Of metapodials, measurements and music – eight years of miscellaneous zooarchaeological discoveries at the IPA, Lisbon

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ABSTRACT

Faunal remains recovered from archaeological sites represent a small part of our heritage. Their study allows us to understand the relations that once existed between people, animals and the environment. In this article we describe various discoveries derived from our studies of Mousterian to post-Medieval Portuguese zooarchaeological remains and propose a series of working hypotheses. Different kinds of data such as measurements, frequencies of species, age-at-death, taphonomic traces, the use of bones as raw material, and recent populations of animals, are explored. Several general questions are formulated and in trying to answer them more have turned up. We suggest that a complete list of species on a site is only obtained as bone sample-size approaches infinity, thus emphasising the importance of large assemblages. We stress the important role played in caves by other animals, perhaps especially hyænas, as accumulators of medium – large size mammal bones. However, perhaps as a result of an increase in the human population, the role of these other bone accumulators decreased after the Early Upper Palaeolithic – a process that went hand in hand with the sad extinction of many important species here. We show that the emotional ties between man and animal may extend as far back in time as 25 millennia, and a presumably affectionate relation with the dog was certainly common in the Chalcolithic. Numerous animals, both wild and domestic, were introduced into Portugal at

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least since the Neolithic either by accident or on purpose. The range of species is broad and extends from the house mouse to the ostrich, or at least its eggs. According to the "rabbit palaeo-thermometer" it was 7°C cooler 20,000 years ago during the last Glacial Maximum. We present evidence for the exploitation of caprine secondary products (like milk, wool and dung) as early as the Chalcolithic – a time when subsistence strategies probably became diversified as evidenced by zooarchaeological assemblages in southern Portugal. The Moslems, well known for their fondness for lamb, improved the sheep of southern Portugal while the Christian invaders improved the cattle subsequently. The surprising absence of any evidence for Roman improvements in the livestock sector here may reflect Roman attitudes towards their Lusitanian province in the extreme west of their empire. We also briefly describe the growing corpora of musical instruments fashioned from vulture ulnae, bone anvils used for serrating steel scythes, and strange pierced cattle metapodials which presumably functioned in some mysterious machine in Moslem times. It is hoped that the working hypotheses we raise, some more speculative than others, will open new avenues of zooarchaeological study in the Iberian Peninsula.

Keywords: Zooarchaeology – Portugal – faunal remains – sample size – measurements – age-at-death – species frequency – environment – bone artefacts

RESUMO

Os restos faunísticos recuperados nas jazidas arqueológicas trazem ao presente uma pequena parte da nossa herança pois o seu registo, estudo e interpretação permitem-nos compreender as relações que existiram entre o Homem, os animais e o meio ambiente. Neste artigo descreve-se uma miscelânea de descobertas derivadas dos estudos por nós realizados com conjuntos faunísticos portugueses, datados desde o Musteriense até ao período pós-medieval, e é proposta uma série de hipóteses de trabalho. Foram explorados diferentes tipos de dados, desde medidas, frequência de espécies, idades de abate, marcas tafonómicas e a utilização do osso como matéria-prima até ao estudo de populações animais actuais. Formulamos várias questões e na tentativa de lhes responder outras tantas surgiram. Sugerimos que só é possível obter a lista completa das espécies presentes numa jazida quando a dimensão da amostra se aproxima do infinito, enfatizando-se assim a importância do estudo de grandes conjuntos. Salienta-se o importante papel desempenhado nas grutas por outros animais, em especial as hienas, acumuladores de ossos de espécies de média e grande dimensão. Porém, como resultado do aumento demográfico, o papel destes acumuladores decresceria após o início do Paleolítico Superior, tendo acompanhado a gradual extinção *de importantes espécies no território português. Mostramos que as ligações emocionais entre o Homem e os animais podem ter-se iniciado há mais de 25000 anos e que a presumível relação com o cão seria comum no Calcolítico. Muitos animais selvagens e domésticos foram introduzidos em Portugal desde o Neolítico, quer de modo intencional, quer de modo acidental. O espectro de espécies é amplo e estende-se desde o pequeno rato doméstico até à avestruz ou, pelo menos, aos seus ovos. De acordo com o "paleo-termómetro coelho" a temperatura seria 7° C mais fria há 20000 anos, durante o último período do Máximo Glacial. Evidenciamos como a exploração dos produtos secundários dos ovicaprinos (como o leite, a lã e o estrume) já estaria presente no Calcolítico – num momento em que as estratégias de subsistência provavelmente se diversificaram, como demonstram os conjuntos faunísticos do sul de Portugal. As populações muçulmanas, conhecidas pelo seu gosto pela carne de borrego, promoveram o apuramento de diferentes raças de ovelhas no sul de Portugal enquanto os Cristãos viriam a desenvolver mais tarde a mesma estratégia em relação ao gado bovino. A surpreendente ausência de evidências de melhorias realizadas pelos romanos no sector da criação de gado pode ser reflexo das suas atitudes para com a província da Lusitânia, na parte mais ocidental do Império. Também descrevemos de forma resumida os instrumentos musicais manufacturados em ulnas de abutres, as safras em osso utilizadas para picar foicinhas de gume serrilhado e uma série de metápodos perfurados associados ao período islâmico, que presumivelmente faziam parte de engenhos mais complexos. Esperamos que as hipóteses de trabalho oferecidas aqui, umas mais especulativas que outras, contribuam para abrir novas avenidas nos estudos de Zooarqueologia na Península Ibérica.*

Palavras-chave: Arqueozoologia – Portugal – restos faunísticos – tamanho da amostra – medidas – idade de abate – frequência das espécies – meio ambiente – artefactos em osso

> Miscellany: a mixture, medley; miscellaneous pieces
> brought together to form a volume
> *Oxford English Dictionary*

1. INTRODUCTION

Zooarchaeology, or archaeozoology, is the study of animal remains found on archaeological sites. For a long time antiquaries had unearthed so-called 'weapons of war' fabricated by people 'who had not the use of metals' associated with extraordinary bones of unknown animals (Frere, 1800) and it was the association between extinct animal remains and man-made artefacts that helped to convince scientists in the latter half of the 19th century that our ancestors lived before Sunday October the 23rd 4004 BC. This was the date originally calculated by Archbishop James Ussher of Armagh (1581-1656), Primate of All Ireland and Vice Chancellor of Trinity College Dublin, for the creation of the world (Tegg, 1811, p. 217). Thus in his *Geological evidences of the antiquity of man*, published in 1863, Charles Lyell wrote:

"the occasional occurrence, in various parts of Europe, of the bones of man or the works of his hands, in cave-breccias... associated with the remains of the extinct hyæna, bear, elephant, or rhinoceros, has given rise to a suspicion that the date of man must be carried further back than we had heretofore imagined."

The application of animal bones to the debate on the antiquity of man was therefore their first contribution to science. As a distinct discipline it may be considered to take its origins in the second half of the 19th century. The geologist, Sir Joseph Prestwich (1861), in an address to the Royal Society in London on the 26th May 1859 (that *annus mirabilis* for biological science), suggested that: "... on this neutral territory between Palaeontology and Archaeology a wide field is opened for investigation, which must eventually lead to a great extension of our knowledge of the history of primeval Man".

The main aim of zooarchaeology is to understand the relations that once existed between people, animals and the environment. To a large extent this discipline tells us about the economic and behavioural patterns of people in antiquity and may be invaluable in interpreting an archaeological site. Most faunal remains represent the leftovers of ancient meals, generally, but not always as we shall discuss, consumed by people.

Although the study of archaeological animal bones was undertaken sporadically for a long time, the full-time employment of zooarchaeologists only began in earnest in the last three decades of the 20th century. Zooarchaeology has now become an integral part of archaeology.

Portugal too saw an early interest in zooarchaeology. In the latter half of the 19th century the shell middens (*Concheiros*) of Muge in the Tagus valley were the subject of rigorous investigations undertaken by Francisco António Pereira da Costa (1865). The absence of certain taxa such as elephant and rhino, he suggested, indicated that these middens were not of very great age – an example of the use of zooarchaeology as a dating tool. In the mid 19th century the geologists Joaquim Filipe Nery Delgado and Carlos Ribeiro became interested in the problem of human origins. Nery Delgado was one of the first to use taphonomic data to understand the process of site formation. He noted for example, that at Casa da Moura (Óbidos) the herbivore bones richest in marrow were the most fractured while those of carnivores, the majority being juveniles, were intact. These observations led him to suggest that humans were responsible for accumulating the bones (see Zilhão, 1993; 2001a). A mere four years after Lyell's comment on the antiquity of man (see above), Delgado wrote: *"este facto, por tanto tempo controvertido, da coexistência da nossa espécie com as espécies extintas de mamíferos, isto é, da existência do homem numa época geológica muito anterior a toda a tradição,..."* (Delgado, 1867, p. 13). Not long after, Estácio da Veiga (1887) related the absence of the large carnivores like hyaena and lion from Neolithic times onwards in Portugal to a change in environmental conditions. Furthermore, he argued that that change would have favoured the local domestication in the Iberian Peninsula of goats, wild pigs, horses and aurochs, rejecting the arrival of domesticated species from the Near East – a subject much debated then and even now. Indeed recent studies of ancient DNA in pigs are confirming what da Veiga suggested over a century ago (see Larson, et al., 2007). His concerns with collecting faunal remains from the sites he excavated and having them correctly identified put him well ahead of his time (Moreno-García and Pimenta, 2007b). Clearly, at that time Portugal was in the forefront of archaeological investigation.

Almost nine years ago the Minister of Culture, on the recommendation of João Zilhão, then director of the IPA, decided to underwrite an archaeological science unit featuring a dedicated zooarchaeology laboratory within this institution (Mateus and Moreno-García, 2003). Our aim here is to illustrate, using data that we have gathered since then (Moreno-García, 2005/6), how remains of animals may help us to understand the patterns of behaviour of our ancestors and the kind of environment in which they lived.

With animal remains deriving from such a long chronological succession – all the way from the Upper Pleistocene to post-Medieval (see map Figure 1) – Portugal is a gold mine for zooarchaeologists, from which they can draw a wide range of inferences. This article is a miscellany, but we hope that it shows how important and varied are the questions that zooarchaeology can tackle. These are still early days, but now is a good moment to take stock, and by asking various questions, we hope to pave the way for new avenues of investigation.

2. THE RAW DATA

Perhaps the most important aspect of zooarchaeology is the way bones are recovered during excavation and their subsequent curation for future research. Archaeological animal bones – our archive – will continue to be re-studied as methods and laboratory techniques improve. One recent example is the use of archaeological bone for extracting ancient DNA to understand the phylogeny of domesticated animals. Hence the need for careful curation and storage cannot be overemphasised. A continuing reluctance to fine sieve soil during excavation means that an unknown part of the fauna – small mammals, many fish and birds, and even many parts (especially small elements and isolated teeth) of large mammals will continue to be absent from the samples that we receive in the laboratory. Many kinds of quantitative data will therefore suffer recovery biases as Sebastian Payne emphasised in a series of sieving experiments undertaken in the 1970s (Payne, 1972; 1975b). This makes it difficult to understand many of our data such as body-part and faunal frequencies and the counts of different age groups of the animals slaughtered in antiquity.

Zooarchaeology is undertaken mainly in the laboratory and the first and most fundamental stage is the correct identification of the fossil remains. A well documented reference collection of securely identified animal skeletons is essential. For this reason during our first few years here we devoted a considerable amount

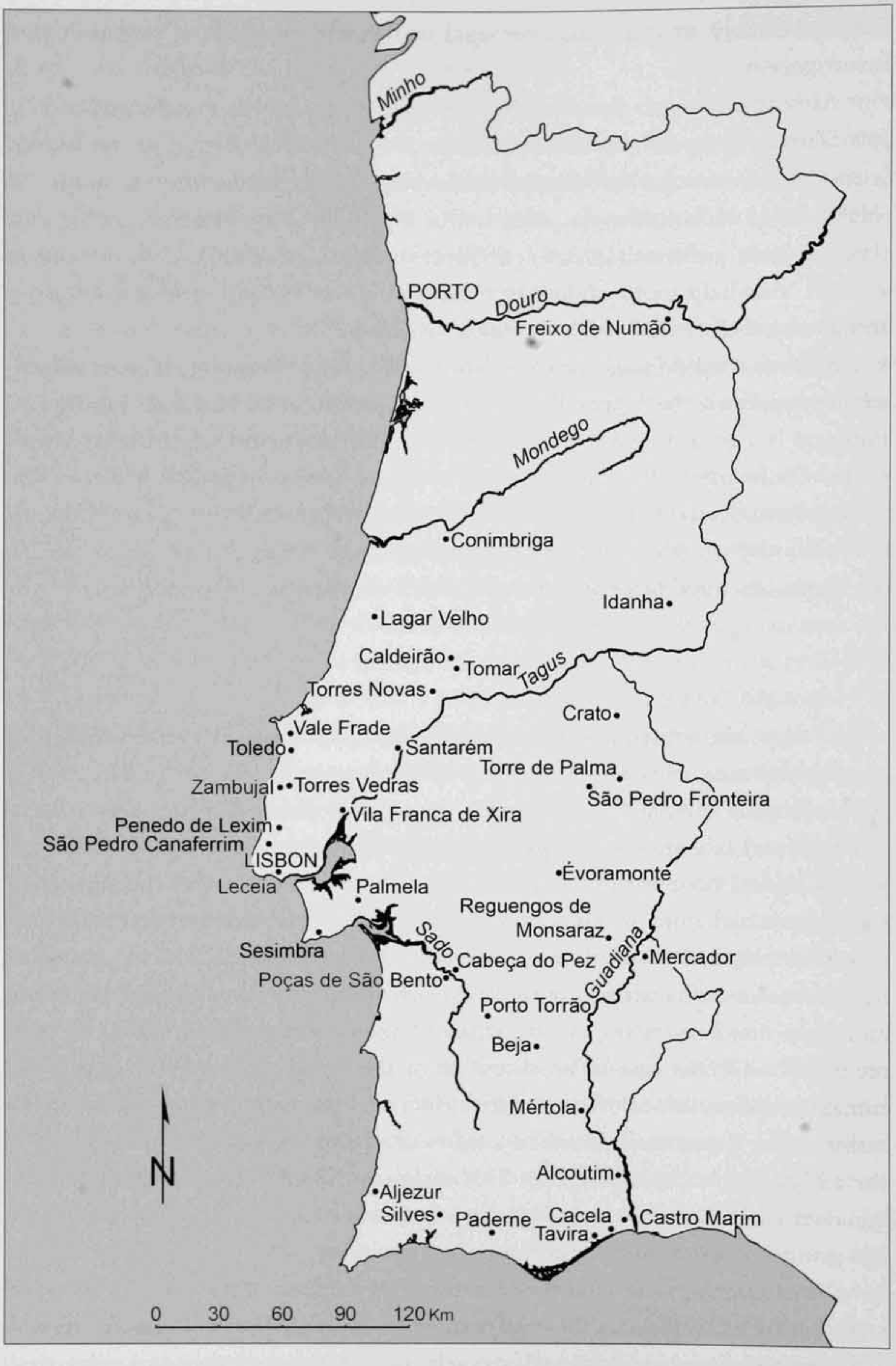

Figure 1 – Map of Portugal showing the locations of sites mentioned in the text and from which osteometric data are derived.

of effort in building such a collection. It now comprises over 2000 specimens and many of the more important mammals and birds of the Iberian Peninsula are represented (see Moreno-García et al., 2003a for our description of the IPA Zooarchaeological reference collection of vertebrate skeletons, and Davis and Payne, 1992 and Davis et al., 1998 for advice on how to go about making such a collection). Identification includes assignment to part of skeleton, taxon (species where possible), age at death, size and sometimes even sex of the animal. Other kinds of observations that should be recorded include various *pre-* and *post-mortem* alterations (evidence of trauma and disease and butchery marks for example). Indeed the list goes on and at the end of the first phase of study the zooarchaeologist may well have built up a large body of data comprising not only a list of identified species, but also quantitative information such as counts of species, different parts of the skeleton, cut marks on different regions of the animal body, measurements and so on.

Here is a list of what may be considered the most important kinds of data from which we may draw various inferences:

- Presence or absence of species
- Their frequencies
- The age-at-death of taxa deduced from epiphysial fusion and tooth wear
- Measurements
- Butchery, burn and gnaw marks and evidence of partial digestion
- Signs of trauma and disease
- Evidence for the use of bone as a raw material for manufacturing implements

Zooarchaeology covers a wide range of subjects, some depend upon minuscule details enabling the distinction between closely related taxa or separating wild from domestic forms; others have a bearing upon events of more general importance like global temperature variations and why did our ancestors begin husbanding animals. Taking the Portuguese zooarchaeological record as a case study, we shall, in this article consider questions like:

- How many bones make a useful sample?
- Who accumulated the animal bones on a site?
- Can we interpret human feelings through animal remains?
- When did certain species become extinct, and when were others introduced?
- How do the frequencies of the large prey species vary through time and why?
- What was the temperature in Portugal in the past?

- Can we distinguish between wild and domestic species?
- Why do kill-off patterns matter?
- How do species' frequencies reflect different subsistence strategies?
- Were domesticated animals improved and if so when?
- How many uses can a dry bone have?
- Do present day fauna have a role in zooarchaeological studies?

3. THE QUESTIONS

3.1. Question 1: How many bones make a useful sample?

How large does a zooarchaeological sample need to be in order to ascertain which species were originally present? This question may at first appear trivial, but zooarchaeologists often consider the presence/absence and number of different species on different sites. It is therefore important to be aware of how different factors – sample size being one of them – may influence the spectrum and number of taxa identified. The number of bones recovered from an archaeological excavation may vary from zero to many hundreds of thousands, even millions. An archaeological faunal assemblage is in effect a sample of the animals that originally inhabited the environs of a settlement (Meadow, 1980). The aim of this study (Davis and Watson, in progress) is to understand the relation between *sample size* and *number of species* by considering over 100 hand-collected and sieved archaeological samples of animal bones from Portugal as well as other parts of Europe, especially England, and the Near East that range in size from 5 to nearly 10,000 recorded and identified specimens. In order to rule out complications due to biases in recovery and problems associated with identification (both factors that will affect the numbers of identified small animals like rodents and many birds and fish whose identification to species level is often difficult or impossible) only mammals of size equal to or greater than a rabbit are considered.

The first table of a faunal report usually comprises a list of animals identified and their numbers and frequencies. In his discussion of sampling of bones in archaeology, Clive Gamble (1978) suggested that questions concerning the relative proportions of the principal taxa can be established by studying a small fraction of the sample. However sample sizes need to be considerably larger for answering questions about age structure, animal size, sex ratios, etc (see in particular his Table 20.7). As a rule of thumb 10 bones may tell us which were the most common animals represented, 100 bones will indicate their frequencies, 1000 bones can reveal the age-at-slaughter of the common taxa, and 10,000 bones should include nearly all (but as is suggested here, not *all*) animals that the inhabitants ever brought back to their settlement in antiquity. Results obtained so far suggest that the total number of taxa is only recognised as sample size approaches infinity.

The problem of sample size and the number of species identified is well known to ecologists trying, for example, to understand the species diversity of a given habitat. As Ricklefs and Miller (1999, p. 546) write in their textbook on ecology – "when an ecologist samples a community to determine the number of species present, the total number of species included in the sample varies with sample size, because as more individuals are sampled, the probability of encountering very rare species increases."

Generally the number of taxa increases asymptotically with sample size (Pité and Avelar, 1996, p. 209). This means that the maximum number of taxa will only be found when sample size becomes extremely large. Thus a plot of *species number* against *sample size* produces a curve which is steep at first and then gradually flattens out as samples become larger.

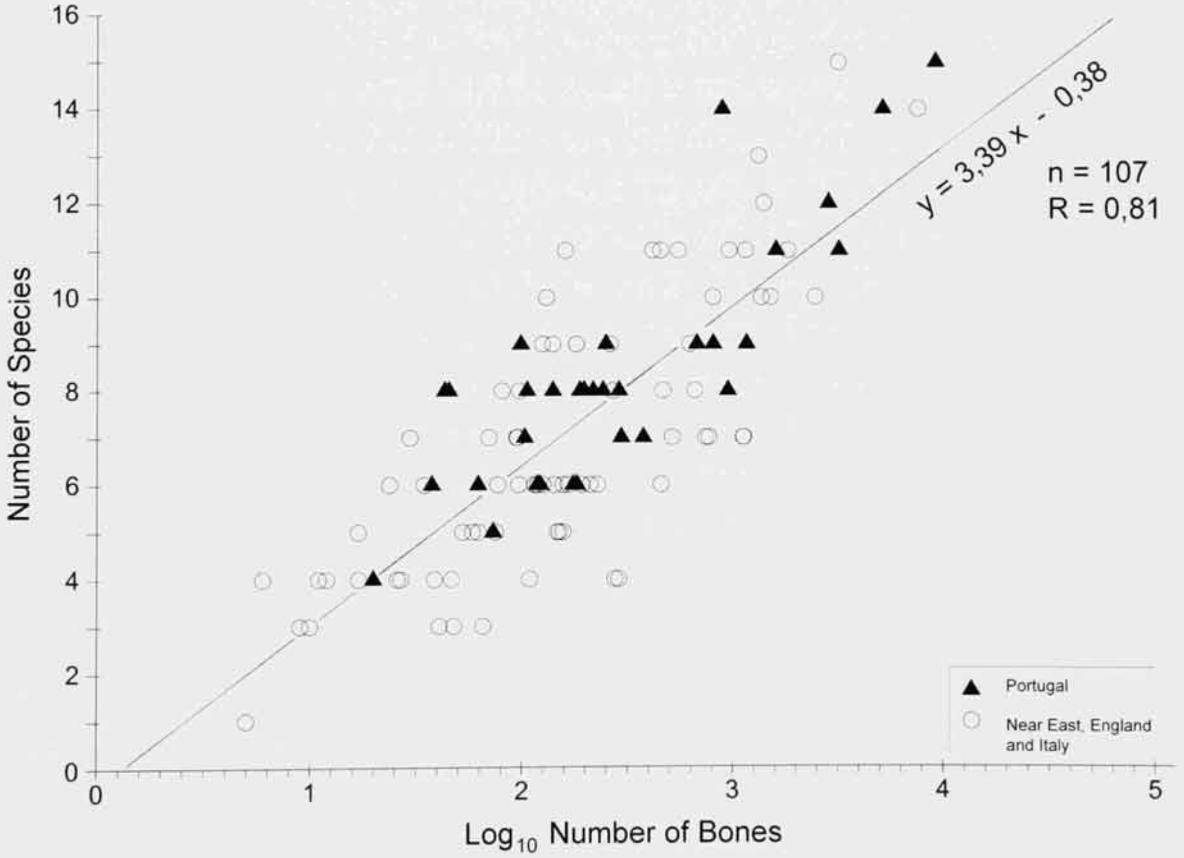

Figure 2 – A plot of the number of mammal species (of size equal to or greater than rabbit) against the decimal logarithm of the number of mammal (of size equal to or greater than rabbit) bones identified to "species" level from 107 archaeological sites/levels in Europe and the Near East studied by SD using the recording method described in Davis (1992; 2002) and similar to the method described by Watson (1979). Faunal assemblages from Portugal (data in Table 1) are shown as filled triangles and sites from the Near East, Italy and England are shown as open circles. The numbers of bones range from 5 to 9673 and the numbers of species range from 1 to 15. The regression of $N_{species}$ on Log_{10} N_{bones} is $y = 3{,}39x + 0{,}38$ ($R = 0{,}81$ with p significant at the 0.1% level).

This kind of non-linear relation between two variables is well known in biology, and a logarithmic transformation of sample size should produce a straight line. Figure 2 (see also Table 1) shows a plot of 'numbers of species identified' against the 'decimal logarithm of the number of bones recorded' for 107 archaeological assemblages. (Unsurprisingly there is no evidence that Portuguese sites behave any differently from the others in the Near East, England and Italy.) The relation is quite clearly a linear one with a correlation of 0.81 (significant at the 0.1% level) and indicates that on average, assemblages with around 100 bones contain approximately 7 species of medium to large-sized mammals, while those with twice this number of species require two orders of magnitude more identifiable bones. Put another way, in order to double the number of species found on a site we need to double the logarithm of the number of bones – that is increase the numbers of bones, say, from 100 to 10000!

3.2 Question 2: Who accumulated the animal bones on a site? – Gruta do Caldeirão – a case study

Almost all archaeological sites, provided soil pH is sufficiently high, contain animal bones. Often it is important to inquire who was originally responsible for accumulating these bones. Zooarchaeologists generally assume that they represent the food debris of our ancestors; an assumption reinforced by the presence of butchery and burn marks on the bones. However certain predators like hyænas and leopards also accumulate animal bones. A study of the fauna from Caldeirão cave in Portugal serves as a case study and has shown that man was not the only bone-collector, at least in the earlier levels of this important cave site.

Caldeirão cave is in the Valley of the river Nabão, near Tomar, and was excavated in the 1980s by João Zilhão (1992; 1997) then of the University of Lisbon. He uncovered levels with a cultural sequence from the Mousterian to the Neolithic making it the only Portuguese site occupied for such a long extent of time.

Like many Late Pleistocene sites in the Iberian Peninsula, the ungulate fauna at Caldeirão is dominated by red deer, goat and two species of equid (see also below). Present in smaller quantities are chamois, wild boar and roe deer. Bones of birds, rodents, amphibians and even a fish were also uncovered and the numerous rabbit remains, currently under study, are providing useful information about the environment (see below). The carnivore fauna comprises a wide spectrum of species – lion, leopard, lynx, wildcat, hyæna, wolf, badger, and fox, as well as several species of avian predators and scavengers (reported in full in Davis,

Site-level	Sieved?	Locality	N Bones	N Species	Reference
Sé de Lisboa Moslem	N	Lisbon	20	4	MM-G & SD 2001
Castro Marim II Iron	N	Algarve	38	6	SD 2007
Almonda Mousterian	Y	Ribatejo	44	8	SD unpublished
Tomar Medieval	N	Ribatejo	46	8	SD 2004
São Pedro Fronteira Roman	N	Alentejo	63	6	SD 2005
Alcáçova de Santarém Modern 2	N	Ribatejo	74	5	SD 2006
Alcáçova de Santarém Medieval 2	N	Ribatejo	101	9	SD 2006
Alcácer do Sal Moslem	N	Alentejo	105	7	MM-G & SD 2001
Castro Marim VII post-Medieval	N	Algarve	108	8	SD 2007
Tomar late Roman	N	Ribatejo	120	6	SD 2004
Tomar Roman	N	Ribatejo	120	6	SD 2004
Castro Marim VI Roman	N	Algarve	124	6	SD 2007
Tomar Medieval-Modern	N	Ribatejo	143	8	SD 2004
Alcáçova de Santarém Modern 1	N	Ribatejo	178	6	SD 2006
Castro Marim III Iron	N	Algarve	185	6	SD 2007
São Pedro Canaferrim Moslem	N	Estremadura	192	8	SD 2005
Alcáçova de Santarém Roman 5	N	Ribatejo	201	8	SD 2006
Castro Marim IV Iron	N	Algarve	222	8	SD 2007
Alcáçova de Santarém Medieval 3	N	Ribatejo	247	8	SD 2006
Alcáçova de Santarém Roman 4	N	Ribatejo	256	9	SD 2006
Castro Marim V Iron	N	Algarve	295	8	SD 2007
Alcáçova de Santarém Roman 3	N	Ribatejo	301	7	SD 2006
Convento S. Francisco, Santarém Moslem	N	Ribatejo	384	7	MM-G & SD 2001
Alcáçova de Santarém Iron 1-7	N	Ribatejo	694	9	SD 2006
Alcáçova de Santarém Roman 2	N	Ribatejo	829	9	SD 2006
Gruta do Caldeirão Mousterian	Y	Ribatejo	928	14	SD 2002
Alcáçova de Santarém Iron 8	N	Ribatejo	973	8	SD 2006
Alcáçova de Santarém Roman 1	N	Ribatejo	1197	9	SD 2006
Gruta do Caldeirão Early Upper Pal	Y	Ribatejo	1667	11	SD 2002
Silves – Almohad *Lixeira*	N	Algarve	2980	12	SD unpublished
Alcáçova de Santarém Medieval 1	N	Ribatejo	3330	11	SD 2006
Gruta do Caldeirão Magdalenian	Y	Ribatejo	5426	14	SD 2002
Gruta do Caldeirão Solutrean	Y	Ribatejo	9673	15	SD 2002

Table 1 – The Portuguese sites, levels, periods and locations of archaeological animal bone assemblages with their numbers of mammal bones recorded (these are PoSACs or Parts of the Skeleton Always Counted, as described in Davis, 1992 and Davis, 2002) and numbers of species identified. The mammals are all of size equal to or greater than a rabbit. Assemblages are ordered in increasing numbers of bones recorded. Many sites are multi-period and each period is treated as a separate entity. Information also shown includes whether the animal bones had been recovered by sieving (Y) or merely hand-recovered (N). In the "reference" column authors' names are abbreviated to "MM-G" and "SD".

2002). Unfortunately most of the bones are covered by calcrete which made it difficult to observe gnawing and cut marks. All fauna at Caldeirão was recovered by sieving through a mesh of 2mm aperture, a significant proportion of which was wet sieved.

Perhaps of greatest relevance here is the presence of the spotted hyæna (*Crocuta*). This animal became widely distributed across the Palaearctic during the Cromerian, and in Europe it became extinct at the end of the last Ice Age (around 12,000 years ago; Kurtén, 1968; Bonifay, 1971; Kahlke, 1999). According to Fernández Rodríguez et al. (1995) hyænas are only poorly documented in archaeological sites in Iberia and they "disappeared almost completely in the latter phases" of the Upper Palaeolithic. Altuna and Mariezkurrena (1988) found that *Crocuta* in northern Spain did not survive after the Solutrean some 20 or so thousand years ago. However, more recent records are known from the Magdalenian of south-western France (see Kahlke, 1999).

Some of the taxa identified at Caldeirão are known accumulators of animal bones. Hence we are confronted with an interesting zooarchaeological puzzle: who was responsible for collecting the Caldeirão animal bones – ***man*** or ***animal*** or ***both***? One possibility is that both people and carnivores used the cave. For example hyænas, as Charles Brain (1981) has pointed out, will tolerate the presence of other species in their dens such as warthogs. However mutual avoidance seems more probable. People may have used the cave for some years or even decades and then carnivores used it. Can we determine the extent of carnivore *versus* human responsibility for the bones in the course of the cave's occupation? Richard Klein (1975) and Kathryn Cruz-Uribe (Klein and Cruz-Uribe, 1984) were among the first to recommend a number of criteria to aid in recognising who accumulated an assemblage of large mammal bones. Let us consider some of these criteria to answer this question in the case of the Caldeirão fauna.

They are as follows:

- The presence/absence of remains of large carnivore species known to collect bones
- The presence/absence of coprolites
- The presence/absence of partially digested bones
- The ratio of carnivores to ungulates
- Juvenile to adult ratios of the ungulate remains
- Cut and burn marks
- The ratio of fauna to stone tools
- The ratio of small unidentifiable fragments to identified bone.

Some seem to indicate considerable carnivore influence, while others indicate clear human occupation of the cave.

Presence of carnivore remains.

One of the most notable carnivore finds from Caldeirão is a mandible of hyæna (Figure 3 above). Given the relative size of the carnassial tooth, it clearly belonged to a spotted hyæna, *Crocuta crocuta*. Included among the finds of large carnivores (Table 2) are lion, leopard, lynx, wildcat and bear, as well as wolf, fox, badger, and several predatory and scavenging birds – the most important being the Bearded vulture, *Gypaetus barbatus.*

What is most interesting however is that the three large species of carnivores, bear, lion and hyæna, appear to have been present only in the two earliest levels of the cave. Both leopard and wolf were present in those two levels and lingered on into the Solutrean, but by Magdalenian times only the smaller species of carnivores are present.

These carnivore faunal changes are paralleled, if perhaps a little earlier, in the Spanish Mediterranean region where Aura Tortosa et al. (2002) note that large carnivores such as leopards and hyænas disappeared at the beginning of the late Pleniglacial during the transition between OIS 3 and 2. This was approximately the time of the extinction of the last Neanderthals some 30,000 years ago. They also note that while large carnivore remains did persist into the early Upper Palaeolithic at some sites, other carnivores like wolf, dhole, lynx and wildcat maintained their numbers, but, they suggest, carnivores ceased to be the principal agent of bone deposition in the sites they consider.

Coprolites (Figure 3 below).

Further evidence for the presence of hyænas comes in the form of coprolites – fossilised faeces. Some are very large – too large to have belonged to wolf. 40 were found in Mousterian levels and another three in the Solutrean. They are yellow, with smooth surfaces and the ends are either pointed or exhibit a central depression, similar to those described by Fernández Rodríguez et al. (1995) from La Valiña in northwest Spain (dated to 35,000 BP and which they identify as spotted hyæna coprolites). The description that Richard Owen (1846, p. 146) gives of the fossilised faeces of spotted hyæna, once used in medicine and known as *album graecum*, from a site in England could equally apply to the Caldeirão specimens:

"its external form is that of a sphere irregularly compressed as in the faeces of sheep, and varying from half an inch to an inch and half in diameter; its colour is yellowish

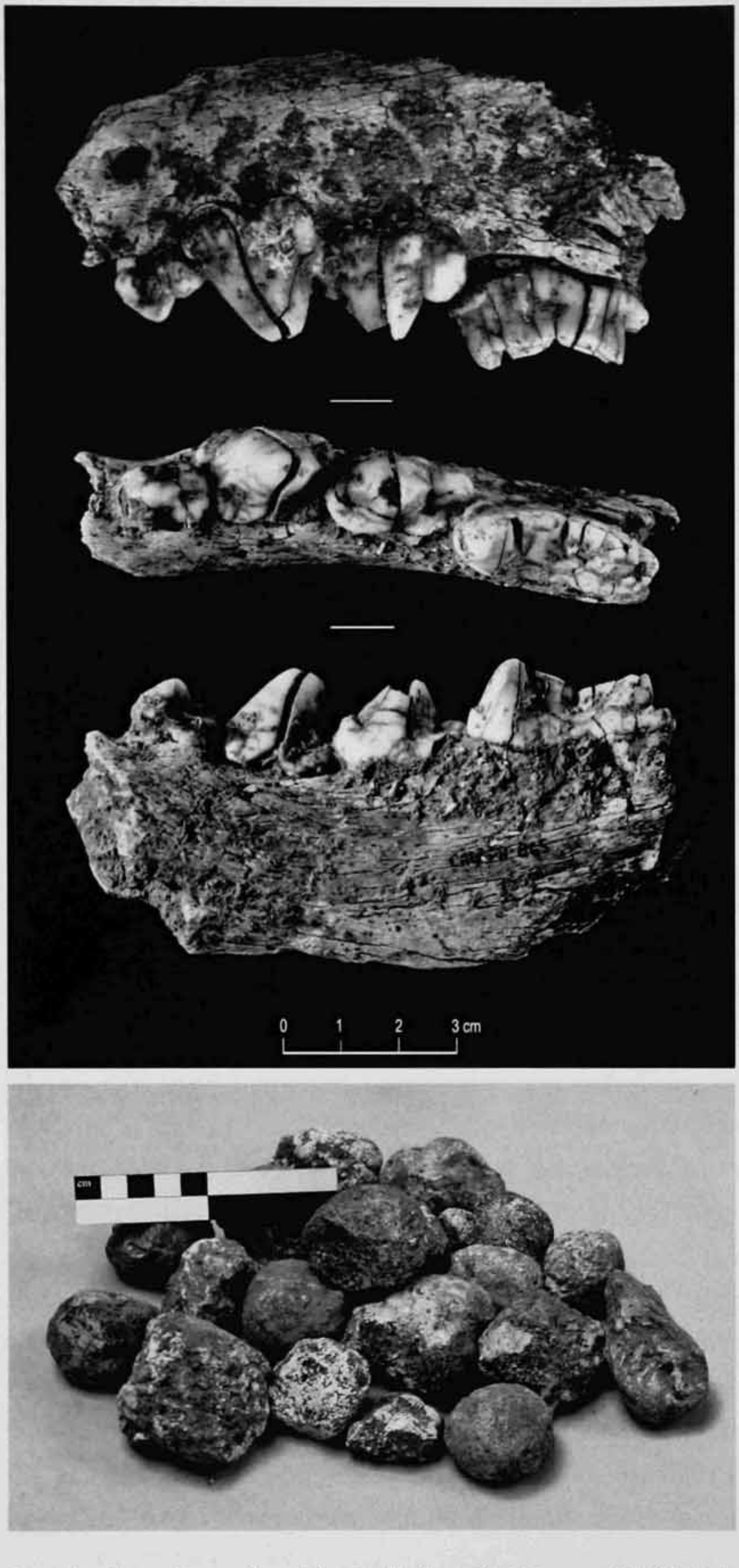

Figure 3 – Above: Hyæna (Crocuta) mandible from Caldeirão cave P11 865 K; Mousterian. Above – buccal, centre – occlusal and below – lingual views.
Below: Coprolites from Caldeirão (P11 sc 907; layer M M1; Mousterian). In view of their large size these are probably derived from hyæna. The scale bar is 10 cms.

	Moust	EUP	Sol	Magd	Neol
Bear	+	+			
Lion		+			
Hyæna	+	+			
Leopard	+	+	+		
Wolf	+	+	+		
Lynx	+	+	+	+	+
Fox	+	+	+	+	+
Wild cat			+	+	+
Badger			+	+	+
N.° of carnivore taxa	6	7	6	4	4

Table 2 – Survival and extinction of carnivores at Caldeirão cave – a working hypothesis.

white; its fracture is usually earthy and compact, resembling steatite, and sometimes granular; when compact, it is interspersed with small cellular cavities, and, in some of the balls, there are undigested minute fragments of the enamel of teeth."

Partially digested bones.

Many carnivores swallow complete bones, or parts of bones. These may be subsequently regurgitated or survive passage through the gut as Payne and Munson (1985) have demonstrated in dogs. Dogs for example will not swallow fragments whose diameter exceeds about 2$^1/_2$ cm. These bones may survive their stay in the stomach, but suffer varying degrees of digestive alteration and present a characteristic eroded appearance. Etched surfaces of partially digested bones tend to be shiny and broken edges wafer-thin and razor sharp. The absence of this sort of corrosion on larger bones rules out soil acids as the cause, as soil corrosion would affect both small and large fragments alike. Hyænas regularly regurgitate indigestible residues of their recent meals (Brain, 1981; Klein et al., 1999; Kruuk, 1972, p. 244).

Large amounts of small fragments of bone were found throughout the Caldeirão sequence. These include many corroded fragments. The pattern of corrosion is similar to that produced by immersion in acid, which suggests they had been partially digested and Figure 4 shows some randomly selected fragments. Note the two on the right which show these characteristics. These and numerous other similarly corroded bones and chips of bones were found mainly in Mousterian and Early Upper Palaeolithic levels. Their presence, as well as the abundance of large carnivores and the coprolites already discussed, are all good evidence for the presence of a bone-eating carnivore(s) in the earlier two periods at Caldeirão (see also Figure 5). However, to make matters more complicated, we shall see below what happens to ungulate bones after being regurgitated by the Bearded vulture!

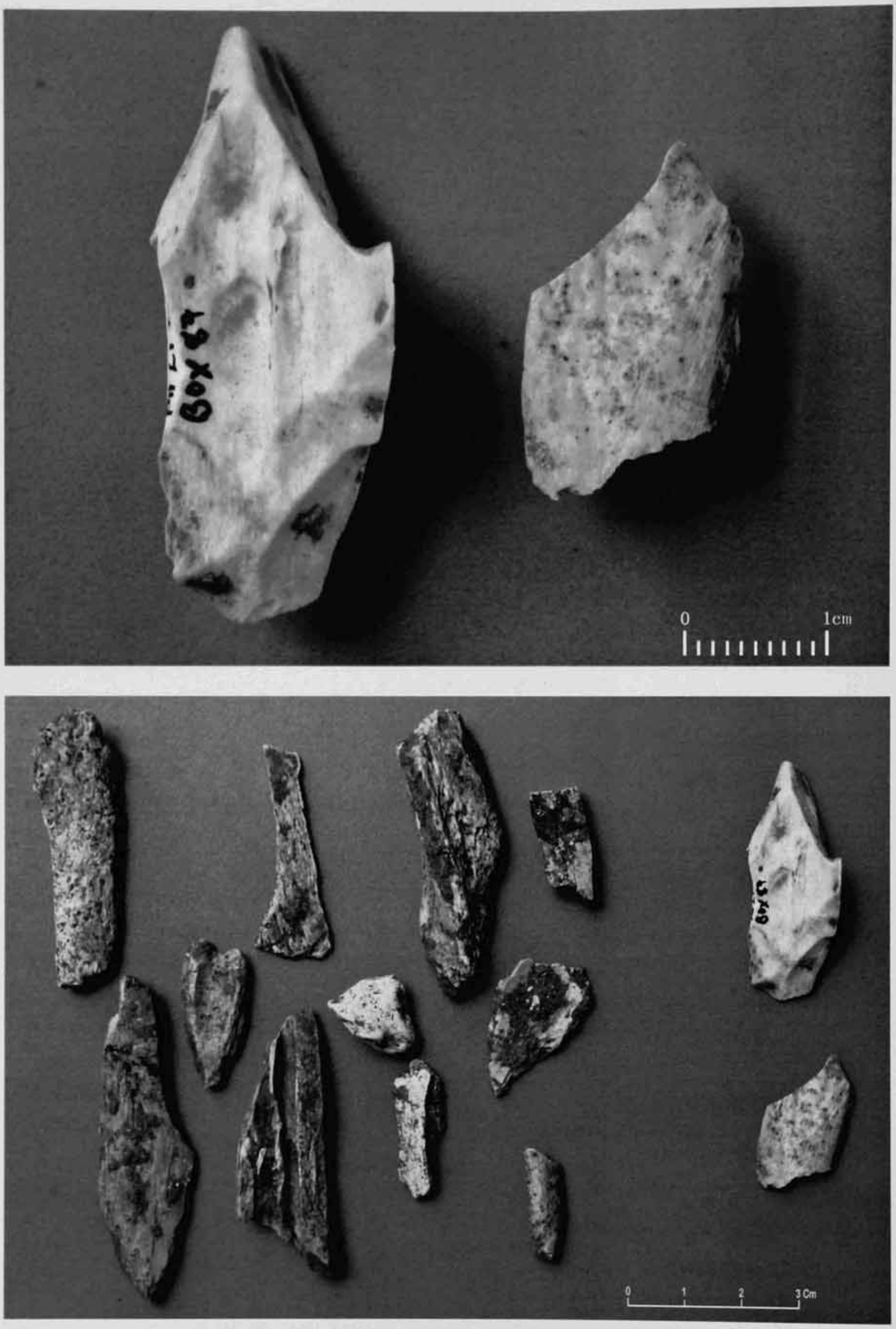

Figure 4 – Bone fragments from Caldeirão cave. Above: Two partially-digested fragments of large mammal bone. Note their shiny surfaces and sharp broken edges. Below: these two fragments, on the right hand side, with 11 ordinary fragments. All are from P11 L1 sc 894; Mousterian.

