Size and shape of the Eurasian wild boar (Sus scrofa), with a view to the reconstruction of its Holocene history

Umberto Albarella, Keith Dobney and Peter Rowley-Conwy

A large assortment of skulls and skeletons of recent wild boar (Sus scrofa) from across the world has been used to collect tooth and bone measurements that can be compared to those from archaeological specimens. The data provide useful information for a reconstruction of the Holocene history of the species. The evidence collected so far highlights the great variability of the species and provides a baseline to be used for the interpretation of ancient material. It is shown that not only the size, but also the shape of teeth and mandibles can help in highlighting patterns of variability in wild boar from different areas. A number of geographic trends are identified in the variation of S. scrofa across its range, mainly concerning the differentiation of insular forms, and the existence of South–North and West–East clines. Other factors such as hybridisation with domestic stock, feralisation and human-induced movement of animals may also play an important role. A comparison with ancient material emphasises the existence of similarities as well as differences between modern and ancient populations. Although some of the geographic trends identified on the basis of the analysis of modern material seem to date back to early Holocene times, the morphological history of the species appears to be complex, and in more than one area fluctuations in body size seem to have occurred.

Keywords: biometry, bones, teeth, wild boar, zooarchaeology, zoogeography

Introduction

The wild boar (Sus scrofa L. 1758) is one of the most common, widespread and important large mammals of the Old World. Its distribution covers most of Eurasia, where it is relatively common in substantial woodland and reedbed areas (Nowak 1999). Wild boar play a significant role in the shaping of many different environments, but it is in their relation with humans that their importance is particularly noteworthy. Not only has the wild boar been hunted by people for millennia — therefore providing an important protein source to the human diet — but it has also given rise to the domestic pig (S. domesticus) (nomenclature follows Gentry et al. 2004), one of the most important farm animals.

The large geographic range occupied by wild boar populations is reflected in the great morphological and size variability that characterises this species (cf. Figs. 1 and 2). This has been intensively investigated, and various assessments of the systematics of the species, and its separation into a number of geographic subspecies have also been carried out (e.g. Epstein 1971; Groves 1981; Mayer and Brisbin 1991; Genov 1999). However, much of this morphological and biometrical work has focused on recent characters, with only marginal attention paid to the earlier Holocene history of the species. Post-Glacial palaeontological sites which contain fossil remains of wild boar are unfortunately rare. In contrast, wild boar remains are commonly recovered from archaeological sites of many different periods. These remains have been studied by archaeologists in many different contexts, but particularly with reference to issues of anthropological relevance, such as the domestication of the species (e.g. Boessneck et al.)
1963; Flannery 1983; Hongo and Meadow 1988; Kuşatman 1991; Warman 2000; Ervynck et al. 2002; Albarella et al. 2005; Albarella et al. 2006a). Zoologists, archaeologists and anthropologists have therefore studied the wild boar using different approaches and with varying agendas in their minds. However, wild boar morphology can be tackled in ways that are of interest and relevance to zoologists and archaeologists alike.

One of the main problems in the application of modern morphometric studies to ancient material is that some of the characters used to assess the variability of the species — such as fur colour, bristle length and body mass — can hardly ever be applied in an archaeological context, as skins and soft tissues do not generally survive post-mortem deterioration. In addition, traits used by zoologists on skeletal materials, such as the greatest length of the skull and the dimensions of the lachrymal bone, are also of little use on archaeological material, since the latter is often fragmented and the finding of complete skulls is extremely rare.

The aim of this article is to assess the morphometric variability of modern wild boar using criteria that can readily be applied to archaeological material, and which can therefore provide the opportunity for an evolutionary and historical approach to the study of this species. Tooth measurements have in

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**Figure 1** Lateral view of the skulls of two wild boar from Sardinia and Russian Far East (Ussuriland). Specimens from the Natural History Museum in Berlin. Photograph by Umberto Albarella (UA)

**Figure 2** Ventral view of the same specimens as in Fig. 1. It shows that the size variation is not due to sex or age differences, as the two specimens are both males and have similar levels of tooth wear, which indicates that they are of similar age. Photograph by UA
particular been used, as teeth are durable and can survive destructive taphonomic processes for millennia. In addition — since most museum collections are predominantly composed of skulls — teeth provide the opportunity to compile large data sets from recent populations. In some archaeological contexts postcranial bones may also be well preserved, and these have also been incorporated in this study, though the availability of such measurements in modern collections is much more limited.

A selection of archaeological data is also used to highlight, with the aid of a few case studies, the potential of having a data set of modern measurements that can be compared with archaeological data. A detailed reconstruction of the Holocene history of the wild boar needs to be carried out first on a regional/local basis (e.g. Albarella et al. 2005; 2006a; 2006b; Rowley-Conwy and Dobney 2007) but here the potential of more general lines of investigation will be explored.

*S. scrofa* is divided into a number of subspecies, which, according to the opinion of different authors are more than twenty (Groves 1981; Mayer and Brisbin 1991), or as few as four (Genov 1999). Genetic analysis based on modern and ancient mitochondrial DNA has demonstrated that there is a well-defined diversity of phylogeographic wild boar types, though these do not necessarily coincide with the subspecies defined by zoologists on the basis of morphological criteria (Larson et al. 2005; 2007). In addition, only rarely can these morphological criteria be applied to archaeological material, which means that a full re-evaluation of the taxonomy of the wild boar is beyond the scope of this paper. Morphometric variability will therefore be discussed exclusively on the basis of geographic distribution and availability of data sets, specifically ignoring any preconceptions generated by the known existence of defined subspecies. In the discussion, references to the present taxonomic framework will be made, but merely to draw parallels with previous work — not with the intention of revising the systematics of the species.

There are a number of problems that have to be considered when assessing the variability of wild boar populations. These can be summarised as follows:

- In South-East Asia, the distribution range of *S. scrofa* overlaps with that of other *Sus* species (*S. salvanius* Hodgson 1847, *S. barbatus* Müller 1838 and *S. verrucosus* Müller 1840), thus generating the possibility of hybridisation (Groves 1984).
- In the recent (and to some extent more distant) past, wild boar have been introduced or reintroduced to areas where they had not previously lived or where they had become extinct or rare. This was often to provide a supply of animals for hunting. For instance, in Italy the wild boar was almost extinct by the mid-20th century (Apollonio et al. 1988), but subsequently allochthonous animals were introduced and now the species is common throughout the Italian peninsula.
- Wild boar can hybridise with domestic pigs, particularly in areas where pig husbandry is practiced in its traditional extensive and free-range form (Redding and Rosenberg 1998; Albarella et al. 2007).
- Feral populations of domestic pigs are today distributed throughout the world. Not only can they hybridise with wild boar, but they may also be morphologically indistinguishable from native wild populations.

These biases may affect both ancient and recent populations. In some cases they can be addressed and excluded, in others they will simply have to be acknowledged in the interpretation of wild boar variability across its range.

**Materials and methods**

As mentioned above, the focus of this paper is on data that are comparable between modern and ancient material. Therefore, measurements were taken exclusively on the mandible and lower teeth and on a selection of post-cranial bones. The upper part of the skull (*calvarium*) was disregarded, as the bony part is generally too fragmented in archaeological collections and the upper teeth would only duplicate the information already obtained from the lower teeth. Coat types and the characteristics of other perishable material were also of no relevance to this study. Since museum collections have many skulls but few complete skeletons, the present analysis focuses mainly on mandibular measurements. Numbers of mandibles from recent animals used in this study are summarised in Table 1, which also provides a breakdown of the sample by main geographic areas and countries. A total of 1407 mandibles were recorded, but almost one-third (417) of these derived from a large collection of German wild boar skulls housed at the Institute for Forest Ecology and Forest Inventory in Eberswalde (Germany). Since this sample significantly skewed the geographic distribution of the data set, and other data from Central Europe were in any case available, it was decided to exclude the Eberswalde collection.
Table 1  Number of mandibles recorded for different countries/geographic areas. Corsica and Sardinia — despite belonging respectively to France and Italy — are treated separately. Russia is split into four different regions, India into two. Four specimens could only be attributed to the former Soviet Union (USSR) but they could still be assigned to one of the broad geographic areas. For the European data set numbers in brackets indicate the total, minus the German specimens from the Institute for Forest Ecology and Forest Inventory in Eberswalde

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from the analysis, and to publish it separately. In addition to the information from the mandibles, post-cranial data from c. 120 complete and semi-complete skeletons were also included.

