4.4% (4/91)	0 (0/2)	-	19.7% (68/346)
Occ_Dent	6.3% (27/431)	2% (1/51)	16.7% (1/6)	4.2% (85/2007)
Cont_Surf	2.9% (12/417)	0 (0/59)	0 (0/5)	10.9% (259/2379)
Cont_Rt	8.3% (43/521)	7.7% (5/65)	0 (0/6)	10.6% (291/2757)
BL_Surf	1.9% (8/428)	0 (0/62)	0 (0/5)	1% (25/2600)
BL_Rt	6.2% (33/529)	3% (2/67)	0 (0/6)	3.5% (96/2800)
Mean	5.5% (146/2652)	2.6% (9/341)	3.6% (1/28)	6.9% (1024/14923)

Table 7.15. Contd.

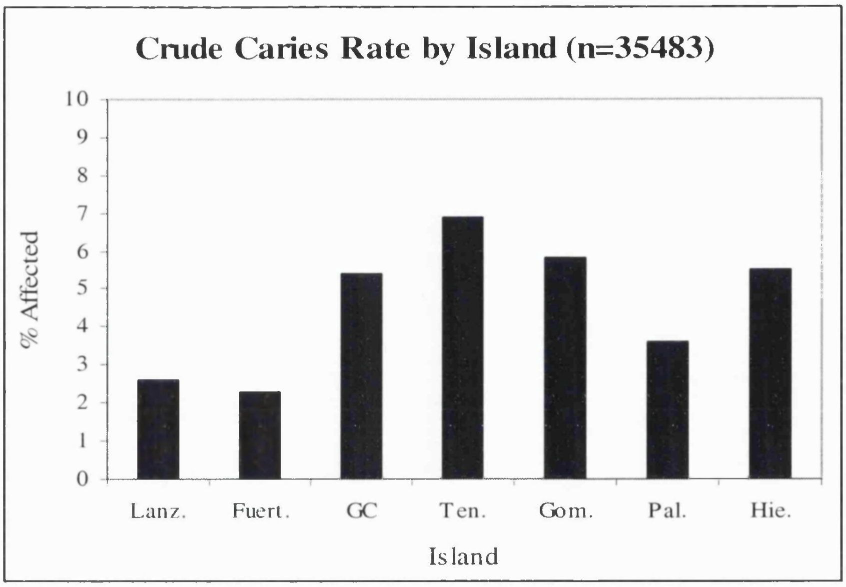

Figure 7.17. Crude Caries Rate by Island
(NB - Scale has been reduced in order to demonstrate inter-island differences)

The pooled total caries score by site for the islands is therefore 5.9%, derived from 2108/35483. It should be noted that this is a by-site system, so that standard studies not using Hillson's system – which permits multiple lesions per tooth to be counted separately – are not directly comparable. The most strongly affected islands were Tenerife and Gomera, followed by Hierro/Gran Canaria (see fig. 7.17). Although samples on La Palma, Lanzarote and Fuerteventura were small, the percentage prevalence of caries was very low in all cases. The former four islands are similar in overall profile, suggesting that while diet may have varied in some respects, the tendency was towards homogeneity rather than heterogeneity. It is interesting to note that while occlusal surface caries was rare on Lanzarote, contact root caries was relatively common, roughly equal to islands with far higher overall caries prevalence. Fuerteventura also follows this pattern, with an even lower total number of caries. The major distinction is therefore between the dry islands towards the east of the archipelago against all the other islands. It was necessary to refine this data in order to establish truly representative trends in caries patterns.

7.5 Tooth Classes Considered by Island

The teeth were divided into classes based on their morphology, eruptive chronology and position in the jaw (see above for further details). The dentition was divided into upper and lower halves, within which there were "anterior" (I1, I2 and C) and "premolars" (P1 and P2); the molars were considered separately, given their differences in eruption time and morphology. The data are based on presence/absence of lesions only; the penetration aspects of dental caries (i.e. enamel-dentine-pulp) are presented later in this chapter. The teeth are paired in upper vs. lower antimeres, so that contrasts between the two can be made. Basis data for the four ageclasses are presented below in tables 7.16 to 7.19, and figures 7.18 to 7.37, and provide the basis for subsequent statistical tests.

7.5.1. Subadult Caries by Island

	U_Ant.	N	U_P	N	UM1	N	UM2	N	UM3	N
Fuert.			100%	1	0	11	12.5%	1/8		3
Gomera					0	10	0	4		3
GC	0	18	0	15	12.2	6/49	16%	4/25		11
Hierro	0	2	0	4	16.7%	1/6	0	2		
Lanz.			0	1	0	2	0	2		2
Tenerife	0	7	0	12	20%	2/25	26.7%	4/15		3
Total	0	27	3%	1/33	11.7%	12/103	16.1%	9/56		22
	L_Ant.	N	L_P	N	LM1	N	LM2	N	LM3	N
Fuert.					0	4	0	2		
Gomera	0	5	0	2	0	7	0	4		
GC	0	14	0	9	12.9%	4/31	33.3%	7/21	22.2%	2/9
Hierro										
Lanz.					50%	1/2	0	2	0	2
Tenerife	0	9	0	8	15.9%	7/44	0	25	0	15
Total	0	28	0	19	13.6%	12/88	13%	7/54	7.7%	2/26

Table 7.16 Subadult Dental Caries by Tooth Class

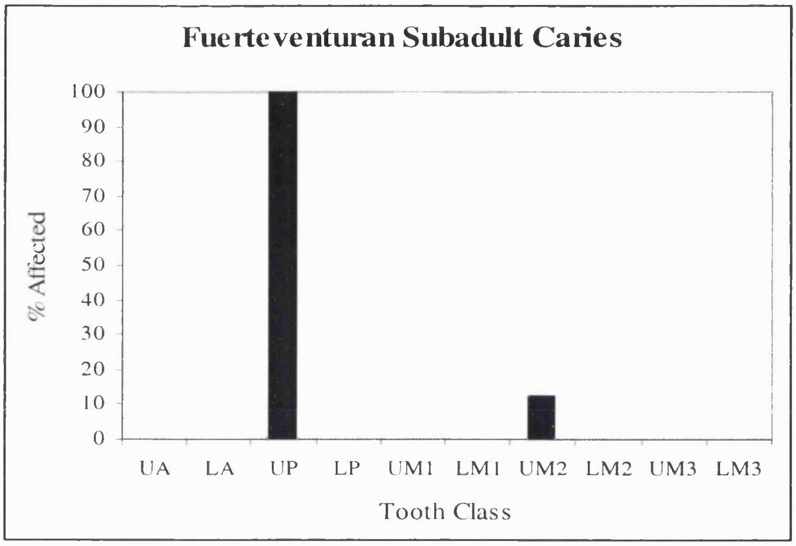

Figure 7.18. Fuerteventuran Subadult Caries

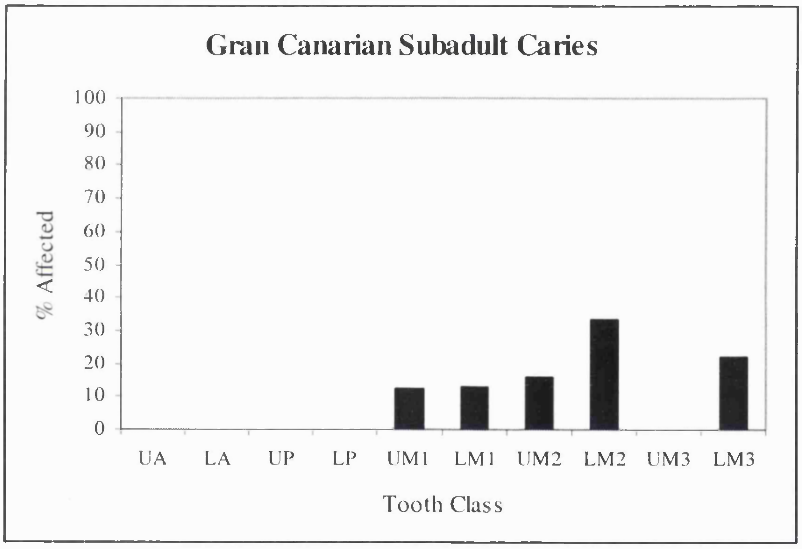

Figure 7.19. Gran Canarian Subadult Caries

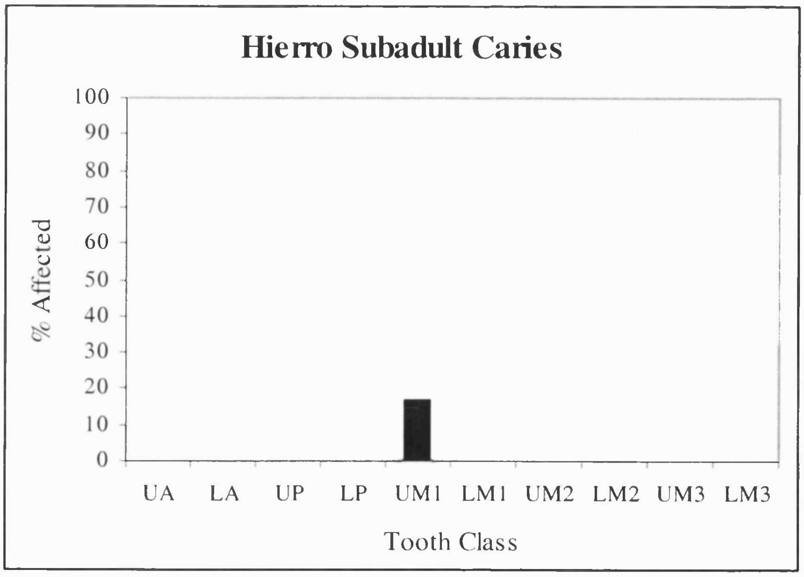

Figure 7.20. Hierro Subadult Caries

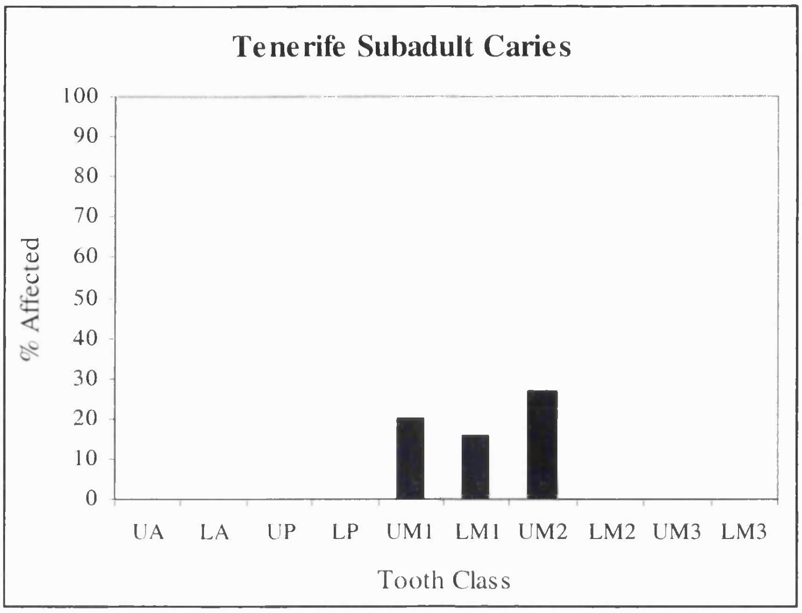

Figure 7.21. Tenerife Subadult Caries

Subadult caries was calculated for all the islands with reasonable sample sizes (table 7.16), as shown in figure 7.18 (Fuerteventura), 7.19 (Gran Canaria), 7.20 (Hierro) and 7.21 (Tenerife). Subadult caries was absent on Lanzarote and Gomera (not shown), and no La Palman specimens were available for study. The high caries prevalence in Fuerteventuran upper premolars is attributable to low sample size. In Gran Canaria, caries were fairly common in all molars, particularly in the mandibular teeth. Only UM1 was affected in Hierro, while Tenerife caries prevalence levels (restricted to UM1-2 and LM1) were comparable to Gran Canarian figures. However, sample sizes do not permit much greater extrapolation concerning childhood diet.

7.5.2 Young Adult Caries by Island

The same procedure was carried out for the young adult samples, considered on an inter-island basis. The raw data are presented in table 7.17, while the individual island profiles are presented graphically in figures 7.22 to 7.26.

	U_Ant.	N	U_P	N	UM1	N	UM2	N	UM3	N
Fuert.	25%	2/8	7.7%	1/13	6.7%	1/15	7.1%	1/4	16.7%	2/12
Gomera	10%	1/10	12.5%	2/16	23.5%	4/17	41.2%	7/17	0	11
GC	2.4%	2/84	11.5%	13/113	20.6%	22/107	24%	23/96	31.1%	23/74
Hierro	0	8	23.8	5/21	36.4%	8/22	23.5%	4/17	43.8%	7/16
Lanz.			0	1			0	1		
Tenerife	17.6%	3/17	12.1%	7/58	27%	17/63	30.2%	19/63	22.5%	9/40
Total	6.3%	8/127	13.1%	29/222	23.2%	52/224	26%	54/208	26.8%	41/153

	L_Ant.	N	L_P	N	LM1	N	LM2	N	LM3	N
Fuert.	20%	1/5	12.5%	1/8	9.1%	1/11	10%	1/10	28.6%	2/7
Gomera	0	8	0	12	31.3%	5/16	42.1%	8/19	46.2%	6/13
GC	1%	1/105	3.4%	4/118	32.6%	42/129	41.3%	50/121	42.3%	44/104
Hierro	6.7%	1/15	0	3	18.2%	2/11	33.3%	4/12	50%	4/8
Lanz.	0	6	0	4	0	3	0	2		
Tenerife	4.2%	4/96	10.1%	16/158	31.9%	88/276	38.6%	110/285	33.3%	78/234
Total	3%	7/235	6.9%	21/303	30.9%	138/446	38.5%	173/449	36.6%	134/366

Table 7.17. Young Adult Dental Caries by Tooth Class

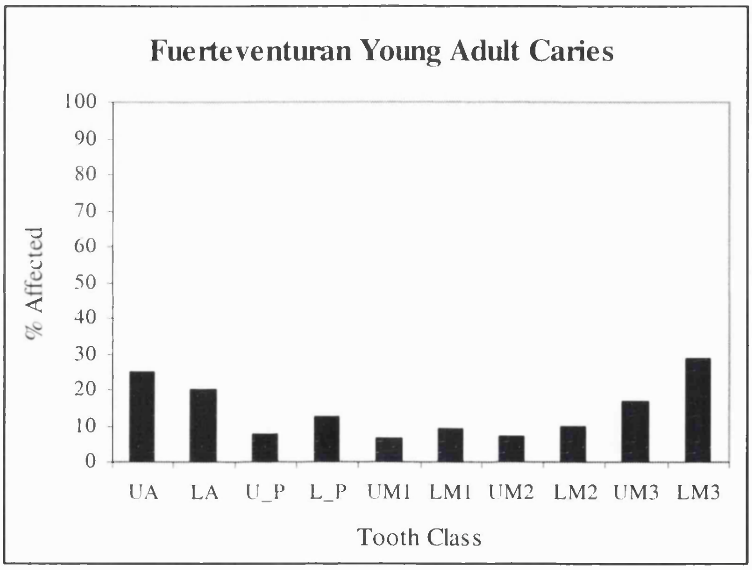

Figure 7.22. Fuerteventuran Young Adult Caries

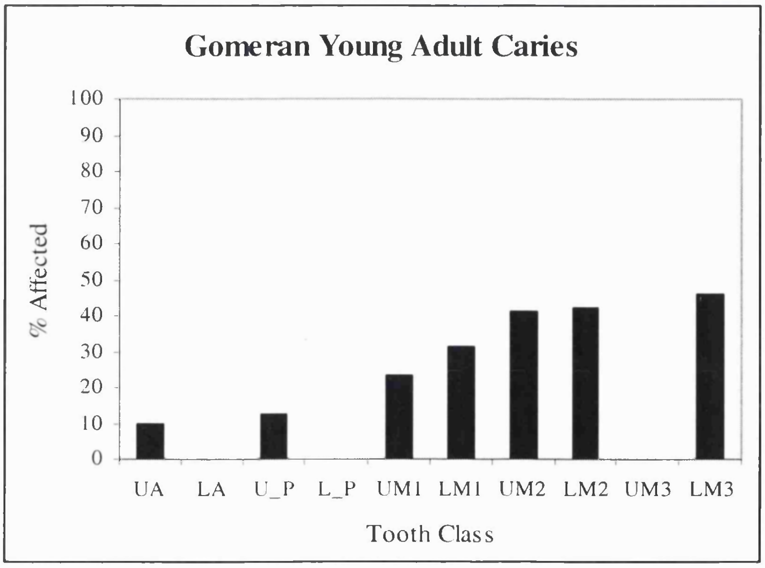

Figure 7.23. Gomeran Young Adult Caries

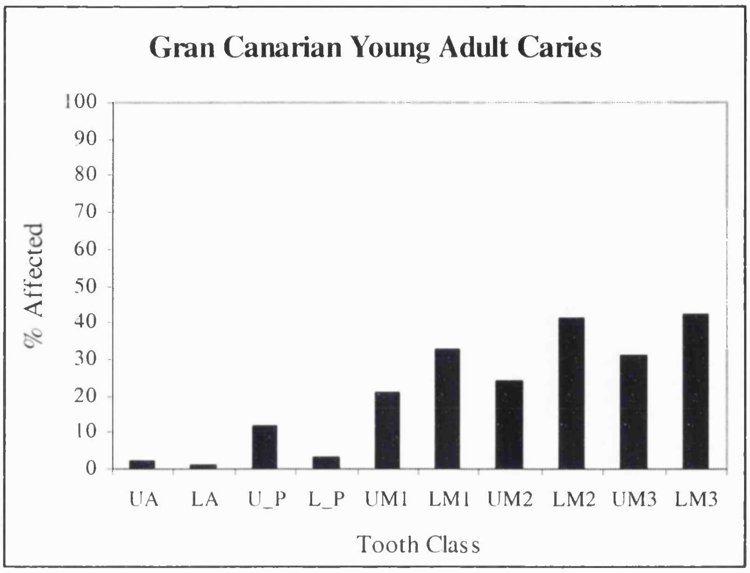

Figure 7.24. Gran Canarian Young Adult Caries

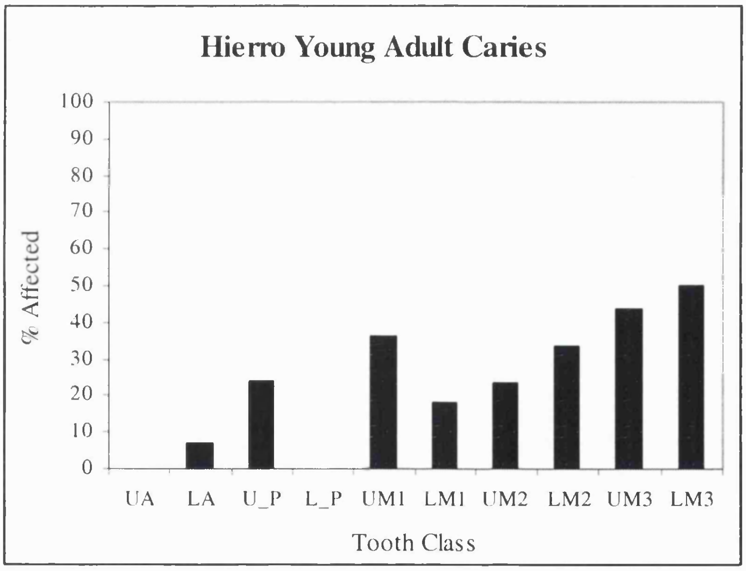

Figure 7.25. Hierro Young Adult Caries

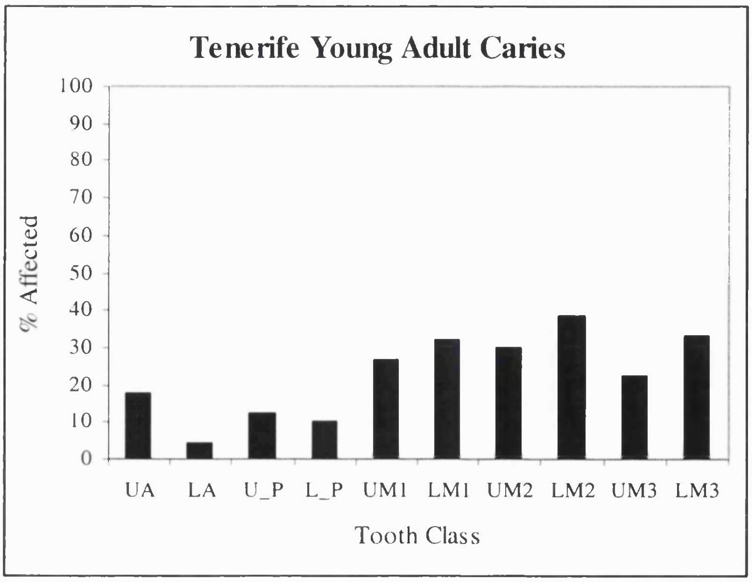

Figure 7.26. Tenerife Young Adult Caries

Caries in young adults was much more common than in the subadult group, with all islands except La Palma (no specimens) and Lanzarote affected to some extent. Fuerteventura's high apparent prevalence of anterior tooth caries (mainly occlusal dentine forms – see below) is mainly attributable to small sample size; the most common form was UM3/LM3 caries. This low general prevalence in the cheek teeth is very different from all other islands, where there is a consistent increase in caries prevalence from the anterior to the postcanine dentition. The highest proportion of affected individuals is difficult to ascertain, as more Tenerife tooth classes were affected throughout the mouth, while Gran Canaria, Gomera and Hierro had a stronger bias towards caritic infestation of the postcanine teeth. In general terms, however, the differences between the islands are not particularly marked.

7.5.3. Older Adult Caries by Island

The same procedure was carried out for the older adult individuals. The raw data are presented in table 7.18, and the individuals islands profiled graphically in figures 7.27 to 7.32.

	U_Ant.	N	U_P	N	UM1	N	UM2	N	UM3	N
Fuert.	16.7%	1/6	28.6%	2/7	16.7%	1/6	0	5	0	2
Gomera	5.3%	1/19	9.1%	3/33	33.3%	9/27	16.7%	5/30	30.4%	7/23
GC	7.4%	10/136	18.8%	41/218	30.7%	46/150	39.1%	54/138	45.6%	41/90
Hierro	16%	8/50	11.6%	10/86	31.3%	14/45	32.4%	12/37	26.9%	7/26
Lanz.	0	6	0	4	0	2	0	2	1	1
La Palma	-	-	-	-	-	-	-	-	-	-
Tenerife	5.3%	3/57	11.4%	10/88	33.3%	21/63	48.3%	29/60	45.2%	19/42
Total	8.4%	23/274	15.1%	66/436	31.1%	91/293	36.8%	100/272	40.8%	75/184
	L_Ant.	N	L_P	N	LM1	N	LM2	N	LM3	N
Fuert.	0	5	0	3	0	6	0	5	25%	1/4
Gomera	14.3%	1/7	30.8%	4/13	57.1%	8/14	25%	3/12	58.3%	7/12
GC	3.1%	4/129	9.9%	19/191	36.4%	48/132	46.2%	54/117	51%	52/102
Hierro	5.6%	2/36	13.5%	5/37	27.3%	6/22	35.7%	1028	38.5%	10/26
Lanz.	0	6	0	4	50%	3/6	0	3	66.7%	2/3
La Palma					50%	1/2	0	2	0	2
Tenerife	4.4%	7/160	14.5%	33/228	40.2%	96/239	43.2%	102/236	42.7%	76/178
Total	4.1%	14/343	12.8%	61/476	38.5%	162/421	41.9%	169/403	45.3%	148/327

Table 7.18. Older Adult Dental Caries by Tooth Class

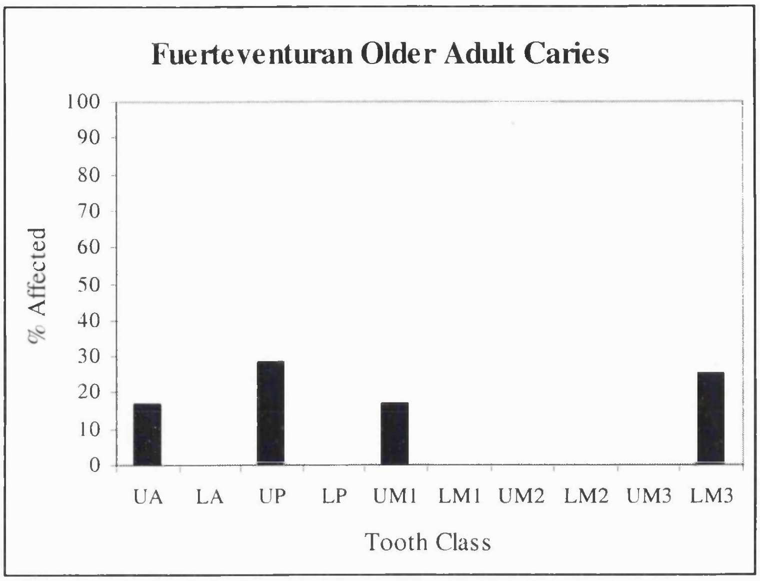

Figure 7.27. Fuerteventuran Older Adult Caries

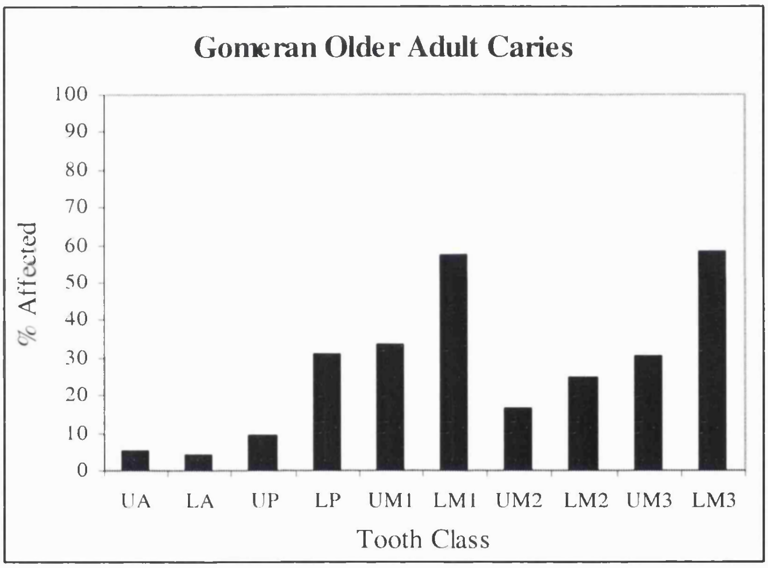

Figure 7.28. Gomeran Older Adult Caries

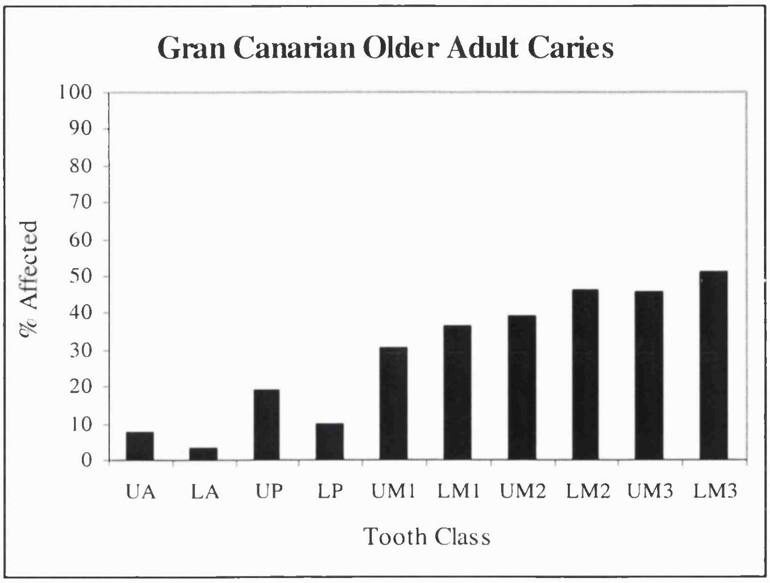

Figure 7.29. Gran Canarian Older Adult Caries

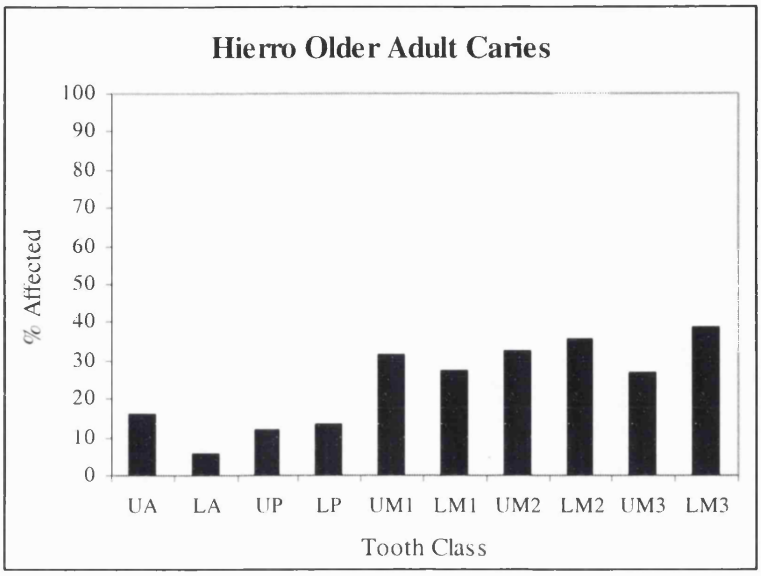

Figure 7.30. Hierro Older Adult Caries

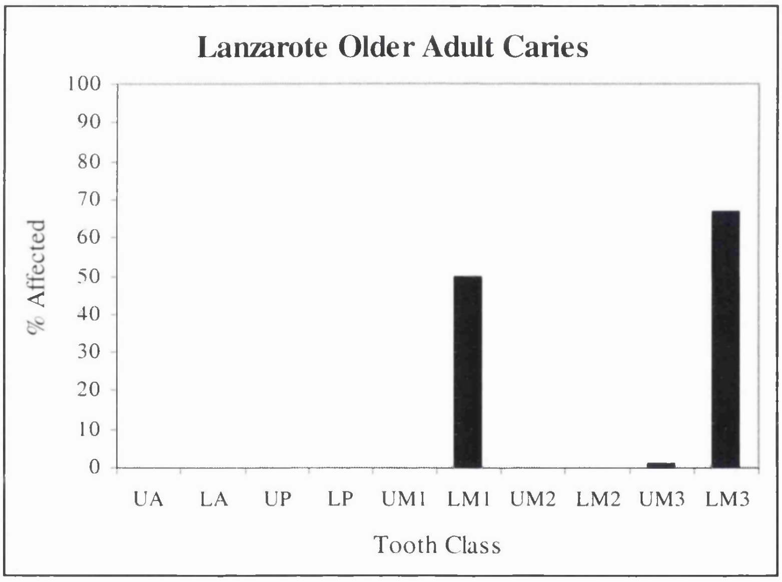

Figure 7.31. Lanzarote Older Adult Caries

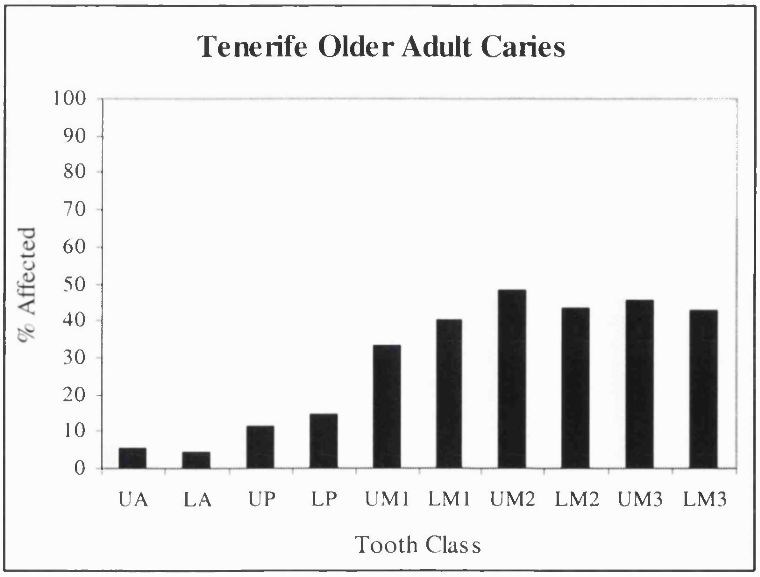

Figure 7.32. Tenerife Older Adult Caries

Older adult caries was generally more common but more unevenly spread in both the dentition and the archipelago than the younger adult group, reflecting high levels of tooth loss in the ageclass (see chapter 9). Fuerteventura displays low numbers (small samples exaggerate prevalence) of upper anterior/premolar and UM1/LM3 caries, while individuals from Gomera, Gran Canaria, Tenerife and Hierro showed a roughly similar pattern of widely distributed (throughout the mouth). Older adults in the Lanzarote sample were affected with low levels of LM3/UM3 and LM1 caries. It should be noted that the two largest samples – Gran Canaria and Tenerife – show a very similar profile, although the extent to which this is a reflection of economic similarity between these two islands, or a true reflection of the profile for the islands as a whole, is debateable.

7.5.4. Mature/Old Adult Caries by Island

The mature and old adult sample (pooled) was assessed as before. The raw data are presented in table 7.19, and then presented graphically in figures 7.33 to 7.37.

	U_Ant.	N	U_P	N	UM1	N	UM2	N	UM3	N
Gran Canaria	11.8%	2/17	11.8%	2/17	16.7%	1/6	54.5%	6/11	25%	1/4
Hierro									100%	1/1
Tenerife	0	2	30.8%	4/13	37.5%	3/8	40%	2/5	33.3%	1/3
Total	10.5%	2/19	20%	6/30	28.6%	4/14	50%	8/16	37.5%	3/8

Table 7.19. Mature/Old Adult Dental Caries by Tooth Class

	L_Ant.	N	L_P	N	LM1	N	LM2	N	LM3	N
Fuerteventura	6.9%	2/29								
Gran Canaria			8.6%	3/35	12.5%	2/16	44.4%	4/9	50%	2/4
Hierro	0	25					0	1	100%	1/1
Lanzarote	3.7%	2/54								
Tenerife			5.3%	1/19	30%	3/10	25%	1/4	80%	4/5
Total			7.4%	4/54	19.2%	5/26	35.7%	5/14	70%	7/10

Table 7.19. Contd. Mature/Old Adult Dental Caries by Tooth Class

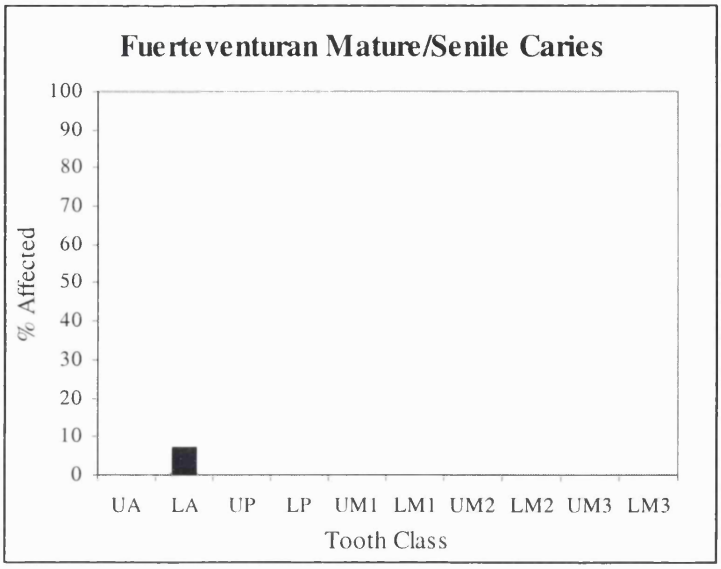

Figure 7.33. Fuerteventuran Mature/Old Caries

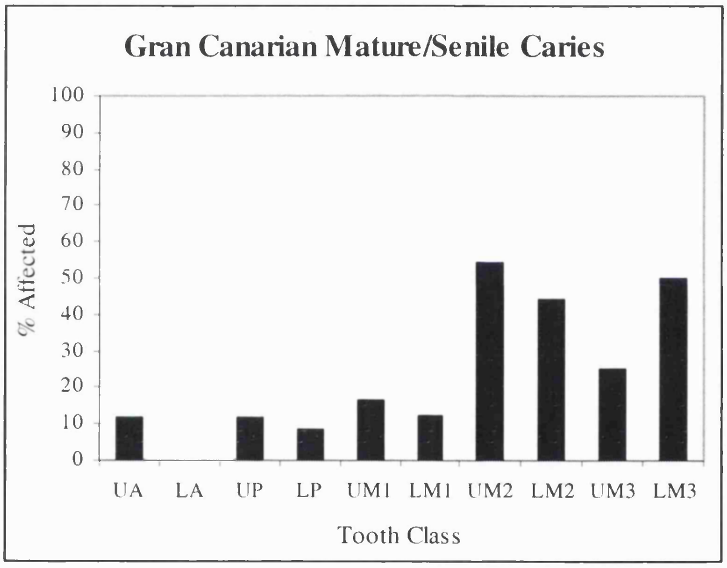

Figure 7.34. Gran Canarian Mature/Old Caries

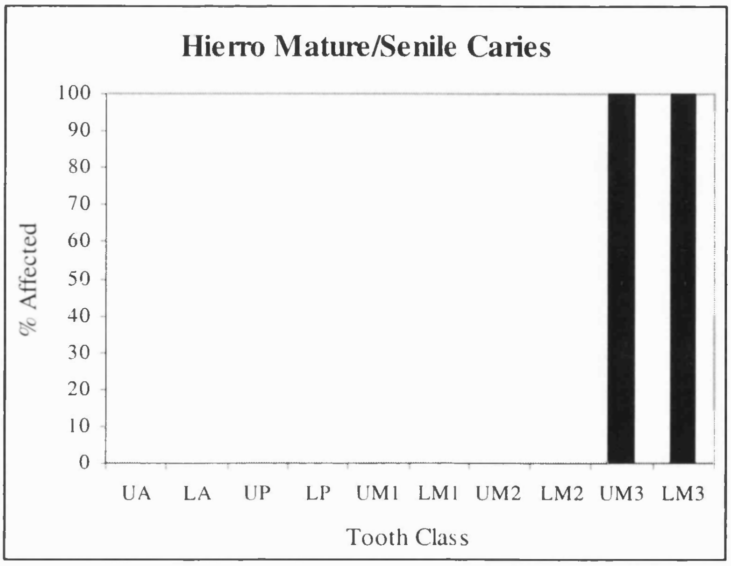

Figure 7.35. Hierro Mature/Old Caries

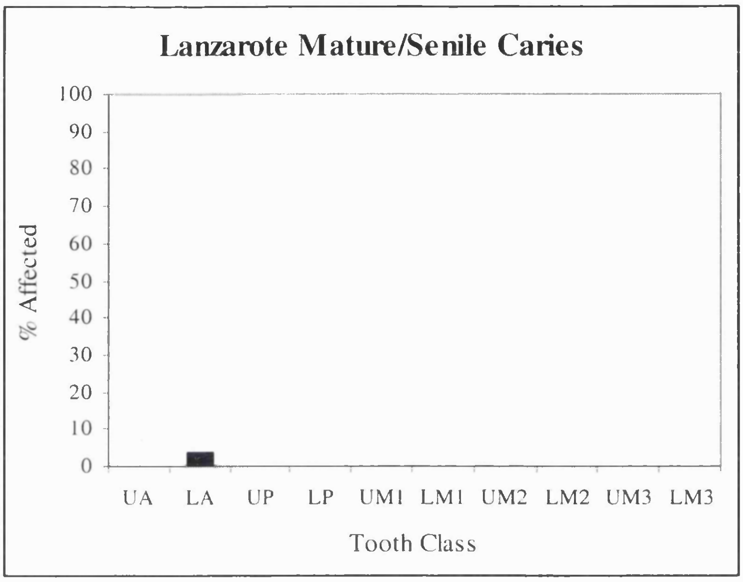

Figure 7.36. Lanzarote Mature/Old Caries

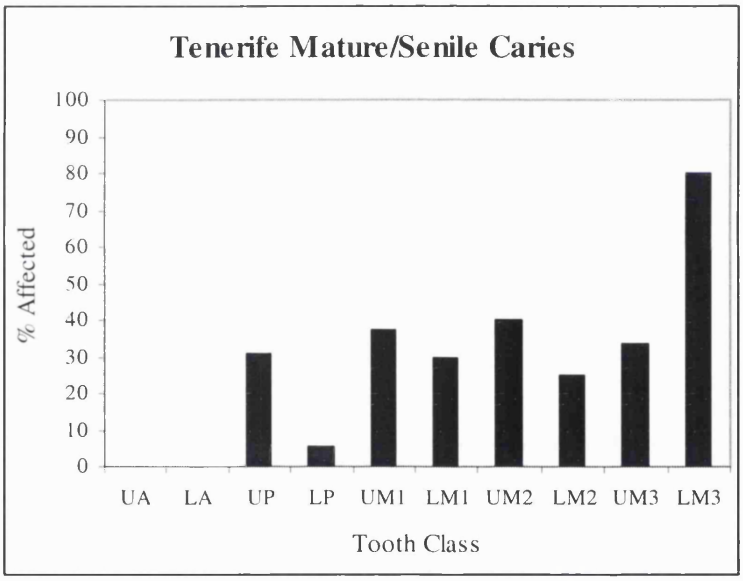

Figure 7..37. Tenerife Mature/Old Caries

Mature/old ageclass caries resembled the older adult sample in that lesions appear in an irregular pattern. Tooth loss was high in all islands, with only Tenerife and Gran Canaria providing relatively large samples of individuals. Lanzarote and Fuerteventura both showed very low prevalence of lower anterior tooth caries, while Hierro showed high peaks of prevalence in upper and lower third molars that is mainly a reflection of small sample size. Gran Canaria and Tenerife were basically similar in terms of prevalence, although the former had a wider spread of caries across the dentition and rising into the second and third molars, while the latter showed higher prevalence in all molars and premolars.

