Neanderthal Diets in Portugal: Small and Large Prey Consumption during the Marine Isotope Stage 5 (MIS-5)

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I, Mariana Vilas Boas de Castro Nabais confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis

Mariana Nabais

ABSTRACT

Gruta da Figueira Brava and Gruta da Oliveira are two key-sites within the Middle Palaeolithic research in the Iberian Peninsula. They are located in Central Portugal, the former occupying a coastal position, whereas the latter is about 60 km inland. They were occupied during the MIS-5 and the retrieval of two important faunal collections are now vital to the reconstruction of the palaeoeconomic activities of the Last Interglacial Neanderthals, as well as to understanding their mobility patterns within the landscape.

Both caves were within resource-rich landscapes with permanent water sources nearby. Gruta da Figueira Brava also profited from its proximity to the coast with access to an ecotonal environment. This results in the formation of faunal assemblages proliferous in ungulate remains, leporids, birds, tortoises, molluscs and crabs. After detailed taphonomical analyses, it was possible to ascertain that all faunal remains resulted from human activities with some contributions from other agents of accumulation. Neanderthals brought in complete carcasses of small prey, deer and ibex, whereas only the nutrient-rich parts of larger animals were brought home for further processing and consumption. All prey sizes were being evenly targeted, with systematic use of shellfish resources that led to the formation of deposits in Gruta da Figueira Brava comparable to those from nearby Mesolithic sites. Biometric analyses of limpets and tortoises hint at the systematic use and overexploitation of such resources. Quick moving small prey were targeted, with leporids and birds being used for food and maybe for pelts and feathers.

The wide range of species exploited demonstrates that Neanderthals had consistent broad spectrum diets, which had implications on the type of site use, with a tendency for year-round occupations, which could have promoted the development of larger Neanderthal groups, and the consequent formation of more complex, more stratified and more organised social structures.

IMPACT STATEMENT

With the extremely accelerated pace our current world evolves, most times, humans are not able to keep up. This is particularly evident to what refers to technology and machine learning in a variety of subjects. Put it simply, today's human evolution is considerably slower than its technological counterpart. This is a new challenge for us since it is the first time that humans are being surpassed by their own inventions. Although this can be slightly worrying for some, for others it is not seen as a problem, because the history of evolution demonstrates the great human adaptability to a myriad of situations. Neanderthals and their malleable subsistence strategies are a good example of such flexibility in a permanently changing world. Maybe because we are so used to our extremely sedentary lives and so tied to our daily routines and very specific sets of foods, we are not keen to change. Conversely, my research showed that Neanderthals could easily alter their food selection, modify their food provision behaviours, move to different landscapes, and adapt their technology accordingly. They survived for thousands of years in Eurasia and overcame a large amount of difficulties. Therefore, humans of today have it in themselves to be able to adapt and modify their behaviours in order to succeed within their fast-pace technological development, as well as other existing challenges, such as climate change.

Archaeological research demonstrated that most of the current world population still bears Neanderthal genes, so we are their living legacy and we should get acquainted with at least some of their adaptations. Zooarchaeological narratives can contribute to such a matter, and sites like Gruta da Figueira Brava and Gruta da Oliveira, in Portugal, remind us that certain aspects of human evolution are mediated by some of the most powerful adaptations, such as culture and social life. Neanderthals, like any other humans, were capable of caring, cooperating, learning and sharing knowledge. These connections and interactions, even in the simplest daily routines – like mollusc collection, or cooking a meal – have significantly contributed to our success and our resilience. The power of zooarchaeology to illuminate details of important and intimate events from a very remote human past, improved considerably our understanding of how human beings evolved and adapted to the most varied circumstances. The value of such finds clearly demonstrates the need of ensuring that the planning policies take into account the zooarchaeology’s potential for scientific advancement, and the use of its adapted results in forthcoming procedures designed to overcome unexpected difficulties.

My research is part of interdisciplinary debates about food provisioning, subsistence strategies, technological and behavioural adaptations, which are transversally relevant in time and space. Although our repetitive lives of today give us a sense of stability, the world is changing, and we should change with it like we have done for thousands of years. Hence, we should study past human behaviours in detail, in order to better understand the variety of possibilities available to us and to perform smooth transitions within present and future challenging situations.

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In Lisbon, I profited greatly from a close relationship and several engaging conversations with other zooarchaeologists in the DGPC Archaeosciences Lab. Sónia Gabriel's immense enthusiasm and passion for the discipline has always been positively contagious and inspiring, and her availability to help me whenever needed is indescribable. Similarly, my interactions with Carlos Pimenta have been very influential on bird bone analysis, having taught me the great importance of such studies. Without his guidance I would have not been able to accomplish many of the positive outcomes of this study. Simon Davis has also been a great influence for the development of my zooarchaeological skills, and most responsible for my eye opening to the huge potential of bone biometry studies. In the lab I have also benefitted from the warm welcoming and caring work environment provided by Ana Cristina Araújo, Ana Costa, Patrícia Mendes, David Gonçalves and Marina Araújo. Ana Cristina Araújo has also facilitated the access to Toledo's sediment samples and Ana Costa arranged everything within the Geology department of the University of Lisbon, so I could process the sample in their labs. Although not in Lisbon, I am also in debt to Lluís Lloveras who has been most kind in sharing his knowledge about rabbit bone analysis, and the help provided in the great variety of skeletal part calculations.

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Bite off more than you can chew and then chew like hell.

Peter Brock (1945-2006), Australian motor racing driver

(…) it is impossible to disentangle what the people of the past thought about plants and animals from what they thought about themselves.

Keith Thomas, 1983, *Man and the Natural World*

It is no easy matter to give novelty to what is old, authority to what is new, freshness to the worn, light to the obscure, charm to the tedious and credibility to the uncertain – and indeed to give all things their nature and assign to nature all that is her own.

Pliny (23-79 AD), Preface to his *Natural History*

To my beloved grandmother Maria Helena Lopes de Castro (1928-2015)
and my dearest friend Maria Antónia Tavares (1953-2019)

Part I

Introduction

This section highlights the overall key questions, issues and general themes related to Neanderthal research. It shows why it is still relevant to keep on investigating such matters today, with a particular focus on Neanderthal subsistence. The thesis general outline is presented at the end of Chapter 1 combined with brief descriptions of each Part and the chapters therein. A more detailed explanation of the thesis' goals, objectives and research questions are defined in Chapter 2, setting the scene for the following chapters.

CHAPTER 1
INTRODUCTION

As the saying goes, “You never have a second chance to make a first impression.” Back in the mid-19th century, when evolution was becoming established, it was easy to assume that fossil meant “primitive”. Thus, the Neanderthals’ robust and stout bodies, protruding eyebrows and projecting face were taken to indicate that they were a less evolved species of human. Almost two centuries since, our knowledge of human evolution has increased immensely. Yet, anti-Neanderthal prejudice remains high, and distancing ourselves from the 19th-century image of Neanderthals as brute cousins endowed with limited intellectual capabilities has not been easy. However, over the last decades Archaeology has demonstrated that, cognitively and behaviourally, Neanderthals were no different from the coeval African populations from which our ancestry mostly derives.

For this matter, the Iberian Peninsula has been providing significant research. Indeed, Iberia corresponds to about one third of the European landmass that is now not submerged, and was not ice-capped, or a polar desert, throughout most of the Palaeolithic. Back in 1998, the discovery of the child burial from Abrigo do Lagar Velho, in Portugal, triggered a new line of reasoning in Neanderthal research. Skeletal evidence of a fully modern child with some unusual traits suggested that Neanderthals and Anatomical Modern Humans had, in fact, interbred (Zilhão & Trinkaus 2002). Such new and polemic ideas stimulated a heated debate within the archaeological community, but recent research conducted by Svante Pääbo and his team (e.g. Green et al 2010; Sankararaman et al 2014; Fu et al 2013, 2016) was able to prove that Neanderthal genes are part of the genetic code of most world populations, with a higher incidence in Eurasia. We are then offspring of Neanderthals and the living representatives of their legacy. Maybe because of this new reality, Neanderthal research has gained a new boost and findings of their modern behaviour have started to emerge. From the recent evidence of Neanderthals being authors of some of the artistic representations in

Palaeolithic caves from Spain (Hoffmann et al 2018a; Pike et al 2012) predating Modern Human arrival by about 20,000 years, to the use of pigments (Bar-Yosef Mayer et al 2009; Zilhão et al 2010c; Hoffmann et al 2018b), shell beads (Vanhaeren et al 2006:), feathers (Peresani et al, 2011; Finlayson et al 2012) and eagle claw pendants (Radovcic et al 2015), the Neanderthal image is willing to be revitalized.

Such an approach is also being conducted within zooarchaeological investigation and food provisioning studies, even though their potential may not be immediately understood as direct evidence of important behavioural capabilities. For many years, these have been investigated in terms of hunting practices and subsistence strategies following the commonly accepted idea of Neanderthal diets being highly dependent on large game. More recently, such notions have been questioned, which has been highly motivated by research conducted in multiple Middle Palaeolithic sites mostly found within the Mediterranean Basin. These have been showing evidence of Neanderthal small game and marine resource consumption comparable to that of Middle Stone Age anatomically modern humans. Therefore, long-standing notions of Neanderthal inability to adapt to changing circumstances (environmental, topographic, demographic, or other) are now often being disproved. Fresh approaches within zooarchaeological and other archaeological sciences research, have been demonstrating Neanderthals' adaptability and malleable behaviours, which allowed them to endure many changes in their living world for thousands of years, when they were roaming and exploiting the Eurasian continent in a myriad of landscape settings – from glaciers to tundra, to forests, mountains, deserts and the seashore.

Having such Neanderthal big topics in mind, this PhD thesis starts by delimiting the scope of its investigation in Chapter 2, where more concrete research questions are delineated. Such research goals are then put into context in Part II, which is formed by Chapters 3 and 4. The former consists of a brief review of Neanderthal distribution in time and space, as well as Neanderthal anatomy and some of the yet controversial behaviours. Chapter

4 entails a literature review of past and current debates about Neanderthal subsistence, and the use of a wide variety of animal resources, including small prey and marine foods. Considering that this study is focused on the analysis of sizable faunal collections recovered from two Last Interglacial key-sites in Portugal, Gruta da Figueira Brava and Gruta da Oliveira, Part III is dedicated to the contextualisation of these case-studies within the Portuguese past environments and the currently known Middle Palaeolithic archaeological evidence (Chapter 5). Chapter 6 is focused on the description of Gruta da Figueira Brava and all archaeological works conducted there, and the same is done for Gruta da Oliveira in Chapter 7.

Part IV is dedicated to the methods used in the analysis of the animal remains. It begins with detailed explanations on how such faunal materials were recovered from the cave sites during excavation, and how they were processed in the laboratory (Chapter 8). Chapter 9 reports all the zooarchaeological methods used in the analysis of bone and shell remains. It is followed by Chapter 10 that is focused on the quantitative and statistical methods used, as well as other palaeoecological specifications, such as the composition analysis of the sediment samples collected from Gruta da Figueira Brava.

Considering the large variety of vertebrate and invertebrate animal groups studied, the results section (Part V) is the longest of the thesis. It was divided in five different chapters, each dedicated to a particular animal group: Mammals (Chapter 11), Birds (Chapter 12), Reptiles (Chapter 13), Molluscs (Chapter 14), Crustaceans and Echinoderms (Chapter 15). Considering that each of these faunal collections has their own research questions and specificities, each chapter starts with a brief literature review focused on the animal group being analysed. Similarly, each of these chapters has its own discussion and conclusion sections. Therefore, such individual discussions and conclusions are used as research foundations that will feed the overall thesis discussion in Part VI. The latter is dedicated to explore broader themes within Neanderthal archaeology, mostly dedicated to Neanderthal adaptability to different landscapes and the flexibility in the subsistence strategies used

(Chapter 16); as well as Neanderthal mobility and use of space, and their social implications for such human groups (Chapter 17). The discussion of these wider trends in Neanderthal research will inevitably lead to a conclusion of the thesis (Part VII), sprinkled with few personal reflections on the matter, and the outline of some of the future research work I would like to conduct next.

Finally, a significantly large amount of references cited throughout the thesis are compiled at the very end of the study, followed by supplementary materials. These were intended not to be overly exhaustive in order to avoid repeating information already provided in the several tables, graphs and images used in the thesis' main body.

All images and tables presented throughout the thesis are my own, unless stated otherwise in the correspondent captions.

CHAPTER 2
AIMS, OBJECTIVES AND RESEARCH QUESTIONS

This project builds upon previous study and experience gained from undergraduate and MSc research projects concerning the Middle Palaeolithic in Portugal. Such past studies have revealed Neanderthal use and consumption of small prey, which often appeared to be burnt. These preliminary results indicated the regular inclusion of small game within Neanderthal diets, thus going against the generally accepted trend of preferred consumption of large prey. Even though Mary Stiner's pioneering research has demonstrated that smaller game (such as birds, tortoises, rabbits and molluscs) could be part of the Neanderthal diet, those resources were always understood as an emergency supply motivated by moments of crisis, like the ones due to demographic pressure. Therefore, the consumption of small prey has been generally accepted as a characteristic of Modern Humans, and therefore a trait of modern behaviour.

Nonetheless, my previous research concerning Neanderthal use of tortoises from Gruta Oliveira pointed to a different direction. Likewise, excavation of Gruta da Figueira Brava has revealed to be extremely rich in marine resources (mainly shell, crab and fish) and small size prey (like tortoises, rabbits and birds) in stratigraphic levels with confirmed Neanderthal occupation. Therefore, it seems consistent to believe that Neanderthals from Central Portugal had a much wider diet than previously accepted, selecting living environments that might have privileged the exploitation of ecotonal areas with access to both terrestrial and marine resources. It seems thus compulsory to rethink Neanderthals subsistence, and their use and control of different environments according to their specific needs.

As such, the present study expanded significantly the zooarchaeological sample analysed for my undergraduate and MSc, now including several animal groups of different sizes and from distinct environments, aiming to explore and challenge the validity of the currently accepted Neanderthal subsistence model. It also aims to design a new evidence-based model drawing on the latest discoveries in two Middle Palaeolithic key-sites in Central Portugal: Gruta da Figueira Brava and Gruta da Oliveira. Consequently, it is essential to reconstruct the palaeoeconomical activities of the Neanderthal groups living in Central Portugal during the Last Interglacial (MIS-5, c. 130 to 71 ka years BP), in order to understand how did Neanderthals use the territory and how did they respond to the environmental conditions extant during this time interval. But to do so, it was first necessary to establish what was the role of Neanderthals in the accumulation of the faunal assemblages, with subsequent discussion on the relative importance of human accumulations in relation to natural events and predator-scavenger activity in both caves.

To provide a focus for this thesis, the research questions can then be summarised as follows:

(1) Are the zooarchaeological assemblages the result of hominin activity, or are they due to natural agency, or are simply the food remains of other carnivores visiting the caves, like hyenas or wolves? Are the faunal accumulations due to the activity of a single agent, or the result of a mixture of contributions from several agents? If so, can we distinguish the different agents of accumulation in a specific faunal collection?

(2) What is the animal biodiversity in Central Portugal during the MIS-5, and what were the animal species consumed by Neanderthals during that time interval?

(3) How are Neanderthal groups likely to have used their territory? Were they using local or more distant resources? Is there any evidence of resource pressure? Is there evidence of preferences in environmental zones and resources? Were Neanderthals changing diets according to season?

(4) Are Neanderthal sites in Portugal characterised by broad spectrum faunal patterns as defined by Flannery (1969), and if so, how can these be interpreted?

Part II

Theories and Contextualisation

The focus of this section is two-fold. The first half is dedicated to the description of Neanderthal distribution in time and space, as well as Neanderthal anatomy and the, yet, controversial behaviours related to the capacity to innovate, the degree of complexity of some activities, including the ability for abstract thinking (Chapter 3). Chapter 4 consists on a brief literature review of previous and more recent models accepted for hominin subsistence behaviours, at a general and more specific European scale. A short description is also given about the variety of potential agents responsible for the accumulation of faunal remains in archaeological sites, and how to differentiate between them.

CHAPTER 3

MIDDLE PALAEOLITHIC REVOLUTION

3.1. NEANDERTHAL ANATOMY AND DISTRIBUTION

In August 1856, 13 km east of Düsseldorf, in Germany, the remains of an adult male were recovered from Feldhofer cave. This was one of the last caves to be explored for quarrying in the region due to its difficult access. Nonetheless, its time came, and with it one of the greatest human quests began. First, quarrymen recovered a skull from near the cave's entrance. Then, towards the inside, the thigh bones, part of a pelvis, few ribs, and some of the bones of the arms and shoulder were also collected. These were extremely robust elements, denoting a more muscular man than a normal human. It became the first example of what was later called a Neanderthal. The name was borrowed from the valley where it was found, the *Neander Thal* valley, a highly suitable designation considering that the Greek origin of the term *Neander* means "New Man" (Trinkaus & Shipman, 1994).

As summarised by Lewin (1999:156), Neanderthals are robustly built with well-developed muscles in a short body. Such features are associated with a physically active routine, and the stoutness of the body with broad trunks, short forearms and legs is traditionally explained by the cold environment they were living in. Skull anatomy is characterised by the extreme protrusion of the upper face with marked supra-orbital ridges and a broad nasal aperture. The latter has also been argued to be an adaptation to the cold weather providing an effective way to warm air before it enters the lungs. However, it is known that Neanderthals did not always experience such cold climatic conditions, and my case studies of Gruta da Oliveira and Gruta da Figueira Brava, in Portugal, are good examples of Neanderthals living in a warm climate during the Last Interglacial, the Marine Isotope Stage 5 (MIS-5).

Despite the short stature, the brain had an average size of 1450 cm^3. Brain size imposes the question of the capacity for spoken language. Apparently, there are no neuroanatomical impediments to such capability. The discovery of a hyoid bone in Kebara cave, Israel, from levels dating from about 60,000 years BP, appeared to be almost identical to the hyoid of present-day populations. It was concluded that bone morphology, and thus human speech capability, was fully developed during the Middle Palaeolithic (Arensburg et al, 1989). Nonetheless, amongst non-human primates, chimpanzees also have quite complex communication skills, which involve a variety of gestures, facial expressions and vocalisations. However, the evidence is that these relate to immediate events rather than to reflective memories (McCrone, 1991). Therefore, it has been advocated that vocal ability does not necessarily lead to language with its underlying symbolic use (Wadley, 2001). However, recent data on Neanderthal use of ochre and manganese (Roebroeks et al, 2012), the presence of transported shells with smeared ochre (Zilhão et al 2010c), ornaments made of eagle talons (Radovcic et al, 2015) and bird feathers (Peresani et al, 2011; Finlayson et al, 2012), or the production of specialised bone tools (e.g. the *lissoirs*; Soressi et al, 2013) show no significant difference in abstract explanations between Neanderthals and Anatomically Modern Humans (AMH). As such, it seems that Neanderthals may have had some form of language (Villa & Roebroeks, 2014). As to the manual precision to perform all the above-mentioned activities, Karakostis et al (2018) re-evaluated the manipulative behaviours of Neanderthals and conducted detailed analysis of their hand muscle attachments. The conclusion of the study is that Neanderthals performed precise manual activities on a regular basis including the operationally complex production of prepared core flake and occasionally blade based industries (see section 3.2.1 for further information).

In terms of eyesight, Pearce et al (2013) showed that Neanderthals had significantly larger visual systems than contemporary AMH. This research concluded that Neanderthals had an enhanced vision, based on the assumption that vision and eye size are correlated. Such big eyes developed at the expense of other areas of the neocortex, which is a part of the brain that is highly important in terms of social cognition. Therefore, it was assumed that their social network was more limited than that of AMH who had smaller eyes and, consequently, a more developed neocortex. The authors deduced that living at relatively high latitudes, with lower light levels, triggered the evolution in the size of Neanderthal eyes. However, as recently discussed by Finlayson (2019), although higher latitudes benefit from low intensity daylight in the winter, they can have longer hours of daylight exposure in the summer. Hence, such large eyes had to be explained in a different way. Finlayson (2019) advances the hypothesis of their relationship with a hunting strategy of preferred activity at dawn and dusk, when animals are more active and easier to ambush, and when light is weaker.

Furthermore, Neanderthals occupied a wide latitude range. It is generally accepted that they lived in Eurasia roughly between 300 to 40 cal BP (Higham et al, 2014; see Marra et al, 2017, providing the oldest evidence in Europe, from central Italy, dating between 295 and 220,000 years BP). Neanderthals covered a large territory (Fig. 3.1) and there is no unambiguous evidence of their presence to the north of Germany, with the generally accepted hallmark of 55ºN latitude as the northernmost boundary. Nonetheless, Slimak et al (2011) claimed the presence of a Mousterian assemblage in the Ural Mountains of Russia, at Byzovaya, as far north as 65ºN, which has been heavily criticized (see Kellberg Nielsen et al, 2017, for a recent summary on this matter). Neanderthal influence is found all the way south to the Arabian Peninsula, where genotype data from five contemporary southern Arabian populations include Neanderthal genomes (Vyas & Mulligan, 2019). However, Tor Faraj (Jordan) may represent the southernmost Neanderthal site. Although no Neanderthal fossils were recovered from this site, a chronologically and technologically classic Tabun-B assemblage is considered to represent a Neanderthal population (see a good summary in Groucutt, 2014). To the far west, there are several confirmed Neanderthal sites in Portugal (see Chapter 5). To the east, based on the morphology of fossils, Neanderthal range reaches Uzbekistan, where a skeleton of a Neanderthal child was found in Teshik-Tash Cave (Debetz, 1940; but cf. Weidenreich, 1945, and Glantz & Ritzman, 2004); but Neanderthal influence extended all the way to the Altai Mountains of Siberia, where Neanderthal DNA was found in bones recovered from the Okladnikov Cave in association with Mousterian lithic technology (Krause et al, 2007), and more recently in Denisova Cave (Slon et al, 2018; discussed in more detail in section 3.3.) (Fig. 3.2).

Fig. 3.1 – Geographical range of Neanderthals. Dark grey: Neanderthal range based on morphology fossils. Light grey: Neanderthal range based on mtDNA. Open circles: sites where mtDNA sequences of the Neanderthal type were detected. Image from Krause et al (2007).

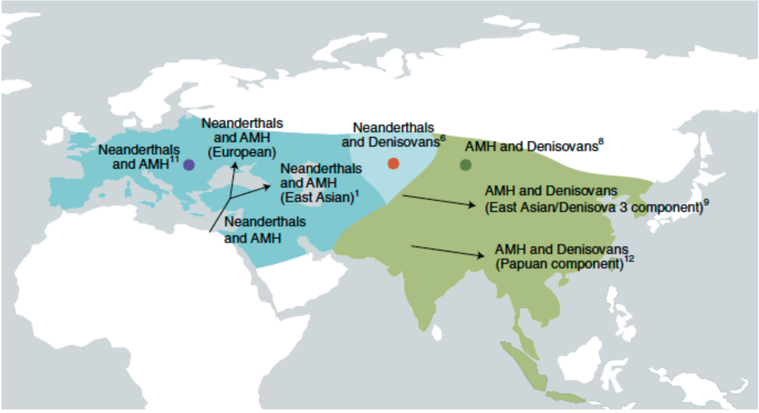


Fig. 3.2 – Map of the encounters between Neanderthals, Denisovans and early Anatomically Modern Humans (AMH). Blue: Approximate distribution of Neanderthals. Green: Approximate distribution of Denisovans. Arrows: Human migration and corresponding encounter. Red Dot: Denisova Cave. Purple Dot: Oase Cave. Green Dot: Mal'ta site. Image from Mafessoni (2019).

Despite their wide distribution and long chronological occupation in Eurasia, Neanderthals have been traditionally viewed as very different in character from AMH populations, and have recurrently been associated with connotations of inferior capacities. As observed by Finlayson (2019:6), the term *Neanderthal* is a way of saying *other*. Conversely, the term *Cro-Magnon* was never widely used, but other indecisive terms were preferred like *Anatomically Modern Humans*, or *Behaviourally Modern Humans*. But what does exactly mean to be behaviourally modern?

3.2. NEANDERTHAL MODERN BEHAVIOUR

Back in 1991, Paul Mellars summarised what were the seven features he considered to be indicative of modern human behaviour in Eurasia, which could be found in the transition from the Middle to Upper Palaeolithic. These included 1) a change in stone tool production, from flake to blade based industries, associated with increased standardisation and more economical techniques in the use of raw materials; 2) an increased variety and complexity of lithic tools; 3) the appearance of tools made of bone, ivory and antler; 4) the appearance of new forms of food procurement and processing technology; 5) the appearance of beads, pendants and other forms of personal ornaments; 6) the appearance of sophisticated and naturalistic art; and 7) marked changes in economic and social organisation. Such “modern” features were argued to have emerged at the same time as the arrival of AMH in Eurasia (Mellars, 2007).

Nowadays, such a “package of modernity” does not appear to be exclusive to AMH. Moreover, other modern features were added to the list. As shown before, despite the differences in body shape, anatomy did not impede Neanderthals from performing the same activities as AMH. Instead, there is growing evidence of Neanderthal independent ability for innovation and complexity, as well as abstract thinking.

3.2.1. Innovation and Degree of Complexity

The capacity for innovation is frequently associated with later hominin technocomplexes. Inevitably, comparisons are made between Neanderthal industries and the ones from the African Middle Stone Age (MSA). According to Wynn and Coolidge (2008) Neanderthals “made the same kinds of tools for 200,000 years without even tinkering with the basic components”. Conversely, the South African industries, such as the Still Bay or the Howiesons Poort, are understood as very dynamic lasting less than 10,000 years each. According to Villa and Roebroeks (2014), changes in tool-type and technological practices within Mousterian industries show regional differentiation and distinct cultural traditions through time and certainly before the emergence of the Proto-Aurignacian at c. 43.000 cal BP and the advent of the European Upper Palaeolithic.

Further support to the ability of lithic technology innovation and material culture complexity is given by several so-called transitional industries dated from the late Middle Palaeolithic, which show a Mousterian tradition combined with what are considered to be Upper Palaeolithic forms. The authorship of such transitional industries is part of an ongoing heated debate, and is generally used in discussions relating to AMH migration routes and the nature of contacts between local and incoming populations in Eurasia. In Russia and in Central and Southeast Europe the Bohunician, the Szeletian, the Bachokirian and the Streletskayan industries were identified. Their makers are still unknown (i.e. whether Neanderthals or AMH) (Hublin, 2012; Škrdla, 2017), so the status of these lithic industries remains uncertain and in need of further contextual evidence. The Uluzzian (found in Italy and Greece) has been considered of Neanderthal tradition (d'Errico et al, 1998, 2012), but Benazi et al (2011) state that the two deciduous molar teeth found in Grotta del Cavallo (southern Italy) are of AMH origin, thus implying the Uluzzian culture may be of modern human origin. Nonetheless, Zilhão and colleagues (2015) refute such assumption. They demonstrated that, despite the AMH origin of the teeth, the analysis of site formation processes and assemblage integrity agrees with Neanderthal authorship of the Uluzzian remains. Finally, Neanderthals are accepted by many, but not by all (e.g. Bar-Yosef & Bordes, 2010), as the authors of the Châtelperronian culture. Grotte du Renne (Arcy-sur-Cure, France) is considered this industry's iconic site, where a large number of bone tools and ornaments were found. Radiocarbon dates taken directly on ornaments found in Châtelperronian levels from this cave demonstrated that the remains were intrusions from the overlying Proto-Aurignacian levels (Higham et al, 2010). This motivated Mellars (2010) to interpret the results as evidence of AMH authorship in the production of the beads analysed, hence denying Neanderthals' modern behaviour. However, considering the high probability of contamination of such dates due to the varnish applied to the decorative material during archaeological work in the 1960s, Hublin and colleagues (2012) conducted further dating research using bone ornaments. They also dated a Neanderthal skeleton found in

Châtelperronian levels from La Roche-à-Pierrot (Saint-Césaire, France). According to their results, dates support a Neanderthal origin for the Châtelperronian in both sites. Further palaeoproteomic research conducted on hominin bone material from Grotte du Renne, supports Neanderthal authorship (Welker et al, 2016). Nonetheless, and despite the Neanderthal origin of the Châtelperronian, the general interpretation of Hublin's team is that such modern behaviour is the result of cultural diffusion from AMH to Neanderthal groups, and not an independent Neanderthal achievement. The controversy continues, and it seems far from being solved, with recent claims of no reliable evidence for a Neanderthal-Châtelperronian association at Saint-Césaire, based on lithic studies of larger assemblages combined with a systematic refitting programme (Gravina et al, 2018).

Still within the realm of lithic tool production, Brown and colleagues (2009) demonstrated how MSA people from Pinnacle Point (South Africa) were systematically manipulating fire to perform heat treatments to stone materials in order to improve their flaking properties. This was mostly done on silcrete tools dated to about 72,000 years and possibly as early as 164,000 years ago, therefore indicating "a sophisticated knowledge of fire and an elevated cognitive ability". The researchers interpreted this behaviour as an AMH advantage during the encounters with Neanderthals when moving into Eurasia. However, as highlighted by Roebroeks and Villa (2011), Brown and his team forgot that Neanderthals were mastering fire in order to make sophisticated chemical compounds to haft stone tools as early as 200,000 years ago. Such evidence was found in Campitello Quarry (Central Italy) where flint flakes still attached to its adhesive were recovered (Mazza et al, 2006). More recent evidence comes from the Dutch North Sea where a birch tar-hafted flint tool was recovered in geological association to Middle Palaeolithic artefacts, a Neanderthal fossil, and was directly dated by AMS to ~50 ka Niekus et al (2019). The study of such glues showed that Neanderthals were synthesizing birch bark pitch through a process that implied distillation in the absence of oxygen and within a specific temperature interval of 340ºC and 400ºC. Attempts of reproducing this technique without using modern technical methods have met many difficulties (Koller et al, 2001; Mazza et al, 2006). Such complicated process shows a clear sign of Neanderthal's considerable technical capabilities, the capacity for thinking in abstract ways and the ability to plan ahead.

Neanderthal fire production, its use and control, is also a contentious issue. As summarised by Alperson-Afil and Goren-Inbar (2010), at the core of the origins of fire controversy lies the difficulty in differentiating 'use of fire' from 'control of fire' based on archaeological evidence. Fire must have been accessible to hominins through lightning, volcanism or spontaneous combustion. However, direct evidence of fire production is only possible when fire-making tools, or *in situ* hearths are found. The latter are generally defined as confined areas with a more or less circular outline, featuring reddened sediment, ashes, charcoal, thermoclasts and burnt animal bones (Meignen et al, 2000). Nonetheless, researchers working in southwest France – namely in Pech de l'Azé IV and Roc du Marsal – claim that Neanderthals lacked the technological ability to make fire (Dibble et al, 2017, 2018; Sandgathe et al, 2011b). They advocate that evidence for fire use is only found in layers associated with warm periods, whereas there is a dramatic decrease in fire evidence in cold periods. Their explanation for such counterintuitive pattern is based on the larger occurrence of natural fires during warm climates, due to the higher probability of storms. Consequently, Neanderthals would only be able to harvest naturally occurring fires during the warm periods, and stoically endure the cold periods without producing fire. Based on this notion, Goldfield et al (2018) argue that, without fire, Neanderthals would only be able to survive in cold environments due to their robust musculature. However, the maintenance of normal body temperature would have been metabolically costly. Conversely, AMH had proper fire-making skills and were thus able to eat cooked meals, which reduce the cost in processing and assimilating nutrients. The authors further conclude that, when moving into Eurasia, AMH had overall smaller energy expenditure and hence a higher advantage in resource competitiveness over Neanderthals. This led them to state that the "frequency in fire use can directly affect the rate and inevitability of

Neanderthal extinction”. However, Sorensen and colleagues (2018) were able to prove Neanderthal fire-making technology through microwear analysis and experimentation. These researchers analysed dozens of bifacial tools recovered from multiple Neanderthal sites throughout France, and concluded that they were repeatedly used as ‘strike-a-lights’. They also refer that Claud (2008) observed traces of repeated contact with mineral materials in bifacial tools dated as far back as the early Acheulean. Additionally, there are many sites confirming Neanderthal production and use of fire in the European Middle Palaeolithic. Limiting our examples to just a few Iberian sites, there is clear evidence of fire-making through the identification of 187 combustion structures found in several levels of Abric Romaní (Spain, MIS-4 and MIS-3; Vallverdú et al, 2012; Courty et al, 2012), 30 superimposed combustion structures in all layers of El Salt (Spain, MIS-3; Gómez et al, 2010), or the hearths found in one of our case-study sites – Gruta da Oliveira (Portugal) – discussed in more detail in Chapter 7. Based on extensive evidence showing hearths found in both glacial and interglacial periods (see the detailed list of Neanderthal fire evidence provided by Roebroeks & Villa, 2011 – supplement 1), it is accepted that Neanderthals were fully aware of fire production techniques using it for a variety of purposes (e.g. heating, lighting, heat treatment of raw materials, protection from predators).

A hearth in layer 21 of Unit C from Esquilleu Cave (Spain, MIS-3) has evidence for possible bedding near it. FTIR and phytolith analyses identified the presence of grass leaves in the hearth’s immediate surroundings suggesting the repeated location of a bedding area (Cabanes et al, 2010; Mallol et al, 2010). Bedding areas in the spaces between hearths in level N of Abric Romaní have also been reported (Vallverdú et al, 2010) and other specialised activities, were described for specific areas in levels O and M (Gabucio et al, 2018). Ethnoarchaeological works have explained the relationship between hearths and sleeping areas concluding that, in most cases, sleeping areas are close to hearths, although not all hearths were used for this purpose (Galanidou, 2000). Therefore, and as advised by Cabanes et al (2010), the lack of evidence for Neanderthal bedding areas should be reexamined and further attention given to data such as phytolith distribution which allows inferences to be drawn on Neanderthal behaviour, such as the sites' function and the use of space within it. Organised use of space has been documented in other sites with pre-modern humans – e.g. Qesem Cave (Israel, ca. 300,000 years old; Blasco et al, 2016b), or Tor Faraj (Jordan, 55,000 years old; Henry, 2012) – where well-delimited task-specific areas have been documented by faunal spatial analysis, refitting and hearth distributions. Some researchers (e.g. Lombard, 2012) consider such deliberate organisation as a trait of modern behaviour, but others (e.g. Videan, 2006) show that activities, such as the construction of bedding areas is well-documented amongst chimpanzees.

In Abric Romaní, between 8 and 10 persons is the estimate for the occupation of a possible wooden hut identified within the rockshelter (Vallverdú et al, 2010). In Tor Faraj, a range of 15 to 20 persons was calculated as hearth-side occupants in each of the two living floors identified (Henry, 2012). These estimations correspond to the number of people in modern foraging groups (Villa & Roebroeks, 2014: supplement 1). But in fact, based on Dunbar's (1998) *Social Brain Hypothesis* and estimations calculated using traditional hunter-gatherer and small-scale horticultural societies, humans could potentially interact with up to 150 people. The reasoning behind this estimate is linked to the size of the brain. As mentioned before: the larger the brain's neocortex, the larger the social group. This notion has been used by some authors (e.g. Mellars, 2007; Harari, 2014) to support the cognitive superiority of AMH. McBreatry and Brooks (2000) had also argued that such larger-scale social networks acted as buffers against environmental downturns, thus increasing the long-term survival of AMH. In order to archaeologically support this idea, these authors reported distances of obsidian transport at MSA sites in Tanzania of 240 km (in Nasera Rock Shelter) and 320 km in Zambia (in Bed VI at Mumba). However, Villa and Roebroeks' (2014) review of the evidence consider that raw materials' long-distance exchange networks do not seem to significantly differ between the African MSA and the European Middle Palaeolithic, especially considering that the quantities of obsidian being transported from MSA groups were minimal indicating weak group interactions (Ambrose, 2012) [but see Brooks et al (2018) showing large quantities of obsidian being transported over a long distance in the early MSA]. Similarly, such weak interactions may have happened among Neanderthals. By comparing the maximum transport distances in Middle Palaeolithic Western Europe (of around 110-120 km) with the Central and Eastern Europe (>200 km), Villa and Roebroeks (2014) argue that such differences result from ecological variability. This is supported by Powell et al's (2017) recent research on primate cognition that shows that brain size seems to be associated with ecological variables (e.g. home range size, diet and activity period), rather than social group size and the size of the neocortex (as proposed by the *Social Brain Hypothesis*).

Based on the evidence presented, and despite the physical differences, it seems that Neanderthals and AMH were not significantly dissimilar in their cognitive capabilities, being sophisticated enough to innovate, to perform complicated activities and to maintain complex social networks. The interesting question at this stage is whether Neanderthals were able to think about objects and ideas that are not physically present, and if they used symbols to represent ideas. In brief, were Neanderthals capable of abstract thinking?

3.2.2. Abstract Thinking

Abstract thinking is linked to a myriad of actions of which ritual burial is amongst the most obvious. As summarised by Pettitt (2011), the sample of Neanderthal mortuary evidence is made of fragmentary skeletal remains corresponding to about 500 individuals spanning roughly between 130 and 40,000 cal BP (from the MIS-5 to the MIS-3). However, burials with reliable chronology are restricted to ca. 70 and 40,000 cal years BP, and burials *sensu stricto* (referring to cases where there is a cut grave pit, opposing to those termed as just “burials” which do not have such cut pit) are limited to the MIS-3. Pettitt argues that Neanderthal mortuary practices must not be seen as one monolithic phenomenon. He suggests that bodies may have first been cached around cave entrances as early as MIS-7. Then, from MIS-5, it is tempting to interpret some fragmentary remains (such as the ones with cut marks) and disposed in different areas from the living as the result of some sort of mortuary rituals. Also, from MIS-5, few sites show convincing evidence of Neanderthals being interred, and Pettitt considers that most scholars would accept as deliberate burials at least La Chappelle-aux-Saints, La Ferrassie, Le Regourdou, in Europe, and Kebara, Amud, Tabun and Shanidar in the Near East. Nonetheless, Pettitt (2011:103) cautions that “it would be incorrect to infer from this simply that Neanderthals buried their dead; it may have been a rare event, although the repeated patterning evident at some sites where multiple individuals were buried suggests that there were at times burial traditions.”

Neanderthal mortuary behaviour is still contested by some (e.g. Dibble et al, 2015). Archaeologists working in Roc du Marsal argue for a non-deliberate child burial and therefore claim the Neanderthals were not involved in deliberate mortuary practices (Sandgathe et al, 2011a; Goldberg et al, 2017). The arguments are mostly focused on the origin and formation of the burial pit, and the deposition of bones in it. Pelletier et al (2017) also consider site formation and post-depositional processes in detail in their research in Le Regourdou. Through the analysis of rabbit bones and their burrows, they bring into question the reliability of the site stratigraphic analysis and its palaeoenvironmental reconstruction, and thus of the veracity of claims in the intentionality of the burials found on site. Yet, in La Ferrassie, Balzeau et al (2020) support an opposite view, with a pluridisciplinary study showing the deliberate removal of sterile sediment in order to build a pit, where the body of the child known as La Ferrassie 8 was deposited and covered. Rendu et al’s (2014, 2016) also support such a notion, with recent excavations at La Chapelle-aux-Saints demonstrating, once more, a deliberate burial. These scholars argue for the anthropogenic origin of the pit, and the rapid burial of the body, which protected it from post-depositional modifications. This is supported by the completeness of the skeleton, the presence of anatomical connections and the identification of the same surface preservation patterns in all bones recovered. Rendu and colleagues (2016) argue that although the presence of grave goods was mentioned by previous researchers working on this site (e.g. Bouyssonie et al, 1913), they cannot confirm that such objects (mainly bones and lithic tools) assumed some kind of ritual expression at the time of their deposition. The authors further note that most burials do not include any form of ritual evidence, which does not imply lack of funerary practices.

The emergence of symbolic material culture does not only reveal abstract thinking, as it reflects a threshold in human evolution. It is frequently used as a proxy for language and consequent assertions on human cognition. As shown before, increasing evidence of the use of body adornments, mineral pigments, shell beads, eagle talons and feathers, has been recovered from European Middle Palaeolithic and African Middle Stone Age sites. Limiting this review to just a few examples in Iberia within a constantly growing corpus of evidence, perforated marine shells alongside lumps of yellow and red pigment recovered from Cueva de los Aviones, have pigment residues preserved inside of some of them (Zilhão et al, 2010c). Additionally, a perforated *Pecten* shell with an orange pigment-stain was found in Cueva Antón, located about 60 km inland. These shells were recovered from Middle Palaeolithic sites in southeastern Spain dating to around 50,000 years ago, demonstrating that Iberian Neanderthals were no different from early AMH in Africa and the Near East (Zilhão et al, 2010c), where the use of body ornamentation is generally understood as modern behaviour. However, considering the 50,000 years old date, it remained possible that such shells could be related with the first wave of AMH in Europe, or that they resulted from their indirect influence through cultural appropriation with an “imitation without understanding” approach (Hublin, 2015; Mellars, 2010). Therefore, Hoffmann et al (2018b) conducted U-series dating of the flowstone capping Cueva de los Aviones deposit and established that the shells dated from 115,000 to 120,000 years old. Consequently, such symbolic finds predated the arrival of AMH in Europe. Furthermore, these shells predated the earliest known comparable evidence of such behaviour associated with AMH (*i.e.* Blombos Cave, South Africa, Jacobs & Roberts, 2017; Grotte des Pigeons, Morrocco, Bouzouggar et al, 2007; Qafzeh Cave, Israel, Bar-Yosef Mayer et al, 2009; Hovers et al, 2003) by 20 to 40,000 years.

Claims of Neanderthal authorship have also been made for a figurine recovered from La Roche-Cotard, in France (Marquet & Lorblanchet, 2003), or a hashtag engraving found in Gorham's Cave, Gibraltar (Rodríguez-Vidal et al, 2014). However, such claims remain unresolved due to difficulties in direct dating (Pettitt & Pike, 2007) and uncertainties in distinguishing between intentional and natural modifications (Pettit 2003; Camarós et al 2017), but see Majkić et al (2018) showing intentional representation engravings from a cortical flint flake from Kiik-Koba (Crimea), or Prévost et al (2021) demonstrating the deliberate production of an abstract engraving on an aurochs bone fragment from Unit III of Nesher Ramla, Israel, dated from ca. 120 ka years ago. Recently, a new technique has been developed allowing U-Th dating of the carbonate precipitates associated with cave art without damaging the art itself (Hoffmann et al, 2016). Such geochronological techniques have been applied to several caves in Iberia, and the first results showed that a red disc on the Panel of Hands in El Castillo (Cantabria, Spain) had a minimum age of 40,800 years BP (Pike et al, 2012). Considering the generally accepted idea that art is exclusive of AMH, El Castillo opened the possibility of Neanderthals also being artists considering that both human groups were present in Cantabria at this point in time (Hublin, 2015; Zilhão, 2006). More recently, Hoffmann et al (2018a) extended the dating method to three other caves covering different regions in Spain. All together, U-Th dates on carbonate crusts overlying a red linear motif in La Pasiega (Cantabria), a hand stencil in Maltravieso (Extremadura), and red-painted speleothems in Ardales (Andalucía) revealed that cave art is older than 64,800 years BP in Iberia. This predates by at least 20,000 years the arrival of AMH in Europe, thus implying Neanderthal authorship (but see Aubert et al, 2018, who challenge such dates).

At the stage of our present knowledge, it is clear that modern behaviour was already performed extensively amongst Neanderthals, and there is currently the working hypothesis that symbolic capacity and advanced cognition abilities may have preceded the period before the divergence of the Neanderthal lineage by more than half-a-million years (Hoffmann et al, 2018b). In addition, there seems to be enough evidence to make it reasonable to accept that there was cultural diffusion from Neanderthals to AMH, supporting the idea that some of the technologies from the early Upper Palaeolithic may have evolved from a Middle Palaeolithic base (Villa & Roebroeks, 2014; Zilhão, 2007). Consequently, such interpretations sustain the notion of an interaction between Neanderthals and AMH, which has been consistently and repeatedly confirmed by genetic investigation as shown in the next section.

3.3. NEANDERTHAL EXTINCTION

Neanderthal disappearance occurred in Eurasia between approximately 45 and 40,000 cal years ago (e.g. Higham et al, 2014; Zilhão, 2013a). Traditionally, the general idea was that the Eurasian Upper Palaeolithic developed from the Middle Palaeolithic with Neanderthals evolving into modern humans. Since the late 1980s, however, the opposite view of a single origin of AMH responsible for the replacement of archaic populations started to be widely accepted. This *Eve Hypothesis* was strongly supported by genetic studies, such as the one undertaken by Cann et al (1987) that provided convincing mitochondrial evidence for an African origin of all modern humans. This view was reinforced by the expansion of dating of Palaeolithic sites in Africa and Eurasia, and increasing evidence of anatomically modern features found in African fossils as old as 195,000 years BP. The *Out of Africa Hypothesis* was therefore formulated claiming that AMH originated in Africa, and around 50,000 years BP expanded into the Near East, and then into Europe (Klein, 2008). As observed by Zilhão (2015: 27), in order to guarantee the internal consistency of all these new hypotheses, it was required that Neanderthals were removed “from the range of human-ness in both biology and behaviour”. That is when Neanderthal extinction started to be routinely explained by the cultural superiority of AMH who were understood as the bearers of complex cultural traditions and high cognitive capacities, which allowed them to replace all other hominins. This interpretation boosted the research in sub-Saharan sites and the direct comparisons between the MSA and the European Middle Palaeolithic in order to prove the cognitive superiority of African populations. In 2000, McBrearty and Brooks argued that many innovations traditionally associated with the European Upper Palaeolithic were gradually developed in Africa and then exported to Eurasia. As demonstrated in section 3.2, this is now highly contested, and there is plenty of evidence of independent Neanderthal behavioural modernity. Additionally, Villa and Roebroeks (2014) argue that there is no clear archaeological evidence of the suggested migration routes out of Africa, and advocate that there was a lack of a strong cultural homogeneity among the AMH migrating groups, therefore compromising their ability to impose their identity on archaic hominins with which they came into contact.

Nonetheless, it is clear that there was contact between AMH and Neanderthals. Research has followed a long path since the first highly contested suggestion of hybridization found in Abrigo do Lagar Velho (Leiria, Portugal), where the discovery of the Lapedo Child showed morphological traits typical of AMH and Neanderthals in a single skeleton (Duarte et al, 1999; Trinkaus et al, 2001; Zilhão & Trinkaus, 2002). Nowadays, results continue to be published revealing that interbreeding was widespread among different hominins, such as the case of the Oase Cave hybrid (Fu et al, 2015). Green et al (2010) and Sankararaman et al (2012) were successful in demonstrating that Neanderthal genome is ubiquitous in modern non-African populations with the genetic contribution of about 2%. This was initially interpreted as the result of a single admixture event. However, subsequent research showed that Neanderthal DNA is higher by ca. 12-20% in modern East Asian populations than in modern European individuals (Prüfer et al, 2017; Vernot, 2016), suggesting that East Asians encountered Neanderthals more than once. Further support to this view is given by Villanea and Schraiber (2019) who revealed that, in both European and East Asian populations, the amount of Neanderthal DNA fragments with a frequency of 2-6% is higher than previously expected, presenting a robust model of multiple encounters between AMH and Neanderthals.

This scenario of multiple interbreeding episodes fits well with the complex interactions between different groups of hominins. Genetic studies have recently demonstrated interbreeding between Neanderthals and Denisovans. The finding of a first generation Neanderthal-Denisovan offspring (Denisova 11) indicates that genetic admixture occurred at least in two occasions, suggesting that mixing was common whenever these two hominin populations met (Slon et al, 2018). It has also been shown that Denisovans interbred more than once with other archaic hominins (Prüfer et al, 2014) and AMH (Lipson & Reich, 2017). Browning et al (2018) revealed that modern human genome has two different Denisovan components: one is related with Australian and Papuan aboriginal populations; and the other is mainly found in East Asian populations. These two Denisovan components are very distinct, which contrasts with a single Neanderthal component in modern human genome. As summarised by Mafessoni (2019), this suggests that when AMH spread into Eurasia, they found an extremely homogenous Neanderthal population, which is supported by the weak differentiation between Neanderthal genes across Western Europe and Siberia. Conversely, Denisovans might have been much more diverse and more widely distributed, which is evident by the new discovery of a Denisovan mandible in a cave in the Tibetan Plateau (China), the first occurrence of this hominin out of Siberia (Chen et al, 2019).

Genetic admixture may have provided AMH with Neanderthal features that allowed them to adapt to non-African environments. However, it may have also introduced alleles [a variant form of a gene; a mutation] that contributed to male hybrid sterility (Sankararaman et al, 2014). Furthermore, low genetic diversity within Neanderthals suggests small population sizes (Prüfer et al, 2014, 2017), which led Fu et al (2013, 2016) to consider that differences in population sizes between Neanderthals and AMH may have led to the absorption of the former by the latter. This is explained by the continuous decline of Neanderthal DNA in AMH genome since ca. 45,000 years BP, resulting in a permanent negative selection against Neanderthal genes. Contrary to this, a new study by Petr et al (2019) shows that Neanderthal DNA did not have a significant decrease in the overall AMH genome in Europe, but instead remained nearly constant. Therefore, long-term genetic modifications are more likely to be the result of other forces rather than negative selection against Neanderthal DNA.

The causes of Neanderthal extinction are therefore still poorly understood. Some proposed hypotheses have been associated with environmental events and climate change. One of them relates to the Campanian Ignimbrite that was the result of a volcanic eruption in the north of Naples (Italy) around 40,000 years. It was the largest eruption in Europe, and its ashes spread over a large territory (from Italy to Russia); it is assumed to have been responsible for a volcanic winter marked by a very cold and dry environment (Costa et al, 2012). This event was interpreted by Fedele et al (2008) as the trigger for climatic deterioration and consequent people redistribution, motivating the major cultural changes happening from the Middle to the Upper Palaeolithic and, thus, Neanderthal extinction. However, Lowe et al (2012) showed that neither Neanderthals nor AMH were adversely affected by the climatic cooling, and refute the hypothesis of Neanderthal demise as a result of such volcanic event.

Environmental implications for the Neanderthal extinction have also been proposed by other authors (e.g. Finlayson & Carrión, 2006; Müller et al, 2011), taking as a premise that the arrival of AMH to Eurasia was coincident with a period of significant climate change. Finlayson (2009) argued that it was the expansion of the treeless steppe-tundra across Europe that triggered the geographical fragmentation of Neanderthals, resulting in population decrease. This view was based on the fact that Neanderthals needed tree cover to successfully use their ambush hunting method of large mammals. As trees disappeared, they had to adapt to a new landscape but their robust physique was not able to change fast enough, and so they went extinct. This interpretation was revised a decade later by Finlayson (2019:34) since Neanderthal sites have been identified in Central Europe associated with large mammals from the steppe-tundra (i.e. reindeer, woolly mammoths and woolly rhinoceros). Finlayson now believes that Neanderthals may only have rarely exploited tundra animals, and possibly only in situations where woodland was not far away. Nonetheless, it has been demonstrated that Neanderthals taking refuge in southerly European regions – like the Balkans, Italy and Iberia – survived for a longer period (e.g. Carrión et al, 2011; Dennell et al, 2011; Finlayson et al, 2006; Zilhão et al 2010b; but see Wood et al, 2013). It is argued that climate conditions were more amenable in these areas, providing hominins with a wide variety of flora and fauna communities. In Iberia, such ecological diversity developed in more littoral areas, contrasting with the peninsula's interior where Neanderthal disappearance around 42,000 years must have been related to hostile environmental conditions due to extremely dry climate (Wolf et al, 2018).

In sum, the circumstances for Neanderthal extinction are not yet sufficiently resolved and the debate whether the disappearance was due to competition with AMH, or assimilation into their genetic pool, or due to environmental causes, is still ongoing. On a personal note, it would not come as a surprise that Neanderthal demise revealed itself as the outcome of a combination of factors, resulting from complex processes that would vary in time and space.

CHAPTER 4

MIDDLE PALAEOLITHIC SUBSISTENCE

4.1. HOMININ LARGE GAME CONSUMPTION

Since the late 19th century the association of lithic tools and faunal remains in archaeological sites has been considered to reflect hominin subsistence behaviour, implying hunting and carcass-processing activities (Domínguez-Rodrigo, 2002). According to Darwin (1871), such accomplishments – together with bipedalism and the abandonment of life in the trees – were indicative of a certain stage of hominization that separated humans from other apes. Further evidence of such humanized behaviours was later given by authors like Dart (1959), who argued for the primacy of meat-eating by early humans in many African sites. Such ideas were widespread, leading to the general acceptance of hunting as the main hominin subsistence strategy, which was later termed the *Hunting Hypothesis* (Domínguez-Rodrigo, 2002; Stanford, 1999).

The *Hunting Hypothesis* was well-received and popular among academics during the first part of the 20th century, reaching its peak with the *Man the Hunter* conference held in Chicago in 1966, where several ethnographic studies of recent hunting and gathering communities were presented (Lee & DeVore, 1968). Hunting was perceived as the most efficient method to adapt to a myriad of environments, since the targeting of substantial herds of large herbivores guaranteed the sustenance of hunter-gatherer groups (Hart & Sussman, 2005; Stanford, 1999). However, in the 1970s, Glyn Isaac and colleagues (Isaac 1978, 1982; Isaac & Crader 1981) changed the focus from the hunting process *per se* to the hominin social cooperation that was seen as the real trait of progress and evolution. The *Home Base / Food Sharing Hypothesis* argued that food resources other than meat were part of the diet, with women being generally responsible for procurement of plant foods whilst men were accountable for hunting activities. Furthermore, Isaac tackled issues like the role of non-anthropogenic factors (e.g. rivers, other carnivores) in the accumulation of archaeological material (Isaac, 1983).

Such taphonomic concerns were extensively explored during the 1970s and 1980s within the frame of the *New Archaeology*, when several actualistic and experimental studies were conducted. This approach resulted in works highlighting the importance of non-cultural agents in the formation of archaeological assemblages. Amongst the most notable works is the one of Brain (1981), who demonstrated through detailed taphonomical analysis that the bone deposits interpreted by Dart (1959) as resulting from hominin hunting activities were, instead, due to predator-scavenger activities, and that humans were among the species preyed upon. Similarly, Binford's ethnographic work among the Nunamiut (Binford, 1978) attempted to reconstruct the different agents and activities involved in the formation of bone accumulations through the body part representation patterns found in faunal assemblages. Binford compared modern hunter-gatherer and predator-scavenger assemblages with archaeological collections, concluding that several Lower Palaeolithic bone accumulations (e.g. in Olduvai Gorge Beds I and II, Swanscombe, Torralba and Klasies River Mouth) were in fact the result of carnivore kills with subsequent hominin scavenging intervention (Binford, 1981, 1984, 1985, 1987). This resulted in a dramatic shift in the interpretation of hominin subsistence behaviour with some authors rejecting early hominins as big game hunters (e.g. Binford, 1981, 1985; Blumenschine 1986, 1992; Selvaggio 1998a, 1998b), but seeing them as purely scavengers relying on the carcasses from other carnivore kills in order to survive. Furthermore, Binford considered that hunting was only possible among Anatomical Modern Humans, an idea also shared at the time by researchers like Mellars and Stringer (1989) who considered that pre-modern humans lacked the physical, behavioural and technological ability for large game hunting.

In the 1990s, the gap between such opposing ideas – i.e. whether hominins were hunters or scavengers – started to narrow down. Some authors placed hominins back in their faunal community context (e.g. Stiner, 1994), and included them in the wider carnivore guild (Stiner, 2002) in order to better understand the interaction and competition of humans and other species for the resources available. Such approach has been producing evidence supporting both hunting and scavenging behaviours (Gaudzinski, 1996). Moreover, zooarchaeological studies from several European Middle Palaeolithic sites have been advocating different, and frequently competing, Neanderthal subsistence behaviours. Specialised monospecific hunting of large and medium-sized game has been proposed for sites where a limited number of species is recorded, mainly focusing on herbivores like large bovids, horses and reindeer. Examples of such monospecific subsistence are found in sites like Wallertheim (Germany; Gaudzinski, 1996), Schöeningen (Germany; Gaudzinski-Windheuser & Niven, 2009), Mauran (France; Farizy et al, 1994) or La Borde (France; Jaubert et al, 1990). Other sites demonstrate the targeting of megafaunal species like the proboscideans from the Spanish sites of Torralba and Ambrona (Villa, 1990) and Preresa (Yravedra et al, 2012), or the mammoths and woolly rhinoceros from La Cotte de St Brelade (Jersey; Scott, 1980, 1986; Smith, 2015), and the Belgium sites of Goyet (Wiβing et al, 2016) or Spy Cave (Weyrich et al, 2017), among others. Current archaeological evidence suggests that Neanderthals were successful hunters of large ungulates (eg. Rendu, 2010; Discamps et al, 2011; Gaudzinski-Windheuser & Kindler, 2012; Kindler et al, 2014). However, there is still some scepticism as to whether Neanderthals specifically targeted megafauna and large ungulates, or if they simply scavenged from other carnivore kills or natural deaths (eg. Burke, 2004; Mellars, 1996; Stiner, 1994). Nonetheless, it is difficult to argue against the fact that scavenging hominins had to compete and fight over carcasses with other carnivores (Gaudzinski, 2004).

Despite the manner of meat acquisition, Neanderthal consumption of large game has been widely accepted, and isotope analysis has been crucial in perpetuating such views (e.g. Wiβing et al, 2016). The first carbon and nitrogen analyses carried out in the 1990s revealed Neanderthals as top meat consumers, clustering close to wolves and hyenas (Bocherens et al, 1991). However, and as later noted by Bocherens (2009), sample size was small (with only 6 samples fulfilling the necessary analysis criteria). Moreover, all samples were recovered from Neanderthal occupations relating to cold periods and to northern latitudes, with clear lack of evidence from sites in more southern positions (Hardy, 2010). Nonetheless, isotope analyses made by Salazar-García et al (2013) in Mediterranean sites showed similar results to those from cold environments, implying a predominant consumption of terrestrial resources. Ecker et al (2013) support such conclusions through carbon and oxygen isotope analyses on Neanderthal tooth enamel samples from southern France, demonstrating a preference for large herbivore consumption.

However, the growing body of vegetal evidence has shown the inclusion of plant foods in pre-sapiens diets (Hardy & Moncel 2011; Henry et al, 2011, 2014; Hardy et al, 2012, 2013, 2016; Weyrich et al, 2017). Nutshells from stone pine (*Pinus pinea*) were found in Gorham's Cave (Gibraltar; Ward et al, 2012), and there is further evidence of consumption of pine nuts, moss and mushroom from Neanderthal teeth from El Sidrón Cave (Spain; Weyrich et al, 2017). Other low ranked plants, like starches and grass seeds, were also consumed in several European Neanderthal sites (Henry et al, 2014), and in the Near East such as Shanidar Cave (Iraq; Henry et al, 2011). In addition, there is rising evidence for the exploitation and consumption of small game and marine resources in the Middle Palaeolithic (e.g. Stiner, 1994, 2005; Barton et al, 1999; Stringer et al, 2008; Zilhão et al, 2010c, 2020; Blasco & Fernández-Peris, 2012a, 2012b; Blasco et al, 2016c). Such research advances are therefore changing the traditional palaeodiet perceptions based exclusively on large game consumption and, instead, are becoming significantly more complex.

4.2. HOMININ BROAD DIETS

Formulations of broad spectrum diet theories had their origin in research related with food production and the dawn of domestication. In a well-known 1968 paper, Lewis Binford criticises Braidwood's nuclear zones theory (Braidwood, 1960, 1963), which stated that food production was not an anthropogenic response to climate change but resulted from an increased cultural awareness of the environment, its resources and how to manipulate them. It was only in the terminal Pleistocene that hunter-gatherers had developed such a deep understanding of the flora and fauna of their living environments, with the direct consequence of domestication. Nevertheless, according to Binford (1968), such cultural decision-making could not be confirmed and it was impossible to test. Moreover, he argued that it was unlikely that prehistoric hunter-gatherer populations would change their long-term subsistence strategies unless there was considerable disequilibrium resulting from changes in the environment, forcing human groups to adapt to a new reality. Binford illustrated his theory by comparing the distribution of Mesolithic and Neolithic sites, which he argued was determined by environmental factors. Rising sea levels and other changes forced people to find new subsistence strategies, like heavy consumption of marine resources and the beginning of food production.

Binford's density disequilibrium model considered demographic increase as a possibility for hominin widening diets, but only in marginal areas and in very specific conditions. In most cases, population increase would only encourage "a regressive change in which a less complex cultural form is adapted" (Binford 1968:331). Conversely, Flannery (1969) presented demographic expansion as a critical factor. Although the importance of climate change was not ignored, he did not consider environment as the main engine to changes in subsistence patterns. Instead, broader diets were triggered by population pressure and disequilibrium towards resource carrying capacity, which forced mid-Upper Palaeolithic groups to use smaller resources, more reliable and predictable in certain seasons of the year, like "fish, crabs, water turtles, molluscs, land snails, partridges and migratory water fowl" (Flannery 1969). The increasingly broad spectrum exploitation from 20,000 years BC to about 6,000 BC was thus responsible for a change in mental attitudes, which started considering any resource as potential food. Flannery then argued that only after these developments would the first domestication be possible (Flannery 1969). Although such small resources would not be a substitute for specialised ungulate hunting, most of them could be storable, some were high in calories (like acorn and pistachio), and others provided important nutrients, like calcium from land snails or vitamin A from mussels. Also, invertebrates and vegetal foods could easily be collected by women and children, which would complement men's ungulate hunting (Flannery 1969).

With Malthusianism theories widely accepted, Flannery's Broad Spectrum Revolution was well received. Further support came from Mark Cohen's *The Food Crisis in Prehistory* (1977) stating in favour of population pressure. Cohen also stressed that changes in the diet would impact on procurement efficiency. Therefore, smaller, lower energy and more labour intensive resources would integrate the new diet patterns with the direct consequence of a significant increase in energy costs. As is well summarised by Christenson (1980:36), the first consequence of population growth would be the intensification and specialisation of the high potential resources already explored. Once these started to decline, then diet diversification would occur incorporating animals giving less energy but with less cost input. However, overexploitation of these low rank resources would eventually occur and other low ranked foods which are more labour intensive would have to be included in the diets. These two types of low rank resources – with less and more cost input – were later zooarchaeologically defined by Mary Stiner and colleagues (2000) as small slow prey (i.e. tortoises, shellfish) and small fast prey (i.e. lagomorphs, birds), respectively.

Archaeological evidence was soon provided by Clark and Straus (1986), who presented the Upper Palaeolithic site of La Riera (Cantabria, Spain) as the perfect example of resource intensification, specialisation and diversification. They started by rejecting any significant environmental change during the cave's occupation and showing a progressive specialisation on red deer consumption through catastrophic mortality profiles suggesting herd hunting. Further intensification was noted through red deer bone breakage patterns that, at a certain stage in the stratigraphic sequence, started showing heavy exploitation of marrow and grease. Such intensification was supported by significant increase in newborn individuals, which was interpreted as a clear sign of red deer overexploitation. Concurrently, limpet shells were intensively consumed resulting in a size decline, indicating overexploitation. In addition, resource diversity was attested by an increase in the range of molluscs from different environments and the inclusion of marine species not previously exploited, like fish and sea urchins.

In the 1980s, archaeologists and anthropologists found support for their energy cost efficiency models in Behavioural Ecology and its Optimal Foraging Theory. The latter assumes that resources are selected so as to maximise the effort spent in collecting or hunting them. The ultimate goal is to define prey choice models in order to understand the rules used by foragers to enhance the efficiency of their resource selection (Zeder 2012 and references therein). Optimal Foraging Theory was embraced by the zooarchaeological community with a spotlight on the work of Mary Stiner and colleagues (Stiner 2001; Stiner & Munro 2002; Stiner et al 2000). They ranked prey according to energy returns on the basis of small size prey's fast or slow locomotion. This ranking system allowed recognition of demographic pressure indicators and the identification of two distinct dietary change revolutions for the Mediterranean Basin: (1) from the Upper Palaeolithic to the Mesolithic, matching the time frame of Flannery's original conception of the Broad Spectrum Revolution; and (2) the transition from the Middle Palaeolithic to the Upper Palaeolithic, closely related with a renewed radiation of Anatomical Modern Humans from Africa into the Near East around 50-44,000 years BP (Stiner & Kuhn 2006; Stiner & Munro 2011; Stiner et al 1999, 2012).

4.3. PUSHING BACK BROAD SPECTRUM DIET CHRONOLOGIES

Mary Stiner and colleagues have been pioneers in pushing back the notion of broad spectrum diets to late Neanderthal times. Increasing evidence has emerged mainly from the Mediterranean Basin. Of particular relevance for the present study are the faunal results obtained for sites in the Iberian Peninsula.

In Portugal, indicators of wider Neanderthal diets were found in the first excavations of Gruta da Figueira Brava in the 1980s where a large variety of bird species was identified, together with several remains of rabbits, tortoises, marine mammals, marine molluscs and crabs (Antunes 2000 and papers therein). Nevertheless, such zooarchaeological research lacked detailed taphonomic studies, so it is difficult to assess if their presence is due to anthropogenic activity. Gruta Nova da Columbeira has a large collection of rabbit bones that seems to be due to human agency (Carvalho et al, 2018). The faunal assemblage also comprises tortoise remains, but according to Hockett & Haws (2009) it has not been confirmed that is was used as food. Conversely, a total of 3,394 tortoise remains were recovered and studied from Gruta da Oliveira's layers 7 to 19, as a pilot study for the current research. Based on stratigraphic association with Mousterian industry, Neanderthal remains and an *in situ* hearth on layer 14, together with evidences of cut marks and preferential burning on the exterior part of the carapace, such tortoise remains were interpreted as the result of Neanderthal consumption (Nabais 2012).

A large tortoise assemblage accumulated by hominins was also recovered from the Middle Palaeolithic levels of Cova del Bolomor (Valencia, Spain) where, together with confirmed bird consumption, it was possible to clearly demonstrate Neanderthal use of small prey (Blasco 2008; Blasco & Fernández Peris 2009, 2012a, 2012b; Blasco et al 2010). Similar evidence was found in Gibraltar caves. Dorothy Garrod's excavations in the early 20th century revealed a wide variety of species in Devil's Tower in stratigraphic association with Neanderthal human remains and Mousterian artefacts. Among the faunal assemblage, 25 mammal species were identified together with 33 bird species, including the currently extinct *Pinguinus impennis* (Linnaeus, 1758), tortoise remains, fish and molluscs (Garrod et al 1928). The Mousterian layers contained mussels and different species of limpets from both Atlantic and Mediterranean environments (Colonese et al 2011). Marine resources were also found in recent excavations of Middle Palaeolithic levels of Gorham's Cave. They consist of rocky intertidal molluscs, such as limpets, mussels and topshells whose exploitation patterns seemed to have remained the same during Middle and Upper Palaeolithic times (Fa 2008). According to Stringer et al (2008) marine mammals were also recovered from levels associated with Mousterian industry, as well as birds and rabbits with human gnawing marks. Currant et al (2012a) identified a long list of mammal remains, reinforcing the large number of rabbits present in the assemblage. Vanguard Cave shows a similar faunal composition, where terrestrial mammals shared the Mousterian levels with marine resources, including dolphins, seals, marine birds, fish, crabs and molluscs (Colonese et al 2011; Currant et al 2012b; Stringer et al 2008). Most shells coincided with the spread of ashes from two underlying hearths; they were burnt or showed some sign of heating (Barton et al 1999). Cueva de los Aviones (Murcia, Spain) has also a Neanderthal occupation associated with bone remains of horse, deer, ibex, rabbit, tortoise and marine molluscs (Zilhão et al 2010c). Among the latter, rocky species are the most abundant (mainly monodonta, mussel and limpet) and seaweed was also identified, essentially *Jania rubens* (Yendo, 1905) (Montes Bernárdez 1989).

Although there is vast evidence of marine resources in hominin diets, especially within Mesolithic contexts in northern Europe, marine resources were generally seen as less productive for hominin exploitation due to their small size, costly processing and unreliability (Erlandson 2001). They were also associated with women and children’s work in most ethnographic societies (Meehan 1983; Siegfried & Hockey 1985), which contradicted the established idea of male-dominated hunting as the central force of subsistence. Moreover, a diet based on shellfish is high in protein but low in fat, and Noli & Avery (1988) considered it to have severe health consequences.

However, it seems from ethnographic studies that many sea foods are storable and seasonally predictable (like salmon going up-stream) (Mannino & Thomas 2002); shellfish is a predictable resource and has significant nutritional benefits due to richness in protein and vitamins D and E (Fa 2008); its collection is an easy and low-risk activity and many recent hunter-gatherers indicate that daily subsistence is based on resources like plants and small game, and not on medium to large game hunting (Bicho & Haws 2008). Furthermore, sea level today is at its highest point and most hominin coastal evidence is probably destroyed or submerged (Bailey & Flemming 2008; Bicho & Haws 2008; Colonese et al 2011; Erlandson 2001). Recently, Mousterian artefacts were found eroding from a creek bank 18m below sea level, close to Cherbourg, France (Flemming 1998 cited by Erlandson 2001:327), and intact bone-bearing deposits in underwater caves near Gibraltar have been investigated (Erlandson & Fitzpatrick 2006). Finally, plate tectonics have also played a significant role and, according to Bailey & Flemming (2008), the Mediterranean region is in a main potential tectonic uplift zone. That is the case for Portugal and Gruta da Figueira Brava that has benefitted from such geological activity with two tectonic uplifts that have helped preserve its deposits above present sea-level (Pais & Legoinha 2000).

4.4. CONSTRAINTS OF NEANDERTHAL CURRENT BROAD SUBSISTENCE MODELS

Although there is increased evidence of wider hominin diets in earlier time periods, it seems that the most recent and accepted broad spectrum theories are still largely dependent on demographic pressure as the main engine for small size resource consumption. This is the trend even after ethnography has shown that small resources, like shellfish, should be ranked in higher positions since they are reliable, predictable, and not at all marginal or difficult alternatives in moments of crisis (Bicho & Haws 2008). Ethnography has also demonstrated that people are willing to walk long distances in order to collect their favourite molluscs. Once they reach intertidal zones, they often prefer some species above others which contain more meat. A good example is the Anbarra community in north Australia, where the consumption of the tapestry shell is preferred over the brown mussel that provides more energy (Meehan 1983). Hence, hunter-gatherers are subjected to the resources existing in their living environment, but they also have the free will to choose other resources that are not necessarily the most fit in terms of energy returns, but they can simply taste better.

Another difficulty with broad spectrum diets relates to the amount of clear evidence for small game consumption, in which marine resources play an important role. Researchers working in Gibraltar were among the first to claim marine resources as highly important in hominin diets (Finlayson 2008; Stringer et al 2008), an argument later followed by Cortéz-Sánchez *et al* (2011) for the Bajondillo Cave, in Málaga (Spain). Both teams have shown Neanderthal's systematic use of seafood, and coastal adaptation through comparisons with the dense shellfish remains recovered from Middle Stone Age South African sites, like Sea Harvest (Volman 1978), Hoedjiespunt (Kyriacou et al 2015; Will et al 2013), Klasies River (Langejans et al 2012; Thackeray 1988), Ysterfontein 1 (Klein et al 2004), Pinnacle Point 13B (Jerardino & Marean 2010; Marean et al 2007) or Blombos Cave (Langejans et al 2012). In spite of the similarities in time-frame, such comparisons were not considered valid by Klein & Steele (2008), who argued that Iberian caves did not have sufficient evidence for extensive shellfish exploitation. Marean (2014) further considers that the small amounts of molluscs are sparsely distributed and only found in thin lenses from large sedimentary deposits, not meeting the definition of a shell midden. Moreover, no definition of "systematic use" is given, revealing no understanding of the consequences of such behaviour.

Two problems arise from these criticisms: (1) the definition of a shell midden, and (2) the clear identification of a hunter-gatherer group's systematic coastal use. Shell middens were first designated in Danish as *køkkenmødding*, which means kitchen midden, referring to the food waste of people living by the sea and using its resources (Speed 1969). This is the generally accepted shell midden definition, but it is extremely broad and subjective. There were several attempts of better defining it, like Andersen (2007) who defines a shell midden as a cultural deposit in which at least 50% of the volume is made of shells forming a continuous horizon with a minimum of 10m^2. If a site fails on this number, then it should be considered as a shell bearing site. Other researchers tried to create shell midden typologies, such as Widmer (1989 cited by Claassen 1998:11) who distinguished between (a) shell midden sites, (b) shell middens, (c) shell bearing midden sites, and (d) shell bearing habitation sites, based on the distinction between site and deposit. Another categorisation is the one from Dupont (2006:41), who establishes three types of shell middens according to morphology and volume: (1) *Amas coquiller*, a mound bigger than 2m^3; (2) *Dépôt coquiller*, a mound smaller than 2m^3; and (3) *Lit coquiller,* a horizontal shell layers. The lack of an accepted definition led Balbo et al (2011) to propose a broad description of shell midden as an "intentional anthropogenic shell accumulation", so it can include all chronologies, geography, sizes and shapes. In the light of this recent definition, the above-mentioned Spanish caves would be accepted as shell middens, as well as their South African counterparts.

Concerning the systematic use of marine resources, it implies a designed subsistence strategy that would intercept the coast at determined periods of the year, sometimes shifting between inland and littoral, or even remaining at the coast all year (Marean 2014). Consequently, a sporadic use of the coast is not a systematic use. Primates (e.g. Russon et al 2014) and other animals (Erlandson & Moss 2001) consume marine resources, but that does not mean they are coastal adapted or that they do it systematically. It should also be cautioned that ethnographic studies have shown that systematic use of costal resources generally result in highly sedentary behaviour with consequent population increase, highest levels of complexity, high technological developments and levels of conflict (Marean 2014).

So how can we identify systematic coastal resource use? Since many animals eat marine resources and are capable of forming small shell heaps, the first step is to clearly define the agent of accumulation. Coastal sites can also contain shell accumulations due to natural activities, like storms or sea high tides. It is fundamental to recognise stratigraphic association between bone/shell remains and well-dated lithic industry or other features, and to identify bone/shell surface modifications (like burning), patterns of mechanical fracture and any other visible taphonomic processes. Another valuable contribution is to report shell densities in comparison to the volume of sediment excavated. Although there are no magic numbers, they will give a feel for the intensity of shell accumulation. The cultural use of shells (i.e. as beads or as containers for ochre) can also be a good indicator of systematic use. A final approach is the use of scientific methods. Isotope analysis on hominin remains can easily tell if they were consuming marine resources, and isotope analyses on shells give precious information on seasonality, as well as permitting environmental reconstruction and discussion on hominin mobility strategies.

Systematic use of marine resources does not imply abandonment of terrestrial foods. However, the contribution of both types of resources should be analysed in detail. It is fundamental to study animal categories individually but also in an integrated manner, so that their contribution to hominin diets and consequent food provisioning strategies can be compared and contrasted in any possible way (e.g. type of environment, animal size, type of animal locomotion). Marine and terrestrial resources should also be assessed from a site formation process perspective through taphonomy, in order to confirm their use and accumulation by hominins.

4.5. FORMATION OF FAUNAL ASSEMBLAGES

Hominin behaviour is one of many potential agents of bone accumulation and modification. Associations of stone tools and faunal remains are still generally accepted as sufficient to infer on hominin meat-procurement and consumption. However, such perception has been criticised since the 1980s by several authors (e.g. Bailey, 1983, 2007; Marshall, 1989) who argue that the finds should be put into site specific context, bearing in mind the environment of the deposition and all possible site formation processes. Consequently, all zooarchaeological analyses should have as their primary concern the use of an explicit and detailed taphonomic methodology, considering all different scenarios regarding bone assemblage formation.

Several natural causes can be responsible for bone accumulation. Assemblages can be formed by natural deaths: whether catastrophic, and therefore concerning several animals; or due to the normal death of an individual. For the first scenario, Conybeare & Haynes (1984) studied mortality profiles caused by mass death events, such as flash floods. The resulting faunal assemblages are characterised by the presence of several species inhabiting the area at the time the floods occurred; there should be variation in terms of sex and age-structure, since there was no specific animal targeting and the whole population was indifferently killed. Haynes (1988) further refers that such events would produce an important opportunity for countless predators. However, low carnivore marks would be found since predators-scavengers would not feed intensively on each of them since there are plenty available. Natural fires can also decimate a population, as it is reported for tortoise populations in South Africa (Avery et al, 2004), France and Spain (Couturier et al, 2014). Assemblages resulting from such events feature individuals of all sexes and ages, with skeletons still in articulation exhibiting completely charred bones. Conversely, each animal can reach the end of its life due to many other causes related to the general health of each individual – disease, old age, hibernation, among others –, and are thus the opposite of the catastrophic scenario. In such cases it is expected to find more restricted age structures with preference for very old or very young animals, and absence of prime-age individuals that are generally more resilient. Males and females should be equally represented, and predator-scavenger and hominin bone modifications may overlap (Conybeare & Haynes, 1984).

Archaeological material can also be naturally transported by physical action due to run-off, aeolian, fluvial or tidal processes resulting in accumulations of derived position and thus forming secondary deposits. Archaeological materials are expected to be found following an orientation aligned with the direction of the movement flow; lighter elements (e.g. vertebrae) tend to travel longer distances than denser elements (e.g. teeth) that are generally accumulated in lag deposits; and transported elements can show rounding of the edges, with different degrees of erosion associated with the distance travelled, i.e. short distances corresponding to low rounding degrees, and vice-versa (Auguste, 1995; Stopp 1997). Due to its secondary deposition, faunal remains with anthropogenic and/or predator-scavenger surface modifications relate to events performed elsewhere other than the location where they were recovered. Therefore, such behaviours should be interpreted with caution since they cannot necessarily provide information on subsistence on the locale where faunal remains were found. Additionally, when digging in cave environments, one should also consider vertical movements. These are frequently produced by (a) accumulations close to cave walls, (b) roof collapses, and (c) sediment slide through cave cracks and fissures that can result in hourglass-shaped accumulations (such as the one found in layers 26 and 27 from Gruta da Oliveira, one of my case-studies).

The predator-scavenger scenario refers to faunal accumulations due to carnivore/raptor feeding behaviours. It is marked by extensive evidence of predator-scavenger modifications, such as gnawing, pitting, punctures, edge crenulations, scores, digestion; mostly confined to the meatiest areas of the bones indicating primary access to the carcass; and should be present in most skeletal elements and species found on site (e.g. Binford, 1981; Brain, 1981). Most frequently, such accumulations are due to the activity of hyenids, canids and felids that show different accumulation characteristics (Auguste, 1995). For example, faunal assemblages formed by hyenas are marked by the lack of long bone epiphyses, mainly the proximal ends of humeri and tibiae, the distal radii and both ends of the femuri which are frequently chewed off (Bunn, 1986). In addition, the presence of juvenile hyena bones, as well as some cannibalistic hyena behaviour, are accepted as evidence of hyena dens (e.g. Diedrich, 2011; Pickering, 2002). Extensive experimental work has been carried out in the last decade on carnivore/raptor bone accumulations focusing, not only on bone surface modification, but also on skeletal part representation patterns (e.g. Arilla et al, 2019; Camarós et al, 2017; Lloveras et al, 2009; Sanchis et al, 2014). Such studies have been essential in the separation of faunal accumulations by very different predators, from larger animals (like lions and hyenas) to smaller species (lynx, eagles, badgers and several others), whose accumulations' features will be further discussed in detail when appropriate.

Finally, the hominin scenario shows anthropic accumulation of faunal remains as direct result of subsistence behaviour on site. In such instances, it is expected to find anthropogenic marks (like incisions and intentional burning) on bones and shells demonstrating primary access to the carcass, i.e. modifications on the meatiest parts (Domínguez-Rodrigues 1999, 2003). There should be numerous hominin modifications distributed across most elements and species, whereas carnivore marks should be limited and restricted to elements with low bearing meat. Whenever both signatures are present, the carnivore marks should overlie hominin modifications (Binford, 1981). However, it should be borne in mind that humans can produce modifications similar to carnivores. Hence, it is important to separate them neatly, especially when considering tooth marks (Fernández-Jalvo & Andrews, 2011; Saladié et al, 2013).

Part III

Archaeological Sites

This part is dedicated to the description of the two archaeological sites under study, putting them in context within the Middle Palaeolithic evidence in Portugal and providing a brief description of the country's climatic and palaeoenvironmental information. Archaeological works on both studied cave sites were conducted under the direction of Dr. João Zilhão and revealed Neanderthal occupations dating from the Last Interglacial, or Marine Isotope Stage 5 (MIS-5). Gruta da Figueira Brava is located about 30 km south of Lisbon, currently facing the sea. Gruta da Oliveira is located at about 120 km NE from the former and has an inland position being approximately 40 km away from the coast. For the present study, faunal remains from all excavated levels from Gruta da Figueira Brava were studied, as well as those recovered from layers 20 to 27 from Gruta da Oliveira, corresponding to the bottom of the stratigraphic sequence.

CHAPTER 5

ENVIRONMENT AND NEANDERTHAL EVIDENCE IN PORTUGAL

5.1. PORTUGUESE PAST AND PRESENT ENVIRONMENTS

Portugal is the westernmost country in mainland Europe. It occupies a significant portion of the Iberian Atlantic façade comprising a western and southern coast of 943 km. Additional 667 km of coast is found in the Azores and 250 km in Madeira Islands. Despite the great influence of the Atlantic, Portugal is considered to be a Mediterranean country (Ribeiro 1945:39). The Mediterranean environment is more evident inland and during the summer, when the temperatures are high, the luminosity is strong and there is lack of precipitation. Autumn is marked by heavy rains, and winter by colder temperatures. Even though, the annual average temperature is 14°C. The vegetation is typically Mediterranean with evergreen trees and shrubs. There is a wide variety of oaks (i.e. *Quercus suber* L.*,* *Quercus ilex* L.*,* *Quercus coccifera* L.), pine trees, tree heath, bay laurel and all the usual Mediterranean perennial herbs like rosemary, oregano, thyme, lavender. Among fruit trees, some of the most common are olive, fig, orange and almond trees; grapes are also a major fruit resource (Ribeiro 1945:48). A more Atlantic environment and consequent vegetation can be found in the northwest of Portugal. Among the most common trees and shrubs are the English oak (*Quercus robur* L.), European ash (*Fraxinus excelsior* L.), poplar, common hazel, sweet chestnut and some gorse species, mainly *Ulex minor* Roth (Ribeiro 1945:102).

Recent bioclimatic maps produced by Badal et al (2011) and Arsuaga et al (2012) show that Portugal is strongly Meso-Mediterranean with a Thermo-Mediterranean climatic zone playing a significant role in littoral areas (Fig. 5.1 A). For the MIS-4 and MIS-3, Badal et al (2011) propose a slightly different bioclimatic zonation, dominated by Oro-Mediterranean climate and Supra-Mediterranean in coastal areas. However, according to Arsuaga et al (2012), MIS-5 bioclimatic zonations might have been similar to today's environment, despite the colder temperatures and lower sea level. The latter was due to gradual accumulation of ice in North America (van Andel 2003) resulting in a MIS-5 Portuguese coastline with additional land on the west and south coasts, with no more than 5 km. With the advent of MIS-4 there was an abrupt drop in temperature that reached its glacial maximum at the end of that same stage (Fig. 5.2). The open tundra and cold steppe marked the environment north of the Pyrenees (van Andel 2003), but Southern Iberia seems to have remained as a refugium during such Pleistocene glaciations (Rey Benayas & Scheiner 2002). The onset of MIS-3 was marked by warmer episodes known as the Dasgaard/Oeschger (D/O) events that were occasionally interrupted by cold episodes with temperatures close to those of late MIS-4, but with drier conditions (van Andel 2003). Nevertheless, temperatures continued to drop during MIS-3 reaching another glacial maximum, the last one, with the beginning of MIS-2. According to Angelucci and Zilhão (2009), throughout

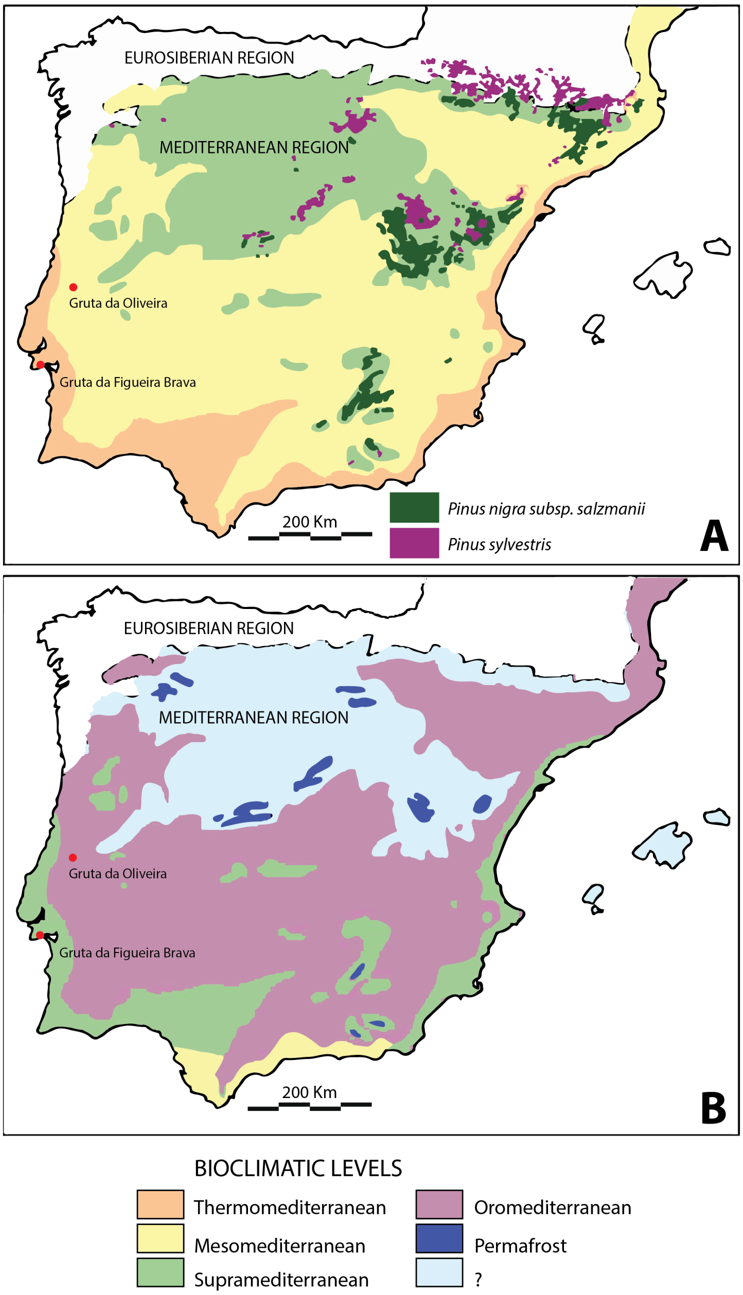


Fig. 5.1 – Iberian Peninsula's bioclimatic zones with location of Middle Palaeolithic sites under study. A) Current bioclimatic map of Iberia and distribution of *Pinus nigra* and *Pinus sylvestris*. B) Hypothetical bioclimatic levels summarising the different climates during the MIS-4 and MIS-3. Image adapted from Badal et al (2011:77).

MIS-3 the North Atlantic polar front fluctuated between the latitude of Galicia (northern Spain) during the cold phases, and of the Algarve (southern Portugal) during the warm ones. Based on charcoal analysis, during such cold phases the landscape was prone to oceanic pine and heath land, with evidences of *Pinus sylvestris* L. and *Erica arborea*. During warmer phases, oaks and pine woodland became dominant, such as revealed by pollen analysis from the same cave showing the presence of *Quercus* sp., *Corylus* sp., *Tilia* sp. L. and *Olea* sp. L. (Zilhão et al 2010a).

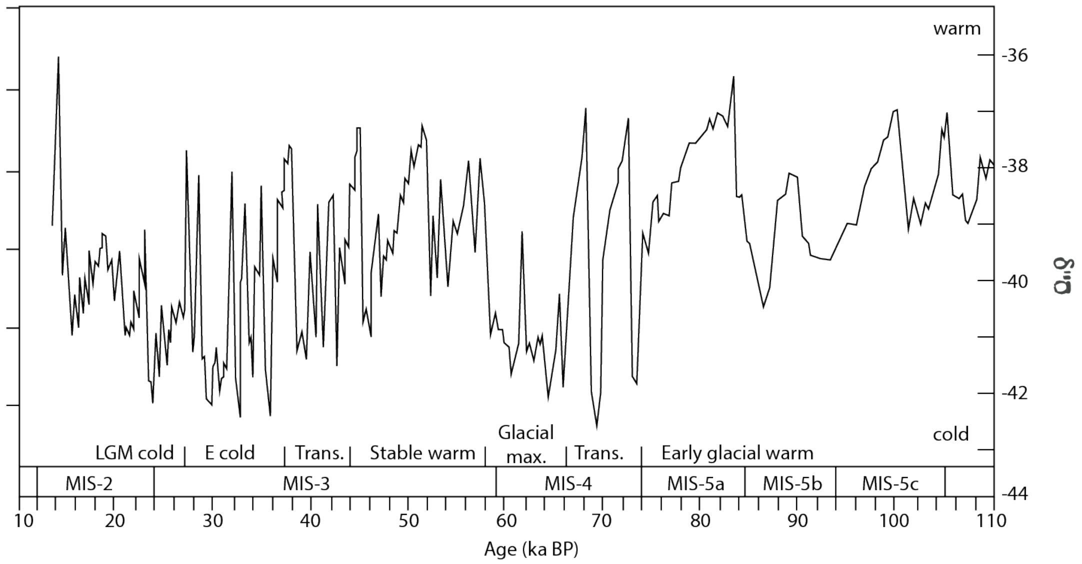


Fig. 5.2 – Climate changes from the Late Penultimate interglacial (MIS-5d) to the onset of the Holocene (MIS-2) recorded by the GISP2 ice-core. Image adapted from van Andel (2003:16).

