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ÍNDICE

THE VELOCITY OF *OVIS* IN PREHISTORIC TIMES: THE SHEEP BONES FROM EARLY NEOLITHIC LAMEIRAS, SINTRA, PORTUGAL

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Abstract

Excavations at Early Neolithic and Late Neolithic Lameiras near Sintra in Portugal have uncovered numerous caprine bones. Many, including milk teeth, humeri, metapodials, calcanea, astragali and terminal phalanges, can be securely identified using well established morphological criteria and osteometrical differences on metacarpal condyles and astragali. Radiocarbon dates on some of these sheep bones indicate their presence in southern Portugal around 5,450 cal BC which is the beginning of the Early Neolithic in this region. It is possible that the change from hunting to husbanding occurred rapidly. Current evidence from the Near East, the region whence our domesticated sheep came, indicates a date of domestication there that is some three thousand years earlier. In other words sheep coming overland must have travelled quite rapidly – perhaps too rapidly – and so it seems likely that livestock were being shipped already in the Neolithic.

Keywords: Early Neolithic, Domesticated animal species, Sheep, Lameiras.

Resumo

Localizado na península de Lisboa, 7km a nordeste da Serra de Sintra e distante 10km da costa Atlântica, o sítio do Lapiás das Lameiras revela um consistente conjunto de dados para a caracterização do Neolítico antigo no extremo ocidental da Península Ibérica. Os estratos arqueológicos conservados permitem definir a sequência das ocupações neolíticas ao nível da cultura material e da morfologia das estruturas conservadas, articulando-a com o estudo de restos carpológicos e faunísticos associados. Neste âmbito, aprofundam-se aqui, especificamente, os resultados da investigação em curso sobre as faunas mamalógicas, que documentam a presença de animais domesticados desde meados do VI Milénio cal. AC.. As datações em torno de 5450 cal AC obtidas sobre três ossos do Neolítico antigo identificados como *ovis aries* – animal exótico oriundo do Médio Oriente – permitem enquadrá-las entre os restos dos primeiros ovinos a chegar a território actualmente português, numa fase precoce do Neolítico.

Palavras-Chave: Neolítico antigo, Espécies animais domesticadas, *Ovies aries*, Lapiás das Lameira.

"…this dim beginning of the Neolithic period, …a time when the world was gathering its forces. …wise men came out of the East, …in the New Stone Age, were to press along to the cry of "Westward Ho," and build up new civilizations. …They had domesticated the dog, and it may have occurred to them to do the same with other animals, and so save themselves the trouble of hunting. …man became a herdsman, and had flocks to tend. This added to his responsibilities; while as hunter, or beach-comber, his cares were few, he must have found that with possessions his troubles began."

(Marjorie & Charles H.B. Quennell, 1922 Everyday life in the New Stone, Bronze & Early Iron Ages, London, Batsford. p. 3.)

1. INTRODUCTION

The domestication of animals (and plants) represents a crucial move to control nature rather than merely take from it – an innovation that ranks in importance alongside the discovery of fire and tools. A domesticated animal is one whose breeding is largely controlled by humans and implies the partial or even total genetic separation of a breeding stock from its wild forebears so that its evolution is largely under our own control. The study of the origin of farm animals and why our ancestors were compelled to control them in this way is one of the more fascinating subjects that zooarchaeologists study – zooarchaeology being the study of animal remains from archaeological sites. To discover where animals were first domesticated, Eduard Hahn (1896) noticed that the distributions of the wild ancestors of all four of our principal farm animals – sheep, goat, pig and cattle – overlap in the Near East and he proposed that that was the region whence they came – an area subsequently known as the 'fertile crescent'. So first, in order to understand when and even why the sheep, as well as the cow, pig, and goat, was first domesticated, we must turn to the zooarchaeological record in that area. And second, in order to understand the subsequent spread of domestic sheep we need a good record of archaeological faunal remains that precede and coincide with the age of early animal husbandry – the Mesolithic and Neolithic.

The aim of this article is a) to show that we have securely identified sheep bones, some with direct radiocarbon dates, from the Early Neolithic layers at Lameiras, near Sintra in Portugal, and b) with secure dates for early sheep domestication in the Near East, suggest that these Portuguese Neolithic sheep, or rather their ancestors, were introduced rapidly into western Iberia, most probably by ship.

2. SHEEP

Where were sheep domesticated? Wild sheep, at least in the late Pleistocene and Holocene, were absent from Europe and so the early sheep bones found on European archaeological sites must have been introduced by people and therefore were under their control – i.e., they were domesticated. Today there are four species of wild sheep – mouflon, argali, urial and snow sheep - distributed across Asia and into the Near East. Which of these was the ancestor of our domestic sheep? In the 1970s geneticists (Nadler *et al.*, 1973; Bunch *et al.*, 1976) counted the number of chromosomes (the karyotype) in these different species. They observed that the urial has 58, the argali has 56 the snow sheep has 52 and the mouflon of southwest Asia has 54. This last, 54, is the same number as our domestic sheep. It was therefore logical to assume that domestic sheep are derived from the mouflon. More recent studies of the structure of the DNA of sheep confirm this western Asiatic origin and even indicate that domestication happened on more than one occasion – i.e., that our domestic animal is descended from several different populations of wild mouflon (see for example Hiendleder *et al.*, 2002; Pedrosa et al., 2005; Chessa *et al.*, 2009). What does the archaeological record tell us?