7.5.5. Summary

The patterns in the sample are ambiguous. In general terms, the highest rates of caries by any one ageclass are the central to western islands of the archipelago, especially in Gran Canaria and Tenerife. However, lesions were never exceptionally common, and there are therefore some grounds for claiming at least moderate levels of dietary homogeneity in the archipelago. The dry islands of the eastern archipelago have generally less caries than the other islands and fit least well in the context of the archipelago as a whole. The reasons for this are unclear, although it is possible that the climate and ecology affected the populations' dietary options. The highest levels of diversity are in the younger adult ageclass, with increasing homogeneity in the older and mature/old populations, although results for the latter are sometimes erratic. However, these results are based upon relatively traditional measures of caries, while one of the Hillson system's central strengths is the ability to exceed the relatively crude measures of caries rates in a population by using site-specific and lesion severity scoring methods. The subsequent section deals with this more specific methodology.

7.6 By-Site Analysis by Tooth Class and Age

Having established the general trends for caries prevalence by island and ageclass, it was decided to control for tooth type using the same principles and then to carry out tests in order to establish whether there were any significant differences in the way in which caries appeared in individual samples. The correspondence between increasing age and caries prevalence by specific site (and tooth class) was tested using Chi-Squared tests. The results are summarised in table 7.20.

Tooth Class	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
Upper Anterior	-	-	.246	.577	.486	.880	.678
Upper Premolars	.000	-	.004	.847	.002	.728	.491
Upper M1	.662	.047	.000	.744	.793	.930	.329
Upper M2	.029	-	.000	.317	.003	.052	.936
Upper M3	.395	.600	.120	.730	.083	.798	.739
Lower Anterior	-	-	.790	.027	.664	.881	.876
Lower Premolars	.919	-	.671	.149	.990	.347	.835
Lower M1	.672	.697	.000	.056	.019	.055	.000
Lower M2	.529	.810	.525	.000	.000	.618	.354
Lower M3	.107	.051	.253	.231	.100	.833	.968

Table 7.20. Results of Chi-Squared Tests for Individual Dental Sites by Ageclass and Tooth Class

The pooled sample demonstrated significant relationships between increasing age and caries prevalence per site. Only buccal/lingual (smooth surface) enamel caries demonstrated no such relationship, while the trend was very weak between age and buccal/lingual root caries and pit caries (see 'BL_Surf', 'BL_Root' and 'Pit' colums in table 7.20). The strongest correlation concerned occlusal dentine and contact root forms, confirming the importance of occlusal wear and alveolar retraction (respectively) in exposing these sites to carious activity. The weaker links between the two variables in occlusal surface and contact surface caries may also be partly explained by the high levels of wear in the sample, as these sites were often destroyed fairly early in life through the native Canarians' highly attritional diet.

As the younger and older adult samples demonstrated both the largest sample size and the most marked variability (see above), it was decided to analyse these ageclasses in more detail. The basic prevalence and percentage data are presented in appendix 3. The young adult and older adult data were assessed using Chi-Squared Tests. The extent of penetration – enamel, dentine and pulp – was also considered in these calculations.

Tooth Class	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
Upper Anterior	-	-	.000	.957	.225	.167	.000
Upper Premolars	.683	-	.726	.968	.972	.225	.000
Upper M1	.014	.741	.580	.122	.476	.251	.025
Upper M2	.713		.746	.373	.042	.877	.399
Upper M3	.133	.413	.534	.992	.418	.008	.464
Lower Anterior	-	-	.011	.994	.864	.958	.004
Lower Premolars	.994	-	.989	.020	.725	.000	.015
Lower M1	.306	.812	.000	.933	.005	.980	.984
Lower M2	.647	.996	.172	.789	.340	.490	.554
Lower M3	.349	.098	.697	.865	.084	.964	.128

7.21. Chi-Squared Test Results: Young Adult Caries by Island, Site and Tooth Class

Tooth Class	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
Upper Anterior	-	-	.000	.726	.258	.381	.393
Upper Premolars	.905	-	.105	.904	.879	.319	.065
Upper M1	.850	.022	.737	.904	.92	.000	.001
Upper M2	.884		.322	.388	.136	.97	.947
Upper M3	.102	.180	.825	.986	.297	.186	.676
Lower Anterior	-	-	.011	.927	.877	.972	.573
Lower Premolars	.987	-	.998	.002	.941	.013	.276
Lower M1	.613	.021	.008	.931	.024	.959	.951
Lower M2	.282	.711	.921	.989	.714	.994	.489
Lower M3	.777	.73	.572	.874	.456	.961	.002

7.22. Chi-Squared Test Results: Older Adult Caries by Island, Site and Tooth Class

The young adult group indicates inconsistent patterns when the counts were considered in reference to the null hypothesis (expected counts). UM1 occlusal surface caries was higher than expected in Gran Canaria and Hierro, and lower in Tenerife, Gomera and Fuerteventura. Occlusal dentine caries was low overall, possibly reflecting high attrition rates preventing the cariogenic process affecting dentine wear facets. Within the occlusal dentine caries group upper anterior caries was significantly higher than expected in the Gomera and Hierro group, and lower than anticipated in Fuerteventura and Gran Canaria. A similar pattern was apparent for the lower anterior group, but with a higher Gran Canarian prevalence and a lower Lanzarote prevalence than anticipated. LM1 occlusal dentine caries was higher in Tenerife and Hierro, and low in Lanzarote, Gran Canaria and Fuerteventura. Lower premolar contact surface caries was high in Tenerife and Gomera, and low in Hierro and Gran Canaria. UM2 contact root caries and lower premolar smooth surface caries was higher than anticipated in Tenerife, and lower in all other islands, while UM3 smooth surface caries prevalence was high in Hierro and low elsewhere. Upper and lower anterior, upper and lower premolar and UM1 buccal/lingual root caries were all high in Hierro and Tenerife (except the upper anterior group) and all low in Gran Canaria.

There was less variation overall in the older adult sample. Occlusal surface caries prevalence was homogeneous, possibly a result of high wear rates. UM1 and LM1 pit caries was higher than expected in Gomera, along with lower anterior occlusal dentine caries and LM1 occlusal dentine caries. Tenerife also displayed a high prevalence of the latter caries form, while Hierro is notable for a higher prevalence of upper anterior occlusal dentine caries. Gomera and Tenerife lower premolar contact surface caries prevalence stood out in the sample, and this trend was repeated (with the addition of Lanzarote) in the LM1 contact surface caries figures. UM1 smooth surface caries was rare overall, but was more prevalent in Gomera and Fuerteventura than would have been predicted under the constraints of the null hypothesis. Hierro and Gomera had a high prevalence of buccal/lingual root caries, while both these islands (and Lanzarote) had a higher than predicted prevalence of LM3 buccal/lingual root caries. The significance of these findings is unclear. If it is hypothesised that increased prevalence of occlusal surface caries signals a group with lower occlusal wear and more cariogenic (starch-rich) diet, then Gran Canaria and Hierro come into this category. However, by the same logic one would therefore expect both of these islands to have a higher than average prevalence of similar sites elsewhere in the dentition – such as the contact points and pit forms – and this is seemingly not the case. However, the fact that these forms of caries were fairly widespread may suggest that while diets were relatively homogeneous, the other islands suffered more acute levels of wear than the Gran Canarians and the Hierro group, so that the occlusal sites were worn away before caries could take hold.

Collateral evidence for this comes from the older adult group, in which there was no variability in occlusal surface caries owing to the high levels of wear in this ageclass, and the fact that older adult Gomerans have significantly higher levels of pit caries than other islands. The other indicator of high wear levels is continuous eruption of the teeth, thus exposing the roots to attack by the cariogenic process. Tenerife had significantly higher levels of UM2 contact root caries than the other islands, and with Hierro had higher levels of upper/lower anterior, upper/lower premolar and UM1 buccal/lingual root surface caries. Gran Canaria, by contrast, had very low levels of these conditions. In the older adult group, Hierro and Gomera had a higher rate of buccal and lingual root caries, while both of these islands (and Lanzarote) also had high levels of LM3 buccal root caries. The significance of occlusal dentine caries is unclear; the dentine must have been exposed through occlusal wear in order for the cariogenic process to take hold, but wear must not be so marked as to grind away evidence of such an attack. Evidently, older adults were essentially homogeneous throughout the archipelago, so wear must have evened the field of variability. However, in the younger adult sample, Tenerife, Gomera and Hierro appear to have possessed diets that were both high-wearing and cariogenic. This was known – to a certain extent – for the Tenerife group, judging from earlier studies (Langsjoen 1992). The geographical proximity of Tenerife to Gomera and Hierro suggests that there is some dietary or economic link between these islands.

The final tests involved a more socially-oriented approach, with the specific site data assessed using the sex variable. Due to the ageclass's high variability with regard to carious lesions (see above) and the large sample size of the ageclass, only younger adult specimens were assessed in this test. As before, all results are presented in appendix 3, while a summary is presented below.

	Occ_Surf	Pit	Occ_Dent	Cont_Surf	Cont_Rt	BL_Surf	BL_Rt
UA	-	-	.762	.275	-	-	.215
LA	-	-	-	.391	.547	.405	.395
UP	.007	-	.574	.622	.548	-	.329
LP	.050	-	.336	.907	.295	-	.261
UM1	.023	.369	.610	.961	.422	.395	.490
UM2	.040	-	.213	.309	.015	.567	.413
UM3	.457	.257	.659	.262	.149	.135	.311
LM1	.128	.429	.183	.007	.005	.551	.313
LM2	.032	.018	.132	.102	.215	.246	.833
LM3	.001	.002	.223	.634	.637	.281	.086

7.23. Chi-Squared Test Results for Specific Site Caries by Sex

Females were more frequently affected with occlusal surface caries than men for the upper and lower premolars, UM1-2 and LM2, while men were significantly more affected with LM3 occlusal surface caries. LM2-3 pit caries, LM1 contact caries, and UM2/LM1 contact root caries followed a similar pattern, being significantly higher in females. Over half of these findings are focused on the occlusal surface, which is associated (as noted above) with a low wear, fairly cariogenic diet. However, the occlusal surface is also the first part of the tooth to come into contact with the cariogenic process (i.e. erupt), and as women are slightly precocious regarding dental eruption, this may possibly be partly responsible for females' consistently high caries prevalence when compared to males (although alternative explanations have also been offered: Lukacs 2003). Assuming that wear levels were fairly even between the sexes (see below for further details), the higher female prevalence of contact surface and contact root caries may be attributable to the teeth facing an increased amount of exposure to the cariogenic process. However, even if females develop and erupt their dentitions faster than males (Hillson 1996: 140), the consistency of this caries finding makes one suspect that a dietary difference may be partly responsible. As yet, there are no comparative data, but it is possible that women had some form of dietary regime that differed from that of men on the basis of behaviour and sociality. This is explored further in chapter 10. Finally, the young adult data were processed using a temporal trichotomy system. The results are summarised in table 7.24.

	Occ_Surf	Pit	Occ_Dent	Contact	Cont_Rt	BL_Surf	BL_Rt
UA	-	-	.000	.512	-	-	-
LA	-	-	-	.727	-	.731	.735
UP	.485	-	.103	.087	.664	-	-
LP	.585	-	.315	.757	.735	-	.638
UM1	.765	.708	.600	.680	.459	-	.525
UM2	.808	-	.870	.828	.553	.092	.733
UM3	.633	-	-	.917	.787	-	.705
LM1	.029	.794	.000	.734	.313	.909	.552
LM2	.141	.137	.085	.911	.312	.821	.734
LM3	.505	.030	.041	.352	.365	.678	.525

Table 7.24. CST Results for Young Adult Caries by Tooth Class and Site, By Period

LM1 occlusal surface caries prevalence rose significantly in the late period when compared to the other groups, while LM3 pit caries was significantly more common in the early sample. The late period saw the highest prevalence of LM1/3 occlusal surface caries, which only affected the upper anterior dentition in the middle period sample. All the traits are therefore coronal rather than radical. However, there was little discernible pattern to caries prevalence along this temporal scale. To confirm this, the data were assessed using the dated samples from Tenerife and Gran Canaria. The CST results are presented (tables 7.25 and 7.26).

	Occ_Surf	Pit	Occ_Dent	Contact	Cont_Rt	BL_Surf	BL_Rt
UA	-	-	.061	.676			
LA	-	-		.644			
UP	.435	-	.103	.990	.809		
LP	.811	-	.104	.809	.820		
UM1	.637	.708	.791	.482	.792		.792
UM2	.712	-	-	.848	.651	.046	.877
UM3	.549	-	-	.926	.878		.869
LM1	.095	.426	-	.577	.309		.643
LM2	.527	.126	-	.293	.024		.896
LM3	.779	.751	-	.522	.522		.717

Table 7.25. CST Results for Gran Canarian Young Adults by Period

	Occ_Surf	Pit	Occ_Dent	Contact	Cont_Rt	BL_Surf	BL_Rt
UA			.461	.657			
LA						.421	.864
UP			.334	.200	.537		
LP	.767		.870	.458	.870		.406
UM1			.447	.514	.265		.339
UM2	.670		.611	.473	.362		.351
UM3	.445			.711	.508		.595
LM1	.813	.414	.000	.962	.606	.921	.320
LM2	.216	.631	.053	.868	.566	.837	.801
LM3	.810	.055	.061	.554	.573	.702	.658

Table 7.26. CST Results for Tenerife Young Adults by Period

There was even less basis for claiming temporal discontinuity on the basis of the large island samples alone. The only significant trends were an elevated level of UM2 contact root caries in the early period, an increase in UM2 smooth surface caries in the late period sample (Gran Canaria) and a late-period rise in LM1 occlusal dentine caries prevalence (Tenerife). From this we can deduce that the economy (on these islands at least) seems to have been essentially unchanging through time. A basic summary of the caries findings and some additional considerations is presented below.

- Caries levels in the archipelago were not especially high (see discussion for further details, including economic associations), with some variability between islands. However, it would appear that Canarian diet was spatially more homogenous than heterogenous.

- Lesions were mainly coronal in the subadult and young adult groups, and both coronal and radicular in the older and mature/old samples. This is in response to the removal of occlusal detail through wear (see below) and the exposure of the roots through continuous eruption once the individual passed the mid-twenties. The specific crown sites that were most affected were the occlusal surface and the contact points. The approximal root surfaces were more frequently affected than either the buccal/lingual sides of the root. The least frequently affected sites were the smooth buccal and lingual enamel surfaces; in most cases where this occurred, the enamel had generally been previously breached.

- The sexes were not dissimilar in terms of caries prevalence. However, females were more frequently affected than males in almost all cases where there was a significant difference. The meaning of this is unclear; while precocious female dental eruption, a difference in diet, the relative availability of foodstuffs, or 'snacking' behaviour (Lukacs 2003) may be partly responsible, it is also possible that the elevated female caries levels reflect hormonal fluctuations and associated modifications in oral pH values (Lukacs 2003).

- There was no apparent temporal trend in caries prevalence. It is therefore unlikely that the islands ever saw a major change in economic behaviour during the periods covered by this thesis (although this may change if earlier groups become available for study).

7.7 Alveolar Retraction

Alveolar retraction (exposure) is related to dental wear, oral health, caries and age (Hillson 2001). As stated above, heavily-worn teeth are prone to continuous eruption, while both wear and alveolar retraction correspond with age. The Canarian sample included many specimens with very marked alveolar exposure, often associated with tooth loss, high wear levels and periodontal activity (plates 7.5 and 7.6).

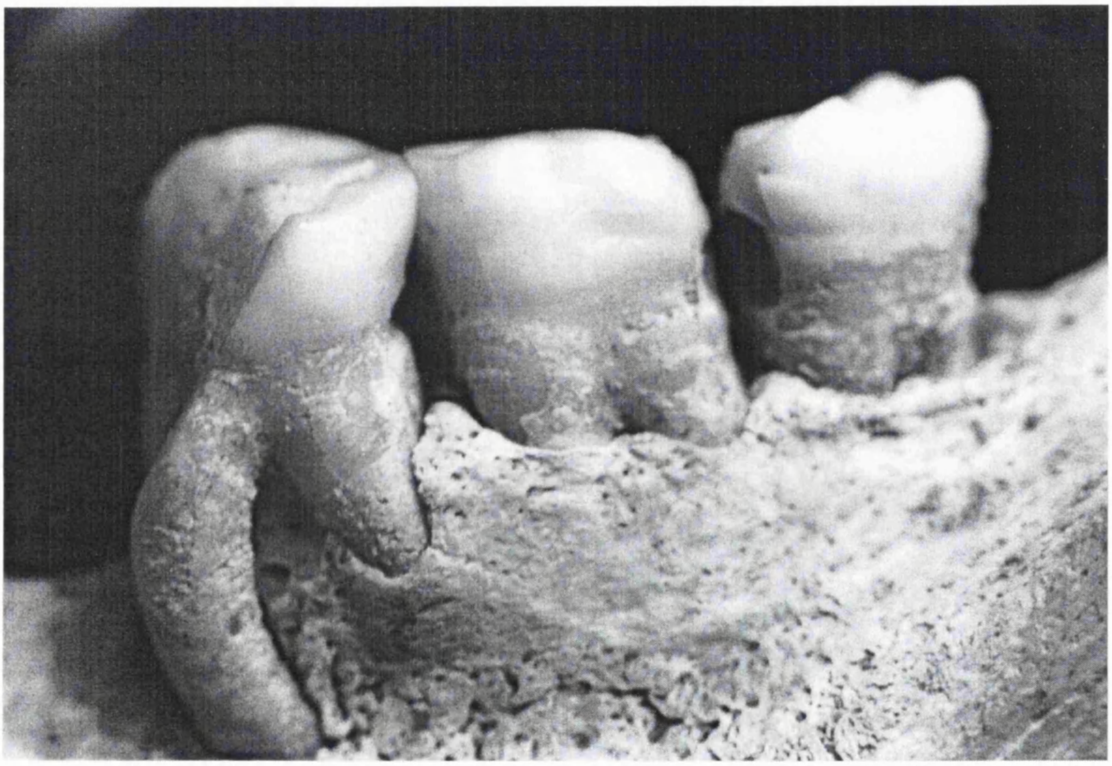

Plate 7.5. Uneven Wear, Alveolar Retraction and Approximal Caries; Tenerife, Younger Adult

The age association was very strong in the Canarian sample, especially in cases of very heavy wear or tooth loss (in which case the roots of adjacent teeth were exposed for almost their full length). In principle, therefore, if age is controlled for, economic differences between populations can be identified. In order to test the tenets of the age association, basic tests were carried out on the population. The Chi-Squared test results are presented in appendix 3; summaries are presented below. Firstly, the teeth were pooled within ageclass, and assessed by island. The results are presented in table 7.27.

	Mesial Root	Distal Root	Buccal Root	Lingual Root
F'ventura	.000	.000	.000	.000
Gomera	.000	.000	.000	.000
GC	.000	.000	.000	.000
Hierro	.024	.000	.000	.041
Lanz.	.000	.000	.000	.000
Palma	-	-	-	-
Tenerife	.000	.000	.000	.000

Table 7.27. Alveolar Retraction – Pooled teeth by Ageclass and Island

There was an extremely strong correspondence with age using this system, for all of the island samples (except for La Palma, for which there was insufficient data). A second test was therefore carried out in order to determine whether the islands were significantly different from one another once the age variable had tested (i.e. analysis by ageclass). To this end, the younger adult and older adult specimens – pooled teeth – were assessed for inter-island patterns (table 7.28).

Tooth Class	Younger Adults	Older Adults
Mesial Root	.000	.000
Distal Root	.000	.000
Buccal Root	.000	.000
Lingual Root	.000	.000

Table 7.28. Alveolar Retraction – Pooled Young and Older Adult Teeth by Island

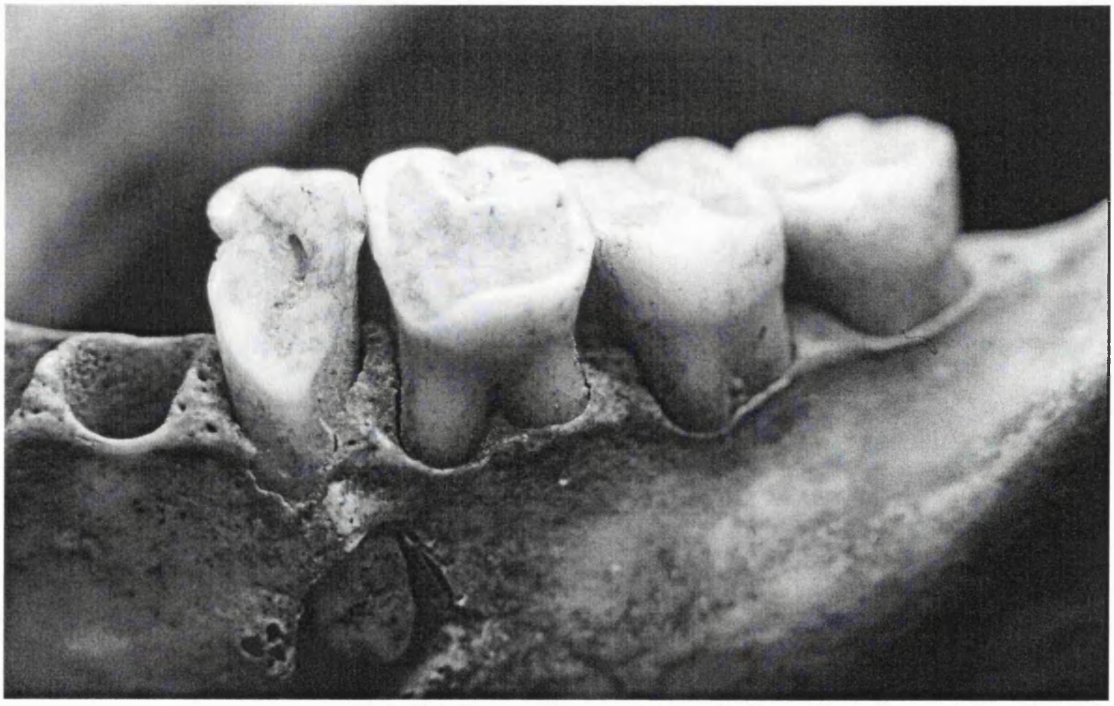

Plate 7.6. Uneven Wear and Alveolar Retraction; Young Adult, Tenerife

The range of alveolar retraction per ageclass was considerable. Younger adult alveolar retraction was typically between 3-7mm, while older adult retraction was usually 6-11mm. The most notable alveolar retraction was observed in the Tenerife and Gomera samples, with less marked alveolar exposure in Gran Canaria, Hierro and the Eastern part of the group. This was repeated for both ageclasses. In order to avoid blurring of the results, LM1 measurements were assessed using the same principle. The results are summarised in table 7.29.

Tooth Class	Younger Adults	Older Adults
Mesial Root	.000	.008
Distal Root	.000	.000
Buccal Root	.002	.000
Lingual Root	.001	.000

Table 7.29. LM1 Alveolar Retraction – Younger and Older Adults by Island

These results echoed the pooled teeth results provided above. The ranges were essentially identical, with buccal and lingual exposure slightly higher than their mesial and distal counterparts. Tenerife and Gomera were consistently highly affected with marked alveolar retraction in both the younger and older adult groups. Gran Canaria, Lanzarote, Hierro and Fuerteventura were consistently low by comparison. In order to provide more easily comprehensible results that provided a more general profile of the alveolar exposure figures, the data were categorised into absent (0-1 mm), normal (2-3mm), moderate (4-7 mm) and high (8mm+). The same tests were run again to ensure that these categories were valid. The by-ageclass results – which are presented in appendix 3 – mirror the earlier study, with highly significant (P = .000) differences between the ageclasses in all four root measurements. In general terms, subadults commence with equal measure of 'none' and 'normal' measurements followed by a marked rise and predominance of 'normal' measurements in young adulthood, declining into older and mature adulthood. The total amount of 'marked' scores does not rise much through increasing age, but comes to constitute a higher proportion of the total tooth assemblage as *ante-mortem* tooth loss erodes the sample. The young and older adult ageclass LM1 alveolar retraction data were re-examined (by island) using this system.

Tooth Class	Younger Adults	Older Adults
Mesial Root	.000	.000
Distal Root	.000	.006
Buccal Root	.152	.001
Lingual Root	.000	.000

Table 7.30. LM1 Alveolar Retraction Using Breakpoints – Younger and Older Adults by Island

With the exception of buccal root exposure – which was elevated in all islands – there was significant variability within the island group for both the younger and older adult ageclasses. Gran Canaria consistently fell below the strictures predicted by the null hypothesis for all tests in both ageclasses. Tenerife exceeded these expectations, while Lanzarote was strongly affected in 2/3 of the younger adult tests (Gomera 1/3) and Gomera and Lanzarote were affected in 3/4 older adult group. This test therefore partly confirms and contradicts the test outlined above, as Lanzarote was not previously grouped with Tenerife and Gomera.

This therefore provides some tentative support for the assertion of extensive alveolar exposure and root surface caries (see above) for the islands of Tenerife and Gomera. The exceptional nature of this islands' alveolar exposure profile is surprising, as many of the other islands have very heavily worn teeth that one would expect to have been accompanied by high levels of alveolar exposure. If one relates this finding to the caries findings above, it is interesting to note that the two islands – Hierro and Gran Canaria – with high levels of occlusal surface caries (and possibly a cariogenic diet) never had high levels of alveolar exposure. One would therefore hypothesise that the populations of Tenerife and Gomera were high-wear, with relatively non-cariogenic diets, while Gran Canaria and Hierro were low wear and possessed highly cariogenic diets. Lanzarote and Fuerteventura are hard to interpret. However, it would appear from the current evidence that Fuerteventuran diet was not particularly cariogenic, and that the teeth do not appear to have suffered the same degree of wear and continuous eruption as experienced on Tenerife and Gomera (and, to a certain extent, Lanzarote).

In order to examine the patterning more closely, the younger and older adult specimens, which showed the strongest variability in the standard alveolar exposure figures (above) and were also the largest available grouping (thus increasing sample size) were assessed to explore approximal and buccal/lingual root exposure patterns. The variables tested included young/older adults by sex, young/older adults by period, young/older Gran Canarian adults by period and young/older Tenerife adults by period. Mesial and lingual exposures of LM1 were used for this test. As before, the results are presented in appendix 3 and a summary is presented below.

	Mesial	Lingual
Young_Sex	.403	.948
Older_Sex	.434	.427
Young_Period	.093	.550
Older_Period	.304	.085
Young_GC_Period	.017	.431
Young_Ten_Period	.137	.673
Older_GC_Period	.056	.051
Older_Ten_Period	.899	.148

Table 7.31. LM1 Alveolar Exposure by Sex and Period

As shown in table 7.31, there was little temporal or inter-sex differentiation in terms of alveolar exposure prevalence. The only significant finding was the Gran Canarian young adults' mesial exposure figures, which indicated a difference between the early and the middle/late group in possessing higher levels of exposure in the early group than either of the later ones. The main points to have derived from this study are presented below.

- The alveolar exposure figures therefore resemble the caries findings in not demonstrating any marked temporal or inter-sex trend. There was a very strong correlation with age, which in turn corresponds well with the wear figures (as these were originally used to age the specimens; see chapter 4 and 7.8).

- The highest diversity in alveolar exposure was between the islands. If the link between age, wear and alveolar exposure is as strong as it seems to be (see above), then the archipelago subdivides into Tenerife and Gomera (high-wear) and Gran Canaria and Hierro (low wear). Lanzarote and Fuerteventura are perhaps intermediate between these two poles.

In order to more fully explore this phenomenon, which is of course related to oral health, dental wear rates were assessed for the same groups.

7.8 Wear Rates

Wear rates are bound up with caries and root exposure, and by extension with more general issues such as economic regime. It was therefore necessary to discuss the general wear patterns and rates in the Canarian archipelago. Over all, wear was very marked in the Canarian sample, thus explaining the low prevalence of occlusal hypoplasias (see chapter 8) and occlusal caries in many of the island populations. Dentine was often exposed in late subadulthood, and the pulp cavity exposed in younger/older adulthood. Wear was often highly irregular, with higher lingual than buccal wear on the maxillary teeth and the exact reverse on the lower dentition. Standard wear scoring systems have not been configured to record non-occlusal wear, which has to be recorded on an individual-specific basis as there is such a wide range of variability in paramasticatory activity (Buikstra and Ubelaker 1994: 48). It was therefore impossible to record the full scope of unusual wear patterns in the sample, notable amongst which was the 'polishing' of mesial and distal alveolar roots that implies some paramasticatory activity – possibly preparation of leather or other fibrous material. This pattern was also found on the buccal surfaces of the teeth (especially on Tenerife) where both the enamel and the root had been severely worn away. The exact implications of this and other wear patterns (including inter-proximal grooves, possibly as the result of toothpicks use or the manipulation of fibrous materials) cannot be addressed in the present study, but do provide avenues for further investigation and add to our appreciation of the data discussed in this project.

It is possible to argue that assessing differences in dental wear on specimens that were aged using this same variable, essentially amounts to a circular argument. However, the fact that the "wear rate" of different samples were calculated by island or by site (where samples permitted) means that differences in wear are 'real' entities, and that the dental wear data could potentially add a great deal to the dental caries and alveolar retraction studies. An array of tests was therefore carried out on the wear data (see below).

There was considerable variability in occlusal wear rates, although Tenerife stood out as being a particularly high wear island, while Gran Canaria was probably the least worn of the sample. The wear categories (see table 4.8 [Smith 1984] and accompanying text) were simplified from a 0-8 scale (+ '10' for fractured/damaged teeth) using the breakpoints listed in table 7.32, so that more general wear profiles could be derived from the wide range of results in the project. The validity of these groupings was confirmed by running a CST (Chi Squared Test) on these categories against the ageclasses. LM1 and UM1 were used as 'index' teeth, as eruption rates for other teeth are often unpredictable (Hillson 1996: 123), and because the present study cannot fully explore the issue of dental wear with the required depth. The data are presented in appendix 3 and summarised in table 7.33.

Category	Subsumed Codes
Absent/Light	0, 1, 2
Medium	3, 4, 5
High	6, 7, 8
Fractured	10

Table 7.32. Wear Rate Categories

Tooth Class	Pearson Chi-Square
LM1	.000
UM1	.000

Table 7.33. Chi-Squared Test Results for Wear by Ageclass

The groupings were thus shown to be valid, and were therefore used for more complex analyses. It was decided to assess the inter-island trends in wear rates, assessing each ageclass separately (see table 7.34).

	LM1	UM1
Subadult	.942	.211
Younger Adult	.000	.000
Older Adult	.000	.001
Mature Adult	.000	.966

Table 7.34. Chi-Squared Test Results for Wear Within Ageclass by Island

Plate 7.7. Young Adult Hierro LM1-3 Wear.

As noted, both the subadult scores are essentially homogeneous between islands, while the mature adult group produced rather erratic results due to high levels of tooth loss, which made the inter-island CST results non-significant. Younger adult high LM1 wear was particularly dominant in Hierro and Tenerife, while Gran Canarians and other islanders fell predominantly into the medium wear category. Fuerteventura is the only island that had a substantial absent/light wear component. UM1 wear patterns echo the LM1 results. Gran Canarian wear figures were low, with most specimens in the low/medium categories, while Tenerife, Gomera and Hierro specimens were substantially more worn for their ageclass. Older adult LM1 figures were all medium and high. The major difference is between Gran Canaria/Fuerteventura and the other islands. The older adult UM1 figures echo these results, with significant levels of high wear in Tenerife, Hierro and Lanzarote, and lower levels for Gomera, Fuerteventura and Gran Canaria. The LM1 mature adult figures echo the younger groups, with dominant high wear in Tenerife, Gomera and Hierro (and La Palma, so far as can be determined), and far more even results for Gran Canaria. The UM1 mature adult figures were not significantly variable between islands, with the vast majority of individuals in the high (or fractured) wear category.

The data were used to assess whether variability in wear rates and levels were prompted by temporal or gender factors, and by period when considered within individual islands. LM1/UM1 data were examined for young adults and older adults, using all these traits. The results of these tests are presented in appendix 3, and are summarised in table 7.35.

	UM1	LM1
Younger Adults by Period	.013	.255
Older Adults by Period	.718	.050
GC Younger Adults by Period	.002	.863
Tenerife Young Adults by Period	.010	.510
GC Old Adults by Period	.453	.123
Tenerife Old Adults by Period	.876	.297
Young Adults by Sex	.629	.307
Older Adults by Sex	.963	.175

Table 7.35. CST Results for UM1/LM1 Wear Rates by Period and Sex

UM1 wear in the younger adult sample was higher in the late period than the early or middle group, and this was also true of the LM1 wear levels for older adults. When considered by single island trajectory, the young adult UM1 Gran Canarian data and both the UM1 and LM1 young adult Tenerife and Gran Canarian data also followed this trend, with increased wear levels in the late samples. As can be seen from table 7.35, sex had no apparent bearing on the amount of wear suffered by younger or older adults.

The significance of these findings is unclear. It is apparent that the wear figures complement the caries and alveolar exposure figures in that marked wear is usually accompanied by a low level of occlusal caries and a higher level of root surface caries, brought about by exposure of the roots to the cariogenic process. Root exposure is mainly brought about by mechanical attrition of the teeth (although caries and gum disease are also involved), which is therefore the differentiating factor in Canarian diet. If – as previously hypothesised (Langsjoen 1992) – the high levels of wear in Tenerife were caused by mineral inclusions in flour brought about by grinding the cereals in stone mortars, it is surprising that the same is not true of Gran Canarian specimens, as there is ample archaeological evidence for this method of corn reduction on the island. It is possible that the petrology of the grinding materials used varied between islands, or alternatively that the nutriment was subsequently consumed or processed differently. The light wear on Fuerteventura may be explicable in terms of the difficulties of cereal agriculture on this rather desiccated island, although the high wear on Lanzarote – which has a similar climatic regime – is less easy to explain. It is possible that the proportion of cereal produce – and therefore the amount of mineral inclusions – was slightly higher in Lanzarote, although historically and archaeologically the eastern islands are known to have had a primary reliance upon goats/sheep and their secondary products.

Wear was therefore found to have varied significantly between islands, and to have been more marked in the late period than earlier groups. If Langsjoen's hypothesis positing mineral inclusions from cereal reduction as a major cause of dental attrition is correct, then this trend may reflect a move towards increased consumption of cereal produce through time. However, the fact that dental caries does not support this trend makes large-scale economic transitions unlikely. There were no significant differences between the sexes when the pooled data in distinct ageclasses were considered. This is at odds with the caries data that supported an increased caries rate in females, and may lend credence to Lukacs' (2003) argument that hormonal factors and salivary pH has more effect on dental pathology than cultural behaviour. Fully appreciating wear patterns and severity is only possible in situations where multifactorial ageing systems can be deployed. While all possible controls have been put in place to control for wear rates, it is not possible to carry out a fully comprehensive analysis of wear in a study where it has been used to age most of the specimens, so this area of research must await new materials that are better suited to the task.

7.9 Deciduous Dental Pathology

Deciduous teeth were assessed in the same manner as the adult dentition, as the manner in which the deciduous dentition is affected by the carious process indicates the dietary proclivities of the population in the first five years of life. The sample was much smaller than for the adults, and was limited almost entirely to postcanine teeth. It should be noted that the amount of detail entered into here does not address the potential importance of these specimens. However, it serves as a preliminary introduction to the material and supplements the adult data presented above. The basic percentage and prevalence data for younger and older subadults (see chapter 5) are presented in appendix 3, and are summarised in tables 7.36 and 7.37.

	LDM1	LDM2	UDM1	UDM2
Occlusal Surface	7.6% (2/26)	10.7% (3/28)	0 (0/15)	3.8% (1/27)
Pit Caries	50% (1/2)	13.3% (2/15)	0 (0/2)	0 (0/4)
Occlusal Dentine	0 (0/20)	0 (0/19)	0 (0/20)	0 (0/20)
Contact Surface	0 (0/27)	11.5% (3/26)	5% (1/20)	10.7% (3/28)
Contact Root	0 (0/27)	0 (0/28)	9.5% (2/21)	3.4% (1/29)
Smooth Surface	0 (0/26)	3.6% (1/28)	0 (0/20)	0 (0/28)
B/L Root	0 (0/26)	0 (0/28)	0 (0/21)	3.4% (1/29)
Pooled	1.9% (3/154)	5.2% (9/172)	2.5% (3/119)	3.6% (6/165)

Table 7.36. Younger Subadult Caries – Pooled Islands

	LDM1	LDM2	UDM1	UDM2
Occlusal Surface	-	-	-	-
Pit Caries	-	-	-	-
Occlusal Dentine	-	-	-	-
Contact Surface	-	-	-	-
Contact Root	0 (0/1)	50% (1/2)	0 (0/1)	0 (0/4)
Smooth Surface	-	-	-	-
B/L Root	0 (0/1)	0 (0/2)	0 (0/1)	25% (1/4)
Pooled	0 (0/2)	33.3% (1/3)	0 (0/2)	12.5% (1/8)

Table 7.37. Older Subdult Caries – Pooled Islands

Prevalence was low overall. The total numbers of lesions per tooth are presented in the 'pooled' category. The second molars were invariably more affected than the first molars, and the lower molars more affected than the upper molars. Wear levels were quite high, although the relatively high prevalence of occlusal surface caries seems to suggest that food was not – on the whole – as abrasive as that consumed by adults. The high apparent prevalence of younger subadult LDM1 pit caries and older subadult LDM2 contact root caries is attributable to small sample size. Most of the individuals dated from the middle period of Tenerife and Gran Canaria, so it was decided not to assess chronological issues. Basic inter-island comparisons within age classes (younger vs. older subadults) were carried out using Chi-Squared tests. The results are presented in tables 7.38 and 7.39.

	Occ. Surf.	Pit	Occ. Dent.	Cont._Surf.	Cont. Rt	BL Surf.	BL Rt.
LDM1	.865	.157	-	-	-	.601	.933
LDM2	.880	.099	-	.587	-	-	-
UDM1	-	-	-	.873	.900	-	-
UDM2	.943	-	-	.979	.516	-	-

Table 7.38. Younger Subadult Occlusal Caries by Island

	Occ. Surf.	Pit	Occ. Dent.	Cont._Surf.	Cont. Rt	BL Surf.	BL Rt.
LDM1	-	-	-	-	-	-	-
LDM2	.157	-	-	-	-	-	-
UDM1	-	-	-	-	-	-	-
UDM2	-	-	-	-	-	-	.505

Table 7.39. Older Subadult Occlusal Caries by Island

As is apparent from the Chi-Squared test results, there was no variability in the distribution of carious lesions by island in either of the subadult ageclasses. On the basis of this, one would hazard the opinion that subadult diet – as intimated by the lack of variability in the sample of adult teeth (see above) – was relatively homogeneous. However, the database is too limited to provide a firm basis for hypothesising further about young/older subadult diet, especially because studies of alveolar exposure and wear are inappropriate for deciduous teeth in light of the continuous eruption and shedding of baby teeth, and the fact that the wear system employed for the present study was not designed with deciduous teeth in mind (Smith 1984).

7.10 *Ante-Mortem* Tooth Loss (AMTL)

Both wear and caries can affect tooth integrity, so *in vivo* tooth loss is the final category of these oral health indicators with the potential to elucidate ancient diet. Once the tendency for tooth loss to increase with age has been accounted for, the spatial and chronological aspects of dietary change can be explored. The data were analysed so that all surviving teeth and *post-mortem* teeth were scored as ‘tooth present’, while all resorbed or partly resorbed sockets were scored as ‘tooth absent’. Firstly, the basic trend – that tooth loss levels increase with age – was demonstrated using pooled teeth and pooled islands. All workings are presented in appendix 3, and are summarised in figure 7.38.