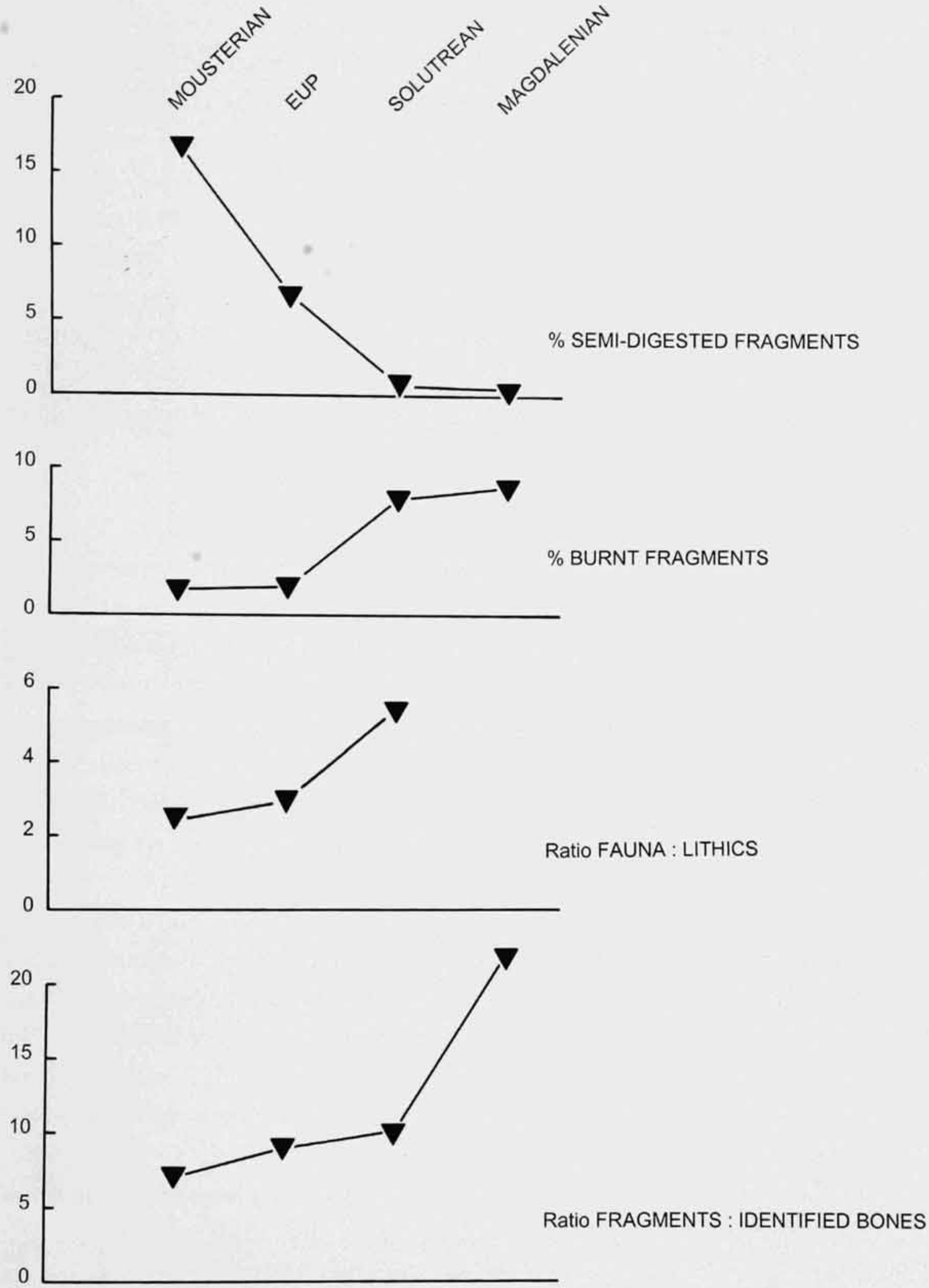

Figure 5 – Carnivores versus humans as bone accumulators in Caldeirão cave. These plots show a change in the pattern of occupation of the cave in the course of time. From top to bottom: percentages of partially digested fragments of bone, percentages of burnt fragments of bone, the ratio 'fauna to stone tools' and the ratio 'fragments of unidentifiable bones to identifiable bones'. Data are in table 8 of Davis, 2002. Note the decrease of *partially-digested bones* and increase of *burnt bones, fauna versus stone tools* (from Zilhão, 1997 vol. 2; 114), and *unidentified versus identified* bones in the course of the succession. These changes may reflect a decrease in the use of the cave by carnivores, especially hyæna, and its increasingly intense use by humans.

Carnivore to ungulate ratio.

Klein (1975) and Klein and Cruz-Uribe (1984) suggested that human food remains could be distinguished from those of carnivores by the proportion of carnivore remains. This is because carnivores like hyænas have a tendency to feed on the carcasses of other carnivores, even of their own species, and to an extent greater than people did. Using this argument, Brain (1981) concluded that large carnivores collected many of the accumulated animal and hominid bones in South African caves. At Caldeirão it is quite clear that the percentage of large carnivores decreases quite drastically from around 10 or 14% in the early two levels to a mere 3% in the later levels (see Figure 6 below). This criterion too corroborates our conclusion that carnivores played a major role in the two early levels of the cave.

Juvenile to adult ratio.

Zooarchaeologists generally consider the age-at-death of the animals represented in the sites they study. An estimate of the mortality pattern of animals culled in antiquity can reveal important information about man-animal relations. At Caldeirão samples are too small to draw secure conclusions, though the data (Figure 6 above) do suggest that most of the red deer and equids in the earlier levels were juveniles, while more or most of these animals in the subsequent periods were adult. One could argue that people were improving their hunting capabilities in the course of time and that it was not until later that people were able to cull the adult (larger) horses and red deer.

An alternative explanation for the age-shift, and the one preferred here, is quite simply that the majority of the equids and red deer in the earlier times were not hunted by people but by carnivores such as hyænas, leopards and wolves. Hyænas are by no means the largest and most efficient of predators and they were perhaps unable to take the faster and more ferocious adult horses and red deer. This may be further evidence for a change of predator between Early Upper Palaeolithic and Solutrean times.

Hans Kruuk (1972) observed that the three species of large mammals most commonly hunted by spotted hyænas in Africa are wildebeest, zebra and Thompson's gazelle. He recorded the ages of over 100 wildebeest killed by hyænas. The majority of the wildebeest were juveniles. The age-at-death data for leopard kills of large mammals are also interesting. Pienaar (1969) noted that while most of the impala, whose average weight is 45 kilos, were adults, the waterbuck, whose average weight is 250 kilos, predated by leopards were mostly juveniles and infants. This preference for the young of the really large

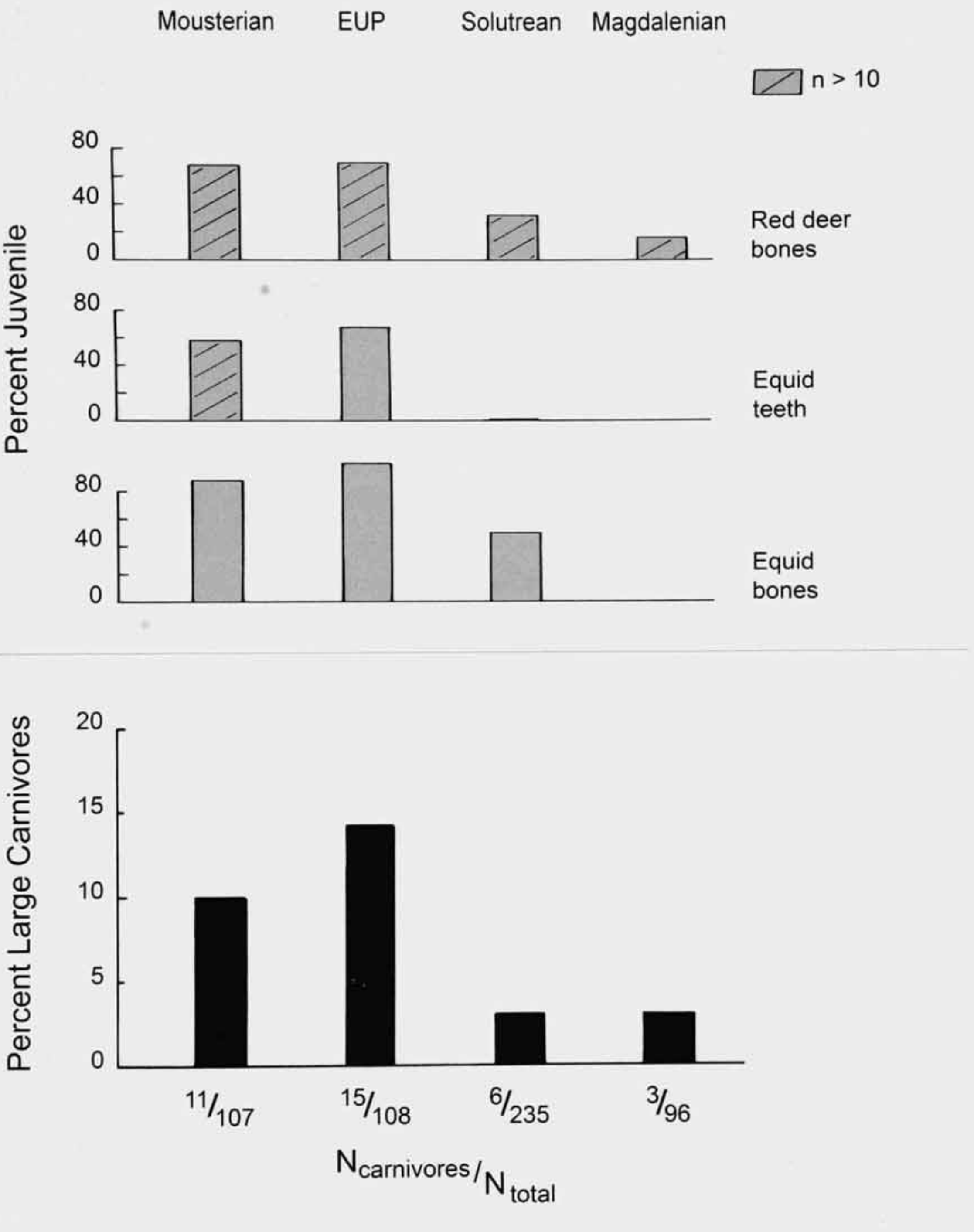

Figure 6 – Above: The red deer and equids at Caldeirão cave – juveniles versus adults. This figure shows the percentages of juveniles calculated separately from teeth and bones (very small samples are excluded). For teeth of red deer, the numbers of deciduous and adult fourth premolars (dP_4 and P_4 respectively) are given. Since equid P_3s and P_4s, and M_1s and M_2s are difficult to distinguish, equid teeth counts are pooled as deciduous premolars ($dP_2 + dP_3 + dP_4$) and adult premolars + molars (P + M). Data are in table 12 of Davis, 2002. In the Mousterian and Early Upper Palaeolithic most of the red deer and equids brought into the cave were juveniles. Subsequently the percentages of juveniles were much lower. Can we link this change from predominantly juvenile culling to culling of more adults with a change of predator – from hyæna to more efficient man? NB: Sample sizes are small and these inferences must be treated with caution.

Below: The percentages of large carnivores in the Mousterian to Magdalenian sequence of periods at Caldeirão cave. The "large carnivore percentage" is calculated by dividing the number of "hyæna + bear + lion + leopard + wolf" bones by the total number of mammal herbivore *and* large carnivore bones. Note the relative decrease of large carnivore numbers between the Early Upper Palaeolithic and the Solutrean. Was man, another and perhaps competing large carnivore, responsible for this change?

animals, in the case of the hyæna and leopard, is, according to Kruuk (1972), quite different from what lions and wild dogs prefer to kill today in East Africa. They take a much smaller proportion of young prey. Again this criterion corroborates our interpretation that in the earlier levels bones were accumulated by hyæna although the leopard too cannot be excluded. Man and lion, both of which hunt in groups, would seem less likely candidates in the two early levels.

What is known from the Iberian Pleistocene? At Cova Negra (Valencia), Villaverde et al. (1996) noticed that levels with a predominance of carnivore marks on the bones show a greater representation of infant as well as old cervids. It is unclear at present why there are so few "old" cervid remains at Caldeirão in the early levels, though it may simply be a matter of sampling. Altuna and Mariezkurrena (2000) studied the animal remains from Labeko Koba, an Upper Palaeolithic cave in the Basque region of Spain, where they found abundant *Crocuta* remains (30% of the animal bones were of this taxon) as well as numerous coprolites. They suggest that their preferred prey at that time were horses, most of which were juveniles. These hyænas also took red deer and the larger bovid species whose remains were mainly derived from juvenile animals.

Cut and burn marks.

The presence of cut marks on bones is generally considered to be conclusive evidence of an association between people and the animal in question. At Caldeirão cut marks were observed on a small number of the bones in all levels, although these are probably under-estimated given the calcrete encrustations which made observation of surface features difficult if not impossible. Clearly people accumulated some of the faunal remains at all times. Burning of bones too, is evidence for man's presence in the cave. Burn marks are relatively scarce in the earlier levels, and common in the more recent ones – almost one in ten bone fragments in the Magdalenian show signs of burning (Figure 5). The fourfold increase of burnt bones between Early Upper Palaeolithic and Solutrean corroborates the notion of large carnivores being replaced by people as the main occupants of the cave.

The ratio fauna to stone tools.

Zilhão (1997) studied various quantitative aspects of the Caldeirão deposits such as the densities of fauna and stone tools (Figure 5). The small size of the artefact assemblages and the low bone-to-tools ratio in the Mousterian and EUP, suggests that people only used the cave intermittently. Moreover, the preponderance of barbs and points (these represent 50% of the retouched tools) in the small artefact assemblages contained in the latest EUP and earliest Solutrean levels suggests a specialized use of the site by humans – perhaps for hunting forays only. The faunal density and the ratio of tools-to-fauna are greater in the early Solutrean. Also, the different stages of lithic reduction systems are all represented in the abundant artefact assemblages recovered from Solutrean and Magdalenian levels, suggesting longer, perhaps seasonal occupations of a residential nature. This inference is consistent with the fact that human skeletal remains of adults, adolescents and children were found in the Solutrean deposits (Trinkaus et al., 2001), suggesting that the adjacent territory was frequented by family groups, not just specialized hunting parties. Zilhão concluded that this change in the nature of the human use of the site, coupled with the decrease or even complete disappearance from the faunal assemblage of the large carnivores after circa 21,000 years ago indicates an intensification of the human use of the cave at that time. (This aspect of the study is incomplete as the Middle and Upper Solutrean and Magdalenian levels have not yet been studied quantitatively in this way. Qualitative observations, however, are fully consistent with this view of the site's stratigraphic sequence.) In other words, while animal predators like hyænas were significant bone accumulators in the Mousterian and Early Upper Palaeolithic, their role declined subsequently when people occupied the cave more intensively.

The ratio of small unidentifiable fragments to identified bone.

A count of the numbers of unidentified fragments of bone (most are fairly small and measure one or two centimetres) compared to the numbers of identified bones revealed an interesting trend (Figure 5). The relative numbers of fragments increased substantially in the Magdalenian. Does this trend have something to do with the feeding behaviour of the occupants of the cave? Both people and bone-eating carnivores such as hyænas break long bones in order to gain access to the marrow. While the hyæna swallows and digests many of the resulting fragments, people do not.

With hyænas present in the early levels, many of the small chips of bone disappeared through complete digestion in their stomachs. But with their absence in the later times, all chips remained as part of the faunal assemblage. We are unsure of the validity of this criterion and as far as we are aware it has not been studied in modern hyæna dens. Moreover, there are no similar changes in the ratios of small to large identified parts of the skeleton.

Another possible agent!

Until recently it seemed most reasonable to assume that hyænas were mainly responsible for many of the bones accumulated in the cave in the Mousterian and EUP. However, recent studies (Robert and Vigne, 2002) in Corsica indicate

Figure 7 – An X-ray image of a living bearded vulture showing the presence of a metapodial (probably caprine), within the oesophagus. From Terrasse, J.-F. (2001; 57). *Le gypaète barbu*. Ed Delachaux et Niestlé S.A. Lausanne Paris. 208 p.

that partially digested ungulate bones in rock shelters and caves may also be derived from the feeding activities of the Bearded vulture – *Gypaetus barbatus*. This scavenging vulture is now extremely rare in Europe being confined to the Pyrenees, Corsica, Crete and parts of the Balkans and the Alps (Hagemeijer and Blair, 1997). It has probably been scarce throughout most of the 20th century and this may explain why many zooarchaeologists interested in the origin of bones in cave deposits have tended to ignore this bird. Until the end of the 19th century it was widespread in the Iberian Peninsula (Hernández and Morales, 1995; Heredia and Heredia, 1991; Cano and Valverde, 1959; Donázar et al., 1993). The Bearded vulture is known to feed on the bones of juvenile large mammals such as calves, and both juvenile and adult medium-sized mammals such as caprines like sheep, goat and wild mouflon (Figure 7). In the late Pleistocene of Corsica, this bird almost certainly consumed bones of the endemic deer, *Megaloceros cazioti* (Robert and Vigne, 2002). In order to gain access to the marrow, large bones and partial carcasses may be carried to some height by this bird and then dropped so that they break on impact. Moreover these birds are capable of swallowing bones as large as caprine metapodials (a bone that may be some 15 or more centimetres long)! Extensive studies of their nesting eyries in Corsica were undertaken by Isabelle Robert (Robert and Vigne, 2002). The Corsican data showed not only that these birds concentrate upon medium and large – sized ungulates, but that they leave a signature on the assemblage which is similar to that left by mammalian carnivores such as hyænas. For example short compact bones like carpals, tarsals and phalanges, are well represented in their accumulations. Terminal (hoof) phalanges are especially common, much more so than proximal and central phalanges, presumably because their partial covering by the keratinous hoof helps to protect these bones from the bird's strong digestive juices. Digestion marks are also common especially on the proximal parts of the phalanges (Figure 8). A recent examination by Robert of some of the Caldeirão bones suggests that this bird may have been

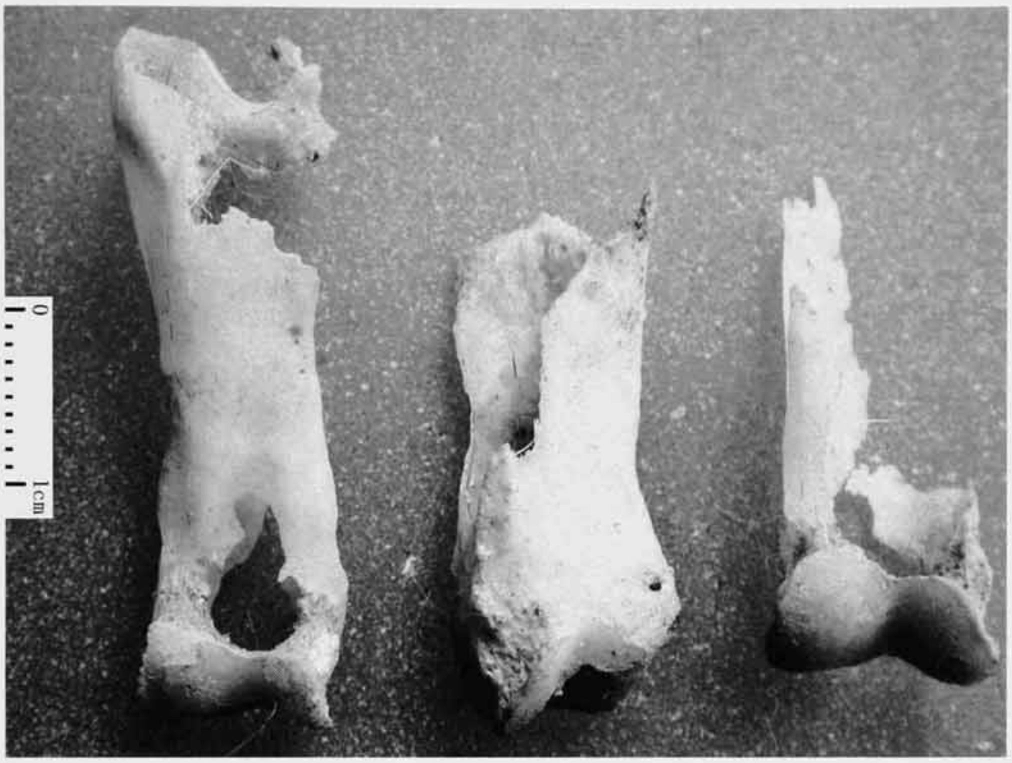

Figure 8 – Partially digested proximal phalanges from a modern bearded vulture nest in the Spanish Pyrenees. Photo Isabelle Robert.

present at Caldeirão at least occasionally. She identified a second phalanx of Bearded vulture in the Mousterian, and a terminal phalanx from the Solutrean perhaps of this species. The high count of red deer terminal phalanges compared to proximal and central ones in the Mousterian and Magdalenian is also of interest. The results are by no means as marked as in the bearded vulture nests in Corsica (see Figure 2 of Robert and Vigne, 2002), but the possibility of an occasional presence of this bird at Caldeirão needs to be considered.

To conclude the study of the Caldeirão cave fauna it is reasonably clear that in the early stages of its occupation, it functioned in part as a large carnivore den (Davis, 2002; Davis et al., 2007). Hyænas were mainly responsible for accumulating the animal bones but leopards and bearded vultures may have played a role too. Then, after the Early Upper Palaeolithic, the cave functioned primarily as a human 'home' – people had become more numerous. The gradual usurping of the role of large mammalian carnivores by people in the course of the Late Pleistocene, a pattern also recognized in the Spanish Mediterranean region, was perhaps the beginning of a more generalised increase of human population as Aura Tortosa et al., (2002) also suggest. They observe an increase from 0,1 to 6,3 archaeological sites per millennium from the Middle Palaeolithic to Epipalaeolithic in Mediterranean Spain as well as a marked increase of fish, marine molluscs and birds at Nerja cave (see also Morales et al., 1998).

Contemporary "demographic pressure" in Israel, as indicated by an increased cull of juvenile gazelle and a shift to smaller mammal, fish and bird exploitation, has also been suggested (Davis, 1989; 2005a). And it was no doubt this "pressure" that forced hunter-gatherers to begin husbanding crops and animals – a strategy that, although requiring a much greater labour input, would increase the carrying capacity of the environment.

3.3. Question 3: Can we interpret human feelings through animal remains?

The relationships that people established with the animal kingdom in the course of time cannot simply be reduced to those of predator/prey – hunter/consumer. The archaeological record, and especially mortuary contexts, provide many examples that can be interpreted as a form of expression of human feelings through and to animal remains (O'Day et al., 2004). Apart from ornaments and many other kinds of artefacts made of bone, tooth or antler, which can be interpreted as indicating personal identity within a group, there are at least two other situations worth considering. First, faunal remains that represent food offerings, and second, carcasses, perhaps of animals killed on purpose, to be buried alone or with a human. Interpreting the former appears to be straightforward since they are usually an expression of the care of loved ones in afterlife. However, the intentions, beliefs, feelings and even symbolic meaning behind animal burials of the second type are more difficult to understand. Another possibility that cannot be entirely excluded is the possibility of both – as will be illustrated by one of our case studies.

Lagar Velho I child burial, Lapedo Valley (Leiria).

Associated with the Lagar Velho I child (Zilhão and Trinkaus, 2002), buried in this rockshelter of the Lapedo valley some time between c.25,000 and c.24,500 BP, the partial carcass of an immature rabbit was found (Moreno-García, 2002a). This is perhaps one of the earliest evidences of the kind in Portugal. A sequence of thoracic and lumbar vertebrae almost in anatomical connection, together with 11 nearly-complete ribs from both sides of the animal's body, were in direct contact with the child's right and left tibiae (Figure 9). They were all stained with red ochre, which can only be explained if the rabbit had been intentionally placed together with the child, over the shroud covering the body. Other rabbit bones recovered in the fill of the grave pit (see Table 8.4 in Moreno-García, 2002a) also presented the ochre coloration. Thus, it was proposed that they all belonged to a single animal and that the processes of decomposition had led to their displacement within the mortuary complex. The meaning of such an offering is open to speculation – was the selection of a juvenile rabbit as a funerary gift made on purpose since the deceased was a child? Did it have any symbolic meaning other than being a meat offering?

Figure 9 – Lagar Velho I child excavation. Detail of the lower part of its legs showing the rabbit lumbar vertebrae in direct contact with the tibiae.

Dog burial at Anta 3, Santa Margarida Herdade (Reguengos de Monsaraz, Évora).

This second example shows a personal relationship between humans and canids that had already been in existence for many millennia as evidenced by the association of their remains in archaeological contexts (Davis and Valla, 1978; Tchernov and Valla, 1997). The Anta 3 of the Santa Margarida Herdade was constructed during the early part of the 3rd millennium BC and rebuilt and reused during the last quarter of the same millennium (Gonçalves, 2003). During this last chronological period the funeral deposition Cm-3 presents a clear record of that emotional bond: a woman of 40-45 years of age was buried next to a young c.18 months old dog. Due probably to the violations that the structure suffered during the Middle Ages, only the hind limbs and three isolated teeth have survived (Figure 10). Both the female human skeleton and the dog were radiocarbon-dated and found to be

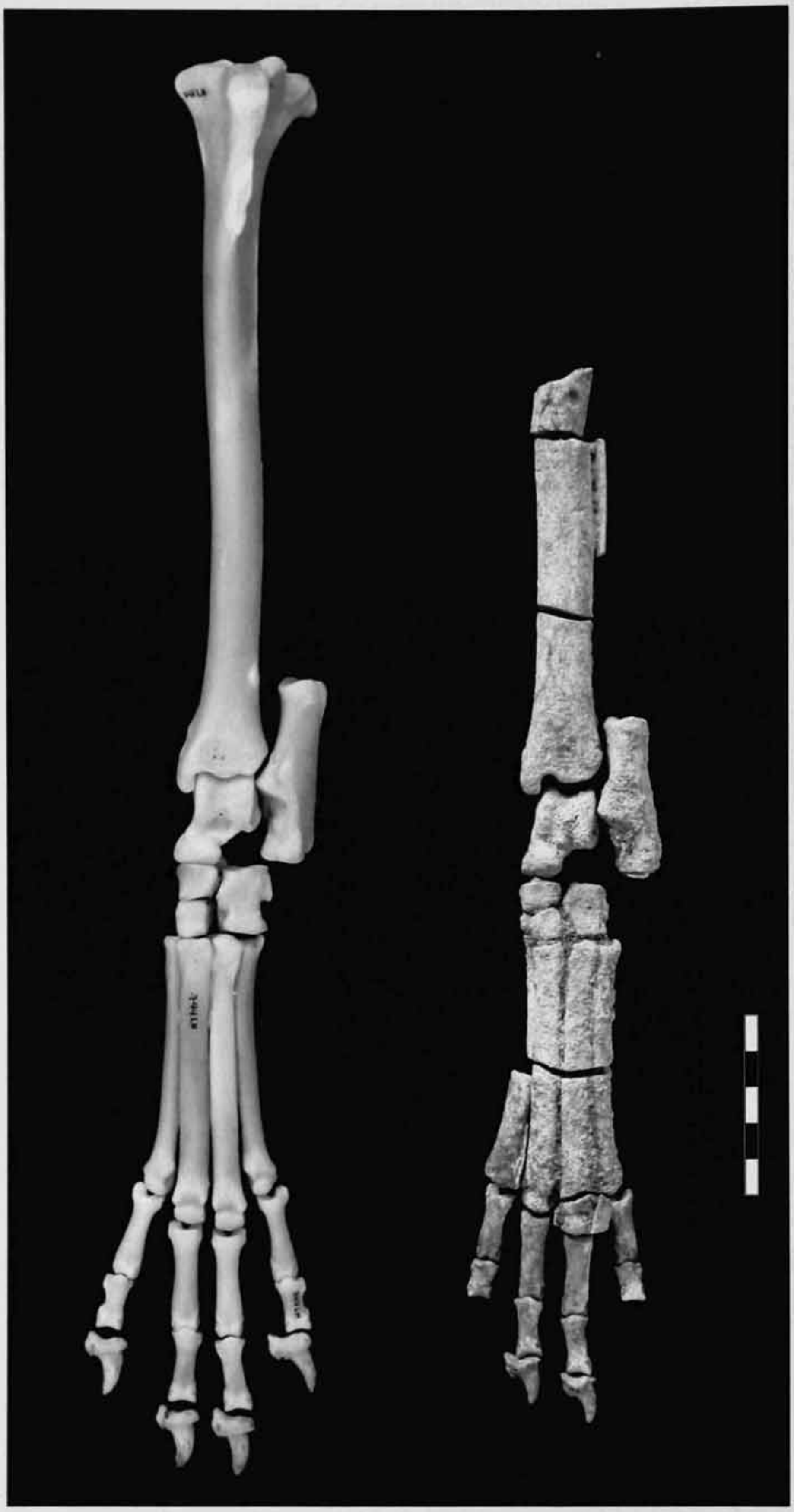

Figure 10 – Anta 3 at the Santa Margarida Estate (Reguengos de Monsaraz). From left to right, hind limb of modern dog from the reference collection (CIPA N.° 744) and the dog remains found together with funeral deposition Cm-3.

contemporary (human sample ^{14}C 3780±40BP, 2280-2140 cal BC 1σ, BETA 166418 and dog sample ^{14}C 3720±50BP, 2200-2030 cal BC 1σ, BETA 166420), leaving no doubt that it was part of the funerary context (Moreno-García, 2003a).

A similar case was reported in the north of the Iberian Peninsula, in the Gruta de Marizulo (Urnieta, Guipúzcoa, Spain; Altuna, 1967). Under a human funerary deposition, dated to 5285±65 BP, the partial skeleton of a dog and a three month old lamb were recovered (Altuna, 1994). These two were interpreted as clear evidence for an affectionate bond between a shepherd and his dog.

3.4. Question 4: When did certain species become extinct and when were others introduced?

Extinctions.

Very large pachyderm (proboscid and rhinocerotid) mammals like *Elephas* and rhino, better known in the Middle Palaeolithic, had clearly become extinct by or during the Upper Pleistocene. The find of *Elephas antiquus* from a Middle Palaeolithic context probably represents the last occurrence of this species in Western Europe (Brugal and Valente, 2007). Taxa such as hyæna, lion and leopard probably became extinct towards the end of the Pleistocene. As already suggested, their absence from the later periods at Caldeirão does not necessarily mean that they had gone extinct. Rather, they may have lingered on but seldom fell victim to man's hunting. Hence they are not visible in the archaeological record. It is likely that early man regarded these large ferocious beasts as dangerous competitors and therefore did his utmost to bring about their demise. Large carnivores like the bear, while not found in the later levels at Caldeirão, certainly did survive in Portugal as is evidenced by the 13th century AD bear metapodial from Alcáçova de Santarém (Davis, 2006). According to historical sources their populations began to decline during the 15th century. Fernão Lopes in his "Chronica de el-Rei D. Fernando" writes that there was no lack of bears in the Beira region, especially in the Riba Côa (Saraiva, 1969, p. 112). Bears survive to this day in Cantabria and the Pyrenees. Similarly no remains of the chamois (seemingly absent after the Magdalenian) have been recognised in the large collections of faunal remains from sites like Penedo de Lexim, Alcáçova de Santarém, Silves *lixeira*, and Mercador. This animal, like the bear, survives today in northern Spain and so it may well have lingered on in Portugal (perhaps in the forests of the north) for some time well into the Holocene. Brugal and Valente (2007) suggest that the scarcity of this animal may be due to its rather secluded location in elevated regions. Whether its absence here in those later times signifies its extinction or merely its failure to be captured by human hunters remains to be seen. The horse also declined in numbers and supposedly became extinct after the Magdalenian to be reintroduced subsequently as a domestic animal perhaps before or during the Chalcolithic.

Besides the horse, another but smaller species of equid once inhabited southern Europe – the so-called Otranto ass or *Equus hydruntinus*. It was first described from Upper Pleistocene Apulia, Italy, by Regalia (1907). Cardoso (1993a) describes two upper molars of this species from a site near Loures dated to "late Würm" and it is also reported from three sites in Spain (Geraads, 1997). A small somewhat pointed equid terminal phalanx from Caldeirão cave (Figure 16 in Davis, 2002) may also have belonged to this species. There is a curious and interesting link between dental morphology and language: the pattern of enamel folds of *E. hydruntinus* teeth is identical to that of the present-day African zebras, though genetic analyses indicate *E. hydruntinus* may have been closer to the Asiatic half-asses (Orlando et al., 2006). The word zebra in the English and French languages is of probable Portuguese or Spanish etymology (Rey, 1993), and presumably refers to a mysterious wild equid thought to have become extinct in the Iberian Peninsula in medieval times and applied to the zebras when first seen by the newly arrived Portuguese in Africa during the age of discoveries. Was *E. hydruntinus* the so-called '*zebro*'? Indeed, was it a zebra and did it have stripes? This could be an interesting topic to bear in mind for future study.

Another formidable animal, presumably once quite common, is the wild cattle or aurochs, known to have inhabited the southern part of the Iberian Peninsula at least until the Chalcolithic, perhaps even a little later (Castaños Ugarte, 1991; Estévez and Saña, 1999). As Driesch and Boessneck (1976) demonstrated, and as can be seen in Figures 11 and 12, bones of the aurochs are considerably larger than those of domesticated cattle and generally plot out in graphs as a well defined separate peak. Hence a clear distinction is often possible between bones of the wild and domesticated forms. While we should keep an open mind about the possibility of aurochsen surviving beyond the Chalcolithic, so far our osteometric data fail to provide any evidence for this animal in Iron Age and later times – there are no large specimens of *Bos* bones or teeth that plot out as a separate peak in the post-Chalcolithic samples (see also below). No doubt the Chalcolithic or Bronze Age (the latter, a period from which we have few data) saw the extinction of this animal – the last specimen of which disappeared in 1627 AD near Warsaw, Poland (Guintard, 1998).

Thus the number of large herbivore species decreased by the end of the Palaeolithic with only five or six surviving into the Holocene – red and roe deer, wild boar, wild goat, aurochs and perhaps the horse. These survivors are "temperate

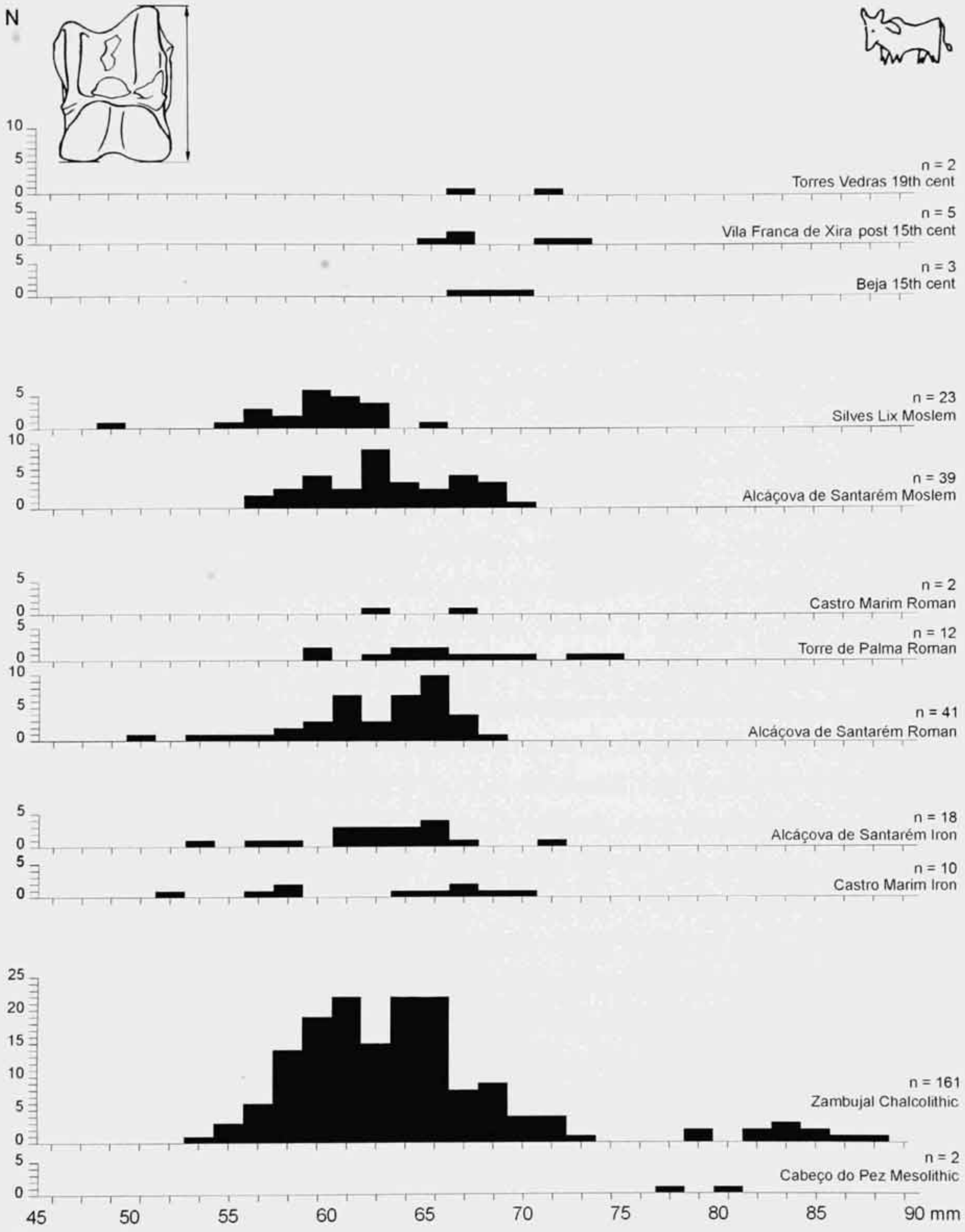

Figure 11 – Cattle size variation in southern Portugal in the course of time – wild versus domestic distinction and the evolution of cattle size. Stacked histograms of measurements of the greatest lateral length (GLl) of astragalus of aurochsen and cattle from the Mesolithic and Chalcolithic (data from Zambujal are from Driesch & Boessneck, 1976), Iron Age, Roman, Moslem and 15th century AD Beja, as well as a few astragali from post 15th century sites. "n" refers to sample size. Note the very large size of the Mesolithic specimens, as well as the almost separate peak of 11 large specimens in the Chalcolithic all presumed to have belonged to aurochsen. The bulk of the specimens being of smaller size are presumed to be of domestic cattle. Note too the absence of any significant size change between Iron Age and Moslem times of these presumed domestic cattle and the subsequent increase by the 15th century AD, although these did not attain the great size of the aurochs.

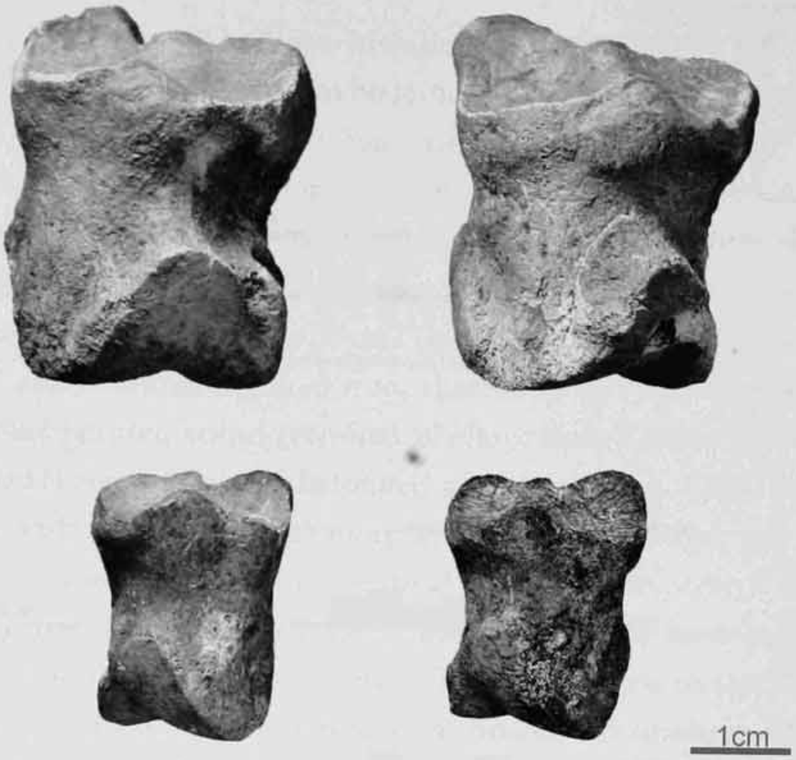

Figure 12 – Mercador (Mourão). Fossa 66 (UE 1017 & UE1022). Above, two second phalanges of aurochs *(Bos primigenius)* and below, two of domestic cattle *(Bos taurus)*. Note the difference in size.

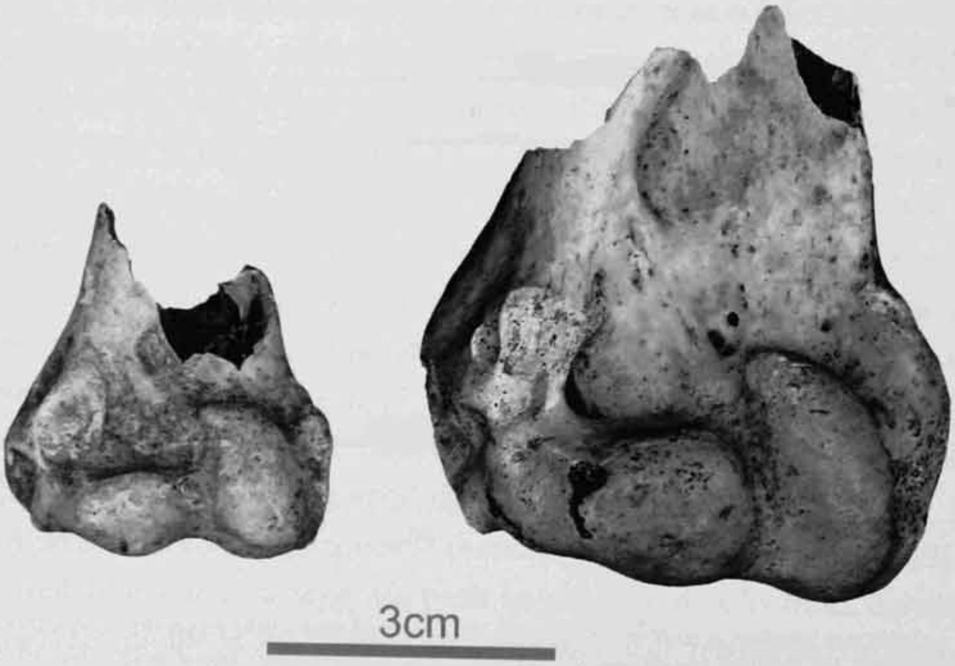

Figure 13 – Two birds now sadly extinct in Portugal in the wild. These two distal humeri, found at Alcáçova de Santarém, are identified as swan (the smaller bone on the left; 1999 UE 162 Roman 2) and pelican (the larger bone on the right; 1999 UE 210, Moslem).

elements found in all southern mammal associations..." (Brugal and Valente, 2007).

Clearly in the recent past Portugal, like most other parts of Europe, once possessed a wider spectrum of bird species. Just to give three examples: at Alcáçova de Santarém swan and pelican (Figure 13) were found in Roman and Moslem levels respectively. Remains of the bearded vulture were found from the Chalcolithic site Penedo de Lexim (Moreno-García, forthcoming).

Introductions.

Zooarchaeology provides a long-term view of an increasingly worrying side effect of man's ability to navigate the oceans. With the ease of transport, geographical barriers today have little relevance. It is clear that once people began navigating the high seas, not only were farm animals and pets transported, but other alien animals and plants were spread, often as accidental stowaways (see articles in Vigne, 1997). The inevitable result is the complete mixing of faunas and floras worldwide. The Iberian Peninsula is no exception and it too has served as a destination for exotic animals, introduced either on purpose or by accident. Table 3 provides a list of introductions into the Iberian Peninsula with the dates of their first occurrences. For some of the domesticated animals like dog, cattle, goat and pig whose wild ancestors were or still are present in Portugal it is difficult to know whether they were introduced from outside Portugal as domesticated animals or whether the wild animals were domesticated locally as first suggested by Estácio da Veiga (1887) and now by Larson et al., (2007) for pigs in northern Europe. Perhaps both happened – with domesticated stock being brought in and some interbreeding occurring with the local wild animals. Genetic evidence for this kind of occurrence is reported for cattle introduced from the Near East into central Europe (Götherström et al., 2005). In the case of the sheep however, the absence from Europe of any wild progenitor in the early Holocene means that archaeological remains of this animal in Europe must derive from animals originally domesticated in the Near East (Zeuner, 1963; Nadler et al., 1973; Hiendleder, 2002). Indeed sheep first arrived in Portugal from the east in the Neolithic – perhaps by a maritime route (see Zilhão, 2000; 2001b).

