A zooarchaeological study of butchery and bone fat processing practices among early Neolithic farming societies in central Europe

Submitted by

Emily Victoria Johnson

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

This thesis presents the results of zooarchaeological investigations into diet in Neolithic central Europe. The aim of these investigations was to gain a better understanding of animal carcass processing, particularly dietary decisions made concerning intensity of exploitation of meat and fat resources. The primary focus was the Linearbandkeramik (LBK) culture, a sedentary community of farmers dating from c. 5500-4900BC in central Europe suspected to be the first society to utilise milk and its products in this region. The adoption of dairying, currently under scrutiny by the NeoMilk project, would have increased the availability of fat on settlements, and could have affected the way in which people utilised primary animal products.

Using in-depth zooarchaeological analysis of butchery, fracture and fragmentation, this thesis presents a snapshot of Neolithic meat and fat exploitation. Patterns of butchery and heat exposure suggest differential cooking practices between sites, with a possible focus on nutrient retention at some, contrasted with a cultural preference for roasting at others. Intensive processing of bone fats, namely bone grease, was not detected at any site and it is likely that the domesticated LBK diet rendered this practice unnecessary to subsistence. Bone marrow was a much more commonly exploited resource, but variation was considerable between sites. It is possible that the intensification of dairying had a significant effect on the utilisation of bone marrow. Sites with the most evidence for milk use, detected through lipid residue and osteoarchaeological evidence, show less intensive exploitation of bone marrow than those with little or no evidence of dairying. This thesis therefore presents evidence of zooarchaeologically detectable dietary decisions being made in the face of adoption of new foodstuffs.

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Chapter 1 Introduction

1.1 Introduction

The early Neolithic in central Europe is characterised by significant changes in the relationship between humans and animals. The arrival of the Linearbandkeramik (LBK) culture in the 6th millennium BC saw the introduction of well-established domesticated species, and with them new forms of animal management and exploitation (Bickle and Whittle 2013). These sedentary agriculturalists were also possibly the first group in central Europe to utilise animal secondary products, particularly milk (Sherratt 1981; 1983; Salque *et al.* 2012; Salque *et al.* 2013). The adoption of dairying is under scrutiny by the NeoMilk project, an interdisciplinary collaboration investigating the spread of cattle-based agriculture by early Neolithic farmers (ERC Advanced Grant ERC324202; Neomilk Website).

The role of dairy products in LBK subsistence is still poorly understood. It is possible that milk and milk products did not contribute greatly to subsistence, as the level of lactase persistence in the Early Neolithic would have likely been low (Itan *et al.* 2009; Burger *et al.* 2007). This would have made the continued consumption of milk uncomfortable, although the level of lactose would be reduced by cheese making (Salque *et al.* 2013). If we consider the possibility of lactose-reduced dairy products, adopting dairying could have had a profound effect on Neolithic life, and especially on diet. If dairy fat was readily available, storable, and often consumed, then old subsistence methods once necessary for survival may have become obsolete or seasonal.

The impact of the adoption and intensification of dairying on diet may be reflected in the zooarchaeological record. Zooarchaeological study of the Linearbandkeramik culture was traditionally hindered by poor bone preservation, but more recent large-scale excavations and new techniques have afforded a much better understanding of animal exploitation in the LBK. Largely the focus of zooarchaeological data has been on species representation, skeletal part abundance, age-at-death analysis and biometrics (see Arbogast 1991; 2000; Glass 1991; Osypinska 2011.; Raczky *et al.* 2010; Schmitzberger 2009; Uerpmann and Uerpmann 1997). This crucial information concerning the type, age, size and deposition of species on LBK sites gives an excellent background for in-depth analysis of carcass processing practices, an area that has until recently been under-utilised by zooarchaeologists (Johnson *et al.* 2016;

Madgwick and Mulville 2015a; 2015b; Marciniak 2005; 2011; Marciniak and Pollard 2015; Parmenter 2015; Parmenter *et al.* 2015). Zooarchaeological analysis of carcass processing practices can indicate patterns of food exploitation, dietary stress, and changes in the material culture of butchering and distributing slaughtered animals. These trends are made visible primarily through analysis of butchery marks, heat exposure, fracture freshness and fragmentation. This thesis will utilise these forms of zooarchaeological analysis to address the current lack of detail in the nature of meat and fat exploitation on archaeological sites in the Neolithic of central Europe, particularly at the time of the adoption of dairying.

1.2 Thesis structure

This thesis will be presented in 16 chapters, beginning by introducing the research area in the context of the NeoMilk project. Ethnographical literature concerning bone fat processing in different subsistence structures will then be assessed, and the methodology used in this thesis presented. The main body of the thesis describes the zooarchaeological analysis of twelve case study sites. Trends identified in these case studies are brought together and analysed in the discussion chapter.

- **Chapter 1: Introduction**

Chapter 1 introduces the aims of this thesis and the overarching research aims of the NeoMilk project. It gives a brief introduction to the Linearbandkeramik culture, particularly focussing on aspects of subsistence and deposition practices. Finally, the importance of fat acquisition in the context of subsistence is identified, and considered in light of the secondary products revolution and evidence for fat consumption in the LBK.

- **Chapter 2: Ethnography**

In chapter 2, ethnographic literature concerning bone fat exploitation in different subsistence structures and environments is analysed. It is used to gain a better understanding and to identify archaeological signatures of these processes, informing the methodological choices detailed in chapter 3.

- **Chapter 3: Methodology**

The main body of the methodology concerns analysing aspects of carcass processing, particularly butchery, heat exposure and bone fat extraction. It also details the basic zooarchaeological identification undertaken, and presents and critiques evidence used to indicate dairying economies on each of the case study sites. Lastly, it presents the structure of each of the case study chapters.

- **Chapter 4-15: Case studies**

Chapters 4-15 present each of the twelve case study sites analysed for this project individually, assessing species representation and analysing carcass processing practices including butchery, heat exposure, fracture and fragmentation. Taphonomic aspects and evidence for milk use are considered. The chapters are arranged roughly chronologically and regionally, and are summarised in figure 16.1 and table 16.1.

- **Chapter 16: Discussion**

The final chapter of this thesis amalgamates the data presented in chapters 4-15 to assess the nature of meat and fat exploitation in the Linearbandkeramik and other Neolithic cultures. Following this, the likelihood of dairying economies on each site will be evaluated, and the nature of meat and fat exploitation analysed in relation to these data. Recommendations will also be made in this section for future work.

1.3 Thesis aims

1.3.1 The NeoMilk project aims

The NeoMilk project is an interdisciplinary project investigating the milking revolution of Neolithic temperate Europe. It explores the spread of cattle-based agriculture by early Neolithic Linearbandkeramik (LBK) farmers and its implications for modelling the Mesolithic-Neolithic transition in Northern and Central Europe (NeoMilk website).

The primary aim of the project is to investigate where and when (and indeed why) dairying arose in Neolithic temperate Europe (NeoMilk website). It combines three research themes based on lipid residue analysis of ceramic sherds, animal bones and evidence of environmental and cultural change. In

Theme 1, lipid biomarkers and stable isotope compositions of food residues in LBK pottery will provide assessments of the major animal products processed in ceramic vessels. Theme 1 also aims to test whether the LBK was a core region for the emergence of the European Lactase Persistence (LP) variant. Theme 2, which this doctoral thesis contributes to, aims to reveal trends in LBK animal exploitation and husbandry, particularly in relation to the intensification of cattle herding and milking. It uses state-of-the-art analyses of herding and slaughtering practices for cattle and caprines (domestic sheep and goats), and of butchery practices and the nature of meat and fat exploitation, to identify and explore the effects of dairying on archaeological sites. Finally, theme 3 chronicles, maps and correlates patterns of environmental and cultural change related to animal management and milk use. It will integrate palaeoenvironmental/ climate records, isotopic and dating evidence from pottery residues and animal remains, and archaeological evidence into an explicit spatio-temporal model, providing an environmental and cultural context for any variations observed. Data from all themes will be brought together to identify the principal influences on changing patterns of animal management and exploitation throughout the entire spatiotemporal range of the LBK (NeoMilk website).

1.3.2 Thesis aims

This thesis aims to gain a greater understanding of the nature of meat and fat exploitation in the LBK. This pertains firstly to the cultural variability of butchery between sites, and secondly to the dietary influence of dairying.

The way in which people process the carcasses of slaughtered animals can be seen as a form of material culture reflecting social structure and symbolic aspects of society (Milner and Miracle 2002: 2; Seetah 2008). Variability in butchery patterns may relate to the food distribution mechanisms within the settlement or to the social significance of certain species, including elements of taste and cultural preference for certain cuts of meat (*ibid.*). In addition, butchery variation can be determined by the nutritional needs of a society, and may highlight difficult periods through intensive utilisation of meat and fat. Deposition practices and taphonomy can further be used to assess spatial distribution of butchered elements, and can indicate differences in specialisation and social standing between areas of settlements.

Variation in meat and fat exploitation will be put into context with evidence for dairying economies based on lipid residue and herd structure analysis, thus aligning this study with the NeoMilk project's aims. The relationship between dairy fat and adipose fat, as suggested by the intensity or carcass processing practices, will be explored.

1.3.2.1 Research questions

Two primary research questions have been identified:

1) **What was the nature of meat and fat exploitation among early Neolithic farming societies in central Europe?**
    a) Was there variability in butchery material culture?
    b) Were all animals treated in the same way?
    c) Were processing decisions economically rational or driven by cultural preferences, particularly pertaining to taste, ritual, etc.?
    d) What does the nature of meat and fat exploitation tell us about the use of sites and deposition spatially?
    e) Were there chronological and/or regional patterns?
2) **How did the adoption and intensification of milking practices affect meat and fat exploitation?**

1.3.2.2 Hypotheses

Based on both the homogeneity and variability that existed within the Linearbandkeramik culture (Bickle and Whittle 2013) it is expected that there was some variability in LBK meat and fat exploitation, perhaps pertaining to regions as with other LBK variations. It is also supposed that the LBK diet of domesticated crops and animals would render intensive bone fat processing unnecessary compared to hunter-gatherer societies. In the same way, it is hypothesised that intensification of dairying would have decreased the need for bone fats.

1.3.2.3 Brief methodology

To test these hypotheses, the faunal assemblages from multiple sites from the Linearbandkeramik and other early Neolithic cultures in central Europe were targeted for zooarchaeological analysis. The sites were selected for study based on those due to be targeted for lipid residue analysis, and those where the animal bone assemblage was of substantial size and had good preservation. Initially, five sites were to be targeted, but the opportunity often arose to sample or study in full the faunal assemblages from other sites stored in the same location. It was also decided that it was plausible in the timescale and budget of the project to target other sites to allow a more complete regional and chronological spread of Neolithic Europe. In total, twelve sites were analysed.

The faunal analysis of these sites included both basic and in-depth elements of zooarchaeological research. A standard identification to species and element was attempted on each specimen, and the fusion state was noted. These data allowed an understanding of species representation, particularly important in the proportions of lactating animals and in assessing the contribution of wild animals to diet. In-depth analysis of butchery, heat exposure, fracture and fragmentation attributes was also undertaken to study carcass processing practices. This data will then be analysed in conjunction with evidence for milk exploitation in the form of herd structure analysis based on fusion (undertaken by myself) and dental age completed by Dr Roz Gillis and lipid residue analysis undertaken by the Organic Geochemistry Unit in Bristol.

1.4 The *Linearbandkeramik* culture

1.4.1 Introduction

Sites of the Linearbandkeramik (LBK) culture are the primary focus of this project, and indeed the Neolithic of Central Europe is characterised by the spread of these “first farmers” (Bickle and Whittle 2013). Archaeological evidence for the LBK is predominantly found in Hungary, western Slovakia, Moravia, Southern Germany and Alsace, dating to the early Neolithic between c. 5500 and 4900 cal BC (*ibid.* 1). This culture was targeted for analysis by the NeoMilk project due to suggestions of dairying economies at some LBK sites (Salque *et al.* 2012; Salque *et al.* 2013), and the modelled emergence of the lactase persistence gene (Gerbault et al. 2013; Gerbault 2014; Burger *et al.* 2007; Itan *et al.* 2009). The LBK culture itself is also has a wide geographical and temporal spread whilst largely retaining dominant aspects of culture, particularly its typologically distinctive and abundant pottery, although regional variation is now better understood (Bickle and Whittle 2013; Marciniak 2005: 11). This section gives a summary origins, landscape, settlement structure, social structure, material culture and most importantly subsistence of the LBK culture, and will highlight how these features may impact analysis of the nature of meat and fat exploitation.

1.4.2 LBK origins

The origins of the LBK in Europe were traditionally contested, with scholars favouring one of two models for dispersal – migration or acculturation. In the migration model the LBK culture was spread through the movement of a defined group of people across Europe, whereas in the acculturation model 'Mesolithic' foragers adopted the culture, becoming the LBK (Bogucki 1996: 242). The migration model has been widely accepted as the similarity of pottery, house forms, crops, settlement location and stone tools strongly suggested a minimal indigenous input (*ibid.* 247). Ancient genomic evidence shows that there was a major population input from the Near East at this time (Haak *et al.* 2010; Haak *et al.* 2015; Allentoft *et al.* 2015).

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of this thesis for copyright reasons

Figure 1.1: Map of the LBK distribution showing earliest (darker) and later phases. After Bickle and Whittle 2013: 1, fig. 1.1 and Jeunesse 1997: 10, fig. 1.

More recent studies have advocated for a greater significance of the role of hunter-gatherers in the transition to farming (Price 2000: 3; see also Robb and Miracle 2007: 103), as it is thought that different interactions with the indigenous hunter-gatherers could have contributed to the variations found in LBK settlements across Europe. Indigenous groups that were displaced or continued to exist alongside the LBK did not wholly accept the Neolithic farming 'package', with some adopting elements of farming that they desired (Robb and Miracle 2007: 102). Others continued with their traditional 'Mesolithic' subsistence methods in environments unfavourable to LBK settlers, such as marine, riverine and lacustrine environments (Price 2000: 4). This resulted in a landscape that was being utilised in different ways, which was potentially exploited in the form of trade networks as discussed below. While thought in the traditional view to be sparsely present, socially amorphous and eventually overwhelmed, foraging societies were perhaps instrumental in the initial spread of the LBK into Europe, contributing to their subsistence and arguably their success (*ibid.* 3).

1.4.3 The LBK landscape

1.4.3.1 Biosphere

The environment that the LBK functioned in undoubtedly affected their material culture and subsistence economy. In central Europe, the LBK culture was faced with terrain, soils and climate markedly different to those in South West Europe (Bogucki 1996: 246). At the time of the LBK the climate in central Europe was warm and wet (Rück 2009), yet subject to fluctuations, which have been postulated as being responsible for the expansion of farming into the European continent, and indeed the eventual decline of the LBK (Gronenborn 2007). The people themselves also had a discernible but limited impact on the woodland settings of their settlements, clearing trees to encourage wild animals at forest edges and supply wood to build houses (Bickle and Whittle 2013: 6).

1.4.3.2 Networks

In the early LBK communities were relatively isolated from each other, but after c. 5300 cal BC settlements became more numerous and closely spaced (Marciniak 2005: 9). There has been the suggestion that some settlements became parent settlements, with smaller daughter/specialised sites connected to them (Zimmerman 1995; Bickle and Whittle 2013: 6; Domboróczki 2009). The parent site of Vaihingen yielded isotope values in cattle teeth that indicated that they were brought in from other settlements (Knipper 2009: 155; Gronenborn 2007: 83). Networks between settlements facilitated material and social exchanges between communities, and were perhaps responsible for the spread of homogenous material culture and ideas (Bickle and Hofmann 2009: 5).

It is possible that contemporary hunter-gatherer societies also formed trade networks with the LBK. Their contributions to the farming cultures likely took the form of foodstuffs, such as hunted meat and fat, or cultural items such as furs (Zvelebil 1998), although unquestionable Mesolithic artefacts in LBK contexts are rare (Amkreutz *et al.* 2009). Interactions with Mesolithic cultures not only involved material goods but also the trade of people, namely women. Strontium isotope analysis of skeletons from Flomborn, Schwetzingen and Dilligen suggests that non-local women from forager communities were marrying into LBK settlements (Bentley *et al.* 2002; Bentley *et al.* 2009; Bentley *et al.* 2012; Bentley 2013). It has been argued that interactions with foragers helped early farmers survive in new surroundings through these exchanges of products and raw materials (Bentley 2007: 117). However, Marciniak argues these exchanges were beyond normal economic requirements and were not necessary for survival (2005: 26).

1.4.4 Settlement structure

LBK settlements were formed of varied numbers of longhouses, ranging from ‘farmsteads’ of a single house to ‘villages’ of twenty or more contemporary houses, often inhabited over many generations (Bickle 2013; Last 2015: 276-281). Specific types of terrain and biospheres were preferred for settlement locations for the LBK, causing a differential geographic dispersal pattern across the various regions of Europe (Bogucki 1996: 246). Lowland settings with proximity to water and highly fertile loess soils suited to the cultivation of barley and wheat were preferred, and settlements often built on slopes to avoid flooding (Bickle and Whittle 2013: 6; Rück 2009: 173; Bogucki 1996: 243; Bogaard 2005). These factors were particularly attractive to LBK settlements to the exclusion of other locations (Hartz *et al.* 2007: 570). The easily recognisable Neolithic longhouse and its immediate surrounds is the primary archaeological signature of excavated LBK settlements, but other features including isolated pits that cannot be assigned to a single house, along with wells and groups of ovens are also found (Milisaukas 1986). Some settlements also show evidence of enclosure ditches, either with or without internal buildings, which could have been defensive, for corralling animals and/or functioning as symbolic, political or economic central places (Boulestin *et al.* 2009; Petrasch 2015; Raczky and Anders 2012).

Regardless of layout or topography, the longhouses on each settlement were aligned in the same direction, with slight regional variation (Last 2015: 275). Using ethnographic analogy, the orientation has been related to the prevailing wind in certain areas (Soudský and Pavlů 1972; Coudart 1998; Květina and Hrnčíř 2013), or symbolically to the Danubian origins of the LBK (Bradley 2001). The identical orientation of the houses often negates the identification of a common centre, such as a free place in the middle of the settlement (Zimmermann *et al.* 2005: 31). However, some atypical LBK settlements do not follow this pattern, such as Füzesabony-Gubakút where houses align the same way but entrances face each other across a stream (Domboróczki 2009). On some LBK settlements, such as Elsloo and possibly Ludwinowo 7, houses are arranged in 'wards' with some open spaces between them (van de Velde 1990; Pyzel 2013: 185; Last 2015: 282). Houses were sometimes built in rows suggesting sequences of building (Last 2015: 282), although radiocarbon dating does not always support this (Domboróczki 2009: 80). It is likely that those living near each other belonged to the same kinship group (Bickle 2013: 156-7), and that the layout of houses on a settlement contributed to social stratification, as will be explored below.

1.4.5 House structure

1.4.5.1 Origin, structure and death

The LBK longhouse is suggested to have its origins in the late Starčevo period, with the first genuine longhouse appearing in southern Transdanubia, Hungary (Bánffy 2013: 118). The monumental structure of the LBK longhouse was formed of a timber framework of rows of upright posts with wattle and daub walls, likely with a pitched roof sloping off towards the long sides (Bánffy 2013: 119; Coudart 2015: 311). These one-story buildings had high roofs allowing for the use of loft space, potentially as storage (Whittle 1988: 67). House length ranges widely from 10-45 metres but varies much less in width, between 5-7 metres (Coudart 2015: 311). Partly due to the lack of living surfaces preserved within the house it has been tentatively suggested that the houses had floors suspended slightly above ground level, although there has been little direct archaeological evidence to support this (Whittle 1988; Květina and Hrnčíř 2013: 341). These longhouses were a stark contrast to the preceding and contemporary hunter-gatherer house structures that existed in that region (Bickle 2013: 159;

Amkreutz *et al.* 2013: 231), necessitating completely new techniques of forest management, woodwork, earthmoving and group organisation and cooperation (Amkreutz *et al.* 2013: 231).

It is likely that the creation of a new LBK longhouse took place every few years (Bickle 2013: 160). Bickle describes house building as “unusual but not unfamiliar, stressful but exciting, a time of celebration but a serious undertaking”, and a marker in the life course of individuals (*ibid.* 160). Through pottery and radiocarbon dates the lifespan of an LBK house was perhaps 20-30 years (Modderman *et al.* 1970; Modderman 1988; Stehli 1989), although this has been challenged by Rück (2009) who suggests houses could last for 80 years. The timespan is still unresolved, but from a lack of intersecting ground plans at many sites abandoned houses often survived as visible ruins, their significance remembered for many generations (Last 2015: 4). A less symbolic alternative is that ruins of houses were used for rubbish disposal (Květina 2010: 362).

1.4.5.2 Life in the longhouse

In the interior of the longhouse, transverse posts would have segmented the house, creating different spaces or modules within (Modderman *et al*. 1970). The number and layout of these spaces is not always consistent, suggesting some variation in house planning was permitted, although all houses feature a central module (Bickle 2013: 151; Coudart 2015). The north module is typically described as the locus of greatest privacy, least accessible to visitors, possibly used for sleeping, as opposed to the central module, the main living space for domestic activities and visitors (Coudart 2015: 315-316; Last 2015). The south module, often interpreted as a grain storage area, was also likely the entrance to the house, due to the lack of exterior pits (Coudart 1998: 71; Hachem 2000; Bickle 2013; Last 2015). Bickle (2013: 163-4) and Milisaukas (1986) have argued that the interior of the longhouse was not ideal for all tasks due to lack of light and space, so it is likely that many activities took place outside the longhouse.

In the immediate vicinity of the house were pits flanking the long walls (commonly referred to as *Längsgruben*, house pits, clay pits and construction pits), widely agreed to have been dug at the time of house construction for the materials needed to daub the walls and later used as refuse dumps (Milisaukas 1986; Bánffy 2013; Bickle 2013; Gomart *et al.* 2015). At Olszanica the volume of house pits would have been sufficient to construct the houses they flank, with hypothetical daub two metres high and ten centimetres thick (Milisaukas 1986: 52). In addition to pits, features such as pit-ovens and fences indicating gardens or stock enclosures are occasionally found within the vicinity of houses (Last 2015: 6). At Olszanica, clusters of two or more post holes not associated with houses are suggested to be the remains of special structures related to keeping animals or fodder (Milisaukas 1986: 80). It is likely that longhouses were self-sufficient, possibly functioning as small farmsteads with related buildings within the settlement (Bánffy 2013: 129; Bickle and Whittle 2013: 9).

1.4.5.3 Refuse deposition

The pits associated with LBK longhouses are thought to contain refuse including ceramic, stone, animal bones and unpreserved material pertaining to the lifespan of that house, thus providing a record of household activity (Bickle 2013: 155; Gomart *et al.* 2015: 232; Květina 2010; Květina and Hrnčíř 2013). The refuse is thought to be "an effective means for identifying cultural, economic and social factors governing social interaction within LBK communities" (Gomart *et al.* 2015: 231), although is surely not as "uncomplicated" as Bickle describes (2013: 155). Květina and Hrnčíř argue that it is not possible to accept that house refuse equals house pits without question (2013: 343). Many factors pertaining to refuse deposition remain poorly understood, particularly the lifetime of the pits, strategies of deposition and redeposition, and communal deposition and waste segregation. All these factors could influence the composition of the faunal assemblage, affecting the types of bones found in different pits and crucially the types of fracture, taphonomic agents and level of fragmentation affecting bones.

1.4.5.3.1 Pit lifetime

The length of time that the flanking pits were open is still not adequately resolved (Bickle 2013: 157). Based on the mix of slaughter ages indicative of different seasons in the house pits at Cuiry-lès-Chaudardes, Hachem demonstrated that pits must have been open for at least a year (2000; 2011; Gomart *et al.* 2015). Domboróczki (2009) and Bedault (2012) estimate a lifespan of four or five years, although some pits could have been open as long as ten (Domboróczki 2009: 105; Bedault 2012: 68-69, 478). Given the postulated lifespans of houses, even the longest estimate indicates that pits were not open for the full length of time that houses were occupied (Allard *et al.* 2013), leaving Domboróczki to wonder where the refuse accumulated in the remaining lifetime of the house was deposited (2009: 105). He suggests that it could have been scattered or piled on walking surfaces (*ibid.*), which has further implications for secondary fracture and taphonomy, as explored below.

1.4.5.3.2 Deposition strategies

Whilst the length of time and contents of LBK long pits is still uncertain, assemblages from these pits can indicate strategies of deposition. Both Bickle (2013: 156) and Allard *et al.* (2013) suggest that deposition was generally unstructured and came together gradually, despite containing some occasional ‘events’. Material from the pits could have originated from temporary dumps both interior and exterior to the house (Hachem 2000: 108; Květina 2010). It is possible that house pits were reopened or expanded for material to make repairs, resulting in new finds groups entering the pits and disturbing the material already within (Domboróczki 2009: 106).

Material in the house pits could also have originated from communal waste disposal activity. Stäuble argues that pits may have been filled during house construction, their contents presumably deriving from middens already present in the settlement (1997, 2005). At Bylany it is possible that old houses were used as middens for refuse from living houses (Květina 2010), although this is not true for all sites, such as Cuiry-lès-Chaudardes (Gomart *et al.* 2015). Domboróczki suggests that casual refuse deposits on walking surfaces around the settlement were highly fragmented by trampling, resulting in being washed into house pits over time (2009: 106; Milisaukas 1986: 176). Many of these processes would result in secondary dry or mineralised fracture to animal bone, depending on the level of degradation.

It is possible that refuse deposition was determined by type of activity. Communal pits away from the vicinity of houses may have held waste from dangerous activities, such as flint knapping, which would be painful underfoot (Květina 2010). In the Aisne valley, Allard *et al.* (2013) argue that butchery was communal based on lack of primary butchery waste and tools in house pits, which must have been deposited elsewhere. Segregated zones based on task have been hypothesised from spatial analysis of Olszanica (Milisaukas 1986: 178).

These factors suggest that refuse could be specific to task, not necessarily representative of house life.

1.4.6 Social structure

Differences in settlement layout and house size, along with the types of refuse from the lateral pits, have been related to social structure within settlements. Many scholars have suggested that each house would be self-sufficient (Coudart 2015; Gomart *et al.* 2015; Hachem 2000; Zimmerman *et al.* 2005) but linked, physically and socially, within the wider settlement and the landscape (Last 2015: 11). House building on such a scale, to such a strictly canonised design, shows highly developed social ties and an elaborate system of cooperation (Bánffy and Sumegi 2011). Evidence strongly suggests that there was some social inequality in LBK settlements in the form of powerful individuals, who perhaps managed a largely egalitarian and cooperative society.

1.4.6.1 Social inequality

There is a general agreement that some sort of social stratification existed within LBK settlements. Coudart (2015: 317) argues that at larger sites a truly egalitarian community would be a hindrance based on the settlement's ability to make decisions quickly. Groups of high power individuals on LBK sites could have been the decision makers, often referred to as "big men" using ethnographic analogy (Pavlů 2012; van de Velde 1990; Květina 2010; Coudart 2015). These individuals may have lived in larger houses (Milisaukas 1986; Květina 2010; Gomart *et al.* 2015) and controlled kinship groups (van de Velde 1990; Bickle 2013: 156-7). The remarkable level of adherence to strict architectural traditions over time at sites like Füzesabony-Gubakút has been further used to suggest the presence of powerful individuals planning and organising settlements (Domboróczki 2009), and indeed enforcing the LBK canon and a sense of community cooperation across the whole of the LBK (Bánffy 2013: 140).

1.4.6.2 Egalitarianism

Although likely controlled by powerful individuals the problems faced in the early LBK necessitated an egalitarian society to overcome the risks posed by the new terrain (Coudart 2015: 317). This allowed the pooling of knowledge, skills and creativity to increase their adaptive potential (*ibid.*). Examples of egalitarian, communal or reciprocal behaviour have been found on many LBK sites. At Cuiry-lès-Chaudardes it is suggested that houses of lower socioeconomic status, possibly belonging to newcomers to the village, traded hunted surplus for pottery and food from larger, well-established houses that had years of experience in pottery production and agro-pastoralism (Gomart *et al.* 2015: 244-246). At Füzesabony-Gubakút, houses had their entrances on opposite orientations so they could face each other across the bank of the stream intersecting the village (Domboróczki 2009), a significant variation from the LBK norm. Some houses at Cuiry-lès-Chaudardes had house pits on opposite sides and thus facing each other, implying that cordial houses could work on tasks together (Hachem 2000: 310; Bickle 2013: 168). Atypically large, centrally positioned houses at Cuiry-lès-Chaudardes and Olszanica have also been interpreted places of assembly, featuring communal consumption or special activities (Gomart *et al.* 2015: 245; Milisaukas 1986: 81). At Ludwinowo 7, clusters of large, irregular pits were found in the settlement, often used over a long period and placed at some distance from the houses (Pyzel 2013: 188). These, along with wells and pit ovens, likely served the inhabitants of more than one household, perhaps of the whole or part of the settlement (*ibid.*; Milisaukas 1986).

1.4.7 Material culture

1.4.7.1 Stone tools

LBK stone tool technology was on the surface quite homogenous and standardised (van Gijn 2010: 114). It consisted mainly of flakes, but also contained long-end scrapers, retouched blades, arrowheads and sickle blades (*ibid.* 115). Flake segments were also used as insert blades in composite tools (Kooyman 2000: 76). The generalised stone blades in LBK assemblages had multiple uses that probably included butchery (*ibid.* 73), which has implications for the form of butchery marks (Greenfield 1999). One of the most characteristic tools of the LBK was the hafted polished stone adze, an essential tool for chopping trees, house building and modelling wood (Verhart 2012: 6; Whittle 1995: 248). Adzes were an essential prestige item in the male domain, often found as grave goods (Verhart 2012: 8). Another essential LBK stone tool was the quern, used as a primary processing implement for cereals and other crops (Verbaas and van Gijn 2008: 2).

1.4.7.2 Ceramics

The pottery of the Linearbandkeramik culture is an incredibly prevalent and important source of archaeological information. Petchl summarises that it "decisively shaped the cultural habitus of the LBK" (2015: 568), embedded in subsistence, social structure and culture. In many regions of Europe, the people of the LBK were the first pottery makers, hand-working roughly-processed material from nearby clay-rich sediments (Petchl 2015: 556, 560). Pots were often decorated with incised lines and three-dimensional features, dried carefully and fired at a low temperature (*ibid*.) The types of pottery found on LBK sites can be roughly divided into fine ware and coarse wear, varying from small, flat bowls, through to bottles and large coarse wear pots (*Kümpfe*; *ibid.*; Bogucki 1984: 16). LBK pottery varies greatly in size, although most pots would have been less than 5 litres in volume (*ibid.*). The range of pottery types likely represents vessels related to food consumption, preparation, cooking and storage, for both individual and communal use (Pechtl 2015: 563-564).

Lipid residue analysis has provided a wealth of evidence about the use of LBK pottery. Ceramic sieves, which appear sporadically on LBK sites, have been shown to contain milk lipids and interpreted as milk sieves for making cheese (Bogucki 1984; Salque *et al.* 2013). *Kümpfe* were often used to process food containing animal meat and fat (Salque *et al.* 2013). The presence of beeswax has also been detected in vessels from Polish LBK sites, suggesting exploitation of the honeybee for honey or perhaps beeswax for waterproofing (Roffet-Salque *et al.* 2015). However, it should be noted that the LBK culture likely had organic containers, such as buckets, baskets and wooden containers, that very rarely survive (Pechtl 2015: 564). These could have been used in addition to pottery to process animal products, as they often are in ethnographic literature (Herodotus *Histories*; Lee 1993), and would result in no lipid markers of vessel use being preserved.

1.4.8 Subsistence

1.4.8.1 Plant-based

A considerable proportion of LBK subsistence was comprised of plant matter. This included both domestic crops grown at settlements and wild flora gathered from the surrounding landscape. While homogeneity in subsistence is often highlighted there was clearly some interregional and intra-site variation concerning the roles of various groups of people in arable agriculture, which influenced social cohesion and structure (Bogaard 2005).

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Figure 1.2: Zones of regional variation in crop cultivation in the LBK (Bickle and Whittle 2013: 11, figure 1.4, after Lüning 2000: 59).

There were five main domestic plants cultivated at LBK sites, the most dominant being the cereals emmer and einkorn (Bickle and Whittle 2013: 9; Kreuz *et al.* 2005), which may have been grown together in mixed fields (Bogaard 2004: 40). Also cultivated were legumes (pea and lentil) and, in the later LBK, linseed, an oil/ fibre plant (Bickle and Whittle 2013: 9). Many other plants were also cultivated to a lesser extent, contributing to interregional diversity in four main zones as identified in figure 1.2 (Lüning 2000; Bickle and Whittle 2013: 10). Exceptions to the regional trends were likely determined by cultural choices but also by climate and by increased regionalisation within the LBK (*ibid.*).

It is suggested that crops in Europe were first cultivated in Hungary in the space between houses (Bánnfy 2004: 333-4), and later in fields that were fixed in the landscape (Bogaard 2002: 163). While traditionally there were doubts about the fertility of loess soils over extensive cultivation, Bogaard has shown that 'shifting' cultivation was not necessary and poor soils could have still achieved productivity through watering, manuring and weeding (2002: 156, 163). Crops were likely sown in both spring and in autumn, resulting in high-yields but increased workload (Bickle and Whittle 2013: 12; Bogaard 2004). It is possible that plant husbandry and processing enforced social structure and cohesion. Based on integrated archaeological analysis of artefactual and archaeobotanical distributions at Vaihingen, Bogaard *et al.* suggest that social standing was related to field location and the type of crop cultivated (2011).

It is believed that LBK settlements consisted of mostly autonomous households (Bogaard 2005), but greater cohesion and subsistence related social interaction has been identified at Vaihingen (Bogaard *et al.* 2011). Archaeobotanical evidence suggests that plant husbandry and plant use played central roles in the construction of social identities, with the configuration of the cultivated landscape favouring some groups within settlements over others (*ibid.* 413). The farming, processing and consuming of the major cereal crop groups also reinforced social cohesion and communal identity (*ibid.*). This example shows how important agricultural subsistence was in displaying and cementing social organisation in LBK settlements.

Cultivated plants were supplemented with wild plants. The most frequent wild plant to be discovered on LBK sites is the hazelnut, although taphonomic biases cause the nutshells to be overrepresented (Bickle and Whittle 2013: 10;

Rowley-Conwy 2000; Jones and Rowley-Conwy 2007). Wild apple, sloe and mistletoe have been found on rare occasions (Jacomet 2007: 236), as has wild cabbage, strawberry, rosehips and ground cherry (Lüning 2000: 61; Kohler-Schneider and Caneppele 2010: 224; Bogaard *et al.* 2011: 396). In addition to their role in the diet of the LBK culture, it is very likely that some wild foods were used for fodder or for their medicinal purposes (Jacomet 2007: 236).

1.4.8.2 Animal-based

Traditionally animals were thought to play a marginal role in LBK economy due to the poor preservation of bone in acidic loess soils (Bogucki 1984: 21), although recent excavation of better-preserved sites has helped create a more detailed zooarchaeological record (Bickle and Whittle 2013: 13). It is becoming increasingly clear that animals contributed significantly to LBK subsistence.

1.4.8.2.1 Domestic food animals

The domestic species that contributed to LBK subsistence were cattle (*Bos taurus,* Bojanus 1827), sheep (*Ovis aries*, Linnaeus 1758), goat (*Capra aegagrus hircus,* Linnaeus 1758), pig (*Sus scrofa domesticus,* Erxleben 1777) and dog (*Canis lupus familiaris*, Linnaeus 1758; Bickle and Whittle 2013: 13; figure 1.3). It is now widely accepted that, for the most part, the domestic animals of the LBK culture arrived in Europe as part of the ‘Neolithic package’ brought by this farming community (Götherström *et al.* 2005: 2345). While caprines had no wild counterparts in Europe, wild boar (*Sus scrofa,* Linnaeus 1758) and aurochs (*Bos primigenius,* Bojanus 1827) could have contributed to cross breeding with domestic stock and possibly secondary domestication (Glass 1991). For pigs, it is probable that there were separate domestication events in Europe (*ibid.* 14) and interbreeding with introduced near Eastern pigs (Bickle and Whittle 2013: 13). For cattle, however, DNA studies (Edwards *et al.* 2007; Bollongino and Burger 2007: 185) have indicated no genetic markers for secondary domestication or cross-breeding with aurochs, accidental or otherwise (Götherström *et al.* 2005: 2349).

Cattle frequently dominate the domestic assemblage from LBK sites, with caprines or pigs following depending on region (Bickle and Whittle 2013: 13; figure 1.3). The dominance of cattle is generally attributed to their suitability for cooler climates and woodland vegetation, although cultural choice was surely the deciding factor (Bickle and Whittle 2013: 13; Marciniak 2004, 2011). Cattle were kept for their primary products, including meat, fat, bone, horn and hide, but also for their secondary products such as milk and traction (Glass 1991: 13). On sites where milk production was particularly intensive meat slaughter may have targeted small stock and infertile or male cattle. Marciniak argues that cattle body part distribution on some sites indicates ceremonial communal consumption of cattle, suggesting their significance was far larger than just providing meat or milk (*ibid.* 2011: 125; 2004: 138; see ethnographic accounts in chapter 2).

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Figure 1.3: Regional variation in domestic animals in the LBK. 1) Lower Saxony, 2) and 3) Poland, 4) Hungary, 5) Lower Austria, 6) Bohemia, 7) Bavaria, 8) Baden-Württemberg, 9) Alsace, 10) Paris Basin (Bickle and Whittle 2013: 13 figure 1.5, after Lüning 2000: 109).

Based on a lack of evidence for caprine milk or wool production in the Neolithic it was suggested that they were largely kept for meat (Lüning 2000: 113; Glass 1991: 14). However, goats are excellent milk-producers, often referred to as the “poor man’s cow”, and separation of slaughter profiles for sheep and goats may show targeting of sheep for meat and goats for milk (Gillis, pers. comm.; Gillis in prep.; Greenfield and Arnold 2015). Age-at-death analysis of caprine teeth, which can often be separated by species, will be carried out during this project by Dr Roz Gillis. Unlike ruminants, suid mammary glands have no cisternae for milk storage (Ellendorff *et al.* 1982: 591) and therefore they must have solely provided primary products.

All three of the main food domesticates also supplied fat. The procurement of fat was very important to past societies (Outram 2001: 401) and evidence exists suggesting specific processing of bones to procure fat in the early and middle Neolithic of Central Europe (Marciniak 2011: 125). Marrow extraction was seemingly quite common throughout the spread of the LBK, although there was some variation in the intensity and the species targeted (*ibid.*). Bone grease processing has not been identified, and was surely only on a small scale if it was practised at all, perhaps during times of hardship or stored for leaner times. Marciniak has noted that marrow processing was less popular in the middle Neolithic (*ibid.* 26), which could be related to a decreased need for fat from this source as the intensification of milking practices caused dairy fat to be readily available.

Domestic dogs likely contributed to LBK diet by aiding in hunting and tracking, rather than providing a source of meat, although it is possible that they also had symbolic purposes (Clutton-Brock and Noe-Nygaard 1990). Domestic dog bones are usually found amongst domestic refuse, although there are some examples of dog partial and complete burials from Polgár-Piócás-dűlő and ritual deposition at Herxheim (highlighted in chapters 5 and 12; Zeeb-Lanz *et al.* 2007: 211-212). It is possible that dog carcasses were processed post-mortem, as specimens occasionally show evidence of butchery and heat exposure, but as marrow processing seems to not have been undertaken it is assumed that they were not treated in the same way as other domestic animals.

1.4.8.2.2 Husbandry practices

Glass (1991: 26) suggested that herd management in the LBK culture allowed animals to forage for themselves over an area of land with some degree of stock control, a hypothesis supported by a lack of archaeological evidence for fencing and cattle barns (Götherström *et al.* 2005: 2349). However, more recent archaeological thought tends towards domestic animals being kept in small-scale and closely managed herds with the probable use of seasonal pasture (Bickle and Whittle 2013: 6-13). Cattle especially could have been driven seasonally to the highlands to graze. Isotopic readings from cattle and humans at Vaihingen imply that cattle had different summer and winter pastures and were herded by one familial group that shared similar isotope values, suggesting a link between heredity and subsistence specialisation (Bentley 2007: 134). Knipper highlights the importance of mobility and a greater involvement of the wider landscapes in the LBK economic system (2009: 155). However, it is possible that the leafy fodder in nearby woodland would have been sufficient to cattle herds (Bickle and Whittle 2013: 14). Potentially the herd management of sheep and goats was less controlled than that of cattle as there were no wild counterparts to disrupt the herd, whereas cattle presumably had to avoid aurochs (Glass 1991: 26).

1.4.8.2.3 Wild animals

The extent to which wild animals were hunted to contribute to LBK subsistence is one of the main indications of regional diversity (Bickle and Whittle 2013: 9). Wild animals generally make up less than 10% of the animal bone assemblages, with wild boar, red and roe deer (*Cervus elaphus* and *Capreolus capreolus,* Linnaeus 1758) and aurochs comprising the majority (*ibid.* 15; Lüning 2000: 113). Other species are also found less frequently include wild horse (*Equus ferus*, Boddaert 1785), hare (*Lepus europaeus*, Pallas 1778) and many species of wild bird. Fishing is not thought to have contributed greatly to diet, but species of freshwater fish along with other aquatic resources such as pond turtle, beaver and mussels have been found in small numbers of LBK sites (*ibid.*). Bickle has suggested that the hunting of different animals affected social cohesion within the settlement and the hunter's interaction with the landscape (Bickle 2009: 137). It was in peoples' interest to clear forest edges to attract red deer, aurochs and wild boar to feed; it was also in their interest to hunt the opportunistic wild boar, which would have been a pest to the settlement's crops (*ibid.*). Individuals or households may have developed specialised hunting techniques and thus best at hunting certain game (*ibid.*), giving them a certain position within the settlement.

1.4.9 Conclusion

This brief study of the LBK culture has aimed to provide a framework within which the nature of meat and fat processing can be analysed. These sedentary communities were heavily involved in their immediate landscape and the animals within it, particularly through agriculture, forest management, herding and the exploitation of wild plants and animals. Beyond their immediate territory may have been other LBK communities, or indigenous hunter-gatherers, with whom trade of material culture, subsistence items and even people may have taken place. Within the settlement, societies were largely egalitarian but likely functioned under the guidance of central decision makers.

LBK subsistence provided people with a good supply of carbohydrates, protein and fat through their diet of crops and primary and secondary animal products. Cattle and caprines supplied meat and could have supplied milk, while pigs were a quickly replenishing meat source. Marrow processing has been documented, suggesting that the LBK culture had a certain amount of reliance on and understanding of bone fats. LBK material culture, particularly ceramics, give indications of cooking techniques. Diet may have had a significant role in enforcing and defining social structure, and certain elements of subsistence also likely took on a symbolic significance to the people within LBK settlements. Throughout this thesis the nature of the LBK will be considered and used to attempt to explain zooarchaeological trends identified.

1.5 Fat, nutrition and the secondary products revolution

1.5.1 Introduction

This final introductory section will explore the importance of fat to human diet, particularly in relation to the LBK culture and the changes brought about by the possible adoption of dairying. It begins with a discussion of the nutritional relationship between fat, protein, and carbohydrate, and considers the ways in which fat can be extracted from animal carcasses (adipose fat). Following this, Sherratt's (1981; 1983) Secondary Products Revolution is introduced and the implications for dairying in the Neolithic discussed. The nutritional value of milk and dairy products is also introduced. Finally, this data is related to evidence given above concerning LBK subsistence, particularly in the use of carbohydrates, fat and milk.

1.5.2 The nutritional value of fat

Whilst 'fat' in the modern Western view has negative connotations it has much greater significance in traditional societies (Outram 2001; 2004). As chapter 2 will show, many societies exert great effort in extracting all possible adipose fat from carcasses, particularly hunter-gatherers with little access to carbohydrates at times of subsistence stress (Speth 1990). Fat is an important nutritional component that can provide 225% of the calories compared to carbohydrate and protein (Outram 2001; 2004; Mead *et al.* 1986; Erasmus 1986). Fat also contains 'essential fatty acids' necessary for proper bodily function, and can be a source of lipid-soluble vitamins such as A, D, E and K (*ibid.*). Consumption of carbohydrates and fat is incredibly important for staving off the effects of a diet based on very lean meat. In very protein-rich diets, amino-acids are broken down to meet energy needs rather than replenishing bodily protein (Speth and Spielmann 1983: 13; Speth 1989; Outram 2004). In severe cases, existing muscle protein will also be broken down (*ibid.*). Increased protein ingestion increases metabolic rate, meaning that the more protein eaten, the higher the total energy intake needed for survival (Speth and Spielmann 1983: 6). Carbohydrates are best at averting protein consumption problems, and additionally supply the brain and nervous system with an energy source in the form of glucose (*ibid.* 14). In areas, subsistence economies or seasons with limited carbohydrates fat must be more intensively utilised.

1.5.2.1 Adipose fat acquisition

Fat acquisition from carcasses does not just involve the consumption of fatty meat, but also the fat found within animal bones. This resource can be extracted and exploited in three main ways, each potentially increasing the amount of energy expended in acquisition. These techniques and the archaeological signatures thereof are further described in chapter 2 and section 3.2.3. The most basic bone fat processing is extracting marrowfat. Marrow-bearing bones, the long bones and the mandible, can be split at midshaft using percussive force, and the marrow extracted. Marrow cavities can have substantial reserves of fat even if animal carcass meat is lean, although this varies seasonally (Speth and Spielmann 1983: 12). Marrow may be extracted from raw bones, or after cooking or heating the bone (Binford 1978). After marrow processing, bones may also be boiled in stews to liquefy soluble nutrients and enrich the broth, which is then consumed. Bones may also be split at the epiphysis and the diaphysis to increase the surface area and thus the rate of nutrient extraction (Oliver 1993; Gifford-Gonzalez 1993). This technique is also applied to bone grease processing, where cancellous axial and articular bone is pounded into small pieces and boiled, resulting in liquefied bone grease that floats to the surface. This final method of bone fat extraction requires a great deal of time, energy and fuel (Church and Lyman 2003, Janzen *et al.* 2014), whereas bone marrow extraction and bone-enriched stew requires comparatively little. However, bone grease has several advantages over bone marrow and bone-fat enriched stews, particularly in that it is a portable, storable fat source (Leechman 1951).

1.5.3 The introduction of milk fat

Andrew Sherratt's Secondary Products Revolution model (1981; 1983) has influenced archaeological discussion about the early role of domestic animals for more than thirty years. It deals with animal products that can be harvested during the lifetime of the animal, particularly milk, wool, animal power (traction) and to a lesser extent manure and blood (*ibid.*). The model proposed that domestic animals were initially managed for meat, and a convergence in the intensification of using 'secondary products' caused an accelerated socio-economic shift to more complex societies in the 4th millennium BC (*ibid.*). The NeoMilk project is naturally concerned with the intensification of one particular secondary product – milk.

The issue of dairying and the Secondary Products Revolution has been extensively tested by archaeologists, and while Sherratt's general model was largely deemed valid, adjustment was necessary in timing and regional variation (Greenfield and Arnold 2015: 793). It was met with criticism early on - the same year that the model was proposed Tony Legge argued that zooarchaeological evidence for high infant calf mortality in Bronze Age Britain, and similar patterns in Neolithic assemblages, suggested earlier intensive management of cattle for milk (Legge 1981; Halstead and Isaakidou 2017). Sherratt (1981; 1983) on the other hand argued that milking was not practised at the beginning of domestication due to early cattle physiology resulting in low milk yields and high dependence on the presence of the calf (Sherratt 1981; 1983; Greenfield 2005: 15-16). The view that cattle physiology was an insurmountable obstacle to early dairying has been largely questioned (Halstead 1998; Ryan 2005), and further zooarchaeological and lipid residue analysis has revealed many indicators of earlier dairying. Vigne and Helmer (2007) argue for a wide development of dairying much earlier than the 4th millennium BC based on zooarchaeological evidence, suggesting dairy products were already part of diet at the very beginning of the Neolithic process, possibly as early as the mid-9th millennium BC (*ibid.*). Lipid residue analysis has identified evidence of earlier milk use in many Neolithic cultures, including the Linearbandkeramik culture (Copley *et al.* 2003; Craig *et al.* 2000; Craig *et al.* 2005; Evershed *et al.* 2008b; Salque *et al.* 2012; Salque *et al.* 2013; Debono Spiteri *et al*. 2016). While these instances point to use of dairy products, the secondary products revolution is a question of scale, of intensification, not of origins (Greenfield and Arnold 2015). The model searches for indicators of domestic animals playing a more significant and different role in prehistory, identifying when their importance and meaning changed for the people of the time (Sherratt 1983; 1997; Greenfield 2010; Marciniak 2011). It is likely that intensive use of animals as milk producers was not happening until later in the Neolithic.

1.5.3.1 Nutritional aspects of milk and dairy products

The adoption of dairying, however small-scale, must have had a significant impact on diet that may have reduced the necessity for other sources of protein and fat. Milk can contribute important nutrients to human diet (Walther *et al.* 2004). It is high in proteins, bioactive peptides, amino acids, fat, fatty acids (including oleic acids), vitamins and minerals (*ibid.* 393-394). In addition, manufacture of cheese eases milk storage and transportation, allowing the nutritional properties of milk to be readily available throughout the year (Salque *et al.* 2013). During cheese manufacture protein- and fat-rich curds are separated from lactose-rich whey, and thus the lactose content of raw milk is reduced, which would have been particularly significant for the people of the LBK culture who may have not yet developed lactase persistence (*ibid.*; Burger *et al.* 2007; Itan *et al.* 2009). These patterns are seen ethnographically, where recent contact with Herero herders has afforded the lactose intolerant !Kung San access to milk (Jenkins *et al.* 1974: 23). The San process raw milk using a yoghurt-like culture, and use the resulting cream to make butter (Lee 1993; 129-30). The enthusiastic adoption of dairy products by the San is suggested to have resulted in increased fertility and decreased child mortality (May 1978: 493; Schrire 1980: 27), highlighting the benefits of readily available dairy fat to a society traditionally reliant on fat from hunted animals. However, it is unlikely that bone fats would have been completely abandoned in favour of milk fats.

1.5.4 LBK fat use

By looking at LBK subsistence we may be able to form an understanding of the importance of fat to this society. It is likely that the people of the LBK had ready access to carbohydrates through domesticated and gathered plants (Bickle and Whittle 2013: 41; Bogaard 2004: 15; Kreuz *et al.* 2005). High-yields of these crops may have been possible through two harvests per year (Bickle and Whittle 2013: 41). Finds of archaeobotanical remains of crops in discrete, high concentrations suggests crops may have been stored inside the entrance of LBK houses (Bickle 2013; Coudart 1998: 71; Hachem 2000; Kreuz *et al.* 2005; Last 2015). This would have surely provided a good source of carbohydrate for extended parts of the year, but it is likely that fat also remained important. Marrow processing has been identified at many LBK sites (Marciniak 2005; 2011; Johnson *et al.* 2016; chapters 4-16), including on human bones (Boulestin *et al.* 2009), although bone grease processing is yet to be identified. It is very likely that at least some LBK sites produced and consumed milk and its products, particularly cheese (Bogucki 1984; 1988; Salque *et al.* 2012; Salque *et al.* 2013). However, as the extent, intensity, and variation of milking practices across the LBK are as yet unknown, it is currently impossible to analyse the contribution of dairy fat to diet (see chapter 16).

1.5.5 Summary

To summarise, the importance of fats to traditional societies has been well established, although it is possible that the LBK culture did not have the same levels of subsistence stress as hunter-gatherers living in marginal environments, due to their access to domestic crops and animal products. The introduction of dairying may have impacted the necessity for the extraction of bone fats, especially if stored carbohydrates were available. However, particularly in the case of bone marrow, it is unlikely that this nutritious (and delicious), relatively easily-acquirable source of fat was abandoned in favour of milk fats. It may have been targeted in seasons or environments where stored dairy and carbohydrates were less abundant, or in times of subsistence stress (Outram 2004). Bone fat may have also taken on a significance that transcended the practical, and may have been a crucial element in ritual feasting as suggested by Marciniak (2005; 2011).

Chapter 2 Ethnography

2.1 Introduction

2.1.1 Introduction to ethnography

This chapter explores ethnographic accounts of bone fat exploitation in relation to subsistence. It focusses on comparable societies that operate today (or have operated and been documented in the past) to reflect on possible practices in Neolithic Europe. Hunter-gatherer, pastoralist and mixed farming groups in Africa, the Americas, Eurasia and Australia will be studied, looking primarily at their use of dairy and bone fat but also at practices of preserving, storing and sharing foods, and how this relates to their overall subsistence. This will then be analysed in relation to the largely domesticated subsistence in the Linearbandkeramik (LBK) culture (Whittle 2009: 249; Bickle and Whittle 2013). Little is currently known about LBK use of bone fats, although zooarchaeological studies incorporating this analysis are increasing (for example, Marciniak 2005; 2011). Thus, the primary reason for studying traditional societies is to discover in what circumstances are people likely to crack bones for marrow, or crush them for bone grease, and particularly if this relates to dairy exploitation.

2.1.2 Ethnographic analogy as archaeological evidence

Ethnographies can give a very real insight into what the life could have been like in past societies. They can help solve the problems that plague the archaeological record, such as the loss of perishable material culture items and intangible social relationships that can often only be found in traces or extrapolated from other evidence. However, ethnographic analogy can be an unreliable form of evidence for archaeological analysis. Some limitations of ethnographic evidence are discussed below.

The ‘traditional’ societies that are documented by ethnographers often live in very different environments to the early farmers in Europe, especially true for those in Africa in arid or semi-arid environments. Any reflection that is made upon the LBK from these societies needs to consider differences of landscape, climate, and biodiversity. This has clear implications for diet, subsistence and cattle-based agriculture, affecting fodder, climate, milk yields and calving behaviour (Marshall 1990: 887). Indeed, many pastoralists in Africa keep zebu cattle, an animal better adapted for arid conditions than European cattle (*ibid.*). However, cattle in the

Neolithic were less selectively specialised than they are today, so their milk yield might well have been more comparable to zebu cattle than taurine cattle.

Problems are also encountered in collecting ethnographic data itself. Once the ‘foreign object’ of the (usually male) anthropologist is introduced, a society is no longer ‘pure’ from outside influence. In fact, they may expect gifts of modern commodities (Lee 1993: 7). Male ethnographers naturally associate with men rather than women who often process food, and may not be interested or trained in looking at diet (Milton 2000: 665; Gifford-Gonzalez 1993). This is especially a problem with bone grease, which is probably the least well known of all food reserves regularly used by foraging societies, despite being a dependable and nutritious resource (Brink 1997: 259). Often one must infer that bone grease processing was being practised by mentions of foods that contain bone grease, such as pemmican (such as in Hoebel 1906: 70), and by descriptions of fragmented bone in refuse heaps (for example, Shahack-Gross *et al.* 2004: 1399).

The informants who provide ethnographic data to researchers can also pose a problem, as they often have a willingness and inclination to selectively remember, forget, exaggerate or misrepresent elements of their culture (Hollowell and Mortensen 2009: 2). One example of this was encountered by Fijn when questioning Mongolian herders about the number of animal deaths from sickness or wolf attacks, finding them unwilling to give a straight answer as it would reflect badly on them (Fijn 2011: 224-225). Another component of this is that often people cannot explain the reasons behind certain elements of their culture. A San man was asked what the Ju/’hoansi did before the introduction of metal cooking pots, he replied ‘with a twinkle in his eye’, “It is well-known that people can’t live without iron cooking pots, so we must have died!” (Lee 1979: 155).

In summary, if these drawbacks are taken into consideration ethnographies can be a valuable tool to aid in archaeological analysis of long past societies. Certainly, a blanket approach is unfeasible, as considering the substantial variation in ‘traditional’ groups in the present, we must assume that this was also the case in the past (Ember 1978: 493). Ethnographies are of course especially valid when used to corroborate other archaeological evidence.

The following ethnographic accounts will be discussed in the past tense, even though societies included here may still be active in the present day. As it is the *accounts* of the ethnographers that are being analysed, rather than primary analysis of the societies themselves, it has been considered best to treat them as observations of past activities. Indeed, some ethnographic accounts included here date from almost 100 years ago, and societies are likely to have undergone dramatic change over even a short period in the modern age.

2.2 Hunter-gatherers

2.2.1 Hunter-gatherers introduction

Accounts of hunter-gatherer societies provide an interesting comparison to the LBK. While domestic foods likely dominated LBK diet, hunted and gathered species are often discovered at LBK settlements, possibly in part traded from contemporary hunter-gatherer settlements (Bentley 2007: 117; Whittle 2009: 249; Bickle and Whittle 2013). Ethnographies of hunter-gatherers that trade with farmers with access to dairy products may thus give an insight into relationships between cultures in the Neolithic. Bone fat processing is typically more intensive among hunter-gatherer groups than those that have adopted domestic animals or crops, as fat provides carbohydrates in the absence of plant matter (Speth and Spielmann 1983: 13; Speth 1989; Outram 2004), and supplies storable foodstuff that can be kept for leaner times (Leechman 1951). These societies offer a crucial example of the conditions in which it is necessary to exploit carcasses in this manner. It should be noted that nowadays many formerly hunter-gatherer societies also keep domestic animals (such as sheep and goats) and cultivate to some degree.

2.2.2 African hunter-gatherers

2.2.2.1 The !Kung San

Perhaps one of the most famous hunter-gatherer groups that still operates today is the !Kung San, who traditionally lived as hunter-gatherers in North-Western Botswana, Southern Africa (Lee 1993: vii). Recent changes to their way of life has increased the importance of farming, herding, cash work and welfare to a subsistence traditionally based on foraging, and San contact with nearby Herero pastoralists has afforded them access both to cow's milk and beef (*ibid.* 125). Their methods of cooking, fat exploitation, and their recent contact with societies with domestic animals present a subsistence where fat has high importance.

Accounts of San cookery, butchery and marrow processing show a focus on retention of nutrients and fat. San methods of cooking meat underwent a shift from roasting to boiling with the introduction of Bantu cooking pots in the 19th century (Lee 1979: 154), preventing nutrient wastage as the broth is also consumed. The !Kung also preserved surplus meat as biltong by sun drying, allowing it to keep for many months without spoiling (*ibid.* 155). After carcass butchery, the marrow was carefully extracted from the long bones and either eaten or rubbed on the body (Speth 1989: 185; Lee 1979: 222). Males typically received the best portion of fat as most or all marrow fat and the fatty organs tended to be consumed when snacking at a kill, bringing primarily lean meat back to camp to share (Speth 1989: 165). However, Speth noted that broken up limb bones and axial elements were systematically boiled up to obtain the grease (1989: 185), which surely took place back at camp due to the time-consuming nature, allowing women and children access to fat. In summary, !Kung subsistence shows that fat has great importance to their diet, retained in cooking methods, and extracted from bones through marrow and grease processing.

Contact with Herero herders has allowed the !Kung access to cow's milk. Whilst studies on the !Kung San implied that less than 10% of the population would be lactose tolerant (Jenkins *et al.* 1974: 23), Lee's observations suggest that they have enthusiastically integrated milk and milk products into their diet. The San regularly visited relatives working at Herero cattle posts to drink milk, and Herero neighbours brought daily milk deliveries (Lee 1993: 129-30, 92). The San processed this milk by pouring it into large gourds containing a yoghurt-like bacterial culture, from which the cream could be taken off and made into butter (*ibid.* 129-30), reducing the amount of lactose. It has been argued that increased access to dairy fats has influenced San sedentism, dietary changes and increased fertility (Schrire 1980: 27). Village dwelling !Kung women (for whom milk is readily available) are 'fatter', the children weaned earlier and the birth interval has decreased (May 1978: 493). Population growth rate has increased by approximately 30% (*ibid.*), and infant and child mortality has also declined significantly (age 1-4 by 75%) leading Pennington to suggest that milk does not in fact cause increased fertility but decreased child mortality (1992: 518). These studies suggest that women and children, who can often be denied access to fat through kill site snacking, could be the biggest beneficiaries of access to dairy fat.

2.2.2.2 The Hadza

The Eastern Hadza lived in the Eastern Rift Valley of northern Tanzania. Local incursions of farmers and pastoralists onto Hadza land has occurred in the last century, however, the Hadza have continued their traditional hunter-gatherer lifestyle quite stubbornly, despite government-sponsored initiatives promoting settlement (O'Connell *et al.* 1988: 116). Milk is not mentioned by their ethnographers, so it is assumed that the Hadza did not benefit from or require it.

Fat acquisition was observed to be especially important to the Hadza, although influenced by the needs of the community at any one time. Kill-site decisions about skeletal transport were made by skeletal fat yield based on the species of animal hunted and the season (Emerson 1993: 152; Bunn 1993: 156). Low-yield marrow-bearing bones were cracked, the marrow consumed, and discarded (Bunn 1993: 160; O'Connell *et al.* 1988: 120; Lupo 2006: 29). On some long bones the cancellous tissue in articular ends was gouged out and consumed, ribs were cracked and sucked, and the fatty tissue around phalanges was dug out and eaten (O'Connell *et al.* 1988: 120). Sometimes fat-rich bones that required processing were discarded without full nutritional exploitation (Lupo 2006: 29), although those with high quality marrow were often retained to feed children (Bunn 1993: 160). Bones returned to camp were stripped of meat, cracked for marrow and discarded as before (O'Connell *et al.* 1988: 121). Vertebrae, ribs and epiphyses were often destroyed or damaged by pot-sizing spongey elements for boiling and grease extraction, and by consumption through gnawing on bones (Bunn 1993: 164; O'Connell *et al.* 1988: 120). Thus, for the Hadza, intensive bone fat processing is common.

2.2.2.3 The Okiek

The Okiek, a hunter-gatherer society that lived in the high-altitude rain-forests of Kenya, are a useful case study of delayed-return hunter-gatherers living in a non-marginal, highly predictable environment, and thus differ from other well-studied African hunter-gatherers such as the !Kung (Marshall 1994: 66). They also have ties with the pastoral Maasai whom they trade with for cattle meat and fat, but not milk (Blackburn 1982: 296). Their own specialised subsistence system was focused on bee keeping, honey storage for lean times, and hunting, with emphasis on food sharing networks, although nowadays all women also herd or cultivate to some degree (Marshall 1994: 65-66).

Fat was traditionally a highly-valued energy food and, along with meat, was obviously very important to the Okiek. Hunting parties were at pains to return to camp with bone fat intact, with bones still fleshed to aid transportation (Marshall 1994: 69). Maasai cattle were often used for ritual purposes, slaughtered for food and symbolically important fat (Blackburn 1982: 296), and shared amongst the community to prevent spoilage (Marshall 1994: 72). The Okiek would sometimes buy the hooves and lower legs of butchered Maasai cows for the edible fat and marrow (Blackburn 1982: 301). The Okiek are interesting in this respect as they had no use for dairy fat, but instead used contact with pastoralists to acquire fatty meat. The Maasai were shocked that they would kill a cow that could provide milk, although the Okiek could not care for the cow in the forest and it would probably have been stolen by Maasai raiders (*ibid.* 296). Their sharing community allows meat and fat to be distributed to those who need it.

2.2.2.4 Kutse Community

The Kutse of Botswana were a recently sedentary community of hunter-gatherers that were dependent on wild game for a vast majority of their meat, although some in the community owned goats and practised small-scale cultivation (Kent 1993b: 327). Sharing networks among the Kutse ensure access to fat for all individuals.

Bones from hunted kills were often returned to camp and shared among the Kutse community. Only the lowest utility meat and marrow bones were consumed at kill sites, and occasionally roasted lower leg bones were returned to camp to process for marrow (Kent 1993b: 336), where women and children were the biggest beneficiaries (Kent 1993a: 497; 1993b: 364). It is probable that bone-grease processing was absent as it is not mentioned by Kent, who was looking specifically at fragmentation and the effect on animal bone assemblages (Kent 1993b). Perhaps grease processing was a seasonal activity, performed in times of hardship, which happened outside of the study period.

The cooking methods of the Kutse community also show utilisation of bone and body fats. Animals were either roasted or boiled whole, in which case the nutrient-rich broth was widely shared (Kent 1993b: 343, 350). The blood of animals that were roasted was drunk by some, especially the elderly, but often it was given to the dogs. One or both ends of the long bones were usually chopped off with an axe to suck out the marrow (*ibid.* 338). In this community, boiling whole animal carcasses negates the need to pot size bones, and perhaps reduces the need for bone grease processing.

2.2.3 North American hunter-gatherers

2.2.3.1 Native American hunter-gatherers

Fat was incredibly important to all Native American groups, influencing almost all aspects of life. Hunting strategies targeted fat-rich wild animals, especially those fattening for hibernation or migration, and most meat was boiled to recover all fat and oil (Saint-Germain 2005: 108-110). Marrow was a choice food, and grease rendering was fundamental, especially useful for its preservation qualities (*ibid.* 112). Grease processing was undertaken both in times of plenty in preparation for hardship and during starvation periods as a survival food (*ibid.*). Hunter-gatherer groups in North America are well known for making pemmican, a concentrated energy source in the form of a 'cake' of grease mixed with dried meat and berries that would keep for long periods of time (Gibson 2003; Hoebel 1906; Leechman 1951; Liboiron and St-Cyr 1988; Vehik 1977). Grease was also used for making butter and tanning hides (Vehik 1977). Ritualization of bone grease processing and fat acquisition permitted a constant provision of fat in times of abundance and scarcity (*ibid.*). Despite the abundance of grease processing among hunter-gatherer groups in North America the practice is often dealt with sparingly by their ethnographers. Accounts of different groups are thus dealt with briefly, save Binford's (1978) archaeologically-orientated study of the Nunamiut Eskimos.

2.2.3.2 The Makah

The Makah were hunter-gatherers in the North West United States that exploited both land and marine resources and placed high importance on storing and preserving food (Kirk 1986; Colson 1979). Their diet consisted of hunted and scavenged meat of marine and terrestrial mammals, and gathered plant foods such as shoots, fruits and roots, which contributed richly to diet (Kirk 1986: 128). The eggs of spawning herring were also collected and sun-dried or smoked (*ibid.* 119). Fish, meat and berries were also preserved in this way (Colson 1979: 21-22). While the Makah are not documented making pemmican, they did make oil from eulachon fish. The fish were ripened and then heated in vats over fires, and the oil skimmed off the top (Kirk 1986: 120). This oil could last for two years, provided it was purified through recooking when rancid (Colson 1979: 21-22). The amount of fish found on LBK sites is small (Bickle and Whittle 2013: 15) so it is unlikely that fish grease contributed to subsistence. Grease products are shown to be heavily relied upon, even when terrestrial grease is not exploited.

2.2.3.3 Old Crow

The people of Old Crow in the Yukon made bone grease and fish grease. They pounded caribou and moose bones into “little pieces”, boiled them and skimmed the fat from the top (Leechman 1951: 355). The resulting bone grease could be kept for three years, and was used in everyday cooking and in making high quality pemmican (*ibid.*). This community also used fish guts to make fish grease using the same method, resulting in grease that needed purifying by reheating and straining (*ibid.* 356). This was also used for pemmican but tasted strongly of fish and was very greasy (*ibid.*). This example shows that indigenous societies will render both bone grease and fish grease, implying that neglecting one of these practices where resources are available is reliant on personal preference and/or nutritional requirements.

2.2.3.4 Blackfoot Indians

The Blackfoot Indians, famous Bison hunters of the forests and plains of the Northeast United States and Canada, made pemmican from the bones of mammals to eat during the winter and while travelling (Gibson 2003: 11-13). They would obtain bone grease by pounding the bones, boiling them in water, and then allowing the vessel to cool causing fat to solidify on the surface (Bradley 1923: 260). The fat was then mixed with berries and dried crushed meat (Gibson 2003: 13). While originally thought to have been a great delicacy used only at feasts (Bradley 1923: 260), it is now understood as a storable form of nutrition during the winter (Gibson 2003: 13; Saint-Germain 2005).

2.2.3.5 Cheyennes Indians

The Cheyennes Indians hunted and gathered in the windy, water deficient grassland of the Great Plains, their diet supplemented by trade with nearby villages for corn, beans, squash and pack horses (Hoebel 1906: 70). The women cooked or dried hunted meat, which was then pounded along with large bones to be cooked in soup or made into pemmican, although grease processing is not specifically mentioned (*ibid.*). Grease was also used in tanning, where it provided body to a mixture of brains, liver and soapweed (*ibid.* 67). This example highlights how difficult it is to determine whether bone grease processing is being practised in ethnographic accounts. Often it must be implied from mentions of the end product in other applications.

2.2.3.6 Nunamiut Eskimos

Made famous to archaeologists by Binford's *Nunamiut Ethnoarchaeology* (1978), the Nunamiut Eskimos were hunters dependent on caribou for 80% of their subsistence (Binford 1978: 12). Binford's study is particularly useful as it explicitly documents sharing, storage, butchery and bone fat processing. The frozen climate of the Nunamiut aids especially in storage, entirely unlike the temperate climate encountered by the LBK in Europe.

Nunamiut subsistence was characterised by two short periods of massive food input annually, meaning preservation of meat and food by freezing or drying was essential (*ibid.* 91, 140). Refuse not intended to be stored, such as bone fragments in middens, was often preserved nonetheless by the freezing arctic climate (*ibid.* 146). For this reason the Nunamiut practised differential dumping of waste so as not to contaminate potential food sources for when times were hard (*ibid.* 146). In general, the Nunamiut did not share food on a large scale. Each family unit was expected to obtain sufficient food for their own needs, but in times of extreme hardship families would share their meat (*ibid.* 140).

Traditionally almost all meat was boiled in a stew or broth (*ibid.* 145). Marrow bones were often a supplement to main meals, first heated up next to the hearth or sometimes in the stew itself, licked clean and then cracked (*ibid.*). Metapodia marrow was made into marrow cakes with strips of dried meat, which were used as trail food by the men during spring hunting (*ibid.* 147-8). Articular ends from marrow processing were saved and, just before the abandonment of a settlement, were gathered up and rendered for bone grease (*ibid.* 157-8). Bones were pounded up and added to boiling water, and snow was used to solidify floating grease (*ibid.*). Fat retention in cooking and in bone fat extraction is therefore shown to be particularly important to the Nunamiut.

2.2.4 Australian hunter-gatherers

2.2.4.1 The Alyawara Aborigines

The Alyawara of central Australia traditionally subsisted on hunting kangaroo and gathering (O'Connell and Marshall 1989: 394). Kangaroos were often butchered and pit roasted in the field depending on ease of transportation and availability of firewood (*ibid.* 394-395). The meat and tendons from the metatarsals were occasionally stripped once they'd been roasted and then cracked for their small marrow cavities, although often these were left in the field unprocessed (*ibid.*). Kangaroos are very lean (less than 1% dissectible fat by weight) but when in good condition they have good marrow cavities in the long bones, which were always brought back to camp (*ibid.* 403). This allowed people at the camp to benefit from the fatty parts, not just the hunters.

2.2.5 Eurasian hunter-gatherers

2.2.5.1 The Evenki

The Northern Evenki lived in the cold Transbaikalian region of Siberia, a harsh environment composed of tundra and boreal forest unable to support cattle or agriculture (Abe 2005). Those studied by Abe (2005) relied on animal and aquatic wild resources to the exclusion of plants and extensively used the freezing temperatures to preserve meat. They also had domesticated reindeer for transport, used only minimally for milk products during calving season, yielding 200cc of milk per female per day (Abe 2005: 6-10).

Studies on the fat content of Evenki diet have yielded ambiguous results. Leonard *et al.* (1994: 335) found that Evenki fat intake was substantially lower than other arctic populations and was comparable to that of African pastoralists, reflecting a diet relatively low in fat content combined with a high-energy lifestyle. The Evenki observed by Abe (2005) made efforts to retain all easily accessible fat but did not always fully exploit fat resources, only seasonally practicing bone grease processing. Marrow bearing bones were cracked for marrow when raw, but the humerus and femur were boiled and cracked for marrow once the meat was consumed (*ibid.* 116). The meat broth in which pot-sized and whole bones were boiled was always eaten, and fat on the top of the broth scooped off and saved for later (*ibid.*).

Seasonal boiling for bone grease was carried out in spring, described as optimum time for bone grease rendering due to high animal fat content and spoilage of Evenki frozen meat stores due to rising temperatures (Abe 2005: 138). Reindeer bones were smashed with an axe butt until 1cm in diameter or until internal cancellous bone was exposed in several places (*ibid.*)[1]. Fat was scooped off the top of the simmering pot and reheated indoors to form pure grease, chunks of which were carried on logistical and day trips (*ibid.*). As well as using grease and oil for nutritional purposes, oil of Tarbagan (*Marmota sibirica*) was drunk for medicinal purposes and used as face grease for cold-weather sled travel. It was also a barter item (*ibid.* 57). Grease was thus an especially useful product seasonally, when the Evenki could not rely on frozen storage.

2.2.6 Hunter-gatherers discussion

Hunter-gatherers around the world place huge significance on the acquisition of fat. It is particularly important in societies that lack sufficient supplies of carbohydrate rich plant matter (Speth 1987). Fat is acquired and retained through hunting and transport choices, cooking techniques, and through specific bone fat processing. Storage and the preservation qualities of fat are often emphasised. In addition, recent access to dairy fat has provided an interesting parallel to the Neolithic.

Kill-site transport decisions are often made based on carcass fat content, such as among the Hadza (Bunn 1993). In some societies men snack on fat-rich resources at the kill site to the detriment of women and children back at camp (Speth 1989: 167-9). However, fat-rich carcass portions are specifically brought back to camp for further processing among the Okiek (Marshall 1994) and Alyawara (O'Connell and Marshall 1989). Sharing networks at base camps encourage the distribution of fat, especially prevalent among the Kutse

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[1] Another technique that the Evenki alternatively used was boiling bone fragments continuously for 2-3 days (Abe 2005: 139)

community (Kent 1993a; 1993b). In the LBK, slaughter of domestic animals possibly took place nearer to settlements, and thus hunters would have less opportunity to benefit from kill-site snacking. Meat could have been shared communally, at atypically large central houses at Cuiry-lès-Chaudardes (Gomart *et al.* 2015: 245) and communal feasting pits at Ludwinowo 7 (Marciniak 2005).

Cooking methods among hunter-gatherer societies are often conscious of wastage, and efforts are made to retain all possible nutrients, including fat. Boiling is a particularly prevalent form of cooking, from whole carcasses among the Kutse (Kent 1993a, 1993b) to extensively pot-sized elements among the Hadza (Bunn 1993; O'Connell *et al.* 1988). Stews in which meat and bones had been cooked were always eaten, allowing for maximum retention of nutrients. Pot-sizing bones allows grease-rich elements to be utilised without the extensive effort used for bone grease processing. This could be a signature found in the pottery-rich LBK.

Bone marrow and grease processing itself is widely practised by hunter-gatherers. Marrow bones may be exploited raw, heated, roasted or boiled beforehand (Abe 2005; Binford 1978). Bone grease can be a fundamental storable survival food, as with Native American groups (Saint-Germain 2005), but elsewhere is only rendered seasonally, for example the Evenki (Abe 2005). While bone fats are primarily nutritional, they can also be used for tanning and for preservation in pemmican (Gibson 2003; Hoebel 1906; Leechman 1951; Liboiron and St-Cyr 1988; Vehik 1977). Meat can also be dried to preserve it, and freezing temperatures may preserve items intentionally or not (Binford 1978). Although the LBK culture enjoyed a plant-rich diet (Bickle and Whittle 2013: 9), use of bone fat extraction is still a possibility. Marrow extraction is more likely to be commonplace than the labour, time and fuel-intensive bone grease processing.

It is interesting how contact with pastoralist societies has affected hunter-gatherer subsistence, especially with the introduction of dairy fat to diet. Some societies, like the !Kung San, have readily embraced dairy products, which have been instrumental in decreasing infant mortality (Pennington 1992). Other hunter-gatherer groups, like the Okiek (Blackburn 1982), use relations with pastoralists to access fat-rich meat. Many have begun to practice garden agriculture and herding on a small scale, and some use domesticated animals for transport. This could be representative of the sorts of relationships between the LBK culture and the 'Mesolithic' hunter-gatherers in Europe.

2.3 Pastoralists

2.3.1 Pastoralists introduction

In this section pastoralists will be studied. True pastoralists are without significant reliance on crops; in this way they are different from mixed farmers or agro-pastoralists (Ingold 1980). Pastoralists raise livestock for consumption, trade or social exchange (Jacobs 1965: 146). The types of pastoralist discussed here Ingold terms “milch pastoralists”, in which animals are valued for the products they yield during their lifetimes – primarily milk, but also blood and dung (Ingold 1980: 25). Species that are not the main milk producer often supplement diet with meat, especially when production is low. Milk producing animals can be used for the cash market to gain access to other agricultural foodstuffs and non-food items, and if slaughtered are often endowed with ceremonial and social importance (Dahl and Hjort 1976: 141-2, 161). One of the most famous ‘traditional’ pastoral groups is the Pastoral Maasai, but other groups will also be studied to see how they use fat and meat in the presence of readily acquirable dairy products.

2.3.2 African pastoralists

2.3.2.1 The Maasai

The pastoral Maasai are the largest of the cattle-keeping tribes in East Africa, living in Kenya and northern Tanzania. They are dependent on their cattle, the main milk producer, and small livestock such as goats, having little reliance on other food sources (Western and Finch 1986: 79). They have been extensively studied by ethnographers (Jacobs 1965; Dahl and Hjort 1976; Western and Finch 1986; Shahack-Gross *et al.* 2004; Ryan 2005).

Milk was a cornerstone in Maasai subsistence. Cow’s milk was taken fresh, or alternatively soured or fermented (Ryan 2005: 99). Goat’s milk was given to children if cow’s milk was in short supply (*ibid.*), but the small livestock are mainly used for meat in times of low cattle milk yield (Western and Finch 1986: 88). The Maasai developed extensive methods for achieving milk let-down in cattle, ideally involving the live calf or alternatively using a surrogate or vaginal stimulation (Ryan 2005: 101). During the dry season milk yield declined (Western and Finch 1986: 88), although Jacobs (1965: 152) argues that the Maasai’s herds of cattle were large enough to supply sufficient fresh milk for subsistence through the dry season. The Maasai did not make cheese or blood cakes, and thus had no long-term storable fat to sustain them through the dry season (Jacobs 1965: 152). Some other African pastoralists, such as the Somali, processed milk to make storable yoghurt-like *han* and sun-dried curd (Dahl and Hjort 1976: 159). The Maasai relied instead on other food sources during times of hardship, generally meat from surplus cattle (males or infertile females), sheep or goats, and also blood (Western and Finch 1986: 90; Ryan 2005: 100).

The Maasai potentially practised marrow extraction, indicated by an observation by Shahack-Gross *et al.* (2004: 1399), who note that trash pits contained bones “crushed by humans (and later, dogs) for the extraction of marrow”. Liquid fat is used and drunk in some Maasai ceremonies, although it is not clear how the fat is produced (*Disappearing World: Maasai Manhood* 1975). This highlights the difficulties and ambiguities of identifying bone fat processing in ethnographic accounts.

2.3.2.2 Other African pastoralists

The pastoral Fulani (Bororo) also depended almost completely on their herds of zebu cattle for milk-based subsistence and as exchange items (Stenning 1957: 57). Stenning (*ibid.* 58) suggests that meat was eaten ceremonially on ritual occasions, but Smith (1992: 125) observed that meat was consumed more regularly. Almost all the meat eaten was from goats and sheep; cattle were used as a cash crop to buy commodities, grain and pay taxes (*ibid.* 125).

Alternate uses of fat are documented among the Turkana by Barton (1921a; 1921b). The Turkana were pastoralists in Kenya subsisting mainly on meat, blood and large quantities of milk, sometimes mixed with cattle urine (Barton 1921b: 206). A piece of fat was traditionally included in the ordinary dress of a Turkana man to be used for oiling the body and cleansing weapons (Barton 1921a: 113). Turkana women are said to have oiled their bodies with rancid butter (*ibid.* 114).

For the Bantu Ithako fat is used in medical and ritual applications. For example, children can be protected from the negative influence of ghosts by killing a sheep and rubbing the child all over the body with the fresh fat (Hobley 1903: 340).

The Rashaayda Bedouin of Eastern Sudan traditionally did not eat meat but survived on milk and bread made from bought grain, and also practised some minor agriculture, growing sorghum and millet (Young 2002: 36-37). However, a goat was commonly slaughtered on migration and shared among the migration party (*ibid.* 19). The animal was defleshed and the meat boiled, with marrow seemingly not extracted as Young remarks that there was "nothing to do" as the meat cooked (*ibid.* 20). However, when Young wonders how to clean his meat-greasy hands, he is told to rub them on the soles of his feet, which helped to prevent dry, cracked feet from not wearing sandals (*ibid.* 21).

These alternate uses of fat and meat cannot be separated from its use as a nutritional foodstuff. We must assume that fat could have had ritual, practical and nutritional importance, and that meat could have been used in trade and exchange in the past as in modern times.

2.3.3 Eurasian pastoralists

2.3.3.1 The Scythians

The Scythians were a nomadic pastoral people that lived inland of the Black Sea region in the 4th century BC. They were utilised as a useful 'barbarian' portrayal for Ancient Greek comedies and are documented by Herodotus in his *Histories* (Book 4). Modern scholarship describes them as "occasional drinkers of blood and constant drinkers of milk" (Hartog 1988: 170), in which the Scythians are very similar to modern African pastoralists – however, the blood they drink is that of humans, not animals, and the milk is horse milk (Herodotus *Histories* book 4).

The Scythians milked their horses by inserting a bone tube into the genitalia of the mares and blowing, which facilitated milk let-down (*ibid.* 4.2.1). The milk was then processed by being poured into deep wooden buckets which were shaken by slaves and the surface product drawn off (*ibid.* 4.2.2). Horses had the most ritual significance attached to them and formed the majority of the animals chosen for sacrifice, although the Scythians used all grazing animals for meat (*ibid.* 4.61.2). This is interesting as the main milk producer is often the most important ritual animal for more modern pastoralists, such as the Maasai and Pakot. A slaughtered animal was butchered and boiled inside its own stomach, with the bones used as fuel (*ibid.*). The Scythians lived in a fairly treeless environment, which was probably why they adopted this method of cooking. They give interesting parallels with other societies that live today in milk let-down and ritual associations attached to milk-producers.

2.3.3.2 Mongolian herders

The herding societies of Inner Mongolia keep sheep, goats, cattle, yaks and horses in an extreme environment where temperatures in the winter rarely make it above -15˚c. One group of Mongolian herders and their surrounding neighbourhood was studied by Fijn (2011).

Fijn notes that milk was of utmost importance in Mongolian pastoral society, not only in terms of nutrition, but as a strong mechanism for keeping animals tame through one-to-one milking (2011: 133). The Mongols made a variety of dairy products primarily from cow's milk, including cheese, curds, butter and yoghurt, some of which could be dried and kept for the winter months (*ibid.* 188). Horse's milk was used to make the symbolically important fermented alcoholic drink *airag*, an integral part of Mongol society (*ibid.* 173). Dairy products are particularly consumed in the summer months as a way to purge the body of fatty meats eaten in the winter (*ibid.* 187).

Interestingly, the Mongols did not utilise bone fats. Mongolian customary tradition ensured an animal was treated with respect, adhering to appropriate skinning and butchering procedures, sharing the meat among the group and consuming the animal without wasting any edible or usable parts (Fijn 2011: 225). Despite this, bone marrow and grease apparently were not exploited (*ibid.* 227). This suggests that enough fat was obtained from other sources, especially through fresh and dried dairy products, and perhaps that breaking the bones would have been disrespectful to the animal.

2.3.4 Pastoralists discussion

This small sample of pastoralist societies suggests that where milk was intensively exploited the likelihood of finding bone fat processing is reduced, although it is possibly often undocumented. This lack of bone fat processing was especially clear where herds were large and well developed enough to sustain a population through leaner seasons such as the Maasai (Jacobs 1965), and where societies made storable dairy products such as Mongolian herders (Fijn 2011). Based on evidence of dairy residues in sieves, Salque *et al.* (2013) have argued that some LBK sites at least were producing cheese. On these sites with established dairying economies, bone fat processing may be less intensive.

In many pastoralist societies the main milk producing animal was often not slaughtered on a day-to-day basis, but instead had ceremonial value or was used in trade as a cash crop. Ritual slaughter of the main milk producer is found among the Scythians (Herodotus *Histories*), and other pastoralists (Dahl and Hjort 1976), and is even echoed by hunter-gather societies such as the Okiek, who attach ritual significance to bartered Maasai cattle (Blackburn 1982). A similar trait has been suggested for the Neolithic by Marciniak (2005; 2011) from the deposition of cattle and small stock on some LBK sites, arguing that small stock was eaten in a domestic capacity and cattle were used for communal feasting.

2.4 Mixed farmers

2.4.1 Mixed farmers introduction

Mixed farming societies often rely equally upon rearing livestock and growing crops for their subsistence, and might also hunt and gather to supplement their diet. They should be the best analogies to make to the LBK as they follow the most relatable subsistence pattern, despite differences in environment. With the inclusion of domesticated crops in diet, and therefore carbohydrate-rich plant matter, it is likely that bone fats do not have such significance to mixed farmers as they do to hunter-gatherers.

2.4.2 African mixed farmers

2.4.2.1 The Tlokwa

The Tlokwa were agro-pastoralists living in the semi-arid Kalahari Desert of eastern Botswana. They maintained a reliable, nutritious food base through a wide diet breadth and food cooking, preservation and distribution mechanisms (Grivetti 1978: 1207). As well as milk and meat from goats, cattle, sheep and donkeys and meat from cats and pigs, the Tlokwa also kept chickens, pigeons, duck and geese, all of which were exploited for eggs and meat (*ibid.* 1209). The staple food of their diet was mainly fermented sorghum porridge (*ibid.* 1207).

The way that the Tlokwa cooked their meat aimed for the best retention of nutrients. Boiling is the most common cooking technique since meat is often tough. Meat broths were prepared with flours or other thickeners and were collected and served over sorghum porridge. Organ meat and brain was eaten (Grivetti 1978: 1212), as was marrow of the lower limb bones (*ibid.* 1218). Food was also stored by traditional preservation techniques such as sun-drying, parching and fermenting (*ibid.* 1207). Their cooking and storing methods allow for maximum retention of nutrients and a buffer for lean times.

Milk had many forms and many applications in cooking. Goat's milk was usually boiled before consumption but cow's milk was used directly. Consumption of fresh milk was encouraged during and soon after pregnancy as a relief for constipation as it caused acute diarrhoea (Grivetti 1978: 1218-9). This suggests that the Tlokwa were lactose intolerant, but still included milk in their diet.

2.4.2.2 The Pakot

The Pakot of west central Kenya were predominantly pastoral but also derived subsistence from cultivation of sorghum and eleusine through slash and burn rain-weather farming, supplemented by some irrigation (Schneider 1957: 279). Unable to grow enough food to support themselves solely through agriculture and unwilling to subsist on the produce of their stock, they depended on bartered grain to support their diet (*ibid.*). They lived in 'neighbourhoods' of scattered homesteads (*ibid.* 280).

The Pakot neighbourhood's main subsistence came from cow's milk, blood and meat. Cow's and goat's milk was drunk without ritual, with surplus saved as soured milk, but the amount produced was not sufficient for complete support (Schneider 1957: 280). Blood was another secondary product utilised, usually mixed with milk or drunk unmixed at ceremonial feasts. The amount of blood produced each year was comparatively small and it was considered a luxury (*ibid.* 287).

Pakot animals were slaughtered in two different ways. Sheep, goats, bulls and retired dairy cows were slaughtered without ceremony, but steers had high ritual importance. The meat of these animals was not allowed to touch the ground and milk was not allowed to be drunk, as there was a taboo against mixing the two in the stomach (Schneider 1957: 282). The Pakot felt that meat should be distributed in the neighbourhood, preferably in a formal feast (*ibid.* 288), which possibly reflects feasting in the Polish Neolithic (Marciniak 2005), although there was no mention of cracking bone for marrow in this ceremony.

2.4.2.3 The Kikuyu and the Kamba

The Kikuyu and the Kamba were Bantu speaking agriculturalists who kept cattle, sheep and goats. Their primary crops were maize, various millets, legumes and sweet potatoes, although they also cultivated bananas, sugar cane and various fruits (Middleton and Kershaw 1972: 17, 69). Both tribes also exploited the bush for wild game, insects and honey (*ibid.*). Despite the domestic and wild meat available, the diet of both tribes was mainly vegetarian, as the domestic animals were only usually eaten upon their natural death, at times of famine, or for sacrifice (*ibid.*). There is no mention of fat rendering or even marrow extraction in their ethnographies.

Milk rarely featured in Kikuyu subsistence. Cow's milk was drunk on occasion, although goat's milk was more regularly consumed by women and children (*ibid.* 18). The Kamba exploited milk and dairy products as part of their everyday subsistence, and it was the women's job to milk the cows and churn butter (*ibid*. 69, 71). Despite this difference there was no 'compensation' for the scarcity of milk in Kikuyu subsistence – their vegetarian diet must have brought all the fat that they needed. Both tribes exercised a considerable amount of internal and external trade ensuring that their diet breadth was maintained (*ibid.* 19, 69).

2.4.2.4 The Bemba

The Bemba was one of the largest and most highly organised tribes in North Eastern Rhodesia (Richards 1951: 15). Their subsistence was based firmly on agriculture, although they kept sheep, goats and some cattle. They were also fond of hunting, fishing and gathering wild plants and fruits from the bush (*ibid.* 18). The Bemba had a wide diet breadth consisting of cereals, roots, pulses, green vegetables, fruit, honey, hunted meat, fish and salt, but no dairy or dairy products (*ibid.* 34). Their main crop was high-protein millet, a harvest of which is dried and lasts 9 months of the year, used to make a dough-like porridge which accompanies every meal (*ibid.* 83).

Despite their wide diet breadth, Bemba subsistence was characterised by a lack of animal fat and protein. Domestic animals were only slaughtered for ceremonial purposes, so when a hunter made a successful kill, every atom of a killed beast was devoured down to the ultimate entrails (*ibid.* 57, 63). Meat was stewed on the bone and the stew eaten with millet porridge, and small shreds of flesh were dried over the fire (*ibid.* 57). Richards makes no mention of marrow or grease processing. It has been well documented that the Bemba diet was deficient in fat (Richards 1951; Richards and Widdowson 1936), but it has also been observed that the Bemba believed that eating too much meat and fat will cause insanity (Brelsford 1950: 51). This is in direct contradiction to Richard's (1951: 57) account of joyous meat feasting and happy fullness that she witnessed after gifting two slaughtered animals to the group. Based on fat deficiency it is surprising that bone marrow and grease processing did not feature or were not observed in Bemba subsistence.

2.4.2.5 The Dassanetch

The Dassanetch on the North-East shore of Lake Turkana adopted a flexible subsistence strategy based on pastoralism, hunting, fishing and cultivation (Gifford-Gonzalez 1993: 182). Their subsistence was highly seasonal depending on the supply of milk, which was most plentiful in the wet season and depleted in the dry season (Almagor 1978: 43).

During the dry season the men left the household to visit meat feasting events, leaving the milk for women and children to drink. Meat was mainly slaughtered and roasted in accordance with ritual, with men receiving the primary share (Almagor 1972; 1978). Gifford-Gonzalez (1993) had a more female-centred approach to her ethnographic study than Almagor (1972), who focuses on masculinity and the male symbolic relationship with the cattle. As such, she viewed more 'basic' food preparation decisions and activities. She found that kill-site decisions were made based on the intended use of the meat in terms of cooking and storage. Often meat was prepared in stews thanks to ceramic cooking technology, into which bones were cracked and pot-sized to liberate fat, marrow and blood (Gifford-Gonzalez 1993: 186). This suggests that the value of bone fats and nutrients was still appreciated despite the ready availability of milk.

2.4.3 Andean Agro-Pastoralists

In the Andes agro-pastoralists studied by Browman (1974) herded camelids (llama and alpaca) and grew high-protein crops at high altitudes such as caijhua and quinoa (*ibid.* 194). The high Andean climate also allowed freeze-dried preservation for potatoes and meat, staples in Andean nutrition. Trading was extensive in these communities – in the dry season caravan trains were formed trading dried meat, fat, hides, wool, and freeze-dried tubers for salt, dried fish and fruits (*ibid.*). These agro-pastoralists are included here as an interesting parallel to societies that focus on milk as the primary product from their animals, whereas here the focus was on wool.

The camelids provided meat and other primary products such as skins, bone and tallow in addition to wool (*ibid.* 193). Consumption of meat was low and targeted infertile females or castrated males (*ibid.*). The meat was sometimes preserved by drying, salting or freezing, the blood was used in several dishes and the hooves and legs were roasted (*ibid.*). This practice of roasting the lower limbs is common with other societies, and can precede marrow extraction. Milk was available in small quantities but does not seem to have been exploited in the past, either fresh or processed (*ibid.* 193). Due to the inclusion of vegetable carbohydrates intensive fat processing techniques were probably unnecessary, despite the lack of milk.

2.4.4 Mixed farmers discussion

The mixed farmers here studied indicate that a large diet breadth, especially when featuring high levels of plant carbohydrate and readily accessible dairy fat, can reduce the likelihood of starvation periods and negate the need for extensive bone fat processing. Boiling bones in stews is common among the Bemba (Richards 1951) and the Dassanetch (Gifford-Gonzalez 1993), and is a form of bone fat processing that liberates fats and nutrients without extensive processing. However, the Tlokwa are the only mixed farming group studied that are documented regularly cracking bones for marrow or crushing them for bone grease (Grivetti 1978). This is understandable where animal fats are readily available in milk, yet some societies crave and are deficient in animal fats and protein (such as the Bemba [Richards 1951]) but still do not intensively process fats. At the other end of the spectrum, the Tlokwa have a wide subsistence base including dairy fat and storage methods and still process marrow (Grivetti 1978: 1207), even though we would not expect them to. These examples show that we cannot completely predict bone fat use based on subsistence.

Mixed farmers have many aspects in common with hunter-gatherer and pastoralist societies. Ritual significance is attached to the primary milk producer, which is often killed ceremonially and consumed in feasts, such as among the Bemba (Richards 1951) and the Pakot (Schneider 1957). These feasts can exclude groups in society, with men typically benefitting rather than women (Almagor 1972). However, in some societies sharing structures ensure everyone access to nutritional food, such as among the Pakot (Schneider 1957), as in hunter-gatherer societies. Mixed farming societies often have extensive trade networks both within their society and outside, facilitating a larger diet breadth, particularly found in the Kamba (Middleton and Kershaw 1972).

2.5 Conclusion

What can the societies studied tell us about the relationship between bone fat and milk in traditional societies? Certainly that, above all, the relationship is complicated and cannot be defined by one ‘catch-all’ statement. When looking at diet one must consider human dietary preference - if the taste of bone fats is particularly palatable to a group of people effort is expended to acquire it even if it is not necessary for diet. Similarly, if it is against a society’s customs to break bones for fat acquisition then they will avoid it, even if fat would be supplementary to the diet. Despite the variation described above, trends in dairy and bone fat use, ritual significance, trade and sharing networks can be identified.

One relationship that is evident is that societies that have a regular supply of fresh milk or make storable dairy products often process less bone fat. Where regular fresh or storable dairy fat is not available a great deal of time is often spent in leeching every last piece of fat from the carcass, for example among the Hadza (Bunn 1993; O’Connell *et al.* 1998). The opposite is true for pastoralists who make storable dairy fat, such as Mongolian herders (Fijn 2011) or whose herds are large enough to sustain milk production during the dry season, such as the Maasai (Jacobs 1965). Cheese making has been identified at some LBK sites (Salque *et al.* 2013) and milking economies have been suggested based on herd structure analysis (Gillis in prep; unpub). If some sites had more intensive dairy economies than others, we might expect their bone fat processing practices to reflect this. Of course, based on the level of variation seen in this chapter it would be unwise to ‘predict’ bone fat processing based on the milk-yield analogy alone.

One practice common across many kinds of societies is that of boiling bones in stews. This practice, seen among the !Kung (Lee 1979), Hadza (Bunn

1993; O'Connell *et al.* 1998), Kutse (Kent 1993b), Native Americans (Saint-Germain 2005), Evenki (Abe 2005) and Dassanetch (Gifford-Gonzalez 1993) allows some bone fat to enhance the stew yet avoids the effort-, fuel- and time-intensive process of bone grease rendering. Bone can be pot-sized for this cooking method, which has the additional advantage of increasing exposure of fat rich areas like the marrow cavity and epiphyses. Bone can also be boiled whole and perhaps broken after consumption to suck the remaining marrow from the bone, which is documented among the Nunamiut (Binford 1978). This could leave a distinctive pattern archaeologically, and would possibly be viable in some LBK pottery.

Many societies benefit from trade and relations with nearby groups with different subsistence bases. The !Kung have gained access to dairy fats from the Herero (Lee 1979; 1993), the Okiek trade honey and skins with the Maasai for fat-rich cattle (Blackburn 1982), and the Evenki trade with convoys from towns that bring medication and condensed milk (Leonard 1994). Many societies also rely on having a surplus to use as a cash crop that can be used to buy grain when times are hard (Dahl and Hjort 1976). These networks are perhaps useful to reflect on Neolithic Europe, where hunter-gatherer societies could have operated in proximity to LBK culture settlements. Would these hunter-gatherers trade with the LBK for surplus milk and animal fat just as hunter-gatherers in Africa have been documented?

There is a tendency in most dairying societies that the main milk producer has high ritual significance and for the small livestock such as sheep and goats to be slaughtered more regularly. Cattle have high significance for the Pakot (Schneider 1957), camels for the Rashaayda Bedouin (Young 2002) and horses for the Mongolian herders and the Scythians (Fijn 2011; Herodotus *Histories*). It is also seen in the Evenki as they will not eat their domesticated reindeer, instead hunting wild reindeer for meat (Abe 2005). The Kikuyu will not kill their animals simply out of hunger even though they do not produce milk, rather they keep them for exchange and sacrifice (Middleton and Kershaw 1972). This selective ritual (and practical) significance is especially important as it is directly equitable to Marciniak's suggestion that cattle were killed, consumed and deposited in a highly ritual, communal manner in the LBK and that sheep and goats were slaughtered with less ceremony (Marciniak 2005).

This point about communal feasting of cattle raises the theme of sharing within groups, which is common in many traditionalist societies. The sharing networks are perhaps best seen in the Alyawara, Okiek and the Kutse community who ensure a supply of fat to less talented hunters, women and children by bringing meat and bones back to camp to butcher and crack for marrow (O'Connell and Marshall 1989; Marshall 1994; Kent 1993a, 1993b). It is also seen in the Rashaayda Bedouin, who quite conspiratorially kill a goat for just the family when on migration as their culture demands sharing (Young 2002), and the Pakot, who kill and consume steers in a ritualised manner, followed by a formal feast (Schneider 1957), again giving credence to Marciniak's formal feasting hypothesis (2005). It is possible that formalised sharing structures existed within LBK settlements, and communal consumption has been suggested based on atypically large, centralised houses at Olszanica and Cuiry-lès-Chaudardes (Milisaukas 1986; Gomart *et al.* 2015). It may have been the case that houses also first had to fend for themselves, based on different species representation per house at the latter site (*ibid.*).

In conclusion, traditionalist societies can help explain and give insights into the behaviour behind the traces left in the archaeological record. Whilst we must consider the differences between modern societies and those that existed in the past there is still much that can be learned from studying these people. From a modern western perspective these studies can broaden a relatively narrow knowledge base concerning the ways in which people survive and thrive in the world.

Chapter 3 Methodology

3.1 Introduction

In this chapter methodologies used for investigating the nature of meat and fat exploitation will be detailed. These particularly focus on carcass processing practices, especially the identification of butchery marks, heat exposure, fracture and fragmentation on animal bones but also include ‘basic’ zooarchaeological identification techniques such as species and element identification and fusion ageing. Following this, an identification and critique of the various methods used to identify dairying will be given. Finally, the chapter structure for each case study will be presented.

Before the methodology for this specific project is detailed it will be useful to highlight some zooarchaeological techniques that were not undertaken as part of this PhD project. While mandibles and maxilla were included in analysis of carcass processing practices, analysis of tooth eruption and attrition for age-at-death determination was undertaken by another member of the NeoMilk project, Dr Roz Gillis. The teeth studied by Gillis will also be subject to isotopic analysis to define weaning stages and seasonal herd management strategies (NeoMilk website). Sex ratios using measurements of the post-cranial skeleton were not collected as part of the NeoMilk project.

3.2 Carcass processing methodologies

Consumption of animal products is a process that includes food preparation, presentation, distribution, storage and disposal, all of which are embedded in social and symbolic aspects of society (Milner and Miracle 2002: 2). Butchery is a concept encompassing and dependent on these culturally specific attitudes, and is thus a form of socio-technological material culture (Seetah 2008: 136). As well as culture, other factors can impact butchery decisions. This may include season, as pertaining to both the life stage and dietary stress of the animal, anatomical constraints presented by certain species, kill location, butchery technology and the nutritional needs of the settlement (White 1953; 1954; 1955; Lyman 1987; 1994: 296; Milner and Miracle 2002; Seetah 2008). This results in highly variable butchery traditions that may be visible in the archaeological record, aided by recent methodological, experimental and theoretical advances (Milner and Miracle 2002; Seetah 2008: 136).

Butchery itself can be defined as the “range of processes, employing implements, by which humans are able to disarticulate a carcass into units depending on its ultimate use” (Seetah 2008: 137). The archaeological signatures of carcass processing on animal bone are predominantly related to evidence of marks caused by cutting implements contacting the bone, bone breakage and the disarticulation of the carcass (Lyman 1987: 258). Further human processing of the carcass can be seen in bone modifications relating to cooking practices (Oliver 1993). In addition to ‘edible’ products such as meat, fat, blood and organs this also includes those parts not intended for human ingestion, such as hide, hair, bone and antler, that may be used for tools, craft and other practical purposes (Lyman 1987: 252). This section will discuss carcass processing and the archaeological signatures thereof, and the methods by which this information was recorded on the material studied for this project.

3.2.1 Butchery

Butchery marks are imparted to bone by a sharp-edged implement during carcass processing (Fisher Jr. 1995: 12). Documentation of butchery marks is now standard protocol in contemporary zooarchaeology (Otárola-Castillo 2010), the analysis and interpretation of which has long been perceived as important by many zooarchaeologists (Lyman 1994: 314). Guilday *et al.* (1962) is often cited as one of the first systematic studies of butchery in an archaeological context, with more advanced methodologies following in the 1980s with the application of microscopic analysis (Shipman 1981; Shipman and Rose 1983; Olsen and Shipman 1988) and the development of ethnographical inference (particularly Binford 1978; 1981). Early studies of butchery marks concentrated on identifying early hominin activity (such as Binford 1981; Blumenschine 1995; Bunn 1986; Capaldo 1997; Shipman and Rose 1983; Shipman 1986), primarily on differentiating between human butchery marks and modifications caused by other agents including carnivore tooth marks (Shipman 1981; Shipman and Rose 1983; Olsen and Shipman 1988; Selvaggio 1994; Lyman 1987; Fisher 1995; Blumenschine *et al.* 1996; Domínguez -Rodrigo *et al.* 2004; Pickering *et al.* 2005). The continuing importance of this analysis today is attested to by the myriad of papers concerning human/carnivore predation given at the fourth ICAZ Taphonomy Working Group meeting in Paris (7-10th September 2016).

Indications of butchery in this thesis will be used to infer patterns of carcass processing and to assess regional and temporal changes in butchery culture.

3.2.1.1 Butchery as an indicator of carcass processing

Overall trends in carcass butchery are composed of individual butchery events on single bone specimens, each of which contains information about the type of butchery activity that was being undertaken based on mark morphology and activity location. The same butchery process on many different carcasses results in repeated patterns of marks in specific locations from processes such as skinning, dismemberment, filleting for consumption or storage, and bone fat processing (Binford 1981: 106). To untangle overall butchery procedure one must analyse both the types of marks, and the locations in which they are found.

3.2.1.1.1 Mark morphologies

Cut mark morphology, form and placement varies with the material and type of tool used and the activity it is used for (Binford 1981: 105; Lyman 1987). We can expect that all butchery marks encountered during this project were made with stone tools based on their archaeological provenance, typically resulting in a series of parallel strokes with a more open cross section than metal tools (Binford 1981: 105; Kooyman 2000: 76; Greenfield 1999; West and Louys 2007). For recording purposes, the marks identified were recorded as scrape, cut, chop and crush (percussion) marks based on their morphology. Scrape marks are identified as multiple fine striations covering a broad area, and can be made when drawing a stone tool across a bone perpendicularly to the tool’s long axis (Shipman 1981: 367-8). Binford noted these scratches and striations can be caused in the removal of the periosteum by Nunamiut (1981: 134). Cut marks are elongated groves with a v-shaped cross section and microscopic fine striations within the main groove, parallel to its long axis (Shipman 1981: 365). They are produced by drawing the sharp edge of a stone artefact across the surface in a continuous direction (*ibid.*; Binford 1981: 129). Chop marks are characterised by broad v-shaped grooves with elongated oval outlines, produced when a heavy-duty artefact is used to strike a bone surface with a blow directed roughly perpendicularly at the bone rather than drawn across it (Shipman 1981: 366). Blunt dynamic impact causes percussion marks on the bone surface, suggesting the use of heavy-duty tools and the practice of marrow extraction (Blumenschine and Selvaggio 1988; Blumenschine 1995; Pickering and Egeland 2006; Galán *et al.* 2009).

3.2.1.1.2 Butchery signatures

The archaeological signatures of certain butchery practices are in part anatomically determined, and can be inferred by ethnographic analogy (Binford 1976; 1981) and experimental archaeology (Soulier and Costamagno 2017). Butchery marks made by skinning are often found on the lower legs and the head, where the skin is close to the bone surface (Binford 1981: 106). Marks made during dismemberment are most often found at the points of disarticulation, particularly the epiphyses (*ibid.*). Filleting marks are usually long, longitudinally oriented cut marks aiming to expose the bone surface, or shorter, more oblique cuts aiming to separate the meat and sever muscle insertions (*ibid.* 129). These marks are particularly common on the 'neck' of long bones, between the articular end and the diaphysis proper, where the bone is irregularly shaped and there are many muscle insertions (*ibid.* 130). Marks made during bone fat processing are detailed more specifically below, but may also include scraping marks from removing the periosteum for marrow processing (*ibid.* 34; Oliver 1993: 109) although this is not always the case.

3.2.1.2 Identification, recording and interpretation

3.2.1.2.1 Identification

On identifiable material, data on butchery mark frequency, location and morphology was collected (Lyman 1987: 281; see table 3.1). Identification of butchery marks was performed by macroscopic inspection of the bone, with ambiguous marks verified using a hand lens (x10 and x20 magnification). Shipman (1981: 365) implies that a microscopic magnification is necessary for distinguishing the difference between tool marks and, for example, tooth marks, but Blumenschine *et al.* (1996) show that marks made by carnivore teeth, hammer stone percussion and metal knife cutting can be distinguished with near perfect reliability without scanning electron microscopy. In addition to this, the practicalities of travelling abroad to archaeological stores with a microscope, and the costs thereof, seemed infeasible.

3.2.1.2.2 Recording

On all identifiable specimens, including partially identifiable large/medium mammal material, the type of butchery observed (scrape, cut, chop, crush) was recorded or listed in the case of multiple types. This basic butchery was used in analysing all identifiable bones from the assemblages from Rosheim *Sainte-Odile* and Bischoffsheim as these pilot sites were used to test analysis duration.

Advanced butchery analysis was performed on any fully identifiable bone where species, element and identification zones could be determined. Butchery was recorded as above but in addition to in-depth recording via a relational database. The database allowed the description of more than one butchery ‘episode’ per bone, defined as a discrete group of marks of the same type. The data recorded is shown in table 3.1. The butchery marks were then digitally drawn on bone templates using GNU Image Manipulation Program and Adobe Illustrator, programs with the capacity for creating and storing multi-layered image files. For each butchered specimen, a new layer was created and named using the site code and the unique Bone ID number. Butchery marks were then drawn onto this layer, using different colours to represent different butchery mark types. This follows the butchery technique used in Velim (Outram and Knight 2007). Images of bones were taken primarily from Barone (1978) and Hillson (1999) and simplified. All elements depicted are of the left side of cattle or deer, save where suid butchery was abundant. Carcass images were provided by Alan Outram.

Table 3.1: Data collected for each butchery episode observed on fully identifiable bones.

Field	Description
Butchery mark ID	Primary key
Bone ID number	Primary key from main identifiable bone database.
Butchery mark type	Scrape/ cut/ chop/ crush.
Location	Bone zone(s) affected by the butchery episode, after Dobney and Rielly (1988).
Orientation	Anatomical position on the bone. For example, lateral, posterior, dorsal.
Number of strokes	Number of strokes in a butchery group.
Severity	Subjective analysis of the intensity of the butchery. Light/ medium/ heavy.
Comments	Any other butchery information can be recorded here.

Other marks recorded on identifiable bone were ‘slice’ marks, and those made during or after excavation. ‘Slice marks’ are long, flat, smooth marks, made by incisions at acute angles to the bone surface, similar to marks made by defleshing with cleavers. While it was originally assumed that this mark was a butchery mark, it is now thought that it represents a fracture characteristic, perhaps caused by bone peeling away from the fracture site. Morin and Soulier (2017: 100) describe a characteristic of fresh fracture called peeling or tear marks (*arrachement*), where green bone breaks off according to a subparallel plane relative to the element’s cortical surface. This decription reflects the archaeological pattern.

Damage made unintentionally by excavators and curators can also mimic butchery. However, these have very irregular, scalloped edges, contain no matrix, and are likely to be lighter in colour than the adjacent bone surface, in the same way as recent breaks (below; Shipman 1981: 366). Both excavator damage and slice marks were recorded in the comments, rather than as butchery marks, as they do not directly relate to butchery damage.

On indeterminate bones instances of butchered bones were counted per context. This included all butchery on rib fragments and indeterminate skull fragments. The type of butchery and the bone type and size was not noted.

3.2.1.2.3 Interpretation

For each case study the butchery proportions on both the overall assemblage and solely the identifiable assemblage will be presented. Butchery proportions may also be presented by phase, context, species and element. However, using percentages of butchery to infer intensity of carcass processing has widely been shown to be ambiguous (Lyman 1994: 302; Egeland 2003; Otárola-Castillo 2010). Therefore, for each site where butchery patterns were sufficiently abundant commonly butchered elements and their butchery marks will be depicted in diagrams, occasionally separated into data from ruminants and suidae. In the site conclusion, all butchery marks recorded are transposed onto a skeletal diagram of bovinae, suidae, and caprines, and analysed in relation to other carcass processing and food exploitation evidence.

3.2.2 Cooking methods

Following reduction of the carcass into “consumable” parts (Lyman 1987: 251-252), cooking may be the next archaeologically visible aspect of carcass processing. The method of cooking may give indications of nutritional requirements and cultural preferences, particularly in terms of taste and ritualised consumption such as feasting. Eating practices, including cooking, “are some of the most fundamental activities in creating and maintaining social life” (Subías 2002: 7). When dealing with heat-affected bone, three processes are predominantly under investigation – boiling, where bone and flesh are heated at a constant temperature, moderated by liquid; roasting/baking, where the bone is partially or wholly protected from the heat source via insulating flesh; and burning/incineration, where the bone is usually in direct contact with fire or an intense heat source (Roberts *et al.* 2002: 489).

3.2.2.1 Boiling and pot sizing

Many hunter-gatherer groups studied by ethnoarchaeologists boil the bones of animals in stews, such as the Hadza (Bunn 1993; Oliver 1993), the Dassanetch (Gifford-Gonzalez 1993), the Nunamiut (Binford 1978; 1981), and the !Kung (Yellen 1991, see also chapter 2). Bones of smaller animals may be boiled whole, fleshed or filleted, or alternatively bones can be broken minimally to make them “pot-sized” (Gifford-Gonzalez 1993; Oliver 1993). This is a different activity from bone grease processing where bone is pounded and boiled to solely obtain pure bone grease. Instead, pot-sizing bone helps release the grease and nutrients within spongey bone by increasing surface area (see Church and Lyman 2003; Oliver 1993), resulting in stews enriched with bone fat. Bones boiled whole may also later be broken for the remaining marrow (Binford 1978: 145). It is important to note that the end product is *not* pure bone grease, and thus does not have the same preservative qualities (Leechman 1951), but this process requires considerably less effort and fuel to reap some of the nutritional benefits.

The archaeological signature of boiling bones in stews may be pot-sized marrow bones, some with the articulations split, and some, but not intensive, fragmentation of the axial skeleton (Gifford-Gonzalez 1993: 186). Boiling bones in stews and in pursuit of bone grease can also cause pot-polish (Madgwick 2014: 164). However, Oliver (1993: 214) argues that boiling bone does not yield visible damage, nor does breaking boiled bone result in diagnostic breakage morphology, although his boiling times were short (<11 minutes). Roberts *et al.* (2002) experimented on boiling cattle ribs, and found that boiling times of 1-9 hours had little or no physico-chemical effects. However, diagnostic breakage may more likely affect long bones broken after boiling (Binford 1978: 145) considering the different mechanical properties of rib and diaphysis bone. Pearce and Luff (1994) found that the longer sheep metapodia were boiled for the less force required to fracture them, which could result in some differences in fracture morphology. However, Outram (pers. comm.; Outram 1998) argues that bone is easiest to fracture for marrow extraction when fresh. More archaeological experiments are needed to accurately ascertain the effects of boiling and breaking marrow bearing bones, especially on smaller mammals such as sheep and pigs whose bones may not need to be pot-sized.

3.2.2.2 Roasting

Evidence of cooking is more likely to be recorded on bones by exposure to dry heat. Flesh-on bones can be roasted for consumption and the flesh ‘protects’ the bone somewhat from drying out (Roberts *et al.* 2002: 489), although largely meat-free elements in articulation will be more severely affected. If largely complete bones have evidence of roasting this could suggest large joints roasted over open fires, typically associated with feasting (Serjeantson 2006: 124). Bones can also be placed on or near a fire before marrow extraction, which may also be part of feasting (*ibid.*), both to make the bones easier to break and to make the marrow more liquid (Jones 1993: 109; Outram 2002: 52), attested ethnographically among the Nunamiut (Binford 1978).

Exposure to dry heat in this way can have specific archaeological signatures. Like boiling, bones can be “hearth-sized” to facilitate roasting (Oliver 1993: 203). Roasting can lightly char limb bones resulting in colour changes to bone fragments, particularly black scorching and more generalised brown roasting (*ibid.* 214, Subías 2002: 11). However, roasting may also show no charring at all, and use of colour can be an imprecise criterion to directly infer temperature of heating (Pearce and Luff 1994: 54; Shipman *et al.* 1984: 320; Subías 2002). Bone surfaces may also be affected by warping and cracking (Shipman *et al.* 1984: 308; Pearce and Luff 1994; 54). Fracture morphology is considerably affected by burning due to the advanced moisture loss caused by heat exposure, as has been investigated by Outram (1998; Karr and Outram 2012b; Oliver 1993; although for ambiguities see Alhaique 1997). It is therefore expected that roasting before marrow extraction, as found in the Kuyavian Neolithic by Marciniak (2005; 2011; Marciniak and Pollard 2015) would cause the bone to fracture with mixed, if not dry fracture characteristics (see below).

3.2.2.3 Use as fuel and incineration

In some societies bones are used as fuel, especially in environments where wood is scarce, and will burn well provided a good fire is established in advance (Costamagno *et al.* 2005: 50). For archaeological assemblages that contain considerable amounts of heavily carbonised and calcined bones, this seems a likely cause (*ibid.*). In some ethnographic accounts refuse dumps, including bone, are subjected to burning (Shahack-Gross *et al.* 2004: 1399). Bones can be thrown into hearths when their usefulness has been expended as refuse deposition. As with burning for fuel, disposal practices such as these would likely cause large amounts of heavily carbonised or calcined bones, depending on the temperature (Shipman *et al.* 1984; Pearce and Luff 1994).

3.2.2.4 Identification, recording and interpretation

On identifiable material, evidence of heat exposure based on colour and surface damage was determined as scorched, roasted, carbonised, approaching calcined, and calcined (see table 3.2). In hindsight, it would have been useful to also note the zones affected by burning, but this was not implemented unless the evidence of burning was particularly intensive around the fracture location, which was included in the comments. On indeterminate material, the number of instances of burnt bone was recorded per context.

Table 3.2: Determinations of burning and their descriptive characteristics.

Type of heat damage	**Description of characteristics (after Shipman *et al.* 1984 and Pearce and Luff 1994)**
Scorched	Blackened in places but not fully carbonised
Roasted	Brown surface colour, sometimes with evidence of cracking and warping
Carbonised	Fully blackened with shiny surface portions
Approaching calcined	Grey surface colour
Calcined	Bluish-white surface colour

3.2.3 Fracture freshness analysis

A wealth of information about carcass processing and depositional practices can be gained by analysing the types of fractures to appear on bone in faunal assemblages from archaeological sites (for example Morlan 1984; Johnson 1985; Outram 1998, 2001, 2002, 2003; Outram *et al.* 2005. Karr and Outram 2012a; 2012b; Parmenter 2015; Parmenter *et al.* 2015; Madgwick and Mulville 2015a; 2015b; Johnson *et al.* 2016). As with butchery marks, bone fracture freshness analysis has long been important for identifying hominid marrow extraction activity on animal bones, especially compared to fractures caused by non-human modifications such as trampling, weathering and carnivore gnawing (Brain 1967; Blumenschine and Selvaggio 1988; Capaldo and Blumenschine 1994; Blumenschine 1995; Blumenschine *et al.* 1996; Myers *et al.* 1980; Andrews and Cook 1985, Haynes 1983; Selvaggio 1994; Alcántara García *et al.* 2006; Pickering *et al.* 2005; Faith *et al.* 2007; Galán *et al.* 2009). Fracture freshness analysis began to be applied to zooarchaeological questions in the 1970s and 1980s with ethnographic and experimental work influencing the understanding of archaeological signatures (Noe-Nygaard 1977; Morlan 1984; Johnson 1985; Vehik 1977; Binford 1978; 1981). However, analysis of fracture freshness from a carcass processing and depositional perspective has been limited or brief in archaeological literature, perhaps due to preconceptions about the amount of time needed for in depth fracture analysis. Indeed, many methods of analysing fracture in the past have revolved around the detailed analysis and interpretation of individual specimens (Biddick and Tomenchuk 1975; Johnson 1985).

New, more efficient recording procedures have provided usable, quantitative methodologies that increase the amount of archaeological data available from a faunal assemblage, particularly in the utilisation of indeterminate fragments (Villa and Maheiu 1991; Outram 1998; 2001; 2002). Actualistic archaeological experiments on modern animal bones have tested these methodologies and documented the fracture characteristics of bone exposed to different environments (Outram 1998; Karr and Outram 2012a; 2012b; 2015). Improvements in graphically representing fracture freshness analysis have also aided the study and interpretation of sequences of fracture and fragmentation (Parmenter 2015; Johnson *et al.* 2016). Application to archaeological sites has shown that fracture freshness analysis is an incredibly useful tool in understanding and untangling carcass processing and depositional practices in the past (for example Outram 1999; 2003; 2005; Munro and Bar-Oz 2004; Harding *et al.* 2007; Karr *et al.* 2010; Karr *et al.* 2015; Karr 2015; Johnson *et al.* 2016). It is used in this thesis as a marker for bone fat exploitation and deposition.

3.2.3.1 Bone fat exploitation

Bone fat exploitation is usually categorised as either bone marrow or bone grease processing, as discussed briefly in chapter 1. In bone marrow processing fresh (peri-mortem), marrow-bearing bones, particularly the long bones but also the mandible, are broken to gain access to the marrow cavity. The marrow is then poked or scooped out, although bone can be heated before extraction to liquefy the marrow (Binford 1981: 154-161; Jones 1993: 109; Kent 1993b: 338; Outram 2002: 52). Certain bones have higher marrow utility than others, depending on species and season, which may be preferentially targeted (Binford 1978; Jones and Metcalfe 1988; Metcalfe and Jones 1988; Blumenschine and Madrigal 1993; Outram and Rowley-Conwy 1998; Rowley-Conwy *et al.* 2002; Madrigal and Holt 2002). High-yield bones in cattle, suidae and caprines are typically the humerus, radius, femur and tibia compared to the lower-yield mandible, metapodia and phalanges. However, marrow resources in high-yield bones in are depleted in stressed animals resulting in comparatively higher values in metapodia (Speth and Spielmann 1983: 11-12; Blumenschine and Madrigal 1993: 569), which are also important for their oleic acid content (Binford 1978: 24). A key consideration with marrow processing is that it requires little preparation (aside from filleting meat and possibly the removal of the periosteum) and can be used both in an ad-hoc as well as intensive manner (e.g. Binford 1981: 157-158).

Bone grease extraction is a far more labour-, time- and fuel-intensive process, involving heavily comminuted axial and articular cancellous bone (Binford 1978: 159). This bone is pounded into very small fragments (comminuted) and submerged in gently boiling water, eventually causing the fat trapped within the bone to liquefy and rise to the surface (Leechman 1951; Binford 1978; Outram 2002: 51; 2005: 33). The smaller the pieces of cancellous bone, the faster the bone fat is released (Church and Lyman 2003), which is important in terms of the time and fuel necessary (Janzen *et al.* 2014). The resultant fat is skimmed from the surface and may need to be boiled again to purify it (Abe 2005: 135). Where the climate permits casual storage, such as in the freezing temperatures of the Nunamiut (Binford 1978: 157-158), a large amount of bone is often saved prior to rendering and then all rendered at once. The resulting product is a fat-rich, nutritious, storable, preservative foodstuff (Leechman 1951; Saint-Germain 1997). This practice is only usually intensively undertaken in hunter-gatherer societies living in extreme climates with no regular access to carbohydrates. However, it may be practised on a small scale or exploited seasonally based on the food sources available at different times of the year (Binford 1978; Speth and Spielmann 1983; Outram 2004). Resources of bone fat can also be exploited for purposes not relating to consumption, such as providing heat and light and waterproofing materials (Binford 1978: 24).

3.2.3.2 Archaeological signatures of bone fat exploitation

Bone marrow processing can be indicated through high levels of perimortem (fresh) fracture on marrow-bearing bones. Bones bearing marrow should rarely be whole where exploitation was intensive, diaphysis fragments will be common, and high-yield marrow-bearing bones may be preferentially targeted. This signature, with additional high levels of fragmentation of cancellous bone, is also found in grease rendering. For bone grease processing the greatest amount of bone, in terms of mass, should be found in the smallest size classes. Fragmented cancellous bone should be common and whole grease-bearing bones and long bones with complete epiphyses are rare (Outram 2001). On sites where bone grease processing is an established practice it is likely that archaeological features related to this activity will be discovered (for example Karr *et al.* 2010; 2012). If the assemblage fragmentation is indeed a result of human agency and not non-human modification such as bioturbation, trampling or compaction, it is likely that non-marrow and grease bearing bones, such as ribs, should be found whole (see Outram 2001: 409).

3.2.3.3 Properties of bone fracture

Detecting bone marrow and grease processing relies partly on the differential fracture characteristics displayed by bone in varying states of decay. Shaft fragments of mammal limb bones fracture in different ways relating to the level of moisture content - their “freshness” (Morlan 1984; Johnson 1985; Outram 2001). Bones can be considered “fresh” when they are in the living condition or from a just-killed animal (Johnson 1985: 160). Bone of this nature can also be considered “green” or “peri-mortem” (*ibid.*), but should not be confused with “recent” breakages that occurs during or after excavation. Dynamic loading on fresh bone causes a helical fracture, with several fracture lines radiating out from a cone of bone displaced beneath the loading point, around which may be evidence of percussion marks (Blumenschine and Capaldo 1988). These fractures spiral around the diaphysis and tend to produce breaks with the fracture surface inclined at about 45 degrees to the longitudinal axis (Johnson 1985: 172), leaving sharp edges against the bone’s cortical surface (Outram 2002). Impact and rebound scars are often found on the fracture surface itself, usually on extremely acute angles of the fracture with hackle marks (Morlan 1984; Johnson 1985; Outram 1998; 2001; 2002). If the bone is struck on a hard surface such as an anvil there may be a rebound scar on the other side of the shaft as a result of equal and opposite forces (Outram 2002: 54). Dynamic impacts on fleshed bones tend to cause ‘butterfly’ fractures (Outram *et al.* 2005: 1703).

Over time bone loses moisture and can be considered “dry”. Bone behaves in a brittle manner when it is well into a dry or altered state (Johnson 1985: 160), with a greater tendency to fracture in straight lines or steps, following drying micro-cracks with the bone’s structure (*ibid.*). The fracture surfaces tend to be perpendicular to the cortical surface and the texture of the fracture is rougher than fresh bone (Johnson 1985: 177; Outram 2001; 2002). All these features are often present in their full extent in mineralised bones that have lost their energy-absorbing capacity and anelastic capabilities through extensive moisture loss and altered microstructure (Johnson 1985: 178; Outram 2001: 403).

3.2.3.4 Fracture freshness recording methodologies

3.2.3.4.1 Identification

Two primary methods of recording fracture freshness were utilised – the objective Fracture Freshness Index (FFI) and the subjective recording of fracture types and sequences. The FFI was devised by Outram (1998; 2001; 2002) based on fracture methodologies designed to detect cannibalism on human bones by Villa and Maheiu (1991), and tested through experimental archaeology (Outram 1998; 2001; Karr and Outram 2012b). It is based on the analysis of the fracture outline, angle and surface texture, three criteria which are scored out of 2 based on the freshness of the characteristics they display. For each criterion, 0 denotes a fresh-fractured bone, 1 a mix of fracture characteristics and 2 a mainly un-fresh specimen (Outram 2001: 406), as described below.

- Outline: The shape of the fracture itself. A fracture with a mostly curving, helical outline will score 0, a fracture with a mostly jagged, stepped outline will score 2. A fracture with both characteristics in more or less equal form will score 1 (Outram 1998; 2001).
- Angle: The angle of the fracture surface to the bone surface. A fracture angle that is mostly acute or obtuse to the bone surface will score 0; a fracture with angles mostly at 90 degrees to the bone surface will score 2. A fracture with both characteristics in more or less equal form will score 1 (Outram 1998; 2001).
- Texture: The texture of the fracture surface. A fracture with a mostly smooth texture, including hackle marks, will score 0; a fracture with a rough, sandy texture will score 2. A fracture with both characteristics in more or less equal form will score 1 (Outram 1998; 2001).

When combined, the three criteria create a score out of six. Scores of 0-2 denote a fresh fracture, and scores of 5-6 indicate a completely dry or mineralised fracture (Outram 2001; 2005). Scores of 3-4 indicate mixed fresh and dry characteristics, suggestive of a bone in a ‘drying’ state perhaps but unlikely still fit for marrow extraction, or the presence of two or more types of fracture (*ibid.*).

The primary drawback with using the Fracture Freshness Index alone is that it gives a combined score for all fractures that have affected a specimen. For example, a bone fractured when fresh for marrow that was fractured again when mineralised by context recutting might receive a score between 3 and 6, which does not represent its original use for marrow. To solve this problem, it was decided to also note the types of fractures visible on the bones, so the cause of different FFI scores could be determined (Parmenter 2015; Parmenter *et al.* 2015; Johnson *et al.* 2016). The fractures recorded were helical (fresh), dry and mineralised. In this order, fractures are ranked in chronological sequence based on bone degradation due to moisture loss over time. Impact and rebound scars, further signatures of fresh fracture, were also recorded where observed.

