The archaeology of pig domestication and husbandry: approaches and case studies

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THE ARCHAEOLOGY OF PIG DOMESTICATION AND HUSBANDRY: APPROACHES AND CASE STUDIES

Umberto Albarella

Abstract

The main aim of this thesis is to present the potential of an integrated analysis for the study of past relations between humans and pigs. In particular, the advent of pig domestication and patterns of early husbandry in southern Europe will be discussed on the basis of a multidisciplinary approach. The core method is represented by a biometrical analysis of pig teeth and bones from archaeological as well as modern collections. The study of recent material provides the opportunity to detect variation in wild boar size and shape across the whole range of distribution of the species. An archaeological baseline for domestic pigs is obtained through the study of a large Neolithic assemblage from England. With the adoption of a size index scaling technique this is then used as a 'standard' reference for the analysis of southern European material. In addition to this biometrical analysis, a historical approach to the study of pig husbandry in medieval England and ethnoarchaeological work in Sardinia and Corsica provide further opportunities to build up an interpretative framework for the archaeological evidence. A number of case studies from prehistoric and historic Portugal and prehistoric Italy are then presented. In Portugal abundant data collected from late prehistoric and historic assemblages are compared with Mesolithic and Neolithic evidence and provide the opportunity to study variations in patterns of pig hunting and husbandry through a long chronological sequence. The evidence for this country indicates that wild boars increased in size after the Mesolithic whereas no improvement in domestic pigs can be detected until the Middle Ages, which means that practices of free-range husbandry were probably adopted for the whole of the prehistoric and early historic periods. In Italy an even larger number of sites is used to illuminate the evolution of pig exploitation in that particular country. Like in Portugal a pattern of size increase in wild boars emerges after the Mesolithic, but in Italy it is also possible to detect size decrease in domestic pigs, with intensification in pig husbandry occurring probably sometime in the late Neolithic. The similarity in size between Mesolithic and Neolithic pigs confirms the suggestion brought about by genetic analysis that pigs were domesticated locally. The use of a diversity of approaches and the large chronological and geographic scale of this analysis provides us with a unique insight into the great variety of interactions that occurred between humans and pigs and the general importance of these animals in human history.

THE ARCHAEOLOGY OF PIG DOMESTICATION AND HUSBANDRY: APPROACHES AND CASE STUDIES

Umberto Albarella

Ph. D dissertation

Volume 1 of 2

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This thesis is dedicated to the millions of pigs, which are today brutalized in mass-producing factory farms.

1. INTRODUCTION

The pig (*Sus scrofa* L. 1758) - 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 greatly to the organisation of human societies, their beliefs, feelings and cultural attitudes (Dawson 1998; Nemeth 1998).

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 (e.g. 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.

Domestic pigs can now be found almost everywhere, and in areas where their wild ancestors did not exist, such as North America, Australasia and many islands across the world. They have in some cases become feral, thus enriching (or depleting, according to the viewpoint) local faunas and ecosystems. Feral pigs are often treated as a pest, because of the damage they cause to agriculture and/or native animal and plant species, but they are interesting creatures, whose history is closely related to that of human groups travelling around the globe.

Despite being one of a handful of animals that have provided a key contribution to human cultural and economic evolution, the history of the pig has been somewhat neglected by archaeologists. It is quite apparent that a greater interest has been shown in the evolution of domestic caprines, bovines and equids. There are probably two main reasons for this. One is that many archaeologists interested in the past relation between people and animals focus their attention on the earliest origin of farming, and, until recently, there was a widespread view that pigs were domesticated somewhat later than sheep and goats (e.g. Bökönyi 1976; Clutton-Brock 1987) (a view that may been superseded if more recent evidence [cf. Redding & Rosenberg 1998; Ervynck *et al.* 2001] is confirmed). Pigs have consequently not been regarded as key contributors to the beginning of the Neolithic revolution. The second reason is that pigs do not provide the same range of secondary products and services – such as milk, wool, transport power etc. - as some of the other common farm animals. This has probably led to the view that they were of lesser interest and the perception that, in a human context, pigs merely existed as meat providers.

Methodological problems in the study of pig bones and teeth from archaeological assemblages have also not helped. To assess the morphological characteristics of animals that lived in the past is generally difficult due to the inevitably fragmentary nature of the zooarchaeological evidence. The problem for pigs is worsened by the fact that they are often slaughtered at a young age, when their bones are not only more porous and therefore fragile, but also not fully formed and consequently less suitable for the reconstruction of the original size and shape of the animals. A breakthrough in methodological advances is represented by the work of Payne &

Bull (1988), who showed how it is possible to get round the problem of assessing morphology in pigs, in spite of the great proportion of juveniles. However, 16 years after publication, the proposed new methodology has, surprisingly, not been taken on board as much as one might have expected.

As a consequence of the above-mentioned attitudes and problems few reviews of the history of pig domestication and husbandry exist, and to my knowledge the only wide-ranging zooarchaeological work available is represented by the unpublished dissertation of the late Berrin Kuşatman (1991). In addition, a very useful collection of articles – widely used in this thesis – is represented by the volume *Pigs for the Ancestors*, edited by Sarah Nelson (1998); this has the great merit of presenting different approaches – mainly ethnographic and archaeological – to the study of pig history. A plethora of other specific works of course exist (e.g. Flannery 1983; Epstein & Bichard 1984; Rowley-Conwy 1999; Smith 2000; Wiseman 2000; Albarella & Serjeantson 2002; Ervynck *et al.* 2001; Magnell 2004) but more general studies which try to detect broad trends through the integration of different sources of evidence have been hard to come by.

There are several issues that make the compilation of an overview of the history of the pig-human relationship a daunting task:

- The first is related to the huge geographic scale of the phenomenon – as we have seen pigs are distributed over a vast area, and they come into contact with humans in a great variety of environmental, economic and social contexts.
- The temporal scale is also very long and encompasses many millennia – pigs have been hunted by humans probably as long as these latter have existed, and

recent evidence tends to suggest that pig husbandry may be as ancient as 10,000 years.

- In addition, pig history can, and probably should, be investigated by using a multidisciplinary approach, which takes into account the potential of disciplines as disparate as zoology, palaeontology, genetics, ethnography, archaeology and history. Each of these subjects can provide an important contribution, but these will be insufficient if taken in isolation. Previous projects have, however, not been able to encompass such a diversity of approaches.

It is with these questions and problems in mind that in the year 2000 we started at the University of Durham (UK) a project on the Archaeology of Pig Domestication and Husbandry (APDH), of which this dissertation represents only one of a number of several planned outputs. The project is centrally coordinated by Peter Rowley-Conwy, Keith Dobney and myself, but it also benefits from many national and international collaborations.

The project is fundamentally zooarchaeological and its core activity has consisted in the analysis or re-analysis of pig bone assemblages from archaeological sites of many different periods across the world. Recent material mainly located in museum collections has also been studied. We were, however, aware of the need to approach our subject of study in a multidisciplinary way and therefore various lines of investigation – within and in addition to zooarchaeology - were undertaken. These can be summed up as follows:

- Traditional zooarchaeology analysis, which includes:

    - Biometry
    - Ageing
    - Investigation of tooth lesions (hypoplasia in particular)
- Tooth microwear analysis
- DNA analysis on modern and ancient specimens
- Isotopic analysis (mainly nitrogen [N] and carbon [C])
- Ethnography
- History

Not all the above-mentioned approaches are discussed in this dissertation as some of them are led by other collaborators to the project, but it is important to mention their existence as it provides an idea of the more general scope of the project. References to the work carried out on DNA, isotopes and microwear will be made in this thesis, even though this does not represent a core part of the present work. The genetic work is in particular of great importance for several lines of interpretation, though so far only the analysis of the modern DNA has been completed (Larson *et al.* 2005). Work on the ancient DNA is presently in progress and preliminary results look extremely promising, as the framework already set up through the study of the modern DNA aids its interpretation. The analyses of bone isotopic composition and tooth microwear are aimed at the reconstruction of pig diet and consequently of possible management systems (Müldner *et al.* in prep.; Wilkie *et al.* forthcoming). The work on the hypoplasia is potentially useful in addressing issues related to living conditions, environmental stress and seasonal factors, and has so far produced two publications, one dealing with the central and northern European evidence (Dobney *et al.* 2004) and another with a more general worldwide overview (Dobney *et al.* forthcoming), but it will not be discussed here as I have not been leading this particular aspect of the project.

In this dissertation I will specifically deal with four of the various approaches used in this project:

- Biometry: this is part of the traditional zooarchaeological approach but it makes extensive use of the relatively recent methodology proposed by Payne & Bull (1988). A set of standard measurements is proposed that can be of use as a baseline that will support the interpretation of the European material.
- Zoogeography: zoological and archaeological data are integrated in order to try to reconstruct wide-ranging trends of morphological variation in populations of wild boar. As for the DNA analysis, the wild boar framework of reference is essential for our interpretation of morphological types occurring in domesticated pigs.
- Ethnoarchaeology: A specific regional case study is chosen to try to detect patterns of traditional pig husbandry that can be useful in our interpretation of the archaeological evidence.
- History: The aim is similar to that of the ethnoarchaeological work but it is achieved through an integration of documentary and archaeological evidence, once again applied to a particular geographic case study. Ethnoarchaeological and historical data are very much complementary, despite being – deliberately – applied to very different geographic areas.

These four approaches will be considered at length in the first four chapters of this dissertation. After this, examples of how they can aid in the interpretation of particular archaeological questions connected with pig exploitation in the past will be provided in the final two chapters. Geographically, these examples are based in Europe, as this is the area where I have taken a main leading role in the project. This choice adds to the originality of this thesis as the only existing comparable work focuses instead on the Middle East (Kuşatman 1991).

There are three fundamental aspects of this work, which provide the opportunity to view and interpret the past history of pig husbandry in a new light:

- Geographic scale
- Temporal scale
- Overview of large amounts of data from different sites and areas.

The question of geographic scale is important because one of the problems preventing a correct interpretation of the evidence from particular sites can be its narrow geographic remit, which does not allow an appreciation of potential patterns of variation in largely different environmental and cultural contexts. Chapter 3 in particular will deal with this question, providing a worldwide overview of wild boar variability. Any approach that deals with large geographic areas inevitably leads to a loss of resolution on specific local issues. This is why it is important to add to the very general view one that is at a much more localised scale. As we will see in this dissertation specific local issues can help in reconstructing the large scale narrative, but this in turn provides the opportunity to see the evidence of a particular site or specific area in its more general context.

If the worldwide geographic approach allows seeing broad patterns of variability in different pig populations and human societies across the globe, the large temporal scale achieves the same objective, but diachronically. Archaeologists have often looked at the phenomenon of pig domestication as it were restricted in time (the Mesolithic-Neolithic transition) and space (the Middle East), but this has generated an unnecessary interpretative straightjacket for our understanding of this complex phenomenon. We will see that both modern and historical practices can be illuminating for our understanding of phenomena that occurred in early prehistory.

Finally, it has to be stressed that if we want coherent patterns to emerge – and they do emerge, as it will be seen in the rest of this thesis – it is important that many different datasets are compared with each other. The study of pig domestication and husbandry has often suffered from the fact that much analysis has been site-based with little attempt to put the evidence in its broader context. Inter-site comparison inevitably brings with it its own problems, but these can be addressed, especially once a sound methodology based on decades of observations and analysis has been developed (this is the main aim of Chapter 2, as we will see).

The thesis is divided into two main sections. The first represents the core of this work and presents the four approaches discussed above: biometry, zoogeography, ethnoarchaeology and history. The key aims/objectives of this first section are:

- To propose a set of measurements that best describe size, age and sex variability in pigs and to develop a method and a metric baseline that allow an effective use of these measurements for addressing archaeological questions.
- To find out whether the variability that is known for modern wild boar

populations distributed across the world can be expressed through biometrical and morphological characters detectable in their bones and teeth.

- To detect how such variability can be best characterised by biometrical and macromorphological methods and to compare it with the archaeological record so that any geographic or chronological trends can be highlighted.
- To describe pig variability not only in terms of size and shape, but also of husbandry patterns, dietary regimes and social interactions as detected from historical and ethnographic information.

The second section provides examples of the application of the methods and the interpretative framework proposed in the first part, and in particular aims to:

- To define patterns of variation in the use of pigs in prehistoric and historic Portugal.
- To analyse the onset of pig domestication in Italy and its further development in later prehistory.

The methods and case studies presented here will, I argue, allow us to extract very much more information from assemblages of archaeological pig bones than has hitherto been possible. The geographical and methodological breadth allows individual sites and areas to be considered in a wider context, rather than in the relative isolation of a single or a few sites. Some of the constraints associated with smaller-scale studies are thus removed. In this thesis I will try to make the point firstly that pigs are not just rather uninteresting meat-producing machines, but have a wider range of relations with humans than probably any other species; and secondly, that this wide range of relationships can be examined using the methods discussed. It is to be hoped that the reader will be convinced of the rightness of such a wide-ranging and multidisciplinary approach to the investigation of ancient pig husbandry.

APPROACHES

2. BIOMETRY: DURRINGTON WALLS AND THE ESTABLISHMENT OF A METRIC BASELINE

2.1 Introduction

Measurements of animal bones from archaeological sites can be valuable for the distinction of taxa, breeds, sexes and also age groups. Innovations in animal husbandry brought about changes in the morphology and size of domestic animals that can be detected biometrically. In addition, the comparison of animal size in different areas, sites and periods can highlight the existence of environmental and cultural differences and similarities (Boessneck & von den Driesch 1978; Uerpmann 1979; Davis 1981; Albarella 2002a). In this thesis, biometry represents the main approach used for the analysis of pig exploitation in the past - this chapter provides the methodological and interpretative foundations, which are applied, further developed and discussed in the rest of this work.

For biometry to work at its best in zooarchaeology, it is desirable to have large sample sizes, which will ensure statistical reliability. This is, unfortunately not always possible, and the problem is particularly serious in the case of pig (*Sus scrofa*) bones, which tend to be porous and therefore fragile. This is not only a consequence of their natural structure but also of the fact that pigs were generally slaughtered at a relatively young age, as already mentioned in the Introduction. Hence, pig post-cranial bones are frequently relatively scarce or fragmented, and rarely provide large samples of measurements. Pig teeth are much more durable, but zooarchaeologists have traditionally more rarely measured them (though see Payne and Bull 1988). The third molar represents an exception to this general trend, and in fact its length has most commonly been used in attempts to distinguish domestic pigs from wild boar (cf. Reed 1961; Boessneck *et al.* 1963) . However, in many assemblages this tooth is found only in small numbers, as it erupts late and will therefore not be present and fully developed in animals less than ca. 24-30 months old (cf. Habermehl 1975).

As a consequence of these problems there is a general dearth of pig biometrical data in archaeology. Many smaller samples of measurements from particular sites are hardly meaningful if analysed in isolation and can only be used as part of a broader data bank of measurements from a particular area or period, or must be compared with key sites, which have produced large data sets of measurements. Few of these are unfortunately available – particularly in northwestern Europe - and many issues regarding the distinction of wild and domestic populations or attempts to detect differences in the size of pigs in different periods and geographic areas are therefore still unresolved.

One of the aims of this study is to contribute to filling this gap. The large sample of well-preserved teeth and bones from the late Neolithic site of Durrington Walls (Wiltshire, southern England) has provided the opportunity to build up a data set that can be of great use as a comparative baseline for other European material, as we will see in the later part of this thesis. In particular a set of mean measurements derived from this assemblage is proposed as a useful 'standard' (cf. Payne & Bull 1988) to be used to assess size and variability in other assemblages of pig bones from archaeological sites in Europe.

2.2 Material and methods

Durrington Walls, in Wiltshire, is one of a series of English Neolithic monuments known as henge-enclosures (Darvill 1987). It is a large nearly circular enclosure, c.470-480m across, surrounded by a ditch and external bank breached by two entrances (Wainwright & Longworth 1971). The site has been attributed to the Grooved Ware culture (Late Neolithic), with dates that calibrate to ca. 2800-2400 BC (Darvill 1989). Henge-enclosures have generally been interpreted as ceremonial or partly ceremonial sites, though their precise function is still not completely understood.

The material discussed here derives from the excavations carried out in 1966-67 (Wainwright & Longworth 1971). These brought to light a number of structures within the enclosure, which, as well as the ditch-end contexts, produced abundant animal bone remains. The faunal assemblage was originally analysed by Harcourt (1971), who identified about 8500 specimens, mainly belonging to domestic cattle and pig. Many bones were in such excellent condition that prompt burial has been suggested (Albarella & Serjeantson 2002). Gnawing marks were present, but not particularly common, while the high frequency of butchery marks leaves no doubt about the fact that the bones represent food remains.

The choice of a Neolithic sample for this study was deliberate. Inevitably the analysis of archaeological material presents problems, as sex, precise age, place of origin and diet and other environmental variables cannot be established in the same way as for modern reference material, and an archaeological sample may include wild boar as well as pigs, and may include pigs from more than one source. No suitable modern reference sample of pig skeletons of a size comparable to that of the Durrington Walls assemblage is, however, available. The Durrington Walls pig bones also have the advantage, if they can be shown to be reasonably homogeneous, that they come from an early stage of pig domestication, and are more comparable with other archaeological pig bones than modern pig bones as modern pigs have been very heavily modified by selective breeding. A full discussion of the choice of 'standard' measurements in zooarchaeology can be found in Meadow (1999) and Albarella (2002a).

In 1991, the Durrington Walls pig bones and teeth were temporarily moved to the Ancient Monuments Laboratory (English Heritage) in London, where they were washed and recorded. The choice of measurements to be taken was mainly based on their general availability in archaeological assemblages. For instance, since complete bones are only rarely found in archaeological sites, no lengths of long bones were taken. A complete list of measurements taken can be found in Table 2.1.

As one of the aims of this study was to investigate the variation of measurements in relation to age and sex, ageing and sexing data were also recorded. Tooth wear was recorded following Grant (1982) (only mandibles) and following a modified version of Bull & Payne (1982) (both mandibles and maxillae). Epiphyses were classified as 'fusing' when the epiphysis was fused to the diaphysis but there was still a visible open area along the fusion line (Bull & Payne 1982), and as 'fused' when there was no longer an open part of the fusion line. Tooth wear and epiphysial fusion were also recorded for specimens that provided no useful measurements, and these are included in the analysis of ageing data. Sex distinction was based on the morphology of canines and canine alveoli. The presence of burning marks and pathological conditions were also noted as they can affect size.

A full data set of the measurements taken is available on the web page of the Archaeological Data Service (ADS) at http://ads.ahds.ac.uk/catalogue/projArch/pigs_durham_2004/. The Durrington Walls faunal remains are presently stored at the Salisbury and South Wiltshire Museum.

2.3 Age and sex in the Durrington Walls pig bone assemblage

The mandibular ageing evidence from the Durrington Walls assemblage points to a killing peak at 'immature' age (*sensu* O'Connor 1988), at a mandibular wear stage (MWS) (Grant 1982) between 9 and 13 (Figure 2.1). These are animals that were probably killed towards the end of their first year. Assuming that most births were likely to occur in spring, these pigs were probably slaughtered in winter (cf. Ervynck 1997). Winter killing makes sense economically as this anticipates the period of shortage of suitable food in the forest, but it could of course also be related to the period of occupation of the site or the timing of particular activities. A smaller number of specimens were killed in their second and third year ('subadult' and 'adult' *sensu* O'Connor 1988), but in these cases the season of slaughter is difficult to establish. Very few specimens belonging to 'juvenile' and 'elderly' animals were found.

The evidence provided by the maxillae is at first sight rather different: there are relatively fewer 'immature' jaws and more 'subadults' and 'adults' (i.e. animals killed in their second and third year, rather than in the first - Figure 2.1). As maxillae are scarcer than mandibles (74 as compared with 112), this may partly be explained by the greater fragility of younger maxillae; the ageing evidence provided by the mandibles is probably to be taken as more reliable. However there are significantly more 'subadult' and 'adult' maxillae than mandibles, which suggests that the explanation may be more complex.

The fusion evidence indicates that about 25-30% of the animals were killed before the early fusing epiphyses fused (i.e. before c.1 year), about 50% before the middle fusing epiphyses fused (i.e. before c.2 years) and 70-90% before the late fusing epiphyses fused (i.e. c.3-3 ½ years). On average therefore the evidence of the post-cranial bones indicates an older kill-off pattern than the mandibles. As the number of post-cranial bones is higher compared to the number of jaws and teeth than is usual in archaeological pig assemblages, this has been taken as suggesting (Harcourt 1971; Albarella & Serjeantson 2002) that the skulls of some of the older pigs may have been disposed of off site or were used for display.

Broadly, however, the sources of evidence all indicate that the pig remains from Durrington Walls mainly derive from animals killed between the second half of their first year and the third year; this makes them very comparable with other archaeological assemblages as this is a typical kill-off pattern for pig populations of the past.

Males and females were probably about equally frequent in the assemblage, on the basis of alveolar counts, which indicate the presence of 15 females and 19 males for the combined total of lower and upper jaws. Male upper canines were much commoner (85%) in the assemblage than female upper canines, but this is probably the result of recovery bias as female canines are much smaller. Male lower canines were relatively scarcer in the material examined (48%), but some of those illustrated in a photograph published by Harcourt (1971) were not found, and it seems likely that the original ratio in the recovered assemblage was closer to that for the upper canines; they were probably similarly affected by initial recovery bias.