There are several criteria that zooarchaeologists use in order to recognize the domesticated status of a species represented by fragments of teeth and bones on an archaeological site. One criterion is finding remains of a species outside its original range of distribution. Another criterion is recognizing a shift in the frequencies of taxa in the course of time from species that were not or could not be domesticated like gazelle and deer to those that we know in later times were domesticated like caprines, pigs and cattle. And another oft-used criterion is a size change; most domesticated animals are smaller than their wild ancestors, some are larger. The act of domesticating an animal, for some reason which we do not fully understand, brought about a size change. The aurochs (ancestor of our cattle), wild goat, wild boar (ancestor of our pig), and wild sheep were/are all larger. The wild rabbit and the jungle fowl (ancestor of the chicken) were/are smaller than their domestic varieties (Darwin, 1885; Reed, 1961; Zeuner, 1963).

When were sheep first domesticated? In the case of the sheep, as already mentioned, finding its bones beyond its range of distribution is a sure sign that it was domesticated. However, working within its original range of distribution, such as in the Near East, this distinction is less easy to make. One complication when using the 'size' criterion is that many species of mammal vary geographically in size. Ideally, in order to register a chronological size change and hence record the 'moment' of domesticating, one needs to study animal bones from a continuous sequence of levels in the same site or a series of sites within a restricted area. Another complication related to size, is that many species of mammal became smaller at the end of the last Ice Age which was not long before many animals were domesticated (for a few examples see: Kurtén, 1965 for Near Eastern carnivores; Harris and Mundel, 1974; Schultz, 1976 for North America; Hendey, 1974; Klein 1976 for South Africa; Tchernov, 1968; Clutton-Brock 1969; Frenkel 1970 and Davis, 1981 for the Near East; Castaños, 1990 and Davis, 2002 for Iberia; Badoux, 1964 for Sumatra and Ruff, 2002 in humans). This size-latitude (i.e., environmental temperature) relation was first observed by Carl Bergmann (1847). Hence Pleistocene-Holocene diminution can be confused with size changes associated with domestication.

Within the Near East, Joris Peters and his collegues (Peters *et al.*, 2005), studying animal bones from archaeological sites in a restricted region of the Fertile Crescent, have 'controlled' both geographical differences and environmental temperature variation and provide a date for sheep domestication. Geographical differences were controlled by considering a series of sites that are located within a very restricted region the upper Euphrates-Tigris basin. Temperature was controlled by considering not only lineages of taxa that were domesticated (sheep, goat, wild boar/pig and aurochs/cattle) but also that of a species – the gazelle – that was not domesticated.

Let us view the evidence for distinguishing between domestic animals and their wild ancestors in the Near East via a) size change and b) the transport of a species beyond its original area of distribution.

a) Peters and his group show that gazelle did not undergo any significant size diminution during the 9th – 7th millennia cal BC while the lineages of the other four taxa did. This happened after the final PPNA and during the PPNB. Hence if temperature were the cause of the diminution of caprines, *Sus* and *Bos* during that time one should expect the gazelle to have become smaller too, but they did not, presumably because environmental temperatures remained constant. Hence the size decline of the caprines is more likely to reflect their change in status from hunted to husbanded. Peters *et al.*, (2005; and pers. comm.) suggest that a probable date for sheep and goat domestication in the Euphrates-Tigris basin approximately 8450 cal BC.

b) That was the mid 9th millennium saw sheep husbanded in the Near East is corroborated, if a little later, by the dates for the earliest remains of sheep introduced onto the island of Cyprus. This island has been isolated from the mainland for some five million years since the Messinian salinity crisis (Hsü *et al.*, 1973) and prior to Neolithic human colonisation, Cyprus was populated by a strange endemic fauna of pygmy

> hippopotamus and pygmy elephant (Forsyth Major, 1902; Bate, 1903; 1906; Boekschoten and Sondaar, 1972). The early, but not the earliest, human colonisations of this island thus saw the shipment of sheep as well as other livestock, from the mainland. This act, like the changes reported in the Upper Euphrates basin, provides an early date for the domestication of sheep: it is reasonable to suppose that it was domesticated sheep rather than their wild relatives that were transported. In '*phase ancienne B*', dated to c. 8032 cal. BC at one of these early Cypriot sites, Shillourokambos, Jean-Denis Vigne has identified the earliest remains of sheep in Cyprus (Vigne, 2011; Vigne *et al*., 2011). These finds of sheep bones beyond the natural range of distribution of this animal provide a sure sign that they had already been domesticated. Thus we now have dates of 8450 cal BC from the Upper Euphrates basin and 8032 cal BC from Cyprus. This now allows us to estimate ovine velocity in prehistoric times!

But first we need to move away from the Near East and discover when domestic sheep first appeared here in the *finis terrae* of Western Europe.

Sheep, like certain cereals, cattle, goats and pigs, form part of the so-called 'Neolithic Package' and therefore provide us with a secure date for the commencement of animal husbandry in the Iberian Peninsula in the sixth millennium BC. The importance not only of secure dates of early Neolithic sheep bones but also their properly documented description – both graphical and metrical – was emphasized by Zilhão (2011) and Martins *et al*. (2015) in their discussions of the evidence for the origin of farming economies in the Iberian Peninsula.

3. LAMEIRAS

Seven kilometres north east of the town of Sintra, 143 metres above sea level, and some 10 kilometres inland as a crow might fly from the present-day coast of the Lisbon Peninsula, lay the ancient settlement of Lapiás das Lameiras. It is at latitude 38° 50′ 47,5 N and longitude 9° 20′ 36,7 W (Figure 1). 230m^2 of this archaeological site were extensively excavated under the direction of one of us, TS, in 2002 and TS, Patrícia Jordão and Pedro Mendes in the three subsequent years (Simões, 2004; Mendes *et al*., 2005; 2005) prior to its destruction to make way for the construction of a housing estate. Some Mousterian and substantial Early and Final Neolithic as well as some Chalcolithic remains were uncovered at Lameiras.