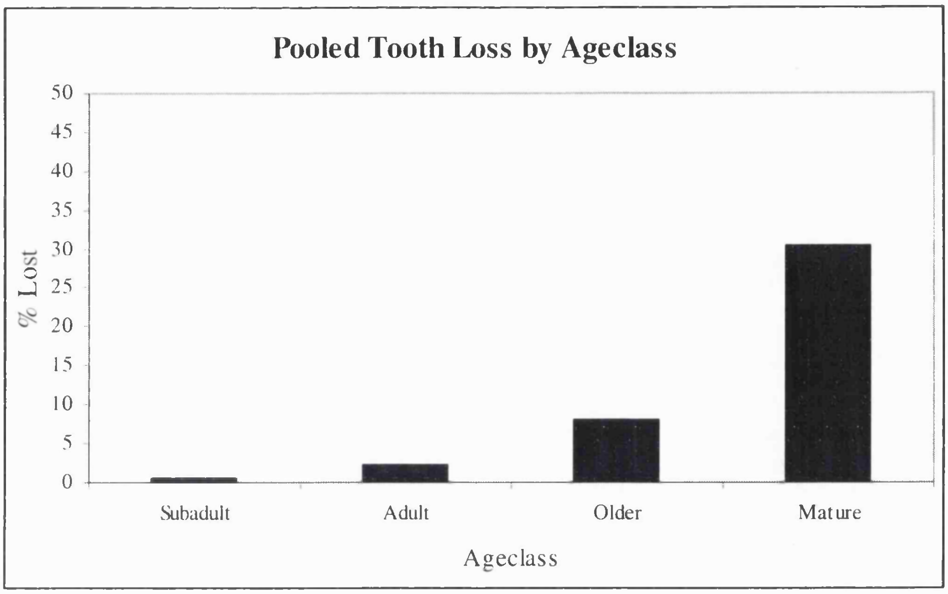

Figure 7.38. Ante-Mortem Pooled Tooth Loss by Ageclass

Unsurprisingly, the Chi-Squared test results are highly significant (P = .000). Tooth loss was particularly exaggerated between the older and mature adult ageclasses (see Plate 7.8), as the latter – at 30.5% of all teeth lost – substantially exceeds the expected count figure generated under the tenets of the null hypothesis (i.e. homogeneity between samples).

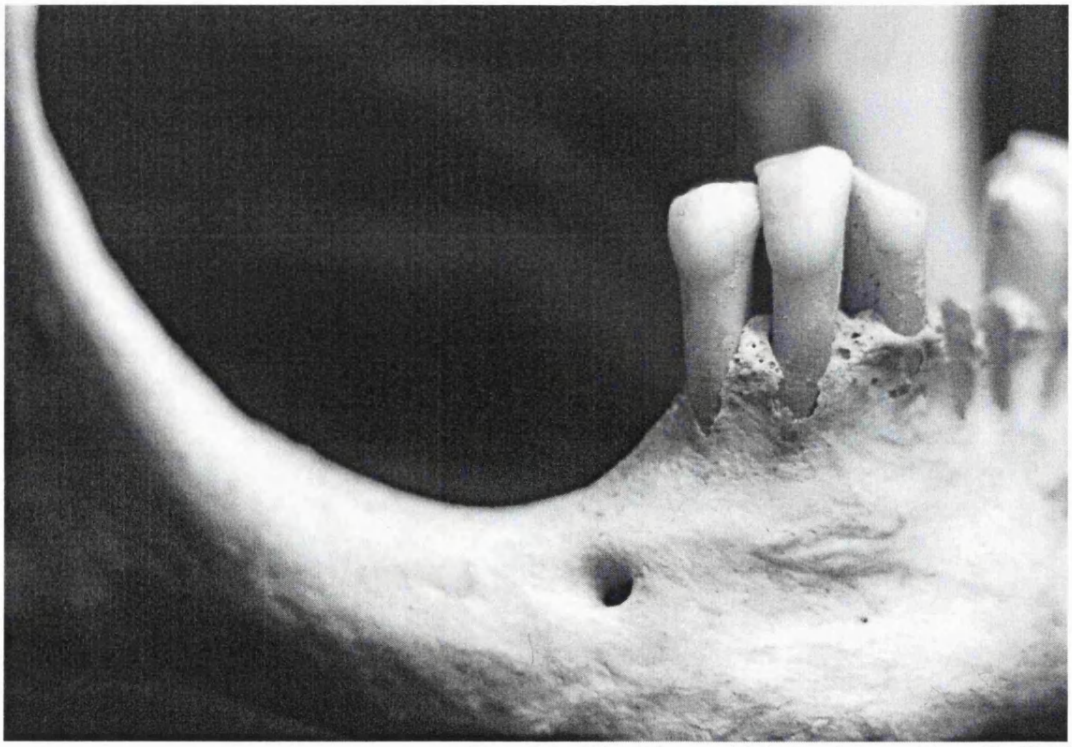

Plate 7.8. Older/Mature Adult Tooth Loss; Tenerife (ICPB)

The younger and older adult samples were tested for variability by sex and by period, as these samples provided the largest samples and widest representation in the archipelago. A summary is presented in table 7.40. Significant results ($P \leq 0.05$) are highlighted.

Factor	Younger Adults	Older Adults
Sex	.815	.631
Period	.135	**.000**

Table 7.40. Younger and Older Adult Pooled Tooth Loss Variability by Sex and Period

Inter-sex tooth loss did not vary significantly. However, in relation to the total sample size for the period, the early group was more severely affected by *ante-mortem* tooth loss (14.7%) than would have been expected under the tenets of the null hypothesis. A basic inter-island test was carried out for both young (figure 7.39) and older (figure 7.40) adult groups, to assess if there was any spatial variability in the patterns of tooth loss. The basic data are presented in table 7.41.

Island	Younger Adults	N	Older Adults	N
F'Ventura	1.6%	4/250	3.6%	4/111
Gomera	1.0%	3/293	5.8%	18/308
GC	1.9%	36/1888	8.7%	173/1997
Hierro	3.8%	12/318	12.1%	57/471
Lanz.	10.5%	4/38	14.3%	9/63
Tenerife	2.5%	76/3051	6.9%	154/2243

Table 7.41. Younger and Older Adult Pooled Tooth Loss Variability by Island

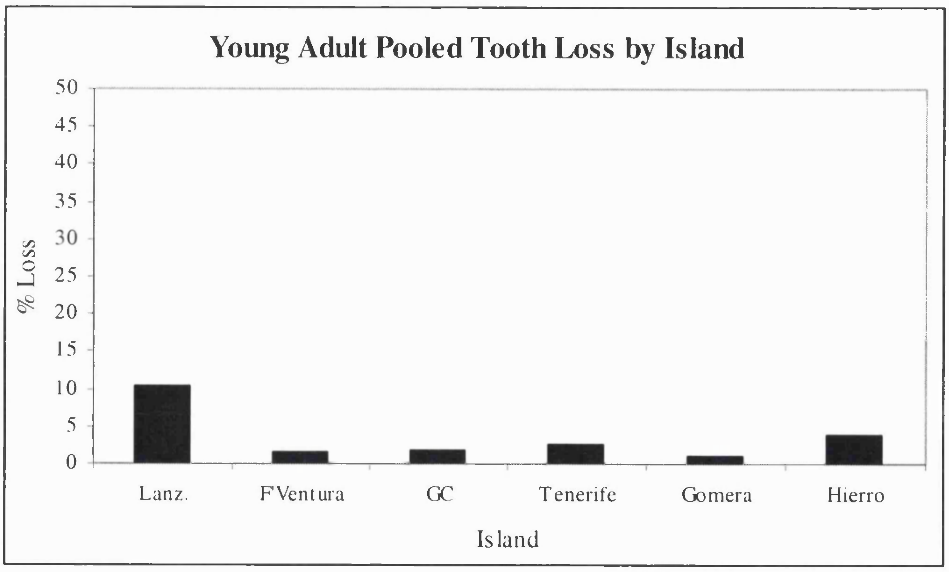

Figure 7.39. Young Adult Pooled Tooth Loss by Island

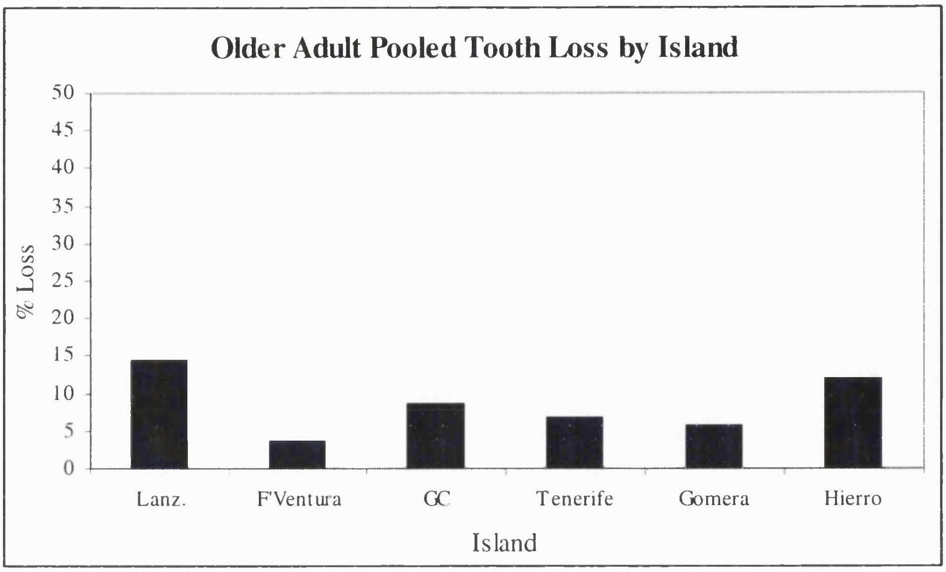

Figure 7.40. Older Adult Pooled Tooth Loss by Island

In both cases, tooth loss was fairly marked. Total figures were 2.3% for the younger adults and 8% for the older adults. Lanzarote (10.5% and 14.3%) and Hierro (3.8% and 12.2%) were the two most strongly affected islands in both age classes, followed by Tenerife then Gran Canaria in the younger adult ageclass (2.5% and 1.9%), and Gran Canaria then Tenerife (8.7% and 6.9%) in the older adult group. Both ageclasses were tested using Chi-Squared tests. The results are presented in table 7.42.

Ageclass	Pearson Chi-Square
Younger Adults	.000
Older Adults	.002

Table 7.42. Chi-Squared Results: Younger/Older Adult Pooled Tooth Loss by Island

As can be seen, this variability in both the younger and older adult samples is highly significant when considered on an inter-island basis. However, the figures do not fit the earlier profile as determined through caries and wear patterns. If tooth loss were caused through caries, the high caries islands (Gran Canaria; Hierro) should have a higher tooth loss prevalence by ageclass. Equally, if caused by wear and continuous eruption, Tenerife and Gomera ought to be the most strongly affected islands. However, the fact that tooth loss can occur through other means than mechanical (attritional) and chemical (cariogenesis) should also be considered. A prominent example includes the breakage and loss of teeth through behavioural (socio-culturally induced) or accidental damage, and there is ample evidence to suggest that Canarian lifestyle included a highly active – and indeed confrontational – component. Evidence for inter-personal contact is explored further in chapter 9, but in the present case it was decided to run some further inter-island tests, controlling for sex, in order to explore the patterning of tooth loss on a more social scale. The younger and older adults were assessed in this manner. The results are presented in appendix 3 and are summarised in tables 7.43 and 7.44.

Island	Males	N	Females	N
F'Ventura	1.8%	4/218	0	0/32
Gomera	1.3%	3/239	0	0/54
GC	1.7%	16/968	2.3%	20/876
Hierro	3%	7/231	5.7%	5/87
Lanz.	13.3%	4/30	0	0/8
Tenerife	2.7%	62/2328	1.8%	12/657

7.43. Younger Adult Pooled Tooth Loss by Island and Sex

Island	Males	N	Females	N
F'Ventura	0	0/28	4.8%	4/83
Gomera	4.9%	9/182	7.1%	9/126
GC	9.3%	90/965	8.1%	78/968
Hierro	14%	42/300	8.8%	15/171
Lanz.	14.9%	7/47	12.5%	2/16
Tenerife	6.8%	100/1473	7.1%	50/702

7.44. Older Adult Pooled Tooth Loss by Island and Sex

Younger males were more frequently affected on Fuerteventura, Gomera, Lanzarote and Tenerife, and younger females on Gran Canaria and Hierro. Older males were more strongly affected on Gran Canaria, Hierro and Lanzarote, and older females on Fuerteventura, Gomera and Tenerife. These data were tested for the strength of trends; the results are summarised in table 7.45.

Ageclass	Males	Females
Younger Adults	.001	.168
Older Adults	.000	.802

7.45. Chi-Squared Test Results for Tables 7.43 and 7.44

While females were essentially homogenous in terms of tooth loss across the archipelago in both ageclasses, the male sample was significantly variable at the P = .001/.000 level. This therefore implies that there was a relatively widespread dietary difference between the sexes, or that some other form of behaviour is responsible for aggravated tooth loss in males and that this behaviour had a substantial spatial (i.e. inter-island) component. As there was some variability in dental pathology (caries), suggesting dietary variability (although completely different diets are not indicated), it is the current author's belief that the latter scenario is more likely. While the behaviour in question is uncertain, it is possibly linked to the very active lifestyle that Canarian males are believed to have led, and is also possibly concerned with cranial trauma (see chapter 9 for further details). Lastly, it was decided to assess which teeth had the most variable loss levels in the archipelago, in order to judge if tooth loss was contingent upon location. Younger, older and mature adults were assessed in this manner.

Tooth	Younger Adults	Older Adults	Mature Adults
LC	.624	.940	.137
LI1	.829	.522	.064
LI2	.944	.742	.947
LP1	.001	.753	.002
LP2	.000	.293	.381
LM1	.012	.122	.197
LM2	.310	.217	.747
LM3	.000	.051	.441
UC	.901	.021	.155
UI1	.498	.944	.136
UI2	.848	.088	.128
UP1	.454	.647	.001
UP2	.608	.647	.007
UM1	.011	.026	.546
UM2	.847	.023	.021
UM3	.823	.004	.043

Table 7.46. Chi-Squared Tests Results for AMTL Variability by Tooth and Island

Younger adult tooth loss was highly variable. Hierro and Fuerteventura both had high LM1 and UM1 loss, Gomera had high LM1 loss, Gran Canaria had high LM3 and LP2 loss and Tenerife stood out with high loss levels for LP1 and LM1. Older adult tooth loss was notable in Lanzarote (UM1, UM2 and UM3), Hierro (UM1, UM2 and UM3) and Gomera (UC). In all cases, Gran Canarian prevalence was higher than that of Tenerife. Mature tooth loss was particularly strong in LP1 (Fuerteventura and Tenerife), UM2 (high in Gran Canaria, Hierro, Fuerteventura and Tenerife, and low in Gomera), UM3 (Gran Canaria, Hierro, Lanzarote, Fuerteventura, and low in Gomera) and UP1/2 (Gomera, Fuerteventura, Lanzarote and Gran Canaria, and low in Hierro). Intuitively, one would expect tooth loss brought about by conflict or accidental breakage to be in the anterior part of the mouth, but of the teeth analysed only UC (Gomeran older adults) and the lower premolars (Gran Canarian and Tenerife younger adults) are anterior. In light of the high caries rate for Gran Canaria, it is possible that the LM3 loss rate for the younger adults is caused by rapid infestation and shedding of the tooth by the carious process, particularly in light of the high level of UM3 agenesis (i.e. preventing LM3 occlusal attrition) in the sample. The high loss of molars (UM1/LM1 and UM2/LM2) is possibly attributable to high wear and avulsion in Tenerife and Gomera, but is harder to account for in Fuerteventura and Hierro. Older adult tooth loss was most notable in the maxillary postcanines, which is possibly a result of the generally lower carious infestation of the upper teeth when compared to the mandibular (hence the later age at which they were shed), and this pattern is continued into the mature group. High wear and avulsion cannot be ruled out, however, although it is unlikely that the UC loss on Gomera was caused by anything other than accidental/intentional breakage. By the mature period, all the lower molars and most of the upper molars have been lost in most populations and are therefore not significantly variable. The extent to which the premolars were used to make up for this loss may explain the significant variability of UP1-2 and LP1 variability in the mature group.

7.11 Summary

Caries, where it occurred, was typically restricted to the postcanine teeth and particularly the molars. The lower teeth were affected more frequently than the maxillary dentition, and the main points of attack were the occlusal surface and the contact areas/roots. Smooth surface caries was very rare, and was usually associated with enamel cracks that are believed to be mainly caused by traumatic damage to the tooth. Temporal trends were weak or absent. However, there was some indication that women were more strongly affected by the cariogenic process, and may therefore have been consuming a more cariogenic (i.e. carbohydrate-rich) diet than males. When considered spatially, pooled and site-specific caries rates indicated increased prevalence of caries in the centre and west of the archipelago, with the highest overall rates in Tenerife and Gomera. Lanzarote and Fuerteventura were generally less strongly affected than the other islands, which may be a reflection of their apparent unsuitability for (cereal) agriculture as summarised in chapter 2. The alveolar retraction and wear data indicated considerable heterogeneity in the archipelago, and as these factors consistently link Gomera and Tenerife specimens, Langsjoen's argument (1992) regarding the probable link between the grinding of cereals, high levels of wear and continuous eruption gains increased credibility. Walker (1978) reported that aggravated dental wear was strongly associated with marine and coastal environments in North America, and this has been confirmed by other authors working in various parts of the world (see Larsen 1997: 247-253 for a review). The extreme levels of wear in some Canarian samples (especially Tenerife [see above] but also for the islands as a whole) has traditionally been associated with mineral inclusions in ground cereals (Langsjoen 1992), and this was substantiated to a certain extent by the finding that Canarian $d^{13}C$ stable carbon isotope ratios indicated virtually no consumption of marine foodstuffs (Tieszen *et al.* 1992). However, this is at odds with findings concerning external auditory exostoses (Martin de Guzman 1984), histomorphometry (Velasco Vaquez *et al.* 1999), archaeology (Rodriguez Santana 1996) and barium/strontium ratios (Gonzalez Reimers *et al.* 2001), all of which suggest that the Canarians did in fact have considerable affinity with the sea and its resources. Intuitively, furthermore, it seems vanishingly unlikely that marine foods could have been ignored, given the crenellated and resource-rich coastline of the islands, surrounded by waters that are extremely rich in terms of fish stocks. It is therefore possible that the assumption of high wear being caused by mineral inclusions in agriculturally derived foods may in fact reflect marine-rich diets. As marine foods are generally protein-rich, this may explain why rates of caries are comparatively low, particularly if dairy produce was also an important resource (owing to the retarding effect of meat and milk products on the cariogenic process [Hillson 1996: 279]). The elevated levels of caries in females could be due to either cultural/social behaviour (different diet or eating behaviours) or hormonal factors (Lukacs 2003). However, the fact that alveolar exposure and wear patterns exhibited little variability between the sexes tends to suggest that the latter scenario is more likely, and that diet was not predicated on sex.

It is therefore clear that the Canaries were not highly diverse dietarily, at least insofar as can be determined by the study of dental pathology (but see Martin de Guzman 1984, Tieszen *et al.* 1992, Rodriguez Santana 1996, Velasco Vazquez *et al* 1999 and Gonzalez Reimers *et al.* 2001). Equally, there is no evidence of dietary transitions occurring through time, or at least that any such transition was relatively minor and not as profound as dental pathology trends in the Near East during the development of agriculture (Molleson *et al* 1991), or North America during the move from mobile hunter-gathering to sedentary agriculture (Larsen 1997: 69). That said, there are such mixed signals from dental pathology, histology and other methods that we are clearly only starting to appreciate the variability in the Canarian sample. The fact that querns and evidence of agriculture are generally sparse in the outlying islands would seem to suggest that agriculture was not necessarily the economic affinity of choice in at least some of the islands, although the exact significance of this variability is not currently understood. Large, sedentary societies are usually agriculturalists rather than foragers, and this in itself would seem to imply that the more substantial populations (as detected both historically and archaeologically) on Gran Canaria and Tenerife may have had more recourse to agriculture than other, less densely populated islands. Bearing the foregoing in mind, the question of to what extent the Native Canarians relied upon agriculture remains unanswered. Historical references state that various missions were sent to help the remnants of Canarian society 'improve their agriculture and living standards' (Mercer 1980: 222) in the 15th and 16th centuries. Whether this was in reference to the displacement of native groups into marginal or unsuitable environments that did not suit their requirements, or is alternatively a true reflection of the Canarians' lack of familiarity with agricultural methods, is uncertain. As stated in chapter 3, one should also avoid using contact-period sources in analyses of pre-contact populations. However, if the Spanish and French invaders' reputation for ecological destruction (Mercer 1980) and intentional sabotage of Native Canarian resources (Morales Mateos 2003) is merited, then it is possible that the Canarians were forced to intensify a comparatively minor subsection of their economic profile (which had previously been comprised largely of pastoralism and foraging) in order to survive.

If, as outlined in chapter 6, the islanders were relatively mobile within the archipelago, then it would appear that they were not strangers to each others' dietary regimes, although the extent to which particular resources were cultivated, exploited or processed may have seen more heterogeneity.

Chapter 8 – Dental Enamel Hypoplasia

The hypoplasia data were processed as laid out in chapter 5, and the results are presented below. The data were processed by all relevant variables, to include island, sex, period, region, and permutations thereof, and presented as percentage figures and bar graphs. Chi-Squared Tests were also carried out on the hypoplasia data, in order to establish the level of variability in individual samples. Expected count figures were examined in order to establish the expectations of the data under the null hypothesis (i.e. homogeneity of the samples, be they spatial or temporal). Linear banding hypoplasia (Plate 8.1), plane defects and pitted defects were all found in the Canarian sample.

Plate 8.1. Hypoplastic Defects on Anterior Teeth of Gran Canarian Female (Museo Canario)
NB: These defects imply a systemic disturbance in the 4th year of life

The lesion depicted in Plate 8.2 – the possible 'mulberry molar' (Hillson and Bond 1997; Hillson 1996: 172) – is often associated with congenital syphilis, and was noted in a single specimen from the Gran Canarian early period sample. Only six islands are presented, due to the very low sample size available for La Palma. The single La Palma female score in age group F (not presented here) was unaffected (i.e. 0/1).

Plate 8.2. 'Mulberry Molar' LM1 Hypoplastic Defect. Gran Canarian Subadult, Museo Canario.

Hypoplasia was found in 9.1% of all dental 'sites', of which 3475 were scored, once the sample had been corrected for individual and ageclass representation. These figures are presented in table 8.1 and figure 8.1.

Ageclass	Sample	%
A	2/488	0.4
B	14/515	2.7
C	33/535	6.2
D	8/485	1.6
E	63/508	12.4
F	112/519	21.6
G	85/425	19.3
Total	317/3475	9.1

Table 8.1. Total Hypoplastic Lesions by Ageclass

There was a double peak of hypoplasia prevalence when considered by ageclass, with a drop in ageclass D between the A-C and E-G peaks. However, the general trend is towards increased prevalence through the developmental sequence, with the highest peak in ageclass F. It would therefore seem that systemic disturbances were less

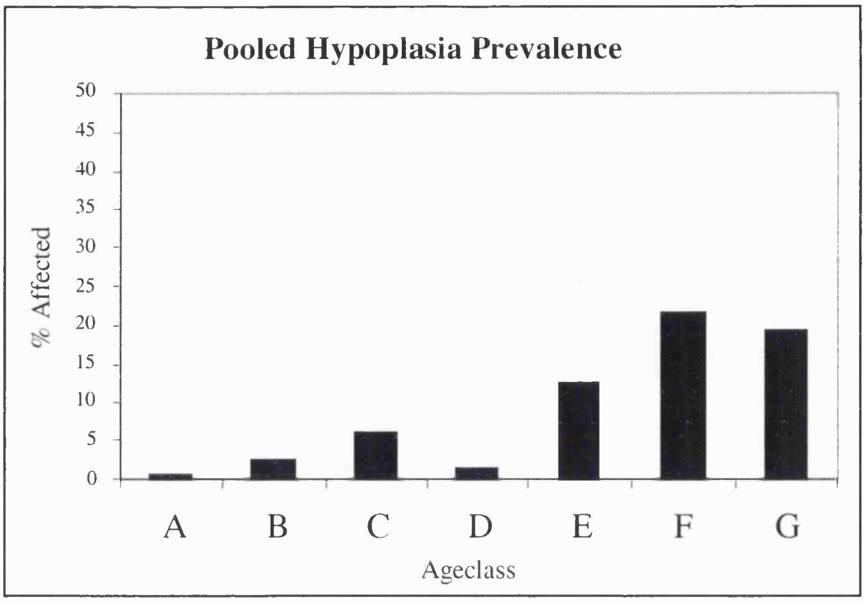

Figure 8.1. Total % Affected with Hypoplastic Lesions by Ageclass

frequent until the age of around 5 years, followed by increasing systemic stress into later childhood and early adolescence. More complex tests were carried out in order to assess the social implications of this general finding.

8.1. Inter-Island Comparisons (by Age Group)

Firstly, simple by-island tests were carried out to detect general island trends. The percentage figures thus derived are presented in table 8.2 and figures 8.2 (eastern islands) and 8.3 (western islands). Please note that the sample sizes given are per tooth segment – occlusal, contact or cervical – and not per individual.

Age	Lanzarote	F-Ventura	GC	Tenerife	Gomera	Hierro
A	0 (5)	0 (11)	0.6% (2/159)	0 (289)	0 (17)	0 (7)
B	0 (6)	0 (12)	6.7% (11/164)	0.7% (2/306)	0 (18)	11.1% (1/9)
C	0 (6)	0 (12)	12% (20/166)	3.4% (11/322)	11.1% (2/18)	0 (11)
D	0 (4)	0 (8)	5% (7/140)	0.3% (1/302)	0 (16)	0 (15)
E	0 (4)	0 (9)	26.9% (39/145)	7% (22/315)	12.5% (2/16)	0 (19)
F	0 (4)	0 (9)	27.6% (40/145)	19.1% (61/320)	26.3% (5/19)	27.3% (6/22)
G	0 (2)	12.5% (1/8)	16.8% (21/125)	19.3% (50/259)	50% (7/14)	35.3% (6/17)

Table 8.2. Inter-Island Trends in Hypoplasia Prevalence.

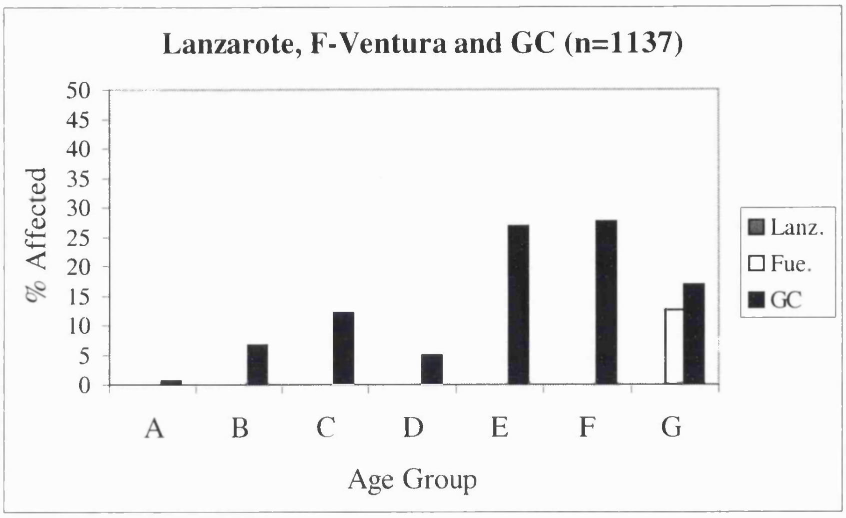

Figure 8.2. Eastern Island Hypoplasia Profile

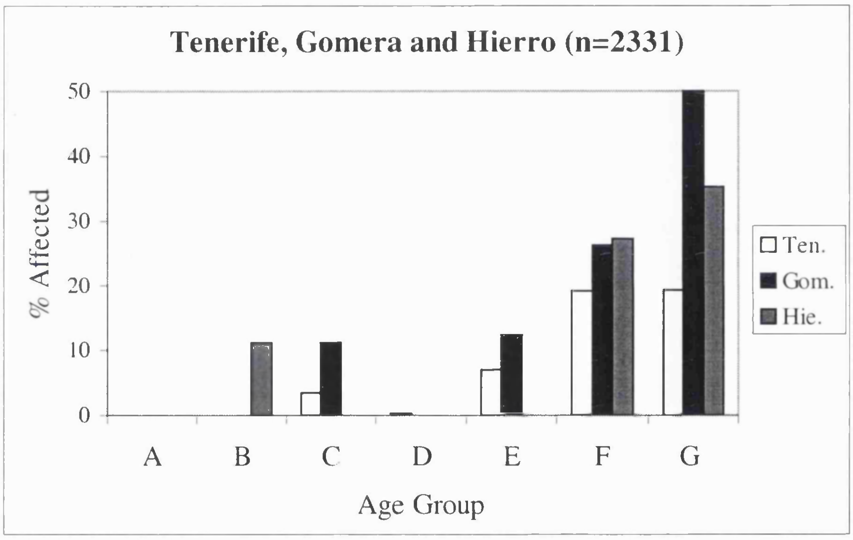

Figure 8.3. Western Island Hypoplasia Profile

The most notable characteristic of these simple comparisons is the low prevalence of enamel hypoplasia in Lanzarote and Fuerteventura, and the relatively high prevalence, occurring at most developmental stages to a greater or lesser degree, in Gran Canaria (and Gomera). The Tenerife sample differs in possessing a prevalence peak in the later stages of tooth development, while Gomera and Hierro show small peaks in age groups A-D, then a steady rise into the later groups. The lowest overall prevalence is in the dry islands of the eastern end of the archipelago, the highest in the central-eastern island of Gran Canaria. The hypoplasia data were assessed using Chi-Squared Tests. The workings are presented in appendix 4, and a summary of the results is presented in table 8.3. Significantly variable results ($P \leq .05$) are highlighted.

Age Group	Chi-Squared Test
A	0.529
B	**0.003**
C	**0.005**
D	**0.018**
E	**0.000**
F	0.184
G	**0.035**

Table 8.3. Chi-Squared Test Results of Hypoplasia Prevalence by Island and Age Group

Significant variability in hypoplasia prevalence was identified in age groups B, C, D, E and G. In ageclass B, variability is due to significantly high hypoplasia prevalence in Gran Canaria, against extremely low levels (or absence) of hypoplasia in the rest of the archipelago. Gran Canarian hypoplasia prevalence was also high in ageclass C, while Tenerife prevalence was unexpectedly low. The same pattern was observed for ageclass D and E, while the western and eastern islands continued to demonstrate very low prevalence levels. Ageclass G showed more diversity, with Gran Canarian prevalence levels dropping beneath the levels predicted by the null hypothesis, and the small island of Hierro showing a significantly higher prevalence than any other member of the group. While Gran Canarians are more generally afflicted with hypoplasia, therefore, it would appear that distribution is more widespread throughout development, while the smaller islands of the west (Gomera at least) have more abruptly deviating prevalence of late-onset hypoplastic lesions. The almost total absence of hypoplasias in Lanzarote and Fuerteventura is intriguing if the association between large population concentrations, ill health and hypoplasias (Larsen 1997: 50-53; see also chapters 3 and 7 of the current project) is considered, as there is historical and archaeological evidence that populations were lowest on these islands, and largest on Gran Canaria and Tenerife. The regional testing of the islands is carried out below. However, it is also important to assess the importance of sex and chronology as agents of hypoplasia prevalence.

8.2 Inter-Period Comparisons (by Age Group)

The data from all islands were pooled in order to establish if chronological position had any bearing on hypoplasia prevalence. The undated specimens were removed from the analysis, although it should be noted that many of these come from the smaller islands of the east and west, and consequently we are missing out on potentially important information. Firstly, the data were ranked by age group, with percentages calculated for all periods. This is represented in table 8.4 and figure 8.4.

Age	Early	Middle	Late
A	3.4% (29)	0.3% (370)	0 (37)
B	3.3% (30)	3.1% (384)	0 (42)
C	11.8% (34)	6.4% (392)	0 (47)
D	0 (29)	2.3% (355)	0 (42)
E	3.3% (30)	13.9% (367)	15.2% (443)
F	22.6% (31)	22.6% (372)	17.4% (46)
G	22.7% (22)	18.8% (314)	8.3% (36)

Table 8.4. Inter-Period Trends in Hypoplasia Prevalence

The general trend is not dissimilar; in all three periods there is a general trend towards increased hypoplasia prevalence in age groups E-G. However, early period specimens appear to be more frequently affected in the early age groups than middle or late period individuals, with very low prevalence in age groups D and E. Only middle period specimens were affected in all seven age groups, although this is probably a function of

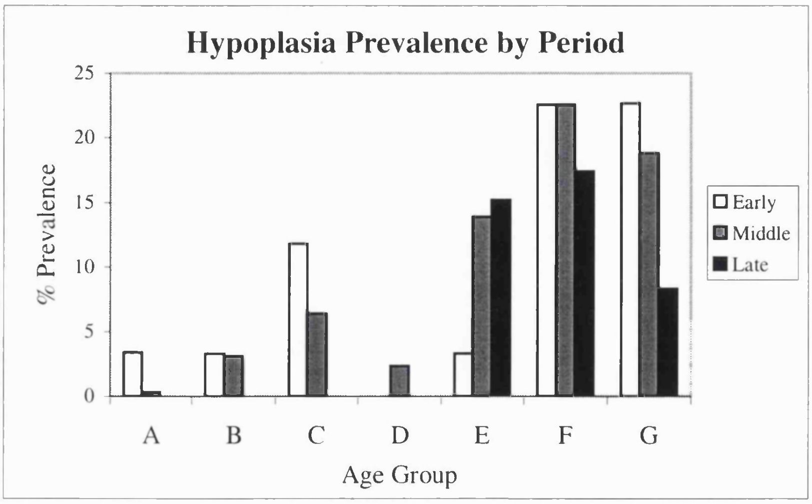

Figure 8.4. Hypoplasia by Period and Age Group

large sample size for this group. Chi-Squared tests were carried out in order to assess the strength of these apparent trends. The workings are presented in appendix 4. A summary of the results are presented in table 8.5. Significantly variable results ($P \leq .05$) are highlighted.

Age Group	Chi-Squared Test
A	**0.047**
B	0.505
C	0.083
D	0.443
E	0.242
F	0.724
G	0.254

Table 8.5. CST Test Results for Period/Age Group Hypoplasia Prevalence

Only ageclass A was significantly variable when considered by period, and was attributable to a relatively high prevalence of the condition in the early group. This is a potentially important finding, as developmentally early hypoplasias have been associated with conditions such as syphilis ('Mulberry Molars' – Hillson 1996: 172) with obvious implications for the islands' populational history. However, the low number of individuals in the sample, caused by the accelerated dental wear of Canarian populations as a whole, should be considered.

8.3. Inter-Sex Comparisons (by Age Group)

Hypoplasia prevalence patterns have implications for identifying differences in lifestyle and cultural adaptation between the sexes. While there is potential room for confusion caused by social traditions that have a direct effect on odontogenesis, the condition will generally appear less in groups with good general health and nutritional status, and more in less valued or socio-economically deprived social (sub)groupings. The prevalence pattern, and the extent to which it differs between the sexes, can provide valuable information about the extent to which gender determined aspects of lifestyle. These results are presented in table 8.6.

Age	Male	Unsexed	Female
A	0 (319)	5.4% (37)	0 (132)
B	2.1% (338)	2.9% (35)	4.2% (142)
C	4.5% (353)	11.1% (36)	8.9% (146)
D	1.2% (338)	0 (16)	3.1% (131)
E	11.6% (354)	13.3% (15)	14.4% (139)
F	22.3% (363)	26.7% (15)	19% (142)
G	20.6% (306)	30% (10)	17.4% (109)

Table 8.6. Inter-Sex Trends in Hypoplasia Prevalence

While included in table 8.6 for comparative purposes, the unsexed category was not represented in figure 8.5 as no useful data could be derived from this subset.

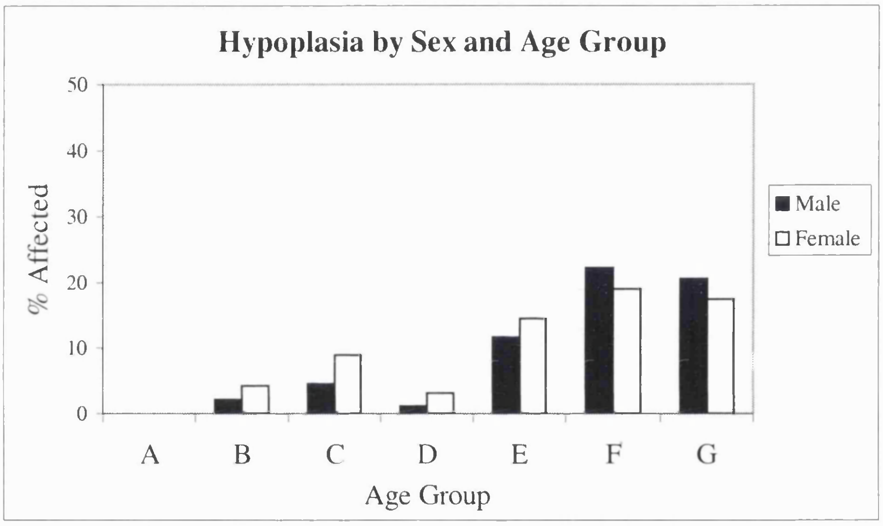

Figure 8.5. Hypoplasia by Sex and Age Group

There appear to be only minor differences in terms of hypoplasia distribution between the sexes. However, it is interesting to note that females were more frequently affected than males from groups B-E (c.0.9-5.1 years), while males were more strongly affected in groups F and G (c.5.8-12.6 years). CSTs were carried out on the data, in order to test the strength of the trends. The workings are presented in appendix 4. A summary of the results are presented in table 8.6. Significantly variable results ($P \leq .05$) are highlighted.

Age Group	Chi-Squared Test
A	**0.047**
B	0.505
C	0.083
D	0.443
E	0.242
F	0.724
G	0.254

Table 8.6a. Chi-Squared Results; Hypoplasia by Sex and Age Group

The only significant finding indicated a strong bias in terms of age group A hypoplasia prevalence towards the unsexed sample (5.4%), compared to both males and females (0%). Males and females distribution had a basically even hypoplasia distribution. The fact that the occlusal surface of the first molars (the indicator for ageclass A) is usually worn away by young adulthood may be partly responsible for this finding.

8.4. Inter-Period and Inter-Sex Comparisons (by Age Group)

The temporal and sex data were combined in order to provide a chronological scale to inter-sex differences in hypoplasia. This could potentially be used to detect differences in social or economic practice between periods. The data are presented in table 8.7, and were used to produce figures 8.7 and 8.8. While presented in tabular form for purposes of comparison, the unsexed individuals were not profiled graphically, nor tested using the Chi-Squared statistic.

