

Pigs of the “Far West”: the biometry of *Sus* from archaeological sites in Portugal

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Albarella U., Davis S. J. M., Detry C. & Rowley-Conwy P. 2005. – Pigs of the “Far West”: the biometry of *Sus* from archaeological sites in Portugal. *Anthropozoologica* 40(2) : 27-54.

ABSTRACT

The main purpose of this study is to outline the osteometric variation of *Sus* from the Neolithic to the present day in Portugal. We start by focussing upon two important Chalcolithic sites — Zambujal and Leceia — with their abundant collections of suid bones and teeth. Although it is difficult to clearly assign individual specimens as wild or domestic *Sus*, the general patterns of distribution of measurements suggest that, at both sites, pig husbandry was more important than wild boar hunting, with slightly more wild boar being represented at Zambujal. Moreover, it appears that, in Portugal Chalcolithic, wild boar was larger than in the Mesolithic. The scarcity of data from Neolithic sites makes it difficult to determine exactly when the pig was first domesticated in Portugal. Our Iron Age to Islamic data indicate stability of pig size in these periods but an abundance of larger forms of *Sus* in the Islamic

KEY WORDS

Size,
osteometry,
pig,
wild boar,
Portugal,
Sus.

period seems more likely to signal an increase of wild boar hunting rather than an improvement of the domestic form. Slight shape differences between wild boar and pig third mandibular molars tend to corroborate this hypothesis. The Portuguese wild boar was and still is smaller than wild boar from regions east of the Iberian Peninsula.

RESUMO

Os porcos do "Far West": a biometria de Sus de sítios arqueológicos em Portugal.
O objectivo principal deste artigo é de compreender a variação do género *Sus* do Neolítico até hoje, em Portugal. Estudámos, em primeiro lugar, dois sítios Calcolíticos importantes — Zambujal e Leceia — com as suas grandes colecções de dentes e ossos de *Sus*. Os espécimes individuais de *Sus*, em Portugal, são difíceis de identificar como domésticos ou selvagens, mas as distribuições gerais das medidas sugerem que o porco era muito mais frequente que o javali, mesmo que a caça do javali fosse bastante importante no Zambujal. Parece que o javali do Calcolítico era maior que o javali Mesolítico. O número reduzido de dados do Neolítico não nos permite determinar o momento da domesticação do porco em Portugal. Os dados da Idade do Ferro até ao período Muçulmano sugerem uma estabilidade do tamanho dos porcos durante estes períodos, mas a abundância da forma maior nos tempos Muçulmanos é muito provavelmente devido à importância da caça ao javali. Ligeiras diferenças de forma dos terceiros molares mandibulares entre o porco e javali parecem corroborar esta hipótese. O Javali em Portugal era, e permanece, mais pequeno que o javali a este da Península Ibérica.

PALAVRAS CHAVE

Tamanho,
osteometria,
porco,
javali,
Portugal,
Sus.

RÉSUMÉ

Les cochons du « Far West » : la biométrie de Sus dans les sites archéologiques du Portugal.
Le principal objectif de cet article est de suivre la variation ostéométrique de *Sus* du Néolithique à nos jours, au Portugal. Nous présentons tout d'abord les abondantes collections de dents et d'ossements de *Sus* de deux sites chalcolithiques importants — Zambujal et Leceia. Bien qu'il soit difficile d'assigner avec certitude les restes à la forme domestique ou sauvage de *Sus*, les tendances générales de distribution des mesures suggèrent que, dans les deux sites, l'élevage du cochon était plus fréquent que la chasse au sanglier, avec, malgré tout, une meilleure présence du sanglier à Zambujal. Il apparaît également que le sanglier chalcolithique était plus grand que le sanglier mésolithique. Le peu de données issues de sites du Néolithique ne permet pas de déterminer précisément le moment de la domestication du porc au Portugal. Nos données de l'Âge du Fer à la période islamique suggèrent une stabilité de la taille des cochons pendant ces périodes, mais l'abondance de spécimens de grande taille à l'époque islamique reflète sans doute une chasse au sanglier plus intense plutôt qu'une amélioration de la forme domestique. De légères différences de la forme des troisièmes molaires inférieures entre cochon et sanglier semblent corroborer cette hypothèse. Notons enfin que le sanglier du Portugal était, et demeure, plus petit que le sanglier des pays à l'est de la péninsule ibérique.

MOTS CLÉS

Taille,
ostéométrie,
porc,
sanglier,
Portugal,
Sus.

INTRODUCTION

Portugal is located at the south-western limit of the Old World distribution of the Wild Boar (*Sus scrofa*) — the ancestor of our domestic Pig. There is firm evidence that the species is native to this region, as it has been found in pre-Neolithic sites, well before the first domestic animals were introduced (Cardoso 1993; Davis 2002). Reviews of the status of Wild Boar populations in their present geographic range have generally neglected Portuguese Pigs (see for example Groves 1981; Genov 1999), but more recent work has highlighted the fact that the Portuguese Wild Boar is the smallest of all continental Wild Boars. This is not surprising as this species has a tendency to increase in size from the southwest to the northeast (Albarella *et al.*, forthcoming a).

The earliest Portuguese Neolithic settlements — characterised by cardial pottery and then impressed ware — can be found in Portugal in the 5th millennium BC (Zvelebil & Rowley-Conwy 1986; Straus 1991; Zilhão 1993; Ribe' *et al.* 1997). For some of these sites, such as Caldeirão cave, there is also certain evidence for the presence of domestic animals such as Sheep (certainly imported from Western Asia; Rowley-Conwy 1992). The status — wild or domestic — of the Pigs found at this site is however uncertain. For example the same remains have been — though tentatively — interpreted as wild (Rowley-Conwy 1992) and domestic (Davis 2002). This uncertainty is hardly surprising, as the small dimensions of the Portuguese Wild Boar makes the general assumption of a size separation between wild and domestic forms particularly difficult to apply to *Sus* remains from this region. In a study of the fauna from Caldeirão, Davis (2002: 49) stated that "a biometric survey of Portuguese Wild Boars and Pigs is clearly needed to aid in the distinction between wild and domestic Pigs". Despite gaps in the chronological and geographic coverage, we attempt to undertake such a survey, using in particular the large assemblages of *Sus* from the Chalcolithic sites of Zambujal and Leceia as a starting point for understanding size variation of this animal in Portugal. The

metric data from these two sites are then compared with those of *Sus* from chronologically earlier and later sites.

Zambujal and Leceia are both located in the Estremadura region of central Portugal (Fig. 1). Like most Portuguese Chalcolithic sites they are fortified settlements, dating to around 2600-1800 BC (Fernández Castro 1995; Jorge & Jorge 1997). The occupation at Zambujal spanned the whole Chalcolithic period (Sangmeister & Schubart 1972), whereas Leceia has an earlier stratigraphic sequence, starting in the late ("final") Neolithic (second half of the 4th millennium BC) but ending before the advent of the bell-beaker period in the late Chalcolithic, at the end of the 3rd millennium BC (Cardoso 1994, 1997; Fernández Castro 1995). Zambujal is therefore a later site, though there is considerable chronological overlap between the two occupation sequences. The animal bones from Zambujal and Leceia were originally studied respectively by von den Driesch & Boessneck (1976) and Cardoso & Detry (2001), but the Pig remains have been re-examined for the purpose of the present work. At both sites there was a predominance of domestic animals, though wild species — with Red Deer (*Cervus elaphus*) the best represented — were also fairly common, particularly at Zambujal. Pig is the most common taxon at Zambujal and in the late Neolithic of Leceia, and the second most common taxon — after the caprines — in the Chalcolithic of Leceia.

METHODS AND MATERIAL

Ageing and measuring of the Pig teeth and bones from Zambujal were carried out in October 2003 by UA and SD at the Instituto Português de Arqueologia in Lisbon (material on loan from the Torres Vedras museum). Pig remains from Leceia were studied in that same month by UA, SD and CD at the Centro de Estudos Arqueológicos do Concelho de Oeiras. The purpose of this work is not a full re-analysis of the material, but rather the collection of a selection of ageing and

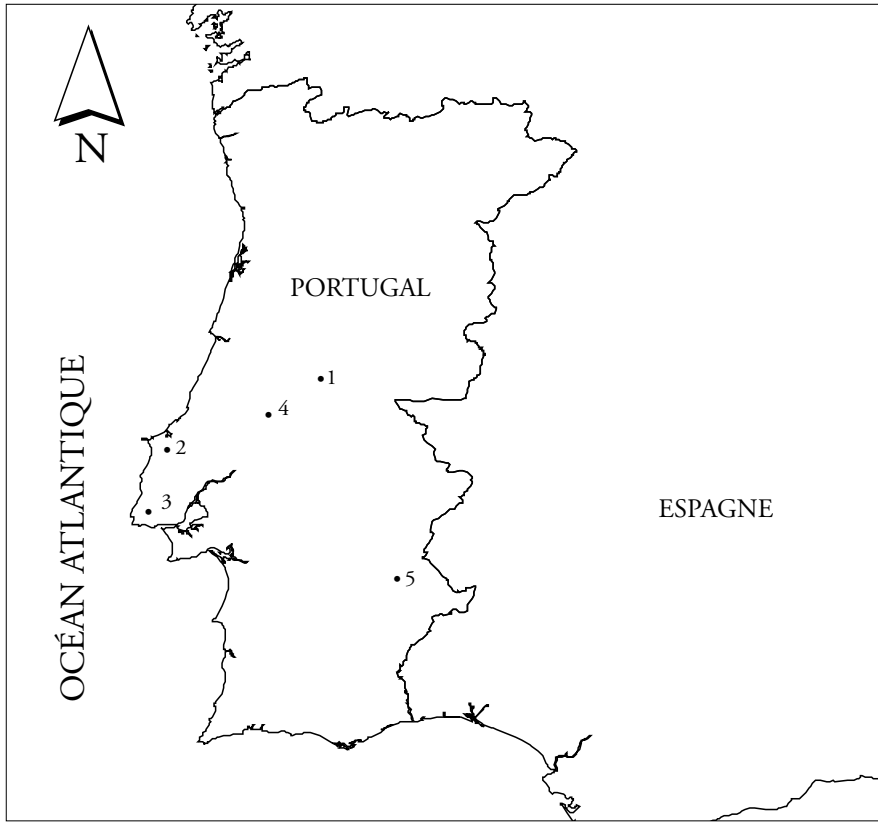


FIG. 1. – Map of Portugal to show the location of the main archaeological sites discussed in the text. 1: Caldeirão; 2: Zambujal; 3: Leceia; 4: Alcáçova de Santarém; 5: Mercador.

metrical data that may serve for comparative purposes. Dental eruption and wear stages were recorded according to Grant (1982), and the fusion stage of all measured post-cranial bones was also noted. Unfused and fused epiphyses were distinguished and epiphyses that had started fusing to their diaphyses but still showed some open gaps in the fusion line were recorded as “fusing”.

The choice of measurements taken was based on the recommendations of Payne & Bull (1988), Albarella & Payne (2005) and von den Driesch (1976) as well as some other personal observations. We measured the widths and lengths of the third deciduous mandibular molar (m_3) and the three mandibular molars M_1 , M_2 and M_3 . In addition we measured the height of the mandible

in front of the first molar (HTMAND), the column of the scapula (SLC), the width and minimum height (= diameter) of the distal humerus trochlea (BT and HTC), the width and depth of the distal tibia (BdP and Dd), the greatest length of the astragalus (GLl) and the greatest length and depth of the calcaneum (GL and GD). The width of the central and posterior cusps of the lower third molar are not included in any of the above references, but were taken according to the same recommendations as for the measuring of tooth widths presented in Payne and Bull (1988). Some additional measurements — not discussed in that paper — were also taken.