5.2. NEANDERTHAL EVIDENCE IN PORTUGAL

By consulting the national database for archaeological sites in Portugal (Endovélico), a total of 270 sites are listed as Middle Palaeolithic. By plotting all those sites on a map, adding a few more that for some reason are not part of the database, six rough clusters can be defined (Fig. 5.3): (1) the Lisbon region including the sites south of the river Tejo; (2) the Peniche area; (3) Serra d’Aire and Candeeiros, including Torres Novas and Tomar; (4) the Coimbra cluster ranging from Pombal to Cantanhede; (5) Castelo Branco, in the east; and (6) the Algarve, in the south. Although the great amount of sites recorded, it must be cautioned that nearly half of them were listed as “surface findings”, “artefact scatter” or incorrectly described as “settlement” or “artificial cave”. Excluding all these vague and/or dubious references, there remain 136 sites of which most of them (n = 97) are open-air.

From the Lisbon cluster (Fig. 5.3 - 1) the Middle Palaeolithic site with most abundant information is Gruta da Figueira Brava (Setúbal), one of my case-study sites. It was first excavated in the 1980s by Miguel Telles Antunes and his team. It revealed a Middle Palaeolithic sequence with Mousterian stone tools (Raposo & Cardoso 2000) associated with a rich faunal assemblage with a wide variety of species, including marine animals. A Neanderthal tooth was also recovered and radiocarbon dates from a limpet and some bones indicated an early MIS-3 occupation (Antunes 2000 and papers therein). Recent archaeological work conducted between 2010 and 2013, directed by João Zilhão, re-dated the 1980’s excavated deposits and considered those dates as minimum ages, pushing back the chronology to MIS-5. The new excavation area, behind Entrance 3 is confirmed to be a MIS-5 sequence and a more detailed description is given in Chapter 6. Further evidence of Neanderthal bone was recovered from Gruta de Salemas (Loures), where a deciduous left molar 2 was found (Cardoso 2002). This cave, together with Pedreira de Salemas (Loures) and Conceição (Alcochete), show scarce Mousterian stone tools and almost no faunal remains (Cardoso 2002; Zilhão 2001, 2006). Gruta do Pego do Diabo (Loures), however, has a faunal assemblage associated with a few Mousterian material, but its accumulation seems to have been due to carnivores (Zilhão et al 2010b; Fig. 5.4).

More substantial collections have been recovered from the Peniche area (Fig. 5.3 - 2). Gruta Nova da Columbeira (Bombarral) was found by quarrying in 1962 and excavated in the same year by Octávio da Veiga Ferreira, revealing a stratigraphic sequence composed of only Middle Palaeolithic deposits. A vast Mousterian lithic assemblage was recovered, associated with faunal remains, charcoal, hearth features and a Neanderthal tooth (Cardoso 2002; Zilhão et al 2011). Recent chronometric investigation revealed that the cave was formed and occupied between MIS-5 and early MIS-3 (Zilhão et al 2011). Gruta da Furninha (Peniche) has also provided

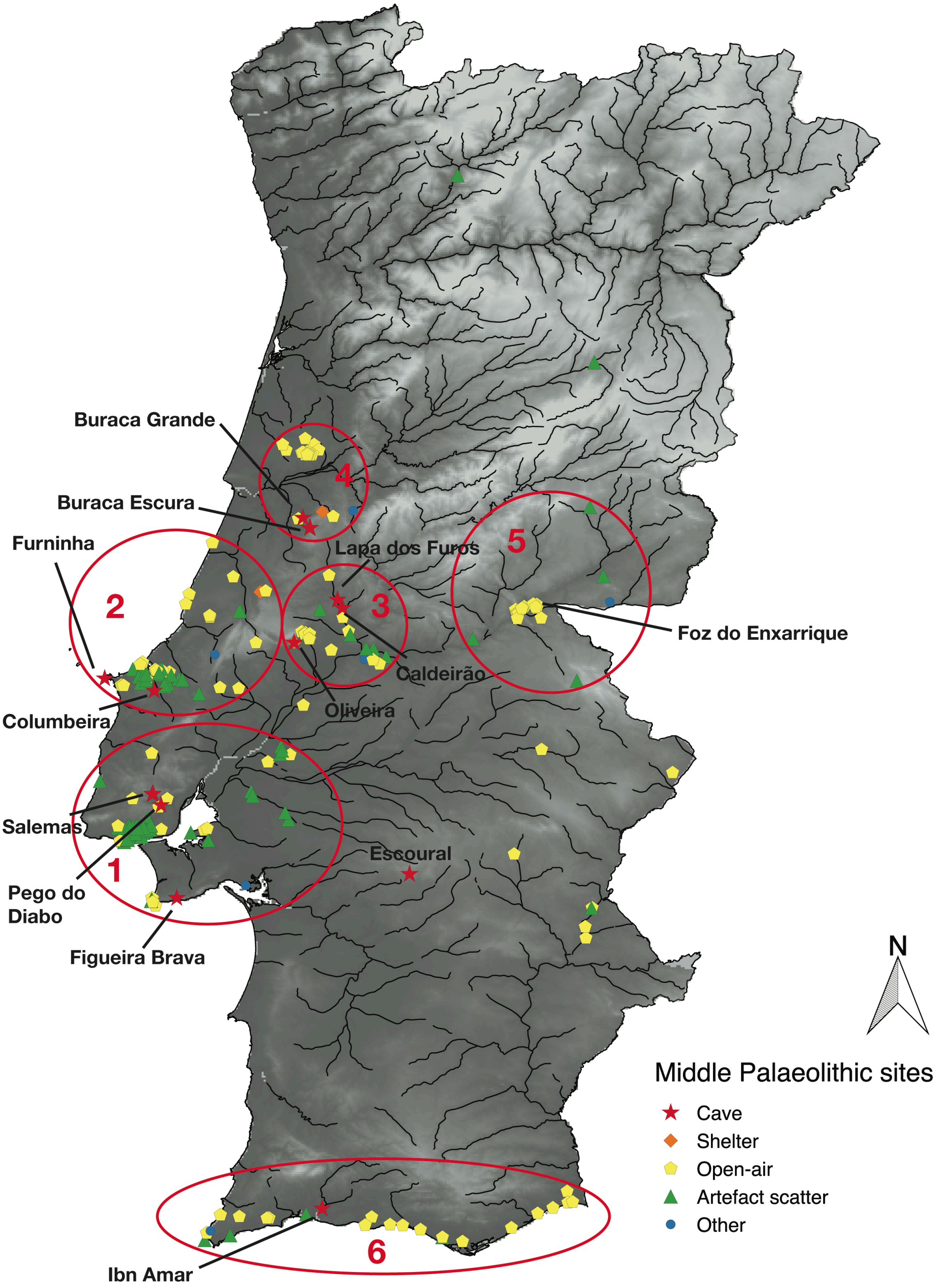


Fig. 5.3 – Middle Palaeolithic sites recorded in the Portuguese Archaeology Archive with clusters mentioned in the text: 1) Lisbon, 2) Peniche, 3) Serra d'Aire and Candeeiros, 4) Coimbra, 5) Castelo Branco, and 6) Algarve.

large Middle Palaeolithic faunal assemblages. It was excavated by Nery Delgado in the late 19th century but evidence of Neanderthal occupation is sparse, and the animal bones reflect a typical carnivore accumulation (Brugal et al 2012; Fig. 5.4). Two other Middle Palaeolithic sites were recently found around Peniche resulting from surveys carried out between 2005 and 2008 by Jonathan Haws. The most significant is Mira Nascente (Alcobaça) located in a raised coastal deposit where several Levallois flakes and points were recovered from sand levels associated with a nearby channel-fill deposit dated to 40,000 – 42,000 years BP (Haws et al 2010). Praia do Rei Cortiço (Óbidos) is located approximately 30 km south of Mira Nascente, also revealing flakes of Levallois tradition (Haws et al 2010). No fauna was preserved in none of the sites.

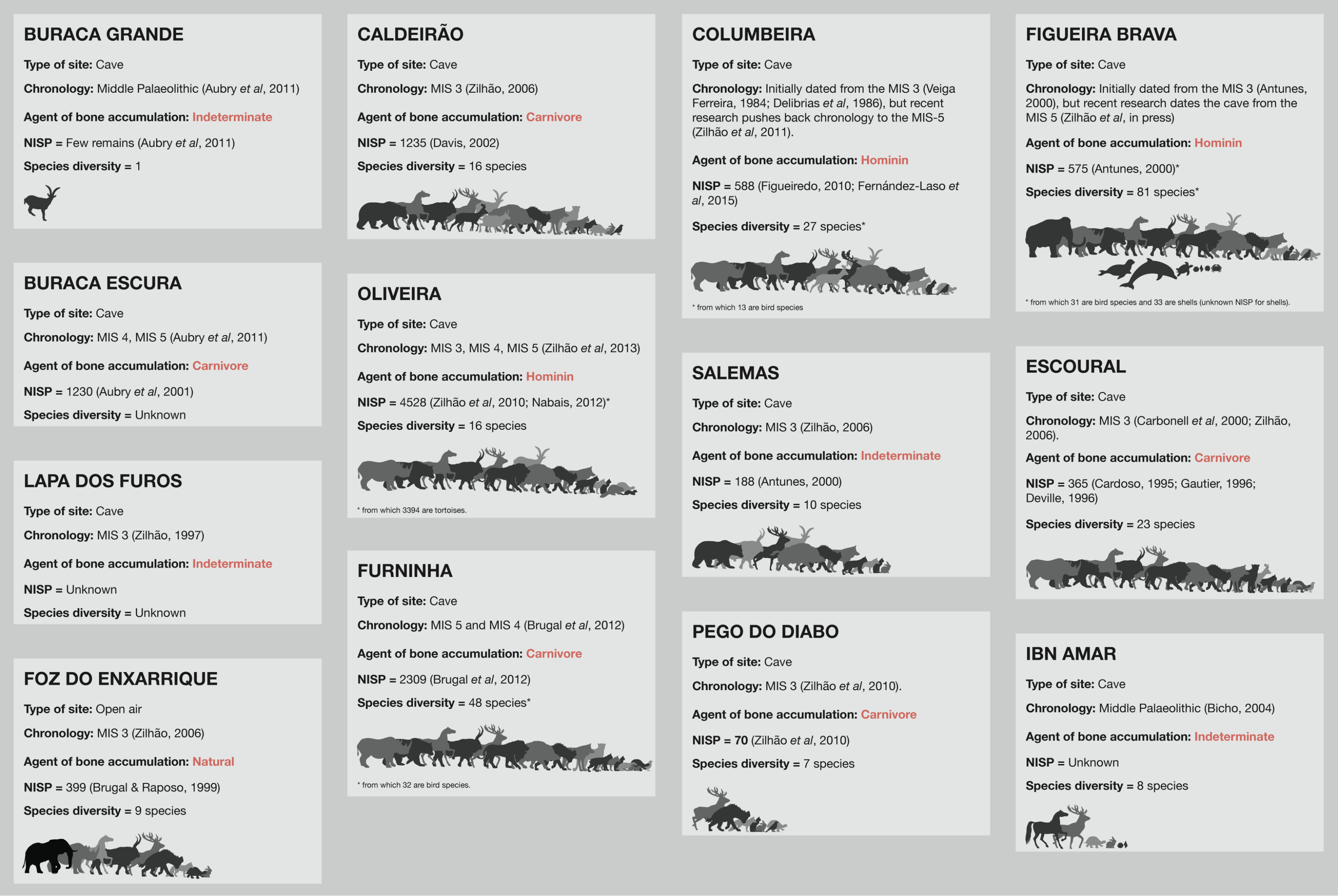
From the nearby cluster of the Serra d'Aire and Candeeiros (Fig. 5.3 - 3), there is Gruta do Caldeirão (Tomar), whose Middle Palaeolithic levels contained a faunal assemblage accumulated by carnivores (Davis 2002; Lloveras et al 2011). In the large Almonda karstic system, there is Gruta da Oliveira (Torres Novas), my other case-study site (see Chapter 7), presenting a long Middle Palaeolithic stratigraphic sequence. An ample and varied faunal assemblage was recovered, as well as abundant Mousterian lithic material with characteristic Levallois flake production, several hearths, and charcoal (Marks et al 2001; Nabais 2011, 2012; Zilhão 2006; Zilhão et al 2010a, 2013; Fig. 5.4). This is also the site providing the largest Neanderthal bone collection in Portugal, with a total of 9 bones identified (Trinkaus et al 2007; Willman et al 2012).

In the Coimbra region (Fig. 5.3 - 4), in Serra do Sicó in particular, archaeological works conducted in Buraca Escura (Pombal) found a Middle Palaeolithic to Late Neolithic anthropogenic sequence. The oldest occupation was confirmed by the presence of lithic material extracted from Levallois, discoidal, Kobewa and bipolar cores with hard-stone hammers, and by U-Th dates with an overlap in the 80,000 – 65,000 years BP interval. The Middle Palaeolithic faunal evidence consists of some coprolites and a significant amount of carnivore remains (Aubry et al 2001, 2011). Opposite to this site there is Buraca Grande. It shows a stratigraphic sequence dating from the Middle Palaeolithic to the Bronze Age. The older levels were excavated in an area smaller than 4 m^2 with scarce Mousterian artefacts and few *Capra ibex* (Linnaeus, 1758) (Aubry et al 2011; Fig. 5.4). In the nearby area, two open-air sites were found during salvage works: Vale da Porta 2 and Vale da Porta 3. Many centripetal discoidal and Levallois flakes date the sites from the Middle Palaeolithic, but no fauna was recovered (Aubry et al 2006).

One of the most important open-air sites in the Portuguese Middle Palaeolithic is Foz do Enxarrique (Ródão) (Fig. 5.3 – 5), found on the right bank of river Tejo on a fossil fluvial beach. The site was U-Th dated to MIS-3 and a Mousterian lithic assemblage with more than 10,000 elements was recovered. The bone assemblage, however, seems to be a natural accumulation for the most part, with a possible exception for red deer (Brugal & Raposo 1999; Cardoso 2002; Zilhão et al 2001; Fig. 5.4). Vilas Ruivas (Ródão) is another open-air site identified nearby, dating from MIS-4. No faunal remains were recovered and the lithic assemblage is small but described as Mousterian (Raposo 1995). There are extremely well preserved features, like two hearths clearly delimited by large quartzite blocks (Zilhão 2001).

More open-air sites were found in the Algarve (Fig. 5.3 – 6). The great majority were discovered in the 1960s – such as Aldeia Nova (Vila Real de Santo António) or Gancho (Castro Marim) – but they rarely showed good stratigraphic sequences with *in situ* findings (Cardoso 2002). Recent surveys carried out by Nuno Bicho in the late 1990s found more Middle Palaeolithic sites. Most of them are partially destroyed and were identified by the presence of lithic material, the sole exception being Gruta de Ibn Amar (Lagoa). This is a cave located close to river Arado's estuary and has evidence of Levallois and discoidal core debitage. Faunal remains were also recovered, being the assemblage mainly composed by marine molluscs, tortoises, rabbits, deer and horse but whose agent of accumulation is unknown (Bicho 2004; Fig. 5.4). Finally, there is Gruta do Escoural (Montemor-o-Novo) in the Alentejo (Fig. 5.3), where a small Mousterian lithic assemblage was found. It has a considerable faunal collection due to carnivore accumulation (Cardoso 1995; Zilhão 2001; Fig. 5.4).

To sum up, there are abundant Middle Palaeolithic sites in Portugal, but only few have been systematically excavated, or present valuable archaeological material and absolute dates. Most sites date from MIS-3 and MIS-4 but more recent chronometric works, essentially based on cave speleothems and stalagmitic crusts, seem to be successful in pushing back chronologies, such as the case of Gruta da Figueira Brava and Gruta Nova da Columbeira. Only 11 sites have provided faunal assemblages (Fig. 5.4). For most, however, the accumulations seem to result from carnivore activity: Gruta do Pego do Diabo, Gruta da Furninha, Gruta do Caldeirão, Buraca Escura and Gruta do Escoural. For Buraca Grande and Gruta de Ibn Amar is not yet clear who was the accumulator, and for Foz do Enxarrique most of the bones seem to have been naturally deposited. Hence, only Gruta Nova da Columbeira, Gruta da Figueira Brava and Gruta da Oliveira show evidence of animal bone accumulations relating to hominin activity. This is why the current research (on two of these three assemblages) will make such a significant contribution to understanding Neanderthal adaptations in Portugal. Lapa dos Furos is another Neanderthal site with some faunal remains, but they were never studied (Zilhão 2015: pers. comm.; Fig. 5.3).



BURACA GRANDE

Type of site: Cave

Chronology: Middle Palaeolithic (Aubry *et al*, 2011)

Agent of bone accumulation: Indeterminate

NISP = Few remains (Aubry *et al*, 2011)

Species diversity = 1

BURACA ESCURA

Type of site: Cave

Chronology: MIS 4, MIS 5 (Aubry *et al*, 2011)

Agent of bone accumulation: Carnivore

NISP = 1230 (Aubry *et al*, 2001)

Species diversity = Unknown

LAPA DOS FUROS

Type of site: Cave

Chronology: MIS 3 (Zilhão, 1997)

Agent of bone accumulation: Indeterminate

NISP = Unknown

Species diversity = Unknown

FOZ DO ENXARRIQUE

Type of site: Open air

Chronology: MIS 3 (Zilhão, 2006)

Agent of bone accumulation: Natural

NISP = 399 (Brugal & Raposo, 1999)

Species diversity = 9 species

CALDEIRÃO

Type of site: Cave

Chronology: MIS 3 (Zilhão, 2006)

Agent of bone accumulation: Carnivore

NISP = 1235 (Davis, 2002)

Species diversity = 16 species

OLIVEIRA

Type of site: Cave

Chronology: MIS 3, MIS 4, MIS 5 (Zilhão *et al*, 2013)

Agent of bone accumulation: Hominin

NISP = 4528 (Zilhão *et al*, 2010; Nabais, 2012)*

Species diversity = 16 species

* from which 3394 are tortoises.

FURNINHA

Type of site: Cave

Chronology: MIS 5 and MIS 4 (Brugal *et al*, 2012)

Agent of bone accumulation: Carnivore

NISP = 2309 (Brugal *et al*, 2012)

Species diversity = 48 species*

* from which 32 are bird species.

COLUMBEIRA

Type of site: Cave

Chronology: Initially dated from the MIS 3 (Veiga Ferreira, 1984; Delibrias *et al*, 1986), but recent research pushes back chronology to the MIS-5 (Zilhão *et al*, 2011).

Agent of bone accumulation: Hominin

NISP = 588 (Figueiredo, 2010; Fernández-Laso *et al*, 2015)

Species diversity = 27 species*

* from which 13 are bird species

SALEMAS

Type of site: Cave

Chronology: MIS 3 (Zilhão, 2006)

Agent of bone accumulation: Indeterminate

NISP = 188 (Antunes, 2000)

Species diversity = 10 species

PEGO DO DIABO

Type of site: Cave

Chronology: MIS 3 (Zilhão *et al*, 2010).

Agent of bone accumulation: Carnivore

NISP = 70 (Zilhão *et al*, 2010)

Species diversity = 7 species

FIGUEIRA BRAVA

Type of site: Cave

Chronology: Initially dated from the MIS 3 (Antunes, 2000), but recent research dates the cave from the MIS 5 (Zilhão *et al*, in press)

Agent of bone accumulation: Hominin

NISP = 575 (Antunes, 2000)*

Species diversity = 81 species*

* from which 31 are bird species and 33 are shells (unknown NISP for shells).

ESCOURAL

Type of site: Cave

Chronology: MIS 3 (Carbonell *et al*, 2000; Zilhão, 2006).

Agent of bone accumulation: Carnivore

NISP = 365 (Cardoso, 1995; Gautier, 1996; Deville, 1996)

Species diversity = 23 species

IBN AMAR

Type of site: Cave

Chronology: Middle Palaeolithic (Bicho, 2004)

Agent of bone accumulation: Indeterminate

NISP = Unknown

Species diversity = 8 species

Fig. 5.4 – Zooarchaeological evidence from Middle Palaeolithic sites in Portugal.

CHAPTER 6

GRUTA DA FIGUEIRA BRAVA

6.1. GEOMORPHOLOGICAL SETTING

Gruta da Figueira Brava is a Middle Palaeolithic site located in Central Portugal with the coordinates 38º 28’ 14’’ N, 08º 59’ 10’’ W. The cave is located in the Setúbal peninsula, at about 30 km south of Lisbon, on the southern slope of the Serra da Arrábida Natural Park, at just 5 metres above sea’s high tide (Fig. 6.1; Antunes & Cardoso, 2000; Zilhão et al, 2020).

Serra da Arrábida is characterised by a series of aligned Jurassic limestone reliefs with a WSW-ENE orientation and transversal extensions varying between 5 and 7 km along a 30 km chain. The chain’s north and east sides are confined by extensive plains, whereas the south and west sides are delimited by the ocean. Serra da Arrábida has a considerable amount of tectonic faults with at least two tectonic phases identified: the first between 17.5 and 16.5 million years ago, and the second between 11.6 and 7.25 million years ago (Kullberg et al 2000, 2013; Pais & Legoinha, 2000).

On the southern slope facing the sea there are plenty of caves formed by different processes. Some are currently under water (like Fojo dos Morcegos) but others are non-aquatic and formed by karst dissolution processes happening in between the Miocene biocalcarenites’ vertical diaclases (mainly where they presented a criss-cross pattern), and due to marine erosion whenever the karst was exposed to it. This is the case of Gruta da Figueira Brava and the nearby cave of Lapa de Santa Margarida (Fig. 6.1). Both caves are associated with a marine terrace at 5 to 8 meters above present sea level. In places, this marine erosion platform is overlain by a beachrock conglomerate. Another marine terrace can be seen located at higher elevation, between 12 and 15 meters (Antunes & Cardoso, 2000; Pais & Legoinha, 2000; Zilhão et al, 2020).

The sedimentation of Gruta da Figueira Brava started in the Lower Miocene, in the Middle Burdigalian (18.8 million years ago), and consists of biocalcarenite deposits featuring quartz pebbles and yellowish fine-grained sandstones. The biocalcarenites are rich in large pectinids and oyster fossils (Kullberg et al, 2000, 2013; Pais & Legoinha, 2000). Currently, Gruta da Figueira Brava features three main entrances (Figs. 6.1, 6.2). The cave interior, however, is only accessible through Entrance 1, which connects to the areas behind the other two entrances, which are speleothem-cluttered The interior space behind Entrance 1 (Areas A and B) is about 10 meters high and most of its original sediment fill was emptied by Holocene marine erosion. In Area C, behind Entrance 2, there were intact archaeological deposits sealed by a stalagmitic crust, where the first excavation campaigns took place in the 1980s. An extremely narrow passage connects this area with a small chamber behind Entrance 3, called Area F (Figs. 6.2, 6.3 A). The archaeological deposits in this chamber were intact and protected by a stalagmitic crust. The most recent excavations (2011-2013) were done in this area. Exteriorly of Area F the cave remains protected by an overhang. The Pleistocene cobble beach is visible, as well as some brecciated Upper Pleistocene deposits on top of it, where charcoal, bone, shells and some stone flakes are present showing anthropogenic use of this area (Zilhão 2012a, 2012b; Zilhão et al, 2020).

These observations demonstrate that when the cave was in use, with sediments and archaeological remains being accumulated, (a) the existing Gruta da Figueira Brava platform was the basal bedrock of a large cave, nowadays unroofed; and (b) the extant entrances were the intersections with tight passages forming the back of the cave. The original cave morphology was lost due to littoral erosion caused by Late Glacial and Holocene sea level rise, but the same did not affect the nearby cave of Santa Margarida. The latter serves as a good example of what Gruta da Figueira Brava might have been while in use during MIS-5 (Fig. 6.1; Zilhão et al, 2020).

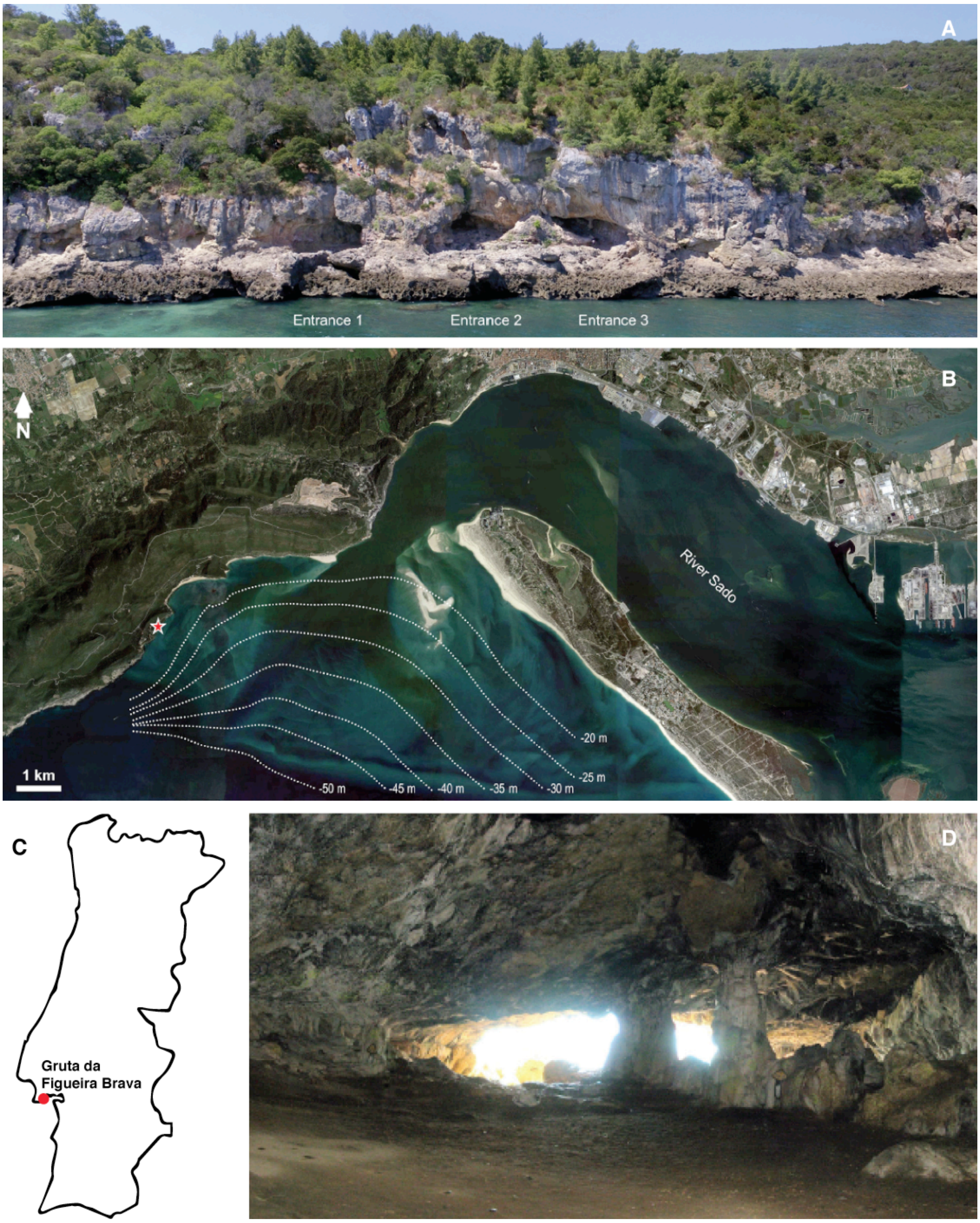


Fig. 6.1 – Gruta da Figueira Brava A) Gruta da Figueira Brava seen from the sea. B) Estimation of distance to coast lines derived from seismic profiles: occupation phases FB1-FB2 (early MIS-5c) with sea level at ~25 m below present with coast line ~750 m away; FB 3 (late MIS-5c) with sea level at ~35 m below present with coast line ~1500 m away; FB 4 (MIS-5b) with sea level at ~45 m below present with coast line ~2000 m away. C) Site location in Portugal. D) The interior of the nearby ca81ve of Lapa de Santa Margarida. Image A photo courtesy by João de Brito Vidigal. Images B and D from Zilhão et al (2020).

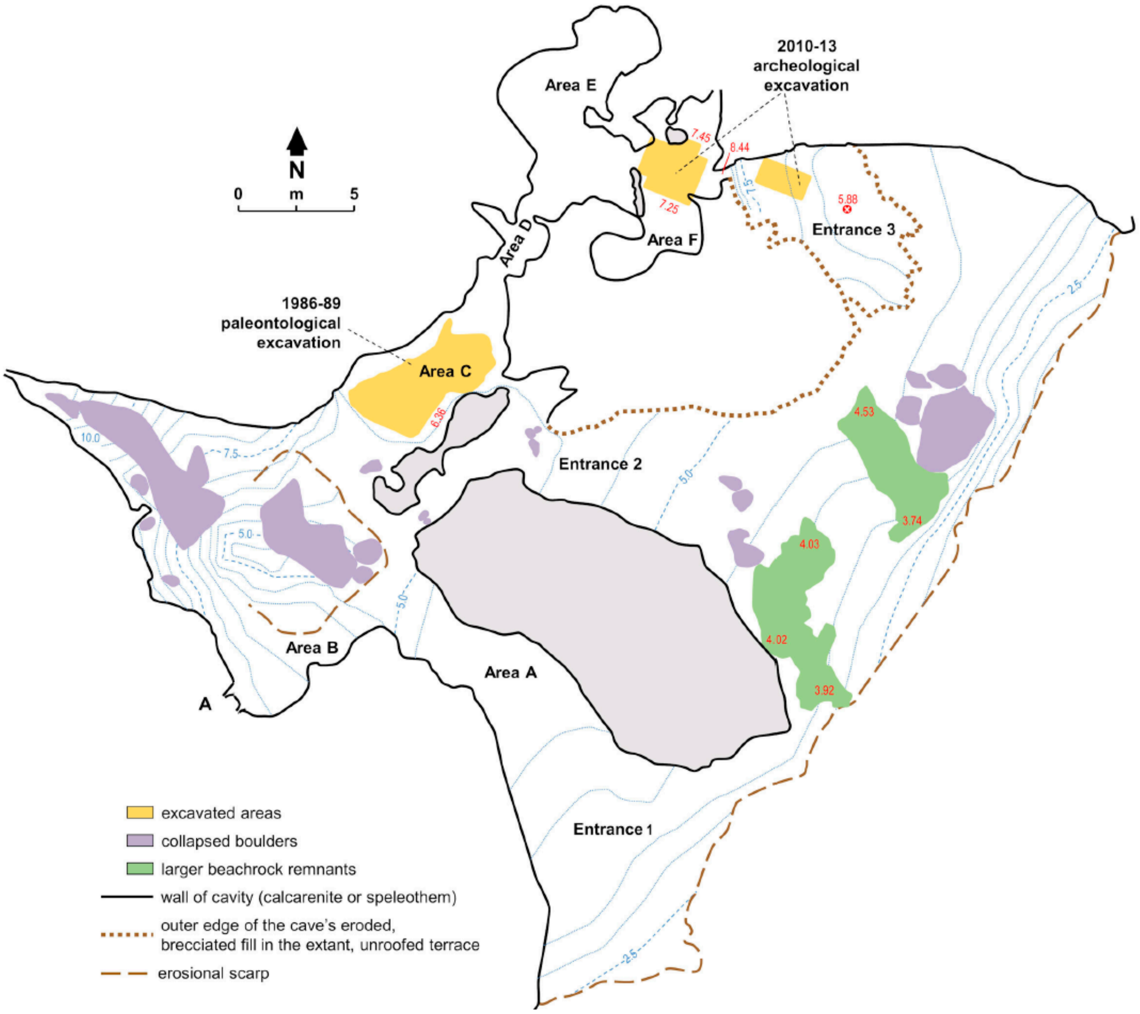


Fig. 6.2 – Plan of Gruta da Figueira Brava cavities. Elevations are in m above sea level (Image from Zilhão et al, 2020)

6.2. PREVIOUS ARCHAEOLOGICAL WORK (1986-1989)

Gruta da Figueira Brava was first mentioned by Breuil and Zbyszewski (1945:326), after their visit to the cave in 1942. However, the site was only surveyed many years later, in 1982 by Silva and Soares (1986), and archaeological work started four years later under the supervision of Miguel Telles Antunes (Fig. 6.2). The very first trench was opened on the western side of Entrance 1 on unconsolidated brown/reddish sands, from which some lithics and microfauna were collected. Another trench was opened just behind Entrance 2, where a thick stalagmitic crust sealed an archaeological deposit. This area became the principal excavation trench from which most of the archaeological materials were recovered (Antunes & Cardoso, 2000; Pais & Legoinha, 2000).

6.2.1. Stratigraphic sequence

According to Antunes and Cardoso (2000:43) a total of five layers were identified. The first layer (C.1) consisted of the stalagmitic crust sealing all the deposits under it. The second layer (C.2) presented archaeological materials and was composed of light brown (5YR 5/6) sands. It showed some sediment disturbance that, according to the 1987-88 excavators, was probably related to Roman dwellers digging the soil to stick their amphorae on the ground, which found support in the presence of such pottery remains. Even though, most of the layer was undisturbed and several animal bones and Mousterian stone tools were collected. Layer C.3 was identified as a moderate brown (5YR 4/4) sand, sometimes becoming grey or even black due to the presence of ashes and charcoal that, together with rubefacted pebbles and cobbles, were interpreted as indicators of the presence of fire structures. However, no *in situ* hearths were documented. Layer C.4 was made of sands of varying colour, ranging from moderate yellowish brown (10YR 5/4) to pale yellowish brown (10YR6/2). The presence of combustion structures was again deduced due to the identification of ashes and charcoal, but no clear hearth evidence was found. Layer C.5 was described as the Pleistocene cobble beach, with many quartz and some quartzite boulders highly corroded and sometimes exceeding 20 cm in length.

Most of the sediments were sands. Layers C.3 and C.4 were composed of extremely poorly sorted sands, whereas sands from C.2 were poorly sorted. All sands were leptokurtic and negatively skewed. Most of the grains were well rounded with numerous pitting marks on their surface, which suggested they were transported by the wind. Thus, the origin of the cave deposits was interpreted as being from nearby sand dunes that might have existed in the littoral plain outside the cave. However, some grains were described as very angular, which might have been related with the high intensity of the mode of transportation, or could result of human activity to some extent, such as trampling (Antunes & Cardoso, 2000).

6.2.2. Dating

Based on a limpet shell bulk sample from layer C.2, the site was dated by radiocarbon to around 30,000 years BP (Antunes 2000). However, although the shell sample is considered not to be contaminated, it should be cautioned that it came from a layer where recent intrusions were detected. Moreover, the dates only concern the last phase of the cave's occupation, not giving any clues about when did the occupation actually start. Such dating issues, and a more detailed comprehension of the stratigraphy and faunal taphonomy (especially with regards to small game and marine resources), are some of the questions that remained to be answered about Gruta da Figueira Brava's Neanderthal occupation.

6.2.3. Archaeological finds

Because the finds made in areas affected by subsurface burrowing were not sorted from those made in intact areas of the deposit, the 1986-89 faunal assemblage contains an undetermined amount of Holocene intrusions (especially where the smaller size animals are concerned). For the larger taxa, post-hoc sorting using patina, degree of fossilisation and concretion coatings enabled the elimination of any such

	n	%
MAMMALS (terrestrial)		
Mammoths	10	1.73
Rhinoceros	14	2.42
Auroch	75	12.98
Horse	28	4.84
Deer	116	20.07
Caprine	101	17.47
Boar	7	1.21
Hare or rabbit	>100	>17.30
Bear	3	0.52
Lion	1	0.17
Leopard	7	1.21
Hyena	25	4.33
Wolf	1	0.17
Wildcat	2	0.35
Fox	8	1.38
MAMMALS (marine)		
Seal	1	0.17
Dolphin	6	1.04
REPTILES		
Emys orbicularis	2	0.35
Testudo hermanni	>5	>1.04
BIRDS		
Terrestrial and aquatic	65	11.25
TOTAL	**578**	**100**

Tab. 6.1 – Fauna from Gruta da Figueira Brava. Data from Antunes (2000:259) and Cardoso (1993:531).

intrusions, mostly a few domestic sheep/goat remains (Antunes, 2000; Cardoso, 1993; Lapparent-De Broin & Antunes, 2000). Table 6.1 provides a list and counts. Both marine and terrestrial mammals are represented, including carnivores and small size prey animals, namely leporids, birds, and two species of chelonians (*Emys orbicularis* and *Testudo hermanni*). Taphonomy is not addressed in any of the faunal studies. Therefore, and even though it is clear that some carnivores (e.g. hyenas, bears, lions) used the cave, human-carnivore interactions are not explored; nor scavenging-hunting and butchering practices are thoroughly discussed; and considerations on agents of accumulation are absent, with the marine invertebrate assemblage being submitted to specialist study as if it consisted of a single stratigraphically homogeneous assemblage.

The lithic industry recovered is a Mousterian with discoid and Levallois blanks, sidescrapers, denticulates and notches. The large amount of quartz knapping debris shows that most flakes were made on site, whereas the few flint artefacts might have been knapped outside the cave (Cardoso & Raposo, 1995; Raposo & Cardoso, 2000).

A Neanderthal left upper second premolar, possibly of a 16-year-old male (Antunes et al., 2000: 289), is the only human remain found in the deposit, in layer C.2.

6.3. RECENT ARCHAEOLOGICAL WORK (2010-2013)

In order to assess the validity of the dates obtained in 1987-1988, new research was initiated by João Zilhão with the following objectives: (1) radiocarbon dating of new shell samples from the old excavations; (2) U/Th dating of the flowstone covering the deposits dug in 1987-1988; (3) geoarchaeological description, sampling and dating of the brecciated deposits preserved in the outside area of Entrance 3; and (4) excavation on the inside area of Entrance 3, now called Area F (Zilhão, 2012a).

Sampling work of the cave's stalagmitic crusts and shells from Area C took place in 2010, along with speleothem and shell sampling from the inside and outside areas of Entrance 3. The following year (in May 2011), the first test trench was opened. The inner part of Entrance 3 has two different chambers: one positioned on the west side (Area E), and another on a more eastern location (Area F). Although Area E is larger and higher, it featured a large burrow. Hence, a 1m^2 trench was opened in the shallower Area F. This chamber was well preserved due to its access limitations. Its naturally protected setting was maintained during excavation and no artificial entrance to the exterior was created. The only way to access Area F is, to date, through Entrance 1 and then by crawling through the narrow passage, Area D (Fig. 6.2).

The first year of excavation consisted in digging square U8. Only two people fit inside the chamber at this time: one was digging and the other was recording finds. The excavation area was enlarged during the second working season (May 2012) by opening square T8, and half-squares T7 and U7. The excavation area was considerably expanded in the following year (May 2013), and squares T9, U9, S8 and S9 were excavated. Outside the cave, a trench was opened, aligned with rows T and S of the inside grid. Due to the highly brecciated sediments, and taking advantage of the extant topography, the trench was opened in a staircase way until the cobble beach was reached (Fig. 6.3).

6.3.1. Stratigraphic sequence

The sedimentary fill of the Area F and its corresponding the outside area (where trench SEx was excavated), form a single body whose excavation was carried out separately. These two *loci* are divided by a massive stalagmitic column, but stratigraphic correlation is possible using as a marker a flowstone skirt extending both inward and outward. The outside area of Entrance 3 can be organised in four complexes, described from top to bottom as follows (Fig. 6.3; Tab. 6.2; Zilhão et al, 2020):

Upper Complex (UC) – It is formed of silty loam sediments alternating with flowstone, ranging from unit UC1 to UC6. UC1 is the flowstone sealing the deposit, which dips inwards to Area F. UC2-UC6 are stratigraphically correlated to units IH2-IH8 from Area F.

Middle Complex (MC) and Lower Complex (LC) – Similar units, composed of sand grains deriving from the bedrock and from aeolian inputs, but separated by an angular unconformity. Their lateral variation was detected by the increasing amount of organic and anthropogenic material as one moves inwards. MC0 is the capping flowstone and MC1 and MC2 are stratigraphically correlated with units IL2 and IL3 from Area F. The LC complex was only found farther outward, and is rich in shells and shell fragments.

Conglomerate (CO) – It is a cemented conglomerate made of pebbles and cobbles lying on a marine abrasion surface corresponding to the 5-8 m marine terrace.

The stratigraphy of Area F is organised in four complexes described from top to bottom as follows (Fig. 6.3; Tab. 6.2; Zilhão et al, 2020):

Interior Top (IT) – It is mainly composed of loose sediments deposited on top of the flowstone that formed Area F’s ground floor prior to excavation. IT0 corresponds to reworked sediments derived from the Pleistocene deposit brought up by subsurface burrowing, and were excavated as spits A1-A2. IT1 refers to the flowstone formed in the Late Pleistocene, and IT2 is a surficial, near-present Holocene deposit found adjacent to the window that communicates Area F with Entrance 3. Archaeologically, unit IT2 was excavated as spit A0.

Interior High (IH) – Unit IH1 is a thick laminar flowstone made of pure calcite.

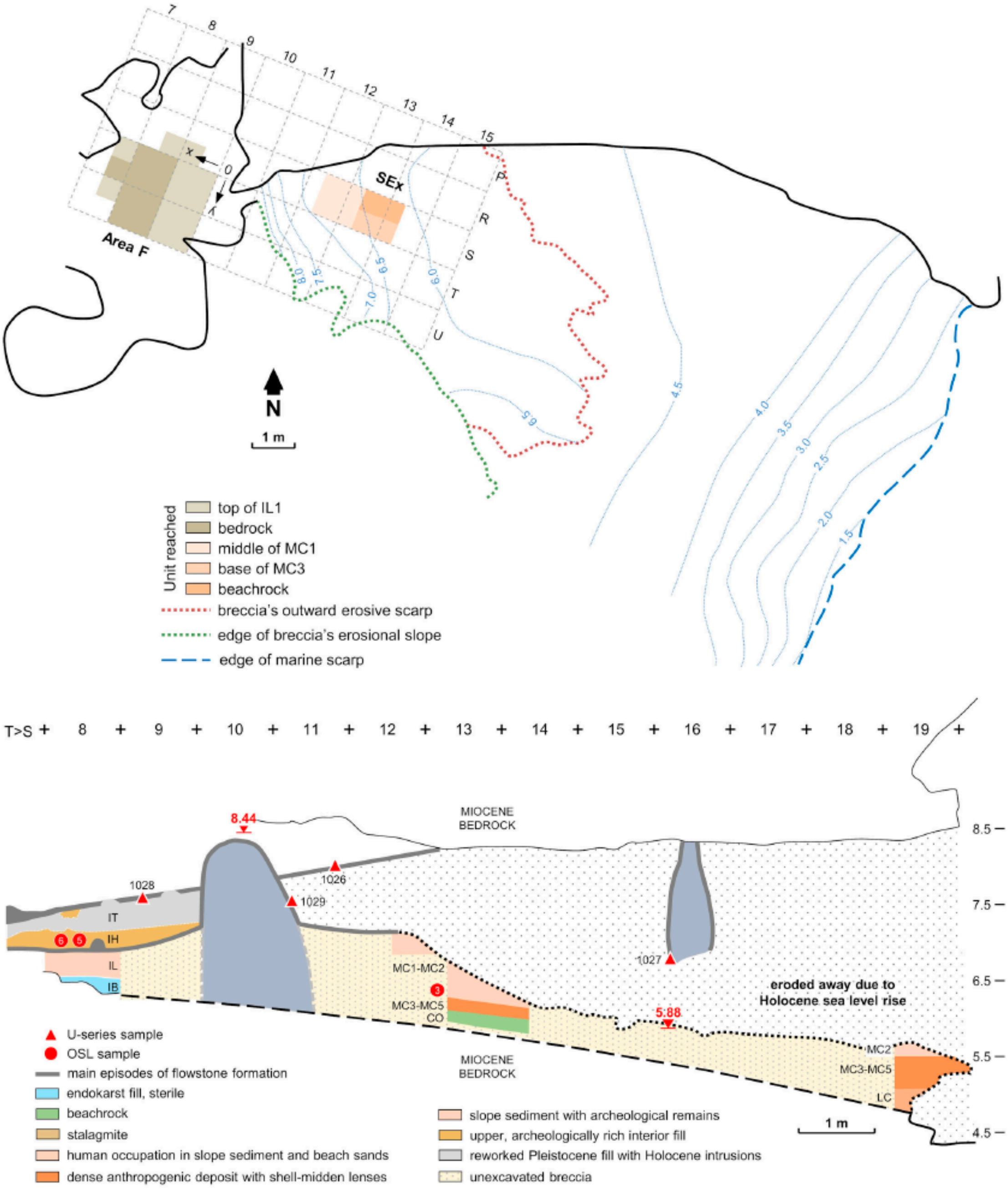


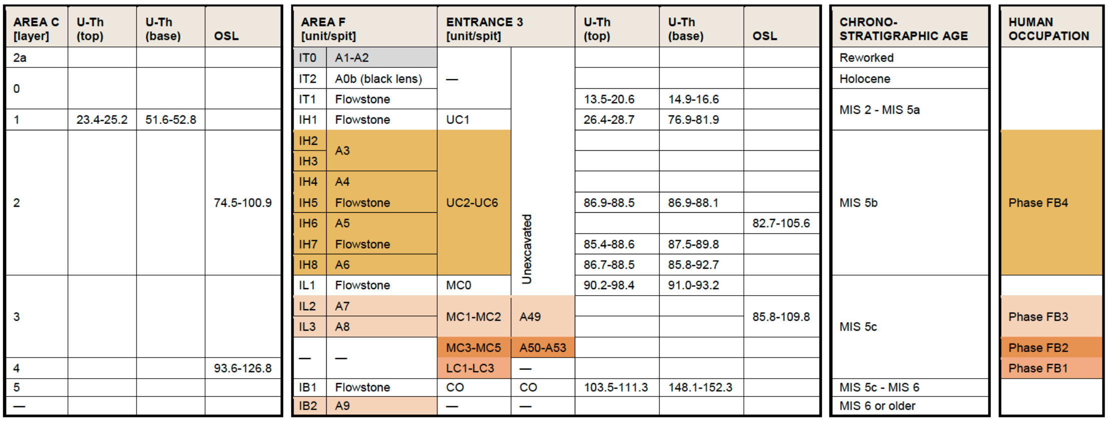
Fig. 6.3 – Area F and Entrance 3: plan, 2010-13 excavation grid, and schematic stratigraphic outline (Image from Zilhão et al, 2020).

IH2 is a well-cemented silty sand deposit, and IH3 is a sort of microconglomerate. Archaeologically, IH2 and IH3 were excavated together as spit A3. Units IH4 (spit A4) and IH6 (spit A5) are uncemented sandy loams that are separated by IH5, a thin and discontinuous calcareous crust. IH7 is another similar crust, which seals unit IH8, a sandy loam that was excavated as spit A6.

Interior Low (IL) – IL1 is flowstone. IL2 is a very cemented sandy silt layer excavated as spit A7, and IL3 is a poorly cemented silty sand excavated as spit A8.

Interior Base (IB) – Unit IB1 is a discontinuous flowstone that covers pockets of the silty sand unit IB2 (excavated as spit A9) that fills cavities in the Miocene bedrock.

Keeping in mind the described stratigraphy, and bringing in site formation processes and anthropic use of the cave into consideration, several different occupation phases can be established. Initially, the cave was not appropriate for human occupation because the marine abrasion platform covered by a sand and cobble beach would have been inundated during high tide (Fig. 6.4 B). The first occupation phase (FB 1) happened during the formation of the Lower Complex (LC) (Fig. 6.4 C) coinciding with the retreat of the shoreline, thus exposing a dry cave floor. This agrees with the dense shell and artefact bed now exposed by erosion. A second occupation phase (FB 2) is related with the formation of units MC3-MC5, when slope dynamics cut back the entrance, and colluvial and aeolian deposits accumulated on the top of the beachrock (CO) (Fig. 6.4 D). With continued accumulation, sediment fill-up pushed the human occupation outwards. Therefore, FB 3 and FB 4 are phases during which occupation happened in the exterior porch but its remains were in part displaced to the back of the cave by low-energy surface dynamics, e.g. gravity or run-off (forming complexes Interior Low and Interior High; Fig. 6.4 E-F). In other words, the space used is a few meters away from the point of eventual archaeological recovery.



AREA C [layer]	U-Th (top)	U-Th (base)	OSL	AREA F [unit/spit]		ENTRANCE 3 [unit/spit]		U-Th (top)	U-Th (base)	OSL	CHRONO-STRATIGRAPHIC AGE	HUMAN OCCUPATION
2a				IT0	A1-A2	—	Unexcavated				Reworked	
0				IT2	A0b (black lens)						Holocene	
				IT1	Flowstone			13.5-20.6	14.9-16.6		MIS 2 - MIS 5a	
1	23.4-25.2	51.6-52.8		IH1	Flowstone	UC1		26.4-28.7	76.9-81.9			
2			74.5-100.9	IH2	A3	UC2-UC6					MIS 5b	Phase FB4
				IH3								
				IH4	A4							
				IH5	Flowstone			86.9-88.5	86.9-88.1			
				IH6	A5					82.7-105.6		
				IH7	Flowstone			85.4-88.6	87.5-89.8			
				IH8	A6			86.7-88.5	85.8-92.7			
3				IL1	Flowstone	MC0		90.2-98.4	91.0-93.2		MIS 5c	
				IL2	A7	MC1-MC2	A49			85.8-109.8		Phase FB3
				IL3	A8							
				—	—	MC3-MC5	A50-A53					Phase FB2
4			93.6-126.8			LC1-LC3	—					Phase FB1
5				IB1	Flowstone	CO	CO	103.5-111.3	148.1-152.3		MIS 5c - MIS 6	
—				IB2	A9	—	—				MIS 6 or older	

Tab. 6.2 – Gruta da Figueira Brava stratigraphic correlation scheme showing equivalence between excavation spits and stratigraphic units of the different areas, available dating evidence, position of the sequence within the Pleistocene record, and archaeological phasing (Table from Zilhão et al, 2020).

6.3.2. Dating

Radiocarbon dating used six single-shell samples from the exterior area of Entrance 3, two from Area F and five from the 1980s excavation labelled as coming from Area C's Pleistocene deposit layer C.2 (Tab. 6.3). The results for the 1980s samples showed that the Pleistocene deposit did include Holocene material, since one of the shells was dated to 2,677±28 BP (OxA-19978). The remaining four samples fall within the 36.4-44.9 ka BP interval, which implies that the result obtained from previous works dated to 30,930±700 BP (ICEN-387) is incorrect, maybe due to the contamination of components from more recent age. The samples from the disturbed parts of Area F's fill dated to 7,390±25 BP (OS-114170) and 12,880±45 BP (OxA-24055) confirming that the reworked Pleistocene sediments contained shells of mid-Holocene and Tardiglacial age. These sampled shells are animal accumulated (by a rodent or a very small carnivore), as exemplified by a dense midden of marine eroded mussel shells, fresh bird bones, bits of plastic, and scraps of a cigarette pack. Such materials might have been brought into the cave for nest-building purposes. In Entrance 3, the oldest result falls in the 45.9-47.9 ka cal BP interval. However, the radiocarbon dates obtained are significantly younger than the speleothems capping the deposits they were found in. Hence, despite the radiocarbon results being clearly of

Middle Palaeolithic age, they should be considered as minimum ages only (Zilhão et al, 2020).

U-series dating used flowstone and stalagmites covering the fill, and flowstone sheets or stalagmites buried within the fill. The results obtained show that the site had close cave conditions in Area F at least from 76.9 ka (the younger limit of sub-sample 1207-6). Open cave conditions occurred between 5.3 ka and 29.7 ka years ago. In Area C, flowstone formation did not begin until about 52.8 ka, whereas in Area F the oldest ages range between 62 and 81.9 ka years ago. Although flowstone eventually formed a continuous crust across Areas C-F, the process begun at different moments, and the accumulation of the archaeological deposit most probably ended before 76.9 ka years ago. The combination of the U-series with the single-grain OSL dating that was done on six sediment samples collected from exposed profiles from the 1980s Area C, and from the most recent excavations in Area F and the exterior part of Entrance 3, concluded the following (Fig. 6.5; Zilhão et al, 2020):

- The sea level retreat that exposed the marine-accumulated sands at the base of the LC Complex (unit LC3) correlates with **MIS-5d**.
- Phases FB 1, FB 2, and FB 3, corresponding to the first stages of the cave's human occupation – represented in complexes IL (Area F), MC and LC (Entrance 3) – occurred during **MIS-5c**.
- A major sedimentation hiatus happened at the onset of **MIS-5b**, corresponding to the formation of the MC0/IL1 flowstone developed in Area F and Entrance 3.
- Phase FB4, the last human occupation phase found in complexes IH (Area F) and IC (Entrance 3), took place during **MIS-5b**.
- The capping of the archaeological deposit by the IH1 flowstone started with the beginning of **MIS-5a**, approximately 85.1 ka years ago.

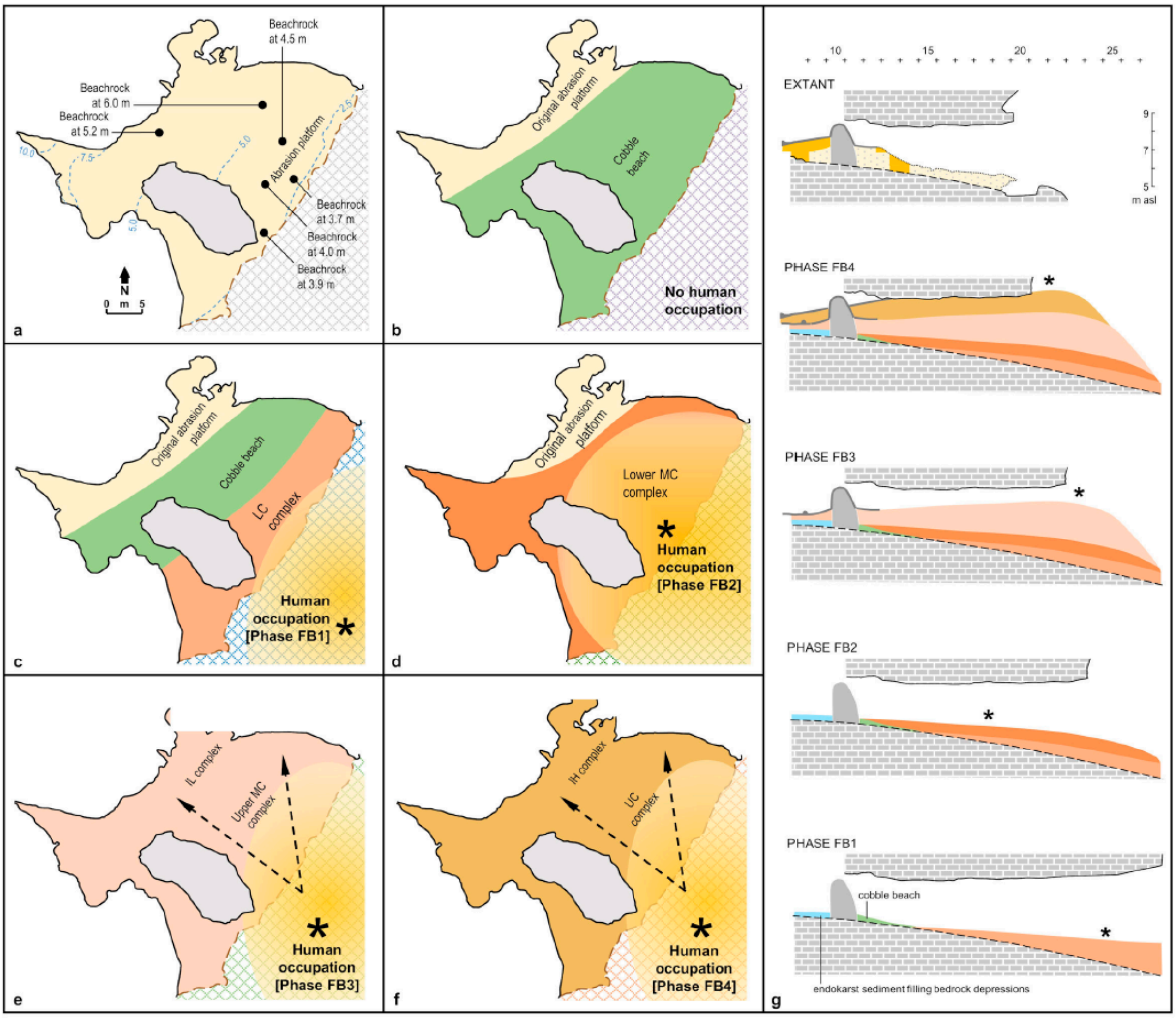
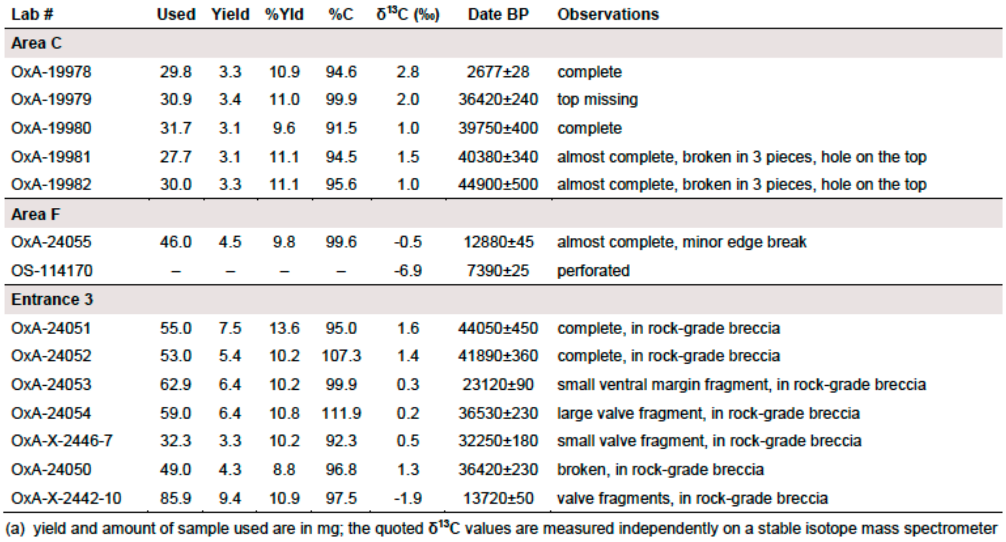


Fig. 6.4 – Gruta da Figueira Brava site formation and human occupation phases. A) Elevation data (m asl) for the marine abrasion platform (dashed contour lines) and individual beachrock remnants. B) During the MIS-5e, the abrasion platform was covered by a cobble beach. C) The retreat of the shoreline exposed a sand beach; the preserved LC sediment containing the remains of Phase FB1 correspond to the innermost periphery of the inhabited space. D) The preserved remnants of MC complex (units MC3-MC5) containing the remains of Phase FB2 correspond to the main habitation area. E-F) The archaeology in upper MC (units MC1-MC2), UC and IL complexes (Phases FB3 and FB4) correspond to material syn-depositionally dispersed to the back of the cave by low-energy dynamics. G) Schematic of the evolution of the cave and fill through the different occupation phases. Image from Zilhão et al (2020).



Lab #	Used	Yield	%Yld	%C	δ^{13}C (‰)	Date BP	Observations
Area C							
OxA-19978	29.8	3.3	10.9	94.6	2.8	2677±28	complete
OxA-19979	30.9	3.4	11.0	99.9	2.0	36420±240	top missing
OxA-19980	31.7	3.1	9.6	91.5	1.0	39750±400	complete
OxA-19981	27.7	3.1	11.1	94.5	1.5	40380±340	almost complete, broken in 3 pieces, hole on the top
OxA-19982	30.0	3.3	11.1	95.6	1.0	44900±500	almost complete, broken in 3 pieces, hole on the top
Area F							
OxA-24055	46.0	4.5	9.8	99.6	-0.5	12880±45	almost complete, minor edge break
OS-114170	–	–	–	–	-6.9	7390±25	perforated
Entrance 3							
OxA-24051	55.0	7.5	13.6	95.0	1.6	44050±450	complete, in rock-grade breccia
OxA-24052	53.0	5.4	10.2	107.3	1.4	41890±360	complete, in rock-grade breccia
OxA-24053	62.9	6.4	10.2	99.9	0.3	23120±90	small ventral margin fragment, in rock-grade breccia
OxA-24054	59.0	6.4	10.8	111.9	0.2	36530±230	large valve fragment, in rock-grade breccia
OxA-X-2446-7	32.3	3.3	10.2	92.3	0.5	32250±180	small valve fragment, in rock-grade breccia
OxA-24050	49.0	4.3	8.8	96.8	1.3	36420±230	broken, in rock-grade breccia
OxA-X-2442-10	85.9	9.4	10.9	97.5	-1.9	13720±50	valve fragments, in rock-grade breccia

(a) yield and amount of sample used are in mg; the quoted δ^{13}C values are measured independently on a stable isotope mass spectrometer

Tab 6.3 – Radiocarbon dating: age of the dated samples. Table from Zilhão et al (2020).

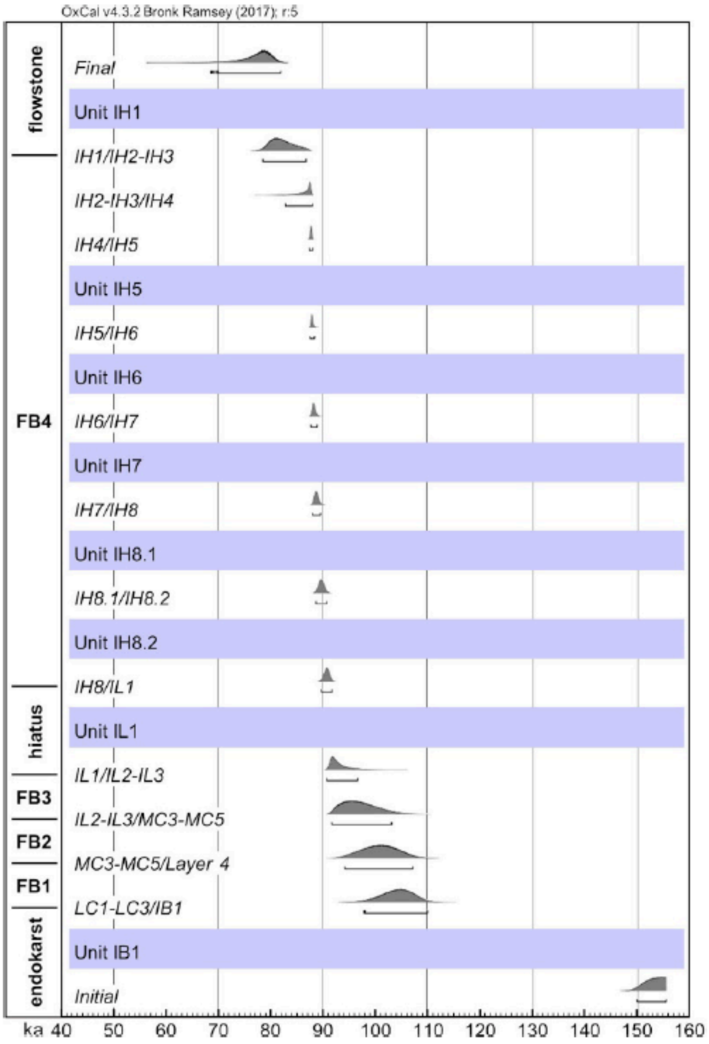


Fig. 6.5 – Age boundaries for the different stratigraphic units and human occupation phases calculated by Bayesian modelling of the U-series and OSL results. Image from Zilhão et al (2020).

6.3.3. Archaeological finds

In the recent 2010-13 excavations, the reworked parts of the deposit were carefully delimited and separately processed. Analysis of the fauna retrieved in the intact parts (of secure Pleistocene age) show the same species composition as in the assemblage from the 1980s work. Despite the minor differences – mostly concerning the absence of the rarer taxa (rhino, elephant and the marine mammals) and the narrower list of small carnivores in the 2010-13 sample – the list and counts in Table 6.1 can therefore be considered to also represent the overall characteristics of the faunal assemblage. For increased sample size, we have also included in the recent studied material a couple of reworked remains that, given their degree of fossilisation and presence of carbonate concretions, doubtless derive from the Pleistocene fill. A considerable number of shell fragments were found in Gruta da Figueira Brava, but only the complete or nearly complete ones were triangulated. Consequently, only 473 shells were recorded on site. However, the figures increased significantly when the malacofauna was analysed in detail, as shown in Chapters 14 and 15. Similarly, the field inventory lists 439 vertebrate remains, a figure that was widely amplified as seen in Chapters 11-13. Numerous fish bones have also been recovered, but they are not studied in this PhD (please refer to supplementary info in Zilhão et al, 2020, for more detailed research on the fish assemblage).

Foraminifera analyses from Pleistocene sediment samples of each excavated unit were conducted by Paulo Legoinha. The few specimens found formed two groups: 1) yellowish and heavily eroded material derived from the bedrock, as shown by the presence of the fossil *Orbulina suturalis* that first appeared 15 Ma years ago; 2) whitish and relatively fresh material with taxa suggestive of brackish, marsh and lagoon environments. A few whitish foraminifera were found in unit MC5 (spit A53); they must come from the upper part of the beachrock, to which the excavated sediment was cemented. No foraminifera were found in units from Area F. No foraminifera were found in the soil micromorphology samples taken from the archaeological levels (Zilhão et al, 2020).

During the 2013 field season, the acquisition of samples for archaeobotanical analysis used sediment floatation. Charcoal and seed remains were recovered by Ernestina Badal, from the University of Valencia (Spain), and results show that stone pine (*Pinus pinea*) is the dominant taxon in Pleistocene levels. Besides wood, the assemblage includes pine needles, cone bracts and nut shell. Some pine cone bracts preserved their original shape, which allows taxonomic attribution to *Pinus pinea* and implies that combustion stopped at the stage of roasting (below 280ºC). These patterns bespeak of the anthropogenic origin of the pine. Conversely, the IT2 archaeobotanical collection is richer in species, including *Olea*, *Quercus* sp., *Rhamnus, Phillyrea, Arbustus unedo, Pistacia* and other woody plants. This composition is very similar to the current vegetation of Serra da Arrábida. The stone pine in the Holocene unit IT2 is only represented by wood, lacking all other features described for the Pleistocene assemblage. Such evidence was studied in detail and concluded that Pleistocene stone pine cones were collected whole in autumn and winter. After being transported to the site, they were heated over the ambers in order to extract the ripe nuts. This explains why the only stone pine missing parts are the nuts themselves, which were eaten, whereas the nut shells were left behind after consumption (Zilhão et al, 2020).

The lithic industry is still under study but from field observations it is clear that it consists on a Mousterian assemblage. A total of 1,116 lithic remains were triangulated on site, and the main raw material used was quartz (n = 903). Flint (n = 97), quartzite (n = 89) and other raw materials (n = 27) were also used but in much lower proportions. Among the tool-types there is evidence of denticulates, notches, scrapers, naturally backed knives and some retouched flakes. According to Zilhão et al (2020), the 2011-13 lithic field inventory compares well with those published from the 1980s excavation (Antunes et al, 2000). Quartz dominates both assemblages and all steps of the reduction sequence are represented reflecting knapping on site. A pilot study on use-wear on quartz artefacts made by Marina Araújo Igreja showed that it was found in 22 out of the 50 pieces analysed. A single edge was used in all cases and the traces indicate processing of organic materials, like animal soft materials (n = 2), and wood (n = 8). Use on hard materials is found in 12 cases, but it is yet unknown the nature of such materials. Nonetheless, these preliminary results show the different kinds of domestic activities one might expect to find in a residential occupation (Zilhão et al, 2020).

CHAPTER 7

GRUTA DA OLIVEIRA

7.1. GEOMORPHOLOGICAL SETTING

Gruta da Oliveira (39º 30' 23" N, 08º 36' 49" W) is located at approximately 100 km NE of Lisbon, in Torres Novas (Portugal), about 40 km away from the coast (Fig. 7.1 A). The cave is part of the Almonda karst system, located at the boundary between the Central Limestone Massif (CLM) and the Tagus Sedimentary Basin (TSB) (Fig. 7.4), in the Meso-Cenozoic Western Border of Iberia. The CLM's southern part corresponds to a major regional reverse fault that causes the Serra d'Aire limestone to overthrust the siliclastic sediments of the TSB. Such tectonic contact is emphasised by an escarpment, called Arrife, that runs for about 40 km along a NE-SW axis, from the municipality of Tomar to Rio Maior (Angelucci & Zilhão, 2009; Leal & Cunha, 2014).

At the base of the ca. 80 m escarpment – the Arrife – the spring of River Almonda is associated with a complex, labyrinthine, multilevel underground network that develops for about 14 km (Angelucci & Zilhão, 2009; Hoffmann et al, 2013; Leal & Cunha, 2014). Among the several passages and cavities of the Almonda karst system those located 5 to 15 m above the current spring contain deposits dated from the Upper Palaeolithic to the Iron Age (Almeida et al, 2004; Zilhão, 1997) (Fig. 7.1 B). Higher up on the escarpment, several collapsed entrances were found. Two of those were cleared for archaeological excavation: Gruta da Aroeira and Gruta da Oliveira. The former is located at the very top of the Arrife, and was excavated between 1997 and 2002, and again between 2013 and 2017. It features sediments dated to >420 ka containing Acheulean industry (Hoffmann et al, 2013; Marks et al, 2002), and the oldest hominin remain ever found in Portugal, the Aroeira 3 cranium, represented by most of the right half of a calvarium and a partial right maxilla (Daura et al, 2017). Halfway up the escarpment, the Middle Palaeolithic site of Gruta da Oliveira shows a preserved 13 m-thick sequence of Mousterian occupations (Angelucci & Zilhão, 2009; Hoffmann et al, 2013; Richter et al, 2014; Deschamps & Zilhão 2018).

Gruta da Oliveira shows a complex morphology (Fig. 7.1 C, 7.3), with roof collapse and sediment deposition resulting in changes of the space available for occupation over time. The original cave entrance is filled-up and remains unexcavated. The excavation area inward from the entrance is the Corredor (Access Corridor), where the oldest layers were found. The Corredor was fed with sediment coming from the two sets of fractures that acted as preferential axes for dissolution and erosion. They are the NW-SE fracture that resulted in the formation of the Sala 27-S (27-S Chamber), and the NE-SW fracture that became the Divertículo (Side Passage). Once sediment accumulation in the Corredor made it possible, the occupation area extended to the Sala 27-S, which filled-up with the deposition of layer 11. From then on, human occupation took place in the Corredor and the Divertículo until both filled-up. After the deposition of layer 8, only animals had access to the cave. Their remains are found in layer 7, which is archeologically sterile. Lastly, a roof collapse (corresponding to layers 1 to 6) sealed the cave, preserving the archaeologically rich underlying stratigraphy (Angelucci & Zilhão, 2009) (Fig. 7.1 D, E).

7.2. ARCHAEOLOGICAL WORK

Gruta da Oliveira was first discovered in 1989, when a team of speleo-archaeologists wandered in the labyrinth of cavities inside the Almonda karstic system. Halfway up the escarpment, several mammal bones (some of them with thermal alterations) and a few Mousterian tools were recovered from sediments that seemed to have fallen down through a roof fissure from a chamber above. This accumulation was designated as the Cone Moustierense (Mousterian Cone) (Zilhão et al 1991, 1993) (Fig. 7.1 E). The Cone Moustierense deposit was partially excavated in 1990, confirming a Middle Palaeolithic chronology through the U/Th dates obtained on a horse molar tooth (Zilhão & McKinney, 1995). The chamber above, that was feeding it, was found through further speleological investigation (Fig. 7.1 C, 7.3). Both this chamber (eventually found to correspond to the back end of the Access Corridor) and the 27-S Chamber were filled-up with sediment and roof collapse. They were reconnected with the exterior in 1991-92, when the collapse sealing the cave's entrance was partially cleared and excavation could start (Zilhão et al 1991, 1993, 2013). Archaeological work continued until 2012, with two to three month-long field seasons.

7.2.1. Stratigraphic sequence

The archaeological sequence is formed of reddish-brown silty loam to silty sand sediments, alternating with flowstone or carbonate crusts. The cave's thick stratigraphic succession can be subdivided in the following blocks (Angelucci & Zilhão, 2009; Willman et al, 2012; Zilhão, 2013b; Deschamps & Zilhão, 2018) (Fig. 7.1 D, E).

Layers 26-27 – These units correspond to the Cone Moustierense sediments and are in secondary position. The finds made therein derive from the sediment column above, from where they migrated through fissures in the bedrock of the Corredor and along the latter's walls.

Layers 23-25 – Corredor's Lower Ensemble. Roof collapse and associated sediment fill with an approximate thickness of 1.5 m. Such massive boulders supported the sediment accumulation above them and in turn allowed the preservation of the empty space below that permitted the 1989-90 discovery of the Cone Moustierense accumulation. The density of archaeological material is low, reflecting the catastrophic nature of the collapse; the deposit is thick, but it represents a short period of time.

Layers 20-22 – Corredor's Middle Ensemble. A 65 cm-thick, sandy-silt deposit accumulated during a period of relative structural stability of the cave's roof and walls, allowing its use for habitation. Several combustion structures are preserved. One, a hearth 1.5 m in diameter, was fully found

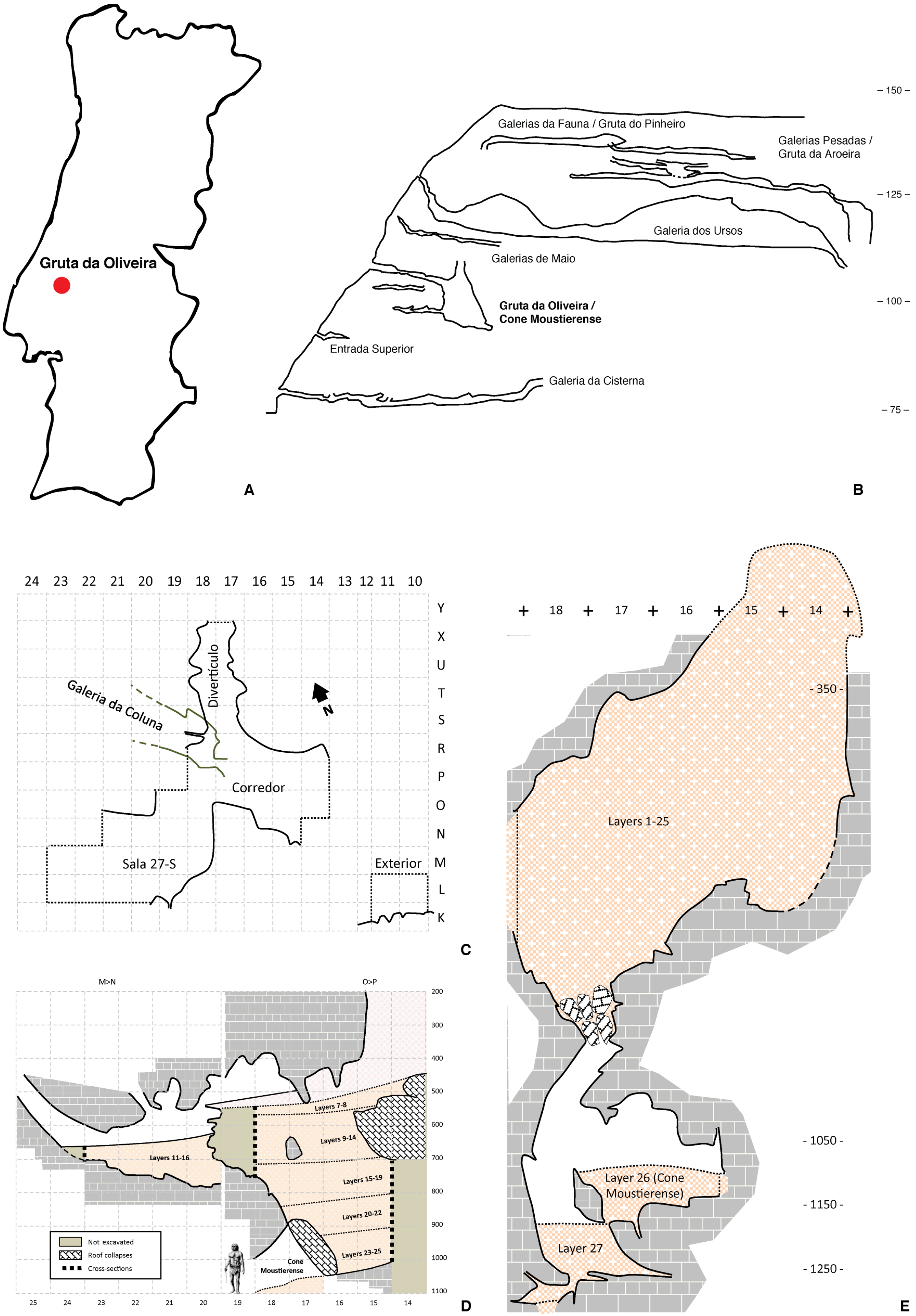


Fig. 7.1 – Gruta da Oliveira. A) Site location in Portugal. B) Cross-section of the Almonda escarpment with location of most of the archaeological sites identified. C) Site excavation plan. D) Cross-section and stratigraphy. E) Cross-section between columns P and R of the excavation grid showing position of the Mousterian Cone. Images B-E are courtesy of João Zilhão (2013b).

within the excavation trench; its contents and scatter correspond to layer 21 (Fig. 7.2). Two other hearths of similar size were identified at the base of layer 22. Their inner edges can be easily recognised on the reference profile (N-R15>14), but they extended outwards into the non-excavated entrance to the cave.

Layers 15-19 – Corredor's Upper Ensemble. A 1.3 m-thick deposit accumulated during a phase of structural destabilisation reflected in three collapse episodes with heavy boulders fallen on the surface of layers 20, 19 and 15. During this phase, most human occupation took place in the unexcavated Exterior area. The abundant archaeological materials recovered in the Corredor accumulated syn-depositionally through run-off and slope processes. The displacement of finds was short-distance, and low-energy is shown by the good preservation of the edges of lithic tools, the multiple lithic refits, and the recovery of faunal remains in anatomical articulation.

Layer 13-14 – Basal Cave Interior. Accumulation located inward of the huge boulder fallen on the surface of layer 15 in grid units O-P/12-15. Human occupation was mostly on Sala 27-S, where sedimentation started with layer 16, during which there was a continuous cave floor connecting the Exterior, the Corredor, and Sala 27-S. A hearth was identified at the base of layer 14, in unit grids K-M/20-22. The scatter of burnt bones, food scraps and lithic debris around the combustion structure shows human activity taking place inside the cave.

Layers 9-12 – Middle Cave Interior. The base of sedimentation in the Divertículo corresponds to layers 11 and 12, with human occupation taking place here and in the adjacent areas of the Corredor since Sala 27-S had filled-up. Lithic refits indicate that the archaeological finds are in primary position, and the slight dispersion of the material is due to bioturbation, mainly related with carnivore activity.

Layers 7-8 – Upper Cave Interior. Formed atop the O-P/12-15 collapsed boulder, and extending both inward and outward. Layer 8 corresponds to the latest human occupation. Layer 7 reflects the abandonment of the site; the faunal remains therein were accumulated by carnivores. Flowstone seals this deposit.

Layers 1-6 – Colmatage Breccia. Correspond to the final roof collapse, which closed the cave and fiiled-up the external parts of the Corredor.

Fig. 7.2 – Excavation of Gruta da Oliveira hearth from layer 21. Left: the hearth's dark stain starts showing. Middle: the elongated boulder of roof collapse on the left was removed, exposing the width of the hearth. Right: the whole hearth is visible, although micromorphology samples were already taken. Photo by João Zilhão (2013b).

7.2.2. Dating

Extensive chronometric work was conducted at Gruta da Oliveira. Absolute dates result from a combination of techniques including radiocarbon on charcoal and burnt bones (Angelucci & Zilhão, 2009), U/Th on animal bones and speleothems (Zilhão & McKinney, 1995; Hoffmann et al, 2013), and TL on burnt flint (Richter et al, 2014). They date the Neanderthal occupation to the Late Pleistocene (Zilhão et al, 2013).

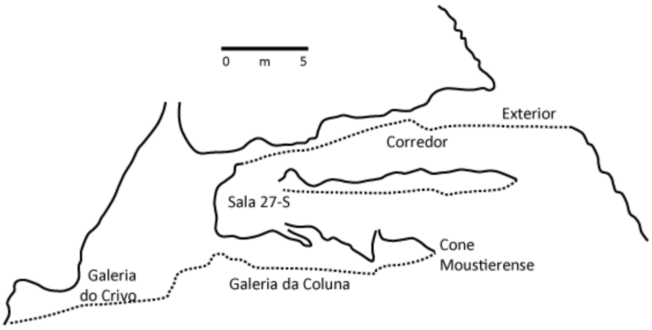


Fig. 7.3 – Schematic cross-section of Gruta da Oliveira and its adjacent cavities (Image adapted from João Zilhão, 2013b).

The baseline for the Gruta da Oliveira accumulation, ~107 ka, is provided by a U/Th-dated stalagmite growing on the surface of an inner passage beyond the Cone Moustierense – the Galeria do Crivo –, which represents the topographic base of the Gruta da Oliveira accumulation (Fig. 7.3), for which it provides a maximum age. A horse (*Equus caballus*) tooth from the Cone Moustierense was dated to ~61,500 by U/Th (Zilhão & McKinney 1995).

TL results on burnt flints from layer 14 show a weighted mean age of 77,000, placing the heating event of the *in situ* hearth between 93,000 and 61,000 BP (2-σ), spanning the MIS-5b to MIS-4 interval (Ritcher et al 2014). Therefore, the underlying deposit (layers 15-25), separated from layer 14 by a significant discontinuity is likely to date to late MIS-5.

The upper part of the stratigraphy was firstly dated by radiocarbon, showing a pattern of increasing age with depth down to layer 11. Below this point, radiocarbon ages reached a plateau reflecting the limitations of the method's applicability (Angelucci & Zilhão 2009). AMS radiocarbon dating of burnt bone from layer 8 provided calibrated 1-σ ages ranging between 35,760 ± 280 BP and 37,100 ± 830 BP (Angelucci & Zilhão 2009). These dates are in accordance with the U/Th ones obtained on bone from the same layer, indicating an age of ~38,000 BP. Moreover, they agree with the dates obtained from the capping flowstone sealing the top of the sequence, which imply a minimum age of ~23,000 years for the archaeological deposit (Hoffmann et al 2013). AMS radiocarbon on burnt bone from layers 9 to 11 range between 42,000 and 49,000 cal BP (Angelucci & Zilhão 2009), suggesting a MIS-3 occupation. The heated flint TL ages (1-σ) for layer 13 have a weighted mean age of 55,000 years (with a 2-σ range from 69,000 to 41,000 BP), spanning MIS-4 and early MIS-3 (Ritcher et al 2014).

Considering the overlap of the probability intervals from the absolute dates obtained by different methods, the potentially incomplete decontamination of the radiocarbon-dated samples, and the few palaeoenvironmental data available, the conclusions until very recently were (Zilhão et al, 2013; Nabais & Zilhão, 2019):

(a) Layers 26 and 27 are in secondary position and its archaeological content derives from the overlying sedimentary column (layers 15-25).

(b) Given the TL chronology obtained for layer 14 (77 ± 8 ka; Richter et al., 2014), we can be confident that Gruta da Oliveira layers 15 to 25 are of broadly the same age as Gruta da Figueira Brava's – late Last Interglacial (MIS-5). However, the cold climate *Pinus sylvestris* is ubiquitously present in the wood charcoal analysed by Badal et al. (2012). Therefore, either, at this latitude, late Last Interglacial climates were colder than today's, or humans occupied Gruta da Oliveira primarily during the colder stadials of that period.

(c) With regards to the upper part of the sequence, the radiocarbon and U-series dating of bones from these units suggests that they span MIS-4 and MIS-3, up to 35-40 ka (Hoffmann et al, 2013). However, no major discontinuity separates layer 14 from the overlying sequence. It remains possible, therefore, that the dates so far available for layers 7-14 are minimum ages only and that these units are of late Last Interglacial age too.

Continued dating research has been in place given the remaining chronometric uncertainties. These are mostly due to: (1) the TL dating of heated flints that showed that the radiocarbon dates for layer 14 were extremely underestimated, with 43-50 ka years by radiocarbon opposing 77 ± 8 ka years by TL (Richter et al 2014); and that, consequently, (b) layer 8's radiocarbon dates could also be underestimated, especially because they were obtained on burnt bone, which is prone to produce unreliable results (Zazzo 2014). Therefore, a last minute update of this PhD thesis was must needed in order to clarify the age of layer 8 and the overall site's stratigraphy. New OSL dating of sediment samples from the existing stratigraphic profiles was recently undertaken, as well as new U-series ages for stratigraphically delimited speleothems and new luminescence ages for sediment infill. Based on the new dating evidence and its Bayesian modelling, the most recent conclusions are (Zilhão et al, *submitted*): layers 8-14 were most likely accumulated between 72.3 and 77.8 ka years ago; layers 15-17 between 85.1

and 87.6 ka; layers 20-22 between 90.1 and 92.0 ka; and layers 23-25 likely date to >92 ka years ago. As such, and has previously suspected, we can now be confident that Gruta da Oliveira archaeological sequence dates entirely from the MIS-5, with layers 8-14 formed during the MIS-5a and layers 15-22 during the MIS-5b (Zilhão et al, *submitted*), thus matching Gruta da Figueira Brava's chronology.

7.2.3. Archaeological finds

7.2.3.1. Lithic material

A total of 31,228 lithic remains were retrieved (Fig. 7.4). Such a figure is prone to increase once the lithic analysis is complete. A first study conducted by Marks et al (2001) for layers 8 and 9, confirmed the generally accepted notion that retouched tools are rare in the Portuguese Middle Palaeolithic. Even though, it was possible to identify three notches, four denticulates, one piece with continuous retouch, two marginally retouched pieces and an atypical inverse Tayac point. There seems to be a preference for non-cortical flakes, and primary flakes and blades are scarce. Levallois flake production is well developed in these layers, and is mainly done on non-flint materials.

According to Angelucci & Zilhão (2009), the lithic material from layers 8 and 9 compares well with other Late Mousterian industries, such as Foz do Enxarrique and Gruta da Figueira Brava (Raposo, 1995). Based on field observations, layers 10 to 14 show the presence of elongated Upper-Palaeolithic-type blanks, alongside Levallois and Kombewa reduction methods. A similar phenomenon was reported for the Mousterian levels 20-21 of El Castillo and 11-12 of Morin, as reported by Maíllo et al (2004). Such Upper Palaeolithic tool types were not found in layers 15 to 27, which yielded a few cleavers and small, flattish handaxes. In addition, flake blanks are considerably larger and flint, chert and chert-like raw materials are more frequently used (Angelucci & Zilhão, 2009; Zilhão et al, 2013).

Most of the flint seems to have been collected from the Tagus Sedimentary Basin (TSB) (Fig. 7.5), which is of excellent knapping quality, otherwise attested by its ample presence in all prehistoric sites of the TSB, and even more than 150 km away in the Côa Valley Upper Palaeolithic sites. This can maybe reflect a long-term residency in the TSB, with Gruta da Oliveira being used as a temporary camp where the good flint was eventually discarded, and the local, medium to low quality Bajocian flint (Fig. 7.5) was only occasionally used. Seasonal movements can also be supported by the significant frequency of Oxfordian flint with known provenience locations around the Nabão River valley. It is also possible that groups living more permanently in the Central Limestone Massif (CLM) could have alternated the use of Gruta da Oliveira with other groups living in the TSB. Support for this hypothesis can be sought in the fact that Oxfordian flints were processed differently, the low frequency of cortical material suggesting the introduction of preconfigured cores (Matias 2016).

Quartzite, lydite and quartz were introduced as cobbles, boulders or large flakes. These raw materials are widely spread in the TSB deposits, but there was a preferential selection of red and green-coloured fine-grained quartzite. This is quite homogeneous and is of exceptional knapping quality. It was mainly used in Levallois reduction schemes. Sources can be found less than 5 km NE of Gruta da Oliveira, which implies local provision. It is rarely found in other Palaeolithic sites in the Almonda karst system and it is absent from Palaeolithic sites located in the TSB. Therefore, it can be suggested that the use of this specific type of fine-grained quartzite is a marker for the regional Middle Palaeolithic (Matias 2016).