This makes this a good reference collection for the purpose of this study, as mean values of different measurements will include similar numbers of both. This is important because the pig is highly sexually dimorphic, with males substantially larger than females.

2.4 Size of the Durrington Walls pigs

In Figs. 2.2 and 2.3, the pig measurements from Durrington Walls are analysed using a size index scaling technique (Meadow 1999), which relates the measurements to standard measurements based on the skeletons of a sample of Turkish wild boar (Payne & Bull 1988). The relative size of the Durrington Walls measurements 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).

This method allows different measurements to be compared directly, as can be seen in Figs. 2.2 and 2.3, in which the distribution of the Durrington Walls measurements is shown in relation to the "0" line provided by the Turkish standard. In general the Durrington Walls measurements are smaller than the Turkish wild boar standard, but larger than most of the pig bones included in the archaeological case studies presented by Payne and Bull (1988).

The means of different measurements in the Durrington Walls assemblage do not always have the same relationship to the Turkish standard, indicating that average proportions are different from the Turkish sample; this is not surprising because there is no reason to believe that the Durrington Walls pigs should have exactly similar proportions. The differences in proportion are not, however, very large.

Different measurements show, as expected, different variability. If measurements of unfused and fusing bones are excluded, thus giving a better estimate of adult variability, Pearson's coefficient of variation (V) in the Durrington Walls assemblage ranges between 3.7 and 10.6, the anterior width of the upper deciduous fourth premolar (dP^4WA) being the least variable measurement, and the width of the neck of scapula (SLC) the most (Tables 2.2-2.4). Most measurements have a coefficient of variation that ranges between 4 and 6, which is the kind of value that would be expected from a single population (cf. Simpson *et al.* 1960); higher values may depend on sexual dimorphism (Brothwell 1993). A similar range of coefficients of variation was reported by Kratochvíl (1981) in a study of a very large pig bone assemblage from Mikulčice (6th-10th cent. AD) in the Czech Republic.

Pearson's coefficient of variation should not be used as a measure of variability for measurements that do not show a unimodal distribution. A Lilliefors test (modified version of Kolmogorov-Smirnov test) (Tables 2.2-2.4) shows that the distribution of most measurements is not significantly different from the normal curve. Exceptions include the widths of the lower first molar (M_1), the length of the lower third molar (M_3) and the width of the proximal radius (BpP). For these measurements a non-parametric coefficient (NPV) is used, which, however, provides comparable results to those deriving from the coefficient of variation. The significantly non-normal distributions of M^1WP, M_1WA and, in particular the highly significantly non-normal distribution of M_1WP, are unexpected. Their variability is however relatively low, and so no sample inhomogeneity is indicated.

This generally low variability suggests that the Durrington Walls pig bones are probably from a single population, as do the generally unimodal or close-to-unimodal distributions in Figs. 2.2-2.3. This is also supported by the low level of intra-group variation found in a pilot study of tooth morphometry (Warman 2000). The relatively small size in relation to wild boar, and the age distribution, suggest that the Durrington Wall pigs were, as would be expected, domestic. A small number of large specimens (e.g. one very large radius and two rather large tibiae [Figure 2.3]) may be from wild boars; but they could equally represent tails of the main distribution, and thus be unusually large domestic specimens. Whichever is the case, their frequency is low and thus they have relatively little effect on assemblage means.

2.5 Age-related variation in the Durrington Walls measurements

Age has an opposite effect on tooth measurements and post-cranial bone measurements (Payne & Bull 1988). Once fully formed, teeth, as a consequence of crown wear, tend to *decrease* in size as the animal gets older, whereas bone size can *increase* even after the full fusion of the epiphysis to the diaphysis.

Age related reductions in molar lengths were recorded by Kratočhvíl (1981) in medieval domestic pigs from Mikulčice and by Payne & Bull (1988) in the modern wild boar population from Kızılcahamam (Turkey). This is confirmed by the analysis of the Durrington Walls pigs, which shows that the lengths of the lower first and second molars are significantly smaller in specimens with advanced wear (Table 2.5 and Figure 2.4; using Student's t-test). By contrast, and as Payne & Bull (1988) also point out, no statistically significant size reduction occurs in molar widths (Table 2.5). A likely threshold for length reduction in molars is when the dentine occupies most of the occlusal surface of both cusps (stage 'g' *sensu* Grant 1982). It can therefore be concluded that the lengths of molars worn beyond this stage should not be used to assess pig size, whereas molar widths can still provide reliable information until molars are very worn. The problem is less serious for the length of the third molar because, being the last to erupt, this tooth is only very rarely found in advanced stages of wear, and only the wear of its anterior cusp can affect its length.

During the early stages of the life of a pig, bones obviously increase rapidly in size with age. Such increase, however, occurs to a different extent and at different stages in different bones. Size increase during the process of fusion can to some extent be assessed by comparing the measurements of unfused, fusing and fused specimens (Figure 2.5). Total size increases through the whole lifespan are larger, and the results reflect the particular age distribution of the assemblage; however relative differences between different parts of the skeleton are indicative. Distal humerus measurements show low increases, of the order of 5%, greatest in the maximum width of the distal epiphysis (Bd) and smallest in the maximum height of the trochlea constriction (HTC), which suggests that this last is the least age dependent of the distal humerus measurements and therefore probably the best for assessing size. This is consistent with age-related patterns of variability is sheep (Davis 1996).

Despite having a small epiphysis that presumably fuses in a relatively short time, the breadth of the proximal radius (BpP) increases substantially between fusing and fully fused stages. Payne & Bull (1988) also found that this measurement showed substantial post-fusion growth; this suggests that this measurement is very age dependent and probably not as useful as others in assessing size. The distal tibia epiphysis is quite obviously not fully-grown when still unfused, but, in contrast to the proximal radius, the increase in its breadth (BdP) between fusing and fully fused stages is minimal, and it is therefore a good measure of size. The size increase in the depth of the calcaneum (GD) between unfused and fused specimens is large, but there are unfortunately too few fusing specimens to assess the level of increase during the fusion process.

Growth in measurements after epiphysial fusion can be partly estimated by comparing measurements of earlier-fusing ends of long-bones in bones whose later-fusing end is unfused, with earlier-fusing ends in bones whose later-fusing end is fused. This requires complete long bones, which are relatively scarce in most archaeological assemblages. The Durrington Walls assemblage included eight complete humeri, one femur, one radius and thirty-one tibiae. Only in the case of the tibia were there enough specimens to assess post-fusion growth in the earlier fusing epiphysis – in this case the distal end. Figure 2.6 compares the maximum widths of fused distal tibiae (BdP) in bones with unfused proximal ends (thus between c. 24 months old and c. 42 months old) and with fused (or fusing) proximal ends (thus older than c. 42 months – ageing follows Silver 1969). No significant difference was observed in the size of the distal width between the two groups, supporting Payne & Bull's (1988) finding that this measurement shows little post-fusion growth. These authors also suggested that in other long bones, such as radius and humerus, the distal end – unlike the tibia – increases substantially even after fusion. The higher coefficient of variation of scapula, humerus and radius measurements (Tables 2.3-2.4) goes some way in supporting this hypothesis. At Mikulčice the width of the distal tibia shows some degree of post-fusion growth (2.1%), but this is smaller than in widths of the distal humerus (3.6%) and the proximal radius (5.0%) (Kratochvíl 1981). In conclusion, of the long bone ends that are commonly found in archaeological sites, the width of distal tibia seems to be the least age related and therefore probably the most reliable measurement in assessing size in pigs.

The width of the neck of the scapula (SLC) and long bone shaft widths (SD) show greatest increase with age (Figure 2.5). These measurements are therefore of little use as indicators of average body size in pigs; but they may, conversely, be very useful in the detection of age grouping and seasonal killing (e.g. Rowley-Conwy 2001). Measurements which show substantial growth in the first year, such as SLC in the scapula and SD in the humerus, and which are reasonably often preserved in archaeological assemblages, are likely to be of particular value.

2.6 Discussion

Most Durrington Walls pigs were slaughtered between their first and third year. If more very young and elderly animals had been present, this would have increased the variation shown; but as the ages of the Durrington Walls pigs is a common pattern of age at slaughter in domestic pig populations, the variability of the Durrington Walls pig bones is likely to represent a typical example of the standard variability to be expected in archaeological pig assemblages.

As we have seen above some measurements are more variable than others, and age plays a greater and more continuous role in the growth (or reduction) of some elements than in others. The two factors are generally correlated - a very age-dependent measurement tends to have a high coefficient of variation; but other factors, such as sex, and diet and other environmental conditions can also affect measurements and their variability (Brothwell 1993). If we want to use biometry to compare distinct populations – for instance domestic and wild or the possible introduction of a new type of animals at a certain phase of a particular site – it is important that we choose those measurements that are less affected by age, sex and environmental differences.

Measurements with low coefficients of variation are likely to be of particular value for this purpose, and likely to be less affected by dietary and other environmental changes.

At Durrington Walls first and second molar widths tend to have low coefficients of variation (Table 2.2) and probably belong to this category of measurements, as Payne & Bull (1988) and Kuşatman (1991) have already pointed out. This makes them well-suited for comparing populations, especially as they are often relatively common in archaeological assemblages.

The width and also the length of the lower third molar, which are also little affected by age and sex variation, are more variable than the widths of the first and second molars. The third molar is in particular much affected by the shortening of the snout, a phenomenon associated with the domestication of the pig and which became gradually more pronounced as a result of further breeding selection throughout the millennia (cf. Albarella *et al.* in press). The high variability of lengths and widths of the third molar makes them awkward measurements to use in comparing populations, as the wide spread of their distributions will tend to mask possible differences in the actual size of the groups being compared, and sample sizes are often small because many pigs are killed before the third molar is fully developed. Nevertheless, the size of M_3 has commonly been used by zooarchaeologists in attempts to distinguish between domestic and wild pigs, as its very plasticity has made it subject to substantial changes in the course of the domestication process. Most zooarchaeologists will know that a pig mandible with a thin and long M_3 is likely to belong to a wild boar, whereas a mandible with a broad and relatively short M_3 is likely to be from an improved, short-snouted, domestic pig. It therefore seems that the same factors make the third molar as the least and the most desirable tooth to use for comparing pig populations; we should continue using third molar measurements, but in association with others, and bearing in mind the potential confusion that can be caused by their high variability.

The least variable post-cranial measurements at Durrington Walls are the distal width (BdP) of the tibia, the length of the acetabulum (LAR), the width of the femur head (DCP), the width of the cranial articulation of the atlas (BFcr) and – as long as only fusing and fused specimens are considered – the depth (GD) of the calcaneum. Of these measurements, however, only the first can generally be taken in reasonable numbers. Astragalus lengths (GLl and GLm) may also be useful. Astragali are relatively common in well-recovered archaeological assemblages; even though the astragalus has no epiphyses, and thus it is harder to exclude younger specimens, GLl and GLm show low variability as compared with measurements higher up the limb, which also include animals of all ages, such as shaft widths and scapula SLC. It therefore appears that the astragalus grows to close-to-adult size relatively early; if care is taken to exclude light and porous specimens, likely to derive from juvenile animals, tibia BdP and astragalus lengths are probably the most useful post-cranial measurements for comparing different sites or periods.

Forelimb measurements in the Durrington Walls assemblage tend to be more variable than hind limb measurements, and this can only partly be explained by age-related increase. This may support Payne & Bull's (1988) hypothesis that fore limb bones are more sexually dimorphic than those from the hind limb. However, measurements of distal humerus, which appear to be the best prospects, show little sign of bimodality (Figure 2.3). In assemblages where it is possible to plot tighter age groups separately, there may be a greater chance to identify sex related clusters in the distribution of post-cranial measurements; at the moment, however, there does not seem to be much evidence that pig sexes can be discriminated on the basis of metric data.

In Table 2.6 coefficients of correlation of several measurements are listed. Poor correlation exists between tooth widths and lengths, whereas, among bones, measurements that are in the same spatial axis tend to be highly correlated, which confirms what had already been concluded by Davis (1996) for sheep. Thus if there is a need to be economical in the choice of measurements to be taken, it may be wise to choose those which are on different axes, as measurements in the same axis, such as the two lengths of the astragalus, are more likely to duplicate information. If a size index scaling technique is adopted and measurements are combined, it may be wise not to do so for measurements that are poorly correlated (Davis 1996; Meadow 1999).

2.7 Standard measurements for archaeological pigs from NW Europe

A set of standard measurements, based on the Durrington Walls assemblage, is presented in Table 2.7. It is suggested that these are more appropriate than the Turkish wild boar standard, for the analysis of European material. Although the Durrington Walls pig standards are included here for the first time, I have – with colleagues - already successfully adopted them when tackling a series of questions regarding the archaeology of pig husbandry. The use of the Durrington Walls standards has for instance helped in highlighting the fact that post-medieval improvements generated pigs with much larger bones than teeth in comparison to their predecessors (Albarella & Davis 1996), and that teeth, such as third molars, located further back in the jaw, tend to be relatively smaller in medieval than prehistoric pigs (Albarella & Davis 1994), a likely consequence of the effect of progressive selection and separation from the original wild type. More recently these standards have been used to demonstrate increase in pig size as a consequence of the Romanization of Britain (Johnstone & Albarella 2002), and Thomas (2002) has suggested that medieval improvement in pig breeding may have occurred as early as the 14th century. All these advances have strongly been aided by a much better understanding of measurement variability and the adoption of the comparative standards calculated from the Durrington Walls assemblage.

Though the choice of measurements to take, and standards to be adopted, will vary according to the assemblages and the archaeological questions that need addressing, it is suggested that a number of measurements may be particularly useful:

- For comparing assemblages
    - Widths of the first two lower molars
    - Width and length of the lower third molar
    - Tibia BdP
    - Astragalus GLl

  [All very or relatively common, little age and sex dependent, and, with the exception of the M_3, they tend to have low variation]

- For detecting seasonality and other age groupings
    - Scapula SLC (unfused and fused)
    - Humerus SD (unfused and fused)

  [Very common and very age dependent]

It is hoped that this study highlights the importance of using and interpreting measurements in a critical way. Biometry can provide important archaeological information, but for this to work we need to be aware of patterns of variability and the causes of variation in different measurements. The understanding of biological factors related to growth, dimorphism and polymorphism in animal populations is essential for a reliable reconstruction of ancient techniques of animal exploitation, which is why such investigation has been necessary to develop a correct methodology and a correct interpretative framework for the issues discussed in the rest of this thesis.

3. ZOOGEOGRAPHY: A WORLDWIDE VIEW OF WILD BOAR VARIABILITY

3.1 Introduction

The wild boar (*Sus scrofa*) 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 boars 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. scrofa* f. domestica), 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. Plates 3.1 and 3.2). This has been intensively investigated, and various assessments of the systematics of the species, and its separation into a number of geographic sub-species have also been carried out (e.g. Epstein 1971; Groves 1981; Mayer & 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 remain of wild boars 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, Jéquier & Stampfli 1963; Flannery 1983; Hongo & Meadow 1988; Kuşatman, 1991; Warman 2000; Ervynck *et al.* 2001). 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 chapter is to assess the morphometric variability of modern wild boars 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 particular been used, as teeth are durable, can survive destructive taphonomic processes for millennia and also tend to be less variable than bones, as discussed in the previous chapter. 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 post-cranial bones may also be well preserved, and these have also been incorporated into 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 dataset 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, as will be shown in Chapters 5 and 6. 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). These subspecies are mainly defined on the basis of criteria that cannot 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 work. 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 boars have been introduced or re-introduced 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, Randi & Toso 1988), but subsequently allochthonous animals were introduced and now the species is common throughout the Italian peninsula.
- Wild boars can hybridise with domestic pigs, particularly in areas where pig husbandry is practiced in its traditional extensive and free-range form (Redding & Rosenberg 1998; but also see Chapter 4).
- Feral populations of domestic pigs are today distributed throughout the world. Not only can they hybridise with wild boars, 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 taken into account in the interpretation of wild boar variability across its range.

3.2 Material and methods

As mentioned above, the focus of this chapter 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 3.1, which also provides a break down 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 dataset, and other data from central Europe were in any case available, it was decided to exclude the Eberswalde collection from the analysis, and to report it separately. In addition to the information from the mandibles, post-cranial data from circa 120 complete and semi-complete skeletons were also included. The choice of measurements was based on the recommendations provided in the previous chapter.

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 & Keith Dobney)
- Natural History Museum, Geneva (Switzerland) (69) (recorders: UA & Keith Dobney)
- Field Museum of Natural History, Chicago (USA) (62) (recorders: Keith Dobney & Peter Rowley-Conwy)
- Department of Biology, University of Hildesheim (Germany) (47) (recorders: UA & Keith Dobney)
- Nara Cultural Institute, Nabunken, (Japan) (45) (recorder: Keith Dobney)
- Natural History Museum, Paris (France) (42) (recorder: Keith Dobney)
- Natural History Museum, Bern (Switzerland) (26) (recorders: UA, Keith Dobney & Jörg Schibler)
- Museum of Comparative Zoology, Boston (USA) (23) (recorders: UA & Keith Dobney)
- Museum for the Study of Domestic Animals, Halle (Germany) (22) (recorder: UA)
- Barry Rolett's private collection (Hawaii) (20) (recorder: Keith Dobney)
- Institute of Portuguese Archaeology (IPA), Lisbon (Portugal) (11) (recorders: UA & Simon Davis)

- Zoology and Anthropology Museum and Laboratory, Lisbon (Portugal) (8) (recorders: UA & Simon Davis)
- Institute of Zoology, Yerevan (Armenia) (7) (recorders: UA & Ninna Manaserian)
- Laboratory of Comparative Anatomy, Paris (France) (4) (recorder: UA)
- Museum of Levie, Corsica (France) (2) (recorders: UA & Filippo Manconi)
- Filippo Manconi's private collection, Sardinia (Italy) (1) (recorder: UA & Filippo Manconi)
- Peabody Museum, Boston (USA) (1) (recorders: UA & Keith Dobney)

Further data deriving from the literature or provided by colleagues (details in the caption of Table 3.1) were added.

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 used as an outgroup for comparison with truly wild specimens. It must, however, be emphasised that this chapter 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 & Brisbin (1991) and will not be discussed here.

All samples include both males and females, in addition to specimens of unknown sex (Table 3.1). 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 study will not focus on the determination of sex related morphological characters, but this is an issue that cannot be altogether ignored, as wild boars 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 & 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 (APDH), which involves Keith Dobney, Peter Rowley-Conwy and the author (see also Introduction). In addition, data from the literature or provided by colleagues have also been considered.

All measurements discussed in this chapter were taken according to the recommendations provided by Payne & Bull (1988), with the exception of the central cusp of the lower third molar (M_3WC), which is not described in that paper but is taken in the same way as the anterior cusp (M_3WA). The height of the mandible was measured in front of the M_1 and on the buccal side (measurement 16b in von den Driesch 1976).

3.3 Size variation in recent wild boars

3.3.1 Large-scale geographic variation

Table 3.2 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 3.1 it is possible to see which countries where assigned to which region. Although the regions were partly defined on the basis of the availability of data, datasets from North Africa and Oceania – the latter exclusively consisting of populations likely to be feral – are much smaller than for the other regions.

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 3.2 and Figure 3.1 using the Pearson's coefficient of variation (V), which is the standard deviation expressed as a percentage of the mean. Unlike the standard deviation, this allows direct comparison of the variability of different measurements as the coefficient of variation is unaffected by size (Simpson *et al.* 1960; Payne & 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 what was discussed in Chapter 2 and previous studies (Payne & Bull 1988; Kuşatman 1991). Due to their larger sample sizes and their smaller variability, measurements of the second molar are better suited to comparing the different geographic datasets. However, for the reasons already discussed, the length of the third molar has often been used in the past by zoologists and archaeologists as a criterion to assess size in wild boar. Consequently, in order to provide the opportunity for comparison of results of the present work with previous studies, the measurements of both the third and second molars are used here.

The variability of measurements differs when the different regions are compared (Table 3.2 and Figure 3.1). 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. 3.2 and 3.3 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, with the highest at the top. In Table 3.3 the statistical significance of the difference between the various groups is evaluated according to a Student's t-test. As discussed in the previous chapter 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), as demonstrated also in the case of the Durrington Walls pigs (see above). Figures 3.2 and 3.3, 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 dataset (a well defined subgroup of tiny dwarf wild boars from the Ryukyu islands in southern Japan) as well as the largest (from eastern Siberia). Measurements of the M_3 (Figure 3.2) and M_2 (Figure 3.3) 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 3.2 and 3.3, 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 Figure 3.4. The combination has been achieved through the use of a size index scaling technique (Meadow 1999), which relates the measurements to standard values based on the skeletons of a sample of Turkish wild boar (Payne & Bull 1988). The relative size of the modern data set of wild boars 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), as also done for the Durrington Walls bones discussed in the previous chapter. The chosen measurements (see Figure 3.4 caption for details) 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) (see Chapter 2). 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 2002a). This must therefore be regarded as a crude comparison of the different datasets, 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 Figure 3.4. 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 boars 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 boars, as the Kashmir and Pakistani boars are the smallest in the whole central Asian dataset 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 boars 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 from Ryukyu. The points at the extreme right of the distribution of the Far Eastern specimens are measurements of a large male wild pig 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 sub-sample 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 boars – 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).