A further type of fracture that was recorded was a recent (or new) break. These fractures happen during or after excavation and can be characterised by a white, chalky surface which is crucially different in surface colour than the bone as a whole. It is important to note these types of fractures to ascertain the levels of fragmentation caused by recent damage rather than archaeological processes. These fractures are not included in analysis of past carcass processing or depositional practices.

3.2.3.4.2 Recording

For each fragment of marrow-bearing bone larger than 30mm in maximum dimensions the Fracture Freshness Index was calculated from each of its three component characteristics, and the type or types of fracture observed (helical [fresh], impact, rebound, dry and/or mineralised) were recorded.

3.2.3.4.3 Interpretation

The fracture freshness analysis will be presented using the mean FFI score (Outram 1998; 2001), the proportions of fractured bones first fractured when fresh, dry or mineralised (Parmenter 2015; Parmenter *et al.* 2015), and in the form of a fracture history profile (Johnson *et al.* 2016). By using these three forms of evidence carcass processing fracture related to marrow exploitation can be viewed alongside taphonomic fracture without underrepresenting or disregarding either form of evidence. Figure 3.1 shows how fracture history profiles can be used to display both marrow extraction practices and the resolution of post deposition fractures (right, number of fractured bones = 100), presented against the same data using a proportion of fracture types observed (Outram and Knight 2007; number of fractures = 132) and using only the first fracture (Parmenter 2015; number of fractured bones = 100).

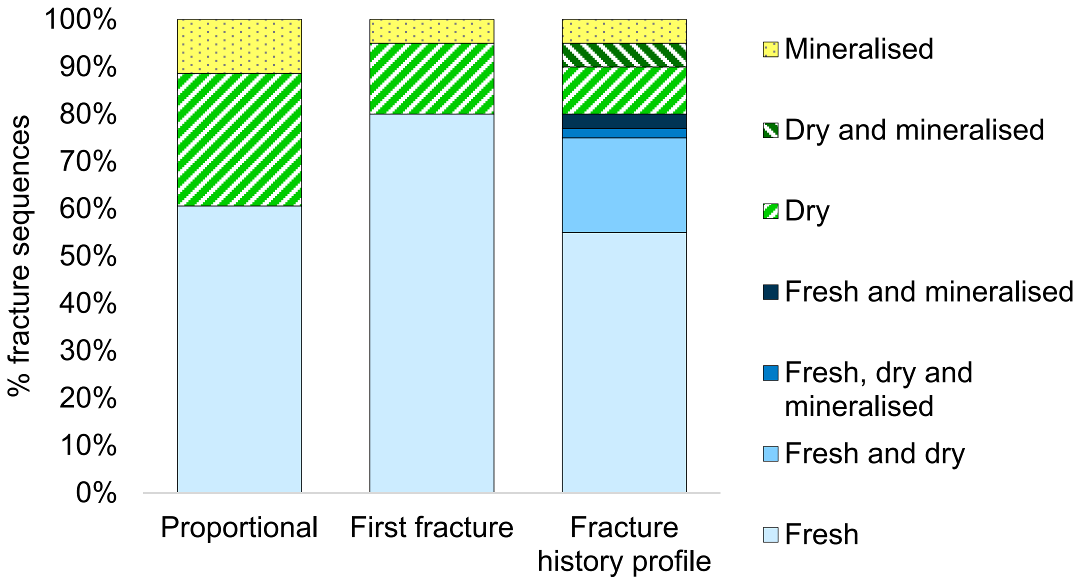

Figure 3.1: Three methods of displaying the same constructed fracture analysis data. Blue shades represent fresh fracture, green stripes dry fracture and yellow dots mineralised fracture. In the fracture history profile (right) different shades and patterns show subsequent fractures (after Johnson *et al.* 2016: 624, figure 1).

These forms of evidence will be applied to many different aspects of each case study, such as phase, context, species, individual element, and combinations thereof, depending on the sample size of the assemblage. The level of fresh fracture affecting the whole sub-sample, and within that the bones assigned to high and low marrow-yield classes, can be calculated. Fracture data will be presented per species in the same way as carcass butchery, on skeletal diagrams featuring overall fresh fracture proportions per marrow-bearing bone, in the discussion sections.

3.2.3.5 Fragmentation recording methodologies

Fragmentation is another important consideration, particularly for analysing the potential for bone grease processing. The archaeological signatures of bone grease processing, as aforementioned, involve highly comminuted cancellous (axial and articular) bone, and could also show a lack of fragmentation of non-grease bearing elements such as the ribs (Outram 2001). Other taphonomic agents of fragmentation all cause additional modifications and indiscriminately affect different types of bones (Marean and Spencer 1991; Madgwick 2014; Outram 2001). To analyse levels of fragmentation the size, weight and type of bone, both identifiable and indeterminate, should be recorded.

3.2.3.5.1 Size

For recording the size of bones it was decided not to exactly measure each specimen due to the large amount of specimens in each assemblage, primarily a time-saving decision. The system implemented uses greatest diameter, or maximum dimension, of the bone in 10, 20 and occasionally 50mm size class increments (as shown in table 3.3; see Gron 2015). For the smallest specimens, bone fragments were included if they were identifiable as bone and moveable by hand without tools (Gron 2015: 726). It was decided to increase the increments as the size classes enlarged as definition in the smallest size classes was more important in deciphering bone grease, and bones larger than 6cm are unlikely to have been a product of intensive bone grease (Janzen *et al.* 2014, but see Church and Lyman 2003 for the potential of larger bone fragments to release grease). In the analysis of Polgár-Csőszhalom (code PCS, table 3.3) it was deemed necessary to increase the number of classes in the largest end of the spectrum to give more detail due to the number of large fragments. These three largest size classes could be combined for comparison to other sites, as they were all 100mm or greater (table 3.3). A letter code was used to describe the size class for easy input, and bones sized using an incredibly efficient methodology using within a 'nest' of rings of graduated diameter (Outram 1999: 105; Aurelie Guidez pers. comm. April 2014).

Table 3.3 Size classes (mm) used in the analysis to group bones by maximum dimensions.

	Size class code									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
All	0-19	20-29	30-39	40-49	50-59	60-79	80-99	≥100		
PCS								100-149	150-199	≥200

3.2.3.5.2 Weight

It was also very important that all bones were weighed. Frequency can be misleading as a measure of how many bones are fragmented, as one bone classified as size class H could be broken into many fragments in size class B, whereas in weight these two values would be the same (Outram 2001: 408). Each identifiable bone was weighed to 0.01g individually, and indeterminate bones were weighed by size class per context, again to 0.01g. In this manner, all bones were accounted for in the weight. There was a slight problem with weighing very large and very heavy bones in that my set of travelling scales only weighed up to 500g. Occasionally a larger, less accurate set of scales was used for individual bones where the facility could provide one, but where this was unavailable the bones were given weights of 500g. Whilst this was unfortunate it was unavoidable, and 500g was considerably large enough to differentiate bones of abnormal weights from heavily fragmented bones.

3.2.3.5.3 Type

All bones were also assigned a bone type. For identifiable bones, types were allocated based on pre-determined combinations of bone zones based on Dobney and Rielly (1988; table 3.4). The frequency of indeterminate bone types within a size class within a context was counted. This analysis made it possible to compare identifiable and indeterminate bones in parity with each other, although it was not possible to compare the weights of different bone types between identifiable and indeterminate bones as frequency, not weight, was recorded per size class for indeterminate bones. This was an oversight, but graphs have been created that deal with this.

Table 3.4: Bone type codes and descriptions for identifiable bones.

Code	Definition
AR	Articular. A whole articulation of a long bone with less than 10% of the shaft.
ARF	Articular Fragment. A fragment of articular bone. This class has possibility for being used in bone grease processing or in pot-sizing.
AX	Axial. Vertebrae that are not whole.
CR	Cranial. In the identifiable assemblage this usually refers to bucrania, horn cores and antler fragments.
RIB	Rib fragment.
ES	Epiphysis and shaft. A fragment of articulation in addition to partial diaphysis. This class also has possibility for being used in bone grease processing and especially pot-sizing.
GI	Girdular. Describes fragments of pelvis and scapula. Also describes mandible fragments that do not include the marrow cavity.
PW	Partial Whole. Used for long bones that have the entire articulation and more than 10% of the shaft, and mandibles that have the marrow cavity plus the whole ascending ramus and mandibular hinge or the end of the diastema and the mandibular symphysis. Usually indicative of marrow processing.
S	Shaft. A diaphysis fragment of long bone or mandible.
W	Whole. Whole bones, especially used for the extremities such as carpals, tarsals and phalanges.

Table 3.5: Bone types recorded per size class for indeterminate bone.

>20mm	20-29mm	30-59mm	≥60mm
Indeterminate	Cancellous Diaphysis Cranial Rib	Cancellous Cranial Rib	Cancellous articular Cancellous axial Cranial Rib

3.2.3.5.4 Interpretation

This section will explain the choice of graphs used in this thesis to display fragmentation analysis concerning bone size, weight and type. These graphs indicate the amount of comminution (human or otherwise) in the assemblages, with high levels of fragmentation of cancellous bone taken as a signature for intensive grease processing. Herxheim is used as an example to show the development of graphs and explain the choices made.

The most basic form of fragmentation graph, figure 3.2, shows the weight by size class of all specimens in the assemblage. In a site or context with intensive grease processing the bones with the smaller diameters should form the heaviest size class, as a result of the systematic comminution of bones for boiling. A site where grease processing is not practised, and where depositional practices or taphonomic effects have not caused fragmentation, will present a small mass of bones in the smaller categories with many unbroken or partially broken bones in the large categories. Whilst simple, this graph still allows one to see at a glance the likelihood of grease processing on a site or context. It is shown in contrast to figure 3.3, which shows that using frequency per size class over-represents levels of fragmentation (see Outram 2001: 408).

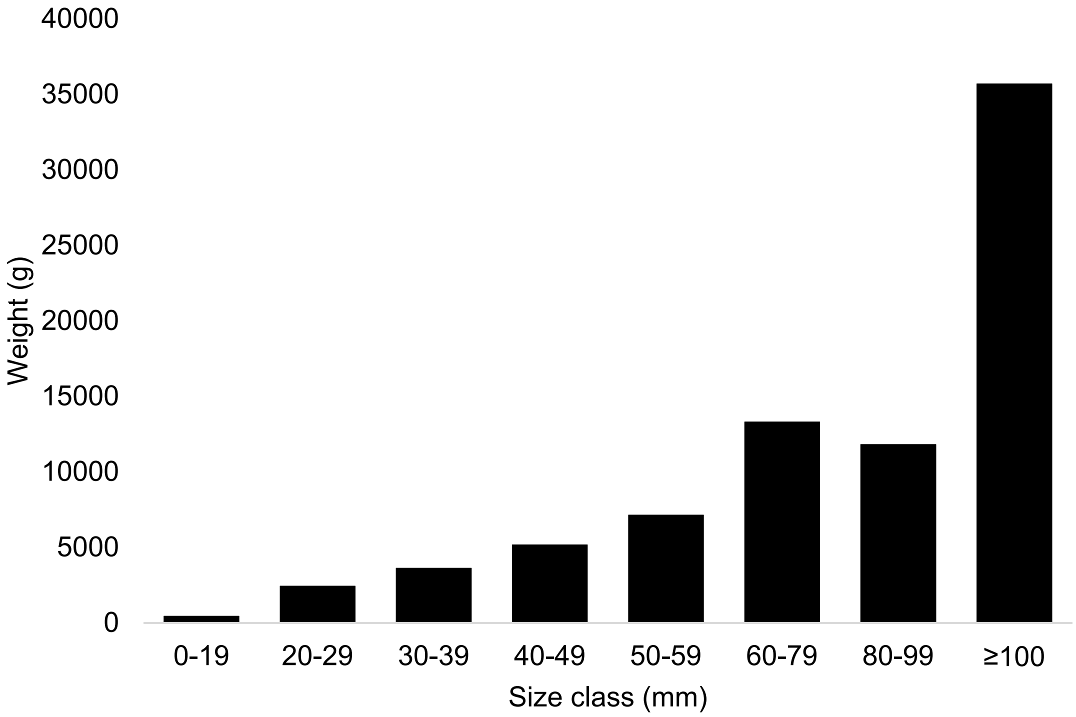

Figure 3.2: Basic fragmentation graph, showing bone weight by size class from Herxheim.

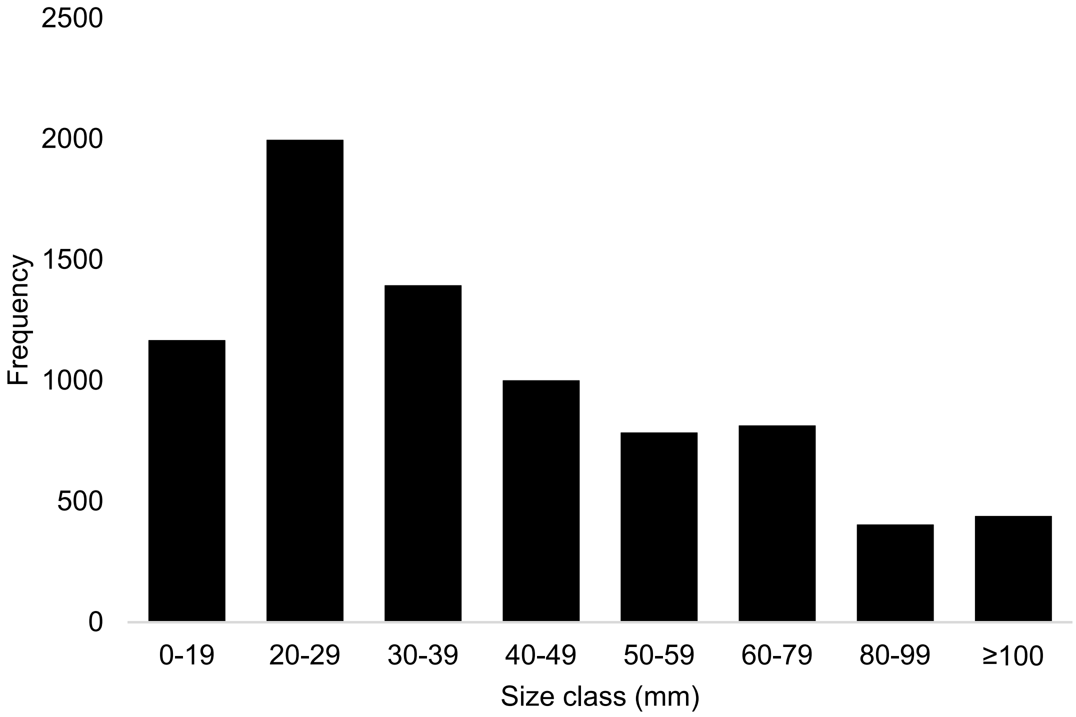

Figure 3.3: The same data using frequency against size class instead of mass.

To enhance the basic fragmentation graph two further categories were created into which specific bone types from all size classes were separated. The *unfragmented epiphyses* class includes whole long bone articulations and whole articulations with shaft fragments attached, i.e. long bones not utilised for bone grease processing, but potentially fractured for marrow (Partial Whole and Articular bone in table 3.4). Whole bones, which were clearly not fragmented for marrow or bone grease production, can over-represent the smaller size classes especially in the case of whole carpals, tarsals and phalanges. By removing them the level of fragmentation is more clearly displayed, in line with graphs of Outram and others (Outram 2001; Karr *et al.* 2010; 2015). A further change made is that indeterminate and identifiable bones are separated, which does not affect the height of the bar but includes more data in the analysis. This graph was chosen to be one of those included in fragmentation analysis for each site.

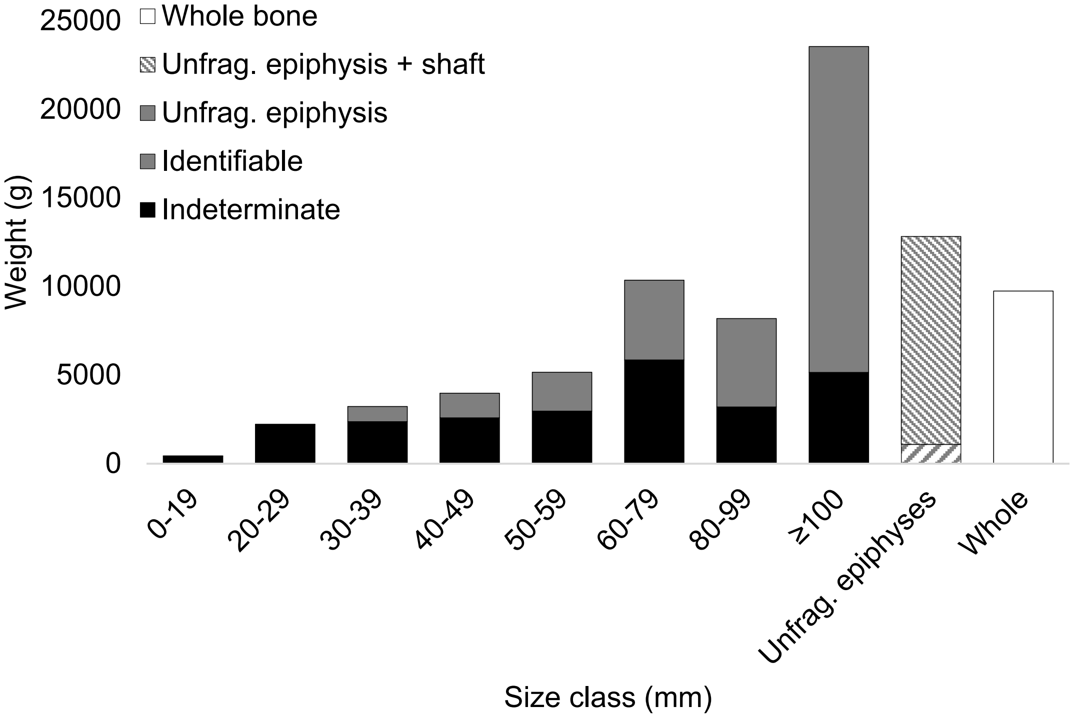

Figure 3.4: Enhanced fragmentation graph. Weight by size class from Herxheim.

A further graph that was considered was a histogram-type graph that accounted for the wider size classes. Like figure 3.4 it separates indeterminate and identifiable bones, and includes a unfragmented epiphyses (UE) and whole (W) class, but the x axis represents the width of the size classes. Whilst most size classes used in identification are 10mm wide, the first class (0-19mm) and the largest two constrained classes (60-79mm and 80-99mm) are 20mm wide (table

3.3). In figure 3.5 these three classes are increased in width and halved in height to account for this. A slight but noticeable difference is clear in the larger size classes compared to figure 3.5. However, this graph does not allow one to accurately include the final size class, "≥100", or the unfragmented epiphyses and whole categories, and so negates the point of the histogram.

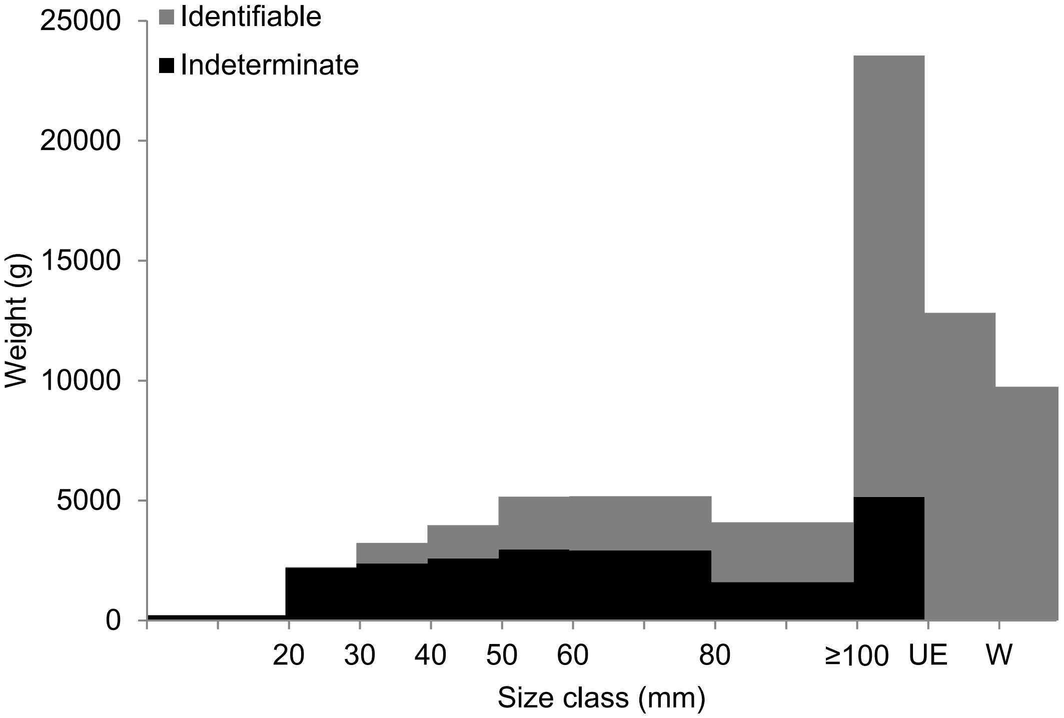

Figure 3.5: Histogram-style chart on weight by size class data from Herxheim.

The above charts are useful for seeing the level of fragmentation in the assemblage, but they do not fully describe the types of bones that were comminuted. Frequency of bone types and sizes can display the amount of comminuted cancellous bone in an assemblage or context compared to ribs, cranial material, diaphysis, girdular bone or unfragmented bones. This can further suggest grease processing through fragmentation of certain bone types (Outram 2001). High amounts of cancellous bones in the small size classes are a good indication of intentional fragmentation for bone grease processing. Large rib fragments show a well-preserved assemblage, implying that fragmentation in the smaller classes is due to purposeful comminution. Figure 3.6 shows the number of bones of certain types in each size class from both indeterminate and identifiable bones. The bones are not separated between indeterminate and identifiable, instead bones of the same type are combined to give an overall impression. See table 3.4 for a definition of different bone types.

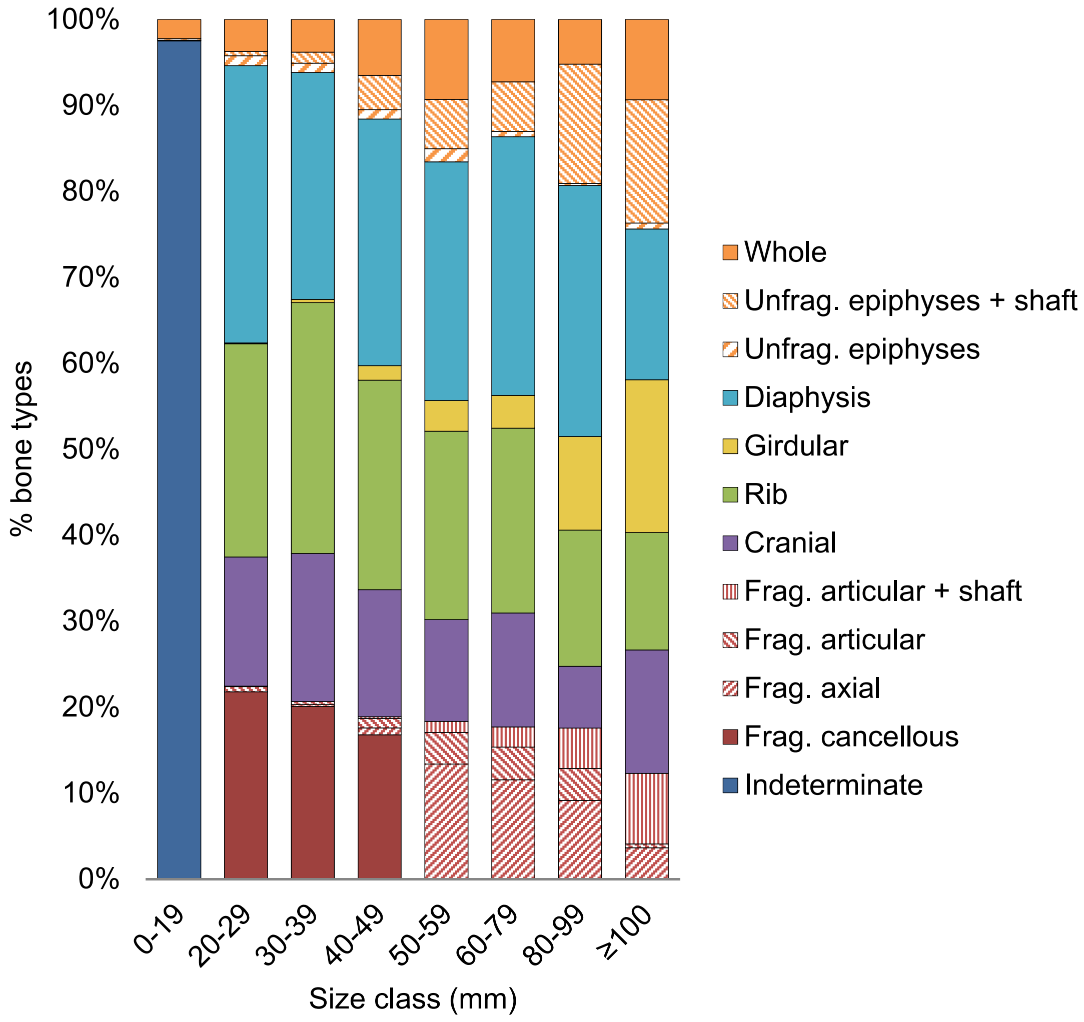

Figure 3.6: Percentage of bone types per size class based on frequency, from Herxheim. Red series indicate fragmented cancellous bone.

3.3 Taphonomy

Bone modifications can be also caused by non-human processes during biostratinomy and diagenesis. It is important to understand and record these processes as they might indicate where fragmentation was due to taphonomic disturbance, rather than human agency through bone fat processing.

3.3.1 Non-human gnawing and digestion

The remains of domestic dogs are often a feature of faunal assemblages from the Linearbandkeramik culture (Bickle and Whittle 2013: 13), so evidence of canid gnawing on skeletal material may be likely. Canid gnawing can emulate butchery marks, percussion marks and spiral fracture (Brain 1967; Blumenschine 1995; Blumenschine *et al.* 1996; Marean and Spencer 1991; Selvaggio 1994; Pickering *et al.* 2005). It can also destroy elements, specifically the less-dense articulations which are often chewed to access the marrow cavity (Brain 1981; Marean and Spencer 1991). Human bone modifications such as fresh fracture and butchery marks may be obscured by this damage. In addition, digestion of bones by dogs causes loss of surface bone and the thinning and rounding of broken edges due to exposure to stomach acid (Shipman 1981: 376-378). Rodent gnawing causes a series of short, very broad, parallel grooves which can be identified and differentiated from butchery marks with the naked eye (Potts and Shipman 1981).

The presence of gnawing could be used to interpret patterns of settlement structure and deposition. High levels of carnivore gnawing could indicate that bones were thrown purposely to dogs, or that dogs were free to roam the village, scavenging bones either from working areas or unsealed refuse pits. Rodent gnawing, similarly, suggests that rodents had access to refuse pits that lay uncovered, although bioturbation could also put bones in the reach of rodents.

3.3.1.1 Identification and recording

Gnawing on the identifiable assemblage was recorded as either canid or rodent. Canid gnawing was identified through heavy pitting and scarring of the bone surface, with occasional puncture marks (Brain 1967; Blumenschine 1995; Blumenschine *et al.* 1996; Marean and Spencer 1991; Selvaggio 1994; Pickering *et al.* 2005). Rodent gnawing was identified through parallel, u-shape scratches, usually affecting ‘edges’ of bones (Potts and Shipman 1981). Digestion was identified through loss of surface bone and exposure of trabecular bone (Shipman 1981: 376-378). On indeterminate bone, bones with evidence of gnawing were counted per context.

3.3.2 Other taphonomic agents

Other taphonomic agents that were noted were weathering, erosion (abrasion), discolouration and root etching. Sub-aerial weathering breaks exposed bones down by changes in levels of moisture and temperature, causing cracks and flaking on the bone surface (Behrensmeyer 1978; Shipman 1981: 375). Abrasion causes the surface bone to be removed, exposing the internal structure of the element, and can be caused by water movement or trampling in hard grained silt (Shipman 1981: 381; Fisher Jr 1995: 17; Fernández-Jalvo and Andrews 2003). Root etching is caused by tiny rootlets that secrete acids and dissolve the bone matrix, direct evidence of the existence of vegetation in the substrate to which the bones were buried (Shipman 1981: 375). Root etching was common in assemblages, and was only recorded when severe. Black or brown staining and discolouration caused during burial was also recorded on identifiable bones. The presence of the above taphonomic effects were recorded on identifiable bones.

3.4 Basic identifiable methodology

In addition to recording butchery, evidence of heat exposure, fracture patterns, elements of fragmentation (bone size, weight and type) and taphonomic agents for each identifiable bone, more standard zooarchaeological data was also collected.

3.4.1 Species and element identification

To identify species and element certain reference materials were used, including Barone (1976), Hillson (1999), Schmid (1972), Cohen and Serjeantson (1996) and reference collections where possible. Identifiable species were abbreviated into three letter codes using the binominal name (for example, *Bos taurus* becomes BO.T). Where the family was identifiable but not the direct species "X" was used to represent family, thus BO.X rather than BO.T (*taurus*) or BO.P (*primigenius*). Sheep and goat were recorded as a combined caprine class (CAP), but were separated where possible using Boessneck's (1969) formula for the distal metapodia and the morphological differences of the horn cores. During analysis animals are often grouped based on species, for example bovine species (bovinae, those in the genus *Bos*), suid species (suidae, those in the genus *Sus*), caprines (specifically domestic sheep and goats in the tribe Caprini), and cervid species (red and roe deer).

Long bone shafts larger than 30mm not identifiable to species or element were recorded as large/medium/small mammal long bone shaft, and were analysed as identifiable bone for carcass processing traits. Ribs and cranial elements (excluding whole horn cores) were included in the indeterminate fragments as these elements do not fracture with the same mechanical properties of marrow-bearing bones, but were useful for fragmentation analysis.

In this way, bone specimens were split into three classes based on the level of identification. Fully identifiable bone includes bones identifiable to species and element, notably including bones where the family but not exact species was recorded (for example, *Bos* sp.). Partially identifiable bones were those that had a species and element type, for example those recorded as large/medium/small mammal or *aves* for indeterminate bird bone. The third class included all indeterminate bone fragments as described in section 3.4.4. It should be noted that for analysis of species diversity bones identifiable to family only were not included as they had the possibility to represent wild or domestic animals (for example, *Bos* sp. represents both *Bos taurus* and *Bos primigenius*), but bones identified as bird were included, as they could only represent wild animals and gave an indication of use of the wild resources. These inclusions and exclusions resulted in some disparity between values reported in the three classes based on level of identification and totals reported for species diversity.

3.4.1.1 Bone zone

For describing the parts of identifiable elements Dobney and Rielly's (1988) bone zonation was used. This was modified for the pelvis, which was reduced in number of zones to 5 – the acetabulum (1), the pubis (2), the ischium (3), the ilium (4) and the auricular surface (5). Partially identifiable shaft fragments were identified as (S) for shaft, and fragmented carpals and tarsals (particularly the naviculo-cuboid) were recorded as (F) for fragment. Whole bones were recorded as (W).

3.4.2 Ageing and sexing

The fusion states of appendicular bones were noted where observable. Bones were grouped into fusion stages after Silver (1969) and a kill-off profile was constructed based on the percentage of bones fused in each fusion stage (see below). Bones that had no fusion data but were obviously neonatal were noted in the comments. Sexing by morphological characteristics was performed where possible on the mandibles of suidae and equids (based on the canines/tusks) and on the pelves of domestic cattle. However, recordable instances of sex determination were rare.

3.4.3 Other

Other features that were noted for bones were included in the comments section. Recently broken bone fragments that were refitted from two or more specimens were noted. The number of fragments involved in this refitting was recorded. Bones that articulated with another bone were also noted. Pathology was not recorded in detail but where injury, disease or anomalies were discovered this was recorded in the comments section.

3.4.4 Indeterminate bone

Data concerning indeterminate bone was stored in a separate spreadsheet. Per context, indeterminate bones were sorted into size classes and then into types of bone, as displayed in table 3.3 and 3.5, and weighed per size class per context. The frequency of bones with evidence of burning, gnawing and butchery were recorded per context.

3.5 Detecting milk in the archaeological record

The NeoMilk project uses integrated interdisciplinary analysis of the archaeological record to detect milking signatures. The primary methods used for analysing the intensity of dairying are herd structure analysis using osteoarchaeological evidence and lipid residue analysis of ceramic sherds to detect milk residues. This evidence is used in each case study and in the discussion chapter to infer the likelihood of intensive dairying. This section will describe these forms of analysis and discuss their drawbacks, concluding that the best course of action is to use these avenues of evidence together.

3.5.1 Osteoarchaeological evidence

Osteoarchaeological evidence used in this project primarily concerns age-at-death analysis of cattle, caprine and pig bones in order to construct mortality profiles and indicate herd structures. The age at which animals are killed in a human-managed herd depends on a range of factors, including seasonal environmental variation in the availability of grazing and feed, but also depending on the value placed on certain animal products (Payne 1973: 281). If animals are exploited specifically for particular products, such as meat, milk or wool, then it is economically rational to cull animals of the different sexes at different ages (Ducos 1968; Vigne and Helmer 2007). The main culling ages are detectable in the zooarchaeological record through age-at-death analysis. Fusion analysis of the post-cranial skeleton was undertaken by myself, while analysis of dental eruption and attrition was undertaken by Dr Roz Gillis.

3.5.1.1 Fusion and dental analysis

Aging of animals by their post-cranial skeleton can be undertaken based on the fusion state of certain bones. Bone develops over time from a cartilaginous structure to full ossification, with ossification centres usually forming at the diaphysis and epiphyses of long bones (Silver 1969). As these ossification centres fuse when animals reach known age ranges, the maximum or minimum age range at which an animal died can be suggested. Four age stages are identified based on the fusion ages of different bone groups by Silver (1969), which vary based on species (table 3.6). Assuming that all parts of the skeleton of all ages of animal are represented for each species, fusion percentages calculated for each stage should decrease over time as animals are slaughtered. If there is a large drop in the percentage of bones that are fused between stages this indicates that a proportion of animals were killed at this age stage.

Table 3.6: Age ranges for fusion of different skeletal elements for cattle, caprines and pigs (Silver 1969).

	CATTLE	CAPRINES	PIGS
Stage 1	**7-10 months**	**6-10 months**	**12 months**
	Scapula – bicipital tuberosity Pelvis – fusion of main bones	Scapula Pelvis	Scapula Pelvis Distal humerus Proximal radius Proximal phalanx 2
Stage 2	**12-18 months**	**13-16 months**	**27-30 months**
	Distal humerus Proximal radius Proximal phalanx 1 Proximal phalanx 2	Distal humerus Proximal radius Proximal phalanx 1 Proximal phalanx 2	Proximal phalanx 1 Distal metapodia Distal tibia Calcaneum
Stage 3	**24-36 months**	**18-28 months**	**37-42 months**
	Distal tibia Distal metapodia	Distal tibia Distal metapodia	Proximal humerus Distal radius Proximal ulna Proximal femur Distal femur Proximal tibia
Stage 4	**37-48 months**	**30-42 months**	**NA**
	Proximal humerus Distal radius Proximal ulna Proximal femur Distal femur Proximal tibia Calcaneum – tuber calcanei	Proximal humerus Distal radius Proximal ulna Proximal femur Distal femur Proximal tibia Calcaneum	

Analysis of age-at-death using the dentition considers eruption and attrition of teeth, and was undertaken by Dr Roz Gillis. As with fusion ages, teeth erupt through the mandible at known age stages in cattle and caprines. This is also true for pigs, although as this species cannot produce milk in the same way as ruminants (Ellendorff *et al.* 1982), this species was not targeted for dental age-at-death analysis. As grass-fed ruminants have a typically unvaried diet their teeth wear down over time producing patterns that can again be attributed to certain age stages. This data is presented using mortality profiles showing frequency density, and therefore increase where there is most evidence for slaughter (Payne 1973; Vigne and Helmer 2007; Gerbault *et al.* 2016; Gillis in prep.; unpub.).

3.5.1.1.1 Recording

All identifiable bones in Silver's (1969) table were analysed for fusion. On teeth, only mandibular teeth were targeted by Gillis, following Ducos (1968) for all species; Payne (1973) and Helmer and Vigne (2004) for caprines; Grant (1982) and Legge (1992) for cattle (Gillis in prep.; unpub.).

3.5.1.1.2 Interpretation

Based on decreases in the percentage of fused bones in different age stages, or the frequency density of mandibular teeth of different ages, past herds can be compared against 'idealised' herd structures (Payne 1973; Legge 1981; Legge 2005; Gerbault *et al.* 2016). Specialised dairy farming is characterised by slaughter of very young males (Payne 1973), and the surviving dairy herd is shown in fusion analysis through a strong survival of adult individuals. Females may be slaughtered later in life when milk production wanes (Gillis pers. comm.). Such a pattern has been identified at archaeological sites such as Grimes Graves where a high proportion of young slaughter, in conjunction with sex ratios that suggest few males made it to adulthood, strongly suggests husbandry directed towards the production of milk, rather than meat (Legge 1981; 1992: 18-33). While osteological analysis of sex was not completed during the NeoMilk project, high proportions of young slaughter and adult survival can indicate a herd managed for diary. Meat animals may be exploited particularly when they are tender, or when they reach maximum size and weight (Vigne and Helmer 2005; Payne 1973). Males may be castrated a few months before slaughter to improve weight gain (Payne 1973: 301). In a wool herd, males and females may both be kept alive until wool production declines (*ibid.*).

3.5.1.2 Drawbacks

It is beneficial to combine fusion and dental analysis due to the problems unique to fusion analysis. Firstly, fusion analysis can only be utilised up to the point at which growth is complete, for cattle around four years, and for caprines and pigs around three-and-a-half (Silver 1969; Payne 1973). Animals may clearly live beyond these ages, especially breeding animals or dairy females. Dental analysis can continue to age skeletally adult animals through wear stages on teeth, and can thus give greater resolution to slaughter patterns affecting adult animals. Secondly, fusion analysis can only indicate that an animal must be older than the minimum, or younger than the maximum, age stage range boundaries, rather than giving a direct age-at-death age stage as is possible with dental analysis. Therefore, it is beneficial to use these methodologies in tandem as ageing using the dentition can give better resolution to both sub adult and adult aged animals.

A further problem affecting fusion analysis more particularly than dental eruption and wear is the difficulties of separation of sheep and goats. While seen as traditionally difficult (Payne 1973) it is now possible to differentiate between sheep and goat teeth morphologically and chemically through isotope analysis (Halstead *et al.* 2002; Balasse and Ambrose 2005). Sheep and goat can also be distinguished postcranially (Payne 1969; Boessneck 1969; Zeder and Lapham 2010), but due to time constraints and fragmentation of bones only the metapodia (Boessneck 1969) and horn cores were positively identified as sheep or goat. Using a “caprine” class thus can be problematic when analysing herd structures due to the different physiological capabilities of sheep and goat, which may result in different exploitation strategies for each species. In fusion analysis, a mixed caprine profile may obscure different patterns of husbandry for sheep and goat, but separation of these species in dental eruption and wear analysis may reduce the sample size. Problems with sample size primarily affect dental analysis, although recent advances in methodologies for representing and comparing mortality profiles use the Dirichlet distribution to generate Bayesian credible intervals based on simulated datasets for each age class, which reduces the problems of low sample sizes (Gerbault *et al.* 2016).

Related to the problems of sample size are problems of equifinality, where varying production strategies may produce similar profiles (Halstead 1989). This is primarily caused by partial and biased survival and retrieval affected by taphonomy, deposition and excavation strategies (*ibid.*). Unfused bones (and very young mandibles) are more fragile than fused bones, and this differential preservation may underrepresent young slaughter (Payne 1973). In addition to this, differential deposition of animals of different ages and different skeletal elements may also skew profiles. If certain age animals (for example, prime meat age) are sent to different sites to be consumed then these animals may be missing from the archaeological record. Similarly, natural infant mortality may happen outside the settlement and therefore not be deposited on site. If butchery practices result in the deposition of some skeletal elements (such as heads) in different areas of the site than others (such as the postcranium), then excavation area may only pick up one of these depositions and thus give varying signals for the dental and fusion ageing. Finally, poor recovery may impact slaughter profiles particularly of small unfused bones in unsieved samples. These factors may cause contradictions in the profiles based on teeth and fusion.

Finally, interpretations of slaughter profile may be problematic as many models are based on idealised herd structures (Payne 1973; Greenfield and Arnold 2015). No society, other than modern industrial societies, ever raise herds exclusively for their secondary products (Greenfield and Arnold 2015: 812). Subsistence producers will rarely focus on a single product from their herds, and herds are more frequently exploited in a mixed economy (*ibid.*). Models to identify mixed profiles, including exploitations of meat, milk and wool, have been suggested by Vigne and Helmer (2005).

If these drawbacks are considered osteoarchaeological analysis may still provide interesting and useful data about herd structures in past societies. With advances in statistical modelling and greater understandings of the problems of equifinality, as well as corroborations with other forms of archaeological evidence, these analyses form a valuable contribution to our understanding of animal husbandry in the past.

3.5.2 Lipid residue analysis

Lipid residue analysis can be used to exploit the wealth of biochemical data preserved in archaeological pottery. When ceramic vessels are used for storing and preparing commodities, markers of cultural and economic information are stored within (Evershed *et al.* 2008a; 2008b). The $\delta^{13}C$ values of individual fatty acids are determined using a gas chromatogram linked to an isotope ratio mass spectrometer (IRMS; NeoMilk website). Isotopic compositions of the fatty acids are linked to the metabolism of the animals from which they derive, based on reference collections from modern animals (*ibid.*). Molecular and stable isotope techniques now exist for identifying fats of the major classes of domesticated animals, (ruminants and non-ruminants), dairying fats, some hunted terrestrial species and fish (Dudd and Evershed 1998; Copley *et al.* 2003; Evershed *et al.* 2002; Evershed *et al.* 2008a; 2008b; Outram *et al.* 2009; Outram *et al.* 2012; Hansel *et al.* 2004, Smyth and Evershed 2016). Seasonal use of animals has also been identified using deuterium isotope analysis (Outram *et al.* 2009). The detection of beeswax is possible and has been used to infer widespread exploitation of the honeybee by early Neolithic farmers, either for honey or for waterproof beeswax (Salque *et al.* 2013; Roffet-Salque *et al.* 2016). It is also now possible to date pottery directly from lipid residue analysis by accelerator mass spectrometry (AMS; Berstan *et al.* 2008; Roffet-Salque *et al.* 2016). The ubiquity of preserved animal fats, and the recent advances in methodologies in detecting them, has resulted in an archaeological analysis that could detect changes in culture and economy. Depending on sample sizes and the types of contexts targeted, it may be possible to see these changes over time, or perhaps spatial focus within settlements on different dietary products. It can also show the differential use of pottery types for specific tasks (Bogucki 1984; Salque *et al.* 2013; Roffet-Salque and Evershed 2015).

3.5.2.1 Drawbacks

Lipid residue analysis has a major drawback in that it relies on animal fats being processed in pottery in the first place. It is very likely that animal products were often collected, stored and processed in organic, perishable containers, made from wood or plant material or animal skins/organs (Roffet-Salque *et al.* 2016). Not only is this often attested ethnographically (for example Lee 1993; 129-30; Herodotus *Histories*), but it is also suggested by lipid residue analysis of ceramics from Ludwinowo 7. While ceramic sieves were shown to contain milk residue other ceramic sherds showed limited evidence of use in processing dairy (Salque *et al.* 2013). The product poured into the sieves must have been poured from another container, perhaps into another container below the sieves. The lack of milk residues in ceramic vessels indicates that these containers were made of organic material not preserved in the archaeological record. This limitation means that milk use may have been more intensive than suggested by the lipid residue analysis, although this does not diminish the evidence of dairy fats in ceramics when they are detected.

3.5.3 Summary

These methods for detecting milk in the archaeological record may seem to be particularly problematic, but combined they give a much more valid and complete picture of dairying. It is worth noting that while absence of dairy signatures cannot be taken as absence of dairying (Roffet-Salque *et al.* 2016), *presence* of signatures for a dairying economy are unlikely to be caused erroneously in the archaeological record (Halstead 1989).

3.6 Applying methodologies – case study structure

This chapter has explained the methodologies used to analyse each of the twelve case studies targeted by this thesis. These case studies will now be presented, roughly in chronological and regional groupings, from the Linearbandkeramik and other Neolithic cultures. Sites will first be introduced with a description of the settlement structure, surrounding environment and date ranges. Sampling decisions will then be described and a numerical overview of the assemblage will be given, including identifying contexts to be focussed on for comparison based on phase, area or individual contexts. The species abundance will then be given for the whole site and for the comparable contexts. Carcass processing practices will be analysed, including butchery patterns, evidence for heat exposure, and fracture and fragmentation analysis. Taphonomic indicators will be used to assess deposition practices, and the likelihood for impact of non-human agents on the assemblage. Percentages are often used to describe data, and are followed by their raw values in the format “x/y”, where “x” is the number of positives and “y” is the total. Where “n=” is used, n refers to the total. The statistical viability of differences will be tested using a chi-squared test of proportions (Chi-Squared Test website), and correspondences between variables will be displayed using PAST correspondence analysis (PAST website). Food exploitation strategies will be studied to discuss the evidence of herd structure analysis, lipid residue analysis, and if present archaeobotanical analysis. All this data will be brought together in the discussion section, which will also present carcass processing profiles for the major domestic species on each site.

Chapter 4 Füzesabony-Gubakút

4.1 Introduction

The site of Füzesabony-Gubakút is located in the Heves County region of Northern Hungary, and was excavated between 1995-1996 on the proposed route of the M3 motorway (Domboróczki 2009: 78). The settlement was built on both West and East banks of the Laskó river, situated on a wooded plain in the approaches to the Northern Central Hills (Vörös unpub. 2). Two rows of large-scale (12-16 x 5-6m) triple-portioned wooden-framed houses and associated pits and graves were built on each bank (*ibid*. 2; Domboróczki 2009: 78; figure 4.1). The houses face each other across the stream, rather than adopting the same orientation, following a strict adherence to architectural tradition suggesting a settlement that was planned and organised (*ibid.* 80, 98).

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of this thesis for copyright reasons

Figure 4.1: Site plan of Füzesabony-Gubakút. Note the separation of the western settlement (left) and the eastern settlement (right), both with settlement rows 1 and 2 (from left to right). From Domboróczki 2009: 78, figure 3.

Radiocarbon dating has placed activity on the site between 5500-5200BC, attributed to the Alföld Linear Pottery Culture (ALPC), the equivalent of the LBK culture on the Great Hungarian Plain (Domboróczki 2009: 80; Bickle and Whittle 2013: 10). The ALPC has different pottery styles to the LBK and connections with the southern Vinča culture (Bickle and Whittle 2013: 49). Unlike many LBK regions the ALPC was not the first Neolithic community in this area, following the early Neolithic Körös culture (Raczky and Anders 2012: 273; Kalicz and Makkay 1977: 38-56; Bánffy 2004; 2008; Whittle 2007). Five phases of ALPC activity were identified at Füzesabony-Gubakút (table 4.3) with a ‘golden age’ in Phase IV (Domboróczki 2009: 83-84). Surface finds and surveys outside the excavation area suggest that the settlement rows extended some distance, and likely two thirds of the settlement remain unexcavated (*ibid.* 95-96).

The Gubakút area was a locale of intensive ALPC activity, featuring many largely contemporaneous interconnected central and satellite settlements (Domboróczki 2009: 102-103). Domboróczki has suggested that within the settlement at Füzesabony-Gubakút there were close kinship ties, with descendants both staying on at the settlement and moving to the surrounding area (2009: 98). Sites are situated between 800 and 1200 metres from each other, possibly determined by pasture needs based on zooarchaeological analysis of herd size from Füzesabony-Gubakút (Domboróczki 2009: 110; Vörös unpub.). The settlement network in the Gubakút area likely collapsed in the final phase of the ALPC due to drastic changes in the region, possibly violent attack or migration caused by climatic change (Domboróczki 2009: 98).

4.2 Assemblage

4.2.1 Sample

The Füzesabony-Gubakút faunal assemblage was sampled, with contexts chosen based on size and phase, although due to time constraints some could not be analysed in full (table 4.4). Based on the total bone count from István Vörös's zooarchaeological report (n=8489) it can be estimated that 50% of the site has been analysed (Vörös unpub.), totalling 4491 specimens (table 4.1). Any difference in values for fully identifiable specimens and species representation (figure 4.2) is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 4.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Füzesabony-Gubakút (FUG).

Fully identifiable (to species and element)	761
Partially identifiable (to species and element type)	1346
Indeterminate	2384
Total	**4491**

The faunal assemblage from Füzesabony-Gubakút could be divided for analysis in two primary groupings based on area and phase. Contexts were separated into material from the West and East bank (table 4.2), and occasionally into settlement rows. The five phases of activity on the site were condensed into four by the zooarchaeological report, considering the overlap of phases II and III (table 4.3; Vörös unpub.). Phase IV was the best represented by the animal bone material sampled, including contexts “likely” belonging to phase IV, making up 62.9% (1429/4491) of the selected assemblage.

Table 4.2: Number of fully identifiable, partially identifiable and indeterminate specimens from the East and West settlement areas from Füzesabony-Gubakút.

	Fully identifiable	Partially identifiable	Indeterminate
East	234	282	547
West	520	1058	1813
Unknown	7	6	24

Table 4.3: Number of fully identifiable, partially identifiable and indeterminate specimens dated to each phase from Füzesabony-Gubakút (phases and date ranges from Domboróczki 2009).

Phase	Date range	Fully identifiable	Partially identifiable	Indeterminate
I	5620-5470	80	62	122
II-III	5490-5300	93	209	421
IV	5325-5220	467	925	1429
V	5170-5000	90	106	348
Unknown	?	5	17	25

Table 4.4: Full list of contexts analysed from Füzesabony-Gubakút.

Object	Modifier	Phase	Area	Row	Fully identifiable	Partially identifiable	Indeterminate
14	0	IV	East	1	3	4	7
19	0	IV	East	2	53	123	101
21	0	V	East	1	36	85	300
35	0	IV	West	2	28	81	106
36	0	II-III	West	2	5	19	65
36	1	?	West	2	4	5	0
36	2	?	West	2	1	12	25
44	0	Likely IV	West	1	32	54	66
45	0	II-III	West	1	66	155	232
46	0	Neolithic	?	?	4	6	23
51	0	I	West	1	61	62	114
52	0	IV	West	1	29	72	89
53	0	IV	West	1	106	250	550
54	0	IV	West	1	26	29	68
57	0	Neolithic	West	1	4	0	0
61	0	IV	West	1	10	2	1
61	1	IV	West	1	51	87	136
61	2	II-III	West	1	22	35	124
61	3	Neolithic	West	1	15	21	15
63	0	IV	West	1	60	174	222
117	0	Neolithic	?	?	3	0	1
131	0	IV	East	1	58	45	64
133	0	IV	East	2	10	4	18
133	A	IV	East	2	1	0	1
134	0	V	East	2	54	21	48
135	0	I	East	2	19	0	8

4.3 Species representation

4.3.1 Site

Cattle and caprines dominated the faunal assemblage, making up 37.1% (273/735) and 35.2% (259/735) of the overall number of identifiable specimens respectively (NISP; see figure 4.2). Pigs were relatively uncommon on the site (8.8%, 65/735), and dogs were only rarely identified (7/735). Wild animals made up 17.8% (131/735) of the NISP, a figure unusually high at LBK sites. Wild boar were the most common wild animal (6.1%, 45/735), with roe (4.1%, 30/735) and red (3.4%, 25/735) deer and aurochs (1.6%, 12/735) following, although it is possible that some domestic cattle or pigs were misidentified as their wild counterparts, or vice versa. Wild birds, species of hare and wild equid were also represented (2.6%, 19/735), and there was scant evidence of consumption of fish and molluscs (Domboróczki 2009: 106). This suggests a picture of varied exploitation of wild habitats for hunting (see also Vörös unpub.).

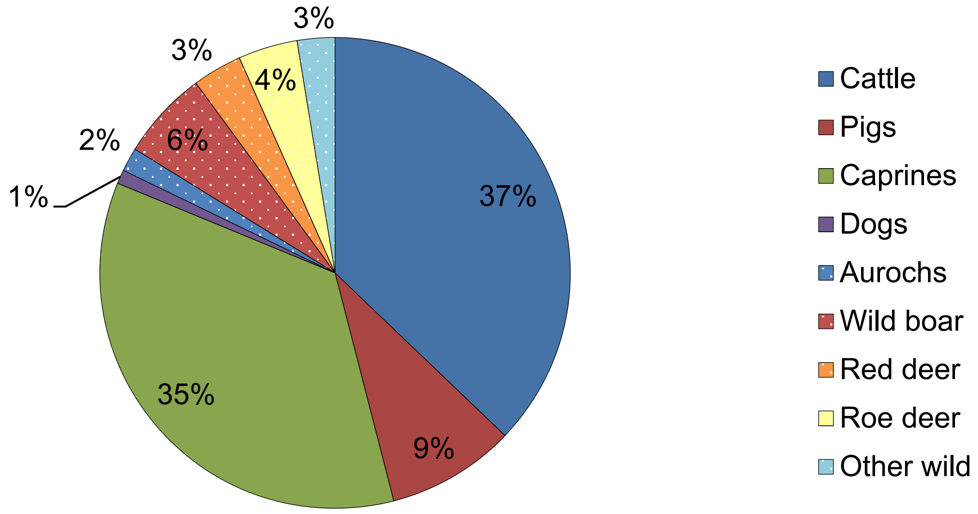

Figure 4.2: Species representation (NISP) for the fully identifiable Füzesabony-Gubakút assemblage (n=735).

Vörös's in-depth zooarchaeological analysis constructed diet per household based on the contents of household pits. He suggested that the meat represented would have easily fed a family of five for five years (Vörös unpub.; Domboróczki 2009: 107). He postulates that small family communities at Füzesabony-Gubakút were supported by their own herds of cattle and sheep and thus always had a reliable source of food, sometimes supplemented with wild meat (Vörös unpub. Domboróczki 2009: 108).

4.3.1.1 Phase

The species diversity by phase shows changing patterns of species exploitation over time (figure 4.3; table 4.5). Phase I was dominated by cattle and caprines, and red deer were the best represented wild species. In phases II-III, numbers of cattle decreased significantly (p=.002; see values in table 4.5) and were replaced by an intensification of small stock management that affected both caprines and, notably, pigs (a significant increase; p=.006). Wild boar, equids and birds were more intensively exploited, although the proportion of domestic to wild animals remained more or less constant. Phase IV, the best represented phase in terms of the NISP, had an increase in cattle numbers at the detriment of pigs, whilst the amount of caprines remained unchanged. Use of wild fauna diversified to include hare and wild birds. Phase II-III and IV were the only phases where domestic dogs were represented skeletally. In the final phase cattle were once again the best represented food animal at 60.7% (37/61) of the number of identifiable domestic specimens. Caprines decreased significantly compared to phase IV (p<.001), far more than pigs. The most substantial change in species representation however is the significant increase in the proportion of wild animals to domesticates (p<.001), particularly wild boar and roe deer. Wild fauna could have been more heavily relied upon in this phase due to the rapid changes and collapse of the ALPC culture in this region (Domboróczki 2009: 98).

Table 4.5: Species diversity (NISP) for each context group from Füzesabony-Gubakút.

Phase	Cattle	Pigs	Caprines	Dogs	Wild	Total
I	37	3	23	0	12	75
II-III	24	16	35	1	15	91
IV	164	39	178	6	69	456
V	37	6	18	0	27	88
Area	**Cattle**	**Pigs**	**Caprines**	**Dogs**	**Wild**	**Total**
East	93	17	56	0	57	223
West	176	48	210	7	71	512

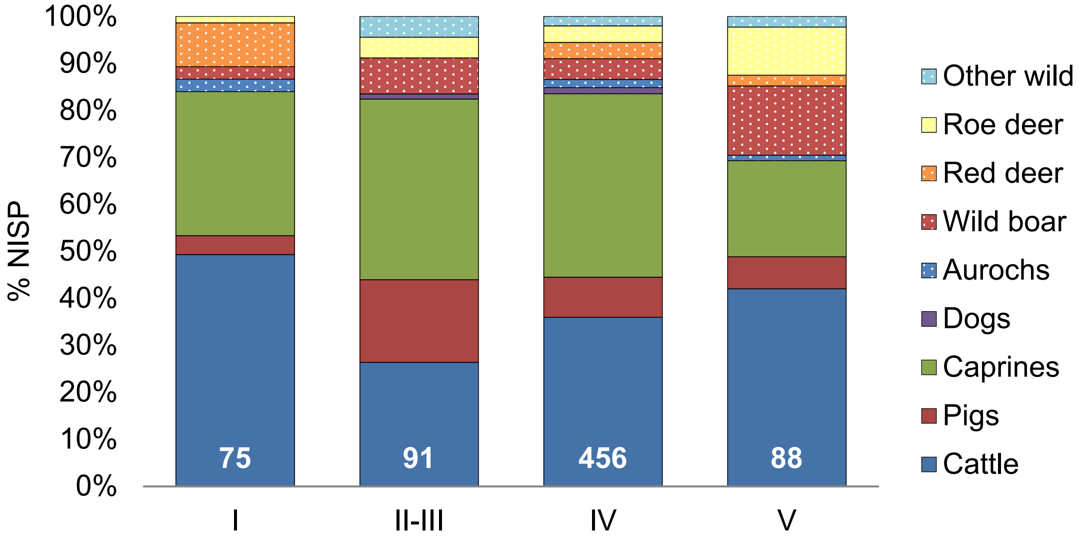

Figure 4.3: Species representation (NISP) for each phase from Füzesabony-Gubakút. N values are at the base of each bar.

4.3.1.2 Area

The largest difference in species diversity between the settlements on the West and East banks was the proportion of wild animals, which was significantly higher in the East portion of the settlement (p<.001; figure 4.3; table 4.5), likely because it is represented by Phase V contexts. Of the domestic animals, cattle were significantly more common in the East settlement than in the West (p=.018), while caprines were significantly better represented in the West than the East (p=.024). The settlement rows largely reflect trends for each bank, although wild animals were better represented in row 1 in each bank (figure 4.5).

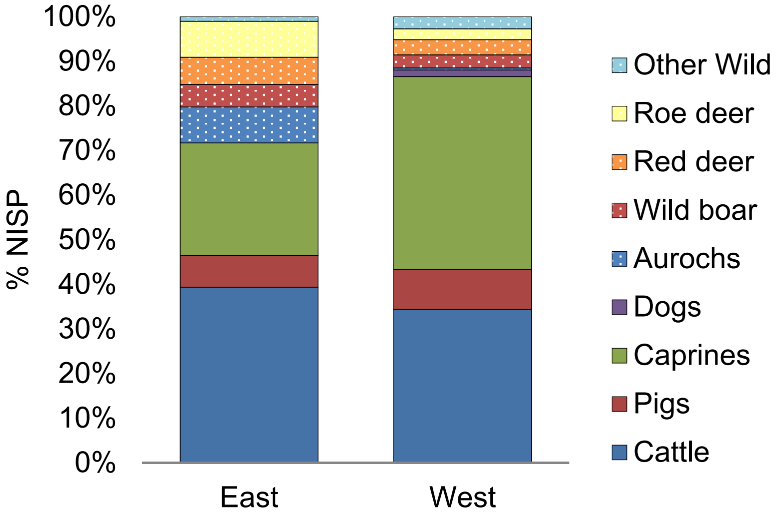

Figure 4.4: Species representation (NISP) for contexts on the West (n=457) and East (n=99) bank of Füzesabony-Gubakút.

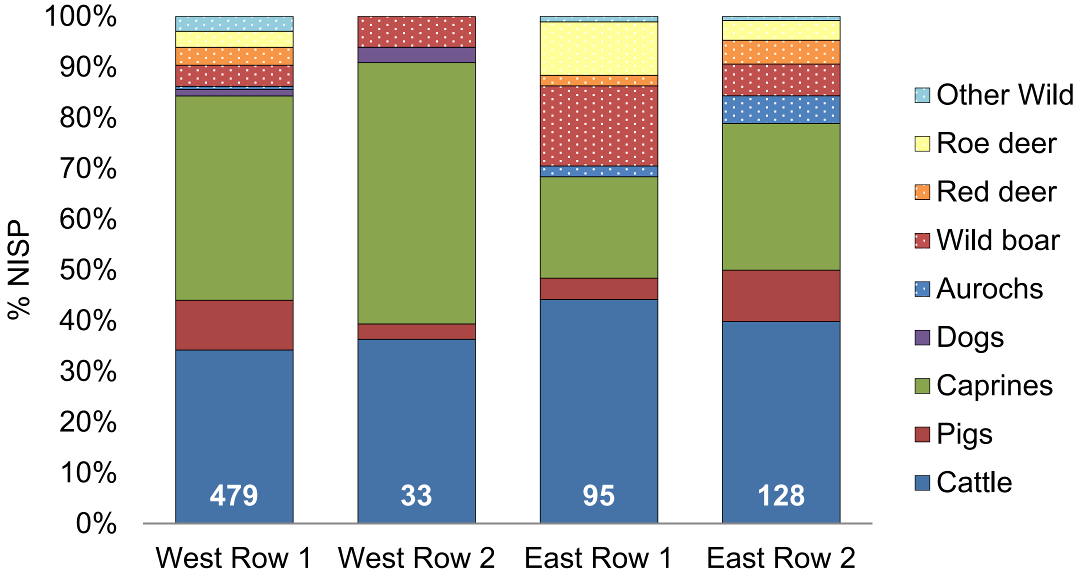

Figure 4.5: Species representation (NISP) for different settlement rows from Füzesabony-Gubakút.

4.4 Butchery

4.4.1 Site

Incidences of butchery were very low throughout the site, with 0.9% (49/4991) of the overall assemblage affected by butchery marks. The low prevalence of butchery marks rendered the use of butchery by element diagrams largely impossible (but see figure 4.10). In the identifiable assemblage, as detailed in figure 4.6, cut and/or scratch marks were present on 1.6% (33/2107) of specimens. Butchery was most prevalent in phase II-III and least prevalent in phase V, although all phases were under 2.5% of the identifiable assemblage in proportion (figure 4.7).

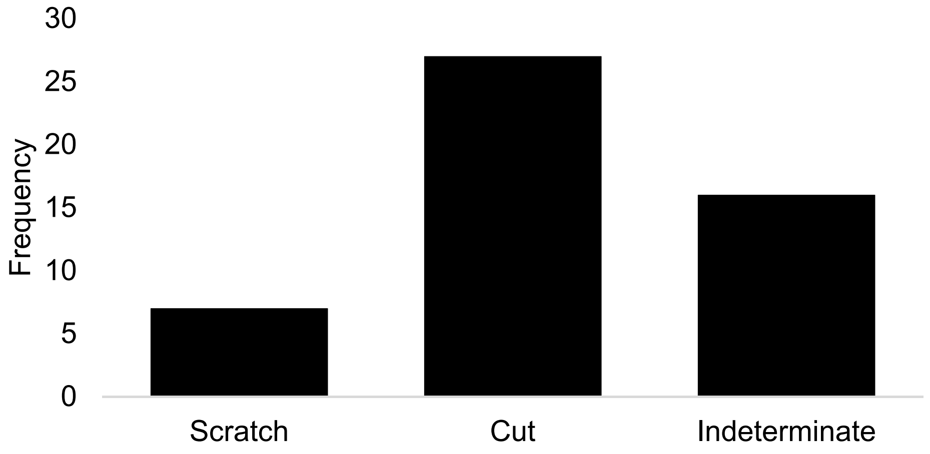

Figure 4.6: Frequency of butchery mark types from Füzesabony-Gubakút.

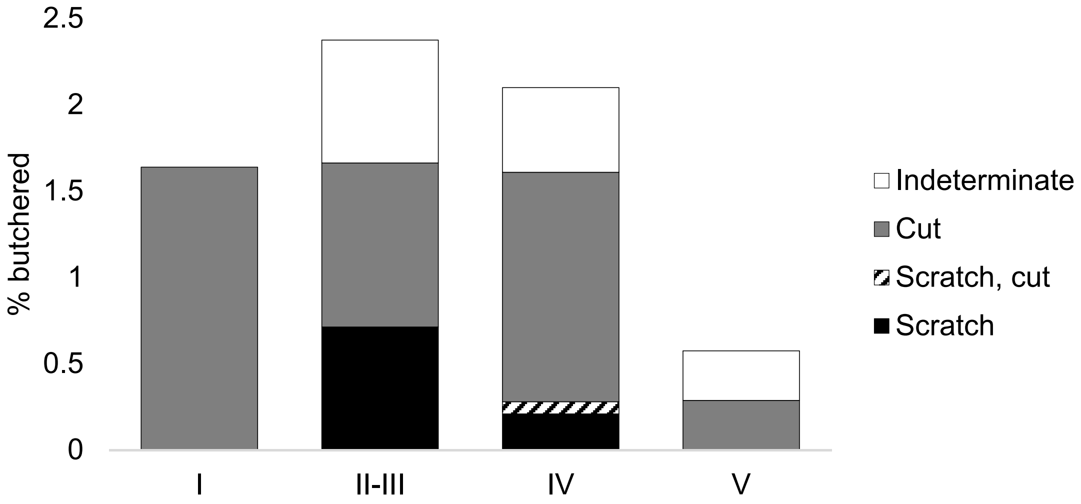

Figure 4.7: Percentage of specimens from each phase with different butchery episodes from Füzesabony-Gubakút.

4.4.2 Species

Surprisingly, dogs were the species most commonly affected by butchery marks (figure 4.8), likely a result of small sample size. Large mammals presented more evidence of butchery marks than the smaller domestic and wild animals although no heavy butchery (chopping or percussive crushing) was noted on this site.

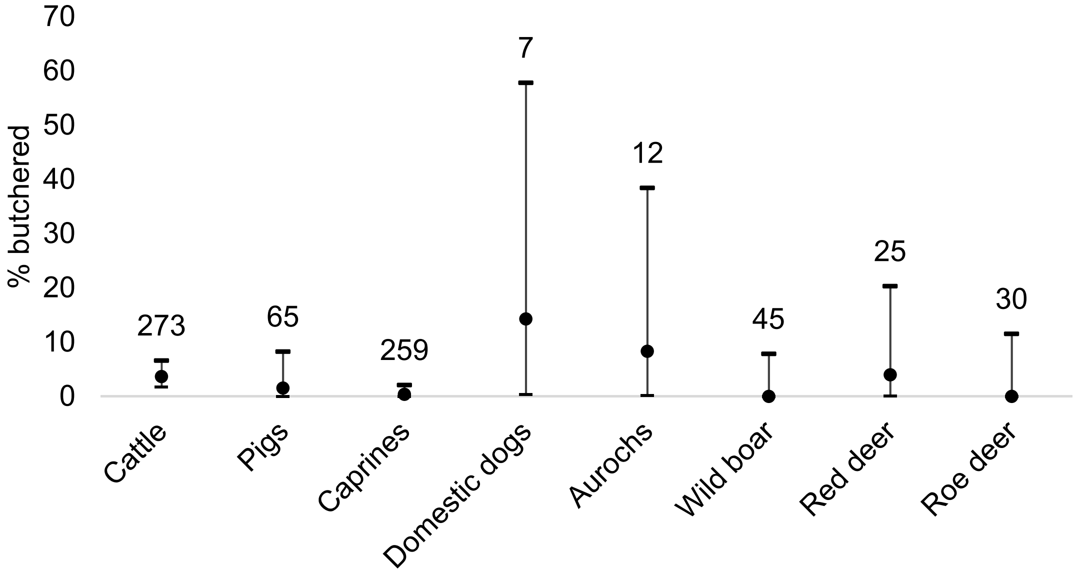

Figure 4.8: Percentage of species with butchery marks from Füzesabony-Gubakút, with 95% confidence intervals. N values are at the top of each series.

4.4.3 Carcass butchery

The majority of carcass parts were affected rarely by butchery. Bones belonging to the forelimb, hindlimb and extremities were butchered in similar proportions, with the cranium and partially identifiable diaphysis shafts showing less evidence (figure 4.9). The forelimb was the most commonly butchered carcass portion. On the radius and ulna, butchery marks clustered around the proximal epiphysis, showing short, distinct, repeated cuts (4.10). The butchery patterns indicate disarticulation from the humerus and possibly defleshing.

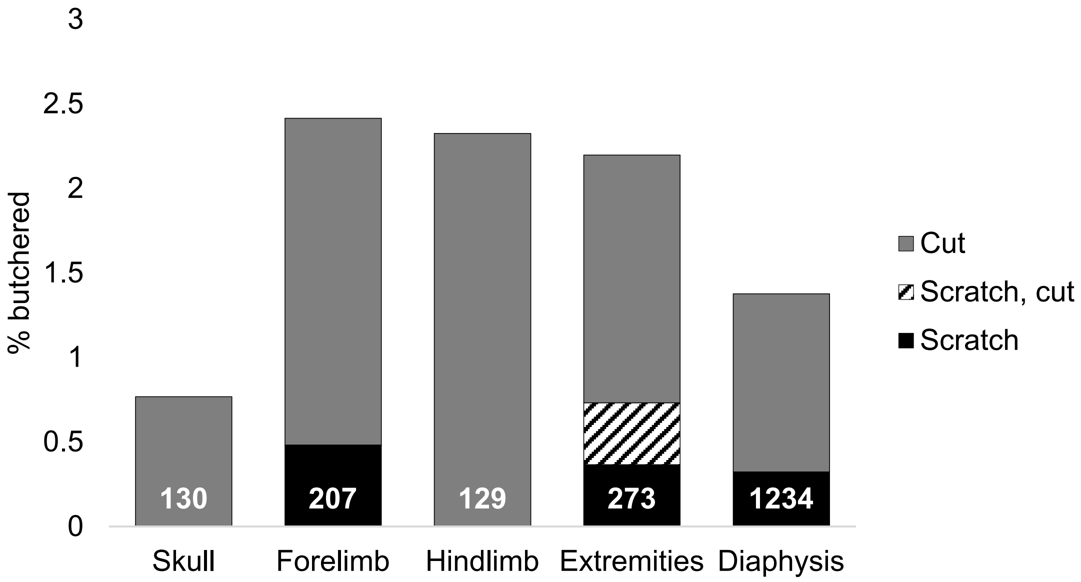

Figure 4.9: Percentage of carcass parts affected by different butchery episodes from Füzesabony-Gubakút.

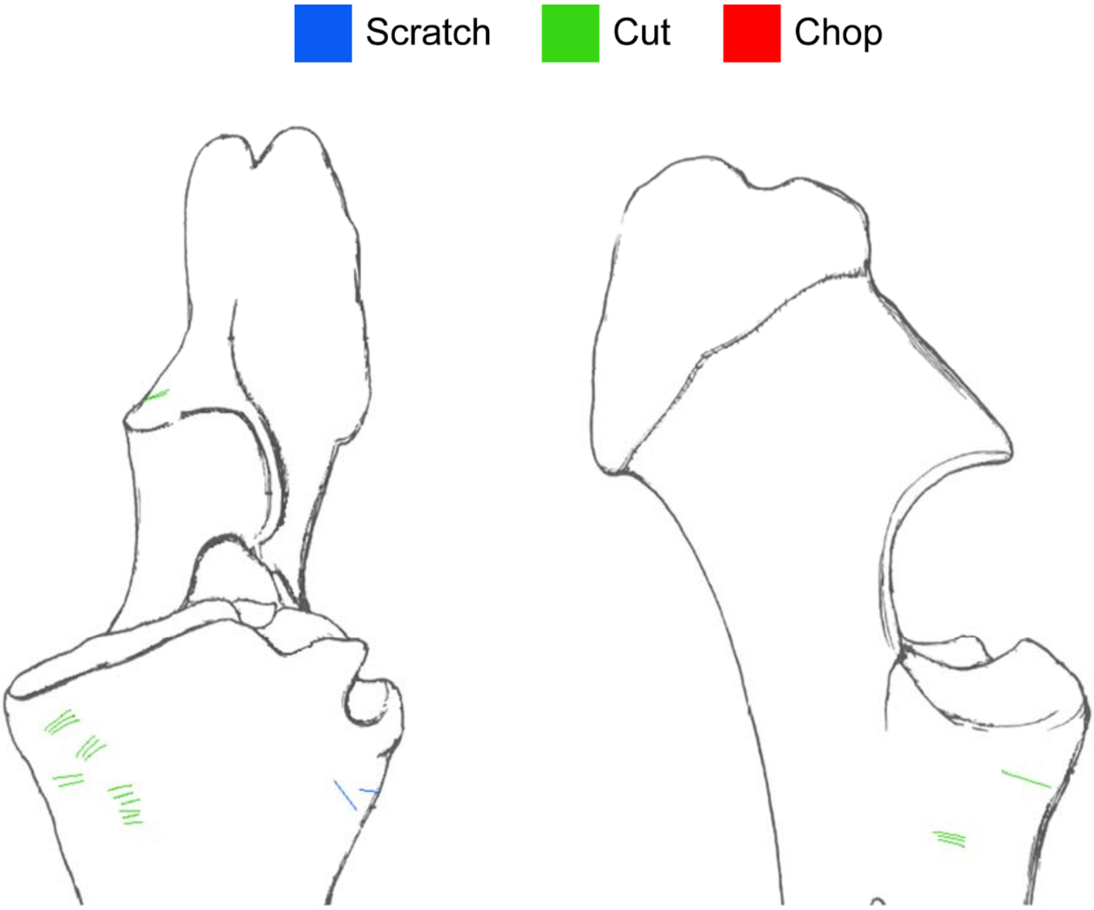

Figure 4.10: Cumulative diagram of butchery on cattle radii and ulnae (n=3) from Füzesabony-Gubakút. Anterior (left) and medial views.

4.5 Heat exposure

4.5.1 Site

Evidence for bones exposed to heat was encountered uncommonly at Füzesabony-Gubakút, present on 3.0% (152/4491) of the whole assemblage (5.3% of identifiable bones, 111/2107). Figure 4.11 shows that roasting was the most common type of heating activity to affect bones, with colour and texture changes suggesting very light roasting also noted. This type of heat exposure was identified based on a lighter brown colour change compared to full roasting, and slight drying and cracking of bone surfaces.

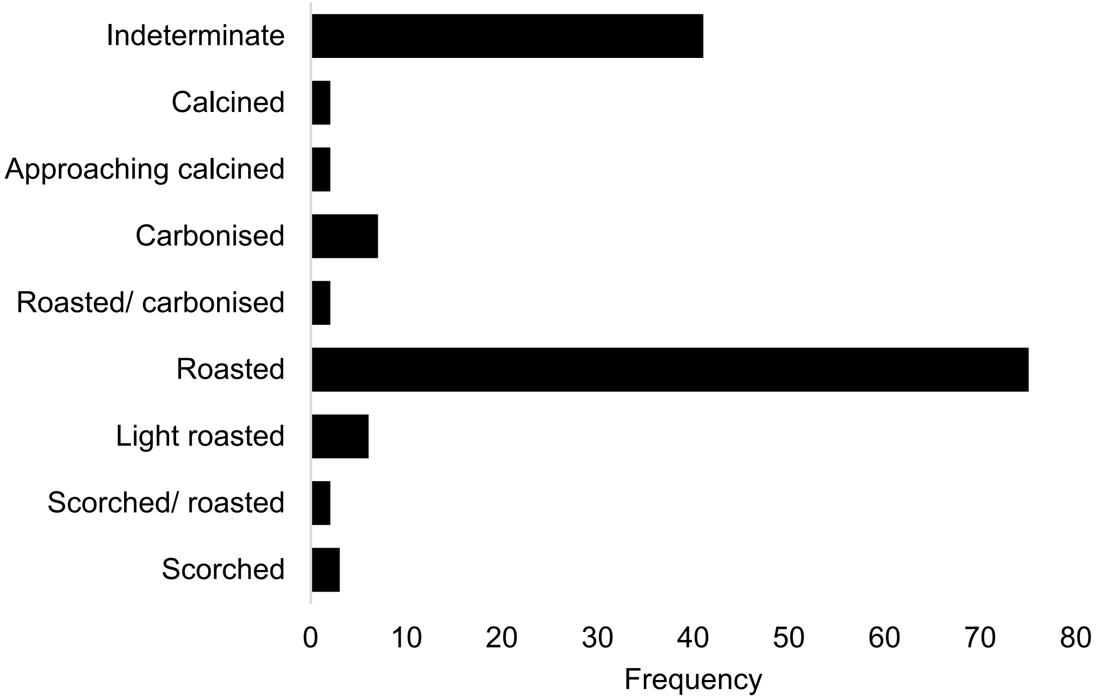

Figure 4.11: Frequency of heat exposure types from Füzesabony-Gubakút.

Phase IV had the most evidence of burning, of which the majority was roasting (figure 4.12). The proportion of the phase IV (112/2821) assemblage that was burnt was significantly greater than the phase II-III (20/732, p=.002) and V (5/544, p<.001) assemblages. This could indicate that roasting bones became more common at the zenith of occupation at Füzesabony-Gubakút (Domboróczki 2009: 83-84).

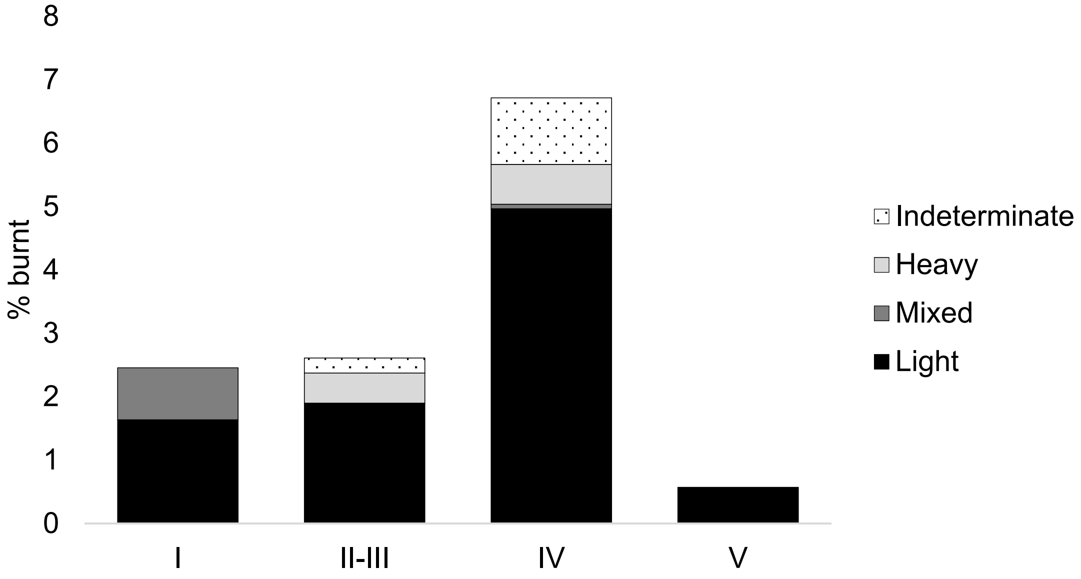

Figure 4.12: Percentage of specimens from each phase affected by different intensities of burning from Füzesabony-Gubakút.

4.5.2 Species

Red deer were the species most commonly affected by heat exposure, with cattle, pigs, caprines and aurochs showing fairly consistent levels of burning (figure 4.13). Wild boar bones were more often exposed to high temperatures than other species, with 4 of 5 burnt bones showing signs of calcination.

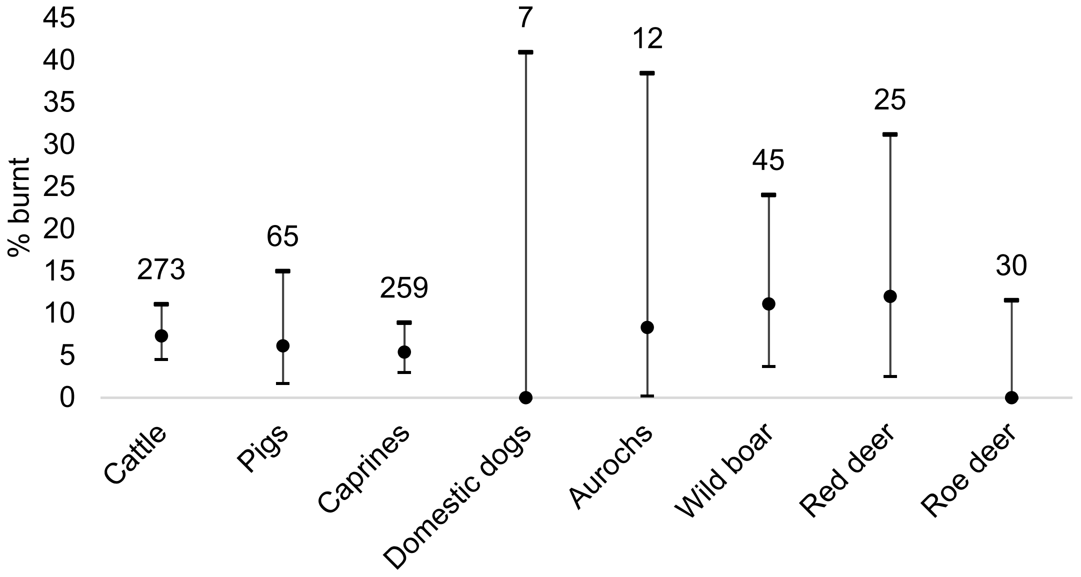

Figure 4.13: Percentage of different species affected heat exposure from Füzesabony-Gubakút, with 95% confidence intervals.

4.5.3 Element

The metacarpals and metatarsals were the most common elements to be affected by burning, at 18.4% (9/49) and 22.6% (7/31) respectively (figure 4.13). Bovine metapodia were burnt in 23.6% (13/55) of specimens, all of which were roasted. Caprine metapodia were also affected (13.2%, 7/53), as were wild boar and red deer. This could suggest a cooking tradition in which the metapodia were roasted, which may imply intentional roasting of these elements or that they were roasted in articulation with jointed meat.

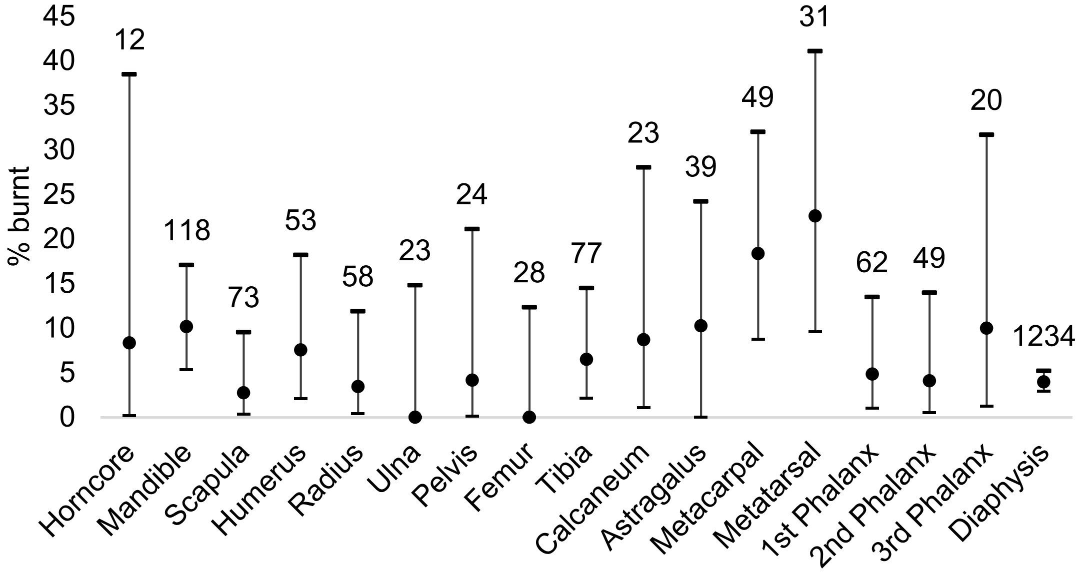

Figure 4.14: Percentage of elements affected by heat exposure from Füzesabony-Gubakút, with 95% confidence intervals.

Figure 4.15: Cattle distal metatarsal showing signs of roasting (marked) and subsequent fracture from Füzesabony-Gubakút.

4.6 Fracture

4.6.1 Site

The faunal assemblage from Füzesabony-Gubakút showed particularly low levels of fresh fracture. Marrow exploitation was likely small scale, as 23.3% (359/1539) of fractured bones showed evidence of fresh fracture (figure 4.16). However, there was evidence that marrow-rich elements were preferentially targeted. High-yield marrow-bearing bones had a significantly higher proportion of fresh fracture than low-yield elements (fresh high-yield 25.0%, 41/164; low-yield 10.8%, 17/158; $p<.001$), although proportions were still low (figure 4.17).

Primary fracture when bone was in a dry or drying state affected 73.5% (1131/1539) of fractured bones (figure 4.16). This was reflected by a mean Fracture Freshness Index score of 4.0, where individual scores of 6 were by far the most common FFI score (34.2%, 527/1539; figure 4.18). Scores indicating dry or drying fracture (3-5) were also common (44.0%, 677/1539). This dry pattern is suggestive of deposition practices at Füzesabony-Gubakút, which Domboróczki has argued caused heavy fragmentation of material within the pits (2009: 81). He postulates that refuse was not deposited immediately and was trodden to pieces on walking surfaces before later deliberate infilling or erosive action deposited them in pits (*ibid.*). This would explain the particularly high level of dry fracture on faunal material from Füzesabony-Gubakút.

Secondary fracture was rare at Füzesabony-Gubakút, which is surprising considering the taphonomic indicators for temporary deposition and trampling. Subsequent dry fracture affected 7.5% (27/359) of freshly fractured bones, and subsequent mineralised fracture affected 1.7% (25/1490) of fresh or dry fractured bones. Some bones that were fractured when fresh and again when dry showed evidence of carnivore gnawing (33.3%, 9/27), although the majority showed no modifications to do with carcass processing or taphonomy. This low level of secondary fracture suggests that bones were not fractured when fresh before trampling on walking surfaces in the settlement. A combination of relatively low levels of marrow exploitation and high levels of deposition fracture and fragmentation likely contributed to the pattern seen at Füzesabony-Gubakút.

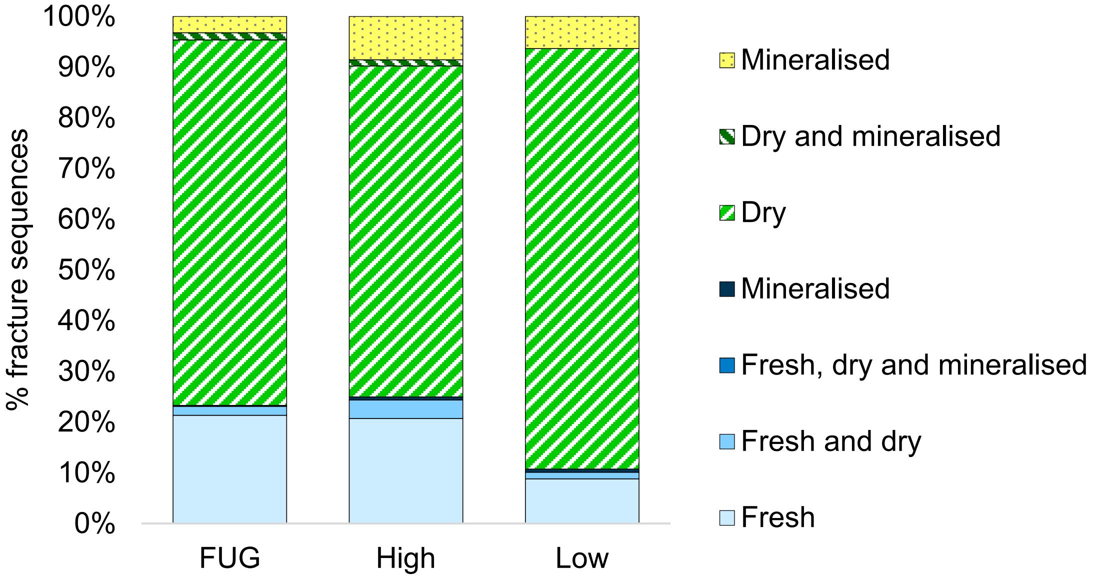

Figure 4.16: Fracture history profiles for the Füzesabony-Gubakút assemblage (left; n=1539) and for high- and low-yield marrow bones (right; n=164/158).

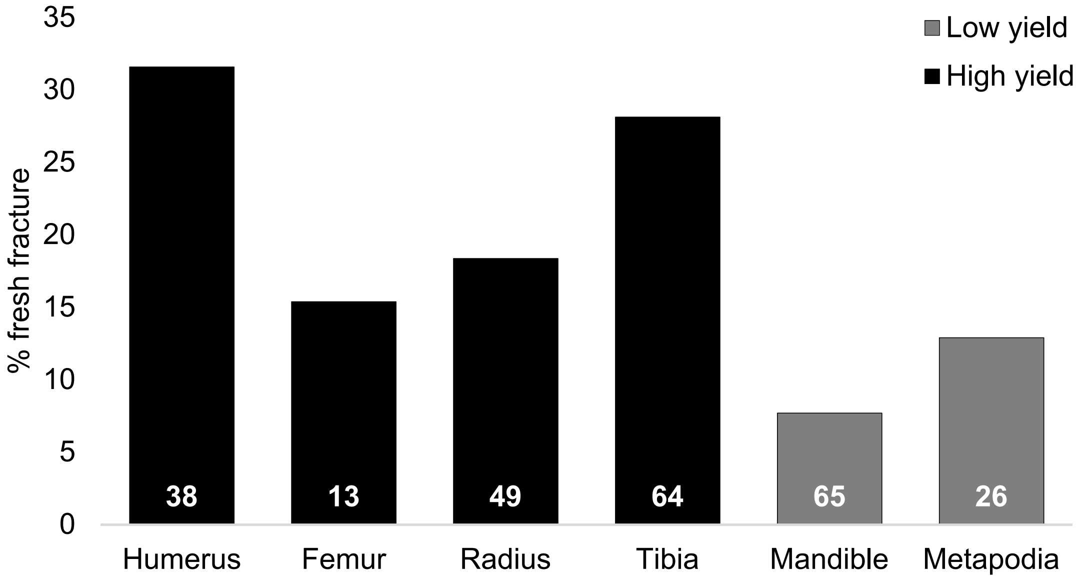

Figure 4.17: Percentage of fractured skeletal elements exhibiting fractures that were fresh from Füzesabony-Gubakút.

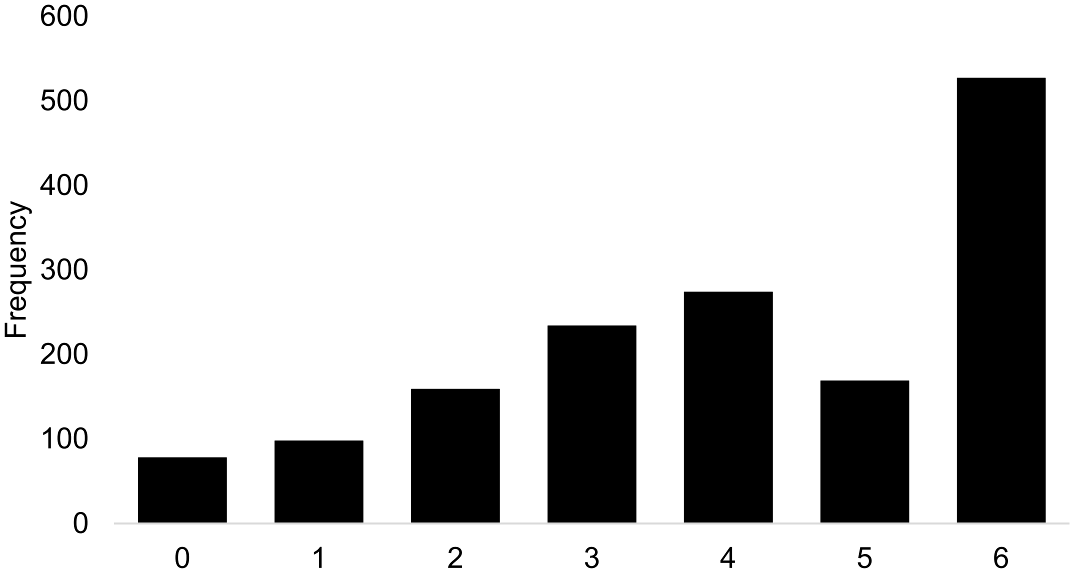

Figure 4.18: Frequency of different Fracture Freshness Index scores from Füzesabony-Gubakút.

4.6.1.1 Phase

The fracture history profiles for each phase do not present a particularly obvious pattern for change over time (figure 4.19), although could suggest a reduction in the intensity of marrow exploitation. Phase I had the highest proportions of fresh fracture at 29.1% (23/79), rising to 42.9% (6/14) on high-yield bones, showing little difference between the amount of fresh fracture on high- and low-yield elements (figure 4.21). There was little variation in the proportion of fracture between phases I and IV, although there was an increased divide in the proportion of fresh fracture on high- and low-yield bones. Phase V had the highest FFI score (figure 4.20) and lowest levels of fresh fracture (10.3%, 13/126) of all the phases, significantly lower than phase II-III (51/239, p=.008) and phases I (23/79) and IV (261/1048; both p<.001), and no high-yield bones were fractured when fresh. Phase V also had significantly higher levels of mineralised fracture than all the other phases (25.4%, 32/126; compared to I 4/79, II-III 8/239, IV 27/1048, all p<.001), both alone and as secondary fracture on fresh and dry bone. This could indicate that there was little reliance on within-bone nutrients in any particular period at Füzesabony-Gubakút, with Phase V showing the least utilisation of bone marrow.

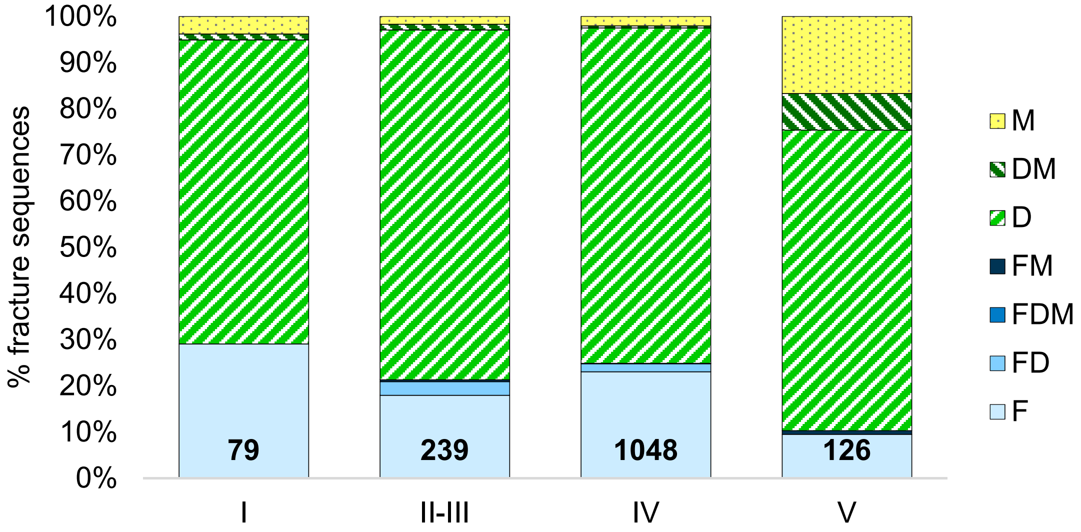

Figure 4.19: Fracture history profiles for each phase from Füzesabony-Gubakút.

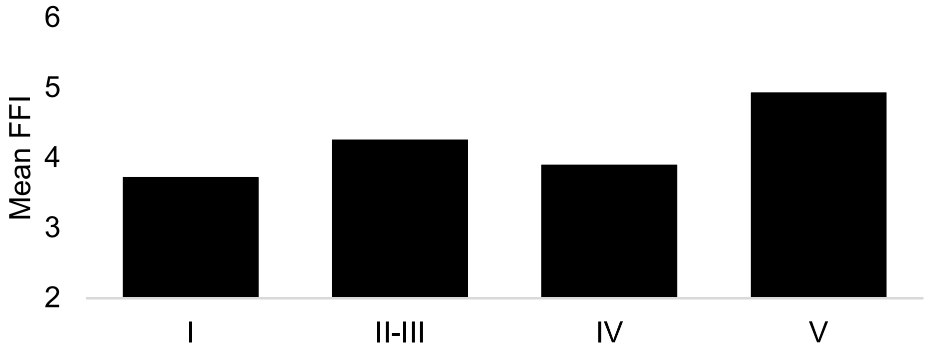

Figure 4.20: Mean Fracture Freshness Index scores for each phase from Füzesabony-Gubakút.

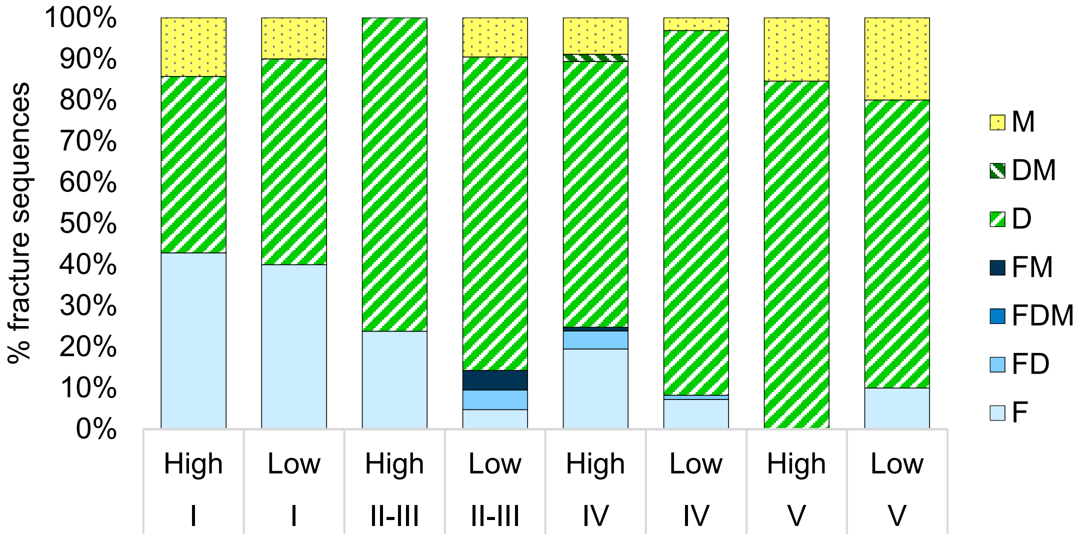

Figure 4.21: Fracture history profiles for high- and low-yield marrow bones from Phase I (n=14/10), II-III (n=22/26), IV (n=113/97) and V (n=13/20) from Füzesabony-Gubakút.

4.6.1.2 Area

<u>4.6.1.2.1 West and East bank</u>

Differences in fracture sequences proportions were extremely minimal between the two settlement banks, with similar proportions of fresh first fracture (West 23.2%, 275/1185; East 23.6%, 82/347; figure 4.22) and mean FFI scores (West 4.0; East 4.1). The East settlement (33/347) had higher levels of mineralised fracture than the West settlement (41/1185; p<.001). In the West settlement, high-yield bones showed greater targeting for marrow extraction than in the East settlement, where high- and low-yield marrow bones had fairly equal amounts of fresh fracture. It is possible that these differences indicate variation in carcass processing and deposition practices across the stream.

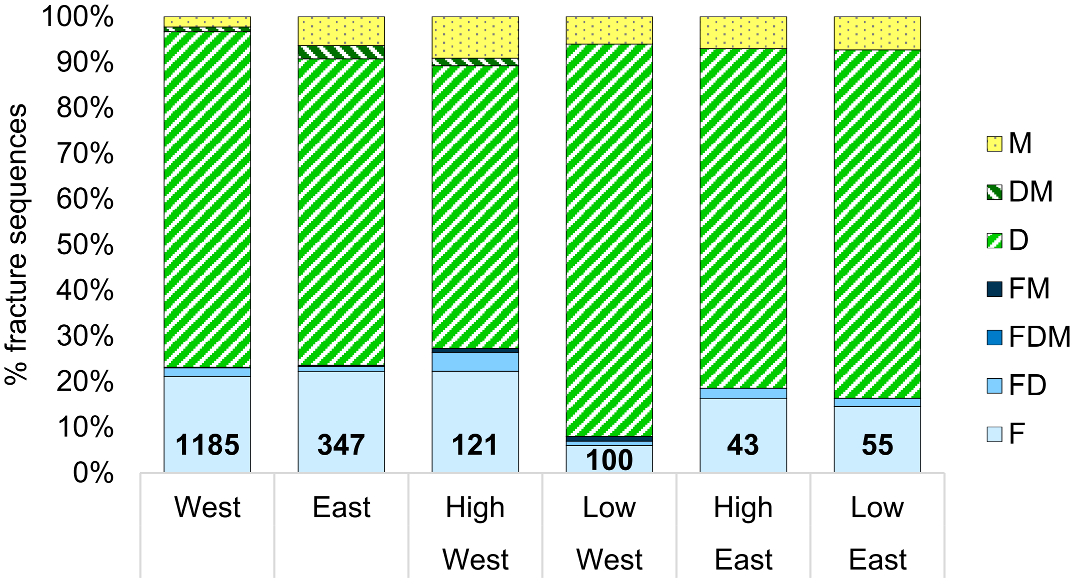

Figure 4.22: Fracture history profiles for the West and East settlement areas from Füzesabony-Gubakút (left), and for high- and low-yield marrow bones from these areas (right).

4.6.1.2.2 Settlement rows

The rows in the West settlement had more in common than those in the East settlement in terms of fracture sequence proportions (figure 4.23). East Row 1 presented large proportions of mineralised and secondary mineralised fracture compared to all other rows, perhaps reflecting disturbance of deposited material. East Row 2 had a relatively high proportion of fresh fracture, suggesting a more intensive focus on bone marrow extraction in this site area.

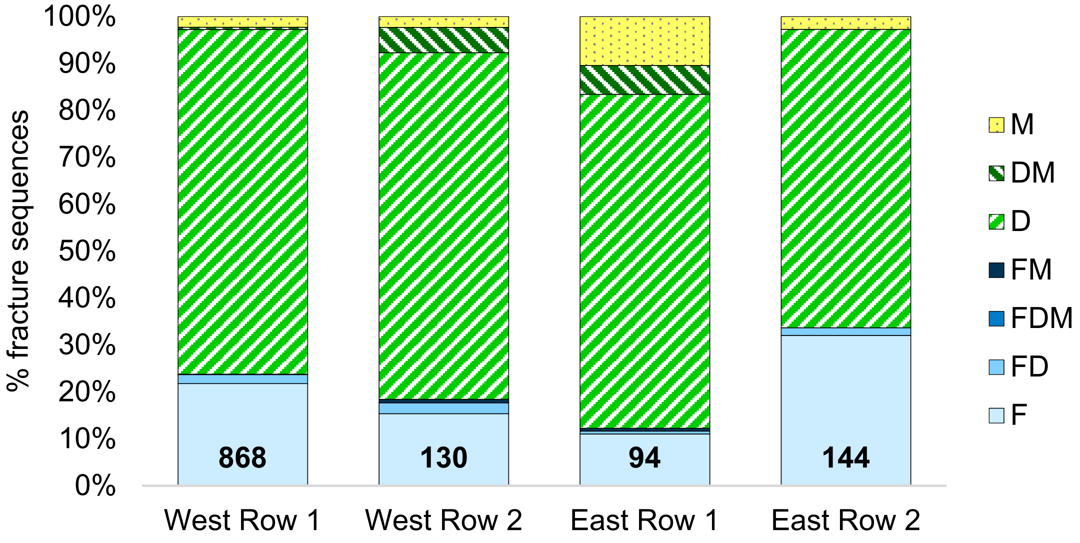

Figure 4.23: Fracture history profiles from rows from Füzesabony-Gubakút.

4.6.2 Species

The types of fractures seen on different species showed interesting patterns in the levels of fresh fracture that set this site apart from other assemblages (figures 4.24 and 4.25). Firstly, 'medium' mammals including caprines, pigs and wild boar were more commonly freshly fractured than large mammals, including cattle, aurochs and red deer. Pigs show the highest proportion of bones that were fractured when fresh (26.7%, 4/15) along with caprines, although the differences compared to other species were not significant. This is in contrast to other sites, where cattle are predominantly the species most commonly exploited for marrow. Secondly, wild animals do not seem to have been particularly targeted for marrow extraction, another unusual trait. The analysis of high and low-yield elements (figure 4.25) still certainly suggests that the high-yield elements of cattle and caprines were targeted for fresh fracture, whilst in wild animals this was less often the case. Dogs only showed evidence of dry fracture (n=2).

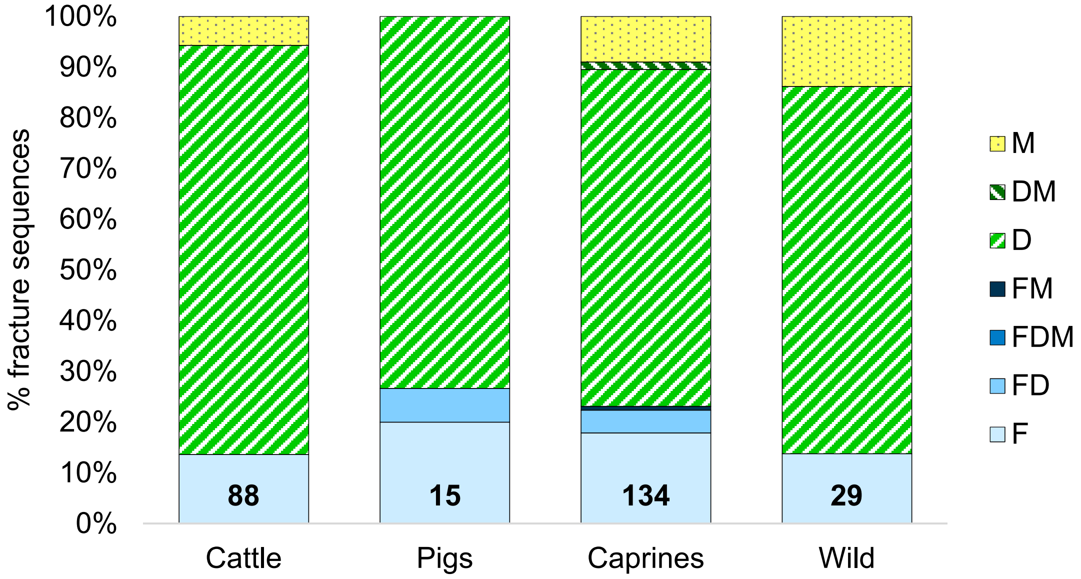

Figure 4.24: Fracture history profiles for cattle, pigs, caprines and wild animals (aurochs, red and roe deer, wild boar) from Füzesabony-Gubakút.

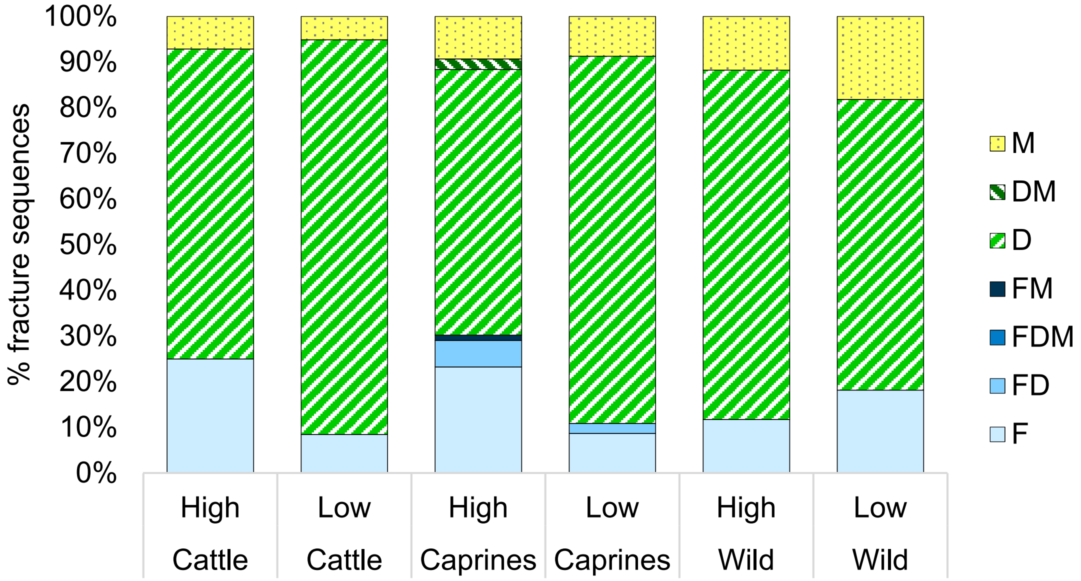

Figure 4.25: Fracture history profiles for high- and low-yield marrow bones of cattle (n=28/59), caprines (n=86/46) and wild animals (n=17/11) from Füzesabony-Gubakút.

Further differences were evident looking at the treatment of bones of large and medium mammals in the different settlement rows. On the West bank, both rows showed remarkable consistency, with large mammal bones presenting drier fracture history profiles than medium mammals in both Row 1 and Row 2. On the East bank, large mammals continue to be fractured less commonly than medium mammals but with far less consistency. In row 1 there was a large proportion of fractured bones than were fractured when mineralised, and low fresh fracture proportions for both large and medium mammals. In Row 2, fresh fracture was much higher than Row 1, and the West rows, for both large and medium mammals, with less differentiation between the two.

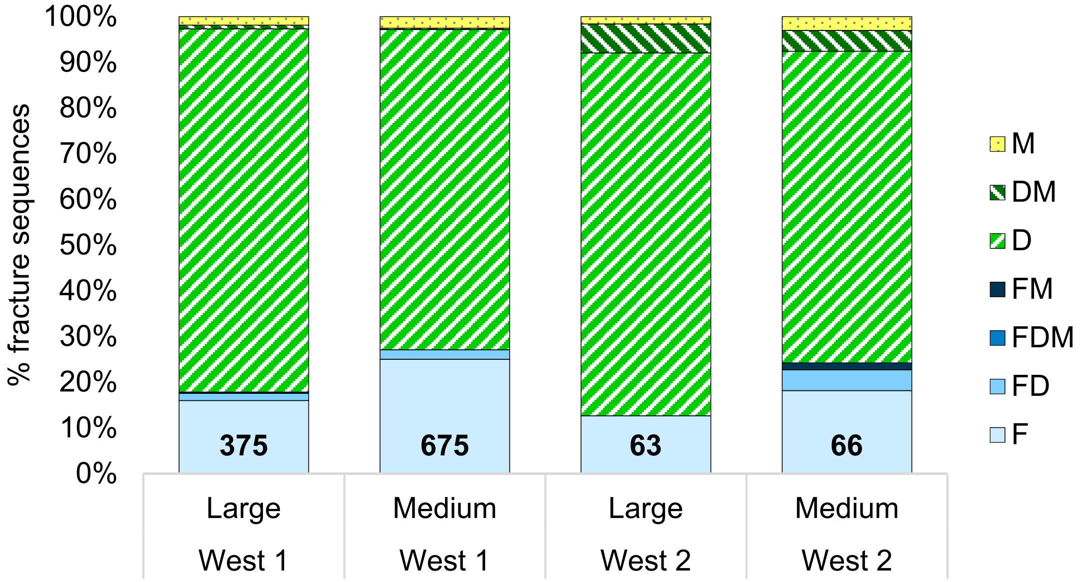

Figure 4.26: Fracture history profiles for bones identified to large and medium mammals from Row 1 and 2 from the West bank of Füzesabony-Gubakút.

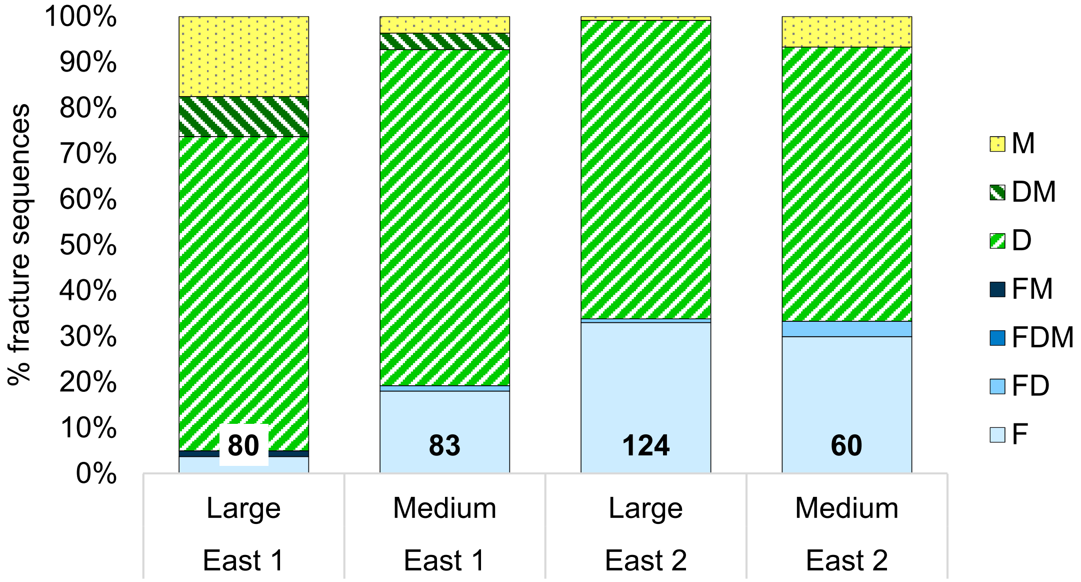

Figure 4.27: Fracture history profiles for bones identified to large and medium mammals from Row 1 and 2 from the East bank of Füzesabony-Gubakút.

4.6.3 Fracture summary

Correspondence analysis highlights the differences in species representation and fracture between the four settlement rows (figure 4.28). The West settlement rows cluster with East Row 2, whereas East Row 1 does not associate with other rows so closely, indicating that varying practices in the East settlement were largely determined by East row 1. The correspondence analysis also suggests that the percentage of fresh first fracture between the settlement rows could relate to the proportion of pigs in the NISP (figure 4.5). As shown in figure 4.24, pigs were often fractured when fresh, but as they were underrepresented at Füzesabony-Gubakút the fresh fracture suggests that areas with higher proportions of pigs were more likely to exploit the marrow of any species.

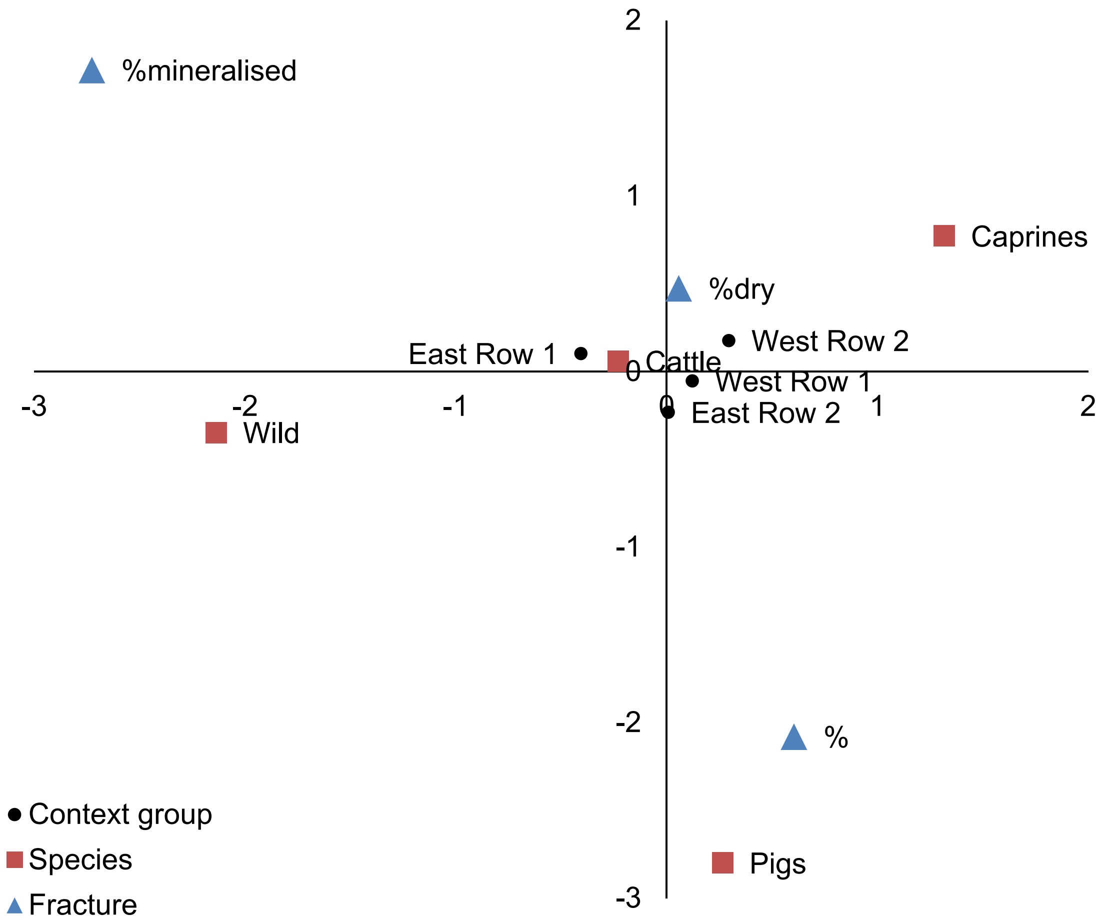

Figure 4.28: Correspondence analysis of the percentage of identifiable specimens and the percentage of fresh, dry and mineralised first fracture for each of the four settlement rows from Füzesabony-Gubakút. Data from dog bones were excluded from this analysis.

4.7 Fragmentation

There was no evidence for intensive bone grease processing at Füzesabony-Gubakút. Figure 4.29 shows that the smallest size classes (0-29mm) are underrepresented in terms of weight, and whole bones and bones with complete epiphyses were relatively common. However, fragmentation of slightly larger size classes was elevated compared to the usual pattern in the LBK, particularly between 30-59mm, and cancellous material was common (figure 4.30). This fragmentation could have been caused by pot-sizing for non-intensive bone grease extraction, or by trampling on walking surfaces, although it would be expected that the smallest size classes would have been affected also

Before analysis of Füzesabony-Gubakút I had been warned that not all faunal material had been retained during excavation and zooarchaeological analysis, corroborated by Vörös's (unpub.) report indicating that 94.6% (n=8489) of the assemblage was identifiable to species and element. This made me concerned that some material, namely small indeterminate fragments, could be missing from this assemblage. My own analysis resulted in the identification (fully or partially) of 42.2% (2107/4491) of material, slightly higher than but still comparable to other sites studied for the project (mean 37.4%). It is possible that the smallest size class (0-19mm) was underrepresented, as only 4.3% (217/4491) of the total number of specimens was included in this class. This number is much higher on some other sites (Těšetice-Kyjovice 14.7%, 774/5252; Herxheim 14.6%,1167/8000; Ludwinowo 7 27.7%, 3714/13429). While it is possible some fragmented bone was absent, certainly the assemblage seemed far more complete than that of Apc-Berekalja I, where 67.6% (848/1255) of the assemblage was identifiable and just 0.2% (2/1255) of specimens were in the smallest size class. The assemblage from Apc-Berekalja I (chapter 7) is much more likely affected by retention bias.

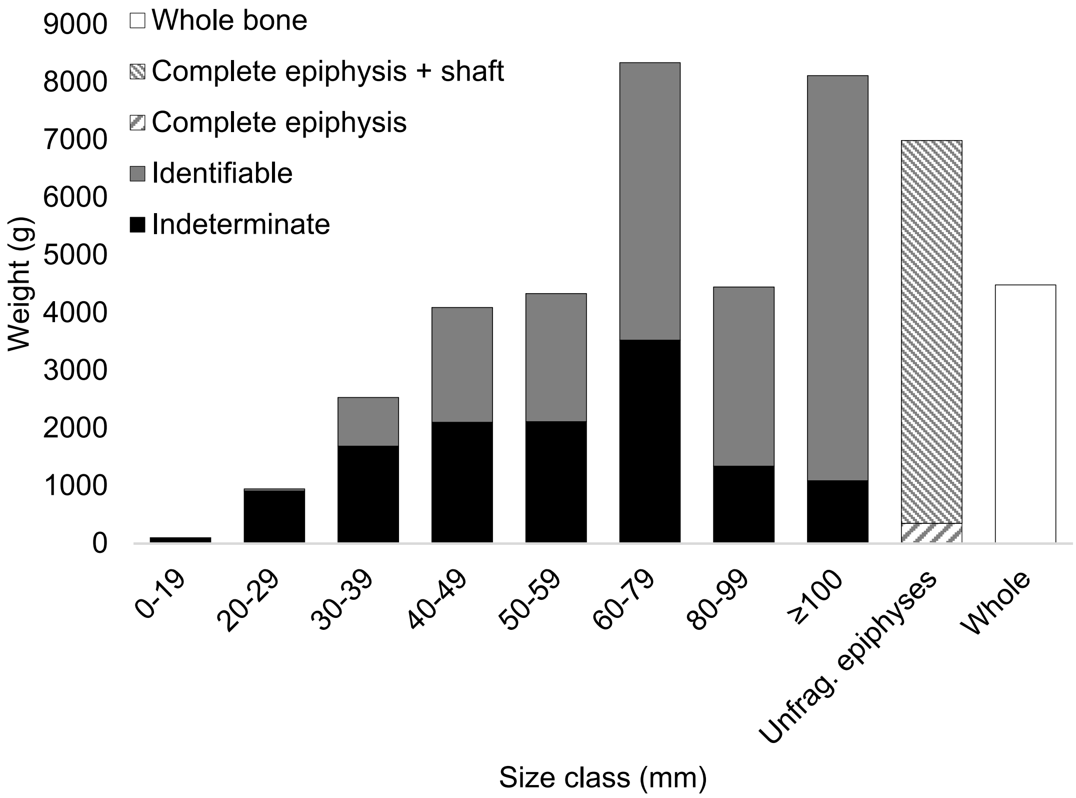

Figure 4.29: Weight by size class of all specimens from Füzesabony-Gubakút.

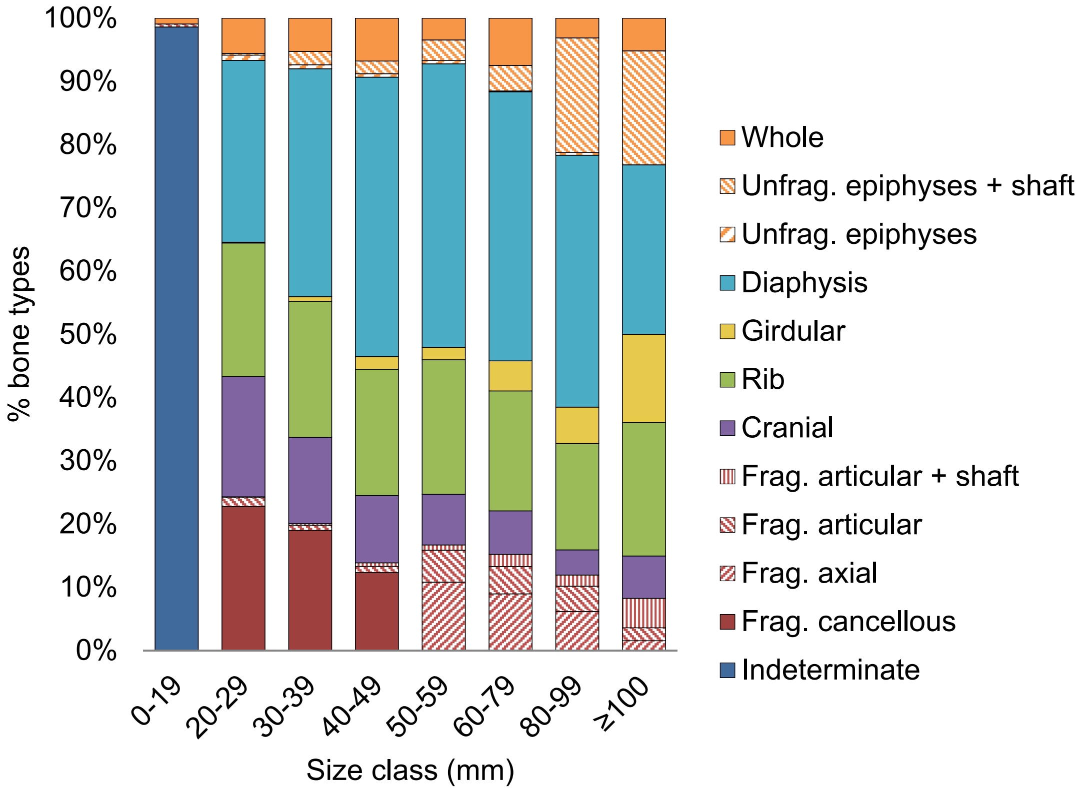

Figure 4.30: Frequency of bone types by size class from Füzesabony-Gubakút. Red series indicated fragmented cancellous bone.

4.8 Taphonomy

4.8.1 Gnawing

Evidence of gnawing was largely indicative of canid activity and was uncommon at Füzesabony-Gubakút (2.3%, 133/4491; figure 4.31). Gnawing was more prevalent in some phases than others, particularly phase II-III and IV and the West settlement, the only context groups to contain specimens identified to domestic dog. Evidence of digestion was noted on one phase IV caprine astragalus. No rodent gnawing was observed on identifiable bones.

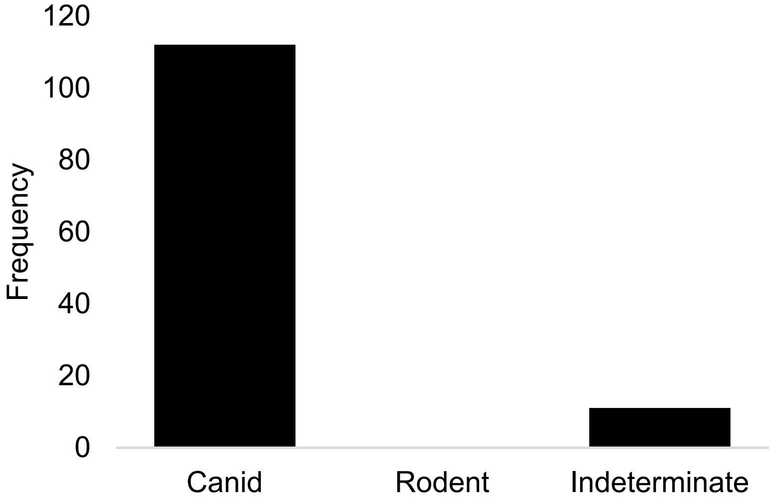

Figure 4.31: Frequency of gnawing types from Füzesabony-Gubakút.