Another large mammal is the donkey, presumably introduced from the Near East or North Africa by the Phoenicians. The first reliable finds of donkey in the Iberian Peninsula date to the Iron Age. These include specimens from Rocha Branca (Silves, Algarve; Cardoso, 2000b), Alcáçova de Santarém (Davis, 2006); Castro Marim (Algarve; Moreno-García, forthcoming); Toscanos, Cerro de la Tortuga (Málaga, Andalucía; Uerpmann and Uerpmann, 1973), La Mota c. 610

Species	Culture/period Date	Locality	References
Dog*	**Mesolithic?**		
(*Canis familiaris*)	5285 BP (earlier dates uncertain, see Altuna 1980)	Marizulo Level II (Urnieta, Guipúzcoa)	Altuna 1980
Sheep (*Ovis aries*)	**Neolithic**		
Goat* (*Capra hircus*)		Numerous	Zilhão 2001
Cattle* (*Bos taurus*)		Caldeirão (Ribatejo)	Davis 2002
Pig* (*Sus scrofa*)			
Horse*(*Equus caballus*)			
House mouse	**Phoenicians**		
(*Mus domesticus*)	7th-3rd centuries BC	El Soto de Medinilla and La Mota (Valladolid)	Morales Muñiz *et al.* 1995a see also Cucchi *et al.* 2005
Donkey	**Phoenicians**		
(*Equus asinus*)	Iron Age	Rocha Branca (Silves, Algarve)	Cardoso 2000
		Muru-Astrain (Pamplona, Navarra)	Castaños 1988
		Ubierna (Burgos, Castilla and León)	Castaños 1989
	c. 610 BC	Toscanos, Cerro de la Tortuga (Málaga, Andalucía)	Uerpmann & Uerpmann 1973
		La Mota (Valladolid province, central Spain) Hoya (Laguardia, Alava, Basque region)	Morales Muñiz *et al.* 1995a Altuna & Mariezkurrena 1986
		Castillo de Doña Blanca Level X (Bay of Cádiz, Andalucía)	Roselló & Morales 1994
	600-575 BC	Castro Marim (Algarve)	Moreno-García (unpub.)
Chicken	**Phoenicians**		
(*Gallus gallus*)	Iron Age	Muru-Astrain (Pamplona, Navarra)	Castaños 1988
	Early 8th century BC	Castillo de Doña Blanca (Bay of Cádiz, Andalucía)	Hernández Carrasquilla 1992
Ostrich	**Phoenicians**		
(*Struthio camelus*) -egg shell	6th-4th centuries BC	The southern part of the Iberian peninsula in the region between La Joya, near Huelva in western Andalusia, and the Carthaginian necropolis, el Puig des Molíns, on the island of Ibiza in the east	San Nicolás 1975; Mayor 1996-7; Harden 1961
	6th-5th centuries BC	Castro Marim (Algarve)	Davis 2007
	-mid-8th century BC	Castillo de Doña Blanca (Bay of Cádiz, Andalucía)	Roselló & Morales 1994
Fallow deer	**Romans**		
(*Dama dama*)	3rd-5th centuries AD	São Pedro Fronteira, and Torre de Palma (Alto Alentejo)	Davis 2005b; Davis & MacKinnon 2009
Camel	**Romans**		
(*Camelus*)	3rd-4th century AD	Imperial Period, Conimbriga (Coimbra, Centro)	Cardoso 1992;
	c. 70-80 AD	Complutum, near Madrid El Val, near Complutum; Cartago Nova (Murcia)	Morales Muñiz *et al.* 1995b;
	'Roman – republican'	Mértola (Baixo Alentejo)	Moreno-García (pers. observation)
Genet	**Moslems**		
(*Genetta genetta*)	13th century AD	Mértola (Baixo Alentejo)	Morales 1994
Mongoose	**Moslems**		
(*Herpestes ichneumon*)	11th-13th century AD	Nerja cave (Andalucía)	Riquelme-Cantal et al. 2008

* the wild ancestors (or closely related species) of these important domesticated mammals were present in the Iberian Peninsula in prehistoric times before domestication. For many of them, distinguishing between the wild and domesticated forms is difficult or impossible when working with archaeological fragments of their bones and teeth. Hence it is difficult at this stage to state with certainty just when they were domesticated in the Iberian Peninsula or when they were introduced as domesticated livestock.

Table 3 – Mammals and birds introduced by humans into the Iberian Peninsula during the Holocene. This list provides the first recorded occurrences of certain important taxa of mammals and birds with their location and date/period, where known. The culture/period associated with the introduction is also given.

BC (Valladolid province, central Spain; Morales Muñiz et al. 1995a), La Hoya (Laguardia, Alava, Basque region of Spain; Altuna and Mariezkurrena, 1986), and Castillo de Doña Blanca Level X: 600-575 BC (Roselló and Morales, 1994). These Iron Age donkey remains may well bear witness to the activities of this maritime people.

It is interesting that this was the time when ostrich egg shells are first reported from a number of sites both here (Tavira and Castro Marim; Figure 14; Pimenta and Moreno-García, 2007b; Davis, 2007) and in southern Spain. The ostrich, a bird found today in Africa, and until fairly recent times in the Near East, was absent from Europe in the Holocene. Archaeological finds of ostrich egg-shell are both geographically and chronologically restricted to the southern part of the peninsula between La Joya, near Huelva in western Andalucía, and the Carthaginian necropolis, el Puig des Molíns, on the island of Ibiza in the east. Most are dated to the 6th, 5th and 4th centuries BC and only very rarely are ostrich egg-shells found before or after that time span. They are usually decorated, and often form funerary objects. Most are found in sepulchres and are generally associated with the Phoenicians (San Nicolás, 1975). They supposedly had some kind of religious or magical property and may have served to provide a magic sustenance to the dead (see Mayor Ortega, 1996-7; Roselló and Morales, 1994). Several archaeologists have discussed the significance of ostrich egg-shell finds in the Iberian Peninsula (Mañá de Angulo, 1947; Harden, 1961; San Nicolás, 1975; Mayor Ortega, 1996-7). These authors note that there must have been a regular import of eggs from North Africa. Decorated cups and disks made of ostrich egg-shell apparently do not occur in the eastern Mediterranean, but abound on western Phoenician sites. Harden (1961) for example, mentions that at Carthage they are common between the 6th and 3rd centuries BC. Clearly the fragments from Tavira and Castro Marim, like the Moroccan pottery also recovered at the latter site (Arruda, 1997; 2003) provide further evidence for the existence of maritime trade between Algarve and North Africa.

Another animal also associated with the Phoenicians and first found here in the Iron Age is the chicken. The chicken, descended from the red jungle fowl (*Gallus gallus*), originally came from east and south-east Asia, where it was probably domesticated several thousand years before Christ (Zeuner, 1963: 444; Benecke, 1993). It was gradually brought across to the Mediterranean and Europe via the Middle East. Its spread across the Mediterranean is associated with the Phoenicians. Hehn (1888) makes the interesting point that Homer fails to mention this bird, and its first appearance in Greek literature is in Theognis (a poet from Megara in Sicily) in the latter half of the 6th century BC – a time when chickens

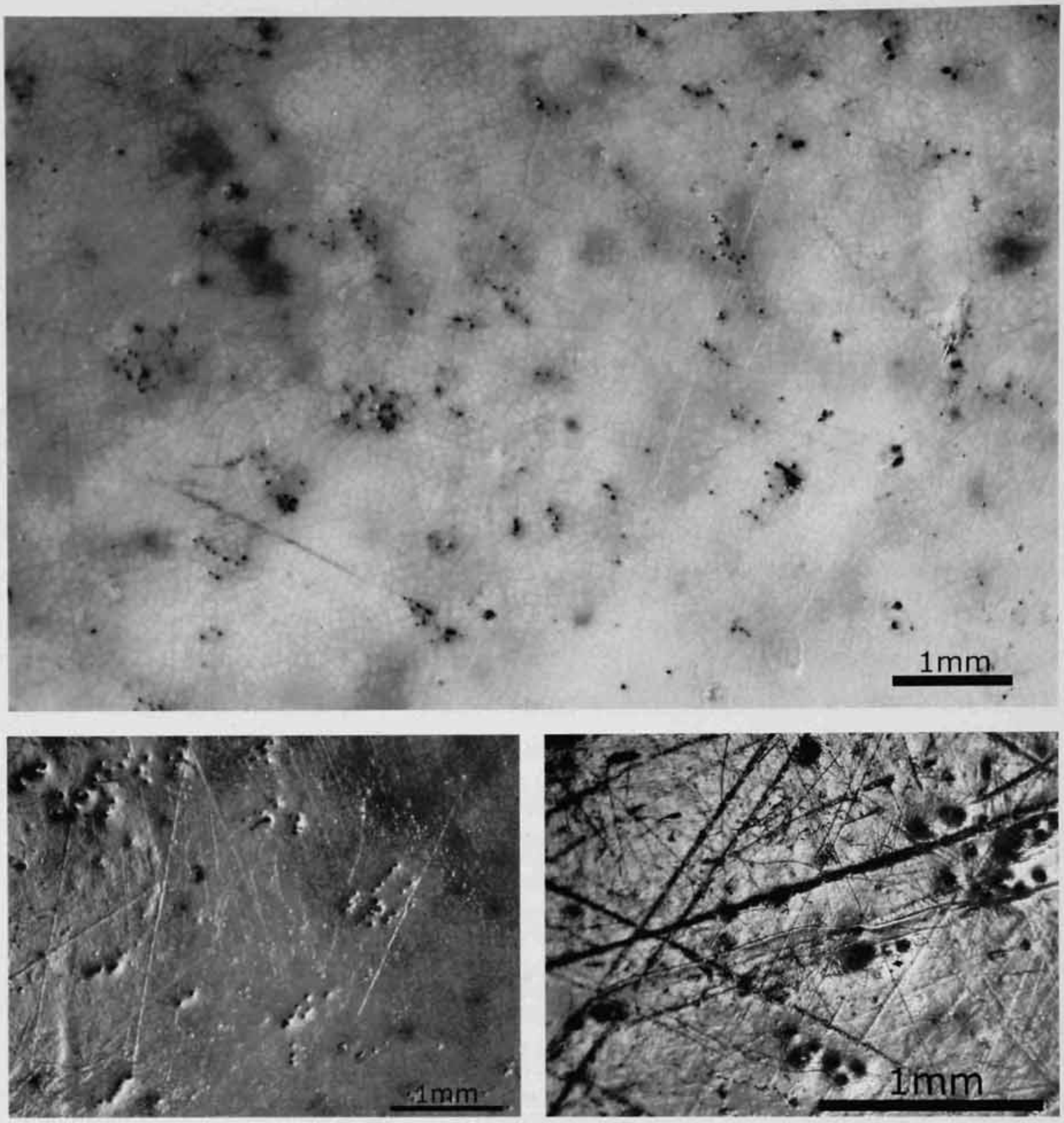

Figure 14 – Ostrich eggshell fragments from Iron Age contexts in Tavira. Details show traces of polishing and scratch marks on their external surface.

first appear on coins and vases in Greece, Sicily and Italy. The earliest evidence of chickens in central Europe dates to the late Hallstatt Age (Phase C and D; Benecke, 1993), *i.e.* approximately 700-450 BC. According to Hernández Carrasquilla (1992), the earliest evidence for chicken in Iberia is during the first part of the Iron Age when its remains appear only in Phoenician sites or sites with Phoenician influence. The oldest reliable date of chicken in Iberia comes from Castillo de Doña Blanca in the Bay of Cádiz early in the 8th century BC. Hernández Carrasquilla also observed that the earliest finds of this bird are in the southern part of Iberia where the Phoenicians sought metals, especially silver. Perhaps the arrival of chicken in the Iberian Peninsula before its apparent arrival in Greece could mean that it was brought here by sea direct from the eastern Mediterranean (*e.g.* Syria/Arabia). It is interesting that the chicken 'suddenly' appears in phase V of Castro Marim (Iron Age: second half 5th century-3rd century BC). Is this further evidence for the arrival of the Phoenicians in Castro Marim?

In chronological terms, there is an interesting correspondence between the arrival in the Iberian Peninsula of the chicken, the house mouse and the donkey! They all arrived in the western part of the Mediterranean at roughly the same time. For example the first reliable finds of house mouse in the Iberian Peninsula come from Iron Age levels (7th-3rd centuries BC) at El Soto de Medinilla and La Mota in Valladolid province of central Spain (Morales Muñiz et al., 1995a). Cucchi et al. (2005) have reappraised archaeological finds of this small rodent in sites in the Mediterranean area. They suggest that although the house mouse spread rapidly throughout the *eastern* part of the Mediterranean in the 8th millennium BC, its spread across to the *western* Mediterranean did not happen until the 1st millennium BC – a time when this region was fully opened to eastern influences and migrations. (They point out that maritime exchanges between eastern and western parts of the Mediterranean basin were rare until the beginning of the 1st millennium BC.)

Cardoso (1992), who studied the bones from the Roman site of Conimbriga, was the first to describe the presence of camel here in Roman times. To that find should be added a camel femur from Mértola (Moreno-García, unpublished). Camel is also known from a number of Roman sites in Spain (Morales et al., 1995b; Fernández Rodríguez, 2003) and it would seem that the Romans were fond of transporting large mammals around the Mediterranean basin and well beyond. Besides the camel, another interesting animal whose spread can now be associated with the Romans is the European fallow deer, *Dama dama*. Fallow deer were present in Europe during the Pleistocene. For example, Cardoso (1993a; 169) describes several very fragmentary remains of this species from the late Pleistocene of Portugal but fallow deer are not known in Portugal in the Holocene. This taxon had probably become extinct by the end of the Pleistocene only to be re-introduced in more recent times. Fallow deer is also unknown in many parts of Holocene Europe before Roman times and the Romans are often credited with its spread – perhaps from Asia Minor (Chapman and Chapman, 1975; 43-44 and see also Lepetz and Yvinec, 2002) and it is now reported from Roman Britain (Sykes et al., 2006). Unlike most cervids, the fallow deer is relatively easy to tame and keep in enclosures. For this reason it was, and still is, often kept in deer parks. Of some interest therefore is a small cervid tibia (Figure 15) found at a Portuguese Roman site –

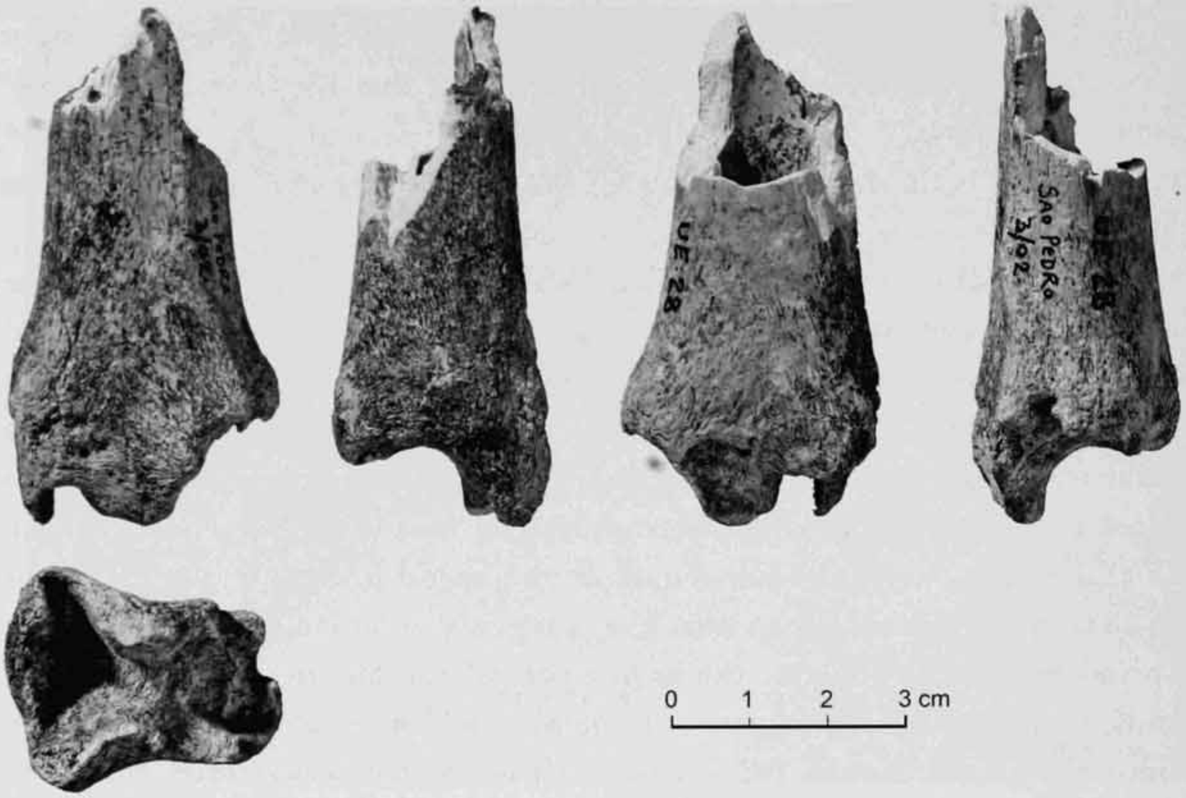

Figure 15 – The cervid distal tibia fragment (Roman; UE 28) from São Pedro Fronteira in anterior, medial, posterior, lateral and distal views. This probably belonged to a fallow deer, *Dama dama*.

São Pedro Fronteira (Davis, 2005b). Distinction between bones of fallow and red deer can be difficult due to their resemblance although fallow deer is somewhat smaller. The specimen from São Pedro Fronteira is rather small to belong to red deer (Figure 16) and is tentatively identified as fallow deer, *Dama dama*. Lister (1996) describes osteological criteria for distinguishing between red and fallow deer. His Figure 2 part 7 describes three characters that enable this distinction for the distal tibia. In all three characters the São Pedro specimen clearly identifies as fallow deer and it may well be the first evidence of fallow deer in this country in the Holocene. Work in progress at another nearby Roman site, Torre de Palma, indicates the presence there too of fallow deer (see Davis and MacKinnon, 2009).

The spread of Islam brought about the unification of a huge part of the Old World from India and China to the Maghreb and Iberian Peninsula. It is therefore of little surprise that the Moslems were able to introduce from the far-flung corners of their empire a substantial number of economically important exotic plants. They include a wide range of species such as sorghum, rice, sugar cane, cotton, Seville orange, lemon, lime, banana, coconut palm, watermelon, spinach, artichoke, aubergine and mango (Watson, 1983). Their cultivation is described in many of the agricultural treatises of the time such as Ibn al-'Awwâm's famous

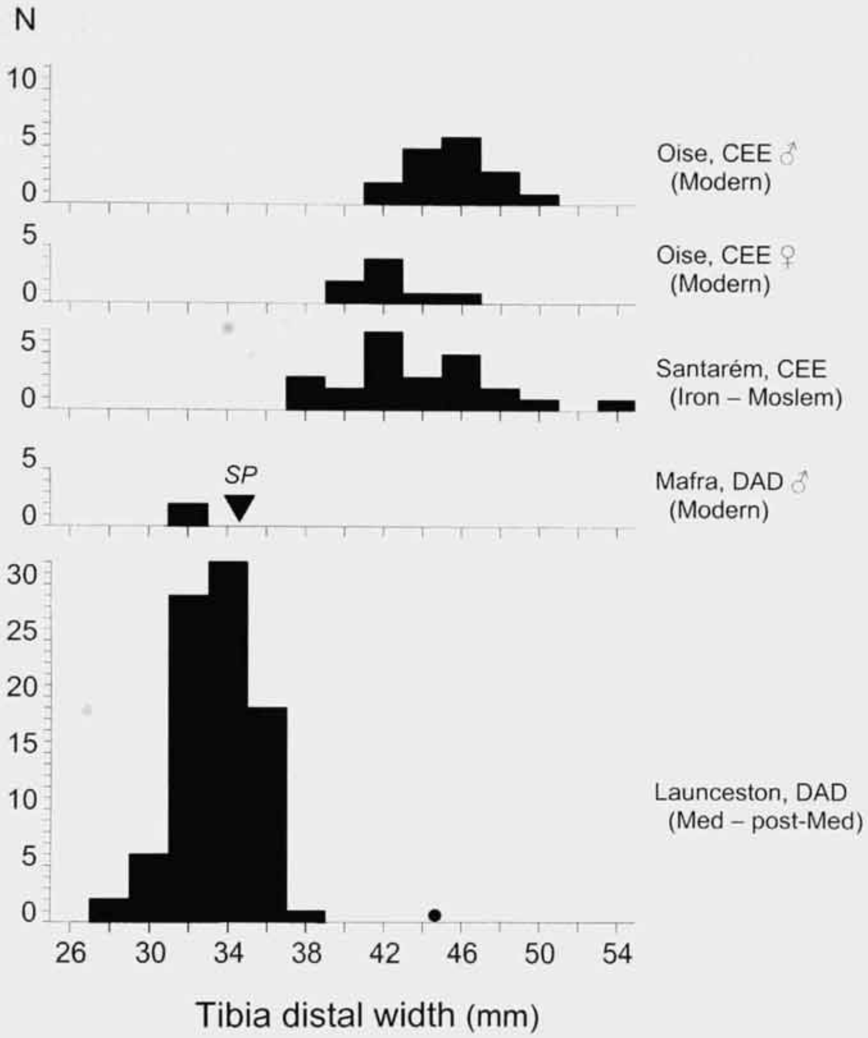

Figure 16 – Osteometric identification of the Roman cervid distal tibia (UE 28) from São Pedro Fronteira. A series of histograms of modern and archaeological red deer and fallow deer distal tibia widths. These show the size difference between these two species. CEE – *Cervus elaphus*, red deer; DAD – *Dama dama*, fallow deer. Samples are as follows from top to bottom:

- Red deer from the Oise, northern France, males;
- Red deer from the Oise, northern France, females;
- Red deer from Alcáçova de Santarém, Iron Age, Roman and Moslem periods;
- Two modern male fallow deer from Tapada de Mafra, Portugal;
- A large sample of medieval and post-medieval fallow deer from Launceston Castle, Cornwall, England (Albarella & Davis, 1996). A single large specimen identified as red deer is shown as a circle.

The São Pedro specimen, shown as an inverted triangle, is metrically more likely to have belonged to fallow deer than red deer. The modern red deer skeletons from the Oise are in the Muséum national d'Histoire naturelle, Paris.

Kitâb al-Filâha (Book of Agriculture), El Faïz (2000). As for animals we do not know to what extent the Moslems introduced exotic species into the Iberian Peninsula, though they may have introduced the genet. The earliest archaeological evidence for this animal comes from Moslem Mértola (Morales, 1994). And recently Riquelme-Cantal et al. (2008) report a find of mongoose dated to the Moslem period in Andalucía. Rather less direct and more speculative is the osteometric evidence (see below) for improved sheep in southern Portugal – perhaps they were the first Merinos supposedly introduced by Beni Merin Berbers from northern Morocco in the 11th/12th centuries AD (Klein, 1920).

We look forward to studying the important zooarchaeological collections uncovered in the Praça da Figueira, Lisbon and other post-medieval urban sites, to encounter osteological evidence for other well known introduced exotic taxa such as the turkey and the guinea fowl.

3.5. Question 5: How do the frequencies of the large prey species vary through time and why?

Table 4 and Figure 17 show how the frequencies of the medium to large-sized herbivores have varied in the course of time in the southern half of Portugal (work in progress). They show a number of interesting trends, some slight and others more marked.

In the earlier part of the sequence, red deer is clearly dominant which as Brugal and Valente (2007) suggest marks the cold conditions of the last glacial period. They also suggest that in general herbivore fluctuations reflect global climate changes, with a predominance of red deer, aurochs (in the Mousterian) and wild goat marking the cold conditions from Mousterian to Solutrean. The increase of wild boar in the Magdalenian could be related to deglaciation and climatic improvement (Brugal and Valente, 2007).

Perhaps the most drastic change that we can see in Figure 17 occurred between the Mesolithic and the Neolithic. This presumably marks the introduction of domesticated animals – most notably sheep, goat and cattle whose frequencies rise as those of red deer fall even further to less than 10%. In other words the bulk of the terrestrial meat supply from Neolithic times onwards derived from four species of medium/large sized herbivores – cattle, sheep, goat and pig. This may also mean that the hunting pressure on wild mammals like the red deer was relaxed after the Mesolithic and could explain why the size of that animal increased afterwards (although they did not return to their former late Pleistocene size; see Figure 12 in Davis, 2002). As one might expect, another domestic animal whose frequencies are high during and after the Neolithic is the pig. However a closer look at the percentages of different taxa in the preceding Mesolithic period reveals a high percentage of *Sus* in that period too! This requires some explanation. It must surely reflect an increase in the hunting of this still wild animal. Pigs and wild boar are well known for their high reproductive capacity. A wild boar sow can produce litters as large as 12, though the average is four to eight (Dewey and Hruby, 2002). They would therefore be better able to withstand increased predation than would the slower reproducers like aurochsen,

Site	Period	Date (yrs BC/AD) where known	Equus	Cervus	Capreolus	Sus	Bos	Rupicapra	Capra/Ovis	Rhino	Elephantid	N
Rua 5 Outubro 33, Crato (M-MG 2002b)	Post-Medieval	16 cent AD	1	2	0	44	19	0	52	0	0	118
Évora (Antunes 2004)	Medieval	15 cent AD	6	1	0	67	169	0	215	0	0	458
Silves(Gomes et al 1996)	Medieval	15 cent AD	1	3	0	22	24	0	127	0	0	177
Conv S. Francisco Santarém (M-MG & SD 2001)	Moslem	11 - 12 cent AD	6	5	0	0	54	0	155	0	0	220
Silo 1 P. Concelho Torres Vedras (Gabriel 2003)	Moslem	12 cent AD	1	0	0	104	20	0	75	0	0	200
Castelo de Silves (Antunes 1991)	Moslem (Almoravid)	11 - 12 cent AD	0	0	0	0	9	0	76	0	0	85
R. Correeiros Lisbon (M-MG & Gabriel 2001)	Moslem	10 - 12 cent AD	3	2	0	2	19	0	68	0	0	94
Mértola (Morales 1993)	Moslem	?	1	4	0	0	42	0	180	0	0	227
Alcáçova Mértola (M-MG & Pimenta in prep)	Moslem	12 cent AD	0	8	0	38	18	0	1645	0	0	1709
Mértola – casa II (Antunes 1996)	Moslem	?	14	1	0	4	23	0	133	0	0	175
Mesas do Castelinho Almodôvar (Cardoso 1993b)	Moslem	9-10 cent AD	0	101*	0	0	4	0	90	0	0	195
São Pedro Canaferrim (SD 2005)	Moslem	9 - 12 cent AD	0	28	0	3	14	0	120	0	0	165
Silves *lixeira* (SD in prep)	Almohad Moslem	12 - 13 cent AD	57	37	0	2	515	0	2038	0	0	2649
Alcáçova de Santarém (SD 2006)	Moslem 1	9 - 12 cent AD	78	119	3	255	808	0	1546	0	0	2809
Castelo de Silves (Antunes 1997)	Moslem	8 cent AD	0	0	0	0	5	0	239	0	0	244
São Pedro Fronteira (SD 2005)	Roman	3 - 5 cent AD	0	9	0	9	19	0	22	0	0	59
Alcáçova de Santarém (SD 2006)	Roman 2	1 cent BC – 1 cent AD	5	72	0	132	210	0	308	0	0	727
Alcáçova de Santarém (SD 2006)	Roman 1	2 cent AD	17	76	0	205	329	0	489	0	0	1116
Castro Marim (SD 2007)	Roman	1 cent BC – 1 cent AD	2	13	0	24	16	0	33	0	0	88
Castro Marim (M-MG in prep)	Roman	1 cent BC – 1 cent AD	0	56	0	129	81	0	169	0	0	435
Alcáçova de Santarém (SD 2006)	Iron 8	3 cent BC	10	84	0	165	336	0	348	0	0	943
Rocha Branca, Silves (Cardoso 1993c)	Iron Age	7 - 6 cent BC	40	15	0	20	66	0	35	0	0	176
Abul, Alcácer do Sal (Cardoso 2000a/b)	Iron Age	7 cent BC	0	6	0	26	40	0	61	0	0	133

Site	Period	Date (yrs BC/AD) where known	Equus	Cervus	Capreolus	Sus	Bos	Rupicapra	Capra/Ovis	Rhino	Elephantid	N
Almaraz, Almada (Cardoso 2000b)	Iron Age	7 cent BC	1	1	0	24	125	0	275	0	0	426
Alcáçova de Santarém (SD 2006)	Iron 1-7	8-4 cent BC	9	119	0	129	139	0	247	0	0	643
Castro Marim (SD 2007)	Iron (ph V)	5-3 cent BC	1	24	0	37	43	0	153	0	0	258
Castro Marim (M-MG in prep)	Iron (ph V)	5-3 cent BC	4	83	0	282	217	0	613	0	0	1199
Castro Marim (SD 2007)	Iron (ph II-IV)	8-6 cent BC	1	23	0	68	75	0	244	0	0	411
Castro Marim (M-MG in prep)	Iron (ph II-IV)	8-6 cent BC	8	140	0	442	344	0	1174	0	0	2108
Penedo de Lexim (M-MG in prep)	Bronze	End 2nd millennium BC	5	0	0	104	10	0	115	0	0	234
Zambujal 3+4 (Driesch & Boessneck 1976)	Late Chalcolithic		125	932	5	9120	5347	0	8410	0	0	23939
Castro da Fornea, Torres Vedras (Driesch 1973)	Chalcolithic		11	20	0	48	27	0	14	0	0	120
Penedo de Lexim (Driesch & Richter 1976)	Chalcolithic	3 millennium BC	0	31	0	601	426	0	679	0	0	1737
Penedo de Lexim (M-MG in prep)	Chalcolithic	1st half 3 millennium BC	1	26	0	1464	79	0	1431	0	0	3001
Monte da Tumba (Antunes 1987)	Chalcolithic	4-3 millennium BC	4	48	5	145	33	0	109	0	0	344
Leceia (Cardoso & Detry 2001-2)	Chalcolithic		2	124	0	3512	2135	0	5245	0	0	11018
Mercador (M-MG 2003)	Chalcolithic	3 millennium BC	53	131	1	846	130	0	258	0	0	1419
Zambujal 1+2 (Driesch & Boessneck 1976)	Chalcolithic		223									
	1724	14	17709	12439	0	17730	0	0	49839			
Leceia (Cardoso & Detry 2001-2)	Early Chalcolithic		2	31	0	1446	945	0	1742	0	0	4166
Leceia (Cardoso & Detry 2001-2)	Late Neolithic		0	7	0	269	221	0	219	0	0	716
Penedo de Lexim (M-MG in prep)	Late Neolithic	4-3 millennium BC	0	4	0	457	17	0	460	0	0	938
Cabeço da Amoreira*	Late Mesolithic	c. 6,5-4,4 K cal BC	9	808	104	691	55	0	0	0	0	1658
Cabeço da Arruda*	Late Mesolithic	c. 6,5-4,4 K cal BC	1	73	3	72	23	0	0	0	0	172

Site	Period	Date (yrs BC/AD) where known	Equus	Cervus	Capreolus	Sus	Bos	Rupicapra	Capra/Ovis	Rhino	Elephantid	N
Moita do Sebastião*	Late Mesolithic	c. 6,5-4,4 K cal BC	2	352	45	397	116	0	0	0	0	912
Cabeço dos Morros*	Late Mesolithic	c. 6,5-4,4 K cal BC	1	4	0	20	2	0	0	0	0	2
Cabeço do Pez*	Late Mesolithic	c. 6,5-4,4 K	3	594	4	351	19	0	0	0	0	971
Concheiros de Toledo e Vale Frade (M-MG in prep)	Early Mesolithic	c. 6820-6530 BC	0	23	28	139	5	0	0	0	0	1
Caldeirão (SD 2002)	Magdalenian	14-8K BC	6	65	3	10	3	1	5	0	0	93
Lagar Velho (M-MG & Pimenta 2002)	Middle Solutrean	18K BC	15	20	3	3	0	0	0	0	0	41
Caldeirão (SD 2002)	Solutrean	20-16K BC	25	151	1	1	1	14	38	0	0	231
Buraca Escura (Aubry et al. 2001)	Gravet–proto Sol		6	6	0	0	2	0	26	0	0	40
Lagar Velho (M-MG & Pimenta 2002)	Terminal Gravettian	19K BC	61	40	0	6	2	0	0	0	0	109
Lagar Velho EE15 (M-MG in prep)	Gravettian	20,5K BC	2	151	0	1	0	2	48	0	0	204
Lagar Velho (M-MG & Pimenta 2002)	Gravettian	23-19K BC	9	45	7	2	0	0	2	0	0	65
Caldeirão (SD 2002)	Early Upper Palaeolithic	25-20K BC	17	41	1	0	0	4	32	0	0	95
Pego do Diabo (Valente 2004)	Aurignacian	28-23K BC	73	197	0	12	0	22	71	0	0	375
Caldeirão (SD 2002)	Mousterian	>25K BC	24	50	1	3	1	5	15	0	0	99
Gruta da Figueira Brava (Antunes 2000)	Mousterian		28	116	0	7	75	0	101	14	10**	351
Gruta da Columbeira (Cardoso,1993a; Antunes 2000)	Mousterian		16	151	1	0	15	0	22	15	0	220

Table 4 – The faunal succession of the southern half of Portugal – a very broad overview. The numbers of identified remains (NISP or, for sites studied by SD, PoSACs) of medium to large-sized species of herbivores from sites (main strata/ periods are given separately for multi-period sites) from Mousterian to post-Medieval times. Note that due to the difficulty of distinguishing between bones of sheep and goat, these two species are treated as a single artificial taxon "sheep/goat", and similarly, due to the difficulty of distinguishing between the different species of equids, all equid remains are recorded here as "*Equus*". So far no remains of sheep are known from pre-Neolithic sites. Key: K = millennia, Conv = Convento, N = the total number of bones and teeth. * data from Mesolithic sites are from Detry (pers. comm.) and the counts of red deer at Mesas do Castelinho, Almodôvar are artificially high due to the multiple finds and recording of antler fragments (Cardoso 1993b). ** See Brugal and Valente, 2007.

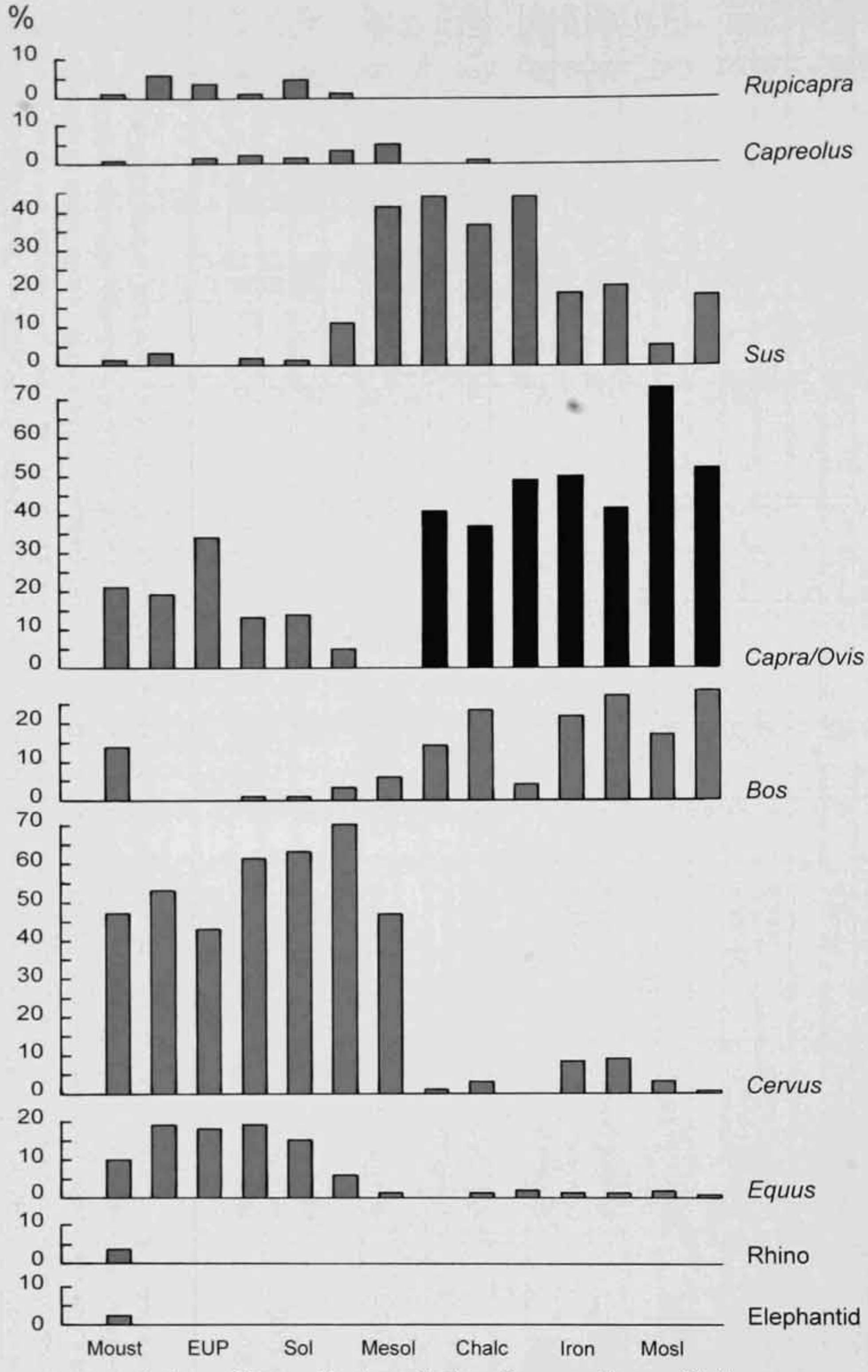

Figure 17 – The Mousterian to post-Medieval faunal succession of the southern half of Portugal. Percentages of the more common medium and large herbivore taxa found on archaeological sites and grouped by period (data in Table 4). Note the major faunal change between the Mesolithic and Neolithic which presumably marks the introduction of domesticated animals. Note also the slightly earlier increase of *Sus* – an animal known for its potential to reproduce rapidly. Due to the difficulties of distinguishing between wild boar and pig, sheep and goat, cattle and aurochs and the different species of equids these are grouped as *Sus*, *Capra/Ovis*, *Bos* and *Equus* respectively. Note however, that sheep are only found from the Neolithic onwards (hence the darker shading of these *Capra/Ovis* bars.

red deer and equids. Hence as predator pressure, that is human hunting, increased, we would expect to see within the archaeological faunal succession a chronological shift from slow reproducing mammals like deer, aurochsen and equids to fast reproducers like *Sus*. Surovell (1999) simulated what can happen to fast reproducing species of small game like hares and partridges, and slow ones like the tortoise, when predation pressure rises due to increasing occupation density and population. He found that the faster reproducing species will increase in number in the archaeological record while slower reproducers will decrease and even become extinct. Was the Mesolithic of southern Portugal a time of increasingly severe hunting pressure due to an increase in the human population? This suggestion was also made to explain the size reduction of Mesolithic red deer (Davis, 2002). Detry (2007) notes an increase in the proportion of juvenile *Sus* during the Mesolithic which she also suggests was due to increased predation of wild boar, in turn due to a substantial increase in the human population in the Mesolithic period. A re-analysis of Portuguese Mesolithic and Neolithic human skeletal remains (Jackes and Meiklejohn, 2004) provides evidence for increased human fertility – perhaps an increase of c. two children per woman, from c. 5 to c. 7, within the Mesolithic. On the basis of other human skeletal evidence they hypothesize a softer diet and a shift to a more sedentary lifestyle. We know from modern examples of newly settled nomads, that sedentism leads to rapid population increase (Sussman, 1972).

A similar line of reasoning may explain the shift from large and medium sized mammals to small mammals, fish and birds and the increased proportion of juvenile gazelles hunted in the Mousterian – Aceramic Neolithic of the southern Levant (Davis et al., 1988; Davis, 1989; 2005a; and see also Stiner, 2003) – perhaps similar to what Morales et al. (1998) describing the shift to exploiting marine resources at Nerja, Andalucía, refer to as the "Tardiglacial paradigm". Was there a food crisis in the Mesolithic of Portugal which brought about a diminution of the red deer, led to a shift from red deer to wild boar, altered the age-profile of this species, and forced people to exploit more marine resources – especially marine molluscs? Renewed excavations of the Muge shell-midden sites should help to answer this question.

Once the four main domesticated food animals – sheep, goat, pig and cattle – had been introduced and formed the main source of meat, few changes in their percentages can be observed at this gross level. The only small 'blip' in the graph is the reduced percentage of *Sus* in the Moslem period – almost certainly a reflection of the low status of this animal in Islam. And even of those that are recorded in the Moslem period of Alcáçova de Santarém, may well have belonged to wild boar, an animal that is not completely taboo in Maghrebi Islam, rather than domestic pig (see below).

Needless to say the pooling of faunal frequency data from sites in different parts of southern Portugal hides small-scale variations (both chronological within periods and of course geographical variation). Indeed as more sites are studied, inter site and intra-period differences will become apparent. One example is the slight decrease of red deer numbers during the Iron Ages and early Roman periods at Alcáçova de Santarém (Davis, 2006). Cervids, with their relatively low-crowned teeth, tend to browse rather than graze – *i.e.* they prefer leaves to grass and are therefore associated with woodlands. This red deer decline probably reflects a contemporary destruction of woodlands in the Santarém region. Cardoso (2002b) also suggests a link between red deer numbers and local vegetation. He found that while a significant proportion of the mammal fauna at Moslem "Mesas do Castelinho" (Almodôvar, Baixo Alentejo) comprised red deer; the subsequent decrease of this animal's numbers was caused by deforestation resulting from an increased exploitation of wood for ship building in the 13th century. What does the palaeobotanical record indicate? It is also possible to link deforestation in the Santarém region with the rise of non-arboreal pollen during the early phases of its occupation thought to be linked with the growth of viniculture (see Arruda, 2003 for a discussion of the reduction of woodlands in Iron Age Portugal and southern Spain and the increasing intensity of agriculture). At a countrywide level, Mateus notes (pers. comm.) that the Roman period in Portugal is characterised by great destruction of forests to an extent even greater than today. Thus for the period 45 to 70 AD palynological data (Mateus, 1992, p. 108) suggest that there was a huge decline of oak, pine, and alder. This forest clearance was undertaken in part to supply firewood for the ceramics industry and also to increase pastureland for wool production.

3.6. Question 6: What was the temperature in Portugal in the past?

Some 65% of mammals and 72% of birds (Meiri and Dayan, 2003) and even man (Ruff, 2002), show an inverse correlation between body size and environmental temperature. This observation was first made by Bergmann (1847; see also Mayr, 1956). For example wolves from Arabia are considerably smaller than their relatives in Scandinavia and Russia, Near Eastern hares are smaller than hares from northern Europe, the woolly mammoth was larger than its relatives the Indian and African elephants, and the puma decreases in size from northern North America and southern South America towards the equator (Kurtén, 1973). Not only does this apply to mammals today but, as Kurtén

(1960; 1965) showed in his pioneering studies, it was true in the past: mammal remains from Glacial periods were larger than those from Interglacials or the Holocene (see also Klein and Scott, 1989; Klein and Cruz-Uribe, 1984). In the Near East it was possible to pinpoint the timing of the size decrease to around 11-12,000 years ago as temperatures rose after the last Ice Age (Davis, 1981). One explanation for this increased size in colder environments involves a consideration of basic geometry. Volume, which produces heat, increases to the power 3. Surface area, which dissipates heat, only increases to the power 2. Hence a large body has relatively smaller surface area and should be a better conserver of body heat in a cold environment. Herreid and Kessel (1967) found that by doubling body weight, birds and mammals can lower heat loss per unit weight by 30 per cent. A large body also has the added strength to carry more fat and longer hairs or feathers. However there are many exceptions to this Bergmann effect or rule. Other factors like food availability and predator pressure also influence body size. One example of the latter may be the small size of Mesolithic red deer, perhaps subject to intense hunting pressure in that period just prior to the introduction into Portugal of domesticated food animals (see above under "How do the frequencies of the large prey species vary through time and why" and Figure 12 in Davis, 2002). Nevertheless, a change in body size is one of several strategies whereby an animal can adapt to different temperature regimes (Mayr, 1956).