3.3.2 Regional and local geographic variation

3.3.2.1 *Europe and North Africa*

In Figure 3.5 measurements of the lower second and third molar and in Figure 3.10 those of the distal humerus for Europe and North Africa areas are plotted. Four main local sub-groups 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 M_2 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 M_2 must be noted. A large specimen from southern Sardinia falling in the middle of the central European distribution for the M_3 is probably an introduced animal, since boars of this size are unknown among the traditional variety living on the island. The humerus plot (Figure 3.10) 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 boars are rather mysterious, as no *Sus scrofa* remains are known from the islands before the 7th millennium BC. 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 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. Due to their clear difference from other European wild boars the pigs from Sardinia and Corsica have traditionally been attributed to a separate sub-species, *S. s. meridionalis* Forsyth Major 1882 (Groves 1981). However, recent work indicates that differences exist in the genetics of some of the Sardinian and Corsican pigs (Larson *et al.* 2005). 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 M_2 plot) are on the small side even of the southern European boars, but, with the exception of the single specimen mentioned above, are larger than 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 boars, which biogeographically would perhaps make more sense. The North-*West* African wild boars 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 Figure 3.5a (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 boars (*S. s. lybicus* Gray 1868). Wild boars supposedly disappeared from the Nile Valley *circa* 1900 (Nowak 1999) and therefore this specimen – recorded at the Natural History Museum in Paris – either represents a recent reintroduction from the Near East or pre-dates the time of extinction. 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 boars (Figure 3.10)

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 (Figure 3.5). Though not particularly large, their average size is well above that of the southern European and insular specimens (see also Figure 3.10). However, the claim by Groves (1981, 29) that in this sub-species the M_3 is "not usually above 40mm long" does not find support in our dataset, as the M_3 length of almost half of the specimens is greater than that.

Wild pigs from Eastern Europe - These are the largest wild boars in the region, as is clearly shown by the plot of the M_2 in particular (Figure 3.5b). There is, however, much variation, with some specimens plotting within the lower range of the central European distribution (Figure 3.5). 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 intergrade with or belong fully to the larger sub-species *S. s. attila* Thomas 1912.

3.3.2.2 *The Middle East*

Measurements of the lower second and third molars are plotted in Figure 3.6 and those of the distal humerus in Figure 3.11. As we have previously discussed, wild boars 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 southwestern group and includes wild boars 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 M_3 from Anatolian wild boars is larger than those from the Levant (Figure 3.6a), but no clear difference seems to occur for the

M_2 (Figure 3.6b). Turkish and Levantine populations are generally regarded as belonging to the same sub-species, *S. s. lybicus* (Groves 1981). The Turkish animals from Kızılcahamam, which were measured by Payne & Bull (1988) and were used as the 'standard' in the previous section, appear to be particularly large. Humerus measurement values (Figure 3.11) suggest that Turkish boars 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 M_3 length is well above 45mm (Figure 3.6a). They are regarded by Groves (1981) as belonging to the same sub-species ("attila") as the eastern European animals, with which they are indeed comparable in size. Their humerus measurements (Figure 3.11) are indistinguishable from those from Anatolia, most likely a consequence of the small sample size.

3.3.2.3 *The Caucasus and central Asia*

In Figure 3.7 measurements of the lower second and third molar and in Figs.3.11 and 3.12 those of the distal humerus for the Caucasus and central Asia are plotted. Due to the apparent similarity in size of the wild boars 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 M_2WA) 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 M_3 (unfortunately no post-cranial measurements were available for animals from this last region). Wild boars 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 boars 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 boars 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 "scrofa" and smaller than "attila", an assumption not supported by the data presented here. Three specimens from the Tien-Shan are represented in the dataset and they all fall in the centre of the distribution of measurement values.

3.3.2.4 *The Far East*

In Figure 3.8 measurements of the lower second and third molars and in Figure 3.12 those of the distal humerus for specimens from the Far East region are plotted. Huge size variability occurs in the populations of wild boars 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 boars found anywhere in the world. They form a discrete and compact small cluster in the distribution of the Far Eastern boars (Figure 3.8), with the length of the third molar regularly less 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 being due to insular dwarfism. Recent genetic analysis indicates that they belong to a different lineage from wild boars 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 boars. They are clearly smaller than Chinese (mainly central and southern) wild boars when the M_3 measurements are considered (Figure 3.8a), but a greater overlap occurs in the measurements of the M_2 (Figure 3.8b). 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 boars 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 sub-species *S. s. leucomystax* Temmink 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 M_3 length above 50mm. Both teeth and humeri provide measurements that are comparable to those of *S. s. scrofa* (Figure 3.12). Groves (1981) considers this area to be inhabited by three different subspecies, but further division of such a limited dataset 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 boars in the world. M_2 measurements in particular form a distinct cluster (Figure 3.8b), but the single humerus measurement value is also much larger than any other measured from the Far East or any other area (Figure 3.12). 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.

3.3.2.5 *South and South-East Asia and Oceania*

In Figure 3.9 measurements of the lower second and third molar and in Figs.3.12 those of the distal humerus for wild boars 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 sub-groups. 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 bodied group in southern Asia, comparable in size to Chinese wild boars. 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 & Brisbin 1991), which politically are part of India, have also been added. The wild boars from this region area classified as *S. s. vittatus* Boie 1828, a well-defined sub-species that is even accepted by Genov (1999) in his scaling down of *S. scrofa* taxonomy to a mere four sub-species. There is, however, great size variability in our dataset, 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 boars are the smallest in the world, with the exception of the insular forms from Sardinia, Corsica and Ryukyu. The length of the M_3 is always below 40mm (Figure 3.9a) and post-cranial measurements also suggest small size (Figure 3.12).

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 "vittatus" origin brought to the islands by early humans 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 (Figure 3.9) and tend to plot in the lower half of the distribution of the Indonesian wild pigs.

3.3.3 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.

3.3.3.1 *Relative dimensions of the third molar*

Kratočhvíl (1981) and more recently Warman (2000) 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 boars. However, the analysis of such complex shapes and characters can be somewhat complex, so cruder systems, such as a simple analysis of the ratio between length and width in teeth can be more straightforwardly employed. In Figure 3.13 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 M_3, 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 M_3s 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 “vittatus” form, which is not surprising considering their likely origin from Indonesia.

3.3.3.2 *Mandible/M_3 ratio*

A different type of shape variation analysis is attempted in Figs.3.14 and 3.15. 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 M_3s, while the opposite will be the case for specimens plotting towards the bottom left corner. In Figure 3.14 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 M_3. This difference is not age-related as all mandibles have fully erupted M_3s and there is no substantial difference in the level of M_3 wear between the European and Oceanic specimens. This diagram therefore provides an additional tool to the analysis of 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 M_3 shape.

Figure 3.15 provides more geographic detail, with three main points of interest to note:

- Wild boars 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 & 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 boars from those of China, and, to a greater extent, of Indian boars 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 M_3s. 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 interpretation is that Indonesian and Oceanic pigs have similarly shaped lower M_3s, but the latter have much deeper mandibles.

3.4 A comparison with ancient wild boars

The recent wild boar and feral pig biometrical dataset 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, although one of the objectives of the APDH project, obviously cannot be fully covered in this chapter. However, 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 in 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 boars 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 boars. The separation of wild and domestic forms from archaeological remains is notoriously difficult and, therefore, any comparison of the modern dataset with material deriving from Neolithic or post-Neolithic sites carries the risk that mixed populations may occur in the archaeological assemblage.

3.4.1 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.3.16-3.21 the modern European dataset (excluding the islands) is compared with Mesolithic data from central-northern (Figs. 3.16, 3.18 and 3.20) and southern (Figs. 3.17, 3.19 and 3.21) Europe.

3.4.1.1 *Denmark*

Wild boars 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 Keith Dobney and Peter Rowley-Conwy. Scatter plots of the third and second molar and the distal humerus indicate that the Danish wild boars were extremely large, as already noted by Groves (1981) on the basis of the observation of Neolithic material. The Danish archaeological wild boars 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 boars from central Asia. The only living populations that seem to be larger than the Danish ancient boars are those from Ussuriland, and some of the Danish humerus measurements even seem to exceed those (compare Figs.3.12 and 3.20). Due to the absence of native wild boars in modern Denmark it is difficult to determine whether a size decline occurred after the Mesolithic, or whether these populations of enormous wild boars were eventually extirpated. What we know is that these very large forms still persisted at least into the Neolithic (Rowley-Conwy 1995; 2003). The Danish Mesolithic wild boars 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.

3.4.1.2 *Britain*

As in Denmark the wild boar is today extinct in Britain, and it has been since at least the 17th century, possibly even earlier (Yalden 1999, 168). The few measurements that are available derive from the sites of Star Carr (my personal data and Legge & Rowley-Conwy 1988), Marsh Benham (my 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 boars were much smaller than those inhabiting Denmark. They tend to plot towards the lower half of the distribution of modern European wild boars 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 the much later site of Roman Wroxeter (Andy Hammon pers. comm.) are well in excess of the measurements obtained for the Mesolithic and almost certainly derive from hunted wild specimens, though it is unfortunately not possible to gain a precise idea of the average size of this population, 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 size increase may have occurred in later periods.

3.4.1.3 *Netherlands*

All data derive from the site of Hardinxfeld-Giessendam Polderweg (Louwe Kooijmans 2001) and were recorded by myself with the help of Roel Lauwerier. M_3, M_2 and humerus measurements consistently plot towards the upper range of the modern European wild boar distribution (Figs.3.16, 3.18 and 3.20), which includes Dutch specimens. Dutch Mesolithic data are therefore comparable with large "attila" and indicate that animals of similar size used to inhabit central Europe in the past.

3.4.1.4 *Germany*

All data derive from the site of Friesack in the North-West of the country and were recorded by myself with the help of Susanne Hanik. It is very difficult to make sense of the tooth measurement data (Figs. 3.16 and 3.18) 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 (Figure 3.20), largely consistent with the measurements of modern European wild boars (most of the modern humerus measurements are from "scrofa" rather than "attila", compare with Figure 3.10).

3.4.1.5 *Switzerland*

The Swiss data derive from the site of Birsmatten-Basisgrotte (Bandi 1963) and were recorded by Keith Dobney, Jörg Schibler and myself. This is also a small data set and, like the German Mesolithic wild boars, is approximately consistent with modern "scrofa" measurements, which also include modern Swiss specimens. What is puzzling about the Swiss picture is that late Neolithic data recorded by Keith Dobney and myself (but also cf. Boessneck *et al.* 1963; Schibler *et al.* 1997) indicate that in this period there were wild boars of a size that was largely in excess of that recorded for Birsmatten-Basisgrotte. Though it is unfortunately 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 boars. 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 – 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 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. A subsequent size reduction must eventually have led to the size of wild boars we see today in Switzerland, which is comparable to that of the Mesolithic period.

3.4.1.6 *Serbia*

Only two M_3 measurements are available from Serbian pigs (from Greenfield forthcoming) (Figure 3.17) 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).

3.4.1.7 *Italy*

This is a small set of data from the sites of Grotta Dell'Uzzo and Grotta della Madonna (recorded by myself with help from Keith Dobney, but for site details see Tagliacozzo 1993 and 2000), with the addition of a single specimen from Grotta delle Mura (Bon & 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 (Figure 3.17) – exactly where the southern European specimens would be expected to occur – but some of the humeri are rather large, even in excess of modern "scrofa" (Figure 3.21). Caution is needed due to the very small sample, but the possibilities that the Italian Mesolithic wild boars had relatively larger bones or that the skulls of some of the larger specimens were left off-site by human hunters may have to be considered. At the Bronze Age site of La Starza, also in southern 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 and Chapter 7 below). The large size of Bronze Age boars 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. It would appear that, as in Switzerland, Italian wild boars have been subject to several size fluctuations throughout their Holocene history. The Italian situation will be analysed in much greater detail in a later chapter, but it was worth including some of the questions here, so to allow direct comparison with the evidence deriving from other regions.

3.4.1.8 *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. 3.17 and 3.19). 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 (data recorded by Simon Davis, Cleia Detry and myself) are consistent with large "scrofa" and therefore much larger that those from the Mesolithic. The Mesolithic sites are in hotter and drier areas than 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 seems to have occurred in Portugal after the Mesolithic. As for Italy, the Portuguese evidence will be further analysed in a later chapter.

3.4.2 The 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 Figure 3.22 the modern Middle Eastern dataset for M_2 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 boars was on average larger than that of recent animals from the regions, which are in any case of a considerable size compared to other boars 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 40mm (cf. Davis 1981, Figure 9), 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 M_3s are shorter than 40mm (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 Keith Dobney and myself, but for site details see Rosenberg *et al.* 1998) and Çayönü (Ervynck *et al.* 2001) seem to be more comparable with the measurements from Ksar'Akil and Kebara Cave than with those from Ein Gev III or recent wild boars. 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 & Rosenberg 1998) though at Çayönü substantial size decrease only occurs from the later period onwards (Ervynck *et al.* 2001).

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 & 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 pig populations may also have been a factor.

3.4.3 <u>The Far East</u>

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 hunther-gatherer period (6900-3000 BP). Measurements of the lower third molar are plotted in Figure 3.23 and derive from the following sites: Haneo and Torihama (early Jomon); Arishikita, Kusakari and Ari Yoshi (middle Jomon); Ohata (middle to late Jomon); Rokutsu, Kokanza, Tagara and Satohama (late Jomon); Ai Kosima (late to final Jomon); and Itoku (final Jomon) (all recorded by Keith Dobney).

The Jomon Japanese wild boars overlap greatly in size with modern boar 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 (Figure 3.23). Their average size seems to be intermediate between those of the modern Japanese and Chinese boars (the difference with both groups is highly statistically significant according to a Student's t-test). Although even in the past Japanese wild boars do not seem to have been 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.

3.5 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 & Mazza 1996). Since wild boars 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 archipelago - where the smallest sized populations of wild boars 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 boars, plotting at the lower end of the Japanese range (cf. Mayer & Brisbin 1991). In contrast, Sri Lanka, which is a slightly larger island but, which is, more importantly, closer to the mainland of India has wild boars that are very large – in fact indistinguishable from those of the Indian sub-continent.

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. Temperature is not only associated with latitude, and Weinstock (2000) has also 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 the wild boars from central Asia may be explained on this basis. The effect of the Bergmann's rule in wild boars 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 this change, although in some cases local climatic variation may also play a part. 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 2003b). 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).

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 boars, as well as in the Middle East, central Asia and the Far East. With the exception of those populations living on islands, 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 a quite distinctive signature.

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

A West-East size gradient in *Sus scrofa* has been previously 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 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 continentality, such as for instance in central Siberia.

The West-East cline is clear in Europe and the Middle East, but in Europe it must be asked to what extent it may represent a recent phenomenon, as some large animals seem to have been present in historic Britain and prehistoric Portugal and the Netherlands.

If the smaller size of western European animals really is a recent phenomenon – and admittedly more archaeological data are needed before we can make a definite statement – 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 very 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 intra-specific 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 southwestern end of the range (Portugal) and those from the most northeastern end (Ussuriland) is huge. There are, however, a few puzzling exceptions, such as the small size of the wild boars 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 boars, such as the Ussuriland, Korea and, to a lesser extent, China. As with Europe, however, archaeological data indicate that Japanese boars 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 boars. 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, which will resolve this question.

Inevitably more work is needed to reconstruct clear patterns of variability in wild boars, as well as to try to understand the multitude of factors that lie behind them. The combination of zoological and archaeological analysis has in many cases generated more questions than answers. Although this can inevitably be frustrating, it provides us with the warning that an analysis which does not consider past history and prehistory, may lead to simplistic and even erroneous conclusions. The way forward is surely a diachronic and more integrated approach to the study of *Sus scrofa*.

4. ETHNOARCHAEOLOGY: HUSBANDRY PATTERNS IN SARDINIA AND CORSICA

4.1 Introduction

The biometric approach discussed in the previous two chapters – at the local, site-based scale in Chapter 2 and the worldwide scale in Chapter 3 – provides us with the opportunity to obtain much information about the morphology of the pigs represented in archaeological assemblages. To acquire a better understanding of how morphological patterns can be related to different systems of pig exploitation, it is, however, necessary to turn our attention to traditional practices of pig husbandry as known from the ethnographic (Chapter 4) and historical evidence (Chapter 5).

In this chapter I illustrate, with examples, present-day traditional practices of pig husbandry in Sardinia and Corsica. The approach to this work is ethnoarchaeological, which means that its main aim is to collect modern socio-economic data that can be useful for the interpretation of zooarchaeology remains of pigs and, more in general, for our understanding of the past (cf. Schiffer 1976, 31). The analysis of modern society as an aid to understanding past history has a long tradition in archaeology, and was particularly encouraged by the innovations in archaeological methods of the late '60s and '70s (e.g. Binford 1978; Gould 1980). The comparison between past and present is based on the concept of analogy (cf. Gould 1980, 29), which has been much discussed and criticised in the archaeology literature (Audouze 1992). Nevertheless, analogy remains a useful tool in archaeological interpretation as long as it is used cautiously and with an understanding of context (Hodder 1982). It can also be argued that archaeological interpretation is inevitably analogical as we cannot directly observe the past, and any attempt to improve our understanding of the past is based on comparative models, whether they are drawn from ethnographic observations or not.

The relation between people and animals represents a core factor in the functioning of past and modern societies. Pig hunting and husbandry in particular constitute very important activities in many different periods and areas of the world. There is a wealth of ethnographic studies on the human-pig relationship in traditional societies, but this is mainly confined to the South Pacific (e.g. Rappaport 1968; Bion Griffin 1998; Sillitoe 2003). Ethnoarchaeological studies of the human-pig relation are much rarer, though the work carried out by ethnographers has occasionally been used for archaeological interpretations (e.g. Nemeth 1998; Redding & Rosenberg 1998).

The geographic bias towards South-East Asia and New Guinea in particular is understandable when we consider the abundance of wild and domestic pigs in those regions, and the great importance that they have for local economies and societies. Conversely, most of western Asia is dominated by Muslim cultures, where pig husbandry is not practiced due to the prohibition of pork consumption (Simoons 1961). In Europe and the Mediterranean industrialised mass production of meat has almost completely replaced traditional systems of animal husbandry. Nevertheless, there are still a number of regions where traditional practices survive, but the potential of these areas for the investigation of patterns of animal husbandry of archaeological relevance has been somewhat neglected. A few ethnoarchaeological studies have focussed on sheep and goat management (e.g. Lewthwaite 1984; de

Lanfranchi 1991; Grant 1991) but pigs have by and large been overlooked (but see Fabre-Vassas 1994 and Moreno García 2004).

Though in Europe and western Asia traditional practices of pig husbandry are gradually disappearing, they can still be observed in areas such as Armenia (pers. observations), Bulgaria (Genov 1999), Greece (pers. observations), Spain (Molenat and Casabianca 1979) and most remarkably in the western Mediterranean islands of Sardinia (Italy) and Corsica (France). Previous investigations of the islands have focused on zootechnical and veterinary aspects (cf. Molenat and Casabianca 1979; Texier *et al.* 1984), and this is the first time that an ethnoarchaeological study of traditional pig husbandry in Sardinia and Corsica, and perhaps in the rest of the Mediterranean, has been carried out. However, ethnographic parallels have been taken into account in works with a more general perspective, such as that by Vigne (1998), who has linked pig slaughter patterns found at a number of prehistoric and historic sites in the northwestern Mediterranean with the ethnozoological data provided by Molenat and Casabianca (1979).

The idea to carry out the research presented in this thesis occurred first in 1986, when a visit to Ogliastra, in central-eastern Sardinia, made me aware of the peculiarly small size of the local breeds of pigs and the widespread free-range system of husbandry. Further visits and observations, together with the analysis of the existing literature, revealed that the phenomenon was widespread and dwarf pigs and extensive husbandry methods could be found throughout Sardinia as well as Corsica. The opportunity to undertake the work came, however, only in 2000 with the start of the project on the Archaeology of Pig Domestication and Husbandry.

The islands of Sardinia (Italy) and Corsica (France) are situated in the western Mediterranean, off the western shores of the Italian peninsula (Figure 4.1). Both islands host thriving populations of wild boars, whose origins are hitherto unknown. The history and archaeology of these pig populations will be discussed elsewhere (Albarella *et al.* forthcoming), and it is here sufficient to say that no pigs -wild or domestic - were present on the islands before the end of the 7th millennium BC (Vigne 1999). Wild boars are excellent swimmers (Nowak 1999) but, considering the fairly large distance of both islands from the continent, it is more likely that they were first brought across from the mainland by human colonists. It is unclear whether the earliest pigs that reached the islands were wild (cf. Groves 1989) or domestic (cf. Vigne 1988; 2002). If the latter is the case - as more recent archaeological evidence also seems to suggest (Costa 2004) - modern animals must be regarded as descendents of domestic pigs that escaped human control and became feral.

Inter-cross breeding between wild (or feral) and domestic animals occurs regularly today, and must have occurred even more in the past, when free-range systems of pig keeping were more or less the rule (cf. Manca dell'Arca 1780; della Marmora 1839). It is therefore not possible to regard wild and domestic populations as genetically distinct, and even their management is not clearly separable. As we will see in the rest of this chapter a great diversity of management systems of pig populations – ranging from the controlled hunting of wild animals to the intensive stock-breeding of improved domestic breeds - occurs on the two islands.

As we have already seen, wild boars from Sardinia and Corsica are extremely small in comparison to other European animals (Figure 3.5a), a likely consequence of insular dwarfism – a phenomenon observed for periods as early as at the beginning of the Neolithic in Cyprus (Vigne *et al.* 2000). The small size of these wild pigs is reflected in the native domestic stock, which is also attested in the archaeological (cf. Vigne 1988; Manconi 2000) and historical (cf. Polybius XII, 3; Cetti 1774; della Marmora 1839, Forsyth Major 1883; Dehaut 1911) literature. The miniature size of the pigs living in these islands undoubtedly affects husbandry and feeding strategies.

