BARELY SURVIVING OR MORE THAN ENOUGH?

The environmental archaeology of subsistence, specialisation and surplus food production

EDITED BY

Maaike Groot, Daphne Lentjes and Jørn Zeiler

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Studying subsistence and surplus production

Maaike Groot[1,2] and Daphne Lentjes[1]

1. Department of Archaeology
Faculty of Arts
VU University Amsterdam
De Boelelaan 1105
1081HV Amsterdam
The Netherlands
m.groot@vu.nl
d.m.lentjes@vu.nl

2. Integrative Prähistorische und
Naturwissenschaftliche Archäologie
University of Basel
Spalenring 145
CH-4055 Basel
Switzerland

Introduction

Everyone needs food to survive. How people produced or acquired their food in the past is one of the main questions in archaeology.[1] Since environmental archaeology focuses to a large extent on food remains and means of production, this research field of archaeology provides the best chances to find out how food production was organised in the past. In studying food production, one major theme is the topic of subsistence and surplus production. Did people only produce food to fulfil their own needs, or did they produce more than they needed for survival – a food surplus? And if surplus food was produced, was this then part of a survival strategy (risk avoidance in case of failed crops or disease affecting livestock; *e.g.* Halstead and O'Shea 1989), or was it produced for an external market (*e.g.* Stallibrass and Thomas 2008)?

1 The autumn meeting of the Association for Environmental Archaeology, which took place at the VU University in Amsterdam on 21 and 22 October 2011, focused on the theme of subsistence and surplus production. The present volume was born out of the discussions that were held during this conference. Some of the contributions were presented here in some form, while others were added later.

One could ask what justifies the publication of another volume on subsistence and surplus production. After all, the subject matter is not new and numerous publications have been dedicated to it in the past, many of which will be discussed in this introduction. The main reason for tackling this topic once again is the wealth of new data that has been collected over the last few years. After a long phase of data collecting and (isolated) case studies it is now time for synthesising research with a regional and diachronic approach. Indeed, most of the papers in this volume offer a regional perspective, bringing together data from many different sites collected by different researchers.

Studying abiotic landscape factors as well as plant and animal remains can show the potential of the landscape and the use that was made of it. The landscape with its relief, soil types, soil fertility and water levels forms the framework for the possibilities for food production. Plant remains can tell us what plant foods were consumed, how they were processed, and whether this food was of local origin or imported. Animal remains provide information on the livestock that was kept, the meat that was consumed and whether animal products were supplied from elsewhere. These environmental data placed in their archaeological context make it possible to reconstruct food production and -procurement in the past.

Subsistence and surplus production are important research topics because they can give us insight into how people organised the management of natural resources, what they had to invest in terms of time and labour and how they survived in times when there was a shortage of food and water. What is more, surplus production was not only a necessary adaptation in order to cope with hard times, it was also one of the requirements for complex societies to develop (see for example Renfrew (1972) and Barrett and Halstead (2004) for the association of surplus production with agricultural specialisation, exchange of agricultural produce and the emergence of complex societies in the Mediterranean). At the same time, the terms subsistence and surplus production are easily used, but what do they actually say about the societies involved? How easy is it to determine whether a society did or did not produce more food than necessary to survive? Which tools and what methods can we use to analyse surplus production in different kinds of societies?

In this volume we look for answers to these questions. While we are fortunate in having received papers from various countries and time periods, there is a strong European bias to the volume. In this introduction, our own research interests and background also become apparent. As a consequence, the research questions, literature and case studies that are used to illustrate the discussion are clearly biased to Northwestern Europe and the Mediterranean in the first millennia BC and AD. The following text is by no means meant to provide an exhaustive overview of all the references to food production in the past. Rather, we wish to discuss methods suitable for studying the topic, discuss three research themes that we feel cover the subjects of the papers in this volume, and highlight some interesting examples.

Subsistence in hunter-gatherer and farming societies

A first question that comes to mind when studying so-called subsistence societies is whether they really exist, in the sense of societies providing for their own needs and nothing more. Subsistence is first of all about survival through the gathering or production of food. The volume edited by Halstead and O'Shea (1989) is vital for understanding subsistence and surplus in self-sufficient societies. In the introduction to the volume, Halstead and O'Shea discuss variability in food availability and strategies developed to cope with this. The amount of food available to both hunter-gatherers and farmers varies due to factors such as seasonal availability, temperature, rainfall, pests and disease. This variability can occur through time, for example in the case of seasonal foods such as migratory species, fruits and nuts, and harvested crops in temperate climates, or through space, with some regions being higher in resources than others. A distinction can be made between predictable and unpredictable variability. The former is easier to accommodate. A consequence of variability is that periods of food scarcity can occur. Societies have developed strategies – called buffering mechanisms – to cope with such periods of scarcity; four basic categories can be distinguished: 1) mobility; 2) diversification; 3) physical storage; and 4) exchange (Halstead and O'Shea 1989, 3). In the first category, people move away from affected regions to regions where food is more abundant. This is not always an option for sedentary farmers. Diversification refers to the broadening of the subsistence base, by exploiting a wide range of resources. The concept of famine foods falls under this category, since by assigning some kinds of food this status, some food is left untouched until it is really needed. Farming multiple fields in different locations also falls under diversification (Halstead and O'Shea 1989, 4). For farmers, keeping domestic animals as well as growing crops is an effective way of diversification; any excess plant foods can be converted into animal protein. For farmers in regions where domestic animals were not available, hunting provided an alternative (O'Shea 1989). Physical storage is self-evident: by storing food, periods of scarcity can be overcome. Of course, not all foods are suitable for storage. Exchange refers to various kinds of social strategies, such as sharing, reciprocal obligations, and negative reciprocity (theft) (Halstead and O'Shea 1989, 4). Which buffering mechanism is employed by which society is dependent on the kind of variability encountered. Some buffering mechanisms can transform societies, for instance when a surplus (initially produced to avoid risk) is appropriated by an elite. Halstead and O'Shea's paper clearly describes the different ways in which subsistent communities can cope with uncertainty.

However, on what basis can we establish whether a society was truly self-sufficient? After all, there are always contacts and exchanges between societies, albeit on a small scale. Evidence for this is formed by exotic items and materials sourced from outside the society's range (for example flint in the Mesolithic Netherlands; Louwe Kooijmans 2001, 519-522; Van Gijn *et al.* 2001, 161-163). Nevertheless, even though some small-scale exchange of artefacts or materials occurred, staple food was never part of the exchange, which means that the term subsistence still applies.

A typical subsistence farming society can be expected to show limited specialisation. A variety of crops and more than one species of animal are grown or kept for two main reasons. First, little or no food is brought in from outside the community, so variety is necessary to provide a balanced diet and enough food throughout the year. Second, risk is much higher in specialised agrarian systems. If a crop fails or disease strikes, it is vital not to have to depend on just one crop or animal species. Subsistence societies spread risk by farming a variety of crops and animals. Hunter-gatherers do show specialisation, in that they sometimes target one prey species or staple plant food that dominates the food consumed (*e.g.* hickory nuts in the Archaic Mid-South (**Carmody and Hollenbach, this volume**); mongongo nuts among the Khoisan (Barnard 1992); caribou among the Nunamiut (Minc and Smith 1989); salmon at the site of Mount Sandel, on the Bann River in Ireland (Woodman 1985)).

As a rule, the scale of production in self-sufficient societies is not (significantly) larger than what is needed to satisfy the community's own needs. However, even subsistent societies will have aimed at producing a surplus. Examples of this can be found in hunter-gatherer societies as well as early farming communities. For instance, Rowley-Conwy and Zvelebil (1989, 51-56) examined the archaeological record of Europe for evidence of storage by prehistoric hunter-gatherers, such as more permanent settlements (presumably made possible by the availability of resources within striking distance) and mass capture technology (such as nets and fish traps). According to these authors, surplus is not automatically linked to food-producing societies. Rather, it should be seen as a response to a particular set of environmental conditions, including seasonally available resources. In such circumstances, surplus storage serves as a risk-buffering mechanism. The same phenomenon is witnessed by Halstead (1989) in early farming communities in Thessaly. It appears that surplus production was a normal response to risk of food shortages here as well. Halstead's case study in Thessaly examines problems caused by seasonal, interannual and long-term variability. To reduce risk, early farmers grew a range of different crops and had mixed livestock, thus reducing the risk of loss due to late frosts, drought and diseases. In hard times people could switch to hunting and gathering, as is suggested by the remains of wild mammals, birds, fish, molluscs, fruits and nuts at several sites. Halstead believes that surplus occurs in all societies. A difference can be made between direct storage (of food itself) and indirect storage (a social concept, where food given to others implicitly creates a debt, which can be collected in the future). Among the Khoisan, for instance, maintaining social ties is an important adaptation against future needs (Lee 1976). The advantage of indirect storage over direct storage is that most storable food items have a limited shelf life.

In short, it can be stated that absence of surplus production is not a reliable indicator for subsistence societies. Instead, we would propose the following characteristics: 1) scarceness or complete lack of imported products; 2) few signs of specialisation in certain products; 3) a variety of crops and animal species (again, reflecting an absence of specialisation but also a risk-avoiding strategy); and 4) a modest scale of production.

Only one of the papers in this volume deals with hunter-gatherer societies. **Carmody and Hollenbach**'s contribution focuses on the Middle Archaic period (8,900–5,800 cal BP) in the Mid-Southern USA. Their analysis of archaeobotanical data shows a certain specialisation in the gathering of hickory nuts, a dietary staple that is high in nutritional value, low in processing cost and good to store. The intensified use of hickory nuts likely resulted in an increase in population size and density (decrease in child mortality) and changes in material culture and site use. Furthermore, because of the greater efficiency of foraging strategies, there was more time for non-subsistence activities, such as the production and exchange of artefacts. Exchange strengthened ties between groups, further reducing food risk and tensions. In this way, a change in food gathering had consequences for society as a whole.

Çakirlar investigates the subsistence economy in the Neolithic Marmara region in Turkey. The Neolithic of this region has frequently been defined as an aquatic forager economy, relying on fishing and foraging rather than farming. However, by synthesising old and new archaeozoological datasets, Çakirlar clearly demonstrates that this definition is out of date. The subsistence economy was characterised by a combination of animal husbandry and intense exploitation of wild resources, both terrestrial and aquatic. Aquatic foraging strategies probably evolved to optimally exploit local environmental resources and supplement the domestic base of the diet.

Most studies on subsistence and surplus are based on food. However, there is another important resource for human subsistence that is often forgotten: water. This is the subject of the paper by **Hellqvist**, who focuses on the use of wells at three Iron Age sites in Southeast Sweden. By studying insect remains stratigraphically it was possible to investigate the history of the construction and use of these wells, and thus how water was supplied. The results indicate that at all sites the use of several wells changed over time from a human water source to a waterhole for livestock. A complicating factor in studying water supply is that wells must have had a complementary function to natural water resources.

The transition from subsistence to surplus production in farming societies

As we have seen above, subsistent societies may have aimed at producing a surplus to serve as a risk-buffering mechanism. It is not until the unused reserves become structural that the buffer develops into a real surplus (Bakels 1996, 334). Bakels further suggests that surplus cultivation is '*the intentional creation of a surplus in order to obtain material or immaterial valuables produced by others*'. However, this overlooks another reason for producing a surplus: to meet demands from elites or the authorities, for instance paying tax. In a hierarchical society, the higher sections may have the power to force farmers into providing them with food. For example, linear B tablets and sealings from Mycenaean Thebes show that sacrificial animals were brought to the palatial centre from distances well over 50 kilometres away (Palaima (2004, 226). According to Palaima, these contributions imply that farmers in these areas bore some form of allegiance to Thebes, or at least acknowledged and respected the palace's power and status in such a way that they provisioned commensal ceremonies and feasts that were held here. Surplus food was thus redistributed through feasting, controlled by the Mycenaean elite. Palace feasts reinforced the palaces' prestige and emphasised social hierarchies (Halstead and Isaakidou 2004; 2011). Mycenaean Greece is not unique in this respect; for example, feasting with large-scale consumption of pork and beef was proven for the Neolithic ceremonial site of Durrington Walls in England (Albarella and Serjeantson 2002). A later study revealed that cattle were brought here from various other parts of Britain (Viner *et al.* 2010). This has consequences for the animal husbandry in this period, suggesting that some surplus animals were kept. In Iron Age Britain, surplus cereals were probably consumed in large communal feasts; later in the period, the surpluses were appropriated by the elite to enhance their power and status (Van der Veen and Jones 2007). Apparently, the farmers who produced these surpluses were not offered anything tangible in return, which makes such exchanges very difficult to detect archaeologically. The same may hold true for taxation in return for access to natural resources. An example of this can be found in Late Medieval England, where peasants provided their lords with chickens in return for access to dead or fallen wood (Woolgar 2011, 8-9). Unlike market exchange, which will result in 'foreign' items or products being encountered in farming settlements, such mechanisms will not leave clear material traces. Evidence outside the farming settlements themselves needs to be taken into account in order to understand the economic situation: whether the society in question has a hierarchical structure, what the economic basis of the elite was, and whether taxation occurred. Unlike the producer sites, archaeological evidence from consumer sites may provide evidence for the movement of food and animals.

In contrast, surplus food that is produced in order to obtain other goods is often easier to detect archaeologically. Two different mechanisms can be distinguished:

a. exchange between neighbouring communities, which each produce different products, for example pastoralists and arable farmers. The societies are economically complementary and depend on each other for part of their food. When communities are culturally different, this type of exchange can be studied indirectly through other, more distinct exchange items, or indeed the containers in which the foodstuffs were transported.

b. production for a market. In this case, an agrarian surplus is sold at a market or exchanged for other products. If these products are artefacts, then their presence in farming settlements provides indirect evidence for surplus production.

A change from subsistence to surplus production, and thus an increase in production, can be achieved in a number of ways. These include:

1. agricultural expansion. This can be accommodated in two basic ways:
   a. by increasing yield per unit (intensification). The yield of crops can be increased by applying more manure to the soil or by tending to the crops in a more intensive way (*e.g.* by weeding and watering). Yield of livestock can

be increased by breeding larger-sized animals, providing better nutrition, or by slaughtering them at the optimum slaughter age instead of sooner. The availability of better technology or new genetic strains can play a role here. Of course, any evidence for increased production has to be linked to demographic data. If an increase in production goes hand in hand with population growth, then it may have served only to feed the local population.

b. by increasing units (extensification). A larger acreage of arable land by itself will provide a larger yield without any other changes in farming. Herd size can be increased, so that eventually more animals can be harvested. Such an increase in production can be identified when the total size of arable fields increases, or – if livestock is stabled – when stable areas increase. Geomorphology can provide evidence for erosion, land degradation and ploughed soils. Of course, in both cases the available land for arable or pasture provides limitations on what is possible. Furthermore, the amount of labour required would have increased, certainly in the case of increasing arable land. Extensive farming of livestock, on the other hand, with semi-wild herds of animals, would have required little extra labour.

2. agricultural rationalisation. By this we mean changes in farming that lead to more efficient production, for instance by organising the available land for farming into plots. Such plots can then be used in a way that increases the yield, or allows the exploitation of marginal soils through crop rotation. Specialisation, where a farm or settlement focuses on the production of a limited scope of agricultural products in order to gain a greater degree of productive efficiency, can also be seen as rationalisation. Specialisation often occurs when a surplus is produced for a market. Most specialised food production in the past was relative; that means that farmers still grew most of their own food, but the surplus they produced did focus on a specific product. Environmental archaeology can be used to study specialisation in food production in many ways, for example through the analysis of archaeobotanical macroremains and pollen analysis – if there is one dominant species (*e.g.* Bakels 1996, 330-331; Jahns 1993, 192; Rösch 2005; Salavert 2008). In archaeozoology, mortality profiles can also highlight specific animal products produced as a surplus, such as wool or dairy. The way in which livestock was slaughtered (how carcasses were segmented and what tools were used) can say something about the scale at which butchery occurred, and whether this was done by professional butchers – suggesting a considerable degree of specialisation – or not.

Some of the papers presented in this volume point at indications of crop specialisation, such as grapes and olives, as evidence of increasing surplus production (**Iborra Eres and Pérez Jordà; Lentjes, this volume**).

Studies with regard to the transition from subsistence to surplus production have the advantage that diachronic development can be studied instead of a stable situation. In other words, two different agrarian strategies can be compared, a 'before' and 'after' situation. In archaeozoology, changes in species proportions can suggest a change in farming strategies, possibly reflecting surplus production. Changes in slaughter ages of animals reflect a change in exploitation, and again, taking into account the existing knowledge for a certain period and region, this can sometimes be interpreted as an indication for a change to surplus production.

It can be assumed that the transition from subsistence to surplus production starts with a small-scale surplus in addition to the food produced to cater for a community's basic needs. This can be problematic, since the combination of production for own needs and small-scale surplus may be difficult to recognise, especially when the surplus is used to pay taxes. However, by studying a transition, any changes in crop or animal spectrum (especially where one species increases significantly) or changes in exploitation can indicate a move to surplus production. Of course, the historical situation as well as other archaeological information needs to be taken into account. For instance, changes in animal husbandry occurring in the 1st century AD in the Central Netherlands coincide with the Roman occupation, which brought a demand for food with it (Groot 2008a and b). The presence of imported items in farming sites – especially large amounts of pottery – suggests that these settlements were involved in trade networks. For the Roman Netherlands, quantitative models have provided insight into the possibilities for surplus production by local farmers (Groot *et al.* 2009; Kooistra 1996; Kooistra *et al.* 2013; Van Dinter *et al.* forthcoming). The presence of granaries with capacities exceeding local requirements provides an indication that surplus production was not only possible, but actually took place (Bakels 1996, 331-333; Groot *et al.* 2009; Kooistra 1996, 66-67). Ideally, a combination of several different kinds of data is used. For instance, a hypothetical change in crop species to a dominance of one kind of cereal in itself is suggestive, but when combined with extension of arable fields, an increase in storage capacity and an increase in older cattle (providing traction power and manure in support of arable agriculture), this makes a much stronger case for surplus production of cereals. Bakels (1996) also recommends using different strands of evidence for surplus production of crops: calculating production versus consumption, evidence for monoculture, excessive storage and the presence of imported goods.

Long-distance trade in plant products, both staple foods such as cereals and exotic luxury items such as pine nuts, dried figs and pomegranates results in direct evidence for surplus production (see Bakels and Jacomet (2003) for Central Europe in the Roman period; Kooistra (2012, 176) for a survey of Roman military sites in the Rhine delta; Van der Veen *et al.* (2008) for evidence for Roman Britain. Another example is the presence of dates, which had to be imported, in Roman and pre-Roman Italy (Ciaraldi 1997; Fiorentino 2008, 99; Jashemski and Meyer 2002)). The presence of non-local arable weeds provides indirect evidence for import of plant crops (Kooistra 2009, 222; Pals and Hakbijl 1992).

Indirect evidence for the movement of foodstuffs is provided by the containers used for transport. A good example is the distribution of Roman amphorae, which have been used to reconstruct trade mechanisms in wine, olive oil and other staple foods (*e.g.* Temin 2001).

Once we have found indications for surplus production, what we really want to know is not just whether a surplus was produced, but how much. Van der Veen and Jones (2007) argue that the presence of archaeobotanical samples rich in cereal grains (compared to chaff and weeds) can be used as an indication for the scale of production, since accidental burning is likelier to occur in sites where cereals are handled in bulk. In some cases, the best evidence for the scale of production comes from research disciplines other than environmental archaeology. For example, systems of ditches (representing droveways and enclosures) are interpreted as evidence for a period of intensive livestock farming in Bronze Age Britain (Pryor 2006). The scale of the Fengate system (Cambridgeshire, UK) was deducted from the size of the fields and the handling system, which indicates the presence of thousands of animals (sheep rather than cattle) (Pryor 2006, 106). Phosphate analysis from the main droveway also points to large numbers of livestock (Pryor 2006, 96).

The extent of surplus production can be quantified, but with each variable involved being an estimate, the question is how reliable the outcome is. An agrarian quantification model requires input such as the available land, crop yields, storage capacity, population size, required food for this population, required and available labour, number of animals supported per hectare, stable size, *etc*. (IJzereef 1981; Kooistra 1996; Kreuz 1995; 2004; Schucany 1999). A comparison between the possible production and the needed quantities to support the local population can demonstrate whether surplus production was possible at all, and give some impression of its scale (Bakels 1996, 329-330; Groot *et al.* 2009; Kooistra *et al.* 2013; Van Dinter *et al.* forthcoming). Obviously, abiotic landscape factors still form the framework for the possibilities for food production, but man can adapt the landscape to a certain level in order to increase it. It is clear that people in the past had an impact on the landscape in this way, for instance by digging ditches to drain marshes or by fertilising fields with mineral, vegetable or animal manure (Szabó *et al.* 2010).

Archaeological data add valuable information. Storage capacity and stable capacity play an important role in identifying surplus production. However, while stable and storage capacity and the available land for certain agrarian activities can say something about the minimum and maximum potential, they tell us nothing about what actually happened. An optimistic farmer may always have had a half-empty stable or granary.

Five of the papers in this volume deal with the transition from subsistence to surplus production. **Pérez Jordà and Chocarro** discuss developments in agriculture in Neolithic Valencia that show transitions from subsistence to surplus production and back to subsistence. By studying crop species and diversity, storage structures, settlement patterns and pollen data, they were able to identify three different stages in the agriculture between the 6th and the 3rd millennia BC, from intensive and diversified horticulture to extensive agriculture with surplus production, and then back to horticulture.

Two papers in this volume analyse the transition from the Iron Age to the Roman Period. **Valenzuela, Alcover and Cau**'s contribution uses archaeozoological data to investigate the changes in the animal husbandry on Mallorca during the transition from the Iron Age to the Roman Period, while **Van Dijk and Groot**'s paper focuses on the same transition in the western and central parts of the Netherlands. Both studies identified changes in animal exploitation, as well as an increase in the size of animals.

The papers by **Iborra Eres and Pérez Jordà** and **Lentjes** also study developments from subsistence to surplus production, the first for Valencia and the second for Southern Italy. Archaeobotanical and archaeozoological data are combined with information on the landscape and settlement structures. Wine and olive oil were important trade products in both regions. Production of amphorae provides an important clue for local surplus production. Both studies show differences between inland and coastal areas, but in Lentjes's study this is related to the colonial Greek presence, whereas in Valencia the convenient location itself is enough of an explanation.

Developing complexity: the emergence of market economies

With the emergence of markets and a non-food-producing population, there are opportunities for rural societies to produce more food than they need for themselves, and exchange or sell this. This creates the circumstances that are necessary for the development of specialisation in production and crafts (spinning, weaving, cereal or bread production). With the rise of urban societies, the degree of specialisation increased and market economies developed. In such economies, complex long-distance networks can play a role in the supply of staple foods, such as cereals. This in turn leads to an even higher level of specialisation in agricultural products and crafts. A large part of the population is dependent on others for their food. The landscape is often optimally utilised, with cereals grown in areas with suitable arable land, and livestock grazed on land less suitable for arable production. Herbs and vegetables were grown in villages or even in vegetable gardens inside towns.

However, these assumptions about the role that food production plays in the development of socio-economic complexity raise many questions. Particularly with regard to early examples of urban societies, we may ask ourselves whether all food producers were specialised somehow. To what extent did inhabitants of small towns produce their own food? Did subsistence farming disappear entirely with the rise of urban societies? If so, how did this change come about? We may look for evidence of specialisation in certain crops or animal species (species proportions; mortality profiles; analysis of skeletal elements) to answer these questions, and detect the presence of excessive storage capacity in the archaeological record, but the disappearance of subsistence farming is probably best studied through the evidence of food trade. In that case, we are not looking for rare examples of exotic items, but the systematic transport of staple foods. Indeed, another issue that needs to be addressed is the origin of food that was sold on town markets.

Not all food came from the immediate environment; natural resources may have been transported over large distances. Examples can be found throughout history in many geographical regions, such as the import of cattle in 17th-century Holland. Gijsbers (1999) has shown that demographic growth and economic prosperity in this period led to a flourishing trade in cattle. These animals were imported from various countries in Northwestern Europe, including Denmark and Northern Germany. The analysis of animal bone measurements is especially suitable to study the relation between producer and consumer sites (*e.g.* Maltby 1994; Oueslati 2006; **Pigière and Lepot, this volume**). Evidence of long-distance trade of food is abundant even in much earlier times. Numerous written sources from Roman times (especially from the 1st century AD onwards) refer to the supply of grain from Egypt and Africa (*e.g.* Erdkamp 2005, 225). There is also much evidence for the large-scale production and commerce of salted fish and fish sauces in the Mediterranean and adjacent areas during the Roman period, in the form of architectural remains of salting installations and amphorae (Curtis 1991), but also of studies of fish bone assemblages (*e.g.* Lernau 1986, 93; Van Neer *et al.* 2010).

Another question that we may ask ourselves with regard to complex societies and the emergence of market economies is how increasing urbanism affected the relationship between town and countryside in terms of food supply. Traditionally, this issue is an important research topic for historical geographers, who created the characteristic model of land use zonation (Chisholm 1968, 43-67; Delano Smith 1979, 172-176). In this model, the growth of a town market leads to the formation of the surrounding landscape in order to facilitate the market in the most efficient way. The result is a series of land zones of varying economic profitability. Distance-to-market and related transportation costs are among the more important variables that dictate the different types of farming systems in each zone. An especially interesting case study is provided by Morley (1996), who discusses the effect of Rome's economic demands on the Italian peninsula in the Late Republican Period. The demographic increase of Rome created an urban market of an unprecedented size, which would have significantly enhanced economic growth in Late Republican Italy. In Morley's version of the land zonation model, the fast-growing city of Rome profited from high urban market prices and relatively low transportation costs. As a result, an intensive farming system came into being in the city's immediate hinterland (up to 30 kilometres away). The economy of this zone focused on the provisioning of Rome with perishable food such as fruit, vegetables and fish. Around this first zone, a second one existed, in which intensive slave-run villas were built that focused on olive oil production and above all viticulture. These villas produced for Rome as well as overseas markets. The final zone in Morley's model consists of the parts of Italy that are further removed from Rome, and therefore less influenced by its demands. Here, specific regional specialities were produced that could easily be transported over long distances, such as wool.

It needs to be emphasised, however, that especially this last part of Morley's model has been criticised by other scholars. Studies in the Brindisi region in Southern Italy, for example, demonstrate that estates practising intensive arboriculture flourished in the hinterland of towns in Southern Italy, where they served local markets as well as a wider Mediterranean network (Kuzišin 1982; Yntema 2006, 101-102). As Attema *et al.* (2010, 169) have pointed out, a range of factors is likely to distort the ideal zonation in geographically oriented models. Although the growth of Rome definitely had a major impact on the socio-economic development of Italy, it did not have the same influence throughout the various zones. Other factors, such as regional socio-economic power relations, unequal access to the primary market, and the presence of alternative urban markets have to be taken into account as well. What is more, variations in climate and soil fertility likely played a role of considerable importance. As such, environmental archaeology could make an important contribution to this kind of research.

An interesting archaeozoological example is provided by Zeder's (1991) study of an early urban economy in the Near East, focusing on modes of distribution of animal resources, which showed a high degree of specialisation in the provisioning of the urban inhabitants. This demonstrates that a market economy is not necessary for a complex economic system, with a high proportion of the population not involved in producing their own food, to function.

Another study with regard to the relationships between urban consumers and rural producers of agricultural products that is worth mentioning is provided by Crabtree (1996). This paper is concerned with the period when the earliest post-Roman urban sites appear in Eastern England. Mammal and bird faunas are examined in order to determine how early urban sites were supplied with animal products and the effect that this early urban growth had on systems of rural animal production. The data indicate that the urban emporium of Ipswich was provisioned with meat from domestic animal species. Cattle are by far the most common species, followed by pig and sheep/goat. Contemporary rural sites show evidence for increasing specialisation in some aspects of animal production, such as pork at Wicken Bonhunt. The contrasting patterns between the different sites suggest that there is an integral relationship between the development of the emporia as centres of craft production and trade, and the appearance of increasing specialisation in certain animal products at rural sites.

Several archaeozoological studies have discussed the relationship between town and countryside and the origin of food consumed in towns (Maltby 1994; O'Connor 2000; Wilson 1994). This relationship was studied through a comparison of mortality profiles, sex distribution, and different types of animals (*e.g.* horned or hornless sheep, different-sized animals). What these studies reveal is the importance of secondary products. Both in the Roman period and Middle Ages, animals were rarely reared primarily for their meat, and only sent to market after having served other purposes. Milk, wool, manure and traction were all of higher importance to the rural sites than supplying meat animals. The analysis of skeletal elements can reveal an underrepresentation of certain body parts, indicating trade in animal products. For instance, the underrepresentation of horncores and phalanges has been interpreted as evidence for the removal of hides from rural sites (Laarman 1996, 354; Zeiler 2007, 162-163, 166). Concentrations of horncores and phalanges, on the other hand, which are often found in cities, provide evidence for tannery workshops, and thus the industrial processing of surplus animal products (Bond and O'Connor 1999, 371, 387, 420; Prummel 1978; Schmid 1972, 45). Historic records and accounts provide an alternative way of studying town-country relations (*e.g.* Murphy and Galloway 1992). O'Connor (1992) emphasises the complexity of urban provisioning, and serves as a warning against approaches that are too simplistic.

Several methodological problems remain. First, most of the data used is not absolute but relative. Archaeozoological and archaeobotanical data are notoriously difficult to quantify. We can usually say something about the relative importance of animals or crops, but it is rare that absolute numbers of animals or amounts of harvested crops can be reconstructed. Next, it is difficult to assess the relative importance between animal husbandry and arable agriculture. Since many past societies practised mixed farming, this presents a serious drawback. Third, the production of food for a market has consequences for our data. In market systems, when livestock is transported on the hoof (probably the most common way of transport for most farm animals in the past), the archaeozoological evidence is thus removed from the producer sites. Even worse, the removal of certain age categories (in specialised production) distorts mortality profiles for producer sites, confusing our interpretations. On the other hand, truncated mortality profiles can be used as evidence for the removal of animals of a certain age (in non-mobile societies; in mobile societies, this provides evidence for seasonal movement (Vigne and Helmer 2007, 22)). For example, in a site where mainly older cattle were present, two explanations are possible: 1) cattle were mainly used for secondary products such as traction and manure, or 2) older cattle are overrepresented because younger animals were sold for their meat, and thus removed from site (Laarman 1996, 353-354). In complex economic systems, data from complementary producer and consumer sites should be compared when possible, in order to achieve the full picture (Groot in prep.). Landon (1997) provides a good example: by comparing faunal data for urban and rural sites, he was able to reconstruct the 17th- and 18th-century food supply for Boston.

This volume includes several studies that apply environmental archaeology to the study of food production in complex societies. **Pigière and Lepot** focus on the Roman *civitas Tungrorum* (Tongeren, Belgium) and its rural hinterland to study the exchange relationships between a city and its countryside. They use an interdisciplinary approach, combining studies of ceramics and archaeozoological data, to document local exchange networks. The results of this study show the importance of cattle in the mass supply of meat and craft products to Tongeren and the nearby town of Braives. **Holmes** discusses the emerging market economy in Middle Saxon England (AD 650–850), focusing on the role of wics (coastal and riverine trading sites) and inland markets as consumer sites, and rural sites as producers of a surplus to supply them. It is concluded that there is evidence for the emergence of specialist producers at specific Middle Saxon sites in the hinterland of wics. The contribution by **O'Meara** focuses on the Middle Ages, using animal bone assemblages from the Cistercian monastery of Holme Cultram in Northwest England as a case study to discuss the application of environmental archaeology at monastic sites. Using evidence from archaeological remains (including artefactal and ecofactual remains), historical sources and landscape studies (including palynological studies for vegetation change) O'Meara was able to demonstrate how the monastery integrated itself into its geopolitical environment. An important consideration here is that monastic sites were not self-sufficient economic units subsisting within a closed system, but part of a complex network of towns, fields and pastoral lands. Finally, the papers by **Iborra Eres and Pérez Jordà** and **Lentjes** not only consider the development from subsistence to surplus production, but also the birth of more complex market economies in Eastern Spain and Southern Italy. Interestingly, in both cases this market economy was primarily based on the production of wine and olive oil.

Conclusion

We are aware that this introduction has only been able to offer a glimpse into existing research on subsistence and surplus production. Indeed, as we stated above, the main aim of this introduction was not to provide an exhaustive overview of all the related research, but rather to create a theoretical framework that can serve as an introduction to several themes and methodologies, focusing on the topics covered by the papers in this volume. What, then, does this framework entail? We have distinguished three research themes that we feel cover the subjects of the papers in this volume, *i.e.* 1) subsistence in hunter-gatherer and farming societies; 2) the transition from subsistence to surplus production in farming societies and 3) surplus production in complex societies and emergent market economies.

With regard to the first theme, the most important issue that we addressed is whether so-called subsistence societies – in the sense of societies not producing surplus food – really exist. We discussed that absence of surplus production is not a reliable indicator for subsistence societies. Indeed, both hunter-gatherers and subsistence farmers have developed so-called 'buffering mechanisms' to cope with periods of scarcity. Instead, we argued that subsistence societies generally share four characteristics:

1. scarceness or complete lack of imported products: evidence for small-scale contacts and exchanges (for example of exotic items) does not necessarily mean that the term subsistence no longer applies, as long as staple food is not part of the exchange.
2. few signs of specialisation in certain products and thus,
3. a variety of crops and animal species are grown or kept to provide a balanced diet and enough food throughout the year and spread the risk of crop failures or diseases;
4. a modest scale of production, *i.e.* not (significantly) larger than what is needed to satisfy the community's own needs.

The two main issues discussed in the second theme – the transition from subsistence to surplus production in farming societies – are how such a transition can be accomplished, and how it can be studied archaeologically. There are two basic reasons for producing a surplus beyond subsistence: 1) to have something to trade with, either for direct exchange with others or to sell at a market; or 2) to pay taxes to maintain an administrative system or an elite. Surplus production can be achieved in two ways: by agricultural expansion and rationalisation. The existence of surplus production can be detected by looking for signs of specialisation, excessive storage capacity and the presence of imported goods. Agrarian quantification models have been developed for a number of areas and time periods, and are useful for assessing the potential scale of surplus production. Any evidence for increased production has to be linked to demographic data to make sure that the increase in production does not simply serve to feed a growing local population – and, therefore, is not surplus production at all.

Finally, the last research theme we discussed is concerned with surplus production and the development of complex societies. Surplus production is a necessary requirement for the emergence of market or urban economies, since it allows a part of the population to become involved in other activities besides food production. We concluded that the systematic transport of staple foods may be one of the best indicators in environmental archaeology of the existence of market or urban economies. Natural resources may have been transported over large distances, and there are many archaeological examples of food imports. Another important issue in the discussion of complex societies is how increasing urbanism affected the relationship between town and countryside in terms of food supply. We discussed the use of geographical models, focusing on the classical land zonation model of town and country, and several examples of studies of the relationships between urban consumers and rural producers on the basis of environmental archaeology. Lastly, we pointed at some methodological problems that still remain to be dealt with in this respect, such as the lack of hard data, the difficulty to assess the relative importance between animal husbandry and arable agriculture, and the interpretation of archaeozoological evidence in market situations, where production and consumption sites are separated from each other.

Especially in the case of complex societies, new methodological approaches of existing environmental materials may lead to new insights. For example, isotope analysis and DNA research can shed light on the origin of food and provide insight into the way in which food production in past societies was organised (*e.g.* Bendrey *et al.* 2009; Berger *et al.* 2010; Schlumbaum *et al.* 2008; Van der Jagt *et al.* 2012; Viner *et al.* 2010). The application of such techniques demonstrates that the topic of subsistence and surplus production remains of interest, and promises to generate more exciting research in the future.

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The role of gathering in Middle Archaic social complexity in the Mid-South: a diachronic perspective

Stephen B. Carmody[1] *and Kandace D. Hollenbach*[2]

1. Department of Anthropology
250 South Stadium Hall
University of Tennessee-Knoxville
Tennessee 37996-0720
United States of America
scarmody@utk.edu

2. Archaeological Research Laboratory
University of Tennessee
5723 Middlebrook Pike Room 237
Knoxville, Tennessee 37996-0600
kdh@utk.edu

Abstract

Archaic mound building and social exchange networks are argued to be related to risk-sharing strategies. 'Risky' conditions are generally based on evidence for increasing population density and decreasing environmental richness associated with the rise and fall of the Hypsithermal period. Plant data are seldom brought to bear on this discussion. Here we compare available data from Middle Archaic sites in the Mid-South to construct evidence for changes in storable foodstuffs prior to and during the Mid Holocene, and discuss the relevance of these changes for arguments regarding economic risk in the region.

Keywords: *paleoethnobotany, subsistence, complexity, foragers, gathering, hickory*

Introduction

During the course of the Middle Archaic Period (8,900 – 5,800 cal BP), gatherers in the Eastern Woodlands of North America appear to have increased their use of hickory nuts (*Carya* spp.). This is not a particularly new observation. In particular, researchers in the lower Illinois and Ohio valleys have noted this trend for over thirty years, perhaps beginning with Nancy Asch Siddell and David Asch (Asch *et al.* 1972), who used data from Koster and Napoleon Hollow to argue against

Caldwell's (1958) notion of 'increasing foraging efficiency' during the Archaic. Rather than Caldwell's view of foragers becoming increasingly familiar with forest resources and therefore using a wider range of plant foods through time, Siddell and Asch, as well as Munson (1986), have demonstrated the opposite trend, with Middle Archaic gatherers focusing on a narrower subset of plant foods than their predecessors, with hickory nuts serving as the major dietary staple.

In this paper, our goal is to compare the nature of this apparent increase in hickory nut use with the archaeobotanical records from three regions of Eastern North America where large numbers of Early and Middle Archaic flotation samples have been analysed: Northwest Alabama with data from Dust Cave, Stanfield-Worley, LaGrange and Rollins rock shelters (Carmody 2009; 2010; Hollenbach 2005; 2009); the lower Illinois Valley, with data from Napoleon Hollow and Nochta, both open-air sites (Asch and Asch 1980; Parker 1990; Simon 1990); and the Little Tennessee Valley, with assemblages from Icehouse Bottom, Howard, and Bacon Farm, also deeply stratified open-air sites (Chapman 1977; 1978; 1979) (Fig. 1). We then review several explanations for an increase in hickory nut use, offer some of our own, and explore the ramifications of the increasing availability and intensive use of hickory nuts, an easily stored, high-quality plant food.

Figure 1. Map of sites included in study area. 1: Lower Illinois Valley; 2: Northwest Alabama; 3: Little Tennessee Valley.

Our discussion is currently limited to the carbonised plant remains recovered from these sites, as uncarbonised remains are not likely to be preserved in the moist, acidic soils of the Eastern United States. This archaeobotanical record is inherently biased due to differences in preservation potential among different plant taxa. Inedible by-products such as nutshells are overrepresented compared to edible plant parts; denser materials are more likely to be preserved than more fragile ones. In addition, items that are high in water and/or starch do not carbonise well, producing amorphous vitreous materials that are very difficult to identify. Thus plant foods such as edible greens, flowers, roots, and tubers are generally not recovered from archaeological sites in this region. This bias must be kept in mind, as early foragers certainly exploited fresh greens and likely relied heavily on roots and tubers. However, in this paper we are focusing on those plant food resources that we can trace through time in the Eastern United States.

We should also note the potential for biases between the rock shelter and open-air sites. While preservation is notably better within the protected deposits of rock shelters, the range of activities performed by the occupants of rock shelter sites does not appear to differ from those performed at open-air sites, especially when stone-tool and feature assemblages are compared. We consider the rock shelter sites to be more robust pictures of early foragers' strategies, whether these sites served as base camps or as stopovers for groups performing specific subsistence tasks. Given the differences in preservation potential, we limit our quantitative comparisons to changes within archaeological sites, but do not view the rock shelters as restricted-use sites.

Natural environment

The Pleistocene environment of Eastern North America was much different from that found in the region today. By the beginning of the Late Glacial interval (16,500–12,500 cal BP), deciduous tree populations began to colonise habitats left vacant by the retreating Laurentide Ice Sheet and accompanying boreal conifers that were unable to compete due to changing climatic conditions (Delcourt and Delcourt 1980, 147). In response to this warming episode spruce-jack pine forests replaced jack pine dominated forests in Kentucky and middle Tennessee, while in the mid-latitudes of the Southeast cool-temperate mixed conifer-northern hardwoods composed of hemlocks, pines, spruce, fir, oak, elm, birch, ash, ironwood, maple and beech trees replaced the jack pine-spruce forests, with oak-hickory-southern pine forests remaining stable in the deep South (Delcourt 1979; Delcourt and Delcourt 1980). Also during this time interval northern pine species were replaced by increasing numbers of mesic boreal and cool-temperate taxa like spruce and fir, a change that reflected warming climatic conditions along with increases in rainfall during the summer growing seasons. Oaks and hickories also increased in numbers due to increases in the length of growing seasons and an increase in the mean-annual temperatures.

The Pleistocene-Holocene transition (*c.* 11,500 cal BP) is generally associated with the end of the Younger Dryas cooling event (Anderson *et al.* 2007; Anderson and Sassaman 2012; Sherwood *et al.* 2004, 544). Changing environmental conditions led to temperate plant communities replacing boreal plant communities as conditions became less tolerable for boreal species (Delcourt and Delcourt 1985, 19; 1987; 2004; Klippel and Parmalee 1974). This transition also resulted in the restructuring of animal communities, which were composed of species that would today be 'ecologically incompatible' (Graham and Mead 1987, 371). In North America this major extinction episode affected 35 different species of megafauna that were more reliant on cooler climates, such as the American mastodon, camel, mammoth, ground sloth, and large cats (Anderson and Sassaman 2012, 40; Bonnichsen *et al.* 1987, 419; Graham and Mead 1987, 386; Wright 1986; 1991, 525). Indications from the archaeological remains of smaller mammals recovered from the Mid-South also provide strong evidence to support the changing climate across the region at the end of the Late Pleistocene (Klippel and Parmalee 1982; Parmalee and Klippel 1981).

The Early-Holocene interval (11,500–8,900 cal BP) is considered to have been a cooler, but more stable climatic interval between the Younger Dryas and the Hypsithermal warming episode (Anderson and Sassaman 2004; 2012). Cool-temperate mesic species expanded throughout the mid-latitudes of the Southeast. During this time period, deciduous and mixed deciduous/pine forests dominated the Southeastern United States (Delcourt and Delcourt 1985, 19; 1987; 2004; Jacobson *et al.* 1987, 282). Between 34 and 37 degrees north latitude, cooler climates favoured the expansion of the mixed hardwood forests (Delcourt 1979; Delcourt and Delcourt 1980). Based on information from sites with sedimentation records that span the Early Holocene interval, the forest communities of the Early Holocene differ greatly from those that developed during the later Middle and Late Holocene (Delcourt and Delcourt 1985).

The transition from the Early Holocene to the Mid Holocene at approximately 8,900 cal BP is marked by the Hypsithermal warming episode, a time when post-glacial warming trends peaked and seasonal temperature extremes were greater (Anderson 2001, 158; Anderson *et al.* 2007; Anderson and Sassaman 2012; Deevey and Flint 1957; Sherwood *et al.* 2004, 548). The warmer and drier climate caused major vegetation changes, resulting in the replacement of the hardwood forests of the initial Holocene with oak-hickory, mixed hardwood, and southern pine forests (Delcourt *et al.* 1983; Delcourt and Delcourt 1985; Sherwood *et al.* 2004, 548). The hot and dry weather conditions also caused a change in the hydrology of river valley floodplains (Anderson 2001; Bense 1994, 74). Low-energy meandering rivers replaced the braided stream systems of the Early Holocene (Saucier 1994, 45). Floodplains stabilised as rising sea levels diminished channel sinuosity (Schuldenrein 1996, 9). The resulting expansion of floodplains and creation of oxbow lakes, swamps, and shoal habitats that stayed wet most of the year, provided favourable environments for freshwater shellfish exploitation, which could have helped situate populations near southeastern river valleys (Anderson 2001, 160;

Anderson *et al.* 2007; Dye 1996; Ford and Willey 1941, 332; Griffin 1952; Klippel and Morey 1986; Sassaman 2005, 88; Smith 1986, 22; Styles and Klippel 1996).

Cultural environment

The Paleoindian Period

The initial colonisation of the Southeastern United States, and greater Eastern North America, occurred sometime after the last glacial maximum, perhaps as early as *c.* 21,000 cal BP, by groups of highly mobile bands of hunter-gatherers (Anderson 2001, 154; Anderson and Sassaman 2012). Early Clovis sites (13,150–12,850 cal BP) are distinguished by the presence of widespread Clovis-style lanceolate projectile points, which are accompanied by a small toolkit comprised of lithic tools made from high-quality cherts that were highly portable and efficient for the butchering and processing of large game animals. Both the broad similarity of Clovis-style points across most of the United States and the common use of non-local cherts for making these points suggest relatively large mobility ranges and high levels of interaction amongst groups, sharing raw materials and manufacturing styles (Anderson and Sassaman 2012; Bense 1994, 4; Futato 1983; Waters and Stafford 2007).

The Clovis period ended with the onset of the Younger Dryas *c.* 12,850 cal BP (Anderson and Sassaman 2012, 56). Across the region these sites are identified by a wide array of projectile points that includes Cumberland, Redstone, and Barnes projectile points (Anderson and Sassaman 2012, 56; Futato 1983). The stylistic differences in projectile points during this period are attributed to regional diversity resulting from adaptations to different environments, the fragmentation of the previous Clovis tradition, and a rapid population increase (Anderson 2001, 155; Bense 1994, 51). Evidence of regionalisation can also be witnessed by the decrease in the use of non-local stone for lithic tools during this time period. Late Paleoindian groups continued this trend, with regional variations of the major point types, Dalton and San Patrice (Anderson *et al.* 1996). The appearance of these new point styles is also accompanied by a changing lithic toolkit that shifted from specialised hunting and processing tools towards tools that could be used for a greater variety of tasks.

The greater frequency of projectile points found in major river drainages across the region throughout the Paleoindian period suggests that these resource-rich areas were used for movement of both people and lithic materials (Futato 1983, 297). Models of subsistence strategies and mobility patterns for the later Paleoindian period propose seasonal movements between camps, from which logistical forays were launched by hunting and gathering parties (Daniel 2001; Gardner 1983; Hollenbach 2009; Meltzer and Smith 1986; Morse 1997; Walthall 1998).

The Archaic Period

The Early Archaic Period began at approximately 11,500 cal BP at the Pleistocene-Holocene transition, and ended at approximately 8,900 cal BP with the onset of the Hypsithermal warming event (Anderson 2001, 156; Anderson and Hanson 1988; Anderson *et al.* 1996, 15; 2007). Early Archaic sites are identified by the presence of Early Side-Notched, Kirk Corner-Notched, and bifurcate forms of projectile points including LeCroy, MacCorkle, St. Albans and Kanawha (Anderson and Sassaman 2012; Bense 1994; Sherwood *et al.* 2004, 546; Walthall 1980, 54). Projectile points manufactured during the Early Archaic were notched, smaller and more triangular than the earlier Paleoindian points, but were more similar to those made and used by Dalton peoples (Bense 1994, 65). An increase in the number of sites and artefacts discovered around the Southeast suggests population rapidly expanded during the Early Archaic Period. As population increased and mobility decreased, it is believed that range size decreased from river valleys to smaller portions of single drainage systems. Small family groups were believed to have occupied river valleys for most of the year, congregating into larger groups during periods of resource abundance (Anderson 2001, 157; Anderson and Sassaman 2012, 67; Bense 1994, 72).

Across the broader Southeastern United States, the Middle Archaic Period (8,900 – 5,800 cal BP) is viewed as a time of '*dramatic cultural change in Eastern North America*' (Anderson 2001), when local cultures were growing in both scale and complexity (Anderson 2001, 158; 2002; 2004, 270; Anderson *et al.* 2007; Anderson and Sassaman 2012; Caldwell 1958, 14; Ford and Willey 1941, 335; Jefferies 1995; 1996; 1997; Kidder and Sassaman 2009, 667; Lewis and Kneberg 1959, 161; Sassaman 2005). Sites in the area are defined by the presence of Eva/Morrow Mountain, Sykes/White Springs/Crawford Creek, and Benton projectile points (DeJarnette *et al.* 1962; Driskell 1994; Futato 1983). Increased population and territoriality during the Middle Archaic Period resulted in restricted group mobility over much of the Southeast, forcing groups to live in closer proximity on the landscape. This created a favourable environment for long-distance exchange and trade networks as a means to acquire ornaments, raw materials, and other materials sought as symbols of high status like beads, pendants and ornaments made of shell, bone, and stone (Anderson 2001; Ford and Willey 1941, 333; Jefferies 1995; 1996; 1997; Johnson and Brookes 1989; Meeks 1998). Regionalisation is witnessed by a reliance on local raw materials and regional stylistic diversity of lithic toolkits reflecting large-scale behavioural and organisational changes that affected the way people operated on the landscape (Amick and Carr 1996, 44; Meeks 1998, 115; Sassaman 1995, 179; Walthall 1980, 58). Significant advances were made in groundstone tool technologies, witnessed by the appearance of grooved axes and other formal woodworking tools, atlatl weights or bannerstones, and netsinkers (Anderson and Sassaman 2012, 73; Griffin 1952; 1967, 156; Kidder and Sassaman 2009, 671; Smith 1986, 18). Human burials in significant numbers are found at sites for the first time in the Southeast during the Middle Archaic Period (Anderson *et al.* 2007; Bense 1994, 78). Human remains recovered with imbedded projectile points from the Mulberry Creek site in the Middle Tennessee River Valley show early evidence of interpersonal violence and competition in the archaeological record in the Southeast (Shields 2003). Organisational changes evident in the Middle Archaic also emerge in the form of earthen mounds and shell midden sites at approximately 7,500 cal BP in the Mid-South (Anderson and Sassaman 2012; Lewis and Kneberg 1959; Russo 1996; Sassaman 2005, 88). These sites are composed of dense layers of midden, called midden mounds, and appear in the Tennessee River Valley, the Upper Tombigbee Valley, and in the Eastern Florida Peninsula.

Methodology

To explore changes in plant use in the Southeastern United States from the Paleoindian and Early Archaic through Middle Woodland Periods, we searched for sites with early deposits from which plant remains had been analysed and raw data were available (Tables 1-3). These include the Napoleon Hollow (Asch and Asch 1980) and Nochta (Parker 1990; Simon 1990) sites in the lower Illinois River Valley; Icehouse Bottom (Chapman 1977), Howard (Chapman 1979), and Bacon Farm (Chapman 1978) sites in the Little Tennessee River Valley; and Dust Cave, Stanfield-Worley Bluff Shelter, LaGrange, and Rollins Bluff Shelter in Northwest Alabama (Carmody 2009; 2010; Hollenbach 2009).

In addition to differences in preservation among the sites, there are a number of differences in the processing, analysis, and reporting of the samples, as well as sample size. Because of these differences, direct comparisons between the assemblages are not feasible. However, we can look for trends within sites, where preservation and post-recovery processes are relatively constant.

To facilitate comparisons, we use the Shannon-Weaver diversity index, as well as boxplots. The Shannon-Weaver index measures the diversity of an assemblage both in terms of richness (the number of taxa present) as well as evenness (the distribution of those taxa). The index is calculated using the following equation:

$$H' = -\Sigma\, p_i \ln (p_i)$$

where p_i is the relative proportion of each taxon in the given assemblage (Reitz and Wing 2008).

Boxplots display summary statistics for sets of samples, where the ends of the boxes mark the 25th and 75th percentile of the data and the 'waist' is the median (Fig. 2). 'Whiskers' extend to values within 1.5 times the hinge spread, which is the difference between the 75th and 25th percentile. Outliers, or values within 3 times the hinge spread, are shown as asterisks; extreme outliers beyond 3 times the hinge spread are displayed as open circles. The notches mark the 95 % confidence interval, so that if the notches of two boxplots do not overlap, the differences between them are statistically significant at the 95 % confidence interval (Wilkinson *et al.* 1992).

Time Period	Phase	Sample Count	Plant Weight	Wood Weight
Alabama Sites:				
Dust Cave - Column Samples				
Middle Archaic[a]	Benton	8	70.27	19.42
Middle Archaic[a]	Eva/Morrow Mtn	25	162.06	27.75
Early/Middle Archaic[a,b]	Kirk Stemmed	8	36.47	4.29
Early/Middle Archaic[b]	Early Side Notched/ Kirk Stemmed	10	6.87	1.46
Early Archaic[b]	Early Side Notched	12	8.07	2.74
Late Paleoindian[b]	Quad/Beaver Lake	36	19.02	3.63
Dust Cave - Feature Samples				
Middle Archaic[a]	Benton	6	55.67	34.19
Middle Archaic[a]	Eva/Morrow Mtn	9	76.73	23.40
Early/Middle Archaic[a,b]	Kirk Stemmed	10	62.57	20.85
Early/Middle Archaic[b]	Early Side Notched/ Kirk Stemmed	6	9.90	4.60
Early Archaic[b]	Early Side Notched	11	15.27	4.27
Late Paleoindian[b]	Quad/Beaver Lake	14	8.90	5.49
LaGrange[b]				
Middle Archaic		6	2.07	0.09
Early Archaic		6	5.66	0.68
Dalton		5	3.98	0.27
Rollins[b]				
Middle Archaic		13	22.29	11.94
Early Archaic		16	74.31	27.11
Dalton		12	12.11	1.13
Stanfield-Worley[b]				
Middle Archaic		10	18.43	7.32
Early Archaic/Dalton		22	51.15	30.78
Tennessee Sites:				
Icehouse Bottom[c]				
Middle Archaic	Morrow Mountain	4	48.30	44.49
Middle Archaic	Stanly	7	63.39	32.42
Early Archaic	Lecroy	4	75.71	15.18
Early Archaic	St. Albans	4	29.13	18.26
Early Archaic	Upper Kirk	8	81.73	57.54
Early Archaic	Middle Kirk	5	48.15	32.47
Early Archaic	Lower Kirk	17	249.66	192.52
Howard[d]				
Middle Archaic	Morrow Mountain	40	808.24	500.86
Middle Archaic	Stanly/Morrow Mtn	5	86.32	59.81
Middle Archaic	Stanly	11	47.78	47.02
Early/Middle Archaic	Kirk Stemmed	16	140.64	128.22

Time Period	Phase	Sample Count	Plant Weight	Wood Weight
Bacon Farm[e]				
Early/Middle Archaic	Kirk Stemmed	7	36.29	13.33
Early Archaic	Upper Kirk	10	95.10	41.14
Illinois River Sites:				
Napoleon Hollow				
Middle Archaic	Zone C (6080-5140 BP)	63	799.20	34.34
Middle Archaic	Zone C/D	14	77.00	29.48
Middle Archaic	Zone D (7050-6630 BP)	40	126.41	89.79
Nochta				
Middle Archaic[f]		81	123.63	16.95
Early Archaic[h]		35	18.08	ct=377

Table 1. Analysed paleoethnobotanical samples from sites discussed in the text.
[a] Data are from Carmody 2009; 2010; samples processed by flotation.
[b] Data are from Hollenbach 2005. All samples processed by flotation with exception of Stanfield-Worley Dalton samples, which were bulk samples. Rollins samples had been sieved through ¼-in mesh prior to flotation. Both Rollins and LaGrange samples were refloated with carbon tetrachlorine. Most non-wood data are reported as counts.
[c] Data are from Chapman 1977. All samples were processed with water flotation. Data are reported as weights, with the exception of seed counts.
[d] Data are from Chapman 1979. All samples were processed with water flotation. Data are reported as weights, with the exception of seed counts.
[e] Data are from Chapman 1978. All samples were processed with water flotation. Data are reported as weights, with the exception of seed counts.
[f] Data are from Asch and Asch 1980 and are presented as percents and are summary data from several excavation squares (five from Zone C, two from Zone C/D, and four from Zone D). All samples were processed with water flotation.
[g] Simon 1990. All samples were processed with water flotation. Only specimens greater than 2.0 mm are reported unless not represented in this size grade, as is standard practice.
[h] Data are from Parker 1990. All samples were processed with water flotation. All identifiable specimens, regardless of size, are reported.

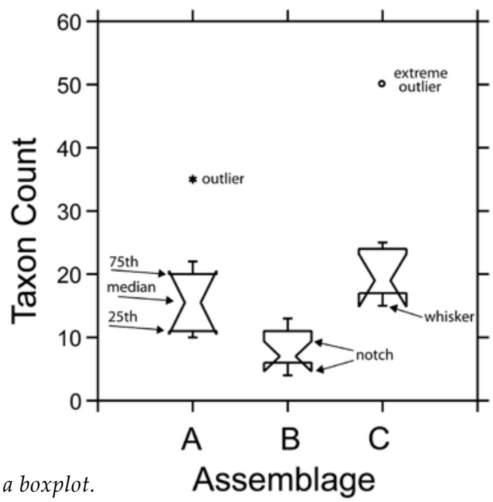


Figure 2. Example of a boxplot.

Time Period	Phase	Hickory Ct/Wt	Walnut Ct/Wt	Acorn Ct/Wt	Walnut Family Ct	Hazelnut Ct/Wt	Other	Seeds
Alabama Sites:								
Dust Cave - Column Samples								
Middle Archaic	Benton	5102	1	113				15 hackberry seeds, 1 Cucurbita seed
Middle Archaic	Eva/Morrow Mtn	10569		395				810 hackberry seeds, 16 persimmon, 3 sumac, 1 purslane, 7 grape, 2 poke
Early/Middle Archaic	Kirk Stemmed	3030		106		2		3 acorn meat, 1 Fagaceae shell, 30 Walnut family nutmeat, 110 hackberry seeds, 3 grape, 6 persimmon, 7 sumac, 3 chenopod, 5 wild legume, 1 poke cf., 1 unknown, 11 unidentifiable seeds
Early/Middle Archaic	Early Side Notched/ Kirk Stemmed	348	13	65	2			12 acorn meat, 10 Fagaceae shell, 6 Walnut family nutmeat, 328 hackberry seeds, 8 grape, 1 persimmon, 1 sumac cf., 11 chenopod, 6 chenopod cf., 5 cheno-am, 3 wild legume, 3 poke, 1 unknown, 2 unidentifiable
Early Archaic	Early Side Notched	191		41				5 acorn meat, 608 hackberry seeds, 2 grape, 1 sumac, 1 persimmon cf., 42 chenopod, 26 chenopod cf., 3 bedstraw, 2 pine seed cf., 2 unidentifiable seeds
Late Paleoindian	Quad/Beaver Lake	565	66	35		37		2 acorn meat, 1 acorn meat cf., 1 Fagaceae shell, 37 Walnut family nutmeat, 1603 hackberry seeds, 1 grape, 1 grape cf., 1 nightshade cf., 55 chenopod, 70 chenopod cf., 2 cheno-am, 2 smartweed, 1 wild legume, 20 poke cf., 4 stargrass, 11 unknown, 8 unidentifiable seeds
Dust Cave - Feature Samples								
Middle Archaic	Benton	2379		45				7 hackberry seeds, 1 persimmon, 1 cucurbit seed
Middle Archaic	Eva/Morrow Mtn	2578		162				203 hackberry seeds, 1 bedstraw
Early/Middle Archaic	Kirk Stemmed	3241	6	683		3		28 acorn meats, 165 hackberry seeds, 40 persimmon, 2 sumac, 2 chenopod, 3 chenopod cf., 20 wild legumes, 1 bedstraw, 1 unknown, 6 unidentifiable seeds
Early/Middle Archaic	Early Side Notched/ Kirk Stemmed	296	2	1300	1			1 hazelnut cf., 114 hackberry seeds, 5 persimmon, 2 grape, 2 sumac, 1 chenopod, 1 wild legume
Early Archaic	Early Side Notched	834	75	142	2			382 hackberry seeds, 6 persimmon, 1 sumac, 1 chenopod, 2 poke, 4 unidentifiable seeds
Late Paleoindian	Quad/Beaver Lake	186	5	30	2			301 hackberry seeds, 7 persimmon, 14 grape cf., 1 black gum cf., 23 chenopod, 14 chenopod cf., 2 bedstraw, 1 poke cf., 1 morningglory cf., 3 unknown, 2 unidentifiable seed

Table 2. Plant remains recovered from sites discussed in the text.

Time Period	Phase	Hickory Ct/Wt	Walnut Ct/Wt	Acorn Ct/Wt	Walnut Family Ct	Hazelnut Ct/Wt	Other	Seeds
LaGrange								
Middle Archaic		37						
Early Archaic		297	50	13	19	1		6 acorn meats, 15 persimmon, 13 weedy legumes, 1 Composite family cf., 1 mulberry, 3 chenopod, 2 chenopod cf., 2 grape, 1 wild bean cf., 1 sumac, 1 unknown, 2 unidentifiable seeds
Dalton		187	67	8	17	3		1 persimmon, 1 chenopod, 2 chenopod cf., 2 grape, 1 Grass family, 2 sumac, 1 Brassica family cf., 2 unknown, 6 unidentifiable
Rollins								
Middle Archaic		100						
Early Archaic		3676	4	122	10			10 acorn meats, 4 persimmon, 2 grape, 1 wild legume, 3 unidentifiable seeds
Dalton		1093	14	9	5			6 acorn meats, 3 persimmon, 9 grape, 1 grape cf., 1 sumac, 1 squash rind cf., 2 unknown, 1 unidentifiable seed
Stanfield-Worley								
Middle Archaic		1398		40				
Early Archaic/Dalton		569	325	23	131	5		52 acorn meats, 33 persimmon, 3 honey locust, 2 grape, 1 sumac, 1 sumac cf.
Tennessee Sites:								
Icehouse Bottom								
Middle Archaic	Morrow Mtn	2.89	0.16	0.76				
Middle Archaic	Stanly	29.87	1.04	0.06				1 grape, 1 unidentified seed
Early Archaic	Lecroy	58.44		2.09				
Early Archaic	St. Albans	8.44		2.43				1 chenopod, 1 unidentified seed
Early Archaic	Upper Kirk	12.68		11.49			chestnut, 0.02 g	1 poke, 1 poke cf., 1 poke/chenopod
Early Archaic	Middle Kirk	15.37	0.26	0.05				1 grape, 1 unidentified seed
Early Archaic	Lower Kirk	47.43		9.70			chestnut, 0.01 g	1 chenopod, 2 poke/chenopod, 1 sumac cf., 1 peppervine, 3 unidentified seed

Table 2 (continued).

Time Period	Phase	Hickory Ct/Wt	Walnut Ct/Wt	Acorn Ct/Wt	Walnut Family Ct	Hazelnut Ct/Wt	Other	Seeds
Howard								
Middle Archaic	Morrow Mtn	249.92	45.91	10.32		0.02	chestnut, 0.22 g; unidentified 0.99 g	64 grape, 14 poke, 2 honey locust, 1 blackberry/raspberry, 1 bearsfoot, 6 Asteraceae, 1 Fabaceae, 13 unidentified seeds, 4 unidentified fruit, 33 alder catkins
Middle Archaic	Stanly/Morrow Mtn	25.97	0.29	0.24			unidentified 0.01 g	43 grape, 1 bearsfoot, 1 Asteraceae, 1 Fabaceae
Middle Archaic	Stanly	0.67		0.02			unidentified 0.07 g	7 poke, 1 grape, 1 unknown fruit seed
Early/Middle Archaic	Kirk Stemmed	11.47	0.19	0.75			unidentified 0.01 g	1 Asteraceae, 1 bean-like, 1 honey locust, 1 yellow passionflower, 1 morningglory, 2 grass, 9 poke, 1 berry, 1 unidentified fruit, 1 fruit cf., 1 catkin, 1 horsetail, 99 unidentified stems, 5 unidentified seeds, 13 unknown seeds
Bacon Farm								
Early/Middle Archaic	Kirk Stemmed	18.56	4.25	0.05				1 persimmon
Early Archaic	Upper Kirk	38.18	0.36	14.46			chestnut, 0.18 g; unidentified 0.58 g	1 amaranth, 4 grape, 1 poke, 3 purslane, 1 copperleaf, 1 knotweed, 6 unidentified seeds
Illinois River Sites:								
Napoleon Hollow								
Middle Archaic	Zone C (6080-5140 BP)	457.44	21.16	3.35		1.36	pecan, 16.69 g; tuber, 1.54 g	2 chenopod, 2 legume, 1 sumpweed, 1 lotus, 1 poke, 2 smartweed, 1 knotweed, 3 wild bean, 1 persimmon, 1 grass family, 1 poison ivy, 13 unknown, 5 unidentifiable seeds
Middle Archaic	Zone C/D	159.95	17.74	2.49			pecan, 19.82 g; tuber, 3.19 g; unidentified 12.14 g; unidentified 6.34 g	1 grape, 3 wild bean, 2 fescue, 2 unknown seeds, 1 unidentifiable seeds
Middle Archaic	Zone D (7050-6630 BP)	206.27	77.63	4.02			pecan, 112.11 g; tuber, 7.80 g; unidentified 23.67 g	6 wild bean, 2 bedstraw, 1 grape, 1 plum/cherry, 1 sumac, 1 fescue, 1 grass family, 4 unknown seeds, 1 unidentifiable seeds
Nochta								
Middle Archaic		2134	10		5406		pecan, 47; nutshell, 304	1 sumpweed, 1 grass family, 4 unidentifiable seeds
Early Archaic		376	50		1251		nutshell, 379	2 grape, 1 sumac, 1 viburnum cf., 1 Smilax cf., 1 unidentifiable seeds

Table 2 (continued).

Taxon	Scientific Name	Category
Acorn	*Quercus* spp.	nut
Alder catkin	*Alnus* sp.	other
Amaranth	*Amaranthus* sp.	edible seed
Aster family	Asteraceae	weedy seed
Bearsfoot	*Smallanthus uvedalius*	edible seed
Bedstraw	*Galium* sp.	weedy seed
Beech family	Fagaceae	nut
Black gum cf.	*Nyssa sylvatica* cf.	
Blackberry/raspberry	*Rubus* sp.	fruit
Cheno-am	*Chenopodium/Amaranthus*	edible seed
Chenopod	*Chenopodium* sp.	edible seed
Copperleaf	*Acalypha* sp.	weedy seed
Cucurbit	*Cucurbita* sp.	edible seed
Fescue	*Festuca* sp.	weedy seed
Grape	*Vitis* sp.	fruit
Grass family	Poaceae	weedy seed
Greenbrier	*Smilax* sp. cf.	weedy seed
Hackberry	*Celtis* sp.	fruit
Hazelnut	*Cornus* sp.	nut
Hickory	*Carya* spp.	nut
Honey locust	*Gleditsia triacanthos*	fruit
Horsetail	*Equisetum* sp.	other
Knotweed	*Polygonum* sp.	edible seed
Lotus	*Nelumbo lutea*	edible seed
Morningglory	*Ipomoea/Convolvulus*	weedy seed
Mulberry	*Morus* sp.	fruit
Mustard family cf.	Brassicaceae cf.	
Nightshade cf.	*Solanum* sp. cf.	
Peppervine	*Ampelopsis* sp.	weedy seed
Persimmon	*Diospyros virginiana*	fruit
Pine seed cf.	*Pinus* sp. cf.	
Poison ivy	*Rhus radicans*	weedy seed
Poke	*Phytolacca americana*	weedy seed
Plum/cherry	*Prunus* sp.	fruit
Purslane	*Portulaca* sp.	weedy seed
Smartweed	*Polygonum* cf. *pensylvanicum*	edible seed
Stargrass	*Hypoxis hirsuta*	weedy seed
Sumac	*Rhus* sp.	fruit
Sumpweed	*Iva annua*	edible seed
Viburnum cf.	*Viburnum* sp. cf.	
Walnut	*Juglans* spp.	nut
Walnut family	Juglandaceae	nut
Wild bean	*Strophostyles* sp.	edible seed
Wild legume	Fabaceae	edible seed
Yellow passionflower	*Passiflora lutea*	fruit

Table 3. Plant taxa discussed in the text.

Results

Beginning with Northwest Alabama, diversity decreases notably through time at all four sites (Fig. 3). The lower diversity is related primarily to an increased use of hickory nuts and a concomitant decrease in recovery of other fruit and edible seeds. At Dust Cave we see a significant increase in hickory nutshell among column samples and a concordant decrease in recovery of seeds relative to other plant resources (Fig. 4). At the other rockshelter sites, an increase in the density of hickory nuts is only seen at Stanfield-Worley; the recovery of wood is higher in

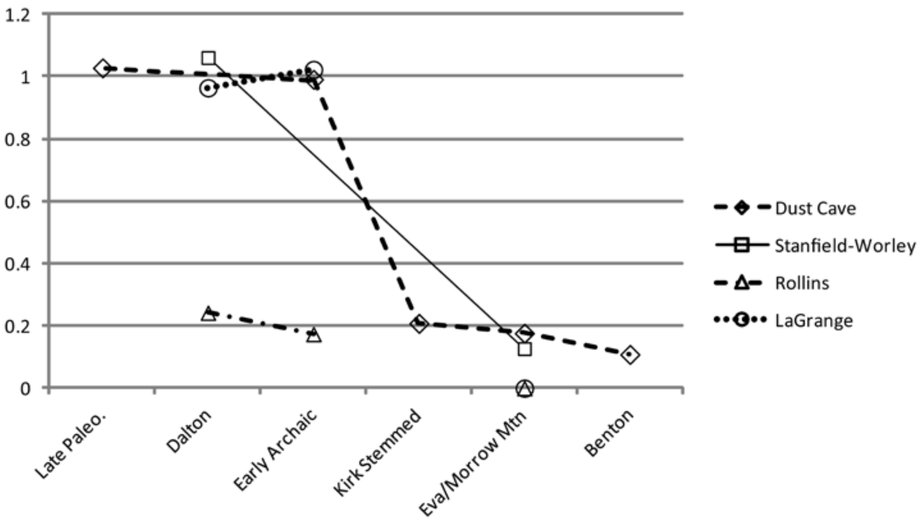


Figure 3. Shannon-Weaver diversity index showing decrease in diversity of plant remains at sites from Northwest Alabama.