Epiphyses were measured regardless of their fusion stage. For the astragalus, which has no epiphyses, we noted the occurrence of particu-

larly light and porous specimens, likely to have belonged to juvenile and therefore not fully developed individuals. At first we did not attempt to identify isolated first or second molars as M_1 (usually small) or M_2 (usually larger than M_1) but their possible metric distinction is discussed below.

The Zambujal animal bones had originally been divided into a number of chronological phases, but were subsequently mixed and, although the number code for each individual specimen was recorded whenever possible, for many specimens this had become illegible. Consequently we had no other choice but to treat the Zambujal assemblage as a single unit. Conversely, the Leceia Pig bones were recorded according to the three-phase system of Cardoso & Detry (2001): late (final) Neolithic, early Chalcolithic and mid (full) Chalcolithic.

PATTERNS OF VARIATION AT ZAMBUJAL AND LECEIA

AGEING

Age-at-death information was recorded mainly in order to qualify the metrical data as many parts of bones vary with age and their dimensions must therefore be considered with respect to this factor. However, it is worth comparing kill-off patterns at Zambujal and Leceia (combined periods), to see if any differences in Pig management occurred.

In figure 2, we present eruption and wear stages of the first and second lower molars at the two sites (according to Grant, 1982). The difference in the proportion of molars which are un-erupted ("nye") and those with no dentine exposed ($U + a$) is due to the fact that at Leceia — but not at Zambujal — isolated teeth, as well as teeth in jaws, could be used (see below). Isolated teeth cannot be assigned to eruption stages and they were therefore all recorded as "unworn". There are, however, some other significant differences between the two kill-off patterns. At Leceia both the first and second molars tend to be at earlier stages of wear. The younger mortality curve of

the Leceia animals is confirmed by the fact that third deciduous molars represent 46% of the total of $m_3s + M_3s$, while at Zambujal this figure is only 34%. There is also a slight difference in the percentage of fully fused distal humeri and tibiae: 65% and 47% at Leceia and 73% and 55% at Zambujal respectively — percentages that would appear to corroborate the dental data. The two sites appear to have a common peak in the slaughtering age, corresponding broadly to the stage when the first molar is unworn and the second molar is un-erupted or not yet fully formed. On the basis of the age sequences reconstructed by Bull & Payne (1982) for Wild Boars and personal observations by one of us (UA) on aged mandibles of unimproved domestic breeds of Pig, such a stage should correspond to animals aged between 5 and 8 months. In temperate regions Wild Boars tend to be born in spring (Nowak 1999: 1057), but great variation in the birth season has been noted for both wild and domestic animals, not just in the Tropics but also in southern Europe. The main killing season of domestic Pigs appears to have occurred generally in late autumn/winter (Albarella *et al.*, forthcoming b). The earlier killing peak at Leceia and Zambujal could be consistent with a spring birth and a slaughter in the late autumn/winter of the same year.

A second slaughtering peak occurs when the first molar is in wear stages "c" to "e" at Leceia and "d" to "g" at Zambujal and the second molar is unworn. This peak corresponds to an approximate age of 16-22 months, closer to the younger part of the range at Leceia and the older at Zambujal. These animals should be approximately a year older than those discussed above, and were probably slaughtered in the following winter. Ervynck (1997) has suggested that there is no substantial variation in the duration of wear stages in Pig molars, and this has been confirmed by more recent work, which relates the duration of wear stages to rates of reduction in crown height (Tams *et al.*, in prep.). This would confirm the notion that the fluctuations in wear stage occurrences presented in figure 2 may reflect seasonal slaughtering, which would be

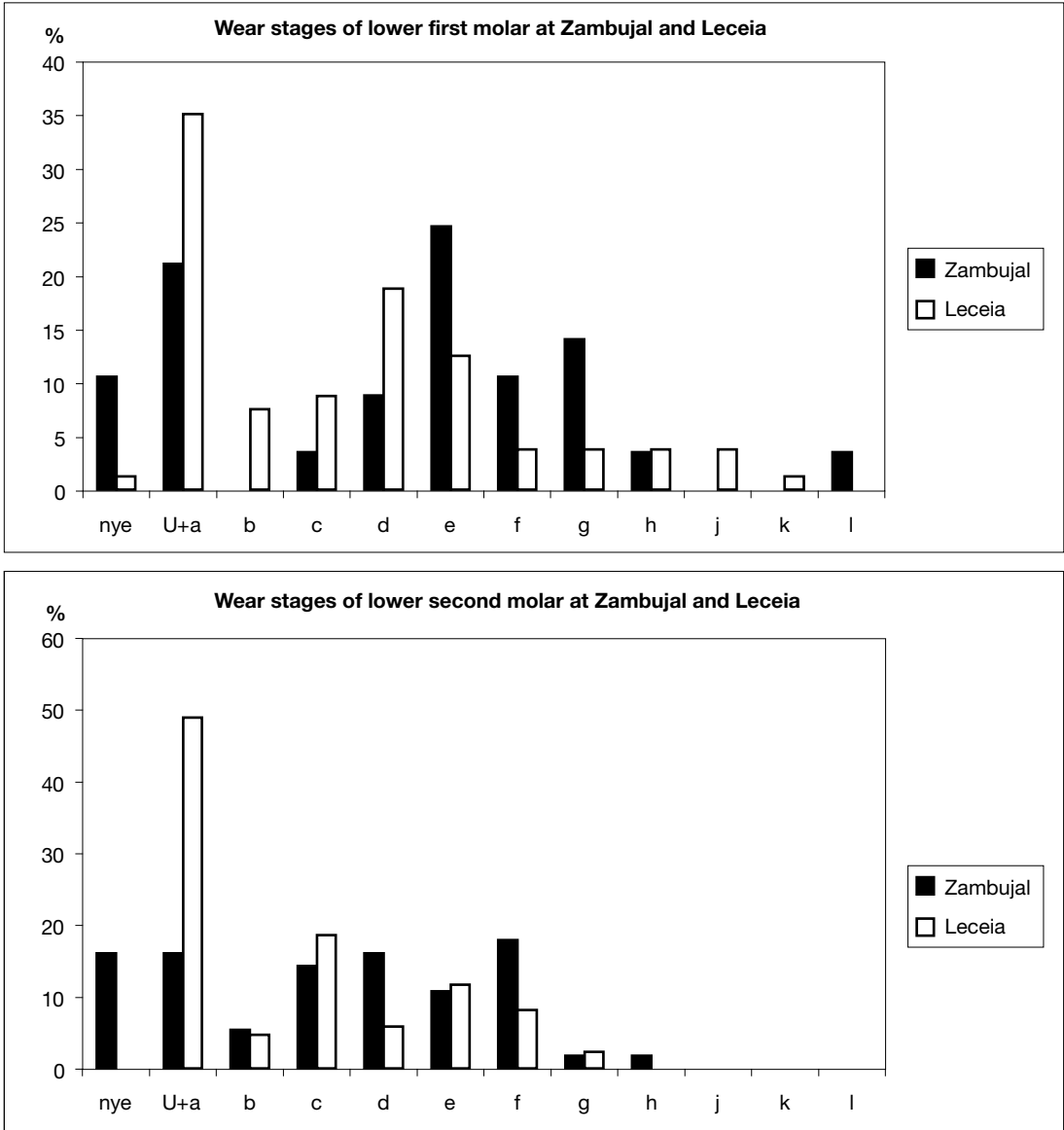


FIG. 2. – Wear stages of the lower first (top) and second (bottom) molars (M_1 and M_2) at Zambujal and Leceia. Only teeth in jaws are included for Zambujal, whereas Leceia also includes isolated teeth. Wear stages follow Grant (1982); nye = not yet erupted; U = unworn.

consistent with traditional management practises for free-range Pigs (Albarella *et al.*, forthcoming b). Needless to say the existence of seasonal activities does not in any way imply seasonal occupation.

The slaughtering of a relatively large proportion of Pigs in their first year indicates intensive use of this resource and a degree of confidence that supplies would not become exhausted. Seasonal feasting could be an explanation for the killing of large num-

TABLE 1. – Summary statistics for pig tooth measurements from the Chalcolithic sites of Zambujal and Leceia. N = number of specimens, V = coefficient of variation (see Simpson *et al.* 1960).

Zambujal						
	N	Minimum	Maximum	Mean	St. Dev.	V
dP4W	100	7.4	10.3	8.6	0.5	6.3
dP4L	63	17.8	22.1	19.3	0.9	4.5
M1WA	44	9.1	12.6	10.2	0.7	6.7
M1WP	42	9.4	13.2	10.8	0.7	6.2
M1L	35	14.3	20.1	16.9	1.0	6.1
M2WA	43	11.3	15.4	13.5	1.0	7.8
M2WP	41	11.7	16.5	13.7	1.1	8.3
M2L	36	19.0	25.1	21.3	1.3	5.9
M3WA	121	13.6	20.5	15.4	1.1	7.4
M3WC	175	12.4	18.1	14.8	1.0	7.0
M3WP	157	8.9	15.5	11.8	1.2	9.9
M3L	112	28.0	44.7	34.3	3.4	10.0
HTMAND	18	17.8	44.9	25.0	7.3	29.2
Leceia						
	N	Minimum	Maximum	Mean	St. Dev.	V
dP4W	49	7.4	9.6	8.5	0.5	5.7
dP4L	47	17.3	20.9	19.0	0.8	4.2
M1WA	47	9.1	12.7	10.1	0.7	7.0
M1WP	45	9.5	13.6	10.7	0.8	7.6
M1L	46	14.7	21.2	16.8	1.2	7.4
M2WA	31	12.0	14.8	13.2	0.8	5.7
M2WP	28	12.1	15.5	13.4	0.9	6.9
M2L	27	18.6	24.1	21.0	1.2	5.7
M3WA	52	13.0	18.4	15.3	1.0	6.3
M3WC	55	11.6	17.5	14.5	1.0	6.8
M3WP	49	10.0	15.3	11.6	1.0	9.0
M3L	50	25.2	40.8	33.5	2.8	8.4
HTMAND	11	17.8	26.0	21.8	2.4	11.2

bers of young animals during a restricted period. However, an explanation for the early slaughtering of second year Pigs at Leceia is more difficult to find, though this may in part be due to the greater proportion of wild specimens in the Zambujal assemblage (see below). Whatever the explanation, it does seem that slightly different systems of Pig management were practiced at the two sites.

TOOTH BIOMETRY

Molar tooth measurements, particularly widths, are less affected by sex, age and intra-population variation than are bones (Payne & Bull 1988; Kuşatman 1991; Albarella & Payne 2005), and therefore are probably more suitable for comparing populations from different sites. Table 1 provides summary statistics for tooth

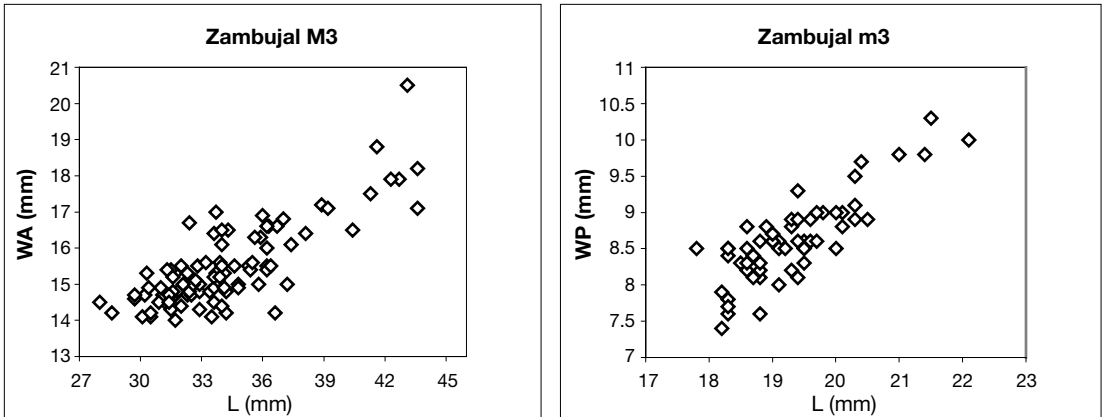


Fig. 3. – Size of the lower deciduous third molar (m_3) and third molar (M_3) at Zambujal. L = length; WA = width of the anterior part of the crown; WP = width of the posterior part of the crown posterior.