Klein and Scott (1989) studied modern hyænas in Africa as well as hyæna remains from cave sites in Upper Pleistocene England. They noted that in Africa today the carnassial length of *Crocuta* increases with latitude and in England during glacial maximum times specimens were larger than in inter-glacial times. These trends both today in Africa and in the past in England, they suggest, exemplify the inverse relation between body-size and temperature predicted by Bergmann's rule. The hyæna (*Crocuta crocuta*) mandible from the Mousterian at Caldeirão cave (Figure 3) is extremely large compared to the English glacial and interglacial specimens of Klein and Scott. Its carnassial tooth, M_1, measures 35,0 mm (see Figure 18) and would, according to Klein and Scott, indicate very cold conditions in Mousterian Portugal. However, as Klein has also pointed out (pers. comm.) it may be even larger than Bergmann's rule would predict due to reduced competition with man.

Perhaps of greater significance in this respect due its superabundance is the omnipresent (in the Iberian Peninsula) rabbit. In her extensive study, Callou (2003, p. 76-9) has shown how modern wild rabbits from France and the Iberian Peninsula vary in size with latitude – the smallest individuals inhabiting southern

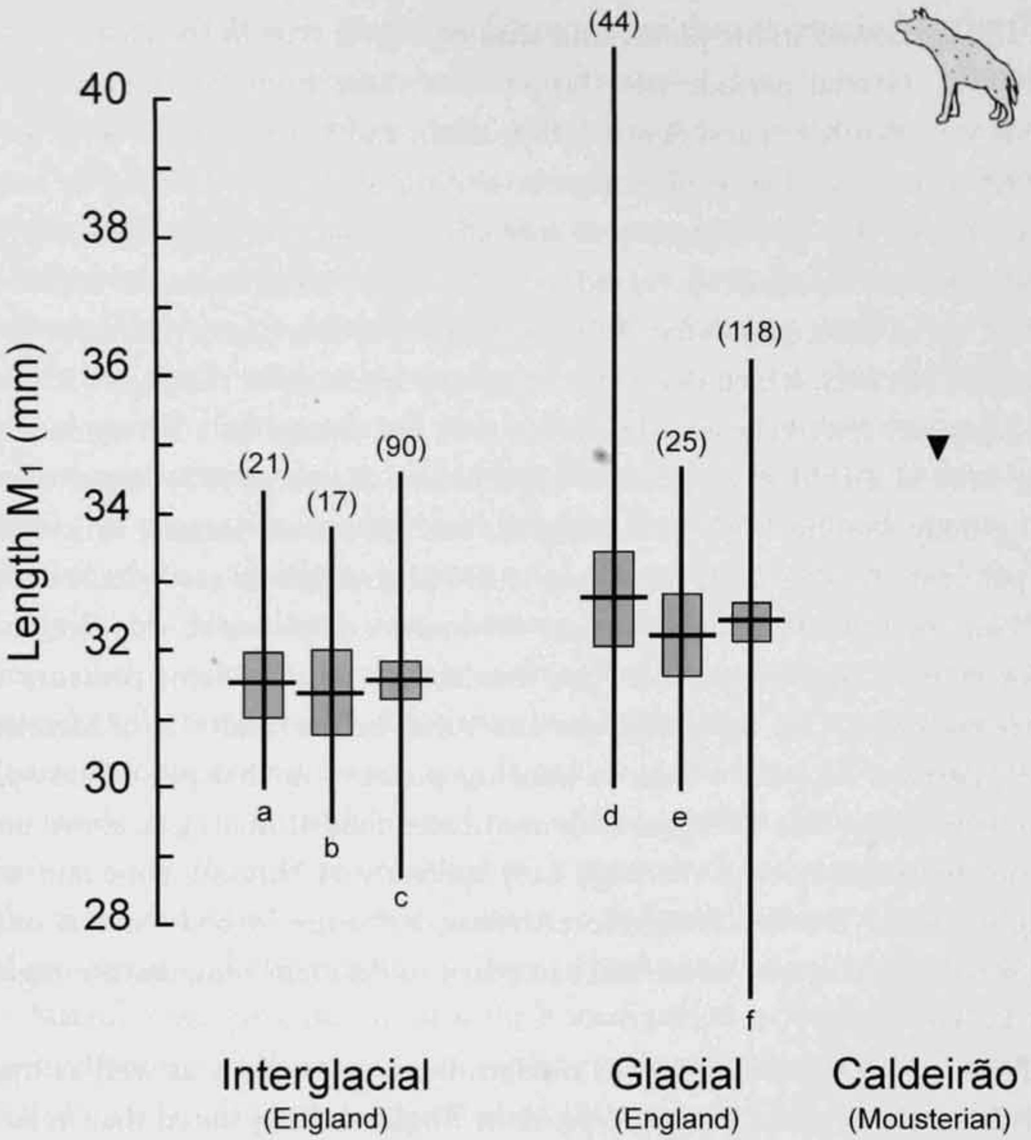

Figure 18 – The spotted hyæna mandible from the Mousterian of Caldeirão cave in biometric perspective. The *Crocuta* (P11 865 K Corte) compared to Glacial and Interglacial samples from English cave sites (data from Klein & Scott, 1989; Table 1). The plots are of the antero-posterior length of the carnassial tooth (M_1). The mean is shown as a horizontal line, the observed range by a vertical line, and the 95% confidence limits of the mean by a rectangle. Sample sizes are given in parentheses. The sites are as follows from left to right: a: Kirkdale Cave, b: Torcourt Cave, c: Tornewton Cave, (three Interglacial sites) and d: Pin Hole, e: Picken's Hole and f: Kent's Cavern (three Glacial sites). Klein and Scott suggest that the three "Interglacial" samples being smaller than the three "Glacial" ones are consistent with Bergmann's rule, which correlates low environmental temperature with greater body size in warm-blooded animals. Note the very large size of the Caldeirão carnassial presumably indicating the cold environment of Mousterian Portugal.

Spain and the largest coming from the Paris area. A study (Davis et al., in prep), seeks to establish the mathematical relation between the size of modern rabbit bones (using the measurements that can be taken on archaeological specimens) and environmental temperature (*eg*, the average temperature of the coldest month of the year, January) in Portugal, Spain and France. For example, distal humerus width and calcaneum length plotted against mean January temperatures from various weather stations (World Weather Records 1971-80, US Dept. Commerce,

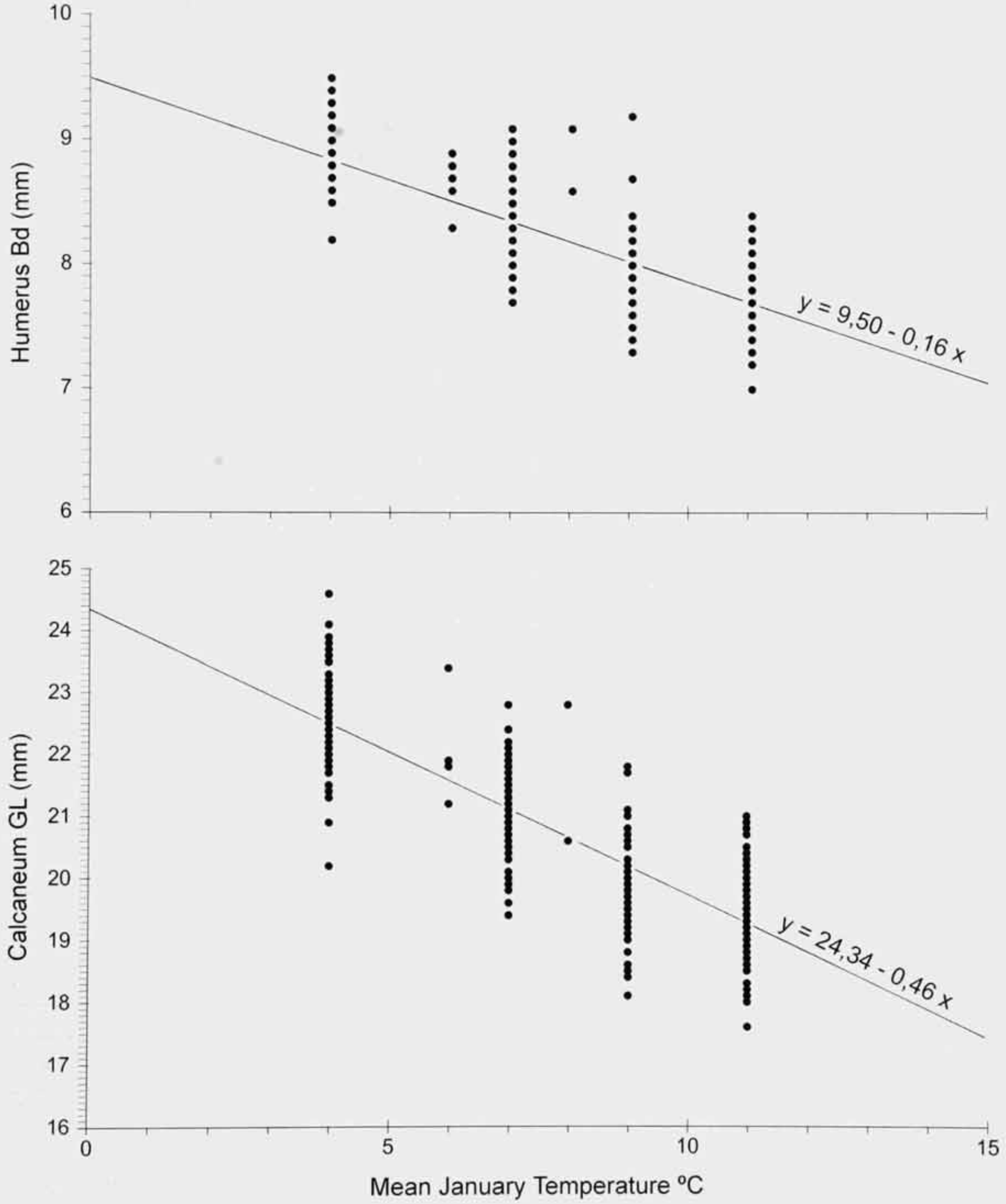

Figure 19 – The wild rabbit of Portugal, Spain and France today - the relation between bone size and environmental temperature. The two graphs show the regression of rabbit humerus distal width (Bd) and calcaneum length (GL) on average January temperatures taken from World Weather Records 1971-80. For humerus, n = 401 and R = 0,81 and for calcaneum, n = 383 and R = 0,84 indicating in both cases a significant inverse correlation between bone size and environmental temperature. This linear relation is used to make an approximate estimate of the temperature change which would be required today to 'bring about' the observed difference of rabbit bone size between different fossil samples, or between a fossil sample such as the one dating to the Solutrean and the present day one.

1987; Figure 19) indicate a significant negative correlation (see also Table 5). A 1 mm size change of the distal humerus width is equivalent to an environmental temperature difference of approximately 6°C and a 5 mm size change of the calcaneum length is equivalent to an environmental temperature difference of approximately 11°C (Table 6). The measurements of the rabbit bones from Caldeirão cave may be compared with their modern relatives in Portugal today. Preliminary results show quite clearly that the Caldeirão rabbits from the Mousterian to Magdalenian periods were large. For example Solutrean humeri were on average 1,1 mm and calcanea 3,2 mm larger. If we assume that the same size/temperature relation existed in antiquity then it should be possible to make an approximate estimate of the temperature change which would be required

Locality		Humerus Bd (mm)			Calcaneum GL (mm)		
		n	Mean	sd	n	Mean	sd
Roissy and Versailles (Paris)	France	74	8,9	0,29	75	22,6	0,79
Landes	France	6	8,7	0,21	5	22,0	0,82
Tour du Valat, Camargue	France	20	8,4	0,23	18	21,1	0,66
Navarre	Spain	77	8,3	0,33	75	21,0	0,76
Badajoz	Spain	14	7,8	0,38	14	19,8	0,91
Las Lomas, Andalucia	Spain	67	7,7	0,26	67	19,3	0,73
Santarém, Ribatejo	Portugal	70	7,8	0,29	64	19,6	0,75
Avecasta, Estremadura	Portugal	13	7,8	0,35	–	–	–
Mafra, Estremadura	Portugal	4	7,7	0,12	4	19,2	0,34
Vila Viçosa, Alentejo Central	Portugal	53	7,9	0,33	48	19,8	0,74

Table 5 – The rabbit today. Summary measurements in millimetres (number of specimens, mean and standard deviation) of the humerus distal width and calcaneum length from various regions of Portugal, Spain and France today (most specimens are housed in the Musée d'Histoire naturelle, Paris). Note the approximate decrease in size from north to south.

Period	Site	Humerus Bd (mm)			Calcaneum GL (mm)		
		n	Mean	sd	n	Mean	sd
Modern	Santarém	70	7,8	0,29	64	19.6	0,75
Solutrean	Caldeirão	76	8,9	0,48	165	22,8	0,81

Bone and Measurement	Solutrean – Modern bone size difference	Equivalent mean January temperature difference today
Humerus Bd	1,1 mm	7 °C
Calcaneum GL	3,2 mm	7 °C

Table 6 – The rabbit yesterday. Measurements in millimetres of the humerus distal width and calcaneum length from the Solutrean level at Caldeirão cave and from Santarém, Portugal today (number of specimens, mean and standard deviation) and, below, what these bone-size differences are equivalent to in °C temperature today. The difference for the humerus is 1,1 mm and for the calcaneum is 3,2. The change of temperature required today to 'bring about' such a change is 7°C.

today to bring about the Solutrean – modern diminution of these rabbit bones. The osteometric changes translate to a difference of approximately 7°C in temperature – a result which is not very far off the figure of 8-9°C colder during the last Glacial maximum (c. 20,000 years ago) suggested by Uriarte Cantolla (2003). They are also similar to the figures of 6°C (McIntyre & Kipp, 1976; as cited in Zilhão, 1997, p. 53) and 10°C (Duprat, 1983; also cited in Zilhão, 1997, p. 53). The rabbit promises to serve as a "palaeo-thermometer" in Iberian zooarchaeology.

3.7. Question 7: Can we distinguish between wild and domestic species?

Today most living domesticated animals are easily distinguished from their wild relatives on the basis of superficial characters like coat colouring, hair length and behaviour. However, apart from size, their skeletons are generally quite similar. Given the fragmented nature of archaeological animal bones, a wild-domestic distinction is therefore a major technical problem confronting the zooarchaeologist. Let us now consider two particularly problematical taxa – *Bos* and *Sus*. In Portugal from Neolithic times onwards one has to consider the probable presence of both wild and domestic forms of *Sus* (pig and its wild relative the wild boar) and *Bos* (cattle and its wild relative the aurochs). Most domestic animals, pigs and cattle being among them, are smaller than their wild ancestors and size is a much used criterion for making a wild-domestic distinction in zooarchaeology. In the case of *Bos* at Chalcolithic Zambujal, Driesch and Boessneck (1976) demonstrated a clear separation of the wild and domestic forms for bones such as the astragalus. Their measurements form two separate peaks when plotted as a graph. Specimens with widths less than 48 mm belonged to cattle and those greater belonged to aurochsen. In the case of *Sus*, a wild-domestic distinction is much less clear-cut due to the small size of the Iberian wild boar. The sizes of most bones and teeth of the two forms overlap considerably (see Albarella et al., 2005).

Using a similar line of approach to Driesch and Boessneck it is possible to demonstrate not only the presence of aurochs in, for example, both Mesolithic and Chalcolithic sites in the southern half of Portugal, but also its absence from subsequent periods. Note (Figure 11) the presence of two clearly separated peaks in the distribution of measurements of astragalus lengths. As mentioned above, the absence of the large form after the Chalcolithic corroborates Castaños Ugarte (1991) who argued that aurochsen probably disappeared from the western part of the Iberian Peninsula during or soon after the Chalcolithic.

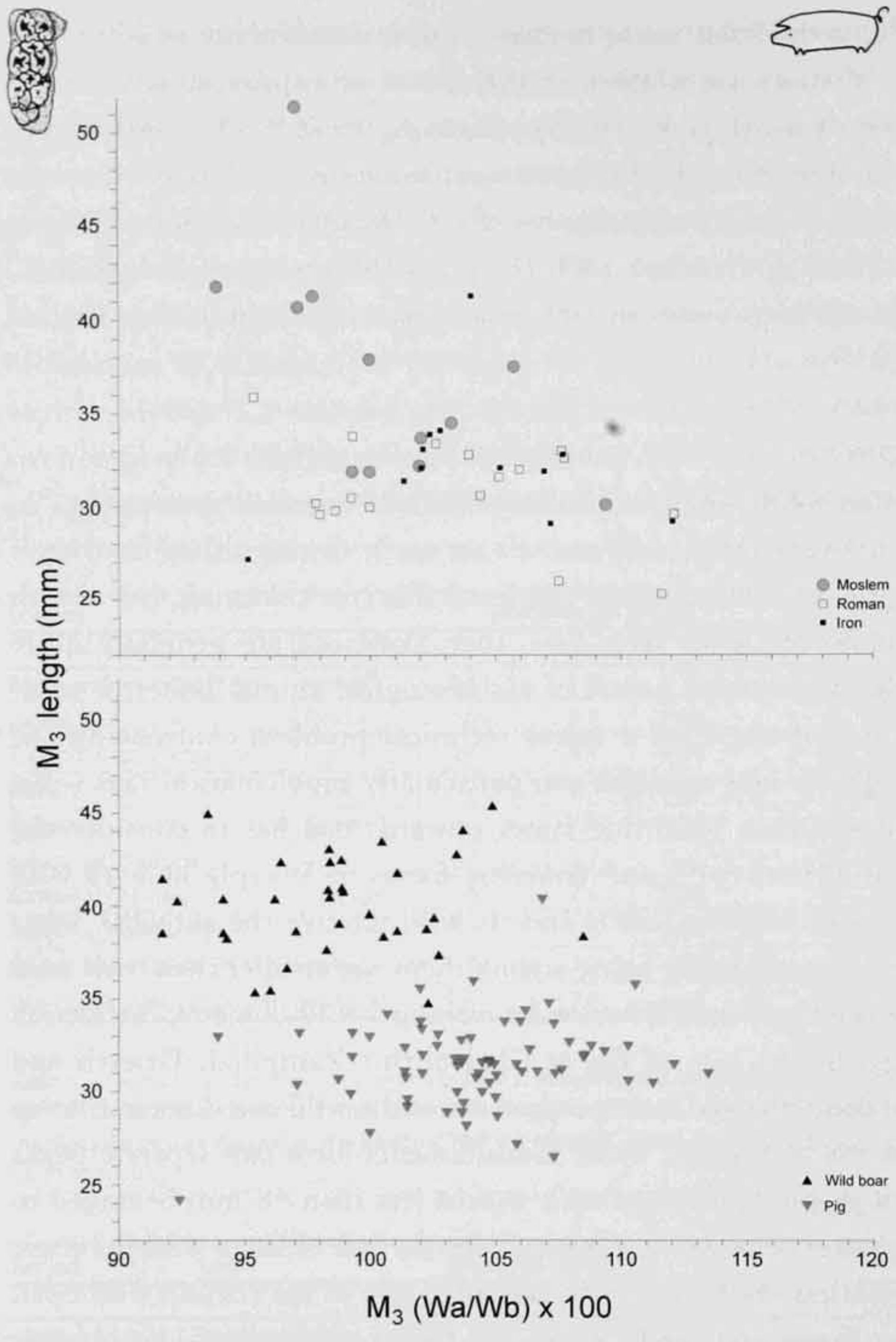

Figure 20 – Distinction between wild and domestic *Sus*, (*i.e.* wild boar and pig) lower third molar teeth (M3) considering both their size and shape. The M3 crown length is plotted against an index of M3 crown width of the anterior pillar (Wa) divided by the crown width of the central pillar (Wb). The resulting plots are therefore size (length M3) versus shape (Wa/Wb or the degree to which the tooth is parallel sided when viewed occlusally). In other words M3s with more or less parallel sides or where Wa approximately = Wb have a shape index of around 100 while "compressed" teeth with triangular outlines have index values slightly > 100. The crowns are measured in the manner described by Payne and Bull (1988). Below: English Medieval and post-Medieval pigs (domestic) from Launceston Castle, Cornwall (Albarella & Davis, 1996) and modern wild boars from Syria and Israel (specimens in the Zoology Museum, Tel Aviv University and Zoology department of the Hebrew University, Jerusalem). Note that besides being larger, the wild boar M3s have parallel sides with Wa approximately = Wb. However, the pigs are not only smaller but are tri-angular in shape when viewed occlusally with Wa > Wb.
Above: The same plot for *Sus* M3s from the Iron Age, Roman and Moslem levels at Alcáçova de Santarém. Note there is a tendency for many of the *Sus* in the Moslem period, unlike most of the Iron Age and Roman ones, to be both large and have values of Wa/Wb around 100 – *i.e.* by analogy with the specimens from the Levant and England, many of them belonged to wild boars.

Confronted with the difficulty of distinguishing between wild and domestic *Sus* remains, we (Albarella et al., 2005) decided to try a different approach and examine shape variation in the lower third molar, M_3 – a tooth which is easily recognisable as it has three pillars (large anterior and central pillars, and a small posterior one) instead of two as in M_1 and M_2. The lower part of Figure 20 combines both size (length of M_3) and shape (the index M_3 width of the anterior pillar, 'a', divided by the width of the central pillar, 'b'). This index is actually measuring how "parallel" the inner and outer sides of the tooth are. Figure 20 (upper part) shows two quite different populations of *Sus*, one is medieval and post-medieval domestic pig from Launceston Castle in Cornwall, England (Albarella and Davis, 1996) and the other, modern wild boars from Israel and Syria. The distribution of plots indicates that besides being considerably longer (most > 35 mm), the wild *Sus* M_3s tend in occlusal view to have parallel sides. In other words the widths of the two pillars are similar giving a 1:1 ratio (100 x Wa/Wb = 100). However the domestic pig M_3s tend in general to plot out to the right *i.e.* their anterior pillar is slightly larger than the central one giving them (in occlusal view) a somewhat triangular appearance. This may be reflecting the antero-posterior compression of the growing tooth crown during the animal's development due to insufficient space within a smaller mandible. Perhaps the different sets of genes controlling tooth and bone size, had been subject to different selective forces in the course of domestication and management of *Sus* over the millennia, leading to an imbalance between tooth and bone (mandibular ramus) size, with dental genes in a more 'archaic' state. Using this line of reasoning, we applied this plot to the *Sus* M_3 measurements from Alcáçova de Santarém (see the upper part of Figure 20). Note that many of the Moslem period *Sus* plot out in the wild boar region with not only longer teeth but also values to the left (*i.e.*, the index Wa/Wb is closer to 100). This corroborates a suggestion that many of the Moslems at Santarém were not in fact eating pork which is strictly *haram* in Islam (see Qur'an 2, 173), but were hunting wild boar which in the Maghreb today is not really considered taboo (Simoons, 1994, p. 341; Moreno-García, 2004).

3.8. Question 8: Why do kill-off patterns matter?

Most faunal remains recovered from archaeological sites reflect the way in which animal resources were exploited. As noted above from the Neolithic onwards faunal assemblages are dominated by domestic species over which people had absolute control since the animal's birth (Clutton-Brock, 1989). Domestication meant that animals could be exploited more extensively than previously, without the need to sacrifice them to get something in return (Sherratt, 1983). Whereas meat, fat, marrow, bones and so on can only be obtained from the dead animal, milk (Mulville and Outram, 2005), wool (Greenfield, 1988), draught power (Sherratt, 1981; Halstead, 1995) and dung (Moreno-García and Pimenta, in press-a) are products that domesticated animals can provide while alive. Thus, different husbandry strategies were developed to exploit at different scales one or more of these so-called secondary products, according to environmental, economic, cultural or social circumstances (Halstead, 1996).

The estimation of the age-at-death of taxa appears as an important variable since it allows zooarchaeologists to gain an insight into the kind of husbandry practised in antiquity (Payne, 1973). In an archaeological assemblage, if priority was given to the production and consumption of meat, one would expect a mortality profile in which animals in their prime, sub-adults of 2-3 years of age, are dominant and a reduced number of mature animals are kept for reproduction. Modern data collected during ethnographic work in the Sierra de Albarracín, Teruel, Spain (Moreno-García, 1999) indicates that there is an important difference in meat yield values between unweaned lambs, less than two months of age (Payne's mandible wear stage 'A') and those between two and six months (Payne's mandible wear stage 'B'). On average, live weights of the former would be over 8 kg but as dressed carcasses they would be a mere 4,5-5 kg. In comparison, lambs weaned later and killed at six months would have live weights between 15-24 kg or 9-10 kg as dressed carcasses. Therefore, meat yield doubles if lambs can be kept until they are at least six months old. A community interested primarily in the exploitation of "secondary products" would keep their animals until the end of their productive lives, so that mature individuals will dominate the flock. Halstead (1998) has noted that a gradual pattern of mortality corresponds to a production strategy in which security of continuous meat supply and domestic demand of "secondary products" are fulfilled.

The two most common methods used by zooarchaeologists to estimate the age-at-death of mammals are the state of epiphysial fusion of long bones (Silver, 1969) and the eruption and wear stages of mandibular teeth (Payne, 1973; 1987; Grant, 1982). The latter analytical approach was applied to two samples of caprine mandibles recovered from the site of Penedo do Lexim (Locus 1), dated to the Late Neolithic (Sousa, 2003) and Chalcolithic, respectively (Moreno-García et al., 2003b; Moreno-García, in progress). The aim was to observe changes in the kill-off patterns of these taxa (sheep and goats) in the course of time.

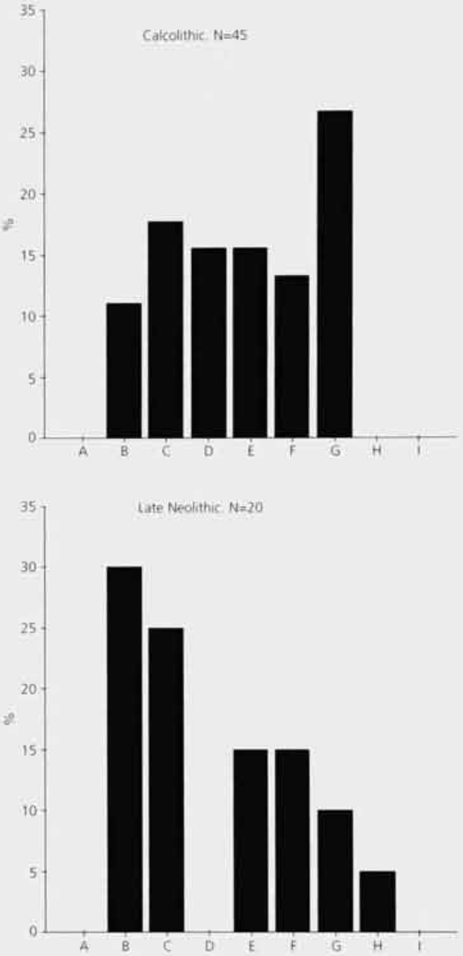

Figure 21 – Age of slaughter of the caprines at Penedo do Lexim (Locus 1), Mafra. Percentages of mandibles assigned to Payne's (1973) dental eruption and wear stages. Note that while half of the sample from the Neolithic period corresponds to young sheep/goats in their first year of life (stages 'B'-'C'); in the Chalcolithic most are fully adult, aged between 4-6 years (stage 'G').

Figure 21 shows that in the Late Neolithic, half the sample comprises young animals with mandible wear stages in categories 'B' (between 2 and 6 months of age) and 'C' (between 6 months and 1 year of age). The other half shows a gradual pattern of mortality distributed steadily among animals in their prime (stages 'E'= 2-3 years and 'F'= 3-4 years) with a few mature individuals (stages 'G'= 4-6 years and 'H'= 6-8 years). However, and in contrast, the Chalcolithic sample reveals an even killing pattern among juveniles and animals in their prime to reach a peak among fully adult individuals of 4-6 years of age.

To summarize; the high juvenile cull in the Late Neolithic may be related to the keeping of flocks for meat, with "secondary products" of lower importance. This situation clearly changed in the Chalcolithic when caprines were not culled until adult, reflecting a more intense exploitation of products such as milk, dung and wool to the detriment of lamb consumption.

Was this a local or a regional trend observed in other contemporary Portuguese sites? The scarcity of faunal remains especially from the late Neolithic, makes it difficult to study this on a wider scale. Cardoso and Detry (2001/2002) present an analysis of the ungulate remains from the prehistoric settlement of Leceia (Oeiras) with its stratigraphic sequence similar to that at Penedo do Lexim. In their study, age-at-death was calculated using the epiphysial fusion method. These authors are aware that their results may be biased by taphonomic factors such as differential preservation causing an under-representation of the more fragile juvenile bones. Nevertheless, arguing that one site is affected by the same taphonomical processes they recognised a change in the kill-off pattern of caprines and cattle in the course of time. From the Late Neolithic to the Chalcolithic they note a decrease of adult and mature caprines. The opposite situation is registered for cattle that appear to have been culled at a much younger age in the earlier than in the later period, suggesting a change in the pattern of exploitation of this animal. While they would have been killed for their meat in the Late Neolithic, in the Chalcolithic cattle were more intensively used as a draught animal. This shift is interpreted as evidence for the intensification of the exploitation of "secondary products" during the Chalcolithic (Cardoso and Detry, 2001/2002).

Since their methodological approach was different from ours, any comparisons with the sample from Penedo do Lexim (Locus 1) must be treated with caution. In addition, it is worth noting that the frequencies of these ungulate species differ at both sites, especially where the presence of cattle is concerned. While suids, cattle and caprines are represented in very similar proportions in the Late Neolithic of Leceia, cattle remains are scarce at Penedo do Lexim (Table 7). This may explain why caprines here were sacrificed for their meat at a younger age together with suids and they were not fully exploited for their "secondary products". During the Chalcolithic, caprines became the dominant species in Leceia and cattle decreased slightly whereas no significant change is observed at Penedo do Lexim.

		Equus		*Bos*		*Ovis/Capra*		*Sus*		
		NISP	%	NISP	%	NISP	%	NISP	%	Total
Penedo do Lexim	Chalcolithic	1	<0,1	79	2,6	1431	48,1	1464	49,2	2975
(Locus 1)	Late Neolithc	–	–	17	1,8	460	49,2	457	48,9	934
Leceia	Middle Chalcolithic	2	<0,1	2135	19,6	5245	48,1	3512	32,2	10894
	Early Chalcolithic	2	<0,4	945	22,8	1742	42,1	1446	35,0	4135
	Late Neolithc	–	–	221	31,2	219	30,9	269	37,9	709

Table 7 – Numbers and percentages of the main species recovered at Penedo do Lexim (Locus 1), Mafra (Moreno-Garcia, in prep.) and Leceia (Cardoso & Detry, 2001/2002) during the Late Neolithic and Chalcolithic. Note the different contribution of cattle in both assemblages.

As a working hypothesis, it seems that although species frequencies vary at both sites, the age-at death of those that were most abundant in each (cattle at Leceia and caprines at Penedo do Lexim) indicates they were exploited mainly for their meat in the Late Neolithic, and it was only later that the other products attained greater importance.

It could be argued that the exploitation of "secondary products" requires a different social and economical setting than that existing in the Late Neolithic. Production diversifies, mechanisms for the distribution of yields must be established and the differentiation between 'producer' and 'consumer' groups began (Renfrew and Shennan, 1982; Chapman, 2003). These are interesting subjects, already being discussed in the archaeological literature dealing with the Iberian Chalcolithic (Kunst, 1995; Chapman et al., 1997) and to which Portuguese faunal studies should provide useful input.

3.9. Question 9: How do species frequencies reflect different subsistence strategies?

Question five (above) discusses the variations of frequencies of medium – large-sized herbivores from Mousterian to Medieval times in the southern half of Portugal. However, pooling these kinds of data from different sites tends to obscure small-scale chronological and geographical variations. To illustrate this point two Chalcolithic faunal assemblages, Penedo de Lexim (Locus 1) in the Portuguese Estremadura region and Mercador (Mourão) in the Alentejo, are compared (Figure 1).

At both sites domestic animals outnumber wild ones (Figure 22). The percentage of wild taxa at Mercador is 16% while at Penedo do Lexim it is 24%. The greatest difference between these two faunal assemblages lies in the composition of the fauna. The composition of the wild animal taxa at Mercador seems much more diversified than that at Penedo do Lexim. The latter site is dominated by rabbit while the wild fauna at the former site is dominated by red deer, horse and rabbit, followed by aurochs, hare and roe deer (Figure 22).

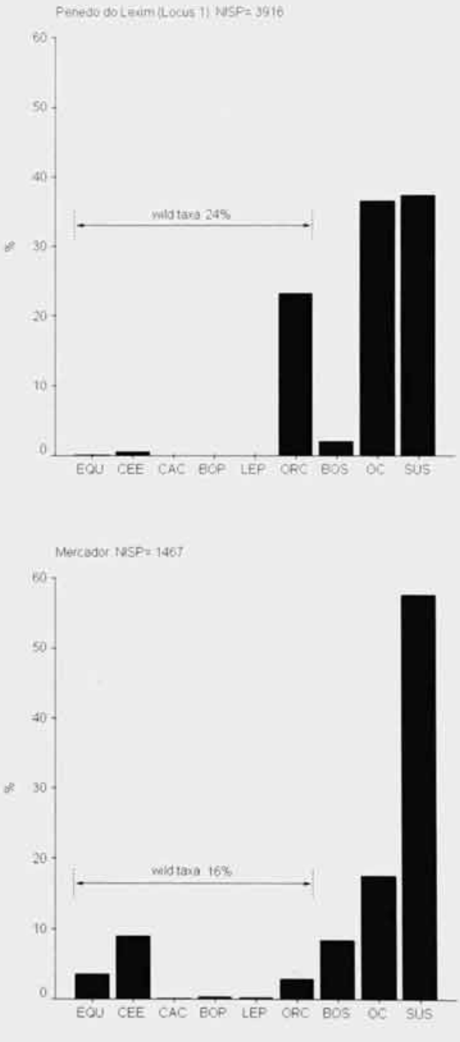

Figure 22 – Species frequencies of the more common mammals at Penedo do Lexim (Locus 1), (Mafra) and Mercador (Mourão) during the Chalcolithic period. Note the varied contribution of wild species, especially large-sized mammals and the scarcity of caprines at Mercador, compared to Penedo do Lexim where the rabbit is the main wild species represented and *Sus* and caprines are equally abundant.

The horse and red deer remains at Mercador are mainly derived from both fore- and hind limbs (Moreno-García, 2003b; Moreno-García and Valera, 2007). Meat, skin and bones were used by the local community as attested by the fine cut marks we observed on some remains (Figure 23) and the occurrence of different kinds of bone artefacts. Among these, three horse proximal phalanges are remarkable. They had been whittled down and their surfaces polished (Figure 24) as has been reported in the manufacture of idols (Cardoso, 1995a). The few remains of aurochs in this settlement indicate that they were also occasionally hunted and must have made an important dietaty contribution. As mentioned earlier (Question 4) during the Chalcolithic their populations would have declined, being limited to the southern part of the Iberian Peninsula whence they probably

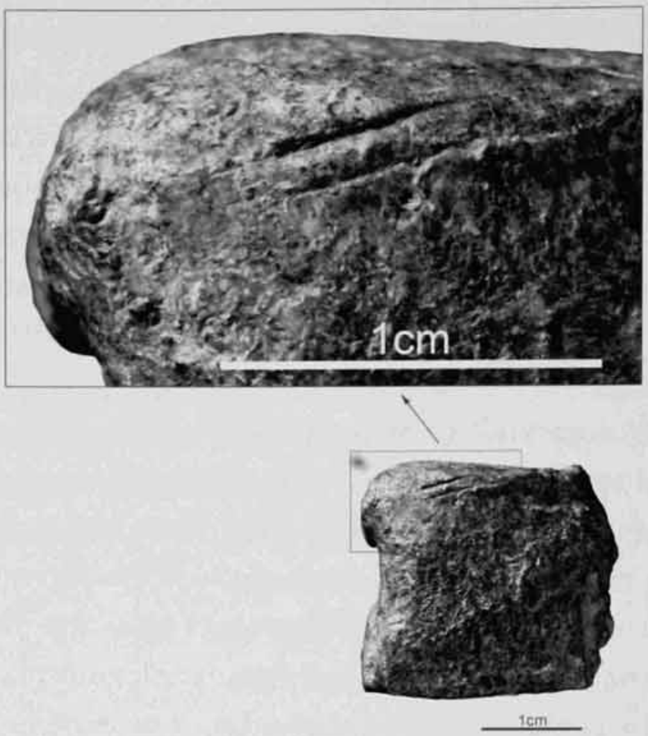

Figure 23 – Butchery marks on a horse (*Equus* sp.) right carpal bone (scaphoid) from Mercador (Mourão). Fossa 66 (UE 1022). The two parallel incisions were perhaps made while skinning the animal.

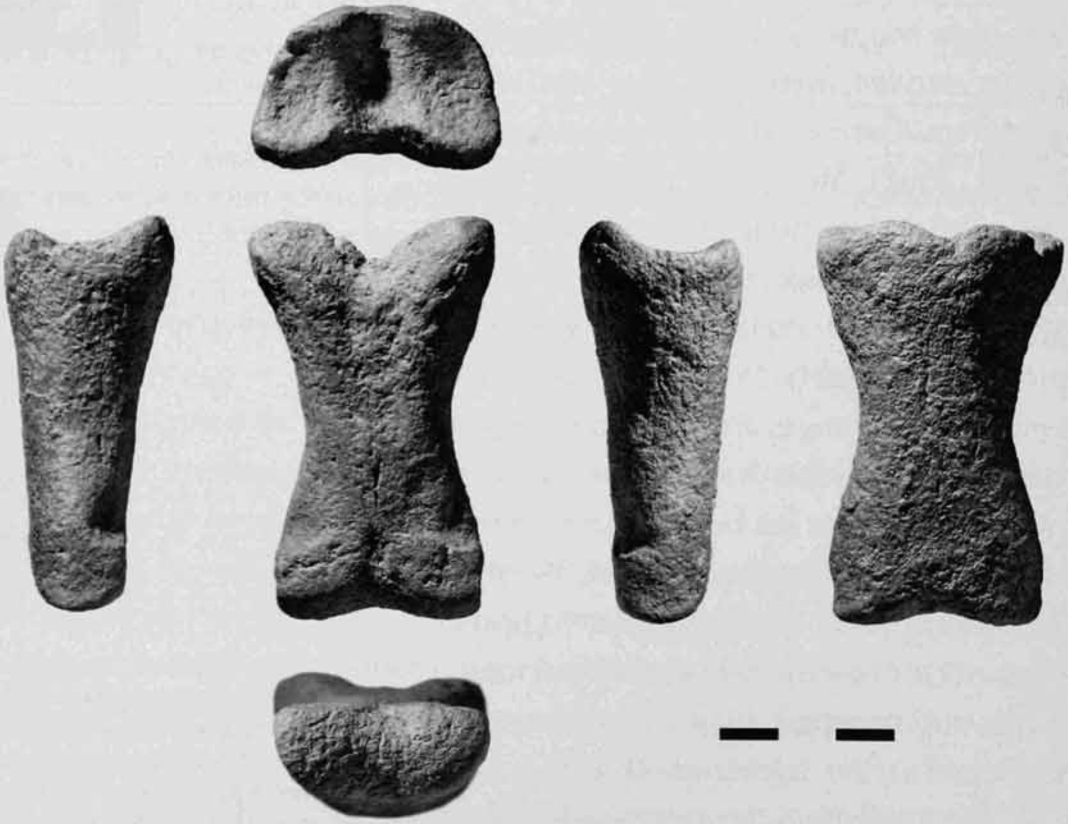

Figure 24 – Phalanx idol. Posterior proximal phalanx of a horse (*Equus* sp.), whittled down and polished on all surfaces. Mercador Mourão. Deposit 1A (UE 391).

became extinct shortly afterwards (Castaños Ugarte, 1991). Finally, a single roe deer scapula suggests the proximity of forest habitat.

More significant differences appear in the frequencies of domestic taxa, particularly the caprines and suids. While both are equally common at Penedo do Lexim, the faunal assemblage recovered from Mercador is dominated by suids. Measurements of the humeri and astragali indicate that most of their remains at both sites probably belonged to the domestic pig (Davis, 2003). The exploitation of this species is focused, almost exclusively, on meat production. Thus, the kill-off patterns at both sites are similar. Both show an abundance of animals culled as juveniles, during their first year of life or as young adults.

To sum up, the species frequencies at Mercador demonstrate that hunted wild species and pigs would have provided much of the meat consumed, while caprines appear to have played a minor role. Their scarcity makes us doubt that there was a particularly intense and generalised exploitation of their "secondary products", as was suggested for the caprines at Penedo do Lexim (Figure 21). On the whole, it seems the inhabitants of Mercador, on the left bank of the river Guadiana, subsisted on hunting and pig husbandry. Could this reflect less human impact on the landscape, favouring a wider availability of wild resources or was there a more mobile settlement pattern in the Alentejo than in Estremadura? Could this mean too that agricultural activities were practised on different scales in these regions four thousand years ago?

Clearly, studies of other Chalcolithic faunal assemblages are needed in order to provide an answer to these questions. As a preliminary exercise however, data from two other Chalcolithic sites in the Estremadura – Leceia (Cardoso and Detry, 2001/2002) and Zambujal (Driesch and Boessneck, 1976) – were added to those from Penedo do Lexim (Driesch and Richter, 1976; Moreno-García, in progress) and these in turn were compared to Chalcolithic faunal remains from Porto Torrão (Arnaud, 1993) and Mercador (Moreno-García, 2003b). Although results (Table 8) must be treated with caution, due to the differences in sample size, they do appear to agree with the trend that we have noted above. During the Chalcolithic, frequencies of caprines and *Sus* are very close to one another in the Estremadura region while suids dominate in the Alentejo. Here, cattle are equally scarce but large wild mammals such as horse and red deer appear to have been more regularly exploited than in Estremadura. Thus, the faunal data indicate that different subsistence strategies were practised by the human communities living in these parts of the country at that time.

		Equus	*Cervus*	*Bos*	*Ovis/Capra*	*Sus*	
		%	%	%	%	%	Total NISP
Estremadura	Leceia (CI) (Cardoso & Detry, 2001/2002)	<0,1	<1	23	42	35	4166
	Leceia (CP)	<1	1	19	48	32	11018
	Zambujal (CP) (Driesch & Boessneck, 1976)	<0,1	3	25	36	35	49379
	Zambujal (CF)	<0,1	4	22	36	37	23560
	Penedo do Lexim (Driesch, 1976)	–	2	25	39	34	1727
	Penedo do Lexim (Moreno-García, in prep.)	<0,1	<0,1	3	48	49	3001
Baixo Alentejo	Porto Torrão (CP) (Arnaud, 1993)	1	2	28	17	42	–
	Porto Torrão (CF)	4	23	18	13	33	–
	Mercador	4	9	9	18	60	1441

Table 8 – Species frequencies of the main mammal species in Chalcolithic sites from the Portuguese Estremadura and Alentejo regions. CI= early Chalcolithic; CP= middle Chalcolithic; CF= late Chalcolithic. Note the equal representation of caprines and suids in assemblages from the Estremadura and the dominance of suids in the Alentejo. Here, also horse and red deer are much more frequent, suggesting hunting was more common in the Alentejo.

3.10. Question 10: Were domesticated animals improved and if so when?
(see also Davis, 2008)

The history of agriculture, like any branch of this discipline, involves extracting basic information from archives such as probate records, wills, manuscripts from public records offices and museums, newspapers, etc. These provide the historian with his primary data. But are not the archaeological remains of animals, also primary data, another independent source of information about agricultural history? One example is the debate concerning the timing of agricultural improvements in medieval – post-medieval England. Some, like the influential Rowland Prothero, also known as Lord Ernle (Prothero, 1888; 1912), suggested that English agricultural improvements began in the mid 18th century with the accession of George III (a.k.a. 'farmer George') to the English throne. Lord Ernle suggested that improvements were rapid and took the form of an "Agricultural Revolution". Others, most notably Eric Kerridge, have questioned such a late date and rapid tempo for agricultural improvements and suggested (Kerridge, 1967) that the English began slowly improving agriculture several centuries earlier. By studying archaeological animal bones from medieval and post-medieval sites in England, and assuming that a size increase in livestock reflects improvement, it was possible to demonstrate a significant increase of size in sheep and cattle in England already in the 15th/16th centuries (Albarella and Davis, 1996). This corroborates the thesis of Kerridge. Here was an example of another contribution of archaeological bones to the study of history.