The modern specimens studied derive from the following collections (number of mandibles in brackets):

- Natural History Museum, Berlin (Germany) (220) (recorder: UA)
- Institute of Zoology, St Petersburg (Russia) (149) (recorder: UA)
- Smithsonian Institution, Washington (USA) (145) (recorders: UA and KD)
- Natural History Museum, Geneva (Switzerland) (69) (recorders: UA and KD)
- Field Museum of Natural History, Chicago (USA) (62) (recorders: KD and PRC)
- Department of Biology, University of Hildesheim (Germany) (47) (recorders: UA and KD)
- Nara Cultural Institute, Nabunken (Japan) (45) (recorder: KD)
- Natural History Museum, Paris (France) (42) (recorder: KD)
- Natural History Museum, Bern (Switzerland) (26) (recorders: UA, KD and Jörg Schibler)
- Museum of Comparative Zoology, Boston (USA) (23) (recorders: UA and KD)
- Museum for the Study of Domestic Animals, Halle (Germany) (22) (recorder: UA)
- Barry Rolett’s private collection (Hawaii) (20) (recorder: KD)
- Institute of Portuguese Archaeology (IPA), Lisbon (Portugal) (11) (recorders: UA and Simon Davis)
- Zoology and Anthropology Museum and Laboratory, Lisbon (Portugal) (8) (recorders: UA and Simon Davis)
- Institute of Zoology, Yerevan (Armenia) (7) (recorders: UA and Ninna Manaserian)
- Laboratory of Comparative Anatomy, Paris (France) (4) (recorder: UA)
- Museum of Levie, Corsica (France) (2) (recorders: UA and Filippo Manconi)
- Filippo Manconi’s private collection, Sardinia (Italy) (1) (recorders: UA and Filippo Manconi)
- Peabody Museum, Boston (USA) (1) (recorders: UA and KD)

In addition, data from 11 specimens from Syria and 63 from Israel were provided by Simon Davis. Data from further specimens were retrieved from the literature, as follows: 18 from Turkey (Payne & Bull 1988), 5 from Spain, 18 from the Netherlands, 1 from Hungary, 4 from Romania, 1 from Slovakia, 5 from Tunisia, 2 from Iran and 5 from Central Asian Russia (Kuşatman 1991).

Recent and modern specimens from the collections used in this study should derive from wholly wild populations of *S. scrofa*. However, the possibility that some represent hybrids with other species or with domestic or feral animals cannot be ruled out. Several mandibles from populations that are certainly feral (e.g. those from Oceania) are also discussed, despite their small number. The existence of populations whose status is uncertain makes it difficult to draw a clear line between wild and feral animals. Therefore, feral and possibly feral animals have not been excluded from the analysis, but rather used as an outgroup for comparison with truly wild specimens. It must, however, be emphasised that this paper will not deal in any detail with the important subject of morphological changes associated with feralisation — feral pig populations from North America are the subject of a detailed study by Mayer and Brisbin (1991) and will not be discussed here.

All samples include both males and females, in addition to specimens of unknown sex (Table 1). All mandibles were sexed on the basis of the morphology of the canines or their alveoli, whereas the information provided on museum labels was recorded, but is disregarded here, as it did not always match the more reliable evidence from the canines. In most of the geographic data sets used in this study, there is a predominance of males — slight in some cases (e.g. Europe), more marked in others (e.g. the Caucasus) — the only exceptions being represented by the specimens from the Middle and the Far East where the two sexes are approximately equally represented. This paper will not focus on the determination of sex related morphological characters, but this is an issue that cannot be altogether ignored, as wild boar are significantly sexually dimorphic, males being larger than females. It has been shown that tooth molar measurements are not substantially affected by sexual dimorphism (Payne and Bull 1988; Kuşatman 1991), but the difference in the proportion of the two sexes may act more significantly on post-cranial measurements.

The archaeological data belong to several collections analysed or re-analysed as part of a general project on the Archaeology of Pig Domestication and Husbandry coordinated by the authors. In addition, data from the literature or provided by colleagues have also been considered.
All measurements discussed in this paper were taken according to the recommendations provided by Payne and Bull (1988), with the exception of the central cusp of the lower third molar (M3WC), which is not described in that paper but is taken in the same way as the anterior cusp (M3WA). The height of the mandible was measured in front of the M1 and on the buccal side (measurements 16b in von den Driesch 1976).

The following measurements were used for the log ratio histograms (see below): posterior width of lower deciduous fourth premolar (dP4WP), anterior and posterior width of lower first and second molar (M1WA, M1WP, M2WA, M2WP), anterior width of the lower third molar (M3WA), greatest width of the distal humerus trochlea (BT), smallest diameter of distal humerus trochlea (HTC), diameter of femur caput (DC), greatest width of the distal tibia (BdP), greatest length of the calcaneum (GL) and greatest length of the astragalus (GLI).

No multivariate analysis has been undertaken because — although potentially valuable in the analysis of complete skulls and skeletons — this was likely to be of limited use for the generally highly fragmented archaeological specimens.

**Size variation in recent wild boar**

**Large-scale geographic variation**

Table 2 provides summary statistics for measurements of the second and third lower molars in eight main geographic areas. These regions are defined on the basis of approximate geographic criteria and should not be regarded as discrete entities of wild boar morphological types. They are also very diverse in extent, the Caucasus being substantially smaller than the others and the Far East probably the largest. In Table 1 it is possible to see which countries were assigned to which region. Although the regions were partly defined on the basis of the availability of data, our data sets from North Africa and Oceania — the latter exclusively consisting of populations likely to be feral — are much smaller than for the other regions.

Our samples for the second molar tend to be larger than those for the third molar, the reason being that in many specimens the third molar had not yet erupted and could not therefore be measured. The variability of different measurements is compared in Table 2 and Fig. 3 using Pearson’s coefficient of variation (V), which is the standard deviation expressed as a percentage of the mean. Although the coefficient of variation is not entirely unaffected by size (Polly 1998), the bias is much less serious than for the standard deviation and this index therefore allows for a better direct comparison of the variability of different measurements (Simpson et al. 1960; Payne and Bull 1988). The third molar is, on average, more variable than the second, and the length of the third molar is by far the most variable measurement, which confirms previous studies (Payne and Bull 1988; Kuşatman 1991; Albarella and Payne 2005). Due to their larger sample sizes and their smaller variability, measurements of the second molar are better suited to comparing the different geographic data sets. However, the length of the third molar has often been used in the past by zoologists and archaeologists (originally by Rutimeyer 1862) as a criterion to assess size in wild boar and, in addition, the third molar can be identified as such also when isolated, whereas the second molar can be confused with the first. This means that in highly fragmented archaeological assemblages third molar measurements can more commonly be obtained. In order to provide the opportunity for comparison of results of the present work with previous and future zooarchaeological studies, the measurements of both the third and second molars are therefore used.