7.2.3.2. Human remains

Nine human remains were recovered from Gruta da Oliveira. With one, possibly two, exceptions (the Oliveira 8 and 9 teeth), they belonged to mature individuals. None of the elements show pathologies, but small carnivores gnawed two of the remains (Trinkaus et al 2007; Willman et al 2012).

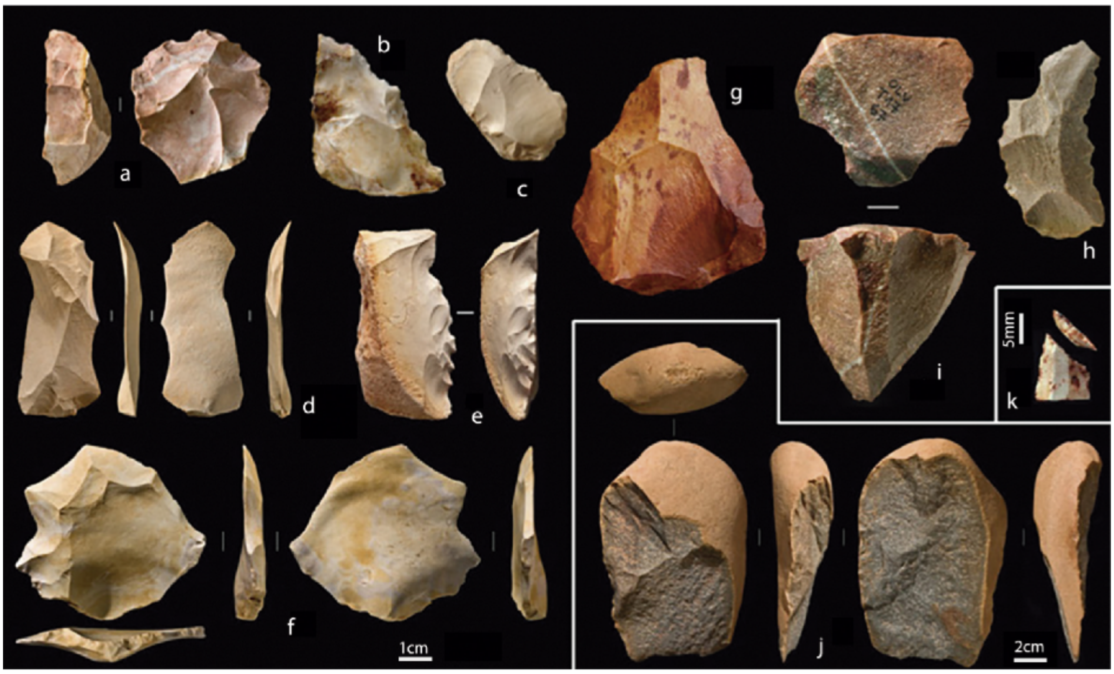


Fig. 7.4 – Selection of stone tools from Gruta da Oliveira. A) Levallois core, layer 20. B) Denticulate sidescraper, layer 26. C) Sidescraper, layer 26. D) Levallois blade, layer 20. E) Denticulate, layer 14. F) Levallois flake, layer 19. G) Levallois core, layer 13. H) Denticulate, layer 26. I) Pyramidal core, layer 10. J) *Hachereau*, layer 20. K) Truncated bladelet, layer 14. A-F, and K: flint. G-J: quartzite (Image from Matias 2016; Photo composition by João Zilhão, 2013b).

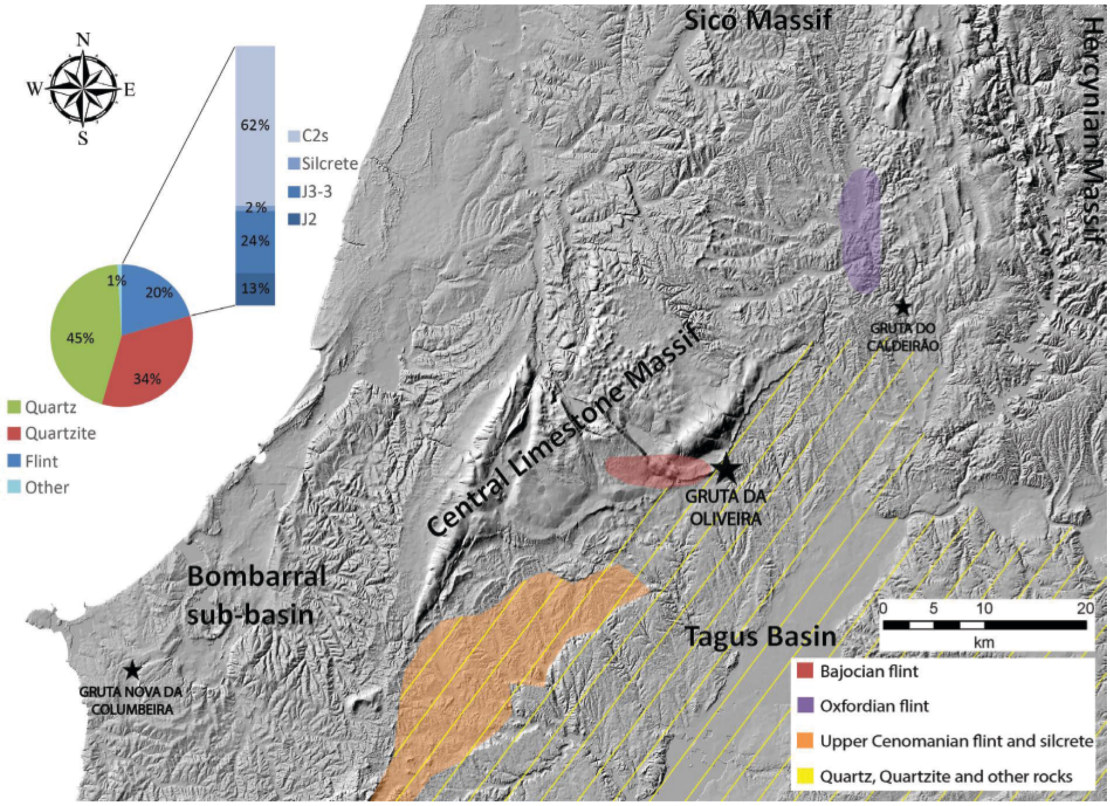


Fig. 7.5 – Regional raw material sources and raw material percentages in layer 14 of Gruta da Oliveira, with indication of the Central Limestone Massif (CLM) and the Tagus Basin (TSB). Image from Matias (2016).

Fig. 7.6 – Human long bone remains recovered from Gruta da Oliveira. A) Oliveira 3, distal right humerus. B) Oliveira 7, distal right humeral diaphysis. C) Oliveira 1, fifth middle manual phalanx. D) Oliveira 5, right manual proximal phalanx 2. E) Oliveira 2, proximal right ulna. F) Oliveira 4, left tibial distal diaphysis (Image adapted from Trinkaus et al, 2007, and Willman et al, 2012. Photo composition by João Zilhão, 2013b).

Oliveira 1 (Fig. 7.6 C) was recovered from layer 9 and is a middle hand phalanx, most likely a fifth digit. Its side is indeterminate, but the large phalangeal articulation aligns well with the Neanderthals'. The same happens with Oliveira 2 (Fig. 7.6 E), the proximal end of a right ulna recovered from layer 10. Based on morphometry, the olecraneon process is Neanderthal-like. Oliveira 1 and 2 could have belonged to the same individual, considering their relatively close deposition (Trinkaus et al, 2007).

Oliveira 3 (Fig. 7.6 A) was recovered from layer 18 and consists of the distal end of a right humeral diaphysis. Osteometry points to a Neanderthal specimen, especially based on the bone's relatively large olecraneon fossa and the narrow thickness of the medial pillar. Oliveira 3 shows a small indentation with a 2 mm diameter, which might be caused by small carnivore activity. Two puncture marks were also found in Oliveira 4 (Fig. 7.6 F), a complete contour of a human left tibia diaphysis from layer 19. The carnivore crenulation and the size of the punctures indicate a canid gnawed on these bones. Oliveira 4 falls well within the morphometrics and biomechanical variation ranges defined for Neanderthal skeletons and archaic *Homo* (Trinkaus et al 2007).

Oliveira 5 (Fig. 7.6 D) is identified as a right second manual proximal phalanx with osteometric values falling along the higher values of the Neanderthal, and Early and Middle Upper Palaeolithic modern humans. The bone was recovered at the interface between layers 17 and 18, in the same stratigraphic position as Oliveira 6. The latter is a fragment of a very worn premolar or molar tooth (Willman et al 2012).

Oliveira 7 (Fig. 7.6 B) is a right humeral distal diaphysis found in the upper part of layer 18, very close to Oliveira 3 (11 cm away and 7 cm below). Morphometrical analysis of Oliveira 7 placed the bone among the most robust of the Neanderthal humeri, comparable to the ones uncovered in southern Iberia, Palomas 96 and Palomas 92, which present “arctic” body proportions (Willman et al, 2012).

Oliveira 8 and Oliveira 9 are tooth fragments. The former consists of a partial crown from the occlusal surface and a root from the distal part of a mandibular tooth, probably from the right side. Based on the slight wear of the cusps, it can be identified as an M3, or an M1 or M2 prior to the eruption of the next distal molar. It comes from layer 22 and was found approximately 25 cm away from Oliveira 9, which is a lower right P3. It is possible that both teeth came from the same mandible, due to their close stratigraphic location. If that is the case and based on the occlusal wearing and root apex fusion of Oliveira 9, it is unlikely that Oliveira 8 represents an M1, but instead an M2 or M3. Oliveira 9 provides a median age of 13 years old and its crown breadth is relatively large for a Late Pleistocene human. However, the relative enamel thickness (RET) follows the general Neanderthal trait of being quite low (Willman et al, 2012).

7.2.3.3. Faunal remains

Preliminary studies have been conducted for the faunal assemblage recovered from Gruta da Oliveira's upper layers. Amongst the microfauna from layers 7 to 16, the taxa identified are *Apodemus sylvaticus, Eliomys quercinus, Microtus brecciensis, Microtus duodecimcostatus/lusitanicus, Glis* sp. and *Castor fiber* (Zilhão et al, 2013). The macro-mammals recorded, from layers 7 to 13, are mostly red deer. Ibex, horse and rhino have a residual presence in layers 7 to 10, but they become more frequent towards the bottom layers. Wild boar is scarce throughout. Taxonomic diversity is larger amongst the carnivores. They are represented by bear, hyena, wolf, red fox, lynx, lion, wildcat and marten (Zilhão et al, 2010a) (Tab. 7.1).

Such carnivores, however, do not seem to have been responsible for the bone accumulation. Large carnivores (like hyena, bear, wolf and lion) comprise only 4% of the studied assemblage. Most bear remains come from layers 7 to 11, and may correspond to hibernation deaths in layers 12 and 13, when human occupation of the cave became more ephemeral, which is evident by the significant decrease in the lithic:bone ratio. Apart from bears', there are no juvenile bones amongst the carnivores, which is unexpected in an assemblage where the main bone accumulator was a carnivore. According to Mills (1983) and Cooper (1993), hyena dens are generally used for the whole clan, and they are used by cubs to find shelter and protection. As such, the lack of hyena juveniles suggests that the cave was not used as a den, at least in the excavated areas. The presence of coprolites, however, identifies two latrine areas in layer 13, squares O16 and N21.

Wood charcoal and coprolite pollen suggest that hyenas were mainly interstadial scavengers of the bones left by humans using the site during the previous stadial (Zilhão et al, 2010a).

	NISP	%
MAMMALS		
Rhinoceros	88	5.94
Auroch	4	0.27
Horse	65	4.39
Deer	643	43.42
Caprine	227	15.33
Boar	2	0.14
Bear	29	1.96
Lion	1	0.07
Hyena	2	0.14
Wolf	12	0.81
Lynx	24	1.62
Wildcat	9	0.61
Fox	24	1.62
Marten	1	0.07
REPTILES		
Testudo hermanni	350	23.63
TOTAL	**1,481**	**100**

Tab. 7.1 – Fauna from Gruta da Oliveira. Data from Zilhão et al (2010a) and Nabais (2012) referring only to layers 7-13.

The primary role played by humans in the accumulation of the cave's animal remains is consistent with the presence of cut marks and the abundance of burnt bones. This is clear in layer 14, where burnt bones cluster around an *in situ* hearth. The burning stages of bone fragments and the wide variety of species and skeletal parts represented suggests the use of bone as hearth fuel (Nabais 2011). In earlier occupation phases (layers 15 to 19), burnt tortoises stand out due to the large presence of cremated fragments. The preferential burning of their dorsal carapace reflects the practice of roasting the animals directly on the coals (Nabais, 2012).

7.2.3.4. Archaeobotanical remains

At present, Gruta da Oliveira is part of a sub-humid, thermo-mediterranean bioclimatic zone dominated by woody flora, where species like *Olea europaea* (olive tree)*, Rhamnus alaternus* (buckthorn)*, Pistacia terebinthus* (terebinth) and *Myrtus communis* (myrtle) are amongst the most common. On thicker soils, evergreen *Quercus* sp. (oak) and maritime pine (*Pinus pinaster*) can also be found (Badal et al 2012).

During Neanderthal times, evidence of plant exploitation is scarce in Iberian sites (Allué 2002; Uzquiano 2008; Badal et al 2011, 2012; González-Sampériz, et al 2012). According to Badal et al (2012), the wood charcoal analysed from Mousterian levels dated from MIS-5 to MIS-3 at Gruta da Oliveira, Cueva Antón and Abrigo de la Quebrada (the last two in Spain), reflect cold climatic conditions. *Pinus sylvestris* woodlands were characteristic of the territories above the latitude of 40ºN, whereas south of it was marked by the presence of mixed woodland where *Pinus sylvestris* and *Pinus nigra* co-existed. Thermophilous and xeric taxa – like *Pinus pinea, Ephedra, Juniperus, Fabacea* and *Olea europaea* – would have been found in southern Iberia, as demonstrated by the finds in Cueva Antón.

The wood charcoal fragments analysed from Gruta da Oliveira were collected from layers 7 to 22. They were extremely small fragments (< 1mm) and were badly preserved due to sediment compression and bio-deterioration by fungus and bacteria. Therefore, species identifications were only securely done for *Pinus sylvestris* and *Juniperus* sp. All other remains could only be distinguished as Angiosperms or Gymnosperms. When considering layers 14 and 15 together, cryophilous Gymnosperms predominate, whereas only 20% of the sample corresponds to Angiosperms (Badal et al, 2012). Previous analyses conducted by Queiroz (Queiroz et al, 2002; Queiroz, 2005) confirmed the presence of *Pinus sylvestris* in layers 10, 13, 14, 15 and 16, as well as the identification of *Erica* cf. *arborea* in layer 13. These two species reflect the wood locally available, suggesting a landscape of open Scot pines and its understorey heathland, typical of the cold phases of the Portuguese Upper Pleistocene (Zilhão et al, 2010a).

Analysis conducted by Carrión and Fuentes (Zilhão et al, 2010a) on pollen recovered from hyena coprolites, shows a different picture. The identification in all samples of mesothermophile taxa – like deciduous and evergreen *Quercus*, *Corylus, Alnus, Tilia, Betula, Salix, Fagus, Ulmus, Myrica* and *Buxus* – indicates a temperate climate. *Quercus suber* and *Olea* were also identified in some of the samples, whereas *Ericacea* was residual.

So far, layer 14 is the only stratigraphic unit that shows evidence of both wood charcoal and pollen, demonstrating that the contrast between them do not reflect different climatic conditions from one layer to another. Zilhão et al (2010a) consider the possibility of the two kinds of landscapes being available in the cave surroundings: the open cold oceanic pine, and the heathland indicated by the charcoal, and the closed sub-humid oak and pine woodland shown by the pollen. The discrepancies would reflect human choice in firewood provisioning, which would only be brought to the cave during cold periods, while the temperate vegetation implied by the coprolite pollen data would reflect use of the cave by hyenas during interstadials.

Part IV

Materials and Methods

In order to better contextualise the materials under study – understanding its condition and degree of preservation – it is necessary to get acquainted with the excavation and post-excavation techniques, the strategies applied on site and in the laboratory, as well as the approaches used in data analysis. This part is dedicated to the description of all methods used in the retrieval and analysis of the faunal assemblages from Gruta da Figueira Brava and Gruta da Oliveira, including species identification, age estimation, osteometry, taphonomy, quantification and the explanation of the different formulae used to calculate a variety of indexes and ratios. Therefore, Chapter 8 summarises the methods used during excavation and in the field laboratory, Chapter 9 describes the zooarchaeological recording protocols used in the bone and shell analyses, and Chapter 10 focuses on the methods of data analysis applied in the study of the fauna collections.

CHAPTER 8

EXCAVATION AND POST-EXCAVATION METHODS

Gruta da Figueira Brava and Gruta da Oliveira were excavated under the direction of João Zilhão. I took part in all archaeological works conducted in the former (2010-2013), but only in three excavation seasons for the latter (2006, 2007 and 2012). Both sites were excavated following the same methodology, and the same applies for post-excavation works and faunal analyses, which facilitates comparisons between assemblages.

8.1. EXCAVATION

Both sites were divided in square metres named with letters and numbers according to their position in the grid (e.g. U8, U7, T7). Each square was then divided in four quadrants (NE, NW, SE and SW). The excavation was done by spits, subdivided in levels of approximately 5 cm of thickness whenever necessary. Each spit was given a number ("A*n*"), from which A1 refers to the first excavation level, at the top of stratigraphic sequence.

All artefacts larger than 3 cm were triangulated (X, Y, Z) on site, as well as faunal remains larger than 5 cm (or smaller than 5 cm but identifiable to species), complete shells, and samples taken during excavation (e.g. charcoal, speleothems, sediment). Provenience information was written in labels for the finds bags, and was also inserted in a handheld PC (or PDA). Such data was daily transferred to a database in Excel. An unique identifier number was given to each find, following the system "year-*n*", in which the "year" corresponds to the year of the excavation season and "*n"* to the sequential number attributed to the find from 1 onwards. All other remains were gathered in general bags and also labelled according to provenience.

All excavated sediments were sieved by spit and quadrant. They were dry sieved using a 2 cm mesh in order to recover larger size finds, and to remove rocks and carbonated blocks. For Gruta da Figueira Brava further sieving was carried out on site in meshes < 2 mm and > 2 mm. The former was washed in the sea, due to the impossibility of freshwater on site; samples of sediment smaller than 2 mm were washed whenever potentially relevant material was identified. A similar strategy was followed for Gruta da Oliveira, where sediment samples were kept for wet sieving and flotation whenever there was relevant finds, such as charcoal, seeds, or concentrations of microfauna. In such cases, that was done at the spring of river Almonda, at the bottom of the escarpment.

A systematic photographic record was kept of each spit, with heights taken on the centre of each quadrant. Photo and perspective corrections (considering that pictures are always slightly oblique) were done using tools from Corel PaintShop Pro X3.

8.2. POST-EXCAVATION

All finds were brought to the field lab on a daily basis, where they were washed and re-bagged when dried. In the case of Gruta da Figueira Brava's sediments, they were washed again in the lab with freshwater. When dried, they were sorted by components: matrix, lithic material, macrofauna, microfauna, fish, shell, crab, and charcoal.

Due to the caves' environment, the faunal material is heavily coated with calcareous concretions. Such condition makes the zooarchaeological analysis more difficult, especially when identifying bone/shell surface modification or observing teeth occlusal surfaces. Therefore, some heavily concretionated bones had to be immersed in vinegar for few hours in order to remove part of the calcareous material. They were then kept in freshwater for 24 hours in order to completely remove the acid, and then air-dried. An engraver was also used in some cases, mainly when bones were glued to stalagmitic crusts.

8.3. UNITS OF ANALYSIS

Faunal remains from the two caves studied were organised by squares, spits and layers. For Gruta da Figueira Brava, the faunal analyses were conducted based on spits. All materials recovered were studied and quantifications were done by spit, and then agglomerated according to chronology: reworked levels, and occupation phases FB 4, FB 3 and FB 2 (Chapter 6, Tab. 6.2).

For Gruta da Oliveira, analyses were conducted by layer, and then joined according to stratigraphic blocks as described in section 7.2.1: layers 20-22; layers 23-25; and layers 26-27. The analysis of units dating from the same chronological framework (the MIS-5), allows a more direct and straightforward comparison of the two caves, despite their different geographical settings: one in a coastal position and another in an inland location.

CHAPTER 9

ZOOARCHAEOLOGICAL METHODS

9.1. FAUNAL TAPHONOMY

The term “taphonomy” was first defined by the Russian palaeontologist Efremov in 1940, by merging the Greek words *taphos* (= burial) and *nomos* (= laws). Although referring to the laws of burial, the term applies to everything that happens to organisms from the biosphere into the geological record (Lyman, 1994). As such, under the taphonomy umbrella, all bone modifications are included, from burning, to breakage, demineralisation, fossilisation, and every type of surface alterations whether natural or due to other organisms.

9.1.1. Fragmentation and breakage

For a quick assessment of the assemblages’ degree of fragmentation, and in order to compare fragmentation profiles within and between assemblages, every bone and shell (whether complete or fragmented) were assigned to a size interval in centimetres: 0-1 cm, 1-2 cm, 2-3 cm, 3-4 cm, 4-5 cm, >5 cm, >10 cm, >15 cm and so on.

Faunal assemblages tend to have a high degree of fragmentation, so the type of fracture becomes of interest, since it can show the impact of the excavation on bones (which is clear through the presence of “new fractures”), and it gives clues towards breakage patterns done in the past, and possible relationships with butchery and consumption practices performed during the caves’ occupations. Bone and shell breakage was recorded following the widely accepted criteria defined by Villa and Mahieu (1991), and adapted by Blasco and Fernández-Peris (2012a), used in the analysis of several Palaeolithic faunal assemblages. The fracture outline was recorded as transverse, curved/V-shaped or longitudinal; fracture angle as oblique, right or mixed; surface edge as jagged or smooth; and the time of fracture was described as old or new, reporting to a breakage happening before or after deposition. “New fractures” correspond to those still fresh with a very bright colour resulting from excavation, which sometimes used heavy machinery, therefore impacting on the condition and preservation of some of the finds. Complete bones and shells were recorded as “complete”, and thus were not submitted to such breakage analyses.

9.1.2. Butchery marks

Considering the heavy calcareous coating of the faunal assemblages, bone and shell surface modification was difficult to detect. Even though, some carcass processing marks (*i.e.* percussion marks, butchery marks and burning) were still possible to be identified.

Clear anthropogenic breakage can be assessed through several types of percussion marks, like percussion pits, percussion notches, impact flakes and adhering flakes (Blasco & Fernández-Peris, 2012a; Blumenschine & Selvaggio, 1988; Capaldo & Blumenschine, 1994; Díez et al, 1999; Pickering & Egeland, 2006; White, 1992). Butchery marks are good indicators of human use of bones and shells, and can also provide insight into carcass preparation activities. Cuts, scrapes and chops were identified according to the criteria defined by Binford (1981), Blasco and Fernández-Peris (2012a), Díez et al (1999) and Fisher (1995). Additional information is given on the number of striations (0 to *n*), striation distribution (isolated, clustered, crossed), striation orientation (oblique, longitudinal, transverse), striation delineation (straight or curved), striation location and side (posterior, anterior, medial, lateral) on the skeletal element. Trampling marks were distinguished from butchery marks following the protocol defined by Domínguez-Rodrigo et al (2009).

9.1.3. Burning

Burning was also recorded. As attested by experimental work (e.g. Mays, 1998; Nicholson, 1993; Shipman et al, 1984; Villagran, 2014), burning changes bone colour according to different temperature exposures (Tab. 9.1). These can give clues on the activities causing burning: (a) accidental burning caused by natural fires (Brain, 1981; David, 1989) or due to bone discard towards the proximity of a hearth (Bennett, 1999; Stiner et al, 1995); (b) ritual practices requiring animal burning (Tchesnokov 1995); (c) utilitarian activities, such as habitat cleaning (Meignen et al, 2000), fat extraction (Outram, 2002), cooking (Gifford-Gonzalez, 1993; Pearce & Luff, 1994; Montón-Subías, 2002) or use of bone as hearth fuel (Costamagno et al*,* 1999, 2005; Théry-Parisot, 2002; Théry-Parisot et al*,* 2005; Villa et al, 2002; Yravedra et al, 2005). Burning colour observations on bone were based on the schemes presented by Shipman et al (1984) and Nicholson (1993), resulting in the creation of five different categories of analysis: (1) Not burnt, (2) Brown, (3) Black, (4) Grey, and (5) White. Blue colour variations were sometimes related with Grey burns, and other with White burns. The same thermo-alteration categories were applied for burnt shell fragments, mostly based on the works developed by Villagran (2014) and Milano et al (2016). Burning identification in crab fragments was done by considering the shell surface, but mainly by confirming the burning on the fragmented sections. Non-burnt crab claws can present a natural dark colour on the outside but not on broken sections, which is usually white or very light coloured. Manganese stains are always patchy, not uniform and do not tend to show on crab claw sections.

9.1.4. Gnawing marks

Carnivore marks were identified according to the categories defined by Binford (1981) and Fisher (1995): punctures, pits, scores, crenulation and digestion. The number of marks, their location on the anatomical element and their distribution (isolated, clustered, crossed) were recorded in the database and photographed. The largest width and length of carnivore punctures were registered in millimetres, as an attempt to narrow down the carnivore producing such marks (Andrés et al, 2012). Note that, traditionally, tooth marks are attributed to non-anthropogenic agents, but experimental work (e.g.

Saladié et al, 2013) has shown that humans might be responsible for some of those marks.

Rodent gnawing was recorded as present or absent, as well as its location on the anatomical element.

Nicholson 1993 Only the results on sheep bones are presented*		**Shipman et al 1984** Experiment made on sheep and goat bones		**Villagran 2014** Experiment made on *Anomalocardia brasiliana* (Gmelin 1791)	
< 300°C	Strong brown	< 285°C	White, pale yellow, yellow	200 – 300°C	Dark brown
300 – 400°C	Black	285 – 525°C	Reddish yellow, reddish brown, dark brown, dark grey	300 – 500°C	Black
400 – 700°C	Grey, light grey	525 – 645°C	Black, blue, yellowish red	500 – 700°C	Grey and dark reddish brown
700 – 900°C	White	645 – 940°C	White, light grey, light blue	> 700°C	Dark grey and white
*Other experiments were made on pigeon bones and five different species of fish. The colours obtained for each of the experiments are all slightly different.		> 940°C	White, some grey and reddish yellow		

Tab. 9.1 – Comparison between three experimental studies exposing mammal bones and mollusc shells to different temperatures.

9.1.5. Abrasion and dissolution

Abrasion is generally identified by the erosion of bone or shell fragments, causing rounding of the edges and polishing of shell sculpture (not to be confused with digestion). It can be caused by exposure to physical processes, such as the wind and sea waves, but also by bioeroders like algae or hermit crabs. Abrasion was recorded as present or absent, as well as its location on the skeletal element (Claassen, 1998; Gutiérrez Zugasti, 2009).

Dissolution is a chemical process frequent in cave environments, where the combination of carbon dioxide and water form an acid solution that can dissolve limestone and other materials, such as bone and shell (Andrews, 1990). It can be identified by the presence of corroded areas on bone and shell surface, colour loss, thinning, chalky appearance and formation of holes and/or perforations (Claassen, 1998; Gutiérrez Zugasti, 2009). Dissolution was recorded as present or absent, as well as it location on the bone or shell.

9.1.6. Encrustation and perforation

Encrustation and perforation were mainly recorded on shells. Encrustation consists on the attachment of different organisms (such as barnacles, bryozoan, algae or other shells) to shell surface. It was recorded as present or absent, its location on the shell and the identification of the organism encrusted (Claassen, 1998; Gutiérrez Zugasti, 2009).

Perforations can result from predator activity, like many spiralled gastropods that bore into living shells for calcium, or to reach the molluscs' soft tissue (Claassen, 1998; Gutiérrez Zugasti, 2009). They can also be due to anthropogenic activity, in order to use shells as pendants (e.g. Bar-Yosef Mayer et al, 2009; Vanhaeren et al, 2006). Recent experimental work conducted by Cabral and Monteiro-Rodrigues (2015) shows that perforations made by predators are extremely regular, which contrasts with the irregularity of anthropic perforations associated with use-wear marks. This is particularly evident in the perforated shells found in the Middle Palaeolithic levels of Qafzeh Cave, Israel (Bar-Yosef Mayer, 2009).

Shells can present several micro-perforations due to organisms like sponges or lichens. Such micro-perforations tend to be concentrated on gastropods' apices and apertures, and on bivalves' umbos. In limpets, they are frequently found on the interior side of the last growth ring (Gutiérrez Zugasti, 2009). Whenever shell perforations were found, their location on the shell was recorded, as well as the number of perforations, maximum length of the perforation in millimetres and the side of the perforation origin (ventral or dorsal).

9.1.7. Other taphonomic processes

Other bone and shell surface modifications were recorded, although no detailed description of their location was given. Other taphonomic processes found were manganese stains, root etching, shell sediment filling and peeling. The latter was mainly identified on mussels, where the outer surface was removed exposing a pearly surface.

9.2. FAUNAL IDENTIFICATIONS

Bone and shell assemblages recovered from both caves were studied and analysed in detail. Every bone and tooth fragment was examined, recorded and counted. Every bone fragment, whether it was triangulated (X, Y, Z) on site or not (i.e. put in general bone bags), was assigned to a unique database number. All bone remains, even if of small size and/or not identified to species or anatomical part, were recorded since they can give valuable information on taphonomic processes. Therefore, indeterminate bone shaft fragments were recorded and considered in the overall counting. Every bone was counted individually even if articulated or fused. Unfused epiphyses were counted individually. Mandibles with teeth were counted as one element, whereas loose teeth were recorded individually. All mollusc, crustacean and echinoderm remains larger than 1 cm or smaller than 1 cm but identifiable to species were also examined, recorded, counted and assigned to a database number. Crustacean and echinoderm fragments smaller than 1 cm but identifiable to class, were also recorded in detail.

Mammal, bird and reptile identifications were made by consulting the Direcção-Geral do Património Cultural (DGPC) Archaeosciences Laboratory (LARC, Lisbon, Portugal) osteological reference collection. Mammal identifications were aided by several osteological atlases, like Callou (1997), Hillson (2005), Lacombat (2005), Lavocat (1966), Louguet (2006), Pérez-Hidalgo and Cobo Rayán (1987), and Schmid (1972). The manuals and atlases used for birds were Catry et al (2010), Cohen and Serjeantson (1996), de Juana and Garcia (2015), Svensson et al (2003), Tomek and Bochenski (2000, 2009). Mammal and bird vertebrae, ribs and shaft fragments are difficult to identify to species, so taxonomic attribution was done only when possible. These elements and all indeterminate remains were assigned to an animal category according to size and class (see section 9.3.1.). Among the reptile assemblage, only Hermann's tortoise (*Testudo hermanni*) was identified. Identification keys, such as the ones provided by Lavocat (1966) Amiranashvili (2000) and the CITES Identification Guide of Turtles & Tortoises (1999), were the ones used (Tab. 9.2). The measurements taken followed Davis (1992) for mammal metapodials and humeri, and von den Driesch (1976) work on macro-mammals and birds. For the latter, the measurements found in several German bird manuals were also used (Bacher, 1967; Erbersdobler, 1968; Fick, 1974; Kellner, 1986; Kraft, 1972; Otto, 1981; Schmidt-Burger, 1982; Woelfle, 1967). For tortoises, the osteometric system used was defined by me, and can be found in Appendix B. All measurements were taken in millimetres using a digital calliper and a measuring box whenever necessary.

Mollusc identifications were conducted in DGPC-LARC, in Lisbon, using part of Pedro Callapez's collection along with my personal reference collection. Methods of analysis and species identifications were complemented by Cabral and Silva (2003), Dupont (2006), Gutiérrez Zugasti (2009), Hayward and Ryland (1995), Kerney and Cameron (1979), Lindner (1976), Saldanha (1995), and Tebble (1966) (Tab. 9.3). The taxonomy of molluscs used the Linnaean designation listed as "accepted" in WORMS (World Register of Marine Species; http://www.marinespecies.org/index.php). Measurements were taken following Gutiérrez Zugasti's (2009) system (Fig. 9.2).

Crab, barnacle and echinoderm analyses were conducted in the archaeomalacofauna laboratory of the Centre de Recherche en Archéologie, Archéosciences, Histoire (CReAAH), in the University of Rennes 1 (Rennes, France). Crab identifications were based on the reference collection and aided by manuals, such as Crothers and Crothers (1988), Gruet (2002), and

Ingle (1996) (Fig. 9.3). The carapace width of *Cancer pagurus* (crab) individuals was estimated from the length of the pincers using a linear regression from measurements made on a sample of 50 individuals from the reference collection (R^2>0.95) (Catherine Dupont, 2015: pers. comm.; Fig. 9.2F). The manual used for barnacle identification was Southward (2008) together with Yves Gruet's personal notes (Gruet 2015: pers. comm.). For echinoderms, identifications were based on Southward and Campbell (2006) and followed Caroline Mougne's (2015) technique of counting pairs of holes in the test.

The portion of the skeletal element present was recorded along with the anatomical part identified. Every element was sided (left, right, indeterminate) and sexed (female, male), whenever possible. Aging was recorded by analysing (1) tooth wear stages on mammals, and (2) the state of fusion of long bone extremities on mammals, birds and tortoises. The different dentine patterns for caprinae followed Payne's (1973, 1987) model. Grant's (1982) dentine patterns were used for suidae and bovinae. Cervidae teeth followed Brown and Chapman's (1990, 1991) scheme, although it was rarely used due to the high amount of calcareous concretion attached to deer mandibles. Long bone fusion was recorded as unfused, fusing or fused in order to estimate age classes like the ones summarised by Reitz and Wing (2008:72) (Fig. 9.1), and comparable among different mammals. For birds and tortoises, fusion was recorded as fusing or fused, since limb bones grow by apposition from the shaft to the extremities (Serjeantson,

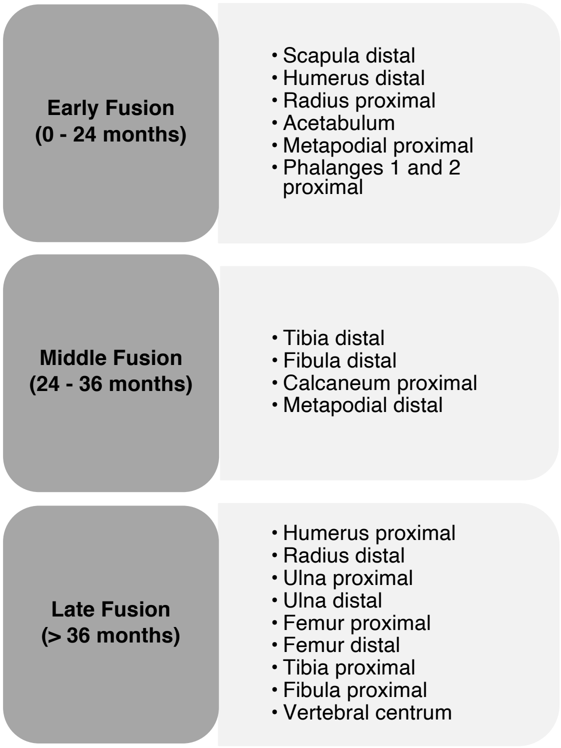


Fig. 9.1 – Time intervals for mammal long bone epiphyseal fusion. Adapted from Reitz and Wing (2008:72).

2009:17). Finally, whenever present, pathologies were recorded in the database and photographed when relevant.

9.3. ANIMAL GROUPS

9.3.1. Animal size

Despite the relatively large amount of unidentified bone and shell fragments, it is still possible to assign such remains to different animal groups. Although they are not anatomically or taxonomically identifiable, the shape and thickness of most fragments allows their assignment to a size category. Therefore, eleven main animal size categories were created, adapted from the model used by Blasco and Fernández-Peris (2012a:17), Bunn (1986:676), and Díez et al, (1999:626):

(1) Very Large Macrofauna: mammals larger than 1,000 kg (e.g. elephant, rhino)
(2) Large Macrofauna: mammals from 300 to 1,000 kg (e.g. horse, auroch, bear)
(3) Medium Macrofauna: mammals from 100 to 300 kg (red deer and generic cervids)
(4) Small Macrofauna: mammals from 20 to 100 kg (e.g. chamois, ibex, hyena, wolf)
(5) >Very Small Macrofauna: indeterminate mammal remains impossible to attribute to one of the animal groups but clearly larger than 20 kg
(6) Very Small Macrofauna: animals smaller than 20 kg (e.g. lynx, cat, fox, rabbit, tortoise)
(7) Indeterminate Macrofauna: indeterminate remains impossible to attribute to one animal group; generally remains heavily fragmented
(8) Birds: all different sizes of birds
(9) Molluscs: bivalves and gastropods, both marine and terrestrial

(10) Crustaceans: crabs and barnacles
(11) Echinoderms: all kinds of sea urchins

To be noted that due to the size overlap of several mammal bones from different categories – e.g. it is impossible to distinguish between fragments of ribs from small and medium macrofauna – the >Very Small Macrofauna group will inevitably include a substantial amount of remains. Nevertheless, the animal size categories created facilitate an overall understanding of the whole faunal collections since it integrates all remains analysed, whether they are identifiable or non-identifiable to species. It also benefits inter- and intra-site comparisons.

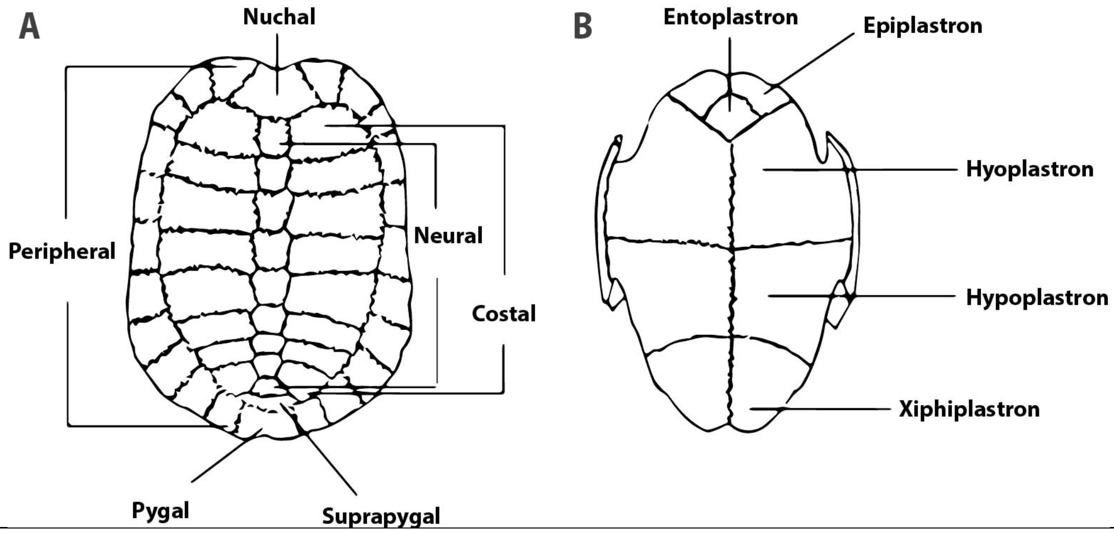
9.3.2. Feeding and locomotion behaviours

Analysis of the wide spectrum of taxa identified from both caves was also made by grouping animals according to their behaviour, mainly based on their feeding habits and locomotion. Such functional classes, alongside bone surface modifications, contribute to the identification of agents of accumulation. For instance, if there is a high concentration of carnivores in a specific layer, maybe the cave was used as a carnivore den during the deposition of such sediments; or, the large amount of diurnal raptors can suggest the presence of a colony.

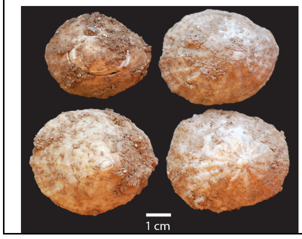
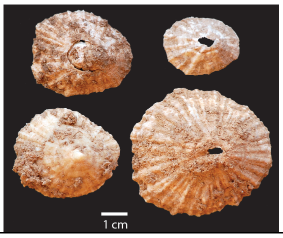
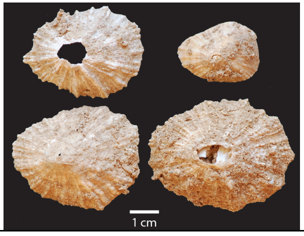
Mammals and reptiles were classified according to feeding behaviours, resulting in three groups (Tab. 9.4). Herbivores include all ungulates, or hoofed animals (e.g. horse, auroch, deer). Boar and bear are considered as omnivores, and carnivores refer to all species that are exclusive meat eaters, such as lions, hyenas or wolves.

For birds, a mixed system was used for their aggregation adapting from the model proposed by Bovy (2002, 2012). Feeding, locomotion and escaping

Testudo graeca (Linnaeus, 1758)	***Testudo hermanni*** (Gmelin, 1789)
Carapace	
• Nuchal bone is hexagonal	• Nuccal bone is octagonal
• Pygal bone is not divided by a sulcus	• Pygal bone is divided by a sulcus
Plastron	
• Epiplastron with a well-developed lip	• Epiplastron with non-developed lip
• Epiplastron with a sulcus matching with the edge angle, which goes inside	• Epiplastron with a sulcus matching with the edge angle, which goes outside
• Entoplastron has no sulcus on its distal end	• Entoplastron with a sulcus on its distal end
• Hyoplastron has a straight distal edge	• Hyoplastron has a curved distal edge
• Hypoplastron has a straight proximal edge	• Hypoplastron has a curved proximal edge
• Hypoplastron has a distal sulcus touching the distal edge	• Hypoplastron has a distal sulcus, which does not touch the distal edge
• Hypoplastron has a distal-lateral edge curving in a L-shape	• Hypoplastron has a distal-lateral edge, which curves in a S-shape
• Xiphiplastron has a sulcus curving at its end	• Xiphiplastron has a sulcus, which does not curve at its end



Tab. 9.2 – Summary of tortoise identification keys based on descriptions from Amiranashvili (2000) and on the analysis of tortoise skeletal bones. A) Tortoise carapace. B) Tortoise plastron. Image adapted from Blasco (2008:2841).

Patella vulgata (Linnaeus, 1758)	***Patella depressa*** (Pennant, 1777)	***Patella ulyssiponensis*** (Gmelin, 1791)	***Patella rustica*** (Linnaeus, 1758)
• High and conical shell with a pointy apex	• Flat and conical shell	• Moderately high and conical shell	• High and conical shell
• Apex central or slightly anterior	• Apex well below the middle of the shell	• Apex clearly anterior to mid-line	• Apex is slightly anterior
• Ellipsoidal outline	• Ellipsoidal-triangular outline	• Ellipsoidal-triangular outline	• Rounded or oval outline
• Shell margins slightly indented	• Shell margins with pointy extensions connected to rays	• Shell margins are finely crenulated	• Shell margins tend to be eroded
• External surface either smooth or with flat and spaced ribs	• External surface with few but prominent ribs	• External surface with several closely spaced, well-marked ribs of unequal size	• External surface with small black granules
• External surface with only few ribs	• Ribs subdivide halfway the external surface	• External pattern of alternating single and triple ridges	• External surface with several radiating ribs
 	 	 	

Tab. 9.3 – Summary of limpet identification keys for species separation based on Cabral and Silva (2003), Hayward and Rayland (1995) for *Patella vulgata*, *Patella depressa* and *Patella ulyssiponensis*; and based on Côrte-Real et al (1996) for *Patella rustica*.

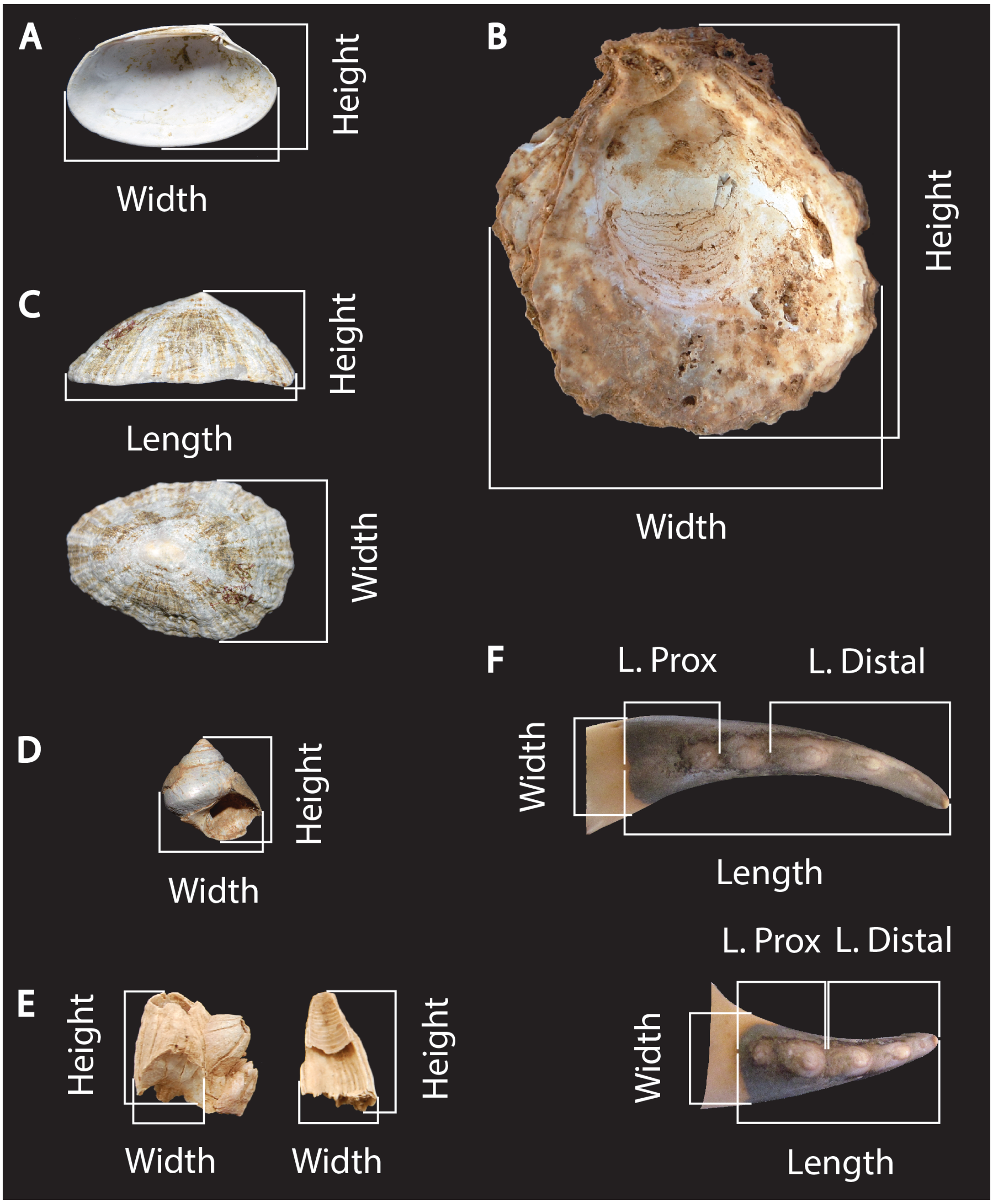


Fig. 9.2 – Biometry for molluscs and crustaceans. A-B) Bivalves of small and large sizes, such as (A) clams and (B) oysters). C) Non-spiralled gastropods, like limpets. From top to bottom, limpet on lateral side and on dorsal side. D) Spiralled gastropods, such as the periwinkle. E) Barnacles. From left to right: measurements taken on a complete barnacle test (note that there are three complete individuals attached), and measurements taken on a complete plate. F) Crabs. From top to bottom: measurements taken on the dactylopodus (flexible finger), and on the propodus (unmovable finger).

Fig. 9.3 – Distinctions between crab species based on claw morphology. In some species, left and right claws show some differences, but in other species claws have similar morphologies. A-D) *Pachygrapsus marmoratus* left propodus (A), left dactylopodus (B), right dactylopodu (C) and right propodus (D). E-H) *Carcinus maenas* left propodus (E), left dactylopodus (F), right dactylopodus (G) and right propodus (H). I) *Maja squinado* right claw right dactylopodus, right claw on anterior side, right claw on dorsal side and right propodus. J-K) *Cancer pagurus* right dactylopodus (J) and right propodus (K).

strategies were considered together forming 14 bird groups. Terrestrial birds were clustered as partridges, passeriformes (small size birds, generally not identifiable to species), cuckoos, corvids, woodcocks, diurnal raptors (vultures, kites, falcons) and nocturnal raptors (all kinds of owls). Marine species were grouped mainly due to their type of locomotion and escaping techniques as dabblers (ducks, geese, swans), divers (gannets, cormorants, loons, sea ducks, grebes), pelagic (shearwater, albatross), alcids (puffins, auks), sandpipers, gulls (gulls, jaegers, terns) and wading birds (herons, storks, ibises) (Tab. 9.5).

For small prey, Stiner's (Stiner et al, 1999, 2000) system was considered. It distinguishes between fast small prey (such as birds, rabbits and crabs) and slow small prey (tortoises, molluscs and barnacles) (Tab. 9.6).

9.4. HABITAT DEFINITION

In order to better assess the different animal physiognomies and their ecological areas around the caves in study, the identified taxa were organised by type of environment: terrestrial or marine. For a more detailed understanding of the different ecologies neighbouring the caves, animal species were further organised according to their habitats. They were defined as intertidal (high, medium and low), marshland, rocky shore, rocky cliffs, heathland and woodland (Tab. 9.7) adapting from the system used by the Joint Nature Conservation Committee (2010). A more detailed insight was given to the marine malacofauna, following Gutiérrez Zugasti (2009) and Dupont (2011), since a wide variety of ecological niches can be found within the intertidal zone (Tab. 9.8)

The intertidal zone is the shore area lying between high and low tide. It is a transitional area between marine and terrestrial conditions and, thus, abundant in life. Depending on the amount of air exposure, the intertidal can be considered high (with significant air exposure), medium and low. Consequently, different environments can be found within the distance of just a few centimetres, which results in the presence of a wide variety of organisms adapting to very specific habitats (Nybakken, 1997).

The intertidal zone can have a sandy substrate that is here defined as shallow water with sand. In this habitat species are prone to bury themselves in the sand. That is the case of the shells from the *Donax* genus, which are small, edible saltwater clams frequently found in the low tide. Many other small organisms populate this habitat (e.g. talitrid amphipods or cirolanid isopods), thus becoming highly attractive to some birds (Nybakken, 1997).

Within the intertidal zone, rocky shores are the ones with highest species diversity. It is striking the different horizontal bands of organisms succeeding one another vertically. This phenomenon is called zonation and is dependent on the slope of the rocky surface, tidal range and exposure to wave activity. Generally, in a temperate system like the Portuguese shore, it is expected to find littorine molluscs on a supralittoral fringe; limpets, trochids and crabs on the midlittoral (Tab. 9.8); and sea urchins on the infralittoral fringe. However, this is a highly simplified scheme and will vary according to each species characteristics, and reproduction cycles. A common feature of rocky shores is the formation of tide pools that can be of variable sizes, depths and locations (Nybakken, 1997).

High limestone escarpments are here defined as rocky cliffs and they can be identified adjacent to both caves. Due to their richness in a basic substrate, they tend to have a very specific flora growing in between their creeks. Some examples are the endemic species of *Silene longicilia* and *Antirrhinum linkianum* (Silva Alves et al, 2009). These habitats are favourable to a wide variety of bird species, mainly birds of prey and corvids. Nowadays, at Gruta da Figueira Brava, the cliffs face the sea which is responsible for their erosion; at Gruta da Oliveira, cliffs are part of the karst system associated with the spring of River Almonda.

Wide tide amplitude is common in most Portuguese estuaries that are rich in organic and mineral nutrients that become preferential areas for animal communities to feed, reproduce and seek shelter. This is particularly evident for fishes, molluscs, crabs, amphibians and a wide variety of birds. Marshland is characterised by its muddy or sandy substrate with a broad spectrum of vegetation ranging from fixed and fluctuant algae to halophyte vegetation that tolerates permanent wet sediment and some degree of water salinity (Silva Alves et al*,* 2009).

Heathland is a shrubland habitat characterised by open, low growing woody vegetation featuring sclerophyllous evergreen leaves tolerant to hot dry summers and mild wet winters. Its typical forma in a Mediterranean climate is also referred to as “maquis”; and if it becomes arborescent, it is generally called as “matorral”. Both caves are located in relatively dry areas with a limestone substrate favourable to the presence of different kinds of heather, lavender and thyme. The vegetation tends to fall in the classes of *Calluno-Ulicetea, Cisto-Lavanduleta* and *Rosmarinetea officinalis.* Insects are prolific in such habitat, which attract a wide variety of birds and tortoises. Rodents and rabbits are common mammal residents, and foxes and wild boar can also be found. (Silva Alves et al, 2009).

The term woodland is understood as a habitat formed by trees, or a low-density forest where there is sunlight and limited shade. Woodlands in the present surroundings of both caves in Serra da Arrábida and Serra d’Aire and Candeeiros are highly dominated by oaks, such as *Quercus faginea* and *Quercus coccifera* (Silva Alves et al, 2009).

Feeding Groups	Taxa identified
Herbivores	*Stephanorhinus* cf. *hemitoechus* *Equus caballus* *Bos primigenius* *Cervus elaphus* *Capra pyrenaica* *Lepus* sp. *Oryctolagus cuniculus* *Testudo hermanni*
Omnivores	*Ursus arctos* *Sus* sp. *Martes* sp.
Carnivores	*Panthera leo* *Panthera* cf. *pardus* *Crocuta crocuta* *Canis lupus* *Felis sylvestris* *Lynx pardinus* *Vulpes vulpes*

Tab. 9.4 – Feeding behaviour groups of mammals and reptiles found in Gruta da Oliveira and Gruta da Figueira Brava.

Small Prey Locomotion	Taxa identified
Slow Small Prey	*Testudo hermanni* Molluscs (all species) *Perforatus perforatus*
Fast Small Prey	*Oryctolagus cuniculus* *Lepus* sp. Birds (all species) Crabs (all species)

Tab. 9.6 – Small prey locomotion groups (including mammals, reptiles, molluscs and crustaceans) found in Gruta da Oliveira and Gruta da Figueira Brava.

Bird Groups	Taxa identified
Partridges	*Alectoris rufa*
Passeriformes	Turdidae *Hirundo rustica*
Cuckoos	*Cuculus canorus*
Doves	*Columba livia*
Corvids	*Corvux corax* *Corvus corone* *Corvus monedula* *Pyrrhocorax pyrrhocorax* *Pica pica* *Cyanopica cooki* *Garrulus glandarius*
Woodcocks	*Scolopax rusticola*
Diurnal Raptors	*Accipiter nisus* *Milvus migrans* *Gyps* sp. Accipitridae *Falco subbuteo*
Nocturnal Raptors	*Athene noctua* *Asio flammeus*
Dabblers	*Anas platyrhynchos* *Anser* sp.
Divers	*Melanitta nigra* *Morus bassanus* *Phalacrocorax aristotelis* *Phalacrocorax carbo* *Gavia stellata*
Pelagic	*Puffinus puffinus*
Alcids	*Pinguinus impennis* *Alca torda* *Uria aalge* *Cepphus grylle* *Fratercula arctica*
Sandpipers	*Calidris* sp.
Gulls	*Larus canus* *Sterna hirundo*
Wading Birds	*Egretta garzetta*

Tab. 9.5 – Terrestrial and marine birds found in Gruta da Oliveira and Gruta da Figueira Brava grouped based on a mixed system that considers feeding, locomotion and escaping strategies.

Type of Habitat		**Taxa identified**	
Shallow water with sand		Marine Molluscs *Cancer pagurus* *Carcinus maenas* *Melanitta nigra* *Calidris* sp.	
Rocky shore		Marine Molluscs *Cancer pagurus* *Maja squinado* *Carcinus maenas* *Pachygrapsus marmoratus* *Eriphia verrucosa* *Vulpes vulpes*	*Morus bassanus* *Phalacrocorax aristotelis* *Phalacrocorax carbo* *Gavia stellata* *Puffinus puffinus* *Pinguinus impennis* *Alca torda* *Uria aalge* *Cepphus grylle* *Fratercula arctica* *Larus canus* *Sterna hirundo*
Rocky cliff		*Capra pyrenaica* *Columba livia* *Corvus corax* *Corvus corone* *Corvus monedula* *Pyrrhocorax pyrrhocorax*	*Milvus migrans* *Gyps* sp. Accipitridae *Athene noctua* *Hirundo rustica*
Marshland		*Canis lupus* *Vulpes vulpes* *Felis sylvestris*	*Scolopax rusticola* *Anas platyrhynchos* *Anser* sp. *Egretta garzetta*
Heathland		*Stephanorhinus* cf. *hemitoechus* *Equus caballus* *Bos primigenius* *Sus* sp. *Capra pyrenaica* *Lepus sp.* *Oryctolagus cuniculus* *Crocuta crocuta* *Panthera leo* *Panthera* cf. *pardus*	*Canis lupus* *Vulpes vulpes* *Felis sylvestris* *Lynx pardinus* *Alectoris rufa* *Asio flammeus* *Falco subbuteo* *Testudo hermanni*
Woodland		*Ursus arctos* *Equus caballus* *Bos primigenius* *Cervus elaphus* *Martes* sp. *Panthera* cf. *pardus* *Canis lupus* *Vulpes vulpes* *Felis sylvestris* *Lynx pardinus*	*Garrulus glandarius* *Cyanopica cooki* *Pica pica* *Accipiter nisus* *Falco subbuteo* Turdidae

Tab. 9.7 – Types of habitat found in the surroundings of Gruta da Oliveira and Gruta da Figueira Brava, and the associated taxa identified from zooarchaeological analysis. Some species are found in several habitats and are highly dependent on available prey (e.g. wolves and foxes). Note that some taxa may occur in different habitats when outside the Mediterranean region (e.g. brown bear).

	Substrate	Open Coast					Estuary				
		Supra littoral	Intertidal			Subti dal	Supra littoral	Intertidal			Subti dal
			High	Medium	Low			High	Medium	Low	
Gastropoda											
Patella vulgata	Rock		▨	▨				▨	▨		
Patella depressa	Rock		▨	▨							
Patella ulyssiponensis	Rock				▨						
Patella rustica	Rock		▨								
Phorcus lineatus	Rock		▨	▨							
Steromphala cineraria	Rock/Sand				▨	▨				▨	▨
Steromphala umbilicalis	Rock		▨	▨				▨	▨		
Littorina obtusata	Rock		▨	▨					▨		
Littorina littorea	Rock		▨	▨				▨	▨		
Littorina saxatilis	Rock	▨	▨				▨	▨			
Melarhaphe neritoides	Rock	▨	▨					▨			
Bittium reticulatum	Sand			▨	▨					▨	▨
Charonia lampas	Rock/Sand				▨	▨					
Nucella lapillus	Rock			▨	▨				▨	▨	
Ocenebra erinaceus	Rock			▨	▨	▨		▨	▨	▨	▨
Tritia reticulata	Sand		▨	▨	▨	▨		▨	▨	▨	▨
Euspira guilleminii	Sand		▨	▨	▨	▨					
Bivalvia											
Glycymeris glycymeris	Sand					▨					
Mytilus galloprovincialis	Rock			▨	▨				▨	▨	
Ostrea edulis	Rock/Sand/Mud							▨	▨	▨	
Pecten maximus	Sand/Mud					▨					▨
Anomia ephippium	Rock				▨	▨					▨
Laevicardium crassum	Sand					▨					
Cerastoderma edule	Sand/Mud		▨	▨	▨			▨	▨	▨	▨
Callista chione	Sand					▨					
Ruditapes decussatus	Sand/Mud							▨	▨	▨	▨
Lutraria lutraria	Sand					▨					▨
Spisula solida	Sand					▨					
Scrobicularia plana	Mud							▨	▨	▨	
Ervilia castanea	Sand				▨	▨					
Solen marginatus	Sand/Mud				▨	▨				▨	▨

Tab. 9.8 – Ecology of the molluscs found in Gruta da Figueira Brava, showing their habitat preferences (represented in grey) in terms of substrate (rock, sand, mud), type of coast (open coast, estuary) and shore levels (from supralittoral to subtidal).

CHAPTER 10

ZOOARCHAEOLOGICAL AND PALAEOECOLOGICAL QUANTIFICATION

10.1. NUMBER OF IDENTIFIED SPECIMENS (NISP)

The basic counting for bones and shells is the Number of Identified Specimens (NISP) per taxon. The NISP was calculated for every taxon and animal category. The NISP is a standard procedure in zooarchaeology, but it is highly sensitive to fragmentation, it does not discriminate bone parts counted and, therefore, it does not demonstrate if the fragments counted belong to the same faunal remain. Thus, different fragments can be from the same bone/shell (Grayson, 1984; Lyman, 2008). The Minimum Number of Elements (MNE) was not calculated since it provides virtually identical results to the NISP, and there is a predictable relationship between the two measures (Grayson & Frey, 2004:27).

10.2. MINIMUM NUMBER OF INDIVIDUALS (MNI)

Considering NISP limitations, the Minimum Number of Individuals (MNI) is used as a complementary measure since it is calculated from a single non-repetitive element. The MNI is not as affected by fragmentation as NISP and it is useful for comparing different animal categories (e.g. shells fragment more easily than bones, so the NISP can give the impression that they are more frequent than mammals in the assemblage). The MNI is particularly relevant when used with the NISP, in order to better assess fragmentation (Stiner et al, 2003). However, MNI is based on the premise that complete animals were brought to the site rather than selected body parts. Moreover, it has a tendency to under-represent common species, whereas rarer animals are over-inflated (Grayson, 1984; Lyman, 1994, 2008).

The MNI calculations for bones followed an adapted version of White's (1953) technique that only considers bones identified anatomically and taxonomically. Every bone was assigned to one side, considering the portion of the bone present (i.e. proximal, proximal + shaft, diaphysis, distal, distal + shaft, complete), and the left or right element showing the highest frequency was considered to be the MNI for the species. White's method does not take age or sex into account, but for the present study such information was taken into account. For tortoises, the MNI was calculated based on limb bones. Tortoise shell fragments are difficult to side due to fragmentation and the heavy concretions attached, so they were not used for MNI, even though they are the best skeletal part represented.

The MNI for gastropods considered fragments where the apex was present. For limpets, remains such as body complete, body fragmented and apical fragments were the ones used. For spiralled gastropods, complete and fragmented bodies were used, as well as the apical-umbilicus fragments, and the ones showing the highest figures between apical fragments and body whorl fragment or umbilicus fragment (Gutiérrez Zugasti, 2009). For bivalves, the shell parts counted were: valve complete, valve fragmented, umbo complete fragments, umbo posterior fragments or umbo anterior fragments (whichever was the highest). Every fragmentation category was divided by left or right, and summed. The one with the highest figure (left or right) was the one considered as the MNI for that species (Dupont, 2006; Gutiérrez Zugasti, 2009). Shell size or attempts of valve-pairing (e.g. Koike, 1979) were not taken into consideration for MNI calculations.

For barnacles, the MNI was based on the amount of complete tests. For crabs, it was calculated based on the highest number of left or right propodus or dactylopodus or mandibles (in rare cases). Thus, in a hypothetical assemblage of three left propodus, one right propodus, seven left dactylopodus and five right dactylopodus, the MNI would be seven. A similar technique was used for echinoderms based on the bones of the Aristotle's lantern. Considering that only one hemipyramid was found, MNI calculations were based on that element.

10.3. MINIMAL ANIMAL UNITS (MAU)

White's final goal for using MNI was not to estimate taxonomic abundance but to calculate meat weight provided by each species (Grayson, 1984:27; Lyman, 2008:42). However, the Minimum Animal Units (MAU) developed by Binford (1978, 1984), was more interested in studying butchery practices, like dismembering and transporting bones, as well as rates of skeletal part's survivorship (Lyman, 2004). His way of calculating the MAU is more standardised and consists on dividing the number of each identifiable element by the number of times it occurs in the body of the animal. Hence, in a hypothetical assemblage of three left tibias and seven right tibias, the MAU would be five, whereas the MNI would be seven. The same procedure was used for mammals, birds, molluscs, crustaceans and echinoderms. For crabs, the elements used were propodus, dactylopodus or mandibles. For barnacles, whenever complete tests were not present, plates were counted and divided by six (the amount of plates in a complete test).

For tortoises, MAU was calculated based on shell remains. Once MAU does not take sides into account, and shell fragments are the most representative elements of tortoises, it is considered to be more accurate to calculate MAU based on shell fragments than on limb bones. This was done by dividing the number of shell fragments by the number of bone plates present in the carapace and plastron.

10.4. WEIGHT

It is common to weigh the faunal remains being analysed. This is frequent in archaeomalacofaunal studies so that taxa abundances and meat weights can be estimated. As noted by Glassow (2000), weight is the measurement used in dietary studies including shellfish and other resources. It is particularly relevant when the assemblages are small, or if the material is highly fragmented. Moreover, using weight is beneficial for site comparisons, since most studies include this measurement in their analyses.

However, weight can become an unreliable measure when there are leaching processes identified that result in missing mass of shell on site (Bailey, 1975). Moreover, rates of shell dissolution and fragmentation are largely variable between different taxa, and there are significant differences in the weight of different taxa. For instance, 100 g of oyster can be related to one individual, but 100 g can correspond to 20 individuals of mussels (Mason et al, 1998). In addition, in terms of weight-to-meat ratios, it should be taken into account that some shellfish have large shells but are low in edible flesh, whereas others have small shells but large amounts of flesh (Meighan, 1972). Therefore, these weight-to-meat ratios are not linear, as well demonstrated by Casteel (1978) for vertebrates, in which the percentage of an animal's bone weight decreases as meat weight increases. As such, Mason et al (2000) agree that shell weight is not a useful measure since it can bias our understanding of the marine habitats being exploited, changes in local environments and identification of anthropogenic overexploitation of certain taxa.

In this study, weight measures were excluded. Despite the arguments presented above, the most determining factor for such a decision is related to cave dynamics. Bones and shells deposited in caves are exposed to calcareous precipitation, which tends to attach to archaeological finds. It is also frequent to find faunal remains glued to stalagmitic crusts or filled with concretionated sediments. All these situations result in a dramatic increase of weight of the finds recovered. Even though some of these external elements can be removed in the lab, the most common situation is to not be able to remove them completely. It could be argued that since all bones and shells were exposed to the same cave dynamics, then the increase in weight would be similar to all remains. However, that is not the case, since some finds can show just some fine calcareous coating, whereas others can be attached to a stalagmitic block.

10.5. LEPORID SKELETAL INDEXES

In order to distinguish the taphonomic signatures of different predators (including humans, raptors and carnivores) on leporid assemblages, several actualistic studies have been conducted in the past 15 years (see mostly references related with the work conducted by Lluis Lloveras). They aim to put forward a series of criteria in order to identify the agent of leporid bone accumulation. Within such an integrated analysis, it is of relevance to conduct quite detailed skeletal part investigation. Therefore, the proportion of leporid skeletal elements were assessed using the ratios described by Lloveras et al (2020):

$$\mathrm{PCRT/CR} = [(\mathrm{PCRT} \times 32)/((\mathrm{PCRT} \times 32) + (\mathrm{CR} \times 184))] \times 100$$

In which the PCRT is the total number of postcranial elements (limbs, vertebrae and ribs), and CR the total number of cranial elements (mandibles, maxillae and teeth).

$$\mathrm{PCRAP/CR} = [(\mathrm{PCRAP} \times 32)/((\mathrm{PCRAP} \times 32) + (\mathrm{CR} \times 114))] \times 100$$

With PCRAP being the total number of limb elements (long bones, scapulae, pelves, patellae, metapodials, carpals, tarsals and phalanges).

$$\mathrm{PCRLB/CR} = [(\mathrm{PCRLB} \times 32)/((\mathrm{PCRLB} \times 32)+(\mathrm{CR} \times 10))] \times 100$$

In which the PCRLB is calculated as the total number of long bones (humerus, radius, ulna, femur and tibia).

$$\mathrm{AUT/ZE} = [(\mathrm{AUT} \times 12)/((\mathrm{AUT} \times 12) + (\mathrm{ZE} \times 98))] \times 100$$

With AUT being the autopodia (metapodials, carpals, tarsals and phalanges) and ZE the zeugopodia and stylopodia (tibiae, radii, ulnae, humeri, femora and patellae).

$$Z/E = [(Z \times 4)/((Z \times 4) + (E \times 6))] \times 100$$

With Z referring to the zeugopodia (tibiae, radii and ulnae), and E to the stylopodia (femora and humeri).

$$AN/PO = [(AN \times 12)/((AN \times 12) + (PO \times 16))] \times 100$$

In which the AN represents the number of scapulae, humeri, radii, ulnae and metacarpals, and PO the pelves, femora, tibiae and metatarsals.

10.6. BIRD SKELETAL INDEXES

Even though they were often criticised (Bochenski, 2005; Livingstone, 1989; Laroulandie, 2000; Serjeantson et al, 1993), several bird indexes were calculated in order to better assess body part representation on birds. Such indexes contribute to the identification of the agent of bird bone accumulation since different predators have different skeletal preferences. Rufà et al (2016a, 2016b) summarised the experimental work of several researchers on such preferences. For instance, if dealing with an assemblage accumulated by an eagle owl, it is expected to find light to moderate digested bones with more wings than legs, more limbs than core bones, more proximal bones than distal ones, and a predominance of elements such as the tarsometatarsus, the humerus and the carpometacarpus. Conversely, if the bird assemblage is dominated by non-digested bones with more legs than wings, more core bones than limbs, more proximal bones than distal ones, and a preference for ribs, synsacrum and the pelvic girdle, it is most probably a bird assemblage accumulated by a lynx.

The indexes were calculated for complete animals for each bird group. These results allowed understanding what is expected in an untouched natural complete skeleton deposition. With such baseline it then becomes easier to read if, for example, there are more wings or more legs than expected. In order to get relevant and comparable results, the different indexes were applied to the bird groups described before (Chapter 9, Tab. 9.5). For Gruta da Figueira Brava, such groups were separated between reworked and MIS-5 levels, whereas in Gruta da Oliveira they were analysed by natural layers.

The core-to-limb ratio was computed following Bramwell et al (1987) and Bochenski (2005), by dividing the total number of core elements in the skeleton (sternum, coracoid, pelvis and scapula) by the sum of core and limb bones (humerus, femur, radius, ulna, tibiotarsus, carpometacarpus and tarsometatarsus), which can be expressed as a percentage if multiplied by 100:

$$[\Sigma \text{ core bones} / (\Sigma \text{ core} + \Sigma \text{ limb bones})] \times 100$$

In the same way, Bochenski and Nekrasov (2001) described the proximal-to-distal bones ratio as the number of proximal elements (scapula, coracoid, humerus, femur and tibiotarsus) divided by the sum of all proximal and distal bones (ulna, radius, carpometacarpus and tarsometatarsus), which can be multiplied by 100:

$$[\Sigma \text{ proximal bones} / (\Sigma \text{ proximal} + \Sigma \text{ distal bones})] \times 100$$

The wing-to-leg ratio was defined by Ericson (1987) and it consists on dividing the total amount of wing bones (humerus, ulna and carpometacarpus) by the sum of both wings and legs (femur, tibiotarsus and tarsometatarsus) identified. In order to get a relative frequency, such result should be multiplied by 100:

$$[\Sigma \text{ wing bones} / (\Sigma \text{ wing} + \Sigma \text{ leg bones})] \times 100$$

Finally, the distal-to-proximal wing ratio was defined by Bovy (2012) in her attempt to identify the use of bird skins, which would be clear by the presence more distal wing bones than expected. The index is calculated by dividing the amount of distal wings (carpometacarpus and wing digit) by the total of distal and proximal wings (humerus, radius and ulna), multiplying by 100 for relative frequency:

$$[\Sigma \text{ distal wing bones} / (\Sigma \text{ distal wing} + \Sigma \text{ proximal wing bones})] \times 100$$

Due to the relatively small size of some bird assemblage, and the commonly overlapping patterns of different agents of bird bone accumulation, it is important to work with a combination of different ratios. Moreover, other evidence should come into play, such as predator/raptor marks, anthropogenic marks, patterns of breakage, bone density, spatial distribution, presence of juveniles or medullary bones. Only in an integrated manner will it be possible to assess the agent of bird bone accumulations.

10.7. TORTOISE LOGARITHMIC SIZE INDEX (LSI)

The Logarithmic Size Index (LSI) is used to investigate animal size variability through time and space, when there is a small number of measurable skeletal parts (Meadow, 1999). The basic idea is to relate the archaeological measurements with the respective measurements in a standard animal (Uerpmann & Uerpmann, 1994). This index was particularly relevant for the study of tortoises, since limb bones tend to have a reduced preservation, especially when compared with their shell. For tortoises, the standard animal measurements are the average of the measurements taken by myself to each pair of limb bone elements of one *Testudo hermanni* (UCL 10.022). The fibula is excluded since it was not present in the UCL's tortoise skeleton. The measured animal is of unknown sex, age and origin (Tab. 10.1).

To calculate the LSI, both the archaeological and the standard measurements are transformed into logarithms. Then, each type of standard measurements (e.g. BD or BP) is subtracted from the archaeological measurements:

$$\text{LSI} = \log \text{Archaeological} - \log \text{Standard}$$

The results are gathered in determined intervals and plotted in a histogram, in which the zero line corresponds to the standard animal. Thus, if the archaeological measurement is smaller than the standard, the LSI is negative; if the archaeological measurement is larger than the standard, the LSI is positive (Meadow, 1981, 1999; Uerpmann & Uerpmann, 1994).

As argued by Meadow (1999), length measurements reflect the height of the animal, which is generally used for inferences of sex and breed differences in domestic animals. On the other hand, breadths and depths reflect the body mass. Therefore, length measurements must be studied separately. For the identification of changes in tortoise body size, the LSI is only based on breadths and depths.

Element	Measurements (mm)						
Scapula	GLA = 11,76	Bg = 8,05	Bap = 7,13	Bpr = 6,8			
Coracoid	H = 24,95	GLP = 7,29	BP = 5,99	SL = 3,6			
Humerus	GL = 47,42	GLh = 43,3	BP = 13,44	BPh = 8,26	Dh = 9,85	BD = 11,66	SD = 5,69
Ulna	GLl = 27,25	GLm = 21,1	Bcp = 7,46	BD = 8,5			
Radius	GL = 24,91	GLP = 6,89	BD = 6,95	SD = 3,55			
Ilium	GL = 43,22	GLP = 9,5	BP = 13,82	BD = 11,94	SD = 4,84		
Femur	GL = 42,85	GLh = 43,63	BP = 15,94	Dh = 10,54	BD = 10,99	SD = 4,89	
Tibia	GL = 34,05	GLP = 8,46	BP = 10,32	BD = 6,83	SD = 3,58		

Tab. 10.1 – Measurements (mm) of the standard animal taken by myself. The measurements are the average of the results obtained for left and right sides of a skeleton of *Testudo hermanni* (UCL 10.022). The sex, age and origin of the latter are unknown. The fibula was absent from the skeleton studied.

10.8. LIMPET RATIOS AND EQUATIONS

In order to establish the accurate area of limpet collection (see Tab. 9.7), several ratios and equations were used. The Length/Height (L/H) ratio defined by Craighead (1995) and Bailey and Craighead (2003) was developed based on modern *Patella vulgata* shells collected from the British seashore. The formula was updated and applied to archaeomalacofaunal studies in northern Spain by Gutiérrez-Zugasti (2009, 2010), which is the one used in this study. The L/H ratio is used to differentiate between high and low intertidal zones where limpets were gathered. Therefore, if L/H values are lower than 2.55, limpets were collected from the high intertidal zone. Conversely, if values are higher than 2.55, limpets were collected from the low intertidal zone.

The same L/H ratio was applied to *Patella depressa*. This time, the procedures follow the work of García-Escárgaza (*in press*) on modern shells from northern Spain. The control value for *P. depressa* is 2.99. Hence, if L/H values are lower than 2.99, limpets were collected from the high intertidal. Consequently, values higher than 2.99 reflect limpet collection from the low intertidal zone.

Following from Craighead (1995) and Bailey and Craighead (2003) work, seashore exposure can also be calculated for *Patella vulgata,* based on the following equation:

$$\text{Exposure} = (\text{Length} \times 0.142) - (\text{Height} \times 0.06) + (\text{Width} \times 0.0489) - 5.328$$

Values more positive than -0.15 reflect sheltered shores, whereas results more negative than -0.15 reflect exposed shores.

Such variations are due to shell morphology, which manifests itself with flatter, wider and more elongated limpets on low intertidal zones than those from the high intertidal. Furthermore, limpets from exposed shores tend to be narrower and flatter than those from sheltered areas. Therefore, larger limpets tend to grow on the low intertidal zone on sheltered shores (Bailey & Craighead, 2003).

Limpet meat yield was assessed for *Patella vulgata, Patella depressa* and *Patella ulyssiponensis* based on the work of García-Escárgaza & Gutiérrez-Zugasti (2020) conducted on modern shells collected from Langre Beach, in Cantabria (Spain). Wet and dry meat yields were calculated based on regression equations obtained from modern limpets, which correlate shell size (maximum length in millimetres) with the weight of the animal's flesh. As confirmed by García-Escárgaza & Gutiérrez-Zugasti (2020), all three limpet species show a similar decrease in meat yield after cooking, with a strong correlation between dry and wet meat yield. However, these authors state a stronger correlation between shell size and wet meat yield values; therefore the wet meat yield is preferred even though both measures (wet and dry meat yield) are presented. The equations used were as shown in Tab. 10.2.

Species	**Wet Meat Yield**	**Dry Meat Yield**
Patella vulgata	$0.0771^{(0.0971 \times \text{Length})}$	$0.0533^{(0.0977 \times \text{Length})}$
Patella depressa	$0.0553^{(0.1039 \times \text{Length})}$	$0.0318^{(0.1104 \times \text{Length})}$
Patella ulyssiponensis	(0.1744 x Length) - 4.3185	(0.132 x Length) - 3.273

Tab. 10.2 – García-Escárgaza & Gutiérrez-Zugasti (2020)'s equations for limpet meat yield calculations based on the experimental work conducted on Langre Beach (Cantabria, Spain) and using limpet shell length in millimetres.

Finally, limpet meat yield was also assessed following Thomas & Mannino (2017), in which the MNI of each species is multiplied by the average meat yield obtained for each taxa obtained from the experimental programme developed by García-Escárgaza & Gutiérrez-Zugasti (2020), as shown in Tab. 10.3.

Species	**Mean Wet Meat Yield**	**Mean Dry Meat Yield**
Patella vulgata	1.98 g	1.41 g
Patella depressa	2.02 g	1.47 g
Patella ulyssiponensis	2.02 g	1.54 g

Tab. 10.3 – Average meat yield on wet and dry limpet species based on the experimental work conducted on Langre Beach (Cantabria, Spain) by García-Escárgaza & Gutiérrez-Zugasti (2020).

10.9. MEASURING TAXONOMIC DIVERSITY

The term *diversity* is generally accepted as sample heterogeneity or variability. The diversity of a zooarchaeological assemblage is, therefore, dependent on the amount of the species present and their abundance. These can be translated in ecological terms as *species richness* and *species evenness*. The former relates to the number of species present in a sample; the latter refers to the relative frequency of each species. Therefore, samples with high species richness, have a large number of species represented; whereas samples with high evenness show similar abundance for each species represented, with no clear dominance of a single species. For a sample to be highly diverse it needs to present both high species richness and evenness (Waite, 2000). High species diversity has been traditionally accepted as an indicator of a stable environment. However, recent research has been demonstrating some exceptions to this paradigm (Nybakken, 1997), and the type of variables measured (Lyman 2008) and sample size (Faith & Du, 2018) can also influence the results.

In order to calculate the NTAXA, or the number of identified taxa, which is also called in ecological literature as *species richness*, only one taxonomic level was used, with preference for the genus. As argued by Lyman (2008), the NTAXA can vary if different taxonomic levels (*i.e.* species, genus, family, and so on) are mixed and summed. Therefore, the sum of different taxonomic levels was avoided, so that the same taxon would not be counted twice. The NTAXA is a nominal measure, so whether taxa are present or absent. However, assemblages can have different taxonomic abundances, or *species evenness*, also known as *taxonomic evenness* or *taxonomic equitability*. Therefore, samples with similar NTAXA (or species richness) can have different structures and compositions, different *species evenness*. As such, assemblages are even when each taxon is represented by the same NISP figures, and uneven when each taxon is represented by different NISPs (Lyman 2008). In the present study, the NISP is the quantitative unit of choice for measuring diversity.

As summarised by Faith and Du (2018), “evenness is now routinely examined to understand how climate change influences faunal community structure, to measure dietary specialisation, or to detect changing encounters with high- and low-ranked prey species”. Hence, measuring evenness, has become a standard procedure in faunal studies with several indexes used. However, the authors caution that such indexes are frequently affected by sample size – larger samples tend to have rarer species (and thus driving evenness down), whereas smaller samples have lower species richness but tend to be more even.

10.10. SEDIMENT COMPOSITION ANALYSIS

To assess the relative weight of the Gruta da Figueira Brava deposits' different components (matrix, lithics, bone, shell), ~100 g sub-samples were extracted from the larger field-collected bulk samples. The sub-samples were disaggregated and then passed through a manually shaken sieve column with three mesh sizes: 4 mm, 2 mm, and 1 mm. The material collected in each sieve was then weighed and macroscopically sorted with fine tweezers. This was done by placing the sediment on a white sheet obliquely illuminated by artificial light. After sorting, each category was briefly scanned under a Meiji EM213 TR microscope to decide on instances for which macroscopic examination had been insufficient and to fix any identification errors. The sorted assemblages were weighed on a digital scale with centigram precision. The different steps of the process were photo-recorded with a Leica Wild M3C microscope or a Nikon Coolpix E995 camera. For comparison, the procedure was repeated for bulk samples taken from a Portuguese Mesolithic site the Toledo shell-midden (Araújo, 2011). As published analyses of similar deposits use density (e.g. "N/m^3", or Kg/m^3") to quantify the proportion of given components, the volume of each of our sub-samples had to be derived from the corresponding weight.

Part V

Faunal Remains

This is the longest part of the study and it works as a results section. Considering the variety of remains analysed, each chapter is dedicated to a specific animal group: Mammals (Chapter 11), Birds (Chapter 12), Reptiles (Chapter 13), Molluscs (Chapter 14), Crustaceans and Echinoderms (15). Due to the specificity of each of these animal groups, every chapter has its own literature review, where more detailed research questions are outlined. In each chapter, the results presentation is followed by its own discussion and conclusion. Therefore, each chapter of Part V can work independently from the overall thesis body, even though they are indispensable to the whole thesis discussion (Part VI) and conclusions (Part VII).

CHAPTER 11

MAMMALS

11.1. LITERATURE REVIEW

Some Middle Palaeolithic sites are characterised by faunal assemblages which indicate Neanderthal monospecific hunting (e.g. Adler et al 2006; Costamagno et al 2006; Daujeard et al 2017; Starkowich 2012) and reveal a mass predation strategy that involves pre-planned tactics, collaboration amongst hominin groups, as well as deep knowledge of the landscape and prey behaviour, in order to drive and trap herds in cliffs, gorges or swamps. Some examples of single-taxa accumulations are the saiga from several sites in Crimea (Patou-Mathis 2006), the reindeer from Salzgitter Lebenstedt (Germany; Gaudzinski & Roebroeks 2000), the bison from Mauran (France; Farizy et al 1994), or the aurochs from Biache-Saint-Vaast (Belgium; Auguste 1995). However, Neanderthal exploitation of a range of species of ungulates seems to have been more frequent (e.g. Discamps et al 2011; Gaudzinski-Windheuser & Kindler 2012; Kindler et al 2014; Rosell et al 2012). In the Iberian Middle Palaeolithic, red deer often predominate in faunal assemblages, in which Cervidae, Equidae and Caprinae taxa are regularly found. Conversely, Bovidae, Rhinocerotidae and Suidae are not as abundant. Nonetheless, taxa frequencies tend to vary according to the geographical settings and local environments (Aura et al 2002; Salazar-García et al 2013; Real et al 2018; Sanz et al 2019; Yravedra & Cobo-Sánchez 2015).

Despite numerous studies on Neanderthal skeletal remains characterising their diet as heavily meat oriented, with enriched δ^{15}N isotope values in comparison with other carnivores, such as lions and hyenas (Bocherens et al 2001, 2005, 2014; Richards et al 2000, 2001; Richards & Trinkaus 2009; Jaouen et al 2019), the consumption of several plant foods, depending on the environmental setting hominins were living in, has also been demonstrated (Hardy & Moncel 2011; Hardy et al, 2012, 2013, 2016; Henry et al, 2011, 2014; Weyrich et al, 2017; Zilhão et al, 2020). Several authors have suggested that Neanderthals were commonly inhabitants of woodlands (e.g. Carrión & Walker 2019; Carrión et al 2018, 2019b; Rosas 2016; Stewart et al 2019), but their accomplished adaptation to coastal settings has also been recently shown (Zilhão et al 2020). As a result, it is becoming clearer that Neanderthals adapted to a wide range of environments and were able to build complex and varied subsistence strategies in each territory (Spagnolo et al 2019).

Highlighting the diversity of mammal remains within these broad Neanderthal diets, there is a growing body of evidence showing the inclusion of small mammals in the menu, such as leporids (rabbits and hares). Therefore, a large portion of this chapter will be dedicated to a more detailed discussion of the leporid assemblage. The first known European evidence of rabbit remains showing anthropic marks dates from the Lower Pleistocene and is generally accepted as a cut mark on a bone recovered from Sima del Elefante TE12a (Huguet 2007). The evidence increases with the Middle Pleistocene (e.g. Desclaux 1992; El Guennouni 2001; Sanchis & Fernández-Peris 2008; Blasco & Fernández-Peris 2012a, 2012b), and there are a growing number of leporid studies from Middle Palaeolithic sites (e.g. Cochard et al 2012; Hardy et al 2013; Rufà et al, 2014; Pérez et al 2017; Pelletier et al 2019; Morin et al 2019). Leporids are predominant within Iberian Upper Palaeolithic and Epipaleolithic faunal assemblages, and where Portugal is concerned, leporid hunting has been examined for such periods by Brugal (2006), Carvalho et al (2018), Haws & Valente (2006), Hockett & Bicho (2000), Hockett & Haws (2002), Lloveras et al (2011), Manne & Bicho (2009), Rowley-Conwy (1992), Valente (2004). The European rabbit (*Oryctolagus cuniculus*) tends to play a central role in faunal assemblages with large amounts of remains in the studied collections (Lloveras et al 2009a), which is expected considering that it is endemic to the Iberian Peninsula (Delibes & Hiraldo 1979) with only scarce appearances and colonisations in the south-western part of France prior to 13,000 years BP (Jones 2012; López Martínez 2008).

Leporids are classified by Stiner and colleagues (Stiner et al 1999, 2000; Stiner & Munro 2002) as small fast-moving animals that, due to their locomotion type and quick escape system, require great hunting skills and complex procurement techniques. However, there are researchers arguing against this classification (e.g. Finlayson 2019), with one of the pillars of the argument being based on prey behaviour – i.e. if animal ethology is known, then catching methods can easily be adapted. Independently of the categories used in the study of leporids, the knowledge of prey behaviour and the cognitive abilities related to capture strategies tend to be used to fuel discussions related to modern behaviour (e.g. Stiner et al 1999, 2000; Fa et al 2013; Finlayson 2019; Morin et al 2019). Controversies aside, it is known that rabbits often provide a considerable amount of meat protein in the diet of some populations due to their abundance, quick population turnover, as well as the possibility of storing the excess meat for deferred consumption (Bean 1974; Spier 1978). Therefore, and considering the large amount of actualistic studies published in the last years related to leporid bone accumulations (e.g. Lloveras et al 2008a, 2008b, 2009a, 2009b, 2012a, 2012b, 2014a, 2014b, 2018a, 2018b, 2020), it is relevant to undertake a detailed analysis of leporid remains.

In this chapter, the patterns observed in these leporid studies are used to assess the taphonomy of the remains recovered from Gruta da Figueira Brava and Gruta da Oliveira, in order to identify the agent of accumulation. Zooarchaeological and taphonomic investigation are also applied to the varied taxa of mammals found in these two Middle Palaeolithic caves, allowing to establish the agent(s) of bone accumulation and providing information regarding seasonality, procurement and hunting strategies of the Neanderthal groups from the Last Interglacial in Central Portugal.

11.2. RESULTS

11.2.1. Taxonomic and body part frequencies

11.2.1.1. Carnivores

Bear (*Ursus arctos*) is the best represented carnivore in Gruta da Figueira Brava (Tabs. 11.1, 11.2; Fig. 11.3 F). It is only present in the MIS-5 levels, and it is mostly recognised by its adult teeth (two incisors and seven canines), and a nearly complete atlas, an axis, a thoracic vertebra and a left humerus. Bear vertebral discs are all fused, but the calcareous concretions attached to the humerus do not allow proper observation of the state of long bone fusion. Based on Andrew & Turner (1992), canines only erupt at 14 months, which indicates that the two bear individuals are more than one year old.