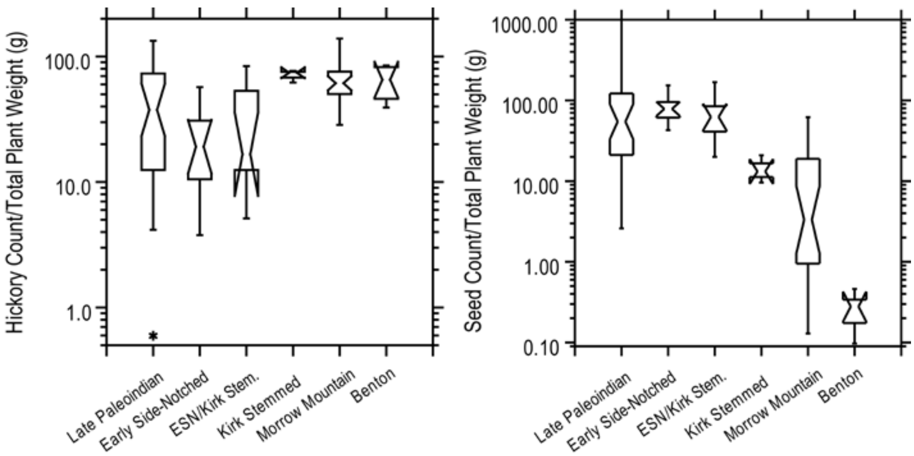


Figure 4. Boxplot showing increase in relative density of hickory nutshell (left), and decrease in relative density of seeds (right) through time at Dust Cave, Alabama.

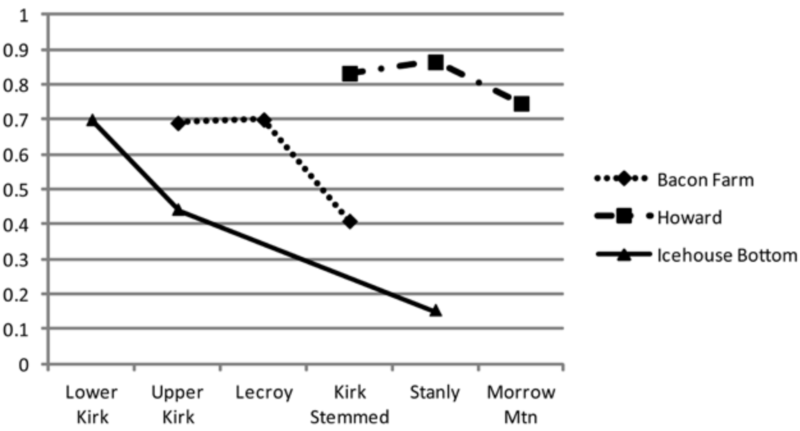
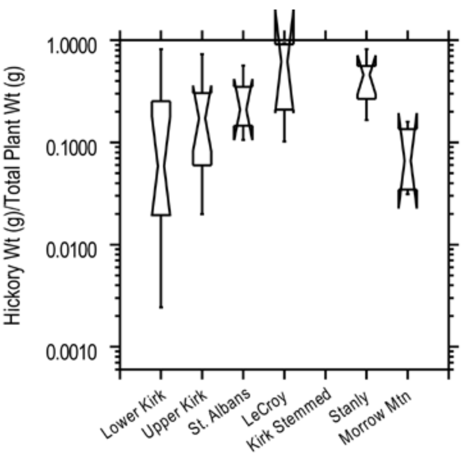
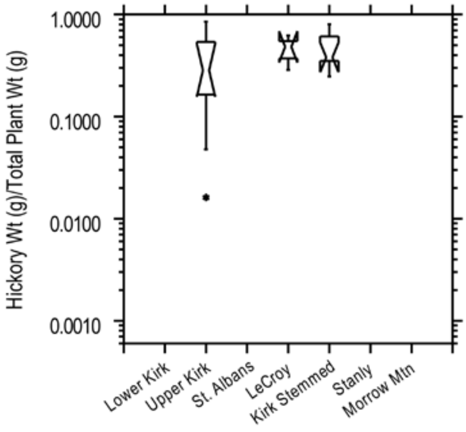


Figure 5. Shannon-Weaver diversity index showing decrease in diversity of plant remains at sites in Eastern Tennessee.





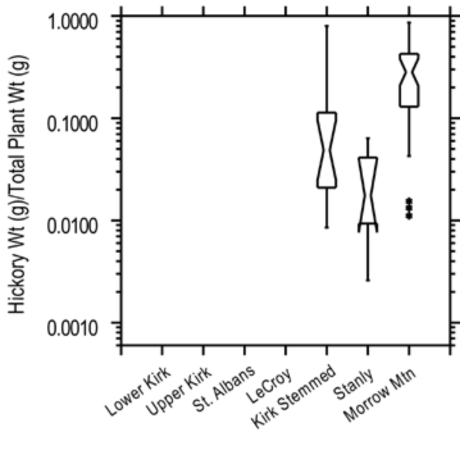


Figure 6. Boxplot showing changes in relative density of hickory nutshells through time at Icehouse Bottom (left), Howard site (centre), and Bacon Farm (right).

Middle Archaic samples at Rollins and LaGrange and thus dampens the relative density of hickory nutshell (Fig. 3). But fruits and wild/weedy seeds are completely absent from the Middle Archaic samples.

In Eastern Tennessee, a similar decrease in diversity through time at each site is apparent (Fig. 5). However, this decrease in diversity is not as clearly linked to intensified use of hickory nuts. At Icehouse Bottom, the recovery of hickory nutshell increases steadily through time until the Morrow Mountain occupation, when it drops to levels comparable to the earliest Kirk occupation (Fig. 6). This may be related to the small sample size for the Morrow Mountain component, with only four samples. But a clear increase in the density of hickory nutshell is evident at the Howard site. The recovery of seed taxa at the sites is much more equivocal, with no clear trends.

The Illinois sites show similar results, with a decrease in diversity through time (Fig. 7). A significant increase in hickory nutshells is apparent from the Early Archaic through the Middle Archaic occupations at the Nochta site (Fig. 8), as well as in the two Middle Archaic components at Napoleon Hollow (Fig. 9). The

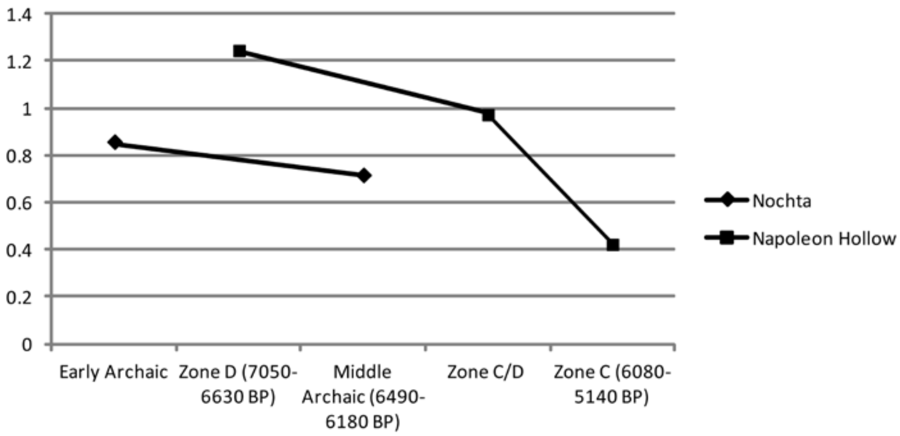


Figure 7. Shannon-Weaver diversity index showing decrease in diversity of plant remains from Illinois sites.

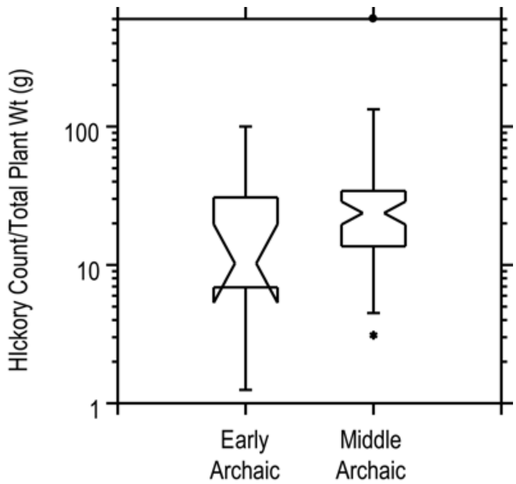


Figure 8. Boxplot showing increase in the relative density of hickory nutshell through time at the Nochta site.

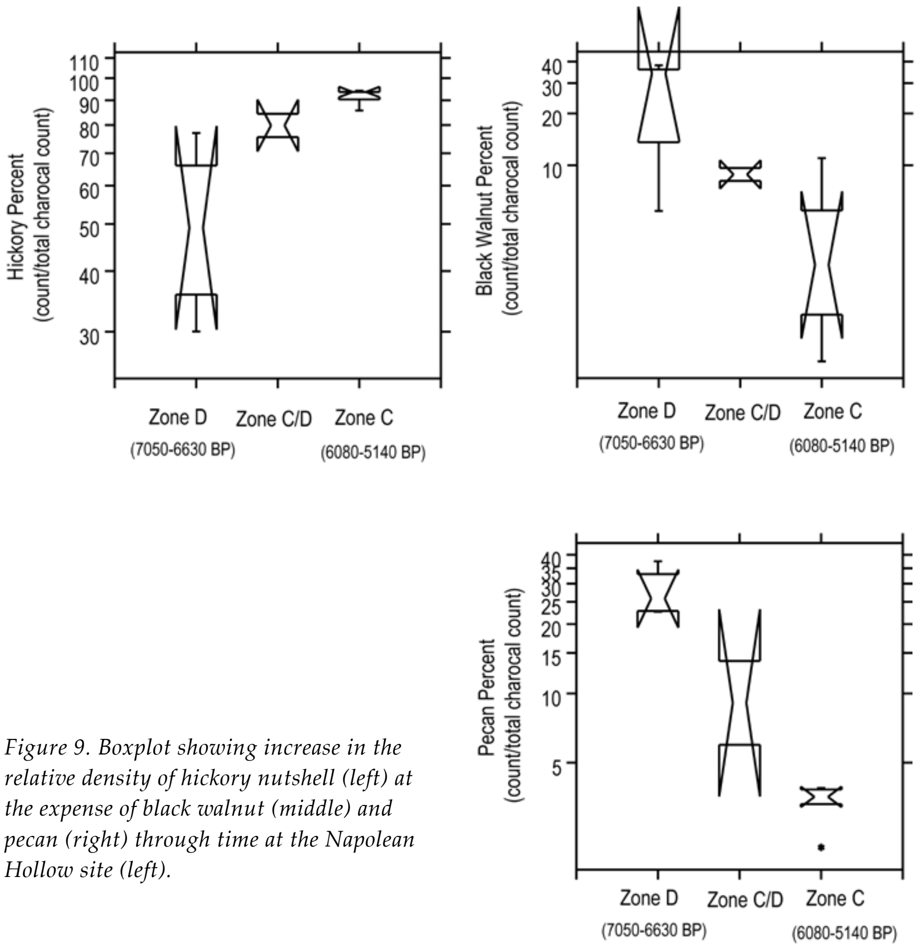


Figure 9. Boxplot showing increase in the relative density of hickory nutshell (left) at the expense of black walnut (middle) and pecan (right) through time at the Napolean Hollow site (left).

increase in hickory nuts at Napoleon Hollow is at the expense of black walnut and pecan, which both significantly decrease. Recovery of seed taxa is roughly similar between the components at both sites, however.

In total, there appears to be some evidence for an increase in use of hickory nuts in Eastern Tennessee and in Illinois, although use of other fruits and edible seeds does not seem to decline as it does among the northern Alabama rockshelter sites. We may be able to explain this to some degree because these open-air, riverine sites are likely to have been home bases rather than logistical outposts, like the bluffline/upland rockshelter sites. A wider variety of foodstuffs at base camps, where occupants would have engaged in a wider variety of activities over a longer period of time, would be expected.

Discussion

These results lead us to the question of why gatherers should intensify their use of hickory nuts. These nuts are highly valued foodstuffs, for several reasons. First, hickory nuts are highly nutritious, containing significantly higher quantities of protein and fat than other available plant resources, including acorns and chestnuts, both of which are much higher in carbohydrates. This fat content is particularly important to foragers during the late winter months, when deer and other game are markedly lean.

Second, hickory nuts have relatively low processing costs when processed using the crush-and-boil method (Talalay *et al.* 1984). If one simply cracks the nut open and picks the nutmeats from the shell, like we are accustomed to doing with walnuts and pecans, nearly as much energy is expended in the process as is gained from eating the nuts. Among modern Cherokee Indians, hickory nuts are crushed – nutmeats, shell, and all – and, once larger pieces of shell are removed, are formed into balls of shell and nutmeat called kenuchee (Fritz *et al.* 2001). These are stored until ready for use; when the ball is placed in very hot water, the nutmeats rise to the top or melt and the nutshell sinks. The resulting milky liquid is used for soups or beverages (Fritz *et al.* 2001; Yanovsky 1936). With their high nutritional value and relatively low processing costs, hickory nuts rank highly among both animal and plant foodstuffs in optimal foraging models that compare return rates (*e.g.* Hollenbach 2009).

A third advantage to hickory nuts is that they are readily stored. They can be stored in the shell for months, if not years (Scarry 2003). Indeed, many of the larger subterranean pit features noted on Archaic sites are presumed to have functioned as cold storage for nuts, including hickory nuts (*e.g.* Hollenbach *et al.* 2011; Stafford 1991). As with other foraging groups who rely heavily on stored nuts (*e.g.* Jackson 1991; Morgan 2012), Paleoindian and Archaic gatherers living in the Eastern United States presumably organised large work parties to collect as many hickory nuts as possible during their two to three weeks of availability in October (Gardner 1997; Scarry and Hollenbach 2012). That being said, work parties could collect significant quantities of hickory nuts in relatively short order. Given a productivity of 1-3 bushels of hickory nuts per tree as reported in silviculture literature, Gardner (1997, 163) calculates that 7-21 trees can produce enough hickory nuts to feed a person for a year. Carmody (2009, 140-141) uses the frequency of hickories in modern forests in Northern Alabama to estimate that a single acre would provide enough hickory nuts to provide between 80 % (one-bushel yield) and 270 % (three-bushel yield) of a person's yearly caloric needs. This does not take competition with wildlife into account, but these rough calculations indicate that hickory nuts were likely very abundant from the Late Pleistocene onward in the woodlands of Eastern North America.

As a highly valuable food resource – highly nutritious, processed in bulk, and readily stored – foragers should target hickory nuts whenever available. According to diet breadth models (MacArthur and Pianka 1966; Winterhalder 1981), an increase in high-ranking resources like hickory nuts would lead to a decrease in use of lower ranked nuts, like acorn, black walnut, pecan, and hazelnut. Gatherers' apparent intensification in their use of hickory nuts during the Middle Archaic Period may well be related to a presumed increase in the availability of hickory nuts in the Eastern Woodlands.

Such as increase in hickory nut availability is probable during the Hypsithermal warming episode, which brought warmer climates to the region, making conditions more favourable for open oak-hickory forests. In southern Illinois, mesic hardwood forests were replaced by oak-hickory forests, and in Eastern Tennessee oak-hickory-chestnut forests expanded.

The warmer conditions of the Hypsithermal might have played a larger role in resource density and distribution, however, by affecting masting periodicity. Masting is a phenomenon in which populations of trees synchronise their reproductive activities, producing variability in reproductive output from year to year (Isagi *et al.* 1997; Kelly 1994, 465; Koenig and Knops 2000; 2005; Satake and Iwasa 2002, 830), and is common among many temperate tree species (Sork 1983, 81). The result of this process is synchrony and variability in seed production from year to year, but at a periodicity that is highly predictable (Gardner 1997). Years with greater production are referred to as 'bumper crops'.

Masting behaviour is beneficial from an evolutionary perspective because it ensures that, during bumper years, some fruits go uneaten and are able to germinate and develop into seedlings. Small crops produced during intervening or nonmast years keep predator populations low so that in good or mast years there are fewer predators, allowing a higher proportion of overabundant seeds to survive (Koenig and Knops 2005; Lalonde and Roitberg 1992, 1293; Satake and Iwasa 2002, 830; Silverton 1980, 236). A second evolutionary advantage of masting behaviour is an increased efficiency of wind pollination. By producing numerous flowers and therefore pollen at the same time, trees maximise their chance of pollination while decreasing the amount of waste in effort (Koenig and Knops 2005, 342).

Interannual variability in fruit production is also considered to be the result of variation in resources available to tree populations (Koenig and Knops 2000; 2005; Satake and Iwasa 2002). Warmer weather will produce more resources for the trees, which will increase the amount of seeds produced. Alternatively, in colder years smaller crops will be produced as a result of lower resource availability and decreased opportunity for photosynthesis. Evidence supports the hypothesis that higher spring temperatures induce flowering, thereby increasing seed production and decreasing the periodicity between bumper crops (McKone *et al.* 1998, 591; Schauber *et al.* 2002, 1215). Availability of resources, particularly as cued by spring temperatures, could also explain why synchronicity occurs in large geographic areas, as rainfall and temperatures usually fluctuate over these areas from year to year (Koenig and Knops 2005, 342).

Masting in forest trees is especially important because of the contributions to food resources that these trees produce for both humans and animals (Koenig and Knops 2000, 59; Schauber *et al.* 2002, 1223). Research suggests that the effects on communities extends from bird populations, young deer weight, and the reproductive success of bears, and continue throughout these communities, affecting ticks and the diseases that they carry (Isagi *et al.* 1997; Koenig and Knops 2000, 59; 2005, 340).

Thus the increase in hickory pollen seen in palynological cores throughout the region during the Hypsithermal may be related to an increase in the absolute number of hickory trees, but perhaps also to an increase in pollen production by extant trees. Warmer spring temperatures in the Hypsithermal may have signalled the availability of additional resources, leading to an increase in pollen production and effectively reducing the number of years between bumper crops for hickories and other trees. Rather than the typical two-to-four-year interval in various species of hickory and two-to-five-year interval for oaks, the interval between bumper crops may have dropped to one to three years. This would reduce the interannual variability in the number of hickory nuts available to both human and animal populations, increasing not only the amount of nuts for longer-term storage but also the number of deer, wild turkeys, squirrels, and other game. From both the hunting and gathering perspective, then, the Hypsithermal may have brought about an overall decrease in food risk for Middle Archaic peoples in these regions.

The productivity of hickory groves may have been enhanced by intentional human efforts as well. Munson (1986) suggests that, at least by the latter half of the Middle Archaic, groups were creating and maintaining open-canopy groves of hickories by girdling unwanted trees. Girdling, or removing a strip of bark from the circumference of the tree, results in the death of the wood tissue above the removed portion of bark. In open-growth situations, hickory trees significantly increase their annual productivity. Just as importantly, competition from squirrels dramatically decreases, as squirrels prefer closed-canopy forests. Management of wild resources through techniques such as girdling, setting controlled fires, and coppicing seems quite reasonable to us, but why this should have occurred in the Middle Archaic rather than earlier is not entirely clear. As such, we find environmental explanations, tying changes in forest composition to the onset of the Hypsithermal, more compelling.

Regardless of the factors driving an intensification of hickory nut use, the ramifications are extensive. Perhaps most importantly, it likely fuelled an increase in population size and density during the Middle Archaic Period (Anderson 2001, 158; Anderson *et al.* 2007; Anderson and Sassaman 2012; Kidder and Sassaman 2009, 667; Sassaman 2005). An increase in the availability and reliability of high-quality foodstuffs leads to a decrease in childhood mortality and quite simply can support larger numbers of people. Because plant foods such as nuts can be easily stored, for months if not years, their availability can be enhanced and extended in ways that most animal resources cannot. If animal populations also thrived on larger hickory nut yields, particularly from managed groves, foraging groups may have also increased their hunting success and enjoyed nutritional benefits of an increase in meat as well.

More intensive use of hickory nuts is also associated with changes in material culture and site use. Homsey (2004) notes repeated use of nut-processing features at Dust Cave and Stanfield-Worley during the Middle Archaic occupations. Munson (1986) and Stafford (1991) point to an increase in shallow basin features presumably used to process hickory nuts, as well as groundstone tools for plant processing, at sites in the lower Illinois and Ohio valleys. Homsey (2004) and

Stafford (1991; 1994), among others, argue that intensive hickory-nut processing is linked to a switch from residential to logistical mobility strategies in these two regions. These differing organisational strategies are believed to be a response to problems presented by the environments that hunter/gatherers inhabited. Logistically organised groups procure specific resources through organised task groups whereas residentially organised foragers move to or 'map onto' specific resources (Binford 1980, 10). These differing organisational strategies are believed to be responses to environmental problems. Logistical strategies also may have become increasingly important as populations increased and distances between neighbouring groups decreased: relocation of residential camps may not have been a viable option as foraging groups expanded in favourable areas.

Carmody (2009) further suggests that a shift to logistical mobility strategies led to an overall increase in foraging efficiency, freeing up time for foragers to invest in non-subsistence activities. This would have been quite advantageous for groups that needed to reduce stress both within and between groups, as populations expanded and as local landscapes changed during the Hypsithermal. Collection and storage of large amounts of hickory nuts would have reduced food risk, but also may have freed up time for making elaborate projectile points, bone pins, and atlatl weights, and exchanging these across significant distances. Trade of non-functional, oversized projectile points in the Benton Interaction Sphere in adjacent areas of Alabama, Mississippi, and Tennessee (Johnson and Brookes 1989; Meeks 1998) and of decorated bone pins across the lower Illinois and Ohio valleys (Jefferies 1995; 1996) strengthened ties among groups in these regions. These ties may have buffered against subsistence risk during times of local food shortage, as groups may have been able to call upon their distant neighbours for help. But these relationships also would have helped ameliorate tensions that could arise between close neighbours as the landscape filled.

Interestingly, the archaeological record in Eastern Tennessee is markedly different, as settlements apparently became more dispersed during the Middle Archaic period: sites occur on a variety of landforms, and larger floodplain base camps are notably scarce (Chapman 1985, 148-9; Davis 1990). By the end of the Morrow Mountain Phase, use of the Little Tennessee Valley is all but non-existent, with no large sites dating to the late Middle Archaic Period. Why this should be the case is not entirely clear. Chapman (1985, 149) raises the possibility that groups moved to the main portion of the larger Tennessee Valley during the warmer, drier period brought on by the Hypsithermal. While hickory nuts should have been just as plentiful and reliable in the Little Tennessee as in the main valley, some aquatic resources such as migratory waterfowl may have been more readily available in the main channel. However, later Middle Archaic sites are also scant along the main channel of the upper Tennessee River. As such, no evidence of the production of specialised artefacts such as non-utilitarian projectile points or decorated bone pins is present in this region. It may be that the groups in Northwest Alabama and in Southern Illinois resided in rich habitats that are adjacent to areas that are relatively resource-poor, namely the pine forests of the Coastal Plain that stretches across most of Alabama and the encroaching prairies in Missouri and Illinois. With fewer resource-rich areas in close proximity, foraging groups in these areas may have invested more heavily in relationships with their neighbours. In contrast, the Ridge and Valley and Southern Appalachians of Eastern Tennessee and Western North Carolina are surrounded by relatively rich landscapes that may have afforded more of a buffer to groups living in this region. Population densities may also have been lower in this region.

Leaving this line of conjecture aside, let us return to the idea of increased efficiency associated with intensive use of hickory nuts, allowing more time for non-subsistence tasks. This has important ramifications for intra- as well as inter-group relations. Women presumably performed the majority of tasks associated with the exploitation of hickory nuts, while men likely produced non-utilitarian Benton points and perhaps decorated bone pins. The question, then, is whether the efforts of women supported these part-time craft specialists, or whether men became more actively involved in the collection of hickory nuts as use intensified. Among western native groups, men frequently participated in the collection of acorns (Jackson 1991; Morgan 2012). Similarly, an 18th-century visitor to a Cherokee village in Western North Carolina noted that all able-bodied group members went into the mountains to collect ripened chestnuts. Middle Archaic men almost certainly joined women during the several key weeks of hickory nut availability to maximise the group harvest.

Processing of nuts more likely remained women's work, and judging by the large quantities of nutshell recovered from some of the features, this task may have been performed by relatively large work parties, at least on occasion. Such work may have increased bonds among women.

While we are more familiar with the role of 'big men' in foraging groups, the roles of women as providers of staple foods – like hickory nuts or, in later prehistory, even corn – are of particular interest. In Northwest Alabama, these roles may be expressed in the burial of ten women in Middle Archaic contexts at Dust Cave, in contrast with only five men (Turner 2006). The opposite pattern is observed at the Mulberry Creek site, a shell midden site located on the Tennessee River just several miles downstream, where Shields (2003) reports only two women as compared with seven men buried in Middle Archaic contexts. While the numbers of sex-assigned burials at the two sites is relatively small, multiple burials are not commonly found at Middle Archaic sites in Eastern North America, perhaps in large part due to preservation issues. As such, we find the apparent differences in burial practices between the two sites intriguing. In addition to honouring the dead, these groups may have buried their deceased members at the sites to mark their claim to a territory and usufruct rights to nearby resource patches. That the majority of the Middle Archaic burials at Dust Cave – a hickory-nut-processing station – are women, while the majority at Mulberry Creek – likely a seasonal aggregation site – are men, may well reflect the roles that women and men played within the group. Their burials also mark these places – and presumably the activities associated with them – as important locations on the social landscape.

The ideas we have put forth here, and indeed those of previous researchers like Siddel and Asch (Asch *et al.* 1972), Munson (1986), and Chapman (1985), of course require additional data to flesh them out. This includes analysis of more plant samples from Paleoindian, Early Archaic, and Middle Archaic contexts, but also more fine-grained reconstruction of local landscapes during the Late Pleistocene and Early and Middle Holocene using palynological and phytolith analyses. These detailed ecological reconstructions would provide a much improved picture of the local resources available to forager groups. By filling out our data, we might further our understanding of how intensive use of storable plant resources underwrites population change as well as socio-political change within groups of various sizes.

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Rethinking Neolithic subsistence at the gateway to Europe with new archaeozoological evidence from Istanbul

Canan Çakırlar

University of Groningen
Groningen Institute of Archaeology
Poststraat 6
9712 ER Groningen
The Netherlands
c.cakirlar@rug.nl

Royal Belgian Institute for Natural Sciences
Vautierstraat 29
B-1000 Brussels, Belgium

Abstract

The Marmara region, located at the juncture of Anatolia, the Balkans and the Aegean, is crucial to understand how Neolithic ways of life were transferred from Southwest Asia to Europe. The Neolithic of the Marmara region has been frequently defined as an aquatic forager economy, based primarily on archaeozoological evidence from the key site of Fikirtepe near Istanbul. This interpretation has been repeatedly put forward to support arguments for a Mesolithic component in the development of the Neolithic at the European-Anatolian frontier. In this paper I synthesise old and recent archaeozoological datasets from the region and show that animal husbandry was an established aspect of subsistence in the region since the emergence of Neolithic communities. I also show that morphologically domestic pigs were absent from the herds of the earliest farming communities of the region. Based on diachronic and inter-regional comparisons, I demonstrate that aquatic foraging strategies probably evolved to optimally exploit local environmental resources and supplement the domestic basis of the diet. These results call for a revision of current views on the Neolithic subsistence of the region and consequently its role in the Neolithisation of Europe.

Keywords: *Neolithic, Mesolithic, Marmara region, pigs, fish, shellfish*

Introduction and background

The westward expansion of the Neolithic way of life from its core areas in Southwest Asia into Europe is intensely debated (*e.g.* Colledge and Conolly 2007; Gatsov and Schwarzberg 2006; Krauß 2011; Lichter and Meriç 2005; Özdoğan and Başgelen 2007). Although the chronological outlines of westward Neolithisation have been explored extensively (Boyadzhiev 2006; Brami and Heyd 2011; Özdoğan 2011a; Reingruber and Thissen 2009), a clear understanding of the social and economic trajectories and transformations of the diverse actors of the Neolithisation process is severely hindered by the scarcity of adequate evidence from the intervening region between Southeast Europe and Southwest Asia. This crucial region consists of the western parts of modern Turkey (Çakırlar 2012a; Çilingiroğlu 2012; Özdoğan 2005; Perlès 2001). A particularly critical bottleneck in this vast frontier zone is the area around the Sea of Marmara, located at the juncture of Anatolia, the Balkans and the Aegean (Özdoğan 1999; Roodenberg 1995) (Fig. 1).

This region has been a hot spot of Neolithic research since the mid-20th century, thanks to the continuing efforts of the Department of Prehistory of the Istanbul University, Istanbul Archaeological Museums, and the Netherlands Institute in Turkey. Extensive surface surveys have revealed the presence of Mesolithic groups flanking the coasts around the Bosporus (Gatsov and Özdoğan 1994), whereas six Neolithic sites have been investigated through excavation (Gerritsen and Özbal 2011; Harmankaya 1983; Kızıltan 2007; Özdoğan 1983; 1999; 2005; Roodenberg and Alpaslan-Roodenberg 2008). Cultural affinities between the region's Mesolithic and Neolithic groups have been proposed based on similarities in lithic assemblages, site locations, and contemporaneity (Brami and Heyd 2011; Düring 2011, 42; Gatsov 2001; Özdoğan 1999). The Mesolithic (the so-called Ağaçlı group, named after the type site of Ağaçlı) and Neolithic (the so-called Fikirtepe group, named after the type site of Fikirtepe) groups in the region share a common microlithic tool kit, are represented at sea and lake shores, and are thought to date to the beginning of the 7th millennium BC. On the other hand, some characteristic elements of material culture trace the origins of the Neolithic groups in the Marmara region to Neolithic cultures in inland Anatolia (Çilingiroğlu 2005; 2012; Düring 2011, 195-199; Özdoğan 2011c). Within the Neolithic cultures of Marmara, Özdoğan (2011c) identifies two distinct subgroups within the Neolithic culture of the region; a coastal group distinguished by round architecture, flexed and cremated burials, shellfish gathering and fishing alongside farming, and an inland group characterised by rectangular architecture, flexed inhumations, and subsistence economies focusing exclusively on farming.

The lack of radiocarbon dates from the coastal Ağaçlı and Fikirtepe groups, the absence of excavated Mesolithic contexts, and the lack of archaeobotanical information from coastal Fikirtepe sites comprise some of the crucial elements missing in the current Mesolithic and Neolithic research in the Marmara region. The absence of such essential data hampers the understanding of the relations between the Mesolithic and Neolithic groups in the region to a great extent. The contemporaneity of the Ağaçlı and Fikirtepe groups has not been demonstrated by absolute dating methods. Without sufficient archaeobiological evidence, discussions about site seasonality and function are largely avoided. The marine focus of the Mesolithic Ağaçlı sites is inferred from their location, not from archaeobiological evidence. The round architecture of the Fikirtepe sites in Istanbul is considered to be a Mesolithic component, not based on direct analogy with Mesolithic architecture, but because it is not common in Neolithic Anatolia (Özdoğan 2011c; although see Derin *et al.* 2009 and Sağlamtimur 2007 for examples of Neolithic round architecture in Central Western Anatolia, and Knapp 2013 for the use of round architecture on Cyprus throughout the Neolithic). Although a distinction between coastal and inland Neolithic sites in the eastern Marmara region is relevant and important to explain the lifeways in the region at large, differences in the components of the subsistence economies of the two geographically defined groups can be explained by resource availability, rather than cultural choices and technological abilities.

Figure 1. Sites mentioned in the text.

Because of a general scarcity of other archaeological evidence, archaeozoological material, or more specifically the presence of aquatic foraging from the key site of Fikirtepe (Boessneck and Von den Driesch 1979), has been considered one of the most important lines of evidence in articulating opinions about how Neolithic lifeways emerged in the region of Istanbul, merging with the existing Mesolithic in the area (Çilingiroğlu 2005; Düring 2011, 181; Öksüz 2011; Özdoğan 1999; 2011c; Thissen *et al.* 2010). This model has implicit affinities with models of forager-farmer type economies known from Europe (*e.g.* Zvelebil 1986), which highlight a gradual transition from Mesolithic systems to production economies. In terms of the present typology of Neolithisation models, the model proposed for the Istanbul area can be considered fusionist, rather than the simplistic diffusionist and anti-diffusionist models that have dominated the westward Neolithisation debates until recently (Özdoğan 2011a).

Below, I offer a regional synthesis of new and existing subsistence evidence that may help build the much-needed 'solid evidence' for the formation of refined perceptions of the Neolithisation of the region. I reconsider the theories introduced above by showing, (a) that animal husbandry was a primary component of all the investigated Neolithic economies in the region, from the beginnings until their abandonment, (b) that when the Neolithic emerged in this region animal husbandry was organised differently than at all other contemporary sites in Anatolia, and (c) that fishing and shellfish gathering cannot be considered *a priori* markers of transitional economies at the Mesolithic-Neolithic interface. In order to identify the distinct developmental trajectories characterising subsistence in Marmara, I use inter-regional comparisons among both contemporary and diachronic assemblages. Based on this synthesis, I argue that the growing body of archaeozoological data from Neolithic Istanbul and related contexts compels a shift in the focus of Neolithisation debates concerning the region, from an emphasis on the exploitation of aquatic resources to an emphasis on the introduction, management and development of domestic technologies.

Material, methods and biases

The primary focus of my practical inquiry has been on three sites in Istanbul: Fikirtepe, the type site of the Fikirtepe culture, its neighbour Pendik, and the submerged and then silted site of Yenikapı.[1] The Istanbul sites represent small villages that consisted of round and oval wattle and daub huts located near or at the shore (Algan *et al.* 2011; Özdoğan 1983; 2011a). Together they make up the

1 The vertebrate remains of Fikirtepe were studied and published first by Röhrs and Herre (1961) and by Boessneck and Von den Driesch (1979). The mollusc remains were exported and are currently housed in the State Anatomical Collections of Bayern in Munich. I studied these remains in May 2011. The mammal remains of the 1981 excavations in Pendik were studied by A. Von den Driesch, late professor at Munich University. The bioarchaeology research group at Munich University kindly sent me copies of hand-written inventories of the Pendik material shortly before the death of Prof. Von den Driesch. I studied the fish and mollusc remains from the 1981 excavations at Pendik in Munich where they are also currently stored. I studied the faunal assemblages from Yenikapı at the Istanbul University Veterinary Faculty. Excavations and archaeozoological study of Yenikapı continue.

total of the excavated Neolithic sites around the Bosporus. I compare the patterns of the archaeozoological evidence from these sites with the evidence available from the earliest layers of Ilıpınar and Menteşe in the eastern Marmara region (Roodenberg 1995; Roodenberg and Alpaslan-Roodenberg 2008). While Ilıpınar is also located near the coast, on the western shore of Lake İznik and not far from the southeastern coast of the Marmara Sea, Menteşe is situated on the inland Yenişehir Plain (Roodenberg and Alpaslan-Roodenberg 2008). The two sites are separated from each other by a high mountain range.

The relative and absolute chronology of Neolithic Marmara is not devoid of problems. In the absence of radiocarbon dates from Istanbul sites (against a good corpus of radiocarbon dates from the relatively recent excavations at Ilıpınar and Menteşe), the present understanding of the chronologies depends on cross-dating methods based on artefactual typologies (Brami and Heyd 2011; Düring 2011; Özdoğan 1999; Thissen 1999). The generally accepted relative chronologies of the sites and assemblages used in the present paper are provided in Figure 2. Moreover, while the results of the excavations at Fikirtepe and Pendik are not yet fully published, excavations at Yenikapı continue at the time of writing. As mentioned above, no archaeobotanical evidence is available from Fikirtepe and Pendik, while the archaeobotanical study of Yenikapı is currently in progress. The present state of research inevitably has a negative effect on any attempt to understand the region's prehistoric past (Çakırlar 2012a).

Other subsets of data I refer to include synthesised datasets that represent both the early and the developed stages of Neolithisation in the Euphrates Valley, Anatolia and the Balkans, and relevant subsistence evidence from the Chalcolithic and Bronze Age settlements located in similar environmental settings on the Black Sea and Northern Aegean coast. This is done in order to demonstrate how resource

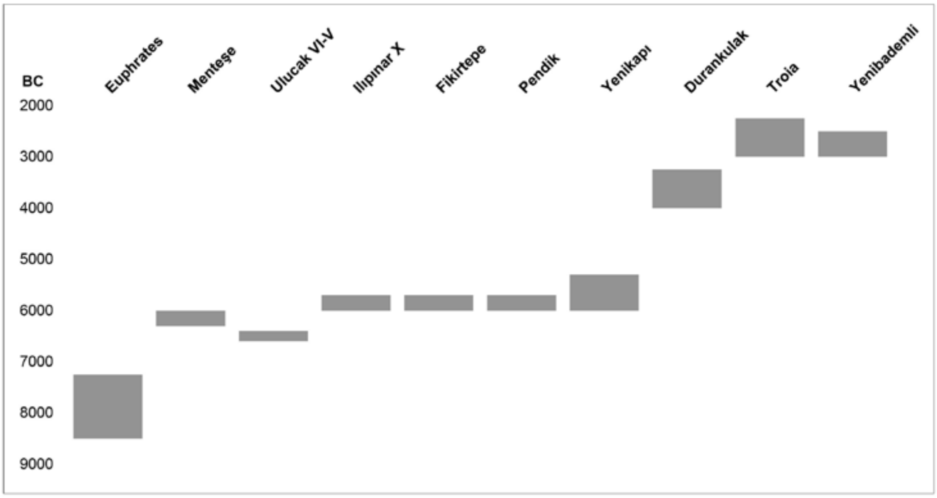

Figure 2. Relative chronology of the Neolithic assemblages discussed in the text (based on Brami and Heyd 2011; Çilingiroğlu 2012). Note that the Neolithic occupations at several of the sites in question continue into the 6th millennium BC.

availability is an important aspect of rational economics regardless of chronological period. Another reason why we have to turn to later periods and other geographical regions for comparison is the lack of archaeozoological data from the Mesolithic of the region in question.

The compatibility of these different datasets is likely to have been affected by differential preservation conditions, excavation techniques, and possibly by intra-site differences in contextual provenances. These are unavoidable problems archaeozoologists and archaeologists have to be aware of when making syntheses (Lyman 1994; Reitz and Wing 2008). Although a series of analytical techniques are available to the archaeozoologist to overcome these compatibility problems (*e.g.* Lyman 2008), problems in integrating published data into quantified interpretive results are difficult to overcome (Atıcı *et al.* 2012).

For the purposes of the present study, the most relevant information concerning the origin of the assemblages in question is that they all stem from hand-collected contexts and mostly from salvage excavations where sampling was almost certainly selective and subjective. Experiments show that fish assemblages are greatly reduced in number and quality when fine mesh sieving is not part of the excavation strategies, causing misinterpretations about the role of fishing in the greater economy (Clason and Prummel 1977; Gordon 1993; Zohar and Belmaker 2005). Therefore, we can assume that the available assemblages are biased towards larger species and individuals; *e.g.* that cattle are overrepresented against mackerels. Moreover, at Yenikapı, while mollusc shells were numerous and ubiquitous, they were not sampled systematically, but at random. At other sites too, it is not clear whether all visible shells were collected or whether decisions as to which ones to sample were left to individual field supervisors (cf. Harmankaya 1983). At Ilıpınar, although flotation took place regularly, heavy residue samples were not sieved, producing faunal assemblages with large amounts of molluscs but very few fish bones (Buitenhuis 1995; 2008). Considering these factors, analytical results such as the relative abundances of represented species and the species spectra must be evaluated with caution in terms of the role and importance of aquatic foraging at these settlements.

The methods used in recording and identifying the faunal assemblages were as diverse as the techniques that were used to excavate them. For the assemblages in question, the only commonly used unit of presenting and calculating species abundances is the NISP (=Number of Identified Specimens); a calculation unit that has been repeatedly criticised for its low value in palaeoeconomic and palaeoecological reconstructions (*e.g.* Uerpmann 1973; Reitz and Wing 2008, 210-212). The basic idea behind the criticisms against the NISP is the simple fact that, for example, half of a cattle femur does not equal a mackerel jaw neither in economical nor in ecological terms. Nevertheless, in the absence of other forms of data, inter-site comparisons of species abundance, including fish and molluscs are necessarily inferred from NISP counts, despite all the pitfalls of this approach. Moreover, essential data regarding ageing, taphonomy, pathologies and other kinds of bone modifications have been recorded and published according to a variety of standards (*e.g.* Grant 1982; Payne 1973) and in varying detail, further hampering accurate comparisons among site-based datasets.

The single standard method that has been applied to each of the assemblages in question is the osteometric methodology of Von den Driesch (1976). Well-defined, standard measurements on archaeological animal bones are used to reconstruct the overall body size of archaeological populations and to infer about the age and sex ratios of culled individuals whenever the individuals of the investigated species are sexually dimorphic. Because human control on wild herds are eventually manifested as changes in body size and age and sex composition, standardised measurement data are crucial to detect domestication as an aspect of developing Neolithic economies (Rowley-Conwy *et al.* 2012; Meadow 1981; 1999; Uerpmann 1978; Zeder and Hesse 2000). Published archaeozoological reports from Marmara sites demonstrate the domestic status of sheep, goats, and cattle based on their small body proportions and assume a domestic status for pigs (*e.g.* Boessneck and Von den Driesch 1979; Buitenhuis 1995; 2008) despite contradicting osteometric evidence; but see Arbuckle 2013). Here I analyse published and new postcranial osteometric data for pigs from Neolithic Marmara using the Logarithmic Size Index (= LSI) method, which enables the comparison of measurements taken on fragmented specimens by relating them to each other by their difference from a standard individual of known sex and age (Uerpmann 1978; Meadow 1981; 1999). The application of the LSI method in this paper follows that suggested by Meadow 1999 (for detailed explanations of the method, see also Arbuckle and Makarewicz 2009; Çakırlar 2012a; Russell and Martin 2005). The standard individual is a recent wild female from Turkey (Hongo and Meadow 2000).

In addition to osteoarchaeological data, I discuss information from a stable isotopic technique that enables distinguishing ruminant milk from other lipid residues in archaeological materials (Dudd and Evershed 1998). The application of this method in the Marmara region has recently altered some of our presumptions regarding the range of products obtained from domestic animals as herding communities emerged at the frontiers of Europe during the 7th millennium BC (Evershed *et al.* 2008; Thissen *et al.* 2010).

Results and discussion

The established role of animal husbandry in Neolithic Marmara

First of all, the established role of animal husbandry in the known Neolithic economies of the Marmara region is demonstrated by the high frequency of domestic animals in the archaeofaunal assemblages. To clarify this point, Figure 3 compares the relative proportions of four major taxonomic groups (molluscs, fish, domestic mammals and hunted mammals) attested at four coastal Neolithic sites in the Marmara region with those from two coastal Early Bronze Age settlements in the Northern Aegean. Inland sites are excluded from this comparison because domestic animals are bound to be overrepresented in the hand-collected archaeofaunal assemblages of these sites due to the absence or scarcity of marine fish and shellfish

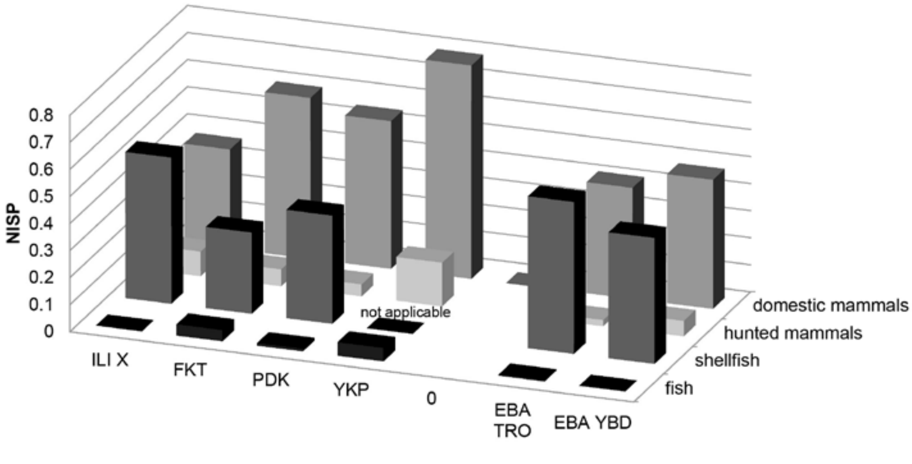

Figure 3. Relative abundance (% NISP) of major taxa in the Neolithic assemblages of the Marmara region and the nearest available Early Bronze Age assemblages in the Northern Aegean for comparison. ILI X = Ilıpınar Layer X (n=969, Buitenhuis 2008); FKT = Fikirtepe (n=9051, Boessneck and Von den Driesch 1979); PDK = Pendik (n=5232, Çakırlar et al. *in prep.); YKP = Yenikapı (n= 559); EBA TRO = Early Bronze Age Troy (n=50109, Çakırlar 2009); Early Bronze Age Yenibademli (n=12576, Çakırlar 2009). 'Domestic mammals' include counts of sheep, goat, unidentified caprines, cattle, and pigs when the majority of the specimens are shown to represent morphologically domestic specimens. 'Hunted mammals' include species with potentially significant dietary contribution, i.e. deer species (Cervidae) and wild boar (*Sus scrofa*).*

in their natural surroundings. It should be added, however, that the inclusion of inland sites would not have altered the picture drastically: Archaeozoological and archaeological data from inland sites are likewise scarce. In fact, the only published Neolithic archaeozoological assemblage from inland Marmara is that of Menteşe Höyük, the earliest phases of which is dated to the final quarter of the 7th millennium BC. Here too, domestic cattle, sheep and goat comprise the majority of the archaeofaunal assemblages (Fig. 4; Gourichon and Helmer 2008).

The earliest layer of Ilıpınar (Level X) represents the earliest archaeozoologically known occupation of farmers on the southeastern Marmara littoral, whereas Fikirtepe, Pendik and Yenikapı represent roughly contemporary coastal Neolithic economies in Istanbul. Troy and Yenibademli are emerging urban economies involved in herding, cultivation, foraging and hunting, along with strong inter-regional exchange (Çakırlar 2009; Hüryılmaz 2002; Ünlüsoy 2006). The similarities in the relative proportions of domestic animals in diachronic assemblages from similar ecological settings in the greater geographical region indicate that there is no reason to think that animal husbandry played a lesser role in Neolithic Istanbul and the Marmara region than it did three millennia later in the Early Bronze Age Aegean.

Another diachronic comparison, this time with earlier sites outside the region in question, provides additional evidence as to why herding should be seen as the predominant means of subsistence when first settled communities emerged in the Marmara region (Fig. 4). A recent synthesis of archaeozoological data from Southwest Asia shows a gradual increase in the NISP proportions of domestic animals in village societies in the Upper Euphrates Valley, thus identifying the Upper Euphrates Valley as one of the core areas of gradual transition from foraging to farming (Conolly *et al.* 2011). When the proportions of mammal remains from the earliest Neolithic of the Marmara region are considered against this background, it becomes clear that there is – as yet – no evidence in the Marmara region that indicates a gradual transformation from foraging to farming.

The mammal assemblages of Neolithic Marmara are dominated by domestic taxa, including sheep, goat and cattle, without exceptions, strongly suggesting that the earliest Neolithic settlers of the region had both viable herds of ruminants and husbandry technologies. Although there is evidence for various extents of hunting at all the Neolithic sites of the eastern Marmara region, there is no clear difference between the proportions from inland or near-shore sites. The apparent dearth of remains of wild mammals in the Menteşe assemblage should be evaluated in view of the small sample size from this site (NISP = 117). Imported herds of sheep and goats quickly adapted to the low plains and valleys around the Marmara Sea, and cattle thrived in the temperate climate and the well-watered environment of Northwestern Anatolia. The important role of cattle in Neolithic Marmara can be seen among the initial phases of Neolithic herding technologies adapting cooler, temperate regions with denser wood cover (Conolly *et al.* 2012). All this is in good agreement with the ample organic residue evidence for milk processing from Neolithic Marmara, which has been loosely linked to cattle rearing (Evershed *et al.* 2008; Thissen *et al.* 2010). Convincing osteoarchaeological data, especially from dental ageing analysis, that point at one or more of the available domestic ruminants as preferred milk suppliers is yet missing from the relevant archaeozoological record (Çakırlar 2012b).

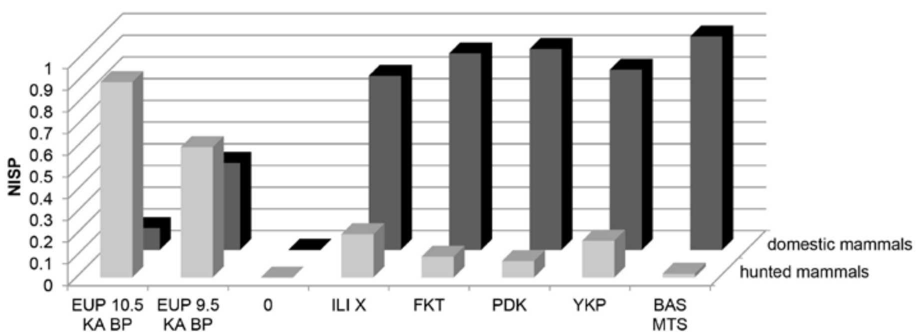

Figure 4. Relative abundance (% NISP) of domestic and hunted mammals at coastal Neolithic sites in the Marmara region (abbreviations as above in Figure 3), basal Menteşe (BAS MTS) and summary data from pre-pottery and pottery Neolithic sites in the Euphrates (= EUP) region. Ilıpınar X: n=438; Fikirtepe: n=5940; Pendik: n=1443; Basal Menteşe: n=117 (after Gourichon and Helmer 2008; Euphrates sites data based on Conolly et al. *2011).*

The distinct character of animal husbandry in Neolithic Marmara

Above I showed that animal husbandry was a defining component of the Neolithic economies in the region, from their known beginnings onwards. This is not, however, to argue that these production economies consisted of a ready-to-install package, applied uniformly in the Marmara region and elsewhere at the European-Anatolian frontier. On the contrary, once human groups with domestic technology emerged in new areas, animal husbandry strategies were modified in different ways. At the beginning of settled life in the region, around 6400–6300 BC, animal husbandry appears to have had a distinct character in the Neolithic Marmara. The composition of the herds was unlike that of any of their known contemporaries or predecessors in Southern Central Anatolia (Russell and Martin 2005), the Lake District (De Cupere and Duru 2003; De Cupere *et al.* 2008) and Central Western Anatolia (Çakırlar 2012a).

In Southern Central Anatolia, the domestic herds were composed solely of sheep and goats until the beginning of the 6th millennium (Arbuckle 2013; Arbuckle and Makarewicz 2009; Russell and Martin 2005). In the Lake District, domestic herds contained sheep, goats, cattle, and pigs since the emergence of the Neolithic there around 6800 cal BC (De Cupere and Duru 2003; De Cupere *et al.* 2008). In Central Western Anatolia, the four-tiered domestic herd was present when an aceramic culture arrived in the Izmir region around 6900 cal BC (Çakırlar 2012a). When Neolithic cultures with pottery arrived in the Marmara region around 6300 cal BC, with their crop plants, and sheep, goats, and cattle, domestic pigs were missing from their package. Morphologically domestic (*i.e.* small) pigs are absent from the earliest layers of Ilıpınar (Buitenhuis 2008) and Menteşe (Gourichon and Helmer 2008) in Southeastern Marmara and from the unstratified assemblages of Fikirtepe (Boessneck and Von den Driesch 1979) and Pendik in southern Istanbul (Çakırlar *et al.* in prep.) (Fig. 5). This trend has been recently discussed by Arbuckle (2013), who deals primarily with the persistent absence of morphologically domestic pigs and cattle in parts of Neolithic Central Anatolia until the mid-5th millennium BC and suggests that pigs were deliberately avoided in Central Anatolia due to cultural conservatism. Cultural avoidance may not be the reason behind the absence of morphologically domesticated pigs in the Marmara region. Evidence supporting this view comes from Ilıpınar's later Neolithic layers (post-Ilıpınar X), in which the proportion of pig remains increases rapidly and pig populations demonstrate a clear decrease in body size (Buitenhuis 2008, Fig. 14). In addition, the ongoing study of Neolithic Yenikapı presents evidence for the morphologically domestic pigs contemporary with the Fikirtepe horizon. Recently revealed ancient DNA sequences from several Neolithic sites across Turkey and Southwest Asia suggests while pig domestication took place initially in Southwest Asia, these domestic lineages did not disperse directly into Europe, but after a significant mixing event in Western Anatolia between local wild boar and presumably incoming domesticated pigs (Ottoni *et al.* 2013). In simplest terms, palaeogenetic results show that the early domestic populations of Europe stem from Western Anatolia. Menteşe is the only successfully sampled

Neolithic Marmara site in the Ottoni *et al.* (2013) study, with a clear Western Anatolian signal (the Y1 haplotype).

Growing evidence shows that although the Neolithic people(s) who came to settle in the Marmara region did not initially bring domestic pigs along with them, they quickly added domestic pigs to their herds. This suggests that these communities, unlike those in Central Anatolia, were not reluctant to include pigs in their herds or to consume pigs. This may have happened in two ways: either through local domestication or through introduction from neighbouring regions. If pigs were domesticated locally, the morphologically wild larger pigs observed in the earlier phases of Neolithic Marmara could also represent herds controlled by

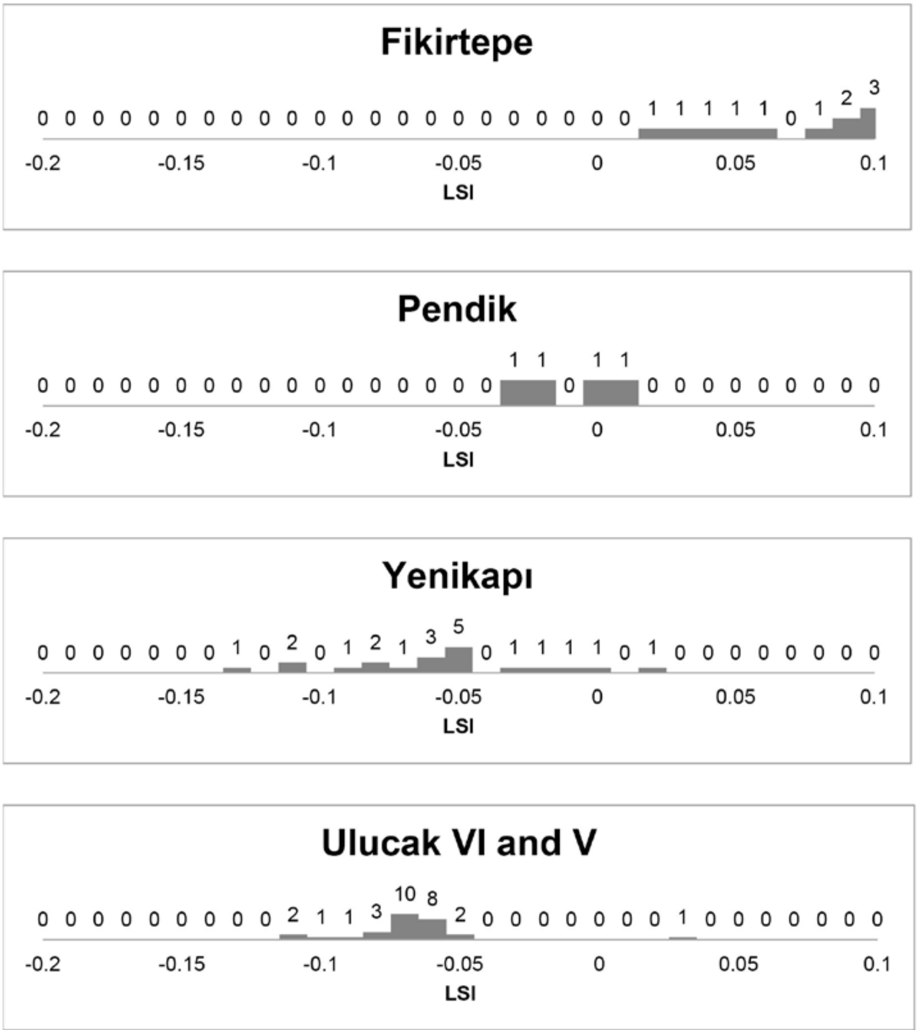

Figure 5. LSI distributions for Sus sp. from Neolithic sites in the Marmara region (Çakırlar et al. *in prep.; Boessneck and Von den Driesch 1979) and earliest phases of Ulucak in Central Western Anatolia (Çakırlar 2012a).*

humans. As it is increasingly acknowledged, size diminution in domestic ungulates is the end result of the domestication process rather than a rapidly occurring reflection of changing human-animal interactions (Zeder 2012). This is especially true in the case of boar and pig (Rowley-Conwy *et al.* 2012). If the idea of pig domestication or the smaller domestic pig populations themselves originated from outside the Marmara region, then the immediate question that comes to mind is: where?

As I pointed out above, Central Anatolia can be ruled out as a possible point of origin because morphologically domestic pigs do not occur in Central Anatolia during the late 7th and early 6th millennium BC (Russell and Martin 2005; Arbuckle 2013). Central Western Anatolia could be shown as a possible point of origin, because when farming began in the Marmara region, Neolithic communities in Central Western Anatolia were already exploiting morphologically domestic pigs for maybe half-a-millennium (Çakırlar 2012a). It should be mentioned, however, that Central Western Anatolia is no less than 300 kilometres away from even the most southerly located Neolithic site in the Marmara region. Unfortunately, the paucity of information about the nature of 7th-millennium economies in regions lying immediately to the east or south of the Marmara region (*i.e.*, Bilecik and Eskişehir regions) prevents hypotheses about the occurrence or role of domestic pigs in those areas to develop any further than speculation.

A third pathway to the introduction of pig husbandry in the Marmara region is partial adoption. Pig husbandry may have been embraced whole-heartedly by some of the Neolithic settlements in the Marmara region, but not by others. The choice of practising pig husbandry may have depended on the function of individual sites. At present there is no evidence as to whether coastal sites like Fikirtepe and Pendik were year-round settlements or seasonally occupied foraging and herding stations. Could the initial absence or later adoption of pigs account for the negative evidence indicating these sites' seasonal function?

The role of aquatic foraging in Neolithic Marmara

NISP counts of fish and shellfish in the different assemblages display similarities, showing that in this geographical setting, fishing and shellfish gathering cannot be considered as markers of transitional economies *a priori.* A close look at the compositions of represented fish and mollusc taxa from different Neolithic sites in the Marmara region provides details about how individual sites adapted to local environmental conditions (Fig. 6). Comparing the patterns of these Neolithic aquatic adaptations to the case of Durankulak, a Chalcolithic site situated in a similar environmental setting, helps to distinguish environmental adaptations from cultural and chronological markers.

The fish bone assemblages from the Neolithic coastal sites in the Marmara region are dominated by freshwater species, such as wels catfish (*Silurus glanis*), roach (*Rutilus rutilus*) and pike perch (*Lucioperca lucioperca*). These are species that seldom enter brackish waters. Fish that occur regularly in estuaries and semi-closed bays are represented by sea breams (*Sparus aurata*) and mullets (Mugilidae). Fully marine species which rarely visit brackish waters such as jackfish (Carangidae),

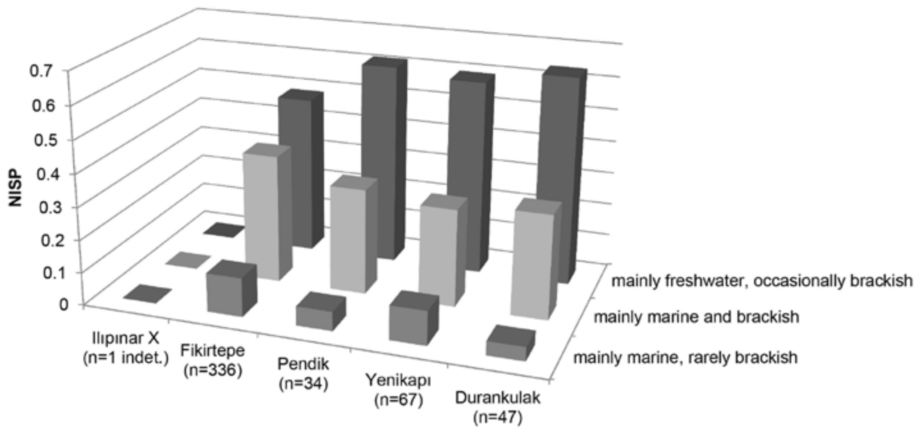

Figure 6. Relative abundance (% NISP) of major fish taxa in the assemblages of coastal sites in the Marmara region and at Durankulak.

tuna (*Thunnus thynnus*) and stingrays (Myliobatoidei) are infrequent, making up in average less than 10 % of the fish specimens. The spectra of fish species from Yenikapı and Pendik largely correspond to that presented by Boessneck and Von den Driesch (1979) for Fikirtepe, with subtle differences. For example, tuna fish are not represented at Pendik or Yenikapı, but other fully marine species such as jackfish and rays are present at these sites. Dolphin (cf. *Tursiops truncatus*) remains were found both in Yenikapı and Fikirtepe, but not in Pendik. Very similar taxonomic configurations of fish and sea mammal fauna have been reported from Durankulak situated on the shore of a semi-closed estuarine lake on the western coast of the Black Sea (Heinrich 1998). Durankulak's main prehistoric occupation is dated to the 4th millennium BC.

For molluscs, data are now available for two Neolithic sites in the Istanbul region. The taxonomic compositions of the molluscs represented at these sites are, like their fish fauna, also conspicuously similar (Fig. 7). Black Mediterranean mussels (*Mytilus galloprovincialis*) are abundant (83-94 %), followed in frequency by common European oysters (*Ostrea edulis*) (2-16 %). The marked difference between the percentages of each taxon is likely to be a reflection of their different physical and chemical properties causing differential taphonomic vulnerability. The nacreous and thin shells of mussels easily break into crumbles by trampling and other agents in the archaeological matrix, resulting in inflated specimen counts. Yet, the fact that several mussel and oyster shells were still clinging to each other when recovered shows that the species formed mixed beds in the vicinity of the sites. Gathering activity was probably opportunistic, targeting neither species. Mixed oyster and mussel beds are common features of marine influenced segments of large estuaries. Lagoon cockles (*Cerastoderma glaucum*), which display a preference for the sheltered sectors of the same brackish habitats, constitute a lesser component of the archaeomalacological assemblages.

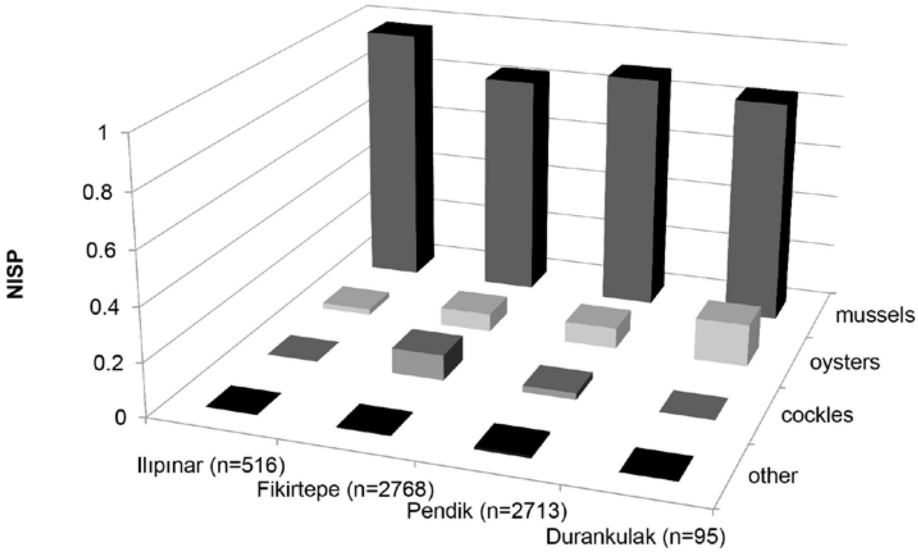

Figure 7. Relative abundance (% NISP) of major mollusc taxa.

If we assume that the Neolithic communities of the Marmara region foraged optimally, practising rational economics, then the fish and mollusc remains should be regarded as proxies for the presence of deep and calm freshwater bodies that merged into semi- or fully closed brackish lagoons near the sites in question. Estuarine shellfish such as mussels, oysters, and cockles are low trophic level species that can be considered marginal resources for humans. These are easy to gather, but of low caloric value. Lagoonal inlets analogous to the extant twin coastal lakes of Büyük and Küçük Çekmece at the outskirts of İstanbul or the Durankulak Lake on the Northern Bulgarian coast were apparently preferred locations to found villages – to occupy year-around or on a seasonal basis. Aquatic resource bases were rich and consisted of co-existing (rather than alternating as it has been recently suggested by Özdoğan 2011b) freshwater, brackish and marine sectors. This reconstruction is in good agreement with the paleontological and sedimentological reconstructions of various locations on the Marmara coast during the Early Holocene (Meriç and Algan 2007). Based on the abundance of deer and boar, it can be postulated that the terrestrial environment consisted of patched forests and possibly open fields. Fertile plains created by the alluvial sediments of the large rivers feeding these inlets would have provided favourable land for agriculture and animal husbandry.

In summary, what the growing datasets from vertebrate and invertebrate remains from the earliest settlement phases in the Marmara region indicate is the existence of a subsistence economy characterised by herding and consolidated by the intense exploitation of wild resources, both terrestrial and aquatic.

Conclusions

The subsistence economy of Neolithic coastal Marmara has often been characterised by its primary reliance on fishing, shellfish collecting, and hunting, rather than on farming (Çilingiroğlu 2005; Düring 2011, 181; Öksüz 2011; Özdoğan 1999; Thissen *et al.* 2010). Together with material cultural evidence, this notion of the subsistence economy was used to argue for a Mesolithic influence on the region's Neolithic (Gatsov 2003; Özdoğan 1999; 2011a; 2011c). The aim of this paper was to reconsider these proposals in light of a synthesis of old and developing archaeozoological evidence from the region's Neolithic.

Through a synthesis of inter-regional and diachronic archaeozoological information, I showed that animal husbandry including sheep, goats and cattle, was one of the pillars of subsistence at all the excavated sites in Neolithic Marmara, at both inland and coastal sites. Husbandry technologies included dairy exploitation. Morphologically domestic pigs were absent from the herds of the earliest Neolithic communities in Neolithic Marmara, including Fikirtepe, Pendik, Ilıpınar X, and Basal Menteşe. In this sense, at least, animal husbandry was divergent from any of the known contemporary subsistence systems in Anatolia. Later on in the Neolithic, pigs were either domesticated locally or more likely introduced from a neighbouring area where domestic pigs were available. If the latter was the case, given the present evidence, the Neolithic populations along the Aegean coast seem to be the most likely source. Whether adopted or locally developed, domestic pigs seem to have been rapidly integrated into the subsistence systems of Neolithic Marmara, unlike in contemporary societies in central Anatolia (Arbuckle 2013). Moreover, recent aDNA analyses demonstrate that it was the Neolithic pig populations of western Anatolia that were introduced as domestic pigs into Europe (Ottoni *et al.* 2013).

In addition, I have showed that aquatic foraging strategies were an integrated part of several (if not all) Neolithic and Bronze Age subsistence economies located along the coasts of the greater region including the Northern Aegean and the western Black Sea. Aquatic foraging strategies observed in coastal Neolithic Marmara were probably supplementary to a well-established animal husbandry system complete with the exploitation of dairy products. A hypothetical stage with terrestrial hunting and aquatic foraging supplemented by animal husbandry (like those known from Western Europe) is currently missing from the archaeological record. Inshore shellfish beds and coastal fisheries were exploited as a supplement to resources obtained through herding, hunting, and possibly agriculture and gathering wild plants. Aquatic species are rich in salt and other essential minerals; in another scenario in which the Neolithic communities along the shore are more mobile, aquatic foraging may have been vital for maintaining community health. Aquatic resources may have played such multifaceted roles in many Neolithic and post-Neolithic communities occupying coastal niches.

The apparent scarcity of evidence for hunting and foraging in inland Neolithic sites can be explained by small sample sizes and resource availability. The lack of substantial evidence at early Ilıpınar is in conspicuous contrast with the large evidence for shellfish exploitation at this lakeside settlement near the Marmara coast; this situation can be explained by the sampling techniques employed at the site or the fishing technologies that were available to its Neolithic inhabitants. All this demonstrates that it is not convincing to argue that evidence for aquatic foraging is an appropriate proxy for Mesolithic influence on Neolithic modes of food acquisition, and the dominant idea of an inland-coastal dichotomy between the Neolithic sites in the eastern Marmara region cannot be corroborated from a subsistence point of view.

The body of evidence on which this paper is based is admittedly scanty. Due to the absence of fully published excavations, archaeobotanical records and excavated Mesolithic sites, interpretative possibilities were necessarily limited. Although the growing body of evidence calls for a revision in the course of discussions about the role of Neolithic Marmara in westward Neolithisation, it is evident that only new research can bring more insight into the problems that are addressed here.