Age	Sex	Early	Middle	Late
A	Males	0 (15)	0 (242)	0 (28)
	Unknown	14.3% (7)	4.2% (24)	0 (1)
	Females	0 (7)	0 (104)	0 (8)
B	Males	6.2% (16)	2% (253)	0 (30)
	Unknown	0 (6)	4.5% (22)	0 (2)
	Females	0 (8)	5.5% (109)	0 (10)
C	Males	5.6% (18)	5% (260)	0 (33)
	Unknown	33.3% (6)	9.1% (22)	0 (3)
	Females	10% (10)	9.1% (110)	0 (11)
D	Males	0 (20)	1.6% (248)	0 (32)
	Unknown	0 (1)	0 (12)	0 (1)
	Females	0 (8)	4.2% (95)	0 (9)
E	Males	5% (20)	12% (259)	18.2% (33)
	Unknown	-	10% (10)	0 (3)
	Females	0 (10)	19.4% (98)	10% (10)
F	Males	23.8% (21)	22.9% (262)	21.2% (33)
	Unknown	-	40% (10)	0 (3)
	Females	20% (10)	20% (100)	10% (10)
G	Males	33.3% (15)	18.2% (225)	11.5% (26)
	Unknown	-	37.5% (8)	0 (2)
	Females	0 (7)	18.5% (81)	0 (8)

Table 8.7. Trends for Period/Sex Hypoplasia Patterns of Prevalence

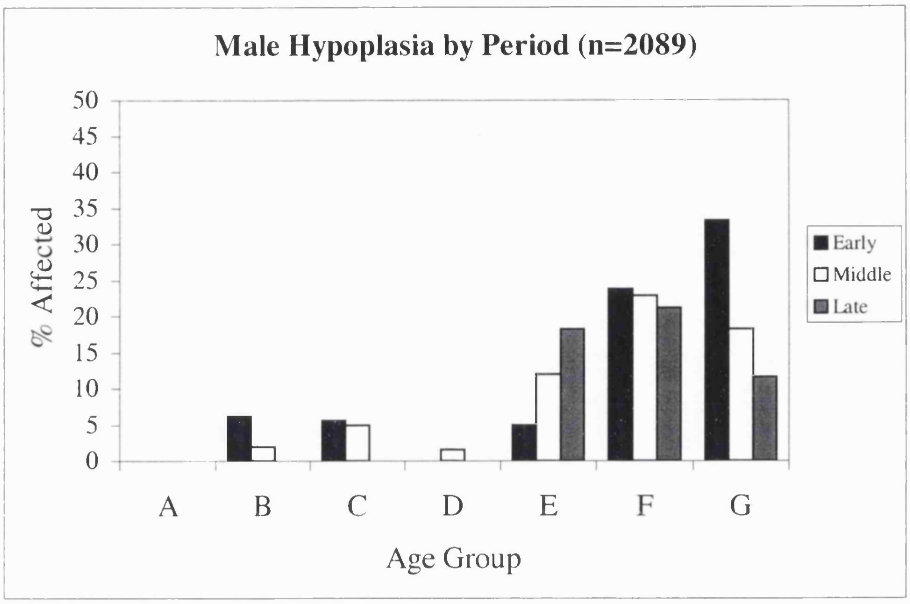

Figure 8.7. Male Hypoplasia Prevalence by Period

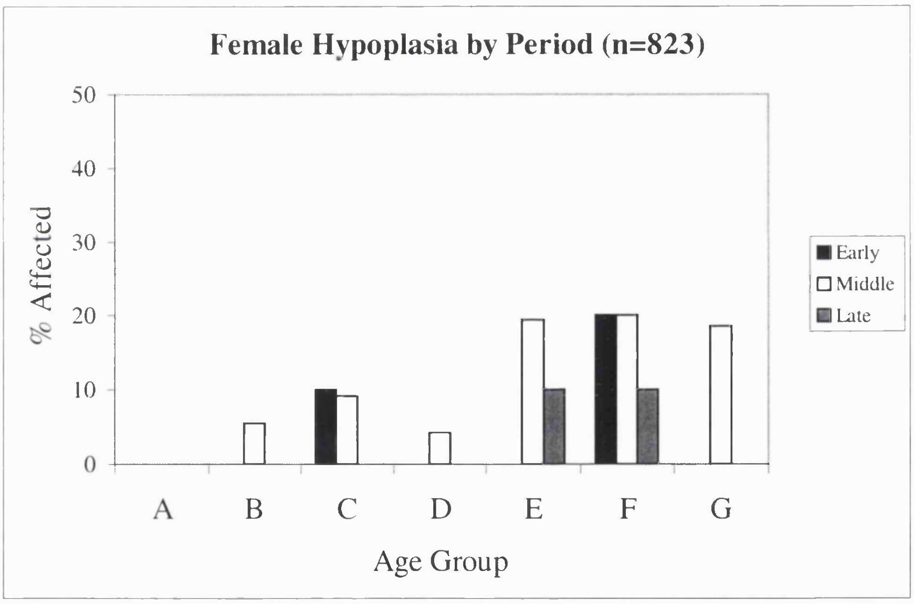

Figure 8.8. Female Hypoplasia Prevalence by Period

There were some hypoplasia profile differences between males and females in terms of general age categories (as above), and also period. Whereas males seem to be more strongly affected with hypoplasia in the early period, females show far less evidence of systemic stress in this group. The males and female groups of the middle period were not dissimilar in terms of overall pattern, although late period hypoplasia is far more common in males (and in later age groups) than females. Females were less commonly affected than males in all periods. As the temporal aspect of hypoplasia has already been covered, this data is only presented for comparative purposes and Chi-Squared Tests were not carried out.

8.5. Inter-Island and Inter-Sex Comparisons (by Age Group)

The islands were all processed for general profiles, but incorporating the sex category. Standard counts and percentages are presented by sex, age group and island in table 8.8 and figures 8.9 to 8.15.

Age	Sex	Lanzarote	F-Ventura	GC	Tenerife	Gomera	Hierro
A	Males	0 (2)	0 (7)	0 (95)	0 (199)	0 (10)	0 (6)
	Unknown	-	0 (1)	16.7% (12)	0 (20)	0 (4)	-
	Females	0 (3)	0 (3)	0 (52)	0 (70)	0 (3)	0 (1)
B	Males	0 (3)	0 (8)	6.1% (98)	0 (211)	0 (11)	14.3% (7)
	Unknown	-	0 (1)	9.1% (11)	0 (19)	0 (4)	-
	Females	0 (3)	0 (3)	7.3% (55)	2.6% (76)	0 (3)	0 (2)
C	Males	0 (3)	0 (8)	7% (100)	3.6% (222)	9.1% (11)	0 (9)
	Unknown	-	0 (1)	27.3% (11)	5% (20)	0 (4)	-
	Females	0 (3)	0 (3)	18.2% (55)	2.6% (80)	33.3% (3)	0 (2)
D	Males	0 (3)	0 (6)	3.4% (88)	0.5% (221)	0 (10)	0 (9)
	Unknown	-	-	0 (4)	0 (10)	0 (2)	-
	Females	0 (1)	0 (2)	8.3% (48)	0 (70)	0 (4)	0 (6)
E	Males	0 (3)	0 (7)	25% (92)	7.3% (231)	10% (10)	0 (11)
	Unknown	-	-	25% (4)	0 (9)	50% (2)	-
	Females	0 (1)	0 (2)	12.2% (49)	6.7% (75)	0 (4)	0 (8)
F	Males	0 (3)	0 (7)	27.2% (92)	20% (235)	33.3% (12)	35.7% (14)
	Unknown	-	-	50% (4)	22.2% (9)	0 (2)	-
	Females	0 (1)	0 (2)	26.5% (49)	15.8% (76)	20% (5)	12.5% (8)
G	Males	0 (1)	20% (5)	15% (80)	20.1% (194)	50% (12)	35.7% (14)
	Unknown	-	-	66.7% (3)	14.3% (7)	-	-
	Females	0 (1)	0 (3)	16.7 % (42)	17.2% (58)	50% (2)	33.3% (3)

Table 8.8. Inter-Island and Inter-Sex Trends in Hypoplasia Prevalence

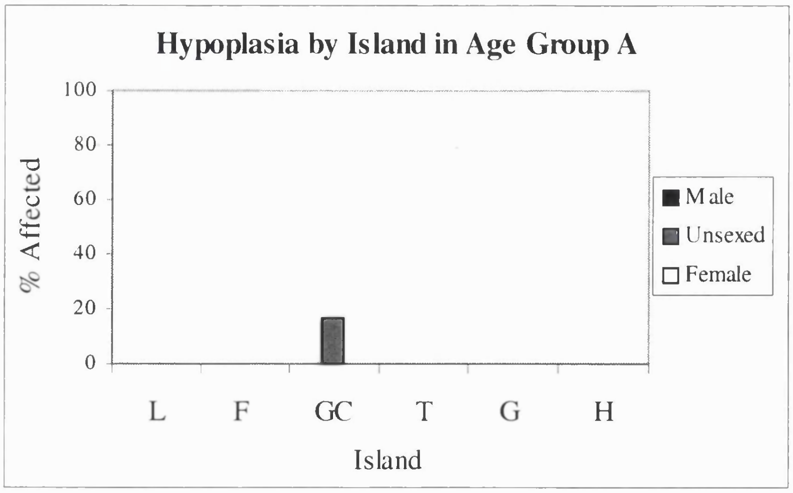

Figure 8.9. Hypoplasia Prevalence by Island in Age Group A

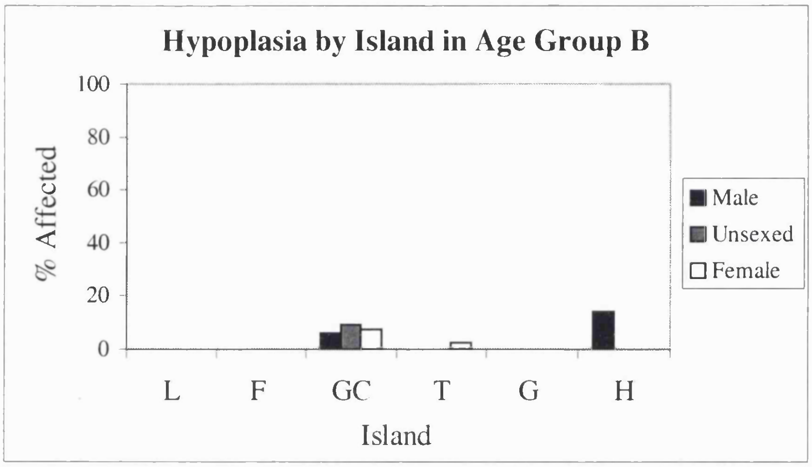

Figure 8.10. Hypoplasia Prevalence by Island in Age Group B

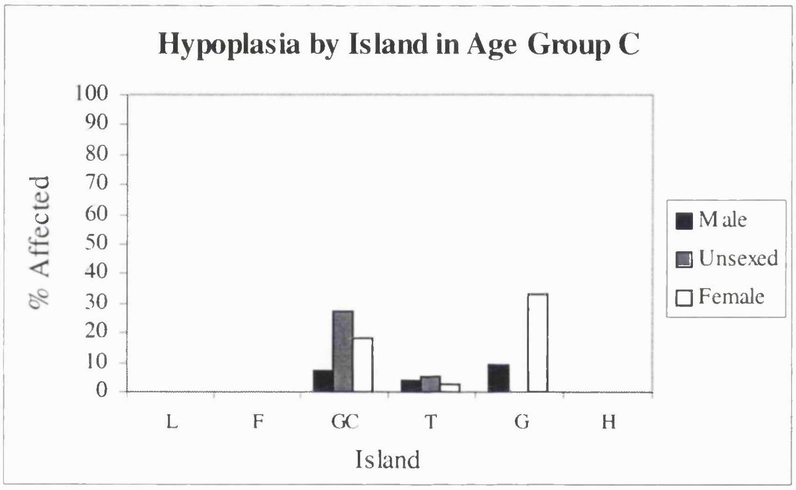

Figure 8.11. Hypoplasia Prevalence by Island in Age Group C

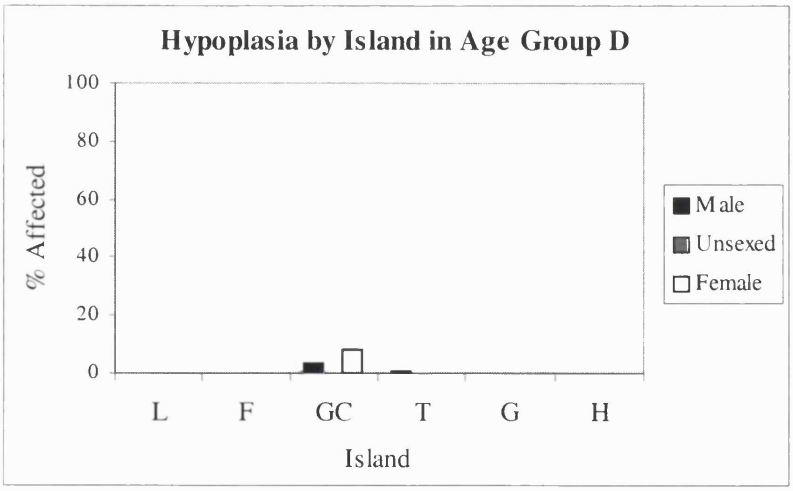

Figure 8.12. Hypoplasia Prevalence by Island in Age Group D

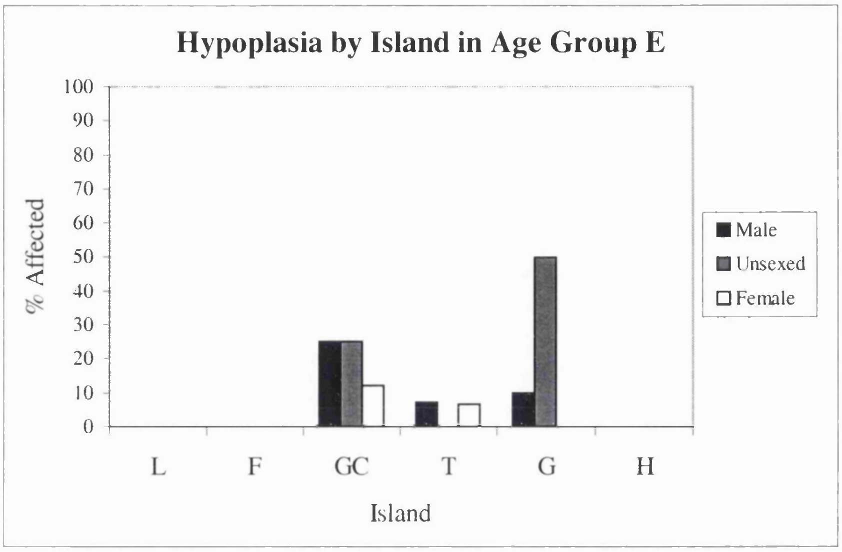

Figure 8.13. Hypoplasia Prevalence by Island in Age Group E

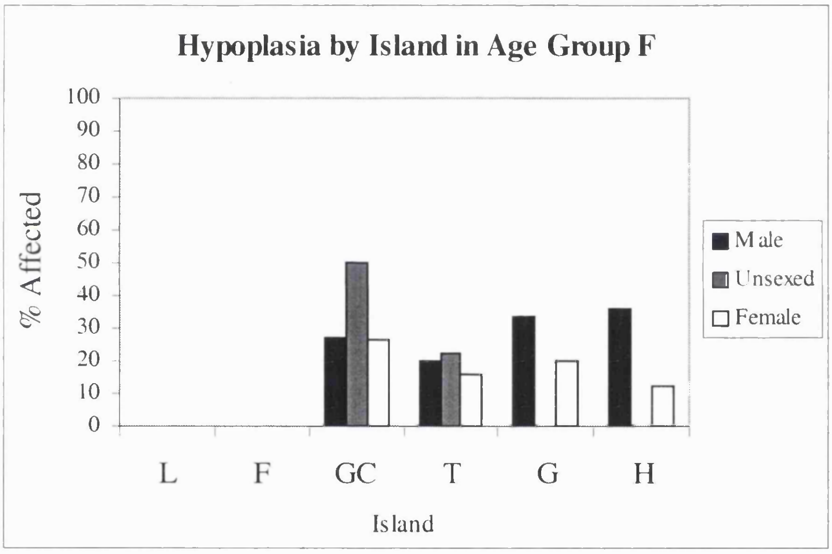

Figure 8.14. Hypoplasia Prevalence by Island in Age Group F

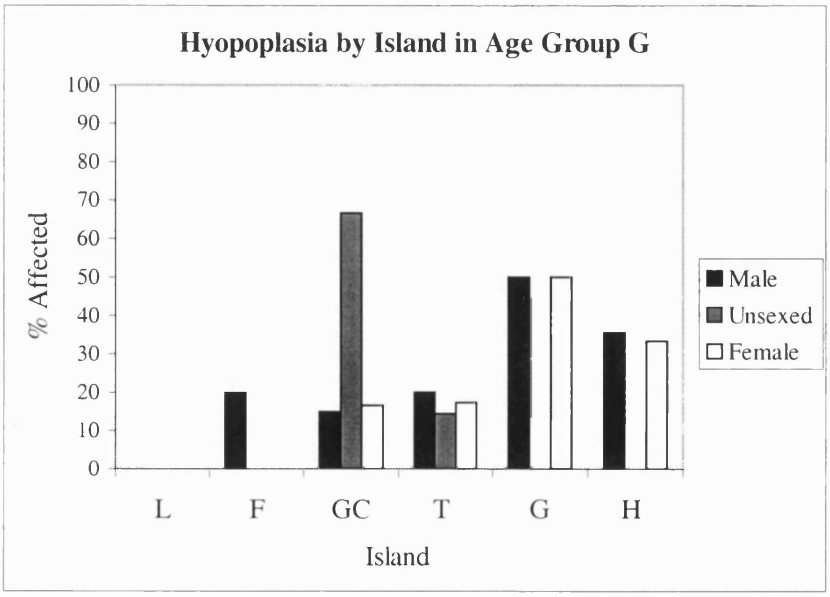

Figure 8.15. Hypoplasia Prevalence by Island in Age Group G

The basic trend is towards higher prevalence through the odontogenetic sequence, particularly in Gran Canaria, Tenerife and Gomera. The lowest overall prevalence was in age groups A and D, with prevalence peaking in groups F and G. As previously noted, males were more frequently affected than females. When considered by island (excluding unsexed individuals and equal distributions), males had more hypoplasia on Fuerteventura (G), Tenerife (B,C,D,E,F,G), Gomera (E,F) and Hierro (B,F,G), while females were more strongly affected on Gran Canaria (B,C,D,G). In order to avoid weakening the test results by using small samples, Chi-Square tests were carried out on the Gran Canaria and Tenerife data only. The unsexed sample was not considered.

Age Group	Gran Canaria	Tenerife
A	-	-
B	.782	**.018**
C	**.033**	.632
D	.214	.574
E	.474	.840
F	.935	.416
G	.809	.629

Table 8.9. CST Results by Island and Sex

Ageclass C was significantly variable within the Gran Canaria sample, and ageclass B in the Tenerife group. In both cases, the female hypoplasia prevalence figures exceeded the expectations of the null hypothesis, while the males were affected less often than predicted. Females were therefore significantly more affected than males.

8.6 Single Island Profiles by Period

Gran Canaria and Tenerife (see below) were the only islands to have substantial dated samples, so these were assessed independently to examine patterns of hypoplasia prevalence through time. While part of this information has already been elucidated in section 8.5, this test will bring a temporal aspect to the study. The general trends for these two islands are presented in table 8.10 and figures 8.16 and 8.17.

Age	Period	GC	Tenerife
A	Early	10% (10)	0 (15)
	Middle	0.8% (132)	0 (238)
	Late	0 (13)	0 (24)
B	Early	11.1% (9)	0 (17)
	Middle	7.2% (138)	0.8% (246)
	Late	0 (13)	0 (28)
C	Early	22.2% (9)	9.5% (21)
	Middle	12.9% (140)	2.8% (252)
	Late	0 (13)	0 (33)
D	Early	0 (8)	0 (19)
	Middle	6.1% (115)	0.4% (240)
	Late	0 (13)	0 (28)
E	Early	12.5% (8)	0 (20)
	Middle	27.5% (120)	7.3% (247)
	Late	30.8% (13)	9.4% (32)
F	Early	25% (8)	23.8% (21)
	Middle	28.3% (120)	20% (251)
	Late	30.8% (13)	12.5% (32)
G	Early	20% (5)	23.5% (17)
	Middle	19% (105)	18.7% (209)
	Late	0 (13)	13.6% (22)

Table 8.10. Gran Canarian and Tenerife Hypoplasia by Period and Ageclass

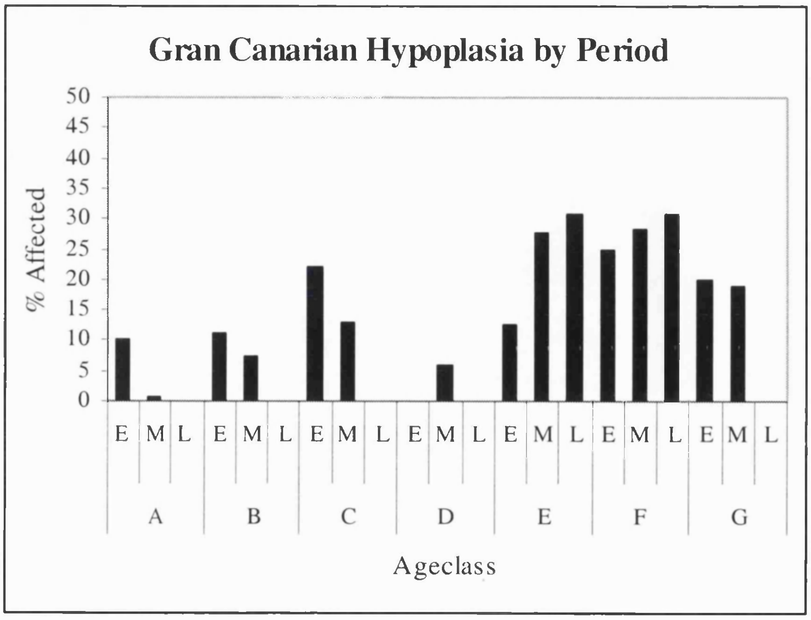

Figure 8.16. Gran Canarian Hypoplasia by Period

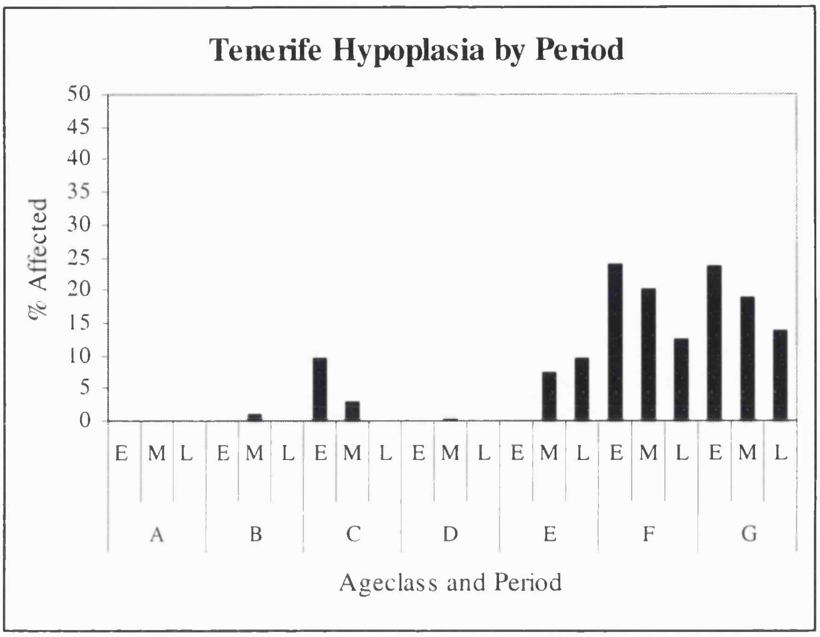

Figure 8.17. Tenerife Hypoplasia by Period

The Gran Canaria and Tenerife samples echo the general temporal trends presented above, owing to the large size of the samples from these two islands. Overall, and as noted above, Tenerife and Gran Canaria are the two islands most strongly affected by hypoplasia in the Canarian archipelago. These data were subdivided by period and are presented below.

8.6.1 Gran Canarian Data

The Gran Canarian early period pattern describes a wide distribution of hypoplasia from age group A to G, with a decrease in groups D and E. The middle period prevalence exceeds or equals early period figures, but is less common in the younger age groups (A-C). Late period hypoplasia was very common in the older age groups (E and F), and was completely absent elsewhere. These data were subjected to Chi-Squared tests, the results of which are presented in appendix 4. A summary is presented below (table 8.11). Significantly variable results ($P \leq .05$) are highlighted.

Age Group	Gran Canaria
A	.040
B	.537
C	.262
D	.510
E	.618
F	.960
G	.224

Table 8.11. Ranking Data by Period for Gran Canarian Hypoplasia Prevalence

As can be seen, the trend data – as described above – is fairly universal between the periods. The only significantly variable group (see table 8.11) was ageclass A at the P = .04 level, with higher than predicted prevalence in the early sample. Based on the current evidence, there was no major temporal component to hypoplasia patterning in this island, and the small sample size – brought about by *in-vivo* reduction (wear) and *post-mortem* taphonomy – should also be considered.

8.6.2 Tenerife Data

The Tenerife profile is very different from the Gran Canarian example. Early period lesions occurred to a limited extent in age group C and were much more common in age groups F and G. Middle period examples started at low levels in groups B-D, rising sharply into age groups E-G. Late period lesions were only found in age groups E-G, but were less common than in the middle period. The data were tested as before. The main details are presented in appendix 4. A summary of the results is presented in table 8.12.

Age Group	Tenerife
A	-
B	.831
C	.123
D	.906
E	.405
F	.528
G	.729

Table 8.12. Tenerife Hypoplasia Prevalence by Period

There was no significant variability in the sample when hypoplastic lesions were considered by ageclass. Systemic health appears to have remained essentially static, per ageclass, when considered by period.

8.7 Hypoplasia Differences by Ecological Region

The islands were categorised according to their ecology and presumed population density in the prehispanic period (see chapter 2). In the final analysis, the islands were grouped in the following three ways. Firstly, the central islands of the archipelago against Lanzarote/Fuerteventura and Gomera/Hierro. The second groupings were Gran Canaria, Tenerife, Lanzarote/Fuerteventura and Hierro/Gomera. The final groupings were Gran Canaria/Tenerife against all the smaller (satellite) islands. This final hypothesis was not originally posited in chapter 2, but has been included as an alternative to the Lanzarote/Fuerteventura, Gran Canaria, Tenerife/Gomera and La Palma/Hierro scenario, as there was no relevant information for La Palma. Percentage values per age group were calculated for each of these scenarios, followed by graphic representation of the values thus derived, and Chi-Squared tests were performed.

8.7.1 Regional Hypothesis 1

Age Group	Eastern	Central	Western	Sample
A	0 (16)	0.4% (447)	0 (24)	487
B	0 (18)	2.8% (469)	3.7% (27)	514
C	0 (18)	6.4% (487)	6.9% (29)	534
D	0 (12)	1.8% (442)	0 (31)	485
E	0 (13)	13.3% (460)	5.7% (35)	508
F	0 (13)	21.7% (465)	26.2% (42)	520
G	10% (10)	18.5% (384)	41.9% (31)	415

Table 8.13. Regional Hypothesis 1 Trend Data

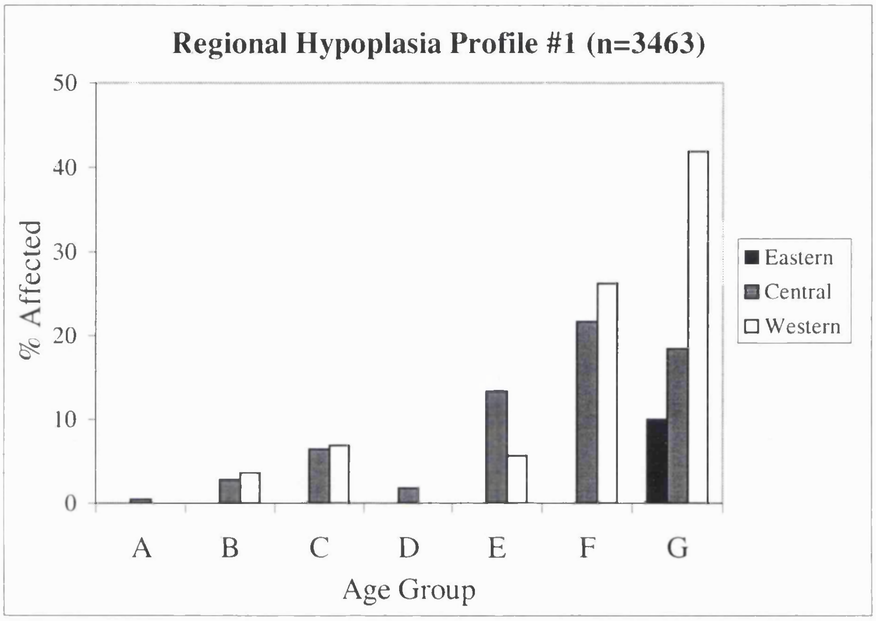

Figure 8.18. Regional Hypothesis 1 Trend Data

In terms of general hypoplasia distribution, there was a low but constant prevalence of central archipelago hypoplasias in the earlier age groups followed by a rise into groups E-G, a lower general prevalence in the west followed by a leap into age groups F and G, and a single age group G prevalence peak for the eastern islands.

8.7.2 Regional Hypothesis 2

Age Group	Eastern	Gran Canaria	Tenerife	Western	Sample
A	0 (16)	1.3% (159)	0 (288)	0 (24)	487
B	0 (18)	6.7% (164)	0.7% (305)	3.7% (27)	514
C	0 (18)	12% (166)	3.4% (321)	6.9% (29)	534
D	0 (12)	5% (140)	0.3% (302)	0 (31)	485
E	0 (13)	26.9% (145)	7% (315)	5.7% (35)	508
F	0 (13)	27.6% (145)	19.1% (320)	26.2% (42)	520
G	10% (10)	16.8% (125)	19.3% (259)	41.9% (31)	425

Table 8.14. Regional Hypothesis 2 Trend Data

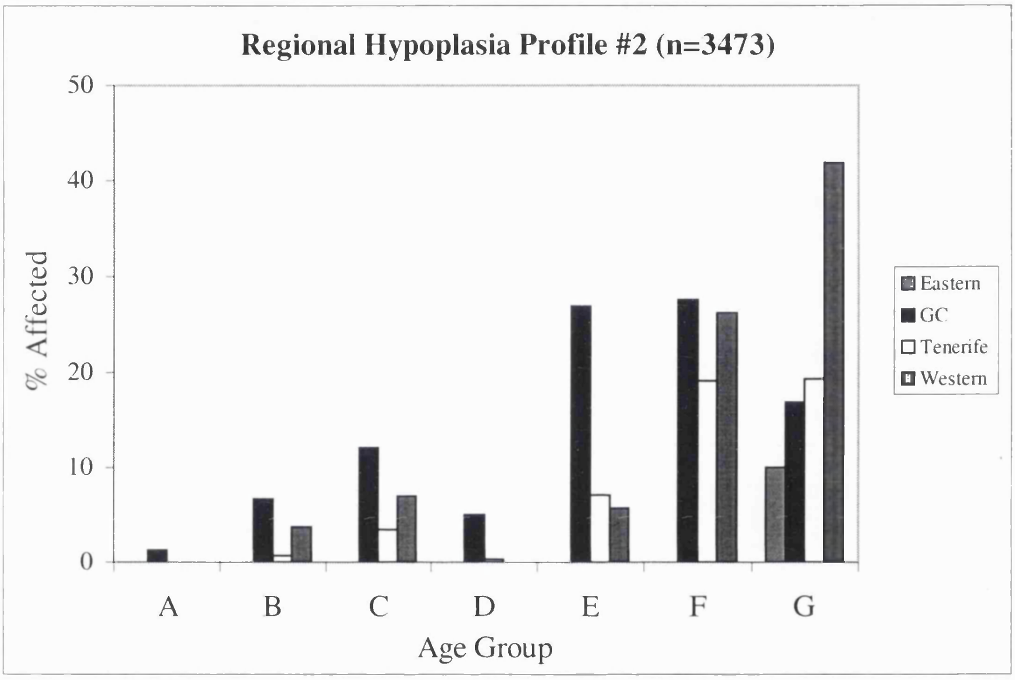

Figure 8.19. Regional Comparison Trend Data Using Regional Pattern 2

The general trend is towards high prevalence of hypoplasia in Gran Canaria, while the western islands (relatively low prevalence throughout the earlier stages of odontogenesis) peak sharply into age groups F and G. Gran Canarian hypoplasia is present in all age groups. With the exception of age group G, Tenerife is always less strongly affected than Gran Canaria, and only appears at levels above 10% in age groups F and G. In this regard, Tenerife and the western islands are very similar.

8.7.3 Regional Hypothesis 3

Age Group	Central	Satellite	Sample
A	0.4% (447)	0 (40)	487
B	2.8% (469)	2.2% (45)	514
C	6.4% (487)	4.3% (47)	534
D	1.8% (442)	0 (43)	485
E	13.3% (460)	4.2% (48)	508
F	21.7% (465)	20% (55)	520
G	18.4% (384)	34.1% (41)	425

Table 8.15. Regional Hypothesis 3 Trend Data

The central islands were more affected with hypoplastic lesions in all the ageclasses except for age group G hypoplasia, which is substantially higher in the satellite islands. As previously noted, prevalence was highest in age classes E-G, with a minor peak in B-C, possibly implying increasing systemic stress from infancy into adolescence.

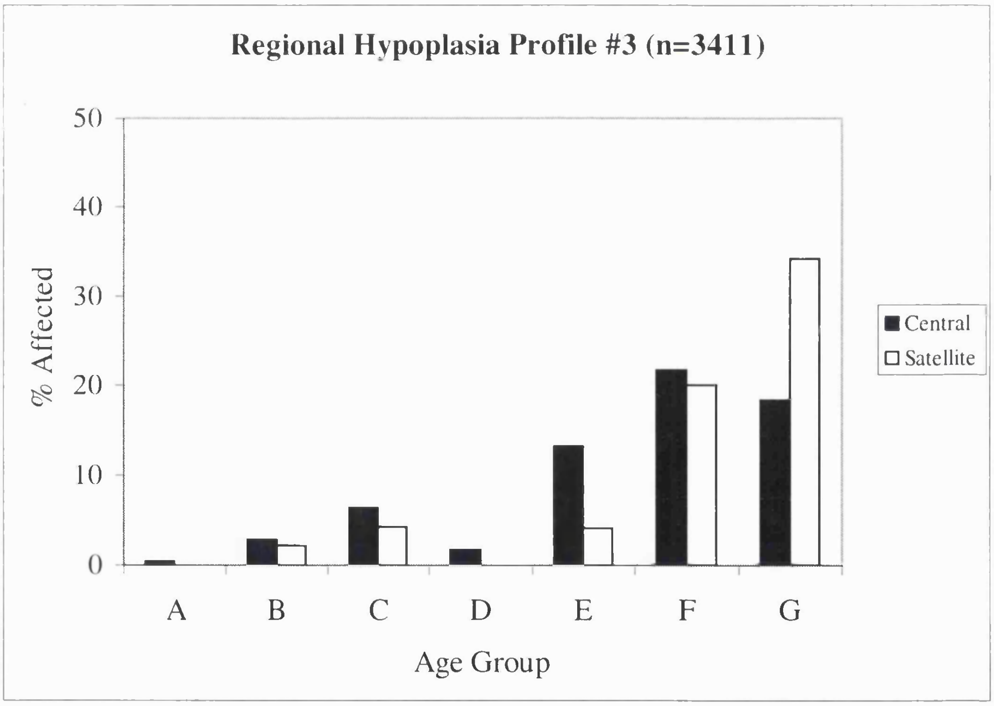

Figure 8.20. Regional Hypothesis 3 Trend Data

8.7.4 Regional Hypothesis Chi-Squared Test Results

The data summarised above were subjected to Chi-Squared tests in order to determine the strength of inter-regional trends in hypoplasia prevalence. The results are presented in appendix 4, and are summarised in table 8.16.

Ageclass	Region_1	Region_2	Region_3
A	.914	.246	.672
B	.739	.002	.829
C	.538	.002	.566
D	.673	.003	.374
E	.166	.000	.069
F	.128	.038	.769
G	.005	.013	.017

Table 8.16. Chi-Squared Tests of Hypoplasia Prevalence by Regional Hypothesis

With the exception of ageclass G (significantly variable in distribution in all three regional hypotheses), only region 2 showed variability throughout the developmental sequence. The remaining ageclasses were assessed with reference to the null hypothesis figures derived from the Chi-Squared test summary tables. Ageclass A was not significantly variable as total lesion prevalence was very low. Ageclass B prevalence was higher in Gran Canaria than would be expected under the terms of the null hypothesis, while Tenerife figures were significantly lower. Ageclasses C, D, E and F followed a similar pattern, with all islands except for Gran Canaria (high) and Tenerife (low) matching the counts expected under the null hypothesis. Ageclass G figures showed significantly more hypoplasia in the western islands under the terms of regional hypotheses 1 and 2, and significantly more lesions in the satellite than the central islands under regional hypothesis 3. The strongest statistical results are those derived from tests where Gran Canaria is separate, as this island always stands out in terms of high hypoplasia prevalence. It seems that younger ageclasses suffered more systemic impacts on Gran Canaria than the other islands, while severe stresses only appear to have made major impact on the older age groups in the western/satellite island groups.

8.8 Profiles of Inter-Sex Hypoplasia Prevalence by Region

The data were processed to examine the distribution of hypoplasia by sex between regions, using each of the three regional hypotheses already defined. This was carried out for illustrative purposes, so no Chi-Squared tests were computed. The results are presented below.

8.8.1 Regional Hypothesis 1

Age Group	Eastern	Central	Western	Sample
A	0 (9)	0 (293)	0 (16)	318
B	0 (11)	1.9% (308)	5.6% (18)	337
C	0 (11)	2.2% (321)	5% (20)	352
D	0 (9)	1.3% (310)	0 (19)	338
E	0 (10)	12.4% (323)	4.8% (21)	354
F	0 (10)	22% (327)	34.6% (26)	363
G	16.7 (6)	18.6% (274)	42.3% (26)	306

Table 8.17. Male Hypoplasia Prevalence by Regional Plan 1

Age Group	Eastern	Central	Western	Sample
A	0 (6)	0 (122)	0 (4)	132
B	0 (6)	4.6% (131)	0 (5)	142
C	0 (6)	8.9% (135)	20% (5)	146
D	0 (3)	3.4% (118)	0 (10)	131
E	0 (3)	19.2% (124)	0 (12)	139
F	0 (3)	20% (125)	14.3% (14)	142
G	0 (4)	17% (100)	40% (5)	109

Table 8.18. Female Hypoplasia Prevalence by Regional Plan 1

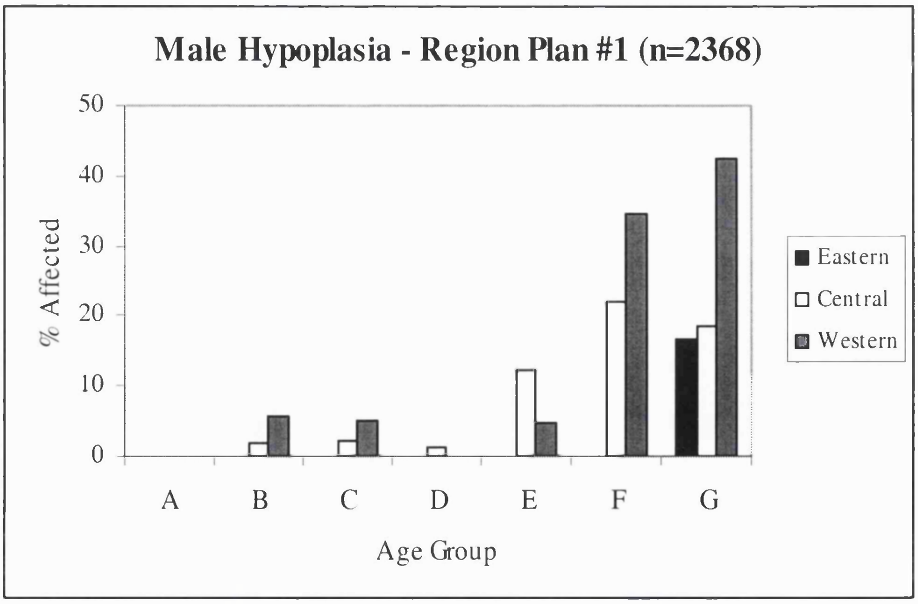

Figure 8.21. Male Hypoplasia by Region 1

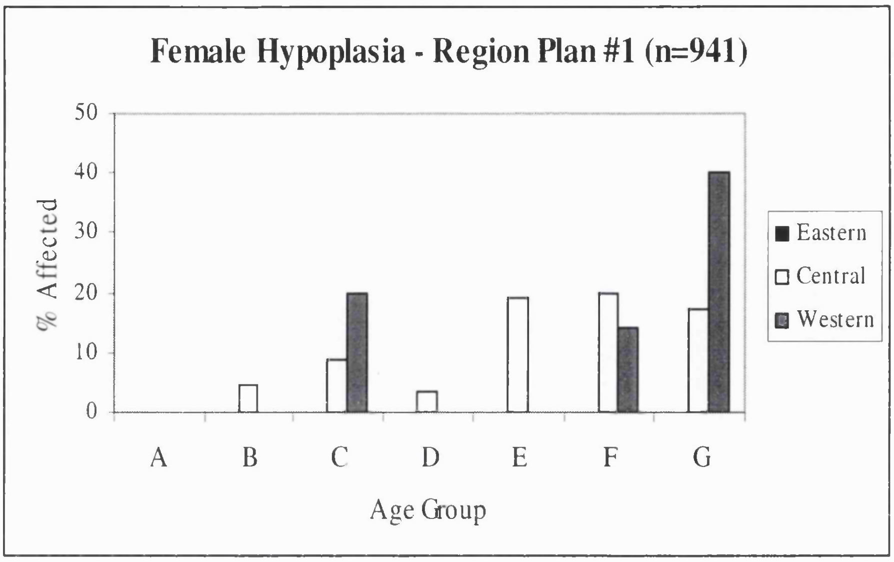

Figure 8.22. Female Hypoplasia by Region 1

When considered in this manner, diversity in male prevalence was more marked than that in females. In both sexes, hypoplasia was most common in the western islands (although sampling may be an issue), lower – yet fairly evenly distributed – in the central group and virtually non-existent in the eastern islands.