### Table 2

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<td>South and South-East Asia</td>
<td>92</td>
<td>17</td>
<td>11.1</td>
<td>6.3</td>
</tr>
<tr>
<td>Far East</td>
<td>69</td>
<td>16</td>
<td>8.1</td>
<td>7.6</td>
</tr>
<tr>
<td>Far East (without islands)</td>
<td>50</td>
<td>17</td>
<td>13.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Oceania</td>
<td>24</td>
<td>14</td>
<td>8.8</td>
<td>3.7</td>
</tr>
</tbody>
</table>

*Albarella, Dobney and Rowley-Conwy The Eurasian wild boar*
The variability of measurements differs when the different regions are compared (Table 2 and Fig. 3). This, to some extent, reflects the variable size of the different geographic areas that are compared, the Far East exhibiting the greatest variation and the Caucasus the least. Other factors, however, play a role, as will be discussed below. It is worth noting that the coefficient of variation — particularly in the Middle East and the Caucasus — is not particularly high, just slightly greater than that indicative of single populations (cf. Simpson et al. 1960). This is somewhat surprising considering that the measured specimens derive from a variety of populations and that in these areas several subspecies are supposed to co-exist (Groves 1981).

In Figs. 4 and 5 the distribution of the measurements of the two molars in the different geographic areas are compared. North Africa and Oceania have been excluded due to their small sample sizes. The histograms are arranged according to average size of the animals, with the largest at the top. In Table 3 the statistical significance of the difference between the various groups is evaluated according to a Student’s t-test. This should in theory only be used when measurements are normally distributed, but it does represent a ‘robust’ test, which is little affected by normality or variance (Simpson et al. 1960). Figs. 4 and 5, as well as the statistical testing, indicate that the two groups that are by far most alike are those with the largest mean values, i.e. Central Asia and Caucasus. The South and South-East Asian, European and Far Eastern groups tend to have similar means, but very different spreads. In South and South-East Asia overall there is a great variability, Europe has a small tail, which corresponds to the small animals from the Mediterranean islands, and the Far East has the smallest animals of the whole data set (a well-defined subgroup of tiny dwarf wild boar from the Ryukyu islands in southern Japan) as well as the largest (from Eastern Siberia). Measurements of the M3 (Fig. 4) and M2 (Fig. 5) provide consistent results, though the size decrease from top to bottom is clearer in the less variable measurements of the second molar — which is thus a better tooth for comparing geographic groups.

It is clear that the mean values for Europe and the Far East are strongly affected by the small insular forms, which are clear outliers. Therefore, in Tables 2 and 3, summary statistics and t-tests for these two regions are also provided with the island populations excluded. Once the insular forms are disregarded it becomes clear that, though on average still significantly smaller than the Middle Eastern, Caucasian and Central Asian animals, the bulk of the animals from Europe and the Far East are larger than most of the South and South-East Asian pigs.

The available sample of post-cranial bones is much smaller. Therefore, to produce sufficiently large sample sizes, different bone measurements have been combined in Fig. 6. The combination has been achieved through the use of a size index scaling technique (Meadow 1999), which relates the
Figure 4  Distribution of measurements of wild boar (*Sus scrofa*) third lower molar from different geographic areas

Central Asia

Caucasus

Middle East

South and South-East Asia

Europe

Far East
Figure 5  Distribution of measurements of wild boar (*Sus scrofa*) second lower molar from different geographic areas.
measurements to standard values based on the skeletons of a sample of Turkish wild boar (Payne and Bull 1988). The relative size of the modern data set of wild boar in comparison to the Turkish standard is calculated as the decimal logarithm of the ratio between the measurement and its standard (Simpson et al. 1960). The chosen measurements (see above) are those which are least variable and less affected by age and sex (with the exception of the width of the distal trochlea of the humerus, which is substantially sexually dimorphic) (cf. Albarella and Payne 2005). Lengths, widths and depths were combined, which allows for different body dimensions to be taken into account, but also tends to obscure possible shape differences (Davis 1996; Albarella 2002). This must therefore be regarded as a crude comparison of the different data sets, which is necessitated by the fact that any further separation would have excessively reduced sample size.

To allow direct comparison between bones and teeth, the distribution of tooth width measurements only of the specimens that also provided post-cranial bone measurements is presented on the right side of Fig. 6. The results are by and large comparable, with most values occurring to the left of the vertical axis (‘0.00’), which represents the standard value. This indicates that the wild boar from Kızılcahamam, in North-Central Turkey, from which the standard value is calculated, are very large — an important point to bear in mind when such standards are used for the interpretation of pig populations of uncertain origin, such as those from archaeological sites.

Only a very small sample of complete skeletons was available for Central Asia (four specimens: one female from Turkmenistan, one male and one of unknown sex from Pakistan, and one of unknown sex from Kashmir), and these tended to be relatively small. However, this should not be seen as contradicting our statement above regarding the large size of the Central Asian wild boar, as the Kashmir and Pakistani wild boar are the smallest in the whole central Asian data set as it will be seen in the next section. The only complete skeleton available from the Caucasus is a female from Armenia and this is also smaller than the Turkish standard, but obviously not much can be inferred from a single specimen, and we cannot refute the impression gained by the analysis of the second and third molar that the Caucasian wild boar are indeed large. The Middle East and Far East regions provide the largest animals, with the former representing the least variable group and the variability of the Far Eastern animals much reduced by the lack of availability of complete skeletons of the tiny pigs

Table 3 Significance of the difference of the mean, as calculated through a student’s t-test, in measurements of wild boar (Sus scrofa) second and third lower molars from different geographic areas; *** very highly significant; ** highly significant; * significant; t-test – two-tailed, no equal variance

<table>
<thead>
<tr>
<th></th>
<th>M3WA</th>
<th>M3L</th>
<th>M2WA</th>
<th>M2WP</th>
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<tr>
<td>Central Asia/Caucasus</td>
<td>0.988</td>
<td>0.592</td>
<td>0.432</td>
<td>0.716</td>
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<td>&lt;0.001***</td>
<td>&lt;0.001***</td>
<td>&lt;0.001***</td>
</tr>
<tr>
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<td>&lt;0.001***</td>
</tr>
<tr>
<td>Central Asia/S and SE Asia</td>
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<td>&lt;0.001***</td>
<td>&lt;0.001***</td>
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</tr>
<tr>
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<td>0.015*</td>
<td>0.002**</td>
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<tr>
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<td>0.016*</td>
<td>0.001**</td>
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<td>0.422</td>
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<td>0.005**</td>
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<tr>
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<td>0.022*</td>
<td>0.006**</td>
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<tr>
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</tr>
<tr>
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<td>0.083</td>
<td>0.011*</td>
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<td>&lt;0.001***</td>
<td>&lt;0.001***</td>
</tr>
<tr>
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<td>0.002**</td>
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<td>Europe (no islands)/Far East (no islands)</td>
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<td>0.178</td>
<td>0.341</td>
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<tr>
<td>S and SE Asia/Europe (no islands)</td>
<td>0.412</td>
<td>0.002**</td>
<td>0.529</td>
<td>0.017*</td>
</tr>
</tbody>
</table>
Figure 6  Measurements of wild boar (Sus scrofa) post-cranial bones and teeth from different geographic areas compared using a Log ratio method (Simpson et al. 1960). The standards (0-00) are those of a Turkish wild boar population provided by Payne & Bull (1988). Only tooth measurements from specimens that also provided post-cranial bones have been included. The scale of the vertical axis is fixed to emphasise differences in sample sizes.
from Ryukyu. The points at the extreme right of the distribution of the Far Eastern specimens are measurements of a large male wild boar from the Vladivostock area. The European data set provided the largest sample, with almost all specimens falling to the left of the ‘standard’ line. The small subsample of insular animals forms a particularly well-defined group in the distribution of tooth measurement values, which appears to be clearly bimodal, whereas it only forms a tail attached to the main distribution of post-cranial bones. These data confirm that tooth measurements — being less variable — are better suited for identifying geographic groupings. The South-East Asian wild boar — as already suggested by the analysis of their second and third molars — are spread over a wide range and are, on average, very small (but note a few extremely large animals).