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Agricultural production between the 6th and the 3rd millennium cal BC in the central part of the Valencia region (Spain)

Guillem Pérez Jordà[1] *and Leonor Peña-Chocarro*[2,1]

1. GI Arqueobiología. Centro de Ciencias Humanas y Sociales (CSIC)
Albasanz 26-28
28037 Madrid
Spain
guillem.perez@uv.es

2. Escuela Española de Historia y Arqueología (CSIC)
Via di Torre Argentina 18
00186 Rome
Italy
leonor.chocarro@csic.it

Abstract

The central part of the Valencia region has been the focus of major research into the Neolithic period. Studies of subsistence, settlement patterns and storage facilities for the period between the 6th and the 3rd millennia have been carried out which are primarily focused on understanding both the development of the various farming strategies and the management of surplus. The earliest evidence of crop cultivation took the form of horticulture practised by semi-mobile communities. In a second phase from the 5th millennium, people lived in aggregated communities, developed extensive dryland agriculture and stored their surplus in large communal silos. This model includes storage structures that reveal clearly that social inequality continued until *c.* 2500 BC. The last phase of the period under consideration is distinguished by a return to a horticultural system characterised by a domestic administration of the surplus.

Keywords: *Neolithic, storage structures, agrarian model, Iberian Peninsula*

Introduction

The emergence and further spread of agriculture is one of the most significant events in the history of mankind. In Iberia food production is documented from *c.* 5600–5500 BC. The earliest data come from the Valencia region which has been the focus of intensive research with a particular emphasis on the Neolithic period (McClure *et al.* 2009; Bernabeu Aubán *et al.* 2012; García Atiénzar and Jover Maestre 2011; García Atiénzar 2009). In fact, this region has become one of the better studied areas of the Iberian Peninsula. Archaeobotanical work, including the application of systematic sampling and recovery techniques, has been integrated into research and it has provided interesting data from various sites in the region (Zapata Peña *et al.* 2004; Pérez Jordà 2005; Buxó i Capdevila 1997; Hopf 1966) which allows both the exploring of agricultural production and the outlining of its main attributes. Plant remains are more abundant for the earliest period, between the mid-6th and the beginnings of the 5th millennia cal BC, but there is a progressive decrease of information over time. The 5th millennium has provided significantly less data than the other periods.

This paper focuses on the period between the 6th and 3rd millennia BC during which there is evidence of changes in the archaeobotanical record and in settlement patterns. The transformations observed have been used to suggest a model of gradual agricultural change with different phases corresponding to the various farming strategies adopted through time (Bernabeu Aubán *et al.* 1995).

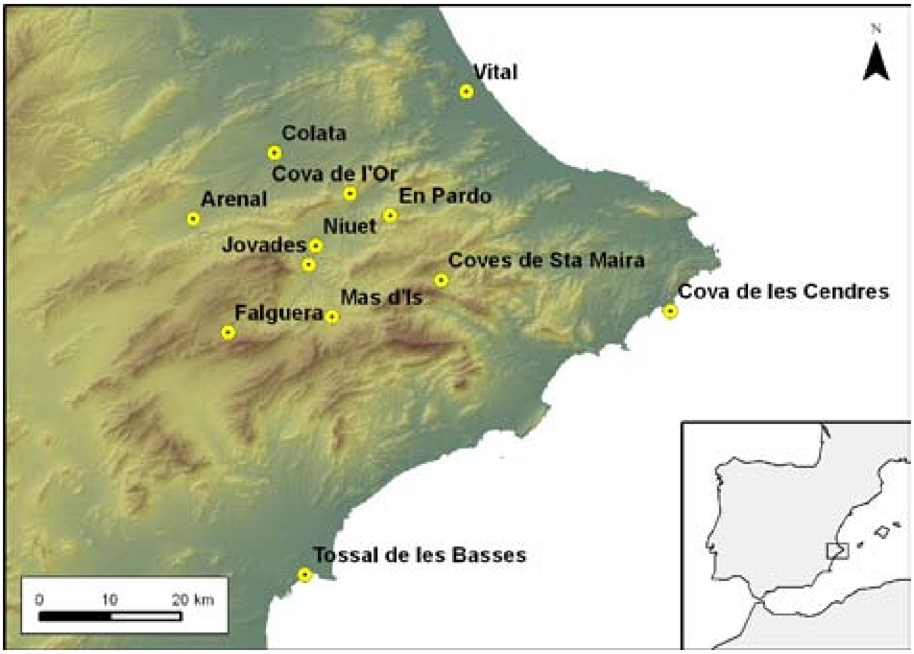

Figure 1. Map showing sites with archaeobotanical studies mentioned in the text.

The model comprises three different stages: a) the first one is characterised by an intensive and diversified horticulture (Pérez Jordà 2005; Bernabeu Aubán *et al.* 1995) which includes the cultivation of a large variety of cereals and legumes following a model similar to that suggested for Greece by Halstead (1989; 2004) based on small-scale intensive horticulture; b) the second phase represents the transition towards an extensive form of agriculture based on the cultivation of a reduced number of cereal species (free-threshing wheats and naked barley). As will be discussed later, the shift to this phase was initially dated to the beginning of the 4th millennium but current archaeobotanical data situate this transition in the 5th millennium; c) the third phase, from the second half of the 3rd millennium, is distinguished by a return to a diversified horticultural system.

Data come from both open-air sites and caves whether used as domestic sites or as herd shelters. Most of the sites considered in this study are located in the interior of the Valencia region, in the northern valleys of the Betic ranges (Fig. 1). The Tertiary marl formations on which most settlements are found are considered excellent for agriculture. There are, however, a few examples of sites located in coastal areas such as Cova de les Cendres (Alicante) and La Vital (Valencia).

Apart from plant remains, the paper considers other issues related to agricultural production such as settlement patterns and storage facilities, with the aim of gaining insights into both the scale of agricultural production and the social organisation of the communities involved.

The following sections will describe in detail the main characteristics of the three phases of the model according to four main aspects: crop diversity, settlement patterns, distribution and size of storage facilities and environmental conditions.

Early agriculture: intensive manual horticulture and crop diversity

The first farming communities settled in this territory during the Atlantic Holocene period when wetter and warmer environmental conditions allowed the spread of oak forests and riverine species (Jalut *et al.* 2009; Badal García *et al.* 1994; Dupré 1988). The earliest dates from AMS dating on charred plant remains go back to 5620–5480 BC (Bernabeu Aubán *et al.* 2003).

Settlements were small and preferably located on valley floors surrounded by rich and fertile soils, where an intensive hoe-based agriculture in fields near the settlements is assumed to have been practised (Chapman 2008; García Atiénzar 2009; Bernabeu Aubán *et al.* 1995; McClure *et al.* 2009). The archaeobotanical data (seeds and fruits) available from various sites show a large variety of crops amongst which cereals are the predominant species (Table 1).

Although the predominant cereals are free-threshing wheats (*Triticum aestivum/durum*) and naked barley (*Hordeum vulgare* var. *nudum*), hulled cereals – einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*) and hulled barley (*Hordeum vulgare* subsp. *vulgare*) (Fig. 2) – appear to have played an important role too.

	5600–5000 BC					5000–4500 BC		
	Cendres	Or	Falaguera	Mas d'Is	Total	Cendres	En Pardo	Total
Number of samples	111	42	39	6	198	18	9	27
Hordeum vulgare subsp. *vulgare*	44 (27)	25(7)	2 (2)	1 (1)		12 (8)	2 (1)	
Hordeum vulgare var. *nudum*	103 (41)	1266 (36)	2 (2)			33 (10)	1 (1)	
Triticum aestivum-durum	182 (67)	3161 (39)	22 (9)	3 (3)		15 (7)	3 (3)	
Triticum dicoccum	148 (41)	50 (17)	3 (3)			5 (4)		
Triticum monococcum	11 (9)	94 (27)	13 (8)	1 (1)		2 (1)		
Lathyrus sp.	1 (1)							
Lens culinaris	7 (6)		1 (1)					
Pisum sativum	8 (5)							
Vicia ervilia						1 (1)		
Vicia faba	3 (1)							
Vicia sativa		1 (1)						
Papaver somniferum								
Total	507	4597	43	5	5152	68	6	74

Table 1. List of plant remains from the different periods considered in the text. The first number in the cells refers to the number of remains for each sample whereas the number in brackets relates to the frequencies of each taxa in each site.

	4500–4000 BC				4000–2300 BC				2300–2000 BC		
	Sta Maira	Mas d'Is	Cendres	Total	Jovades	Colata	Niuet	Total	Mola	Arenal	Total
Number of samples	27	25	3	55	17	23	6	46	3	4	7
Hordeum vulgare subsp. *vulgare*	3 (3)		3 (1)		3 (3)						
Hordeum vulgare var. *nudum*		5 (4)	1 (1)		39 (12)	6 (4)			1226 (3)	104 (1)	
Triticum aestivum-durum	5 (4)	5 (3)	4 (2)		8 (5)	67 (5)	3 (3)		4222 (3)	1 (1)	
Triticum dicoccum											
Triticum monococcum									605 (3)	3 (1)	
Lathyrus sp.							2 (2)				
Lens culinaris	1 (1)										
Pisum sativum					4 (2)				21 (2)		
Vicia ervilia											
Vicia faba					1 (1)				97 (2)		
Vicia sativa	5 (3)										
Papaver somniferum									2 (1)		
Total	13	10	8	31	55	73	5	133	6173	108	6281

Table 1 (continued).

Figure 2. Cereal species identified. *1.* Hordeum vulgare *var.* nudum, *2.* Hordeum vulgare *subsp.* vulgare, *3.* Triticum aestivum/durum, *4.* Triticum monococcum, *5.* Triticum dicoccum.

Legumes are also present from the earliest Neolithic contexts but always in lower proportions. Their presence is continuous throughout the sequence without predominance of a particular species. Pea (*Pisum sativum*), grass pea (*Lathyrus* sp.), broad bean (*Vicia faba*), vetch (*Vicia sativa*), bitter vetch (*Vicia ervilia*) and lentil (*Lens culinaris*) are the commonest species represented (Figs. 3 and 4). The limited presence of weeds in the Iberian archaeobotanical record does not allow assessing the intensity of crop husbandry in the region as it has been done for other European areas (Bogaard 2004; Halstead 2004).

For at least 500 years after the first establishment of farmers, anthracological spectra do not seem to show evidence for forest degradation which is probably related to the type of agriculture practised based on intensive horticultural work.

The contemporary use of caves and small open-air settlements suggests that these farming communities or just some small groups practised some degree of mobility (García Atiénzar 2011; García Borja *et al.* 2011) aimed at exploiting

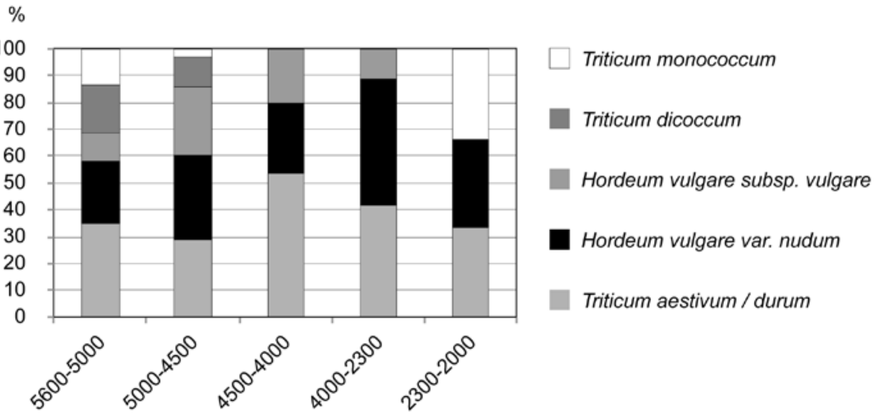

Figure 3. Frequencies of the various cereal species identified.

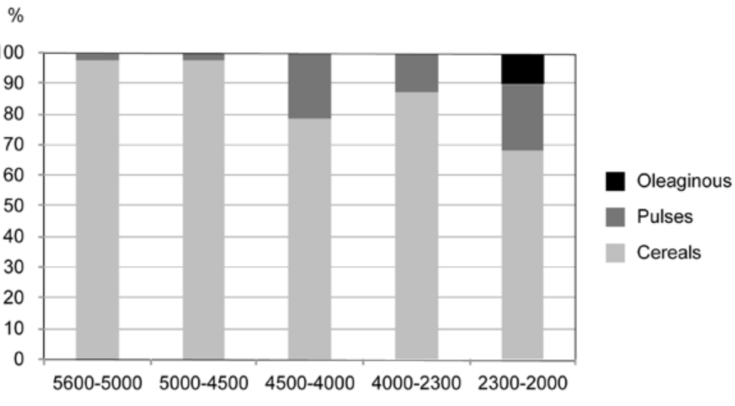

Figure 4. Frequencies of the different crops identified.

different environments. These movements may also have helped to cope with soil fertility depletion due to intensive land use (Bernabeu Aubán *et al.* 1999; McClure *et al.* 2006; McClure *et al.* 2009).

At these sites, both open-air sites and caves, containers for storage were not particularly large. Ceramic pots reached *c.* 50 litres while sizeable unfired clay containers rarely went over 100 litres. The only silos documented in the area are those of Cova de les Cendres in Alicante (Bernabeu Aubán and Fumanal García 2009) which had a capacity of *c.* 500 litres.

The second phase: towards extensive agriculture

From 5000 BC both charcoal (Badal García *et al.* 1994) and pollen analyses (López Sáez *et al.* 2011; Jalut *et al.* 2000) show progressive forest clearances corresponding to farming activities. Forest degradation reached a peak at the beginnings of the 5th millennium cal BC. Besides, sedimentological studies carried out at one of the key sites of the period, Benàmer (Valencia) (Torregrosa Giménez and Jover Maestre 2011), provide evidence of an arid phase characterised by marked rainfall seasonality and high erosion rates during the second half of the millennium. This phase is correlated to the Bond Event 4 (Ferrer García 2011). Different factors affecting vegetation cover appear to be acting at the same time; on the one hand natural factors such as aridity which led to erosion processes and, on the other, a millennium of anthropic activities which brought about landscape transformations. This process may have been intensified by the practices implicit in the new extensive model which entailed forest clearing for agricultural expansion and intensive ploughing around the sites. Yet, it is unclear whether increasing aridity may have reduced the chances of sustaining an intensive horticultural system due to land cover degradation and soil impoverishment and, therefore, inducing human groups to develop a new farming strategy based on extensive agriculture. Therefore, a combination of environmental constraints and a millennium of human-induced activities probably bolstered by changes in the farming strategy are key to understanding the underlying causes of this complex process of change.

Archaeobotanical data from 5000–4500 cal BC are frustratingly scarce in the region but an analysis of the relative proportions of cereal in the archaeobotanical samples shows that hulled wheats declined or even disappeared during this period (Table 1). In fact, from 4500 cal BC a reduction in crop diversity is observed; einkorn and emmer vanished from the archaeobotanical record and, from this point onwards, free-threshing cereals, both wheat (*Triticum aestivum/durum*) and barley (*Hordeum vulgare* var. *nudum*) became the only cereal species.

The evidence of clearances of wooded areas related to larger-scale cultivation and the presence of cereal dominant crop assemblages suggest that the economic system was undergoing significant transformations. A change towards an extensive form of farming has been initially proposed for the beginning of the 4th millennium BC (Bernabeu Aubán *et al.* 1995) although new data suggest that it started at some point during the 5th millennium BC.

A further interesting point relates to the internal structure of these communities which may have also promoted changes in the farming strategy. Systems based on intensive farming tend to restrict community internal growth as the group development depends on the capacity of the land to support its productive system. This type of strategy based on intensive small-scaled cultivation tends to be practised by small communities which encourage group segregations when resource stress emerges. The segregated group then moves to a new area where the model is reproduced. Some authors such as McClure *et al.* (2006; 2009) have suggested that other factors such as soil impoverishment due to intensive cultivation or increasing population density may have also triggered the segregation process. In any case, it is likely that the process of change detected at sites like Benàmer results from a combination of a series of interrelated factors.

From 4500 cal BC onwards, there is also evidence for a transition to a new system of resource storage. The excavation of the open-air site of Benàmer (Alicante) has stressed the main differences with the previous phase. Although information on the domestic units of the site is still missing (Torregrosa Giménez *et al.* 2011), the novelty relates to the presence of a large concentration of cereal storage pits, at least 200, from phase IV. Some of these structures have capacities of over 6000 litres, which are far beyond annual domestic consumption suggesting an increasing accumulation of wealth related to the growing of social inequality. The high concentration of underground pits seems to point to a considerable number of families living at the site at the same moment. However, such a concentration may have resulted from a long occupation period. Dates that could throw some light onto the occupation length are still unavailable.

Settlements are bigger now and expand over larger territories where new agricultural fields are established. Extensive agriculture allows for increasing production so surplus is accumulated and stored. In addition, there is a gradual transition towards the use of caves as animal shelters (Badal García and Martí Oliver 2011) as the new farming strategy entails keeping herds away from the areas of agricultural activity. This is a common practice in the Mediterranean region, aimed at exploiting resources (pastures) in montane areas and, at the same time, preventing animals from entering cultivated fields and damaging harvests. Ethnographic (Seguí 1999) and archaeological (Boschian and Montagnari Kokelj 2000; Carrión Marco *et al.* 2006; Mlekuž *et al.* 2008; Mlekuž 2009) data provide numerous examples of the use of caves for animal penning during late spring and summer.

Despite the sites' long occupational histories, there are some elements which allow recognising differences amongst them such as the distribution of storage structures within the habitats or the sizes of such structures (Fig. 5). For some researchers (Bernabeu Aubán *et al.* 2006; Pérez Jordà *et al.* 2011) these two aspects are important issues for exploring the internal organisation of these communities.

The earliest evidence for the presence of silos comes from Benàmer which is the only site dated to the second half of the 5th millennium; the excavation has revealed a confined storage area with numerous silos which seem to have been repetitively in use (Fig. 6) as is demonstrated by the various structures cutting

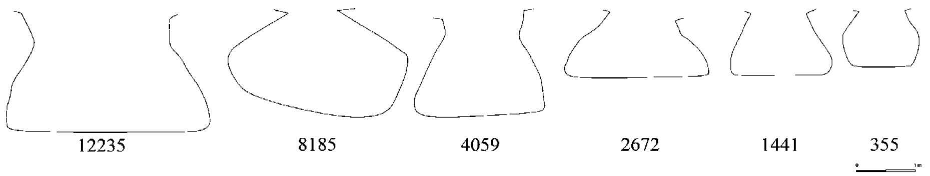

Figure 5. Sections of silos from La Vital site.

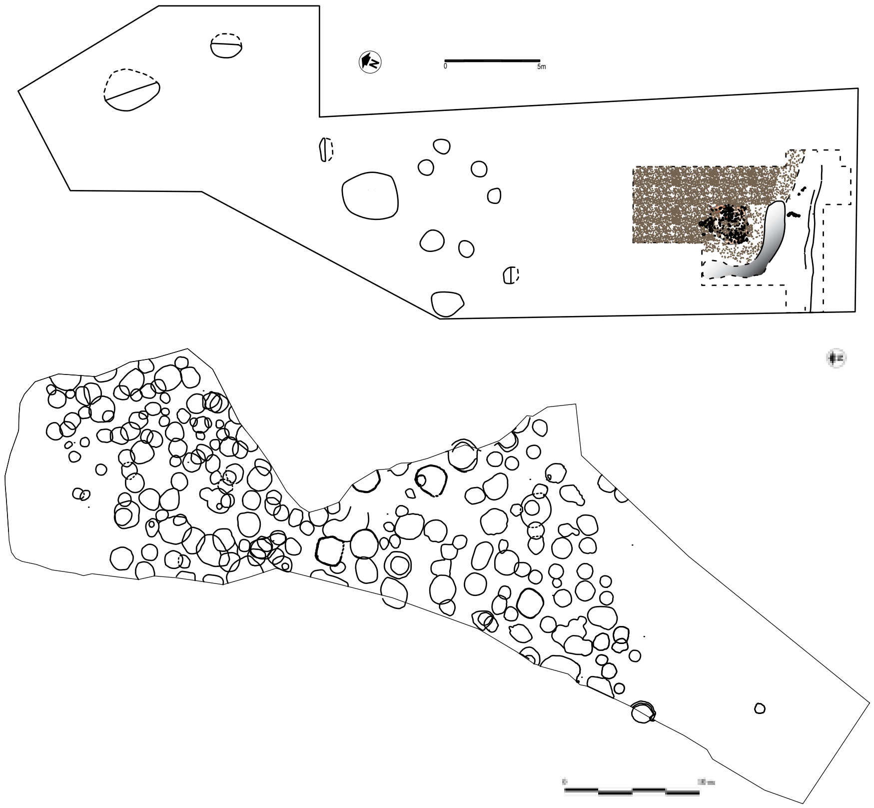

Figure 6. Distribution of silos at the sites of Benàmer (below) (from Torregrosa Giménez et al. *2011, modified) and La Vital (above) (from Pérez Jordà* et al. *2011, modified).*

across each other. This superposition of structures became a differentiating element for the late 5th millennium and, in the case of Benàmer, indicates a continuous occupation of the area (Torregrosa Giménez and Jover Maestre 2011; Jover Maestre *et al.* 2011). During the 4th and 3rd millennia, instead, storage facilities appear scattered around the houses and the storage pits rarely cut previous structures. Moreover, there do not seem to be specific areas for storage and both houses and associated private storage facilities are located within the site without following a particular organisation (Gómez Puche *et al.* 2011).

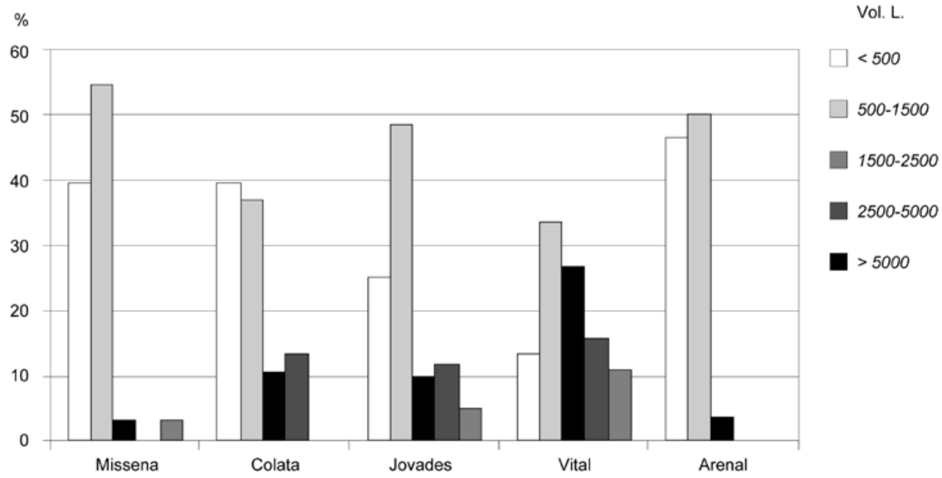

Figure 7. Capacities of silos from the main 4th and 3rd millennia sites. The number of silos at Missena is 33, at Colata 38, at Jovades 60, and at Arenal 28.

The differences we observe in the management of the storage structures reveal aspects of the group's internal organisation. In fact, the variations detected in the location and management of storage pits during this phase represent also changes in the group's social structure. Benàmer is probably reflecting a communal administration of cereal resources while in more recent settlements the management of food resources is sustained by the domestic units. A second differentiating element refers to the storing capacities of the documented structures (Fig. 7).

While there are only a few examples of large structures (1500-4500 litres) or of rather oversized ones (up to 4500 litres), the average capacity of most silos is below 1500 litres, which corresponds with the usual production of a family unit per year.

The long life-span of some of the sites where silos have been found makes it difficult to establish their chronological occupational sequence. The available data suggest that the site of Benàmer was the oldest, but it partly developed at the same time as others such as Missena (Valencia) (Pascual Beneyto *et al.* 2004). The latter was still in use during the 4th millennium BC as were others such as Colata (Valencia) (Gómez Puche *et al.* 2004) and Jovades (Alicante) (Bernabeu Aubán 1993.) Some (for instance Jovades) spread also through the 3rd millennium while at the same time new settlements such as La Vital (Gandía, Valencia) appeared for the first time. The last example of 3rd-millennium sites where silos are still documented is the site of Arenal (Valencia) (Pascual Benito *et al.* 1993) (Fig. 8).

So, the existing differences amongst the various open-air sites from the region of Valencia considered in this paper are based on the variable presence of large storage structures. These are already recorded by the 5th millennium cal BC although in small proportions. During the 4th millennium the situation is rather similar and, only by the 3rd, in sites like La Vital, has a significant increase in the number of large-capacity silos (Pérez Jordà *et al.* 2011; Bernabeu Aubán *et al.* 2006) been documented.

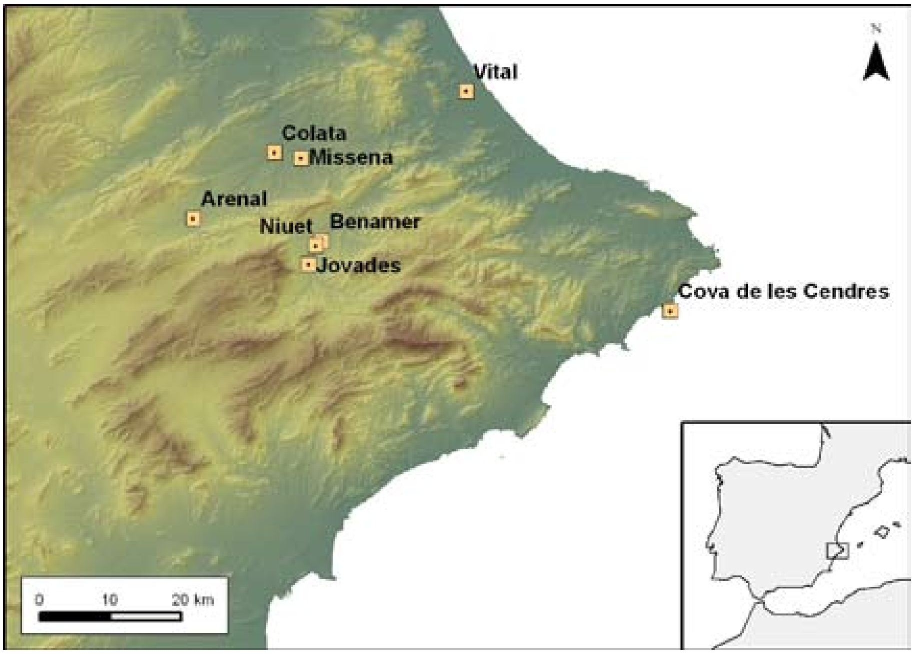

Figure 8. Map of sites where silos have been found.

Although with some changes, this model was in use throughout the 4th and the 3rd millennia cal BC (McClure *et al.* 2009; García Atiénzar 2009). The 4th millennium BC corresponds to the warmest Holocene phase (Magny 1999) which in the Mediterranean area coincides with an arid episode (Jalut *et al.* 2009). In addition, rainfall became more seasonal and by the beginning of the 3rd millennium the new environmental conditions reached a peak with an important reduction of spring rainfall.

The third phase: a change in the model

From an environmental point of view, the last part of the 3rd millennium is distinguishable by a substantial increase in precipitation (McClure *et al.* 2009; Aguilera *et al.* 2012). Archaeobotanical data point to a new period of crop diversification of which attests not only the reintroduction of einkorn (*Triticum monococcum*), reaching high numbers at some sites, but also the cultivation of new crops such as flax (*Linum usitatissimum*). These agricultural developments are coincident with the disappearance of the large storage structures that characterised the previous phase. Arenal de la Costa (Pascual Benito *et al.* 1993) is the last site where silos are recorded and here storage capacities do not exceed 1500 litres. Simultaneously, new sites such as Mola d'Agres, Les Moreres (González Prats and Ruiz Segura 1991-1992), Peñón de la Zorra or Puntal de los Carniceros (Jover Maestre and López Padilla 2004), all in the Valencia region, have not provided evidence of large-capacity storage structures. Simultaneously, the large centres of aggregated population characteristic of the 4th millennium gave way to a pattern of more dispersed and smaller settlements occupying hilltops, while in the plains sites are hard to find.

Scale of agricultural production

According to current data, the first Neolithic groups were family-based communities that lived either in dispersed huts or in small aggregated habitats and caves and practised intensive horticulture. These communities grew at least five different cereal species and a wide range of legumes. However, despite being territorially structured, the earliest farming groups did not use medium or large-capacity storage facilities. Instead, their resources were stored in small structures. This pattern is evident from 5500 cal BC until the beginning of the 5th millennium when the system enters into crisis. Archaeobotanical data from the beginning of the 5th millennium are scarce but they point to a reduction in crop diversity, with hulled wheats already having disappeared by 4500 BC. At the same time, caves lost their function as domestic sites or ritual places and became animal shelters. Settlements are generally located in the lowlands. If Benàmer represents the typical settlement of the second half of the 5th millennium, we can assume that, by now, the population had aggregated in larger villages which, for the first time, stored their surplus in large storage facilities. The structures unearthed represent storage installations that were probably managed centrally through a complex system different from that of the previous phase. Now, the storage structures and consequently, the community's wealth, were concentrated in a confined area. Moreover, in some cases, their storage capacity is overwhelmingly bigger than the capability of production of the family unit.

We argue that the agricultural system associated with these structures is an extensive one. This does not exclude the presence of garden plots in areas where environmental conditions were favourable but, in general, in the Valencia region, the horticultural system did not allow increasing production. Consequently, in order to feed the growing population of the site, the only solution was to enlarge the cultivated area. Given the good quality of soils cereal agriculture was easily developed.

The site of Jovades and, later on, that of Colata, can be seen as examples of the transformation of the system at the beginning of the 4th millennium BC, characterised by a less centralised internal organisation. Our knowledge of the domestic structures is limited but there does not seem to be evidence of large concentrations of silos such as those found at Benàmer. Now, silos are distributed around the houses in sites spread across the territory near the agricultural fields. The system was still extensive but not centrally managed and domestic units still played an important role in the management of resources. This new trend did not exclude large storage structures for keeping large productions beyond the capacity of the family unit. In fact, these huge structures for keeping the overproduction of cereals have been interpreted as reflections of growing inequalities within the community. It implies the existence of local groups able to accumulate not only the agricultural production but also labour input and animal force.

There is evidence that the farming strategies, based on an extensive agricultural system, developed in the region from the 4th millennium, varied and changed through time. By the 3rd millennium BC there is clear evidence of social inequalities within these settlements. The site of La Vital, characterised by the greatest concentration of large storage structures, is a clear example of a new situation in which some individuals concentrate wealth and there is a restricted access to the accumulated surplus. The role of this site in the arrival of copper mineral and the production of metal tools from 2800 cal BC (Molina Balaguer and Orozco Köhler 2011; Rovira and Montero Ruiz 2011) is probably related to the new social condition of some individuals or groups. No further data are available from the region for this period so it is unclear whether inequalities are also present at other sites or if, instead, this social appropriation of surplus is a characteristic of La Vital.

During the late 3rd millennium, there is evidence of new sites on low-lying areas, such as Arenal de la Costa. The main difference with the previous phase refers to the size of the storage pits documented. Silo capacity has been reduced to a maximum of 1500 litres which corresponds to production at family scale. Social inequalities, well documented in the previous phase and represented by the large storage structures and rich burials, disappeared now (García Puchol *et al.* 2011; García Puchol and Gómez Pérez 2011). Silos from this last phase do contain burials but grave goods are absent. As for the settlements, now the population moved to higher locations.

Most of this evidence reflects the collapse of a model that with some variation survived for a long time. This period of population reorganisation coincides with a new cycle of agrarian diversification which appears to be a return to an intensive model. It seems that when the system collapsed small family units developed more conservative strategies which could guarantee their subsistence by minimising risk.

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From subsistence to market exchange: the development of an agricultural economy in 1st-millennium-BC Southeast Italy

Daphne Lentjes

VU University Amsterdam
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands
d.m.lentjes@vu.nl

Abstract

A series of unprecedented changes took place in the Southeastern part of Italy between the Archaic Period and the arrival of the Romans. Particularly the process of Greek colonisation has spawned a huge archaeological bibliography. In recent years, research of the contemporary indigenous regions has also taken a giant leap forward, leading to important new insights in the processes of urbanisation and growing social and economic complexity in these areas. Combining archaeological, archaeobotanical and archaeozoological data, I will investigate how agricultural land use evolved during the different stages of Greek colonisation. I will show that while the Greek colonial towns were already involved in surplus production in the Archaic and Classical periods, farmers in the contemporary inland areas did not supply goods to a market. Rather, they aimed to be self-supporting and gain subsistence for their own families. This changed in the Early Hellenistic Period (*c.* 325–200 BC), when the scale and efficiency of agricultural production increased considerably, and the inland areas became more accessible for long-distance trade. The consequences of this are clearly reflected in a number of new developments, such as increasing market-oriented agricultural production and, probably as a result of that, agricultural specialisation. These developments can be witnessed especially when archaeobotanical and archaeozoological assemblages from archaeological sites in Southeast Italy are integrated with information from archaeological excavations, field surveys and ancient written sources. In this paper, some examples of evidence

for surplus production and agricultural specialisation will be presented, and it will be shown how the focus of the rural economy in the entire region shifted from subsistence- to market-oriented.

Keywords: *Pre-Roman Italy, agricultural production, archaeobotany, archaeozoology*

Introduction and background

This paper is concerned with the Archaic/Classical periods (*c.* 600–325 BC) and the Early Hellenistic Period (*c.* 325–200 BC) in Southeast Italy (Fig. 1). The research area consists of the regions around the Gulf of Taranto, including the Salento Isthmus in the southern part of Apulia, the Basilicata (or Lucania) region, the southernmost tip of Campania and the north of Calabria. This area is rather varied in terms of relief, hydrology and vegetation patterns (Van Joolen 2003, 44-61, 92-100; Attema *et al.* 2010, 59-60, 81-82). The Salento district is largely made up of a slightly undulating plain with light arable soils which, starting from the Adriatic, rises very gradually to approximately 60 metres above sea level. The coastal zone consists mostly of dunes, low cliffs and lagoons. Toward the south, the plain merges into the more hilly, calcareous landscape of the Serre Leccesi. To the west and north, the Brindisi district encompasses some of the hard limestone spurs of the Murge uplands, a plateau which gradually rises up to the Apennine mountain chain. Basilicata, on the other hand, is the most mountainous region in the south of Italy, covering an extensive part of the Southern Apennines. It is bordered to the east by the Bradano river depression which is traversed by numerous streams and declines to the southeastern coastal plains towards the Ionian Sea. The north of Calabria consists largely of an alluvial plain, delimited to the north by a crescent-

Figure 1. Research area with the sites mentioned in the text, indicating the locations of the archaeozoological and archaeobotanical samples (Bert Brouwenstijn).

shaped mountain range, with few access points to the mountainous hinterland. Inland routes are largely restricted to the wide river beds of the streams entering the plain from the mountains.

Between the 8th and 6th centuries BC, small groups of Greek seafarers settled along the coast of Southern Italy ('Magna Graecia') and established colonies, including Taras (modern Taranto), Metapontion (Metaponto), Siris/Herakleia (Policoro) and Sybaris (Sibari) (Fig. 1). Archaeological research of the Greek colonisation movement has focused mainly on the colonial Greek cities and the diffusion of Greek art, architecture and town planning (Nenci and Vallet 1977-2005; Dunbabin 1948; *Atti Taranto*, especially 1961, 1978, 1997, 2000, 2012; Boardman 1998). However, in the past few decades, research of the contemporary indigenous regions has also taken a giant leap forward (see particularly Peroni 1984; 1994; D'Andria 1988; 1990; 1991a; 1991b; 1996; Pacciarelli 2001; Osanna 2008; 2009; Osanna and Serio 2009; Cerchiai 2010). A more recent trend in archaeological research in Southeast Italy involves the investigation of ancient landscapes, which is illustrated particularly well by the growing number of archaeological field survey projects and excavations of rural sites (see Barker 1995, with extensive bibliography; Yntema 1993; Small 2001; Burgers 1998; Carter 2000; 2006; De Siena 2001; Attema *et al.* 2010, among many others). However, whereas our knowledge of habitation patterns and human impact on the landscape has increased enormously, the basic understanding of what this landscape looked like and how it was used (besides for settlement building) has lagged behind. The purpose of this paper is to review one aspect of this hitherto mostly ignored research topic, *i.e.* how the scale and organisation of agricultural production in Southeast Italy developed during the heyday of the Greek colonial towns. This touches on some core issues in the debate of Greek colonisation in Southern Italy, namely the colonists' means of subsistence in their new homelands, as well as their relationship with indigenous societies. Moreover, this study of local land use represents a step forward in our understanding of everyday life in Pre-Roman Southeast Italy.

To achieve this objective, this paper will examine two main research questions:

1. Which temporal changes in farming and landscape formation can be witnessed in Southeast Italy between the 7th and the 3rd centuries BC, *i.e.* through the Archaic/Classical and Early Hellenistic periods?
2. What was the effect of the Greek colonisation process on local land use?

These broad questions will be answered by addressing more specific research questions:

A. What developments in exploitation of crops and animals, and specialisation in crop regimes and livestock can be identified in the different phases of the Greek colonisation process, *i.e.* the heyday of the Greek colonial towns in Italy (in the Archaic/Classical periods) and the later phase (Early Hellenistic Period)?

B. During these phases, what are the main differences in crop and livestock exploitation and specialisation that can be identified between the colonial towns and indigenous/'mixed' settlements?

C. When can intensification and specialisation in farming first be identified?

Materials and methods

To carry out this investigation, I will present archaeobotanical and archaeozoological research data from eleven sites in Southeast Italy, dating to two different phases, *i.e.* the Archaic/Classical periods (*c.* 600–325 BC) and the Early Hellenistic Period (*c.* 325–200 BC) (Fig. 1). These are the only research data available for these periods; I did not have access to unpublished archaeobotanical and archaeozoological data. Archaeobotanical and archaeozoological analyses were only rarely an integral part of archaeological investigations in Southeast Italy until recently (Hopf 1991, 243; Rottoli 1993, 305; Carter and Costantini 1994, 104; Veenman 2002, 9; Bartosiewicz 2010, 21-22). There are several explanations for this, including the unfavourable environmental circumstances for the preservation of plant and animal remains. However, both disciplines are slowly coming of age in Italy. The first important steps in this process were taken in the 1970s and early 1980s, when archaeobotanical research concentrated on the need to catalogue the finds, and create a general image of the available species (*e.g.* Castelletti 1972; 1976; Follieri 1971; 1973; 1975; LaCroix Phippen 1975; Hjelmqvist 1977; Barker 1977; Follieri and Coccolini 1979; Costantini 1979; 1980; 1983a; 1983b; 1983c; Scali 1983; Steele 1983). Today, this phase of collecting information is slowly coming to an end, making way for synthesising, regional studies. The research presented in this study clearly fits into this trend, but also wishes to take a step forward, integrating archaeobotanical and archaeozoological data into a multidisciplinary research framework.

The reason for this incorporation is to avoid factors that create a bias in archaeobotanical and archaeozoological research. Plant and animal remains have been collected at only a few archaeological sites in Southeast Italy, which are not necessarily representative for the whole region. Comparison between samples is made even more difficult because of differences in site function, sampling methods and environmental circumstances at individual sites. Moreover, the animal bone and plant assemblage from a given site may not reflect the actual range of species that was present at the time of habitation (Willerding 1971; 1991; Clason and Prummel 1977; O'Connor 2000; Serjeantson 2009). Indeed, certain plant and animal types are much more frequently found than others. This particularly holds true for domesticated species; plants and animals that had no economic value are less likely to be preserved in the archaeobotanical assemblage. Moreover, the majority of archaeobotanical assemblages discussed in this paper consists of carbonised plant remains. Pantanello is the only site with waterlogged conditions. The interpretation of carbonised archaeobotanical remains brings its own set of problems, since not all plant remains have the same chance of survival. A considerable quantity of publications has been dedicated to these complications (*e.g.* Hillman 1981; 1984;

Boardman and Jones 1990; Van der Veen 2007). A notorious problem is the rarity of cereal chaff remains in carbonised plant assemblages (Hillman 1981, 140). The presence of chaff is indicative of cereal cleaning activities and may be used to distinguish production and consumption sites, but the only components that are likely to survive in charred form are the small, dense items able to drop quickly through the flames and into the ashes without being burned themselves. Light chaff remains such as straw and rachis fragments are the first components to be lost. In order to overcome these biases, this study will integrate archaeobotanical and archaeozoological studies with information from archaeological excavations, field surveys and ancient written sources.

Results

*The Archaic/Classical periods (*c. *600–325 BC)*

The archaeobotanical samples from this period are presented in Table 1 (at the end of this paper). Some basic information about the nature of the sites and sampling methods is also included. The samples were collected at five archaeological sites, namely l'Amastuola, Botromagno, Monte Papalucio, Roccagloriosa and Pizzica Pantanello (Lentjes 2011; Colledge 2000; Ciaraldi 1997; Bökönyi *et al.* 1993; Costantini 2001; Carter *et al.* 1985). It must be emphasised that material culture at these sites displays both indigenous and Greek colonial elements, with the exception of Botromagno, which is located inland, about 100 kilometres from the Greek colony of Taras and 70 kilometres from Metapontion. No Greek influence can be detected in the material culture at Botromagno until around 500 BC (Small 2000). Pizzica Pantanello, on the other hand, represents a clear case of a rural place of worship belonging to the Greek colonial world, located in the agricultural territory (*chora*) of Metapontion.

The published research data did not in all cases include the exact number of archaeobotanical remains from each site, which is why only presence/absence of species is included in Table 1 (and Table 3). Fortunately, since systematic soil sampling was conducted at most of these sites, the archaeobotanical data probably reflect the general picture of available species in the period of habitation. The data from the early excavations at Monte Papalucio form a possible exception, since only a few soil samples were collected during this phase. However, the abundance of archaeobotanical remains from the later excavations largely overrides this problem. Botromagno is the only site where no systematic soil sampling was conducted, but the excavators did make sure that the samples were retrieved from a representative range of contexts, including occupation deposits, pot burials, postholes, construction layers and tomb fills (Colledge 2000).

Among the arable crops from these sites are cereals such as barley and different types of wheat (free-threshing, club, emmer, einkorn, spelt), pulses including chick pea, vetchling, lentil, field pea, broad bean and bitter vetch, a few fruits (fig, crab apple, date, pomegranate and grape) and possible forage crops (oat and medick) (scientific names can be found in Tables 1 and 3). The wild plant assemblage consists for the most part of arable weeds and other indicators of cultivated grounds. The samples from Pizzica Pantanello, which is located near a spring basin, also included plant species belonging to wetlands. Palynological data from Southeast Italy are scarce; the pollen core from the waterlogged environment at Pantanello is almost unique for this region (Carter *et al.* 1985). In the late 6th and early 5th century BC, the Pantanello pollen spectrum shows cereal and olive pollen, but a significant increase of grazing indicators such as knapweeds (*Centaurea*) and plantain (*Plantago*) can also be observed.

The archaeozoological samples from this period are presented in Table 2. Only domesticated animals are included in the two tables with archaeozoological data (Tables 2 and 4). The samples were retrieved from three sites: Valesio, Cavallino and Pizzica Pantanello (Zeiler 1996; Sorrentino 1979; Bökönyi 2010). The number of animal bones that was retrieved at these sites varies considerably; for example, Bökönyi (2010, 7) studied over 1,000 bone fragments from the Pantanello sanctuary, whereas only 22 bones were collected from a refuse dump that is referred to as the 'Greek pit'. All these contexts were in use between the 6th and 3rd centuries BC. The archaeozoological assemblage from the sanctuary is dominated by cattle (53 %), followed by sheep/goat, horse and pig. In the necropolis and the 'Greek pit', the animal remains included a much smaller number of cattle bones. The samples from the two other Archaic/Classical sites where archaeozoological samples were collected, Valesio and Cavallino, consisted of 400 and 697 bone fragments, respectively. At Cavallino, cattle bones were the most numerous ones (42 %), followed by sheep/goat (39 %) and pig (19 %). At Valesio, sheep/goat was the best represented species (45 %), with almost equal parts of cattle (26 %) and pig (22 %).

site	Valesio 1	Cavallino	Pizzica Pantanello 1	Pizzica Pantanello 2	Pizzica Pantanello 3	
reference	Zeiler 1996	Sorrentino 1979	Bökönyi 2010	Bökönyi 2010	Bökönyi 2010	
context	settlement	settlement	sanctuary	necropolis	refuse deposit	
date	6th-5th centuries BC	8th-5th centuries BC	6th-3rd centuries BC			
domesticated animals	%	%	%	%	n	common name
Bos taurus	26 %	42 %	53 %	4 %	3	cattle
Ovis/Capra	45 %	39 %	23 %	33 %	9	sheep/goat
Sus scrofa dom.	22 %	19 %	6 %	1 %	9	pig
Equus caballus			14 %	49 %		horse
Equus asinus			1 %	13 %	1	ass
Canis familiaris	2 %		3 %			dog
n=	400	697	1,029	308	22	

Table 2. Archaeozoological remains from southeast Italy, Archaic/Classical periods.

With regard to the survey and excavation data, it can be concluded that differences between the coastal and inland regions of Southeast Italy were quite clear in this period. In the coastal areas, the Greek settlements of Metapontion, Siris, Sybaris and Taras grew considerably and acquired some distinct urban features (Yntema 2000, 14). Survey data from the agricultural territory of Metapontion indicate that this urban development was accompanied by a reorganisation of the surrounding countryside. In the course of the 6th and 5th centuries BC, the territory or *chora* of Metapontion became littered with farmsteads, small rural necropoleis and sanctuaries (Carter 2006; De Siena 2001). A system of ditches or canals was made in order to divide the *chora* into regular plots. Indeed, the apparent prosperity of the colonial towns in this period can possibly be explained by the flourishing export of agricultural produce, including wine and olive oil. Part of the surplus was exported in so-called Corinthian B amphorae (Sourisseau 2011). Such transport vessels were made in several production centres along the Southern Italian coast, including Sybaris, Taras and Metapontion. The few contemporary written records that deal specifically with land use and the consumption and production of food in colonial Greek Southeast Italy confirm this picture of a thriving agricultural economy. Especially the famous vineyards of Sybaris are frequently mentioned, for instance by the Greek historian Timaeus of Tauromenium (modern Taormina) in Sicily (*c.* 345–250 BC) (Zancani Montuoro 1982, 559). The Sybarites were said to be extremely wealthy, their lifestyle being synonymous with pleasure and luxury. Information about wine production in other colonial Greek contexts is sparse.

No such literary references exist for the indigenous areas. On the basis of survey and excavation data, however, it can be concluded that the processes of rural infill and land divisions only took place around the colonial Greek towns. Some innovations, such as the replacement of oval huts by rectangular houses with a stone foundation, can be found in the inland settlements (D'Andria 1996, 412; Yntema 1993, 169; in press, 120; Attema *et al.* 2010, 135-140). However, these indigenous centres differed considerably from the Greek settlements on the coast in terms of scale and spatial organisation. Differences are also apparent in the organisation of the countryside, which remained void of rural habitation (Yntema 1993, 174-176; in press, 121; Attema *et al.* 2010, 137).

The Early Hellenistic Period (325–200 BC)

The archaeobotanical samples from this period are presented in Table 3. The samples were collected at Monte Papalucio, Vaste, Roccagloriosa, Pomarico Vecchio, Pizzica Pantanello and Muro Tenente (Ciaraldi 1997; Solinas 2008; Bökönyi *et al.* 1993; Costantini 2001; Caramiello and Siniscalco 1997; Carter *et al.* 1985; Lentjes 2010). With regard to the representativeness of the samples, it should be noted that systematic soil sampling was conducted at all of these sites except for Vaste and Pomarico Vecchio. At the former site, a few samples were collected from the bottom of a pit that may have been used for ritual depositions (Solinas 2008). At Pomarico Vecchio, archaeobotanical macroremains were retrieved from one single context, a closed amphora datable between the late 4th and early 3rd century BC. The research at this site also included pollen coring (Caramiello and Siniscalco

1997), but these cores cover a relatively short chronological range (between the 4th and 3rd centuries BC), meaning that they cannot be used to study chronological changes in the crop spectrum.

Few differences can be noted in the crop spectrum in comparison to the Archaic/Classical periods, although olives and grapes seem to appear slightly more frequently in the samples from the Early Hellenistic Period. The presence of naked barley at Early Hellenistic Muro Tenente is a surprise, since according to Hopf (1991, 247), *Hordeum vulgare* var. *nudum* had disappeared from Italy after the Middle Neolithic Period.

In the Pantanello core, the grazing indicators decline from the middle of the 4th century BC onwards. Instead, *macchia* species such as *Pistacia* and *Phillyrea* appear, and olive, cereals and legumes peak. The pollen cores from Pomarico Vecchio shows indicators of grazing in the Early Hellenistic period (notably plantain (*Plantago*) and the teasel family (Dipsacaceae)), but there are also signs of agricultural activity in the form of cereals, pulses and the carrot (Umbelliferae) and lily (Liliaceae) families, and fruit trees, including *Prunus* sp., *Vitis* sp. and *Olea* sp. (Caramiello and Siniscalco 1997, 256-257).

The archaeozoological samples from this period are presented in Table 4. The samples were collected at four sites: Valesio, Vaste, Roccagloriosa and Monte Irsi (Zeiler 1996; Albarella 1995; Bökönyi *et al.* 1993; Barker 1977). The differences between these samples is considerable, with regard to their contents, but also to their size. The samples from Vaste and Monte Irsi are relatively small (147 and 113 bone fragments, respectively), while comparatively large samples were retrieved from Early Hellenistic Valesio (910 fragments) and Roccagloriosa (1,763). Sheep/goats tend to dominate most of the samples in this period, followed by pigs (29 %, 16 % and 23 % at Valesio, Roccagloriosa and Monte Irsi, respectively) and/or cattle

site	Valesio 2	Vaste	Roccagloriosa	Monte Irsi	
reference	Zeiler 1996	Albarella 1995	Bökönyi *et al.* 1993	Barker 1977	
context	settlement	settlement	settlement	settlement	
date	4th-3rd century BC	mid 3rd century BC	4th-3rd century BC	4th-3rd century BC	
domesticated animals					
Bos taurus	15 %	1 %	35 %	27 %	cattle
Ovis/Capra	43 %	1 %	45 %	46 %	sheep/goat
Sus scrofa dom.	29 %	98 %	16 %	23 %	pig
Equus caballus			1 %	4 %	horse
Equus asinus			1 %		ass
Canis familiaris	1 %		1 %		dog
Gallus domesticus	1 %		1 %		chicken
n=	910	147	1,763	113	

Table 4. Archaeozoological remains from Southeast Italy, Early Hellenistic Period.

(15 %, 35 %, 27 %) At Vaste, the animal remains consisted almost exclusively (98 %) of pig bones.

The survey and excavation data from the Early Hellenistic period indicate that this was a period of notable change, especially in the inland areas. Two general, and probably interconnected, trends can be discerned, namely a process of rural infill and of urban expansion. Surveys in the Brindisino (Burgers 1998, 255; Yntema 1993, 186), the Murge hills (Attema *et al.* 2010, 149), the Tarantino (Crielaard and Burgers 2012, 97) and the Sibaritide (Attema *et al.* 2010, 149) have attested the appearance of rural settlements, rural burial sites, and isolated farmsteads in the countryside outside the larger centres in this period. Even in marginal areas with less fertile soils, rural settlements came into existence. This indicates that the rural infill reached a point where even infertile soils were taken into cultivation (Burgers 1998, 255; Yntema 1993, 186). Most of the rural settlements, however, were located near good arable soils, indicating that agriculture rather than stock-raising was the prime economic activity.

In addition to a major increase in rural settlements, the Early Hellenistic period in Southeast Italy is also characterised by a regional trend toward urban expansion. Some of the indigenous settlements acquired increasingly urban features, such as public buildings and orthogonal street plans, which are found, for instance, at Pomarico Vecchio (Barra Bagnasco 1997, 12). It has been argued that some of the larger indigenous settlements may have functioned as tribal centres in this period (D'Andria 1991a, 447). Such centres fulfilled urban functions for a larger rural area, such as producing craft products, and offering facilities for the processing, storage and exchange of agricultural products, including wine and olive oil. Brun (2004, 167-168) lists several examples of olive oil and/or wine presses that were found *in situ* at indigenous rural sites, among which the farmstead of Montegiordano in Calabria. At this site, a press installation and two pithoi were found that were probably in use between 350 and 275 BC. This is also the period when the production of locally made Graeco-Italic amphorae took off (Vandermersch 1994). These two developments are likely to be related, with local production of wine and olive oil going hand in hand with the local manufacturing of transport vessels to export these products in.

If we are to follow descriptions in ancient written sources, the settlement dynamics in native Southeast Italy were accompanied by a period of even greater prosperity in the colonial towns on the coast. Taras in particular had become very wealthy and powerful in this period (De Juliis 1988, 15). There is also evidence of grape and olive cultivation in the territory of one of the colonial towns, Herakleia, from the so-called Herakleia tablets, which date between 350 and 300 BC (Uguzzoni and Ghinatti 1968). The writings on these two bronze plaques address a new division of two land plots that were sacred to Athena and Dionysos, and describe in some detail what these lands looked like and which crops were cultivated. The tablets make it clear that grapes and olives were the most profitable crops in the area, but also refer to other considerably advanced agricultural practices, such as the use of irrigation systems. They also mention that the Greek city had trade contacts with indigenous people who lived in the inland areas, and acquired (goat) dairy products and wool from them (Uguzzoni and Ghinatti 1968, 118). There are very few literary references to inland Southeast Italy in this period, but the vineyards and olive groves in this area are frequently mentioned by Roman authors from the 2nd century BC onwards (Hitchner 1993, 500; Burgers 1998, 257).

Discussion

*The Archaic/Classical periods (*c. *600–325 BC)*

With regard to the research questions that were raised at the beginning of this paper, the first issue that needs to be addressed is which differences can be witnessed between the coastal regions, where the Greek settlements of Metapontion, Siris, Sybaris and Taras were located, and the 'indigenous' inland areas. The survey and excavation data show that in this period, one or two centuries after Greeks had settled on the coast of Southeast Italy, the colonial towns and their agricultural territories flourished greatly. As we have seen, this phenomenon is studied especially well in the *chora* of Metapontion, but ancient written sources also mention the wealth and prosperity of some of the other colonial towns. For example, Sybaris, with its famous vineyards, was known as one of the richest cities in the Archaic Greek world. Meanwhile, land use in the contemporary inland areas was not nearly as large in scale and strictly organised as in the Greek *chorai* on the coast. In fact, the countryside around the inland centres remained uninhabited. Based on this distinction, it can be hypothesised that inland farmers were generally not involved in market-oriented surplus production (Lentjes 2013).

Does the archaeobotanical and archaeozoological evidence support this hypothesis? At first glance, the apparent contrast between the Greek colonial territories and their indigenous counterparts is not directly reflected in these data. No clear differences appear in the crop spectra from the coastal and inland areas, which are both dominated by cereals. Additional evidence of arable cultivation can be found in the weed finds, which include Adonis (*Adonis*), oat (*Avena*), sandwort (*Arenaria*), corn gromwell (*Buglossoides arvensis*), ryegrass (*Lolium perenne*), darnel (*Lolium temulentum*) and sow thistle (*Sonchus*). There are no clear differences to be noted in the livestock composition either. No clear pattern can be discerned in the archaeozoological assemblage from the Archaic/Classical periods, with sheep/goat dominating the sample from Valesio, almost equal percentages of cattle and sheep/goat at Cavallino, mostly cattle in the sample from the Pantanello sanctuary, horse in the Pantanello necropolis, and sheep and pig in the sample from the refuse pit at Pantanello.

The only difference between land use in the colonial Greek territories and the inland areas, then, appears to be the role of arboriculture. Olive stones and grape pips are relatively rare in samples from inland sites, appearing in the samples from Cavallino, l'Amastuola and Monte Papalucio only in very small quantities (Table 5). The grape and olive finds from Archaic/Classical l'Amastuola, for example, consist of one single grape pip and nine olive stone fragments, which were all found in one single context (a cooking pot, cf. Lentjes 2011, 97; Fig. 2).

Figure 2. L'Amastuola, Southeast Italy: olive stone fragments from cooking pot (5th century BC).

period	**Archaic/Classical Periods**			
site	Pizzica Pantanello	l'Amastuola	Botromagno	Roccagloriosa
reference	Carter *et al.* 1985	Lentjes 2011	Colledge 2000	Bökönyi *et al.* 1993
context	refuse deposit?	settlement	settlement	settlement
total number of analysed seeds and fruits from this site	?	3,039	463	4
olive	'abundant (xxx)'	9	0	0
grape	'abundant (xxx)'	3	0	3

period	**Early Hellenistic Period**				
site	Vaste, Piazza Dante	Roccagloriosa	Pomarico vecchio	Pizzica Pantanello	Muro Tenente
reference	Solinas 2008	Bökönyi *et al.* 1993	Caramiello and Siniscalco 1997	Carter *et al.* 1985	Lentjes 2010
total number of analysed seeds and fruits from this site	294	431	348	?	5,628
olive	86	9	0	'numerous (xx)/present (x)'	32
grape	6	195	2	'numerous (xx)/present (x)'	5,255

Table 5. Grape and olive remains from Southeast Italy, Archaic/Classical and Early Hellenistic Periods.

In contrast, it appears that most of the Greek colonial towns were involved in wine and olive oil production in the Archaic Period, and also produced transport vessels to export their surpluses to overseas markets. The evidence for this not only consists of archaeobotanical data (waterlogged grapes and olives in the Pantanello sanctuary; grape and olive pollen in the Pantanello pollen core) but also of archaeological finds (the distribution of transport amphorae) and references in ancient written sources (for example to the vineyards of Sybaris). Large-scale (*i.e.* archaeologically visible) olei- and viticulture is a risky business that requires stable settlements and settled conditions. It can be profitable enough to face this risk if the fruits are converted into storable commodities (*i.e.* wine and olive oil), and sold on a market (Renfrew 1972, 280). But whereas the Greek colonial towns were actively involved in external exchanges, there is no archaeological evidence that such a market existed in the inland areas. It is no surprise, then, that viti- and oleiculture was still in its infancy in the inland areas in this period.

In short, integrating the archaeobotanical and archaeozoological evidence with archaeological data and information from written sources, it can be inferred that the colonial settlements on the coast were involved in surplus production, notably of wine and olive oil. Meanwhile, the inland settlements continued to concentrate on subsistence agriculture. The crop spectra in the inland and coastal areas are remarkably similar, but there are clear differences in the scale and organisation of agricultural production.

*The Early Hellenistic Period (*c. *325–200 BC)*

There can be no doubt that the above-mentioned changes (rural infill, urbanisation) that took place between the end of the 4th and the beginning of the 3rd century BC had far-reaching consequences for the scale, diversity and organisation of agricultural production in the inland areas. The question remains whether these changes are mirrored in the archaeobotanical and archaeozoological assemblages. The crop spectra of Greek colonies and indigenous settlements still appear to be fairly similar for the period under discussion. For instance, the samples from Pantanello and Roccagloriosa (a fortified centre in inland Lucania with only weak links with the Greek colonial world) both contained hulled barley, club wheat and emmer wheat. The fruit assemblage from Roccagloriosa and Pantanello is much the same, and consists of figs, olives and grapes; chick peas and bitter vetches were found at Pantanello, vetchling at Roccagloriosa. Legumes are altogether rare at sites in Southeast Italy but the waterlogged assemblage from Pantanello show a larger variety of pulses in comparison to most other sites. It is remarkable that chick peas and the genus *Pisum* (pea) only occur in the Archaic Period, but this in itself should not be taken to indicate that they were introduced by Greek colonists, since the earliest finds of both chick peas and peas are from native sites (Monte Irsi and Cavallino).

Some distinct changes, however, can be noted in the archaeobotanical and archaeozoological data in comparison to the Archaic/Classical periods. Most prominently, olive and grape remains abound in all the archaeological sites from Southeast Italy with habitation levels from the Early Hellenistic Period (Table

5). The only exception to this trend is Pomarico Vecchio, where the sample was particularly small and consisted of the contents of an amphora, which contained a few grape pips, but no olive stones. The pollen cores from this site, however, clearly point to viticulture and oleiculture (Caramiello and Siniscalco 1997, 255-256). These finds tie in well with the archaeological evidence (finds of olive oil and/or wine presses in indigenous inland areas; production of local transport amphorae (Fig. 3)) and information from ancient written sources, which both show that wine and olive oil were produced and traded on a large scale in the late 4th and 3rd centuries BC, both in the indigenous and colonial Greek towns. Indeed, evidence of grapes and olive cultivation also continues to abound in the samples from the sanctuary of Pantanello. Apart from the macroremains, the Early Hellenistic layers also contained waterlogged olive and grape wood. Some of these branches show pruning cuts, clearly indicating that they belonged to cultivated olive trees and vines. Furthermore, the olive pollen from Pantanello peak around the middle of the 4th century BC (Carter *et al.* 1985).

Veenman (2002, 84-86) has argued that many of the indigenous centres also started to engage in their own form of livestock specialisation in the Early Hellenistic Period. Uguzzoni and Ghinatti (1968, 118) have drawn similar conclusions on the basis of the Herakleia tablets, which mention the export of dairy and wool from inland Basilicata. It is clear that more archaeozoological data are needed to convincingly support this hypothesis. For instance, the striking dominance of pig

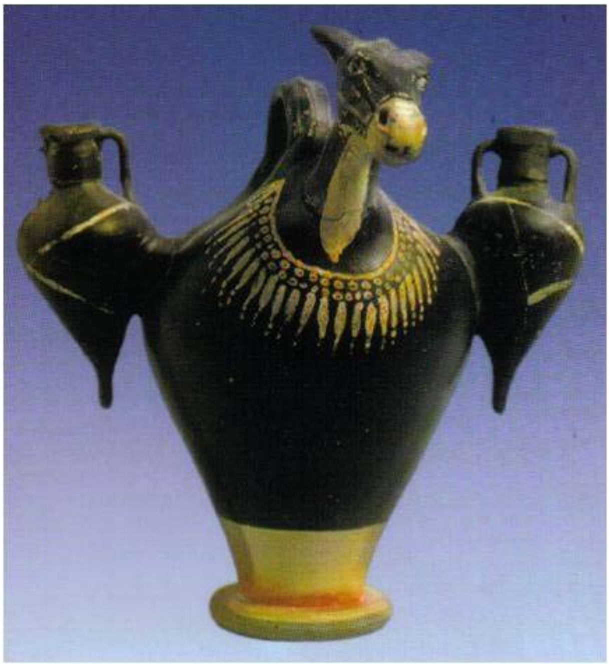

Figure 3. Apulian 'Gnathia-style' askos *(small pouring vessel) in the form of a mule carrying two transport amphorae,* c. *280-240 BC (Museo Archeologico di Bari).*

bones at Early Hellenistic Vaste (Albarella 1995, 289-290) may be interpreted as an indication of livestock specialisation, but the archaeozoological sample from this site is too small to be completely reliable.

Conclusions

When Greeks settled along the coast of Southern Italy, they were faced with an indigenous population that operated mixed farming systems, combining small-scale arable cultivation and sheep/goat herding. Such a system of land use is characteristic of farmers with limited involvement in the market, who seek to secure subsistence and reduce the risk of crop failure. Indeed, it appears that riskier businesses such as the large-scale cultivation of olives and grapes were largely avoided by indigenous farmers. In contrast, a few generations after the establishment of Greek colonial towns in Southeast Italy, agricultural production was thriving on a considerable scale in these parts. Not only did the Greek towns acquire some distinct urban features, they also had well-organised agricultural territories that produced surplus for a market.

This contrast between the inland and coastal areas largely vanished in the Early Hellenistic Period, when the former underwent a major transformation. The infill of rural areas created better opportunities for the transport of agricultural products, facilitating their way to reach a market (Yntema 1993, 194). The economic prosperity that characterises Southeast Italy in this period (Attema *et al.* 1998, 355; Yntema 1993, 186) may be indicative of this development. The larger inland settlements and the colonial coastal towns possibly performed 'urban' functions for a larger rural area, for example operating as distribution centres and markets for the (overseas) exchange of agricultural products. This may be the main reason why large-scale olive oil and wine production really took off in the inland areas in the late 4th and 3rd centuries BC. Indeed, it appears that a complementary economic system started to emerge in this period, with individual towns or areas specialising in specific products that were sold on regional or more distant markets. The focus of the rural economy shifted from subsistence- to market-oriented, paving the way for large-scale land exploitation after the Roman conquest (Yntema 2006).

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site	l'Amastuola	Botromagno 1	Monte Papalucio 1	
reference	Lentjes 2011	Colledge 2000	Ciaraldi 1997	
conservation of macroremains	carbonised	carbonised	carbonised	
sampling method	systematic	random	random (early excavations); systematic (recent excavations)	
sieving method	flotation: 5 and 1 mm meshes	flotation: 1.18 mm and 300 µm meshes	dry sieving: 2 mm meshes (early excavations); flotation: 0.2 mm meshes (recent excavations)	
context	settlement	settlement	sanctuary	
date	early 6th–first half 5th century BC	600–400 BC	mid 6th–early 5th century BC	
cultivated plants				
cereals				common name
Hordeum vulgare	*	*	*	hulled barley
Hordeum sp.	*			barley
Triticum aestivum/compactum	*	*	*	free-threshing wheat
Triticum aestivum/durum			*	bread/ macaroni wheat
Triticum dicoccum	*		*	emmer wheat
T. monococcum/dicoccum		*	*	einkorn/ emmer wheat
Triticum cf. *spelta*			*	spelt wheat
Triticum sp.		*		wheat
pulses				
Cicer arietinum			*	chick pea
Lens culinaris	*			lentil
Pisum sativum			*	field pea
Vicia faba var. *minor*	*		*	broad bean
Vicia ervilia	*			bitter vetch
Vicia/Lathyrus			*	vetch/vetchling
Vicia sp.	*			vetch
fruits				
Ficus carica			*	fig
Malus cf. *sylvestris*			*	crab apple
Olea europaea	*		*	olive
cf. *Phoenix dactylifera*			*	date
Punica granatum			*	pomegranate
Vitis vinifera	*		*	grape
forage crops				
Avena	*			oat
Medicago	*			medick

Table 1. Archaeobotanical remains from Southeast Italy, Archaic/Classical Periods; part one.

site	l'Amastuola	Botromagno 1	Monte Papalucio 1	
wild plants				
weeds in arable fields				
Adonis sp./ cf. *annua*	*			(autumn) adonis
Avena sp.	*			oat
Lolium cf. perenne/rigidum		*		ryegrass
uncultivated or abandoned zones				
Rumex sp.	*	*		sorrel
cultivated ground, waste places, waysides				
Heliotropium sp.	*			heliotrope
Medicago hispida	*			bur medick
wetlands				
Scirpus sp.		*		bulrush
Mediterranean *macchia*				
Pistacia lentiscus	*			mastic
possible forage crops				
Bromus sp.	*			brome
Phalaris sp.		*		canarygrass
other				
Chenopodium sp.		*		goosefoot
Euphorbiaceae	*			

Table 1, part one (continued).

Table 1. Archaeobotanical remains from Southeast Italy, Archaic/Classical Periods; part two.

site	**Roccagloriosa**	**Botromagno 2**	**Pizzica Pantanello 1**	
reference	Bökönyi *et al.* 1993	Colledge 2000	Carter *et al*. 1985	
conservation of macroremains	carbonised	carbonised	waterlogged	
sampling method	systematic	random	systematic	
sieving method	wet sieving: mesh width unknown	flotation: 1.18 mm and 300 µm meshes	flotation: 4, 2, 1 and 0.5 mm meshes	
context	settlement	settlement	refuse deposit?	
date	6th–5th centuries BC	400–300 BC	4th century BC	
cultivated plants				
cereals				common name
Hordeum vulgare		*	*	hulled barley
Triticum aestivum/compactum		*		free-threshing wheat
Triticum compactum			*	club wheat
Triticum dicoccum			*	emmer wheat
T. monococcum/dicoccum		*		einkorn/ emmer wheat
Triticum monococcum		*		einkorn
Triticum sp.	*	*		wheat
pulses				
Pisum sativum			*	field pea
fruits				
Ficus carica			*	fig
Olea europaea			*	olive
Vitis vinifera	*		*	grape
wild plants				
weeds in arable fields				
Arenaria sp.		*		sandwort
Buglossoides arvensis		*		corn gromwell
Lolium cf. *perenne/rigidum*		*		ryegrass
Lolium temulentum			*	darnel
Sonchus sp.			*	sow thistle
uncultivated or abandoned zones				
Euphorbia helioscopia			*	sun spurge
cultivated ground, waste places, waysides				
Carex sp.			*	sedge
Ceratophyllium demersum			*	loosestrife
Scirpus sp.		*		bulrush
Zannichellia sp.			*	horned pond weed

site	Roccagloriosa	Botromagno 2	Pizzica Pantanello 1	
possible forage crops				
Phalaris sp.		*		canarygrass
other				
Chenopodium sp.		*		goosefoot
Liliaceae (small seeded)		*		
Ranunculus sp.			*	buttercup family
Rubus sp.			*	blackberry

Table 1, part two (continued).