8.8.2 Regional Hypothesis 2

Age Group	Sex	Eastern	GC	Tenerife	Western
A	Males	0 (9)	0 (95)	0 (199)	0 (16)
	Unknown	0 (1)	16.7% (12)	0 (20)	0 (4)
	Females	0 (6)	0 (52)	0 (70)	0 (4)
B	Males	0 (11)	6.1% (98)	0 (211)	5.6% (18)
	Unknown	0 (1)	9.1% (11)	0 (19)	0 (4)
	Females	0 (6)	7.3% (55)	2.6% (76)	0 (5)
C	Males	0 (11)	7% (100)	3.6% (222)	5% (20)
	Unknown	0 (1)	27.3% (11)	5% (20)	0 (4)
	Females	0 (6)	18.2% (55)	2.6% (80)	20% (5)
D	Males	0 (9)	3.4% (88)	0.5% (221)	0 (19)
	Unknown	-	0 (4)	0 (10)	0 (2)
	Females	0 (3)	8.3% (48)	0 (70)	0 (10)
E	Males	0 (10)	25% (92)	7.3% (231)	4.8% (21)
	Unknown	-	25% (4)	0 (9)	50% (2)
	Females	0 (3)	12.2% (49)	6.7% (75)	0 (12)
F	Males	0 (10)	27.2% (92)	20% (235)	34.6% (26)
	Unknown	-	50% (4)	22.2% (9)	0 (2)
	Females	0 (3)	26.5% (49)	15.8% (76)	14.3% (14)
G	Males	16.7 (6)	15% (80)	20.1% (194)	42.3% (26)
	Unknown	-	66.7% (3)	14.3% (7)	40% (5)
	Females	0 (4)	16.7 % (42)	17.2% (58)	41.9% (31)

Table 8.19. Hypoplasia Profile by Sex, Using Regional Pattern 2

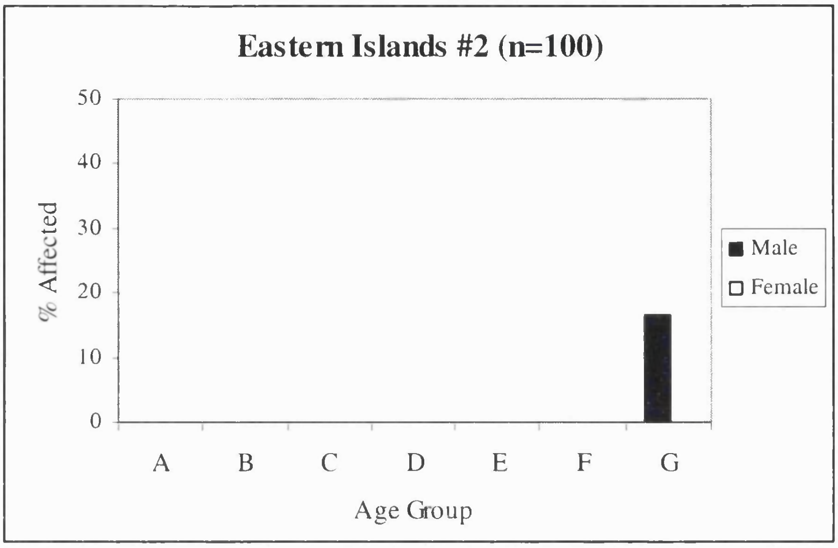

Figure 8.23. Hypoplasia Profile by Sex Using Regional Pattern 2; Eastern Islands

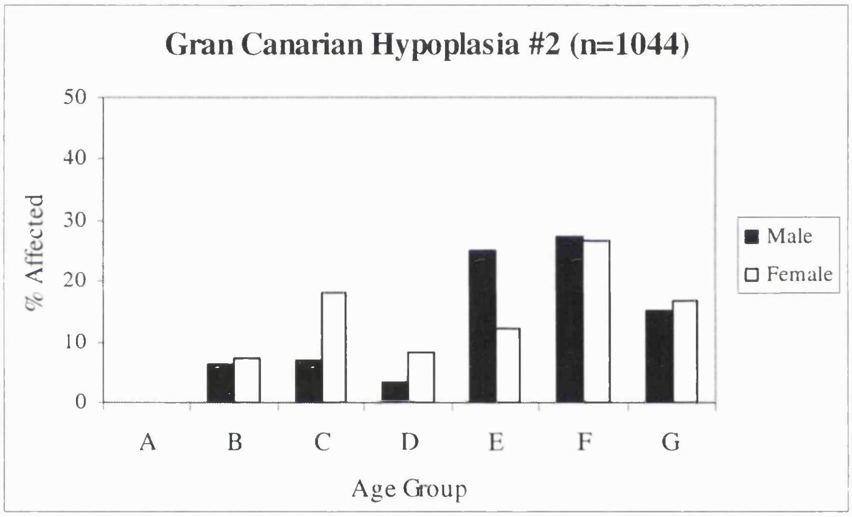

Figure 8.24. Hypoplasia Profile by Sex Using Regional Pattern 2; Gran Canaria Only

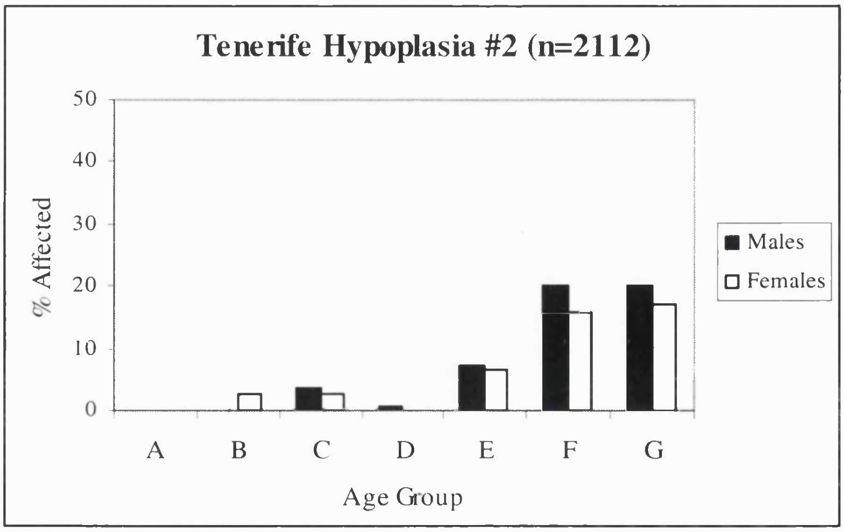

Figure 8.25. Hypoplasia Profile by Sex Using Regional Pattern 2; Tenerife Only

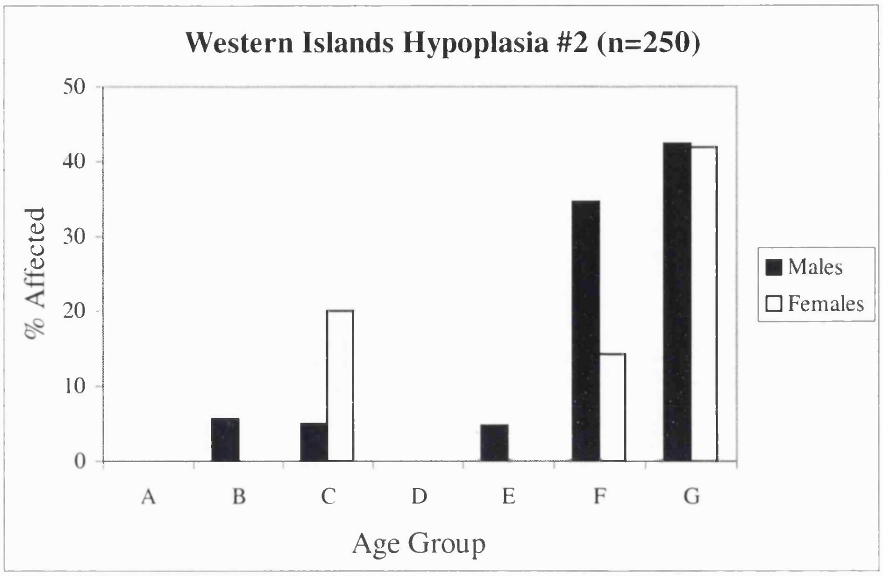

Figure 8.26. Hypoplasia Profile by Sex Using Regional Pattern 2; Western Islands

The profiles for the region #2 test indicated a similar pattern of prevalence between the sexes and the regions concerned. As before, the eastern islands were barely affected (males only) and males were more strongly and regularly affected with hypoplasia in all regions of the archipelago. Females were irregularly affected, but followed the general male trend with increased prevalence from ageclass C onwards. As before, the eastern islands stand out against the other sections of the archipelago, with very low prevalence levels overall. The central islands are very different from one another (see above), and are clearly distinguishable from the eastern and western islands, although the disadvantages of irregular sample size should also be considered. The increased prevalence of hypoplasia in males seems to be widespread in the archipelago.

8.8.3 Regional Hypothesis 3

This section contains the data reworked into the final island grouping system posited in chapter 2, with the large islands of the central archipelago as a single unit separated from the smaller (satellite) islands. The basic trend data are presented in table 8.20.

Age Group	Sex	Central	Satellite
A	Males	0 (294)	0 (25)
	Unknown	6.2% (32)	0 (5)
	Females	0 (132)	0 (10)
B	Males	1.9% (309)	3.4% (29)
	Unknown	23.3% (30)	0 (5)
	Females	4.6% (131)	0 (11)
C	Males	4.7% (322)	3.2% (31)
	Unknown	12.9% (31)	0 (5)
	Females	8.9% (135)	9.1% (11)
D	Males	1.3% (310)	0 (28)
	Unknown	0 (14)	0 (2)
	Females	3.4% (118)	0 (13)
E	Males	12.4% (323)	3.2% (31)
	Unknown	7.7% (13)	50% (2)
	Females	16.1% (124)	0 (15)
F	Males	22% (327)	25% (36)
	Unknown	30.2% (13)	0 (2)
	Females	20% (125)	11.8 (17)
G	Males	18.6% (274)	12/32
	Unknown	30% (10)	37.5% (5)
	Females	17% (100)	37.1% (35)

Table 8.20. Trend Comparison Trend Data by Sex Using Regional Pattern 3

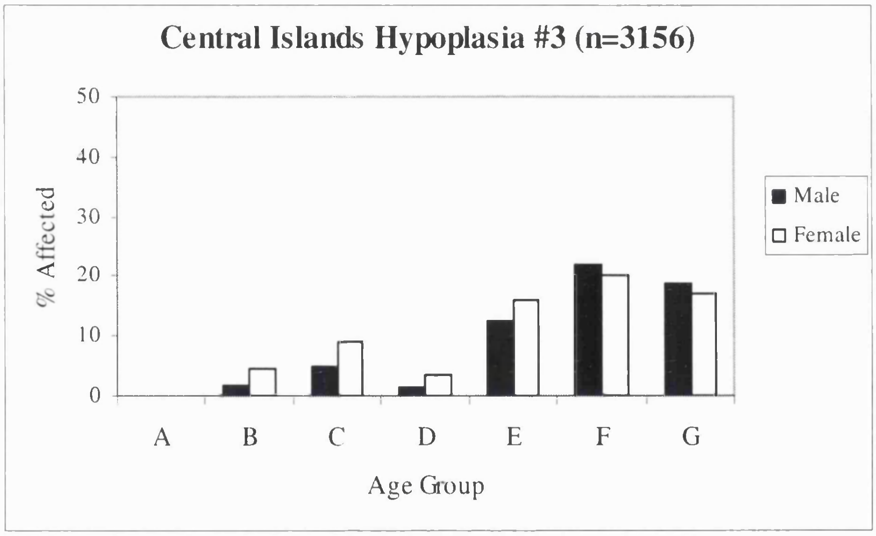

Figure 8.27. Trend Data by Sex Using Regional Pattern 3 (Central Islands)

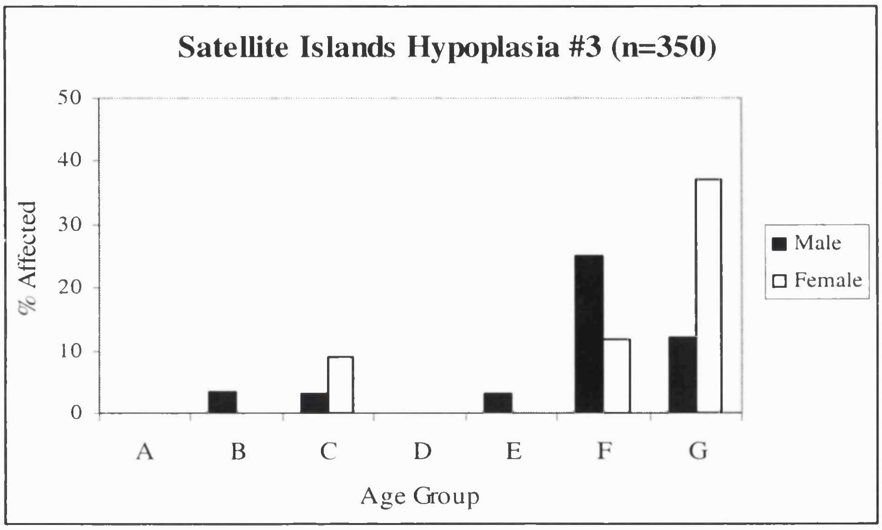

Figure 8.28. Trend Data by Sex Using Regional Pattern 3 (Satellite Islands)

Central island hypoplasia prevalence is widespread and constant when compared to the satellite islands sample. Females were more affected in age classes B-E of the central islands, and males more affected in groups F and G. The satellite islands – possibly as a result of sampling – have more infrequent yet marked prevalence peaks, particularly in age groups F and G. Males were more frequently affected than females in groups B, E and F, and this was reversed in groups C and G.

8.9 Summary

Hypoplastic lesions were not uncommon in the Canary Islands, and demonstrated considerable spatial and inter-sex variability. As for the caries data, pooled hypoplasia prevalence did not vary along the timescale. While single island tests by period confirmed the differences in profile between the islands tested (Gran Canaria and Tenerife – see below), there was little discernable temporal patterning. Temporally-linked major lifestyle changes such as the hunter/gatherer-agriculturist transition observed at various sites in the Near East and North America cannot therefore be proposed for the island group (Larsen 1997: 29-55). Hypoplasia appears to have been most common in late childhood and early adolescence, with a general increase in overall prevalence through the developmental process. There was more variability between the islands than between the ecological groupings proposed in chapter 2, although diversity was always high when Gran Canaria was considered independently (regional hypothesis #2). Indeed, this island had the highest and the most evenly distributed overall hypoplasia prevalence in the archipelago. By contrast, Lanzarote and Fuerteventura individuals were very rarely affected with hypoplastic lesions, while Tenerife and the western islands were generally affected to a minor extent in the earlier agegroups but with a peak in prevalence in late childhood to early adolescence. The sex trend was not especially strong, although females generally had more hypoplasia earlier in their lives (ageclasses B-E) and males were more affected in ageclasses F-G. There was little apparent significance to temporal tests of hypoplasia prevalence by sex, although female prevalence was more erratic and sporadic than male prevalence.

The significance of these findings is, of course, difficult to interpret, as the potential causes of hypoplasia cover such a wide range of pathological and physiological afflictions. However, if taken as a general measure of systemic health that reflects an individual's living conditions and environment, certain conclusions can be drawn. Hypoplasia was most common on Gran Canaria, where evidence for large populations, agriculture and structures suggesting sedentary lifestyles has been recovered. In direct contrast, Lanzarote and Fuerteventura never supported particularly large groups, and there is little evidence of major settlements. Where hypoplasia occurred, it can usually be linked with the later stages of odontogenesis in all islands except, again, for Gran Canaria, which may suggest that there was some significant difference in the way children were raised/weaned, although it is currently impossible to distinguish between nutritional or pathological causes. However, judging from the fairly low level of other evidence for disease in Canarian remains (Rodriguez-Martin 1992; Aufderheide and Rodriguez-Martin 1998), I would propose that this hypoplasia pattern is a reflection of maturation into adulthood beyond what appears to have been a relatively stress-free childhood. The exception to this rule is Gran Canaria, where the density of the population, as evidenced archaeologically and historically, seems to have resulted in more systemic stress during development (particularly when compared to the dry islands of Lanzarote and Fuerteventura). It should be remembered that the G age category is sampling a potentially much larger span of time than ageclasses A-F, and is therefore at best a very general measure of health into early adolescence. Regardless of this, however, later childhood (as substantiated by class F) appears to have been a physiologically testing time for the Canarians, and the lack of temporal trends in the sample suggests that this trend remained the same throughout the period of history sampled in the current study.

Chapter 9 – Cranial Trauma Results

The trauma data was processed and organised by all relevant factors with potential for elucidating aspects of native Canarian behaviour, including side, cranial site, sex, age group, island and region. Internal variability of certain islands with large samples was also explored, in addition to a more general discussion of the lesions and their implications for behaviour in Canarian society. Prevalence data (with percentage values) are presented, while Chi-Squared Tests (CSTs) were carried out to test the polarity of the observed variability. The data are presented in appendix 5; the main findings are presented in the present chapter.

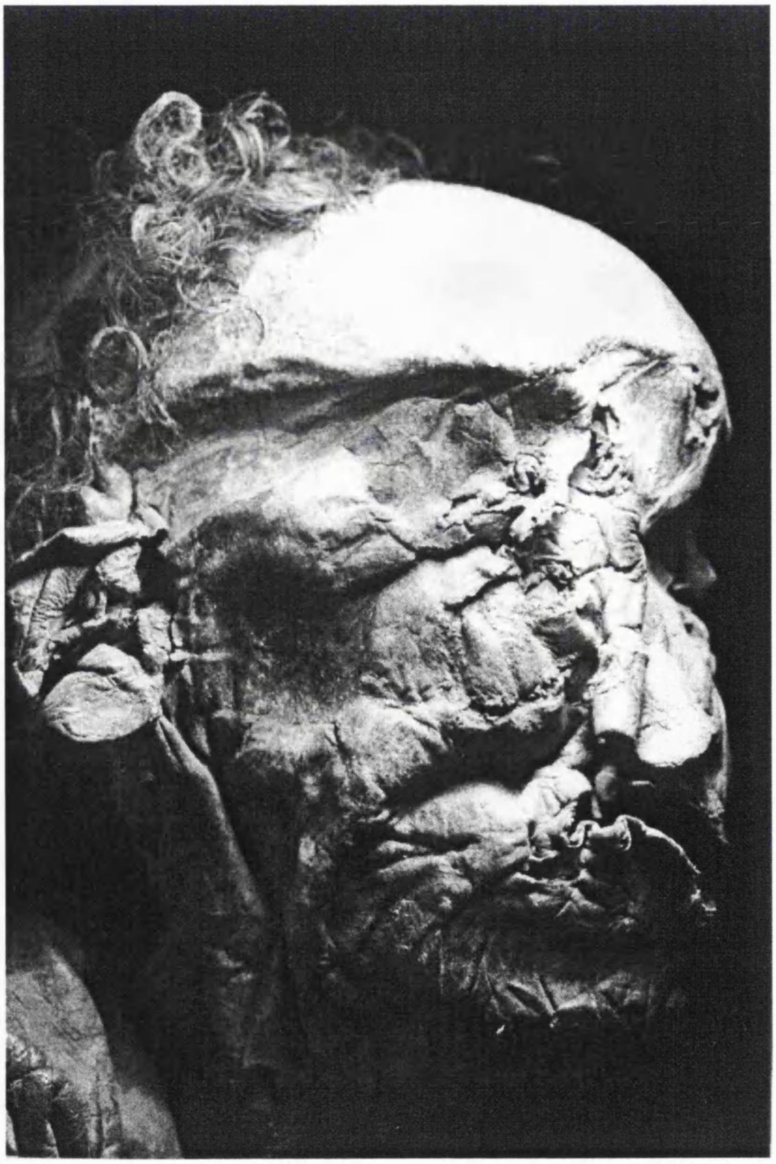

Plate 9.1. Male Mummy from Tenerife with Multiple Traumatic Lesions
Duckworth Collection, University of Cambridge

9.1. Traumatic Lesions in the Canarian Sample

Lesions were fairly plentiful in the Canarian sample, and fell into five rough categories. These included 1) circular depressed lesions ranging from 0.9-5 cm in diameter and up to 0.5 cm deep (in addition to open lesions penetrating the inner bone table of the calvarium) found primarily on the frontal and parietal bones, 2) crushing fractures, notably of the zygomatics and frontals, 3) distortions – concealing healed fractures – of the nasal bones and the maxillae, 4) disproportionate anterior tooth loss, and 5) slashing and cutting wounds (very rare – plate 9.2). All bones except for the occipital were affected, although lesions on this bone may have been concealed by muscle markings. Some of these lesions were associated with trepanation (=trephination) scars, particularly on Tenerife and Gran Canaria. The vast majority of lesions were partially or fully healed, implying survival for considerable periods after the lesions were sustained (Plate 9.3).

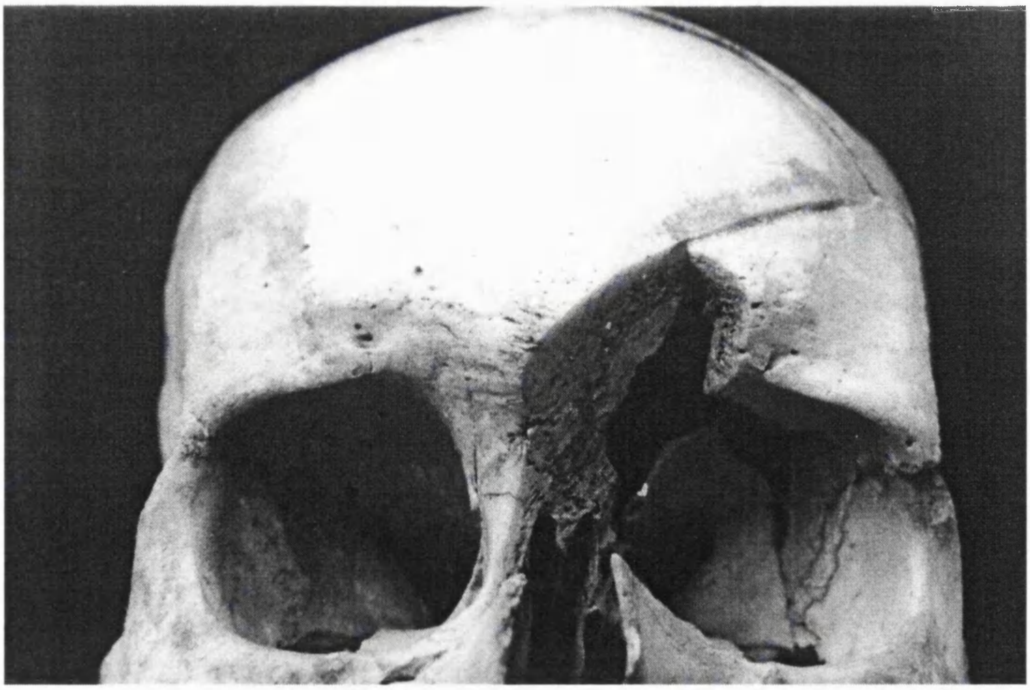

Plate 9.2. Fatal Sword (?) Injury; Gran Canarian Female (Museo Canario)

However, some of the depressed fractures and all the cutting/slashing injuries were apparently fatal, or were *peri-mortem* in origin (Plate 9.2).

Plate 9.3. Non-Fatal Depressed Lesion; Gran Canarian Male (Museo Canario)

9.2 Cause of Cranial Lesions

Identifying the cause of lesions is often problematic (Larsen 1997), and the present case is no exception. Some of the lesions are relatively easy to interpret, notably the slingshot/stone injury in Plates 9.3 and 9.4, the cutting/slashing injury in plate 9.2 and the stabbing lesions in 9.6. The general intention in the present case is to accurately distinguish between accidental traumatic injuries suffered as a result of active lifestyles in a rugged environment (Rodriguez-Martin 1992), and the lesions caused by inter-personal violence and confrontation which can (with caution) be used as a measure of social dynamics and behaviour.

In the Canaries, the known candidates for causes of trauma include stones, slingshots (possibly the cause of the lesion in Plates 9.3 and 9.4), staves (the possible cause of the lesion presented in plate 9.1, as well as several other lesions on the same individual), a form of hand-held stone and leather 'club', resembling an Argentininian bola (Rodriguez-Martin 1999: 6), and injury derived from unarmed pugilism.

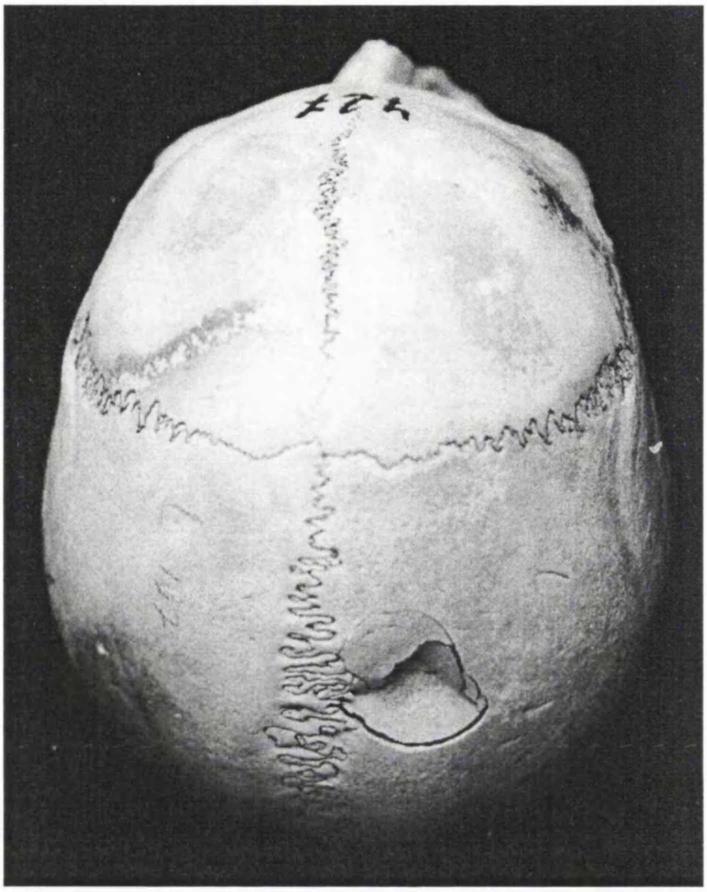

Plate 9.4. *Peri-Mortem* (Slingshot?) Right Parietal Lesion; Tenerife (ICPB 727)

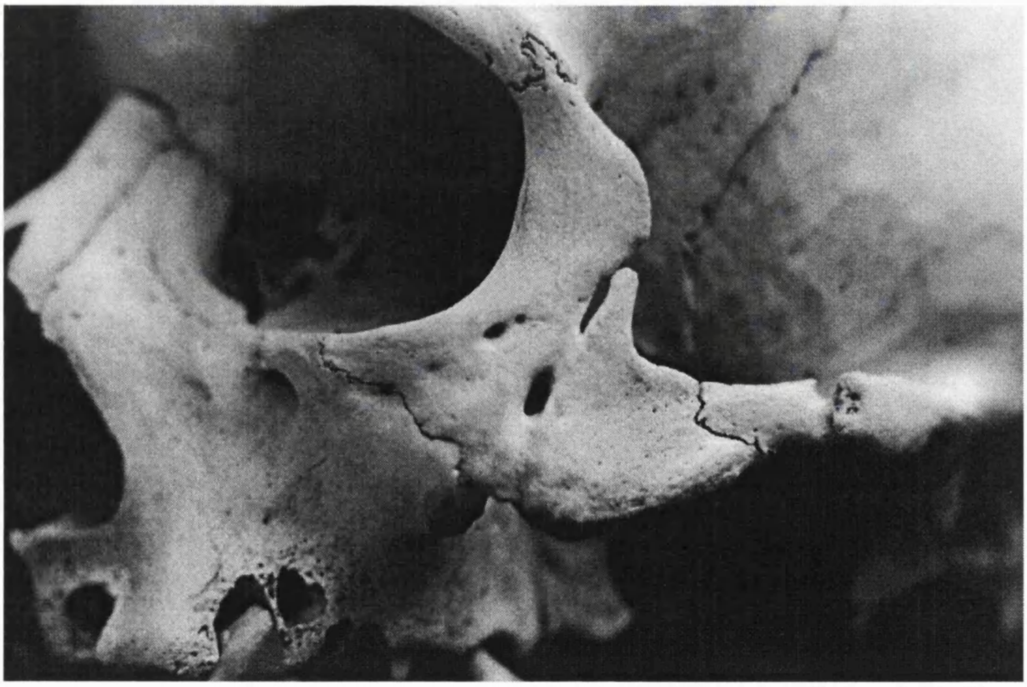

Plate 9.5. Left Zygomatic Trauma. Male (Tenerife)

Fire-hardened wooden swords (see plate 9.2) are also a possibility (Rodriguez-Martin Pers. Comm.), although lesions caused by these weapons could potentially be confused with those caused by the metal weapons of non-native groups entering the archipelago prior to and during the conquest. Firstly, however, it was important to distinguish between the intentional and accidental traumatic injury, and it was anticipated that the manner in which the trauma is distributed between the sexes and periods, and across the skull, would provide some clues regarding the cause of traumatic lesions.

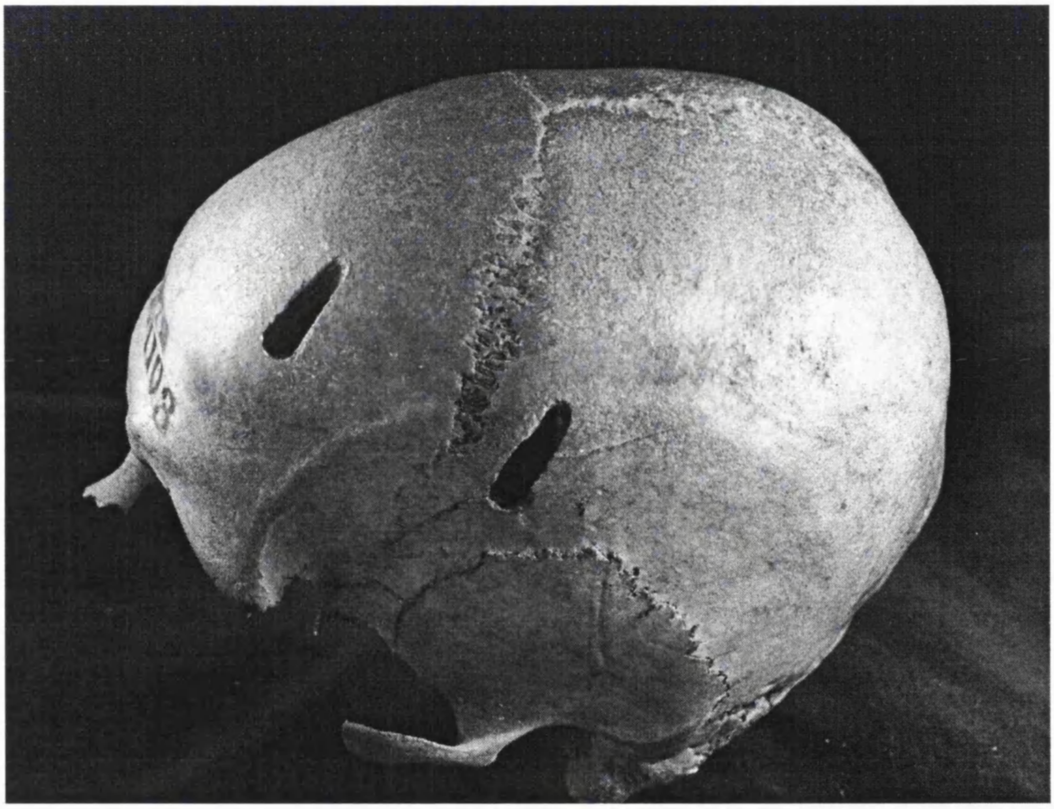

Plate 9.6. Fatal Left Frontal and Parietal Trauma; Tenerife (NHM 1103)

9.3 Basic Trauma Trends – Pooled Trauma

The total number of lesions in the sample was calculated and is presented here to give a general impression of total trauma prevalence. This was calculated in reference to island, period, sex, side, age and region.

9.3.1 Basic Trauma Prevalence by Island

The data were processed to produce an individual count on an affected/unaffected dichotomy. These are presented below.

Island	Affected	% Affected	N
Fuerteventura	4	20%	20
Gomera	12	32.4%	37
Gran Canaria	32	14%	229
Hierro	8	10%	80
Lanzarote	4	33.3%	12
La Palma	0	0	2
Tenerife	46	25.3%	182
Total	106	18.9%	562

Table 9.1. No. of Individuals Affected by Cranial Trauma, by Island

When assessed in this manner, 18.9% of individuals were affected with at least one cranial lesion. The most strongly affected islands were Gomera and Lanzarote (although samples are not large), followed by Tenerife, Fuerteventura, Gran Canaria and Hierro. In ‘real’ terms – i.e. taking sample size into account – Tenerife and Gomera were the most strongly affected islands in the group (see figure 9.1a).

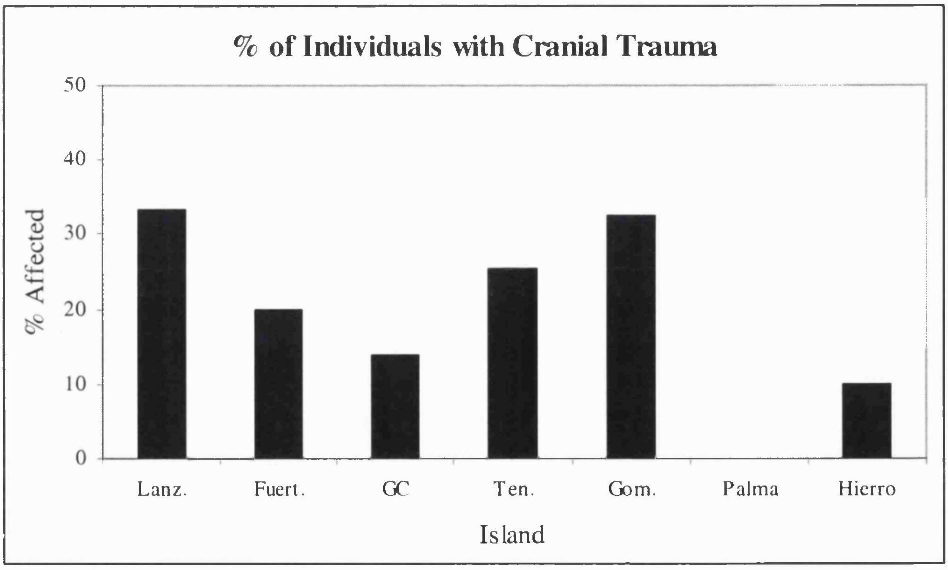

Figure 9.1a. Total Cranial Trauma by Individual and Island

Viewed in this way, the proportion of individuals affected by cranial trauma is extremely high. Next, the data were reprocessed in order to show the total number of affected ‘sites’ (sub-sections of the skull) against the total number of sites in the sample.

Island	Sample	Affected	% Affected
Lanzarote	78	6	7.7
Fuerteventura	174	7	4.0
Gran Canaria	2262	84	3.7
Tenerife	1104	94	8.5
Gomera	321	19	9.0
La Palma	5	0	0.0
Hierro	629	18	2.9

Table 9.2. Total Numbers of Cranial Sites Affected by Trauma, by Island

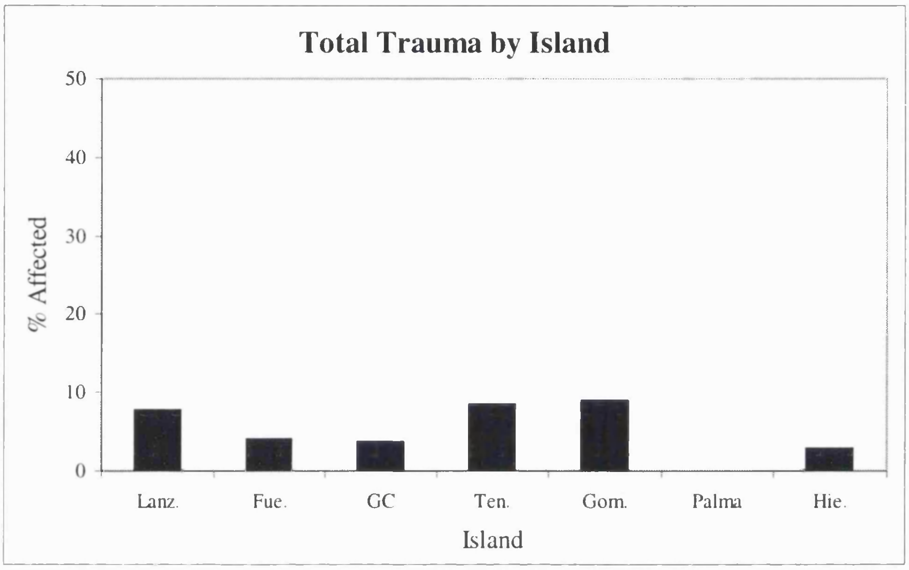

Figure 9.1b. Trauma by Cranial Site and Island

When considered by island, Gomera was the most frequently affected (9%), followed by Tenerife (8.5%), Lanzarote (7.7%), Fuerteventura (4%), Gran Canaria (3.7%), Hierro (2.9%) and La Palma (0% – but n=2). When assessed using Chi-Squared Tests (see appendix 5), these results were highly significant (P = .004). The parameters of the null hypothesis (i.e. the expected counts per group) suggest a higher than expected prevalence in Tenerife, Lanzarote and Gomera, and lower than predicted figures in Hierro and Gran Canaria. These groupings do not address the archipelago's configuration (save for the Tenerife/Gomera grouping).

In order to examine how this data (above) breaks down into cranial vs. facial trauma, the categories were split and the data processed by island.

Island	Cranial	% Affected	N	Facial	% Affected	N
Fuerteventura	4	20	20	0	0	20
Gomera	19	51.4	37	8	21.6	37
Gran Canaria	58	25.3	229	24	10.5	229
Hierro	13	16.3	80	4	5	80
Lanzarote	5	41.7	12	2	16.7	12
La Palma	0	0	1	0	0	1
Tenerife	61	33.9	180	20	11.1	180
Total	160	28.6	559	58	10.4	559

Table 9.3. Cranial/Facial Trauma by Island

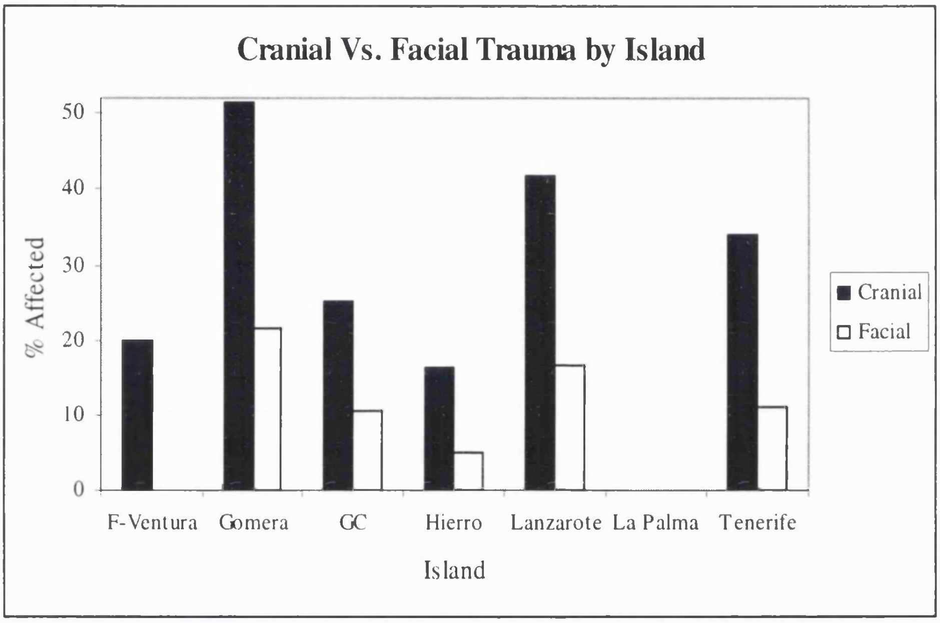

Figure 9.2. Cranial/Facial Trauma by Island

Facial trauma was always rarer than cranial lesions. As noted above, the CST results were highly significant (P = .004).Gomera had the highest rate of both forms of trauma – with over half of the sample affected with cranial trauma and 1/4 affected with facial lesions – followed by Lanzarote and Tenerife. However, the Lanzarote sample is so small that these findings are questionable, and it is more likely that Tenerife and Gomera are in fact more similar to one another than these preliminary results suggest. Gran Canaria and Hierro both had fairly low levels of cranial/facial trauma.