Let us return to Portugal and try and understand what was happening in medieval and post-medieval times here.

On April 28th 711, Tariq bin Ziyad and 7000 Berbers invaded the Iberian Peninsula – a region that was to become an important centre of culture and learning. Not only were song, literature, and mathematics encouraged, but agronomy too. Agriculture flourished: the Moslems introduced new irrigation techniques such as the *qanāt* and the *noria*, and new plants (see above). This is referred to as the 'Arab Green Revolution' (Glick, 1979; Watson, 1983; Araújo, 1983; Boissellier, 1999; Guichard, 2000). In his introduction to Ibn al-'Awwâm's famous *Kitâb al-Filâha* (Book of Agriculture), El Faïz (2000, p. 23-49) refers to the 11th and 12th centuries as *le moment andalou* in Hispano-Arab history. Seville had become a Mecca for agronomists, and its hinterland, or *Aljarafe*, their laboratory. But while the literature speaks much of oranges and lemons, and apart from the famous Arab horses, we know little about the rest of the livestock sector in both the Moslem period and following the subsequent Christian conquest (Alvarez de Morales, 1990). For over five centuries Moslems ruled the southern part of what was to become the Kingdom of Portugal. With the aid of the Crusaders, many of whom hailed from northern Europe, the Christians gradually advanced south and brought about the demise of Moslem rule. Both Santarém and Lisbon were captured in 1147 AD, and by 1250 AD, Algarve, the last bastion of Islam in the south, fell to forces of the cross under D. Afonso III. Soon Portuguese ships were sailing the high seas in search of new lands. 161 years after the capture of Lisbon, the Portuguese signed a commercial treaty with the English. The 1415 seizure of Ceuta heralded the age of the Portuguese "discoveries". But at home not all was well. The Portuguese, like most Europeans, suffered terribly from the pestilences of the 14th century. Moreover a series of contemporary agricultural crises as well as the plague led to a severe population decline (Gerbet, 2000, chap IX). These events raise the question as to what extent these historical changes affected the domestic animals in Portugal. Here we consider the osteometric variation of sheep and cattle in southern Portugal – that part of the country once under Moslem rule. The aim is to determine if and when sheep and cattle were improved and to establish if it is possible to link osteometry with what we know about the Moslems and Christians who lived in the Iberian Peninsula. The abundant remains of sheep and cattle from sites in the southern half of Portugal have been used in an osteometric survey of their size in the course of time.

Since we are interested in seeing when these two animals underwent a size increase in the course of time due to artificial selection (*i.e.*, agricultural improvement), it is important to be able to rule out the various other 'complicating' factors that can also affect the average size of a sample of domesticated mammal bones. These factors include the following:

observer variation – different people often take measurements in a slightly different way,
age differences – bones of young animals may be smaller than those from adults, and
sex – most mammals display sexual size dimorphism with females being smaller than males. Hence a sample of bones derived mainly from females will on average be smaller than a sample from the same population derived mainly from males.

The first complicating factor does not apply in this study as most measurements (except those of the *Bos* astragali from Zambujal) were taken by SD. Age complications were avoided by only considering bones from adult animals with fused epiphyses, fully ossified astragali and measuring (in the case of the cattle M_3s) tooth widths – a dimension that remains unaffected by the animal's age. Sex has proved to be a slightly more difficult problem. In the case of the sheep it has been shown that certain measurements taken on some bones such as the humerus minimum trochlea diameter (HTC) shows almost no sexual dimorphism with males a mere 1% larger on average than females (Davis, 2000). Artiodactyl molar teeth are considered to show little sexual dimorphism (see for example Degerbøl, 1963; Degerbøl and Fredskild, 1970, p. 87 for *Bos*; Payne and Bull, 1988 for *Sus* and Steele, 2002; Figure 6.1 for *Cervus*) so any size change of cattle third molars, like a size change of sheep humerus HTC should reflect real size change, and therefore improvement, of the animals to which these bones and teeth belonged. Other bone measurements like the cattle distal metacarpals display considerable sexual dimorphism and with sufficient material separate peaks plot out (see also Svensson et al., 2008). We shall see that for cattle both the small (cow) and large (bull) specimens increased in size in parallel indicating a general size change of the cattle in the course of time.

The stacked histograms (Figures 25 and 26) show size variation of sheep bones. In most cases there is little evidence for any substantial change between Chalcolithic and Roman times, but by the Moslem period sheep were clearly larger. While the evidence for a Roman-to-Moslem size increase is clearer in some bone measurements than others, they do all show the same general trend of increasing size over time. A series of "t" tests (see table 2 in Davis, 2008) indicate that the average differences are significant when most sheep bones from

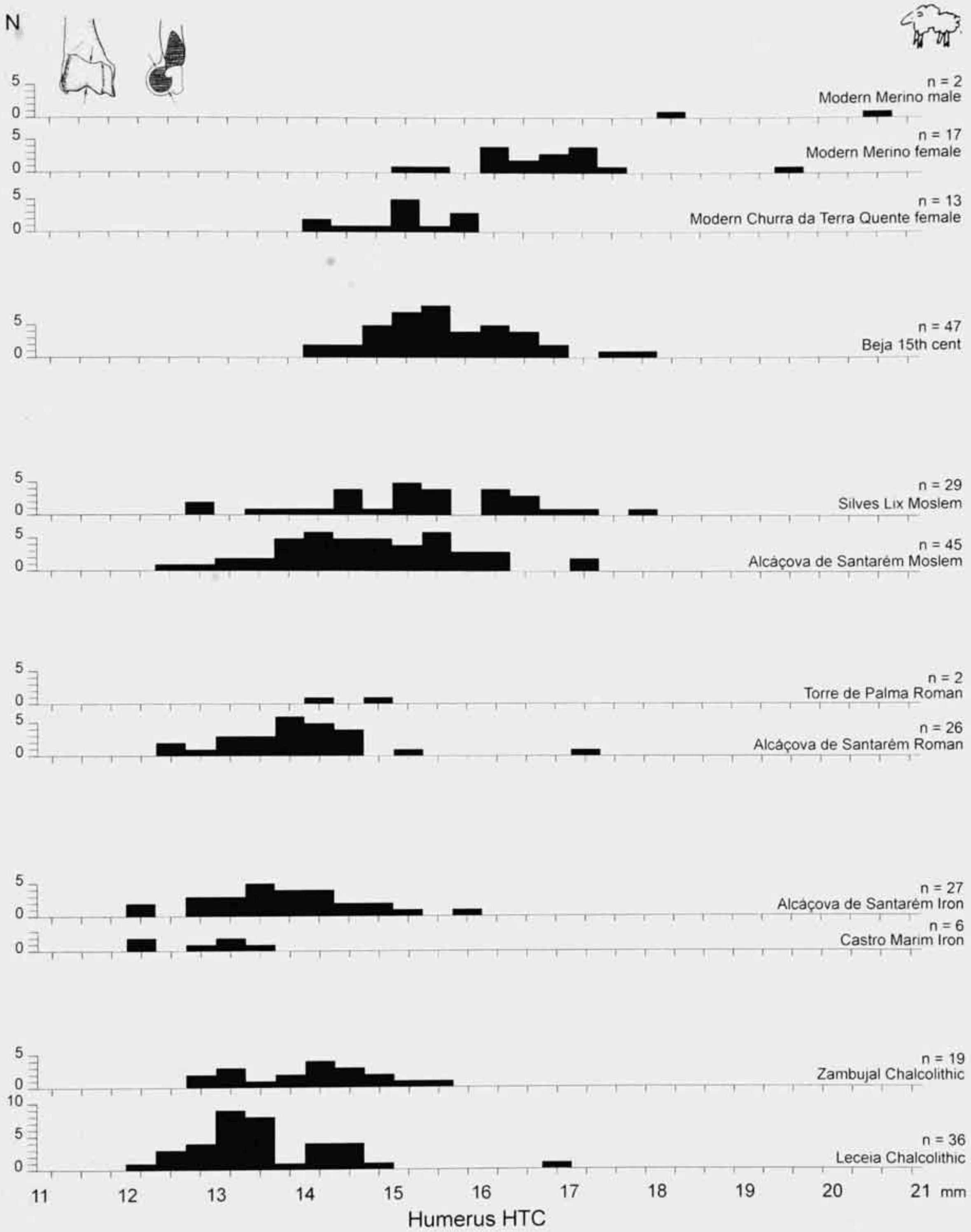

Figure 25 – The increase of sheep size in southern Portugal in the course of time. Stacked histograms of measurements of the minimum trochlea diameter (HTC) of sheep humeri from Chalcolithic, Iron Age, Roman, Moslem, 15th century AD Beja, and modern Churra da Terra Quente ewes, Merino ewes and two Merino males above. "n" refers to sample size. Note the increase in size between Roman and Moslem periods. Since humerus HTC is a measurement that shows almost no sexual dimorphism in the Shetland sheep (Davis, 2000), the increased size of this part of the humerus must reflect a real size increase of the sheep and not a change in the sexual composition of the samples.

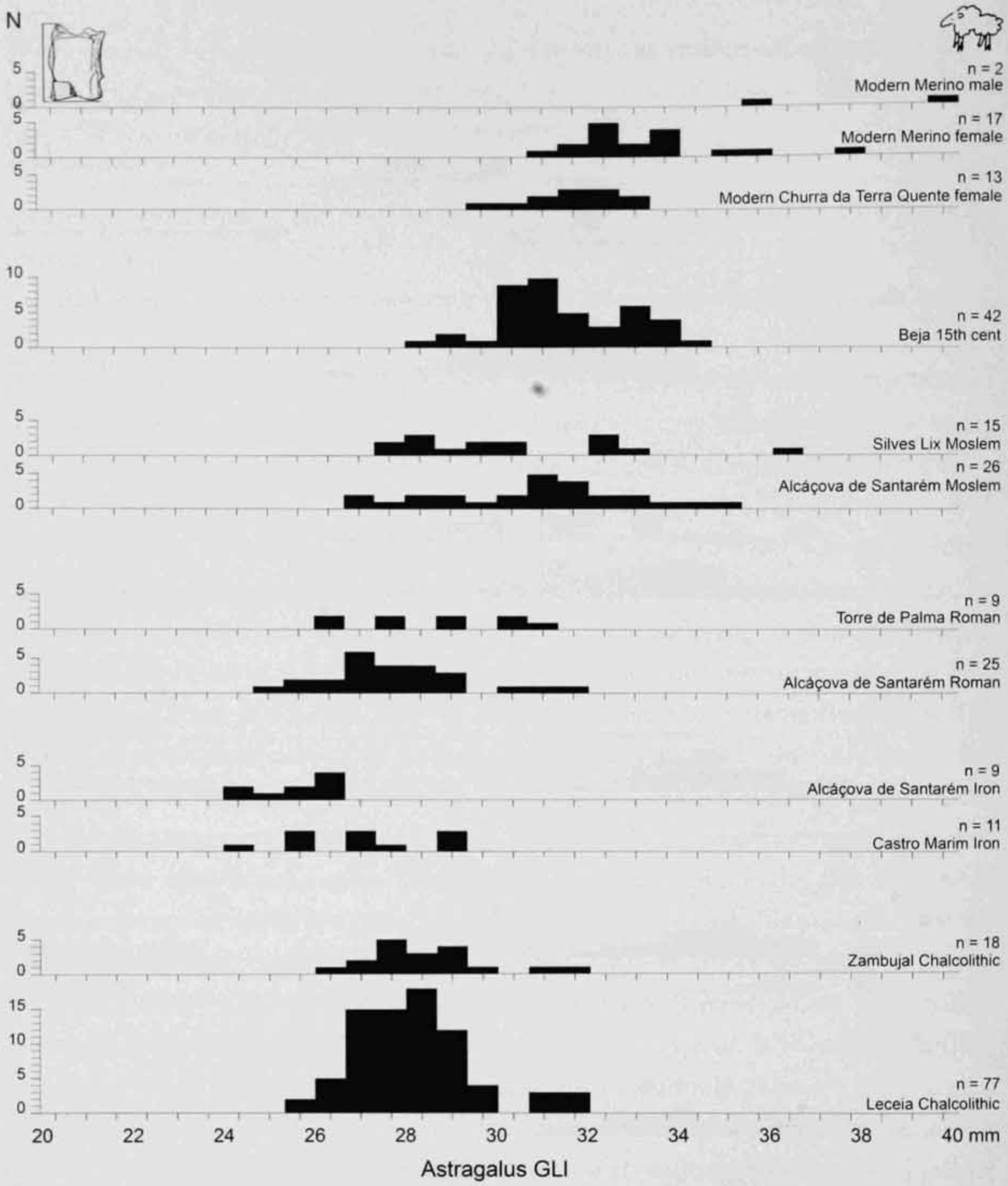

Figure 26 – The increase of sheep size in southern Portugal in the course of time. Stacked histograms of measurements of the greatest lateral length (GLl) of sheep astragali from Chalcolithic, Iron Age, Roman, Moslem, 15th century AD Beja and modern Churra da Terra Quente ewes, Merino ewes and two Merino males above. "n" refers to sample size. Note the increase in size between Roman and Moslem periods. Astragalus GLl is a measurement that shows little sexual dimorphism in the Shetland sheep (Davis, 2000), so its increase in the course of time must reflect a real size increase of the sheep and not a change in the sexual composition of the samples.

the Moslem period are compared to sheep bones from earlier periods. Following the Moslem period there was a further increase in size. The modern Churra da Terra Quente ewes are large by Roman standards, and the Merino ewes are similar in terms of size to the sheep from 15th century Beja. Figures 11, 27 and 28 are stacked histograms of M_3 and limb-bone measurements to show the variation

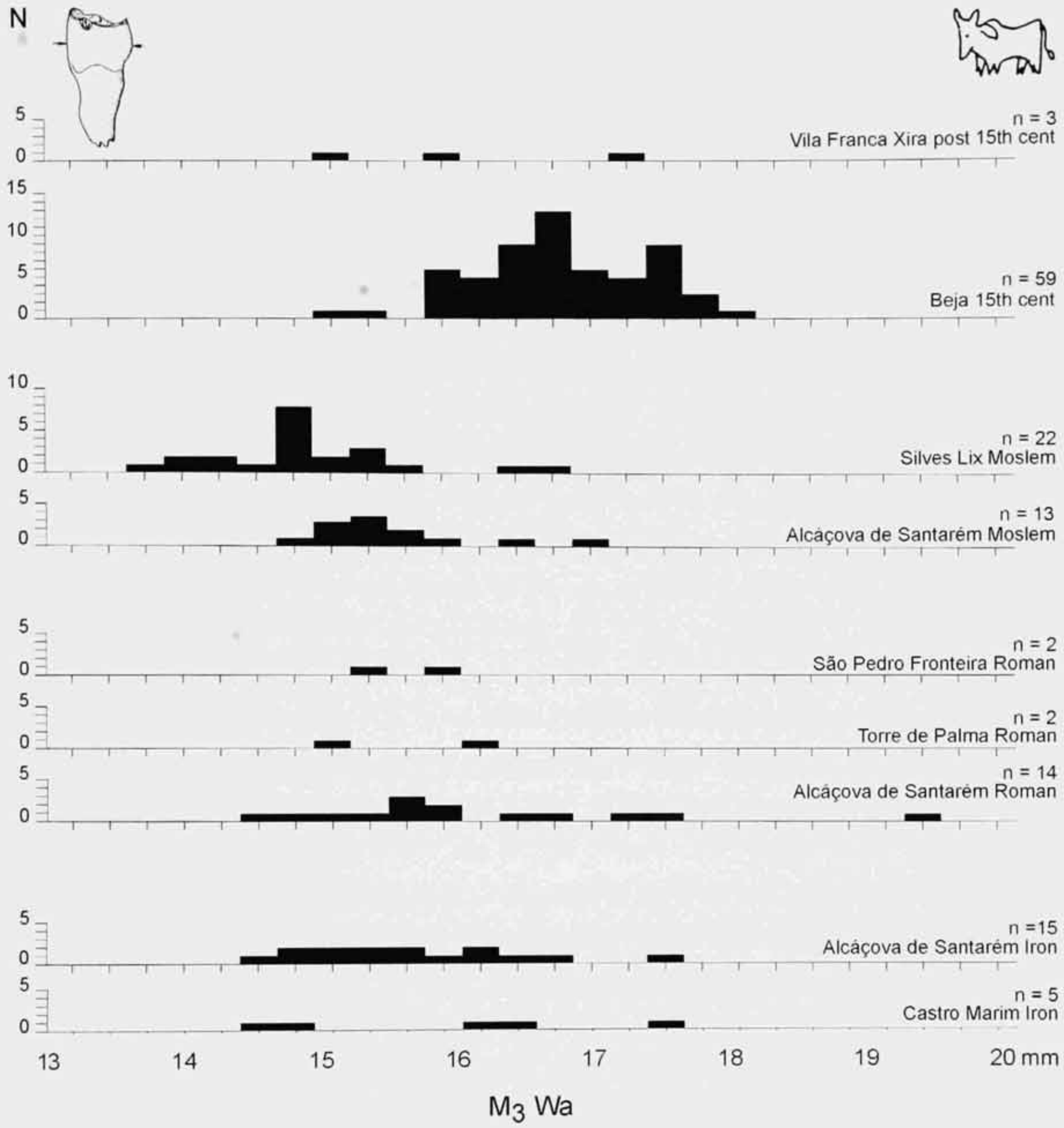

Figure 27 – Cattle size variation in southern Portugal in the course of time. Stacked histograms of the crown width of the anterior lobe of the lower third molar tooth, M_3, from Iron Age to post-Medieval times. Note the absence of any significant size change between Iron Age and Moslem times and the subsequent increase by the 15th century AD. "n" refers to sample size. Artiodactyl molar teeth are not considered to show much sexual dimorphism so that the Moslem to 15th century size increase represents a real size change of cattle in southern Portugal and not a shift in the sex ratio.

of *Bos* (cattle and aurochs) size. As mentioned above, the aurochs was larger than cattle by so great a margin that measurements of its bones generally plot out as a separate peak. Most of the specimens in the Chalcolithic (and subsequent periods) are small; they plot further to the left of the large ones identified as aurochs (see above) and are assumed to have belonged to domestic cattle. The series of stacked histograms for each dimension of the domestic cattle indicate little change of size between Chalcolithic and Moslem periods. Most striking is

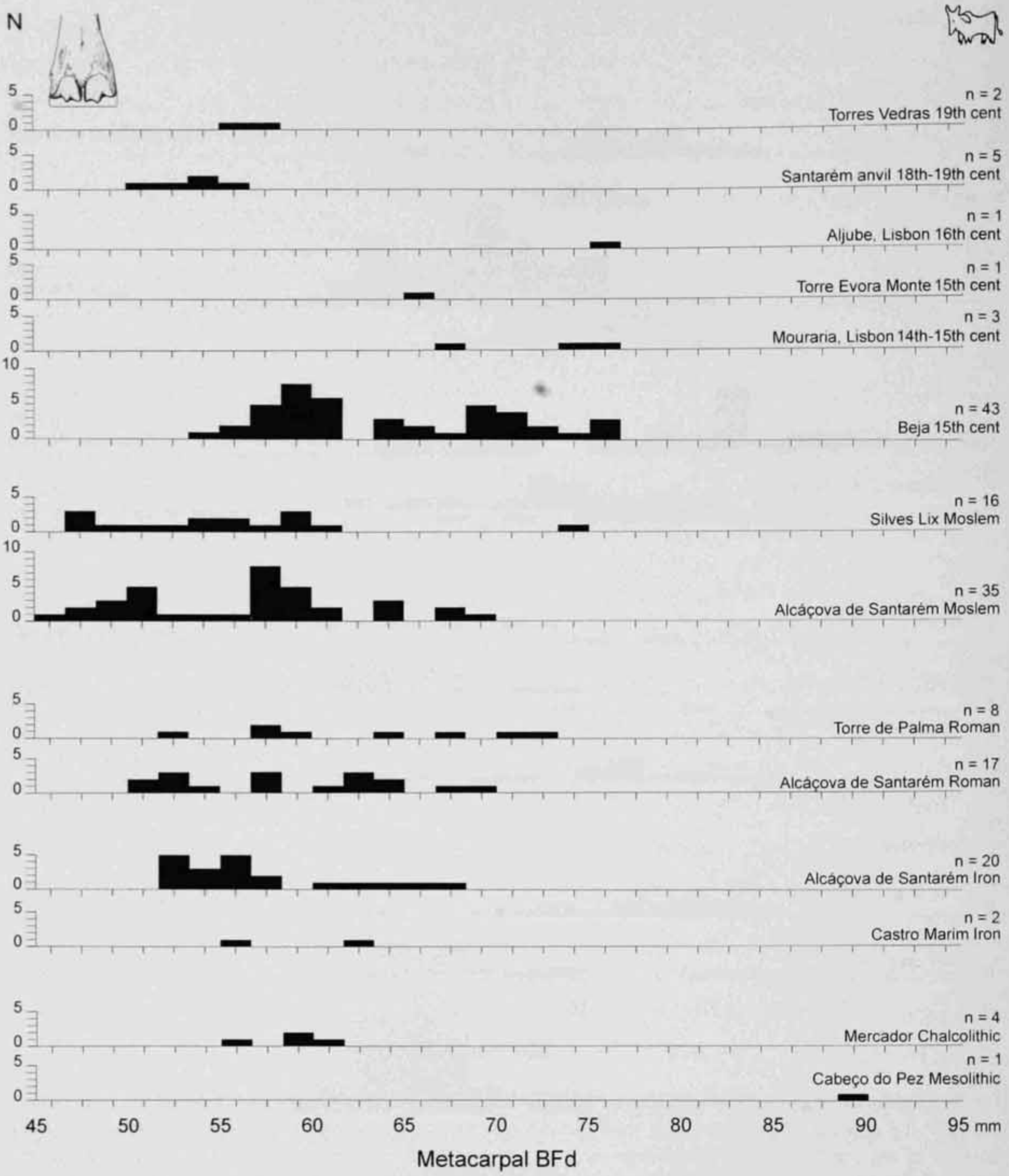

Figure 28 – Cattle size variation in southern Portugal in the course of time. Stacked histograms of the distal width (BFd) of metacarpals from the period spanning Mesolithic and Chalcolithic times to the 15th century AD with some small samples from 15th century and later times. "n" refers to sample size. Note the very large size (89 mm) of the Mesolithic specimen, presumed to be aurochs, and the absence of any significant size change between Iron Age and Moslem times of the presumed domestic cattle and the subsequent increase by the 15th century AD, although these recent large cattle did not attain the great size of the aurochs. The larger samples from Moslem Santarém and 15th century Beja show a bimodal distribution of their widths, presumably representing the two sexes. If correct then we can see here that both females and males increased in size between Moslem times and the 15th century.

the considerable size increase between the Moslem period and the 15th century. In order to confirm that the increase in size between the Moslem period and the 15th century was geographically widespread rather than restricted to the area around

Beja, an attempt was made to locate cattle remains from other post-Moslem sites. The few that could be found and measured are mostly similar in size to the Beja specimens, suggesting that the size increase of cattle following the Christian invasion of the south was a general trend in southern Portugal at that time. (Five metacarpals used as anvils from Santarém and two metacarpals from Torres Vedras are very small and represent an enigma.)

Clearly then it seems sheep increased in size during the Moslem period and cattle subsequently. Unlike central and northern Europe (see for example Breuer, et al., 2001; Matolsci, 1970; Peters, 1998; Schlumbaum et al., 2003; Teichert, 1984), Roman cattle in southern Portugal were no larger than those in the Iron Age. This is interesting. Does it mean that the Romans in Lusitania failed to invest in the bovine sector and improve local breeds of cattle? Audoin-Rouzeau (1995) writes: "*Une analyse de la répartition géographique de ces animaux indigènes et «romains» semble montrer une présence d'autant plus forte des premiers que la province est plus éloignée de l'Italie ou d'accès difficile.*"

On the basis of Audoin-Rouzeau's criteria, Lusitania was *une province éloignée*! And unlike the sheep from southern Portugal, the Portuguese cattle in the Moslem period were little different in size from their Roman ancestors. This leads us to question why these animals were improved in Moslem and Christian times. Can we link improvement to what we know about the Moslems of the Iberian Peninsula and the Christians who subsequently took control and to what we know about Arab and Christian dietary preferences and farm animal exploitation? An improvement of sheep by the Moslems is not surprising given their well known improvements to Iberian agriculture (see for example Watson, 1983) and the esteem with which they held, and still hold, mutton. Since higher meat yield in sheep is correlated with larger bones (Hammond, 1960, p. 131), it is logical to link the increased size of sheep in the Moslem period with their improved meat yield. It is however a little more difficult to relate the subsequent size increase of cattle with any documented advance in the agriculture of this region that can be associated with the Christians.

Perhaps in part because pork is forbidden to Moslems, the Arabs have a well known fondness for lamb and mutton – "*... the favourite meat of the people*" (Khayat and Keatinge, 1959, page x). In his review of early Arab cuisine, Rosenberger (1999) writes that in the Arab world beef was not much liked and cows and oxen gave milk or laboured in the fields. Most meat came from the vast flocks of sheep. The Arabs liked the taste of mutton and the abundant fat that it provided, and Arab physicians regarded the meat of the yearling lamb as being close to perfection. Glick (1979, p. 66) notes that in 400 years the pattern of agriculture that emerged in al-Andalus included an increase, over Roman times, in the economic significance of sheepherding. Glick's interesting remarks about Moslem *versus* Christian attitudes are relevant here. He writes (p. 103): "*To a society of town-dwellers and agriculturalists the sheep was an animal primarily raised for meat; its wool was a by-product. The Christians of the later middle ages turned the equation around: they cared only for wool and ascribed a low value to the meat.*" Thus the Christians, obsessed with wool production, may have preferred to eat pork and beef rather than mutton, and this is certainly the case in much of Portugal today.

Age-at-death data can also shed some light upon the nature of the animal economy (as discussed in Question 8). A high cull of young animals suggests an emphasis upon meat as, in terms of food input and meat gained, it makes little sense to maintain sheep or cattle much beyond their second or third year. In contrast, an economy geared towards the so-called secondary products such as milk, wool and power, will maintain cattle and sheep until they are quite old. The age-at-death data for the Iron Age, Roman and Moslem assemblages at Alcáçova de Santarém (Davis, 2006, p. 49-52) provide some support. Thus the caprines were slaughtered at a somewhat younger age in the Moslem period than in the Roman and Iron Ages, indicating a shift by the Moslems towards meat. In the Moslem period fewer calves were slaughtered suggesting that cattle were now kept more for milk and power. The Almohad (Moslem; 12th century) period bones from a *lixeira* or rubbish pit in Silves (work in progress) also indicate that the sheep and goats were kept primarily for their meat. Thus their mandibles show a distinct peak of slaughter at 2-3 years (Payne, 1973 wear stage 'E') while the majority of the cattle derive from much older animals. For example there are 13 cattle P_4s (adult fourth premolars), and no dP_4s (deciduous fourth premolars), at Silves.

Did the Moslems improve the local sheep or did they import new stock from, say, the Maghreb or the Middle East? Evidence from the Cairo Genizeh indicates quite clearly that the Mediterranean world of the 11th and 12th centuries was a kind of medieval common market with the Islamic world forming a free trade area (Goitein, 1967). This communications network, shared by Christians, Jews and Moslems, expressed the notion (Glick, 1979, p. 27) that there was "blessing in movement" as the Arab proverb states "fi'l-haraka baraka". Moreover, Klein (1920, p. 4-6) suggested that it was the Beni Merin Berbers who introduced the Merinos from northern Morocco during the Almohad expansion into the Iberian Peninsula. Not only was the Mediterranean important, but the Atlantic maritime trade between Spain, Portugal and the Maghreb at this time is also well known (Picard, 1997). Klein (1920, p. 4-6) also remarked that many present-day

Spanish pastoral terms are derived from Arabic. There are indeed several likely etymologies of the word *merino* and possible origins of this most important breed of sheep (see for example Laguna Sanz, 1986; Sánchez Belda and Sánchez Trujillano, 1986) although Riu (1983) suggests that the Merinos resulted from cross-breeding of coarse-woolled ewes with north-African fine-woolled rams in the mid 14th century. Even today Merinos tend to be reared in the southern part of Spain and Portugal and they are genetically somewhat distinct from other breeds kept in central and northern Spain (Arranz et al., 1998). A genetic (mitochondrial DNA) study of seven modern breeds of Portuguese sheep (Pereira et al., 2006) reveals the presence of maternal lineages until now only found in the Middle East and Asia. A broad north – south pattern indicates a trend with southern Portuguese sheep clearly distinct from most other breeds. This is interpreted in terms of an influx of new genetic diversity, via a maritime route, although it is impossible at the moment to know when this happened. Clearly further studies, both osteological and genetic, of sheep remains dating back over the last two or three millennia in Portugal are needed, but it is tempting to presume that at least some live sheep accompanied the oranges and lemons into the Iberian Peninsula. So much for the Moslems' improvement of sheep, can we explain the subsequent improvement of cattle by the Christians?

The obvious assumption is that a shift in emphasis from mutton to wool occurred (Glick, 1979, p. 103) once the Christians took over southern Portugal. Klein (1920, p. 25) too, writing about Christian Spain, noted that the consumption of mutton was uncommon (and it certainly is today in many parts of Portugal). He provides two explanations. First, the seasonal migrations of the merinos made their meat tough and this sheep was regarded as being more valuable for its wool. Second, in place of mutton much pork was eaten. There were two reasons for this – first because of its high quality due to the abundance of acorn fodder, and second because its consumption removed suspicions of Judaism. Luard, in his *Portrait of Southern Spain* (1984, p. 117), is worth quoting. He writes: "*Old Fernando, who told me the Moors were the best thing that ever happened to Spain, had at the same time the common Andaluz prejudice against eating lamb on the grounds that it was 'Moors' food' and therefore not worthy of Christians.*" In her history of Iberian husbandry, Gerbet (2000) emphasises how wool production really took off in the Iberian Peninsula in medieval times. Indeed in 1273, 'Alfonso el Sabio' (1221-1284) established the Mesta, the powerful association of sheep holders, in Castile (Klein, 1920). In other words Christianity provided the impulse for breeding cattle with heavier carcasses and greater meat yields. Today at least, the famous meat breeds of cattle, in contrast to the dairy breeds, are characterized by their wide limb bones (see for example Guintard, 1998). With the establishment of the new Christian kingdom of Portugal, it is plausible that the Crusaders, many of whom came from the north, introduced new and bigger breeding stock from their homelands. The father of D. Afonso Henriques (1111-1185), first King of Portugal, hailed from Burgundy.

One other speculation is that the Christians may have seen cattle as a source of power (and perhaps even status!) for ploughing the now enlarged estates (due to the demographic losses incurred during the terrible pestilences of the 14th and 15th centuries) and so bred larger and therefore more powerful animals. Indeed, Oliveira Marques (1968) writes that although known in earlier times, the "Arado Quadrangular" or "Charrua" (Quadrangular, or Chariot plough), which was pulled by oxen or cows, became widespread in Portugal in the 14th, 15th and especially the 16th centuries. This plough was more complex and stronger than its predecessors, well adapted to wet and heavy soils, and was of Nordic origin.

In many parts of Europe there is now substantial zooarchaeological evidence that livestock and even fowl were improved in later Medieval and post-Medieval times (Matolsci, 1970; Clavel et al., 1997; Albarella and Davis, 1996; Audoin-Rouzeau, 1997; Davis and Beckett, 1999). A pre-15th century AD date for improved cattle in Portugal is indeed somewhat early in comparison and may indicate an advanced state of farming here at that time. And the even earlier size increase of the sheep comes as a greater surprise, though in many areas of human endeavour the Moslem world of the 10th to 12th centuries AD was certainly more advanced than Christian Europe. More recent zooarchaeological investigations by Thomas (2005) are revealing evidence for agricultural changes as early as the 14th century in England as Dyer (1981) had found in his studies of the documentary evidence. He, like Dyer, links these 14th century improvements with the Black Death (1348-1350) and the resulting demographic decline, and suggests that the demand to feed an expanding population had dissipated and the market in grain crashed. Animal husbandry became a viable alternative being less labour intensive but requiring more land – this being plentiful following the effect of the Black Death. A possible chain of explanations for these 14th century changes in England which these authors propose include a downward social distribution of access to land and the tendency for peasants to become landowners. Peasants who were in more "intimate contact" with animals were better able to take "technological initiatives". A similar 14th century crisis and disease induced demographic decline in Portugal (Oliveira Marques, 1980, p. 27-8) can be cited here to explain the apparent improvement of Portuguese cattle. According to Gerbet (2000, p. 306): *"La crise de la deuxième moitié du XIVe s. et du début XVe s. entraîna une diminution* *du sol cultivé et une croissance de l'élevage et des pâturages."* Such a line of reasoning, although very speculative, does at least provide a link between the demographic crisis and an improvement of cattle.

To conclude this section on the improvement of farm animals in southern Portugal it may be suggested that the size increases of both the sheep and cattle were "meat-driven"; reflecting selection for heavier boned animals with greater meat yield. In the case of sheep this seems quite logical since mutton was and still is much favoured in the Moslem world. Whether new stock such as the Merino was imported from abroad or whether local animals were 'improved' must remain within the realm of speculation. While an absence of any observable shape change of the sheep bones between Roman and Moslem periods tends to point in favour of a local improvement rather than import of new stock, the genetic evidence based on modern sheep in the Iberian Peninsula does indicate some input from overseas, though just when this occurred is unknown (Pereira et al., 2006). Following the Christian conquest of southern Portugal the sheep took on a new role as provider of wool – a prime source of wealth for Medieval Portugal and Castile. However, as a source of meat this animal was relegated to a subsidiary role with beef and pork becoming the favoured meats. As with the sheep, it is impossible to verify at this stage whether the Christians improved local cattle or imported new stock from abroad. While their Crusader origins would favour a northern source, genetic analyses of Portuguese breeds of cattle favour an African input (Cymbron et al., 1999) though this is now thought to have happened in much earlier times – during or before the Bronze Age (Anderung et al., 2005). It is hoped that continuing archaeological investigations in southern Portugal will produce more data with refined dates which should in turn improve our understanding of the relations between people and their domesticated animals during the last two millennia.

3.11. Question 11: How many uses can a dry bone have?

The use of bone as a raw material is widely recognised in the archaeological record. Throughout the millennia people have used the hard parts of animals (*i.e.*, bone, horn, antler and ivory) to produce a wide variety of implements, from ornaments to tools (MacGregor, 1985; Choyke and Bartosiewicz, 2001; Luik et al., 2005). However, their study is often treated as a kind of ancillary subject. Unfortunately too, it is still common practice to exclude such finds from the zooarchaeologist's bench! As MacGregor (1985, p. 30) writes: *"for the most part, the species involved were identical with those generally exploited for food or motive power."* As a result many remain unpublished and stored for years (or even decades) in museum reserves. Only the most stunning are exhibited but even then they fail to be correctly identified to taxon and part of skeleton. Also, in many cases their original use remains undetermined.

Until recently, the study of worked bone objects was generally descriptive and typological. The application of new analytical techniques such as traceology (d'Errico et al., 1982/83; d'Errico and Giacobini, 1986; d'Errico and Redouron, 1988) has opened new avenues of research. Experimental work has shown that various stone tools and different methods of polishing left specific marks that can be used to trace the technological history of the manufacture of prehistoric bone artefacts (David, 2007). In addition, use-wear analyses are able to identify what they were used for (d'Errico, 1993; LeMoine, 1997; van Gijn, 2005). Archaeologists have now realised that behind these traces the gestures that our ancestors made can be deciphered.

The projects that are currently underway in our laboratory result from contacts established with Portuguese and Spanish archaeologists. They are concerned mainly with medieval materials and at this early stage our work has focused on three basic aspects:

i) the production of a catalogue of groups of typologically and sometimes chronologically related objects considered to be unusual
ii) the identification, where possible, of their taxonomic and anatomical source, and
iii) an understanding of how they were manufactured

The resulting corpus of data should serve as a general background against which individual finds scattered across the archaeological record may be viewed in perspective. We also feel strongly that it is time for bone artefacts from the more recent past, *i.e.*, historical periods, to be studied with the same technological resources as those from earlier times. They not only attest to the extended use of this raw material, but also they allow us to recognize the origins of cultural traditions often still in practise today.

Musical instruments.

Archaeological finds of wind instruments (*i.e.*, pipes, flutes and whistles) have been reported world-wide. Although they are dated to different periods, the prehistoric ones have drawn more attention as being supposedly relevant to the origins of music (Brade, 1982; Hickmann et al., 2002). Thus, among the earliest examples are the well known Aurignacian aerophones from Geissenklösterle Cave (southwestern Germany) carved from mammoth ivory (Conard et al., 2004) and the swan ulna (wing-bone) (Münzel et al., 2002). Over 20 fragments of bone pipes were recovered in a Gravettian layer in Isturitz Cave (southern France; Passemard, 1922), and later identified as having been fashioned from vulture ulnae (Buisson, 1990). The largest assemblage found at any single site comes from the Neolithic site of Jiahu, in the Yellow River valley in Henan Province, central China (7,000-5,800 BP) where over 30 aerophones made on crane ulnae were recovered (Zhang et al., 1999). Martí Oliver et al. (2001) report a collection of diaphyses of vulture and eagle ulnae recovered from Cueva de l'Or (Beniarrés, Alicante, Spain), dated to the Neolithic (5,000 BP), and interpreted as Pan pipes. Finally, Fages and Mourer-Chauviré (1983) published a Chalcolithic flute fashioned also from a vulture ulna in Veyreau, Aveyron, France.

It is evident that independently of geographical and chronological contexts, the wing bones of birds, in particular the ulnae, have served as the preferred raw material for making pipe-type instruments (Figure 29). However, it is very likely that our ancestors used other raw materials of a more perishable nature such as wood or reed that have failed to survive in the archaeological record. Bird ulnae (known as the *cubitus* in the human skeleton) are ideally suited for making aerophones. They are long, thin, hollow and light (Figure 30). By removing their proximal and distal ends one is left with a tube through which air can be blown and sound produced.

Figure 29 – Preparation of a Griffon vulture skeleton (*Gyps fulvus*, CIPA N.° 1668). Detail of the left wing to show both the ulna and radius. Note the attachment of secondary feathers to the *Papillae ulnare* of the ulna.

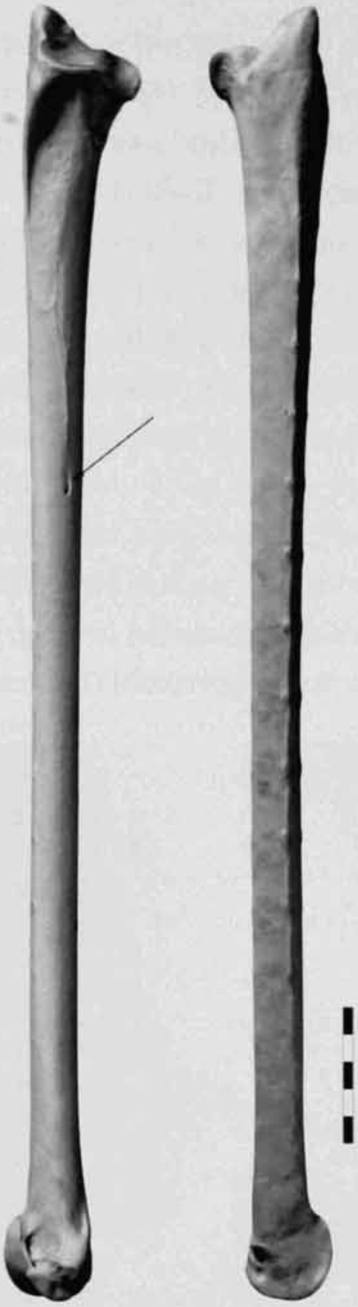

Figure 30 – Ulna of a Black Vulture, *Aegypius monachus*, ventral and dorsal views (from left to right). The arrow points to the location of the nutrient foramen.

During a workshop on transhumance in the village of Guadalaviar (Teruel, Spain) in September 2003, one of the authors (MM-G) was particularly struck by a presentation of traditional pastoral musical instruments. Two pipes made from a wing bone of a vulture, we were told, are common instruments not only in Aragón but also in other parts of Spain to this day. Is it possible that nothing similar had ever been found in the archaeological record of the Iberian Peninsula? We found this difficult to believe. Our suspicion was that archaeological finds had either not been identified correctly or were simply awaiting study. Our suspicions soon proved to be correct.

In the last four years of this project, over 20 bird bone artefacts – probable musical instruments – from Iron Age to Post-medieval Portugal and Spain, have been recorded.

Identification to species has been possible for many of the different kinds of instruments now recognised (see Table 9 and Figure 42 Moreno-García and Pimenta, 2004; 2006a; 2006b; 2007a; 2007d; in-press-b; Moreno-García, 2005; Moreno-García et al., 2005a; forthcoming; Pimenta and Moreno-García, 2007a). From a zooarchaeological perspective it is interesting that the majority were made from vulture ulnae (Table 9). In addition, many of the instruments from Moslem times do not appear to be aerophones, as was originally suggested (Zozaya, 1995; Macias, 1996; AAVV, 1998; 2000). They have a variable number of opposing holes – incompatible with the known functioning of a wind instrument (Figure 31). Also, closer inspection reveals differential wear at the edges caused by attrition from an external body passing through them. At present, different interpretations are being assessed. Could they be related to the vast group of stringed instruments such as harps? Are the holes for pegs and/or strings? Are they mere parts of more complex instruments? Or do they represent other kinds of objects totally unrelated to music? Certainly, more data are needed to draw conclusions. Traceological analysis of the areas around the holes appears as the proper approach

Species	Bone	Site	Date	Museum	Reference
Flamingo	Tibiotarsus	Cacela (Portugal) [1]	unknown	Museu Nacional de Arqueologia, Lisbon	Moreno-García & Pimenta, 2006a; Pimenta & Moreno-García, 2007a
Vulture	Ulna	Torres Vedras (Portugal) [1]	Late medieval	Convento da Graça, Museu Municipal, Torres Vedras	Luna & Cardoso, 2002; Moreno-García et al., 2005a
Black vulture	Ulna	Alarcos, Ciudad Real (Spain) [1]	Medieval	Parque Arqueológico de Alarcos, Ciudad Real	Moreno-García & Pimenta, 2006b
Vulture	Ulna	Jaén (Spain) [1]	Islamic	Museo Arqueológico, Jaén	Unpublished *
Griffon vulture	Ulna	Seville (Spain) [1]	Islamic	Museo Arqueológico, Seville	AAVV, 1998; Moreno-García et., al, forthcoming
Vulture	Ulna	C/San Fernando, Seville (Spain) [1]	Islamic	?	Unpublished
Vulture	Ulna	Alarcos, Ciudad Real (Spain) [1	Islamic	Museo Arqueológico, Ciudad Real	Zozaya, 1995; Moreno-García & Pimenta, 2006b
?Vulture	Ulna	Silves Castle [1]	Islamic	Under study	Unpublished *
Undetermined	?Tibiotarsus	Silves Castle [1]	Islamic	Under study	Unpublished *
6- Vulture 1- Black vulture	Ulna	Mértola (Portugal) [7]	Islamic	Museu Islâmico, Mértola	Macias, 1996; Moreno-García et al., 2005a; Moreno-García & Pimenta, 2006b
Vulture	Ulna	Roman Theater, Zaragoza (Spain) [1]	Islamic	Museo del Teatro Romano de Caesar Augusta, Zaragoza	Moreno-García et al., 2005a; Moreno-García & Pimenta, 2006b
Griffon vulture	Ulna	Albarracín, Teruel (Spain) [1]	Islamic	Museo Arqueológico Municipal, Teruel	AAVV, 2000; Moreno-García & Pimenta, in press-b
Griffon vulture	Ulna	Roman Villa del Val, Alcalá de Henares, Madrid (Spain) [1]	Hispano-Visigothic	Museo Arqueológico Regional de Alcalá de Henares, Madrid	AAVV, 1998; Moreno-García & Pimenta, 2007a
Griffon vulture	Ulna	Conimbriga (Portugal) [1]	Roman	Museu Monográfico de Conimbriga	Alarcão & Ponte, 1974; Moreno-García & Pimenta, 2004; Moreno-García et al., 2005a
?Crane	Ulna	La Gavia, Madrid (Spain) [1]	Iron Age	Museo Arqueológico Regional de Alcalá de Henares, Madrid	Moreno-García, 2005

Table 9 – Bird-bone instruments recovered from excavations in Portugal and Spain. The number of objects is given in square brackets.