Lameiras is the first excavation of a Neolithic site in Portugal that has provided a substantial quantity of animal bones which include, as we shall describe, many of sheep. The abundance of bones from this zooarchaeologically little-known period in Portugal makes this an important faunal assemblage. With an ever expanding knowledge of faunal remains from late Pleistocene, and Chalcolithic to post-Medieval archaeological sites, Lameiras fills an important gap in the history of the fauna of Portugal during the last 30 millennia. In other words we now have a chronologically more complete sequence which can help us understand the evolution of some of Portugal's domesticated animals. The entire fauna of Lameiras will be described in Davis *et al*. (forthcoming).

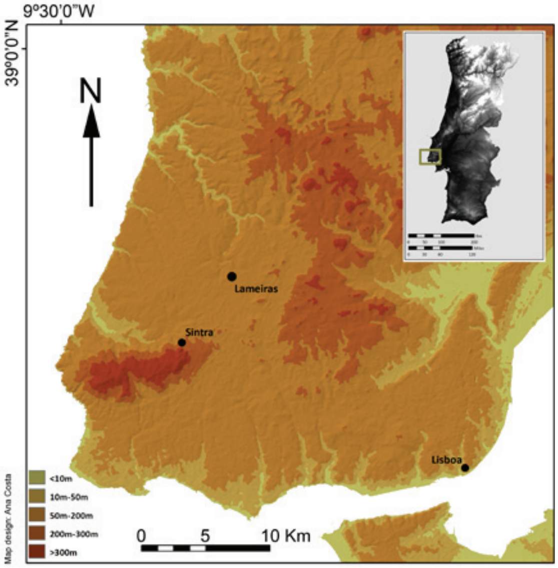

Figure 1 – Map of Portugal and the Lisbon Peninsula enlarged showing the location of Lameiras.

4. MATERIAL AND METHODS

The Lameiras bones were recovered by hand and most are well preserved. They include some 1000 remains of medium-sized and large mammals – caprines (most are sheep and some goats), *Sus* (probably most if not all are pig; wild goat and pig being difficult to distinguish), *Bos* (most if not all are cattle but there may be some aurochs bones), red and roe deer, rabbit, hare, dog and fox, a few birds, amphibia and reptiles and some 60 – 70 fish bones.

5. DATES

Four humeri and a metacarpal identified as sheep (see below for the reasoning) could be radiocarbon dated. Their dates and calibrated ranges (2σ) are as follows:

Distal humerus UE 71 (Late Neolithic) 4122 ± 33 BP OxA-29112 = 2869-2579 cal BC

Distal humerus UE 53 (Early Neolithic) 6186 ± 36 BP OxA-29234 = 5286-5019 cal BC

Distal humerus UE 27-2 (Early Neolithic) 6314 ± 33 BP OxA-29111 = 5357-5220 cal BC

Distal metacarpal UE 53 (Early Neolithic) 6494 ± 34 BP OxA-29110 = 5517-5374 cal BC

Distal humerus UE 53 (Early Neolithic) 6497 ± 34 BP OxA-29109 = 5521-5375 cal BC

The two oldest radiocarbon dates obtained from these Lameiras sheep bones, like the two sheep bones from the Early Neolithic at Caldeirão cave, can be calibrated to approximately 5,450 cal BC. This is the beginning of the Early Neolithic in Portugal which is generally considered to date from a little before approximately 5,400 cal BC (Zilhão, 2001; Carvalho, 2003 and pers. com.; Bernabeu *et al.*, 2014). The Early Neolithic has similar dates in Catalonia (Cebrià *et al.*, 2014; Martins *et al.*, 2015). Martins *et al.*, (2015) even argue that the date of arrival of the Early Neolithic in Catalonia is "statistically indistinguishable" from its arrival in Portugal which supports Zilhão's (2001) maritime colonization hypothesis, but is delayed by many centuries in NW Portugal, Galicia and Cantabria (see also below). In order to avoid problems associated with stratigraphic contamination and factors like the 'old wood' problem, they restricted their considerations to radiocarbon dates obtained from charred seeds of wheat and barley as well as confirmed sheep bones from Catalonia.

6. A DESCRIPTION OF THE CAPRINES (SHEEP AND GOATS) IDENTIFIED AT LAMEIRAS

A considerable proportion of the Lameiras medium/large mammals are caprines – sheep and goat. These two related genera of bovids are both classified within the sub-family caprinae and tribe *caprini*. Despite a probable 7 million year separation of the lineages that gave rise to sheep and goat (i.e., in the late Miocene; Randi *et al.*, 1991; Bibi, 2013), many of their bones are difficult to identify to species. Since bones of *Capra* and *Ovis* are not easy to distinguish and most caprine bones can only be determined as "sheep/goat", it is necessary here to consider carefully the various characters, both morphological and osteometrical, which can help to determine with certainty the bones from Lameiras as *definite* sheep or *definite* goat. These difficulties were experimentally highlighted by Zeder and Lapham (2010). Small morphological differences observable on bones like the distal humerus, distal metapodials, calcanea, astragali and terminal phalanges described by Boessneck *et al.*, (1964) and Boessneck, (1969) are often quite useful when identifying archaeological bones of caprines. Use of these criteria enabled Rowley-Conwy (1992) to identify 6 of the 20 caprine fragments from the Neolithic of Caldeirão as sheep while none could be assigned to goat. The mandibular milk teeth, dP_3 and dP_4, can also be separated (Payne, 1985), and measurements can help in the case of the distal metacarpal (Payne, 1969) and the astragalus (Davis, in press). What follows are more detailed descriptions of certain parts of these bones that confirm their identification as either definite sheep or definite goat. Then some consideration will be given to the two metrical methods used to separate sheep from goat metacarpals and astragali.