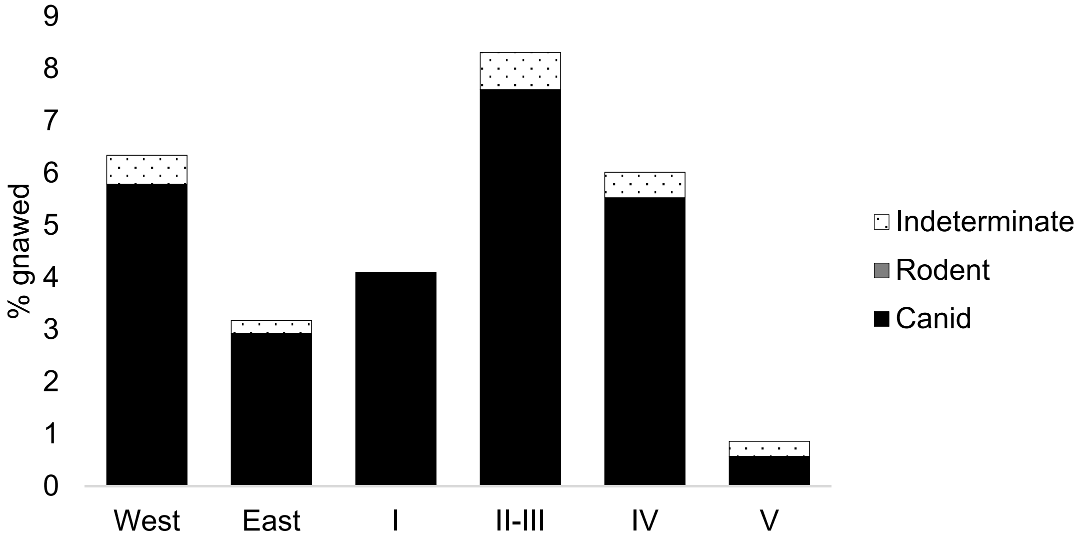

Figure 4.32: Percentage of specimens from the settlement areas (West and East) and phases (I-V) affected by gnawing from Füzesabony-Gubakút.

4.8.2 Taphonomy and recent breaks

The effects of taphonomic agents were rarely observed in the form of root etching and weathering which, along with mud cementations, were recorded on 0.3% (7/2107) of identifiable bone. The assemblage was well preserved and curated, with new breaks made during excavation or curation low at 3.4% (71/2107) of the identifiable assemblage. This indicates that fragmentation at Füzesabony-Gubakút is unlikely a result of excavation or curation techniques.

4.9 Food exploitation strategies

4.9.1 Herd structure analysis

4.9.1.1 Cattle

Cattle fusion analysis presented little intensive kill-off until 3 years, where survival dropped to 47.4% (9/19; figure 4.33). This suggests a cull of meat-age individuals and low survival of milk-producing females, which does not indicate an intensive milk management strategy. Age-at-death analysis for cattle teeth (n=80) simulates considerable mortality between 0-15 months (Gillis unpub.b), only reflected slightly in the fusion diagrams. The presence of some older animals (>8 years) was possible (*ibid.*). Along with the fusion analysis this could suggest a dairy herd with slaughter of optimum meat-weight males.

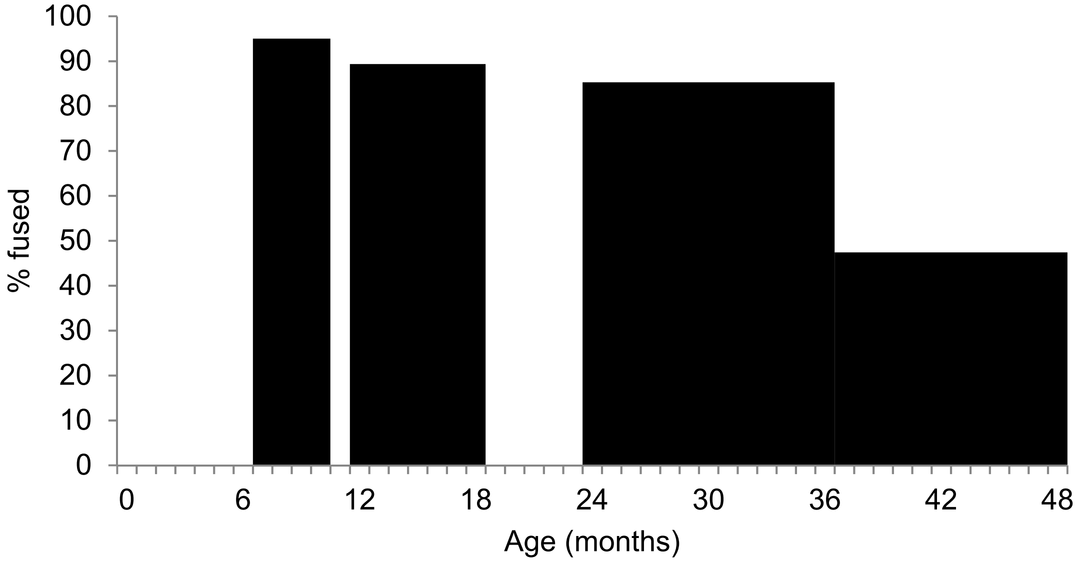

Figure 4.33: Cattle slaughter profiles based on epiphyseal fusion from Füzesabony-Gubakút (n=148).

4.9.1.2 Caprines

The caprine fusion graph was hampered by small sample sizes in the youngest age classes, but suggests considerable slaughter between 0-18 months (figure 4.34). There was further slaughter of individuals between 18-28 months, and despite some further deaths 43.2% (16/37) of bones in the final fusion stage showed survival to fusion maturity (>30 months). This suggests a mixed pattern of meat and dairy exploitation with slaughter of meat-age animals interspersed with potential removal of animals under 10 months and survival of dairy females.

The mortality profiles for sheep (n=146) and goat (n=119) teeth, where it is possible to separate sheep from goats, help make sense of the epiphyseal fusion data. The sheep mortality profiles agree with the fusion profiles, showing some young slaughter between 6-12 months and again between 12-24 months and 2-4 years following the Meat A or Meat B models (Gillis unpub.b; Vigne and Helmer 2007 for model descriptions). Goat infant slaughter was high between 0-6 months, perhaps suggesting removal of infants to increase milk available for human consumption (*ibid.*). It is likely that goats were managed for meat as well as dairy, whereas sheep were primarily meat producers.

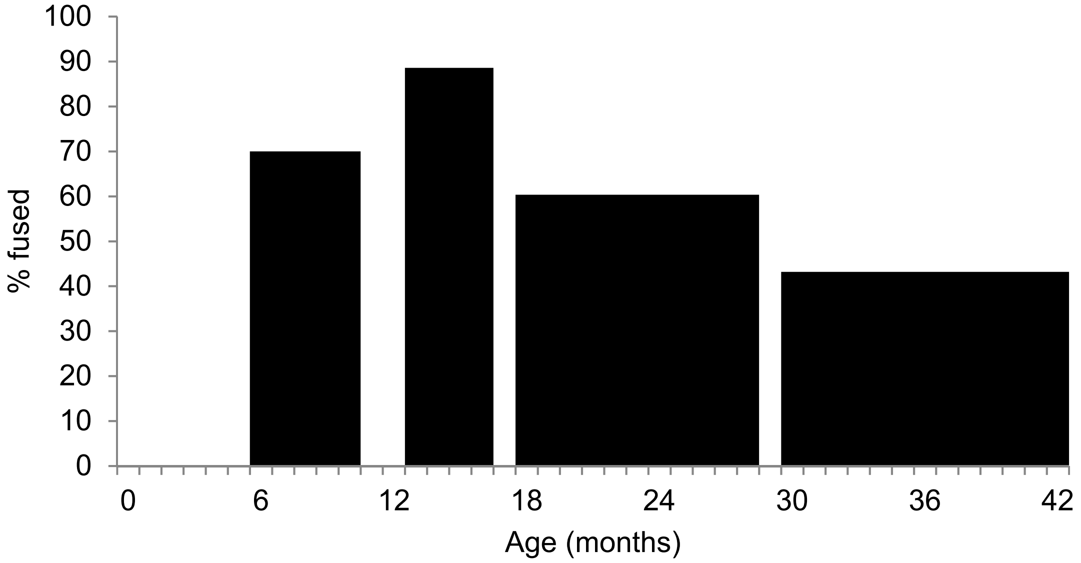

Figure 4.34: Caprine slaughter profiles based on epiphyseal fusion from Füzesabony-Gubakút (n=140).

4.9.1.3 Pigs

Although sample sizes for pig fusion were particularly small (n=17) it can still be suggested that very young animals (<1 year) were being slaughtered, supplying the settlement with young, tender pork (Stage 1: 40% fused, 2/5). While there was no evidence for further slaughter, it is unlikely that many pigs survived into fusion maturity based on patterns throughout the sites studied.

4.9.2 Lipid residue analysis

Thus far, a total of 20 perforated and non-perforated sherds have been analysed from Füzesabony-Gubakút. 45.5% (5/11) of non-perforated sherds have so far contained animal fats, including 36.4% (4/11) adipose fats, and one non-perforated sherd contained possible milk fats (9.1%). Lipid residue analysis on perforated vessels (n=9) is yet to detect animal fats. However, every single refuse pit from Füzesabony-Gubakút contained sieves, which have been used to suggest dairying was part of the economy based on patterns from other sites, such as Ludwinowo 7 (Domboróczki 2009:106; Salque *et al.* 2009). The lipid residue analysis thus shows that animal products, including possibly milk, were processed in ceramic vessels.

4.10 Discussion

4.10.1 Meat and fat exploitation

Domboróczki, based on zooarchaeological analysis by Vörös, has suggested that the meat supply in Füzesabony-Gubakút was plentiful, organised on a household scale and largely composed of domestic meat but supplemented by wild (Vörös unpub. Domboróczki 2009: 108). Based on the herd structure profiles it is likely that optimum-weight meat and young meat was being supplied by both cattle and sheep (figures 4.33 and 4.34), and probably young pigs. Carcasses were likely skinned, with incisions made at the metapodia and phalanges in cattle, and disarticulated to separate meat-rich upper-limbs from the extremities (figures 4.35 and 4.36). Defleshing was evident on the scapula, humerus, radius and femur, although butchery instances were very low, perhaps indicating a lack of intensity in the face of stable food supply.

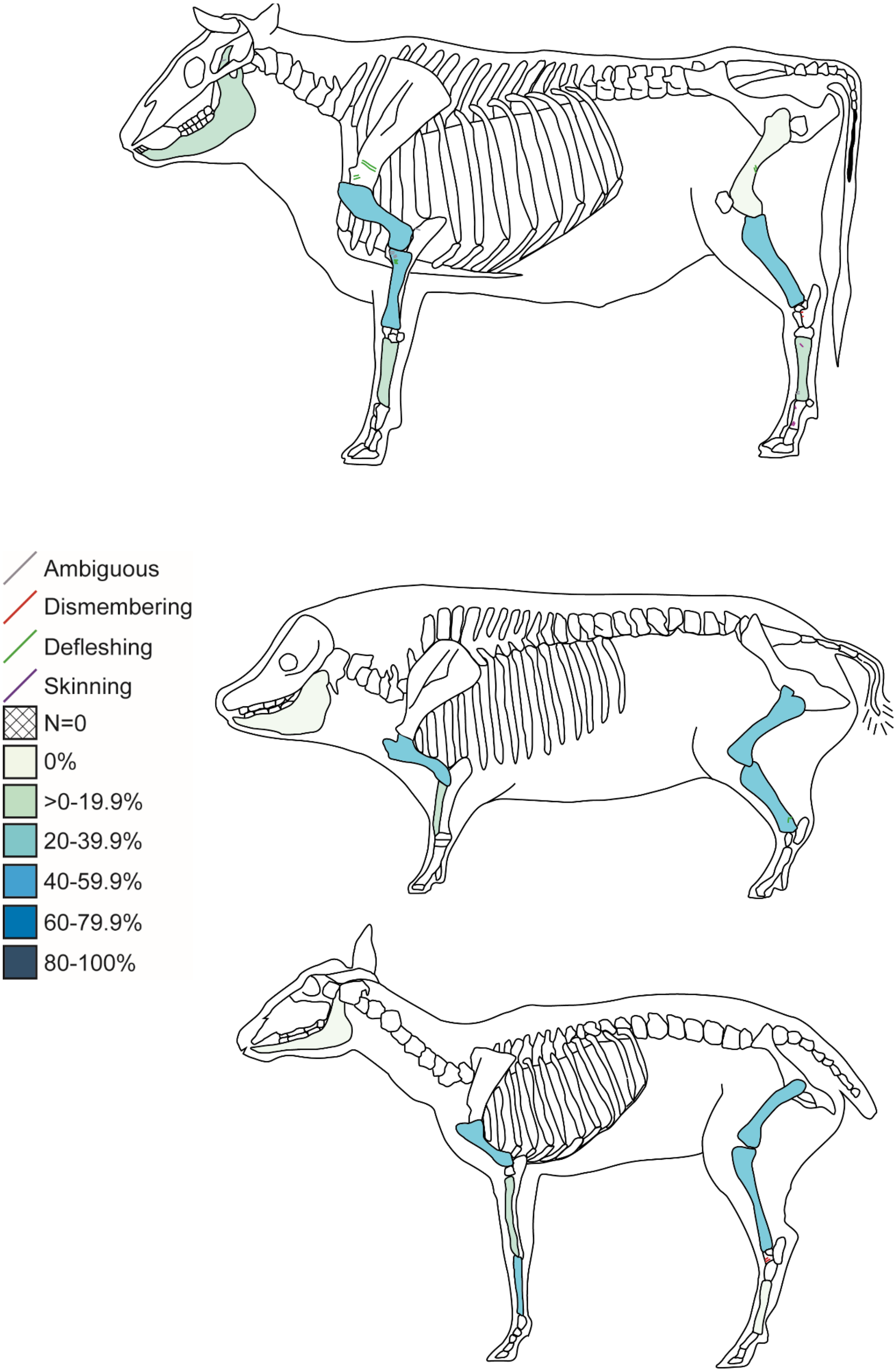

Figure 4.35: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Füzesabony-Gubakút. Values in table 4.6.

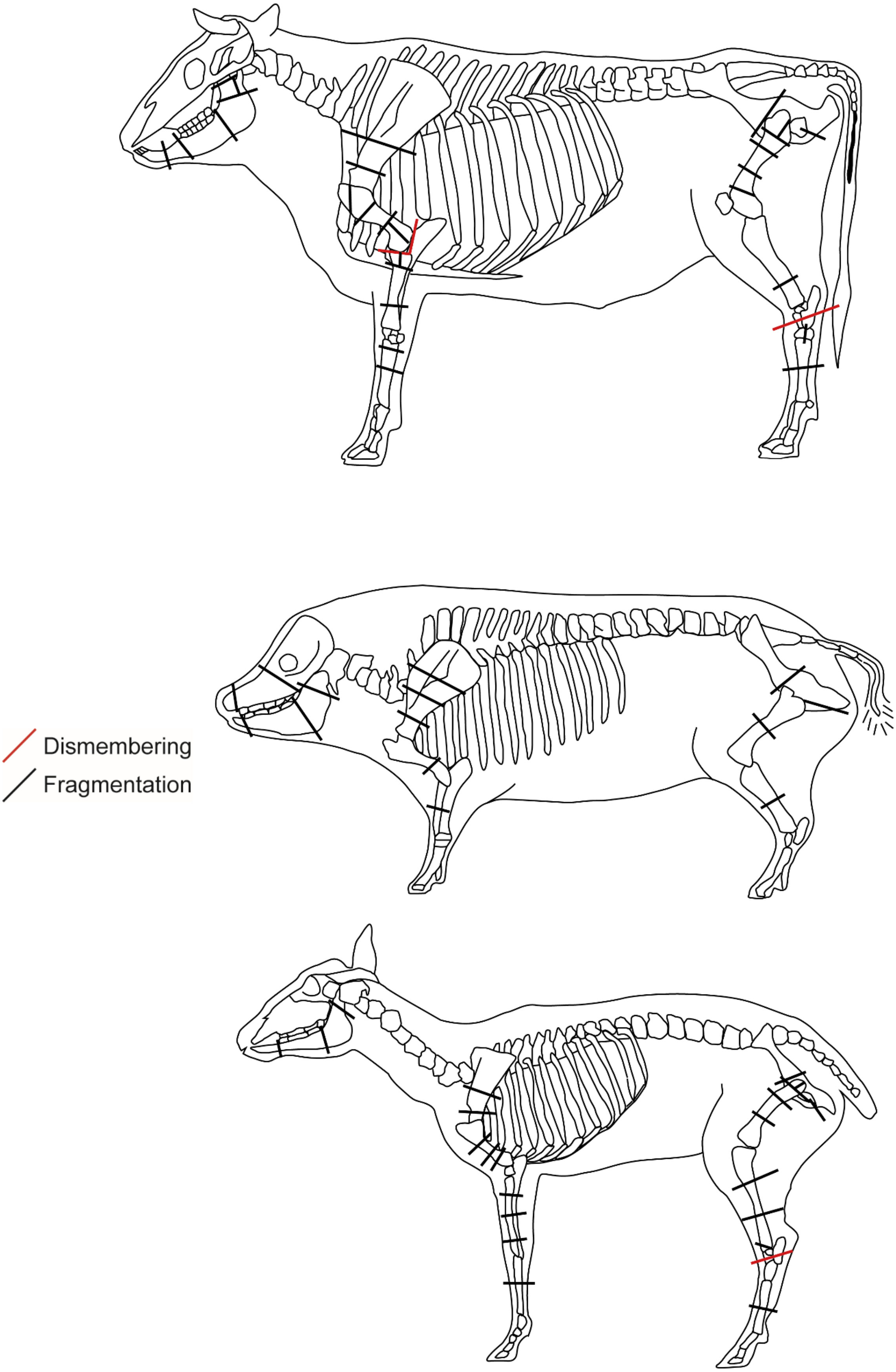

Figure 4.36: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Füzesabony-Gubakút.

Table 4.6: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Füzesabony-Gubakút (see figure 4.35).

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	29	7	36	17	0	6	0	9	5	35	13	26	7	16
Suidae	33	9	0	2	0	3	25	8	6	16	-	-	-	-
Caprines	38	16	12	25	33	6	38	39	0	7	27	15	0	9

Similarly, based on the low levels of fresh first fracture, it is likely that marrow and grease processing did not contribute greatly to subsistence, although the assemblage was highly fragmented. It is possible that low levels of marrow exploitation relate to the stable and rich diets at Füzesabony-Gubakút. The plentiful supply of meat, perhaps supported by nearby satellite sites, combined with the probable availability of milk and a considerable amount of crop cultivation (Domboróczki 2009: 106), could indicate that marrow extraction was not a dietary necessity at Füzesabony-Gubakút. Elements could have been fractured as and when they were required or desired, perhaps targeted at leaner times of the year or in certain areas. It is also possible that the tradition of roasting elements caused dry or drying fractures to bones that may have been fractured for marrow, particularly the low-yield metapodia. Finally, the proposed trampling and erosive action on refuse (Domboróczki 2009) is likely the dominant factor in the proportions of dry fracture and high degrees of fragmentation (figures 4.36).

4.10.2 Conclusion

The faunal assemblage from Füzesabony-Gubakút reveals a well situated and supplied settlement, possibly with links to other settlements in the Gubakút region. Marrow processing was very low in the face of a likely plentiful meat, crop and dairy supply, and deposition practices ensured the fragmentation of marrow-bearing bone despite this.

Chapter 5 Polgár-Piócás-dűlő

5.1 Introduction

The site of Polgár-Piócás-dűlő is located in the Polgár region, an alluvial island of favourable loess soils towards the north of the Great Hungarian Plain, (Whittle *et al.* 2013a: 73; Raczky and Anders 2009: 31). Planned motorway constructions in the area resulted in systematic heritage surveys, field walking, mapping and excavation, creating a broad database of archaeological sites and placing Polgár-Piócás-dűlő in an area of intensive Neolithic activity (Raczky and Anders 2009: 33). Throughout the phases of the ALP (Alföld Linear Pottery) culture there were between six and twenty contemporary sites occupying the area known as the Polgár island (*ibid.* 31).

Polgár-Piócás-dűlő was excavated by the Déri Múzeum in 2006 and 2007, unearthing an Alföld Linear Pottery Culture (ALPC) settlement dating from 5600/5500 BC (Giblin 2011: 163). The excavation uncovered 91 pits, two houses, 36 post holes, three wells and eight graves associated with the AVK[2] in a 1.36 ha area (*ibid.*). Like all settlements of the ALPC I phase in the Polgár area, and indeed like Füzesabony-Gubakút, the site was located on the banks of a prehistoric riverbed (Raczky and Anders 2009: 35). Polgár-Piócás-dűlő was contemporaneous with the early ALPC I phase of Polgár-Ferenci-hát, which lies within five kilometres to the north (*ibid.* 34-37).

5.2 Assemblage

5.2.1 Sample

The whole faunal assemblage dating to the ALPC culture from Polgár-Piócás-dűlő was studied, which totalled 2753 bone specimens (table 5.1 and 5.3). Differences in values for fully identifiable specimens (table 5.1) and species representation (figure 5.1) relates to the exclusion of *Bos sp*. and *Sus sp*. and inclusion of wild birds (*Aves*; see section 3.4.1). The majority of specimens date specifically to the ALPC 1 phase (ALPC n=366; ALPC 1 n=730). As these phases likely contain activity that was contemporaneous, seven contexts were chosen

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[2] The *alföldi vonaldíszes kerámia* (AVK) is another name for the Alföld Linear Pottery Culture (ALPC; Whittle *et al.* 2013: 49).

based on their size, date and interpretation for comparison. These contexts are detailed in table 5.2 and 5.3 and will be referred to by their structure number.

Table 5.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Polgár-Piócás-dűlő (PPD).

Fully identifiable (to species and element)	667
Partially identifiable (to species and element types)	429
Indeterminate	1657
Total	**2753**

Table 5.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens from selected contexts from Polgár-Piócás-dűlő.

Object	Structure	Phase	Interpretation	FID	PID	IND
9	13	ALPC	Pit	71	75	130
75	111	ALPC	Pit	23	14	97
132	203	ALPC 1	Pit	141	112	219
132	233	ALPC 1	Well	49	24	73
141	230	ALPC 1	Well	35	9	34
164	243	ALPC 1	Pit	113	96	183
182	261	ALPC 1	Pit	82	54	148

Table 5.3: Full list of contexts analysed from Polgár-Piócás-dűlő.

Object	Structure	Phase	Interpretation	FID	PID	IND
8	12	ALPC	pit	0	0	7
9	13	ALPC	pit	71	75	130
18	24	ALPC	pit	0	0	2
22	28	ALPC	pit	0	1	0
24	30	ALPC	pit	1	0	0
27	33	ALPC	pit	9	4	20
30	36	ALPC	pit	0	0	1
37	47	ALPC	pit	0	0	3
42	53	ALPC	pit	0	1	0
43	54	ALPC	pit	1	0	0
48	60	ALPC	pit	1	0	0
57	71	ALPC	well	4	5	1
59	73	ALPC	well	2	1	0
75	111	ALPC	pit	23	14	97
92	136	ALPC	posthole	0	1	0
109	174	ALPC	pit	0	1	6
121	188	ALPC	pit complex	0	1	0
123	193	ALPC	pit	2	0	9
123	229	ALPC	well	2	0	0

127	198	ALPC	pit	9	5	21
128	199	ALPC	pit	0	2	1
132	203	ALPC 1	pit	141	112	219
132	233	ALPC 1	well	49	24	73
138	210	ALPC	well	8	3	25
140	212	ALPC	posthole	0	1	0
141	230	ALPC 1	well	35	9	34
142	214	ALPC	pit	0	0	5
144	216	ALPC	pit	3	3	1
145	218	ALPC	pit	0	0	1
148	222	ALPC	pit	3	0	0
153	227	ALPC	pit	4	1	5
153	277	ALPC	pit	2	1	0
154	228	ALPC	pit	0	0	2
155	238	ALPC	pit	1	0	2
156	232	ALPC	pit	0	1	0
156	234	ALPC	dog skeleton	34	0	259
160	239	ALPC	pit	2	0	2
164	243	ALPC 1	pit	113	96	183
165	244	ALPC 1	pit	9	5	9
180	255	ALPC	pit	2	0	0
180	259	ALPC 1	pit	1	0	9
181	260	ALPC	pit	2	1	1
182	261	ALPC 1	pit	82	54	148
182	281	ALPC	posthole	1	0	0
183	262	ALPC	dog skeleton	48	0	377
184	263	ALPC	pit	0	1	0
186	265	ALPC	pit	0	1	1
193	272	ALPC	pit	0	0	1
194	273	ALPC	pit	0	1	0
196	275	ALPC	pit	0	1	0
199	278	ALPC	pit	2	3	2

5.3 Species representation

5.3.1 Site

In the overall assemblage cattle dominated the Number of Identifiable Specimens (NISP) at 37.7% (251/665; figure 5.1). Of the other domestic food animals caprines followed at 16.8% (112/665), including goat, and pigs at 10.5% (70/665). Dogs were also well represented compared to other sites in the NISP at 12.8% (85/665). The minimum number of individuals (MNI) indicates that there were at least four domestic dogs in the settlement, of which two were largely complete dog burials in contexts 234 and 262, accounting for the high NISP (table 5.3). However, there were also dog bones in the assemblage that were not deposited in the same way – a lone scapula and a tibia were part of the assemblage of Well 233 and two other pits yielded individual dog remains.

Wild animals were unusually high at 22.1% (147/665) of the NISP compared to other LBK sites studied. Wild boar was the most commonly identified wild species, but aurochs, red deer, roe deer, wild horse and some indeterminate wild birds were also present. The prevalence of wild boar suggests that forested landscape was being exploited for hunting and gathering.

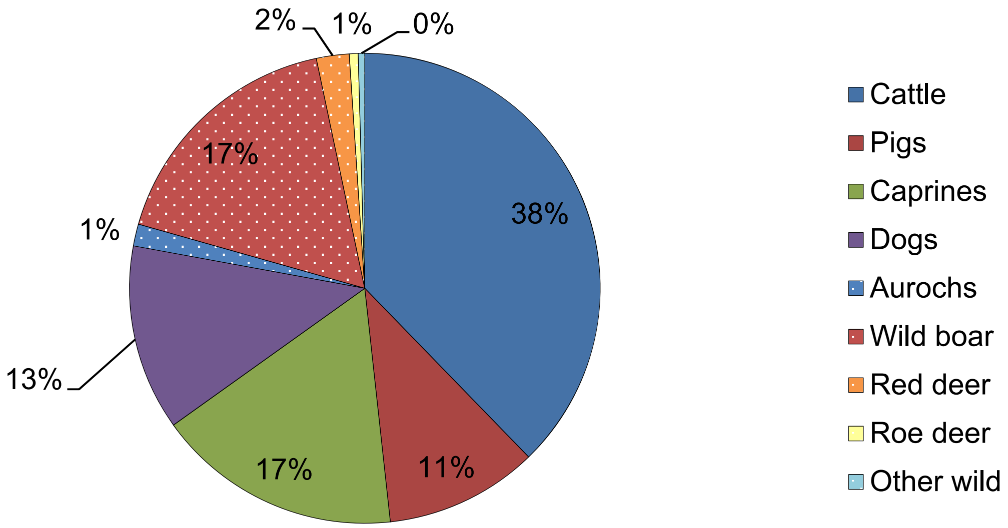

Figure 5.1: Species representation (NISP) for the fully identifiable assemblage from Polgár-Piócás-dűlő (n=665).

5.3.1.1 Contexts

There was no obvious pattern in deposition between pits and wells of different phases, with all contexts showing different distributions of domestic and wild animals (figure 5.2). Both wells had high proportions of cattle but varied in the amount of small stock and wild animals.

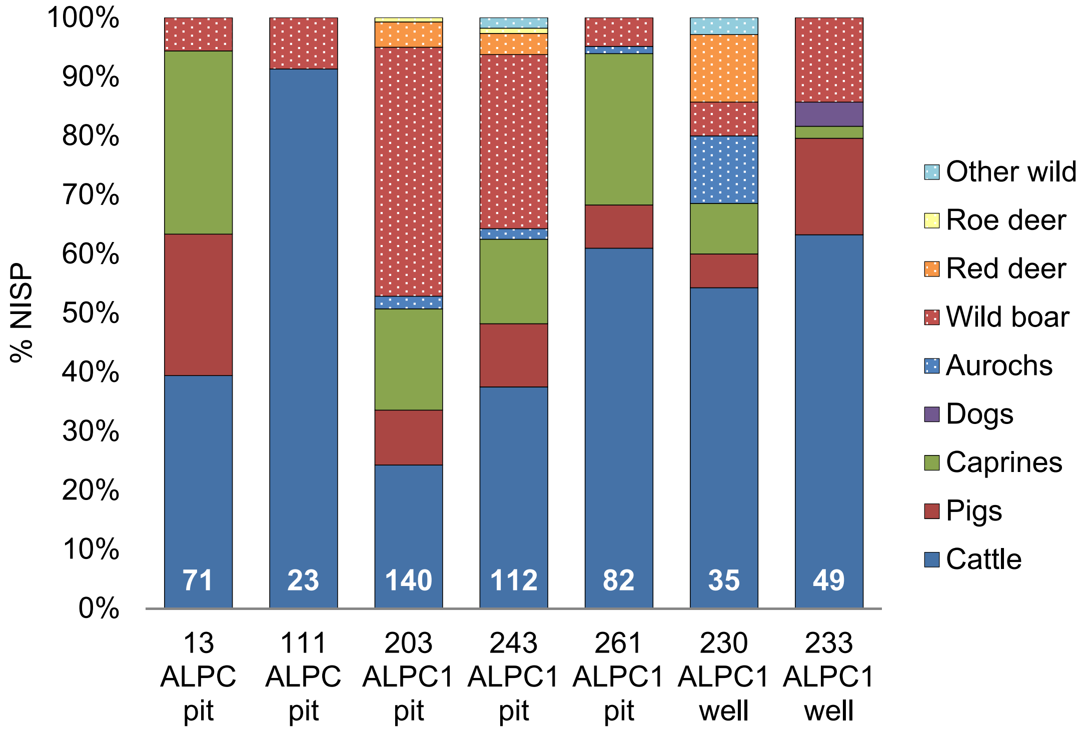

Figure 5.2: Species representation (NISP) for individual contexts from Polgár-Piócás-dűlő. N values are at the base of each bar.

5.4 Butchery

5.4.1 Site

On the overall assemblage butchery affected 2.7% (75/2753) of all specimens, and 5.4% (59/1096) of the identifiable assemblage. Most identifiable butchery marks were cut and scratch marks, although evidence of heavier butchery was also recorded in chop marks (figure 5.3). Crush marks likely result from percussive attempts to access the marrow cavity. The two ALPC I wells 230 and 233 (9.4%, 21/224) had a significantly higher proportion of butchered bones compared to the pit contexts (3.0%, 47/1558, $p<.001$; figure 5.4).

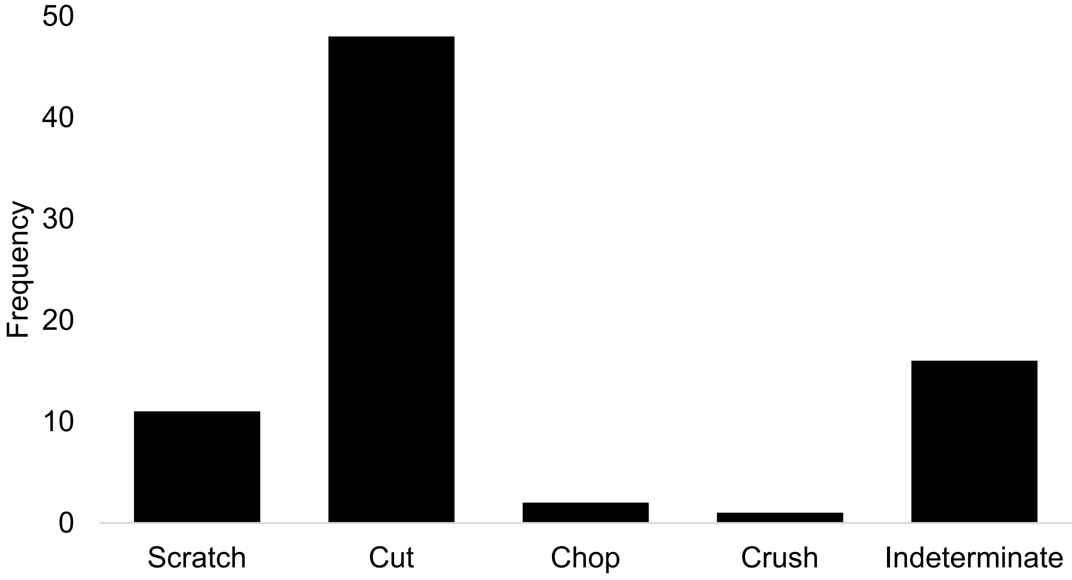

Figure 5.3: Frequency of butchery mark types from Polgár-Piócás-dűlő.

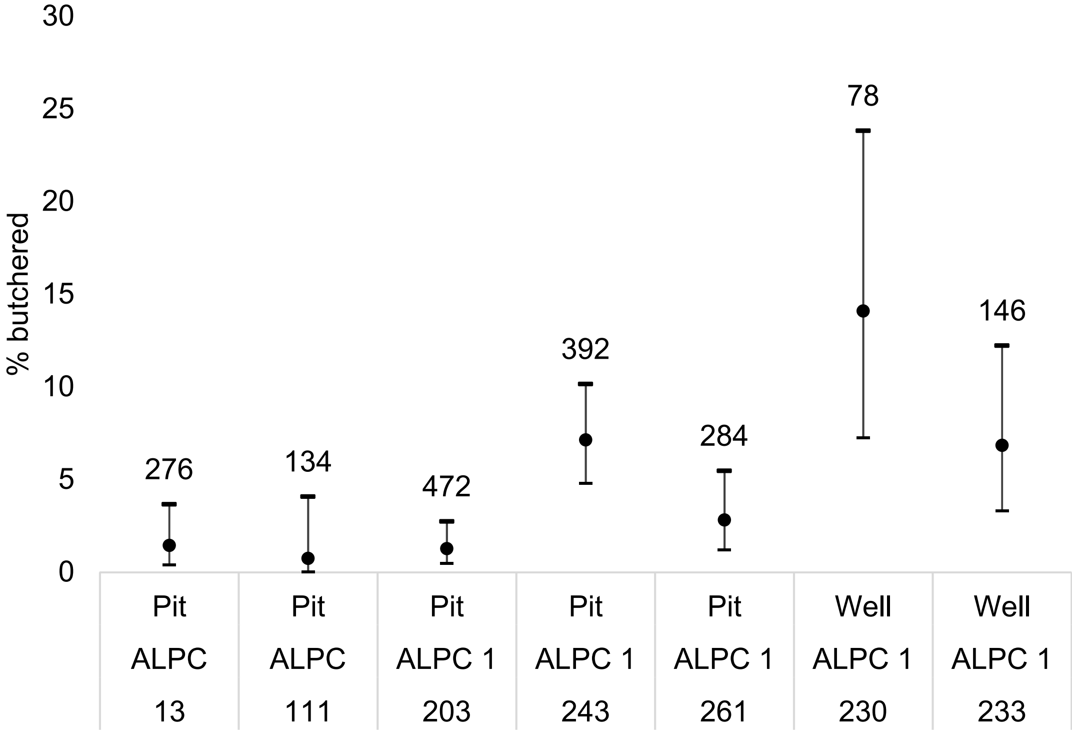

Figure 5.4: Percentage of individual contexts with butchery marks from Polgár-Piócás-dűlő, with 95% confidence intervals. N values are at the top of each series.

5.4.2 Species

The bones of wild animals (13.9%, 20/144) were significantly more often affected by butchery marks than domestic animals (7.0%, 30/426, p=.012; figure 5.5), particularly large wild species. Red deer, aurochs and wild boar were the most commonly butchered species, followed by domestic cattle and pigs. Caprines were rarely butchered, and no butchery was recorded on roe deer. These patterns of butchery could relate to more intensive kill site butchery of wild animals, especially those dismembered for transport. However, due to low sample sizes, differences between species were not statistically significant. One domestic dog tibia, from the near-complete dog skeleton in structure 262, featured a cut mark, potentially suggesting some form of carcass processing on this individual. However, as no other dog bones in this single context showed evidence of butchery, it is likely that dogs were not butchered in the same way as other animals, particularly as this animal was buried whole.

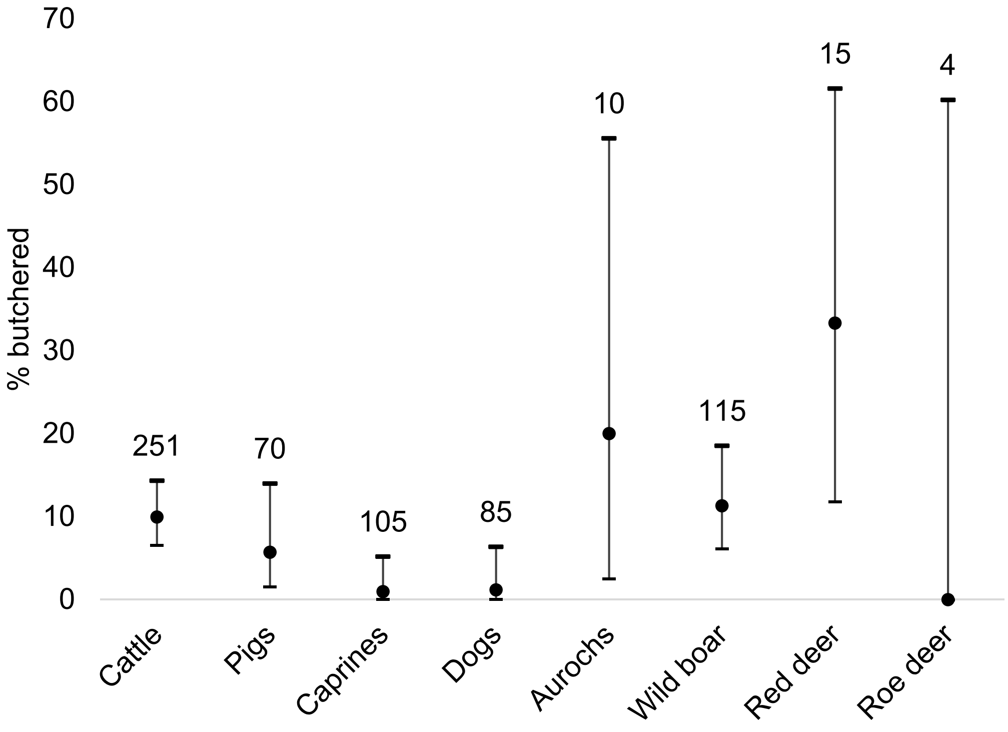

Figure 5.5: Percentage of different species with butchery marks from Polgár-Piócás-dűlő, with 95% confidence intervals.

5.4.3 Carcass butchery

Butchery marks were found in varying concentrations in different carcass parts. The forelimb and extremities were particularly commonly affected, whereas on the cranium and mandible no butchery was recorded (0/125; figure 5.6), significantly less than on the hindlimb (6/110, p=.008), forelimb (25/199) and extremities (18/168; both p<.001). The forelimb was also significantly more affected by butchery than the hindlimb (p=.046).

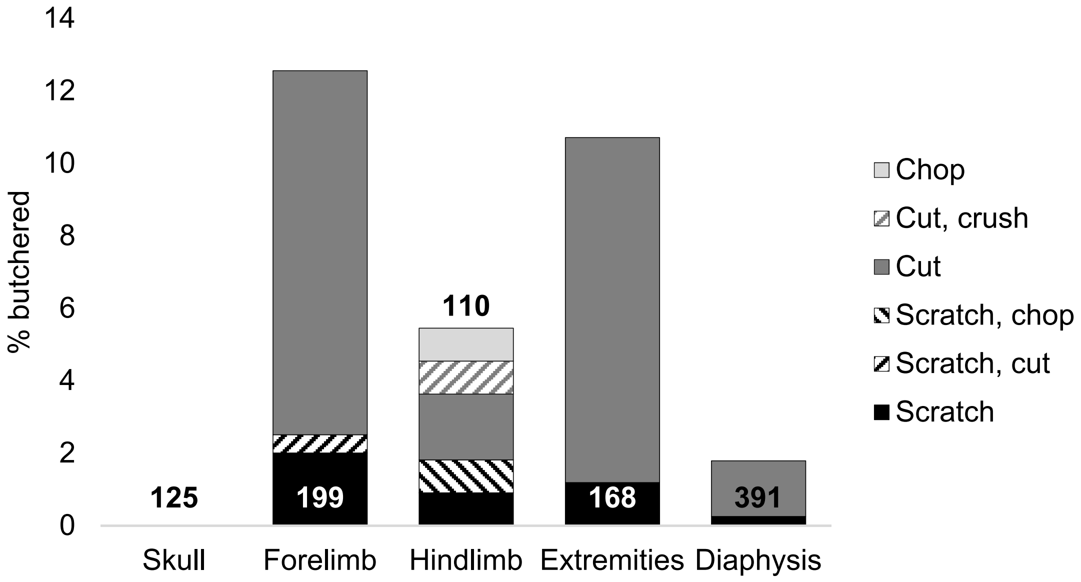

Figure 5.6: Percentage of carcass portions affected by different butchery episodes from Polgár-Piócás-dűlő.

5.4.3.1 Forelimb butchery

The scapula showed interesting patterns of butchery, particularly a cross hatching of scratch marks on one fragment of medial cattle scapula, suggesting defleshing of the subscapularis muscle (figure 5.7). Defleshing butchery was also represented on the medial neck of the scapula. Butchery on the humerus (figure 5.8) suggests disarticulation from the radius and ulna, particularly on the lateral face, and defleshing of the meaty humerus (Soulier and Costamagno 2017). On the radius and ulna (figure 5.9), butchery resulting from disarticulation from the humerus was common on the olecranon process. Butchery also clustered on the anterior diaphysis, suggesting stripping of soft tissue or removal of the periosteum (*ibid.*).

🟦 Scratch 🟩 Cut 🟥 Chop

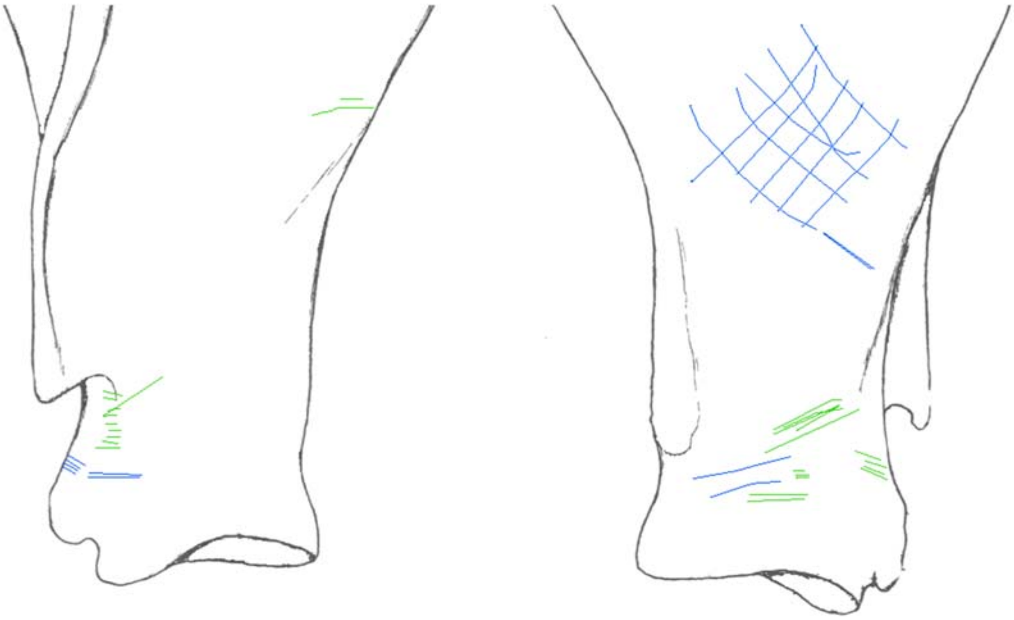

Figure 5.7: Cumulative diagram of butchery on bovine (n=5), suid (n=3) and red deer (n=1) scapulae from Polgár-Piócás-dűlő. Lateral (left) and medial views.

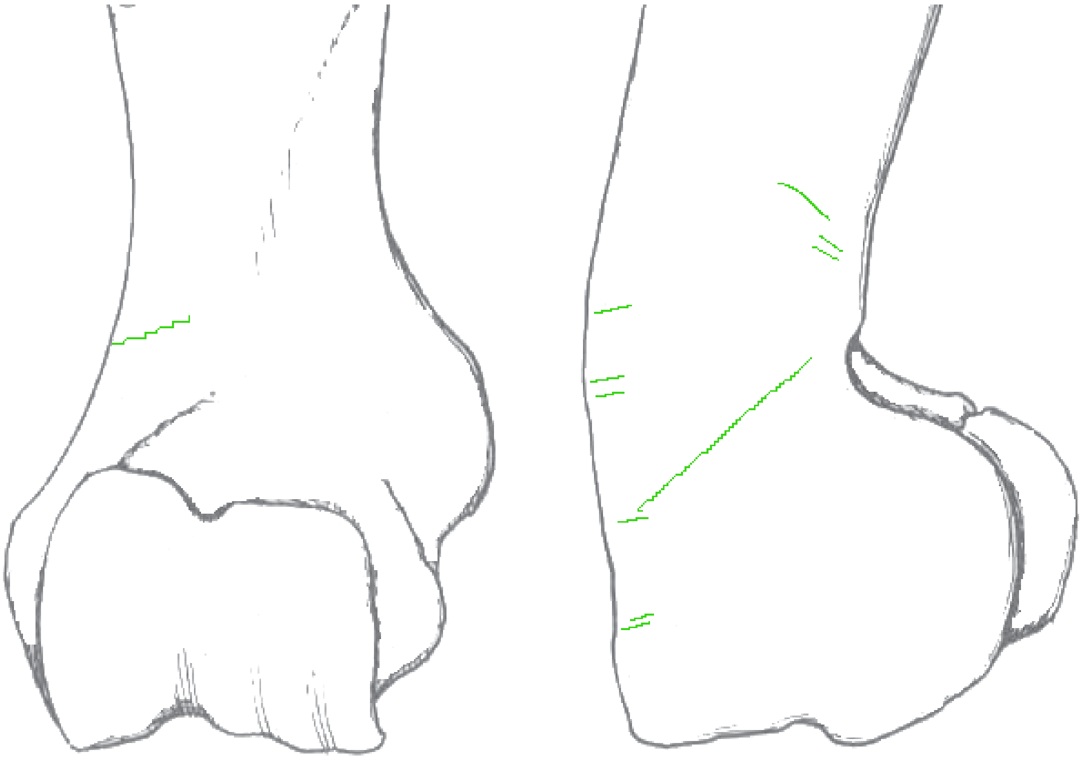

Figure 5.8: Cumulative diagram of butchery on bovine (n=1) and suid (n=3) humeri from Polgár-Piócás-dűlő. Anterior (left) and medial views.

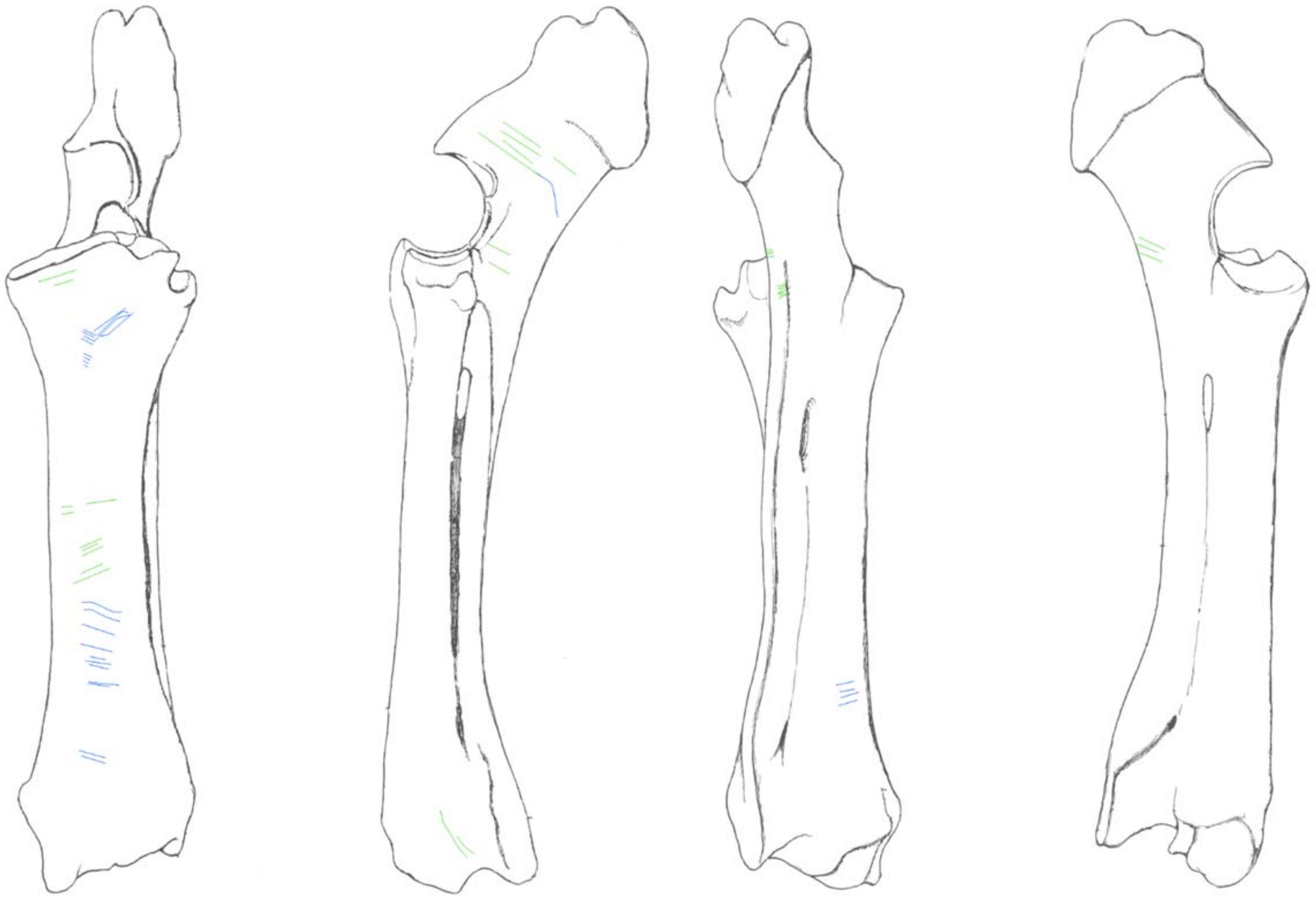

Figure 5.9: Cumulative diagram of butchery on bovine (n=7) and wild boar (n=3) radii and ulnae from Polgár-Piócás-dűlő. Left to right; anterior, lateral, posterior and medial views.

5.4.3.2 Extremities butchery

The clustered cut and scratch marks at midshaft on ruminant metapodia could result from circular incisions during skinning (figure 5.10; Soulier and Costamagno 2017), reflected in the suid metapodia (figure 5.11). Bovine phalanges, as well as likely exhibiting evidence of skinning, also could indicate utilisation of the extensor tendons, which attach at the external faces of the medial and lateral phalanges (figure 5.12).

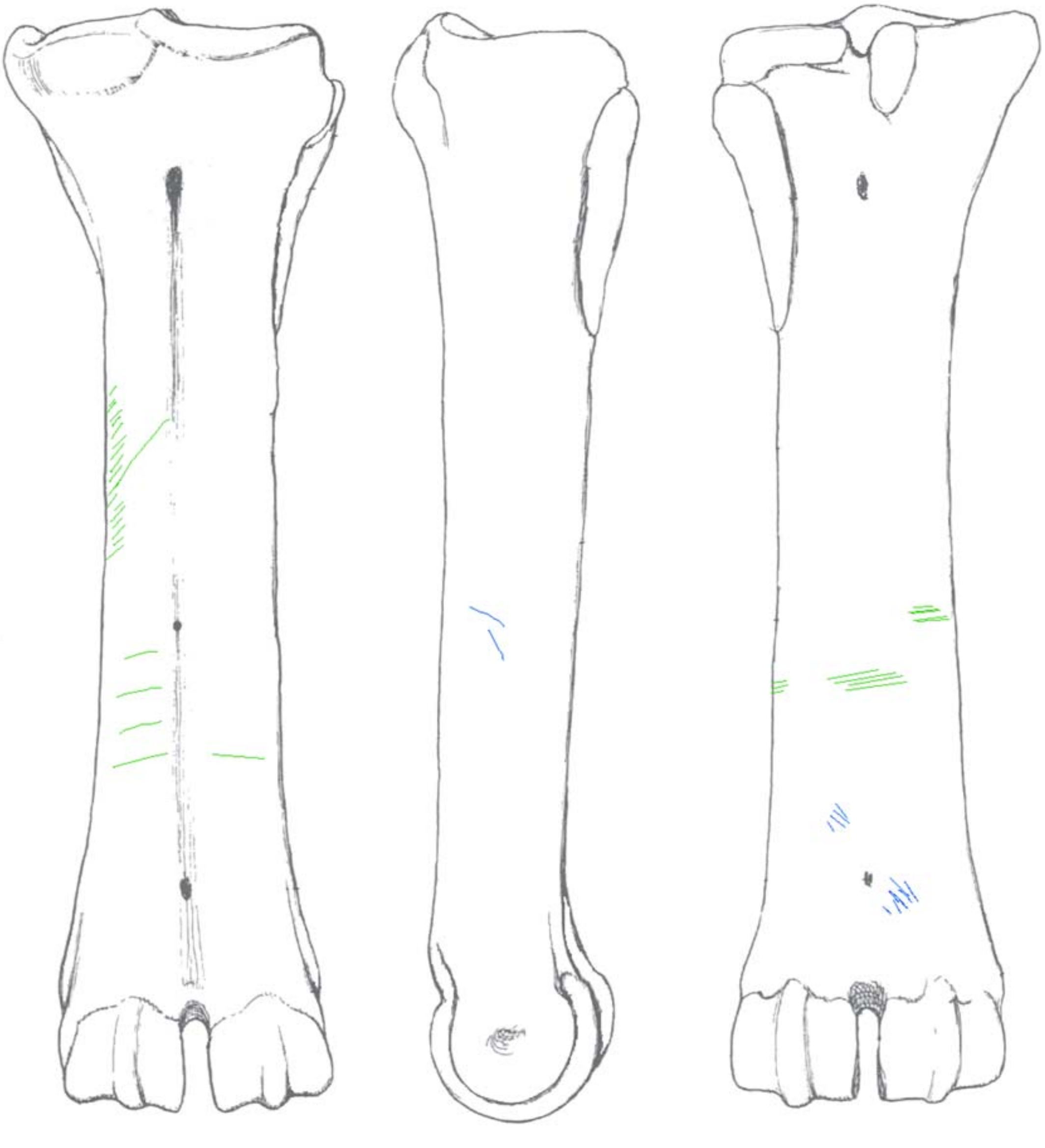

Figure 5.10: Cumulative diagram of butchery on cattle (n=4) and red deer (n=2) metapodia from Polgár-Piócás-dűlő. Left to right; anterior, lateral and posterior views.

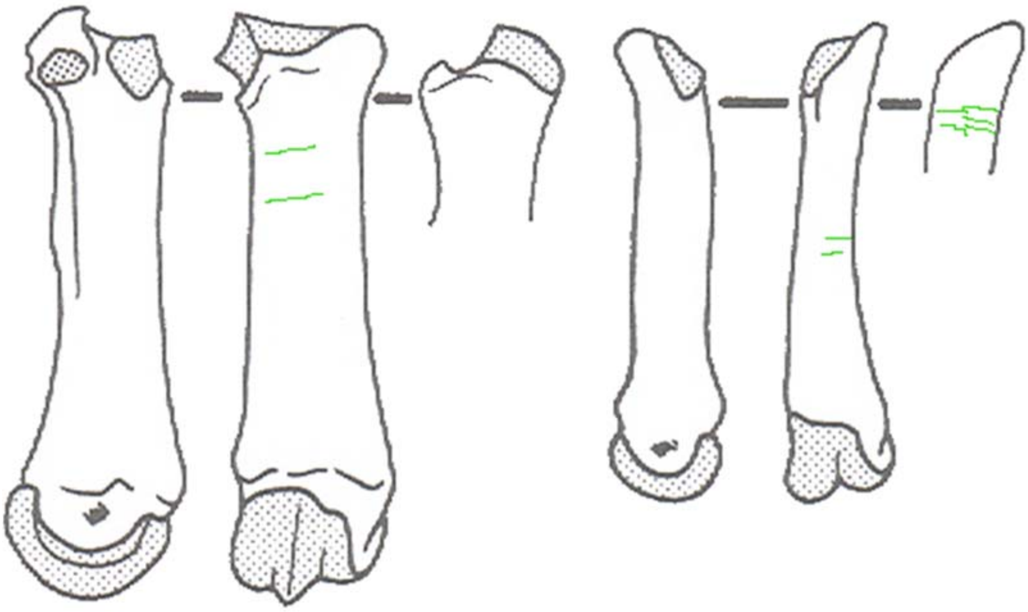

Figure 5.11: Cumulative diagram of butchery on suid metacarpals (n=3) and metatarsals (n=1) from Polgár-Piócás-dűlő. Left to right; medial, anterior and lateral views of the 4th and 5th metacarpal.

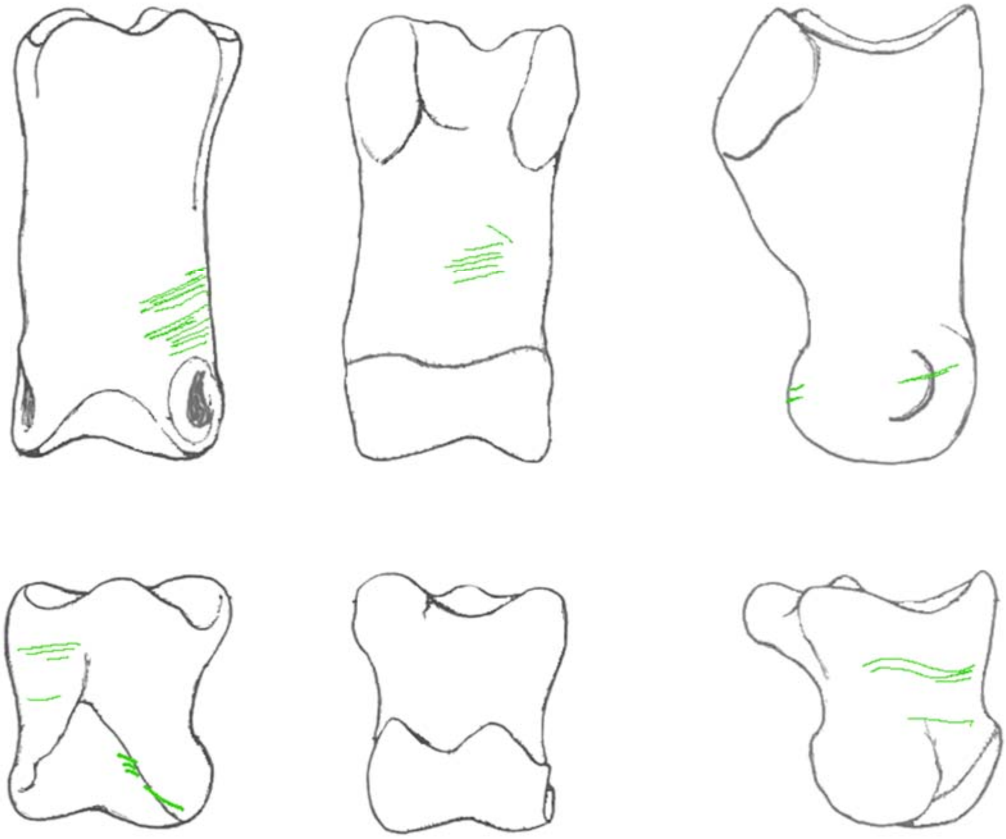

Figure 5.12: Cumulative diagram of observable butchery on bovine phalanges (n=3) from Polgár-Piócás-dűlő. Left to right; anterior, posterior and medial views.

5.5 Heat exposure

5.5.1 Site

Evidence of burning was present on 5.5% (151/2753) of the entire assemblage from Polgár-Piócás-dűlő, and 7.5% (82/1096) of the identifiable assemblage (figure 5.13). Roasting affected 3.6% (40/1096) of identifiable bones, almost exclusively affecting bones with marrow cavities. Three bones had been roasted on the fracture area before being fractured, whereas one bone was clearly fractured and then roasted. Roasting was extremely present in the ALPC pit 111, where 59.5% (22/37) of identifiable bones were roasted (figure 5.14) This was a significantly greater proportion than all other selected contexts (p<.001[3]).

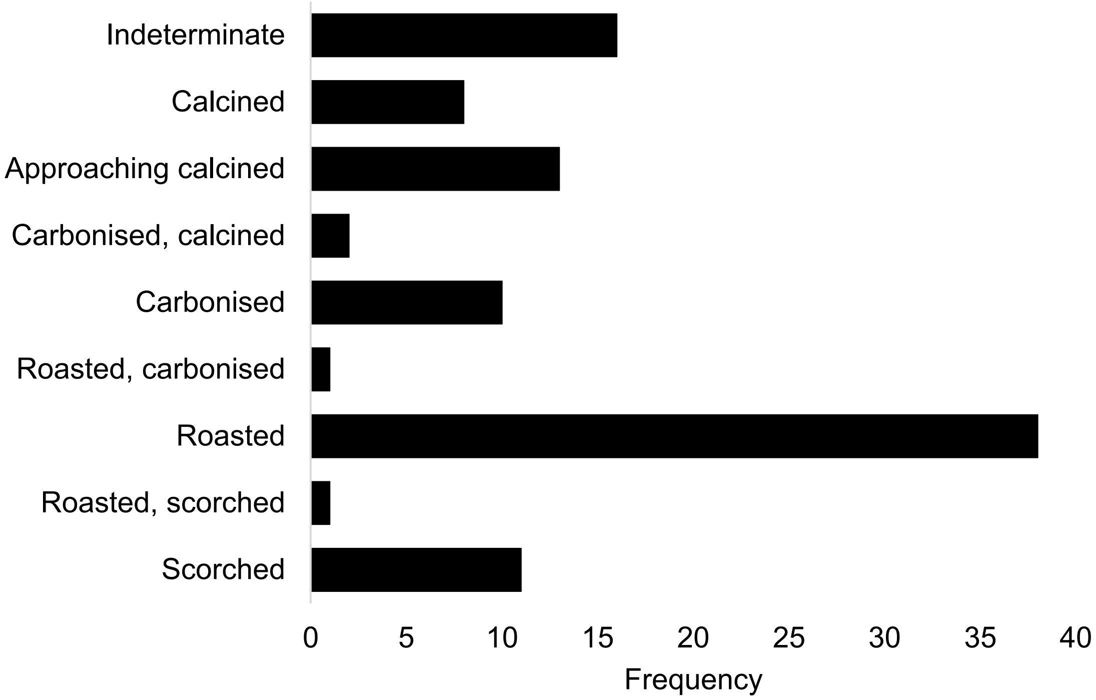

Figure 5.13: Frequency of heat exposure types from Polgár-Piócás-dűlő.

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[3] ALPC pit 13 n=0/146; ALPC pit 111 n=22/37; ALPC 1 pit 203 n=2/253; ALPC 1 pit 243 n=2/209; ALPC 1 pit 261 n=3/136; ALPC 1 well 230 n=0/44; ALPC 1 well 233 n=0/73.

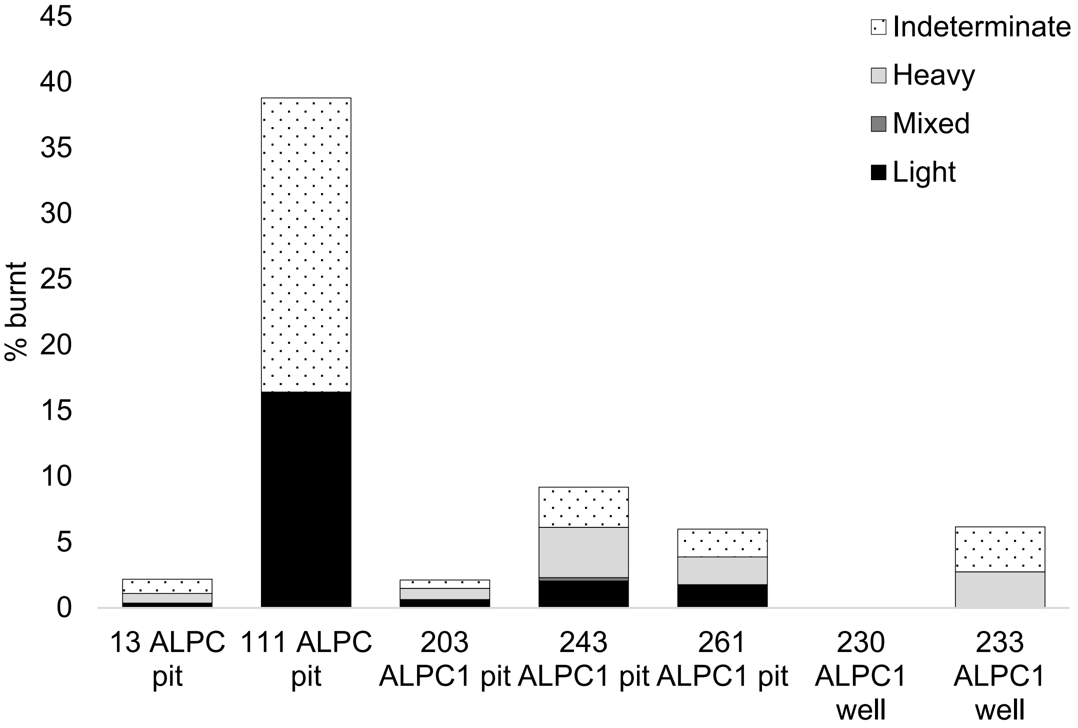

Figure 5.14: Percentage of bones affected by different intensities of heat exposure from selected contexts from Polgár-Piócás-dűlő.

Figure 5.15: Cattle metatarsal from ALPC pit context 111 showing evidence of roasting from Polgár-Piócás-dűlő.

5.5.2 Species

Bones belonging to large mammals were significantly more affected by heat exposure (13.9%, 70/503) than medium mammals (3.0%, 15/505, p<.001). Roasting was more common on large mammals than on medium mammals (figure 5.16). Cattle bones were particularly affected by burning, on 14.7% (37/251) of identifiable specimens.

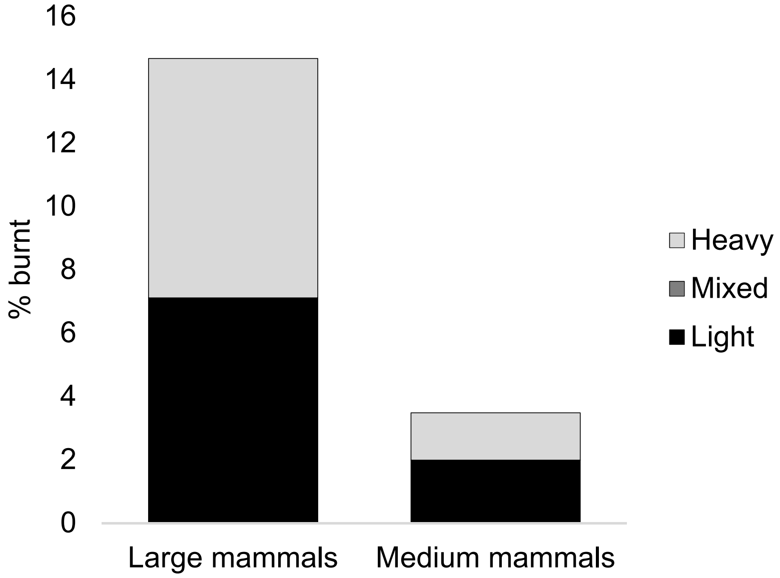

Figure 5.16: Percentage of large (n=503) and medium (n=505) mammal bones affected by different intensities of heat exposure from Polgár-Piócás-dűlő.

5.6 Fracture

5.6.1 Site

The site of Polgár-Piócás-dűlő showed substantial fresh fracture, on 54.1% (314/580) of fractured bones (figure 5.17), with a mean fracture freshness index of 2.9 out of six (figure 5.18). This suggests an assemblage in which marrow was commonly extracted from the long bones. High-yield elements were fractured when fresh more commonly than low-yield elements (figure 5.17), indicating that the bones with the highest marrow yields were being targeted for marrow extraction. An abundance of very fresh (0) and very dry (6) FFI scores suggest that bones were either exploited for marrow, or were broken when all organic content had been lost (figure 5.18).

Dry and mineralised fracture also affected the assemblage, and thus not all bones that could have been fractured for marrow were broken whilst the marrow was still fresh. Mineralised fracture was high overall, implying that some specimens must have been disturbed after deposition. Secondary dry and mineralised fracture was present, although in low proportions, suggesting that contexts were not often disturbed post-deposition. 7.0% (22/314) of bones with fresh fractures were fractured secondarily when dry, of which 22.7% (5/22) showed evidence of burning, suggesting that heat exposure made bones more susceptible to dry fracture.

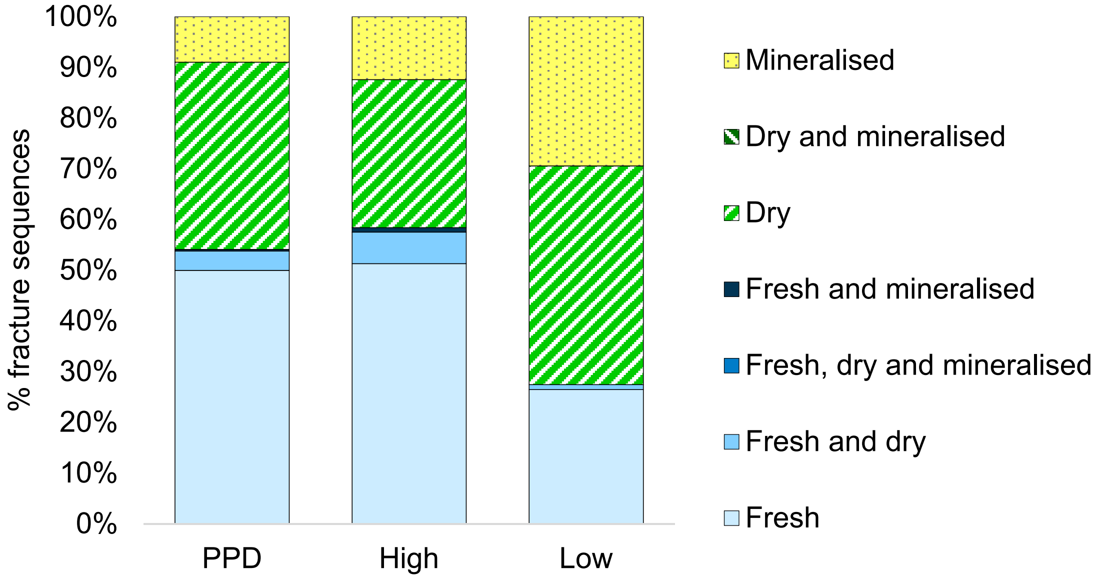

Figure 5.17: Fracture history profiles for the Polgár-Piócás-dűlő assemblage (left, n=580) and for high- and low-yield marrow bones (right, n=113/102).

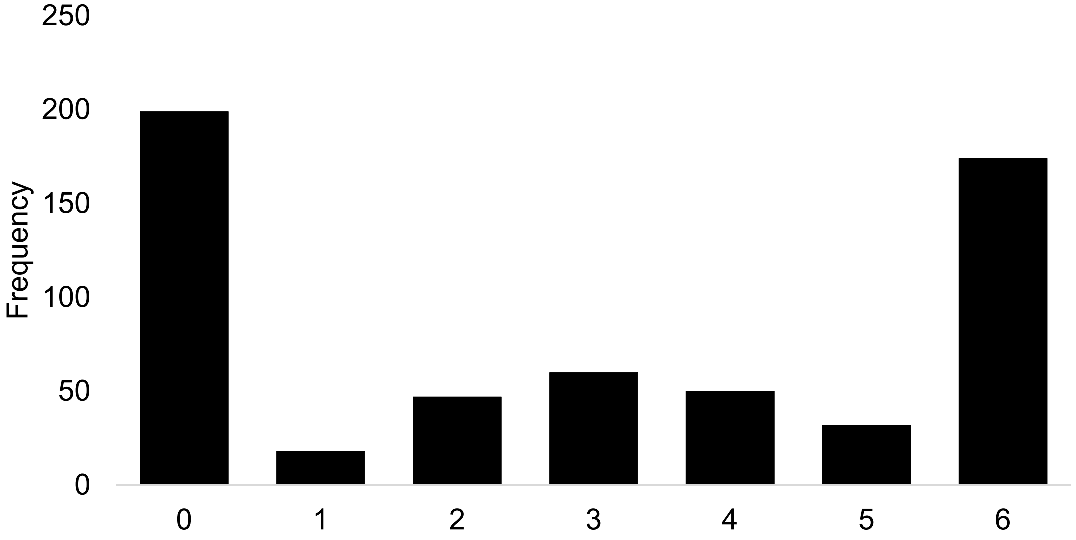

Figure 5.18: Frequency of Fracture Freshness Index scores from Polgár-Piócás-dűlő.

5.6.1.1 Contexts

In the comparable contexts there was no clear pattern relating to the phases or types of contexts. Different levels of fracture freshness were detected in the majority of contexts, although fresh first fracture was more common on contexts dated to the ALPC rather than to the ALPC 1 period (69.7% ,101/145 and 55.6%, 213/383 respectively, when mineralised fracture was removed). Structures 13, 243 and 230 showed particularly high values and structures 111, 203, 261 and 233 presented lower values (figures 5.19, 5.20 and 5.21). Sample sizes for analysing high- and low-yield marrow bones were small, but many contexts (13, 203, 243 and 261) had higher proportions of fresh fracture on high-yield bones than low-yield bones. Context 111 had a comparatively high amount of mineralised fracture, including secondary mineralised fracture, affecting the assemblage. This could suggest that the context was disturbed post-deposition.

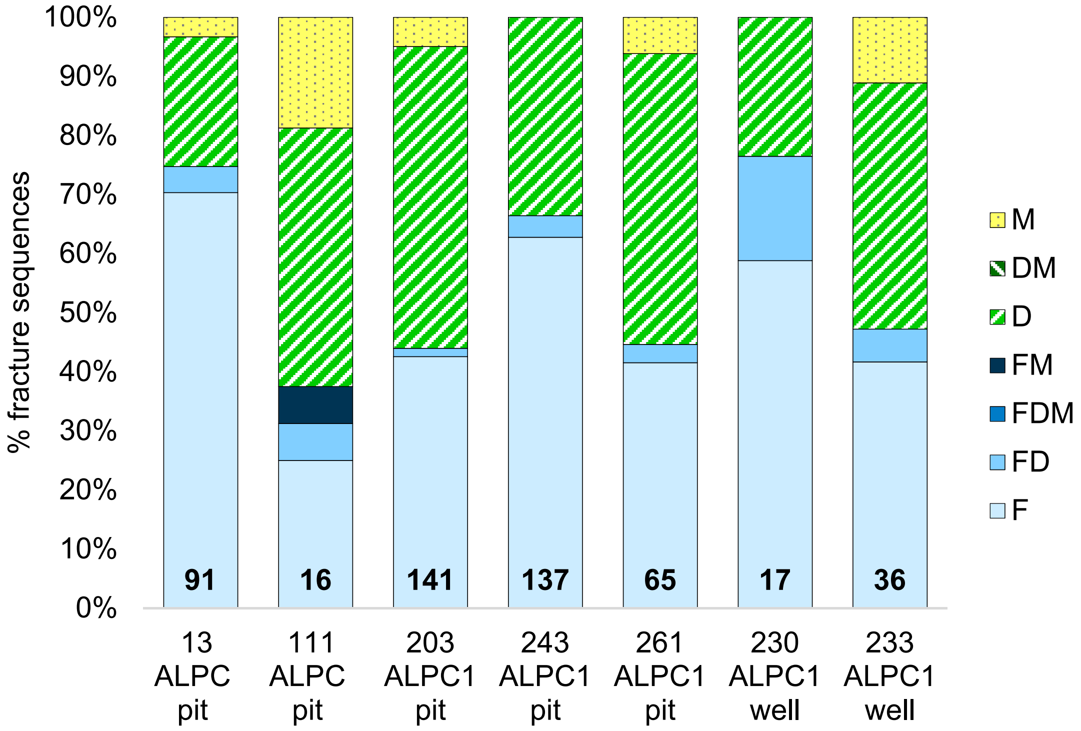

Figure 5.19: Fracture history profiles from selected contexts from Polgár-Piócás-dűlő. N values are at the base of each bar.

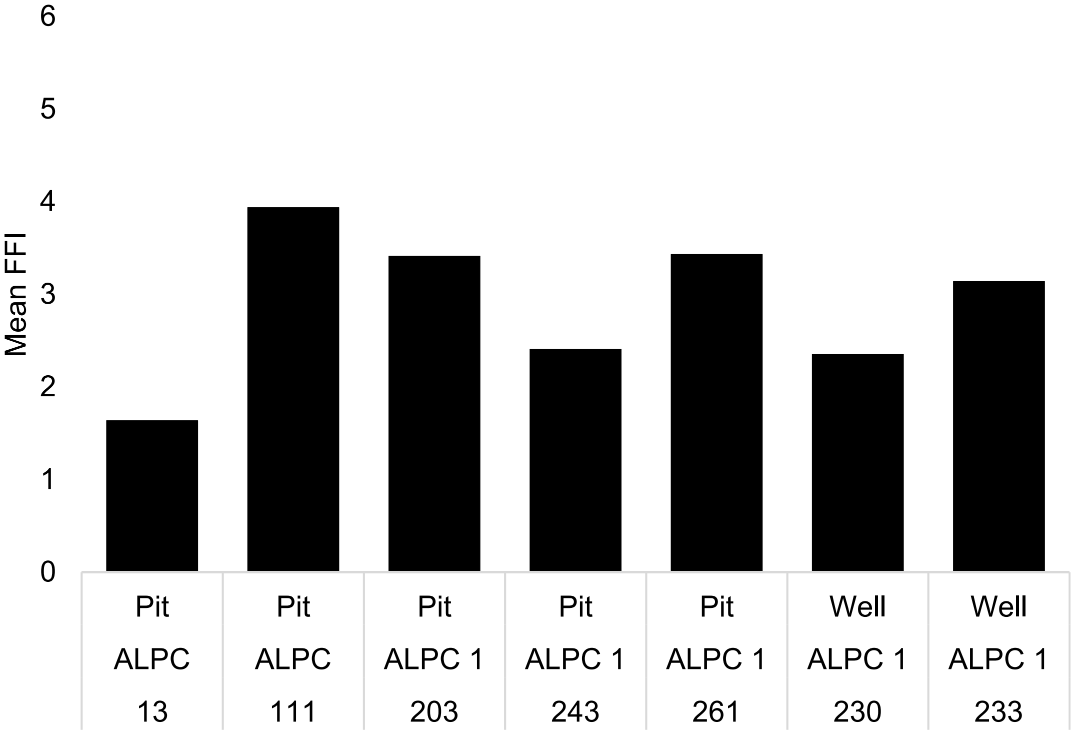

Figure 5.20: Mean Fracture Freshness Index scores from selected contexts from Polgár-Piócás-dűlő.

Figure 5.21: Example of likely marrow processing from context 243 from Polgár-Piócás-dűlő. Note that not all bones exhibit 'perfect' fresh fracture.

5.6.2 Species

Cattle showed surprisingly low levels of fresh fracture, despite having large marrow cavities (figure 5.22). As at Füzesabony-Gubakút, medium mammals showed a much higher proportion of bones that were first fractured when fresh, particularly domestic pigs. Wild animals were also often fractured when fresh. High-yield bones of medium mammals were preferred to low-yield elements for marrow extraction, while large mammal bones did not show such high disparity (figure 5.24). Domestic dog bones were only fractured when mineralised.

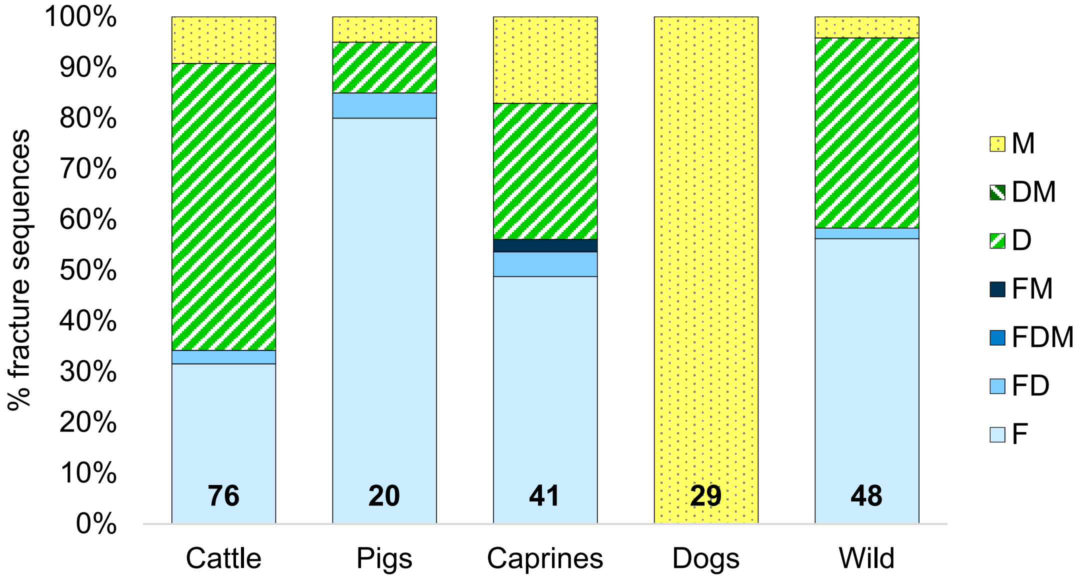

Figure 5.22: Fracture history profiles for species from Polgár-Piócás-dűlő.

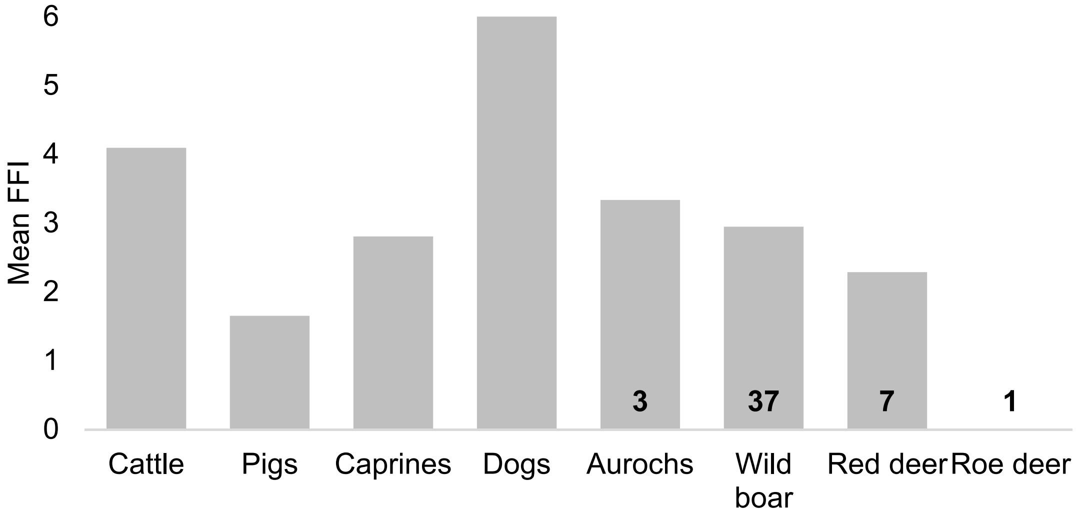

Figure 5.23: Mean Fracture Freshness Index for species from Polgár-Piócás-dűlő. N values for individual wild species are at the base of each bar.

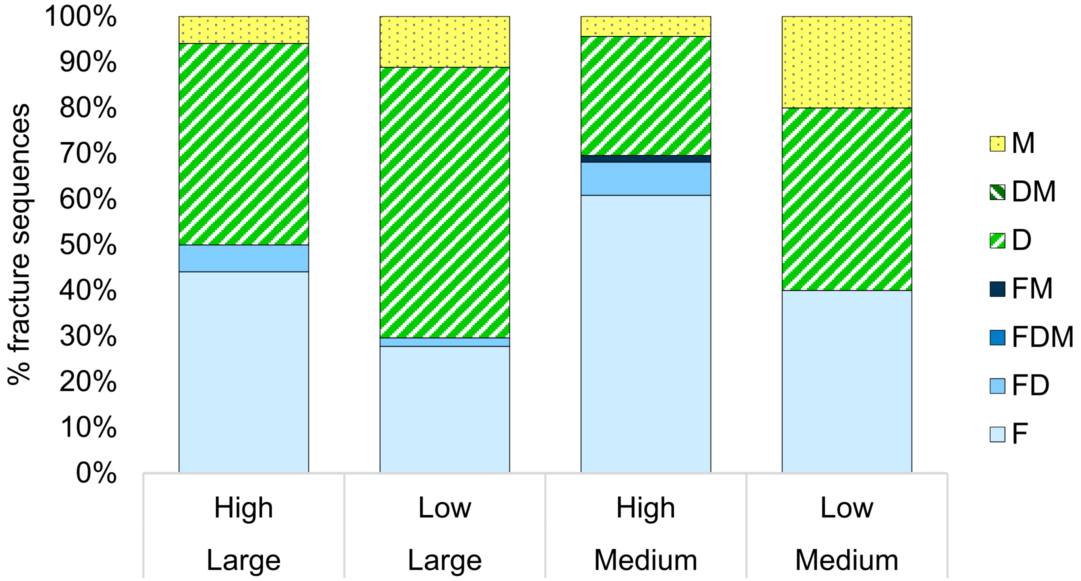

Figure 5.24: Fracture history profiles for high- and low-yield marrow bones from large (n=34/54) and medium mammals (n=69/30) from Polgár-Piócás-dűlő.

5.6.3 Fracture summary

Correspondence analysis shows that the percentage of fresh fracture was partially related to the proportions of small stock (figure 5.25). Contexts high in fresh fracture were also high in small stock and, to a lesser extent, wild animals. This, and the association of cattle with mineralised fracture, is corroborated by the analysis of fresh fracture between species. The percentage of caprines and pigs in the NISP of each context also correspond with each other. The different context types do not separate clearly, suggesting that deposition practices did not differ strongly between contexts.

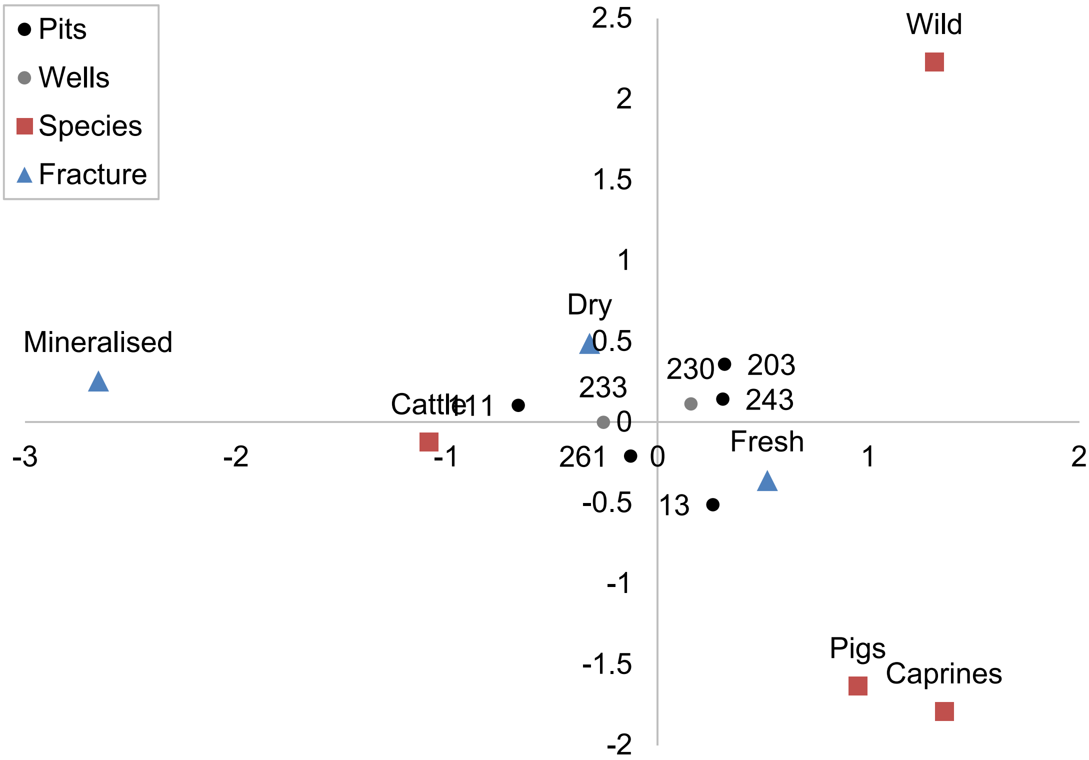

Figure 5.25: Correspondence analysis of the percentage of identifiable specimens and fresh, dry and mineralised first fracture affecting selected contexts from Polgár-Piócás-dűlő.

5.7 Fragmentation

The level of fragmentation from Polgár-Piócás-dűlő does not suggest systematic bone grease processing. The proportion of the assemblage weight found in the smallest size classes was very low (figure 5.26), although there was a large amount of cancellous material within these contexts (figure 5.27). Many bones were whole, particularly phalanges, vertebrae and carpals and tarsals, and bones often had unfragmented grease-rich epiphyses.

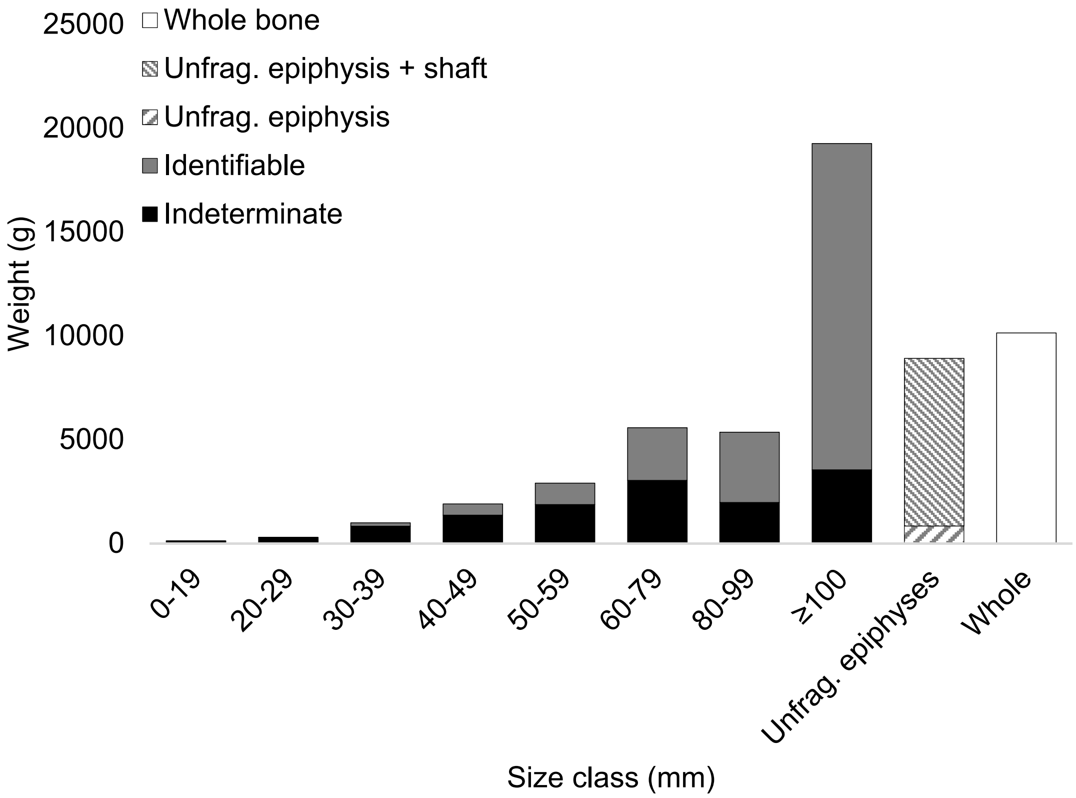

Figure 5.26: Weight by size class of all specimens from Polgár-Piócás-dűlő.

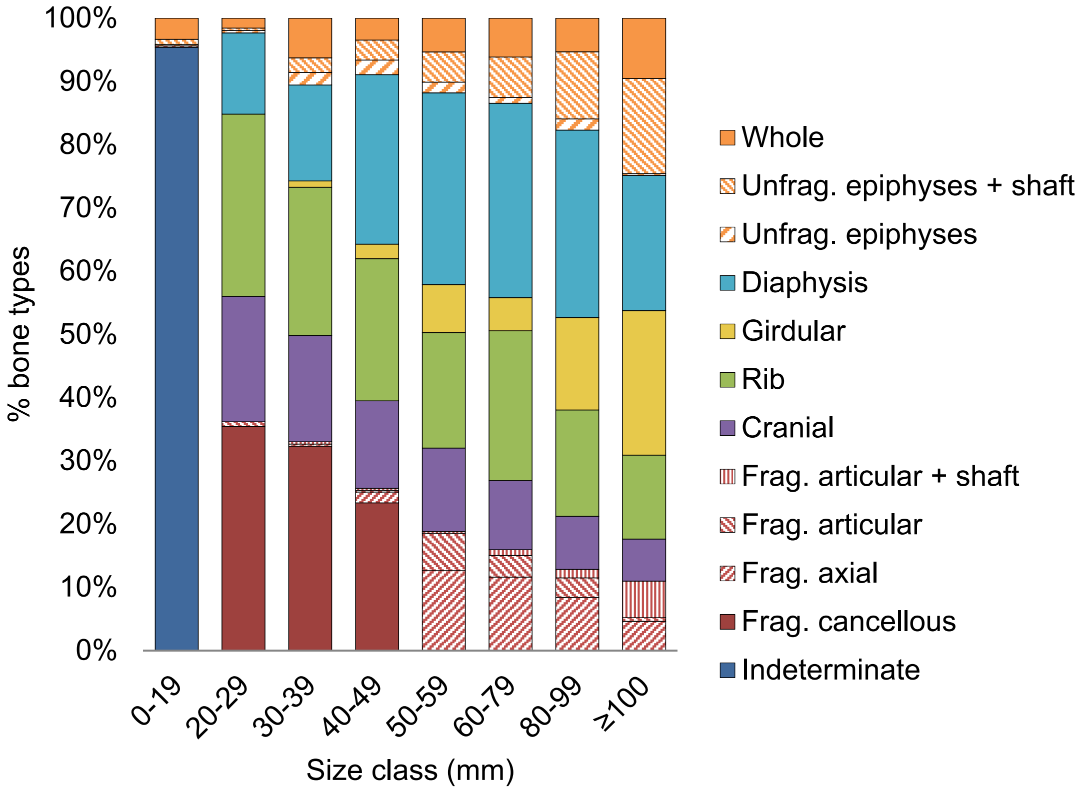

Figure 5.27: Frequency of bone types by size class from Polgár-Piócás-dűlő. Red series indicate fragmented cancellous material.

5.8 Taphonomy

5.8.1 Gnawing

Gnawing affected 1.6% (44/2753) of the assemblage from Polgár-Piócás-dűlő. Canid gnawing was the most common type of gnawing (n=38), although rodent gnawing was also present (n=4; figure 5.28). It is likely that this level of gnawing could have been caused by the domestic dogs present on site, and did not dramatically impact the signatures of human carcass processing.

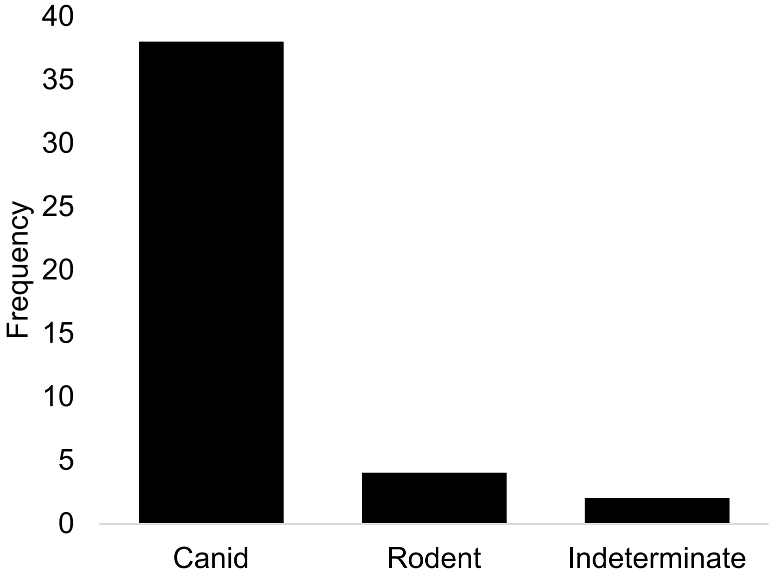

Figure 5.28: Frequency of gnawing types from Polgár-Piócás-dűlő.

5.8.2 Taphonomic agents and recent breaks

Taphonomic agents, particularly cementations of mud but also erosion, weathering and root etching, were present on 6.4% (70/1096) of the identifiable assemblage (figure 5.29). Cemented mud, present on 5.0% (55/1096) of the identifiable assemblage, impacted fracture freshness and butchery analysis through obscuring bone surfaces, sometimes hampered basic identification. Recent breaks were also present on 10.1% (111/1096) of the identifiable assemblage (figure 5.31). These incidences were more common in some contexts, particularly in the ALPC pit 111, which showed high levels of new breaks (45.9%, 17/37) and cementations of mud (35.1%, 13/37; figure 5.30).

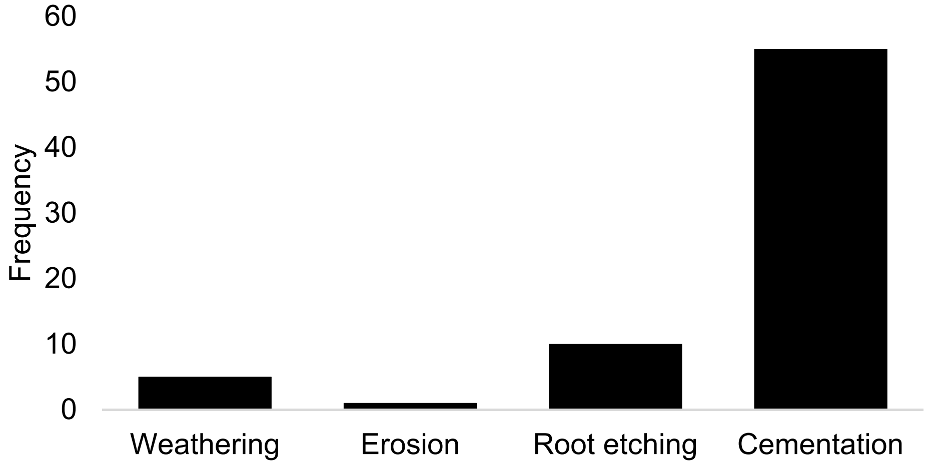

Figure 5.29: Frequency of taphonomic agents from Polgár-Piócás-dűlő.

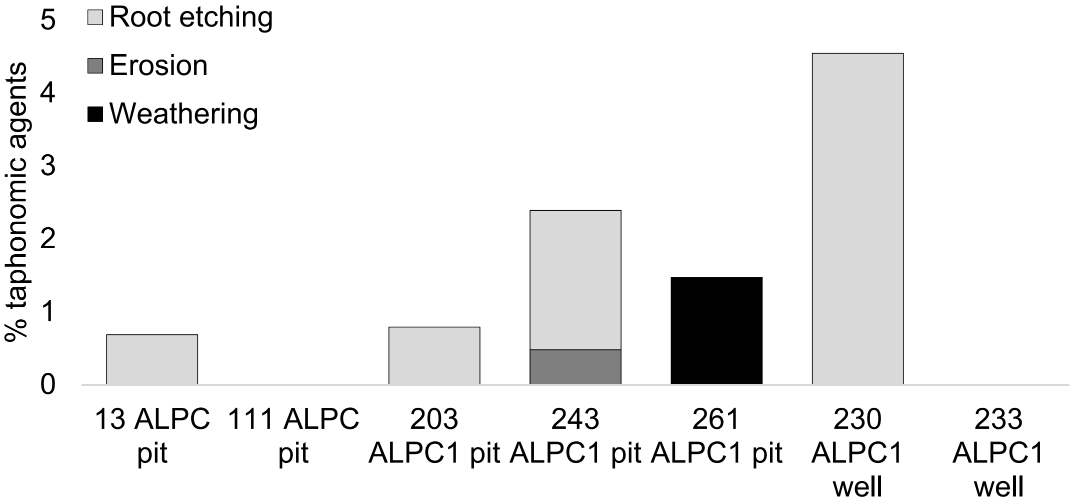

Figure 5.30: Percentage of identifiable specimens affected by different taphonomic agents from selected contexts from Polgár-Piócás-dűlő.

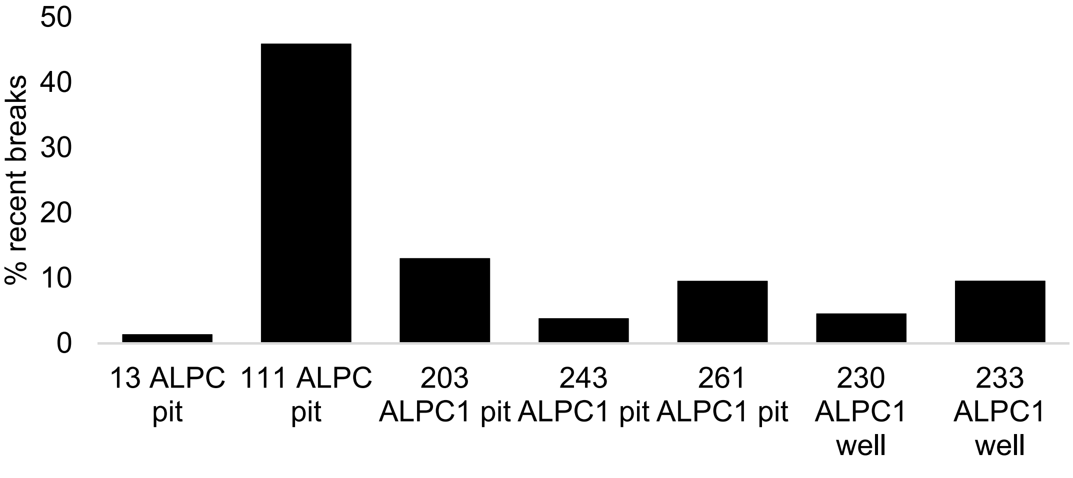

Figure 5.31: Percentage of the identifiable assemblage affected by recent breaks from selected contexts from Polgár-Piócás-dűlő.

5.9 Food exploitation strategies

5.9.1 Herd structure analysis

5.9.1.1 Cattle

The cattle fusion (figure 5.32) from Polgár-Piócás-dűlő showed minimal young slaughter, with the largest slaughter event at 18-36 months. 68.2% (15/22) of animals survived past their third year, into adulthood and full size. The high adult survival could indicate the presence of lactating females, although intensive dairy management in the slaughter of young males is not in evidence. The mortality profiles from teeth suggest that there was an increase in animals slaughtered between 15-26 months, which is reflected in the fusion ageing, however they also show that teeth from adult animals were underrepresented (Gillis unpub.b). Based on the high numbers of fused bones from animals that reached adult size this is surprising. The herd structure analysis suggests minor exploitation of meat weight animals, likely between 18-26 months, with a surviving dairy herd.

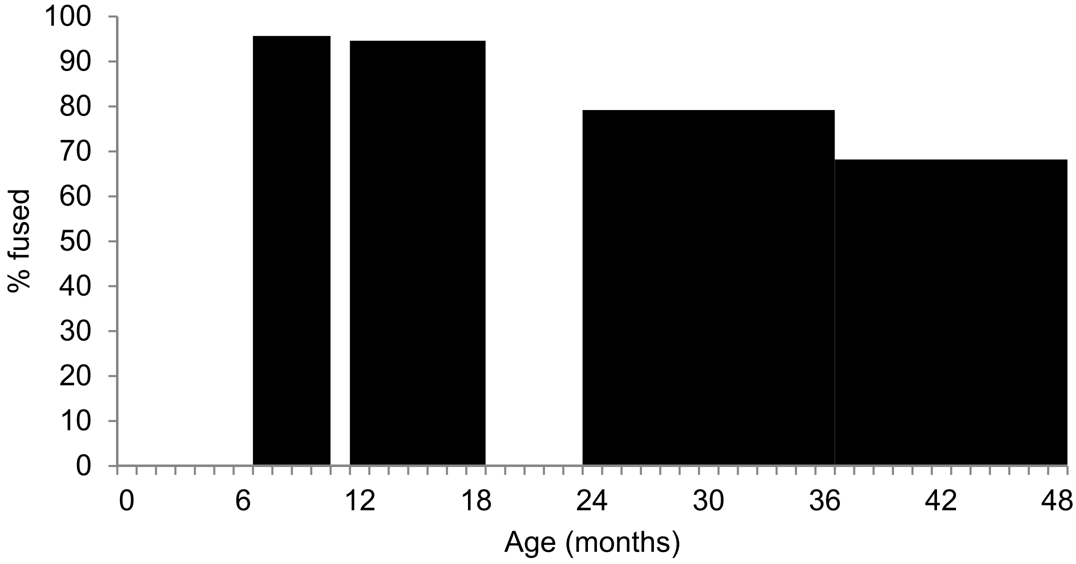

Figure 5.32: Cattle slaughter profile based on epiphyseal fusion from Polgár-Piócás-dűlő (n=106).

5.9.1.2 Caprines

The slaughter profile for caprines (figure 5.33) was affected by a small sample size. It shows some young slaughter, and a main slaughter event between 1.5 and 2.5 years at prime age for meat slaughter. Mortality profiles based on teeth show a large slaughter event at 2-4 and 4-6 years in sheep, and a suggestion of young slaughter (mirrored in the fusion profile), possibly indicating a Milk B herd structure where milk is exploited without intensive slaughter of very young lambs and retired females are slaughtered between 2 and 6 years (Gillis unpub.b; Vigne and Helmer 2007: 23). The goat mortality profile for teeth suggests management for milk, with infant size classes highly represented indicating kids removed from lactating females (*ibid.*). Caprines therefore were likely managed for meat and goat-focussed milk.

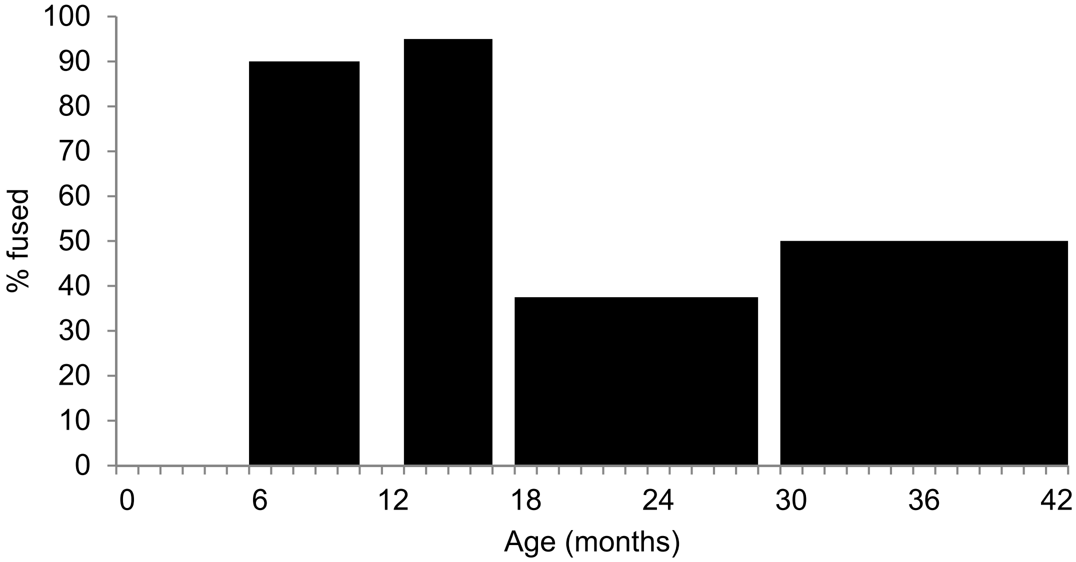

Figure 5.33: Caprine slaughter profile based on epiphyseal fusion from Polgár-Piócás-dűlő (n=50).

5.9.1.3 Pigs

Unusually for the domestic pig fusion (figure 5.34), there was no evidence of slaughter before one year (stage 1, n=13). It seems that pigs were largely slaughtered between 1 and 1.5 years of age, represented in the fusion diagram by a large kill-off. No specimens were fused from stage 3 (n=6), suggesting that most animals were killed before 3 years old. This pattern represents pig meat consumption.

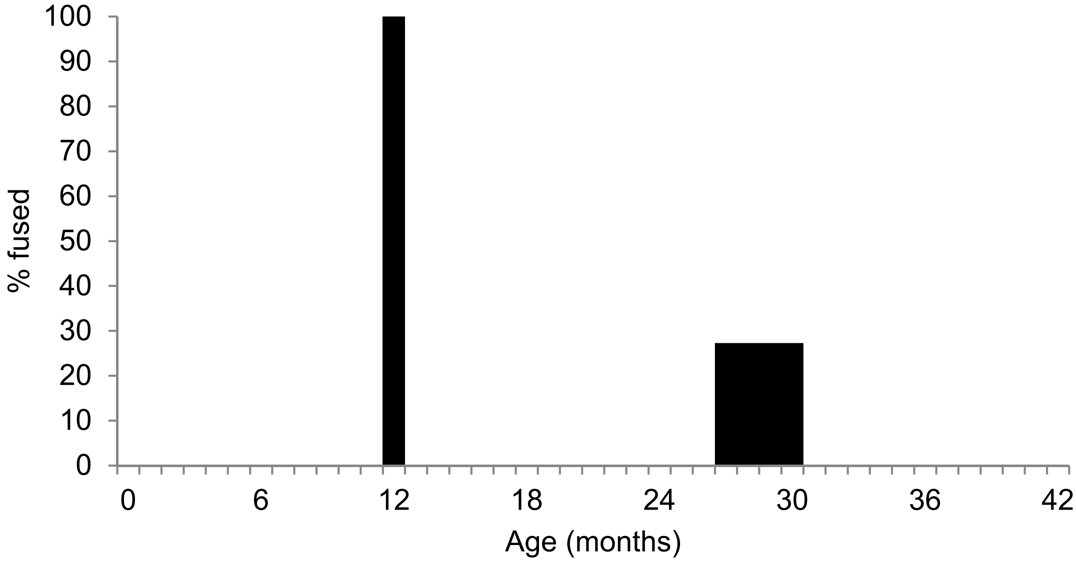

Figure 5.34: Pig slaughter profile based on epiphyseal fusion from Polgár-Piócás-dűlő (n=30).

5.9.2 Lipid residue analysis

No lipid residue data is currently available for Polgár-Piócás-dűlő.

5.10 Discussion

5.10.1 Meat and fat exploitation

Herd structure analysis suggests that Polgár-Piócás-dűlő possibly had a supply of milk from cattle and goats, with sheep, cattle and pigs also managed for meat slaughter. Carcasses were skinned, with evidence of this practice particularly strong on phalanges and metapodia, and disarticulated primarily at elbow and ankle (figure 5.35). Bones were extensively defleshed, evident on cattle scapula and radii, and often fractured for marrow, with marrow exploitation at Polgár-Piócás-dűlő quite extensive despite the supply of meat and possibly milk at the settlement. Primarily the high-yield bones were targeted for marrow extraction, but fracture and fragmentation of all marrow-bearing elements was evident (figures 5.35 and 5.36).

The levels of fresh fracture were particularly high in comparison to nearby Polgár-Ferenci-hát, although are more comparable with the contemporary early (underrepresented) Szatmár II phase on the site. This could suggest that marrow exploitation was more necessary in the early phase of the ALPC. It is also possible that Polgár-Piócás-dűlő had a different site function to Polgár-Ferenci-hát, which featured an enclosure ditch and therefore may have had an elevated social position in the Neolithic landscape. Polgár-Piócás-dűlő may have acted as a possible satellite site as the two are very close, although this is difficult to analyse as material from the early phase of Polgár-Ferenci-hát is limited.

It is likely that the same deposition practices seen at Füzesabony-Gubakút are not in evidence here. Based on the high proportion of fresh fracture and the comparatively low levels of fragmentation it can be suggested that material was likely deposited quickly at Polgár-Piócás-dűlő, and not strewn on walking surfaces to be trampled as at Füzesabony-Gubakút (Domboróczki 2009).

Table 5.4: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Polgár-Piócás-dűlő.

	HUM		**RAD**		**FEM**		**TIB**		**MAND**		**MC**		**MT**	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	78	9	29	11	60	12	25	10	17	49	33	17	27	14
Suidae	83	18	20	10	50	6	38	8	14	22	-	-	-	-
Caprines	78	9	70	10	83	6	60	5	0	6	-	0	0	2

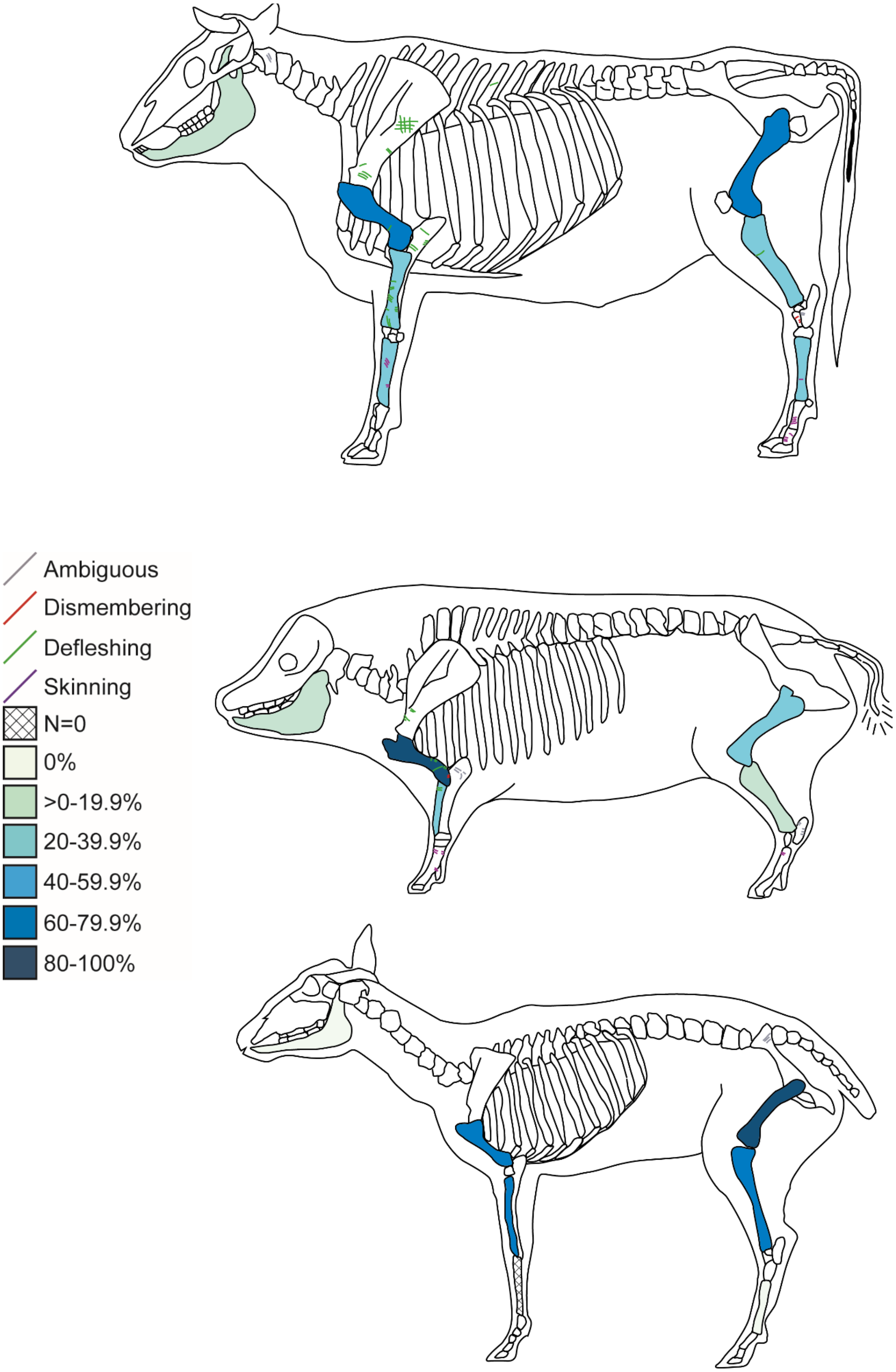

Figure 5.35: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Polgár-Piócás-dűlő. Values in table 5.4.

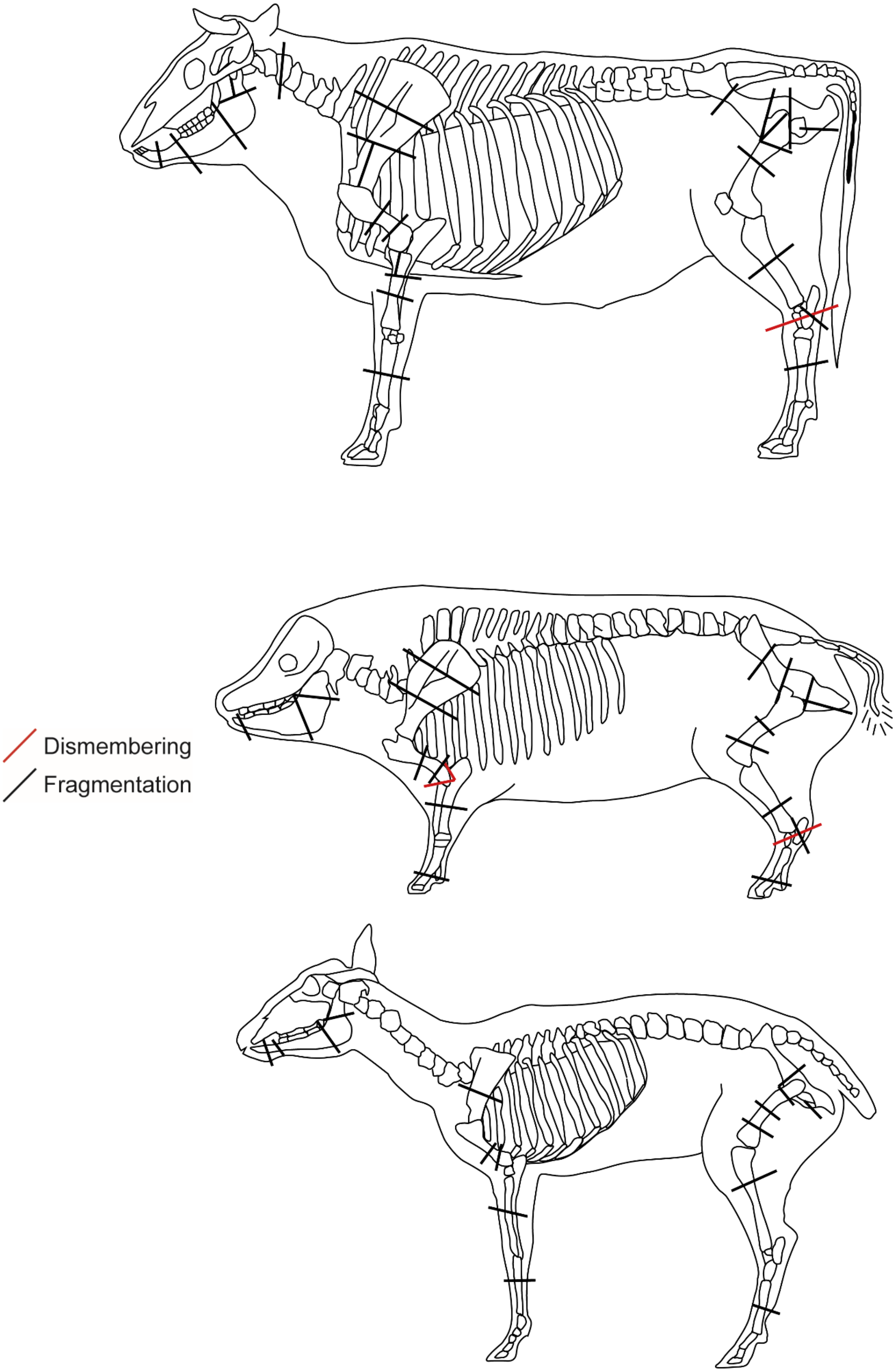

Figure 5.36: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Polgár-Piócás-dűlő.

Chapter 6 Polgár-Ferenci-hát

6.1 Introduction

As Polgár-Piócás-dűlő, Polgár-Ferenci-hát is situated on the favourable loess of the Polgár Island, and was discovered prior to the building of the M3 motorway (Whittle *et al.* 2013a: 73). Rescue excavations in 2001-2002 revealed a middle Neolithic settlement covering 9-12 hectares dating from the earliest phase of the ALPC (phase I, Szatmár) to phase IV, with radiocarbon dates from burials representing a time span of 5320 and 5030 BC (*ibid.*; Raczky and Anders 2009: 280). At this date range it is contemporary with many sites in the Polgár region – at its earliest, with Polgár-Piócás-dűlő (*ibid.* 34).

The site contains a double ditch system closed by a third ditch segment, which was filled rapidly in a single event (Raczky and Anders 2012: 276). Raczky and Anders suggest that the creation and sealing of this context transcended rational activity and may be regarded as a symbolic gesture (*ibid.*). Inside the enclosure were traces of intensive settlement activity, including two burnt houses, several pits and a refuse layer 50-60cm thick, possibly a direct precursor of later tell sites (Raczky and Anders 2012; figure 6.1). Circular pits near the ditch system showed signs of intensive burning and intentional destruction of ground stone and special vessels (*ibid.* 277). Outside the enclosure were traces of a rather dispersed flat settlement (Whittle *et al.* 2013a).

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Figure 6.1: Site plan of Polgár-Ferenci-hát showing the individual features and ditch system (Raczky and Anders 2012: 278, figure 6).

6.2 Assemblage

6.2.1 Sample

The entire Neolithic assemblage from Polgár-Ferenci-hát was studied, totalling 2907 bones (table 6.1). Difference in values for fully identifiable specimens (table 6.1) and species representation (figure 6.2) is due to the exclusion of *Bos sp*. and *Sus sp*. and inclusion of wild birds (*Aves*; see section 3.4.1). The material studied spans the middle Neolithic (Szatmár II, the LBK-ALPC and Tiszadob groups) to the end of the middle Neolithic, in four phases as identified in table 6.1. Material from the LBK-AVK phase was by far the most common, and the Szatmár II phase was the least well represented. Six comparable contexts were also chosen for individual analysis based on the number of specimens per context, context type and phase (see table 6.3). However, due to a lack of labelled site plans it is currently impossible to assign these contexts to the ditch interior or exterior.

Table 6.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Polgár-Ferenci-hát (PFH).

Fully identifiable (to species and element)	459
Partially identifiable (to type of species and element)	384
Indeterminate	2064
Total	**2907**

Table 6.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens from each phase from Polgár-Ferenci-hát.

Phase		FID	PID	IND
Middle Neolithic (Szatmár II)	I	10	10	46
LBK-ALPC	II	189	118	1050
Tiszadob	III	92	62	346
End of the Middle Neolithic (final)	IV	168	194	622

Table 6.3: Number of fully identifiable, partially identifiable and indeterminate specimens in selected contexts from Polgár-Ferenci-hát.

Obj.	Str.	Phase		Interpretation	FID	PID	IND
49	**96**	LBK-ALPC	II	Pit fragment	33	16	265
304	**478**	LBK-ALPC	II	Pit	23	26	291
322	**497**	LBK-ALPC	II	Pit	78	48	268
36	**46**	Tiszadob	III	Pit fragment	92	62	346
625	**901**	Final	IV	Pit fragment	65	78	132
819	**1152**	Final	IV	House ruin	81	68	391

Table 6.4: Full list of contexts analysed from Polgár-Ferenci-hát.

Ob.	Str.	Phase	Interpretation	FID	PID	IND
6	6	LBK-AVK	part of a pit	17	15	107
14	15	LBK-AVK	pit	1	0	0
36	46	Tiszadob	part of a pit	92	62	346
49	96	LBK-AVK	part of a pit	34	16	265
84	163	LBK-AVK	part of a pit	18	8	59
219	371	LBK-AVK	pit	17	4	56
304	478	LBK-AVK	pit	23	26	291
322	497	LBK-AVK	pit	78	48	268
624	900	End of Middle Neolithic (final)	part of a pit	1	0	0
624	1195	End of Middle Neolithic (final)	well	2	0	39
625	901	End of Middle Neolithic (final)	part of a pit	65	78	132
656	956	LBK-AVK	pit	0	1	0
707	1014	LBK-AVK	pit	1	0	1
769	1087	End of Middle Neolithic (final)	?	0	0	3
798	1125	Szatmár II	pit	10	10	46
812	1145	End of Middle Neolithic (final)	House ruin	19	48	57
818	1150	LBK-AVK	?	0	0	2
819	1152	End of Middle Neolithic (final)	House ruin	81	68	391
969	1003	LBK-AVK	?	0	0	1

6.3 Species representation

6.3.1 Site

Cattle (38.3%, 177/462) and caprines (36.6%, 169/462, including 3 specimens identified as goat) dominated the domestic assemblage, with domestic pigs also present at 14.7% (68/462) of the number of identifiable specimens (NISP; figure 6.2). Domestic dogs were rarely identified at 1.7% (8/462) of the assemblage. Wild animals made up 8.7% (40/462) of the overall assemblage and included some 'unusual' species in addition to more common wild animals on LBK sites. One specimen of wild horse was identified, along with 7 hare bones (1.5%, 7/462). Wild birds were comparatively common at 2.4% (11/462), likely including goose (*Anser sp.*) and likely mallard (c.f. *Anas platyrhynchos*) and crane (c.f. *Grus sp.*).