4.2 Methods and area of study

The work was carried out using two main methods:

- Fieldwork: direct observation and photographing of pig activities, environment and management
- Interviewing of pig breeders with the aid of a standard questionnaire.

The survey is far from comprehensive and only included four main areas (Figure 4.2):

- Central eastern Sardinia (Ogliastra and Supramonte)
- Northern Sardinia (Gallura)
- Northeastern Corsica (Castagniccia)
- Southern Corsica (Alta Rocca, area around Levie)

To understand the results of this work it is necessary to consider that, although in Sardinia and Corsica traditional systems of husbandry are still practiced, both islands are now undergoing intense economic transformation. Traditional practices are disappearing rapidly due to the pressure to intensify productivity and keep up the pace with international economic forces. Pig husbandry is not immune from these changes and in the two islands a combination of tradition and innovation can be observed - though this occurs at a different level in different areas.

Sardinia and Corsica are mountainous islands, and the four areas discussed here are all characterised by a diverse terrain covered by a mix of woodland, Mediterranean maquis and agricultural land. The Castagniccia area, in Corsica, is – as the name suggests – dominated by sweet chestnut woodland, ideal for pig pasture.

The choice of the areas was partly dictated by deliberate selection and partly by logistics. Four breeders were interviewed in Gallura and four in the Alta Rocca (Levie area); none were interviewed in Ogliastra/Supramonte and Castagniccia, though many free-range pigs were observed in these areas.

Conversations with the pig breeders were tape-recorded and written notes were also taken. The two systems of recording were then checked against each other to minimise the possibility of misunderstandings, always possible in an area characterised by a multitude of local dialects.

4.3 Results

Observations of free-range pigs living in central-eastern Sardinia were undertaken in 1986, 1997 and 2002. The pigs living in this area are small, slim, and hairy and have a long and straight snout (Plate 4.1). They are in many respects similar to wild boars, except for their hanging ears, variable colours and occasional curly tails. Those observed are likely to belong to the traditional Sardinian breed, though its purity is questionable, as crossbreeding with imported animals is likely to have occurred. The 18th century zoologist Cetti (1774, 87) described the domestic pig of Sardinia as having a straight and big tail, a body covered in bristles, which are straight on the back, and short, straight, bristly ears. A similar description is offered by Dehaut (1911) for the early 20th century. In the last few decades some of the characters of this traditional breed have been diluted through genetic introgression from continental pig breeds, but the Sardinian pig remains peculiar in its aspect and behaviour.

In this region pig herds are found in remote areas with a rather inhospitable terrain (Plate 4.2). Even in June – not a rich season for woodland food resources – they seemed to live independently, feeding on short grass (Plate 4.3) and possibly roots and worms. Despite a long search, no swineherd could be found in the vicinity. Conversations with local people led to the understanding that in the last twenty years traditional pig husbandry has been severely reduced and can only be observed in the most remote areas. Together with Barbagia (the area located just to the west, in the geographic centre of Sardinia) this is, however, the area where traditional practices and breeds are more likely to have survived.

The other area that I studied in Sardinia – the Gallura – is located in the far North. Gallura maintains a certain cultural independence from the rest of the island, and seems to have been affected to a greater extent than central Sardinia by agricultural innovation and mechanisation. Yet traditional practices survive in conjunction with more modern systems of husbandry, thus creating a fascinating stage of transition from the old to the new. In this area the introduction of allochthonous wild boars also seems to have been particularly intense (cf. Onida *et al.* 1995). The situation in this region can be best summarised through the analysis of the interviews with the pig breeders, discussed below.

In Corsica, one of the best-known areas for pig herding is the Castagniccia (Raichon *et al.* 1976; Molenat & Casabianca 1979). As is well known to people travelling in that area, roaming pigs can be found everywhere. Most pigs seem to live rather independently, pasturing along roads and in woodlands under little or no control. Pig types seem to be very variable, with many different coat colours represented and also different levels of improvement. Small pigs with very straight - wild boar type - snouts, are also found (Plate 4.4). Though rich in pigs the Castagniccia is, however, not the best area to study traditional husbandry as the pure original Corsican breed seems to have disappeared. Molenat & Casabianca (1979) have shown that the Castagniccia has been subject to a heavy introgression of the Large White breed, and tends to attract several pig types originating from across the island. The wealth of woodland products also causes seasonal movements, as some breeders periodically leave their pigs in the area to feed on sweet chestnuts (F. de Lanfranchi, pers.

comm.). This inevitably causes further crossbreeding and genetic contamination of the original domestic and wild populations (de Lanfranchi-Firroloni 1979).

The area where the traditional Corsican breed is more likely to be found is represented by the central part of the island where the main mountain watershed is located (cf. Molenat & Casabianca 1979, Figure 5). The Alta Rocca – where some of our pig breeders were interviewed – lies at the extreme South of this area, at the foothills of the Bavella mountains.

The results of the interviews with the pig breeders of Sardinia and Corsica are summarised in Table 4.1, but some of the essential points will be highlighted in the rest of this section.

Herd – Most of the interviewed breeders kept only a relatively small number of animals (from 2 to 50), which is consistent with a non-communal, home-based system of husbandry. The proportion of adults and juveniles varied considerably, but the number of males was in some cases surprisingly high. However, two of the breeders – one from Sardinia and one from Corsica - had particularly small herds and borrowed their sires from other breeders.

Breeds – All breeders from northern Sardinia have genetically mixed animals, substantially more improved than the traditional Sardinian type. Yet, even the heavier animals with pronouncedly squashed skulls (Plate 4.5) seem to adapt well to a relatively independent life, in free-range conditions. Two of the Corsican breeders owned unimproved North-European breeds, whereas the others owned the traditional

Corsican breed (Plate 4.6). Of these two, particularly interesting is the case of a breeder from the village of Orone, near Levie, who has a double system of pig husbandry. Some animals – mainly imported, but including a handful of Corsican pigs too - are kept enclosed in the vicinity of the village, whereas another small herd of pure Corsican animals is kept in the mountains at a substantial distance from the village.

Wild boars – Wild boars are traditionally hunted on both islands, but there are cases in which they are husbanded, though these will require enclosure, otherwise the animals would escape. In 1997 – well before the beginning of the APDH project - I informally interviewed a wild boar breeder, who kept his animals in a pen built around a natural rock shelter at Monte Pulchiana, in northern Sardinia. It became clear that his activity was more like a hobby than a sustainable economic enterprise, and I was not surprised to hear in 2002 that his herd had eventually been disbanded. None of the eight interviewed breeders kept any wild boars, though two mentioned having owned some in the past. In general wild boars are not regarded as being very profitable due to their extremely small size. All breeders agreed that interbreeding between wild and domestic pigs occurs, but the hybrids are invariably immediately slaughtered, as they do not grow sufficiently. Hybridisation is therefore regarded as inevitable but undesirable. The perception of the problem may, however, have changed over time, as traditional domestic breeds were probably even smaller than they are today – that is before they became partly contaminated with allochthonous genes.

Castration – All breeders were consistent in claiming that castration is practiced on all males (and in one case also females) not used for reproduction, and the practice is safe, with no casualties or infections ever recorded. The age of castration varied, ranging from 1 month to 1 year of age.

Litters – There is no specific birth season in Sardinia and Corsica, as pigs can be born at any time, though, in Corsica, a preference for the early autumn was mentioned. Most pigs, including those of the traditional Corsican breed, produce two litters per year, though one of the Sardinian breeders mentioned the possibility of treble farrowing. Most pigs – but not those kept in completely free-range conditions - give birth in a sty. This is mainly aimed at protecting the piglets from fox predation – a concern mentioned by all pig breeders.

Purchase – When small herds are kept, inbreeding is an issue and several breeders mentioned the need to buy the occasional animal to increase the genetic diversity of the herd.

Slaughter – The breeders unanimously agreed that the best slaughter season is the winter, before the food shortage of woodland products. However, the age at slaughter seems to be extremely variable. In Sardinia it seems to be common practice to slaughter pigs when they are well into their third year, and females even when they are 4 or 5 years old. In Corsica pigs are generally killed at a younger age, when they are 1 or 2 years old. The age at slaughter is, however, connected with the speed of growth. For instance, the breeder from Orone kills his enclosed pigs at 1 year of age, whereas those living in the mountains – with their inferior diet and growth rate - are slaughtered when they are at least 2 years old. It is difficult to account for the reasons for the difference in kill-off patterns between the two islands, but it may relate somehow to the use of meat. In Corsica pig meat is almost entirely processed to make ham and salami ("charcuterie"), while in Sardinia there is a preference for fresh meat.

Movements – All Corsican breeders and one of the Sardinians keep at least one herd in completely free-range conditions, so that the animals can roam freely in an area up to 50 hectares; those enclosed live in areas ranging between 1 and 30 hectares. When trespass occurs the animals tend to go back and losses are rarely recorded. Males tend to roam in a larger area, and more movements occur in summer (presumably because less food is available, and this must be sought in a larger territory). Some of the free-range herds spend the day as well as the night in the scrubs; others – including all those that are enclosed – return to the sty for the night, particularly in winter. During the day the pigs tend to stay as close as possible to water sources.

Control - It is not possible to draw a clear distinction between free-range and enclosed pigs as some of the latter – like in the case of the Sardinian breeder from Scupetu – live in an area that is almost as large as their maximum home-range. The labour involved is minimal as both free-range and enclosed pigs are sufficiently independent and need to be fed at most once a day – castration and slaughter are the only other human activities involved. The two herds of the Corsican breeder from Orone represent the two extremes of the typical levels of control found in traditional husbandry. The herd kept near the village lives in small woodland of 1 hectare, while the other lives in rather impervious mountainous country (Plate 4.7), and hardly requires any labour or control. This breeder only visits his pigs two or three times a year, but – remarkably – has no problems in making himself familiar to the animals, which immediately recognise his call. Only the small and sturdy traditional Corsican breed can live in the tough conditions occurring in the mountains – other pigs would die within weeks. This double system of husbandry practiced by this breeder was already recognised by the geographer della Marmora (1839, 154) in early 19th century Sardinia. La Marmora distinguishes the "porco indomito" (literally 'indomitable pig') from the 'porco manso' (tamed pig). About the former he writes that *"e' tenuto in campagna, dove si nutre di radici, grani e di rettili per una parte dell'anno; poi ingrassa prodigiosamente quando ottobre gli offre abbondanti banchetti nelle foreste di querce dell'interno. Rientrato allora .... allo stato primitivo di natura, prende non solo le abitudini e l'aspetto dei cinghiali, con i quali si mescola di sovente, ma la sua carne acquista un gusto che si cercherebbe invano in quella dei porci allevati continuamente allo stato domestico"* [it is kept in the countryside where it feeds on roots, grains and reptiles for part of the year; then it fattens prodigiously when in October it is offered abundant meals in the oak forest of the interior. Gone back then .... to its primitive natural state, not only does it assume the behaviour and appearance of wild boars, with which it often mixes, but its meat acquires a taste that it is not possible to find in pigs that are constantly kept in a domestic state] .

Capture – For animals living in enclosed environments this is obviously not a problem as they can easily be attracted by food or they just respond to the call of the swineherd. Those that are free-range also respond to the call for food but, being less tame, they may need to be driven into an enclosure. In Corsica I have seen several remains of stonewall enclosures that could have had such a function (Plate 4.8). One of the Corsican breeders, however, shoots his animals. He claims that killing the pigs in this way makes the meat taste better. Another breeder, also working in the Alta Rocca, claimed exactly the opposite. In the eighties, in Levie, Jean-Denis Vigne (pers. comm.) observed that some breeders trained dogs to catch and immobilise the pigs for slaughter, by biting their ears. This use may be related to the strategy, adopted in this area, to kill the pigs by piercing their heart, which causes an internal haemorrhage (Vigne & Marinval-Vigne 1992).

Diet – All pigs of Sardinia and Corsica are broadly self sufficient in their procurement of food, particularly in late autumn and winter when they can rely on the products of the woodland – acorns and chestnuts. Outside this season the natural diet consists of grass, roots, berries, worms and reptiles, to which is added feed provided by the swineherds mainly consisting of barley, corn, food scraps and occasionally bran, maize and legumes.

Weight – This of course depends on the breed, as in relatively improved animals found in Sardinia it can even reach 300 Kg. The maximum figures for the traditional breed range between 80 and 150 Kg in Sardinia and 70 and 120 Kg in Corsica. The Corsican pigs owned by one of the Levie breeders (Fondansaes) were said to be able to reach 150 Kg if kept enclosed and well fed. The purity of this herd must, however, be questioned as this breeder claims to borrow a boar for reproduction from a colleague (Ricci), who I also interviewed, and has English pigs. The pigs kept by the Orone breeder in the Bavella Mountains are slaughtered at 80Kg, and apparently they cannot grow any further than 90Kg even if fed in the best possible conditions (cf.

Quittet & Zert 1971). It therefore seems that the weight of the animals is determined by a combination of nutritional rates, environmental conditions and genetics. The effect of the environment should not be underestimated as dwarf pigs living in the Aegean island of Tilos were proved to be able to grow to a much greater weight when kept under controlled diet and conditions in an experimental agricultural station in Italy (Masseti 2002, 251).

Damage – By rooting, pigs can cause damage to crops and gardens, but this seems to be a relatively minor concern in Sardinia and Corsica; in some cases this is because the enclosed territory, however large, does not include any agricultural land. All Corsican breeders and one from Sardinia mentioned the insertion of an iron wire (but I have also seen rings) in the pig snout (Plate 4.9) as an easy device to avoid rooting activity in pigs. One of the breeders from Levie mentioned that, once the iron has been applied, a pig "grazes like a sheep". This practice has been recorded in 16th century England (Wiseman 2000, 40) and probably still survives in areas where pigs can roam freely.

Products – Meat is by far the main product of the pig. In Corsica it is almost invariably processed to make "charcuterie". Lard is also much used and one of the breeders mentioned the use of bones to make jelly. Most of the meat is produced for family and private use, though the sale of the occasional piglet was mentioned by a breeder from Levie. The sale of "charcuterie" significantly increased in Corsica with the development of tourist activities.

4.4 Conclusions

A great diversity of husbandry strategies is practiced in Sardinia and Corsica. Many of these concern adaptation to specific climatic, environmental and cultural conditions occurring on the two islands, and we should therefore be wary of using them as a model to apply to other societies, periods and parts of the world. Yet there are elements that provide useful insights into the type of challenges that pig breeders must have faced in a variety of situations in the past.

It is therefore worth highlighting what are the lessons that we have learnt about traditional pig husbandry that may address archaeological questions. The first point to make is that zooarchaeologists may sometimes be too keen to make a clear distinction between the management of domestic and wild resources. This hardly seems to be applicable to all areas and situations. In Sardinia and Corsica not only is there a biological continuum between the two pig forms, but also husbandry practices are geared towards a combined management of wild boars and domestic pigs, whose interbreeding is in some cases regarded as an opportunity, but more often as a nuisance.

There are several cases known in the archaeological literature in which it has been difficult to determine whether pigs had been hunted or reared. At the Turkish early Neolithic sites of Çayönü and Hallan Çemi – among the earliest to provide some evidence of impending pig domestication – there seems to be a gradual transition towards a domestic state that implies the occurrence of a number of other intermediate practices which cannot easily be classified as predation or husbandry

(Hongo & Meadow 1988; Redding & Rosenberg 1988; Ervynck *et al.* 2001; Horvitz *et al.* 2004). These questions do not only apply to the onset of the domestication process, as similar dilemmas have also been raised concerning the status of early Neolithic pigs in France (Helmer 1992) and middle Neolithic pigs in northern Italy (Jarman 1976a; Rowley-Conwy 1997; Albarella *et al.* in press) as will be further discussed in Chapter 7. To try solving the problem by introducing the possible existence of a third biological status placed somewhere in between the wild boar and the domestic pig, would only mean to move from a simplistic explanation to another. Our study of modern Sardinian and Corsican pig husbandry indicates that the emphasis in our explanations must be on *management* rather than *biological status*, as the second is by and large the product of the first. In these two islands wild and domestic, local and imported, enclosed and free-range pigs all play a role in shaping a rather complex and dynamic economic system, which is difficult to place in predetermined categories.

Our study also draws attention to the difficulties related to attempts to assess seasonality from the study of pig archaeological remains. In Sardinia and Corsica even the traditional fully unimproved breeds can give birth twice a year, and the litters can be born at virtually any time of the year, with the possible exception of the summer. This is probably a consequence of the mild Mediterranean climate that provides the opportunity for survival even to animals born at the beginning of the winter, and we must therefore be careful not to extend these conclusions to animals living in more rigid climatic conditions, where harsh winters can limit the flexibility of the birth season. Nevertheless, caution must be exercised when we assume spring births in view of the attempted detection of seasonal activities – in domestic pigs the picture can be more complex.

Slaughtering follows a more regular seasonal pattern, partly due to the seasonality of village activities, but also, as emphasized by Molenat & Casabianca (1979), as a consequence of the accumulation of fat occurring in the season of greatest food abundance (i.e. the autumn). This could explain why many archaeological kill-off profiles in the Mediterranean area show a clear seasonal pattern (Vigne 1998).

Much has been made of the potential incompatibility of free-range pig husbandry and agricultural activities, to the extent that this has been regarded as one of the issues affecting the shape of early farming societies (cf. Redding & Rosenberg 1998). The Corsican and Sardinian herders, whose pigs can roam as freely as is potentially possible for these animals, do not, however, perceive this as a major problem. One of the reasons could be that both islands have a long tradition of greater reliance on livestock than crops, which does not necessarily apply to other parts of the world. Yet, it seems that a simple device, such as the use of iron wire in the pig snout, makes these animals no more harmful to cultivated crops than sheep. It seems unlikely that early societies, even those that did not possess metals, could not think of similar strategies to avoid pig damage. It is certainly true that grazing – and not just rooting – can also cause damage, but if pigs could only graze they would be relieved of their specificity, as they could make no more damage than any other domestic livestock.

Finally, it is worth mentioning again that the two islands are currently undergoing a phase of rapid transition, which makes them ideal laboratories for the study of economic change. Much of the reasoning of modern Sardinian and Corsican breeders echoes the questions and dilemmas of livestock producers at the onset of the 16th and 17th centuries in central and northern Europe (cf. Albarella & Davis 1996; Davis 1997; Davis & Beckett 1999). Traditional practices and unimproved breeds are gradually disappearing, as breeders face the increasing demands of market forces. This does not only apply to pigs, but also to cattle that in Sardinia and Corsica (Vigne 1988) are characterised by a small and rather coarse breed (Plate 4.10) that is becoming increasingly rare. The local unimproved breeds do not seem to be particularly productive, but they have distinct advantages deriving from centuries of adaptation to the local environment. They are sturdy, resilient and immune to most local diseases and – as we have seen in the case of the "indomitable" pigs of the Bavella mountains – able to care for themselves. The main dilemma of the Sardinian and Corsican breeders is whether to carry on with their low impact, environmentally sustainable, but also relatively unprofitable systems of husbandry or revert to more demanding, intensive but rapidly lucrative practices. The latter choice could lead to the disappearance of endemic breeds, traditional activities and landscapes, and with them probably the whole infrastructure of Sardinian and Corsican economy and proud independence from international market forces. We must wonder how many times herders of the past must have faced similar dilemmas.

5. HISTORY: DOCUMENTARY AND ARCHAEOLOGICAL EVIDENCE OF PIG MANAGEMENT IN MEDIEVAL ENGLAND

> *"During his lifetime the pig was an important member of the family, and its health and condition were regularly reported in letters to children away from home, together with news of their brothers and sisters. Men callers on Sunday afternoons came, not to see the family, but the pig, and would lounge with its owner against the pigsty door for an hour, scratching piggy's back and praising his points or turning up their noses in criticism. . . . The family pig was everybody's pride and everybody's business"* (Thompson 1939)

5.1 General importance of the pig

The above quote is extracted from Flora Thompson's famous autobiographical account of childhood spent in a late nineteenth century village in Oxfordshire, and it reminds us of the centrality of pig husbandry in the social and economic life of rural England until relatively recent times. The tradition of keeping a family pig in a sty at the back of the house – widespread in the last century - goes back a long way in time (Dyer 1989, 196; Wiseman 2000, 46). It was the product of a combination of changes in agriculture and land management that occurred throughout the last millennium, and which caused several transformations in the style of swine keeping in Britain. Several different forms of husbandry were practiced over the centuries, but pigs always played an important role in the shaping of British economy and society, and, with their meat and lard, provided key components for medieval and modern diets.

Although they were useful for the production of manure and had unselective eating habits that came in handy in the cleaning of backyards and town streets, pigs were almost exclusively reared as meat suppliers. Unlike cattle and sheep they do not provide important secondary products, such as milk, wool, or traction power. Pig milk was used in Hittite rituals (Simoons 1994, 23), but such exploitation is unknown in historic Europe. The inability to provide a wide range of products as other domesticates is, however, compensated for by the fact that pigs represented a more productive source of energy, comparing favourably even to the use of animals for dairying (Campbell 2000, 165). Such productivity is partly a consequence of the fecundity of this species. Even at times when no selection of breeds had yet occurred, nine to twelve piglets – and sometimes more - could be produced every year (Markham 1657 in Davis 2002a; Campbell 2000, 165; Kelly 2000, 81).

