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Pig Hunting and Husbandry in Prehistoric Italy: a Contribution to the Domestication Debate

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In this article the evidence of pig exploitation in the prehistory of the Italian peninsula and Sicily is presented. Though some differences in pig morphology seem to have existed between different parts of the country, a broadly consistent diachronic pattern of change has emerged. In the Mesolithic fairly small wild boars (with bones quite large in relation to the teeth) lived in Italy. For most of the Neolithic pigs of a similar size and shape could be found across the peninsula but signs that a few changes in systems of pig exploitation had started occurring can be found at several sites. This is interpreted as most probably indicating the beginning of a slow and gradual process of domestication of local animals. The hypothesis that early and middle Neolithic pig husbandry relied mainly on imported animals can be fairly confidently refuted. Sometime during the late Neolithic and/or the early Bronze Age, practices of pig husbandry seem to have changed throughout the country, and a much clearer separation appears between the wild and domestic populations. The average size of domestic pigs decreased, probably as a consequence of a closer confinement of domestic herds, but wild boar size seems to have increased, possibly as a consequence of climatic change or of a release in hunting pressure. Recent Italian wild boars (of the traditional Maremman type) are, however, as small as their Mesolithic counterparts, a possible indication that habitat fragmentation caused by human demographic pressure brought about a further change in wild boar size.

INTRODUCTION

The pig (*Sus scrofa*) – in its wild and domesticated forms – has played a very important role in human evolution. Across most of the Old World pigs have been hunted and farmed for millennia and – though in some cultures the consumption of pork came to be forbidden – in many periods and regions they have provided the most staple type of meat for human populations. Pigs, however, have not simply been 'meat producing machines' but have contributed significantly to the organisation of human societies, their beliefs, feelings, and cultural attitudes (Dawson 1998; Nemeth 1998).

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The wild ancestor of the domestic pig – the wild boar – has a very broad natural distribution, including virtually the whole of North Africa, Europe and Asia, with the exception of the Arctic. In several regions within this area (eg, British Isles and Scandinavia) wild boars have been hunted by humans to the point of extinction, but at the same time wild boars have been introduced in many other areas where they did not previously exist, or reintroduced where they had disappeared.

Unlike sheep and goat – whose wild ancestors live in restricted geographic ranges – pigs could potentially have been domesticated anywhere in Eurasia (Clutton-Brock 1987; Davis 1987). The earliest evidence of domestic pigs hitherto known derives from the Far East (Jing & Flad 2002) and the Near East (Flannery 1983; Peters *et al.* 1999; Vigne & Buitenhuis 1999) and dates back to the 8th millennium BC, possibly earlier. The distinction between domestic and wild animals is difficult, particularly at the beginning of the domestication process, when it is hard to pinpoint where – morphologically – the stage of transition occurred. It

is beyond the scope of this paper to discuss the criteria adopted for the identification of domestic animals, and it will suffice to say that they are generally based on a combination of factors such as size decrease, morphological (ie, shape) modification, and demographic change (Ducos 1968; Davis 1987; Benecke 1994). More recently biomolecular analysis has developed into another promising avenue of investigation (Zeder *et al.* 2006), leading to the suggestion that multiple centres of domestication occurred for pigs (Giuffra *et al.* 2000; Larson *et al.* 2005).

Biometrically, the Near Eastern evidence has been thoroughly investigated, raising the suggestion that the process of domestication in pigs could have been extremely gradual – perhaps involving as long as two millennia before a morphologically fully domesticated pig was developed. A gradual reduction in size, uneven in different parts of the body, has been recorded at the Eastern Anatolian site of Çayönü Tepesi (Hongo & Meadow 1998; Ervynck *et al.* 2002), whereas at Hallan Çemi, also in Turkey, strategies involving the cross-breeding of domestic and wild forms may have occurred (Redding & Rosenberg 1998).

It is generally assumed that agriculture and husbandry spread from the Near East to the central Mediterranean via the Balkans (Barker 1985; Bogucki 1988; Price *et al.* 1992; Thorpe 1996; Price 2000; Vigne 2000), reaching the Italian shores probably at the end of the 7th or beginning of the 6th millennium (Skeates 2003). Though alien animal species such as sheep and goat must have necessarily been imported, it is debatable whether pigs and cattle were introduced or locally domesticated. Recent genetic work suggests that the European aurochs (*Bos primigenius*) contributed only minimally to the formation of domestic breeds of cattle (Bailey *et al.* 1996; Troy *et al.* 2001), but there is no reason to expect that a parallel phenomenon should necessarily have occurred in pigs too. The spread of husbandry is likely to have been complex, with different human populations reacting to change in different ways, according to geographic location, environmental, and social conditions. Different factors such as movements of people, animals, goods, and ideas may have operated in different ways in different areas, while introduced and local cultural elements probably both contributed to the shaping of Neolithic societies in the central Mediterranean, as elsewhere in Europe. It would therefore be unwise to try to explain the spread of animal domestication on the basis of a simple dichotomy of indigenous or introduced elements.

The uncertainty that we still have about how animal husbandry emerged as a new cultural and economic element in the Italian peninsula is due to intrinsic difficulties in understanding such a transition in the archaeological record, the dearth of well-dated evidence, but also the fact that many studies carried out so far have focused on local issues. Regional reviews – based on the gathering of large amounts of data – are more rarely attempted. The aim of this paper is to collect comparable data from many prehistoric sites in Italy in order to detect patterns of regional and chronological change. These should provide us with a better understanding of biological variation in pig populations under the influence of environmental as well as cultural factors. Although the study of the earliest pig domestication in Italy represents the main focus of this paper, we have deliberately extended our analysis to later prehistoric sites (up to the end of the Bronze Age) as the domestication processes can be better understood by taking a long term view. The analysis is mainly based on biometrical data – more easily comparable between sites than other sources of evidence – but references to the evidence of kill-off patterns, sex distribution, carcass processing, and genetic diversity will also be made.

MATERIAL AND METHODS

The evidence discussed in this paper derives from three main sources:

1. Data collected in the years 2000–2004 as part of the project on *The Archaeology of Pig Domestication and Husbandry* (APDH), funded by the Arts and Humanities Research Board (now 'Council') and the Wellcome Trust.
2. Published and unpublished data previously recorded by us as part of different projects.
3. Data derived from the literature.

1. This represents the bulk of the evidence discussed in this paper. The recording occurred in three different stages in July 2001 (UA & KD), January 2002 (UA) and January 2003 (UA) and was based at the *National Museo Preistorico e Etnografico 'Luigi Pigorini'* (Rome, Italy). Some

of the material analysed had previously been recorded – and in some cases even published – by one of us (AT) and collaborators. Details of individual assemblages will be provided below. The decision to record previously analysed material is based on the need to apply the same recording protocol to many different pig bone assemblages so that comparability could be enhanced. The purpose of this work was not a full re-analysis, but rather the collection of a selection of ageing and metrical data that could be of particular importance for comparative purposes.

2. Some important pig bone assemblages (published and unpublished) from Italian prehistoric sites – such as Arene Candide, Rivoli, and La Starza – had been previously recorded by two of us (PRC & UA), using similar recording protocols, and could therefore be used as an important additional source of evidence.
3. Although there are some problems in using data already existing in the literature, as there may be differences in the way measurements are taken even when similar definitions are applied, this was too important a source of information to be ignored. Selected measurements, which could relatively unambiguously be taken, were chosen for comparison with the data collected under 1 and 2.

Eruption and wear stages in teeth were recorded following the method developed by 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 the diaphyses, but still showed some open gaps in the fusion line, were recorded as 'fusing'.

The choice of measurements to take was based on recommendations in Payne and Bull (1988), Albarella and Payne (2005), and some other personal observations. Widths and lengths of the 4th deciduous premolar and of the three molars were taken for all mandibular teeth. In addition we measured the width and minimum height of the distal humerus (BT and HTC), the width of the distal tibia (BdP), the greatest length of the astragalus (GLl), and the greatest length of the calcaneum (GL). All these measurements are discussed in the two publications referred to above, or in von den Driesch (1976). The widths of the central and posterior cusps of the lower 3rd 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). Many additional measurements – not discussed in this paper – were also taken. All recorded mandibles were also sexed when canines or canine alveoli were present. Sex can, however, reliably be determined only in individuals old enough to have a sufficiently developed permanent canine.

Epiphyses were measured regardless of their fusion stage, but not necessarily used in the analysis. For the astragalus – which has no epiphyses – we noted the occurrence of particularly light and porous specimens, likely to belong to juvenile, not fully developed, individuals. No attempt was made in separating isolated 1st and 2nd molars on morphological grounds, and none of the assemblages had a sufficient number of these teeth to attempt a separation on metrical basis. Only measurements of 1st and 2nd molars that could be identified on the basis of their position in the mandible were therefore used in the analysis.

Since for most sites samples of individual measurements were insufficiently large to provide significant results, most of the analysis relies on the combination of different measurements through the use of a size index scaling technique (Meadow 1999). This relates the measurements to standard values based on an assemblage of domestic pigs from a late Neolithic site (second half of the 3rd millennium BC) – approximately contemporary with the Italian late Eneolithic/early Bronze Age – in England (Albarella & Payne 2005), and a population of modern wild boars from Turkey (Payne & Bull 1988). The relative size of the various datasets in comparison with the English late Neolithic standard is calculated as the decimal logarithm of the ratio between the measurement and its standard (Simpson *et al.* 1960; Payne & Bull 1988). In other words measurements are plotted not on the basis of their absolute values, but rather of how smaller or larger they are than the standard. The main point is not to compare the data with the standard, but rather for this to act as a yardstick with which to compare the different datasets with each other. The downside of this type of analysis is that the result of pooling different measurements is some loss in resolution, but the great advantage is that it allows us to deal with larger samples and also to carry out a direct comparison of tooth and bone data (Meadow 1999; Albarella 2002a), as will become clearer in the examples provided below.

The statistical significance of the differences between some of the metric data sets has been 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). In cases when the distribution of measurements was obviously much different from normality the test has, however, not be applied. A further difficulty in applying the test to log ratio distributions is that some measurements may derive from the same specimen (eg, up to three measurements could be taken on each lower molar). Consequently, the number of measurements used to create a diagram can be – and generally is – higher than the number of specimens measured. This means that not all measurements are independent from each other – a necessary criterion for the application of t-tests. Nevertheless, it was decided that the calculation of some tests could still provide a useful, though not fully statistically orthodox, interpretative tool. It must be stressed that the results should not be taken at face value but only as an approximate guide to the estimation of differences of means.

The geographic area discussed in this paper includes the whole of the Italian peninsular and Sicily, although coverage is inevitably uneven. The archaeology and zoogeography of Sardinia are peculiar and, since they are more logically associated with Corsica (France) than with the rest of Italy, they are discussed in a separate article dealing with the two central Mediterranean islands (Albarella *et al.* 2006).

Since the beginning of pig domestication in Italy represents a central issue of this paper, the chronological focus is on the Mesolithic–Neolithic transition, but this can only be interpreted in light of a much broader chronological span. This is why data ranging from the upper Palaeolithic to the late Bronze Age have also been considered.

The location of the main sites discussed is presented in Figure 1. Log ratios for tooth measurements are presented in Figures 2–5 and for post-cranial bone measurements in Figures 6–8.

MODERN ITALIAN WILD BOARS

All archaeological data are compared with tooth measurements from modern Italian wild boars and therefore a few words about the present status and recent history of the species in the Italian Peninsula are needed. *Sus scrofa* is a native species in Italy, as its Pleistocene and early Holocene finds prove (see below), though it was extirpated from most of the Italian peninsula and Sicily during the 19th and 20th centuries, mainly due to over-hunting. Relict indigenous populations survived in relatively small geographic pockets in southern and central Italy, but became threatened by interbreeding with introduced wild boars, mainly from eastern Europe (Apollonio *et al.* 1988). At present wild boars can be found across most of the country but many populations are the results of these restocking programmes for hunting. The closest populations to the original Italian animals can be found on the Tyrrhenian side of central Italy, in an area known as 'Maremma', lying between northern Latium and southern Tuscany. Some introgression of eastern European genes is, however, likely to have also occurred in the Maremman wild boars. Taxonomically the native Italian wild boar has been traditionally regarded as a separate sub-species, called *Sus scrofa majori* (De Beaux & Festa 1927) though, more recently, several scholars have questioned its real difference from the nominal sub-species present in most of Europe (eg, Groves 1981; Apollonio *et al.* 1988). Recent mitochondrial DNA work that we carried out as part of the APDH project on Maremman wild boar skulls from the late 19th and early 20th centuries – namely before the main phase of allochthonous introductions – has proved that the Italian wild boars are characterised by a distinct genetic signature comparable only to some specimens found on the island of Sardinia (Larson *et al.* 2005).