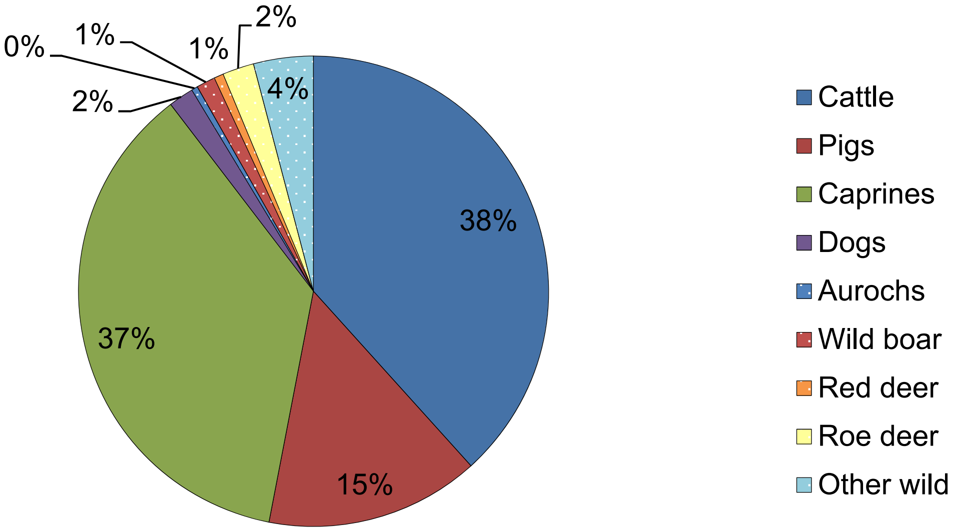

Figure 6.2: Species representation (NISP) for the fully identifiable assemblage from Polgár-Ferenci-hát (n=462).

6.3.1.1 Phase

Whilst the Szatmár phase (phase I) could not be analysed due to small sample size (n=15) it contained high levels of caprine bones, with only pigs and wild birds (likely goose and crane) also represented. Phase II showed the highest proportion of cattle (83/192), significantly more than in phase III (24/92, p=.005) but very similar to the final phase (figure 6.3). Phase III had a significantly higher proportion of caprines (71/192) than phase IV (48/168, p=.002), which had the highest proportion of pigs (38/168) compared to phase II in particular (15/192, p<.001). The species representation suggests changing animal management strategies over time, with pigs consistently increasing in proportion compared to fluctuating levels of cattle and caprines. Wild animals remain poorly represented in all phases, largely comprised of wild birds.

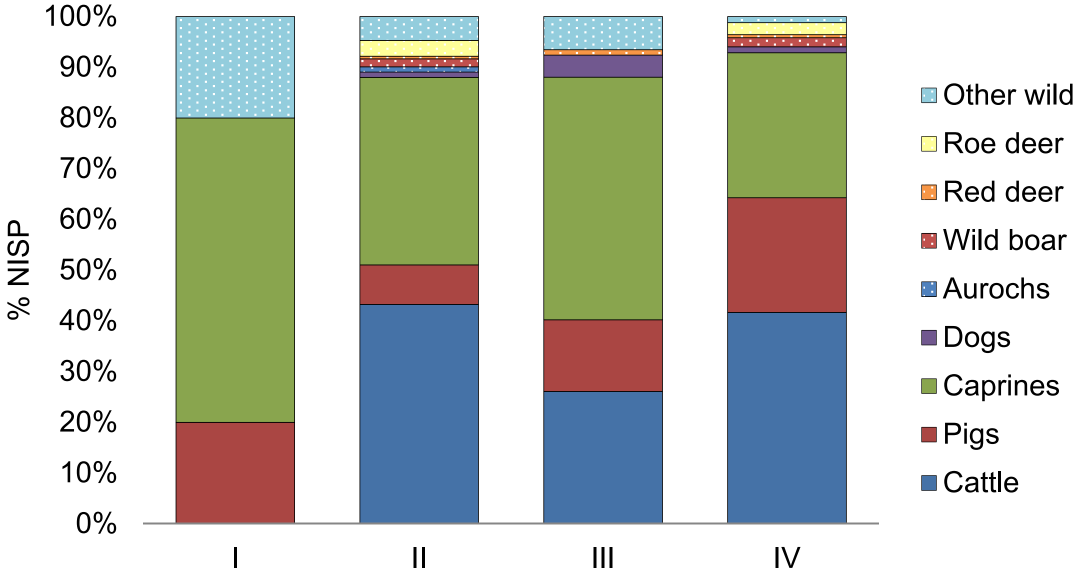

Figure 6.3: Species representation (NISP) for the LBK-AVK (II; n=192), Tiszadob (III; n=92) and Final (IV; n=168) phases from Polgár-Ferenci-hát.

6.3.1.2 Comparable contexts

The species representation for individual contexts could suggest that a varied deposition of species in different contexts in phase II was replaced with more standardised deposition by the end of the middle Neolithic (phase IV; figure 6.4). Pit fragments 46 and 96 and pits 478 and 497 show vastly different proportions of species diversity, whereas pit fragment 901 and house 1152 show directly comparable species proportions. However, this may be a result of small numbers of large individual contexts from each phase.

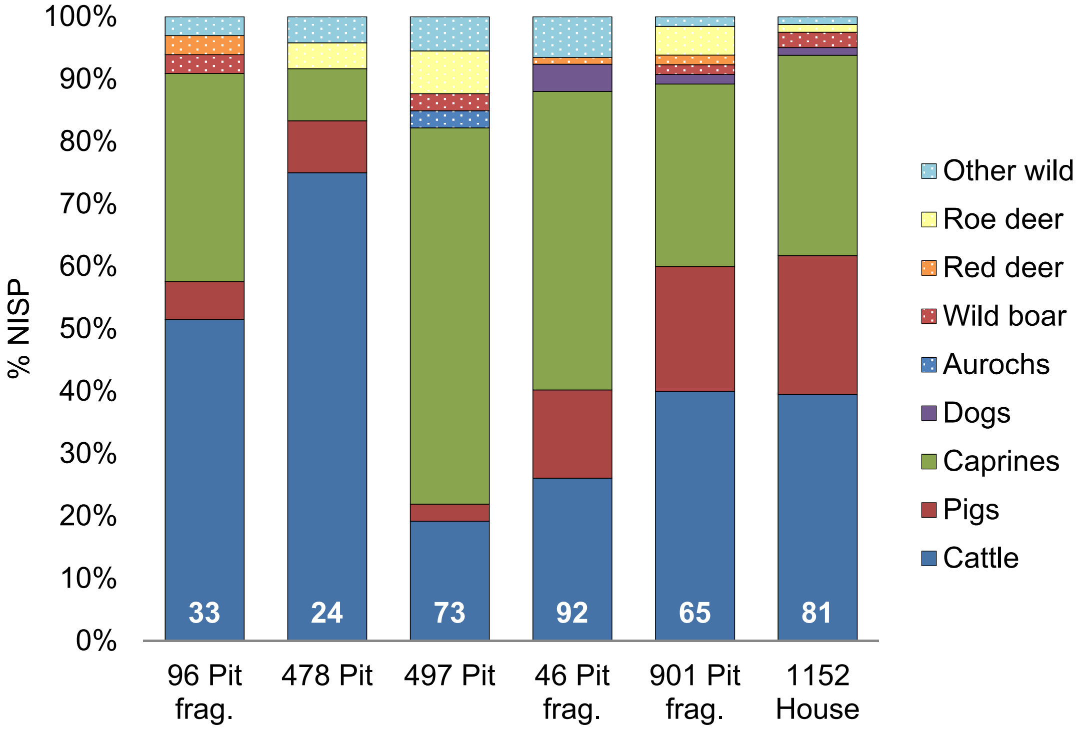

Figure 6.4: Species representation (NISP) for selected contexts from phase II (96, 478, 497), III (46) and IV (901, 1152) from Polgár-Ferenci-hát. N values are at the base of each bar.

6.4 Butchery

6.4.1 Site

Butchery marks were observed on 1.1% (32/2907) of the assemblage from Polgár-Ferenci-hát, and on 3.0% (25/843) of identifiable material. Cut marks were the most prominent form of butchery (figure 6.5). Evidence of butchery was highest in the Tiszadob phase, but the differences were not significant and proportions all below 2.5% of the assemblage (figure 6.6).

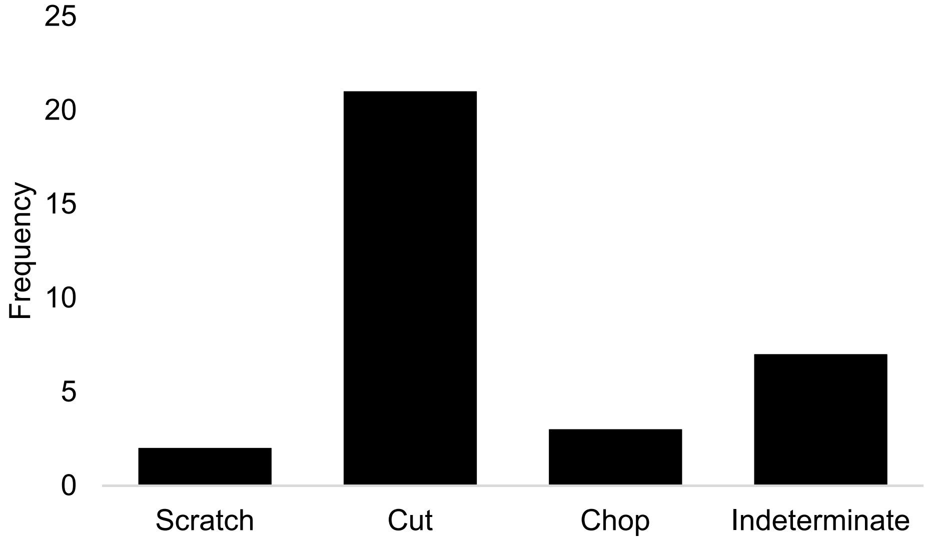

Figure 6.5: Frequency of butchery mark types from Polgár-Ferenci-hát.

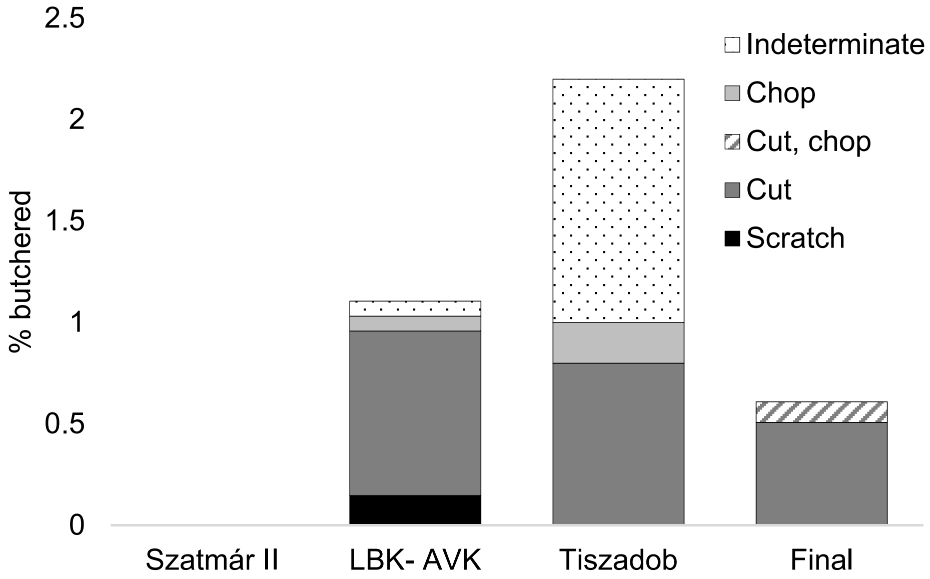

Figure 6.6: Percentage of specimens from each phase affected by different butchery episodes from Polgár-Ferenci-hát.

6.4.2 Species

Wild boar were the most commonly butchered species at 16.7% (1/6) of identifiable specimens. Hare bones were also commonly subject to butchery (14.3%, 1/7). Butchery marks were observed on 7.9% (14/177) and 5.9% (4/68) of cattle and pig bones respectively (figure 6.7). Large mammal bones were more commonly affected by butchery (3.8%, 14/364) than medium mammal bones (2.3%, 10/444), likely due to the increased butchery needed to disarticulate larger carcasses, although there was no significant difference. Dog bones showed no evidence of butchery.

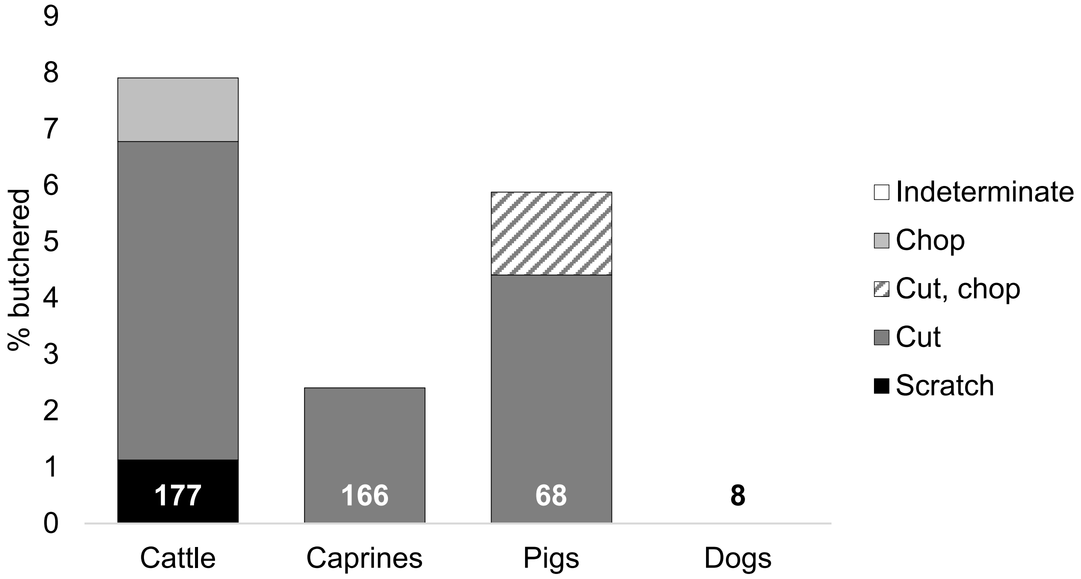

Figure 6.7: Percentage of specimens identified to domestic species with different butchery episodes from Polgár-Ferenci-hát.

6.4.3 Carcass butchery

Butchery of animal carcasses primarily affected the hindlimb and extremities, although recordable butchery incidences were rare. The butchery of some elements featured many short strokes per butchery episode although long strokes are also common, reflecting a specific, perhaps intensive, butchery technique, or the mark of untrained butchers more likely to mark bone surfaces.

Butchery of the humerus indicates disarticulation from the radius and ulna on the anterior distal epiphysis (figure 6.9; Soulier and Costamagno 2017). Defleshing is also suggested by cut marks to the anterior, lateral and medial face of the diaphysis. The marks on the anterior diaphysis represent the butchery of a single specimen. Short, repeated strokes are also present on the pelvis, where butchery could indicate disarticulation of the hindlimb or filleting (figure 6.10; Binford 1981: 114). On the metapodia (figure 6.11) and phalanges (figure 6.12) primarily suggests skinning.

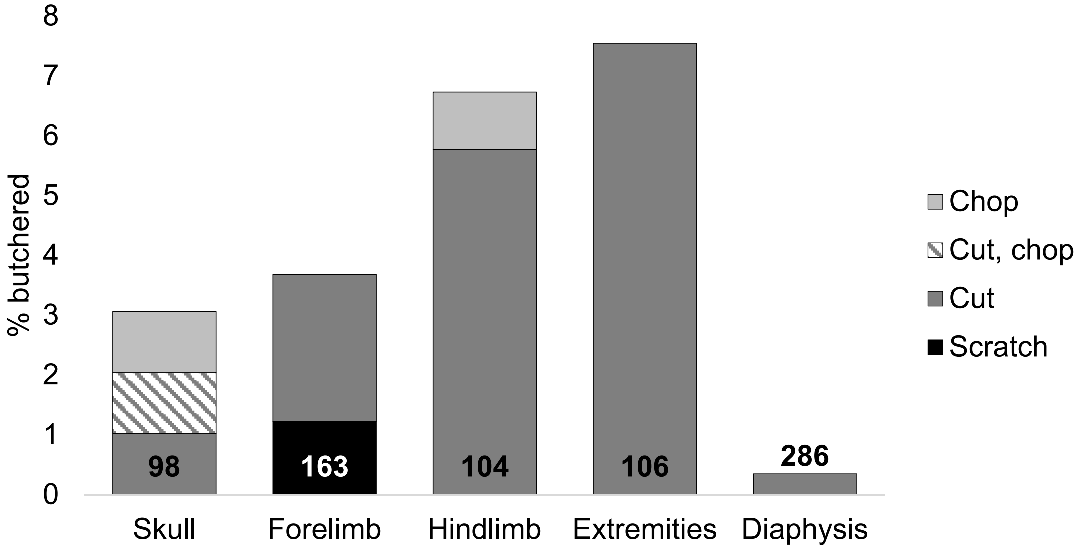

Figure 6.8: Percentage of carcass portions affected by different butchery episodes from Polgár-Ferenci-hát.

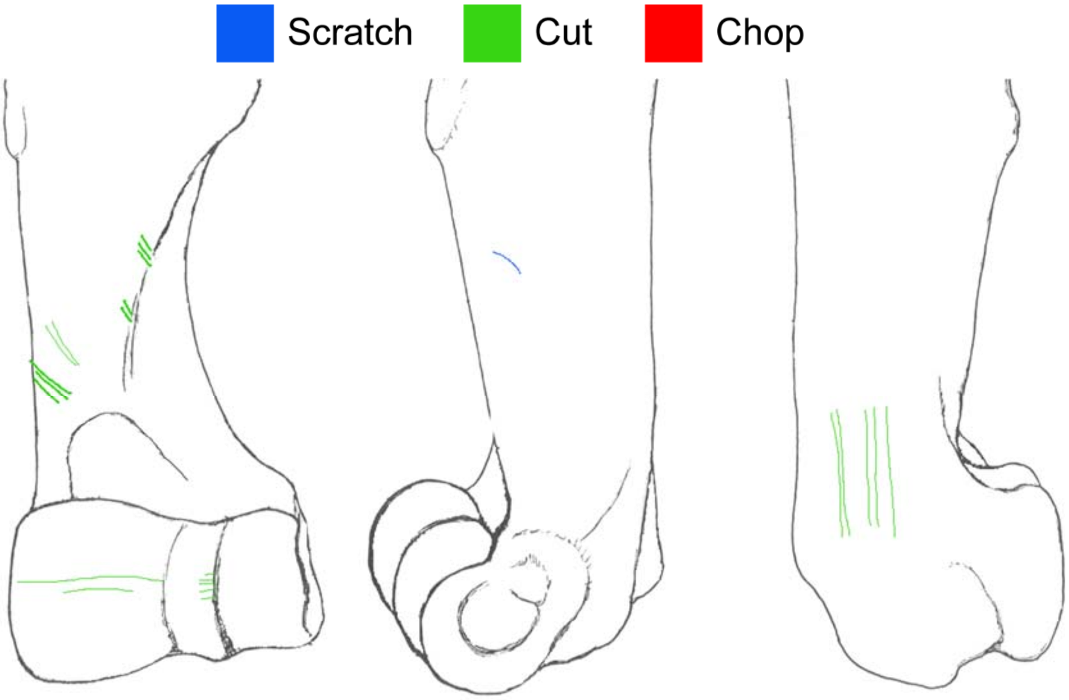

Figure 6.9: Cumulative diagram of butchery on cattle distal humeri (n=3) from Polgár-Ferenci-hát. Left to right; anterior, lateral and medial views.

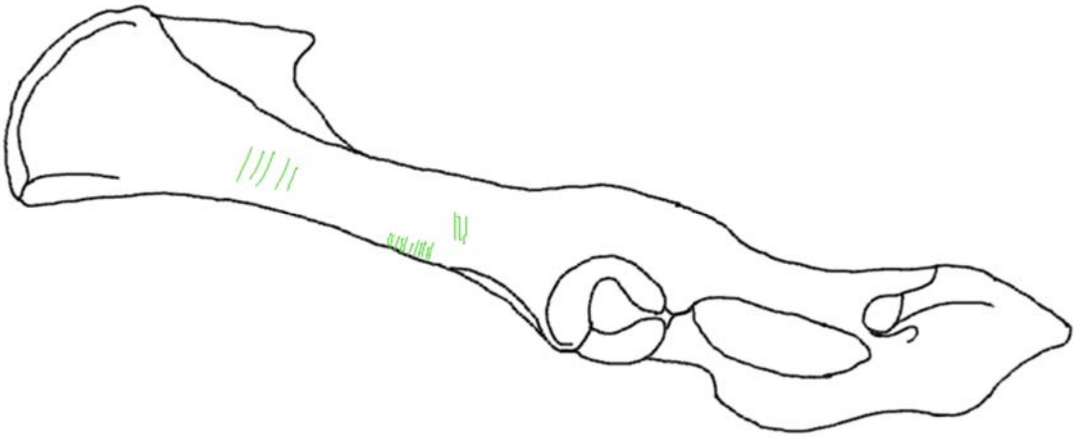

Figure 6.10: Cumulative diagram of butchery on caprine pelves (n=2) from Polgár-Ferenci-hát. Lateral view.

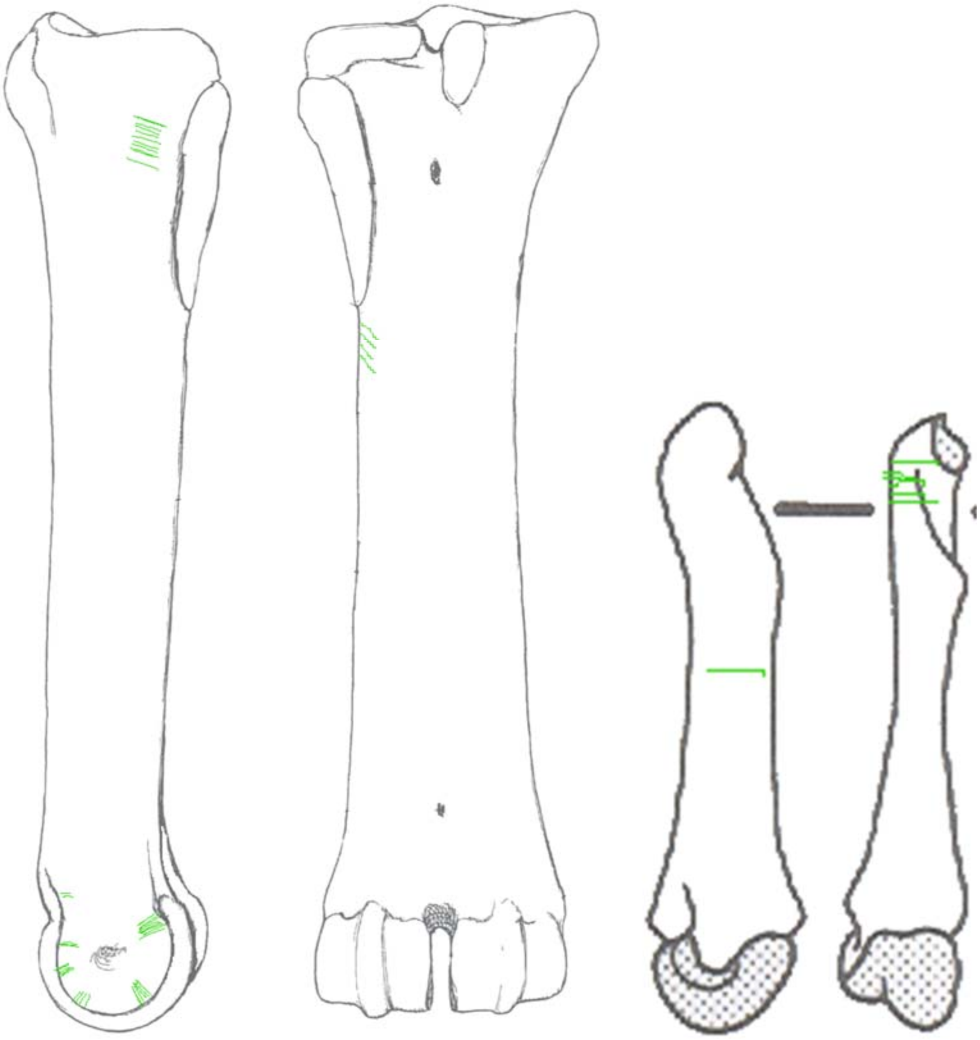

Figure 6.11: Cumulative diagram of butchery on cattle metapodia (left, n=3), lateral and posterior views, and suid second metapodia (right, n=2) from Polgár-Ferenci-hát. Medial (left) and anterior views.

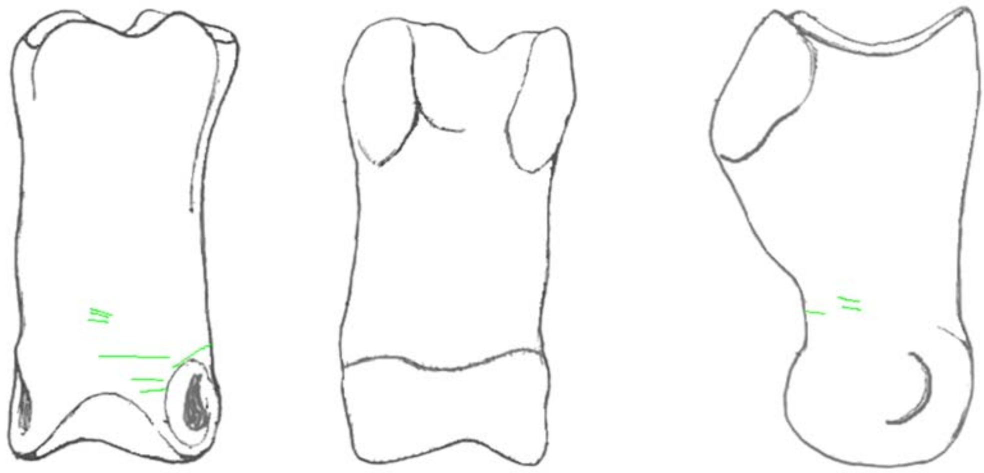

Figure 6.12: Cumulative diagram of butchery on cattle (n=1) and caprine (n=1) first phalanges from Polgár-Ferenci-hát. Left to right; anterior, posterior and medial views.

6.5 Heat exposure

6.5.1 Site

5.1% (148/2907) of all specimens from Polgár-Ferenci-hát showed evidence of heat exposure, recorded on 17.4% (147/843) of the identifiable assemblage. Roasted, carbonised and burning on indeterminate specimens were the most common types of burning (figure 6.13). Carbonised bone was common compared to other sites, likely causing fragmentation and contributing to the levels of indeterminate burnt bones. It is possible that these heat exposure types relate to the intentionally burnt contexts near the enclosure ditch.

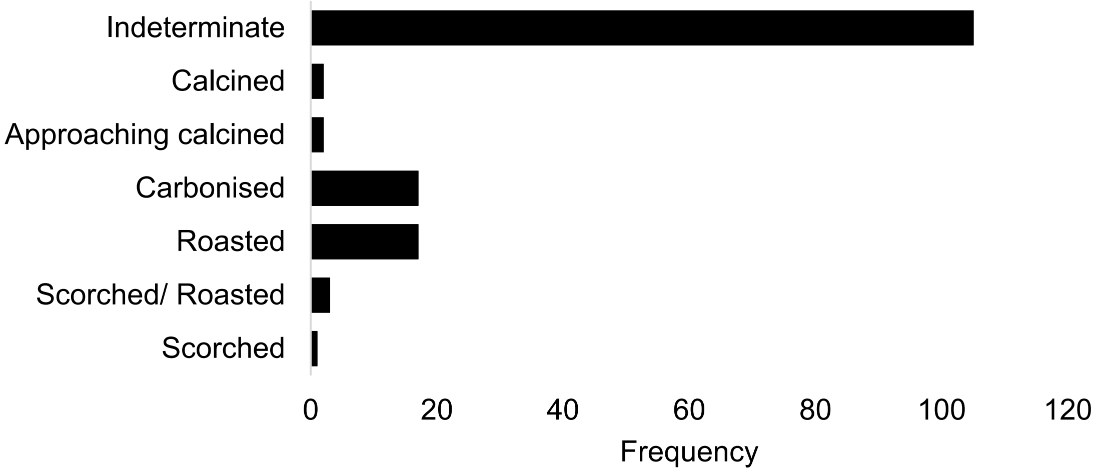

Figure 6.13: Frequency of heat exposure types from Polgár-Ferenci-hát.

6.5.1.1 Phases and contexts

There were differences between phases and individual contexts in the amount of specimens with evidence of heat exposure (figures 6.14 and 6.15). No evidence for burning was discovered in the small faunal assemblage from phase I (0/66), which was significantly lower than the levels of heat exposure in phase II (97/1357, p=.024; especially in context 96) and III (30/500, p=.041). There was no significant different between phases II and III, and they could represent the time when the enclosure ditch and nearby burnt circular pits were formed (Raczky and Anders 2012: 277). They both show relatively high levels of indeterminate and heavy burning for LBK sites, where roasting is usually the most common form of heat exposure. However, there was a significantly greater proportion of roasting in phase III (10/500) compared to phase II (9/1357; p=.011). The proportion of specimens affected by burning decreased significantly into the end of the middle Neolithic (20/984) compared to phases II and III (p<.001) and could suggest that burning practices related to carcass processing and deposition changed again in the final phases of the site. These differences between phases, which are reflected in the individual contexts from each phase (figure 6.15), likely show changing deposition practices over time, particularly relating to the potential ritual burning of deposits near the enclosure, especially in pit fragment 96.

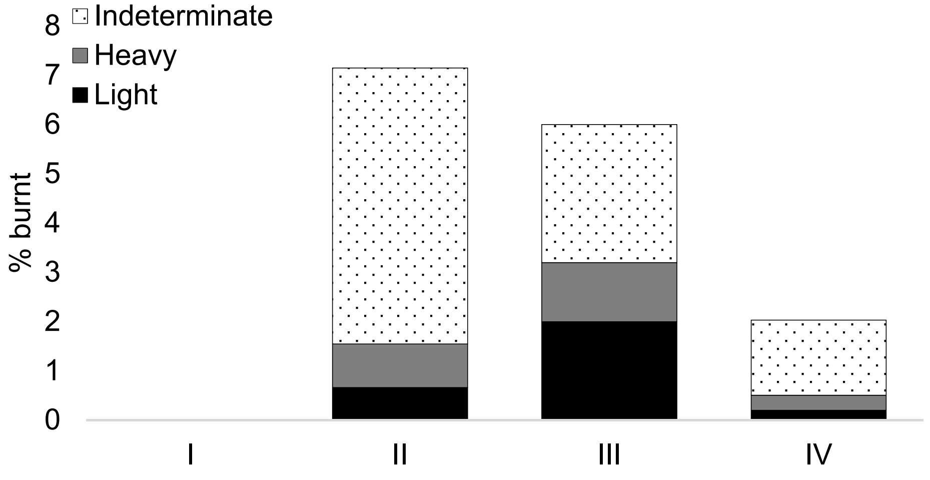

Figure 6.14: Percentage of specimens from each phase affected by different intensities of burning from Polgár-Ferenci-hát.

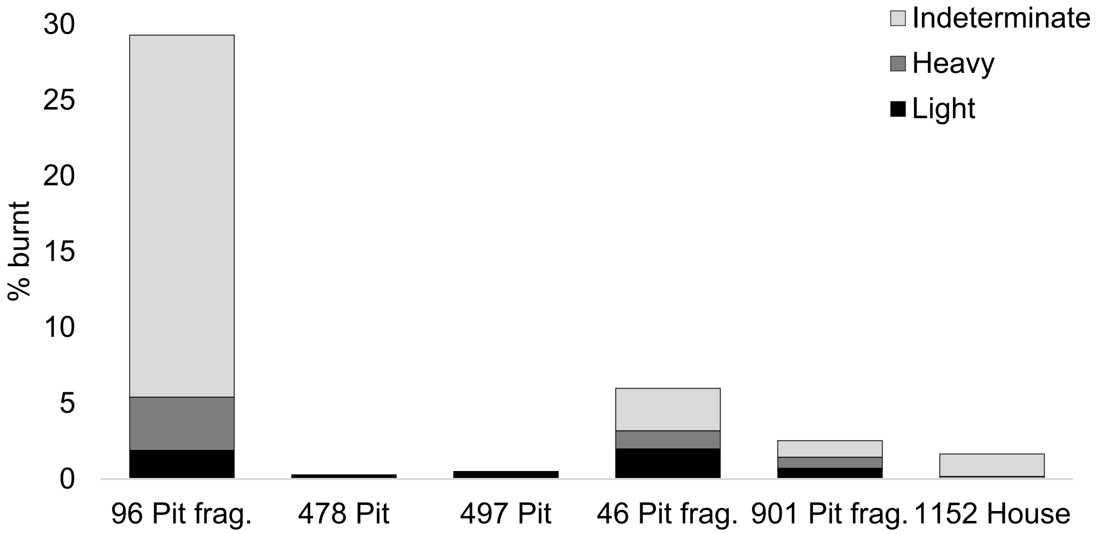

Figure 6.15: Percentage of phase II (96, 478, 497), III (46), IV (901, 1152) selected contexts affected by different burning intensities from Polgár-Ferenci-hát.

6.5.2 Species

The bones of large animals (30/364), especially cattle, were more often affected by burning than those of medium-sized mammals (12/444, p<.001; figure 6.16). The proportions of light burning (predominantly roasting) could represent different cooking techniques between species, whereas the heavy burning more likely relates to deposition practices, possibly the burning of deposits near enclosure ditches. Domestic dogs showed no evidence of burning.

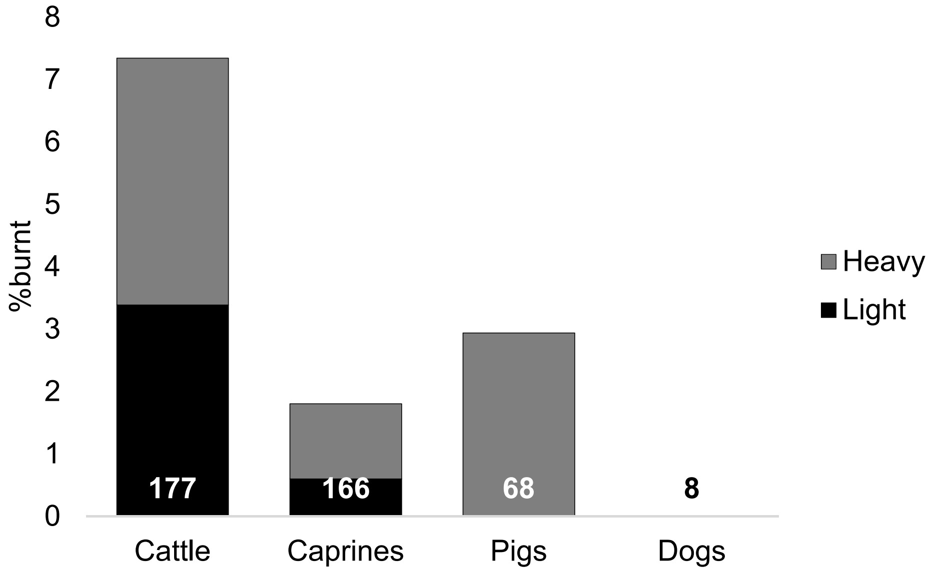

Figure 6.16: Percentage of domestic species affected by different intensities of burning from Polgár-Ferenci-hát.

6.6 Fracture

6.6.1 Site

The faunal assemblage from Polgár-Ferenci-hát showed that marrow-yielding bones were often fractured when fresh. 32.8% (146/445) of fractured bones displayed evidence of fresh fracture, which rose to 42.4% (42/99) when looking solely at high-yielding marrow bones (figure 6.17). This indicates some targeting of high-yield bones for marrow extraction, however it does not suggest intensive marrow exploitation practices at Polgár-Ferenci-hát.

The Fracture Freshness Index (FFI) mean of 4.0 denotes a site with more drying, dry or mineralised fracture than fresh. The most common FFI score was six, suggesting that dry and mineralised fractures often showed no trace of fresh fracture characteristics. Mineralised fracture was particularly high at Polgár-Ferenci-hát (6.17), which suggests disturbance of deposited or temporarily deposited remains, although levels of secondary fracture remained low.

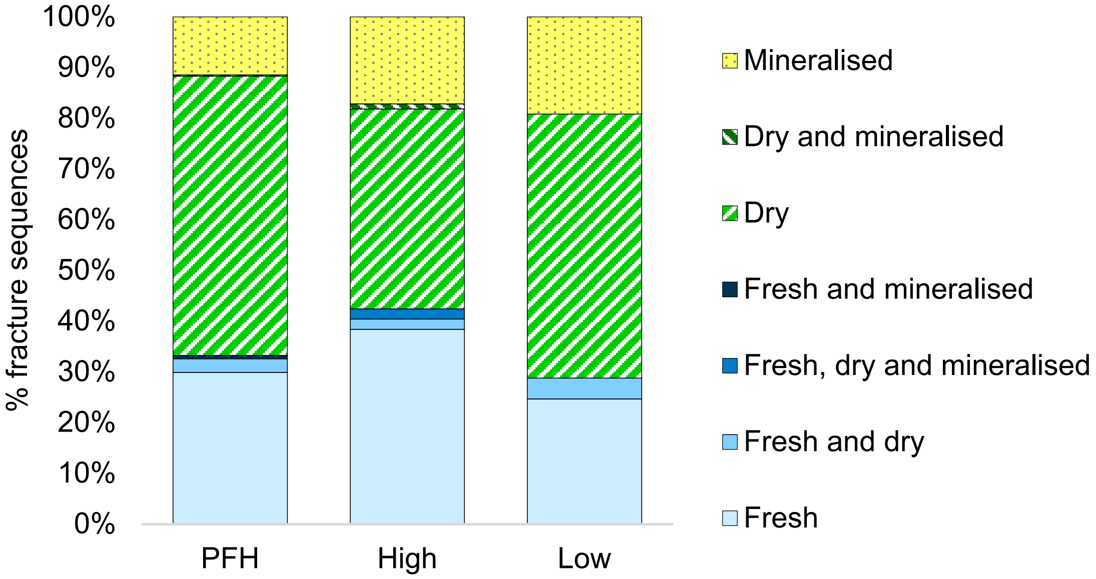

Figure 6.17: Fracture history profiles for the Polgár-Ferenci-hát assemblage (n=445) and for high- and low-yield marrow bones (n=99/73).

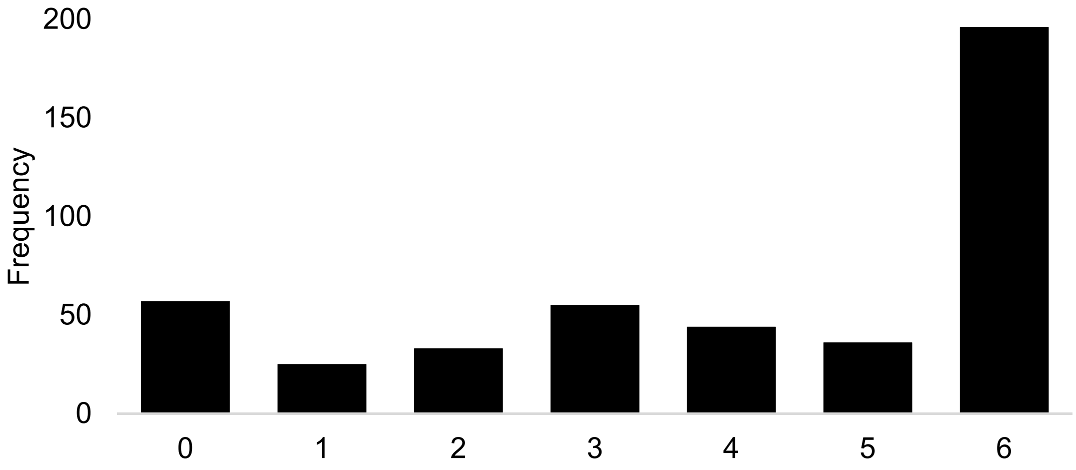

Figure 6.18: Frequency of Fracture Freshness Index scores from Polgár-Ferenci-hát.

6.6.1.1 Phase

There was a slight increase in the percentage of fresh fracture over time, although the amount remained low throughout the timespan of occupation at Polgár-Ferenci-hát (figures 6.19 and 6.20). Phase I had the highest percentage of fresh fracture (37.5%, 3/8) and lowest FFI score (3.0), but had a particularly small sample size. High-yield marrow-bearing bones were more often fractured when fresh in phase II and IV, but in phase III low-yield elements were fractured freshly slightly more commonly (figure 6.21). However, this may result from poor sample sizes. Mineralised fracture was high in all phases (figures 6.19 and 6.21).

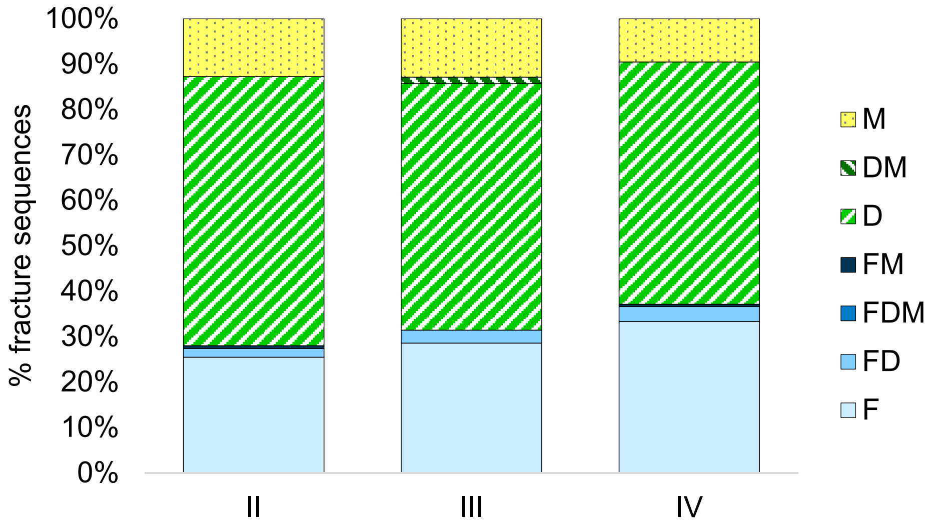

Figure 6.19: Fracture history profiles for phases II (n=157), III (n=70) and IV (n=210) from Polgár-Ferenci-hát.

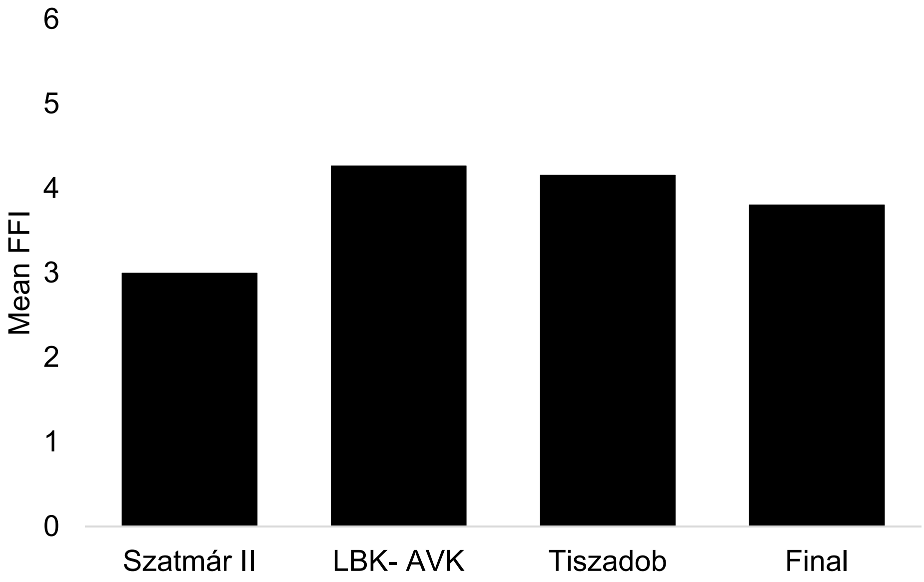

Figure 6.20: Mean Fracture Freshness Index scores for each phase from Polgár-Ferenci-hát.

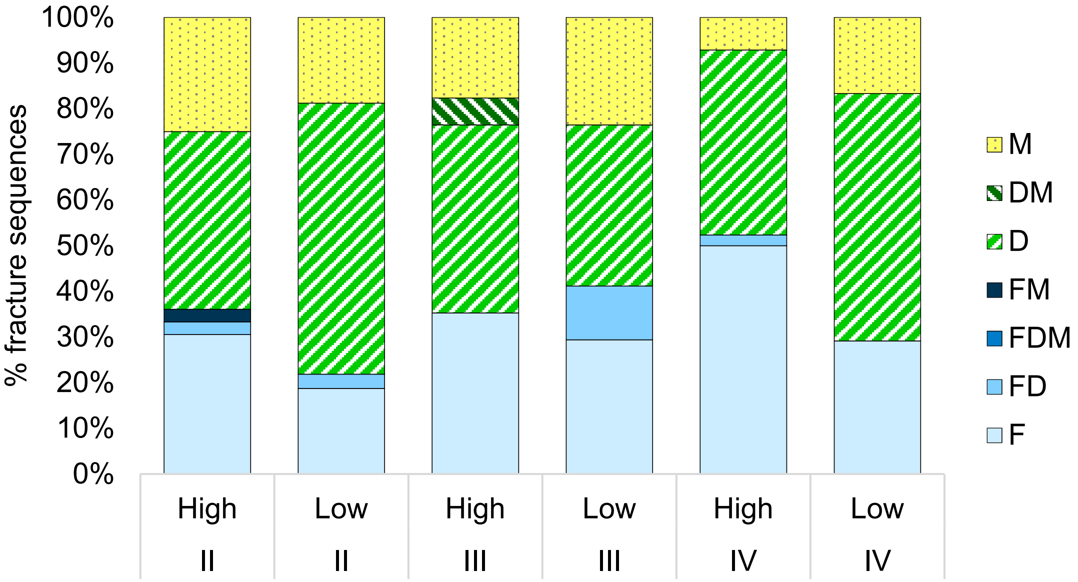

Figure 6.21: Fracture history profiles for high- and low-yield marrow bones from phase II (n=36/32), III (n=17/17) and IV (n=42/24) from Polgár-Ferenci-hát.

6.6.1.2 Contexts

The comparable individual contexts in general showed similar proportions of fresh fracture, save for pit 478 (3/29), which had a significantly lower proportion for fracture freshness than the other phase II pit 497 (22/62, p=.012). In the final phase house context 1152 (38/84) had significantly more fresh fracture than pit fragment 901 (22/81, p=.016), which could suggest higher consumption of marrow in domestic contexts, although without other house plans this is impossible to corroborate.

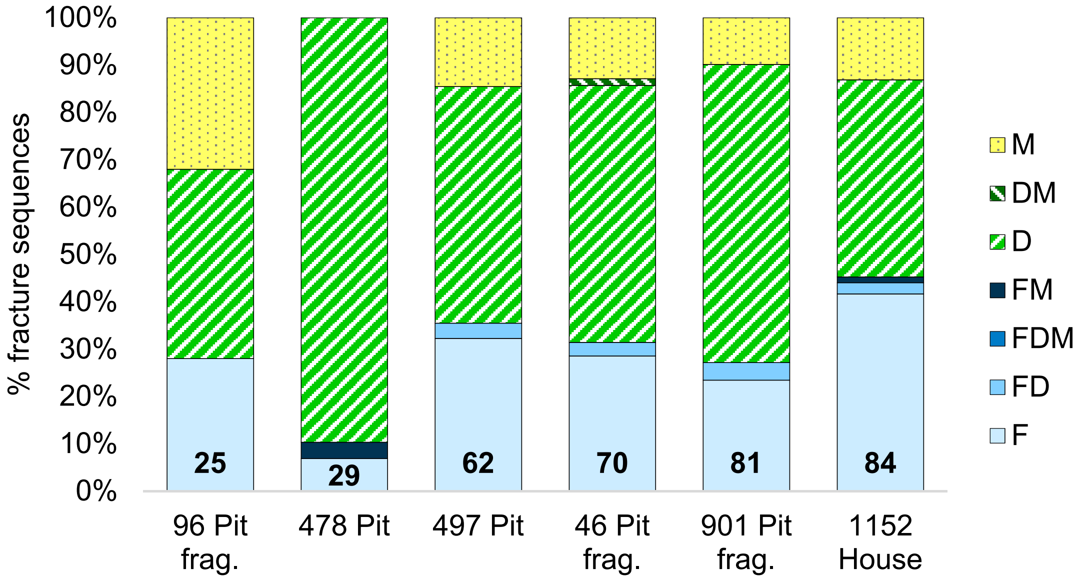

Figure 6.22: Fracture history profiles for selected contexts from phase II (96, 478, 497), III (46) and IV (901, 1152) from Polgár-Ferenci-hát.

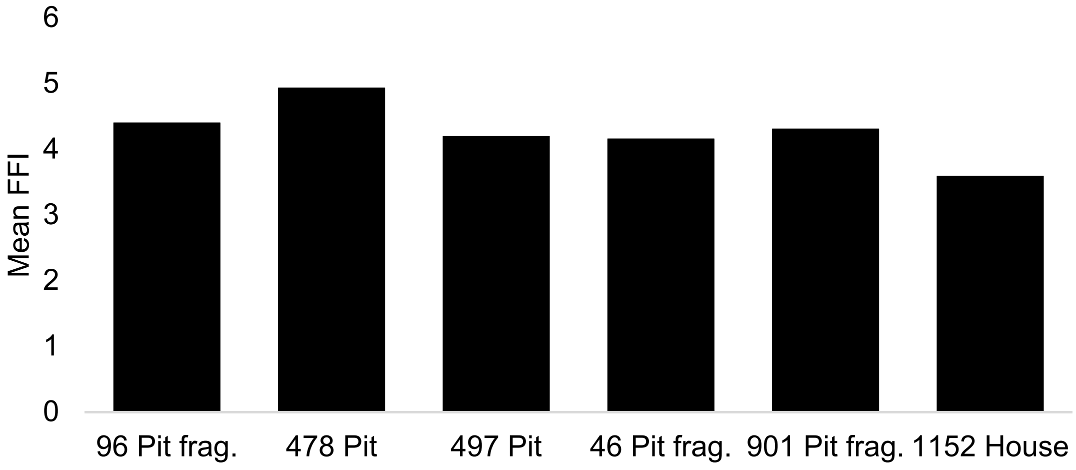

Figure 6.23: Mean Fracture Freshness Index scores for the selected contexts from Polgár-Ferenci-hát.

6.6.2 Species

When looking at the proportions of fracture by species, medium mammal bones (40.6%, 89/219) were more often fractured freshly than large mammal bones (26.6%, 59/222). Cattle bones in particular show lower proportions of fresh fracture than pigs and caprines, although the differences were not significant (figures 6.24). Large mammal bones (bovinae, red deer, horse) also showed little difference in the proportions of freshly fractured high-yield marrow bones as opposed to low-yield, whereas in medium mammals (suidae, caprines, roe deer) the proportion of fresh fracture was significantly higher in high-yield bones (high-yield 32/65, low-yield 11/41, p=.022; figure 6.25). Mineralised fracture particularly affected medium mammal bones, and thus the proportions of fresh fracture were further elevated when this fracture type was excluded from analysis. Caprines (19/72) were significantly more affected by mineralised fracture than cattle (5/60, p=.017). This could suggest different carcass processing and deposition practices for different species.

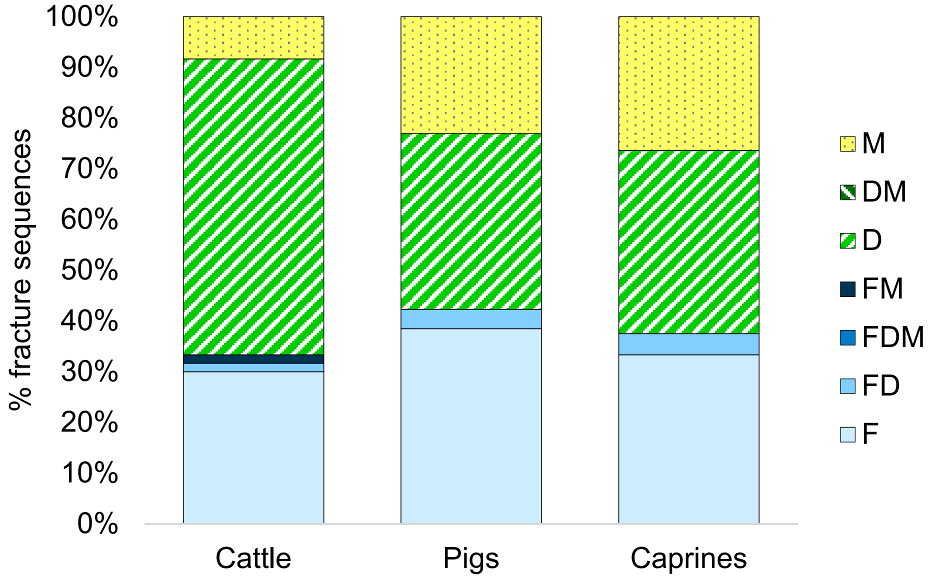

Figure 6.24: Fracture history profiles for cattle (n=60; mean FFI 4.1), pigs (n=26; FFI 3.8) and caprines (n=72; FFI 4.1) from Polgár-Ferenci-hát.

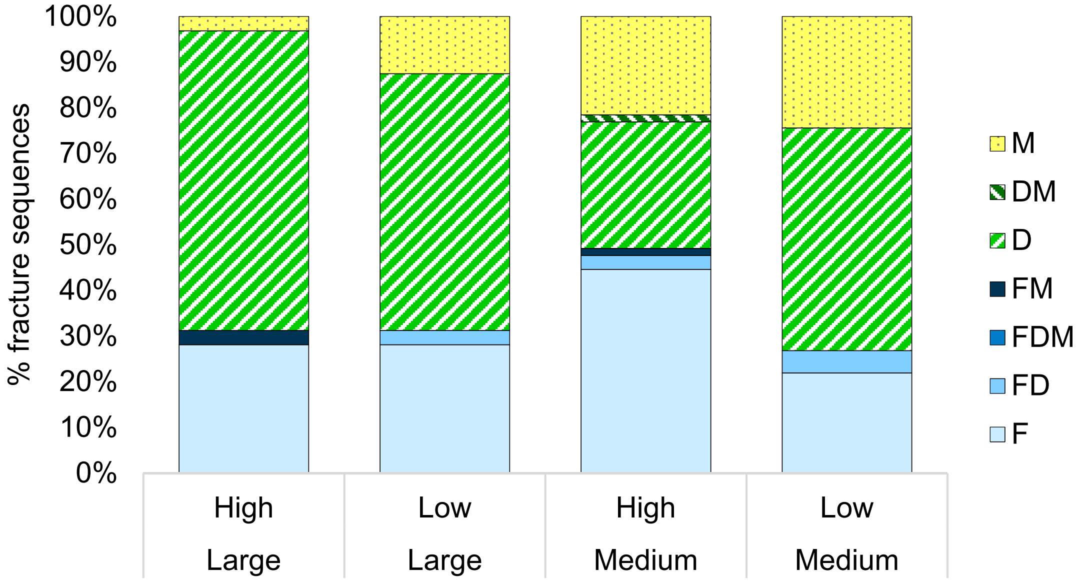

Figure 6.25: Fracture history profiles for high- and low-yield marrow bones from large (n=32/32) and medium mammals (n=65/41) from Polgár-Ferenci-hát.

6.7 Fragmentation

The assemblage of Polgár-Ferenci-hát was not particularly fragmented, with large proportions of the assemblage weight found in the larger size classes, and a large amount of bones that were whole or partially whole, with in-tact grease-rich epiphyses (figure 6.26). These patterns are not indicative of intensive bone grease processing. However, in figure 6.27 the 20-29mm size class shows an abundance of fragmented cancellous material, which could have been comminuted for boiling.

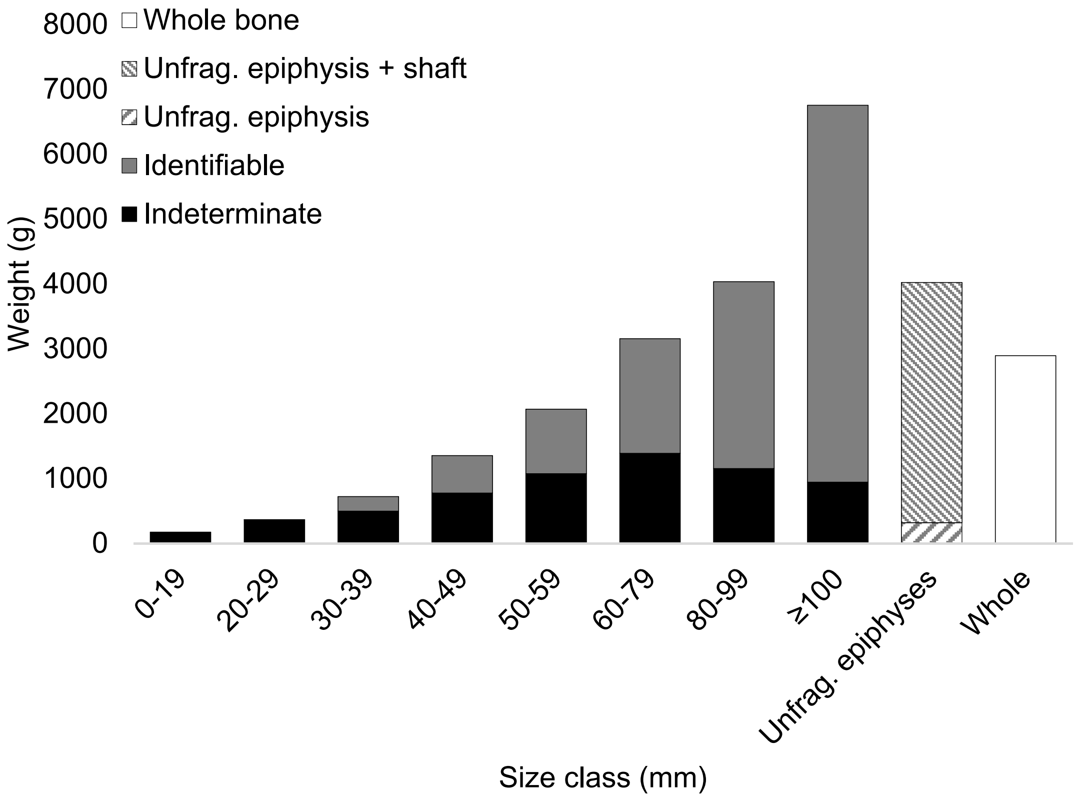

Figure 6.26: Weight by size class of all specimens from Polgár-Ferenci-hát.

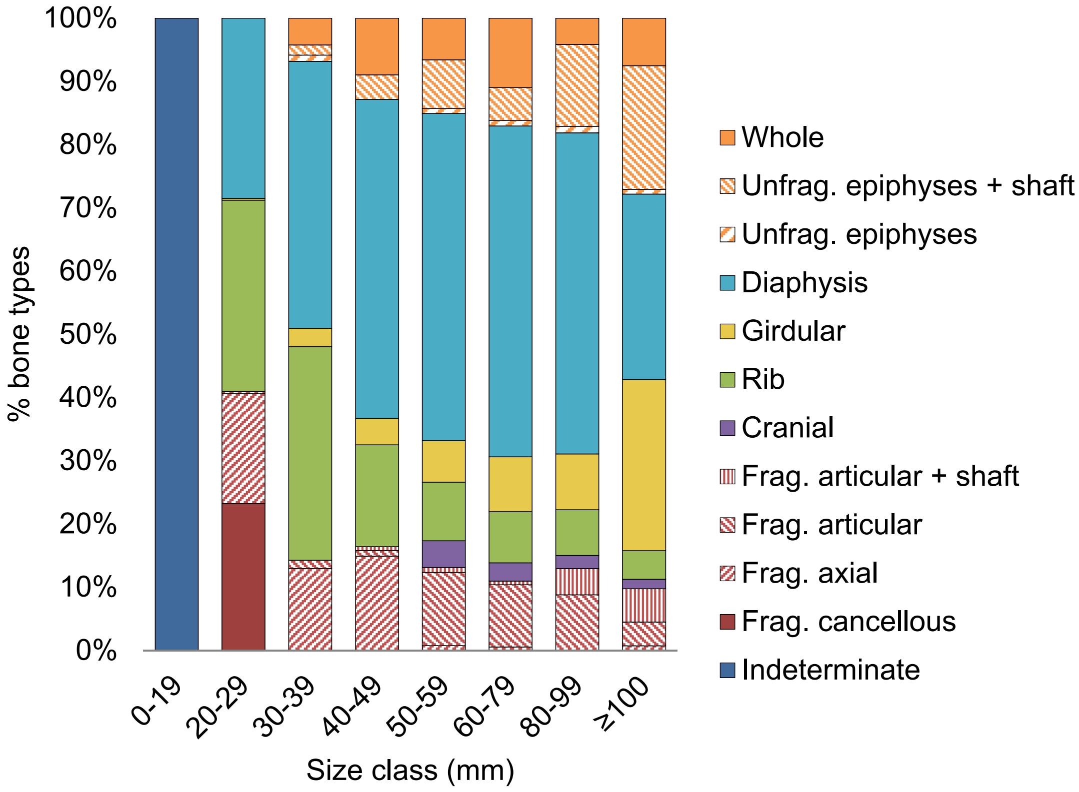

Figure 6.27: Frequency of bone types by size class from Polgár-Ferenci-hát. Red series indicate fragmented cancellous bone.

6.8 Taphonomy

6.8.1 Gnawing

Gnawing, predominately canid, was rare on this site, affecting less than 1% (20/2907) of the whole assemblage (figure 6.28). This was higher in some contexts, in particular the Tiszadob group, but was below 2% throughout. Thus, it is unlikely that levels of fragmentation can be attributed to intensive canid gnawing.

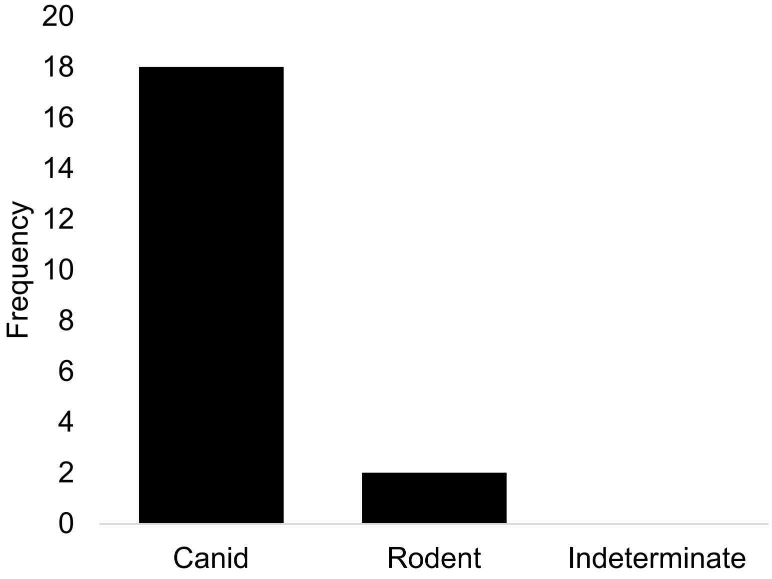

Figure 6.28: Frequency of gnawing types from Polgár-Ferenci-hát.

6.8.2 Taphonomic agents and recent breaks

Taphonomic agents such as weathering, erosion and root etching affected specimens only rarely, and were more common in phase II and III than phase I and IV (figure 6.30). This could suggest different depositional practices between these phases. The most common taphonomic condition to affect bones were mud concretions that hampered identification of species, element and especially concealed fracture surfaces and butchery marks (n=7), but overall the Polgár-Ferenci-hát assemblage was well preserved, with new breaks affecting 8.3% (70/843) of identifiable bones.

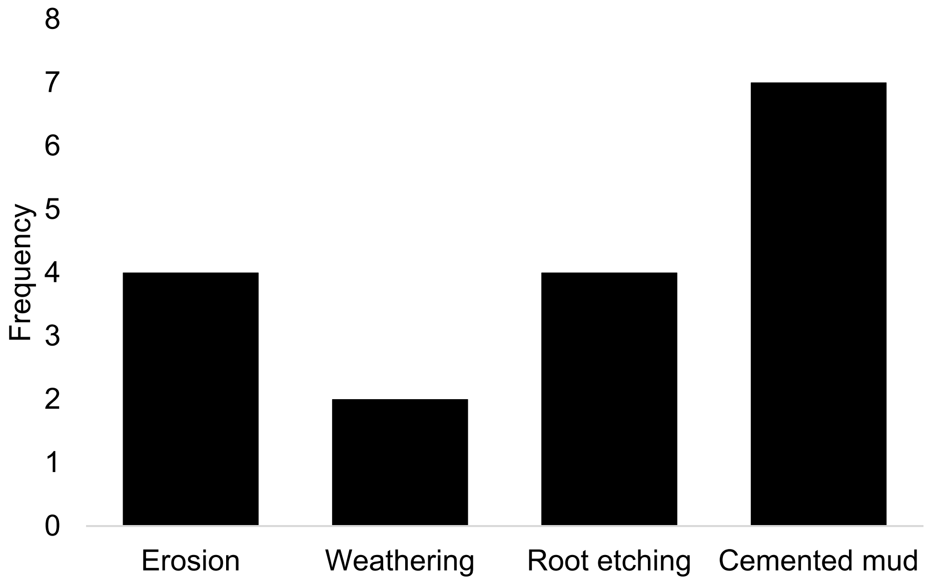

Figure 6.29: Frequency of taphonomic agents from Polgár-Ferenci-hát.

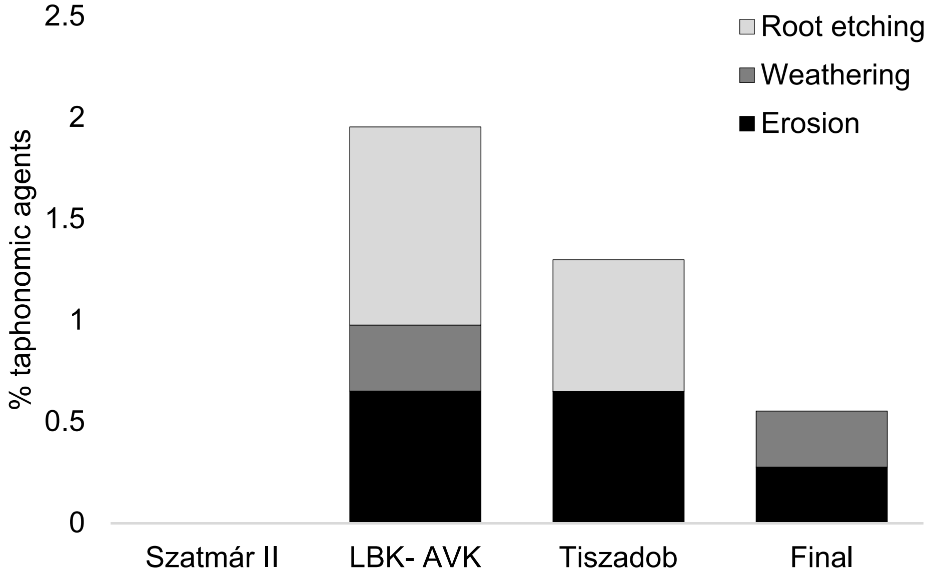

Figure 6.30: Percentage of the identifiable assemblage affected by different taphonomic agents (excluding cemented mud) from each phase from Polgár-Ferenci-hát.

6.9 Food exploitation strategies

6.9.1 Herd structure analysis

6.9.1.1 Cattle

Aging of cattle by epiphyseal fusion suggests that most cattle were killed after they had reached fusion maturity. While there was some juvenile death before 36 months, 69.0% (20/29) of cattle survived past their third and likely fourth year (figure 6.31). This indication of some young slaughter and high survival into adulthood could represent a dairy herd, with young males slaughtered elsewhere. Interestingly, the mortality profiles for teeth show slaughter of animals 6-15 months, but very little adult slaughter, which Gillis suggests could be due to animals being raised for primary meat consumption, or deposition bias, perhaps with animals coming for slaughter from other sites (Gillis unpub.b). I would suggest the latter, as there is no obvious slaughter event in either fusion or tooth ageing profile to indicate intensive meat age slaughter. Cattle herd structure analysis likely therefore may represent a dairy herd, with some animals slaughtered or deposited elsewhere.

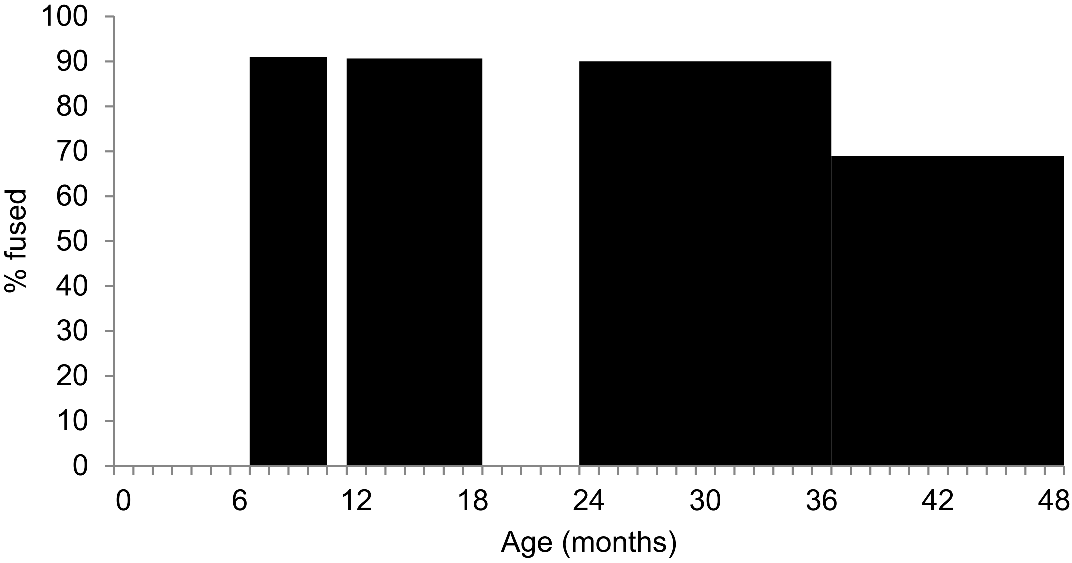

Figure 6.31: Cattle slaughter profile based on epiphyseal fusion from Polgár-Ferenci-hát (n=90).

6.9.1.2 Caprines

Caprine fusion showed young slaughter between 0-12 months, and further minor slaughter until a large cull of animals aged over 30 months. Only 18.9% (7/37) of bones from the final fusion stage were fused, suggesting a large slaughter of animals at optimum meat age. In the dental mortality profiles, Gillis argues that high frequencies of sheep slaughtered in the 6-12 month age class indicate that tender meat from milk lambs was being exploited. The unusually high slaughter in the fusion graph, and the low survivability into adulthood, could suggest differential use of sheep and goats with herd management strategies aimed at sheep meat and goat milk. Surely the surviving adults would not be a viable amount of animals for the continuation of the herd.

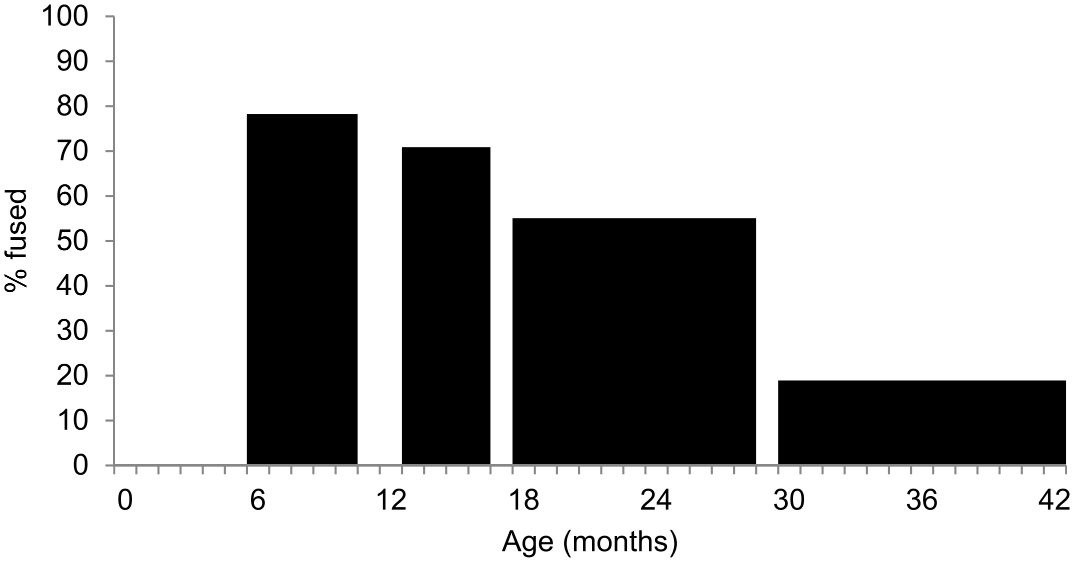

Figure 6.32: Caprine slaughter profile based on epiphyseal fusion from Polgár-Ferenci-hát (n=104).

6.9.1.3 Pigs

Although pig specimens suitable for fusion analysis were less well represented than cattle and caprines the slaughter profile still indicates trends in herd management. Slaughter of young pigs was quite considerable (<1 year), and most animals were slaughtered by 2.5 years (figure 6.33). One specimen in the final fusion age stage were fused (1/6). This suggests a meat herd structure that exploited both young, tender pig meat and slightly older optimum weight animals. It is unlikely that many individuals lived to fusion maturity.

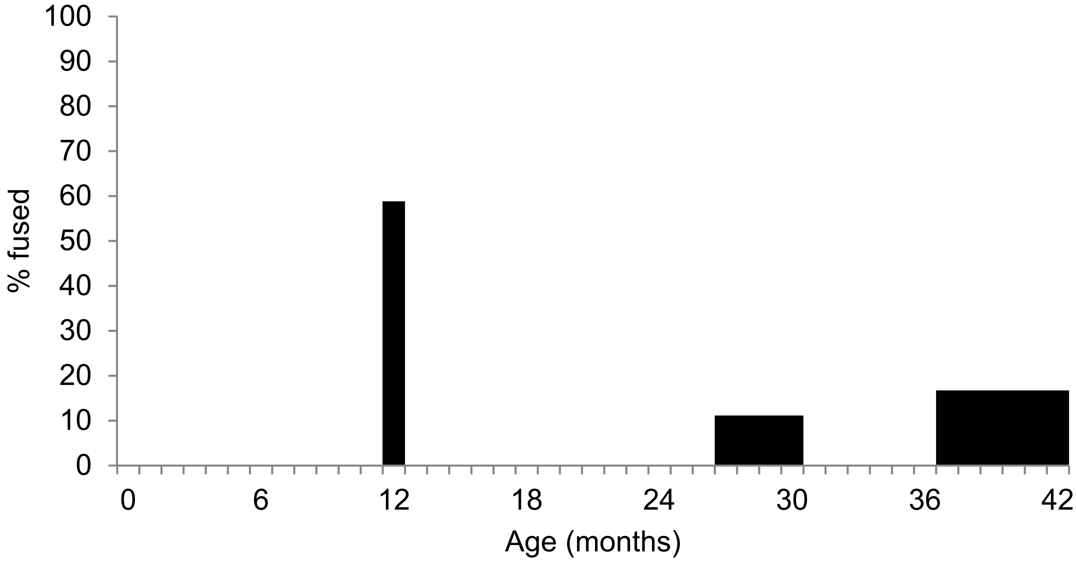

Figure 6.33: Pig slaughter profile based on epiphyseal fusion from Polgár-Ferenci-hát (n=32).

6.9.2 Lipid residue analysis

A total of 84 non-perforated sherds have been subject to lipid residue analysis from Polgár-Ferenci-hát. 25.0% (21/84) of ceramic sherds presented evidence of adipose fat, and 4.8% (4/84) of sherds contained milk fats. This corroborates possible evidence for dairying from cattle and caprine age-at-death analysis, and suggests that milk was available at least in some capacity at Polgár-Ferenci-hát.

6.9.3 Archaeobotanical analysis

Archaeobotanical material in the form of charred grains from Polgár-Ferenci-hát suggests crop cultivation, principally barley but also wheat, rye and millet, likely grown in mixed fields (Gyulai 2013: 886-887). Other noteworthy species were small seed lentil, field pea, grass pea vine and flax, along with weed seeds from the natural environment (*ibid.*). This suggests that Polgár-Ferenci-hát had a varied supply of cultivated plants.

6.10 Discussion

6.10.1 Meat and fat exploitation

As an enclosure site, Polgár-Ferenci-hát must have had a heightened capacity for mobilising communal manpower to plan, build and maintain earthworks (Raczky and Anders 2009: 271), which could have extended to food production strategies. A dairy herd may have been present at Polgár-Ferenci-hát, exploiting cattle but likely also goats (figures 6.31 and 6.32). Prime meat was supplied predominantly by sheep and pigs. It is possible that adult animals were brought from other sites, or slaughtered and deposited elsewhere, as the fusion and dental mortality profiles seem to suggest different trends. Crops were also cultivated, completing a picture of varied diet at Polgár-Ferenci-hát.

The faunal assemblage from Polgár-Ferenci-hát showed some interesting trends in carcass processing. Evidence of butchery was quite rare, but observed butchery technique was repetitive, often involving multiple strokes on butchery locations on the same specimen. Butchery evidence on the metapodia and phalanges suggests skinning, with disarticulation zones certainly at the elbow and ankle but also at the mandibular hinge, knee and distal metapodia (figures 6.34 and 6.35). The major meaty elements were defleshed, particularly the humerus and scapula. Burning was likely related to deposition more than carcass processing, especially considering that ritualised burning of contexts near the enclosure was taking place.

Table 6.5: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Polgár-Ferenci-hát.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	56	9	33	10	25	9	13	11	44	28	50	7	0	10
Suidae	67	9	0	2	0	4	50	2	24	21	-	-	-	-
Caprines	90	10	36	14	25	8	40	10	29	14	14	7	25	4

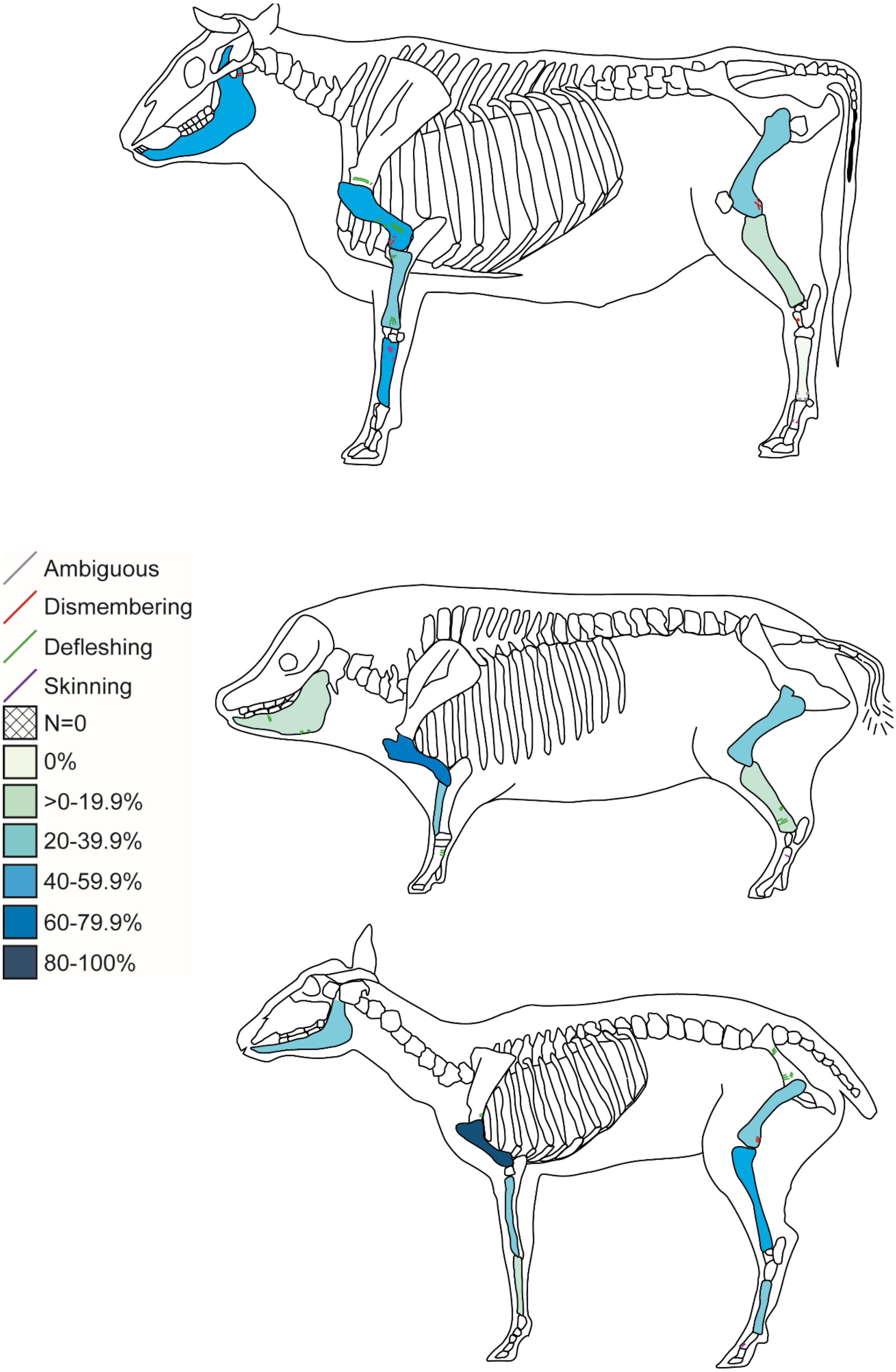

Figure 6.34: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Polgár-Ferenci-hát. Values in table 6.5.

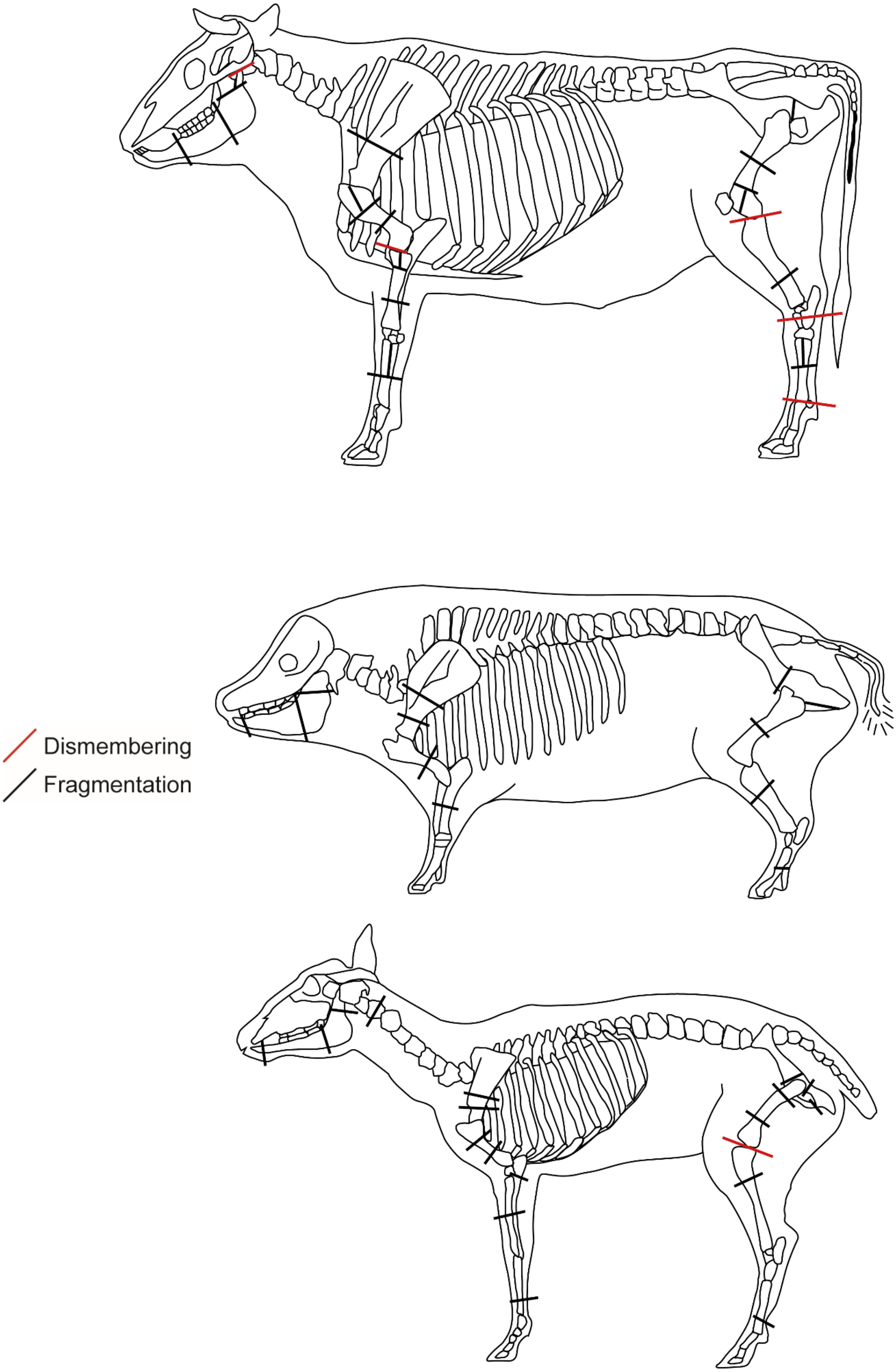

Figure 6.35: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Polgár-Ferenci-hát.

Marrow was certainly targeted for extraction at Polgár-Ferenci-hát but not as intensively as at other sites, particularly nearby Polgár-Piócás-dűlő and later Polgár-Csőszhalom (figure 6.34). Despite some possible small scale comminution there was similarly a lack of evidence for intensive bone grease processing, suggesting that the full nutritional potential of bone fats was not utilised. It is possible that there was an increase in bone marrow extraction over time, in conjunction with an increase in the proportion of the NISP comprised of pigs. The relationship between fresh fracture and the contribution of pigs to the NISP has been attested at other sites also, including Füzesabony-Gubakút and Polgár-Piócás-dűlő.

The seemingly non-intensive butchery and bone fat processing on the site may relate to the site's significant social position in the landscape, and the availability of milk, meat and crops as suggested above. Resources coming from nearby sites could have negated the necessity for this practice, and caused the truncation and confliction of the fusion and dental ageing profiles. We await lipid residue analysis to shed more light on the economic practices of the site.

Chapter 7 Apc-Berekalja I

7.1 Introduction

The archaeological site of Apc-Berekalja I is located in Northern Hungary within a substantially flat, narrow, alluvial basin in the fertile catchment area of the Zagyva river (Domboróczki *et al.* unpub.). An archaeological rescue excavation began between 2008-2009 in response to road building but was hampered by site flooding and contractor limitations (Domboróczki *et al.* unpub.). Despite these setbacks a large, multi-period site was discovered, partially excavated and recorded, dated to the Transdanubian Linear Pottery Culture (TLPC [5470-4950 cal BC]; *ibid.*, figure 7.1). The TLP culture likely originated from immigrant southern Neolithic populations bringing the Starčevo culture to the area, and it is probable that interaction with late Mesolithic communities led to the formation and rapid spread of the TLPC (Whittle *et al.* 2013a: 56). It is contemporary with the ALPC, but their interconnectivity is disputed (*ibid.* 55).

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of this thesis for copyright reasons

Figure 7.1: Site plan of Apc-Berekalja I. The two rows of the plan link at the top right and bottom left to form one continuous strip. Domboróczki *et al.* unpub.

Apc-Berekalja I is the largest and easternmost TLPC settlement known, at an estimated 20-30 hectares in size and very close to the borders of the Alföld Linear Pottery (ALP) culture (Domboróczki *et al.* unpub.). An estimated 10% of the settlement has been excavated, revealing 20-30 north-south orientated house plans in 10-15 settlement rows (*ibid.*). Typically houses were <20m in length and 6-8m wide, although there were some larger houses. Some superimposition of house plans indicates different settlement phases at Apc-Berekalja I. An artefact-free zone containing a thick humus layer suggests that an active river ran through the site during prehistoric times. Archaeological contexts tentatively identified as walking surfaces were later determined as layers of flooding and washing, indicating that refuse features remained open for some time, as at Füzesabony-Gubakút (*ibid.*; Domboróczki 2009).

7.2 Assemblage

7.2.1 Sample

The whole assemblage was analysed from Apc-Berekalja I, a total of 1255 specimens (table 7.1). Difference in values for fully identifiable specimens (table 7.1) and species representation (figure 7.2) is due to the exclusion of *Bos sp*. and *Sus sp*. and inclusion of wild birds (*Aves*; see section 3.4.1). It should be noted that it is likely that this assemblage was itself a sample of the original material excavated as it became clear that not all bones had been retained, and that 'indeterminate' bones had likely been disposed of. 67.6% (848/1255) of bones were identifiable, more than 30% higher than the average of other sites studied. This will render the indeterminate fragmentation and identification of bone grease processing practices particularly problematic.

Table 7.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Apc-Berekalja I (APC).

Fully identifiable (to species and element)	700
Partially identifiable (to species and element type)	148
Indeterminate	407
Total	**1255**

Four phases of occupation were present at Apc-Berekalja I, which will be compared in this case study as contexts were generally small (table 7.2). These phases were the Archaic LBK, the Notenkopf, a combined Notenkopf/Zeliezovce phase and the Zeliezovce phase, which were generally of comparable size although the Notenkopf was smaller.

Table 7.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens from different phases from Apc-Berekalja I.

Phase	Fully identifiable	Partially identifiable	Indeterminate	Total
Archaic LBK	165	21	76	262
Notenkopf	94	25	31	150
Notenkopf/Zeliezovce	173	43	145	361
Zeliezovce	118	30	78	226

Table 7.3: Full list of contexts analysed from Apc-Berekalja I.

Context	Phase	Interpretation	FID	PID	IND
2	Notenkopf	ditch	23	7	0
14	Notenkopf	ditch	2	0	0
16	LBK	N/A	3	0	1
17	Notenkopf	pit	1	1	2
19	Neolithic	pit	1	0	0
40	Notenkopf	pit	1	0	3
44	Zeliezovce	pit	0	2	3
66	Neolithic	pit	1	1	0
68	Zeliezovce	pit	0	0	1
70	Zeliezovce	pit	13	4	10
72	Notenkopf	pit	9	0	0
75	Zeliezovce	pit	4	3	34
76	Zeliezovce	pit	19	2	7
77	Notenkopf/ Zeliezovce	N/A	64	21	100
79	Notenkopf/ Zeliezovce	post hole	8	2	1
83	Notenkopf/ Zeliezovce	pit	1	1	1
103	Notenkopf/ Zeliezovce	ditch	7	2	1
104	Notenkopf/ Zeliezovce	ditch	2	1	3
106	Notenkopf/ Zeliezovce	pit	2	0	3
107	LBK	ditch	15	5	8
108	Zeliezovce	pit	1	3	1
162	Zeliezovce	pit	6	3	0
163	Notenkopf	pit	4	0	0
164	Zeliezovce	pithouse	6	1	1
165	Notenkopf/ Zeliezovce	pithouse	10	1	5
166	Notenkopf/ Zeliezovce	pithouse	1	0	1
167	Notenkopf	N/A	0	1	2
168	Notenkopf/ Zeliezovce	pit	13	2	3
207	Notenkopf/ Zeliezovce	pit	4	0	1
209	Notenkopf	pit	9	1	5
210	Notenkopf	pit	9	2	10
211	LBK	pit	4	0	2
218	Notenkopf/ Zeliezovce	pit	10	1	4

268	Zeliezovce	ditch	1	0	0
269	Neolithic	pit	1	0	1
272	Zeliezovce	N/A	0	0	2
284	Notenkopf	pit	5	1	0
290	Notenkopf	pit	11	6	2
291	Notenkopf	pit	1	0	0
351	Notenkopf	pit	2	1	0
364	Archaic LBK	ditch	6	0	14
386	Neolithic	pit	13	1	0
387	Notenkopf/ Zeliezovce	pit	4	1	1
392	LBK	pit	0	1	1
414	Notenkopf/ Zeliezovce	pit	8	2	2
419	Archaic and Notenkopf	pit	3	2	1
427	Neolithic	pit	4	0	2
428	LBK	pit	1	0	1
429	Neolithic	pit	1	0	0
430	Zeliezovce	pit	12	1	1
432	Neolithic	post hole	1	0	0
454	Archaic LBK	pit	5	0	3
455	Archaic LBK	pit	20	1	10
468	Notenkopf/ Zeliezovce	ditch	6	2	5
472	Notenkopf/ Zeliezovce	pit	4	1	5
473	Notenkopf/ Zeliezovce	ditch	23	3	7
476	Notenkopf	pit	0	0	1
483	Archaic and Notenkopf	ditch	10	2	2
497	Neolithic	pit	1	1	4
499	Neolithic	pit	0	0	1
505	Archaic and Notenkopf	pit	3	0	0
506	Archaic LBK	N/A	6	1	0
529	Archaic and Notenkopf	pit	12	1	2
546	Archaic LBK	pit	5	1	3
554	Archaic and Notenkopf	pit	7	0	3
555	Notenkopf/ Zeliezovce	pit	6	3	2
559	LBK	pit	3	2	0
561	Notenkopf	pit	0	1	0
598	Archaic LBK	post hole	16	1	8
609	Zeliezovce	pit	32	7	6
612	Notenkopf	pit	0	1	0
615	LBK	pit	21	4	9
638	Zeliezovce	pit	2	1	1
664	LBK	ditch	8	0	0
671	Archaic LBK	pit	5	1	2
677	Archaic LBK	post hole	1	0	4
697	Archaic LBK	pit	44	10	16
705	Neolithic	pit	0	1	3
720	Zeliezovce	pit	2	0	2

722	Archaic LBK	pit	5	0	1
762	Zeliezovce	well?	5	0	1
763	Zeliezovce	pit	7	1	6
778	LBK	pit	0	0	1
780	Neolithic	pit	3	0	0
814	Archaic LBK	ditch	2	0	0
822	Neolithic	pit	3	0	2
914	Archaic LBK	pit	3	0	1
915	Archaic LBK	pit	15	3	5
919	Archaic LBK	pit	14	2	5
926	LBK	ditch	9	3	11
932	Archaic LBK	pit	2	0	0
1017	LBK	pit	1	0	0
1058	Archaic LBK	pit	2	0	1
1060	Archaic LBK	pit	3	0	0
1094	LBK	pit	3	0	0
1164	LBK	pit	1	0	0
1178	LBK	pit	2	0	0
1186	Archaic LBK	post hole	1	0	1
1235	LBK	pit	2	0	0
1238	Notenkopf	pit	8	2	2
1339	LBK	post hole	3	1	2
1354	Zeliezovce	pit	1	1	2
1359	LBK	pit	5	1	4
1367	Notenkopf	pit	9	1	4
1378	Zeliezovce	pit	0	1	0
1387	Archaic LBK	pit	9	0	2
1388	LBK	pit	1	0	0
1394	Zeliezovce	pit	7	0	0
1399	LBK	pit	1	0	0
1411	LBK	pit	0	1	0
1428	Archaic LBK	pit	1	1	0
160/12	N/A	N/A	0	0	1
2 AROK	N/A	N/A	0	0	12
53/2	LBK	pit	3	2	3

7.3 Species representation

7.3.1 Site

The species representation from Apc-Berekalja I shows that cattle were the most commonly identified domesticate (60.4%, 403/667), followed by caprines (21.3%, 142/667, including one caprine bone identified as sheep) and pigs (9.9%, 66/667; figure 7.2). Domestic dogs were present on the site, represented by one bone specimen but likely also indicated by the presence of canid gnawing. Wild animals did not make up a large proportion of the species represented at Apc-Berekalja I (8.2%, 55/667). Aurochs were the most commonly identified wild animal, with wild boar and roe deer not recorded in the assemblage. Other wild animals included birds, hare and one lesser mole-rat (*Spalax leucodon*).

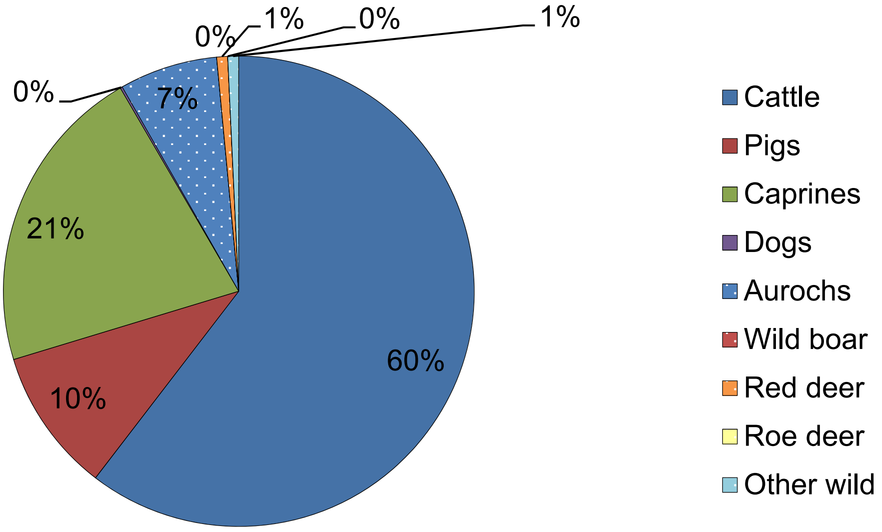

Figure 7.2: Species representation (NISP) for the fully identifiable assemblage from Apc-Berekalja I (n=667).

7.3.1.1 Phase

Species representation by phase suggests a continuing importance of cattle throughout the LBK period (figure 7.3). There was some minor variation in the percentages of caprines and pigs, with a statistically significant decrease in the proportions of caprines over time between the Archaic LBK (44/148) and Zeliezovce phases (16/144; p=.003). Wild animals contribute a similar proportion to the percentage NISP in all phases.

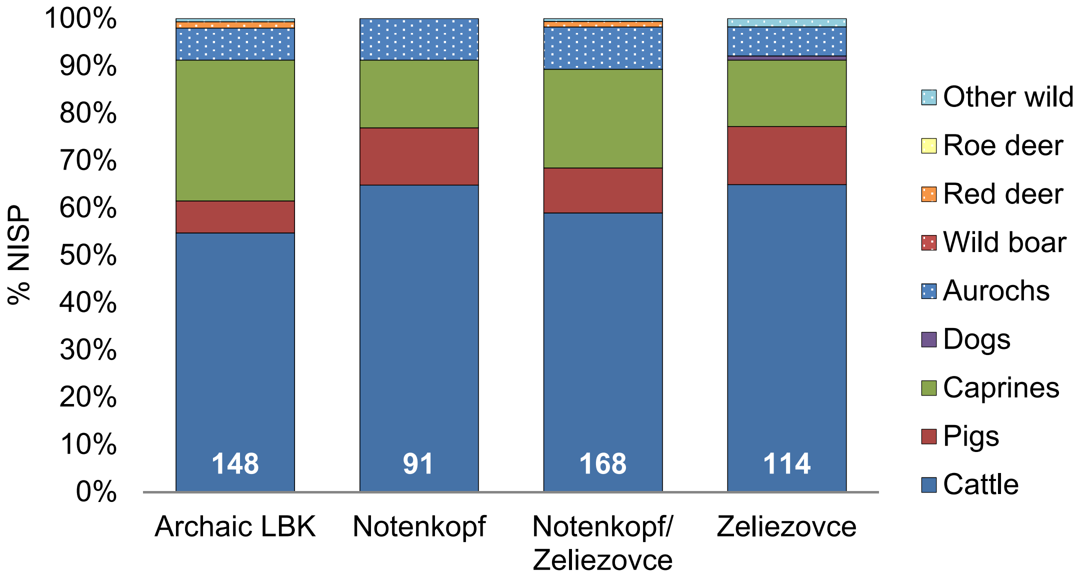

Figure 7.3: Species representation (NISP) for each phase from Apc-Berekalja I. N values are at the base of each bar.

7.4 Butchery

7.4.1 Site

Evidence for the presence of butchery marks was limited at Apc-Berekalja I, present on 2.9% (36/1255) of the assemblage, and 3.7% (31/848) of the identifiable assemblage. The types of butchery marks noted on identifiable specimens were predominantly scratch and cut marks, with considerably more scratch marks than at other sites (figure 7.4). ‘Saw’ marks were likely caused by repeated strokes in the same location. The Notenkopf phase had the highest proportion of butchery marks at 7.3% (11/150), significantly more butchered than the Archaic LBK (2/262, p<.001), Notenkopf/ Zeliezovce (7/361, p=.030) and Zeliezovce (6/226, p=.033) phases (figure 7.5).

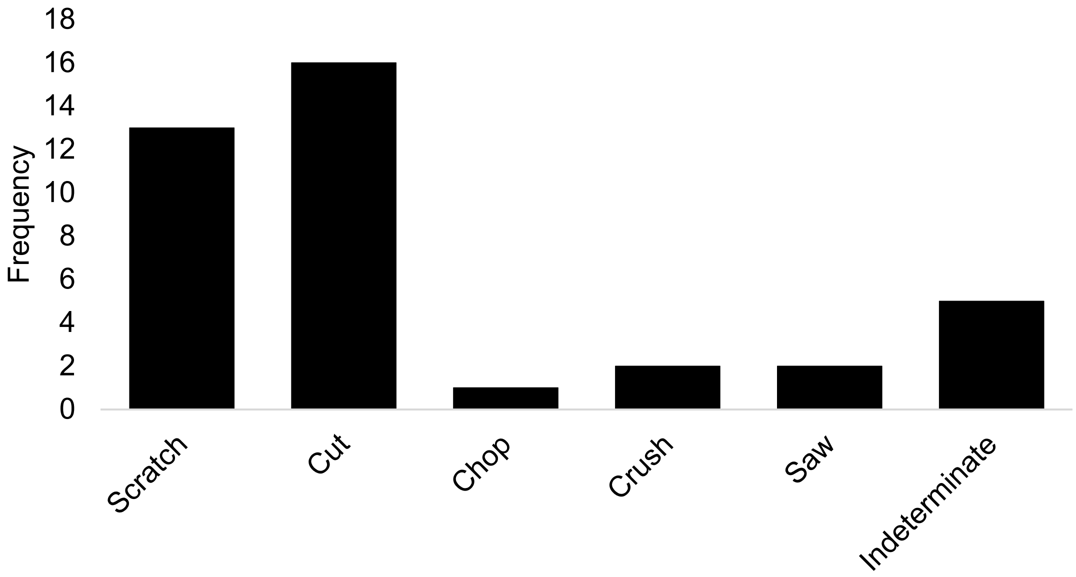

Figure 7.4: Frequency of butchery mark types from Apc-Berekalja I.

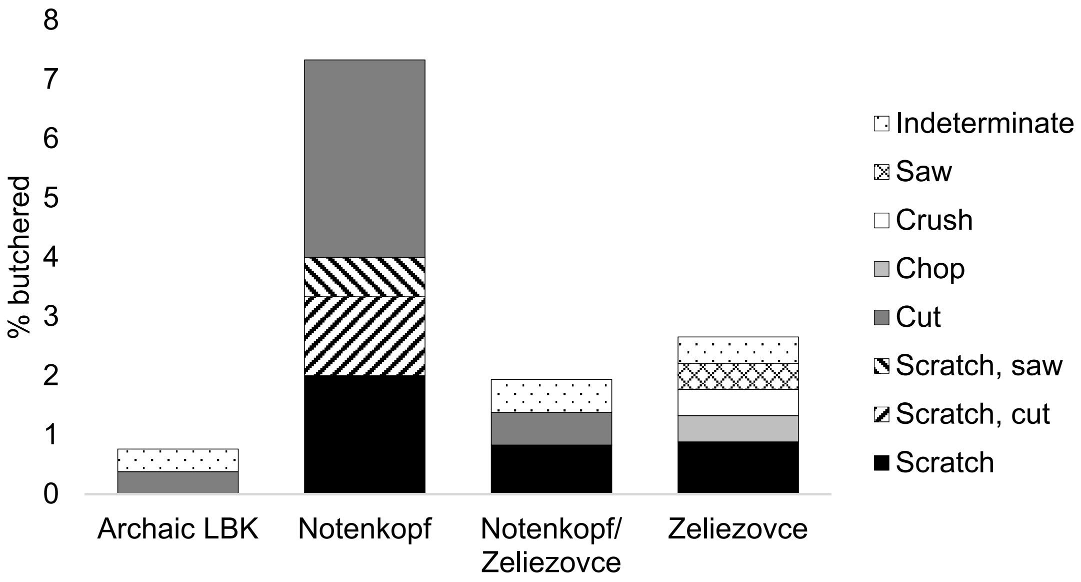

Figure 7.5: Percentage of specimens from each phase with different butchery episodes from Apc-Berekalja I.

7.4.2 Species

Large mammal bones, including indeterminate large mammal bones, bovinae and red deer, showed significantly greater proportions of butchery (4.7%, 28/593) than those of medium mammals (1.2%, 3/250, p=.013; figure 7.6). It is possible that large carcasses require more intensive butchery to disarticulate them.

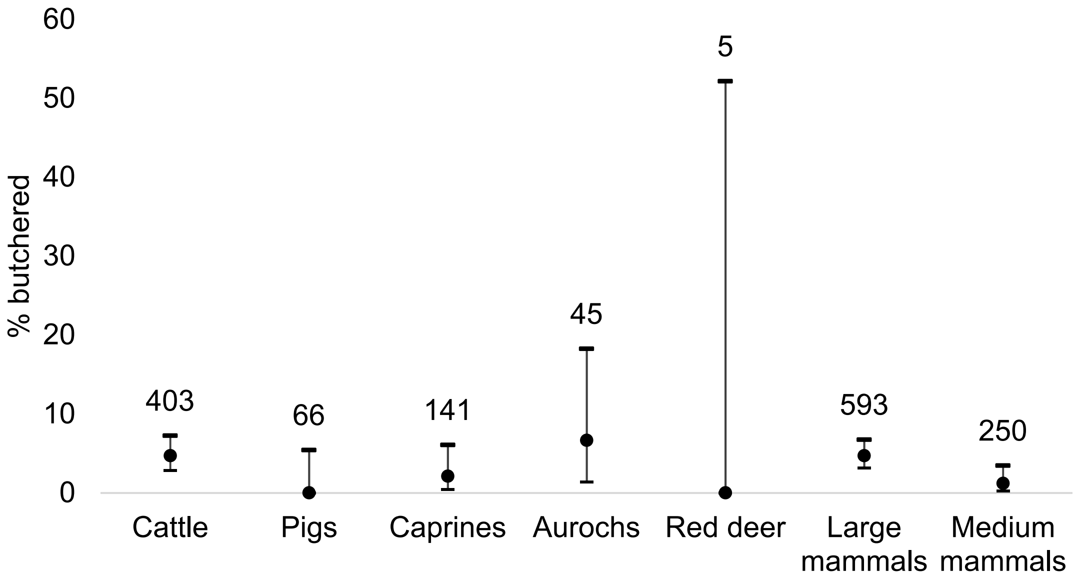

Figure 7.6: Percentage of species with evidence of butchery from Apc-Berekalja I, with 95% confidence intervals. N values are at the top of each series.

7.4.3 Carcass butchery

The forelimb was the most commonly butchered carcass portion (11/173), significantly more so than the skull (1/94, p=.046) and the hindlimb (2/128, p=.043; figure 7.7), and showed the highest proportion of scratch marks (see also figure 7.9). The extremities were also more commonly affected by butchery than other carcass parts, although the differences were not significant.

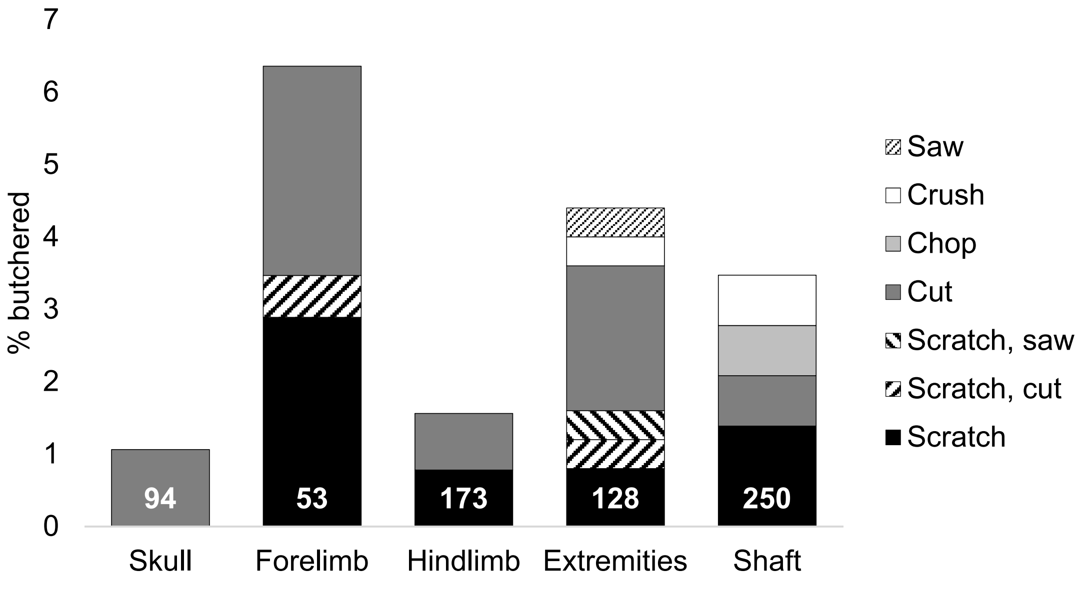

Figure 7.7: Percentage of bones in different carcass portions with different butchery episodes from Apc-Berekalja I. N values are at the base of each bar.

7.4.3.1 Forelimb butchery

On the humerus (figure 7.8) butchery clustered around the distal epiphysis, largely formed of short cut marks. Butchery of the radius and ulna (figure 7.9) exhibited far more scratch marks, also short in length. These patterns likely resulted from both the disarticulation of the humerus and radius and defleshing these elements (Soulier and Costamagno 2017).

🟦 Scratch 🟩 Cut 🟥 Chop

Figure 7.8: Cumulative diagram of butchery on cattle (n=4) and caprine (n=1) humeri from Apc-Berekalja I. Left to right; anterior, lateral and medial views.

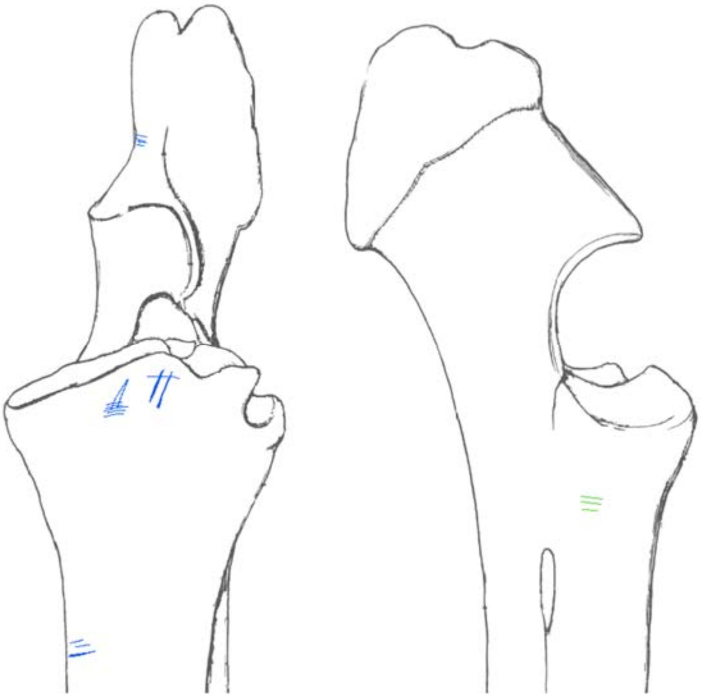

Figure 7.9: Cumulative diagram of butchery on cattle radii and ulnae (n=4) from Apc-Berekalja I. Anterior (left) and medial views.

7.4.3.2 Extremities butchery

Butchery on the astragalus appeared quite intensive, although the marks in figure 7.10 only represent the butchery patterns on four specimens. These multiple strokes were likely as a result of disarticulation of the meat-rich upper hindlimb from the metapodia and phalanges (Soulier and Costamagno 2017).

Figure 7.10: Cumulative diagram of butchery on cattle astragali (n=4) from Apc-Berekalja I. Left to right; anterior, lateral and posterior views.

7.5 Heat exposure

As with butchery, there was limited evidence for burning on the assemblage of Apc-Berekalja I. Of the whole assemblage, 4.1% (52/1255) was affected by evidence of burning, and 5.0% (42/848) of the identifiable assemblage. The most common type of heat exposure was roasting, but bones were also burnt at higher temperatures (carbonised or calcined; figure 7.11).

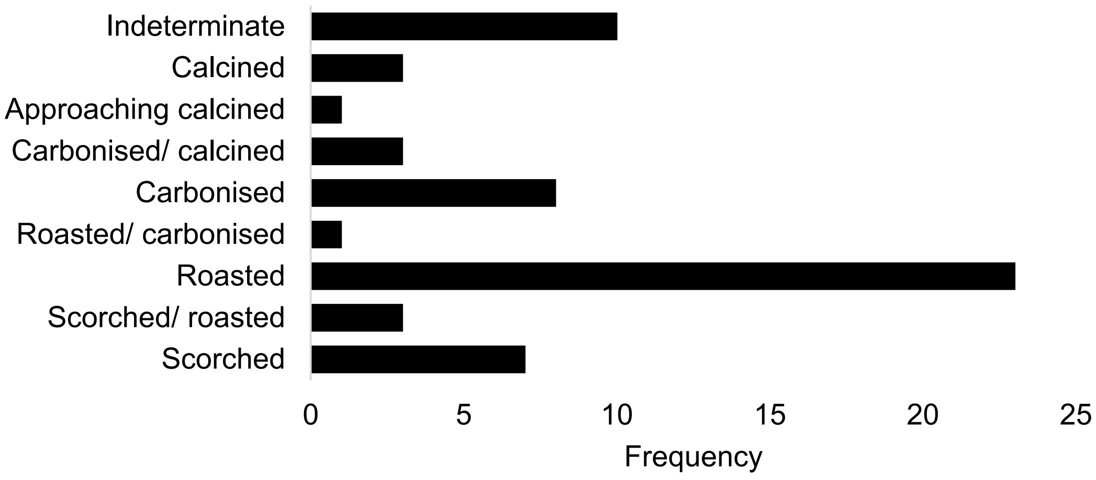

Figure 7.11: Frequency of heat exposure types from Apc-Berekalja I.

7.5.1.1 Phase

The Notenkopf/Zeliezovce phase had the highest proportion of bones affected by heat exposure, although the differences with the other phases were not significant. This could suggest different carcass processing over time, or that contexts from this phase were those more likely to include burnt material. Apart from in the Notenkopf phase, light burning (roasting and scorching) made up the majority of incidences of burning.

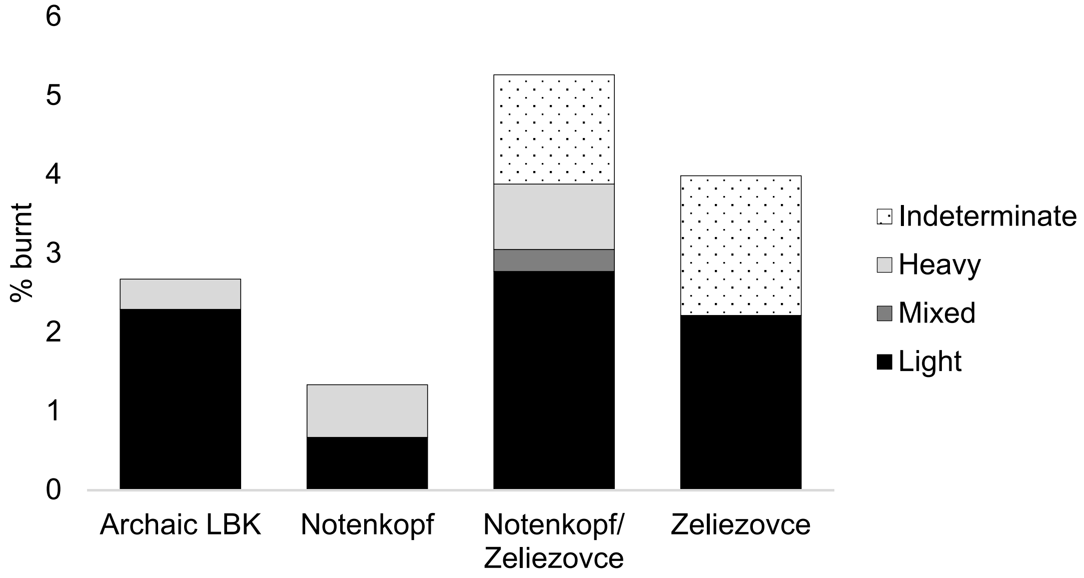

Figure 7.12: Percentage of identifiable bones from each phase affected by different intensities of burning from Apc-Berekalja I.

7.6 Fracture

7.6.1 Site

The percentage of fractured bones that were fractured when fresh was low in Apc-Berekalja I at 29.3% (111/379), although preferential fresh fracture of high-marrow-yield elements suggests some degree of marrow exploitation (figure 7.13). The mean Fracture Freshness Index reflected the dry nature of the assemblage at 3.9 out of 6, and the frequency of FFI scores indicates bones were often fractured with mixed characteristics (scores 3-5, 40.4%, 153/379) as well as when completely dry (score 6, 32.5%, 123/379; figure 7.14). Thus, while bone was often fractured when all nutritional benefit was surely lost, there was a larger body of specimens fractured when drying. As figure 7.13 shows, both mineralised fracture and secondary breakages were rare, suggesting that the material was not disturbed post-deposition. It is possible that similar conditions to those seen at Füzesabony-Gubakút, including low marrow need and high fragmentation of refuse before deposition, contributed to these patterns.

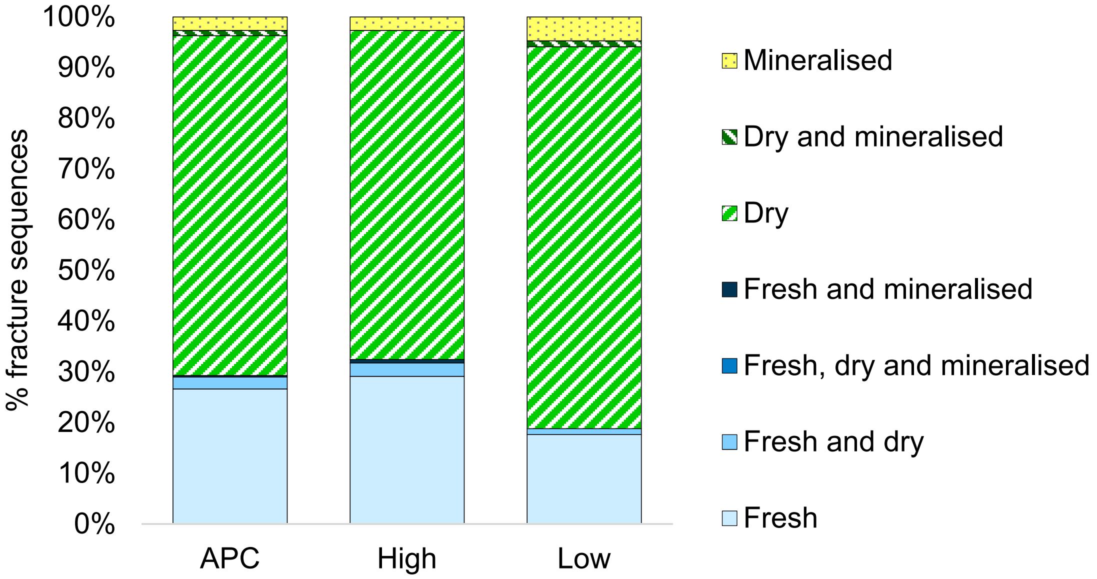

Figure 7.13: Fracture history profiles for the Apc-Berekalja I assemblage (n=379) and for high- and low-yield marrow bones (n=151/85).

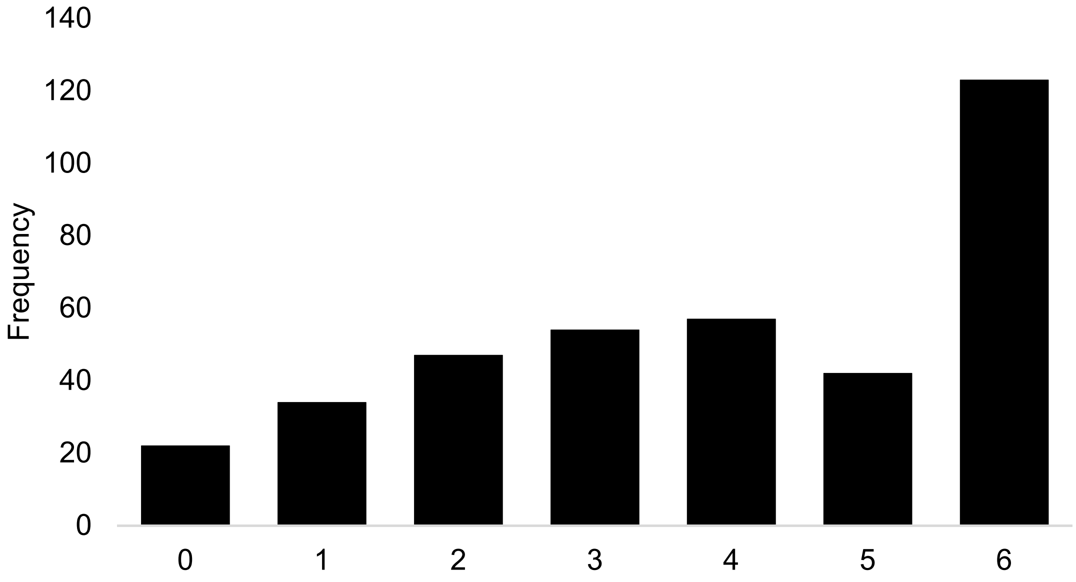

Figure 7.14: Frequency of Fracture Freshness Index scores from Apc-Berekalja I.

7.6.1.1 Phase

There were only slight differences between the phases in the types of fracture sequences and levels of fresh fracture. The most notable was an increase in the percentage of fresh fracture from the Archaic LBK period which stayed constant through to the Zeliezovce phase (figure 7.15). The difference between the Archaic LBK (17/80) and the combined proportion of freshly fractured bones from the other three phases was statistically significant (74/219, p=.037). Another interesting difference was the increase in secondary mineralised fracture in the Notenkopf period, perhaps an indicator of disturbance of a particular context. The mean FFI (figure 7.16) fluctuated only slightly between 3.7 and 4.0 out of 6, suggesting no great changes in carcass processing and deposition over the phases of the site. Analysis of high- and low-yield marrow-bearing bones from these phases was not possible due to small sample sizes.

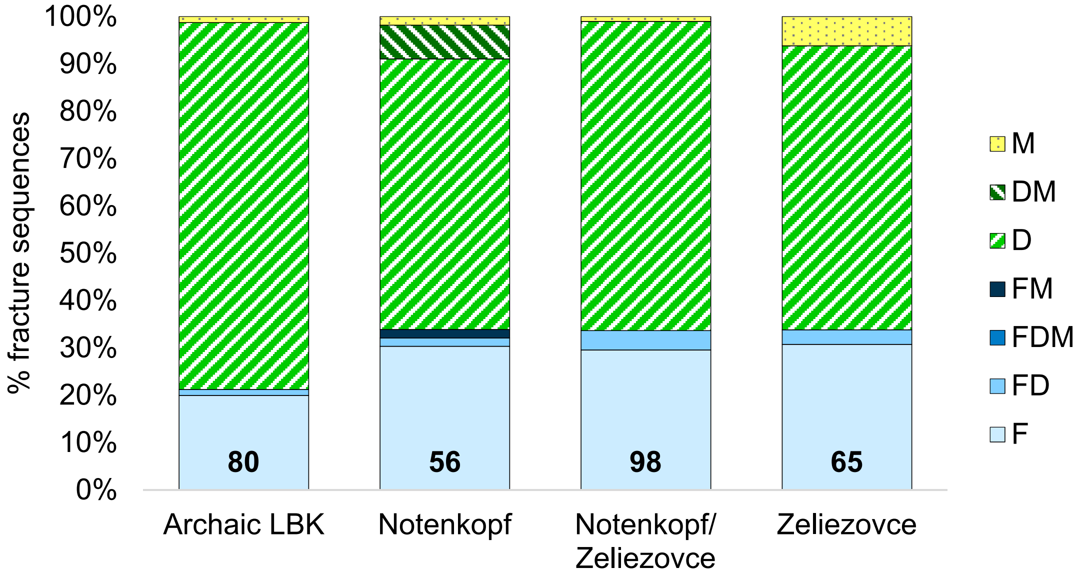

Figure 7.15: Fracture history profiles for each phase from Apc-Berekalja I.

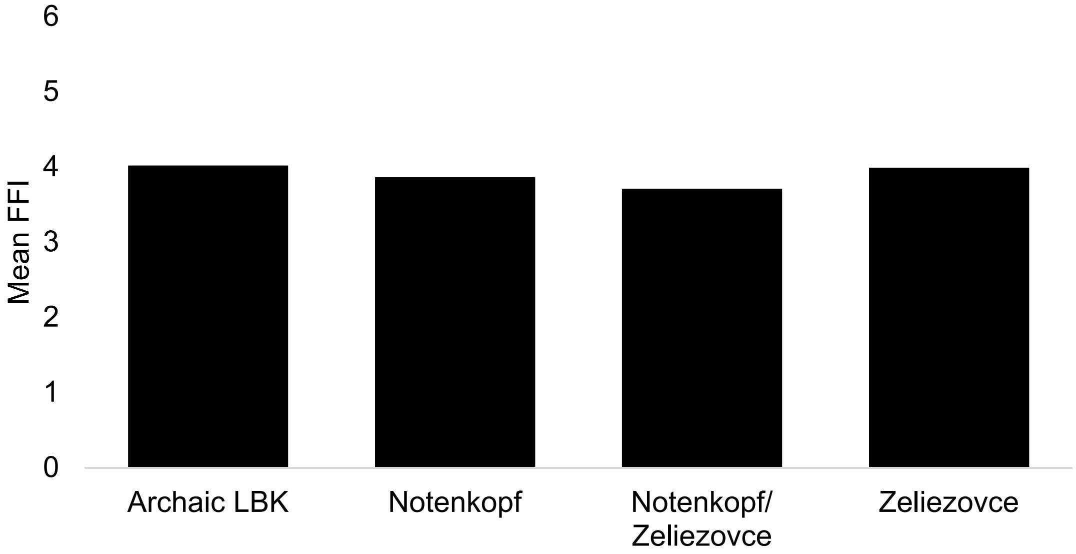

Figure 7.16: Mean Fracture Freshness Index scores for each phase from Apc-Berekalja I.