Pigs are versatile animals, which could be reared even on poor quality land (Wiseman 2000, 37), and which act as a buffer resource in critical times for cattle and sheep husbandry (Campbell 2000, 167). They were also an important source of fat, in an age when meat, produced from largely unimproved animals, tended to be much leaner. In addition, pig meat was particularly suitable for long-term preservation (Woolgar 1999, 116; Wiseman 2000, 37), a quality that cannot be overrated, when we consider that food storage had to be practiced without the aid of modern refrigerators. In fact, the lower classes almost exclusively consumed pork (i.e. the flesh of pig used as food) in its preserved form (bacon and ham) (Dyer 1980, 328; Dyer 1989, 116; Rixson 2000, 120). Archaeologically the distinction between the use of pork in its fresh and preserved forms is hard to pinpoint, as animal bones normally derive from a diversity of activities, and only rarely can they be associated with specific butchery processes.

There is a general consensus among historians that pork (mainly fresh) tended to be – after beef - the most commonly eaten meat in aristocratic houses (Dyer 1989, 60; Salisbury 1994, 58; Campbell 2000, 103). Peasants would rely on an almost exclusively vegetarian diet, but that little meat they could afford to consume was mainly pork – preserved as bacon or ham (Dyer 1989, 154). Even in later medieval times (after the Black Death), when both historical and archaeological sources point towards an overall increase in meat consumption (Dyer 1989, 158; Albarella 1997; Woolgar in press), this situation probably did not change.

The archaeological evidence is not entirely comparable with the historical sources, as most studied assemblages of animal bones derive from urban sites, for which there is only a scanty documentary record. Whether sites are urban or rural, the archaeological record suggests that pigs tend to be the third most common species after cattle and sheep, with these last two in a variable ranking order (Albarella in press). In eighty-seven out of 112 medieval and post-medieval sites (and phases) from central England (i.e. 78 per cent) pig remains represent less than 20 per cent of the total of cattle, sheep/goat and pig (this percentage is calculated by taking into account only sites where the total number of identified specimens – NISP - of the main three taxa is greater than 300). The pattern is not dissimilar in other areas of the country (Grant 1988; Albarella & Davis 1996; Albarella *et al.* 1997). Nevertheless, once we take into account the different weights of the three main domesticates, there is little doubt that beef ranks as the most commonly consumed meat, but pork is likely to be second, at least in the early medieval period. This is of course a gross generalisation, but it is nevertheless reassuring that historical and archaeological sources provide information that is – despite difficulties in their comparability - by and large consistent.

The issues mentioned above will be further discussed in the rest of this chapter, which will focus in particular on changes in pig management strategies throughout the medieval period. The analysis is based on an integration of zooarchaeological and historical evidence and will highlight the pros and cons of the two sources of evidence in clarifying aspects of the history of pig husbandry. The importance of this investigation goes beyond the mere study of medieval practices in England, as it provides the opportunity to understand aspects of the pig/human relationship that are bound to be more obscure for periods for which such a wealth of documentary evidence is not available. In other words, medieval England can represent a useful case study for the reconstruction of possible models of pig exploitation that can be applied – alongside the evidence gathered from the ethnographic work in Sardinia and Corsica - to the prehistory and history of other regions of the world.

5.2 Pig rise and decline

Though pigs were undoubtedly important throughout the whole of English history, the heyday of swine husbandry probably belongs to the Saxon period, well up to the Norman conquest in the eleventh century AD. From the eleventh or twelfth century onwards there seems to be a slow but steady decline in pork consumption (in comparison to other types of meat) and, apart from occasional local circumstances, pigs never regained the economic relevance that they had had in Anglo-Saxon England.

Several authors – relying on documentary evidence – indicate that it was only after the eleventh century that swine husbandry became less widespread (Trow-Smith 1957, 55; Harvey 1988, 130; Wiseman 2000, 39). Trow-Smith goes as far as suggesting that pigs represented the "hallmark of Saxon pastoral husbandry". Since early Saxon literary sources are scarce and only a few assemblages of animal bones from early and middle Saxon sites have been analysed, it is difficult to find out whether the importance of pigs suddenly emerged after the Roman period or there was a steady increase throughout Saxon times. The few sites which provide a chronological sequence within the Saxon period – such as West Stow (Suffolk) (Crabtree 1989), Ipswich (Jones & Serjeantson 1983) and St Peter's Street (Northampton) (Harman 1979) - do not offer a clear answer to this question, as no consistent pattern emerges.

There is much clearer archaeological evidence that pig bones are more commonly found in Saxon than in later times. In Table 5.1 a number of sites with assemblages from different periods within the medieval sequence are listed – see Figure 5.1. for their geographic location. Pig frequencies are compared with those of the sheep, as it has been suggested that it was the rise of sheep husbandry that – among other factors – caused the demise of the pig (Wiseman 2000, 39). In Figure 5.2 (top) the differences in pig frequency (compared to sheep) between Saxon and later sites are plotted. It can be seen that most sites register a decrease in pig frequencies after the Saxon period. The sites of Portchester Castle (Hampshire) (Grant 1977) and St Peter's Street

(Northampton) (Harman 1979) show an opposite trend, but the occurrence of exceptions is not surprising. Campbell (2000, 167) points to the existence, even in the later medieval period, of a few demesnes where pigs represented the most common livestock. Whenever possible Saxon (and Saxo-Norman) data have been compared with those from early, rather than late, medieval levels, which proves the point that a change in pig husbandry occurred relatively soon after the Norman conquest. Using more refined chronologies Sykes (2001) has, however, suggested that this could have occurred in the Angevin (i.e. second half of 12th century) rather than in Norman period.

Pig decline, however, did not stop then. Documentary evidence from Winchester indicates that pork consumption was still gradually going out of fashion in the later Middle Ages (Dyer 1989; Woolgar in press). In the archaeological record, the gradual decrease in pig frequency during the Middle Ages (and even more so in post-medieval times) was highlighted by Grant (1988) and has more recently been confirmed by further surveys carried out by Albarella & Davis (1996) and Albarella *et al.* (1997). Jones (2002) also identifies such a trend, in particular for the period after the fifteenth century. In Figure 5.2 (bottom) we can see that, as in the case of the Saxon/medieval transition, in most sites there is a further decrease in pig frequency between early and late medieval times. However, more exceptions occur, suggesting that the phenomenon was much more varied and less universal than for the previous transition.

Figure 5.3 considers the average from a larger number of sites (even those which are not multi-period) and brings cattle also into the frame, as percentages are calculated from the total for all three main domesticates. It is possible to see that, while sheep increases steadily in number, pig decreases, reinforcing the point that – though probably the main decline occurred early in the Middle Ages – pig kept losing further ground to sheep husbandry in the later part of the period.

These quantifications are biased by a high number of different factors – above all, differential preservation and recovery between sites – but, once a large number of sites are considered, general trends can still be detected. For a particular phenomenon not to be obscured by all these confusing factors it has to be substantial, as the gradual decrease in popularity of pig husbandry probably was. In addition, we have to bear in mind that the direct comparison of pig and sheep bones, animals of comparable size, minimises the effects caused by a recovery bias.

There is another specification that is necessary at this point. Though undoubtedly pig numbers decreased at the expense of sheep, we have to remember that the archaeological evidence merely indicates a change in relative importance of these two animals. Once we consider that, after the Black Death, there was a trend towards giving agricultural land over to pasture and that more animals were therefore present in the countryside (Dyer 1980, 324; Overton & Campbell 1992), it becomes obvious that the absolute number of pigs may not necessarily have diminished, but simply became less significant in comparison with other species.

5.3 Husbandry regimes

Medieval swine husbandry relied heavily on the exploitation of woodland areas, where pigs would be folded seasonally to feed on roots, acorns, and beech mast (Campbell

2000, 165) (Plate 5.1). The best demonstration of how widespread this practice was can be found in the Domesday Book, which generally measures woodland in terms of the number of pigs that it could support (Williams & Martin 2002). The payment of the right to exploit demesne woodland by swineherds is known as 'pannage' (Harvey 1988, 127). This practice probably dates back to the seventh century AD (Trow-Smith 1957, 51) and certainly survived at least until the end of the Middle Ages (Overton 1996, 25). Apart from having an obvious economic impact – revenue obtained through the leasing of woodlands for pig pasture could be substantial (Fryde 1996, 55; Wiseman 2000, 33) – this practice represented an important element in the organization of the society. Pannage was managed in a predominantly communal way (Harvey 1984, 228), as swineherds collected pigs from different owners during the day and drove them to woodland areas, where they could even spend one or more nights in the company of the animals (Kelly 2000, 82; Wiseman 2000, 33-4).

Although the association between pigs and woods was particularly strong in the Saxon period and in the early Middle Ages (Trow-Smith 1957, 53), it would be wrong to assume that it was the only strategy used to fatten the animals. Pannage, after all, only occurred in autumn and early winter (Wiseman 2000, 33), the richest season for woodland products. There was therefore the need to feed the pigs in alternative ways at different times of the year, as Walter of Henley also acknowledged (Wiseman 2000, 35). We must as well consider that pigs were also kept – though probably in smaller numbers - in areas that were not so rich in woodland, as proven by the fact that the number of swine owned by some estates could be higher than the potential number of animals that a local woodland could support (Williams & Martin 2002). In addition to natural resources pigs could be fed on cereals and legumes (Kelly 2000, 83; Dyer

2003, 126) and occasionally grazed upon pasture rather woodland (Trow-Smith 1957, 81). Moreover, even in these early times, some could be housed or yarded rather than being kept in free-range conditions (Trow-Smith 1957, 53).

The pannage system started breaking up after the Norman conquest, mainly as a consequence of the gradual reduction of available woodland (Grant 1988; Campbell 2000, 166; Wiseman 2000, 40). This must have been an important factor in the relative decrease of the importance of pig husbandry in the later Middle Ages. Obviously, there must have been a fair degree of geographic variation in the way this phenomenon occurred, as pannage probably continued almost unabated in regions still rich in forest coverage (Campbell 2000, 166; Dyer 2003, 17). In areas where woodland areas were more depleted intensive methods of swine husbandry became gradually more common. Sty-feeding of animals on legumes, cereals, house-waste and even by-products of the dairy and brewery industries (Overton 1996, 25; Campbell 2000, 166; Rixson 2000, 120; Wiseman 2000, 41) started replacing the traditional forms of free-range husbandry. This was mainly in response to the reduction of the season of pannage, a consequence of the growing concern in the preservation of diminishing pockets of forest. While in Anglo-Saxon England pigs were allowed to roam in the woodland for more than four months (from August to December), after the Conquest this right was restricted to a period of six to eight weeks (between October and November) in many counties. In others, such as Lancashire, there is documentary evidence that the length of the pannage season had not changed as late as the sixteenth century (Wiseman 2000, 33 and 39-40).

These differences in the dietary regimes of pigs are difficult to detect archaeologically, but recent technological advances have started providing useful data that seem to have a great potential for future research. Isotopic analysis carried out on pig bones from sites of different periods in Britain shows that pigs with a highly diversified diet could already be found in pre-Norman times but they are more common in urban than rural sites (Müldner *et al.* in prep.), a possible indication that pigs kept in towns were fed on house waste, not just vegetable products. Work on tooth microwear has also shown that it is possible to discriminate between rooting and stall-fed pigs (Ward & Mainland 1999), and these criteria - initially devised on modern pigs with a known diet - have recently been applied to archaeological material from medieval York and other sites. Preliminary work indicates the potential presence of stall-fed animals in towns and foraging/rooting populations in rural contexts (Wilkie *et al.* forthcoming).

The increasing urbanisation of the medieval landscape brought about other changes in the style of pig-keeping. Pigs adapted very well to town environments as shown by a wealth of artistic, historical, and archaeological evidence (Dyer 1989, 186; Lilley 2002, 220; Dyer 2003, 199). Due to their omnivorous habits, pigs were occasionally encouraged to roam free and scavenge for food (Wiseman 2000, 42), as an effective way to clean the town streets. This would cause occasional problems, and ordinances to ban or at least restrict pig movements in the city abound (Rixson 2000, 115). There was also a concern that they could prove dangerous for children, and cases of attacks were recorded (Smith 2000). Archaeological evidence from the town of Norwich indicates that the number of bones of neonatal pigs – suggestive of on-site breeding - increased in the sixteenth century, while newborn cattle and sheep were, by this period, no longer found. It is possible that an increase in the urbanisation at the end of the medieval period favoured the keeping of the adaptable pigs, which did not need large areas of pastureland to feed (Albarella in press).

Modifications in the strategies of pig husbandry went hand in hand with changes in the general perception and status of the pig and the consumption of its meat. Already by the time of the Domesday survey pigs had become regarded as poor people's animals, a concept that may have affected the accuracy of their counting (see below). It has even been suggested that pig numbers were proportionally related to the number of poor people in a certain region (Hallam 1988). The reputation that these animals had acquired may derive from the increasingly poor quality of their meat, a consequence of inadequate feeding, based on industrial by-products (Rixson 2000, 120). While this could certainly have been a factor, the association between pigs and poverty relied probably more heavily on the fact that even the less well off peasants could keep one or two pigs at low financial and labour cost. It is possible that initially the low status of this species only applied to its keeping, but towards the end of the Middle Ages it seems that its consumption was regarded likewise. Aristocratic households and town people would consume little pork (Woolgar 1999, 133; Smith 2000, 716), and by the sixteenth century "there was a common perception that it was peasant food" (Woolgar in press).

It is perhaps excessive to state that "the defeated Saxons had favoured [the pigs, while] the victorious Normans disdained them" (Salisbury 1994, 28), but it is probably true that, as pigs were gradually pushed out of the woods and became enclosed in sties and urban contexts, their reputation suffered and the consumption of their meat consequently decreased.

5.4 Social and geographic variation

The archaeological evidence indicates that there is a great degree of variation in the frequency of pig bones when town, village, and castle sites are compared, but, on average, they tend to be more abundant on high status sites, followed by villages and then urban sites (Albarella & Davis 1996). This evidence is only apparently in contradiction with that discussed in the previous section, as historical and archaeological data describe different phenomena. Whereas the evidence of the animal bones tells us about net consumption of meat, the documents inform us about supply and husbandry strategies. The bones that we find in archaeological sites do not necessary originate from animals that were kept locally, therefore the supposed greater emphasis in urban pig-keeping that characterizes the later Middle Ages is not necessarily reflected in a higher consumption of pork. Most of the meat that was consumed in towns was probably imported and town dwellers consumed less pork and mutton and more beef than their rural counterparts (Albarella in press). This is despite the fact that the number of pigs found in towns probably far exceeded the number of cattle.

The greater abundance of pig bones in village sites supports the view that pork was considered as predominantly peasant food. However, according to the archaeological evidence, even in low status sites beef seems to have been the most commonly consumed type of meat, though not to the same extent as in towns. Despite problems with zooarchaeological quantifications, the possibility that beef consumption by the peasantry has so far been underestimated by historians should perhaps be considered (for a fuller discussion of this question see Albarella 1999).

The apparently high consumption of pork in high status sites, which has also been claimed by Jones (2002), is more difficult to explain. Perhaps, as suggested above, the decline in status of pork consumption only really took place towards the very end of the medieval period, when pig meat had become less common in all sectors of the society. There is also evidence, for the earlier Middle Ages, that pig meat – especially if consumed young – could be considered appropriate for a delicate taste (Dyer 1989, 60; Woolgar in press), and that castle garrisons were supplied by levies on the peasants (Sykes 2001; Serjeantson, pers. comm.).

The few archaeological data that we have for monastic sites – also of a high status – confirm that pork played a rather important role in the ecclesiastical diet too. At the Dominican Friary in Chester (Morris 1990), at Eynsham Abbey (Oxfordshire) (Ayres *et al.* 2003), at St.Gregory's Priory in Canterbury (Powell *et al.* 2001) and at Shrewsbury Abbey (Jones 2002) pork is – in most phases – the second most frequently consumed meat, but at Evesham Abbey (Worcestershire) (Lovett 1990) and Austin Friars, Leicester (Thawley 1981) it is less well represented. Documentary evidence from the Misericord at Westminster Abbey (late fifteenth - early sixteenth century) is more in line with these two latter sites, as pork was substantially less eaten than beef or mutton (Harvey 1993, 53). We cannot, however, rule out the possibility that in earlier times more pork had been eaten. The trend towards a reduction in pork consumption throughout the Middle Ages has indeed been observed for monastic sites too (Jones 2002; Ayres *et al.* 2003).

Pig husbandry and pork consumption occurred at a variable frequency not only in different types of sites but also in different geographic areas. As mentioned above, areas with a greater woodland coverage – such as the West Sussex Weald, the southwest and the northwest of the country - tended to have more pigs (Campbell 2000, 166). A survey of a small sample of entries in the three counties covered by the Little Domesday (Williams & Martin 2002), also shows that pigs were – in comparison with sheep – more common in Essex than Suffolk and Norfolk (Table 5.2), which, once again, probably emphasizes the effect that the availability of greater woodland resources could have had on the success of pig husbandry. Unfortunately there are too few animal bone assemblages studied from Norman and early medieval sites in Essex and Suffolk to carry out a reliable comparison between the archaeological and documentary evidence, but the archaeological data from Norfolk provide nonetheless an interesting insight. In this county, evidence from sixteen sites - mainly urban - indicates an average proportion of 41 per cent of pig remains out of the total of sheep/goat and pig. This is in contrast with the 12 per cent suggested by the Domesday Book. It is possible that the Norfolk towns imported some of their pig meat from areas outside the borders of the county but, considering that nearby areas were also unlikely to have a thriving economy of pig husbandry, we must perhaps accept the possibility that pig counts in the Domesday Book are underestimated, as already suggested by Trow-Smith (1957, 80) and Salisbury (1994, 28).

Economic, rather then purely environmental, factors also played a role in the geographic distribution of pig husbandry. For instance, the East Midlands, despite their poor woodland coverage, had many pigs (Harvey 1988, 127; Mortimer 1712 in Davis 2002a, 56). Campbell (2000, 168) suggests that the soil of this region was mainly dedicated to arable production, probably incompatible with extensive sheep and cattle husbandry. Therefore, in order to produce a sufficient protein supply, a specialisation towards an intensive system of pig keeping took place. The archaeological data are, however, once again at odds. A comparison between the frequency of pigs between the two East Midland counties of Northamptonshire and Leicestershire and East Anglia on the one hand and the West Midlands on the other indicates that pigs were no more common in the East Midlands than elsewhere (Figure 5.4). It is possible that the difference was too subtle to be highlighted by this rather crude comparison of archaeological data, but also that once again we are witnessing a difference between data indicating consumption and others indicating production. Pig meat was not necessarily eaten in the same area where it was produced.

5.5 Slaughter, seasonality, trade

Pigs were slaughtered for consumption at almost any age (Trow-Smith 1957, 128), but on average the pig bones found in archaeological sites are younger than those of sheep and cattle. This is not surprising, as pigs, unlike the other domesticates, were exclusively kept for meat, and consequently there would be no point in keeping them alive beyond their moment of maximum growth – apart for the few specimens kept for reproduction.

Suckling pigs could occasionally have been consumed as a delicacy, but most pigs would be fattened up before slaughtering (Kelly 2000, 85). Bones of very young pigs are found in archaeological sites, but they represent a relatively small minority.

Some animals were killed in their first year, but pigs were believed to make the best porkers and baconers when they were rising two (Campbell 2000, 165; Davis 1794 in Davis 2002a, 57; Woolgar in press). The archaeological evidence is consistent with this, as, in most sites, pig bones tend to belong to 'immature' and 'subadult' categories. As in the case of the historical record there are a few exceptions, such as at the middle-medieval village of Thuxton (Norfolk) (Cartledge 1989) and at the late medieval urban site of Towcester (Northamptonshire) (Holmes 1992), where there is a predominance of first year killings. This suggests that different husbandry strategies and uses of pigs must have been in place.

Despite the claim that Saxon pigs would be particularly slow growing and would therefore not be slaughtered until their third year (Trow-Smith 1957, 54), there is little zooarchaeological evidence of a widespread change in kill-off patterns between the Saxon and medieval periods. A tendency to kill animals at an earlier stage has however been detected for the early post-medieval period, and it is probably a consequence of the development of new faster growing breeds (Albarella 1997), possibly associated with a further intensification of husbandry techniques.

The age at slaughter was partly determined by seasonal cycles. When only one farrow a year was possible this would generally occur in spring (Wiseman 2000, 37), whereas the most convenient time of the year for slaughter was the late autumn or early winter (Dyer 1989, 58; Wiseman 2000, 35), when pigs had been fattened on the products of the woodland and a shortage of natural resources was imminent. This situation mirrors what is found in traditional pig husbandry in Sardinia and Corsica (see previous chapter), though it is interesting to note that in more northern climates the season of birth seems to have been more stable than in the Mediterranean. Many pigs born in spring would therefore be killed in the early winter of the following year – at about one and half years of age, which is consistent with the documentary information available for the thirteenth century demesne farm at Stevenage (Hertfordshire) (Trow-Smith 1957, 126). Much of the pig flesh would not be eaten immediately but would rather be preserved for later use.

Seasonality can be difficult to detect archaeologically, but work on pig mortality, as detected through tooth wear from a number of medieval sites in Belgium, confirms the suggestion of a killing peak in winter (Ervynck 1997). No corresponding data are available for English sites.