The biometric data presented here by and large derive from the same specimens that were analysed genetically. The measurements were taken by Kusatman (1991) at the Museum of Zoology *La Specola* of the University of Florence and are unfortunately limited to dental material as no post-cranial bones were available – a common problem with museum specimens, particularly those deriving from historical collections. The 71 tooth measurements (Figs 2–5) derive from 11 individuals, all from Maremma, with the exception of a wild boar from Campania. They include two males, one female, and eight individuals of unknown sex. It can be seen that most measurements plot in between the 'standards' for the British Neolithic domestic pigs (vertical line) and the modern Turkish wild boars (star). The small outliers are puzzling and are either

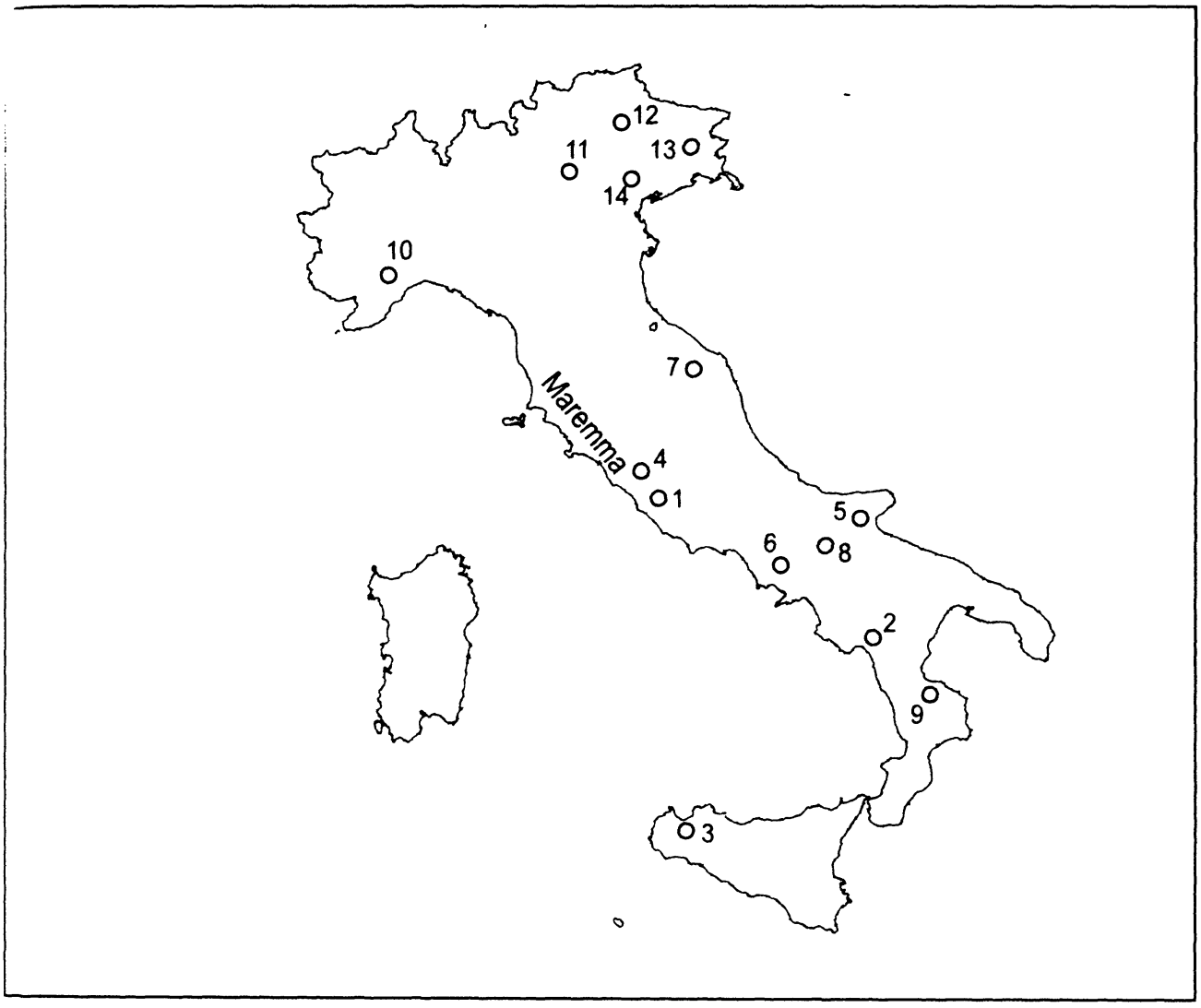


Fig. 1.
Location of the main sites discussed in the text. 1: Palidoro; 2: Grotta della Madonna; 3: Grotta dell'Uzzo; 4: La Marmotta; 5: Masseria Candelaro; 6: Mulino S. Antonio; 7: Conelle di Arcevia; 8: La Starza; 9: Torre Mordillo; 10: Arene Candide; 11: Rocca di Rivoli; 12: Cornuda; 13: Concordia Sagittaria; 14: Molino Casarotto.

abnormal or perhaps the result of recording mistakes.

A recent review has shown that native Italian wild boars are not only smaller than Middle Eastern animals, but are also smaller than wild swine living in central Europe, though they are substantially larger than tiny insular forms from Sardinia and Corsica and slightly larger than specimens from the southern and western parts of the Iberian peninsula (Albarella *et al.* forthcoming a).

SOUTHERN AND CENTRAL ITALY

Palidoro (Latium, central Italy)

Preliminary work on the animal bone assemblage from this site was originally carried out by Cassoli (1976–7). The faunal assemblage derives from upper Palaeolithic levels belonging to the Epigravettian culture (Bietti 1976–7), dating back to the second Würmian pleniglacial/tardiglacial *c.* 18,000–8000 BC (Guidi & Piperno 1992). Tooth measurements indicate that the swine from Palidoro were similar in

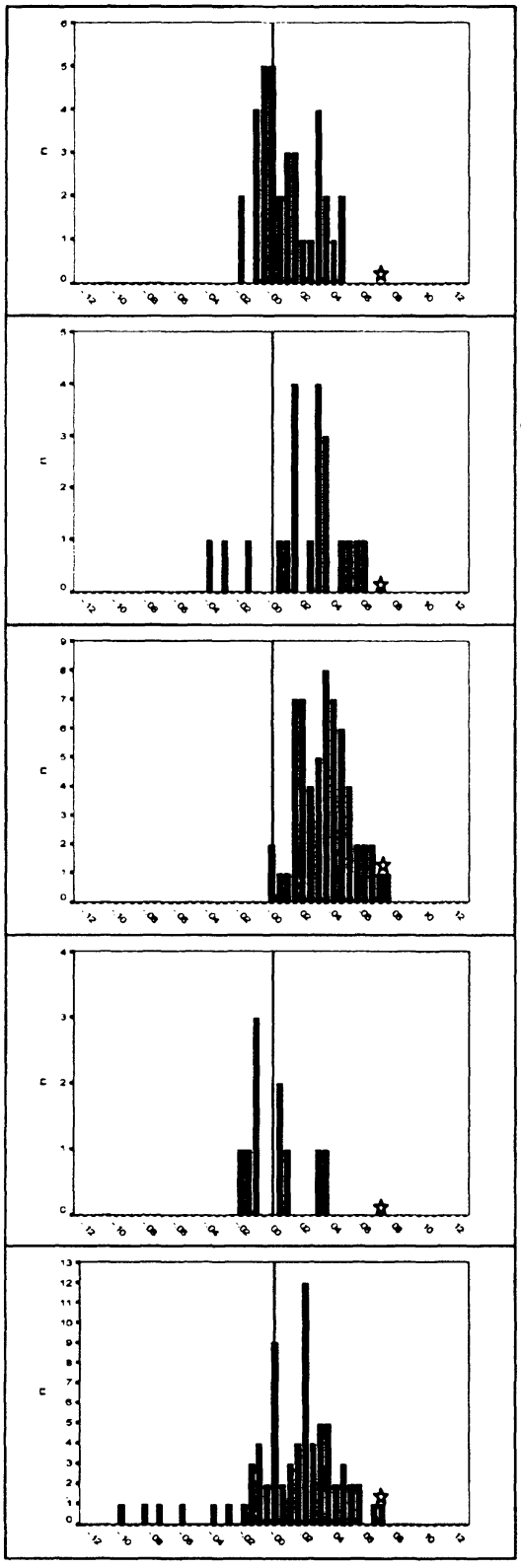


Fig. 2.
Comparison of pig lower tooth measurements from the sites of Palidoro and Grotta della Madonna and modern Italian wild boars (data from Kusatman 1991). The posterior width & length of the anterior deciduous 4th premolar, the anterior & posterior width & length of the 1st and 2nd molars, and the anterior width & length of the lower 3rd molar are combined using a log ratio technique (see text). First and 2nd molars were only used when they could be identified with certainty (ie, they were embedded in a jaw). Lengths of the molars where only used when the wear stage was no higher than 'g' (sensu Grant 1982). The standard 'o' is expressed by a vertical line and is calculated from the late Neolithic assemblage of Durrington Walls (England) (Albarella & Payne 2005), whereas a star indicates the position of the mean value for a modern population of Turkish wild boars (Payne & Bull 1988).

size to modern Maremman wild boars, and substantially smaller than the modern Turkish standard (Fig. 2). Although the small sample size calls for caution, the post-cranial evidence indicates that, in comparison to both the Neolithic domestic and the modern wild standards, body sizes at Palidoro were relatively larger than teeth (Fig. 6). All in all these wild boars were, however, not very large, which suggests that they more probably belong to the later phase of the Epigravettian period, when the temperature had started warming up. The size of modern wild boars is known to follow the Bergmann's rule, namely it tends to be smaller when temperature is high (Groves 1981; Magnell 2004; Albarella *et al.* forthcoming a) and a similar trend has been recognised in animals of the past (Davis 1981). It is worth mentioning that the very few measurements available from the earlier upper Palaeolithic (Aurignatian, 30,000–25,000 BC; Guidi & Piperno 1992) site of Grotta del Fossellone, also in Latium, appear to be much larger, which indicates that pig size decrease occurred in the course of the last Glacial.

Grotta della Madonna (Calabria, southern Italy)

This site has produced a remarkable faunal sequence spanning from the upper Palaeolithic to the Bronze Age. Results of the analysis of the fauna of the Neolithic–Bronze Age levels can be found in Tagliacozzo (2000), whereas the study of the pre-Neolithic assemblage – which has produced the bulk of the data discussed here – is still in progress. The upper Palaeolithic levels at Grotta della Madonna are more precisely dated than those at Palidoro, thanks to a number of radiocarbon dates; they belong to the final Epigravettian (*c.* 10,000–7000 BC), whereas the Mesolithic phase could be attributed to the first half of the 7th millennium BC (Tagliacozzo 2000, 101). The site is on the Tyrrhenian side of northern Calabria (Fig. 1) on a high rocky cliff facing the sea. In the upper Palaeolithic the wild boars from Grotta della Madonna appear to be similar in size to those from Palidoro, perhaps only slightly larger (the difference is statistically insignificant, cf. Table 1). Like Palidoro, the bones were relatively larger than teeth (in comparison to the standards) (Figs 2 & 6). A small

TABLE 1. SIGNIFICANCE OF THE DIFFERENCE OF THE MEAN, AS CALCULATED THROUGH A STUDENT'S T-TEST, IN MEASUREMENTS OF PIGS (USING LOG RATIOS) FROM DIFFERENT PREHISTORIC SITES IN ITALY

Site and date range	*Log ratio (teeth)*		*Log ratio (bones)*	
Palidoro UP/Grotta della MadonnaUP	0.089			
Palidoro UP/Grotta della Madonna Mes	0.000	**		
Palidoro UP/Grotta della Madonna UP+Mes			0.300	
Grotta della Madonna UP/Mes	0.043	*		
Grotta della Madonna Mes/MB	0.000	**		
Grotta della Madonna UP+Mes/MB			0.000	**
Grotta della Madonna Mes/Grotta dell'Uzzo Mes	0.000	**		
Grotta della Madonna UP+Mes/Grotta dell'Uzzo Mes+ Trans			0.003	**
Grotta dell'Uzzo Mes/Trans	0.706			
Grotta dell'Uzzo Mes/EN0.594				
Grotta dell'Uzzo Mes+Trans/EN			0.008	**
La Marmotta EN/La Starza MB	0.000	**	0.000	**
La Starza MB/Torre Mordillo LB	0.011	*	0.017	*
Arene Candide MN/LN			0.039	*
Rivoli MN/Concordia Sagittaria LB	0.000	**	0.001	**

** highly significant; * significant; t-test = two-tailed, no equal variance. The standard from which the log ratios are calculated derives from the late Neolithic assemblage of Durrington Walls (England) (Albarella & Payne 2005).
UP=Upper Palaeolithic, Mes=Mesolithic, Trans=Mesolithic–Neolithic transition, EN=early Neolithic, MN=mid Neolithic, MB=mid Bronze Age, LB=late Bronze Age.

size increase in tooth measurements occurs between the upper Palaeolithic and the Mesolithic, and this is statistically significant (Table 1). Nevertheless, the two phases had to be combined in the post-cranial bone analysis, otherwise too few measurements would have been available.

It is unfortunate that the samples available for the Neolithic, Eneolithic, and early Bronze Age levels are too small to produce meaningful plots. There are also not very many measurements for the middle Bronze Age, but the evidence from this period is presented in Figures 2 and 6, as the occurrence of much smaller animals is easily detectable despite the small sample, particularly in the case of post-cranial bones, and is statistically significant (Table 1). This size reduction is undoubtedly a consequence of the fact that the Bronze Age animals are the result of a process of domestication and selection, with its well-known size decrease effect. No large outliers are visible in the Bronze Age plots, which suggests that the population is likely to have been entirely domestic. It is perhaps worth mentioning that the few measurements available for the early and mid Neolithic indicate the presence of animals more similar in size to those from the Mesolithic than the Bronze Age, and this is consistent with the evidence found at other sites (see below).

Grotta dell'Uzzo (Sicily)

This is one of the most famous sites in Europe for the study of the emergence of farming, as it provides more or less continuing occupation during the key period of the Mesolithic–Neolithic transition (but see Biagi & Spataro 2001 for details about possible gaps in the sequence). The cave is in north-western Sicily (Fig. 1) on the promontory of San Vito lo Capo at *c.* 65 m above sea level; a small plain is easily accessible from the site, and this represents the only fertile area in an environment otherwise little suitable for human habitation. Excavations at Grotta dell'Uzzo were carried out for many years and several different trenches were excavated; the animal bone assemblages from trench M and the very important trench F were analysed by Tagliacozzo (1993), whereas the material from other trenches is still in course of study. Both unpublished and published remains were analysed for the sake of this study, but they are grouped in this article by period rather than trench. The whole period of occupation at the site is regarded to span from the middle of the 9th to the beginning of the 5th millennium BC. Two Mesolithic levels – here pooled together to increase sample size – were identified at Grotta dell'Uzzo, and these are radiocarbon dated from the middle of the 9th to the middle of the 7th millennia BC. They are followed by a period regarded to be 'transitional' between the Mesolithic and the Neolithic, which is dated to the late 7th–early 6th millennia BC (Tagliacozzo 1993, 8). Though transitional, the assemblage from this period seems to have characteristics – such as frequency of the main mammal species – similar to the later Mesolithic phase, and no domestic animals are yet attested. There is, however, in this phase an increase in the range of resources exploited. In trench F a chronological gap seems to separate the transitional phase from the Neolithic levels, whereas in other trenches there is clearer evidence of continuing occupation. Two early Neolithic phases – datable from the mid 6th–early 5th millennium BC – were recognised, the second of which is associated with pottery of the Stentinello type (Tagliacozzo 1997). Introduced domestic species, such as sheep and goat, are attested from the beginning of the Neolithic and evidence of cultivated cereals and legumes has also been found (Costantini 1989). Pig measurements from the two early Neolithic phases were combined – to increase sample size.