**Regional and local geographic variation**

**Europe and North Africa**

In Fig. 7 measurements of the lower second and third molar, and in Fig. 8 those of the distal humerus for Europe and North Africa areas are plotted. Four main local subgroups from this region can be identified:

Wild or feral pigs from Corsica and Sardinia

These are very small animals, forming a separate cluster, particularly well defined in the M2 measurements. Very little overlap occurs with other specimens from the region, though the presence of one specimen from Southern Europe (Andalusia, Southern Spain) and one from North Africa (Tunisia) within the insular cluster for the M2 must be noted. A large specimen from southern Sardinia falling in the middle of the central European distribution for the M2 is probably an introduced animal, since wild boar of this size are unknown among the traditional variety living on the island. The humerus plot (Fig. 8) only includes Sardinian animals and confirms the small size of the pigs living on this island, though the separation is not quite as good as that obtained from the teeth — a clear illustration of the greater variation found in post-cranial bones outlined previously. Sexual dimorphism does not seem to be a factor in this patterning, as two males, one female and one animal of unknown sex are included, and the two males are the smallest. The origins of the Sardinian and Corsican wild boar are rather mysterious, as no *Sus scrofa* remains are known from the islands before the 7th millennium BC (Albarella et al. 2006b). This has led some to suggest that they were introduced by early human settlers, though it is unknown whether the animals introduced were wild (Groves 1989) or domestic (Vigne 1988). If the latter were true, it would follow that the present ‘wild’ boar populations originate from animals that escaped captivity in the distant past, in which case they should be regarded as feral rather than truly wild. The Corsican mouflon (*Ovis orientalis musimon* Pallas 1811) is also widely regarded to be a feral sheep (Poplin 1979). Due to their clear difference from other European wild boar the wild pigs from Sardinia and Corsica have traditionally been combined into a separate subspecies, *S. s. meridionalis* Forsyth Major 1882 (Groves 1981). However, recent work indicates that some genetic differences exist between some of the Sardinian and Corsican pigs (Larson et al. 2005; 2007). More than one introduction probably took place and the small size of these animals may therefore be a consequence of an insular dwarfism occurring at different times and independently on the two islands.

Wild pigs from North Africa and Southern Europe

These are larger than the insular forms discussed above, but still tend to fall at the lower end of the distribution. Animals from Central Italy (of the type regarded as belonging to the original Italian wild boar *S. s. majori* de Beaux and Festa 1927), Northern and Southern Spain, Portugal and North Africa are included. The Andalusian animals (four specimens only represented in the M2 plot) are on the small side even of the Southern European wild boar, but, with the exception of the single specimen mentioned above, are larger that the Sardo-Corsican specimens. Larger samples are needed to ascertain whether the Southern Spanish pigs can be referred to as *S. s. meridionalis* as suggested by Groves (1981). On present biometrical evidence they seem to be closer to the Portuguese wild boar, which biogeographically would perhaps make more sense. The North-West African wild boar are traditionally regarded as belonging to the subspecies *S. s. algira* Loche 1867, and they seem to be similar in size to the Southern European animals. The very large North African specimen in Fig. 7a (a male) is the only one from the North-East of Africa (Egypt) and its difference from the other African specimens is unsurprising as it is geographically closer to the range of the Near Eastern wild boar (*S. s. lybicus* Gray 1868). Wild boar disappeared from the Nile Valley c. 1900 (Nowak 1999) and this specimen — recorded at the Natural History Museum in Paris and collected at the time of the Napoleonic war in the late 18th century — pre-dates the time of this extinction event and is therefore a genuine representative of the
original Egyptian wild boar. The only Southern European specimens for which we have post-cranial measurements are from Northern Portugal. Two females plot at the bottom end of the distribution, whereas the one male is consistent with some of the smaller central European wild boar (Fig. 8).

Wild pigs from Central Europe
These should largely coincide in size with the animals regarded as belonging to the nominal subspecies *S. s. scrofa* Linnaeus 1758. They are moderately sized and form a consistent and compact spread of measurement values (Fig. 7). Though not particularly large, their average size is well above that of the Southern European and insular specimens (see also Fig. 8). However, the claim by Groves (1981, 29) that in this subspecies the $M_3$ is ‘not usually above 40mm long’ does not find support in our data set, as the $M_3$ length of almost half of the specimens is greater than that.

Figure 7 Size of lower third (7a) and second (7b) molars in wild boar from different geographic areas in Europe and North Africa. Central—Austria, Czech Rep, France, Germany, Netherlands, Switzerland; Eastern—Belarus, Bosnia, Hungary, Macedonia, Poland, Romania, Russia, Slovakia, Ukraine; Southern—Italy, Portugal, Spain; Islands—Corsica, Sardinia; North Africa—Morocco, Algeria, Tunisia, Egypt.
Wild pigs from Eastern Europe
These are the largest wild boar in the region, as is clearly shown by the plot of the M2 in particular (Fig. 7b). There is, however, much variation, with some specimens plotting within the lower range of the Central European distribution (Fig. 7). These smaller specimens are all from Poland, where, according to Groves (1981) the subspecies present is *S. s. scrofa*, whereas most of the larger specimens are from Belarus and Russia and, therefore, either inter-grade with or belong fully to the larger subspecies *S. s. attila* Thomas 1912.

The Middle East
Measurements of the lower second and third molars are plotted in Fig. 9 and those of the distal humerus in Fig. 10. As we have previously discussed, wild boar from this region tend to be of a large size. They have been divided into three main local groups.

Wild pigs from the Levant
This is the South-Western group and includes wild boar from Palestine, Israel, Jordan and Syria (Golan) (most data provided by Simon Davis), which in general all seem to be of a similar size. They include the smallest animals of the region, but much overlap occurs with other Middle Eastern specimens.

Wild pigs from Turkey
On average the M3 from Anatolian wild boar is larger than those from the Levant (Fig. 9a), but no clear difference seems to occur for the M2 (Fig. 9b). Turkish and Levantine populations are generally regarded as belonging to the same subspecies, *S. s. lybicu*s (Groves 1981). The Turkish animals from Kızılcahamam, which were measured by Payne and Bull (1988) and were used as the ‘standard’ in the previous section, appear to be particularly large. Humerus measurement values (Fig. 10) suggest that Turkish wild boar are slightly smaller than Eastern European *S. s. attila*, but larger than Central European *S. s. scrofa*.

Wild pigs from Iraq and Iran
This is the most Eastern and — in terms of size — largest local group from the Middle Eastern region, with several specimens whose M3 length is well above 45 mm (Fig. 9a). They are regarded by Groves (1981) as belonging to the same subspecies (‘attila’) as the Eastern European animals, with which they are indeed comparable in size. Their humerus measurements (Fig. 10) are indistinguishable from those from Anatolia, most likely a consequence of the small sample size.

The Caucasus and Central Asia
In Fig. 11 measurements of the lower second and third molar and in Figs. 10 and 12 those of the distal humerus for the Caucasus and Central Asia are plotted. Due to the apparent similarity in size of the wild boar from these two regions (see above), they are discussed together in this section. In general these are very large animals, comparable to or even larger (cf. in particular M3-WA) than the Eastern European and Iranian/Iraqi specimens (*S. s. attila*). No clear local groups are detectable, with the exception of the few specimens from the most Southern part of the region, including Afghanistan (n=1), Pakistan (n=2) and Northern India (Kashmir; n=3). These are definitely smaller in terms of all tooth measurements except the
length of the M₃ (unfortunately no post-cranial measurements were available for animals from this last region). Wild boar from Pakistan are included by Mayer and Brisbin (1981), together with the Indian animals, in the subspecies S. s. cristatus Wagner 1839. The size similarity between the wild boar of Northern Caucasus (mainly in Russia) and Transcaucasia (Georgia, Armenia, Azerbaijan and a smaller part of Russia) is noteworthy, as Groves (1981, 33) regards the difference in the pigs of these two regions to be ‘quite striking’, attributing the Northern animals to S. s. attila and the Southern to S. s. lybicus. The status of the central Asian wild boar is undefined by Groves (1981), with the exception of the populations living in the Tien-Shan mountain range, which are regarded as belonging to the subspecies S. s. nigripes Blanford 1875. These are considered to be larger than S. s. scrofa and smaller than S. s. attila, an assumption not supported by the data presented here. Three specimens from the Tien-Shan are represented in the data set and they all fall in the centre of the distribution of measurement values for this region.
The Far East

In Fig. 13 measurements of the lower second and third molars and in Fig. 12 those of the distal humerus for specimens from the Far East region are plotted. Huge size variability occurs in the populations of wild boar from this region and four main local groups can be identified.