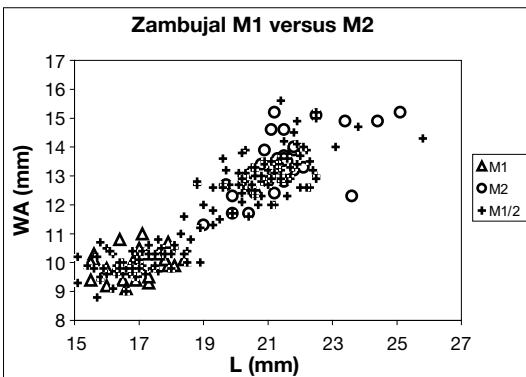


Fig. 4. – Size of the lower first (M_1) and second (M_2) molars at Zambujal. $M_{1/2}$ s are isolated first or second molars. L = length; WA = anterior width.

measurements from Zambujal and Leceia. For all measurements the average value is greater at Zambujal than Leceia, but this difference means little without a proper analysis of the distribution of individual measurements.

Figure 3 shows the distribution of m_3 and M_3 measurements at Zambujal. Both graphs show that most measurements plot in the lower left part of the distribution, with a smaller number spreading towards the top right. The distribution is not unimodal because the large ‘tail’ at the upper end of the range is not mirrored by a simi-

lar one towards the lower end of the range. The existence of a ‘peak and tail’ distribution of many of the Zambujal Pig measurements had already been highlighted by von den Driesch and Boessneck (1976) and Rowley-Conwy (1995).

It seems likely that at Zambujal there were two populations of *Sus*. The majority, the smaller animals, belonged to domestic Pigs, and a minority, the ‘tail’, belonged to the larger Wild Boar. The two groups, however, overlap and it is impossible to determine the boundary between domestic Pigs and Wild Boars.

The presence of this tail of larger specimens also prevents us from separating first from second lower molars (Fig. 4). About half of these teeth could be identified on the basis of their position in the jaw, but loose ones could only be recorded as ‘ $M_{1/2}$ ’s. Such a cautious approach is justified by the fact that overlaps occur between the two groups, probably because the large Wild Boar first molars plot amongst the domestic second molars. To ignore teeth that plot in the uncertain range would be a mistake, as this would artificially skew the distribution towards smaller first molars and larger second molars and bias the interpretation. Only the first and second molars from Zambujal that were still embedded in their respective jaws are therefore considered here (including the ageing evidence discussed above).

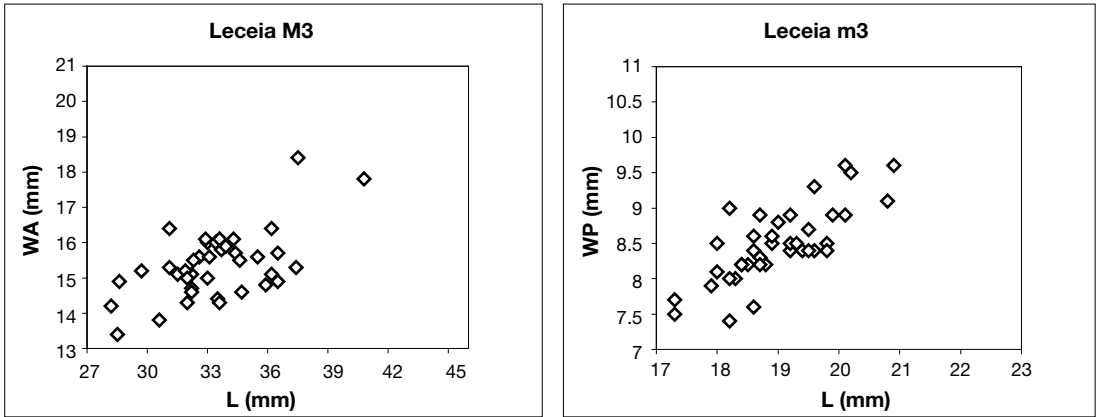


FIG. 5. – Size of the lower deciduous third molar (m_2) and third permanent molar (M_3) at Leceia. L = length; WA = anterior width; WP = posterior width.

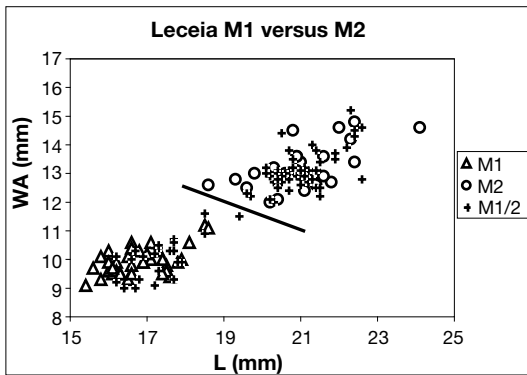


FIG. 6. – Size of the lower first (M_1) and second (M_2) molars at Leceia. $M_{1/2}$ s are isolated first or second molars. L = length; WA = anterior width.

The plots of the third deciduous molar and third permanent molar at Leceia (Fig. 5) indicate that the larger tail visible for Zambujal is either absent or much reduced, with only a couple of specimens spreading away from the main distribution. Wild Boars would therefore appear to have been scarce or absent at Leceia. Hence a much clearer separation of first and second molars is possible at this site (Fig. 6), and, unlike Zambujal, loose first/second molars could be metrically identified as either first or second molars.

A possible mixture of populations at Zambujal is also indicated by the greater coefficients of varia-

tion (this is the standard deviation expressed as a percentage of the mean; Simpson *et al.* 1960) of most measurements compared to Leceia (Tables 1-2; Fig. 7). It is also interesting that both sites' coefficients of variation are greater than in the modern Anatolian Wild Boar population recorded by Payne & Bull (1988) and a combined sample of modern Israeli and Syrian Wild Boars (SD's personal data). It is likely that different populations contributed to the formation of the assemblages from the two Portuguese sites, though at Leceia the contribution of Wild Boars was probably minimal.

BONE BIOMETRY

Table 2 provides summary statistics for bone measurements at Zambujal and Leceia. The patterns of variation of the post-cranial bone measurements are similar to those of the teeth. At Zambujal measurements of the distal humerus and tibia show a bimodal distribution with most specimens plotting in the smaller group (presumably domestic). The presence of two specimens in between the two main tibia clusters shows how unwise it would be to draw a line of separation between domestic and wild animals (Fig. 8). At Leceia most specimens, like the teeth, plot in the domestic cluster, though two huge distal humeri are certainly in the wild range. The presence of two large, but not so distinctively

TABLE 2. – Summary statistics for pig bone measurements from the Chalcolithic sites of Zambujal and Leceia. N = number of specimens, V = coefficient of variation (see Simpson *et al.* 1960).

Zambujal							
	N	Minimum	Maximum	Mean	St. Dev.	V	
Astragalus GLI	114	34.3	51.1	40.7	3.2	7.8	no light
Humerus BT	74	25.6	38.2	29.4	2.7	9.2	only fused
Humerus HTC	101	16.1	24.7	18.9	2.0	10.4	only fused
Tibia BdP	72	25.3	41.5	29.6	3.5	12.0	no unfused
Tibia Dd	72	21.8	34.1	25.9	2.6	10.2	no unfused
Scapula SLC	73	16.7	32.3	22.3	2.2	9.9	only fused
Calcaneum GD	11	25.9	37.1	30.0	3.7	12.3	no unfused
Calcaneum GLI	9	70.2	94.6	78.3	6.9	8.8	no unfused

Leceia							
	N	Minimum	Maximum	Mean	St. Dev.	V	
Astragalus GLI	134	33.9	46.4	39.5	2.1	5.4	no light
Humerus BT	93	23.8	39.2	28.4	2.4	8.4	only fused
Humerus HTC	110	16.1	25.0	18.1	1.4	7.8	only fused
Tibia BdP	80	24.6	33.1	28.4	1.7	5.9	no unfused
Tibia Dd	75	22.5	29.5	24.8	1.4	5.7	no unfused
Scapula SLC	148	18.0	30.1	21.9	1.8	8.1	only fused
Calcaneum GD	14	26.1	36.8	29.4	3.0	10.1	no unfused
Calcaneum GLI	13	67.3	98.9	78.2	8.6	11.0	no unfused

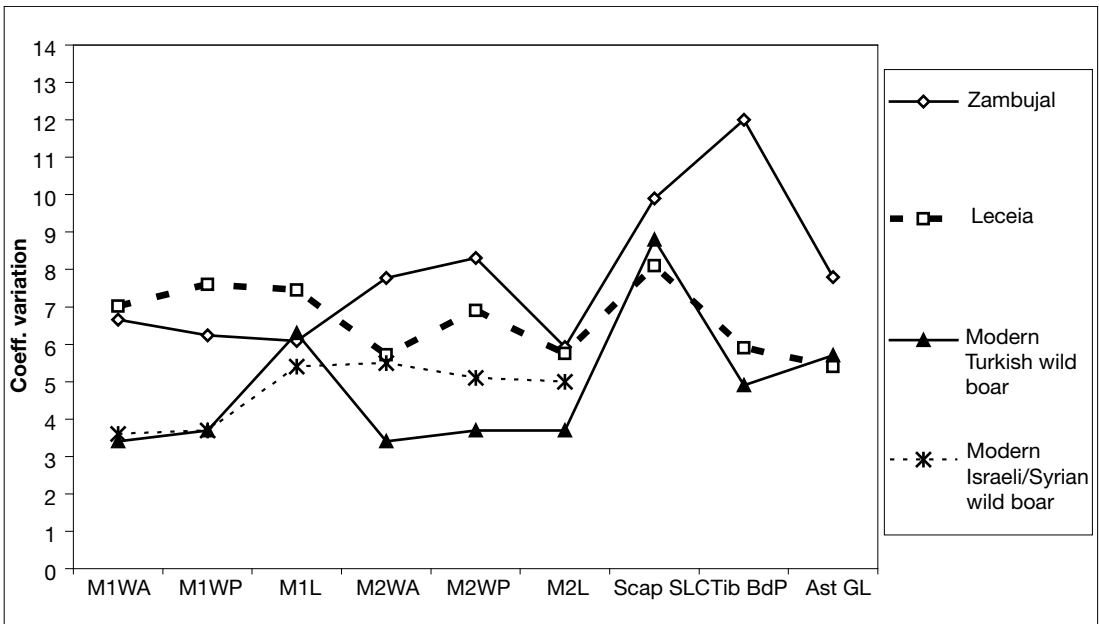


Fig. 7. – Coefficient of variation of various measurements from Zambujal, Leceia and modern populations of Turkish (Payne & Bull 1988) and Israeli + Syrian (SD's personal data) wild boars.