The tooth metric evidence indicates that no change in size occurred in the Uzzo wild boars between the Mesolithic and the following transitional phase (Fig. 3; Table 1). Consequently, to increase sample size, the two phases have been combined for the analysis of post-cranial bone measurements (Fig. 6). Overall the Mesolithic pigs from this site are smaller than those from Grotta della Madonna (Fig. 3; Table 1), but this is unlikely to be due to climatic and environmental factors, as these are similar at the two caves. It is possible that the Sicilian pigs were subject to a slight expression of the phenomenon of insular dwarfism, as the Messina Strait could certainly be negotiated by strong swimmers such as wild boars (Nowak 1999), but could have still represented a geographic barrier which might have encouraged the isolation of some populations. The relative size of teeth and bones is not much different from Palidoro and Grotta della Madonna, with bones relatively larger than teeth in comparison to the standards.

In the Neolithic there is a slight decrease in size, though only perceivable in post-cranial bones (Figs 3 & 6; Table 1). Since no climatic change occurred in

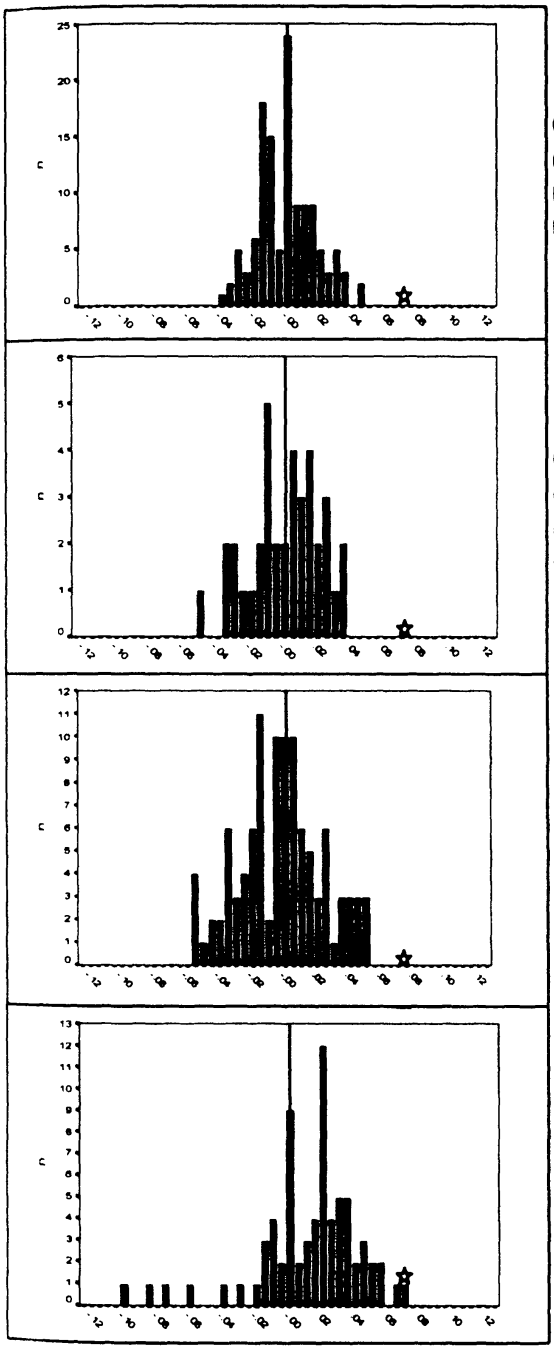


Fig. 3.
Comparison of pig lower tooth measurements from the site of Grotta dell'Uzzo and modern Italian wild boars (data from Kusatman 1991).
For details see Fig. 2

the region at the time of the Mesolithic–Neolithic transition such change is more likely to be due to human interference with the pig population, possibly incipient domestication. This trend had already been identified by Tagliacozzo (1993) and seems to be associated with an increase in the number of animals killed before the end of the 1st year; the proportion of deciduous teeth increases from 39% to 50% from the Mesolithic to the Neolithic (percentage calculated out of the total of dP4+M3; n=49 [Mesolithic] and 20 [Neolithic]). Younger animals are more likely to occur in a domestic herd, as people will have no interest in keeping feeding animals that are close to reaching their maximum growth. Although we cannot be sure that the Neolithic pigs were fully domesticated, the evidence suggests that at least greater hunting pressure – perhaps anticipating a full domestication event – was operated by the inhabitants of the site on the pig population. As a consequence of the overall similarity between the Mesolithic and Neolithic populations, it seems less likely that the pigs from the later period represent the product of importation from other areas, but we will return to this point in the discussion.

La Marmotta (Latium, central Italy)

According to calibrated radiocarbon dates this site can be dated to the middle of the 6th millennium BC and is therefore contemporary to the earliest phase of Neolithic occupation at Grotta dell'Uzzo. It represents, apparently, the earliest known Neolithic lakeside settlement in western Europe (Fugazzola Delpino & Mineo 1995). A preliminary study of the animal bone assemblage – which has revealed the occurrence of both domestic and wild animals – can be found in Cassoli and Tagliacozzo (1993), whereas a specific group of material associated with a well preserved wooden canoe is described in Cassoli and Tagliacozzo (1995). The material analysed for this work includes that discussed in the two publications mentioned and an additional sample, which is still unpublished. The pig metrical dataset is important as it refers to the earliest period of farming in Italy but it is more difficult to interpret than at Grotta dell'Uzzo, due to the absence of comparable earlier material. The more obvious comparisons are with the upper Palaeolithic data from Palidoro (also in Latium) and the Mesolithic data from Grotta della Madonna, which, however, is further south. As can be seen in Figures 4 and 7 pig teeth and bones from La Marmotta are comparable in size to these earlier sites, and the relative proportions of teeth and bones are also similar. This means, that – despite the presence of other domestic animals in the assemblage – we cannot exclude the possibility that they all derive from wild boars. The occurrence of a few small outliers in the post-cranial bone plot, however, raises the possibility that a few domestic animals may also be present in an assemblage. We will return to the interpretation of this dataset once the evidence from other sites has been discussed.

Masseria Candelaro (Apulia, southern Italy)

This site – one of a series of Neolithic ditched settlements found in the Tavoliere, the largest plain of southern Italy – was occupied from the early Neolithic, but the material analysed for this work belongs to the so called middle Neolithic of Scaloria (first half of the 4th millennium BC; Guidi & Piperno 1992). The small assemblage of early Neolithic fauna was reported by Bökönyi (1983), whereas work on the middle Neolithic material is still in progress. On the basis of tooth measurements the pigs from this site represent a homogeneous group with a unimodal distribution (Fig. 4) comparable to La Marmotta and therefore indistinguishable from pre-Neolithic wild boars from the Italian peninsula. It is unfortunate that very few post-cranial bone data could be taken from this assemblage, but those available indicate measurements at the lower end of the La Marmotta range. Consequently, the evidence from this site need not necessarily be interpreted in the same way as for La Marmotta, as an element of body size reduction, presumably a result of domestication, may have been in place at Masseria Candelaro.

The few measurements available from the late Neolithic site of Mulino S. Antonio (Campania) (Albarella 1987–88) indicate the presence of large (domestic?) pigs consistent with La Marmotta and Masseria Candelaro, with some measurements (wild boars?) plotting beyond the upper end of the range recorded at these sites.

Conelle di Arcevia (Marche, central Italy)

The assemblage from this site has produced one of the most important data sets of pig measurements for Italian prehistory. The data discussed here have not

been collected by us, but have been taken from Wilkens (1999). The animal bones were collected from a large defensive ditch datable to the Eneolithic period (*c.* 2nd half 4th/beginning 3rd millennium BC; Skeates 1996; Cazzella & Moscoloni 1999). The evidence from this site is very different from that of the assemblages discussed above, as there is a much greater level of variation and a tendency to a bimodal distribution, particularly clear in the plot of post-cranial bone measurements (Figs 5 & 7). There can be no doubt that both domestic and wild pigs are present at Conelle and in fact the plot of post-cranial bones proves that they are approximately equally frequently represented. The domestic group appears to be of a smaller body size than any of the datasets discussed above – a likely consequence of a more advanced stage of the domestication process – but the wild boars are, on average, substantially larger than any of the Mesolithic or Neolithic animals. Though this may seem surprising, an increase in wild boar size after the Mesolithic has also been attested in other European areas (Albarella *et al.* 2006; Albarella *et al.* forthcoming a). It is also interesting to note that the separation between wild and domestic populations is clearer in bones than teeth. Tooth measurements are generally better suited to assess body size of particular pig populations (Payne & Bull 1988; Albarella & Payne 2005), but what we are witnessing here is a higher rate of size reduction in bones than teeth, as a consequence of domestication. Teeth are more conservative and less susceptible to environmental change, while bones are more plastic and would have reacted more quickly to the selective pressures resulting from human control (Payne & Bull 1988). It can be seen, for instance, that the bones of the domestic pigs from Conelle are far smaller than those of the La Marmotta animals, whereas the difference in tooth size is less pronounced. In other words the tooth/bone size ratio in the domestic pigs from Conelle is more in line with that of the British Neolithic and the Turkish wild boar standards than with the original Italian wild boar – whether this is a consequence of local selection and modification or of importation of exotic stock is hard to say.

La Starza (Campania, southern Italy)

A small animal bone assemblage of Eneolithic and Bronze Age date came out from earlier excavations at this site (Trump 1960–1), but the material discussed here is more substantial and derives from later excavation – still unpublished – carried out under the direction of Claude Albore Livadie in the '80s and '90s. The site lies on a chalky hill at *c.* 400 m above seal level, within a few kilometres of the main Apennine watershed. The evidence presented in this article was collected from an assemblage – so far only partly published (Albarella 1999) – dated to the middle Bronze Age and in particular to the cultural phase known as Protoapennine B (*c.* mid 2nd millennium BC; Guidi & Piperno 1992). The pig metrical sample is strongly biased towards tooth measurements, which are far more common at this site, and display a unimodal distribution consistent with the existence of a single population (Fig. 4).

The average size is similar to that of the domestic element at Conelle, and definitely smaller than in any of the Neolithic sites (Table 1). There can therefore be little doubt that the bulk of the pig teeth found at La Starza derives from domestic animals. The post-cranial bone evidence (Fig. 7) is unfortunately scanty, but it is interesting to note that in addition to the smaller specimens consistent with the tooth measurements, there are a few large outliers, comparable in size to the wild boars from Conelle. Although it is reasonable to assume, on the basis of the evidence discussed above, that wild boars may have had relatively larger bones in comparison to domestic pigs, the difference between the large bone outliers and the teeth is too large to be explained in such a way. A more likely option is that most wild boar skulls were disposed of off site during the hunt and only the main meat bearing parts were introduced to the settlement (Albarella 1999).

At the roughly contemporary sites of Tufariello (Campania; Barker 1975) and Coppa Nevigata (Apulia; Siracusano 1991) the size of the pigs is similar to La Starza, with an absence of any of the large wild outliers. In the small assemblage from Laurino (Campania, Apennine; Albarella 2002b) the situation is similar to La Starza, with a predominance of small domestic pigs and a few very large wild outliers, only represented by post-cranial bones. It is fairly clear that the people of the Protoapennine and Apennine cultures relied little on hunting, as not only wild boars but also other game species, such as deer, are poorly represented at these sites.

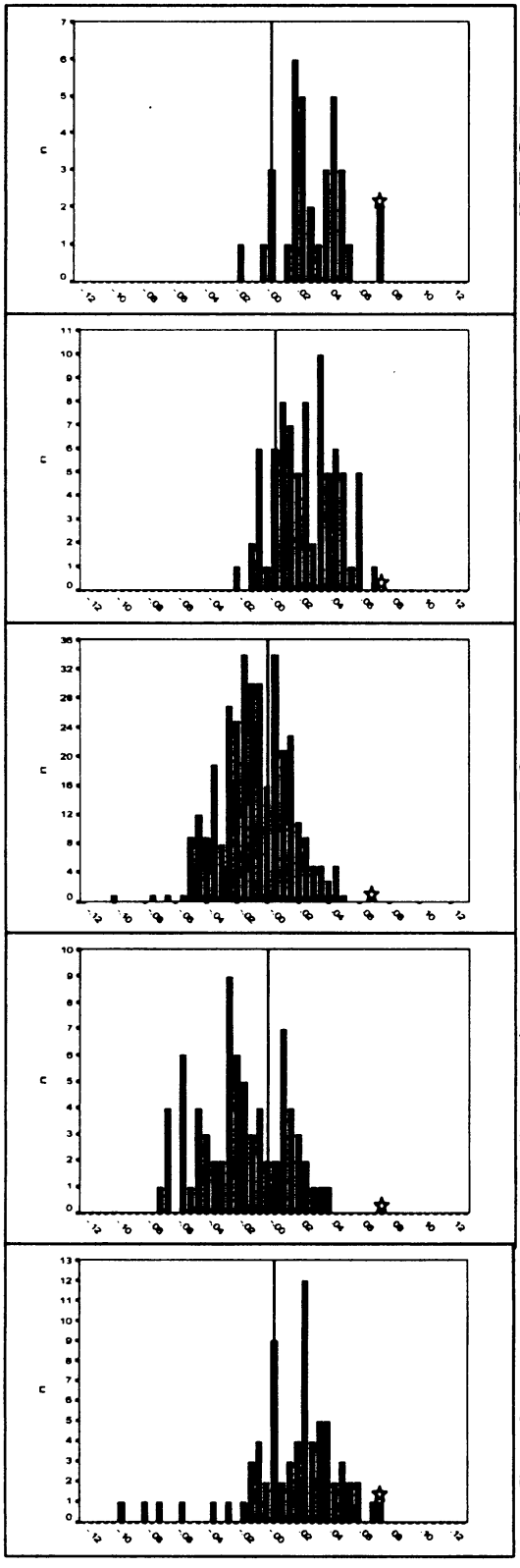


Fig. 4.
Comparison of pig lower tooth measurements from the sites of La Marmotta, Masseria Candelaro, La Starza, Torre Mordillo, and modern Italian wild boars (data from Kuşatman 1991). For details see Fig. 2, but for the site of La Starza measurements of the upper molars (equivalent to those described for the lower molars) have also been included.