Wild pigs from Ryukyu islands

Ryukyu is an archipelago of small islands located between the Southern Japanese mainland and the island of Taiwan, and it hosts the smallest wild boar found anywhere in the world. They form a discrete and compact small cluster in the distribution of the Far Eastern wild boar (Fig. 13), with the length of the third molar regularly smaller than 30mm. Unlike the wild or feral pigs of the Mediterranean islands the fossil record for their presence on Ryukyu is long and there has been no suggestion that they may have been introduced by humans — their small size is certainly due to insular dwarfism. Recent genetic analysis indicates that they belong to a different lineage from wild boar found on the Japanese mainland (Watanobe et al. 1999) and this supports their traditional classification as a distinct subspecies, *S. s. riukiuanus* Kuroda 1924, originally defined on size and morphological characters.

Wild pigs from Japan and Taiwan

These animals are much larger than the Ryukyu specimens but still rather small — i.e. comparable in size to Southern European wild boar. They are clearly smaller than Chinese — mainly Central and Southern — wild boar when the M3 measurements are considered (Fig. 13a), but a greater overlap occurs in the measurements of the M2 (Fig. 13b). The largest sample of measurements is from Southern and Central Honshu, thus, in view of a possible North–South size decrease (Groves 1981), the average size of the Japanese wild boar could be larger. Japanese and Taiwanese wild pigs do not seem to be distinguishable on size alone, but they have traditionally been attributed to two different subspecies *S. s. leucomystax* Temminck 1842 and *S. s. taivanus* Swinhoe 1863.

Wild pigs from China and Mongolia

This is of course a huge area, which explains the rather large variability. The measured specimens come from many different regions of China and Mongolia (East and West), rather than from a discrete geographic group. Some large animals are included but none with an M3 length above 50 mm. Both teeth and humeri provide measurements that are comparable to those of *S. s. scrofa* (Figs. 12 and 13). Groves (1981) considers this area to be inhabited by three different subspecies, but further division of such a limited data set would have reduced sample size further and made group comparison questionable.

Wild pigs from the Russian Far East

These specimens all derive from the Vladivostock area (Ussuriland) and are by far the largest wild boar in the world. M2 measurements in particular form a distinct cluster (Fig. 13b), but the single humerus measurement is also much larger than any other measured from the Far East or any other area (Fig. 12). The gigantism of this form is well known and explains its traditional classification as a separate subspecies (*S. s. ussuricus* Heude 1888) (Groves 1981). Measurements of the length of the third molar and anterior width of the second molar of a single
Korean specimen available are consistent with the enormous size of this form.

**South and South-East Asia and Oceania**

In Fig. 14 measurements of the lower second and third molar and in Fig. 12 those of the distal humerus for wild boar and feral pigs from South Asia, South-East Asia and Oceania are plotted. As with the previous group this region is characterised by great variability and three main local groups can be postulated.

Wild pigs from Nepal, India, Sri Lanka and Indochina

It should be noted that the Northern Indian region of Kashmir was discussed together with the Central Asian pigs. The other Indian specimens come from several different parts of the countries (both North and South). No obvious difference seems to exist.
between the size of the Indo-Chinese and Indian pigs, and the Sri Lankan and Nepalese animals also do not represent discrete entities, although larger samples may provide the opportunity to identify further subgroups. Sri Lanka seems to be a sufficiently large island not to be affected by the size diminution typical of many insular forms. Despite wide variability this represents, on average, the largest group in Southern Asia, comparable in size to Chinese wild boar. According to Groves (1981) three different subspecies live in this region, *S. s. cristatus*, *S. s. davidi* Groves 1981, and *S. s. affinis* Gray 1847, which is consistent with the fairly large variability mentioned above.

Wild/feral pigs from Island South-East Asia

Most *Sus* specimens studied from this region are from Indonesia, with a few from the Malay Peninsula and associated islands. Two specimens from the Andaman and Nicobar islands (probably feral, cf. Mayer and Brisbin 1991), which politically are part of India, have also been added. The wild boar from this region are classified as *S. s. vittatus* Boie 1828, a well-defined subspecies, even accepted by Genov (1999) in his scaling down of *S. scrofa* taxonomy to a mere four subspecies. There is, however, great size variability in our data set, which could partly be a consequence of hybridisation with other *Sus* species (cf. Groves 1984) and the occurrence of some feral populations. On average these wild boar are the smallest in the world, with the exception of the insular forms from Sardinia, Corsica and Ryukyu. The length of the M3 is consistently below 40mm (Fig. 14a) and post-cranial measurements also suggest small size (Fig. 12).

Feral pigs from near and remote Oceania

Most recorded animals are from the Marquesas and Marianas islands and Vanuatu, with a single specimen from New Guinea. The Oceanic populations probably originate from unimproved domestic stock of *S. s. vittatus* origin brought to the islands by early voyaging between as early as c. 1000 BC and 200 BC (Allen et al. 2001). Groves (1981) has suggested that the New Guinea pigs could be the result of hybridisation of two *Sus* species — *S. scrofa* and *S. celebensis*. These pigs are generally small with a poor correlation between different tooth measurements (Fig. 14) and tend to plot in the lower half of the distribution of the Indonesian wild pigs.

Shape variation in recent wild boar

Morphological characters commonly used to distinguish different wild boar types include the general height of the skull and the shape of the lachrymal bone. These are, however, of little use for archaeological material, and therefore other characters that can be used to describe skull shape must be identified.

Relative dimensions of the third molar

Kračový (1981) and more recently Warman (2005) have suggested that molar morphotypes based on the number and shape of the various cusps can be used to distinguish between pig types. Though their work was mainly focused on domestic pigs, there is no reason why detailed morphometric analyses of cusp variation, shape and outline could not be applied to wild boar, as, for instance, done by Cucchi et al. 2009. However, cruder systems, such as a simple analysis of the ratio between length and width in teeth can be more straightforwardly employed. In Fig. 15 scatter plots of the ratio between length and anterior and
central widths of the lower third molar are presented (it must be borne in mind that these diagrams describe shape and are by and large size independent). Teeth that plot at the bottom left corner of the distribution will tend to be thin and long, whereas those at the top right end will be — relatively speaking — broad and short. It can be seen that there is a fair amount of variation in the shape of the M₃, although clear groupings do not always appear.

In the European distribution none of the teeth are particularly thin (note the space to the lower left of the distribution). The island populations overlap greatly with the specimens from Mainland Europe, though they seem to align along a slightly different regression line. The Middle Eastern specimens are not substantially different from those from Europe, with the Iran/Iraq teeth spanning the entire distribution. The Turkish and Levantine specimens do separate out, although the sample sizes here are very small. The few specimens from Kashmir do seem to have the thinnest M₃s of all and — as has already been observed for their size — are clearly distinguished from Central Asian specimens. Some differences occur in the Far Eastern distribution, with the
Ryukyu specimens stretching towards the top of the distribution and the Chinese towards the bottom. The huge size of the Eastern Siberian animals does not seem to affect shape as they plot, like the Japanese, towards the middle of the range. It is interesting to note that the Ryukyu specimens plot approximately in the same area as the Sardo-Corsican pigs, which raises the possibility that small size may partly determine tooth shape.

The best separation occurs in the South and South-East Asian pigs, where there is little overlap between the specimens from Nepal/India/Sri Lanka — which have long and thin teeth — and those from Indonesia — which tend to be broad and short. The Indo-Chinese pigs are transitional between the two forms, whilst the feral animals from Oceania plot in the same areas as the *S. s. vittatus* form, which is not surprising considering their likely origin.
Mandible/M₃ ratio

A different type of shape variation analysis is attempted in Figs. 16 and 17. Here the ratios between the height of the mandible and the length and width of the third molar are plotted. Specimens plotting towards the top right corner will have a deep mandible with relatively small M₃s, while the opposite will be the case for specimens plotting...