7.6.2 Species

Medium mammals were fractured when fresh in greater proportions than cattle, although the differences were not significant (figure 7.17 and 7.18). Caprines showed a much greater disparity between the proportion of fresh fracture on high- (40.5%, 17/42) and low- (0%, 0/15, p=.003) yield marrow-bearing bones than cattle (figure 7.19), which showed very little variation. Evidence for fresh fracture on wild animals was very limited, although it could be noted that aurochs bones (n=11, FFI 3.5) had a lower FFI score than cattle bones (FFI 4.1), suggesting that they were more often freshly fractured than their domestic counterparts (figure 7.18).

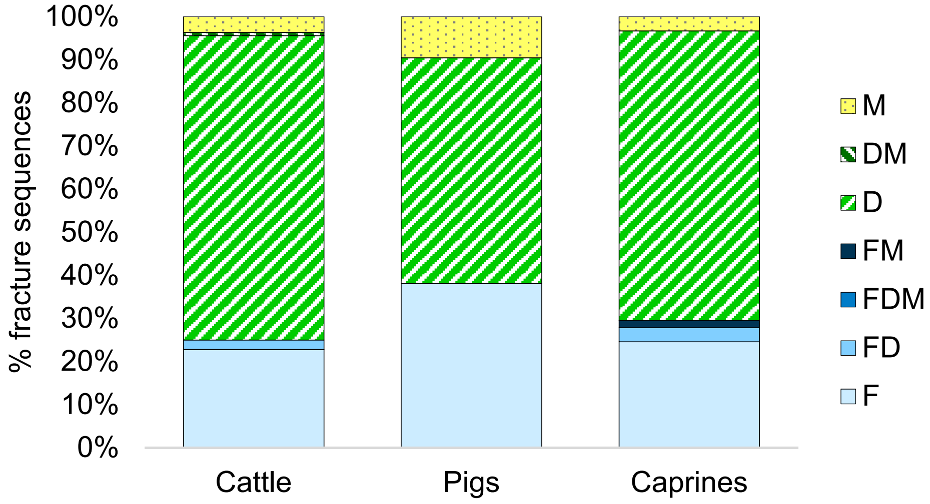

Figure 7.17: Fracture History Profiles for cattle (n=136), pigs (n=21) and caprines (n=61) from Apc-Berekalja I.

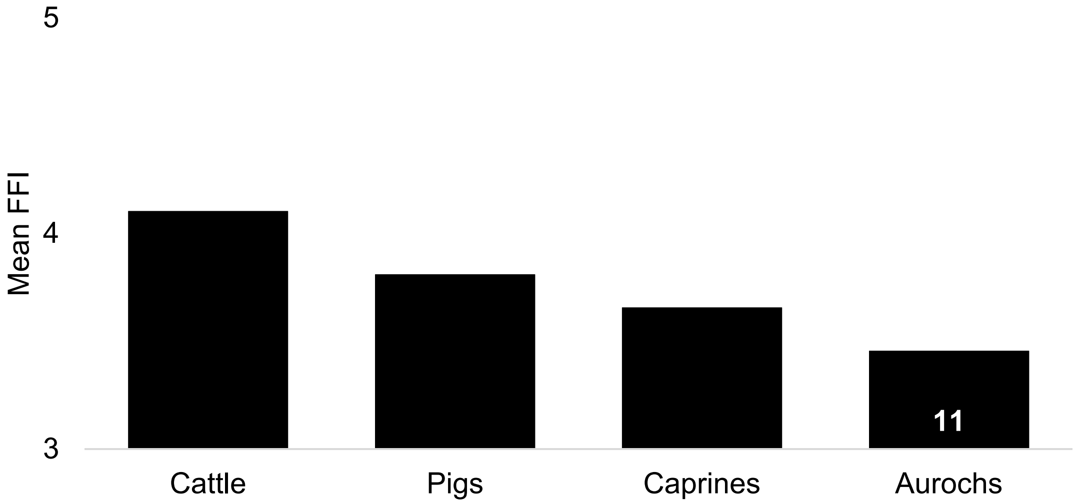

Figure 7.18: Mean Fracture Freshness Index scores for species from Apc-Berekalja I.

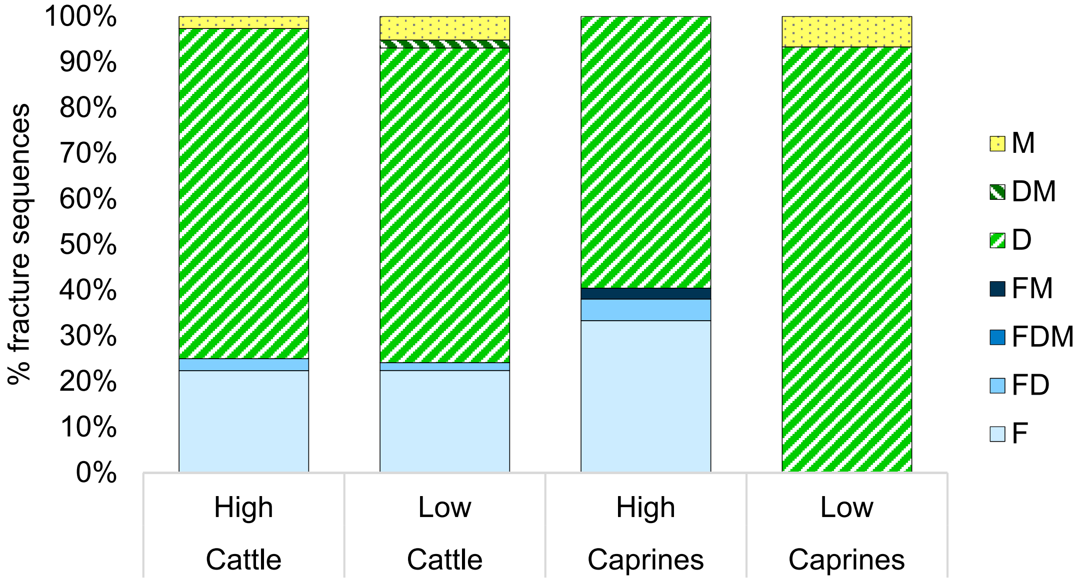

Figure 7.19: Fracture history profiles for high- and low-yield marrow bones from cattle (n=76/58) and caprines (n=42/15) from Apc-Berekalja I.

7.7 Fragmentation

Fragmentation analysis for Apc-Berekalja I was difficult due to the assumption that not all material was retained from excavation. This resulted in an unrealistic representation of the amount of fragmentation on the site, as it is likely that the discarded material would have been fragmented indeterminate specimens. Figure 7.20 shows an incredibly low, almost non-existent, proportion of the assemblage weight derived from bones under 60mm, and that specimens over 100mm in length and those that had unfragmented epiphyses or were whole were overrepresented. For this site, it makes sense to show figure 7.21 as a stacked column chart, as it unusually shows that even the frequency of bones in the smallest size classes was low compared to those in the largest size classes. Fragmented axial and articular bone could suggest that bone grease processing might have taken place on a small scale, or pot-sizing bones to boil in with stews, releasing some bone grease without intensively bone grease processing. It could also have been caused by deposition fragmentation. However, without the indeterminate bones it is impossible to say whether this is the case.

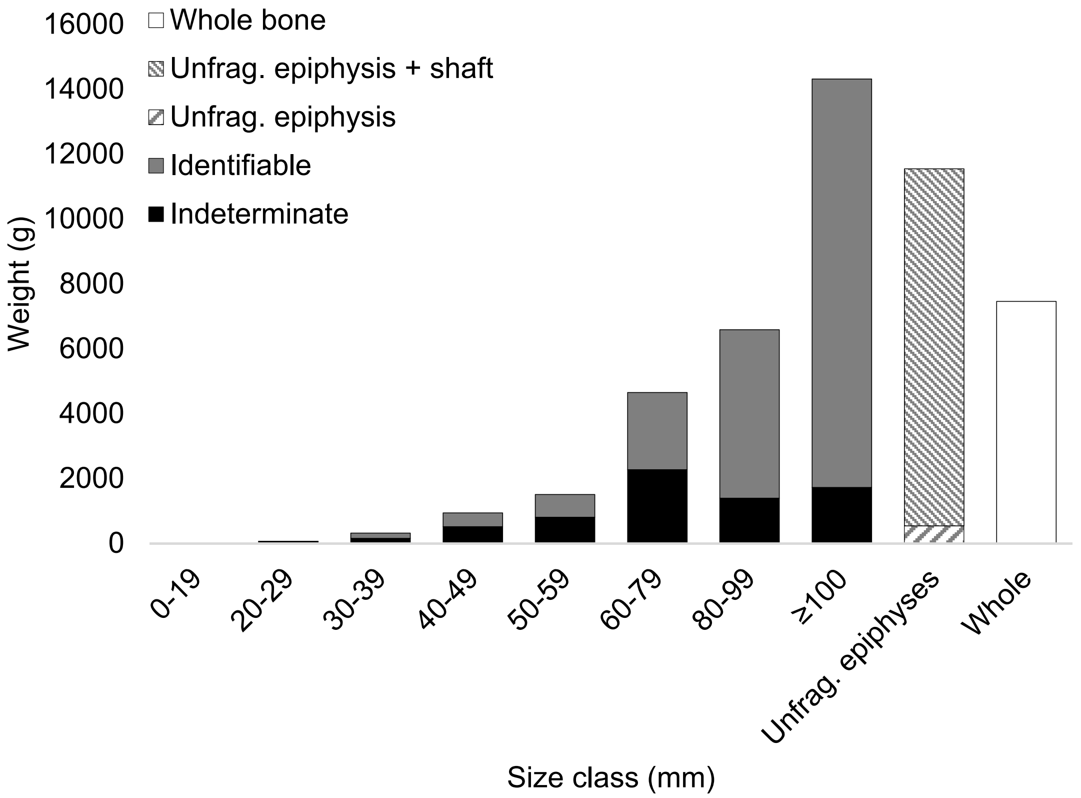

Figure 7.20: Weight by size class of all specimens from Apc-Berekalja I.

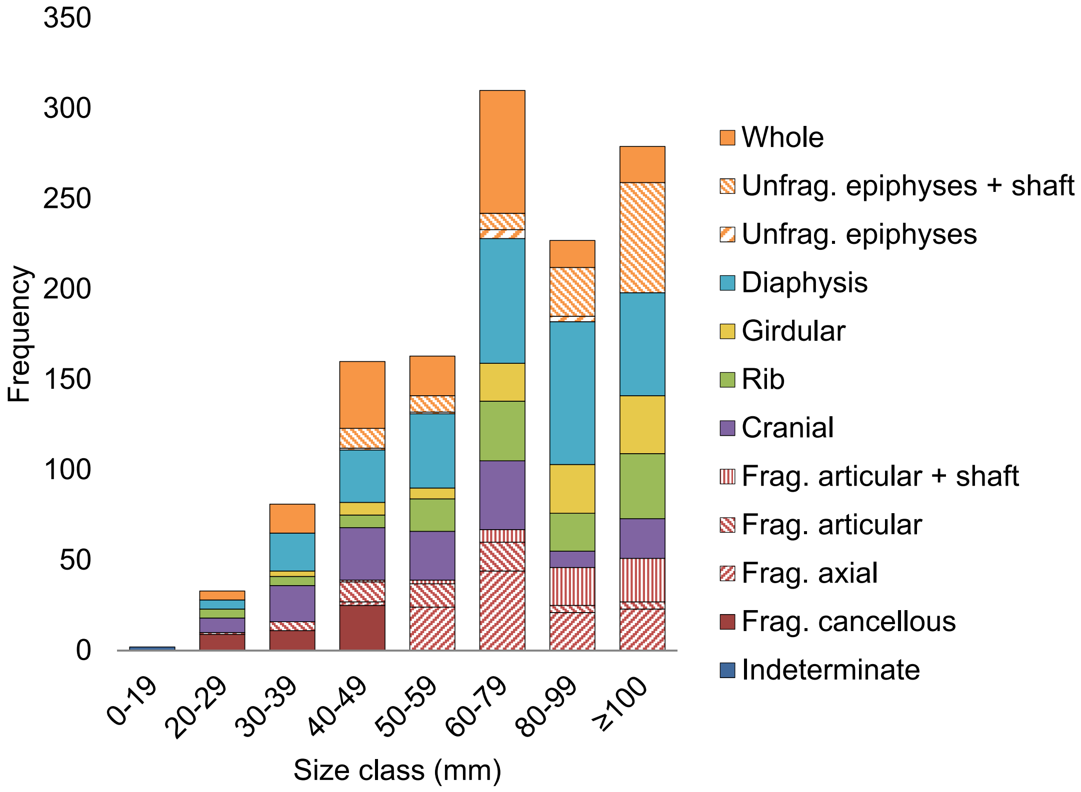

Figure 7.21: Bone type frequency by size class from Apc-Berekalja I. Red series indicate fragmented cancellous bone.

7.8 Taphonomy

7.8.1 Gnawing

Gnawing affected just over 2% (28/1255) of the entire Apc-Berekalja I assemblage, the majority identified as canid gnawing. Rodent gnawing was also present (figure 7.22). Although the Notenkopf/Zeliezovce phase had the highest degree of gnawing the differences between phases were not significant.

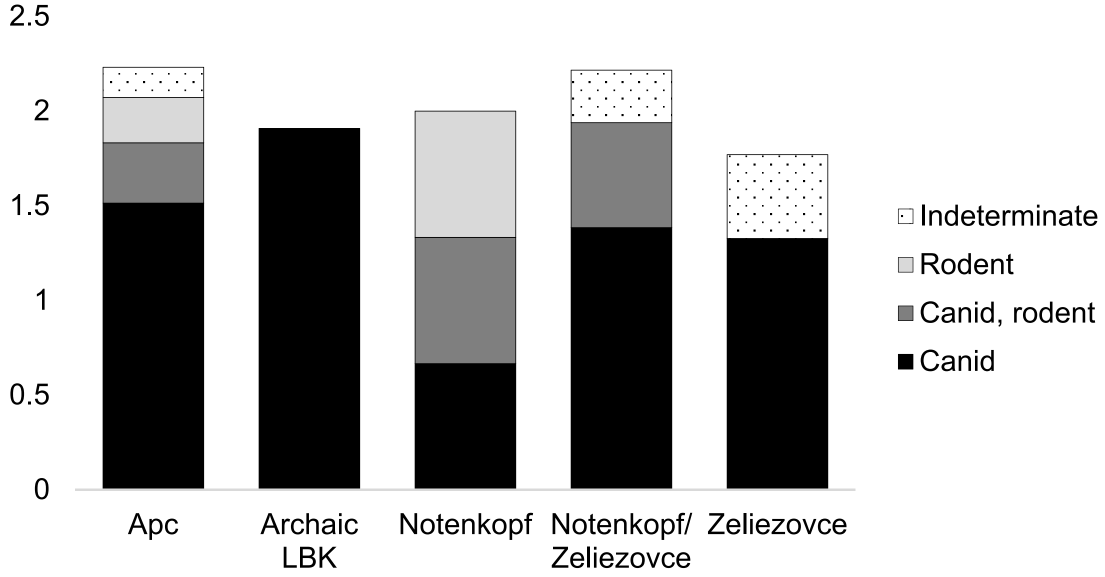

Figure 7.22: Percentage of the Apc-Berekalja I assemblage and each phase affected by different types of gnawing.

7.8.2 Taphonomic agents and recent breaks

Taphonomic agents indicating depositional practices were not identified at Apc-Berekalja I. Only cemented mud, which can affect butchery and fracture analysis by concealing bone surfaces, was present (n=20). New breaks affected 11.2% (95/848) of the identifiable assemblage. The Archaic LBK phase was the phase most strongly affected by recent breaks (15.6%, 29/186).

7.9 Food exploitation strategies

7.9.1 Herd structure analysis

7.9.1.1 Cattle

Cattle slaughter profiles showed limited deaths in animals under 1.5 years of age, followed by a large cull between 1.5 and 3 years of likely meat-age animals (figure 7.23). Surviving adults could have been milked, but there is no evidence for an intensive dairy economy. Based on the mortality profiles of cattle teeth there was a much higher level of infant slaughter or natural mortality between 0-6 months (Gillis unpub.b), so it is possible that taphonomic bias has removed neonatal and juvenile bones from the assemblage. It is likely that cattle at Apc-Berekalja I represent a dairy herd with optimum meat-age slaughter at 1.5-3 years.

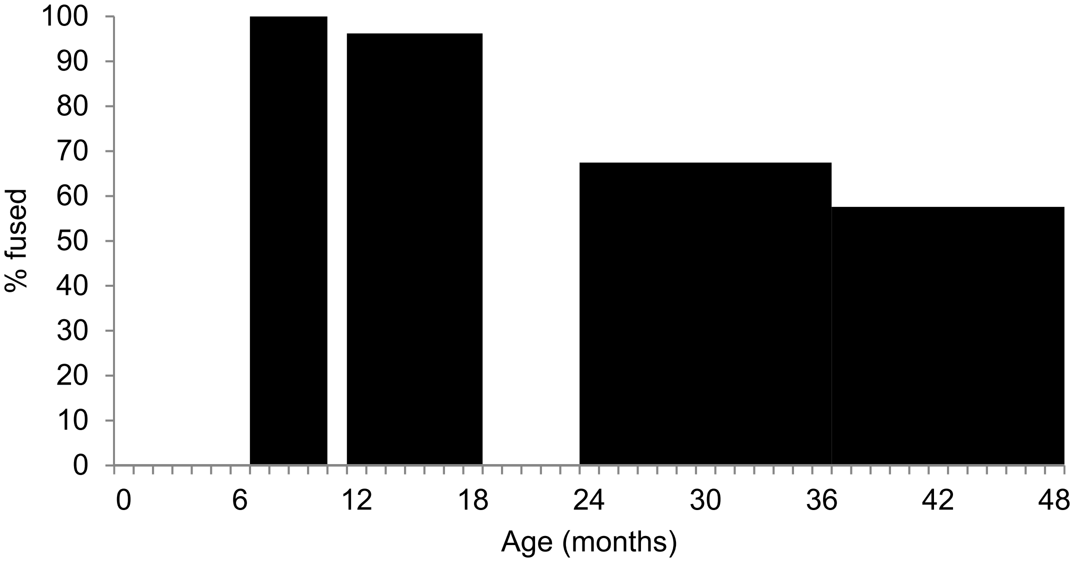

Figure 7.23: Cattle slaughter profiles based on epiphyseal fusion from Apc-Berekalja I (n=180).

There was some evidence for change in husbandry practices over time, which showed that greater numbers of younger animals were killed in the Archaic LBK phase than the later Zeliezovce phase (figure 7.24). It could also suggest that meat-age animals were being consumed elsewhere in the site in the Zeliezovce phase.

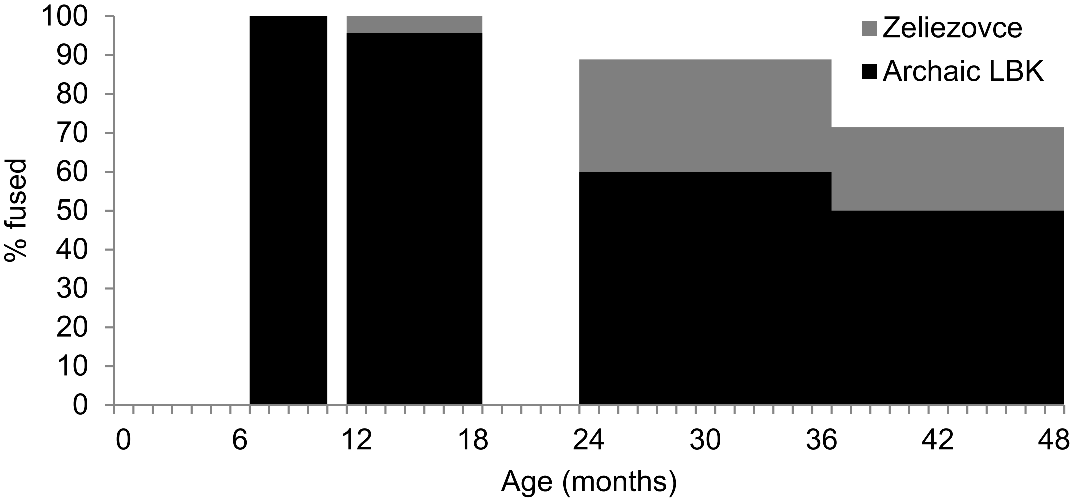

Figure 7.24: Cattle slaughter profiles based on epiphyseal fusion from the Archaic LBK (n=41) and the Zeliezovce (n=32) phases from Apc-Berekalja I.

7.9.1.2 Caprines

Caprine fusion ageing showed no major slaughter of animals until after 1.5 years (figure 7.25). Following a cull between 18 and 28 months there was very little further kill-off until animals had reached fusion maturity, suggesting a similar husbandry practice to cattle. However, as with cattle, there was likely a taphonomic bias for young animals as the sheep dental mortality profile showed a high frequency of animals slaughtered in 6-12 months, suggesting a Meat A model where tender meat from milk lambs was being exploited (Gillis unpub.b).

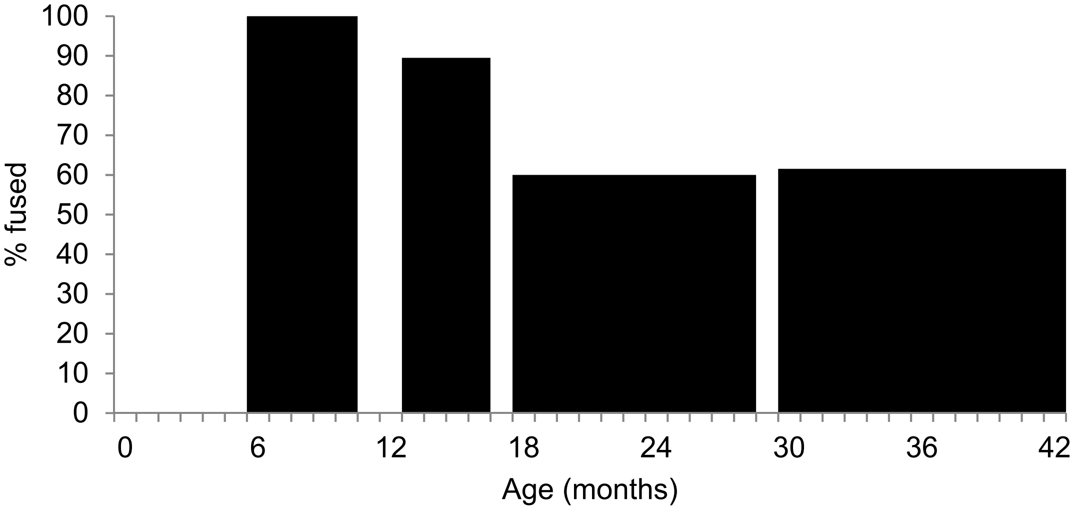

Figure 7.25: Caprine slaughter profiles based on epiphyseal fusion from Apc-Berekalja I (n=64).

7.9.1.3 Pigs

The sample size of domestic pigs was too small to perform fusion analysis. However, some trends can be identified. Of twelve specimens fusing before 1 year 83.3% (10/12) were fused, thus meat from very young pigs was not consumed at Apc-Berekalja I in similar proportions to other sites such as Füzesabony-Gubakút and Těšetice-Kyjovice. In the final age-stage just one specimen was fused (1/8), indicating that animals were often slaughtered before they reached fusion maturity.

7.9.2 Lipid residue analysis

Lipid residue analysis has been undertaken on non-perforated and perforated sherds from Apc-Berekalja I. Animal fats have been detected in 30% of non-perforated sherds (3/10), all of which were adipose fats. Perforated vessels (sieves) reported animal fats in 33% of sherds (2/6) all identified as milk fats. The lipid residue analysis therefore suggests that non-perforated vessels were not used to store or contain milk, but it is likely that it was sieved, potentially to make cheese as at Ludwinowo 7 (Salque *et al.* 2013). This further suggests that there was a supply of dairy products at Apc-Berekalja I.

7.10 Discussion

7.10.1 Meat and fat exploitation

The faunal assemblage and lipid residue analysis of Apc-Berekalja I suggests that milk and dairy products could have been consumed, in addition to prime-age meat from cattle, caprines and pigs. The carcass processing profiles in figures 7.26 and 7.27 give an indication of butchery traditions. Marks from skinning were present on metapodia of cattle, with evidence of disarticulation at the elbow and ankle (in cattle) and the hip (in caprines). Butchery patterns indicating defleshing were also present on the humerus, radius, ulna and scapula. Fresh fractures suggesting marrow extraction were most common on the humerus and tibia, but were low in general, as was true for all fractured marrow-bearing bones from the site.

Whilst marrow was likely exploited to some extent at Apc-Berekalja I, dry fracture was the most dominant fracture type in the assemblage. Mixed fracture characteristics could indicate fracture on drying bone, which may still have had unspoiled marrow within, and could represent a preference for ‘ripe’ marrow (Johnson 1985; e.g. Kirk 1986: 123). However, it is likely that the fat-rich dairy and meat supply negated the need for intensive marrow exploitation, and that high levels of dry fracture are a result of deposition practices similar to those at Füzesabony-Gubakút. Refuse deposited in pits could have been trampled on walking surfaces for long periods of time before final deposition, causing dry fracture and fragmentation (see Domboróczki 2009). Fragmentation patterns (figures 7.20 and 7.27) were less intensive than at Füzesabony-Gubakút, but it is likely that this also resulted from the discarded indeterminate bone fragments.

Table 7.4: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Apc-Berekalja I.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	42	26	11	33	7	20	42	25	6	40	25	17	38	31
Suidae	50	8	17	6	NA	0	38	8	0	11	-	-	-	-
Caprines	62	13	20	10	38	8	36	11	0	9	0	2	NA	0

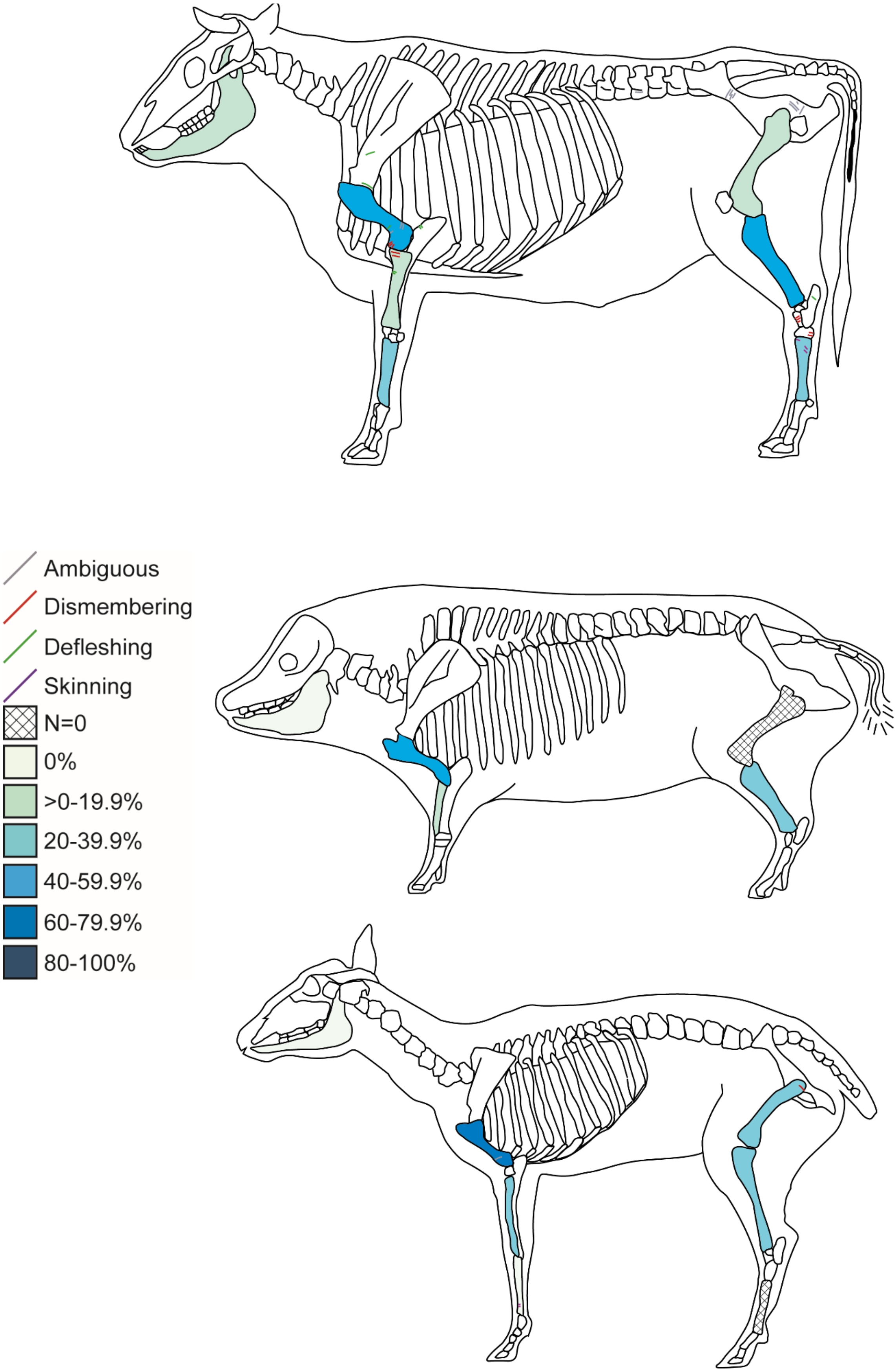

Figure 7.26: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprine (bottom) from Apc-Berekalja I. Values in table 7.4.

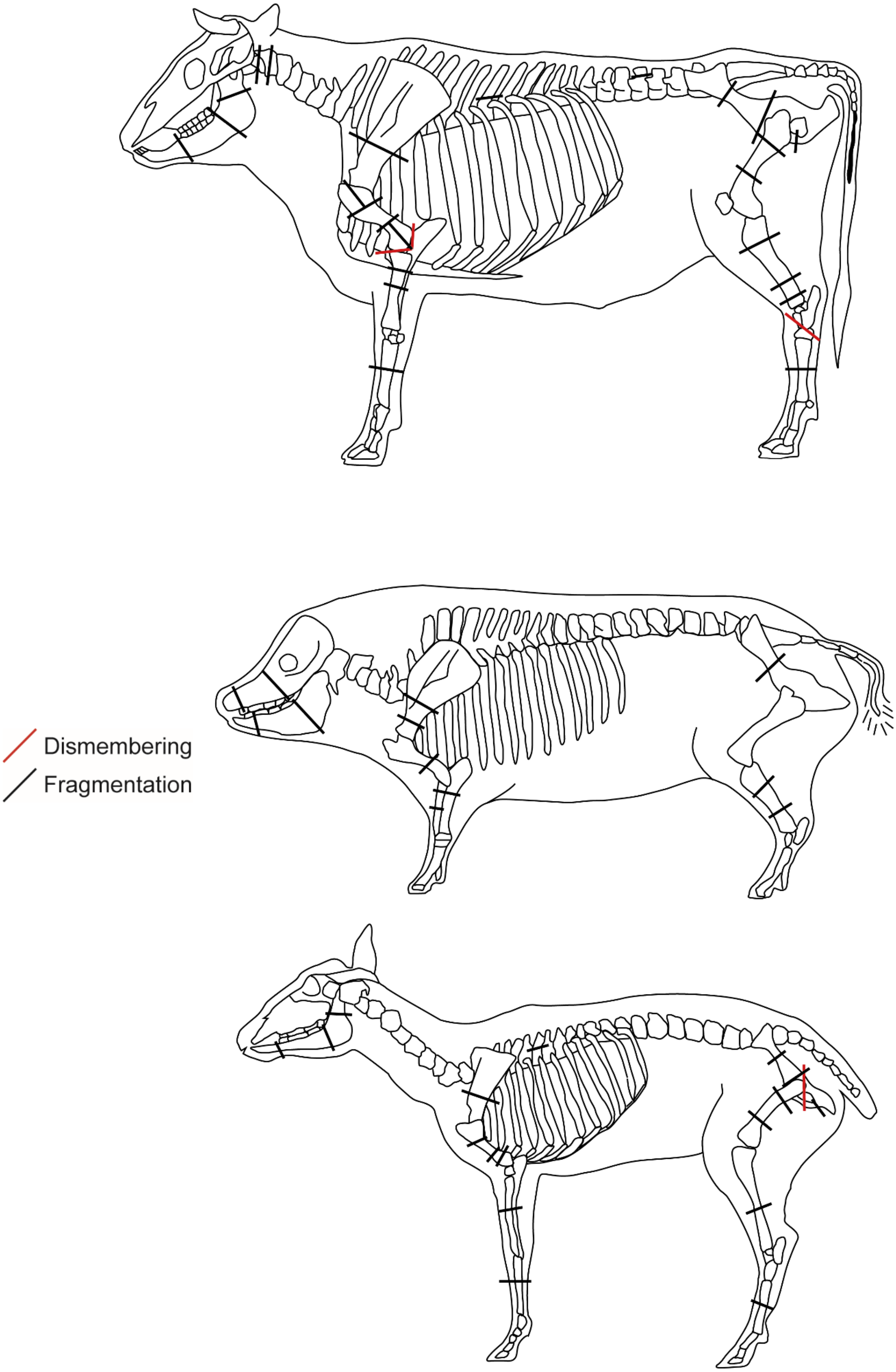

Figure 7.27:: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Apc-Berekalja I.

Chapter 8 Těšetice-Kyjovice “Sutny”

8.1 Introduction

The village of Těšetice is situated in Southern Moravia in the Czech Republic, at the point at which the Bohemian Massif meets the wider Carpathian area, forming a sand gravel subsoil to the loess (Whittle *et al.* 2013b: 127; Mateiciucová 2008: 238). First discovered as part of a rescue excavation in 1956, systematic research on the site is ongoing under the direction of the Institute of Archaeology and Museology of the Faculty of Arts, Masaryk University in Brno (Uhlířová and Dreslerová unpub. 1). The excavation site is polycultural, with the predominant settlement dated to the Neolithic and sporadic settlements in the Eneolithic, Early and Late Bronze Age (*ibid.*). The area of the LBK settlement consists of 13 longhouses and their accompanying pits and several graves, situated on a gentle hillside sloping to the south east, on the left bank of the Unanovka stream (figure 8.1; Mateiciucová 2008: 238; Whittle *et al.* 2013b: 127; Dočkalová, and Čižmář 2008).

8.2 Assemblage

8.2.1 Sample

The vast majority of the LBK assemblage from Těšetice-Kyjovice “Sutny” (henceforth referred to as Těšetice-Kyjovice) was studied, excluding two small contexts that could not be completed due to time constraints. These were surveyed qualitatively and judged to be similar to the rest of the assemblage. In total, 5252 specimens were studied (see table 8.1). Any difference in values for fully identifiable specimens (table 8.1) and species representation (figure 8.2) is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 8.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Těšetice-Kyjovice “Sutny” (TES).

Fully identifiable (to species and element)	634
Partially identifiable (to species and element type)	903
Indeterminate	3715
Total	**5252**

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Figure 8.1: Site plan of Těšetice-Kyjovice highlighting LBK households (Ivana Vostrovská pers. comm.; Dočkalová and Čižmář 2008: 41).

Six house contexts were analysed in full, forming parallel house rows. One row included H20, H22 and H24 and the other H26, H27 and H28 running parallel directly to the south (figure 8.1). The majority of houses date simply to the LBK, but House 28 is dated as early-middle LBK, House 20 to the middle LBK. In addition to these 6 houses, clay pit 556 and a combined group of the remaining settlement pits were analysed (table 8.2 and 8.3).

Table 8.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens from context groupings from Těšetice-Kyjovice

	Contexts	Phase	FID	PID	IND
House 20	464	Middle LBK	76	114	490
House 22	458, 735, 736, 742, 749	Middle LBK, LBK	33	63	202
House 24	640, 713	LBK	28	56	460
House 26	389, 407, 412	Middle LBK, LBK	32	45	255
House 27	591, 593, 594, 595, 596, 605	Middle LBK, LBK	209	297	1090
House 28	597	Early-middle LBK	86	165	422
Clay pit 556	556	LBK	75	59	262
Pits (no clay pits)	63, 230, 329, 336 ,340, 398, 415, 511, 514, 516, 519, 526, 536, 555, 564, 589, 649, 650, 1644, 1651, 1652, 1657	LBK Middle LBK (650)	64	91	338

Table 8.3: Full list of contexts analysed from Těšetice-Kyjovice.

Context	Phase	Context Type	House	FID	PID	IND
63	LBK	Circular settlement pit		3	1	2
230	LBK	Irregular settlement pit		10	19	37
295	LBK	Irregular settlement pit	15	0	1	1
309	LBK	Oval settlement pit	18	3	1	14
314	LBK	Circular settlement pit	18	2	0	9
329	LBK	Oval settlement pit		2	7	1
336	LBK	Oval settlement pit		0	1	0
340	LBK	Oval settlement pit	18? x 14 x 29	1	5	45
389	Middle LBK	Irregular clay pit	26	31	41	236
398	LBK	Oval settlement pit		1	0	2
407	LBK	Rectangular settlement pit	26	0	2	6
412	LBK	Rectangular settlement pit	26	1	2	13
415	LBK	Oval settlement pit		0	10	61
458	Middle LBK	Irregular building pit	22	21	42	115
464	Middle LBK	Oval building pit with kiln(?)	20	76	114	490
511	LBK	Oval settlement pit		0	1	3
514	LBK	Oval settlement pit		5	1	65
516	LBK	Circular settlement pit		1	1	0

519	LBK	Oval settlement pit		8	4	2
526	LBK	Oval settlement pit		0	1	14
536	LBK	Oval settlement pit		5	7	47
555	LBK	Irregular settlement pit		8	11	36
556	LBK	Irregular clay pit		75	59	262
557	LBK	Irregular settlement pit		0	0	2
564	LBK	Oval settlement pit		6	3	7
589	LBK	Oval settlement pit		8	8	76
591	LBK	Irregular building pit	27	37	94	416
592	LBK	Irregular clay pit	27?	13	3	0
593	Middle LBK	Oval settlement pit	27	47	36	90
594	LBK	Irregular settlement pit	27	8	8	31
595	LBK	Circular settlement pit	27	2	3	0
596	Middle LBK	Irregular building pit	27	109	154	540
597	Early-middle LBK	Irregular building pit	28	86	165	422
605	LBK	Irregular settlement pit	27	6	2	13
640	LBK	Irregular settlement pit	24	0	0	2
649	LBK	Irregular settlement pit		0	1	0
650	Middle LBK	Circular settlement pit		1	0	3
713	LBK	Irregular building pit with neonate burial	24	28	56	458
735	LBK	Irregular settlement pit	22	0	1	18
736	Middle LBK	Irregular settlement pit	22	7	5	8
742	LBK	Irregular settlement pit	22	0	6	17
749	Middle LBK	Irregular settlement pit	22	5	9	44
1609	LBK	Oval settlement pit		0	0	15
1644	LBK	Circular settlement pit		10	9	19
1651	LBK	Oval settlement pit		1	7	11
1652	LBK	Oval settlement pit		4	1	4
1657	LBK	Irregular settlement pit		3	1	58

8.3 Species representation

8.3.1 Site

Domestic cattle, caprines and pigs made up 89.7% (551/614) of the number of identifiable specimens (NISP) from Těšetice-Kyjovice (figure 8.2). Cattle were the most dominant species at 39.6% (243/614), with caprines (both sheep and goat) following at 30.0% (184/614) and pigs at 20.2% (124/614). Domestic dogs were also very occasionally identified, comprising less than 1% (2/614) of the number of identifiable specimens and only noted in one house and one settlement pit.

Wild species represented 9.9% (61/614) of the number of identifiable specimens. Of the wild fauna aurochs were the most common, followed by red deer, roe deer, and wild boar. Other wild species of small mammal (rat, hare) and bird were also identified in small numbers. Small mammal bones were in fact particularly common at Těšetice-Kyjovice compared to other sites, and likely reflect the good preservation and careful excavation of the faunal assemblage. They could, however, also point to intrusive behaviour by burrowing rodents.

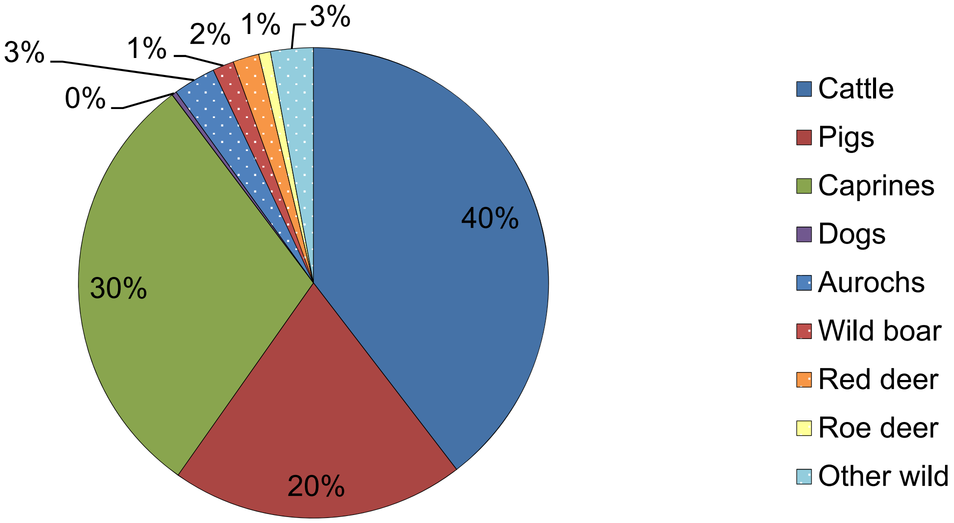

Figure 8.2: Species representation (NISP) for the fully identifiable assemblage from Těšetice-Kyjovice (n=614).

8.3.1.1 Phase

Whilst the phases overlap at Těšetice-Kyjovice it is possible to suggest a shift in animal exploitation over time. The early-middle LBK phase, represented solely by material from house 28, had a focus on caprines replaced in the middle LBK by a dominance of cattle and pigs (figure 8.3). There was a significantly lower proportion of caprines in the middle LBK (82/282) compared to the early-middle LBK (44/86, p<.001), although the differences in proportions of cattle and pigs were not significant.

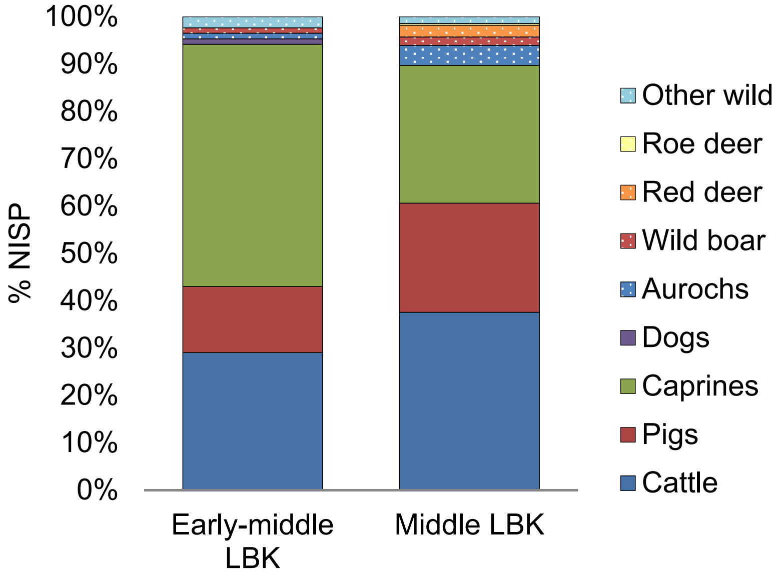

Figure 8.3: Species representation (NISP) for the Early-middle (n=86) and Middle (n=282) LBK phases from Těšetice-Kyjovice.

8.3.1.2 Context groups

The comparable context groups did not show a commonly followed pattern of subsistence in any context type (figure 8.4). House 28 as described above is an early-middle LBK dated context showing high proportions of caprines. House 20, the sole house securely dated to the middle LBK, also shows a high number of caprines, although the other houses with middle LBK material (22, 26 and 27) show much higher proportions of cattle and pigs. Wild animals were relatively well represented in house 20, particularly including aurochs, rodent (likely *Rattus* sp.) and avian bones. In general, however, wild species were uncommon in house contexts.

Clay pit 556 had one of the highest cattle percentages of all the comparable contexts at just under 60% (41/69), representing two individuals. This clay pit also had the smallest proportion of pigs compared to the house contexts. In the combined settlement pits, cattle, pigs and caprines were relatively equally represented. One bone of domestic dog was identified, and wild animals were slightly better represented than clay pit 556 and most other house pits.

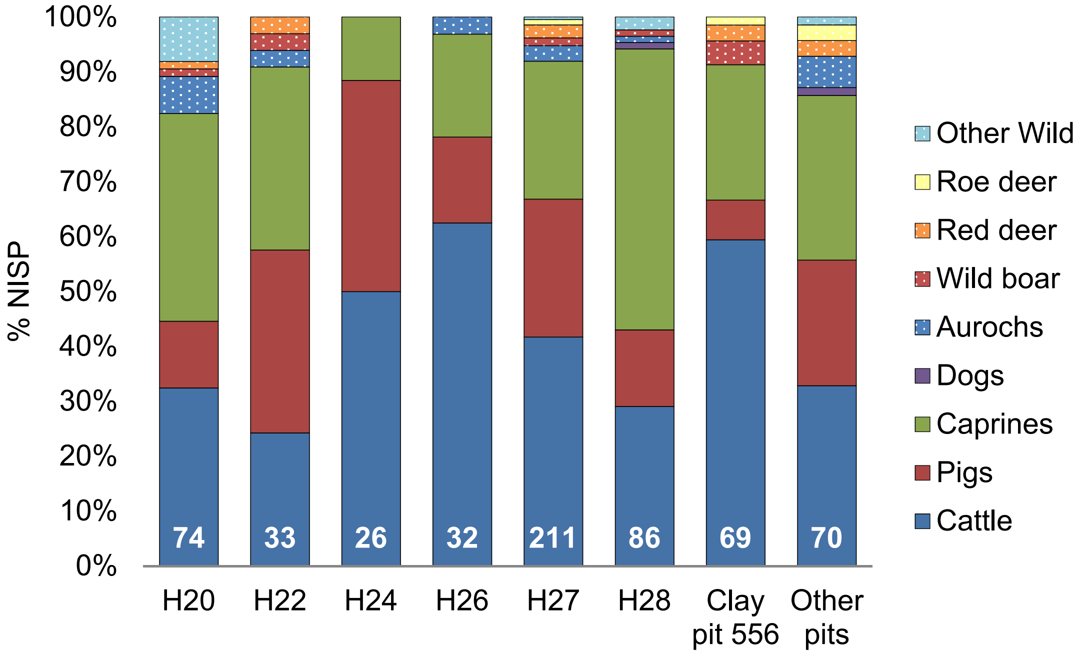

Figure 8.4: Species representation (NISP) for house and pit contexts from Těšetice-Kyjovice. N values are at the base of each bar.

8.4 Butchery

8.4.1 Site

Butchery marks were uncommon at Těšetice-Kyjovice, which was unexpected on such well-preserved bones. 0.6% (33/5252) of the assemblage showed evidence of butchery marks, affecting 1.6% (24/1537) of the identifiable assemblage. Cut marks were the most common form of butchery marks on identifiable specimens, followed by chop and scratch marks (figure 8.5).

'Slice' marks were also present at Těšetice-Kyjovice. First identified during analysis of Ludwinowo 7, these marks were originally thought to represent a butchery technique common to filleting with a cleaver, where a cleaver is run at an acute angle parallel to the bone surface resulting in the removal of a long flake of bone (figure 8.6). Analysis of Těšetice-Kyjovice suggests that this bone modification was more likely a result of fresh fracture. Slicing was only found on marrow-bearing bones, all of which were fractured (84.6% freshly, 11/13). Based on patterns from Outram's (1998) fracture experiments it is possible that this feature of fracture is characteristic of bones boiled before fracture, although more experimental work is needed to confirm this. If this is the case, the presence of slice marks at Těšetice-Kyjovice and Ludwinowo 7 could suggest similar cooking practices.

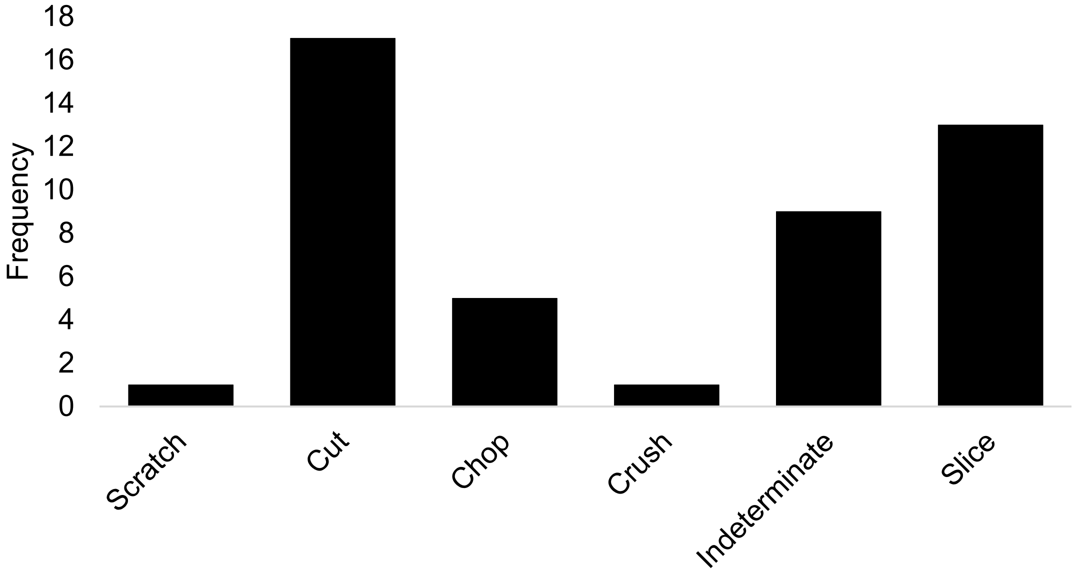

Figure 8.5: Frequency of butchery mark types from Těšetice-Kyjovice.

Figure 8.6: An example of 'slicing', right, found on a bone fragment at Těšetice-Kyjovice.

8.4.1.1 Context groups butchery

House 20 (10/680) and clay pit 556 (5/396) showed elevated proportions of butchery compared to the other house and pit contexts, although only the differences between houses 24 (1/542; p=.018 and p=.041 respectively) and 27 (5/1612; p=.002 and p=.016) were significant. All proportions of butchery per context groups remained very low.

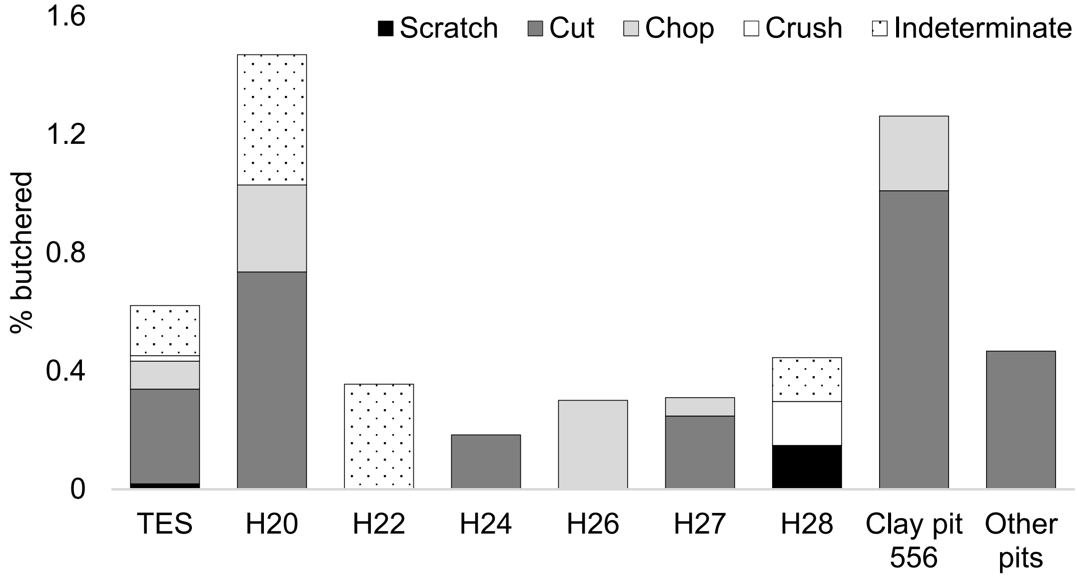

Figure 8.7: Percentage of specimens with different butchery episodes selected contexts from Těšetice-Kyjovice.

8.4.2 Species and carcass butchery

Cattle (4.9%, 12/243) were the species most affected by butchery, significantly more than pigs (1/124, p=.043) and caprines (1/184, p=.009). In terms of carcass butchery, the majority of butchery marks were recorded on the bones of the hindlimb and on indeterminate shaft fragments, however, the butchery diagrams showed little data of significance as recordable butchery was rare, discussed in section 8.10.

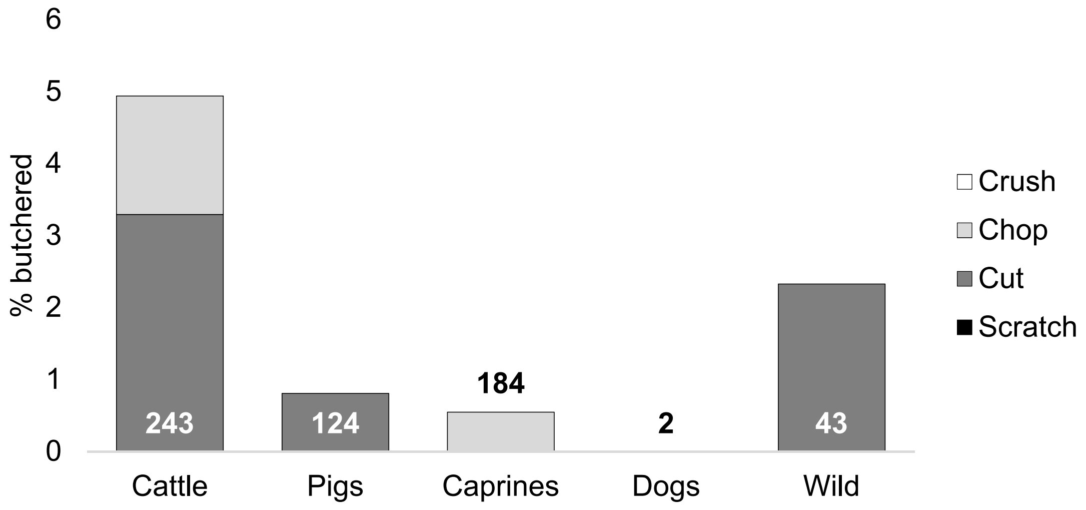

Figure 8.8: Percentage of bones of different species affected by different butchery episodes from Těšetice-Kyjovice.

8.5 Heat exposure

8.5.1 Site

Evidence of heat exposure was rare at Těšetice-Kyjovice on 3.1% (165/5252) of the whole assemblage and 5.1% (79/1537) of identifiable bones (figure 8.9). Roasting was clearly the most commonly identified form of burning, included in many cases scorched and blackened portions of the bone (figure 8.9), although burnt bones were often indeterminate. Variation between contexts made difficult to interpret due to small sample sizes.

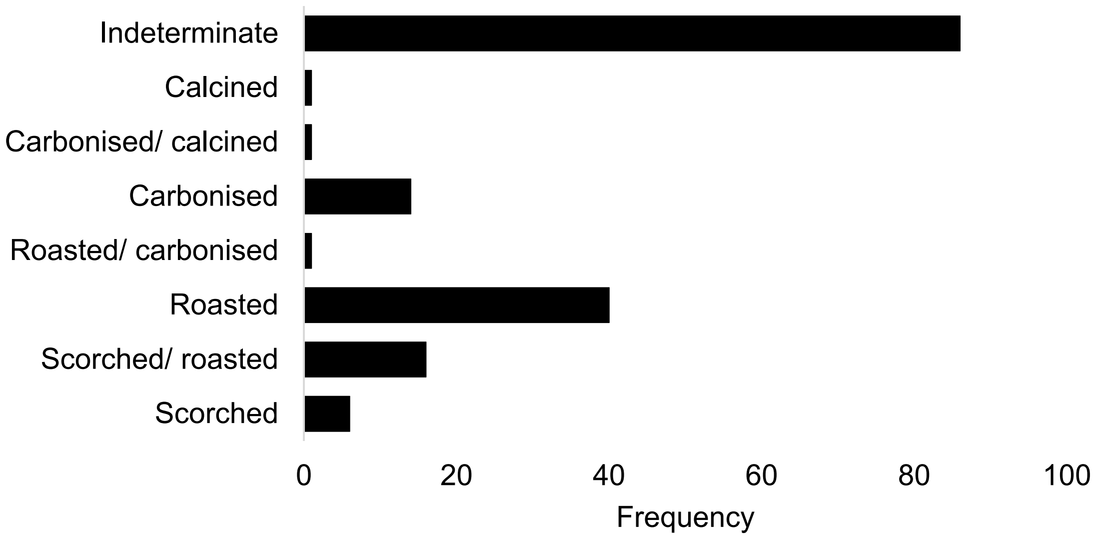

Figure 8.9: Frequency of heat exposure types from Těšetice-Kyjovice.

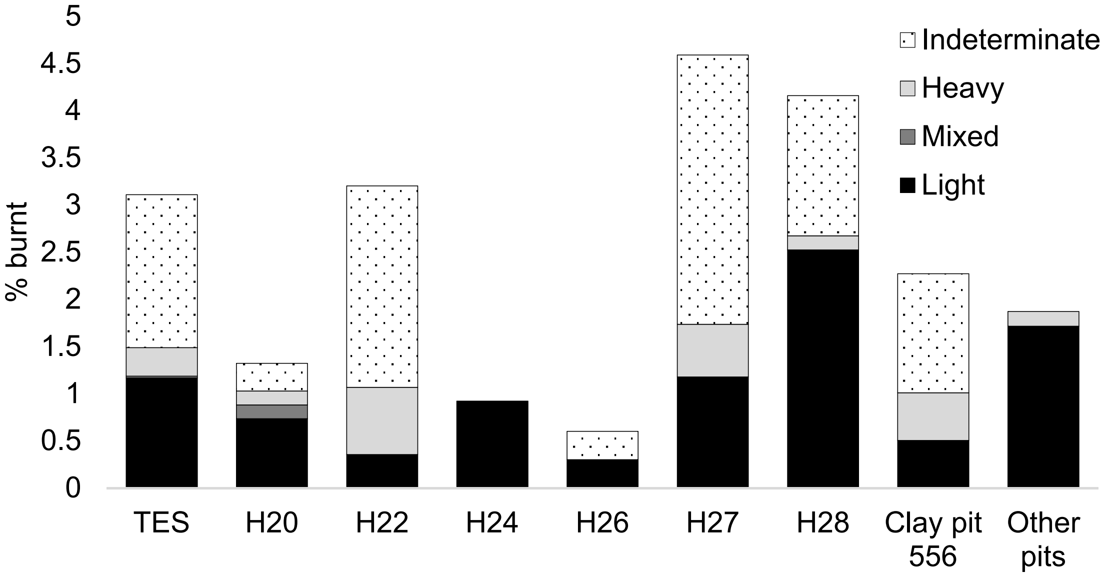

Figure 8.10: Percentage of specimens showing evidence of different intensities of heat exposure from selected contexts from Těšetice-Kyjovice.

8.5.2 Species

There was little variation in the proportion of bones from different species that were exposed to heat. Cattle, pigs, caprines and combined wild fauna (aurochs, wild boar, red and roe deer) showed similar levels of burning, primarily roasting (figure 8.11). Domestic dogs showed no evidence of burning, although the sample size was very small (n=2).

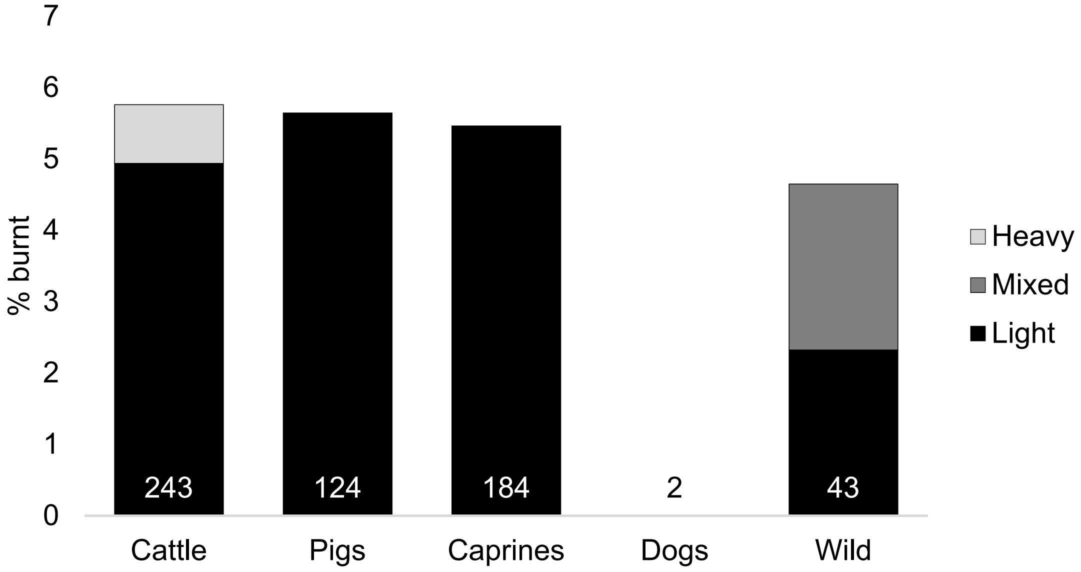

Figure 8.11: Percentage of bones of different species affected by different intensities of heat exposure from Těšetice-Kyjovice.

8.6 Fracture

8.6.1 Site

The fracture freshness analysis from the whole assemblage at Těšetice-Kyjovice implies relatively high levels of marrow processing, with 53.0% (503/949) of fractured bones first fractured when fresh, and a mean Fracture Freshness Index score of 3.1 (figures 8.12 and 8.13). The high- and low-yield fracture analysis in figure 8.12 suggests that high-yield bones were being targeted for fracture when fresh, highlighting the importance of marrow acquisition. Subsequent fracture on fresh bones was low and mostly dry in nature. The distribution of FFI scores indicate that bone was fractured when fresh *or* dry, rather than with mixed characteristics caused by drying or secondarily fractured bone (figure 8.13). Coupled with a low level of mineralised fracture overall this suggests that disturbance of the bones was unusual.

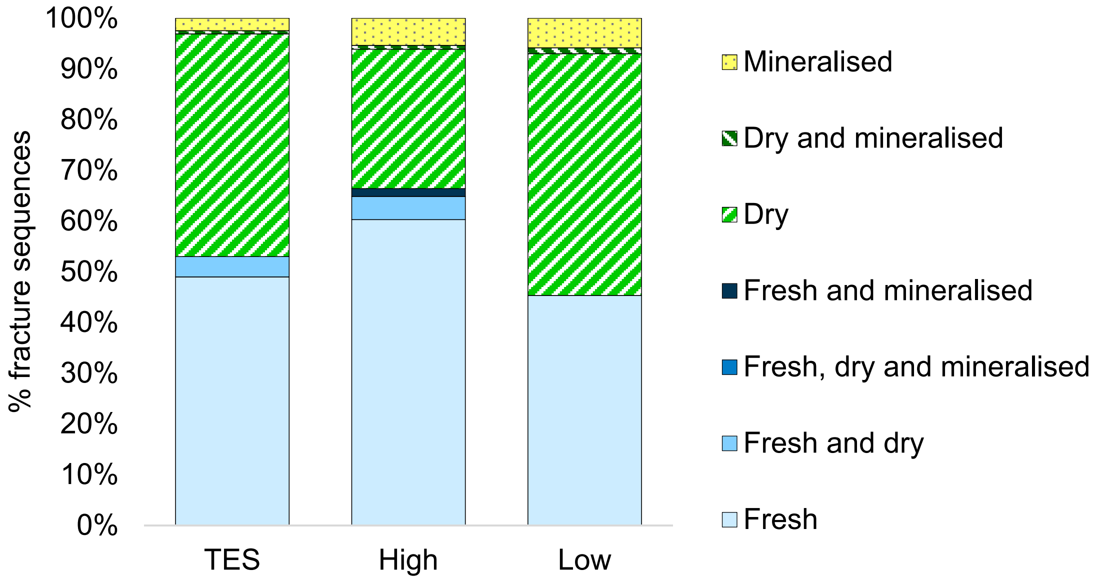

Figure 8.12: Fracture history profiles for Těšetice-Kyjovice (n=949) and for high- and low-yield marrow bones (n=131/86).

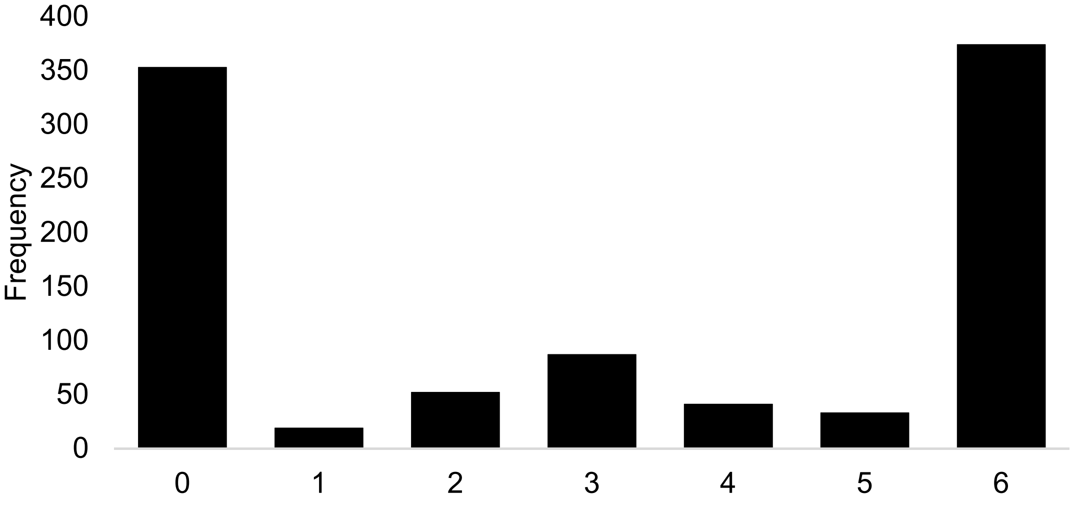

Figure 8.13: Frequency of Fracture Freshness Index scores from Těšetice-Kyjovice.

8.6.1.1 Phase

Analysis of fracture proportions between the early-middle and middle LBK indicates an increase in marrow exploitation over time. There was a significant increase in the proportion of fresh first fracture from the early-middle LBK phase (39.6%, 63/159) to the middle phase (59.9%, 255/426, p<.001; figure 8.14), although this early phase is represented by a single context. While this almost certainly is related to the increase in marrow-rich species like cattle and pigs over time, this could also relate to the types of contexts present in each phase, analysed below.

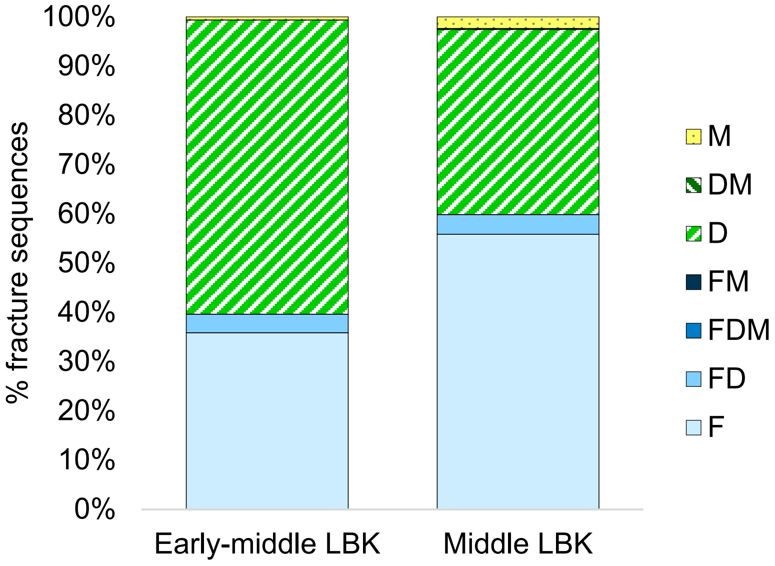

Figure 8.14: Fracture history profiles for the early-middle (n=159) and middle (n=426) LBK phases from Těšetice-Kyjovice.

8.6.1.2 Context groups

The fracture freshness analysis of the comparable contexts yielded some interesting results. Between the house rows there were differences in the amount of fracture when fresh. The house row containing houses 26, 27 and 28 showed a higher mean FFI score and significantly lower proportion of fresh fracture (46.8%, 244/521, FFI 3.4) than the house row containing houses 20, 22 and 24 (63.6%, 175/275, p<.001, FFI 2.3; figure 8.15 and 8.16). House 28, the oldest context analysed, was the context with the highest percentage of dry fracture. As postulated above, this could potentially indicate an increase in marrow processing intensity over time in domestic contexts. The differences between house rows were not so marked in the fractures on high- and low-yield marrow bones, where both rows showed a preference to high-yield bones (figure 8.17).

The isolated clay pit 556 was one of the driest comparable contexts, with an FFI score of 3.6. Together, isolated pit contexts had a significantly lower proportion of fresh fracture (49.7%, 86/173) than the freshest house row (20, 22, 24; p<.001), and a significantly higher proportion mineralised fracture (15/173) than the combined house contexts (20/778, p<.001). Despite this, these contexts still indicate marrow exploitation, and present similar differences in high- and low-yield marrow bone exploitation as in the house pits. This pattern could suggest that material in these pits was redeposited from temporary middens, or was more susceptible to post-depositional disturbance than house pits.

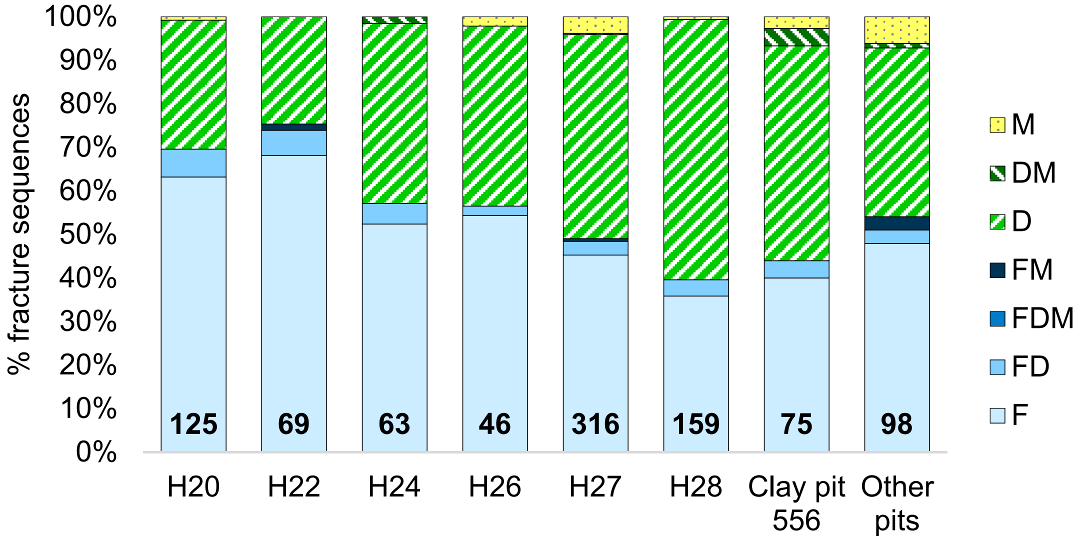

Figure 8.15: Fracture history profiles for contexts from Těšetice-Kyjovice.

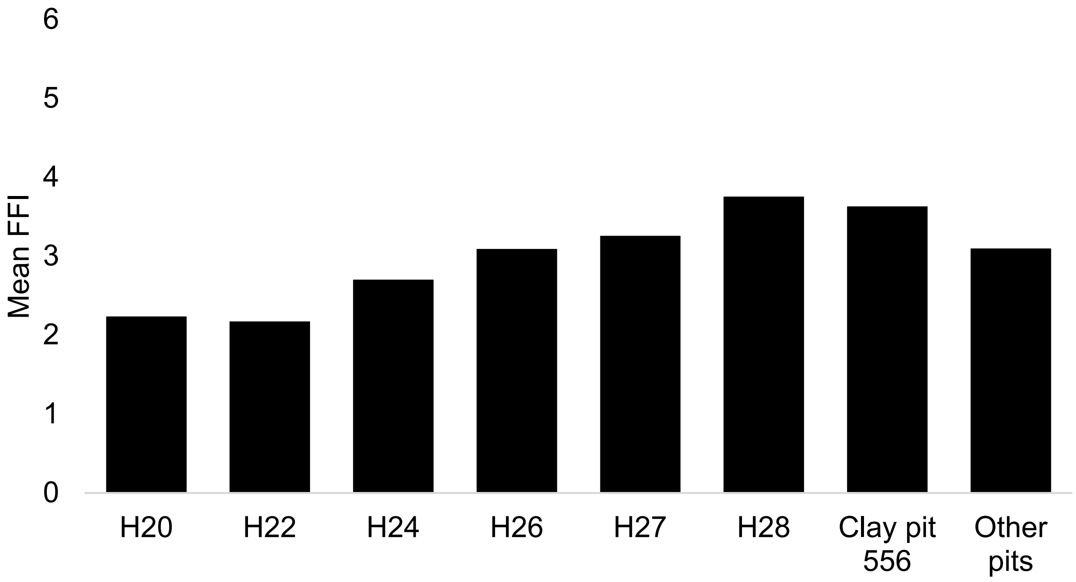

Figure 8.16: **Mean Fracture Freshness Index scores for selected contexts from Těšetice-Kyjovice.**

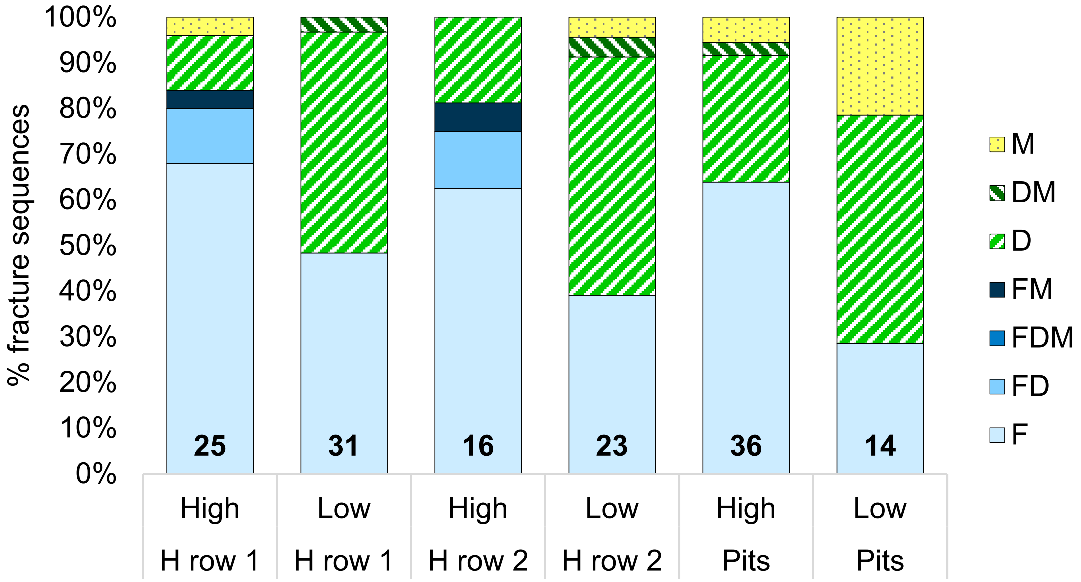

Figure 8.17: Fracture history profiles for high- and low-yield marrow bones from house row 1 (H20, H22, H24), row 2 (H26, H27, H28) and settlement pits from Těšetice-Kyjovice.

8.6.2 Species

The fracture freshness analysis of species identified on the site showed that all three main food domesticates and wild animals were often fractured freshly (figure 8.18). Pig and caprine high-yield bones were more often preferentially targeted than low-yield bones, with a much greater difference in fresh fracture proportions than in cattle high- and low-yield elements (8.20). This could imply that when marrow was sought from cattle all marrow bearing bones were broken regardless of their yield, whereas bones with the highest marrow content were targeted from smaller species.

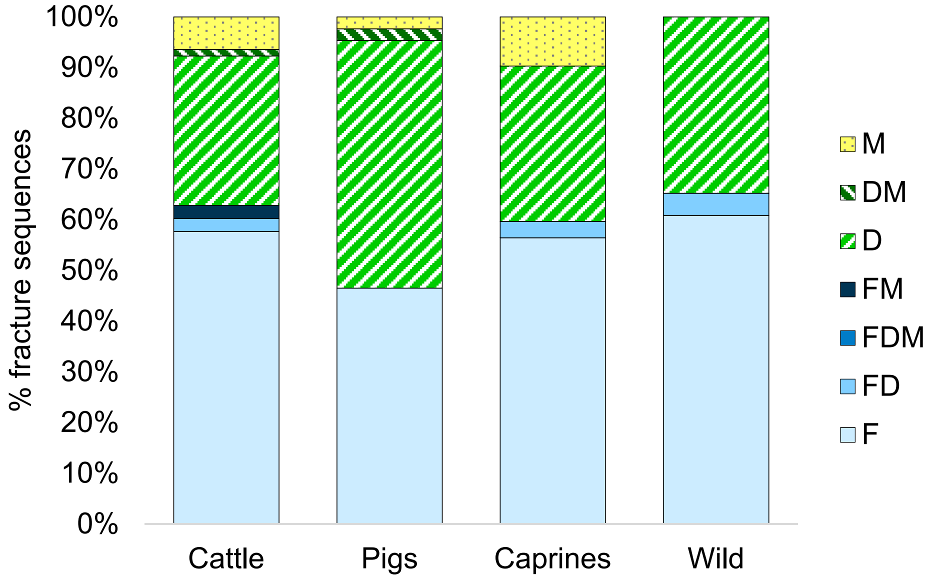

Figure 8.18: Fracture history profile for cattle (n=78), pigs (n=43), caprines (n=62), dogs (n=0) and the major wild animals (n=23) from Těšetice-Kyjovice.

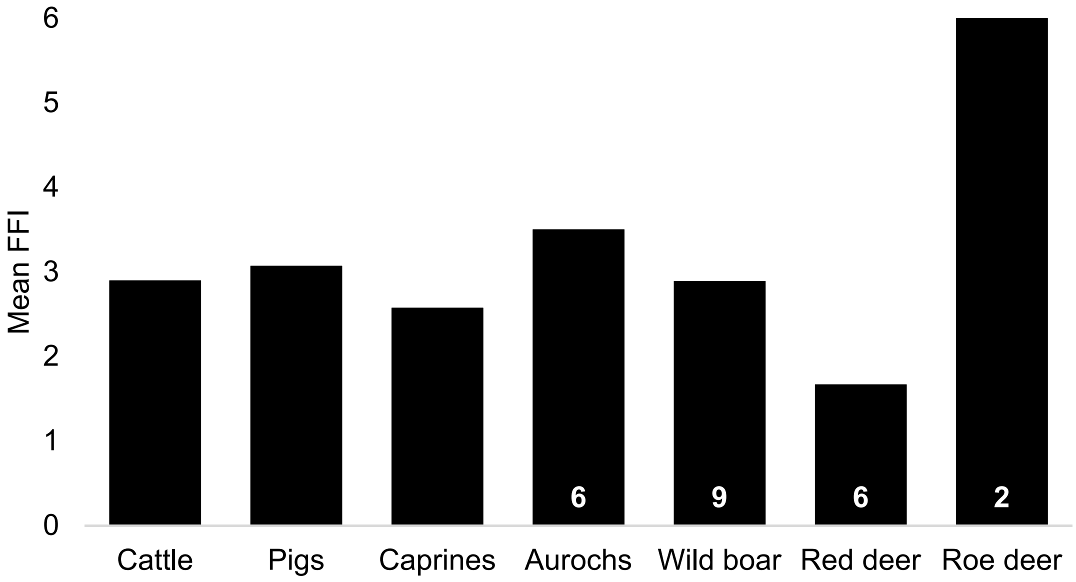

Figure 8.19: Mean Fracture Freshness Index scores for different species from Těšetice-Kyjovice.

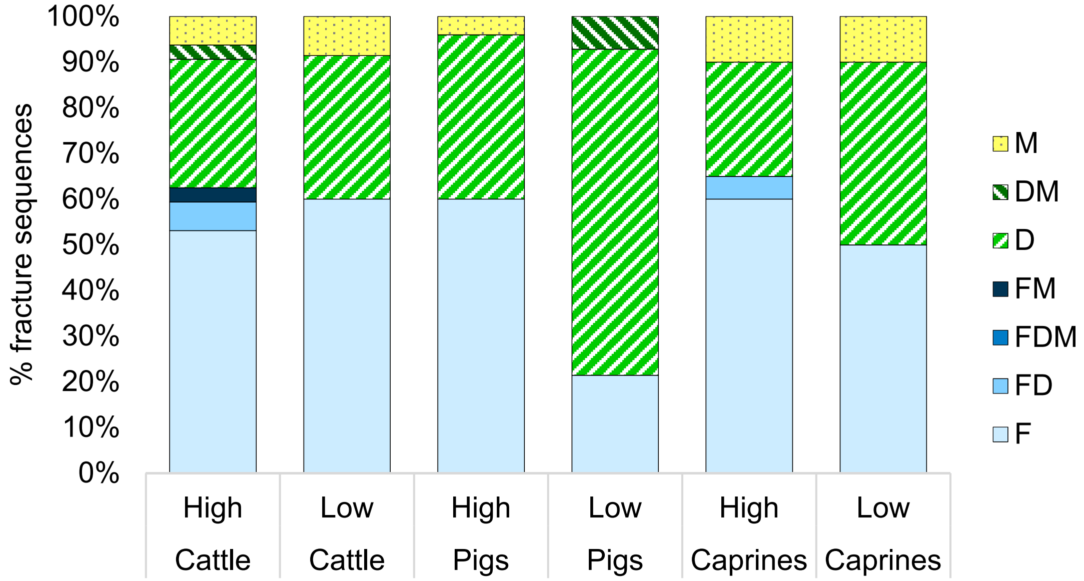

Figure 8.20: Fracture history profiles for high- and low-yield marrow bones of cattle (n=32/35), pigs (n=25/14) and caprines (n=40/20) from Těšetice-Kyjovice.

8.6.3 Fracture summary

Correspondence analysis of the species representation and percentage of each first fracture type in the comparable context groups suggests similar assemblages and deposition practices as they cluster closely (figure 8.21). The two house rows separate slightly from each other, with house row 1 drawn towards fresh fracture. Clay pit 556 associates more strongly with mineralised and dry fracture than the other context groups, whereas material from all other pit contexts clusters within the house contexts. This could suggest that material from the isolated pits came from many different house contexts within Těšetice-Kyjovice, but that material from the isolated clay pit 556 was perhaps not so related to domestic activity.

Fresh fracture was associated with all species, but was most closely associated with the proportions of pigs in each context. Cattle surprisingly cluster with dry and mineralised fracture most closely. This could indicate that contexts with higher percentages of pigs were more intensively processing marrow of all species than contexts with high proportions of cattle. As pigs are solely meat producers as opposed to cattle and caprines this trend could indicate marrow exploitation based on the availability of dairy fat.

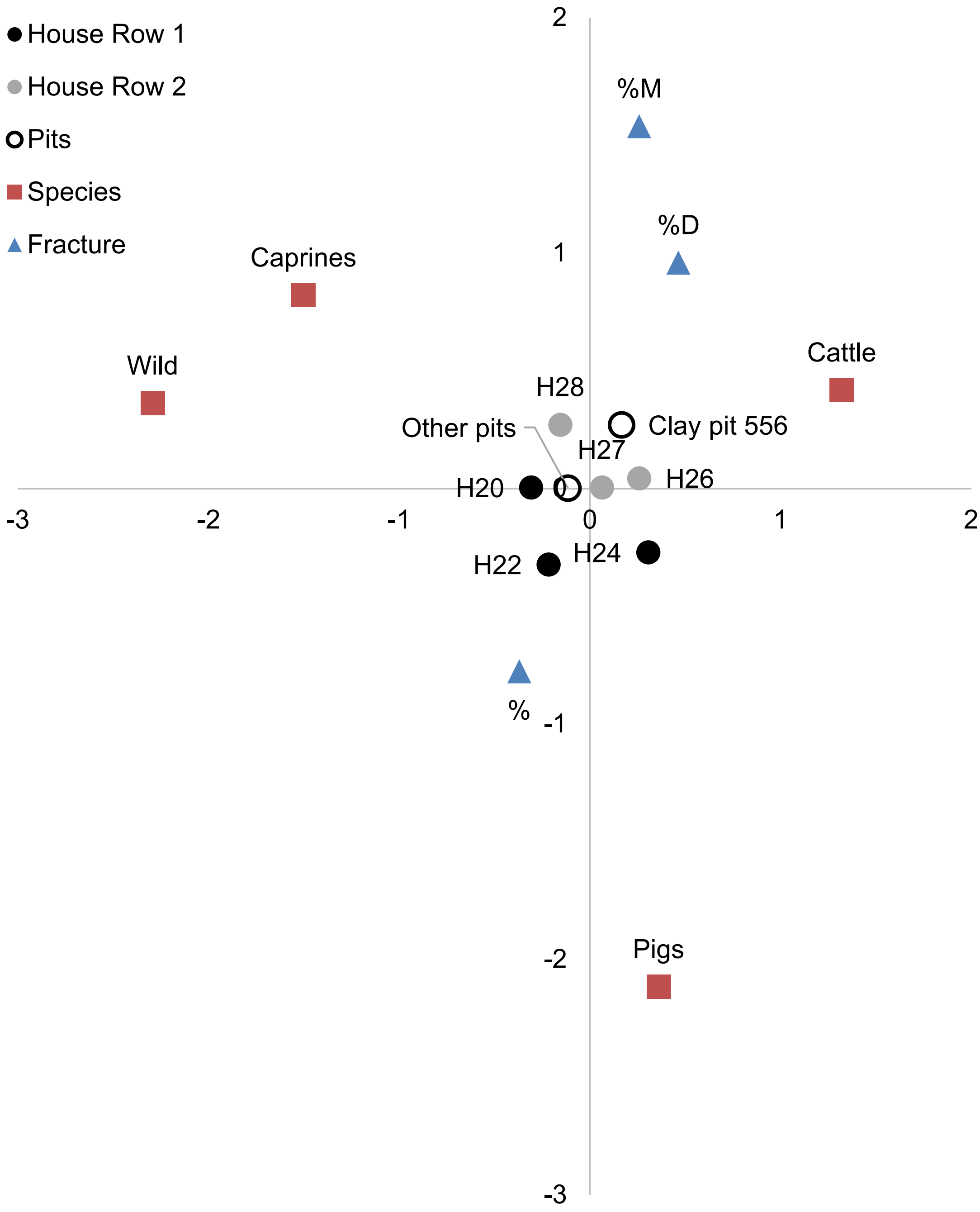

Figure 8.21: Correspondence analysis of the proportion of cattle, pigs, caprines and wild animals (NISP) and the proportion of first fractures that were fresh (F), dry (D) or mineralised (M) from the comparable context groupings from Těšetice-Kyjovice.

8.7 Fragmentation

The levels of fragmentation at Těšetice-Kyjovice were low, although there was the possibility for isolated bone grease processing. The weight of bones found in the smallest size classes (<30mm, figure 8.23) was not consistent with a signature for intensive bone grease exploitation. However, this is not to say that grease processing was not taking place at all, as some cancellous material was fairly comminuted (20-30mm size class; figure 8.24). Context 536, an LBK oval settlement pit that was not associated to a house, had several pieces of broken cancellous articular material noted in the indeterminate fragments (figure 8.22). In addition, all epiphyseal or vertebral cancellous material identified in this context was fragmented. This could be representative of localised bone grease production.

Figure 8.22: Potential evidence of localised bone grease production from context 536 from Těšetice-Kyjovice.

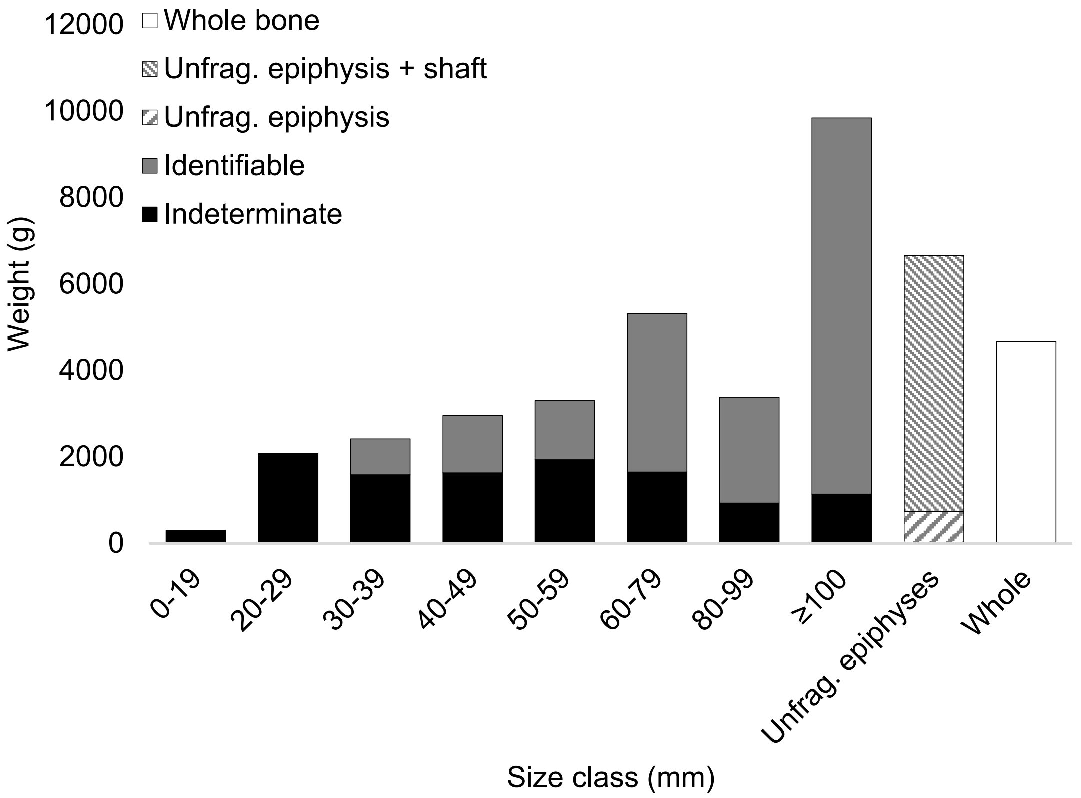

Figure 8.23: Weight by size class of all specimens from Těšetice-Kyjovice.

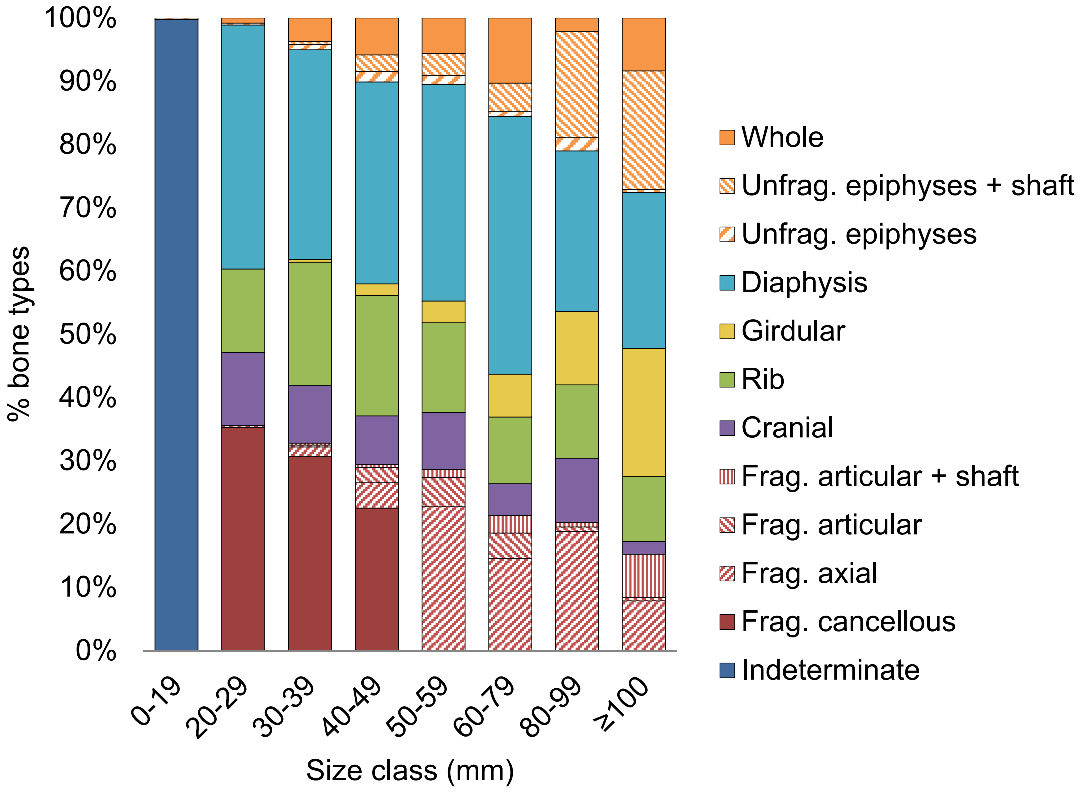

Figure 8.24: Bone type frequency by size class from Těšetice-Kyjovice. Red series indicated fragmented cancellous bone.

8.8 Taphonomy

8.8.1 Gnawing

Gnawing was present on 1.2% (61/5252) of the assemblage and was primarily carnivore gnawing (figure 8.25). The context in which gnawing was most common was in house 22, where gnawing was identified on 2.8% (8/281) of specimens in the assemblage. From this it can be suggested that carnivores were not permitted easy access to animal bones. It is likely that dogs on the site did not roam freely and/or that deposition pits were covered promptly.

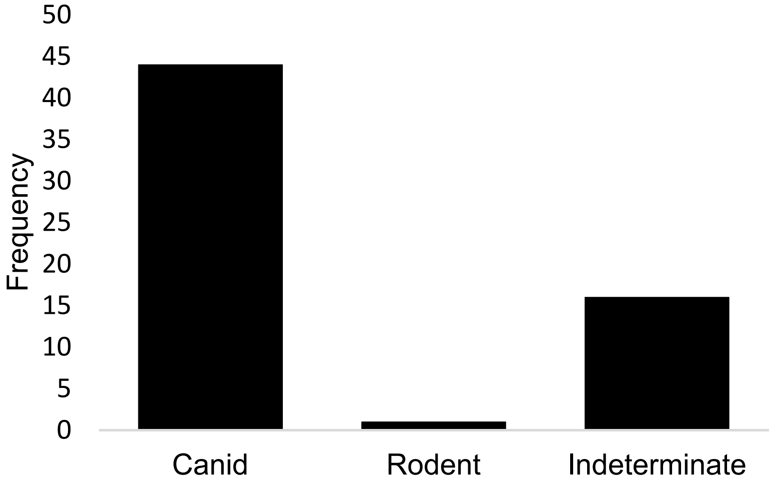

Figure 8.25: Frequency of different gnawing types from Těšetice-Kyjovice.

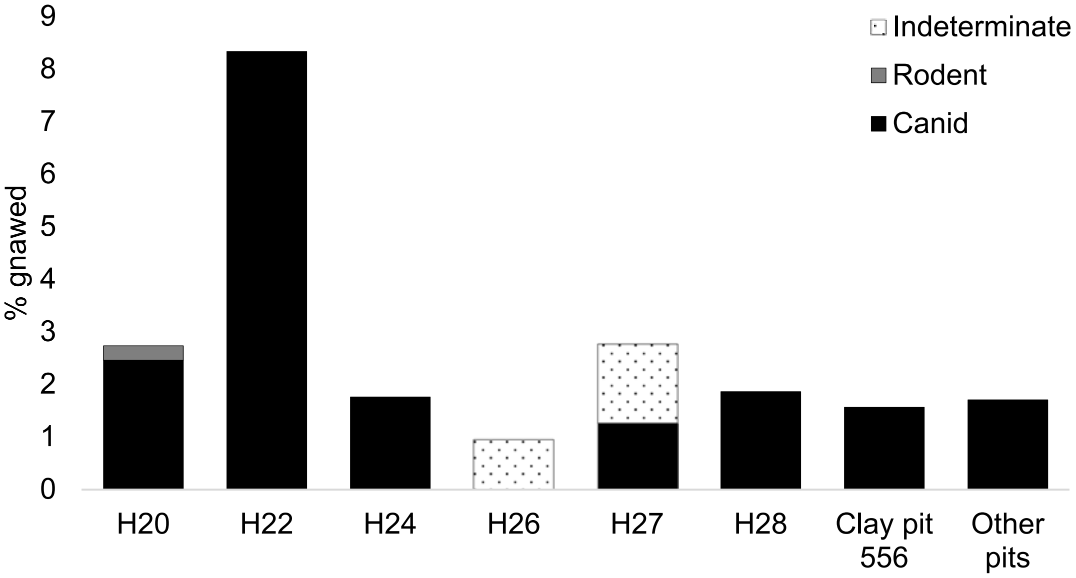

Figure 8.26: Percentage of specimens in house and pit contexts affected by gnawing from Těšetice-Kyjovice.

8.8.2 Taphonomic agents

Root etching, weathering and cemented mud were noted, but in generally small percentages (2%, 0.2% and 4.9% of the identifiable assemblage respectively, n=1537). Cemented mud can cause issues in identifying butchery and fracture types by obscuring bone surfaces.

8.8.3 Recent breaks

The assemblage was very well preserved, although post-excavation breaks were common, recorded on 19.2% (295/1537) of identifiable specimens. Many specimens refitted to other bone fragments and did not cause intensive fragmentation of the smaller size classes. Houses 20 and 22 had notably lower rates of recent breakage at 7.4% (14/190) and 7.3% (7/96) of the identifiable assemblage respectively.

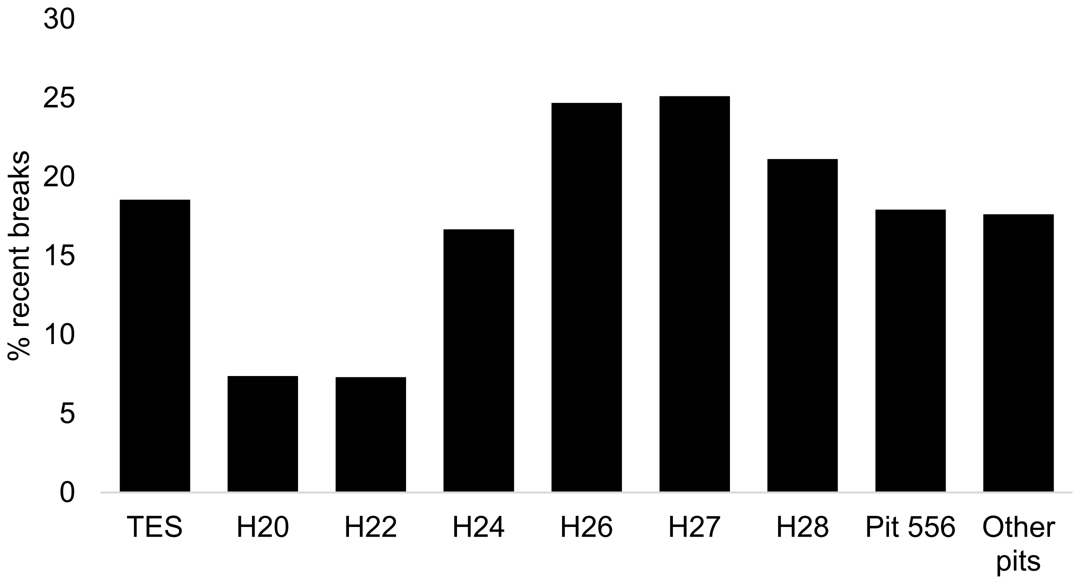

Figure 8.27: Percentage of the identifiable assemblage affected by recent breaks from Těšetice-Kyjovice and the selected contexts.

8.9 Food exploitation strategies

8.9.1 Herd structure analysis

8.9.1.1 Cattle

Cattle fusion ageing (figure 8.28) suggests some young slaughter before one year, but the main slaughter event was between 1.5 and 3 years, with no further kill-off before fusion maturity. The slaughter of animals under one year could represent slaughter of young males, followed by a kill-off at optimum meat weight, with older animals being kept on for milk production. However, the pattern does not suggest intensive management of the cattle herd for dairy production.

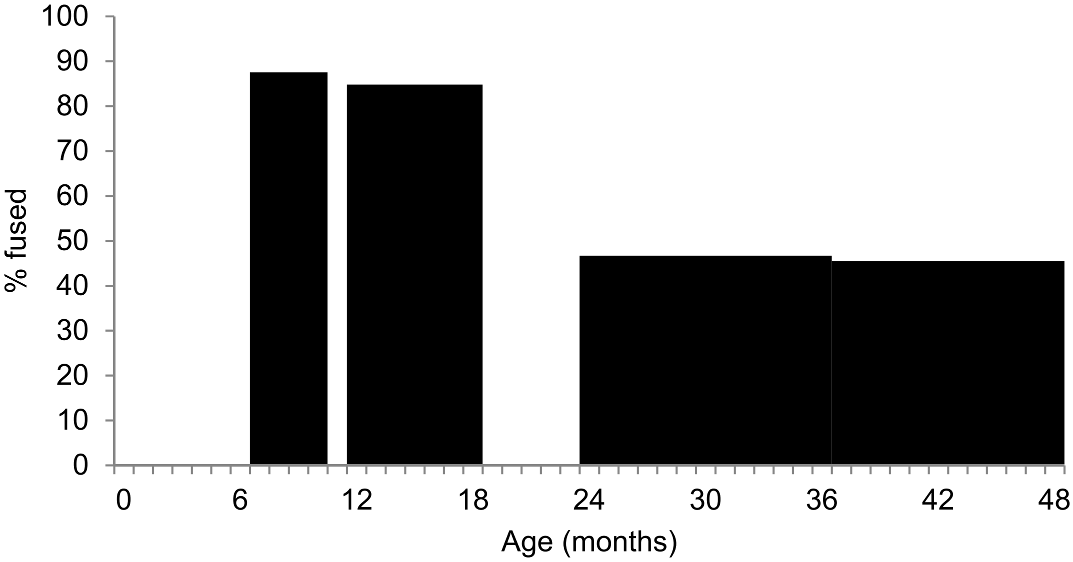

Figure 8.28: Cattle slaughter profile based on epiphyseal fusion from Těšetice-Kyjovice (n= 125).

8.9.1.2 Caprines

Caprine slaughter profiles suggest continuous small scale slaughter of juvenile animals until 2.5 years, when survival dropped to 44.4% (12/27; figure 8.29). Young slaughter could be to increase milk yields for humans or as post-lactation slaughter. Slaughter at 2.5-3.5 years may have targeted prime-meat weight animals. The primary herd structure in evidence is one focussed on tender and full size meat.

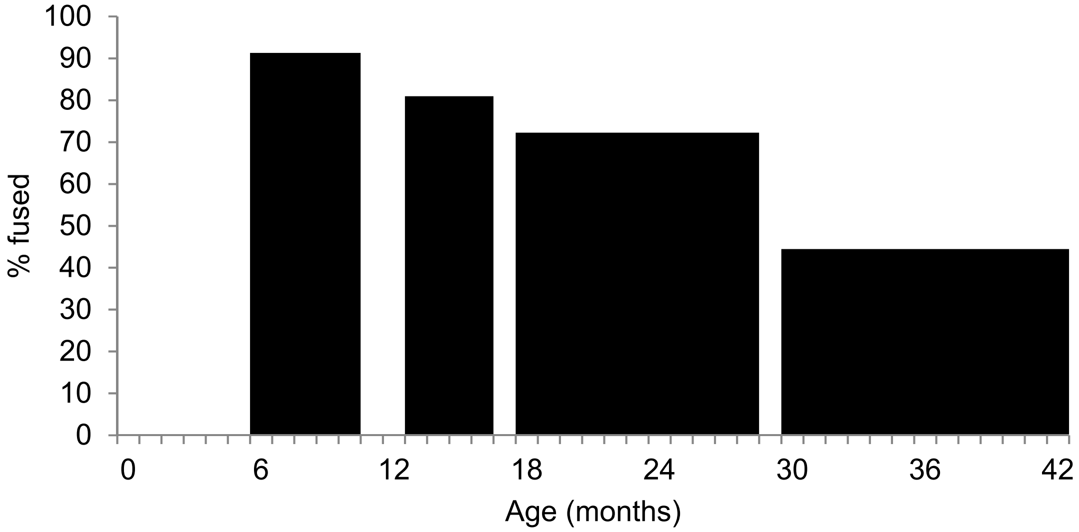

Figure 8.29: Caprine slaughter profiles based on epiphyseal fusion from Těšetice-Kyjovice (n=110).

8.9.1.3 Pigs

There was a large slaughter of juvenile domestic pigs before one year, with little further slaughter suggested by the fusion profile (figure 8.30). The proportion of fused specimens in the final fusion stage is relatively high (44.4%, 8/18), and unusual for the LBK. While it is possible that some specimens were wild boar, the herd structure analysis suggests pig husbandry at Těšetice-Kyjovice allowed pigs to reach full adult size, perhaps for breeding.

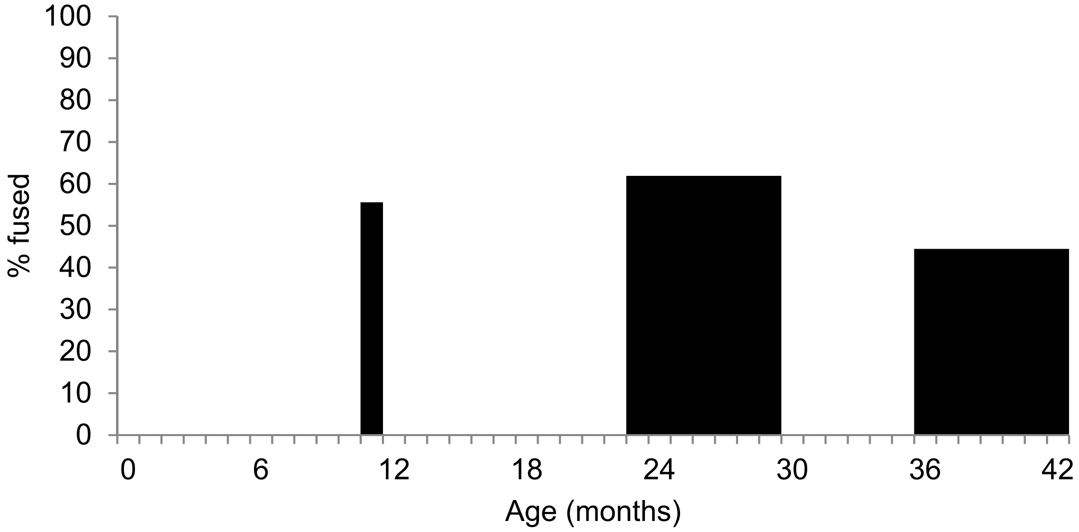

Figure 8.30: Pig slaughter profile based on epiphyseal fusion from Těšetice-Kyjovice (n=66).

8.9.2 Lipid residue analysis

Lipid residue analysis of non-perforated sherds from Těšetice-Kyjovice has yielded animal fats in 26.7% of samples (n=45), with all animal fats identified as adipose fats. Sherds have been analysed from Houses 20, 26, 27 and 28, although sample sizes are low. House 20 presented adipose fats in one third of sherds analysed (n=3), and house 26 presented adipose fats in 40% of sherds analysed (n=5). Houses 27 (n=7) and 28 (n=1) did not return evidence of lipid residues. Whilst this could indicate some differences in dietary and cooking or storage practices between houses the samples sizes are so small that conclusions of this nature cannot be valid. The predominant conclusion to be drawn is that there is currently no direct evidence for milking at Těšetice-Kyjovice, although suggested by slaughter profiles for cattle and perhaps caprines. On the other hand, it is possible that animal products were occasionally processed in pots, including meat and bone, perhaps boiled in stews to release nutrients, or the comminuted bone from isolated bone grease processing.

8.10 Discussion

8.10.1 Meat and fat exploitation

The patterns of animal exploitation at Těšetice-Kyjovice suggest that the main three domesticates supplied the site with meat-age animal carcasses. Cattle were largely slaughtered between 2-3 years, caprines 2.5-3.5 years and pigs when under 1 year or mature. It is possible that cattle and caprines were also managed for dairy. Direct evidence of milk exploitation has not currently been detected by lipid residue analysis, although this is not to say dairying was not taking place, perhaps collected, processed or stored in organic vessels.

Patterns of skinning, dismembering and defleshing are hard to interpret based on scant butchery evidence at Těšetice-Kyjovice (figures 8.31 and 8.32). Evidence of skinning is plausibly present on cattle and caprine metapodia, and carcasses show potential evidence for disarticulation at the neck, mandible, hip and ankle. Butchery patterns relating to defleshing were present on the meat-bearing bones of the upper forelimb, the mandible and the lumbar vertebrae. On a site with such well-preserved bone surfaces it is possible that this lack of butchery represents processing and cooking techniques where butchery was not intensive, such as boiling.

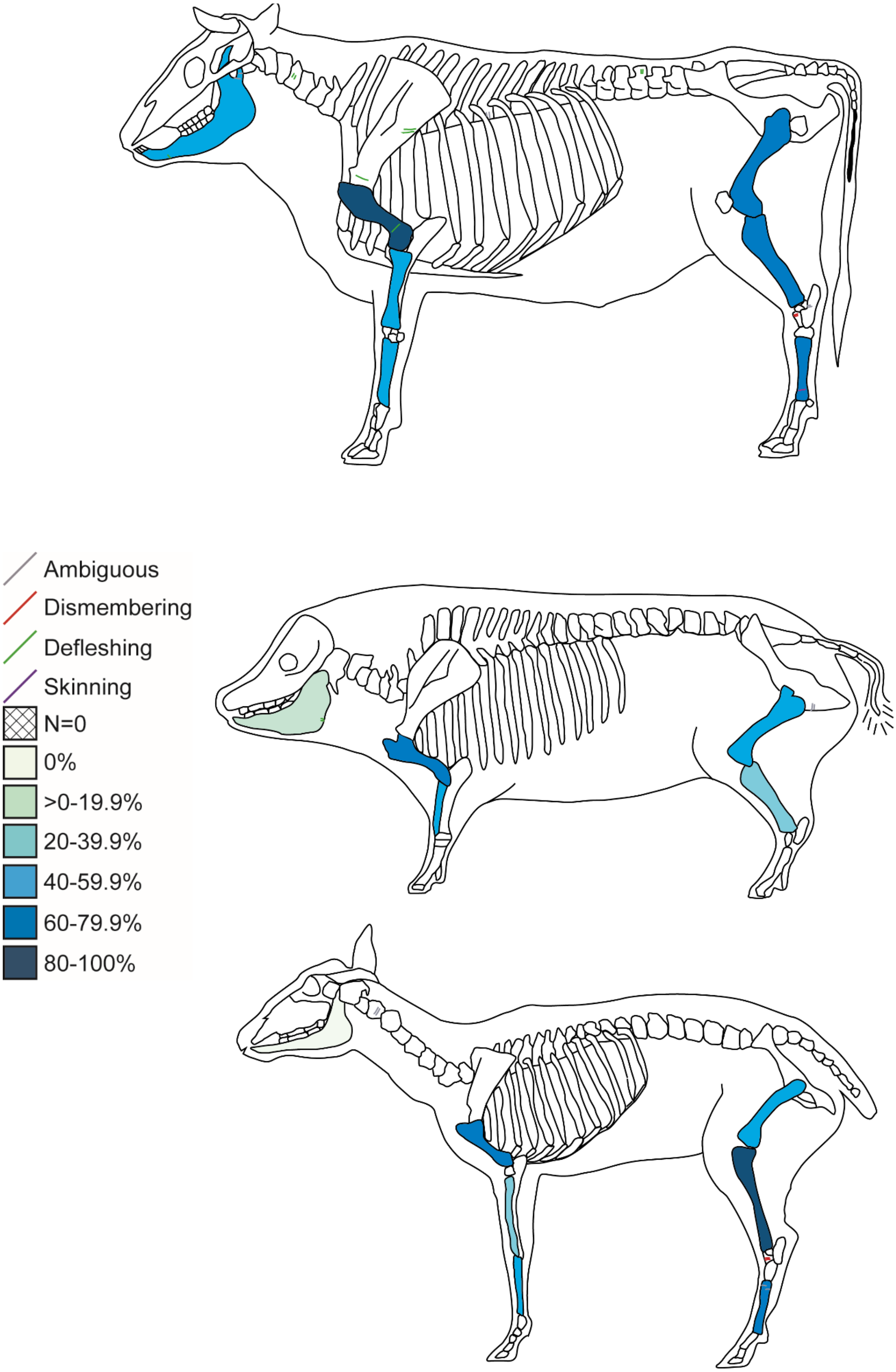

Figure 8.31: Carcass processing profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Těšetice-Kyjovice. Values in table 8.4.

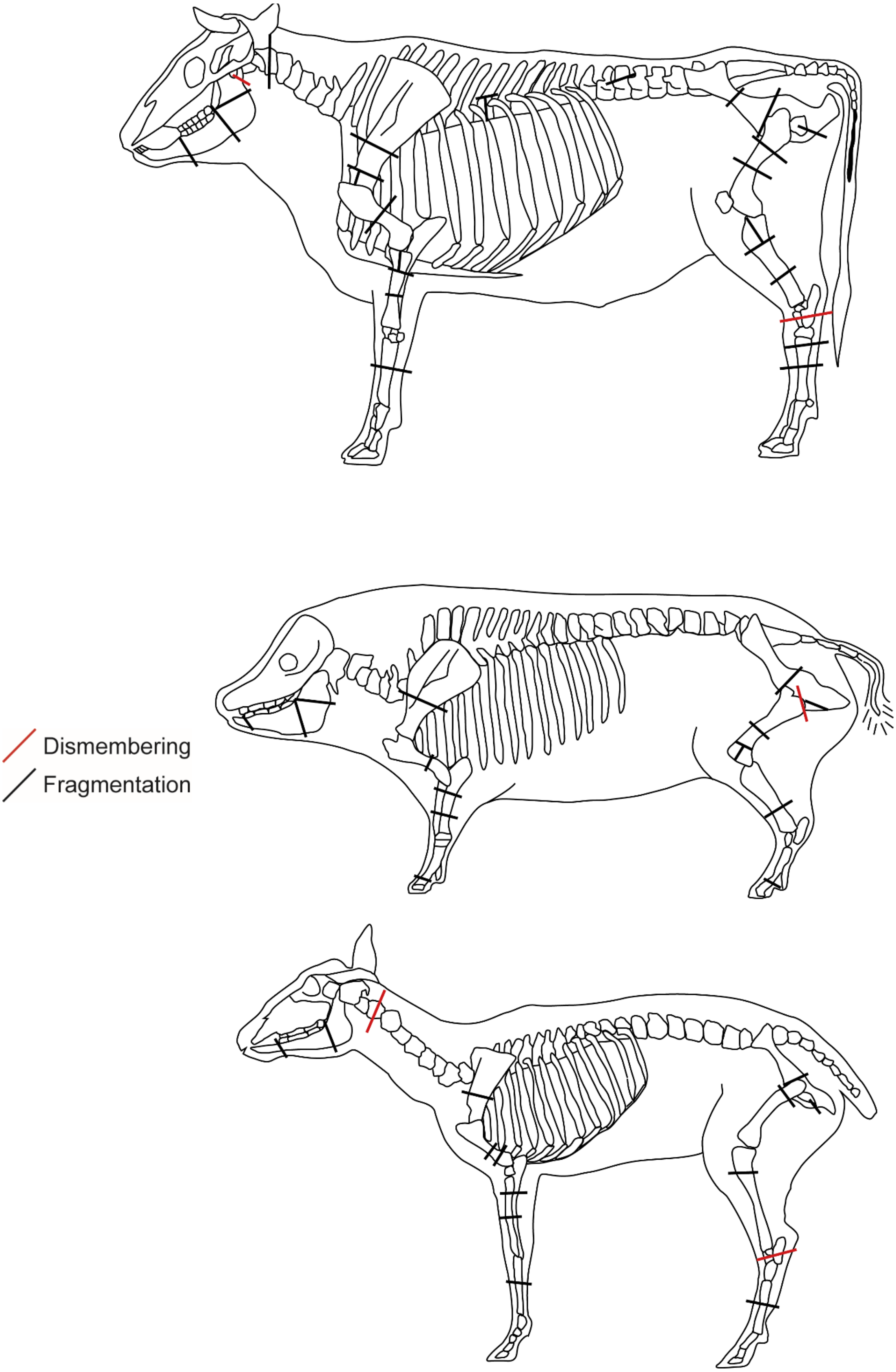

Figure 8.32: Carcass processing profile showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Těšetice-Kyjovice.

Table 8.4: Percentage of fractured marrow-bearing elements fractured when fresh from bovinae, suidae and caprines from Těšetice-Kyjovice.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	80	5	53	19	70	19	78	20	50	18	55	13	67	20
Suidae	60	10	50	8	47	15	20	10	15	20	-	-	-	-
Caprines	73	15	29	7	43	7	91	11	0	1	44	9	67	3

Whilst the evidence for meat exploitation is difficult to interpret, evidence for bone fat exploitation was much more elucidating. Fresh fracture proportions show that cattle bones, especially the humerus, were commonly fractured for marrow, whilst pig and caprine bones were less intensively exploited (figure 8.31). Still, it is clear that marrow from all species was exploited, likely in a non-standardised manner that differed slightly between houses. Bone grease processing was not intensively practised at this site, but evidence for potential localised bone grease processing from context 536 suggests that within-bone nutrients were still highly valued.

Chapter 9 Ludwinowo 7

9.1 Introduction

The LBK settlement of Ludwinowo 7 is located in the Kuyavia region in the Polish lowlands (Pyzel 2012: 160). It is situated on the edge of a small plateau on heavy gley soil (*ibid*.). The site was discovered during surveys preceding motorway construction in 2000 and was excavated during 2000-2001 and 2008-2009 (*ibid*.). Traces of the earliest occupation were dated to the Kuyavian phase I (the late Ältest LBK), with the main occupation of the site dating to the Kuyavian phase IIA (early Notenkopf) to Kuyavian phase III (*ibid*. 163; table 9.1).

Table 9.1: Absolute dating of Kuyavian phases based on 14C-dates and relative chronology developed by Pyzel (2009).

Kuyavian Phase	Proposed Absolute Dates
Phase I	N/A
Phase IIA	c. 5300/5250-5200 cal BC
Phase IIB	c. 5200-5100/5000 cal BC
Phase III	c. 5100/5000-4900/4800 cal BC

Some 809 features, mostly clay pits and pits with ambiguous function, could be connected to the LBK (*ibid.* 162). Finds were concentrated in the north-west and south-east portions of the site, divided by a 100m wide flat area largely free of pits and postholes (figure 9.1). The posthole distribution suggests 13 or 14 poorly-preserved longhouses at a shallow depth (mean 18cm). The mean house size was 6.1x21.3m, although influenced heavily by one very large longhouse (*ibid.*). No pits other than those directly alongside a house could be attributed to that house (*ibid.* 163).

9.2 Assemblage

9.2.1 Sample

The size of the Ludwinowo 7 faunal assemblage necessitated the analysis of a sample rather than the entirety. Contexts were chosen for study based on their LBK phase, context type (house pits, unassociated pits and clay pits) and the number of animal bones contained within them. In addition, a qualitative study of the rest of the assemblage indicated that the types of bones and fracture types were similar to the sampled assemblage. Any contexts different from the sample were taken out and analysed. In total, 13428 bones were included in the sample (table 9.2). Any difference in values for fully identifiable specimens (table 9.2) and species representation (figure 9.2) is due to the exclusion of *Bos sp.* and *Sus sp*. and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 9.2: Number of fully identifiable, partially identifiable and indeterminate specimens from Ludwinowo 7 (LDW).

Fully identifiable (to species and element)	887
Partially identifiable (to type of species and element)	1681
Indeterminate	10861
Total	**13429**

Two occupation phase sequences exist for Ludwinowo 7 based on pottery analysis by Joanna Pyzel (Pyzel phase) and LBK phases. LBK phases have larger sample sizes but Pyzel phases give a higher resolution of changes over time. Due to sample sizes it was often only possible to compare data between LBK Phase IIB and III and Pyzel phases II, III, V and VI (see table 9.3 and 9.4).

Table 9.3: Number of fully identifiable, partially identifiable and indeterminate specimens dated to each LBK phase from Ludwinowo 7.

LBK phase	Fully Identifiable	Partially Identifiable	Indeterminate
I	9	24	0
IIB	270	567	4395
III	588	1064	5932
Unknown	20	26	534

Table 9.4: Number of fully identifiable, partially identifiable and indeterminate specimens dated to each Pyzel phase from Ludwinowo 7.

Pyzel Phase	Fully Identifiable	Partially Identifiable	Indeterminate
I	6	5	18
II	61	172	826
III	200	375	3534
IV	10	17	45
IV or VI	1	0	2
V	211	296	1579
VI	127	230	1107
Unknown	271	586	3750

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of this thesis for copyright reasons

Figure 9.1: Site plan of Ludwinowo 7 showing the location of house plans dated by Pyzel phase (key top right; Pyzel unpub. figure 1).

Four house contexts, houses 8, 15, 18 and 22, were analysed in their entirety. Most other houses were sampled. Houses 2 and 6 had a large enough sample to be used in comparison with the other four houses. In addition, four large contexts that were not associated with houses were analysed in full - two pits (B156 and G64) and two clay pits (K66 and K82; see table 9.5).

Table 9.5: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens in selected context groups from Ludwinowo 7.

Context group	Interpretation	LBK phase	FID	PID	IND
H15	House	IIB	88	174	2353
H18	House	IIB	34	110	421
H22	House	IIB	112	201	1181
H2	House	III	86	115	613
H6	House	III	77	110	563
H8	House	III	147	371	2214
B156	Isolated pit	III	38	52	237
G64	Isolated pit	III	25	90	361
K66	Clay pit	III	119	144	927
K82	Clay pit	III	48	84	816

Table 9.6: Full list of contexts analysed from Ludwinowo 7.

Context number	LBK Phase	Pyzel Phase	Interpretation	House Number	FID	PID	IND
A281	IIB	II	House	18	5	19	65
A282	IIB	II	House	18	1	7	31
A356	III	IV	House	1	3	5	11
A372	?	IV or VI	House	1 or 2	1	0	2
A408	III	IV	House (clay) pit?	1	0	1	1
A440	III	VI	House	2	24	56	351
A49	IIB	II	House (clay) pit	18	13	77	232
A75	IIB	II	House	18	1	0	21
A83	IIB	II	House	18	13	4	64
A84	?	II	House	18	1	3	8
B156	III	?	Pit		38	52	237
B240	III	VI	House (clay) pit	2	59	55	258
B256	III	IV	House (clay) pit	1	5	5	14
B257	III	IV	House	1	2	6	19
B258	III	VI	House	2	3	4	4
C115	III	?	House (clay) pit	8	5	13	216
C156	III	?	House	8	142	358	1998
C5	?	?	?		1	0	0
C56	?	?	?		8	3	38
D108	?	?	?		1	3	20
D127	?	?	Pit		1	2	9
D68	?	?	?		2	4	4
D77	III	V	House	6	77	110	563
D88	III	VI	House (clay) pit	20	0	4	14

D91	?	VI	House	20	1	0	0
D95	III	VI	House	20	7	5	30
D96	III	VI	House	20	1	10	23
D97	III	VI	House	20	3	1	0
E6	IIB	II	House (clay) pit	11	15	36	172
E9	IIB	II	House (clay) pit	11	5	12	41
F119	III	V	House	12	5	4	24
F16	IIB	III	House	22	19	46	128
F165	?	?	Pit		1	0	9
F184	?	?	Pit		7	22	159
F185	?	?	Pit		4	9	103
F40	IIB	III	House	22	32	41	204
F44	?	?	Well		2	5	33
F6	IIB	III	House	22	61	114	849
F60	IIB	I	House (clay) pit?	21	6	5	18
G39	III	V	House (clay) pit	13	7	36	65
G42	?	?	Pit		9	24	37
G48	III	V	House	13	3	2	0
G54	?	VI	Clay pit		2	3	21
G64	III	VI	Pit		25	90	361
G70	?	VI	Pit		2	2	45
H154	?	?	Pit		0	3	22
H161	IIB	?	Pit		0	0	42
H42	IIB	III	House (clay) pit	15	84	167	2336
H48	?	III	House	15	4	7	17
K66	III	V	Clay pit		119	144	927
K82	III	?	Clay pit		48	84	816
L8	?	?	?		2	4	7
O23	IIB	II	House	24	7	14	192

9.2.2 Methodological choices

Poor preservation in the Ludwinowo 7 faunal assemblage resulted in heavy fragmentation of scapula and pelvis fragments, making species determination difficult. Indeterminate fragments of these elements under 60mm in maximum diameter were classed as cancellous (pelvis) or rib (scapula blade) fragments. Specimens with maximum dimensions equal or greater to 60 mm were classed as indeterminate girdular fragments. Fragments of pelvis that allowed sex determination and scapula fragments for which species could be determined were included in identifiable fragments.

In depth butchery analysis was performed on this site assemblage for the first time, following pilot study of Rosheim *Sainte-Odile.* During the analysis, an additional field was added for severity of stroke, qualitatively scored as heavy, medium or light.

During the analysis of this assemblage I had problems procuring a set of scientific weighing scales. I used two sets, one that weighed to 0.01g up to 100g but unsuitable for weighing large bones, and another that weighed to 1g with a 1.5kg limit. This will have affected the accuracy of some weights in the assemblage.

9.3 Species representation

9.3.1 Site

Cattle were by far the dominant species identified in the Ludwinowo 7 assemblage, making up 74.7% (645/864) of the number of identifiable specimens (NISP; figure 9.2). One caprine bone was identified as goat, but both species were likely present at 8.7% (75/864) of identifiable specimens. Pigs made up 5.9% (51/864) of the identifiable assemblage. Domestic dogs were present in small numbers (1.6%, 14/864). Wild animals represented 9.1% (79/864) of the NISP, including aurochs, red deer, roe deer, wild horse and some indeterminate wild birds. It is possible that some wild boar and further aurochs were present in the assemblage but identified as indeterminate suid (n=3) and bovine (n= 13) species. As on all sites, these bones were excluded from analysis of species representation. For a more detailed report on the species present at Ludwinowo 7 see the full zooarchaeological report by Osypińska (2011).