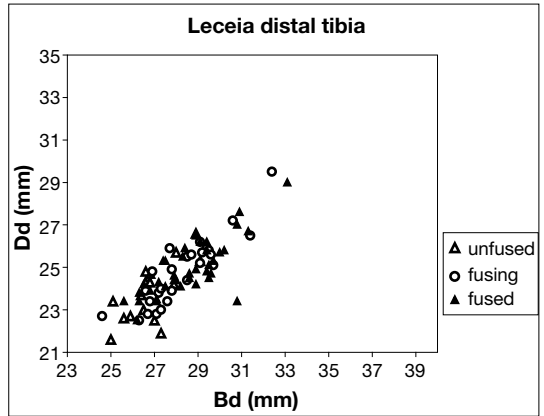
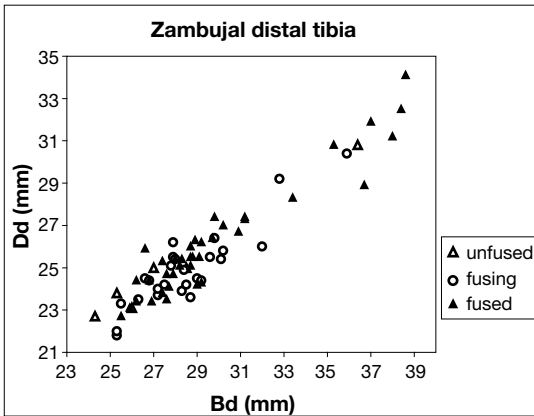
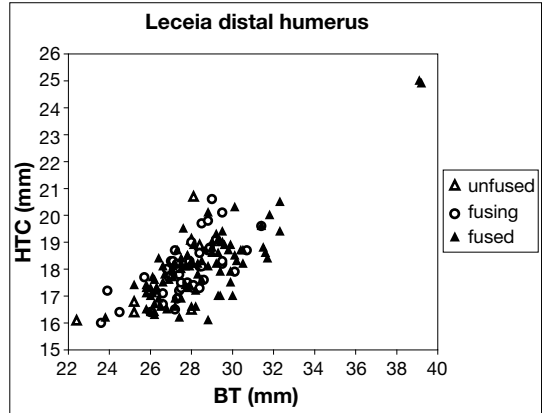
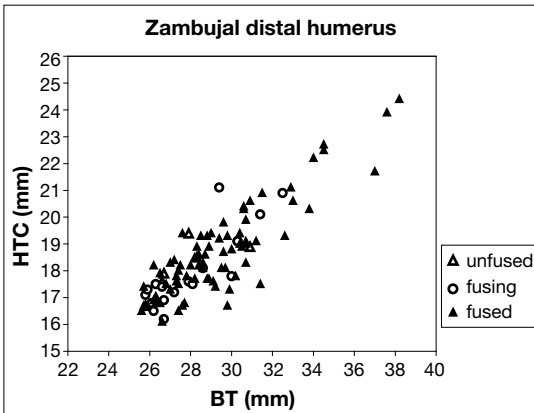


Fig. 8. – Scatter diagrams showing the size of the distal humerus (top) and distal tibia (bottom) at Zambujal. BT = width of the distal trochlea; HTC = minimum height of the trochlea; BdP = distal width; Dd = distal depth.

Fig. 9. – Scatter diagrams showing the size of the distal humerus (top) and distal tibia (bottom) at Leceia. BT = width of the distal trochlea; HTC = minimum height of the trochlea; BdP = distal width; Dd = distal depth.

different distal tibiae (compare with Fig. 8) is a reminder that the clear separation visible for the humerus distribution is probably due to chance — an artefact of the small numbers of Wild Boar in this sample (Fig. 9). The astragalus data show very clearly the much more unimodal distribution of the Leceia Pigs compared to those from Zambujal (Fig. 10).

In view of the tooth ageing evidence, it is worth observing the distribution of the measurements of the scapula neck (Fig. 11). This measurement is very variable in that it is also related to the age of the animal (Payne & Bull 1988; Albarella & Payne 2005). It is therefore unreliable for

comparing body size in different populations, but can be useful for detecting age groups (Vigne *et al.* 2000; Rowley-Conwy 2001). Despite the great variability of this measurement it is still possible to detect a few large specimens, probably wild, at both Zambujal and Leceia. What is more interesting is the clear tail on the left of the distribution (very obvious if specimens with both fused and unfused coracoids are combined), which probably corresponds to the group of animals slaughtered in their first year (see ageing evidence above). As for the astragalus the distribution is much more unimodal for Leceia than Zambujal.

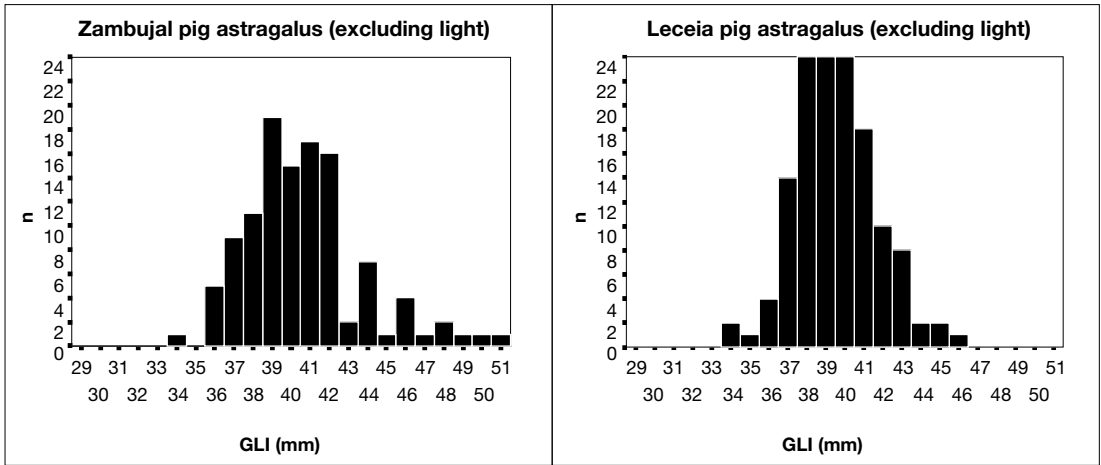


Fig. 10. – Size of the astragalus at Zambujal (left) and Leceia (right). GLI = greatest length. Light specimens are porous and probably belonged to juvenile animals. The distribution of measurements did not change significantly when light specimens were added.

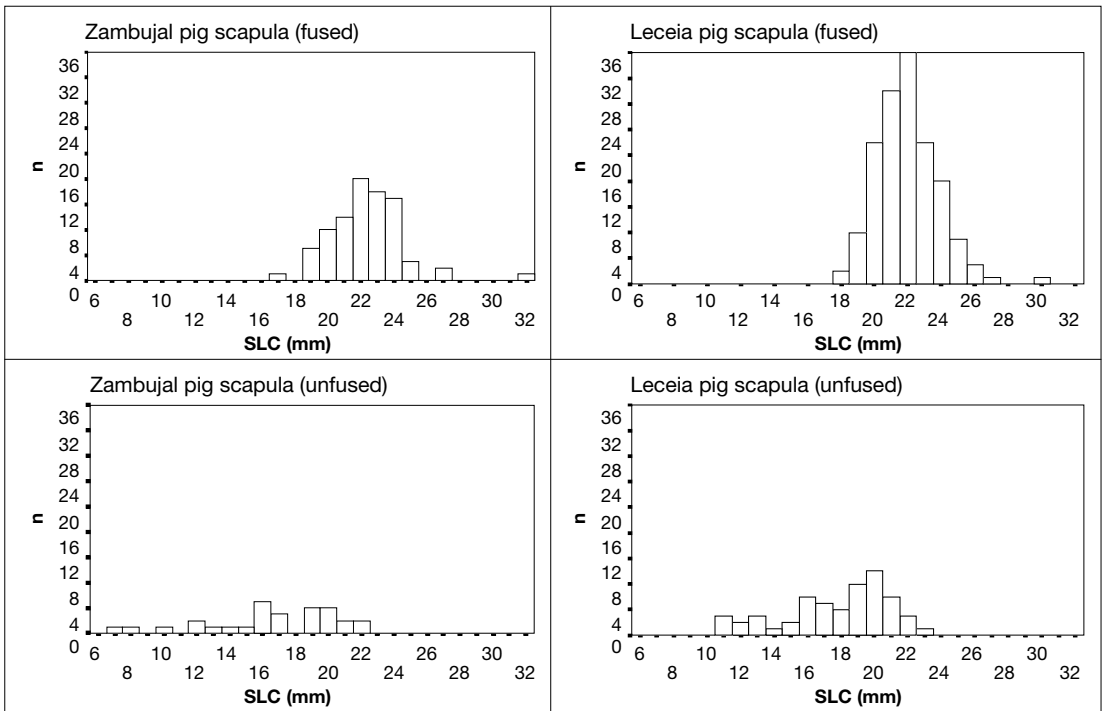


Fig. 11. – Size of the scapula at Zambujal (left) and Leceia (right). SLC = Length of the collum.

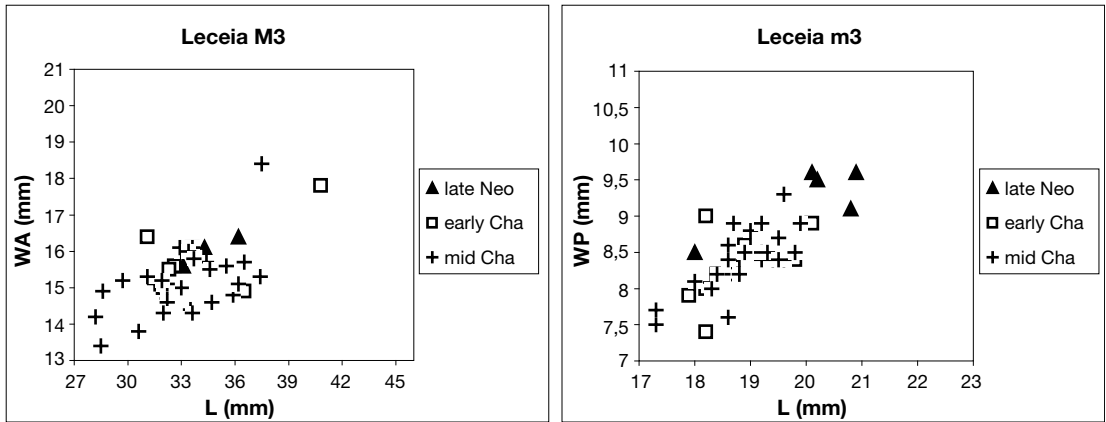


FIG. 12. – Size of the lower deciduous third molar (m_3) and third permanent molar (M_3) at Leceia in different periods. Cha: Chalcolithic

LECEIA – CHRONOLOGICAL VARIATION

So far we have treated the Leceia assemblage as a single unit, but as mentioned in the introduction, Cardoso (1994) identified three different phases at this site, and here we consider the possibility of chronological variation.

Figure 12 is the same as Figure 5, except that specimens are now discriminated on the basis of the phase to which they belong. Despite the smallness of the early Chalcolithic and late Neolithic samples, it does appear that the Neolithic specimens tend to plot towards the top of the distribution. These seem, however, more likely to be large domestic specimens than Wild Boars. There also seems to be a slight size decrease between the early and mid Chalcolithic, but this is less noticeable and is limited to the third molar. We must therefore test, by checking other measurements, whether a gradual size decrease occurred in the Leceia Pigs from the late Neolithic to the mid Chalcolithic.

Interpretation of the plots of the first and second molars (Fig. 13), the distal humerus and tibia (Fig. 14) and the astragalus (Fig. 15) is again difficult due to the rather small number of Neolithic specimens. However, the few available specimens still tend to plot in the larger half of the distribution, whereas there does not appear to be clear evidence that the early Chalcolithic animals were larger than those from the mid Chalcolithic. It is

possible that a larger wild component existed in the late Neolithic, but large outliers are so scarce at Leceia (and they are not necessarily Neolithic, see Fig. 14), that a more likely explanation is that there was indeed a genuine size decrease of domestic Pigs during the Neolithic-Chalcolithic transition. One possibility is that in the later period the domestic Pig population had become genetically more isolated from its wild counterpart — as for instance has been suggested in Italy (Albarella *et al.*, in press.) — but more data from other Portuguese sites are needed to identify a possible husbandry change at this important cultural transition.