Hyenas were also identified in Gruta da Figueira Brava based on two metapodials, a left astragalus and a first phalange. Hyena bones are most probably of *Crocuta crocuta*, considering it is the species that is recurrently found in Middle and Upper Pleistocene caves in Europe (Sanz et al 2016). Additionally, among the 37 carnivore coprolites recovered, only 28 were complete and allowed measurements (Tab. 11.5). Most of them (NISP = 22) can be attributed to hyenas. This is not only due to their spherical morphology, with flattened or concave ends (Horwitz & Goldberg 1989; Larkin et al 2000), but also because their size compares well with that described for *Crocuta crocuta* (Fig. 11.2). However, Fig. 11.2 shows that one very large coprolite is probably of bear due to its proximity to morphotype 3 Furninha. Moreover, apart from an outlier of very small size that does not relate to any of the species presented in Fig. 11.2, there are four other coprolites that cluster within the morphotype 2 coprolites (Sanz et al 2016; Fig. 11.2) and may belong to wolf (*Canis lupus*). Indeed, the wolf is also present in the cave based on the identification of a complete left calcaneum.

As for smaller carnivores, the wildcat (*Felis silvestris*) is well represented in the MIS-5 levels of Gruta da Figueira Brava due to the presence of fused long bones – three metatarsals, a right humerus, a left tibia

– and three maxillary fragments showing permanent teeth. Wildcat presence within the reworked levels is scarce, even though a fused left pelvis and a fragment of right maxilla with permanent premolars 2 and 3 were recorded. As for lynx (*Lynx pardinus*) and fox (*Vulpes vulpes*), they were only confirmed in the MIS-5 levels by the presence of one left upper canine and a right fused fifth metacarpus, respectively.

In Gruta da Oliveira, only three coprolites were recorded. The coprolite from layer 22 has a typical hyena shape, with its globular morphology with a flat bottom and a pointy top, similar to the ones already described for the upper levels of the cave (Zilhão et al 2010a), and in Fig. 11.2 it clusters within the morphotype 1 range as described by Sanz et al (2016). The coprolite from layer 22 was the only one allowing morphometry, matching the size of hyena scats (Fig. 11.2); the remaining coprolites were not measured because they are covered in concretions, or broken. Despite the identification of hyenas through their scats, no skeletal parts of this taxon were recovered from layers 20 to 27.

Only one bear bone was found in Gruta da Oliveira – a left fused proximal tibia, from layer 20 –, which contrasts with the identification of several elements recovered from the upper layers of the cave (Tab. 11.4). Conversely, the lion (*Panthera leo*) is better represented in layer 20 than in any other layers so far analysed (Tabs. 11.3, 11.4). This is due to the presence of several bones that may have belonged to a single paw as shown in Fig. 11.3 B. The presence of leopard (*Panthera* cf. *pardus*) is indicated by the identification of a nearly complete atlas (Fig. 11.3 E).

Amongst the smaller carnivores, wildcat is the best represented (Tabs 11.3, 11.4) with clear predominance of front limbs (one scapula, two humerus, three ulnas), even though hindlimbs were also identified (two femurs, one fibula and one calcaneum). All wildcat bones are fused, except for one proximal femur. Finally, and contrary to what was found in the upper layers of the cave, the bottom layers show limited presence of fox (only one first phalanx), and none of lynx or marten (Tab. 11.4).

11.2.1.2. Ungulates

The most recent excavations at Gruta da Figueira Brava did not recover any remains from the very large size category, even though it is represented in the 1986-89 excavation of Area C by a molar fragment of an elephant (*Elephas antiquus*; Cardoso & Regala, 2001-2002). This tooth fragment displays the calcareous coating characteristic of the Pleistocene remains. The largest species found in the 2010-13 archaeological work is the aurochs, which was recognised by the presence of five fragments of teeth (a permanent molar and incisors), as well as a left naviculo-cuboid, and a fragment of horn core (Tab. 11.1). Equids were also identified mainly based on teeth remains (NISP = 13, from which five are milk teeth; Fig. 11.3 J), one astragalus, two metatarsals and one metacarpal that allowed species identification as *Equus caballus*.

Deer is the best represented ungulate in Gruta da Figueira Brava, and identification as *Cervus elaphus* was possible for the majority of the remains, which suggests that most of the fragments assigned as Cervidae are probably of the same species. Red deer cranial elements predominate – mandibles (NISP = 14), maxillae (NISP = 4), loose teeth (NISP = 37) –, but the appendicular skeleton is also well represented, mostly by phalanges (NISP = 7), hind limbs and tarsals (NISP = 8), and front limbs (NISP = 4) (Fig. 11.4). The state of long bone fusion and dentition indicate that deer of all ages (from juvenile to senile) are represented.

Caprines show similar NISP counts to deer. They were mainly represented by loose teeth (NISP = 69; from which three milk teeth were recorded), two adult mandibles and two adult maxillae. Front and hind limbs are evenly represented by three elements each, as well as two first phalanges that could not be assigned to front or hind legs. All bones are fused, except for a distal humerus. Tooth morphology was explored in order to attempt species identification, and based on the LARC-DGPC reference collection used in Lisbon, Portugal, *Capra ibex* is the best candidate. Finally, boar is the less

	PHASE FB4			PHASE FB3			PHASE FB2			REWORKED			TOTAL		
TAXON	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**
LARGE MACRO-MAMMALS															
Equus caballus	1	1	0.5	-	-	-	-	-	-	-	-	-	**1**	**1**	**0.5**
Equus sp.	14	4	1.91	2	2	0.08	-	-	-	-	-	-	**16**	**6**	**1.99**
Bos sp.	6	3	1.17	-	-	-	-	-	-	1	1	0.03	**7**	**4**	**1.2**
Herbivore	6	-	-	5	-	-	2	-	-	1	-	-	**14**	**-**	**-**
Ursus arctos	9	2	1.5	4	2	1.5	-	-	-	-	-	-	**13**	**4**	**3**
Indeterminate	36	-	-	19	-	-	-	-	-	1	-	-	**56**	**-**	**-**
MEDIUM MACRO-MAMMALS															
Cervus elaphus	53	7	5.5	18	2	1.5	-	-	-	2	1	0.5	**73**	**10**	**7.5**
Cervidae	42	4	3	5	2	1	1	1	0.5	4	2	0.75	**52**	**9**	**5.25**
Herbivore	10	-	-	-	-	-	-	-	-	1	-	-	**11**	**-**	**-**
Indeterminate	81	-	-	8	-	-	4	-	-	2	-	-	**95**	**-**	**-**
SMALL MACRO-MAMMALS															
Caprinae	58	5	4	12	2	1	-	-	-	11	2	1	**81**	**9**	**6**
Herbivore	3	-	-	-	-	-	-	-	-	4	-	-	**7**	**-**	**-**
Sus sp.	4	2	1	1	1	0.06	-	-	-	-	-	-	**5**	**3**	**1.06**
Hyaenidae	3	1	0.5	1	1	0.5	-	-	-	-	-	-	**4**	**2**	**1**
Canis lupus	1	1	0.5	-	-	-	-	-	-	-	-	-	**1**	**1**	**0.5**
Martes sp.	-	-	-	-	-	-	-	-	-	1	1	0.5	**1**	**1**	**0.5**
Carnivore	33	-	-	3	-	-	-	-	-	1	-	-	**37**	**-**	**-**
Indeterminate	165	-	-	21	-	-	3	-	-	31	-	-	**220**	**-**	**-**
> VERY SMALL MACRO-MAMMAL															
Herbivore	24	-	-	4	-	-	-	-	-	3	-	-	**31**	**-**	**-**
Indeterminate	542	-	-	142	-	-	12	-	-	73	-	-	**769**	**-**	**-**
VERY SMALL MACRO-MAMMALS															
Hystrix sp.	1	1	0.5	-	-	-	-	-	-	-	-	-	**1**	**1**	**0.5**
Oryctolagus cuniculus	2	2	1	-	-	-	-	-	-	5	3	2	**7**	**5**	**3**
Lepus sp.	3	2	1	-	-	-	-	-	-	-	-	-	**3**	**2**	**1**
Leporidae	157	13	11.5	3	2	1	-	-	-	290	26	22.5	**450**	**41**	**35**
Erinaceus europaeus	-	-	-	-	-	-	-	-	-	2	1	0.5	**2**	**1**	**0.5**
Felis silvestris	7	5	3	1	1	0.5	-	-	-	2	1	0.5	**10**	**7**	**4**
Lynx pardinus	1	1	0.5	-	-	-	-	-	-	-	-	-	**1**	**1**	**0.5**
Vulpes vulpes	1	1	0.5	-	-	-	-	-	-	-	-	-	**1**	**1**	**0.5**
cf. *Vulpes vulpes*	-	-	-	-	-	-	-	-	-	1	1	0.5	**1**	**1**	**0.5**
Carnivore	-	-	-	-	-	-	-	-	-	2	-	-	**2**	**-**	**-**
Indeterminate	480	-	-	28	-	-	-	-	-	344	-	-	**852**	**-**	**-**
INDETERMINATE MACRO-MAMMALS															
Indeterminate	1989	-	-	105	-	-	1	-	-	304	-	-	**2399**	**-**	**-**
TOTAL	**3732**	**55**	**37.58**	**382**	**15**	**7.14**	**23**	**1**	**0.5**	**1086**	**39**	**28.78**	**5223**	**110**	**74**

Tab. 11.1 – Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimal Animal Units (MAU) of macro-mammals recovered from Gruta da Figueira Brava.

	PHASE FB4				PHASE FB3		TOTAL
TAXON	**IH2-IH3**	**IH4**	**IH6**	**IH8**	**IL2**	**IL3**	
UNGULATES							
Horse	7	2	2	4	1	1	**17**
Aurochs	3	-	2	1	-	-	**6**
Deer	16	27	20	32	9	14	**118**
Caprine	9	1	13	35	8	14	**80**
Boar	-	1	-	3	-	1	**5**
LAGOMORPHS							
Hare or Rabbit	53	38	50	21	1	2	**165**
LARGE CARNIVORES							
Bear	-	-	1	8	3	1	**13**
Hyena	-	-	-	3	1	-	**4**
Wolf	-	-	-	1	-	-	**1**
SMALL CARNIVORES							
Wildcat	1	-	6	-	1	-	**8**
Lynx	-	-	-	1	-	-	**1**
Fox	-	1	-	-	-	-	**1**

Tab. 11.2 – Number of Identified Specimens (NISP) of macro-mammals recovered from Area F of Gruta da Figueira Brava: vertical distribution per stratigraphic unit.

	LAYERS 20-25			**LAYERS 26-27**			**TOTAL**		
TAXON	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**
VERY LARGE MACRO-MAMMALS									
Stephanorhinus cf. *hemitoechus*	5	3	1.04	1	1	0.04	**6**	**4**	**1.08**
Rhinocerotidae	23	2	0.53	6	2	0.123	**29**	**4**	**0.653**
Indeterminate	14	-	-	-	-	-	**14**	**-**	**-**
LARGE MACRO-MAMMALS									
Equus caballus	16	5	4	3	1	0.1	**19**	**6**	**4.1**
Equus cf. *caballus*	2	2	0.75	1	1	0.25	**3**	**3**	**1**
Equus sp.	21	4	1.67	3	1	0.5	**24**	**5**	**2.17**
Equidae	2	2	0.75	-	-	-	**2**	**2**	**0.75**
Bos primigenius	4	3	1.5	-	-	-	**4**	**3**	**1.5**
Bos sp.	8	3	1.5	-	-	-	**8**	**3**	**1.5**
cf. *Bos* sp.	2	2	0.625	-	-	-	**2**	**2**	**0.625**
Bovidae	3	2	1	-	-	-	**3**	**2**	**1**
Herbivore	6	-	-	4	-	-	**10**	**-**	**-**
Ursus arctos	1	1	0.5	-	-	-	**1**	**1**	**0.5**
Indeterminate	85	-	-	3	-	-	**88**	**-**	**-**
MEDIUM MACRO-MAMMALS									
Cervus elaphus	80	8	7.5	15	2	1.5	**95**	**10**	**9**
Cervidae	149	7	6.125	23	2	0.63	**172**	**9**	**6.755**
SMALL MACRO-MAMMALS									
Capra pyrenaica	47	7	5	20	3	1.5	**67**	**10**	**6.5**
cf. *Capra pyrenaica*	4	3	2	1	1	0.13	**5**	**4**	**2.13**
Caprinae	81	11	6	7	2	0.75	**88**	**13**	**6.75**
Panthera leo	9	1	0.5	1	1	0.05	**10**	**2**	**0.55**
Panthera cf. *pardus*	1	1	1	-	-	-	**1**	**1**	**1**
Felidae	-	-	-	1	1	0.5	**1**	**1**	**0.5**
Canis lupus	12	2	1.5	5	2	1	**17**	**4**	**2.5**
cf. *Canis lupus*	2	1	0.5	2	1	0.5	**4**	**2**	**1**
Carnivore	2	-	-	2	-	-	**4**	**-**	**-**
Indeterminate	675	-	-	129	-	-	**804**	**-**	**-**
> VERY SMALL MACRO-MAMMALS									
Herbivore	81	-	-	69	-	-	**150**	**-**	**-**
Indeterminate	2318	-	-	734	-	-	**3052**	**-**	**-**
VERY SMALL MACRO-MAMMALS									
Oryctolagus cuniculus	64	14	12	55	9	7.5	**119**	**23**	**19.5**
cf. *Oryctolagus cuniculus*	-	-	-	1	1	0.5	**1**	**1**	**0.5**
Lepus sp.	2	1	1	-	-	-	**2**	**1**	**1**
Leporidae	411	23	18.5	275	12	11	**686**	**35**	**29.5**
cf. Leporidae	10	5	2.51	1	1	0.5	**11**	**6**	**3.01**
cf. *Vulpes vulpes*	-	-	-	1	1	0.05	**1**	**1**	**0.05**
Felis silvestris	8	2	2	-	-	-	**8**	**2**	**2**
cf. *Felis silvestris*	1	1	0.5	-	-	-	**1**	**1**	**0.5**
Felidae	-	-	-	1	1	0.5	**1**	**1**	**0.5**
Carnivore	4	-	-	3	-	-	**7**	**-**	**-**
Indeterminate	837	-	-	424	-	-	**1261**	**-**	**-**
INDETERMINATE									
Indeterminate	921	-	-	585	-	-	**1506**	**-**	**-**
TOTAL	**5911**	**116**	**80.5**	**2376**	**46**	**27.623**	**8287**	**162**	**108.123**

Tab. 11.3 – Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimal Animal Units (MAU) of macro-mammals recovered from Gruta da Oliveira.

	7-13*	20	21	22	23	24	25	26	27	TOTAL
UNGULATES										
Rhinoceros	88	8	17	2	1	-	-	4	3	**123**
Horse	65	19	3	16	2	1	-	6	1	**113**
Aurochs	4	6	4	2	4	-	1	-	-	**21**
Deer	643	111	25	53	23	14	3	33	5	**910**
Caprine	227	43	5	30	23	26	5	19	9	**387**
Boar	2	-	-	-	-	-	-	-	-	**2**
LAGOMORPHS										
Hare or Rabbit	?	206	53	78	78	55	17	222	110	**819**
LARGE CARNIVORES										
Bear	29	1	-	-	-	-	-	-	-	**30**
Hyena	2	-	-	-	-	-	-	-	-	**2**
Lion	1	9	-	-	-	-	-	1	-	**11**
cf. Leopard	-	1	-	-	-	-	-	-	-	**1**
Wolf	12	13	-	1	-	-	-	6	1	**33**
SMALL CARNIVORES										
Fox	24	-	-	-	-	-	-	-	1	**25**
Lynx	24	-	-	-	-	-	-	-	-	**24**
Wildcat	9	6	-	-	3	-	-	1	-	**19**
Marten	1	-	-	-	-	-	-	-	-	**1**

Tab. 11.4 – Number of Identified Specimens (NISP) of macro-mammals recovered from Gruta da Oliveira: vertical distribution per stratigraphic unit. *Data from Zilhão et al (2010a).

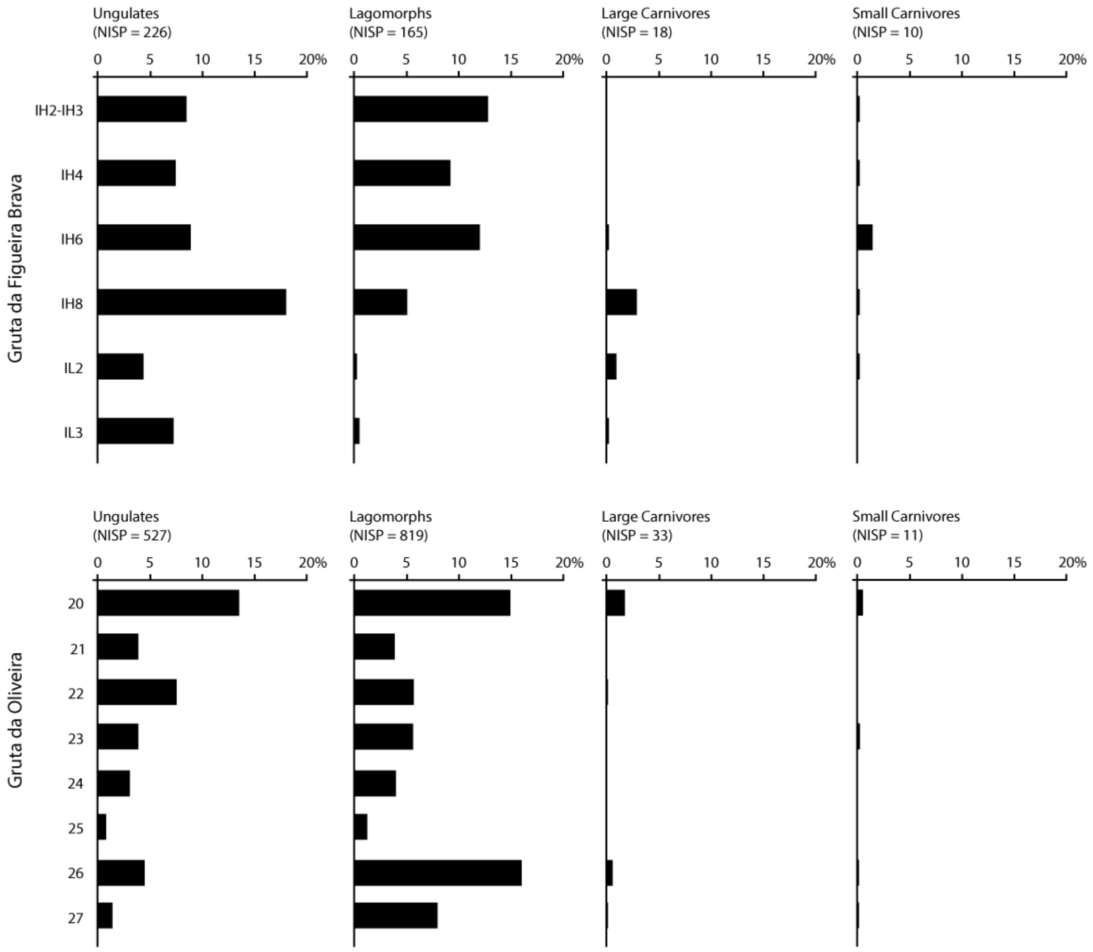


Fig. 11.1 – Vertical distribution, per stratrigraphic units, of the MIS-5 macro-mammals from Area F of Gruta da Figueira Brava (100% = 418 NISP; more detailed information in Tab. 11.2), and Gruta da Oliveira layers 20 to 27 (100% = 1390 NISP; more detailed information in Tab. 11.4).

GRUTA DA FIGUEIRA BRAVA				
ID	**Unit**	**Length (mm)**	**Width (mm)**	**Fragment size (cm)**
1	Reworked	53.02	33.16	> 5
2	Reworked	39.24	36.22	3-4
3	IH2-IH3	78.88	-	> 5
4	IH2-IH3	26.47	22.86	2-3
5	IH2-IH3	36.47	30.21	3-4
6	IH2-IH3	52.88	41.37	> 5
7	IH2-IH3	43.09	-	4-5
8	IH2-IH3	38.31	37.45	3-4
9	IH4	35.40	35.31	3-4
10	IH4	28.12	26.85	2-3
11	IH4	36.82	33.16	3-4
12	IH4	71.18	47.73	> 5
13	IH4	21.65	15.75	2-3
14	IH4	37.16	2818	3-4
15	IH6	48.06	34.3	4-5
16	IH6	55.06	45.15	> 5
17	IH6	13.24	11.05	1-2
18	IH6	20.35	-	2-3
19	IH6	32.87	31.11	3-4
20	IH6	-	21.80	2-3
21	IH6	49.97	39.57	4-5
22	IH6	28.94	27.53	3-4
23	IH6	54.25	47.38	> 5
24	IH6	38.38	34.13	3-4
25	IH6	31.54	-	3-4
26	IH8	52.81	-	> 5
27	IH8	24.7	25.29	2-3
28	IH8	45.51	42.92	4-5
29	IH8	28.90	19.58	2-3
30	IH8	28.36	23.29	2-3
31	IH8	28.91	24.79	2-3
32	IH8	39.93	-	3-4
33	IH8	49.28	35.02	4-5
34	IH8	47.00	-	4-5
35	IH8	50.75	-	> 5
36	IL3	33.43	32.24	3-4
37	IL3	33.45	30.86	3-4
GRUTA DA OLIVEIRA				
1	20	-	-	3-4
2	22	38.74	47.22	4-5
3	26	-	-	3-4

Tab. 11.5 – Vertical distribution, per stratigraphic units, of coprolites and their measures from Gruta da Figueira Brava and Gruta da Oliveira.

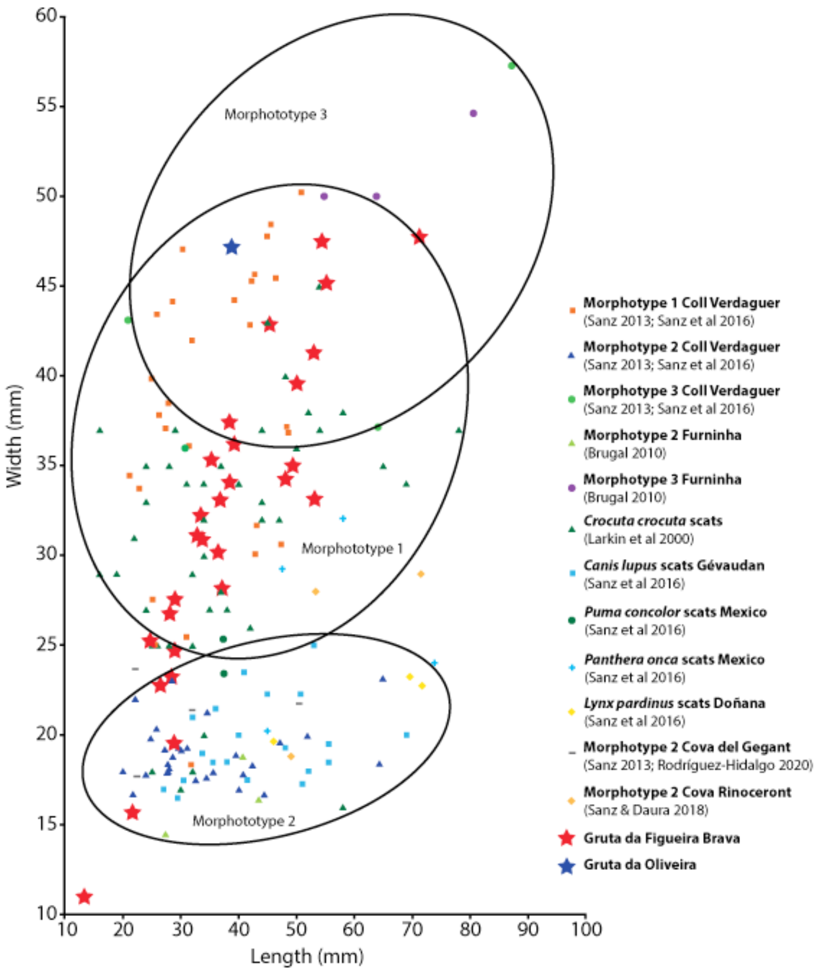


Fig. 11.2 – Morphotypes and modern feces morphometric comparative analysis (in mm). Graph adapted from Sanz et al (2016) with updated information provided by Montserrat Sanz (pers. commun., October 2020) and data from the most recent excavations at Gruta da Figueira Brava and Gruta da Oliveira (layers 20 to 27).

Fig. 11.3 – Carnivore and ungulate remains. A) Coprolites recovered from the MIS-5 levels of Area F of Gruta da Figueira Brava. **B)** Right tarsals, metatarsals and phalanges from *Panthera leo* recovered from layer 20 of Gruta da Oliveira. **C)** *Felis silvestris* bones recovered from Gruta da Oliveira: left humerus, left ulna, right ulna, unfused femur, left calcaneum (from left to right). **D)** Left mandible of *Canis lupus* with P4 and M1 still present. **E)** Atlas of *Panthera* cf. *pardus* from layer 20 of Gruta da Oliveira. **F)** Canines of *Ursus arctos* recovered from the MIS-5 levels of Area F of Gruta da Figueira Brava. **G)** Unfused right tibia and tarsals of *Capra pyrenaica* from Gruta da Oliveira, layer 24. **H)** Left M3 of *Bos primigenius* (Grant's wearing stage K) from Gruta da Oliveira, layer 23. **I)** Right mandible of *Cervus elaphus* with M1, M2 and M3 still present (note the heavy wearing on the M1), recovered from layer 20 of Gruta da Oliveira. **J)** *Equus caballus* teeth from the MIS-5 levels of Area F of Gruta da Figueira Brava: two permanent premolars/molars, deciduous premolar 4, permanent incisor 3 (from left to right). **K)** Left mandible of *Stephanorhinus* cf. *hemitoechus* with molar with Louguet-Lefèbre's wearing stage 4 (corresponding to 4 to 9 years old), recovered from layer 20 of Gruta da Oliveira.

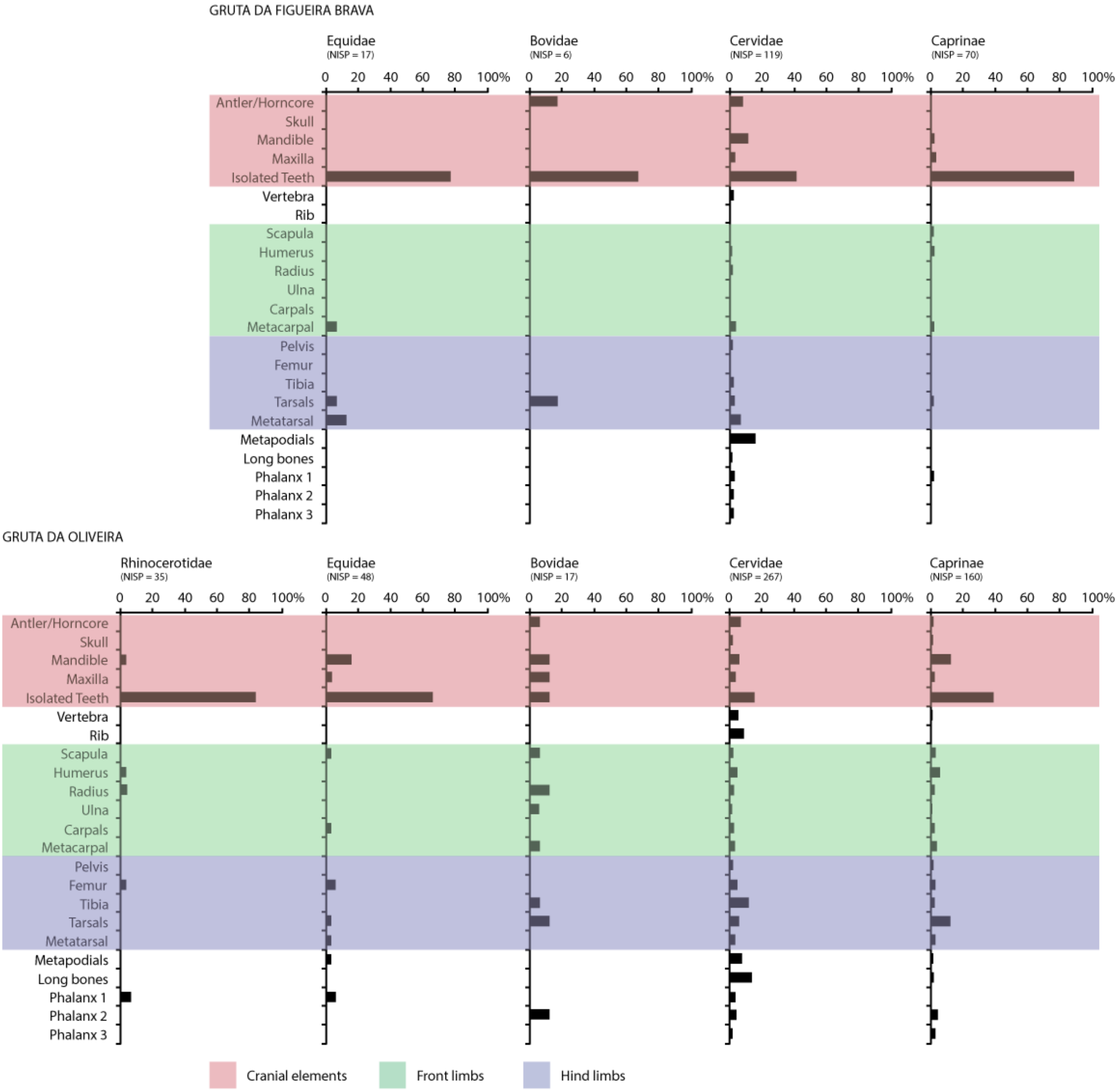


Fig. 11.4 – Ungulate body part representation of the MIS-5 macro-mammals from Gruta da Figueira Brava and Gruta da Oliveira layers 20 to 27.

frequent ungulate in the cave, represented by two metapodials, two adult mandibular teeth and a juvenile mandible, all recovered from Area F.

In Gruta da Oliveira, ungulates are the second-best represented group of mammals after lagomorphs, but ungulates still comprise a total NISP of 527. Very large mammals are present, represented by 35 remains of rhinoceros, including one adult mandible and five permanent mandibular loose teeth that allowed identification as *Stephanorhinus* cf. *hemitoechus* (Fig. 11.3 K). Therefore, and considering that no other very large taxa was identified on site, the remaining 14 indeterminate bone fragments recorded as being of very large animals are most probably of rhinoceros. Based on dentition and long bone fusion, it was possible to determine that almost all age classes are represented: adults (NISP = 6), sub-adults (NISP = 2) and juveniles (NISP = 3) (Tabs. 11.6 and 11.7).

ELEMENT	FUSION	LAYER
Humerus Prox	Fusing	Layer 20
Radius Complete	Unfused	Layer 20
Femur Dist	Ind.	Layer 21
Phalanx 1 Complete	Unfused	Layer 2
Phalanx 1 Complete	Unfused	Layer 26

Tab. 11.6 – Rhinoceros long bone fusion from Gruta da Oliveira layers 20-27.

	AGE	TEETH	LAYER
Stage 1	10 to 21 years olds	1 premolar/molar	Layer 20
		1 premolar/molar	Layer 23
Stage 2	8 to 21 years old	1 molar	Layer 20
		1 premolar/molar	Layer 26
Stage 4	4 to 9 years old	1 molar	Layer 20
Stage 5	1.5 to 7 years old	1 molar	Layer 20

Tab. 11.7 – Rhinoceros mandibular teeth from Gruta da Oliveira layers 20 to 27 providing age information according to the *Stephanorhinus hemitoechus* dental age wear stages defined by Louguet (2006).

Aurochs are the least frequent ungulates found in Gruta da Oliveira (Tabs. 11.3, 11.4; Fig. 11.3 H), but two left mandibles and two left maxillae allowed species identification to *Bos primigenius*, which can be extrapolated to all other large bovids examined. Other aurochs remains were recovered, such as two mandibular tooth fragments, one horn fragment, five front limbs (one scapula, one ulna, two radius and one metacarpal), one tibia, two tarsals and two second phalanges. All skeletal parts presented fused epiphyses, and all teeth were permanent, which shows that only adult animals were brought to the site. As for equids, species identification as *Equus caballus* was provided by 19 dental remains, all from adult individuals, except for two juvenile mandibles showing milk premolar teeth. One metatarsal and one first phalanx identified as *Equus* cf. *caballus* also presented unfused epiphyses, showing that some young horses were brought to the cave. However, most equid teeth and bones are from adult animals (NISP = 37; seven elements are of indeterminate age).

Deer is the best represented ungulate in Gruta da Oliveira (Tabs. 11.3, 11.4; Fig. 11.3 I), and *Cervus elaphus* is the species identified for 35.58% of cervid remains. Long bone fusion and dentition reflect the presence of all age classes: juvenile = 17; sub-adult = 7; adult = 112; senile = 2. In addition, all deer body parts were represented, even though representation was skewed towards hind limbs (NISP = 46 vs front limb NISP = 32). A similar body part representation was found among caprids with a preference for hind limbs (NISP = 32) rather than front limbs (NISP = 25), even though all skeletal parts were represented in the cave (Fig. 11.4). Caprids are the second-best represented ungulate and species identification was mostly done on dental remains, indicating the presence of Iberian ibex (*Capra pyrenaica*). Most skeletal parts were fused (NISP = 56), but seven fusing epiphyses and six unfused ones were recorded (Fig. 11.3 G). Dentition gives further insight into age groups, with a clear preference for animals with permanent teeth (NISP = 61) from which only two mandibles allowed a more age specific interval, since they were recorded as Payne's (1973) wear stage G, corresponding to animals ranging between 4 and 6 years old. A left mandibular milk third premolar, together with a mandible assigned to Payne's stage C (corresponding to an animal aged between 6 and 12 months) are the youngest ibex recorded.

11.2.1.3. Leporids

Leporids are well represented in both mammal assemblages: 8.81% (or NISP = 460) of the remains at Gruta da Figueira Brava and 9.88% (or NISP = 819) at Gruta da Oliveira (Tabs 11.1-11.4). Identification to species was made difficult due to calcareous concretions attached to most bones (Fig. 11.6), but it was still possible based on, mostly, teeth and pelves. Even though some hares (*Lepus* sp.) have been identified, most bones belonged to rabbits (*Oryctolagus cuniculus*).

The proportion of leporid unfused limbs in Gruta da Figueira Brava is very distinct within its stratigraphic sequence given the predominance of adult individuals in the MIS-5 levels, which sharply contrasts with a significant frequency of unfused epiphyses from the Reworked levels (Tab. 11.8). In Gruta da Oliveira, unfused limbs were mostly found within the Mousterian Cone (layers 26-27), showing good representation of juveniles, but also of sub-adults and young adults. For layers 20-25, however, the relative abundance is skewed towards young adults (Tab. 11.9). Even though juveniles are represented on both sites, no deciduous teeth were recovered.

All parts of the skeleton are represented in Gruta da Figueira Brava (Fig. 11.5), even though vertebrae, ribs, skull fragments and patellae are scarcer than all other remains. Within the MIS-5 levels there is clear predominance of front limbs, mandibles and isolated teeth, even though pelves and metatarsals are also well represented. Conversely, the Reworked levels show preference for the hind limbs, with a peak on metatarsal and mandible representation, but isolated teeth are scarce. Phalanges are also well represented, but they were not separated as belonging to front or hind legs. Skeletal indices (Tab. 11.10) that compare postcranial to cranial

			REWORKED			**MIS-5**		
Age Class	**Element**	**Age fusion**	**# of ends**	**# unfused**	**%unfused**	**# of ends**	**# unfused**	**%unfused**
Juveniles	Radius Prox	> 3 months	13	-	-	8	-	-
	Humerus Dist	> 3 months	20	2	10	18	-	-
Sub-Adults	Femur Prox	> 5 months	9	3	33.33	1	-	-
	Tibia Dist	> 5 months	19	7	36.84	5	2	40
	Ulna Prox	> 5 months	12	2	16.66	4	-	-
Young Adults	Radius Dist	> 9 months	1	-	-	3	-	-
	Humerus Prox	> 9 months	3	2	66.66	4	-	-
	Femur Dist	> 9 months	3	1	33.33	-	-	-
	Tibia Prox	> 9 months	3	-	-	1	-	-
		TOTAL	**83**	**17**	**20.48**	**44**	**2**	**4.54**

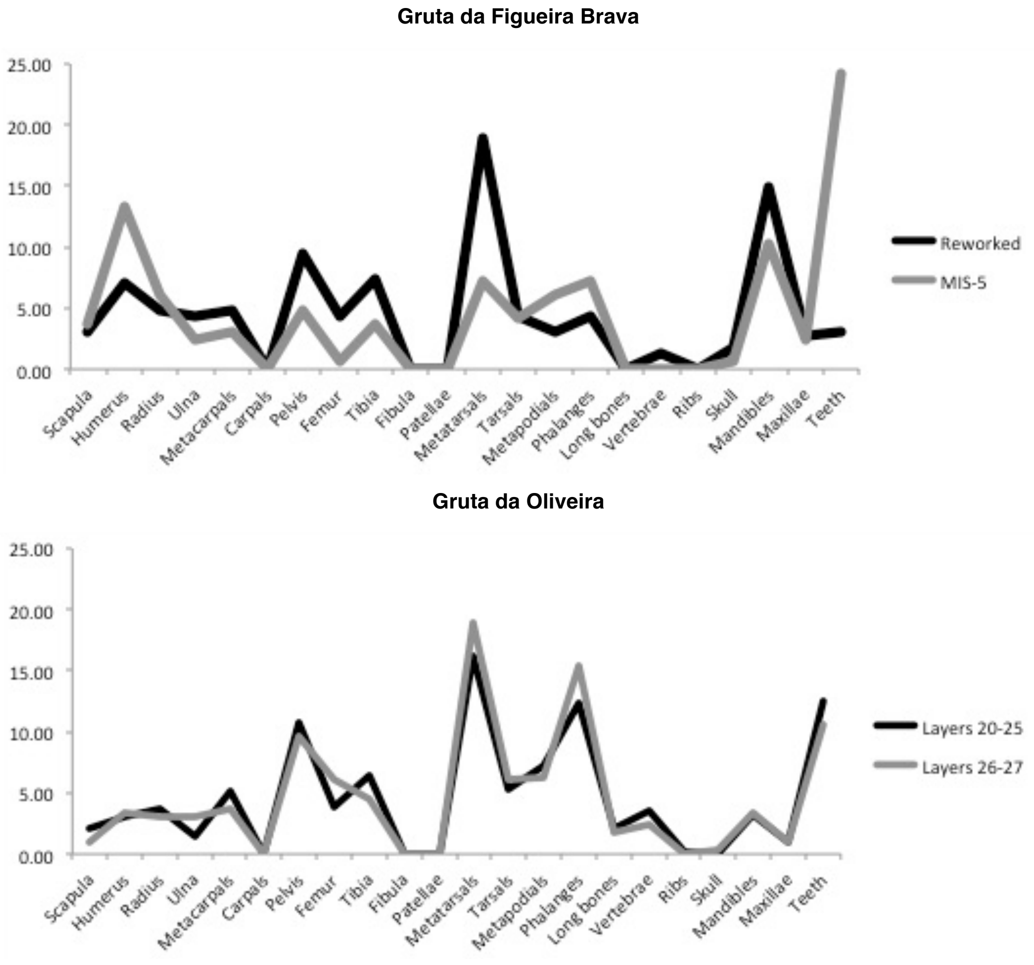
Tab. 11.8 – Percentages of leporid unfused long bone epiphyses in Gruta da Figueira Brava (adapted from the model used by Cochard et al, 2012).

			LAYERS 20-25			**LAYERS 26-27**		
Age Class	**Element**	**Age fusion**	**# of ends**	**# unfused**	**%unfused**	**# of ends**	**# unfused**	**%unfused**
Juveniles	Radius Prox	> 3 months	10	-	-	6	-	-
	Humerus Dist	> 3 months	15	2	13.33	11	3	27.27
Sub-Adults	Femur Prox	> 5 months	12	3	25	14	9	64.28
	Tibia Dist	> 5 months	19	6	31.58	9	2	22.22
	Ulna Prox	> 5 months	6	-	-	10	1	10
Young Adults	Radius Dist	> 9 months	8	-	-	3	-	-
	Humerus Prox	> 9 months	2	1	50	-	-	-
	Femur Dist	> 9 months	6	-	-	1	1	100
	Tibia Prox	> 9 months	10	4	40	3	1	33.33
		TOTAL	**88**	**16**	**18.18**	**57**	**17**	**29.82**

Tab. 11.9 – Percentages of leporid unfused long bone epiphyses in Gruta da Oliveira (adapted from the model used by Cochard et al, 2012).

	GRUTA DA FIGUEIRA BRAVA			**GRUTA DA OLIVEIRA**		
	Reworked	**MIS-5**	**Total**	**Layers 20-25**	**Layers 26-27**	**Total**
PCRT/CR	39.50	22.70	32.12	46.21	50.02	47.70
PCRAP/CR	50.87	32.16	43.01	56.99	61.08	58.62
PCRLB/CR	81.32	69.28	76.77	77.84	81.17	79.21
AUT/ZE	13.41	11.58	12.80	23.44	23.65	23.53
Z/E	49.00	36.70	44.66	52.34	42.94	48.28
AN/PO	30.91	56.63	37.74	23.71	20.97	22.59

Tab. 11.10 – Proportions of skeletal elements using the ratios defined by Lloveras et al (2020) and described in section 10.5 **PCRT** = total number of postcranial elements: limbs, vertebrae and ribs. **CR** = total number of cranial elements: mandibles, maxillae and teeth. **PCRAP** = total number of limb elements: long bones, scapulae, innominate, patellae, metapodials, carpals, tarsals, phalanges. **PCRLB** = total number of long bones: humerus, radius, ulna, femur, tibia. **AUT** = autopodia: metapodials, carpals, tarsals and phalanges. **ZE** = zeugopodia and stylopodia: tibia, radius, ulna, humerus, femur and patellae. **Z** = zeugopodia: tibia, radius and ulna. **E** = stylopodia: femur and humerus. **AN** = anterior elements: scapula, humerus, radius, ulna and metacarpals. **PO** = posterior bones: innominate, femur, tibia, metatarsal.



Gruta da Figueira Brava

Gruta da Oliveira

Fig. 11.5 – Skeletal part representation for leporid remains based on %NISP. Gruta da Figueira Brava: Reworked levels NISP = 295; MIS-5 levels NISP = 165. Gruta da Oliveira: Layers 20-25 NISP = 487; Layers 26-27 NISP = 332.

Fig. 11.6 – Examples of leporid long bone cylinders from Gruta da Oliveira layers 20 to 27. Top row: femuri shafts. Bottom row: indeterminate long bones, one radius and three tibia shafts

elements (PCRT/CR; PCRAP/CR) show that MIS-5 levels are predominantly represented by cranial elements, which reflects the large number of isolated teeth; whereas the values of PCRAP/CR are more even in the Reworked levels. Nonetheless, when comparing cranial elements with long bones (PCRLB/CR), there is a clear predominance of the latter in all levels of the cave. Within the limbs (AUT/ZE), upper limb elements are better represented in both samples. The Z/E for the Reworked sample demonstrates that zeugopodium and stylopodium elements are evenly represented, which further shows that within the AUT/ZE index the deficit affects only the autopodium elements. The same does not apply to the MIS-5 sample that shows a Z/E index with prevalence of stylopodia (i.e. femuri and humeri). The AN/PO index confirms that the Reworked sample has higher frequencies of hind elements, and that the opposite happens in the MIS-5 levels.

Gruta da Oliveira shows all parts of the skeleton, with exceptions to patellae, which are absent, and low numbers of vertebrae, ribs and skull fragments (Fig. 11.5). Leporid skeletal representation in layers 20-25 matches the distribution in layers 26-27, with preference of hind limbs over front limbs. Bones with higher representation are pelves, metatarsals and isolated teeth. To be noted that the term “metapodials” in Fig 11.5 refer to the broken ends that cannot be identified as metacarpal or metatarsal. Front and hind phalanges were not separated, which contributes to their high representation in the graph. Considering the skeletal indices on Tab. 11.10, the *in situ* deposit (i.e. layers 20-25) ratios comparing postcranial and cranial elements (PCRT/CR; PCRAP/CR) show they are fairly even. However, when cranial elements are compared to long bones (PCRLB/CR), the latter are the best represented. When looking at lower and upper limbs (AUT/ZE), the significant underrepresentation of the former is clear. However, considering that the Z/E index is fairly even (52.34), showing a similar representation of zeugopodium and stylopodium elements, the deficit in the AUT/ZE affects only the autopodium remains. Finally, the AN/PO index confirms that hind limbs survived better than front limbs. A fairly similar trend is followed by layers 26-27, which mixes material from layers 15-25 above.

11.2.2. Fragmentation and type of fracture

The mammal assemblage from the MIS-5 levels of Gruta da Figueira Brava is marked by severe fragmentation since only 3.17% (or NISP = 131) of the remains are complete. Moreover, the MIS-5 assemblage is characterised by 55.42% (or NISP = 2220) of the fractured bones being smaller than 2 cm. Overall, MIS-5 bones show preferential curved-V-shaped (42.04%, or NISP = 1739) and longitudinal (35.63%, or NISP = 1474) fractures, with oblique (56.08%, or NISP = 2320) or right (35.48%, or NISP = 1468) angles, and smooth edges (85.60%, or NISP = 3541). Such fracture patterns denote bones that were broken when fresh. From a total of 35 mandibles from the MIS-5 levels, transverse fractures predominate (60%, or NISP = 21), followed by longitudinal fractures (37.14%, or NISP = 13). Of the 25 vertebrae found, only three are complete; most (NISP = 18) show fractures along their transversal axis. Transversal fractures are also the most common among ribs (83.04%, or NISP = 93 from a total of 112 remains). About half of the phalanges are complete (53.57%, or NISP = 15 from a total of 28), but 35.71% (or NISP = 10) show transversal fractures. Most limb bones are broken (98.112%, or NISP = 1146 from a total of 1168), and longitudinal (50.86%, or NISP = 594) and curved/V-shaped (27.39%, or NISP = 320) fractures are predominant. The pattern remains valid if we only consider deer (63.64%, or NISP = 21 limbs are longitudinally broken; whereas 24.24% or NISP = 8 are curved/V-shaped), as one would expect given that they are the most common taxa. In contrast, leporids are the only taxa showing limb bones preferentially broken transversally (72.37%, or NISP = 55 from a total of 76).

At Gruta da Oliveira, only 3.68% (or NISP = 305) mammal remains are complete. Most mammal bones show longitudinal (41.91%, or NISP = 3473) or curved-V-shaped (35.36%, NISP = 2930) fractures, with oblique (46.37%, or NISP = 3843) or right (47.64%, or NISP = 3948) angles, and smooth edges (93.74%, or NISP = 7768). As before, this is indicative that most bones were mainly broken green. Such breaking process forms an assemblage that is characterised by small remains, with 57.63% (or NISP = 4600) of the fractured bones being smaller than 3 cm. From a total of 76 mammal mandibles, 43.42% (or NISP = 33) show longitudinal fractures. Similarly, 59.81% (or NISP = 125 from a total of 209) of mammal vertebrae show preference for fractures along their longitudinal axis. Conversely, 65.05% (NISP = 242 from a total of 372) of all mammal ribs are transversally broken. Phalanges are preferentially complete (71.26%, or NISP = 123 from a total of 174), or transversally broken (16.09% or NISP = 28). As for limb bones, from a total of 3240 remains, 46.73% (or NISP =1514) are fractured longitudinally. Within specific taxa, it should be noted that half the limbs of deer show longitudinal fractures (50.93%, or NISP = 55 from a total of 108); whereas leporids are the taxa presenting the highest frequency of transversal fractures (45.82%, or NISP = 192 from a total of 419 limbs; Fig. 10.6), even though the curved/V-shaped outline is also well represented (31.26%, or NISP = 131).

11.2.3. Burning

Hearths were not identified in Gruta da Figueira Brava, but there is evidence of burning among macro-mammal bones with 13.19% (or NISP = 689) of the remains showing thermo-alterations (Tab. 11.11). Most burnt remains (78.66% or NISP = 542) could not be assigned to species or to a macro-mammal size category mainly due to the very small size of the fragments (< 2 cm) and the absence of any visible diagnostic features. Overall, there is a predominance of black burns (73.88% or NISP = 509), followed by brown burns (22.64% or NISP = 156); whereas grey and white thermo-alterations are less frequent (4.79% or NISP = 33 grey and white burns together). Most burning modifications were observed on Phase FB 4, and despite most mammal fragments being burnt on its entirety, there are 37 of them (or 6.16%) that show thermo-alterations only on one side of the bone, mostly on the exterior part of the remains (burning on the interior part of the bone was only recorded for four fragments). Most burnt fragments from the MIS-5 levels of Area F are long bone shaft remains (NISP = 575), followed by 23 burnt epiphyses, and three black burnt tooth fragments which allowed species identification: a maxillary canine fragment of a bear from unit IH8, one leporid tooth fragment and one mandibular premolar of deer from unit IH4.

At Gruta da Oliveira, burnt remains show comparable frequencies to Gruta da Figueira Brava's phases FB 4 and FB 2 (Tab. 11.11). Similarly to what was recorded for the upper layers of Gruta da Oliveira (layers 7 to 19; Nabais, 2011), there is a predominance of brown and black burns (Fig. 11.7 A), corresponding to 96.33% (or NISP = 998) of the burnt remains from layers 20 to 27. Most burnt remains are from indeterminate species (n = 974, or 94.02%), mainly due to a significant part of the burnt collection being smaller than 2 cm (n = 485, or 46.81%); or because 9.75% (or n = 101) of the burnt remains are spongy bones that are more fragile and prone to lose their diagnostic traits; or due to exposure to higher temperatures, as suggested by the number of grey and white burns (n = 33, or 3.19%). Nonetheless, it was possible to recognise one burnt tooth of horse, nine remains of ibex, 17 burnt fragments of deer, 30 of leporid (within which there are two calcanei, four metapodials, five phalanges, seven pelves, and three incisors, among other skeletal parts), and three wolf remains (one ulna, one phalanx 2 and one metapodial). Of the burnt items, 10.03% (or n = 104 from 1036 remains) are partially burnt, and only 1.83% (or n = 19) show thermo-alterations on the interior part of the bone. Finally, double colouration was recorded for 24 remains (or 2.32%).

	Gruta da Figueira Brava				**Gruta da Oliveira**			
	Reworked	**Phase FB4**	**Phase FB3**	**Phase FB2**	**Layers 7-14***	**Layers 15-19***	**Layers 20-25**	**Layers 26-27**
Brown	28	127	1	-	204	235	236	83
Brown/Black	-	-	-	-	635	505	6	7
Black	48	451	7	3	1444	2618	458	207
Black/Grey	-	-	-	-	124	85	1	4
Black/White	-	-	-	-	27	39	1	0
Grey	-	16	-	-	162	123	19	4
Grey/White	-	-	-	-	41	87	3	2
White	1	7	-	-	8	56	3	2
None	1009	3131	374	20	?	?	5184	2067
Total	**1086**	**3732**	**382**	**23**	**2645**	**3748**	**5911**	**2376**
%Burnt	**7.09**	**16.10**	**2.09**	**13.04**	**-**	**-**	**12.30**	**13.01**
%Non-Burnt	**92.91**	**83.90**	**97.91**	**86.96**	**-**	**-**	**87.70**	**86.99**

Tab. 11.11 – Burning on macro-mammal remains recovered from Gruta da Figueira Brava and Gruta da Oliveira. *Data from Nabais (2011); data from non-burnt material from layers 7-19 not yet available.

11.2.4. Bone surface modification

Percussion marks are the most frequent in Gruta da Figueira Brava (Tab. 11.12). Impact flakes are the most common and, within the MIS-5 levels (phases FB 4 to FB 2), they were all found on indeterminate mammals, except for those observed on deer remains, such as on the cranial side of a distal shaft humerus, on the shafts of two metapodials, on the cranial side of shaft ends of a metatarsal and a metacarpal. As for the Reworked levels, all impact flakes were also on indeterminate taxa, except for a deer metapodial recovered from IL2 burrow. Percussion notches in the MIS-5 layers were all found on shaft remains of indeterminate mammals but for those observed on the dorsal side of a proximal shaft of a horse metacarpal, and on the dorsal side of a proximal shaft of a first phalanx of deer. Within the Reworked levels, a first phalanx of an ibex, as well as leporid long bones (NISP = 6) and pelves (NISP = 4), were the only identifiable taxa showing notches. Among adhering flakes, no bones of identifiable taxa were recorded, and the only MIS-5 taxa identified were a leporid humerus displaying the mark on the lateral side of its proximal shaft, and a deer metatarsal with an adhering flake on the lateral side of the distal shaft. Percussion pits are the least represented and the only MIS-5 taxon identified was a deer metatarsal; within the Reworked levels, pits were mostly recorded on leporid bones (NISP = 8). Cut marks are also mainly represented on leporid bones (NISP = 4) from the Reworked sample, as well as on an ibex first phalanx; the cuts found on the MIS-5 levels were all on indeterminate taxa. Carnivore marks are scarce, and in the MIS-5 layers are mostly represented by punctures on the root surface of mandibular teeth of caprines and cervids. Carnivore marks from the Reworked sample are all on leporids (except for four indeterminate remains of very small size animals), with higher frequencies on metapodials (NISP = 8) and pelves (NISP = 7).

Most anthropogenic marks in Gruta da Oliveira are percussion marks, with predominance of impact flakes (Tab. 11.12). Such evidence was mostly identified on indeterminate remains but, in layers 20-25, 5.13% (or NISP = 16) of the impact flakes were found on deer long bone shafts frequently associated with longitudinal fractures. There is also evidence of impact flakes

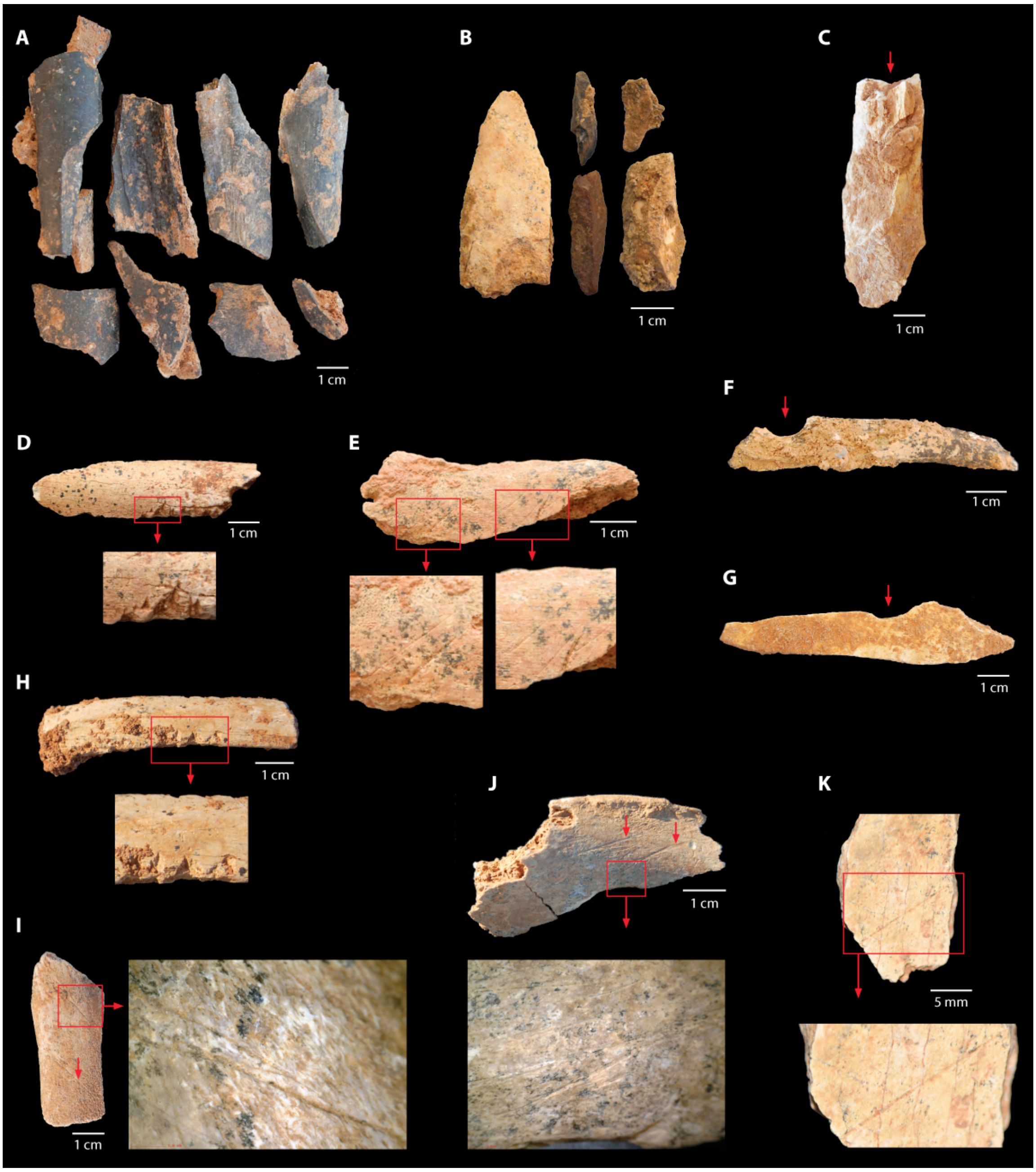


Fig. 11.7 – Anthropogenic modification on mammal remains recovered from the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira A) Examples of indeterminate macro-mammal remains showing black thermo-alterations referring to fire exposures of up to 400ºC (Nicholson 1993), recovered from Gruta da Oliveira **B)** Examples of impact flakes on indeterminate macro-mammal remains recovered from the MIS-5 levels of Area F of Gruta da Figueira Brava. **C)** Example of a percussion notch (red arrow) and consequent impact flake on indeterminate mammal remain recovered from layer 20 of Gruta da Oliveira. **D)** Chop marks (and close-up view) on long bone fragment of > Very Small Macro-Mammal from layer 27 of Gruta da Oliveira. **E)** Incisions (and close-up views) on long bone fragment of > Very Small Macro-Mammal from layer 26 of Gruta da Oliveira. **F-G)** Percussion notches (red arrow) on long bone fragments of > Very Small Macrofauna from layer 20 of Gruta da Oliveira. **H)** Chop marks (and close-up view) on a small mammal rib from layer 20 of Gruta da Oliveira. **I-K)** Incisions (red arrows and close-up view and red arrows) on > Very Small Macro-Mammal remains from layers 20, 22, and 24 (from left to right).

	GRUTA DA FIGUEIRA BRAVA				GRUTA DA OLIVEIRA	
	Reworked	**Phase FB4**	**Phase FB3**	**Phase FB2**	**Layers 20-25**	**Layers 26-27**
BUTCHERY						
Chops	12	2	-	-	5	1
Cuts	13	10	2	-	16	7
Scrapes	1	1	-	-	0	1
None	1060	3719	380	23	5890	2367
%Butchery	**2.39%**	**0.35%**	**0.52%**	**0%**	**0.36%**	**0.38%**
PERCUSSION						
Impact Flake	51	143	29	1	291	21
Adhering Flake	1	13	1	-	21	1
Percussion Notch	28	29	9	-	39	2
Percussion Pit	12	6	2	-	2	1
Peeling	-	-	-	-	4	1
None	994	3541	341	22	5554	2350
%Percussion	**8.47%**	**5.12%**	**10.73%**	**4.35%**	**6.04%**	**1.09%**
CARNIVORE						
Carnivore Pit	10	-	-	-	5	3
Carnivore Puncture	16	14	-	-	12	5
Crenulation	-	-	-	-	6	2
Scores	-	1	-	-	-	-
None	1060	3717	382	23	5888	2366
%Carnivore	**2.39%**	**0.38%**	**0%**	**0%**	**0.39%**	**0.42%**

Tab. 11.12 – Bone surface modification on macro-mammal remains recovered from Gruta da Figueira Brava and Gruta da Oliveira.

on five ibex long bones, all seen on the shaft ends of the bone (whether proximal or distal); on a first phalange of an equid; and on an ulna and two tibiae shafts of leporids. Percussion notches are the second best represented, and from the six remains identifiable to taxa, four were found on deer long bone shafts, one on an aurochs' proximal radius, and another on the proximal shaft of a leporid fourth metatarsal. Adhering flakes were observed on indeterminate remains and two deer long bones, and all on shaft fragments. Peeling and percussion pits are the least represented; the former was found on five indeterminate long bone shafts, and there are percussion pits identified on indeterminate small mammal long bone shafts. Incisions are scarce, but the ones found were mainly on long bone shafts of animals larger than the very small macrofauna category (n = 11) with a straight configuration, oblique (n = 5) or longitudinal (n = 3) orientations, and, whenever more than one cut was present, always clustered. Two clustered and straight incisions were also found on the lateral side of an aurochs second phalanx, transversally to the bone; and three straight, clustered cuts were recorded on the medial side of a rabbit acetabulum. Chop marks are all on indeterminate taxa and half of them were found on epiphyses, whereas the other half were observed on long bone shafts. Finally, nearly half of the carnivore marks were found on leporid bones (n = 15), from which eight were on pelves and four on femora. Four deer long bones also show pitting, punctures and crenulation marks on their ends; and a proximal femur and a scapula's articular of ibex show punctures and crenulation. No digestion marks were detected in any of the bones.

11.3. DISCUSSION

11.3.1. Local palaeoenvironmental reconstruction

The ungulates identified have different dietary patterns. Red deer is the best represented in both caves and it is known to have a mixed feeding behaviour, its diet varying from browsing to grazing, depending on the season (Solounias & Semprebron 2002; Hofmann & Stewart 1973; Hofmann 1989). As a result, it has great dietary adaptability, feeding on a wide range of resources, like grasses, sedges, leaves of trees and shrubs (Carranza & Valencia 1992; Azorit et al 2012; Berlioz et al 2017). Therefore, red deer are found in most habitats in the Iberian Peninsula, occupying mixed patches of forest, grassland and scrubland (Geist 1998; Clutton-Brock 1982).

In woodlands, aurochs would have thrived in denser forests, where they would sustain their grazer feeding behaviour by foraging on grasses and graminoids, but also on forbs, leaves and branches of bushes and trees (van Vuure 2002, 2005). As for the more open landscapes, horses and rhinoceros would have been their frequent inhabitants, due to their feeding preference for low-density forest and grassland settings (García García et al 2009). Horses normally graze on a large variety of grasses (Schulz & Kaiser 2012, Mihlbachler et al 2011), whereas a rhinoceros diet is mainly based on herbaceous plants and shrubs (Lacombat 2005; Feranec et al 2010).

Ibex comes second among the ungulates in both caves. It is adapted to mountainous settings, with limbs adjusted to move on rocky and steep slopes. However, it can also be found in other landscapes depending on food availability. Its altitudinal movement is seasonal with highlands preferably occupied in the summer and autumn, whereas lower altitude open areas are mainly used during winter and spring (Granados et al 2001).

Ungulate species seem to be permanent throughout the MIS-5 sequences studied from Gruta da Figueira Brava and Gruta da Oliveira, indicating the presence of several habitats surrounding the caves. The mountainous landscapes (indicated by the presence of ibex) – and within which the caves are still part of today – were interspersed with wooded areas (suggested by the presence of red deer and a few aurochs) and open spaces (due to the occurrence of equids), where animals would feed on leaves and shrubs, as well as on grasses. Finally, and as recently argued by López-García et al (2020), the identification of Cabrera's vole (*Microtus cabrerae*) on both sites supports the evidence of a Mediterranean climate, with a high-water table and year-round herbaceous cover. In the case of Gruta da Figueira Brava, the coastal setting allowed for the exploitation of aquatic resources as discussed in the following chapters. In sum, the ungulates identified in both caves stand for different ecological niches, which supports the idea that interspecific competition for resources was not in place and that, a wide spectrum of dietary resources was available to the caves' human inhabitants.

11.3.2. Agents of accumulation of macro-mammals

Many different agents can be responsible for faunal accumulations in archaeological sites. Several natural causes can generate faunal accumulations. Catastrophic events are hard to conceive as agents of bone accumulation in both caves. Natural fires can be excluded since evidence thereof — uncontrolled burning on most artefacts, bones, cave walls, and sediments, completely charred skeletons, faunal assemblages featuring animals of all ages and sexes (Avery et al, 2004; Couturier et al 2014; Conybeare & Haynes 1984) — was found in neither of the caves. Catastrophic mortality profiles are also to be expected in other settings, like flash floods (Conybeare & Haynes 1984), that we can therefore also rule out. Other natural causes include individual accidental deaths, for instance due to natural trapping of animals in vertical karst shafts, e.g., the French sites of Coulet des Roches (Pelletier et al 2020), or Igue du Gral (Castel et al, 2014). However, the morphology of both Gruta da Figueira Brava and Gruta da Oliveira does not support such a hypothesis. Individual deaths can also occur due to animal condition (i.e. age, health), and are more prone to happen to animals that frequently use the sites. This is particularly the case with carnivores that take shelter in caves. Considering the absence of anthropogenic or carnivore marks on the bones of carnivores from the two sites, the parsimonious explanation is that carnivores died naturally during their use of Gruta da Figueira Brava and Gruta da Oliveira. The presence of isolated carnivore skeletal elements should be understood as representing sporadic usage as refuge, when humans were not occupying the caves.

The studied faunal assemblages are dominated by prime-adult ungulates. However, this tends to also be the age group mainly represented in hyena dens (e.g. Dusseldorp 2009). Mostly due to the recovery of hyena coprolites, it is known that the studied caves were used by such carnivores. Indeed, the hyena coprolites found across the IH complex in Gruta da Figueira Brava are indicative of the occasional return of such animals to the cave. However, the scarcity of hyena skeletal elements, as well as the absence of juveniles, excludes the possibility of the sites being systematically used as hyena dens. Lions (*Panthera leo*) also specialise in hunting small and medium ungulates but, contrary to hyenas, they do not bring their hunt to the den (Domínguez-Rodrigo 1993), and therefore cannot be held responsible for the formation of the faunal assemblages, despite the lion paw from Gruta da Oliveira (Fig. 11.3). Similarly, bears and wolves consume their prey at the killing site (Domínguez-Rodrigo 1993, 1994; Sala & Arsuaga 2013) and do not produce significant faunal accumulations in archaeological sites (Stiner 1999; Saladié et al 2011; Sala & Arsuaga 2013), although they can modify pre-existing ones. Whenever wolves transport food back to the den, it tends to be as eaten meat parts that are regurgitated in order to feed the cubs (Domínguez-Rodrigo 1994; Castel et al 2010; Sauqué et al 2018). However, neither digested bone remains nor skeletal remains of young wolves were recovered. As for accumulations produced by leopards (*Panthera pardus*), they are not common in Iberia but there are some examples of their presence in faunal assemblages from Amalda VI (Yravedra 2007, 2009, 2011), Zafarraya (Gerads 1997; Caparrós et al 2012), Racó del Duc (Sauqué & Sanchis 2017) and Los Rincones (Sauqué et al 2016). However, this is not a suitable candidate as accumulations by felines tend to privilege axial elements (Domínguez-Rodrigo 1993; Carlson & Pickering 2003; Brugal & Fosse 2004), which is not the case for Gruta da Figueira Brava or Gruta da Oliveira. Although none of the carnivores mentioned seem to have been primary accumulators, they did take part in the modification of some of the remains and they did take shelter in both caves. In Gruta da Figueira Brava, the scarce carnivore marks were mainly found on the root surface of mandibular teeth of deer and ibex, which can probably be related to scavenging on the ventral part of such ungulate mandibles in search for marrow, or what was left of it. Similarly, in Gruta da Oliveira, the few carnivore marks identified on layers 20 to 25 are mostly on deer and ibex bone ends, a typical carnivore gnawing pattern intent on acquiring the fat stored in the epiphyses of long bones (e.g. Binford 1981; Blumenschine 1995).

Ungulate bone accumulation in both caves is the direct result of human subsistence behaviour. The two ungulate assemblages show similar features indicative of human agency. Ungulates are mainly represented by two predominant taxa – red deer and ibex –, even though other larger ungulates were also consumed, like rhinoceros, aurochs and horse. Such prey tends to be preferably of adult animals, with better representations of higher utility parts (like cranial elements and limb bones) in contrast with the low frequencies of axial elements. The evidence of selective burning marks, as well as intentional breakage, and butchery marks due to carcass processing, also contribute to the notion of an anthropogenic origin of the ungulate assemblages. As shown below (section 11.3.3), all such characteristics indicate that humans had a primary and immediate access to ungulates, undertaking intensive exploitation of their carcasses (e.g. Binford 1981; Domínguez-Rodrigo 1999; Gaudzinski & Roebroeks 2000, among others).

11.3.3. Ungulate hunting and processing

Ungulate provisioning and processing patterns are very similar for Gruta da Figueira Brava and Gruta da Oliveira, supporting a fairly consistent subsistence strategy used by human groups inhabiting both caves. The Mediterranean environment – marked by dry and warm summers, and mild winters – favours the arrival of optimal herbaceous coverage earlier than in more northern latitudes (Carranza et al 1991). With the abundance of food, ungulate populations move to forage in such prime areas leading to the formation of larger herds, which also function as protection against predators. Consequently, ungulate hunting was potentially undertaken when animals were feeding in open settings, or when they were on their migration routes (Costamagno et al 2006; Rosell et al 2012; Niven et al 2012). Ibex are a good example of this considering they are easier to target whenever feeding on open land, which tends to happen in the winter and spring (Granados et al 2001). Despite the presence of some juvenile remains, adult animals are predominant in both caves, with senile individuals being avoided. As for deer, the general agreement is that they form larger herds in autumn, when females and males join for breeding. During such period, animals do not usually run away if they are attacked (Rosell et al 2012), and hence it is expected that prime animals would be targeted. Deer evidence from both caves show that all age classes were being hunted, but the preference for adult animals is clear.

In the Iberian autumn and summer, ungulates have to rely more on leaf browsing, which implies that herds become smaller (with the above mentioned exception of deer). In addition, prey detection by humans may reduce considerably since leaf browsing implies the use of areas with increased vegetation density, such as trees and shrubs (Allen et al, 2019). Therefore, the low frequencies of aurochs in the assemblages may be influenced by their habitat preference within the denser parts of woodland environments, which makes prey detection ability and animal hunting more complex. In such circumstances, the hunting of immature animals is expected to be easier. Considering that calves are mostly born at the end of spring, juveniles would be available during the summer and autumn. However, aurochs remains recovered from both sites are all from adult individuals. As for horses, foals are born between May and September, which implies that the Gruta da Figueira Brava juveniles were hunted in late summer and autumn. In Gruta da Oliveira foals are scarce, and adult animals predominate, with the presence of the odd senile individual.

Animal size does not seem to have prevented humans from acquiring large game as already demonstrated for many other Middle Palaeolithic sites (e.g. Smith 2015; Livraghi et al 2020; Terlato et al 2019) and supported by the presence of very large size animals, like the rhinoceros, in the Gruta da Oliveira assemblage. Despite some younger individuals, most remains are of adult rhinoceros aged between 10 and 21 years old (Tabs. 11.6 and 11.7). Nonetheless, it does seem that large and very large animals were not brought whole to the sites since body part representation (Fig. 11.4) indicates selective transport from kill site to home base. This is clear in Gruta da Figueira Brava where equid and large bovid remains are biased in favour of mandibular/maxillary elements. In Gruta da Oliveira, the bias towards cranial elements (mostly isolated teeth), and the scarcity of axial and acropodial elements, indicate the preference for meatier parts of the skeleton, which is further supported by the presence of upper limbs (i.e. the meat-bearing parts) and the lower limbs (i.e. the non-meat-bearing parts) of rhinoceros, horse and aurochs (Fig. 11.4). This agrees with ethnographic observations by several authors showing that hunters dealing with carcass transport constrains need to choose a limited number of skeletal elements to bring back to the site for consumption (Yellen 1977; Binford 1978; Bunn et al 1988; O'Connell et al 1988, 1990; Bartram 1993; Abe 2005). Indeed, the low number of axial and acropodial parts should not be explained as the result of differential preservation due to post-depositional processes, because the same bone parts from other mammals are preserved on both sites. Additionally, according to actualistic and experimental research, vertebrae, ribs and the ends of long bones tend to disappear in anthropogenic and faunal accumulations (e.g. Blumenschine 1988; Marean & Spencer 1991; Marean et al 1992). Such skeletal representation bias, coupled with scarce evidence of carnivore activity, was used to explain differential carcass transport in other Mousterian sites, like Level J of Abric Romaní (Spain; Rosell et al 2012), or Unit 7 of De Nadale Cave (Italy; Livraghi et al 2020), Les Pradelles (France; Costamagno et al 2006), or the Iranian sites of Kobeh Cave (Marean & Kim 1988) and Kujin (Marean & Cleghorn 2003), to name just a few. However, this factor does not seem to be of importance at Gruta da Oliveira, where all parts of red deer and ibex skeletons are represented, suggesting a carcass transport strategy different from that used for rhinoceros. Red deer and ibex were brought whole to the cave where they were processed and consumed. This is also supported by the identification of an ibex leg with several bones in articulation (Fig. 11.3). Such may have also been the case at Gruta da Figueira Brava, where ibex may have been less frequently used. Therefore, there seems to be a differential selection of body parts according to ungulate weight in both Gruta da Figueira Brava and Gruta da Oliveira. However, it should be noted that several other variables could also affect transport decisions, such as distance between the kill site and home base, the number of individuals within the hunting party, the condition of the animals, the risk of attack by other predators, among others (Yellen 1977; Faith et al 2009; Speth 2012; Monahan 1998).

Carcass transport decisions may also relate to the potential for marrow extraction. Indeed, large ungulate skeletal profiles for both caves are biased towards high utility elements, with predominance of limbs and mandibular remains, which are elements containing medullary cavities filled with marrow (e.g. Binford 1978; Thomas & Mayer 1983). This may have been the case for equids and aurochs, but not for rhinoceros considering the great thickness of their long bones, and the absence of marrow cavities (Niven 2006; Dascheck & Mester 2020). Medium and small ungulates, like deer and ibex, were also exploited for marrow, as it is shown by their breakage patterns, with preferential longitudinal breaks on limb bones, and metapodials in particular, performed when bones were still fresh. A soft tissue such as marrow can easily be removed by hand, or using tools, or by simply sucking it directly from the bone. This animal fat is an important resource for human diet (e.g. Binford 1978; Brink 1997), and its caloric intake is higher than that of carbohydrates and protein (Mead et al 1986; Outram 2001). Additionally, bone fat appears to be of high quality since it is richer in fatty acids than any other part of an animal carcass (Brink 1997). Moreover, marrow extraction is a relatively low-cost activity, considering that it only takes a few minutes to perform it successfully, especially if bones are not covered in flesh, as is the case of metapodials (Marean & Cleghorn 2003). The latter are, in fact, the bone elements where percussion marks are more frequent in Gruta da Figueira Brava and Gruta da Oliveira, mostly on shaft ends, and frequently associated with longitudinal fractures. Most evidence for this comes from deer, but a similar pattern was also recorded for ibex, horse and aurochs.

Evidently, before being fractured for marrow exploitation, bones had to be detached from the carcass, skinned and defleshed. Due to the heavy calcareous concretions attached to most bones, incisions are hard to detect. Although scarce, all observed incisions were on long bone shafts, suggesting a connection to activities related to defleshing. Such an interpretation was also the one made for De Nadale Cave, where cuts were all found on ungulate shaft remains (Livraghi et al, 2020). At Gruta da Oliveira, half of the chop marks were found on epiphyseal elements, which indicate disarticulation and dismembering processes taking place in the cave. As for the cut mark found on an ibex first phalanx from Gruta da Figueira Brava, according to Shipman & Rose (1983) and Domínguez-Rodrigo et al (2009) it can be associated to skinning activities, which is one of the first actions performed during carcass processing.

Gruta da Figueira Brava shows low figures for burning, but the evidence for this type of modification is much stronger in layers 20 to 25 of Gruta da Oliveira. Despite the different size of the samples, both assemblages show similar burning patterns. Burnt bones were mostly exposed to temperatures below 400ºC, which can be inferred from the predominance of brown and black burns (Nicholson 1993); the burnt assemblages show partial burning of bone elements; and double colouration was recognized on about

10% of the burnt assemblage from Gruta da Oliveira. These are all characteristics associated with cooking activities (Gifford-Gonzalez, 1993; Pearce & Luff, 1994; Montón-Subías, 2002; Rosell 2001), as also identified in the tortoise material (see Chapter 13). The burning evidence associated with elements like a bear canine from Gruta da Figueira Brava, or three wolf limbs from Gruta da Oliveira, which presumably were not consumed by humans, may indicate that other activities were taking place – such as habitat cleaning (Meignen et al 2000). However, a simpler explanation is preferred: such bones might have been burnt due to the firing of a hearth above those previously deposited remains.

11.3.4. Agents of accumulation of leporids

Rabbits and other mammals (like badgers, for instance) can strongly compromise archaeological stratigraphy and the reliability of the materials recovered, due to their burrowing skills and consequent moving of archaeological finds vertically and horizontally, with severe impact on spatial distribution (Bocek 1986; Balek 2002; Mallye 2007, 2011). Once established that leporids visit archaeological sites, the possibility of natural accumulations of leporid bones should be considered, particularly when this is the taxa showing higher number of remains within the mammal assemblages recovered. As summarised by Pelletier et al (2020), there are five main criteria to identify a natural leporid accumulation. Firstly, absence of human exploitation and sporadic evidence of carnivore marks must be observed: leporid remains are expected to display a low frequency of surface modification marks which, if present, must be due to natural post-depositional processes. Leporid assemblages should feature a high frequency of complete bones and/or a moderate fracturing of dry bones due to natural causes, and skeletons are expected to be found in anatomical connection or in relative proximity. Finally, in the case of rabbits, there should be a predominance of immature individuals; whereas for hares, an even distribution of age classes is expected. The combination of all these criteria allowed researchers to identify an accidental-natural leporid accumulation for the French sites of Coudoulous II (Cochard 2004), Igue des Rameaux (Cochard 2004), Régourdou (Pelletier et al 2015), Igue du Gral (Castel et al 2014) and Coulet des Roches (Pelletier et al 2020). As for Gruta da Figueira Brava and Gruta da Oliveira, the fact that no deciduous teeth were recovered implies that none of the caves were used as a leporid-nursing site. When weaned rabbits (<1 month of age) leave the warren, the permanent teeth are all in place (Dice & Dice 1941; Callou 2003), so nursing sites are easily identified by the presence of appreciable numbers of milk teeth (Callou 2003; Cochard et al 2012; Pelletier et al 2016). Within the MIS-5 levels of Gruta da Figueira Brava and the *in situ* layers 20-25 of Gruta da Oliveira, the leporid assemblages are adult-dominated with low numbers of complete bones and, despite all skeletal parts being represented, none were found in anatomical connection. Additionally, anthropogenic and carnivore modifications were found on leporid bones, which supports that leporid natural deaths does not explain the accumulation in none of the caves.

Given that small prey can be processed without tools (Charles & Jacobi 1994), breakage patterns are frequently used in order to identify the agent of leporid accumulations. Abundance of diaphysis cylinders produced by systematic fracture of the humerus, femur and tibia in order to push marrow through or to suck it directly from the bone, is one of the main characteristics of anthropogenic leporid assemblages (e.g. Aura et al, 2010; Carvalho et al 2018; Hockett & Haws 2002; Lloveras et al 2016; Morales Pérez 2015; Pérez Ripoll 2004, 2005; Real 2017; Rosado-Méndez et al 2018, 2019; Rufà et al 2017; Sanchis & Fernández-Péris 2008; Sanchis et al 2011; Sanchis 2012). Considering that marrow is accessible through the breakage of both ends of long bones, transversal fractures are indicative of such marrow consumption, similarly to long bone shaft cylinders. This is the case for Gruta da Figueira Brava and Gruta da Oliveira, in which 72% and 46% of limb bones are broken transversally, respectively, with several cylinders identified (Fig. 10.6). In Gruta da Oliveira, limb bone breakage is complemented by an extra 31% of curved/V-shaped fractures, which further supports the evidence for marrow consumption. Moreover, the presence of cut marks due to carcass processing are also indicative of human agency in leporid accumulations (Pérez-Ripoll 1992; Cochard 2004; Lloveras et al 2009a; Sanchis 2010). According to experiments, most butchery marks are located on vertebrae, pelves, ribs, femora and tibiae, although roasted rabbits tend to display less marks than those butchered raw (Lloveras et al 2009a). The same experimental study has also demonstrated that cooking damage mainly affects terminal feet bones (i.e. phalanges), as well as the ends of long bones, and the anterior part of the mouth where incisive teeth are located (Lloveras et al 2009a). In the studied sites, evidence of cut marks is limited, but the three straight cuts found clustering around a rabbit acetabulum from Gruta da Oliveira agree with human agency related to skinning and disarticulation, as interpreted for the Solutrean levels of Gruta do Caldeirão (Lloveras et al 2011). Human agency is also supported by the presence of percussion marks, mainly impact flakes. Thermo-alterations are scarce in Gruta da Figueira Brava, and the black burnt tooth fragment recovered from IH4 is most probably due to accidental burning. Gruta da Oliveira has a larger sample of burnt leporid bones, with burnt elements already found on the upper layers of the site (Nabais 2011), and now also recovered from layers 20-27. Among the burnt bone elements from these bottom layers, there is preference for distal feet (including phalanges, metapodials and calcanei), as well as incisors and pelves, therefore matching the burning pattern described from experimental work in which elements with less meat attached tend to show higher burning marks (Lloveras et al 2009a). This pattern is also in agreement with the observations made by Hockett (1991) on North American hares, and Vigne et al (1981) and Hockett & Bicho (2000) on archaeological leporid remains.

When looking at skeletal profiles, it is known that a high frequency of mandibles, girdles, stylopodials (humerus and femur) and zeugopodials (radius, ulna and tibia) is associated with anthropogenic accumulations (Cochard 2004; Pérez Ripoll 2004; Yravedra 2008; Lloveras et al 2009a). This is the case with the MIS-5 assemblages studied here, in which the large numbers of metapodials (mainly metatarsals) and phalanges is, however, undeniable (Fig. 11.5). The large frequency of such foot elements might be interpreted as related to the production of pelts, if more cut marks were to be found on such bones, as proposed for the Middle Palaeolithic sites of Les Canalettes (Cochard 2004) or Pié Lombard (Pelletier et al 2019). However, the leporid skeletal pattern described for the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira also match the one generated by lynx (Lloveras et al 2008a). But when comparing the skeletal ratios of the studied assemblages (Tab 11.10) with the ones provided by Lloveras et al (2020, tables 3 and 4) and Pelletier et al (2020, figure 5) featuring different types of leporid accumulations, interpretations may differ. Following Pelletier et al (2020), the MIS-5 levels of Gruta da Figueira Brava are a close match with the anthropogenic accumulations of La Faurélie II (Cochard 2004) and Arbreda Cave (Lloveras et al, 2016) for all ratios, except for the Z/E. This is also supported by the non-match of any of the Figueira Brava leporid ratios with the combination of ratio results provided by Lloveras et al (2020) for the different non-human predators. Nonetheless, when comparing OLV layers 20-25 with Pelletier et al (2020)'s graph, the values cluster closer to birds of prey on PCRAP/CR% and AN/PO%, and they are similar to terrestrial carnivores on PCRT/CR% and PCRLB/CR%, although they cluster within the anthropogenic realm with AUT/ZE% and Z/E%. When compared with Lloveras et al (2020), Gruta da Oliveira results they do not fit in with any of the ratio combinations provided for non-human leporid predators. Additionally, digestion marks are absent from the studied assemblages, and there are only few carnivore marks identified on leporid bones. Although they may relate to human chewing, especially due to their preferential location on pelves and femora (Lloveras et al 2009a), the involvement of some other carnivores should not be excluded, the more so because remains of leporid-focused predators – like wild cats (*Felis silvestris*), lynx (*Lynx pardinus*) or foxes (*Vulpes vulpes*) – were found within the mammal assemblages (Tabs 11.1, 11.3). Finally, the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira are adult-dominated leporid assemblages, but once more, several predators other than humans – i.e. lynx, dholes, eagles or badgers – target adult leporids (e.g. Hockett 1991; Hockett & Bicho 2000; Jones 2004;

Cochard 2004, 2007; Lloveras et al 2011, 2016, 2018b; Cochard et al 2012; Rufà et al 2017). Therefore, although most of the leporid accumulation seems to be due to human agency, it should be assumed that other carnivores might have also contributed to the formation of such assemblages.

11.3.5. Leporid hunting and processing

In rabbits, adult body size and sexual maturity are reached at about five months old (Biadi & Le Gall 1993), but fusion of long bones is only complete by eight months (Jones 2006). Such aging intervals are slightly different in hares: adult sizes are attained around four months, and complete epiphyseal fusion at 11 months (Flux 1970). Focusing on the European rabbits (*Oryctolagus cuniculus*), which are endemic to Iberia, females have a gestation period of one month. Although rabbit litters include several kittens, mortality rate within the first three months is high (Southern 1940). Nonetheless, this species has a rapid turn-over, not only due to early sexual maturation, but also because rabbits can produce several litters a year at any season, despite the sharp peaks in breeding in the spring and fall (Southern 1940; Poole 1960; Soriguer & Rogers 1979). Therefore, breeding tends to drop significantly in hot and dry weather, generally coinciding with the summer months, when the young have lower survival rates (Garson 1979). Consequently, adult rabbits should be more abundant during the summer and winter, when breeding is slow and many of the young may have been targeted by predators. This is the basis for the interpretation of rabbit exploitation at Picareiro Cave (an Upper Palaeolithic in Portugal), whose leporid assemblage was mostly formed by adult individuals, leading to the assumption that the site was mainly used during the summer and winter, or both (Hockett & Bicho 2000). However, it should be considered that rabbits could also produce litters in early or late winter (Flux 1965; Boyd & Myhill 1987; Gibb 1990), given that environmental conditions – such as increased precipitation and new growth of vegetation – are in place (Poole 1960; Garson 1979). Therefore, a predominance of adult leporids could also be argued to support evidence for leporid hunting during spring, as well as summer (Cochard et al 2012).

The leporid age profile from the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira is mainly adult-dominated. Thus, leporid exploitation was conducted at least during the summer and winter months, if not during most of the year. Although some juvenile remains were recovered from both caves, they are not young enough (due to lack of milk teeth) to consider the possibility of mass harvesting of rabbits at warren sites, because at least some kittens (<1 months) would be expected to be found in the recovered assemblages (Jones 2004, 2006). The assumption that solitary adult animals were the ones being targeted by humans, because kittens would remain in the nest chambers of warrens (Kolb 1985), is hard to confirm since, among other factors, the predominance of adult rabbits in the archaeological assemblages might reflect a lack of interest for presumably lower-ranked juveniles (Cochard et al 2012). Nonetheless, despite the fast locomotion of hares and rabbits, and their quick escape methods, leporid hunting is not a hard task. As pointed out by Finlayson (2019), it is plausible to consider that Neanderthals could easily catch rabbits without leaving trace of any hunting device, or without using any special implements. Traditional techniques for catching rabbits relied on the blockage of all exits of the burrows, except one, which becomes the only available escape direction. If we think about the possibility of using smoke to force the animals out of their holes, one person can easily catch a rabbit with its bare hands.

This does not mean, however, that simple traps were not in use. Ethnographic accounts report that even if some tools are to be used in leporid hunting, they generally refer to basic methods – such as pitfall traps, or sticks to extract animals from their burrows –, that can be complemented by more sophisticated gear, like strings, or nets (Fowler 1989; Schmidt 1999). Therefore, it is possible that several animals could have been caught at one occasion, which is more efficient than single-animal hunting. Consequently, the commonly low ranked rabbit within Optimal Foraging models becomes a considerably more important prey when several individuals are trapped at once, thus sharply reducing the time costs of pursuing and processing of the animals. Leporids could have been consumed immediately after being caught, or upon arrival at the home base, or they could also have been prepared for deferred consumption. The latter is reported to be the case among the Great Slave Lake and the Nelson Slave indigenous groups from northwest Canada, who dried whole rabbits after skinning (Honigmann 1946). Leporid meat could also have been sliced and dried along with bones (Densmore, 1979), and there are also references to the occasional fermentation of hare stomach contents before consumption among the Arctic Inuit (Wadsworth 1984).

11.4. CONCLUSION

The mammal assemblages recovered from Gruta da Figueira Brava and Gruta da Oliveira are mainly composed of leporids and ungulates, although a variety of carnivore species were also identified. Both assemblages are the result of human activities, even though some other predators may have also contributed to the accumulation of leporid remains. Carnivores visited the caves whenever humans were not present, and some of them may have died naturally on site while hibernating, or due to old age or health conditions. Despite the identification of several coprolites (mainly in Gruta da Figueira Brava), the absence of juvenile carnivores or digested bone remains does not support interpretations related to the use of caves as dens; if they were so used, it was only sporadically.