Table 3. Archaeobotanical remains from Southeast Italy, Early Hellenistic Period, part one.

site	**Monte Papalucio 2**	**Vaste, Piazza Dante**	**Roccagloriosa**	**Pomarico vecchio**	
reference	Ciaraldi 1997	Solinas 2008	Bökönyi *et al.* 1993	Caramiello and Siniscalco 1997	
conservation of macroremains	carbonised	carbonised	carbonised	carbonised	
sampling method	random (early); systematic (recent)	100 %	systematic	100 %	
sieving method	dry sieving: 2 mm meshes (early)	flotation: 4 and 0.5 mm meshes	wet sieving: mesh width unknown	flotation: mesh width unknown	
context	sanctuary	sanctuary	settlement	settlement	
date	2nd half 4th–1st half 3rd century BC	4th–3rd century BC	4th–3rd century BC	4th–3rd century BC	
cultivated plants					
cereals					common name
Hordeum vulgare	*		*	*	hulled barley
Hordeum sp.		*	*		barley
Triticum aestivum/compactum	*			*	free-threshing wheat
Triticum aestivum/durum	*	*			bread/ macaroni wheat
Triticum compactum			*		club wheat
Triticum dicoccum		*	*		emmer wheat
Triticum monococcum/dicoccum	*				einkorn/ emmer wheat
Triticum monococcum		*	*		einkorn
Triticum sp.		*	*		wheat
Panicum sp.			*		millet
pulses					
Cicer arietinum	*				chick pea
Lathyrus sp.			*		vetchling
Lens culinaris		*	*		lentil
Pisum sativum	*				field pea

Table 3, part one (continued).

site	Monte Papalucio 2	Vaste, Piazza Dante	Roccagloriosa	Pomarico vecchio	
cf. *Pisum* sp.			*		pea
Vicia faba var. *minor*	*		*		broad bean
Vicia ervilia		*			bitter vetch
Vicia/Lathyrus	*				vetch/vetchling
Vicia sp.		*			vetch
fruits					
Ficus carica	*		*		fig
Malus cf. *sylvestris*	*				crab apple
Olea europaea	*	*	*		olive
Punica granatum	*	*			pomegranate
Vitis vinifera	*	*	*	*	grape
forage crops					
Avena sp.		*			oat
Medicago sp.		*			medick
Secale cereale		*			rye
wild plants					
weeds in arable fields					
Adonis sp./ cf. *annua*				*	(autumn) adonis
Avena sp.		*	*		oat
Galium aparine			*		stickyweed
Lathyrus sativus/cicera			*		grass/red pea
Polygonum sp.			*	*	knotweed
Umbelliferae				*	carrot family

Table 3, part one (continued).

site	Monte Papalucio 2	Vaste, Piazza Dante	Roccagloriosa	Pomarico vecchio	
dry, stony grounds					
Echium sp.				*	bugloss
Lathyrus aphaca			*		yellow vetch
uncultivated or abandoned zones					
Euphorbia helioscopia			*		sun spurge
Fumaria sp.				*	fumitory
Malva sp.				*	mallow
cultivated ground, waste places, waysides					
Chenopodium album			*		white goosefoot
possible forage crops					
Bromus sp.		*			brome
other					
Bifora sp.				*	bifora
Chenopodium sp.				*	goosefoot
Veronica sp.				*	speedwell

Table 3. Archaeobotanical remains from Southeast Italy, Early Hellenistic Period, part two.

site	Pizzica Pantanello 2	Pizzica Pantanello 3	Muro Tenente	
reference	Carter *et al.* 1985	Carter *et al.* 1985	Lentjes 2010	
conservation of macroremains	waterlogged	waterlogged	carbonised	
sampling method	systematic	systematic	systematic	
sieving method	flotation: 4, 2, 1 and 0.5 mm meshes	flotation: 4, 2, 1 and 0.5 mm meshes	flotation: 5 and 1 mm meshes	
context	refuse deposit?	refuse deposit?	settlement	
date	early 3rd century BC	late 3rd century BC	4th–2nd century BC	
cultivated plants				
cereals				common name
Hordeum vulgare	*	*	*	hulled barley
Hordeum sp.			*	barley
Hordeum vulgare var. *nudum*			*	naked barley
Triticum aestivum/compactum			*	free-threshing wheat
Triticum compactum	*	*		club wheat
Triticum dicoccum		*	*	emmer wheat
pulses				
Cicer arietinum		*		chick pea
Lens culinaris		*		lentil
Pisum sativum		*		field pea
Vicia faba var. *minor*	*	*	*	broad bean
Vicia ervilia		*	*	bitter vetch
Vicia sp.			*	vetch

Table 3, part two (continued).

site	**Pizzica Pantanello 2**	**Pizzica Pantanello 3**	**Muro Tenente**	
fruits				
Ficus carica	*	*		fig
Olea europaea	*	*	*	olive
Vitis vinifera	*	*	*	grape
Rosaceae			*	
forage crops				
Avena sp.		*	*	oat
Medicago sp.	*	*		medick
Secale cereale			*	rye
wild plants				
weeds in arable fields				
Avena sp.		*	*	oat
Lathyrus sp.	*	*		vetchling
Lolium temulentum	*	*		darnel
Polygonum sp.	*	*		knotweed
Secale cereale			*	rye
Sonchus sp.	*			sow thistle
uncultivated or abandoned zones				
Euphorbia helioscopia	*	*		sun spurge
wetlands				
Carex sp.	*			sedge
Ceratophyllium demersum	*			coontail
Zannichellia sp.	*			horned pond weed
Mediterranean *macchia*				

Table 3, part two (continued).

site	**Pizzica Pantanello 2**	**Pizzica Pantanello 3**	**Muro Tenente**	
Pistacia lentiscus			*	mastic
possible forage crops				
Medicago sp.	*	*		medick
other				
Galium sp.	*	*		bedstraw
Rubus sp.	*	*		blackberry

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Three systems of agrarian exploitation in the Valencian region of Spain (400-300 BC)

Mª Pilar Iborra Eres[1] and Guillem Pérez Jordà[2]

1. PhD Archaeology IVC+R Archaeology and Paleontology
C/ Pintor Genaro Lahuerta, 25, 3 Planta, 46010
Valencia
Spain
HAR2009-13791 Ministerio de Ciencia e Innovación
mpiborraeres@gmail.es

2. GI. Bioarcheology. CCHS. CSIC. Madrid
C/ Albasanz 26-28, 28037
Madrid
Spain
guillem.perez@uv.es

Abstract

During the Iberian Culture, the introduction of new technologies and new species brought about a change in the model of territorial use to one based on the exploitation of ploughed land. The study of seeds, fruits and faunal remains reveals different agrarian production models in the analysed area.

Keywords: *agriculture, livestock, food production, subsistence, surplus production*

Introduction

The peoples who resided on the western strip of the Iberian Peninsula, from Andalusia to Languedoc, during the period 600-100 BC are known as Iberians. The term *Iberian Culture*, which is essentially archaeological, is used to define the set of peoples who inhabited this territory following the arrival of and contact with Phoenician and Greek colonists. This contact with colonial people is reflected by the presence of large foundation cities, small cities inside the indigenous hinterland or only a commercial establishment, but even then this interaction was crucial for the development of all the *Iberian* societies.

Iberian society during this period was highly urbanised and socially stratified, and it was characterised by the development of writing, wheel-thrown pottery and iron metallurgy. From an economic perspective, society was still predominantly

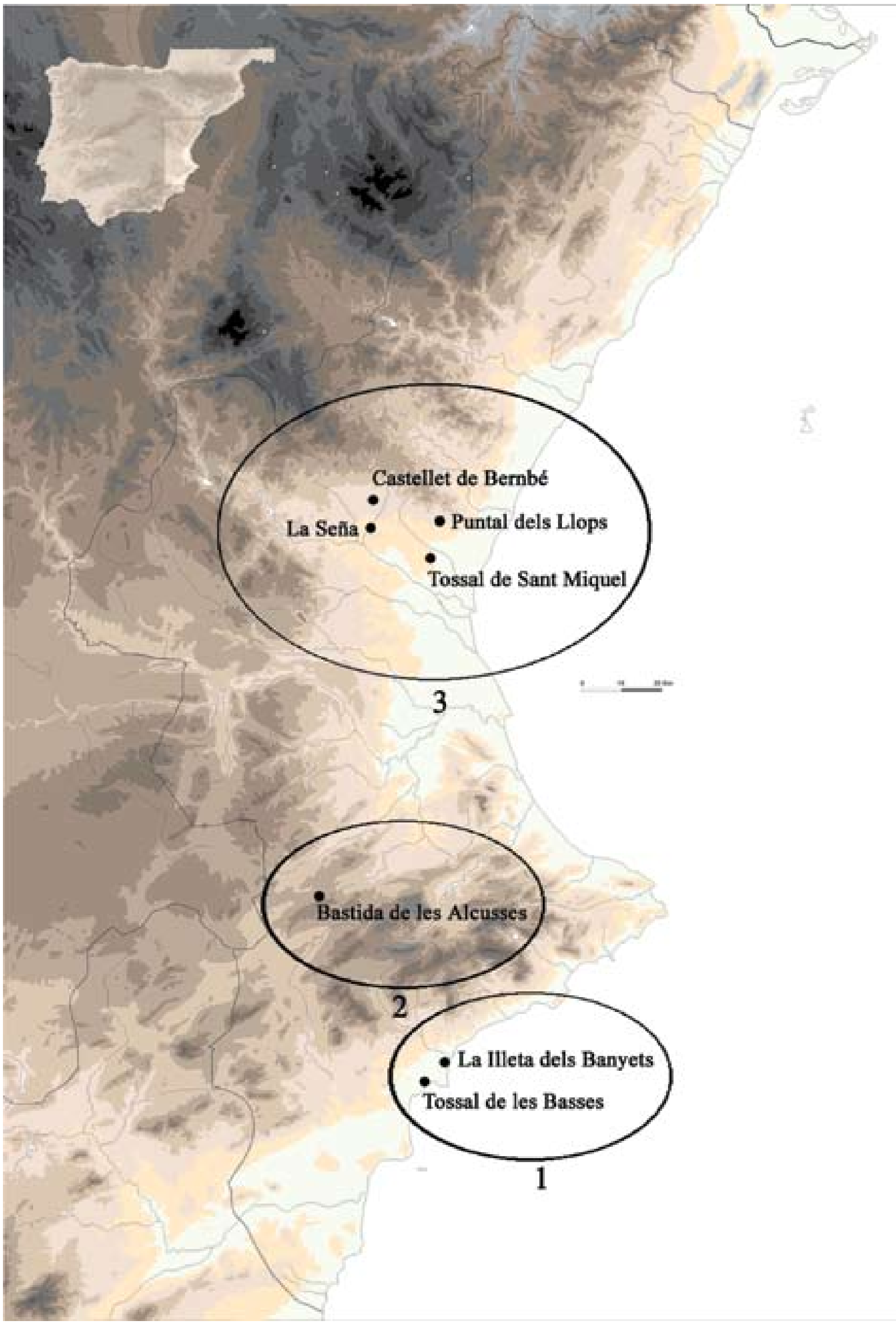

Figure 1. Map showing the location of Iberian sites in the region of Valencia (Iborra and Perez 2009).

agrarian, with agriculture and livestock husbandry constituting the basis for subsistence, although at the same time, there was also some integration in the Meditteranean trade routes. Indeed, some of the agrarian products, along with other goods proceeding from activities such as metallurgy, were among the primary elements that different groups used to participate in these networks. From a political point of view, this world was neither homogeneous nor united, but rather structured into different territories. These territories were characterised by a significant and complex hierarchical settlement pattern with a functional specialisation that was related to the protection and exploitation of resources and the storage and distribution of the surplus. The principal nucleus was the *oppidum* as capital of political areas, a large site of around 10-15 hectares. The other settlements were small, and depending on size are categorised as small towns, hamlets, farmsteads, hillforts and military establishments. Also in the territory we can find ritual sites and necropoleis (Ruiz and Molinos 1998; Sanmarti 2009).

This paper will analyse a series of Iberian territories located in the present-day region of Valencia, from the mouth of the Segura River to the Palancia River during the end of the 5th and beginning of the 3rd century BC (Fig. 1). As is the case with its peoples, the land is not uniform; it has different territorial units with diverse socioeconomic realities (Mata and Bonet 2001).

The models of land exploitation and occupation, along with the integration or lack thereof into the Mediteranean trade routes, reveal a complex reality. The analysis of archaeological remains and the transformation of agrarian products is fundamental to characterising systems of production, commercial orientation and the self-sufficient nature of different production processes.

Archaeobotanical and archaeozoological information from the 4th and 3rd century BC points to the consolidation of the agricultural system based on livestock and diversified agriculture, in which fruits have a distinct trade function. Agriculture and livestock husbandry are the two main economic activities in the territory of the Iberian Culture because they ensured food production for daily consumption. There were also goods used for exchange or trade, although the scale depended on the settlement location.

This study focuses on the analysis of plant and animal remains performed on- and off-site in several settlements. The results allow us to distinguish three types of settlements, conditioned not only by the features of landscape but also by the basis of subsistence and surplus production, *i.e.* coastal trade sites, inland farming sites and central sites with trading activities.

Coastal trade sites

Tossal de les Basses (Alacant) and Illeta dels Banyets (El Campello), located on the coastline, are both surrounded by freshwater ponds with areas of marsh and grassland. The area immediately surrounding the sites consists of a gentle coastline, a narrow stretch of flat land with a thermo-Mediterranean climate, and, to the northwest, diverse Subbaetic reliefs of considerable altitude that negatively influence travel towards the interior.

The chronological period of both sites is from the 5th century to the first half of the 3rd century BC. They are contemporary, and towards the beginning of the 3rd century gradually declined due to the consequences of the First Punic War. The sites are fortified, and the industrial zone and the trading port are situated beyond the city walls. Extensive archaeological investigation has shown remains with an extent of approximately 1.5 hectares for Tossal de les Basses, although the site has only partially been excavated. So far, the excavations have brought to light two enclosure walls, part of the *acropolis* surrounded by streets where the houses are located, an industrial zone with ceramic kilns, metallurgical furnaces, forges and a nearby trade port (Esquembre and Ortega 2008).

The same layout can be observed in the Illeta dels Banyets. This site has been identified as a port of trade. In the inhabited area (circa 6000 square metres) there are temples, a cistern, some winemaking installations and a storage building. The ceramic kilns are located outside the walls (Olcina *et al.* 2009).

To sum up, these settlements are small in extent and are situated on a documented major road network, joining the site, the industrial zone and the trading port. The sites are recognised as important trading centres (Olcina 2005; Rosser and Fuentes 2007; López 2000; Ortega *et al.* 2004).

The faunal and botanical remains were recovered from levels dated to the end of the 5th to the 4th century BC.

Faunal data

Faunal remains are dominated by domestic animals: 96 % in Tossal de les Basses and 86 % in the Illeta dels Banyets. The main species are sheep (*Ovis aries*) and goat (*Capra hircus*), followed by cattle (*Bos taurus*), pig (*Sus domesticus*), horse or donkey (*Equus caballus/Equus asinus*) and dog (*Canis familiaris*) (Fig. 2).

Bones of sheep were found in great quantities (on average 50-65 %) in both settlements. The evidence for the age at death shows the same mortality profile with a proportion of circa 15 % and 20 % infants (0-6 months) and young animals (9-12 months) and with the majority (60-65 %) of mortality occurring in adult animals (3-6 years). This scheme is completed with the absence of slaughter at 6-9 months and few deaths at 12-24 months. The mortality profile suggested by the tooth wear analyses and bone fusion confirms that the animals were killed to obtain meat, milk and maybe that they were also exploited for wool.

Cattle is the second species in remains, with 18.40 % in Tossal de les Basses and 11.32 % in Illeta dels Banyets. The mortality profile for both sites shows slaughter of young, subadult and adult animals.

In both sites approximately 9 % of the identified bones were those of pig. This slight proportion of remains indicates a minor importance of this species. The mortality profile shows death at adult (64 %) and young (36 %) age.

The Equidae, *Equus caballus/Equus asinus* and the hybrid forms (mules) were not consumed but rather used as pack animals to transport commercial products from the inhabited area to the port; they could also have been among the goods sold. The sites had enough natural resources (grassland and freshwater ponds) to support the breeding of equines. This species is more abundant in Tossal de les

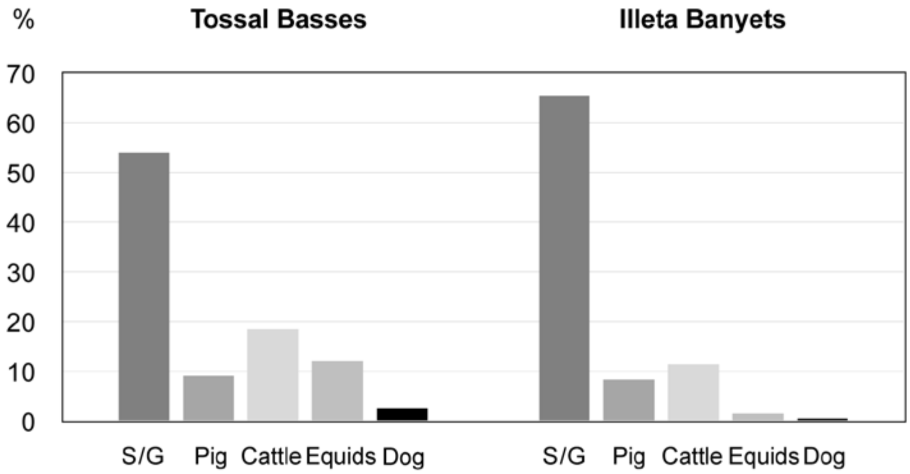

Figure 2. Faunal data from Tossal de les Basses and Illeta dels Banyets. Domestic species (M.P. Iborra).

Basses than in Illeta dels Banyets. The age at death is at adult (6-7 years) and older ages (17-19 years), as indicated by tooth wear analyses. Analysis of the skeletons showed abnormalities: pathological alterations (exostoses) found in the acetabulum and in the last thoracic and first lumbar vertebrae.

The remains of hunted wild species are scarce (4 %) in Tossal de les Basses represented by red deer (*Cervus elaphus*) and rabbit (*Oryctolagus cuniculus*) whereas they are more numerous in the Illeta dels Banyets (14 %) where the following species have been identified: red deer (*Cervus elaphus*), Iberian ibex (*Capra pyrenaica*), rabbit (*Oryctolagus cuniculus*) and hare (*Lepus granatensis*).

Another characteristic of these coastal settlements is the exploitation of seabirds, such as gulls (*Larus* sp.) and Cory's shearwaters (*Calonectris diomedea*). This tendency is similar to that observed in other Punic sites such as Na Guardis, located on the southern coast of Mallorca (Guerrero 2005; Iborra 2005, 657-692) and indicates an opportunistic component in the diet. On occasion, the capture of these birds may have been for the purpose of obtaining fat.

Paleobotanical data

The archaeobotanical data for each of these sites have different origins. In Illeta dels Banyets, samples were collected from the inhabited area, some of them from the homes or streets and others from the inside of a cistern. While it is true that there are differences between these data sets, they can be explained partly by taphonomic factors. The interior of the cistern is a garbage container, with a high concentration of organic material; this facilitates the calcification of botanical remains. This fact can explain the notable difference between the two sets of samples; however, we cannot rule out that this group of samples is a reflection of the importance of wine production and the use of other fruit trees in this habitat (Fig. 3).

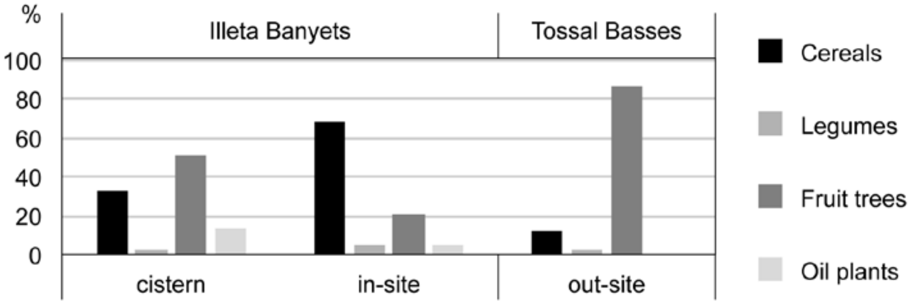

Figure 3. Paleobotanical data Tossal de les Basses and Illeta dels Banyets (G. Pérez).

All of the samples from Tossal de les Basses come from the industrial zone in the area surrounding the settlement, where the most notable activities included pottery-making (generally amphoras) and metallurgy (Rosser and Fuentes 2007). In this case, cereals were only nominally present, both in the collections with carbonised material and in those where the materials were preserved in a waterlogged context. The most common group are fruit trees, especially grape (*Vitis vinifera*), fig (*Ficus carica*) and pomegranate (*Punica granatum*), while olive (*Olea europea*) is also present to a lower degree.

Samples from the inhabited zone are the reflection of the products stored for later consumption and the remains left from the processing of the food; logically, cereals as the main basis of the diet appear most frequently. However, outside we find the remains generated or reused by the different industrial activities. The wine-making process is carried out inside using the documented wine press of large dimensions, used for the primary fermentation (Pérez Jordà 2000; Olcina *et al*. 2009; Olcina 2005). The wine could then be moved to the wineries to finish the production process. Although the waste generated from the pressing of crushed grapes or from the other fruits is often dumped outside, it can also be reused as fuel. The high percentage of fruit trees, in particular grapes, points to an industrial activity aimed at producing goods derived from the different fruits. Off-site, there is a kiln area mainly devoted to producing amphoras for wine and other fruit storage

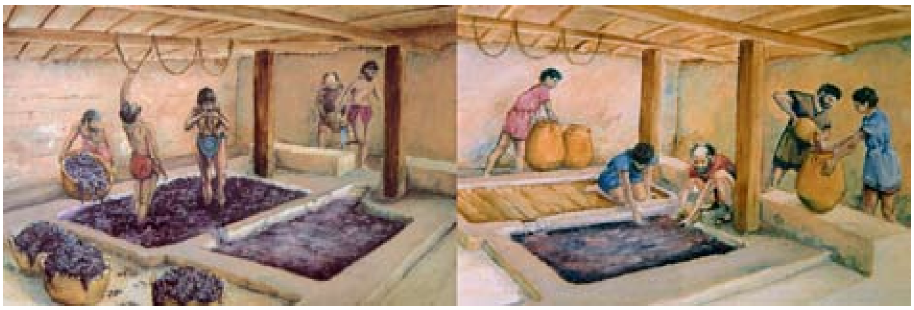

Figure 4. Reconstruction of the activities in a winemaking facility (Diés and Chiner 1993).

vessels (López 1997; 2000; Rosser and Fuentes 2007). Hence, we can surmise that wine was one of the main products exported from these two port trade sites.

The specificity of these two sites is also observed in other elements, mainly in the construction materials used for the wine presses in Illeta dels Banyets. In the rest of the Iberian settlements, wine presses and mills for making olive oil were built from earth and covered by a layer of lime (Pérez Jorda 2000), whereas in this site a lime mortar was used (Olcina 2005, 155) (Fig. 4). This characteristic is shared with other documented structures in Punic enclaves, such as Las Cumbres (Puerto de Santa Maria), Kerkouane (Túnez) (Ruiz Mata 1995, 196-203), or Truncu e Molas on the island of Sardinia (Van Dommelen *et al.* 2010). This element, then, follows a pattern which is more Punic than Iberian, confirming a Punic presence in the area as early as the 4th century BC.

Inland farming sites

La Bastida de les Alcusses (Moixent, Valencia) is located in a semi-mountainous area that borders the Cányoles river valley, a natural corridor between the Castilian plateau and the Mediterranean coast. The landscape is framed within the Mesomediterranean belt; in the present day, the plains are used for dry-land farming (vines and cereals), and the mountains are covered by pine forests and significantly degraded holm oak (*Quercus ilex*).

The settlement is located at the top of a hill and covers an area of 4 hectares. The site is an *oppidum* with a strong defensive system of walls, towers and gates. The urban plan is structured with a main road, a perimeter circuit and a network

Figure 5. Virtual view of la Bastida de les Alcusses (Archive SIP).

of squares and streets. The houses (which measure 70-150 square metres on average) have rooms and courtyards. The number of people living at the site has been estimated at between 450 and 840. The site was occupied from the end of the 5th century to the second half of the 4th century BC (Bonet and Vives-Ferrandiz 2011) (Fig. 5).

The site has a very significant agricultural base, which seems to have had a self-sufficient production scheme, including both livestock and agricultural products. The richness of the environment, with its high-quality soil and water resources, constitutes the basis for cereal crops and for large livestock such as cattle.

Faunal data

The faunal remains show a dependence on domestic species (96.36 %), much less on wild animals (3.64 %). The identified domestic taxa are *Ovis aries/Capra hircus*, *Bos taurus*, *Sus domesticus, Equus caballus* and *Equus asinus*. These species mainly provided meat and milk for domestic consumption, and other products like wool/hides, and manure and traction for farming (Iborra 2011).

Sheep and goat bones were most commonly recovered (53.18 %). The age distribution based on dental wear stages and bone fusion indicates that the majority (65.5 %) was slaughtered between 6 months and 3 years, but also points to slaughter of adults and older animals (34.5 %). This mortality profile may be considered as evidence that animals were used to produce meat and wool. In the case of goats the animals were slaughtered at adult and older ages, which seems to suggest a dairy orientation pattern. Furthermore, these flocks are important in maintaining the fertility of the land by depositing manure.

Overall, approximately 20 % of the identified bones were those of cattle. The mortality profile shows high mortality in adulthood with a lower proportion of males than females. There is also some slaughter at young ages. It is significant that the animals were kept until maturity; this suggests the exploitation of secondary products. Cattle seem to have been exploited for meat, milk and as draught animals.

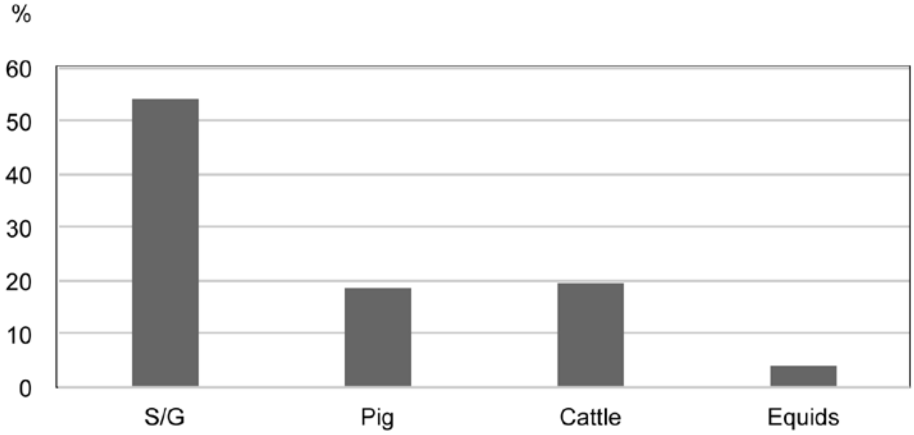

Figure 6. Faunal data from Bastida de les Alcusses. Domestic species (M.P. Iborra).

Figure 7. Bronze figure from Bastida (©Archive SIP) and Bos taurus*, metacarpal distal side (M.P. Iborra).*

Using cattle as draught animals explains the work-related bone pathologies documented in the phalanges and metacarpals of cattle and the material findings such as yokes or the bronze figure of a bovine (Pla 1968) (Fig. 7). The pathologies around the proximal articular surface of the first phalanx suggest a response to stress. The marked widening of the articular condyle in the metacarpal should be understood in the same way (Arbogast 1994; Fabîs 2005).

Pig is the third species among the faunal remains, with 18.4 %. The proportion of pigs is similar to that for cattle. The age at death suggested by tooth wear analyses and bone fusion data shows a culling pattern that emphasises primary products.

Equidae remains are rare at approximately 4 %. The remains occurred as isolated bones, mainly loose teeth, and as a complete skeleton. A donkey skeleton was recovered from the abandoned layer in the perimeter circuit, related to the time when the site was destroyed by fire (Díes Cusí *et al.* 2006). None of the donkey bones shows pathologies such as those identified on cattle bones.

The bones of all wild species together, mammals and birds, amounted to less than 5 % of the total number of identified bones. The wild mammals whose bones have been found at Bastida were *Capra pyrenaica*, *Cervus elaphus*, *Sus scrofa*, *Oryctolagus cuniculus* and *Lepus granatensis*. These species indicate a forest landscape, whereas the bird identified, the little bustard (*Tetrax tetrax*), is associated with agricultural landscapes.

Paleobotanical data

The archaeobotanical data, which come entirely from the inside of the settlement, show a scheme dominated by cereals and, to a lesser degree, fruits. In contrast, leguminous and oleaginous plants are much less common. Among the cereals, there is a certain balance between hulled barley *(Hordeum vulgare* var. *vulgare)* and naked wheat (*Triticum aestivum/durum)*, whereas the rest of the species, einkorn

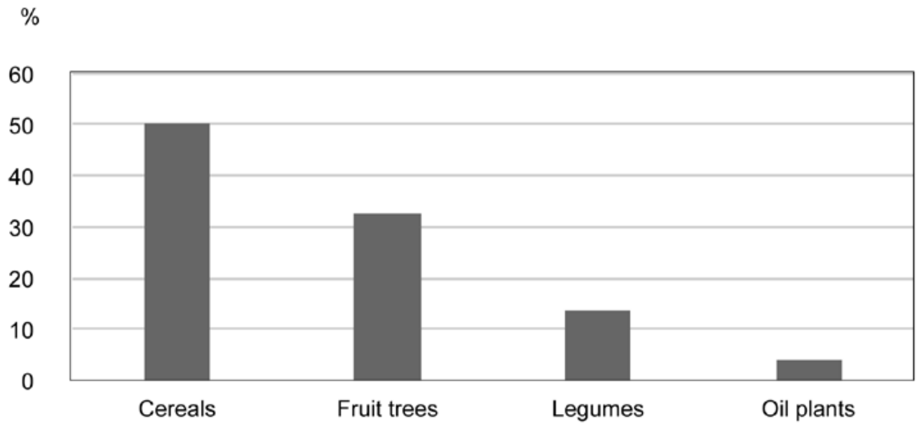

Figure 8. Paleobotanical data from Bastida de Les Alcusses (G. Pérez).

(*Triticum monococcum),* common millet (*Panicum miliaceum)* and Italian millet (*Setaria italica*), are quite scarce (Fig. 8). The balanced presence of the two main cereals can be observed in places with good-quality soil, while areas with poorer soils have a higher concentration of *Hordeum vulgare* var. *vulgare*. Likewise, the predominance of the fruit trees is also closely linked to the quality of the soil. Thus, in this case, the percentage of fruits is not very high; *Vitis vinifera* and *Ficus carica* are the most common. This low percentage of fruits is also related to the fact that this is one of the few sites where no structures for making wine or oil have been found.

It appeares that agricultural and livestock production was mainly aimed at providing subsistence for the local population; there is no specialised production with a strong trade orientation. Although the taxa recorded are similar in the coastal and inland sites, differences can be observed among the agricultural products, with a more established and balanced pattern with a higher proportion of cereals, the staple foods at Bastida. In the faunal assemblage pigs are rare in the coastal sites (9 %), whereas they are rather more common at Bastida (20 %). The intensity of pig breeding is widespread in agricultural settlements (Uerpmann 1977). The increment on pig breeding coincides with an emphasis on the production of secondary products, with an increase in sheep and cattle productivity. Further evidence is the lower proportion of pack animals (Equidae) in Bastida (4.10 %) than in Tossal de les Basses (12.20 %).

In Bastida, the quality of the surrounding land and the existence of water and grazing land allowed a greater presence of cereal farming as well as the development of goat and sheep herds in a setting where cattle played an important role in the production of foodstuffs, such as milk and meat, as well as in agricultural contexts as a force of traction. Additionally, the importance of cereal farming is indicated indirectly by the presence of the little bustard. The cereals are a product that facilitates feeding of cattle, complementing their natural diet with grain stubble and grains if necessary.

Central sites with trading activities

The city of *Edeta* (Lliria, Valencia) is located in the region of Camp del Turia, with an area of almost 1000 square kilometres. This region is occupied almost entirely by dry-land farming on the plains and by pine forests (*Pinus halepensis*) in the mountainous elevations. The surrounding area is predominantly flat. Towards the east there is an alluvial plain, with occasional elevations of 171–177 metres above sea level.

The territory of *Edeta* is characterised by a complex hierarchical settlement pattern, consisting of the *oppidum* (main site) and other small dependent sites, such as rural hamlets, fortified farms, hillforts, small villages and ritual sites. The total number of sites located in this territory is 46, but only 15 % has been partially or completely excavated (Bonet *et al.* 2008). Archaeological evidence from these settlements is indicative of the presence of economic elites, landowners and peasantry (Pérez Jordà *et al.* 2000). The inhabitants of all of these settlements exploited the surrounding land through agriculture and livestock husbandry.

The paleobiological data come from the following sites; *Edeta* (main city), Puntal dels Llops (hillfort), Castellet de Bernabé (fortified farm), La Monravana and La Seña (villages). The city of *Edeta* occupies approximately 10 hectares, although it has only been partially excavated. The excavation uncovered 11 dwellings, a temple, streets, streets and open spaces. The finds revealed the presence of powerful occupants such as the landowners that coexisted together with merchants, artisans, peasants and servants (Bonet et *al.* 2008). The villages of La Seña and La Monravana have a surface area of approximately 1 hectare and 6000-8000 square metres, respectively. Both sites are surrounded by an enclosure. La Seña has a broad street and attached spaces, one of them with a large courtyard. In La Monravana there was a processing area with milling and wine presses. The inhabitants were mainly peasant families (Bonet *et al.* 2008). The Castellet de Bernabé is a fortified farm with an area of 1000 square metres. The space shows a central street and is divided into three areas. The first is a large house, the second one includes an oil press, storerooms, a barn with two grinding wheels, a forge, a lead foundry, and the third are several small houses. The inhabitants of this rural site included an elite family, peasants and servants (Guérin 2003). The last site is the hillfort of Puntal dels Llops, which is surrounded by a double walled enclosure with a large tower in the entrance. The site is organised around a central street with 17 rooms opening off the street. The rooms were use for milling, storage, weaving, metallurgy, cooking and religious activities (Bonet and Mata 2002). Significantly, mining and the cupellation process (silver and lead) were the main activities carried out at the site (Ferrer Eres *et al.* 2010). The estimated population is around 20-30 people, consisting of servants as well as aristocratic and equestrian people (Bonet *et al.* 2008).

Although there was agrarian activity at all the sites, and fruits were cultivated in all of them, some products, such as oil and wine, only occur in some sites: oil at La Seña and Castellet de Bernabé, where oil presses were documented, and wine at Edeta and La Monravana, where wine presses were found. At Puntal dels Llops, there is also evidence for mining and metalworking (Fig. 9).

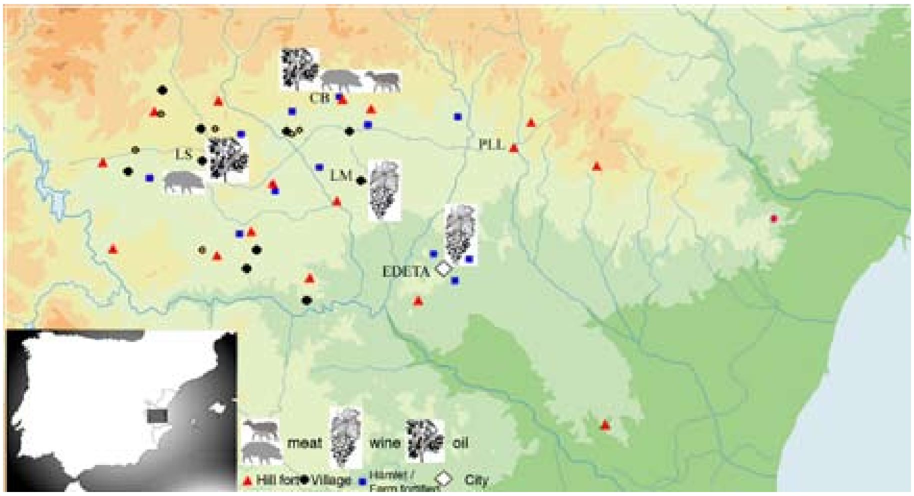

Figure 9. Map of the territory of Edeta *with the possible exchange goods. The sites: PLL (Puntal dels Llops), LM (La Monravana), CB (Castellet de Bernabé), LS (La Seña) and Edeta (Iborra and Perez 2009).*

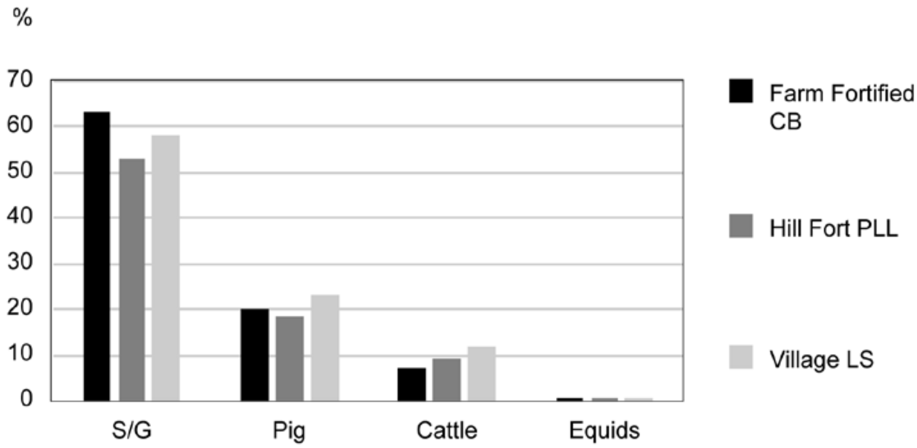

Figure 10. Faunal data from the territory of Edeta*. Domestic species (M.P. Iborra).*

Faunal data

The domestic taxa are dominated by *Ovis aries/Capra hircus* followed by *Sus domesticus, Bos taurus, Equus caballus* and *Gallus gallus*. The relative proportion of domestic species is between 84 and 90 %. The highest percentages for domesticates are found in the city of *Edeta* and in the village of La Seña, whereas wild animals are more numerous in the hillfort of Puntal dels Llops and the fortified farm of Castellet de Bernabé. Livestock provided resources for human consumption (meat and milk), craft (wool, skin, bones) and agriculture (manure and animal traction for ploughing) (Fig. 10).

The faunal record shows the presence of mixed herds with sheep and goat in all the sites analysed (50-60 %), although goats were more commonly kept in Puntal dels Llops (Iborra 2004). Sheep and goat were complemented by pig breeding (20 %) and a rather low proportion of cattle (10 %). Despite this uniformity it is possible to discern differences, taking into account the mortality profiles and the occurrence of the different skeletal elements. This evidence shows the potential for production of animals or their products for sale or barter.

At the fortified farm Castellet de Bernabé, one important feature is the breeding of animals like *Ovis/Capra* for sale or exchange. We examined the potential productivity of the flock through the analysis of sex and the age at death, assessed by morphology, tooth wear and epiphyseal bone fusion. The mortality profiles indicate a slightly low proportion of infantile and juvenile animals (10 %). In theory, a surplus of juvenile male sheep may have been traded or exchanged (Iborra 2004). Another feature is the trade of anatomical units of processed pork. Trade was determined by the absence of some of the hindquarter bones, in this case the lack of the pelvic acetabulum and proximal femur. Furthermore, the analysis of age at death shows a high presence of animals between 18 months and 3 years, when the animal reaches matury and its optimal weight in a traditional exploitation system. This picture is broadly similar to the one observed in the village of La Seña. The hypothesis is that the absence of a part of the hindlimb is associated with the production process of ham by salting or smoking, as a product for exchange or sale. Interestingly, the classical literature of Estrabon and Polibio includes comments about the autochtonous breed of Iberian pigs and the high quality of their cured meats (Olmeda 1974).

Regarding the production of secondary goods such as milk, we can argue that there is dairy production at Castellet de Bernabé and Puntal dels Llops, where the mortality profile indicates the slaughter of sheep between 2 and 6 months together with the death of adult goats. However, it is impossible to quantify its importance as a trade product.

Hunting in the Edetan territory was a common practice with implications for the economy. Prey included large mammals such as red deer and Iberian ibex, but also medium and small-sized prey, such as rabbit or red-legged partridge (*Alectoris rufa*), among other species. This practice occurred not solely as a means of subsistence but also as a common recreational activity, as the analysis of anatomical units, sex and the age at death of the wild species in each site shows.

Red deer were the most frequently represented wild mammals. The remains found in the city of Edeta and in the village of La Seña were mostly of mature males, as is usual in trophy hunting. Decorations of hunting scenes are common on fine-ware vessels recovered from Edeta (Bonet 1995). On the other hand, in the smaller sites like Castellet the Bernabé, the red deer remains were of both female and male animals, both mature and younger. This seems to reflect non-selective hunting, suggesting that hunting was carried out both to obtain food and to protect crops.

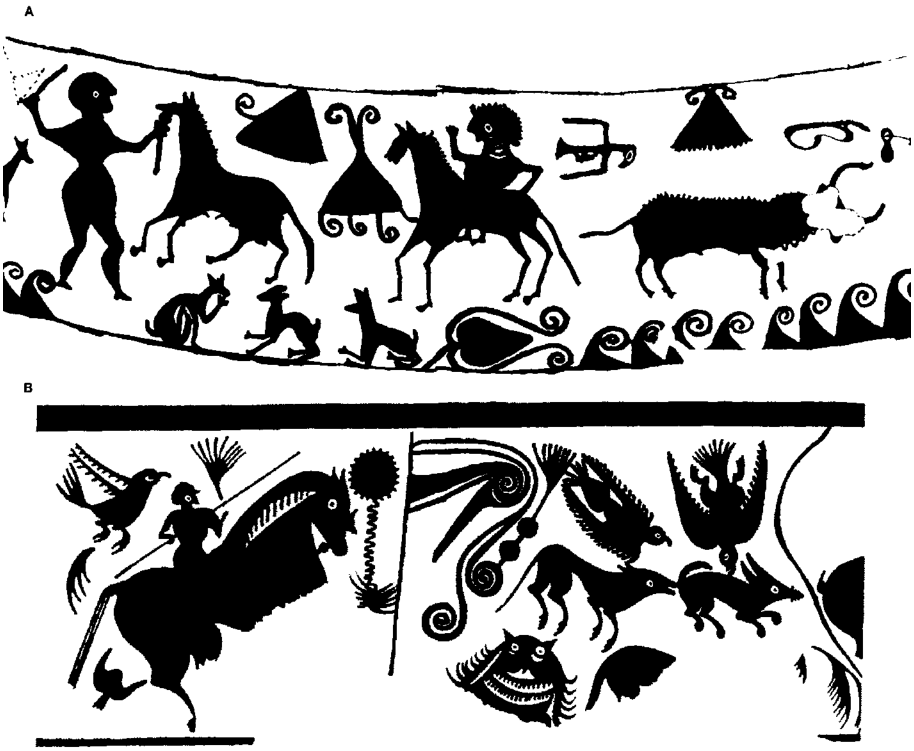

Figure 11. Figurative decoration on a pot from Edeta*, the "Vaso de la Doma" (Archive SIP) and Castellito de Alloza, Teruel (Maestro 1989).*

Hunting of small prey such as rabbit and Iberian hare, as well as birds such as rock dove (*Columba livia*), red-legged partridge and red-billed chough (*Pyrrhocorax pyrrhocorax*), may have been carried out in different ways. One of these is through falconry. Dove hunting may have been practised with the peregrine falcon (*Falco peregrinus*), whereas the northern goshawk (*Accipiter gentilis*) would have been used to hunt rabbits and hares.

Unfortunately no bones of birds of prey were recovered in the settlements in the Edetan territory. All the evidence comes from the decoration on pottery vessels. One of them is the hunting scene represented on the so-called "dressage vessel" from the city of *Edeta* (Bonet 1995, f9), where a horseman has an arm raised very close to a bird of prey. Similar scenes are depicted on the ceramic vessel from the Iberian site El Castellito de Alloza, located in Teruel (Maestro 1989) (Fig. 11).

Other species present were Anatidae such as mallard (*Anas platyrhynchos*) and the griffon vulture (*Gyps fulvus*). The bones (ulnas) of the latter species were used to make a musical instrument (pan flute) in the site of La Seña.

Paleobotanical data

The data from this territory come mainly from two sites: Tos Pelat, where we have samples from the middle of the 4th century BC, and Castellet de Bernabé, from the end of the 3rd century BC. Data from the 4th century BC show that cereals constitute the largest group of seeds, although fruits were also quite abundant. *Hordeum vulgare* var. *vulgare* is clearly more abundant than *Triticum aestivum/durum*, although the importance of *Setaria italica* should not be discounted either. Among the fruits, *Ficus carica* is predominant, while *Vitis vinifera*, *Olea europea* and *Punica granatum* are much less common.

In Castellet de Bernabé, the main characteristic is the presence of fruits as the most frequent crop, more common than cereals (Fig. 12). We attribute this phenomenon to the poor-quality soil of the area, which is not suitable for cereal farming but is adequate for a good production of fruit trees. The low-quality soil is also reflected in the presence of *Hordeum vulgare* var. *vulgare*, which is much more abundant than *Triticum aestivum/durum.* Other crops that are undemanding of soil quality are also plentiful, including hulled wheats (*Triticum monococcum* and *Triticum dicoccum*).

The fruits display considerable diversity, with two crops standing out (*Vitis vinifera* and *Olea europea*), although the presence of olive stones is related in this case to the presence of a mill for making olive oil. Likewise, other sites in the area also have structures related to oil or wine production (Bonet 1995; Pérez Jordà 2000) (Fig. 9). Generally, these structures have less production capacity than those in Illeta dels Banyets. However, the fact that at some sites we only find wine presses or mills for olive oil, and in the other there is no evidence for these structures, suggests a certain exchange of oil and wine.

In conclusion, self-sufficient provision of goods seems to be the main premise of the sites in this territory, although this does not preclude the exchange of certain products. Both the products made from livestock and the derivatives of agrarian products seem to circulate between the different sites (Fig. 9). As we argued above it is possible to discriminate sites such as Edeta, Castellet de Bernabé, La

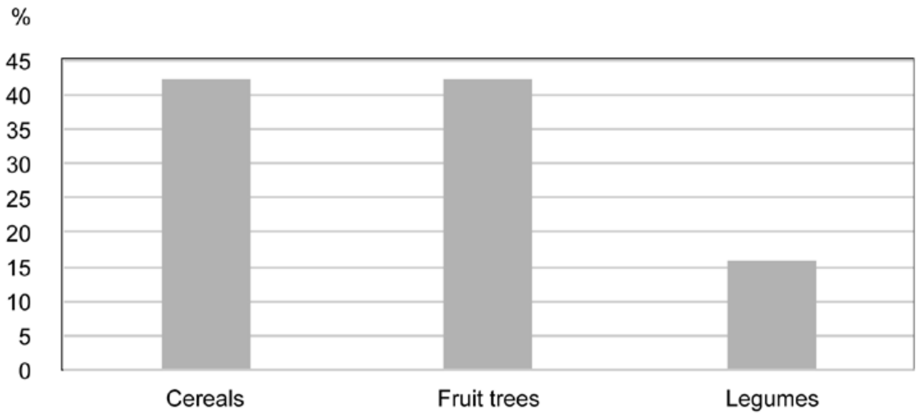

Figure 12. Paleobotanical data from the territory of Edeta *(G. Pérez).*

Monravana and La Seña, where it was possible to achieve a surplus (wine, oil and cured meat). These are settlements where the landowners had the resources to improve production areas and maintain processing equipment such as wine and olive oil presses (Perez Jordà *et al.* 2000). It is also true, however, that production does not seem to have been primarily oriented towards trade; trade would have been secondary to the prevailing economic structure which had subsistence as its primary goal.

Subsistence, surplus and exchange

The data set of each of the three cases demonstrates that agrarian strategies were not uniform. This is true not only in terms of the crops and types of livestock (which are similar, but not completely homogeneous) but also with respect to the orientation of production (Fig. 13). The products intended for commercial trade are basically those from fruit trees. Wine, which is produced on a large scale in coastal settlements such as Illeta dels Banyets and possibly in Tossal de les Basses, is a product meant for inclusion in the Mediterranean trade routes. In that sense, a number of large presses were constructed, with capacity tanks of 1200 litres each. At the same time, a potter's area existed to produce amphoras for the storage and shipping of wine. At this time, we do not know if the cultivation of fruit trees was carried out by the inhabitants of these settlements or if the population was dispersed in the surrounding region, where the farmers and livestock farmers who produced the goods lived. In any case, the final step of the process (wine making) was performed in the harbour enclaves, whose function was therefore not exclusively commercial. At the same time, other products such as metals (mainly iron and silver) were also part of commercial networks. The transformation process of metals also took place in the industrial area of the sites.

In the inland territories, the economic orientation was different. There is some trading, but its scale is not comparable to that of the coastal settlements. The oil and wine presses located in the inland settlements have a much smaller capacity, there are no large pottery kilns associated with amphora production and the metallurgical structures related to silver and iron making are also smaller and less common than in the coastal sites.

These are economies that are primarily directed towards the communities' subsistence, and the purpose of trading was to obtain resources that their community lacked or to overcome periods of shortage. In addition, in a hierarchical society as proposed for these territories (Ruiz and Molinos 1998; Bonet *et al.* 2008), some type of tax system may have been imposed by the elite community members. The only example of a large warehouse that could have been used to store surpluses is that of Bastida de les Alcusses (Bonet and Vives-Ferrándiz 2011), where a large granary existed in the central part of the settlement, and in the Illeta dels Banyets (Olcina 2005). Structures of this kind may have existed in other large *oppida*, such as in Edeta (Bonet 1995), but these have only been partially excavated, so we do not have enough data to confirm or deny their existence one way or the other. In any case, hierarchical societies such as these suggest the existence of certain social

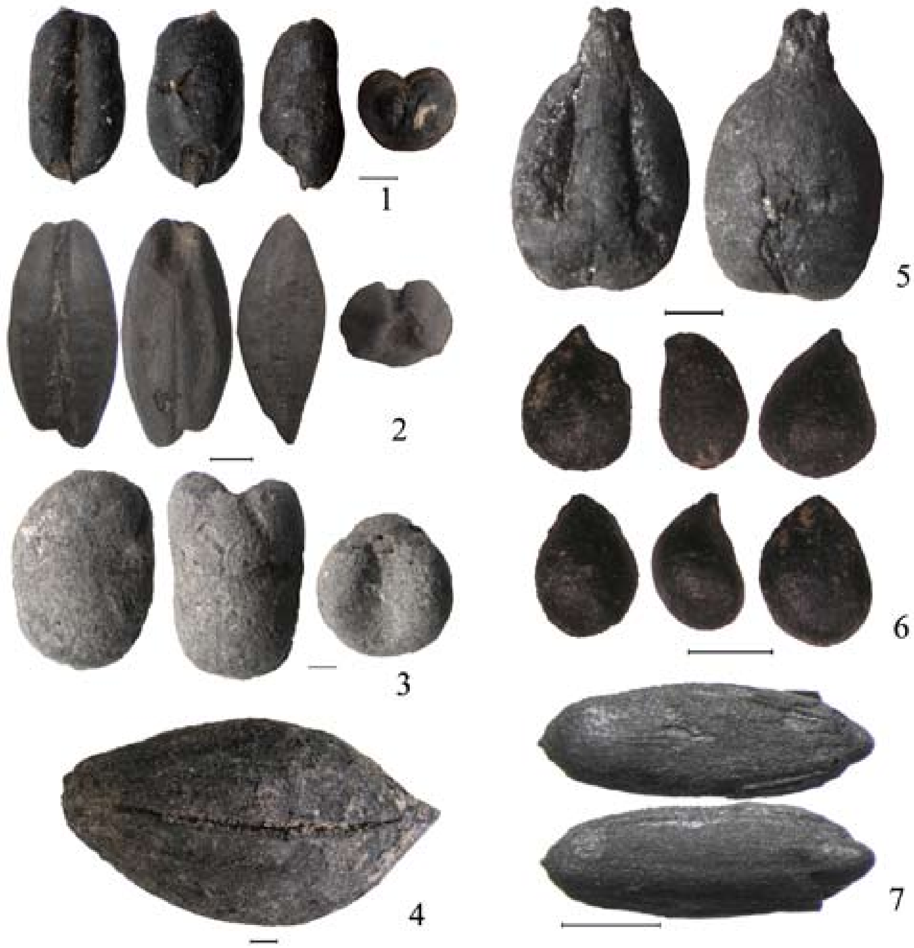

Figure 13. Paleobotanical finds from Castellet de Bernabé and Tossal de les Basses. 1 Triticum aestivum/durum*; 2* Hordeum vulgare*; 3* Vicia faba*; 4* Olea europaea*; 5* Vitis vinifera*, 6* Ficus carica*; 7* Lolium perenne-rigidum*. Scale 1 mm (G. Pérez).*

incentives (Wolf 1966) to stimulate production by domestic units that exceeds the local necessity for food. These surpluses may have been in the form of work or cereals, fruit, fruit products, live animals, or processed animal parts.

Because their published record is incomplete, we lack evidence to infer whether the coastal settlements were producers of agrarian and livestock products, but there is no doubt that all of the inland settlements, regardless of size, produced these goods. The archaeobotanical data set demonstrates that the final tasks of cleaning the cereal harvests were being carried out in every settlement. The iron tools confirm the presence of the different phases of the agricultural cycle, and the pathological changes observed on bones of cattle indicate their use as a force of traction. In parallel, the faunal data set attests the breeding of different kinds of livestock in the settlements. All of these exploited their surroundings in a balanced way, selecting the plants and animals that were best adapted to the environment.

Thus, sites with good-quality soil had more demanding species, such as *Triticum aestivum/durum* and cattle, while those with poor-quality soils focused on less demanding species, such as *Hordeum vulgare* var. *vulgare*, fruit trees, sheep and goats. Hunting and gathering complemented these resources. At the same time, hunting was not only an activity meant to provide meat or hides, but in some cases it also constituted a strategy to protect crops by eliminating competitors. In other cases, it appears to have been a recreational activity carried out primarily by the elite members of the community (Iborra 2004). Therefore there are different socioeconomic trajectories within this territory. The societies share a similar state of technological development, but this does not stop their economic orientations from diverging. Trading activity is concentrated in the coastal areas, which is logical given that overland transport of heavy merchandise, with little added value, was scarcely profitable at that time. Moreover, the specialisation in the cultivation of fruits and production of derivatives of these is confirmed, in contrast to the area of Northern Catalonia, where grain production had a more important role, also for exportation (Alonso 2000; Pérez Jordà 2000). The inland areas would have been a more insular world, though not without contact with the outside, as evidenced by the presence of imports such as Punic amphoras and black-gloss ceramics (Mata *et al.* 2004). It is clear that we lack data to allow us to narrow our focus from a very general analysis to one that is more specific, examining as far as possible the sphere of each domestic unit. Yet, there is no doubt that these were dynamic societies that adapted to their surroundings and were capable of making the most of the opportunities offered by the trade networks of the Mediterranean.

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The well in the settlement: a water source for humans and livestock, studied through insect remains from Southeast Sweden

Magnus Hellqvist

Uppsala University
Department of Earth Sciences
Villavägen 16
752 36 Uppsala
Sweden
magnus.hellqvist@geo.uu.se

Abstract

Water is the most important resource for human subsistence, essential for the survival and the base of many other parts of the processes in sustenance. One important part of settlements' water resources is the well, in prehistory and still today. It also plays an important role in understanding the utilisation of the palaeohydrological situation of the landscape. In order to understand the water resource in the local well constructions in the settlement, the content of insect remains together with stratigraphy were studied, in order to investigate the history of construction and use and sediment composition of wells at three Iron Age sites in Southeast Sweden. The study concentrated on the Pre-Roman Iron Age to Roman Iron Age (2500–1600 cal BP), and the wells were situated in a rural landscape. There was a trend in the usage of the wells over time within the settlements. The results indicate a change of the well as a water source for humans to a waterhole for livestock after abandonment, and through that a change in land use within a small geographical range. A complicating situation, when reconstructing the water resource management, is that all three studied sites were situated close to or in direct connection to running water. This partly makes the role of the wells as a water source within the palaeohydrological situation in the landscape unclear, since we do not know which was most important for the water supply for subsistence for people and cattle. In the study area the distance to the Baltic Sea has changed in time through land uplift, resulting in a longer distance to the sea up to the present time and a total change in the landscape from open sea to archipelago and finally to land.

Keywords: *well, water supply, insect remains, waterhole, Sweden*

Introduction

Arranging an adequate water supply is the most important resource management problem humans have been forced to find solutions for throughout history. It is the most important ingredient for human survival and the basic resources in daily life and likewise an important resource for livestock. What we find in the archaeological context are remnants of different solutions to guarantee the water supply to the settlement. The most obvious feature is the well, the man-made construction that supplies water locally within the settlement. On the one hand it is reasonable to expect that people ensured that there was always a surplus of available water resources over the year, so they would never have to face a situation of water shortage. Deficiency of fresh water must be considered as an extremely problematic situation, especially for the livestock. On the other hand, solutions for fresh water supply must be arranged locally so it is available in everyday life.

Well construction has played an important role in providing a water supply for people since prehistoric and historic times. The study of wells in settlements in the prehistoric landscape requires the consideration of the hydrological situation in its entirety, and the relation between people and different water resources. We do not always have a clear understanding of the use of the well, and in the study presented here, there was a unclear relation between the well and other natural water sources in the landscape surrounding the settlement. One aspect of the situation is the fact that all investigated settlements were situated close to natural water sources, such as smaller rivers. One question is whether wells functioned as a complementary water source or whether they formed the main water supply, or if these resources worked as complementary water supplies over the year to provide fresh water.

During investigations of insect remains from wells at two Iron Age farm settlements in South Central Sweden (Hellqvist 1999), a relationship between the settlement and a nearby river was established through insects living in the river environment. The fact that they were trapped and deposited in the well indicates that they were moving between the two aquatic situations. The results from the well show how difficult the relation between natural water sources in the landscape and wells within a settlement may be, and that it is not easy to reconstruct the daily water resource management; however, the role of water for survival of people and animals is unquestionable.

Wells and similar features are common findings during archaeological excavations in Sweden, but unfortunately, until the mid-1990s, many archaeologists in Sweden considered wells as features of less interesting parts of the excavation. This affected the opportunities for studying subfossil insect remains, with limited studies of wells in Sweden (*e.g.* Lemdahl 1994; 2003; Hellqvist 1999; 2004; 2007b; Hellqvist and Lemdahl 1996), although there are a lot of studies of insect remains from wells and pits from other parts of Europe (*e.g.* Buckland 1980; Coope and Osborne 1968; Hall *et al.* 1980; Kenward *et al.* 1986; Osborne 1994). The idea of the well as a trap for insects was presented in the 1980s (Buckland 1980; Girling 1989;

Hall *et al.* 1980; Osborne 1981). The investigation presented here increases the knowledge on well constructions in Sweden and the interaction between humans and water resources in the landscape.

During archaeological excavations connected to a new highway construction in the southeastern part of Central Sweden, in the county Uppland (Fig. 1), samples were collected for analysis from several excavated wells and similar constructions (Table 2). The results from investigations of sediment and subfossil insect remains

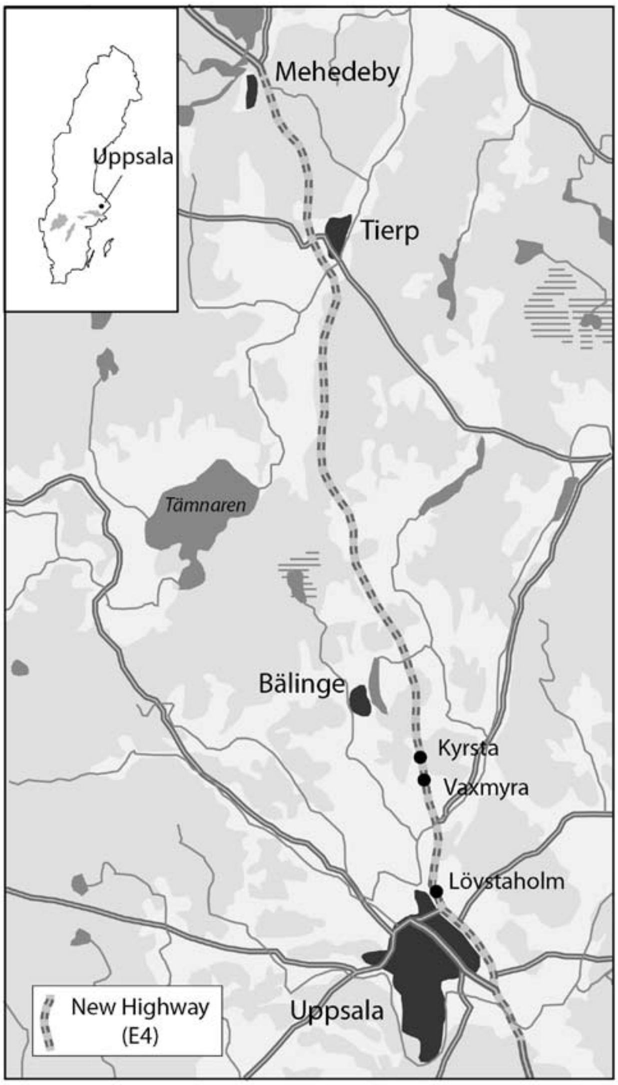

Figure 1. Map of all studied archaeological sites that were excavated along a section where a new road would be built in the county Uppland in Southeast Sweden. Wells were found at the sites Lövstaholm, Vaxmyra and Kyrsta (Eklund 2005; Häringe et. al. *2007; Onsten-Molander and Wikborg 2006) (Håkan Thoren).*

Archaeological/historical period	Radiocarbon years	Calendar years
Modern Time (MoT)		
Middle Ages (MA)	AD 1500	AD 1500
Viking Age (VA)	AD 1050	AD 1050
Vendel Period (VP)	AD 800	AD 800
Migration Period (MP)	AD 550	AD 550
Roman Iron Age (RIA)	AD 400	AD 400
Pre-Roman Iron Age PRIA)	0	0
Late Bronze Age (LBA)	500 BC	500 BC
Early Bronze Age (EBA)	800 BC	1000 BC
Late Neolithic (LN)	1500 BC	1800 BC
Middle Neolithic (MN)	1800 BC	2300 BC
Early Neolithic (EN)	2600 BC	3300 BC
Mesolithic Time (MT)	3100 BC	4000 BC

Table 1. Archaeological time-scale for Southern Sweden, after Hedeager and Kristiansen (1985).

from three prehistoric settlements are presented. The settlements date from Neolithic times until the Iron Age, but the majority of the wells investigated were from the first part of the Iron Age, primarily the Pre-Roman Iron Age and Roman Iron Age, according to the chronology by Hedeager and Kristiansen (1985) (Table 1).

Insect analysis, primarily that of beetle remains (Coleoptera), is an advantageous method for working with samples from archaeological excavations and constructions like wells. One important factor is that insects are not prevented from falling into the well, even if it is covered, which was demonstrated in a taphonomic project on insect remnants from a modern farm well (Hellqvist 2004), where covering the well did not negatively influence insect remains within the well.

Insects are also mobile and find their way into a settlement through different ways, such as transport in substrates, by coincidence during movement in the landscape, and actively searching for attractive environments and/or substrates created by or connected to human activities (Kenward 1985). Although information on the surrounding landscape is gained, the differentiated influx may affect the results, so any interpretation needs to be made cautiously.

Study area and methods

The studied wells together with their dating are presented in Table 2. The sites Vaxmyra and Kyrsta are situated in the same valley with a small unnamed river situated centrally in the area. At Vaxmyra (Eklund 2005; Hellqvist 2005) one well construction was studied and at Kyrsta (Onsten-Molander and Wikborg 2006; Hellqvist 2006) seven well constructions were studied. At the site Lövstaholm (Häringe *et al.* 2007; Hellqvist 2007a) another seven well constructions were studied. The site Lövstaholm was situated at the bottom of a small valley with a river (River Samnan) situated centrally in the valley, characterised by repeated flooding up to the present day. All constructions were described as wells during fieldwork, and samples were collected during excavation. However, some constructions have later been revised to pits in general, as a result from the insect analysis (Table 2). However, they probably were part of the effort to manage the water situation in the settlement, to create the water surplus for daily activities.

Sweden has experienced heavy land elevation since the end of the last glaciation (Weichsel), and all the investigated sites have been under the sea level, gaining new land to the east through land uplift. The study area was previously situated closer to the Baltic Sea at the time of activity and coastal areas changed into isolated lakes and wetlands before the whole landscape dried up. The current isostatic land

Site (Reg. nr.) [nr.in fig. 2]	Arch field interpret.; Shape of construct.	Approx. depth (cm)	Nr of layers	Dom. Sed. type	Insect remains (yes/no)	Age according to table 1	Interpretation from insect remains and shape of construction
Vaxmyra (A9952)	Well; funnel shaped	133	7	Clay	Yes	Older (IA)	Well, later used as waterhole for grazing animals
Kyrsta (A1353) [I]	Well, finally used as grave; funnel shaped	120-130	2	Clay	Yes	(LN)	Well in primarily stage, in later stage used as grave, level with pottery
Kyrsta (A11580)	Well; funnel shaped	210	7	Clay, sand/gravel in bottom	No	(PRIA)	Well , collapse of well walls, short usage time
Kyrsta (A11808)	Well; pit, cup shaped	170	10	Clay, silt clay	No	Older (PRIA)	Well , collapse of well walls, short usage time
Kyrsta (A42011)	Well; pit hole, U-form	130	5	Clay	No	Younger (PRIA)	Well
Kyrsta (A43821)	Well; funnel shaped	170	5	Clay	No	(PRIA-RIA)	Well, short usage time
Kyrsta (A49309) [IIa-IId]	Well, large pit made of two smaller pits	200-260	7	Clay	Yes	(RIA)	Well, a smaller pit, later comb. to one larger pit, used as waterhole for grazing animals
Kyrsta (A114930)	Well; pit, cup shaped	150	11	Clay, stones in bottom	No	Younger (PRIA)	Pit rather than well
Lövstaholm (A1098)	Well; funnel shaped	165	10	Clay	No	(PRIA-RIA)	Well
Lövstaholm (A1242) [I]	Well; funnel shaped	176	8	Clay	Yes	(PRIA-RIA)	Well
Lövstaholm (A3922) [II]	Well; funnel shaped	150	4	Clay, stones in bottom	Yes	(PRIA-RIA)	Well
Lövstaholm (A7866) [IIIa-IIIb]	Well; funnel shaped	252	10	Clay, clayey silt	Yes	(PRIA-RIA)	Well
Lövstaholm (A8270)	Well; funnel shaped	230	8	Clay	No	(PRIA-RIA)	Well
Lövstaholm (A11632) [IVa-IVb]	Well; larger pit made of two pit constructions	194-234	2	Clay	Yes	(PRIA-RIA)	Two features (wells?), combined to one construction
Lövstaholm (A15113)	Well**?**; pit, U-form	126	1	Clay	No	(PRIA-RIA)	Pit rather than a well

Table 2. Table with information on the investigated constructions, interpreted as wells during fieldwork, together with stratigraphical data and the final interpretation of the feature. Abbreviations on the dating are explained in Table 1.

uplift ranges from 4 mm/year in the south to almost 5 mm/year in the north of the region investigated. Therefore, there was a possibility that some of the wells might have been affected by seawater (brackish to salt) through salt groundwater or deposited lenses of sea water, affecting the quality of the well water.

Samples were collected in the field during excavations directly in open sections (Fig. 3). Sample preparation and extraction of insect remains followed more or less standard techniques developed by Coope and Osborne (1968), also described by several authors (*e.g.* Coope 1986; Buckland and Coope 1991; Elias 1994; Kenward *et al.* 1980; Osborne 1973), except for the paraffin flotation procedure. The samples were treated with water flotation and complete microscope sorting of residue.

The sample volume for all samples varied from around 250 ml (*c.* 400 g) to 1000 ml (*c.* 2000 g), and the sample volume was primarily determined by the field conditions of the construction investigated and the amount of sediment available to sample from each layer. Numbers of insect remains per litre volume sample are presented in Figure 2.

A regional archaeological classification of wells constructed in prehistoric settlements in Sweden was presented by Eriksson (1995), based on interpretations of wells during archaeological excavation in the region, dividing wells into three main groups based on the infilling layers: (a) collapsed and filled with sedimentation by natural causes, (b) natural sedimentation through water and wind erosion, and (c) active human infilling. The last group is subdivided into two groups: (c1) accumulation during a period or (c2) on one occasion. This description of well

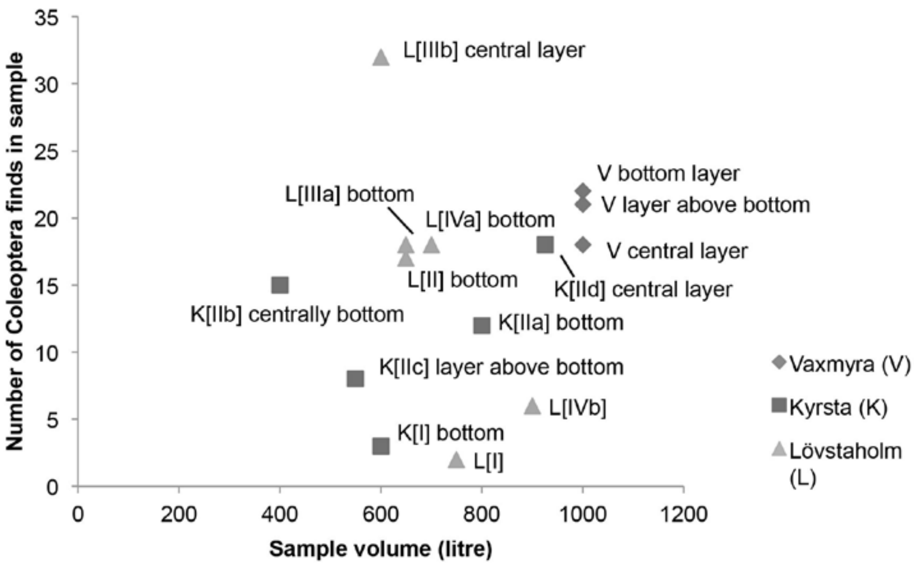

Figure 2. Number of insect remains found per volume (l) soil sample. From this, it is obvious that not only the sediment volume determined the number of finds. It is probably also factors like a short period of use that are important, providing less time for insects to be deposited in the well.

history is more a description of the most likely deposition history of the layers in the construction.