ZAMBUJAL AND LECEIA IN CONTEXT

WILD BOARS

Although we could not obtain a complete separation of domestic from wild populations at Zambujal — and to some extent at Leceia too — these two sites still provide an approximate guide to the size of Portuguese Wild Boars in the third and second millennia BC. We now compare these data with those of other Wild Boar populations of different periods and geographic origin. In figures 16-17 the tooth size of the Zambujal and Leceia Pigs is compared with that of Mesolithic (presumed) Wild Boar specimens and

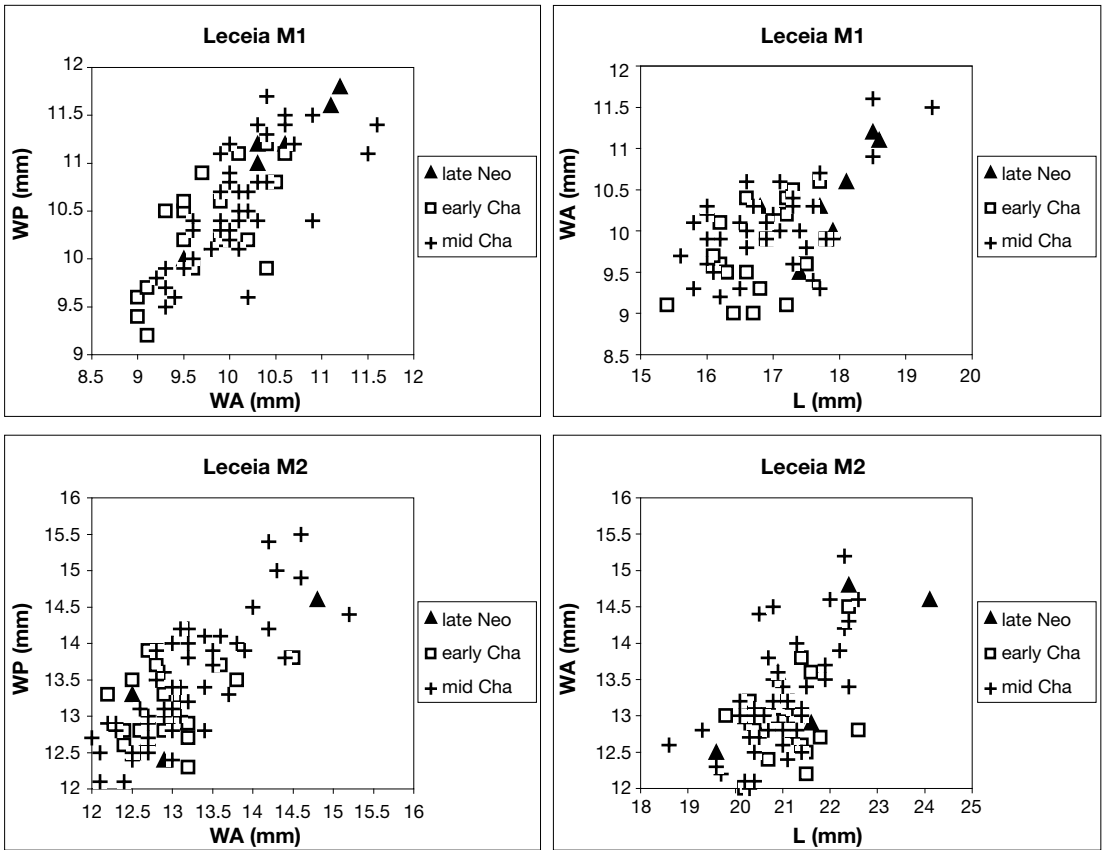


Fig. 13. – Size of the lower first (M₁) and second (M₂) molars at Leceia in different periods. Cha: Chalcolithic

modern Portuguese and French Wild Boars. The Mesolithic data were collected by SD and derive from the following sites: Moita do Sebastião (Muge), Cabeço da Arruda (Muge) and Cabeço do Pez (Alcácer do Sal). The modern Portuguese Wild Boars were measured by UA and SD in the Instituto Português de Arqueologia (IPA) and the Museu e Laboratório Zoológico e Antropológico (Museu Bocage) in Lisbon. The IPA specimens come from northern Portugal, whereas the specimens from the Museu Bocage are from the Alentejo region in south-eastern Portugal. Measurements of the French Wild Boars were taken by UA and Keith Dobney from numerous collections across the world.

These two figures indicate quite clearly that the upper part of the Zambujal distribution — pre-

sumably representing wild specimens — is more similar in size to modern French Wild Boars than either Mesolithic or modern Portuguese Wild Boars, which tend to be smaller. There is, however, overlap between the various groups, with several wild specimens plotting well within the likely range of domestic animals. At Leceia the few large outliers (see plot of third molar — top of Figs. 16-17) also tend to be in the same range as French Wild Boars. Post-cranial bone evidence (Fig. 18) confirms this situation but — rather puzzling — in these plots Mesolithic specimens appear to be larger than the teeth had indicated. In figures 19-20, tooth widths and a number of post-cranial bone measurements are compared between these various groups. Data from another Chalcolithic site — Mercador (Alentejo; Fig. 1)

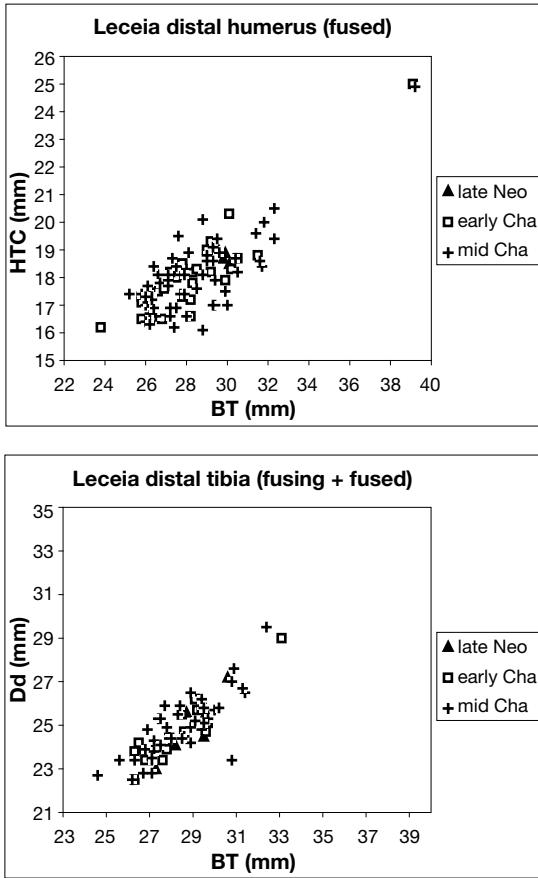


FIG. 14. – Scatter diagrams showing the size of the distal humerus (top) and distal tibia (bottom) at Leceia in different periods. Cha: Chalcolithic

— are also added. The measurements of bones from this site were originally taken by SD (Davis 2003b). The sample is much smaller than those from Zambujal and Leceia, but it is still useful for comparative purposes. The late Neolithic data from Leceia have been excluded from this analysis. Measurements of tooth widths have been combined using a size index scaling technique, which relates the measurements to standard values based on an assemblage of domestic Pigs from Durrington Walls — an English late Neolithic site which is approximately contemporary with the Portuguese Chalcolithic (Albarella & Payne 2005). The relative size of the various data sets in comparison to the Durrington Walls

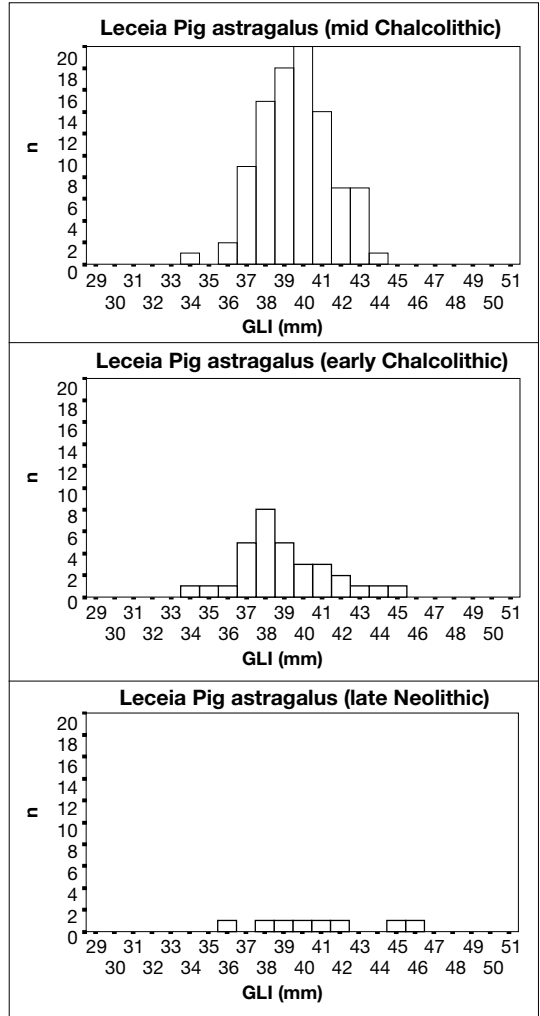


FIG. 15. – Size of the astragalus at Leceia in different periods. "Light" specimens have been excluded.

standard is calculated as the logarithm to base 10 of the ratio between the measurement and its standard (Simpson *et al.* 1960; Meadow 1999). This method proceeds by first calculating the logarithm of the ratio between a measurement and its standard. This is repeated for each measurement. Each log ratio value is plotted with the "standard" being 0. Plots of other measurements may then be stacked on top as in figures 19-24, so that differences in the size of each bone or tooth and its respective 'standard' may be

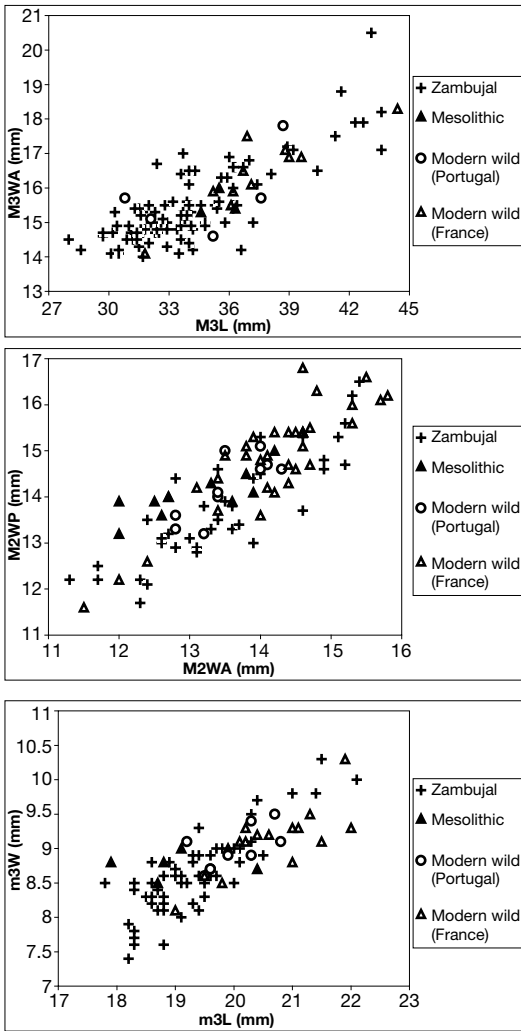


FIG. 16. – Size of the lower third molar (top), lower second molar (centre) and lower deciduous third molar (bottom) at Zambujal compared with three Portuguese Mesolithic sites and modern wild boars from Portugal and France.