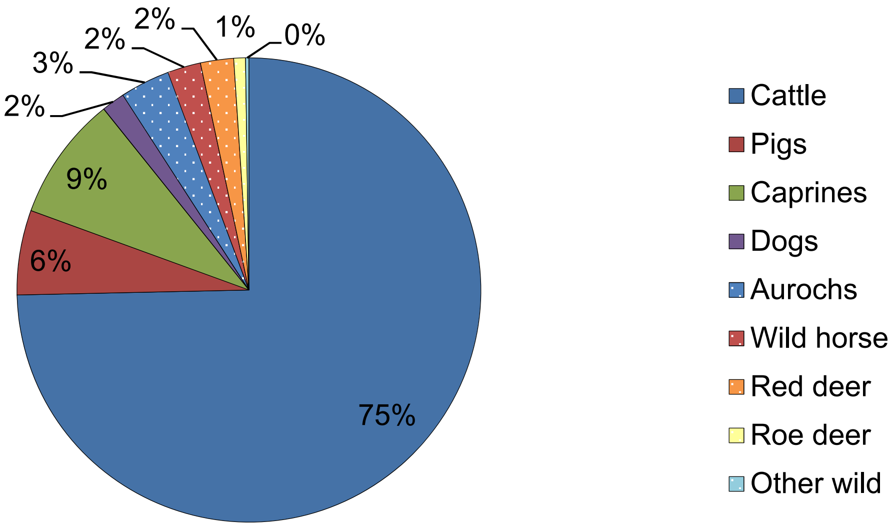

Figure 9.2: Species representation (NISP) for the fully identifiable assemblage from Ludwinowo 7 (n=864).

9.3.1.1 Phase

There was a slight change in species representation between the largest LBK phases (IIB and III; see figure 9.3). In Phase IIB the assemblage contained predominantly cattle, a small number of pigs and a relatively large number of caprines and wild fauna, primarily aurochs but also red and roe deer and one specimen of wild horse. In LBK Phase III there was a slight but statistically significant increase in the proportions of cattle (from 69.3%, 178/257 to 76.9%, 444/577; p=.019) and pigs (from 2.3%, 6/257 to 7.6%, 44/577; p=.003), making pigs the secondary domesticate above caprines. Wild animals also decreased, with wild horse in this phase replacing aurochs as the most frequent wild animal from Phase IIB, although these differences were not significant.

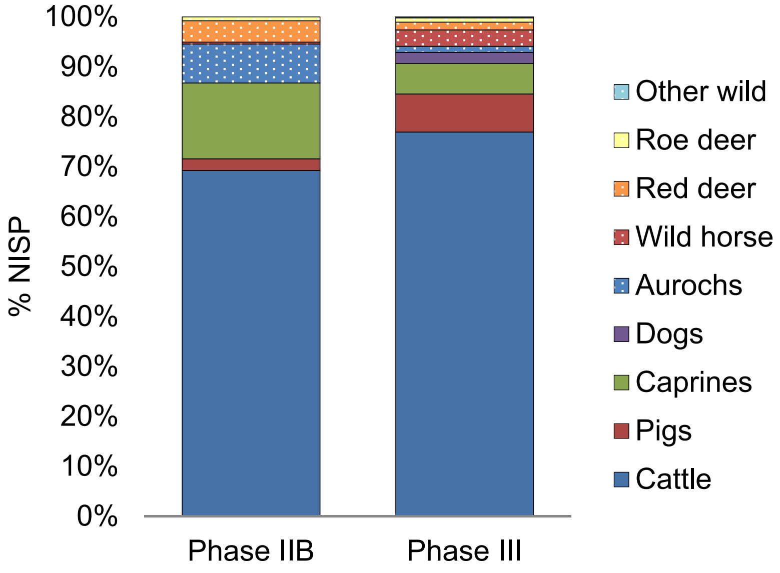

Figure 9.3: Species representation (NISP) for LBK phase IIB (n=257) and III (n=577) from Ludwinowo 7.

In the Pyzel phases, where sample sizes were much smaller, a more detailed picture reveals changes in species diversity over time (figure 9.4). Cattle were particularly dominant in phases II and V. The proportion of cattle in phase II (49/58) and V (174/208) was significantly higher than phase III (123/190; p=.004/ p<.001 respectively) and phase VI (77/127; p=.001/ p<.001). In phase III caprines and wild animals played a larger role, and similarly in phase VI pigs and caprines increased where wild animals and cattle decreased. Phase V was the phase where domestic dogs were best represented. However, some of the species diversity could be affected by the types of features present in each phase (see figure 9.5).

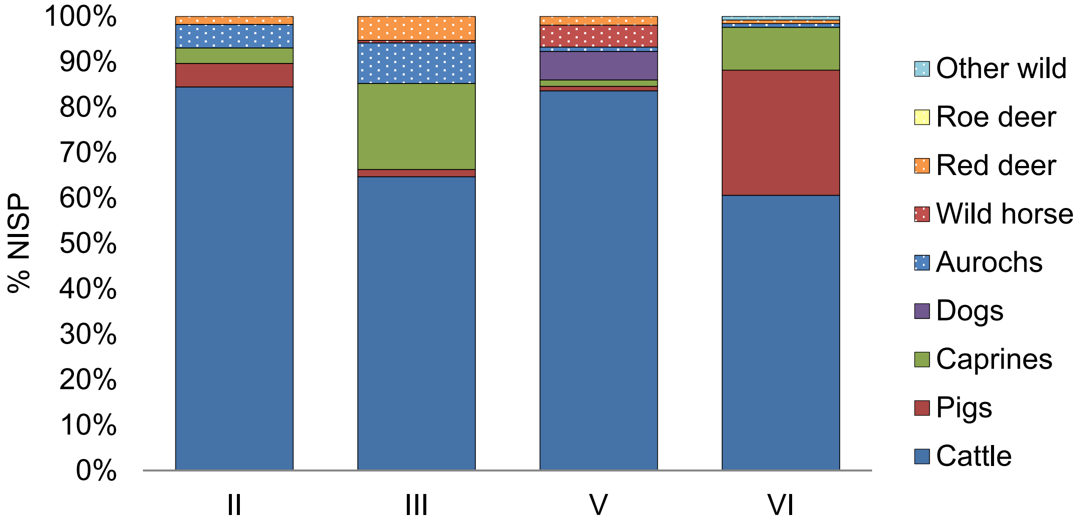

Figure 9.4: Species representation (NISP) for Pyzel phase II (n=58), III (n=190), V (n=208) and VI (n=127) from Ludwinowo 7.

9.3.1.2 Context groups

The comparable contexts follow similar trends for species diversity, with cattle the main domestic animal followed by caprines and low numbers of pigs. Wild animals were represented most often included aurochs but also red and roe deer, wild horse and bird species. However, there was some considerable deviation between and within context types, explored below (figure 9.5; table 9.7). Values used in calculating percentages and significance can be found in table 9.7.

Table 9.7: Species representation (NISP) by context group from Ludwinowo 7. BO.T = cattle, SU.D = pig, CAP = caprine, CA.F = dog, BO.P = aurochs, EQ = wild horse, CE.E = red deer, CA.C = roe deer, O.W. = other wild.

	LDW	**H15**	**H18**	**H22**	**H2**	**H6**	**H8**	**B156**	**G64**	**K66**	**K82**
BO.T	645	49	30	74	43	61	108	33	19	104	40
SU.D	51	1	0	2	34	0	3	4	1	2	0
CAP	75	19	2	17	8	1	12	0	3	0	4
CA.F	14	0	0	0	0	12	0	0	0	0	0
BO.P	30	14	1	3	0	2	3	0	1	0	1
EQ	20	0	0	1	0	0	8	0	0	10	0
CE.E	20	0	1	10	0	1	2	0	1	2	2
CA.C	7	0	0	0	0	0	4	1	0	0	0
O.W.	2	0	0	0	1	0	1	0	0	0	0
N	864	83	34	107	86	77	141	38	25	118	47

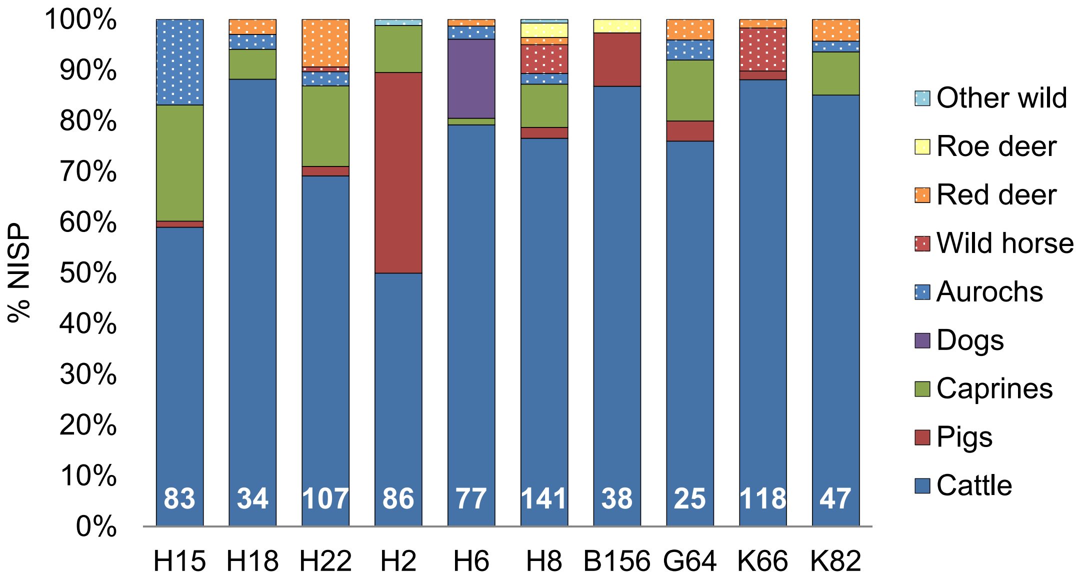

Figure 9.5: **Species representation (NISP) by context group from Ludwinowo 7, including LBK phase IIB (H15, H18, H22) and III houses (H2, H6, H8), isolated pits (B156 and G64) and clay pits (K66 and K82). N values are at the base of each bar.**

9.3.1.2.1 House contexts

In all houses cattle were the most dominant species. In phase IIB houses, House 18 was particularly high in cattle, in fact containing the highest proportion of cattle of the comparable contexts. Houses 15 and 22 were similar in their higher proportion of caprines and wild animals, primarily aurochs for House 15 and red deer for House 22. For houses dated to LBK phase III, House 2 had an incredibly high proportion of pigs, significantly higher than all other contexts groups (B156 p=.001, all others p<.001, see table 9.7 for values). House 6 was notable for the high proportion of dog bones, significantly higher than the combined context groups for phase IIB houses, other phase III houses, pits and clay pits (all p<.001). A minimum number of two individuals were represented, including specimens from a single hind paw burnt at high temperatures. House 8 also shows a concentration of wild horse bones that are only seen elsewhere in clay pit K66.

9.3.1.2.2 Pit contexts

All pit contexts had high proportions of cattle. Of the isolated pits, B156 had one of the highest percentage of pigs outside of House 2, although sample sizes were small. Caprines were better represented in G64. The two clay pits K66 and K82, originating from the same pit complex, again had very high proportions of cattle, representing at least 5 individuals in K66 and at least 4 individuals in K82. K66 had a small concentration of wild horse (MNI: 2, one male), and caprines were more common in K82.

9.4 Butchery

9.4.1 Site

Butchery marks were present on 2.1% (285/13429) of the sampled assemblage at Ludwinowo 7, and 7.4% (189/2568) of identifiable bones. The majority of butchery marks were cut and scratch marks (figure 9.6). Chop marks, made with increased force, were also relatively common. Crush marks suggesting striking with a blunt instrument were uncommon. 'Slice' marks, as described in Chapter 8, were first identified at Ludwinowo 7. Their presence at this site possibly indicates similar patterns of carcass processing and fracture as at Těšetice-Kyjovice as they were not seen at such high proportions at other sites.

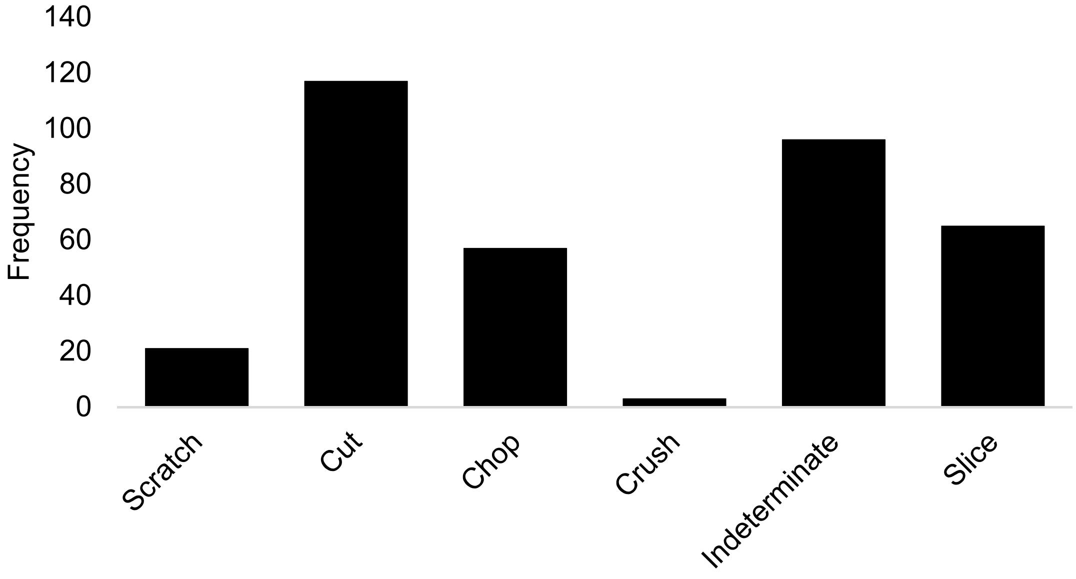

Figure 9.6: Frequency of butchery mark types from Ludwinowo 7.

9.4.1.1 Phase

There was a significant increase of the prevalence of butchery marks between the two LBK phases (IIB 91/5132; III 183/7680; p=.019), especially in the number of cut and scratch marks (see figure 9.7). This more intensive butchery could relate to the additional contexts groups that form phase III, particularly clay pits, which had a higher proportion of bones affected by butchery than other context types.

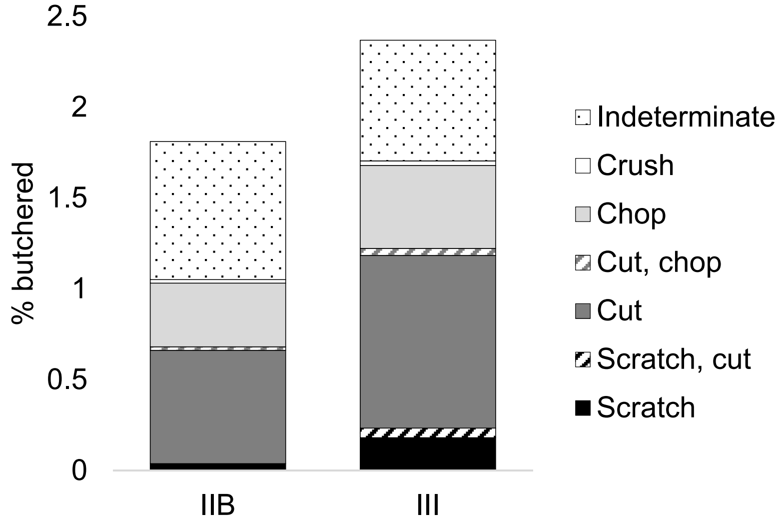

Figure 9.7: Percentage of specimens from LBK phase IIB and III affected by different butchery episodes from Ludwinowo 7.

9.4.1.2 Context groups

Butchery was analysed by context type rather than by individual contexts due to small sample sizes. Contexts showed little variation in the proportions and types of butchery (figure 9.8). Clay pits (2/2164) showed a significantly greater proportion of specimens with crush marks than house contexts (1/9813, p=.029), which could relate to the more intensive marrow processing in these contexts (see section 9.6 and figure 9.33).

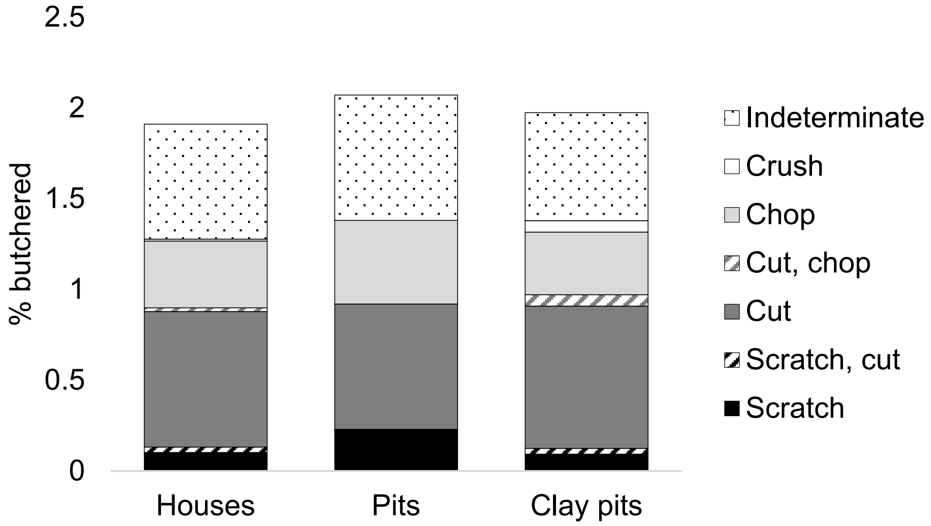

Figure 9.8: Percentage of house pit (n=9813), isolated pit (n=1261) and isolated clay pit (n=2164) contexts affected by different butchery episodes from Ludwinowo 7.

9.4.2 Species

The butchery mark analysis per species suggests that large wild mammals were more intensively butchered than domestic animals, although the differences were not significant (figure 9.9). The bones of aurochs and red deer were some of the most commonly butchered bones in the assemblage, with 23.3% (7/30) and 30.0% (6/20) of specimens showing evidence of butchery marks respectively. Red deer bones were significantly more butchered than domestic cattle (13.3%, 86/645, p=.029). This difference in butchery prevalence could be explained by more intensive kill-site butchery of large wild animals for transportation back to site, which is also supported by the low proportion of butchered roe deer bones, which could likely be transported whole or in larger carcass portions. Domestic animals, presumably slaughtered at or near the settlement, would not need to be butchered for transport in this way. Domestic dogs in particular showed no evidence of butchery, indicating that their carcasses were processed in a different way to other animals.

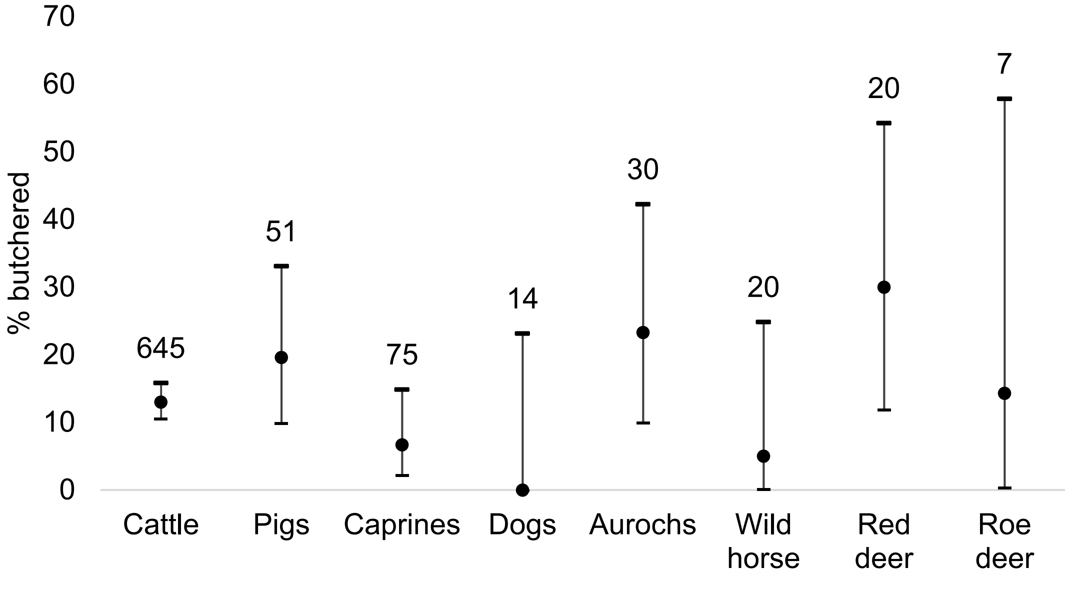

Figure 9.9: Percentage of bones of different species with butchery marks from Ludwinowo 7, with 95% confidence intervals. N values at the top of each series.

9.4.3 Carcass butchery

There were some differences in the proportion of different elements and carcass parts affected by butchery. The forelimb was one of the most butchered parts of the carcass (23.2%, 48/207), with a significantly higher percentage of butchery found on the scapula than the overall identifiable assemblage (7.4%, 189/2568, p<.001; figures 9.10 and 9.11). The hindlimb and extremities also showed high proportions of butchery, especially compared to the mandible and diaphysis fragments, likely due to heavy fragmentation of these elements.

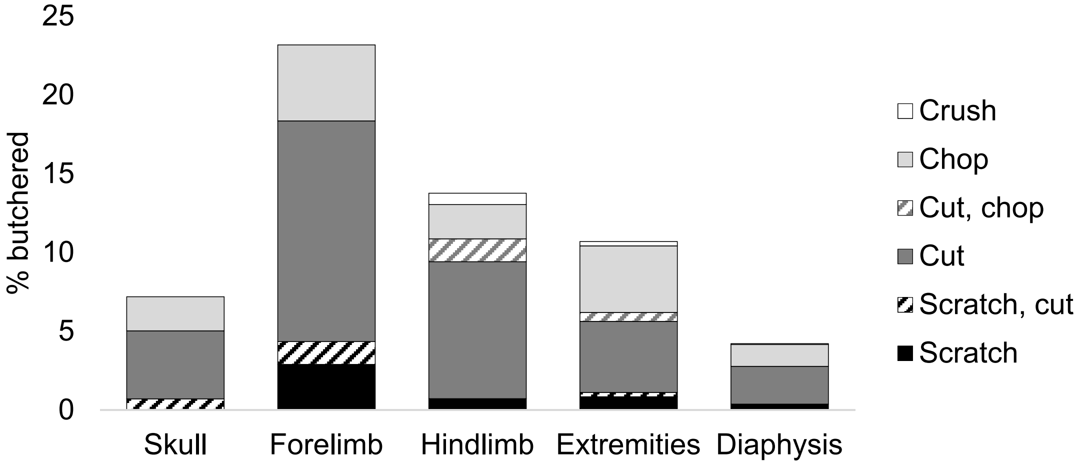

Figure 9.10: Percentage of specimens in different carcass portions with different butchery episodes from Ludwinowo 7.

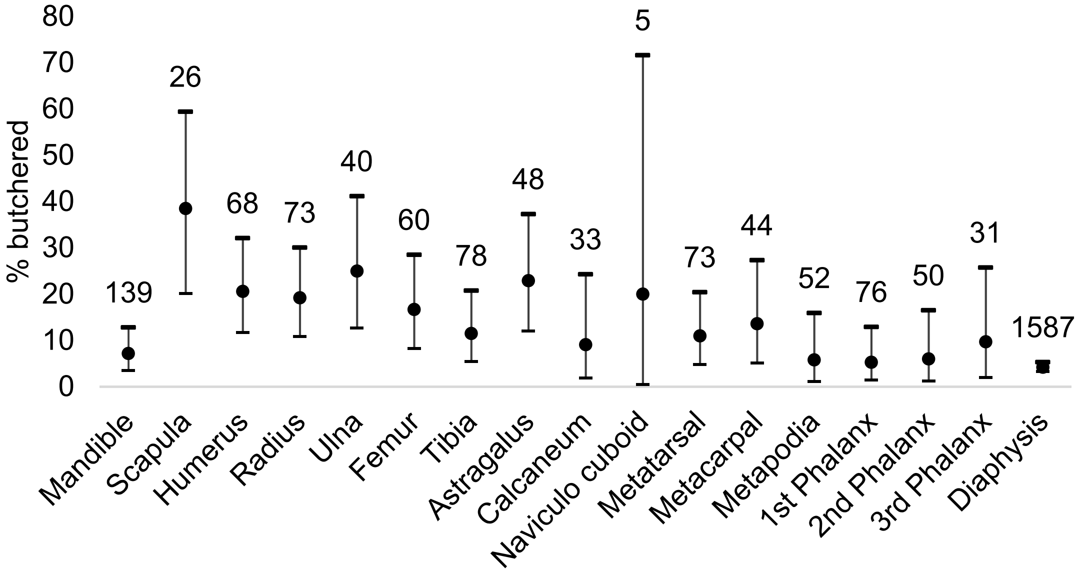

Figure 9.11: Percentage of elements with evidence of butchery from Ludwinowo 7, with 95% confidence intervals.

9.4.3.1 Forelimb butchery

The neck of the distal scapula was commonly affected by butchery marks (zones 4 and 5, figure 9.12). Marks clustering around the articulation were likely produced in dismembering the scapula and humerus, but could also suggest defleshing of the scapula (Binford 1981: 122; Soulier and Costamagno 2017). Butchery marks affecting the blade of the scapula particularly suggest defleshing, especially longitudinal marks (*ibid.*).

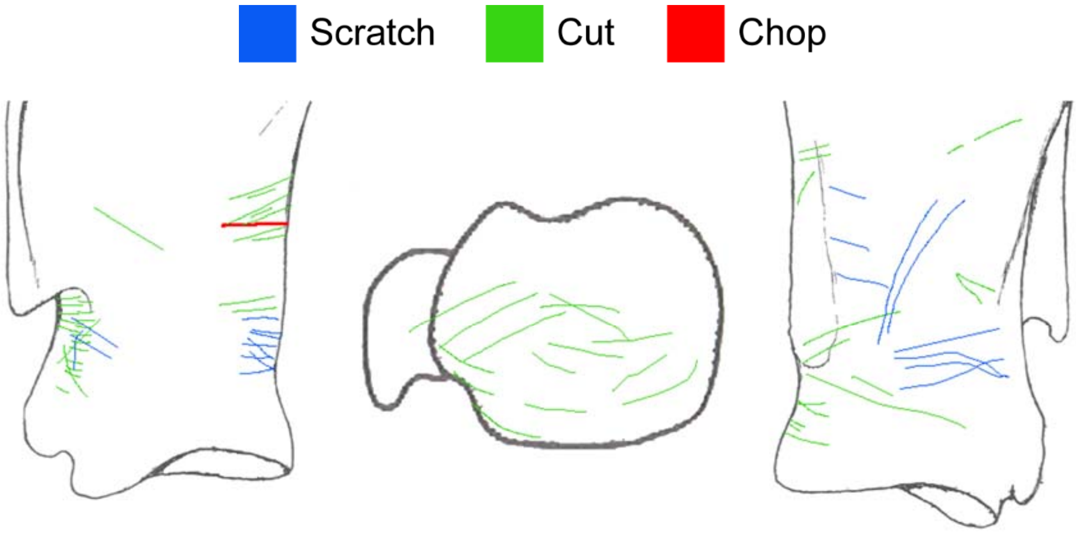

Figure 9.12: Cumulative diagram of butchery on cattle scapula (n=8) from Ludwinowo 7. Left to right; lateral, distal and medial views.

Disarticulation of the humeral head from the scapula is reflected in heavy butchery to the proximal shaft of the humerus (figure 9.13; Binford 1981: 123). Butchery marks on the diaphysis and distal epiphysis suggests defleshing. Cut, scratch and chop marks on the distal articulation indicate disarticulation of the elbow joint, particularly on the medial, lateral and distal aspects (*ibid.*; Soulier and Costamagno 2017). These patterns are mirrored in the butchery of the ulna and radius, with butchery patterns consistent with disarticulation on the proximal epiphysis (figure 9.14; Binford 1981; Soulier and Costamagno 2017). On the diaphysis butchery more likely indicates defleshing, with possible further disarticulation of the carpals and metacarpals.

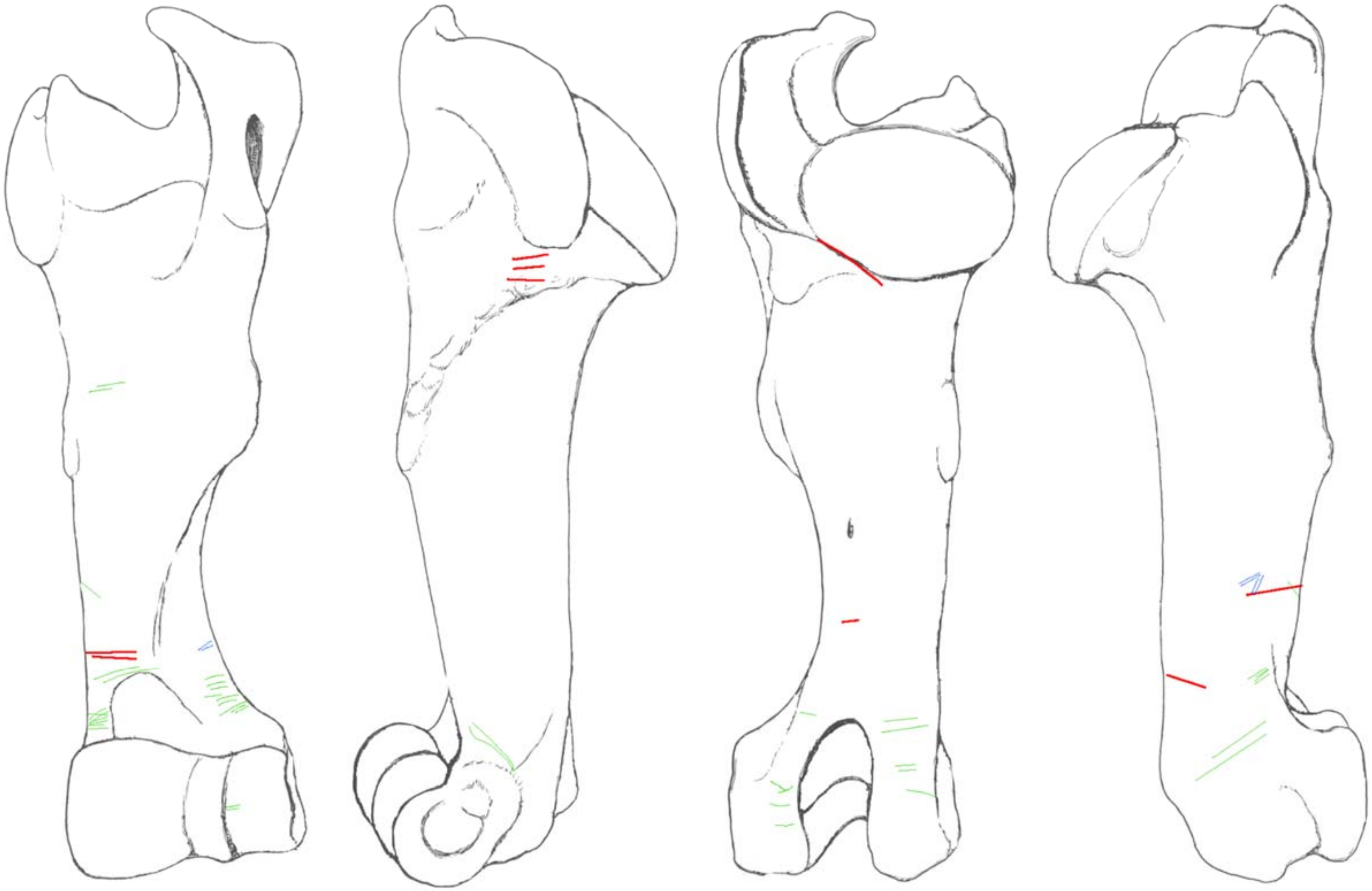

Figure 9.13: Cumulative diagram of butchery on bovine humeri (n=14) from Ludwinowo 7. Left to right; anterior, lateral, posterior and medial views.

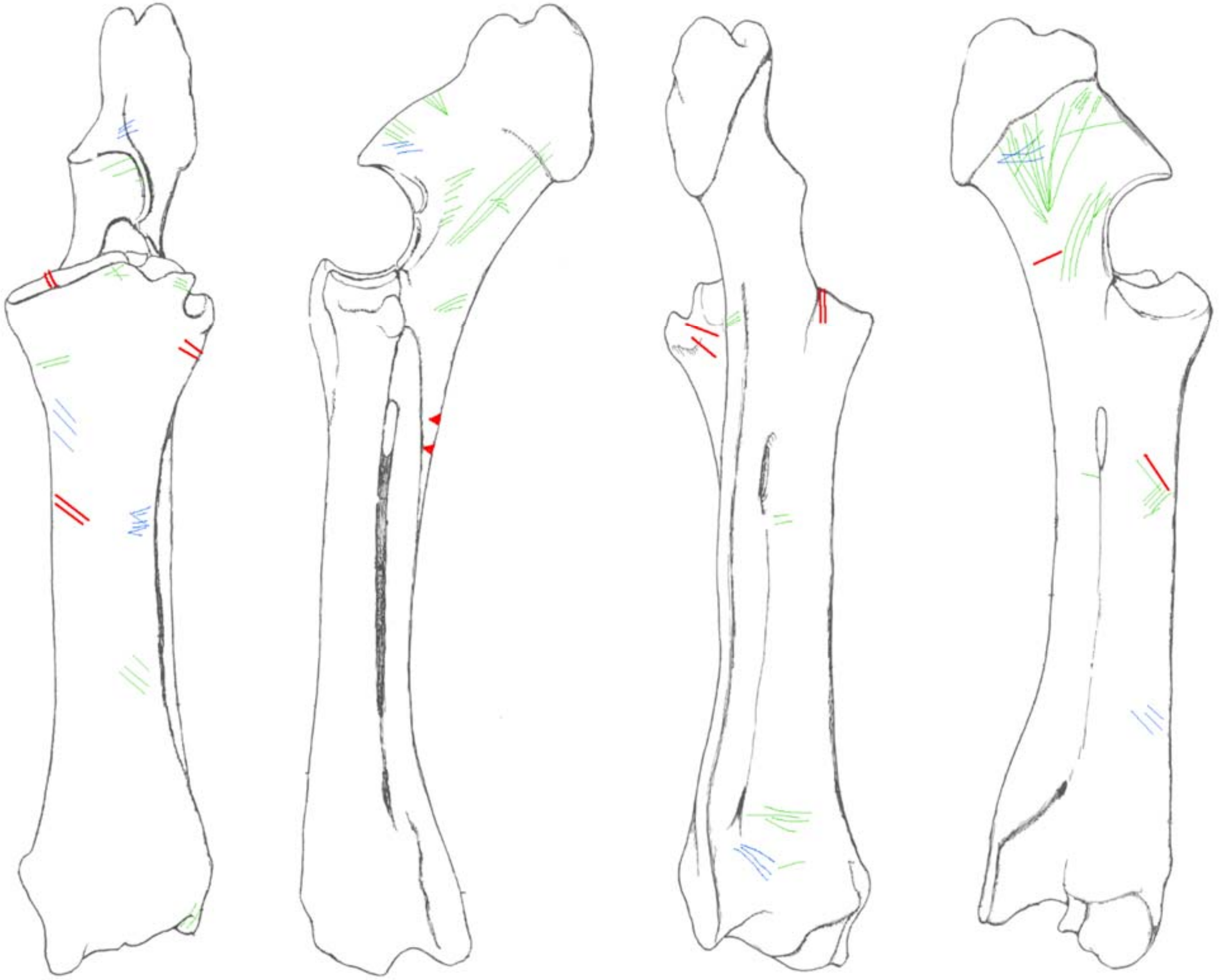

Figure 9.14: Cumulative diagram of butchery on bovine (n= 17), caprine (n=1) and wild horse (n=1) radii and ulnae from Ludwinowo 7. Left to right; anterior, lateral, posterior and medial views.

9.4.3.2 Hindlimb butchery

Butchery on the femur indicates disarticulation from the pelvis and tibia, and defleshing of the meat surrounding the femur (figure 9.15). Disarticulation from the pelvis was suggested by butchery on the femoral head (Binford 1981: 177; Soulier and Costamagno 2017). On the distal femur disarticulation from the tibia was likely through chop marks on the medial condyle (in one pig specimen) and cut marks to the distal diaphysis (*ibid.*). Butchery on the shaft reflects defleshing of this element.

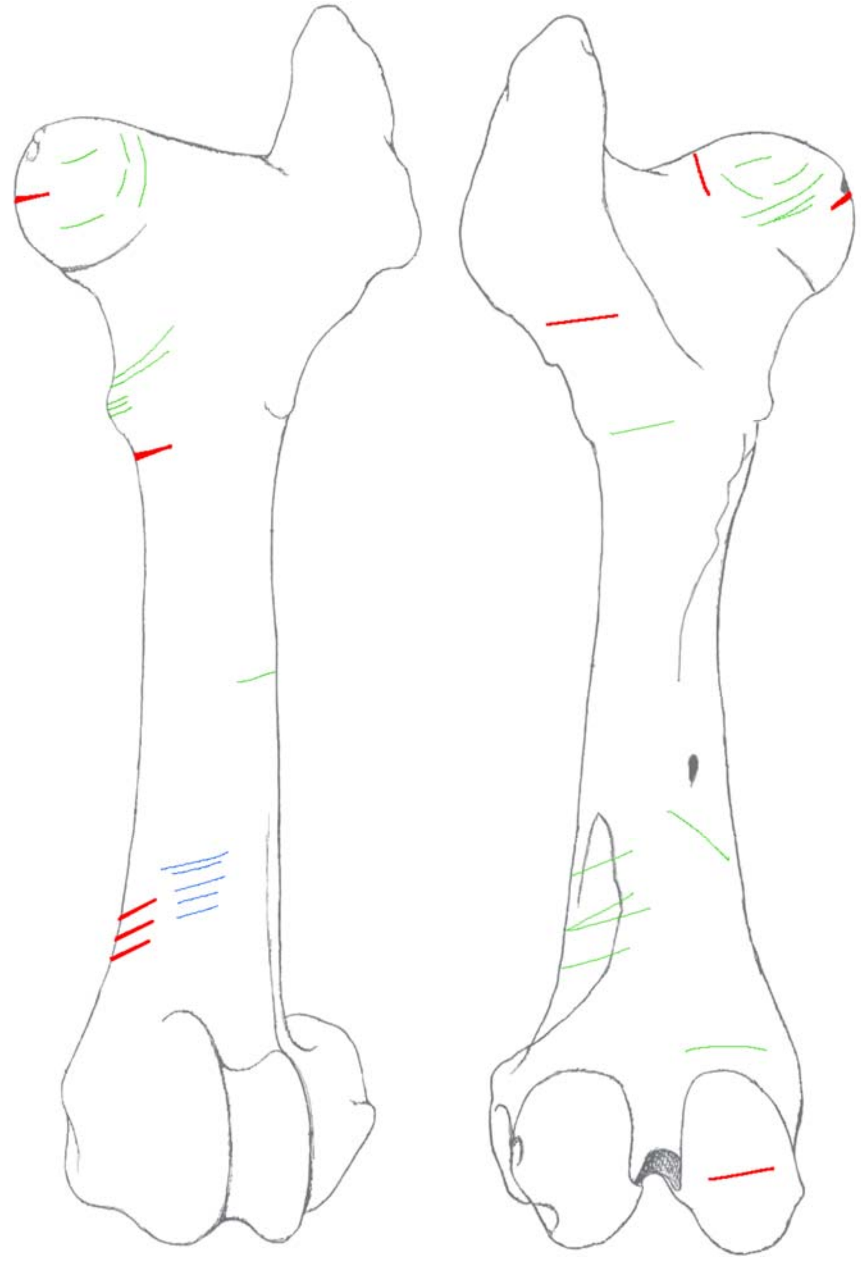

Figure 9.15: Cumulative diagram of butchery on bovine (n= 10) and pig (n=1) femora from Ludwinowo 7. Anterior (left) and posterior views.

No evidence of disarticulation was detected on the tibia, thus disarticulation butchery concentrated on the distal femur and tarsals (figure 9.16; Soulier and Costamagno 2017). Butchery on the tibia shaft strongly suggests defleshing, particularly common on the posterior face. Crush marks on the tibia included one incidence of intensive crushing around almost the entire circumference of the fracture.

Figure 9.16: Cumulative diagram of butchery on bovine (n= 5), pig (n=1), caprine (n=4) and red deer (n=1) tibia from Ludwinowo 7. Anterior (left) and posterior views. Orange indicates crushing.

Butchery of the astragalus and calcaneum likely represents removal of the extremities from the meat-rich hind-limb at the tibio-tarsal junction (figure 6.17; Soulier and Costamagno 2017). Butchery of the calcaneum also suggests defleshing of muscle groups located on the tibia.

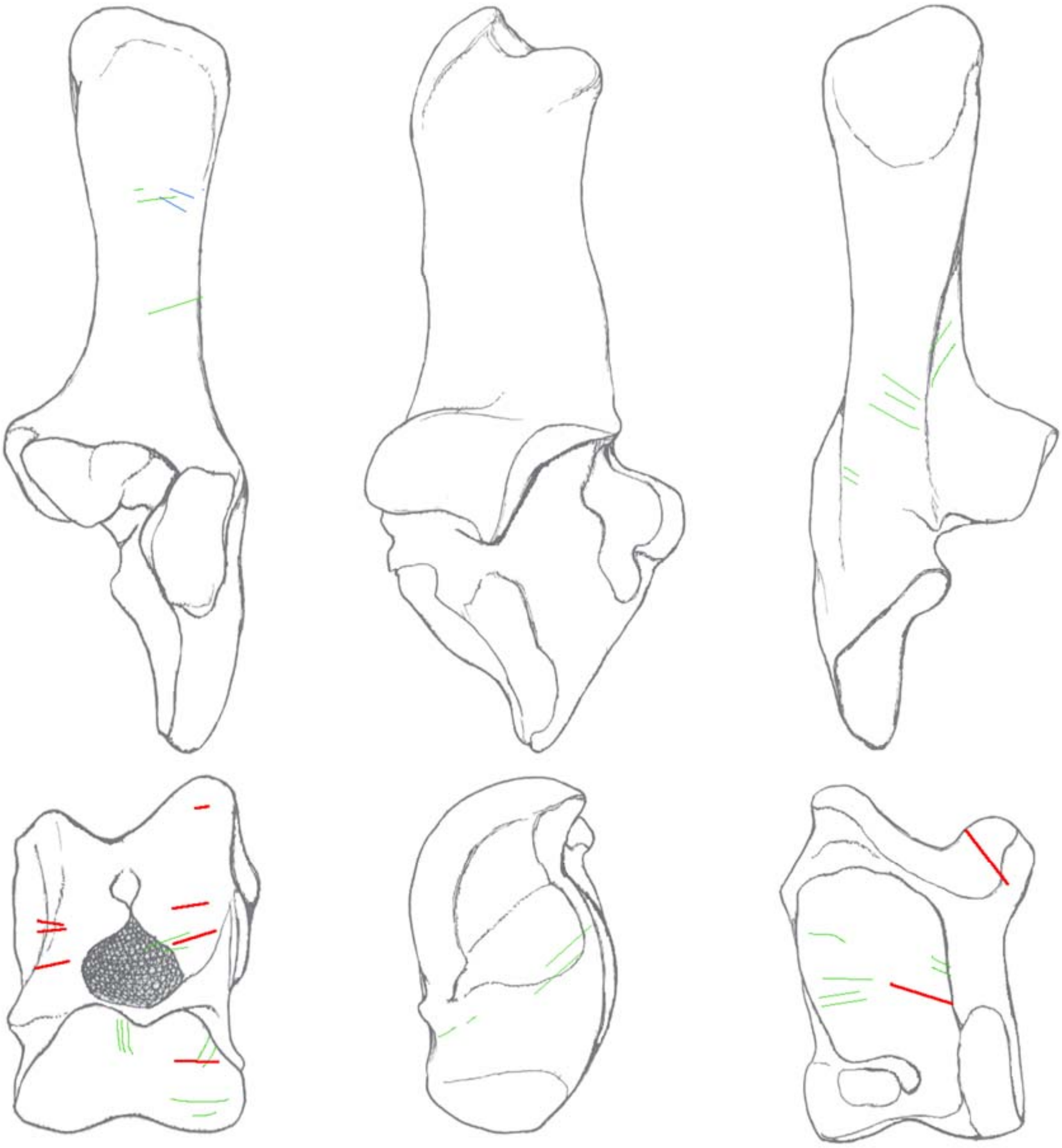

Figure 9.17: Cumulative diagram of butchery on bovine calcanei (top, n=3) and bovine (n= 6) and red deer (n=1) astragali from Ludwinowo 7. Left to right; anterior, medial and posterior views.

9.4.3.3 Extremities butchery

Butchery on the extremities, particularly the metapodia, suggests skinning in all species and possibly tendon removal in ruminants (figures 9.18 and 9.19). Multiple cuts suggest incision points from which the hide was peeled away, patterns also repeated on the phalanges (Soulier and Costamagno 2017).

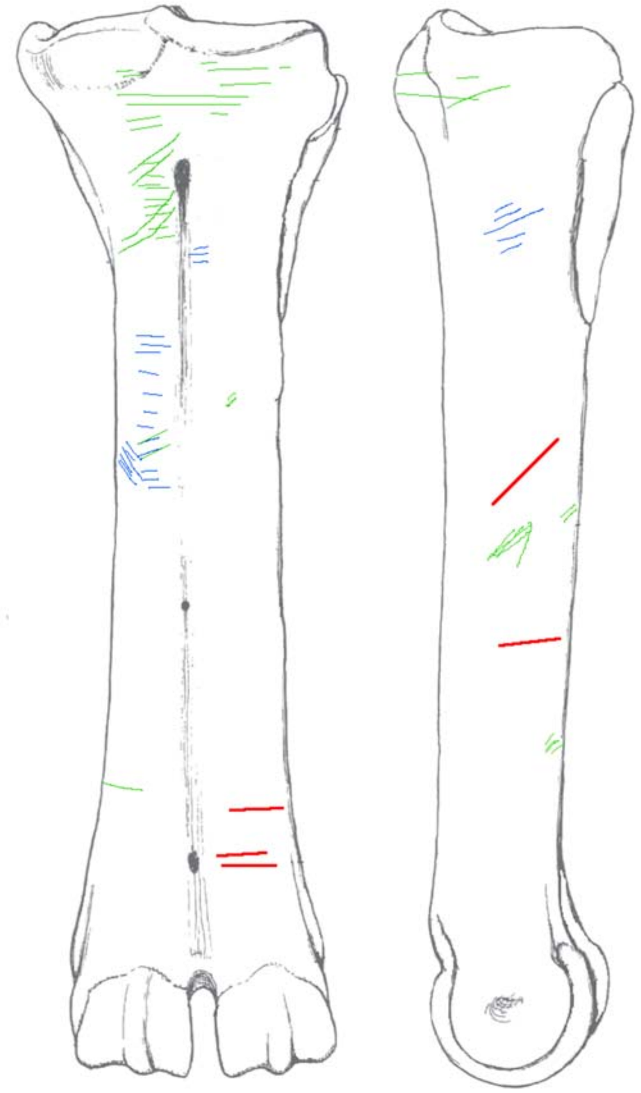

Figure 9.18: Cumulative diagram of butchery on ruminant (bovine, n=9; caprine, n=2 and red deer, n=1) metapodia from Ludwinowo 7. Anterior (left) and lateral views.

Figure 9.19: Cumulative diagram of butchery on pig metapodia (n=3) from Ludwinowo 7. Anterior view.

9.5 Heat exposure

9.5.1 Site

Burning affected 9.9% (1331/13429) of the overall assemblage and 31.5% (810/2568) of the identifiable assemblage, a particularly high proportion that is unusual to the other LBK sites studied. Roasting was the most common form of heat exposure to affect identifiable material (figure 9.20). Evidence of heat exposure affected a high number of bones in different contexts, species and elements.

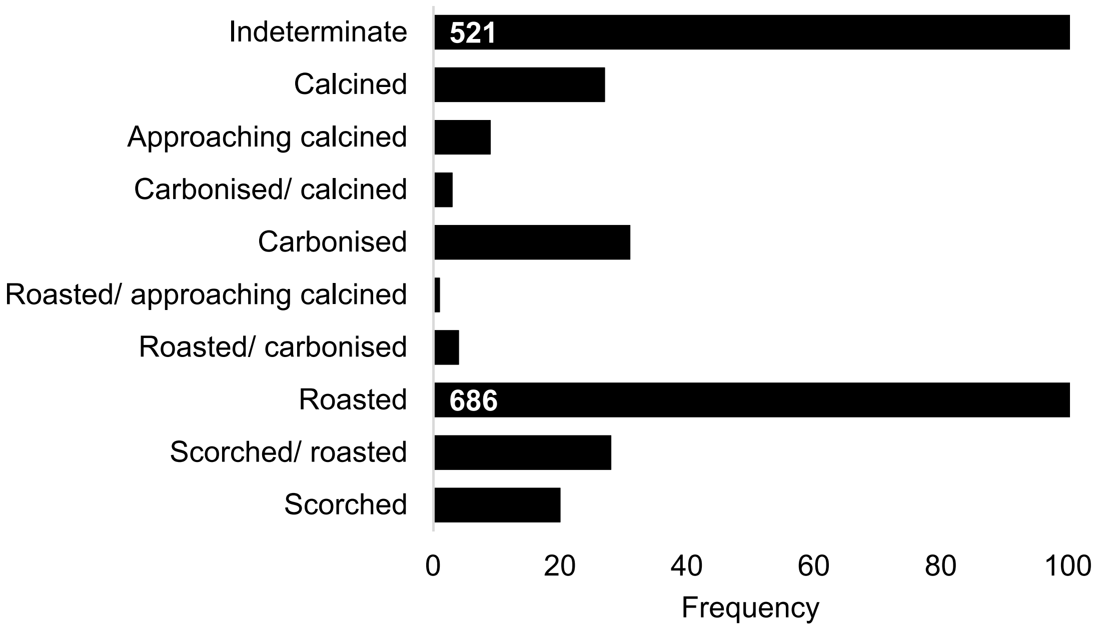

Figure 9.20: Frequency of heat exposure types from Ludwinowo 7. Due to high numbers of roasted identifiable and burnt indeterminate bone the graph is truncated and the frequency of these types displayed at the base of each bar.

9.5.1.1 Context groups

Specimens from LBK phases IIB and III showed remarkably similar levels of burning, whereas the individual context groups were more variable (figure 9.21). House pits were mainly affected by burning largely through roasting, the majority showing similar proportions. House 18, however, was significantly less burnt[4] and House 6 had significantly more heavy burning[5] than other house

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[4] H15, H22, H6, H8 p<.001; H2 p=.006.

[5] H15 p=.002; H18 p=.018; H22 p<.001; H2 p=.002; H8 p=.008.

contexts. Generally, the unassociated pits with houses showed less evidence of heat exposure, however, K82 (225/1129) showed elevated levels of burning compared to K66 (84/1153, p<.001), suggested to be part of ritual, communal consumption of cattle (Marciniak 2005; 2011). This data suggests that the houses were largely similar, but the unassociated pits and clay pits did not conform to a particular trend.

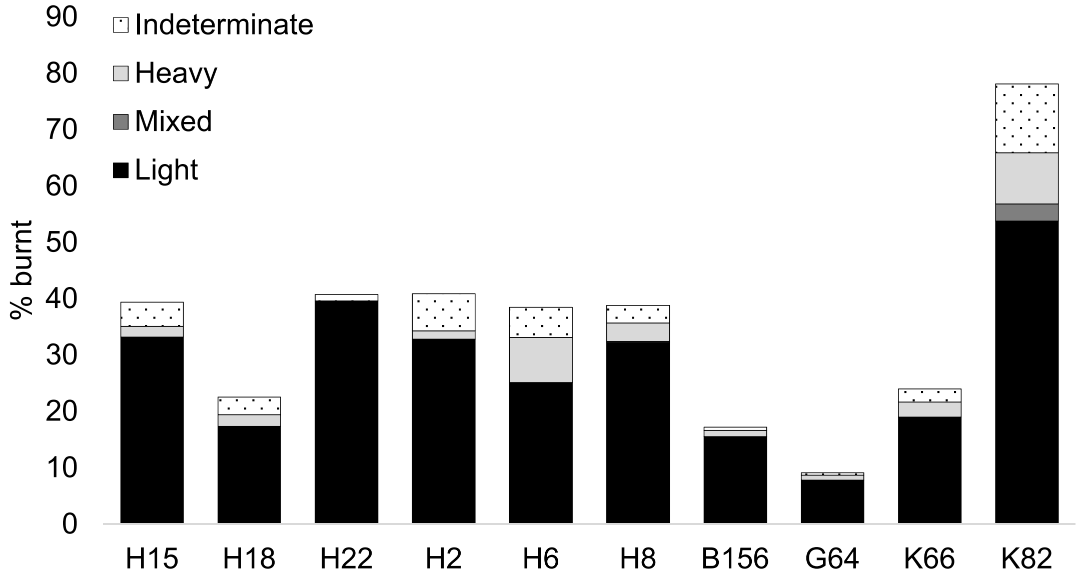

Figure 9.21: Percentage of each context group affected by different intensities of heat exposure from Ludwinowo 7.

9.5.3 Species

All species showed evidence of heat exposure on 20% or more of identifiable specimens (figure 9.22), a particularly high proportion compared to other sites. Wild animal bones were significantly more affected by heat exposure (46.8%, 36/77) compared to domestic food animals (35.3%, 272/771, p=.046). Domestic pigs (25/51) were the most commonly burnt domestic food animal, significantly more than cattle (217/645, p=.026). Marciniak suggests that pigs and cattle were eaten in a similar manner which included roasting of marrow bones (2005; 2011). He argues that caprines were eaten in a different way, although figure 9.22 suggests that caprine bones too were roasted. Specimens of domestic dog showed evidence of high-temperature heat exposure unlikely related to cooking practices.

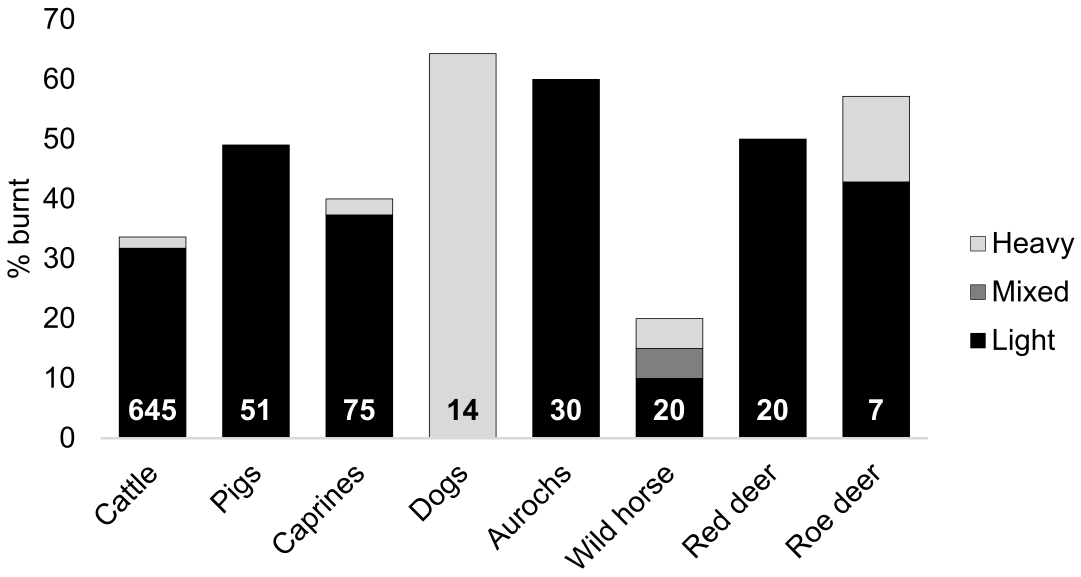

Figure 9.22: Percentage of different species affected by different intensities of burning from Ludwinowo 7. N values are at the base of each bar.

9.5.4 Element

Burning was particularly common on the mandible and metapodia (figure 9.23). It can be suggested that low-yield marrow-bearing bones were roasted before cracking for marrow, as pictured in figures 9.24, 9.25, and 9.26. This practice is corroborated by ethnographic analogy (for example, Kent 1993b: 336) and has implications for the fracture analysis as heating bones can change their fracture characteristics (Pearce and Luff 1994; Subías 2002; Karr and Outram 2012). Alternatively, low-yield marrow bearing bones could show elevated levels of burning through articulation with roasted meat-rich elements.

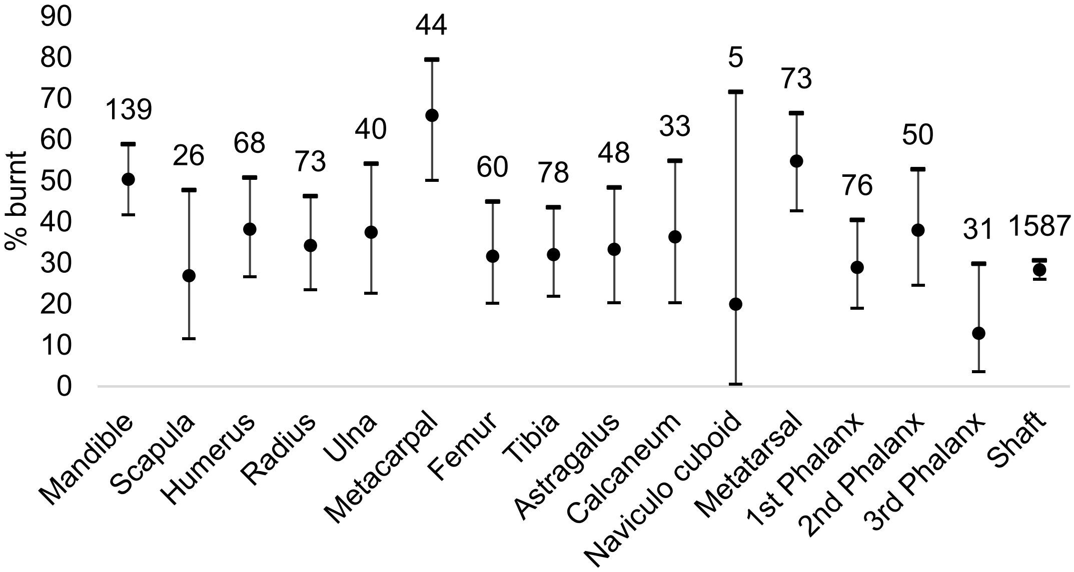

Figure 9.23: Percentage of elements affected by burning from Ludwinowo 7, with 95% confidence intervals.

Figure 9.24: Left cattle mandible tooth row showing signs of roasting and fracture from Ludwinowo 7.

Figure 9.25: Cattle left metacarpal showing signs of roasting and fracture from Ludwinowo 7.

Figure 9.26: Cattle first phalanx showing signs of roasting and crushing, perhaps to expose the small marrow cavity, from Ludwinowo 7.

9.6 Fracture

9.6.1 Site

Fresh fracture was present on 44.3% (812/1831) of fractured bone from Ludwinowo 7, indicating that marrow extraction took place on site (figure 9.27). High-yield bones were more often affected by fresh fracture than low-yield bones, suggesting that they were preferentially targeted for marrow extraction, although this certainly was not undertaken as intensively as at other sites studied (e.g. in the Rhine Valley, Chapters 14 and 15).

The site presents an assemblage with a large proportion of dry first fracture, affecting 50.8% (931/1831) of marrow-bearing bones. The mean Fracture Freshness Index suggests a mix of fractures at 3.6, of which most were completely dry (6) but some showed mixed fracture characteristics (3; figure 9.28). The proportion of secondary dry fracture indicates that bones that had been fractured when fresh were perhaps not always buried immediately, allowing them to be affected by taphonomic fracture caused by, for example, carnivore gnawing, trampling or secondary deposition.

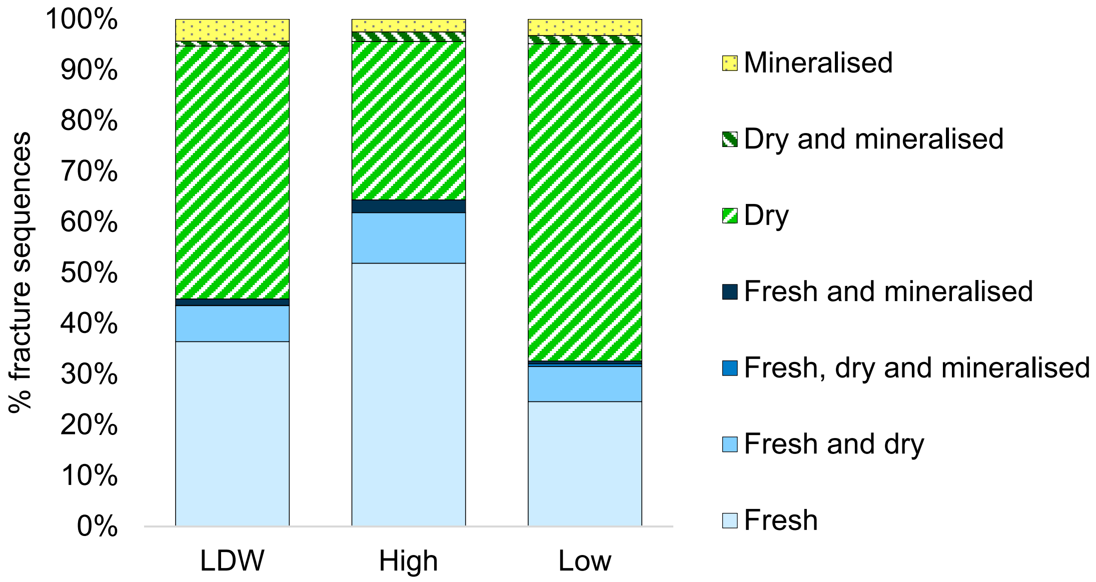

Figure 9.27: Fracture history profiles for Ludwinowo 7 (n=1831) and for high- and low-yield marrow bones (n=160/187).

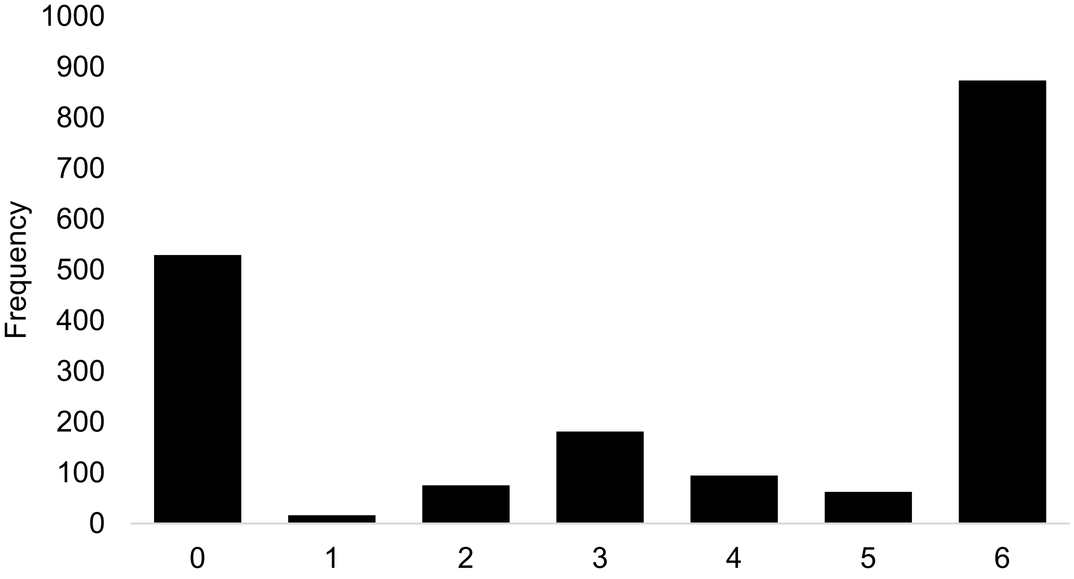

Figure 9.28: Frequency of Fracture Freshness Index scores from Ludwinowo 7.

9.6.1.1 Phase fracture

Between LBK phase IIB (44.2%, 272/615) and III (45.6%, 531/1164) there was a very slight increase in the proportions of fresh fracture, although the mean FFI remained the same at 3.6 for both phases (figure 9.29). There was a significant increase in the proportion of mineralised fracture (IIB 5.9%, 36/615; III 7.3%, 85/1164; p=.044), suggesting disturbance of later contexts was more common. In phase IIB high- and low-yield marrow-bearing bones were fractured freshly in roughly equal proportions, whereas in LBK phase III the difference was much greater (figure 9.30). It is possible that the practice of consuming marrow became more focussed on the high-yield elements over time. However, the LBK phase III isolated clay pits, which showed very high proportions of fresh fracture (figure 9.33), could have influenced phase fracture proportions.

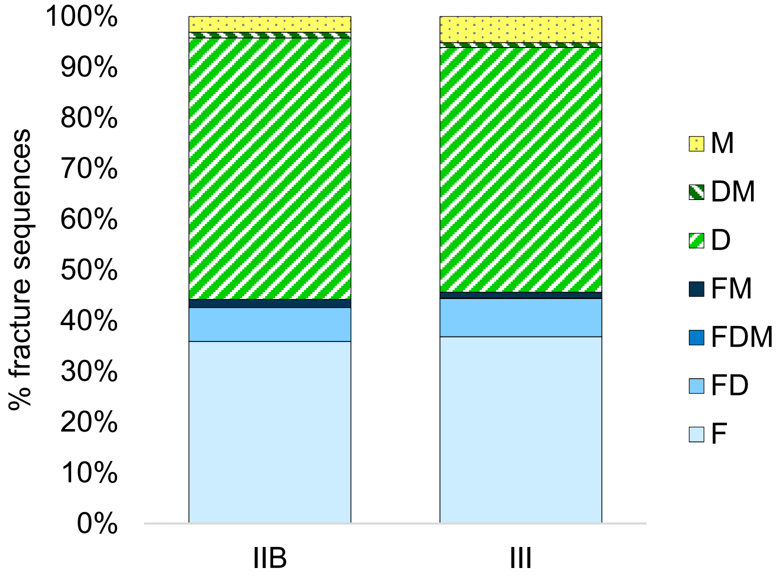

Figure 9.29: Fracture history profiles for LBK phase IIIB (n=586) and III (n=549) from Ludwinowo 7.

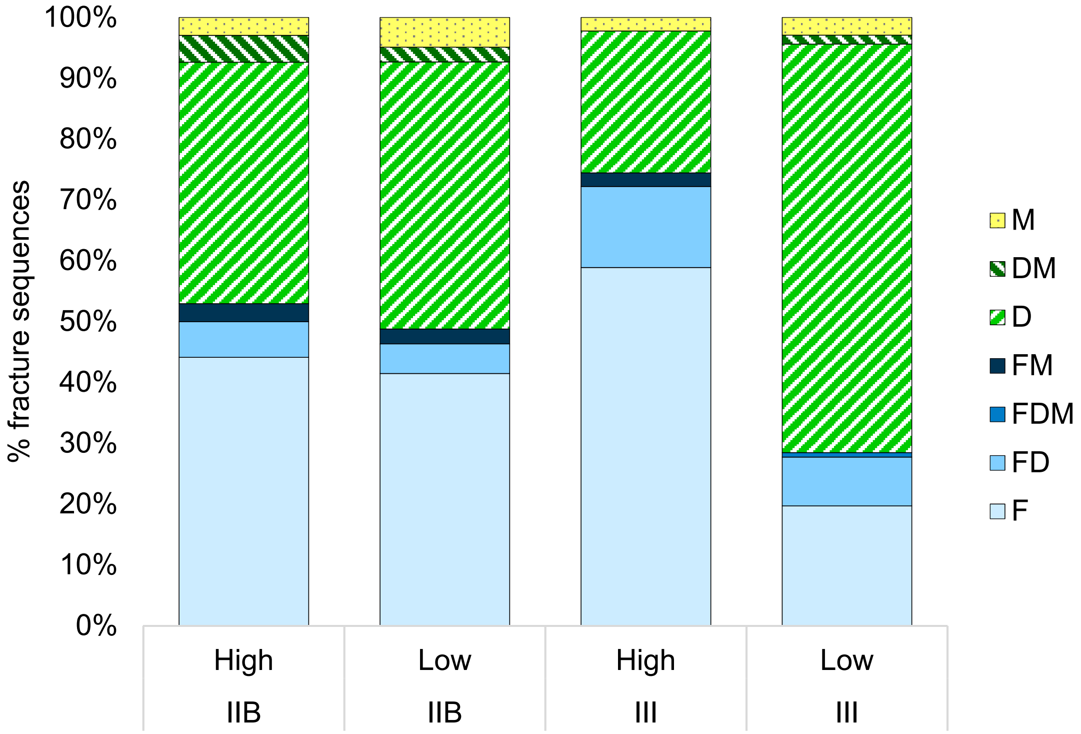

Figure 9.30: Fracture history profiles for high- and low-yield marrow bones from LBK phase IIB (n=68/41) and III (n=90/137) from Ludwinowo 7.

9.6.1.2 Context groups

The different context types at Ludwinowo 7 show varying trends in fracture history (figures 9.31 and 9.32). House pits present a somewhat average proportion of fresh fracture compared to the isolated contexts, where isolated clay pits featured high proportions of fresh fracture and systematic fracture of high-yield elements and pit contexts contained drier fracture proportions than house and clay pits. These trends could suggest differential carcass processing and deposition practices in different context types, analysed in greater depth below.

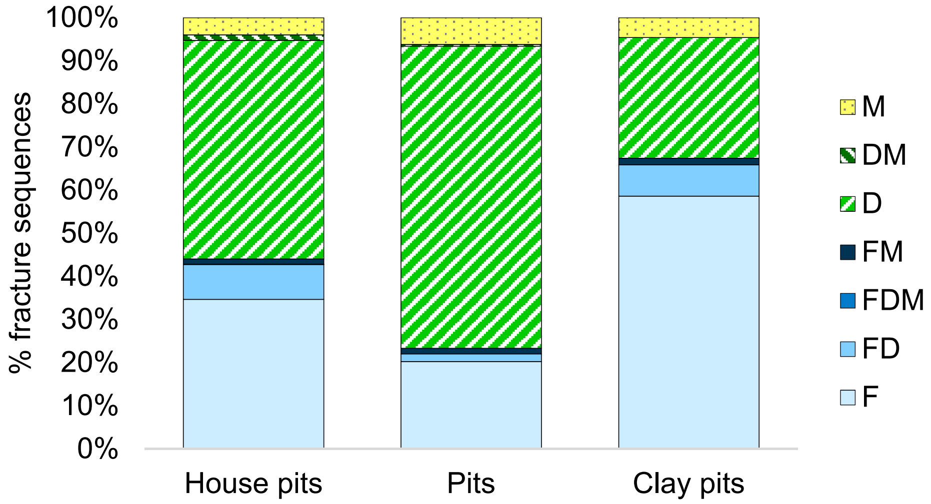

Figure 9.31: Fracture history profiles for house pit (n=1312), isolated pit (n=227) and isolated clay pit (n=261) contexts from Ludwinowo 7.

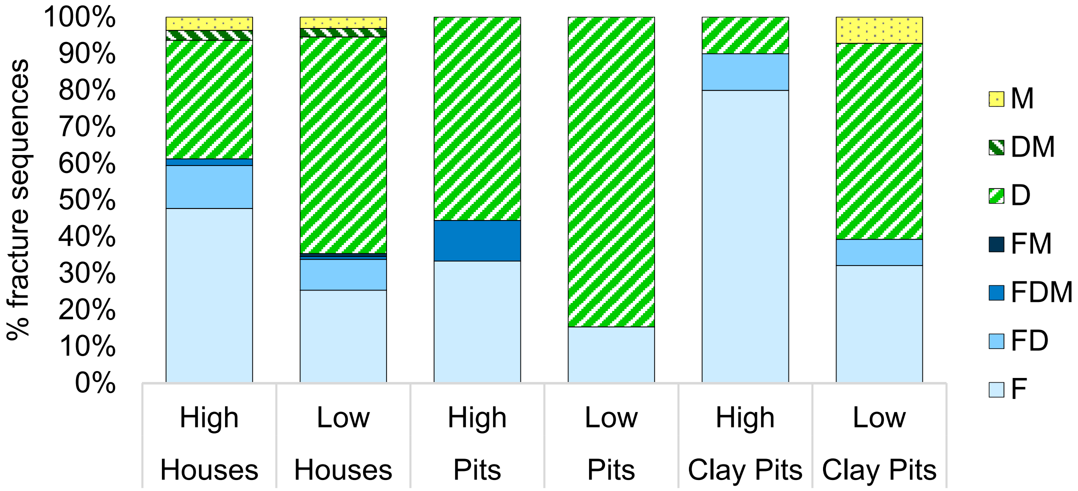

Figure 9.32: Fracture history profiles for high- and low-yield marrow bones from house pit (n=111/130), isolated pit (n=18/26) and isolated clay pit (n=30/28) contexts from Ludwinowo 7.

9.6.1.2.1 House pits

The house pits showed consistent levels of fresh fracture, although there were some exceptions to this trend. Houses 2 and 8 in LBK Phase III had slightly elevated levels of fresh fracture compared to the phase IIB houses, whereas House 6 showed significantly reduced levels of fracture freshness compared to the other phase III houses ($p<.001$; for values see table 9.8; figures 9.33 and 9.34). House 6 contained several dog bones fractured when dry or mineralised ($n=3$) although this was unlikely the sole cause for such a drier assemblage. There was some secondary fracture notable in the house pits, particularly House 18 and House 2, perhaps suggestive of some post-depositional breakage. Overall, these selected house contexts indicate that marrow was exploited in these contexts, but not as intensively as in the clay pits or as other houses from other analysed sites (for example Polgár-Csőszhalom).

9.6.1.2.2 Isolated pits

The two isolated pits, pit B156 and G64, were not as obviously comparable as the house pits. Whilst both had similarly low levels of fresh fracture, pit B156 featured high proportions of mineralised and secondarily mineralised fracture (figure 9.33). B156 also showed high levels of butchery, burning and erosion compared to G64. These patterns could suggest that material in B156 was deposited or disturbed in the pit after the organic content of bone had been lost. A dominance of low-yield marrow bones in B156 compared to G64 could have also contributed to high levels of dry and mineralised fracture due to high levels of specimens not usually targeted for marrow extraction (figure 9.34). The likely interpretation for these contexts is that they were isolated depositions that were unrelated to each other, perhaps used for random depositions of temporary middens or site refuse that had been subjected to taphonomic fracture.

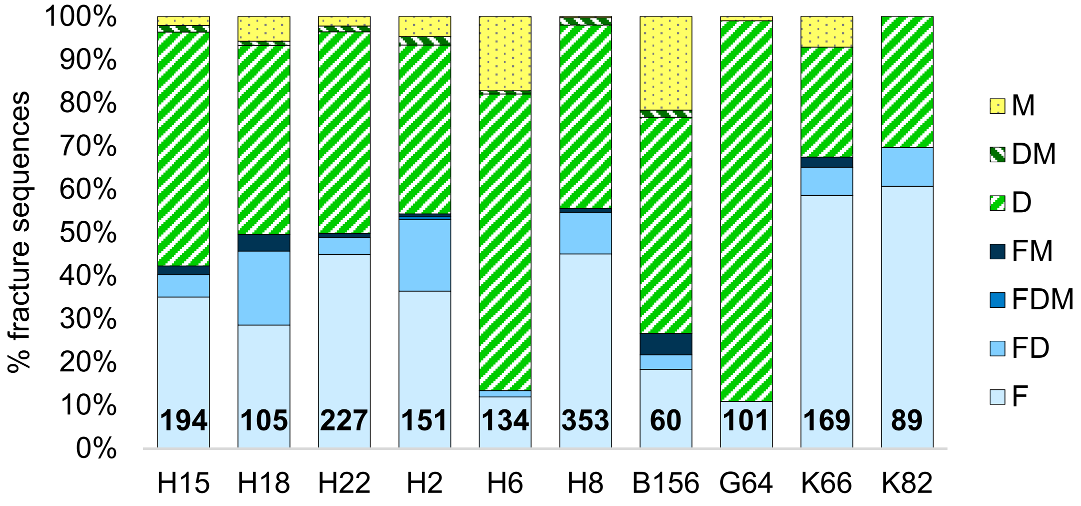

Figure 9.33: Fracture history profiles for each context group from Ludwinowo 7.

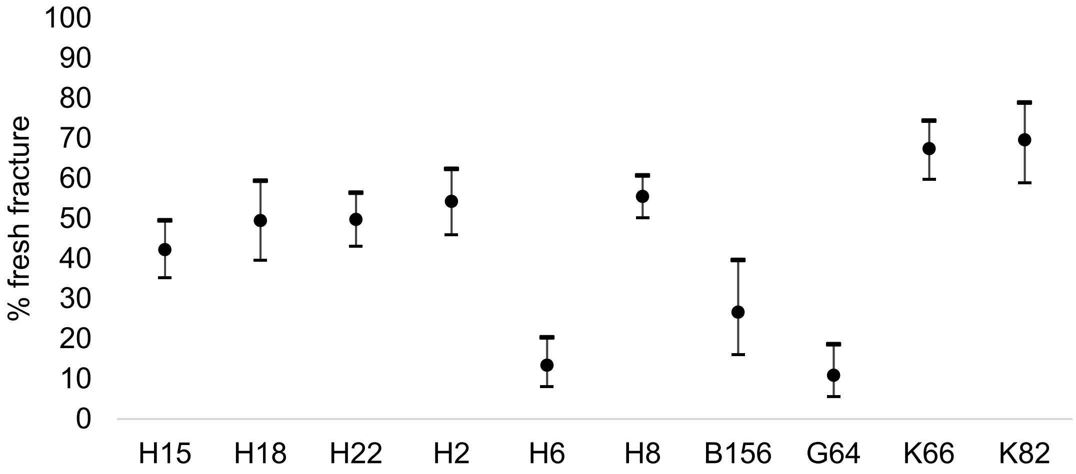

Figure 9.34: Percentage of fractured bones that were fractured when fresh from each context group from Ludwinowo 7, with 95% confidence intervals.

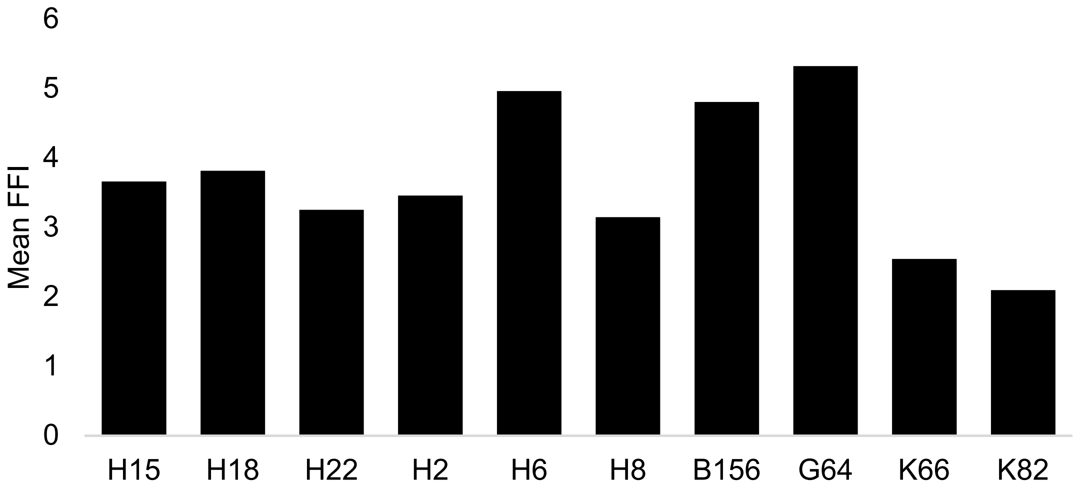

Figure 9.35: Mean Fracture Freshness Index scores for each context group from Ludwinowo 7.

Table 9.8: Fracture history values for context groups from Ludwinowo 7. F = Fresh, D = Dry, M = Mineralised, N = number of fractured bones.

Context	LBK Phase	F	FD	FDM	FM	D	DM	M	N
LDW	IIB	667	130	1	23	913	18	79	1831
H15	IIB	68	10	0	4	105	3	4	194
H18	IIB	30	18	0	4	46	1	6	105
H22	III	102	9	0	2	106	3	5	227
H2	III	55	25	1	1	59	3	7	151
H6	III	16	2	0	0	92	1	23	134
H8	III	159	34	0	3	150	6	1	353
B156	III	11	2	0	3	30	1	13	60
G64	III	11	0	0	0	89	0	1	101
K66	III	99	11	0	4	43	0	12	169
K82	IIB	54	8	0	0	27	0	0	89

9.6.1.2.3 Isolated clay pits

The clay pits were clearly different from the two other contexts types. These two contexts are parts of a pit complex in the same area and phase although they do not directly abut. Both K82 and K66 had very high levels of fresh fracture and a high disparity in the amount of fresh fracture between high- and low-yield elements. This was especially notable in the humerus, radius and tibia as over 90% (n=26) of these elements were fractured freshly. This supports the argument that there was a tradition of ritual feasting and marrow consumption in clay pits (Marciniak 2011: 125). Elevated levels of heat exposure in K82 in particular supports Marciniak's argument that roasting of cattle bones was a method of marrow consumption particular to spaces between the longhouses (*ibid.*), although it shows that within this practice there was also variation.

9.6.1.2.4 Summary

Using correspondence analysis, the association between different archaeological features is displayed based on their fracture histories. The contextual groupings are highlighted, with the house pits clustered in the centre of the graph showing association with fresh and dry fracture (9.36). House 18 and house 6 show more association with secondary dry and mineralised fracture, which is to be expected based on the individual fracture history profile (figure 9.35). The clay pits (K66 and K82) associate with each other and with fresh fracture, whereas the isolated pits B156 and G64 do not group with each other or with any other contexts, which corroborates the suggestion of different depositional histories between these contexts.

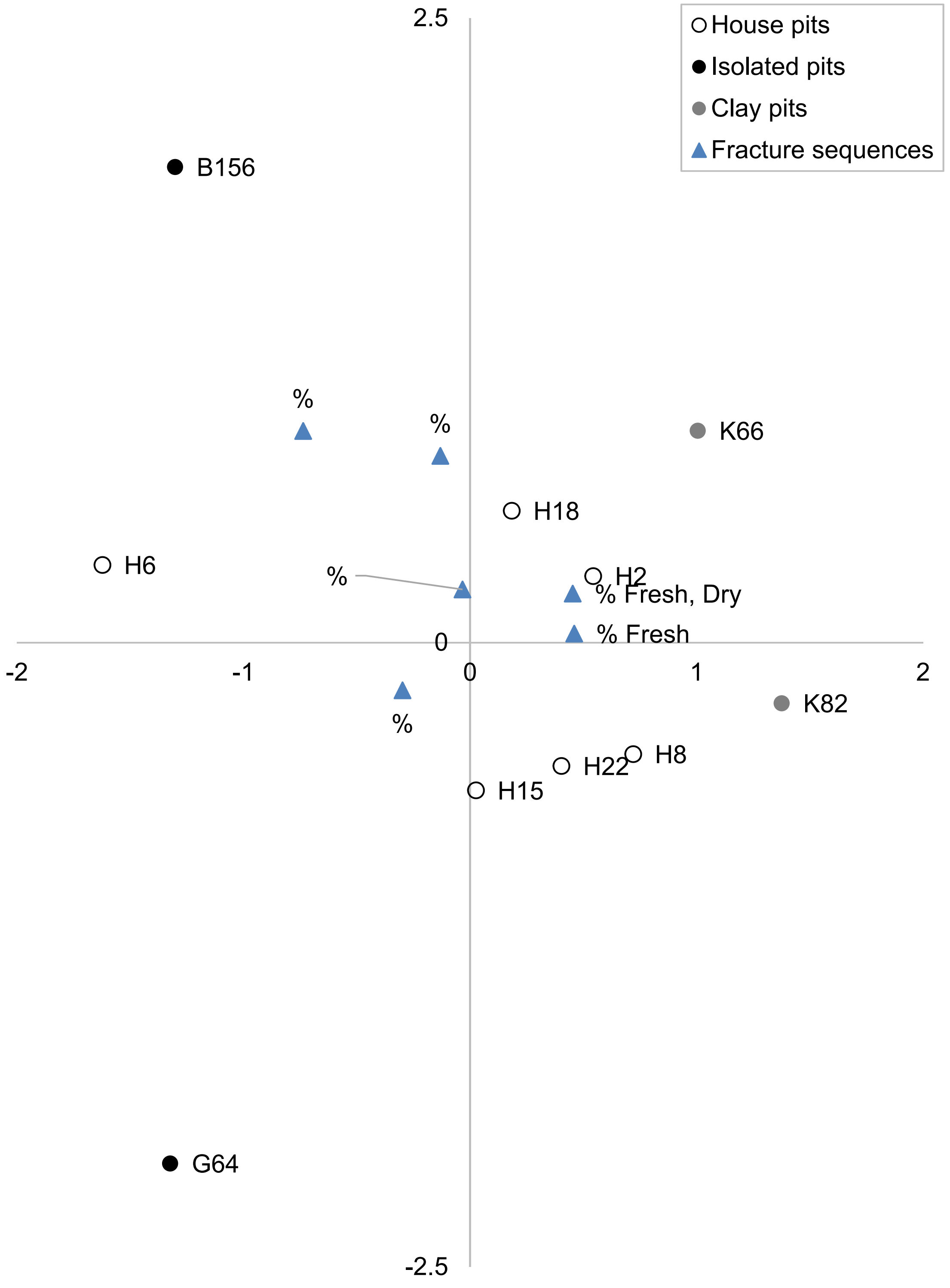

Figure 9.36: Correspondence analysis for the proportion of the different fracture sequences affecting the comparable contexts from Ludwinowo 7.

9.6.2 Species

Sample sizes were fairly low when comparing fracture freshness analysis between species. Figure 9.37 shows that wild animals (aurochs, wild horse and red and roe deer) were the species most often fractured when fresh, closely followed by cattle. Caprines and pigs were also often fractured when fresh, although a much larger proportion of mineralised fracture was detected on pig bones. Dog bones were consistently fractured when dry or mineralised, suggesting no evidence for marrow extraction on dog bones. These patterns were similarly mirrored in the mean Fracture Freshness Index (figure 9.38). The high and low-yield analysis (figure 9.39) suggests that cattle and pig bones were targeted for marrow but caprine bones were not in the same way. The bones of wild animals were fractured fairly freshly for both high and low-yield, suggesting that marrow from these species was particularly favoured regardless of marrow yield.

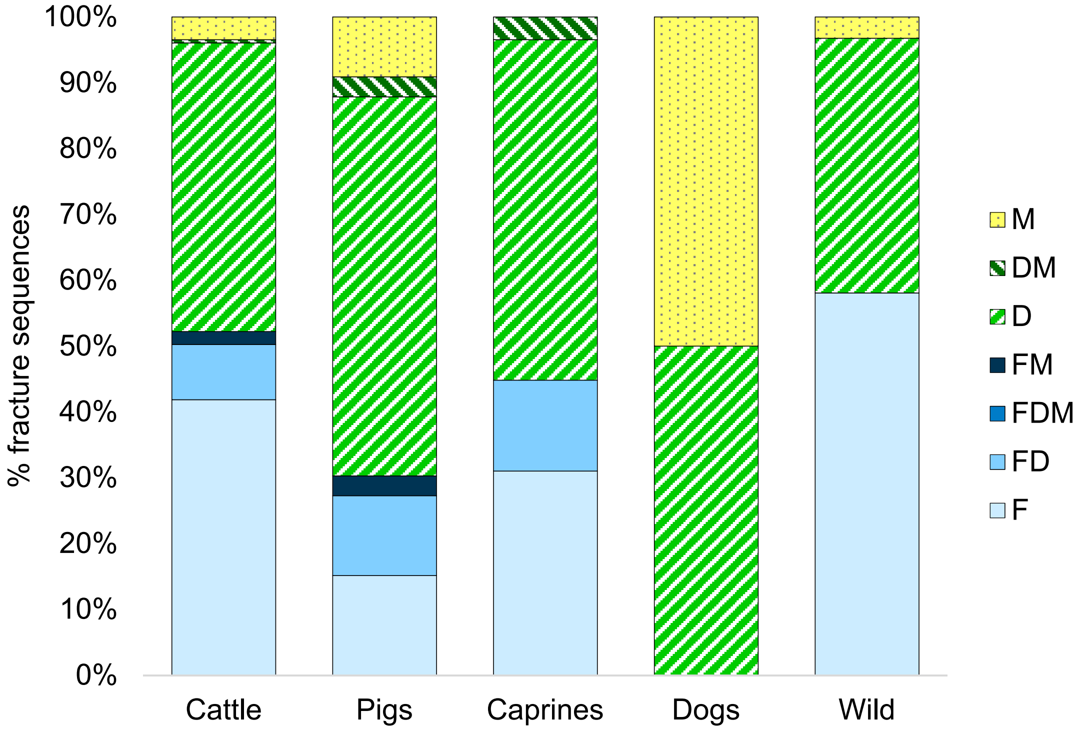

Figure 9.37: Fracture history profiles for cattle (n=203), pigs (n=33), caprines (n=29), dogs (n=4) and wild animals (aurochs, red and roe deer and wild horse n=31) from Ludwinowo 7.

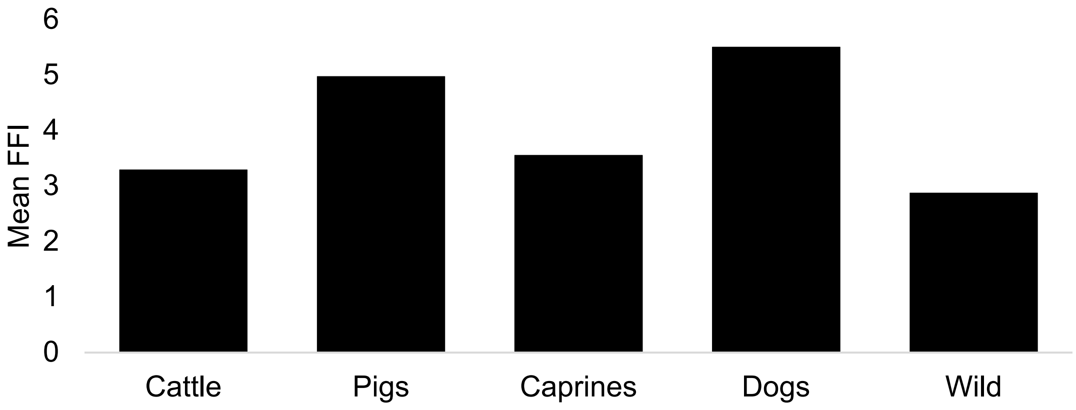

Figure 9.38: Mean Fracture Freshness Index scores for different species from Ludwinowo 7.

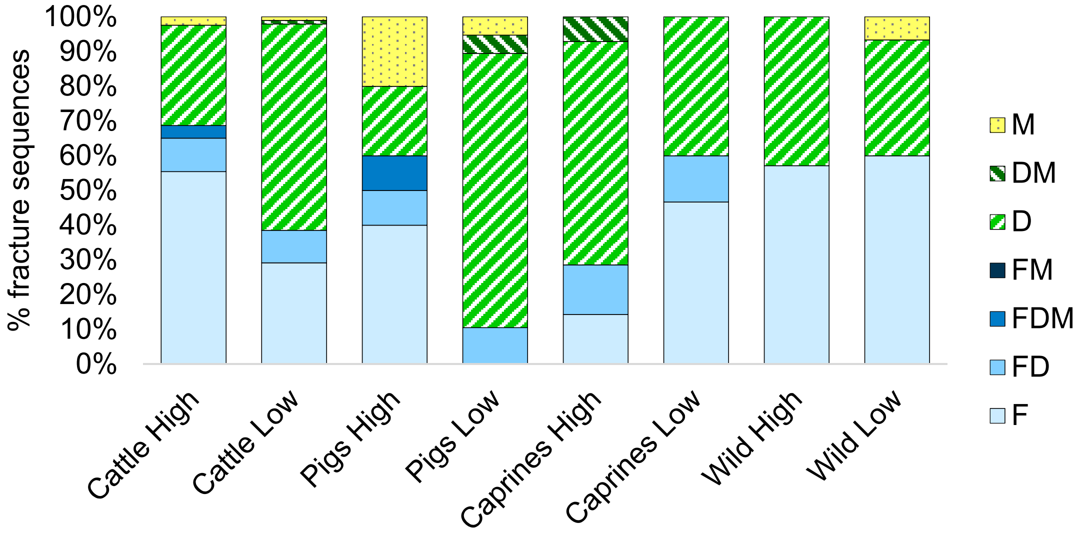

Figure 9.39: Fracture history profiles for high- and low-yield marrow bones for cattle (n=83/96), pigs (n=10/19), caprines (n=14/15) and wild species (n=14/15) from Ludwinowo 7.

9.7 Fragmentation

The sampled assemblage from Ludwinowo 7 showed greater fragmentation than other LBK sites, and yet did not present the expected pattern for intensive bone grease processing. Figure 9.40 shows that the smallest size classes were not overrepresented by weight, suggesting comminution into bone-grease-processing size fragments was not commonplace. The proportion of cancellous material under 40mm in diameter again does not present a classic pattern of intensive bone grease processing (figure 9.41). As suggested below, the increased fragmentation of the other size classes could be in part due to the high levels of post-excavation breakages and poor preservation found on the site.

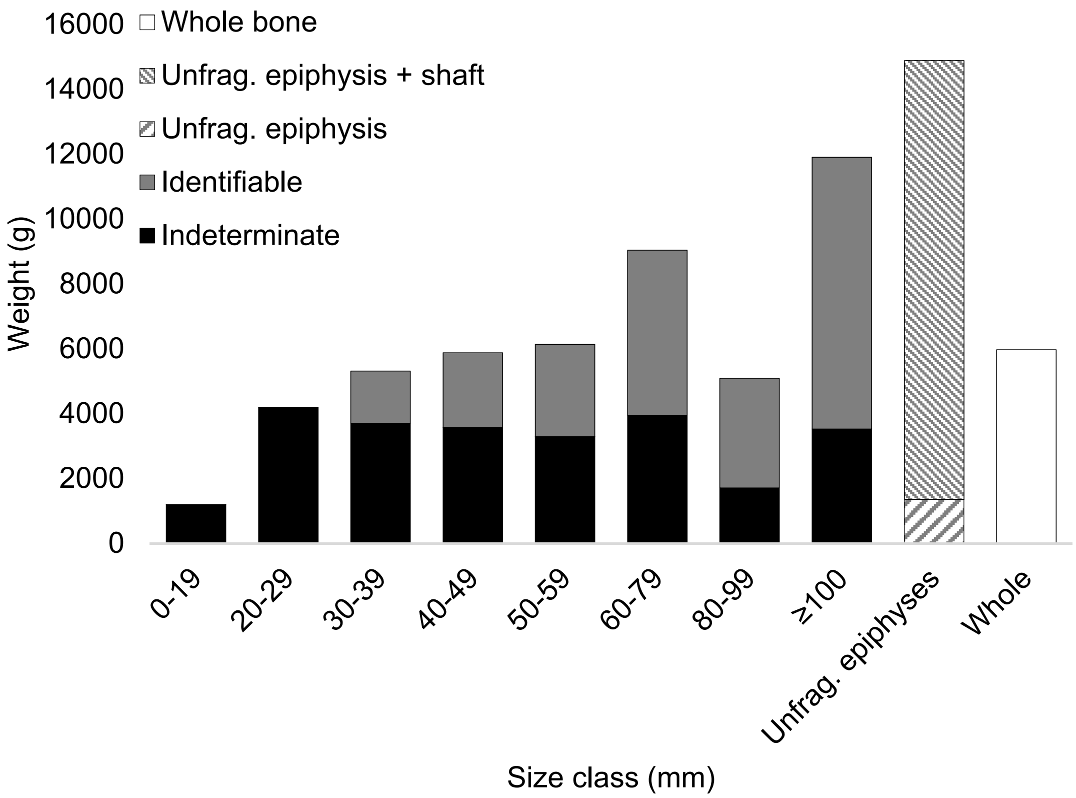

Figure 9.40: Weight by size class for all specimens from Ludwinowo 7.

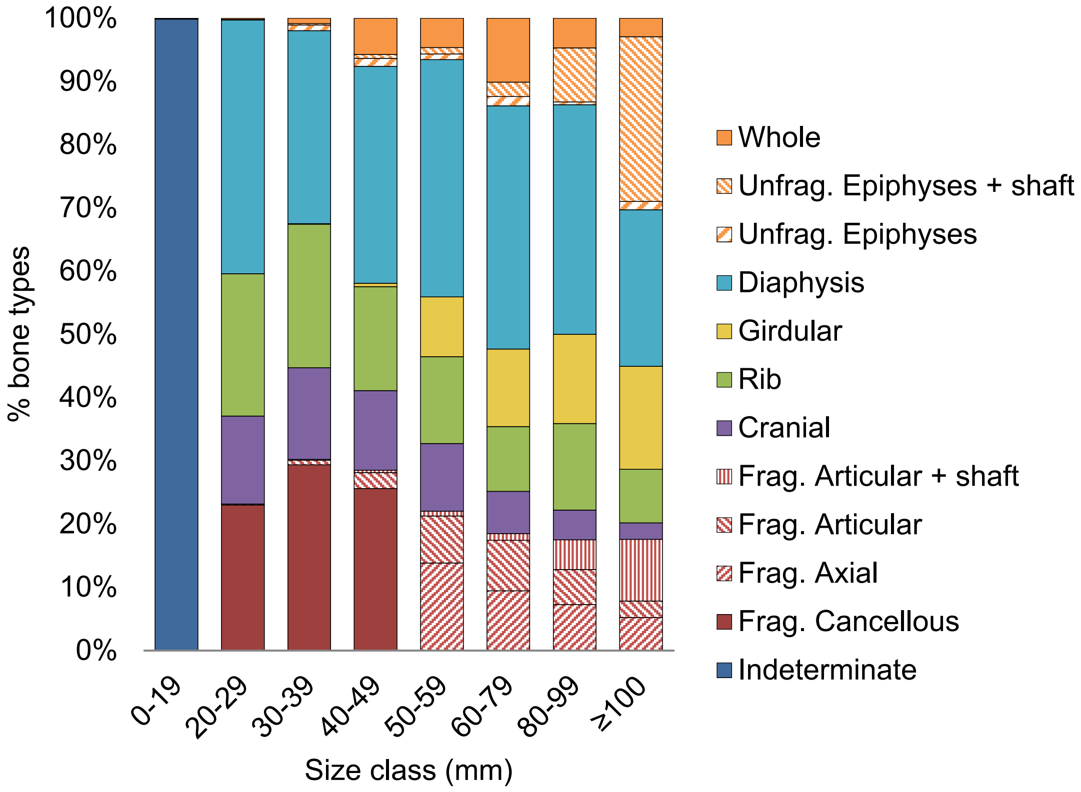

Figure 9.41: Frequency of bone types by size class from Ludwinowo 7. Red series indicate fragmented cancellous remains.

9.8 Taphonomy

9.8.1 Gnawing

Evidence of gnawing on the sampled assemblage affected 0.8% (101/13429) of specimens and 3.1% (80/2568) of the identifiable assemblage. Gnawing was predominantly identified as canid (n=68) although rodent gnawing was also observed (n=12). Gnawing was rare (>1% of the whole assemblage) on all context types, although there were some differences. Incidences of gnawing were most common in isolated pits, perhaps suggesting secondary deposition of these contexts, with time allowed for canids to scavenge (figure 9.42). Rodent gnawing was only discovered in pits associated with houses, which showed slightly less proportions of gnawing than isolated pit contexts. The clay pits had the lowest levels of gnawing, which could suggest that they were single-event contexts that were covered quickly. Despite these postulations, the proportions of canid gnawing were not significantly different between context types, and it is likely that these low levels of carnivore activity did not contribute to the high levels of fragmentation as described above.

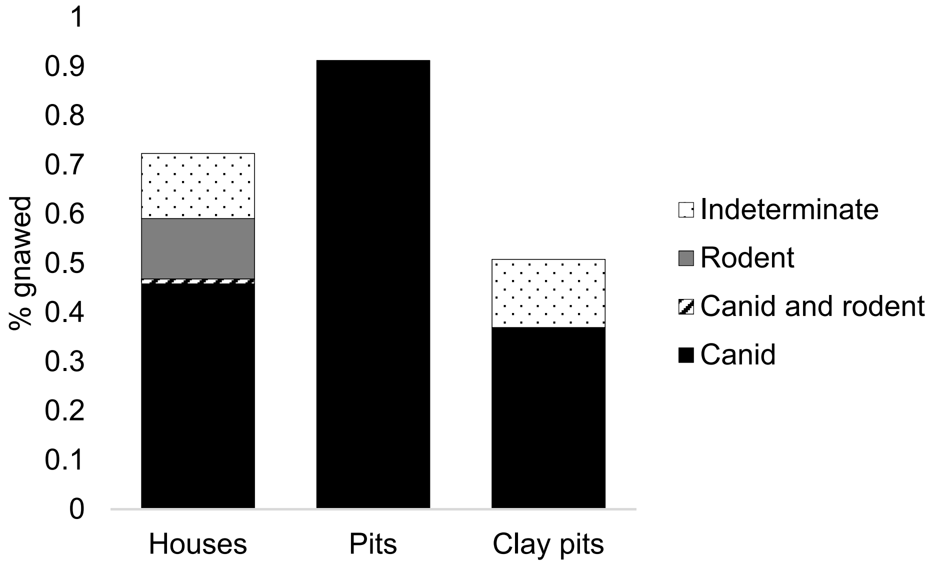

Figure 9.42: Percentage of house pit, isolated pit and isolated clay pit contexts affected by incidences of gnawing from Ludwinowo 7.

9.8.2 Taphonomic agents and recent breaks

Taphonomic agents were rarely identified at Ludwinowo 7. Weathering was very occasionally observed on 0.1% (2/2568) of identifiable material, suggesting contexts were not long left exposed. Erosion caused destruction of fracture and bone surfaces, affecting 2.8% (72/2568) of the identifiable assemblage. It was particularly common in context B156 and House 6 (figure 9.43), which suggests it could be related to dry fracture and perhaps secondary deposition. Root etching was observed on 4.0% (102/2568) of the identifiable assemblage, particularly in House 2.

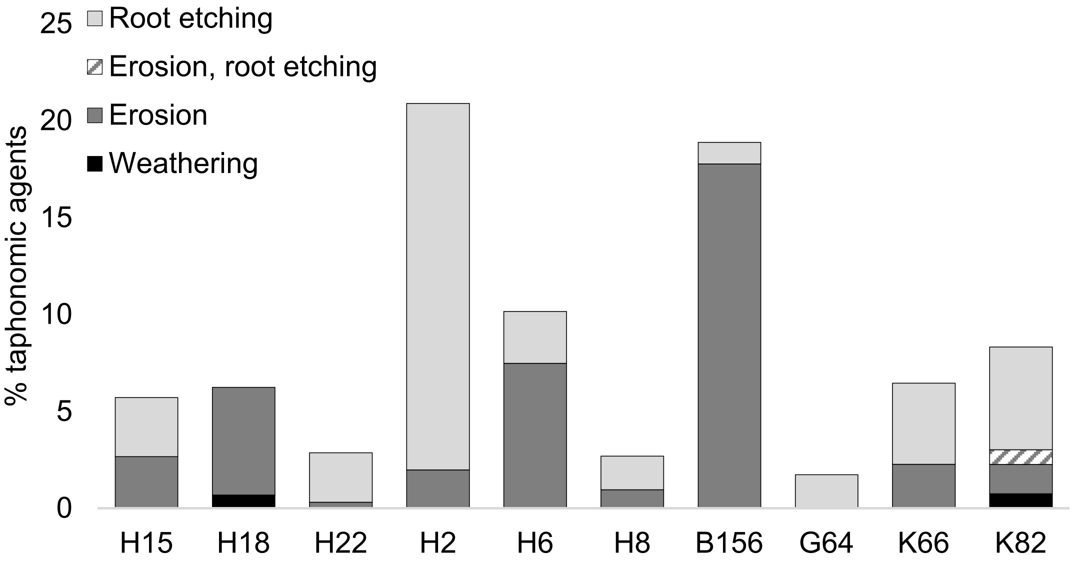

Figure 9.43: Percentage of the identifiable assemblage from each context group affected by taphonomic agents from Ludwinowo 7.

Recent breaks affected 25.8% (663/2568) of the bones in the identifiable assemblage, and many more indeterminate bones, obscuring fracture surfaces and thus impeding fracture freshness analysis in particular. Fragmentation analysis was also affected as many of the smallest bones in the assemblage had fractured recently, meaning that the smallest size classes (0-30mm diameter) were likely over-represented. The worst affected comparable context was G64 (see figure 9.44).

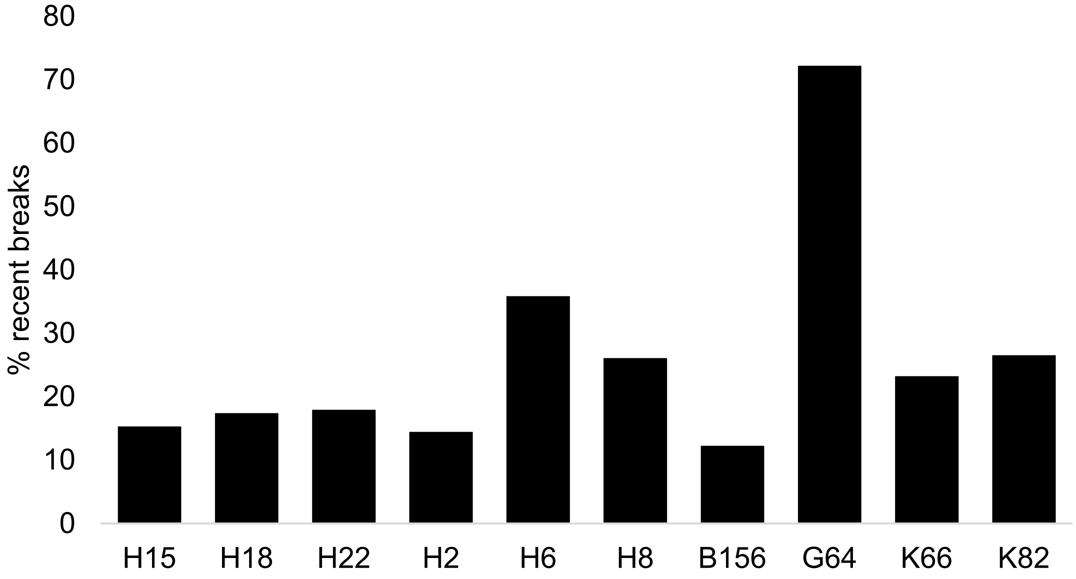

Figure 9.44: Percentage of the identifiable assemblage from each context group affected by breaks during or after excavation from Ludwinowo 7.

9.9 Food exploitation strategies

9.9.1 Herd structure analysis

9.9.1.1 Cattle

It was possible to separate cattle epiphyseal fusion profiles into LBK phase IIB and III slaughter patterns (figures 9.45 and 9.46). Phase IIB fusion showed very little slaughter before 2 years, followed by a large kill off between 2 and 4 years with 54.8% (17/31) of adults surviving into fusion maturity (over 3 years old). While surviving adult females could have been milked, young male slaughter associated with intensive milking economies is not present. Males were likely killed at optimum meat weight. In LBK phase III there was an earlier kill off between 1.5 and 3 years, followed by continued survival into fusion maturity. This could indicate a shift in herd management strategy over time, perhaps focussing on younger meat.

The age-at-death analysis based on tooth eruption and wear suggests further changes in herd management over time (Smyth *et al.* in prep.), although some trends were not identified by the fusion analysis. In phase IIB, the mortality profiles suggest slaughter of young males of optimum weight for meat (15-26 months). Low intensity milk exploitation is also likely, based on potential evidence of post-lactation slaughter (3-15 months) and a strong presence of adult animals, likely lactating. It is probable that phase IIB represents low intensity milk exploitation, with the majority slaughtered at 15-26 months for meat. In LBK phase III there was stronger evidence for dairy exploitation with post-lactation slaughter of young animals and a continued presence of meat-age slaughter and adult animals (Smyth *et al.* in prep.). It is possible that differences in fusion and dental analysis were caused by biases in taphonomy or differential deposition, or by the sample analysed, as the dental analysis included all teeth from the site.

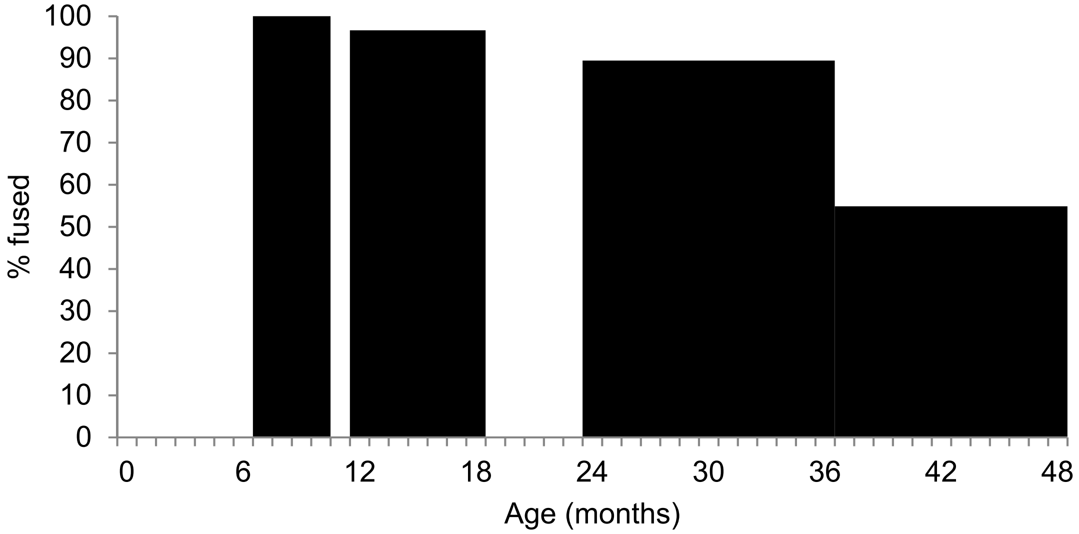

Figure 9.45: Cattle slaughter profile based on epiphyseal fusion from LBK Phase IIB from Ludwinowo 7 (n=85).

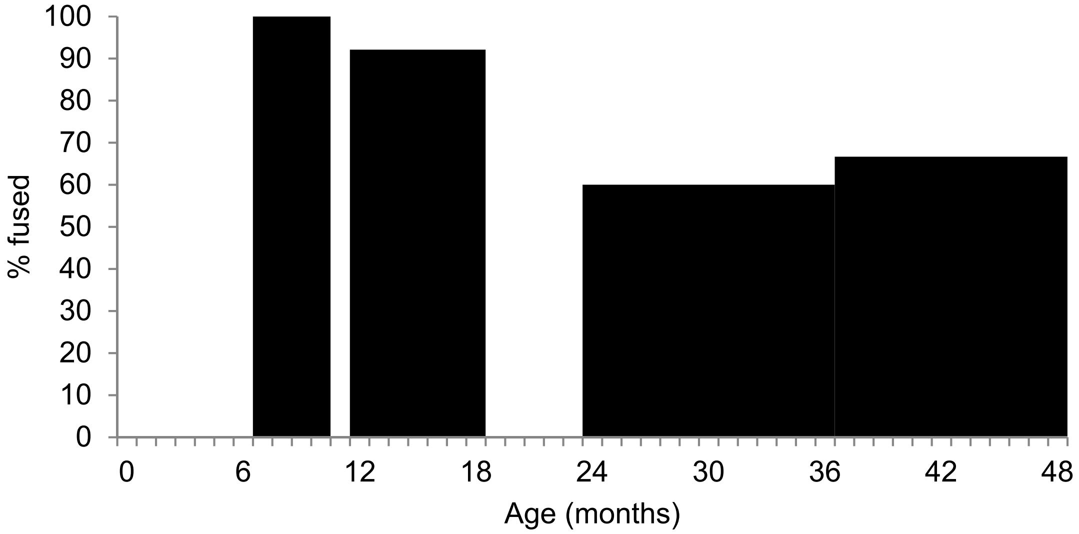

Figure 9.46: Cattle slaughter profile based on epiphyseal fusion from LBK Phase III from Ludwinowo 7 (n=79).

9.9.1.2 Context groups

There were some differences in slaughter patterns by context type. Consumption of adult animals is suggested in house, pit and clay pit contexts, but animals deposited in clay pits more often had reached fusion maturity than those deposited around houses and in isolated pits (figure 9.47). 87.5% (7/8) of specimens that fuse in age stage 4 had reached fusion maturity in in clay pits, as opposed to 66.6% (8/12) of pits and 53.3% (24/45) of house pits. Slaughter of animals younger than 18 months was only in evidence in house and isolated pits. This could indicate consumption of animals of specific ages in different contexts, and particularly that adult animals, perhaps that had even passed optimum meat weight and age, were often consumed in the clay pits.

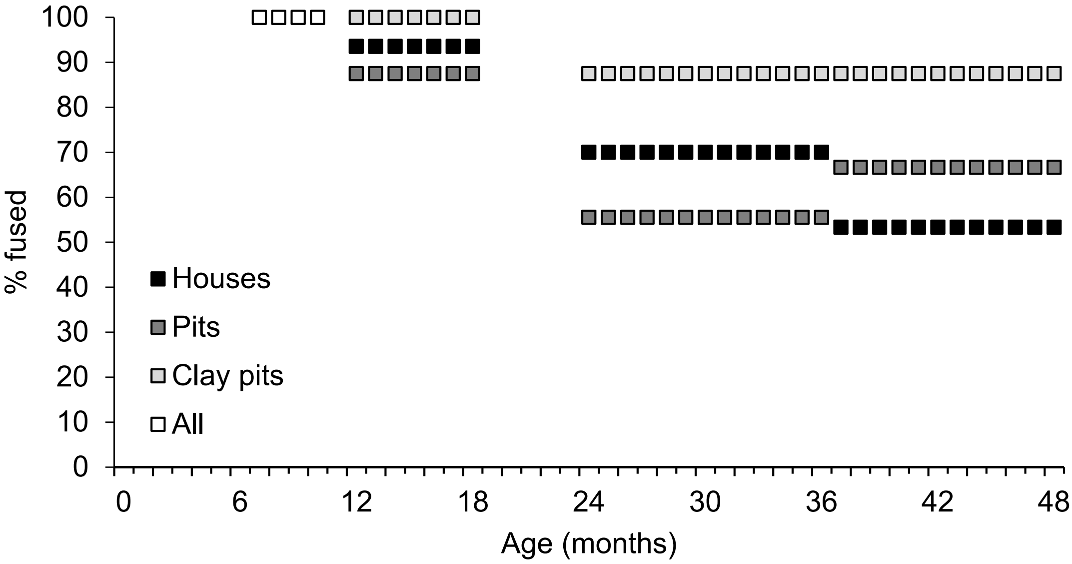

Figure 9.47: Cattle slaughter profiles based on epiphyseal fusion from house pit (n=167), isolated pit (n=38) and clay pit (n=49) contexts from all phases from Ludwinowo 7.

9.9.2 Lipid residue analysis

Lipid residue analysis indicates multiple use of ceramics at Ludwinowo 7, and highlights the likelihood of dairying. The presence of adipose fats in Kümpfe suggests that pots were used to process animal carcass parts (Smyth *et al.* in prep.; Salque *et al.* 2013), indicating that bones were either pot-sized and cooked with meat attached, or that meat was filleted before cooking. Beeswax was also detected in collared flasks, suggesting active use of bee products perhaps as waterproofing agents (Salque *et al.* 2013; Smyth *et al.* in prep.). One of the most significant finds from the lipid residue analysis was that perforated pottery sherds were found to contain evidence of dairy fats, and were thus suggested to be sieves used in cheese making (Salque *et al.* 2013). This implies a rich dairy economy, corroborated by evidence for a cattle rich faunal assemblage (see also Osypińska 2011) and primarily the dental herd structure analysis, particularly that from teeth.

9.10 Discussion

The cattle-rich assemblage from Ludwinowo 7 showed evidence of standardised marrow processing practices in an economy where dairying and cheese production have been identified.

9.10.1 Meat and fat exploitation

Based on the optimum meat age slaughter represented in the fusion and dental age-at-death analysis and the high representation in the NISP it is likely that prime cattle meat formed a large proportion of diet in Ludwinowo 7. Evidence suggests that carcass processing practices were standardised to some degree, particularly in the skinning and disarticulating of the carcass (figures 9.48 and 9.49). Butchery indicating skinning was identified on metapodia and phalanges of both ruminants and suidae. Dismemberment butchery patterns were fairly intensive, at the mandibular hinge, on the proximal humerus and elbow joint, at the hip, tarsals and possibly at the junction between metapodia and phalanges. Butchery patters suggesting filleting were present on all meaty bones. It is possible that once meat was removed from the bone it was cooked in pots based on the lipid residue analysis, although high frequencies of roasted bones suggests that boiling was not the only cooking method used on animal bones.

Filleted bones were commonly fractured for marrow, particularly high-yield elements. The low-yield mandible and metapodia could have been roasted before fracture. Whilst fragmentation on the site was high, it is likely that a signature for intensive bone grease processing is not in evidence. Taphonomic instances before and particularly after burial, including erosion of this shallow site as described by Pyzel (2012: 163) and high levels of post-excavation fracture, likely caused the relatively high levels of fragmentation. It is of course possible that grease processing was happening elsewhere on the site, or that the dietary availability of dairy fats negated the need for intensive grease processing.

Carcass processing was undertaken with varying intensity across the site, depending on the context. For the house contexts, the fracture history profiles showed a fairly even split between dry and fresh first fracture. In these contexts marrow was perhaps processed as and when required, and not as intensively as in the clay pits. It also was suggested that the house pits had a medium life time, being open for enough time to cause some secondary fracture. The unassociated pits were similar to the houses but had a larger amount of dry fracture. It is possible that these pits represent depositions from temporary middens around the site, based also on taphonomy. The clay pits, on the other hand, were the 'freshest' of the comparable contexts. The interpretation for these pits is that they were short-lived contexts involving a feast with intensive marrow processing of animal bones, with cattle perhaps of a certain age the primary focus.

Table 9.9: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Ludwinowo 7.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	64	25	70	27	44	18	75	50	13	67	60	36	49	48
Suidae	100	1	50	4	0	2	75	4	11	19	-	-	-	-
Caprines	50	4	50	4	-	0	14	7	0	1	50	4	75	8

9.10.2 Conclusion

The site of Ludwinowo 7 presents a particularly interesting case study for the NeoMilk project. Analysis by phase shows an intensification of dairying practices over time, but no change in the intensity of marrow processing, as could be expected if the sole purpose of bone fracture was nutritional value. However, an increase in burning and the spatial differences between house and clay pits could suggest ritual marrow processing of cattle in phase III. This in turn implies that with the intensification of milk, and thus a decrease in the nutritional need for marrowfat, marrow may have taken on a more ritualistic function. This is in line with what has been suggested for the Polish Neolithic by Marciniak (2005; 2011; Marciniak and Pollard 2015).

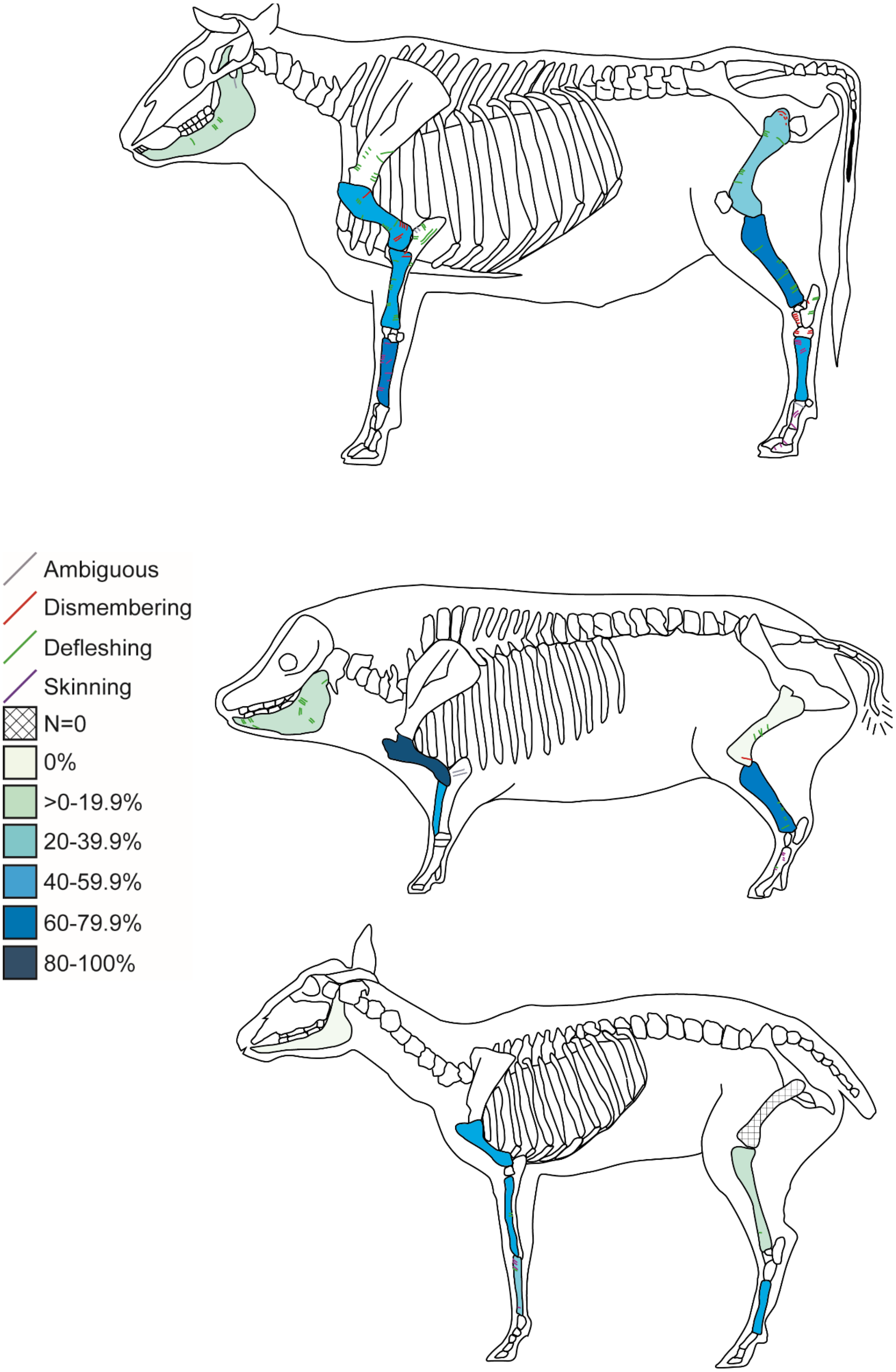

Figure 9.48: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Ludwinowo 7. Values in table 9.9.

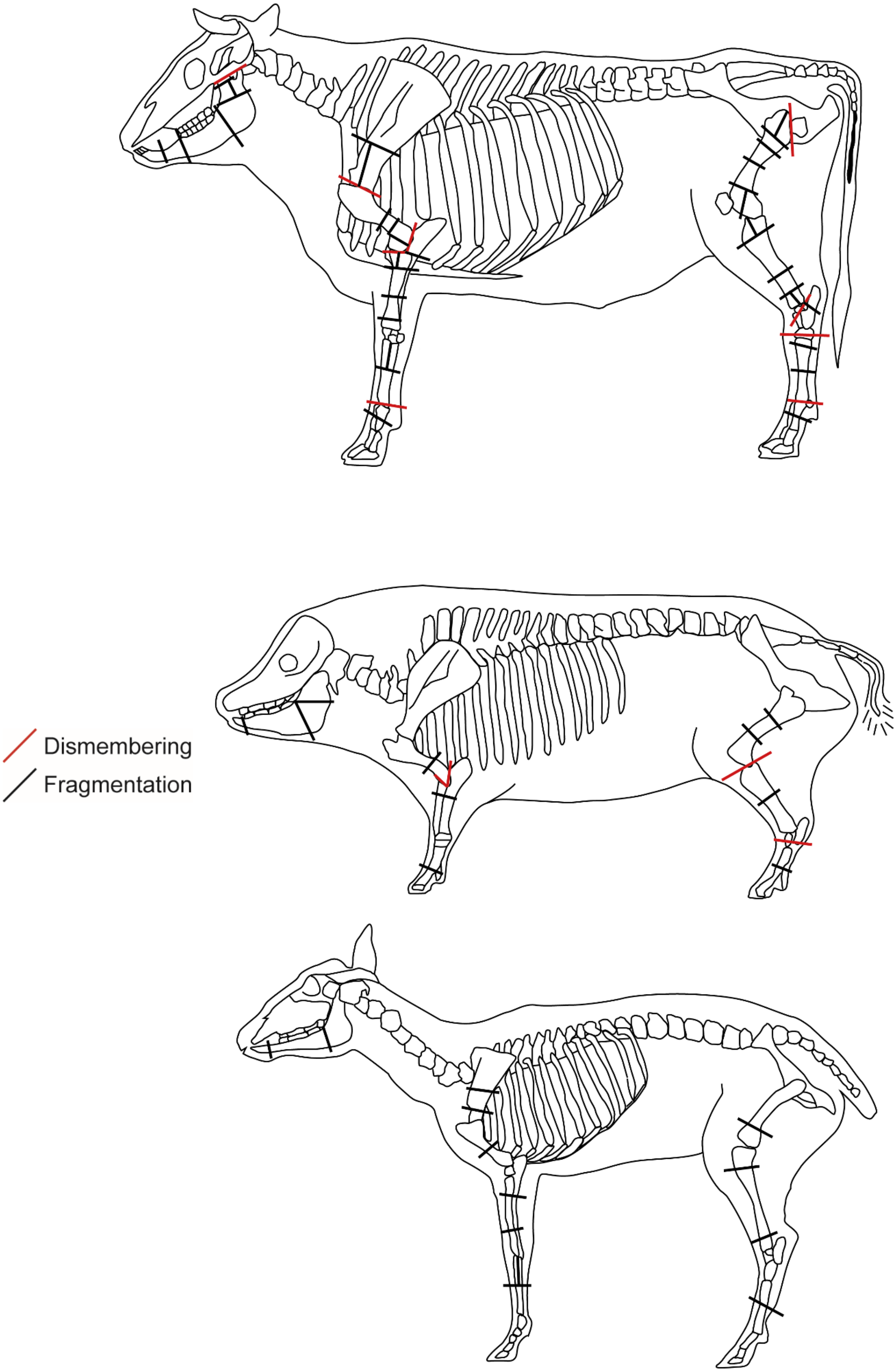

Figure 9.49: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Ludwinowo 7.

Chapter 10 Stephansposching

10.1 Introduction

The Linearbandkeramik settlement of Stephansposching, located near Deggendorf in Lower Bavaria, was discovered during planned rescue excavations in the years 1984-1995 (Pechtl 2008: 36, author's translation; Pechtl 2009). The settlement had its beginnings in the Ältere/Notenkopf LBK and continued to the end of the LBK in that region (*ibid*.). So far around one hundred house plans have been identified, along with an enclosure ditch and four fence systems (*ibid*.; Pechtl 2012: 130, author's translation; figure 10.1). Phases of the settlement have been identified through ceramic chronology (Pechtl 2012: 132).