Figure 15 Ratio between width and length of the lower third molar in various geographic areas. WA is the greatest width of the anterior cusp, whereas WC is the greatest width of the central cusp.
towards the bottom left corner. In Fig. 16 the European specimens are used as a basis for comparison with specimens from all other geographic areas. When viewing the data, it is clear that although the shapes of the different distributions do vary, there is much overlap between the groups. The only group that seems to clearly plot in a different area of the diagram is represented by the feral pigs from Oceania, which have a very deep mandible in relation to the length (but not the width) of the M₃. This
difference is not age-related as all mandibles have fully erupted M3s and there is no substantial difference in the level of M3 wear between the European and Oceanic specimens. This diagram therefore provides an additional tool for studying the shape of the third molar, because it allows a distinction between the European and Oceanic animals that was not possible on the basis of the M3 shape.

Fig. 17 provides more geographic detail, with three main points of interest to note:

- **Wild boar from Sardinia and Corsica are totally indistinguishable from those from Mainland Europe.** This is important when we consider that the feral forms from Oceania — of, admittedly, completely different origin — are morphologically very different. The animals from these islands seem to be just miniature forms of the European wild boar. Groves (1989) also pointed out that their cranial capacity in relation to body mass is very similar to that of the truly wild form. If these animals are feral they must have escaped from captivity when domestication had not yet had any major morphological effect, or they must have reacquired the wild characteristics after becoming feral. It has been suggested that the Sardinian wild boar may represent the product of the interbreeding between *S. s. scrofa* with domestic forms of *S. s. vittatus* (De Beaux and Festa 1927; Masseti 2002, 255), but the Sardinian pigs appear to have nothing in common — either morphologically, or genetically (Larson et al. 2005) — with those from Indonesia.

- **Separation of the Ryukyu wild boar from those of China, and, to a greater extent, of Indian wild boar from those from Indonesia also occurs in these scatter-plots.** The separation, however, occurs along the axis stretching from top-left to bottom-right, which means that this has nothing to do with the depth of the mandible, but it is rather a consequence of the different shape of the M3s. These particular diagrams therefore present the same evidence discussed above, but in a different fashion.

- **The Oceanic feral pigs, which appeared so similar to those from Indonesia when the shape of the**
third molar was considered, plot in a very different area when the height of the mandible is taken into account. The implication is that Indonesian and Oceanic pigs have similarly shaped lower M₃s, but the latter have much deeper mandibles.

**A comparison with ancient wild boar**

The recent wild boar and feral pig biometrical data set presented so far constitutes a useful baseline for comparison with ancient wild boar; this should allow an exploration of the variability of this species from a diachronic perspective. A full reconstruction of the history of the species *Sus scrofa* in Eurasia cannot be undertaken in this paper, but several case studies will be presented in order to illustrate how valuable modern data can be for our understanding of the past, and, in turn, how archaeological material can provide crucial insights into the present patterns of variability of the species.

There are two main problems that must first be considered when interpreting archaeological data:

- An important factor affecting overall body size is temperature (cf. Davis 1981; Rowley-Conwy 1995; Magnell 2004) and therefore animals that lived in colder periods, being subject to climatic conditions that are so obviously different from those existing today, may not be directly comparable with modern populations. Although size differences between Pleistocene and modern wild boar can still teach us interesting lessons, the Holocene history of the species is probably more relevant to our understanding of the present variability in *S. scrofa*.
- After the beginning of the Neolithic (whose starting date varies according to the geographic region) it is expected that archaeological sites will produce domestic pig bones and teeth in addition to (or to the exclusion of) those of wild boar. The separation of wild and domestic forms from archaeological remains is notoriously difficult and, therefore, any comparison of the modern data set with material deriving from Neolithic or post-Neolithic sites carries the risk that mixed populations may occur in the archaeological assemblage.

**Europe**

Considering the caveats mentioned above the most obvious first step is to use the remains of animals that lived before the advent of domestication, but are still as close as possible to us in date. In Europe this period corresponds to the Mesolithic (c. 9000–4000 BC cal depending on the region), which is pre-domestication but also post-glacial. In Figs. 18–23 the modern European data set (excluding the islands) is compared with Mesolithic data from Central-Northern (Figs. 18, 20 and 22) and Southern (Figs. 19, 21 and 23) Europe.

**Denmark**

Wild boar became extinct in Denmark in the late 18th century (Aaris-Sørensen 1988, 229) and therefore the
availability of archaeological data for this region — our largest Mesolithic sample — is particularly useful. These derive from the Early Mesolithic sites of Holmegaard, Lundby, Mullerup, and Svaerdborg, the Middle Mesolithic sites of Kongemose and Bloksbjerg, and the Late Mesolithic sites of Agernæs, Flynderhage, Nivaa, Norslund and Sludegaard and were recorded by KD and PRC. Scatter plots of the third and second molar and the distal humerus indicate that the Danish wild boar were extremely large, as already noted by Groves (1981) on the basis of the observation of Neolithic material. The Danish archaeological wild boar are, on average, larger than *S. s. attila* from Eastern Europe (the difference with the Eastern European group is highly statistically significant according to a Student’s t-test) and are more comparable in size to the modern wild boar from Central Asia. The only living populations that are larger than the Danish ancient wild boar are those from Ussuriland, and some of the Danish humerus measurements even seem to exceed those (compare Figs. 12 and 22). Due to the absence of native wild boar in modern Denmark it is difficult to determine whether a size

*Figure 19 Size of lower third molar in modern and archaeological European wild boar (archaeological specimens from southern Europe). Island populations are excluded.*

*Figure 20 Size of lower second molar in modern and archaeological European wild boar (archaeological specimens from Central and Northern Europe). Island populations are excluded.*
decline occurred after the Mesolithic, or whether these populations of enormous wild boar were eventually extirpated. What we do know is that these very large forms still persisted at least into the Neolithic (Rowley-Conwy 1995; 2003). The Danish Mesolithic wild boar are on average larger than any others from prehistoric Europe (see below), which is consistent with the above suggestion that temperature affects body size, because Denmark is the coldest area of prehistoric Europe from which samples are available.

**Britain**

As in Denmark the wild boar is today extinct in Britain. The species was extinct by the late 13th century, then reintroduced and finally disappeared in the late 17th century (Albarella in press). The few measurements that are available derive from the sites of Star Carr (UA’s data and Legge and Rowley-Conwy 1988), Marsh Benham (UA’s data) and Faraday Road (Claire Ingrem, pers. comm., but for details of the site see Ellis *et al.* 2003). The sample size is small, but it is clear that the British Mesolithic wild

![Size of lower second molar in modern and archaeological European wild boar](image)

**Figure 21** Size of lower second molar in modern and archaeological European wild boar (archaeological specimens from Southern Europe). Island populations are excluded.

![Size of distal humerus in wild boar from different geographic areas in Europe](image)

**Figure 22** Size of distal humerus in modern and archaeological European wild boar (archaeological specimens from Central and Northern Europe). Island populations are excluded. Only fused and fusing specimens included.
boar were much smaller than those inhabiting Denmark. They tend to plot towards the lower half of the distribution of modern European wild boar and are, therefore, probably even slightly on the small side for *S. s. scrofa* from Central Europe. According to a student’s t-test the difference is not statistically significant but this may be a consequence of the small size of the archaeological sample. Some of the measurements from later prehistoric sites (Albarella in press) and the Roman sites of Wroxeter and Chedworth Villa (Hammon 2005; Andy Hammon, pers. comm.) are well in excess of the measurements obtained for the Mesolithic and almost certainly derive from hunted wild specimens. It is unfortunately not possible to gain a precise idea of the average size of these populations, because of the problem of distinguishing the lower end of the wild boar biometrical distribution from the domestic pigs. Yet we are left with the impression that British Mesolithic pigs were particularly small and that size increase did occur in later periods.