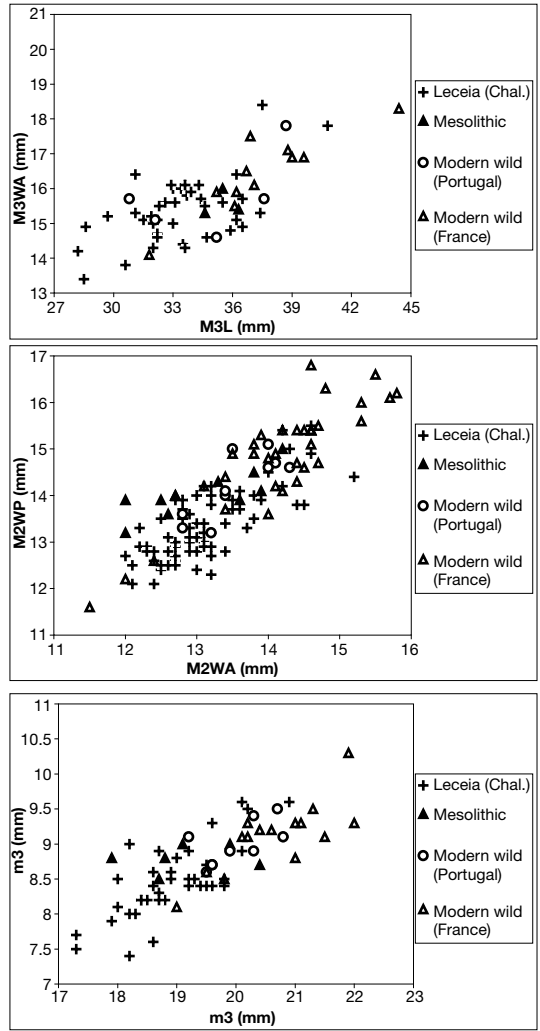


FIG. 17. – Size of the lower third molar (top), lower second molar (centre) and lower deciduous third molar (bottom) at Leceia (only Chalcolithic levels) compared with three Portuguese Mesolithic sites and modern wild boars from Portugal and France. Cha: Chalcolithic

observed simultaneously. The technique allows us to deal with larger samples and therefore provides more weight to the assumptions made above.

The analyses of both tooth widths and post-cranial bones show once again that the “tail” of large specimens from Leceia and Zambujal represents specimens of a larger size than any of the modern Portuguese Wild Boars. Mercador shows a neat

unimodal distribution, and is probably entirely comprised of domestic animals — the Pig economy of this site seems in this respect to be more similar to Leceia than Zambujal. There is no substantial variation in size between the domestic Pigs at the three Chalcolithic sites, which also show tooth measurements similar to those from the Mesolithic. Modern Portuguese Wild Boars are only slightly larger than domestic Pigs from

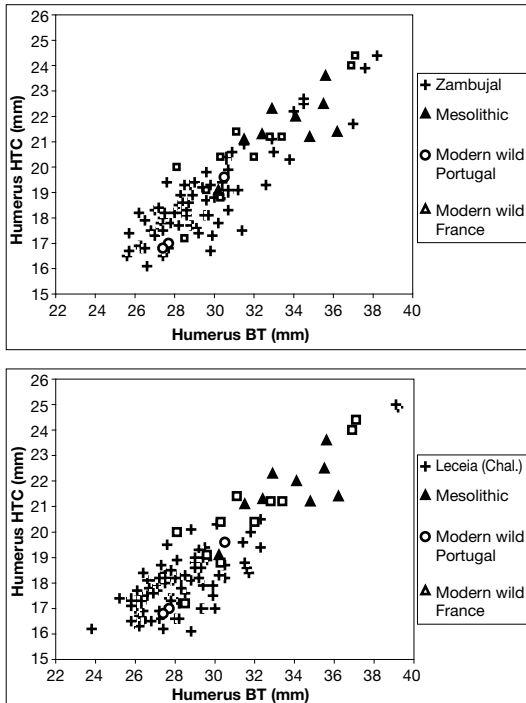


FIG. 18. – Size of the distal humerus at Zambujal (top) and Leceia (bottom) compared with three Portuguese Mesolithic sites and modern wild boars from Portugal and France. Cha: Chalcolithic

the Chalcolithic. A comparison of figures 19 and 20, however, also confirms the impression that Mesolithic Wild Boars had relatively larger bones than teeth. Variation in the relative size of dental and bone measurements has been noted for other prehistoric and historic sites in Europe (Albarella & Davis 1996; Albarella *et al.*, forthcoming a), and the existence of large-boned Mesolithic Pigs is not limited to Portugal, but can also be observed in Switzerland and — to a lesser extent — Denmark, as our data indicate (Figs 21-22). Swiss and Danish Wild Boars were much larger than those from Portugal, and so this is probably independent of allometric growth.

We may conclude as follows:

– Some fluctuation has occurred in the size of Portuguese Wild Boars from Mesolithic to modern times.

– Chalcolithic Wild Boars were — on average — larger than either Mesolithic or modern Wild Boars and more similar in size to modern Wild Boars from central Europe (*S. s. scrofa*).

– When comparing size of domestic or Wild Pigs between periods, attention must be paid to whether teeth or bones are used, as the relative size of dental and post-cranial measurements seems to have changed in the course of time.

– The size of the domestic Pigs in the Chalcolithic seems to have been homogeneous, though data from more sites in other regions are needed. On average these Chalcolithic Pigs are smaller than contemporary animals from England. One may wonder whether we have here an example of a domesticated animal obeying Bergmann's (1847) rule.

Let's return briefly to the Pigs from Caldeirão cave, mentioned in the introduction to this article. Very few measurements are available from this site, but those that we have are similar to those of domestic Pigs from the Portuguese Chalcolithic (Davis 2002). However, we know that this provides little help in deciding whether they should be attributed to the domestic or wild form. If Wild Boars in the early Neolithic were similar in size to their Mesolithic ancestors, it would be possible for the Caldeirão specimens to be wild (though they could equally be domestic). On the other hand, if the Chalcolithic Wild Boars offered a better comparison, we could be quite confident in assuming that the Caldeirão specimens are too small to belong to Wild Boars. There is unfortunately no possible way to solve this problem until more Neolithic data are available. There is too much variation in *Sus* bones and teeth to provide a comfortable degree of confidence in making a domestic/wild distinction, unless there are large contemporary data sets available for comparison. In addition, it is now clear that modern Wild Boars do not represent an adequate comparison for prehistoric Pigs, as much size change has occurred over the centuries.

A COMPARISON WITH LATER PERIODS

The evidence for Pig size from historical sites in Portugal is sparse, but a recent study of the faunal

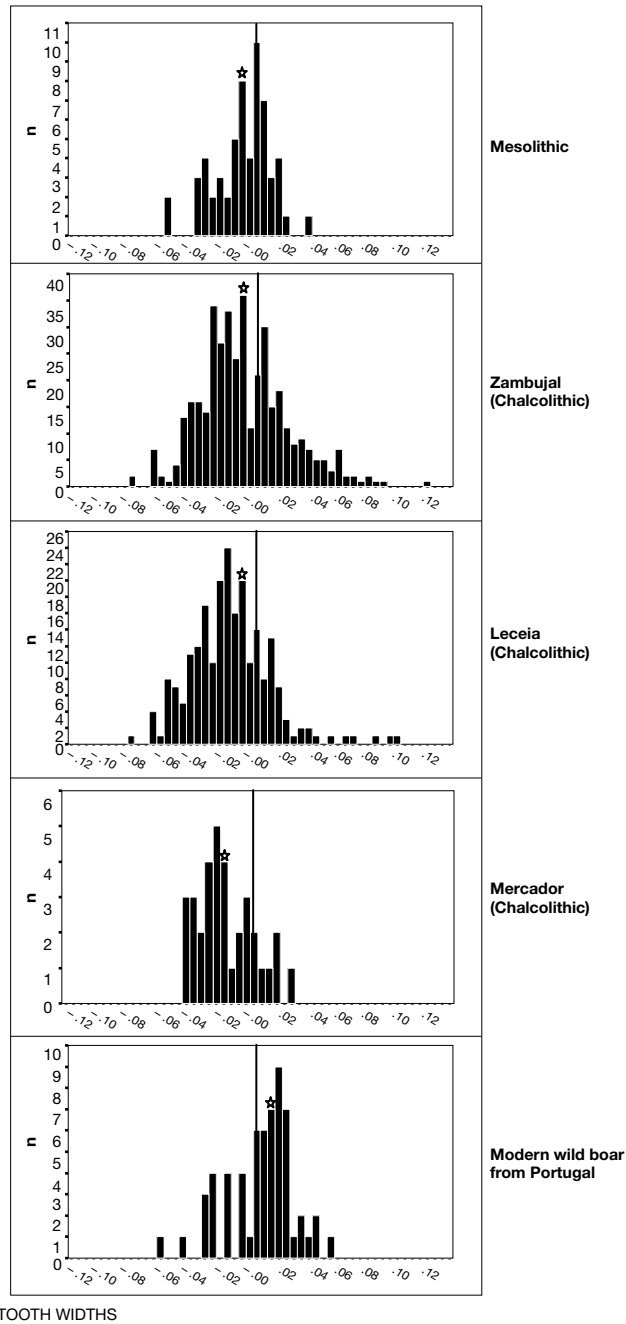


FIG. 19. – Comparison of Pig lower tooth widths from Mesolithic and Chalcolithic sites and modern Portuguese wild boars. The widths of the anterior deciduous third molar, the anterior and posterior first molar, the anterior and posterior second molar and the anterior second molar are combined using a log ratio technique (see text). The star indicates the mean, whereas the standard ('0') is expressed by a vertical line and is calculated from the late Neolithic assemblage of Durrington Walls (England; Albarella & Payne 2005).

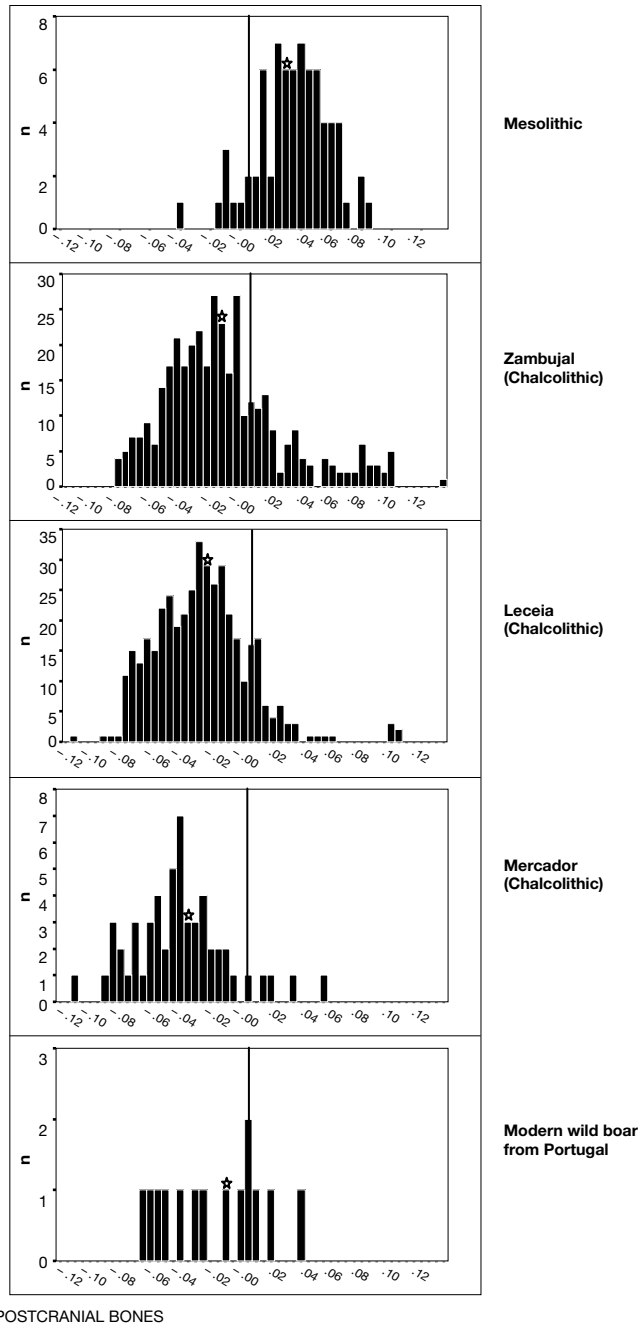


Fig. 20. – Comparison of Pig post-cranial bone measurements from Mesolithic and Chalcolithic sites and modern Portuguese wild boars. Humerus BT and HTC, Tibia BdP, Astragalus GLI and Calcaneum GL are combined using a log ratio technique (see text). The star indicates the mean, whereas the standard ('0') is expressed by a vertical line and is calculated from the late Neolithic assemblage of Durrington Walls (England; Albarella & Payne 2005). No unfused specimens are included and for humerus fusing specimens have also been excluded.