7. MORPHOLOGICAL METHODS TO DISTINGUISH SHEEP BONES FROM GOAT BONES

(see Figures 2 to 6 which show various caprine bones from Lameiras).

Last deciduous molar tooth dP$_4$. One character that separates goat dP$_4$ from sheep dP$_4$ is the presence or absence of the so-called bovine pillar(s) on the buccal side and at the base of the crown (Payne, 1985). Three well preserved dP$_4$s are shown in Figure 2. Note the prominent bovine pillar on two of the specimens (UE 53; and UE 73) – which are therefore identified as goat. Note also the absence of any pillar on the third specimen (UE 41) which presumably therefore belonged to a sheep.

Distal humerus. In sheep, the distal part of the medial epicondyle – labelled ‘a’ in Figure 3 – ends more or less as a right angle whereas this tends to be oblique in the goat. Note in this figure that the distal humerus identified as probable goat has an oblique medial epicondyle while the other four have right angled epicondyles and are identified as sheep. Another characteristic that helps to distinguish the trochleae of sheep from goat is the relatively small minimum diameter (measurement HTC) in the goat. The probable goat humerus from UE 4 shown in this figure has a rather more constricted trochlea. Compare it for example to the one below (UE 27) identified as sheep.

Distal metacarpal. Figure 4 shows distal metacarpals of a young goat and two adult sheep. In the goat metacarpal, the two peripheral parts of the trochlear condyles – labelled with arrows in the figure – are considerably more compressed compared to the central condyles in the sheep. It is this difference that forms the basis of the metrical separation between sheep and goat metacarpals described by Payne (1969).

Astragalus. Figure 5 shows four of the better preserved caprine astragali from Lameiras. Each one is shown in medial and plantar views. Boessneck et al. (1964) and Boessneck (1969) described several characters on the astragali that help to distinguish between sheep and goat. These are labelled ‘a’ – ‘d’ on the top left specimen in this figure and as in Boessneck (1969: figure 64 and 65). Perhaps the most distinguishing feature is the projecting lobe ‘a’. This is the projection at the proximo-plantar angle of the medial articular ridge of the trochlea. It is more strongly developed in the sheep where it is rather wide and blunt, but in goat it tends to be more pointed. And the adjacent indentation ‘b’ is generally less pronounced in sheep. The dorsally projecting “cusp” ‘c’ on the medio-dorsal ridge tends to be more pronounced in goat than in sheep and the indentation at ‘d’ is often more pronounced in goat. Another character, perhaps more variable and therefore less trustworthy, is the crest on the medial side of the plantar surface which generally, though not always, remains parallel to the medial side in goat and curves ‘inwards’ (i.e., towards the centre of the astragalus) in sheep.

Terminal phalanx. Figure 6 shows five caprine and two cervid terminal phalanges. The latter are characteristically for the cervids lacking an extensor process labelled ‘ep’ on the specimen in the centre of the top row. Caprine terminal phalanges, unless very well preserved can be difficult to identify as sheep or goat. In lateral view the goat terminal phalanx tends to be rectangular in outline while that of the sheep is more tri-angular. Moreover the distal part of phalanx can be very thin and wafer-like in the goat but thicker in the sheep. Of the five better preserved caprine specimens from Lameiras shown here, one is definitely goat, one is definitely sheep, and three are almost certainly sheep.

Figure 2 – Milk teeth of one lamb and two kids shown in buccal view on the left and lingual view on the right. Note the marked presence of one or more ‘bovine pillars’ at the base of the dP_4 crown of the two specimens identified as *Capra*. Bovine pillars are absent from the dP_4 identified as *Ovis* (see Payne, 1985).

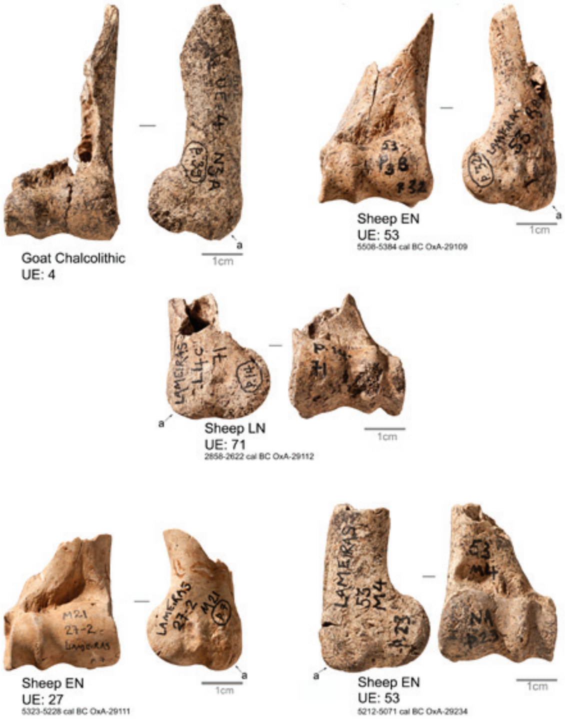

Figure 3 – Distal fragments of five caprine humeri from Lameiras shown in anterior and medial view. One is identified via Boessneck’s (1969) criteria as goat and four as sheep. Note the epitrochlea, labelled ‘a’, which tends to form a right angle in the sheep but an oblique one in the goat. Identification is followed by the date (Chalcolithic, EN – Early Neolithic; LN – Late Neolithic). The four sheep humeri from UE 27, 53, 71 and 53 have been radiocarbon dated (see text) and the results are also indicated here.