* Currently under study.

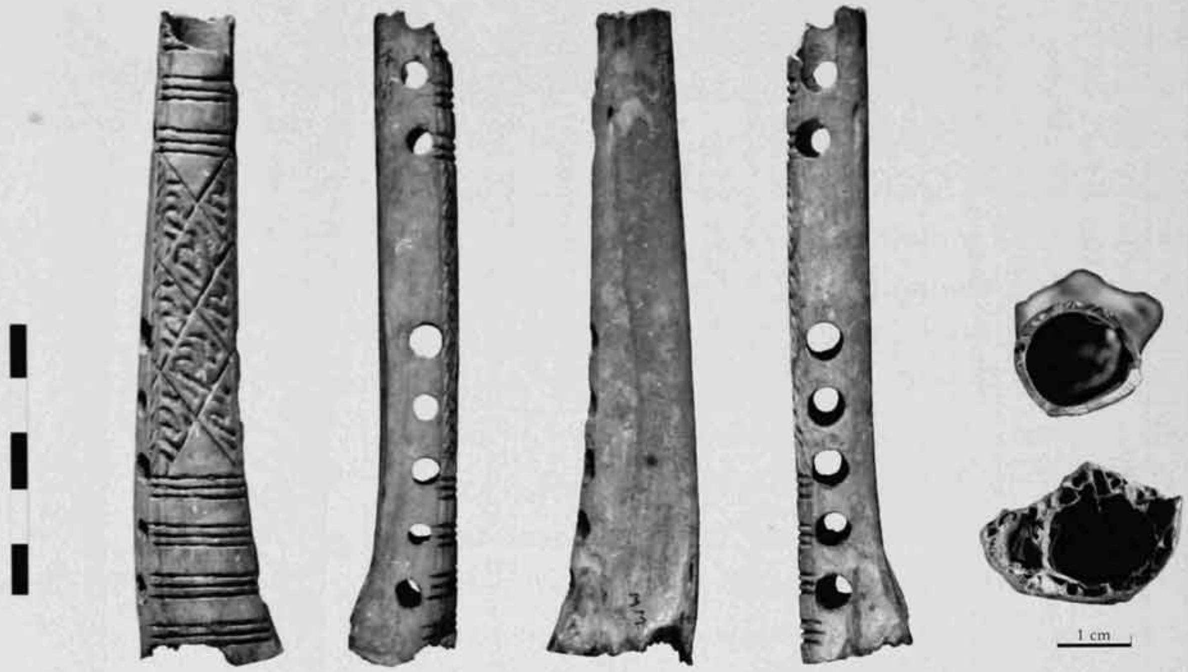

Figure 31 – Bone instrument from the Islamic period "Os-Div 4/59 (n.º 0246)" from Mértola (Portugal) fashioned on a vulture ulna. From left to right, dorsal, lateral, ventral, medial views and details of both ends. Note how the holes on the medial side are slightly larger and better aligned than those on the lateral side.

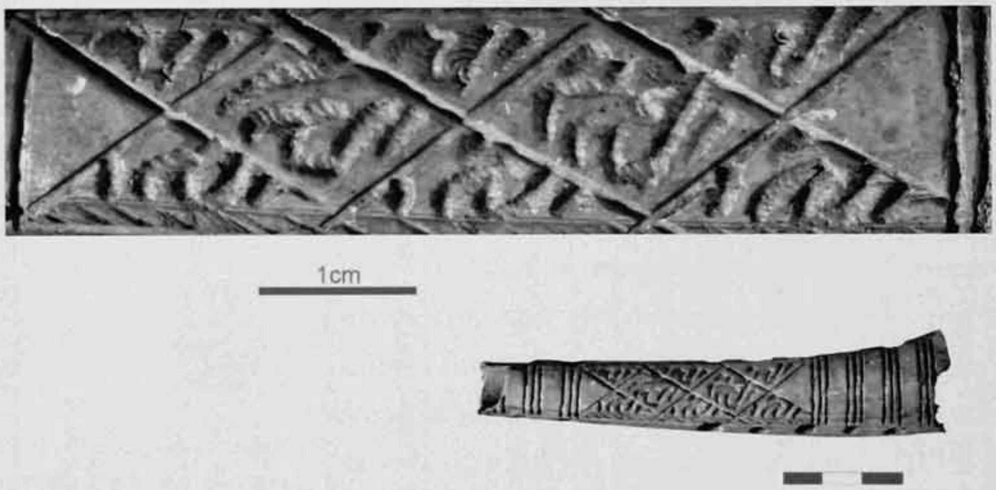

Figure 32 – Bone instrument from the Islamic period "Os-Div 4/59 (nº 0246)" from Mértola (Portugal) fashioned on a vulture ulna. Detail of the Arab word "ilāh", divinity, engraved on the dorsal side of the ulna. (Translation by Nadia Bentahar).

to characterize how the wear of their edges was produced. The association of most of these objects with palatial contexts seems worth exploring too. Maybe they were not 'popular' or common artefacts but related to people of 'high status'. One sample from the Alcáçova (castle) of Mértola (Figure 32) and another from Seville are meticulously decorated with engraved Arabic texts – the term "divinity" (*'ilāh*) on the former and the expression "happiness and prosperity" (*al-yumn wa-l-iqbāl*) on the latter (Moreno-García et al., 2005a; forthcoming; Moreno-García and Pimenta, 2006b). As for the others, the motifs of engraved geometrical decoration they display appear to be similar in all cases. Do they all derive from the same workshop or were they manufactured in various towns in al-Andalus?

In conclusion, we are still far from understanding the true significance of these Iberian bird bone instruments. Collaboration between archaeologists, zooarchaeologists, musicologists, historians and ethnologists will now be necessary and should also allow us to assess the relationship between our ancestors and these scavenging vultures. Little did we suspect that they could have provided so many wings to develop one of man's most beautiful and universal means of expression.

Bone anvils.

During the last few decades, archaeologists working in south-eastern France, the Iberian Peninsula, northern Morocco and the Ukraine have uncovered a particular kind of bone object fashioned primarily from cattle, horse and ass metapodials (lower limb bones). So far there is a unique find from Seville (Spain) dated to the Taifa-Almoravid periods (11th-12th-centuries AD) manufactured on a camel radius-ulna (Moreno-García et al., 2007). These objects have one or several faces of the diaphysis whittled down and smoothed in such a way that their original convexity has been transformed into flat or even concave surfaces and they have become quadrangular in cross section. In addition, they feature parallel rows of tiny triangular-shaped indentations across the longitudinal axis of the diaphysis that in turn, are partially erased by multiple fine scratch marks (Figure 33). For a long time their function was a mystery. While many were simply described as decorated bones (Molinero Pérez, 1971; Julià et al., 1992; Castillo et al., 1999; Antoñanzas et al., 2000) amulets or bone idols (Serrão, 1978; Sá Coixão, 1996) or even archer's wrist-guards (Zozaya, 1995), others were interpreted as functional objects like polishers, files or sharpeners (Serrão, 1978; Peters, 1986; Briois et al., 1995; Cardoso and Varela Gomes, 1996; Rodet-Belarbi et al., 2002; Gerrard, 2003) following the work carried out by Semenov (1964) on samples from Graeco-Scythian colonies around the Black Sea.

The idea that these bones were related to an artisan's activity gained support after nearly 200 samples were uncovered at al-Basra in northern Morocco from deposits associated with metal production. Here large quantities of metal slag and charcoal, along with possible smelting pits and furnace remains, were found (Benco et al., 2002). Thus, these bones contained iron particles and grains of silica inside the triangular indentations suggesting that they might have been used for smoothing or burnishing metal (Benco et al., 2002).

Figure 33 – Left metacarpal of cattle (*Bos taurus*) from Beco de São Marçal, Lisbon, Portugal, 14th-15th centuries. The convex anterior surface of the diaphysis was flattened and smoothed in order to create a stable surface that could be used as an anvil on which the toothed-sickle could rest. Repeated use of the anvil involved successive grinding of the bone surface to keep it flat. This action resulted in the reduction in thickness of the bone, making it more fragile.

Making use of ethnographic information from Catalonia (Spain) Esteban Nadal (2003) discovered their true function. They were used by blacksmiths as anvils to anchor the blade of an iron sickle while being cut with a wedge-shaped pointed chisel to make a serrated edge (Figure 34). Additional ethnographic evidence from other regions in Spain (Aguirre et al., 2004) and Portugal (Veiga de Oliveira et al., 1976; Moreno-García et al., 2005d; 2006b) attest to the survival of this practice in the Iberian Peninsula until the end of the 20th-century.

Studies of bone anvils from the Iberian Peninsula demonstrate their long chronological existence from the Visigothic period (5th-8th-centuries AD) until the 20th-century, with a considerable concentration of finds from sites dated

Site	Date	Bone							Total
	century	Mandible	Humerus	Radius	Metacarpal	Tibia	Metatarsal	Undetermined	
FREIXO DE NUMÃO (Sá Coixão, 1996)	unknown	-	-	-	-	-	-	2	2
IDANHA (Serrão, 1978)	unknown	-	-	-	-	-	-	1	1
SESIMBRA (Serrão, 1978)	unknown	-	-	-	1b	-	-	-	1
SANTARÉM	18th-19th	-	-	-	8b	-	8b	1	17
TORRES VEDRAS	15th-17th	-	-	-	3b	-	5b	-	8
BEJA	15th-17th	-	-	-	3b	-	4b	-	7
PALMELA	15th	-	-	-	1b	-	-	-	1
LISBON, Mouraria	14th-15th	-	-	-	3b		1b		4
SILVES, House (Cardoso & Gomes, 1996)	15th-16th	-	-	-	-	-	-	1	1
SILVES, Biblioteca	12th-14th	1b	1b	3c, 1b	7b, 1a	2c, 1b	1b, 2c	7	27
TOTAL		**1**	**1**	**4**	**27**	**3**	**21**	**12**	**69**

Table 10 – Bone anvils recovered from Portuguese archaeological sites. Note the trend towards the use of cattle bones and in particular metapodials (metacarpals and metatarsals); a= ass; b = bovid; c = horse.

Figure 34 – Blacksmith on his bench cutting the teeth of a serrated sickle. Detail of the edge of the metal sickle to show how each tooth corresponds to a V-shaped indentation on the bone anvil. Note that the sickle is positioned across the bone. Drawing by J. Martí and R. Sala.

to the Islamic period (Moreno-García et al., 2005d; 2006b; 2006c). The assemblage recovered from an Almohad (12th-13th-centuries AD) *Arrabalde* (suburb) in Silves is exceptional due to the number of examples and the variety of bones used (Table 10; Moreno-García et al., 2006b). They allowed us to consider, as a working hypothesis, that earlier blacksmiths used a wide variety of bones including mandibles (Figure 35), humeri, radii, femora and tibiae. Later, in post-medieval and modern times, a standardisation towards the exclusive use of metapodials seems to have occurred (Esteban Nadal and Carbonell Roure, 2004; Esteban Nadal, 2005). Certainly, metapodials are bones that not only provide long-lasting working surfaces, since their diaphyses are thicker and more robust than those of any other long bone, but also they can easily be flattened and smoothed. Finally, as far as species representation is concerned, it is clear that in Iberia as well as in the other geographical regions mentioned above (Rodet-Belarbi et al., 2007), the use of cattle bone dominates (Table 11), suggesting that they were easier to obtain and perhaps the only abundant large mammal available too.

Figure 35 – Left cattle (*Bos taurus*) mandible from an Almohad period Arrabalde in Silves (Biblioteca), Portugal, 12th--13th centuries. Note the presence under the second and the third molar teeth of fifteen lines of V-shaped indentations perpendicular to the body of the mandible.

	Bone	Cattle	Equid	Dromedary
SPAIN	Radius	-	-	1
	Metacarpal	10	4	-
	Tibia	1	-	-
	Metatarsal	24	2	-
	Metapodial	3	3	-
	TOTAL	**38**	**9**	**1**
PORTUGAL	Mandible	1	-	-
	Humerus	1	-	-
	Radius	1	3	-
	Metacarpal	26	1*	-
	Tibia	1	2	-
	Metatarsal	19	2	-
	TOTAL	**49**	**8**	-
FRANCE	Mandible	9	-	-
	Radius	6	2	-
	Metacarpal	17	4	-
	Pelvis	-	4	-
	Tibia	3	1	-
	Metatarsal	27	5	-
	Metapodial	8	4	-
	TOTAL	**70**	**20**	-
MOROCCO	Radius	(7)	-	-
	Tibia	(7)	-	-
	Metapodial	178	1	-
	TOTAL	**185**	**1**	-
TUNISIA	Metatarsal	-	-	1
	TOTAL	-	-	**1**
UKRAINE[1]	Metacarpal	4	-	-
	Tibia	1	-	-
	Metatarsal	3	2	-
	TOTAL	**8**	**2**	-
HUNGARY[2]	Radius	-	1	-
	TOTAL	-	**1**	-

Table 11 – Bone elements used as anvils in different countries with their identifications. All periods are pooled.

* Specimen identified as *Equus asinus* (Moreno-García et al., 2006b).

[1]Unpublished data (E. Antipina *pers. comm.*). [2]Unpublished data (L. Bartosiewicz *pers. comm.*).

Pierced metapodials.

Following our request to Portuguese archaeologists to let us know of any musical instruments made of bone, we were presented with some cattle metapodials with a variable number of perforations on their posterior side (Figure 36). Different stages of wear were clearly evident on the internal borders of some of them which excludes their interpretation as wind musical instruments. We now know of 32 examples from Portuguese sites and eight more from Spain (Table 12;

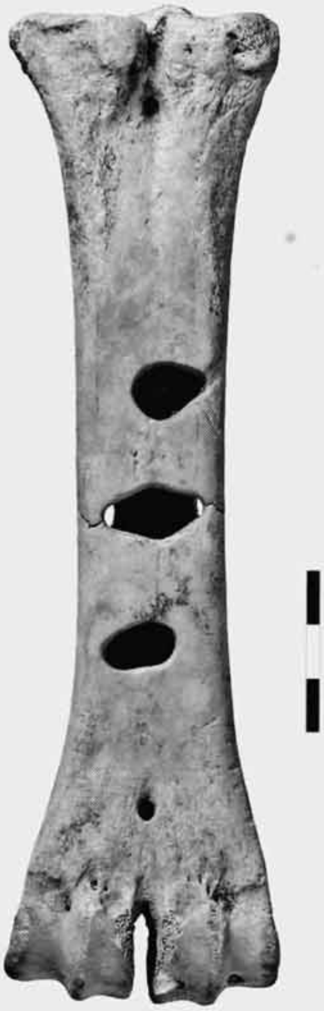

Figure 36 – Right metacarpal of cattle (*Bos taurus*) recovered from excavations at Fundação Ricardo Espírito Santo (Lisbon; n.° FRESS 001). Three perforations are visible on the posterior surface. While that in the centre appears oval-shaped, those at the top and bottom show that the original round perforation suffered progressive wear towards opposite sides, towards the lateral and medial surfaces of the diaphysis.

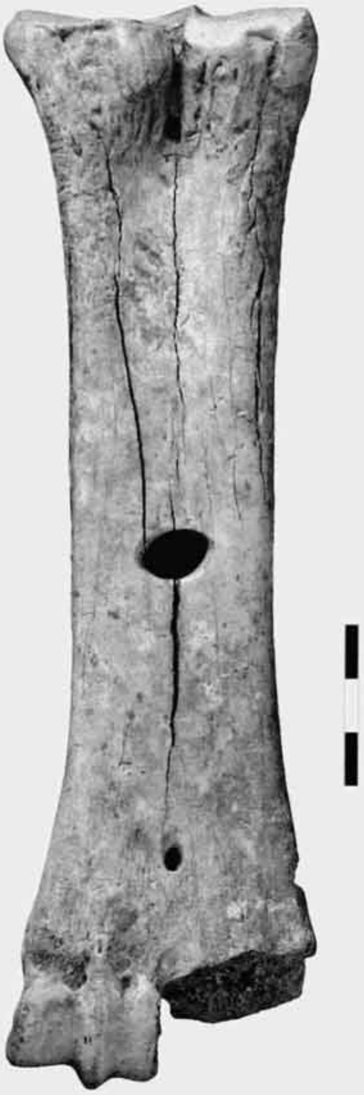

Figure 37 – Right metacarpal of cattle (*Bos taurus*) recovered from Alcáçova de Mértola (os-vários 4A, 4K (1C); n.° MER 001). A single oval perforation is visible on the posterior side of the diaphysis.

Moreno-García et al., 2006a; Lopes et al., 2007; Moreno-García and Pimenta, 2007c). Most are derived from cattle metapodials. We only know of two from donkey and one from a sheep metacarpal. These (donkey and sheep) were recovered from an Almohad *Arrabalde* and the castle – both in the city of Silves, Algarve.

These pierced long-bones are associated with the Moslem presence in the Iberian Peninsula and are dated to the period from the 10th to the 13th-centuries AD. They have been found isolated or in small numbers (with the exception of those recovered in the Silves *Arrabalde*) together with other faunal remains.

	Cattle		Ass		Sheep	Unobserved*	Total
PORTUGAL	MTC	MTT	MTC	MTT	MTC		
Silves							
Biblioteca	12	4	2	-	-	-	18
Teatro Gregório Mascarenhas	-	1	-	-	-	-	1
Castelo (unpublished)	-	-	-	-	1	-	1
Alcoutim, Castelo Velho (Catarino, 1997/1998)	1	-	-	-	-	1	2
Aljezur, Ribat da Arrifana (unpublished)	-	1	-	-	-	-	1
Paderne, Castelo (Catarino & Inácio, 2006)	1	-	-	-	-	1	2
Mértola, Alcáçova	3	-	-	-	-	-	3
Palmela, Castelo	1	-	-	-	-	-	1
Lisbon, Fundação Ricardo Espírito Santo	3	-	-	-	-	-	3
Total	21	6	2	-	1	2	32
SPAIN							
Calatayud (Zaragoza) (Cebolla et al., 1997)	-	1	-	-	-	-	1
Alicante, Fortí de Denia (unpublished)	1	-	-	-	-	-	1
Valencia							
Alqueria de Benipeixcar (unpublished)	1	1	-	-	-	-	2
Paterna (Mesquida Garcia 1989)	-	-	-	-	-	2	2
Seville							
C/San Luís n.º 93	2	-	-	-	-	-	2
Total	4	2	-	-	-	2	8

Table 12 – Pierced metapodials from Portugal and Spain. MTC= metacarpal; MTT= metatarsal.
* This column refers to specimens not seen by us (Catarino *pers. comm.*).

There seems to have been a preference for metacarpals rather than metatarsals (28 of the former and 8 of the latter; Table 12). It is likely that the semi-circular cross-section of the metacarpal shaft with its flat posterior and convex anterior surface made it easier to use than the metatarsal with its square cross-section. No previous preparation of the bones is evident. Complete specimens have one (Figure 37), two or three holes. Although the number of perforations varies, there is always one placed in the middle of the diaphysis that was originally circular. It seems that in the course of their use, the borders of the holes tended to wear away towards one or both (medial and lateral) sides. This progressive wear caused the holes to become oval, and when wear was in an advanced stage, breakage of the bone across its shaft resulted.

From broken examples it was possible to observe that the wear of bone tissue is not limited to the border of the perforations. The internal side of the diaphysis, visible through the hole, presents a rounded and abraded depression that in some cases is covered by a thin black layer (Figure 38). Micro X-ray fluorescence spectrometry analysis of this black deposit showed that it mainly consisted of iron (Lopes et al., 2007).

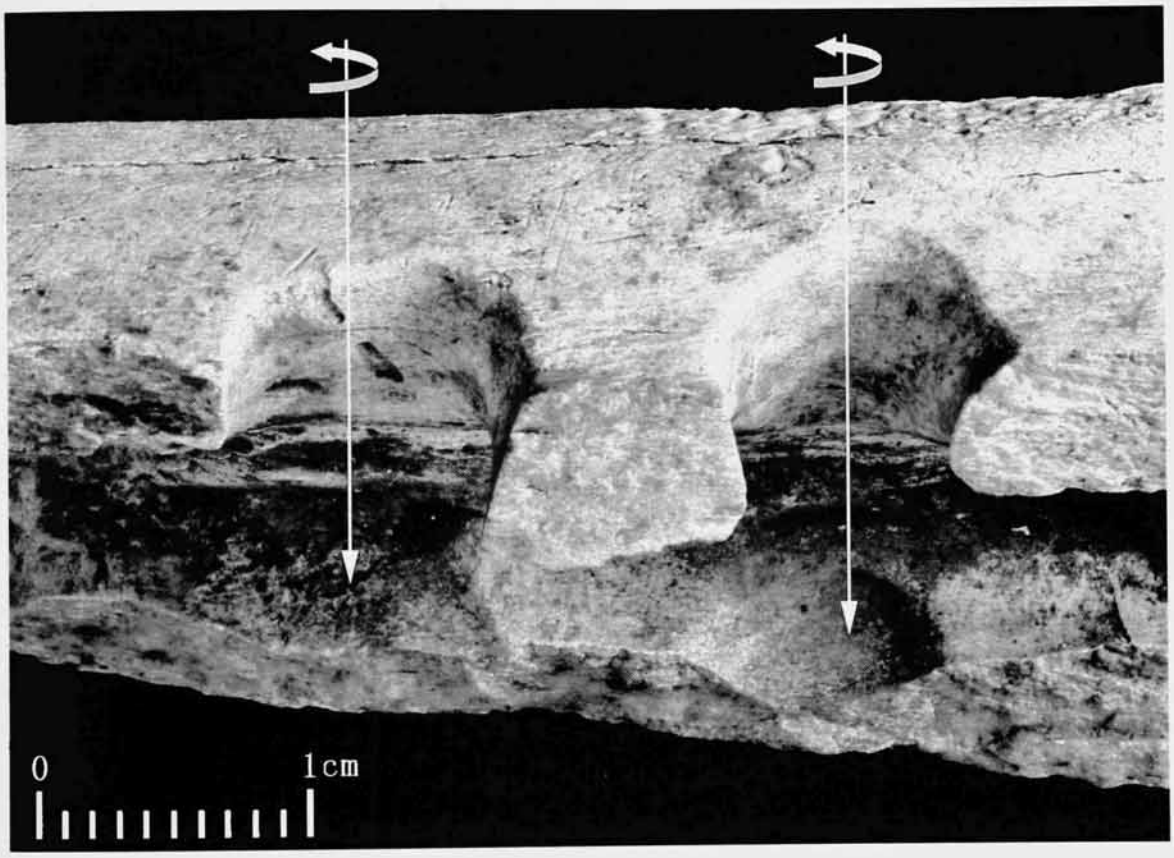

Figure 38 – Right metacarpal diaphysis fragment of cattle (*Bos taurus*), recovered from Silves *Arrabalde* (n.° SILV 007). Note that the wear of bone tissue is not limited to the border of the perforations. The internal side of the diaphysis, opposite the hole, presents a rounded and abraded depression which could have been caused by the continuous action of spinning axes, as suggested by the arrows.

Based on the above observations we suggest that the morphological changes of the borders of the perforations and the internal depression of the diaphysis are compatible with the presence and continuous action of spinning (iron?) axes. Thus, these bones may have formed a part of a more complex structure, perhaps a machine used in textile manufacture, in which single or multiple axes would have been at work simultaneously.

Concluding remarks.

These are just some examples that demonstrate how items of worked bone cannot be simply regarded as isolated finds. To put them in perspective and thoroughly understand their role after they were carved out of a blank it is necessary to approach their study with a wider view, involving many other disciplines such as history, ethnology, biology, traceology and chemistry. Many subjects remain to be studied and questions to be answered. Why were some bones and some animal species preferred to others? Was it always a question of availability or were there practical reasons? Does the retrieval of metapodials, the bones most widely used as raw material for the manufacture of implements, affect body-part representation in an archaeological context? Since most worked bone items are of relatively small size they could have been transported, attesting to the migration of people. Were some bone artefacts the means for spreading particular ideas or beliefs among different cultures? Some skeletal materials like ivory are considered to be extremely valuable and were traded over long distances.

In conclusion, after an animal carcass has been processed its hard parts were not always considered as waste by our ancestors. Even today, it is common to find in handicraft fairs necklaces, rings and small boxes made of bone that will remain for future zooarchaeologists to identify!

3.12. Question 12: Do present day fauna have a role in zooarchaeological studies?

It should be clear from the questions above that the study of archaeological faunal remains is based to a very important extent on an understanding of their present day relatives. Not only is it essential to understand their osteology to identify the bones and species represented in a faunal assemblage but also we need to be aware of their ecology, diet, reproduction patterns and so on. It could be argued that these are topics within the domain of the natural sciences, far removed from archaeology. However, as zooarchaeologists we believe that studies of present day interactions between humans and animals in different parts of the world may also provide clues about such interactions in the past. Of special importance is the work carried out with endangered species and those close to extinction that in a few decades may be lost forever.

From this perspective, we are engaged in a number of projects involving some of the most emblematic species of the Iberian fauna:

i) the Iberian wolf (*Canis lupus signatus*)
ii) the Black, Griffon and Egyptian vultures (*Aegypius monachus, Gyps fulvus* and *Neophron percnopterus*), the Lammergeier (*Gypaetus barbatus*) and
iii) the Iberian lynx (*Lynx pardinus*)

At first sight, the importance of these species in archaeological contexts or to humans in the past may not be very obvious. However our studies are beginning to show that they probably played an important role.

The Iberian wolf *(Canis lupus signatus).*

Populations of the Iberian wolf (*Canis lupus signatus*) were severely reduced during the 20th-century, largely through hunting and poisoning. Nowadays, the wolf is a protected species in Portugal, and there are two populations located north and south of the river Douro. In September 1999, the Portuguese ICNB (Institute for Nature Conservation and Biodiversity) created an interdisciplinary program – *Sistema de Monitorização de Lobos Mortos* (SMLM – Monitoring System of Dead Wolves) to collect dead wolves. Its three main aims are:

i) to register mortality patterns of this species;
ii) to improve our understanding of the causes of death of the wolf, and
iii) to develop relevant studies from different research areas that may help to conserve this endangered species.

Since 2002, the IPA Zooarchaeology lab has been a partner involved in the project.

42 complete skeletons of individuals of different age and sex (11 females and 31 males) have been prepared in our laboratory. They are on loan from the ICNB and form part of our vertebrate reference collection (www.ipa.min-cultura.pt/cipa). It is evident that the mortality pattern of this species shows a bias towards males. They are mainly the young adult or sub-adult males that venture abroad in search of new territory and mates and consequently expose themselves to greater danger than do the females or puppies that remain at home. This might be a recent phenomenon related to human pressure and the reduction of their habitat, with no reflection in the archaeological record. Indeed, ethnographical work with traditional agro-pastoral communities in the Rif Mountains in northern Morocco indicates that hunters aim to locate the dens where female jackals (*Canis aureus*) and their puppies live in order to ensure the killing of future

generations. Occasionally, the meat of these animals ends up in the pot to be consumed by children, as it is considered to be highly nutritious (Moreno--García, 2004).

Wolves are opportunistic and explore a variety of resources, aiming to get the maximum return with the minimum loss of energy. This means that attacking a flock of sheep/goats is more advantageous than hunting wild animals, like small deer or wild boar. Livestock constitute a regular and accessible food source. Thus, the bond established between wolf and man was probably based on that profitable feeding strategy. Once human populations felt the need to guard their basic living resources, wolves were seen as an external threat to be eliminated.

The wolf carcasses received from the SMLM attest to the poor relationship between man and wolf even today. Many of the traumatic injuries on their bones are clearly man-induced and are often the cause of death. These include bullet wounds, car collisions, snares,... In addition, a variety of pathological conditions have been recorded, and include healed fractures (Figure 39), inflammation and infection causing abnormal bone growth, oral pathologies and abnormalities (Figure 40), diseases of joints and so on (Moreno-García et al., 2003c; 2005b; 2005c; 2005e). These data should prove useful when making comparisons with pathological conditions in bones both recent and ancient. Moreover veterinary scientists have here the opportunity to observe pathological conditions on bones and teeth of a wild animal. And it is hoped their work will contribute towards developing animal palaeopathology, an area of study that until recently tended to be neglected by zooarchaeologists (but see Baker and Brothwell, 1980; Davies et al., 2005). It should be noted that had only the skull and skin been prepared – the usual policy in most natural history museums – most of these post-cranial lesions would have gone unrecorded.

Finally, as part of the project, measurements are being taken on the skull, teeth and limb bones. We hope to improve our understanding of the osteometry of the extant populations of the Iberian wolf which should prove useful for comparing with archaeological specimens of wolf and dog – in particular the traditional breeds of Portuguese shepherd dogs (Moreno-García and Pimenta, 2006c). Preliminary results on some skull and teeth measurements show the mean differences between male and female Iberian wolves are highly significant (*t-test* $P< 0,001$), with females being smaller than males. This does not mean that there is a complete separation of males from females. Thus, we must be aware that any isolated specimen cannot be sexed with certainty. Relative to

Figure 39 – Adult modern male wolf, *Canis lupus signatus*, SMLM 47 (CIPA n.° 1789). From left to right, cranial and caudal views of the right femur. Note the old breakage at the mid midshaft and later abnormal consolidation of both proximal and distal ends that resulted in the shortening of this leg bone.

wolves, male and female specimens of the traditional breeds of Portuguese shepherd dogs, Castro Laboreiro and Serra de Estrela, exhibit narrower and shorter carnassial teeth (Figure 41) for example.

A multidisciplinary program such as that of the SMLM should provide data relevant not only to zoologists and environmental biologists, but also to zooarchaeologists.

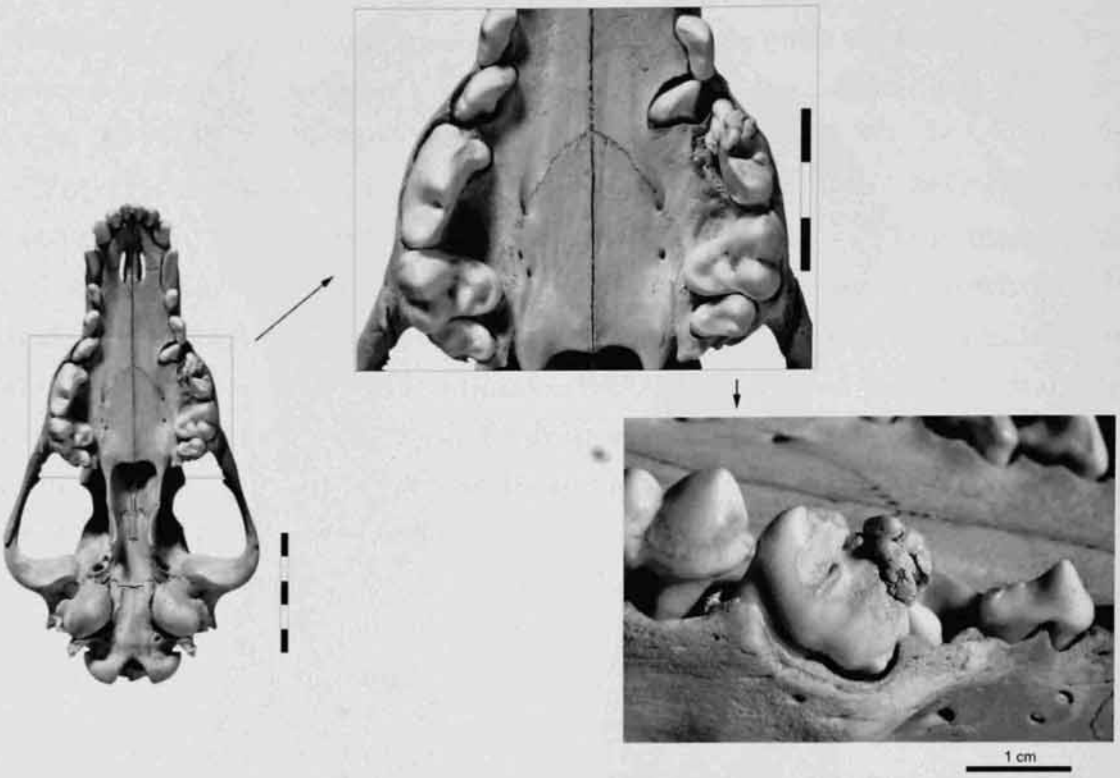

Figure 40 – Juvenile modern male wolf, *Canis lupus signatus*, SMLM 47 (CIPA n.° 1537). Skull and details of the palatal bone and upper teeth. Note the malformation at the occlusal surface of its left first molar (M^1). The left 4th premolar (P^4) is rotated 90° towards the inside.

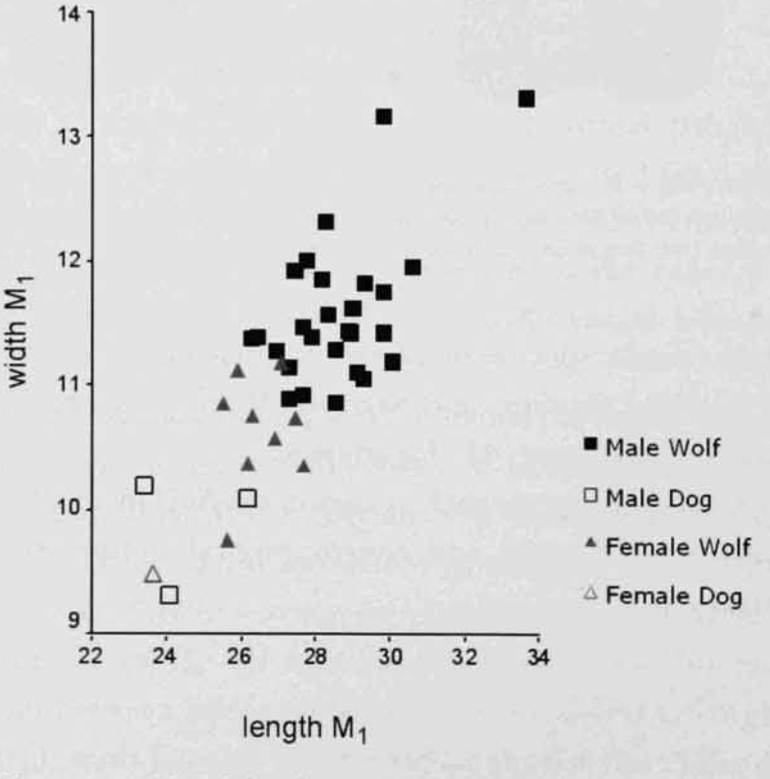

Figure 41 – Plot of lower carnassial tooth length versus width showing: i) two clusters for male and female Iberian wolves and ii) a separation of wolves from traditional Portuguese sheperd dog breeds. The carnassials of dogs are both narrower and shorter. Measurements are in milimeters.

Vultures.

These scavenging birds have established a mutualistic relationship with humans, derived essentially from their role as cleaners of carcasses of wild and domestic animals. Thus, in contrast to the situation described above for wolves, their presence would not have bothered people; they would have been considered beneficial. Even today there are some cultures that practise excarnation and leave their dead exposed for animals to scavenge. The association of vultures with Death was probably responsible for the symbolic meaning these birds have had since antiquity as evidenced for example in Egyptian art (Houlihan, 1988).

The decline of vulture populations in many parts of the world is linked to the abandonment of traditional shepherding practices and to poisoning by ingestion of contaminated carrion (Risebrough, 2004). Both are the cause of death of many of the vulture skeletons now in the IPA reference collection, especially Griffon vultures (Pimenta et al., 2004).

Our interest in this group of scavenging birds grew after many of the Iberian bone musical instruments were initially identified as fashioned from one of their wing bones – the ulna. Since the two large species of these birds – the Griffon (*Gyps fulvus*) and the Black Vulture (*Aegypius monachus*) occur in Iberia, we attempted to distinguish them on the basis of osteometric and morphological characters (Moreno-García et al., 2005a). Neither the proximal nor the distal part of the ulna is present in the archaeological specimens of ulnae so we searched for diagnostic characters on the diaphysis. Here, the position of the nutrient foramen, located on the ventral side of this bone, appeared to be useful (Figure 30). Thus, a sample of 25 *Gyps fulvus* and 10 *Aegypius monachus* ulnae from the CIPA bird reference collection, the *Laboratorio de Arqueozoologia* (Universidad Autónoma Madrid) in Spain and the *Staatssammlung für Anthropologie und Paläoanatomie* München in Germany were studied. Two measurements were defined: FP, or the distance between the distal end of the nutrient foramen and the beginning of the *cotyla ventralis* in the proximal epiphysis; and FD, the distance between the distal end of the nutrient foramen and the beginning of the *tuberculum carpale* in the distal epiphysis (Figure 42).

Table 13 shows that according to FP values, the nutrient foramen in Griffon Vultures is located closer to the measured point in the proximal epiphysis (FP mean=99,6 mm) than in Black Vultures (FP mean=110,6mm). We note the opposite situation for FD values – in Griffons the nutrient foramen is placed further in relation to the distal epiphysis (FD mean=207,0 mm) and closer in Black Vultures (FD mean=202,9 mm). *Gyps fulvus* FP values are significantly smaller than those registered in the *Aegypius monachus* sample (t-test $P<1\%$, df= 33).

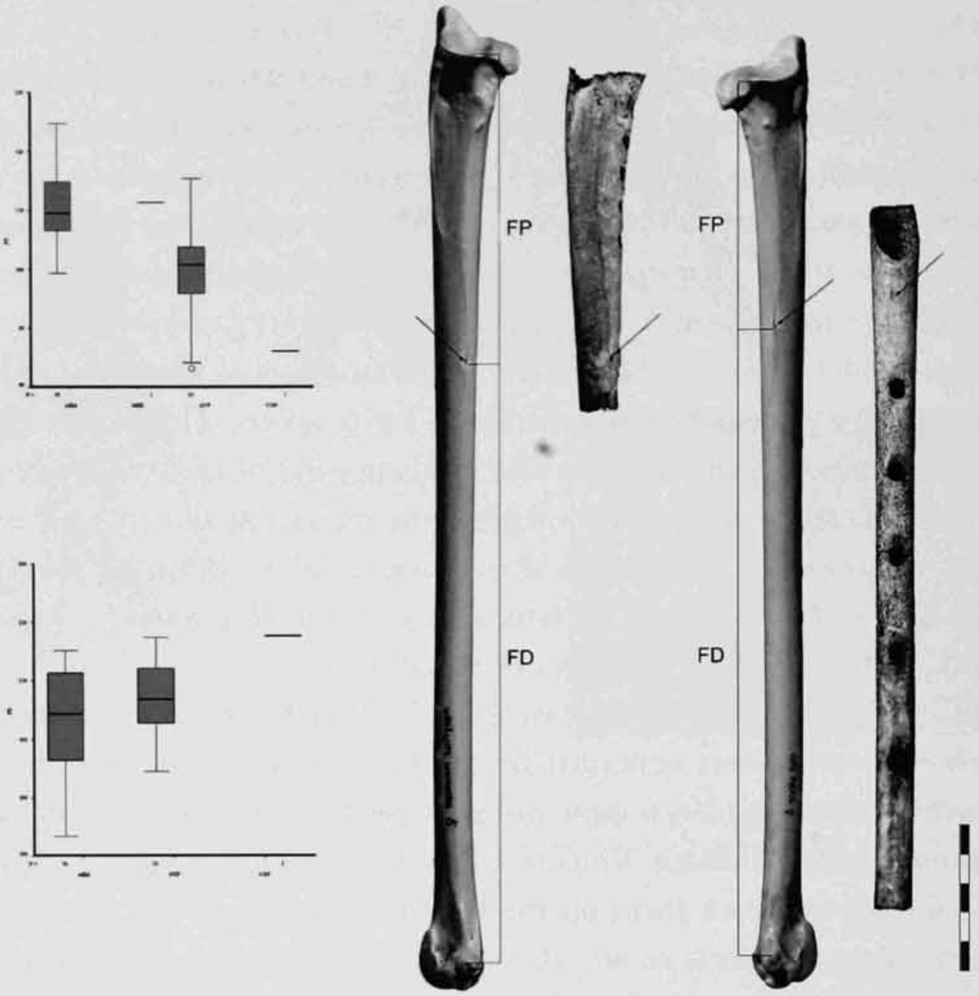

Figure 42 – Identification of two archaeological bone flutes – an osteometric method.
1. On the right are ventral views of two flutes made from vulture ulnae alongside modern specimens from the CIPA reference collection of Black and Griffon vultures. These are as follows from left to right:
Modern left Black Vulture (*Aegypius monachus* ♀ CIPA N.° 1670), Bone instrument from Mértola "Os-Div 4/59 (no 0246)", Modern right Griffon Vulture (*Gyps fulvus* ♀ CIPA N.° 1672, and Roman wind instrument from *Conimbriga*. The arrows indicate the position of the nutrient foramen.
Key: FP – distance between the distal end of the foramen and the beginning of the *cotyla ventralis* of the proximal end of the bone; FD – distance between the distal end of the foramen and the *tuberculum carpale* on the distal end of the bone.
2. On the left are two boxplots showing range (vertical line), mean (horizontal line) and 95% confidence limits of the mean of measurements (enclosed within the rectangle) of FP (above) an FD (below).
The graph of FP values shows a sample of modern of Black Vultures (AEM, 10 individuals, the worked bone ofrom Mértola (MER), a modern sample of Griffon Vultures (GYF, 25 individuals) and the wind instrument from *Conimbriga* (CON).Note that the values for *Aegypius monachus* tend to be greater than those for *Gyps fulvus*, which makes it more likely that the specimen from Mértola belonged to Black vulture, while the specimen from Conimbriga is more likely to have belonged to Griffon vulture. The graph of FD values shows that there is no statiscally significant difference between the two species of vulture and the estimated value for the *Conimbriga* instrument lies beyond the maximum values of both modern samples.

Differences between the FD values of the two species are not statistically significant. Therefore, it can be concluded that whereas in Black Vultures the nutrient foramen tends to be placed in a more central position on the diaphysis, in Griffons it is closer to the proximal epihysis.

Using these metric criteria we tried to identify the Roman musical instrument from Conimbriga and "Os-Div 4/59 (n.º 0246)" from Mértola (Figure 42). Their FP and FD values had to be estimated since both proximal and distal epiphyses are absent. In the case of the *Conimbriga* aerophone the distance between the nutrient foramen and the edge of the surviving distal diaphysis is 202,8 mm. The ulna fragment that is missing to the *tuberculum carpale* of the epiphysis can be estimated as approximately 15 mm. This gives an FD value of 217,8 mm, which exceeds the modern Griffon Vultures FD average of 207,0 mm, and it is beyond the range recorded for Black Vultures (Figure 42). As far as its FP value is concerned, based on the position of the nutrient foramen and the distal area of the diaphysis that was removed, we compared it to CIPA specimen n.º 1672 and estimated that it would have measured approximately 86 mm. This result again places the Roman ulna from *Conimbriga* closer to the range for Griffon Vultures and well beyond that of the Black Vulture (Figure 42). Thus, we conclude this wind instrument was probably made from an ulna of *Gyps fulvus*.

For "Os-Div 4/59 (n.º 0246)" from Mértola it was only possible to estimate the FP value. The presence of most of the ridge coming from the *cotyla ventralis* and the depression for the articulation ligaments under it led us to suppose that the proximal diaphysis was cut transversally very close to the point used in our FP measurement. The actual distance between the nutrient foramen and the cut edge is 101,6 mm. We estimate that no more than 10 mm would be missing, which results in an FP value of c. 112 mm. That is within the 95% confidence interval (P<1%) obtained from our sample of modern Black Vultures (Figure 42). Consequently, it is concluded this musical instrument was very probably made from an ulna of *Aegypius monachus*.