Bone surface modifications, skeletal profiles and age assessments through long bone fusion and tooth wear patterns, indicate that humans had primary access to adult ungulates and leporids. These animals benefitted from a year-round herbaceous cover in the caves’ surroundings, profiting from a landscape characterised by patches of forest, grassland and shrubland. The ungulate assemblages are mainly represented by red deer and ibex that were brought whole to the caves, where they were skinned, dismembered and defleshed. Larger size ungulates – like horses, aurochs and rhinoceros – were also targeted, but only the most productive parts of the skeleton were brought home from the kill sites. Meat was being processed and cooked on site, as is clear from the burning patterns from Gruta da Oliveira, which are coincident with cooking activities. Marrow extraction was conducted on both sites, as shown by breakage patterns and the location of percussion marks.

It is hard to determine the seasonality of the human occupation of both sites only based on bone analysis, a task that is made even more complicated due to the scarcity of juveniles. But considering animal ethology, and the prime location of the caves within extremely resource-rich landscapes (even more so in the case of Gruta da Figueira Brava, where the sea was nearby), there is potential in envisaging a year-round — meaning intermittent, not continuous, featuring visits during any and all of the year's seasons — occupation of the sites. Herds are easier to target whenever feeding in open land, and such behaviour is typical of deer during autumn, and of ibex during winter and spring. Additionally, young horses (such as the ones found in Gruta da Figueira Brava) are mainly available in the late summer and autumn, whereas the adult population of leporids is larger during winter and summer, despite being available year-round. A great variety of animals, from very large rhinoceros to small prey – like rabbits –, might have been hunted locally, in a prosperous environment that permitted the co-habitation of several species within the same ecosystem.

CHAPTER 12

BIRDS

12.1. LITERATURE REVIEW

Small fast-moving animals (like leporids and birds) are never ranked as high-yield species. For many researchers, the energy spent in their procurement and processing is not paid off by the little amount of food these small animals provide (e.g. Munro, 1999; Stiner et al, 1999; Stiner, 2001). Indeed, birds' average body mass is of 37 g, and very few species weigh more than 1 kg (Blackburn & Gaston 1994). Additionally, it is generally considered that the rapid movement of such prey would imply the use of sophisticated technology in their procurement, which some researchers believe that Neanderthals did not have (e.g. Stiner et al, 1999, 2000; Klein, 2001; Klein et al, 2004). However, Avery and Underhill (1986) noted that birds could be easily caught in particular circumstances if humans are acquainted with their ethology. Birds are ubiquitous in all environments (from the dry deserts to the frozen steppes), and their behaviour can be easily learnt from observing the landscape. This is confirmed by several ethnographic and historical accounts that describe how easily both terrestrial and marine birds can be caught by hand – e.g. vultures gorge themselves and are unable to fly after feeding –, or by using simple technology, such as wood clubs or through pit-trapping (e.g. Bovy 2012; deFrance 2005; Finlayson & Finlayson, 2016; Negro et al, 2016; Serjeantson, 2014).

Archaeological evidence confirms human use of birds since the Early Pleistocene. The earliest evidence comes from level TE9a of Sima del Elefante (1.2 Ma, Spain; Huguet et al, 2013) where a cut-marked radius of a large bird was recovered; and from Dursunlu (0.9 Ma, Turkey; Güleç et al, 2009) where several incisions were found on a distal tarsometatarsus of another large-size bird. As summarised by Blasco et al (2019) there is a total of 25 European and Near Eastern Pleistocene sites showing cut-marked bones, both from terrestrial and aquatic birds (i.e. ducks and swans). Despite the low numbers of bird assemblages, bird ubiquity shows a progressive increase towards the end of the Pleistocene. Nonetheless, most of the evidence seems to reveal occasional events of bird use. However, the low abundance of bird remains may not reflect their real contribution to the diet if we ponder the possibility of many birds being consumed on the spot right after capture (Negro et al, 2016), or if we consider bird bones' vulnerability to taphonomical processes (Higgins, 1999). Conversely, there are cases where birds were more regularly consumed, and the Iberian Peninsula seems to provide most of such evidence (Gómez-Olivencia et al, 2018). In Bolomor Cave (MIS-9 to MIS-5e, Spain), cut marks and human tooth marks were identified on numerous meat bearing bones, reflecting processing and consumption of several terrestrial birds, as well as waterfowl, through the stratigraphic sequence (Blasco et al, 2010, 2013; Blasco & Fernández-Peris 2009, 2012a, 2012b). Another example is Gorham's Cave (MIS-3, Gibraltar) where rock doves (of the genus *Columba*) and choughs (of the genus *Pyrrhocorax*) were continually sought for consumption (Blasco et al, 2014, 2016a).

Not withstanding the size of the assemblages within Middle Palaeolithic contexts, the presence of avian remains support the notion of Neanderthal broad diets. In fact, the application of Optimal Foraging Theory is repeatedly criticised in relation to small prey use by Neanderthals considering that such animals do not provide only meat. Amongst the edible resources, birds also provide eggs, whereas non-edible products, like feathers and talons of raptors and corvids, played a significant role as ornaments. Wing bones are low on meat, but they serve as anchors for the large flight feathers where cut marks tend to be found whenever related to wing feather exploitation (Romandini et al, 2016). This is the case for the Mousterian levels of Grotta di Fumane (Italy) where incisions were found on medium- and large-size raptors, as well as choughs and pigeons (Peresani et al, 2011; Fiore et al, 2016; Romandini et al, 2016). Further evidence comes from the Gibraltar caves, where the procurement of bird's plumages is indicated by several cut marks on the pectoral-wing bones of raptors and choughs. This was interpreted as a systematic Neanderthal behaviour due to its identification in three different caves – i.e. Gorham's, Vanguard and Ibex Caves –, and in several stratigraphic levels in one of them (Gorham's Cave) (Finlayson et al, 2012; Blasco et al, 2016a). In Qesem Cave (Israel, 420-200 ka) the bird bone showing the highest number of cut marks is a carpometacarpus (a wing bone) of a swan (*Cygnus* sp.). It is noted that swans were extremely rare in the Levant (Blasco et al, 2019), which could possibly enhance the interest in keeping feathers of such a species. There is also potential selection of birds based on feather colouration, and Blasco et al (2019) provide examples of researchers – e.g. Jones & MacGregor (2002), Jackson & Scott (2003) – who made parallels between the colour of bird feathers and a colour-based symbolism.

Further symbolic connotations are frequently put forward whenever incisions or specific polishing are found on bird talons. Neanderthal procurement of claws has been confirmed for large diurnal raptors and scavengers, such as the ones recovered from the Spanish Châtelperronian site of Cova Foradada (Rodríguez-Hidalgo et al, 2019), the Italian Middle Palaeolithic cave of Rio Secco (Romandini et al, 2014, 2016), or many other coeval French sites, like Combe Grenal, Les Fieux, Mandrin, Peche de l'Azé, Grotte de l'Hyéne à Arcy-sur-Cure (Mourer-Chauviré, 1975; Fiore et al, 2004; Soressi et al, 2008; Dibble et al 2009; Morin & Laroulandie, 2012; Romandini et al, 2014; Laroulandie et al, 2016). As noted by Rodríguez-Hidalgo et al (2019), even though some authors have been prudent in defining such elements as personal ornaments, others opted for more straightforward expressions, such as "Neanderthal jewellery" (Radovčić et al, 2015). Despite the term used, it is generally accepted that bird features and behaviours could have been emblematically transmitted through the use of claws and feathers, similarly to several other ethnographic parallels – such as the well-known example of the Ameridian tribes using eagle feathers and claws as symbols of power (e.g. Finalyson et al, 2019). Indeed, the symbolic meaning and the non-utilitarian use of these non-edible bird parts implies that Neanderthals would have had the ability for abstract thinking related to encoded non-verbal concepts related to the social identity of whoever was using such bird ornaments (Kuhn, 2014).

The bird bone assemblages recovered from Gruta da Figueira Brava and Gruta da Oliveira are a valuable contribution to the current debate of Neanderthal-bird interactions. Therefore, taphonomic analysis coupled with an exhaustive skeletal part representation examination was conducted in order to understand the origin of the bird bone accumulations. Only then was it possible to proceed with inferences related to the contribution of birds to Neanderthal diet and other non-utilitarian uses they may have had.

12.2. RESULTS

12.2.1. Taxonomic and body part frequencies

A total of 189 bird bones were recovered from the most recent excavations in Area F of Gruta da Figueira Brava (Tabs. 12.1, 12.2; Fig. 12.1). Of these, 79 (or 41.79%) are indeterminate, and simply recorded as bird bones. Apart from the two remains of *Larus* sp. and *Gavia stellata* that were found on Phase FB 3 deposits, all the remainder were recovered from FB 4 levels (NISP = 26, or 13.76%) or reworked levels (NISP = 82, or 43.39%). Surface appearance, degree of fossilization and presence of carbonate concretions allowed sorting the mix of Pleistocene-derived ("with concretion" showed within brackets in Tabs 12.1 and 12.2) and Holocene-intruded material found in the reworked levels. Once the Pleistocene-derived specimens are removed from the Holocene-derived assemblage (a total of ten elements), the contrast between the reworked and MIS-5 levels is clear. Aquatic bird remains represent 82.93% (or NISP = 68) of the Holocene assemblage but only 42.86% (or NISP = 12) from the MIS-5 levels. Divers are the best represented, with a clear predominance of Phalacrocoracidae (*i.e.* cormorants and shags, NISP = 35 within the Holocene assemblage). As for the terrestrial bird remains (and including the "with concretion" remains recovered from the reworked levels within the MIS-5 levels quantification), they are mostly from MIS-5 levels (NISP = 21): Corvids are the best represented (NISP = 6), followed by Diurnal Raptors (NISP = 5), Woodcocks and Partridges (NISP = 3 each) and Nocturnal Raptors (NISP = 2).

Differential bone density (Higgins 1999; Lyman 1994) does not seem to have had a strong effect on bone preservation in the deposits since all elements of the birds' skeletons are represented (except for the skull), including axial elements that tend to be more fragile. Partridges and Dabblers show more axial bones [most commonly called "core bones" in the skeletal ratios] than limbs in the Reworked and MIS-5 levels. Within the latter levels, Woodcocks and Gulls also have more core bones. Overall, proximal bones are better represented than distal bones with the exception of Partridges, Corvids, and Raptors; Alcids and Passeriforms for the Reworked levels, and Divers from the MIS-5 are better represented by distal limbs. The wing-to-leg ratio shows a clear predominance of wing bones within the Reworked deposits, mostly referring to proximal wing elements. MIS-5 levels follow a similar pattern, with more wings than legs (Fig. 12.2).

The bird bone assemblage from Gruta da Oliveira represents 4% of the overall faunal collection of layers 20 to 27, and is composed of 421 remains. Of these, 49 are indeterminate, and two remains are of aquatic environments, most probably mallards (*Anas* cf. *platyrhynchos*) living in freshwater pools near the cave (Tabs. 12.1, 12.2; Fig. 12.1). Therefore, the assemblage is heavily composed of terrestrial species, with a predominance of Corvids, which form 76% (or NISP = 321) of the collection. Within the wide variety of corvid species identified, there is a significant prevalence of the red-billed chough (*Pyrrhocorax pyrrhocorax* and cf. *Pyrrhocorax pyrrhocorax* together refer to 21.74%, or NISP = 121, of the assemblage) and the western jackdaw (*Corvus monedula* and cf. *Corvus monedula* together represent 34.92%, or NISP = 147, of the bird collection). Female corvid individuals were identified based on the presence of medullary bone growth in two jackdaw remains (an ulna and a tibiotarsus; Fig. 12.1 I). Passeriformes are the second bird group best represented on site (6.89% or NISP = 29), with a predominance of thrushes (Turdidae) within such bird group. Partridges (NISP = 13, or 3.09%) and Doves (NISP = 11, or 2.61%) are also present, the former mostly found in layers 26-27, whereas the latter is barely represented in such levels. Diurnal and Nocturnal Raptors, as well as Woodcocks, are present but rarely found on site.

Similarly to Gruta da Figueira Brava, differential bone density does not seem to have significantly affected the assemblage, with the exception of skulls that are absent from the collection. Skeletal part analysis demonstrates that bird bones recovered from Gruta da Oliveira (Fig. 12.3) show more limbs than core bones, except for Woodcocks and Nocturnal Raptors from layers 20-25. Within the limbs, most bones are distal elements, with the exception of Partridges and Woodcocks for layers 20-25, and Passeriformes for layers 26-27, which show more proximal than limb bones. When comparing legs to wings, the latter are the best represented. This is striking amongst most bird groups except for Nocturnal Raptors and Dabblers in layers 20-25, and Partridges and Diurnal Raptors in layers 26-27. As for wing representation, most remains are from proximal wing bones (*i.e.*, humerus, radius, ulna), excluding Diurnal and Nocturnal Raptors, from layers 20-25 and 26-27 respectively, which are both represented by the distal wing element, the carpometacarpus.

12.2.2. Fragmentation and type of fracture

Nearly a third of the terrestrial bird remains from the reworked levels of Gruta da Figueira Brava (NISP = 5) are smaller than 2 cm, with most Passeriformes (NISP = 4) and all Partridges (NISP = 4) being complete or nearly complete. Transversal fractures with right and oblique angles have been observed on half of the terrestrial birds (NISP = 7) from these levels, whereas only three elements present longitudinal fractures with right angles. Aquatic birds from reworked deposits are predominantly smaller than 5 cm (NISP = 38), although there are several fragments reaching larger sizes (> 5 cm = 26; > 10 cm = 3). Most of their fractures are transversal (NISP = 51), with oblique (NISP = 31) and right (NISP = 19) angles; only seven remains are complete.

Within the MIS-5 terrestrial birds, all Woodcock bones are complete, and the same applies to the humerus of *Athene noctua* (Fig. 12.1 D). All other remains (NISP = 12) show transversal fractures with both oblique and right angles (each NISP = 6). Half of the bones are smaller than 5 cm, whereas only three remains are larger than 5 cm. The MIS-5 aquatic bones are all fragmented, mostly showing transversal fractures (NISP = 10) with right (NISP = 8) and oblique angles (NISP = 2). Half of the marine bird bone fragments are smaller than 3 cm, and only one *Phalacrocorax* cf. *aristotelis* humerus is larger than 5 cm.

Most of the bird assemblage from Gruta da Oliveira is composed of fragmented bones, with 19.03% (or NISP = 82) of the remains referring to complete or nearly complete elements. Corvids predominate in this latter category (NISP = 61), which is expected considering their high frequency within the assemblage (Tab. 12.1). Overall, most bird bones (NISP = 288, or 66.82%) are within the size interval of 1 to 3 cm. Transverse fractures are the most frequent (NISP = 261, or 60.56%), followed by curved/V-shaped (NISP = 89, or 20.65%) and longitudinal (NISP = 43, or 9.98%). The fracture angle is preferentially oblique (NISP = 259, or 60.09%), followed by right angles (NISP = 134, or 31.09%), whereas mixed angle fractures were not observed (Fig. 12.4).

12.2.3. Burning

Burnt remains are absent from Gruta da Figueira Brava. Thermo-alterations were observed on 2.32% (or NISP = 10) of the bird bones recovered from Gruta da Oliveira, mostly from layers 20 to 25 (Tab. 12.3). All modifications occur on limb bones and they are mainly black burns on corvid species (Fig.12.1 L). Thermo-alterations cover the whole surface of the bone remains except for the *Asio flammeus* coracoid that is only burnt on its distal end.

Taxon/Site	Gruta da Figueira Brava						Gruta da Oliveira					
	MIS-5			Reworked			Layers 20-25			Layers 26-27		
	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU
PARTRIDGES												
Alectoris rufa	-	-	-	3(1)	1	0.5	3	2	1	7	2	1.5
cf. *Alectoris rufa*	-	-	-	1(1)	1	0.5	-	-	-	3	2	1
cf. *Alectoris rufa / Perdix perdix*	1	1	0.5	-	-	-	-	-	-	-	-	-
CUCKOOS												
cf. *Cuculus canorus*	1	1	0.5	-	-	-	-	-	-	-	-	-
DOVES												
Columba livia	-	-	-	-	-	-	8	5	3	-	-	-
cf. *Columba livia*	-	-	-	-	-	-	2	1	0.5	-	-	-
Columba sp.	-	-	-	-	-	-	-	-	-	1	1	0.5
CORVIDS												
Garrulus glandarius	-	-	-	-	-	-	2	1	0.5	1	1	0.5
cf. *Garrulus glandarius*	-	-	-	-	-	-	2	1	0.5	1	1	0.5
Cyanopica cooki	-	-	-	-	-	-	-	-	-	1	1	0.5
cf. *Cyanopica cooki*	-	-	-	-	-	-	1	1	0.5	-	-	-
Pica pica	-	-	-	-	-	-	3	1	1	3	1	0.5
cf. *Pica pica*	-	-	-	-	-	-	4	4	2	2	2	1
Pyrrhocorax pyrrhocorax	-	-	-	1(1)	1	0.5	75	13	12	23	4	3
cf. *Pyrrhocorax pyrrhocorax*	-	-	-	-	-	-	17	7	4	6	2	1
Corvus monedula	-	-	-	-	-	-	69	14	8.5	29	3	2.5
cf. *Corvus monedula*	-	-	-	-	-	-	38	10	3	11	5.5	1.5
Corvus corone	-	-	-	-	-	-	1	1	1	2	0.5	0.5
Corvus cf. *corone*	2	1	0.5	-	-	-	-	-	-	-	-	-
Corvus corax	-	-	-	-	-	-	2	2	1	-	-	-
Corvus cf. *corax*	1	1	0.5	-	-	-	-	-	-	-	-	-
cf. *Corvus corax*	-	-	-	-	-	-	1	1	0.5	-	-	-
Corvus sp.	2	1	0.5	-	-	-	-	-	-	-	-	
cf. *Corvus* sp.	-	-	-	1	1	0.5	-	-	-	-	-	-
Corvidae	-	-	-	-	-	-	17	7	4	10	2	1
WOODCOCKS												
Scolopax rusticola	3	1	0.5	-	-	-	1	1	0.5	-	-	-
DIURNAL RAPTORS												
cf. *Accipiter nisus*	1	1	0.5	-	-	-	-	-	-	-	-	-
Milvus cf. *migrans*	-	-	-	1(1)	1	0.5	-	-	-	-	-	-
cf. *Milvus migrans*	1	1	0.5	-	-	-	-	-	-	-	-	-
cf. *Gyps* sp	1	1	0.5	-	-	-	-	-	-	-	-	-
Accipitridae	1	1	0.5	-	-	-	-	-	-	-	-	-
cf. *Falco subbuteo*	-	-	-	-	-	-	1	1	0.5	1	1	0.5
NOCTURNAL RAPTORS												
Athene noctua	1	1	0.5	-	-	-	1	1	0.5	1	1	0.5
cf. *Athene noctua*	-	-	-	1(1)	1	0.5	-	-	-	-	-	-
Asio flammeus	-	-	-	-	-	-	1	1	0.5	-	-	-
PASSERIFORMES												
Turdidae	-	-	-	-	-	-	10	5	3	7	3	1.5
cf. Turdidae	-	-	-	-	-	-	2	2	1	3	1	0.5
Hirundo rustica	-	-	-	-	-	-	2	2	1	1	1	0.5
cf. *Hirundo rustica*	-	-	-	-	-	-	1	1	0.5	-	-	-
Passeriforme	1	1	0.5	6	1	1	2	2	1	1	1	0.5
TOTAL	**16**	**12**	**6**	**14(5)**	**7**	**4**	**266**	**87**	**54**	**114**	**34**	**20**

Tab. 12.1 – Terrestrial birds from Gruta da Figueira Brava and Gruta da Oliveira (see Chapter 9, Tab. 9.5 for bird groups. Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), and Minimal Animal Units (MAU) per taxon. The MIS-5 levels from Gruta da Figueira Brava refer only to Phase FB4. Numbers in brackets refer to the amount of remains showing calcareous concretion attached, therefore originally deposited in the MIS-5 levels. Layers 20-25 from Gruta da Oliveira were grouped for increased sample size considering they are all from the same stratigraphic ensemble, the Corredor's Ensemble (see Chapter 7).

Taxon/Site	**Gruta da Figueira Brava**						**Gruta da Oliveira**					
	MIS-5			**Reworked**			**Layers 20-25**			**Layers 26-27**		
	NISP	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**	**NISP**	**MNI**	**MAU**
DABBLERS												
Anas sp.	1	1	0.5	-	-	-	-	-	-	-	-	-
Anas cf. *platyrhynchos*	3	1	0.5	-	-	-	1	1	0.5	-	-	-
cf. *Anser* sp.	-	-	-	1(1)	1	0.5	-	-	-	-	-	-
Anatidae	-	-	-	3	1	0.5	-	-	-	1	1	0.5
DIVERS												
cf. *Melanitta nigra*	-	-	-	1	1	0.5	-	-	-	-	-	-
Morus bassanus	1	1	0.5	1	1	0.5	-	-	-	-	-	-
Phalacrocorax aristotelis	-	-	-	6	2	2	-	-	-	-	-	-
Phalacrocorax cf. *aristotelis*	2	2	1	13	2	2	-	-	-	-	-	-
Phalacrocorax carbo	-	-	-	3	1	1	-	-	-	-	-	-
Phalacrocorax cf. *carbo*	-	-	-	1	1	0.5	-	-	-	-	-	-
Phalacrocorax sp.	-	-	-	6	2	1	-	-	-	-	-	-
cf. *Phalacrocorax* sp.	-	-	-	6	1	1	-	-	-	-	-	-
Gavia stellata	1	1	0.5	-	-	-	-	-	-	-	-	-
Gavia *sp.*	1	1	0.5	-	-	-	-	-	-	-	-	-
PELAGIC												
Puffinus cf. *puffinus*	-	-	-	2	1	0.5	-	-	-	-	-	-
Puffinus sp.	-	-	-	3	2	1	-	-	-	-	-	-
Procellariidae	-	-	-	1	1	0.5	-	-	-	-	-	-
ALCIDS												
Pinguinus impennis	-	-	-	2(2)	2	1	-	-	-	-	-	-
Alca torda	-	-	-	2	1	0.5	-	-	-	-	-	-
cf. *Alca torda*	-	-	-	5	3	1.5	-	-	-	-	-	-
cf. *Alca torda / Uria aalge*	1	1	0.5	1	1	0.5	-	-	-	-	-	-
cf. *Cepphus grylle / Fratercula arctica*	-	-	-	2(2)	1	0.5	-	-	-	-	-	-
SANDPIPERS												
Calidris sp.	1	1	0.5	2	2	1	-	-	-	-	-	-
GULLS												
Larus cf. *canus*	-	-	-	1	1	0.5	-	-	-	-	-	-
Larus sp.	1	1	1	-	-	-	-	-	-	-	-	-
Laridae	-	-	-	1	1	0.5	-	-	-	-	-	-
Sterna hirundo	-	-	-	1	1	0.5	-	-	-	-	-	-
cf. *Sterna hirundo*	-	-	-	1	1	0.5	-	-	-	-	-	-
WADING BIRDS												
cf. *Egretta garzetta*	-	-	-	3	2	1.5	-	-	-	-	-	-
TOTAL	**12**	**10**	**5.5**	**68(5)**	**33**	**20**	**1**	**1**	**0.5**	**1**	**1**	**0.5**

Tab. 12.2 – Aquatic birds from Gruta da Figueira Brava and Gruta da Oliveira (see Chapter 9, Tab. 9.5 for bird groups). Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), and Minimal Animal Units (MAU) per taxon. The MIS-5 levels from Gruta da Figueira Brava refer only to Phase FB4 and FB3. Numbers in brackets refer to the amount of remains showing calcareous concretion attached, therefore originally deposited in the MIS-5 levels. Layers 20-25 from Gruta da Oliveira were grouped for increased sample size considering they are all from the same stratigraphic ensemble, the Corredor's Ensemble (see Chapter 7).

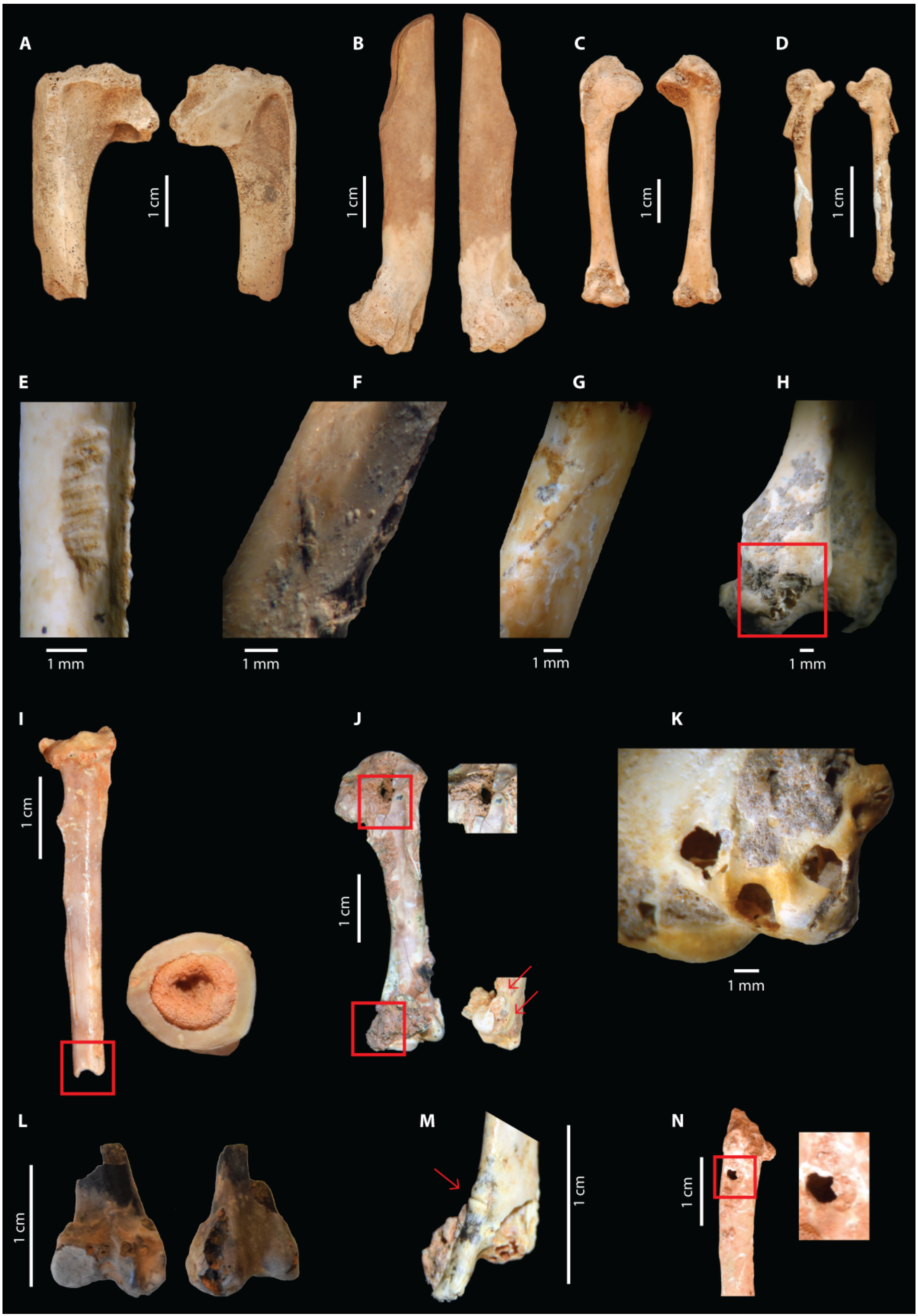


Fig. 12.1 – Bird bones. Gruta da Figueira Brava: A-B) Pleistocene *Pinguinus impennis* (great auk) proximal and distal left humeri, from reworked sediment but with concretions removed (correspondent to the white stains on the bone). **C)** *Scolopax rusticola* (woodcock) right humerus from unit IH6. **D)** *Athene noctua* (little owl) left carpometacarpus. **E)** Rodent gnawing mark on a right coracoid shaft of *Alectoris rufa* (red-legged partridge) from the reworked levels. **F)** Possible cut mark on right distal shaft of a *Corvus* cf. *corax* (raven) from unit IH8. **G)** Possible cut mark on right distal humerus shaft of *Phalacrocorax* cf. *aristotelis* (European shag) from unit IH8. **H)** Possible squashing and notching on right distal humerus of *Anas* cf. *platyrhynchos* (mallard) from unit IH8**. K)** Carnivore punctures on right distal humerus of *Corvus* cf. *corone* (crow) from unit IH8. **Gruta da Oliveira: I)** Medullary bone in left tibiotarsus of female *Corvus monedula* (jackdaw) from layer 25. **J**) cf. *Corvus monedula* left humerus with carnivore puncture on proximal end and a wrench mark on the distal end from layer 25. **L)** Burnt distal right femur of *Pyrrhocorax pyrrhocorax* (red-billed chough) from layer 25. **M)** Cut mark on left carpometacarpus of cf. *Corvus monedula* from layer 25. **N)** Carnivore puncture on a left ulna of *Corvus monedula* from layer 20.

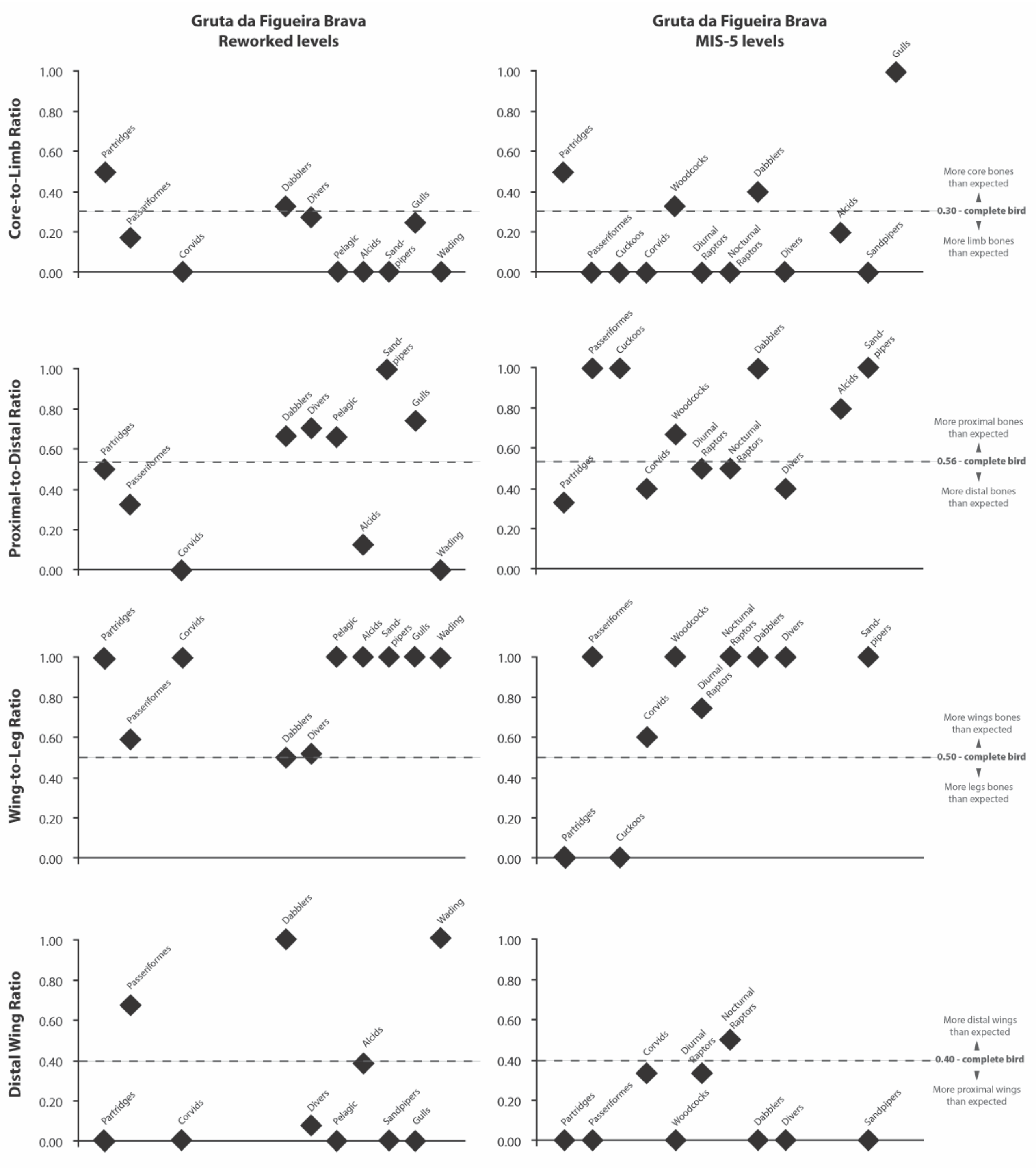


Fig. 12.2 – Gruta da Figueira Brava bird skeletal part indexes (as described in Chapter 10, section 10.5) for Reworked and MIS-5 levels.

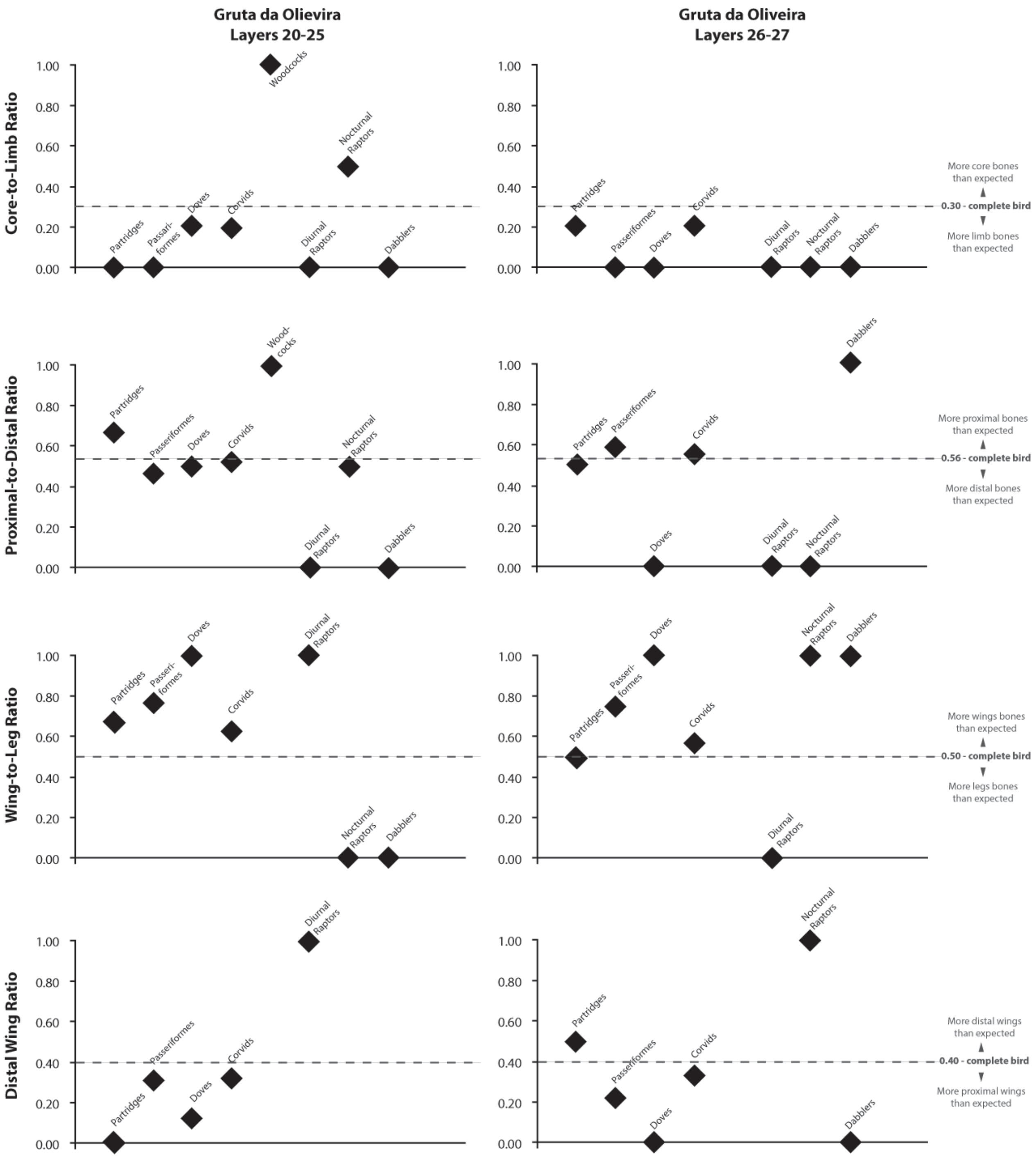


Fig. 12.3 – Gruta da Oliveira bird skeletal part indexes (as described in Chapter 10, section 10.5) for layers 20-25 and 26-27.

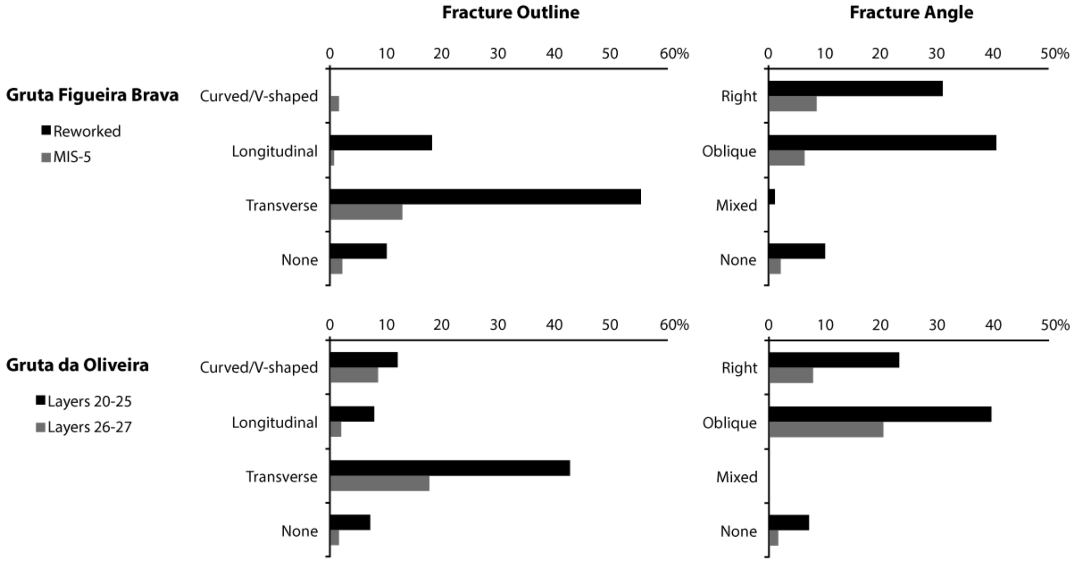


Fig. 12.4 – Overview of the fracture outline (%) and fracture angle (%) of the bird remains recovered from Gruta da Figueira Brava and Gruta da Oliveira.

	Layers 20-25		**Layers 26-27**	
	Brown	**Black**	**Brown**	**Black**
CORVIDS				
Pyrrhocorax pyrrhocorax				
humerus	-	1	-	-
Corvus monedula				
humerus	1	-	-	-
ulna	-	-	-	1
femur	-	1	-	-
cf. *Corvus monedula*				
coracoid	-	1	-	-
humerus	-	-	-	1
tarsometatarsus	-	1	-	-
Corvidae				
femur	-	-	1	-
NOCTURNAL RAPTORS				
Asio flammeus				
coracoid	-	1	-	-
PASSERIFORME				
Turdidae				
ulna	-	1	-	-
TOTAL	**1**	**6**	**1**	**2**

Tab. 12.3 – Thermo-alteration on bird remains recovered from Gruta da Oliveira.

12.2.4. Bone surface modification

In Gruta da Figueira Brava, bone surface modification was mainly observed on remains recovered from the reworked levels (Tab. 12.4). Rodent (Fig. 12.1 E) and carnivore marks are the most frequent and are mainly found on aquatic species of Divers, Pelagic and Alcid birds. Two humeri distal shafts of *Phalacrocorax* cf. *aristotelis* showed two transverse cuts each, and one of the humeri also presents a percussion notch that seems to be related to the cuts due to its same lateral and distal position. Two percussion notches were recognised on the cranial side of an ulna shaft of cf. *Alca torda/Uria aalge*, and the shaft of a tibiotarsus of a cf. *Phalacrocorax* sp. Within the MIS-5 levels, rodent marks are absent and few carnivore marks were found on terrestrial birds, such as the probable carnivore pit on the arboreal end of a cf. *Gyps* sp. mandible, the punctures on *Corvus* cf. *corone* humerus (Fig. 12.1. K) and tibiotarsus. Anthropogenic marks were mostly recognised on aquatic birds, like peeling and fissures associated to a fracture on the distal radius of *Morus bassanus*, a cut and a percussion notch on a *Phalacrocorax* cf. *aristotelis* ulna, or a squash and notch on a distal humerus of an *Anas* cf. *platyrhynchos* (Fig. 12.1. H).

Far fewer bone surface modifications were found in Gruta da Oliveira, where only three corvid remains show carnivore punctures on their proximal ends (Tab. 12.5, Fig. 12.1 J and N). One of them – a complete humerus of cf. *Corvus monedula* –, other than the puncture on the proximal end, also displayed a wrench mark on its distal part (Fig. 12.1 J), which strongly supports human agency for the carnivore mark identified. Another cf. *Corvus monedula* carpometacarpus from layer 25, showed a straight transversal cut mark (Fig. 12.1. M), and the tibiotarsus of a *Corvus monedula* from the same level presented a squash mark on its distal end. From layer 27, only one peeling mark was found on the proximal ulna of a *Pyrrhocorax pyrrhocorax*.

12.3. DISCUSSION

12.3.1. Agents of bone accumulation

Currently, Gruta da Figueira Brava's Entrances 2-3 are a sea-facing, unroofed platform that can be used by seabirds and was probably already in use throughout the Holocene. Thus, it is not surprising that seabird carcasses were accumulated by natural death and predator kills, or thrown ashore by the waves, eventually finding their way into the adjacent cave spaces. In contrast, during Phases FB 4 and FB 3, the cave was roofed and was in an inland environment, with the seashore at >1500 m away during the IH8 deposition. Also, the steepness of the Arrábida coast means that lakes, ponds, marshes and river margins that are the habitat of Dabblers and some Divers, could only have existed in flat land to south and southeast, away from the cave, in the currently-submerged river Sado's alluvial plain.

Cormorants (*Phalacrocorax carbo*) can be seen today wherever fish-rich, extensive water bodies exist (whether in the coast or inland). They are a common sight in the Arrábida coast, and frequently seen on its rocky shores, rocky islets close to the coast, and fishing harbours (Elias et al, 2006; Meirinho et al, 2014). Their predominance in the Holocene-derived deposits is thus expected. *Phalacrocorax* remains from the MIS-5 levels are considerably smaller than the females of *P. carbo* and have therefore been assigned to *P. aristotelis* (shag). Since shags are exclusively marine, their presence implies transport from the coastline, i.e. over a distance of 1500 m, implicating human agency, as no other alternative predators are known to have carried their prey to dens located at such a distance. Other aquatic birds whose preferred habitat are seashores, estuaries and coastal lagoons are represented in the MIS-5 assemblage and Pleistocene-derived material from the Reworked levels. Mallards (*Anas* cf. *platyrhynchos*), geese (cf. *Anser* sp.), gannets (*Morus bassanus*), sandpipers (*Calidris* sp.), great auks (*Pinguinus impennis*), razorbills (*Alca torda*), guillemots (cf. *Cepphus grille)* or Atlantic puffins (cf. *Fratercula arctica*), and red-throated divers (*Gavia stellata*) are interpreted as being accumulated by humans for the same reason as shags.

	Percussion Notch		Percussion Pit		Peeling		Squashing and Notch		Cut		Crenulation and Scores		Crenulated Edge		Crenulated Edge and Pit		Carnivore Pit		Carnivore Puncture		Rodent Gnawing	
	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5	Reworked	MIS-5
PARTRIDGES																						
Alectoris rufa	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-
CORVIDS																						
Corvus cf. *corax*	-	-	-	-	-	-	-	-	-	1?	-	-	-	-	-	-	-	-	-	-	-	-
Corvus cf. *corone*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
DIURNAL RAPTORS																						
cf. *Gyps* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1?	-	-	-	-
DABBLERS																						
Anas cf. *platyrhyncos*	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DIVERS																						
Morus bassanus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phalacrocorax aristotelis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-
Phalacrocorax cf. *aristotelis*	1	1	-	-	-	-	-	-	2	1	-	-	-	-	-	-	1	-	1	-	3	-
Phalacrocorax sp.	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
cf. *Phalacrocorax* sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
PELAGIC																						
Puffinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Procellaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
ALCIDS																						
Alca torda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
cf. *Alca torda*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
cf. *Alca torda / Uria aalge*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GULLS																						
Laridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Sterna hirundo	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
INDETERMINATE																						
Indeterminate	2	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	3	1?	5	-
TOTAL	**5**	**1**	**1**	**-**	**-**	**1**	**-**	**1**	**2**	**4**	**1**	**-**	**2**	**-**	**2**	**-**	**5**	**1**	**6**	**3**	**17**	**0**

Tab. 12.4 – Bone surface modifications on bird remains recovered from Gruta da Figueira Brava.

	Peeling		Squashing		Wrenching		Cut		Carnivore Puncture	
	Layers 20-25	Layers 26-27	Layers 20-25	Layers 26-27	Layers 20-25	Layers 26-27	Layers 20-25	Layers 26-27	Layers 20-25	Layers 26-27
CORVIDS										
Pyrrhocorax pyrrhocorax	-	1	-	-	-	-	-	-	-	-
Corvus monedula	-	-	1	-	-	-	-	-	1	-
cf. *Corvus monedula*	-	-	-	-	1	-	1	-	1	-
Corvidae	-	-	-	-	-	-	-	-	1	-
TOTAL	**-**	**1**	**1**	**-**	**1**	**-**	**1**		**3**	**-**

Tab. 12.5 – Bone surface modifications on bird remains recovered from Gruta da Oliveira.

Body part representation and carnivore damage data are also consistent with an anthropogenic origin for Gruta da Figueira Brava's Pleistocene aquatic birds. Carbonate accretions were found in none of the Phalacrocoracidae from the reworked sediment, and all body parts are represented, which suggests that the bones retrieved come from the disintegration of whole carcasses. Taking the Holocene Phalacrocoracidae as a standard for a naturally accumulated assemblage of seabirds, we see that the IH and the Pleistocene-derived concretion-bearing elements within the Reworked levels show different features: the marine birds of the MIS-5 levels are mostly proximal, meat-bearing bones (coracoid, scapula, humerus, ulna and radius). Hence, even though when looking at individual taxa the numbers are low to allow certainty, the overall pattern suggests that these birds were procured for food, not plumage. Their human consumption is abundantly documented in the archaeological, ethnographical and historical records (Serjeantson, 2009), and the likely anthropogenic squashing and notching seen in the right distal humerus of a mallard from unit IH8 is consistent with mastication-induced damage (Fig. 12.1. H).

The Pleistocene terrestrial bird assemblage has a more complex interpretation. Both wings and legs, and even a mandible, are represented, reflecting the introduction of complete bird carcasses. The leg-to-wing proportion is similar to that of the naturally accumulated Phalacrocoracidae from the Holocene deposits. A raven (*Corvus* cf. *corax*) shaft is possibly cut-marked (Fig. 12.1 F), but a distal humerus of a *Corvus* cf. *corone* has punctures consistent with carnivore agency (Fig. 12.1. K). Therefore, it is plausible to consider a mixed origin to this assemblage. Partridges and Woodcocks may have been targeted for food, whereas Diurnal Raptors – like the sparrowhawks (*Accipiter nisus*) and the black kite (*Milvus migrans*) – may reflect procurement for plumages, as reported for several Middle Palaeolithic sites (e.g. Peresani et al, 2011; Finlayson et al, 2012). Vultures, represented by a quadrate of *Gyps* sp., and the little owl (*Athene noctua*) (Fig. 12.1 D), could be the non-human agents involved in the accumulation of the other terrestrial birds, since both are known to use caves for shelter. In addition, in the MIS-5 levels, carnivore damage is rare and only observed on terrestrial or indeterminate birds – none was found on aquatic bird remains. The taphonomic evidence is thus consistent with the notion that the aquatic birds from Pleistocene levels are anthropogenic.

Gruta da Oliveira is predominantly composed of Corvid bones. Corvids might have been inhabitants of the cave's surroundings during the MIS-5. This is supported by the ecological position of the cave, and by the presence of juvenile bones, as well as appendicular elements with medullary bone growth reflecting the presence of females laying eggs (Fig. 12.1 I). This evidence could suggest that part of the corvid bone deposition was due to natural deaths. However, no corvid axial elements were recovered and, within the appendicular skeleton, there is a clear bias towards wing elements. Therefore, it is possible that no complete birds integrated the archaeological deposits, which compromises the possibility of a natural accumulation. If that were the case, then all parts of the corvid skeleton are expected to be found, even if in low numbers. The corvid skeletal part representation pattern – more limbs than core bones, and more wings than leg bones – agrees with accumulations of a variety of carnivore and raptor species (as summarised by Rufà et al, 2017b). However, within such carnivore accumulations, proximal limbs tend to prevail, which is not the case in Gruta da Oliveira where there is preference for distal elements, despite the ulna being the best represented bone within the Corvid assemblage if skeletal elements are considered individually. Furthermore, there are plenty of examples of anthropogenic accumulations where wings predominate (e.g. Bovy, 2002, 2012; Livingston, 1989).

Bone surface modification is scant, with no digestion marks identified, and three bones presenting carnivore punctures. Two of those elements, a jackdaw's (*Corvus monedula*) humerus and an ulna (Fig. 12.1. J and N), show punctures on their proximal end, and even though humans could potentially be responsible for such a modification, it is difficult to distinguish from other carnivores (Andrés et al, 2012; Laroulandie, 2005; Romero et al 2016). However, the humerus puncture is also associated with a wrenching mark on the distal end of the bone, which can be indicative of anthropogenic action

(Fig. 12.1. J). As observed by Bochenski et al (2009), the damage inflicted on the distal humerus could have been related to the manual disarticulation of the bone due to the overextension of the elbow. A corvidae tibiotarsus shows three punctures clustered on its proximal end. The fact that there is more than one hole clustering together, suggests the presence of a non-human predator (Laroulandie, 2005). However, most burnt bones are from corvid species, which again supports human-agency in their use and accumulation. Additionally, other corvid uses (rather than feeding) could have been in place, which is implied by the cut mark on the distal carpometacarpus of a jackdaw (Fig. 12.1 M). It can reflect feather removal, similarly to what was interpreted for the choughs recovered from Gorham's Cave (Blasco et al, 2016a). The only Diurnal Raptor identified – *Falco subbuteo*, the hobby – commonly uses old corvid nests (de Juana & Garcia, 2015), and its presence can also be related to plumage exploitation, even though this remains to be confirmed.

Neanderthals were targeting pigeons, as demonstrated by the work conducted in Gorham's Cave (Blasco et al, 2014). The doves from Gruta da Oliveira refer only to wing bones, with preference for meat-bearing elements. However, despite the skeletal part representation agreeing with an accumulation by human-agency, no mechanical modifications were identified. Similarly, an anthropic accumulation is possible for wild fowl, like partridges and Woodcocks, that could have also been hunted. The same interpretation can perhaps be extended to the odd mallard bones identified, which may have been caught from nearby freshwater lakes or ponds. Hence, it is possible that such birds relate to human consumption, but the evidence is still elusive.

Nocturnal Raptors, such as owls (like the little owl, *Athene noctua*) could have been the non-human agents involved in the accumulation of the remaining birds, especially passeriforms. Even though owls target mainly rodents, and voles in particular (who have been reported for the upper deposits of the cave, comprising layers 7 to 16; Zilhão et al, 2013), they also predate on smaller birds, amphibians, reptiles and insects (de Juana & Garcia, 2015). Additionally, despite not being frequent hunters, Corvids' behaviour should be considered since they are the best represented birds on site. Attempting to distinguish between mammal and bird (mainly corvids) scavenging on birds, Oliver & Graham (1994) concluded that mammals cause greater damage on bird leg bones. Conversely, Corvids show preference for birds' head, neck and breast. Although core bone evidence is fairly low, no beak marks were identified.

12.3.2. Bird hunting and seasonality

The vegetation cover in Gruta da Figueira Brava and Gruta da Oliveira should have been similar to today's since the climatic conditions during the accumulation of the MIS-5 deposits were not significantly different. Therefore, one can legitimately extrapolate to the MIS-5 time frame the observed migratory behaviour of most bird species.

As shown in Tab. 12.6, all aquatic species identified, if not resident in Portugal, are winter visitors. Mallards (*Anas platyrhynchos*) are the only aquatic birds found in both caves. They are a resident species, but their numbers increase during the winter, when several migrants arrive from northern and central Europe. Many of the breeding birds are fairly sedentary, and they avoid fast-flowing streams and rivers (de Juana & Garcia, 2015). Similarly, geese (*Anser* sp.) are known to winter in the river Sado estuary nowadays, and they share the same habitat with mallards (Elias et al, 2006). Dabbling ducks and geese feed in shallow waters in marshy areas, and can be easily targeted due to their gregarious behaviour evident in the large winter flocks. Ducks have been hunted in Iberia since at least MIS-6, as demonstrated by several remains recovered from Bolomor Cave level XI (Spain) showing mechanical alterations associated with human processing and consumption (Blasco & Fernández-Peris, 2009). Several indigenous people of North America hunted mallards with nets. For example the Lumni used poles attached to the nets in order to scoop up the birds from the water, or the Samish would throw their nets directly at the flocks (Suttles, 1974). The Nootka would hunt mallards on dark, stormy nights, when the flocks would take cover in small sheltered bays. The hunters would blind them with firelights making them easily caught by hand (Arima, 1983; Kenyon, 1980). Similar accounts were described for geese that would be trapped in nettle twine nets while feeding near the surface of shallow waters (references in Bovy, 2012). The Coast Salish usually roasted and consumed anatids as soon as slaughtered, but meat was also dried and stored (Kenyon, 1980). Many cultures also raided for duck egg collection (Department of Indian and Northern Affairs Canada, 1973).

Divers – like gannets (*Morus bassanus*), cormorants (*Phalacrocorax carbo*) and shags (*Phalacrocorax aristotelis*) – are also resident in the Portuguese shores, with growing winter populations. Gannets can form large flocks when feeding, and they only come to land for breeding. Large colonies of Phalacrocoracidae can be easily found on coastal cliffs and cave creeks, where they lay their eggs between February and July (Catry et al, 2010; Meirinho et al, 2014). Alcids are also seashore dwellers forming large colonies in the winter, and just like Divers, could have been easily caught manually. As summarised by Serjeantson (2014), there are plenty of descriptions of the methods used for seabird fowling dating back to the 16th century in Scotland, when parties of men visited the cliffs to manually harvest seabirds and their eggs from their breeding sites. This should also apply to the currently extinct great auk (*Pinguinus impennis*) – the last pair was killed in 1844 in Edley Rock (Iceland; Bengtson, 1984) – which was also found in other Upper Pleistocene sites in Iberia, such as the Gibraltar caves and Gruta da Furninha, in Portugal (Pimenta et al, 2008).

The *Calidris alba* (sanderling) is an Artic breeder, a long-distance migrant, and is the most frequent sandpiper in the Portuguese coasts (Meirinho et al, 2014). Due to the birds' small size, among the Kutchin, sandpipers were given to children for eating, whereas adults would consume larger birds (Osgood, 1936). Some ethnographic references mention that North American indigenous peoples would eat sandpipers after being boiled, roasted or fried (Ashwell, 1978; Hara, 1980). Ethnography has also provided extended evidence of gull (*Larus* sp.) meat and egg consumption (e.g. Ashwell, 1978; Hara, 1980; Meyer, 1985; Suttles & Sturtevant, 1990), and there are references of some northern American cultures having been intensive gull hunters (Whitney, 1974).

Corvids are the best-represented terrestrial bird group in both studied caves. All corvid species are resident (Tab. 12.7) and highly sedentary. They have a predilection for open woodland habitats, preferably with abundance of oak trees. Choughs (*Pyrrhocorax pyrrhocorax*) and jackdaws (*Corvus monedula*) are frequently seen together, and both species require cavities for nesting, making use of cliffs, mountain escarpments and riverine gorges for that effect. They are highly gregarious, forming large flocks easily observed when feeding (de Juana & Garcia, 2015). Therefore, from an economic standpoint, it is not surprising to find these two species as the most common birds within Gruta da Oliveira, which would offer Neanderthals living amongst them a guaranteed and permanent supply of meat and eggs (as shown by the presence of female birds; Fig. 12.1 I). Corvids are frequently found in Middle Palaeolithic sites: it is confirmed that choughs (*P. pyrrhocorax* and *P. glaucus*) and ravens (*Corvus corax*) have been exploited by Neanderthals (e.g. Blasco et al, 2016a; Peresani et al, 2011; Finlayson et al, 2012; Fiore et al, 2016; Laroulandie et al, 2016; Romero et al, 2017), whereas jackdaws, magpies (*Pica pica*) and carrion crows (*Corvus corone*) have been found in Neanderthal levels in the Gibraltar caves, where corvid processing was observed (Blasco et al, 2016a; Finlayson et al, 2012). In Gruta da Oliveira and Gruta da Figueira Brava there are not many mechanical alterations on corvid bone surfaces. This is somehow expected considering that human processing of small animals is unlikely to leave marks since hands and teeth would be the tools for immediate consumption. In other words, the smaller the prey the less need to use tools (Larounlandie 2001; Steadman et al, 2002).

Ethnographic sources show that corvids played an important role in the subsistence of several cultures: the Hare and the Kwakiutl were known to eat raven (Hara, 1980), whereas the Fraser Valley Stalo, the Kwakiutl, the Tlingit and the Micmac are reported to have eaten crows (Government of British Columbia, 1966; Oberg, 1973; Speck & Dexter, 1951). Crows were either boiled or roasted, and meat, organs and eggs were consumed (Post, 1938;

Speck, 1940). Due to corvids' regular scavenger behaviour, their close relationship with humans (as well as diurnal raptors and other scavengers, like vultures) was originally proposed by Finlayson et al (2012) based on the idea that ungulate carcasses would attract large gatherings of scavengers. Such episodes would not only indicate the presence of fresh carcasses for food, but would also provide an ideal opportunity for Neanderthals to ambush the birds feeding on such carcasses without the use of complicated technology (Finlayson and Finlayson, 2016). Indeed, Fowler (2008) gives examples of raptors and corvids being captured by throwing a cloth at the birds and then wrapping it around them.

Sea cliffs and mountain escarpments are the natural habitat of rock doves (*Columba livia*), forming large and year-round colonies. Their absence from Gruta da Figueira Brava and the low numbers in Gruta da Oliveira are, hence, slightly unexpected especially when compared with sites such as Gorham's Cave where they have been largely and systematically used (Blasco et al, 2014, 2016a). Caves are also known to host nests of little owls (*Athene* noctua) and barn swallows (*Hirundo rustica*). The latter only visits in the summer, similarly to cuckoos *(Cuculus canorus*), black kites (*Milvus migrans*) and hobbies (*Falco subbuteo*). These are species that favour a woodland environment, but they will also benefit from swampy grounds, rich in reptiles, amphibians and small mammals. These marshy environments are also keen to accommodate woodcooks (*Scolopax rusticola*), the short-eared owl (*Asio flammeus*), and sparrowhaws (*Accipiter nisus*), which are all winter migrants. Despite their resident status in Portugal, sparrowhawks can only be found in Gruta da Figueira Brava's surroundings during the winter months (Elias et al, 2006; de Juana & Garcia, 2015).

Woodcocks are ground-dwelling and ground-nesting birds, with cryptic plumage allowing them to blend with the landscape. They have dawn and crepuscular habits, and they can become more visible during breeding. Female ducks, partridges (*Alectoris rufa*) and thrushes (Turdidae) can also broadly fit into this description. These can provide useful food supplies to humans who can easily catch these ground birds, as well as their eggs, if they are acquainted with the animals' behaviour (Finlayson, 2019). Indeed, such birds are sought for food even today, and a variety of non-complex fowling methods can be used, from simple snares, traps, nets and bird lime (the latter mainly for passerines and partridges), or by using decoys and "call-birds" (like the little owl), or by clubbing or catching them by hand (Shrubb, 2013).

The fact that researchers often catalogue birds as fast-moving animals, implying that they were a "hard-to-get" prey (e.g. Klein, 2001; Klein et al, 2004; Stiner et al, 1999, 2000), does not mean that birds were not being exploited by Neanderthals. Given that humans were acquainted with bird ethology within their environment, captures were harmless and relatively easy, and birds could have been a regular intake. In Gruta da Figueira Brava, the acquisition of most aquatic birds took place between late autumn and early spring, coinciding with a demographic increase of the residential birds due to the arrival of their winter counterparts. Fowling on terrestrial species is more evident from Gruta da Oliveira, where corvids, doves, partridges and thrushes were available year-round. The predominance of choughs and jackdaws in all stratigraphic levels analysed, shows that these birds were probably taken regularly, as already demonstrated for other Iberian Neanderthal sites (e.g. Finalyson et al, 2012; Blasco et al, 2016a). Finally, bird ecology from terrestrial species recovered from both caves reflects a preference for open woodland with swampy grounds – probably around freshwater and/or costal lakes – also being exploited.

12.3.3. Bird uses

Alimentary exploitation of birds is generally the most obvious interpretation in human-accumulated assemblages. Despite their relative small size, there are many archaeological descriptions of their consumption, and several ethnographic accounts confirm their relevance within human diets. Indeed, the ubiquitous presence of birds in all environments and the

	WINTER			SPRING			SUMMER			AUTUMN		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
DABBLERS												
Anas platyrhynchos	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Anser sp.[1]	▨	▨	▨	▨	▨						▨	▨
DIVERS												
Morus bassanus	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Phalacrocorax aristotelis	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Phalacrocorax carbo	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Gavia stellata[2]	▨	▨	▨	▨	▨							▨
ALCIDS												
Pinguinus impennis[3]	▨	▨	▨	▨	▨	▨						▨
Alca torda	▨	▨	▨	▨	▨	▨					▨	▨
Uria aalge	▨	▨	▨	▨	▨	▨						▨
Cepphus grylle[4]	▨	▨	▨									▨
Fratercula arctica	▨		▨	▨	▨	▨						▨
SANDPIPERS												
Calidris sp.[5]	▨	▨	▨									
GULLS												
Larus sp.[6]	▨	▨	▨	▨	▨						▨	▨

Tab. 12.6 – Seasonality for the aquatic birds found on MIS-5 deposits from Gruta da Figueira Brava and Gruta da Oliveira. [1]Information gathered for *Anser anser* [2]Currently a very scarce winter visitor to Portuguese coast, but most of the rare observations were done in the river Sado estuary (de Juana & Garcia, 2015). [3]Extinct species, seasonality is thus following the same pattern of the other alcids identified. [4]Extremely rare nowadays, and only observed four times in northern Spain between 1992 and 2005. [5]*Calidris alba* is currently the most numerous species of this genus in the Portuguese coast in the winter. [6]Most of *Larus* species on Portuguese coasts are winter birds, excluding the yellow-legged gull (*Larus michaelis*) that is a resident species. References used are: Catry et al (2010), Elias et al (2006), de Juana and Garcia (2015), Meirinho et al (2014).

	WINTER			SPRING			SUMMER			AUTUMN		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
PARTRIDGES												
Alectoris rufa	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
CUCKOOS												
Cuculus canorus				▨	▨	▨	▨	▨	▨			
DOVES												
Columba livia	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
CORVIDS												
Garrulus glandarius	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Cyanopica cooki	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Pica pica	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Pyrrhocorax pyrrhocorax	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Corvus monedula	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Corvus corone	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Corvus corax	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
WOODCOCKS												
Scolopax rusticola	▨	▨	▨	▨								▨
DIURNAL RAPTORS												
Accipiter nisus[1]	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Milvus migrans					▨	▨	▨	▨	▨			
Gyps sp.[2]	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Falco subbuteo					▨	▨	▨	▨	▨	▨	▨	
NOCTURNAL RAPTORS												
Athene noctua	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Asio flammeus	▨	▨	▨	▨								▨
PASSERIFORMES												
Turdidae[3]	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Hirundo rustica			▨	▨	▨	▨	▨	▨	▨	▨		

Tab. 12.7 – Seasonality for the terrestrial birds found on MIS-5 deposits from Gruta da Figueira Brava and Gruta da Oliveira. [1]Only present in the river Sado estuary between November and March. [2]The most frequent in the country is the residential griffon vulture (*Gyps fulvus*). [3]The mistle thrush is the most abundant thrush in Portugal; other thrush species are frequently observed in the winter, such as the redwing (*Turdus iliacus*). References used are: Catry et al (2010), Elias et al (2006), de Juana and Garcia (2015).

specific behaviour of certain species could make them a sustainable resource. Moreover, the extensive observation of the landscape allows human groups to understand bird behaviour and to choose optimal periods for capture, therefore diminishing the difficulty in obtaining these animals and to incorporate them in the diet. In addition, birds can also take advantage of human habitats, since anthropogenic spaces can become attractive in terms of shelter and nesting opportunities, and can offer new foraging possibilities (Isaksson et al, 2018). This is particularly evident in the human-corvid relationship, and Marzluff and Angell (2005, 2007) argue that there is a close co-evolutionary bond between these two parties in human-shaped environments. Such interconnection seems to date back to the Palaeolithic, and Tchernov (1993) has demonstrated an increase in corvid bone frequencies in human occupation sites in the Levant from the Mousterian to the Epipalaeolithic, matching a growing level of human residentiality. Gruta da Oliveira contributes to such views with its large amount of corvid bones. A mutually beneficial relationship may have been in place between Neanderthals and corvids, and both humans and birds may have taken advantage of the presence of one another. In other words, corvids may have been attracted to the food scraps left by humans, whereas Neanderthals could have benefitted from a permanent corvid population to feed upon and for feather removal.

Birds not only provide meat and eggs, but also other non-edible resources. The best examples can be found in the suggested ornamental use of feathers and talons of raptors and scavengers – such as eagles, falcons, vultures and corvids – by Neanderthals. As recently summarised by Rodríguez-Hidalgo et al (2019), there are at least 23 large raptor phalanges from ten different sites dated between ~130 and 42 ka years that present marks of human manipulation, as well as several other archaeological examples of the use of feathers. It is not possible to ascertain the use of bird talons in none of the sites studied here, but feather exploitation could have taken place. In Gruta da Figueira Brava, plumage procurement may be reflected in the presence of sparrowhawks (*Accipiter nisus*) and the black kites (*Milvus migrans*). The use of corvid feathers has already been demonstrated for other Neanderthal sites (Peresani et al, 2011; Finlayson et al, 2012; Finlayson & Finlayson, 2016), and when we have a closer look at the corvid assemblage from Gruta da Oliveira, it is not only the cut marked jackdaw's carpometacarpus (Fig. 12.1 M) that is indicative of such practice. Magpies (*Cyanopica cooki* and *Pica pica*) and jays (*Garrulus glandarius*) are medium-size bird species that are very noisy and colourful. The blue feathers of these passerine birds in the crow family are very beautiful and, perhaps, could have attained a special connotation due to their colour. The same can apply for ducks. Colour-based symbolism has already been described for birds, and the appearance of some species – like male mallards – in archaeological sites has been attributable to their bright-coloured plumage (e.g. Jones & MacGregor 2002; Jackson & Scott, 2003). Colourful feathers have always been prized by various cultures all over the world. There are several ethnographic examples of American indigenous groups displaying colourful plumage in order to create socially and ritually significant acts. Many other historical examples show feathers being used as ornaments in innumerable paintings and other artworks in all cultures (Negro et al, 2016; Pedergnana & Blasco, 2016).

It is not only the visual characteristics of the feathers that may promote human interest in them. Feathers can also have a functional utility. American tribes used gull feathers to stuff pillows (Lillard, 1985). Gulls also provided other products – for instance, gull skin was used for socks (Bilby, 1923), and fishing gear was made from their wing tendons (Nelson, 1969). Therefore, human-bird interactions can reach several dimensions and a single bird could have provided a myriad of products, from food, to tools, ornaments and symbolism. Symbolic significance may deepen with human selection and use of animal body parts which can endow the owner with the strength and skills of the hunted prey, allowing humans to "become" the animal (e.g. Tanner, 2014). As demonstrated by Finlayson et al (2019), one of the birds conferring such empowerment is the golden eagle (*Aquila chrysaetos*) that has been targeted since Neanderthal times and throughout history (e.g. Holmes, 2020;

Cocker, 2013; Mohan 2015). North American indigenous people confer a special significance to the feathers and talons of this bird. Golden eagle feathers were displayed for each warrior successful achievement; eagle claw necklaces were frequently worn and sometimes showed a complete foot hanging from the centre position. Similarly, published data on Neanderthal use of golden eagles show that feathers and talons of such bird were the primary targets of attention (Finlayson et al, 2019). Raptor talons are powerful weapons in prey immobilisation (Fowler et al, 2009), and may have been chosen as symbols of authority and command. Finally, birds are frequently understood as god emissaries, or directly associated with gods of the sky and thunder, and thus endowed with supernatural skills (Holmes 2018, Rogers 2014). Therefore, birds have been globally used within human cosmological perceptions of world-order in which they are frequently interpreted as "more-than-animal", or even as "near-persons", lying in between the human and animal realm (e.g. Frie, 2019; Hill, 2019; Kost & Hussain, 2019; Russell, 2019).

12.4. CONCLUSION

Anthropogenic use and consumption of small prey does not require the use of technology, and this is particularly evident within bird remains whose manual handling does not leave significant marks on bone surfaces (e.g. Romero et al 2016). Therefore, it is expected to find a low number of mechanical evidence of human origin within the bird bone assemblages studied. Nonetheless, the bird collections recovered from the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira seem to be mainly due to human action. This is revealed by body part representation, showing patterns associated with human-agency, as well as cut marks and burning. This is very clear in Gruta da Figueira Brava, when comparing the naturally accumulated bones from the Reworked levels with the anthropogenic accumulations from the MIS-5 deposits.

Aquatic birds were mostly found in Gruta da Figueira Brava, where they were brought into the cave from a distance of about 1500 m from the coast. They refer mainly to winter catches, coinciding with a significant population increase alongside the resident species (such as mallards, cormorants, shags and gannets) due to the arrival of their winter migrants. Therefore, birds (and mostly seabirds) were an important complement to the Neanderthal diet during the winter, when other resources – like crabs – were less available on the shore.

In Gruta da Oliveira, there was a regular intake of terrestrial birds, which is confirmed throughout all the analysed layers. There is a high incidence of choughs and jackdaws, even though other birds (like partridges and rock doves) could have also been consumed. These are all resident species that would live near the cave. The human-corvid interaction may reflect a mutually beneficial relationship in which corvids would scavenge on food scraps discarded by Neanderthal meals on site, while Neanderthals would take advantage of a permanent colony of birds living nearby to feed upon or for other uses.

The large evidence of wing bones shows that feather exploitation might have been in place in both caves, mostly targeting raptors and corvids. This is more apparent in Gruta da Oliveira, where the large amount of corvids would fulfil the Neanderthal preference for black feathers (as suggested for the Gibraltar caves; Finlayson et al, 2012), but would also provide colourful plumes from jays and magpies, and eventually male mallards.

Finally, feather exploitation and the consumption of flying birds are traditionally considered a hallmark of behavioural modernity exclusive to Anatomically Modern Humans (e.g. Klein 2001; Klein et al, 2004), since such small prey are traditionally considered difficult to capture and, thus, beyond Neanderthal capacity. Gruta da Figueira Brava and Gruta da Oliveira add to this debate demonstrating that such modern behaviour activities were already in place during MIS-5 in Portugal. Terrestrial and aquatic birds were being exploited as part of a varied diet, as well as for the use of their feathers.

CHAPTER 13

REPTILES

13.1. LITERATURE REVIEW

It has been widely accepted that modern human behaviour in Eurasia emerged abruptly with the arrival of Anatomical Modern Humans from Africa and the advent of the Upper Palaeolithic, at the expense of the local Neanderthal population. Conversely, the emergence of modern behaviour has been understood as more gradual in the Middle Stone Age of Africa (e.g. Marean 2014). However, evidence of Neanderthal's modern behaviour is plentiful as shown in Chapter 3. Behavioural modernity can also be investigated in terms of palaeodiet, subsistence strategy, and resource selection (see Chapter 4). The Mediterranean Basin is of significant relevance for this line of research, due to the number of Middle and Upper Palaeolithic faunal collections and the relative stability of animal communities during the Late Pleistocene (Stiner & Kuhn, 2009). The analysis of the tortoise remains recovered from several of its Middle Palaeolithic sites is a topic of growing interest (e.g. Stiner, 1994, 2005; Speth & Tchernov, 2002; Blasco, 2008; Blasco et al., 2016c; Nabais, 2012; Sanchis et al., 2015) – as has also been the case for coeval sites in South Africa (e.g. Klein & Cruz-Uribe, 1987; Thompson, 2010; Thompson & Henshilwood, 2014a).

Testudo hermmani is the only tortoise species found in Iberian Palaeolithic sites (Morales & Sanchis, 2009). It is a thermophilic, slow-moving animal that becomes nearly immobile when temperatures are high (>27° C). To cool down, it can dig holes in low vegetation areas, and it hibernates during the winter months, when temperatures are low (body temperature cannot drop below 4° C; Pursall, 1994; Bertolero, 2015). Its few natural predators, small carnivores and some raptors, tend to prey mostly on eggs and juveniles. Adult tortoises can thus attain a considerable size, ranging between 120 and 230 mm total length (females being larger than males) and reaching a weight between 2 and 2.5 kg (Lavender, 2012).

There is an extensive ethnographic literature on the capture and use of tortoises as food. Examples are the Seri Indians of north Mexico (Felger et al., 1981), the Wichí communities and rural populations of Mendonza and Santiago del Estero, in Argentina (references in del Papa, 2016), the Mekranoti from the Amazon (references in Sanchis et al., 2015), or the peoples of Gabon (references in Blasco et al., 2016c). Klein and Cruz-Uribe (1983) were among the first to discuss tortoises as a Middle Stone Age (MSA) food resource at the sites of Byneskranskop Cave 1 and Die Kelders Cave 1, in South Africa. Sampson (2000) provided a more detailed identification of tortoise accumulations with comprehensive observations, based on body part representation, on how to distinguish between assemblages accumulated by modern Bushmen versus other, non-human, predators.

Examples of archaeological sites yielding tortoise remains associated with human occupation are numerous (see Morales & Sanchis, 2009, for a summary of sites in Europe). Assessing how tortoises were processed, however, requires detailed taphonomic analysis, such as developed by Stiner (1994) for the tortoise remains recovered from Moscerini Cave, in Italy, and further developed for those from Kebara Cave (Speth & Tchernov, 2002) and Hayonim Cave (Stiner, 2005), in Israel. These studies demonstrated that tortoises were roasted on the coals and cracked open with hammer stones from the side of the shell. Amongst subsequent examples, this practice was documented at Blombos Cave (Thompson & Henshilwood, 2014a) and Pinnacle Point Cave 13B (Thompson, 2010), in South Africa, Qesem Cave (Blasco et al., 2016c), in Israel, Cova del Bolomor (Blasco, 2008) and Abric del Pastor (Sanchis et al., 2015), in Spain, and Gruta da Oliveira (Nabais, 2012), in Portugal.

These results prompted discussions related to diet breadth and Optimal Foraging Theory models that often place large mammals in a top-ranking position and consider small size prey as secondary resources. However, such a ranking, based on the animals' energy return, which is dependent on their caloric value and handling costs (e.g. Winterhalder & Smith, 2000; Dusseldorp, 2010), has been challenged (e.g. Cochard et al.

2012; Langejans et al. 2012; Thompson & Henshilwood 2014b). In fact, mass collection of small prey can result in return rates comparable to large game's (Madsen & Schmitt, 1998), and Hockett & Haws (2003, 2009) have shown that dietary diversity is nutritionally beneficial on its own right. Additionally, ethnographic studies (e.g. Mehaan, 1983; Siegfried & Hockey, 1985) confirm that hunter-gatherers are willing to travel long distances to acquire foods with little net return but with high nutritional variety, such as those provided by plants and small animals, including shellfish.

The actual contribution of tortoises within a diet that includes small prey has been addressed by some researchers. For Qesem Cave, Blasco et al. (2016c) consider that the meat consumed mainly came from ungulates and that the small number of tortoise remains indicates they most probably held a secondary, supplementary role. Regular tortoise predation, however, has been proposed for South African sites. Klein and Cruz-Uribe (1983, 2000) relate tortoise body size decline from the MSA to LSA contexts in Die Kelders Cave 1, Byneskranskop, Klipfonteinrand and Blombos Cave, to hunting pressure associated with demographic increase and a more developed hunting-gathering technology during the LSA. However, recent studies of Blombos Cave and Pinnacle Point Cave 13B (Thompson, 2010; Thompson & Henshilwood, 2014a, 2014b) suggest that, at these sites, MSA people preyed less intensively on tortoises because the caves were closer to the sea and shellfish was the protein resource of choice, whereas, during the LSA, with the caves further away from the sea, tortoise harvesting substituted shellfish collection.

Reduction over time in tortoise size has also been argued for the Mediterranean Basin. In Kebara Cave, Speth and Tchernov (2002) stated that tortoises were larger during the early and late occupations, when the cave was sporadically used by humans. Conversely, when the site was occupied more intensively, tortoise mean body size decreased. These researchers have also related larger tortoises with summer dwelling, and smaller animals with winter-spring occupations, when tortoises are more active, and rates of encounter are higher. Human overexploitation of tortoises, explaining a decrease of mean body size, has also been proposed by Stiner (2005) for Hayonim Cave.

These studies used osteometric analyses of tortoise bones made on several skeletal elements. Klein and Cruz-Uribe (1983) used humeri, Stiner (2005) the humerus and the nuchal plate, Munro (2009) the average breadth of the narrowest part of the humerus' shaft, and Nabais (2012) integrated several measurements but did not describe each individually. More recently, Vitek (2018) used a geometric morphometric approach to analyse Eastern box turtles (*Terrapene carolina*). This approach requires complete or nearly complete carapaces, which is not possible in most Middle Palaeolithic tortoise assemblages.

This study uses an osteometric method to assess tortoise body size that allows the combined consideration of several skeletal elements – whether complete or fragmented (section 10.6, Appendices B and C). The tortoise assemblages from my two case study sites, Gruta da Figueira Brava and Gruta da Oliveira, are analysed with this method. To identify the agent of accumulation, describe processing techniques, and assess the role of the resource within the diet, a detailed taphonomic analysis of those assemblages is also conducted. Finally, the intensity of human use and what impact it may have had on tortoise populations are discussed.

13.2. RESULTS

13.2.1. Taxonomic and body part frequencies

The Gruta da Figueira Brava tortoise sample comprises 91 remains (Tabs. 13.1, 13.2). All are of *Testudo hermanni.* Most are shell fragments (NISP = 88 or 96.7%), among which peripheral (NISP = 17) and costal plates (NISP = 12) predominate; only three limb bones were recovered (Fig. 13.1). The relatively thick shell, and its deep and well-pronounced sulcus (Lavocat, 1966) allows the identification of testudines even in small fragments. Following Amiranashvili (2000; Tab. 9.2), the identification to species was confirmed based on: (a) the presence of an epiplastron showing a poorly developed lip and a sulcus matching the anterior angle of the bone's edge; (b) one hypoplastron with a sulcus with its posterior part curving in a S-shape and not touching the medial-posterior edge of the bone; and (c) a xiphiplastron with no curvature of its lateral-posterior groove. The limb bones recovered correspond to one femur and two possible femora or humeri that, even though broken, show the accentuated curvature and stoutness typical of testudines. Given that no other species of tortoise is present among the identified material, it is reasonable to assume that the remains without species-specific features are of *Testudo hermanni* too.

Site/Levels	NISP	%NISP	MNI	%MNI
Gruta da Figueira Brava				
Reworked levels	6	6.59	4	23.53
MIS-5 levels	85	93.41	13	76.47
TOTAL	**91**	**100.00**	**17**	**100.00**
Gruta da Oliveira				
Layer 7*	20	5.71	1	9.09
Layer 8*	2	0.57	1	9.09
Layer 9*	29	8.29	2	18.18
Layer 10*	8	2.29	1	9.09
Layer 11*	45	12.86	2	18.18
Layer 12*	18	5.14	1	9.09
Layer 13*	47	13.43	1	9.09
Layer 14*	181	51.71	2	18.18
Sub-Total	**350**	**100.00**	**11**	**100.00**
Layer 15*	251	8.25	2	15.38
Layer 16*	1,490	48.95	6	46.15
Layer 17*	759	24.93	2	15.38
Layer 18*	408	13.40	2	15.38
Layer 19*	136	4.47	1	7.69
Sub-Total	**3,044**	**100.00**	**13**	**100.00**
Layer 20	583	29.97	14	33.33
Layer 21	752	38.66	14	33.33
Layer 22	349	17.94	5	11.90
Layer 23	97	4.99	4	9.52
Layer 24	142	7.30	4	9.52
Layer 25	22	1.13	1	2.38
Sub-Total	**1,945**	**100.00**	**42**	**100.00**
Layer 26	280	77.35	10	76.92
Layer 27	82	22.65	3	23.08
Sub-Total	**362**	**100.00**	**13**	**100.00**
TOTAL	**5,701**		**79**	

Tab. 13.1 – Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI) of tortoise recovered from Gruta da Figueira Brava and Gruta da Oliveira. *Data from Nabais (2012).

The Gruta da Oliveira tortoise sample is much larger. The remains from layers 7 to 19 total 3,394 bone fragments (Nabais, 2012), while the hitherto unstudied material from layers 20 to 27 total 2,307, for an overall NISP of 5,701 (Tab. 13.1).

Tortoise shell is the best represented skeletal part in all the Gruta da Oliveira samples. A significant number of the 5,327 shell fragments could be separated into carapace (NISP = 1,689 or 29.63%) or plastron (NISP = 360 or 6.31%). Within the carapace, peripheral (NISP = 593 or 10.40%) and costal plates (NISP = 335 or 5.88%) are the most common; cases of costal and peripheral plates still in connection are not infrequent, and there is at least one instance of a costal, a peripheral and one neural plate found in articulation. Amongst plastron bones, the xiphiplastron is the most frequent (NISP = 50 or 0.88%), followed by the hyoplastron (NISP = 34 or 0.60%) and the epiplastron (NISP = 27 or 0.47%). Within the long bones, all skeletal parts are represented, but there is a bias towards the forelimbs (NISP = 218; hindlimbs, NISP = 90). The humerus is the best represented (NISP = 82 or 1.44%), followed by the scapula (NISP = 73 or 2.34%), the femur (NISP = 32 or 0.56%) and the ulna (NISP = 27 or 0.47%; Figs. 13.1 – 13.3).

Species identification was mainly based on the shell bones (Fig. 13.3). In the carapace, the diagnostic *Testudo hermanni* features (Amiranashvili 2000) that have been identified are: nuchal plates with an octagonal shape and an elongated central sulcus; pygal plates with a middle groove. In the plastron, the features already described for Gruta da Figueira Brava are found on epiplastra, hypoplastra and xiphiplastra, while the delineation of an entoplastron shows two indentations emerging on each side of the bone, whose posterior part presents the sulci that will merge with the medial hyoplastron Amiranashvili (2000). Almost all the articulated plastron plates also display these diagnostic features.

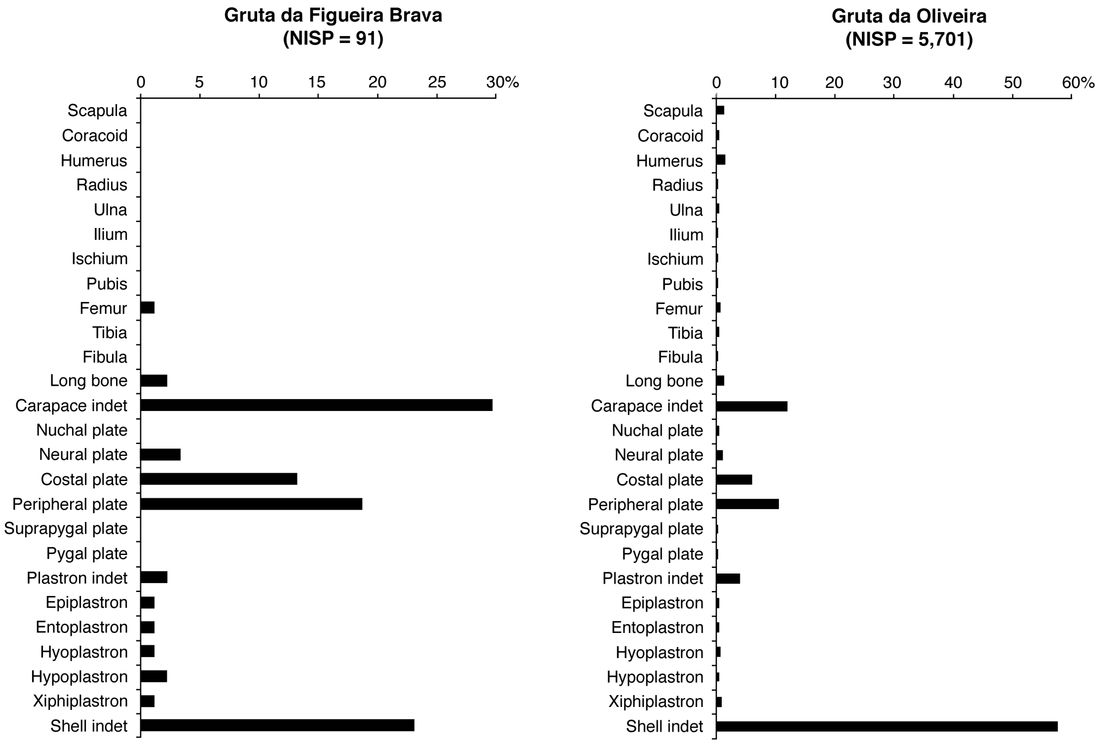


Fig. 13.1 – Body part representation of tortoise remains recovered from Gruta da Figueira Brava and Gruta da Oliveira.

Fig. 13.2 – Tortoise long bones recovered from Gruta da Oliveira (layers 20 to 27). A) Humeri. B) From left to right: two scapula, one ischium, one femur and two tibiae.

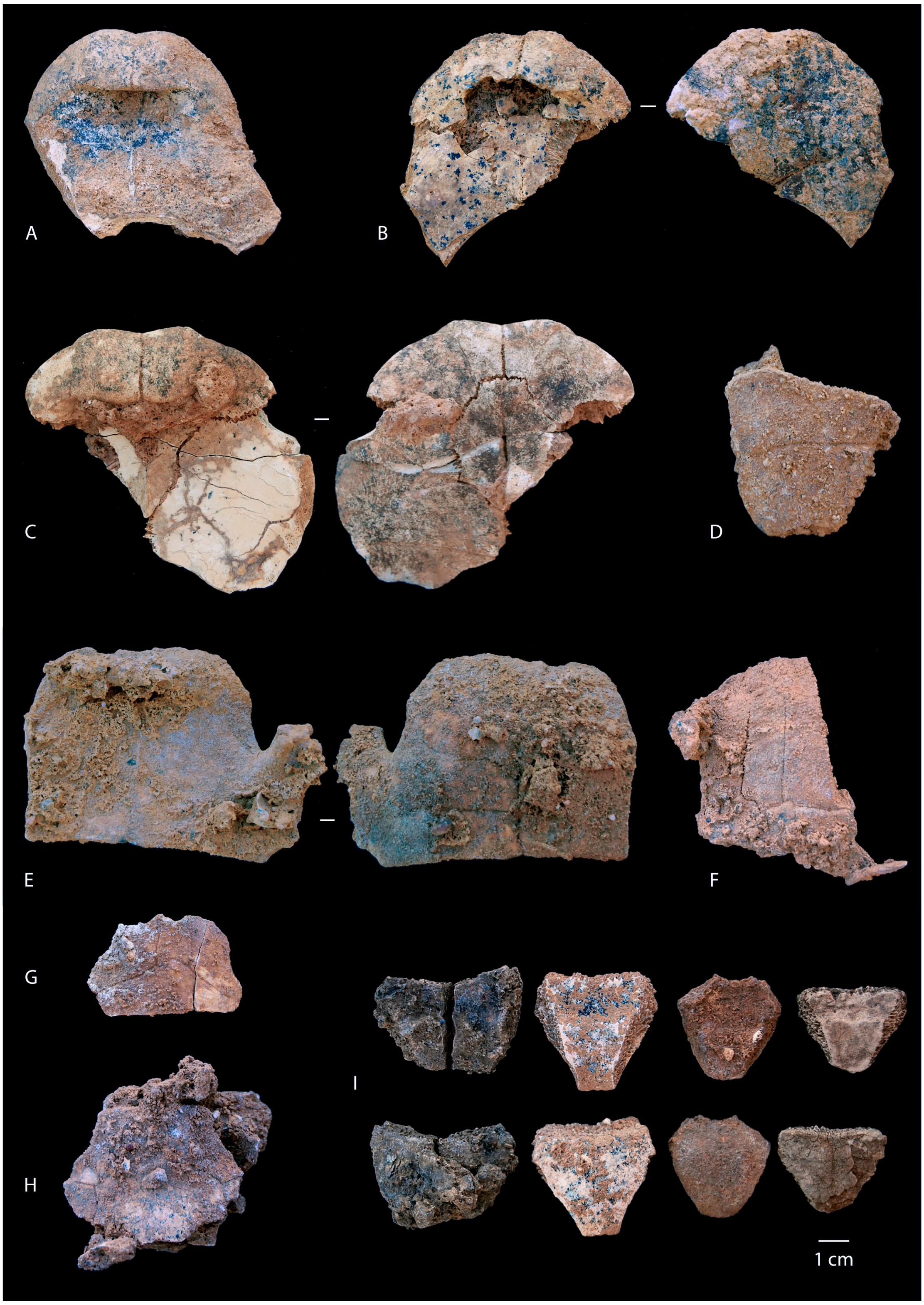


Fig. 13.3 – Examples of diagnostic *Testudo hermanni* shell remains recovered from Gruta da Oliveira (layers 20 to 27). A) Epiplastra, entopolastron and hyoplastron on ventral side (from left to right) from layer 20. B) Epiplastra, entoplastron and hyoplastron on ventral side and dorsal side (from left to right) from layer 24. C) Epiplastra, entoplastron and hyoplastron on ventral side and dorsal side from layer 26. D) Right xiphiplastron on dorsal side from layer 20. E) Epiplastra, entoplastron and hyoplastra on ventral and dorsal sides from layer 20. F) Peripheral and costal plates on dorsal side from layer 20. G-H) Nuchal plates on dorsal side from layer 20 and 21, respectively. I) Pygal plates on ventral and dorsal sides (from upper and lower rows, respectively) from layer 20 except the last one from layer 22 (from left to right).