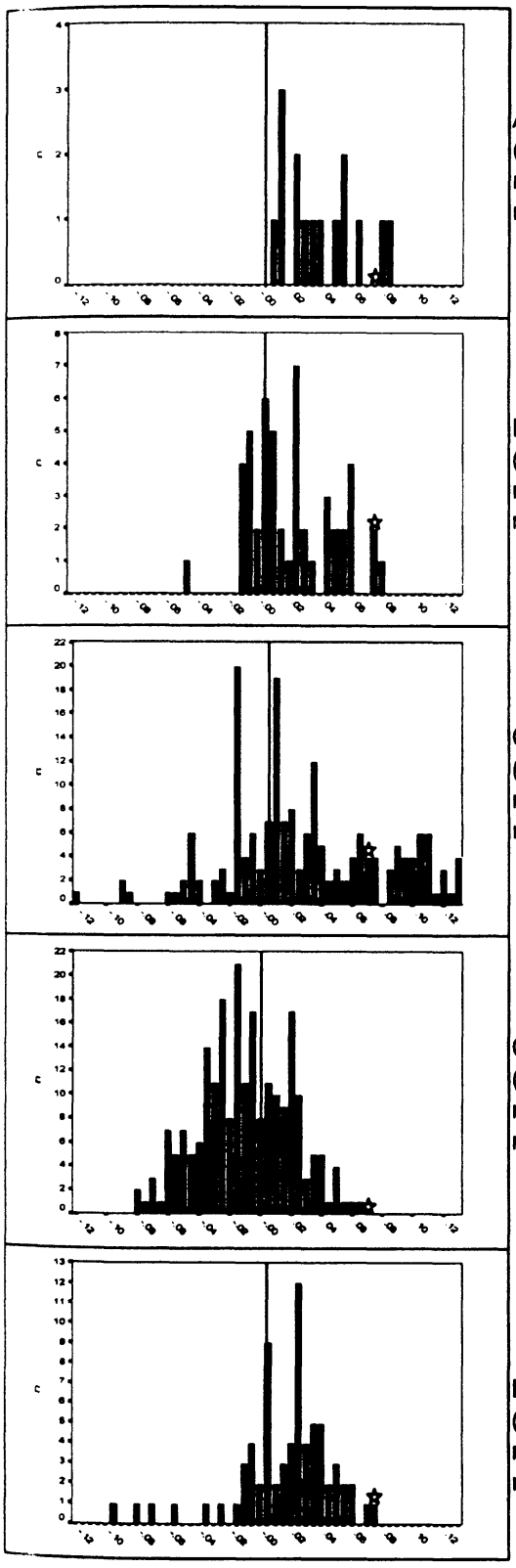


Fig. 5.
Comparison of pig lower tooth measurements from the sites of Arene Candide (data from Rowley-Conwy (1997), Rivoli, Conelle (data from Wilkens 1999), Concordia Sagittaria, and modern Italian wild boars (data from Kuşatman 1991). For details see Fig. 2, but for the site of Arene Candide and Conelle only measurements of the third molar were available.

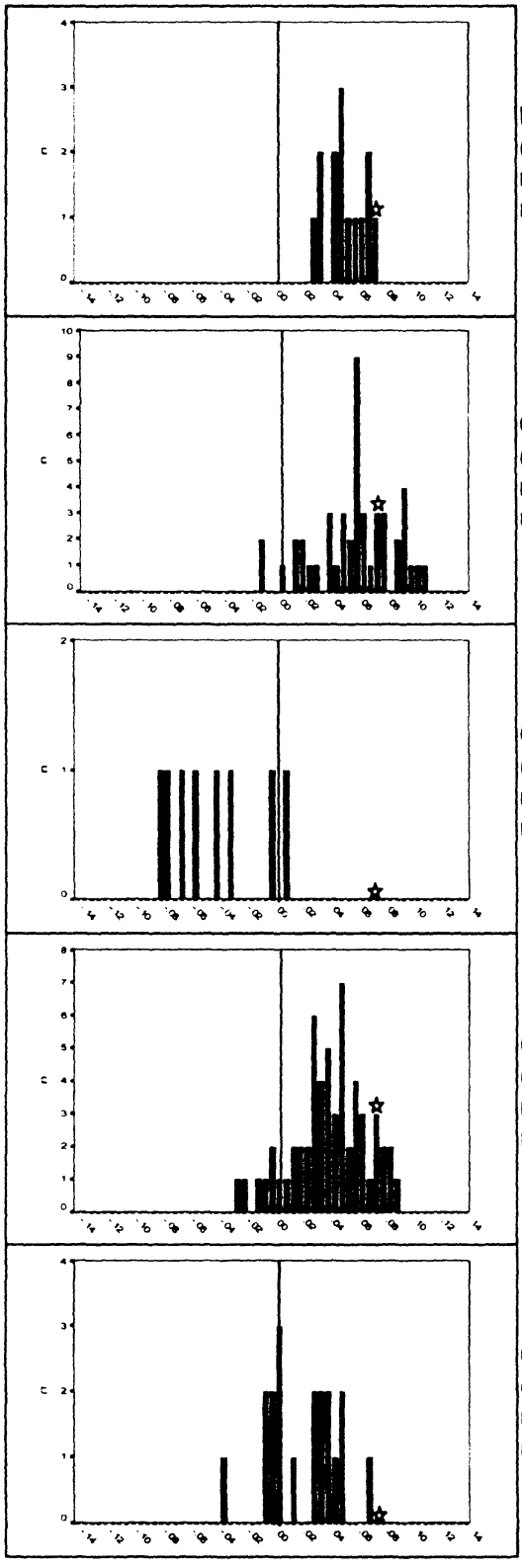


Fig. 6.
Comparison of pig post-cranial bone measurements from the sites of Palidoro, Grotta della Madonna, and Grotta dell'Uzzo. The greatest width of the distal humerus trochlea (BT), smallest diameter of distal humerus trochlea (HTC), greatest width of the distal tibia (BdP), greatest length of the calcaneum (GL), and greatest length of the astragalus (GLl) (following Payne & Bull 1988) are combined using a log ratio technique (see text). The humerus measurements only include fully fused specimens whereas fusing tibiae and calcanei have also been used. Measurements of astragali that were recorded as 'light' and 'porous' were excluded. The standard ('0') is expressed by a vertical line and is calculated from the late Neolithic assemblage of Durrington Walls (England) (Albarella & Payne 2005), whereas a star indicates the position of the mean value for a modern population of Turkish wild boars (Payne & Bull 1988).

Torre Mordillo (Calabria, southern Italy)

The site is on the Ionian side of northern Calabria (Fig. 1) at the edge of a plateau dominating the Sibari plain. Human occupation at this site started in the middle Bronze Age and ended in the Hellenistic period (Tagliacozzo & Curci 2001) but only the late/final Bronze Age phase (late 2nd millennium/early 1st millennium BC; Guidi & Piperno 1992) has produced a substantial dataset of pig measurements. Pigs from this site appear to be, on average, even smaller than those from La Starza, as tooth and post-cranial bone evidence indicate (Figs 4 & 7). It is possible that the process of population isolation following domestication had made further progress in moving from the mid–late Bronze Age, though Torre Mordillo is further south than La Starza and, therefore, geographic variation may have also played a role. Like at La Starza no outliers are visible in the plot of tooth measurements, but two very large outliers – presumably wild boars – can be detected in the post-cranial bone plot. The same explanation suggested for La Starza, namely the disposal of heads off-site, may apply here.

NORTHERN ITALY

Arene Candide (Liguria)

This is a large cave on a promontory at about 90 m above the sea level. The history of the investigation of this site is complex as several excavations by different teams have been carried out over the years and the animal bone assemblages from various excavations and periods of occupation were studied by different researchers. The occupation of the site spans from the Palaeolithic to the Bronze Age, but it is the Neolithic sequence that is of particular importance for the study of past pig exploitation. The pre-Neolithic animal bones were studied by Cassoli and Tagliacozzo (1994), whereas reports of the faunal assemblages from the Neolithic levels excavated by S. Tinè and L. Bernabò Brea can be found respectively in Sorrentino (1999) and Rowley-Conwy (1997). The evidence discussed here mainly derives from this latter work, and the material was not specifically re-analysed for this article. Three main Neolithic levels are considered (from Rowley-Conwy 1997):

- Early Neolithic: 4900–4150 BC, associated with Impressed Ware.
- Middle Neolithic: 4000–3400 BC, associated with Square Mouthed Pottery.
- Late Neolithic: 3300–2800, associated with Chassey pottery.

The middle Neolithic was originally divided into two sub-phases, here combined. The later phase of the Squared Mouthed Pottery culture (Mid Neolithic II at Arene Candide) is regarded by Bagolini (1992) as belonging to the earlier part of the late Neolithic, but, here, for the sake of consistency, the terminology used in the Arene Candide publication will be adopted.

Since only 3rd molars were measured, the early and late Neolithic tooth samples are unfortunately insufficiently large, but the middle Neolithic phase has produced enough data for a comparison with other Italian sites to be carried out (Fig. 5). Although post-cranial bone metric samples for the early and late Neolithic are also small, they are more substantial than for teeth and are, therefore, plotted in Figure 8.

The evidence from tooth and bone measurements indicates that the Arene Candide middle Neolithic pigs are by and large similar in size to those from other Neolithic sites such as Grotta della Madonna and La Marmotta. However, the tendency to a relatively larger size of the bones in comparison to teeth recorded at these sites is not witnessed at Arene Candide; as a consequence the pigs from Arene appear to have slightly larger teeth and smaller bones than those from Grotta della Madonna and La Marmotta. It is, however, possible that this is merely an artefact of the different recording systems adopted, as at Arene only 3rd molars were measured and therefore the different datasets are not exactly comparable. Different authors have interpreted the middle Neolithic pigs as wild (Rowley-Conwy 1997) or domestic (Sorrentino 1999) and, although we will return to this subject once the evidence from other northern Italian sites has been discussed, it is worth mentioning here that the few measurements available from the Mesolithic levels (Cassoli & Tagliacozzo 1994) indicate that 3rd molars may have undertaken a size reduction after the Mesolithic (Fig. 9). A handful of astragalus Mesolithic measurements also plot at the upper end of the middle Neolithic range.

The early Neolithic bone measurements are slightly larger than those from the middle Neolithic (Fig. 8), thus providing a hint that a small element of size reduction may have occurred between the two phases. The late Neolithic sample is tiny but strikingly different, and more comparable to those found in

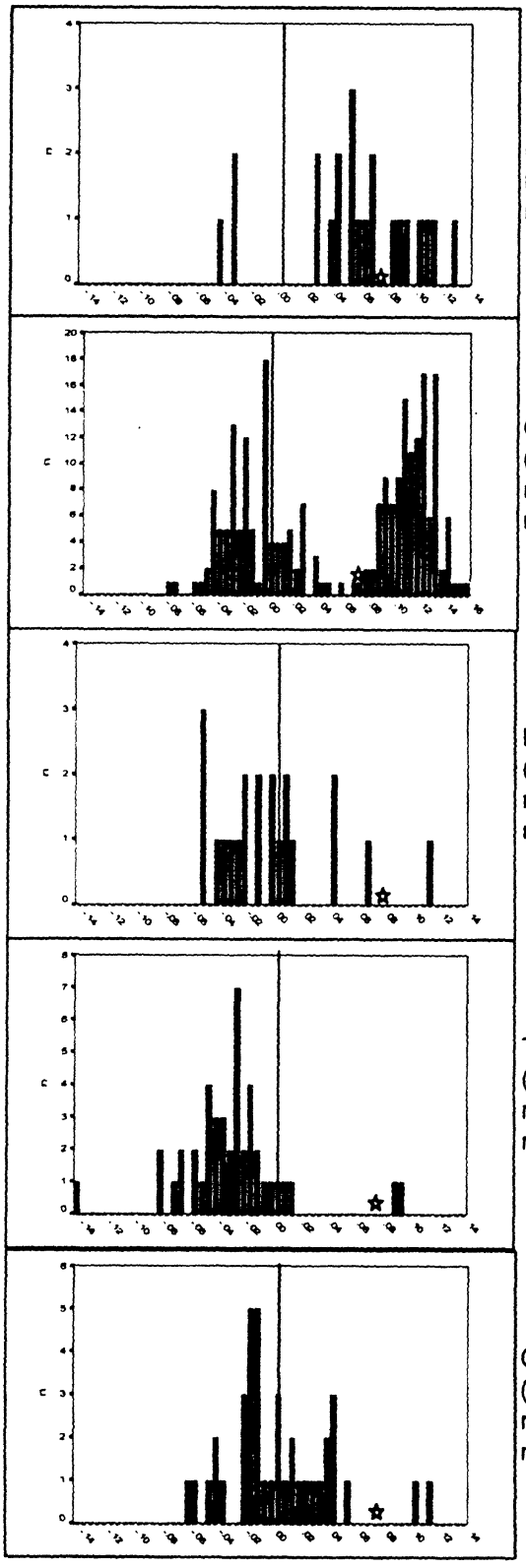


Fig. 7.
Comparison of pig post-cranial bone measurements from the sites of La Marmotta, Conelle (data from Wilkens 1999), La Starza, Concordia Sagittaria, and Torre Mordillo. For details see Fig. 6. Note the slightly different scale used for Conelle. No humerus measurements were used for Conelle as no distinction between fused and fusing distal epiphyses was made in the original report.