The positioning of the nutrient foramen in modern Griffon and Black Vulture ulnae allowed us to identify with confidence other bird bone instruments from the Iberian Peninsula (Table 9). This kind of information could be useful for determining the geographical distribution of these species in the past; although some caution is needed as such instruments could have been traded far and wide.

		N	Min	Max	Mean	sd
FP	Black Vulture	10	99,3	124,7	110,6	7,33
	Griffon Vulture	25	83,2	115,5	99,5	8,54
FD	Black Vulture	10	183,4	215,2	202,9	10,38
	Griffon Vulture	25	194,5	217,4	207,0	6,29

Table 13 – Number, minimum, maximum and mean values (in mm) and standard deviation of FP (= distance between the distal end of the nutrient foramen and the beginning of the *cotyla ventralis* in the proximal epiphysis) and FD (= distance between the distal end of the nutrient foramen and the *tuberculum carpale* in the distal epiphysis) in the modern sample of 10 Black Vulture and 25 Griffon Vulture *ulnae*.

The Iberian lynx *(Lynx pardinus).*

This felid species, once present throughout the Iberian Peninsula as attested by the archaeological record (Altuna, 1972), is now, sadly, one of the most endangered members of the cat family (Delibes et al., 1998). Its highly specialised diet of rabbits has made it particularly vulnerable (Aldama et al., 1991).

Lynxes are regular visitors to caves and rock-shelters where their prey leftovers and scats, containing digested bone fragments, may accumulate. Taphonomic studies have provided the means for identifying which predators were responsible for the accumulation of faunal remains in archaeological contexts (Richardson, 1980; Cruz-Uribe, 1991; Palmqvist et al., 1996; Ruiter and Berger, 2000). However, in the case of leporid remains, while some work has attempted to distinguish those modified by humans (Pérez Ripoll, 1993; 2004) from those modified by other predators like coyote (Schmitt and Juell, 1994), fox (Sanchis Serra, 2000; Cochard, 2004), Golden Eagle (Hockett, 1995; 1996; Schmitt, 1995), Spanish Imperial Eagle (Lloveras et al., 2008b), Eagle Owl (Guillem Calatayud and Martínez Valle, 1991; Sanchis Serra, 2000; Cochard, 2004; Lloveras et al., 2008c) and other birds of prey (Hockett, 1989; 1991; 1995; Cruz-Uribe and Klein, 1998), few studies have tried to characterize rabbit remains consumed by the Iberian lynx. This gap is currently being filled by work with modern Iberian lynx scats in our laboratory, funded by the Portuguese Fundação para a Ciência e Tecnologia (FCT) and in collaboration with several Spanish institutions such as the Estación Biológica de Doñana and the Universitat de Barcelona (Lloveras et al., 2008a).

In most Palaeolithic and Epipalaeolithic Iberian sites the European rabbit (*Oryctolagus cuniculus*) is, in terms of numbers of remains represented, the dominant taxon in archaeological faunal assemblages. Recently, several studies have demonstrated the important role played by leporids (hares and rabbits) in the diet of prehistoric people, their relevance being used to explain mobility patterns and increase of populations (Villaverde et al., 1996; Morales et al., 1998; Stiner et al., 1999; 2000; Hockett and Bicho, 2000; Davis, 2002; Hockett and Haws, 2002; Davis et al., 2007). Thus, once the taphonomic signature of the Iberian lynx has been identified and documented, the true contribution this terrestrial carnivore might have had in the accumulation of archaeological remains of leporids in the Western Mediterranean can be assessed.

Concluding remarks.

Certainly, there is an affirmative answer to the question posed at the beginning of this section. In the case of the Iberian Peninsula, due to its biological specificity, characterised by the occurrence of a large number of endemic species and ecological conditions absent from other parts of Europe, it appears essential that the comparative material used in zooarchaeological studies comes from present day Iberian wild animals. How do bones of the modern Iberian wolf differ from those found elsewhere in Europe? And how do they vary in relation to archaeological specimens? The same applies to the Iberian lynx. Also, tracing the taphonomic signature of the main Iberian predator species will be essential in order to understand the taphonomy of many Iberian archaeological faunal remains.

4. SOME FINAL WORDS

Portugal, although a small country, has a rich archaeological record that extends far back into the Pleistocene and which includes an abundant zooarchaeological record. Moreover, many different civilizations had an important impact on her history – Phoenicians, Greeks, Romans, Visigoths, Moslems, Crusader and so on and their influences upon the zooarchaeology of Portugal are proving to be extremely interesting. These vary from the accidental introduction of mice, the possible transport of livestock and ostrich eggs from the Maghreb to the construction of mysterious machinery incorporating cattle metapodials and the manufacture of flutes from vulture ulnae. There is much to do and zooarchaeology here is still in its infancy. This discipline, a kind of applied palaeontology, is, we believe, an indispensable tool in modern archaeological and historical research. Perhaps it is already possible to discern several strands connecting all these miscellaneous data. One might be the growing imprint of man upon the environment due to his ever increasing numbers. This is already visible in the Caldeirão sequence and is subsequently reflected in the extinction of many taxa, the need to husband animals and later to intensify this relation in the Chalcolithic by milking some of them and then to improve meat yields by selecting or importing larger animals. We hope that this miscellany provides the reader with a few pointers to fruitful avenues of study in the future.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge João Zilhão and Antonio Monge Soares for all their efforts in setting up the archaeological science facility in the IPA and for inviting us here to help establish a zooarchaeology laboratory. We have benefited from the hospitality and help of numerous archaeologists who have asked us to study their "bones". The ICNB (*Instituto de Conservação da Natureza e Biodiversidade*), innumerable naturalists, zoologists, wildlife organisations and farmers have provided us with support in our efforts to build up the skeletal reference collection or *Zooteca* – a task which, without the help of Carlos Pimenta, would have been almost impossible. He is also acknowledged as an integral part of many of the projects currently under way in our lab. Nuno Caldeira has consistently helped us on the computer side and José Paulo Ruas with his excellent photographic skills has played a central role in our work. In writing this résumé of our findings Cleia Detry has kindly provided us with data concerning Mesolithic sites in Portugal from her unpublished PhD thesis. We have greatly benefited from an exchange of ideas with Umberto Albarella, Arturo Morales and John Watson. Cathy Douzil has, over the years, read many of the draft versions of papers and reports and has contributed her artistic skills. We are also very grateful to all our colleagues here in the IPA and the CIPA for their encouragement. Finally, we thank Luis Raposo (Director of the Museu Nacional de Arqueologia in Lisbon) for inviting us to write this article.

Commentary by Arturo Morales-Muñiz[*]

In this very useful and interesting paper, packed with a wealth of documentary and graphic information, the authors take an essentially zoo-archaeological (i.e.,"bottom-down") approach to the analysis of animal remains from archaeological sites in order to structure eight years of apparently miscellaneous discoveries into a coherent piece of work summarizing the state-of-the-art in Portugal (contrary to the opinion of the authors, I understand that issues dealing with "*...minuscule details enabling the distinction between closely related taxa...*"(p. 3) and the like, reflect the opposite, – "down-upwards" – approach that is embodied by the term archaeozoology).

The work is clearly addressed to non-specialists and for this reason each of the questions into which the paper is divided begins with an introductory

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paragraph on the intricacies of the issues, featuring additional explanations at specific places to aid with the interpretation of the data. I think this is a fine approach for the lay reader but sometimes I find that, by virtue of their length and detail some of these explanatory paragraphs break the fluidity of the discourse. Take, for example the condensed review of the Portuguese Middle Ages and the preceding paragraph on the agricultural improvements in England that introduce the subject of breed improvement in Portugal. May I suggest, as a preliminary recommendation that many of these paragraphs be kept to their minimum in order not to dilute the main message in the mind of the reader?

The questions selected can be arbitrarily divided into those with the emphasis laid on biological issues and those with an emphasis on cultural issues. Only the first one (How many bones make a useful sample?) breaks such pattern and, although interesting, I remain unsure whether the confirmation that Portuguese sites behave exactly in the same way as those from the rest of the world deserves such an exhaustive introduction.

Since a detailed review of all of the questions discussed would make my contribution unduly long I have chosen a few items for the authors to reconsider.

First of all, certain ways of referring to Middle Age events seem a bit peculiar. This is the case when the authors talk about the "Christian invasion" or the "Christian invaders" to refer to the Reconquest (i.e., the fight that expelled the Muslims from Iberia). Perhaps this only reflects a personal bias but, given that. (a) Iberia had been Christian for several centuries at the time that the Muslims arrived, (b) that the Reconquest fight started a mere seven years after that event (i.e., Covadonga; 718AD) and (c) that a large portion of the population under Muslim rule remained Christian at all times, historians have often refrained from using the term invasion when referring to the Christian conquests.

The proposals that the Crusaders helped improve Portuguese cattle by introducing stock from their homelands and that bovine improvement in southern Portugal may somehow link with the demographic decline and concomitant increase of free land that the Black Death brought about, are interesting but probably require some further elaboration as well. For one thing, the role played by the Crusaders – a 1095AD concept coined by the Pope Urban II – in the Reconquest fight was far less massive and far more punctuated than the authors would apparently concede. Secondly, it is doubtful that expeditionary armies would bring with them stock in excess of what one can label – to paraphrase the title of a famous book – a walking larder, especially considering that in this case they often travelled through friendly lands. Third, there are little data indicating that there ever existed an extensive settling of these mercenaries in

Iberia. Finally, one should keep in mind that large areas of southern Portugal are the home of savannah-type ecosystems ("dehesas") that are most conducive to the rearing of cattle. On the Spanish side this translated in that all throughout prehistory and well into historical times cattle from the region we now call Extremadura (nothing to do with the Portuguese Estremadura) have been systematically larger and more robust than their northern and eastern counterparts. As I see things, the question is not so much why did cattle in southern Portugal increase in size at the end of the Middle Ages but, rather why they remained so small until that time!

As a final cultural aspect, the authors mention in a couple of places that a lot of what we have considered pigs in Muslim sites may in fact represent wild boar, an animal that some populations in the Rif area of northern Morocco are fond of eating. This is a most interesting hypothesis yet they should also stress here that, *Haram* or not, wild boar would still require being captured alive to be slaughtered according to Islamic precepts in order to be acceptable as food for moslems.

The incorporation of a section on bone instruments (question n.º 11) is both innovative and instructive, breaking the secular tradition of tools being studied by "conventional" archaeologists. This section has been possible in that, by a fortunate coincidence, one of the authors happens to be one of the leading specialists in the field. Altogether, the approach reveals to what an extent does traditional research benefit from the contribution of the bone-oriented analyst and nowhere is this more evident than in the last figure of the paper.

Turning to more biological issues, I have several general thoughts to share in connection with the topic of extinctions and introductions. One thing I would like the authors to make clear is that, even today the Iberian archaeozoological record is painfully patchy and scarce, thus most inappropriate for generalizations. For the lay reader it should likewise be stressed that Portugal is not a biogeographical entity of any kind, its faunal data requiring evaluation within the wider interpretive frame of the Iberian Peninsula. No wonder that boreal and mountain species from the Pleistocene disappear here first since the corridors taking them into northern latitudes (i.e., the mountain chains) run in an essentially West-East direction. A final general comment is that, just as a swallow makes no spring, isolated finds should never be taken as evidence of anything, be that survival as it is argued for the bear at Alcáçova de Santarém (Question n.º 4) or the presence of a forest as is the case of the Roe deer from Mercador (Question n.º 9).

The single one issue that has caught my attention in the section of extinctions was the authors' apparent acceptance that the horse "*… supposedly became extinct after the Magdalenian*". Is this for Portugal or Iberia? Eisenmann's hypothesis may hold true for large parts of Europe but certainly not for Mediterranean Spain where horses are found, albeit in small numbers, throughout the Mesolithic and into the Neolithic. It is in fact this uninterrupted presence that makes it so difficult to decide whether horses in Neolithic sites were wild or domesticated and, if the latter was the case whether domestication was a local process or not.

In the section of introductions I find the paragraph on ostrich egg shells a bit out of place. Perhaps the authors should consider the convenience of incorporating another question (eg., traded items) to their list or else divide Question 4 into two separate ones as, indeed the connotations of extinctions and introductions are very different from a cultural perspective, the former often "passive" the latter often "active".

Question n.º 5 raises an issue of size reduction of red deer during the Mesolithic that also pops out in connection with question n.º 6. To relate such a phenomenon with an increase in the hunting pressure may be a bit over-simplistic without first considering the role played by the basic sources of size variation (eg., age and sex). Are the authors referring to samples of animals that they know were in all cases made up of adults or could there be non-adults there as well? Could the size shift be reflecting a larger proportion of females in the Mesolithic samples? It seems sensible that until these two more parsimonious alternatives can be safely eliminated from the discussion – and the authors probably have data along these lines to do so – one should not entertain the less parsimonious explanations involving human behaviour.

The last Question is suggestive of the way faunal data from archaeological sites might be crucial for conservation and wildlife management policies. The issues presented deal with rather "trivial" questions instead of the things wildlife managers really need in order to dictate specific policies for living populations. But the section is important in that it highlights that there is much more to zooarchaeology/archaeozoology than a mere description of finds or evidencing of past patterns. Faunal data have a heuristic potential that we would do well in exploiting as, no matter how incomplete the data we provide are no one else can provide them. And that, I would add is not a bad start after all!

Commentary by Jean-Philip Brugal[*]

La contribution de S.Davis et M.Moreno-García propose un bilan des activités menées depuis huit ans, en particulier par ces deux chercheurs, dans le domaine de la zooarchéologie (ou archéozoologie, voire anthropozoologie) au Portugal. Il faut tout d'abord remarquer la création d'une véritable unité de zooarchéologie dans ce pays, très opérationnelle, concrétisée par la mise en place d'une importante collection de vertébrés avec plus de 2000 spécimens actuels de comparaison (j'ai pu personnellement utiliser, et apprécier, cet outil essentiel lors de mes propres travaux); de brefs compléments sur cette collection seraient peut être nécessaires, telles que les proportions selon les grands groupes (reptiles, oiseaux, mammifères herbivores, mammifères carnivores, rongeurs,… origine géographique ?).

Les activités de cette unité, s'inscrivant dans le cadre de l'Instituto Português de Arqueologia, ont été très soutenues ces dernières années, conduisant des études variées depuis le Paléolithique jusqu'aux périodes historiques. Un bilan de ces études est brièvement présenté, de manière originale sous la forme de questionnements, dans ce cas 12 questions (mais suivant les périodes et les lieux, il pourrait y en avoir d'autres), chacune illustrées par des exemples choisis favorisant une approche largement diachronique. Cette 'formule' est judicieuse car elle permet de montrer toutes les facettes et les apports des études sur la relation Homme-Animal, et rend compte de la richesse et la multiplicité des recherches, en même temps qu'une certaine cohésion transculturelle de cette discipline (au moins méthodologique). Les informations sur le matériel faunique sont riche d'enseignements pour tout Archéologue et cela, quelque soit sa période de prédilection.

De nos jours, et malgré ce qui est dit, l'Archéozoologie ne se fait pas seulement en laboratoire, et de plus en plus de spécialistes participent et dirigent des fouilles, permettant entre autre d'introduire et d'élargir l'apport des analyses taphonomiques. Pouvant servir de charnière, ce dernier outil permet de mieux appréhender nos objets d'études et leurs origines, et il devient incontournable à tous travaux et matériaux. Cependant, identifier les espèces (Taxonomie) et analyser les paléocommunautés en terme climatique par exemple, concernent les domaines de la Paléontologie et de la Paléoécologie; la Zooarchéologie a des objectifs différents, bien que nécessitant parfois les précédentes en les intégrant dans sa démarche (surtout pour les périodes les plus anciennes); elle devient alors complémentaire car participant à une Paléobiologie et à une meilleure connaissance

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des comportements de subsistance des sociétés humaines. Lorsqu'on utilise des mesures postcrâniennes d'une espèce, comme ici *Oryctolagus* (lapin), pour en inférer des paléo-températures, on fait plutôt de la Paléoclimatologie quantitative; et devrait alors s'assortir de marge d'erreur (*sigma*), même si les valeurs obtenues sont en effet comparables à celles fournies par d'autres méthodes (voir aussi Bard, 2002; Grousset, 2001).

La question première concerne la représentativité des séries étudiées, quelque soit les types d'analyses (écologique, éthologique, taphonomique, squeletto-chronologique, isotopique, etc.). La diversité taxinomique d'un assemblage parait être en relation directe avec le nombre de restes et d'individus retrouvés à la fouille. On pourrait ajouter quelques compléments; par exemple, l'importance dans le cas d'activités biologiques, et humaines en particulier, des types (plein-air, abri, grotte,...) et de la zonation des habitats, montrant des lieux spécifiques d'activités. Suivant l'implantation de la fouille, ce facteur aura des implications sur les fréquences des restes (et d'autant sur les structures en âge, sexe, représentation anatomique); les filtres culturels sont certainement prépondérant dans la représentativité (par exemple les sites de chasse spécialisée). Le nombre d'espèces présentes dans un gisement est une donnée importante, et ce point est régulièrement débattu, notamment dans la communauté des écologistes et paléoécologistes (cf. Damuth, 2000 avec les *Species Locality Occurrences* et ex. *in* Brugal et Yravedra, 2005-6 ; les travaux en cours de S. Legendre sur l'estimation du nombre d'espèce par analogie avec les approches écologiques basées sur les ré-échantillonnages; et autres travaux plus classiques: Maguran, 1988; Odum, 1959,...), et qui trouve des échos évidents dans les démarches taphonomique et archéozoologique (*e.g.*, Grayson, 1984). Combien d'espèces sont suffisantes pour comprendre et définir un écosystème, ou pour approcher les actions anthropiques sur les stocks animaux? Questions en relation non seulement avec la diversité trophique mais aussi avec la densité des taxons dans les environnements. A une autre échelle, celle de la fouille, cette densité prend une autre signification, directement corrélable avec une surface/épaisseur d'un dépôt (soit volume) qui va aussi influencer les nombres de vestiges et de taxons. Il demeure que cette information (volume) est le plus souvent omise des études publiées et des comparaisons entre assemblages osseux.

Une autre question concerne la dynamique des peuplements de mammifères et leurs disparitions au cours du temps de certaines zones géographiques. Il n'est pas exact de parler d'extinction, car à l'exception du cerf géant (*Megaloceros*), du Mammouth (*Mammuthus*), du rhinocéros laineux (*Coelodonta antiquitatis*) et de l'ours des cavernes (*Ursus spelaeus*), la plupart des autres espèces présentes au

Paléolithique supérieur en Europe continuent d'exister à l'Holocène. Il n'y a pas de véritable crise biologique fini-pléistocène (Brugal et al., 2004) à l'instar d'autres crises reconnues dans le Passé, et on assiste surtout à des disparitions locales et des variations (réduction) des aires de distribution des espèces, suivant en cela les variations des environnements climatiques et les réajustements des biomes végétaux. L'extinction de ces quatre grands taxa n'est également pas synchrone à l'échelle de l'Europe, voire de l'Eurasie (*e.g.* Stuart, 1991) et peut concerner d'autres espèces (par ex. *Crocuta*; ou *Panthera leo*: Bemili, 2000). En ce qui concerne le Portugal, il a en effet été montré que les grands prédateurs disparaissent avant ou juste après le dernier maximum glaciaire et qu'aucun élément arctique n'est présent dans les associations animales (Brugal et Valente, 2007, mais voir García et Arsuaga, 2003). La situation péninsulaire ibérique démontre l'importance des facteurs biogéographiques, conduisant également à la persistance de formes plus anciennes qui ont disparues du reste de l'Europe (exemple 'emblématique' des néandertaliens). Ils peuvent induire des problèmes d'identifications (entre cerf de petite taille et daim: ex. du tibia de São Pedro Fronteira), et seul un matériel suffisant et pertinent (avec mesures, traits morphologiques, variation sexuelle) peut affirmer l'existence de ces deux cervidés au Portugal. Il est également intéressant de relever que ces changements (disparition des grands carnivores) voient le développement de l'exploitation des ressources de petite taille (lagomorphes, oiseaux, etc.), concomitant à une explosion démographique humaine, mais corrélative à l'abondance de prédateurs de moyenne taille (loup, renard, lynx) qui exploitent aussi ces petits gibiers. Ceci pose alors la question de compétition et d'accès aux ressources animales pour la fin du Paléolithique supérieur entre différents prédateurs.

L'origine des assemblages fossiles au Paléolithique est l'objet d'une très abondante littérature, et on constate une certaine complexité suivant l'agent accumulateur et le degré de modifications par différents carnassiers (hyène, loup, lion, etc.), en plus de l'homme; il existe quelques distorsions entre les données africaines (travaux cités de Klein) et ouest-européennes, lorsqu'on compare les repaires d'hyènes actuelles et fossiles notamment (*e.g.*, Brugal et al., 1997, Brugal et Fosse, 2004), modulant ou ajoutant quelques critères. L'étude du cas de Caldeirão est intéressante car montrant une variation au cours du temps des occupations humaines et d'autres carnivores. Le critère de taille des fragments osseux parait discriminant pour distinguer les agents prédateurs, humains *vs* non-humains (par ex. Villa et al., 2004). L'éthologie des 'mangeurs de viande' est donc importante à considérer, et il faut noter que les hyènes tachetées *Crocuta*, contrairement à leurs 'mauvaises réputations', sont aussi bon chasseurs que lion(nes) ou hommes, et peuvent agir en bande. Enfin, un pourcentage des actions humaines (stries de découpe, impact) aurait bien complété le schéma proposé dans l'exemple de Caldeirão, qui par ailleurs constitue un nouveau cas remarquable, et rare, de l'action des vautours *G.barbatus*, telle celle décrite par I. Robert et J. D. Vigne.

Les relations Hommes-Animaux sont multiples, et l'aspect symbolique est évoqué à travers deux courts exemples: la sépulture de Lagar Velho I (gravettien) et le jeune chien associé à une sépulture de Herdade de Santa Margarida ($3^{ème}$ mill. BC). Elles démontrent de liens privilégiés entre les hommes et certaines espèces. Le premier cas désigne la présence d'une partie de squelette d'un lapin immature, tel qu'il est usuel de trouver dans les garennes – et ce gisement est certainement une garenne au vu des milliers de restes trouvés naturellement dans ces dépôts. Si l'aspect symbolique, comme 'funerary gift' est possible, il est tout aussi possible qu'il s'agisse d'un problème taphonomique de bioturbation, avec un terrier et une mort naturelle d'un jeune individu dans une terre enrichie en ocre, au contact même de la sépulture. Les liens 'au-delà' de la mort entre sujets humains et animaux sont alors, parfois, ténus à vérifier et toujours emprunt d'émotion. Ces aspects symboliques peuvent d'ailleurs rejoindre des fonctions esthétiques et identitaires entre les groupes humains du Passé, et la parure, tirant profit des matières dures animales, constitue un support riche, peut être pas suffisamment développé à travers les exemples portugais.

L'utilisation de la matière animale présente souvent un caractère technique, et peut avoir des fonctions énigmatiques, demandant un véritable travail d'enquêtes, à la fois taphonomique mais aussi ethnographique et historique, voire épigraphique et sémantique: aérophone, flute, chordophone(?) en os d'oiseau (vautour), métapode percé et enclume osseuse [pour ce dernier cas nous reportons l'existence d'un métapode de dromadaire, encore gras, provenant de Tunisie, récolté par G. et H. Camps, et montrant exactement les mêmes traces – coll. LAMPEA-MMSH[1]]... sont autant de cas fascinants de telles exploitations.

Ce bilan de 8 ans de recherches au Portugal n'est certainement pas complet et de très nombreuses analyses ont été menées par les membres du CIPA et autres chercheurs et étudiants qui ont pu profiter de cette structure. Cette 'matière osseuse' est riche d'enseignements, autant en Préhistoire qu'en Histoire, et les études de cas présentées dans ce 'pot-pourri' illustrent parfaitement cela. Certains se lisent comme des contes, et d'autres précisent quelques points de portée générale. L'ensemble est dense et varié; comme le souligne plusieurs fois les auteurs: il s'agit bien de miscellanées! Il devient alors difficile de commenter une telle revue et nous nous

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[1] Confié récemment pour étude à F. Poplin.

sommes alors contentés de brèves remarques, plus discussions que critiques. Cette contribution originale permet de proposer aux lecteurs une vue élargie, essentielle et importante, des travaux possibles dans le domaine de cette spécialité, cherchant à comprendre les relations privilégiées et multiples entre les Hommes – quelque soit la période – et les Animaux – quelque soit (ou presque) leur statut!

A Arqueozoologia em Portugal: passado, presente e futuro (comentário a um artigo de S. Davis e M. Moreno-García)

Comentário de João Luís Cardoso[1]

1. Justificação

Fui convidado pelo Director do Museu Nacional de Arqueologia para elaborar breve comentário a extenso artigo de S. Davis e M. Moreno-García, seguindo a orientação de "O Arqueólogo Português" relativamente aos artigos de fundo nele publicados. Como em casos anteriores, acedi com gosto a tal convite, não só porque a prestigiada Revista, o seu Director, e os autores do artigo em causa me merecem a maior consideração, mas também pela experiência acumulada da temática em apreço, expressa através de estudos publicados desde há mais de vinte anos. Enfim, o interesse do trabalho produzido contribuiu, naturalmente, para que a resposta fosse favorável.

2. Aspectos metodológicos

Como os autores sublinham, o estudo dos restos dos mamíferos encontrados em estações arqueológicas foi devidamente contemplado por pioneiros como Pereira da Costa e Nery Delgado. Tal realidade não se poderá desligar da sua formação científica, no campo da Geologia e da Paleontologia, dando origem àquela que foi considerada a "Idade de Ouro da Arqueologia Pré-histórica" em Portugal, mas de duração fugaz, em resultado das fragilidades do sistema institucional em que se apoiava. Contudo, se a qualidade desses trabalhos pioneiros, comparáveis ao que de melhor se fazia além-fronteiras, se devia à realidade apontada, considerar a Arqueozoologia, na actualidade, como "a kind of applied

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palaeontology", já se afigura excessivo porque, se fosse assim, faltava-lhe a necessária componente das ciências sociais, que constituem a sua essência. Está-se na situação, já por mim assinalada em trabalho de carácter epistemológico sobre esta disciplina científica, publicado há já mais de uma década, segundo a qual "a afirmação da "Arqueozoologia" (...), passará pela sua plena afirmação como domínio intrinsecamente pluridisciplinar; embora recorrendo, como ferramenta principal de trabalho, ao método comparativo, do foro anátomo-biológico, a dimensão económica, social e até cultural dos elementos assim obtidos não deverá jamais deixar de ser sublinhada, constituindo a consequência e corolário da análise desenvolvida. Desta forma, se esta recorre a técnicas e métodos do foro das Ciências Naturais, já a síntese deverá fazer uso de conhecimentos do foro das Ciências Sociais e Humanas" (Cardoso, 1996a, p. 78). E é precisamente a importância da disciplina enquanto poderoso factor caracterizador da realidade económica e social, que se afigura menos presente do que seria desejável entre as 12 questões apresentadas neste trabalho, até por ser esta dimensão que constitui a principal razão de ser da Arqueozoologia, enquanto disciplina científica. Esta realidade foi, aliás, já claramente assumida em Portugal, tanto em teses de doutoramento, como de mestrado, no âmbito da Arqueologia, tendo os respectivos autores, reconhecendo a relevância potencial da informação prestada pelos restos faunísticos exumados nas suas escavações, recorrido ao apoio do signatário (Catarino, 1997/1998; Simões, 1999; Arruda, 1999/2000; Fernandes, 2004).

O artigo reflecte, como se indica no próprio título, a experiência de cerca de sete anos do laboratório de Arqueozoologia criado no âmbito do extinto Instituto Português de Arqueologia. Constitui, assim, importante repositório de observações, apresentadas sempre com preocupações didácticas e de forma acessível, sendo, por isso, facilmente compreendidas por todos, especialmente por aqueles que não se encontram familiarizados com a disciplina, a quem o trabalho parece essencialmente ser destinado. Num período de crise institucional no âmbito da Arqueologia, em Portugal, parece, com efeito, oportuno, dar a conhecer, de forma acessível, o trabalho efectuado, na sequência, aliás, de estudos anteriores, produzidos com objectivo idêntico (Moreno-García et al., 2003b; Moreno-García, 2005/2006). É, precisamente, a forma acessível como este estudo se encontra redigido, ao longo dos doze sugestivos temas escolhidos para análise, que fazem tão agradável a sua leitura, que desde já se aconselha a estudantes universitários de Arqueologia, dando assim natural continuidade a outros contributos da mesma índole (Cardoso, 1995a, 1996a), afigurando-se útil para todos aqueles que desejem obter mais informação sobre as potencialidades oferecidas por este campo de estudos no quadro da prática transdisciplinar da Arqueologia.

Embora o trabalho se centre na própria experiência acumulada dos autores, não parece, ainda assim, justificada a dispensa à citação dos trabalhos que, anteriormente ou em simultâneo, continuaram a ser produzidos por outros investigadores em Portugal, os quais foram sumarizados até o ano de 2000 em artigo de minha autoria, citado na bibliografia (Cardoso, 2002a), até porque não deixam de citar muitos outros trabalhos publicados em outros países, a propósito das questões que elegeram para discussão. Outras vezes, sobre uma dada temática, citam-se trabalhos menos relevantes, o que acabou por limitar uma correcta perspectiva dos próprios resultados obtidos; por exemplo, a citação a um curto trabalho dedicado ao estudo dos mamíferos do sítio islâmico das Mesas do Castelinho (Almodôvar), publicado em 1993 (Cardoso, 1993b), não poderia dispensar a consulta do trabalho, mais importante e completo, publicado logo no ano seguinte (Cardoso, 1994), que não consta da bibliografia.

Aspecto que se encontra omisso deste trabalho, mas que é incontornável a qualquer estudo de arqueozoologia de mamíferos, é o contributo para a caracterização da natureza do estabelecimento humano a partir do padrão de distribuição dos segmentos anatómicos conservados das diversas espécies presentes na amostra. Muitos seriam os exemplos que se poderiam citar, tão interessantes diversificadas são as conclusões obtidas, desde o Paleolítico à actualidade, nalguns casos reforçando o carácter comercial dos correspondentes estabelecimentos, como foi o caso da feitoria fenícia de Abul (Cardoso, 2000a).

3. Comentários específicos

Conforme acima se referiu, a discussão de muitas das 12 questões seleccionadas pelos autores ficaria valorizada com a consulta da bibliografia portuguesa; os exemplos seguintes corporizam tal afirmação.

Questão 2 – a realidade observada na Gruta Nova da Columbeira (Cardoso, et al., 2002) teria interesse em ser devidamente sublinhada, por ilustrar, de forma clara, a frequência do local, alternadamente, por carnívoros e pelo Homem (no caso, Neandertais), sendo, assim, comparável à situação documentada na Gruta do Caldeirão, mas mais expressiva do que esta, pela clareza com que se verificou serem os níveis com maior abundância indústrias líticas, aqueles que menor quantidade de restos de carnívoros conservavam.

Enfim, a relação entre os juvenis e os adultos, invocada como critério diferenciador da actividade cinegética humana face à dos predadores, encontra confirmação em espécies de grande porte, como é o caso extremo do rinoceronte

(*Dicerorhinus hemitoechus*). Trata-se de espécie bem representada na Gruta Nova da Columbeira (Bombarral) e na Lorga de Dine (Vinhais), sobretudo por dentes lacteais, oriundos de níveis com escassa ou nula presença humana, respectivamente, pelo que a sua presença se deve atribuir à actividade de predadores de médio e/ou grande porte, documentados em ambas as estações (Cardoso, 1993a; Cardoso, et al., 2002). É interessante verificar que a presença de indivíduos senis da mesma espécie, na ausência de adultos vigorosos, na Gruta da Figueira Brava (Cardoso, 1993a), pode, também, ser relacionada com a maior facilidade da sua captura, por parte de predadores, ou de necrófagos, presentes no registo faunístico respectivo.

Questão 3 – teria interesse referir, no que à presença do cão diz respeito, a existência de um enterramento mesolítico, de um indivíduo não consumido, num dos concheiros do Vale do Tejo (Cardoso, 2002b), bem como o sacrifício ritual de cães, em contexto fenício, na Quinta do Almaraz (Almada) (Cardoso e Gomes, 1997). Estes dois exemplos, entre muitos outros publicados do território português, sobre o uso ritual dos animais, sobretudo em contextos funerários, reflectem a valia e diversidade da investigação arqueozoológica feita em Portugal, em época anterior ou coeva da investigação desenvolvida pelos autores e, naturalmente, sem prejuízo daquela que por estes vem sendo desenvolvida.

Questão 4 – a tardia sobrevivência do elefante antigo no território português, representada pela lamela da Foz de Enxarrique (Vila Velha de Ródão), face ao que é conhecido no contexto europeu e peninsular, fora já devidamente sublinhada desde a década de 1990 (Cardoso, 1993a; 1996a; 1996b), acompanhando a tardia extinção de outras espécies. Por outro lado, relativamente à extinção do urso, teria interesse referir a sua ocorrência, em contexto tardo-medieval, no castelo de Leiria, a qual é discutida com base nas fontes históricas e na iconografia, relativas a Portugal (Cardoso, 2001). Nestes termos, o trabalho citado constitui um bom exemplo de articulação entre os elementos arqueozoológicos e históricos, preocupação para a qual os autores não deixam – e bem – de chamar a atenção, ainda que não citem um dos elementos bibliográficos mais importantes para o conhecimento das referidas fontes, a "História florestal, aquícola e cinegética", coordenada por C. M. Baeta Neves (Neves, 1980), nem o estudo deste autor, dedicado, precisamente, à extinção do urso em Portugal (Neves, 1967).

Também a hipótese de o cavalo "supposedly became extinct after the Magdalenian to be reintroduced subsequently as domestic animal perhaps before or during the Chalcolithic" merece comentário: em primeiro lugar, porque de facto o cavalo não se extinguiu, ao menos na faixa ocidental do território peninsular, dada a sua presença nos concheiros do vale do Tejo, onde foi identificada logo no primeiro trabalho a eles dedicado (Costa, 1865) e recentemente reafirmada (Cardoso, 1995a; Morales Muñiz et al., 1998; Detry, 2007); em segundo lugar, porque, não há evidências materiais (odontológicas ou outras) seguras, no que ao território português diz respeito, da presença de cavalo doméstico no Calcolítico (e, por maioria de razão, antes desta época).

Interessantes são os considerandos relativos ao "zebro"; a presença do equídeo asinino *Equus hydruntinus*, no território português, no Plistocénico Superior foi pela primeira vez por mim efectuada (Cardoso, 1995b); mas a conotação desta espécie com o zebro, antes da sua definitiva extinção, no decurso do século XVI é assunto que vem sendo discutido de há muito, no concernente ao território português (Cardoso, 1996a). Trata-se de mais um exemplo em como a investigação em arqueozoologia deverá ser acompanhada da pesquisa das fontes documentais, neste caso, sobretudo, da época medieval. Teria interesse, por exemplo, enquadrar a discussão apresentada com os contributos apresentados em trabalho publicado em 2006, de M. T. Antunes, o qual, como outros, foi ignorado pelos autores.

A presença de *Gallus gallus*, na Península Ibérica tem sido associada à colonização fenícia, passe a especulação de, ao ter sido identificado na fase V da ocupação de Castro Marim (segunda metade do século V/século III a.C.), se ter admitido, de forma interrogativa, "the further evidence for the arrival of the Phoenicians in Castro Marim". No entanto, a ocorrência da espécie, sob reserva, no povoado calcolítico Leceia (Oeiras), por se tratar de dois restos de indivíduos juvenis (Gourichon e Cardoso, 1995), deverá ser reequacionada, à luz da recente demonstração da existência, no levante peninsular, de verdadeiras importações calcolíticas de marfim de elefante asiático, certamente pela via próximo-oriental, por Schuhmacher e Banerjee.

Outra questão abordada é a data da reintrodução do gamo (*Dama dama*) em território português, depois de aqui ter vivido até ao final do Plistocénico (Cardoso, 1989); admite-se, em geral, o seu desaparecimento ulterior do território peninsular, apesar de estar referenciado, com reserva, no povoado calcolítico do Monte da Tumba, em trabalho publicado em 1987, de M. T. Antunes, para só voltar a ser reintroduzido no período romano.

Conquanto existam alguns critérios morfológicos de diferenciação, a separação entre os restos desta espécie e os de veado (*Cervus elaphus*) é sempre difícil, porque o critério utilizado mais acessível, é o do tamanho, assinalavelmente menor, no caso do gamo. Contudo, porque ainda pouco se sabe das variações biométricas do veado, no decurso do Holocénico, em território português, além das devidas ao dimorfismo sexual, considera-se que aquele critério, na falta de outros, deve ser utilizado com precaução; por isso, na publicação recente de um conjunto osteológico romano recolhido na lixeira baixo-imperial da *villa* da Quinta das Longas, Elvas (Cardoso e Detry, 2005), optou-se por considerar em conjunto ambas as espécies. Com efeito, a pequenez do veado, pode ser condicionada por múltiplos factores, entre os quais o stress ambiental, provocado ou não pelo Homem: o estudo recente dos restos do sítio do Neolítico Antigo de Xarez 12 (Cardoso, e.p. a) é, a esse título, muito sugestivo.

Questão 6 – é muito interessante a importância do coelho como paleotermómetro, no decurso da fase final da última glaciação; a superabundância desta espécie, em certas estações, permitirá, em futuro próximo, análises mais detalhadas, para as quais os autores chamam justamente a atenção.

Questão 7 – a questão da diferenciação entre espécies selvagens e os seus equivalentes domésticos é um dos temas da maior importância em Arqueozoologia, dados os significados completamente distintos que uma ou outra das situações detêm, no âmbito da interpretação paleoeconómica e paleossocial. É sabido o valor das investigações que, especialmente, Simon Davis, tem dedicado à difícil diferenciação entre o javali e o porco doméstico, com base em critérios morfológicos. Foi possível, deste modo, confirmar a presença do javali no contexto islâmico da alcáçova de Santarém, a qual já tinha sido assinalada anteriormente em Portugal, associada à ocupação muçulmana das Mesas do Castelinho, Almodôvar (Cardoso, 1994), ainda que com base em critérios que devam, nalguns casos, ser revistos, à luz das mais modernas investigações. Seja como for, a escassa presença, nesta fortificação, de escassos quatro restos de suídeo, é condizente com as leis corânicas, sobretudo quando comparada com a abundância do veado, espécie que partilharia com o javali o mesmo biótopo.

Questão 8 – o aumento da idade de abate dos caprinos, no povoado calcolítico do Penedo de Lexim, Mafra, entre o Neolítico Final e o Calcolítico, foi relacionado com o aproveitamento do leite e da lã que estes animais poderiam oferecer, no âmbito da chamada Revolução dos Produtos Secundários. Embora esta realidade seja contrária à observada no povoado coevo de Leceia, Oeiras, importa não esquecer, como bem sublinham os autores, que, neste último sítio, os bovinos são abatidos mais velhos no Calcolítico do que no Neolítico Final (Cardoso e Detry, 2000/2001), provavelmente devido à sua utilização mais intensa como animais de tiro, revelando uma outra faceta do seu aproveitamento secundário, para além do leite. É muito interessante verificar que esta realidade encontra confirmação no registo artefactual: com efeito, é apenas no Calcolítico Pleno que, em Leceia, os cinchos de cerâmica, relacionados com o fabrico de derivados do leite, fazem a sua aparição (Cardoso, 2007). Outros exemplos da relação entre o registo arqueológico e o arqueozoológico poderão ser futuramente desenvolvidos, como a existente entre técnicas culinárias, denunciadas pela morfologia dos recipientes de cozinha, e o modo de esquartejamento dos segmentos anatómicos, relação que foi exemplificada pela confecção dos característicos ensopados de borrego da época islâmica (Cardoso, 1994).

Contudo, as idades de abate precoces, tanto de ovinos, como de bovinos, podem reflectir realidades sociais específicas das respectivas comunidades, ou de segmentos privilegiados das mesmas; trata-se de aspecto ignorado pelos autores, apesar de ter sido já devidamente valorizado em diversos estudos realizados em Portugal.

Questão 9 – a comparação entre a composição de diversos registos faunísticos domésticos do Calcolítico, dois da Estremadura (Leceia e Penedo de Lexim), e outro do Baixo Alentejo (Mercador), evidenciou diferenças, reportadas a diferentes estratégias de subsistência; mas, independentemente das questões suscitadas sobre a organização social e a demografia, importaria analisar a questão de saber até que ponto a composição de um dado conjunto arqueozoológico não revela, antes de mais, a natureza dos próprios recursos faunísticos potencialmente disponíveis na região em causa. Até que ponto as características dos recursos cinegéticos de uma dada região não terão determinado, à partida, a estratégia de subsistência adoptada pelo grupo humano nela residente, a saber, uma caça especializada, privilegiando uma determinada espécie, por ser particularmente abundante, por oposição a uma caça mais oportunista, que promovia indiferenciadamente a captura dos recursos cinegéticos disponíveis, nos casos em que se não verificava a predominância de qualquer uma das espécies sobre as demais? Este seria, por certo, um bom elemento de discussão, para a qual seria útil ter presentes, além dos dados publicados por J. M. Arnaud em 1993, outros resultados, como os obtidos nos povoados calcolíticos do Monte da Tumba, Alcácer do Sal, e do Porto das Carretas, Mourão (Cardoso, e. p. b).

Questão 10 – também nesta área os trabalhos dos autores conduziram a resultados de evidente interesse: refiro-me à incidência da domesticação no melhoramento genético das espécies. No caso das ovelhas, os autores concluem que, no território português, o tamanho se teria mantido inalterado entre o Calcolítico e a época romana, sofrendo depois um claro aumento no período islâmico, atribuível á predilecção então verificada pelo consumo da carne destes animais, que explicaria o seu melhoramento genético. Já no caso dos bovinos, parecem verificar-se poucas alterações entre o Calcolítico e o período islâmico. Contudo, importa ter presente que, no vasto espaço geográfico ocupado pelo Império Romano, teriam existido diversos morfotipos, diferenciados tanto pela coloração das pelagens, como pelo tamanho. Columela (Livro VI) oferece detalhada descrição de tais morfotipos, conhecidos nas diferentes regiões do Império, enquanto Plínio o Velho, na sua "Historia Natural", insiste, sobretudo, em diferenças de tamanho. Contudo, tais diferenças ainda não foram reconhecidas em contextos arqueológicos romanos da antiga Lusitânia; já em estudo por mim efectuado, se tinha chegado a essa conclusão: "Os pequenos exemplares que caracterizam as populações de Conimbriga, correspondem a uma raça não melhorada, de tamanho idêntico à existente no Neolítico (...)" (Cardoso, 1995c, p. 305). Contudo, a explicação para a aparente manutenção de morfotipos antigos, na época romana – conclusão que ainda está longe de se encontrar plenamante confirmada, dada a escassez de estudos biométricos – não parece poder-se atribuir à posição periférica da Lusitânia no mapa do Império, referida pelos autores. Ao contrário, esta província mantinha múltiplas e intensas relações comerciais, expressas pela exportação e importação de variados produtos alimentares (vinho, conservas, azeite, etc.), especialmente por via marítima, com o Mediterrâneo; assim, recorrendo a navios mercantes, poderiam ser facilmente importadas cabeças de gado melhorado, destinado a reprodução, se tal fosse considerado necessário e economicamente rentável. Uma explicação para não se ter verificado tal situação, poderá resultar da própria utilização dada aos bovinos (aproveitamento da força de tracção, para a produção de carne e de leite e para fins sacrificiais, entre outros), e da adequabilidade que, para essas finalidades, mostravam os exemplares autóctones.