Plate 9.7. Nasal (Facial) Trauma. Gomeran Younger Male

9.3.2 Basic Trauma Prevalence by Side

The pooled cranial data were divided by side to determine whether there was any strong patterning in lesion side, which may provide some indication of behavioural traditions in the sample. Unsided (nasal) trauma was excluded. The pooled data were analysed for side trends.

Side	Absent	%	Present	%	N
Left	441	81.8	98	18.2	539
Right	468	86.5	73	13.5	541
Total	909	84.2	171	15.8	1080

9.3.1. Basic Pooled Trauma Prevalence by Side

The general trend was towards trauma of the left rather than the right side – which is a potentially indicator of inter-personal violence, specifically of bludgeoning in a face-to-face confrontation by a right-handed assailant. A preliminary CST test indicates significantly (P=0.03) more trauma on the left than the right side of the skull (Chamberlain pers. Comm.).

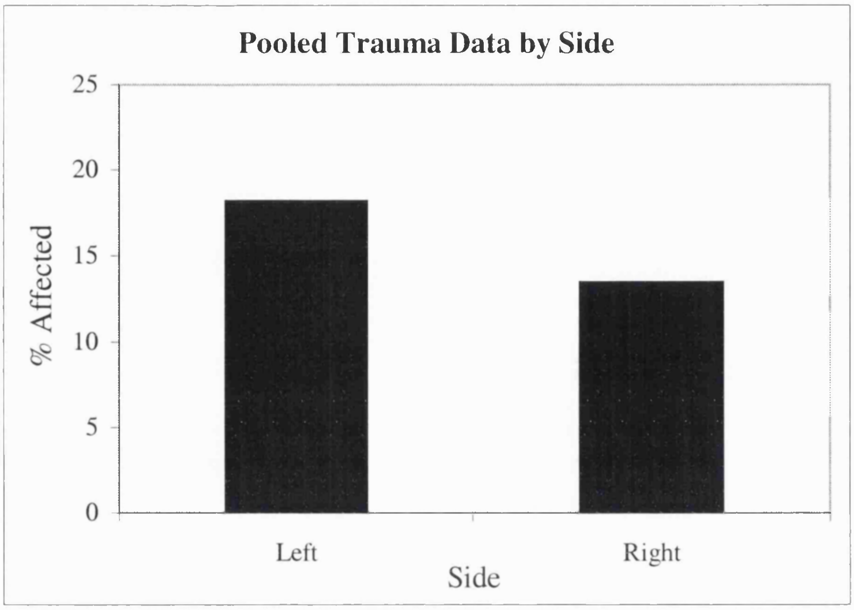

Figure 9.3. Basic Pooled Trauma Prevalence by Side

9.3.3 Basic Trauma by Side and Island

The side data was considered by island (La Palma was excluded). The basic trend data are presented in table 9.4.

Island	Left	%	Right	%	Left/Right	%	N
Fuerteventura	3	15	1	5	0	0	20
Gomera	12	32.4	4	10.8	3	8.1	37
Gran Canaria	29	12.7	22	9.6	4	1.7	229
Hierro	8	10	3	3.8	1	1.3	80
Lanzarote	1	8.3	4	33.3	0	0	12
La Palma	0	0	0	0	0	0	1
Tenerife	25	14	19	10.7	11	6.2	178
Total	78	14	53	9.5	19	3.4	557

Table 9.4. Positional Trauma Data by Island

Double lesions on one side were only counted as a single lesion (note that multiple lesions are uncommon – see section 9.3.5 and table 9.11) for the current test, in order to facilitate analysis. These data echo that provided in the standard by-island test performed above (P = .004), but with increased resolution concerning the number of lesions per person. The double lesions demonstrate increased prevalence towards the western end of the archipelago, peaking in Gomera, which also sees the highest prevalence of left side trauma.

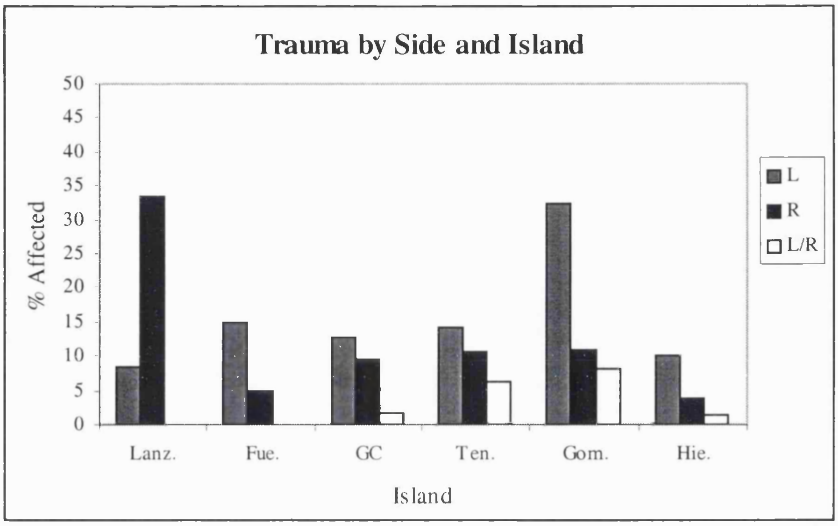

Figure 9.4. Trauma by Side and Island

Gomera and Tenerife also share the archipelago's highest prevalence of right side trauma (where small sample size could be discounted). As noted, left side trauma always exceeded right side (or bilateral) lesions in terms of prevalence, to an often striking extent.

9.3.4 Basic Trauma Prevalence by Period

The data were also tested for chronological trends. Trauma from all sites was pooled and examined across all periods and the undated group. The basic data are presented in table 9.5, with graphic output in figure 9.5.

Period	% Affected	Sample	Unaffected
Undated	4.4	59/1352	1293
Early	5.2	12/229	217
Intermediate	5.7	142/2471	2329
Late	5.9	22/373	351

Table 9.5. Pooled Cranial Trauma by Period (by-Site Basis)

There was a slight increase from the early (5.2%) to middle (5.7%) and late (5.9%) periods. 4.4% of the undated sample (essentially the western islands and Fuerteventura) was also affected.

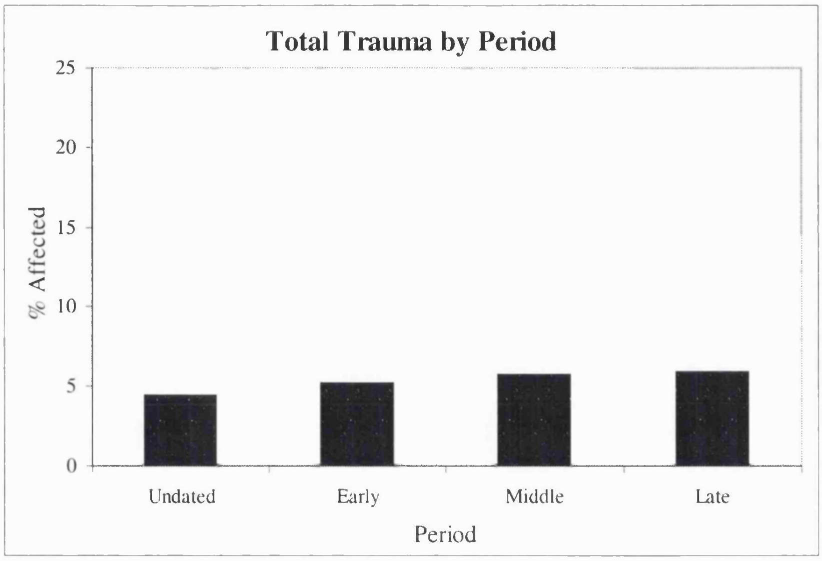

Figure 9.5. Pooled Cranial Trauma by Period

When considered by individual rather than by site, the results presented in 9.6 were obtained.

Period	Affected	% Affected
Undated	29/157	18.5%
Early	4/28	14.3%
Middle	66/326	20.2%
Late	7/50	14%
Total	106/561	18.9%

Table 9.6. Pooled Trauma Prevalence by Period (Individual Basis)

A Chi-Squared test was carried out on the table 9.6 data (see appendix 5). However, the undated material was excluded because this subgroup had little relevance for assessing temporal trends. Once processed in this manner, it was apparent that there was no temporal trend in trauma prevalence patterns (P = .463). Whether this is also true when the trauma is considered by specific sites on the skull is discussed further below. The single/multiple lesion data (using the facial/cranial dichotomy – see below) were assessed along the chronological timeline, to provide the data in table 9.7. As before, the trend was not significant (P = .477).

		None	Cranial	Facial + Cranial	N
Early	Count	20	4	4	28
	% within PERIOD	71.4%	14.3%	14.3%	100.0%
Middle	Count	225	65	34	324
	% within PERIOD	69.4%	20.1%	10.5%	100.0%
Late	Count	39	5	6	50
	% within PERIOD	78.0%	10.0%	12.0%	100.0%
Total	Count	284	74	44	402
	% within PERIOD	70.6%	18.4%	10.9%	100.0%

Table 9.7. Pooled Trauma Prevalence by Number of Lesions and Period

The same tests were run to assess whether there was a temporal component to trauma by side. The trend data are presented in table 9.8, and graphically in figure 9.6. The undated sample was not included in the CSTs as this was irrelevant to the purpose of investigating temporal trends, but is presented in table 9.8 for the purposes of reference.

Period	Left	%	Right	%	Bilateral	%	N
Undated	25	15.9	11	7	4	2.5	157
Early	3	10.7	4	14.3	1	3.6	28
Middle	46	14.3	35	10.9	12	3.7	322
Late	4	8	3	6	2	4	50
Total	78	14	53	9.5	19	3.4	557

Table 9.8. Trend Data for Left and Right Side Trauma by Period

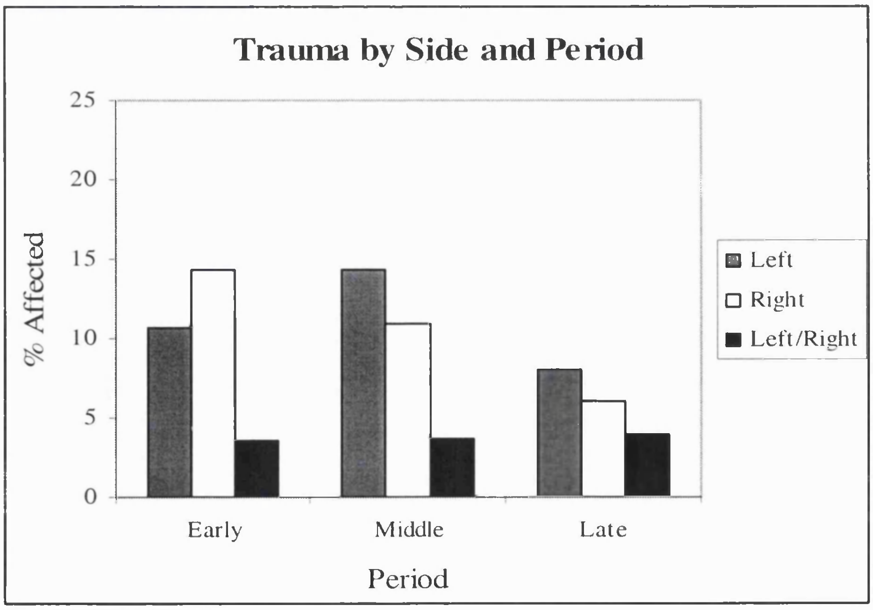

Figure 9.6. Left and Right Side Trauma by Period

The trend data demonstrate a fairly even spread of left/right side lesions (with a slight rise in the late sample), while left side lesions were most prevalent in the middle period and lowest in the late group, and right side lesions peaked in the early group and dropped off through subsequent periods. However, with a P. value of .738, this variability was not significant.

9.3.5 Basic Trauma Prevalence by Sex

The same data were reassessed to determine whether there were any differences in terms of trauma prevalence between the sexes.

SEX	Affected	% Affected	N
Male	70	24.8%	282
Sex Unknown	7	12.1%	58
Female	29	13.2%	220
Total	106	18.9%	560

Table 9.9. Pooled Trauma Prevalence by Sex

In percentage terms, males were about twice as strongly affected as females and the unsexed group. When tested using CSTs (the poorly-defined unsexed group was removed for the analysis), this trend was significant at the P = .001 level (see appendix 5), with males by far exceeding, and females falling below, the figures predicted under the terms of the null hypothesis. The same data tested by side (single/multiple lesions) and sex (see table 9.10) produced a P value of .000, further confirming that males suffered more frequently and severely from cranial lesions than females.

		None	Left	Right	Left and Right	N
Male	Count	175	51	36	18	280
	% within SEX	62.5%	18.2%	12.9%	6.4%	100.0%
Female	Count	179	23	15	1	218
	% within SEX	82.1%	10.6%	6.9%	.5%	100.0%
Total	Count	354	74	51	19	498
	% within SEX	71.1%	14.9%	10.2%	3.8%	100.0%

Table 9.10. Pooled Trauma Prevalence by Sex and Side (Single/Multiple Lesions)

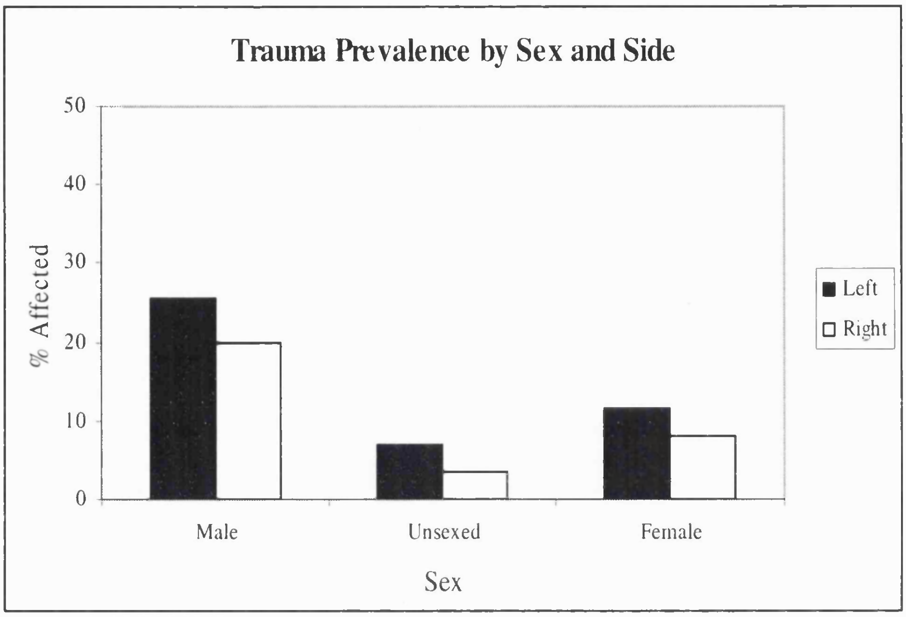

Figure 9.7. Trauma Prevalence by Sex and Side

The data were processed to assess the relative proportions of single and multiple lesions, using the sex variable. The general trend data are presented in table 9.11 and figure 9.8. Note that the scale of figure 9.8 has been altered to show the very low prevalence of double and triple cranial trauma prevalence more clearly.

	Single	Double	Triple
Male	7.3 (160/2204)	0.5 (10/2204)	0.1 (1/2204)
Female	2.9 (52/1744)	0.2 (3/1744)	0 (0/1744)

Table 9.11. Prevalence of Single and Multiple Cranial Traumas by Sex

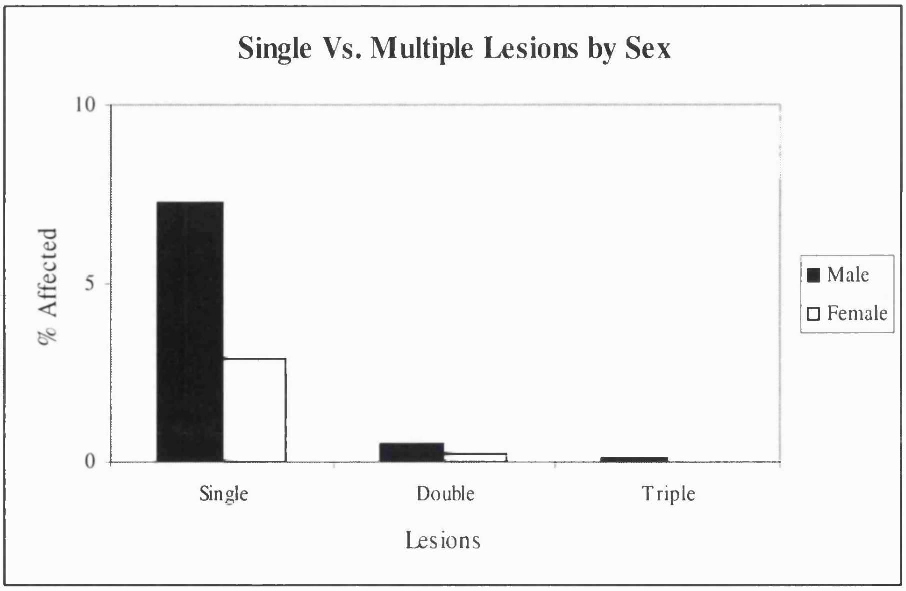

Figure 9.8. Prevalence of Single and Multiple Cranial Traumas by Sex

Single lesions were much more common than double or triple examples. As before, males were far more strongly affected than females, and only males were affected in the triple lesions category. Statistical tests were not carried out on this data.

A simple comparison between the sexes was carried out in order to establish whether there were any significant differences in their respective profiles of cranial vs. facial trauma, as this may have potential for distinguishing between different forms of violence (i.e. domestic vs. martial). 'Facial' was defined as the maxillae, the pyriform aperture and the zygomatics; 'cranial' as the parietals and the frontals. This data is presented in table 9.12 and figure 9.9.

		None	Cranial	Facial + Cranial	N
Male	Count	170	69	43	282
	% within SEX	60.3%	24.5%	15.2%	100.0%
Female	Count	177	27	14	218
	% within SEX	81.2%	12.4%	6.4%	100.0%

Table 9.12. Cranial/Facial Trauma by Sex

As noted above, male had a significantly (P = .000) higher prevalence of all forms of cranial trauma than females, which consistently fell beneath the requisite levels of the null hypothesis.

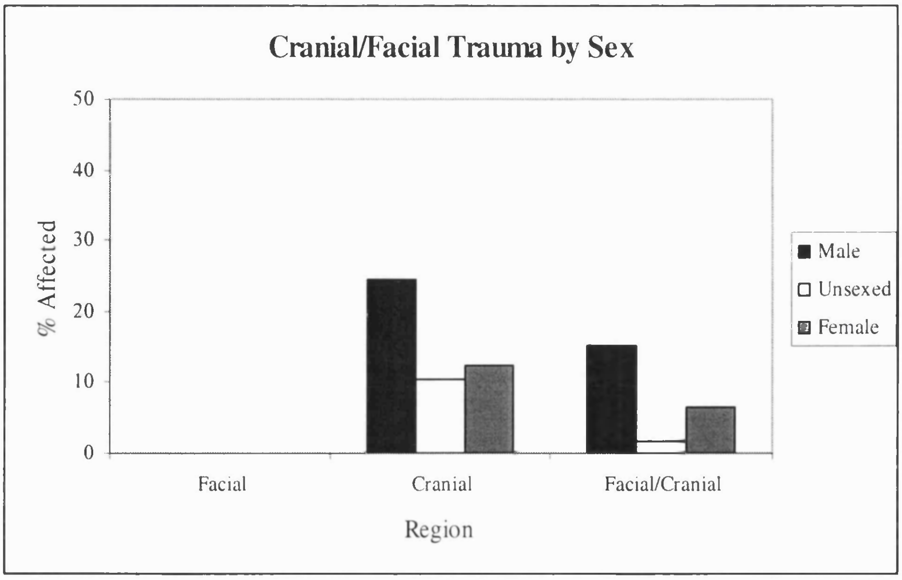

Figure 9.9. Cranial/Facial Trauma by Sex

The most notable finding in the profile produced above is that individuals were never only affected by facial trauma. Based on published work – which posits a strong stress on the facial bones as a major target for battery and assault in a domestic context, whereas cranial trauma is a phenomenon more associated with martial contexts – there is no apparent difference in the manner in which males and females acquired their traumatic lesions. Insofar as dangerous environment is concerned, the islands are fairly uniform; vertiginous and highly variable both climatically and ecologically. If all the trauma were incurred as a result of falls, accidents and other factors inherent in highly active lifestyles (Rodriguez-Martin 1992), one would expect a consistently diffuse pattern of trauma (although the lack of postcrania limits the level of refinement this study can reach). Rodriguez-Martin has posited behavioural reasons for the high levels of sexual dimorphism in the Canarian sample, linked to higher activity levels in men. If this is indeed the case, it may also be true that the more active males would sustain more injuries than females.

9.3.6 Basic Trauma Prevalence by Ageclass

The age at which lesions were obtained may provide some indication of the cause of the traumas, and also the social context in which this arose. The data are presented in appendix 5 and are summarised in tables 9.13 and 9.14 and figure 9.10. Ageclasses were collapsed in order to provide general age bands that reflected major phases of life history, to maximise sample size, and to strengthen the value of assertions made upon the basis of the evidence.

	Affected	% Affected	N
Subadults	6	10.9%	55
Younger Adults	53	19.1%	277
Older Adults	47	20.5%	229
Total	106	18.9%	561

Table 9.13. Trauma Prevalence by Ageclass

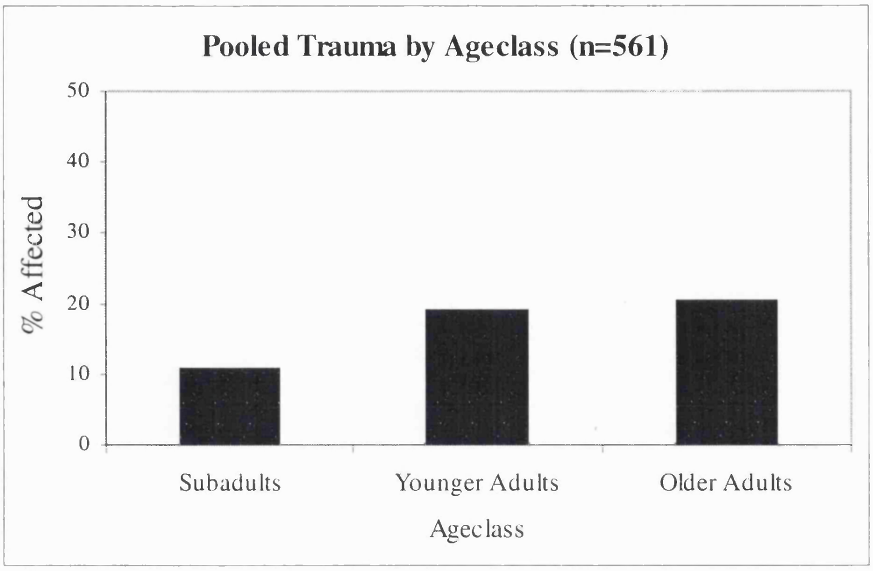

Figure 9.10. Trauma Prevalence by Ageclass

Ageclass		None	Cranial	Facial + Cranial	N
Subadults	Count	7	3	0	10
	% within AGE	70.0%	30.0%	.0%	100.0%
Younger Adults	Count	194	53	22	269
	% within AGE	72.1%	19.7%	8.2%	100.0%
Older Adults	Count	146	40	35	221
	% within AGE	66.1%	18.1%	15.8%	100.0%
Total	Count	347	96	57	500
	% within AGE	69.4%	19.2%	11.4%	100.0%

Table 9.14. Single/Multiple Trauma Prevalence by Ageclass

The pooled data (i.e. affected/unaffected by individual) demonstrate a general tendency for trauma prevalence to increase in accordance with age. However, with a P value of .066, this trend was not significant. In general terms, however, the difference between the pooled adult sample vs. the subadult group would clearly be highly significant, so CSTs were not carried out.

9.3.7 Pooled Trauma Prevalence by Region

The three hypotheses for regional differentiation proposed in chapters 2 and 8 (Eastern/Central/Western; Eastern/GC/Tenerife/Western; Central/Satellite) were tested for trauma diversity. The basic trend data are presented in table 9.15 (see appendix 5), and the CST results in table 9.16.

		Left	%	Right	%	Left/Right	%	N
REGION_1	Eastern	4	12.5	5	15.6	0	0	32
	Central	54	13.3	41	10.1	15	3.7	407
	Western	20	16.9	7	5.9	4	3.4	118
REGION_2	Eastern	4	12.5	5	15.6	0	0	32
	GC	29	12.7	22	9.6	4	1.7	229
	Tenerife	25	14	19	10.7	11	6.2	178
	Western	20	16.9	7	5.9	4	3.4	118
REGION_3	Satellite	24	16	12	8	4	2.7	150
	Central	54	13.3	41	10.1	15	3.7	407

Table 9.15. Single/Multiple Trauma Prevalence by Region

	Chi-Squared Test
REGION_1	.529
REGION_2	.225
REGION_3	.702

Table 9.16. Chi-Squared Test Results for Trauma Prevalence by Region

The CST results demonstrate that there was no significant diversity using these subdivisions of the archipelago. The ecological arguments that derived from a study of environmental regimes in the archipelago are therefore inappropriate for this part of the study; this particular aspect of human behaviour therefore clearly cannot be determined from the viewpoint of ecological determinism. To further refine this work, the general trend data for region (considered by side) is presented in table 9.17.

	Region_1	L	%	R	%	L+ R	%	N
REGION_1	Eastern	4	12.5	5	15.6	0	0	32
	Central	54	13.3	41	10.1	15	3.7	407
	Western	20	16.9	7	5.9	4	3.4	118
	Total	78	14	53	9.5	19	3.4	557
REGION_2	Eastern	4	12.5	5	15.6	0	0	32
	GC	29	12.7	22	0.4	4	0.4	229
	Tenerife	25	14	19	10.7	11	6.2	178
	Western	20	17.5	7	0.8	4	3.4	118
	Total	78	14	53	9.5	19	3.4	557
REGION_3	Satellite	24	16	12	8	4	2.7	150
	Central	54	13.3	41	10.1	15	3.7	407
	Total	78	14	53	9.5	19	3.4	557

Table 9.17. Regional Variability in Cranial Trauma Considered by Side

These data were tested using CSTs. The results are presented in table 9.18, but none of the three tests produced significant results.

Region	CST
REGION_1	0.529
REGION_2	0.225
REGION_3	0.702

Table 9.18. Chi-Squared Test Results for Cranial Trauma by Region and Side

It is therefore apparent that there was no direct link with trauma prevalence when the islands were grouped with reference to ecological zoning, and that cranial trauma, in the present case at least, is more of a social than ecologically-forced phenomenon.

9.4 Basic Trauma Trends: Non-Pooled Trauma

This section assesses the cranial trauma data, incorporating more complex subdivisions and category definitions.

9.4.1 Basic Trauma Trends: Trauma by Location (Unsided)

The data were reprocessed to establish the pattern of trauma when considered by cranial bone, without reference to side. This was to establish the generalities of trauma distribution per skull section, in order to set the parameters for more complex analyses (see below). The data are presented in table 9.19 and in figure 9.11.

Site	Sample	Affected	% Affected
Parietals	780	58	7.4
Frontals	1010	88	8.7
Maxillae	974	53	5.4
Zygomatics	930	13	1.4
Pyriform Aperture	507	16	3.2
Totals	4201	228	5.4

Table 9.19. Trauma by Cranial Region

Complete bone comparisons see a peak in frontal (8.7%) and parietal (7.1%) trauma, followed by lesions of the maxilla (5.5%), pyriform aperture (3.2%) and zygomatics (1.4%). Prevalence was not particularly variable, although the lower prevalence of zygomatic trauma is highly statistically significant (Chamberlain Pers. Comm.). Most of the injuries were therefore cranial rather than facial, and this distinction is explored in more detail in section 9.5.

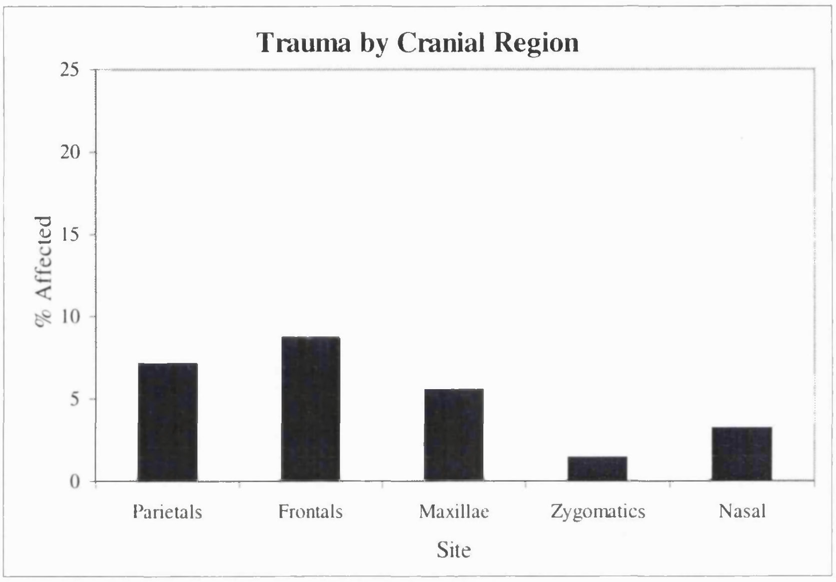

Figure 9.11. Trauma by Cranial Region

9.4.2 Basic Trauma Trends: Bones by Side

In order to pursue the question of cause, lesions were assessed across the skull with reference to the bones affected. The basic percentage values are presented in table 9.20 and figure 9.12.

	Left	Right	Unsided
Parietals.	9.8	7.6	-
Frontals	8.4	5.7	-
Maxillae	6.2	4.7	-
Zygomatics	2	0.8	-
Nasal Bones	-	-	3.2

Table 9.20. Cranial Trauma by Bone and Side

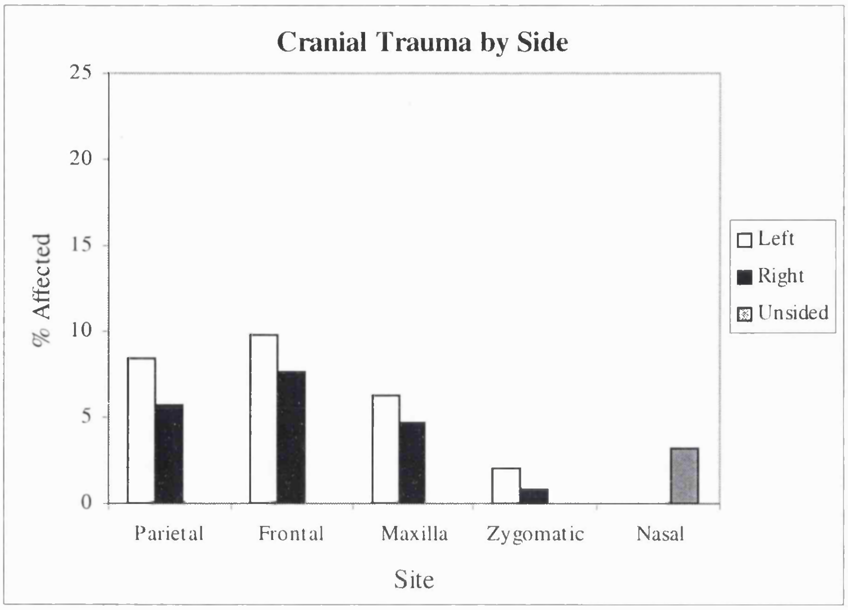

Figure 9.12. Cranial Trauma by Bone and Side

This review complements section 9.3.4 in terms of providing an anatomical breakdown of the side trends observed in the pooled sample. The left side of all the paired bones were more frequently affected than the right in all cases. The strongest focus for trauma is therefore the front and the sides of the calvarium – especially on the left side – then the facial bones.

9.5 Complex Trauma Trends: Specific Lesion Location

The data were processed to derive more detailed information about the location of lesions on the cranium, and were treated using a similar range of methods to those employed in section 9.3 and 9.4. The cranial trauma data were processed CSTs. The variables were island, period and sex. Those islands with respectable samples (Gran Canaria and Tenerife) were analysed by period and sex. The dearth of dates for the remaining islands – especially the western group – is regrettable, as it prevents the study of temporal trends within smaller islands, which may differ from temporal differences on Tenerife and Gran Canaria. These variables, having been tested for significance, were then subjected to CSTs in order to determine the polarity of a trend's prevalence.

Site	Unaffected	Affected	% Affected	Sample
Left Parietal	457	42	8.4	499
Right Parietal	265	16	5.7	281
Left Frontal	451	49	9.8	500
Right Frontal	471	39	7.6	510
Left Maxilla	454	30	6.2	484
Right Maxilla	467	23	4.7	490
Left Zygomatic	449	9	2.0	458
Right Zygomatic	468	4	0.8	472
Pyriform Aperture	491	16	3.2	507
Totals	**3973**	**228**	**5.4**	**4201**

Table 9.21. Total Counts for Trauma by Specific Site – Pooled Samples

In terms of crude comparison, 5.4% of cranial 'sites' (228/4201) were affected by at least one traumatic lesion. About one quarter of individuals were affected (228/896 = 0.25% lesions per person). Multiple lesions featured on the parietals and frontal (see above). The highest prevalence was in the left frontal, followed by the left parietal and the right frontal. In all cases, the left side was more strongly affected than the right. The most rarely affected site was the right zygomatic.

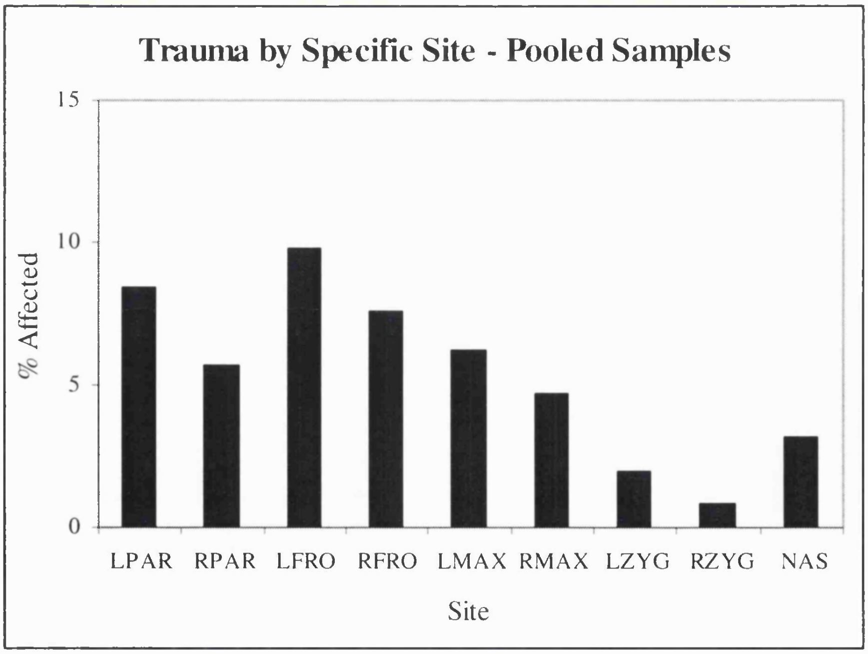

Figure 9.13. Total Counts for Trauma by Specific Site – Pooled Samples

Tooth loss was used as a proxy for oral injury. The Hillson system enabled the encoding of *ante-mortem* tooth loss figures, which were compared against the remaining teeth (defined as present and lost *post-mortem* teeth). While calculations were carried out for all ageclasses, only young and older adults were used in the final summary, as the anterior dentition (first and second incisors, canines) all erupt before 18 years of age, and were not usually affected by carious lesions and tooth loss (through abscessing etc) until relatively late in life. Each set of three teeth was treated as a group (upper and lower left and right quadrants). An 'affected' score was defined by *ante-mortem* loss of any tooth within each quadrant. These data were processed by age (younger/older adults), sex and island. Pooled sample studies are presented in table 9.22.

	Quadrant	Young Adults	Older Adults
Male	L_Lower	3.2%	9.4%
	L_Upper	2.2%	8.2%
	R_Lower	1.8%	7.4%
	R_Upper	2.2%	5%
Female	L_Lower	2.2%	8.8%
	L_Upper	2.1%	5.5%
	R_Lower	2.1%	6.4%
	R_Upper	1.4%	5.5%

Table 9.22. Anterior Tooth Loss by Sex and Age

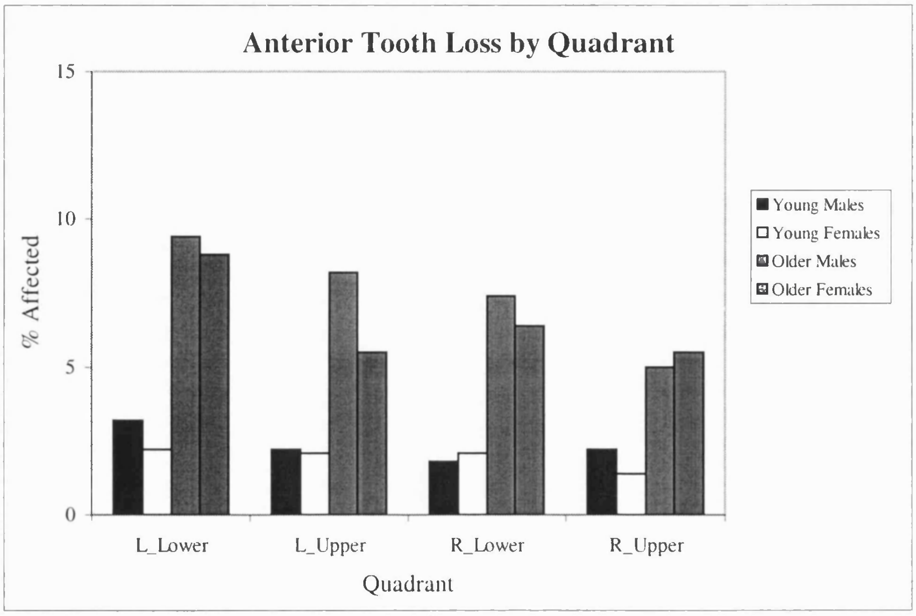

Figure 9.14. Anterior Tooth Loss Patterns

The general pattern of tooth loss is towards low trauma prevalence in youth (1.4% to 3.2%) and a notable increase into older adulthood (5% to 9.4%). This would imply that the cause of trauma was not restricted to any one ageclass, as the extremely high leap in anterior tooth loss exceeds any figures expected from the perusal of caries (and therefore abscessing and tooth loss) data in this project. The highest overall prevalence was on the left rather than the right quadrants (2.1% to 9.4% vs. 1.4% to 6.4%), and the lower teeth more than the upper (1.8% to 9.4% vs. 1.4% to 7.4%). In the young adult group, males were more strongly affected than females in all quadrants except for the right upper, and this pattern was repeated in the older adult group (with higher overall prevalence). The siding data therefore echoes that for the other forms of cranial trauma, as does the sex data (i.e. more males than females affected in 3/4 cases per ageclass), although trends were not strong. The dental loss system used in the present study was only designed to give a general measure of implied trauma patterns, so it was judged inappropriate to use CSTs on the tooth loss data for fear of generating misleading results. Therefore only the trend data is presented in the examination of inter-island and inter-period trauma patterns (see below).

9.5.1 Cranial Trauma by Location and Island

The specific site data were assessed by island. The CST results are presented in appendix 5 and are summarised below (table 9.23).

Site	Chi-Squared Test
Left Parietal	.001
Right Parietal	.091
Left Frontal	.220
Right Frontal	.020
Left Maxilla	.405
Right Maxilla	.103
Left Zygomatic	.197
Right Zygomatic	.773
Pyriform Aperture	.698

Table 9.23. Cranial Trauma by Location and Island

As can be seen, only two sites demonstrated significant variability in terms of lesion prevalence by island. It should be noted that the most frequently affected lesion site (left frontal) did not demonstrate significant spatial patterning as high levels of trauma in this region were fairly universal. The loss of anterior dentition in young and older adult groups was also assessed as laid out above. The percentage data is presented in table 9.24 and figure 9.15.