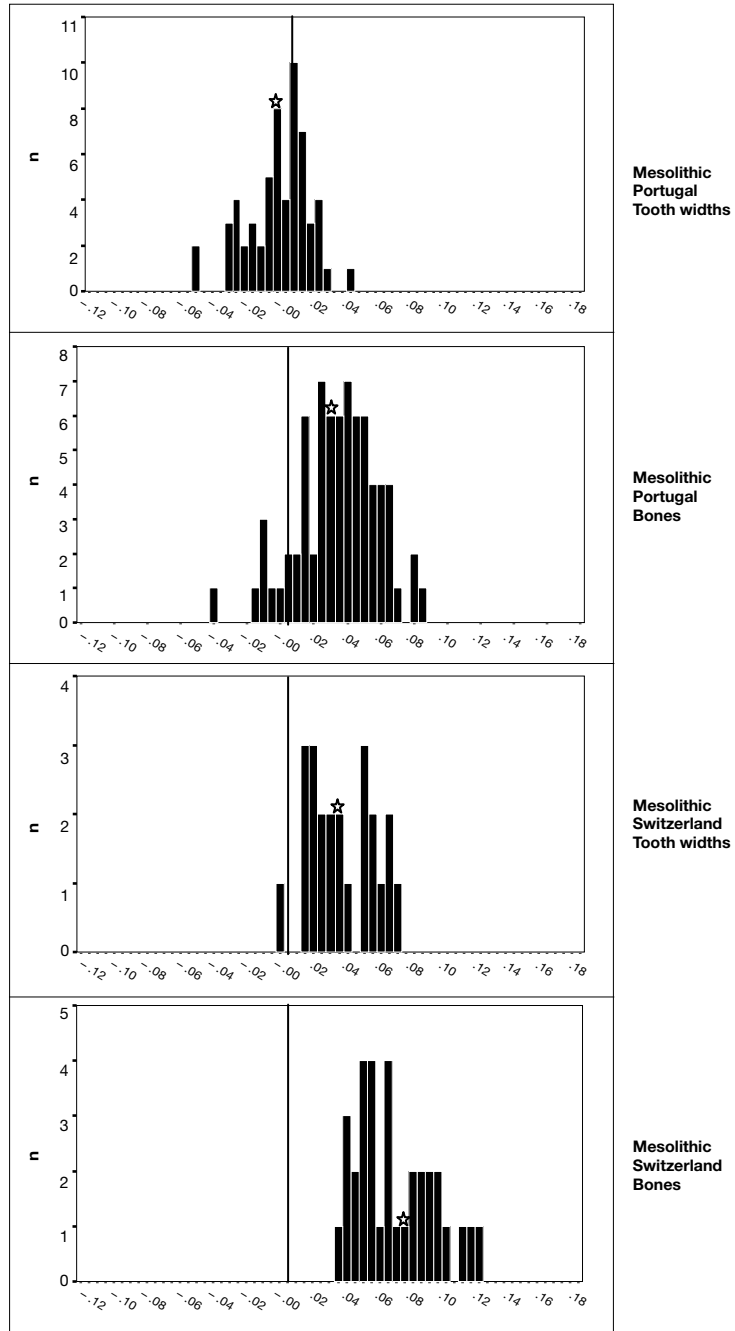


FIG. 21. – Comparison of tooth widths and post-cranial bone measurements in Mesolithic Portugal and Switzerland. See captions of Figs.19-20 for further details.

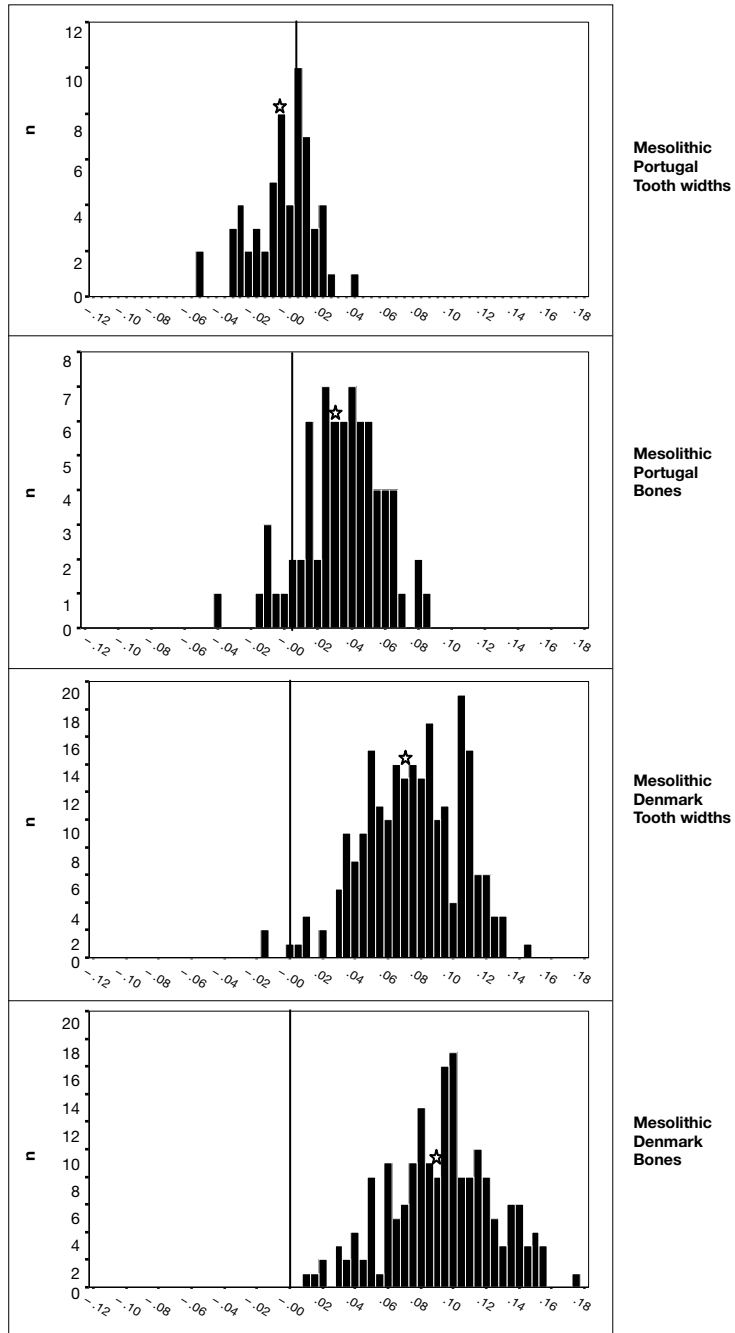


FIG. 22. – Comparison of tooth widths and post-cranial bone measurements in Mesolithic Portugal and Denmark. See captions of Figs.19-20 for further details.

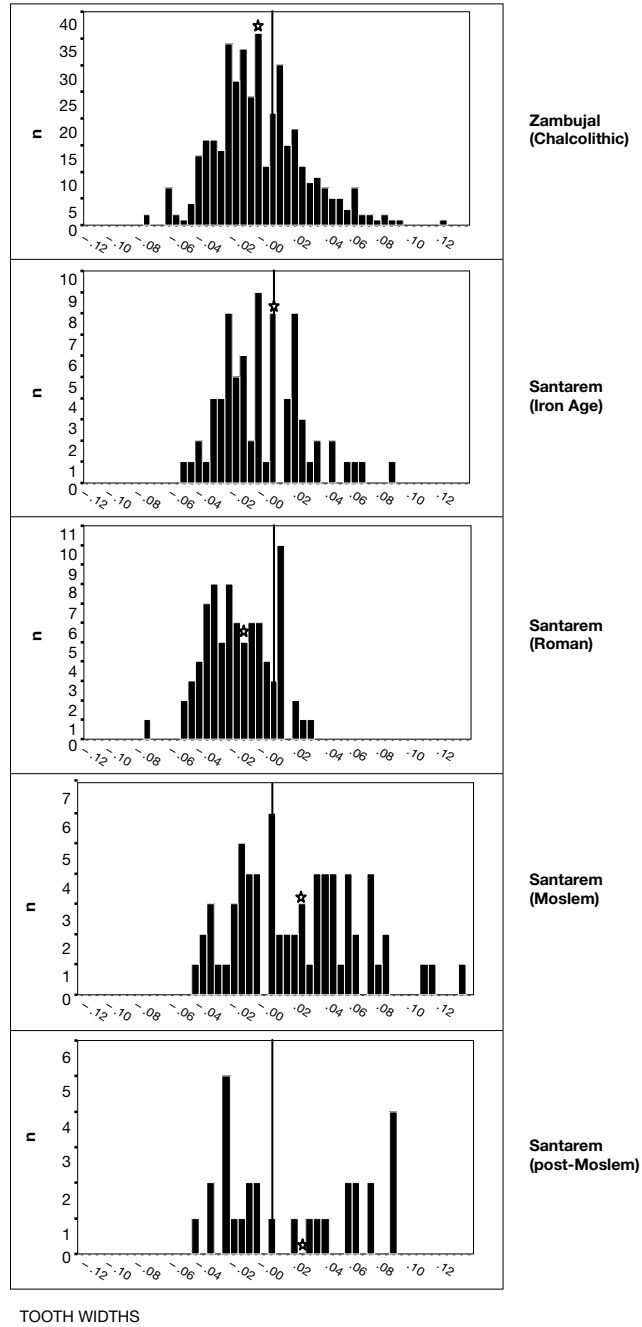


FIG. 23. – Comparison of pig lower tooth widths from Zambujal and Santarém. See caption of Fig.19 for further details.

remains from Alcáçova de Santarém (Davis 2003a) in central Portugal (Fig. 1) provides a chronological study of *Sus* size from Iron Age to Moslem times at this site. Here we compare tooth and post-cranial bone measurements from Zambujal with those from Santarém (Figs. 23-24). The domestic Pigs from Zambujal and the Iron Age levels at Santarém are similar, perhaps an indication that Pig husbandry did not change substantially in prehistoric times. A small "tail" of large specimens, presumably Wild Boars, is present at Iron Age Santarém as it was in the Chalcolithic sites. Like at Zambujal, hunting almost certainly provided an important but secondary source of meat (this is hardly surprising since 12% of the Iron Age fauna at Santarém is Red Deer, an animal that must have been hunted).

In Roman times there is no substantial change in the size of Pigs, which seem to be no larger, or even smaller, than in the previous period. This lack of improvement in livestock size is at odds with what has been recorded in the northern Roman provinces (Teichert 1984; Lauwerier 1988; Johnstone & Albarella 2002). It is possible that the Romans preferred to use smaller breeds in warmer regions. This view is supported by the fact that there was also no increase in the size of Roman Sheep and Cattle (Davis 2003a). A few large specimens — potential Wild Boars — can be seen in the plot of post-cranial bones but not for teeth (Figs. 23-24), which raises the possibility that Wild Boar heads may have been disposed of off site. Whatever is the case, it seems that some hunting was still being practiced in Roman times. This again is hardly surprising as Red Deer were still an important minor part of the fauna (they comprise approximately 8%).