Neste ponto, discutem-se ainda aspectos de grande interesse, com evidente incidência histórica, como é o caso de as grandes crises sociais e demográficas dos finais da Idade Média terem tido como consequência, também em Portugal, a melhoria genética (aumento de tamanho) dos bovinos, sem esquecer a possibilidade, admitida pelos autores, de tal também se ficar a dever à importação de exemplares, mais corpulentos, do norte da Europa. Também neste campo, os estudos genéticos, a partir do ADN, poderão conduzir, no futuro, a interessantes resultados.

Questões 11 e 12 – diversos estudos, conduzidos pelos autores, por vezes em colaboração, evidenciam a importância e diversidade de usos que o material ósseo proporcionou, ao longo dos tempos, a par da demonstração da importância que a constituição de colecções de comparação detém, para a identificação de tais restos, que, não fosse esse recurso, só mediante o acesso a colecções de comparação existentes no estrangeiro poderiam ser devidamente estudados. É o caso de um osso longo de Conímbriga que, não coincidindo com nenhum osso homólogo de espécies conhecidas, obrigou-me, em 1992, a uma deslocação a França, para ali ser devidamente identificado: tratava-se, com efeito, de um camelídeo (Cardoso, 1992), grupo pela primeira vez registado no território português. O mérito da constituição de uma osteoteca, que se deve inteiramente ao trabalho da equipa de arqueozoólogos do ex-IPA, através das parcerias entretanto estabelecidas com diversas Instituições, é evidente, e dispensaria outros comentários: basta recordar a dificuldade, talvez jamais ultrapassada, não fosse o trabalho altamente especializado efectuado, da classificação específica dos ossos longos de ave em que foram talhados os aerofones de Conímbriga e de Mértola, profundamente modificados pelos artífices, tornando a identificação muito difícil. A este propósito, e porque são apresentadas considerações de ordem geral sobre a ocorrência, em contextos arqueológicos de diversos continentes, de instrumentos de sopro, valeria a pena, até pelo seu interesse, já histórico, ter mencionado um dos estudos pioneiros feitos em Portugal, sobre um desses instrumentos, sobre osso de ave, quase completo e, por isso, susceptível de os seus sons poderem ser ainda recuperados, recolhido no povoado calcolítico de Leceia. Desprovido de contexto estratigráfico, a dificuldade de obtenção, tanto à época da publicação, como presentemente, de paralelos calcolíticos (Ferreira e Cardoso, 1975), justificou a sua atribuição ao Paleolítico Superior, o que não inviabiliza, contudo, que seja actualmente considerado mais provavelmente como calcolítico, dado o volume de informação entretanto reunido naquela estação, ainda quase totalmente por explorar, à data da referida publicação.

A importância da osteoteca reunida merece, também, justo destaque, pela sua utilidade ultrapassar o âmbito estrito da Arqueozoologia, projectando-se em outros domínios científicos, mediante o estabelecimento de protocolos de colaboração, cuja relevância científica justifica e impõe assegurar a devida continuidade.

3. Aspectos institucionais

Feitos os principais comentários que me suscitou a leitura deste artigo, importa, sem embargo, sublinhar a importância dos trabalhos desenvolvidos pelo laboratório de Arqueozoologia do ex-IPA (actual IGESPAR), aliás bem documentada pela bibliografia produzida, tanto em qualidade, como em quantidade. Mas, como a própria investigação produzida poderá, em futuro mais ou menos próximo, ser questionada, até por não estar enquadrada em nenhum laboratório de investigação do Estado, é desejável, desde já, assinalar a ausência de alternativas, devidamente estruturadas e suportadas, no nosso País, excepção feita a trabalhos do foro individual ou empresarial, feitos ao sabor das disponibilidades e das circunstâncias, sendo precisamente nesse campo que eu próprio me incluo. Daí que considere, sem falsa modéstia, que a prossecução do trabalho destes especialistas se afigura necessária, bem como a manutenção e acesso do rico acervo documental com tanto esforço e competência reunido, com destaque para a importante osteoteca, cuja consulta se afigura indispensável a todos quantos, futuramente, desenvolvam estudos de Arqueozoologia em Portugal.

Por ter sido professor de Arqueozoologia, a nível pós-graduado, na Faculdade de Letras de Lisboa, de 1993 a 2006 e o orientador das primeiras dissertações de Mestrado e de Doutoramento no âmbito da Arqueozoologia defendidas em Portugal, mantendo intacta a minha capacidade de julgamento, até pelas circunstâncias não me terem proporcionado colaboração científica com nenhum dos autores deste importante trabalho, sinto-me especialmente à vontade para sublinhar a importância dos resultados que alcançaram. Resultados que, para serem ainda mais úteis e consequentes, se deverão projectar directamente na formação pós-graduada de futuras gerações de recém licenciados (tanto em Arqueologia, como em Biologia, ou em domínios científicos afins), que entendam abraçar a Arqueozoologia, em Portugal, como actividade profissional.

A importância da Arqueozoologia no nosso País deve, pois, ser incrementada, a começar pela legislação. Se, em Portugal, qualquer escavação arqueológica realizada em contexto funerário, carece obrigatoriamente da participação de um especialista em Antropologia Física, porque não estender idêntica obrigação ao acompanhamento das explorações das estações arqueológicas, onde a ocorrência de restos de alimentação seja segura, ou, ao menos, tornar a sua colaboração obrigatória, ao nível da produção de relatório técnico complementar dos trabalhos arqueológicos efectuados?

É que, em Portugal, se ainda não são assim tão longínquos os tempos em que os arqueólogos rejeitavam os restos faunísticos recuperados, por serem pouco relevantes ou simplesmente inestéticos, não existir quem os estudasse, ou, até, ocuparem demasiado espaço nos depósitos, tão triste herança (aliás comum a outros Países), foi sendo felizmente redimida, com o reconhecimento, indiscutível, da relevância dos contributos da Arqueozoologia para o conhecimento das sociedades pretéritas. Criem-se, pois, os requisitos legais, plenamente justificados no quadro das exigências da moderna investigação arqueológica, e assistir-se-á à afirmação de muitas jovens vocações que, por ora, ainda não encontram o ambiente propício à sua cabal afirmação. E é, também, neste registo, que o presente trabalho, meritório a vários títulos, deve ser valorizado como merece.

Commentary by Mary Jackes[*] and David Lubell[*],

Davis and Moreno have provided us with an extremely interesting miscellany, full of fascinating leads to an enormous array of facts, some new to us, as well as to several publications with which we were not familiar. Furthermore, the lay-out of the figures of measurements is excellent and some of the images are beautiful. What a useful paper to give a student to read, especially as it provides a vivid illustration of how a zooarchaeological career can be so much more than merely a narrow specialization in one type of site or one time period!

We were a little disappointed with one aspect of the paper. We had hoped to learn more about early sheep in Iberia, since Davis has already co-authored a very interesting paper on Iberian sheep (Pereira et al., 2006), and the genetic diversity of sheep is very much a current research topic (e.g. Meadows et al., 2007; Pedrosa et al., 2007). The figures of measurements provide no data on Neolithic sheep, the text cites only Zilhão (2001b) and the table of immigrant species (also published in Davis, 2002) gives no details; it simply refers us again to Zilhão and to Davis on Caldeirão. Davis (2002) lists the Neolithic sheep at Caldeirão as four bones of uncertain identification. Zilhão (2001b) refers mainly to Cova de l'Or, excavated many years ago and said to have sheep bones. Cova de l'Or has now been dated on *Triticum aestivum* seeds to 6275±70 bp and 6310±70 bp (Bronk Ramsey et al., 2002), making it contemporaneous with the bones originally identified as sheep at Caldeirão, dated to 6230±80 bp and 6330±80 bp. It would be very interesting to have direct dates for the sheep at Cova de l'Or and to compare them metrically with other later Iberian material. There is no doubt that we can expect Neolithic elements to be quite wide-spread in Iberia by these dates, so we had hoped there would be more information available on sheep. Perhaps someone will soon do as thorough a job on domestic sheep as Cucci et al. (2005) have done in their fascinating paper on the house mouse. It is clear that there are well dated sites of this exact age with many sheep in the Western Mediterranean (e.g. Fernández et al., 2006) so we hope to see published results soon.

A discussion on human population increase prior to the end of the Mesolithic and reduction in size of red deer is mixed in with remarks on the reduction in the frequency of red deer bones at archaeological sites after the end of the Mesolithic. It should be emphasized that Muge people had access to abundant rabbits, shellfish and other estuarine resources – a situation consistent with an

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increasingly sedentary lifestyle. Furthermore, it needs to be noted that these resources were consumed contemporaneously with red deer, so extreme predation pressure on red deer seems unlikely. A diet based on small mammal and estuarine resources may indeed have been one of the elements that led to increased fertility – intercorrelated factors would certainly be reduced mobility and shortened birth intervals. It seems clear that human remains at the Muge sites indicate an increase in fertility within the late Mesolithic. The information from Moita do Sebastião has now been completely reassessed, and our methodology rigorously tested through the application of alternative approaches, yet our results are unchanged (Jackes and Meiklejohn, in press) from those published previously.

To repeat, red deer were still being eaten towards the end of the Mesolithic – as the human population was increasing. Red deer are well represented at Muge (Lentacker, 1991, Fig. 11.8) and *Cervus elaphus* made up 55% of the NISP at Fiais (Lubell et al., 2007) which is dated to 6260±80 BP on a *Bos* fragment deep within an undisturbed portion of the bone bed deposit (Sq. A10, coordinated bone #60, z=244).

Perhaps Bergmann's rule, rather than extreme predation, applies to red deer of this period and we could expect a size reduction since the climate was warming. But, in fact, Davis (2002, Fig. 12) does not give us a fine-grained picture for red deer size changes during this period, whereas Lentacker's (1991) data for the Muge sites suggest that there was no change through late Mesolithic time in *Cervus elaphus* astragalus length and the Cabeço do Pez data (Davis, 2002, Fig. 12) seem to be in accord with this, while the Fiais red deer size is congruent with that of Sado remains analyzed by Rowley-Conwy (Lubell et al., 2007).

The idea of rabbit bones serving as a palaeothermometer is new to us – as an aside, Lentaker's data would indicate a mean January temperature of ~8°C. The question of *Oryctolagus cuniculus* and its role in late Mesolithic life is of particular interest to us. While it might be argued that rabbits became more important through time during the late Mesolithic at Muge (see e.g. Jackes and Lubell, 1999, Fig. 7 and comment page 32), the situation is complicated by the details of the excavation at Moita do Sebastião (Jackes and Alvim, 2006). A further complication to a proper interpretation of the situation is illustrated by Fiais. The carefully controlled 1986 excavations made it clear that the excavated area was located in what had been a rabbit warren, truncated by the plough zone, and the distribution of the rabbit bones throughout the site was not random (Lubell et al., 2007, p. 213). The relationship between the scarce *in situ* material plotted within the bone bed and the material closer to the surface, in which rabbit bone is very much more common, is enigmatic. While Davis does not mention such problems, he suggests an additional consideration for some sites – that is, the accumulation of rabbit bones by predators.

As a final point, the appeal to archaeologists to provide Davis, Moreno and their colleagues with worked bone for full analysis and placement within a wider context strikes us as particularly useful.

Bones of contention – Commentary by Nuno Ferreira Bicho[*]

Zooarcheology, Archaeozoology and other theoretical and methodological considerations: commentary to *Of metapodials, measurements and music – eight years of miscellaneous zooarchaeological discoveries at the IPA, Lisbon*

It was with great pleasure that I received the work of Simon Davis and Marta Moreno-García to comment on. I should start saying that their work is of the highest quality and their time dedicated to Portuguese archaeology, not only in pure research, but, perhaps more significantly, in applied research is of the utmost importance for Portuguese Archaeology.

In my opinion, their work, together with Carlos Pimenta, has had one of the most important and fundamental implications in the quality (and quantity) of archaeological research in Portugal – all these words, partially because of the wonderful *zooteca* they have built in IPA during the last decade (Moreno-García et al, 2003a). In fact, their work, accessible to all professionals and students (which I am in a position to appreciate more than some, since many of my students and colleagues involved in my research projects use frequently) is probably the single most important asset put together in the Portuguese archaeological framework since the creation of the Geological Museum (*Museu dos Serviços Geológicos*) and of the National Museum of Archaeology (*Museu Nacional de Arqueologia*) in the 19th century.

This paper is a fairly long one, reflecting not only much of the work that Davis and Moreno-García have carried out in Portugal, but also their interests. As they say, "the article is a miscellany" of data, ideas, results, work in progress, and suggestions for future research. It is a wide, very diverse paper, and thus, very interesting and pedagogic in nature (and again, as a professor, I need to emphasise the fact that it will be extremely helpful for students, more so when put together with the paper by Moreno-García et al., 2003b).

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Because of the diversity of topics presented in the paper it is difficult to comment on every single point made by the authors, but some could be highlighted, out of the important kinds of data listed by Davis and Moreno-García as well as by the 12 questions answered by them. I will, however, only refer to a single aspect, which for me is the most interesting of the topics presented by the authors – that is the section *Why do kill-off patterns matter?* There, the difference in the mortality patterns between the Late Neolithic and the Chalcolithic is discussed: the high juvenile mortality in the late Neolithic may be related to the maintenance of the flocks for meat (what some authors call L-Shaped mortality pattern – Stiner 1994; Lyman, 1987; 1994; Bicho, 2006 for a Portuguese reference), while in the later period the mortality pattern is identical for all age cohorts of the faunal assemblage, indicating that there was an increase in the importance of the secondary products, that is, the milk, wool and even dung.

Though not mentioned by the authors (which is understandable, since they tend to focus on societies dedicated to husbandry), kill-off patterns are also very important to our understanding of hunter-gatherer societies. This importance resides in the fact that mortality patterns as well as sex ratios may indicate, among other things, levels of social organization and the type of hunting strategies used – for example, the bones in an assemblage can be from old and/or juvenile animals or, on the contrary, representing the whole age range of the population. The two profiles will tell a very different story of hunting strategies of the hunters: in the first case hunting was targeting single animals which move with greater difficulty, escape or even defend themselves, and, thus, hunting was possibly done in an individual manner selectively, perhaps to maintain the demographic viability of the prey species; in the second case, the hunters caused a pattern generally known as "catastrophic" (Klein and Cruz-Uribe, 1984; Stiner, 2005) where all age classes or cohorts were killed likely due to some kind of trap, net or any other type of entrapment or ambush. Usually in this case of hunting technique, a large part of the human group was involved, thus suggesting some kind of social structure, cohesion or incipient organization.

Clearly, the quality of the authors' work is faultless, so why the title of this comment – Bones of contention? The controversy resides in the authors' theoretical framework. In the first few words of the paper, the authors state that "Zooarchaeology, or archaeozoology is the study of animal remains found in Archaeological sites". Thus, for the authors, the terms "zooarchaeology" and "archaeozoology" are synonyms and this is exactly the central point of the disagreement (Bicho, 2006). Zooarcheology is the study of animal remains from archaeological contexts in an anthropological perspective and its main aim is to reach a better understanding and knowledge of human behaviour and its relation with the local environment (Reitz and Wing, 1999:3), and is commonly used by New World experts – to a certain extent, one can argue that it is the result of the work of Binford and Schiffer in what relates to the new perspectives put forward by both in the early 80's regarding Middle Range Theory (Binford, 1979; Schiffer, 1983; 1987) and the actualistic studies proposed by Binford (1981). Archaezoology, on the contrary, is frequently used by European researchers and emphasizes the biological aspects of the remains, and in its limit, can be just the study of animal remains without any relationship to human behaviour (Olsen and Olsen, 1981). The later concept is obviously present, though sometimes only implicitly, in the text – that is the case of the statement "This discipline, a kind of applied paleontology, is we believe an indispensable tool in modern archaeological and historical research" present in the last section of the paper and where the stress is on the biological (paleontology) side of the discipline. This perspective is also present in the list of topics considered as the most important kinds of data as well as in the type of questions posed by the authors to give examples of the Portuguese archaeological record in what concerns faunal remains.

Regarding the first aspect, it seems that one type of data that is not present in the list presented by the authors is the anatomical element analysis – this is one of the most important aspects to study settlement and mobility patterns, seasonality, landscape use as well as to build subsistence models, all of which are clearly anthropological in their goals. The importance of all of these can be seen, for example, in Binford's seminal ethnoarchaeological work *Nunamiut Ethnoarchaeology* from 1978, and supported by several of his Ph.D. students, such as Mary Stiner (1994; 2005).

In what concerns the set of questions answered by the authors, they can be divided into various groups, at least based on the answers provided in the paper: predominantly archaezoological (questions 4, 5, 6, and 10); zooarchaeological (3, 8 and 9); and methodological (1, 2, 7, 11, and 12), of which are important to both perspectives. Other possible questions that are unequivocally zooarchaeological and, thus, anthropological, are, for example:

1) What kinds of bones do make a useful sample?
2) How were they brought and accumulated at the site?
3) What kind of hunting strategies were used?
4) How were animal and their respective body parts transported and to where?

Another aspect that usually separates both perspectives is the counting methodology. NSP (number of faunal specimens), NSUP (number of unidentified specimens), NISP (number of identified specimens) and MNI (minimum number of animals) are frequently used by almost every faunal analyst, either archaeozoologist or zooarchaeologist, sometimes using slightly different ways of counting the specimens (Davis, 1992; 2002; Reitz and Wing, 1999; Stiner, 1994; 2005). Some experts, however, prefer even not to obtain MNI results since they believe this might be frequently erroneous (Olsen, personal communication). What is not commonly used by both groups, but almost exclusively by zooarchaeologists (see Schiffer, 1983 on the importance of the representation of body parts), are skeletal portions and frequency in relation to utility indices – is the case of MGUI (modified general utility index), MAU (minimum number of animal units), and MNE (minimum number of elements) (all in Binford, 1978, but simplified explanations are present in Reitz and Wing, 1999), of which the last seems to be most frequently used by zooarchaeologists (in the past decade), although there are various approaches to the methodology (perhaps, the one worth referring to are Marean's (1995); Marean and Kim, 1998) where bone refitting takes a major role in his analysis). The importance of these quantitative variables is to give insight into questions 3 and 4 posed above; and these are anthropological in nature and, thus, more often used by zooarchaeologists.

Now, it should be said that the training of both groups is usually different, that is to say that their background is different: while archaezoologists have frequently their academic training in biological sciences, zooarchaeologists are archaeologists (or anthropologists if one follows the American perspective) with formal education in anthropological or archaeological departments, but specifically in zooarchaeology. The result is that they study in a theoretical framework that is dedicated to zooarchaeology as a subdiscipline of archaeology (and not of biology as is palaeontology).

Finally, another (possible) difference between the two perspectives is that while zooarchaeology is eminently anthropological and has a synchronic perspective, archaeozoology is mostly historical and, thus, diachronic. This can be identified in the paper in various moments, such as the three first basic research aspects in regards to question 11 (How many uses can a dry bone have?) that are unequivocally cultural-historic:

1) production of a typological and chronological catalogue;
2) identification of taxonomic and anatomical source;
3) identification of manufacture procedures.

This dichotomy is interesting in Portugal since there are two main schools of faunal analysis. On the one side the archaezoological perspective, marked by the authors, João Cardoso, and Jean-Philip Brugal (and their "second academic generation", Cleia Detry and Maria João Valente) with an historical perspective and regionally originating from the Old World (France and the UK), and connected to various universities and research centers in Lisbon; on the other side, the zooarchaeologists with an anthropological perspective, Mary Stiner (and her second and third generation students, respectively Rebecca Dean and Tiina Manne, and Cláudia Costa), Bryan Hockett and Jonathan Haws, all from the USA, and traditionally connected with the University of Algarve. The interesting aspect in this duality is that there is a tendency to overlook the "other side", as it is suggested by the respective published work where the bibliographic citations from the "other side" are usually very brief.

From my standpoint, both perspectives are as valid and necessary (see Reitz and Wing, 1999:3 and 6, on this matter), and more importantly, complementary: that is the reason why, personally, in my present projects I invited experts from both sides of the fence…

Finally, a word of caution. It is without doubt that faunal analyses are fundamental for a better and more complete study of archaeological contexts. However, fauna is not a world in itself – we have to see and read other types of data. One good example is the so-called Tardiglacial paradigm mentioned by the authors answering question 5 (How do the frequencies of the large prey species vary through time and why?).

In 1968 Binford noted that at the end of the Pleistocene human societies underwent two major changes leading to new patterns of mobility, settlement systems and land use. Flannery (1969) named this dietary shift the Broad Spectrum Revolution (BSR) (see Stiner, 2001 for an historical review): immediately before the Pleistocene-Holocene transition, there was the emergence of husbandry in the Near East resulting from a set of conditions that included diversification of dietary resources and an increase in human population. This ecological imbalance resulted from the relation between the climatic instability at the end of the Pleistocene and population pressure (Keeley, 1988; Cohen, 1977; Yesner, 1984).

With the adoption of a behavioral ecology perspective in Archaeology (Winterhalder, 1981; 1986; Hill et al., 1987; Jochim, 1988; Kelly, 1995), marine animals, especially shellfish, came to be thought of as marginal resources, because traditionally these are seen as low ranked resources since they provide a lower net energy return than do terrestrial animals or plants. Recently, however, this idea has lost strength due to the research of Bailey and Milner (2002), Erlandson

(1988; 2001), and Pálsson (1988; 1991). In any case, with the optimal foraging models archaeologists believed that human foragers would not use such low ranked items regardless of their abundance unless higher-ranked ones decreased or as a means of risk-avoidance (Winterhalder, 1986; Kelly, 1995). A rather circular argument has come about: marine resources are marginal, and if humans exploited them, this was necessary because there was pressure on resources; since few coastal Pleistocene sites are known, oceans did not become productive until the Holocene when sea level stabilized and there are many coastal sites, therefore coastal adaptations began in the Holocene as a result of population pressure on resources.

Faunal data, however, are not the only ones that we have. The fact that small prey species and marine fauna (marine mammals and shellfish) are present since at least 30.000 years ago in Portugal and Spain (Haws, 2003; Haws and Bicho, 2006; Hockett and Haws, 2005); there were severe transformations of the coast morphology due to tectonic action (Bicho, 2004); upwelling information shows that marine biomass productivity was much higher in the OIS 3 and 2 than in the early Holocene (Abrantes, 1990; 1991; 2000); and, finally, there are a wide set of technological innovations present in the Early Upper Paleolithic of Portugal, namely fish hooks and bone grease rendering (Bicho et al, 2004; Manne et al., 2005; Stiner, 2003) indicate that the process of resource intensification included an unmistakeable broadening of the dietary spectrum (large and small terrestrial animals, fish, shellfish, marine mammals, birds, plants and fruits), but also an increase in the amount of fat and other essential nutrients, obtained from the spongy bone areas of large and medium ungulates as well as from lagomorphs. So in conclusion, the conditions seen traditionally in the so-called Tardiglacial paradigm started, in fact, some 20.000 years before, already with the Neanderthal occupation of Iberia. But this can only be seen if a wide range of data sets are integrated with the whole data from the faunal analyses. By itself, faunal data (more so if they are truncated) can be misleading...

Commentary by Rebecca M. Dean[*]

Davis and Moreno-García present a cogent argument for the importance of zooarchaeological research, both within Portugal and within the discipline of archaeology as a whole. They deserve great credit for the creation of the comparative collections at IPA, which have facilitated faunal analyses by many

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scholars in Portugal, and for driving much of the zooarchaeological research in the country in the last eight years.

In this article, the authors posit twelve archaeological questions that can be usefully answered with faunal data. I would like to expand on the final question, which to me seems the most critical: "Do present day fauna have a role in zooarchaeological studies?"

In answer to this question Davis and Moreno-García present examples of archaeological research that have produced a greater understanding of endangered species – including how their remains and range can be indentified archaeologically, and how the IPA collections can identify mortality patterns in modern populations. As the authors themselves suggest, there is much more work to be done in this context, and I would like to broaden both the question and the scope of the answer. Archaeology in general, and zooarchaeology in particular, have a critical role to play in studies of modern environmental issues. Recent years have seen an explosion of popular and scholarly interest in the importance of archaeological data for understanding human/environmental interactions (for example, Diamond, 2005; Redman, 1999; Redman et al., 2004). Faunal data, in particular, have been singled out for their contribution to conservation biology (Lyman, 1998; Lyman and Cannon, 2004).

Much of conservation biology is aimed at restoring natural environments. But what is "natural"? – an environment that was never affected by human actions? Just by looking at the research reported by Davis and Moreno-García, it is clear that "natural" and "pristine" are not terms that can be easily applied to any ecosystem in Europe. The time depth of archaeological data allows for a much better understanding of how significant human agency has been in shaping world environments. As predators, humans have impacted prey species and competed with and excluded large carnivores since the Paleolithic, as seen at the site of Caldeirão. As agriculturalists, our herd animals and plows have transformed whole landscapes. Our villages and fields effectively have created new ecosystems, beneficial to some species, both domestic and wild, while excluding others completely.

Zooarchaeology is particularly effective for exploding myths of human-created landscapes, especially the assumption that all anthropogenic environments are impoverished. Traditional agricultural techniques in Portugal and in other parts of the world, for example, may actually increase biodiversity (Dean, 2005; Estabrook, 2000). In these cases, removing human impacts from the environment may actually *decrease* plant and animal diversity. The study of such mutually beneficial human/landscape relationships is particularly important in Portugal, which is known for certain ecologically sound agricultural practices, including cork forest management in the south.

We humans are, in effect, both a part and a creator of our environment, and this has been true since well before our species first entered Portugal. We evolved within an environmental context, and the environment evolved along with us. To return to a non-anthropogenic, "natural" environment would require turning the geological clock back millions of years. If nothing else, the deep temporal record of faunal manipulation in Portugal, as discussed by Davis and Moreno-García, should prove a gold-mine for understanding the complex and multi-faceted nature of human/landscape interaction over the long history of our species. Without a thorough understanding of the relationship between people and their environment, we have no hope of preventing the loss of critical biodiversity in modern habitats.

For this reason, I believe that Davis and Moreno-García's most important question is the last one. I would like to rephrase it, however, from "do present day fauna have a role in zooarchaeological studies?" to "do zooarchaeological studies have a role in understanding present day fauna?" Certainly, this is the question that mostly clearly articulates the importance of zooarchaeology, not only to archaeologists but to the society at large. This is the question that can be used to explain to the average person on the street why it is important to invest money and resources in what otherwise may appear to be nothing more than an esoteric and even bizarre collection of animal skeletons in wooden crates.

The article by Davis and Moreno-García illustrates very clearly how important zooarchaeological research has become in Portugal, and the critical contribution of IPA's zooarchaeological laboratory to the development of archaeology within the country. I look forward to many more years of publications from the IPA laboratory, particularly broadening the research focus on human/environmental relationships. I commend Davis and Moreno-García on the work they have already done regarding this issue.

Authors' reply

We are very grateful to the six commentators who carefully read our "report of 8 years' activities" and we are also encouraged by many of their remarks. It is our hope that we and an ever increasing number of research students shall be able to continue these and other projects for many years to come.

As a general comment we would like to point out that our article, written at the request of the OAP editor, is a summary report of what we have accomplished or are in the process of doing. Indeed many of the subjects are very incomplete and require considerable additional work – tasks for the future! We tried to be reasonably brief and much of the work by others in Portuguese zooarchaeology is accounted for in the various more detailed reports that we have published (see bibliography). For clarity we have replied to some of the comments and these now follow under their respective headings.

Archaeozoology vs Zooarchaeology

Bicho dwells on the choice of terms – archaeozoology or zooarchaeology – an interesting area of discussion which we prefer to leave to our lexicographical and etymological colleagues! In our view the task of the archaeozoologist/zooarchaeologist is to extract the maximum amount of information from the bones. This may include an understanding of the relationship between man and animals, the evolution (perhaps better termed "micro-evolution") of the species themselves, how they can aid in the reconstruction of palaeoenvironments, and so on.

Reference Collection

In answer to Brugal's question concerning the origin of skeletons in the CIPA reference collection (a.k.a. the *Osteoteca*), here, in table form, is a count of the major groups of animals by country of origin, as of January 2008:

This shows that over 70% of the more than 2000 skeletons acquired and prepared so far come from Portugal.

Animal group	Portugal	Spain	Britain	Poland	Mauritania	Morocco	France	Cyprus	Italy	Belgium	Israel	Bulgaria	Other*
Birds	478	226	77	53	-	2	18	3	6	-	-	2	5
Carnivorous mammals	282	19	6	-	-	-	-	-	-	-	1	-	2
Rabbits and Hares	213	-	3	-	-	-	-	1	-	-	-	-	-
Fish	135	6	-	-	33	20	-	-	-	6	-	-	-
Ungulates	133	6	1	-	-	-	1	3	-	-	-	-	-
Reptiles	102	11	1	-	-	-	-	-	-	-	-	-	-
Rodents	55	11	6	5	-	1	-	2	-	-	1	-	1
Amphibia	45	-	2	-	-	1	-	-	-	-	-	-	-
Insectivores	34	3	2	5	-	-	-	1	-	-	-	-	-
Cetaceans	9	-	-	-	-	-	-	-	-	-	-	-	-
Bats	7	-	-	-	-	-	-	-	-	-	-	-	-
Seals	3	-	-	-	-	-	-	-	-	-	-	-	-

(* includes Canada, Egypt, Greenland, Hungary, Kenya, Russia, South Africa and Syria)

Body-parts

We agree with Bicho and Cardoso that the study of body-part frequencies is important. While the original inhabitants of a settlement probably often selected certain parts of animals, we feel that the two main factors responsible for the pattern observed are **recovery bias** and **differential preservation**. Our experience indicates that, especially where soil conditions are aggressive, the more delicate parts of the skeleton fail to be preserved. Let us take bones of similar structure and hardness such as the proximal and terminal phalanges: the ratio between these two bones, 1:1 in the living animal, is often severely biased in cases where recovery was by hand alone, with a marked scarcity of the smaller and therefore less visible terminal phalanges. As a general rule we observe that within skeleton differences increase as animal size decreases. To take one example: an Almohad period rubbish pit in Silves (SD work in progress). Here, when cattle skeletal parts are compared with caprine skeletal parts the percentage representation of the different bones for the cattle are fairly similar. Thus the four principal fore-limb bones – scapula, humerus, radius and metacarpal – all comprise 7%, 5%, 7% and 8% respectively of the total numbers of cattle bones (total minimum number of bone elements = 181). However, in the case of the caprine forelimb bones – their respective percentages are 9%, 12%, 3% and 4%. Clearly their percentages show a much wider fluctuation (total minimum number of bone elements = 699). Although it is difficult to prove, the probable explanation for the larger discrepancies between different parts of the skeleton in the case of the caprines is that preservation and/or recovery biases have had a greater effect on their smaller bones.

Sample size

Brugal suggests that the taxonomic diversity of archaeological faunal assemblages may be influenced by other factors besides sample size. Our graph showing the relation between the 'logarithm of the number of bones identified to species level' and 'number of species' is not meant to reflect diversity. It indicates that the maximum number of taxa is attained as sample size approaches infinity and the relation between the two counts appears to be linear. And this relation, according to analyses undertaken so far, is similar for sieved and unsieved samples (probably due to the decision to consider only taxa of size equal to, or greater than, a rabbit/domestic cat), Portuguese and non-Portuguese samples (this is hardly surprising) as well as pre-Neolithic and post-Neolithic ones. It is doubtful whether we have sufficient data for assemblages from different habitats although of the six small desert assemblages (northern Negev and Sinai) analysed, four did indeed plot well below the line indicating an impoverished fauna.

Ritual practices

Cardoso's comments on the presence of dog remains associated with ritual practices in Portugal are correct. However our aim was not to review the occurrence of this domestic species in Portuguese funerary contexts or the ritual aspects involved in the consumption of its meat. Rather, we were interested in showing that the association of animal burials with human beings demonstrates how certain animal species were chosen as a means of expressing feelings of care towards loved ones. In addition, these associations also show how early in time such close bonds between man and animal occurred to the extent that they would continue as companions in the afterlife or that they would deserve a burial of their own. The archaeological record of such finds is not that common and in Portugal the dog buried at Anta 3, Santa Margarida Herdade (Reguengos de Monsaraz, Évora) stands out as a rare example.

Neolithic bone assemblages

We share Jackes and Lubell's disappointment at the scarcity of Neolithic (as well as Bronze Age) animal bone samples from Portugal. This serious lacuna will, we hope, be filled in the years to come.

Extinctions

Brugal emphasizes the distinction between two kinds of extinction – local and general. Where a species such as the spotted hyaena became extinct in Portugal, today it survives in Africa south of the Sahara. This is clearly a case of local extinction. Other taxa, like the woolly rhinoceros, sadly became totally extinct. In the Portuguese Upper Pleistocene succession, we discuss the extinction of taxa from Portugal – in most if not all cases local extinction only.

Horse remains

Both Cardoso and Morales have found an error in our text indicating the horse may have become extinct (locally of course) after the Magdalenian. In fact it should, as table 4 shows, have read Mesolithic. The horse is in fact only absent from two Neolithic levels – Leceia and Penedo de Lexim. The possible "re-appearance" of this animal in the Chalcolithic would, if true, suggest its arrival as a domesticated animal introduced by man. However, given the scarcity of data from the Neolithic the question of wild horse 'survival' here or 'extinction followed by re-introduction as a domesticated animal' is better left open until more substantial Neolithic assemblages are available for study. This equid enigma will probably remain unresolved for a long time since equid bones are generally scarce in zooarchaeological assemblages and it is difficult, perhaps impossible, to distinguish between wild and domestic horses on the basis of fragments of their teeth and bones.

Red and fallow deer

Cardoso rightly questions the wisdom of relying upon size alone to distinguish between fallow and red deer bones; although as Lister (1996) demonstrated, there are few morphological characters that enable a secure separation. Further work (Davis and MacKinnon, 2009) on five medium-sized cervid bones from another Roman site near São Pedro Fronteira reinforces our belief that the fallow deer was present here in Roman Portugal, though it may have disappeared once Roman rule had disintegrated, only to be reintroduced to the *coutadas reais* or royal hunting grounds by the Kings of Portugal as a source of venison. Our collection, now comprising six putative fallow deer bones from the Roman period, includes two astragali. Red and fallow deer astragali measurements from Portugal, France and England (ancient and modern) indicate a clear osteometric separation between these two taxa. Our two astragali fall well within the range of fallow deer and are too small to be red deer.

Relative abundances of different taxa

Jackes and Lubell dwell upon what is possibly one of the most interesting aspects of quantitative zooarchaeology – the change over time of the relative abundances of different taxa. These changes can often be explained in ecological terms. We agree that many of the animal species were undoubtedly abundant in the Mesolithic, although we doubt it is possible, using zooarchaeological data, to understand just how abundant, in absolute terms, was each animal. Rather we suggest that a slight change occurred in the relative abundance of different taxa in the course of time. There is certainly no evidence that red deer became scarce in the Mesolithic or later. Indeed this animal has survived here till today. What we suggest in our discussion of the frequencies of medium and large sized mammals in the Portuguese zooarchaeological succession is that certain ***shifts*** occurred which in turn reflect an increase of predator pressure in turn due to an increase in the human population. This would have affected first the slow reproducers, like red deer, and resulted in the gradual increased abundance of the fast reproducers, such as wild boar, (what ecologists term the "r" selected taxa). With further increased demographic and therefore hunting pressure people would have had to shift increasingly to small mammals and eventually marine resources. This is now clear in the faunal succession in Israel (Davis et al., 1988;

Davis, 1989; Davis, 2005a) and Andalucía (Morales et al., 1998), just to give two examples. We do not suggest therefore that certain resources or taxa became scarce, but rather that the delicate balance between the different taxonomic components of the biosphere changed – perhaps only very slightly. In the course of millennia these changes became reflected in the archaeological record. Put another way, we do not doubt that even large prey species like the red deer were still abundant in the Mesolithic but compared to earlier times their abundance may have become relatively less compared to smaller and less worthwhile (in terms of meat gained per unit of energy expended in its capture) prey species such as rabbits, fish and birds. The adoption of a sedentary lifestyle leads to demographic increase (Sussman, 1972), and this may have been the ultimate cause of population increase and hence the shift to smaller prey species. If correct, then while we can answer the question 'what caused the population increase and the resulting shift to smaller prey species?' we are left with another and new question – why did people become sedentary when they did?!

Size change

Jackes and Lubell question the "grain size" of our osteometric data for red deer and Morales rightly questions the problem of disentangling other factors influencing size such as age and sex from predator pressure. We look forward to acquiring a more chronologically detailed picture of red deer size change in the course of time in Portugal. Disentangling the different factors that may have caused size change in this animal is a major task that confronts us. In the Near East it seemed that those taxa that obey Bergmann's rule today did so in the past in that they underwent a size reduction at the Pleistocene-Holocene boundary (Davis, 1981). Taxa that fail to show a size-temperature relation today do not appear to have changed in size 11 or 12,000 years ago. So far we lack sufficient metric data to determine precisely when red deer decreased in size and what we can relate this to, although as a working hypothesis, we suggest that the size decrease in the Mesolithic is somehow related to increased predator pressure. Age can be safely eliminated: only adult bones (i.e. with epiphyses fused) were measured. We are also aware of the dangers of using average size of samples of bones due to sexual size dimorphism. Sex cannot be ruled out as we still lack a sufficiently large sample of modern sexed specimens. The collection of red deer from the Oise being assembled in the Muséum d'Histoire naturelle in Paris is still too small to enable a clear understanding of sex related size differences. Large samples are needed to determine whether an average size difference is due to a chronological change in the sex-ratio.

The spectrum of exploited resources

Zoo-archaeologists generally consider the frequencies of different species and their age-at-death profiles. Two examples relevant to an understanding of the beginnings of domestication are Kent Flannery's (1969) discussion of the increased spectrum of species exploited in the Near East prior to the Neolithic which he called "the broad spectrum revolution" and William Elder's (1965) study of deer mandibles from Palaeo-Indian sites in Missouri, USA, before and after the arrival of European settlers.

Bicho discusses the broadening of the resource base of hunter-gatherers towards the end of the Pleistocene – a process that preceded the advent of domestication. He suggests, and we agree, that this process began quite early. Besides the exploitation of marine resources as exemplified by the Mesolithic *concheiros* in Portugal (and elsewhere such as the Danish Køkkenmøddinger); the increased numbers of rabbit remains may indeed reflect an earlier and even more gradual change in the resource base here in Portugal. Although the evidence in Portugal is somewhat sparse, the faunal remains from Caldeirão are suggestive. We have noted (Davis, 2002; Davis et al., 2007) that in that cave's sequence the ratio of rabbit to ungulate remains appears to rise gradually from the Mousterian, EUP, Solutrean to Magdalenian as follows: 0,63 – 0,70 – 0,90 – 0,95. One interpretation we offer for such a gradual shift to this small mammal is that it reflects an increase in pressure on the wildlife due to the increased human population.

In the Near East there was a clear widening of the spectrum of exploited resources. Elsewhere similar changes have been observed. At the caves of Franchthi in Greece and Nerja in Andalusia, Payne (1975a) and Morales et al., (1998) observed that fishing began in the Mesolithic and Magdalenian periods respectively.

In North America Elder (1965) interpreted a shift in the age-at-death profiles of a prey species in terms of hunting pressure. He noticed a marked increase of juvenile deer hunted by Missouri Indians in the 18th century AD which he linked to increased hunting intensity and efficiency – a consequence of the introduction by Europeans of firearms and horses and the remunerative venison trade. In South Africa Klein (1979) noticed that limpets found in Late Stone Age sites were smaller (*i.e.*, younger) than those from the Middle Stone Age which he suggested reflected increased foraging pressure.

The Mousterian to Pre-Pottery Neolithic-A (PPN-A) succession of faunal assemblages in the southern Levant reveals a chronological shift towards smaller prey and an increase in the proportion of juvenile gazelles hunted, gazelle being the most important ungulate. The down-sizing of prey and increased juvenile-

-gazelle cull in the course of the Mousterian to PPN-A were also viewed in terms of increased predator pressure (see Davis et al.,1988; Davis 1989; 1991; 2005a). With the adoption of sedentism in the Natufian, just before the Neolithic (Perrot, 1966), population increase must have been more rapid. We know from modern examples of newly settled nomads that sedentism is soon followed by substantial population increase (Sussman, 1972). A rise in pressure on the environment just before the appearance of domesticated food animals in the Levant explains why it became necessary for people to take control of their meat sources and begin domesticating – people were *forced* by demographic pressure. Otherwise, as Lee (1968) pointed out, hunting and gathering peoples living at low population density have little need to go to the effort of managing livestock. Husbanding animals is more arduous than simply going out and hunting them. As for the timing of these changes, while the demographic increase undoubtedly, as Bicho suggests, began quite early during the course of the Upper Pleistocene, the actual beginnings of plant and animal domestication did not begin until the Holocene, perhaps in the ninth millennium BC as evidenced by the shipment of livestock to the island of Cyprus and size change of sheep, goat, cattle and pig (Vigne et al., 2003; Peters et al., 2005).

Wild boar hunting

The point made by Morales about the slaughtering of wild boar according to Islamic precepts is an aspect that we indeed did not discuss. During ethnographic work in the Rif mountains of northern Morocco (undertaken by MMG) it was observed that wild boar are hunted in parties in which men armed with sticks, ropes and knives and accompanied by dogs work together. Traditionally, in order to overcome these fierce wild beasts, dogs are sent into the attack while men throw stones or beat the poor beast with wooden sticks. Then, to immobilise it the hunters put a stick across its mouth, from whose ends two ropes are attached and tied around its neck to suffocate it. In order to reduce danger, the tusks are broken with stones or an axe. If the animal is caught by a leg then its tendons are cut with knives. Once paralysed, it is tied with ropes to be killed on the spot or dragged down to the village (Moreno-García, 2004). It is interesting also that sometimes wild boar carcasses are processed for feeding dogs and not for human consumption.

Age-at-death

We chose the change in culling profiles of the main domestic species from the Late Neolithic to Chalcolithic periods at Penedo do Lexim (Mafra) and Leceia (Oeiras) as an example to illustrate the importance in zooarchaeology of recording age-at-death. Such a change was interpreted as evidence for intensification in the use of secondary products during the Chalcolithic that, in turn, was related to a change in the social and economic circumstances between Late Neolithic and Chalcolithic times. Precisely, the emergence of privileged social groups during the Chalcolithic as is evidenced by other kinds of archaeological finds (i.e., fortified settlements) may have been one of the causes that influenced the obtained pattern. Thus, it appears to us that the effect social differentiation might have in kill-off patterns, as Cardoso suggests, is a topic we did not overlook. However we prefer to be cautious in our conclusions since there are few Portuguese Neolithic and Chalcolithic sites with large studied faunal samples. The assumption that an age-at-death profile with many young indicates a preference for tender or 'high quality' meat by high-status groups within a community may indeed be correct, however we tend to think that this may be simplistic as it ignores a range of other variables, such as environmental and economical constraints, that can also influence the mortality profile.

Subsistence strategies

We agree with Cardoso that the composition of a faunal assemblage reveals primarily the locally available resources. Therefore, it is expected that the subsistence strategies adopted by any human community develop from such resources. For that reason, we questioned if the variety of hunted species and dominance of pig in the Chalcolithic samples analysed from the Alentejo region reflected wider availability of wild fauna there than in the Portuguese Estremadura. His suggestion of opportunistic or specialised hunting seems appropriate and will be taken into account in future studies.

The improvement of cattle

Like Cardoso and Morales, and despite the references to different morphotypes in the Roman literature, we too are surprised by the absence of any osteometric evidence for a size increase of cattle here in Roman times while there is now abundant evidence that the Romans improved cattle in central and northern Europe. One possible line of investigation that may eventually be possible as we acquire more osteometric data is to study shape change in cattle metapodials as was found in medieval – post-medieval England (Albarella and Davis, 1996). While we are not suggesting that Lusitania was a peripheral region of the Roman Empire, we do suggest that perhaps it was in relation to the bovine sector of the economy.

A final observation

As members of the ex-IPA and concerned archaeological scientists, we share many of the commentators' worries about the future of archaeo-sciences in Portugal. One aspect that especially disturbs us is the scarcity of available developer funding for post-excavation study of archaeological finds like animal bones. While developers are rightly obliged to underwrite the excavation of sites they 'destroy', there seems to be little understanding that post-excavation studies may take a considerably longer time than their actual excavation.

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