10.2 Assemblage overview

10.2.1 Sample

The entire LBK assemblage from Stephansposching was analysed where context validity could be verified, totalling 2716 specimens (table 10.1). Due to the small size of the assemblage compared to other LBK sites there were few contexts or phases large enough to compare during analysis. Instead context groups were analysed, separated into the enclosure ditch, all house contexts, and all settlement pits not assigned to a house (table 10.2). Any difference in values for fully identifiable specimens (table 10.1) and species representation (figure 10.2) is due to the exclusion of *Bos sp.* and *Sus sp*. and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 10.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Stephansposching (STE).

Fully identifiable (to species and element)	365
Partially identifiable (to species and element type)	409
Indeterminate	1677
Total	**2451**

Table 10.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens belonging to each context group from Stephansposching.

	FID	PID	IND	Total
All house pits	137	105	519	761
All settlement pits	118	139	687	944
Enclosure	93	153	449	695

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of this thesis for copyright reasons

Figure 10.1: Plan of excavations at Stephansposching "Bauplatz Eggert" (Pechtl 2012: 131).

Table 10.3: Full list of contexts analysed from Stephansposching.

Context	Sect.	Interpretation	House Number/ Context group	FID	PID	IND
10	0	Longitudinal Pit	16	0	0	18
19	0	Pit Complex	Pit	16	35	168
21	0	Pit	Pit	0	1	0
81	A	Pit Complex	Pit	0	0	10
81	G	Pit	Pit	0	8	23
83	0	Pit Complex	Pit	0	0	7
119	0	Pit	15	1	0	3
130	0	Wall Trench	15	2	0	0
134	A	Pit	Pit	1	1	0
134	D	Pit	Pit	0	0	2
134	E	Pit Complex	Pit	2	0	0
134	F	Pit	Pit	4	11	22
135	0	Pit Complex	20	3	0	7
144	0	Pit	Pit	0	0	3
159	F	Pit	159F1 - ?	2	0	1
164	0	Post	92	0	0	2
166	0	Pit Complex	90	1	0	1
166	D	Longitudinal Pit	91	0	1	0
166	F	Pit Complex	89	2	12	29
166	H	Pit Complex	92	1	0	6
211	0	Post	97	1	2	5
223	0	Pit Complex	94	0	0	6
223	B	Pit Complex	94	7	10	55
264	E	Pit Complex	87	2	2	14
324	0	Pit	94	0	0	2
337	0	Longitudinal Pit	Pit	0	0	3
387	0	Pit Complex	Pit	4	1	24
387	A	Pit	Pit	2	0	1
458	0	Pit Complex	Pit	0	1	2
477	0	Post	73	0	0	12
523	A	Longitudinal Pit	67	0	0	3
524	A	Pit Complex	Pit	0	0	3
529	0	Post	77	0	0	1
548	A	Longitudinal Pit	85	2	2	17
551	0	Pit	House fragment 3	1	2	0
552	0	Pit Complex	House fragment 3	0	4	13
553	0	Pit	Pit	0	1	0
559	0	Pit Complex	Pit	2	0	0
570	0	Pit Complex	Pit	3	2	3
578	0	Pit	Pit	1	0	0
581	B	Gate-slot pit	Enclosure	6	13	35
581	C	Earthwork	Enclosure	45	106	282
581	C1	Pit Complex	12	3	3	16
581	C5	Longitudinal Pit	34	0	0	1
581	D	Earthwork	Enclosure	29	23	65
581	D4	Pit Complex	Enclosure	0	0	9
581	D5	Pit Complex	Enclosure	5	0	7
581	E	Earthwork	Enclosure	4	3	32
581	F	Earthwork	Enclosure	3	8	19
581	G	Earthwork	Enclosure	1	0	0
581	G2	Pit	51	6	7	33

584	0	Pit	Pit	6	0	4
587	0	Pit Complex	Pit	1	1	1
599	0	Pit Complex	Pit	3	1	3
610	0	Wall Trench	63	2	0	0
614	0	Pit Complex	63	29	16	46
625	0	Pit Complex	Pit	2	1	3
625	A	Longitudinal Pit	Pit	0	1	1
628	0	Longitudinal Pit	69	0	0	18
645	0	Post	66	0	1	0
654	B	Pit	63	0	0	2
659	0	Post	64	2	1	2
678	0	Pit Complex	Pit	1	0	3
679	0	Pit Complex	Pit	0	0	5
697	0	Longitudinal Pit	71	10	7	3
700	0	Pit Complex	Pit	0	3	23
700	A	Pit	Pit	2	0	22
701	0	Longitudinal Pit	71	6	0	14
723	0	Pit Complex	75	1	1	4
724	0	Post	75	1	0	0
761	0	Pit	Pit	3	4	10
766	B	Pit Complex	Pit	0	2	6
771	0	Post	53	1	0	0
779	0	Longitudinal Pit	65	0	1	0
808	E	Pit Complex	53	0	0	15
829	0	Pit	Pit	0	0	18
832	0	Pit Complex	15	0	2	1
834	0	Pit Complex	Pit	1	3	12
897	0	Longitudinal Pit	53	0	1	8
909	0	Pit Complex	54	1	2	5
910	0	Pit	54	1	0	13
944	0	Post	76	1	0	0
945	0	Pit Complex	52	0	0	1
954	0	Pit Complex	Pit	0	0	9
969	0	Pit	54	0	0	4
972	0	Pit Complex	Pit	0	2	16
972	B	Pit	Pit	4	0	1
972	E	Pit Complex	Pit	0	0	5
972	G	Pit Complex	Pit	1	0	4
972	I	Pit Complex	Pit	0	0	11
987	B	Longitudinal Pit	52	1	0	10
994	0	Longitudinal Pit	54	1	0	0
999	0	Pit	54	1	0	0
1034	0	Pit Complex	49	0	3	3
1035	0	Post	Fence Section 2 - ?	2	0	0
1047	0	Pit	Pit	0	0	4
1058	B	Pit Complex	Pit	2	0	4
1058	C	Pit Complex	Pit	2	0	0
1058	D	Pit	Pit	0	0	1
1071	0	Longitudinal Pit	Pit	1	0	0
1080	0	Post	46	0	0	10
1112	0	Pit	Pit	0	1	2
1133	0	Pit Complex	46	0	0	7
1136	0	Longitudinal Pit	45	1	0	0
1140	0	Wall Trench	63	0	1	1
1140	B	Pit	Pit	1	0	0

1142	0	Pit Complex	Pit	1	1	14
1142	I	Pit Complex	Pit	2	6	6
1142	L	Pit Complex	Pit	0	1	2
1149	0	Post	Pit	2	0	9
1157	0	Pit	Pit	6	9	6
1160	0	Pit Complex	30	2	0	4
1161	0	Pit	Pit	0	1	0
1169	0	Pit Complex	?	12	12	21
1182	A	Pit	31	2	0	0
1190	C	Pit Complex	Pit	3	1	3
1204	0	Pit Complex	Pit	0	4	5
1216	0	Longitudinal Pit	Pit	0	0	3
1221	0	Pit	Pit	0	0	1
1229	0	Pit Complex	86	2	0	2
1232	0	Longitudinal Pit	87	1	2	0
1240	0	Pit Complex	Pit	0	0	8
1241	0	Pit Complex	Pit	1	0	0
1242	0	Pit Complex	Pit	3	3	3
1247	0	Post	Pit	0	1	5
1282	B	Pit Complex	Pit	1	0	0
1282	E	Pit Complex	44	0	0	2
1291	0	Post	11	0	0	2
1302	0	Longitudinal Pit	12	1	0	0
1322	0	Pit Complex	Pit	0	1	1
1350	0	Longitudinal Pit	11	0	1	0
1351	0	Pit Complex	Pit	2	1	6
1352	0	Pit	11	1	1	0
1357	0	Pit Complex	12	10	1	21
1404	0	Pit Complex	Pit	0	0	3
1404	G	Longitudinal Pit	19	1	0	1
1420	0	Post	24	1	0	0
1422	0	Longitudinal Pit	Pit	0	0	1
1423	0	Pit	Pit	0	0	4
1434	0	Pit	Pit	1	0	1
1435	0	Pit Complex	Pit	1	0	0
1444	0	Pit	Pit	0	0	8
1449	C	Pit Complex	Pit	2	1	0
1449	E	Pit Complex	34	0	0	24
1449	N	Pit Complex	Pit	1	0	0
1449	P	Pit	Pit	1	2	0
1449	Q	Pit Complex	34	6	2	5
1450	0	Pit Complex	Pit	3	6	0
1450	C	Pit Complex	Pit	2	2	3
1450	D	?	?	1	0	0
1450	G	Pit	Pit	1	0	0
1450	K	Pit	Pit	0	0	1
1464	0	Pit	Pit	0	0	15
1467	0	Longitudinal Pit	36	3	3	11
1468	0	Pit	Pit	1	2	2
1472	0	Pit Complex	Pit	1	2	1
1481	0	Pit Complex	35	3	3	7
1482	0	Longitudinal Pit	Pit	1	1	3
1484	/1186	Longitudinal Pit	32	0	1	5
1485	0	Pit	Pit	0	0	4
1509	0	Pit Complex	Pit	0	0	19

1515	0	Pit Complex	61	1	0	0
1575	0	Pit	60	0	1	0
1601	0	Pit Complex	Pit	0	0	2
1601	E	Pit Complex	Pit	2	3	11
1608	A	Pit Complex	83	1	0	0
1623	0	Longitudinal Pit	Pit	2	0	7
1673	0	Pit	Pit	0	1	3
1685	0	Pit	10	1	1	2
1690	0	Longitudinal Pit	11	3	0	0
1699	0	Pit	Pit	3	2	2
1762	0	Pit	Pit	1	0	0
1769	0	Pit Complex	Pit	2	2	21
1785	0	Pit	Pit	1	0	0
1824	0	Pit Complex	10	1	0	0
1824	B	Pit Complex	10	1	3	7
1835	B	Pit	Pit	0	1	1
1840	0	Pit	House fragment 3	1	0	0
1841	0	Pit	Pit	4	2	0
1845	0	Pit Complex	Pit	0	1	0
1855	F	Pit	Pit	1	0	0
1893	0	Longitudinal Pit	27	0	1	0
1929	F	Pit	Pit	0	0	20
1929	H	Pit Complex	26	1	0	4
1938	0	Longitudinal Pit	26	0	0	1
1970	0	Pit Complex	Pit	1	0	0
B3	0	Pit	Pit	0	0	8
N119	?	Longitudinal Pit	7	2	3	9
N128	0	Pit Complex	Pit	0	0	5
N257	0	Pit Complex	8	1	1	0
R1	0	Pit Complex	Pit	0	1	19
R222	0	Pit Complex	Pit	0	1	5
R24	0	Pit Complex	Pit	0	0	7
R255	0	Longitudinal Pit	81/82	0	0	1

10.3 Species representation

10.3.1 Site

Cattle were the most commonly identified species at Stephansposching at 53.5% (189/353) of the number of identifiable specimens (NISP), more common than the combined small stock (figure 10.2). Domestic pigs followed at 18.1% (64/353), with caprines least commonly identified at 9.9% (35/353). Domestic dog bones were present on the site in very small numbers (n=2), but were also evident in the incidences of canid gnawing and digestive action found on bones. Wild animals were common at 17.8% (63/353) of the assemblage. Red deer was the most commonly identified wild animal (9.1%, 32/353), followed by aurochs, wild boar and roe deer. Some indeterminate deer antler and some wild birds, including swan, were also identified.

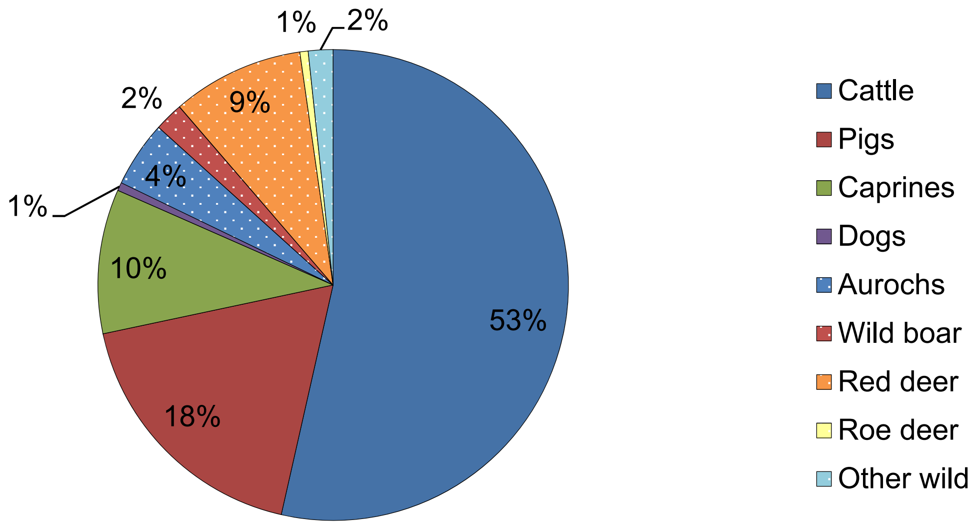

Figure 10.2: Species representation (NISP) for the fully identifiable assemblage from Stephansposching (n=353).

10.3.1.1 Context groups

The species representation between the house pits, settlement pits and the enclosure showed some differences in the proportions of different species (figure 10.3). House (62.5%, 80/128) and settlement (56.9%, 66/116) pits had a significantly higher proportion of cattle than the enclosure (35.5%, 33/93; houses p<.001 and pits p=.002). In place of cattle, the enclosure ditch had significantly higher proportions of domestic pigs (28.0%, 26/93) than in the houses (pigs

17/128, p=.007) and red deer (18.3%, 17/93) than in the houses (6/128, p=.001) and pits (red deer 9/116, p=.022). This clear differential deposition suggests varying consumption practices contributed to the assemblages from the enclosure and the other pits within the settlement.

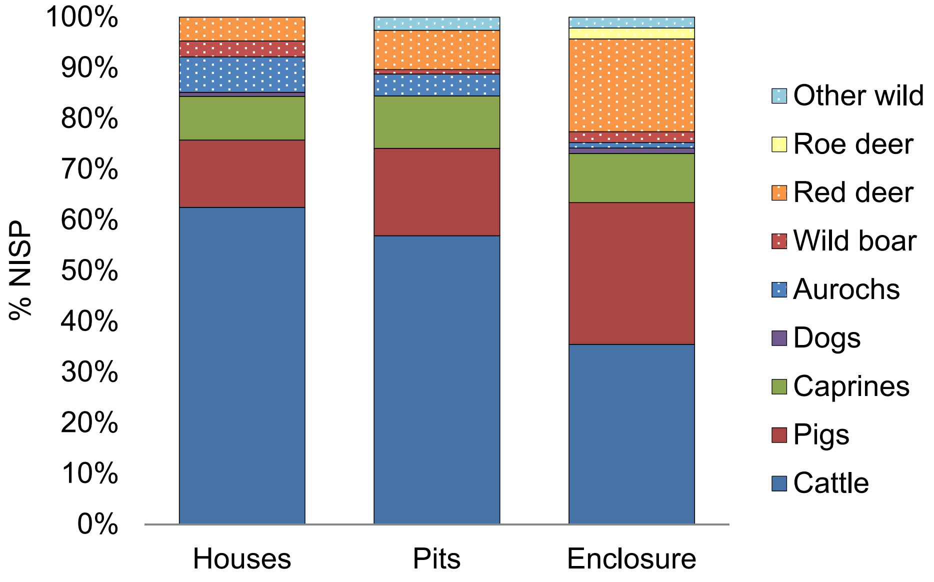

Figure 10.3: Species representation (NISP) for the house pits (n=128), pits (n=116) and enclosure (n=93) from Stephansposching.

10.4 Butchery

10.4.1 Site

Butchery affected 2.8% (68/2451) of the entire Stephansposching assemblage, and 7.6% (59/774) of identifiable bones. The most commonly recorded butchery marks were cut marks (see figure 10.4). Slice marks were also present in a small capacity (n=10).

10.4.1.1 Context groups butchery

The house pit assemblage showed a significantly greater proportion of butchery than the settlement pits (29/761 compared to 20/944, p=.038; figure 10.5). The enclosure also showed less butchery than the house pits, although the difference was not significant. This could suggest more intensive carcass processing practices in the house pits as opposed to other contexts in the settlements.

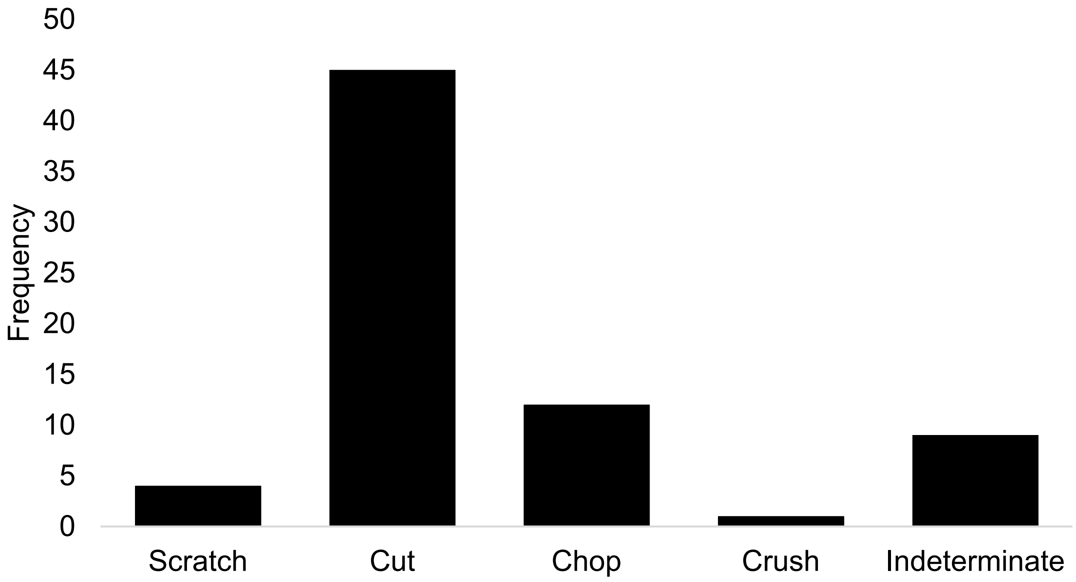

Figure 10.4: Frequency of butchery mark types from Stephansposching.

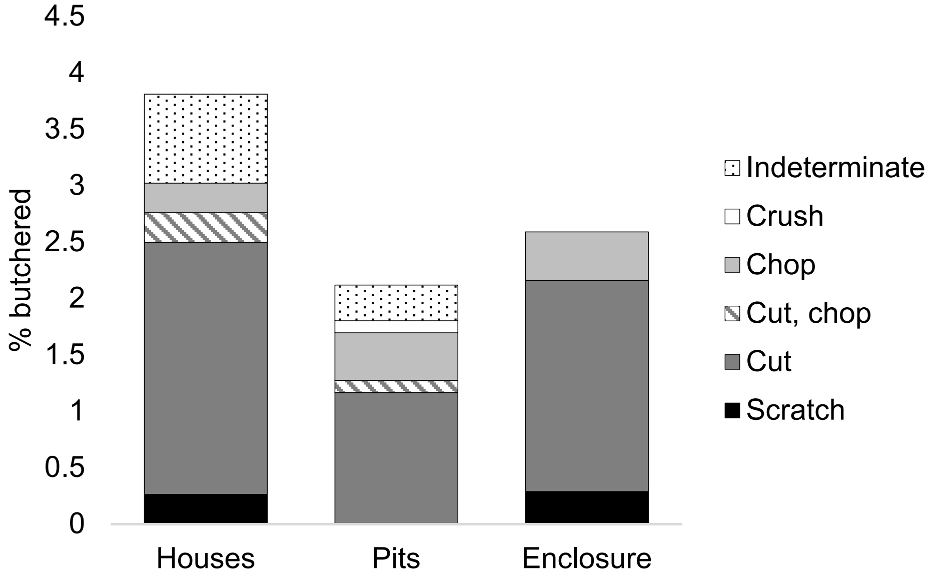

Figure 10.5: Percentage of specimens from the house pits (n=761), settlement pits (n=944) and the enclosure (n=695) affected by different butchery episodes from Stephansposching.

10.4.2 Species

Cattle were the domesticate most affected by butchery (figure 10.6). Pigs were occasionally butchered, but interestingly there was no evidence for caprine butchery. The wild species tended to be well butchered, with aurochs and roe deer especially affected, although this data could be related to low sample sizes. Chop marks were more common on the large species – cattle, aurochs and red deer. There was no evidence for dog butchery.

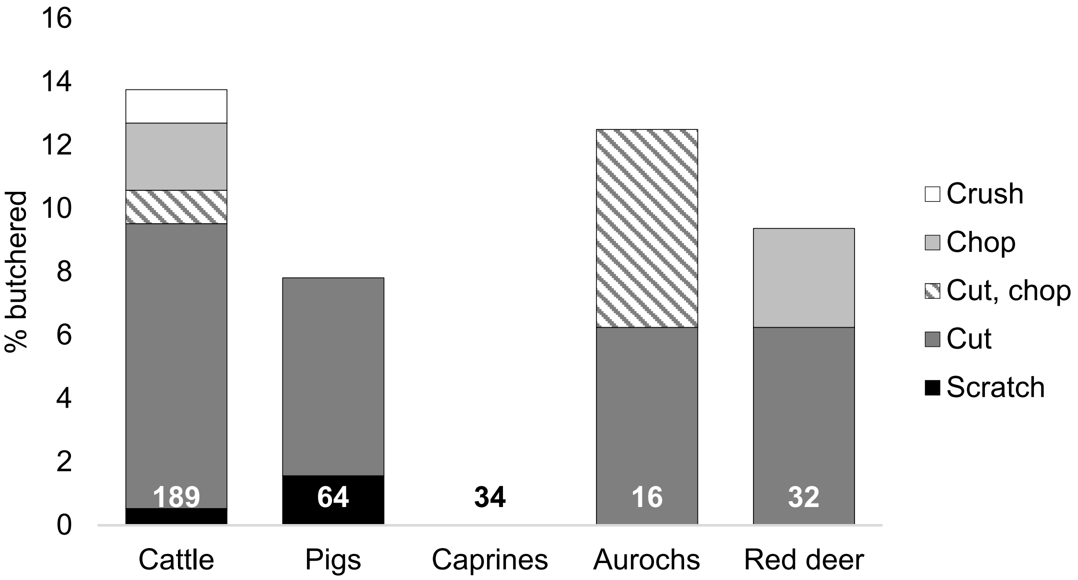

Figure 10.6: Percentage of specimens identified to different species with evidence of butchery from Stephansposching. N values are at the base of each bar.

10.4.3 Carcass butchery

While butchery affected many parts of the skeleton, the highest concentrations of butchery were found on the forelimb, affecting the humerus, radius and ulna of cattle, red deer and pigs, and among the distal limb elements, namely the metapodia and phalanges (figure 10.7). On the radius and ulna, marks clustering around the olecranon process and articulation with the humerus likely suggest disarticulation, while cut marks on the shaft could represent muscle stripping, possibly prior to marrow extraction (Soulier and Costamagno 2017; figure 10.8). On the metapodia, butchery could represent skinning but likely also shows the removal of meaty scraps or the periosteum, again prior to marrow removal (*ibid.*; figure 10.9). Butchery on the phalanges suggests skinning activity (*ibid.*; figure 10.10).

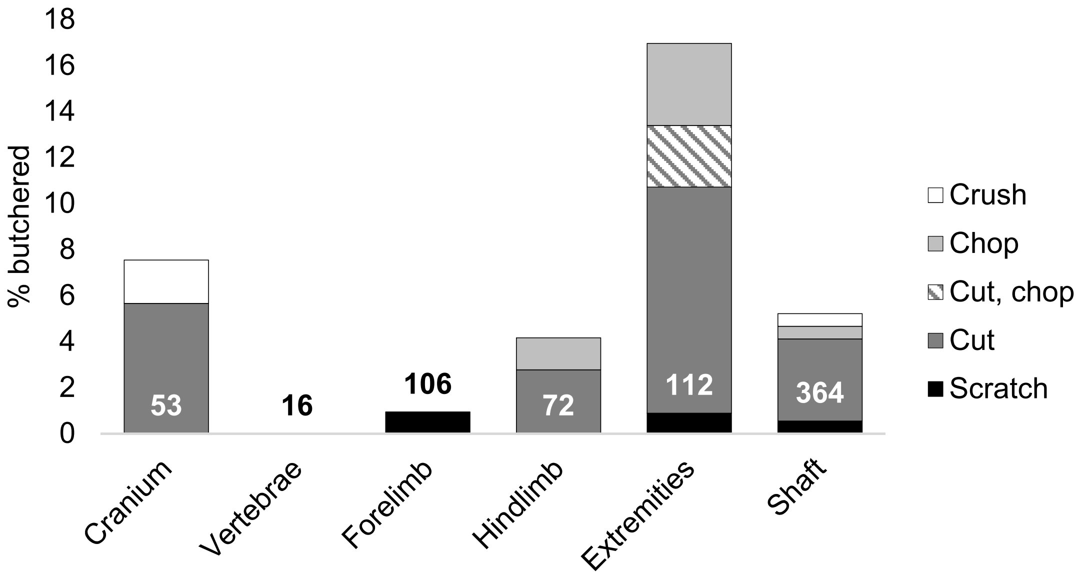

Figure 10.7: Percentage of specimens in different carcass parts with different butchery episodes from Stephansposching.

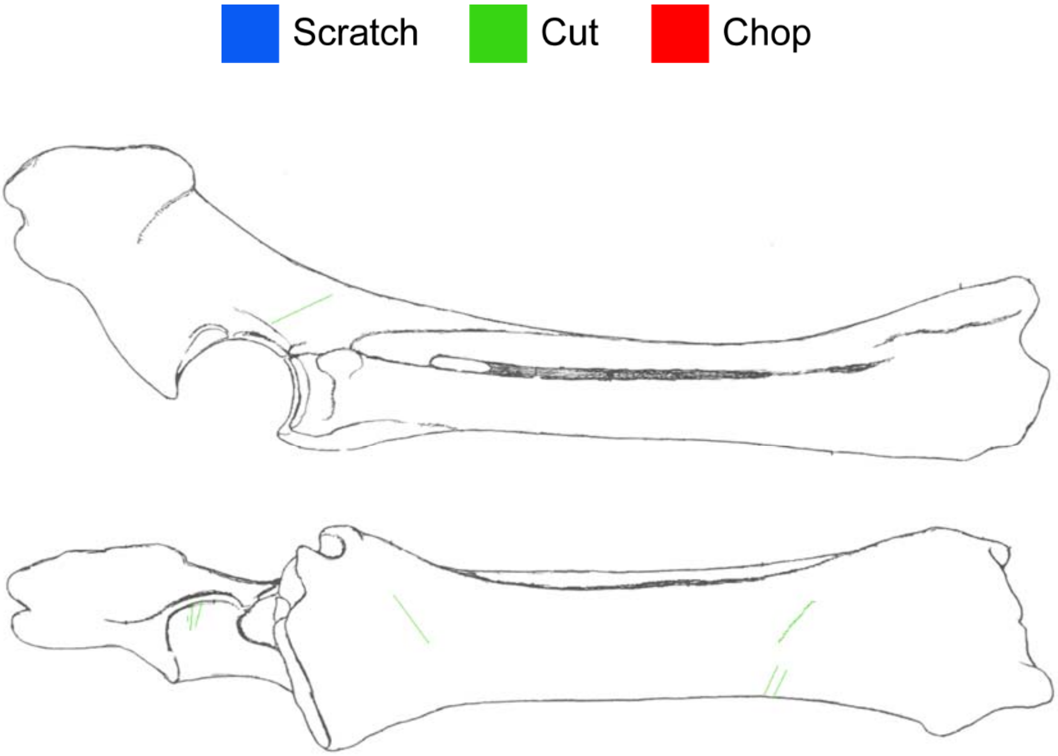

Figure 10.8: Cumulative diagram of butchery on cattle (n=2) and suid (n=3) radii and ulnae from Stephansposching. Lateral (top) and anterior views.

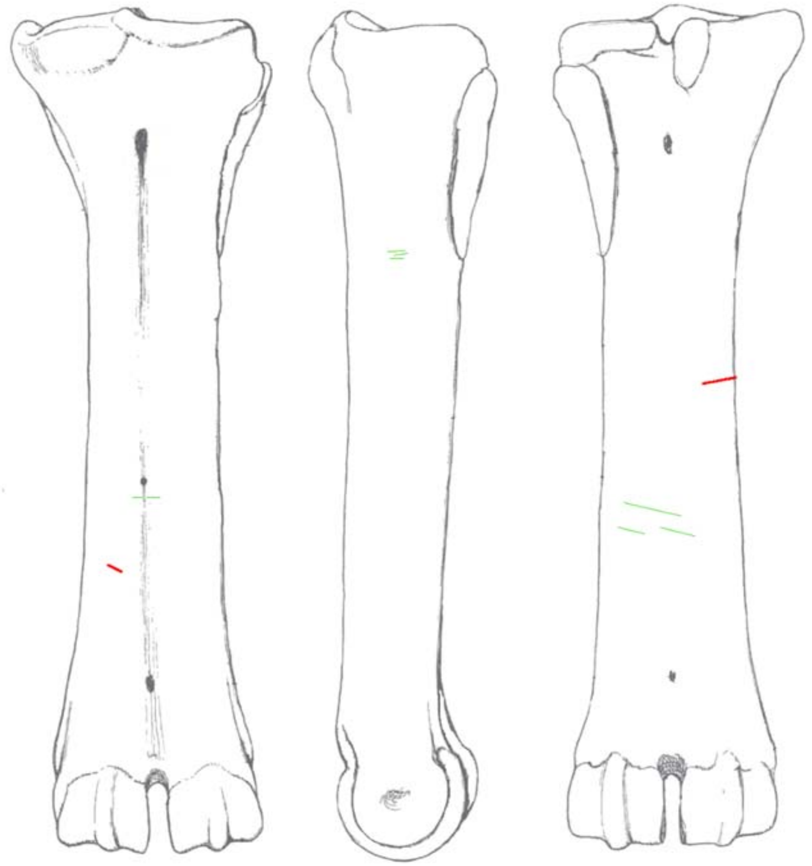

Figure 10.9: Cumulative diagram of butchery on cattle (n=4) and red deer (n=1) metapodia from Stephansposching. Left to right; anterior, lateral and posterior views.

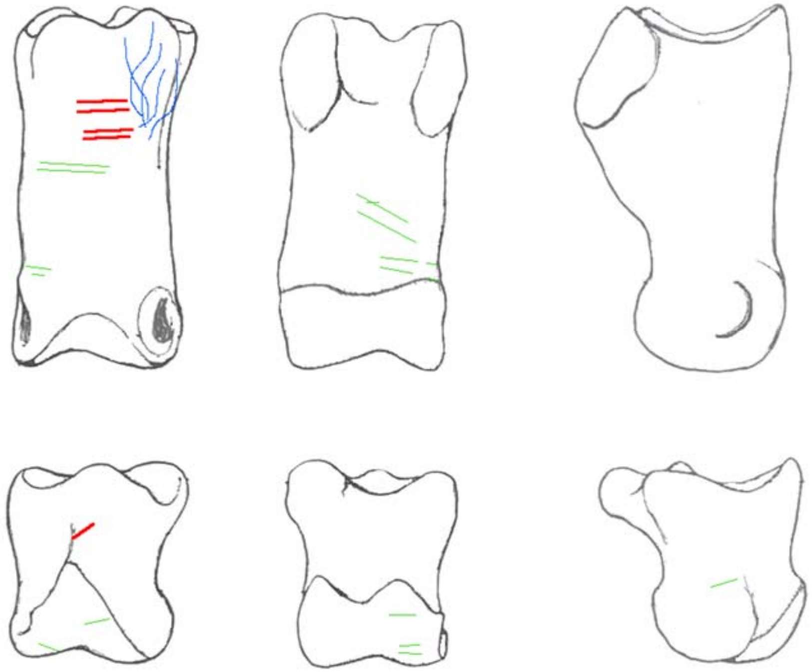

Figure 10.10: Cumulative diagram of butchery on bovine (n= 4) and cervid (n=2) first phalanges and bovine second phalanges (n=2) from Stephansposching. Left to right; anterior, posterior and medial views.

10.5 Heat exposure

10.5.1 Site

Evidence of exposure to heat affected 3.8% (92/2451) of the assemblage from Stephansposching, and 7.9% (61/774) of the identifiable assemblage. The most common type of burning was roasting (figure 10.11), indicating that cooking animal carcasses in this way could have been part of carcass processing traditions.

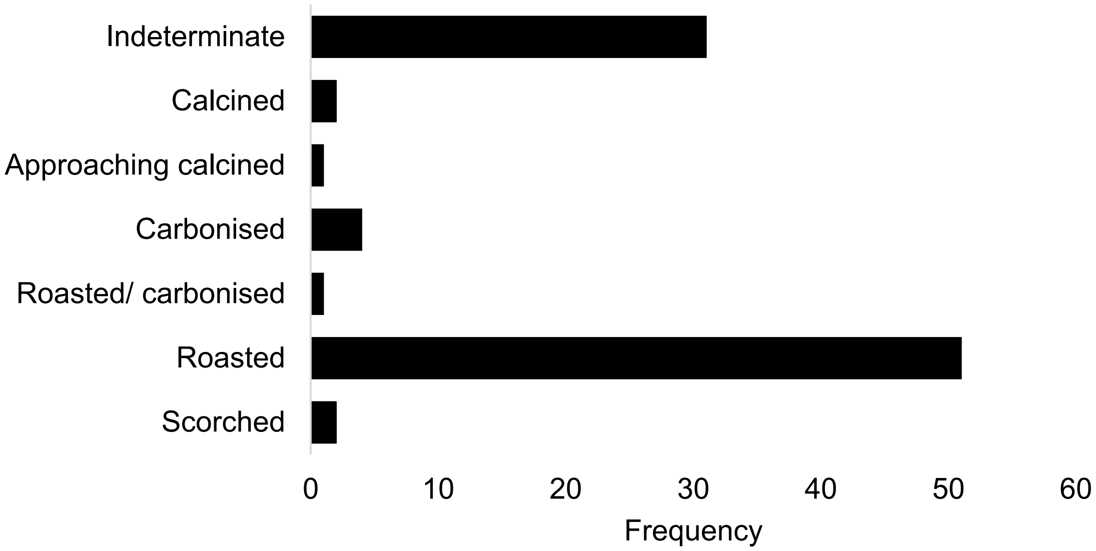

Figure 10.11: Frequency of heat exposure types from Stephansposching.

10.5.1.1 Context groups

The houses were significantly more affected by burning than the settlement pits and the enclosure (47/761 compared to 12/695, $p<.001$), indicating that roasting could have been a domestic household activity, rather than communal (figure 10.12). If this is the case it is unlike the communal roasting contexts seen at Ludwinowo 7. The enclosure showed the highest proportion of specimens affected by heavy burning (i.e. carbonised or calcined), although the differences were not significant. This could suggest more depositional or ritualistic burning in contexts related to the enclosure.

10.5.2 Species and element

Cattle were the species with the highest proportion of specimens affected by heat exposure (14.3%, 27/189; figure 10.13). The amount of burning was significantly greater than on pigs (3.1%, 2/64, $p=.015$), but the differences between caprines and wild animals (aurochs, wild boar, red deer and roe deer) were not significant. Cattle mandibles showed roasting on 50% (12/24) of specimens, and cattle metapodia on 20.4% (11/54). This tradition of roasting low-yield marrow bearing bones may have contributed to drier fracture of these elements due to moisture loss, and has been seen at other LBK sites such as Ludwinowo 7.

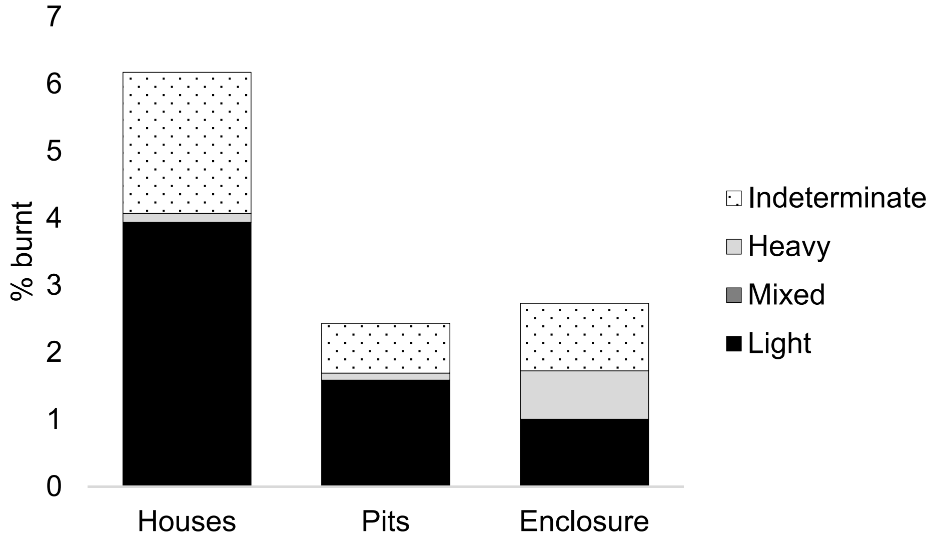

Figure 10.12: Percentage of specimens from the Houses (n=761), Pits (n=944) and Enclosure (n=695) affected by different intensities of heat exposure from Stephansposching.

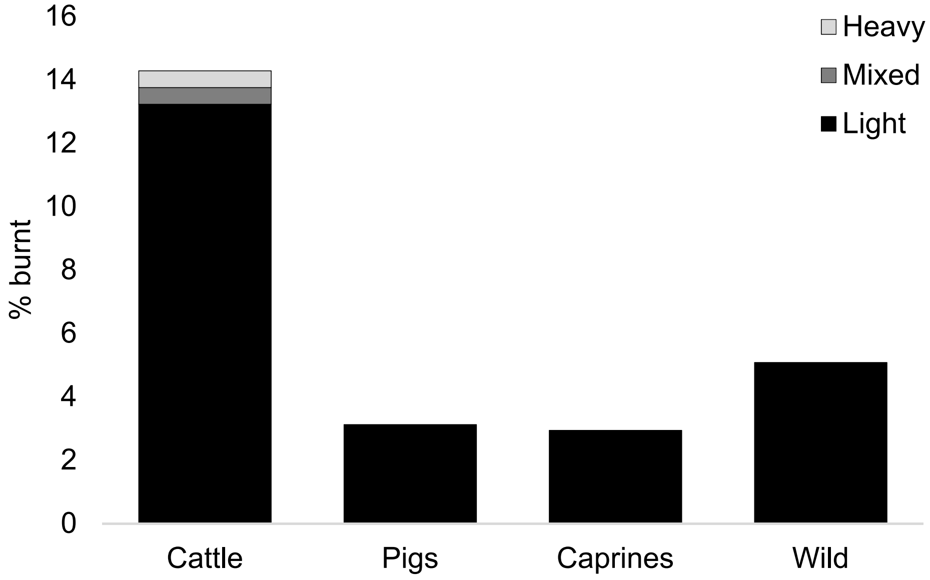

Figure 10.13: Percentage of species affected by different intensities of heat exposure from Stephansposching.

10.6 Fracture

10.6.1 Site

Fresh fracture was present on 69.5% (337/485) of fractured bones, and the mean Fracture Freshness Index for the assemblage was 2.16, suggesting marrow was commonly exploited (figure 10.14). The high levels of fresh fracture on high-yield marrow-bearing bones confirm targeting of marrow. Dry fracture was also present, indicating that some bones were not broken for marrow before the nutritional value was lost. FFI scores suggest that bones were broken when fresh *or* dry, with little evidence of mixed fracture characteristics (figure 10.15).

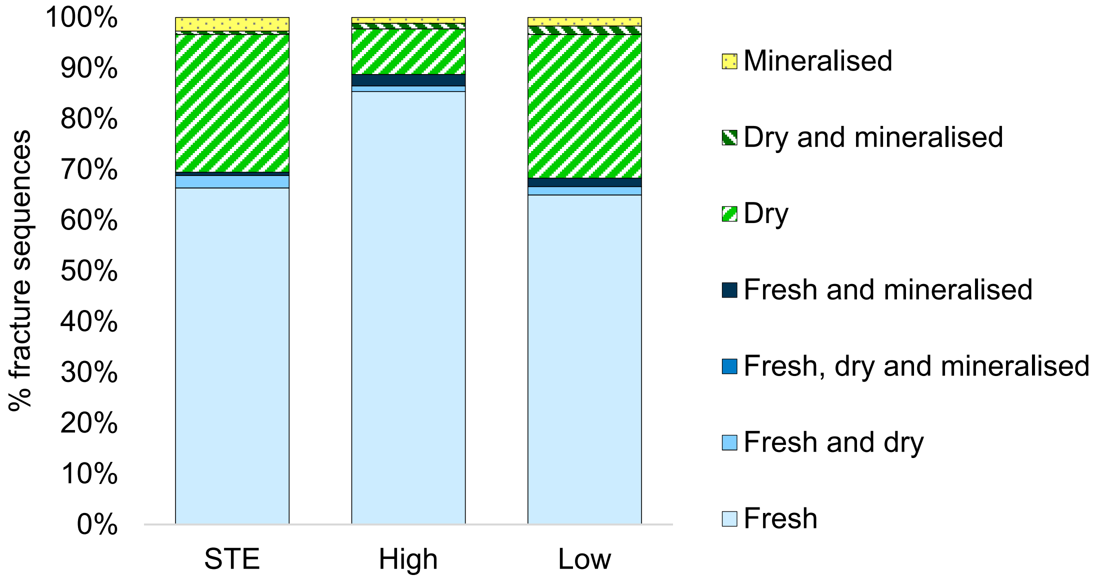

Figure 10.14: Fracture history profiles for Stephansposching (n=485) and for high- and low-yield marrow bones (n=89/60).

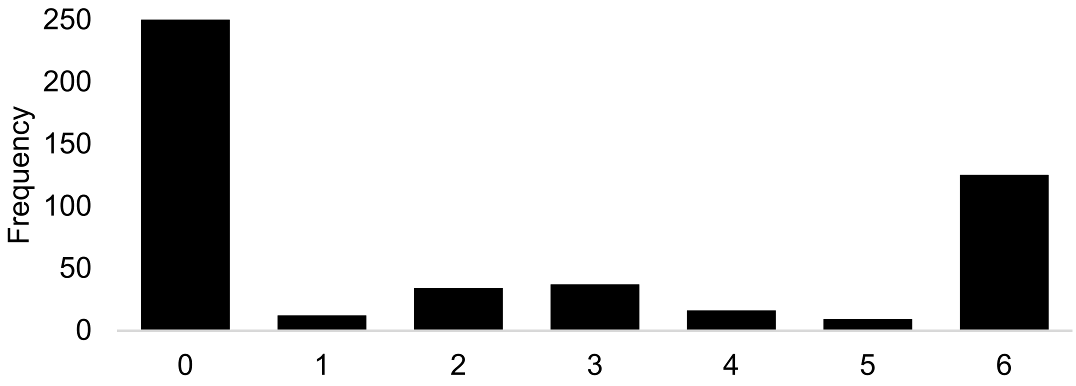

Figure 10.15: Frequency of Fracture Freshness Index scores from Stephansposching.

10.6.1.1 Context groups

Fracture proportions between the three context groups showed very little difference (figure 10.16). The proportions of fresh fracture were extremely similar, with the frequency slightly elevated in the enclosure and a slightly lower mean FFI (settlement contexts both 2.2, enclosure 2.1). All contexts also showed that high-yield marrow-bearing bones were more commonly fractured freshly than low-yield bones (figure 10.17). The difference between high- and low-yield fracture was least pronounced in the enclosure, although sample sizes were too low to draw meaningful conclusions. Dry and mineralised fracture seemed similarly unaffected depending on context group. The fracture analysis suggests that carcass processing practices related to marrow extraction and depositional practices were likely the same for all three context types.

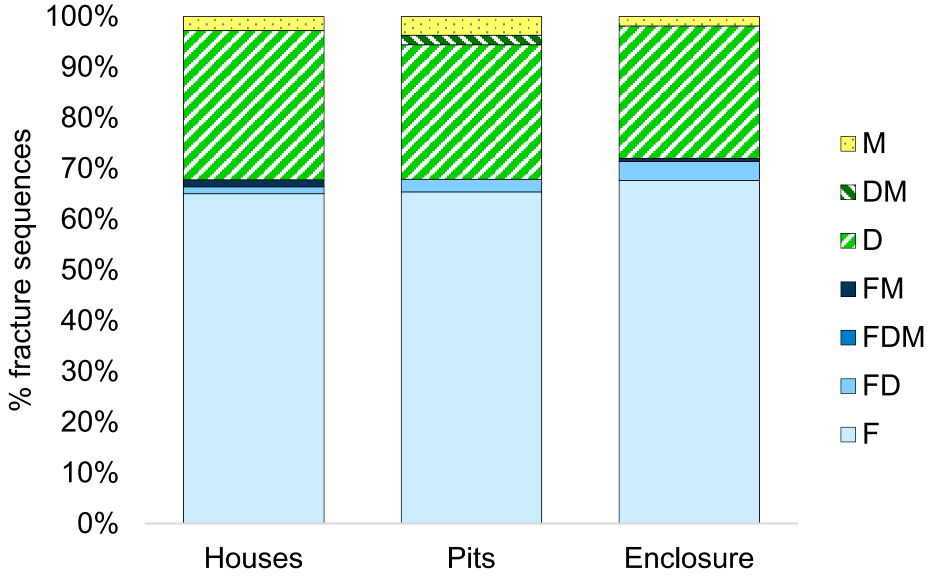

Figure 10.16: Fracture history profiles for house contexts (n=146), settlement pits (n=162) and the enclosure (n=161) from Stephansposching.

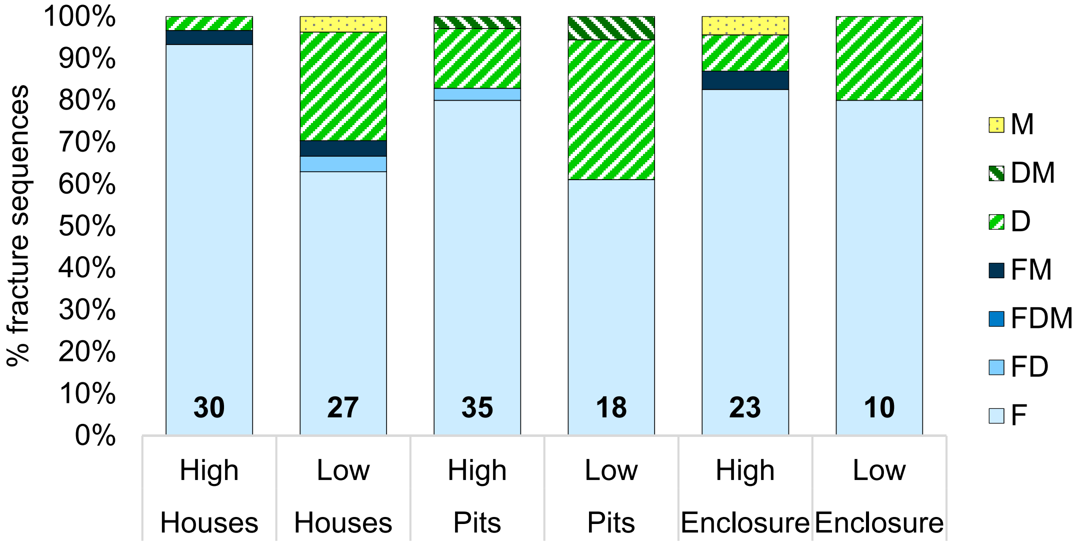

Figure 10.17: Fracture history profiles for high- and low-yield marrow bones from house contexts, settlement pits and the enclosure from Stephansposching.

10.6.2 Species

Cattle were the domestic animal with the highest proportion of fresh fracture, with 97.0% (32/33) of cattle high-yield marrow elements fractured when fresh (figure 10.20). Both pigs and caprines also had high proportions of fresh fracture, although caprines showed a significantly lower amount of fresh fracture (62.5%, 10/16, p=.041) and a higher mean FFI score compared to cattle (84.6%, 66/78, figures 10.18 and 10.19). Wild animals were extremely freshly fractured, especially red deer, with 100% (13/13) of fractured bones freshly fractured and a very low FFI mean of 0.69.

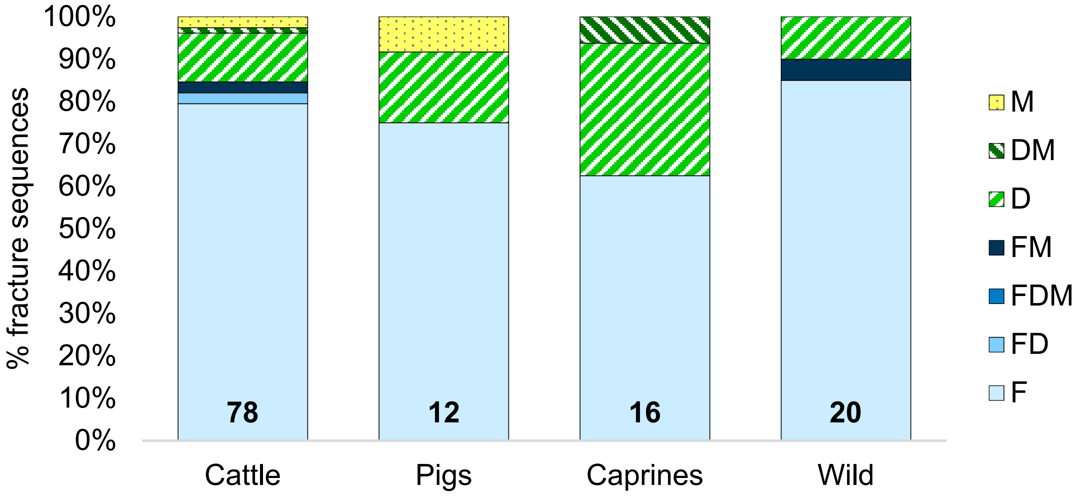

Figure 10.18: Fracture history profile for species from Stephansposching.

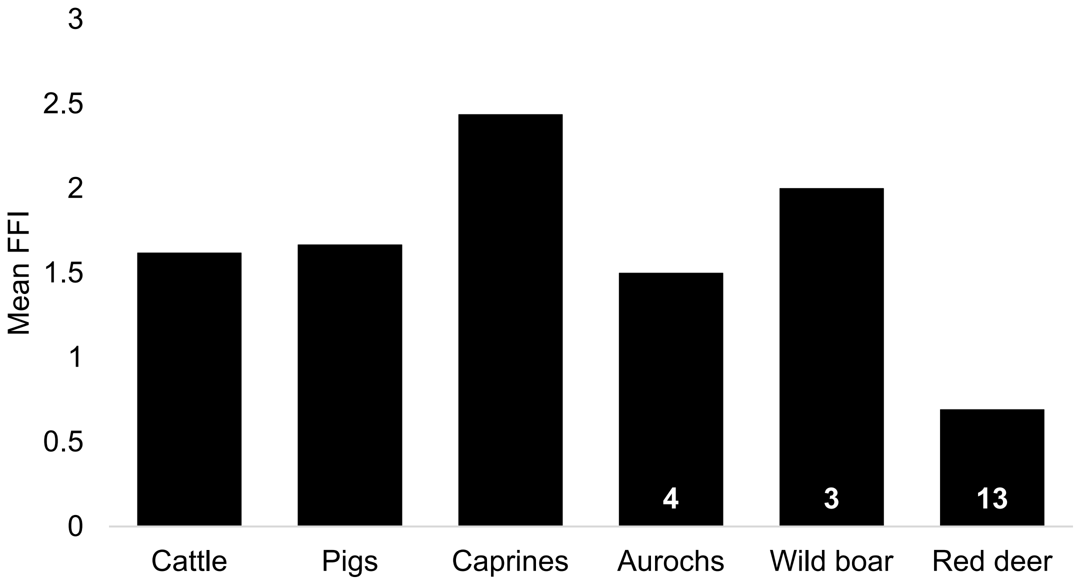

Figure 10.19: Mean Fracture Freshness Index scores for different species from Stephansposching.

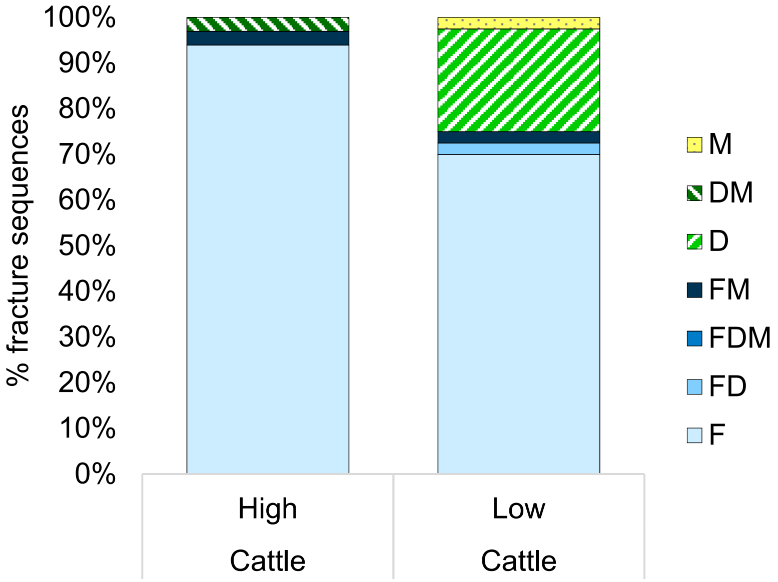

Figure 10.20: Fracture history profile for high- and low-yield marrow bones of cattle (n=33/40) from Stephansposching.

10.7 Fragmentation

The fragmentation analysis does not reflect patterns of intensive grease processing yet does highlight the abundant marrow processing activity. The large weight of bones described as ‘complete epiphysis and shaft’ suggests that bones were cracked at midshaft and the epiphysis remained intact, not broken for bone grease processing (figure 10.21), and the proportion of bone types identified as diaphysis was particularly high (figure 10.22). For an assemblage with intensive grease processing one would expect the smaller size classes to have the greatest weight of bone due to the comminution of large elements for boiling. However, isolated incidences of bone grease processing could be suggested by fragmented cancellous material (figure 10.22), although proportions were still minimal. At a site with such high proportions of fresh fracture it is likely that the importance of bone fats was not overlooked, although overall the pattern is one of marrow and not grease processing.

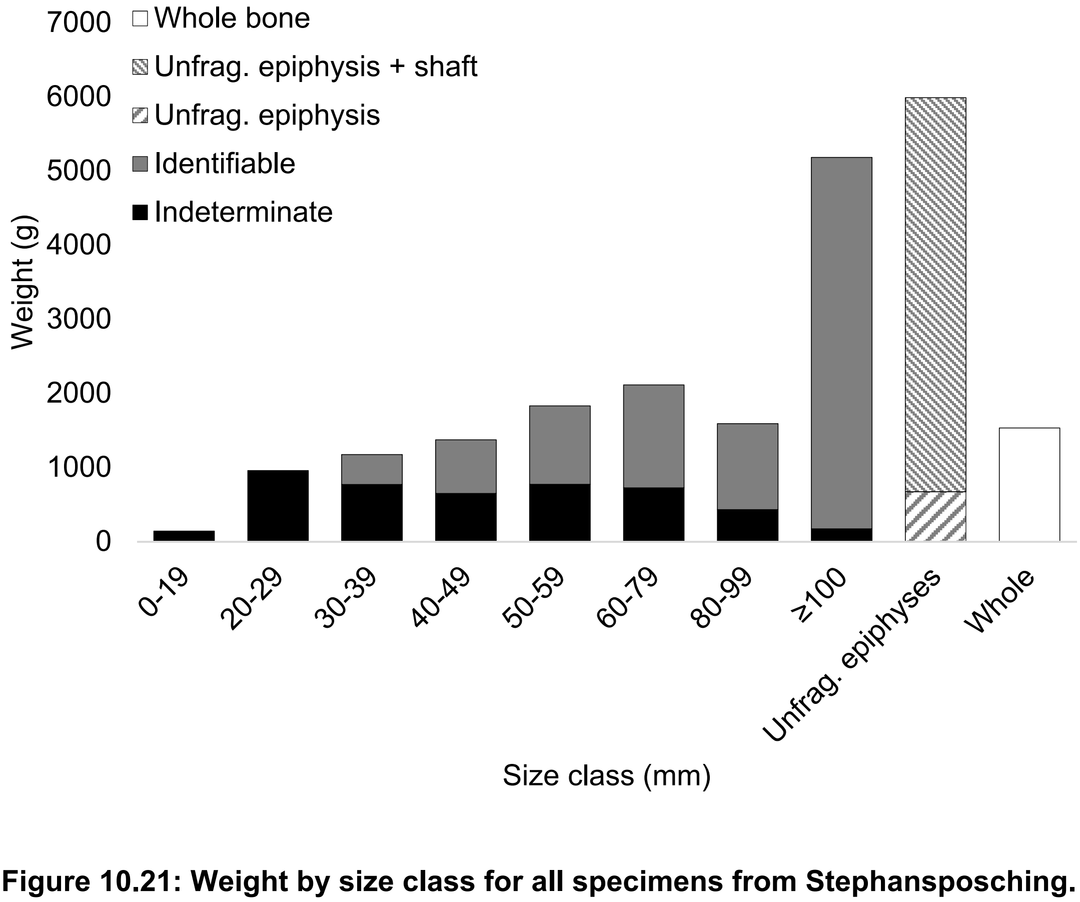

Figure 10.21: Weight by size class for all specimens from Stephansposching.

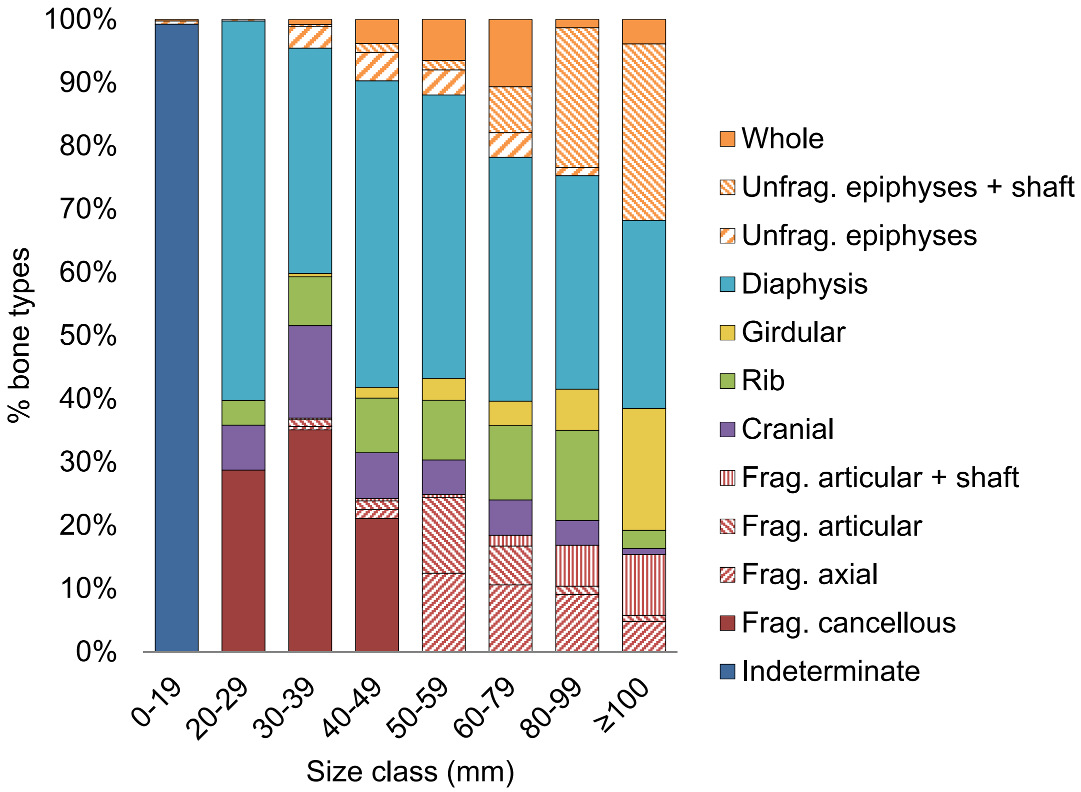

Figure 10.22: Bone type frequency by size class for Stephansposching. Red series indicate fragmented cancellous bone.

10.8 Taphonomy

10.8.1 Gnawing

Gnawing affected 2.3% (57/2451) of the assemblage and was canid in the vast majority. Three bones also showed evidence of having been digested. This low level of canid disturbance likely did not contribute to the levels of fragmentation, although could have been responsible for dry breaks on marrow-bearing elements. There was little difference between context groups (figure 10.23), although the enclosure ditch showed no evidence of rodent gnawing compared to the settlement contexts, possibly indicating different depositional histories.

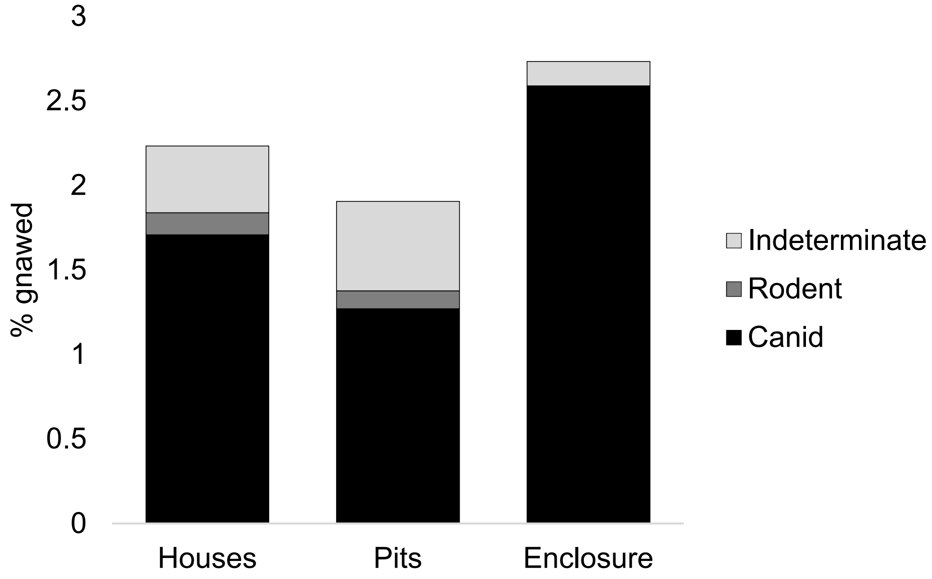

Figure 10.23: Percentage of specimens in different context groups affected by gnawing from Stephansposching.

10.8.2 Taphonomic agents and recent breaks

Other taphonomic effects, such as severe root etching, erosion and polishing were present but uncommon (2.5%, 19/774 of the identifiable assemblage). 36.7% (284/774) of identifiable specimens showed evidence of post excavation breaks, higher in the house contexts (40.9%, 99/242) than in the enclosure ditch (23.2%, 57/246; figure 10.24).

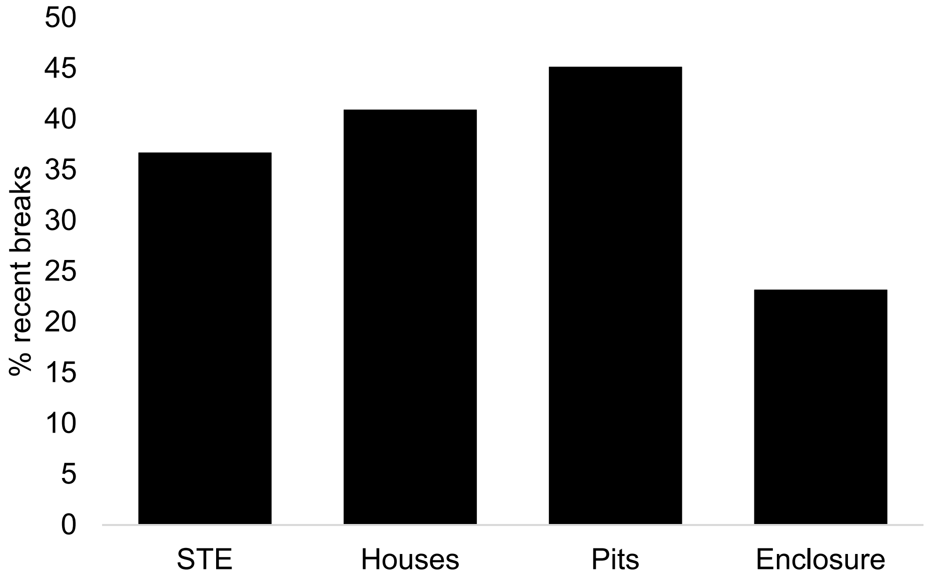

Figure 10.24: Percentage of the different context groups affected by breakages during or after excavation from Stephansposching.

10.9 Food exploitation strategies

10.9.1 Herd structure analysis

10.9.1.1 Cattle

Cattle fusion aging using specimens from all context groups at Stephansposching showed that the vast majority of animals, nearly 80%, survived past the final stage of fusion (3-4 years; 76.2%, 16/21; figure 10.25). Some slaughter was detected between 12-18 months, and further slaughter happened between 3-4 years. The high level of old animals may indicate retaining adult milking animals that had passed prime meat age and weight. However, 80% survival suggests some males were also kept alive into maturity, or that young individuals were being consumed elsewhere. Some meat slaughter is possible at 3-4 years, but there seems to be very little targeted slaughter of animals of specific meat ages.

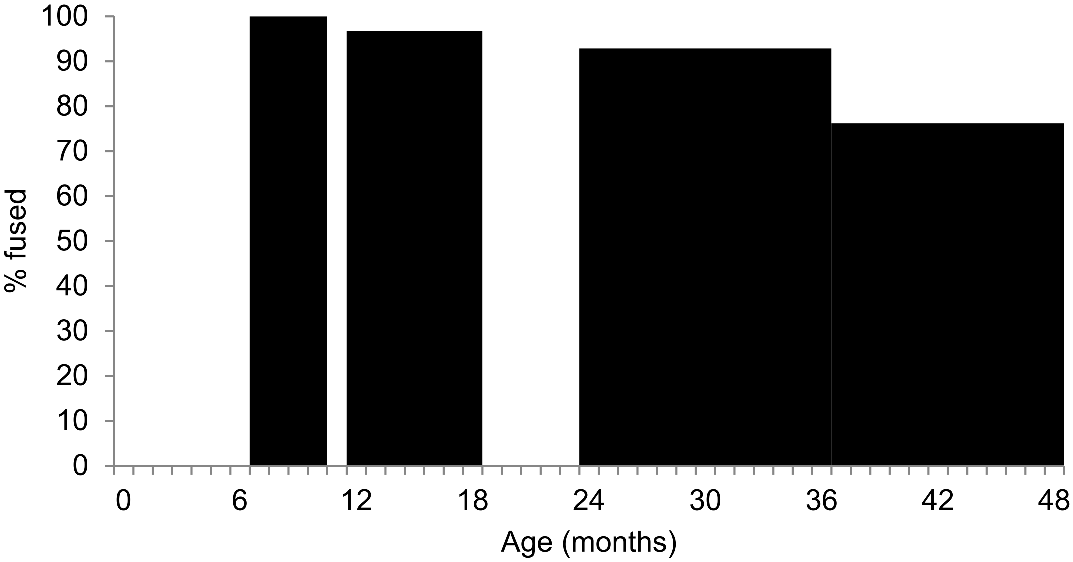

Figure 10.25: Cattle slaughter profile based on epiphyseal fusion from Stephansposching (n=73).

10.9.1.2 Pigs

Aging on domestic pigs produced similar patterns to other sites in the LBK (figure 10.26). Some slaughter before the first year was reached was detected, followed by a slaughter event between 1 and 2 years. There were no fused stage 3 specimens (n=5), suggesting that domestic pigs rarely lived longer than 3.5 years. This familiar slaughter profile for domestic pigs suggests that pigs were kept for meat slaughtered between 1 and 2.5 years.

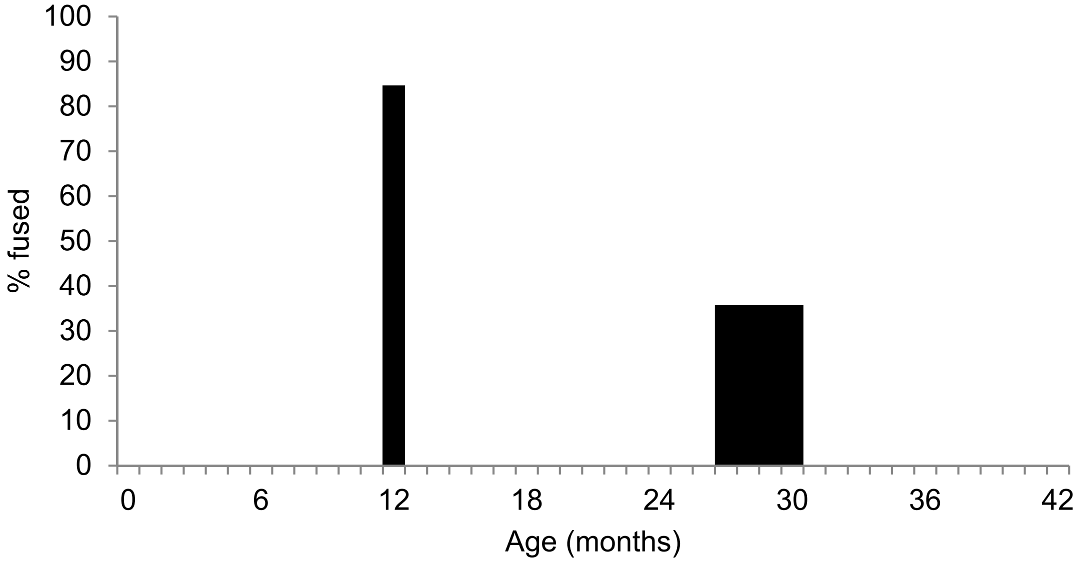

Figure 10.26: Pig slaughter profile based on epiphyseal fusion from Stephansposching (n=32).

10.9.2 Lipid residue analysis

Thus far the lipid residue analysis of ceramic sherds from Stephansposching has yielded no evidence of dairy fats. 34.1% (15/44) of non-perforated sherds contained evidence of adipose fats, suggesting that animal products such as meat and fat were processed in pots. Dairy fats could have been processed in non-ceramic containers, thus this does not rule out a dairy economy at Stephansposching, especially in the light of a cattle dominated faunal assemblage (figure 10.2) with high survival of adult animals (figure 10.25). Mortality profiles based on cattle and caprine teeth, carried out by Roz Gillis, are awaited to corroborate this evidence.

10.10 Discussion

10.10.1 Meat and fat exploitation

The faunal assemblage from Stephansposching contained considerable amounts of cattle and wild animals. Cattle could have been managed as a milk herd, although high survival of all age classes could suggest that young males and/or meat-age animals were being slaughtered elsewhere on site. Pigs and likely caprines and wild animals supplied the site with prime-meat.

Trends in carcass processing show some repeated butchery techniques, particularly for bovinae and suidae. Caprines were excluded from analysis based on low sample sizes. In bovinae, evidence for skinning was identified on the phalanges and metapodia, and disarticulation involved detaching the lower forelimb from the humerus, the tarsals from the tibia, the femur from the pelvis and possibly the head (figure 10.27). In suidae, evidence of disarticulation was limited to the elbow and neck, likely due to smaller sample sizes than cattle. Evidence of defleshing was common on the mandible, scapula and forelimb, and also on the femur in cattle. Fragmentation was intensive on the long bones, especially in cattle, resulting in very high levels of fresh fracture that focused on high-yield elements. The mandible and metatarsal were less freshly fractured, however, and could have been roasted before fracture. Whilst there was no evidence of intensive bone grease processing from Stephansposching, fragmentation of the epiphyses of femur, humerus and proximal tibia perhaps suggest opening grease cavities for boiling bones in stews.

Differential carcass processing methods between the three context groups highlight variation in burning and butchery proportions, which were both elevated in house contexts. However, proportions of different fracture sequences were remarkably similar, suggesting similar marrow exploitation and depositional histories between the three context groups.

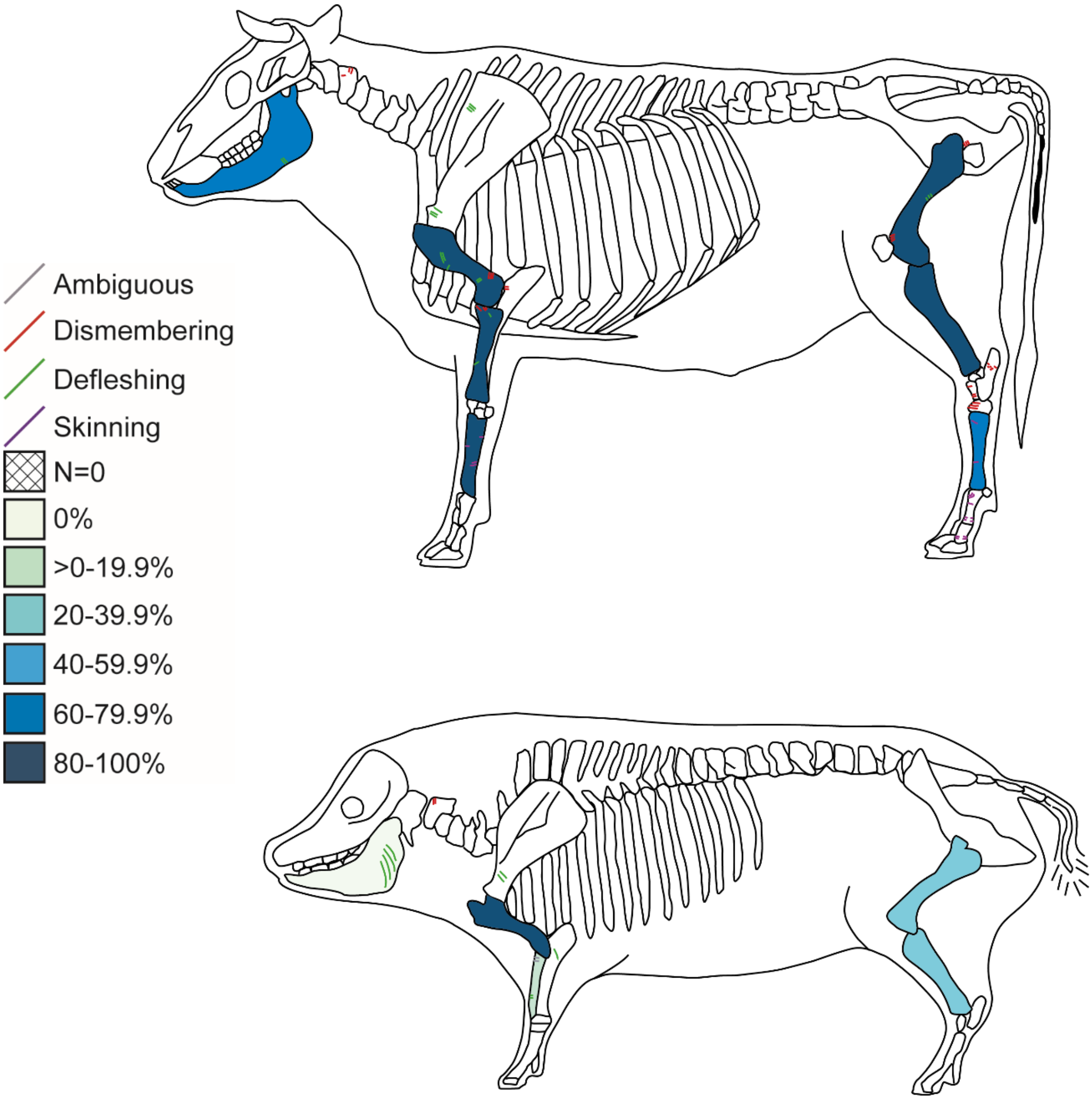

Figure 10.27: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top) and suidae (bottom) from Stephansposching. Values in table 10.4.

Table 10.4: Percentage of bovine and suid marrow-bearing elements fractured when fresh from Stephansposching.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	92	13	91	14	100	14	100	12	75	24	86	11	70	13
Suidae	100	5	17	6	33	3	33	6	0	12	-	-	-	-

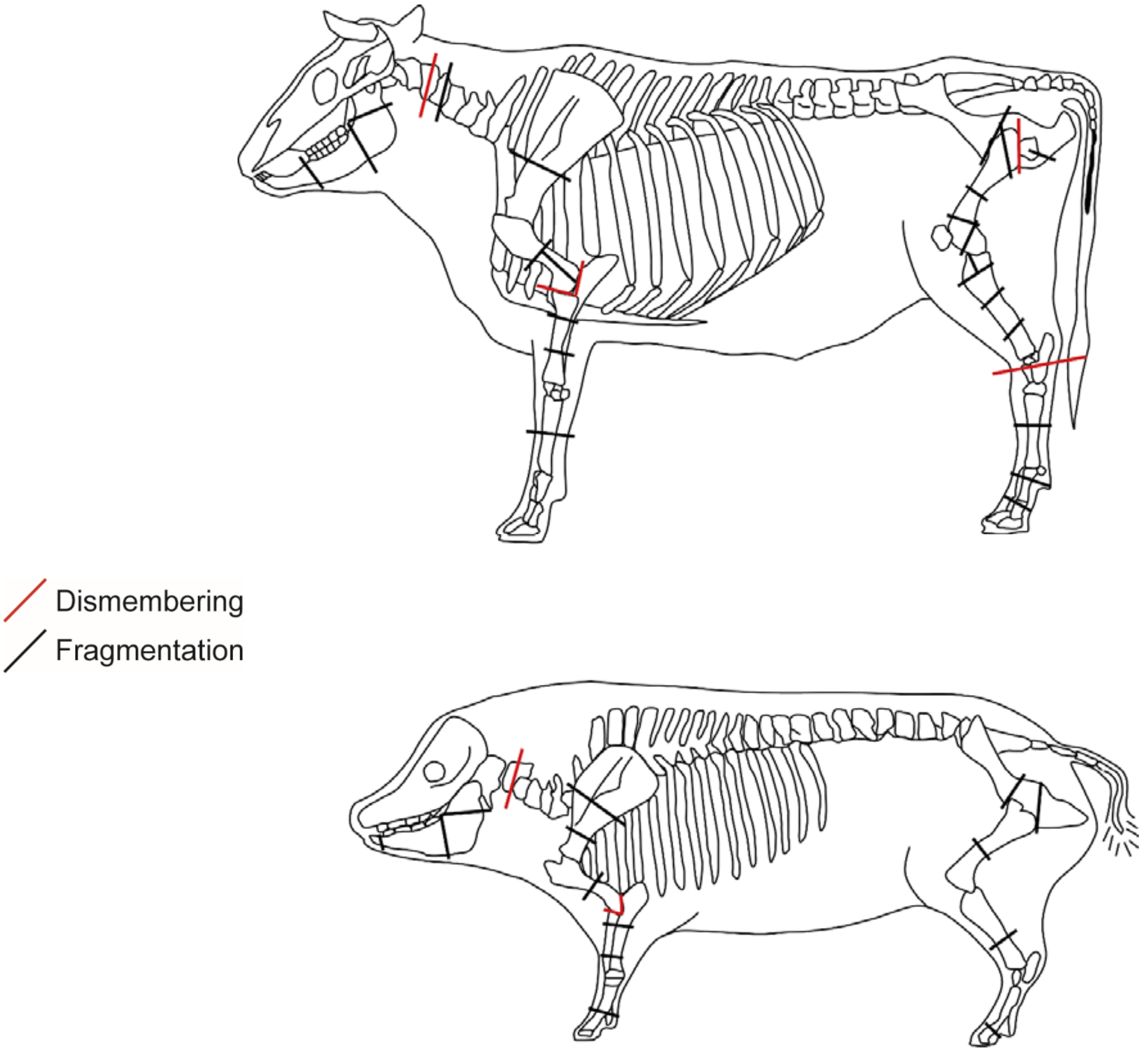

Figure 10.28: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Stephansposching.

10.10.2 Conclusion

Stephansposching presents a high-intensity marrow processing LBK site. As an enclosure site it is possible that the site held significance in the landscape as a possible central place, as has been argued for sites such as Herxheim (Boulestin *et al.* 2009). Some contextual differences in species diversity and carcass processing did not affect the necessity for marrow exploitation, which was equally important in all three context groups. While lipid residue analysis has thus far revealed no evidence of dairy fat in pottery sherd the fusion profile for cattle suggests a large survival into adulthood, perhaps as dairy females. If confirmed by dental age-at-death analysis this site could be an example of intensive marrow processing alongside availability of dairy fats.

Chapter 11 Dillingen-Steinheim “Wickenpoint”

11.1 Introduction

The site of Dillingen-Steinheim “Wickenpoint” was favourably situated on a naturally protected high terrace between the Danube and Egau river valleys, with access to fresh water, plentiful resources, extremely fertile loess soil and traffic routes (Pechtl pers. comm. 09/01/2017). Excavations have revealed likely a quarter of the settlement, although erosion by the Danube has resulted in the destruction of the better part of the site (*ibid.*). The settlement features of the site, including 5 house plans, were discovered inside a ditch and double palisade enclosure, typologically and radiocarbon dated to the Ältere - Mittlere LBK (*ibid.*). However, occupation of the site did not end with the LBK, and continued in almost all periods (*ibid.*).

11.2 Assemblage

11.2.1 Sample

The entire Linearbandkeramik faunal assemblage from Dillingen-Steinheim “Wickenpoint” (henceforth Dillingen-Steinheim) was analysed after completion of the targeted site Stephansposching. This was a small assemblage, totalling 611 specimens (table 1). Any difference in values for fully identifiable specimens (table 11.1) and species representation (figure 11.1) is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1). The site is best viewed as a whole due to its small size, but the majority of the bones came from context 24 (table 11.2).

Table 11.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Dillingen-Steinheim *Wickenpoint* (DST).

Fully identifiable (to species and element)	109
Partially identifiable (to species and element type)	72
Indeterminate	430
Total	**611**

11.2.2 Methodological choices

Due to the small size of the assemblage, many analyses such as in-depth fusion, burning and butchery analysis are omitted from this report, or dealt with briefly.

Table 11.2: Full list of contexts analysed from Dillingen-Steinheim *Wickenpoint*.

Context	Structure	Fully identifiable	Partially identifiable	Indeterminate
14	S1,2	0	0	11
24		10	6	30
24	B14	1	13	0
24	G22,23	2	0	0
24	S1,2	7	7	0
24	S10,11	9	1	58
24	S11,12	6	1	22
24	S12,13	1	1	8
24	S13	1	0	3
24	S14,15	3	3	36
24	S15,17	11	0	47
24	S2,3	8	6	22
24	S3,4	3	2	3
24	S4,5	0	4	10
24	S5,6	4	3	30
24	S6	1	0	0
24	S6,7	5	0	0
24	S7,8	0	0	6
24	S7,9	1	2	2
24	S8	11	4	6
24	S9,10	1	1	9
24	Fauna in grave 13	1	0	0
119	S2,3,7	4	3	2
141		1	0	11
142		1	0	0
290		1	2	9
512		3	10	102
515		3	0	0
516		2	0	0
521		2	0	0
565		1	0	0
573		1	0	3
579		0	1	0
638		0	1	0
639		2	0	0
673		2	1	0

11.3 Species representation

Cattle were the dominant species in the faunal assemblage from Dillingen-Steinheim at 46.5% (47/101) of the number of identifiable specimens (NISP), followed by pigs (25.7%, 26/101), caprines (15.8%, 16/101) and wild animals (11.9%, 12/101). The minimum number of individuals (MNI) for each species was 3 cattle, 5 pigs and 1 caprine. The wild animals present in the assemblage were aurochs, red deer and wild boar. The species diversity is similar to Stephansposching.

Brief fusion analysis on cattle (n=22) suggests that animals were slaughtered between 24-36 months (75.0% fused, 6/8) but primarily at 36-48 months (33.3% fused, 2/6), possibly indicating meat slaughter of full size animals. Pigs (n=9) showed that some slaughter of animals less than one year old (66% fused, 4/6), with no animals surviving after 3.5 years (0% fused, 0/3).

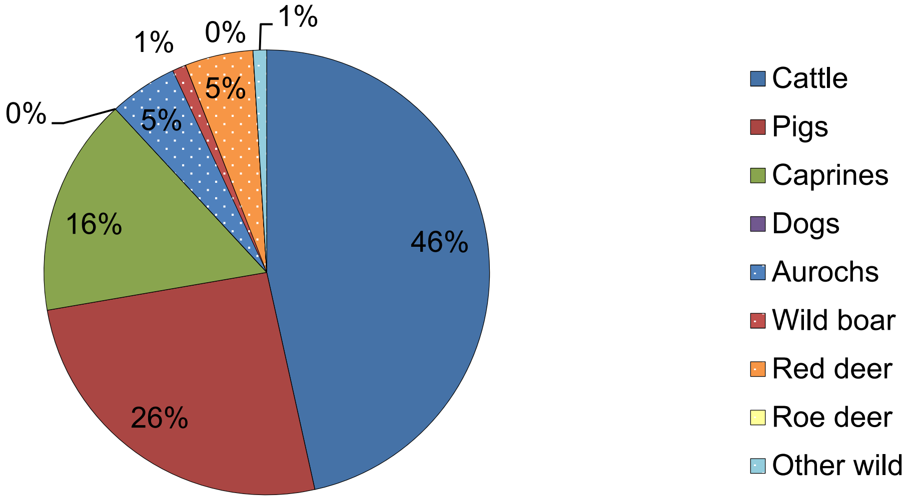

Figure 11.1: Species representation (NISP) for the fully identifiable assemblage from Dillingen-Steinheim Wickenpoint (n=101).

11.4 Carcass Processing

11.4.1 Butchery and heat exposure

There was little evidence for butchery and burning from the small Dillingen-Steinheim assemblage. Butchery marks were present on 2.0% (11/611) of the whole assemblage, the majority of which were cut marks. Slice marks were noted on three bones. The inclusion of a sawing mark, as shown in figure 11.2 and photographed in figure 11.3, suggests worryingly that this context (part of C24, section 1,2) has been intercut by later metal-working groups. However, it is also possible that this mark was made during sampling for scientific analysis (Outram pers. comm.). Burning was discovered on two bones that had been roasted.

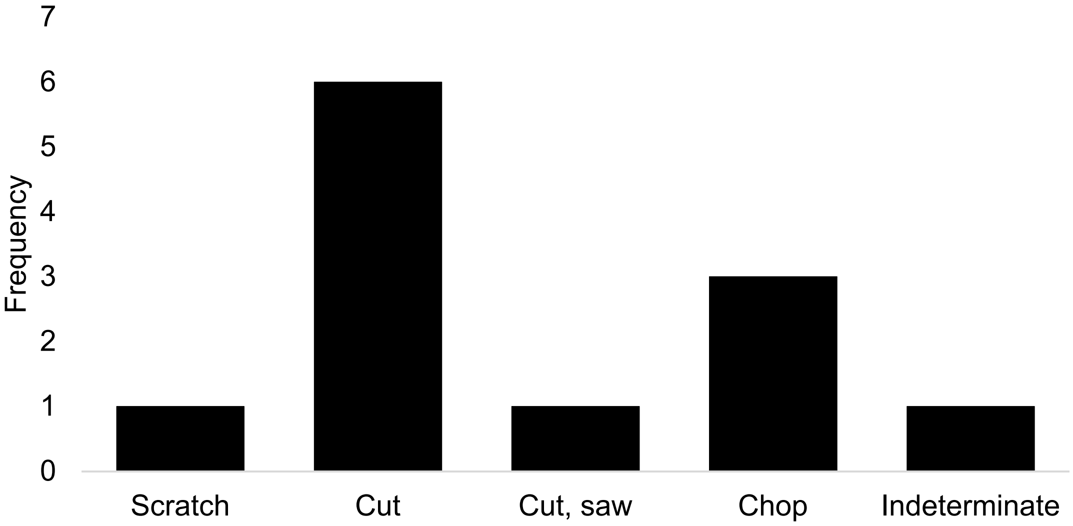

Figure 11.2: Frequency of butchery mark types from Dillingen-Steinheim Wickenpoint.

Figure 11.3: Evidence of sawing at Dillingen-Steinheim Wickenpoint.

11.4.2 Fracture

The percentage of fresh fracture (68.4%, 67/98) and the mean Fracture Freshness Index score (2.6) indicate that fresh fracture for marrow extraction was common at Dillingen-Steinheim (figures 11.4 and 11.5). The fracture history profiles also show that high-yield marrow bones were favoured for fresh fracture, with 89.7% (26/29) of high-yield bones fractured when fresh, supporting the suggestion that marrow was processed on site. Subsequent fracture was rare suggesting site disturbance was low, although some mineralised breaks point to activities affecting the bones long after their initial deposition. This fracture history profile is similar to that of Stephansposching and sites in the Alsace region, such as Rosheim *Sainte-Odile* and Bischoffsheim.

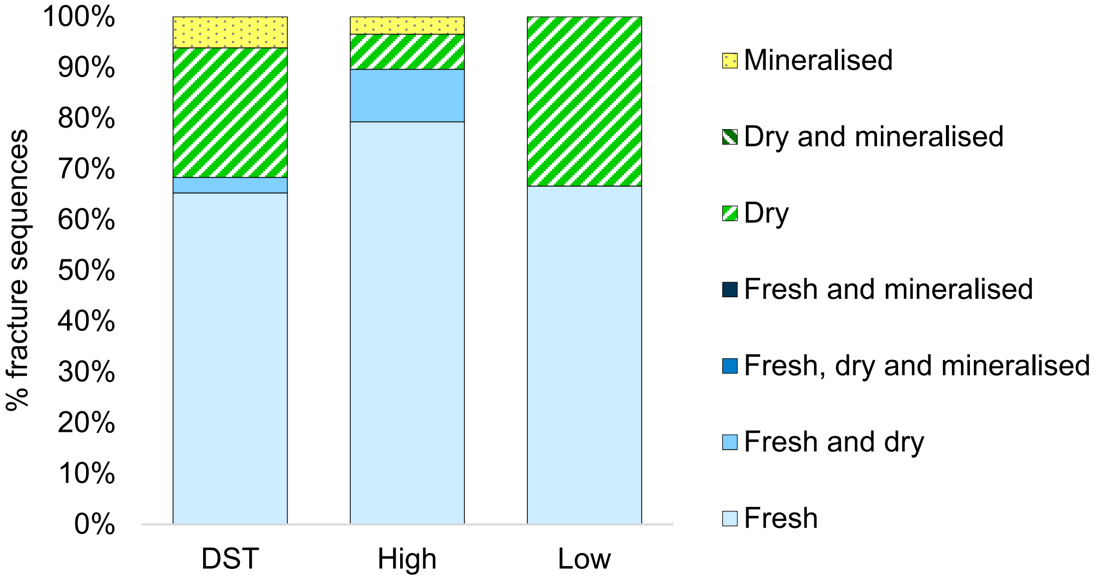

Figure 11.4: Fracture history profiles for Dillingen-Steinheim Wickenpoint (left; n=98) and for high- and low-yield marrow bones (right; n=29/9).

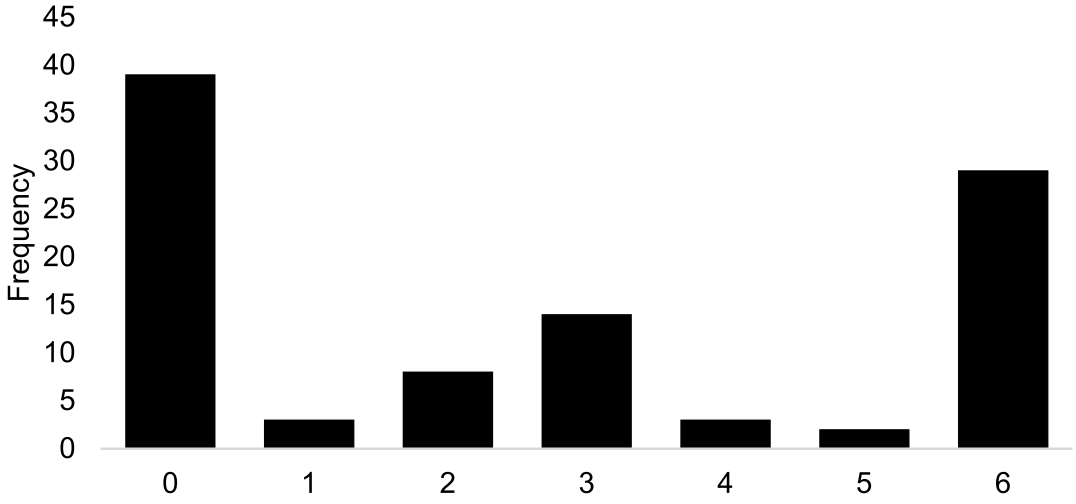

Figure 11.5: Frequency of FFI scores from Dillingen-Steinheim Wickenpoint.

11.4.3 Fragmentation

There was no evidence of intensive bone grease processing at Dillingen-Steinheim Wickenpoint. Size classes up to 60mm in diameter were underrepresented in terms of mass, and whole bones and those with unfragmented epiphyses were common (figures 11.6 and 11.7).

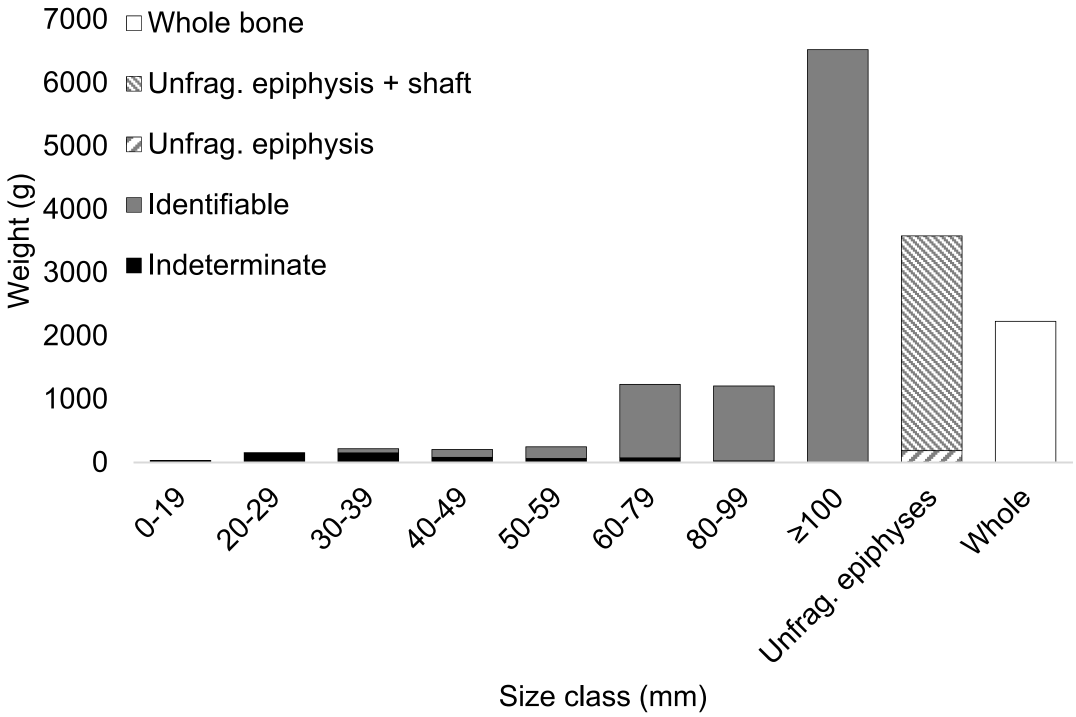

Figure 11.6: Weight by size class for all specimens from Dillingen-Steinheim Wickenpoint.

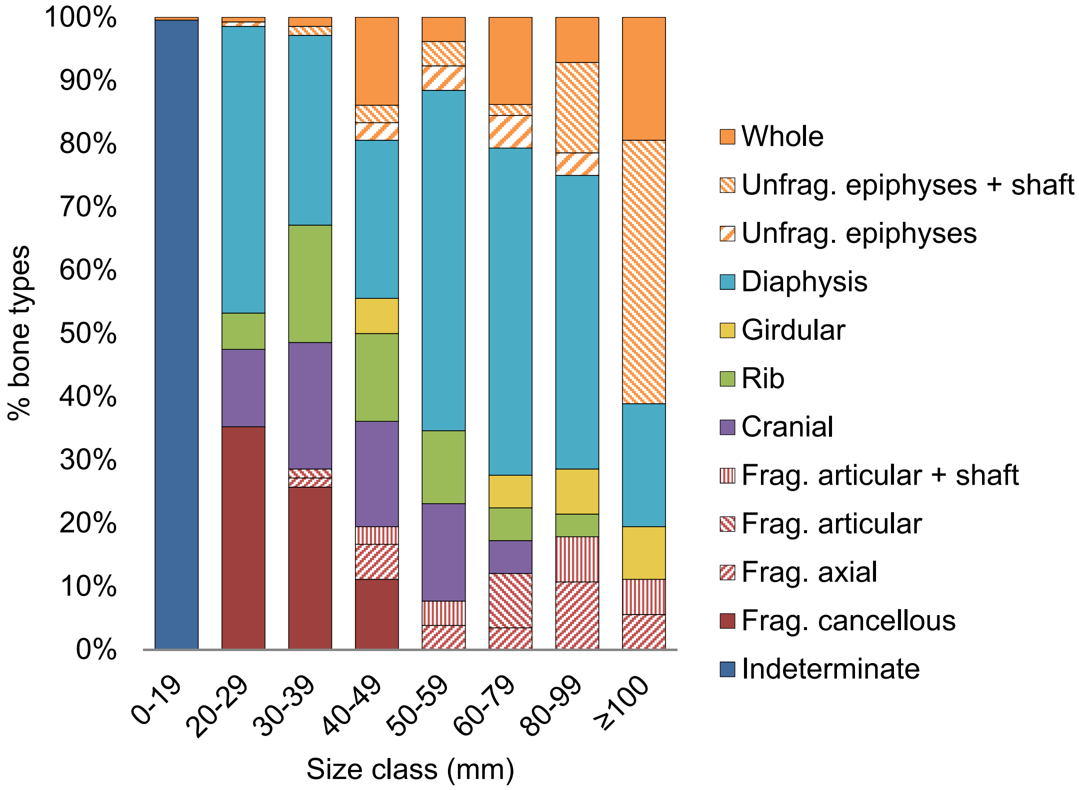

Figure 11.7: Frequency of bone types by size class from Dillingen-Steinheim Wickenpoint. Red series indicate fragmented cancellous bone.

11.5 Taphonomy

Gnawing was uncommon on this assemblage and entirely canid in nature, affecting 1.6% (10/611) of the whole assemblage. Minor incidences of taphonomic agents were found, such as root etching (n=5) and erosion (n=1). The assemblage was fairly well preserved, but recent breaks were common, on 29.3% (53/181) of the identifiable bones, which could have contributed to fragmentation levels.

11.6 Discussion

11.6.1 Food exploitation strategies

Due to the small size of the faunal assemblage herd structure analysis was not possible, although it can be postulated that prime meat from cattle and pigs was consumed on the site. Lipid residue analysis has shown animal fats in 25% of analysed non-perforated sherds (n=40) with one possible instance of dairy fat.

11.6.2 Meat and fat exploitation

Whilst butchery and heat exposure evidence were low from Dillingen-Steinheim, the fracture freshness analysis suggests intensive exploitation of marrow, preferentially targeting high-yield elements. No signatures of bone grease processing were identified.

11.6.3 Conclusion

Dillingen-Steinheim Wickenpoint fits into the trends that have been found regionally, matching Stephansposching very closely and following the expected species diversity for Bavaria (as outlined in Bickle and Whittle 2013: 13). It also abides by the patterns in fracture and fragmentation that have been found regionally and across the LBK. Although evidence is sparse it is possible that people in this region had access to milk, but continue to exploit marrow from animal long bones.

Chapter 12 Herxheim

12.1 Introduction

Herxheim is situated in the south of the German Federal State of Rhineland-Palatinate, on a spur above a loess plateau at the confluence of two small rivers (Boulestin *et al.* 2009: 969; Haack 2016). Two phases of excavation were carried out in 1996-1999 and 2005-2008 (*ibid*.). The discovered structures indicate a village inhabited between 5300 and 4950BC (Flomborn to the Jüngste LBK), surrounded by two trapezoid parallel ditches (*ibid.*; figure 12.1). Due to the rarity of enclosure sites in the LBK, it is possible that these types of settlements could have enjoyed a central position on a micro-regional or even regional level (Boulestin *et al.* 2009: 971).

Herxheim is certainly an atypical LBK site. The ditches contain systematically butchered human remains, along with animal bones, ceramics, stone and bone tools and rare decorative artefacts (*ibid.*). These deposits all date to the last phase of the LBK (Jüngste). Based on patterns of species and skeletal representation it has been suggested that the faunal assemblage was specially selected for deposition in the pseudo-pits as high numbers of domestic dog bones and extremities of all species were recovered compared to the settlement pits (*ibid*., corroborated by my own analysis below).

12.1.1 Ditch interpretation

Debates among archaeologists exist concerning the nature of the ditches. Jeunesse and Lefranc (1999) argue that they represent Rosheim-type “pseudo-ditches”, in that they are a product of overlapping pits, dug over several centuries to a pre-determined design (*ibid*.). However, this is refuted by Haack who argues that the minimal erosion of ditch walls and rain-washed sediments indicates that they were filled quickly (Haack 2016: 113-115). The deposits themselves likely represent one deposition event of soil, remnants of cleared out fireplaces and refitting artefacts, some of which were likely secondarily deposited (*ibid*.). Haack describes these depositions as ‘ritual waste’ (*ibid.*), and his findings have implications in particular for taphonomy, as will be discussed in section 12.8.

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Figure 12.1: Site plan of Herxheim, showing reconstruction of the ditches based on excavation and geophysical survey and the two excavation areas A (1996-1998) and B (2005-2008; Boulestin *et al.* 2009: 970, figure 1).

12.2 Assemblage

12.2.1 Sample

A large sample of the faunal assemblage from Herxheim was analysed, totalling 8000 specimens (see table 12.1). Contexts were selected for analysis based on phase and interpretation (i.e. settlement pit or ditch) to allow for a varied sample to be taken of the excavated portion of the site. The total number of specimens in each context was also considered, based on Arbogast's previous zooarchaeological study of the site (Arbogast in prep.). The largest contexts were chosen for analysis from each settlement phase, and the ditches were analysed to an estimated 90%. A brief qualitative survey was undertaken on the remaining contexts, which did not differ substantially from the material already analysed. The difference in values for fully identifiable specimens (table 12.1) and species representation (figure 12.2) is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 12.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Herxheim (HER).

Fully identifiable (to species and element)	1291
Partially identifiable (to type of species and element)	1216
Indeterminate	5493
Total	**8000**

The faunal material on the site can be combined into six contextual groupings - the four phases of occupation in the settlement (Ältere, Mittlere, Jüngere and Jüngste) and the Jüngste phase internal and external ditches (table 12.2 and 12.3). The settlement interior was widely destroyed by erosion (Boulestin *et al.* 2009), thus in this assemblages there were no 'house pits', simply settlement pits. Given that the ditches were not present in the site before the Jüngste phase they are not compared directly to previous phases.

Table 12.2: Number of fully identifiable (FID), partially identifiable (PID) and indeterminate (IND) specimens in each context grouping from Herxheim.

Phase	Code	Area	FID	PID	IND
Ältere	ALT	Settlement	21	45	203
Mittlere	MIT	Settlement	41	89	369
Jüngere	JRE	Settlement	137	138	446
Jüngste	JST	Settlement	210	431	1632
Jüngste	INT	Internal ditch	639	309	1772
Jüngste	EXT	External ditch	206	170	934

Table 12.3: Full list of contexts analysed from Herxheim.

Context	Phase	Interpretation	FID	PID	IND
281	Jüngste	External Ditch	120	60	546
282	Jüngste	Internal Ditch	618	307	1749
296	Jüngste	Settlement	52	127	337
343	Jüngste	Settlement	20	39	107
374/376	Jüngere	Settlement	6	2	3
470	Jüngste	Settlement	17	35	110
589	Jüngste	Settlement	55	100	526
1052	Mittlere	Settlement	17	46	218
1077	Ältere	Settlement	21	45	203
1327	Jüngere	Settlement	7	22	78
1336	Jüngste	Settlement	6	6	14
1350	LBK	Settlement	0	5	4
1357	Jüngere	Settlement	4	4	12
1360	LBK	Settlement	0	0	2
1496	Jüngste	Settlement	29	81	428
1660	Mittlere	Settlement	24	43	151
5001	Jüngste	External Ditch	6	3	36
5002	Jüngste	External Ditch	4	0	7
5003	Jüngste	External Ditch	5	1	2
5006	Jüngste	External Ditch	4	3	10
5007	Jüngste	External Ditch	1	0	5
5008	Jüngste	External Ditch	8	5	15
5009	Jüngste	External Ditch	0	0	1
5011	Jüngste	External Ditch	8	19	33
5013	Jüngste	External Ditch	1	0	2
5014	Jüngste	External Ditch	0	1	7
5016	Jüngste	External Ditch	0	0	3
5017	Jüngste	External Ditch	11	15	46
5018	Jüngste	External Ditch	0	0	13
5019	Jüngste	External Ditch	5	0	4
5021	Jüngste	External Ditch	3	0	3
5022	Jüngste	External Ditch	0	1	1
5026	Jüngste	External Ditch	1	2	14
5027	Jüngste	External Ditch	1	0	0

5028	Jüngste	External Ditch	1	2	1
5030	Jüngste	External Ditch	24	45	145
5033	Jüngste	External Ditch	3	6	22
5034	Jüngste	External Ditch	0	7	15
5105	Jüngste	External Ditch	0	0	3
7002	Jüngste	Internal Ditch	3	1	4
7007	Jüngste	Internal Ditch	2	1	4
7008	Jüngste	Internal Ditch	5	0	1
7013	Jüngste	Internal Ditch	2	0	11
7024	Jüngste	Internal Ditch	1	0	0
7025	Jüngste	Internal Ditch	0	0	1
7026	Jüngste	Internal Ditch	1	0	0
7027	Jüngste	Internal Ditch	2	0	2
7032	Jüngste	Internal Ditch	1	0	0
7034	Jüngste	Internal Ditch	2	0	0
7059	Jüngste	Internal Ditch	2	0	0
9001	Jüngere	Settlement	45	45	136
9041	Jüngste	Settlement	2	1	5
9048	LBK	Settlement	1	0	0
9078	Jüngste	Settlement	26	39	103
9084	Jüngere/Jüngste	Settlement	31	24	90
9094	Jüngere	Settlement	16	14	70
9102	Jüngere	Settlement	17	18	38
9120	LBK	Settlement	0	0	27
9134	Jüngere	Settlement	5	0	9
9136	Mittlere/Jüngere	Settlement	1	0	14
9147	LBK	Settlement	0	1	0
9167	Jüngste	Settlement	2	1	2
9171	Jüngere	Settlement	37	33	100
9174	LBK	Settlement	4	4	0
9191	Jüngste	Settlement	1	2	0

12.2.2 Methodological choices

Butchery analysis was completed to as full an extent as possible, including bucrania, to be used as a comparison to the detailed human butchery study undertaken by Bruno Boulestin (Zeeb-Lanz, pers. comm.; Boulestin *et al.* 2009). It should be noted that Boulestin used a microscope in identification and recording of human butchery, whereas butchery marks on animal bones were perceived with the naked eye and a hand lens. Thus whilst data from both animal and human butchery practices will be drawn together their results are not directly comparable.

12.3 Species representation

12.3.1 Site

The species representation (Number of Identifiable Specimens, NISP) of the overall sample reflects general trends in the Alsace and Baden-Württemberg regions of the LBK, with cattle, pigs and caprines being relatively equally represented (figure 12.2; see chapters 13 and 14). Domestic cattle were the most common domestic animal (29.6% NISP, 375/1267), followed by pigs (28.2%, 357/1267) and caprines (18.1%, 229/1267). Both sheep and goat were present in the assemblage, identifiable by their crania. The proportion of domestic dogs was unusually high at Herxheim compared to many other LBK sites at 12.2% (154/1267). Wild animals were fairly well represented at 12.0% (152/1267), including red deer, roe deer, wild boar and aurochs. Other wild fauna included small mammals and species of bird.

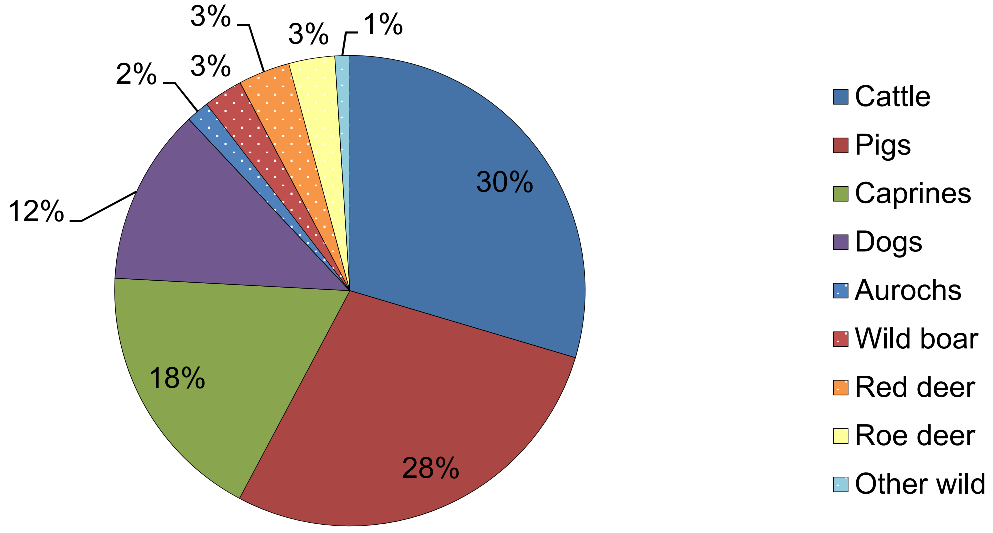

Figure 12.2: Species representation (NISP) for the fully identifiable assemblage from Herxheim (n=1267).

12.3.1.1 Settlement phases

Whilst the sample sizes for the Ältere and Mittlere phase were relatively low it was possible to compare the phases of settlement at Herxheim (figure 12.3). The highest proportion of cattle was found in the Ältere phase, which decreased in the Mittlere phase in conjunction with a rise in the proportions of caprines and wild animals, although the differences were not significant. Domestic pigs played a much larger role in the Jüngere and Jüngste assemblages, with caprines decreasing significantly over time between the Mittlere (37.5%, 15/40) and Jüngste phases (18.0%, 37/205, p=.006). In the final phase of the LBK pigs were the most common domestic animal, followed by cattle and then caprines. Red deer were also more common in this phase than in preceding phases.

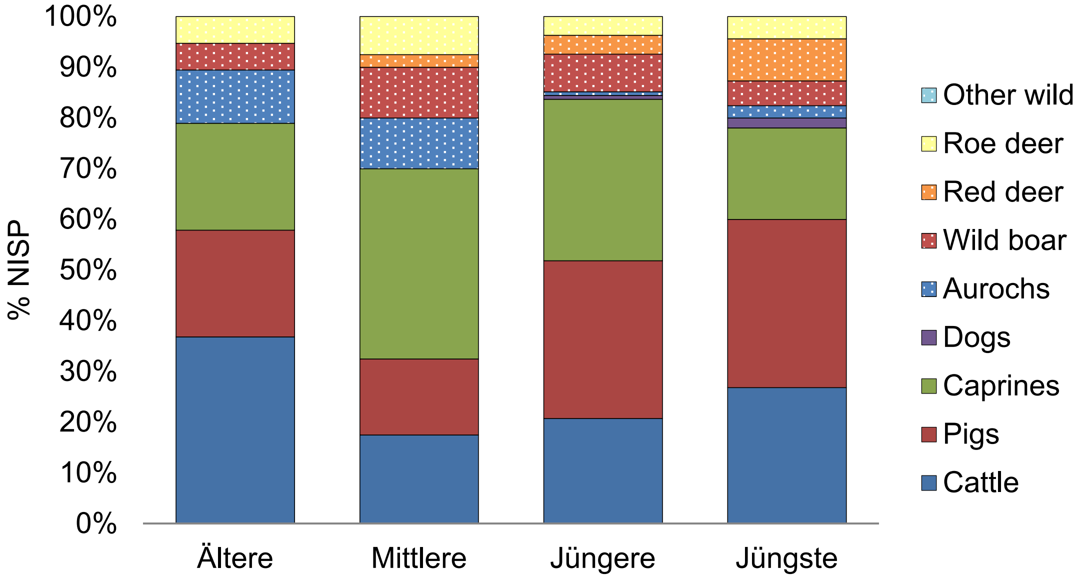

Figure 12.3: Species representation (NISP) for the Ältere (n=19), Mittlere (n=40), Jüngere (n=135) and Jüngste (n=205) phase settlement contexts from Herxheim.

12.3.1.2 Jüngste phase

In the Jüngste phase, the species representation from the settlement contexts can be compared with that of the internal and external ditches. Interestingly, the species proportions in the external ditch and settlement pits were similar, whereas the internal ditch differed particularly in the significantly higher proportions of domestic dog (22.4%, 141/630, MNI=5) compared to both other contexts (JST 2.0%, 4/205; EXT 3.0%, 6/202; both p<.001; figure 12.4). The internal ditch also had the highest proportion of cattle (INT 34.0%, 214/630;

MNI=10; significantly higher than the external ditch 24.8%, 50/202, p=.014), and the lowest combined percentage for the small domesticates (36.3%, 229/630) than both the external ditch (59.9%, 121/202) and settlement 51.2%, 105/205; p<.001).

Although wild fauna was less well represented in the ditches compared to the settlement there were certainly more birds, including possible geese (*Anser sp.*), grouse (*Tetrao sp.*) and woodcock (*c.f. Scolopax sp.*), and bones of fox (*Vulpes vulpes*) and hare (*Lepus europeaus*). The analysis of the Jüngste phase species representation suggests preferential deposition of certain species, particularly dog and domestic cattle, in the internal ditch, whilst the external ditch showed an assemblage with more in common with the settlement.

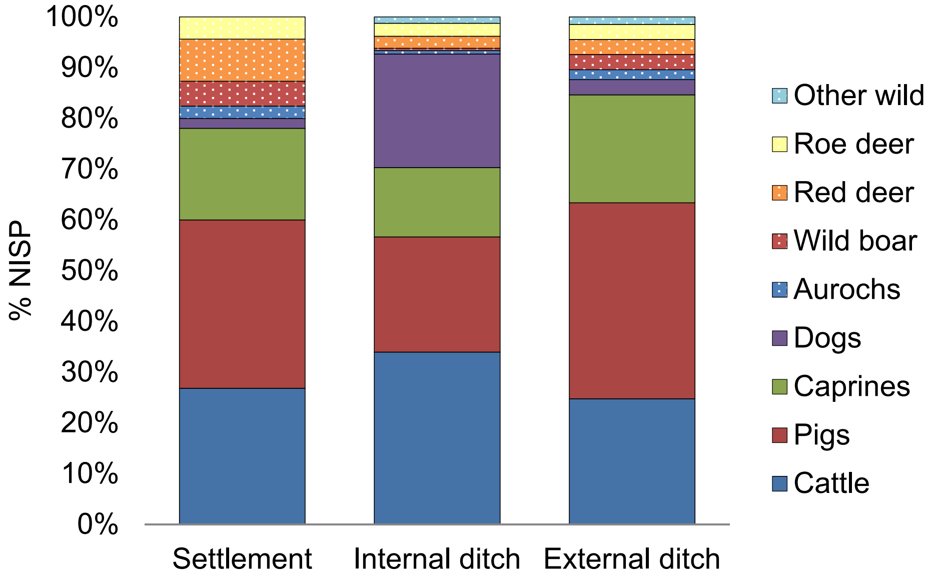

Figure 12.4: Species representation (NISP) for the Jüngste phase settlement (n=205), internal ditch (n=630) and external ditch (n=202) contexts from Herxheim.

12.3.2 Skeletal part abundance

The element representation further implies that carcasses were being butchered and preferentially deposited in the Jüngste phase settlement pits or the ditches (figure 12.5). Boulestin *et al.* state that the ditches contained more extremities than the settlement pits (2009: 971). My analysis showed a statistically significant difference between the settlement pits and the internal and external ditch assemblages in terms of the proportion of metapodia and phalanges identified. In the fully identifiable assemblage from the settlement extremities made up 16.7% (40/240), whereas in the internal and external ditches the proportion was 30.8% (169/549, p<.001) and 26.0% (58/223, p=.014) respectively (figure 12.5). Dog bones were excluded from this analysis due to the differential deposition between contexts and the increased number of metapodia and phalanges in canid anatomy.

The forelimb bones, including the scapula, humerus, radius and ulna, and the hindlimb bones including the femur and tibia, were relatively equally represented between contexts. However, the proportion of diaphysis fragments (not included in figure 12.5) in the identifiable and indeterminate assemblages differed between the settlement and ditch contexts. Diaphysis fragments contributed to 62.3% (397/637) of all bone types in the assemblage in the settlement and 32.0% (258/807) and 39.7% (147/370) in the internal and external ditches respectively. This difference is notable and statistically significant (p<.001). It suggests that long bones in the settlement contexts were prone to higher degrees of fragmentation than the ditch contexts (see also figure 12.39), possibly relating to marrow extraction.

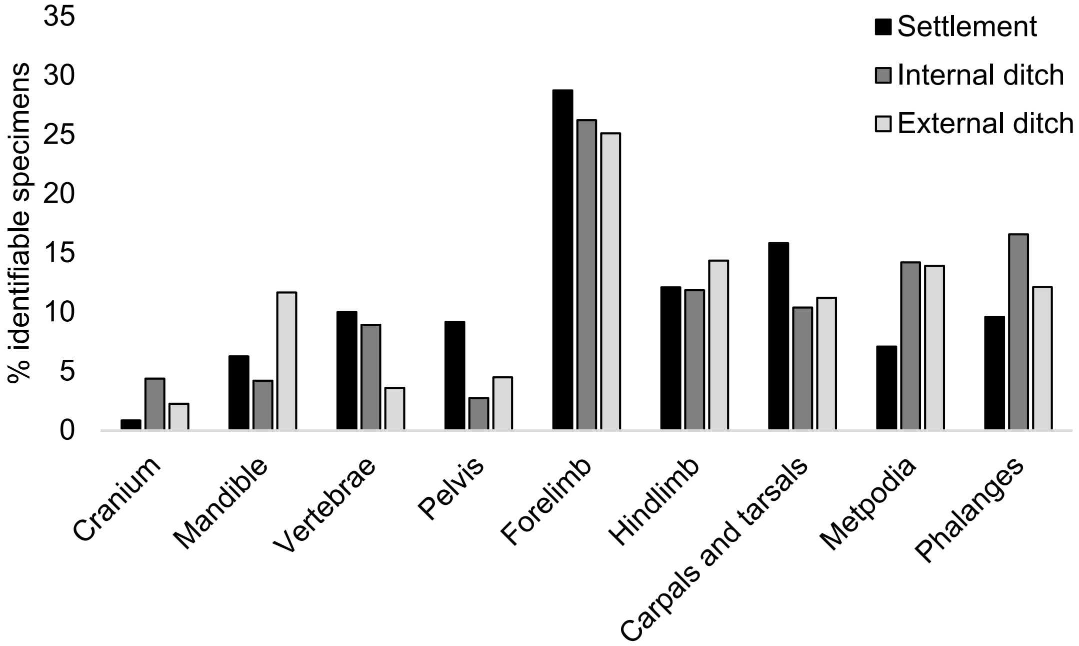

Figure 12.5: Percentage of the Jüngste phase settlement (n=240), internal ditch (n=549) and external ditch (n=223) fully identifiable assemblage assigned to certain elements or element groups from Herxheim.

12.4 Butchery

12.4.1 Herxheim butchery

Human bones showed repeated and frequent butchery argued to reflect typical butchery found on animals, indicative of skinning, defleshing and processing for marrow (Boulestin *et al.* 2009: 976). This was used as evidence to suggest that cannibalism was being practised at Herxheim. A study of a similar nature, carried out on animal bones, was necessary to confirm similarities between human and animal butchery. Similar butchery patterns and intensities on animal bones could indicate that cannibalism at Herxheim was nutritionally focussed and perhaps secondarily ritualised. Different human and animal butchery patterns could suggest that cannibalism was ritualised first and foremost and was not a result of (but perhaps contributed to) nutritional requirement. However, as different methodologies were used, especially regarding microscope use, conclusions drawn must be very basic.

Butchery marks were present on 2.3% (186/8000) of the entire faunal assemblage, and on 5.5% (139/2507) of identifiable material, typical for other LBK sites that have been analysed as part of this project. Cut marks were the most frequent type of butchery, although scratch marks, chop marks and evidence of percussion (crush marks) were also noted (figure 12.6). This light and infrequent pattern of butchery marks and the high proportion of cut and scrape marks is likely due to the LBK toolkit, and as a result of practiced butchers avoiding blunting their knives against bone surfaces. On the human bone studied by Boulestin, cut marks were present on 21.7% of the minimum number of elements (MNE, n=345) and scrape marks present on 7.8% (Boulestin *et al.* 2009: 975), suggesting that the total proportion of butchered bone is ≥21.7%. On fully identifiable animal bone from the Jüngste phase (contemporary with the human bone deposits) butchery was observed on 8.8% of specimens (NISP, 93/1055). Despite quantitative issues comparing the NISP against the MNE and the differential use of a microscope this disparity may suggest more intensive butchery on human bones.

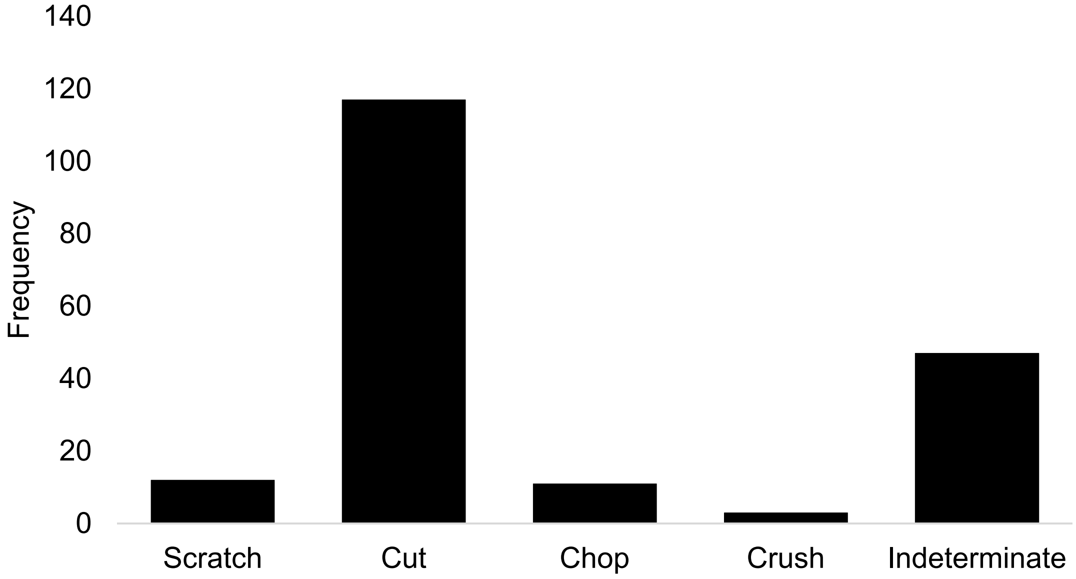

Figure 12.6**: Frequency of butchery mark types from Herxheim.**

12.4.1.1 Context groups

Butchery was most common in the Jüngere settlement phase (figure 12.7), although the differences were not significant. The Jüngste phase showed heightened butchery in the ditch contexts, particularly in the internal ditch where the percentage of bones butchered was significantly higher than the settlement contexts (INT 2.8%, 75/2720; JST 1.9%, 43/2273; p=.045; figure 12.8), although in general the proportions remained similar.

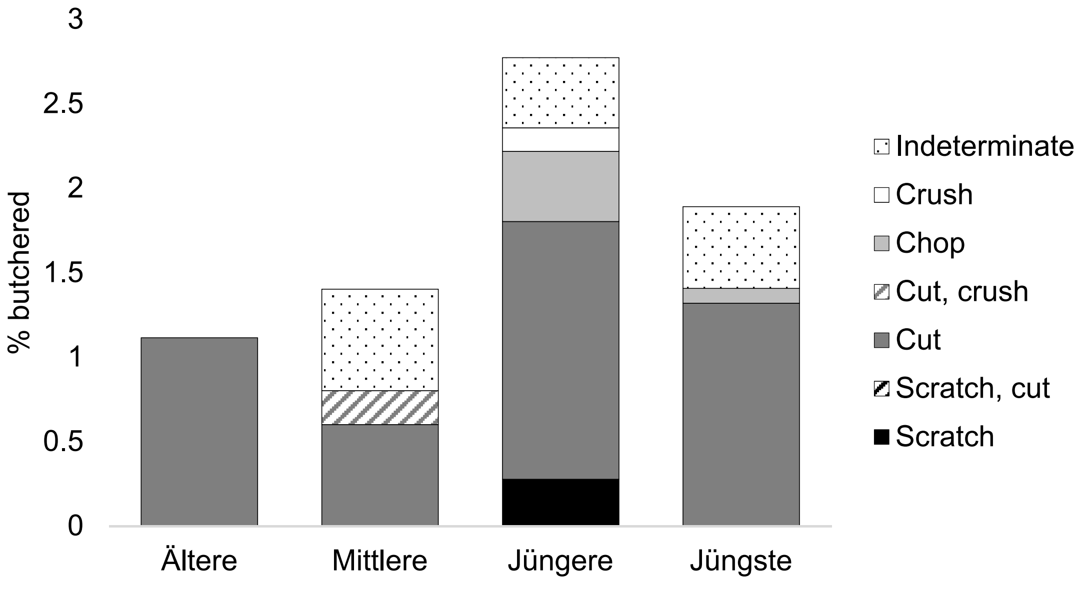

Figure 12.7: Percentage of specimens with different butchery episodes from each settlement phase from Herxheim.