In the study presented here, a simple categorisation was used, based on the results from the subfossil insect analysis and the original construction of the well and type of use. The wells are categorised into (I) typical well constructions, usually funnel-shaped (Fig. 3), (II) wells or well-like pits with a changing use and construction through time, and (III) well-resembling constructions or pits used primarily as a water source for livestock.

The first category (I) are wells primarily used as a water source for people at the settlement. They had a characteristic funnel-shaped form, wider in the upper part and becoming narrower deeper in the ground (Fig. 3). The wells were usually filled with different kinds of layers of infilling materials, which could also be the result of collapsed walls in the well construction.

With the second category (II), the function changed over time, with the well initially being used as a water source for people. Then, after being partly filled to a level higher up in the stratigraphy, it was reused as a water source (waterhole) for livestock, usually through apparent grazing in direct connection to the well. This was indicated by the aquatic situation together with evidence for grazing animals.

Figure 3. The well (A7866) at Lövstaholm during excavation and sampling for subfossil insect remains, with the funnel-shaped form typical for wells (category (I) (Photo: Magnus Hellqvist 2003).

This type of well was characterised by a shift from primarily a construction with two separated pits and/or wells that were later combined into a larger construction. In the third category (III), the primary purpose was to construct a water pit for cattle.

Several of the wells investigated revealed little or no macrofossil remains. The sediment in all the wells provided good preservation conditions, with clay and moist soil conditions, so the reason that several wells lacked remains was most probably a result of a short period of use, resulting in a shortened deposition period.

It is difficult to determine the actual period of use of wells without appropriate proof, for instance a well constructed from timber, where wood can be used for dendrochronological analysis. An interesting example is presented in Aaby and Robinson (1995), where dendrochronological dating of wood in the well provided suitable material to measure the time of use to at least 40-50 years. Since the authors assumed repeated clearance of the bottom of the well, they estimated the deposition of the bottom sediment to the last 10-20 years of use. Unfortunately, there were none such available opportunities for dating in the investigation presented here.

Results

In the constructions investigated (n=15), a total of 59 stratigraphical units was sampled and analysed for subfossil insect remains, but only 7 contained insect remains (Table 2). Subfossil remains of Coleoptera dominate, but there were also unidentified remains of mites (Acaria), true fly puparia (Diptera) and mosquito larvae remains (Chironomidae). In a well from Kyrsta there were remains of unidentified water flea (Cladocera) and caddis fly larvae (Trichopera); the last group is seldom found in archaeological contexts. These last three groups of insects also provided unequivocal evidence of an aquatic situation in the wells because of their corresponding natural habitats. Information concerning the present geographical distribution and biology of the taxa was according to Chinery (1993), Gärdenfors *et al.* (2004), Hansen and Henriksen (1927), V. Hansen (1965; 1968), M. Hansen (1987), Koch (1989), Landin (1957; 1961; 1970), Lindroth (1985; 1986), Lundberg (1995), T. Palm (1963) and E. Palm (1996). Each insect assemblage was defined by the insect taxa recorded in each well. A complete species list may be found in original papers by the author (Hellqvist 2005; 2006; 2007a; 2007b) or Buckland and Buckland (2006).

In order to present the results in a systematic way, the recorded insect taxa in each assemblage, *i.e.* each analysed sampled layer from the wells, were grouped into major environmental preferences with the purpose of reconstructing the contemporary environment. The results are presented in Figures 6, 8 and 11. The wet environment was grouped into aquatic and hydrophilic, *i.e.* indications of humidity for moist ground conditions or water margins. Species living in aquatic and wet conditions get attracted to the environment in the well when there is a water table, providing indications on these conditions, but several of these species are more specifically found in natural habitats, like running water and special bottom conditions, and therefore primarily indicate the natural habitat.

The surrounding environment of the settlement is described by the occurrence of species preferring generally open landscape and arable land (cultivated fields). The term 'open landscape' refers to an open country environment, without any specificity of land use. Those species found connected to agricultural crops are usually pests on the plants and therefore strong indicators of growing crops. It is not possible to make assumptions on or measurements of the distance to the cultivated fields from the wells, since harvested products are usually transported to the settlement, but the proof for the activity and human presence is without doubt. Information concerning buildings, activities, livestock and local environment could be derived from insects indicative of the presence of dung/manure, compost and synantrophy, *i.e.* species bound to and/or favoured by human activity, for example, indoor habitats. The presence of dung beetle species (*Aphodius*) is usually a very strong indication for grazing in the close surroundings. Dung beetles are dependent on fresh dung in different stages of decay and sometimes they are even bound to certain livestock species, and therefore indicators for specific domestic animals.

The total number of insect taxa identified from the site Vaxmyra is 38 from one well, dominated by species living in aquatic and moist habitats, and dung beetles (*Aphodius*) (Fig. 6). Among the other identified species is a weevil, *Otiorhynchus ovatus*, providing an indication for plants in the surroundings. The weevil usually feeds on many different plant species, and several remnants were found in the well sample as macrofossil plant remains (Ekblom 2005), such as *Rumex* spp. (sorrel) and *Potentilla* species (silverweed); the species is usually found on both dry and moist sea margins. Higher up in the stratigraphy from sample 2 (S2, Fig. 5) the beetle *Aclypea opaca* was found, also present at Lövstaholm. It is sometimes considered a severe pest on beet (*Beta vulgaris*). Another beetle found (S2 & S3, Fig. 5) is *Ptinus fur*, classified as synantrophic and often found in indoor environments. These species may be a pest of stored products, but even though it is difficult to interpret these two finds as pests on crops or stored products at the site, there would have been a storage facility with suitable conditions at the settlement.

From the site Kyrsta, a total of 37 insect taxa was identified from samples in one well (Fig. 7, of seven studied), dominated by aquatic and hydrophilic species (Fig. 8) through all layers of the well. The second most common group of insects are those connected to dung (*Aphodius*) and decaying organic matter, and together with the dominating group, this leads to an obvious interpretation. In this case, it is obvious that there are indications for both a natural water environment and stagnant water in a natural situation or in the well. Support for a natural aquatic situation is found in the central part of the construction, with beetle remains like the diving beetles (*Dytiscidae* and *Coelambus impressopunctatus*), indicating an aquatic environment, or *Coelambus impressopunctatus* that normally lives in shallow water bodies with a lot of vegetation. Another beetle species, *Ochtebius minimus*, is bound to both stagnant and running fresh water, but occasionally found in brackish water. An example of the hydrophilic species is *Helophorus granularis* that lives in stagnant to slow-running water or temporary water collections, in this case probably indicating the presence of a water table in the well. Other beetles indicated a moist or aquatic environment, as they live on plants appearing in these environments, for example, two identified ground beetles: *Bembidion varium* and *Pterostichus nigrita*. The weevil *Notaris acridulus* found in the same layer lives on vegetation growing along running water and lakes and may originate from locations in or close to the settlement.

Another find from this well consists of larvae heads from Chironomids (mosquitoes), indicating an aquatic situation with a high water table. This interpretation was supported by remnants of egg capsules of Cladocera (water flea), found in almost all sampled layers in the well. There are about 95 species of Cladocera in Scandinavia, usually named after the genus *Daphnia*. These insects primarily live in fresh water conditions and are found in large numbers in smaller water collections; therefore, they are strong indicators of an aquatic environment, at least periodically.

An extraordinary group of insects found in this well is the Trichoptera (caddis fly), that supports the interpretation of an open water surface. There were remnants of both adult animals and larvae: a number of individual larvae remains were found in one sample from a layer in the original pit construction and one sample from the central position of the larger construction. The larvae remains consist of small tubes of sand and plant fragments that the larvae build up as protection. These larval remains are very unusual to find in samples, since they are strictly living in natural aquatic environments, normally with some kind of flowing conditions. Almost all Trichoptera larvae live in fresh or brackish water: in this particular case, they were, together with the Cladocera, unambiguous indicators of an aquatic situation, open water surface and maybe a light current.

The total number of insect taxa identified from the site Lövstaholm is 48 from four wells, with a variation of habitat and substrate preferences for the insects through all layers of the well (Fig. 11). Contrary to the previously discussed wells from Vaxmyra and Kyrsta, one of four of the investigated wells in Lövstaholm is not so easy to interpret. The groups that partly dominate in different parts of the well are connected to wet and moist or dung (*Aphodius*) and decaying organic matter.

The dung beetles are very important finds in archaeological contexts and those found in Lövstaholm prove this very well. The dung beetle *Aphodius foetens* (well IIIa) lives on the dung from livestock, especially cows, on more exposed and sandy ground and *Aphodius granarius* (well IIIa, Fig. 11) is found in both dung and decaying plant material and carrion; the larvae of this beetle species are found in cow and horse dung. Other dung beetles identified were the two species *Aphodius sphacelatus* (wells IIIB and IVa, Figs. 4 and 11) and *Aphodius fimetarius* (well IIIb, IVa, Fig. 11); the larvae of these species live in dung from cow, sheep and horse.

Examples of species identified in samples from Lövstaholm that live in aquatic and moist environments are similar to the finds from Kyrsta. A difference is formed by the beetles of the genus *Donacia* (well IVa, Fig. 11), and although not identified to species level, members of this genus are found on water plants, *e.g.* leaves of

Figure 4. The dung beetle Aphodius sphacelatus. *A species commonly found in all kinds of dung, on open grazing areas. This species belongs to a group of dung beetles that also reproduce in other kinds of substrates than dung, like dung heaps (that may contain many kinds of substrates like dung, hay* etc.*).*

water lily. Other species found in addition to this are weevil species of the genus *Notaris*, which lives on vegetation in moist localities, for example *Carex*, Typha and Sparganium, and the weevil species *Curculio salicivorus,* which primarily feeds on *Salix*.

The results from well II provide a clear indication for aquatic and moist conditions in the bottom sample analysed (Fig. 11), but also indicate an open grazing area around the well, although there were remnants of beetles preferring open water with some depth, such as the diving beetle from genus *Agabus,* a species preferring aquatic environments and stagnant water. The water beetle *Orectochilus villosus*, found in running water, lakes and brackish water along the coast, was also found in well II along with the water beetle *Ochtebius minimus*, which is usually found in larger numbers, in the shallower parts rich in vegetation of all types of fresh water environments, stagnant and running water, and brackish water. There were similar indications in well II from the beetle *Limnebius truncatellus*, which lives in all types of running water in the shallower parts with vegetation such as grass and mosses. In a higher level of the well, there were species found in moist and/or aquatic environments and connected to grazing animals, for example dung beetles.

In the samples from Lövstaholm there were also indications for crops and vegetation typical of ruderal areas around settlements and spaces around buildings. Two beetle species living strictly on vegetation (*i.e.* phytophagous), *Phyllotreta vittula* and *Chaetocnema hortensis*, were identified. Species of the genus *Phyllotreta* are generally considered to be severe pests on different plants and *Phyllotreta vittula* is a pest on major agricultural crops in a broad sense. *Chaetocnema hortensis* is primarily found on plants of Poaceae spp. (grass). The picture of the cultivated fields and probable pests on crops was reinforced by the presence of the phytophagous beetle *Chaetocnema*, through the common *Chaetocnema concinna*, which is often found on cultivated plants such as beet (*Beta vulgaris*), on which it may feed, and plants of *Polygonum* spp. and *Rumex* spp., common plants within the family Polygonaceae. The ground beetle *Pterostichus cupreus,* which lives in open, but not too dry meadows and fields with rather dense vegetation, was also found. This ground beetle species is an example of insects favouring human activities and is often found on arable land, especially on areas with cultivated cereals. In the filling layer of well IIIb (Fig. 11), that lay above the bottom layer, the beetle *Aclypea opaca*, which was mentioned earlier, was found.

Discussion

A characteristic for this investigation is that at all studied sites, the use of several wells changed over time. This is most evident through the change from a human water source to a waterhole for livestock, together with change of the physical construction of the well. This change was probably determined by several reasons. One is the requirement of water for livestock and/or changed land use. This must be solved in a sustainable way in all households keeping livestock, and very likely for the whole year. Another reason may be that the water table in the well decreased and/or the quality of the water deteriorated, which is a problem today and was most certainly a problem during prehistoric times. The change in use in this way probably reflects human activities to arrange the water supply during the year and to have a surplus of fresh water close to the activity areas. In the studied wells, the pattern of change in the use of wells differs between sites. The site Vaxmyra represents the basic system of water management for a settlement, a well constructed for fresh water for people and changed at a later stage into a waterhole for livestock. The site Kyrsta represents a successful example of interaction between natural water resources in the landscape and human constructions above the basic water management. The site Lövstaholm, on the other hand, represents a problematic situation where the well and the natural river create a damp and moist situation due to the wells being close to the river, which flooded repeatedly, probably creating poor conditions at the site.

At Vaxmyra the well (Fig. 5) seems to have changed in use to secondary use for other purposes. The bottom layer (S1) corresponds to a typical situation when the well was actively used as a water source for humans, with a more varied picture from the beetles since the influx of insects is determined more by random causes, *i.e.* different surrounding environments (Fig. 6). The interpretation of the landscape

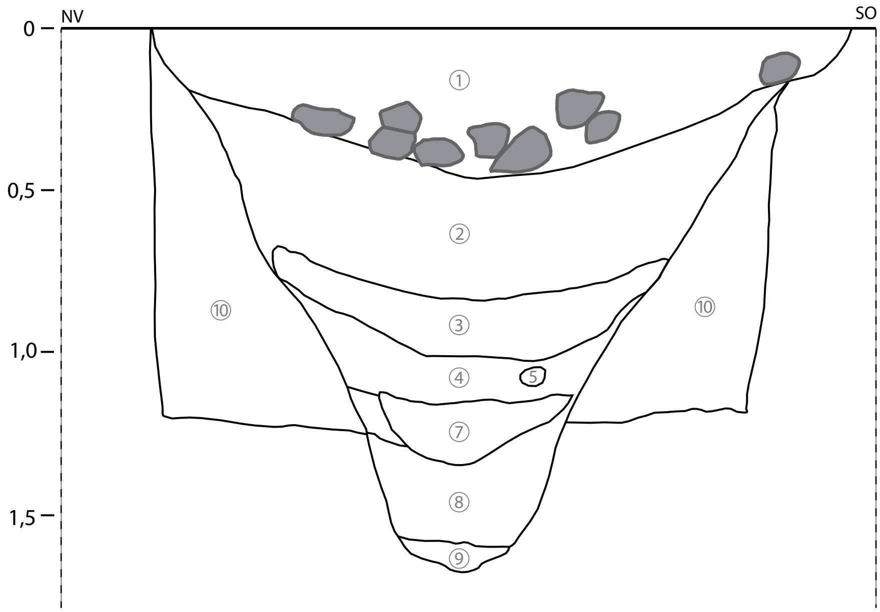

Figure 5. The well that was developed into a waterhole for livestock at Vaxmyra. The layers are built up of clay with different colours and charcoal, wood etc. *The grey indications are stones. Samples for insect analysis are named as S1 (layer 9), S2 (layer 7) and S3 (layer 3). Figures mark different stratigraphical layers (Håkan Thoren after Fig. 91 in Eklund 2005).*

surrounding Vaxmyra from the insect assemblage is as an open and diverse cultural landscape with arable land, both closer to and further away from the settlement. There were few aquatic species in the sample from the bottom layer of the well, possibly caused by the well being too deep or covered, hiding the water mirror in the bottom.

There are indications for plants in the surroundings, indicating both dry and moist water margins. Higher up in the stratigraphy there are indications for cultivated plants and human buildings close to the well, maybe both crops and stored products attacked by pests and infestation in a storage facility at the settlement.

However, the part above the bottom of the well (S2) was composed of infilling by organic debris and therefore represents a transitional layer between the two bottom situations. Simultaneously, the species indicating moist and/or wet conditions increased, which contradicted the interpretation as filling layer. The insects could originate from a smaller river north of the settlement area as several species are found in aquatic situations.

In the most central part of the well (S3), there were also species indicating an aquatic environment in the well, an open water surface, and a period when the well had a water table, at least temporarily. This combined with an increased presence of dung beetles (*Aphodius*), indicating grazing, points to a construction that was used as a waterhole for livestock, similar to the other studied wells. Vaxmyra is

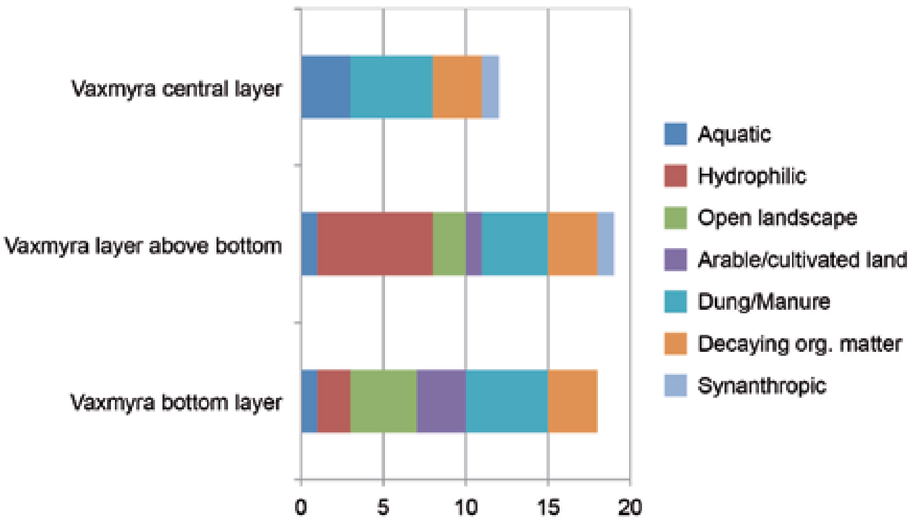

Figure 6. Diagram of the habitat preferences of Coleoptera for selected habitats or food substrates from the well at Vaxmyra, which changed from a well into a waterhole for livestock. The calculations are based on the number of individuals. Some species indicate more than one habitat. Habitat preferences: Aquatic; Hydrophilic (i.e. *moist and water margins); Open landscape (in a general sence); Arable/Cultivated land; Dung/Manure; Decaying organic matter* (i.e. *compost, moulding organic matter* etc.*); Synantrophic* (i.e. *close connection to/ favoured by human environment and activity) (Hellqvist 2005).*

situated in the lower part of a valley; thus, the hydrological conditions would have been suitable for using this construction as a waterhole when it was abandoned as a water supply for humans.

Also in Kyrsta, wells were sometimes used for other purposes than as a water source for people. One well, dated to the late Neolithic and thus earlier than the focus of this paper, appeared to be a well construction with the typical funnel-shaped form; however, in the centre of the construction, there was an urn covered with a boulder that was surrounded with stones in a ring. It was primarily a well for fresh water, but was then filled up to a new higher level in the construction and secondarily used as grave. The sample from the bottom layer offered only remains from one beetle that could be identified to species level, the beetle *Atholus corvinus*. It is common today and found in different types of environments and substrates such as dung, compost and carrion although it is only found in sandy places and along coastal shores, and could indicate the closer location to the sea (Baltic Sea) during late Neolithic times than today.

A large well construction with a diameter of 600 cm and a maximum depth of 260 cm and with an obvious secondary purpose was excavated at Kyrsta (Fig. 7). The construction comprised two pit holes, a small pit to the east and a larger pit towards the west, cutting through the eastern part and postdating this. The former pit had a twig construction in the bottom, and remnants from this were found in the bottom layer of the final pit hole. The construction history was unclear in the bottom layers, but the larger main well construction appeared to have been

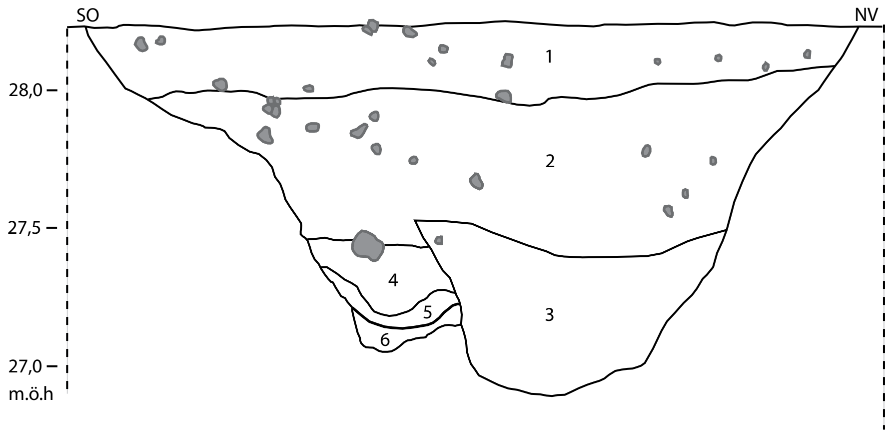

Figure 7. Plan and profile of well IIa-d, which was developed into a waterhole for livestock (A49309) at Kyrsta. The layers are mainly built up of clay with varying contents of charcoal, wood etc. *The grey indications are stones. Figures mark different stratigraphical layers (Håkan Thoren after Fig. 27 in Onsten-Molander and Wikborg 2006).*

widened through the smaller well construction. Supplying fresh water must have been the main purpose of the construction; but it was the layer sampled centrally that provided strong evidence for a freshwater situation.

The aquatic situation at the bottom of the original excavated pit was proven by subfossil insect remains. However, the insects also indicated natural water situations in the close surroundings, such as a small river. Obviously, people have used both resources to solve the water situation already from the beginning of the construction of the well, a way to guarantee available abundance of water.

The picture changed drastically in the later history of the well construction, which is obvious from the sample from the centrally situated layer higher up in the construction (Fig. 8). The sample is rich in remains of Chironomids (mosquitoes) larvae, egg capsules of Cladocera (water flea), and finds of both adults and larvae remains of Trichoptera (caddis fly). Together these insects indicate open, fresh water conditions and a high water table in a small water collection; therefore, they are strong indicators of an aquatic environment, at least periodically. The more confusing part of the finds is the Trichoptera larval remains, since they strictly live in natural aquatic environments and normally with some kind of flowing conditions. The strong indicators of aquatic and moist soil conditions were also present in the results from the total insect assemblage in the same layer. There were also dung beetles (*Aphodius*), therefore, in a later phase, when the larger construction was in use, there must have been grazing animals present, such as cows, horses and sheep.

The most probable conclusion is that the well was primarily constructed for fresh water for people, in the form of a smaller well pit. Later a new small pit was constructed that was widened and partly filled in for use as a water supply for grazing animals, which could also explain the larger circumference of the well. But some of the finds, like the Trichoptera larvae, provide a more diverse picture, and reveal an obvious connection between the man-made constructions for fresh water

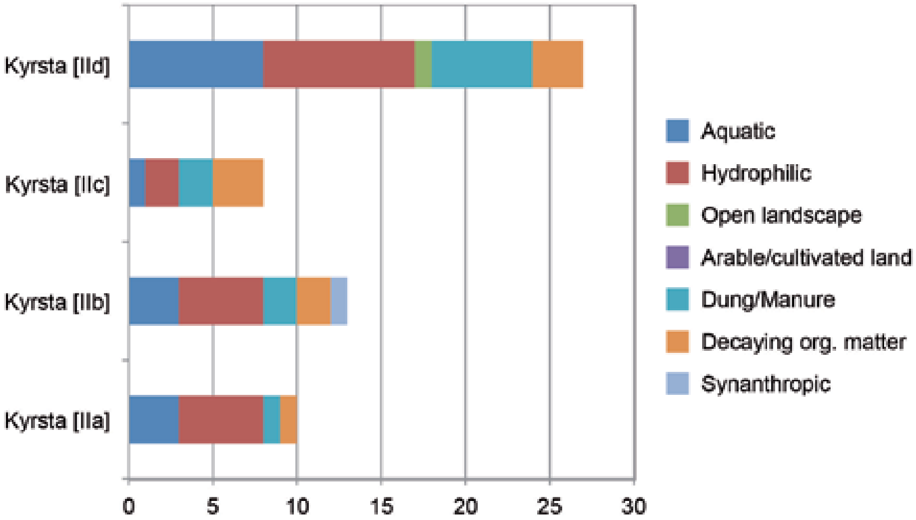

Figure 8. Diagram of the habitat preferences of Coleoptera for selected habitats or food substrates from four samples from the well that was developed into a waterhole for livestock at Kyrsta (Hellqvist 2006). The calculations are based on the number of individuals. Some species indicate more than one habitat. For habitat preferences, see Figure 6.

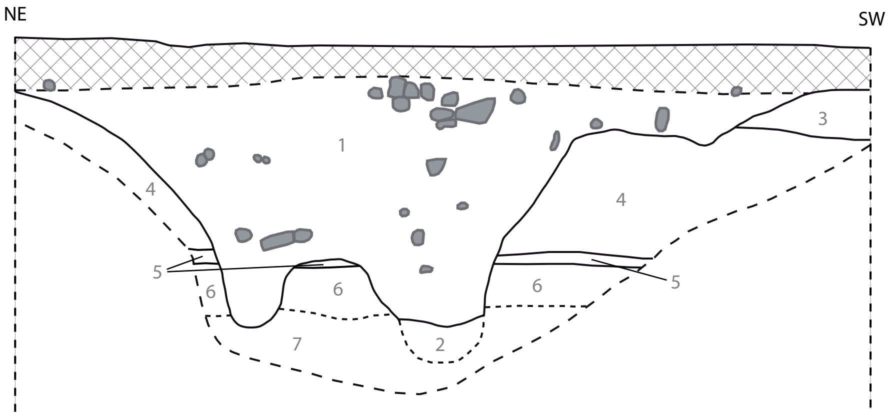

Figure 9. Profile of the northwestern part of well IVa-b, which was primarily constructed as a waterhole for livestock (A11632) at Lövstaholm. The layers are generally clayey with varying contents of charcoal, wood etc. *Figures mark different stratigraphical layers. The top layer is a post-dating cultural layer covering the well (Håkan Thoren after Fig. 13 in Häringe Frisberg* et al. *2007).*

and the natural resources available. Both resources have been used simultaneously, and the finds of the Trichoptera larvae point to the solution that natural water in the surroundings was redirected through the constructed larger pit ("well") to function as a sustainable waterhole for livestock. The solution probably provided water close to the settlement and animals year round, with the winter being the most difficult period.

Similarly, a well found at Lövstaholm (IVa-IVb) had been turned into one larger construction from two smaller pits (Fig. 9), but there were no obvious indications in the stratigraphy that the two pits had been two singular pits and/or wells from the beginning. The most probable interpretation is that the two smaller pits originally functioned as singular smaller wells, later connected to each other and turned into one larger construction. The combined larger construction served a new purpose as a water source for livestock in the settlement.

Two samples of macrofossil insect remains were analysed from the larger construction, one from the bottom layer of the former pit/former well (well IVa, Fig. 11) and one from the central layer of the enlarged construction (well IVb, Fig. 11), covering both unified pits in the larger construction. There was an aquatic and moist situation already from the beginning of the constructed well, indicated from species living in these situations.

The results from the bottom sample indicate open ground around the well and an open landscape around the settlement with grazing animals, an interpretation based on beetle species indicating these environments and substrates, like ground beetles (*Carabidae*, Fig. 10) hunting on open ground and dung beetles (*Aphodius*) living on fresh dung from grazing animals. This was also supported by the presence of *Cryptopleurum minutum*, a common beetle in all kinds of moulding organic material, dung and carrion. Contemporary analysis of macrofossil plant remains indicates a cultural landscape with arable land and probably grazing close to or in the direct vicinity of the well, together with a moist environment (Ranheden 2007).

The interpretation of the environment for the other two studied wells (II, IIIa-n) indicates a similar situation: a moist and sometimes shadowy place, although there were signs of both standing and moving water and a periodic permanent aquatic environment. The species found are usually connected to aquatic habitats with clay sediments and with a higher degree of vegetation at the bottom. There are also indications of species that live in compost, mosses and places with higher vegetation or leaf vegetation on organic rich soils, such as marshes with a vegetation of *Salix* (willow). Even if the insects found did not live directly in the well, they may have been deposited into the well from their natural aquatic environment through being drowned in the well or through infilling material. In the filling layer that lay above the bottom layer the picture of the cultivated fields and probable pests on crops was reinforced by the presence of the phytophagous beetles and for example the beetle *Aclypea opaca*, classified as a pest on beet. However, as no remains from these plants were found at the site, this is seen as an indication of ruderal plants within the family Polygonaceae.

The wells appear to have been situated within a meadow or similar grazing area connected to the settlement and at the edge of or within arable land surrounding the settlement. Together, all these indications of grazing, open areas with grass and arable land suggest a moist activity area with grazing, close to or near arable land,

Figure 10. The ground beetle (Carabidae) Calathus melanocephalus. *A species occurring in the litter layer of decidous forests, more rarely in coniferous forests, and especially in light stands of beech. It is also found in parks and gardens. It is recorded to prefer mull-soils (Lindroth 1986).*

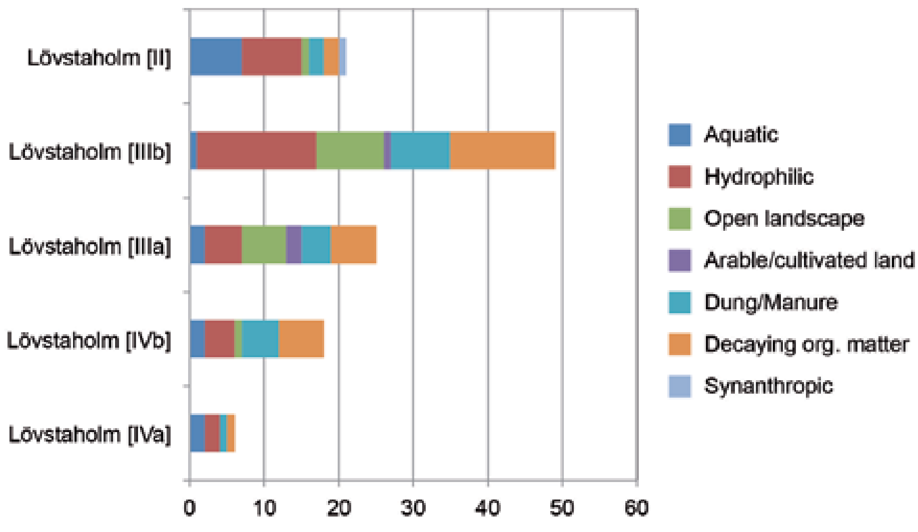

Figure 11. Diagram of the habitat preferences of Coleoptera for selected habitats or food substrates from samples from wells II, III and IVa-b at Lövstaholm (Hellqvist 2007a). The calculations are based on the number of individuals. Some species may indicate more than one habitat. For habitat preferences, see Figure 6.

and could mean the Iron Age people at Lövstaholm had severe problems with pests on crops.

Although it is difficult to reconstruct the palaeohydrological situation for the local area, one possible reason for locating the waterhole in this situation would be to facilitate ground water inflow to this spot, thus creating a natural waterhole for animals available during the whole year and thus providing a surplus of water for the settlement economy. However, the river Samnan is situated very close to the site; therefore, the underlying reason for the purpose of the wells is unclear. Many of the species found would have originated primarily from the natural situation in the river environment and secondarily found their way into the well, while searching for other environments in the area. This 'exchange' between the natural environments is a scenario observed in previous investigations in the region (Hellqvist 1999).

The results also reveal an apparently moist and aquatic environment, with periods of relatively high water tables in the well. Aquatic beetles often fly around looking for new habitats and the water table needs to be high for them to have been attracted by the well. Aquatic insects would be present in the air around the settlement, because of the Samnan River, and the population might have increased when the river flooded and covered the valley bottom and the wells with water. Some aquatic beetles are also connected to brackish water and could have originated from the Baltic Sea coast, as the site was situated much closer to the sea during this time. From the assemblages found in the wells, the site at Lövstaholm appears to be characterised by moist conditions; this may have been a problematic area for people living at the settlement, partly caused by repeated flooding of the small river (Samnan) at the bottom of the valley.

Conclusions

Wells have played an important role in people's daily life by supplying fresh water, both during prehistoric and historic times. Nevertheless, it is difficult to reconstruct the former hydrological situation and the problems people had to deal with. By looking into the actual situation in and around the archaeologically excavated settlement, there is a possibility to get closer to this issue. It is most probable that people aimed to create sustainable solutions for their fresh water supply in the immediate surroundings of the settlements, by using both natural resources and by developing constructions like wells, and in this way creating a surplus of water to avoid water shortages.

The study emphasises that the construction of a well may have many types of use. A typical situation for the wells investigated was a change from primary use for humans to a secondary use as a waterhole for livestock. Sometimes the primary purpose was to create a waterhole for grazing animals. This raises the possibility that some constructions and features found during archaeological excavations, interpreted as common pits or just unidentifiable holes, may in one way or another primarily have been part of the effort to manage the water supply.

A well is a water source together with other water supplies in the surrounding landscape. There is a diffuse relation between the role of these wells and different natural sources, such as natural springs, brooks, rivers and lakes near the settlements, which must have played an important role as water sources. Wells must have had a complementary function to these natural resources. During the winter period, the water supply would have been more problematic to arrange, because of winter conditions and frozen natural water supplies, but running water may still have been more or less open and available. However, all the wells investigated appear to have played some role in a system of solving the water supply. The well from Kyrsta provides a solution with a strong indication for redirected natural water through the well construction, probably to keep the water table high. The wells in Lövstaholm give insight into problems with solving the situation due to the severe impact from flooding of the natural river.

The results from the work presented here highlight the importance of understanding the interaction between humans and water in the landscape, which can be considered the most important natural resource for human settlement.

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The Late Iron Age-Roman transformation from subsistence to surplus production in animal husbandry in the Central and Western parts of the Netherlands

Joyce van Dijk[1] *and Maaike Groot*[2,3]

1. Archeoplan Eco
Oude Delft 224
2611HJ Delft
The Netherlands
joyce.vandijk@archeoplan.nl

2. Department of Archaeology, Faculty of Arts
VU University Amsterdam
De Boelelaan 1105
1081HV Amsterdam
The Netherlands
m.groot@vu.nl

3. Integrative Prähistorische und Naturwissenschaftliche Archäologie
University of Basel
Spalenring 145
CH-4055 Basel
Switzerland

Abstract

The arrival of the Romans in the Netherlands caused a transformation in the agrarian economy south of the river Rhine from a self-sufficient to a surplus-producing system. It is still not well understood how the farming communities achieved this change in their economy. By studying the animal husbandry of two regions, modern South Holland and the River Area – roughly coinciding with respectively *civitas Cananefatium* and *civitas Batavorum* – and focusing on the Late Iron Age to Early Roman transition, a better understanding of the factors facilitating the surplus production of animals is reached. The data of a large number of sites from both regions is used to demonstrate changes in species proportion, mortality profile and withers heights during the Middle Iron Age to the Early/Early Middle Roman Period. Based on Roymans' model of a cultural valuation of cattle – instead of a purely economical one – and a breeding strategy aimed at obtaining a large herd as a sign of wealth and as means of gift exchange, it is argued that this cultural surplus was transformed into an economic surplus in the Early Roman Period.

Keywords: *Iron Age, Roman Period, animal husbandry, surplus, cattle as wealth, the Netherlands*

Introduction

The incorporation of the southern half of the Netherlands into the Roman empire had a major impact on the agrarian economy of the region. The arrival of the Romans meant that the local agrarian population now lived side by side with a population that relied on others to produce their food. While there is evidence for food supply from outside the region (mainly bread and spelt wheat and 'exotics' such as wine; Kooistra 2009), much of the meat is assumed to have been supplied by local farmers (Groot 2008b; Groot in prep.; Filean 2006; Robeerst 2005, 88; Whittaker 2002). Finds of imported materials such as pottery and Roman coins in rural sites indicate that rural communities were incorporated into Roman trade networks. Developments in agriculture suggest that this was a result of their ability to produce surplus food (Groot *et al.* 2009; Groot and Kooistra 2009; Groot 2008a; Groot 2008b). Thus, the agrarian economy south of the river Rhine changed from mainly self-sufficient to surplus-producing. Farmers still produced most of their own food, but now they also produced a surplus that was transported to the army camps and urban settlements, whether it was in the form of taxation or trade. The rise of towns such as *Ulpia Noviomagus Batavorum* (Nijmegen) and *Forum Hadriani* (Voorburg) may not have been possible without local food supply.

How these farming communities managed to achieve the transformation from subsistence to surplus production is still not well understood. This paper will investigate this issue through a case study of animal husbandry in two regions south of the river Rhine, focusing on the Late Iron Age to Early Roman transition. The two regions are the modern province of South Holland – roughly coinciding with the Roman *civitas Cananefatium* – and the Central and Eastern River Area – the Roman *civitas Batavorum* (Fig. 1). Both were part of the province of *Germania Inferior* from *c.* AD 85 onward.

The geological situation in the research area is quite diverse, with an alternation of sand dunes, clay and peat in South Holland, and an alternation of low-lying, clayey flood plains and higher, sandier levees in the Central and Eastern River Area. The land suitable for arable crops was limited, but there was more space for grazing livestock. The main risk was flooding, by rivers and the sea. The agrarian settlements in the research area were small, consisting of one to five farmhouses. People lived in byrehouses, together with their livestock (cattle, sheep, pigs and horses). Their means of subsistence was mixed farming, with the cereals emmer wheat and barley as their main crops (Kooistra 2009, 223). There are no indications that Iron Age communities were not self-sufficient in their food. In the Roman Period, settlements became more diverse, with military camps, towns and *vici* arising, while rural settlements were still found in the countryside. In the 1st and 2nd centuries AD, cattle were the main meat provider in most of the army camps (Cavallo *et al.* 2008, 72-3; Kooistra *et al.* 2013). Assuming that cattle were supplied by local communities, they are one of the likeliest surplus products of rural sites in the two regions.

Roymans' (1999) paper on cattle in Iron Age and Roman Northwest Europe describes a model in which cattle are highly valued for their cultural significance. Although Roymans' research area is much larger than ours, it includes both our study regions (Roymans 1999, 291). According to Roymans, the economic significance of cattle has been overemphasised, at the expense of the social and ideological dimensions of man-cattle relationships. He assumes that cattle were kept primarily for milk; meat consumption was related to ritual and ceremonial activities.

Roymans uses several kinds of evidence to support the cultural significance of cattle. First, livestock farming was dominated by cattle. The high proportions of cattle seen in his research area – since the Late Neolithic – are not found in other areas in Northwestern Europe (Roymans 1999, 292). Second, the byrehouse, which housed man and cattle under the same roof, is typical for this part of Northwestern Europe. Distribution of this house type seems to coincide with the area where high proportions of cattle are found. The sharing of living space is an expression of the cultural valuation of cattle (Roymans 1999, 293). A second, more practical reason for stabling cattle is the collection of manure (Zimmermann 1999). Third, there is evidence that cattle were used as a medium of gift exchange, as Roymans shows. This role of cattle is well-known from ethnographic parallels of other cattle-dominated economies, such as Early Medieval Ireland and submodern Northeast Africa. Owning cattle was a sign of wealth, and cattle were exchanged on social occasions such as marriage (Roymans 1999, 294).

Quotes from Tacitus suggest that cattle had a similar role in Late Iron Age Northwestern Europe, where they were used as a medium of exchange in marriages and to pay fines (Roymans 1999, 294; *Germania* 12, 18, 21). In Early Medieval Ireland and Northeast Africa, the role of cattle as a means of payment was gradually replaced by coins. In Northern Gaul and the Rhineland, Celtic coins were introduced in the Late Iron Age. However, in the region where byrehouses dominate no coins are found in this period. According to Roymans the widely accepted role of cattle as a means of payment delayed the use of coins (Roymans 1999, 295). The small size of cattle is a final argument for their role as a standard of value, with quantity being preferred over quality (Roymans 1999, 295). Roymans' model has important implications for the surplus production of cattle. At some point the purpose of producing a surplus of cattle changed from increasing one's wealth to reacting to a market demand. This change should be visible in the archaeozoological record.

The main research question of this paper is: in what respects did the Late Iron Age animal husbandry system change to incorporate the Roman demand for agrarian products? To answer this question and put it into a regional context, several sub-questions need to be addressed:

- Do the two study regions show changes in species composition over time?
- What can we say about (changes in) the exploitation of livestock? Do the zooarchaeological data from our regions support Roymans' model? If they do, then how can the idea of cattle as money explain the easy transition to surplus production?
- What evidence is there for surplus animal products in the Early Roman Period?
- Do the two regions show different developments in animal husbandry?

Methods

This paper will discuss zooarchaeological data from two regions - the River Area and South Holland – and three time periods: the Middle Iron Age (500–250 BC), Late Iron Age (250–12 BC) and Early/Early Middle Roman Period (12 BC–150 AD). We have chosen to include the Middle Iron Age in our study, in order to trace developments that were already going on during the Iron Age. The choice for the two regions is based on the likelihood that they were involved in

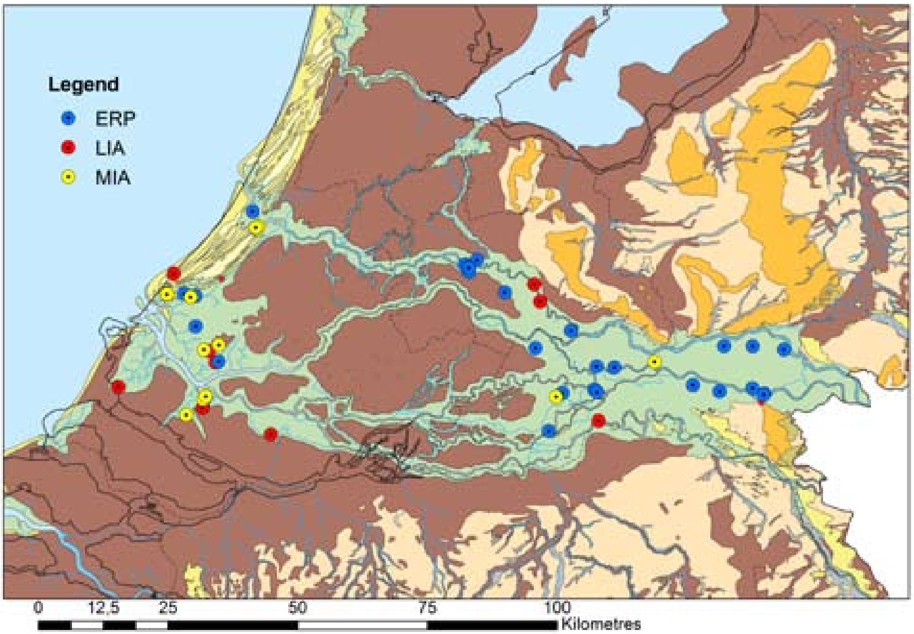

Figure 1. Paleogeographical map of the centre of the Netherlands with sites included in this study. MIA: Middle Iron Age; LIA: Late Iron Age; ERP: Early Roman period (E.G.C. Dullaart. Paleogeographical map after Vos et al. *2011).*

surplus production in the Roman Period, and that they provide a good amount of zooarchaeological data, due to preservation conditions. The regions developed slightly differently over time. On the one hand, the geology of the two regions is different and this may have had an effect on animal husbandry. On the other hand, the cultural differences may have developed as a result of the respective proximity to the Roman border, the *limes.* Many of the sites in the River Area are very close to the *limes*.

A major difference between the two regions is found in the continuity or discontinuity of habitation in the Early Roman Period. Continuation in the occupation of South Holland between the 1st centuries BC and AD has not convincingly been proven (Eimermann 2009, 188; De Bruin 2005, 27). The settlements in this region cannot be dated earlier than the second half of the 1st century AD (Van der Feijst *et al.* 2008, 203). Only one site has a possible starting date in the first half of the 1st century AD (Van Londen 2006, 159, 172). In the River Area, on the other hand, there are no signs of a gap in habitation.

A total of 23 sites was included for South Holland, while a total of 35 assemblages from 29 sites was available for the River Area (Tables 1 and 2; Fig. 1). One problem in our data that is immediately visible is the discrepancy in the number of sites per period for the two research areas. While the Iron Age is best represented in South Holland, the Roman Period is much better represented in the River Area. Several sites had to be discarded due to dates that overlapped two periods. The period referred to here as the Early/Early Middle Roman Period includes the Early Roman Period (12 BC–AD 70) and the early part of the Middle Roman Period (up to 125/150 AD). The reason for this is pragmatic: due to the gap in habitation, there are no sites in South Holland with Early Roman phases. The only way to trace developments in animal husbandry over time, and compare them between the two regions, is to widen the time period to include the available sites for South Holland. The study is limited to rural settlements because our research question is concerned with the local animal husbandry system and its possibilities to change from self-sufficient to creating a surplus. The focus will therefore lie on sites where farming was practised, and not on towns or army camps.

Our study focuses on three aspects: species proportions (between the three main meat species cattle, sheep/goat and pig, and of horse compared to the main meat species), slaughter ages of cattle and sheep (the other two species were excluded because of a lack of data) and withers height of cattle, sheep and horse.

Analysis of slaughter ages is primarily based on epiphyseal fusion. While tooth eruption and wear generally provide more detail, and have less to suffer from taphonomic biases, too few mandibular data were available for sites in South Holland and Iron Age sites in the River Area to allow a meaningful comparison. Furthermore, not everyone uses the same methods to age mandibles, which means the data are not always comparable. This problem affects the epiphyseal fusion data to a lesser extent. Mandibular data are discussed briefly where available in addition to epiphyseal fusion. A minimum of 20 scored epiphyses per site was used. This is still low, and the size of the data set will need to be taken into account in the interpretation of the data. Because the number of epiphyses was low in most sites, we have used a basic age classification, which should show broad trends. For cattle, the classification is: 0-2 years, 2-4 years and older than 4 years. For sheep, the classification is: 0-2 years, 2-3.5 years and older than 3.5 years. The advantage of using a broad age classification and comparing it to very basic production models (milk-meat-traction/wool) is an increased chance of matching data to a production model (Marom and Bar-Oz 2009, 1186). A disadvantage is that the long time span of the youngest age category hides any evidence for dairying.

Traditionally, research on measurements of animal bones in the Netherlands has focused on reconstructed withers height. While the use of raw measurements may be preferable, we have chosen to use withers heights because most publications contain information on withers height, but do not always include raw measurements. The calculation of withers height is based on Von den Driesch and Boessneck (1974) and Matolcsi (1970) for cattle, Teichert (1975) for sheep[1] and May (1985) for horse.

Surplus production in animal husbandry can be difficult to identify, especially if animals were transported on the hoof to the location where they were slaughtered and consumed. No direct evidence will then be left at the site where the animal was bred. Only a review of producer and consumer sites will give insight into this topic but that is beyond the scope of this study. Earlier studies by Groot (2008b, 87; Groot *et al.* 2009, 233, 234) demonstrate that major changes in animal husbandry using species composition and mortality profiles can indicate a surplus. However, the scale of the surplus is difficult to assess. Animal bones cannot be quantified to that end. The size of stables can only give an estimate of the minimum number of animals, since it is likely that not all animals were stabled (Zimmermann 1999). However, to use stable size to estimate minimum herd sizes it is necessary that settlements are excavated entirely, and that the number of byrehouses in use at the same time is known (Groot *et al.* 2009, 234). For most of the sites in our research area, this is not the case. Another complicating factor is that different kinds of livestock may have been stabled. In this study, we will attempt to identify surplus production by changes in the species spectrum, changes in the exploitation of livestock and changes in the size of animals. Changes in size can reflect changes in exploitation.

Results

Tables 3 and 4 provide a summary of our data. In the River Area, cattle are the dominant species at most sites, with four Early/Early Middle Roman exceptions, where sheep/goat is dominant (Table 1). The average proportion of cattle increases from 54 % in the Middle Iron Age to 70 % in the Late Iron Age (Table 3). In the Early/Early Middle Roman Period, the proportion decreases to 56 %. The proportion of sheep/goat shows a decrease from 28 % to 22 % in the Late Iron Age, followed by an increase to 35 % in the Early/Early Middle Roman Period. Pig proportions decrease in the Late Iron Age and show little change in the Early/

1 Goat is found in our study area, but generally in much smaller numbers than sheep. The majority of the fragments identified as sheep/goat are likely to be from sheep.

Early Middle Roman Period. Proportions of horse are always variable, but it is only in the Early/Early Middle Roman Period that high proportions are found. Some of the variety in the species composition can be related to the dates of the assemblages, with the high values in horse mostly dated between 50 and 150 AD, and the high values in sheep dated before 70 or 100 AD.

In South Holland, cattle are the dominant species at all sites and in all periods. The average proportion of cattle is stable through time, but the range of proportions does show a development, with the lower numbers increasing in the Late Iron Age, and the higher numbers decreasing in the Early/Early Middle Roman Period (Table 4). Sheep/goat shows a slight increase from the Middle to Late Iron Age, and an even slighter one in the Early/Early Middle Roman Period. The proportion of pig shows a small decrease over time. Horse seems to be stable throughout the Iron Age and shows a slight increase in the Early/Early Middle Roman Period. Overall, there seems to be less development in species composition in this region compared to the River Area.

Slaughter ages for cattle in the River Area show a clear development over time (Table 5). While the majority of cattle are killed as adults in the Middle Iron Age, slaughter peaks are found in the two lowest age categories (0-2 years and 2-4 years). Since this is based on only two sites, it is unclear whether this is representative for the period. In the Late Iron Age, much higher proportions of cattle reached adulthood than before. In the Early/Early Middle Roman Period, some sites still have high proportions of adult cattle, but more sites show high slaughter rates in the middle age category (2-4 years). Slaughter ages based on mandibles show a reversed pattern for the Iron Age, but this is based on only two sites. The slaughter age pattern for the Roman Period does not change.

In South Holland, high proportions of cattle reach adulthood in both the Middle and Late Iron Age, with a slight increase in slaughter age in the Late Iron Age (Table 6). In the Early/Early Middle Roman Period, slaughter patterns are variable, with some sites still showing high proportions of adults, while others show slaughter peaks in the youngest age category (below 2 years). Mortality profiles based on mandibular tooth eruption and wear show younger slaughter peaks for the Middle Iron Age and Roman Period. No mandibular data are available for the Late Iron Age.

Mortality profiles for sheep/goat in both Iron Age periods in the River Area show slaughter peaks in the middle age category (2-3.5 years; Table 7). This changes little in the Roman Period, except that two of the sites now also show a peak in the youngest category. In South Holland, there is no development over time (Table 8). Sheep/goats are mainly killed in the two youngest age categories. One Early/Early Middle Roman site shows a slaughter peak in the oldest category.

The withers heights of cattle in the River Area show an increase in size over time (Table 3). Sheep/goat shows a slight increase in size in the Early/Early Middle Roman Period. Horse decreases in size in the Late Iron Age, combined with a wider range, followed by an increase in size in the Early/Early Middle Roman Period. In South Holland, no data on withers heights are available for the Late Iron Age. The average for Roman cattle is smaller than for the Middle Iron Age, while the Roman sheep are larger than the Middle Iron Age sheep (Table 4). No development can be traced for horse in this region, since withers heights are only available for the Roman Period.

Discussion

Cattle dominated the species spectrum at all sites in both regions in the Iron Age (Figs. 2, 3 and 4). The dominance of cattle fits with the existing data published by Roymans (1999, Fig. 2). The idea of a pastoral economy based on cattle clearly applies to our two regions. The mortality profiles for cattle in the Late Iron Age in both regions show that the majority of cattle reached adulthood. Traditionally, high slaughter ages are seen as a reflection of the exploitation of secondary products, such as milk, traction and manure. Since there seems to be no evidence for milk production (based on the mandibular data), traction and manure would be the likely products in our regions.

However, an alternative explanation is provided by Roymans' model of cattle as items in a system of gift exchange. Cattle circulated in society through social transactions, for instance as bridewealth. In a society where cattle provide the main means of exchange, we would expect to find large herds with high proportions of adults. An ethnographic example is Swaziland where cattle are held as income but also as a store of wealth. Apart from a role as cash value to satisfy the current

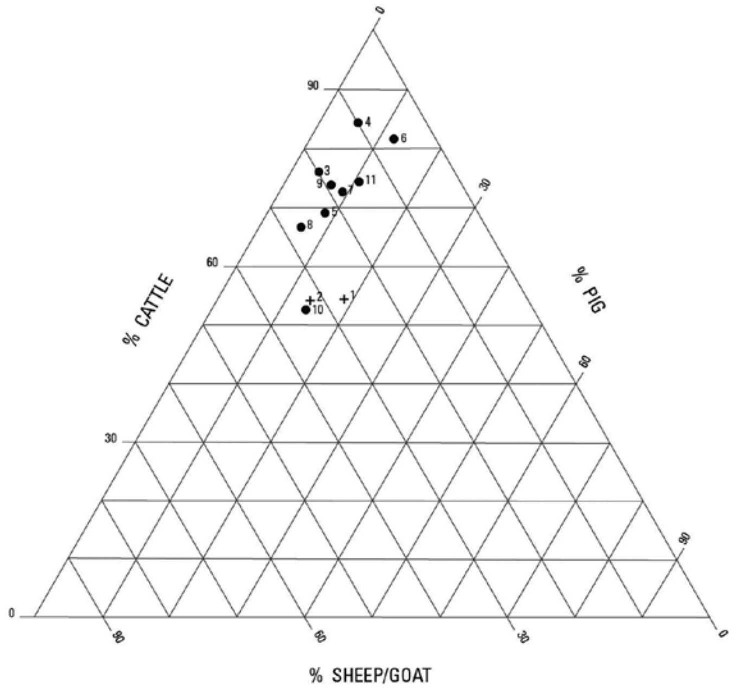

Figure 2. Tripolar diagram showing the proportions of the three main species for the Middle Iron Age. Crosses: River Area; dots: South Holland.

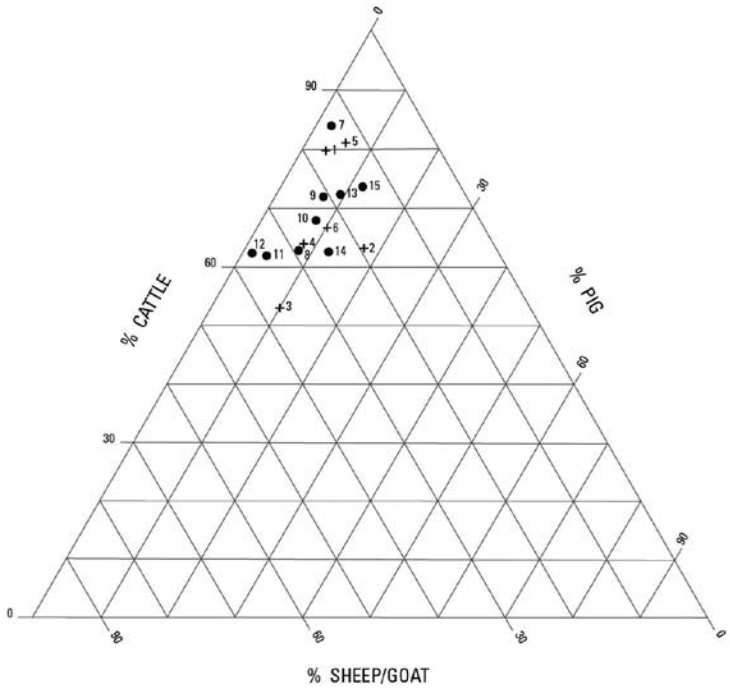

Figure 3. Tripolar diagram showing the proportions of the three main species for the Late Iron Age. Crosses: River Area; dots: South Holland.

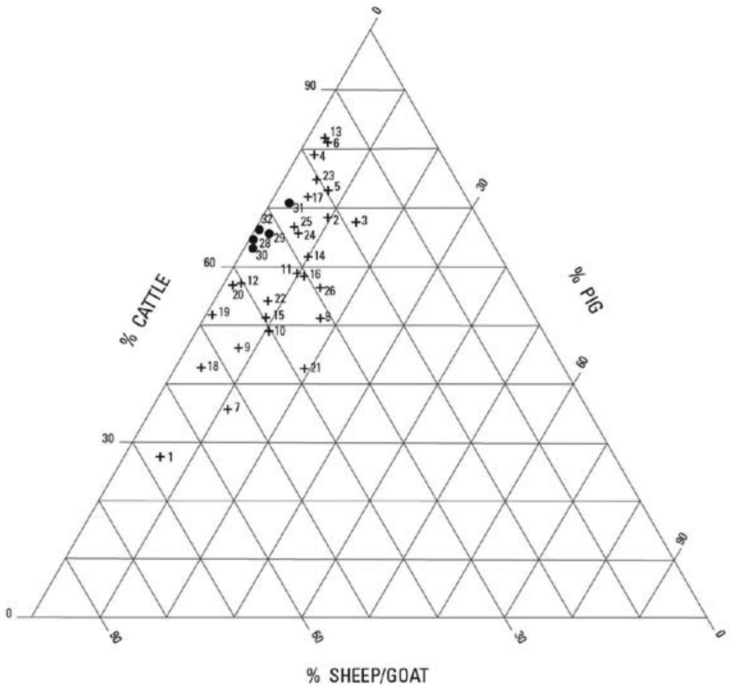

Figure 4. Tripolar diagram showing the proportions of the three main species for the Early/Early Middle Roman Period. Crosses: River Area; dots: South Holland.

consumption needs, the number of cattle is important in terms of security, prestige and status (Doran *et al.* 1979, 42).

Especially of interest is the mortality profile of the Swazi herd. It shows that 60 % consists of animals older than three years (Bishop 1974 in Doran *et al.* 1979, 42). This is similar to the high slaughter ages of cattle in the Iron Age, so in that respect our data fit the hypothesis of cattle as a means of exchange. Roymans claimed that the lowest withers heights are found in the Late Iron Age (1999, 295); based on the available data, this point may have occurred earlier in the River Area, because cattle withers height in the River Area is lowest in the Middle Iron Age. However, the number of measurements for the Middle Iron Age is low, so a comparison between the Late and Middle Iron Age is of limited value. Unfortunately, for Late Iron Age South Holland no data on withers height were available.

According to Filean (2006), smaller mammals such as sheep, goats and pigs are not suitable as a representation of wealth. Classification of something as wealth depends on its scarcity, durability and mobility. Compared to sheep, goats and pigs, cattle have a low reproductive rate and are therefore relatively scarcer than smaller mammals. Combined with a long lifespan, cattle fulfill all criteria, while sheep, goats and pigs only fulfill the last one (Filean 2006, 104). On the other hand, the smaller domestic mammals are eminently suited as meat providers in small communities, as animals can be taken from the herd for slaughter more often without endangering herd security; furthermore, the smaller amount of meat available per animal prevents waste (Filean 2006, 98). The mortality profiles for sheep and goats in the Iron Age remain the same in both regions, and suggest that sheep and goats were exploited mainly for meat.

To sum up, the pastoral side of the Iron Age agrarian economy had a strong focus on cattle. Cattle were small in size, and mainly slaughtered as adults. They were certainly killed for meat, but their role alive was more important, as objects of value. Cattle were also important for arable farming, as providers of manure and traction. Herds were probably larger than necessary from a strictly subsistence point of view in order to be used as an item of gift exchange. Sheep and goats were mainly kept for their meat.

Cattle were still the dominant species in South Holland and in most sites in the River Area in the Early/Early Middle Roman Period, but a few sites in the latter region show a dominance of sheep/goat. Sites in the River Area also show more variation, but this could be a result of the large number of sites. Most cattle reach adulthood, but a larger part of the herd is slaughtered at a young age in the River Area. This can be interpreted as an increased emphasis on meat production. In South Holland two sites have a rather high proportion of young cattle and this could indicate dairying, but because of the broad age category we cannot be certain. The increase in withers height for cattle noted in the Early/Early Middle Roman Period in the River Area '*implies a changing attitude towards cattle, with more emphasis being laid on their economic dimension within the context of an expanding market economy*' (Roymans 1996, 48). Therefore, the size increase may be related to the abandonment of the role of cattle as a medium of gift exchange (Roymans

1999, 296). In accordance with this changing role, a practical desire for larger cattle, either for beef or for traction, may also have been a stimulus.

So far, we have attributed the changing role of cattle to the increased demand for food in the Early Roman Period. An alternative explanation is that it is related to ethnic changes. The River Area saw a major ethnic change in the 1st century BC, when Batavian immigrants moved there. However, this did not result in an archaeologically visible discontinuity in habitation. In South Holland, continuity in habitation cannot be demonstrated between the late 1st century BC and *c.* 60/70 AD (Eimermann 2009, 188; Van der Feijst *et al.* 2008, 203; De Bruin 2005, 27). It is unclear what kind of people inhabited the earliest Roman settlements, but they may well have been immigrants. Whatever their ethnicity, the economic situation would have provided a stimulus to produce a surplus.

If cattle lost their cultural meaning as items for gift exchange, a surplus of cattle would become available for trade. The question arises if, apart from cattle, there are any other indications for surplus production of animals or animal products in the Early/Early Middle Roman Period. The increase in the proportion of sheep, especially in the River Area can be explained in two ways. First, it can be a consequence of the removal of cattle from the rural sites to the consumer sites; this would cause a relative increase in all other species. Second, it could reflect an actual increase in the importance of sheep and goats. If the latter is the case, then an explanation can be found in the faster reproduction and maturing of sheep and goats compared to cattle; sheep and goats provide a faster way to produce meat (although the amount of meat per animal is much smaller than for cattle). The slaughter peaks in the youngest and middle age category indicate that sheep and goats were mainly kept for their meat in both regions except for one site in South Holland which shows an emphasis on older sheep and wool production. Perhaps milk was important as well but again the age categories are too broad to be certain.

The high proportions of horse (more than 20 %) at several sites in the River Area also suggest a surplus (Groot 2008a, 78). These sites date to the period 50–120/150 AD. A current study of the River Area in the Roman Period shows that horses were almost certainly a surplus product. Although the highest proportions of horse are found in the 2nd and 3rd century, horse breeding for trade may have started in the late 1st century (Groot in prep.).

In the Early/Early Middle Roman Period, two sites in the River Area have rather high proportions of pig. Both are located close to *Ulpia Noviomagus Batavorum* (Nijmegen). Unfortunately, it is difficult to establish whether the high proportion of pig is a result of production (breeding pigs close to a potential market) or consumption (the influence of higher consumption of pigs in Roman towns spreading to the surrounding countryside). Pigs could form another surplus, but this cannot be proven at this point.

What differences can be observed between the two regions? In the Iron Age, proportions of pig and horse are slightly higher in the River Area. Cattle proportions are stable in South Holland, but show an increase from the Middle to Late Iron Age in the River Area. Pig decreases in both regions in the Late Iron

Age, but more so in the River Area. Mortality profiles for cattle show little change in South Holland, but indicate increased slaughter ages in the Late Iron Age in the River Area. In both Iron Age phases, sheep or goats were slaughtered somewhat younger in South Holland. Although the sample size is small, cattle seem to have been larger in Middle Iron Age South Holland than in the River Area. Cattle husbandry in the Late Iron Age River Area is more similar to that in South Holland than before.

The following differences between the two regions in the Early/Early Middle Roman Period can be observed: in the River Area, there is a stronger emphasis on meat (beef and mutton) production. Breeding horses, sheep and perhaps pigs – in sites close to *Ulpia Noviomagus Batavorum* (Nijmegen) – was another way to achieve a surplus. In South Holland, animal husbandry shows more diversification, with dairying and wool production occurring as strategies to achieve a surplus. One important point to consider is that the number of sites in South Holland is much smaller than that in the River Area. This is unlikely to be solely caused by excavation intensity. The number of farming sites has implications for the size of the agrarian surplus that could be produced; this was probably much larger in the River Area.

Conclusion

During the transformation from the Late Iron Age to the Roman Period, exploitation of cattle changed its focus to meat production. The cultural significance of cattle in the Iron Age had resulted in herds that were larger than strictly necessary for subsistence. For the Romans, this meant a ready surplus of beef. The economic role of cattle now became more important and slowly took over the previous cultural significance. The introduction and spread of coins may have played a part in the changing role of cattle. What the zooarchaeological data cannot tell us is the order of events. Either the role of cattle changed in the Early/Early Middle Roman Period because they were taken as meat surplus by the Roman army, or it was only possible for cattle to be perceived as meat surplus after their role had changed, perhaps as a result of wider changes in society and the introduction of Roman coinage. Even though the cultural role of cattle may have changed, society kept a strong pastoral focus in both regions in the Early Roman Period. This is reflected in the fact that the byrehouse remains the typical house in the Roman Period (Roymans 1999, 293).

Sheep and goats were already mainly exploited for meat, but gained a more prominent role in the Early/Early Middle Roman Period. Some diversification in production is visible in South Holland, with dairying, wool and meat production occurring side by side. Sites in the River Area also focused on horse breeding, but not until later in the 1st century AD. Livestock in the River Area increased in size, which is suggestive of a change in husbandry or the arrival of new stock.

Since the rural sites in this study produced both their own food and a - probably modest – surplus (which is not found at the site where the animals were produced), the data are not always straightforward to interpret. Requirements for subsistence and herd security must have been fulfilled first; only then was it possible to aim for production of a surplus that could be traded.

There seem to have been two characteristics of the Late Iron Age agrarian economy that enabled a relatively easy transformation to surplus production for the Roman markets. First, there are indications that cattle functioned as standards of value and mediums of gift exchange in the Late Iron Age. This would have resulted in larger herds than strictly necessary for subsistence purposes and herd security. When the economic situation changed, the extra animals would be available as meat surplus. Second, the diversity of the species spectrum made it possible to produce different animals or animal products at the same time: animals for meat (cattle, sheep/goats, and pigs), live horses, milk (cheese) and wool.

Our study has not only demonstrated the value of animal bones to provide insight into cultural and economic developments, but also the limitations of the current data set. Although the number of assemblages is relatively large, the majority of these is small; 69 % has less than 500 fragments for the four main domesticates. There are also lacunae in the data set, for instance the Middle Iron Age in the River Area, and the Early/Early Middle Roman Period in South Holland. In the latter case, however, this may partly reflect low population densities in this region. What is really needed are large, multi-period archaeological sites with a detailed chronology. Unfortunately, the restraints of the current system of developer-funded archaeology mean that even when such sites are excavated, there is little chance of analysing large animal bone samples.

Acknowledgements

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Tables

No. in tripolar graph	Site	Date	n cattle	n sheep/ goat	n pig	n horse	n total	Publication
MIA	Middle Iron Age - River Area							
1	Meteren-Lage Blok	MIA	1189	597	407	200	2393	Buitenhuis/ Halici 2002
2	Kesteren-De Woerd	500–250 BC	224	134	57	82	497	Zeiler 2001
LIA	Late Iron Age - River Area							
1	Geldermalsen-Hondsgemet	120–50 BC	735	154	32	76	997	Groot 2009
2	Odijk-Singel West/Schoudermantel	LIA	199	61	55	21	336	Zeiler 2007
3	Bunnik-Werkhoven	LIA	73	51	14	16	154	Groot in press
4	Lith-De Bergen	end 3rd-early 1st cent. BC	562	245	72	50	929	Roymans s.a.
5	Houten-Doornkade	LIA	125	20	9	16	170	Taayke 1984
6	Tiel-Oude Tielseweg	300–175 BC	156	54	24	34	268	Groot 2008a

Table 1. Sites in the River Area, with date, reference and number of fragments for the four main domestic animals.