Figure 4 – Distal metacarpals of a young goat and two adult sheep from Lameiras shown from all six sides – lateral, plantar, anterior, superior, medial and posterior. Note the considerably more constricted trochleae of the goat metacarpal compared to those of the sheep – the basis of Payne’s (1969) metrical method for distinguishing metacarpals of these two taxa. Identification of each metacarpal is followed by the date (EN – Early Neolithic, EEN – Evolved Early Neolithic) and stratigraphic unit number. The sheep metacarpal from UE 53 has been radiocarbon dated to 5491-5328 cal BC (1σ, OxA-29110).

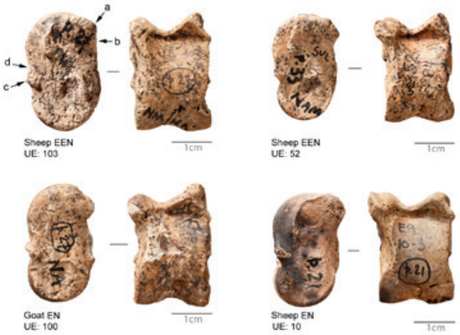

Figure 5 – Four caprine astragali from Lameiras shown in medial and plantar views. Three are identified via Boessneck's (1969) criteria as sheep and one as a goat. Note that most have a pronounced and wide projecting lobe on the plantar edge of the medial face (Boessneck's 'a') and a relatively reduced 'spine' in the centre on the dorsal side (Boessneck's 'c'). The dates are shown as EN – Early Neolithic and EEN – Evolved Early Neolithic. The stratigraphic unit number, UE, is also given.

Figure 6 – Seven terminal phalanges of sheep, goat and roe deer from Lameiras in external view. All come from the Early Neolithic, EN. Four of the caprine terminal phalanges are identified as sheep or probable sheep and there is one definite goat. Note the two on the right which, like all cervids, lack an extensor process (labelled 'ep' on the specimen in the centre of the top row) and are identified as roe deer.

8. METRICAL METHODS TO DISTINGUISH SHEEP BONES FROM GOAT BONES

Measurements taken on two bones, the distal metacarpal and the astragalus can be used to separate sheep from goat (Payne, 1969 for the metacarpal; Davis, in press for the astragalus). These metrical methods should not be used alone to make the distinctions but rather used as an aid to corroborate the distinctions made on the basis of morphology. At Lameiras, we see an interesting difference in the sheep : goat ratio between the distal metacarpal and the astragalus. Thus Figure 7 (which shows the method described by Payne, 1969) for the metacarpal condyles indicates an approximately equal proportion of sheep and goat. Another metrical method has recently been described by one of us (see Davis, in press). This utilises the small shape difference between sheep and goat astragali. Instead of plotting simple measurements on a scatter diagram, two indexes are plotted, one is the lateral depth (Dl) divided by the greatest lateral length (GLl) and the other index is the distal width (Bd) divided by the lateral depth. With the first index plotted on the vertical axis and the second on the horizontal axis modern sheep tend to plot out in the top left hand side while goats are below and/or to the right. The distribution of the scatters is more distinct in Cyprus and less so elsewhere and so does not provide a certain method but may serve as a rough guide (Davis, in press). Figure 8 indicates many more sheep at Lameiras than goat. Sample sizes are small so these differences need to be treated with caution, but the possible mis-identification of some of the metacarpals and astragali needs to be considered.

In sum. Let us consider the sheep and goat teeth and bones separately. Unfortunately only seven parts of the caprine skeleton can be identified to species with reasonable security. These are: the last milk molar (dP_4), distal humerus, distal metacarpal, astragalus, calcaneum, distal metatarsal and the terminal phalanx. While the overall picture at Lameiras appears to indicate more sheep than goats, when one examines the counts for individual parts of the skeleton the sheep: goat ratio varies between 15% goats (metatarsals), to 40% goats (metacarpals). The average percentage of goats among all the sheep + goat teeth and bones that could be identified with reasonable certainty is 25%. The large variation in the sheep: goat ratio is partly due to the smallness of the samples to hand and perhaps too to SJMD's varying ability to make the sheep-goat distinction correctly! But overall it can be suggested that for every three sheep reared by the ancient inhabitants of Lameiras there was one goat.