Throughout the Middle Ages pig husbandry was more rooted in self-sufficiency than in the case of other animals, to the extent that Farmer (Farmer 1991, 458) claims that "the amount of pork reaching the market was probably . . . small". Most castles, manors, priories, hamlets and villages could easily afford at least a pigsty and, as we have seen, swine could also quite happily live in urban environments – though towns would have certainly imported much of their pork from elsewhere. Demesne production was mainly for local consumption and most of the pork sold on the market was supplied by peasants (Thornton 1992, 35; Campbell 2000, 167). Since manors hardly ever purchased pork on the market (Thornton 1992, 31; Farmer 1991, 455), presumably most of the sale must have been directed towards the urban market.

In most archaeological sites of the Saxon and medieval periods, pig bones are represented by remains deriving from all parts of the body, supporting the view that complete carcasses, rather than selected bits of meat, were processed on site. Whenever there is a bias in the distribution of the parts of the body this almost invariably concerns the presence of a large number of cranial elements, mainly teeth. This is much more likely to be related to the higher level of preservation of the durable dental elements than to any butchery pattern. It is interesting, however, to note that butchery patterns revealing a systematic way of distribution of the carcass, such as the longitudinal splitting of skulls and vertebrae, are almost exclusively found at urban sites, such as Aylesbury (Buckinghamshire) (Jones 1983), Leicester (Gidney 1991a), Thetford (Norfolk) (Jones 1993), and Lincoln (O'Connor 1982).

5.6 Improvement

As long as pigs were managed under an extensive system of husbandry there was probably little opportunity and perhaps even little motivation for improvement. With only limited control on the reproduction process (domestic pigs could even interbreed with wild boars during the pannage season) it was practically impossible to select for new types and breeds (Plate 5.2), as we have also seen for Sardinia and Corsica (Chapter 4). The increasing tendency during the Middle Ages – in particular after the Black Death – to enclose the animals and to exercise closer control over their life cycle must have generated the opportunity to experiment with possible ways to increase the energy output of these animals. Ironically, possible attempts to improve pig breeds may have occurred just at the time when these animals were declining in their general economic importance (Wiseman 2000, 42). Nevertheless, according to the historical record, there is not much evidence of improvement during the medieval period and the earliest references to the emergence of regional types are as late as the seventeenth century, and even for those it is not clear whether the improvement was due to genetic or nutritional factors (Overton 1996, 115-6; Wiseman 2000, 47).

The zooarchaeological evidence also does not provide a great wealth of information about any size increase occurring before the end of the Middle Ages. It is not always clear whether this is due to a genuine phenomenon or to an insufficient detail in the analysis of biometrical data. At Flaxengate (Lincoln) there is no change in the size of the pigs between late Saxon and Saxo-Norman levels (O'Connor 1982), and the same is true for the early to middle medieval transitions at West Cotton (Northamptonshire) (Albarella & Davis 1994) and Exeter (Maltby 1979). O'Connor (1982), though, also notes that the pigs from Lincoln are smaller than contemporary animals from Exeter, which at least indicates some degree of regional variation. A hint that, in some areas, some improvement may have already occurred in the late medieval period is provided by the analyses of the animal bones from Launceston Castle (Cornwall) (Albarella & Davis 1996) and Castle Mall (Norwich) (Albarella *et al.* 1997). At both these sites pigs from the late medieval levels are slightly larger than those from earlier phases, though the increase is much less than that occurring in the post-medieval levels from the same sites. This increase is reflected in the bones rather than the teeth, and since post-cranial bones can be modified by environmental factors, this slight change is more likely to be the consequence of an improvement in the pig diet than in a real genetic difference.

Recent work at Dudley Castle (West Midlands) (Thomas 2002) has provided for the first time firm evidence that some degree of improvement occurred well before early modern times. Increase in the size of both pig teeth and bones occurs at Dudley as early as the transition between the thirteenth and the fourteenth centuries, perhaps as a consequence of a change in husbandry strategies, from an extensive, woodland based, system of breeding to the enclosure of pigs in sties under closer human control. Since the size increase also affects teeth we can be reasonably confident that it is related to the creation or perhaps introduction of a genetically different type of animal. It is possible that the West Midlands represented an area of advanced experimentation in animal breeding, but this is unlikely to be an isolated case, and as more zooarchaeological work is carried out in England, similar examples will probably emerge.

Larger animals were likely to grow faster and therefore to provide a greater protein output in a similar time span, which explains why size increase tends to be related with a tendency to slaughter animals at an earlier age (Albarella 1997).

Meat gains could also be increased by improving birth and mortality rates, and in general health conditions. Birth rates could be improved by increasing the number of piglets per litter or the number of litters per year. In unimproved pigs litters would only comprise up to eight or nine piglets (Thornton 1992, 34; Kelly 2000, 81), but already in the fourteenth century at the manor house of Rimpton (Somerset) there are records of litters with returns of as many as thirteen piglets (Thornton 1992, 34). Early modern agricultural writers mention litters of up to twenty piglets, but these were exceptional cases (Markham 1657 in Davis 2002a, 56). Farrowing would traditionally occur only once a year, generally in spring (Kelly 2000, 81) but, writing in the thirteenth century, Walter of Henley suggests the possibility of having as many as three litters per year

(Davis 2002a, 56). This may have been an exaggeration, but it still hints at the fact that at least two litters per year may have been commonplace in medieval England. In the Saxon period there was probably still only one birth per year, if the evidence from early Christian Ireland represents a valid parallel. Zooarchaeology is almost powerless in this area of analysis, but recent work on the analysis of enamel hypoplasia – a dental defect related to stress events including birth, weaning, food shortage etc. – is at least making an attempt to provide a contribution. Preliminary work by Ervynck and Dobney (2002) has so far failed to identify cases of farrowing occurring twice a year in animal bones assemblages from Roman, Anglo-Saxon and medieval sites in England and Belgium. More work is needed to find out whether this is due to a failure of the methodology or to a genuine rarity of the phenomenon in the medieval period.

Finally, it is worth mentioning that at thirteenth century Rimpton piglet mortality was less than 10 per cent, a figure that compares positively with contemporary standards of intensive pig farming (Thornton 1992, 35). In early Christian Ireland the weakest piglet of the litter was generally hand-reared on milk and eventually kept as a pet (Kelly 2000, 81), which shows the great degree of care that was taken in managing these animals. The general good health of medieval pigs finds some confirmation in the rarity of records of pathological conditions in pig bones from archaeological sites (UA's pers. obs.).

5.7 Conclusions

Pigs played an important role in medieval economy and society and pork was – on average – the second most commonly eaten meat during the Middle Ages. Peasants ate pork mainly in its preserved form, while upper classes also consumed it fresh. Pig husbandry was very prominent in the Saxon period, when there was sufficient woodland coverage in the country to allow a widespread and extensive management of pigs, focussed on the seasonal system of 'pannage'. The gradual breaking up of the forest generated a decline in pig production and consumption and a change in pig husbandry strategies. Intensive systems of pig keeping, with pigs frequently stalled or yarded, which already existed in the Saxon period, became more common and, by the late Middle Ages, were the prevalent form of pig husbandry in many regions.

A consequence of these changes was that a closer control over the pig reproductive cycle became possible and this opened up the opportunity for improvement in meat output and the creation of regional types and eventually even genetically distinct breeds. As faster growing pigs were created, the age of slaughter of the animals could be made younger and many animals would have consequently be killed in their first rather than second year. Though most of the improvement took place in post-medieval times archaeological data indicate that some changes were already occurring perhaps as early as the fourteenth century.

The medieval style of pig husbandry was less intensive than that practiced in modern and contemporary times, but it was not necessarily inferior. Pig populations seem to have been healthy, the well-known fecundity of the species guaranteed good reproductive returns, and the meat – as long as pigs were allowed to graze in the forest – must have been of a good quality. The particular suitability of pork for long term preservation, made it possible to have a protein supply at times of the year when other types of meat were not readily available.

Pigs were food providers and, as such, all aspects of their management were directly or indirectly related to diet. It would, however, be grossly unfair to regard them as mere meat producing machines; pigs were much more than that. They were living creatures that contributed substantially to the shaping of the medieval community, to its organisation, settlement, movements, everyday activities, seasonal cycles, entertainment, and also feelings. It has been written that pigs' "role as a major contributor to the development of medieval society has rarely been acknowledged" (Wiseman 2000, 39). It is a fair point, which should remind us of how much domestic animals have helped in our history, and how little they have received in exchange.

CASE STUDIES

6. PORTUGAL: PIG EXPLOITATION IN THE CHALCOLITHIC AND BEYOND

6.1 Introduction

Portugal is located at the southwestern limits of the Old World distribution of the wild boar (*Sus scrofa*). There is firm evidence that the species is native to this region, as it has been found in pre-Neolithic sites, well before the time of the introduction of the first domestic animals (Cardoso 1993; Davis 2002b). Reviews of the status of wild boar populations in their present geographic range have generally neglected Portuguese pigs (see for example Groves 1981; Genov 1999), but, as we have seen in Chapter 3, this thesis has highlighted the fact that the Portuguese wild boar is the smallest of all continental wild boars. This is not surprising, as I have shown that this species has a tendency to increase in size from the southwest to the northeast.

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

Zambujal and Leceia are both located in the Estremadura region of central Portugal (Figure 6.1). Like most Portuguese Chalcolithic sites they are fortified settlements, dating to around 2600-1800 BC (Fernández Castro 1995; Jorge and Jorge 1997). The occupation at Zambujal spanned the whole Chalcolithic period (Sangmeister and Schubart 1972), whereas Leceia has an earlier stratigraphic sequence, starting in the late ('final') Neolithic (second half of the 4th millennium BC) but ending before the advent of the bell-beaker period in the late Chalcolithic at the end of the 3rd millennium BC (Cardoso 1994; Fernández Castro 1995; Cardoso 1997). Zambujal is therefore a later site, though there is considerable chronological overlap between the two occupation sequences. The animal bones from Zambujal and Leceia were originally studied respectively by von den Driesch and Boessneck (1976) and Cardoso and Detry (2001-2), but the pig remains have been re-examined for the purpose of the present work. At both sites there was a predominance of domestic animals, though wild species - with red deer (*Cervus elaphus*) the best represented - were also fairly common, particularly at Zambujal. Pig is the most common taxon at

Zambujal and in the late Neolithic of Leceia, and the second most common taxon - after the caprines - in the Chalcolithic of Leceia.

6.2 Material and methods

Ageing and measuring of the pig teeth and bones from Zambujal were carried out in October 2003 by myself with the help of Simon Davis at the Instituto Português de Arqueologia in Lisbon (material on loan from the Torres Vedras museum). Pig remains from Leceia were studied in that same month by Simon Davis, Cleia Detry and myself at the Centro de Estudos Arqueológicos do Concelho de Oeiras. The purpose of this work is not a full re-analysis of the material, but rather the collection of a selection of ageing and metrical data that may serve for comparative purposes. As for the modern material (see Chapter 3) dental eruption and wear stages 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 their diaphyses but still showed some open gaps in the fusion line were recorded as 'fusing'.

The choice of measurements taken was based on the definition of Payne and Bull (1988) and von den Driesch (1976) and the recommendations stated in Chapter 2. I measured the widths and lengths of the fourth deciduous mandibular premolar (dP_4) and the three mandibular molars M_1, M_2 and M_3. In addition I measured the height of the mandible in front of the first molar (HTMAND), the collum of the scapula (SLC), the width and minimum height (=diameter) of the distal humerus trochlea

(BT and HTC), the width and depth of the distal tibia (BdP and Dd), the greatest length of the astragalus (GLl) and the greatest length and depth of the calcaneum (GL and GD). The width of the central and posterior cusps of the lower third molar are not included in any of the above references, but were taken according to the same recommendations as for the measuring of tooth widths presented in Payne and Bull (1988). Some additional measurements – not discussed in this thesis – were also taken. All recorded mandibles were also sexed when canines or canine alveoli were present. Gender 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, I noted the occurrence of particularly light and porous specimens, likely to belong to juvenile and therefore not fully developed individuals. At first I did not attempt to identify isolated first or second molars as M_1 (usually small) or M_2 (usually larger than M_1) but their possible metric distinction is discussed below.

The Zambujal animal bones had originally been divided into a number of chronological phases, but were subsequently mixed and, although the number code for each individual specimen was recorded whenever possible, for many specimens this had become illegible. Consequently I had no other choice but to treat the Zambujal assemblage as a single unit. Conversely, the Leceia pig bones were recorded according to the three-phase system of Cardoso and Detry (2001-2): late (final) Neolithic, early Chalcolithic and middle (full) Chalcolithic.

6.3 Patterns of variation at Zambujal and Leceia

6.3.1 Ageing

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

In Figure 6.2 eruption and wear stages of the first and second lower molars at the two sites (according to Grant 1982) are presented. The difference in the proportion of molars which are un-erupted ('nye') and those with no dentine exposed (U + a) depends on the fact that at Leceia – but not at Zambujal - isolated teeth, as well as teeth in jaws, could be used (see below for the reason). Isolated teeth cannot be assigned to eruption stages and they were therefore all recorded as 'unworn' (U + a). There are, however, some other significant differences between the two kill-off patterns. At Leceia both the first and second molars tend to be at earlier stages of wear. The younger mortality curve of the Leceia animals is confirmed by the fact that fourth deciduous premolars represent 46% of the total of dP_4s + M_3s, while at Zambujal this figure is only 34%. There is also a slight difference in the percentage of fully fused distal humeri and tibiae: 65% and 47% at Leceia and 73% and 55% at Zambujal respectively – percentages that would appear to corroborate the dental data.

The two sites seem to have a common peak in the slaughtering age, corresponding broadly to the stage when the first molar is unworn and the second molar is unerupted or not yet fully formed. On the basis of the age sequences reconstructed by Bull and Payne (1982) for wild boars and personal observations on aged mandibles of unimproved domestic breeds of pig, such a stage should correspond to animals aged between 5 and 8 months. In temperate regions wild boars tend to be born in spring (Nowak 1999, 1057), but, as we have seen in Chapter 4, great variation in the birth season has been noted for both wild and domestic animals, not just in the Tropics but also in southern Europe. The main killing season of domestic pigs appears to have occurred generally in late autumn/winter (see Chapters 4 and 5). The earlier killing peak at Leceia and Zambujal could be consistent with a spring birth and a slaughter in the late autumn/winter of the same year.

A second slaughtering peak occurs when the first molar is in wear stages 'c' to 'e' at Leceia and 'd' to 'g' at Zambujal and the second molar is unworn. This peak corresponds to an approximate age of 16-22 months, closer to the younger part of the range at Leceia and the older at Zambujal. These animals should be approximately a year older than those discussed above, and were probably slaughtered in the following winter. Ervynck (1997) has suggested that there is no substantial variation in the duration of wear stages in pig molars, and this has been confirmed by more recent work, which relates the duration of wear stages to rates of reduction in crown height (Tams *et al.* in prep.). This would confirm that the fluctuations in wear stage occurrences presented in Figure 6.2 may reflect seasonal slaughtering, which would be consistent with historical and traditional management practises of free-range pigs, as we have seen in Chapters 4 and 5. Needless to say the existence of seasonal activities does not in any way imply seasonal occupation.

The slaughtering of a relatively large proportion of pigs in their first year indicates intensive use of this resource and a degree of confidence that supplies would not become exhausted. Seasonal feasting may represent a possible explanation for the killing of large numbers of young animals during a restricted period. However, an explanation for the early slaughtering of second year pigs at Leceia is more difficult to find, though this may in part be due to the greater proportion of wild specimens in the Zambujal assemblage (see below). Whatever the explanation, it does seem that slightly different systems of pig management were practiced at the two sites.

6.3.2 Tooth biometry

We have seen in Chapter 2 that molar tooth measurements, particularly widths, are less affected by sex, age and intra-population variation than are bones (see also Payne & Bull 1988; Kuşatman 1991), and therefore are probably more suitable for comparing populations from different sites. Table 6.1 provides summary statistics for tooth measurements from Zambujal and Leceia. For all measurements the average value is greater at Zambujal than Leceia, but this difference means little without a proper analysis of the distribution of individual measurements.

Figure 6.3 shows the distribution of dP_4 and M_3 measurements at Zambujal. All graphs consistently show that most measurements plot in the lower part of the distribution, with a smaller number spreading towards the top. The distribution is not unimodal because the large 'tail' in the upper end of the range is not mirrored by a similar one towards the lower end of the range. The existence of a 'peak and tail' distribution of many of the Zambujal pig measurements had already been highlighted by von den Driesch and Boessneck (1976) and Rowley-Conwy (1995).

It seems likely that at Zambujal there were two populations of *Sus*. The majority were domestic pigs – the smaller animals – and a minority – the "tail" – were the larger wild boars. The two groups, however, overlap and it is impossible to determine the boundary between domestic pigs and wild boars.

The presence of this larger tail also prevents us from separating first from second lower molars (Figure 6.4). About half of these teeth could be identified on the basis of their position in the jaw, but those that were found loose could only be recorded as $M_{1/2}$s. Such a cautious approach is justified by the fact that overlaps occur between the two groups, probably because the large wild boar first molars plot amongst the domestic second molars. To ignore teeth that plot in the uncertain range would be a mistake, as this would artificially skew the distribution towards smaller first molars and larger second molars and bias the interpretation. Only the first and second molars from Zambujal that were still embedded in their respective jaws are therefore considered here (including the ageing evidence discussed above).

The plots of the fourth deciduous premolar and third molar at Leceia (Figure 6.5) indicate that the larger tail visible for Zambujal is either absent or much reduced, with only a couple of specimens spreading away from the main distribution. Wild boars would therefore appear to have been rare or absent at Leceia. Hence a much clearer separation of first and second molars is possible (Figure 6.6), and, unlike Zambujal, loose front molars could be metrically identified as either first or second molars.

A possible mixture of populations at Zambujal is also indicated by the greater coefficients of variation (V, *i.e.* the standard deviation expressed as a percentage of the mean; Simpson *et al.* 1960) of most measurements compared to Leceia (Tables 6.1 and 6.2; Figure 6.7). It is also interesting that both sites' coefficients of variation are greater than in the Anatolian wild boar population recorded by Payne and Bull (1988) and even than a combined sample of Israeli and Syrian wild boars (SD's personal data). It is likely that different populations contributed to the formation of the assemblages from the two Portuguese sites, though at Leceia the contribution of wild boars was probably minimal.

6.3.3 Bone biometry

Table 6.2 provides summary statistics for bone measurements at Zambujal and Leceia. The patterns of variation of the post-cranial bone measurements are similar to those of the teeth. At Zambujal measurements of the distal humerus and tibia show a bimodal distribution with most specimens plotting in the smaller group (presumably domestic). The presence of two specimens in between the two main tibia clusters shows how unwise it would be to draw a clear line of separation between domestic and wild animals (Figure 6.8). At Leceia most specimens, like the teeth, plot in the domestic cluster, though two huge distal humeri are certainly in the wild range. The presence of two large, but not so distinctively different distal tibiae (compare with Figure 6.8) is a reminder that the clear separation visible for the humerus distribution is probably due to chance – an artefact of the small size of the wild boar sample (Figure 6.9). The astragalus data show very clearly the much more unimodal distribution of the Leceia pigs compared to Zambujal (Figure 6.10)

In view of the tooth ageing evidence it is worth having a look at the distribution of the measurements of the scapula neck (Figure 6.11), as we have seen in Chapter 2 that this measurement is very variable, being related to the age of the animal. It is therefore unreliable for comparing body size in different populations, but can be useful for detecting age groups (Rowley-Conwy 2001). Despite the great variability of this measurement it is still possible to detect a few large specimens, probably wild, at both Zambujal and Leceia. What is more interesting is the clear tail on the left of the distribution (very obvious if specimens with both fused and unfused coracoids are combined as well as specimens of unknown 'fusion'), which probably corresponds to the group of animals slaughtered in their first year (see ageing evidence above). As for the astragalus the distribution is much more unimodal for Leceia than Zambujal.

6.3.4 Leceia – chronological variation

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

Figure 6.12 is the same as Figure 6.5, except that specimens are now discriminated on the basis of the phase to which they belong. It is quite obvious that the early Chalcolithic and late Neolithic samples are rather small. Nevertheless, it is noticeable that the Neolithic specimens tend to plot towards the top of the distribution. These seem, however, more likely to be large domestic specimens rather than wild boars. There also seems to be a slight size decrease between the early and middle Chalcolithic, but this is less noticeable and is limited to the third molar. I must therefore test, by checking other measurements, whether a gradual size decrease occurred in the Leceia pigs from the late Neolithic to the middle Chalcolithic.

Interpretation of the plots of the first and second molars (Figure 6.13), the distal humerus and tibia (Figure 6.14) and the astragalus (Figure 6.15) is once again difficult due to the rather small number of Neolithic specimens. However, the few available specimens still tend to plot in the larger half of the distribution, whereas there does not seem to be clear evidence that the early Chalcolithic animals were larger than those from middle Chalcolithic. It is not impossible that a larger wild component existed in the late Neolithic, but large outliers are so scarce at Leceia (and they are not necessarily Neolithic, see Figure 6.14), that a more likely explanation is that there was indeed a genuine size decrease of domestic pigs during the Neolithic-Chalcolithic transition. One possibility is that in the later period the domestic pig population had become more genetically isolated from its wild counterpart – as for instance has been suggested for some north Italian sites (Albarella *et al.* in press; see also Chapter 7) – though nutritional factors should also be considered. More data from other Portuguese sites are needed in order to identify a possible husbandry change at this important cultural transition.