	Fragmentation	Reworked		MIS-5	
		NISP	%NISP	NISP	%NISP
Carapace	Complete	1	25.00	11	20.00
	Incomplete	3	75.00	44	80.00
	Total	**4**	**100.00**	**55**	**100.00**
Plastron	Complete	-	-	2	28.57
	Incomplete	1	100.00	5	71.43
	Total	**1**	**100.00**	**7**	**100.00**
Girdle	Complete	-	-	-	-
	Incomplete	-	-	-	-
	Total	**-**	**-**	**-**	**-**
Limbs	Complete	-	-	-	-
	Incomplete	1	100.00	2	100.00
	Total	**1**	**100.00**	**2**	**100.00**
Carapace + Plastron	Complete	1	20.00	13	20.97
	Incomplete	4	80.00	49	79.03
	Total	**5**	**100.00**	**62**	**100.00**
Girdle + Limbs	Complete	-	-	-	-
	Incomplete	1	100.00	2	100.00
	Total	**1**	**100.00**	**2**	**100.00**

Tab. 13.2 – Fragmentation of tortoise remains recovered from Gruta da Figueira Brava. Girdle bones = coracoid, scapula, ilium, ischium, pubis. Limb bones = humerus, radius, ulna, femur, tibia. Indeterminate shell and indeterminate long bones were not included in the fragmentation quantification.

	Fragmentation	Layers 7-14		Layers 15-19		Layers 20-25		Layers 26-27	
		NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP
Carapace	Complete	4	3.28	26	5.74	34	3.61	4	2.34
	Incomplete	118	96.72	427	94.26	909	96.39	167	97.66
	Total	**122**	**100.00**	**453**	**100.00**	**943**	**100.00**	**171**	**100.00**
Plastron	Complete	2	15.38	13	24.07	8	3.11	-	-
	Incomplete	11	84.62	41	75.93	249	96.89	36	100.00
	Total	**13**	**100.00**	**54**	**100.00**	**257**	**100.00**	**36**	**100.00**
Girdle	Complete	-	-	-	-	13	18.84	6	37.50
	Incomplete	7	100.00	38	100.00	56	81.16	10	62.50
	Total	**7**	**100.00**	**38**	**100.00**	**69**	**100.00**	**16**	**100.00**
Limbs	Complete	3	15.79	12	24.00	22	30.56	8	21.62
	Incomplete	16	84.21	38	76.00	50	69.44	29	78.38
	Total	**19**	**100.00**	**50**	**100.00**	**72**	**100.00**	**37**	**100.00**
Carapace + Plastron	Complete	6	4.44	39	7.69	42	3.50	4	1.93
	Incomplete	129	95.56	468	92.31	1,158	96.50	203	98.07
	Total	**135**	**100.00**	**507**	**100.00**	**1,200**	**100.00**	**207**	**100.00**
Girdle + Limbs	Complete	3	11.54	12	13.64	35	24.82	14	26.42
	Incomplete	23	88.46	76	86.36	106	75.18	39	73.58
	Total	**26**	**100.00**	**88**	**100.00**	**141**	**100.00**	**53**	**100.00**

Tab. 13.3 – Fragmentation of tortoise remains recovered from Gruta da Oliveira. Girdle bones = coracoid, scapula, ilium, ischium, pubis. Limb bones = humerus, radius, ulna, femur, tibia. Indeterminate shell and indeterminate long bones were not included in the fragmentation quantification.

		Gruta da Figueira Brava		Gruta da Oliveira	
		NISP	**%NISP**	**NISP**	**%NISP**
Carapace + Plastron	Complete	14	20.90	91	4.44
	Incomplete	53	79.10	1958	95.56
	Total	**67**	**100.00**	**2049**	**100.00**
Girdle + Limbs	Complete	-	-	64	20.78
	Incomplete	3	100.00	244	79.22
	Total	**3**	**100.00**	**308**	**100.00**

Tab. 13.4 – Fragmentation comparison of tortoise remains recovered from Gruta da Figueira Brava and Gruta da Oliveira (all layers). Girdle bones = coracoid, scapula, ilium, ischium, pubis. Limb bones = humerus, radius, ulna, femur, tibia. Indeterminate shell and indeterminate long bones were not included in the fragmentation quantification.

13.2.2 Fragmentation and type of fracture

Both assemblages are highly fragmented. In the Gruta da Figueira Brava sample, 80.22% (or NISP = 73) of tortoise remains are smaller than 3 cm. At Gruta da Oliveira, fragmentation data are available for the basal sample only, with most remains <3 cm (NISP = 1,574, or 60.38%) but there are many complete elements (Tab. 13.2-13.4). Together with the shell bones found in connection, this complete material explains the higher percentage of remains >3 cm (some reaching sizes in the 10-11-cm interval).

Fragmentation is heavier among shell bones; at both sites, carapace and plastron remains are more incomplete than girdle and limb bones (Tab. 13.4). For Gruta da Figueira Brava, the higher percentages for complete shell must be observed with caution considering that the sample size is considerably smaller than at Gruta da Oliveira. In the latter, fracture outline data are available for the basal sample only, in which curved/V-shaped breaks predominate (36.89% or NISP = 851). In the Figueira Brava sample, most fractures are transverse (54.95% or NISP = 50), and the three girdle and limb elements show transverse fractures that leave the shaft intact. This type of fracture is much more frequent in Gruta da Oliveira’s basal sample, in which it amounts to 85.38% (or NISP = 222) of those same bones (NISP = 260). In this sample, the bones with transversal fractures tend to be broken into two or three parts, the proximal ends being more commonly present (NISP = 43 or 16.54%) than the distal ends (NISP = 32 or 12.31%); curved/V-shaped fractures occur in only 15 cases (or 5.77%), and longitudinal fractures are rare (3.08% or NISP = 8).

13.2.3. Burning

Thermo-alteration was identified in both caves: 15.38% (or NISP = 14) in the Gruta da Figueira Brava sample, 49.76% (or NISP = 2,837) in Gruta da Oliveira's (Tab. 13.5, Fig. 13.4).

At Gruta da Figueira Brava, black burns are the most frequent; the burning colours reflecting very high temperatures (grey and white) are nearly absent. Burning is always found on both sides of carapace and plastron bones, except for one indeterminate shell and one peripheral plate that are only burnt on the dorsal side; one femur is also completely burnt.

At Gruta da Oliveira, most burnt remains are shell fragments (458 carapace, 60 plastron, and 2,280 indeterminate), with a higher incidence on the peripheral (7.18% or NISP = 201) and costal plates (2.75% or NISP = 77) and reflect exposure to temperatures lower than 400ºC (Nicholson, 1993). Brown and black colours represent 46.43% (or NISP = 2,647) of the burnt assemblage, and double colouration was observed in 38 shell fragments (1.34%). Thermo-alterations are predominantly found on the shell's dorsal side (NISP = 1,839, or 64.82%). A little under one third are burnt on both sides (NISP = 868, or 30.60%), but burning of the ventral side alone is minimal (NISP = 118, or 4.16%). Burnt girdle and limb bones (NISP = 39, or 1.37%) are mostly (NISP = 29) completely burned.

13.2.4. Bone surface modification

One impact flake on the distal-dorsal side of a peripheral plate was observed in the Gruta da Figueira Brava sample. The ventral side of one of its costal plates bore a straight, transversal incision. No carnivore marks, and no raptor digestion or beak marks were detected.

Percussion marks were identified on 2.98% (or n = 170) of the Gruta da Oliveira assemblage (Tab. 13.6). Impact flakes are the most frequent (77.06% or n = 131); they are mainly of carapace elements (56.49% or NISP = 74), with higher incidence on the dorsal side of peripheral plates (NISP = 26). Most plastron impact flakes (n = 16) are also dorsal, i.e., on the exterior side. Other percussion marks were also recognised, such as adhering flakes (n = 16) (Fig. 13.7) and notches (n = 23). They are all found on shell bones, except for a notch located on a distal coracoid (Fig. 13.6). The latter is ambiguous, and it

Fig. 13.4 – Tortoise burnt shell from Gruta da Oliveira (layers 20 to 27), from left to right: two costal plates, one peripheral, one costal and two shell fragments.

	Gruta da Figueira Brava	**Gruta da Oliveira**			
		Layers 7-14	**Layers 15-19**	**Layers 20-25**	**Layers 26-27**
Brown	4	4	256	115	26
Brown/Black	-	-	-	15	12
Black	9	31	1816	243	126
Black/Grey	-	-	-	1	2
Grey	1	-	127	11	1
Grey/White	-	-	-	7	1
White	-	-	40	3	-
None	77	315	805	1,550	194
Total	**91**	**350**	**3,044**	**1,945**	**362**
%Burnt	**15.38**	**10.00**	**73.55**	**20.31**	**46.41**
%Non-Burnt	**84.62**	**90.00**	**26.45**	**79.69**	**53.59**

Tab. 13.5 – Burning on tortoise remains recovered from Gruta da Figueira Brava and Gruta da Oliveira.

can be argued to represent a bite notch. The small size of both bone and notch, however, make it unlikely that the agent involved is a carnivore. Even though specific assignment must remain open, we find it more likely that the notch stands for damage inflicted by humans, not carnivores. Notches on the shell are mostly dorsal (n = 14), which probably correlates with the position of the impact flakes and reflects their cracking open with hammer stones.

Striation marks were only found on seven elements, and are frequently filled-in with brecciated matrix, and thus not available for direct observation across much of their length. Nonetheless, their depth and outline are fully consistent with the interpretation that they are cut marks (Tab. 13.6, Fig. 13.5). Chop marks are present on the distal shafts of two humeri, and there is a proximal tibia shaft exhibiting a straight incision on its anterior side. Four other straight incisions are found on shell fragments, always on the interior side of the plates. Round-shaped depressions, with a maximum diameter of 1.64 mm, are present on the dorsal side of a shell fragment from the basal sample (Fig. 13.7). When viewed in detail, these marks seem to be due to the natural loss of small areas of the surface due to cracking rather than to carnivore activity; the previous study of the upper and middle samples, however, identified 18 instances of carnivore pits on tortoise shell fragments (Nabais, 2012).

13.2.5. Body size

Body size analysis was only possible for Gruta da Oliveira. Most remains providing biometric data (NISP = 365, or 90.57%) are from the basal and middle units (Fig. 13.8). The basal sample shows a bell-shaped curve similar to the distribution of a healthy living tortoise population despite the odd outlier in the -0.60 class, which reflects a very young animal (the measurement is for an extremely small ilium); most remains (55.10%) are larger than the standard animal. The distribution for the middle sample is still bell-shaped, but somewhat skewed to the left, showing a slight decline in tortoise body size; indeed, most remains (58.33%) are smaller than the standard. Such size reduction is very marked in the upper sample, where only 5.26% of the remains are larger than the standard animal.

As other researchers have most commonly used the humerus for biometric purposes (Klein & Cruz-Uribe, 1983; Stiner, 2005; Munro, 2009), data for this element alone are provided in Fig. 13.9 and Tab. 13.7. Based on the mean humerus SD measurement, a sharp decline in size from the basal to upper units is apparent: from the large basal sample mean size of 6.2 mm to almost half (3.3 mm) in the upper sample.

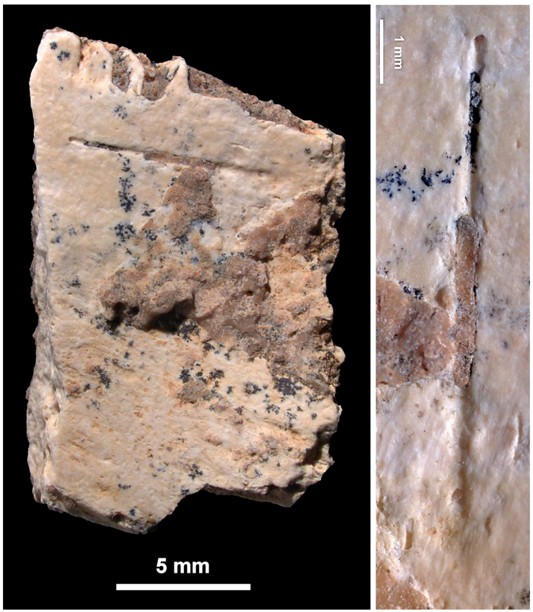


Fig. 13.5 – Cut mark on ventral side of tortoise carapace fragment from Gruta da Oliveira (layer 20), and its close-up, from left to right.

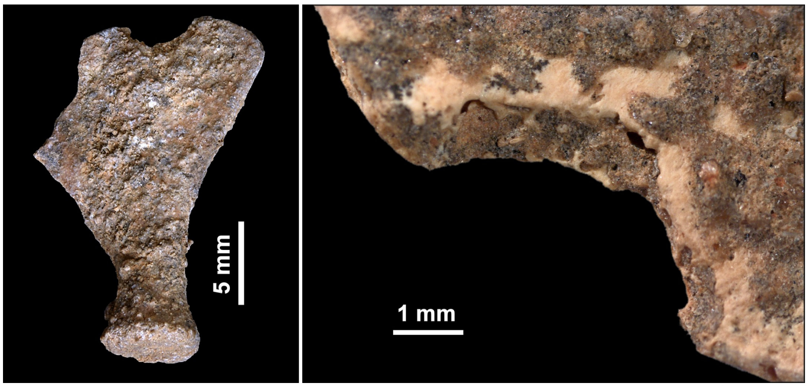


Fig. 13.6 – Percussion notch on distal coracoid from Gruta da Oliveira (layer 21) and its close-up, from left to right.

Fig. 13.7 – Adhering flake on peripheral plate (layer 20), and shell fragment with cracked surface and small pits (layer 20) that could macroscopically be misinterpreted as carnivore marks, from left to right.

	Layers 7-14	Layers 15-19	Layers 20-25	Layers 26-27
Percussion				
Impact flake	2	41	84	4
Adhering flake	-	-	16	-
Notch	2	9	12	-
None	346	2,994	1,833	358
Total	**350**	**3,044**	**1,945**	**362**
%Percussion	**1.14**	**1.64**	**5.76**	**1.10**
%Non-Percussion	**98.86**	**98.36**	**94.24**	**98.90**
Striation				
Chop	-	0	1	1
Cut	-	1	4	0
None	350	3,043	1,940	361
Total	**350**	**3,044**	**1,945**	**362**
%Striation	**-**	**0.03**	**0.26**	**0.28**
%Non-Striation	**100.00**	**99.97**	**99.74**	**99.72**

Tab. 13.6 – Percussion and striation marks found on Gruta da Oliveira tortoise remains.

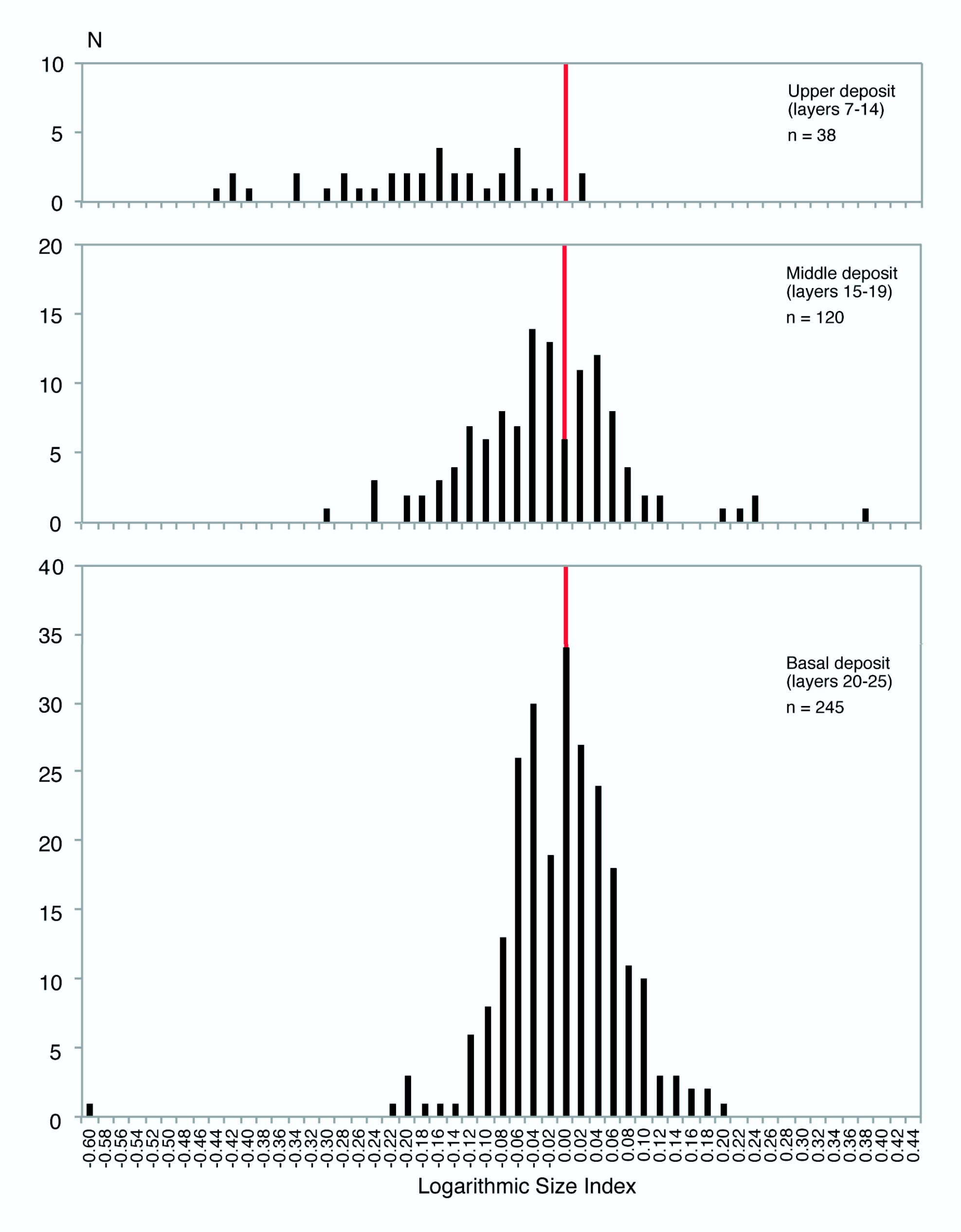


Fig. 13.8 – Logarithmic Size Index (LSI) for tortoise long bones recovered from Gruta da Oliveira. The red line marks the standard animal whose measurements can be found in Tab. 10.1.

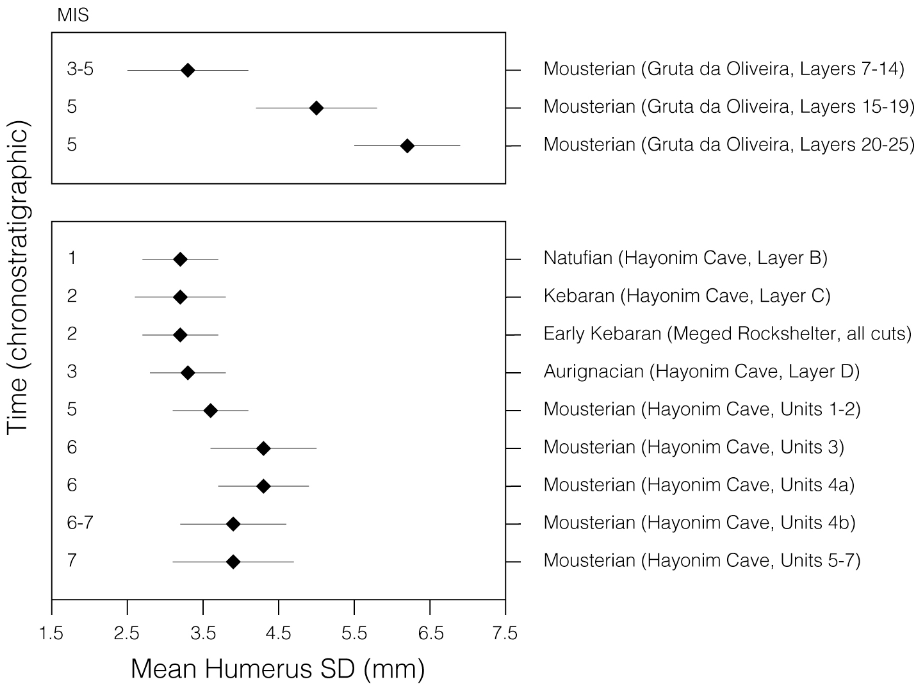


Fig. 13.9 – Mean values and standard deviations for humerus SD, in the time-ordered Gruta da Oliveira and Wadi Meged assemblages. MIS denotes Marine Isotope Stage. After Stiner (2005:140), modified.

Assemblages	MIS	Humeri Measured	Mean Humerus SD	Standard Deviation
Mousterian (Gruta da Oliveira, Layers 7-14)	3-5 (?)	5	3.3	0.8
Mousterian (Gruta da Oliveira, Layers 15-19)	5	21	5.0	0.8
Mousterian (Oliveira, Layers 20-25)	5	17	6.2	0.7
Natufian (Hayonim Cave, Layer B)	1	109	3.2	0.5
Kebaran (Hayonim Cave, Layer C)	2	63	3.2	0.6
Early Kebaran (Meged Rockshelter, all cuts)	2	58	3.2	0.5
Aurignacian (Hayonim Cave, Layer D)	3	74	3.3	0.5
Mousterian (Hayonim Cave, Units 1-2)	5	15	3.6	0.5
Mousterian (Hayonim Cave, Units 3)	6	25	4.3	0.7
Mousterian (Hayonim Cave, Units 4a)	6	39	4.3	0.6
Mousterian (Hayonim Cave, Units 4b)	6-7	29	3.9	0.7
Mousterian (Hayonim Cave, Units 5-7)	7	20	3.9	0.8

Tab. 13.7 – Measurements of tortoise humerus SD for Gruta da Oliveira and the Wadi Meged series (table adapted from Stiner 2005:140).

13.3. DISCUSSION

13.3.1. Agents of accumulation

The tortoise assemblages from both caves are monotaxic: all the identified remains in our samples are of *Testudo hermanni*, as previously observed for Gruta da Oliveira's layers 7-19 (Nabais, 2012). The *Emys* *orbicularis* bones from the 1986-89 excavation of Gruta da Figueira Brava reported by Lapparent-De Broin & Antunes (2000) are likely to stand for Holocene intrusions.

Natural accumulations of tortoises can be due to death during hibernation or to wildfires. Hibernation deaths happen on an individual basis, not systematically (Bertolero 2002), and archaeological accumulations of this type are thus highly improbable (Sanchis et al., 2015). Wildfires are known to have a high impact on tortoises, killing a significant number of individuals. Couturier et al. (2014) demonstrated that today's northern Mediterranean tortoise populations decrease by 31% in areas affected by wildfires. Such catastrophes result in the accumulation of complete animals, thus with all skeletal elements present in anatomical connection (Avery et al., 2004). Subsequently disassembled skeletons would be expected to result in shell plates separated along the suture lines with no breakage (Stiner, 1994, 2005). Complete burning of shell and skeleton is fairly common (Avery et al., 2004; Bertolero, 2015), but one would expect the amount of burning to vary with the distance to the fire, the intensity and duration of the exposure to high temperatures, and with the nature of the sediment that eventually buried the remains (Royer et al., 2011).

Wildfires in caves tend to be caused by the spontaneous combustion of guano. This is something that can happen in tropical environments but not in temperate Europe, and would in any case result in burnt cave walls and thermoclast accumulations associated with extensively reddened sediments – none of which exist in the caves studied (at Gruta da Oliveira, thermoclasts and reddening occur only in the well-delimited areas occupied by the hearths identified in layers 14, 21 and 22; Angelucci & Zilhão, 2009; Deschamps & Zilhão, 2018). Moreover, in the studied samples, burning is mostly of the shell; at Gruta da Oliveira, only 12.7% of the limb bones (39 out of 308) show thermo-alterations of any sort. Therefore, we can confidently exclude a natural origin for both sites' accumulations of *Testudo hermanni*.

In tortoise assemblages of raptor or carnivore origin, limb and girdle elements outnumber plastron and carapace ones, there is no burning, and a preference for juvenile individuals is apparent (Sampson, 2000). A predominance of axial bones, low frequencies of girdle elements, and the presence of intact crania and mandibles characterises raptor-accumulated assemblages, while those accumulated by small carnivores – in the Ebro Basin (Spain), foxes and badgers, but also black rats, are the main predators of tortoise (Bertolero, 2015) – feature a high frequency of forelimbs and shoulder bones, coupled with a scarce representation of cranium and axials.

Based on these criteria, a non-human origin has been assigned to tortoise assemblages from Blombos Cave, South Africa, where the relatively high frequency of limb and girdle elements in the M3 assemblage suggests a raptor input (Thompson & Henshilwood, 2014a). In Spain, the tortoise bones recovered from Cova de Dalt del Tossal de la Font de Vilafamés (Saladié et al., 2010) and in the Cova del Rinoceront, a Middle and Upper Pleistocene paleontological site near Barcelona (Daura et al., 2006), are possibly related with carnivore activity, if not accumulated by natural pit-fall trapping (for sub-layers IIIa-IIIb of Cova del Rinoceront; Daura et al., 2015) The material from Gruta da Figueira Brava and Gruta da Oliveira is distinct. There are no gnawing marks, pits or punctures diagnostic of carnivore interference with the remains, nor are there beak or digestion marks diagnostic of raptor input. This absence cannot be explained by the calcareous coating shown on bones, which, if indeed a significant factor, would have also hindered the recognition of anthropogenic modifications – for which, however, the evidence is plentiful.

The distribution across the skeleton of anthropogenic marks is preferential in both samples, in which, moreover, they are associated with incisions made on the internal side of the carapace. These patterns imply intentional tortoise processing, while the skeletal part representation matches Sampson's (2000) criteria for an anthropogenic accumulation, namely with regards to the absence of skulls, the low representation of radius, ulna and tibia, and the conversely high frequencies of femur and humerus. At Gruta da Oliveira, all anatomical parts are represented, reflecting the introduction of complete animals, even though there is a strong bias – replicated even clearer in the Gruta da Figueira Brava sample – towards the shell. In addition, most of Gruta da Oliveira's complete tortoise elements were found in layers 20-22 (n = 63, or 1.11%), which include *in situ* occupations with considerable amounts of intra-level stone tool refits (with layers 21 and 22 featuring spatial distributions that reflect hearth-structured human activity in the Access Corridor area of the site; Deschamps & Zilhão, 2018).

13.3.2. Prey processing

Our samples' skeletal part representation and the several examples of tortoise shell conjoins found at Gruta da Oliveira bespeak of the introduction of complete animals. How these were processed can be inferred from the burning and breakage patterns.

Differential burning of the shell is very clear in the Gruta da Oliveira sample. Most burning is found on the dorsal side, especially on the costal and peripheral plates, reflecting roasting upside down on an open fire, as described elsewhere (e.g. Speth & Tchernov, 2002; Blasco, 2008; Thompson & Henshilwood 2014a). Burning marks are mostly brown and black, reflecting exposure to fire temperatures below 400° C (Nicholson, 1993), typical for cooking (e.g. Pearce & Luff, 1994; Montón-Subias, 2002). According to Sampson (1998), this is the easiest way to process tortoises: exposure to fire loosens the ligaments and makes the shell more prone to breakage, as confirmed by experimental work (changes in the crystal structure of burnt bones make them more susceptible to fragmentation; Stiner et al., 1995).

Two shell fragments from Gruta da Figueira Brava were also only partly burnt. Their parsimonious interpretation is that they reflect the roasting of the animal on coals, as documented at Gruta da Oliveira and contemporary sites in the Mediterranean basin. Other than cooking, no anthropogenic activities or post-depositional events that would only affect one side of a tortoise's shell are easy to picture.

The predominance of curved/V-shaped fractures bespeaks of the intentionality of the breakage evident in the Gruta da Oliveira sample. The most frequent percussion marks are notches and impact flakes, which hints at the use of stone tools to open the tortoise shell. Most percussion marks are found on the dorsal side of peripheral plates, implying the use of hammerstones to attack the weakest point of the animal's carapace, as seen also at coeval archaeological sites in the Levant (Stiner, 2005; Blasco et al., 2016c; Biton et al., 2017) and South Africa (Thompson & Henshilwood, 2014a) – even though exceptions exist, as in level IV of Cova del Bolomor, where hammering is mostly seen on neural and costal plates (Blasco, 2008).

Once the shell is open, the viscera are accessible for consumption and the limbs can be removed by hand via twisting actions that result in damage to the proximal epiphysis, as seen in most femora and humeri from the Gruta da Oliveira sample, as well as at Hayonim Cave (Stiner, 2005) and the site of Nahal Mahanayeem Outlet (Biton et al., 2017), in the Levant. Further manipulation is demonstrated by the striation marks, the chops and the cuts found on limb bones, mostly located at the shafts' ends, reflecting the use of stone tools for defleshing and the detaching of ligaments. In both our samples, striation marks are also found on the shell's interior, implying the use of stone tools for the removal of viscera. This practice seems to go back to the Early Pleistocene, as documented at the site of Sima del Elefante (Atapuerca, Spain; Blasco et al. 2011). Thereafter, the practice is documented at the Spanish sites of Cova del Bolomor (Blasco, 2008), Torrejones (Arribas et al., 1997), Abrigo de la Quebrada (Sanchis et al. 2013) and Abric del Pastor (Sanchis et al., 2015), as well as, in the Near East, at Qesem Cave (Blasco et al., 2016c) and Nahal Mahanayeem Outlet (Biton et al., 2017), and, in South Africa, at Blombos Cave (Thompson & Henshilwood, 2014a).

Most shell fragments from Gruta da Figueira Brava are burnt on both sides. The same happens with 40% of the burnt tortoise bones from Gruta da Oliveira. Burning on both sides of tortoise shell was also found in Pinnacle Point Cave 13B, where it was interpreted as the result of post-depositional processes (Thompson, 2010). At Qesem Cave, where much the same was found, cleaning of the living space was put forth as a possible explanation; if so, it was not a common practice though (Blasco et al., 2016c). One would expect the post-depositional burning of previously discarded faunal remains to produce significant amounts of calcined elements, which one would therefore also expect to find among the scattered material resulting from floor sweeping or similar habitat maintenance tasks. However, calcined elements are absent among the tortoise as much as the ungulate assemblages from those two sites. An alternative hypothesis is that the bones were used as hearth fuel (Costamagno et al., 2005, 2009; Théry-Parisot, 2002; Théry-Parisot et al., 2005; Yravedra et al., 2005), which is consistent with the evidence from layers 14 and 15 of Gruta da Oliveira, where burnt tortoise shell was spatially associated with a hearth situated at their interface (Nabais, 2011; Zilhão et al., 2010a). The scarcity in our sample of bones burnt to grey, blue or white is consistent with this hypothesis, as it can be explained by taphonomically induced under-representation (exposure to very high temperatures renders bone more susceptible to breakage; Stiner et al., 1995).

13.3.3. Dietary role

Tortoises are not aggressive animals and their slow movement motivated Stiner and colleagues (Stiner et al., 1999, 2000; Stiner, 2001) to include them within the category of easily collected small prey, together with shellfish. The animals' defence mechanism of hiding within the shell, and the lack of an escape system, make tortoises an easy target and, hence, a fairly reliable resource. The harvesting of tortoises is therefore considered to be closer to gathering than hunting (Brain, 1981; Isaac & Crader, 1981); very little technology, if any, is necessary to collect them, as shown by the ethnographic examples summarised in Blasco et al. (2016c), e.g. the occasional catching of tortoises by Gabon populations when checking their animal traps, or when collecting mushrooms. Other simple methods for catching tortoises are to tap a stick on the burrow's walls, to use long hooks to drag the animal out (the Seri Indian technique), or to place water at the burrow's entrance, thereby tempting the animal to come out. Moreover, several animals can be easily packed for transportation, e.g. by skewering, as del Papa (2016) observed among the rural populations of Mendonza, in Argentina. According to this author, each household can catch four to eight tortoises while searching for other resources. Additionally, tortoises are resilient animals surviving for many days without being fed. Hence, they can be simply stored and used as "tinned fresh meat", as described by Sanchis et al. (2015).

Modern hunter-gatherers rely on group coordination to acquire the resources needed to feed the whole community. Hunting is mostly a male task, performed by adult men who may spend up to several days out of the base camp pursuing and processing large ungulates. Although these animals present a significantly high-energy return rate due to the considerable amounts of meat obtained from just one individual, there is a high potential for failure (e.g. Lee, 1968; Hurtado et al., 1992; Bliege Bird et al., 2001). Therefore, nutritionally, the meat obtained by women, children and other less mobile individuals through less socially prestigious activities such as snaring, trapping and the collection of small game (Wadley, 1998) can be equally, if not more, significant. Thus, where available, it is likely that tortoises were a relatively low cost but significant contributor to Neanderthal diet.

Gruta da Figueira Brava is close to the sea, benefits from an ecotonal environment, and marine foods played a significant role in the diet of its human inhabitants (Antunes, 2000). At inland Gruta da Oliveira, no such foods were available, and the role of supplementary small animals must have been played mostly by tortoises, even though it cannot be excluded that the site's rabbits and birds may be anthropogenic in part. Based on the NISP calculated during our ongoing zooarchaeological study of the ungulates from the site's layers 20 to 27 (n = 687), tortoises (with a NISP of 2,307; Tab. 13.1) seem indeed to have represented a non-negligible, regularly procured food resource.

Diet-breadth models rank tortoises low because of their small size, attendant limited caloric value, and energy spent on procurement and processing (Winterhalder & Smith, 2000; Bird & O'Connell, 2006). Such ranking derives from the common assumption that hunter-gatherers preferentially target animals with a large body size (Dusseldorp, 2010). However, tortoises have a predictable behaviour, and if their hibernation burrows or their favourite spot for sunbathing are known, searching costs decrease dramatically, especially if, as pointed out by Thompson & Henshilwood (2014a), other gathering activities are conducted in areas of known tortoise territory. The energy investment and the time spent on transport and processing are also minimal, and, apart from the simple advantage of nutrient diversity within the diet (Hockett & Haws, 2003, 2009), tortoises present an appealing protein and fat package. Indeed, Thompson & Henshilwood (2014b) demonstrated that one tortoise alone can cover up to one-third of the calories required by a female rural worker. Thus, if collected intensively, tortoises could have had return rates comparable to large ungulates' (Madsen & Schmitt, 1988). In the long-term, however, their slow growth and slow reproduction rates – due to old maturity age and the need of specific conditions for egg laying (Pursall, 1994) – may inhibit sustainable mass collection.

13.3.4. Tortoise body size

Tortoise body size can change due to two main causes, forage quality and hunting pressure, but shifts in size can also be due to species replacement (Stiner, 2005:139). The growth of tortoises is continuous, even though non-linear (it can slow down in the animal's later years), and it is also highly influenced by environmental conditions, such as temperature and precipitation, which impact vegetation and food availability. One can therefore expect climate change to imply change in tortoise mean body size. Indeed, when comparing the tortoises from Hayonim and Kebara caves, Stiner (2005:141) suggests that Kebara's larger animals reflect the richer vegetation of the cave's surroundings.

The values for tortoise humerus SD in Gruta da Oliveira's basal and middle samples are larger than for all the Wadi Meged assemblages in Stiner (2005:140) (Fig. 13.9, Tab. 13.7). This size difference can be because a different species, *Testudo graeca*, is represented in the Near Eastern sites. However, Hailey et al (1988) indicate that, where they co-exist, *Testudo hermanni* and *Testudo graeca* tend to be roughly the same size, and Ernst and Barbour (1989) state that *Testudo hermanni* is on average smaller. Thus, we can confidently state that Gruta da Oliveira's tortoises from layers 15 to 25 were larger than those in Stiner's (2005:140) sample. Whether this size difference relates to more favourable environmental conditions, namely vegetation cover, in Iberia or at least along its Atlantic Façade, cannot be assessed without additional osteometric data. However, note that Klein and Cruz-Uribe (1983) have shown that no significant differences exist in mean body size between modern South African tortoise populations from environmentally distinct parts of the country. This conclusion finds archaeological support in Stiner's (2005:141) observation that no significant mean size shifts can be identified in Hayonim Cave's record, which spans the 200-44 ka interval, from MIS-7 to MIS-3. Moreover, Gruta da Oliveira's upper sample presents *Testudo hermanni* mean body size values comparable to the Near Eastern ones dating from the MIS-3 to MIS-5 (Fig. 13.9, Tab. 13.7), supporting that environmental conditions are unlikely to be the cause of body size change.

In a healthy living tortoise population, animal size distributions assume a bell-shaped curve (Stiner 2005:144). Therefore, if curves are skewed towards the left, there is a juvenile-biased population, whereas skewing towards the right reflects a predominance of adults. The basal sample of Gruta da Oliveira features a predominance of remains larger than the standard animal and a distribution akin to that of a healthy tortoise population (Fig. 13.8). This reflects the preferred predation of adult tortoises, as might be expected given their larger body size and, hence, greater nutritional value. Despite the slight skewness towards negative values in the middle sample, and the feeble decrease in the humerus mean size, the tortoise population seems to have remained fit through layers 15 to 19. Conversely, the upper sample shows a predominance of negative values, which is also very clear on the considerable size reduction of the humeri. This evidence suggests that, when compared with the Near Eastern sites (from the MIS-7 to the MIS-1), human impact on the tortoise populations of Iberia's Atlantic Façade was very strong. In the areas surrounding the Almonda karst specifically, such pressure may have precipitated a massive reduction, if not extinction of the species within a relatively short time (Fig. 13.9, Tab. 13.7). Severely depleted of its sexually mature individuals, humans began to target tortoise juveniles, eventually inhibiting population recovery.

Tortoises are low turnover species. Females take nearly a decade to become sexually mature, and they need highly specific temperature and humidity conditions to lay their eggs. Moreover, infant mortality is high, due to the juveniles' numerous predators (Lambert 1982; Pursall 1994; Bonin et al 2006). *Testudo hermanni* being sexually dimorphic (Lavender, 2012), the targeting of larger animals implies preferential culling of the larger adult female and, therefore, that intensive human exploitation of the resource has the potential to severely alter the age and size structure of the population. In addition, population loss can only be compensated by recruitment from nearby areas at a very slow pace. In this context, mean body size reduction can be interpreted as reflecting a population's overall size decrease. Thus, the significant shift observed at Gruta da Oliveira (Figs. 13.8 and 13.9) probably reflects the long-term effect of human pressure and attendant shrinking of the local tortoise population.

Reliability on a low turnover species is interpreted by Stiner and Kuhn (2009) to indicate that human groups were small and low-density; otherwise, the regular harvesting of tortoises would be unsustainable. Thus, the chain of inference from decrease in tortoise mean body size to decrease in tortoise numbers can be taken further to suggest that, all other things remaining constant, a decrease in tortoise mean body size reflects human demographic growth. This is the case made for Kebara by Speth and Tchernov (2002) and is a legitimate interpretation for the change through time observed between the basal and upper Gruta da Oliveira samples.

13.3.5. Could tortoises have gone extinct at the onset of MIS-4?

The most recent review of the Quaternary record of tortoises in western Europe (Morales & Sanchis, 2009) concludes that *Testudo hermanni* was the only species present through the Pleistocene, suggesting that all *Testudo graeca* identifications should be revised. The large body of evidence compiled has also demonstrated a sharp decline from the early and middle Upper Pleistocene (ca. 125 to 35 ka BP; roughly matching the Middle Palaeolithic) to the late Upper Pleistocene (ca. 30 to 10 ka BP; roughly matching the Upper Palaeolithic), when tortoises became nearly absent from the Iberian record. *Testudo hermanni* disappeared from Iberia around 10 ka BP, with the possible exception of one population traditionally considered endemic in the Catalan Coast (Alt Empordà, Girona, Spain).

Since the publication of Morales and Sanchis's exhaustive review, tortoise remains have been reported from several other Middle Palaeolithic Iberian sites.

Pérez et al (2017) report nine Testudinae remains from El Salt (Alicante; dated to MIS-3) and present the revised number of 697 Testudinae remains for Abric del Pastor (Alicante; >75 ka BP; Vidal-Matutano et al, 2015). Level IV of Abrigo de la Quebrada (Valencia; MIS-3 to MIS-5a) yielded 275 *Testudo hermanni* remains (Sanchis et al, 2013; Carrión et al, 2018; Real et al, 2018). Thirty-three remains, referred to *en passant* as *Testudo hermanni* and part of the faunal assemblage's non-anthropogenic component, are listed in level M of Abric Romaní (Barcelona; MIS-3), the only level of the site's thick stratigraphic sequence to have yielded chelonian remains (Fernández-Laso, 2010:407, 411).

At Abric del Pastor and Abrigo de la Quebrada, specific identification to *Testudo hermanni* is supported by differential diagnosis showing that the remains belong to tortoise as opposed to freshwater turtle (such misidentifications can easily occur as discussed by Lapparent-De Broin & Antunes, 2000). The dating evidence places Abric del Pastor in MIS-5, while the radiocarbon results for level IV of Abrigo de la Quebrada are minimum ages only; they show that the level cannot be younger than MIS-3 but are consistent with an earlier age. The El Salt and Abric Romaní remains might belong in MIS-3, but no diagnostic features are described in support of an attribution to *Testudo hermanni*. At El Salt, the Testudinidae material represents no more than 0.02% of the site's total faunal assemblage (NISP = 4,096; Pérez et al, 2017:332) and comes entirely from the sequence's basal level. The Abric Romaní remains belong to a single individual, one that was retrieved in the fill of a channel excavated in the archaeological deposit by a stream originating in a spring then extant at the back of the shelter (Saladié, personal communication). Whether this El Salt and Abric Romaní material belongs indeed to *Testudo hermanni* therefore remains to be demonstrated.

Similar problems exist with the Portuguese evidence. As discussed above, the Gruta da Figueira Brava tortoise remains are of MIS-5 age, and the remains from layers 7 to 13 of Gruta da Oliveira included in Nabais' (2012) study of 3,394 diagnostic remains of *Testudo hermanni* from that site were recently dated to the MIS-5 (Zilhão et al, *submitted*). At Gruta Nova da Columbeira (Bombarral), the species is well described by Jiménez-Fuentes et al (1998) but, as reported by Zilhão et al (2011), the site dates to MIS-5, not to MIS-3. At Gruta do Escoural (Middle Palaeolithic to Neolithic; Otte & Silva, 1996), Crespo (2002) reproduces the information in Lapparent-De Broin & Antunes (2000). The specimen discussed by the latter is a humerus from the 1960s excavations of M. Farinha dos Santos, reportedly found in the C-I chamber at a depth of ~1 m. Even though Lapparent-De Broin and Antunes (2000) refer the remain to the Upper Palaeolithic, the 1990s re-excavation of this sector of the cave showed that that depth corresponds to the Holocene/Pleistocene interface and that the stone tools found in the Pleistocene deposit are of the Middle Palaeolithic (Otte & Silva, 1996). A horse tooth found at slightly higher elevation (60-70 cm below the surface) in a 1990s test trench adjacent to the cross-section left by the 1960s work was dated by U-series (Early Uptake) to 48.9/+5.8/-5.5 ka. Such results are always minimum ages, and the more so in this case, given the stratigraphically higher elevation of the sample relative to the remain. In short, it is by no means certain that the *Testudo* humerus from Escoural is of MIS-3 (or later) age. Lastly, Davis (2002) reports the presence of six osteoderm fragments in the Middle and Upper Palaeolithic levels from Gruta do Caldeirão (Zilhão, 1992, 1997). They are referred to as “tortoise” in general, with no specific taxonomic assignment to *Testudo*. Such remains were revised for the present study and cannot be assigned to species. Four, one from a burrowed area and three from Early Upper Palaeolithic layers can, however, be assigned to cf. *Testudo* sp.; none show diagnostic features, all are rather thin, but they have marked sulci, a feature that is associated with *Testudo*. All the chelonian remains from the site’s Neolithic and Upper Palaeolithic levels that could be precisely taxonomically identified are *Mauremys leprosa* (Lapparent-De Broin & Antunes, 2000:110; and confirmed by my own observations).

To sum up, our review of the evidence indicates that there is no case of unambiguous identification of *Testudo hermanni* in Pleistocene contexts of Iberia that securely post-date MIS-5. Apparently, therefore, the onset of MIS-4 resulted in populations shrinking to the extent that human exploitation became uneconomic, if not in the altogether extinction of the species at the local or regional level. However, as shown by the evidence from e.g., Sima del Elefante (Blasco et al, 2011) and Cova del Bolomor (Blasco, 2008), tortoise persisted in Iberia across several cold phases of the Early and Middle Pleistocene, which suggests that climate deterioration alone does not seem capable of explaining why tortoises should disappear at the onset of MIS-4. Therefore, the marked rarefication, if not extinction of the species across a significant portion of Iberia’s geography is best explained by human impact having been greater than hitherto thought, inhibiting species turnover. Whether this happened at the end of the Last Interglacial or only somewhat later cannot be ascertained at present. In Portugal at least, however, the evidence from Gruta do Caldeirão is that the Last Glacial Maximum is a secure *terminus ante quem* for the disappearance of *Testudo hermanni*.

13.4. Conclusion

Traditionally, diet broadening is associated with the dawn of domestication (Flannery 1969) and, hence, with Anatomically Modern Humans with fully sapient cognition. Such diet broadening was considered by Flannery (1969) and Cohen (1977) to be associated with a human demographic burst that triggered the procurement and processing of previously ignored or rarely considered resources (such as tortoises, rabbits, birds and shellfish). Moreover, demographic increase per se has been interpreted by some as an indication of modernity (French, 2016), since it reveals the ability of a human community to maintain a larger healthy population alive and, consequently, lower mortality rates. However, the tortoise evidence shows that Portugal's Last Interglacial Neanderthals exploited a variety of food resources, implying a broad diet. Although Neanderthal groups might have been relatively small, the reduction in the frequency of tortoise remains and, in the animal's mean body size seen across the Gruta da Oliveira sequence is suggestive of human demographic growth at the end of the Last Interglacial, leading to overexploitation, and, possibly, extinction of the resource.

CHAPTER 14

MOLLUSCS

14.1. LITERATURE REVIEW

Once thought as a feature-specific developed by African early modern humans, and therefore closely associated with traits of modern behaviour (e.g. Marean et al, 2007; McBrearty & Brooks, 2000), marine resource use has also been observed as a reliable food supply in several European Neanderthal sites (e.g. Córtes-Sánchez et al, 2011; Will et al, 2019; Zilhão et al, 2020). Shellfish is traditionally considered as a fallback food that can be easily tapped into during times of resource stress due to its predictability (Waselkov, 1987). Despite molluscs being available throughout the year (e.g. Kyriacou et al, 2014; Jerardino, 2016), ethnographic accounts report the preference of many cultures to gather them in winter when the risk of shellfish poisoning is highly reduced. This is the case of the Nootka (Jewitt, 1993) or the Tlingit Indians (Emmons, 1991) of North America, to name just a few examples. However, recent oxygen isotope data from the archaeological site Ksâr ʻAkil (Lebanon) indicate that shellfish were collected during different seasons, and could have been regularly used since the early Upper Palaeolithic in that site. According to the authors, such practice is not related, nor is a consequence, of food resource depletion or overexploitation (Bosch et al, 2015, 2018).

So far, shellfish use has been confirmed in a total of 30 sites of the European Middle Palaeolithic (see summary by Will et al, 2019). Most sites date to early MIS-3, but there is strong evidence from MIS-4 and MIS-5. The oldest evidence was detected from the MIS-6 levels of Bajondillo Cave, Spain, dating from ~150 ka (Cortés-Sánchez et al, 2011), which roughly matches the earliest evidence in Africa in Pinnacle Point 13B (dating from ~160 ka; Jerardino & Marean, 2010; Marean et al, 2007; Marean, 2010). Most shellfish remains are interpreted as the result of Neanderthal feeding activities, but there is also evidence of shell collection for other purposes. In Cueva de los

Aviones (Spain), three perforated and ochred shells were found dating from 115 ka (Hoffmann et al, 2018b), thus predating their African counterparts by about 20 ka years in terms of the symbolic behaviour associated to such objects. Moreover, a scallop shell with ochre stains was recovered from Cueva Antón (Spain) – a Middle Palaeolithic site located about 60 km inland – , confirming shell transportation over long distances, and contacts between the coast and more inland occupations (Zilhão et al, 2010c). Additionally, shell scrapers were found in several Middle Palaeolithic sites in Italy and Greece (Douka & Spinapolice, 2012; Romagnoli et al, 2016), which also demonstrates the important role of shells within Neanderthal material culture.

Intensified use of coastal resources is often interpreted as an indicator of population pressure and/or reduced residential mobility (e.g. Stiner, 2001; Fa, 2008; Finlayson et al, 2006; Prendergast et al, 2016). Through the lenses of the Broad Spectrum Revolution, increased population density can be seen in the archaeological record through resource diversification (Flannery, 1969). As such, coastal occupations become extremely relevant considering their ecotonal positions, benefiting from both land and terrestrial landscapes, such is the case of Gruta da Figueira Brava. As described in more detail in Chapter 4 (section 4.4.), the debate is currently focusing on whether, or not, such coastal occupations do in fact reflect a systematic use of marine resources that would imply the transmission of such knowledge to the following generations, using proxies like the ratio between land and marine taxa, shell sizes and density (e.g. Langejans et al, 2012; Will et al, 2016, 2019). Some argue that Neanderthals were only using marine resources opportunistically, and are not comparable to their MSA counterparts (e.g. Klein & Steele, 2008; Marean, 2014). Others reason that only minor differences existed between both human groups (e.g. Bicho & Haws, 2008; Fa et al, 2016). Whereas some authors state that Neanderthals and MSA modern human exploitation of the shore was similar and comparable (e.g. Stringer et al, 2008; Zilhão et al, 2010c, 2020).

Marine resources have been considered as marginal foods for most of the Palaeolithic (e.g. Colonese et al, 2011; Jerardino, 2015). As seen with crustaceans in Chapter 15, this is especially true whenever Optimal Foraging Theory models are used, and the caloric value and energy intake of different animals are compared (e.g. Dusseldorp, 2010; Stiner 2001, 2010). The paradigm changes when a Nutritional Ecology approach is used, and many essential nutrients are considered, with a particular focus on vitamins, iron, folate, potassium, calcium and omega-3 fatty acids (e.g. Hockett & Haws, 2003; Haws & Hockett, 2004). In addition, shells can be easily gathered in the intertidal zone of the shore. This is a very low risk activity in which young and elderly people can partake, as shown by several ethnographic groups (e.g. Meehaan, 1983; Waselkov, 1987). Procurement of shell blanks could have also been conducted during shellfish gathering at the shore. Shells from the subtidal zone can be found at the beach and collected empty, generally showing traits of marine abrasion, natural perforations, or encrustations of sorts attached to the inside of the shell (Dupont, 2019; Zilhão et al, 2010c). It is also possible that some of the subtidal specimens were gathered from the sea floor as shown by Villa et al (2020) for the Moscerini Cave, in Italy. In addition, some small non-dietary shells can accidentally incorporate the archaeological deposits due to their encrustation on the dorsal side of other shells, or if seagrasses and seaweeds were being collected. Seagrasses and seaweeds rarely survive in the archaeological record, but they are edible and can be used for fuel, nets, basketry, and to wrap and steam food, among other purposes (Ainis et al, 2014).

Contrary to the idea that Neanderthals were unable to systematically use coastal resources (Marean, 2014), the shellfish assemblage from Gruta da Figueira Brava shows the largest collection recovered from a Neanderthal site so far. This site is positioned on the Atlantic coast and benefits from significant upwelling, which results in nutrient-rich waters (see Chapter 6). Consequently, and similarly to South African MSA sites, Gruta da Figueira Brava supports a sizable number of large molluscs, and great exposure to spring low tides. Such an assemblage is, therefore, of the utmost interest in order to understand the role of coastal resources within Neanderthal diet and daily activities.

14.2. RESULTS

14.2.1. Taxonomic and body part frequencies

Molluscs represent 37.94% (or 3960 remains) of the 10,437 NISP remains (excluding fish) recovered from Gruta da Figueira Brava. Most shell remains were recovered from Area F's MIS-5 deposit, but they were very fragmentary, as is also the case in Entrance 3's levels. Consequently, NISP and MNI counts are expected to underestimate shell abundance, thus the latter was also assessed in terms of density based on the analysis of bulk sediment sample (as previously described in Chapter 10, section 10.9), and compared with similar bulk samples from the Mesolithic site of Toledo (Fig. 14.1; Appendix D).

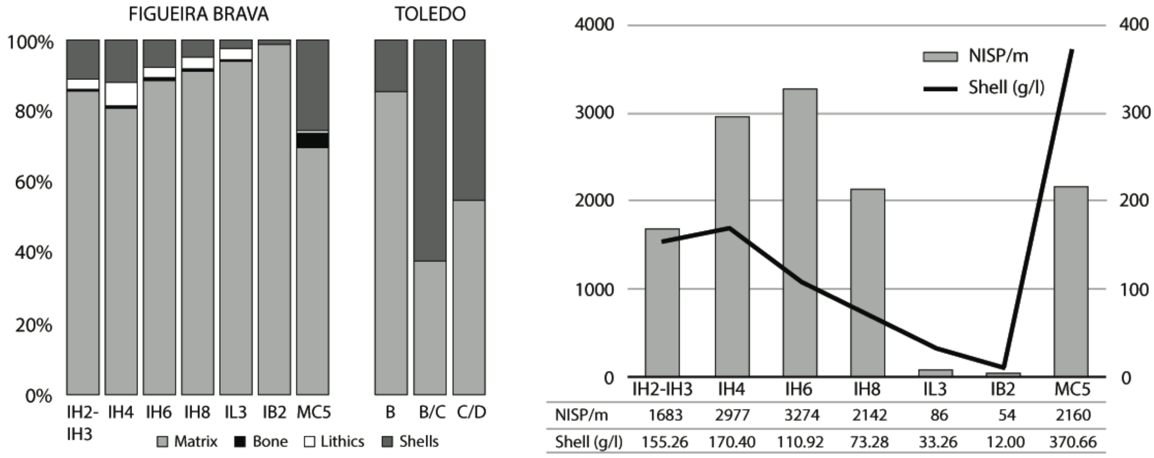


Fig. 14.1 – Density of marine invertebrate remains (including molluscs and crabs). In terms of site formation processes, Toledo sample B can be considered an analogue for FB 4 levels of Gruta da Figueira Brava, whereas samples B/C and C/D may be comparable to FB 2 units. See also Appendix D for more detailed info.

Overall, the mollusc collection is composed of 62.70% of bivalves (or NISP = 2483), 36.89% of marine gastropods (or NISP = 1463), and 0.40% of land gastropods (or NISP = 16). Mussels and clams dominate the bivalve assemblage (Tab. 14.3; Fig. 14.2), which is particularly striking on all occupation phases from the MIS-5 levels. Mussels are fragile shells that break easily, but five valves were recovered intact from MIS-5 levels, together with two valves of *Glycymeris glycymeris* and another two complete valves of *Ostrea edulis*. Nonetheless, most bivalves from the MIS-5 deposits are fragmented (99.58% or NISP = 2158), even though most of them allow species identification based on the preservation of their umbos or the sculpture of their outer shell. Identifications were not possible for only 2.12% (or NISP = 46) of the MIS-5 bivalves. Amongst the reworked levels, mussels are also the best represented (86.39% or NISP = 273), with 11.72% (or NISP = 32) of the mussel remains showing complete valves. *Ervilia castanea* and *Callista chione* are the other two species showing complete valves (Tab. 14.3).

Marine gastropods were mostly recovered from the MIS-5 levels, whereas only 6.98% (or NISP = 102) were collected from the reworked deposits (Tab. 14.1). Limpets dominate the MIS-5 marine gastropod assemblage (98.01% or NISP = 1332) and 10.66% of such limpets are complete (NISP = 142). Nonetheless, whenever broken, marine gastropods tend to show their apical part present, which happened in 14.98% of the overall marine gastropod assemblage (or NISP = 219), which in most cases allows species identification. This is a common feature in all four limpet species identified on site. Species diversity is large within the reworked levels, where 14 species are represented compared to the ten species in the MIS-5 deposits. This is particularly clear among *Littorina* species, even though several remains of other small gastropods are present within the MIS-5 occupation phases, like *Bittium reticulatum* or (Fig. 14.4).

Five different species of land gastropods were recovered, but they are the worst represented within the mollusc assemblage (NISP = 16) (Tab. 14.2). Despite their thin shells, a total of six remains were recovered complete from the reworked levels. Land gastropods are part of the environmental background noise

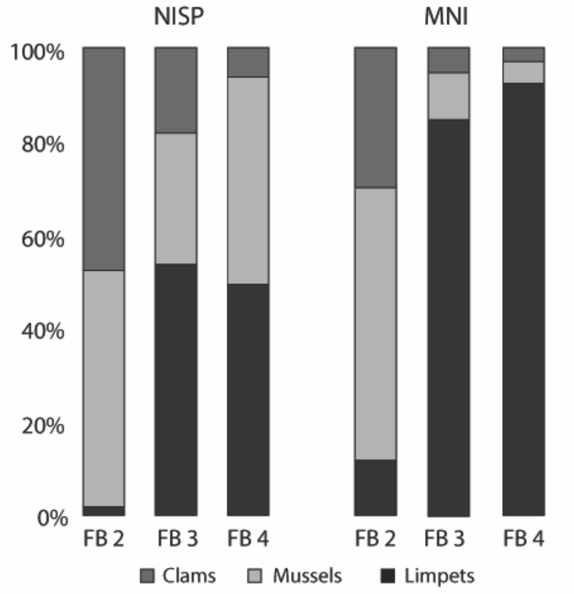


Fig. 14.2 – Chronological variation in the frequency of the main marine molluscs across human occupation phases. Histogram comparing limpets, mussels and clams on FB 4, FB 3, FB 2 by NISP and MNI.

TAXON	Phase FB4			Phase FB3			Phase FB2			Reworked			TOTAL		
	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU
PATELLIDAE															
Patella vulgata	414	193	193	20	15	15	6	6	6	16	9	9	456	223	223
Patella ulyssiponensis	35	20	20	4	3	3	1	1	1	4	4	4	44	28	28
Patella depressa	127	73	73	6	4	4	1	1	1	22	21	21	156	99	99
Patella rustica	2	2	2	-	-	-	-	-	-	1	1	1	3	3	3
Patella sp.	668	136	136	46	22	22	2	2	2	30	10	10	746	170	170
TROCHIDAE															
Phorcus lineatus	3	2	2	-	-	-	-	-	-	3	2	1	6	4	3
Steromphala cineraria	-	-	-	-	-	-	-	-	-	3	3	3	3	3	3
Steromphala umbilicalis	1	1	1	-	-	-	-	-	-	1	1	1	2	2	2
Steromphala sp.	4	3	3	-	-	-	1	1	1	2	2	2	7	6	6
LITORINIDAE															
Littorina obtusata	1	1	1	-	-	-	-	-	-	1	1	1	2	2	2
Littorina littorea	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
Littorina saxatilis	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
Littorina sp.	3	2	2	-	-	-	-	-	-	1	1	1	4	3	3
Melarhaphe neritoides	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
CERITHIIDAE															
Bittium reticulatum	1	1	1	-	-	-	1	1	1	-	-	-	2	2	2
RANELLIDAE															
Charonia lampas	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
cf. *Charonia lampas*	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
MURICIDAE															
Nucella lapillus	2	2	2	1	1	1	-	-	-	-	-	-	3	3	3
Ocenebra erinaceus	-	-	-	-	-	-	-	-	-	3	2	2	3	2	2
NASSARIIDAE															
Tritia reticulata	-	-	-	-	-	-	3	3	3	-	-	-	3	3	3
NATICIDAE															
Euspira guilleminii	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
INDETERMINATE															
Indeterminate	6	-	-	-	-	-	-	-	-	9	-	-	15	-	-
TOTAL	**1267**	**436**	**436**	**77**	**45**	**45**	**15**	**15**	**15**	**102**	**63**	**62**	**1461**	**559**	**558**

Tab. 14.1 – Marine gastropods from Gruta da Figueira Brava. Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimum Animal Units (MAU) per taxon and occupation phase.

TAXON	Phase FB4			Phase FB3			Phase FB2			Reworked			TOTAL		
	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU
ZONITIDAE															
Oxychilus cellarius	-	-	-	-	-	-	-	-	-	3	3	3	3	3	3
SUBULINIDAE															
Rumina decollata	-	-	-	-	-	-	-	-	-	3	2	2	3	2	2
COCHLICELLIDAE															
Cochlicella barbara	-	-	-	-	-	-	1	1	1	-	-	-	1	1	1
HELICIDAE															
Helicella conspurcata	-	-	-	-	-	-	-	-	-	2	2	2	2	2	2
Cepaea nemoralis	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
Helicidae	6	1	1	-	-	-	-	-	-	-	-	-	6	1	1
TOTAL	**6**	**1**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**9**	**8**	**8**	**16**	**10**	**10**

Tab. 14.2 – Land gastropods from Gruta da Figueira Brava. Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimum Animal Units (MAU) per taxon and occupation phase.

TAXON	Phase FB4			Phase FB3			Phase FB2			Reworked			TOTAL		
	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU
GLYCYMERIDAE															
Glycymeris glycymeris	11	4	2	-	-	-	5	2	0.5	2	2	1	18	8	3.5
Glycymeris sp.	-	-	-	-	-	-	4	1	0.5	-	-	-	4	1	0.5
MYTILIDAE															
Mytilus galloprovincialis	1095	19	14.5	39	5	3	276	50	46	273	45	41.5	1683	119	105
OSTREIDAE															
Ostrea edulis	19	4	2	1	1	0.5	-	-	-	1	1	0.5	21	6	3
PECTINIDAE															
Pecten maximus	3	3	2.5	1	1	0.5	-	-	-	-	-	-	4	4	3
Pectinidae	4	3	1.5	-	-	-	-	-	-	2	2	1	6	5	2.5
ANOMIIDAE															
Anomia ephippium	8	3	1.5	1	1	0.5	-	-	-	1	1	0.5	10	5	2.5
CARDIIDAE															
Laevicardium crassum	1	1	0.5	-	-	-	7	2	1.5	-	-	-	8	3	2
Cerastoderma edule	-	-	-	-	-	-	1	1	0.5	3	2	1	4	3	1.5
Cardiidae	6	4	2	1	1	0.5	10	2	1	-	-	-	17	7	3.5
VENERIDAE															
Callista chione	18	4	2.5	1	1	0.5	10	3	1.5	1	1	0.5	30	9	5
Ruditapes decussatus	164	16	12	26	3	2	263	26	21	3	3	1.5	456	48	36.5
Veneridae	121	4	2	3	2	1	9	3	1.5	3	2	1	136	11	5.5
MACTRIDAE															
Lutraria lutraria	-	-	-	-	-	-	1	1	0.5	-	-	-	1	1	0.5
Spisula solida	-	-	-	-	-	-	-	-	-	1	1	0.5	1	1	0.5
Mactridae	11	1	0.5	-	-	-	-	-	-	1	1	0.5	12	2	1
SCROBICULARIDAE															
Scrobicularia plana	-	-	-	-	-	-	-	-	-	4	2	1.5	4	2	1.5
SEMELIDAE															
Ervilia castanea	-	-	-	-	-	-	-	-	-	4	3	2	4	3	2
SOLENIDAE															
Solen marginatus	1	1	0.5	-	-	-	-	-	-	4	2	1	5	3	1.5
INDETERMINATE															
Indeterminate	45	-	-	1	-	-	13	-	-	13	-	-	59	-	-
TOTAL	**1507**	**67**	**44**	**74**	**15**	**8.5**	**586**	**91**	**36**	**316**	**68**	**54**	**2483**	**241**	**142.5**

Tab. 14.3 – Marine bivalves from Gruta da Figueira Brava. Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimum Animal Units (MAU) per taxon and occupation phase.

TAXON	Phase FB 4		Phase FB 3		Phase FB 2		Reworked		TOTAL	
	Black	Grey	Black	Grey	Black	Grey	Black	Grey	Black	Grey
BIVALVIA										
GLYCYMERIDAE										
Glycymeris glycymeris	3	-	-	-	-	-	-	-	3	-
MYTILIDAE										
Mytilus galloprovincialis	40	5	1	-			2	-	48	5
VENERIDAE										
Ruditapes decussatus	13	-	-	-	-	-	-	-	13	-
Veneridae	2	-	-	-	-	-	-	-	2	-
MACTRIDAE										
Mactridae	1	-	-	-	-	-	-	-	1	-
INDETERMINATE										
Indeterminate	3	-	-	-	-	-	1	-	4	-
GASTROPODA										
PATELLIDAE										
Patella vulgata	6	-	-	-	-	-	-	-	6	-
Patella depressa	2	-	-	-	-	-	-	-	2	-
Patella sp.	13	-	-	-	-	-	-	-	13	-
TOTAL	**83**	**5**	**1**	**-**	**-**	**-**	**3**	**-**		**5**

Tab. 14.4 – Burning on mollusc remains recovered from Gruta da Figueira Brava. Note the incidence of most burnt remains on limpets, mussels and clams from the MIS-5 levels.

and were not systematically recovered during excavation, as they are likely to be intrusive.

14.2.2. Fragmentation and type of fracture

Most MIS-5 marine mollusc remains (83.35% or NISP = 2939) cluster within the 1-3 cm size interval. However, there are several remains of larger dimensions, which are generally associated with shells of stronger robustness, such as the case of 12 *Ostrea edulis* remains ranging between 3 and 12 cm, and four *Pecten maximus* remains clustering between 7 and 12 cm. Limpets are also sturdy shells, and 23.01% (or NISP = 307) of the MIS-5 remains are larger than 3 cm, and they can reach up to 7 cm. Although thin-shelled, 6.01% (or NISP = 85) of mussel remains are also larger than 3 cm, and can get as large as 7 cm.

The type of fracture diverges between MIS-5 marine gastropods and bivalves. The latter tend to break longitudinally (49.65% or NISP = 1076); whereas gastropods break mostly transversally (74.03% or NISP = 1006), which preserves the apical part of the body. Whenever present, shell edges from MIS-5 levels tend to be well preserved, which contrasts with the commonly damaged edges of shells from the reworked deposits.

14.2.3. Burning

Thermo-alterations were mainly observed on molluscs recovered from the MIS-5 levels of Area F; very few were recognised on remains from the reworked levels (Tab. 14.4). The MIS-5 burnt shells are mostly black (NISP = 84, or 94.38%) and were mostly found on limpets, mussels and clams. Grey burns were only identified on mussel remains from the FB 4 occupation phase.

14.2.4. Surface modification

All bivalves were disarticulated, and most marine molluscs recovered from MIS-5 levels present calcareous concretions attached (96.97% or NISP = 3419). Conversely, only 22% (or NISP = 92) of the reworked remains show calcareous coating. Sediment filling was found in two limpets and one *Phorcus lineatus* from the reworked deposits (corresponding to 0.72% of the reworked assemblage); whereas it was better represented in the MIS-5 levels (5.05% or NISP = 178) with most cases observed in limpet shells (NISP = 144).

In Area F, abrasion was observed on three shells from the MIS-5 deposits, whereas the reworked levels present 11 (or 2.63%) mollusc remains with signs of abrasion, mostly on mussel shells. Dissolution associated with cave activity was found on 15 (or 3.51%) remains of the reworked levels, and on 90 (or 3.13%) remains from the MIS-5 deposits.

Encrustations were rare, and only found on the dorsal side of three limpets from the reworked levels, and one from MIS-5. Encrustations are all of *Perforatus perforatus* (the acorn barnacle). In Area F, perforations were found on three mussel remains, one on *Euspira guillemini* and one on a *Littorina obtusata* recovered from the reworked levels (Fig. 14.5). Eight perforations were found in MIS-5 levels remains: six on mussel shells, one on a scallop and one on a limpet shell.

Fig. 14.3 – Non-food bivalves from the MIS-5 deposits. A) *Ostrea* sp. (right valve; manuported Miocene fossil?; square U9, unit IH8). B) *Callista chione* (square S8, unit IH6). C) *Glycymeris* sp. (SEx trench, unit MC5). D) *Pecten maximus* (left valve; square U8, unit IL 2). E) *Glycymeris glycymeris* (SEx trench, unit MC5). F) *Pecten maximus* (left valve; square U9, unit IH2-IH3). Original photos by João Zilhão, in 2013.

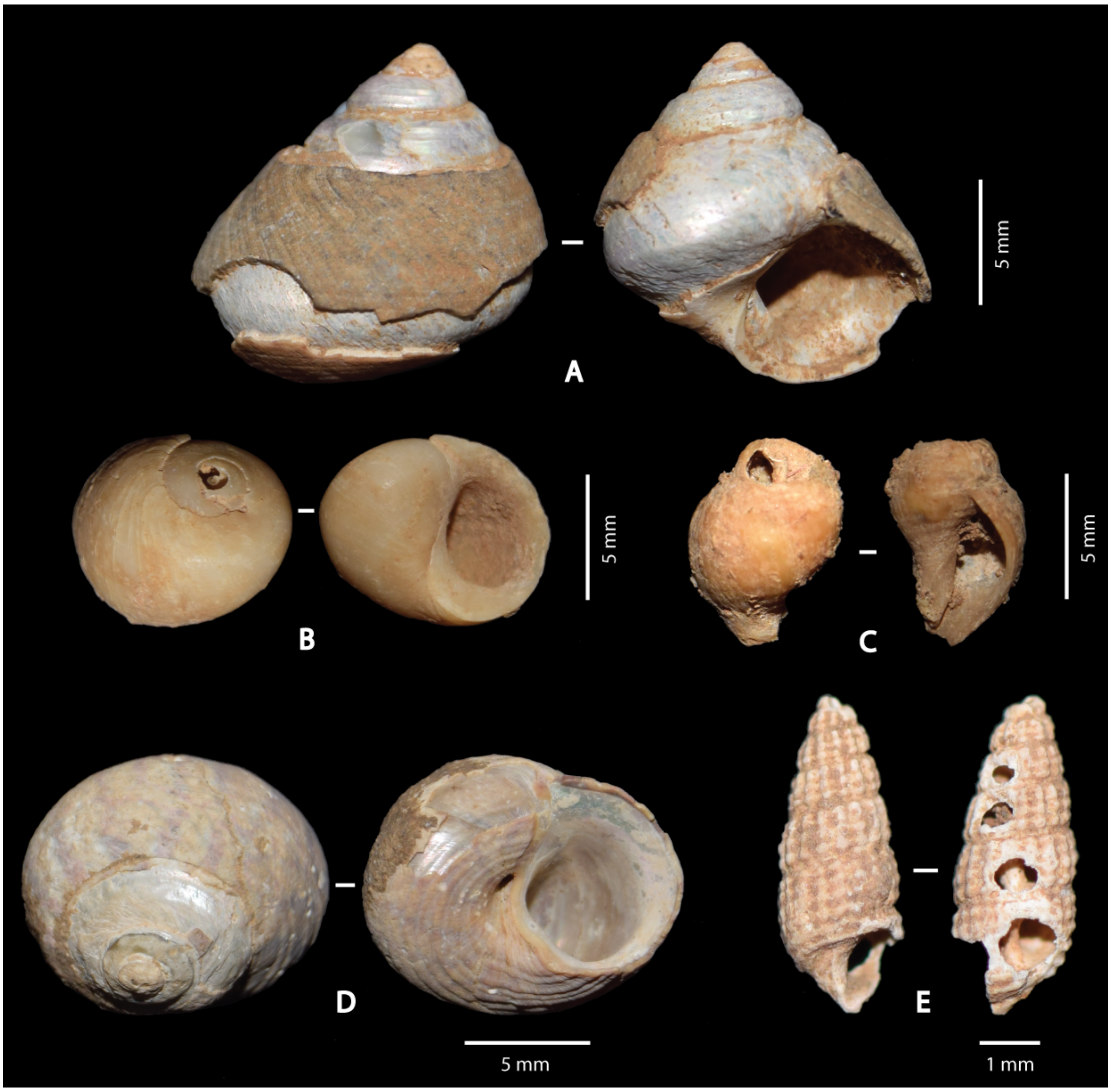


Fig. 14.4 – Non-food gastropods from the MIS-5 deposits. A) *Phorcus lineatus* (square U8, unit IH2-IH3). B) *Littorina obtusata* (square T8, unit IH8). C) *Nucella lapillus* (square S9, unit IH6). D) *Steromphala umbilicalis* (square U8, unit IH2-IH3). E) *Bittium reticulatum* (square S9, unit IH4).

Fig. 14.5 – Perforated gastropod shells. A) *Littorina obtusata* (from the small mammal nest in T9, reworked unit IT0). B) *Euspira guilleminii* (square T9, unit IT2). Original photos by João Zilhão, in 2013.

14.2.5. Body size

Biometry was more frequently done on limpets due to their higher degree of completeness when compared to the remaining shells of the collection. Length was the measurement most frequently taken. *P. vulgata* and *P. depressa* are the ones providing more abundant data. Both species present a similar pattern of size distribution (Fig. 14.7). In both cases FB 2 shows only one specimen. Sample size increases significantly towards the most recent occupation phases, showing larger mean values for individuals in FB 3, than in FB 4. The latter phase, however, presents a wider span of limpet sizes. The same happens with *P. ulyssiponensis*, showing increased frequency and size amplitude in FB 4.

The larger the frequency and limpet size, the larger the meat yields (Tab 14.9). Therefore, FB 4 is the occupation phase with larger limpet meat yield contribution to the diet. The amount of 800,54 g for FB 4 is considered as a minimum (Fig. 14.6), since that it is a value obtained from only the limpets that allowed length measurements (see section 10.7).

In order to assess the zones of the intertidal that were being exploited, *Patella vulgata* and *Patella depressa* are of most significance due to the several ratios and equations also described in section 10.7. As shown in Table 14.5 *P. vulgata* collection during the FB 4 occupation shows a preference for the low intertidal. But the same does not apply for FB 3 and FB 2, even though the low intertidal is still being exploited during the FB 3. As for seashore exposure, *P. vulgata* was mostly gathered in sheltered areas. Nonetheless, exposed seashore areas were not ignored (Tab. 14.8).

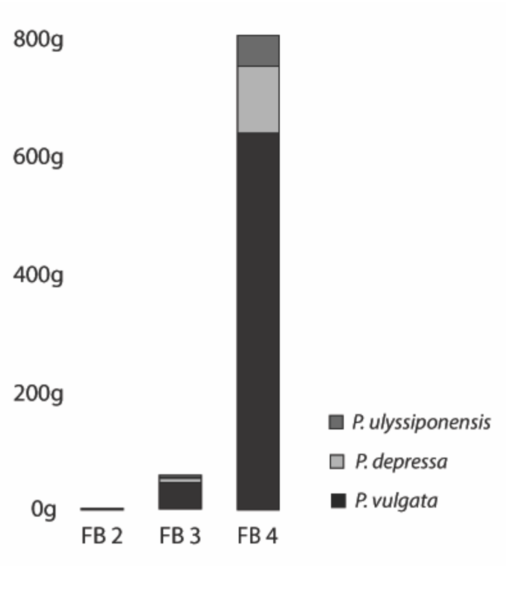


Fig. 14.6 – Total limpet wet meat yield in grams per occupation phase, based on García-Escárgaza & Gutiérrez-Zugasti (2020) formulae described in Chapter 10, section 10.7.

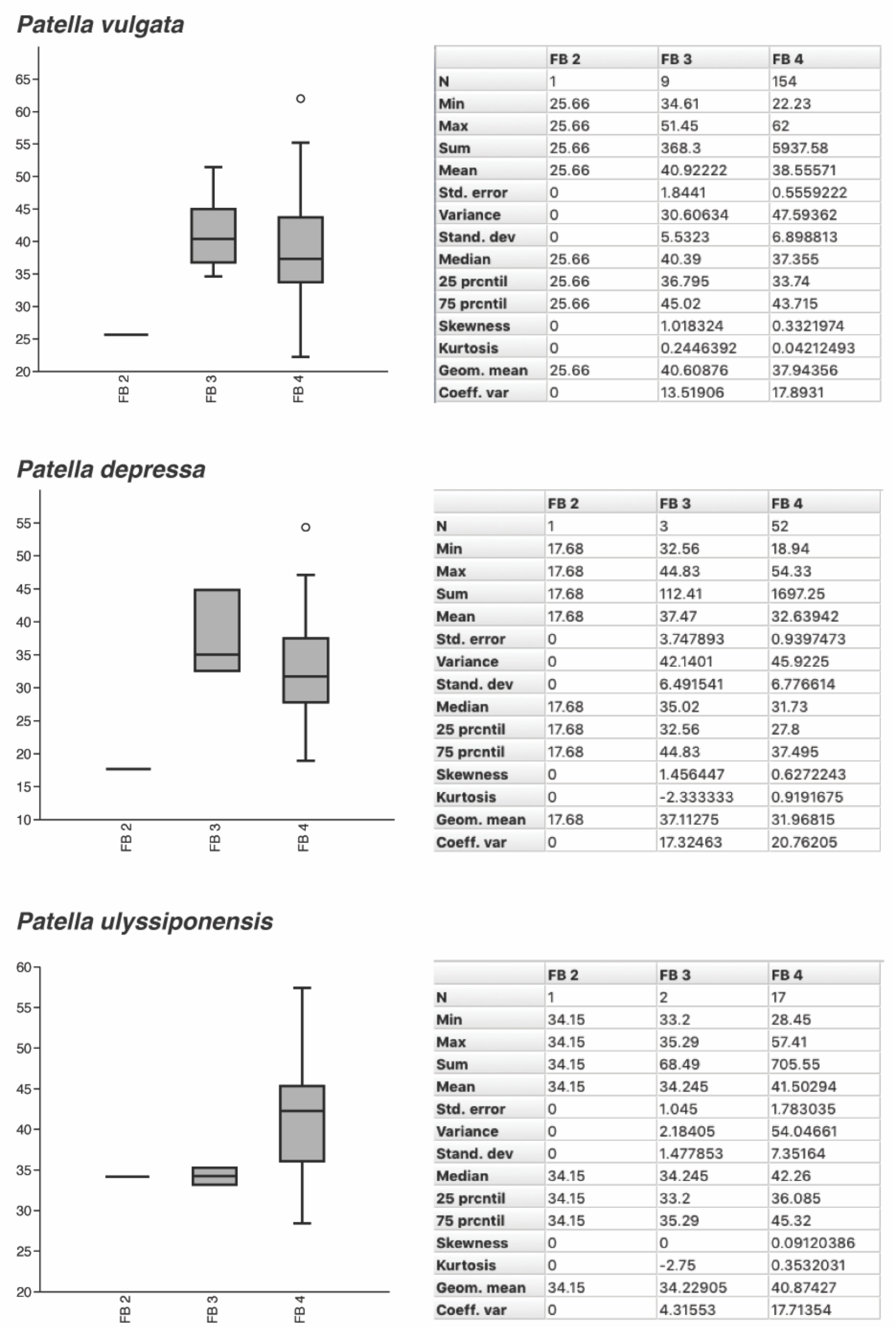
As for *P. depressa* and other shells (Tabs. 14.6 and 14.7) it is clear that collection was mostly done on the high intertidal zone for all the MIS-5 occupation phases. However, the low intertidal played an important role as well, especially when considering the MNI of the main other shells procured as food resources (*P. rustica*, *P. ulyssiponensis*, *M. galloprovinciallis* and *R. decussatus*), which reflect a fairly even exploitation of the high and low intertidal for phases FB 3 and FB 4 (Tab. 14.7).

14.3. DISCUSSION

14.3.1. Agents of accumulation

Most of the archaeological deposit from Entrance 3 was eroded away due to Holocene sea level rise. However, it is still visible a dense anthropogenic deposit with shellmidden lenses in the LC and MC complexes (section 6.3.1), where molluscs present a sub-horizontal, well-layered orientation, and not a random alignment within the sedimentary matrix. Therefore, shell remains found on such basal levels of Entrance 3 – referring to occupation phases FB 1 to FB 3 (Fig. 6.4; Tab. 6.2) – are not the result of natural thanatocenoses due to hydrodynamic action. The shell lenses reflect the refuse of on-site consumption of molluscs harvested nearby.

The anthropogenic nature of the mollusc accumulation in Entrance 3 can also be found in Area F's MIS-5 levels, and it is further supported by the following features: (a) deposits are largely composed of edible species, such as limpets, mussels and clams; (b) most shells are broken, and the edges, when preserved, are sharp; (c) many shells are burnt; (d) the fragments belong to edible-size shells with mussels and limpets reaching 7 cm in length; (e) small-size specimens are scarce, and articulated valves are absent, which are both common features in beach-like mussel accumulations; (f) many fragments lie on their convex side, whereas natural deaths would show most shells with their concave side facing down, since wave energy would have



Patella vulgata

	FB 2	FB 3	FB 4
N	1	9	154
Min	25.66	34.61	22.23
Max	25.66	51.45	62
Sum	25.66	368.3	5937.58
Mean	25.66	40.92222	38.55571
Std. error	0	1.8441	0.5559222
Variance	0	30.60634	47.59362
Stand. dev	0	5.5323	6.898813
Median	25.66	40.39	37.355
25 prcntil	25.66	36.795	33.74
75 prcntil	25.66	45.02	43.715
Skewness	0	1.018324	0.3321974
Kurtosis	0	0.2446392	0.04212493
Geom. mean	25.66	40.60876	37.94356
Coeff. var	0	13.51906	17.8931

Patella depressa

	FB 2	FB 3	FB 4
N	1	3	52
Min	17.68	32.56	18.94
Max	17.68	44.83	54.33
Sum	17.68	112.41	1697.25
Mean	17.68	37.47	32.63942
Std. error	0	3.747893	0.9397473
Variance	0	42.1401	45.9225
Stand. dev	0	6.491541	6.776614
Median	17.68	35.02	31.73
25 prcntil	17.68	32.56	27.8
75 prcntil	17.68	44.83	37.495
Skewness	0	1.456447	0.6272243
Kurtosis	0	-2.333333	0.9191675
Geom. mean	17.68	37.11275	31.96815
Coeff. var	0	17.32463	20.76205

Patella ulyssiponensis

	FB 2	FB 3	FB 4
N	1	2	17
Min	34.15	33.2	28.45
Max	34.15	35.29	57.41
Sum	34.15	68.49	705.55
Mean	34.15	34.245	41.50294
Std. error	0	1.045	1.783035
Variance	0	2.18405	54.04661
Stand. dev	0	1.477853	7.35164
Median	34.15	34.245	42.26
25 prcntil	34.15	33.2	36.085
75 prcntil	34.15	35.29	45.32
Skewness	0	0	0.09120386
Kurtosis	0	-2.75	0.3532031
Geom. mean	34.15	34.22905	40.87427
Coeff. var	0	4.31553	17.71354

Fig. 14.7 – Size variation (length in millimetres) and sample description of *Patella vulgata, Patella depressa* and *Patella ulyssiponensis* from the different occupation phases of Gruta da Figueira Brava.

Phase	Chronology	MNI	Zonation *P. vulgata*	
			High intertidal (%)	**Low intertidal (%)**
FB 4	MIS-5b	124	44.35	55.65
FB 3	MIS-5c	5	60	40
FB 2	MIS-5c	1	100	0
TOTAL		**130**	**45.38**	**54.62**

Tab. 14.5 – Length/Height (L/H) ratio for *Patella vulgata* based on formula provided by Gutiérrez Zugasti (2010), in which values of L/H lower than 2.55 reflect High intertidal, and values higher than 2.55 reflect Low intertidal. MNI = Minimum Number of Individuals.

Phase	Chronology	MNI	Zonation *P. depressa*	
			High intertidal (%)	**Low intertidal (%)**
FB 4	MIS-5b	34	61.76	38.24
FB 3	MIS-5c	3	66.67	33.33
FB 2	MIS-5c	1	100	0
TOTAL		**38**	**63.16**	**36.84**

Tab. 14.6 – Length/Height (L/H) ratio for *Patella depressa* based on formula provided by García-Escárgaza (*in press*), in which values of L/H lower than 2.99 reflect High intertidal, and values higher than 2.99 reflect Low intertidal. MNI = Minimum Number of Individuals.

Phase	Chronology	MNI	Zonation *Other Shells*	
			High intertidal (%)	**Low intertidal (%)**
FB 4	MIS-5b	57	50.88	49.12
FB 3	MIS-5c	11	59.09	40.91
FB 2	MIS-5c	77	81.82	18.18
TOTAL		**145**	**67.93**	**32.07**

Tab. 14.7 – Seashore zones preferred for collecting other shells used as food resources (such as *P. rustica, P. ulyssiponensis, M. galloprovincialis* and *R. decussatus*), following their habitat preferences in terms of shore levels as described in Chapter 9 (Tab. 9.7). MNI = Minimum Number of Individuals.

Phase	Chronology	MNI	Seashore exposure	
			Exposed (%)	**Sheltered (%)**
FB 4	MIS-5b	108	19.44	80.56
FB 3	MIS-5c	4	0	100
FB 2	MIS-5c	0	0	0
TOTAL		**112**	**18.75**	**81.25**

Tab. 14.8 – Seashore exposure equation for *Patella vulgata* based on formula provided by Bailey & Craighead (2003): Exposure = (Length x 0.142) – (Height x 0.06) + (Width x 0.0489) – 5.328. Values more positive than -0.15 reflect Sheltered shores, and values more negative than -0.15 reflect Exposed shores. MNI = Minimum Number of Individuals.

	Phase	n	Mean length (mm)	WET Meat Yield (g)					DRY Meat Yield (g)				
				Total	**Mean**	**±SD**	**Max**	**Min**	**Total**	**Mean**	**±SD**	**Max**	**Min**
P. vulgata													
MIS-5b	FB 4	154	38.56	637.36	4.14	3.54	31.74	0.67	452.30	2.94	2.53	22.77	0.47
MIS-5c	FB 3	9	40.92	42.6	4.73	3.03	11.39	2.22	30.24	3.36	2.17	8.12	1.57
MIS-5c	FB 2	1	25.66	0.93	0.93	0.00	0.93	0.93	0.65	0.65	0.00	0.65	0.65
P. depressa													
MIS-5b	FB 4	52	32.64	113.55	2.18	2.31	15.64	0.40	84.03	1.61	1.88	12.8	0.26
MIS-5c	FB 3	3	37.47	9.56	3.19	2.30	5.83	1.63	7.16	2.39	1.83	4.49	1.16
MIS-5c	FB 2	1	17.68	0.35	0.35	0.00	0.35	0.35	0.22	0.22	0.00	0.22	0.22
P. ulyssiponensis													
MIS-5b	FB 4	17	41.50	49.63	2.99	1.28	5.69	0.64	37.49	2.21	0.97	4.31	0.48
MIS-5c	FB 3	2	34.24	3.31	1.66	0.26	1.84	1.47	2.49	1.25	0.19	1.39	1.11
MIS-5c	FB 2	1	34.15	1.64	1.64	0.00	1.64	1.64	1.23	1.23	0.00	1.23	1.23

Tab. 14.9 – Limpet wet and dry meat yield in grams per occupation phase, based on García-Escárgaza & Gutiérrez-Zugasti (2020) formulae described in section 10.7.

inverted most remains to a more stable position (Kidwell, 1991; López, 1999); and (g) foraminifera are not observed in soil micromorphology as previously discussed in section 6.3.3.