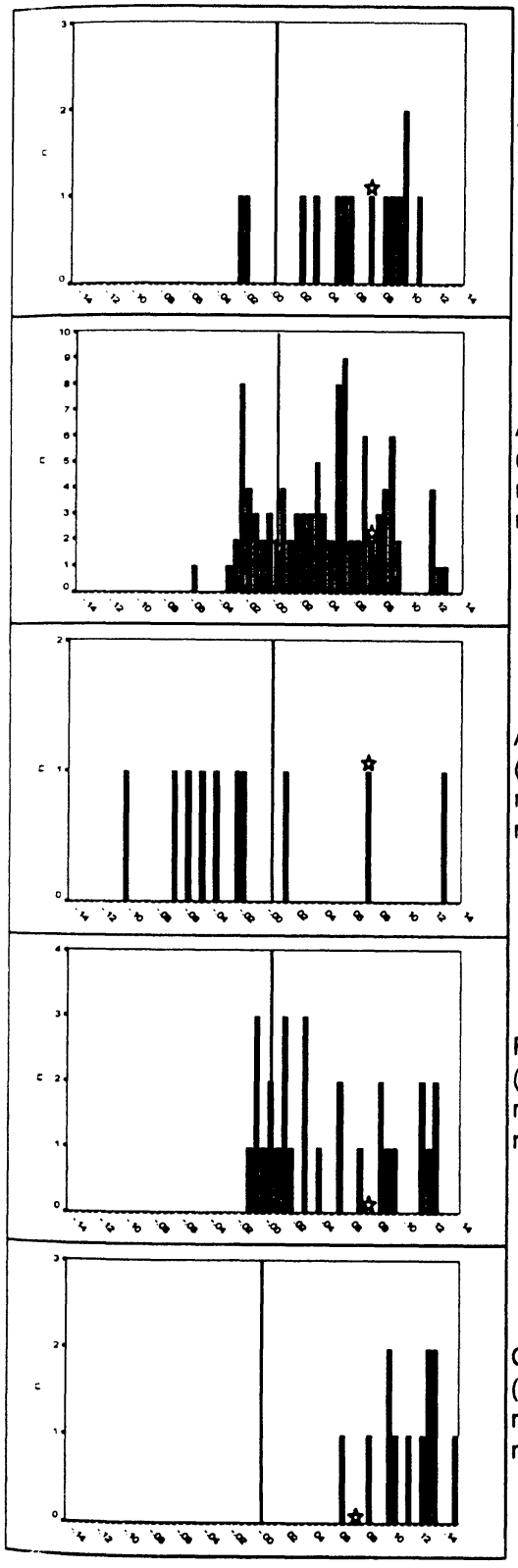


Fig. 8.
Comparison of pig post-cranial bone measurements from the sites of Arene Candide (data from Rowley-Conwy (1997), Rivoli (data from Piper 2001), and Cornuda (data from Riedel 1988). For details see Fig. 6.

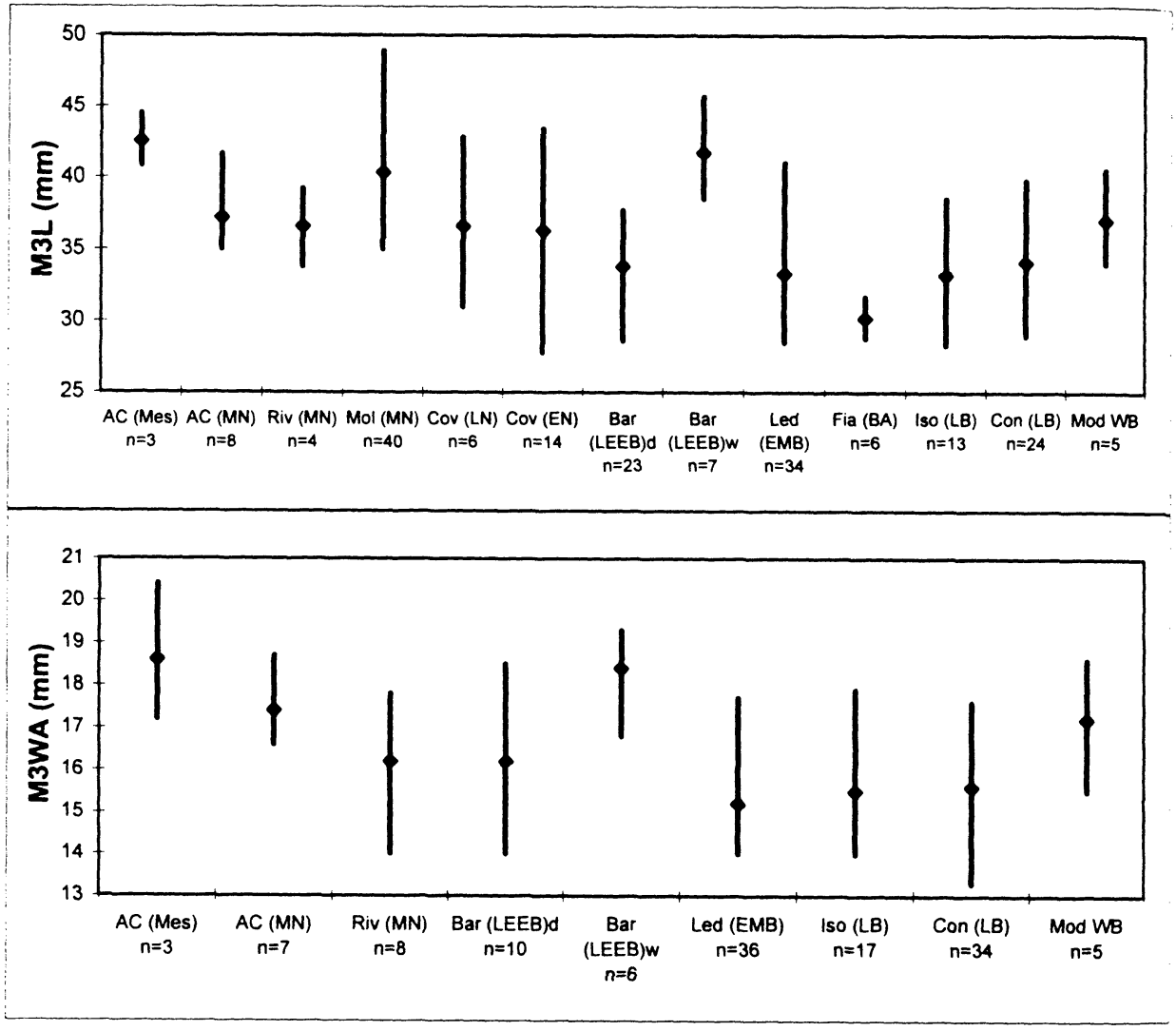


Fig. 9.
Ranges and means of lengths (top) and widths (bottom) of lower 3rd molars from prehistoric sites from northern Italy. Site abbreviations: AC=Arene Candide (Liguria) (from Cassoli & Tagliacozzo 1994; Rowley-Conwy 1997), Riv=Rivoli (Veneto) (from Piper 2001), Mol=Molino Casarotto (Veneto) (from Jarman 1975), Cov=Monte Covolo (Lombardy) (from Barker 1981a), Bar=Barche di Solferino (Lombardy) (from Riedel 1976b), Led=Ledro (Trentino) (from Riedel 1976a), Fia=Fiavei (Trentino) (from Jarman 1975), Iso=Isolone della Prevaldesca (Lombardy) (from Riedel 1976c), Concordia Sagittaria (Veneto) (pers. data); Mod WB=Modern Italian wild boar (from Kusatman 1991). Period abbreviations: M=Mesolithic, MN=middle Neolithic, LN=late Neolithic, LEEB=late Eneolithic/early Bronze Age, EN=Eneolithic, EMB=early/mid Bronze Age, BA=Bronze Age, LB=late Bronze Age. For Barche di Solferino values for specimens identified as domestic ('d') or wild ('w') are presented separately.

Bronze Age sites from southern Italy, with a majority of small animals (domestic) and the occurrence of a few large outliers (wild). Whatever our interpretation of the status of the early and middle Neolithic pigs, a major change – comparable to the Neolithic/Bronze Age shift observed for southern Italy – occurred at the middle/late Neolithic transition at Arene Candide.

Rocca di Rivoli (Veneto)

The site is on a hill on the eastern side of Lake Garda.

at a short distance from the foothills of Monte Baldo. The animal bone assemblage from this site was originally studied by Jarman (1976), but the material was re-analysed as part of a BSc dissertation at the University of Birmingham (UK; Piper 2001), supervised by one of us (UA). This more recent analysis only dealt with the middle Neolithic assemblage, which is associated with the final phase of the Square Mouthed Pottery culture (Barfield & Bagolini 1976), and is therefore contemporary, or perhaps slightly later, than the middle Neolithic II at Arene Candide (for problems with the period terminology see above). Pig size at this site is comparable with the evidence from the broadly contemporary phase at Arene Candide, though teeth are slightly smaller and bones slightly larger (Figs 5, 8, & 9). This means that the relative proportion of teeth and bones – unlike Arene Candide – is at Rivoli similar to the other Neolithic sites considered so far. This confirms the suspicion that the Arene Candide pattern may have been generated by the more restricted set of measurements used (at Rivoli all lower permanent molars and deciduous 4th premolars were measured). Despite the fact that Rocca di Rivoli is slightly more northern and much more eastern and further from the sea than Arene Candide (Fig. 1), climatic conditions are not substantially different between the two sites as, at Rivoli, these are tempered by the vicinity of Lake Garda.

Conuda (Veneto)

This is a site located at the piedmont of the Alps at about 350 m above sea level. The animal bones were studied by Riedel (1988) and belong to the later phase of the Square Mouthed Pottery culture and are therefore contemporary with Rivoli. The data used here were not recorded by us but were extracted from the original publication. The sample is small, particularly for teeth (not plotted), but it is of great interpretative importance as it shows a pattern very different from the other northern Italian sites discussed so far. As can be seen in Figure 8 the size of the pigs from Cornuda is very large, comparable to the wild population from Conelle (Fig. 7). It is quite clear that most, if not all, measured bones belong to wild boars, and these are of a considerably larger size than those found in the Mesolithic of central and southern Italy. The occurrence in the assemblage of smaller, not measurable, pig bones, likely to belong to the domestic form, is mentioned by Riedel (1988), but the interpretation of the large specimens as belonging to wild boars is supported by the fact that, in general, wild species dominate this assemblage. Hunting of red deer, wild boar, and aurochs seems to have been the predominant means of meat procurement at this site. A 'return' to hunting practices, after a long period of heavy reliance on husbandry, has been witnessed at a number of sites in Italy in the later part of the Neolithic and the Eneolithic (Albarella 1987–88; Wilkens 1999).

Concordia Sagittaria (Veneto)

The faunal assemblage from this late Bronze Age site is still in course of study by one of us (AT) and collaborators and is therefore still unpublished. Measurements of pig teeth and bones were, however, specifically collected for the purpose of this work and have provided a fairly abundant sample particularly for teeth. The pattern that emerges is consistent with that observed at other Bronze Age sites, such as La Starza and Torre Mordillo, namely teeth seem rather small and unimodally distributed, whereas bones follow a similar pattern but with the addition of a few, presumably wild, large outliers (Figs 5 & 7). The group of supposedly domestic pigs has a body size that is smaller than the main distribution of middle–late Neolithic animals, but the two large specimens recorded in the post-cranial dataset are consistent with the size of the wild boars from Conelle and Cornuda. In comparison to the 'standards', bones are relatively larger than teeth, but without approaching the difference found in most pre-Neolithic and Neolithic sites.

Other northern Italian sites

A number of other important animal bone assemblages has been studied from prehistoric sites in northern Italy, but for these we do not have full datasets of comparable individual measurement. Nevertheless, it is still worth trying to use them as much as we can in comparison with the evidence discussed so far. Figure 9 presents means and ranges for measurements of the lower 3rd molar, which are commonly recorded by zooarchaeologists. Most puzzling are the data from the middle Neolithic site of Molino Casarotto, Veneto (Jarman 1975), as the mean seems to be intermediate between the main

groups found at Arene Candide and Rivoli and that obtained for wild boars (*cf.* Barche di Solferino in the same diagram). Rowley-Conwy (2003) has, however, shown that at this site there is a typical 'peak and tail' distribution, which means that if we added a few wild boars of similar size to those found at Conelle, Cornuda, or Barche di Solferino to the Arene Candide dataset, we would probably end up with a distribution similar to Molino Casarotto.

All other sites have produced evidence that supports and agrees with the discussion so far. In late Neolithic and Eneolithic levels at Monte Covolo, Lombardy (Barker 1981a) the size of the pigs seems to be consistent with Rivoli, which suggests that the substantial size reduction occurring at Arene Candide at the middle/late Neolithic transition, may have occurred in other geographic areas slightly later, perhaps not until the Bronze Age. In the late Eneolithic/early Bronze Age assemblage of Barche di Solferino, Lombardy, Riedel (1976b) felt confident enough to separate wild and domestic pigs. Even if we take into account the possibility that he may have got the odd identification wrong, the ranges that he eventually comes up with are consistent with the size of domestic and wild pigs at other Eneolithic and Bronze Age sites. At the other Bronze Age site of Nogarole Rocca,Veneto, the measurements are similar to those from Barche, with wild boars representing about 20% of the pig assemblage (Riedel 1992). At early/middle Bronze Age Ledro, Trentino, where the assemblage seems to be more strongly dominated by the domestic component, Riedel (1976a) felt less sure about the separation and a combined range is therefore presented. Fiave', Trentino (Jarman 1975) seems to have had particularly small pigs, even for the Bronze Age standard, whereas the late Bronze Age evidence from Isolone della Prevaldesca in Lombardy (Riedel 1976c) is very consistent with that found at Barche and Concordia Sagittaria. At these Bronze Age sites small domestic pigs, the result of a long history of domestication, seem to dominate.

Shape of the third molar

Some recent work (Albarella *et al.* forthcoming a; Davis 2006) has shown that the shape of the lower 3rd molar may vary in different pig populations and, in particular, in domestic and wild pigs, and that such a difference can be described through the ratio of linear measurements. Consequently such an analysis has been attempted here, as the detection of different morphological types may provide a useful addition to the evidence purely based on size.