6.4 Zambujal and Leceia in context

6.4.1 Wild boars

Although I could not obtain a complete separation of domestic from wild populations at Zambujal – and to some extent at Leceia too – these two sites still provide an approximate guide to the size of Portuguese wild boars in the third and second millennia BC. We now compare these data with those of other wild boar populations of different periods and geographic origin.

In Figures 6.16 and 6.17 the tooth size of the Zambujal and Leceia pigs is compared with that of Mesolithic (presumed) wild boar specimens and modern Portuguese and French wild boars. The Mesolithic data were collected by Simon Davis and derive from the following sites: Moita do Sebastião (Muge), Cabeço da Arruda (Muge) and Cabeço do Pez (Alcácer do Sal; see Figure 6.1 for location). The modern Portuguese wild boars were measured by Simon Davis and myself in the Instituto Português de Arqueologia (IPA) and the Museu e Laboratorio Zoologico e Antropologico (Museu Bocage) in Lisbon. The IPA specimens come from northern Portugal, whereas the specimens from the Museu Bocage are from the Alentejo region in southeastern Portugal. Measurements of the French wild boars were taken by Keith Dobney and myself from numerous collections across the world.

Figures 6.16 and 6.17 indicate quite clearly that the upper part of the Zambujal distribution – presumably representing wild specimens - is more similar in size to modern French wild boars than either Mesolithic or modern Portuguese wild boars, which tend to be smaller. There is, however, overlap between the various groups, with several wild specimens plotting well within the likely range of domestic animals. At Leceia the few large outliers (see plot of third molar - top of Figures 6.16 and 6.17) also tend to be in the same range as French wild boars. Post-cranial bone evidence (Figure 6.18) confirms this situation but in these plots Mesolithic specimens appear to be larger than the teeth had indicated, a puzzling situation already mentioned in Chapter 3.

In Figures 6.19 and 6.20 tooth widths and a number of post-cranial bone measurements are compared between these various groups. Data from another Chalcolithic site – Mercador (Alentejo; Figure 6.1) – are also added. The measurements of bones from this site were originally taken and studied by Davis (2003a). The sample is much smaller than those from Zambujal and Leceia, but it is still useful for comparative purposes. The late Neolithic data from Leceia have been excluded from this analysis. Measurements of tooth widths have been combined through the use of the size index scaling technique, which relates the measurements to the standard values based on the assemblage of domestic pigs from Durrington Walls (see Chapter 2) – which is late Neolithic and approximately contemporary with the Portuguese Chalcolithic. The relative size of the various data sets in comparison to the Durrington Walls standard is calculated as the logarithm to base 10 of the ratio between the measurement and its standard (Simpson *et al.* 1960; Meadow 1999). The logarithm of the ratio between a measurement and its standard has been calculated for each measurement and the log ratio values are plotted with the 'standard' being 0. These plots are stacked on top of each other as in Figures 6.19-6.24 so that differences in the size of each bone or tooth and its respective 'standard' may be seen simultaneously. 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 together 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 it will become clearer in the examples provided below.

The analyses of both tooth widths and post-cranial bones show once again that the tail of large specimens from Leceia and Zambujal represent specimens of a larger size than any of the modern Portuguese wild boars. Mercador shows a neat unimodal distribution, and is probably entirely comprised of domestic animals – the pig economy of this site seems in this respect to be more similar to Leceia than Zambujal. There is no substantial variation in size between the domestic pigs at the three Chalcolithic sites, which also show tooth measurements similar to those from the Mesolithic. Modern Portuguese wild boars are only slightly larger than domestic pigs from the Chalcolithic. A comparison of Figures 6.19 and 6.20, however, also confirms the impression that Mesolithic wild boars had relatively larger bones than teeth. We have already seen in Chapter 3 that there is variation in the relative size of dental and bone measurements in prehistoric sites in Europe, and this has also been demonstrated for historic times (see Chapter 5 and Albarella & Davis 1996). The existence of large-boned Mesolithic pigs is not limited to Portugal, but can also be observed in Switzerland and - to a lesser extent - Denmark, as our data indicate (Figures 6.21 and 6.22). Swiss and Danish wild boars were much larger than those from Portugal, and so this is probably independent of allometric growth.

We may conclude as follows:

- Some fluctuation has occurred in the size of Portuguese wild boars from Mesolithic to modern times
- Chalcolithic wild boars were – on average - larger than either Mesolithic or modern wild boars and more similar in size to modern wild boars from central Europe (*S. s. scrofa*)
- When comparing size of domestic or wild pigs between periods attention must be paid to whether teeth or bones are compared, as the relative size of dental and post-cranial measurements seems to have changed in the course of time
- The size of the domestic pigs in the Chalcolithic seems to have been homogeneous, though data from more sites in other regions are needed. On average these Chalcolithic pigs are smaller than contemporary animals from England. One may wonder whether we have here an example of a domesticated animal obeying Bergmann's (1847) rule or these pigs lived on a poorer diet (McCance & Widdowson 1957).

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

6.4.2 A comparison with later periods

The evidence for pig size from historical sites in Portugal is sparse, but a recent study of the faunal remains from Alcáçova de Santarém (Davis 2003b) in central Portugal (Figure 6.1) provides a chronological study of *Sus* size from Iron Age to Moslem times at this site. Here I compare tooth and post-cranial bone measurements from Zambujal with those from Santarém (Figures 6.23 and 6.24).

The domestic pigs from Zambujal and the Iron Age levels at Santarém are similar, perhaps an indication that strategies of pig husbandry did not change substantially in prehistoric times. A small tail of large specimens, presumably wild boars, is present at Iron Age Santarém as it was in the Chalcolithic sites. Like at Zambujal, hunting almost certainly provided an important but secondary source of meat (this is hardly surprising since 12% of the Iron Age fauna at Santarém is red deer, an animal that must have been hunted.)

In Roman times there is no substantial change in the size of pigs, which seem to be no larger, or even smaller, than in the previous period. This lack of improvement in livestock size is at odds with what has been recorded in the northern Roman provinces (Teichert 1984; Lauwerier 1988; Johnstone & Albarella 2002). It is possible that the Romans preferred to use smaller breeds in warmer regions. This view is supported by the fact that there was also no increase in the size of Roman sheep and cattle (Davis 2003b). A few large specimens – potential wild boars – can be seen in the plot of post-cranial bones but not for teeth (Figures 6.23 and 6.24), which raises the possibility that wild boar heads may have been disposed of off site. Whatever is the case, it seems that some hunting was still being practiced in Roman times. This again is hardly surprising as red deer were still an important minor part of the fauna (they comprise approximately 8%).

A change occurs in the Moslem (9th-13th cent.) and post-Moslem periods, when a much greater variation in pig size seems to occur. Such an increase in variation is mainly the consequence of the presence of a fair proportion of animals of very large size, comparable indeed to the Chalcolithic wild boars (Figures 6.23 and 6.24). It is therefore possible than wild boars represented a much greater component of *Sus* meat in the medieval period than they had done in any of the previous phases. While pork consumption is strictly forbidden in Islam, many Moslems, especially in the Maghreb, hunt and eat wild boar. In Morocco wild boar liver is consumed to gain the animal's strength and its flesh is said to be bracing for children, a remedy for syphilis and renders man insensitive to pain (Simoons 1994, 341; Moreno García 2004). Another possible explanation is that pig improvement occurred in the medieval period and this saw the emergence of new and larger pig breeds. However, given the Moslem prohibition, this hypothesis seems a little beyond belief and remains to be tested -

perhaps by comparing *Sus* remains from Medieval Moslem and Christian sites.

By making more detailed studies of tooth size and shape it is possible to gain a better understanding of the status – wild or domestic – of the larger *Sus* teeth from the Moslem period at Alcáçova de Santarém. Figure 6.25 combines both size (length of M_3) and a shape index (M_3 - width of anterior pillar divided by the width of the central pillar). This index is actually measuring how "parallel" the lingual and buccal sides of this tooth are. Figure 6.25 shows two quite different populations of *Sus*, one is medieval and post-medieval pig from Launceston Castle in Cornwall, England (Albarella & Davis 1996) and the other modern wild boars from Israel and Syria (housed in the Universities of Tel Aviv and Jerusalem). The distribution of the plots indicates that besides being considerably longer (most > 35 mm) the wild *Sus* M_3s tend to have parallel sides; in other words the widths of the two pillars are similar giving a 1:1 ratio (WA/WC x 100 = 100). However, the domestic pig M_3s tend in general to plot out somewhat to the right *i.e.* their anterior pillar is slightly larger than the central pillar giving them (in occlusal view) a slightly tri-angular appearance. This is probably reflecting compression of the growing tooth crown during the animal's development due to insufficient space for the developing crown within a smaller mandible. Perhaps the different sets of genes controlling bone size and tooth size, had been subject to different selective pressures in the course of domestication and management of *Sus* over the millennia, leading to an imbalance between tooth and bone (mandibular ramus) size, leaving the dental genes in a more 'archaic' state. If we accept this rather speculative line of reasoning, then we can make the same plot for the Santarém tooth measurements as in Figure 6.26 – and note how many of the Moslem *Sus* M_3s plot out in the wild boar region with not only longer teeth but also values to the left (*i.e.*

WA/WC index around 100). This corroborates the suggestion made earlier that many of the Moslem Santarém *Sus* remains derive from wild boars – considered less unclean than domestic pig by western Moslems.

6.5 Conclusions

This study of osteometric variation of Portuguese pig populations in Chalcolithic and other times indicates the existence of a complex pattern probably determined by many different factors that may include climate, environment, trade, type of husbandry and other cultural factors. It must be stressed that it would be a mistake to compare the size of the domestic animals against a supposedly immutable baseline of wild boar. From the Mesolithic onwards wild boar size and shape changed more than once and it is becoming increasingly clear that such fluctuations can be observed in many other areas besides Portugal. For instance in England, Switzerland and Italy, there is also evidence that much larger wild boars than those living in the Mesolithic were present in later prehistoric and historical times (see Chapter 3 above and Chapter 7 below). Considering the inverse relation existing between body size and temperature (Davis 1981), it has been mentioned in Chapter 3 that the climatic deterioration that occurred in Europe after 3000 BC (Bell and Walker 1992, 71) may have brought about such size increase. Another possible explanation for this post-Mesolithic size increase has to do with intense hunting pressure in the Mesolithic (a time of possible stress; Davis 1989; 1991) and subsequent relaxation of hunting pressure once domesticated ungulates became a primary source of meat supply. This line of reasoning was used to explain the small size of Mesolithic Portuguese red deer compared to later red deer in this region (Davis 2003b).

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

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

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

7. PREHISTORIC ITALY: PREDATION, DOMESTICATION AND INTENSIFICATION

7.1 Introduction

In this chapter the evidence for pig exploitation in prehistoric Italy will be discussed. None of the sites that I have personally studied (or re-studied) can boast as large samples as those from the Chalcolithic Portuguese sites of Zambujal and Leceia, but, to compensate, a larger number of sites and a greater geographic and chronological coverage are available for the Italian peninsula. Since – unlike Portugal – a fair amount of Neolithic data are available, a key issue that will be discussed is represented by the question of the origins of pig domestication in Italy.

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), because – as discussed (Chapter 3) – wild boars are distributed across the whole area. The earliest evidence of pig domestication dates back to the 8th millennium BC, perhaps even earlier, and derives from the Far East (Jing & Flad 2002) and the Near East (Flannery 1983; Peters *et al.* 1999; Vigne & Buitenhuis 1999). 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 work 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 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.* in press), leading to the hypothesis that multiple centres of domestication may have 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.* 2001), whereas at Hallan Çemi, also in Turkey, strategies involving the crossbreeding 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 (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 BC (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 chapter 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 chapter, I have deliberately extended my analysis to later prehistoric sites (up to the end of the Bronze Age) as the domestication process 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.

7.2 Material and methods

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

1. Data collected in the last four years as part of the project on The Archaeology of Pig Domestication and Husbandry (APDH)
2. Published and unpublished data previously recorded by the author as part of different projects
3. Data derived from the literature.

1. This represents the bulk of the evidence discussed in this chapter. The recording was carried out by myself in three different stages in July 2001 (with the help of Keith Dobney), January 2002 and January 2003 and was based at the "Museo Preistorico e Etnografico Luigi Pigorini" (Rome, Italy). Some of the material analysed had previously been recorded – and in some cases even published (see below for specific references). 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 Rivoli and La Starza – had been previously recorded by myself (in the case of Rivoli with the help of a student), 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. In this way data from important sites such as Arene Candide and Conelle di Arcevia could also be used.

The recording of pig teeth and bones from the Italian sites followed the same methods as for the Portuguese material (see Chapter 6). In this case, however, no attempt could be made in separating isolated first and second molars, as none of the assemblages had a sufficient number of these teeth to try a separation on metrical basis. Only measurements of first and second 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 (see above). The standard values used ('0') are those from the late Neolithic – approximately contemporary to the Italian Eneolithic - site of Durrington Walls, which are discussed and presented in Chapter 2. A comparison is also carried out with the values (expressed as a star in the diagrams) obtained from a population of modern wild boars from Turkey (Payne & Bull 1988). Like for the Portuguese data, the relative size of the various data sets in comparison to 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). It is worth reminding here that the main aim of this analysis is not to compare data with the standard, but rather the different datasets with each other.

The statistical significance of the differences between some of the metric data sets has been evaluated according to a Student's t-test. Although, as we have seen, this test is little affected by normality or variance (Simpson *et al.* 1960 and Chapter 2), in cases where the distribution of measurements was obviously much different from normality the test has not be applied. A further difficulty in applying the test to log ratio distributions is that some measurements may derive from the same specimen (e.g. 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 chapter 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 will be discussed in a separate work dealing with the two western Mediterranean islands (Albarella *et al.* forthcoming).

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

7.3 Results

The location of the main sites discussed is presented in Figure 7.1. Log ratios for tooth measurements are presented in Figs.7.2-7.5 and for post-cranial bone measurements in Figs.7.6-7.8.

7.3.1 Modern Italian wild boars

All archaeological data are compared with tooth measurements from modern Italian wild boars and therefore a more detailed account of the present status and recent history of the species in the Italian Peninsula than that presented in Chapter 3 is 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 century, 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', located between northern Latium and southern Tuscany (Figure 7.1). 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 and Festa 1927, though more recently several scholars have questioned its real difference from the nominal subspecies present in most of Europe (e.g. 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 Kuşatman (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.7.2-7.5) 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 abnormal or perhaps the result of recording mistakes.

As we have seen in Chapter 3, 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.

7.3.2 Southern and central Italy

7.3.2.1 *Palidoro (Latium, central Italy)*

Preliminary work on the animal bone assemblage from this site was originally carried out by Cassoli (1976-77). The faunal assemblage derives from upper Palaeolithic levels belonging to the Epigravettian culture (Bietti 1976-77), dating back to the second Würmian pleniglacial/tardiglacial c.18,000-8,000 BC (Guidi & Piperno 1992). Tooth measurements indicate that the swine from Palidoro were similar in size to modern Maremman wild boars, and substantially smaller than the modern Turkish standard (Figure 7.2). 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, bone measurements at Palidoro were relatively larger than teeth (Figure 7.6). 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. As shown in Chapter 3, the size of modern wild boars is known to follow the Bergmann's rule, namely it tends to be smaller when temperature is high (see also Groves 1981; Magnell 2004) 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.

7.3.2.2 *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 to 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.10,000-7,000 BC), whereas the Mesolithic phase could be attributed to the first half of the 7th millennium BC (Tagliacozzo 2000, 101). 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 7.1). Like Palidoro, the bones were relatively larger than teeth (in comparison to the standards) (Figs.7.2 and 7.6). A small size increase in tooth measurements occurs between the upper Palaeolithic and the Mesolithic, and this is statistically significant (Table 7.1). 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 Figs.7.2 and 7.6, 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 7.1). 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 middle 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).

7.3.2.3 *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. 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 thesis 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 dated – with the aid of calibrated radiocarbon dating - from the middle of the 9th to the middle of the 7th millennium 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 millennium 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. 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 to the 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. Pig measurements from the two early Neolithic phases were combined – in some cases even with material only generically dated to the Neolithic – 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 (Figure 7.3, Table 7.1). Consequently, to increase sample size, the two phases have been combined for the analysis of post-cranial bone measurements (Figure 7.6). Overall the Mesolithic pigs from this site are smaller than those from Grotta della Madonna (Figure 7.3, Table 7.1), 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.7.3 and 7.6, Table 7.1). Since no climatic change occurred in 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 dP_4+M_3). Although we cannot be sure that the Neolithic pigs were fully domesticated, there is sufficient evidence enough to suggest 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 I will return to this point in the discussion.

7.3.2.4 *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 & Tagliacozzo (1993), whereas a specific group of material associated with a well-preserved wooden pirogue is described in Cassoli & 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 data set 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 located further south. As can be seen in Figs.7.4 and 7.7 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 the assemblage. I return to the interpretation of this dataset once the evidence from other sites will have been discussed.

7.3.2.5 *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 4th millennium BC; Guidi & Piperno 1992). The small assemblage of early Neolithic fauna was reported by Bökönyi (1983) (with no measurements), whereas work on the middle Neolithic material is still in progress. On the basis of tooth measurements the pigs from this site represent a homogenous group with a unimodal distribution (Figure 7.4) 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.

7.3.2.6 *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 myself, 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 millennium/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.7.5 & 7.7). 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 as we have seen in previous chapters (see Chapters 3 and 6). It is also interesting to note that the separation between wild and domestic populations is clearer in bones than teeth. As I have discussed in Chapter 2 tooth measurements are generally better suited to assess body size of particular pig populations, 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.

7.3.2.7 *La Starza (Campania, southern Italy)*

A small animal bone assemblage of Eneolithic and Bronze Age date emerged from earlier excavations at this site (Trump 1960-61), 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 evidence presented in this chapter 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 Protoappenninico 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 (Figure 7.4). The average size is probably similar to that of the domestic element at Conelle, and definitely smaller than in any of the Neolithic sites (Table 7.1). There can therefore be little doubt that the bulk of the pig teeth found at La Starza derive from domestic animals. The post-cranial bone evidence (Figure 7.7) 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 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; Appenninico) (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 Protoappennico and Appenninico cultures relied little on hunting, as not only wild boars but also other game species, such as deer, are poorly represented at these sites.

7.3.2.8 *Torre Mordillo (Calabria, southern Italy)*

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.7.4 and 7.7). It is possible that the process of population isolation following domestication had made further progress in moving from the middle to the late Bronze Age, though Torre Mordillo is located 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.

7.3.3 Northern Italy

7.3.3.1 *Arene Candide (Liguria)*

The history of the investigation of this cave 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 & 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 thesis. 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 (middle 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 third 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 (Figure 7.5). 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 7.8.

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 third 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 I 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 third molars may have undertaken a size reduction after the Mesolithic (Figure 7.9). A handful of Mesolithic astragalus 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 (Figure 7.8), 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 what was found in 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 mid/late Neolithic transition at Arene Candide.

7.3.3.2 *Rocca di Rivoli (Veneto)*

The animal bone assemblage from this site was originally studied by Jarman (1976b), but the material was re-analysed as part of a BA dissertation at the University of Birmingham (UK) (Piper 2001), supervised by the writer. 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.7.5, 7.8 and 7.9). 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 fourth premolars were measured). Despite the fact that Rocca di Rivoli is slightly more northern and much more eastern and farther from the sea than Arene Candide (Figure

7.1), climatic conditions are not substantially different between the two sites as, at Rivoli, these are tempered by the vicinity of Lake Garda.

7.3.3.3 *Cornuda (Veneto)*

The animal bones from this site were studied by Riedel (1988) and belong to the later phase of the Square Mouthed Pottery culture and are therefore contemporary to Rivoli. The data used here 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 7.8 the size of the pigs from Cornuda is very large, comparable to the wild population from Conelle (Figure 7.7). 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).

7.3.3.4 *Concordia Sagittaria (Veneto)*

The faunal assemblage from this late Bronze Age site is still in course of study by Antonio Tagliacozzo 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 what was 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.7.5 and 7.7). The group of supposedly domestic pigs has a body size that is smaller than the main distribution of middle to late Neolithic animals from other sites, 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 rate found in most pre-Neolithic and Neolithic sites.

7.3.3.5 *Other northern Italian sites*

A number of other important animal bone assemblages have been studied from prehistoric sites in northern Italy, but for these we do not have full data sets of comparable individual measurements. Nevertheless, it is still worth trying to use them as much as we can in comparison with the evidence discussed so far. Figure 7.9 presents means and ranges for measurements of the lower third 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 at the Arene Candide dataset we added a few wild boars of similar size to those found at Conelle, Cornuda or Barche di Solferino, 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 1981) the size of the pigs seems to be consistent with Rivoli, which suggests that the substantial size reduction occurring at Arene Candide at the mid/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 (1976a) 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 (1976b) 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 (Lombardy) (Riedel 1976c) is very consistent with what was 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.

7.3.4 Shape of the third molar

As we have seen in Chapters 3 and 6 (but also see Davis 2002b) the shape of the lower third molar may vary in different pig populations and in particular in domestic and wild pigs, and 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 M_3s from several Italian sites, combined by main chronological periods, have been plotted and the most significant diagrams are presented in Figure 7.10. It can be seen that much overlap occurs between the three selected groups – pre-Neolithic, Neolithic and Bronze Age – but some trends, admittedly tenuous, can be identified through a closer scrutiny of the scatter plots. For instance in Figure 7.10A – 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 perceivable, 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 7.10B 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.