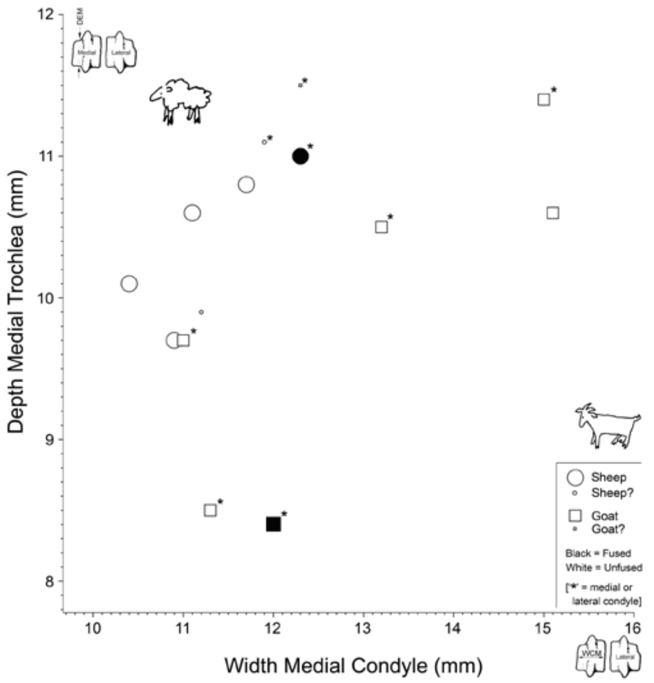

Figure 7 – Metrical separation of sheep and goat metacarpals at Lameiras (following Payne, 1969). Specimens identified morphologically as goat or sheep are represented by large squares and circles respectively, while those less securely identified are shown as small symbols. An '*' denotes condyles whose position – medial or lateral – was uncertain due to their being isolated from their respective adjacent condyle. Black symbols denote adult (epiphysis fused) specimens and white symbols denote juvenile (epiphysis unfused) ones.

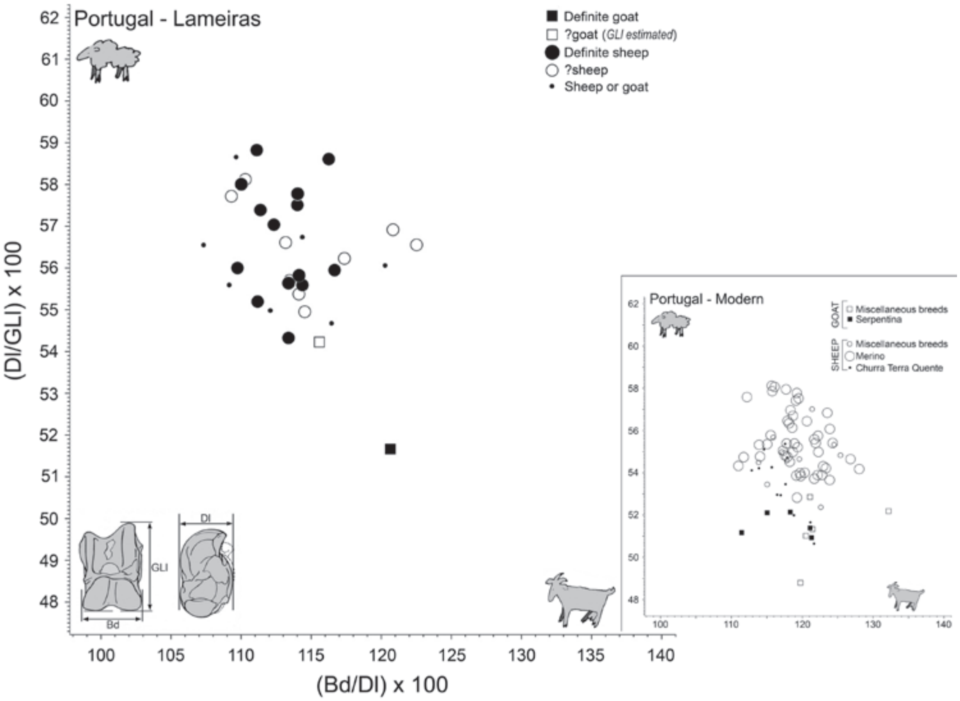

Figure 8 – Metrical separation of sheep and goat astragali at Lameiras (following Davis, in press) using the three measurements commonly taken on artiodactyl astragali. A plot of Dl/GLl *versus* Bd/Dl for the 32 caprine astragali identified via the morphological criteria described in Boessneck (1969). Specimens identified morphologically as goat or sheep are represented by black-filled squares and circles respectively, while those less securely identified are shown as white symbols. Seven could not be identified to species and are shown as small black dots. There is, on the basis of modern specimens from Portugal (see insert for modern Portuguese caprines of known identity) and other countries, a fair amount of overlap which means that an individual specimen cannot be identified with certainty. On the basis of this metrical distinction sheep appear to far outnumber goats.

9. THE FREQUENCIES OF THE DIFFERENT TAXA

There were quite clearly few remains of wild mammal in the Neolithic of Lameiras. In this respect Lameiras is similar to late Neolithic Belas (Davis unpub.) and Penedo do Lexim (Late Neolithic; Moreno-García & Sousa, 2013) and also Chalcolithic Leceia (Cardoso & Detry, 2002) and Zambujal (Driesch & Boessneck, 1976). In all these sites situated in the Lisbon Peninsula, domesticated animals like sheep, goat, cattle and pigs greatly outnumber those of wild ones. They clearly differ in terms of wild: domestic fauna from Chalcolithic sites further east in the Alentejo such as São Pedro, Redondo (Davis & Mataloto, 2012) and Porto Torrão (Arnaud, 1993) with their abundant remains of wild mammals. The high proportion of domestic livestock may reflect the denser human habitation in the Lisbon peninsula. Was human habitation there in Neolithic times also dense – much denser than the interior of the country? It will be interesting to discover whether the faunal compositions of Neolithic sites in the Alentejo also included a significant wild component. So much for geographical variation, what about chronological changes?

The two main Neolithic levels (Early and Late) show very small and probably insignificant differences and, as mentioned above, comprise predominantly caprines (mostly sheep) and pigs with some cattle and equids. Red deer were scarce. In other words there was very little hunting of big game in the Neolithic at Lameiras.