Various combinations of measurements and measurement ratios of M3s from several Italian sites, combined by main chronological periods, have been plotted and the most significant diagrams are presented in Figure 10. It can be seen that much overlap occurs between the three selected groups – pre-Neolithic, Neolithic, and Bronze Age – but some

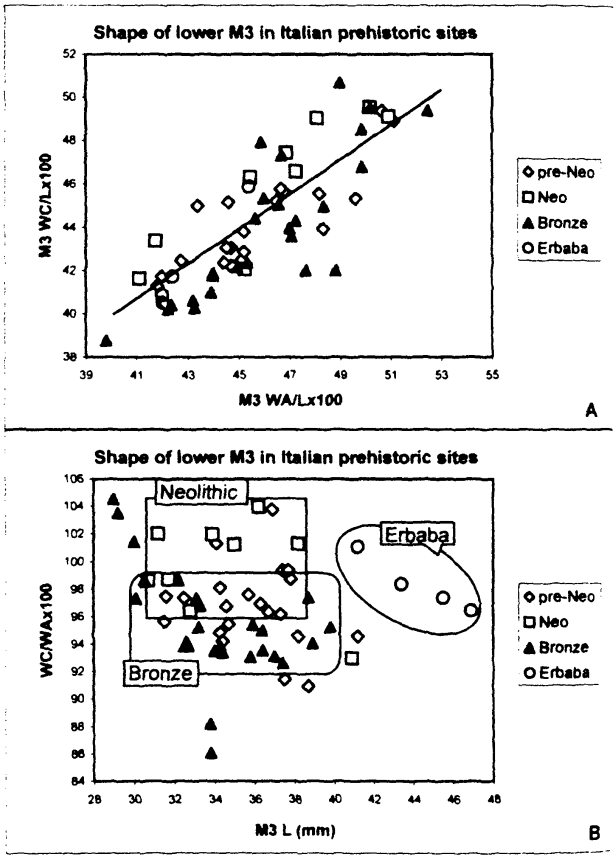


Fig. 10.
Analysis of the shape of lower 3rd molars in pre-Neolithic, Neolithic and Bronze Age times in Italy. L=length; WA=width of anterior cusp; WC=width of central cusp. The following sites are included: Fossellone (upper Palaeolithic, n=1), Palidoro (upper Palaeolithic, n=4), Grotta Romanelli (upper Palaeolithic, n=1), Grotta della Madonna (upper Palaeolithic, n=2; Mesolithic, n=3), Grotta dell'Uzzo (Mesolithic, n=5; Mesolithic-Neolithic transition, n=5; early Neolithic, n=5), La Marmotta (early Neolithic, n=2), Masseria Candelaro (mid Neolithic, n=2), Torre Mordillo (late Bronze Age, n=4), Concordia Sagittaria (late Bronze Age, n=24). The data from the Turkish site of Erbaba (6th millennium) are included as a comparison.

trends can be identified through a closer scrutiny of the scatter plots. For instance in Figure 10A – a size independent scatter plot with ratios on both axes – a diagonal line allows us to separate the small sample of Neolithic specimens (above the line) from most of those belonging to the Bronze Age (below the line). There is no complete separation but the trend is nonetheless apparent, which means that in Neolithic pigs the width of the central cusp (WC) tends to be relatively larger. The scatter of pre-Neolithic wild boars tends to plot across the line and therefore cannot be distinguished from the Neolithic or Bronze Age groups.

In Figure 10B size (length) and shape (ratio of the anterior and central cusps) are compared. It can be seen that in teeth of equal length, the width of the central cusp in comparison to the anterior cusp tends to be larger in the Neolithic. As in the above diagram the pre-Neolithic wild boars are distributed across the Neolithic and Bronze Age groups. Though these differences are not striking, and the sample for the Neolithic is small, these diagrams raise the possibility that size change at the Neolithic/Bronze transition was also accompanied by some modification in tooth relative proportions.

DISCUSSION

A summary of the results presented in the previous section can be found in Figures 11–13. Three main phases of development in pig exploitation can be identified, and these are discussed in chronological order below.

Before domestication

The main evidence available for pre-Neolithic wild boars originates from one site in Sicily (Grotta dell'Uzzo), one in southern Italy (Grotta della Madonna), and one in central Italy (Palidoro), whereas, unfortunately, no large dataset is available for northern Italy. Animals that lived at the peak of the glacial period were probably very large, as expected on the basis of the Bergmann's rule. By the later stages of the upper Palaeolithic, when the temperature had started warming up, body size had decreased, and these pigs appear small in comparison to contemporary animals found in central and, particularly, northern Europe (Albarella *et al.* forthcoming a). Hunting pressure as well as climatic conditions can explain the relatively small dimensions of these animals. A small sample of measurements from Arene Candide suggests that northern Italian Mesolithic wild boars may have been larger, but the evidence from this region is unfortunately scanty. Conversely, Sicilian wild boars were at the lower end of the size variation found in pre-Neolithic Italy, perhaps as a consequence of a modest insular dwarfism. Mesolithic wild boars were on average of a similar size to modern Italian wild boars of the traditional Maremman type, but it would be wrong to assume continuity between Mesolithic and modern times, as size fluctuations occurred, as we have seen in the previous section and as will be further discussed below.

In comparison to modern Turkish wild boars the Italian pre-Neolithic pigs seem to have been large boned in relation to the size of their teeth (Fig. 12). There are three possible explanations for this difference:

- they were of a genuinely different morphological type,
- the archaeological assemblages contain a greater proportion of males, known to be larger boned (Payne & Bull 1988),
- the skulls of some of the larger males were routinely left off site by Palaeolithic and Mesolithic hunters.

Unfortunately only a few of the teeth that were measured could be sexed on the basis of the morphology of the canines, and those are just sufficient to say that males and females are both represented at all sites, though we are not sure in what proportions. Isolated canines were not recorded, but these are in any case highly susceptible to recovery bias and human manipulation for tool making, and do not therefore represent reliable evidence for the reconstruction of sex ratios. Nevertheless, the original work carried out by Tagliacozzo (1993) indicates that no bias in the representation of the two sexes occurred in the Mesolithic levels of Grotta dell'Uzzo.

A relatively larger size of post-cranial bones has also been attested in the Portuguese Mesolithic (Albarella *et al.* forthcoming a) and this supports the assumption that this characteristic genuinely typifies early Holocene wild boars from southern Europe. This is important to bear in mind when comparisons with Neolithic and later pigs are carried out.

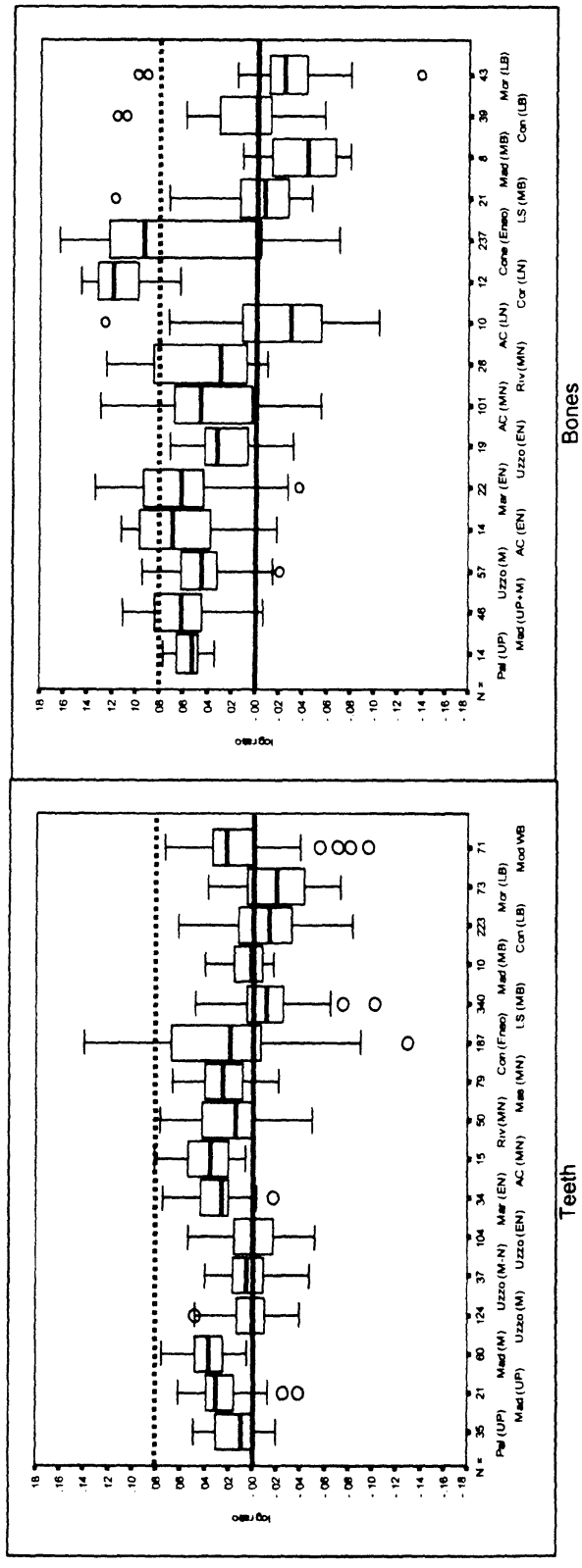


Fig. 11.
Summary statistics for combined pig bone measurements (using a log ratio technique) from a number of Italian prehistoric sites. The standard ('0') is expressed by a horizontal solid line and is calculated from the late Neolithic assemblage of Durrington Walls (England) (Albarella & Payne 2005) whereas a horizontal dotted line indicates the position of the mean value for a modern population of Turkish wild boars (Payne & Bull 1988). The boxplots show extreme values, median, and quartiles, whereas the small circles represent outliers. Site abbreviations: Pal=Palidoro, Mad=Grotta della Madonna, Uzzo=Grotta dell'Uzzo, Mar=La Marmotta, AC=Arene Candide, Riv=Rivoli, Mas=Masseria Candelaro, Cone=Conelle, LS=La Starza, Con=Concordia Sagittaria, Mor=Torre Mordillo. Mod WB=Modern Italian wild boar. Period abbreviations: UP=upper Palaeolithic, M=Mesolithic, M-N=Mesolithic/Neolithic transition, EN=early Neolithic, MN=middle Neolithic, LN=late Neolithic, Eneo=Eneolithic, MB=mid Bronze Age, LB=late Bronze Age.

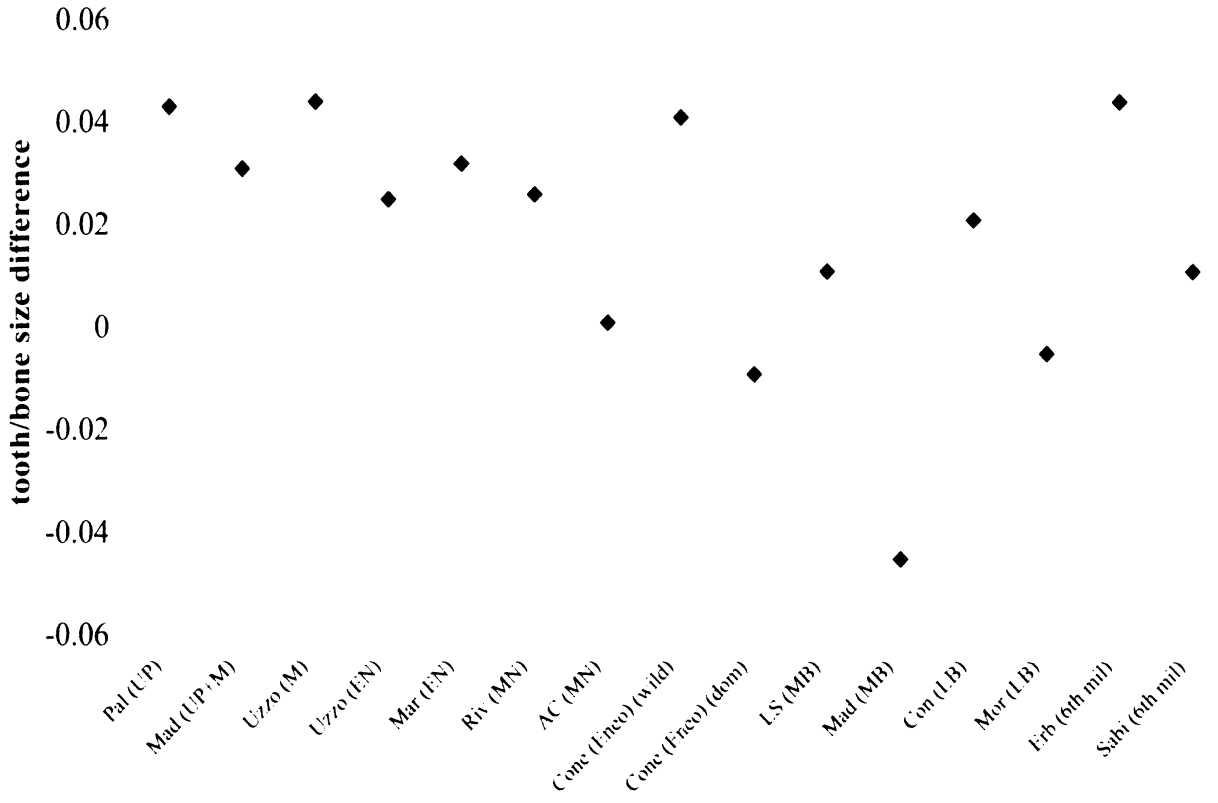


Fig. 12.
Difference in the relative size of pig tooth and post-cranial bone measurements from a number of Italian prehistoric sites. Two Middle Eastern sites (Erbaba, Turkey and Sabi Abyad, Syria) are included for comparison. For abbreviations see Fig. 12. Positive values indicate that bone measurements are relatively larger than teeth in comparison to the late Neolithic assemblage of Durrington Walls (England) (Albarella & Payne 2005), used as a standard. Values on the '0' line indicate that the relatively proportion of teeth and bones is identical to Durrington Walls, whereas a relatively smaller size of post-cranial bones results in negative values. The separate values for wild and domestic pigs at Conelle are estimated.