7.4 **Discussion**

A summary of the results presented in the previous section can be found in Figs.7.11, 7.12 and 7.13. Three main phases of development in pig exploitation can be identified, and these are discussed in chronological order below.

7.4.1 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 (see chapter 3). 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 (Figure 7.12). 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 much 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 (see Chapter 6) 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.

7.4.2 Early farmers

A recent review of radiocarbon dates for the earliest Neolithic evidence in Italy (Skeates 2003) indicates that early farming activity started sometime between 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, 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 very early sites. The site of Masseria Candelaro, in the Apulian Tavoliere, has, however, produced useful evidence for the middle Neolithic period (i.e. 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.7.11 and 7.13). 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.

7.4.2.1 *The wild hypothesis*

Northern Italy - The possibility that the Arene Candide early and middle Neolithic pigs were wild has been raised (Rowley-Conwy 1997 and 2003), but, with the emergence of new evidence, a number of factors seem to argue 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 (Figure 7.9). In addition, there is mounting evidence that wild boar size in Italy increased after the Mesolithic – as it did in other parts of Europe (see Chapter 3) (Figure 7.13). 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 (e.g. 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.

7.4.2.2 *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 to 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 accredited hypothesis 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, but 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 (Figure 7.11). Had 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.* 1996; 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 I collected measurements from the 6th millennium sites of Erbaba in Turkey (Bordaz 1973) (in collaboration with Keith Dobney) 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 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 Figs.7.14 and 7.15 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 (Figure 7.12) and the shape of the third molar at Erbaba (Figure 7.10) 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 a few 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 was neither widespread nor involved large numbers of animals. No clear discontinuity occurs between the Mesolithic and the Neolithic, and the Neolithic pigs of Italy - whether wild or domestic - certainly 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.* 2001), 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. The lesson learnt from present-day Sardinia and Corsica and medieval England are particularly instructive, as we have seen that in those cases combinations of different systems of pig management occurred. 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 I have discussed so far.

7.4.3 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 Sardinia (Chapter 4) 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.

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

1976a; Tagliacozzo 1992) (Figs.7.11 and 7.13). Domestic pigs had decreased in size probably as a consequence of more controlled systems of management, 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.7.12 and 7.13). 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 Figure 7.12 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 third molar between Neolithic and Bronze Age sites has also been discussed (Figure 7.10).

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 (Chapter 3) 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, as already suggested in the case of Portuguese pigs. This date would approximately fit with the chronological pattern detected in Italy, where most of the truly large pigs are found from the third millennium BC onwards. As for Portugal, 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 after the Mesolithic (Davis 2002b). 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 as belonging 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 Maremman wild boar. A similar phenomenon has been recorded for other areas of the world, such as central Europe and Japan (see Chapter 3)

7.5 Conclusions

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 with 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 chapter 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 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 in.

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 (Figure 7.13).

This work 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 thesis I have mainly tried to highlight general tendencies, but this does not mean that I do not appreciate that domestication and husbandry may have developed unevenly in different areas of the country. My 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.

8. GENERAL CONCLUSIONS

The history of animal domestication and husbandry goes hand in hand with the history of people in the last 10,000 years, and it is key to the understanding of our origins, heritage and attitude towards the natural world. In this history, pigs have played a very significant role, and archaeologists and historians should therefore give this animal an attention proportionate to its importance, something that has not quite happened so far. As stated in the Introduction there are reasons for this (partial) neglect, and the work presented in this thesis not only provides the opportunity to contribute to filling this gap in our knowledge, but also to highlight how future research can compensate for such an overlook.

There are two main reasons why the study of the archaeology of pig exploitation has suffered drawbacks in recent years. These are represented by a general lack of *initiative* and of *opportunity*.

8.1 Initiative

Methodologically we have seen in the foregoing that the study of pig remains from archaeological sites presents several challenges – e.g. the difficulty in distinguishing domestic and wild forms, the dearth of adult animals in the archaeological record and the general fragmentary nature of the evidence – but there are ways in which these problems can be tackled and probably zooarchaeologists have not displayed sufficient *initiative* in adopting them. For example some of the earlier works cited in this thesis reveal that a quite strong element of conservatism has characterised attempts to assess morphological characters of archaeological pigs and wild boars. By carrying on simply using measurements of third molars and withers heights – useful as they may be – and sticking to criteria for the separation of wild boars and domestic pigs – such as the shape of the lachrymal bone – which are rarely applicable to archaeological material, zooarchaeologists have often missed the opportunity to exhaust the potential of available bone assemblages. Most reports of animal bones from archaeological sites almost inevitably end with the statement that not enough data were available to assess pig size or shape. Equally frequently pig remains are attributed to the domestic or wild form without a proper justification for such identifications. If this approach was justifiable thirty years ago or so, today this is no longer the case.

In this thesis it has been shown that much better use can be made not only of newly excavated collections of pig remains but also of material already studied, but still available for further analysis. In particular:

- the understanding of which measurements are suitable for which questions
- a more extensive use of dental biometry
- the adoption of scale index techniques

can improve substantially our ability to make the most of the available evidence.

Another aspect that has been strongly neglected, but has a good potential, is the analysis of variation in *shape* (as opposed to *size*) of pig body parts. In particular, we have seen that the ratio between tooth and bone size is variable in pig populations and can therefore be very informative for addressing questions such as domestication, selection and animal movements and trade. For example the size reduction that accompanies the evolution of more fully domesticated pigs in the Italian Bronze Age goes hand in hand with a different size proportion of teeth and post-cranial bones (Chapter 7). The shape of some pig teeth has also been revealed as a useful tool for defining the characteristics of the pig population under study. This is particularly clear in the case of Indonesian pigs which have a third molar shape that is different even from that of pig populations living in neighbouring areas (Chapter 3). Archaeologically, there are hints of a difference in third molar shape between wild and domestic forms in Portugal and Italy (Chapters 6 and 7). This is probably just the tip of the iceberg, as so much more can be attempted, in particular on the many large pig bone assemblages housed in various world institutions. For obvious reasons of limitations in time and space only a selected number of examples of a more imaginative use of biometrical analysis could be presented here, but there are endless further opportunities. For instance, assemblages like that deriving from the Eneolithic site of Conelle di Arcevia, where a quite clear separation occurs between wild and domestic pigs, can have a remarkable potential in addressing a large number of methodological questions regarding changes brought about by domestication and selection. Data from this assemblage have been used in this dissertation, but there has not been the opportunity to re-analyse the material, which would surely be a worthwhile exercise. Many more similar opportunities certainly exist – and without the need to excavate a single pig bone!

8.2 Opportunity

As mentioned, the other important area that has prevented a rapid development of pig studies has been the lack of *opportunity* to carry out synthetic work. Zooarchaeologists are often faced with the frustrating constraints of only having time to report briefly on the material deriving from an individual site, without the opportunity to put this evidence in context and therefore to interpret it more accurately. This is often a question of logistics as well as of funding, as more and more rarely are reviews of specific zooarchaeological questions provided with the necessary financial support. The project from which this thesis originates represents a useful exception to this trend, as we have had the opportunity to start looking at the relation between pigs and humans at a chronological and geographic scale which had been previously unthinkable (but see Kuşatman 1991). Another common problem with zooarchaeological interpretation is that this is often too narrowly focused on archaeological assemblages, whereas in this thesis I have tried to propose a number of different approaches, which integrate archaeological, zoological, ethnographic and historic data. The new research opportunities offered by technological advances in genetic (DNA) and isotopic analyses have not been discussed here in detail, but they do represent another important underlying element of this project and a valuable alternative approach.

The risk of interpreting the evidence divorced from its wider context becomes obvious when we look at some of the case studies presented in this work. To provide just an example, if I had just focussed on the traditionally used third molar measurements when trying to detect signs of the beginning of domestication at the Mesolithic/Neolithic transition, I would have run the risk of coming up with spurious conclusions. This is demonstrated by the realisation that most Mesolithic wild boars – at least in Europe – had, in relative terms, much larger bones than teeth in comparison to later prehistoric pigs (see Chapters 3, 6 and 7).

We must also wonder whether, in trying to establish the wild or domestic status of Neolithic pigs, Bronze Age wild boars represent an appropriate comparison. The answer to this question is that we cannot be sure, as the problem has to be considered by looking at local and regional patterns. The reason for such uncertainly is that this thesis has demonstrated that in several European regions wild boar size increased from the Mesolithic to the Bronze Age, and we do not know whether Neolithic wild pigs were more similar to those of the earlier or later period. The consequence of the lack of awareness of such a wide chronological trend – highlighted for the first time in this thesis – is that in the past this question had not even been posed, in the erroneous conviction that post glacial wild boars living in a specific region had always been more or less of the same size.

8.3 Summary of main results

The novel and wide-ranging approach taken in this dissertation has allowed me to provide the following answers to the key aims/objectives set up in the Introduction:

- The large assemblage of animal remains from the late Neolithic site of

Durrington Walls (Wiltshire, England) has provided the opportunity to examine patterns of variability in the measurements of pig bones and teeth in a large archaeological sample, and to propose a set of 'standard' measurements to be used as a comparison with other European sites. The results indicate that different measurements are suited to tackle different questions, such as the separation of populations, sexes and age groups. An understanding of which measurement is appropriate to address which problem is of great importance for the interpretation of archaeological assemblages of pig remains.

- The biometrical study of a large assortment of skulls and skeletons of recent wild boars from across the Old World 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 boars 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 of the data discussed above 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.

- The results of recent ethnographic work on traditional practices of pig husbandry in the western Mediterranean islands of Sardinia (Italy) and Corsica (France) indicate that in both islands free-range husbandry is widely adopted with minimal control of pig populations. Interbreeding with wild (or feral) populations occurs regularly, with little effect on the general size of the animals, as both wild boars and domestic breeds belong to dwarf types – a well-known phenomenon for island populations. It is suggested that patterns of pig husbandry similar to those practiced in the two islands may well have been adopted in different geographic areas in the past and can therefore illuminate some of the archaeological questions concerning the origins of pig husbandry.
- Historical sources have been used to examine the evolution of systems of pig husbandry in medieval England – from Saxon times to the beginning of the modern era. Changes in the perceived importance of pigs and in practices of pig husbandry occurred in time, space and across the social spectrum of medieval society. Modifications in pig morphology are probably associated with the introduction of new systems of husbandry, dictated by deforestation, reorganisation of economy and society and human demographic fluctuations. The introduction of a more closely controlled system of husbandry and the possible importation of new breeds brought about the opportunity to select improved animals that could be slaughtered at a younger age. Changes did not occur in a uniform way across the country, as free-range practices of husbandry and traditional breeds survived alongside animals kept in sties under a closely controlled regime. This combination of practices and of old and new attitudes towards pig husbandry mirrors the sort of phenomena

witnessed in Sardinia and Corsica and provides useful interpretative tools for our understanding of prehistoric strategies of pig exploitation.

- The evidence from the two important Chalcolithic sites of Zambujal and Leceia (Portugal) indicates that at both sites pig husbandry was predominant over wild boar hunting, but, particularly at Zambujal where wild boars are more frequent, domestic and pig populations could not be clearly separated on morphological grounds. Wild boars were of a larger size in the Chalcolithic than in the Mesolithic, and this makes the scanty evidence of pig size and shape for the Portuguese Neolithic difficult to interpret. The evidence from the site of the Alcáçova de Santarém indicates that, in later periods, domestic pig size remained rather stable, probably suggesting that free-range practices were still widely carried out in later prehistoric (Iron Age) and historic times. It is possible that – as for other species like cattle and sheep – some improvement started occurring in the Moslem period, but this phase of change also coincides with the well-known introduction of the cultural prohibition to consume pig meat that characterises Moslem societies. It does seem that in this period there was a resurgence in wild boar hunting, as the taboo only applied to the consumption of the meat of domestic animals.
- From the evidence of pig exploitation in the prehistory of the Italian peninsula and Sicily emerges a broadly consistent diachronic pattern of change. In the Mesolithic fairly small wild boars (with bones quite large in relation to the teeth) lived in Italy. For most of the Neolithic period, 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 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 wild and domestic populations. The average size of domestic pigs decreased, probably as a consequence of a closer confinement of domestic herds, but, as in Portugal, 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 due to human demographic pressure brought about a further change in wild boar size.

8.4. Future work

Some of the possible avenues of further investigation of the past relation between humans and pigs have been highlighted in previous sections, but it is worth spelling out here which are the most promising areas of investigation for future research.

- *Diet* – As discussed above pig diet is versatile and therefore prone to great variation. Consequently it can provide a key insight into systems of management of domestic pigs and is also important because affects growth, size and morphology. A combined analysis of tooth microwear and isotopic analysis should provide an important contribution to the clarification of many issues regarding various aspects of pig variability. In particular the assessment of the stable isotope composition of the same mandibles used for the study of tooth microwear will allow a direct comparison of the results. In general bone chemistry represents a potential source of information that has so far been insufficiently explored. Brothwell (2001) has also recently highlighted the importance of iodine deficiency in retarding growth in animals, but this is a factor that has been neglected in archaeological interpretations, but which has a better chance to be tackled with the improvement of techniques of chemical analysis of bone.

- *Genetics* – The work by Larson *et al.* (2005), carried out as part of the APDH project, has proved that wild boars possess a clear phylogenetic structure. This allows us to make inferences on the geographic origins of populations of domestic pigs on the basis of their mitochondrial DNA characteristics. However, this analysis - although powerful – does not provide fine geographic detail. For instance all European wild boar populations – with the exception of those living on the Italian peninsula - are characterised by just two different haplotypes that are spread all over the continent. Methods and techniques for DNA extraction in modern, historical and ancient material will probably improve in the future. This should eventually open the possibility to start targeting nuclear DNA in the hope that further, and more refined, genetic information will be obtained.
- *Morphometry* – The morphometric analysis illustrated in this dissertation only represents the tip of an iceberg of possibilities in the processing and analysis of metric data. There are certainly endless more opportunities to look at various different types of analysis of linear measurements – some may prove

inconclusive, but there is always the possibility of identifying a morphometric pattern that allows some distinction of populations. A potential future development that has not been sufficiently been explored in pigs – with the possible exception of the work by Warman (2000) – is the study of geometric morphotypes, as for instance applied by Bignon *et al.* (2005) to equid bones. It is possible that this may in the future provide an even greater potential for distinguishing populations than any analysis of linear measurements, however sophisticated.

8.5 Pig/human relationships

Although much more work can be done on the data that have been collected for this project, let alone on existing assemblages, the evidence presented in this dissertation has already provided the opportunity to clarify aspects of the pig/human relationship which have hitherto been obscure. A key question that I was particularly interested in addressing - as I had worked on this problem as early as the mid '80s (Albarella 1986) – concerned the multiplicity of relations between humans and animals, pigs in this case, ranging from random predation to the factory farms sadly common in our modern world. Archaeologists have often described past relations between humans and animals simply in terms of a dichotomy between hunting and husbandry. Such an approach cannot entirely be discounted as superficial, because the archaeological evidence can often provide only enough information for an extremely simplified view of the past. However, if we must accept that the past can at best be described with the limited tools available to us, we must not forget that what we try to explain is not the past but just an approximation of it. In addition we must try to find ways to better understand the complex factors affecting the functioning of past societies, and not just be content with the interpretative models set up by previous research.

That the relationship between pigs and humans cannot easily be categorised has emerged clearly from this work. 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. We have seen (Chapter 3) that the size and morphology of wild pigs may vary according to hunting pressure as well as habitat modification caused by encroaching human settlements. In some cases wild boars live in very close contact with human populations, and sometimes they are even partly managed. A recent phenomenon is the trend for wild boars to settle in urban environments, as amply reported in media news (e.g. Möllers 2004). This situation seems to mirror that of the urban medieval pig (Chapter 5), which was, however, regarded as domestic, and indeed it was, but the thin line between wild and domestic can be well appreciated in this case.

In prehistoric times, Neolithic pigs from Italian sites, such as Grotta dell'Uzzo and perhaps also Arene Candide, Molino Casarotto and others (Chapter 7), may partly represent wild boars that were hunted in an intensive and perhaps partly managed system, which eventually led to local domestication. We must wonder whether the enigmatic remains from Caldeirão cave in Portugal (Chapter 6) may not belong to animals that were undergoing a similar process of transformation. The Chalcolithic sites from Portugal, with their 'peak and tail' distribution of pig measurements, resemble that found in middle and late Neolithic sites from Northern Italy such as Molino Casarotto. Whatever is our interpretation of the status of these pigs we can be fairly certain that separate domestic and wild populations co-existed in the area, and crosses were also likely to have occurred.

Redding & 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, including Italy. We have also seen that in Sardinia and Corsica (Chapter 4) regular interbreeding between domestic pigs and wild boars occurs, though this is rarely a deliberate policy.

Even when full domestication was achieved, control of domestic pig herds could have been very loose. We have seen several cases in which pigs have proved to be largely self-sufficient in their dietary requirements, without losing their domestic status for this. Free-range pigs – living totally independently at certain times of the year – were commonly kept in medieval England and represent the traditional system of pig-keeping in Sardinia and Corsica. If my interpretation is correct, they must also have been commonplace in prehistoric Italy. That pigs were kept off–site is likely to have been the case at the early and middle Neolithic at Arene Candide, due to the evidence (or better, lack of it) of shed teeth (Rowley-Conwy 1997), and Rivoli, where the settlement area, on the hill-top, is so small (Barfield & Bagolini 1976) that only a handful of animals could have been kept there.

Similar systems of pig management are not necessarily associated with similar economic patterns of organisation of human societies. In Saxon and early medieval England free-range pigs were taken to pasture according to a communal management system, whereas in Sardinia and Corsica the organisation is entirely based on the enterprise of the individual swineherd, though economic relations between different breeders do occur (i.e. loaning of sires, sale and purchase of animals etc.). It would be interesting to find out what kind of relation between free-range husbandry and organisation of the society could have occurred in prehistoric societies – whether, for instance, it was more similar to medieval England or modern Corsica, or something altogether completely different. To try providing an answer to this question is beyond the aims of this dissertation, but it is at least worth raising it in the hope that it will be addressed by future work. An integration of different sources of archaeological evidence will certainly be needed.

Systems of free-range husbandry could easily lead to a complete loss of control of the pigs, which would eventually go back to a fully independent life. When all ties with the swineherds are cut, pigs become feral, and may even acquire morphological characters more typical of wild boars. Sardinian and Corsican wild boars may be feral, despite their fully wild appearance. The work done in Sardinia and Corsica shows that individual pigs kept free-range are rarely lost, therefore pigs can only become feral either as a consequence of deliberate human action (e.g. introductions to islands where they could represent a source of meat through hunting) or because of a change in economic circumstances. These could potentially make pig keeping not worth bothering with, either because other resources become more viable or due to the abandonment of human settlements in areas suitable for pigs. Feral pigs can also be hunted, as is today the case for the feral pigs of Australia (Lee & Seymour 2003). This shows that the process of evolution from predation to domestication is not necessarily unidirectional. This phenomenon of a return to hunting practices as a consequence of the feralisation of domestic animals has also been reported for other species, such as reindeer (Ingold 1974).

Several factors such as the depletion of the environment, the reduction of forest coverage (ideal pasture for pigs) and the need to increase the meat output per individual animal can bring about the need to move from free-range systems of pig husbandry to closer forms of control. It is unrealistic to think of intensive stock-breeding in the later prehistory of Portugal and Italy, but changes in animal management certainly occurred and a greater separation between wild and domestic populations can be identified in the archaeological record. Work in progress shows that a similar phenomenon occurred in other European areas such as Switzerland and Greece (Albarella *et al.* in prep. a; Albarella *et al.* in prep. b). In Sardinia and Corsica the change goes hand in hand with the introduction of improved breeds – a phenomenon that could also have occurred in late medieval England - but this must have also triggered attempts to achieve improvement locally through selection and confinement of animals. It is interesting to compare the situation in modern Sardinia and Corsica with later prehistoric Italy and Portugal. In the first case practices not so dissimilar from prehistoric management were common until recently, but improvement could rapidly be achieved due to contacts and trade with technologically advanced economic systems, but in prehistory this was not the case and, although greater control of animal movements probably occurred, improvement had to wait at the very least until the beginning of the Roman period (and in Portugal even later).

In Figure 8.1 I have tried to summarise the range of possible relations between humans and pigs that I have illustrated in this thesis. More possibilities certainly exist. I have also tried to highlight – with arrows - a possible evolutionary itinerary from early forms of hunting to intensive stock-breeding. It must be stressed that all suggested changes from one form of exploitation to the other have been recorded in human history, but these should not be seen as an inevitable progressive sequence – in some societies pig hunting may well have remained the most viable system to procure protein supply. The great number of possible interactions between pigs and humans indicates that 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. Conversely, feral pigs – which biologically may be regarded as domestic – are, from an anthropological and archaeological point of view, wild, because they live totally independently from humans. 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.

Pigs are fascinating creatures that have enriched our history and still contribute to make the biological diversity of the world interesting and stimulating. Sadly, many wild pig species and populations are today threatened, traditional practices of pig husbandry are disappearing and most domestic pigs are kept in poor conditions, deprived of their most basic biological needs. By studying the archaeology of the relation between pigs and humans we can hopefully contribute to raising awareness in the importance that these animals have had for our history, and persuade our society to treat them with greater respect and compassion.

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