**Netherlands**

All data derive from the site of Hardinxveld-Giessendam Polderweg (Louwe Kooijmans 2001) and were recorded by UA and Roel Lauwerier. Third and second lower molar and humerus measurements consistently plot towards the upper range of the modern European wild boar distribution (Figs. 18, 20 and 22), which includes Dutch specimens. Dutch Mesolithic data are therefore comparable with large *S. s. attila* and indicate that animals of similar size used to inhabit Central Europe in the past.

**Germany**

All data derive from the site of Friesack in the North-West of the country and were recorded by UA and Susanne Hanik. It is very difficult to make sense of the tooth measurement data (Figs. 18 and 20) as the values appear to cover a broad range (this includes at least one very small tooth that must represent either an abnormality or an intrusive domestic specimen from upper levels — occupation at Friesack continued in the Neolithic). The humeri form a more compact group (Fig. 22), largely consistent with the measurements of modern European wild boar (most of the modern humerus measurements are in the *S. s. scrofa* rather than *S. s. attila* range, compare with Fig. 8).

**Switzerland**

The Swiss data derive from the site of Birsmatten-Basisgrotte (Bandi 1963) and were recorded by UA, KD and Jörg Schibler. This is also a small data set and, like the German Mesolithic wild boar, is approximately consistent with modern *S. s. scrofa* measurements, which also include modern Swiss specimens. What is puzzling about the Swiss picture is that late Neolithic data recorded by the authors (but also cf. Boessenec et al. 1963; Schibler et al. 1997) indicate that in this period there were wild boar of a size that was largely in excess of that recorded for Birsmatten-Basisgrotte. Though it is unfortunately

Figure 23 Size of distal humerus in modern and archaeological European wild boar (archaeological specimens from Southern Europe). Island populations are excluded. Only fused and fusing specimens included.
not possible to establish what the size range or average size value of the Neolithic populations was (due to the difficulty of separating them from the domestic pigs), it is clear that the upper part of the distribution is consistent with that of the huge Danish Mesolithic wild boar. Although microclimatic differences between Swiss sites may play a role in determining body size the overall evidence suggests that an increase in wild boar size after the Mesolithic is likely. This is a phenomenon that, as we have seen, seems to have also occurred in Britain. This size shift cannot be linked with domestication, which brought about size diminution, and is thus more likely associated with environmental factors. Bearing in mind the relationship between body size and temperature (Davis 1981), the climatic deterioration that occurred in Europe after 3000 BC (Bell and Walker 1992, 71), may well have triggered such an increase. A subsequent size reduction must eventually have led to the size of wild boar we see today in Switzerland, which is comparable to that of the Mesolithic period.

Serbia

Only two lower third molar measurements are available from Serbian pigs (from Greenfield 2008) (Fig. 19) and these are consistent with S. s. lybicus, which is supposed to live in the area today (Groves 1981). All that can be said is that they are much larger than the Portuguese and Italian Mesolithic specimens (see below).

Italy

This is a small set of data from the sites of Grotta Dell’Uzzo and Grotta della Madonna (recorded by UA and KD, but for site details see Tagliaacozzo 1993 and 2000), with the addition of a single specimen from Grotta delle Mura (Bon and Boscato 1993). All sites are located in the South of the country. Tooth data consistently plot at the lower end of the modern European wild boar distribution (Fig. 19) — exactly where the Southern European specimens would be expected to occur — but some of the humeri are rather large, even in excess of modern S. s. scrofa (Fig. 23). Caution is needed due to the small sample, but the possibilities that the Italian Mesolithic wild boar had relatively larger bones than teeth is confirmed by work on later prehistoric sites undertaken by Albarella et al. (2006a). At several Bronze Age sites in Italy, some of the post-cranial measurements are much larger than those provided by any of the Mesolithic bones or indeed recent Central European animals (cf. Albarella 1999; Albarella et al. 2006a). The large size of Bronze Age wild boar in comparison to modern Italian individuals had already been noted by Apollonio et al. (1988), though their hypothesis that this represented the continuation of a phenomenon of Pleistocene gigantism is not supported by our data. Nineteenth- and early 20th-century wild boar of the traditional form found in Maremma (Central Italy) are smaller than these late prehistoric specimens and comparable is size to the Mesolithic animals. It would appear that, as in Switzerland, Italian wild boar have been subject to several size fluctuations throughout their Holocene history.

Portugal

All data were provided by Simon Davis and derive from the sites of Moita do Sebastião, Cabeço da Arruda and Cabeço do Pez. Teeth are very small and plot at the lower end of the modern distribution, where the modern specimens from Portugal can also be found (Figs. 19 and 21). The humeri overlap more with the modern Central European distribution, but not to the same extent as those from Italy. The largest specimens from the Chalcolithic sites of Zambujal and Leceia (Albarella et al. 2005) are consistent with large S. s. scrofa and therefore much larger than those from the Mesolithic. The Mesolithic sites are in hotter and drier areas than those from the Chalcolithic, so it is possible that this size difference is due to micro-climatic factors (Rowley-Conwy 1995). Alternatively, as in Switzerland, Italy and possibly Britain a size increase occurred in Portugal after the Mesolithic.

Middle East

The final period of hunting and gathering in the Middle East is the Epipalaeolithic, but unfortunately very few data were available for this period. In Fig. 24 the modern Middle Eastern data set for M2 measurements is compared with the range and mean of pig measurements from the Middle to Upper Palaeolithic (late Pleistocene) site of Ksar’Akil in Lebanon (data from Kuşatman 1991). It is clear that during the late Pleistocene the size of the wild boar was on average larger than that of recent animals from the regions, which are in any case of a considerable size compared to other wild boar from across the world (see above).

Data from the Mousterian (c. 50,000–40,000 BP) site of Kebara Cave (Mount Carmel, Israel) indicate that the length of the lower third molar was consistently above 40 mm (cf. Davis 1981, fig. 11), whilst the opposite seems to be the case for the Geometric Kebaran (c. 12th–11th mill. BC) site of Ein
Gev III (Galilee, Israel), where all M₃s are shorter than 40 mm (unpublished data from Simon Davis). However, data from the pre-pottery Neolithic A levels (9th–8th mill. BC) of the Turkish sites of Hallan Çemi (recorded by UA and KD, but for site details see Rosenberg et al. 1998) and Çayönü (Eryüñck et al. 2002) seem to be more comparable with the measurements from Ksar’Akil and Kebara Cave than with those from Ein Gev III or recent wild boar. Geographic differences may play a role in these differences as these Turkish sites are a long way north of the Israeli ones, therefore climatic conditions would not be the same. At both Hallan Çemi and Çayönü incipient domestication has been suggested (Redding and Rosenberg 1998) though at Çayönü substantial size decrease only occurs from the later period onwards (Eryynck et al. 2002).

In the Levant a gradual size decrease seems to have occurred in S. scrofa after the end of the Pleistocene, which was probably linked with climatic change, and in particular with a rise in temperature (cf. Davis 1981; Ducos and Kolska Horwitz 1998). However, the evidence from Ein Gev III indicates that the size decrease may not have been linear and that fluctuations probably occurred. The existence of regional variation in the size of different wild boar populations may also have been a factor.

**Far East**

The only available wild boar archaeological data are from Japan, and these derive from a number of sites which collectively represent settlements from the Jomon hunter-gatherer period (6900–3000 BP). Measurements of the lower third molar are plotted in Fig. 25 and derive from the following sites: Haneo and Torihama (early Jomon); Arishikita, Kusakari and Ari Yoshi (mid-Jomon); Ohata (mid- to late Jomon); Rokutsu, Kankanza, Tagara and Satohama (late Jomon); Ai Kosima (late to final Jomon); and Itoku (final Jomon) (all recorded by KD).