Let us also view the Lameiras Neolithic within a longer chronological faunal sequence extending from the Mousterian to Bronze Age. This is depicted in Figure 9 and includes the Mesolithic remains from the Muge and Sado estuaries (data from Detry 2007; table 4 in Davis & Moreno-García 2007). This chronological succession shows quite clearly an abrupt shift from red deer to caprines (mainly sheep) that occurred between the Mesolithic and the Early Neolithic. Several other species of large mammals like roe deer, equids and chamois were also exploited, if to a lesser extent, before the Neolithic although some of these (*Capra*, equids and chamois) became scarce or even locally extinct in the Mesolithic.

Why were red deer and horses so scarce in the Neolithic at Lameiras? In the Mesolithic it seems there had been a shift towards exploitation of marine resources such as fish and especially molluscs. This probably reflects a relative scarcity of large mammals in the environment. We write *relative* as the actual numbers of deer and equids may not have decreased to a very great extent, the increase in the human population may have been such that there were simply insufficient deer and equids to feed an ever increasing human population. It has been suggested that a gradual increase of the human population here as in the Near East caused the shift from large mammals to small ones and then birds and maritime resources (Davis, 1985; 2005; Munroe, 2004; Davis & Detry, 2013). Once domesticated animals like sheep and goats were introduced, these dietary shortages were alleviated and it was no longer necessary to have to gather molluscs, fish and hunt wild mammals. Perhaps these resources anyway had become scarce or even locally extinct. It was not until later times, like the Chalcolithic, that we find substantial presence of wild animals like aurochsen, red deer and horses on some Chalcolithic sites although they appear to be smaller sites situated in the interior.

10. IN GENERAL

The Lameiras Neolithic fauna has some bearing upon the history of the people of southern Portugal. One interesting question is how the Neolithic 'way of life' arrived here. Was it adopted gradually or did it happen suddenly. Put another way, did farmers gradually spread their way of life and their domesticated animals so that local hunter-gatherers gradually adopted this way of life – the cultural diffusion explanation (Ammerman & Cavalli-Sforza, 1984) – or did husbanding and farming suddenly take over – a scenario that suggests (admittedly rather speculatively) that there could even have been a change