No. in tripolar graph	Site	Date	n cattle	n sheep/ goat	n pig	n horse	n total	Publication
ERP	Early/Early Middle Roman Period - River Area							
1	Tiel-Passewaaijse Hogeweg 3.1	AD 40–100	92	225	18	37	372	Groot 2008a
2	Geldermalsen-Hondsgemet 3	AD 50–120	388	125	55	144	712	Groot 2009
3	Druten-Klepperhei 2	AD 75–125	290	79	61	54	484	Lauwerier 1988
4	Heteren-Het Lage Land 2	AD 50–150	131	31	4	42	208	Lauwerier 1988
5	Houten-Doornkade d	AD 50–150	379	103	39	135	656	Taayke 1984
6	Wijk bij Duurstede-De Horden	ER	253	49	10	172	484	Laarman 1996
7	Medel 6	12 BC – AD 70	57	85	18	19	179	Groot 2005a
8	Oosterhout-Van Boetzelaerstraat	25 BC – AD 75	80	50	27	17	174	Whittaker 2002
9	Kesteren-De Woerd a-b	AD 1–80	419	421	70	133	1043	Zeiler 2001
10	Tiel-Oude Tielseweg 2	AD 25–70	460	379	101	92	1032	Groot 2008a
11	Tiel-Oude Tielseweg 3	AD 70–120	148	79	25	27	279	Groot 2008a
12	Arnhem-Schuytgraaf	ER	69	49	30	12	160	Esser and Van Dijk 2004
13	LR57	ER	99	19	3	17	138	Meijer 2009
14	LR41/42	AD 0–50	1115	513	184	172	1984	Esser 2009a
15	LR46S	1st cent. AD	373	289	66	72	800	Groot 2010
16	LR46S	AD 70–125	63	33	12	15	123	Groot 2010
17	LR35	1st cent. AD	158	51	11	46	266	Esser 2009b
18	LR60	AD 0–70	111	139	10	25	285	Meijer 2011
19	LR60	AD 70–100	47	43	1	4	95	Meijer 2011
20	Ewijk-Keizershoeve 1	before AD 100	38	28	1	4	71	Van Dijk 2012
21	Lent-Petuniastraat	1st cent. AD	20	18	9	11	58	Whittaker 2002
22	Lent-Steltsestraat	1st cent. AD	27	19	4	7	57	Whittaker 2002
23	Huissen-Loostraat Zuid D	AD 40–120	204	56	13	53	326	Groot 2008c
24	Druten-Deest	AD 50–125	509	216	52	115	892	Buitenhuis 2003; Halici 2004a
25	Culemborg-Lanxmeer	AD 50–150	72	30	6	18	126	Halici 2004b
26	Zaltbommel-De Wildeman C	AD 50–150	143	74	37	161	415	Esser *et al*. 2010
27	Zoelen-Scharenburg	1st cent. AD	22	12	0	3	37	Van Dijk 2011a

Table 1 (continued).

No. in tripolar graph	Site	Date	n cattle	n sheep/ goat	n pig	n horse	n total	Publication
MIA	Middle Iron Age – South Holland							
3	Monster Polanen		113	30	6	4	153	IJzereef, Laarman and Lauwerier 1992
4	Wateringen 2 (Paalman)		91	11	6	16	124	Paalman 1997
5	Midden Delfland 15.04		1564	514	190	128	2396	Van Dijk 2007
6	Voorne-Putten 10-28		119	9	18	3	149	Prummel 1991
7	Voorne-Putten 17-34		494	125	63	1	683	Prummel 1991
8	Bernisse 10-172		656	271	59	25	1011	Van Dijk and Esser 1996
9	Leiden Stevenshofjespolder vpl I en II		53	14	5	2	74	Van Heeringen 1983
10	Leiden Stevenshofjespolder Vlek 17		410	264	108	42	824	Kirkels 1997
11	Leiden Stevenshofjespolder 30-OOST-54		253	51	37	12	353	IJzereef, Laarman and Lauwerier 1992
LIA	Late Iron Age – South Holland							
7	Den Haag strand Kijkduin		147	24	4	9	184	IJzereef, Laarman and Lauwerier 1992
8	Den Haag Ockenburg		141	66	18	5	230	Van Beurden *et al.* 2007
9	Vlaardingen d'Engelsche Boomgaert		212	62	21	12	307	Paalman *et al.* 2002
10	Midden Delfland 10.07		152	54	18	5	229	Verhagen and Esser 1995
11	Rockanje 08-52		450	251	27	69	797	Verhagen and Esser 1992
12	Rockanje 08-53		431	251	10	31	723	Esser *et al.* 1994
13	Spijkenisse De Dalle		154	39	20	3	216	Kootker 2011
14	WestMaas-Maaszicht		55	22	11	0	88	Van Heeringen *et al.* 1998
15	Leiden Stevenshofjespolder vpl IV		103	20	17	8	148	Van Heeringen 1985
ERP	Early/Early Middle Roman Period – South Holland							
28	MD 21.23	AD 20–120	646	349	6	62	1063	Groot 1998, Van London
29	Vlaardingen Hoogstad 6.36 fase 1	AD 70–125	1414	694	55	323	2486	Van Dijk *et al.* 2003
30	Den Haag Uithofslaan fase 1	60–150 AD	209	119	4	46	378	Van Dijk 2011b
31	Wateringen Juliahof	*c.* 60–2nd cent. AD	147	55	6	20	228	Van Dijk 2009
32	Wateringse Veld Hoge Veld	AD 40-125	195	98	2	21	316	Nieweg 2009 (appendix 9.1)

Table 2. Sites in South Holland, with date, reference and number of fragments for the four main domestic animals.

River Area	Middle Iron Age		Late Iron Age		Early/Early Middle Roman Period	
Number of assemblages	2		6		27	
% cattle	range	54 %	range	53-81 %	range	28-82 %
	average	54 %	average	70 %	average	56 %
% sheep/goat	range	27-32 %	range	13-37 %	range	16-67 %
	average	28 %	average	22 %	average	35 %
% pig	range	14-19 %	range	3-17.5 %	range	0-19 %
	average	18 %	average	8 %	average	9 %
% horse	range	8-17 %	range	5-13 %	range	4-39 %
	average	10 %	average	7.5 %	average	12 %
Slaughter peak cattle	0-2 years/2-4 years		> 4 years		2-4 years/> 4 years	
Slaughter peak sheep	2-3.5 years		2-3.5 years		0-2 years/2-3.5 years	
Withers height cattle	range	101-108 cm	range	98-117 cm	range	99-129 cm
	average	104 cm	average	109 cm	average	113 cm
	n	7	n	27	n	59
Withers height sheep/goat	range	57-59 cm	range	52-60 cm	range	51-66 cm
	average	58 cm	average	58 cm	average	60 cm
	n	2	n	4	n	37
Withers height horse	range	126-132 cm	range	108-144 cm	range	121-151 cm
	average	129 cm	average	125 cm	average	137 cm
	n	5	n	10	n	83

Table 3. Summarised zooarchaeological data for the River Area. Percentages for cattle, sheep/goat and pig are out of the total numbers of fragments for these three species, whereas the percentage for horse is out of the total for the three meat providers plus horse. Slaughter peaks are based on epiphyseal fusion.

South Holland	Middle Iron Age		Late Iron Age		Early/Early Middle Roman Period	
Number of assemblages	9		9		5	
% cattle	range	52-84 %	range	62-84 %	range	63-71 %
	average	68 %	average	66 %	average	66 %
% sheep/goat	range	6-34 %	range	14-36 %	range	26-35 %
	average	23 %	average	29 %	average	32 %
% pig	range	4-14 %	range	1-13 %	range	1-3 %
	average	9 %	average	5 %	average	2 %
% horse	range	0-13 %	range	0-9 %	range	5-13 %
	average	4 %	average	4 %	average	9 %
Slaughter peak cattle	> 4 years		> 4 years		0-2 years/> 4 years	
Slaughter peak sheep	0-2 years/2-3.5 years		0-2 years/2-3.5 years		0-2 years/2-3.5 years	
Withers height cattle	range	110-117 cm	range	-	range	104-119 cm
	average	115 cm	average	-	average	110 cm
	n	8	n	-	n	8
Withers height sheep/goat	range	56-62 cm	range	-	range	62-67 cm
	average	59 cm	average	-	average	64 cm
	n	2	n	-	n	8
Withers height horse	range	-	range	-	range	125-150 cm
	average	-	average	-	average	134 cm
	n	-	n	-	n	23

Table 4. Summarised zooarchaeological data for South Holland. Percentages for cattle, sheep/goat and pig are out of the total numbers of fragments for these three species, whereas the percentage for horse is out of the total for the three meat providers plus horse. Slaughter peaks are based on epiphyseal fusion.

Site	< 24 months	24-48 months	> 48 months	n
Middle Iron Age - River Area				
Meteren-Lage Blok	14 %	31 %	55 %	253
Kesteren-De Woerd	36 %	22 %	41 %	44
Late Iron Age - River Area				
Geldermalsen-Hondsgemet 1	4 %	23 %	72 %	197
Odijk-Singel West	25 %	10 %	65 %	47
Tiel-Oude Tielseweg	14 %	18 %	68 %	41
Early-Early Middle Roman Period - River Area				
Tiel-Passewaaijse Hogeweg 3	14 %	26 %	60 %	66
Geldermalsen-Hondsgemet 3	9 %	39 %	52 %	121
Druten-Klepperhei 2	23 %	30 %	47 %	58
Heteren-Het Lage Land 2	8 %	37 %	55 %	23
Oosterhout-Van Boetzelaerstraat	4 %	42 %	55 %	37
Kesteren-De Woerd ab	13 %	25 %	63 %	56
Tiel-Oude Tielseweg 2	11 %	40 %	50 %	47
Tiel-Oude Tielseweg 3	18 %	24 %	58 %	29
Arnhem-Schuytgraaf ER	7 %	43 %	50 %	20
LR57	0 %	55 %	46 %	29
LR41/42	17 %	16 %	66 %	307
LR46S	15 %	33 %	51 %	96
LR35	27 %	43 %	30 %	25
Huissen-Loostraat Zuid D	22 %	8 %	70 %	28
Druten-Deest 10	8 %	28 %	64 %	70

Table 5. Mortality profiles for cattle for sites in the River Area, based on epiphyseal fusion.

Site	< 24 months	24-48 months	> 48 months	n
Middle Iron Age – South Holland				
Midden-Delfland 15.04	14 %	22 %	64 %	243
Voorne-Putten	7 %	22 %	71 %	81
Bernisse 10-172	9 %	22 %	69 %	70
Late Iron Age – South Holland				
Vlaardingen 'd Engelsche Boomgaert	28 %	1 %	71 %	32
Rockanje 08-52	3 %	14 %	83 %	56
Rockanje 08-53	0 %	19 %	81 %	33
Early-Early Middle Roman Period – South Holland				
Vlaardingen 6.36 fase 1	31 %	31 %	38 %	165
Wateringen Juliahof	0 %	33 %	67 %	29
Midden-Delfland 21.23	52 %	13 %	35 %	75
Den Haag Uithofslaan fasen 1-3	18 %	11 %	71 %	34

Table 6. Mortality profiles for cattle for sites in South Holland, based on epiphyseal fusion. Data from Den Haag-Hogeveld could not be included due to incompatibility.

Site	0-2 years	2-3.5 years	> 3.5 years	n
Middle Iron Age - River Area				
Meteren-Lage Blok	27 %	40 %	33 %	125
Kesteren-De Woerd	13 %	87 %	0 %	20
Late Iron Age - River Area				
Geldermalsen-Hondsgemet 1	8 %	77 %	14 %	26
Early-Early Middle Roman Period - River Area				
Tiel-Passewaaijse Hogeweg 3	15 %	54 %	31 %	86
Kesteren-De Woerd ab	30 %	65%	6 %	44
Tiel-Oude Tielseweg 2	28 %	39%	33%	31
LR41/42	48%	28%	24 %	125
LR46S	20 %	70 %	10 %	66

Table 7. Mortality profiles for sheep/goat for sites in the River Area, based on epiphyseal fusion.

Site	0-2 years	2-3.5 years	> 3.5 years	n
Middle Iron Age – South Holland				
Midden-Delfland 15.04	52 %	34 %	14 %	95
Late Iron Age – South Holland				
Rockanje 08-52	41 %	42 %	17 %	40
Early-Early Middle Roman Period – South Holland				
Vlaardingen Hoogstad 6.36	29 %	24 %	47 %	55
Midden-Delfland 21.23	29 %	41 %	30 %	67
Den Haag Uithofslaan fasen 1-3	55 %	45 %	0 %	29

Table 8. Mortality profiles for sheep/goat for sites in South Holland, based on epiphyseal fusion. Data from Wateringse Veld-Hogeveld could not be included due to incompatibility, but are similar to three of the other four Roman sites in showing an emphasis on meat.

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Tracing changes in animal husbandry in Mallorca (Balearic Islands, Western Mediterranean) from the Iron Age to the Roman Period

Alejandro Valenzuela[1], Josep Antoni Alcover[1], Miguel Ángel Cau[2]

1. Department of Biodiversity and Conservation
Mediterranean Institute for Advanced Studies (UIB-CSIC)
Mallorca
Spain
avalenol@gmail.com
jaalcover@imedea.uib-csic.es

2. Institució Catalana de Recerca i Estudis Avançats (ICREA)/Equip de Recerca Arqueològica i Arqueomètrica
Universitat de Barcelona (ERAAUB)
Barcelona
Spain
macau@ub.edu

Abstract

Major changes in animal husbandry between the Late Iron Age and the Roman periods have been noted by several authors. Although there is an extensive review of this topic on different regions, there was no synthesis of it in the Balearic Islands. Using zooarchaeological data, this paper attempts to provide a first insight into the changes in the livestock of Mallorca during the transition to the Roman period. A significant modification in the composition of the domestic livestock is recorded. At the same time, the biometrical analysis reveals a significant increase in body size of sheep/goat, cattle and pig. This research provides evidence to sustain that some degree of surplus livestock production occurred in Mallorca during the Roman occupation.

Keywords: *Mallorca, animal husbandry, Iron Age – Roman transition, improvement, zooarchaeology*

Introduction

During the course of the Iron Age, the Balearic Islands (*i.e.* Mallorca and Menorca) were inhabited by the Talaiotic society. This prehistoric community was characterised by the construction of talaiots. These were round or square tower-like megalithic buildings with a roof supported by a large stone central pillar. The function of these structures has received different interpretations such as a community space (*e.g.* Gasull *et al.* 1984) or watchtower (Guerrero 1995; Lull *et al.* 2001). During the Early Iron Age (*c.* 900–600 BC) the talaiots were built within or surrounding the villages. The domestic buildings were small rectangular structures, internally subdivided and often attached to each other (Salvà and Hernández-Gasch 2009). The Talaiotics produced a coarse handmade pottery with a limited typological range (Lull *et al.* 2008). The metallurgy of iron was initiated in this period, but it seems to have been undeveloped (Lull *et al.* 2008). Some authors state that the social relations within this community were characterised by egalitarianism (Gasull *et al.* 1984), while others have highlighted a growing social differentiation, especially at the end of the period (Hernández-Gasch 1998; Castro *et al.* 2003). The Late Iron Age is defined as a turning point in the development of the prehistoric inhabitants of Mallorca (Lull *et al.* 1999; Aramburu-Zabala 2009; Hernández-Gasch 2009). From *c.* 600 BC onwards a series of changes that affect large areas of the Talaiotic settlements are documented, including fire layers in the settlements and abandonment of habitat structures. New buildings appeared outside the walled area as well as new types of structures, such as sanctuaries. The foundation in 654 BC of the Carthaginian colony of Ebusus, in the nearby island of Eivissa, is most probably responsible for those changes. The foundation of this town involved the start of trade relations with Mallorca that were fully developed from *c.* 400 BC onwards (*e.g.* Guerrero 1997; Costa *et al.* 2004). In addition, it is worth mentioning the active participation of the Talaiotic slingers in the Punic Wars as mercenaries of the Carthaginian army, reinforcing the connections of the island with the rest of the Western Mediterranean. The prevalent view of the Mallorcan Iron Age economy is that it was based on a subsistence of pastoralism of sheep and goat (*e.g.* Guerrero 1995). Nevertheless, some authors have recently suggested a mixed farming economy (Hernández-Gasch *et al.* 2002; 2011).

In 123 AD, the consul *Quintus Caecilius Metellus* successfully incorporated Mallorca into the Roman Republic. The ultimate reasons for this conquest are still under discussion (*e.g.* Morgan 1969; Orfila and Arribas 1997; Zucca 1998), but it is generally emphasised that it was due to the strategic position of the Balearic Islands on the shipping routes of the Western Mediterranean. The Roman invasion involved a process of profound changes in the socio-political structures of the islands (Orfila 1988). The cities of *Palma* and *Pollentia* were founded and acted as new administrative centres. There was a resettlement of population onto the islands (Strabo III, 5.2, in Blanes *et al.* 1990) and the volume of imported goods from overseas territories was intensified. Furthermore, a new territorial organisation was established dividing the land into *centuriae* (Carlsen *et al.* 1994; Cardell and Orfila 1992), related to the full agricultural exploitation of the countryside (Orfila *et* *al.* 1996). All these processes suggest direct consequences on the agricultural and animal husbandry practices of the Mallorcan inhabitants.

Several studies have compared the faunal remains from sites of the Iron Age-Roman transition in many regions (*e.g.* Teichert 1984; Lauwerier 1988; Lepetz 1996; Albarella *et al.* 2008). They compared the features of the animal exploitation and consumption in order to explore the transformations of the domestic stock throughout this period. The most significant results demonstrate an increase in the livestock size and a change in the mortality profiles of the species, pointing to an intensification of production as a response to the growing demand for meat. However, there are some examples that these changes (size increase and mortality profiles shift) were not extended everywhere (*e.g.* Albarella *et al.* 2008). For the Balearic Islands the Iron Age-Roman animal husbandry transition has not been surveyed. The main constraint comes from the scarcity of zooarchaeological studies in Mallorca. Nevertheless, in recent years the knowledge has been improved, with published reports on Son Ferragut (Estévez and Montero 2003), Ses Païsses (Ramis 2005; Martínez 2011) and Cas Canar (Martínez and Aramburu-Zabala 2012). Unfortunately, no published reports are available for the Roman sites. This paper presents the first zooarchaeological results from the Roman city of *Pollentia* and attempts an interim approach to the changes occurring on Mallorca in the transition to the Roman period.

Material and methods

Materials

All the zooarchaeological data available, both from the bibliographical survey and from our own zooarchaeological research, were collected and presented in a chronological framework to assess trends in animal use through the Iron Age and Roman periods. Our analysis is based on approximately 25,000 animal bone fragments of the four most important domestic animals: cattle, sheep/goat and pig (Table 1). We excluded the remains of equids, deer, rabbits and other mammals for their generally limited representation in the assemblages (*i.e.* less than 5 %). All the material was divided into four periods, defined as closely as possible, between the Early Iron Age (from *c.* 850 BC) and the Late Roman Period (contexts ending *c.* 400 AD). The first group is formed by assemblages from the Early Iron Age (*c.* 850–550 BC), the second group consists of contexts from the Late Iron Age (*c.* 550–123 BC), the third group are the animal bones of contexts ranging from 123 BC to 100 AD, and the fourth group comprises bone assemblages from the 2nd to the 3rd centuries AD. The Iron Age division follows the proposal of Lull *et al.* (1999; 2001) who defined two periods: the Talaiotic (*c.* 850–550 BC) and Post-Talaiotic (*c.* 550–123 BC). In this study, however, we use the terms of Early Iron Age and Late Iron Age respectively, in order to facilitate the comparison with other European areas. The Roman Period is divided into two main phases following the stratigraphy of the different contexts studied from the Roman city of Pollentia. In some sites, such as S'Illa des Porros (Nadal 2000), the osteological sample could not be differentiated between Early and Late Iron Age because the bones were not subdivided into different phases.

In total, we discuss 17 sites from the Iron Age and the Roman Period (Fig. 1). The majority of sites have been published and studied archaeologically but it was also possible to include zooarchaeological information from some unpublished reports. This is the case with the faunal remains at Pou Celat (Porreres) coming from the infilling of the wall of the fortified settlement (Pons 1994; Noguera 2001a). A radiocarbon date of bone collagen (KIA-15713) points to a mainly Late Iron Age assemblage (Micó 2005). In the case of Puig den Pau (Costitx) the results of the excavation have not been published yet so the origin of the materials cannot be specified (Noguera 2001b). Despite this, the chronology has been fixed by radiocarbon dating in the Early Iron Age (Micó 2005).

In addition, the first Roman assemblages from Mallorca are presented here. They come from the Roman city of *Pollentia*. This settlement was located on the north coast of the island of Mallorca, strategically placed on an isthmus between

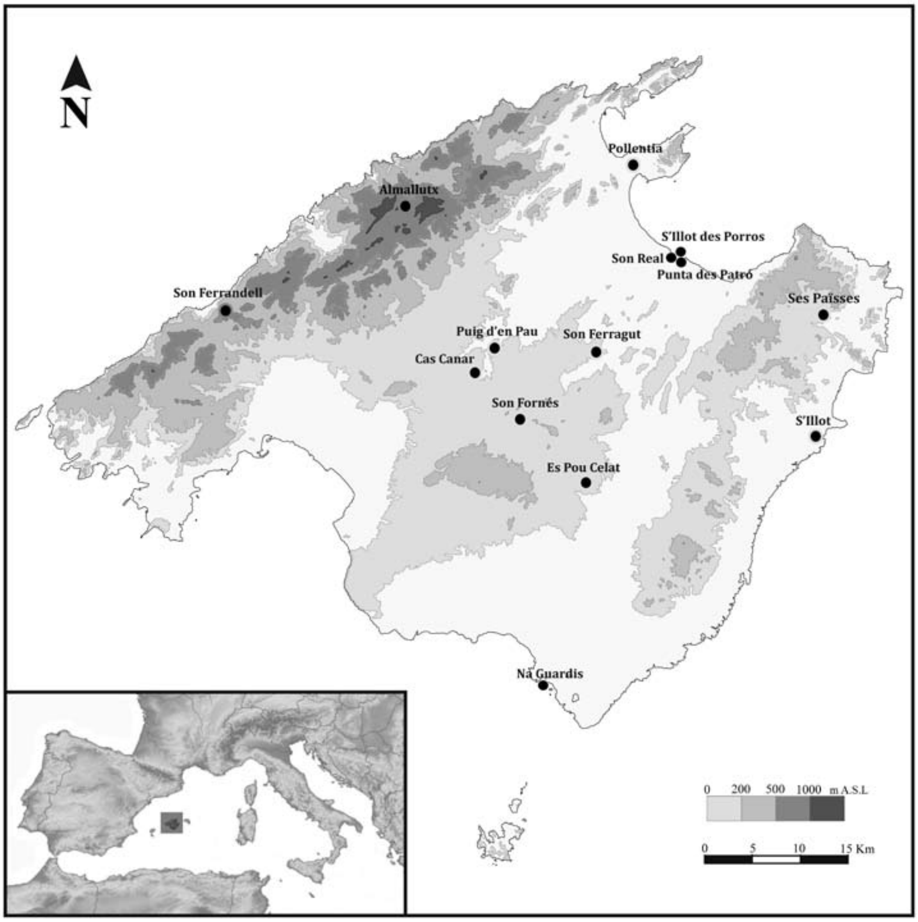

Figure 1. Location of Mallorca and the different sites studied.

the current Alcúdia and Pollença bays. The surrounding mountains defend both bays protecting them from northwestern winds and providing an excellent shelter for sailing. The city extended over around 18 hectares, being an intermediate settlement within the other cities of *Hispania*. Although the foundation of the city in 123 BC is cited in the written sources, the first Roman structures found so far in the forum date to the early 1st century BC. A turmoil period was witnessed in the 3rd century AD when a fire – precisely dated in the forum area in 270/280 AD – destroyed many parts of the city (*e.g.* Orfila *et al.* 1999; 2006; Orfila 2000). After the fire the site changed from its imperial image to a Late Roman city and was inhabited throughout the Vandal and Byzantine periods. The urban area was occupied in the Islamic period and, probably reduced to a small settlement, until the 13th century AD (*e.g.* Riera *et al.* 1999; Cau 2012).

The bone assemblage from *Pollentia* comprises *c.* 9500 identified fragments, of which 546 were complete enough for biometric analysis. The Early Roman faunal remains were recovered from different layers of the tabernae and from one well (E-107) of the forum area (Rivas 2004). The Mid to Late Roman assemblage comes

n.	Site	Date	Type	Sh / Gt %	Cattle%	Pig%	NISP	Reference
1	Son Ferragut	Early Iron Age	settlement	70.4	24.6	5	697	Estévez and Montero, 2003
2	Cas Canar	Early Iron Age	settlement	79.1	9.9	11	648	Martínez and Aramburu-Zabala 2012
3	Son Fornés- Total	Early Iron Age	settlement	49	28.5	22.5	1745	Estévez 1984a
4	Son Fornés- without Talaiots	Early Iron Age	settlement	61.4	22.7	15.9	564	Estévez 1984a
5	Pou Celat	Late Iron Age	settlement	62.3	23.5	14.2	358	Noguera 2001a
6	S'Illot	Early Iron Age	settlement	72.2	18.2	9.5	4685	Uerpmann 1971
7	Almallutx	Early Iron Age	settlement	70.4	11.7	17.9	*	Romero 1971
8	S'Illot des Porros	Iron Age	Funerary site	75.1	15.1	9.8	1376	Nadal 2000
9	Ses Païsses - 99/00	Late Iron Age	settlement	72.7	17.7	9.6	3600	Ramis 2005
10	Son Ferrandell	Late Iron Age	settlement	81.3	9.5	9.3	3248	Chapman and Grant, 1995; 1997
11	Cas Canar	Late Iron Age	settlement	86.6	6.1	7.5	335	Martínez and Aramburu-Zabala 2012
12	Ses Païsses - Edifici 14	Late Iron Age	settlement	86	7.9	6.1	1298	Martínez 2011
13	Na Guardis	Late Iron Age	settlement	80.4	7	12.6	199	Iborra 2005
14	Puig d'en Pau	Early Iron Age	settlement	69.6	22.3	8.2	355	Noguera 2001b
15	S'Illot- LIA	Late Iron Age	settlement	75.5	15.2	9.3	1805	Uerpmann 1971
16	Punta des Patró	Late Iron Age	Sanctuary	75	17.9	7.1	200	Hernández-Gasch *et al.* 2002; 2011
-	Son Real[1]	Late Iron Age	Funerary site	15.8	73.7	10.5	19	Nadal 1998
17	Pollentia	1st C BC - 1st C AD	Roman town	33	24.7	42.3	2463	this paper
18	Pollentia	2nd - 3rd C AD	Roman town	39.4	29.4	31.2	7024	this paper

Table 1. Percentages of sheep/goat, cattle and pig of the Iron Age and Roman sites of Mallorca.
[1] Due to the scarce number of bones this site is not considered in the Figure 1.
** Number of identified specimens not specified.*

from some 2nd-century-AD buildings as well as from different levels of destruction of the forum that, as mentioned above, occurred in the late 3rd century AD (Orfila *et al.* 1996). Almost all of the assemblage was hand collected, with the exception of the mesh-screened bones from the well. A full report on the analysis of these remains is currently ongoing; however, species composition, mortality profiles, and biometrical data are presented here.

Methods

The study is undertaken on the basis of species composition, mortality profiles and biometry. In order to analyse and compare the faunal assemblages, NISP (Lyman 1994, 100) is used, since it is the most commonly reported measure. This method may be seen in faunal reports under various names (*i.e.* Number of Fragments), but the quantification method can be considered to be NISP regardless of any other name the analyst may have chosen. In the text, all recorded percentages were expressed as mean. Additionally, in order to trace any change in diet, the three principal domestic mammals have been plotted (converted into percentage form, % NISP) onto a triangular graph, following King (1999).

Age data provide further information on the nature of the exploitation. Unfortunately, a recurring problem of the reviewed reports is that there is a scarce and inconsistent approach that makes it difficult to compare data between the different sites under study. Each author used a different method to determine the age of the animal bones. Some authors used tooth wear analysis, others epiphyseal fusion, and it is not always clear which of the two methods was used. For *Pollentia*, tooth wear stages for mandibles, isolated fourth deciduous premolars and third molars of cattle, sheep/goat and pigs were recorded following Grant's method (Grant 1982). For mandibles with no missing molars, a mandible wear stage was established. For incomplete mandibles, the most likely mandible wear stage was estimated by comparison with Grant's tables 2-4. Because Grant's mandible wear stages are not presented as absolute ages, they were converted to the age stages of Payne (1973) for sheep/goat and Halstead (1985) for cattle and pig according to Hambleton's tables (Hambleton 1999).

Measurements for all presented sites generally follow Von den Driesch (1976), with the exceptions noted on each report. At *Pollentia* some additional measurements were taken following the criteria of Davis (1992) and Payne and Bull (1988).

In order to maximise the potential information of the data, the log ratio technique of Simpson *et al.* (1960) was used to look at size variation in domesticates. This method calculates the logarithm of the ratio between a measurement and its standard (*e.g.* Meadow 1999; Albarella 2002). Although Davis (1996) suggests a separate analysis of the measurements taken along different axes (length, width or depth), in this study they were kept together, due to the scarcity of the data. The standard used for the calculation of cattle log ratios was the mean of the measurements from Period II from Elms Farm (Johnstone and Albarella 2002); for pigs the mean of the sample from Late Neolithic Durrington Walls (Albarella and

Payne 2005); for caprines the mean of the sample of unimproved Shetland ewes (Davis 1996). Where relevant, the Mann-Whitney U-test was used to determine the significance of observed biometrical differences.

Results

Species representation

Data from the 18 samples are summarised in the form of percentages of sheep and goat, cattle and pig in Table 1; the mean values of each period are plotted in a histogram in Figure 2.

Cattle.- The frequency of occurrence of cattle bones shows a slight decrease throughout the Iron Age. In the Early Iron Age they account for 19.6 % descending in the Late Iron Age to 12.6%. This tendency changes markedly in the Early Roman contexts of *Pollentia*, where the percentage increases to 24.7 %. The increase in the amount of cattle bones becomes particularly clear in the 2nd- and 3rd-century-AD contexts, where it rises to 29.4 %.

Sheep/goat.- The highest frequencies of sheep and goat not only appear fairly constant throughout the Iron Age, but increase in the late phase before the Roman invasion. In the Early Iron Age the domestic caprine percentage is 67.1 %, reaching 78.6 % in the Late Iron Age. From that moment onwards, the trend reverses. The amount of sheep/goat bones falls abruptly to 33 % in the Early Roman levels of *Pollentia*. Finally, in the Mid and Late Roman levels there is a slight increase to 39.4 %.

Pig.- In the case of pig the trend seems to be linked to that observed in cattle during the Iron Age. The frequency decreases from 13.2 % in the Early Iron Age to 8.7 % in the Late Iron Age. With the arrival of the Romans, pigs show the largest increase of the domestic stock, rising to 42.3 % in the 1st-century-BC-to-1st-century-AD assemblages. This percentage decreases to 31.2 % in the later layers of *Pollentia*.

Mortality profiles

As noted above, the various ways to record the age-at-death in the zooarchaeological reports of the Iron Age in Mallorca precludes a detailed examination of this aspect. However, some characteristics can be inferred from a direct survey of some sites of the island.

For the Early Iron Age, the largest assemblage available is from S'Illot (Uerpmann 1971). At this site, the mandibular dataset of sheep/goat is consistent with an emphasis on secondary products exploitation: 65.2 % are individuals older than 3 years, but there also seems to be a kill-off peak of subadult animals between 1 and 2 years old. Although less abundant, the results for cattle are comparable to the caprines. Half of the aged specimens were slaughtered at an adult age, and there is also a peak for calves of less than 1 year old. The limited data for pigs indicate an age profile more consistent with intensive pork production, with large numbers of subadult animals.

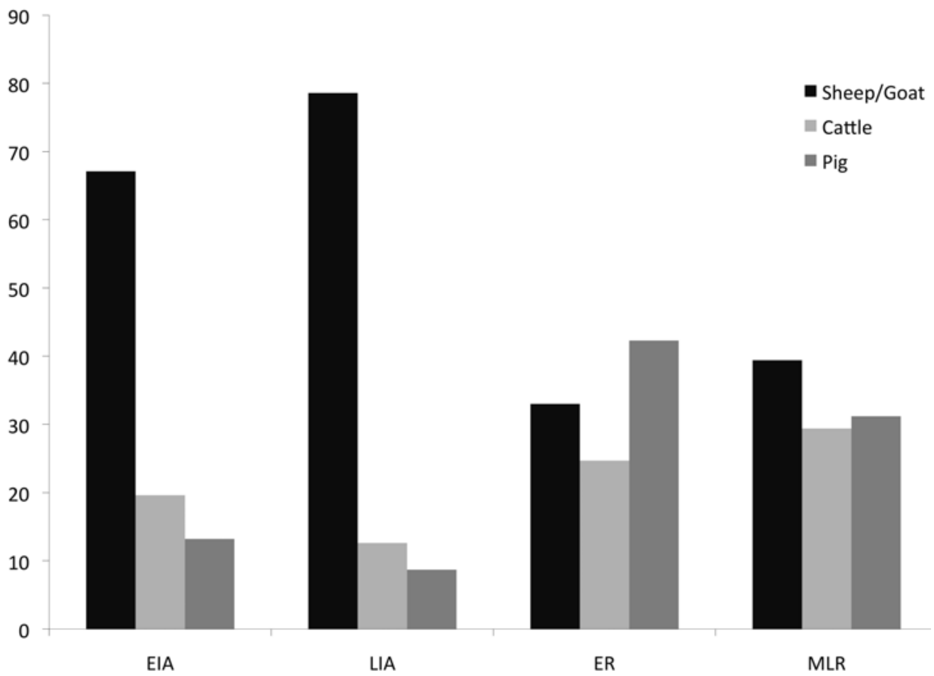

Figure 2. Representation of the principal domesticated animals by period. Mean values were used. EIA: Early Iron Age; LIA: Late Iron Age; ER: Early Roman 1st C. BC- 1st C. AD; MLR: Mid-Late Roman, 2nd-3rd C. AD.

Estévez (1984a) presents similar age-at-death profiles for the Early Iron Age assemblage of Son Fornés. The aged cattle specimens suggest a bimodal distribution between calves killed under 1 year and adult cattle older than 3 years. Approximately 72 % of aged sheep/goat at this site were killed at an adult age. All pigs were slaughtered between the ages of 1 and 3 years. This also seems to be the pattern at Son Ferragut (Estévez and Montero 2003). Both cattle and sheep/goat were mainly adults. The small age data set for pigs makes it impossible to draw conclusions. At Pou Celat, all the domestic animals were slaughtered at young ages (Noguera 2001a): 47 % of sheep/goat (n=15) were aged between 6 and 12 months. The rest are, in similar proportions, juveniles under 6 months and subadults between 1 and 2 years. All cattle were aged younger than 3 years (n=9). The pig data set is too small to define a profile, but the two aged individuals were suckling pigs younger than 1 year. This culling profile for the domestic livestock stays the same in the Mallorcan Late Iron Age, with just a slight shift towards the slaughtering of older animals (*e.g.* Chapman and Grant 1989; 1995; Noguera 2001b; Ramis 2005; Hernández-Gasch *et al.* 2011; Martínez 2011). For example, in this period a few more elderly cattle are present, although there is still a slaughter peak of young calves aged between 8 and 18 months. The same is true for the caprines, with a slightly lower peak in the 6-12 months age category.

The age profiles for domestic mammals at *Pollentia* are presented in Figure 3.

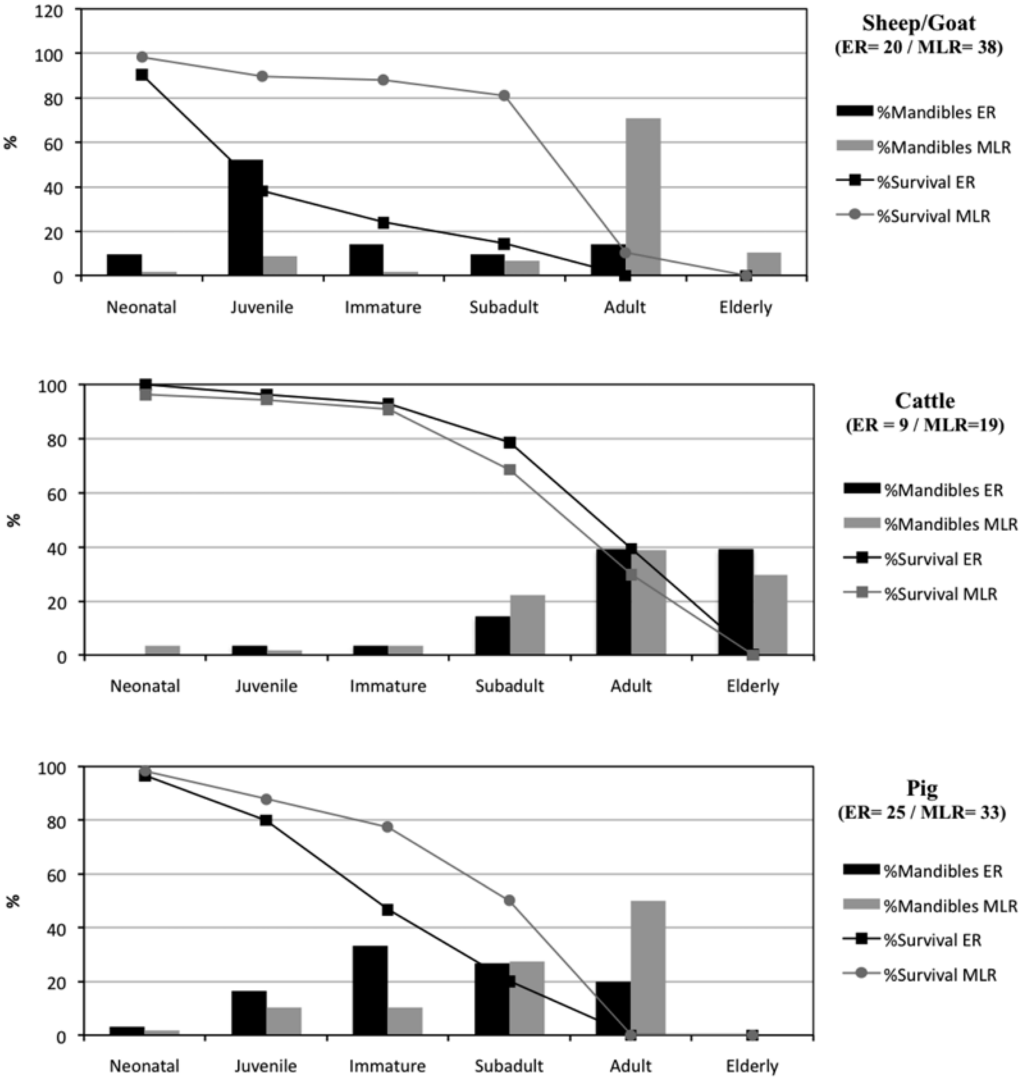

Figure 3. Kill-off patterns of the different animal species by period in Pollentia.

There is clear evidence for the selection of particular age groups in both periods. The 1st-century-BC-to-1st-century-AD data show a preponderance of very young caprines, almost all being between 2 and 6 months. This may suggest an emphasis on meat, as they were killed before their first wool clip. This trend is reversed in the data for the 2nd–3rd century AD, when it is clear that most specimens were killed as adults, with some younger and elderly animals also present. The largest proportion of adult individuals falls mainly into the age categories E and F outlined by Payne (1973). This points to adult animals killed between the ages of 2 and 4 years. This would suggest that animals were kept into their early adulthood, beyond the point where full carcass size would be attained. Thus, it may be outlined that in the Late Roman period a further emphasis was put on wool production. At *Pollentia* it is evident that a great number of adult and old cattle were used for the meat provision of the town. Most have been assigned older than 3 years. This applies to both periods: there is no significant change in the kill-off pattern. The almost complete absence of younger animals is related to an expected profile for a Roman town as a consumer or market oriented for surplus production. Most pigs from the 1st century BC to 1st century AD were killed before 7 months of age. This particular abundance of suckling pigs probably reflects the well-known preference that the Romans had for them (White 1970). On the other hand, it could also be a reflection of the production of these animals within the town. During the 2nd–3rd century AD the pattern changes significantly, with a kill-off peak of pigs between 2 and 3 years old. Although the orientation is still on meat, there seems to be an optimisation of this resource in this period since the animals were killed when their optimum weight was reached.

Biometric analysis

The results of log ratio measurements of the domestic mammals are presented according to the different species by each studied site. In general, the size of sheep and goat remains unchanged throughout the Iron Age period (Fig. 4), although there are some differences between some sites (*e.g.* Son Fornés in relation to other Early Iron Age assemblages; see Table 2). However, an abrupt change in size seems to occur between the 1st century BC and the 1st century AD; the differences are highly significant. Finally, this trend is slightly reversed in the later Roman period, but there is still a very significant difference compared to the whole Iron Age.

As is the case with sheep and goat, the size of cattle did not change throughout the Iron Age (Fig. 5), neither chronologically nor at an inter-site level. From the 1st century BC on the change becomes very significant (Table 4) with most of the measurements beyond the average of the Early and Late Iron Age sites. This increase in size lasted throughout the 2nd and 3rd century AD. The situation seems to be different for pigs (Fig. 6). There is a significant change in size between

	Site	Period	Summary						Statistical difference between sites (P)						
			Min.	Max.	n	Mean	SD	V	I	II	III	IV	V	VI	VII
I	Son Ferragut	Early Iron Age	-0.1628	0.0920	43	-0.0785	0.0486	-0.619		N	*	N	*	***	***
II	S'Illot	Early Iron Age	-0.1776	0.1171	310	-0.0671	0.0566	-0.843			**	N	N	***	***
III	Son Fornés	Early Iron Age	-0.1461	0.1301	117	-0.0523	0.0673	-1.286				*	N	***	***
IV	S'Illot	Late Iron Age	-0.1710	0.0610	118	-0.0594	0.0489	-0.823					N	***	***
V	Son Ferrandell	Late Iron Age	-0.1450	0.0283	48	-0.0494	0.0369	-0.747						***	***
VI	Pollentia	1st C BC - 1st C AD	-0.0467	0.1447	84	0.0531	0.0364	0.685							*
VII	Pollentia	2nd C - 3rd C AD	-0.0542	0.1785	318	0.0389	0.0463	1.190							

*Table 2. Sheep/goat: summary table for log ratio measurements. Only sites with a sample >10 are reported. Results of Mann-Whitney U-test: N, not significant; * significant at the 95% confidence interval; ** significant at the 99% confidence interval; *** significant at the 99.9% confidence interval.*

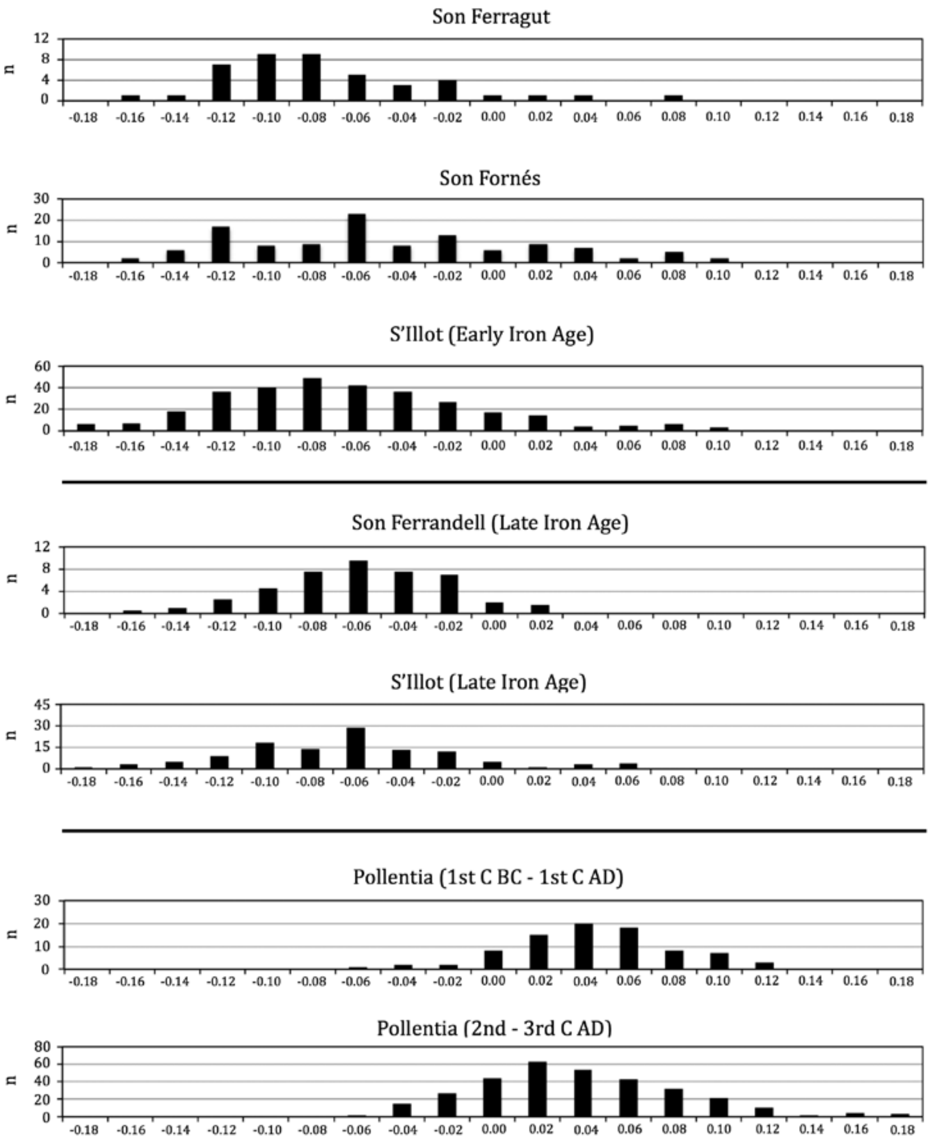

Figure 4. Log ratios of sheep/goat post-cranial measurements from the different sites by period.

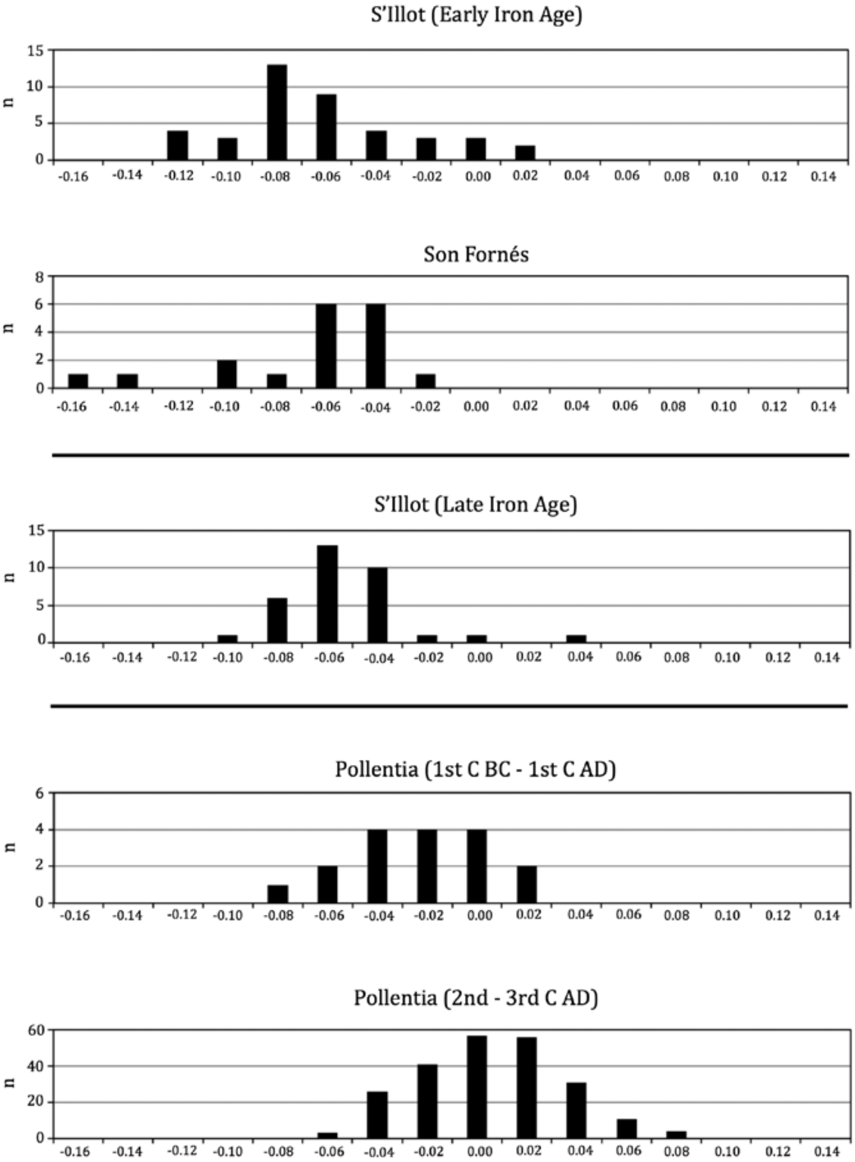

Figure 5. Log ratios of cattle post-cranial measurements from the different sites by period.

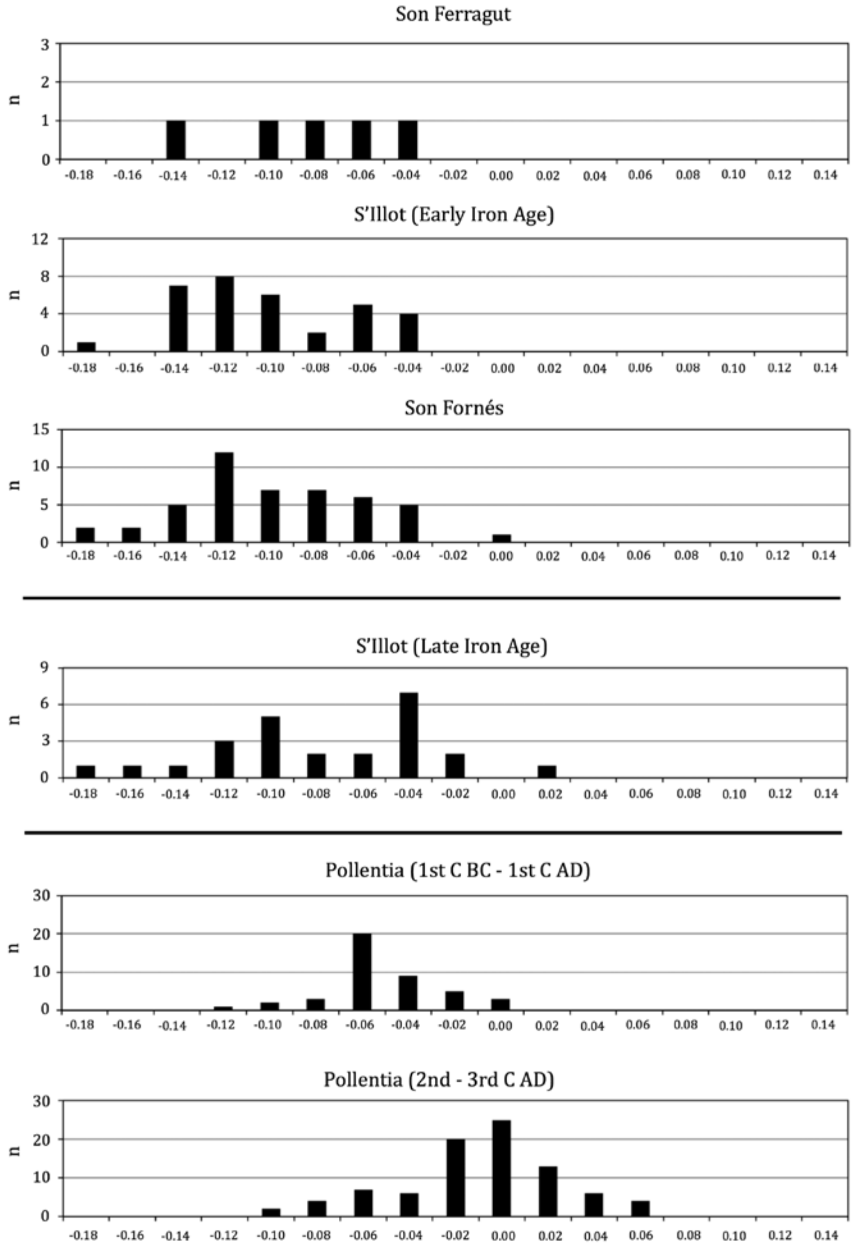

Figure 6. Log ratios of pig post-cranial measurements from the different sites by period.

	Site	Period	Summary						Statistical difference between sites (P)				
			Min.	Max.	n	Mean	SD	V	I	II	III	IV	V
I	Son Fornés	Early Iron Age	-0.1696	0.0169	18	-0.0517	0.0386	-0.7483		N	N	***	***
II	S'Illot	Early Iron Age	-0.1191	0.0330	41	-0.0594	0.0359	-0.6058			N	***	***
III	S'Illot	Late Iron Age	-0.0888	0.0375	33	-0.0509	0.0234	-0.4603				***	***
IV	Pollentia	1st C BC - 1st C AD	-0.0702	0.0337	17	-0.0203	0.0276	-1.3650					***
V	Pollentia	2nd C - 3rd C AD	-0.0558	0.0908	229	0.0115	0.0298	2.6034					

*Table 3. Cattle: summary table for log ratio measurements. Only sites with a sample >10 are reported. Results of Mann-Whitney U-test: N, not significant; * significant at the 95% confidence interval; ** significant at the 99% confidence interval; *** significant at the 99.9% confidence interval.*

	Site	Period	Summary						Statistical difference between sites (P)					
			Min.	Max.	n	Mean	SD	V	I	II	III	IV	V	VI
I	Son Fornés	Early Iron Age	-0.1725	-0.0011	47	-0.0978	0.0377	-0.3854		N	N	*	***	***
II	S'Illot	Early Iron Age	-0.1845	-0.0280	33	-0.0992	0.0367	-0.3706			N	*	***	***
III	Son Ferragut	Early Iron Age	-0.1432	-0.0325	5	-0.0702	0.0410	-0.5839				/	/	/
IV	S'Illot	Late Iron Age	-0.1899	0.0332	25	-0.0841	0.0494	-0.5877					*	***
V	Pollentia	1st C BC - 1st C AD	-0.1182	0.0097	43	-0.0491	0.0258	-0.5268						***
VI	Pollentia	2nd C - 3rd C AD	-0.0977	0.0675	87	-0.0010	0.0344	-35.925						

*Table 4. Pig: summary table for log ratio measurements. Only sites with a sample >10 are reported. Results of Mann-Whitney U-test: N, not significant; * significant at the 95% confidence interval; ** significant at the 99% confidence interval; *** significant at the 99.9% confidence interval.*

the Early Iron Age and the Late Iron Age. Although it seems to be a slight change during the Early Roman period, it is not until the 2nd century AD that the size of pigs increased considerably (Table 3).

Discussion

The results of the zooarchaeological analysis show that animal husbandry significantly changed with the arrival of the Romans. In Figure 7, the samples have been plotted onto a triangular graph in order to contextualise the pattern of species representation. It becomes very clear that there is a tendency towards a predominance of sheep and goat throughout the Iron Age. Thus, it could be argued that a certain degree of specialisation in sheep and goat breeding occurred. Nevertheless, as has already been noted by Hernández-Gasch *et al.* (2002, 280), this may be more a reflection of the environmental constraints of the island than a deliberate livestock strategy. The main difference between the Mallorcan Early and Late Iron Age is that Late Iron Age sites have, on average, more sheep/goat than earlier sites, although there is a fair degree of variation.

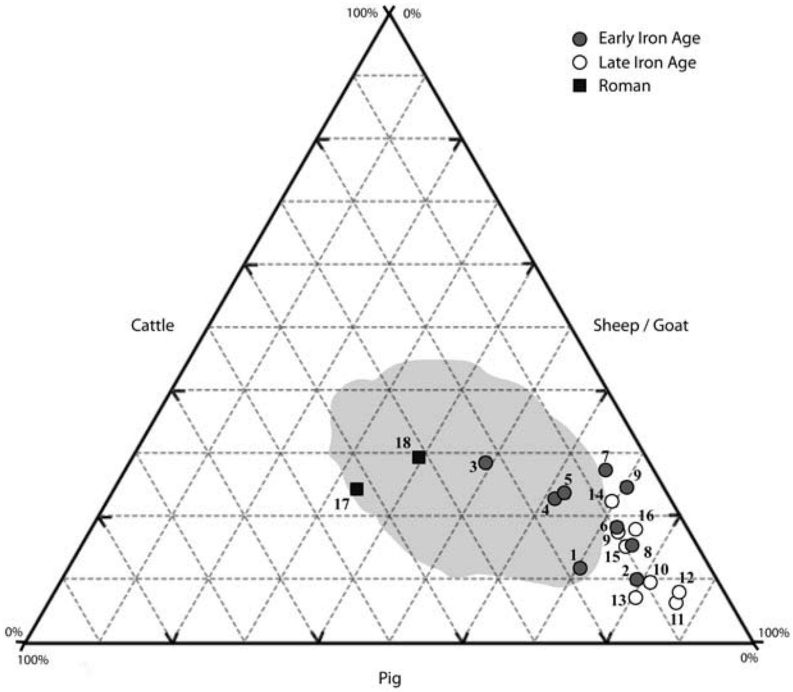

Figure 7. Tripolar diagram showing the relative proportions of cattle, sheep/ goat and pig at eighteen Iron Age and Roman period sites in Mallorca. The pattern of the Roman diet in Spain established by King (1999) is represented by the grey area. Numeration follows Table 1.

However, not all Iron Age sites show this pattern. The faunal assemblage from Son Fornés (Estévez 1984a) displays a different pattern, having relatively high pig and cattle percentages and reflecting a possibly anomalous pattern among Mallorcan Iron Age assemblages. Part of the animal bones were recovered from the talaiot. Several interpretations have been proposed about the function of these structures as ritual or communal spaces (*e.g.* Gasull *et al.* 1984; Lull *et al.* 2001). Thus, the sample from inside the talaiot could be derived from a non-domestic activity. For this reason, the Son Fornés assemblage has been analysed in two different ways (following Hernández-Gasch *et al.* 2002). The first one takes into account the whole assemblage (n. 3 in Table 1 and Figure 3) and the second just takes those animal bones from domestic buildings of the site (*i.e.* excluding the material obtained in the talaiot; n. 4 in Table 1 and Figure 3). Strikingly, the latter fits better with the rest of the Iron Age assemblages.

The other case is Son Real. As the author of the report notes (Nadal 1998), there are several reasons not to consider this sample as a reflection of the herd composition of the Iron Age. First of all, the remains come from a funerary context, limiting its reliable economical significance. Furthermore, the very low number of recorded specimens (n=19) suggests that some kind of selection was performed during the recovery process. In fact, all the cattle bones are worked bones called ‘taps’ (*i.e.* stoppers), usually not associated with domestic contexts; their ultimate function is unknown (*e.g.* Font 1969; Waldren 1982; Hernández-Gasch 1997; Hernández-Gasch and Ramis 2010). For these reasons, in Table 1, Son Real was included only for comparative purposes. At the same time some differences between sites could depend greatly on recovery and taphonomic factors, aspects not always specified in the reports.

It seems likely that, with the Roman invasion, the picture changed markedly. Both in the Early and Mid-Late Roman deposits of *Pollentia*, pig and cattle bones became much more common. A pork-rich diet seems to be a regular dietary pattern in the Early Roman period, showing a characteristic ‘Roman diet’ influence (King 1999; 2001). The Roman diet pattern of the Iberian Peninsula outlined by King (1999) is presented as a grey area in the tri-plot graph of Figure 7. The animal bones from both phases of *Pollentia* fit perfectly in that area. This Roman-oriented diet reflects a highly significant shift in the pattern of animal consumption on the island and suggests that this new focus should also force a change in the production structures that were supplying the urban site.

The analysed log ratios of the sizes of domestic mammals provide an overview for the Iron Age and Roman sites of Mallorca. On the basis of the biometric results summarised above, there is no significant change in size throughout the Iron Age for cattle or caprines. Only in the case of pig a slight change just before the Roman arrival is noted. Some authors have suggested that the prehistoric animals of the island were smaller compared with those from the mainland (Uerpmann 1971; Estévez 1984b). They claim that this feature is the result of two converging factors, namely: little genetic exchange with other populations and the ecological constraints of the island. Therefore, the slight improvement noted in pigs for the Late Iron Age could be the result of the improvement of local herds.

On the other hand, the results of the biometric analysis demonstrate highly significant differences from the Roman arrival onwards. Cattle and sheep/goat from the 1st century BC – 1st century AD were clearly bigger than the bovids from the end of the Iron Age. This increase in size was sustained in the Mid-Late Roman period. The only difference between the species is that for sheep/goat a slight decrease in size in the Mid-Late Roman Period was noted. The possible explanation for this could be a more sustained importation of large cattle over time.

This size of the post-cranial skeleton could be influenced by both genotypic and phenotypic factors (*e.g.* Albarella 1997; Davis 1997; Thomas 2005). In the absence of more specific data (*i.e.* size changes in teeth), the increase in the size of skeletal elements could be both a consequence of selective breeding as well as the introduction of new stock. In any case, there is a clear trend to improve the livestock of the island.

The age-at-death profiles reveal a mixed husbandry strategy for sheep/goat and cattle during the Iron Age, with animals slaughtered for meat consumption and a few slaughtered between 2 and 3 years of age, suggesting that they were kept also for wool and milk. In the Late Iron Age an emphasis on dairy products of the caprines is witnessed since more adults were present. At *Pollentia*, it is interesting to note that in the Early Roman Period most of the sheep/goat are from relatively young animals, which were slaughtered at an age that suggests that meat production was the main concern. This suggests a greater cultural link with the Roman tradition (King 1999; 2001), than the intensive use of sheep for wool that typifies the later Iron Age in Mallorca (Hernández-Gasch *et al.* 2002; 2011). Although there was pork production throughout the Iron Age, there was a noticeably increase in the Roman period. The high fecundity and ability to produce large litters without a land cost, made them ideal meat producers, able to withstand regular culling of young individuals in order to supply the new consumer town. There is a possibility that some breeding sows were kept and bred within the city itself.

The interpretation of these results must be carefully considered and reviewed when further information will be available. These results are affected by a number of uncontrolled factors, such as possible differential preservation and recovery bias of the different contexts. Another factor to take into account is that perhaps some of the differences outlined here are the result of the different nature of the sites. In contrast to the Iron Age sites, all the Roman period assemblages come from an urban site, which could be reflecting other kind of differences, such as social status (Crabtree 1990). Besides, the comparison is unbalanced toward the Iron Age phase with a larger number of assemblages. But given the results presented here, a general trend can be seen of major changes in the development of the production and consumption of livestock with the arrival of the Romans.

Conclusions

The evidence outlined here provides some support for the existence, timing and nature of animal improvements in the Roman period. Throughout the Iron Age the subsistence economy is focused on sheep/goat breeding with a trend to further exploitation of wool in the later period. With the arrival of the Romans the strategy is totally reconfigured. An emphasis on meat of young caprines and pigs is evidenced, related to the need to feed a growing population. Cattle were used in agriculture and transportation until an adult age, maximising their productive lifetime. Furthermore, the size of these animals changed abruptly in the Roman period indicating new livestock importation for the principal domesticates. Although more work is required, it is hoped that this and other ongoing research will eventually deepen the knowledge of the development of animal husbandry in Mallorca in the transition from the Iron Age to the Roman period.

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Food production and exchanges in the Roman *civitas Tungrorum*

Fabienne Pigière[1] *and Annick Lepot*[2]

1. Royal Belgian Institute of Natural Sciences
Rue Vautier 29
B-1000 Brussels
Belgium
fabienne.pigiere@naturalsciences.be

2. Université catholique de Louvain
Centre de Recherches d'Archéologie Nationale
Rue du Marathon 3
B-1348 Louvain-la-Neuve
Belgium
annick.lepot@uclouvain.be

Abstract

This paper presents a micro-regional approach taking account of both 'producer' and 'consumer' sites in order to document the network of the supply of animal products. Through an interdisciplinary study of common ceramics and archaeozoological data the study stresses that it is possible to give information about the exchange relationships between a city and its countryside and about the surplus produced at rural sites. This approach has been illustrated with the case study of the *Caput Civitatis* of Tongeren, the small town of Braives and the rural sites located within a radius of 30 kilometres. Indeed, the study of the supply of culinary ceramics at these sites has made it possible to document local exchange networks. These common ceramics were bought at the local market, where the peasants possibly sold their surplus products. Within this framework, it has been possible to examine and to compare the production, acquisition and consumption of animal products of Tongeren, Braives and seven *villae*. Cattle played an important role in the mass supply of meat and craft products to the town of Tongeren and the small town of Braives during the Early Roman period. Preliminary evidence has been gathered indicating that both sites relied on rural production for their cattle provisioning. In addition, the diversity in the animal production of the rural sites located around Tongeren has been examined within the framework of the complexity of local exchange networks.

Keywords: *archaeozoology, ceramology, Roman period, town, rural hinterland*

Introduction

Archaeozoological data available for the loess region in Central Belgium reflect the installation of a market economy during the Early Roman Period (Pigière 2009). Cattle husbandry became of major economic importance, which can be partly explained by an intensification of agriculture in the area and the need of cattle for traction. Indeed, this region is part of the hilly area covered with Pleistocene loess, where most of the soils are fertile and very suitable for agriculture. The intensification of agriculture in this zone during the Roman Period is demonstrated by changes in land use, choice of crops, technical equipment, and social organisation of the production (Roymans 1996, 58-65). At the same time, the breeding of cattle responded to the need for mass production of meat and raw material for craft activities in urban centres (Pigière 2009). However, considering the issue of food supply, the exchanges between town, small towns and rural sites remain to be investigated. This paper presents a micro-regional approach in order to document the exchange relationships between a town and its countryside. The research focuses on the *Caput Civitatis* of Tongeren, the small town of Braives and several rural sites. The study of the supply of culinary ceramics at these sites can be used to identify the local exchange relationships between them. The local or regional distribution of these daily-use wares may reflect the network of redistribution of the surplus of animal products. Indeed, the peasants possibly sold their surplus products at the same local market that supplied the *villae* with cooking wares. Therefore, using archaeozoological data, we investigate the production and consumption patterns of animal products of the town of Tongeren, the *vicus* of Braives and seven *villae*. This study will first compare the acquisition, processing and consumption of animal resources between the city and the small town. Then, their relationship with the producer sites will be examined. Also, we will compare the husbandry practices of the rural sites located in the micro-region around Tongeren. Finally, in order to approach the regional trends in the surplus production of animal products, it is necessary to consider the data from both 'producer' and 'consumer' sites: at the places of the production of the surplus and also where it was sold. In the Roman socio-economic system, it is assumed that the food provisioning of that part of the population, such as the military, the civilian services, and the craftsmen, who were not involved in the primary production, depended on a surplus produced by the rural population (Garnsey and Whittaker 1985; Roymans 1996). At the same time, the extreme theory that the city was the parasite of the countryside now seems to have been abandoned (Wallace-Hadrill 1991; Hopkins 1978). More and more studies have demonstrated that the city was involved in the trade and the production of goods. Recently, researchers have provided evidence that animals consumed in cities were partly bred in the town itself or in its close vicinity and partly imported from the countryside (Maltby 1994; Oueslati *et al.* 2006).

Materials and methods

In order to document the relationships between town, *vicus* and rural sites related to the supply of animal resources during the Early Roman Period, we focus on a micro-region located within a radius of thirty kilometres around Tongeren. We have selected nine sites for this interdisciplinary research: the *civitas* capital Tongeren, the small town of Braives and seven *villae* in the countryside, all located in the fertile loess region (Fig. 1).

Among consumption goods, regional ceramics – particularly cooking wares – are a useful class of pottery for studying local exchange networks. Using a technological approach, we can identify Gallic heritage in terms of specific temper, or new technological progress of the Gallo-Roman culture such as the use of a potter's wheel (Lepot 2012). Analysis of the morphology allows us to group wares into specific 'cooking sets' – jar, bowl, plate and lid for example – which evolve typologically during the three centuries. For the region of Tongeren, we have highlighted four series of cooking sets (Lepot and Espel 2010). Changes between different sets are usually linked with periods of unrest such as the Batavian revolt in 69–70 AD or the political and economic crises of the end of the 3rd century AD. Moreover, the identification of production centres or regions, localised thanks to the analysis of pottery fabrics, contributes to the understanding of distribution patterns. Ceramics are examined at a macroscopic level and attached to regional or technological groups before undergoing petrological examination to identify particular fabrics. In certain cases these fabrics are attributable to individual

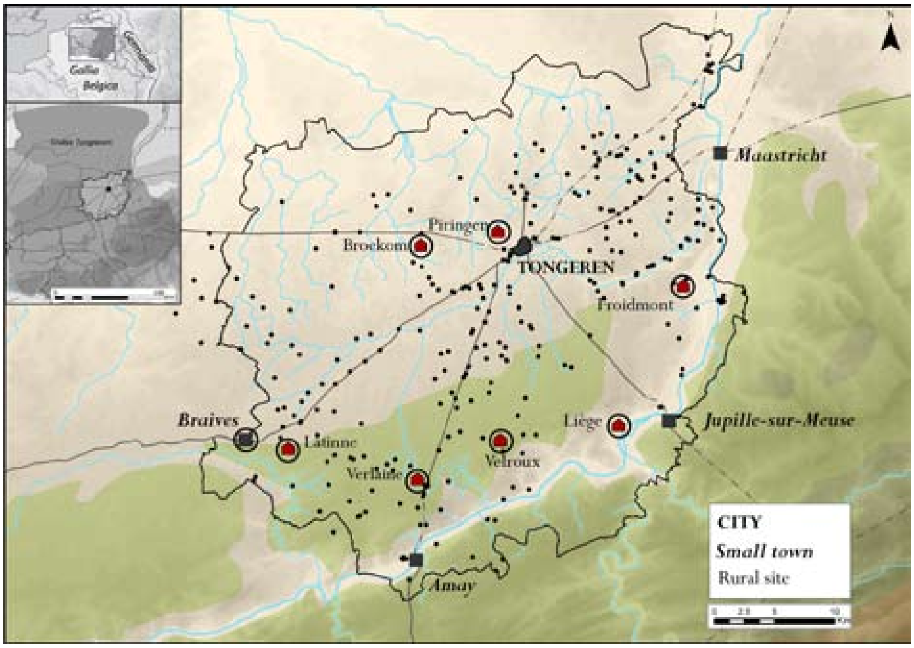


Figure 1. Map of the micro-region around Tongeren with location of the sites mentioned in this paper (APIS/UCL/CRAN).

workshops (Brulet *et al.* 2010). We discuss in this paper a corpus of 1016 wares (MNI) divided into 24 assemblages from 16 sites within the micro-region.