The Jomon Japanese wild boar overlap greatly in size with modern animals from both Japan and China, and form a relatively compact cluster, falling mid-way between the miniature pigs from Ryukyu and the huge ones from Ussuriland (Fig. 25). Their average size seems to be intermediate between those of the modern Japanese and Chinese wild boar (the difference with both groups is highly statistically significant according to a student’s t-test). Although even in the past Japanese wild boar were not particularly large, there is evidence that the very small size of modern populations could represent a relatively recent phenomenon. It could perhaps be a consequence of the introgression of domestic genes into the wild populations, or of environmental factors such as habitat fragmentation.

**Conclusions**

From the data outlined above, there appear to be three main trends affecting size variation in wild boar populations in Eurasia:
The occurrence of isolated populations of small size living on islands
A size increase along a South–North cline
A size increase along a West–East cline

Insular dwarfism is a well-known zoological phenomenon (cf. Foster 1964; Sondaar 1977), mainly associated with the selective pressures operating in restricted environments with limited food resources (Masseti and Mazza 1996), as well as the potential absence of ground predators. Since wild boar are good swimmers (Nowak 1999; Allen et al. 2001) isolation can only occur on islands that are very distant from the mainland. The islands of Sardinia, Corsica and the Ryukyu and Ardaman archipelagoes — where the smallest-sized populations of wild boar living today can be found — are all well separated from their respective mainlands. Taiwan is approximately the same distance from mainland China as Corsica is from mainland Italy, and also hosts a population of small wild boar, plotting at the lower end of the Japanese range (cf. Mayer and Brisbin 1991). In contrast, Sri Lanka, which is only slightly larger but closer to the mainland than Taiwan, has wild boar that are very large — in fact, indistinguishable from those of the Indian subcontinent.

In the Northern Hemisphere the existence of a South–North size cline has been traditionally associated with temperature, in particular with the so-called Bergmann’s rule, which suggests that individuals with a large body mass are better suited to survive cold environments (Bergmann 1847; Mayr 1963). Various criticisms have been raised of the Bergmann’s rule (cf. Davis 1981 for a review), but in wild boar there seems to be a convincing inverse relationship between body size and temperature. This relationship may be the consequence of the effect of temperature on food availability rather than directly on body mass (Dayan et al. 1991).

Temperature is not exclusively associated with latitude. Weinstock (2000) has, for instance, emphasized the important effect of continentality, not just in affecting temperature, but also in reducing the level of intra-specific competition during the growth season, as a consequence of the higher mortality during the harsh winters (Weinstock 2000, 101). The large size of wild boar from Central Asia may be explained on this basis. The effect of the Bergmann’s rule in wild boar has been mentioned in relation to apparent size reduction after the end of the last glaciation, which has been witnessed in different areas (Europe and the Middle East in particular). We have seen that a size increase occurred in some parts of Europe after the Mesolithic, and this has led to the tentative suggestion that climatic degeneration may have triggered such change. A further possible explanation is that this occurred as a consequence of a relaxation in hunting pressure following the advent of animal husbandry, as also suggested for the increase in red deer size in Portugal after the Mesolithic (Davis 2006). A diminution in the size of wild boar inhabiting the Bialowieza forest in Poland has been shown to be associated with an excessively high culling of adult animals (Milkowski and Wojcik 1984 in Magnell 2004). Mesolithic settlements were, however, rather sparse and therefore unlikely to

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Figure 25 Size of lower third molar in modern and archaeological (Jomon Japan) populations from the Far East

- The occurrence of isolated populations of small size living on islands
- A size increase along a South–North cline
- A size increase along a West–East cline

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exercise a very intense pressure on wild animal populations. The climatic explanation for the size increase of these animals must therefore be regarded as more likely.

Populations living in Northern areas tend to be larger than their Southern counterparts living at similar longitudes. This trend is clear in both recent and ancient populations of European wild boar, as well as in the Middle East, Central Asia and the Far East. With the exception of those populations affected by insular dwarfism, the smallest subspecies of wild boar is *S. s. vittatus*, which is also the most Southern. The Indonesian pigs also seem to have developed peculiar tooth morphological characters as demonstrated above. It will be interesting to test such characters on archaeological material, as they seem to represent quite a distinctive signature.

A few exceptions to the South–North cline occur, such as the larger size of the South-East European wild boar in comparison with those living in Central Europe. However, we have seen that this may represent a relatively recent phenomenon, as wild boar of *S. s. attila* size (or larger) were present during the Dutch Mesolithic, in Roman Britain, in the Swiss Neolithic and most clearly in the Danish Mesolithic.

A West–East size gradient in *Sus scrofa* has previously been identified (Genov 1999; Magnell 2004) and this has also been observed in other mammal species, such as brown bear (*Ursus arctos*) and red deer (*Cervus elaphus*) (Weinstock 2000). All these species tend to increase in size moving from West to East. Temperature and continentality may both play a role in this phenomenon as a large part of Western Europe is affected by the warming effect of the Gulf Stream. In addition, a move from West to East tends to coincide with an increase in distance from the sea, such as for instance in Central Siberia. The West–East cline has clearly been demonstrated for both Europe and the Middle East, but in Europe it may represent a recent phenomenon, as some large animals seem to have been present in historic Britain and prehistoric Portugal and the Netherlands — all Western Europe countries.

If the smaller size of Western European animals represents a genuinely recent phenomenon, then an alternative to the ‘climatic’ hypothesis will have to be considered. A move from West to East roughly coincides with a decrease in density of human population, from the much-urbanised areas of Central Europe to the sparsely populated steppes of Central Asia. A higher density of human occupation is often the cause of a greater level of environmental disturbance and deforestation. Perhaps the small size of the animals living in the West is a consequence of the relative isolation of populations confined to increasingly smaller pockets of suitable habitats. In these restricted areas wild boar population density could be high, which would result in high intraspecific competition and eventually size reduction (Magnell 2004).

Whatever the local and particular causes, varying combinations of the three factors considered here can explain most of the size variability at least in recent wild boar. If we look at their worldwide distribution, the size difference between those living at the South-Western end of the range (Portugal) and those from the most North-Eastern end (Ussuriland) is huge. There are, however, a few puzzling exceptions, such as the small size of the wild boar living in one of the most Eastern areas — Japan. The Japanese islands are too large to produce typical insular effects, and the country is surrounded by areas with enormous wild boar, such as the Ussuriland, Korea and, to a lesser extent, China. As with Europe, however, archaeological data indicate that Japanese wild boar used to be larger, which raises the question of what may have caused their size diminution. Perhaps a relatively dense human population in recent times has played a part here too. Even more intriguing is the case of Mongolia, which, being Northern, Eastern and continental, has all the characters to be expected to host very large wild boar. This is, however, not the case; perhaps aridity is another factor affecting pig body size, and this could be important in the Mongolian case. Archaeological data from this area — at the moment not available — may provide useful clues to resolve this question.

Inevitably more work is needed to reconstruct clear patterns of variability in wild boar, as well as in trying to understand the multitude of factors that lie behind them. Many questions remain open, but the combination of zoological and archaeological analysis has shown that this complexity can only be understood through a diachronic and more integrated approach to the study of *Sus scrofa*. To achieve this, the biometric approach used in the analysis of modern specimens must consider the comparability of such data with the much more fragmented archaeological evidence. If multiple measurements taken on skulls can help in defining the modern taxonomy of the species, these are also going to be of little use in comparisons with ancient material. A combined biometrical approach to the past and present has already started providing very
important information regarding the variability and evolution of a species which has contributed so much to the development of human societies. With the help of the biometrical framework of reference provided by this paper further archaeological and zoological work has the opportunity to place in a context elements of what promises to become an increasingly fascinating story.

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**References**


Weinstock, J. 2000. Late Pleistocene reindeer populations in Middle and Western Europe. An Osteometrical Study of Rangifer Tarandus (Bioarchaeologica 3). Tübingen: Mo Vince Verlag.