The intrusive reworked Holocene-age deposits from the top of the sequence in Area F provide the example of a natural, seashore-accumulated mollusc assemblage. Mussel shells are abundant and are frequently complete, or nearly complete, with no calcareous concretions attached, nor sediment filling, and with surfaces only slightly patinated. They tend to show dulled or damaged edges, and perforations made by gastropods. Such taphonomical contrasts between natural- and human-accumulated shell assemblages match the clearly distinct taxonomical composition of other marine invertebrates, such as the crabs described in Chapter 15.

As reported by Erlandson & Moss (2001), several non-human agents feed on shellfish and, thus, are able to accumulate shell remains. There are several large caves along the central and southern Portuguese coast, adjacent to the seashore or no further inland than Gruta da Figueira Brava. However, no evidence of non-human accumulations has been reported for any of the caves. Moreover, the association with wood charcoal, stone tools, and animal bones with butchery marks support the idea that humans accumulated Gruta da Figueira Brava's Middle Palaeolithic shell assemblage.

Further evidence comes from the sediment composition analysis made for the Middle Palaeolithic levels of Gruta da Figueira Brava (Fig. 14.1; Appendix D). With all mesh sizes combined, shell remains (which include all marine invertebrates, like shellfish, crustaceans and echinoderms) stand for 25.6% of the deposit in the MC5 bulk sample from Entrance 3. However, it only reaches 5 to 11% in bulk samples from IH2-IH8 in Area F. This can be explained based on site formation history. As shown in Chapter 6 (Fig. 6.4), the lowermost units of the MC complex correspond to occupation phase FB 2. Therefore, our understanding of shell importance is based on areas of the site located near the main Neanderthal activity *loci*, in which the occupation debris is largely *in situ*. Conversely, complex IH of Area F corresponds to occupation phase FB 4. Hence, shell samples are from areas peripheral to the actual activity *loci* containing debris derived from a primary source located outward. Therefore, less breakage but more scattering is expected in materials from FB 4 resulting, by comparison with FB 2, in higher NISP/m^3 ratios for the excavated material but lower g/l ratios for the bulk samples (Fig. 14.1).

Comparison of Gruta da Figueira Brava with Mesolithic Toledo bulk samples support the inferences above. Sample B from Toledo comes from layer B, a colluvial deposit. Samples B/C and C/D are from dense shellmidden accumulations: B/C refers to the interface between layer B and the fluvial sands of layer C, which is a terrace of River Alcabrichel; C/D is the interface with sands of the Jurassic bedrock, layer D, in parts of the site where layer C is missing. The Mesolithic occupation took place over a surface where layer B colluvium was found in lateral continuity with layer C fluvial sands, and post-depositional processes redistributed the finds across the site, both vertically and horizontally (Araújo, 2011). Consequently, sample B reflects the end term of this process, in which the density of finds is impacted by post-depositional scattering. Samples B/C and C/D are preserved remnants of the original contexts of deposition, explaining why shell stands for 14.6% of the total in sample B but between 45% and 62.2% in the other two (Fig. 14.1; Appendix D).

Consequently, Toledo sample B can be considered an analogue for FB 4 levels of Gruta da Figueira Brava, whereas samples B/C and C/D may be comparable to FB 2 units. The only caveat is that Gruta da Figueira Brava is a cave, in which trampling and repeated use must have impacted the shell component more severely than in more intact depositional environments as the ones found in Toledo samples B/C and C/D. Therefore, it is clear that Gruta da Figueira Brava's Middle Palaeolithic cave deposits are fully comparable to the Toledo's Mesolithic open-air ones. Shells are abundant in both sites, and they were both accumulated by humans. Additionally, data on shell density (kg/m^2) from Zilhão et al (2020) show levels comparable to, or in excess, of MIS-5 occupation at Blombos Cave.

14.3.2. Mollusc harvesting and processing

Sediment composition analysis also contributes to explain variation in the distance to procurement areas. The higher density of marine invertebrates during phase FB 2 in Entrance 3 coincides with MIS-5c. This is when the sea level was higher, and therefore, the coastline was closer to the cave. The lowered shell density seen in FB 4 in Area F coincides with the MIS-5b, when sea level was lower and the coastline further away (Fig. 6.1 B). Such variation does not mean that shellfish were being harvested less intensively during FB 4 than in the previous occupation phases; it simply means that they were being discarded on site less often than before because the role played by Gruta da Figueira Brava in the overall settlement-subsistence system changed as a result of the changes in the site's environmental setting. It is likely that the role played by Gruta da Figueira Brava in phase FB 2, when the sea was about 1000 m away, was the same played by sites located at a similar distance during phase FB 4. However, given the lowered stand of MIS-5b, such localities may have become buried in the seabed.

Such situational factors are also illustrated by the variation in the taxonomic composition (Tabs. 14.1, 14.3; Fig.14.2). For instance, clams make a more substantial contribution to the shellfish assemblage during phase FB 2. This likely reflects the changes of the environmental setting, since we can infer the proximity of the habitats preferred by the species, such as estuarine and lagoon areas with shallow, clean, sandy bottoms, and the intertidal zone of sandy beaches. The zones of the intertidal area where shells were harvested, also hint at the strategies used in shellfish harvesting (Tabs. 14.5 - 14.8). It is clear that the low intertidal and more exposed areas of the shore which are less protected from wave action and sea currents were explored during phase FB 4. Conversely, shells from the high intertidal were preferentially gathered in phases FB 2 and FB 3. In addition, during phase FB 3 shell procurement was only conducted on sheltered areas of the shore.

Some of the shells could have been consumed while harvesting. Waselkov (1987, citing McGee, 1898) gives ethnographic examples describing the opening of uncooked bivalves by cracking or using broken shells as knives to loosen the closed valves. However, most ethnographic observations tend to show a preference for some sort of processing, by roasting or boiling the shells before consumption, known to provide higher caloric intake, and to lower dietary risks. As demonstrated by Aldeias et al (2019), the lack of burning evidence and hearths in archaeological sites does not imply that shellfish was not being cooked. Shellfish is not in direct contact with fire when boiling, and low temperatures (~100ºC, just above the boiling point) are enough to cook them without leaving thermo-alteration marks on shell surface. As for roasting, shells get in direct contact with the coals but only for a few minutes, and it requires very little preparation of the burning area. Aldeias et al (2019) further describe that well-preserved hearths are not expected, since all shell roasting methods involve spreading the fire residues. Such spreading and dumping of fuel residues result in almost invisible cooking areas. Nevertheless, Gruta da Figueira Brava shows evidence of shell surface thermo-alterations. They are mostly found on food taxa (such as limpets, mussels and clams), and are mainly recovered from the FB 4 occupation phase (Tab. 14.4). Despite the sea being the furthest away, this did not mean that a considerable amount of shellfish was still brought back to the site, where it was processed and consumed.

14.3.3. Mollusc dietary role

The increasing consumption of marine resources has been traditionally explained as part of an intensification process in shellfish exploitation as a consequence of population growth (e.g. Straus & Clark, 1986). Recent research has been demonstrating that exploitation of more dangerous coastal areas – such as the low intertidal zone, or exposed areas of the seashore – also reflect resource intensification (Gutiérrez Zugasti, 2010, 2011; García-Escárgaza & Gutiérrez Zugasti, 2020). The exploitation of the low intertidal implies a good control and knowledge of the tides, since the lower areas of the shore are only available twice a month with spring tides. Indeed, these are areas that are accessible for small amounts of time, but there is extra effort made to exploit them. Similarly, spring tides also grant access to more exposed areas of the shore that are constantly wave-beaten, but which, despite the risks associated, are still being explored. Such resource intensification indicators are mostly found during the FB 4, even though they were also practiced during the FB 3, but nearly absent from the FB 2. This idea is further supported by limpet length analysis (Fig. 14.7). Indeed, during the FB 4 limpet mean length size is smaller than in FB 3, even though there is a strong increase in frequency. In addition, less limpet selection was conducted in FB 4, which is evident by the larger variability of the shell sizes collected. This can reflect a demographic increase in human population, and a consequent intensification in the exploitation of shellfish.

Limpet shell size also has implications in meat yield. It is not possible to quantify the meat yield from Gruta da Figueira Brava assemblage using limpet weight due to the amount of concretions attached to the shells, which can result in substantial overestimations (as discussed in section 10.4). Nonetheless, and as demonstrated by García-Escárgaza and Gutiérrez-Zugasti (2020), estimations of limpets wet meat yield based on shell size show a strong correlation and are, therefore, reliable. Overall, the limpet meat yield is significantly larger for FB 4 than for other phases (Fig. 14.6; Tab. 14.9), which is expected since it is the occupation phase with most complete individuals. Nonetheless, it should be noted that in terms of average meat yield, phase FB 3 tends to show fleshier individuals. It could be suggested that because it was impossible to measure many of the limpet shells due to high fragmentation, maybe their mean length was smaller than those studied. However, some of the fragmented limpets were in fact larger than those complete. Nevertheless, the data for limpet meat yield is in line with the probable resource intensification noted before from phase FB 3 to FB 4.

As shown by ethnographic research (Meehan, 1982; Bird & Bliege Bird, 1997), the molluscs found in large shellfish accumulations may not reflect the quantity or the full range of species consumed, since considerable amounts of shells may have been consumed and discarded away from the occupation sites. Nonetheless, it is clear that shellfish had a great dietary importance for Gruta da Figueira Brava, which is not only relevant in terms of meat yield or energy return. Similarly to crabs (Chapter 15), molluscs have several nutritional benefits in addition to calories (Meehan, 1982; Erlandson, 1988). Moreover, they can stay fresh for a long time, allowing deferred consumption, as reported for the North American Kwakiutl and the Tlingit that dried large quantities of mussels for winter consumption (Oberg, 1973; Boas, 1966). Additionally, molluscs can also be eaten for pleasure and for the keeping of social relations (Milner, 2005). This has been demonstrated by Moss (2013) who showed that shellfish is associated with social and symbolic meanings among some North American ethnographic groups, reflecting traditions associated with gender, social status and different life stages.

14.3.4. Non-dietary taxa

A small number of other taxa are present alongside the predominant limpets, mussels and clams (Tabs. 14.1 and 14.3). Among the marine gastropods, shells like *Phorcus lineatus* or *Littorina littorea* are edible and are found within the same rocky habitats as limpets and mussels. Therefore, their presence may simply reflect incidental collection. The same applies for bivalves such as *Cerastoderma edule* and *Solen marginatus*, which are found in the same habitat as clams.

Most of the other, scarcer gastropods, are not edible (Fig. 14.4). *Nucella lapillus* is a mussel predator, whereas the different species of *Steromphala, Littorina, Bittium* and *Nassarius* are too small for consumption. There are several examples of their use for personal ornamentation during the Upper Palaeolithic, but it has only been hypothesised for two of those remains (see section 14.3.5), since no others present anthropogenic modifications. Thus, the presence of these small gastropods is likely to be accidental. They can reflect the introduction of the algae they live or feed on, which is the hypothesis put forward for the mollusc assemblage from Cueva de los Aviones (Murcia, Spain; Zilhão et al, 2010c; Hoffmann et al, 2018b). For this site, the algae were interpreted as the package used for transporting the edible species into the cave. In Holocene contexts, it has been suggested that algae were procured as food, and that the presence of < 2 cm non-edible gastropods are a proxy of the on-site use of seaweeds and seagrasses (Ainis et al, 2014).

As for other bivalve taxa, the interpretation is less straightforward. The oyster shells may reflect subsistence behaviour. However, in at least one case, the valve is a fossil, as shown by the carbonate crust found on the inner side of the shell that is clionid-holed (Fig. 14.3 A). Considering that oyster shells can occasionally be found in the local bedrock, this specimen is at the very best a manuport.

As for the five *Glycymeris* shells recovered from FB 2, it can be excluded that they derive from the underlying beachrock since (a) the sediment attached to them corresponds to the matrix of the MC complex, and not to the marine sands of the CO complex (Fig. 14.3 C-E); and (b) no *Glycymeris* shells have been observed in any of the CO complex preserved all over the cave's marine abrasion platform. Most of the remaining *Glycymeris* remains from FB 4, as well as *Pecten* shells, are complete or bear minor excavation breaks, and none are perforated on the umbo. Whenever the remains of such species are fragmented, as it happens with the *Callista* (Fig. 14.3 B), the edges are not rounded. All observations suggest collection of beached shells targeting complete specimens that broke on site. The only exception being a *Pecten* whose edges are eroded and smoothed (Fig. 14.3 D) indicating that it was already fragmented at the time of collection. All these observations show that beach collection of empty large bivalves was a common practice, even though the purpose of their uses is still intangible. Nonetheless, it is possible that some of these non-food shells may have had a proto-symbolic meaning (cf. Bar-Yosef Mayer et al, 2020, for Misliya Cave).

14.3.5. Perforated shells

As already discussed in detail by Zilhão et al (2020), two gastropods show perforations on the body whorl (Fig. 14.5) similar to those seen in specimens recovered from Iberian Upper Palaeolithic sites, and which were interpreted as shell beads. However, one of the gastropods – the *Euspira guilleminii* – was recovered during flotation of the IT 2 unit sediment sample. This unit is of Holocene age and naturally accumulated. Consequently, this specimen cannot be interpreted as an artefact. Nonetheless, it shows that gastropod shells can become perforated by natural agency, and should not be attributed to human behaviour by default with no further inspection.

As for the *Littorina obtusata*, it was found in the IT 0 sediment within what was interpreted as a small mammal's nest. Hence, it was considered the possibility of this shell to be of Middle Palaeolithic age, since the deposit was composed of reworked Pleistocene and Holocene materials. Again, as already discussed by Zilhão et al (2020), the shell was examined microscopically and through Raman spectroscopy, in order to assess any anthropogenic modifications. None was found. Such evidence coupled with the pitting and smoothing of the surface, and the rounding of the perforation's edges, reflects abrasion on a sandy sea-bottom after the perforation was made – possibly by a crab, like *Carcinus maenas*, which is a known predator of periwinkles. Independent corroboration was obtained through radiocarbon dating (Tab. 6.3), whose 7390 ± 25 years BP confirmed it to be of Holocene age. Once more, such small gastropod shell is not an object of personal ornamentation.

Finally, the size and shape of the punctures found on limpets, scallops and mussels are reflections of clionid holes and perforations made by the gastropod *Nucella lapillus*, which is a predator with high preference for mussels. Such perforations are then of natural agency, and are not the result of human behaviour.

14.4. CONCLUSIONS

The mollusc assemblage from Gruta da Figueira Brava clearly shows that Neanderthals were perfectly adapted to the seashore, from which they benefitted from several marine resources. Even though terrestrial animals – from a wide range of mammals, to tortoises and birds (Chapters 11-13) – were being exploited, marine invertebrates (including molluscs and crabs) composed about 50% of the diet, as demonstrated by NISP and MNI figures, but also by the sediment composition analysis comparable to Mesolithic shellmidden of Toledo.

Molluscs contributed significantly to the diet, not only in terms of valuable nutrient intake (such as the different kinds of vitamins and fatty acids), but also in terms of meat yield with a significant contribution from limpets, mussels and clams. Limpet size analysis also provided evidence that some riskier areas of the seashore were being exploited, especially the low intertidal in exposed areas of the coast, where wave action is more intense and dangerous. Such behaviour complies with a deep knowledge of the tides, which implies a fit adaptation to the coastal environment. In addition, the need to explore the perilous shore areas reflects the necessity to feed more mouths within the human group. This is particularly evident in the last phase of occupation FB 4, when a wider range of limpet size is being collected, reflecting a reduction in the average size of the shells when compared with the previous occupation. The evidence supports intensification in the exploitation of molluscs (and limpets in particular) during FB 4, which therefore shows that such marine resources were being systematically used, akin to coeval MSA sites in South Africa.

CHAPTER 15

CRUSTACEANS AND ECHINODERMS

15.1. LITERATURE REVIEW

There is growing evidence for Neanderthal's subsistence exploitation of small land animals. This has been demonstrated in Chapters 12 to 14, and by several studies like Morin et al (2019) for leporids, Blasco et al (2016a) for birds, Nabais (2012) for tortoises, to name just a few examples from the Iberian Peninsula. This evidence fits the argument that Neanderthals preferentially consumed terrestrial animals (Jaouen et al, 2019; Naito et al, 2016), in agreement with the scarcity of marine species in Middle Palaeolithic faunal assemblages. Moreover, shellfish and other small size marine resources have been frequently considered to be a rather unproductive source of food. According to Optimal Foraging Theory (OFT), such resources rank low because of their limited raw meat weight and energy return (e.g. Winterhalder & Smith, 2000; Dusseldorp, 2010). However, the Nutritional Ecology approach outlined by Hockett & Haws (2003, 2004, 2005) ranks marine resources much higher, considering their protein and vitamin intake, fat content, reliability, and low-risk collection; with their dietary importance demonstrated by a number of studies (e.g. Hardy & Moncel, 2011; Langejans et al, 2012; Zilhão et al, 2020). This change of perspective has boosted the study of the archaeology of molluscs, but crustaceans and echinoderms still get little attention.

An important contribution to the zooarchaeology of crabs is a study of the Lower Palaeolithic occupation at Gesher Benot Ya'aqov, Israel (Ashkenazi et al, 2005). There is also brief mention of crab remains in faunal assemblages from the Spanish Upper Palaeolithic levels of Altamira (Álvarez Fernández, 2010), and Fuente del Salín (Gutiérrez Zugasti et al, 2013). Crustacean and echinoderm remains become increasingly visible in the Late Pleistocene and Early Holocene, as apparent at several sites from northern Spain (e.g. García-Escárzaga et al, 2017; Gutiérrez Zugasti, 2009, 2011;

Gutiérrez Zugasti et al, 2016). In Portugal, crustaceans have been found in the Mesolithic sites of Toledo (Dupont, 2011), Fiais (Lubell et al, 2007), Cabeço da Amoreira (Pinto, 1986), Moita do Sebastião (Roche, 1958), Montes de Baixo (Silva & Soares, 1997), Cabeço da Arruda (Lentacker, 1986), Arapouco (Arnaud, 2000), Cabeço do Rebolador (Arnaud, 2000), Vale Frade (Araújo et al, 2014), Barranco Quebradas 1, Barranco Quebradas 4 and Rocha das Gaivotas (Carvalho, 2001, Valente, 2008; Dupont, 2011). However, crustaceans and echinoderms tend to only be briefly mentioned in these Portuguese studies. In-depth crustacean research has been carried out at the French Mesolithic sites of Beg-er-Vil (Gruet, 2002; Dupont & Gruet, 2005), Beg-an-Dorchenn (Dupont & Gruet, 2005; Dupont et al, 2010), Hoëdic and Téviec (Dupont et al, 2007), and the Neolithic site of Ponthezières (Gruet & Laporte, 1996; Gruet, 2009). Despite these examples, crustaceans and echinoderms remain mostly understudied; more often than not, their presence is simply intimated by inclusion in species lists.

Echinoderms and crustaceans are easily found in coastal areas (scientific names of marine species used in this paper follow the WoRMS [2020] nomenclature). Echinoderms (sea urchins), e.g. *Paracentrotus lividus* (Lamarck, 1816), are distributed from Scotland to southern Morocco, including the Mediterranean Sea. *P. lividus* inhabits several substrates from rocks and boulders to sea meadows, living from the low-water limit down to -20 m. It is found at low densities in meadows of *Posidonia oceanica* ([Linnaeus] Delile, 1813) – an endemic Mediterranean species – but it is more frequent in shallow, hard substrate algal communities, like the red algae *Lithophyllum incrustans* (Philippi, 1837). It is commonly found in Portugal, in intertidal rock pools and shallow subtidal reefs. *P. lividus* thrives under highly variable environmental conditions (e.g., temperature and wave action) and can switch from grazing-feeding behaviours to drift-feeding when in its self-built burrow (Bayed et al, 2005; Boudouresque & Verlaque, 2001; Jacinto et al, 2013; Saldanha, 1995; Tomas et al, 2004). *P. lividus* is a “regular echinoid” featuring the typical spherical shape flattened at the top (with the anus at its centre) and at the base (where the mouth is located). Its surface is made of test plates that are covered by needle-like spines. The edible part is the roe, which is only large enough for a few weeks in the year, thus making *P. lividus* a good seasonality indicator. It is easily harvested by hand at low tide, and is often found in large groups (Campbell, 2008; Hayward & Ryland, 1995; Martin, 2012). According to Campbell (2008), the most frequent processing technique is to break out the base and the mouth structures, and fill the test with the roe from other urchins.

Nowadays, crustaceans — crabs, shrimp, and lobsters (from the Malacostraca class), and barnacles (from the Maxillopoda class) — are some of the most appreciated seafood. Crabs are easily identifiable through their outer shell, or exoskeleton. The exoskeleton needs to shed several times in a lifetime to accomodate the animal's growth. This process (known as molting) happens in hiding, since the animals get very soft and defenceless. It is also frequently associated with reproduction, e.g. in the *Cancer* genus: molting female crabs attach themselves to hard-shelled males with copulation occurring in the process (see a summary in Oesterling, 2012). The other notable feature of crabs is their pincers, which function in defence and feeding. They yield substantial amounts of meat and are the most taxonomically diagnostic elements. In all crab species, two types of pincers exist: crusher (shorter and stouter; generally on the right), and cutter (longer and thinner; generally on the left) claws. Each pincer has two fingers – a dactylopodus (flexible finger) and a propodus (unmovable finger) (Crothers & Crothers, 1988; Gruet, 2002; Ingle, 1996) – from which carapace body size estimations can be calculated based on the measurements described in Chapter 9. On rocky seashores, crabs will shelter under stones or in nearly any hole, cave or crevice. Therefore, most seawater crabs can be found in the intertidal zone, and even subtidal species (like *Maja squinado* Herbst, 1788) come to shore for reproduction (Gruet, 2002; Ingle, 1996). Ethnographic studies confirm that crabs can be easily caught by hand from low tide pools, sometimes with the aid of long poles (Losey et al, 2004; von Brandt, 1984). They are always eaten fresh and prepared for consumption through roasting on a fire, stone boiling, or pit steaming (Suttles, 1974; Batdorf, 1990; Emmons, 1991).

Barnacles are found attached to hard substrates in all marine habitats, and on all zones of the shore. They are divided into two orders: the Sessilia (acorn barnacles) that grow their shell directly onto the substrate, and the Pedunculata (goose barnacles and others) that attach themselves by means of a stalk (Lohse & Raimondi, 2007). In the studied assemblage, only the acorn barnacle *Perforatus perforatus* (Bruguière, 1789) was found. It has a volcano-like shape composed of six test plates that attach to the substrate at the base, whereas the top forms an opening (the operculum) that is covered by two pairs of movable plates, the terga and the scuta (Southward, 2008). *P. perforatus* occurs naturally from SW Wales to West Africa, and in the Mediterranean Sea, in semi-exposed and shady rock surfaces, crevices, cave entrances or encrusted onto shells and the skin of marine mammals. The breeding season of this species begins earlier and lasts longer in the Portuguese Atlantic coast essentially due to favourable water temperatures and food availability provided by the Canary/Iberian upwelling (Cunha et al, 2018). *P. perforatus* is one of the larger barnacles of European coasts and, although not eaten, can be used as fishing bait (Claassen, 2013).

15.2. RESULTS

15.2.1. Taxonomic and body part frequency

The sea urchin sample comprises five remains: one hemipyramid, and four test plates (Tab. 15.1). Species identification is based on one test plate that is large enough to allow the diagnostic count of pore-pairs, indicating the presence of *Paracentrotus lividus* (Lamarck, 1816). All specimens come from the reworked parts of the deposit that contain Holocene intrusions.

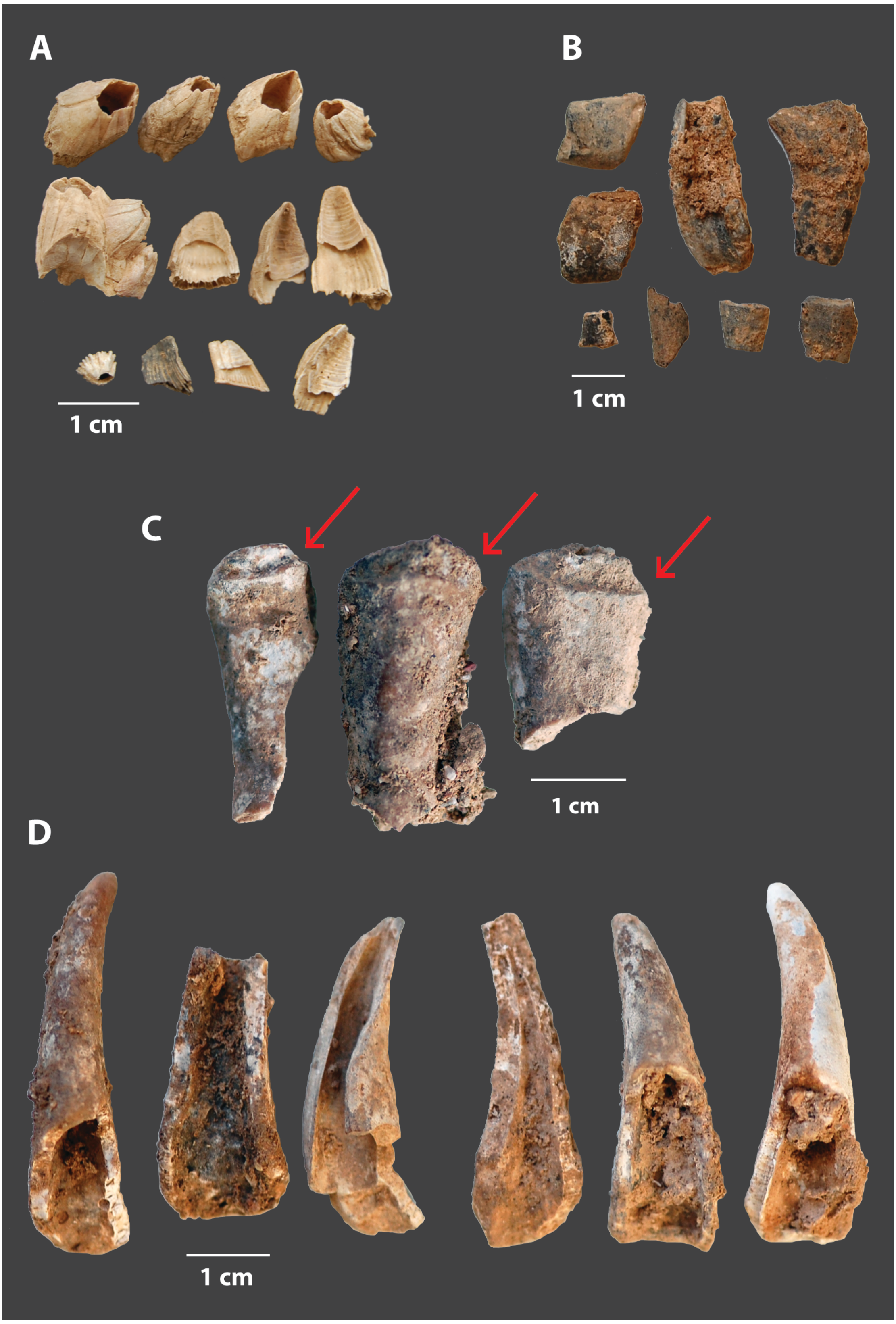


Fig. 15.1 – Crustaceans from Gruta da Figueira Brava. A) *Perforatus perforatus* recovered from reworked levels, note their good preservation and absence of calcareous concretion. B) *Cancer pagurus* carapace and pincer fragments with black burns; recovered from MIS-5 levels. C) *Cancer pagurus* dactylopoda showing impact flakes on their ventral proximal side, reflecting pincer disarticulation; recovered from MIS-5 levels. D) *Cancer pagurus* pincers with longitudinal breaks; recovered from MIS-5 levels.

Barnacles were identified as *Perforatus perforatus* (Bruguière, 1789) for 81.25% (NISP = 130) of the assemblage based on test remains (Fig. 15.1A); no terga or scuta plates were recovered. About a quarter of the remains (38.13% or NISP = 61) were recovered from reworked levels, but the great majority was found in MIS-5 levels, mostly from Phase FB 4, and a single remain from Phase FB 2 (Tab. 15.1).

With regards to crabs, a total of 809 remains were recovered and examined; more than half (or 56.7%) were identified to species (Tabs. 15.1, 15.2). The taxonomic identification was based on pincers (propodus and dactylopodus) and mandibles, allowing the identification of five different species. The *in situ* deposit is overwhelmingly dominated by *Cancer pagurus* (Linnaeus, 1758; the brown crab). It is also represented in the reworked sediment, but most remains derive from the Pleistocene levels since they feature the diagnostic concretion coating of the MIS-5 deposits. Conversely, *Pachygrapsus marmoratus* (Fabricius, 1787; the marbled rock crab) is absent from the *in situ* Pleistocene assemblage, despite being the dominant taxon amongst non-concreted crabs of the reworked deposits. *Maja squinado* (Herbst, 1788; the spider crab) occurs more frequently in the MIS-5 levels than in reworked levels. A few non-concreted remains of *Eriphia verrucosa* (Forsskål, 1775; the yellow crab) and *Carcinus maenas* (Linnaeus, 1758; the green crab) were found in the reworked parts of the deposit that contain Holocene intrusions.

15.2.2. Fragmentation and type of fracture

Remains recovered from the reworked levels tend to show less fragmentation when compared to those found in the *in situ* MIS-5 deposit. This is clear for barnacles, which, in the reworked levels, are complete in 75.40% (or NISP = 46) of the cases, as opposed to only 53.54% (or NISP = 53) for the *in situ* MIS-5 sediments. Such degree of completeness, however, is strongly related with the robust calcite tests. As for sea urchins, all remains show recent fractures.

Overall, crab remains are mostly fractured (90.98% or NISP = 736). However, it is notable that 67.5% (or NISP = 27) of the *P. marmoratus* assemblage shows complete or nearly complete claws, confirming good shell preservation of a species that is naturally fragile and prone to breakage. The opposite happens to the robust shell of *Cancer pagurus*, for which only 7.03% (or NISP = 26) of the claw remains are nearly complete (Tab. 15.2). The use of heavy-duty tools to dig the heavily brecciated parts of the deposit does not seem to have had much impact on the crab remains, since most show no excavation-induced breakage; most recent fractures were observed in the reworked levels (NISP = 83; cf. NISP = 5 for MIS-5 levels). Finally, whenever broken, most crab claws identified to species present transversal fractures, except for *Cancer pagurus* that shows predominantly longitudinal fractures and has no complete pincers (Tab. 15.3). Longitudinal fractures are regularly found on the outer edge of the pincers of *Cancer pagurus*, *i.e.* on the edge opposite to the claw's protuberances (Fig. 15.1D). However, whenever the propodus and the dactylopodus are identified based on the presence of their distal ends, fractures tend to be transverse. Both longitudinal and transverse fractures on *Cancer pagurus* claws are clean and smooth edged with a right angle.

15.2.3. Burning

Thermo-alterations were found on two barnacle plate fragments, but are mostly represented by crab remains; they are absent from sea urchin elements. A total of 8.41% (or NISP = 68) of the crab assemblage is burnt (Tab. 15.4). Black burns are the most frequent (Fig. 15.1 B), whereas burning colours reflecting very high temperatures (grey and white) are nearly absent. Burning occurs mostly on crab claws (with the exception of six carapace elements), and preferentially on *Cancer pagurus* ones.

TAXON	Phase FB 4			Phase FB 3			Phase FB 2			Reworked		
	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU	NISP	MNI	MAU
MALACOSTRACA												
Cancer pagurus	324	29	23	2	1	0.5	-	-	-	44 (30)	6	4.5
Maja squinado	29	6	4.5	-	-	-	-	-	-	13 (2)	2	2
Carcinus maenas	1	1	0.5	-	-	-	-	-	-	4	2	1.5
Pachygrapsus marmoratus	-	-	-	-	-	-	-	-	-	40	6	6
Eriphia verrucosa	-	-	-	-	-	-	-	-	-	2	2	1
Crab Indeterminate	311	4	1.75	-	-	-	-	-	-	39 (8)	2	1.5
MAXILLIPODA												
Perforatus perforatus	75	33	33	-	-	-	1	1	0.17	54	26	26
Cirripedia	23	13	12.2	-	-	-	-	-	-	7	3	2.17
ECHINOIDEA												
Paracentrotus lividus	-	-	-	-	-	-	-	-	-	5	1	0.5
TOTAL	**763**	**86**	**74.95**	**2**	**1**	**0.5**	**1**	**1**	**0.17**	**208**	**50**	**45.17**

Tab. 15.1 – Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI) and Minimum Animal Units (MAU) per taxon and occupation phase of Gruta da Figueira Brava. Numbers in brackets in Reworked column refer to number of crab specimens with concretion, therefore, originally from MIS-5 levels but brought up in the sequence due to burrowing activity.

	Carapace	Mandible	Leg	Claw	Propodus	Dactylopodus	Dactylus	Carpus Claw	Indeterminate	Test whole	Test plate	Hemipyramid
MALACOSTRACA												
Cancer pagurus	-	-	-	175	59	115	-	6	15	-	-	-
Maja squinado	1	4	-	16	10	7	-	-	4	-	-	-
Carcinus maenas	-	-	-	-	2	2	1	-	-	-	-	-
Pachygrapsus marmoratus	-	-	-	-	12	14	-	2	12	-	-	-
Eriphia verrucosa	-	-	-	-	-	2	-	-	-	-	-	-
Crab Indeterminate	3	4	1	5	-	-	-	-	337	-	-	-
MAXILLIPODA												
Perforatus perforatus	-	-	-	-	-	-	-	-	-	49	81	-
Cirripedia	-	-	-	-	-	-	-	-	-	7	23	-
ECHINOIDEA												
Paracentrotus lividus	-	-	-	-	-	-	-	-	-	-	4	1
TOTAL	**4**	**8**	**1**	**196**	**83**	**140**	**1**	**8**	**368**	**56**	**108**	**1**

Tab. 15.2 – Body part representation per taxon from Gruta da Figueira Brava. Note the predominance of crab claws, and test plates for barnacles and sea urchins.

	Curved/V-shaped	Longitudinal	Transverse	None	TOTAL
Cancer pagurus	14	230	111	-	355
Maja squinado	1	6	25	1	33
Carcinus maenas	-	-	4	1	5
Pachygrapsus marmoratus	4	-	14	10	28
Eriphia verrucosa	-	1	1	-	2
TOTAL	**19**	**237**	**155**	**12**	**423**

Tab. 15.3 – Type of fracture on all identifiable to species crab claws from Gruta da Figueira Brava. Note that transverse fractures predominate in most species, except for *Cancer pagurus* that shows a higher figure for longitudinal fractures and has no complete pincers.

	Brown	Black	Grey	White	None
Cancer pagurus	1	62	2	-	305
Maja squinado	-	1	-	-	41
Carcinus maenas	-	-	-	-	5
Pachygrapsus marmoratus	-	-	-	-	40
Eriphia verrucosa	-	-	-	-	2
Crab indeterminate	-	2	-	-	348
TOTAL	**1**	**65**	**2**	**-**	**741**

Tab. 15.4 – Burning on crab remains recovered from Gruta da Figueira Brava. Note the incidence of most burnt remains on *Cancer pagurus* remains.

15.2.4. Surface modification

Sea urchins present no surface modifications. Half of the barnacle assemblage (51.3% or NISP = 82) shows calcareous coatings, but only two remains feature sediment fillings and another two have dissolution marks on their dorsal side. Abrasion and incrustation are absent. There is evidence of one perforation, but due to its size and shape, it is probably due to gastropod predation.

Crab remains do not feature incrustation or abrasion marks, the latter implying the lack of exposure to strong tide activity. Focusing on the MIS-5 levels, all remains show coating with calcareous concretions, 18.2% (or NISP = 122) have sediment fillings, and dissolution was detected on ten remains. No carnivore or rodent gnawing marks were detected, and anthropogenic incisions are also absent. Nonetheless, a total of ten impact flakes were consistently found on the ventral side of the proximal end of *Cancer pagurus* dactylopoda (Fig. 15.1 C).

15.2.5. Body size

From the reworked levels, two *Carcinus maenas* remains allowed carapace width, revealing a population ranging in size between 53 and 73 mm. The *in situ* deposit is overwhelmingly dominated by *Cancer pagurus*, whose carapace width was estimated from the length of the pincers to range between 111 and 223 mm, averaging 162 mm (Fig. 15.2).

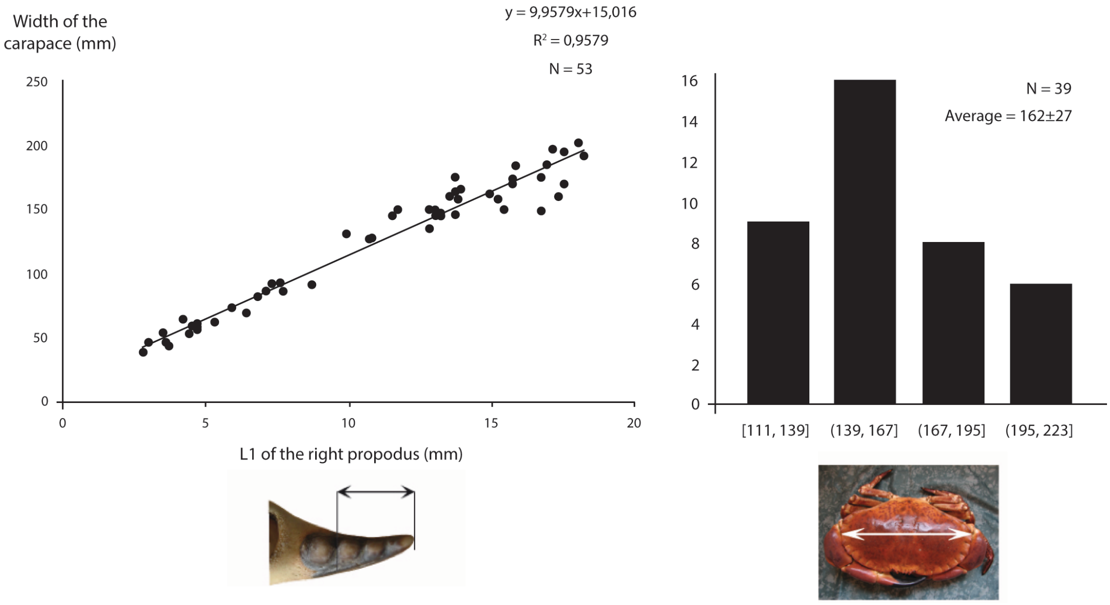


Fig. 15.2 – *Cancer pagurus* carapace width (mm). Left: Regression line reflecting the biometric relationship between the size of the right propodus and the carapace (graph produced by Catherine Dupont). Right: Carapace width for MIS-5 units.

15.3. DISCUSSION

15.3.1. Agents of accumulation

Considering the scarce bibliography available for archaeological crustacean and echinoderm analyses, most of the assumptions used for identifying agents of accumulation for other shellfish and small animal remains are adopted. Crab natural accumulations are expected to show individuals in anatomical connection or in close association, with a relatively good state of preservation and low fragmentation (Bishop 1986).

As summarised by Erlandson & Moss (2001), several carnivores — e.g., canids, felids, bears, and otters — are opportunistic shellfish predators. There are also several non-human primates that eat crabs (Russon et al, 2014; Koops et al, 2019). These animals can transport crabs to archaeological sites, and their interference in the accumulation can be inferred from the presence of their own skeletons and the identification of digestion, gnawing and bite marks. A variety of birds can also be responsible for the accumulation of crab remains, e.g. cormorants, condors, sea eagles, corvids and gulls. Such accumulations are frequently related with nesting and show high levels of fragmentation with random types of fracture, as those birds use gravity (dropping of the shellfish from high above onto rocks below) to break the shell open and expose the edible flesh (Erlandson & Moss, 2001).

An anthropogenic crab accumulation is expected to be found in stratigraphic association with stone tools and other features, such as hearths; to show surface modifications (like burning), patterns of mechanical fracture and, potentially, some cuts and percussion marks. Based on such criteria, Neanderthal mollusc accumulations have been identified in Gibraltar caves (Finlayson, 2008; Stringer et al, 2008), as well as in Bajondillo Cave, Spain (Córtez-Sánchez et al, 2011). Similar criteria have been used for the South African Middle Stone Age shellfish accumulations recovered from Sea Harvest (Volman, 1978), Hoedjiespunt (Kyriacou et al, 2015; Will et al, 2013), Klasies River (Langejans et al, 2012; Thackeray, 1988), Ysterfontein 1 (Klein et al, 2004), Pinnacle Point 13B (Jerardino & Marean, 2010; Marean et al, 2007) and Blombos Cave (Langejans et al, 2012). Moreover, an anthropogenic accumulation is expected to be size-selective, thus showing preference for larger animals with higher meat content.

Two different agents seem to have been responsible for the crab accumulation of Gruta da Figueira Brava. Reworked levels show high species diversity since *Pachygrapsus marmoratus* and *Eriphia verrucosa* are exclusive to these levels, and evidence for *Carcinus maenas* was mostly recovered from that deposit. Remains of such crab species are fragile and prone to breakage. However, they tend to be well preserved and with a high degree of completeness. The same applies to the fragile test fragments of sea urchins. We can therefore conclude that these remains were not exposed to damage by sedimentation dynamics. They also show no evidence of the impact of marine dynamics (e.g., shell abrasion, or incrustation by barnacles or parasites). Likely, the remains represent natural deaths, whether in the cave itself or in the adjacent rocky beach, whose remains eventually made their way into the sedimentary fill via natural agency, namely burrowing by small mammals. Indeed, nowadays *Pachygrapsus marmoratus* is common in the intertidal pools around Gruta da Figueira Brava. As is also the case with *Carcinus maenas* and *Eriphia verrucosa*, these crabs move within rock creeks and crevices, and they inhabit seashore caves whose wet environment provides welcoming shelter (Ingle, 1996). Moreover, no carnivore marks were identified in any crustacean or urchin remains. Despite *Pachygrapsus marmoratus, Eriphia verrucosa* and *Carcinus maenas* being small-sized crabs with fragile shells, their remains are well preserved; there are several complete pincers and most fractures are recent, which rules out an accumulation by carnivores, which would typically feature a high degree of fragmentation.

With regards to the *in situ* deposits, which are dominated by *Cancer pagurus*, none of the remains bears evidence of carnivore or raptor modification. Moreover, brown crabs were selected for large carapace width (on average, 160 mm), which reflects a preference for adult males weighing around 800 g (Haigh et al, 2015; Woll, 2006). Apart from humans, the other agents capable of moving such large crabs are the aquatic eagle and other raptors of similar size (Erlandson & Moss, 2001). However, such birds do not nest in caves, and even less so in deposits featuring continued human occupation. In addition, the brown crab is a species that although it can occupy the low levels of the shore, in the adult age indicated by the body size estimations, has a preference for living in the sea floor. Therefore, it rarely forms natural seashore thanatoceneses. Furthermore, the animals were transported for over more than 1500 m inland, the site-to-shore distance estimated for MIS-5b (Chapter 6, Fig. 6.1 B), during which 99% of *Cancer pagurus* and *Maja squinado* remains, those from phase FB 4, entered the cave (Tab. 15.1). Finally, the type of fracture observed on crab pincers, the fact that many remains are burnt, and the impact flakes suggesting claw disarticulation further corroborate anthropogenic agency in the accumulation of the MIS-5 crabs.

15.3.2. Crab harvesting and processing

The presence of diverse skeletal parts, even if some are poorly represented, bespeaks of the introduction of complete animals. However, archaeological crab remains are mostly identified by their pincers. Experimental work on the cuticle of crabs confirms that crab pincers are the body part most likely to preserve due to its low porosity (Plotnick et al, 1988; Mutel et al, 2008; Waugh et al, 2009). Krause et al (2011) have also shown that pincers have a high calcium carbonate content and, hence, preserve better than any other parts of the exoskeleton. Unsurprisingly, all five crab species represented at Figueira Brava were identified through their pincers, which are also the most diagnostic. All taxa can be found in the Portuguese Atlantic coast nowadays, and they are edible, even though some (e.g., *Pachygrapsus marmoratus*) are currently ignored due to their small size. All species are intertidal and can easily be found in low tide pools among algae, beach boulders and rock creeks. However, adult *Cancer pagurus* and *Maja squinado* are only found in those locations in the summer months (sometimes until October), when seawater warms up and the crabs migrate to the shore for reproduction. During the rest of the year, these two species remain confined to the subtidal zone (Gruet, 2002; Ingle, 1996; Woll, 2006).

Nowadays, several commercially important species of crab are harvested using entrapment gear, like basket traps or pots, baited with herring, squid or shad. Only sessile or slow-moving animals, like molluscs, gooseneck barnacles and sea urchins are harvested by hand (Flick, 2012). Nonetheless, and despite the crabs' quick movement and escape strategies, there are several ethnographic examples of hand-collection, frequently aided by spears. The Nehalem Tillamook men of the northern Oregon Coast of America hunted crabs using long poles to stab them (Losey et al, 2004). This practice is also mentioned by von Brandt (1984) for coastal countries in Western Europe. Such technique can be easily applied on shallow waters, as described by Swan (1972) for the Chinook of Willapa Bay in Washingston State (USA), who waded for crabs of large size in low tide pools. The

Squamish people (Canada) are known to gather crabs from the beach in the summer (Conner & Bethune-Johnson, 1986). This is an activity described for women from several indigenous peoples from the Pacific Northwest Coast (e.g., the Squamish, Conner & Bethune-Johnson, 1986; the Kwakiutl, Wolcott, 1967; the Haida, Murdock, 1963); whereas men tend to be associated with crab hunting by spearing, as observed within the Makah (Renker & Gunther, 1990), the Eastern Abenaki speaking people (Snow, 1978), or the Wampanoag Indians of Massachusetts (Speck & Dexter, 1948). Batdorf (1990) notes that Dungeness crabs (from the *Cancer* genus) were hit by spears on the area behind the eyes, in order to daze the crab and to facilitate hand collection.

The *Cancer pagurus* assemblage from Gruta da Figueira Brava shows clear selection for large size animals, which reflects individual hunting and not mass collection. If crabs were mass harvested, one would expect to find animals of all sizes, as described by Losey et al (2004) for the Oregon coast of America. Large individuals are easier to spot than smaller animals, and based on ethnography crab harvesting is a female dominated activity at low tide, which would explain the brown crab accumulation in Gruta da Figueira Brava. Although the Chinook people only keep crab claws and discarding the rest of the animal (Swan, 1972), skeletal elements other than the propoda and dactylopoda are represented at Gruta da Figueira Brava. Therefore, complete animals should have been brought to the cave alive, or freshly killed, for consumption. How crabs were processed can be inferred from the burning and breakage patterns.

Even though most burning is found on the pincers, it can be seen on carapace fragments too (Fig. 15.1), which further supports the notion of complete animals being processed on site. Ethnographic studies indicate that crabs are not consumed raw, and that they are commonly boiled, steamed or roasted (Suttles, 1974; Batdorf, 1990; Emmons, 1991). Boiling and steaming are not likely to result in the burning of crab remains, but roasting on the coals does leave thermo-alteration marks. At Gruta da Figueira Brava, the most common is burning to black, reflecting exposure to fire temperatures between 300ºC and 500ºC (Milano et al, 2016; Villagran, 2014), typical for cooking (e.g. Pearce & Luff, 1994; Montón-Subias, 2002). Ethnography demonstrates that crab meat is considered to be cooked when it does not stick to the shell (Batford, 1990). Exposure to temperatures starting at 300ºC results in dramatic changes in shell surface colour, texture and microstructure. As a result, shells become more fragile and easier to break (Milano et al, 2016); and, when processed, they will shatter because of their lower density (Rick et al, 2015). The flaking marks found on the ventral proximal side of dactylopoda suggest manual disarticulation. The predominance of longitudinal fractures on *Cancer pagurus* pincers bespeaks of the intention to access the flesh within the fingers, while the carapace was targeted for its large brown meat content (Tab. 15.5), as is the case today.

Cancer pagurus is one of the crustaceans mostly consumed in Southern Europe – Portugal, Spain, France and Italy – during the summer holidays and over Christmas (Barrento et al, 2008). The marks seen on the archaeological material are very similar to those empirically produced when eating them today. The disarticulation of the claw fingers is done by manually breaking the joint backwards, which is sometimes aided by a small hammer. Such hammers, however, are most valuable for breaking the fingers themselves to access the white meat inside, which recurrently produces the same kinds of longitudinal fractures observed on the archaeological material.

	Meat yield (g)	**Meat yield (%)**
Claws	50.4	6.3
Walking legs	20.8	2.6
Body	44	5.5
White Meat TOTAL	115.2	14.5
Brown Meat TOTAL (including roe)	120	15
TOTAL MEAT YIELD	**235.2**	**29.4**

Tab. 15.5 – Meat yield for boiled and hand picked *Cancer pagurus* crabs, which on average were 800 g live weight, adapting from the values given by Woll (2006) for female crabs caught in October.

15.3.3. Crab dietary importance

Currently, crabs are seen as important food resources, considered to enhance good healthy living due to its high-quality and low-calorie protein, associated with a wide range of vitamins and minerals, but essentially due to the presence of long-chain polyunsaturated fatty acids (also known as PUFAs) including docosahexaenoic (DHA) and eicosapentaenoic (EPA) acids (Hicks, 2012; Ovat et al, 2018, Tsape et al, 2010). *Cancer pagurus*, in particular, provides ample doses of elements such as potassium, calcium, copper, zinc, selenium and PUFAs. Overall, brown meat (*i.e.* tissue in the body cavity comprising mostly gonads and hepatopancreas) contains higher fat, cadmium, calcium, iron, magnesium and copper, whereas muscle (*i.e.* the white meat in the legs and claws) has higher zinc values. Therefore, such crabs are among the seafoods with a higher potential for the improvement of cardiovascular and neurological aspects of human health (Maulvault et al, 2012).

Such nutritional properties are even more relevant if the crabs in question are adult *Cancer pagurus,* as the ones found in Gruta da Figueira Brava, and they can be enhanced through culinary treatment. Crab cooking results in a decrease of the moisture content and EPA but increases minerals, protein, carbohydrates, carbon, zinc, bromine and chlorine contents (Maulvault et al, 2012). Therefore, despite the low ranking of crabs in diet-breadth models due to their small size and apparent limited caloric intake (e.g. Winterhalder & Smith, 2000; Bird & O'Connell, 2006), they offer the benefit of nutrient diversity (Hockett & Haws, 2003, 2009) and are an appealing protein, fat and PUFA package easily acquired from the nearby shore, within minimal processing and transport efforts. In terms of meat yield, the selection for 800 g crabs would guarantee about 200 g of edible crab meat, since about 70% of the weight corresponds to the exoskeleton (Tab. 15.5).

With regards to seasonal crab availability, opinions diverge, as noted by Gutiérrez Zugasti et al (2016). For instance, Brown & Bennet (1980) report on the rarity of adult *Cancer pagurus* on the shore during the winter months, even though juveniles can remain in intertidal waters year round, but Silva et al (2014) observe this species' presence throughout the year with comparable densities for all seasons. This could be explained by the optimal conditions of food availability provided by upwelling, which results in an earlier breeding season of *Cancer pagurus* in Portugal (Cunha et al, 2018). Even though seasonality is, therefore, difficult to assess, it is clear that crabs were consistently consumed throughout Phase FB 4, when they were most certainly considered as a staple resource. Food is not only consumed for satisfying nutritional needs, but also to experience esteemed flavours and to fulfil specific roles in social life. Therefore, and as demonstrated by ethnographic studies in Australia (Bailey, 1975; Meehan, 1977, 1983), resources that can be interpreted as minor within an assemblage, if consumed continuously and systematically over a period of time, must be seen as providers of additional significance. However, whether such foods are perceived as tasteful, or reflect some sort of festivity, or add social value to whoever harvested them, or have any other meanings associated with their consumption, is, at this stage of the research, beyond our grasp.

15.4. CONCLUSION

The marine crustacean assemblage recovered from Gruta da Figueira Brava is the first known from the Middle Palaeolithic. The anthropogenic nature of the accumulation is unquestionable for the in situ MIS-5 deposits, dominated by large size specimens of *Cancer pagurus*, indicating a harvest that targeted mature individuals with a high meat content. Their collection might have been done during spring and summer, when these animals come to shore for reproduction, but it is also possible that such resources were available and consumed year-round. Foraging was performed at low tide, most probably by women who would catch the large crabs by hand, possibly aided by long poles. The catch was brought to the cave for cooking in the coals, and consumed on site. Neanderthal diets therefore included a wide range of marine foods, among which crabs played an important role. The continuous and consistent consumption of crabs may well have entailed meanings other than the satisfaction of alimentary needs, but this must remain speculative; it certainly provided an ample array of nutrients with significant amounts of protein, DHA, calcium and sodium, which are important contributors to a healthy diet.

Part VI

Trends in Last Interglacial Neanderthals in Portugal

Feeding upon the results and discussion presented in Part V, this section aims to explore ampler themes in Neanderthal research. Using human subsistence behaviour and the broadening of the diet as a starting point, such topics are further encompassed within a wider scope of Neanderthal adaptability to different landscapes and the varying human-prey dynamics depending on the subsistence strategies used (Chapter 16). In Chapter 17 themes like Neanderthal mobility, use of space, and their social implications are also tackled based on the zooarchaeological evidence previously provided.

CHAPTER 16

NEANDERTHAL ECOLOGICAL ADAPTABILITY AND SUBSISTENCE STRATEGIES

16.1. Neanderthal environmental adaptation and faunal species diversity

During their history, from their first emergence c. 300-400,000 years ago, Neanderthals expanded through a wide range of habitats over a vast geographic area of western Eurasia, stretching from the Iberian Peninsula to south-central Siberia, and from Germany to the Levant (e.g. Krause et al 2007; McDermott et al 1993; Fig. 3.1). Such an extensive territory was not continuously populated; instead, Neanderthals were inhabiting localised habitats which would have expanded and contracted with changing climatic conditions. Nonetheless, a great variety of environments were available to them – from inland to coastal areas, and from flat to mountainous terrain – thus implying different soil compositions, humidity, and temperature, which are largely dependent on latitude, altitude and distance to the sea. Consequently, the fauna and flora available vary according to geographic location and climatic conditions. Neanderthals lived for tens of thousands of years – ranging from at least MIS-8 to MIS-3 – and during such time, Pleistocene Europe was exposed to numerous climatic oscillations marked by alternating cycles of glacial and interglacial periods. If one focuses on the period from which data is most extensive (MIS-6 to MIS-3), the ice sheets formed during the Penultimate Glaciation (or the MIS-6, ca. 191-124 ka years) began to melt with the advent of the Last Interglacial (or the MIS-5e, ca. 130-115 ka years), so climate would gradually start cooling down again from MIS-5d to MIS-5a (ca. 115-71 ka years) culminating in the Last Glacial cycle between MIS-4 and MIS-2 (ca. 71- 11.7 ka years) (Otvos 2015). Such climatic fluctuations led to the formation of varied environments, spanning from cold and open habitats to warm and wooded landscapes, which greatly influenced the expansion and contraction of plant and animal communities. Pollen data confirm that such alternating sequences are applicable to all Europe, even though less variation and a greater stability is found in southern areas (Bardají et al 2009; CAPE – Last Interglacial, Project Members 2006; Sirocko et al 2007; Ehlers et al 2011).

Focusing on MIS-5 in southern Europe, and in the Mediterranean region in particular, this is when the sea rose to levels ~ 5 m higher than the present day and there was an expansion of Mediterranean evergreen woodland (such as *Olea* or evergreen oak), with Mediterranean taxa found all the way to the south of the Alps (Tzedakis 1994; van Andel & Tzedakis 1996). Bear in mind, however, that despite sea level rise, the sea was still between 750 and 2000 m away from Gruta da Figueira Brava during its MIS-5c-5b occupation (Zilhão et al 2020). With greater climatic stability, and within the hypothesis of species displacements towards southern territories during the cold stages, Iberia is often understood as a glacial refugia from where migration towards northern areas would occur during climatic amelioration (e.g. Hewitt 2000; von Koenigswald 2011; O'Regan 2008). The Mediterranean basin is extremely rich in endemic species (Gomez-Campo 1985; Myers 1990), which is mainly due to the cool wet winters and the hot dry summers that allow Mediterranean forests to contain up to 100 tree species. About half of such species are fruit- and nut-bearing trees, which is highly contrasting with the 37 tree species found in the vast central and northern European forests (Quézel 1976; Blondel & Aronson 1999). Additionally, the Mediterranean forest is interspersed with shrubland plant communities, mainly the *matorral* type, which was present throughout the Pleistocene (Groves 1991; Trabaud 1991). The matorral was described by di Castri (1981) as mainly dominated by evergreen shrubs with sturdy (sclerophyllus) small leaves, with a complex underwood of smaller trees and herbaceous perennials. Such an environment is very stable and recovers quickly from recurrent fires and other disruptions, thus promoting the co-existence of several ecological niches (Trabaud 1991).

Being amongst the richest regions in plant species in western Eurasia, the Mediterranean has a remarkably high assortment of faunal taxa. From a rough total of 500 European bird species, as many as 366 of them are found in the Mediterranean, with Iberia playing an important role in several migratory bird routes. Moreover, a quarter of the reptile species in Iberia are endemic, and a total of 74 mammal species can be found in that territory (Cheylan 1991). As noted by Stiner (2005), closely associated with matorral habitats, are partridges, many warbler species, as well as tortoises and leporids (i.e. hares and rabbits). As for the marine environments, they are also very rich in plants, invertebrates, fishes and mammals (Tortonese 1985), a feature that is highly marked in the Atlantic coasts of Portugal due to the strong upwelling activity and high tidal amplitude (Abrantes 1990, 2000; Loureiro et al 2005).

However, the great biodiversity of the Mediterranean occurs in spatially limited areas, and it is not homogenously spread throughout the region. Therefore, species diversity is variable, and it should be understood at a more local scale. Ecotonal areas are expected to have been repeatedly visited by human foragers due to the large amount of resources made available to them. The question to be posed is how can we assess the natural availability of these past local ecotones when our primary evidence is represented by the prey of one kind of predator, i.e. Neanderthals? Such a behavioural filter most definitely biases the composition of the recovered faunal assemblages. Nonetheless, and as argued by Stiner (2005), it is a fairly consistent filter. It should also be added that, in some circumstances, nearby sites where faunal assemblages were originated by non-human carnivores can give valuable insight about past landscapes. Furthermore, not all animal remains are due to carnivore activity, there can also be contributions by naturally accumulated remains, which most frequently concern small size mammals and birds. Nonetheless, inferences of past environments based on faunal remains from human occupations have problems (Discamps et al 2011; Discamps & Royer 2017). Firstly, the viability of analogies between past and present ecosystems, and secondly, the ecological plasticity of ungulates, such as red deer.

The difficulty in the use of modern ecosystems as analogues is mainly due to the lack of modern environments that match some of the past ones, which has led to scepticism by some researchers in terms of niche stability in the past (e.g. Guthrie 1982, 1990; Stewart & Lister 2001; Stewart 2005).

However, as demonstrated by Discamps et al (2011), ecological modelling and isotopic analyses on several Pleistocene ungulates show a stable dietary adaptation to the environment, despite the climatic oscillations that occurred through the Pleistocene. As for the second issue, recent research on teeth meso- and micro-wear analyses have been demonstrating the great plasticity of ungulates, mainly red deer, due to their high tolerance to a great variety of environments (e.g. Rivals et al 2009; Sánchez-Hernández et al 2020). Therefore, the inference of past environments based on such ungulate communities has been challenged. Even though, and following Shelford's tolerance law (1911), several species with different ecological niches can coexist, some would flourish, others would struggle. Nonetheless, there are some key limiting factors that would have moulded the local faunal communities, e.g. temperature tolerance, type of vegetation, or site altitude. Therefore, it is fundamental to compile the data available not only on ungulates and their environments, but also on the extant taxa of the faunal assemblages – e.g. mammal predators, birds, reptiles and micro-mammals (the latter tending to be highly sensitive to local environmental changes). Such combined information from all animal groups will, thus, make it possible to assess what was the dominant type of local environment.

This was the research approach used for both Gruta da Figueira Brava and Gruta da Oliveira, where several animal groups (except fishes and micro-mammals) have been analysed in order to better understand local palaeoenvironments. Based on the results presented in Part V (Chapters 11 to 15), it is clear that both caves benefitted from environmentally rich landscapes. Due to its geographical setting in a more coastal position, Gruta da Figueira Brava profited from both aquatic and terrestrial environments, which clearly resulted in high biodiversity levels reflected in a species richness of 57 from the MIS-5 levels. Although on a more reduced scale due to the association to a narrower inland niche, Gruta da Oliveira also showed relevant levels of faunal biodiversity, with a species richness of 31, which is mainly due to birds. All faunal remains studied confirm a fairly steady interglacial environment, with mild temperatures but with a significant presence of water that allowed a year-round herbaceous cover (López-García et al 2020) and supported wooded environments where the few aurochsen identified would take shelter. Patches of open grassland were also available in the surroundings of the caves, where horses and rhinos were permanent inhabitants due to their grazing adaptation. Mountainous shrubland is still part of today's local environments, and this is where ibex would be more easily found. As for red deer, due to its mixed feeding behaviour and its great environmental tolerance, it would be found in all of these habitats, depending on the seasons of the year.

The matorral type of environment favoured the existence of different ecological niches within a same region, which means that different species were able to thrive and to avoid resource competition with their peers in the surrounding areas of the caves. Ungulate animals were also complemented by a great variety of other vertebrates, such as tortoises and rabbits, the latter being endemic to Iberia and highly adapted to the matorral. A wide range of birds was also available, and both Gruta da Oliveira and Gruta da Figueira Brava benefited from resident and migratory animals. The greater biodiversity in the latter cave is due to its coastal position that promoted the exploitation of a great diversity of aquatic resources, including marine birds, molluscs and crabs. Therefore, alongside the terrestrial catchment areas already mentioned – grassland, shrubland, woodland, forested mountain slopes – Neanderthals from Gruta da Figueira Brava were also exploiting the rocky shores, coastal lagoons and the alluvial plains between the Arrábida mountain chain and the paleo-estuary of River Sado. Based on recent research, Zilhão et al (2020) have shown that nearby dune pinewoods were also targeted, given the large amounts of pine bracts and nut shells recovered from the MIS-5 occupations, reflecting reliance on a pine nut economy similar to that seen at other Iberian Late Glacial and Holocene sites, like Cueva de Nerja (Spain; Badal 1998).

Based on the data presented in Part V, it is clear that Portuguese Last Interglacial Neanderthals were perfectly adapted to different landscapes, including coastal environments where they systematically procured marine resources. Neanderthal coastal adaptation has been firstly argued for the

Gibraltar caves (Finlayson 2008; Stringer et al 2008) and then for Bajodillo Cave in Spain (Cortéz-Sánchez et al 2011), but severely criticised mostly by researchers working in the Middle Stone Age (MSA) in South Africa (e.g. Klein & Steel 2008; Marean 2014). Nonetheless, a coastal adaptation in Gruta da Figueira Brava is clear based on (1) the human agency in the accumulation of the large amount of marine resources, (2) the taphonomic evidence concerning aquatic birds, crabs and food molluscs (i.e. limpets, mussels and clams), but also by (3) the demonstrated preference for the collection of large size crabs and molluscs, as well as (4) the intense exploitation of limpets evidenced by a decrease in shell size, which (5) motivated the exploration of riskier areas of the shore. Additionally, (6) the amount of shell debris (from molluscs and crabs) recovered from the MIS-5 levels of Gruta da Figueira Brava is comparable to that of the Mesolithic site of Toledo, and (7) to several other African and Iberian coastal sites, as extensively discussed by Zilhão et al (2020). Therefore, Neanderthals in Gruta da Figueira Brava had a subsistence strategy that was clearly designed in order to include these marine resources in their diets which, based on the data presented, cannot be understood as sporadic or occasional procurement. The systematic use of aquatic resources once thought as exclusive to modern humans, is now shown to have also been a feature of Neanderthal subsistence behaviour.

In sum, the ecosystems described for Gruta da Figueira Brava and Gruta da Oliveira must have not significantly changed over the thousands of years covered by the layers examined from both caves. The studied fauna is very regular and consistent throughout the stratigraphic sequences and, despite species' preferences for different ecological niches, they seemed to have flourished and have been well adapted to their local environments, considering that several prime adult animals (whether large or small size, aquatic or terrestrial) were available for human exploitation. Based on the presence of all age groups (even if juvenile and senile animals are a minority in the human accumulated assemblages) the ecosystems surrounding the caves seemed to have hosted healthy animal populations, which do not seem to have experienced major disruptions other than punctual intensification of human predation, as shown by the overexploitation of tortoises at Gruta da Oliveira and limpets at Gruta da Figueira Brava. The evidence of such a stable environment is in agreement with what was previously mentioned of southern Mediterranean regions functioning as floral and faunal refugia due to the stability of their ecosystems, especially during MIS-5, as can be seen by comparison with the continuous fluctuations characteristic of the following climatic stages (MIS-4 to MIS-2) (Fig. 5.2). This suave and constant climate, associated with such a great mosaic of ecological niches, allowed Neanderthals to thrive and benefit from roaming and exploring environments that offered plenty and variable resources.

16.2. Predator-prey dynamics and Neanderthal dietary breadth

At this point, it has been established the constancy of the environment, the availability in the nearby ecosystems of a wide array of animal species mostly accumulated through human agency, as demonstrated in the beginning of the discussion in each chapter from Part V. Therefore, and because it is assumed that we are dealing with a human filter, the main concern that follows is the variation in species representation that may be related with particular trends within the studied faunal series. The first is related with variations in key prey species – such as red deer, ibex, tortoises or molluscs –, depending on the site. Secondly, the overall proportions of small to large prey, and terrestrial to aquatic prey. And finally, the degree of difficulty in predating on these animals, the implications such different resources had on human diets, and what impact human predation may have had on the local animal populations.

Similarly to Bolomor Cave (Fernández-Peris 2004) and to many other Valencian Middle Palaeolithic sites in Spain (Eixea et al 2020), the role of non-human carnivores as agents of accumulation and bone modification is low in the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira. Nonetheless, a great variety of predators visited the caves and may have been responsible for part of the leporid bone accumulation. Similarly, some of the birds may have used the sites for building their nests, and it cannot be excluded that some of their osteological material integrated the stratigraphic sequence due to natural deaths. Nonetheless, skeletal part representation and anthropogenic modifications – mainly impact flakes, incisions and burning – do point towards taxa diversity mostly due to human

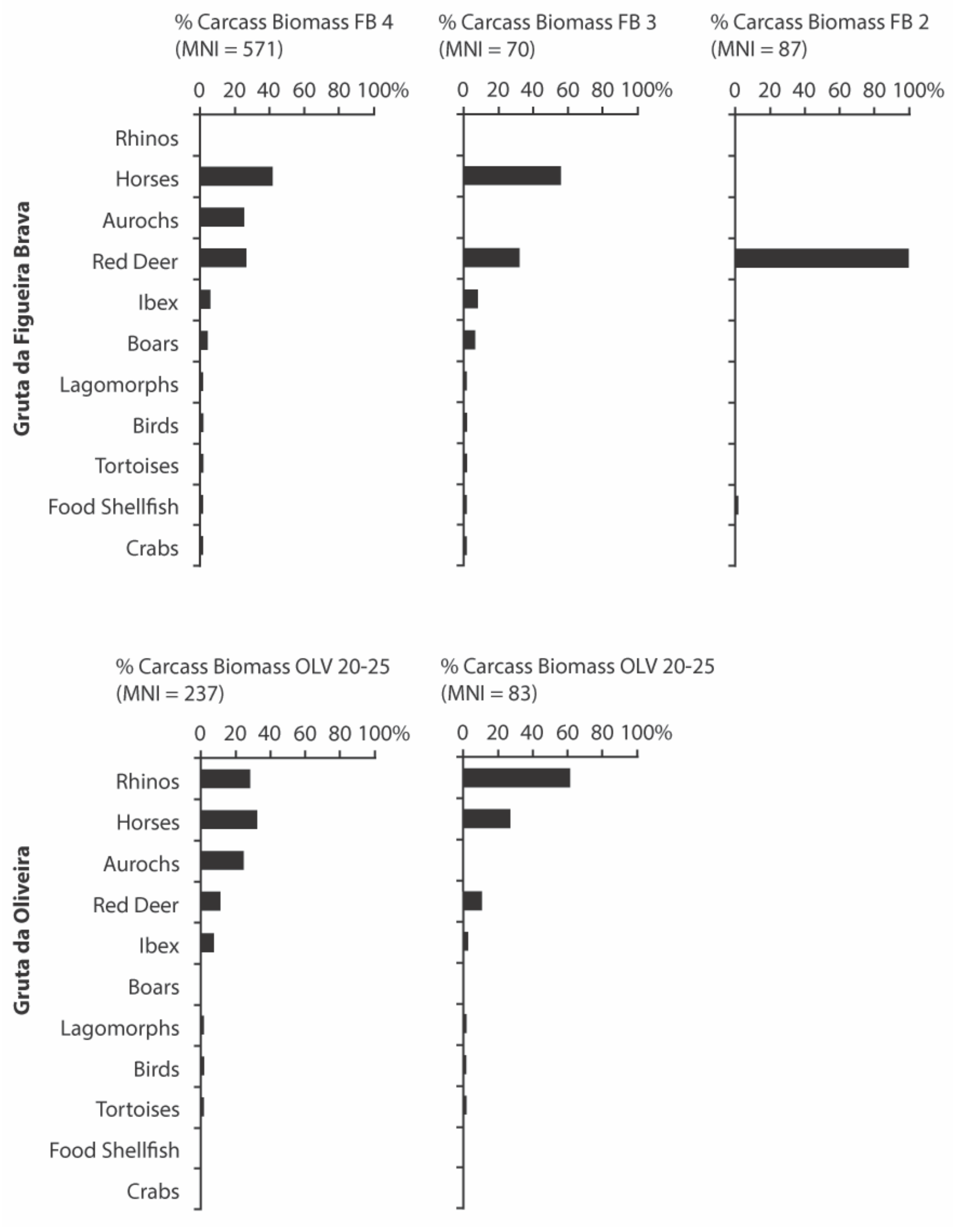


Fig. 16.1 – Percentages of total prey biomass consumed from size-ordered prey-species based on MNI for each species multiplied by the estimated carcass weight (Appendix E) from the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira.

predation. Since animals have dramatically different body weights, the food resources provided vary significantly according to prey size. Therefore, the food obtained from a single large animal easily outweighs the total amount of food provided by several small species. This is easily demonstrated in Fig. 16.1, which compares carcass biomass from different species based on MNIs multiplied by the estimated average carcass weight, following White (1953). For both studied caves, large amounts of food are acquired from just a few large ungulate individuals, horses and aurochs being a good point in case. Both taxa show MNIs significantly lower than red deer, but their food contribution is larger than that of red deer, despite the latter's higher MNI (e.g. FB 4 horse MNI = 5 vs red deer MNI = 11). Such a contrast becomes even clearer when comparing ungulates with small size prey, whose food contribution is inevitably lower than ungulates, despite high MNI values, like the ones for food shellfish (e.g. FB 4 shellfish MNI = 459 vs FB 4 horse MNI = 5). Therefore, despite the wide range of taxa predated upon, it is not unexpected to find food contributions of large animals above 90% which greatly contrast with the < 2% contribution from small prey in both caves.

Contrary to western-central European Neanderthal subsistence strategies showing preference for a single ungulate species (Gaudzinski 2006), Neanderthals from Mediterranean regions targeted a wider ungulate spectrum, mostly cervids, bovids and equids (e.g. Fiore et al 2004; Brown et al 2011; Daujeard et al 2012; Rosell et al 2012). Even though ibex (*Capra pyrenaica*) and chamois (*Rupicapra rupicapra*) have been traditionally associated with Upper Palaeolithic assemblages (Freeman 1973; Straus 1987; Gamble 1995), recent research has demonstrated that these species were also targeted by Neanderthals (Fiore et al 2004; Díez et al 2008, Yravedra & Cobo-Sánchez 2015). They played an important role in the diet together with deer, which is often the most frequent ungulate found in Middle Palaeolithic sites (e.g. Valensi 2000; Sanz et al 2019). Gruta da Figueira Brava and Gruta da Oliveira fit well within this picture, with clear predominance of red deer, followed by ibex, even though other ungulate prey were also consumed. Of relevance are the rhinoceros from Gruta da Oliveira since their weight and dimensions imply anticipatory planning, collaboration and organisation in the hunting of such big game (Rendu et al 2012). All these features are compatible with communal hunting and a subsistence strategy that could anticipate food needs through storage of surplus meat. These traits have been associated with complex behaviour (e.g. David & Enloe 1993; Marean & Assefa 1999; Costamagno et al 2006) but, as observed by Discamps et al (2011), they are not exclusive to humans since several other predators hunt in packs (e.g. wolves, hyenas, lions) and many other animals practice food storage (e.g. insects, birds, dogs, hyenas). Nonetheless, skeleton part selection of large game prey (i.e. rhinoceros, horses and aurochs) was in place, since incomplete carcasses were brought back to the site. There seems to have been a preference for heads that were probably transported from a short distance away, similarly to what has been interpreted for the large ungulates from Abri du Maras level 5.3 (France; Marín et al 2020). Ethnographic research indicates that horse skulls are highly praised by hunter-gatherers (O'Connell et al 1988) because they are less susceptible to fat depletion compared to other parts of the body (Levine 1998; Lupo 1998; Stiner 1994), and maybe such a view could have been extended to the rest of the large size animals.

Given the abundant food contribution of ungulates, it is not surprising that most of the discussions of human diet and predation have focused on large game. Such discourses have also been nurtured by biological anthropological research demonstrating the extremely high levels of Neanderthal physical activity (e.g. Trinkaus 1986; Weinstein 2008; Raichlen et al 2011), which required an energy-rich diet. Nonetheless, zooarchaeological analyses have relied less and less on comparisons of carcass biomass due to their “blind-ranking” system based only on the amount of food intake in terms of energetic-return, and ignoring all its other components. This trend has also been motivated by the steep escalation of the evidence related to small game and plant use – not only due to zooarchaeological studies, but also isotope analyses, human and animal dental wear studies, or microfossils in teeth calculus. These have been triggering discussions related with conscious human food selection being based on more than energy return rates, namely on consideration of the local environment and the nutrient diversity found in each food resource (e.g. Hockett & Haws 2003, 2009). Furthermore, it has been proposed that some resources may have been selected simply due to their pleasant taste, or because they have properties (like their rarity, or the difficulty in getting them) that can relate to status, or some other meaning – whether social, economic, religious, historical, or cultural (Twiss 2007, 2019; Curet & Pestle 2010). Even today we have what we consider to be elite foods – like caviar, oysters, lobsters, truffles or saffron – that carry great social status. It is possible that a similar understanding of foods could have happened in prehistory, especially when considering that that was the approach for the whole of the historical period (e.g. Ashley et al 2004 and references therein), and that other primate species also have ways of distributing food associated with social and politically meaningful acts (e.g. Hohmann & Fruth 1996; McGrew 1996; Whiten et al 1999).

With such considerations in mind, when looking at the NISP data presented in Figs. 16.2 and 16.3 (in this context, NISP should be preferred over MNI; see sections 10.1-10.2), the contribution of large game is considerably less than implied by carcass biomass based on MNI data (Fig. 16.1). In fact, small game seems to dominate the assemblages with relevant contributions from tortoises in Gruta da Oliveira, and crabs and marine molluscs (i.e. limpets, mussels and clams) for Gruta da Figueira Brava. For the latter, the importance of aquatic resources (including aquatic birds) in the faunal collection, which in association with shell density comparable to many other sites with proven systematic consumption, supports an interpretation of site use dedicated to a recurrent exploitation of aquatic resources. This is evident through the specific targeting of large marine individuals, such as crabs with an average carapace size of 16 cm (Chapter 15). Additionally, the largest molluscs were also consistently gathered. When humans collect sessile small animals, there is a predilection for adults, since these are the ones with larger meat yields (e.g. Yesner 1981). However, the decrease in average size of limpet shells (Fig. 14.6) is indicative of intensive human exploitation of this resource (Chapter 14). It could be argued that changes in habitat quality – like the variations in sea level – could be responsible for such a size reduction (Bailey 1983b; Jerardino 1997). Indeed, during MIS-5e, the cave was underwater. However, during its human occupation (between MIS-5d and MIS-5b), climatic fluctuations may not severely impacted the local limpet population, even though sea level varied between 750 and 2000 m.

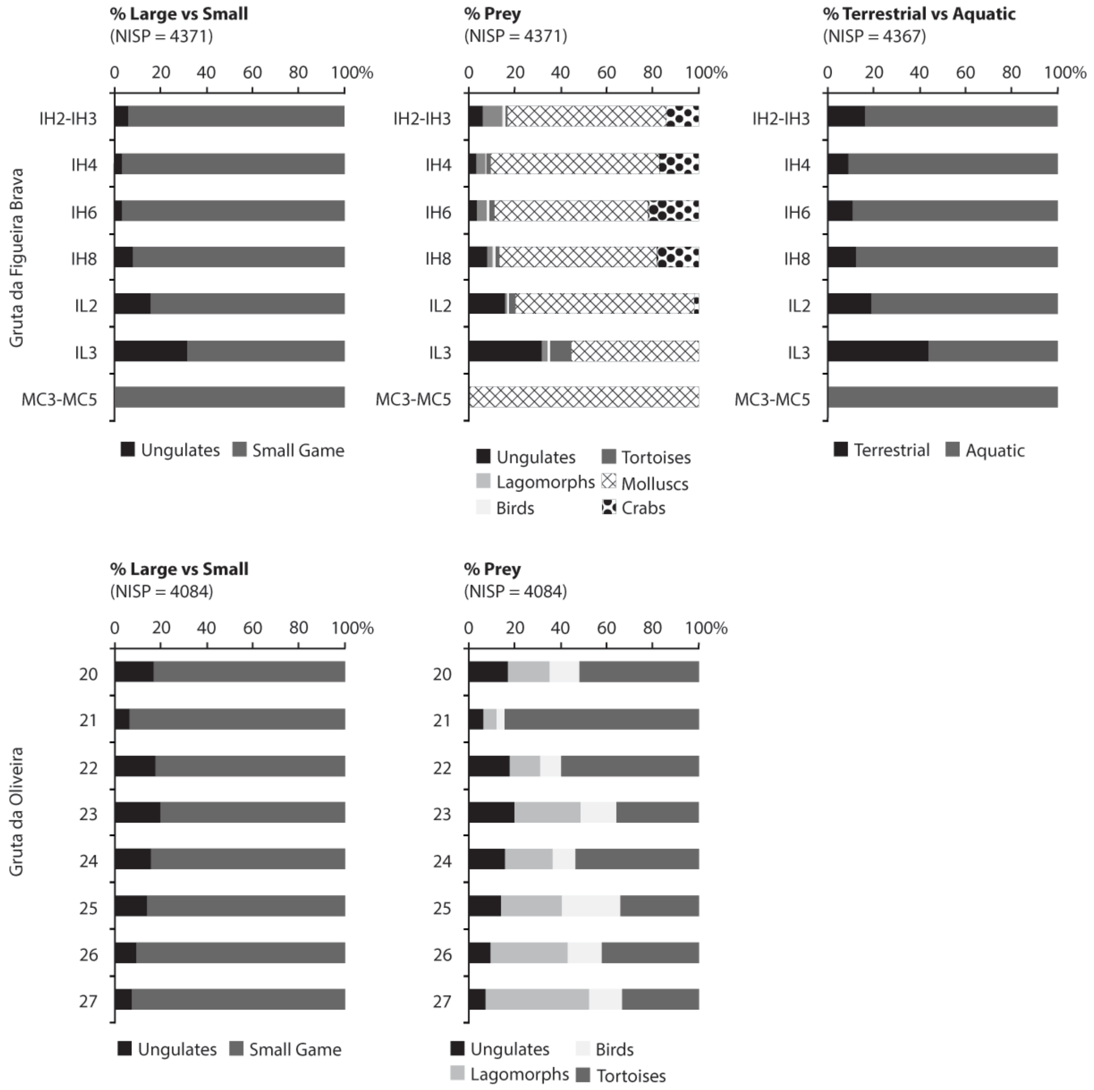


Fig. 16.2 – Patterns in prey representation based on species NISP from the MIS-5 levels from Gruta da Figueira Brava and Gruta da Oliveira.

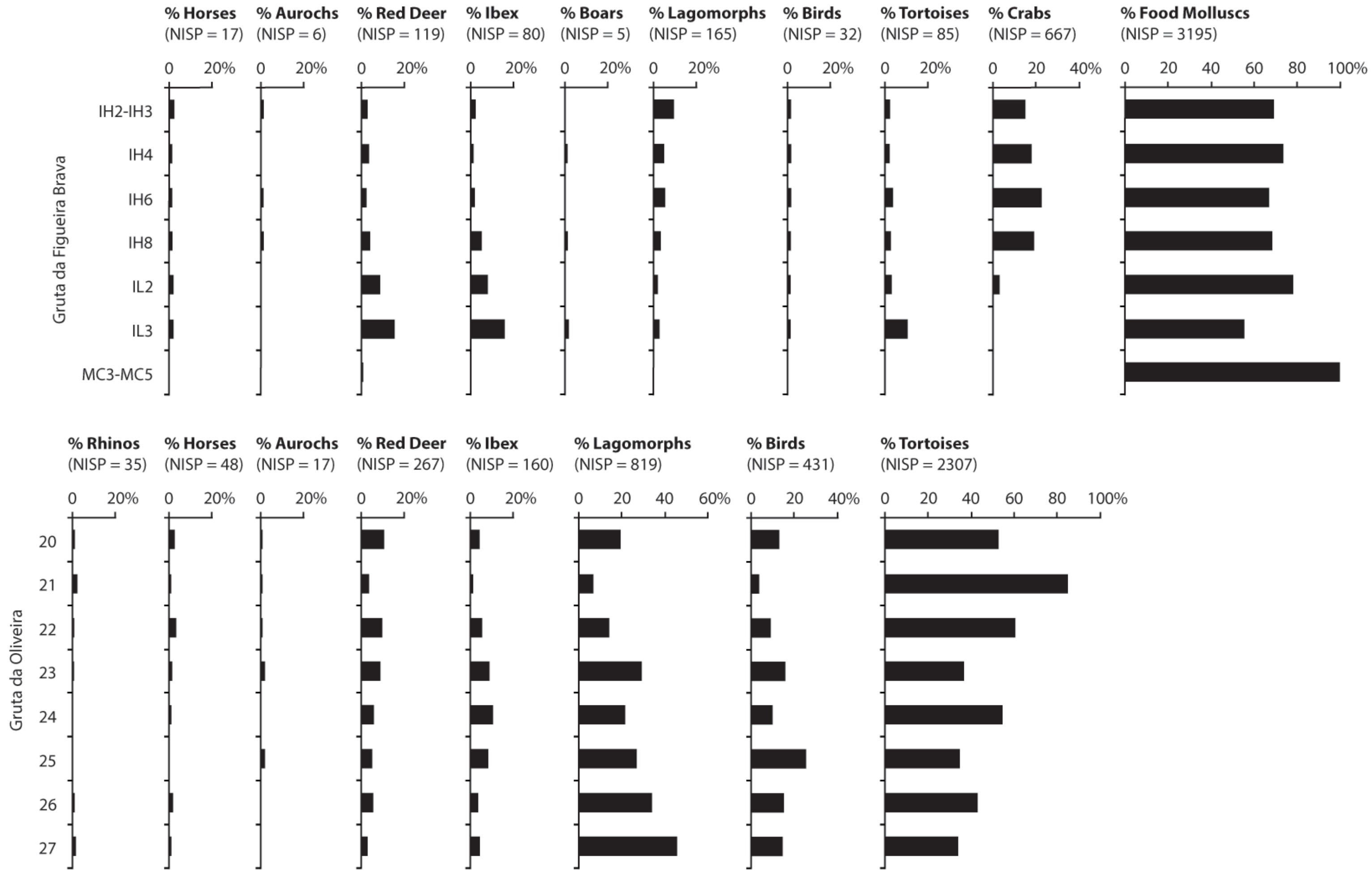


Fig. 16.3 - Prey species distribution as the percent of all species-specific identifications and assemblage sizes (NISP) by MIS-5 levels from Gruta da Figueira Brava and Gruta da Oliveira. The percent data exclude many remains that could not be identified to species or genus, thus the data presented are a fraction of the total NISP for each assemblage. The Food Molluscs from Gruta da Figueira Brava only include limpets, mussels and clams.

At Gruta da Oliveira, humans relied more on the exploitation of ungulates than at Gruta da Figueira Brava. Small game was also procured, but not all leporids and birds are anthropogenic. In addition to food use, leporid fur and bird feathers may have been exploited, though the evidence is fairly elusive (Chapters 11 and 12). It is different with tortoises (Chapter 13). Tortoises were all accumulated and processed by humans, and they were somewhat equivalent to Gruta da Figueira Brava's molluscs: a staple resource Neanderthals could rely upon. They were so intensively targeted that the local population had a sharp decline in individuals.

Tortoise and shellfish are somewhat similar resources because, if not disturbed by human predation, they can exist at very high densities due to their low metabolic rates, high adult survival rates, and considerably long life spans (Hailey 1988; Shine & Iverson 1995). They are very slow moving or sessile animals that are easy to capture: low cost of searching, basic technology or none at all, and low energy spent on capture (Stiner 2005; Stiner et al 1999, 2000). Therefore, they have a similar net return (i.e. caloric value minus energy spent on search and handling costs), demonstrating high revenues upon encounter since they are easy to find, to collect and to process. Hence, it is not unexpected to observe a substitution of Neanderthal diets with shellfish consumption in the coast by tortoise exploitation inland. Such a shift from shellfish to tortoises depending on distance to the coast was first proposed for MSA sites in South Africa. Following from Thompson & Henshilwood's (2014b) model, shellfish gathering was progressively reduced by increased distance to the sea, thus making tortoise exploitation a more relevant resource to collect inland. As a result, continued human predation resulted in a similar impact on both shellfish and tortoise populations.

Consequently, it is clear that Neanderthals were deliberately choosing to include small prey within their subsistence strategies, whether inland or in a coastal location. In the eyes of an optimal foraging model, the presence of small animals in human diets is repeatedly associated with a decline in high ranked animals. However, a great variety of ungulates in both studied caves continued to be hunted, and there is no indication of a reduction in their population size due to hunting pressure, with prime adult ungulates still being targeted through the timespan represented by the stratigraphic sequences. Many researchers also associate broad spectrum diets with a human demographic increase and technological developments (e.g. Marean & Assefa 1999; Stiner 2001; Stiner et al 1999, 2000). Past human demographics are always difficult to assess and often conflicting. This is clear by revisiting the original Broad Spectrum Revolution (BSR) hypothesis (Flannery 1969), in which the argument starts with demographic crowding, i.e. human population size above the carrying capacity of the local environment. But according to Muller (2004), there is no such thing as human overpopulation, because population size can only grow according to the resources available, and if there is not enough food, then human demographics above carrying capacity are not possible. According to such reasoning, Muller (2004) and Newton (2000) argue that the sequence and causality of the BSR events should be reversed: the size of the human population may have changed due to changes in the carrying capacity of the local environment, and not the way around. Subsequently, the consumption of small game could be interpreted as a trigger for the increase in human population size, not a result from it. In other words, human population increase cannot explain BSR, but it is the broadening of the diets that leads to population growth (Muller 2004; Delpech 1999; see comments by Bietti, Brugal and Newton in Stiner et al 2000).

Even though new developments will hopefully shed light on these research issues – human demography, lithic analysis and chronometry – the parsimonious explanation for Last Interglacial Neanderthal broad diets is the one already proposed by Bar-Yosef, in 2004: “eat what is there”. At this stage of research, there is extensive archaeological evidence showing that Neanderthal subsistence strategies were extremely flexible and adapted to the different environments in Eurasia, with variations across the faunal spectrum depending on where humans were living and what species were available seasonally in the local environment. As a result, a more specialized ungulate-focused diet is found in northern latitudes (e.g. Gaudzinski 1995, 2006; Gaudzinski & Roebroeks 2000; Costamagno et al 2006), whereas a wide array of fauna and flora species were available to Neanderthals living in southern Eurasia, especially those in Iberia benefitting from living in environmental refugia.