Based on archaeozoological analysis, we examine the production, acquisition, processing and consumption patterns of the animal resources of the town, the small town and the *villae*. As this study investigates the production of the countryside and its exchanges with urban sites, we have focused on the three main domesticates (pig, cattle and ovicaprines). This research is based on a corpus of 16,826 identified animal bones from the nine sites (Table 1). The data set is quite large for Tongeren and Braives and is the result of excavations in several sectors of the settlements. For the *villae*, the assemblages are usually smaller, partly because these sites were only partially excavated. Moreover, archaeozoological studies from different authors are integrated into this research, creating difficulties for inter-site comparisons, especially when dealing with slaughtering ages (see below). However, the data already available allow us to produce a first archaeozoological synthesis for this micro-region. Age-at-death of the animals was established based upon the fusion of bone epiphyses and the eruption and attrition of mandibular teeth. For the Verlaine and Velroux sites, tooth wear stages follow Grant's system (1982) and

Site	**Site type**	**Date**	**Reference**
Tongeren-Momberstraat	Town	Mid 1st cent. AD	Lentacker *et al.* 2007
Tongeren-Hondstraat	Town	Flavian-first half of 2nd cent. AD	Ervynck and Vanderhoeven 1997; Vanderhoeven and Ervynck 2007
Tongeren-Minderbroederstraat	Town	First half of 1st cent. AD-second half of 2nd cent. AD	Vanderhoeven *et al.* 1994
Tongeren-Elisabethwal	Town	Flavian-2nd cent. AD	Vanderhoeven and Ervynck 2007
Tongeren-Veemarkt	Town	1st cent. AD-3rd cent. AD	Vanderhoeven *et al.* 1993
Tongeren-Kielenstraat	Town	1st cent. AD-3rd cent. AD	Vanderhoeven *et al.* 1987; 1992; Van Neer 1994
Braives-Sector 1	Small town	End 2nd cent. AD-beg. 3rd cent. AD	Cordy 1981
Braives-Sector 2	Small town	2nd cent. AD-3rd cent. AD	Cordy and Stassart 1983
Braives-Sector 3	Small town	1st cent. AD-3rd cent. AD	Cordy and Rapaille 1985
Braives-Sector 4	Small town	1st cent. AD-3rd cent. AD	Trabert 1990
Braives-Sector 5	Small town	1st cent. AD-3rd cent. AD	Yernaux *et al.* 1992
Broekom	Rural site	2nd cent. AD-3rd cent. AD	Van Neer 1988
Latinne	Rural site	Early Roman period	Cordy 1984
Piringen	Rural site	85/90-110/120 AD	Van Neer 1990
Velroux	Rural site	1st cent. AD-3rd cent. AD	Pigière in press
Verlaine	Rural site	2nd cent. AD-first half of 3rd cent. AD	Pigière in prep.
Froidmont	Rural site	Second half of 2nd cent. AD-3rd cent. AD	Tromme *et al.* 2008
Liège/Place Saint-Lambert	Rural site	2nd cent. AD-first half of 3rd cent. AD	Gautier and Hoffsummer 1988

Table 1. Sites of the civitas Tungrorum *used in this research.*

these were grouped into the age stages suggested by Payne for ovicaprines (1973). In older archaeozoological studies carried out at Braives, only rough wear classes were used for the third molar, classified as little worn, medium worn and heavily worn. The bone measurements have been taken according to the methods of Von den Driesch (1976). The log-ratio method has been used in the osteometric analysis of the cattle bones. The log size index (LSI) is the logarithm of the ratio between a measurement 'X' and its standard 'S', and calculated as log (X/S) (Meadow 1999). The standard used here is a female aurochs from Ullerslev (Denmark) from the Boreal Period (De Cupere and Duru 2003, 116, Table 9).

Several archaeozoological tools have been developed to document the mode of acquisition of the domesticated animals on a site. This approach relies on the notion of the physical distance separating producers and consumers (Oueslati 2006; Oueslati *et al.* 2006). The greater the physical distance, the more producers and suppliers will be involved in the system. Conversely, the distance will be short when the consumer is directly in contact with the producer or when the consumer is the producer himself. The mortality and sex profiles of the animals are used to shed light on this question. When the distance between producers and consumers is large, the selection of animals within this supply system leads to a greater uniformity of age and sex, and only certain slaughter ages will be represented in the mortality profile. In contrast, when the distance is small, the consumer will have access to a more diversified range of ages and sexes. The animals killed because they are no longer productive, or that died from accident or disease, will be more readily available for consumption under these circumstances. Another approach to this distance relies on the hypothesis that animal morphology tends to be relatively homogeneous within a single herd (Oueslati *et al.* 2006). Thus, metrical data will show less variability in a single flock/herd than in an assemblage derived from several different flocks/herds from various production centres. Following the method described by Oueslati *et al.* (2006), standard deviation and Pearson's coefficient are used to evaluate species size diversity within an archaeological assemblage.

Cooking wares and the local exchange network in the micro-region around Tongeren

The cooking wares of the Early Roman settlements appear to be linked with a Gallic tradition of calcite-tempered wares (Lepot and Vilvorder in press). The so-called *kurkurns*, native to the calcareous region of the Condroz in Belgium, are the principal cooking vessels of the inhabitants of the city of Tongeren and the small town of Braives during the Augusto-Tiberian period (Vanderhoeven 1996, 202). From the Claudian Period onwards, Tongeren produced its own cooking wares using a reduced fabric (Vilvorder *et al.* 2010). The corpus produced in the pottery kilns includes Italic vessel types but also retains some traditional forms that evolved over the centuries. This Gallo-Roman cooking ware production represents about 80 % of the ceramic assemblages of Tongeren. These products are also represented in small towns, such as Jupille-sur-Meuse and Braives, and in the early *villa* settlements of Broekom, Piringen and Velroux. This ceramic distribution

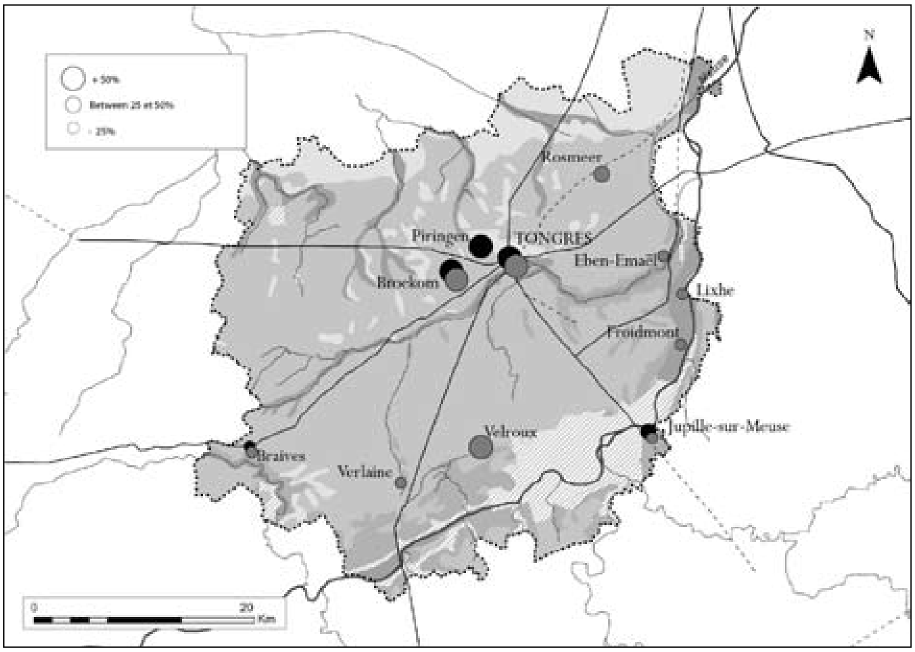
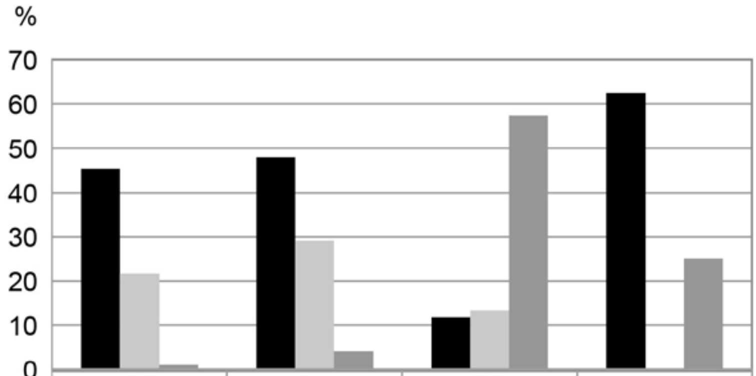


Figure 2. Distribution of cooking pottery of Tongeren reduced (black dots) or smoked (grey dots) fabrics within the assemblages from the countryside sites (APIS/UCL/CRAN).

pattern shows the connections between the earlier *villa* sites and the capital (Lepot and Espel 2010). The importance of the urban market is confirmed during the 2nd century AD. At this time, the cooking ware products of Tongeren changed in colour, being surface smoked in accordance with a more 'Italic' fashion fabric (Vilvorder *et al.* 2010). In buying more local products for their kitchens the *villae* sites seem to have many more exchange relationships with Tongeren than the small towns (Fig. 2).

Quantification tests on the assemblages of the micro-region dated to the 3rd century AD highlight differences in the exchange relationships. Distribution studies show that where the quantity of Tongeren products decreased a new market took over. This was the case around the small towns, such as Tienen, producing their own cooking wares (Martens and Willems 2002). Supply patterns also changed when sites were located near an important commercial route such as the Meuse valley. Considering the case of the two contemporaneous *villae*, Verlaine and Velroux, located at a distance of eight kilometres from each other, we see very clearly that the Verlaine assemblages include more cooking vessels produced in the Meuse valley, as is also the case in assemblages from other sites along the river (Fig. 3). In contrast, Velroux seems to have kept its commercial links with Tongeren until the Late Roman period. It appears that these two *villae* were involved in different exchange relationships.



	Verlaine (H VIII)	Velroux (H VIII)	Verlaine (H IX)	Velroux (H X)
■ CFU-TON	45.36%	47.92%	11.76%	62.50%
■ CEN-/CCL-DEQL	21.65%	29.16%	13.24%	0.00%
■ CFU-MOSA	1.03%	4.17%	57.35%	25.00%

Figure 3. Relative proportion of the Tongeren fabric (TON) and Meuse valley fabric (MOSA) in the assemblages of Verlaine and Velroux during the 2nd (HVIII) and the 3rd centuries AD (HIX and HX).

Acquisition, processing and consumption of animal resources at Tongeren and Braives

Documenting the consumption of animal resources

For both Tongeren and Braives, large assemblages of consumption remains from several sectors of the settlements give information about the food habits of the inhabitants. At Tongeren, general consumption waste excavated at the Kielenstraat and Veemarkt sites shows that cattle are predominant among the main domestic animals consumed throughout the Early Roman Period (Fig. 4). Pig is the second most common species, followed by ovicaprines.

Concerning the age-at-death of the consumed animals, limited published data are available for the sites of Tongeren. Information based on the epiphyseal fusion of the bones from several sites at Tongeren are summarised in Table 2. These data show that mainly adult cattle were consumed. This is recorded in the general dump of the Veemarkt site as well as in the Momberstraat context associated with the town's rich inhabitants. Only at the Kielenstraat site are both young and adult individuals found. As far as the ovicaprines are concerned, mainly adult individuals have been recorded at two sites. The dietary habits of the rich inhabitants of Tongeren are distinguished, among other things, by a high proportion of pig as shown by the sites Veemarkt (Vanderhoeven *et al.* 1993) and Momberstraat (Vanderhoeven *et al.* 2007). These animals were very young individuals, usually less than one year old.

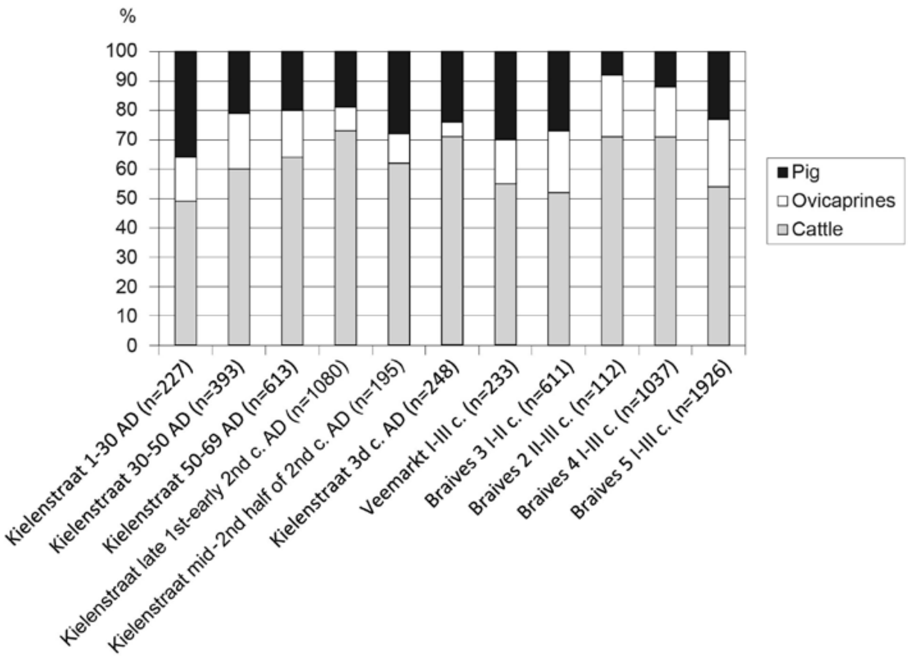


Figure 4. Relative proportions of pig, cattle and ovicaprines at Tongeren and Braives.

Site	Context type	Date	Cattle	Ovicaprines	Pig
Momberstraat	Closed context of rich inhabitants	Mid 1st cent. AD	Adult	Mainly adult, few sub-adult and senile	Very young
Kielenstraat	General consumption waste	1st cent. AD	Young and adult	Mainly adult	-
Veemarkt	General consumption waste	1st-3rd cent. AD	Adult > 4 years old	-	-
Veemarkt	Closed context of rich inhabitants	Flavian-first half of 2nd cent. AD	-	-	Very young < 1 year old

Table 2. Summary of information about age-at-death based on the epiphyseal fusion of the bones of pig, cattle and ovicaprines at Tongeren.

The analysis of assemblages from several sectors at Braives shows, as for Tongeren, that cattle are prevalent among the food remains of the inhabitants during the Early Roman Period (Fig. 4). Ovicaprines are usually the second most common species, which is different from the situation at Tongeren where pig predominates over ovicaprines. The age-at-death of the animals consumed has been established, based upon state of eruption and attrition of teeth from lower jaws, for several sectors in Braives (Cordy and Stassart 1983; Trabert 1990; Yernaux *et al.* 1993). At sector 2, cattle were mainly killed between the ages of 18 and 30 months (33 %) and as young adults (Table 3: 31 %). Few were consumed between the ages of 6 and 18 months. Finally, adult and senile individuals are uncommon. At sector 5, there is also a peak in mortality between 18 and 30 months (43 %)

Stages	Suggested age	Braives 2 2nd-3rd cent. AD		Braives 5 1st-3rd cent. AD		Braives 4 1st-3rd cent. AD
M1 absent, p4 present	0-6 mth	0	11 %	0	9 %	24 %
M1 erupting	6 mth	0		0		
M1 in wear, M2 not erupted	6-18 mth	2		0		
M2 erupting	18 mth	3		6		
M2 in wear, M3 not erupted	18-27 mth	9	33 %	18	43 %	30 %
M3 erupting	27-30 mth	6		11		
M3 + worn	Young adult	14	31 %	3	4 %	46 %
M3 ++ worn	Adult	5	11 %	14	21 %	
M3 +++ worn	Senile	6	13 %	16	24 %	
NISP total		45		68		46

Table 3. Age-at-death based upon state of eruption and attrition of teeth for cattle at Braives. + little, ++ medium, +++ heavy.

and a significant number were adult (21 %) and very old individuals (24 %). Data about the kill-off patterns of cattle from sector 4 are not detailed enough, however they show that a high number of very young cattle of less than 18 months were consumed (24 %). Again, cattle aged between 18 and 30 months are numerous (30 %) and 46 % were culled after they were 27-30 months old. The kill-off patterns at Braives show a strong selection of sub-adults and young adults for consumption, which indicates that the majority of animals were primarily exploited for their meat. Concerning ovicaprines, data for sector 5 indicate that a significant quantity was killed under 12 months of age (Table 4: 45 %). A high number were also culled when they had become adults (25 %). Some were aged between 1 and 2 years old and a small group corresponds to very old individuals. This mortality profile seems to suggest an exploitation of ovicaprines for dairy purposes and meat (Helmer *et al.* 2007). Indeed, in milk exploitation a surplus of lambs is slaughtered to ensure a steady milk supply for human consumption and a high number of adults (mainly female) are kept for breeding. Regarding the meat production, the selection of young animals culled before 1 year old indicates a selection for tender meat. The few data available for sector 4 also indicate a selection of animals under a year old (31 %). The majority are young adults or adult individuals (63 %), while very old animals are not represented. Finally, only sector 5 has provided enough data to examine the kill-off patterns of pigs (Table 5). The majority of pigs were slaughtered under 12 months of age (45 %) and between 13 and 22 months of age (24 %). A high percentage reached an older age and these animals were probably kept for breeding.

Stages	Suggested age	Braives 5 1st-3rd cent. AD		Braives 4 1st-3rd cent. AD
m3/p4 unworn	0-2 mth	6		
m3/p4 in wear, M1 unworn	2-6 mth	10	45 %	31 %
M1 in wear, M2 unworn	6-12 mth	8		
M2 in wear, M3 unworn	1-2 yr	7	13 %	6 %
M3 + worn	2-3 yr	3	6 %	63 %
M3 ++ worn	Adult	13	25 %	
M3 +++ worn	Senile	6	11 %	-
NISP total		53		16

Table 4. Age-at-death based upon state of eruption and attrition of teeth for ovicaprines at Braives. + little, ++ medium, +++ heavy.

Stages	Suggested age	Braives 5 1st-3rd cent. AD	
M1 absent, p4 present	0-6 mth	0	
M1 erupting	6 mth	5	45 %
M1 in wear, M2 not erupted	6-12 mth	8	
M2 erupting	12 mth	6	
M2 in wear, M3 not erupted	13-18 mth	6	24 %
M3 erupting	18-22 mth	4	
M3 + worn	2-3 yr	1	2 %
M3 ++ worn	Adult	4	10 %
M3 +++ worn	Senile	8	19 %
NISP total		42	

Table 5. Age-at-death based upon state of eruption and attrition of teeth for pig at Braives. + little, ++ medium, +++ heavy.

Documenting the acquisition of domestic animals

The aforementioned demographic data for cattle at Braives, which result from three different sectors, supply evidence for the physical distance separating producers and consumers. Mortality profiles of cattle are truncated: individuals of less than 6–18 months of age are lacking. Although differential preservation and recovery of these age groups may have led to some under-representation, this result is an indication of a certain distance between producers and consumers.

The same analysis cannot be provided for Tongeren, for which there are not enough data available to establish the survival curves of the main domestic animals. However, the distance between producers and consumers can be evaluated through the diversity in size of the animals that were consumed on the site. Conversely, no published metrical data are available to carry out the latter analysis on the material from the small town of Braives. The coefficient of variation for cattle has been calculated for the metrical data from bone assemblages from two sites in Tongeren: the Hondstraat site dated to the Flavian Period- first half of the 2nd century AD and the Kielenstraat site dated to the 2nd century AD (Boussier 2011). These data are compared to those from nine sites in France dated between the La Tène and Roman Period, published by Oueslati *et al.* (2006). The values of the coefficient of variation for the different sites range from 8.27 to 12.59. The sites are ranked in decreasing order of the value of the coefficient of variation in Table 6. One assemblage has a higher value than Tongeren-Kielenstraat: the La Tène site Villeneuve-Saint-Germain. However, some caution must be used when comparing the Tongeren data with that from Villeneuve-Saint-Germain because of the broad time period covered by the latter assemblage compared to the Roman samples. Both sites at Tongeren have higher values than the other Roman towns of Lyon, Lutecia, Saint-Marcel, Arras and Vieux. Therefore, it can be stated that cattle from Tongeren show a high diversity in size during the Flavian Period and the 2nd century AD.

Another indication for the distance between producers and consumers has been found at Braives. The abandonment layer of a well dated to the end of the 3rd century AD yielded the remains of carcasses of pig, cattle and ovicaprines (Table 7). The corpses also included the foetuses of pigs and ovicaprines, showing that local breeding of these species took place. It is striking that when we compare

Site type	Site	N	Mean	Min	Max	Std.Dev.	Coeff. V.
Urbain-La Tène	Villeneuve-St-Germain	99	48.57	50.5	63	6.12	12.59
Urban	Tongeren-Kielenstraat	21	53.47	44.8	68.4	6.5	12.15
Urban	Lyon	41	54.07	45.2	67.5	6.39	11.82
Urban	Tongeren-Hondstraat	46	54.36	42.7	67.1	6.33	11.64
Urban	Lutecia	68	60.86	44.9	76	6.81	11.19
Urban	Saint-Marcel	144	51.17	44	70	5.36	10.47
Urban	Arras	29	57.38	43.9	71.4	5.92	10.32
Rural	Zouafque	19	58.54	49.4	66.7	5.6	9.56
Urbain-La Tène	Levroux	15	50.86	42.4	58.9	4.51	8.87
Port complex	Meulan	29	50.69	45	61	4.42	8.73
Urban	Vieux	19	53.41	48.7	64.2	4.42	8.27

Table 6. Statistical data of the measurements of the distal width of cattle metatarsals from Tongeren and nine comparative sites in France (after Oueslati et al. *2006). Sites are ranked according to their value of coefficient of variation.*

Site		Date	Pig	Cattle		Dog	Horse	Reference
Braives	Sector 5	End 3rd cent. AD	x	x	x	x	x	Lentacker *et al*. 1993
Tongeren	Extra-muros	-					x	Gautier 1975
Tongeren	Kielenstraat	3rd cent. AD				x	x	Vanderhoeven *et al*. 1987
Tongeren	Veemarkt	Second half of 2nd cent. AD				x		Vanderhoeven *et al*. 1993

Table 7. Presence of carcasses of domestic animals in wells at Braives and Tongeren.

faunal assemblages from the same type of context in the town of Tongeren, there is no indication of local breeding; the contents of three wells with animal carcasses yielded only dogs and horses.

In brief, evidence has been gathered that the distance between producers and consumers is quite large regarding the acquisition of cattle for both the town of Tongeren and the *vicus* of Braives. In addition, the identification of foetuses of pigs and ovicaprines demonstrates the local breeding of these species at Braives, but this evidence does not allow evaluation of the importance of this activity in this small town.

Documenting the processing of animal products

The presence of large-scale, professional cattle butchery processing has been identified at Tongeren. An assemblage of bones typical of specialised cattle butchery from the second half of the 2nd century AD has been excavated at the Kielenstraat site (Vanderhoeven *et al*. 1991). The assemblage is mainly composed of cranium fragments and thoracic vertebrae, which are skeletal elements rejected at the beginning of the processing of the carcass (Lepetz 2007). Moreover, several craft activities dependent on these cattle butcheries for their raw material supply were established at Tongeren from the Flavian Period onwards. Specialised assemblages of cattle bones attesting to bone-working craft were found at the site of the Gallo-Roman museum of Tongeren (Vanderhoeven 2007). Horn-working and/or tannery have been attested at the Elisabethwal site and large-scale production of marrow, grease and glue at the Hondstraat site (Vanderhoeven and Ervynck 2007). Bulk cattle processing also appears to have been carried out in the small town of Braives. A faunal assemblage discovered in a refuse dump excavated in the central zone of the *vicus,* dated to the end of the 2nd century – beginning of the 3rd century AD can be related to this activity (Cordy 1981). The overwhelming presence of cattle bones in the assemblage (NISP=504, 99 % of total NISP) and the overrepresentation of some skeletal elements (mainly rib bones and to a lesser extent scapulae) are typical remains of specialised cattle butchery (Lepetz 2007). A small assemblage of severely fragmented long bones was also thrown away in the dump (NISP=81). These are remains of the production of marrow, grease and glue (Stokes 2000; Lentacker *et al.* 2001), but on the basis of this sample it is difficult to determine how extensive this latter production was. The presence of professional cattle butchery is also attested in many other small towns of the loess region, as for example at Tienen, Maastricht and Liberchies (Pigière 2009). Cattle were doubtlessly also processed inside the domestic units in parallel with the existence of professional butchery, as has been shown for urban Lutecia (Oueslati 2006, 248). In addition, no data show that pig and ovicaprines were processed in a dedicated butchery in the loess region (Pigière 2009). Although a few exceptions have been found in the territories of the Gauls, the data available so far show that professional butchery focused on cattle.

Production and consumption of animal products in *villae* around Tongeren

The ceramic study provides information about the trade relationships between Tongeren and several *villae* from the countryside around the capital. Archaeozoological data have been gathered for three of these *villae*: Broekom, Piringen and Velroux. If we consider the proportion of the main domestic animals, we see a relative emphasis on cattle compared to pig and ovicaprines during the 1st and 2nd centuries AD at these sites (Fig. 5). Assemblages from Velroux indicate that cattle are preponderant from the Claudian Period onwards and that they remained predominant during the 2nd century AD.

However, indices of diversity in the animal production of the countryside around Tongeren have been collected by making a comparison between the *villae* of Velroux and Verlaine. These two *villae* located at eight kilometres from each other are implanted in the same agricultural landscape (Fig.1). However, as shown by the ceramological study, they seem to have been involved in different local exchange networks during the 3rd century AD. Indeed, Velroux has relationships

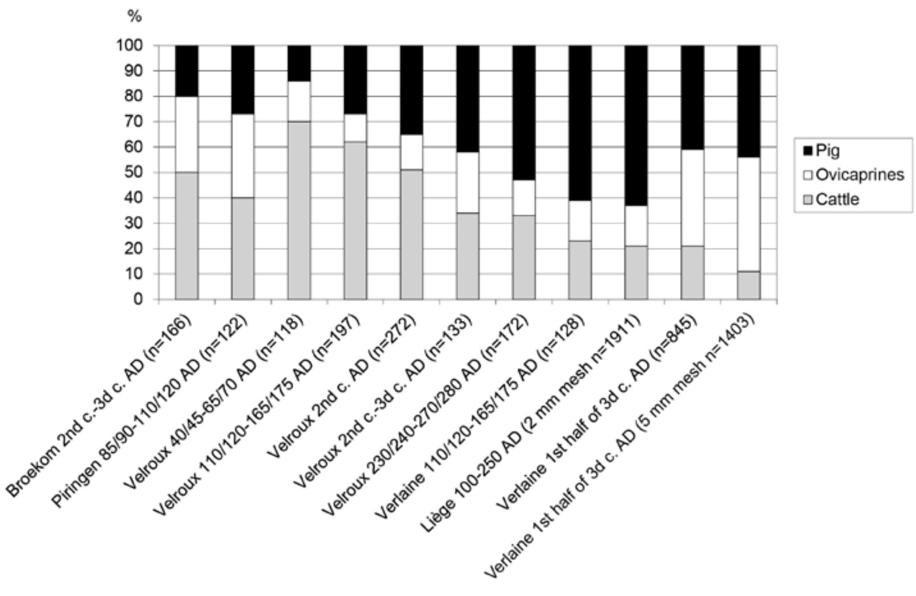


Figure 5. Relative proportions of pig, cattle and ovicaprines at the villae *around Tongeren.*

with the *Caput Civitatis* of Tongeren while Verlaine had links with a small town in the Meuse valley. Differences between the two *villae* also appear when the relative importance of the main domestic animals is examined. The species ratio indicates an emphasis on cattle at the *villa* of Velroux during the 1st and the 2nd centuries AD (Fig. 5). During the 3rd century AD, the proportion of cattle decreases to the benefit of pigs, and the ovicaprines come only in third position. These results are indicated by different context types (dumps and closed refuse contexts such as wells) and therefore may indicate a new orientation in the husbandry practices at the *villa* of Velroux.

For Verlaine, only a small sample is available for the 2nd century AD. Pig is predominant among the triade remains during this period (Fig. 5). It is notable that the data collected at the *villa* of Liège, also situated in the Meuse valley, show an emphasis on pig for the period of the 2nd century – first half of the 3rd century AD. More archaeozoological data are available for the first half of the 3rd century AD at Verlaine. During this period, ovicaprines and pigs are most prevalent and cattle come only in third position.

It was possible to study the age-at-death of ovicaprines consumed at Verlaine. The mortality profile has been established on the basis of mandibles discovered inside the backfill of a well located in the vicinity of the main building and dated

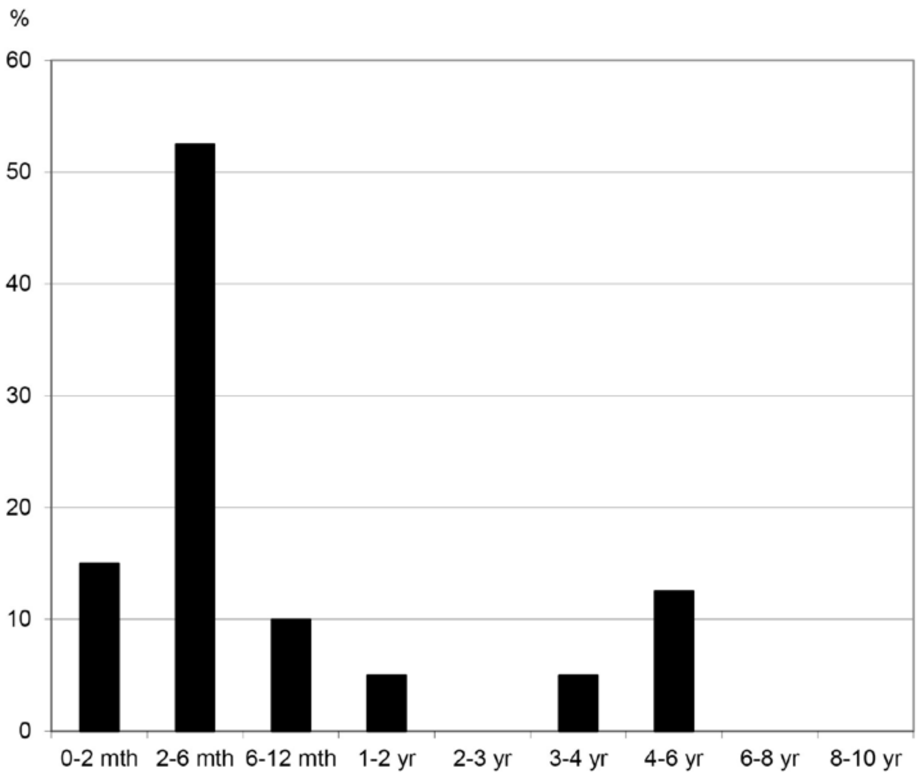


Figure 6. Ovicaprines mortality profile of the first half of the 3rd century AD at the Verlaine site (MNI=29).

7-10 months	F	NF
Scapula, tuber scapulae	1	-
Pelvis, acetabulum	-	-
NISP total	1	-
1 year - 1 year 1/2	**F**	**NF**
Humerus, distal	6	-
Radius, proximal	5	-
Phalanx 1, proximal	8	-
Phalanx 2, proximal	3	-
NISP total	22	-
2 - 3 years	**F**	**NF**
Metacarpus, distal	2	1
Tibia, distal	4	-
Metatarsus, distal	1	-
Metapodia, distal	1	-
NISP total	8	1
3 years 1/2 - 4 years	**F**	**NF**
Humerus, proximal	1	-
Radius, distal	1	-
Ulna, proximal	1	-
Femur, proximal	2	-
Femur, distal	-	-
Tibia, proximal	2	-
Calcaneum, proximal	-	-
NISP total	7	-

Table. 8. Epiphyseal fusion data for cattle dated to the end of 1st century – 3rd century AD at Velroux.

to the first half of the 3rd century AD (Fig. 6). The frequency of each age class has been corrected in proportion of its probability following the Vigne and Helmer method (2007). In addition, the mortality profile of Verlaine has been compared to the models of exploitation for meat, milk and wool productions according to Helmer *et al.* (2007). The mortality profile indicates that most of the animals were killed when they were less than 1 year old (79 %). The main peak of slaughter corresponds to an age of 2–6 months (53 %). The remaining animals were then killed between 3 and 4 years and above all between 4 and 6 years. The profile of Verlaine is closest to the meat model type A proposed by Helmer *et al.* (2007), in which many lambs are killed between 2 months and 1 year. However, the significant number of animals also slaughtered under 2 months of age and between 4 and 6 years of age suggests a mixed exploitation of meat, milk and wool. As this material was thrown away in the vicinity of the main building of the *villa*, there is a greater chance that it represents the consumption by the owner of the *villa*. This could result in a bias at the benefit of the young individuals bred for meat. In consequence, the milk and wool production could have been more important in the economy of the *villa* than is reflected by these data.

At Velroux, some data are available for the age-at-death of cattle. The epiphyseal fusion data seem to indicate that mainly adult individuals were consumed at Velroux (Table 8). The few data available for the age-at-death based upon teeth confirm the results of epiphyseal fusion. Indeed, based on an assemblage of 12 mandibles, 8 jaws are from adult and very old individuals, 2 are from young adults and 2 others from sub-adults. We also see an emphasis on large cattle at Velroux compared to the *villae* from the Meuse valley (Verlaine and Froidmont) (Fig.1). The length and breadth measurements of the long bones of cattle from Velroux, Verlaine and Froidmont are compared using the Log Size Index (Figs. 7 and 8). The largest cattle have been recorded at Velroux. Using data regarding age at death, sex ratios and pathologies related to traction, a previous archaeozoological study performed on the Belgian loess region has pointed out that large cattle were bred in the first instance to be used as draft animals (Pigière 2009; 2011).

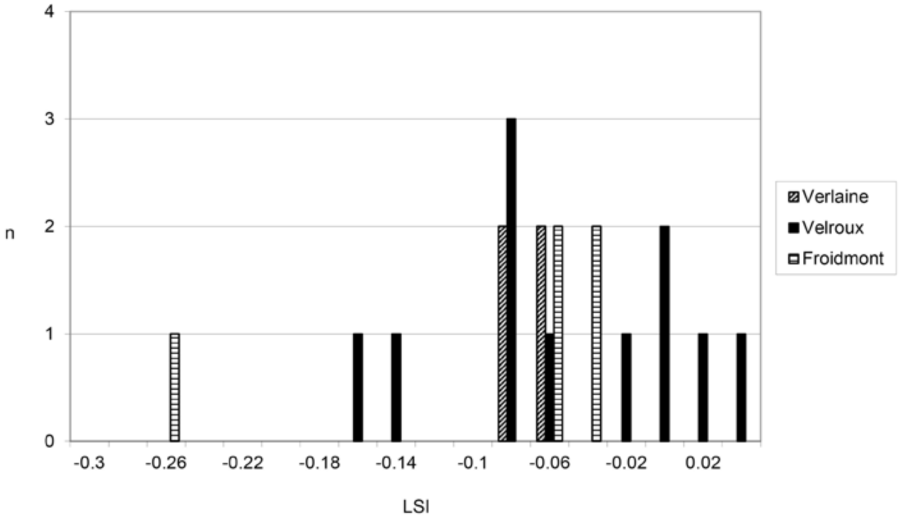


Figure 7. Log ratio diagrams for length measurements of cattle at Velroux, Verlaine and Froidmont.

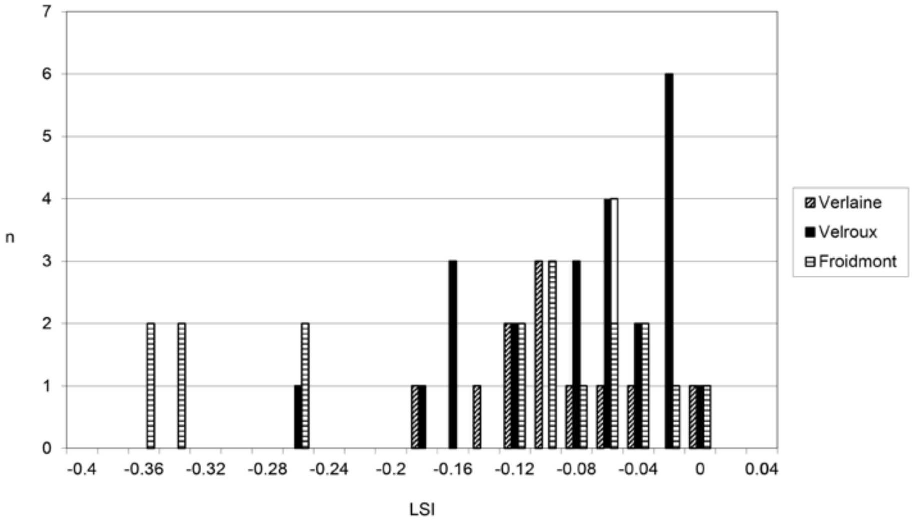


Figure 8. Log ratio diagrams for width measurements of cattle at Velroux, Verlaine and Froidmont.

Food surplus production in the micro-region around Tongeren

Professional cattle butchering activities are probably the most remarkable evidence of the Roman centralised system of food provisioning that developed in response to the need to feed large populations at the urban and military sites. The presence of these professional butcheries at Tongeren and Braives indicates that there was a need to provision the settlements with cattle on a large scale. Moreover, archaeozoological data from the general consumption waste from both sites confirm that cattle were the main meat suppliers throughout the Early Roman Period. First sets of evidence with regard to the distance between producers and consumers seem to show that both sites relied on the countryside to provide them with cattle. However, different kill-off patterns at Braives and Tongeren seem to reveal that they were supplied with cattle bred in different husbandry regimes. A great number of cattle consumed at Braives are sub-adults and young adults that were bred for meat. At Tongeren the few data available show that cattle are mainly adults, even on sites related to rich inhabitants, and therefore bred in the first instance for traction and/or milk production and breeding. Cattle are also predominant in the assemblages of the rural sites that appear to have had trade relationships with Tongeren during the 1st and the 2nd centuries AD. In addition, at the *villa* of Velroux, the combined information of the older age of the animals and the presence of large cattle seem to indicate that they have been bred for traction. These results fit with the agrarian vocation of the fertile loess region. In an arable-oriented economy, cattle played a complementary role providing manure and agricultural labour. However, evidence for diversity in the production of the countryside around Tongeren has been recorded by drawing a comparison between the *villae* of Velroux and Verlaine. These two *villae*, which were located in the same agricultural landscape, seem to be involved in different local exchange networks during the 3rd century AD. Accordingly, the surplus could have been produced with differentiation between the targeted markets: Tongeren versus a small town in the Meuse valley. At Velroux, archaeozoological data show that pigs predominated among the main meat suppliers and cattle were the second most common species during the 3rd century AD. At Verlaine, ovicaprines and pigs are the most common species at that period. The mortality profile of the ovicaprines at Verlaine suggests a husbandry regime orientated towards a mixed production of meat, milk and wool.

Conclusion

The present study stresses the necessity to have a global approach of both 'producer' and 'consumer' sites inside a micro-region in order to approach the network of the supply of animal products. Through an interdisciplinary study of common ceramics and archaeozoological data it is possible to give information about the exchange relationships between a city and its countryside and about the surplus produced at rural sites. This approach has been illustrated with the case study of the *Caput Civitatis* of Tongeren and its rural hinterland. Indeed, the study of the supply of culinary ceramics at the sites of the *civitas Tungrorum* has given information about the local trade network. Inside this framework, it has been possible to examine and compare the production, acquisition, processing and consumption of animal products of the town of Tongeren, the small town of Braives and several *villae*. Archaeozoological tools have recently been developed to approach the organisation of the urban site's supply of domesticated animals. In this study, the limited data available have only given preliminary evidence about the mode of acquisition of cattle at Tongeren and Braives. Large age-at-death data sets need to be built for the town of Tongeren in order to confront the evidence given by the metric approach on a greater distance between the producers and the consumers with regard to the provisioning of cattle. Similarly, the metric approach needs to be applied to the data from the small town of Braives. In addition, the consumption patterns of the inhabitants of Tongeren and Braives have been documented throughout the Early Roman Period. The results of this study show the importance of cattle in the mass supply of meat and craft products to both sites. At the same time, cattle are predominant among domesticated animals in the *villae* that had trade relationships with Tongeren. In addition, indices of diversity in the production of the countryside inside the micro-region have been recorded and examined in the framework of the complexity of the local exchange network. In the future, more interdisciplinary studies need to be performed in order to examine the agricultural landscape, the husbandry and agricultural activities of the *villae* and the local exchange networks in which they are involved.

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Entrepreneurs and traditional farmers: the effects of an emerging market in Middle Saxon England

Matilda Holmes

Consultant Archaeozoologist
45, Welland Rise
Sibbertoft
Leicestershire, LE16 9UD
England
matty@archaeozoology.co.uk

Abstract

It has been suggested that the emergence of new trading settlements in the Middle Saxon phase housed the first population of non-agrarian workers, merchants, administrators and craftsmen since the Roman Period in England. At the same time, a network of inland markets and trading sites has been hypothesised. This paper attempts to elucidate the role of wics (coastal and riverine trading sites) and inland markets as consumer sites, and rural sites as producers of a surplus to supply them. Utilising archaeozoological data from Early and Middle Saxon sites within England to investigate trends in diet, animal husbandry and the production of meat and raw materials, results suggest that surplus production was limited to the hinterland of wics; inland rural sites continuing a regime based on self-sufficiency from the Early Saxon phase.

Keywords: *Saxon, England, wic, surplus, specialisation, market*

Background to the study period

Following the withdrawal of Roman influence in the Early Saxon phase (AD 410–650), England split into numerous territories fought over by British and Saxon warlords (Esmonde Cleary 2011, 26). The majority of the population were farmers living in kinship groups, continuing with the preceding Romano-British or Iron Age agricultural economy, providing enough for themselves, their family and servants (Crabtree 1991, 36-37), as well as enough surplus to provide for hard times and food taxes paid to the King in return for protection (Hodges 1988, 4; Härke 1997, 157).

By the Middle Saxon phase (AD 650–850) there was considerable consolidation of territories leading to five major kingdoms: Northumbria; Mercia; East Anglia; Wessex; Sussex; and Kent (Hinton 1990, 60). The relative stability that this enabled led to a change in agriculture, where large estates were established under the control of an estate centre or vill. These estates incorporated a number of farmsteads which were expected to produce a surplus of food as tax for the Church, King or Queen of the region, collected at the estate centre (Fowler 2002, 71; Jones and Page 2006, 81). Following a rejection of the church during much of the Early Saxon phase, a number of minsters and monastic sites were re-established in the Middle Saxon phase, initially under the protection and influence of Royal patrons, but later becoming independent estate holders themselves (Blair 2005, 204).

The combination of comparative political stability and potential for the production of wealth in the form of a surplus of food and raw materials led to the beginnings of a market economy in England. The scale and mechanisms of trade at this time have been widely debated, but three main forms have been identified:

- Local markets and fairs held countrywide at secular or ecclesiastical estate centres, allowing trade in bulk goods such as raw materials, food and wool (Astill 1991, 103; Naylor 2004, 134). It has been suggested that these were the main routes of trade in Western England (Griffiths 2003, 71). The importance of the role of ecclesiastical sites in the production and redistribution of goods has been emphasised by both documentary and historical sources (Blinkhorn 1999, 14).
- Productive sites where large quantities of coins and metalwork have been recovered (Ulmschneider 2000, 63). Their location on major inland trade routes suggests that these sites were localised centres of trade, important for both local and inter-regional communication. There is also evidence for some of these sites to be centres of production of food and raw materials, and many are associated with ecclesiastical and high-status sites such as Brandon and Wicken Bonhunt (Naylor 2004, 15; Palmer 2003, 54).
- The final category of trading site in the Middle Saxon phase are the wics or emporia. These were large sites of international trade under the control of the local elite who would exact tolls on goods passing through. They were situated on the southern and eastern coastal and riverine regions to optimise trade with Europe. These sites depended on the trade of surplus food taxes, raw materials and high quality manufactured goods (Astill 1991; Vince 1994). Archaeological evidence exists for the specialisation of occupations consistent with the presence of craft workers and merchants within wics (Blackmore 2002, 289; Driver 1984, 401; Riddler 2001, 66; 2004, 145). This would have resulted in a population that could not produce food or materials to meet their own needs, who were dependent on external provisioning for their food and raw materials (DeFrance 2009, 107-108; Saunders 2001, 12).

The role of these three types of market on local and regional production must be considered in order to understand the demands put upon the rural producers. For example, Hodges (1996, 289) suggested that wics monopolised all regional and inter-regional exchange, with smaller markets fulfilling a relatively unimportant role. This theory is based upon the control of surplus production from rural sites by the elite occupying estate centres, who would then use excess food and raw materials to provision craft manufacturers within estate centres and wics, in return for taxes and trade in luxury goods through these wics (Hamerow 2007, 228; O'Connor 2001). If wics were under royal patronage, it is likely that these provisions were redistributed from local estate centres, which collected surplus from farms within their lands.

Alternative theories based on the quantity of coinage found at productive sites and regional markets suggest there was greater interaction along inland trade routes, with rural producers given the opportunity to freely market their surplus on inland sites as well as those on the coast (Astill 1991, 101; Brookes 2007, 26; Naylor 2004, 15; Palmer 2003, 53; Ulmschneider 2000, 71). If so, it may be expected that excess production of goods and food would occur at inland rural sites for distribution through inter-regional trade routes.

With the intention of furthering the current state of historical and archaeological knowledge regarding the nature of wics and inland trading sites, and their influence on the surrounding rural sites, this study aims to address three key questions:

1. Did the emergence of coastal trading sites (wics) in Middle Saxon England coincide with surplus production from local rural sites?
2. Is there evidence for specialisation and surplus production on rural sites further inland that may be used to infer the presence of similar, significant trading sites (productive sites and local markets) at more central regions within England?
3. If so, was this enabled by increased production *prior* to the founding of these trading sites, or was it brought about it by demand concurrent with their creation and their population by a non-agrarian section of society?

Surplus production or subsistence living?

To answer these questions, some criteria must be established for the identification of sites that were consumers of food and raw materials purchased, traded or redistributed from rural sites, and the subsequent identification of rural sites as producers of surplus or specialist goods. The mechanics of distribution and foodways between rural sites and wics or other trading sites in Middle Saxon England (see Hamerow 2007; Holmes forthcoming) are not specifically considered here, rather evidence for the types of production and consumption will be investigated.

Three major modes of production are commonly associated with animal husbandry (*e.g.* Davis 1987, 155-162; Maltby 1994, 85; O'Connor 1992): subsistence or self-sufficient production where animals are largely bred, reared, worked, killed and consumed within one site; net producer sites, where a surplus of animals is raised either for meat or secondary products that can then be traded, exchanged, sold or given as tax; and net consumer sites, where the majority of food and raw materials are bought in from producer or distribution sites. How are these different models reflected in the archaeological record?

Self-sufficient sites of which the inhabitants are both producer and consumer of animals and their products may be expected to include fairly non-specific signatures, either a narrow or diverse range of species, with animals culled at a range of ages providing both meat and secondary products and bones from all stages of processing (Clark 1987, 184). However, it should be borne in mind that this pattern may be consistent with some producer sites (Gumerman 1997, 116), depending on the intensity of production.

The specialist production of animals as sources of primary (*i.e.* meat, bone, skin) or secondary (*i.e.* wool, dairy, eggs) products will lead to the presence of animals at specific ages on both producer and consumer sites (Crabtree 1996a, 72), depending on where the processing of carcasses was taking place. Clark (1987, 184) has further refined this speculation, with regards to the provisioning of meat, suggesting that greater numbers of young males will be found at consumer sites, while missing from producer sites. Within the urban context itself, specialisation of industries such as butchery may also be indicative of a consumer site, as the consuming population becomes further divorced from the methods of food production (Gumerman 1997, 116). Alternatively, if animals were butchered at the producer site to provide specific cuts of meat, there may be an excess of primary butchery debris at that site, and a corresponding absence on the consumer site – subsequently there may appear to be an over-representation of young animals at prime meat age in the tooth wear data at the sites where such butchery took place (Clark 1987, 184).

Specialisation of secondary products will indicate a demand for goods such as wool or dairy (Gumerman 1997, 113). These may be observed by older, castrated and female sheep at producer sites where wool was of importance and older female animals where the onus was on dairy production (Crabtree 1996b, 102; Maltby 1994, 90; Wapnish and Hesse 1988, 84). It is likely that some of these older animals would also be marketed to consumer sites, as an excess of livestock and possibly a number of young males in the case of a dairy economy. Therefore some mixing of archaeozoological signatures should be expected between sites exhibiting different modes of production.

Materials and methods

Animal bone assemblages from 43 Early and 51 Middle Saxon sites in England were included in the data set (Table 1), conforming to the following criteria:

- Only domestic rural and wic sites were included - industrial or craft working sites were not included because of the potential for specific animal bones to be required at such sites.
- Ecclesiastical and high-status sites were included given their likely role in the specialist production of food and raw materials in Middle Saxon England.
- A minimum combined NISP (number of identified specimens) of 100 cattle, sheep and pig bones was chosen to maximise the potential data set.

Early Saxon Inland Rural Sites	County	Reference
Hartigans, Milton Keynes	Buckinghamshire	Burnett 1993
Pennyland, Milton Keynes	Buckinghamshire	Holmes 1993
Walton vicarage, Aylesbury	Buckinghamshire	Noddle 1976
Orton Hall Farm	Cambridgeshire	King 1996
Spicer's Warehouse, Sawston	Cambridgeshire	Holmes 2009
Stonea grange, Cambridgeshire	Cambridgeshire	Stallibrass 1996a
Sherborne House, Lechlade	Gloucestershire	Maltby 2003
Empingham west, Rutland water	Leicestershire	Morrison 2000
Eye Kettleby	Leicestershire	Knight forthcoming
Kings Meadow lane, Higham Ferrers	Northamptonshire	Albarella and Johnstone 2000
Middleton Stoney	Northamptonshire	Evans 2007
Aelfric's Abbey, Eynsham	Oxfordshire	Ayres *et al.* 2003
Audlett drive, Abingdon	Oxfordshire	Levitan 1992
Barton Court Farm, Abingdon	Oxfordshire	Wilson *et al*. 1986
Mill st, Wantage	Oxfordshire	Maltby 1996
New Wintles	Oxfordshire	Noddle 1975
Oxford Science park, Littlemore	Oxfordshire	Ingrem 2001
St Helen's Avenue, Benson	Oxfordshire	Hamilton-Dyer 2004a
Cadbury Congresbury	Somerset	Noddle 1970
Saxon County School, Shepperton	Surrey	Ayres 2005
Market Lavington, Wiltshire	Wiltshire	Bourdillon 2006
Deansway, Worcester	Worcestershire	Nicholson and Scott 2004
Early Saxon Rural Sites Close to Wics	**County**	**Reference**
Poundbury, Dorchester	Dorset	Buckland-Wright 1987
Fossets Farm, Southend	Essex	Grimm 2007
Old Down Farm, Andover	Hampshire	Bourdillon 1980
Manston rd, Ramsgate	Kent	Hamilton-Dyer 1997
Nettleton Top	Lincolnshire	Berg 1993
Quarrington, Lincs	Lincolnshire	Rackham 2003
Baynard's Castle	London	King 1980
Distillery site, Hammersmith	London	Ainsley *et al.* 2008
Harlington, London	London	Grimm 2009
Melford Meadows, Brettenham	Norfolk	Powell and Clark 2002b
Mundham, Norfolk	Norfolk	Leach and Morris 2008
Redcastle Furze, Thetford	Norfolk	Wilson 1995
Spong Hill, Norfolk	Norfolk	Bond 1995
West Stow a	Suffolk	Crabtree 1989
West Stow b	Suffolk	Crabtree 1989
West Stow c	Suffolk	Crabtree 1989
Botolphs, Bramber	Sussex	Stevens 1990
Caythorpe pipeline, North Humberside	Yorkshire	Stallibrass 1996b

Early Saxon Inland High Status Sites	**County**	**Reference**
Yeavering	Northumbria	Higgs and Jarman 1977
Cadbury Congresbury, Somerset	Somerset	Noddle 1992
Early Saxon Ecclesiastical Sites Close to Wics	**County**	**Reference**
Bishopstone, Sussex	Sussex	Gebbels 1977; Poole and Reynolds 2010
Middle Saxon Inland Rural Sites	**County**	**Reference**
Chicheley, Bucks	Buckinghamshire	Jones 1980
Walton Lodge, Aylesbury	Buckinghamshire	Sadler 1989
Marefair, Northampton	Northamptonshire	Harman 1979a
Saxon palaces, Northampton	Northamptonshire	Harman 1985
St Peters Rd, Northampton	Northamptonshire	Harman 1979b
Cresswell Field, Yarnton	Oxfordshire	Mulville and Ayres 2004
The Orchard, Walton Rd, Aylesbury	Oxfordshire	Hamilton-Dyer 2004c
Yarnton	Oxfordshire	Mulville and Ayres 2004
Cadley rd, Collingbourne Ducis	Wiltshire	Hamilton-Dyer 2001
High Street, Ramsbury	Wiltshire	Coy 1980
Middle Saxon Inland Trading Sites	**County**	**Reference**
Lake End Road, Dorney	Berkshire	Powell *et al*. 2002
Lot's Hole, Dorney	Berkshire	Powell *et al*. 2002
Middle Saxon Rural Sites Close to Wics	**County**	**Reference**
Riverdene, Basingstoke	Hampshire	Hamilton-Dyer 2003
Quarrington, Lincs	Lincolnshire	Rackham 2003
National Gallery Basement	London	West 1989b
National Portrait Gallery	London	Armitage 2004b
The Treasury, Whitehall	London	Ainsley *et al*. 2008
Chalkpit Field North, Sedgeford	Norfolk	Poole 2007
Crow hall park, Downham Market	Norfolk	Curl 2008
Hay Green, Terrington St. Clement	Norfolk	Baker 2002
Rose Hall Farm, Walpole St. Andrew	Norfolk	Baker 2002
Sedgeford, Norfolk	Norfolk	Clutton-Brock 1976
Brandon	Suffolk	Crabtree 2012
Friars Oak, Hassocks	Sussex	Stevens 2000
Cottam, Yorkshire	Yorkshire	Dobney *et al*. 1999
Site 39, Wharram	Yorkshire	Stevens 1992
Sites 94 and 95, Wharram	Yorkshire	Pinter-Bellows 1992
The south manor, Wharram	Yorkshire	Pinter-Bellows 2000

Middle Saxon Wic and Trading Sites	**County**	**Reference**
Sandtun, West Hythe	Kent	Murray and Hamilton-Dyer 2001
Anderson's road, Southampton	Hampshire	Knight 2006
Cook St, Southampton	Hampshire	Bourdillon 1993
St Mary's Stadium, Southampton	Hampshire	Hamilton-Dyer 2005
Melbourne St, Southampton	Hampshire	Bourdillon and Coy 1980
Six Dials, Hamwic	Hampshire	Bourdillon and Andrews 1997
Church Lane, Canterbury	Kent	King 1982
21-24 Maiden Lane and 6-7 Exchange Court a	London	Hamilton-Dyer 2004b
21-24 Maiden Lane and 6-7 Exchange Court b	London	Hamilton-Dyer 2004b
James Street, London	London	Armitage 2004a
Jubilee Hall, Covent Garden	London	West 1988
Lyceum Theatre, Exeter Street	London	Rackham and Snelling 2004
Maiden Lane	London	West 1988
National Gallery Extension	London	Rackham 1989
Peabody site	London	West 1989a
Ipswich 1974-88	Suffolk	Crabtree 1994
Ipswich	Suffolk	Jones and Serjeantson 1983
Fishergate, York	Yorkshire	O'Connor 1991
Middle Saxon Ecclesiastical Sites Close to Wics	**County**	**Reference**
Church Close, Hartlepool	Durham	Huntley and Rackham 2007
Church walk (76), Hartlepool	Durham	Huntley and Rackham 2007
Hartlepool Monastery	Durham	Rackham *et al*. 1988
Wearmouth and Jarrow	Durham	Noddle *et al*. 2006
Middle Saxon Inlnd Ecclesiastical Sites	**County**	**Reference**
Aelfric's Abbey, Eynsham	Oxfordshire	Ayres *et al*. 2003
Middle Saxon High-Status Sites Close to Wics	**County**	**Reference**
Wicken Bonhunt, Essex	Essex	Crabtree 1996a
Flixborough	Lincolnshire	Dobney *et al*. 2007
Caister-on-Sea, Great Yarmouth	Norfolk	Harman 1993
North Elmham Park	Norfolk	Noddle 1980
Middle Saxon Inland High-Status Sites	**County**	**Reference**
Copeshill rd, Lower Slaughter	Gloucestershire	Hambleton 2006
Middleton Stoney	Northamptonshire	Evans 2007

Table 1: Sites included in the analysis.

Rural, high-status and ecclesiastical sites were categorised depending on their proximity to wics and trading sites (Fig. 1), dividing the country into two zones – those close to wics, in a good position to supply them with food and raw materials, and inland sites that would not have been in such close contact with these consumer centres.

To investigate the mode of production, a combination of methods will be employed: animal husbandry will be investigated with mortality and sexing data where available; specialist butchery through carcass parts present; and diet through the relative numbers of particular species recorded at each site.

Mortality data is based on tooth wear data from sites with more than ten mandibles available per species. The conversion of tooth wear and eruption from a number of sources was made possible using Hambleton's (1999, 64) method. Cattle at prime meat age may be culled at around the age of 36 months – wear stage F-G, whereas sheep and pigs reach maturation earlier, and culls of these animals for meat may be expected at approximately wear stages E-F and D-E respectively. Sexing of cattle and sheep metacarpals was undertaken using metrical analysis described by Albarella (1997, 45) for cattle, and Davis (2000, 389) for

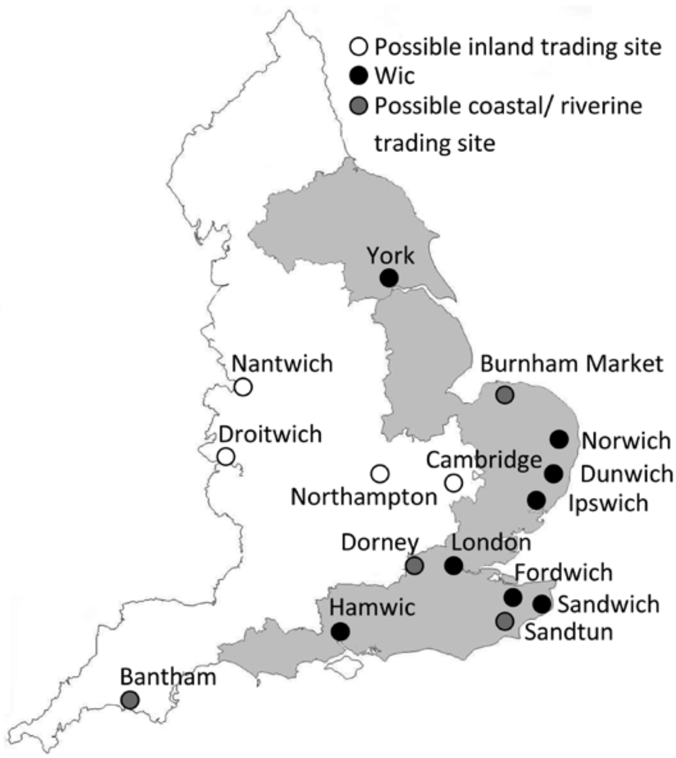

Figure 1. Map of England showing regions close to wic sites (grey) and those further inland.

sheep, based on the premise that these bones are more slender in females, robust in males and longer in castrates.

The relative quantities of particular carcass parts recorded at sites with a NISP or MNE of more than 40 elements per species were plotted to investigate the production of specialist cuts of meat or a demand for raw materials. This was based on the mean number of elements from various parts of the carcass (feet= phalanges; lower legs= metapodials; upper legs= scapula, humerus, radius, pelvis, femur, tibia; mandible; horn cores) plotted as a proportion of the most commonly occurring element. Ethnographic work by Brain (1981) has shown that, when animals are slaughtered, butchered, processed, consumed and disposed of on one site, there is a hierarchy of carcass parts more likely to survive for longer. For example, the dense, early-fusing bones are subject to best preservation and recovery, whereas later-fusing bones, attractive for dogs to chew on are more likely to be destroyed. Therefore, by considering the relative frequency in which parts of the carcass are present from a site they can be compared with this hierarchy. On a self-sufficient site, where animals are bred, eaten and disposed of within, it is likely that mandibles will be most commonly recovered, followed by lower and upper legs, then feet and horn cores. Sites where significant redistribution of body parts takes place will have more specific signatures, with a bias of particular elements varying from the expected pattern.

Wics and surplus production

Initial investigation will consider the role of wics as net consumers. The predominance of cattle and pigs at wic sites is striking (Fig. 2), and perhaps not surprising, as the provisioning of consumer sites that demand a meat supply is more likely to be met with larger animals, providing greatest quantities of meat per carcass such as cattle (Zeder 1991, 38). Furthermore, pigs are easy to raise within an urban environment, living off food waste and only requiring a small amount of space. Combined with this is the presence of younger cattle and sheep at the majority of wics (York, Hamwic and London), which is also consistent with the presence of a net consumer population. The exception to this is the site at Ipswich, which, as well as a number of animals culled at prime meat age, also has a considerably higher number of older cattle and sheep – possibly having been used for dairy or wool production or traction (Figs. 3 and 4). At St Mary's Stadium, Hamwic a very high number of sheep were culled later, indicative of those used largely for wool or dairy. Pigs were culled primarily for meat, even at Fishergate, York where the cull comes later (Fig. 5), nearly all animals had died by the time of maturity.

With the exception of Ipswich, where similar proportions of both male and female cattle were recorded (Crabtree 2012), there was no sexing data available for animals within wics.

There is little evidence for specialist butchery deposits, although both cattle and sheep horn cores are recorded in greatest quantities from wic sites (Figs. 6 and 7), which indicates the deliberate supply of these sites with horn for working.

Similarly, high numbers of cattle feet and metapodials and sheep metapodials from Fishergate, York suggest that this site was involved with craft working. Metapodials are bones that have little meat on them, yet are fairly straight, and therefore ideal for the manufacture of objects. There are also higher proportions of sheep and pig limb bones recorded at wics, suggesting that they were provisioned with particular cuts of meat. With these exceptions, however, the proportion of carcass parts from all the main domesticates (see also Fig. 8) are generally indicative of the deposition of all parts of the carcass, suggesting that animals were brought to wics 'on the hoof', and then butchered on site.

The evidence for wics is consistent with the deliberate provisioning of meat and some raw materials from cattle and sheep, where both cattle and sheep were apparently available at around prime meat age as well as following use for secondary products. The delayed cull of sheep at St Mary's Stadium, on the northern outskirts of Hamwic could indicate the presence of a farm outside the wic that was responsible for the provisioning of wool as well as meat.

The confirmation of the inhabitants of wics as net consumers in the Middle Saxon phase leads onto the next part of the investigation – whether this required surplus production from surrounding rural sites. A higher number of sheep can be observed at the majority of rural, high-status and ecclesiastical sites than within wics. Exceptions to this include Crow Hall Park, Norfolk and Friars Oak, Sussex,

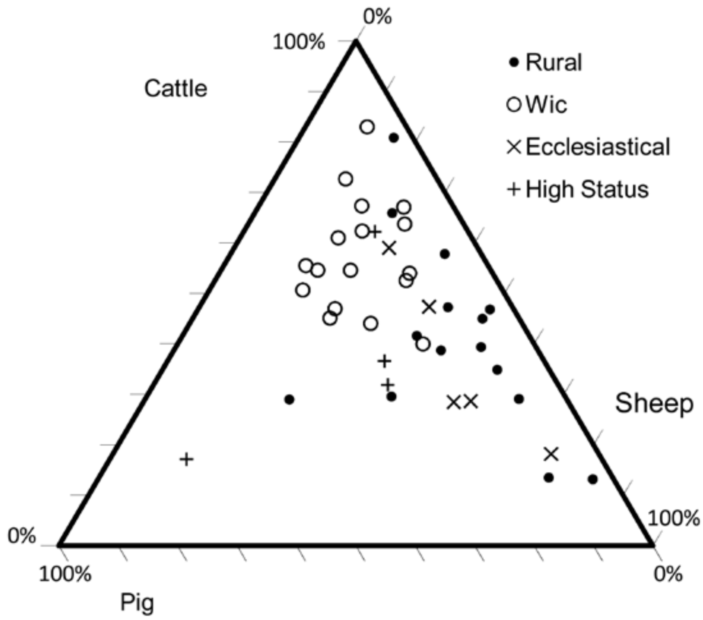

Figure 2. Relative proportions of cattle, sheep and pigs represented at wics and all other sites close to wics (NISP count) in the Middle Saxon phase.

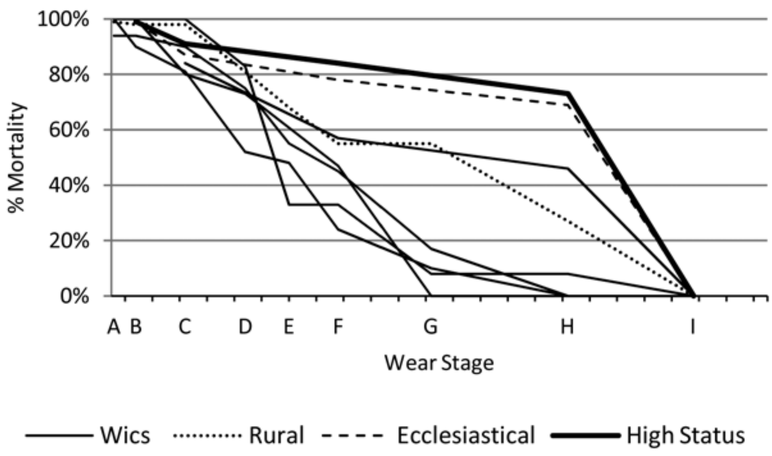

Figure 3. Middle Saxon cattle mortality data from sites close to wics. 1. Wicken Bonhunt; 2. Brandon; 3. Ipswich; 4. The South Manor, Wharram; 5. Melbourne St; 6. Anderson's Rd; 7. James St; 8. Fishergate.

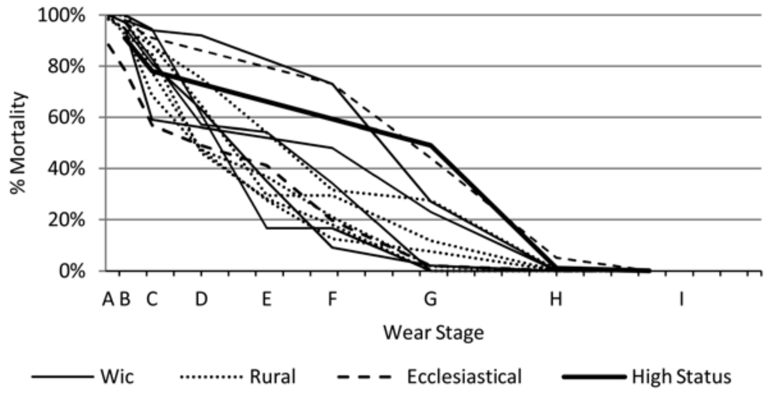

Figure 4. Middle Saxon sheep mortality data from sites close to wics. 1. Friend's Provident; 2. Brandon; 3. Wicken Bonhunt; 4. The South Manor, Wharram; 5. Ipswich; 6. Fishergate; 7. Hartlepool; 8. Hay Green; 9. Rose Hall; 10. Melbourne St; 11. James St; 12. National Portrait Gallery; 13. Sites 94 and 95, Wharram.

where cattle predominate; Riverdene, Hampshire and Wicken Bonhunt, Essex, which both recorded high numbers of pigs.

When the mortality profiles are considered it becomes apparent that some of the oldest cattle are found at the rural settlement at Wharram, Yorkshire, the high-status site of Wicken Bonhunt, Essex and the ecclesiastical site at Brandon, Suffolk (Fig. 3). At the latter two sites the evidence suggests that very few animals of prime meat age were present. This implies that there was specialisation of cattle herds, leading to a high number of old animals, such as dairy production, or that the younger animals from these sites were sent to the wics for meat upon reaching

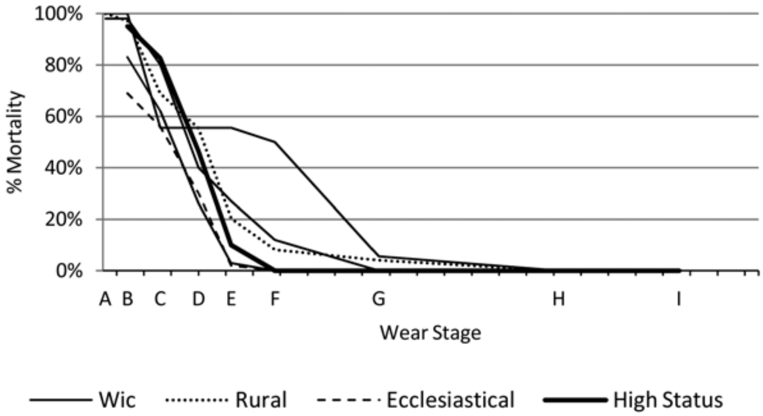

Figure 5. Middle Saxon pig mortality data from sites close to wics. 1. Fishergate; 2. The South Manor Area, Wharram; 3. Wicken Bonhunt; 4. Melbourne St; 5. Ipswich; 6. Brandon.