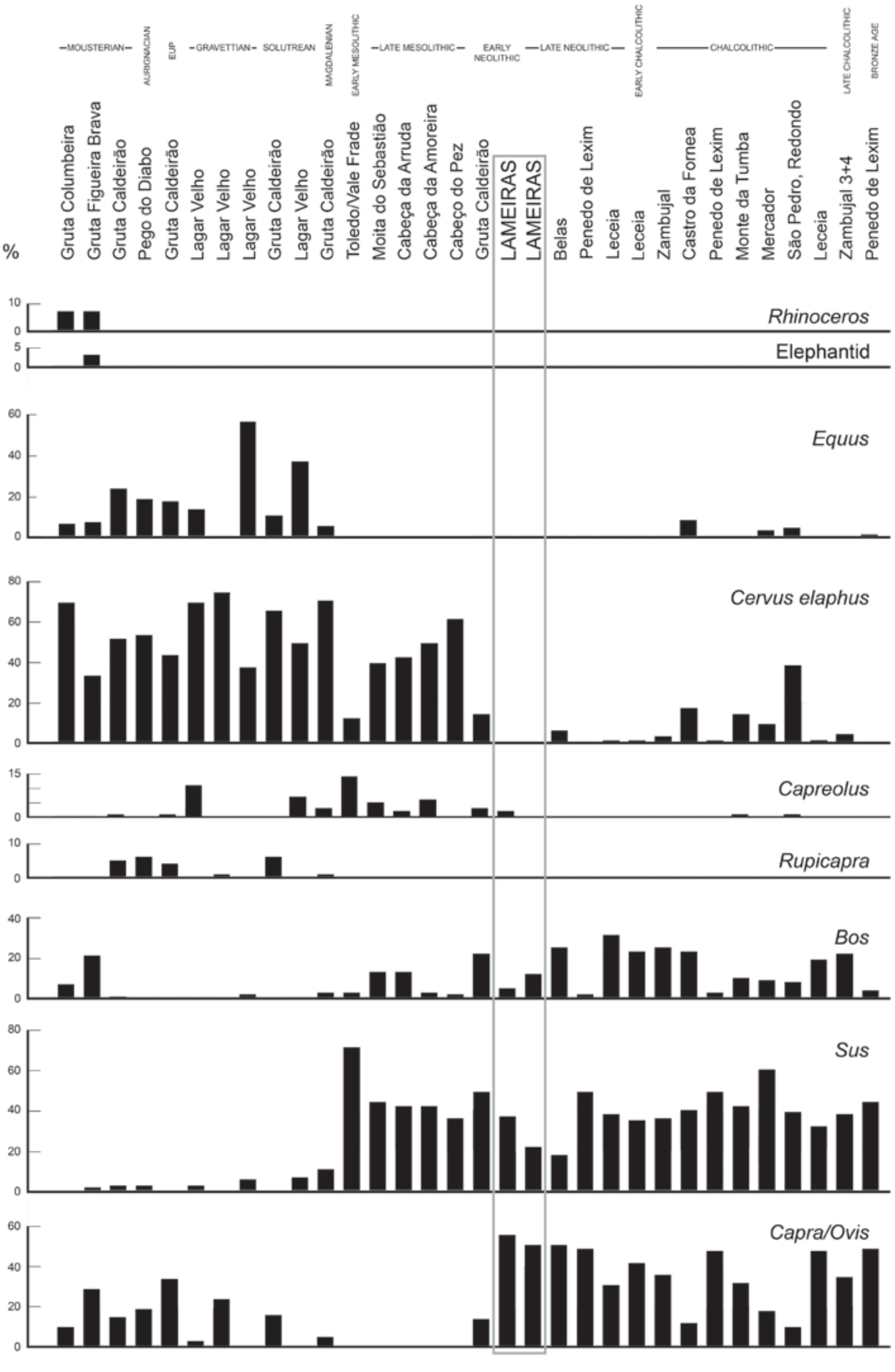

Figure 9 – From left to right: the Mousterian to Bronze Age faunal succession in the southern half of Portugal. This bar chart shows the percentages of the more common medium and large herbivore taxa found on archaeological sites and grouped by period (many of these data are in table 4 of Davis & Moreno-García, 2007). Note the major faunal change from red deer to sheep and goat between the Mesolithic and Neolithic which presumably marks the beginning of animal husbandry and the introduction of domesticated animals. The Neolithic of Lameiras clearly belongs to the 'domestic animals' side of the spectrum. Note also the earlier, Mesolithic, increase of *Sus* – an animal known for its ability 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. Equids, roe deer and chamois were also more common in the earlier periods. For the rarer taxa the vertical bars are slightly enlarged for clarity.

of the human populations at that time, a scenario that Ammerman and Cavalli-Sforza have termed demic diffusion. Take the case of Britain for example. Mesolithic and Neolithic faunal assemblages in southern Britain indicate that sheep, and often goats too, are present in nearly all Early Neolithic settlements there (Serjeanston, 2014). Both the scarcity of wild animals and presence of sheep and goats support the theory of an immigrant population rather than one which added farming to an already existing hunting and gathering lifestyle. The animal data from southern Britain do not support the theory that there was a gradual acculturation of the Mesolithic people, rather the Neolithic arrived all together and the four principal domestic animals were the mainstay of economic life from the earliest Neolithic. A similar somewhat abrupt shift in diet at the onset of the Neolithic not only in Portugal but also in Denmark and coastal Britain is indicated by the carbon isotope ($\delta^{13}C$) ratios found in human bones. These indicate a sudden change from a marine to a terrestrial-based diet (Lubell *et al.*, 1994; Tauber, 1981; Richards *et al.*, 2003). To take one other region as an example, in their report on the fauna from Vela Spila in Croatia, Rainsford *et al.* (2014) write: "Fishing at the site changed from one of the primary activities in the Mesolithic, contributing significantly to subsistence, to a small-scale and opportunistic activity in the Neolithic, taking up little time and providing a modest source of protein". We suggest that a similar change happened here in southern Portugal. Whether the Mesolithic human population was totally replaced or suddenly adopted a new kind of lifestyle, or even a mix of the two, will be difficult to determine. The rate of adoption of the Neolithic lifestyle probably varied from region to region as Saña (2013) has suggested for Spain, and as Zilhão (2001) had already pointed out for Portugal, drawing attention to the "enclave" nature of Early Neolithic territories in the littoral and the centre, emphasizing their contrast with contemporary Mesolithic hunter-gatherers in their own inland territories.

11. OVINE VELOCITY

We shall assume then that sheep were domesticated in the mid 9th millennium cal. BC in the Near East. This date is some three millennia before the Early Neolithic in the southern Iberian Peninsula and the direct radiocarbon dates of c. 5450 cal BC obtained on the Early Neolithic sheep bones from Lameiras (see above), as well as those of 5500-5250 BC from Caldeirão cave (Zilhão, 2000) - the earliest appearance of domesticated sheep in Portugal and a mere two centuries after the first appearance of the Early Neolithic in Languedoc (Rowley-Conwy *et al.*, 2013). Given that the ancestors of our Portuguese sheep came from the Near East and with the dates at hand we can calculate approximately how long it took for domesticated sheep to walk overland from east to west. A terrestrial route of some 4877 kms (calculated in a very arbitrary manner from Aleppo to Sintra via Istanbul, Tirana, Zagreb, Marseilles, Valencia, Malaga and Ayamonte) and a difference of some 3000 years would mean sheep travelled at a speed of some 1,6 kilometres per year! As Zilhão (2000) points out, this is considerably faster than the 1 km per year proposed by Ammerman and Cavalli-Sforza (1984) in their "Wave of Advance" model. Such a rapid spread of sheep (i.e., the Neolithic 'package' or way of life) means that sheep and the Neolithic peoples may well have come to the southern part of the Iberian Peninsula in boats (Zilhão, 2000). A similar line of reasoning was made by Rowley-Conwy *et al.* (2013) in their discussion of the evidence for the first appearance of domestic animals in Italy, Istria, the Tyrrhenian islands and southern France. They note the lack of any sign of continuity between the Mesolithic and the Early Neolithic in these regions and also the rapid spread of the Neolithic in southern Greece (6400 – 6000 cal BC) to southern Italy (6000 – 5700 cal BC) to Sardinia/Corsica as well as Languedoc (5700/5600 cal BC). They also suggest that initial forays by colonising farmers were made by sea and that the numerous islands of this region served as stepping stones for maritime transfers enabling Neolithic peoples to leapfrog hunter-gatherer enclaves in eastern Liguria and the Rhône delta. That people were navigating the sea in those early times is attested by colonisation of Mediterranean islands like Cyprus in the first half of the 9th millennium BC and even earlier transportation of obsidian from the island of Milos in the Cyclades (Dixon & Renfrew, 1973). Human ancient DNA evidence suggests a spread of Neolithic people from the Balkans to western Europe derived from a common ancient population located in or around the Balkan Peninsula (Olalde, 2015).

Thus the dates we have from Lameiras at the very least provide corroborative evidence for the early presence in the mid 6th millennium BC in southern Portugal of sheep and the possibility that they were shipped to coastal Portugal rather than having had to have been shepherded overland across southern Europe and Iberia.

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