Early farmers

A recent review of radiocarbon dates for the earliest Neolithic evidence in Italy (Skeates 2003) indicates that farming activity – ie, agriculture and husbandry – started sometime around the end of the 7th and the beginning of the 6th millennium BC in the south-east of the peninsula and from there it spread northwards and southwards, reaching Sicily (Grotta dell'Uzzo) after three or four centuries. Though dates for the early Neolithic in north-east Italy are not quite as early, it is possible that the introduction of the Neolithic 'package' to the north of the country occurred through a different route, with the Po Valley representing the dividing line between these two areas of farming development. In support of the radiocarbon dating evidence there is the claim of a rather abrupt start of the Neolithic in Apulia and Basilicata (Bökönyi 1983; Tagliacozzo 1992), which are the regions that have provided the earliest Neolithic dates. It has been suggested that in this region the beginning of farming represents a predominantly allochthonous phenomenon (Rowley-Conwy 2003), with the Balkans and/or the Aegean area, where farming was well on its way in the 7th millennium (Halstead 1996), as likely areas of origin.

Whether imported domestic pigs were also part of this 'package' is questionable, particularly because we do not have large metric datasets available for these

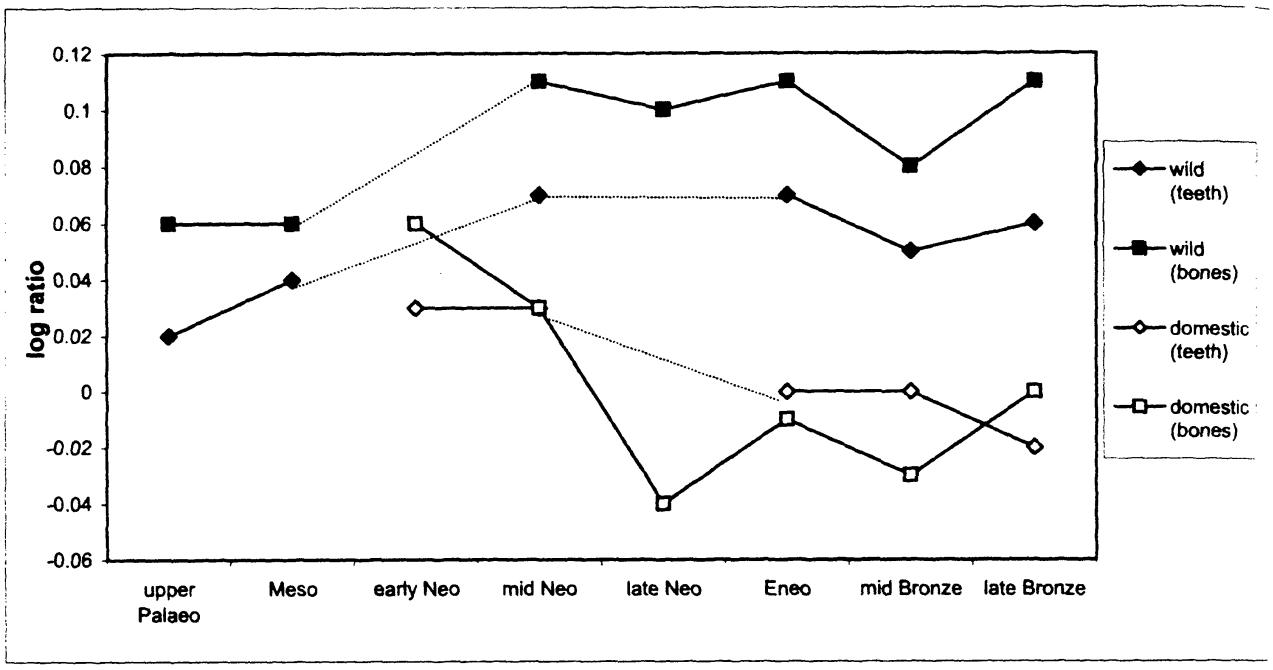


Fig. 13.
Estimate of general trends in size evolution of pigs from prehistoric Italy. Dotted lines indicate that, due to the lack of data in a specific period, the transition from one period to another must be regarded as tentative. In Bronze Age sites, where no wild boar teeth could be found, their size is estimated on the basis of post-cranial bones, assuming that the ratio between teeth and bones was the same as at Conelle. Data from Grotta dell'Uzzo have not been taken into account, to reduce the effect of geographic variation.

very early sites. The site of Masseria Candelaro, in the Apulian Tavoliere, has, however, produced useful evidence for the middle Neolithic period (ie, younger by *c.* two millennia), and this shows that by then pigs were still of a remarkable size, almost indistinguishable from Mesolithic wild boars. In general our evidence – gathered from sites such as Grotta dell'Uzzo, La Marmotta, Arene Candide, and Rivoli – indicates that, for most of the Neolithic, pig body size showed little signs of any substantial decrease from the Mesolithic standard (Figs 11 & 13). Any possible interpretation is, however, made more complicated by the fact that only one site – Grotta dell'Uzzo – has provided the opportunity for a direct comparison of extensive datasets of measurements between Mesolithic and Neolithic levels.

Three possible interpretations for the status of Neolithic pigs in the Italian peninsula can be suggested:

1. Most, if not all, Neolithic pigs are wild, as pig husbandry did not take off until the late Neolithic at the earliest.
2. These were imported domestic animals – and their descendants – that happened to be of a size comparable to the native Italian wild boars.
3. Neolithic pigs were locally domesticated, which brought about a steady but gradual process of size decrease, which would explain their similarity with Mesolithic pigs.

THE WILD HYPOTHESIS

Northern Italy

The possibility that the Arene Candide early and middle Neolithic pigs were wild has been raised (Rowley-Conwy 1997; 2003), but, with the emergence of new evidence, a number of factors seem to conspire against this hypothesis. The small set of Mesolithic measurements from Arene Candide (Cassoli & Tagliacozzo 1994) suggests that a size reduction after this period may well have occurred – though early and middle Neolithic pigs at this site are still rather large (Fig. 9). In addition, there is mounting evidence that wild boar size in Italy increased after the Mesolithic – as it

did in other parts of Europe (Albarella *et al.* forthcoming a) (Fig. 13). Large sized wild boars have been identified from the slightly later sites of Conelle, Cornuda, and, to some extent, Molino Casarotto, and the dimensions of these pigs are well in excess of the majority of those from Arene Candide. A similar pattern to that found at Arene Candide has been identified in other areas in northern Italy, such as the Lake Garda region (eg, Rivoli, Monte Covolo), which means that no great regional variation can be claimed. Although it is difficult to disprove this hypothesis entirely, the balance of the evidence presently available points against it. It seems more likely that at Arene Candide, as well Rivoli, Molino Casarotto, and Monte Covolo, the bulk of the assemblage is made up of remains of domestic pigs, with a variable component of wild boars not easily distinguishable from the domestic population.

Central and southern Italy

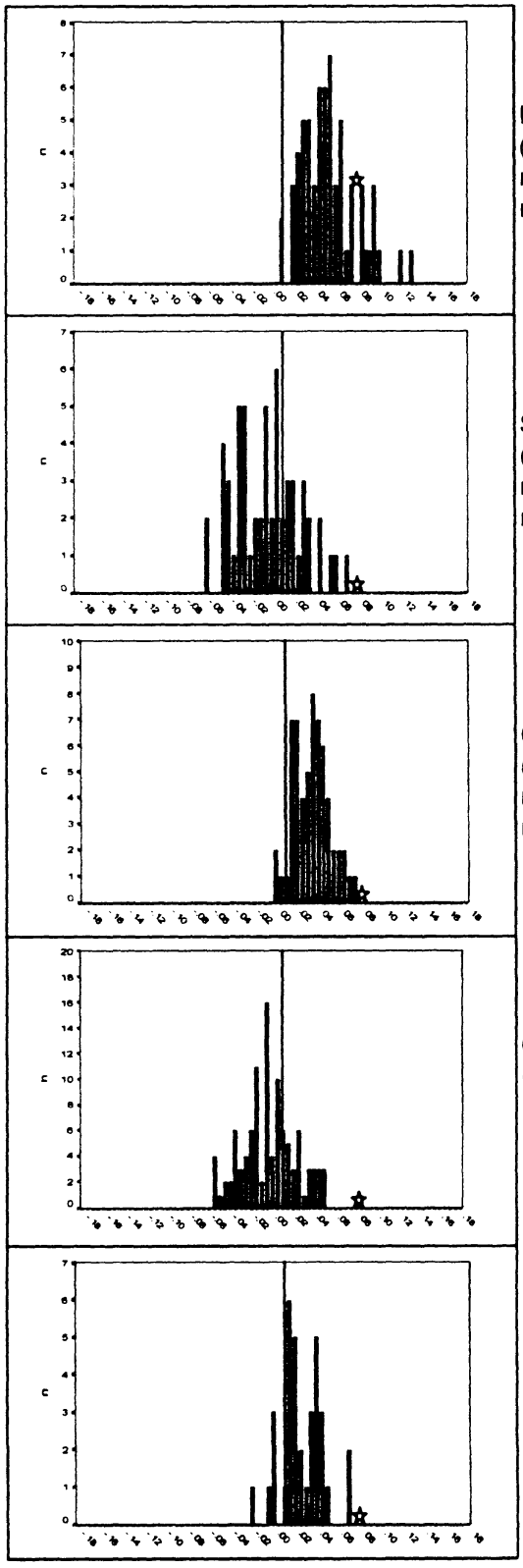
We have seen that it is possible that a wild component may have existed in the early Neolithic pigs from Grotta dell'Uzzo, though small changes in the size of the animals and in the kill-off pattern indicate the occurrence of greater levels of interference with the pig population on the part of the human inhabitants in comparison with the Mesolithic. It is perhaps unrealistic to think that in a period of intense cultural change Neolithic farmers just went on hunting wild boars in the same fashion as their Mesolithic counterparts. The situation at La Marmotta and Masseria Candelaro is in many respects similar to Arene Candide, except that at these two sites we know that no substantial size decrease occurred after the Mesolithic (*cf.* Palidoro and Grotta della Madonna). Yet wild boars identified at the later Eneolithic site of Conelle and at a number of Bronze Age sites are larger, which means that if the wild boars from La Marmotta and Masseria are wild the main size increase of the wild species must have occurred after the middle Neolithic – but, unless we assume substantial geographic variation, the large middle Neolithic wild boars from Cornuda in northern Italy contradict this possibility. If we also bear in mind the possible reduction in bone size occurring at Masseria Candelaro (see above) it seems likely that at these sites, as in northern Italy, the bulk of the population was domestic, possibly interbreeding regularly with wild boars.

INTRODUCED OR LOCALLY DOMESTICATED?

That some of the livestock used by early Italian farmers had originally been imported is unquestionable, as the ancestors of domestic sheep and goats do not live in Europe. The almost complete disappearance of the aurochs by the time of the Mesolithic–Neolithic transition at Grotta dell'Uzzo (Tagliacozzo 1993) also suggests that some domestic cattle must have been imported, an assumption supported by recent evidence from mitochondrial DNA (Bailey *et al.* 1996; Troy *et al.* 2001). Concerning pigs, however, there are several lines of evidence that provide little support for the assumption that Neolithic pig husbandry relied heavily on introduced animals or their descendants. Unlike cattle, modern genetic evidence has highlighted the occurrence of two or more pig domestication events in Europe (Larson *et al.* 2005). Though the evidence analysed so far points to central Europe as a main area of swine domestication, and zooarchaeological data support this (Döhle 1997); there is a strong possibility that this may have occurred in Italy too. The genetic signature of the Italian wild boar seems to be distinctive and, outside the peninsula, it has only been found in Sardinia. If we accept the commonly held suggestion that Sardinian wild boars originate from domestic animals that became feral in prehistoric times (Vigne 1988) (no wild boars were present in Sardinia before the Neolithic), the inevitable conclusion is that, at some point in the past, Italian wild boars must have been locally domesticated and that the Italian peninsula is indeed the place of origin of Sardinian 'wild' and domestic pigs. The evidence is therefore tantalising, and it needs to be further tested through the analysis of ancient DNA presently in progress as part of the APDH project.

Concerning the morphological evidence, we have seen that there are some indications of a slow and gradual process of transformation of Mesolithic wild boars into domestic pigs, such as the slight reduction in size and change in kill-off pattern at Grotta dell'Uzzo and the possible reduction in bone, but not tooth size, at Masseria Candelaro. Even more compelling is the observation that the early Neolithic pigs from Uzzo are smaller than those from the other early Neolithic sites (Fig. 11). Had the majority of the pigs been imported, such regional differences, which reflect the body size of the native wild boar populations, would not be expected.