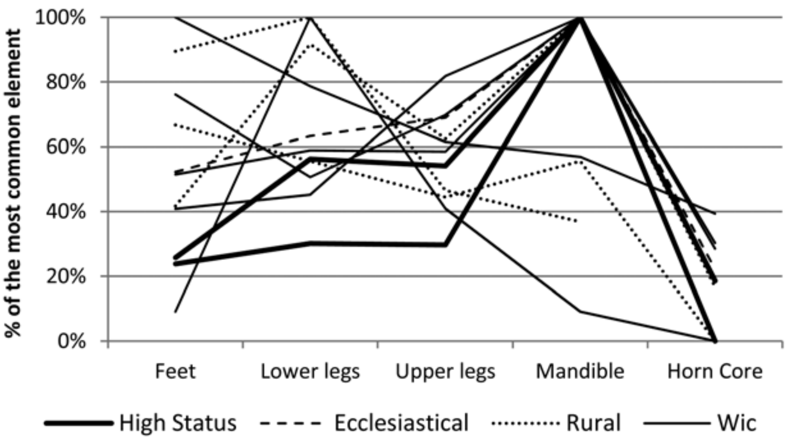

Figure 6. Cattle body part representation from sites close to Middle Saxon wics. 1. Fishergate; 2. Sites 94 and 95; 3. Friend's Provident; 4. Hay Green; 5. Brandon; 6. Peabody Site; 7. Rose Hall Farm; 8. Melbourne St; 9. North Elmham Park; 10. Flixborough; 11. Anderson's Rd.

maturity. By way of contrast, the animals at Wharram present a mixed strategy, with some culled for meat and others kept longer, possibly for milk or traction. It is also possible that a proportion of cattle at prime meat age at Wharram were also sent to the wic at York, therefore inflating the proportion of older animals in the assemblage.

There is less variation in the mortality profiles of sheep, with the majority of those from rural sites showing similar patterns to those from wics, whereby sheep were mostly at prime meat age (Fig. 4). Exceptions to this exist at Wharram, which has a combination of meat age animals and those culled later, and also at Brandon and Wicken Bonhunt, where, as with the cattle assemblage, the greatest number

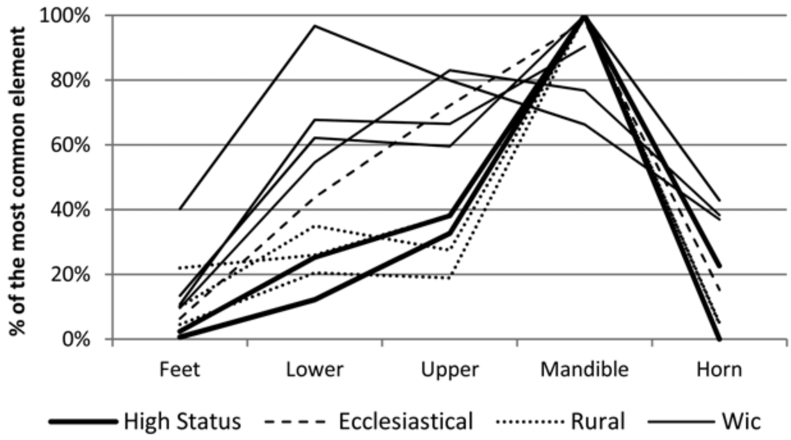

Figure 7. Sheep body part representation from sites close to Middle Saxon wics. 1. Fishergate; 2. Sites 94 and 95; 3. Friend's Provident; 4. Peabody Site; 5. Melbourne St; 6. Brandon; 7. Hay Green; 8. Flixborough; 9. Rose Hall Farm; 10. North Elmham Park.

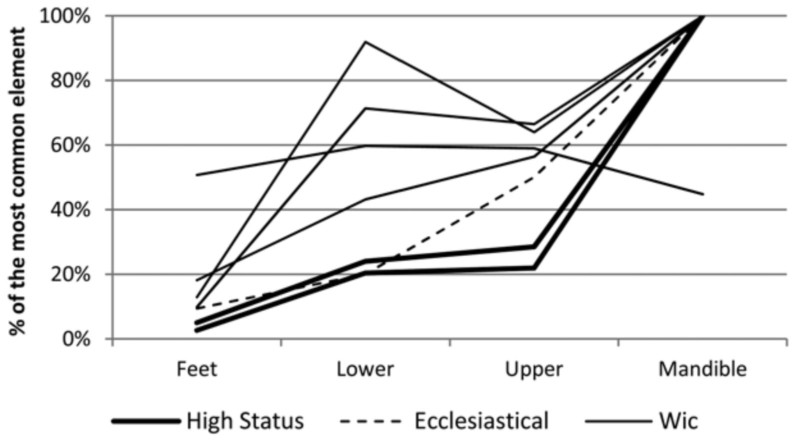

Figure 8. Pig body part representation from sites close to Middle Saxon wics. 1. Fishergate; 2. Friend's Provident; 3. Peabody Site; 4. Melbourne St; 5. Brandon; 6. Flixborough; 7. North Elmham Park.

of older sheep were recorded. Even at these latter sites, however, nearly all animals were culled before reaching wear stage H, which suggests that they were less than 6 years of age – old enough for long-term production of wool or dairy, but if these products were intensively harvested the animals could have been kept alive for longer. Again, it may reflect a husbandry strategy where animals at prime meat age were sent to consumer sites.

Unfortunately there is very little sexing data from Middle Saxon sites, the only sample of raw data available for analysis came from North Elmham Park, from which a large group of mature male cattle was recorded (Fig. 9), and the same is recorded at Wicken Bonhunt (Crabtree 2012). This contrasts with Brandon, where a larger number of cows are present (Crabtree 2012). Both sites with greater numbers of male animals are considered high-status sites, where the keeping of larger animals is prevalent throughout the Saxon period (Holmes 2011, 98), which is likely to be related to the visual display of status through the possession of the largest animals. The evidence from Brandon, however, is more consistent with the use of older females for milk.

No raw data of substantial sample size were available for the sheep assemblage, although metrical analysis from Brandon revealed a greater proportion of males, suggesting their use for wool, whereas those from Wicken Bonhunt were mostly older females (Crabtree 2012) and may again have been used for wool and/or dairy production.

Although the majority of sites are indicative of animals being bred, butchered, consumed and disposed of on site, there are a number of exceptions. An under-representation of pig limb bones at both high-status sites of Wicken Bonhunt and Flixborough is indicative of the redistribution of specific cuts of meat to wics. A similar pattern in the cattle and sheep data can be seen at the high-status sites of Flixborough and North Elmham and the rural sites of Rose Hall Farm, Wharram and Hay Green, where fewer upper limb and mandible bones were recovered than may be expected (Figs. 6-8), again suggesting they were exported to other sites.

The data suggest that the rural sites in the hinterlands of wics fulfilled a variety of purposes. A number show signatures indicative of self-sufficient regimes, which do not reflect surplus production or the husbandry of producer sites. However, there are a few that exhibit specialist production regimes, some quite narrow in

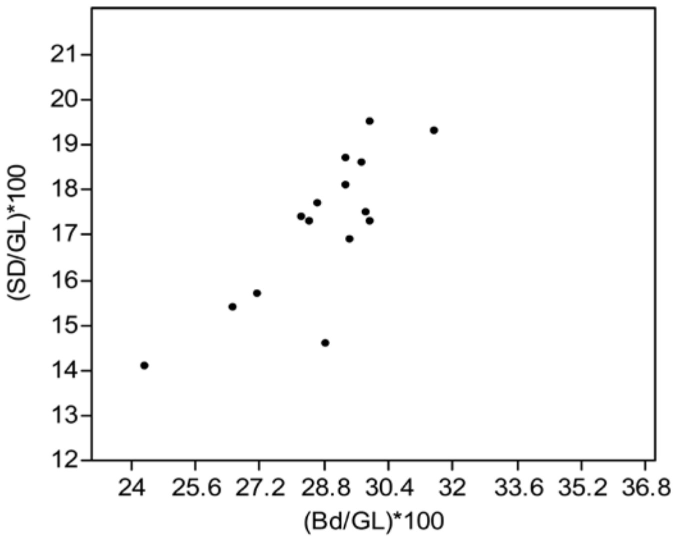

Figure 9. Middle Saxon cattle sexing data from North Elmham Park, based on metacarpal measurements. Bd= breadth distal end; GL= greatest length; SD= smallest diameter of shaft.

their base, such as Brandon and Wicken Bonhunt in the east and Wharram to the north. Combined with this is the function of wics as consumer sites, which seem to have been provisioned with young cattle to provide the mainstay of the diet, as well as a number of raw materials such as horn. This implies that there was no widespread obligation for rural sites to specialise as suppliers of meat, milk, wool or raw materials to the new consumer sites, rather a number of enterprising farms made the move towards surplus production.

Inland sites and surplus production

The second question to be addressed here is whether the move towards specialisation at some rural sites in the Middle Saxon period was localised to a few entrepreneurs in the hinterland of wics, or if it was more widespread, and required by the presence of inland markets. When the relative proportions of cattle, sheep and pigs are considered (Fig. 10), the two trading sites available (both from related sites close to the village of Dorney, near Maidenhead) record the greatest proportions of cattle, with the exception of the rural site at Yarnton, Oxfordshire. This is comparable to the proportions from wic sites (Fig. 2) and similar high proportions of sheep at other site types are also in evidence, although many inland rural sites also have higher numbers of pigs than their contemporaries in the hinterland of wics.

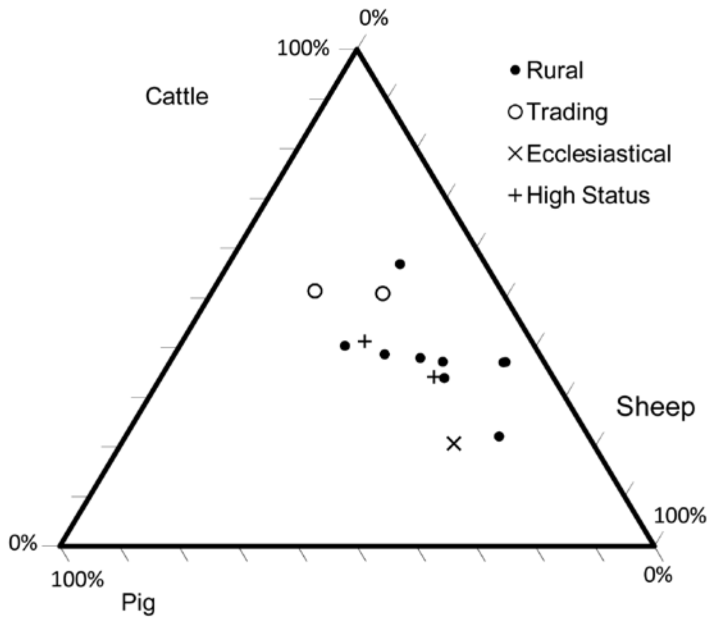

Figure 10. Relative proportions of cattle, sheep and pigs represented at inland sites (NISP count).

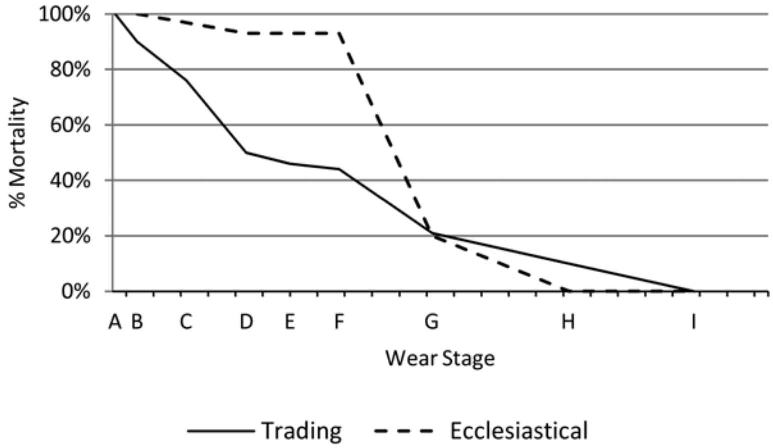

Figure 11. Middle Saxon cattle mortality data from inland sites. 1. Aelfric's Abbey; 2. Lake End Rd.

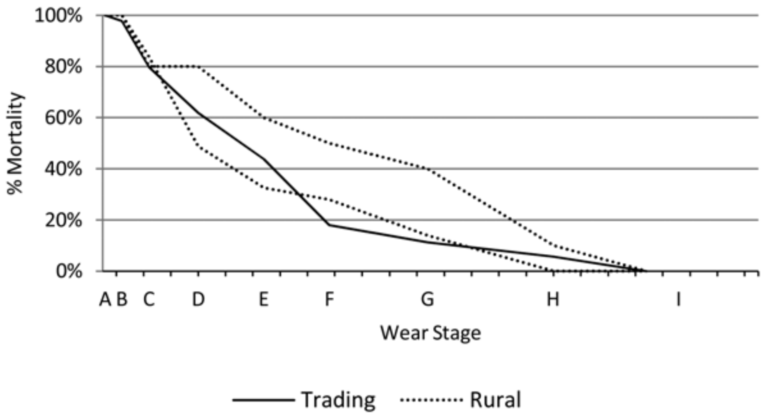

Figure 12. Middle Saxon sheep mortality data from inland sites. 1. St Peter's Rd; 2. Cadley Rd; 3. Lake End Rd.

As with wics, inland trading sites tend to have the youngest cattle and sheep (Figs. 11 and 12). Although cattle from the ecclesiastical site of Aelfric's Abbey, Oxfordshire and sheep from the rural site at St Peter's Road, Northampton exhibit later culls, the majority are culled by maturity. There are no sites that represent the production of a surplus of older stock, either for breeding or secondary products. Pigs at both available sites were culled young (Fig. 13). When the distribution of carcass parts is considered, cattle from the trading site of Lake End Road, Dorney are consistent with the deposition of all parts of the carcass, although it is notable that, as at many wic sites, there are more horn cores recovered than at other contemporary sites. Another outlier comes from the rural site of Walton lodge, Aylesbury, where there are more feet and lower leg bones than expected if complete

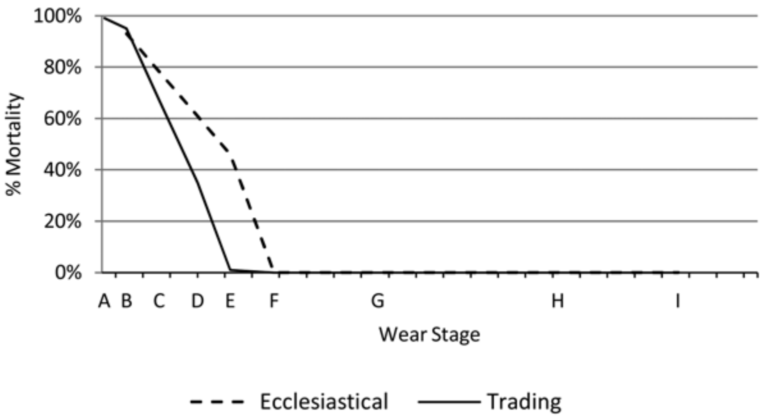

Figure 13. Middle Saxon pig mortality data from inland sites. 1. Aelfric's Abbey; 2. Lake End Rd.

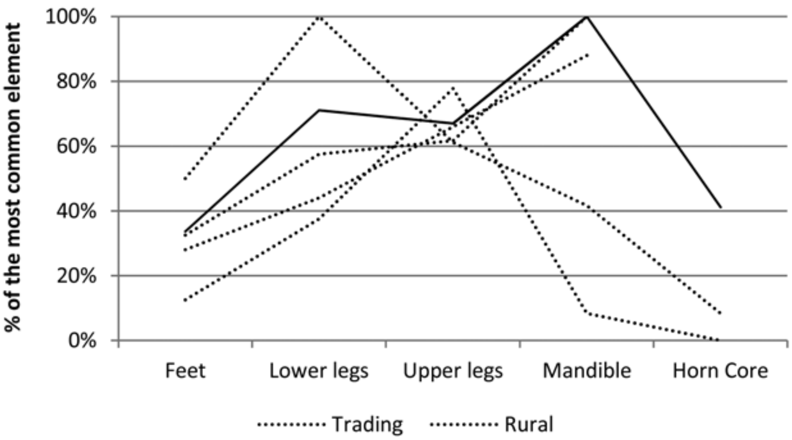

Figure 14. Middle Saxon cattle body part representation from inland sites. 1. Walton Lodge; 2. Lake End Rd; 3. Cadley Rd; 4. Marefair; 5. St Peter's Rd.

carcasses were deposited. Both the cattle and sheep assemblages from St Peter's Road (Figs. 14 and 15) include more upper leg bones, reflecting the predominance of meat-bearing cuts of meat. Despite these isolated sites, the majority are consistent with the deposition of complete carcasses (see also Fig. 16).

Unlike sites within wics, and those in their hinterland, inland settlements exhibit less specialisation and more consistent patterns. The size of the data set has limited the confidence with which generalisations can be made, particularly with reference to trading sites, of which only two were available (Lake End road and Lot's Hole, Dorney), both from the same settlement. Nonetheless, the results of this analysis have implied that there is some possibility that inland trading sites occupied a consumer status similar to that of wics, from the abundance of young cattle and horn cores, suggesting deliberate provisioning. The source of

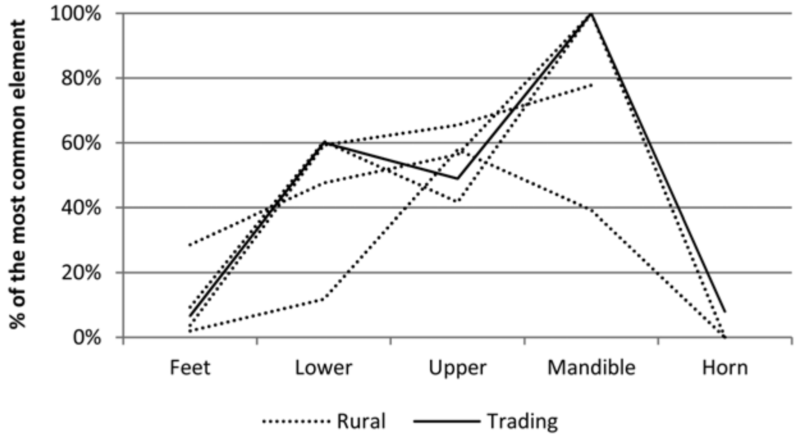

Figure 15. Middle Saxon sheep body part representation from inland sites. 1. Walton Lodge; 2. Cadley Rd; 3. Lake End Rd; 4. Marefair; 5. St Peters Rd.

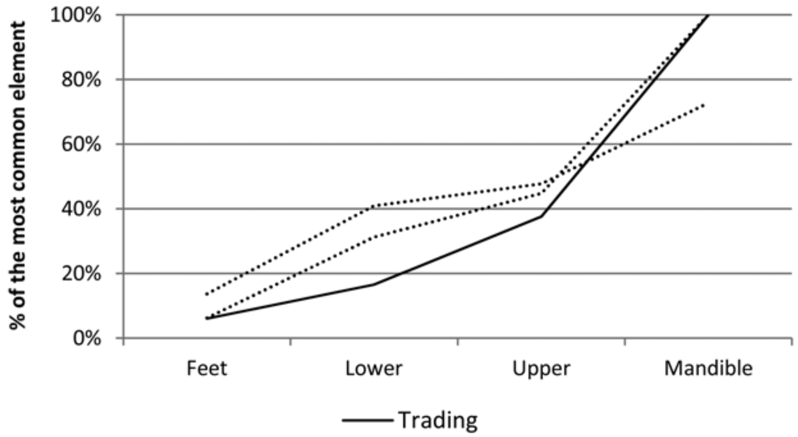

Figure 16. Middle Saxon pig body part representation from inland sites. 1. Marefair; 2. St Peters Rd; 3. Lake End Rd.

this provisioning is not clear, however, as the data from rural sites are generally consistent with a self-sufficient economy where animals were culled and disposed of on site, and used largely for meat with some small-scale secondary production.

Early Saxon progenitors

The final consideration to be made in relation to surplus production in the Middle Saxon phase is whether it was rooted in the preceding phase, contributing to the creation of new trading centres, or was brought about after their creation. The proportion of the main domesticates is more consistent at inland rural sites, although high numbers of cattle can be observed at Hartigans, Buckinghamshire and pigs at Cadbury Castle, Somerset (Fig. 17). There is greater variation at sites closer to wics, particularly at Spong Hill, Norfolk, Nettleton Top, Lincolnshire and Fossets Farm, Essex where cattle are recorded as over 80 % of the main domesticates and Baynard's Castle, London, West Stow, Suffolk and Botolphs, Sussex where pigs are observed in greatest proportions.

Little variation can be observed in the mortality profiles of cattle, sheep and pigs (Figs. 18-20), as all exhibit culls consistent with the production of meat, alongside the small-scale production of secondary products, although at Fossets Farm cattle are alive slightly longer, apparently being more important for secondary products. A similarly recurrent pattern can be observed in the proportions of various parts of the carcass recorded, which indicate that whole animals were disposed of on the majority of sites (Figs. 21-23), with little direct evidence for redistribution. The main outlying site is that of Baynard's Castle, where there is an over-representation of sheep lower limb bones.

In general, then, the archaeozoological evidence is consistent with a self-sufficient economy in the Early Saxon phase at the majority of sites. Husbandry strategies emphasise the use of animals for meat, and the breeding, working, consumption and disposal of animals within the settlement itself. Although greater variation in species proportions can be observed in areas that later become the hinterlands of wics, there are also a number of distinctly outlying sites inland as well, which suggests that there was no particular emphasis on any one species in any area in the Early Saxon phase.

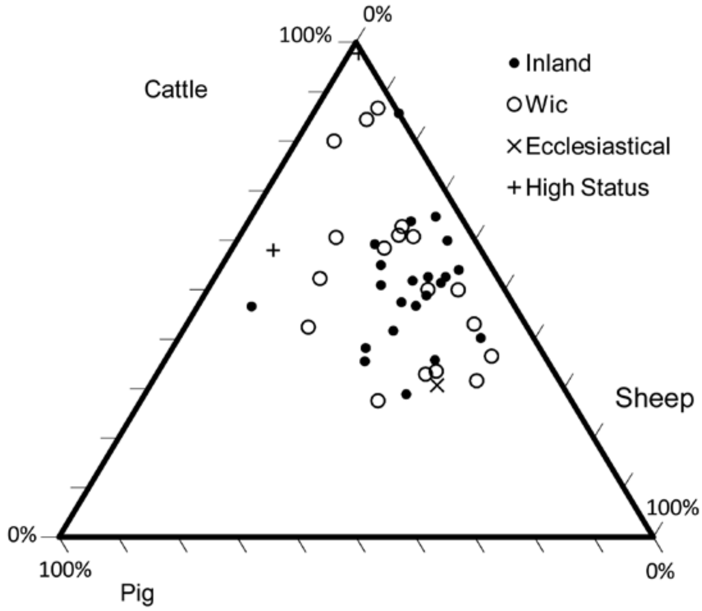

Figure 17. Relative proportions of cattle, sheep and pigs represented at Early Saxon sites (NISP count).

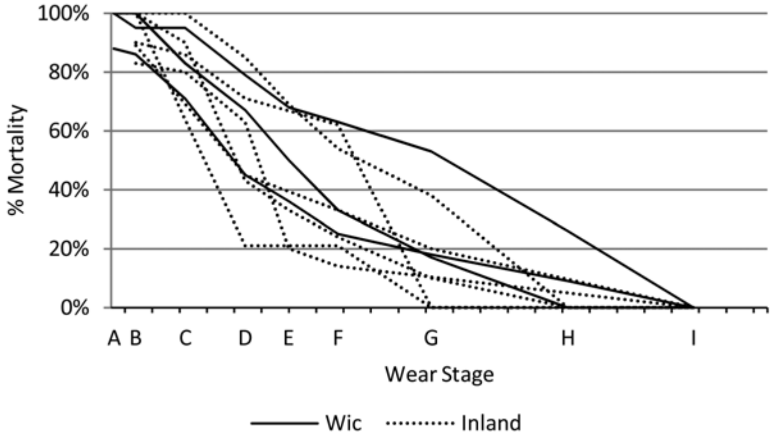

Figure 18. Early Saxon cattle mortality data from all sites. 1. Oxford Science Park; 2. Fossets Farm; 3. Market Lavington; 4. Melford Meadows; 5. Pennyland; 6. Aelfric's Abbey; 7. West Stow; 8. Sherbourne House; 9. Eye Kettleby.

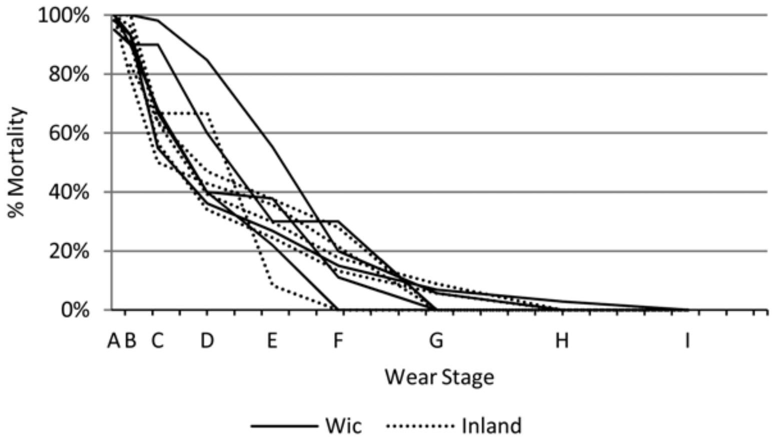

Figure 19. Early Saxon sheep mortality data from all sites. 1 and 2. West Stow; 3. Oxford Science Park; 4. Market Lavington; 5. Pennyland; 6. Aelfric's Abbey; 7. Melford Meadows; 8. Eye Kettleby; 9. Sherbourne House; 10. Redcastle Furze.

Discussion and conclusions

It has been asserted that the ability to provide food and raw materials to support the development of wics as consumer sites in the Middle Saxon phase was made possible by the production of surplus goods by rural sites at the end of the Early Saxon phase (Crabtree 2010, 132). With the exception of Fossets Farm, where an exceptionally high number of cattle were recorded, some far older than observed on other, contemporary sites, no such evidence has been forthcoming from this analysis. However, the separation of sites from the late Early Saxon phase in

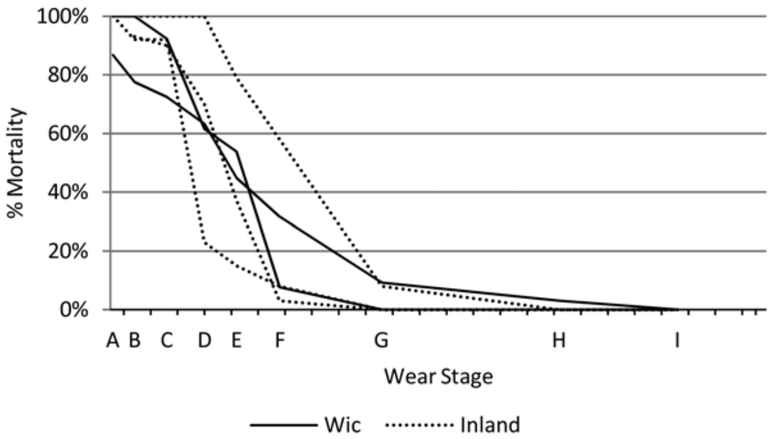

Figure 20. Early Saxon pig mortality data from all sites. 1. Aelfric's Abbey; 2. Pennyland; 3. West Stow; 4. Fossets Farm; 5. Eye Kettleby.

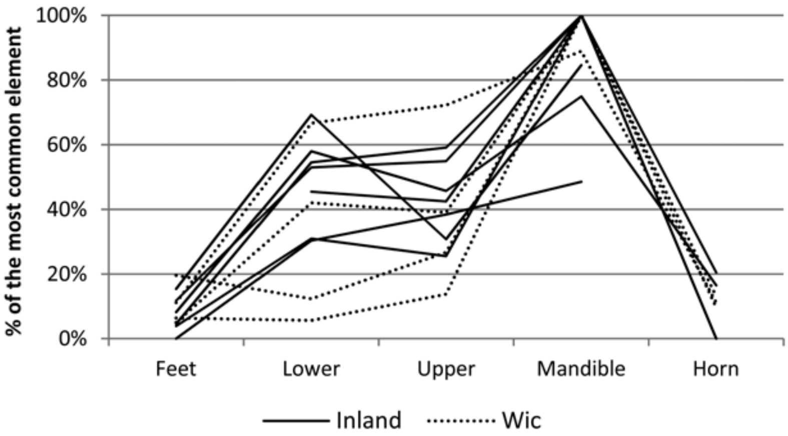

Figure 21. Cattle body part representation from all Early Saxon sites. 1. Baynard's Castle; 2. Orton Hall Farm; 3. Mill St; 4. Pennyland; 5. Redcastle Furze; 6. Poundbury; 7. Spong Hill; 8. Nettleton Top; 9. Melford Meadows; 10. St Helen's Ave; 11. Eye Kettleby; 12. Oxford Science Park; 13. West Stow; 14. Hartigans.

this study has not been possible, and it may be that only well-dated site-specific investigations will show this phenomenon. In general, there is no definite evidence for specialists in the Early Saxon phase, where both inland settlements and those near the south and east coasts are largely self-sufficient. Furthermore, it appears that this underlying husbandry regime continues in the Middle Saxon phase in inland areas, and many sites close to wics, with little apparent motivation towards specialist production.

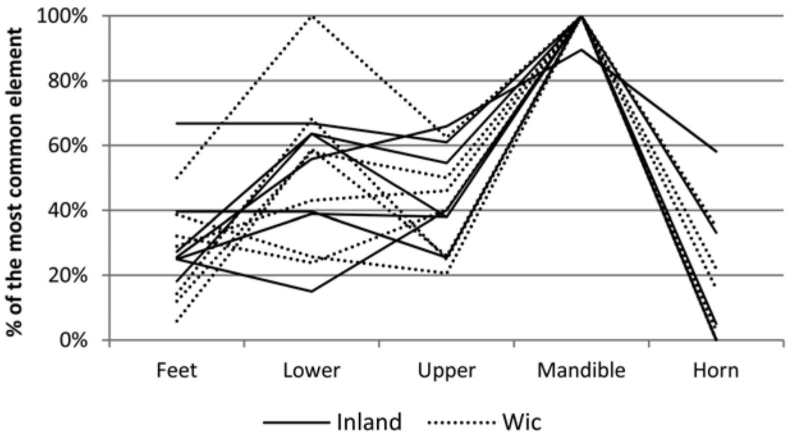

Figure 22. Sheep body part representation from all Early Saxon sites. 1. Melford Meadows; 2. Mill St, Wantage; 3. Eye Kettleby; 4. Oxford Science Park; 5. Orton Hall Farm; 6. Stonea Grange; 7. West Stow; 8. St Helen's Ave; 9. Pennyland; 10. Poundbury; 11. Redcastle Furze.

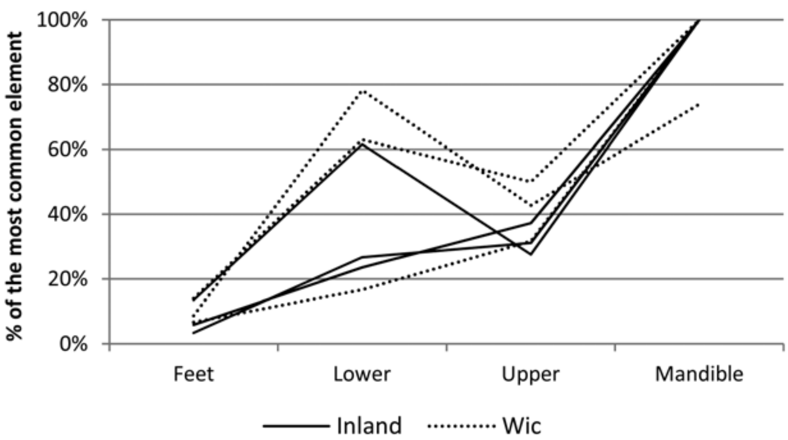

Figure 23. Pig body part representation from all Early Saxon sites. 1. Redcastle Furze; 2. West Stow; 3. Pennyland; 4. Eye Kettleby; 5. Orton Hall Farm; 6. Poundbury.

Evidence for the emergence of specialist producers at specific Middle Saxon sites in the hinterland of wics does occur. At rural sites these include goods such as: pork at Riverdene; beef at Crowhall Park and Friar's Oak; and dairy and/or traction and/or beef at Wharram. At the high-status site of Wicken Bonhunt they include pork and wool, and at the ecclesiastical site of Brandon wool, dairy and beef. Although some rural sites appear to have specialised in particular species, there is a less obvious production of any specific surplus such as dairy or wool (except at Wharram) to that observed on high-status and ecclesiastical sites. The origin of surplus products at these site types reflects the claims that secular and ecclesiastical estate centres were instrumental in the provisioning of wics, and the absence of prime meat age cattle at either of these sites reinforces the probability that these animals were sent directly to consumer sites. The apparent redistribution of particular cuts of meat and raw materials such as horn cores from many rural and high-status sites to wics has also been observed, and further indicates the production of food and raw materials for the populations within wics.

Problems persist in the small data sets, particularly for inland trading sites, but nonetheless these findings can act as a springboard for future assemblages to be compared with. Greater homogeneity of inland animal husbandry indicates an economy that had fewer demands placed upon it, able to continue the Early Saxon regime of relative self-sufficiency. While this was apparently true of some rural sites in the vicinity of wics, some enterprising elites and possibly some independent farmers recognised the need for surplus production and specialisation with the emergence of a consumer demand specific to the areas around wics.

Although it cannot be concluded whether excess production was present prior to the establishment of wics, or whether demand from wics brought about the new regimes, it was not a widespread phenomenon, and there is no corresponding change on inland sites, suggesting that inland markets did not have the same consuming populations as wics.

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Scant evidence of great surplus: research at the rural Cistercian monastery of Holme Cultram, Northwest England

Don O'Meara

West Cumbria Archaeology Society
Grampus Heritage, Ashgill, Threapland, Wigton
Cumbria, CA7 2EL
England
donomeara@gmail.com

Abstract

The theme 'subsistence and surplus' is very apt when discussing the topic of Medieval Christian monasticism. The institutions that followed the rule of Saint Benedict, such as the Cistercians, celebrated material poverty while simultaneously amassing fortunes through regional and international trade; a paradox briefly explored by Weber (2009) in his assessment of pre-Reformation proto-capitalism (Silber 1993). However, examining this theme through studies of archaeological remains from monastic sites challenges the discipline of environmental archaeology to recover and identify material suitable to investigate this topic. Though monastic sites have been a consistent focus for antiquarian and archaeological interest there has not been a consistent contribution to our understanding of the phenomenon of Medieval monasticism from the discipline of environmental archaeology. The Cistercian monastery of Holme Cultram, in Cumbria, Northwest England is used here as a case study to discuss issues relating to the application of environmental archaeology at monastic sites. Through an examination of various strands of environmental evidence from both archaeological and documentary sources it is hoped to show that the theme 'subsistence and surplus' is not merely another interesting avenue of research, but rather a central means of examining monasticism as a phenomenon of Medieval society and economy.

Keywords: *Cistercians, Cumbria, Medieval, archaeozoology*

Introduction

The first aim of this paper is to present and discuss the results of the environmental archaeology evidence available for the Cistercian monastery of Holme Cultram in Cumbria, England. This evidence includes the remains of animal bones collected during excavation, documentary sources relating to animals and landholdings held by the monastery, as well as evidence from palynological investigations of the wetlands in the surrounding region. Many of the issues encountered during the Holme Cultram investigations have been encountered during the examination of environmental remains from other analogous monastic sites. Contrary to this point, however, it is also intended to discuss that the range of individual histories of monastic sites means caution must be used when drawing comparisons between evidence from different regions, time periods, monastic orders and even between monasteries from the same order. The second aim is to discuss issues relating to the application of environmental archaeology at monastic sites. Though the examination taken here is from the point of view of the history and archaeology of one monastery in Northwest England it is hoped that some of the themes discussed here will be of interest to those working at other monastic sites; with full regard to their own particular historic and archaeological background.

Background

As institutions monasteries were capable of producing great surpluses of both capital wealth and material products. The difficulty for the archaeologist is to separate phases of expansion and growth as being actual increased capital revenues in real terms, or in terms of ambitious speculation. Initially the Cistercian monasteries of Britain experienced successful expansion in the 12th century with almost 60% of the monasteries founded between 1128 and 1150 (Robinson 2002, 19). This initial rapid expansion was followed later by economic difficulties which meant by the time of the Dissolution of the Monasteries (1536–1540 AD) many of these institutions were already under financial pressure. In many cases building expansions and land acquisitions were funded by speculation in wool prices, which when followed by outbreaks of disease in sheep flocks would lead to financial strain or ruin for many of these institutions (Butler 1989; Robinson 2002; Sykes 2006, 60). The importance for archaeological interpretations is that the expansions led to the creation of buildings which would become archaeological remains by the time they were examined in the modern period. Without the historic documents the archaeological remains might suggest a broadly successful economic base for these institutions up until the mid-16th century. The end of the Cistercian monastic system in England during the Reformation is significant for historic reasons, taking place with the passing of legislative acts between 1536–1540; an archaeologically very brief period. From an archaeological point of view it is the systematic destruction of these sites for either economic gain or political-religious reasons which is of significance for interpreting their later archaeology; a destruction process that occurred extensively in the late 16th century, but continued on an ad hoc basis until the 20th century.

During the period of Cistercian activity in the British Isles (1128–1540) the monasteries were at their core religious institutions, or in the words of Butler '*Oratories to God and workshops of prayer*' (Butler 1989). Therefore they are ultimately ritual areas where deposits and remains should, in theory, reflect the ritual practices and organisation of the monastery. Adopting a spatial analysis approach (such as the one advocated by Wilson 1996) may allow spatial patterning of environmental remains. This may, in theory, give some indication of activities and processes acting within this economic unit, as well as a means of examining bias within individual archaeological samples. As outlined by O'Connor (1993, 107): '*There is thus every reason to think that an excavated monastic site would show clear patterning in the distribution of all categories of artefact and occupation debris, including bones*'. However, the identification of these activities is hampered by a range of natural and cultural taphonomic processes; some of which operate on all monastic sites, others which are specific to individual monasteries and their individual circumstances. Therefore care must be taken when applying the conclusions of general analysis upon individual sites. Though this is true of all archaeological investigations, monastic sites have the combined complexity of being sites of economic as well as ritual activity. The ritual element of their activity placed constraints on the diets of the residents, the economic activities and use of space within the monastic precincts in a manner not seen in secular settlements such as manor houses. This is particularly true when examining the overarching themes being discussed here; subsistence and surplus. Individual successes and deprivations may be masked if placed within an assessment that examines the evidence in too general a manner. This can often be a problem for sites with shallow stratigraphy and an archaeological phasing which spans broad periods of the site development (such as at the scale of a hundred years or more). Most challengingly these can include issues of individual agency, affecting specific monasteries at specific periods, such as the economic planning decisions of an individual abbot.

Holme Cultram in context

The region of West Cumbria in Northwest England is characterised by a low plain bordered to the north by the estuary of the Soloway Firth and to the west by the Irish Sea; see Figure 1 for the location of the monastery. To the south the lowlands of the Soloway plain give way to the mountainous landscape of the Skiddaw massif and the Lake District, while to the east the north-south line of the Pennine mountain range forms the eastern boundary of this area (Bewley 1994). The monastic core of the Cistercian monastery of Holme Cultram is located on a ridge of sand and gravel known today as the Abbeytown Ridge, placing the site above periodic flooding which can affect the Soloway plain. Up until the post-Medieval period much of this plain was bog and marshland, to the extent that Medieval documents refer to 'the Island of Holme Cultram' (Grainger and Collingwood 1929, 21). The historic records for the monastery survive better than those for many other monastic sites in Northern Britain and include three cartularies (Jamroziak 2008, 27). Historic records from the post-Dissolution period make frequent reference to

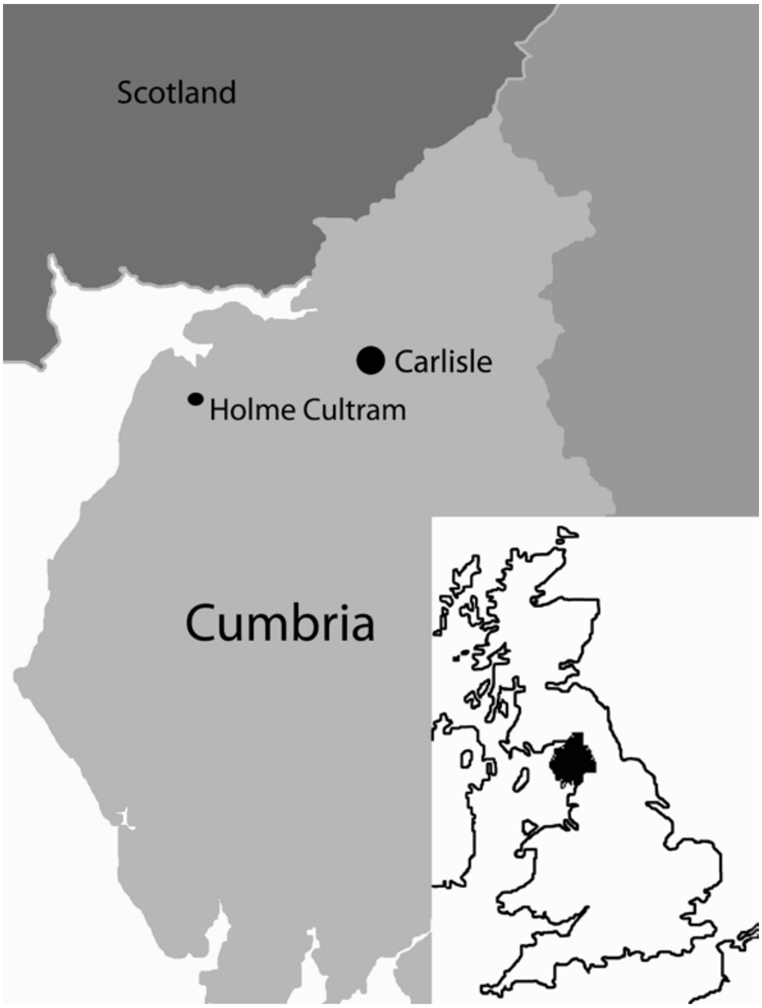

Figure 1. Location map for Holme Cultram, Northwest England.

agriculture and the condition of the land. These records were compiled largely in the 18th century and can be combined with recent palaeoecological work to allow inferences to be made regarding the landscape during the Medieval period.

It is generally accepted that Holme Cultram was founded in 1150 by Prince Henry, son of King David I of Scotland (reigned 1124–1153), with monks from Melrose Abbey in Scotland providing the initial population of the monastery. During this period much of Northern England was held by the Scottish crown due to a mixture of traditional claims (particularly to Cumberland) and due to King David's involvement in the political turmoil which characterised the reign of King Stephen of England (also known as 'The Anarchy' from 1135–1153). Cumberland passed back into English control in late 1154, but the monastery would remain a frontier site throughout its existence. Being situated near the political frontier of England and Scotland created difficulties for Holme Cultram as its economic activities operated essentially at a supra-national level. The location of the monastery on the Soloway Firth allowed it to develop a productive salt industry, as well as maintaining access to land it held in Scotland and access trade and fishing routes connecting it with Ireland and Hiberno-Norse communities on the Isle of Man. When these frontiers became established political borders the monastery was drawn into the emerging nationalist politics of these developing nation states. The monastery was an important staging post for English armies invading Scotland, particularly those of Edward I of England (reigned 1272–1307). In return the community was raided on a number of occasions by Scottish armies who recognised its military importance for the supply of English armies invading Scotland. Irish chancery rolls show that some of these supplies came from Anglo-Norman towns on the east coast of Ireland, mainly Dundalk, Dublin, Waterford, New Ross, Cork and Youghal (CIRCLE 2012). In this respect the monastery, via its port at Skinburness (to the north of the monastery on the Soloway coast), was an important military location. Therefore we must view Holme Cultram as a religious site, but also a military site and a regional centre for trade, both regional and international (to Ireland via the port of Skinburness and to Central Europe via property held in Hartlepool and Boston on the east coast of England).

How then do the activities of a religious, trading and military centre manifest in the archaeological record? One of the difficulties for interpreting this site is how to disentangle periods of destruction from periods of expansion and growth. The initial patronage came from Scottish royal sources, but Holme Cultram can be described as truly international during a period when the monastery was patronised by both Scottish and English royal sources. As national differences became better defined this patronage was increasingly restricted to English sources. The benefits offered by this source of income were periodically offset by Scottish raids which led to destruction of property and the loss of moveable goods. In the 14th century the monastic community had to be temporarily disbanded due to Scottish raids, while in 1385 the monastery was threatened by the Scottish Earl of Douglas in revenge for an English attack on Melrose Abbey (ironically this was the mother house of Holme Cultram). In that particular case the monastery paid a ransom of £200 to prevent attack (Jamroziak 2008). The loss of this revenue may have spared the physical fabric of the monastery, but led to financial impoverishment.

Archaeological evidence

Three excavation seasons, mainly focused on 3 x 30 metres trenches around the cloister (Fig. 2), have recovered a wide range of archaeological material, including glass, metalwork, carved stone, Medieval floor tiles and ceramics (Walker and Graham 2013). Among these artefacts approximately 50 kg of animal bones was recovered by hand during excavation. For the free-draining acidic soils of rural Cumbria this is a relatively large assemblage. An outline of the identified and quantified mammal and bird bones is presented in Table 1.

Fish remains were recovered in low numbers, though with frequent finds of bucklers from thornback rays, as well as bones of cod and herring. The low numbers of bird and fish bones recovered do not allow the type of detailed analysis

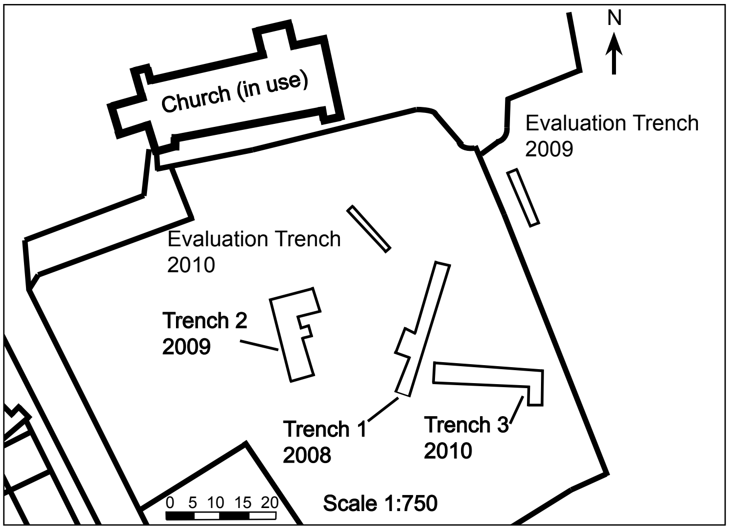

Figure 2. Trench location plan of the three main trenches and two evaluation trenches (Walker and Graham 2013, 20).

to be undertaken here which has been so successful for other monastic sites (*e.g.* Küchelmann 2012). Almost 40 soil samples ranging from 10-40 litres were taken to assess macro plant preservation but these produced very infrequent remains. From all of the samples only 4 charred grains were recovered by flotation of the soil samples. The only other notable plant remains were seeds of deadly nightshade, *Atropa belladonna*, which may relate to the production of medicinal herbs at the site. A possible midden feature produced appreciably more fish remains than other areas of the site. It is hoped that future work will explore this midden further. This will be undertaken bearing in mind that analyses of fish remains have been the source of evidence for a varied monastic diet from other regions (Van Neer and Ervynck 1996). The question that will remain for the present time is how much the present state of knowledge will change when new phases of excavation in other areas of the monastery commence in the future. From the three main domesticated animals (cattle/sheep/pigs) approximately 569 bones were identified. In total this equates to roughly 46 % cattle, 46 % sheep and just over 7 % pig. These percentages vary between the different phases of excavation, as can be seen in Table 2.

These differences may reflect potentially significant variation in depositional activities or may represent the chance distribution of remains in an area with shallow stratigraphy, potentially representing many decades of accumulation. In comparison with Medieval material from Carlisle (the nearest city) there seems to be a much higher occurrence of sheep at this site. Material from Scotch Street, Carlisle showed that of the three main domesticated species cattle occurred (based on NISP counts) as 72 % of bones, with sheep as 15.4 % and pig at 12.6 %. Considering the importance of sheep to the monastic economy it is interpreted that the more frequent occurrence of sheep here reflects an economy where sheep

	MNI	NISP
Bos taurus (cattle)	11	263
Ovis/Capra (sheep/goat)	28	264
Sus scrofa domesticus (pig)	5	42
Equus (horse)	2	7
Canis (dog)	6	16
Cervus elaphus (red deer)	1	1
Capreolus capreolus (roe deer)	1	5
Vulpes vulpes (fox)	1	1
Lepus europaeus (hare)	1	2
Dama dama (fallow deer)	?1	?1
Pinniped species (seal)	1	1
Gallus gallus (domestic fowl)	5	21
Anser cf. *anser* (goose)	4	16
Phasianus cf. *colchicus* (pheasant)	1	3
Corvid species (crow family)	1	1
Perdicinae species (partridge)	1	1
Columbidae species (pigeon)	1	1
Passerine species (perching/song birds)	1	1
Scolopax species (woodcock)	1	1
Numenius species (curlew)	1	1

Table 1. Mammal and bird bones from Holme Cultram.

formed a relatively more important element of the diet than it did for the secular population in Carlisle. Considering the results of the analysis of the three main domestic animals certain patterns emerge which may reflect not only the species represented at the monastery, but the importance of different meat-bearing elements of the carcass, as presented in Table 3.

The proximal heads of ribs were conspicuously absent for all contexts and periods though rib midshaft fragments were relatively common; *e.g.* only one cattle rib head occurs in the whole assemblage. Likewise, vertebra fragments were not particularly common considering the numbers which can be produced by a single individual animal. The low numbers of mandible, maxilla and cranium fragments recovered from the three main domesticates suggests primary butchery was not being undertaken in this part of the site. The bone recovered represents mainly the waste from prepared joints of meat and these are generally from a limited number of carcass elements, as summarised in Table 4 (approaching the data from the perspective of body part analysis; O'Connor 2000, 72).

Thus the assemblage represents material that already underwent a number of different taphonomic processes before it reached the consuming population that lived within the monastic precinct. Again, material from excavations in Carlisle

Cattle			
Element	**2008**	**2009**	**2010**
Calcaneus	3	5	10
Talus	1	1	10
Phalanges	16	17	37
Femur	6	4	13
Humerus	2	2	6
Acetabulum	3	5	2
Metapodials	8	7	13
Radius/Ulna	9	6	14
Tibia	4	4	11
Scapula (glenoid cavity)	5	1	2

Sheep			
Element	**2008**	**2009**	**2010**
Calcaneus	7	2	8
Talus	3	-	3
Phalanges	1	-	1
Femur	6	1	5
Humerus	7	17	23
Acetabulum	3	8	5
Metapodials	3	11	1
Radius/Ulna	13	20	28
Tibia	12	14	23
Scapula (glenoid cavity)	2	-	12

Table 2. Differences in sheep and cattle bone numbers recovered in 3 years.

indicates that the Medieval bone assemblage showed a frequency of toe and skull bones which might suggest that the area acted as a primary butchery site (Cussans unpub.). Whether specific joints of meat were brought from Carlisle or the source of supply was a different part of the monastery, is not clear. Sheep bones show a dense clustering around the articulation of the humerus and radius/ulna, as well as the lower half of the tibia and calcaneus/talus. These elements represent over 55 % of the bones recovered for sheep. Though a number of possible modifying factors were considered such as differential dog scavenging (Davis 1987, 26) it was concluded that due to the infrequent occurrence of gnawing on bones in the assemblage this was not the primary modifying factor (and in this respect analogous with the remains from Eynsham Abbey, Oxfordshire: Ayres *et al.* 2003, 401). Likewise, the results for cattle show clustering around the distal humerus/proximal radius-ulna, and around the distal tibia/calcaneus/talus, though in general there is a preference for denser bone elements to be preserved. The remains of pig bones at this site are the lowest of the three domesticates; a result which is common for Medieval

Element	Cattle	Sheep	Pig
Patella	3	1	
Phalange: Proximal	36		2
Phalange: Intermediate	21		
Phalange: Distal	13	2	
Humerus: Proximal			
Humerus: Midshaft	1	11	4
Humerus: Distal	9	36	3
Radius: Proximal	7	23	1
Radius: Midshaft	9	24	
Radius: Distal	3	5	1
Ulna	11	8	3
Acetabulum	9	16	4
Femur: Proximal	7	3	1
Femur: Midshaft	11	3	4
Femur: Distal	6	6	
Tibia: Proximal	3	7	1
Tibia: Midshaft	5	18	
Tibia: Distal	10	25	1
Calcaneus	18	17	1
Talus	12	6	2
Mandible	3	8	7
Axis/Atlas	5	3	
Metacarpal: Proximal	8	1	
Metacarpal: Distal	5		
Metatarsal: Proximal	4	7	
Metatarsal: Distal	3	1	
Scapula: Glenoid	15	10	1
Totals	237	241	36

Table 3. Differences in elements recovered from cattle, sheep and pigs.

sites in Britain (Sykes 2006), but contrasts with some sites in Northwest England where pig was the second most frequently recovered domesticate (Morris 1990). However, there is some internal fluctuation within these figures, as discussed above. The frequency of pig bones recovered from the 2009 excavations (the eastern side of the cloister) might hint at higher pig consumption (or disposal of pig bones) in this area.

How then do these results compare with the historic record? In this respect the presence of surviving monastic documents gives current research a reasonably good collection of primary records relating to the activities of the monastery. This allows the sort of comparison between the historic and archaeological records as advocated by other writers on this topic (Albarella 1999). The following are some

Cattle	Total	No. per individual	Modified Count
Phalanges	70	24	2.9
Distal Humerus-Proximal Radius-Ulna	26	6	4.3
Acetabulum-Proximal Femur	16	4	4
Distal Femur-Proximal Tibia	10	4	2.5
Distal Tibia-Calcaneus-Talus	40	6	6.7
Metapodials	20	4	5

Sheep	Total	No. per individual	Modified Count
Phalanges	2	24	0.08
Distal Humerus-Proximal Radius-Ulna	67	6	11.1
Acetabulum-Femur	19	4	4.7
Distal Femur-Proximal Tibia	13	4	3.2
Tibia Midshaft/Distal-Calcaneus-Talus	66	8	8.2
Metapodial	19	4	4.7

Table 4. Bone of cattle and sheep examined through body part analysis.

typical entries which relate to domestic animals on land in Cumbria and Southern Scotland owned by or granted to the monastery (all taken from Grainger and Collingwood 1929):

- West Seaton – common pasture for 8 oxen, 2 cows, calves to two years and 2 horses.
- Caldbeck – grant of pasture for 6 oxen, 6 cows, 2 horses, 20 sheep, 6 swine, a boar and young up to two years.
- Distington – pasture for 600 sheep, 8 oxen, 7 cows, 2 horses, building material for sheepfolds and sheep-cotes.
- Setmurthy – pasture for 8 oxen, 2 horses, 60 ewes, as many goats, 6 swine and young of all these animals up to 3 years.
- Wigton – land for 10 cows, calves up to 2 years, 2 horses and 10 pigs up to one year.
- Kirkgunzeon (Scotland) – pasture for 4 oxen and 500 pigs.
- Kirkby Thore – pasture for 400 sheep, 20 wethers, lambs to 1 year, 6 swine and piglets to 1 year, and a boar.
- Blencogo – pasture for 100 sheep, lambs to two years, 28 cows, 1 bull, calves to two years and two horses.

Throughout the records cattle are mentioned with much less frequency than sheep. This may reflect real differences in flock sizes, which correlates well with the economic importance of the wool trade for the monastery. Alternatively, it may relate to the nature of the land which was granted to the monastery being more suitable for sheep rearing. In fact the cattle, particularly the oxen, could have been of greatest importance for the foresting activities of the monks. This is made clear in records from 1298 which discuss the rights of the monastery to the forest of Inglewood located to the east of the monastery (Parker 1905). In this case during a dispute regarding access to the Forest of Inglewood reference is made to '*draught oxen which draw timber and other necessaries*' (Gilbanks 1891, 82). We know that the monks engaged in iron production via a mine in Copeland (West Central Cumbria), but they were expressly forbidden within the conditions of this grant from processing the ore within the region of Copeland. The grant stipulating the grant of mining but not processing rights within the region may have increased the demands for traction animals by the monastery (Grainger and Collingwood 1929, 21). Transportation of wool to markets was another requirement and therefore it is possible that the population of cattle and horses maintained by the monastery were primarily for traction. Accounts of Scottish raids, such as the 1315 raid, record cattle and horses being driven away from the monastery, but not sheep (Grainger and Collingwood 1929). It is likely that the sheep were pastured away from the wetlands around the monastic core, which the pollen record suggests was not greatly drained or altered during the Medieval period (Hodgkinson *et al.* 2000, 120). Thus, there may be a bias in the archaeological and historic records if animals used for traction and transportation (oxen and horses) were kept around the monastic precinct. During periods when the monastery was attacked these animals may have been more likely to be driven off than sheep or pigs pastured in more distant areas.

Sheep are mentioned in the greatest numbers in the historic record, as one would expect from a monastery with a thriving wool trade. Total sheep flock numbers of 10,000 have been suggested as being owned by the monastery before the 14th century (Miller and Hatcher 1978, 219). Frequent mentions of sheep-cotes in the historic records (*e.g.* in Distington, mentioned above) show the locations of at least some of the monastic flocks. Goats are rarely present in the historic records but the entry for Setmurthy quoted above shows that flocks were maintained within the monastic estates.

Deer (whose bones were not found in particularly high numbers during the excavation) are referenced several times in the historic record, in particular with regard to the encroaching of monastic activity onto the forest of Inglewood, which was a royal hunting ground (Parker 1905). It could be suggested that, as with the raiding of cattle and horses, these references to deer are linked to conflicts, and thus are more likely to be mentioned as special events in the records of the monastery (similarly Albarella 1999, 872 notes that the frequency of references to dogs in Medieval documents often reflects legal conflict such as illegal hunting or dog attacks). Red and roe deer are expressly mentioned as living within the forest of Inglewood at the time of Henry III (reigned 1216–1272) and thus their presence is to be expected, particularly considering the contribution the forest made towards supplying the royal household (Parker 1905, 52; Birrell 2006).

Pigs are occasionally referenced in the historic documents, and then only in small numbers, though the foundation charter for the monastery grants the right of free pannage in the forest of Inglewood, demonstrating that pigs did play an important role in the monastic economy (Gilbanks 1891). A later grant, of *c.* 1217, for land in the region of Islekirk (*c.* 20 kilometres south of the monastery) granted forage for pigs, except in times of pannage (Grainger and Collingwood 1929, 76). These sorts of distinctions show that even though pigs occur infrequently in the archaeological remains, and are mentioned in relatively small numbers in historic documents, the value of pannage and the role of pigs in the early history of the monastery is still an important one. The one exception to the low numbers of historic references can be seen above and relates to Kirkgunzeon, within the lands of the monastery in Scotland. Here a record of pasture for 500 pigs is exceptional, though whether these numbers were actually kept in this region is unclear. Considering the low incidence of pig bones recovered during this phase of excavation this draws attention to whether these pigs were being raised to supply an urban market elsewhere, perhaps in Carlisle or Dumfries. If pigs were kept in such numbers and destined for consumption outside the monastic precinct, then this highlights issues as to how such an important resource could be detected archaeologically. The rearing of livestock for sale in external markets is an example where difficulties arise in the identification of surplus production. As monastic economies develop they take on an increasingly administrative role in production of animals and material on lands not physically attached to the monastery itself via a system of granges. The identification of surpluses in lands separated from the main monastic precinct may become increasingly difficult and could not be identified solely on the basis of the archaeozoological material.

Environmental archaeology at monastic sites is hampered by a number of factors, made all the more difficult in the case of rural sites such as Holme Cultram. Some of the issues encountered during the current phase of excavations will be familiar to others involved in excavations at monastic sites. A number of analogous sites with comparable issues are discussed here, but in the words of Hall and Huntley (2007, 12): '*We are thus faced with a difficulty in making valid comparisons across a region or between different cultural periods simply because the evidence is 'patchy' – as for any class of biological material or, indeed, for any cultural remains.*' When considering the remains from Holme Cultram one of the issues faced was to determine what issues were part of a wider concern in monastic environmental archaeology, and what issues might be considered localised to the region, or to the individual site. Among the issues of preservation four of the key taphonomic factors are:

1. Shallow soils, often typical of rural sites. This is compounded at Holme Cultram by the acidic nature of the soil.
2. The cleaning and maintenance activities of the monks.
3. Issues of individual agency and site histories.
4. An early and sustained interest by antiquarians and archaeologists.

For rural monasteries like Holme Cultram the shallow stratigraphy, and often poor preservation where acidic soils are present, means that monastic sites do not in all cases provide samples of sufficient size to allow detailed inferences to be made regarding the economy of the site. Issues of bone preservation and recovery on monastic sites were discussed by Jones (1989) in his assessment of fish remains from archaeological sites. Even when extensive sieving and collection procedures have taken place monastic sites can produce poor assemblages of archaeozoological material. Several of these are outlined by O'Connor (1981; 1993) in his assessment of archaeozoological assemblages from monastic sites, including investigations at Llanthony Priory where a specific sampling strategy failed to yield large volumes of material. To this could be added the recent remains from Kelso Abbey (Lowe 2005), Hollyrood Abbey (Bain 1998), Pluscarden Priory (McCormick 1994) and Hulton Abbey (Outram 2005), all of which generated only small assemblages of animal bone.

In discussing the housekeeping activities of the monastic household, Jones reminds us that '*vast amounts of potential data invaluable to environmental and other archaeologists were lost by the prudent actions of monks and their servants*' (Jones 1989, 174). The systematic maintenance and clearing coupled with the stratigraphic record allows in most cases only a very general division between broad phases. These factors are applicable to many archaeological remains in rural locations, but are likely to be compounded at monastic sites.

Another factor which unites monastic sites across the British Isles was their shared history of Dissolution from the mid–late 16th century, through to a period of decay until they attracted the interest of antiquarians and early archaeologists. Each monastic site and its archaeological remains is the product of a combination of patterns of activity common to the monastic communities generally and to individual circumstances at individual sites. Thus, the Black Death, the sheep murrain and the Dissolution of the Monasteries by Henry VIII are experiences shared more or less by all monasteries in England and Wales. However, the Dissolution was experienced differently in Scotland and England due to differing political circumstances (Robinson 2002). Likewise, due to a rebellion in Northern England (known as the Pilgrimage of Grace) the levels of destruction may not be directly comparable with sites in southern England. For the region being discussed here the effects of the Anglo-Scottish Wars are shared by a small number of monasteries in Northern England and Southern Scotland, while specifically for Holme Cultram individual raids from Scotland or the poor economic planning of particular abbots led to localised impoverishment. In one incident the finances of Holme Cultram were largely squandered by the abbot, Adam of Kendal, '*by means of banquets sumptuously served, as well as by many bribes*' in the early 13th century (Gilbanks 1891, 45).

The interest antiquarians and archaeologists took in these sites is also a factor that has affected the current environmental archaeology potential of these sites. During early investigations by antiquarians and archaeologists it was the uncovering of monastic buildings in plan which was the main aim, with attempts made to describe the architectural changes and development of the site. Butler

(1989, 9) has argued that these early aims within monastic archaeology changed little from the 19th century to the later 20th century and the results were a record of architectural plans and the creations of '*well-ordered piles of masonry amid green lawns*'. Work of this nature undoubtedly did much to remove cultural material and obscure stratigraphic sequences which in the contemporary period would be viewed as of major interest to environmental archaeologists. From an early date clearings of this type were undertaken at Holme Cultram (Hodgson 1907), as well as other monastic sites in the region. Jedburgh, another border monastery, though on the Scottish side of the border, was excavated in the 1930s, though no excavation report was prepared (Lewis and Ewart 1995). Melrose, of which Holme Cultram was a daughter house, was exposed to large-scale clearance/excavation work from 1921 to the 1950s (Ewart and Gallagher 2009). With an emphasis on the retrieval of architectural fragments, ceramics and metalwork there is at best only passing reference to the presence of archaeozoological material, or deposits which might have been of interest to environmental archaeology studies. Butler (1989, 9) has also discussed this in relation to the 1913 Ancient Monument Act which placed 22 rural monasteries into state protection, many of which were then exposed to clearance works that were likely to have affected the archaeological record.

How far the monastic diet at Holme Cultram may have changed through time is not yet clear due to broad dating for many of the layers encountered and issues of preservation due to cultural and natural taphonomic factors. The targeting of midden features and the greater use of sieving are also factors which future research will need to consider. That is not to say that this situation is typical, however, and under the right conditions excellent preservation has produced a number of important results. From an archaeobotanical perspective Dickson's (1996) work at Paisley Abbey and Greig's (2002) work at Shrewsbury Abbey both show the potential for waterlogged remains. From an archaeozoological perspective excavations at Kirkstall, West Yorkshire and the Austin Friars in Leicester (Thawley 1981) both produced sizeable assemblages of animal bones. Similarly the excavations at the Benedictine Abbey at Eynsham produced an important assemblage of bones spanning the Anglo-Saxon to post-Dissolution period, including a large fish bone assemblage (Ayres *et al.* 2003). However, when remains are well preserved interpretation needs to consider another set of taphonomic factors, including that the monks operated (theoretically) under a dietary regime which encouraged fasting and the consumption of simple meals. Coupled with this the mixing of kitchen waste from meals from different social classes may obscure evidence for intra-site variation (Sykes 2006, 68; McCormick 2002). This is particularly relevant for monastic institutions where monks, lay-brothers and those in the infirmary may all have been consuming slightly different diets (Woolgar 2006, 195).

Conclusion

Examining the diet and economy of the monastery of Holme Cultram, Cumbria has many parallels with the investigations undertaken at analogous monastic sites. Issues of shallow stratigraphy, cleaning activities which prevented the accumulation of dietary debris and later destruction and disturbance will be familiar to many others who have excavated at rural monastic sites. However, using evidence from archaeological remains (including artefactal and ecofactual remains), historical sources and landscape studies (including palynological studies for vegetation change) a pattern emerges which places the site within local, regional, national and international spheres of activity. For an examination of the theme 'subsistence and surplus' a monastic site presents the environmental archaeologist with many problems linked to preservation and taphonomy. However, due to the multiple strands of evidence available there is also great potential for environmental archaeology to contribute to investigations of these sites as economic, social and religious centres. For Holme Cultram the environmental evidence demonstrates how the monastery integrated itself into the geo-political environment which developed through its history. This included benefitting and profiting from its position, but also at times being constrained by local and international factors.

It is acknowledged that the focus here is a quite restricted view of what is a broad European phenomenon which began sooner, and lasted longer than it did in Great Britain. Ultimately it is hoped that research from other regions such as the Iberian Peninsula, France, Scandinavia, Central and Eastern Europe can be collated to investigate whether we can view monastic environmental archaeology as being a cohesive field of study. For monastic environmental archaeology moving towards a more integrated pan-European approach, may be the best way to appreciate the pan-European nature of the medieval monastic economy. This would utilise the fact that monastic sites were not self-sufficient economic units subsisting within a closed system, but part of a complex network which laid important foundations for the system of surplus production and reinvestment which would define the later economy of Europe.

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BARELY SURVIVING OR MORE THAN ENOUGH?

How people produced or acquired their food in the past is one of the main questions in archaeology. Everyone needs food to survive, so the ways in which people managed to acquire it forms the very basis of human existence. Farming was key to the rise of human sedentarism. Once farming moved beyond subsistence, and regularly produced a surplus, it supported the development of specialisation, speeded up the development of socio-economic as well as social complexity, the rise of towns and the development of city states. In short, studying food production is of critical importance in understanding how societies developed.

Environmental archaeology often studies the direct remains of food or food processing, and is therefore well-suited to address this topic. What is more, a wealth of new data has become available in this field of research in recent years. This allows synthesising research with a regional and diachronic approach.

Indeed, most of the papers in this volume offer studies on subsistence and surplus production with a wide geographical perspective. The research areas vary considerably, ranging from the American Mid-South to Turkey. The range in time periods is just as wide, from c. 7000 BC to the 16th century AD. Topics covered include foraging strategies, the combination of domestic and wild food resources in the Neolithic, water supply, crop specialisation, the effect of the Roman occupation on animal husbandry, town-country relationships and the monastic economy. With this collection of papers and the theoretical framework presented in the introductory chapter, we wish to demonstrate that the topic of subsistence and surplus production remains of interest, and promises to generate more exciting research in the future.

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