This deliberate exploitation of various food resources challenges one of the most cited hypothesis for Neanderthal demise that considers narrow diet breadth (when compared to Anatomical Modern Humans) as one of the main causes of Neanderthal extinction (Hockett & Haws 2005). Furthermore, broad diets are recurrently used in debates related to cognitive development and are, presently, troubling notions concerning the definition and extent of behavioural modernity (e.g. Mellars 1996, 2004; Burke 2000, 2004; McBrearty & Brooks 2000; Stiner 2001; Bar-Yosef 2004; Speth 2004; Straus 2010). For instance, the hunting of small fast game, like leporids and birds, is understood by Stiner and colleagues (1999; 2000) as a more difficult task to achieve, since it would imply a more sophisticated technology and considerable planning. According to these researchers, this is one of the reasons why the increase in consumption of such prey is only seen in Upper Palaeolithic sites, and not in Neanderthal occupations where slow moving animals (like tortoises and shellfish) are preferred. But then there is Gorham's cave demonstrating that the catching of birds was not a sporadic Neanderthal practice and was not beyond Neanderthal ability (Finlayson et al 2012; Blasco et al 2014). There is also Bolomor Cave showing regular use of rabbits and birds, alongside tortoises (Blasco et al 2013). Indeed, and as summarised by Finlayson (2019), fast moving prey are not difficult to catch and do not need special tools. If animal ethology is known – which most certainly was the case with the Neanderthals, who were fully dependent of their landscape to survive –, and if some planning were in place, leporids and birds would be easily caught. Depending on the species and their behaviour, leporids and birds can be caught by hand, or by using simple technology, as shown in Chapters 11 and 12. So the ways of catching small fast moving prey mostly rely on stalking, a keen eye, basic technology and pre-arranged tactics, similarly to what was done for the exploitation of other prey, like the communal hunting of large ungulates. Therefore, deliberate selection of a particular type of prey (whether large or small, terrestrial or aquatic), and categories such as slow- or fast-moving prey, cannot be meaningfully used in predicting cognitive capacities because they do not show significant differences between Neanderthals and Anatomically Modern Humans. Finally, and despite cultural preferences being very hard to evaluate reliably in such old deposits, dismissing human dietary preferences – i.e. because a type of food tastes better than other, or because it adds value to the person feeding on it – seems imprudent and unrealistic.

CHAPTER 17

NEANDERTHAL RESOURCE USE AND SOCIAL BEHAVIOUR

17.1. Inside and Outside: Neanderthal use of space

Mobility strategy made its way into theoretical archaeology in the early 1980s, following from a series of papers on recent hunter-gatherers that synthesised how they moved in the landscape, and how such movements were predictable depending on habitat structure and resource availability in time and space (Binford 1976, 1980, 1982; Kelly 1983, 1992). Following from this, it became clear that, in light of mobility thinking, all kinds of archaeological assemblages could provide valuable information about landscape use, subsistence strategies, group size, social interaction and organisation, and several other behaviours of past human groups. A good example is the extensive work of Geneste (1985, 1988b, 1989, 1990, 1991) who related techno-economic studies with Neanderthal mobility in southern France; or Kuhn's research in the central Italian Mousterian (Kuhn 1991, 1992, 1995), exploring relationships between tool reduction and raw material transport with feeding strategies. These research approaches have the common goal of trying to understand patterns of mobility, which are consequences of decisions related to the physical and social environment (Kelly 1992, 1995). Therefore, mobility is intimately associated with a strategic displacement of a residential site to another location, in order to profit from natural resources – like food, water, raw materials, fuel –, and thus reduce human groups' risks derived from the discontinuous character of such biological resources (Ingold 2000). In other words, the resources available in a given space and time are not always the same due to several disruptions, whether due to environmental causes (e.g. natural fires, sea level rise, seasonal changes), or due to human exploitation (e.g. resource overexploitation, domestication, intentional fires). Hence, mobility is one of the strategies available to hunter-gatherers to balance the uneven distribution of resources in a given territory (Kelly 2013).

Humans' management of mobility and landscape can use different tactics. The processual approach, mainly inspired by Binford (1978, 1980, 1982, 1983), considered that a "foraging system" implied a low degree of planning and organisation. Therefore, foragers would be exploring the environment in the immediate vicinity of their residential site in a quite intensive manner, and would be highly dependent on seasonal resources. Conversely, a "logistical system" would reflect a more organised behaviour with complex planning in order not to deplete the natural resources surrounding a residential camp. Inevitably, such contrasting notions were transferred to the eternal debate opposing Neanderthals and Anatomical Modern Humans, assigning the foraging system to the former, and the logistical system to the latter (e.g. David & Enloe 1993; d'Errico et al 1998; Gamble 1998; Texier et al 1998, 2005; Roebroeks & Tuffreau 1999; Gaudzinski 2000a, b; Grayson & Delpech 2002; Costamagno et al 2006; Burke 2004, 2006; Rendu 2007).

Human fitness relies on biological factors, but also on cultural ones (Henrich & McElreath 2007), and the latter does not seem to be seriously considered in notions such as foraging and logistical systems. Despite human planning in natural resource management, or the lack of it, none of these notions actually contemplate the possibility of niche construction. Both foraging and logistical systems have as premises that the natural resources are the same; they are simply more or less preyed upon by humans. However, as noted by Thompson et al (2020), predators do have an actual impact on their ecosystem and can structure their environments whether by direct prey depletion, or by altering prey behaviour. At this stage, it has already been established that the Portuguese Last Interglacial Neanderthals had in place several tactics to overcome changes in resource abundance. They preferred to occupy ecotonal areas that allowed a broader diet, and they adapted to different types of ecosystems with a notable mention to the systematic use of aquatic resources for those occupying coastal positions. Understandably, such an adaptation to different prey and environments implied some adjustments in skillset and knowledge. Even though such behavioural adjustments can be hard to detect archaeologically, they are implicit in simple things such as the knowledge of the tides in order to gather molluscs and crabs more efficiently; or the awareness of bird, rabbit or tortoise behaviours in order to collect them with no need of complex technology; or the strategy of positioning a hunting party in a known ungulate migratory route; among others. These are knowledge acquisitions that would come naturally to humans that were embedded in their environments.

A growing research trend has been to focus attention on the controlled use of fire by recent and past hunter-gather communities in order to reconfigure resources within the landscape. Such a practice has been extensively studied within the Martu people from the Australian Western Desert who regularly design landscape fires to clear off large stands of hummock grass in order to increase efficiency for searching and tracking animals, with outstanding results. The resources acquired following from this burning strategy make up more than half of all hunting time, and provide nearly half of all the game people consume (Bird et al 2016; Bliege Bird et al 2020). Additionally, the latest research in northern Malawi has been demonstrating the ability of MSA people to restructure the vegetation composition of their catchment areas during the Late Pleistocene. These practices had impacts such as reducing the landscape overall biodiversity and decreasing the presence of fire-intolerant species. Conversely, it amplified predation opportunities and stimulated the growth of resources beneficial to human consumption (Thompson et al 2020). The archaeological record has plenty of examples in which humans alter their ecological balance, but the Malawi one implies the use of fire as a resource management tool thousands of years ago, demonstrating that human niche construction began in the Pleistocene.

Although no *in situ* hearths were found in Gruta da Figueira Brava, there is extensive evidence of controlled use of fire in order to process different foods on site. The absence of hearths is due to taphonomical processes rather than the absence of fire use. The main site occupation was located at Entrances 2-3 (Figs. 6.2, 6.3), where most of the archaeological stratigraphy was washed away due to Holocene sea transgression. Nonetheless, several burnt remains were recovered from the MIS-5 levels of Area F, with greater expression on stratigraphic units IH2-IH8, corresponding to occupation phase FB 4 (Fig. 17.2). Controlled use of fire was also observed in Gruta da Oliveira, where *in situ* hearths have been identified. In layer 14, for instance, one such hearth was associated with a cluster of lithic remains and burnt bone (Nabais 2011). Similarly, for the *in situ* hearths identified on layers 21 (on squares N-O/15-16) and 22 (only the edges of two hearts were observed on the N-R15>14 profile), the highest amount of burnt bone remains is coincident with the squares where the hearths were found (Fig. 17.3). Site formation processes had a more intensive impact on layers 23 to 25, since the accumulation of archaeological materials in these levels is mostly affected by the collapse of several roof blocks, hence implying the deposition of archaeological finds within the gaps of such fallen boulders. Nevertheless, controlled use of fire was already in place since MIS-11 (ca. 400 ka), as recently demonstrated for layer X in Gruta da Aroeira, which is part of the same network of karst caves as Gruta da Oliveira (Sanz et al, 2020), placing such evidence among the oldest in Europe. However, this evidence does not imply that Pleistocene Iberian humans manipulated their landscapes with fire. Human-environment interactions may shape human social organisation in ways that favour reduced mobility due to an increased control over resource abundance and location (e.g., via agriculture), and it has been suggested that the so-called “complex” hunter-gatherers (e.g. American Indians of NW North America) became societies of settled villagers thanks to storage and other mechanisms of optimising foraging returns (Testart, 1982).

Humans occupying Gruta da Figueira Brava and Gruta da Oliveira lived in dense patches of resources, and had many ways of overcoming resource changes. In such circumstances, and as argued by some researchers (e.g. Hamilton et al 2007; Ames 1994), hunter-gatherers do not show great disparity in resource yields in comparison to farmers or pastoralists. In the case of the Portuguese Neanderthals of the Last Interglacial, it is clear that the two caves studied here were used recurrently, although not on a permanent basis. Even though animals' seasonal behaviours can only be inferred from modern examples, these must have not been significantly different considering the similarity of today's climate with that from MIS-5 (see Chapters 5-7). Ungulates are easier to target when feeding on grassland, and ibex tend to climb down from their preferred mountainous terrain towards open land in winter and spring. These seasons are also the preferred ones for targeting adult rabbits and horses. However, the foals from Gruta da Figueira Brava were likely hunted in late summer and autumn, and red deer gather for reproduction in more open landscapes during the fall. Most terrestrial birds are residential and available throughout the year, but aquatic ones must have been taken in autumn and winter, matching the time of the year when mature pinecones were harvested at Gruta da Figueira Brava. Adult crabs migrate to shallow water for reproduction in the spring and summer, and can be easily caught when trapped on low tide pools.

This seasonality evidence shows that Gruta Figueira Brava was visited at different times of the year. At Gruta da Oliveira, the remains of carnivores, and the evidence of their impact on the bone assemblage (cf. the carnivore-damaged Neandertal tibial fragment; Trinkaus et al., 2007), demonstrate the alternating use of the site. A diverse range of not very abundant, non-human predators was identified via their skeletal parts and coprolites. Even though hyenas were not denning at Gruta da Oliveira during the time-span covered by the layers analysed for this study (which only yielded three coprolites), their presence was significant higher-up, in layers 11 and 13 (Fig. 17.1; Zilhão et al 2010a). In these layers, however, coprolites clustered in specific parts of the cave that do not match the more intensively human-used areas of the site, as demonstrated by the clustering of lithic material.

As for the size of the territory across which the Gruta da Oliveira Neanderthals procured their food, it can be approached via lithic raw material procurement studies. Neanderthals used red- and green-coloured fine-grained quartzites that could be found less than 5 km NE of the cave, implying a local provision manifested in the introduction of cobbles or large flakes, while flints came from distances between 10 and ≥ 20 km (Matias 2016). Similarly, carcass transportation seems to have been of short-distance, since the ungulates preferentially targeted (deer and ibex) were brought whole to the cave.

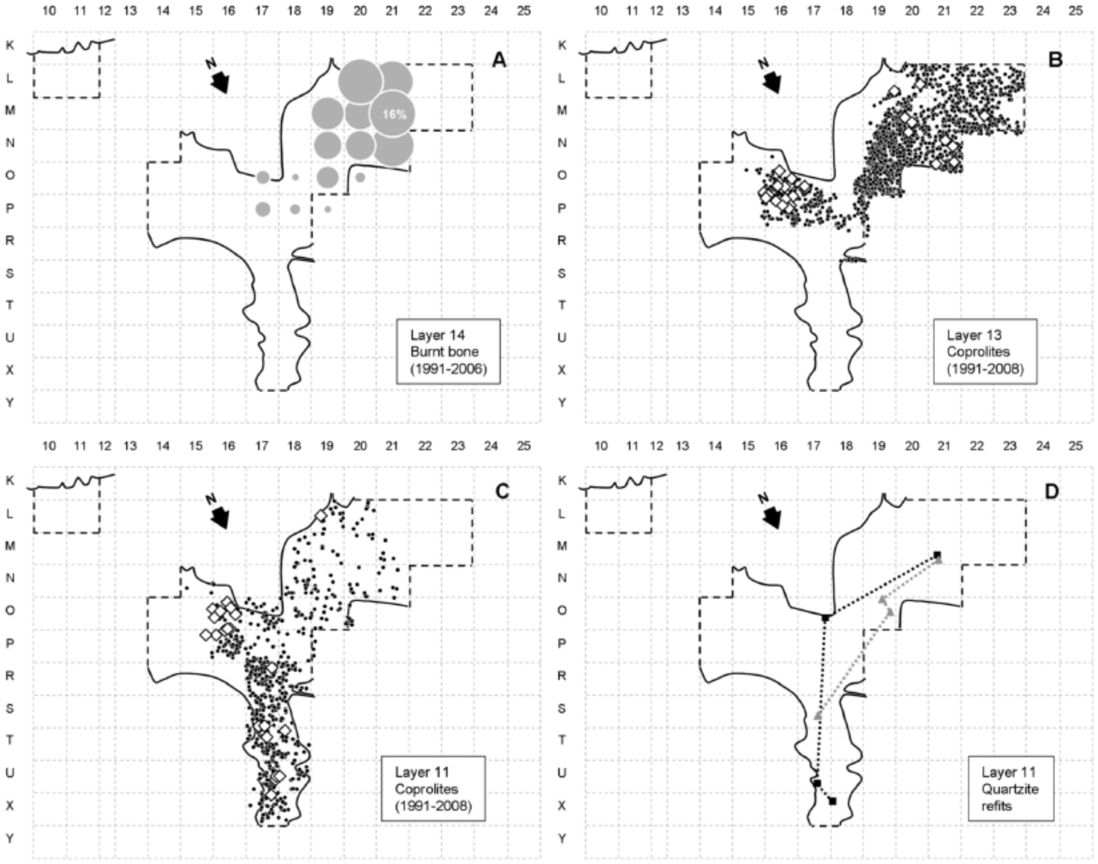


Fig. 17.1 – Image from Zilhão et al (2010a) showing aspects of Gruta da Oliveira distributions in some of the top layers of the sequence. A) Layer 14 burnt bones. B-C) Layers 13 and 11 piece-plotted coprolites (white diamonds) and lithics (black dots). D) Horizontal dispersion of two layer 11 refits.

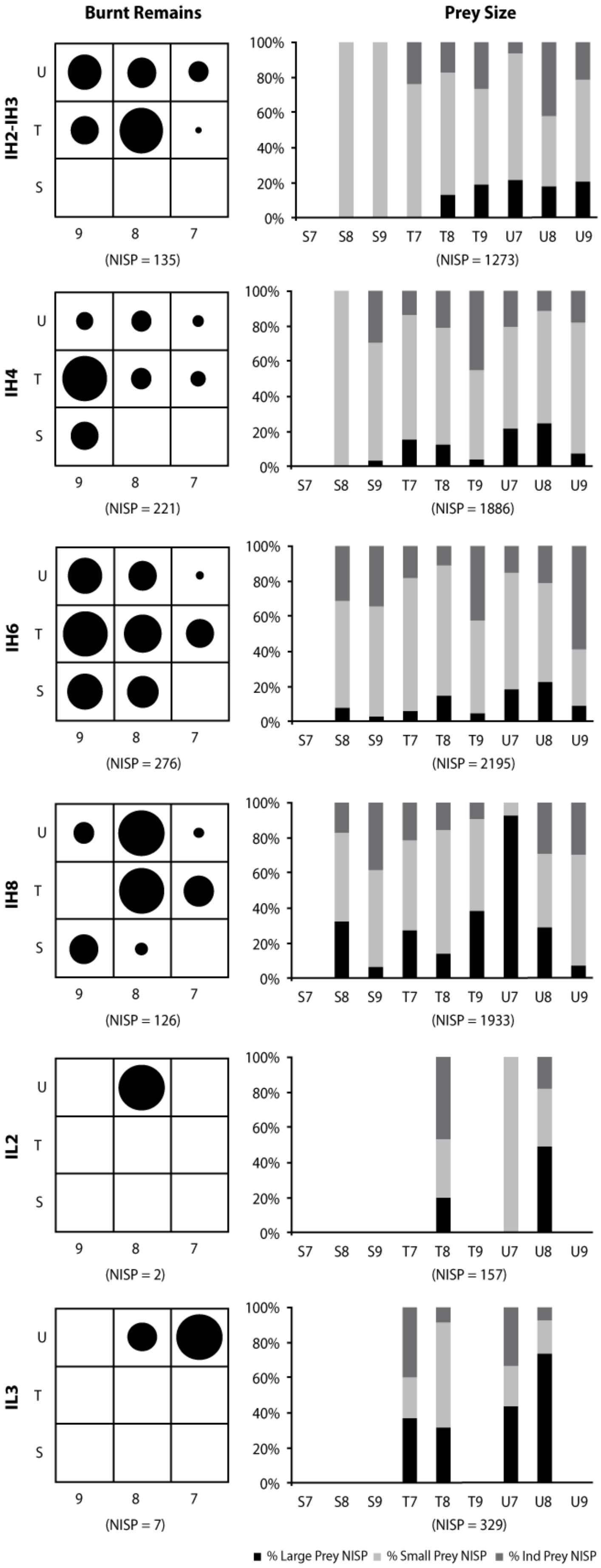


Fig. 17.2 – Gruta da Figueira Brava MIS-5 levels from Area F, corresponding to occupation phase FB 4 (units IH2 to IH6) and phase FB 3 (units IL2 and IL3).

Left column: distribution of the burnt faunal remains within the excavated squares in Area F (percentage per square of piece-plotted and sieved remains).

Right column: proportions of prey size remains distributed within the excavated squares in Area F (percentage per square of piece-plotted and sieved remains).

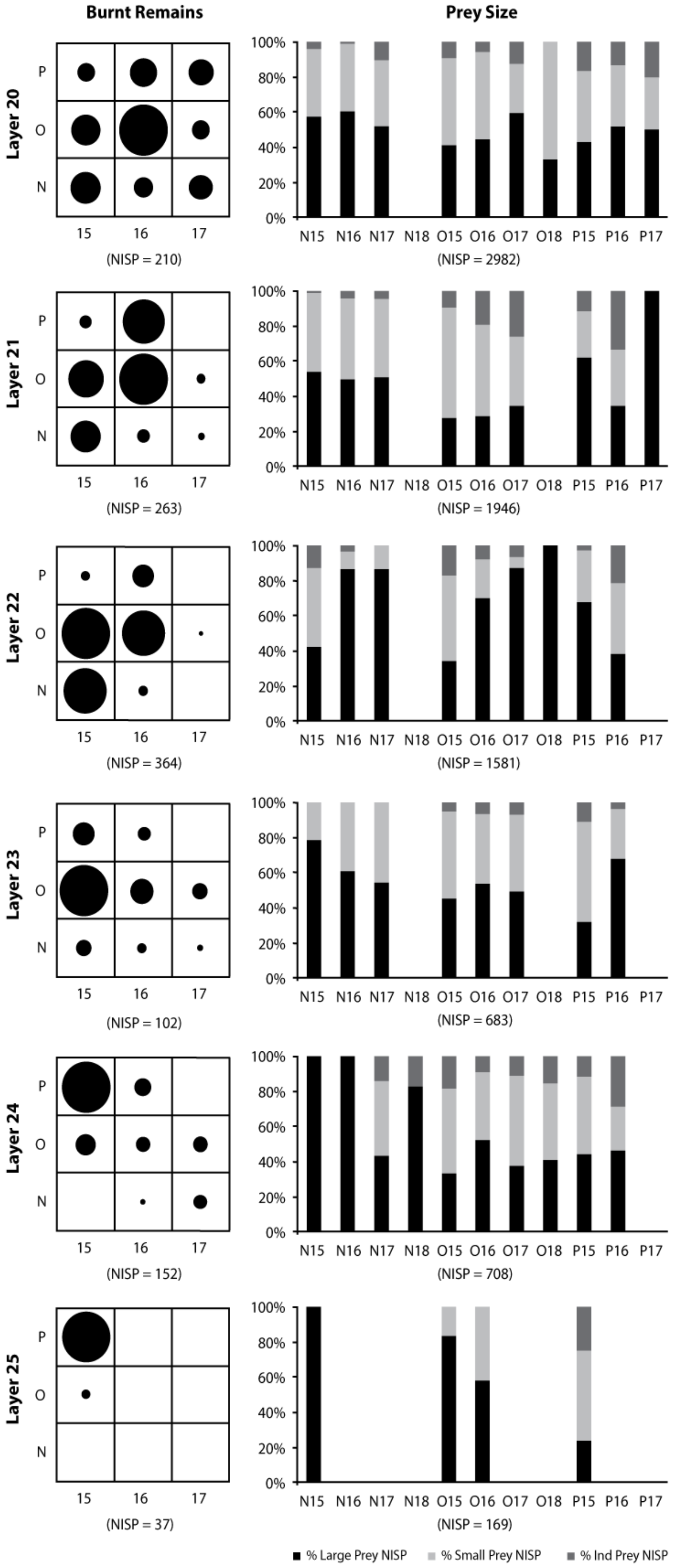


Fig. 17.3 – Gruta da Oliveira MIS-5 layers 20 to 25.

Left column: distribution of the burnt faunal remains within the excavated squares (percentage per square of piece-plotted and sieved remains).

Right column: proportions of prey size remains distributed within the excavated squares (percentage per square of piece-plotted and sieved remains).

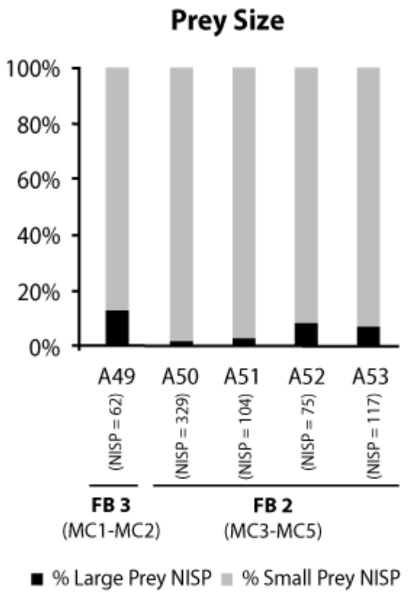


Fig. 17.4 – Gruta da Figueira Brava MIS-5 levels from Entrance 3. Proportions of prey size remains in excavated spit A49 (corresponding to occupation phase FB 3), and excavation spits A50--A53 (corresponding to occupation phase FB 2); percentage per square of piece-plotted and sieved remains.

The presence of hearths implies a degree of intra-site spatial organisation, which are one of the features that can be observed in archaeological sites following the criteria applied in many ethnoarcarchaeological studies (Yellen 1977; Binford 1983; O'Connell 1987; Gamble & Boismier 1991; Kroll & Price 1991 referred by Rosell et al 2012 and by Bargalló et al 2020). For instance, the !Kung Bushmen form groups organised in family units, each with a hut with a central hearth. Most domestic activities take place around the fireplace, including food processing and consumption, tool production and maintenance (Yellen 1977). In archaeological sites, such domestic activity areas are expected to present hearth-related accumulations, and a high number of knapping remains and animal processing products (Bargalló et al 2020). Around the hearths there is a communal activity area where other more social activities take place – like conversation and play, resting or sleeping –, or the distribution and sharing of food (Yellen 1977). Therefore, in an archaeological setting, such communal zones generate a relatively small amount of remains (Bargalló et al 2020).

These domestic and communal activity areas can be related to the "drop and toss zones" defined by Binford (1978, 1983): the drop zone is located near the hearth due to the *in situ* deposition of the remains resulting from the activities performed in its close proximity; and the toss zone relates to where remains were intentionally removed by humans away from the fireplace area. The drop zone is characterised by smaller remains, whereas the toss zone has mostly large size remains. These assumptions led Stevenson (1991) to consider that small remains are good indicators of *in situ* activities in a known occupational event, and such drop and toss model may explain the distribution of materials in several Middle Palaeolithic sites, like the examples given by Vaquero & Pastó (2001) for Tor Faraj, Kebara Cave, or Les Canalettes. Only specific activities – especially those that require more space, are dirty or generate more waste – are performed away from hearths and the domestic space, and are found in marginal zones around the perimeter of the camp (Yellen 1977). Such activity areas are generally associated with accumulation of a very particular type of remains related to a specific activity (Bargalló et al 2020).

If we follow the reasoning that a) drop zones imply the predominance of small remains, and toss zones of large remains, and b) small prey is mostly related to small size remains, and ungulates are mostly related to large remains; then we should consider the spatial distribution of such faunal evidence within the caves with a particular focus on Gruta da Oliveira's *in situ* hearths. The hearth found on layer 21 spread out through squares N-O/15-16. A consistent preferential accumulation of small prey remains (and consequently of smaller size bones) is found on squares O15 and O16. Squares N/15-17 also show an even representation of small and large prey remains (Fig. 17.3). The edges of the two other hearths at the base of layer 22 indicate they extended outwards, towards the non-excavated original entrance of the cave. They were mostly identified on profile, and a predominance of burnt bones is found in squares O15, N15 and O16, which are also the ones with highest evidence for small prey bones, except for square O16. The squares showing higher representation of large size prey are the ones further away from layer 22 hearths, such as squares N17, O17, O18 (Fig. 17.3). Consequently, and following the drop and toss model, the cave's main human activity area was concentrated within the southern part of the cave, probably facing the exterior during its MIS-5 occupation. Indeed, during the accumulation of layer 20 to 22, the cave's roof and walls showed structural stability – i.e. with no roof or boulder collapse events – and the site was used for human habitation. As for the remaining layers 23 to 25, they relate to depositions associated with roof collapses; and materials recovered from layers 26 and 27 are displaced (see section 7.2.1. for a more detailed stratigraphic description).

Such hints of spatial organisation are more difficult to glean from the Gruta da Figueira Brava data due to the finds not being in primary archaeological position as explained in section 6.3.1., and due to the absence of hearths. Within the MIS-5 levels of Area F, large prey remains increase with depth, showing progressive rise in rows U and T of the excavation grid. At Entrance 3, large prey frequency is most significant in unit MC1-MC2, but it does not exceed 13% (Fig. 17.4).

Considering that neither of the caves were excavated in their totality, it is difficult to identify all activity areas, but there is no doubt that some degree of spatial organisation was in place and that domestic fires played an important role. Such features lead to the proposition that both Gruta da Oliveira and Gruta da Figueira Brava were recurrently visited and used as residential sites. This is supported by the huge amount of archaeological finds recovered, associated with the extensive evidence for a broad resource base exploited at all seasons, the primary access to animal carcasses, the presence of whole carcasses or their best parts, the low levels of carnivore activity, as well as the evidence that most lithic raw materials were collected from the immediate vicinity (Sullivan 1992; Jones 1993; Lordeau 2011; Vaquero et al 2001, 2007, 2019; Rosell et al 2012). As noted by Blasco et al (2016b), home bases are efficient promoters of social behaviour since they provide a beneficial environment for inter-generation knowledge transmission through prolonged contact.

17.2. Social implications of Neanderthal subsistence strategies

Many of the changes in the Middle Palaeolithic record reflect the incorporation of new resources into the diet – e.g. consumption of small game, systematic use of marine resources –, reflecting adaptability to different ecological niches and the occupation of ecotonal areas with a demonstrated controlled use of fire. Thus, it should be expected to find associated changes in the dynamics between human groups, their social organisation and relationships. Zooarchaeology may not seem the most direct way to investigate such changes, but considerable importance has been given to subsistence strategies, which are understood as the material bases of social organisation (Díez & Rosell 1998; Stiner 2005).

In the past, a number of researchers argued that Neanderthal populations might have been composed of very small social units, widely spread across the landscape, with densities considerably lower than those of modern humans (e.g. Stringer & Gamble 1993; Soffer 1994; Mellars 1996; Finlayson 2004). Conversely, Ofek (2001) argued for a large number of individuals within a group similar to that of baboon troops, thus allowing better protection from predators. Henry (2012), however, noted that others interpreted the evidence of Neanderthal groups following a similar system to that of modern hunter-gatherers, whose demographics are frequently adjusted, with more or less people within a band depending on the circumstances. These tend to be mostly related with a site's carrying capacity and the availability of critical resources in its surroundings. Nonetheless, the dispersal or coalescence of individuals can also be motivated by social reasons. Humans move across social landscapes, and social factors can cause push and pull movements, such as seeking out for new places to live, or looking for new individuals to interact with, finding a mating partner, or moving out of confortable zones due to social tensions within a social unit or between groups (Whallon 2006; Kuhn et al 2016; Kuhn 2020). Social networks are important to modern hunter-gatherers since they can be sources of materials, mates, knowledge and information, and are meaningful ways of cultural transmission (Winterhalder 1996; Whallon 2006; Hamilton et al 2007; Fitzhugh et al 2011; Kuhn 2020).

Inferences about Neanderthal group size and inter-band relationships have been made. Based on calculations of floor area per person (around 3 m^2 per person) Hayden et al (1996) concluded that a single band would include 12 to 28 people. Group size calculations have also used resource catchment area of raw materials as a proxy, resulting in estimations of a maximum of 25 people per band (Burke 2006). Other researchers used the number of sleeping hearths on Neanderthal sites and the available space in between them. This was made for Abri Romaní, Tor Faraj, or Moldova I with estimations of 13 to 16, or perhaps even 20, people occupying these sites (Vallverdú et al 2010; Henry 2003; Henry et al 2004; Hayden 2012). At the Middle Palaeolithic bison kill site at Mauran, and based on the amount of meat available from a single bison kill, Farizy et al (1994) estimated a group size of up to 30 people. Therefore, several lines of archaeological research point towards local bands ranging between 12 and 30 people. Regardless of the exact numbers composing Neanderthal groups, these estimation approaches challenge those theories proposing very small or very large human groups. Additionally, these group estimations match the number of people in modern hunter-gatherer bands, which average 25 people per band (Kelly 1995; Hayden 2012). It is also possible that different Neanderthal groups could have met for specific events – such as communal hunting drives of large size ungulates, or to overcome difficulties like starvation, or enemy attacks by visiting allied bands – therefore generating a macroband network (Wiessner 1982; Hayden 1987, 2012). Based on ethnographic studies from the Australian Western Desert, one of the lowest population density territories in the world with no transport aids, band aggregations range between 130 and several hundred people (Tindale 1935; Bates 1938; Strehlow 1947; Gill 1968; Gould 1969). Such ethnographic inter-band congregations are, however, punctuated events. Most of the time, hunter-gatherers remain with their local group.

The occupation area that was preferably used by the Last Interglacial Neanderthals living in Gruta da Figueira Brava was located in the porch of Entrances 2-3, on the eastern part of the site. Most of its sedimentary deposit was eroded away due to Holocene sea level rise. Nonetheless, there are plenty of archaeological finds still embedded in the preserved breccia, and the excavation of the SEx trench recovered finds from the oldest occupations of the cave, phases FB 2 and FB 3 (Figs. 6.2 to 6.4). Currently, this space corresponds to an area of approximately 350 m² and, at the time of occupation, must have been significantly more, given the truncation of the cave by marine erosion and attendant cliff recession. Using the ratio of 3 m² per person of Hayden et al (1996), the site could have provided shelter for as much as 100 people. This number is perhaps unrealistically high, but nonetheless goes to show that the Gruta da Figueira Brava archaeological record does not correspond to occupation by a single individual, or a small number of individuals; rather, it is more likely to reflect use by a whole band or at least a group of families. For Gruta da Oliveira's layers 20-22, the levels reflecting an *in situ* occupation, the same rough calculation suggests that a minimum of four people could have stayed in the excavated squares N/O/P15-18 at any given time (Fig. 7.1). In fact, the total number of people occupying the site would have been larger, as the original occupation area was not excavated to its full extent. Furthermore, both sites show the presence of a wide variety of resources, amongst which several large prey (or even very large ungulates like the rhinoceros from Gruta da Oliveira), reflecting the need of a hunting party that would require the engagement of several individuals.

It is within this local band scope that zooarchaeological data can contribute to a better understanding of the group's organisation and dynamics. Shanidar Cave has been used as one example of a Neanderthal nuclear family group dynamic, with the presence of males, females and children in one site (Solecki 1995). However, Soffer (1994) argued for a non-nuclear Neanderthal organisation in which mothers and their offspring (and perhaps some few adult females) would form a co-residential unit separated from other all-men units. Nonetheless, the analysis of site structure and the in-site movement of tools related to food preparation in Tor Faraj, point to a cooperative and integrated group within a nuclear family organisation. In addition, Tor Faraj does not show any evidence of marked segregation or spatial clustering that would support an occupation based on gender specific units (Henry 2003, 2012).

Such a Neanderthal small family group organisation was also argued for by Finlayson (2004), who further highlighted the idea of limited within-group division of labour. This notion of a not pronounced, or even absent, division of labour has been theorised by several researchers (e.g. Kuhn &

Stiner 2006; Waguespack 2005; Goodman et al 1985; Estioko-Griffin & Griffin 1981; Geller 2017; Gero & Conkey 1991). This theory is often based on the premise that Neanderthals were heavily dependent on meat resources that implied the participation of all band members in communal hunts, not leaving much available time for other foraging activities, like gathering plant foods, which are generally associated with women and children. This idea would find support in the limited evidence of plant processing tools from Middle Palaeolithic sites. Conversely, during the Upper Palaeolithic, such an organisation would have shifted towards a gender-divided system, when there was a broadening of the diet, and increased plant processing, clothes tailoring and hide treating tasks (Kuhn & Stiner 2006; Naito et al 2016; Sistiaga et al 2014). These tasks are ethnographically demonstrated to be associated with women and children, whereas men would take the hunter role (Binford 1971; Kelly 2013; Bird 1999; Gurven & Hill, 2009). Nonetheless, several authors oppose such comparisons arguing that modern gender constructs do not reflect those in the past (Goodman et al 1985; Estioko-Griffin & Griffin 1981; Geller 2017; Gero & Conkey 1991; Arnold & Wicker 2001). This idea is fostered by evidence showing that both men and women take residence decisions within ethnographic hunter-gatherers (Dyble et al 2015). Likewise, discoveries like that of a Viking woman warrior (Hedenstierna-Jonson 2017) or the female hunters of the early Americas (Haas et al 2020), further challenge the uncritical comparisons made between modern and past hunter-gatherer gender-specific activities.

If modern ethnographic constructs are considered valid then the large amounts of small prey animals found in Gruta da Figueira Brava and Gruta da Oliveira would reflect women and children’s work. These are generally seen as more engaged in less prestigious food acquisition activities – like snaring, trapping or manual collection –, whereas men tend to fulfil the role of hunters, despite the high potential for failure in their ungulate hunting activities (Bliege Bird et al., 2001; Hurtado et al., 1992; Lee, 1968; Wadley, 1998). This does not mean, however, that (a) the human groups occupying the site were mostly composed by women and children, or instead, that (b) men also took part in the gathering of small prey. Although men generally take more risks in food acquisition than women and children (e.g. Binford 1971; Kelly 2013; Bird 1999), several North American indigenous groups show that men also carry out the hunting of small prey (see ethnographic examples of crab harvesting in Batdorf, 1990; Renker & Gunther, 1990; Speck & Dexter, 1948). The evidence for shellfish gathering in Gruta da Figueira Brava, especially during phase FB 4, when it was conducted in more dangerous areas of the shore (see section 14.3.2), supports the notion that the whole Neanderthal band took part in the provisioning of small game.

Regardless of gender roles in acquisition and how gender affected the provision of the animal protein acquired, who had priority access to it is also a question that needs to be asked. Murdock & Provost (1973) were among the first to explore these gender issues with a detailed study focused on specific tasks like tool production, the preparation of skins and food processing. Most of these activities can leave marks in the human skeleton (Villote et al 2011) while others produce unique non-masticatory tooth wear marks (e.g. Lukacs & Pastor 1988; Molnar 2008, 2011; Estalrrich & Rosas 2013, 2015). Cultural striations on Neanderthal dentition have been suggested to result from the use of the teeth as a third hand in many activities. Through the analysis of a total of 99 Neanderthal incisor and canine teeth from individuals of both sexes and different ages from El Sidrón (Spain), l'Hortus (France) and Spy (Belgium), Estalrrich & Rosas (2015) concluded that all teeth showed non-masticatory striations and dental chipping irrespective of gender and age. Therefore, the study supports the notion that all individuals performed tasks with their teeth and followed similar behaviours. The only gender-specific difference refers to the predominance of dental chipping on male maxillary teeth, following the pattern known from ethnographic studies (Bonfiglioli et al 2004; Scott & Winn 2011), whereas females show prevalence of chipping on their mandibular teeth. Therefore, despite some slight differences, the evidence suggests that some Neanderthal behaviours could have been performed differently than those observed ethnographically. In reality, a full understanding of how Neanderthals categorised gender is yet inaccessible to today’s researchers.

Part VII

Conclusion and Reflections

The conclusion of the study is composed by a summary of the research presented on the previous chapters, the drawing out of several potential new avenues that I would like to explore in future research, and some personal reflections and comments on Neanderthal research.

CHAPTER 18

CONCLUSIONS AND FUTURE RESEARCH

Although different archaeological materials, like stone tools and faunal remains, may appear deposited together, it does not mean that a direct association between the two exists, or that they were accumulated due to human activity. However, through a well-defined and explicit methodological approach, marked by attentive taphonomical analysis and detailed evaluation of the skeletal parts preserved on each studied site, it was possible to demonstrate that most faunal remains recovered from the MIS-5 levels of Gruta da Figueira Brava and Gruta da Oliveira were anthropogenic. They display very distinctive characteristics when compared to those accumulated by natural agency, the crab assemblage from Gruta da Figueira Brava being a paradigmatic example of such differences. Additionally, it was also possible to identify the presence of different carnivore species in both caves, mainly through the preservation of their skeletal parts and coprolites. Although it was established that carnivores have only sporadically visited the sites, they may have been responsible for part of the accumulation of some of the smaller vertebrates, e.g. part of the rabbit collections. The detailed skeletal representation analyses did not allow the identification of a single predator, and thus several carnivores may have accumulated the assemblages. Nonetheless, taphonomical analysis suggests that Neanderthals were among the principal accumulators of the small game found in the caves.

Once established that the accumulations were due to human agency, then meat-procurement strategies could be investigated, starting with an evaluation of the spatial and temporal framework, with implications for our understanding of the environment, fauna, flora, and geographical setting of the occupations. During the Last Interglacial, with a climate somewhat similar to present-day, the Iberian Peninsula was populated by a large variety of plant and animal species, therefore providing a large spectrum of available food resources. Neanderthals living in Portugal during that time took advantage of such rich landscapes, where they benefitted from hunting different size ungulates, from rhino to deer and ibex, as well as small game, like rabbits and tortoises. In coastal areas, like Gruta da Figueira Brava, the small game spectrum is broadened by the inclusion of aquatic remains, like fishes, crabs, mussels, clams and limpets; whereas in Gruta da Oliveira, in an inland setting, it was tortoises that had a paramount role in the Neanderthals' exploitation of small game. Large size individuals seem to have been preferentially targeted, indicating a predilection for adult animals, whether vertebrate or invertebrate. Although some odd juvenile and senile ungulates were also consumed, intensive exploitation of food resources was only detected among small game. This was particularly clear within the limpet assemblage from the MIS-5 levels of Gruta da Figueira Brava, which show a decrease in size over time, as well as a change in shape, reflecting the changing coastal dynamics over time otherwise implied by the diminished role of clams when the earlier FB 2 phase is compared with the later FB 3-FB 4 phases. At Gruta da Oliveira, the consumption of tortoises may have had an impact on the local population, as possibly suggested by the decrease in size and in number of remains from the older to the most recent occupations.

Such results agree with the growing corpus of Eurasian literature that challenges previous interpretations of Neanderthal dietary preferences. In the Mediterranean Basin, and the Iberian Peninsula in particular, it is clear that Neanderthals had a broad spectrum subsistence where all kinds of animal food resources were procured and included in the diet. Neanderthal exploitation encompassed all ungulate sizes (from very large, e.g., rhinoceros, to small, e.g. ibex) and extended to slow and quick moving small vertebrates (like tortoises and birds, respectively), and to several aquatic animals (aquatic birds, fishes, several molluscs and crabs). The present work has demonstrated that Neanderthals had primary access to the carcasses, which they butchered and that most of their prey was brought whole to the sites of residence with the exception of large and very large ungulates. Most animals were acquired locally, within the surroundings of the caves, and different resources were exploited according to the season of their availability. Both studied sites were occupied year-round, even though not in continuous manner, as implied by the presence of several species of carnivores that sporadically used the caves. Although not sedentary, Neanderthal groups living in Portugal exploited smaller territories than in northern Europe, as one would expect on purely paleoenvironmental and paleoecological grounds. Based on ethnographic analogy, it seems that no gender-specific division of labour was in place, at least regarding food acquisition. The evidence from elsewhere in Neandertal Eurasia reflects that both sexes participated in all meat-provision events, namely the collaborative hunting of large ungulates, and there is no evidence to question that such was also the case with the harvesting of shellfish and tortoise.

There is still work to be undertaken to fully understand Neanderthal subsistence behaviours, and there are a number of areas to which future research could be usefully directed. Firstly, it is fundamental to continue zooarchaeological analysis at the site of Gruta da Oliveira, in order to fully understand the Neanderthal occupation through the sequence, and not only in the basal layers.

Secondly, sclerochronological analysis of marine shells coupled with cementum increment analysis of mammal teeth would help to clarify the time(s) of the year of their procurement. Also of relevance are isotopic analyses of marine shells ($\delta^{18}O$) and vertebrate remains ($\delta^{13}C$, and $\delta^{15}N$), which have the potential to provide further insight on past environmental reconstructions. The combination of such information with mortality profiles will strengthen inferences about seasonality and a more comprehensive understanding of the integration of the cave sites within the structured annual rounds whereby individual bands of Neanderthal hunter-gatherers exploited their territories.

Thirdly, it would be most relevant to conduct a detailed spatial analysis combining GIS with lithic and faunal refits at Gruta da Oliveira. This will allow the analysis of intra-site spatial distribution of archaeological finds in order to reconstruct and identify any potential discrete activity areas, improving our knowledge of the types of occupation.

Fourthly, it is essential to expand the scope of this research in time and space. It would be interesting to include more Middle Palaeolithic sites from the Mediterranean Basin (and from Portugal in particular) ranging from MIS-5 to MIS-3 to provide a broader understanding of Neanderthal subsistence strategies, and how they varied with environmental conditions.

Finally, it is necessary to conduct zooarchaeological analysis on open-air sites, and other more temporarily occupied localities. Although this may implicate a slight modification to the database to incorporate other taphonomic agents that are unique to such sites, it would provide a more holistic understanding of Neanderthal subsistence behaviour across different types of occupation in the most diverse geographical settings.

CHAPTER 19

PERSONAL REFLECTION

The confirmation of certain qualities in Neanderthal subsistence strategies, like (1) their adaptability to the varied resources available in the landscape, (2) their broad spectrum diets, including (3) the hunting of small fast game, (4) the systematic use of marine resources, and (5) the recurrent use of the same sites at different times of the year, have been considered by many researchers as part of a modern behaviour package. However, such traits were clearly embedded within the Last Interglacial Neanderthal groups living in Portugal, thus offering a rich seam for debating the emergence of modernity. But based on the evidence provided, which is integrated in an emerging consensus arguing that differences between Neanderthals and Anatomical Modern Humans are not as marked as previously thought, my personal reflection is if one can still consider that there is such a thing as modern behaviour?

We tend to think of our current selves as highly developed beings. We are proud of our political system, our economy, our social structure, our religious (or non-religious) views. We are aware they are not perfect, but we tend to believe those are the most advanced systems in the world. The worrying part is that we expect everyone else to be like us, and to adapt to the world as we do. For centuries we attempted on colonising other territories and tried to make them think like us. Back in 1494, the Pope even divided the world in half so that the Portuguese and the Spanish could conquer and spread the seed of the most advanced Catholic way of living at the time. As recently as 1884-85, European countries divided Africa using a square ruler so that everyone could get their share. Obviously no African people were consulted, because it was all considered to be “for their own good”. Europeans were modernizing those countries and bringing them the fortune of technology, industry, democracy. This has been repeatedly shown in history throughout the world. Without going further into issues related with people’s identities, countries' artificial border divisions and many other concerns, I focus on the prejudice of evolution. Europeans clearly thought of themselves as more evolved and, therefore, had to impose their modernity. They completely ignored the natural rhythm of people and did not consider the possibility of their contentment living in their own systems. Because they did not have trains or electricity, they were considered inferior and less evolved, instead of simply being seen as differently adapted.

Maybe technology is different with computers, mobile phones and satellites, but the same applies today. Countries that believe that they are more politically advanced try to impose their governmental structure on countries where that system is not used. Economically wealthy countries that believe that their system is a success try to indoctrinate less wealthy countries on how to become richer. People that believe they are more evolved in their religious views try to evangelise others that have not yet seen "the light". Be it a country, tribe or individual, I wonder why is it not acceptable for one to develop at its own pace? Being differently adapted to the world does not mean being inferior; the same way that not having a mobile phone does not mean you are not able to communicate. Different adaptations of life in general do not have to be considered better or worse, or more or less evolved, simply because they are different. And I believe the same is true with our Neanderthal ancestors.

The results presented in this study demonstrated that Neanderthal populations did not have significant structural divergences from modern populations in food procurement. Additionally, there is a growing body of evidence showing that Neanderthals were endowed with symbolic thinking, which is revealed by the practice of personal ornamentation and burial, their controlled use of fire, complex lithic technology, extensive social networks and production of cave art, all of which have been considered hallmarks of modern humans. The zooarchaeological research at Gruta da Figueira Brava and Gruta da Oliveira has shown that such is also the case with their subsistence economy. Therefore, it is my strong belief that Neanderthals are still somehow subjected to an unconscious racist bias because, in fact, the evidence shows that they were humans just like us.

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Appendix A

Detailed methodological description of faunal analysis

VERTEBRATES' BONES

1. **Bone ID**
   Automatically generated number

PROVENIECE

2. **Site Name**

   Figueira Brava

   Oliveira

3. **Date**

   dd/mm/yyyy

4. **Number**

   Number attributed during excavation

5. **Square**

   Excavation grid composed by a letter and a number, eg. U7

6. **Quadrant**

   NE NO SE SO

7. **Spit**

   A0 – A*n*

FAUNAL IDENTIFICATION

8. **Group Size**

   Very Large Macro-mammals:

   larger than 1000 kg, eg. elephant, rhino

   Large Macro-mammals:

   from 300 kg to 1000 kg, eg. horse, auroch, bear

   Medium Macro-mammals:

   from 100 to 300 kg, eg. red deer and generic cervids

   Small Macro-mammals:

   from 20 to 100 kg, eg. boar, goat, wolf, hyena

>Very Small Macro-mammals:

indeterminate mammal remains impossible to attribute to one of the animal groups but clearly larger than 20 kg

Very Small Macro-mammals:

smaller than 20 kg, eg. lynx, fox, badger, weasel, lagomorphs

Birds:

all different size of birds

Indeterminate:

indeterminate remains impossible to attribute to one animal group; generally mammal remains heavily fragmented

9. Species

Species name, eg. *Equus caballus*

Family name: when not identifiable to species, eg. Equidae

Indeterminate: unidentifiable remains

10. Element

Skull:

Horn
Antler
Skull

Axial Skeleton:

Atlas
Axis
Cervical verteb
Toraxic verteb
Lumbar verteb
Caudal verteb
Vertebra indet
Rib
Sternal segment
Pelvis
Ilium
Ishium
Pubis
Sacrum

Front Limb:

Long bone
Flat bone
Scapula
Coracoid
Furcula
Humerus
Radius
Ulna
Metapodial
Metacarpal
Metacarpus 1
Metacarpus 2
Metacarpus 3
Metacarpus 4
Metacarpal 5
Carpometacarpus
Carpal
Radial
Intermediate
Ulnar
Accessory
First
Second
Third
Fourth

Hind Limb:

Femur
Patella
Tibia
Tibiotarsus
Fibula
Metatarsal
Metatarsus 1
Metatarsus 2
Metatarsus 3
Metatarsus 4
Metatarsus 5
Tarsometatarsus

Tarsal
Astragalus
Calcaneum
Central
1st Tarsal
2nd Tarsal
3rd Tarsal
4th Tarsal

Feet:

Sesamoid
Phalanx indet
Phalanx 1
Phalanx 2
Phalanx 3
Digit 2 Phalanx 1
Digit 2 Phalanx 2

Carapace (tortoise):

Shell indet
Carapace
Nuccal
Neural
Costal
Peripheral
Suprapygal
Pygal

Plastron (tortoise):

Plastron
Epiplastron
Entoplastron
Hyoplastron
Hypoplastron
Xiphiplastron

Other:

Coprolite

11. Portion of Element

Complete
Nearly Complete

Skull:

Rosette
Pedicel
Tip
Frontal
Nasal
Lacrimal
Zygomatic
Temporal
Parietal
Occipital
Occipital condyle

Pelvis:

Ilium
Ishium
Pubis
Acetabulum
Acetabulum + Ilium
Acetabulum + Ishium
Acetabulum + Illium + Ishium
Pelvis Frag

Long bone and rib:

Epiphysis indet
Epiphysis Prox
Epiphysis Dist
Shaft indet
Shaft Prox
Midshaft
Shaft Dist
Epiphysis indet + Shaft
Epiphysis Prox + Shaft
Epiphysis Dist + Shaft

12. Lateralisation

Left
Right
Indeterminate

13. Age/Fusion

Unfused
Fusing
Fused
Indeterminate

TAPHONOMY

14. Fracture Outline

None
Transverse
Longitudinal
Curved/V-shaped

15. Fracture Angle

None
Right
Oblique
Mixed

16. Fracture Edge

None
Smooth
Jagged

17. Fracture Time

None
Old
Recent

18. Fragment Size

0-1 cm
1-2 cm
2-3 cm
3-4 cm
4-5 cm
>5 cm
>10 cm
etc..

19. Fragment Length

0 – *n* mm

20. Fragment Width

0 – *n* mm

21. Percussion Marks

None
Pit
Notch
Impact Flake
Adhering Flake

22. Percussion Location

None
Portion of Element used

23. Percussion Side

None
Posterior
Anterior
Medial
Lateral
Ventral
Dorsal
Cranial
Caudal
Plantar
Palmar

24. Butchery Marks

None
Cut
Scrape
Chop

25. Striation Number

0 – *n*

26. Striation Distribution

None   Isolated   Clustered   Crossed

27. Striation Orientation

None   Oblique   Longitudinal   Transverse

28. Striation Delineation

None   Straight   Curved

29. Striation Location

None   Portion of Element used

30. Striation Side

None   Posterior   Anterior   Medial

Lateral   Ventral   Dorsal   Cranial

Caudal   Plantar   Palmar

31. Burning

None   Brown   Black   Grey

White

32. Burning Location

None   Complete   One side   Interior

Exterior   Posterior   Anterior   Medial

Lateral   Ventral   Dorsal   Cranial

Caudal   Plantar   Palmar

33. Carnivore Marks

None   Puncture   Pit   Score

Crenulation   Digestion

34. Carnivore Number

0 – *n*

35. Carnivore Location

None   Portion of Element used

36. Pit Length

0 – *n* mm

37. Pit Breadth

0 – *n* mm

38. Rodent

None   Yes

39. Rodent Location

None Portion of Element used

40. Other Modification

None Manganese Root etching

OTHER INFO

41. Photo

None Yes Taken

42. Comments

Additional observations

43. Measurements

Measurements in mm following von den Driesch (1976) and Nabais (2010 unpublished MSc dissertation)

VERTEBRATES' TEETH

1. **Bone ID**
   Automatically generated number

PROVENIECE

2. **Site Name**

   Figueira Brava

   Oliveira

3. **Date**

   dd/mm/yyyy

4. **Number**

   Number attributed during excavation

5. **Square**

   Excavation grid composed by a letter and a number, eg. U7

6. **Quadrant**

   NE NO SE SO

7. **Spit**

   A0 – A*n*

FAUNAL IDENTIFICATION

8. **Group Size**

   Very Large Macro-mammals:

   larger than 1000 kg, eg. elephant, rhino

   Large Macro-mammals:

   from 300 kg to 1000 kg, eg. horse, auroch, bear

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   from 100 to 300 kg, eg. red deer and generic cervids

   Small Macro-mammals:

   from 20 to 100 kg, eg. boar, goat, wolf, hyena

>Very Small Macro-mammals:

indeterminate mammal remains impossible to attribute to one of the animal groups but clearly larger than 20 kg

Very Small Macro-mammals:

smaller than 20 kg, eg. lynx, fox, badger, weasel, lagomorphs

Indeterminate:

indeterminate remains impossible to attribute to one animal group; generally mammal remains heavily fragmented

9. Species

Species name, eg. *Equus caballus*

Family name: when not identifiable to species, eg. Equidae

Diet group: when not identifiable to species and/or family, eg. Herbivore

Indeterminate: unidentifiable remains

10. Element

Maxilla	Mandible	Tooth frag	Tooth maxillar
Tooth mandibular			

11. Portion of Element

Complete	Nearly Complete	Shaft indet	Diastema
Teeth area	Alveolus	Enamel	Roots
Enamel + Roots	Incisor	dI1	dI2
dI3	I1	I2	I3
Canine	dCanine	Premolar	Molar
Premolar/Molar	dP2	dP3	dP4
P1	P2	P3	P4
M1	M2	M3	

When more than one tooth present, teeth are listed, eg. P2, P3, P4, M1

12. Lateralisation

Left	Right	Left, Right	Indeterminate

13. Age/Wear

Juvenile	Adult	Senile	Payne A – I
Grant A – P	Indeterminate		

TAPHONOMY

14. **Fracture Outline**

    None
    Transverse
    Longitudinal
    Curved/V-shaped

15. **Fracture Angle**

    None
    Right
    Oblique
    Mixed

16. **Fracture Edge**

    None
    Smooth
    Jagged

17. **Fracture Time**

    None
    Old
    Recent

18. **Fragment Size**

    0-1 cm
    1-2 cm
    2-3 cm
    3-4 cm
    4-5 cm
    >5 cm
    >10 cm
    etc..

19. **Fragment Length**

    0 – *n* mm

20. **Fragment Width**

    0 – *n* mm

21. **Percussion Marks**

    None
    Pit
    Notch
    Impact Flake
    Adhering Flake

22. **Percussion Location**

    None
    Complete
    Nearly Complete
    One side
    Shaft indet
    Diastema
    Below teeth
    Alveolus
    Enamel
    Roots
    Enamel + Roots

23. **Percussion Side**

    None
    Posterior
    Anterior
    Mesial
    Distal
    Lingual
    Buccal
    Occusal
    Lateral

24. **Butchery Marks**

    None
    Cut
    Scrape
    Chop

25. **Striation Number**

    0 – *n*

26. **Striation Distribution**

    None
    Isolated
    Clustered
    Crossed

27. **Striation Orientation**

    None
    Oblique
    Longitudinal
    Transverse

28. Striation Delineation

None	Straight	Curved

29. Striation Location

None	Complete	Nearly Complete	One side
Shaft indet	Diastema	Below teeth	Alveolus
Enamel	Roots	Enamel + Roots	

30. Striation Side

None	Posterior	Anterior	Mesial
Distal	Lingual	Buccal	Occusal
Lateral			

31. Burning

None	Brown	Black	Grey
White			

32. Burning Location

None	Complete	Nearly Complete	One side
Shaft indet	Diastema	Below teeth	Alveolus
Enamel	Roots	Enamel + Roots	

33. Carnivore Marks

None	Puncture	Pit	Score
Crenulation	Digestion		

34. Carnivore Number

0 – *n*

35. Carnivore Location

None	Complete	Nearly Complete	One side
Shaft indet	Diastema	Below teeth	Alveolus
Enamel	Roots	Enamel + Roots	

36. Pit Length

0 – *n* mm

37. Pit Breadth

0 – *n* mm

38. Rodent

None	Yes

39. Rodent Location

None	Complete	Nearly Complete	One side

Shaft indet Diastema Below teeth Alveolus

Enamel Roots Enamel + Roots

40. Other Modification

None Manganese Root etching

OTHER INFO

41. Photo

None Yes Taken

42. Comments

Additional observations

43. Measurements

Measurements in mm following von den Driesch (1976)

INVERTEBRATES' EXOSKELETON

1. **Shell ID**
   Automatically generated number

PROVENIECE

2. **Site Name**

   Figueira Brava

   Oliveira

3. **Date**

   dd/mm/yyyy

4. **Number**

   Number attributed during excavation

5. **Square**

   Excavation grid composed by a letter and a number, eg. U7

6. **Quadrant**

   NE NO SE SO

7. **Spit**

   A0 – A*n*

FAUNAL IDENTIFICATION

8. **Group Size**

   Mollusc:

   bivalves and gastropods (both marine and terrestrial)

   Crustacean:

   crabs and barnacles

   Echinoderm:

   sea urchins

9. **Class**

Gastropoda

Bivalvia

Malacostraca

Maxillipoda

Echinoidea

10. Species

Species name, eg. *Pecten maximus*

Family name: when not identifiable to species, eg. Pectinidae

Indeterminate: unidentifiable remains

11. Element

Gastropoda:

- Body

Bivalvia:

- Valve

Malacostraca:

- Mandible
- Carapace
- Propodus
- Dactylopodus
- Claw
- Carpus claw
- Dactylus
- Leg
- Indeterminate

Maxillipoda:

- Test
- Plate

Echinoidea:

- Test
- Hemipyramid
- Epiphysis
- Compass
- Rotula
- Spine

12. Portion of Element

Gastropoda:

- Body Complete
- Body Fragment
- Body Whorl
- Columella
- Apical
- Apical-Umbilicus
- Fragment

Bivalvia:

- Valve Complete
- Valve Fragment
- Umbo Complete
- Umbo Anterior
- Umbo Posterior
- Umbo Fragment
- Fragment

Malacostraca:

Complete	Nearly Complete
Proximal end	Distal end
Articulation dorsal	Articulation ventral
Articulation posterior	Articulation indet
Spike	Fragment

Maxillipoda:

Complete	Nearly Complete
Fragment	

Echinoidea:

Complete	Nearly Complete
Fragment	

13. Lateralisation

Left	Right	Indeterminate

14. Type of Claw (for crabs only)

Cutter	Crusher	Indeterminate

TAPHONOMY

15. Fracture Outline

None	Transverse	Longitudinal	Curved/V-shaped

16. Fracture Angle

None	Right	Oblique	Mixed

17. Fracture Time

None	Old	Recent

18. Fragment Size

0-1 cm	1-2 cm	2-3 cm	3-4 cm
4-5 cm	>5 cm	>10 cm	etc.

19. Abrasion

None	Dorsal	Ventral	Dorsal-Ventral
Anterior	Posterior		

20. Encrustation

None Dorsal Ventral Dorsal-Ventral

Anterior Posterior

21. Dissolution

None Dorsal Ventral Dorsal-Ventral

Anterior Posterior

22. Perforation

None Dorsal Ventral Dorsal-Ventral

Anterior Posterior

23. Perforation Number

0 - *n*

24. Pit Maximum Length

0 – *n* mm

25. Percussion Marks

None Pit Notch

26. Percussion Location

None Dorsal Ventral Dorsal-Ventral

Anterior Posterior

27. Butchery Marks

None Cut Scrape Chop

28. Butchery Location

None Dorsal Ventral Dorsal-Ventral

Anterior Posterior

29. Striation Number

0 – *n*

30. Striation Distribution

None Isolated Clustered Crossed

31. Striation Orientation

None Oblique Longitudinal Transverse

32. Striation Delineation

None Straight Curved

33. Burning

None Brown Black Grey

White

34. Burning Location

None
Dorsal
Ventral
Dorsal-Ventral

Anterior
Posterior

35. Carnivore Marks

None
Puncture
Pit
Score

36. Carnivore Location

None
Dorsal
Ventral
Dorsal-Ventral

Anterior
Posterior

37. Carnivore Distribution

None
Isolated
Clustered
Crossed

38. Carnivore Number

0 – *n*

39. Pit Length

0 – *n* mm

40. Pit Breadth

0 – *n* mm

41. Other Modification

None
Manganese
Peeling
Sediment filling

OTHER INFO

42. Photo

None
Yes
Taken

43. Comments

Additional observations

44. Measurements

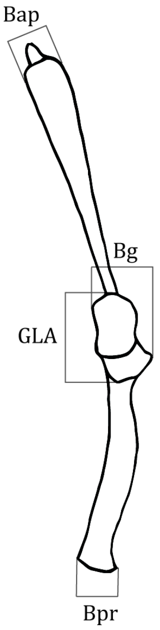
Measurements in mm following Zugasti (2009) for molluscs, Catherine Dupont (2015: pers. comm.) for crabs and Caroline Mougne (2015: pers. comm.) for sea urchins.

Appendix B

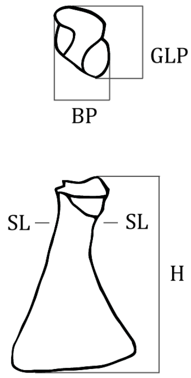
Testudo hermanni measurements from left side elements

Bap = greatest length of the acromion process.
Bcp = greatest breadth of the coranoid process.
BD = greatest breadth of the distal end.
Bg = greatest breadth of the glenoid cavity.
BP = greatest breadth of the proximal end.
BPh = greatest breadth of the head.
Bpr = greatest breadth of the procoracoid.
Dh = greatest depth of the head.
GL = greatest length.
GLA = greatest length of the articulation.
GLh = greatest length from the head.
GLl = greatest length of the lateral side.
GLm = greatest length of medial side.
GLP = greatest length of the proximal end.
H = height of the spine.
SD = smallest breadth of the diaphysis.
SL = smallest length of the neck.

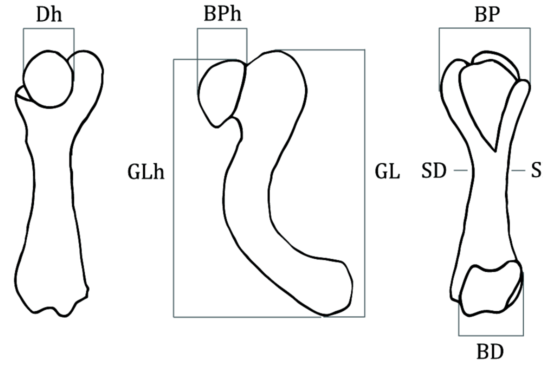
SCAPULA



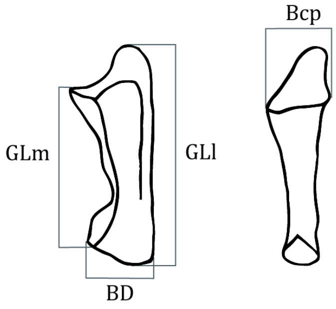
CORACOID



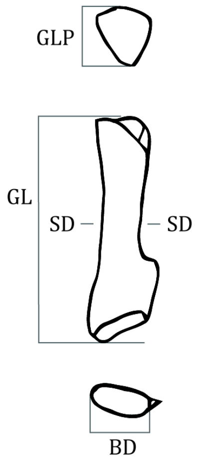
HUMERUS



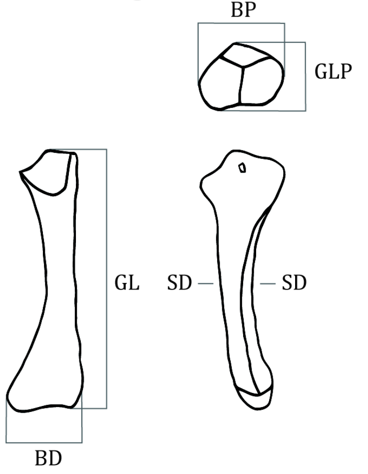
ULNA



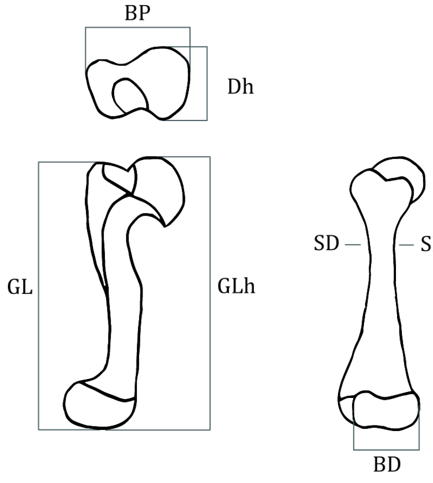
RADIUS



ILIUM



FEMUR



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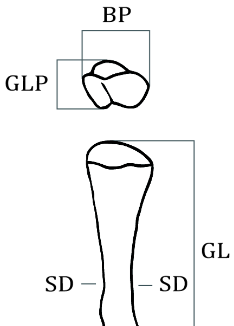
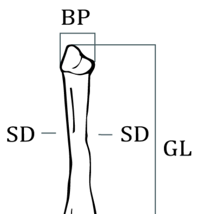


FIBULA



Appendix C

Testudo hermanni long bone measurements from Gruta da Oliveira layers 20 to 27

SCAPULA

Date	Number	Square	Spit	Layer	Bap	Bg	Bpr	GLA
07/06/2010	Limpeza	Limpeza	A66	20	.	8.58	.	11.78
27/05/2010	N16-G-205	N16	A66	20	4.61	.	.	.
27/05/2010	N16-G-206	N16	A66	20	4.77	.	.	.
13/07/2009	N17-G-390	N17	A66	20	.	7.4	6.62	11.72
13/07/2009	N17-G-391	N17	A66	20	.	6.37	5.58	10.18
31/05/2010	O16-860	O16	A66	20	.	6.53	.	10.05
04/06/2010	O16-G-1164	O16	A66	20	.	7.3	.	10.09
04/06/2010	O16-G-1165	O16	A66	20	.	7.53	.	12.39
2010	O16-G-1233	O16	A66	20	.	9.44	.	12.94
2010	O16-G-1235	O16	A66	20	.	.	.	11.67
01/06/2010	O16-G-1313	O16	A66	20	.	.	.	12.18
31/05/2010	O16-G-957	O16	A66	20	.	6.79	.	12.28
21/06/2010	O15-G-696	O15	A67	21	.	7.47	.	11.03
21/06/2010	O15-G-697	O15	A67	21	.	.	6.83	.
21/06/2010	O15-G-700	O15	A67	21	.	.	8.16	.
18/06/2010	O15-G-738	O15	A67	21	.	7.95	.	12.27
18/06/2010	O15-G-739	O15	A67	21	.	.	8.44	.
18/06/2010	O15-G-740	O15	A67	21	.	6.77	.	11.72
18/06/2010	O15-G-741	O15	A67	21	.	7.14	.	13.45
08/06/2010	O16-G-1576	O16	A67	21	.	6.37	.	12.17
08/06/2010	O16-G-1577	O16	A67	21	.	6.18	.	9.21
14/06/2010	O16-G-1851	O16	A67	21	.	9.09	.	12.27
28/06/2010	O16-1315	O16	A68	22	.	7.17	.	12.23
01/07/2010	O16-G-1754	O16	A68	22	.	7.64	.	10.61
01/07/2010	P16-G-392	P16	A68	22	.	9.17	.	12.8
08/06/2011	O15-G-751	O15	A69	23	.	7.75	.	11.94
08/06/2011	P15-G-315	P15	A69	23	.	11.3	.	7.5
22/06/2011	O16-G-2005	O16	A70	24	.	.	7.5	.
22/06/2011	O16-G-2006	O16	A70	24	7.88	.	.	.
28/06/2011	P15-G-271	P15	A70	24	.	.	.	11.29
22/06/2011	P15-G-291	P15	A70	24	.	9.24	.	12.1
14/06/2012	O16-G-1785	O16	A73	25	.	9.18	.	12.32
1990	Cone Moustierense	Zona 2	.	26	.	8.81	7.78	12.23
1990	Cone Moustierense	Zona 1	.	26	.	6.95	.	11.04
13/07/2010	Cone Moustierense	Limpeza superfície	.	26	.	9.59	6.64	13.26
20/06/2012	O16-1875-12	O16	A74	26	.	8.59	.	12.86
22/06/2012	O16-G-1992	O16	A74	26	.	9.93	.	.
22/06/2012	O16-G-1993	O16	A74	26	.	.	7.72	.
20/06/2012	O17-1413	O17	A74	26	.	6.91	.	11.22
26/06/2012	P16-G-485	P16	A74	26	.	9.41	.	14.11
05/07/2012	R18-G-15	R18	A76	27	.	7.17	5.59	10.08

CORACOID

Date	Number	Square	Spit	Layer	BP	GLP	H	SL
02/06/2010	O16-G-1387	O16	A66	20	.	.	.	4.75
14/06/2010	O15-G-1013	O15	A67	21	8.21	6.96	.	.
21/06/2010	O15-G-1079	O15	A67	21	.	.	.	5.43
14/06/2010	O15-G-626	O15	A67	21	6.19	7.54	.	.
14/06/2010	O16-G-1852	O16	A67	21	5.03	6.25	.	4.5
14/06/2010	O16-G-1853	O16	A67	21	6.27	6.98	21.32	4.53
01/07/2010	O16-G-1757	O16	A68	22	5.6	6.58	.	4.11
30/06/2010	P16-G-418	P16	A68	22	7.32	8.22	.	5.3
30/06/2010	P16-G-419	P16	A68	22	7.04	6.74	21.38	5.71
14/06/2011	O16-G-2004	O16	A69	23	4.61	4.41	.	3.18
22/06/2011	P15-G-306	P15	A70	24	6.9	6.44	.	.
30/06/2011	P15-G-308	P15	A70	24	7.15	8.16	23.24	4.85
20/06/2012	O17-G-459	O17	A76	27	6.92	6.89	.	.

HUMERUS

Date	Number	Square	Spit	Layer	BD	BP	BPh	Dh	GL	GLh
11/07/2009	N17-45	N17	A66	20	.	.	.	.	.	.
11/07/2009	N17-G-408	N17	A66	20	.	.	10.63	.	.	.
03/06/2010	O15-G-371	O15	A66	20	12.69	.	.	.	.	.
03/06/2010	O16-1020	O16	A66	20	.	.	7.69	8.74	.	41.32
03/06/2010	O16-1024	O16	A66	20	11.71	.	.	.	.	.
31/05/2010	O16-895	O16	A66	20	11.83	.	9.52	9.25	49.57	42.87
31/05/2010	O16-947	O16	A66	20	14.92	15.52	10.46	11.3	49.07	48.21
01/06/2010	O16-G-1307	O16	A66	20	.	.	7.9	10.62	.	.
01/06/2010	O16-G-1308	O16	A66	20	11.76	.	.	.	.	.
03/06/2010	O16-G-1345	O16	A66	20	.	.	9.14	8.68	.	.
14/06/2010	O15-G-621	O15	A67	21	12.01	.	.	.	.	.
14/06/2010	O15-G-622	O15	A67	21	.	16.97	12.18	9.66	.	.
14/06/2010	O15-G-623	O15	A67	21	.	12.52	10.09	.	.	.
18/06/2010	O15-G-736	O15	A67	21	.	.	8.97	8.99	.	.
18/06/2010	O15-G-737	O15	A67	21	.	14.59	12.38	10.7	.	.
08/06/2010	O16-1048	O16	A67	21	.	.	7.29	7.39	.	.
18/06/2010	O16-1195	O16	A67	21	.	11.87	9.83	8.93	.	.
17/06/2010	O16-G-1673	O16	A67	21	.	11.66	7.3	8	.	.
17/06/2010	O16-G-1674	O16	A67	21	.	.	8.37	9.26	.	.
17/06/2010	P15-425	P15	A67	21	.	.	.	.	.	.
02/07/2010	O15-G-509	O15	A68	22	.	.	9.27	9.93	.	.
09/06/2011	O15-997	O15	A69	23	.	.	9.12	9.02	.	.
09/06/2011	P16-G-489	P16	A69	23	13.02	.	.	.	.	.
30/06/2011	O15-1079	O15	A70	24	12.72	.	.	.	.	.
22/06/2011	O17/18-G-1	O17/18	A70	24	.	.	.	.	.	.
22/06/2011	P15-G-290	P15	A70	24	12.38	.	.	.	.	.
15/06/2012	O16-1863	O16	A73	25	.	.	.	.	.	.
1990	Cone Moustierense	Zona 1+2	.	26	.	.	.	.	.	.
13/07/2010	Cone Moustierense	Limpeza superfície	.	26	13.51	.	.	.	.	.
21/06/2012	O16-1893	O16	A74	26	.	.	.	.	.	.
22/06/2012	O16-G-1989	O16	A74	26	.	15.52	12.56	10.3	.	.
22/06/2012	O16-G-1990	O16	A74	26	13.58	.	.	.	.	.
26/06/2012	P16-928	P16	A74	26	14.08	.	.	.	.	.
26/06/2012	P16-G-486	P16	A74	26	.	.	.	7.6	.	.
25/06/2012	P17-G-139	P17	A74	26	9.9	.	.	.	.	.
02/07/2012	R16-526	R16	A75	26	.	16.31	10.64	10.22	.	.
20/06/2012	O17-G-462	O17	A76	27	14.13	.	.	.	.	.
06/07/2012	S18-120	S18	A76	27	.	14.26	10.8	9.59	.	.

RADIUS

Date	Number	Square	Spit	Layer	BD	GL	GLP	SD
1990	Cone Moustierense	Zona 2	.	26	7.26	26.97	6.54	3.35
07/06/2010	Limpeza	Limpeza	A66	20	.	.	6.52	3.94
05/07/2010	O15-G-421	O15	A68	22	7.98	24.89	6.98	3.01
14/06/2010	O16-G-1856	O16	A67	21	8.24	24.46	6.9	3.9
22/06/2012	O16-G-1995	O16	A74	26	7.77	24.89	6.18	3.4
22/06/2012	O16-G-1996	O16	A74	26	8.13	.	.	3.35

ULNA

Date	Number	Square	Spit	Layer	Bcp	BD	GLl	GLm
1990	Cone Moustierense	Zona 1	.	26	.	8.5	27.63	22.17
11/07/2009	N17-G-300	N17	A66	20	.	9.02	.	.
02/07/2010	O15-G-510	O15	A68	22	.	7.91	23.96	18.45
21/06/2010	O15-G-698	O15	A67	21	7	7.43	20.15	17.77
21/06/2010	O15-G-699	O15	A67	21	7.26	.	.	.
18/06/2010	O15-G-745	O15	A67	21	.	7.34	.	.
08/06/2011	O15-G-752	O15	A69	23	.	10.11	.	21.35
2010	O16-G-1228	O16	A66	20	8.07	.	.	.
01/06/2010	O16-G-1309	O16	A66	20	7.63	7.75	24.38	18.58
14/06/2010	O16-G-1855	O16	A67	21	7.82	7.63	.	19.89
10/06/2011	O16-G-2002	O16	A69	23	5.62	6.58	17.76	14.65
02/07/2012	O16-G-2018	O16	A75	26	.	8.34	.	21.49
31/05/2010	O16-G-2593	O16	A66	20	.	8.86	.	.
20/06/2011	O16/17-G-20	O16/17	A70	24	7.92	.	.	.
12/06/2012	O17-G-263	O17	A74	26	.	7.99	23.9	20.74
15/06/2010	P16-G-391	P16	A67	21	.	8.71	.	.
30/06/2010	P16-G-420	P16	A68	22	7.49	8.17	24.51	18.77
06/07/2012	S19-G-5	S19	A76	27	7.84	9.66	.	20.71

ILIUM

Date	Number	Square	Spit	Layer	BP	GL	GLP	SD
14/06/2010	O15-586	O15	A67	21	16.05	.	.	6.89
14/06/2010	O15-G-625	O15	A67	21	16.78	11	.	.
18/06/2010	O15-G-744	O15	A67	21	14.1	.	9.52	.
02/06/2010	O16-G-1386	O16	A66	20	12.92	.	10.45	5.23
12/06/2012	O17-G-262	O17	A74	26	.	.	.	4.53
20/06/2011	P15-G-229	P15	A70	24	.	.	.	4.31

ISCHIUM

Date	Number	Square	Spit	Layer	GL
23/06/2010	O15-G-1358	O15	A68	22	.
2010	O16-G-1229	O16	A66	20	.
22/06/2012	O16-G-1997	O16	A74	26	30.19
26/06/2012	P16-G-487	P16	A74	26	.

PUBIS

Date	Number	Square	Spit	Layer	BP
14/06/2010	O15-G-1014	O15	A67	21	13.19
14/06/2010	O15-G-1015	O15	A67	21	10.77
03/06/2010	O16-G-1346	O16	A66	20	.
15/06/2010	O16-G-1705	O16	A67	21	.
28/06/2011	P15-G-272	P15	A70	24	.

FEMUR

Date	Number	Square	Spit	Layer	BD	BP	Dh	GL	GLh	SD
10/07/2009	N17-G-387	N17	A66	20	.	.	.	.	.	4.72
02/06/2010	O16-1000-2	O16	A66	20	.	13.9	.	.	.	5.98
14/06/2010	O16-1119	O16	A67	21	.	.	.	.	.	5.41
2010	O16-G-1230	O16	A66	20	12.49	16.43	11.02	39.04	42.11	6.17
14/06/2010	O16-G-1857	O16	A67	21	.	.	9.05	.	.	.
22/06/2012	O16-G-1985	O16	A74	26	.	.	.	.	.	4.91
22/06/2012	O16-G-1987	O16	A74	26	.	.	.	.	.	4.81
22/06/2012	O16-G-1988	O16	A74	26	.	.	.	.	.	6.23
02/07/2012	O16-G-2017	O16	A75	26	.	20.03	12.88	.	.	.
15/06/2011	O16-G-2023	O16	A69	23	11.37	.	.	.	.	4.37
20/06/2011	O16/17-G-19	O16/17	A70	24	.	.	11.07	.	.	5.44
20/06/2011	O16/17-G-2	O16/17	A70	24	.	.	.	.	.	5
21/06/2011	O18-G-18	O18	A70	24	10.75	.	.	.	.	.
29/06/2012	R16-G-162	R16	A75	26	.	.	10.42	.	.	.

TIBIA

Date	Number	Square	Spit	Layer	BD	BP	GL	GLP	SD
18/06/2010	O15-621	O15	A67	21	.	9.73	.	7.15	4.29
30/06/2010	O15-G-502	O15	A68	22	5.63	.	.	.	.
2010	O16-G-1231	O16	A66	20	7.01	9.3	26.78	7.52	3.75
2010	O16-G-1232	O16	A66	20	7.28	10.46	31.11	.	4.61
01/06/2010	O16-G-1310	O16	A66	20	.	9.73	.	7.52	.
01/06/2010	O16-G-1311	O16	A66	20	.	9.58	.	6.78	.
01/06/2010	O16-G-1315	O16	A66	20	.	.	.	.	.
02/06/2010	O16-G-1402	O16	A66	20	8.02	.	.	.	4.87
22/06/2012	O16-G-1994	O16	A74	26	8.64	.	.	.	5.27
20/06/2012	O17-G-460	O17	A76	27	5.58	.	.	.	.
08/06/2011	O17-G-467	O17	A69	23	.	9.35	.	6.82	.
30/06/2010	P16-G-421	P16	A68	22	6.94	.	.	.	.
28/06/2012	P17-G-114	P17	A75	26	7.97	.	.	.	.
25/06/2012	P17-G-140	P17	A74	26	.	10.45	.	8.68	.
09/07/2012	R19-G-47	R19	A76	27	.	.	.	.	4.15

Appendix D

Sediment composition analysis of bulk samples from Gruta da Figueira Brava

Sediment component weights per stratigraphic unit. Gruta da Figueira Brava sample proveninence: U9-NW for units IH2-IH8, T7-SE for units IL3-IB2, and SEx trench for units MC5. Due to the heavily indurated nature of units IL2 and the top levels of the SEx trench, no bulk samples could be obtained.

Sample provenience	Sample weight (g)	Matrix		Lithics		Bone		Shell	
		g	%	g	%	g	%	g	%
> 4mm									
Figueira Brava IH2-IH3	55.24	46.69	84.52	0.17	0.31	1.66	3.01	6.72	12.17
Figueira Brava IH4	52.14	40.15	77.00	0.52	1.00	4.28	8.21	7.19	13.79
Figueira Brava IH6	57.17	50.42	88.19	0.71	1.24	1.00	1.75	5.04	8.82
Figueira Brava IH8	37.35	33.01	88.38	0.47	1.26	1.14	3.05	2.73	7.31
Figueira Brava IL3	58.88	56.27	95.57	0.06	0.10	1.28	2.17	1.27	2.16
Figueira Brava IB2	78.02	77.38	99.18	0.08	0.10	0.01	0.01	0.55	0.70
Figueira Brava MC5	95.27	65.11	68.34	5.27	5.53	-	-	24.89	26.13
Toledo B	29.34	23.67	80.67	-	-	-	-	5.67	19.33
Toledo B/C	13.06	3.00	22.97	-	-	-	-	10.06	77.03
Toledo C/D	3.79	0.41	10.82	-	-	-	-	3.38	89.18
[2-4] mm									
Figueira Brava IH2-IH3	25.56	20.95	81.96	0.34	1.33	0.84	3.29	3.43	13.42
Figueira Brava IH4	23.72	18.99	80.06	0.17	0.72	1.41	5.94	3.15	13.28
Figueira Brava IH6	19.00	15.74	82.84	0.20	1.05	1.19	6.26	1.87	9.84
Figueira Brava IH8	35.39	32.60	92.12	0.17	0.48	1.16	3.28	1.46	4.13
Figueira Brava IL3	25.62	22.80	88.99	0.05	0.20	1.95	7.61	0.82	3.20
Figueira Brava IB2	18.73	18.36	98.02	0.03	0.16	0.11	0.59	0.23	1.23
Figueira Brava MC5	18.27	12.21	66.83	0.05	0.27	0.38	2.08	5.63	30.82
Toledo B	23.84	19.47	81.67	-	-	-	-	4.37	18.33
Toledo B/C	12.60	1.55	12.30	-	-	0.05	0.40	11.00	87.30
Toledo C/D	7.28	1.42	19.51	0.06	0.82	-	-	5.80	79.67
[1-2] mm									
Figueira Brava IH2-IH3	25.01	22.97	91.84	0.02	0.08	0.84	3.36	1.18	4.72
Figueira Brava IH4	25.40	22.67	89.25	0.05	0.20	1.12	4.41	1.56	6.14
Figueira Brava IH6	22.00	20.81	94.59	0.02	0.09	0.57	2.59	0.60	2.73
Figueira Brava IH8	26.39	24.80	93.97	0.01	0.04	0.76	2.88	0.82	3.11
Figueira Brava IL3	25.35	24.51	96.69	0.01	0.04	0.40	1.58	0.43	1.70
Figueira Brava IB2	13.19	13.01	98.64	0.01	0.08	0.04	0.30	0.13	0.99
Figueira Brava MC5	14.34	11.84	82.57	-	-	0.33	2.30	2.17	15.13
Toledo B	33.19	30.62	92.26	-	-	0.01	0.03	2.56	7.71
Toledo B/C	19.86	12.58	63.34	-	-	0.03	0.15	7.25	36.51
Toledo C/D	17.79	13.99	78.64	-	-	-	-	3.80	21.36
All meshes									
Figueira Brava IH2-IH3	105.81	90.61	85.63	0.53	0.50	3.34	3.16	11.33	10.71
Figueira Brava IH4	101.26	81.81	80.79	0.74	0.73	6.81	6.73	11.90	11.75
Figueira Brava IH6	98.17	86.97	88.59	0.93	0.95	2.76	2.81	7.51	7.65
Figueira Brava IH8	99.13	90.41	91.20	0.65	0.66	3.06	3.09	5.01	5.05
Figueira Brava IL3	109.85	103.58	94.29	0.12	0.11	3.63	3.30	2.52	2.29
Figueira Brava IB2	109.94	108.75	98.92	0.12	0.11	0.16	0.15	0.91	0.83
Figueira Brava MC5	127.88	89.16	69.72	5.32	4.16	0.71	0.56	32.69	25.56
Toledo B	86.37	73.76	85.40	-	-	0.01	0.01	12.60	14.59
Toledo B/C	45.52	17.13	37.63	-	-	0.08	0.18	28.31	62.19
Toledo C/D	28.86	15.82	54.82	0.06	0.21	-	-	12.98	44.98

Appendix E

Carcass biomass for prey species from Gruta da Figueira Brava and Gruta da Oliveira

Taxon	Kg	GRUTA DA FIGUEIRA BRAVA									GRUTA DA OLIVEIRA					
		FB 4			**FB 3**			**FB 2**			**Layers 20-25**			**Layers 26-27**		
		MNI	MNI x Kg	%MNI x Kg	MNI	MNI x Kg	%MNI x Kg	MNI	MNI x Kg	%MNI x Kg	MNI	MNI x Kg	%MNI x Kg	MNI	MNI x Kg	%MNI x Kg
Rhinoceros	1600	-	-	-	-	-	-	-	-	-	5	8000	27.39	-	-	-
Horse	700	5	3500	40.45	2	1400	55.02	-	-	-	13	9100	31.16	-	-	-
Aurochs	700	3	2100	24.27	-	-	-	-	-	-	10	7000	23.97	7	4900	84.29
Red Deer	200	11	2200	25.43	4	800	31.44	1	200	99.27	15	3000	10.27	2	400	6.88
Ibex	90	5	450	5.20	2	180	7.07	-	-	-	21	1890	6.47	-	-	-
Boar	150	2	300	3.47	1	150	5.89	-	-	-	-	-	-	2	300	5.16
Leporid	2	17	34	0.39	2	4	0.16	-	-	-	43	86	0.29	1	2	0.03
Sm-Med Bird	0.5	20	10	0.12	2	1	0.04	-	-	-	88	44	0.15	6	3	0.05
Tortoise	2	9	18	0.21	4	8	0.31	-	-	-	42	84	0.29	104	208	3.58
Food Shellfish	0.017	459	7.80	0.09	52	0.88	0.03	86	1.46	0.73	-	-	-	-	-	-
Crabs	0.8	40	32	0.37	1	0.80	0.03	-	-	-	-	-	-	-	-	-
TOTAL		**571**	**8651.80**	**100**	**70**	**2544.68**	**100**	**87**	**201.46**	**100**	**237**	**29204**	**100**	**122**	**5813**	**100**
Large game (ungulates)				**98.82**			**99.42**			**99.27**			**99.27**			**98.88**
Small slow game				**0.30**			**0.35**			**0.73**			**0.29**			**0.33**
Small quick game				**0.88**			**0.23**			**-**			**0.45**			**0.80**
Small game				**1.18**			**0.58**			**0.73**			**0.73**			**1.12**

Notes:

(a) Kg is the estimated average carcass weight for each taxon. Total food weight estimates are intermediate values.

(b) Kg information for ungulates was collected from Stiner (2005), for crabs from Woll (2006), for limpets (8 g) from Vafidis et al (2020), for mussels (18 g) from Azizi et al (2020), and for clams (24 g) from Ojea et al (2004).

(c) Kg info for shellfish is an average of the three mean weights of each taxa = (0.008 + 0.018 + 0.024) / 3 = 0.017 g

Appendix F

Example of MNI and MAU calculations for large and very large macrofauna from layer 20 of Gruta da Oliveira

	VERY LARGE MACROFAUNA									LARGE MACROFAUNA																										
	norhinus cf. hemit			Rhinocerotidae			Indeterminate			Equus caballus			Equus sp.			Equidae			Bos sp.			cf. Bos sp.			Bovidae			Herbivore			Ursus arctos			Indeterminate		
	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet	Left	Right	Indet
AXIAL SKELETON																																				
Antler/Horncore Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skull	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mandible	**1**	0	0	0	0	0	0	0	0	**2**	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maxilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tooth Mandibular	2	1	0	0	0	0	0	0	0	2	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tooth Maxillary	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isolated Tooth	0	0	0	0	0	1	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**	0	0	0	0	0	0
Atlas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Axis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertebra Cervical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Vertebra Thoracic	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Vertebra Lumbar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertebra Caudal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertebra indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Rib	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sacrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APENDICULAR SKELETON																																				
Scapula Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sacpula Acromion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scapula Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coracoid Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus Prox	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius Complete	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulna Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulna Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulna Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Os Crochu Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaphoid Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sesamoid Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sesamoid Frag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Metacarpal Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpal Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpal Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 2 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 2 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 2 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 3 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 3 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 3 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 4 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 4 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 4 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 5 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 5 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metacarpus 5 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Nearly Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Ilium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Ischium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Pubis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Acetabulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pelvis Acetabulum + Ilium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Acetabulum + Ishium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Acetabulum + Ilium +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Acetabulum + Ilium +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelvis Frag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Femur Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Femur Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Femur Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Femur Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
Tibia Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tibia Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0
Tibia Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tibia Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Astragalus Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcaneum Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcaneum Frag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicular	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuboid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3rd Cuneiform	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0
Tarsal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsal Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsal Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsal Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 2 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 2 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 2 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 3 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 3 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 3 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 4 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 4 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 4 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 5 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 5 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metatarsus 5 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metapodial Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metapodial Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx Frag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 1 Complete	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 1 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 1 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 2 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 2 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 2 Dist	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Phalanx 3 Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phalanx 3 Prox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long bone Epiphysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Long bone Shaft	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
Flat bone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Indeterminate Ephiphysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Indeterminate Shaft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Coprolite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tortoise Shell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carapace plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuccal plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neural plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Costal plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peripheral plate indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peripheral plate 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peripheral plate 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pygal plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plastron plate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hinge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epiplastron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entoplastron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyoplastron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypoplastron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphiplastron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	1	0	0	2	2	0	0	8	7	3	0	2	3	3	0	0	1	2	1	0	1	0	0	0	2	0	0	0	3	1	0	0	2	0	45
MNI	1			1						2			1			1			1			1			1						1					
MAU	0.5			0.5						1.5			0.5			0.25			0.5			0.5			0.5						0.5					