Hypothetical imported pigs would not necessarily originate from the earliest area of domestication – the Middle East – but they might have reached Italy via the Aegean Sea and/or the Balkans. It we had to accept, however, the idea of livestock introduction as opposed to local domestication in Europe, we should still expect that these pigs would have some characters that are referable to the original Middle Eastern populations, as it has been proved for cattle (Bailey *et al.* 1997; Troy *et al.* 2001). A comparison with Middle Eastern pigs is therefore not out of place, and it is made possible by the fact that as part of the APDH project we collected measurements from the 6th millennium sites of Erbaba in Turkey (Bordaz 1973) and Sabi Abyad in Syria (Cavallo 2000) – due to their chronology and context these are likely to be mainly from domestic animals. Turkey is a more likely area of origin for pig domestication but, nonetheless, the comparison with Syrian material is worthwhile, in order to appreciate the



Erbaba (Turkey)
(6th millennium BC)
n=63
mean=0.056

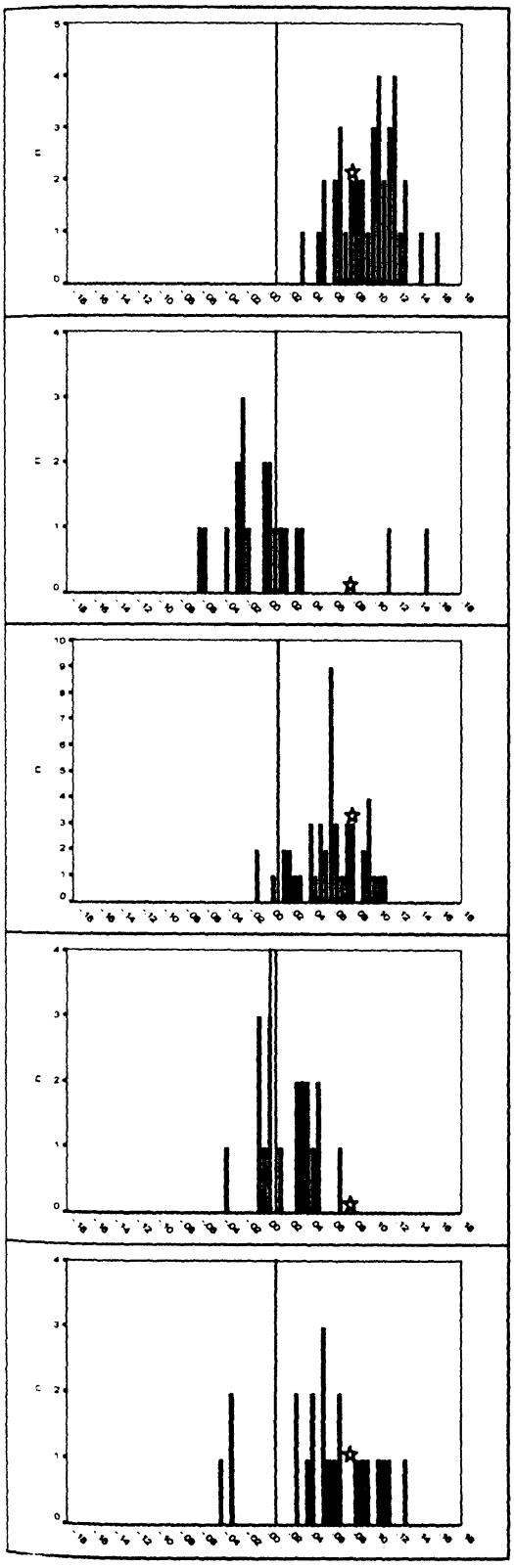
Sabi Abyad (Syria)
(6th millennium BC)
n=57
mean=-0.001

Grotta della Madonna (Calabria)
(7th millennium BC)
n=60
mean=0.037

Grotta dell'Uzzo (Sicily)
(6th millennium BC)
n=104
mean=0.000

La Marmotta (Latium)
(6th millennium BC)
n=34
mean=0.029

Fig. 14.
Comparison of pig lower tooth widths from Middle Eastern and Italian sites. For details see Fig. 2.



Erbaba (Turkey)
(6th millennium BC)
n=38
mean=0.099

Sabi Abyad (Syria)
(6th millennium BC)
n=20
mean=0.009

Grotta della Madonna (Calabria)
(10th-7th millennium BC)
n=46
mean=0.061

Grotta dell'Uzzo (Sicily)
(6th millennium BC)
n=19
mean=0.024

La Marmotta (Latium)
(6th millennium BC)
n=22
mean=0.060

Fig. 15.
Comparison of pig post-cranial bone measurements from Middle Eastern and Italian sites.
For details see Fig. 6.

variation that occurred within the Middle East. Needless to say the two sites cannot be taken as representative of the whole Middle Eastern area. In Figures 14 and 15 tooth and bone log ratios from the Mesolithic of Grotta della Madonna and the Neolithic of Grotta dell'Uzzo and La Marmotta are compared with those of the two Middle Eastern sites. Both Italian Neolithic sites seem to be more similar to native Mesolithic pigs than to either the pigs from Sabi Abyad, which are smaller, or Erbaba, which are larger. The tooth/bone ratio at both sites (Fig. 12) and the shape of the third molar at Erbaba (Fig. 10) also seem very different. If pigs were introduced to Italy in the Neolithic, we would have to assume that they had gone through substantial morphological variation in their journey from the Middle East to the Italian shores.

It is at this point worth going back to our three main hypotheses, to evaluate – on the basis of the data discussed above – which seems to be the most likely:

1. Due to the morphological similarity between Mesolithic and early Neolithic pigs at several sites, the suggestion that no pig domestication occurred in Italy until the late Neolithic cannot be completely ruled out, but, as we have seen, there are several lines of evidence that point to the fact that at least some form of incipient domestication was already on its way in the early Neolithic.
2. It is perfectly possible that domestic pigs were imported to Italy alongside livestock, such as sheep and goats, of certain exotic origin. Our evidence, however, indicates that, if such introduction occurred, this did not involve large numbers of animals. No clear discontinuity occurs between the Mesolithic and the Neolithic, and the bulk of Neolithic pigs of Italy – whether wild or domestic – is more likely to derive from local rather than foreign stock.
3. At the moment local domestication seems to be the more likely hypothesis, as the evidence of a slow and gradual change from wild to domestic pigs tantalisingly mirrors that obtained in Anatolia (Hongo & Meadow 1998; Redding & Rosenberg 1998; Ervynck *et al.* 2002), where the idea of the domestication of native animals is widely accepted. It is, however, important to keep an open mind as we are dealing with complex issues and a combination of events may well have concurred to the origin of pig husbandry in Italy. Forthcoming new evidence, particularly that based on ancient DNA analysis, will hopefully help in clarifying some of the mechanisms that contributed to the patterns of size variation that we have discussed so far.

Evolution and selection

By the late Neolithic pig domestication was well on its way in Italy, and a reduction in body size of many pig populations is clearly detectable. The change can be particularly well observed at Arene Candide, where, after the middle Neolithic, not only pig size decreased, but shed deciduous teeth, indicative of pigs kept on site, start appearing in the cave (Rowley-Conwy 1997). It does, therefore, seem that size diminution must have been the result of a change in management methods. It is likely that in the earlier part of the Neolithic pigs were kept in free-range conditions and would probably spend little or no time on site. If wild boar populations lived in the area pigs kept in these loose conditions would inevitably interbreed and this potential style of management led Jarman (1971) to suggest that in the Neolithic some form of intermediate condition between wild boar and domestic pig existed. Although some of the free-range domestic pigs may have indeed mated with wild boars there is, however, no reason to question their full domestic status (Rowley-Conwy 2003). Our ethnoarchaeological work in Corsica (Albarella *et al.* forthcoming b) suggests that pigs kept completely loose (they could be visited by the herder as rarely as twice a year) would still recognise the swineherd and accept feed from him. These pigs are likely to have some wild boar blood, but, anthropologically as well as archaeologically, they should be regarded as domestic, as it is the way they are perceived by humans rather than their biological status that matters most. An interesting parallel to this situation is that highlighted by Zvelebil (1995) for late Mesolithic sites – mainly coastal – in the Baltic area.

The relationship between pigs and humans cannot easily be categorised. If we start at the predation end of the spectrum of potential interactions, we can observe that even wild boar populations are affected to a variable degree by human activities and in general by the creation of human-made environments. In some cases wild boars live in very close contact with human populations, and sometimes they are even partly managed. Neolithic pigs from some of the sites discussed above may partly represent wild boars that were hunted in an intensive and perhaps partly managed system, which eventually led to local domestication. Redding and Rosenberg (1998) have suggested that management patterns observed in contemporary New Guinea may be applicable to the interpretation of the evidence from sites of potential early domestication in Anatolia. In some New Guinea human populations (Rosman & Rubel 1989) all male pigs born in the village are castrated and reproduction

relies on females straying into the forest where they mate with wild pigs (which in New Guinea should more properly be regarded as 'feral'). It is certainly possible that such practices were adopted in prehistoric societies.

Due to the great diversity of possible interactions between pigs and humans (Fig. 16) the classification of swine as either wild or domestic can only help to describe these animals in very crude terms. Nevertheless, this does not mean that such a distinction is invalid, as most human societies interacting with pigs will have no hesitation in perceiving them as belonging to either one or the other category. Even pigs that cross regularly with wild boars are regarded as domestic by their owners, because they maintain some form of mutual interaction with human groups, even if this may only be represented by occasional feeding or shelter. Inevitably some grey areas between different forms of interaction do exist, but this problem is inherent to the complexity of the natural world, and should not stop us from trying to categorise it.

In the Eneolithic and Bronze Age practices of free-range pig management were likely to have continued but the evidence unambiguously points to the fact that a greater separation existed by then between domestic and wild populations (*cf.* also Riedel 1976b; Tagliacozzo 1992; Figs 11 & 13). Domestic pigs had decreased in size probably as a consequence of more controlled social systems of resource management (Barker 1981b; Barker & Stoddart 1994; Robin Skeates pers. comm. November 2004), which must have caused greater isolation of the domestic herds. At the same time wild boars of a considerable size, unknown at early Mesolithic or Neolithic sites, appear. It is interesting in this respect to contrast sites such as Molino Casarotto (Neolithic), which led Jarman to propose his idea of the 'intermediate' pig, and Conelle di Arcevia (Eneolithic). The earlier site has large pigs, but also a continuum between smaller (domestic?) and larger (wild?) forms, but at Conelle the domestic pigs are smaller and the wild boars are larger, thus generating a curve that, particularly for post-cranial bones, is fairly neatly bimodal.

It is also worth paying attention to the fact that this evolution of pig systems of management not only brought about size diminution but also different relative sizes of different parts of the body. Bones, which are more susceptible than teeth to environmental change, reacted more rapidly to the effects of domestication and decreased in size more substantially (Figs 12 & 13). For the same reason exactly the opposite phenomenon accompanied husbandry improvements in late medieval and post-medieval times: bone rapidly increased in size while teeth remained relatively small (Albarella & Davis 1996). This is why at Conelle the distinction between domestic and wild pigs is more easily carried out on bones than teeth. In Figure12 we can see that the tooth/bone ratio tends to be different in Mesolithic/Neolithic sites on the one hand and Bronze Age sites on the other. As discussed above Arene Candide probably does not follow this pattern due to differences in the recording system. The existence of a slight difference in the morphology of the 3rd molar between Neolithic and Bronze Age sites has also been discussed (Fig. 10).

We must, however, return to the evolution of the Italian wild boar, to wonder why and when such a post-Mesolithic size increase occurred. As mentioned, post-Mesolithic increase in wild boar size has also been observed in other European regions, such as Britain, Switzerland, and Portugal (Albarella *et al.* 2006; Albarella *et al.* forthcoming a) and cannot therefore be explained on the basis of local factors. Bearing in mind the direct relationship between body size and temperature (Davis 1981), the climatic deterioration that occurred in Europe after 3000 BC (Bell & Walker 1992, 71), may well have triggered such an increase. This date would approximately fit with the chronological pattern detected in Italy, where most of the truly large pigs are found from the 3rd millennium BC onwards. Another possibility is that this occurred as a consequence of a gradual 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 boars inhabiting the Bialowieza forest in Poland has been shown to be associated with an excessively high culling of adult animals (Milkowski & Wójcik 1984 in Magnell 2004).

The average body size of the Italian wild boar did not remain stable after the Bronze Age, since, as we have seen, recent wild boars traditionally regarded to belong to the native Italian type are no larger than their Mesolithic counterparts. It is therefore possible that progressive human pressure and habitat fragmentation occurring in historic times may have led to the partial dwarfism today witnessed in the

Fig. 16.
A. Wild boar from Sweden (Photo: Ola Magnell);
B. Domestic pig/wild boar hybrid from Sardinia (Photo: Umberto Albarella); C. Feral pigs from Australia (Photo: Oliver Brown);
D. Domestic pigs (Photo: Jeff Veitch).

Maremman wild boar. A similar phenomenon has been recorded for other areas of the world, such as central Europe and Japan (Albarella *et al.* forthcoming a).

CONCLUSION

To try to explain the spread of farming on the basis of an antithesis between the introduction of an exotic cultural element on the one hand and a local development on the other may be comforting for archaeologists, but it probably bears little relation to the real mechanisms of cultural contact. Recent works (Binder & Maggi 2001; Biagi 2003; Rowley-Conwy 2003) have emphasised the importance of foreign influences for the introduction of the Neolithic in Italy, but have also highlighted the complexity of the issue. The evidence presented in this paper highlights the importance that local resources may have had in the shaping of the life of early farming communities, but it is not necessarily in contradiction with the view of a largely imported Neolithic. If pigs had for the most part been locally domesticated this could still be consistent with the idea of a demic diffusion (Ammerman & Cavalli-Sforza 1973), as new people may well have brought with them the idea of domestication and applied it locally. Unlike sheep, goats, and perhaps cattle, pigs may not have been part of the Neolithic package in the sense that they were physically transported in large numbers to the country, but rather that the idea of their domestication was already well set in the minds of the newcomers. The evidence from Mesolithic sites shows that wild boars were a common and widespread resource on Italian soil and this means that there could have been little incentive in introducing large numbers of pigs. The situation could have been different for wild cattle because, as we have seen in the case of Grotta dell'Uzzo, they had become rare by the time the first farming communities had started settling down.

Unless we accept the idea, which on the basis of the evidence discussed above looks more and more unlikely, that no domestic pigs were present in Italy before the late Neolithic, we must conclude that the domestication of the wild boar was a slow process, and it took millennia before wild and domestic forms became clearly morphologically distinct. The complexity of the interpretation of the evidence for the Neolithic, when domestic pigs appear to have been relatively similar to wild boars, is also caused by the fact that the size of the wild boar changed with time, and cannot therefore be taken as a fixed variable with which to compare the morphological evolution of the domestic pig. The clearer separation between domestic pigs and wild boars that we can observe from the late Neolithic onwards is as much a product of a size *decrease* in domestic pigs as it is of a size *increase* in wild boars (Fig. 13).

This article represents the first attempt to undertake a wide-ranging review of pig husbandry in prehistoric Italy, but it only represents a first step towards a full discussion on this subject. Many gaps still exist in the evidence and these should not only be filled to clarify some of the chronological trends discussed here, but also to try to understand in greater detail possible patterns of geographic variation. In this paper we have mainly tried to highlight general tendencies, but this does not mean that we do not appreciate that domestication and husbandry may have developed unevenly in different areas of the country. Our priority has been to provide a general model that should be integrated and tested at a more detailed geographic scale. The earliest Neolithic communities in Italy may well have mainly relied on the cultivation of cereals and the husbandry of cattle and caprines, but pig exploitation soon also started playing a major role. It is therefore a subject that should not be neglected if we want to understand better the mechanisms of the spread of farming and the beginning of a productive economy in the Mediterranean.

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domestic pigs. This paper is dedicated to the memory of our friend and colleague Pier Francesco Cassoli, who contributed so much to the development of zooarchaeology in Italy.

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