	Younger_Left	Younger_Right	Older_Left	Older_Right
Lanzarote	0	0	8.3	5.6
Fuerteventura	0	1.6	4.2	0
Gran Canaria	2.2	1.6	9.1	5.4
Tenerife	2.7	2	5.4	4.8
Gomera	1.8	1.6	8.2	13.2
Palma	-	-	16.9	-
Hierro	3.7	1.3	10.2	7.6

Table 9.24. Anterior Tooth Loss by Ageclass and Island

Traumatic tooth loss was also assessed in the same manner as the cranial trauma figures, although statistical analysis was not deemed to be of great utility. However, the general pattern supports that of the cranial figures proper (see above) with higher prevalence of tooth loss per age class in the left side of the mouth, particularly in the upper jaw. It is

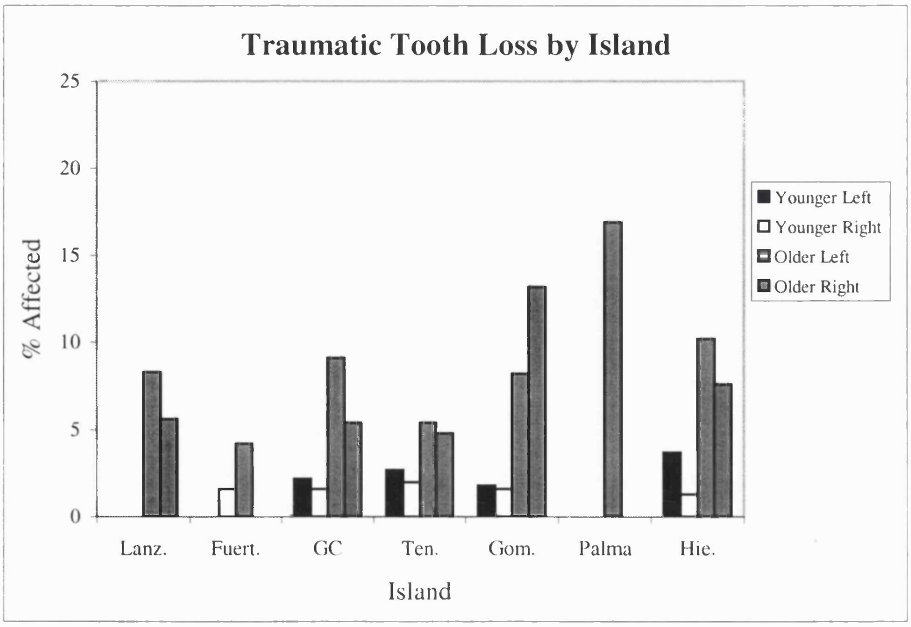

Figure 9.15. Anterior Tooth Loss by Island

interesting to note that the Gomera sample – which is very strongly affected in older adulthood – was much less affected in younger adulthood (absent in Lanzarote). Fuerteventura and Tenerife were the least affected islands overall, although Tenerife was affected in all quadrants and both ageclasses unlike Fuerteventura. There is a general trend for increased trauma prevalence towards the western archipelago, although there is considerable variability in the samples.

9.5.2 Trauma by Cranial Site and by Period

The specific site data was assessed along chronological lines to produce table 9.25 and figure 9.16, and tested using CSTs (table 9.26). The workings are presented in appendix 5; summaries are provided below. The undated category was not considered.

Site	Early	Middle	Late
Left Parietal	3.7% (1/27)	10.1% (28/277)	9.1% (4/44)
Right Parietal	0 (0/28)	5.7% (6/281)	4.7% (2/43)
Left Frontal	10.7% (3/28)	9.3% (26/279)	5% (2/40)
Right Frontal	7.1% (2/28)	9.2% (26/283)	9.1% (4/44)
Left Maxilla	8% (2/25)	6.6% (18/271)	5% (2/40)
Right Maxilla	12.5% (3/24)	4.7% (13/277)	7.3% (3/41)
Left Zygomatic	0 (0/22)	1.6% (4/253)	5.3% (2/38)
Right Zygomatic	0 (0/22)	1.1% (3/262)	2.5% (1/40)
Pyriform Aperture	4% (1/25)	2.8% (8/288)	4.7% (11/356)

Table 9.25. Trauma by Cranial Site and Period

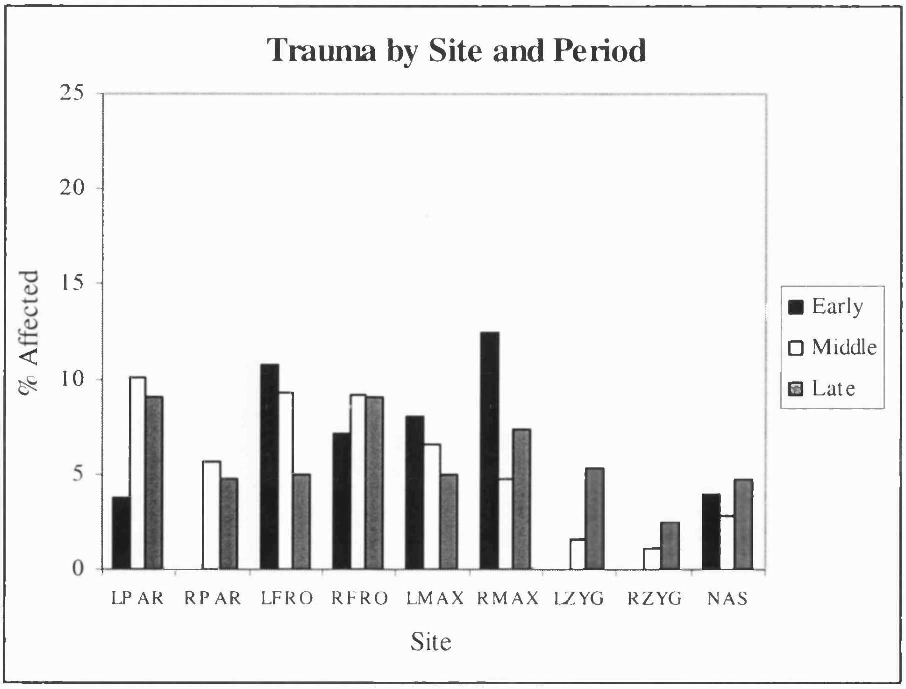

Figure 9.16. Trauma by Cranial Site and Period

In this test, the data were inconsistent, showing a wide range of trauma patterns without evident temporal trends. This was confirmed by the CSTs, which demonstrated that there was no significant variability in the sample when considered by period.

Site	Chi-Squared Test
Left Parietal	.553
Right Parietal	.423
Left Frontal	.631
Right Frontal	.937
Left Maxilla	.884
Right Maxilla	.242
Left Zygomatic	.241
Right Zygomatic	.664
Pyriform Aperture	.774

Table 9.26. CST Results – Trauma by Cranial Site and Period

The tooth loss data was also examined, and are presented in figure 9.17. Patterns were essentially homogenous, so CSTs were not carried out.

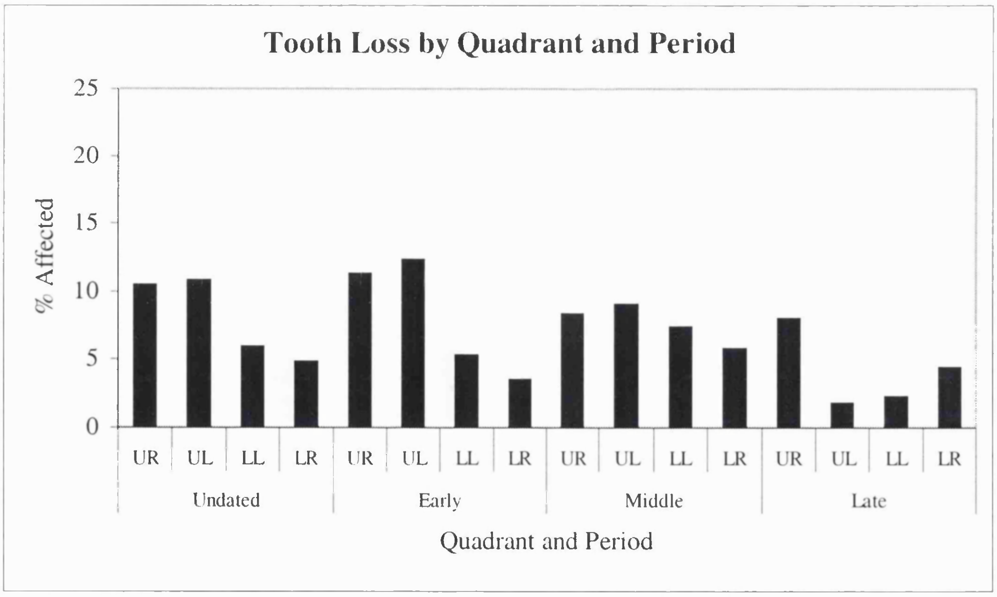

Figure 9.17. Tooth Loss by Quadrant and Period

As for the cranial data proper, the dental loss data did not demonstrate any particular trend when assessed along a temporal scale. Loss was highest in the early group and lowest in the late sample. When patterns were considered, there was a consistent tendency for increased prevalence in the upper jaw, and the left side was more affected than the right in all groups except the late sample.

9.5.3 Intra-Island Trauma by Period

The two largest island samples (Gran Canaria and Tenerife) were reviewed to ascertain whether there were any internal temporal trends in the prevalence of cranial trauma. The results are presented in appendix 5. Only a summary of the CST results are presented here (table 9.27).

Site	Gran Canaria	Tenerife
Left Parietal	.769	.191
Right Parietal	.855	.840
Left Frontal	.539	.239
Right Frontal	.412	.573
Left Maxilla	.451	.296
Right Maxilla	.196	.877
Left Zygomatic	.064	.946
Right Zygomatic	.829	.377
Pyriform Aperture	.635	.840

Table 9.27. CST Results for Gran Canaria/Tenerife Internal Variability by Period

None of the tests – for either island – showed significant variability when considered by period, thereby implying that there was no temporal trend in trauma prevalence.

9.5.4 Cranial Trauma by Location and Sex

The same data were processed by the sex variable, to determine whether the prevalence of trauma for each of the specific sites into which the skull was divided was dependent upon sex. The data are presented in appendix 5 and figure 9.18. In all cases, males were more strongly affected than females, and the left side was more strongly affected than the right. The only site where the sexes were roughly equal in trauma prevalence was the pyriform aperture (males 3.6%; females 3%). The data were processed to examine the strength of these trends.

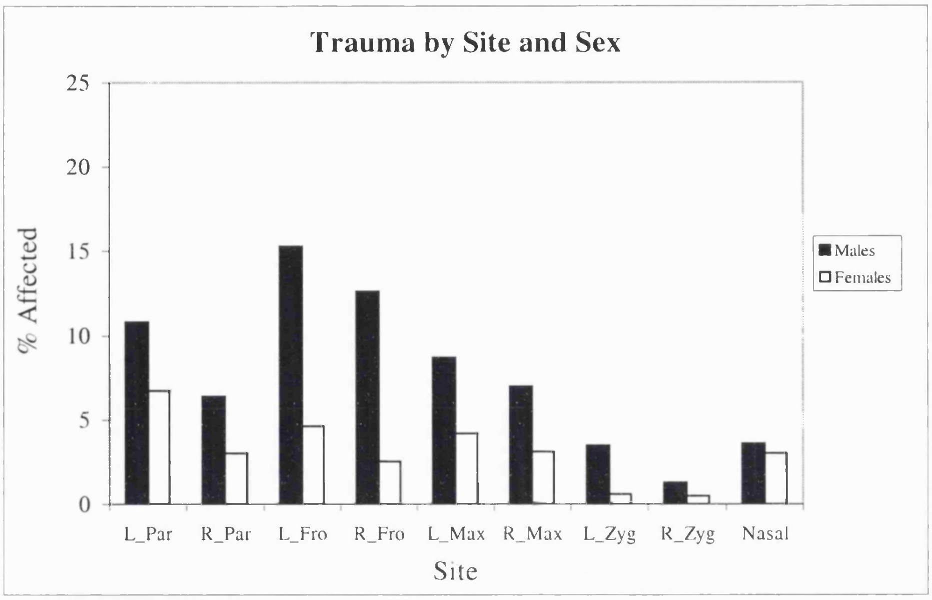

Figure 9.18. Trauma by Specific Site and Sex

Site	Chi-Squared Test
Left Parietal	.309
Right Parietal	.210
Left Frontal	.001
Right Frontal	.002
Left Maxilla	.066
Right Maxilla	.163
Left Zygomatic	.044
Right Zygomatic	.422
Pyriform Aperture	.723

Table 9.28. Trauma Prevalence by Cranial Site by Sex

Right and left frontal and left zygomatic trauma prevalence was strongly variable between the sexes. It is interesting to note that all these bones are either facial or forward-facing cranial elements, as this may have some bearing on their cause.

9.5.5 Single Island Trauma by Sex

The large Tenerife and Gran Canaria samples were assessed for inter-sex trends, to assess if this factor affected the fairly marked differences between these islands as ascertained by other tests. The CST results are presented in table 9.29.

Site	Gran Canaria	Tenerife
Left Parietal	.402	.387
Right Parietal	.350	.222
Left Frontal	.017	.066
Right Frontal	.001	.464
Left Maxilla	.292	.118
Right Maxilla	.705	.112
Left Zygomatic	.047	.812
Right Zygomatic	.852	.324
Pyriform Aperture	.747	.489

Table 9.29. Inter-Sex Variability in Cranial Trauma in Gran Canaria and Tenerife

As noted above, Tenerife was the island most strongly affected with cranial trauma. The fact that none of the trauma prevalences by site was significantly variable therefore reflects the fact that Tenerife prevalence of cranial trauma is universally high, whereas Gran Canarian trauma varied significantly in 3/8 of sites. This would tend to suggest that the sexes were more equally exposed to causes of traumatic injury on Tenerife than Gran Canaria. Further, the fact that the same three traits as identified in section 9.4.3 were significant in the present section underlines the fact that general trends may obscure or mask important variability in islandscape analyses.

9.5.6 Cranial Trauma by Location and Ageclass

The ageclass data used above (section 9.3.6) was assessed using the specific cranial lesion sites. As before, the trend data is presented in appendix 5, and a graphic representation of the percentage results (table 9.30) in figure 9.19.

Trauma	Subadult	Young Adult	Older Adult
Left Parietal	4	9.5	8
Right Parietal	3.9	4.5	4.8
Left Frontal	5.8	11.4	10.4
Right Frontal	1.9	7.2	9.6
Left Maxilla	0	4.3	10.8
Right Maxilla	0	0.5	9.9
Left Zygomatic	0	3.3	0.6
Right Zygomatic	0	3.5	1.1
Pyriform Aperture	3.7	3	3.2

Table 9.30. Percentage Values for Cranial Trauma by Site and Ageclass

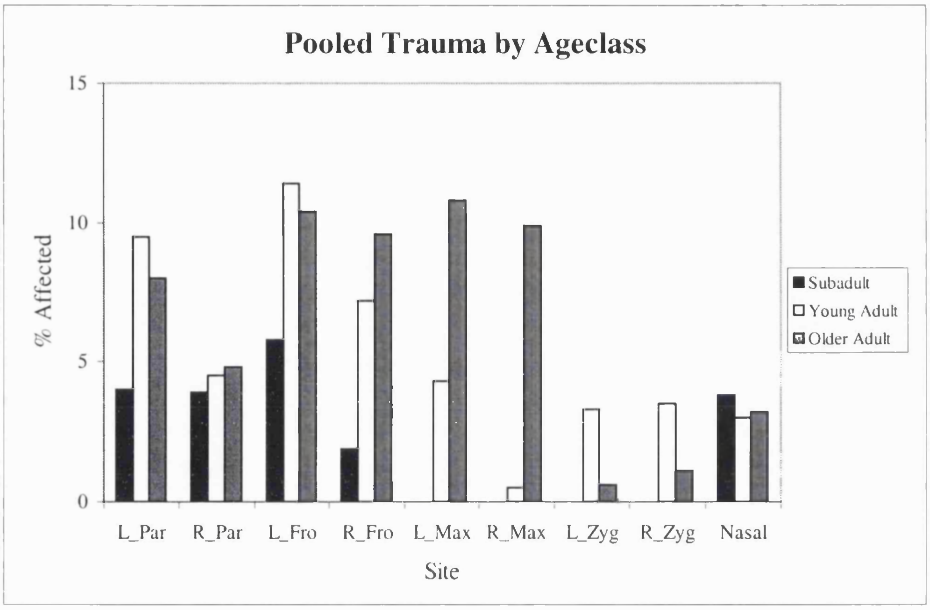

Figure 9.19. Percentage Values for Cranial Trauma by Site and Ageclass

Young adults were more frequently affected for left parietal, left frontal, left zygomatic and right zygomatic lesions, while older adults were more often affected with right parietal, right frontal, left maxilla and right maxilla lesions. Generally, however, older adults were more strongly affected than the younger group. Nasal trauma was the only instance in which subadults exceeded younger and older adults in terms of prevalence, and this is partially attributable to small sample size. Other than this, subadults were rarely afflicted with traumatic lesions. The data was tested using CSTs, as summarised in table 9.31.

Site	Chi-Squared Test
Left Parietal	.649
Right Parietal	.991
Left Frontal	.552
Right Frontal	.536
Left Maxilla	.003
Right Maxilla	.000
Left Zygomatic	.091
Right Zygomatic	.730
Pyriform Aperture	.966

Table 9.31. CST Results for Cranial Trauma by Ageclass

Maxillary lesions had a very strong correspondence with age, with absence in subadulthood, considerable prevalence in younger adults and a meteoric rise into older adulthood. Other than this, however, the differences between the ageclasses were not significant. A basic test of traumatic tooth loss (for methodology see above) was also carried out, and the results are summarised below.

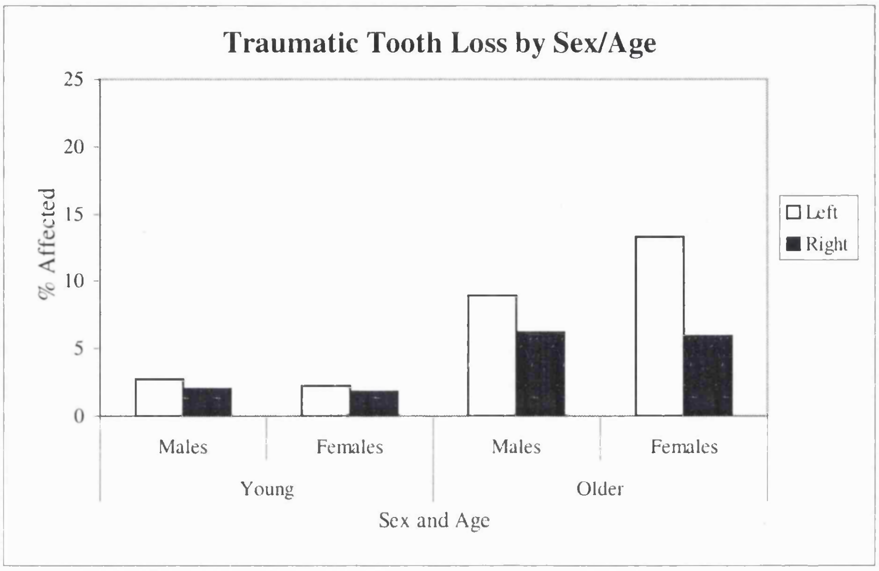

Figure 9.20. Traumatic Tooth Loss by Sex and Age

When subdivided by age and sex, the left side of the skull was more frequently affected for both males and females, and in both ageclasses. The disparity between left and right side trauma increases sharply from young adulthood into the older adult ageclass, and is particularly accentuated in older females (13.3% vs. 5.9%) rather than males (8.9% vs. 6.2%). While females suffered less trauma on both sides in young adulthood, female trauma prevalence was exceeded by that of males in older adulthood on the right side (females 5.9%; males 6.2%), but the roles were strongly reversed for the left side (females 13.3%; males 8.9%). CSTs were not carried out on this data.

9.5.7 Cranial Lesions by Location and by Region

The cranial trauma data were processed using the regional divisions posited in chapter 2, designed to determine whether ecology has influenced social patterning in the archipelago's ancient populations. The trend data are presented below in tables 9.32, 9.33 and 9.34.

REGION_1	Eastern	Central	Western
LPA	0 (30)	9.6% (34/354)	7% (8/107)
RPA	3.2% (1/31)	7.3% (19/359)	2.6% (3/115)
LFRO	9.7% (3/31)	9.1% (32/353)	12.1% (14/116)
RFRO	9.4% (3/32)	8.6% (31/361)	4.3% (5/117)
LMAX	3.7% (1/27)	6.8% (22/344)	6.2% (7/113)
RMAX	4% (1/25)	5.1% (18/352)	3.5% (4/113)
LZYG	0 (24)	2.2% (7/320)	1.8% (2/114)
RZYG	0 (24)	1.2% (333)	0 (115)
NAS	3.6% (1/28)	3% (11/364)	3.5% (4/115)

Table 9.32. Trauma Prevalence by Cranial Location and Region 1

REGION_2	Eastern	GC	Tenerife	Western
LPA	0 (30)	6.2% (14/226)	15.6% (20/128)	7% (8/115)
RPA	3.2% (1/31)	3.1% (7/227)	0.8% (12/132)	2.6% (3/115)
LFRO	9.7% (3/31)	6.6% (15/226)	13.4% (17/127)	12.1% (14/116)
RFRO	9.4% (3/32)	5.2% (12/229)	14.4% (19/132)	4.3% (5/117)
LMAX	3.7% (1/27)	7.1% (16/225)	5% (6/119)	6.2% (7/113)
RMAX	4% (1/25)	3.5% (8/226)	7.9% (10/126)	3.5% (4/113)
LZYG	0 (24)	1.4% (3/222)	4.1% (4/98)	1.8% (2/114)
RZYG	0 (24)	0.9% (2/226)	1.9% (2/107)	0 (115)
NAS	3.6% (1/28)	3.1% (7/229)	3% (4/135)	3.5% (4/115)

Table 9.33. Trauma Prevalence by Cranial Location and Region 2

REGION _3	Satellite	Central
LPA	5.5% (8/145)	9.6% (34/354)
RPA	2.7% (4/146)	5.3% (19/359)
LFRO	11.6% (17/147)	9.1% (32/353)
RFRO	5.4% (8/149)	8.6% (31/361)
LMAX	5.7% (8/140)	6.4% (22/344)
RMAX	3.6% (5/138)	5.1% (18/352)
LZYG	1.4% (2/138)	2.2% (7/320)
RZYG	0 (139)	1.2% (4/333)
NAS	3.5% (5/143)	3% (11/364)

Table 9.34. Trauma Prevalence by Cranial Location and Region 3

The strongest apparent contrasts were in the second of the three regional hypotheses, as Tenerife consistently stood out against the other groupings. In the first and third hypotheses, the low overall prevalence of trauma on Gran Canaria reduced the ‘central islands’ peak considerably, while levels of trauma were always considerably lower on Hierro than the nearby island of Gomera, which tends to have more in common with Tenerife (see above). The strength of these apparent trends was tested using CSTs. The results are presented in appendix 5 and summarised in table 9.35.

Site	REGION_1	REGION_2	REGION_3
Left Parietal	.155	.004	.135
Right Parietal	.434	.037	.252
Left Frontal	.640	.166	.392
Right Frontal	.290	.006	.214
Left Maxilla	.856	.829	.778
Right Maxilla	.778	.262	.483
Left Zygomatic	.745	.359	.601
Right Zygomatic	.431	.471	.194
Pyriform Aperture	.963	.994	.783

Table 9.35. Cranial Trauma by Site and Geographical Region (CST Results)

As predicted, the variability in REGION_2 is attributable to the very high prevalence of all three forms of trauma on Tenerife, which considerably exceeded the figures posited under the terms of the null hypothesis, while Gran Canarian, western and eastern island figures either matched or fell short of these levels. Neither of the other groupings indicated any significant variability between component parts of the archipelago, thus casting doubt on the feasibility of ecological interpretations of human behaviour – at least so far as physical trauma is concerned.

9.5.8 Subadults Only

As most subadults cannot be sexed (when under about 16 years of age), the subadults referred to above only include a very small sample of the total subadult group. The basic data are presented in appendix 5. Overall, subadult trauma was rare when compared to adult trauma prevalence. Left parietal trauma was uncommon, occurring in 7.4% of the middle group only (28.6% of the Tenerife sample). No other islands or periods were affected. Right parietal trauma occurred in a single undated Lanzarote individual (100% of 1) and 14.3% of the middle period Tenerife sample. Left frontal trauma was found in the undated Gomeran sample (20%) and the middle period samples from Tenerife (12.5%) and Gran Canaria (5%). Right frontal trauma – by contrast – only occurred in Tenerife's middle period sample (12.5%). Left maxillary (n=53), right maxillary (n=52), left zygomatic (n=48) and right zygomatic (n=50) trauma was absent for the subadult Canarian sample. Nasal trauma was limited to the Gran Canarian middle period sample (20%). No other islands or periods were affected. It should be noted that while the percentage values seem to support a high prevalence of subadult trauma in Tenerife and Gran Canaria, this is more likely to be a function of faulty or inconsistent recovery methods rather than a reflection of ancient Canarian behaviour.

9.6 Discussion and Summary

In the absence of ample contextual, archaeological and historical data, the causes and significance of trauma prevalence is often hard to assess. This has been compounded by the nature of the materials in the present study, as trauma studies are best carried out on samples where the entire skeleton is preserved. Nonetheless, various conclusions can be drawn from the current study.

To provide a general idea of Canarian cranial trauma rates, they have been contextualised in table 9.36 using comparative data from Larsen (1997: 116-154). The trauma rate has been calculated from at least one lesion per individual, rather than by site, sex or side. While the clinical samples (modern New York, modern London, modern rodeo riders and modern New Mexico) are not – strictly speaking – appropriate comparatives for palaeopathological data, they do at least provide a basis for general comparisons as minimum figures, since clinical data will invariably be more common than the severe traumas that are necessary to create osteologically-visible lesions.

As can be seen, trauma was quite common in Canarian samples. However, in order to elucidate the complexities of the patterns, the same data were processed on a single bone basis, in order to assess whether the grouped data system was concealing important variation. In addition to confirmation of the basic trends, the test identified the specific sites for the most traumatic lesions – the frontals and the parietals – further noting that every right side site was consistently less affected with trauma than the left antimere. This pattern also applied to anterior tooth loss, which was taken as a general measure of oral injury. Interestingly, the male figures were highest for the left side in both ageclasses, while the right side is equally divided between the sexes. The high rate of male frontal and left zygomatic injury in the pooled sample and also within Gran Canaria (but not Tenerife) further indicates the rougher lifestyle that men appear to have had. There were no significant differences in the position of trauma when considered by period, or within island by period. When split into the component parts, regional hypothesis 2 was significantly variable in 3/9 trauma sites, due to the fact that Tenerife (with very high prevalence) was posited as an independent unit. Lesion cause varied considerably, judging from the variability in lesion shape and size. The majority of lesions were circular, depressed fractures that suggest the use the stones, slingshots or, according to the historical evidence, hand-held bolas that were used in face-to-face confrontation during the contact period (Rodriguez-Martin 1999: 5). Linear fractures were probably caused by staves and sticks, while the slashing lesions are likely to have

Population	Sample	% Affected
Danish Mesolithic	-	43.8%
Rodeo Riders (USA)	(181)	39.2%
Neanderthals	(17)	29%
Swansport, Australia	31/110	29%
Canary Islands	**106/560**	**18.9%**
Rapa Nui	31/271	11.4%
Nubians	(160)	10.6%
Danish Neolithic	-	9.4%
Libben (N.America)	(94)	6.4%
Modern New York	(11959)	6.2%
Modern London	(1730)	6.2%
Danish Middle Ages	-	5.1%
Danish Iron Age	-	4.7%
Viking Period	-	4.3%
Modern New Mexico	(792)	1.6%

Table 9.36. General Comparisons for Canarian Cranial Trauma Prevalence

been caused by swords. The most dramatic examples of the latter lesion form date to the middle periods of Tenerife and Gran Canaria, and although no microscopic studies of the wound edges have so far been carried out, it is possible that these were caused by metal blades, thus reflecting some form of hostile contact with the mainland. The pair of stab-wounds on a single Tenerife specimen (plate 9.6) seem to have been caused by a backed blade with a roughly triangular section; however, the specimen is undated, so no further implications can be drawn. The use of the 'banot' (stave), which is testified to historically (Mercer 1980; Rodriguez Martin 1999) and survives as 'juego de palo' (lit. 'stick game'), can also be supported archaeologically, judging from the nature of the lesions on the Cambridge University mummy from Tenerife. However, most of the lesions were either not sufficiently well defined to identify with specific causes, or pertained to other forms of weaponry. The patterning of trauma was assessed using a control sample (Shermis 1984) of modern assault victims (primarily women), to assess whether the Canarian results matched unarmed domestic violence profiles, or if they fell into a separate category (the provisos concerning use of clinical data for this purpose have already been discussed). The results are presented in table 9.37 and figure 9.21.

Left	Shermis	%	Canaries	%
Left	49/70	70	98/171	57.3
Right	21/70	30	73/171	42.7
Facial	28/70	40	58/218	26.6
Cranial	42/70	60	160/218	73.4

Table 9.37. Shermis (1984) vs. Canarian Trauma Trends

The patterning revealed some similarities and differences between the samples. While following the same general format, Canarian trauma was more generalised than the Shermis data, with proportionally more right side trauma and less focus on the left side of the skull. Equally, the Shermis data showed a considerably higher proportion of facial to cranial trauma than the Canaries. In domestic violence in general (especially against women), the main target area is the face and the ventral surface of the torso (Shermis 1984: 149).

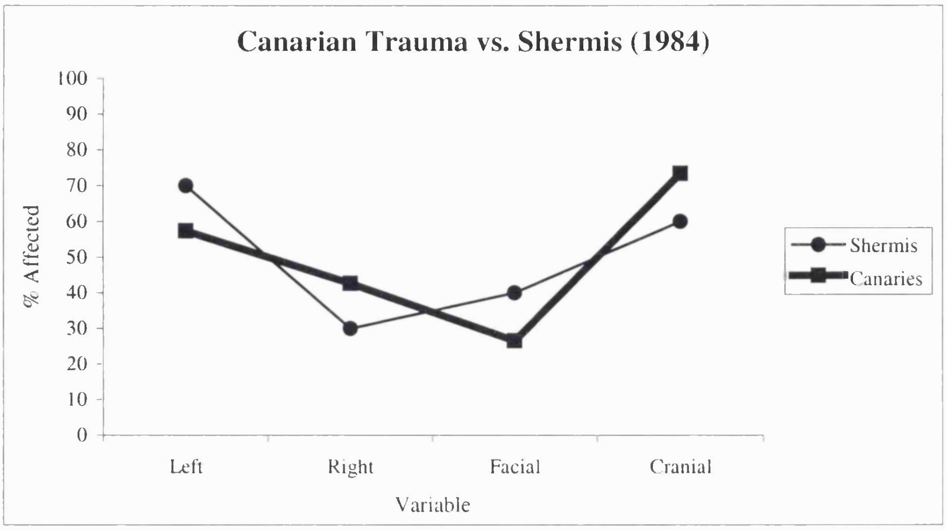

Figure 9.21. Canarian Trauma vs. Shermis (1984)

Left-side lesions were always more common than those on the right, and cranial lesions more common than facial lesions as the hands may have been used to ward off facially-oriented blows. It therefore seems unlikely that the preponderance of Canarian traumas was caused by unarmed inter-personal conflict (but see plate 9.5). The fact that there are few inter-sex differences in the distribution of facial/cranial trauma implies that, whatever the cause of the lesions, both men and women were equally subject to its effects. The fact that males were affected more frequently than females would also tend to support the seemingly active lifestyle that men appear to have enjoyed, and which is reflected in higher levels of postcranial trauma (Rodriguez-Martin (1992). The exact cause behind the high trauma levels in the Canarian sample continues to elude us; there is no increase in trauma through time, for example, which often reflects increasing population size and social rivalries (Larsen 1997: 139-141). It is possible that the contact-period ‘menceyatos’ (see chapter 3) may reflect some long-term trend towards regionalisation of societies, which may have competed for resources such as pasturage (Rodriguez-Martin 1999: 5) or territory. Larsen’s ‘ritualised’ violence (1997: 140) is difficult to demonstrate from the current dataset, although the current author feels that the fatal consequences of at least some lesions make such a scenario unlikely.

10 – Discussion and Conclusions

This project has been configured as an analysis of variation, examining the distribution of a range of genetic and life history markers as preserved in dental and skeletal remains. By investigating population biology and life history variables along temporal, spatial and inter-sex/ageclass scales, it was anticipated that a more fine-grained image of Canarian society would emerge.

10.1 Population Biology

The population biology results yielded a mixed picture. It is clear from simple comparisons that the Canary Islanders were not composed of two 'poles' of Cromagnoids and Mediterranoids (Onrubia Pintado 1987), and that while there is certainly some morphological variability in the sample, there is nothing to suggest that the islands were colonised by diverse founding populations (see Guatelli-Steinberg *et al* 2001). Both dental and cranial data indicate populational stability through time and across space. This is therefore a clear departure from other colonisation sequences characterised by multiple migrations into the same region by distinct groups (such as the Caribbean [Coppa *et al* 2002] or Austronesia [Flannery 1994]), which deal with highly morphologically distinct populations emanating from either different geographical areas or periods, as the full range of potential colonists of the Canaries (Europe; NW Africa) is fairly homogeneous when compared to the Pacific or the Caribbean.

It was this project's express intention to ascertain whether there was any pattern to the more subtle variability observed in the Canarian sample, and to interpret this variability in the context of inter-island analysis rather than as an exercise in human migration studies. Spatially, only about 12% of the traits used demonstrated significant inter-island variability, and it is therefore likely that the islands were characterised by homogeneity rather than heterogeneity when considered on a global/regional basis, with populations sharing a common populational base. Of the five traits exhibiting significant variability, only Tenerife demonstrated a trait that was unique for the archipelago (mesial canine ridges). Other traits suggested comparative homogeneity of the eastern islands as far west as Gran Canaria. However, like Tenerife, Gran Canaria showed a certain amount of separation from both the eastern and western islands. Finally, Gomera generally resembled Tenerife in most traits, but showed independence in some characteristics that marked the island out from the remainder of the archipelago. Gran Canaria and Tenerife/Gomera might be dubbed "poles of variability" as these are the most distinctive islands in the group. The preliminary MMD evidence for diversity in the western islands when compared to the rest of the archipelago may also indicate some form of population flux that is currently unclear; this question is currently undergoing further investigation.

When considered temporally, the Canary Islands are relatively homogenous in terms of population stability through the Canarian sequence as sampled in the current study. It therefore appears that the same general population sources were responsible for island colonisation. The 6 out of 32 morphological traits displaying significant variability between periods indicates some temporal flux in population biology which (when combined with spatial indicators and single island profiles) provides information as to patterns of biological affinity in the archipelago. Tenerife's possession of mesial canine ridges is restricted to a sudden appearance of the trait in the middle/late period, suggesting some form of biological discontinuity at this point in the archipelago's colonisation sequence. Other than this trait – unique to Tenerife – the central divide in the chronological sequence (as judged from significantly variable traits) is between the early and the middle/late group, with some significant differences also between the middle and the late periods. This corresponds with the proliferation of archaeological sites in the middle period (see chapter 3 of the present work), suggesting in turn that the early populations of the Canaries (mainly restricted to Gran Canaria in the present study) were added to in terms of both volume and biological diversity in the middle period, and possibly yet again in the late group.

The nature of the materials available for the present study prevented a detailed chronological examination of the human remains collections for each of the individual islands. However, the samples on Tenerife and Gran Canaria did permit such a study. These single island samples echoed the general trends detected for the archipelago. Neither island possessed very strong swings in terms of population biology, with only 4/32 and 5/32 significantly variable traits for Gran Canaria and Tenerife respectively. As before, consequently, there is no basis for postulating major populational changes in either island through time, although these minor deviations in the sequence may have implications for lower-level populational movements. Both of the islands exhibit essentially similar profiles, with some discontinuity between the early and the middle/late groups and more subtle yet still significant changes between the middle and the late period samples. In general terms, therefore, the middle and late periods were relatively homogeneous, demarcating a departure from the population biology of the early period sample. Immersive "waves" of new populations – such as the putative arrival of Vikings in the islands, thus explaining the Native Canarians' supposedly pale complexion (see Spence 2000) – cannot therefore be supported, or at least not from substantially different sources than the original population. This underscores the distinctiveness of the Canaries as an arena for studies of this sort, when compared to the often marked levels of biological differentiation to be found in other island population studies. It would seem more likely that there were smaller influxes of groups from other sources sporadically entering the islands through time, particularly in the 5th-10th centuries AD, and, to a lesser extent, the 11th to 15th centuries AD.

It is therefore difficult to characterise the Canarian populations' biological characteristics. As there is limited evidence of some temporal discontinuity in the sample, the assertion of a single, unchanging founder population with no subsequent genetic input from outside the archipelago – derived from studies of mtDNA and MMD tests of pooled dental non-metric traits (Guatelli-Steinburg *et al* 2001) – may not be appropriate. There are historical grounds for doubting the validity of genetic studies carried out on modern populations, as there is an unspoken assumption that the European conquest of the Canaries was a single event, and that any non-European genetic information must therefore pertain to the pre-conquest groups. This is, of course, erroneous, as there was considerable genetic flux between NW Africa and the archipelago from the 15th to the 18th centuries (i.e. slaving missions: Mercer 1980), and there is an substantial likelihood of attributing post-conquest genetic signatures to the archipelago's aboriginal inhabitants. Guatelli-Steinburg *et al.*'s other assertion, namely that the Canary Islanders were one common population by the time of European conquest, is difficult to test. Historically (see chapter 3), the sources suggest that the island cultures were variations on a theme – essentially homogeneous but variable in certain details. This is problematic, as the limited archaeological evidence for cultural change, restricted to a preliminary ceramic sequence (Navarro Mederos 1998), has been interpreted by the present author as implying an originally homogeneous group that subsequently developed an array of distinctive styles on different islands. On the present evidence it is difficult to determine whether the discontinuity of dental/cranial traits between the early and the middle/late sample is the result of genetic drift on each island, accompanied by population increase by genetically similar people from outside the archipelago, or an influx of slightly biological distinct populations into the islands in the middle period. It is tempting to hypothesise that the cultural diversity of the islands, which seems particularly notable from the middle period onwards, was triggered by the influx of new groups into extant populations, and that the material culture changes were a statement of identity. However, the data are not sufficiently clear to propound such a theory, although further analyses of material culture may clarify this issue.

10.2 Dental Pathology

Analysis of the Canarian sample's dental pathology produced a substantial volume of data with implications for oral health and diet. The basic tenets (see Hillson 1996, 2001) were tested against the data, revealing caries, tooth loss and alveolar exposure all increasing in accordance with age. Mandibular caries were more prevalent than maxillary lesions, while pit caries and occlusal surface caries were generally limited to the subadult and younger adult group due to high levels of dental wear and loss in the older group. In general terms, caries was not particularly common in the Canarian sample, with about 6% of all sites affected (pooled age-classes; pooled teeth; pooled sexes; pooled islands). This approximates to 'agricultural-foraging/agricultural' figures as defined by Larsen (1997: 68), based on a wide review of hunter-gatherers, mixed economy and agricultural populations. There was, however, considerable variability between the islands (see below). Females were more frequently affected than males (pooled value 8.3% vs. 5.4%) in all forms of caries except buccal/lingual smooth surface caries, which was noted to be strongly associated with damaged teeth and cracked enamel. This trend was also supported for the LM1 data (pooled ageclasses and islands). When all the teeth were tested for inter-sex differences, the results indicated an increased prevalence of caries of LM1-3 and UM2 in females. The significance of this is uncertain. It would seem unlikely that this emerged solely from the precocious eruption of the female dentition, and it is therefore probable that women's diet was slightly more cariogenic then men's (although inter-island variability is also important – see below). When assessed using the complex system, 10/11 significantly variable caries sites were more strongly affected in females than males, implying a very significant difference in diet or lifestyle, for it seems unlikely that such a wide range of sites would have been affected purely because of marginally precocious dental eruption (Hillson 1996: 121-4). Studies of various populations (both historical and archaeological), suggest that humans living in agricultural (or part agricultural) economies tend to demonstrate significant differences in dental caries prevalence patterns, with increased prevalence in women. This has been attributed to women's traditional role in subsistence responsibilities, focusing on gathering/processing of plant material, while men often consume proportionally less carbohydrate-rich food and focus more on meat products (Lukacs 2003; Larsen 1997: 73). Given the very high levels of sexual dimorphism in the Canarian sample (Rodriguez Martin 1995), it is possible that male robusticity pertains in some way to a behavioural difference – such as high levels of mobility, maybe associated with pastoral activity (Rodriguez Martin 1992, 1995, 1999) – from women, who may have been less mobile and instead focused on the gathering/processing of plant produce. Equally, there may have been a social construct in place in which one sex received preferential treatment in terms of diet (in Lamanai [Belize], for example, elite groups had more access to protein-rich foods, especially meat, than their non-elite contemporaries, and consequently had notably less caries: Larsen 1997: 76). Alternatively, Lukacs' hypothesis concerning increased female caries prevalence as a reflection of fluctuating hormone levels and salivary pH may be of relevance, although this would not explain the very marked sexual dimorphism levels in the sample. Temporal trends in crude caries prevalence were limited. In general terms, therefore, while there is a slight tendency towards higher caries prevalence in the early period, caries was essentially homogeneous throughout the sequence. This was demonstrated from both pooled samples and single island analyses, although the lack of reliably dated material in the western end of the archipelago has hampered more balanced studies and would benefit from further attention. Analyses revealed very few significantly variable dental caries 'sites'; where present, these were coronal rather than radicular, affecting the occlusal surface and occlusal dentine. Economic transitions of the sort visible in sites such as Abu-Hureyra (Molleson and Jones 1991; Larsen 1997) are therefore not demonstrated for the Canaries.