A change occurs in the Moslem (9th-13th cent.) and post-Moslem periods, when a much greater variation in Pig size is to be seen (for a discussion of the puzzling presence of Pig remains in Moslem contexts, see Davis 2003a). Such an increase in variation is mainly the consequence of the presence of a fair proportion of animals of very large size, comparable indeed to the Chalcolithic Wild Boars (Figs. 23-24). It is therefore possible than Wild Boars represented a much greater

component of *Sus* meat in the medieval period than they had done in any of the previous phases. While pork consumption is strictly forbidden in Islam, many Moslems, especially in the Maghreb, hunt and eat Wild Boar. In Morocco Wild Boar liver is consumed to gain the animal's strength and its flesh is said to be bracing for children, a remedy for syphilis and renders humans insensitive to pain (Simoons 1994: 341; Moreno García 2004). Another possible explanation is that Pig improvement occurred in the medieval period and this saw the emergence of new and larger Pig breeds. Given the Moslem prohibition, this hypothesis seems a little beyond belief and remains to be tested — perhaps by comparing *Sus* remains from Medieval Moslem and Christian sites.

By making a more detailed study of tooth size and shape it is possible to improve our understanding of the status — wild or domestic — of the larger *Sus* teeth from the Moslem period at Alcáçova de Santarém. Fig. 25 combines both size (length of M_3) and a shape index (M_3 - width of anterior pillar divided by the width of the central pillar). This index is actually measuring how "parallel" the lingual and buccal sides of this tooth are. Fig. 25 shows two quite different populations of *Sus*, one is medieval and post-medieval domestic Pig from Launceston Castle in Cornwall, England (Albarella & Davis 1996) and the other modern Wild Boars from Israel and Syria (housed in the Universities of Tel Aviv and Jerusalem). The distribution of the plots indicates that besides being considerably longer (most > 35 mm) the wild *Sus* M_3 s tend to have parallel sides. In other words the widths of the two pillars are similar giving a 1:1 ratio (100 x WA/WC = 100). However the domestic Pig M_3 s tend in general to plot out to the right *i.e.* their anterior pillar is slightly larger than the central pillar giving them (in occlusal view) a slightly triangular appearance. This is probably reflecting 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 bone size and tooth size, had been subject to different selective

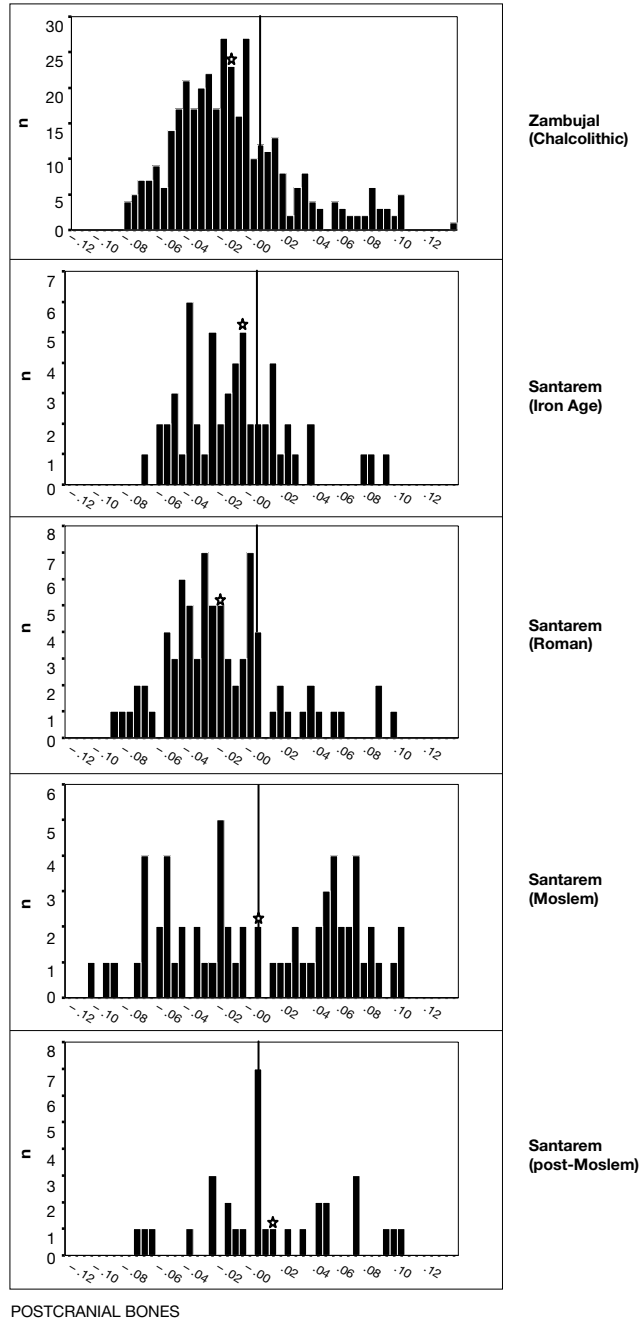


Fig. 24. – Comparison of pig post-cranial bone measurements from Zambujal and Santarém. See caption of Fig.20 for further details.

pressures in the course of domestication and management of *Sus* over the millennia, leading to an imbalance between tooth and bone (mandibular ramus) size, leaving the dental genes in a more 'archaic' state. If we accept this rather speculative line of reasoning, then we can make the same plot for the Santarém tooth measurements as in figure 26 — and note how many of the Moslem period *Sus* M_3 s plot out in the Wild Boar region with not only longer teeth but also values to the left (*i.e.* WA/WC index around 100). This corroborates the suggestion made earlier that many of the Moslem Santarém *Sus* remains derive from Wild Boars — considered less unclean than Pig by certain western Moslems. Clearly we need more data for modern and ancient Wild Boar teeth from Iberia.

CONCLUSIONS

This study of the osteometric variation of Portuguese Pigs in Chalcolithic and other times indicates the existence of a complex pattern probably determined by many different factors. These may include climate, trade, husbandry practises and other cultural factors. We stress that it would be a mistake to compare the size of the domestic animals with a supposedly immutable baseline of Wild Boar. From the Mesolithic onwards both the size and shape of Wild Boar changed more than once and it is becoming increasingly clear that such fluctuations can be observed in many other areas besides Portugal. For instance in England, Switzerland and Italy, there is also evidence that much larger Wild Boars than those living in the Mesolithic were present in later prehistoric and historical times (Albarella *et al.*, forthcoming a). Considering the inverse relation between body size and temperature (Davis 1981), it is possible that the climatic deterioration that occurred in Europe after 3000 BC (Bell & Walker 1992: 71) brought about such size increase. Another, and we suspect, more likely explanation for this post-Mesolithic size increase has to do with intense hunting pressure in the Mesolithic — a time of possible stress (Davis

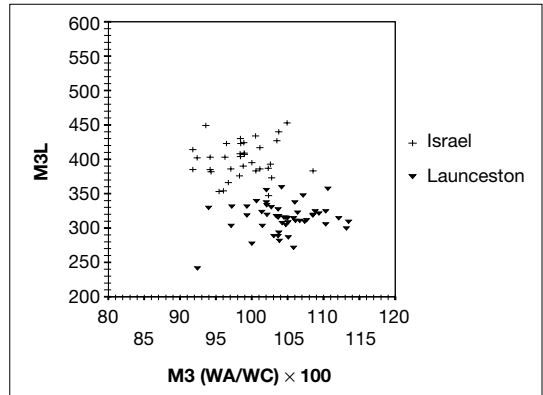


FIG. 25. – *Sus* lower third molar tooth – size versus shape of pig M_3 s from Medieval and post-Medieval Launceston Castle, England (Albarella & Davis 1996) and modern wild boars from Syria and Israel (specimens in the Zoology Museum, Tel Aviv University and Zoology department of the Hebrew University, Jerusalem). The M_3 length (y axis) is plotted against (x axis) an index of M_3 width of the anterior pillar (WA) divided by the width of the central pillar (WC). The resulting plots are therefore size (length M_3) versus shape (WA/WC or the degree to which the tooth is parallel sided when viewed occlusally). In other words M_3 s with more or less parallel sides or where WA more or less = WC have a shape index of around 100 while anterior-posterior "compressed" teeth with triangular outlines have index values slightly > 100. Note that besides being larger, the wild boar M_3 s have parallel sides with WA more or less = WC. However, the pigs are not only smaller but are triangular in shape when viewed occlusally with WA < WC. Note that in this graph measurements are in tenths of mm.

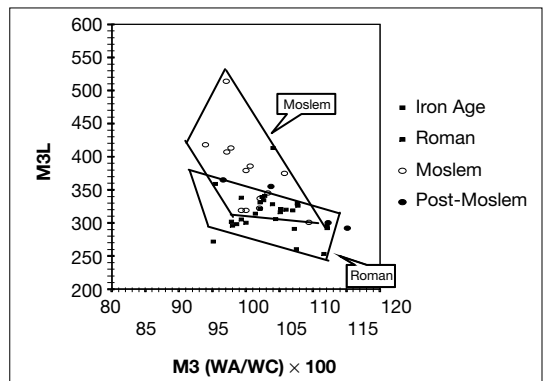


FIG. 26. – The same plot as Fig.25 for *Sus* M_3 s from Alcaçova de Santarém. Note there is a tendency for many of the *Sus* in the Moslem period at this site, unlike say the Roman ones, to be both large and have values of WA/WC around 100 – *i.e.* by analogy with Fig.25 they are more likely to have belonged to wild boars. Note that in this graph measurements are in tenths of mm.

1989, 1991) and subsequent relaxation of hunting pressure once domesticated ungulates had become the primary source of meat for humans. This line of reasoning was used to explain the small size of Mesolithic Portuguese Red Deer compared to later animals of this species in Portugal (Davis 2003a).

The samples from Zambujal and Leceia serve as a benchmark for comparing data from both earlier and later periods. The variation at these two sites is what might be expected in an economy in which both husbandry and hunting played a role, with the former definitely of greater importance than the latter. The scarcity of Wild Boar remains at Leceia — also typical of the other, but smaller, Chalcolithic assemblage of Mercador — is probably indicative of a different system of Pig management, also suggested by the slightly different age-at-death pattern. The distribution of measurements at Zambujal tends to be bimodal — reflecting the existence of two distinct populations — one domestic and the other wild. However, it is impossible to draw a clear line between the two, and we must accept the fact that not all specimens can be identified as either domestic or wild. It is also possible that crosses may have occurred, as Wild Boars could certainly have mated with free-range domestic Pigs.

We found little evidence for any differences in the size of Pigs at the three Chalcolithic sites considered here. However, there is some indication of a size decrease between the late Neolithic and the Chalcolithic at Leceia. The long chronological sequence provided by the site of Alcáçova de Santarém is of particular interest as it provides a good insight into the kind of fluctuations in the size of domestic Pigs that occurred in historical times. Hunting probably still played a small but nevertheless important role in Iron Age and Roman times. Many, perhaps most, of the large specimens found in the Moslem period are, we would like to suggest, Wild Boar rather than domestic Pig — a reflection of a tendency among certain western Moslems (and still prevalent in the Maghreb) who consider the Wild Boar a permissible source of food.

It is quite obvious that — to throw further light on the history of the exploitation of this species in the region — many more metric data from Portuguese Pigs are needed. This article, however, provides what we hope represents a basis for future comparisons. It also illustrates some of the dynamics of size and shape variation in Pigs that need to be borne in mind when analysing metric data from other sites. Simplistic attempts to assign Pig bones to domestic or wild forms without giving due thought to the variability of populations are not going to be effective for our understanding of the past. There is now, however, the opportunity to undertake a much more sophisticated analysis, as some of the more general patterns of variation begin to be understood, and more will certainly be, once further evidence becomes available.

Acknowledgements

The work presented in this paper was made possible by financial support from the Arts and Humanities Research Board (award ref. B/RG/AN1759/APN10977). We would like to thank Michael Kunst, Isabel Luna, and João Luis Cardoso for making the Pig bones from Zambujal and Leceia available to us for study, and Graça Ramalinho of the Museu Bocage for her help in that institution. SD thanks Tamar Dayan, Tsilla Shariv and Heinrich Mendelssohn of the Tel Aviv University Zoology Museum for allowing access to the collection of Wild Boar skulls from the Levant.

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Submitted on 6 December 2004;
Accepted on 2 May 2005.