The spatial (i.e. inter-island) data was more productive, however, with considerable variability in caries prevalence between the islands. The dry eastern islands (mean 2.4%) had a considerably lower level of cariogenic affliction than the central and western part of the group (crude rate of 6.1%), and were comparable with Larsen's (1997: 68) foraging to mixed agriculture range (1.7-4.4%), and well below the pure agricultural group mean (8%+). The geographical proximity and ecological similarity (see chapter 2) of Gomera and Tenerife is reflected in the fact that they have the highest rates of caries (5.8% and 6.9%), but the fact that the rather ecologically dissimilar islands of Gran Canaria and Hierro resemble each other in terms of crude caries prevalence (5.4% and 5.5%) is less clear. When assessed by tooth class and age group, the results are substantially the same. Subadult caries is generally low, and is highest in Tenerife but affects more teeth in Gran Canaria (samples for other islands were rather small). These lesions – which occur mainly on udm1-2 and the lower molars where present – are of the occlusal surface detail and the pit features, rather than the approximal surfaces or the roots. This would imply that the cariogenic process moved fairly rapidly in subadulthood, the tooth being affected not long after eruption. Furthermore, the roots were not exposed through continuous eruption, so subadult foodstuffs was probably relatively soft. In general terms, Lanzarote and Fuerteventura stand out in terms of their low overall caries prevalence, which can usually be differentiated from the rest of the archipelago, while Tenerife and Gran Canaria have variable relationships with both each other and the western islands. In order to elucidate the nature of the patterns, by-site analysis was used, controlling for ageclass. Of the 63 caries/tooth class combinations tested in the young adult group, only 14 (=22.2%) were significantly variable between islands. As there is only the most limited evidence for temporal transitions in caries prevalence (see above), there was clearly no timeline transition on the scale of Epi-Palaeolithic/Neolithic populations in the Near East (Molleson and Jones 1991), implying that Canarian economy constituted variations on a spatial and temporal theme rather than a series of major paradigmatic shifts. A case could be made for suggesting that the eastern islands (Lanzarote and Fuerteventura) had considerably less reliance upon cariogenic foodstuffs than did the remaining islands in the group.

For further information about the variable state of dental health in the archipelago, alveolar exposure, wear rates and subadult caries figures were consulted. Per ageclass, alveolar bone exposure rates on Tenerife and Gomera were consistently higher than those on Gran Canaria and Hierro within each ageclass, with accordingly high rates of root caries. A study of wear levels suggests that this pattern may be linked to continuous eruption brought about by extreme levels of wear in Tenerife and Gomera, whereas the Gran Canarian and Hierro individuals had a lower wear rate and a correspondingly lower extent of alveolar exposure/continuous eruption. Unlike the caries data (see above) there was no difference in the alveolar bone retraction between the sexes, and only one group demonstrated any temporal distinction. There was some evidence for variability in wear rates between periods, notably younger adult UM1 wear and older adult LM1 wear being higher in the late period than the earlier groups. This was found to be echoed in both Tenerife and Gran Canaria's internal temporal scale. Sex did not affect the results, implying that the consistency of diet was not predicated on gender.

Subadult teeth were fairly rare for the sample. The small number that were scored suggest dietary homogeneity. No inter-sex tests could be carried out due to the nature of the remains (which cannot usually be sexed with any degree of certainty), and the small size of the sample precluded the analysis of temporal trends. Tooth loss was high in the archipelago as a whole, and especially so in males. This is interesting in light of the fact that wear, and alveolar exposure do not differ notably between the sexes, and that caries – a frequent contributor to *ante-mortem* tooth-loss (AMTL) – was actually lower in males than females. It therefore seems possible that AMTL was contributed to by another source, and it is possible that this was trauma and/or interpersonal violence (see below for further details).

The significance of the dental pathology findings is not unequivocal. It is apparent from caries, wear and alveolar exposure figures that the Canarian populations were not so diverse as to permit claims of distinct founding populations and economies. There appears to have been some variation across the archipelago, which was presumably related to ecological factors. The data therefore suggest that the Canary Islanders had a mixed economy which included a substantial element of carbohydrate-rich produce such as cereal crops. When compared with the crude estimate figures from Larsen (1997), the Canarians are considerably less affected by carious lesions than fully agricultural societies, yet exceed the low caries rate of hunter/gatherers in most cases, while some islands exceed the intermediate position of the foraging/agriculture category. Histomorphometric studies of Canarian human remains (Velasco Vazquez *et al.* 1999;

Gonzalez Reimers *et al.* 2001) have indicated economic variability in the archipelago, with a substantial reliance upon cereal agriculture in Gran Canaria, against a more general (foraging etc) profile for Hierro and Fuerteventura, and this has been confirmed using barium/strontium ratios (Gonzalez-Reimers *et al.* 2001) revealing a marine-rich diet in the latter. These results are not inconsistent with the findings of the current project, although it would seem that diet in the Canary Islands is characterised by diversity and breadth rather than clear-cut inter-island economic divisions. There clearly are differences in economic detail in the archipelago, but the extent of these differences is currently unclear. Macro-morphologically, one should in principle be able to determine certain characteristics of Canarian economy by examining the interplay between patterns of caries, wear and alveolar exposure.

If – as previously hypothesised – the high levels of wear in Tenerife were caused by mineral inclusions in flour brought about by grinding the cereals in stone mortars (Langsjoen 1992), it is surprising that the same is not true of Gran Canarian specimens as there is ample archaeological evidence for this practice on the island. It is possible that the petrology of the grinding materials used varied between islands, or alternatively that the nutriment was subsequently consumed or processed differently. For example, 'gofio' (ground, roasted cereal flour eaten as a powder or moulded with water) was described historically and is still consumed today in the archipelago (Gonzalez Anton *et al.* 1992a). The light wear on Fuerteventura may be explicable in terms of the difficulties of cereal agriculture on this rather desiccated island, although the high wear on Lanzarote – which has a similar climatic regime – is less easy to explain. Finally, the fact that individuals in seemingly (semi)agricultural economies like Gran Canaria have a relatively low rate of caries may be attributable in part to sheep and goat farming. Dairy produce has a retarding effect on the onset and development of caritic lesions

(Hillson 1996: 279), and it is possible that the variability in terms of caries and other pathological conditions may be instigated in part by the fairly extensive dairy exploitation recorded both archaeologically and historically (as well as currently) throughout the Canarian archipelago (Gonzalez Anton *et al.* 1992; Zoller *et. al.* 2003). This may be particularly true of the drier eastern islands, where cereal agriculture is often impractical, and where contact-period texts have recorded an animal-based economy that is at odds with other, more well-watered islands in the group (Boutier and Le Verrier 1872). As comparative data from other studies using the Hillson system become available, contextualisation of the Canarian results will become possible. While the archipelago was not the arena for monumental economic transitions based purely on ecological or behavioural factors, there were certain differences in terms of inter-island economy. It seems unlikely that the islanders were unaware of each others' economic affiliations and variability, although the extent to which the differences were exploited by trade, exchange or intentional insularity is currently not understood.

10.3 Hypoplasia

Extensive comparisons of Canarian hypoplasia patterns with those of other islands and regions were not carried out, due to the directives of the current project and the lack of appropriately recorded comparative material. However, it was useful to examine the distribution of hypoplasia between islands, areas, periods and the sexes, in order to establish a framework of childhood health standards for Canarian populations. The general profile of dental enamel hypoplasia in the Canarian sample suggests a generally healthy infancy (0-4yrs), followed by an ever-increasing physiological load through later childhood (<7yrs) and very early adolescence (<12.6yrs – although the size of the band represented by ageclass G should be considered). The fact that Gran Canaria was the most extensively affected island of the group is interesting given the long-standing association between hypoplasia and systemic health – through elements such as overcrowding, insanitary conditions, illness and malnutrition – as of all the islands in the archipelago, Gran Canaria has possibly the largest settlements. The fact that the geographically adjacent islands of Lanzarote and Fuerteventura – which are the most ecologically similar to Gran Canaria (see chapter 2) – have the lowest prevalence of the group precludes the possibility that the trend is purely ecological, and points towards the large pre-conquest and contact-period populations on the island. Particularly revealing was the fact that Gran Canaria, Tenerife (and, to a certain point, Gomera) are distinguished by possessing a rather widespread hypoplasia prevalence profile, while the other islands tend to have lesions dating to the later stages of odontogenesis. Five of the seven age classes demonstrated significant spatial variability, the remaining two classes being universally low (ageclass A) or universally high (ageclass F). Gran Canaria had the highest prevalence in all groups except for ageclass G (Hierro). Temporal trends were not strong; only ageclass A varied significantly between periods (prevalent in the early group). However, the fact that congenital syphilis has been associated with certain pathological hypoplastic defects of the occlusal aspect of the first molars – dubbed 'Mulberry Molars' (Hillson 1996: 171-2) – makes this a finding of some epidemiological importance, although alternative causes should also be considered.

It was important to determine the sex trend for the collection, in order to assess how the sexes compared in terms of juvenile health and (by extrapolation) perceived social value. The percentage values placed female hypoplasia prevalence higher than that of males until ageclass E (4.5-5.1yrs), followed by an increase in male prevalence in ageclasses F and G. This would seem to support Rodriguez-Martin's (1992) hypothesis that social maturity was reached during early adolescence, as evidenced by stress markers and trauma prevalence. This may in turn demonstrate some social function (possibly pastoralism: Rodriguez-Martin 1992) that boys adopted at this stage, as reflected in the often marked sexual dimorphism in the Canarian sample. However, there were no significant hypoplasia differences between the sexes, implying that there was no selectivity towards either sex in terms of 'social value' or otherwise. When the samples for Tenerife and Gran Canaria were assessed in detail, however, 1/6 ageclasses demonstrated statistically significant differences between the sexes on each island. In both cases the female sample was more strongly affected than the male, occurring between 0.9-1.3 (Tenerife) and 1.8-2.5 (Gran Canaria) years of age. However, the low number of significant differences between the sexes seems to suggest a absence of any systematic bias towards either one sex or the other, and that Canarian society – in this regard at least – seems to have been fairly equitable. This was also true of the temporal/gender study. Males differed from females by having a very strong peak of hypoplasia prevalence in age groups E-G (5.1-12.6yrs) in all periods, while females were irregularly affected to a lesser extent throughout the sequence. There were no major temporal trends for the sex-specific data, although females were only strongly affected with hypoplasia in the middle period, with lesser afflictions in the early (age groups C/F) and late (E-F) periods. Male hypoplasia in the late period only occurred in age groups E-G, with none of the low-level prevalence in earlier age groups as seen in the early and middle periods. As before, the only significant finding was that between the unsexed group and both the males and the females in age group A, although this may be an artefact of taphonomy. In general terms, therefore, the differences between the periods, by sex, are not striking, and there is no basis for claiming major temporal flux in male/female nutrition and health during development.

The remaining task was to assess whether there was a clear link between the islands' ecology and their inhabitants' systemic health, and from this data to assess the relative importance of environment and society in determining the quality of human lifestyle in the ancient archipelago. In the first hypothesis (Lanzarote/Fuerteventura, Gran Canaria/Tenerife, Hierro/Gomera) the most distinctive group was the eastern islands, with an absence of hypoplasia in all age groups except for G. The central islands had a wide overall spread rising into early adolescence, while the western islands had sporadic prevalence in the earlier age groups and a sharp double peak from 5.8-12.6 years. The only significant test result, however, was towards a high prevalence of age group G hypoplasia in the western islands. When considering the sex variable in addition to the regional trend, the only significant findings were a probable taphonomic artefact (significantly more hypoplasia in Gran Canaria's unsexed group A), along with a significant bias towards unsexed over female groups in the western islands' age group E (4.5-5.1 years). When split by sex and compared between regions, there was no diversity in the female sample. However, the males of the western group were significantly more affected with hypoplastic lesions in age group C (1.8-2.4 years) than those from the central islands. In this scenario, therefore, there were few substantial differences in any of the schemata proposed, although there was a higher overall prevalence of male hypoplasia (particularly in the later stages of development).

In the second hypothesis (Lanzarote/Fuerteventura, Gran Canaria, Tenerife, Gomera/Hierro) the eastern islands again hang together, Gran Canaria and Tenerife are distinct from one another and from the other groups, while the sporadic peaking of prevalence in the western islands is partly attributable to small sample size. The pooled sexes study demonstrated significantly higher prevalence of hypoplasia in Gran Canaria compared to Tenerife from 0.9-4.9 years, and compared to both Tenerife and the western islands from 4.5-5.1 years. From 9.9-12.6 years, individuals on the western islands were significantly more affected than those from the central islands of the archipelago. The wide range of timing indicates some fairly large-scale differences in health and/or nutrition between Gran Canaria and Tenerife (and the western islands, which Tenerife more closely resembles), while Hierro and Gomera appear to have had some spatially restricted shift in late childhood health/nutrition. The same data reviewed by sex (discounting the probably artefactual difference in Gran Canaria's age group A – see above) determined that males were significantly more affected with lesions than females (Tenerife 0.9-1.3 years), although a significant rise in unsexed over male specimens (western archipelago 4.5-5.1 years) was also noted. When compared by sex between regions, males had significantly more hypoplastic lesions in Gran Canaria and the western islands than Tenerife in early childhood (age group B – 0.9-1.3 years). Tenerife males had significantly less hypoplasia than Gran Canaria in age group E (5.1-6.1 years), and both the larger islands had significantly less hypoplasia in the very latest stages of odontogenesis when compared to the western islands (9.9-12.6 years). The females followed a generally similar pattern: more hypoplasia in Gran Canaria than Tenerife (1.8-2.5 years), more hypoplasia in Tenerife and the western islands than Gran Canaria (9.9-12.6 years), but there were less significant differences between the islands. The number of significant differences between the islands, even when the increased number of categories is taken into account, seems to suggest that this grouping has some form of internal integrity. Gran Canaria has a relatively even distribution of hypoplasia which rises into the latest stages of odontogenesis. At this point, the western islands' (and, to a lesser extent, the eastern islands') prevalence increases, implying some sort of discontinuity in health trends in late childhood/early adolescence. Tenerife resembles the western islands in possessing an irregular hypoplasia profile, generally at lower levels than Gran Canaria. As for all the other islands, stress appears to have increased through the odontogenetic process, suggesting a decreasing level of childhood health/nutrition (or perhaps social care) as individuals approached adolescence and adulthood.

In the third and final hypothesis, a central/satellite regionalisation was observed (Gran Canaria/Tenerife, Lanzarote/Fuerteventura/Gomera/Hierro). Profiles of the hypoplasia data using this dichotomy indicated substantial differences between the poles, but only age group G differed significantly, being more prevalent in the satellite islands. When considered by sex, the only significant result was the high prevalence of hypoplasia in the central islands' age group A, although this is likely to be a reflection of sampling. When the sexes were compared across both regions, the only significant finding was a higher prevalence of hypoplasia in satellite males in age group G. No other age groups (nor the female sample) showed any significant diversity. The satellite islands' increased level of hypoplasia in the 9.9-12.6 years group is interesting, as there is little apparent link between the four islands of this group in ecological or archaeological terms. This phenomenon may therefore be explicable in terms of socioeconomic regime, with greater agricultural dietary components in the central group, combined with higher population density, when compared to the smaller or drier islands in the archipelago. The increased prevalence in males may imply some differentiation of the sexes, and is in accordance with previous findings (see above). The grouping that placed Gran Canaria as an independent unit always demonstrated highly significant variability in 6/7 ageclasses, whereas only ageclass G (which is very variable in most tests performed) was significantly variable in the other two scenarios. This therefore tends to confirm that Gran Canaria's high prevalence of hypoplasia, and what it implies, was a social rather than (just) an ecological phenomenon, and that the living conditions and structure of Gran Canarian society may have differed from that of the other islands in the archipelago. One particular contrast is with Fuerteventura and Lanzarote, where one would intuitively expect large settlements to be impractical, and this is borne out by the archaeological data. Hypoplasia prevalence studies are predicated on the assumptions that affected individuals suffered systemic disturbances (such as illness or malnutrition) during childhood; that hypoplasia prevalence can therefore be taken as a crude measure of developmental health; that hypoplasias are associated with crowded or unsanitary living conditions, and are therefore more closely linked with agricultural than with pastoral/hunter-gatherer populations (Larsen 1997). It is interesting to note the peak of prevalence on the large islands of the central archipelago, as both Gran Canaria and Tenerife are known to have seen considerable population density and agricultural intensification in the contact period at least. The dry islands, by comparison, are more hostile to agriculture, while Gomera and Hierro possessed lower population density than the large islands, but a diet intermediate between Gran Canaria/Tenerife (agriculture) and the eastern group. It is also worth noting that the eastern islands had small, dispersed populations, in contrast to the considerable size of settlements in the central islands, while the western group was less sparse than the former yet less dense than the latter.

10.4 Trauma

Trauma patterns fell into an easily recognisable pattern. The vast majority of lesions examined in the study were non-lethal circular/elliptical depressed fractures, reminiscent of wounds left by stones and sling-shots. Lethal injuries included stabbing and slashing wounds to the skull, and also strongly depressed fractures with no signs of healing. Other lesions were more difficult to identify, particularly breakages of irregularly-shaped areas such as the zygomatics (plate 9.1), the pyriform aperture (plate 9.3) and the maxilla. It was therefore decided to examine the distribution of lesions between all relevant groups (sex, age, period, side) to assess whether the trauma observed could be interpreted as an expression of ecological adaptation or as a cultural construct. This study used the basic principles as stated by Shermis (1984), which includes modern and archaeological data designed to distinguish between martial, accidental and domestic trauma, in which the position of trauma on the body is a key element in determining cause. Tenerife and Gomera had the highest total prevalence of affected individuals, especially with lesions of the cranial bones (notably the frontals and parietals) rather than the bones of the face. There was a general – but weak – trend towards increased prevalence of lesions (pooled) on the left side of the face and head, and this was the case for every island except for Lanzarote. Gomera had over three times as much left- as right-side trauma, while the other islands were more balanced in terms of side. Traumas of both sides of the head were found in Gran Canaria, Tenerife and the western islands, although bilateral trauma was overshadowed by left side trauma in all islands where both were found. It is interesting that the left side of the head appears to be strongly affected. The very frequency of the lesions is the most striking characteristic of the sample; what is less clear, however, is the cause of the trauma. Rodriguez Martin (1992) has described various forearm fractures from a large sample of Tenerife individuals, and it is possible that these are 'parry' lesions designed to protect the face and head from attack. Given the form of the cranial lesions that survive, however, it would appear that while the general pattern of affliction was the same, the cause of the lesions is still uncertain.

There was a weak temporal trend towards increased trauma prevalence over time, but there are no grounds for assuming an entropic process taking place in the islands (unlike Rapa Nui – Bahn and Flenley 1992). When assessed by side and by period, the pattern that emerged was of a generalised, diffuse form of trauma in the early period (predominantly right side), switching to left side dominance in the middle and late period samples. While this trend was not found significant, it is possible that it reflects a trend away from random injury and towards more focused interpersonal violence. Males were invariably more affected than females, although both sexes shared a similar left/right proportionality pattern. This tends to suggest that while men appear to have had a more robust lifestyle than women, and additionally possessed more multiple lesions (double and triple), as well as cranial/facial lesions per individual, there was nothing particularly different about the pattern of afflictions possessed by each sex. Subadults were not affected in any way as much as the adult groups, and there was a general trend for the amount of trauma to increase with age, although this was not significant. This differs from findings on Rapa Nui, where younger adults had consistently more trauma than older individuals, implying that the bulk of their wounds may have led to a premature death (Larsen 1997: 139). Intuitively, the nature of the ecology determines the manner in which people live their lives, by preventing or promoting different social and economic traditions. However, as there was no significant link between traumatic lesions and ecological zone, social factors would seem to be the most likely cause for the diversity in the archipelago as summarised above.

The cause of the lesions is generally equivocal, although edged weapons (i.e. swords) can be implicated in some cases. Larsen (1997: 68) has argued that depressed fractures may constitute evidence of a society in which the assailants sometimes wish to wound rather than kill. Whether or not this is the case for the Canary Islands is uncertain, as it would certainly need more than the current evidence to hypothesise ritualised warfare systems. It may be argued that most of the lesions in the Canarian sample – especially depressed fractures – are the evidence of stone-throwing and (possibly) the use of slings, given the lesions' consistent appearance. This is an interesting finding, as the historical evidence (see chapter 3) points to the possession of slings on Gomera, but not on any of the other islands (Boutier and Le Verrier 1872). It is therefore possible that the use of slingshots was originally common to the archipelago, but was subsequently lost in several of the islands. This finding is additionally intriguing as Balearic slingers were renowned throughout the ancient world, and were incorporated into the Carthaginian army in their wars against the Romans (Svinth 2002). The historical ramifications of this are not currently understood, but merit further investigation.

The current project was designed to test the hypotheses laid down in chapter 3, namely that the study could differentiate between isolated and interactive worlds, that homogeneity of biological and cultural/behavioural traditions would imply a network with extensive inter-island contact, whereas cultural heterogeneity could mean either mechanical or cultural 'isolation' from neighbouring islands or the mainland. Most importantly, however, it was recognised that any of these issues was prone to change across temporal and spatial boundaries, and that the interpretation of the Canarian islandscape had to assume dynamism unless demonstrated otherwise.

10.5 Summary of Ancient Canarian Society

There are indications that the Canaries were first colonised well before this study's timescale begins, bringing with them the elements – notably seacraft, domestic animals and (probably) cereal agriculture – which helped to shape their world. It seems likely that early colonisations either failed, or remaining human presence was minimal, for there is no direct evidence of human settlement prior to about 500BC except for faunal profiles indicating the appearance of human commensals including goats, mice and donkeys (Zoller *et al.* 2003 and Pers. Comm.) that have been contentiously dated to several millennia earlier. Human society in the Canaries is something of an unknown until the BC/AD boundary, followed by expansive growth and development of the human populations within the archipelago.

As far as can currently be ascertained, the early period populations were relatively homogeneous in terms of cultural heritage, with very similar ceramics and selected material traditions that were common to more than one island. There can be little doubt that these groups were confident with the sea, and probably used small- to medium-sized vessels to move between and around the islands. There is some indication that subsequent populations either developed different cultural styles, be it through mechanical or social 'isolation', or that there was an influx (or several influxes) into the archipelago from the mainland, thus promoting cultural diversity between the islands (see Chapter 3). The details of this process are elusive at the present time. What is apparent from the present project is that both the internal and the external conduits of cultural change appear to be partly responsible for the emerging complexity in the archipelago. The dental and cranial non-metric traits reflect standard continuity throughout the sequence, with minor temporal and spatial fluctuations, which seems to indicate that much of the archipelago's social landscape was created by internal populations, rather than by repeated large-scale invasion or re-occupation. The chances of each individual island being completely compartmentalised from other members of the group (and the mainland) are therefore remote. That there was at least some link with the mainland during the 'middle' period of the Canarian sequence is indicated by the appearance of the mesial canine ridge in the Tenerife sample, a trait which is absent in the early group. The reduction in LM1 cusp number and LM1 anterior fovea, and the appearance of the palatine torus during the same period also suggest some form of discontinuity, and there are some similar – yet weaker – distinctions in the middle-late group. There is no evidence for comprehensive population replacement, and it seems likely that the incoming groups were from the same general populational base as the original settlers. If the islands had become totally insular (*sensu stricto*) one would have expected to find more variability in the spatial distribution of traits, but there were few such examples. Tenerife stands out as the only island with the UC mesial accessory ridge, and sees notable differentiation between the early and middle periods when internal variation was considered. However, there is little reason to hypothesise true 'isolation' for this or any other of the islands.

While much has been made of the Canary Islanders' origins and biological variability, less is known about their lifestyle. One of the main issues concerning this question is that of economy; how individual were the islands' economies, and how did this impact upon social organisation? The sheer variety of Canarian ecology posits a series of diverse challenges for human settlers, and is likely to produce a heavy impact on the way in which they lived their lives. Archaeologically, evidence for the largest and most complex settlements, the greatest range of material culture types and the largest populations of people are to be found on the two large islands in the centre of the archipelago. By contrast, the dry islands in the eastern archipelago and smaller, vertiginous islands towards the west do not appear to have supported such large populations or such flamboyant material culture, although the western islands – possibly as a result of biocultural 'isolation' from then rest of the archipelago – do demonstrate a range of cultural markers not found elsewhere in the islands. The dental pathology of the inhabitants has proved very informative on the subject of economy. Carious lesions, while not especially common for the archipelago as a whole, are particularly rare on the dry eastern islands of Lanzarote and Fuerteventura, and are much more common in the central and western group. While producing mixed results, Tenerife, Gomera and Gran

Canaria all produced data indicative of a carbohydrate-rich diet, associated with heavy wear (probably a result of inclusions from millstones used to grind corn) and marked alveolar exposure (caused by continuous eruption). While the smaller islands certainly appear to have had cereal agriculture, Gran Canaria and – particularly – Tenerife appear to have relied more heavily on this aspect of their economy, as determined by both their caries levels, tooth loss, wear and histological studies. Interestingly, the prevalence of hypoplasia – traditionally associated with systemic disturbances that are strongly linked to insanitary living conditions, malnutrition and poor health (and therefore settled agricultural communities – Larsen 1997) – is highest on Gran Canaria and Tenerife, which resonates with the discovery of large settlements on these islands.

While infancy appears to have been a relatively healthy time for the inhabitants of the other islands, Gran Canarian individuals were affected with hypoplastic lesions throughout their development. By late childhood to early adolescence, which was seemingly the most physiologically challenging period in terms of development, both Gran Canaria and the other islands share a peak in hypoplasia prevalence that may denote some behavioural facet of the populations (perhaps the onset of maturity, or social independence [Rodriguez Martin 1992]). If we assume that social agglomeration is indeed the cause of poor health (leading to hypoplastic lesions) then the fact that there was only a single significant inter-period fluctuation in hypoplasia prevalence (ageclass A) must imply that social structuring remained essentially the same throughout the occupation sequence (the Tenerife and Gran Canaria internal profiles). It is therefore possible that the populations arrived in the Canary Islands already accustomed to an agricultural way of life, and perhaps also to living in substantial communities. If this is the case, then the necessarily sparse way of life dictated by the ecological constraints of the dry and small/vertiginous islands must have been a secondary, rather than primary, adaptation.

The sexes were fairly equal in terms of hypoplasia prevalence when the islands were pooled, possibly implying egalitarian status for the sexes. Single-island profiles (Tenerife and Gran Canaria) produced limited evidence for inter-sex differences in hypoplasia prevalence, reflecting a higher prevalence for females than males. This pattern of high hypoplasia in Gran Canaria may be cultural rather than ecological, as demonstrated by the fact that the only significantly variable regional paradigm pattern (REGION_2) was that which included Gran Canaria as a separate category. While ecological factors determine parameters for the development and maintenance of social traditions (such as settlement patterns and economy), the social landscape was seemingly more important than the any standard environmental measure. Given that rainfall is extremely variable in the Canary Islands, it is possible that the high rate of hypoplasia in Gran Canaria is caused less by crowded and insanitary living conditions than by sporadic crop failures impacting heavily on a well-developed social infrastructure. In the smaller/drier islands, by comparison, the flexibility of human groups may have guaranteed their survival in times of adversity.

The study of trauma was adopted as an alternative way of examining social conditions and conventions in the Canarian archipelago, as it expanded the life-history ramifications of the study, acting as both a measure of human behaviour, and also ecological adaptation. It would seem (from the present study, and also from others that examined life-history indicators [i.e. Rodriguez-Martin 1992, 1999]) that the ‘average’ Canary Islander had a highly active and rugged life. This is due to two factors: firstly, their lifestyle was lived out in a very challenging environment, with high levels of activity and (possibly) mobility, which has been directly associated with higher levels of traumatic injury than with fully sedentary societies (Smith 1990), and secondly, the behavioural characteristics of the group appear to have directly contributed to their prevalence of traumatic injury.

Claims for 'warfare' as defined in Larsen (1997: 119) usually have to be substantiated archaeologically, which cannot be done with the present collection. However, there is little suggestion that such was the case, for while there are some remarkable examples of fatal injury, a large proportion of individuals suffered traumatic lesions sufficiently severe to mark the bone, yet survived. While the Canaries could hardly be called a warring society (or series of societies), however, at almost 20% of individuals affected, rates of Canarian pooled trauma exceeded that of troubled island communities such as pre-contact period Rapa Nui (Larsen 1997). In the latter island, it has been theorised that battle and wounding were ritual functions, and that the aim was to maim but never to kill the victim. However, the Canarian sample contains various examples of specimens pertaining to individuals fatally wounded by stones/slingshots, staves/poles and possibly swords, which – in the current author's opinion – does not support this point of view.

While many depressed fractures immediately suggest stones or slingshots, for example, it is surprising to find them so consistently in the left side of the head, as projectile weapons would not naturally strike the left hand side of the victim as would a club or spear (if wielded by a right handed person). Rodriguez-Martin's (1999: 5) proposal of a hand-held bola may explain some of the lesions, but the small size of the cranial indentations do not seem to support such a substantial hand-held weapon. The Cambridge mummy (Plate 9.1), which shows numerous longtitudinal lesions on the head and torso, and the slashing (Plate 9.1.1) and stabbing (Plate 9.2.3) wounds, suggests execution rather than combat. However, the vast majority of lesions cannot easily be assigned a cause. There were no notable temporal trends in the pooled trauma sample, suggesting that rather than a violent society being fuelled by burgeoning population size and diminishing resources, the level of trauma caused was essentially static. However, the tendency for left side trauma to dominate the middle and late groups – compared to the less focused early period sample – may have some significance for studies of inter-personal conflict.

As before, island variability was strong, and it is interesting to note that the highest rate of basic trauma was in the small island of Gomera, closely followed by neighbouring Tenerife. Males and females were both affected by high levels of trauma, and while men were affected by about twice as many traumatic lesions, there was no apparent difference between their general distribution patterns. This therefore implies that while the sexes may not have been treated equally, their roles cannot have been extensively differentiated (see slashed female skull in Plate 9.1.1). Subadulthood did not preclude traumatic injury, although the majority of lesions were recorded on the older adults. As before, ecology as an independent variable did not affect trauma prevalence, so a certain amount of confrontational behaviour may thus have been endemic in Canarian groups. As this was not prompted by ecological conditions, it is tempting to hypothesise that the Canarians had some form of rivalry, or perhaps active competition or political manoeuvering, perhaps on the basis of competing or warring tribes. Rodriguez-Martin (1999: 4) contends that the Tenerife trauma relates to regionalised groups in conflict over livestock and grazing rights, while historians in the 15th century noted the rivalry between factions holding separate sections of a once-united kingdom (Mercer 1980), who fought a protracted guerrilla war with both each other and the invading Europeans. However, the assumption that the traumas were caused by members of the same island population is dangerous, for the contact period (and later) fragments seem to suggest that Gran Canarians at least were not averse to sailing '...to Tenerife and to Fuerteventura to raid' (Torriani 1999: 162). If the economic considerations mentioned above are indeed accurate, it is possible that – or perhaps just a desire for material gain – brought about an aggressive rather than conciliatory relationship with other islands in the group.

10.6 Future Work and New Directions

What is increasingly evident is that those seeking to explore the deep past of Canarian society can no longer rely upon the chronicles left by it's destroyers, as these are biased, fragmentary and lack the refinement that is so necessary if we ever hope to achieve a more holistic understanding of ancient Canarian lifestyles. The futility of heavy reliance upon the historical sources is underlined by the increasingly large hiatus between the earliest colonisation of the archipelago and the arrival of reliable chroniclers, in light of an ever-deepening chronology (Zoller *et.al.* 2003). It is therefore appropriate to explore new avenues of archaeological research, with a fuller awareness of conceptual and practical concepts underlying the potential for dynamism and variation in ancient societies. The present author is extremely grateful to have had the opportunity to add to what is currently known about ancient Canarian lifestyle, and would like to propose that the following avenues be more fully explored in order to enhance our understanding of this fascinating field.

- to recognise that contact period historical texts, while an important and valuable resource, should not be permitted to dictate the intellectual topography of research into ancient Canarian society

- to increase the usage of chronological information where possible, and to develop the database of radiometric dates so that a temporospatial framework of Canarian colonisation and settlement can be created

- to adopt a landscape-oriented approach to Canarian archaeological sites, thus ensuring that visually unimpressive sites are not ignored in favour of their more flamboyant counterparts, as these (while important) may be only a minor element in the human colonisation and settlement process

- to examine the wider distributions of artefacts within and between sites, islands and with the mainland, rather than considering individual islands as 'isolated' units within the group and profiling their archaeological heritage on an 'insular' basis

- to exploit recent developments in biologically-based phylogenetic analysis of material culture, in order to explore the perplexing variability of Canarian cultural heritage

- to follow up on pioneering work by Velasco-Vazquez and others in examining histological and biochemical signals in human bone, and to exploit developments in mineral sourcing, isotopic analysis and similar techniques along the temporospatial lines described above

- to widely promote the Canaries' immense potential for illuminating pattern and process in island colonisation and settlement by humans, and to thus enhance the parameters of an island archaeology increasingly defined by Pacific and Mediterranean groups

10.7 Concluding Remarks

The Canary Islanders' place in history is an uneasy one. One of the first native peoples to be driven over the brink of cultural extinction by the burgeoning Late Mediaeval European thalassocracies, their fate served as the template for much of Europe's colonial development throughout the late mediaeval period (Crosby 1986). Unlike later records taken in the Pacific, however, detailed documentary sources concerning the manner in which the native groups lived their lives is sadly lacking, and we are therefore very dependent upon what the archaeological record can tell us about their history.

In the present study, the picture that has emerged is of a series of island societies living in a loose network that does not appear to have altered substantially throughout their history (so far as can be ascertained from the materials currently available for study). However, as is evident from stylistic change in archaeological remains, there appear to have been phases in the islands' history when islands promulgated their individuality through the development of stylistic trajectories that, so far as can be determined, do not appear to have led to changes in biological relationships between island populations. However, there is no indication that the islands were isolated as a group from the 'outside world', judging from apparent immigration during the settlement sequence.
While the island societies varied in terms of economy, the essential elements of cereal agriculture and foraging were present to a greater or lesser extent in all the islands studied (while La Palma could not be studied in this way due to material sampling limitations, it seems likely that historical accounts of this island's population living 'only on flesh' [Boutier and Le Verrier 1872: 127] are erroneous [Azurara – in Mercer 1980: 194]). Socioeconomic parameters were loosely defined by ecological variables, so there was less cereal agriculture and lower population size/density on Lanzarote and Fuerteventura and the western group than the large, central islands. However, it is clear that this approach is only a part of what could potentially be done with the archaeological evidence and skeletal remains. For example, while difficult to detect micro-morphologically with available materials, there are certain strands of evidence suggesting that the Canary Islanders were heavily reliant upon marine resources, a point

of view vehemently denied by workers using other techniques. The fact that histomorphometry, biochemistry, archaeology, palaeoeconomy, anatomy and dental pathology provide consistently contradictory results serves to reinforce claims for economic heterogeneity in the archipelago, but also underlines the importance of multidisciplinary studies in attempts to understand the configuration of ancient Canarian lifestyle and behaviour.

Health varied considerably according to the way in which different Canarian groups lived their lives. Comparatively elevated levels of enamel hypoplasia were cautiously attributed to either the result of over-crowded and unsanitary living conditions, or as reflecting systemic stress brought about by (possibly climatically induced) economic hardship. The lower levels of hypoplasia on the drier islands and the western group appear to suggest that these conditions were less severely felt in these more sparsely populated parts of the group, or that their lower population density meant that their flexibility and recovery rate were greater than the larger societies in Tenerife and (particularly) Gran Canaria. The fact that all the islands experienced peaks of hypoplasia prevalence in the later stages of odontogenesis has been taken to suggest a constructed social maturation that was essentially universal for the group.

All the work that has so far been carried out on human remains seems to suggest that the Native Canarians led highly active lives, and were impacted upon by the challenging nature of their environment. What is also clear is that the human populations on some islands appear to have engaged in confrontational, aggressive behaviour with other populations within (or possibly outside) their islands. The sexes appear to have shared this behaviour, although the extreme levels of sexual dimorphism in the Canarian sample seems to suggest that males and females may have played different social roles.

However, the differences in inter-sex developmental systemic health, which can be interpreted as a measure of perceived social value within a group, do not support any bias in favour of either sex in what appears to have been a fairly equitable series of human populations.

The current study is somewhat unusual in its aims and wide spread of approaches to Canarian human remains. However, while there is certainly room for refinement of these systems, and considerable potential for further, more detailed studies, everything that has so far been discovered about the ancient Canarians suggests that simple approaches – be they towards single islands, or the use of a limited range of methods – will miss a great deal of information about what was clearly a diverse and complex group of societies. It therefore behoves us to approach the Canarian islandscape with caution, a wide range of methodologies and a flexible approach, which, indeed, appears to be exactly what the aboriginal Canarians did.

Plate 10.1. Anthropomorphic Figures, Lomo Boyero, La Palma.
(www.almogaren.org/gallery/canarias.htm)

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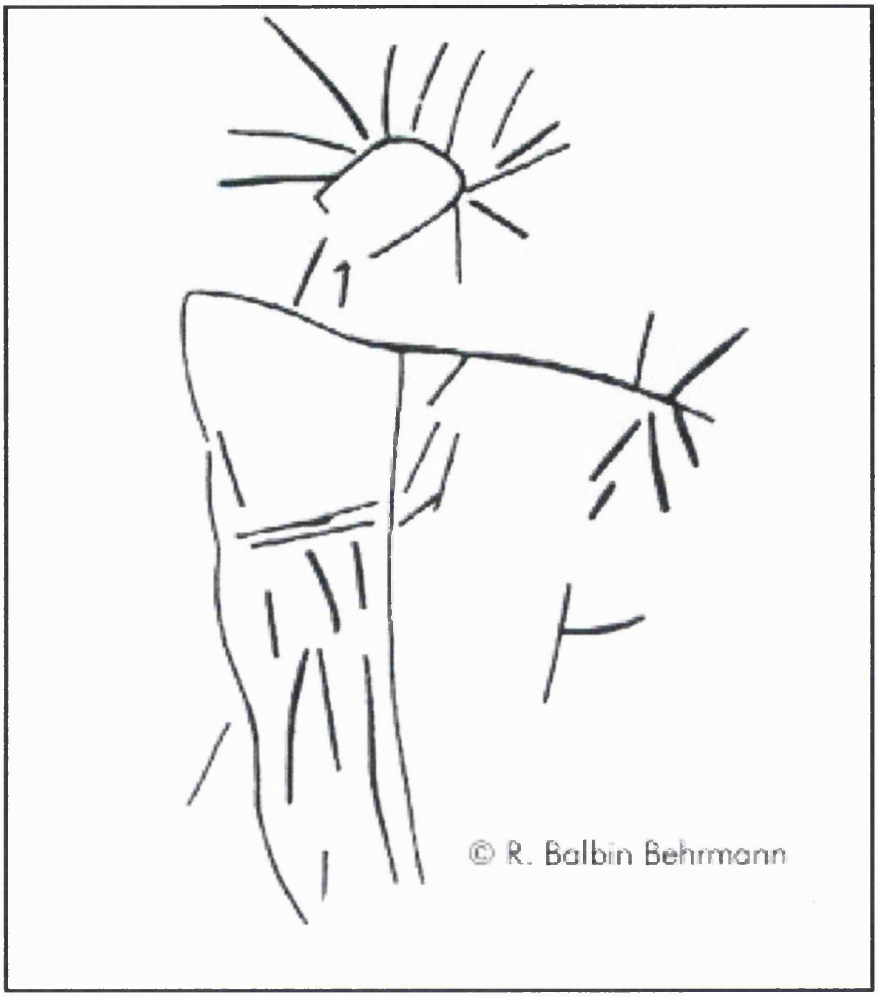

Plate 11.1 Anthropomorphic Figure, Aripe, Tenerife
(www.almogaren.org/gallery/canarias.htm)