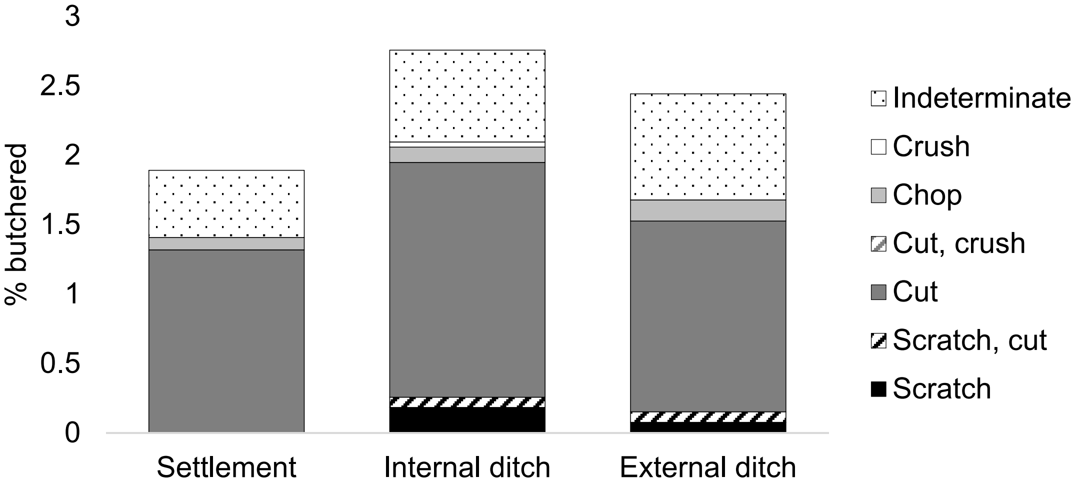

Figure 12.8**: Percentage of specimens with different butchery episodes from Jüngste phase settlement and ditch contexts from Herxheim.**

12.4.2 Species

The difference between the percentage of wild animals (14.4%, 20/139) and domestic animals (8.0%, 76/949) showing evidence of butchery was statistically significant (p=.013; figure 12.9), possibly due to more intensive kill-site butchery on hunted animals. Wild boar and red deer were particularly affected by butchery at 20.6% (7/34) and 24.4% (11/35) of specimens respectively. Roe deer, a wild species which showed no observed evidence of butchery, possibly could have been transported whole, and needed no intensive kill-site butchery. Interestingly the bones of dogs were subject to some butchery (4/145), but significantly less than cattle (42/375; p=.001), pigs (28/357; p=.025), wild boar and red deer (both p<.001; figure 12.9).

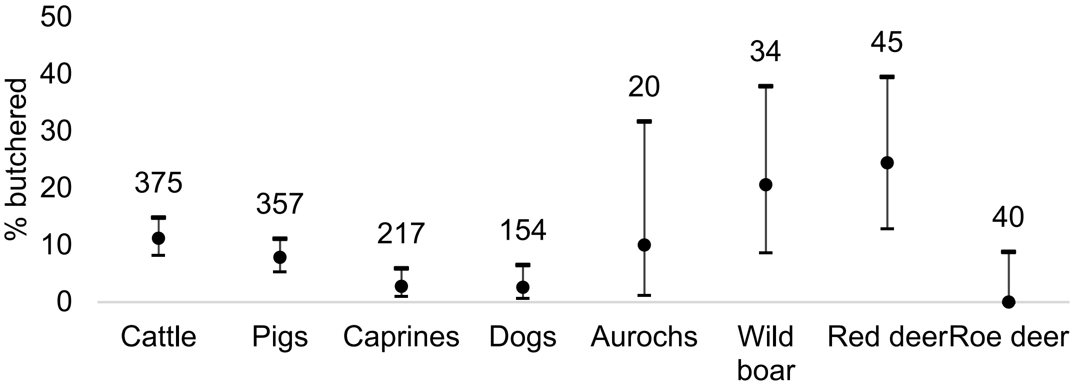

Figure 12.9: Percentage of species affected by butchery from Herxheim, with 95% confidence intervals. N values are at the top of each series.

12.4.3 Carcass butchery

Butchery analysis by skeletal element and carcass portion showed some differences in carcass processing (figures 12.10 and 12.11). Areas of the cranium were particularly affected by butchery, although a certain bias exists as only crania with attached horn cores were included in identifiable bones and thus subjected to advanced butchery analysis. Of the appendicular skeleton, the meat-rich elements of the upper fore- and hind-limb showed elevated levels of butchery compared to lower limb elements. However, metapodia and particularly tarsals showed high levels of butchery, likely due to skinning and dismemberment.

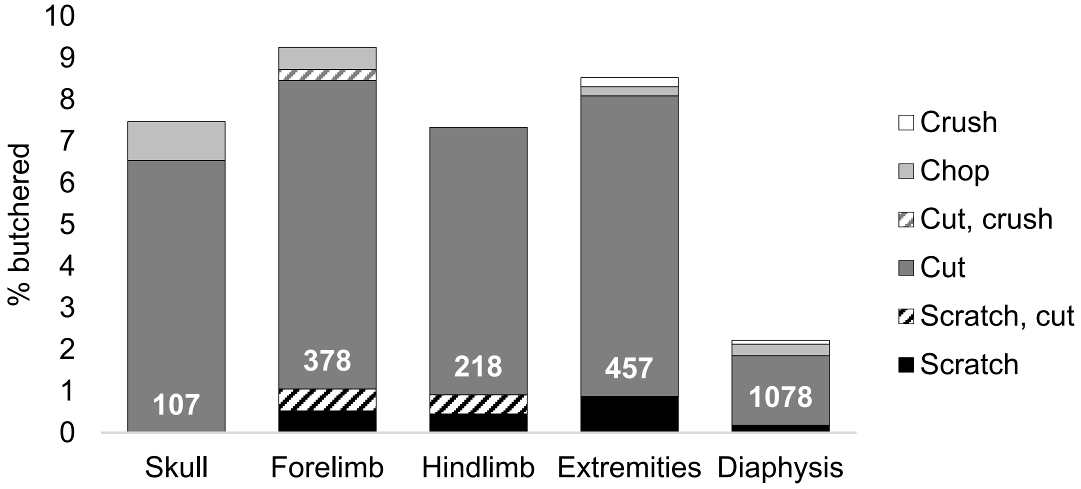

Figure 12.10: Percentage of carcass portions with different butchery episodes from Herxheim. N values are at the base of each bar.

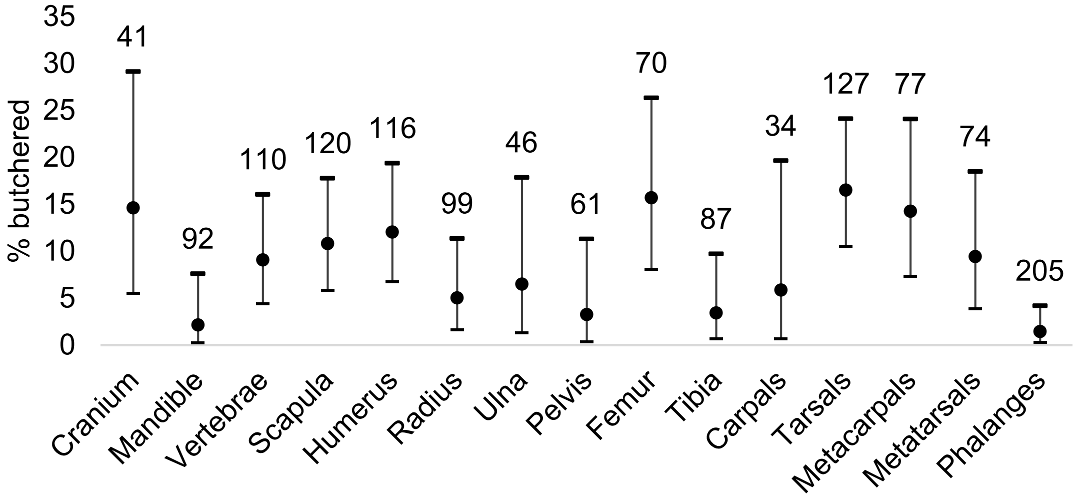

Figure 12.11: Percentage of elements affected by butchery from Herxheim, with 95% confidence intervals.

12.4.3.1 Cranium butchery

Bucrania of cattle and goats were predominantly found in the Jüngste phase ditches and were qualitatively subjected to more intensive butchery analysis than less determinate cranial fragments. Cut marks clustered around the base of the horn core, representing repeated strokes of individual butchery events (figure 12.12). It is possible that these marks represent the removal of the skin, and suggests that if these bucrania were being deposited in the ditches as part of ritualistic behaviour that they were skinned and possibly defleshed beforehand, as with the human crania (Boulestin *et al.* 2009).

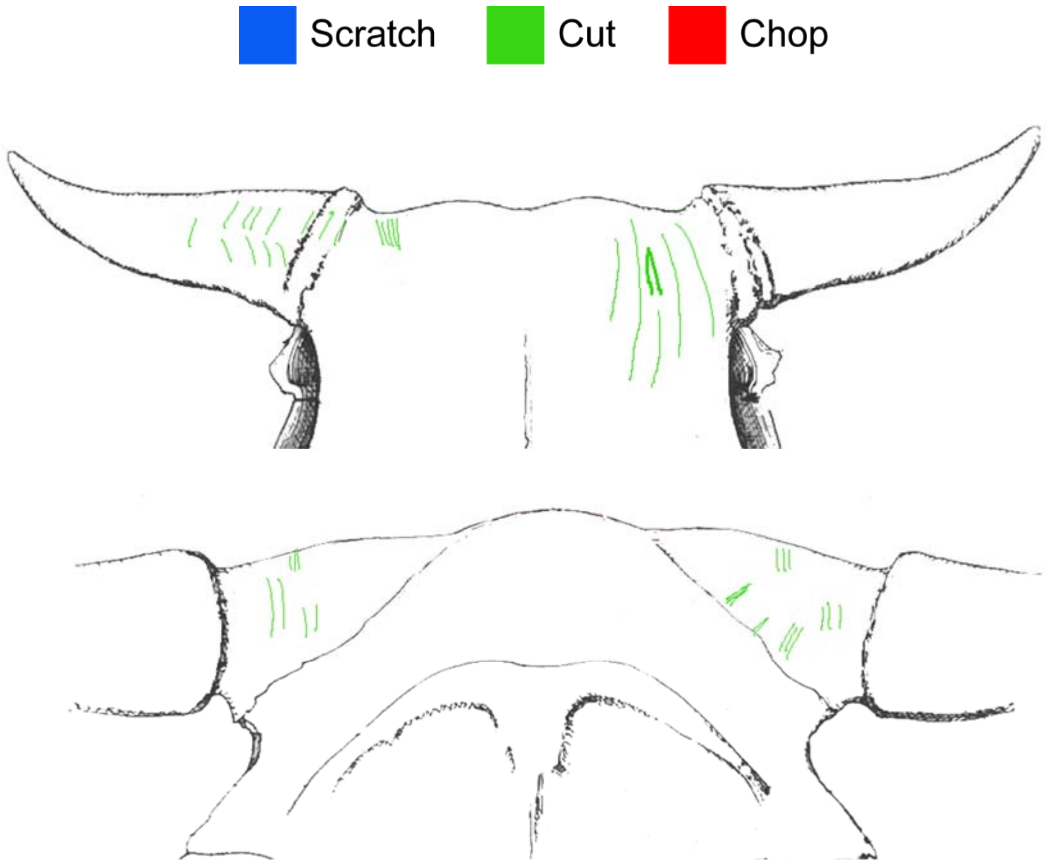

Figure 12.12: Cumulative diagram of butchery on bovine bucrania (n=5) from Herxheim. Dorsal (top) and posterior views.

12.4.3.2 Scapula butchery

The scapula was one of the more commonly butchered elements. The distal articulation, neck and emergence of the spine were the most common portions of the scapula recovered. Some heavier chop marks were present on cattle scapulae around the spine, the location of which suggests defleshing (figure 12.13; Soulier and Costamagno 2017). On suid scapulae cut and scratch marks around the neck of the scapula were more common, possibly indicating dismembering (Binford 1981: 122: figure 12.14). The repeated butchery on the lateral face of the scapula in pigs could suggest filleting and meat stripping.

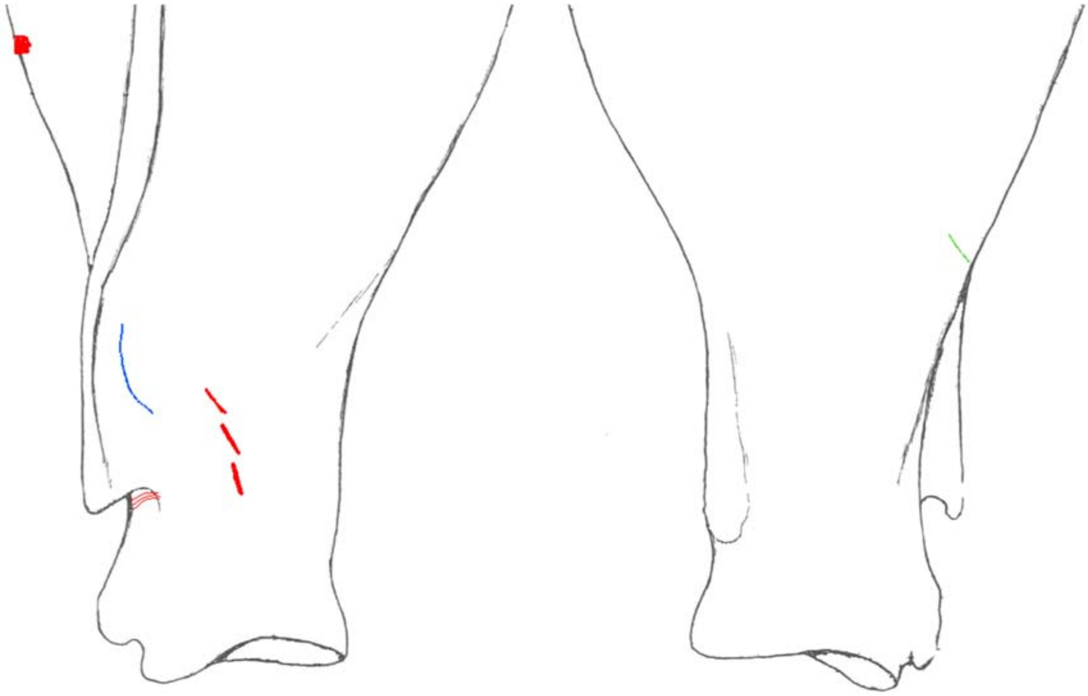

Figure 12.13: Cumulative diagram of butchery on bovine scapulae (n=5) from Herxheim. Lateral (left) and medial views.

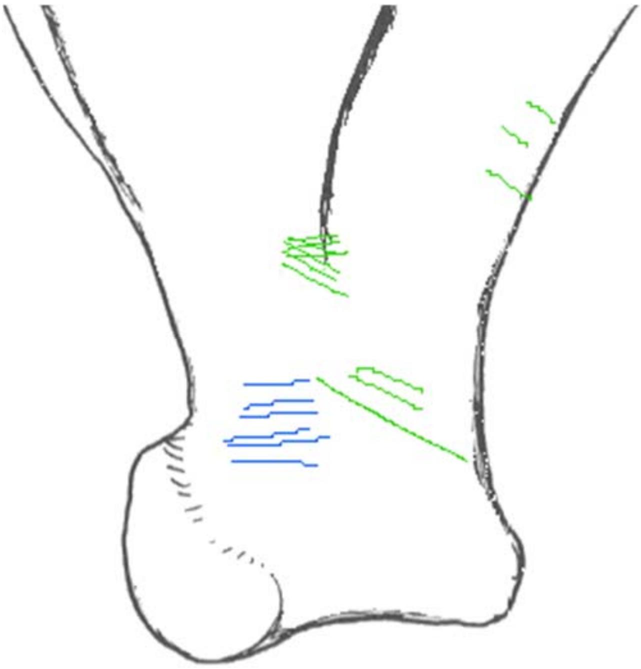

Figure 12.14: Cumulative diagram of butchery on suid scapulae (n=5) from Herxheim. Lateral view.

12.4.3.3 Long bones butchery

Over 90% (114/116) of humeri from all species were fragmented, predominantly broken at midshaft and best represented by the distal epiphysis. Cut and scratch marks clustered around the distal articulation and shaft (figures 12.15 and 12.16). Butchery predominantly on the shaft of the humerus suggests filleting, whereas on the articulation itself, primarily on the medial and posterior aspects, suggests disarticulation from the radius and ulna (Soulier and Costamagno 2017; Binford 1981: 123).

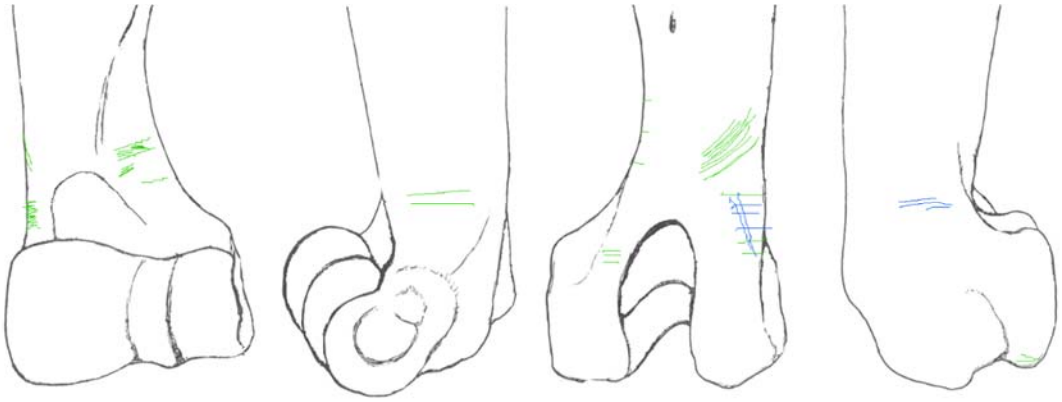

Figure 12.15: Cumulative diagram of butchery on bovine distal humeri (n=6) from Herxheim. Left to right; anterior, lateral, posterior and medial views.

Figure 12.16: Cumulative diagram of butchery on suid distal humeri (n=4) from Herxheim. Left to right; anterior, medial and lateral views.

On suid femora (figure 12.17) cut and scratch marks were more common on the shaft than on the humerus. Although some could represent disarticulation they are likely the product of filleting the meat-rich femur.

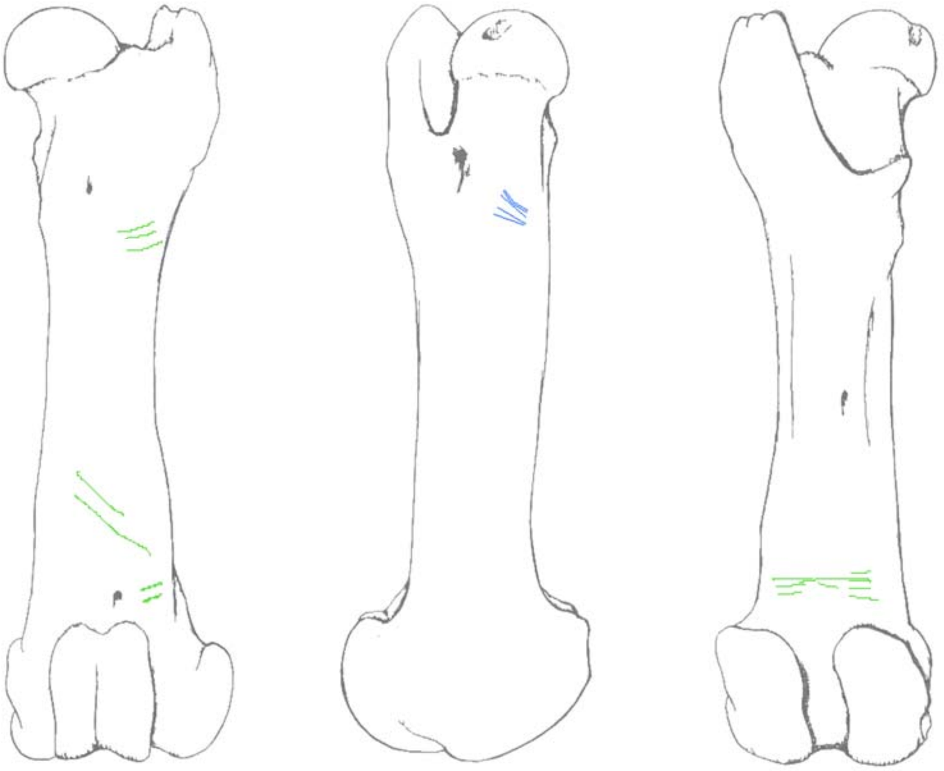

Figure 12.17: Cumulative diagram of butchery on suid femora (n=4) from Herxheim. Left to right; anterior, medial and posterior views.

12.4.3.4 Extremities butchery

The extremities, particularly the tarsals and metapodia, were frequently butchered. On the calcaneum, especially in suidae, butchery around the *tuber calcanei* could suggest defleshing, while butchery of the sustentaculum is more likely related to dismembering (figure 12.18; Soulier and Costamagno 2017). On the astragalus, horizontal cuts to the anterior and lateral faces indicate dismembering of the extremities from the upper limb bones (figures 12.18 and 12.19; *ibid.*). Butchery on suid metapodia corresponded to marks on adjacent metapodia (figure 12.20 and 12.21). It is likely that this butchery represents incisions made in skinning.

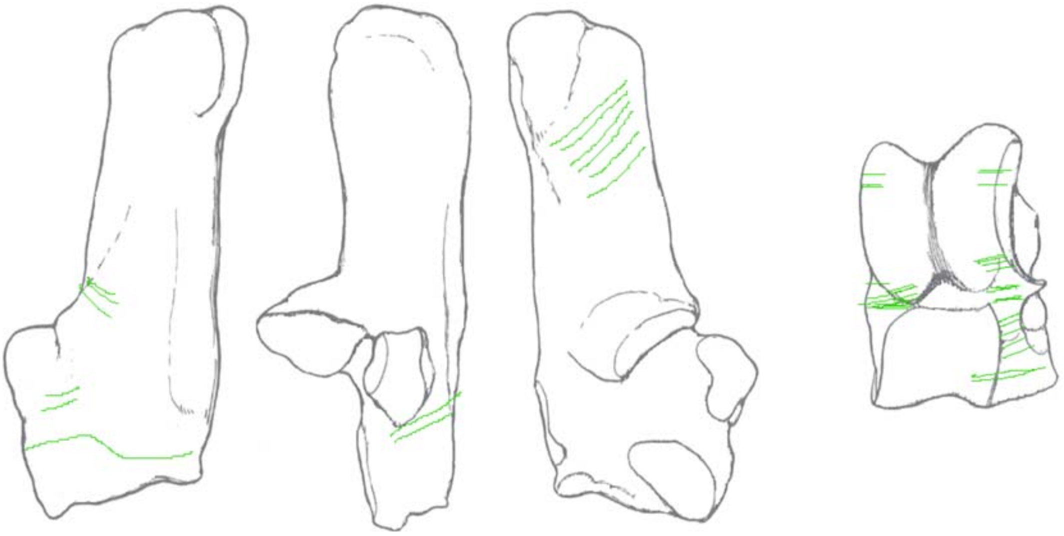

Figure 12.18: Cumulative diagram of butchery on suid calcanei (n=3), lateral, anterior and medial views, and astragali (n=5), anterior view, from Herxheim.

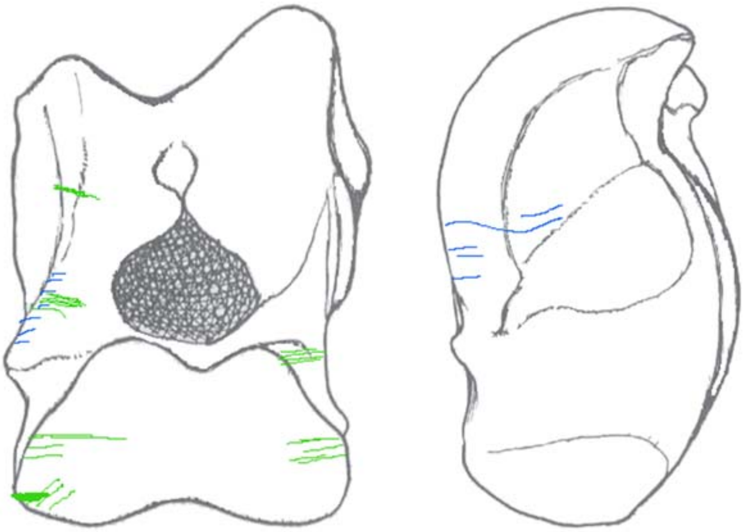

Figure 12.19: Cumulative diagram of butchery on bovine (n= 4) and caprine (n=3) astragali from Herxheim. Anterior (left) and lateral views.

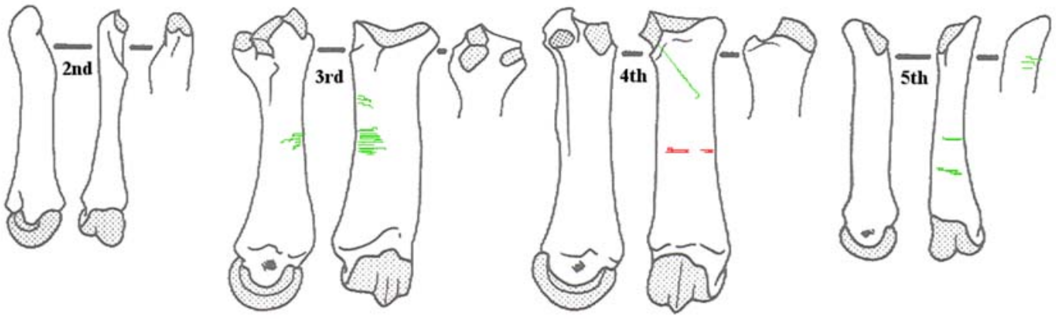

Figure 12.20: Cumulative diagram of butchery on suid metacarpals (n=7) from Herxheim. Left to right; medial, dorsal and lateral views.

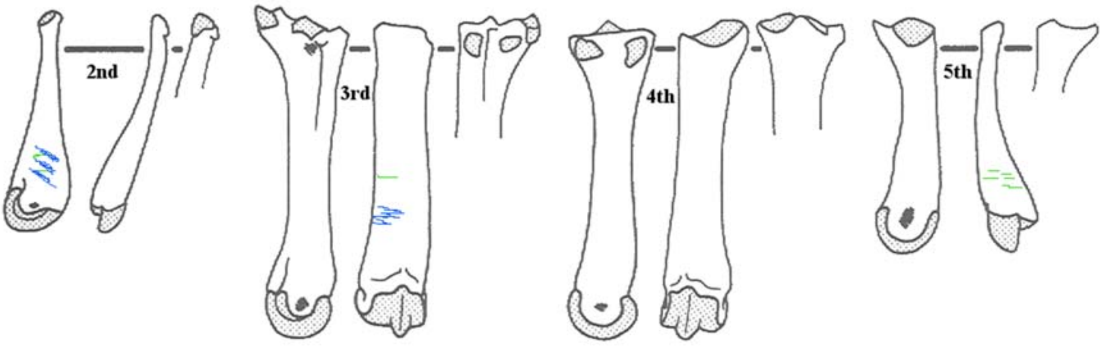

Figure 12.21: Cumulative diagram of butchery on suid metatarsals (n=5) from Herxheim. Left to right; medial, dorsal and lateral views.

12.4.3.5 Dog butchery

There was some limited evidence of butchery on domestic dogs. Cut marks were recorded on the metacarpals (n=2), femur (n=1) and tibia (n=1), possibly indicating skinning on the metapodia and defleshing on the tibia and femur. This suggests that some carcasses of domestic dogs were processed after their death, but possibly in a different way from the food animals and humans.

12.4.3.6 Summary

From the butchery study completed on animal bones it is clear that some elements were subjected to repeated butchery traditions. The butchery was mainly light, reflecting patterns seen on animals on other LBK sites. Compared at a very basic level with the human bones, which was intensive in its attempt to fully deflesh bones, the animal butchery seemed infrequent.

12.5 Heat exposure

12.5.1 Site

Evidence of heat exposure was observed on 5.4% (432/8000) of the assemblages from Herxheim. On identifiable bones, roasting was the most common type of burning, although evidence of high-temperature burning was also observed (carbonised or calcined; figure 12.22). The number of indeterminate burnt bones far exceeded identifiable specimens and is thus truncated in figure 12.22, and could be debris from cleared fireplaces as suggested by Haack (2016: 113-115).

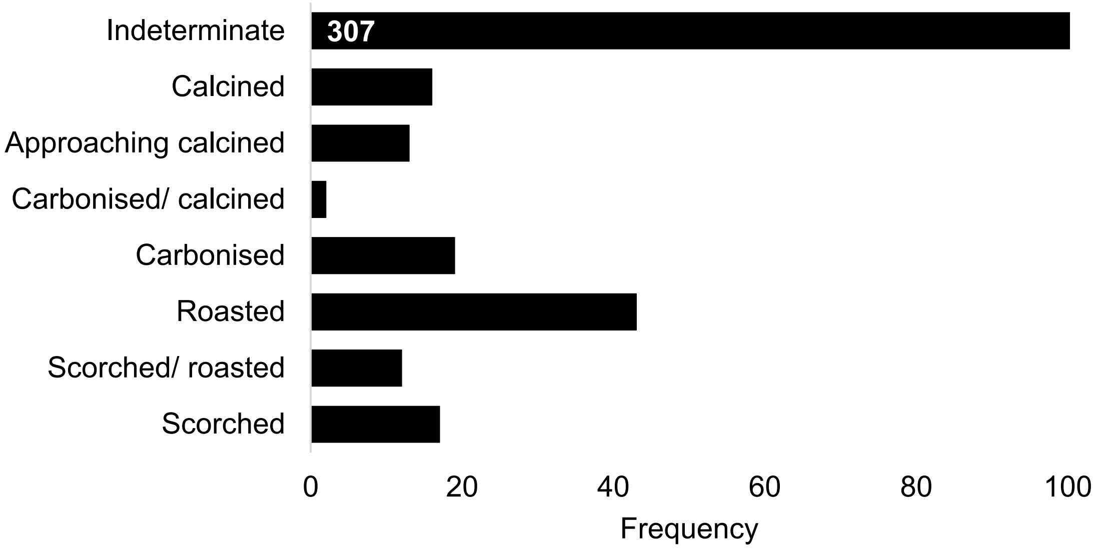

Figure 12.22: Frequency of heat exposure types from Herxheim.

12.5.1.1 Context groups

Heat exposure varied little over time, with the Ältere (21/269), Mittlere (41/499) and Jüngste (190/2273) settlement phase assemblages all showing between 7.8 - 8.4% of specimens affected (figure 12.23). The Jüngere phase, however, showed reduced burning at 4.4% (32/721), significantly less than the Ältere (21/269, p=.036), Mittlere (41/499, p=.006) and Jüngste (190/2273, p<.001) phase settlement contexts, perhaps suggesting changes in consumption practices. In all phases except the Ältere phase roasting was the most common form of burning. In the Ältere phase the majority of burnt identifiable bones were carbonised (n=4).

In the Jüngste phase contexts the pattern of burning was very interesting, in that the settlement pits were significantly more affected by heat exposure than the internal (100/2720) and external (41/1310) ditch contexts (both p<.001; figure 12.24). This suggests that bones from the settlement were more susceptible to burning, either through cooking or deposition practices. Despite Haack indicating that fire was a key part of the deposition of the ritual refuse in the ditches, including remnants of cleared fireplaces, the evidence suggests that the settlement was just as much affected by burning as the ditch contexts (Haack 2016: 113-115).

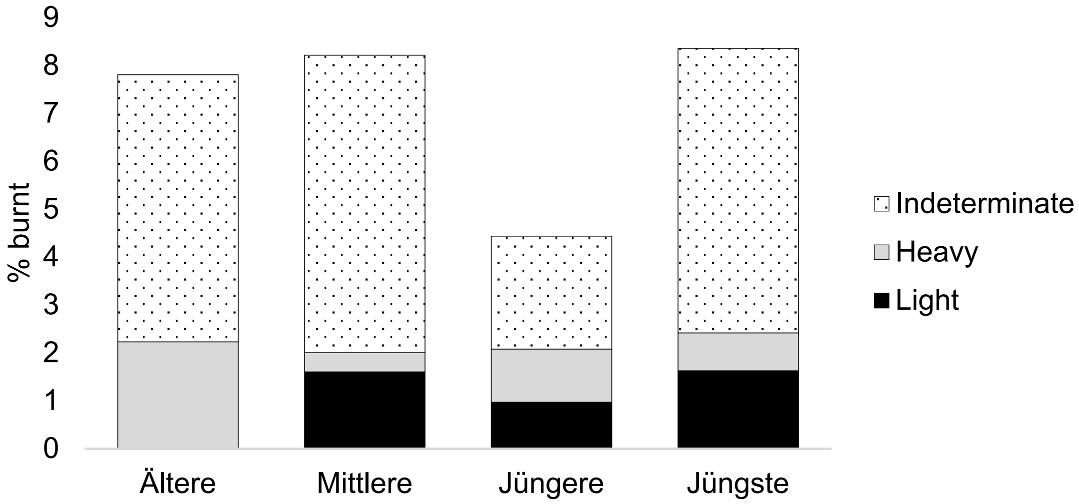

Figure 12.23: Percentage of specimens from each settlement phase affected by different intensities of heat exposure from Herxheim.

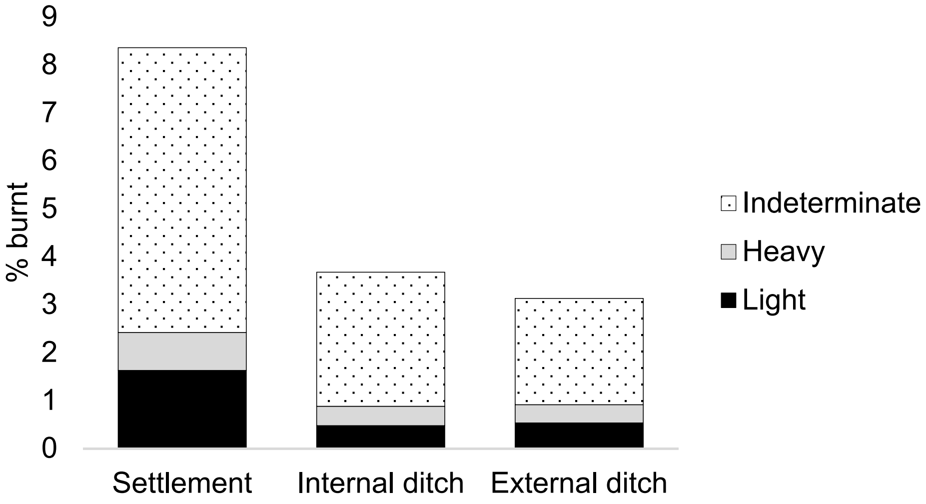

Figure 12.24: Percentage of the Jüngste context groups affected by different intensities of heat exposure from Herxheim.

12.5.2 Species

For many species on the site the percentage of burnt identifiable material was low (<6%; see figure 12.25). There was an interesting difference in the amount of wild boar bones that were burnt, evidence showing that 17.6% (6/34) were affected exposed to heat. The difference between the level of burning on wild boar bones compared to domestic pig bones (6/357) was statistically significant (p<.001). Domestic dogs were also subject to burning, particularly the extremities (calcaneum, metapodia, phalanges) but also on one femur and tibia. The type of burning on dog bones was also varied, showing a mix of light (n=5) and heavy (n=3) burning. This adds to the increasingly complex picture of dog carcass processing at Herxheim.

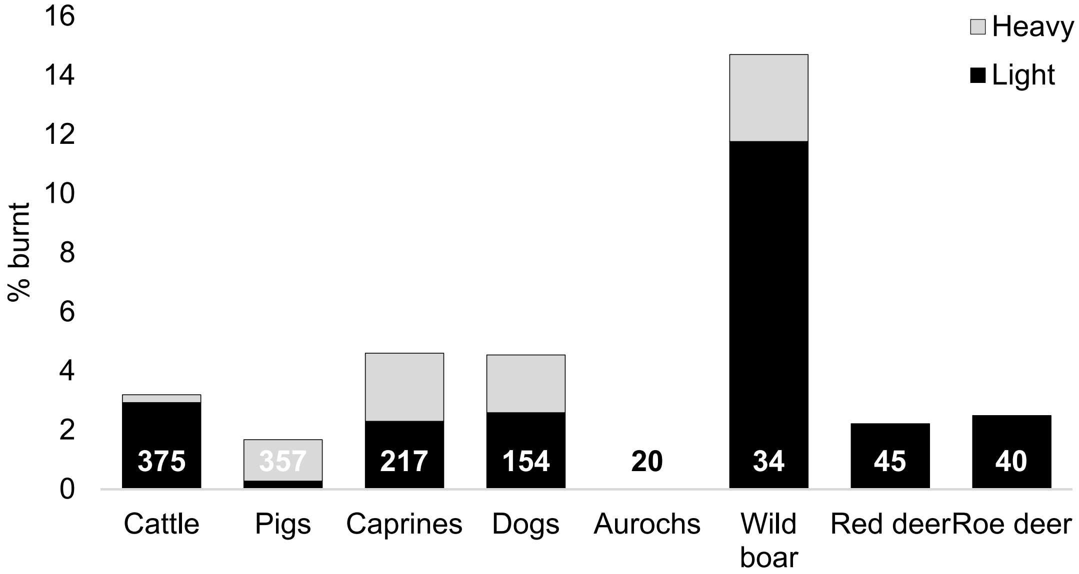

Figure 12.25: Percentage of species affected by different intensities of heat exposure from Herxheim.

12.5.3 Element

Certain skeletal elements showed a higher percentage of burning than others (figure 12.26). Mandibles of bovinae and suidae were affected along the tooth row by roasting or scorching. The metapodia of ruminants were also commonly affected, possibly suggesting that these low-meat bearing elements were roasted and then fractured, or were roasted in articulation with meat-rich elements. This is a carcass processing tradition identified at other sites, such as Ludwinowo 7 and Rosheim *Sainte-Odile*. Scapulae of medium mammals were also commonly burnt, largely roasted but some were also exposed to higher temperatures.

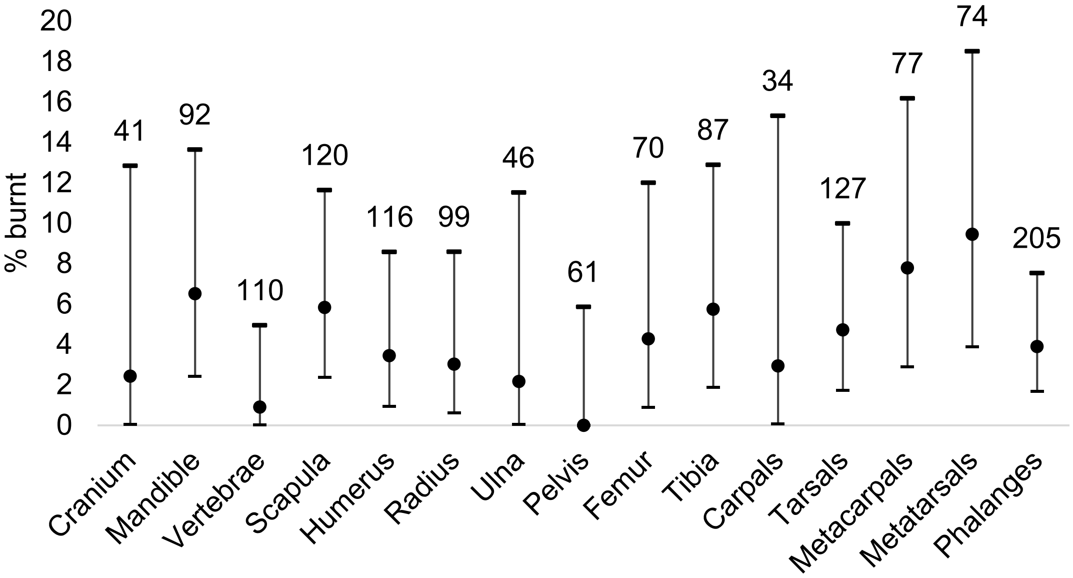

Figure 12.26: Percentage of elements affected by heat exposure from Herxheim, with 95% confidence intervals.

12.6 Fracture

12.6.1 Site

The fracture history profile for the sampled Herxheim assemblage shows that 54.1% (788/1457) of fractured specimens were broken when the bone was in a fresh (peri-mortem) state (figure 12.27), reflected by a mean FFI score of 2.89. There was a statistically significant difference in the amount of fresh fracture on high- and low-yield marrow bones from the site, with 58.1% (155/267) of high-yield bones fractured when fresh opposed to 44.3% (54/122) of low-yield bones (p=.007). However, this difference was not as pronounced as at other sites. The rate of fresh fracture, and the slightly elevated levels of fresh fracture on bones with high-marrow yields, suggests that bone marrow was commonly exploited at Herxheim.

The number of different fracture freshness index scores (figure 12.28) suggest also that fragmented marrow-bearing bones were either fractured when fresh *or* dry, and that mixed characteristics (scores of 3-5) were relatively uncommon. Bones were also often subjected to dry and mineralised fracture. Mineralised fracture was significantly more common on low-yield marrow bones compared to all marrow bearing bones (p=.001). Few specimens were affected by secondary fracture (3.6%, 53/1457), largely represented by freshly fractured bones fractured again when dry. Mineralised fracture suggests disturbance of specimens long after degradation of marrow, with some bones not fractured for marrow when fresh.

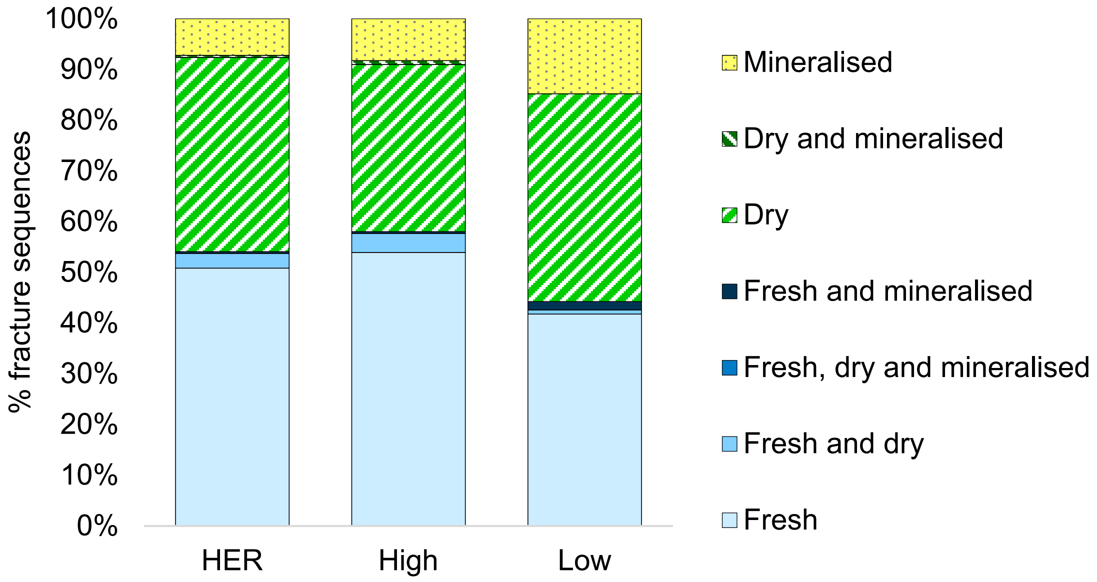

Figure 12.27: Fracture history profiles for Herxheim (left; n=1457) and for high- and low-yield marrow bones (right; n=267/122).

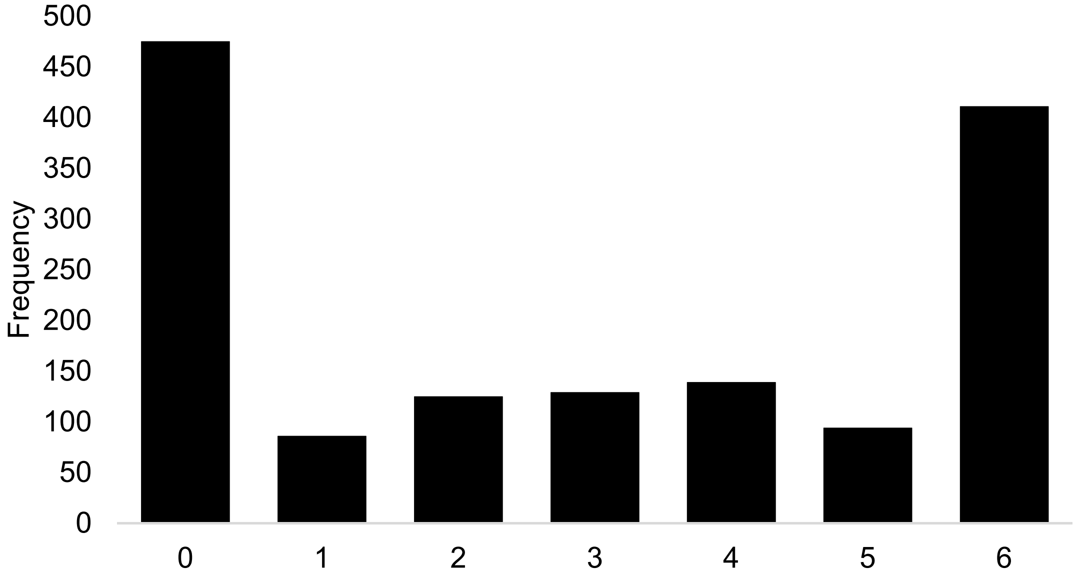

Figure 12.28: Frequency of Fracture Freshness Index scores from Herxheim.

12.6.1.1 Settlement phases

Analysis of the fracture freshness of the settlement phases shows consistency in the proportions of fracture sequences over time, save in the Mittlere phase, which had a significantly higher proportion of dry fracture (68.3%, 69/101) and a higher mean FFI score (3.9) than the other settlement phases (ALT 18/47; JNG 53/173; JST 174/442; all p<.001; figure 12.29 and 12.30). The low level of fresh fracture cannot be entirely explained by a difference in species proportion (figure 12.3) as fracture analysis for all animals in the Mittlere phase presented drier signatures than other phases. This could indicate a phase where bone marrow processing was not as necessary than in other phases.

There was a slight decrease in the level of fresh fracture between the Jüngere and Jüngste phase settlement contexts, although the difference was not statistically significant. Further differences are apparent in fracture patterns for high- and low-yield marrow bearing bones (figure 12.31). The Jüngere phase had a greater difference between the amount of fresh fracture on high-yield elements and low-yield elements than the Jüngste phase settlement assemblage. The analysis could suggest that the need for bone fats was reduced in the Jüngste phase, but may also be influenced by the higher level of burning found in this phase (figure 12.23). Exposure to heat reduces the moisture content of fresh bone and causes it to fracture with drier characteristics (Karr and Outram 2012), even though the fracture may have occurred whilst the marrow was still fresh.

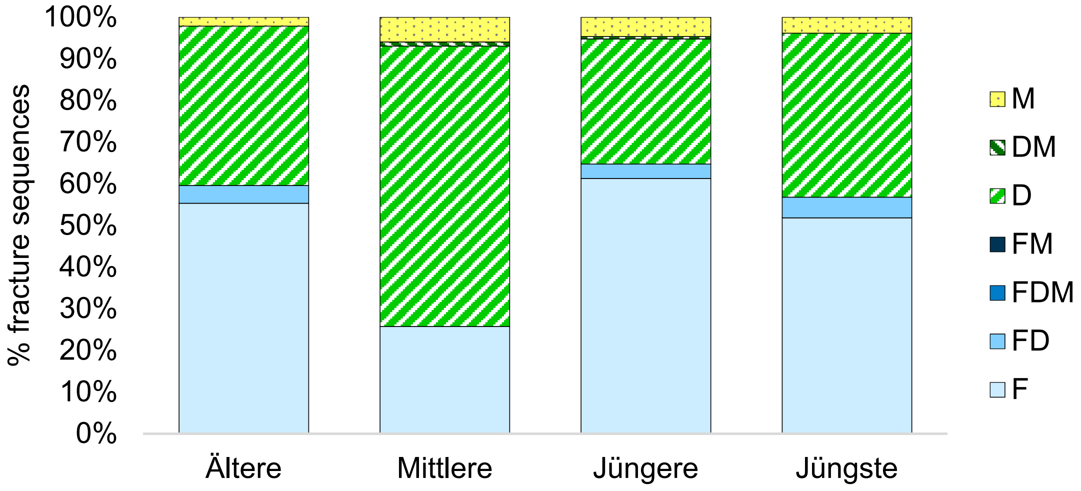

Figure 12.29: Fracture history profiles for the Ältere (n=47), Mittlere (n=101), Jüngere (n=173) and Jüngste (n=442) phase settlement contexts from Herxheim.

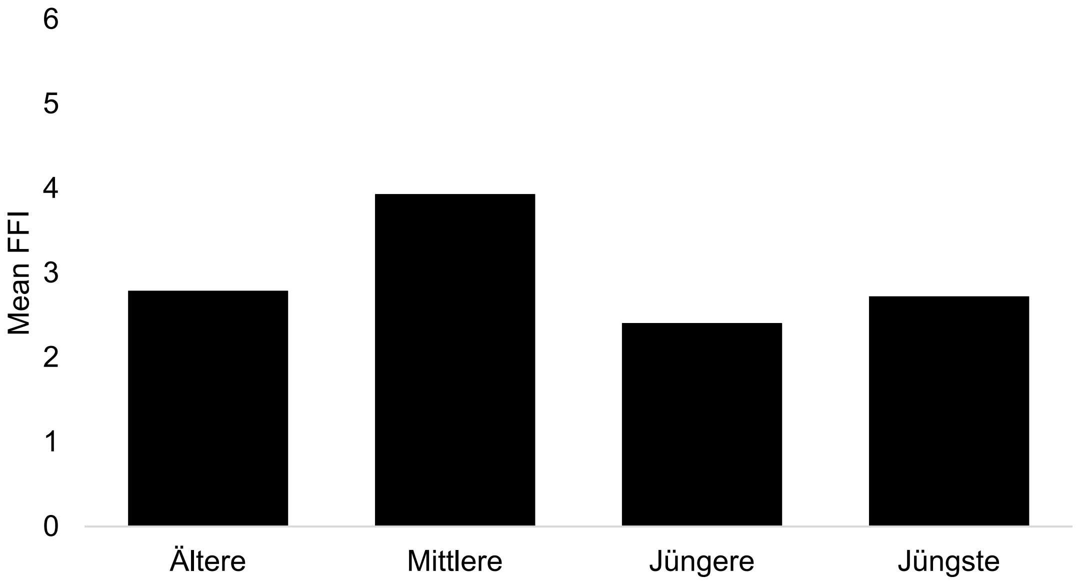

Figure 12.30: Mean Fracture Freshness Index scores for settlement phases from Herxheim.

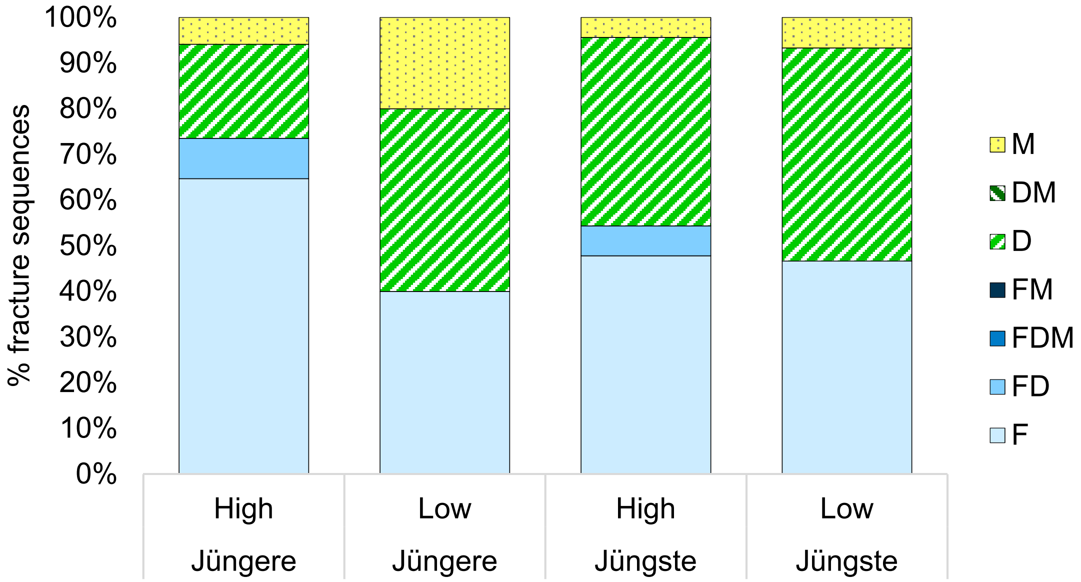

Figure 12.31: Fracture history profiles of high- and low-yield marrow bones from Jüngere (n=34/15) and Jüngste (n=46/15) settlement contexts from Herxheim.

12.6.1.2 Jüngste phase fracture

There were strong similarities between the settlement and ditch contexts, both in the proportion of fresh fracture and the differences in fracture on high- and low-yield marrow bones (figures 12.32 and 12.33). However, there was an increase in the amount of mineralised fracture in the internal and external ditch compared to the settlement. High levels of dry and mineralised fracture are often suggested to indicate post depositional disturbance, such as at the Bronze Age site of Velim-Skalka (Knüsel *et al.* 2007, 21; see also Outram *et al.* 2005). However, careful excavation of the ditches at Herxheim revealed no evidence of recutting of these contexts, and suggested that material once deposited in the ditches was covered quickly after deposition (Zeeb-Lanz, 2016, pers. comm., 27 July; Haack 2006). Coupled with statistically higher levels of erosion in the ditches (22/1324) compared to the settlement (0/641; p=.001; figure 12.45), a possible explanation is that material from the ditches was secondarily deposited.

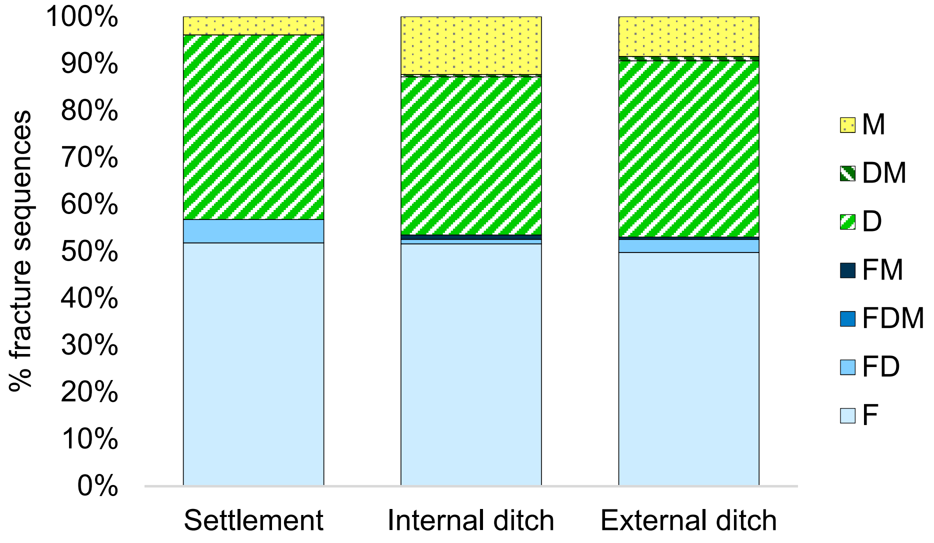

Figure 12.32: Fracture history profiles for the Jüngste phase settlement (n=442), internal ditch (n=430) and external ditch (n=213) contexts from Herxheim.

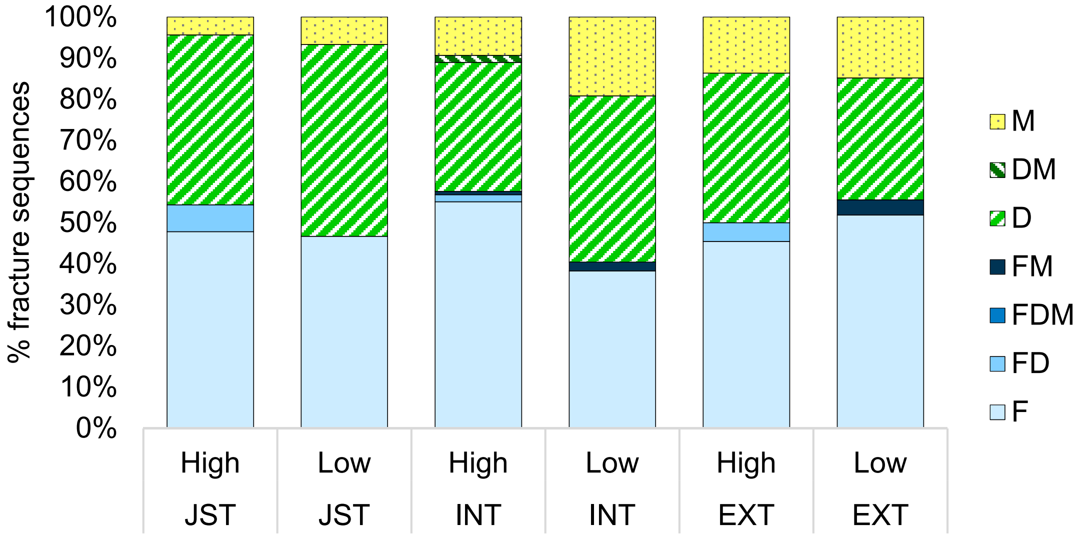

Figure 12.33: Fracture history profiles for high- and low-yield marrow bones from the Jüngste phase settlement (JST, n=48/15), internal ditch (INT, n=118/47) and external ditch (EXT, n=44/27) contexts from Herxheim.

12.6.1.3 Context groups summary

Correspondence analysis suggests that the amount of fresh fracture in the comparable context groupings may be related to the percentage of the NISP identified as domestic pig (figure 12.34). This association has been noted at other sites analysed, such as Füzesabony-Gubakút and Polgár-Piócás-dűlő. Surprisingly cattle, the species most commonly fractured when fresh, cluster most strongly with mineralised fracture. This is likely due to the high proportion of cattle in the internal ditch, where mineralised fracture was also relatively high. The settlement phase contexts cluster very closely, along with the external ditch, whereas the Mittlere settlement and internal ditch were more distinct in their patterns of species representation and fracture freshness.

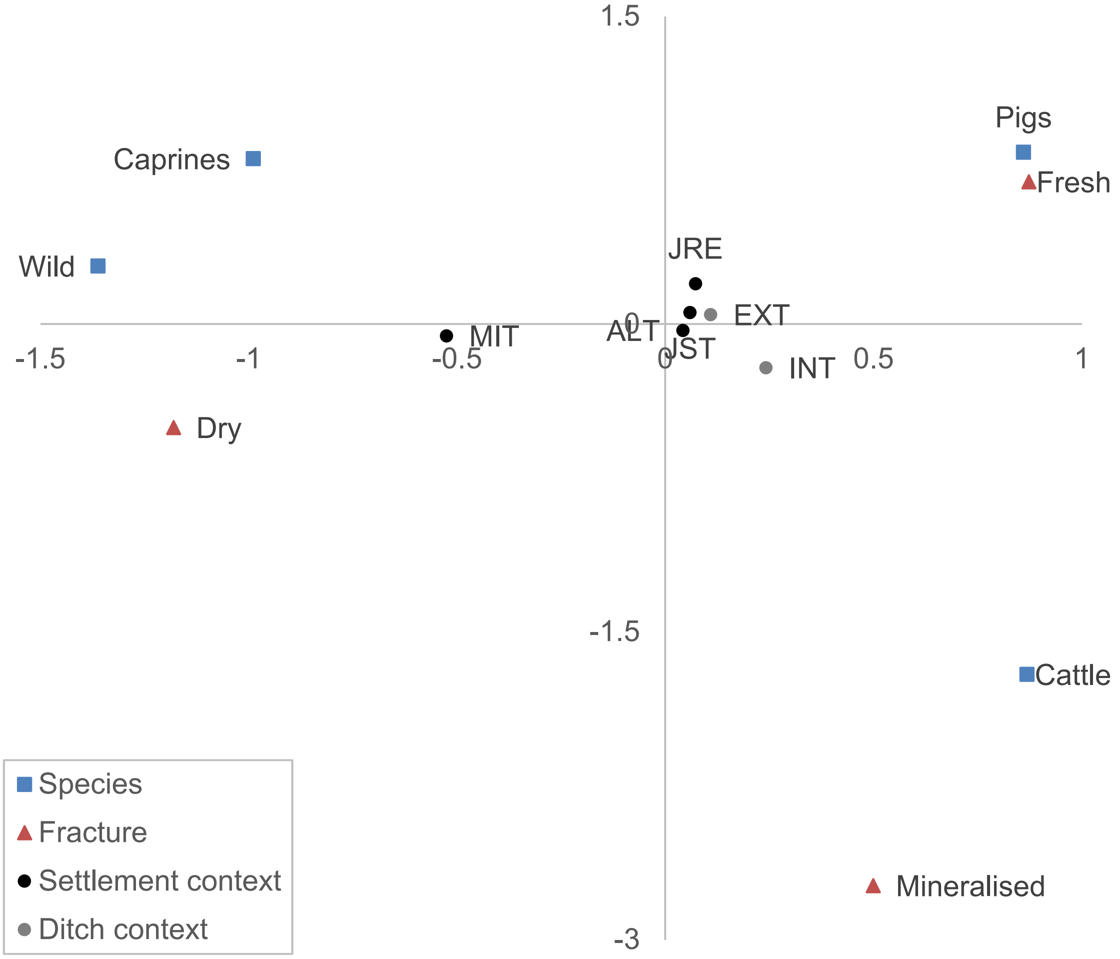

Figure 12.34: Correspondence analysis of the proportion of cattle, pigs, caprines and wild animals (NISP) and the proportion of first fractures that were fresh, dry or mineralised from the comparable context groupings from Herxheim. All data from dog bones were removed from this analysis.

12.6.2 Species fracture

Cattle were the species most commonly affected by fresh fracture (74.0%, 80/112; mean FFI 2.2; figures 12.35 and 12.36), with significantly higher proportions of fresh fracture than pigs (51/94; p=.011), caprines (44/81; p=.014) and wild animals (23/44; p=.023). Despite a preference for cattle marrow, likely due to higher-yielding marrow cavities, pigs, caprines and wild animals also showed considerable levels of fresh fracture, and preferential fresh fracture high-yield marrow bones (figure 12.37). Pigs and wild animals showed elevated levels of mineralised fracture compared to the other food animals. The proportion of pig (15/94) and wild (6/44) specimens first fractured when mineralised was significantly higher than cattle (7/112; p=.004/p=.021 respectively) and caprines (3/81; p=.013/p=.040). Pigs and wild animals could have been subject to deposition practices that increased the likelihood of mineralised fracture, possibly through redeposition.

Domestic dog bones were solely subjected to dry and mineralised fracture at Herxheim, with a mean FFI of 5.2. Many marrow-bearing bones of domestic dog were whole (38.9%, 28/72) compared to other animals (for bovinae, suidae, caprines and cervids this was 1.9%, 10/523). This suggests that dog carcasses were not exploited for marrow, and were thus treated differently from the carcasses of the common food animals and humans, as examined below.

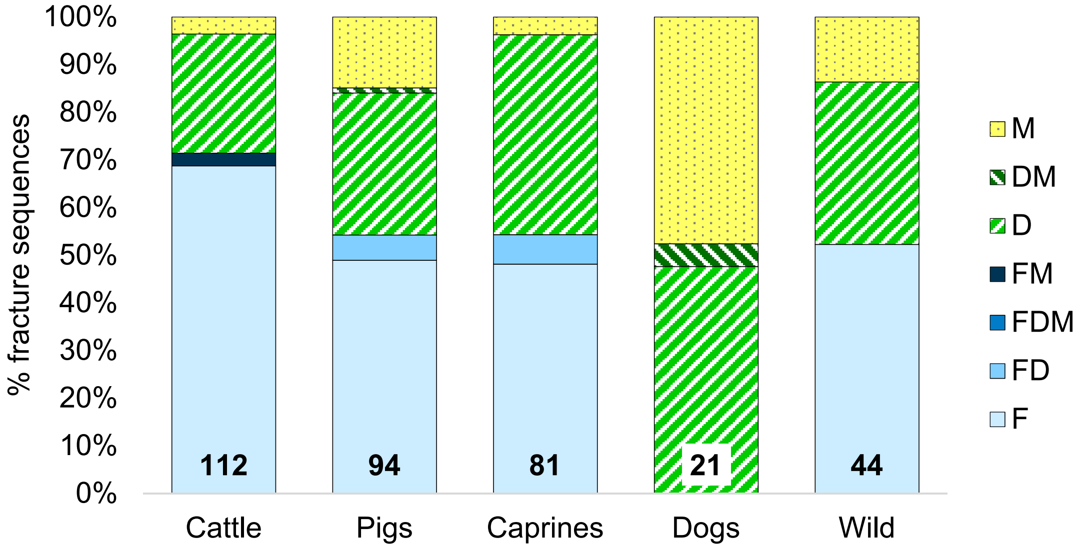

Figure 12.35: Fracture history profiles for different domestic and wild (aurochs, wild boar, red and roe deer) species from Herxheim.

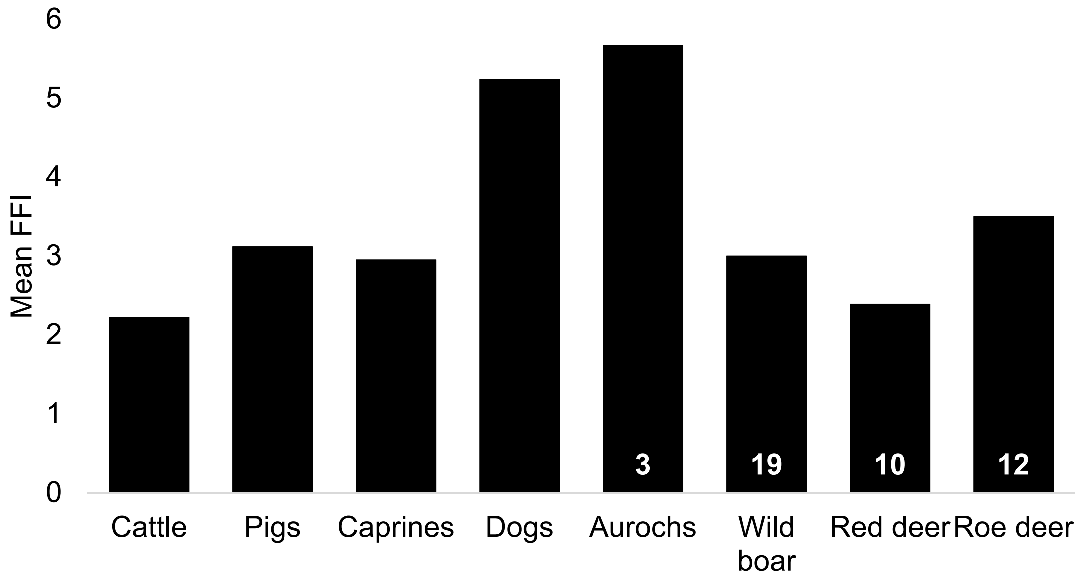

Figure 12.36: Mean Fracture Freshness Index scores for species from Herxheim.

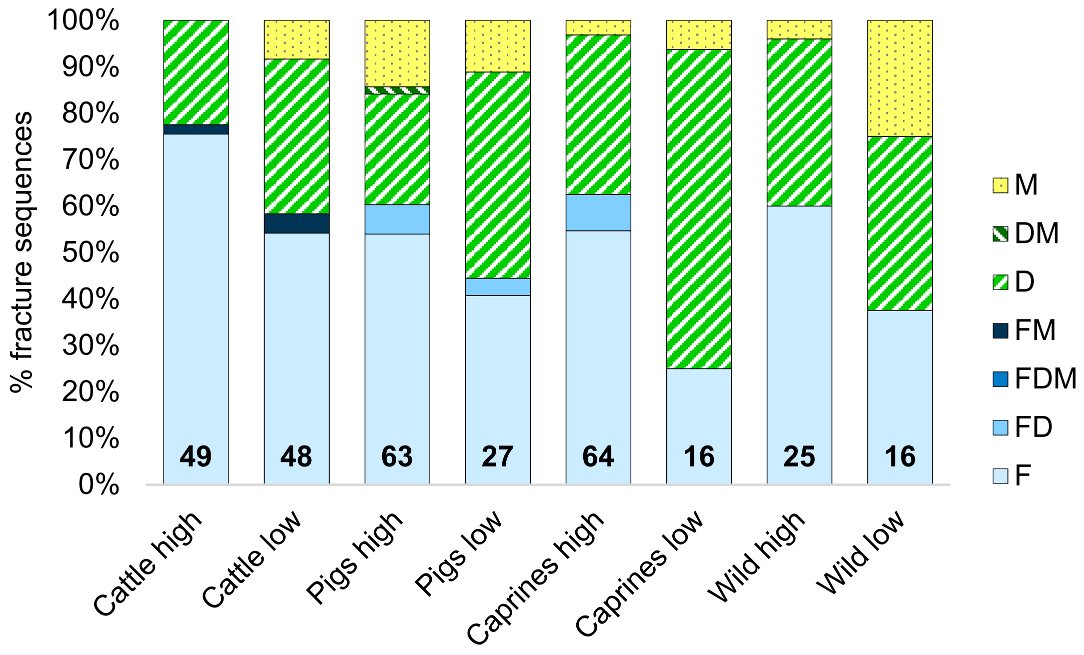

Figure 12.37: Fracture history profiles for high- and low-yield marrow bones of cattle, pigs, caprines and wild species from Herxheim.

12.6.2.2 Human-animal comparison

Boulestin *et al.* (2009) analysed fracture on humans as part of their study of cannibalism at Herxheim, concluding that marrow extraction of human bones was common, particularly on the high-yield marrow bearing bones such as the femur (*ibid.* 975). They utilised White's (1992) criteria for identification of fresh fracture, analysing the freshness of characteristics of the fracture shape (outline), angle and texture, a method comparable to the Fracture Freshness Index. Figure 12.38 shows the percentages of these three fracture components that showed fresh characteristics in the human bone as derived from Boulestin *et al.* 2009. This is plotted against percentage of FFI outline, angle and texture scores equalling zero, i.e. only fresh characteristics. The data show that in many ways humans were comparable to the faunal data, and excepting cattle were often subjected to higher levels of fresh fracture. Domestic dogs are clearly different from humans and animals, showing only occasional fresh characteristics of fracture. However, as N values were not given explicitly by Boulestin *et al.* (2009) we cannot test the statistical significance of this claim.

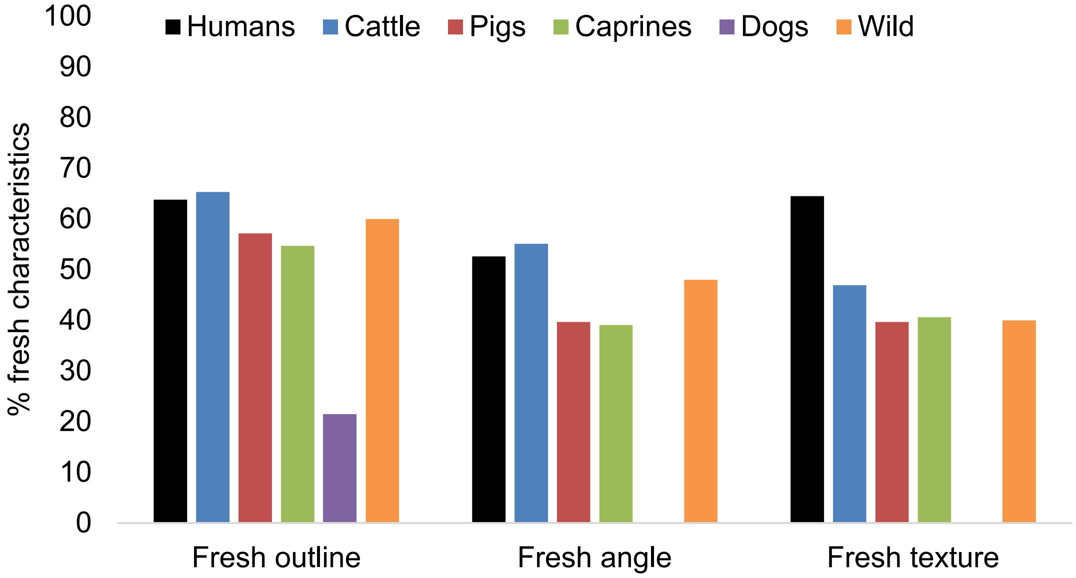

Figure 12.38: Percentage of fractures on bones of different species with completely fresh fracture characteristics from Herxheim. Human data from Boulestin *et al.* (2009).

12.6.3.2 Summary

The analysis of fracture freshness for different species shows that humans and animals were largely treated in the same way in terms of marrow exploitation, except in the case of domestic dogs. Levels of fresh fracture at Herxheim suggest common marrow extraction, although not all bone fat resources were exploited. This could suggest that consumption of human remains was not nutritionally determined as animal resources were not as intensively exploited as at other sites. Alternatively, ritual consumption of human marrow in this way could in turn decrease the necessity for intensive faunal marrow extraction.

12.7 Fragmentation

12.7.1 Site

Whilst there is certainly evidence for marrow processing at Herxheim the evidence for bone grease processing is more ambiguous. The fragmentation profiles for the whole assemblage show that grease processing was not regularly practised at Herxheim (figure 12.40). Low weight values of highly-fragmented specimens and consistent levels of cancellous material across the size classes (figure12.41) do not reflect intensive bone grease processing.

12.7.1.1 Context groups fragmentation

The level of fragmentation in the Jüngste LBK phase assemblage (figure 12.39) shows higher levels of fragmentation in the settlement pits than in the ditches. The settlement contexts showed a statistically higher proportion of the assemblage mass in size classes less than 30mm in maximum dimension (774/17391g) than the ditches (1369/45578g; p<.001). Similarly, the ditch contexts showed a statistically higher proportion of bone weight classified as “Part Whole” (those with unfragmented epiphyses, UE in figure 12.39) or “Whole” (14915/45578) than the settlement (3716/17391; p<.001), suggesting less fragmentation in the ditches. Despite these differences, the general patterns are similar and do not imply an intensive bone grease processing regime.

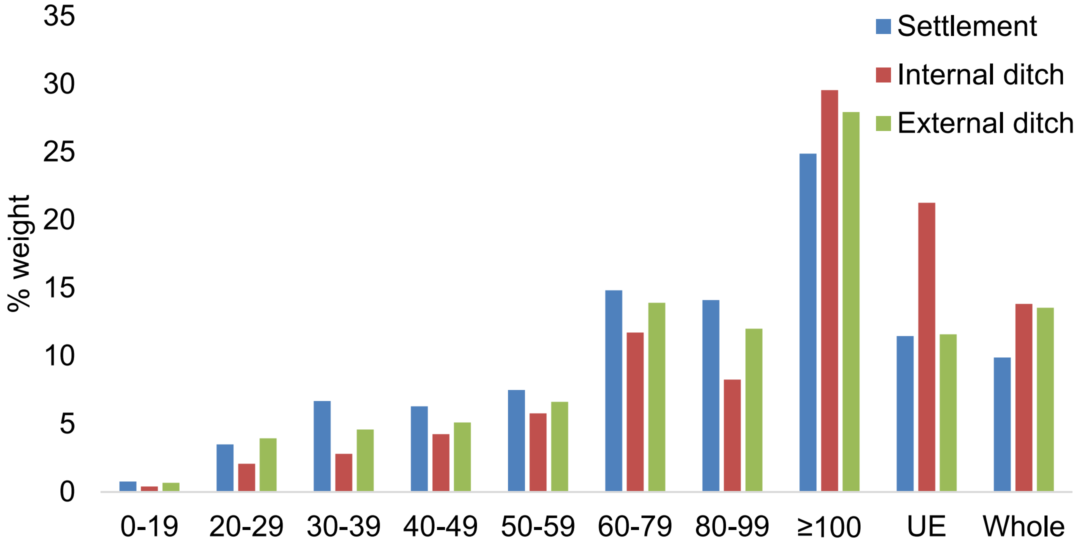

Figure 12.39: Percentage of the assemblage weight in different size or bone type classes from the three Jüngste phase context groups from Herxheim.

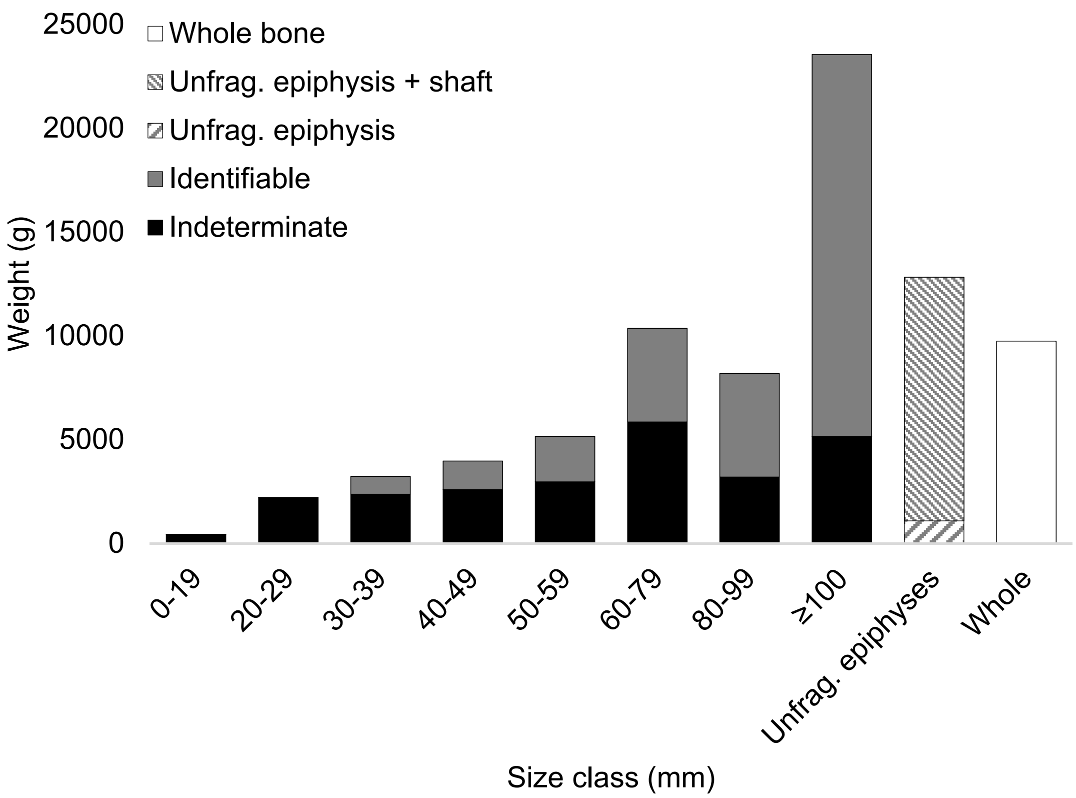

Figure 12.40: Weight by size class of all specimens from Herxheim.

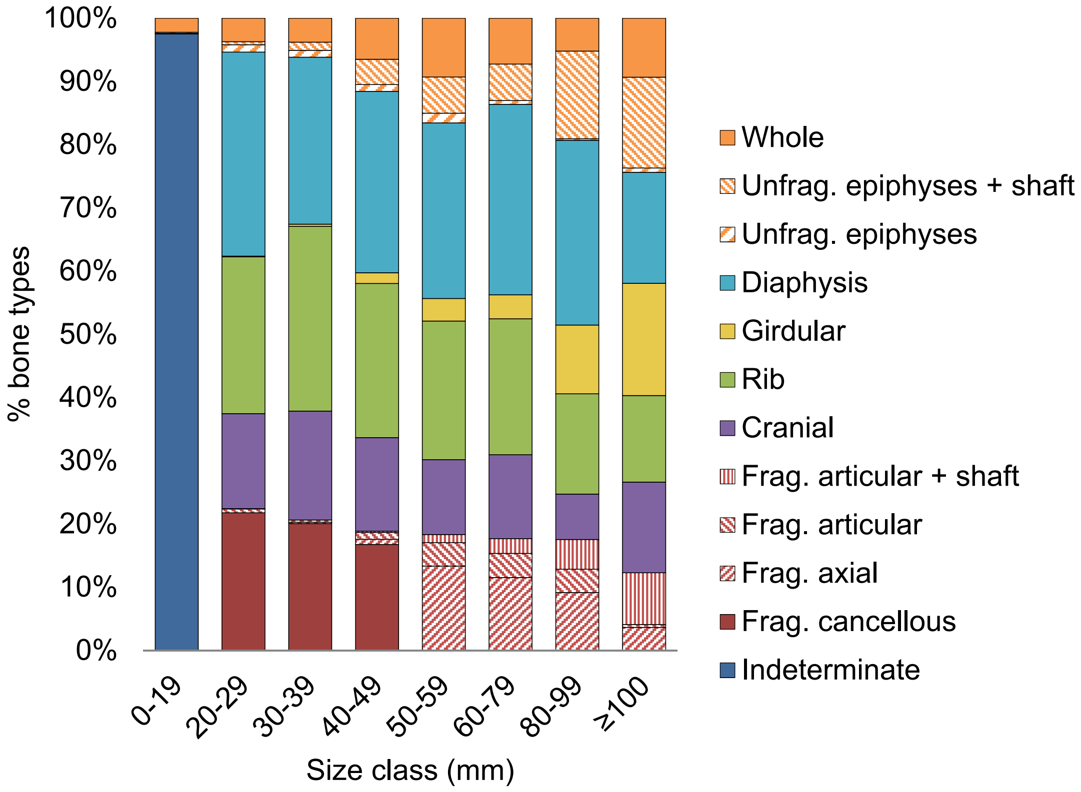

Figure 12.41: Frequency of bone types by size class from Herxheim. Red series indicate fragmented cancellous bone.

In the settlement there was one context (589-4) which could be indicative of bone grease processing happening on a small scale (figure 12.42). The bones in pit 589-4 do not perfectly match the ideal characteristics of an assemblage where bone grease processing is intensive, yet they were qualitatively different from the fragmentation patterns seen in the rest of the assemblage. This context could be the result of bone grease processing on a minor, ad-hoc scale, which has certain indications for the site at Herxheim. It is a potential indicator of times of nutritional stress, as bone grease processing implies an increased need for fat in the diet. Alternatively, the intended product could have been for practical, craft based or perhaps ritual applications. This event could also highlight the difference between a domestic space in the settlement and a ritual space in the ditches, where there was no comparable evidence of bone grease processing.

Figure 12.42: Potential evidence of bone grease processing in Jüngste phase settlement context 589-4 from Herxheim. The specimens are arranged in bone types within size class groups.

12.8 Taphonomy

12.8.1 Gnawing

Instances of animal gnawing on the assemblage were rare and almost exclusively canid; rodent gnawing was only observed in 2 cases. In total, gnawing affected 3.2% (257/8000) of the assemblage, indicating that food refuse was not often left uncovered to be scavenged by rodents and carnivores, domestic or wild.

12.8.1.1 Context groups

All settlement phases showed evidence of canid gnawing, but the Jüngere phase assemblage (38/721) was significantly more affected than earlier and later phases (ALT 5/269, p=.019; MIT 14/499, p=.036; JST 75/1632, p=.016; figure 12.43). This could suggest a deposition method that made bones more susceptible to gnawing in this phase.

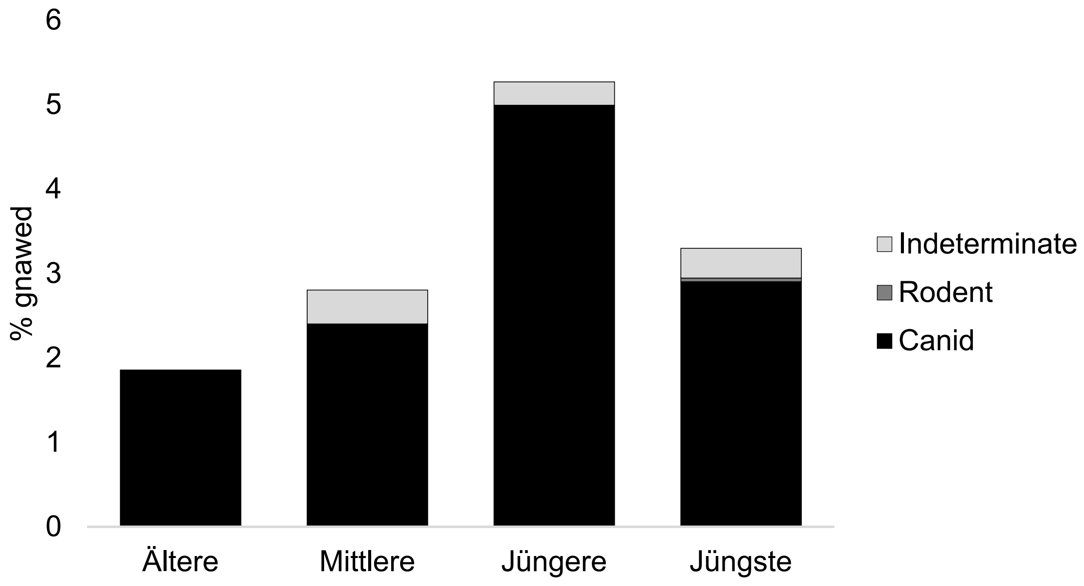

Figure 12.43: Percentage of the settlement contexts affected by different types of gnawing from Herxheim.

In the Jüngste phase assemblage there were some differences between the settlement and the pits. The external ditch (64/1310) was significantly more gnawed than the settlement pits (75/2273, p=.018) and the internal ditch (46/2720, p<.001; see figure 12.44). Indeterminate gnawing was more common in the external ditch than in the other contexts, which could be due to increased gnawing causing bones to fragment and become indeterminate. It could be possible that further away from the settlement the external ditch was more susceptible to scavenging, but only if deposits were left open, which would refute Haack (pers. comm. October 2014; Haack 2016). Perhaps more likely, these contexts could have been gnawed before being placed in the pits as a result of temporary deposition.

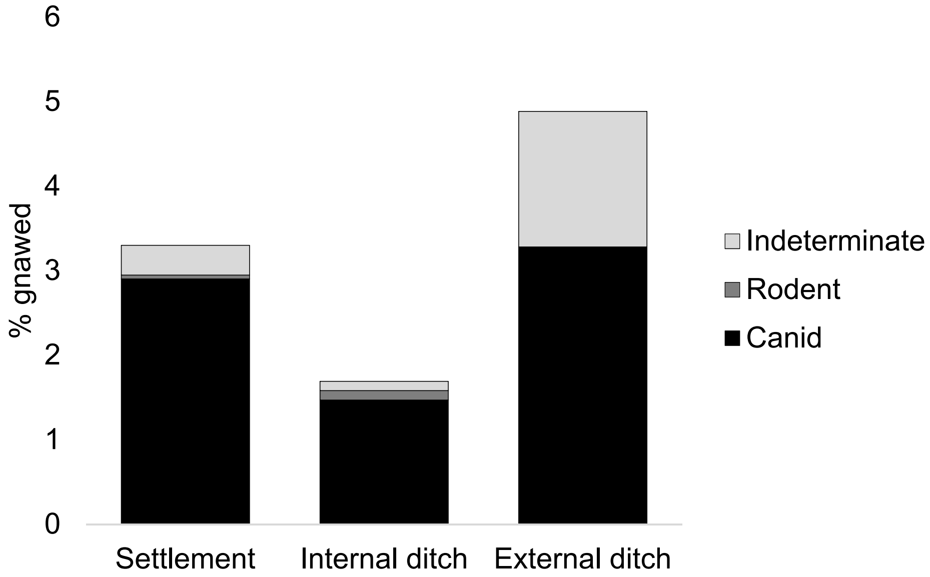

Figure 12.44: Percentage of the Jüngste phase contexts affected by different types of gnawing from Herxheim.

12.8.1.2 Species and element gnawing

There were some interesting patterns of gnawing of different species and elements at Herxheim. 58.8% (20/34) of domestic pig scapula were affected by gnawing, commonly observed on the glenoid cavity, destroying the epiphysis and fusion surface. The olecranon of the ulna was also commonly affected, as was the *tuber calcanei* on the calcaneum. In the case of the calcaneum and ulna it is likely that the high levels of gnawing on these bones is due to their proximity to the skin of the animal and their late fusing nature, making the bones more succulent and easy to mark and destroy. However, gnawing around the glenoid of the scapula suggests that this element (and perhaps the ulna and calcaneum) were purposefully given to dogs on site after butchery.

12.8.2 Taphonomic agents

The prevalence of different taphonomic agents is a particularly important consideration at Herxheim based on the varied deposition practices characterising the Jüngste phase settlement and ditch contexts. Instances of taphonomic agents were particularly low, with only 1.2% (31/2507) of the identifiable assemblage affected by either cemented mud, erosion, root etching or weathering. The Jüngste phase was the only phase with any recorded taphonomic activity, apart from two instances of bones with concretions of mud attached to them from the Ältere phase. Within the Jüngste phase there was a significantly higher proportion of the identifiable assemblage affected by taphonomy in the internal (21/948, p<.001) and external (7/376, p=.003) ditches than in the settlement pits (1/641; figure 12.45). The ditches were affected by elevated levels of erosion which perhaps suggests that faunal material was not deposited immediately after its original use, but was temporarily deposited before inclusion in the ditches, or disturbed and redeposited in their creation.

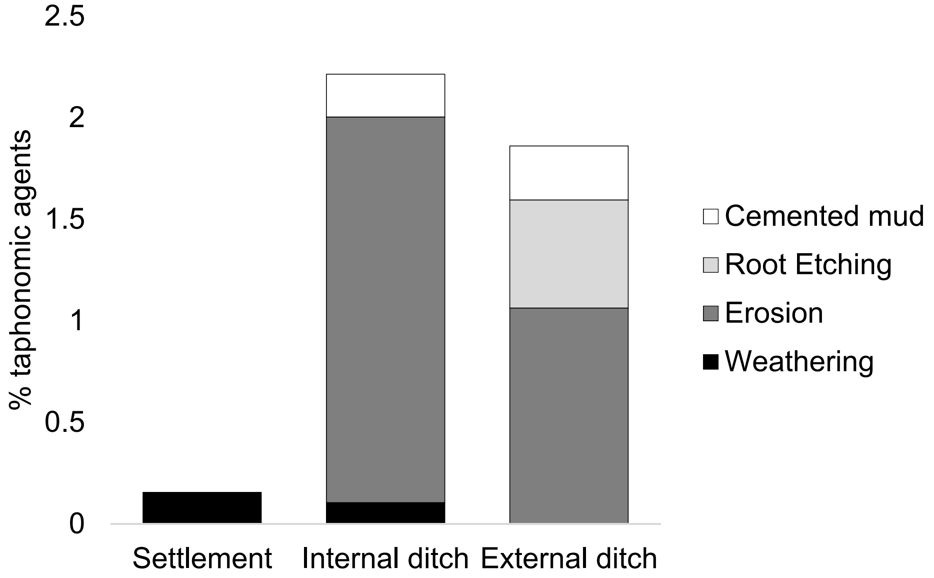

Figure 12.45: Percentage of the identifiable assemblage from Jüngste phase settlement (n=641), internal ditch (n=948) and external ditch (n=375) contexts affected by different taphonomic agents from Herxheim.

12.8.3 Recent breaks

Overall the assemblage from Herxheim was well preserved. Evidence of breaks during or after excavation was found on 8.5% (214/2507) of the identifiable assemblage (figure 12.46). The settlement contexts of the Ältere and Mittlere phase were least affected, whilst the Jüngere and Jüngste phases were affected to a larger degree. Within the Jüngste phase, the internal ditch was the most affected at 10.0% (95/948) of the identifiable assemblage and the external ditch was affected by 7.5% (28/376) recent breaks. These numbers are within the usual scale of recent breaks. They may increase fragmentation but likely not to a substantial degree. Some specimens, particularly of dog, had been sampled for DNA analysis, essentially cutting the fracture surface from the bone and leaving a recent break behind. Whilst these were in low numbers they were often on fully identifiable elements which could have aided fracture analysis, which was frustrating.

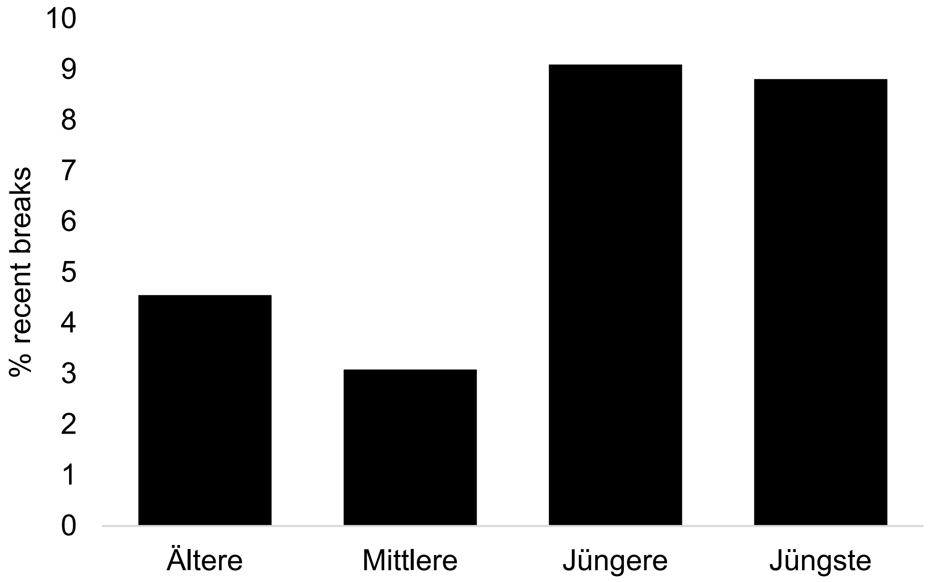

Figure 12.46: Percentage of the identifiable phase assemblages, including the Jüngste phase ditches, affected by recent breaks from Herxheim.

12.9 Food exploitation strategies

12.9.1 Herd structure analysis

Fusion ageing resulted in sufficient data for slaughter profile analysis for cattle, caprines and pigs, and to compare cattle data from the settlement (all phases) and the ditches. Fusion analysis was also undertaken by Arbogast (in prep.), who looked solely at the whole site. Gillis (in prep.) provided mortality profiles based on age-at-death analysis of teeth.

12.9.1.1 Cattle

Analysis of the epiphyseal fusion of the whole faunal assemblage by Arbogast indicated that most cattle were slaughtered between 15 months and 2 years of age, suggesting targeting of young adults that had reached maximum weight (Arbogast in prep.). However, Arbogast argues that the survival of older individuals could also indicate exploitation for milk.

Separation of the fusion analysis for cattle revealed no evidence for slaughter before one year in settlement contexts, although there was some young slaughter before 18 months, followed by a large kill-off between 18 and 36 months (figure 12.47). It seems that there was little further slaughter of adults until they reached fusion maturity. In the ditch contexts, there were some juvenile specimens but no major slaughter event between 18 and 36 months, instead affecting animals between 36 and 48 months (figure 12.48). These slaughter profiles do not indicate strong dairy herd signatures, and largely suggest meat slaughter. Older animals in the ditches could have had greater social or ritual significance. In many societies with a cattle-based economy special importance is placed on animals at certain ages, as has been discussed in the Ethnography chapter. It could alternatively indicate differential deposition of animal body parts or animals of different ages in different parts of the site.

Dental ageing carried out by Gillis (in prep.) gives greater resolution in age classes, particularly those of adults, and corroborates the findings of the fusion analysis. The 0-6 month size class was better represented in the ditches as opposed to the settlement, reflected by the epiphyseal fusion profiles. Slaughter of animals in 0-6 months and 6-12 months could indicate male calves, possibly slaughtered post-lactation. 6-8 years was the most well represented age class for both settlement and ditch contexts, followed by 26-36 months. These ages could indicate slaughter of males raised for meat or young infertile females (26-36 months; Gillis in prep.) and potentially retired dairy females (6-8 years). Together, the fusion and dental analysis could show a herd exploited for prime meat, and one that had the potential for dairy exploitation.

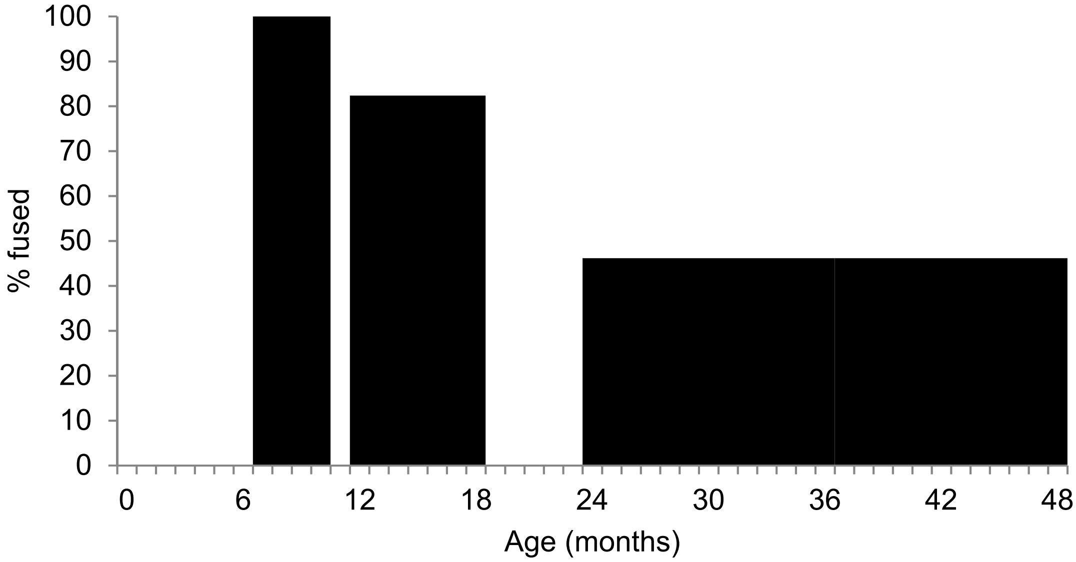

Figure 12.47: Cattle slaughter profile based on epiphyseal fusion from all phase settlement contexts at Herxheim (n=50).

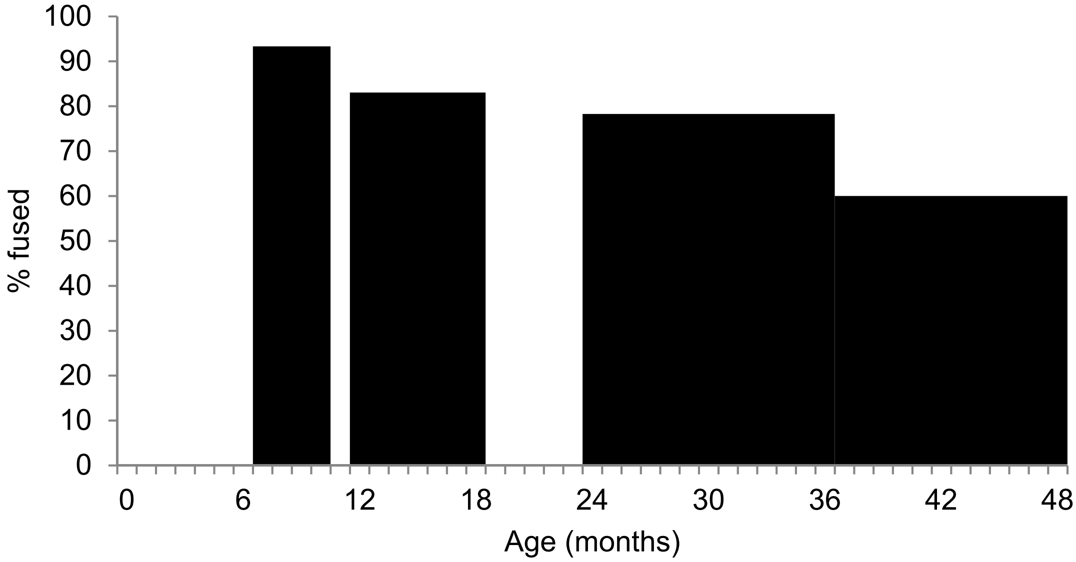

Figure 12.48: Cattle slaughter profile based on epiphyseal fusion from Jüngste ditch contexts at Herxheim (n=121).

12.9.1.2 Caprines

The sample size for caprines was smaller than cattle, only allowing for a comparison of material from all contexts from all phases, the majority coming from the Jüngere and Jüngste phases. The fusion analysis suggests some juvenile slaughter followed by a slaughter event between 1-5 years, but the majority of animals survived past 3.5 years (figure 12.49). This could represent meat-age slaughter with a surviving dairy herd.

The dental mortality reflects sheep exploitation for heavy lambs, followed by adults dying of natural causes or deliberate removal in age class 4-6 years. This presence of adults may also reflect animals being managed for dairy. There was a strong simulated representation of age class 0-2 months and 4-6 years in the goat mortality profile, suggesting slaughter of kids and that goats were managed primarily for milk (Gillis in prep.).

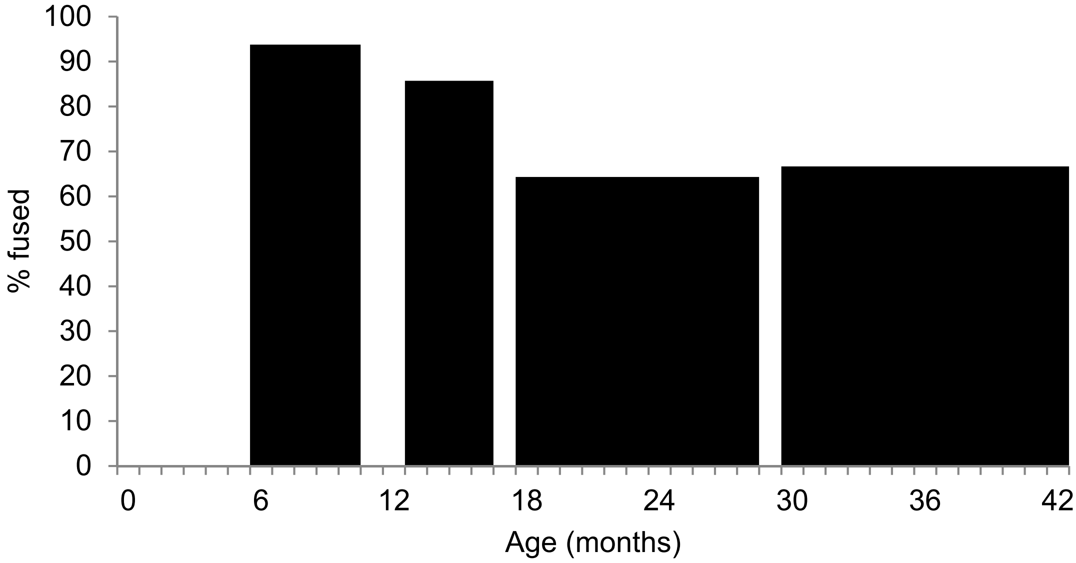

Figure 12.49: Caprine slaughter profile based on epiphyseal fusion from all phase contexts at Herxheim (n=112).

12.9.1.3 Pigs

As an animal whose primary function is meat, pigs follow a very typical pattern for meat consumption (figures 12.50 and 12.51). Some slaughter of juvenile pigs younger than one year was present in both ditch and settlement contexts, followed by a large slaughter before 30 months. No animals older than 30 months were detected in the settlement pits (0% fused, 0/10), whereas in the ditch contexts there was some survival into fusion maturity (28.6% fused, 8/28), representing at least four individuals. These individuals could be older breeding animals, or perhaps had ritual significance, and further suggest that older animals existed in the ditches than the settlement contexts.

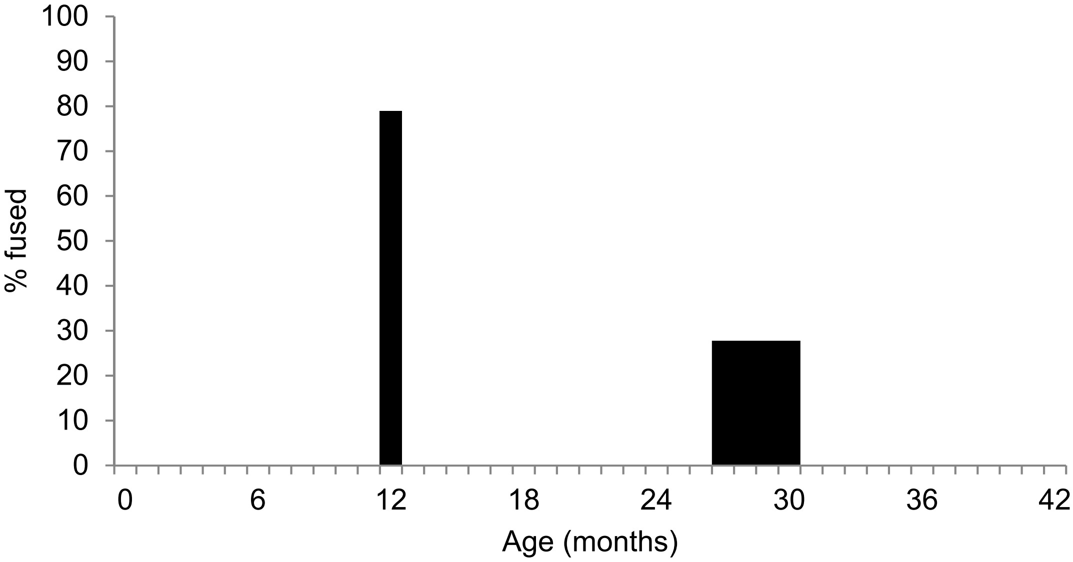

Figure 12.50: Pig slaughter profile based on epiphyseal fusion from all phase settlement contexts at Herxheim (n=66).

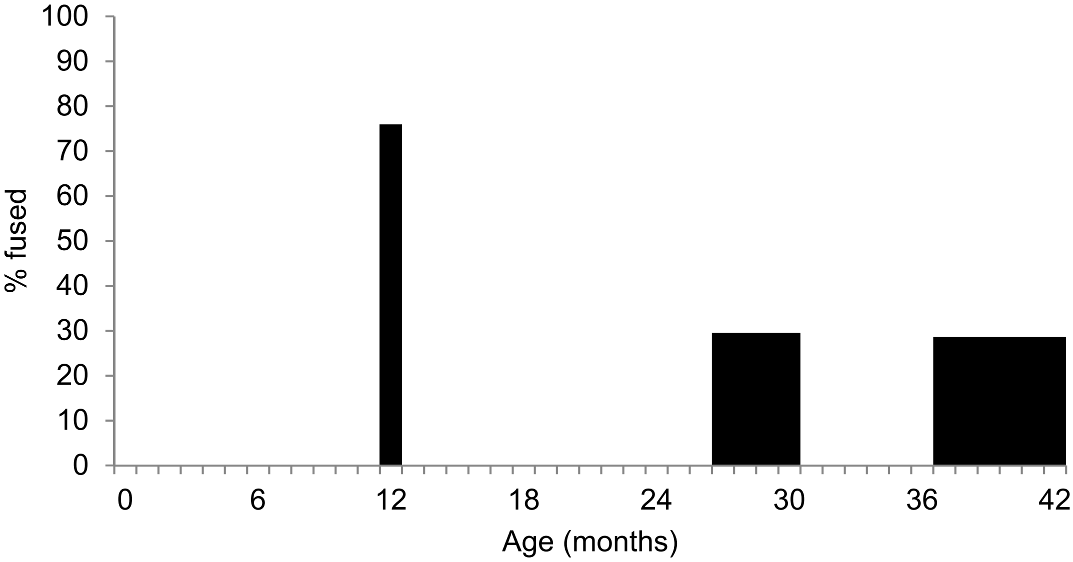

Figure 12.51: Pig slaughter profile based on epiphyseal fusion from ditch contexts at Herxheim (n=126).

12.9.2 Lipid residue analysis

No lipids have currently been detected from 28 non-perforated sherds subjected to lipid residue analysis from the Herxheim ceramic assemblage.

12.10 Discussion

Herxheim presents and extremely interesting site, with differences in carcass processing and deposition related to species, phase, and context.

12.10.1 Meat and fat exploitation

The species representation of the domestic food animals at Herxheim follows general trends in the Rhine Valley region, with similarities with Bischoffsheim and Rosheim *Sainte-Odile* (chapters 13 and 14). Animals were likely managed for both meat and milk, with meat-age slaughter suggested in all three domesticates and a surviving dairy herd possible for cattle and goats. Based on deposition practices animals may have had different levels of social significance based on species and age, especially in the Jüngste phase. Animals alive for a longer period of time were surely more likely to be known within the settlement and thus acquire social significance, although younger meat-age animals may be preferred for ritual slaughter, both factors commonly found in ethnographic literature (see chapter 2).

Analysis of butchery marks from Herxheim implies repeated butchery techniques indicating skinning, disarticulation and muscle stripping (figures 12.52 and 12. 53). The carcasses were skinned with incisions made on the distal first phalanx and the metapodia, and also on bucrania of bovinae and caprines around the base of horn cores. Primary areas of disarticulation are suggested at the ankle (tarsals) for all three species groups, and at the elbow (humerus, radius, ulna) and hip (pelvis, femur) for suidae and bovinae. Marks resulting from defleshing are suggested for many elements of the skeleton, but particularly the meat-rich scapula and humerus of bovinae and suidae, and the femur in suidae. Butchery was thus similar to other LBK sites studied, and was potentially less intensive than that of human bones from Herxheim.

Table 12.4: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Herxheim.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	79	19	78	18	67	6	83	6	77	13	56	16	56	16
Suidae	75	24	41	17	75	12	40	10	37	19	-	-	-	-
Caprines	83	12	55	20	67	9	57	23	0	2	60	5	0	3

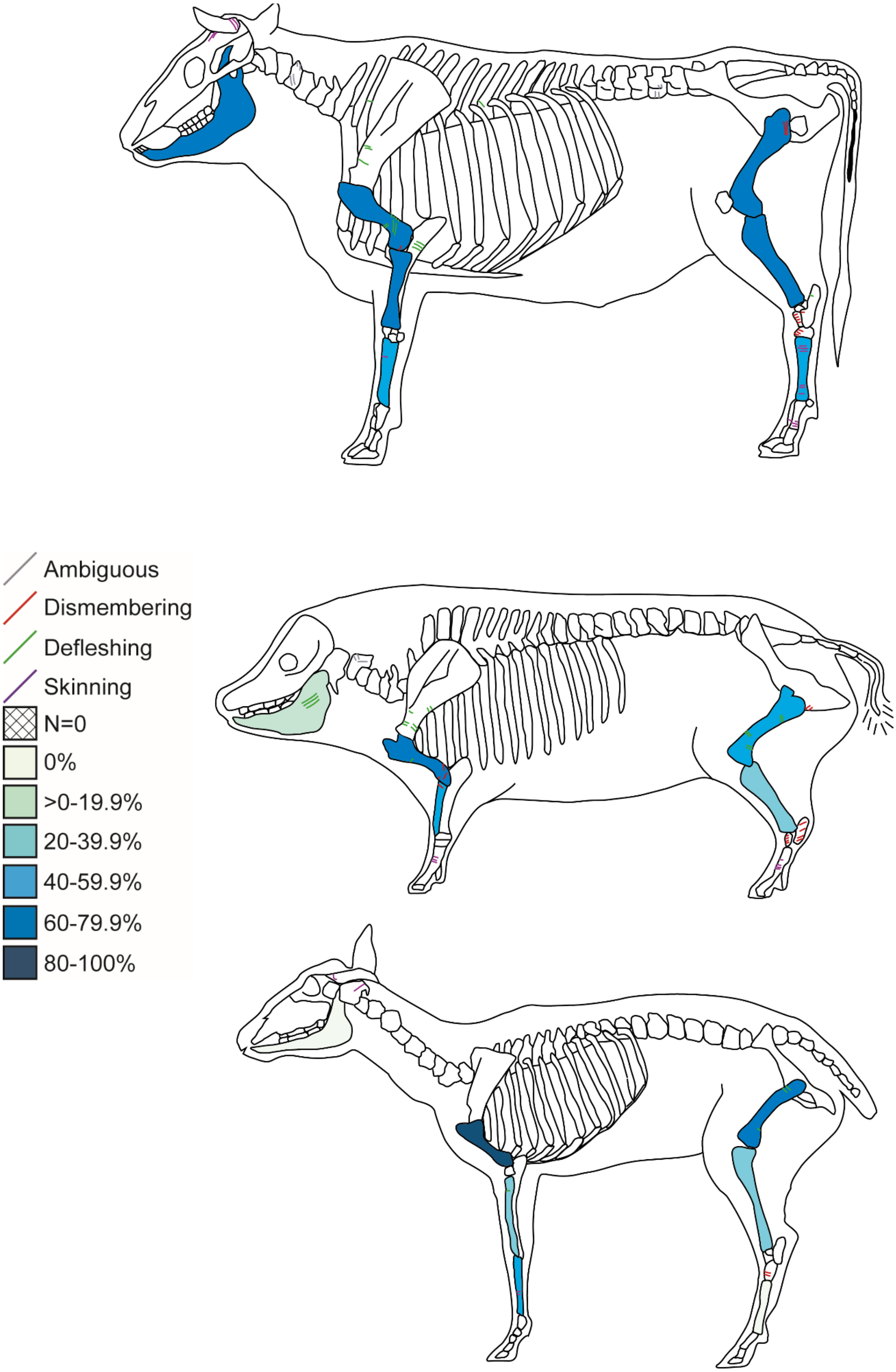

Figure 12.52: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Herxheim. Values in table 12.4.

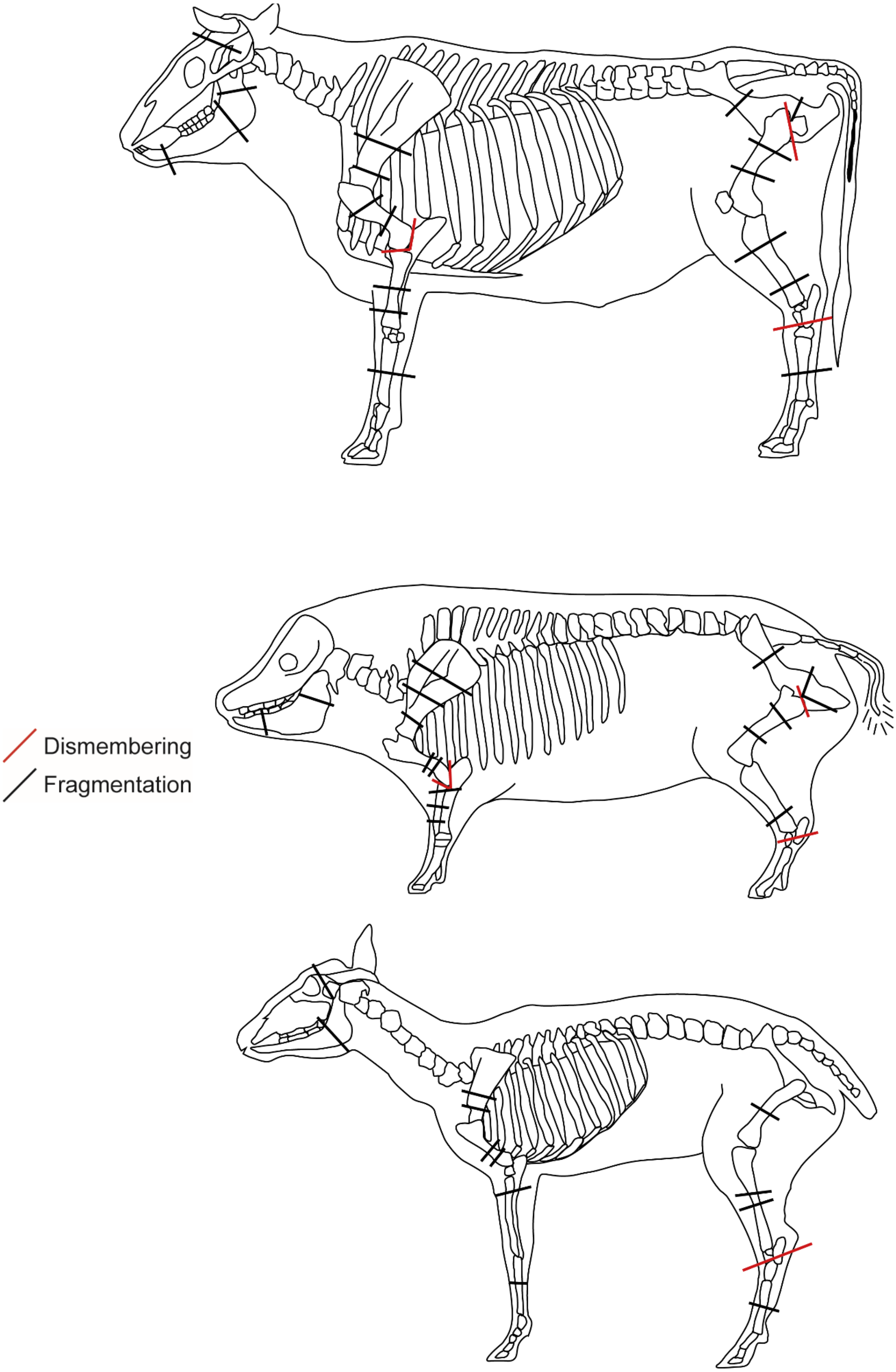

Figure 12.53: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Herxheim.

The levels of fresh fracture and fragmentation of long bones at Herxheim suggest that marrow was commonly extracted from animal bones and showed some possible evidence of bone grease extraction. Despite this, bone fat exploitation strategies were not particularly intensive, as many sources of bone fat were not utilised. Marrow exploitation was not a part of the differential deposition processes contributing to the settlement and ditch contexts of the Jüngste phase, as fresh fracture levels are very similar. Fracture analysis does highlight differences in species carcass processing by suggesting that humans and animals were similarly processed for marrow, particularly bovinae (figure 12.52), but that domestic dogs were not. The patterns of fracture freshness show that some animal bones were not exploited for their full nutritional value, further suggesting that marrow processing and possible bone grease processing (from evidence of pot polish; Zeeb-Lanz, pers. comm.) on human bones was not as a result of survival cannibalism, but at least also had a ritual undertone.

The “ritual waste” deposits of the Jüngste phase ditches (Haack 2016: 113-115) yielded some interesting results from taphonomic and fracture analysis. Higher levels of mineralised fracture and erosion in the Jüngste phase ditches than in the settlement pits suggests that disturbance was a part of the taphonomic histories of the material in the ditches. As it is likely that material was deposited in ditches in one episode of opening and refilling, this suggests that the faunal assemblage within the ditches derived from temporary or closed middens elsewhere in the settlement before being deposited secondarily in the ditches. This could include material from old pits disturbed during construction of the ditches. It could be the case that accumulations of material were saved up in temporary middens specifically for this purpose.

12.10.2 Conclusion

Herxheim is an atypical LBK site that yet follows typical LBK zooarchaeological trends. There is evidence for common exploitation of marrow on a site that likely had a mixed meat and milk economy. Potential evidence for bone grease processing here attests to the continued value placed on bone fats, although like other sites it was not intensive, and the full nutritional value of bones often went unexploited. However, ‘animals’ were not the only meat-bearing entity that likely contributed to diet at Herxheim, and must be studied with consideration of the impact that consumption of human flesh might have had on dietary needs.

Chapter 13 Bischoffsheim

13.1 Introduction

The village of Bischoffsheim is located around 20km west of Strasbourg on loess soil in the Vosges foothills, an area rich with Neolithic activity (Bischoffsheim unpublished report: 4, author's translation). In the same area are two other Rubané (LBK) sites, and on the loess band 15 sites have been discovered (*ibid.*). The site is located on a fairly considerable north-west to south east slope (*ibid*. 10) and was likely served by a tributary of the river Ehn (*ibid.* 4). It was excavated in 1985 and 1986, and more recently in 2002, when further extensions of the site, including 41 mostly well preserved houses and traces of several palisades, were uncovered (*ibid*. 11-12). Ceramic seriation suggests the site was occupied from the *Rubané ancien* (Flomborn) to *récent*, with the *final* phase of the *Rubané* absent. In its last phase, it was likely contemporary with Rosheim *Sainte-Odile*.

13.2 Assemblage

13.2.1 Sample

A sample of the Bischoffsheim LBK animal bone assemblage was analysed. This included three house contexts, Houses 31, 40 and 43, and three isolated contexts – two pits, 1313 and 796, and a pit complex, 434. These contexts date from the *Moyen*, and *Récent* IVa1 and IVb phases (see table 13.2). The total specimens analysed was 1309 (table 13.1). Any difference in values for fully identifiable specimens (table 13.1) and species representation (figure 13.1) is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 13.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Bischoffsheim (BIS).

Fully identifiable (to species and element)	229
Partially identifiable (to species and element type)	312
Indeterminate	674
Total	**1215**

Table 13.2: Full list of contexts analysed from Bischoffsheim.

Context	Phase	Interpretation	House	Fully/ Partially Identifiable		Indeterminate
39	Récent IVa1	Long pit	43	2	2	59
434	Moyen	Pit complex		31	84	107
796	Moyen	Pit		13	17	20
926	Récent IVb	Long pit	31	3	0	2
941	Récent IVb	Long pit	31	32	49	103
990	Récent IVb	Long pit	31	0	0	1
1313	Moyen	Pit		13	15	38
1403	Moyen	Long pit	40	56	43	131
1404	Moyen	Long pit	41	8	5	25
1806	Récent IVa1	Pit/ long pit	43	32	56	91
1807	Récent IVa1	Pit/ long pit	43	37	37	95

13.2.2 Methodological choices

The sampled faunal assemblage from Bischoffsheim was analysed in two phases; first during the analysis of Rosheim *Sainte-Odile* and second during the analysis of Herxheim. The first phase of analysis therefore reflects the methodology of Rosheim *Sainte-Odile*, with only basic butchery analysis completed, whereas the second phase involved advanced butchery analysis in addition. Proportions of different assemblage elements therefore can still be compared in terms of butchery prevalence, but the number of specimens involved in the advanced butchery analysis is more restricted. However, this does not have a large impact on the assemblage, as sample size would have likely limited the effectiveness of advanced butchery analysis regardless.

13.3 Species representation

13.3.1 Site

The overall number of identifiable specimens (NISP) for the assemblage sampled was dominated by domestic pigs (36.0%, 80/222), followed by cattle (33.3%, 74/222; figure 13.1). Caprines were also present at 19.4% (43/222), including one bone identified as goat. No dogs were present in the sample studied, although it is likely that they were present on the site to account for the carnivore gnawing. The wild animals, which made up 11.3% (25/222) of the identified assemblage, were aurochs, red deer, wild boar and potentially bear (c.f. *Ursus sp.*). The species diversity for food animals here is very similar to other sites in the region such as Rosheim *Sainte-Odile* (Chapter 14) and Herxheim (Chapter 12), especially in the prevalence of pigs.

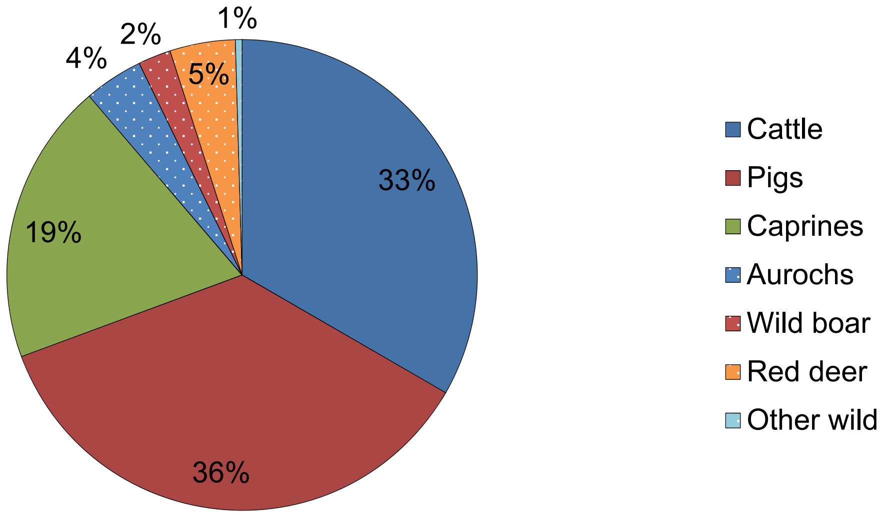

Figure 13.1: Species representation (NISP) for the fully identifiable assemblage from Bischoffsheim (n=222).

13.3.1.1 Contexts

From the comparative species diversity (figure 13.2) it is clear that there were some differences between households and other contexts. Houses 31, 40 and 43 have the highest proportions of pigs, cattle and caprines respectively. However, only the differences in proportion of pigs were statistically higher in house 31 (20/34) than 40 (17/64, p=.002) and 43 (25/68, p=.034). The two contexts not associated with houses show different proportions of species. Pit

1313 had a complete absence of wild animals, whereas pit complex 434 had an abundance, far greater than any of the other contexts at 40.0% (12/30), with red deer and wild boar particularly represented. This was significantly different from the house contexts (12/166, $p<.001$) and context 1313 (0/13, $p=.007$). This varying species diversity in the house contexts could suggest that different houses concentrated on the husbandry of different domestic animals, compared to some unassociated contexts where wild animals were particularly common. More contexts should be analysed to see if trends continue elsewhere on the site.

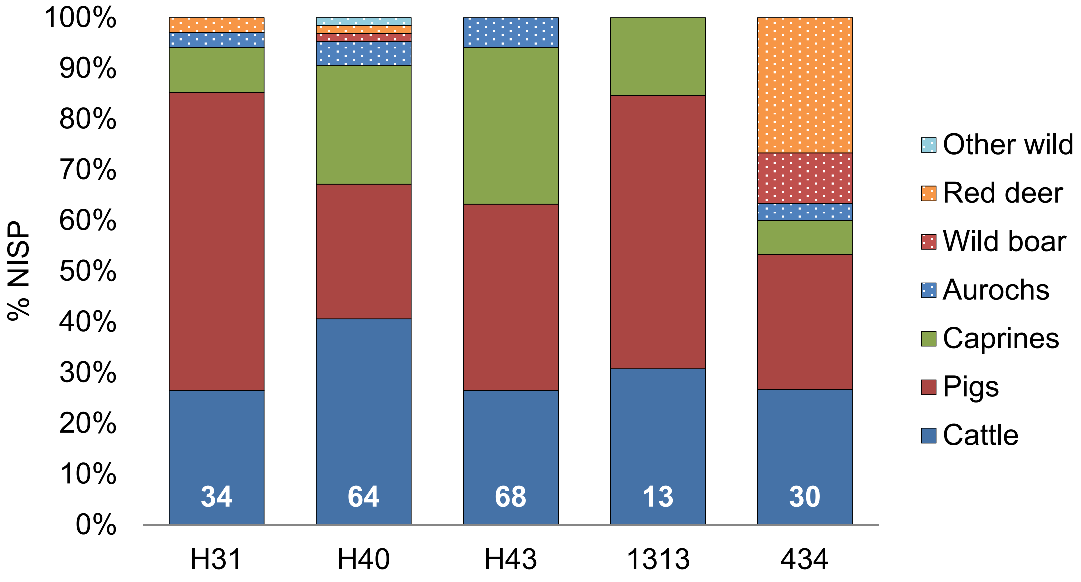

Figure 13.2: Species representation (NISP) for house contexts (H31, H40, H43) and isolated contexts (1313, 434) from Bischoffsheim. N values are at the base of each bar.

13.4 Butchery

Butchery was present on 1.5% (18/1208) of the whole assemblage and 3.0% (16/534) of the identifiable assemblage, which did not yield enough data for a full butchery study. All butchery marks were light, comprising of cut and scratch marks (figure 13.3). This is a typical pattern for other sites in the LBK, but the proportions are substantially less than those from nearby Rosheim *Sainte-Odile*. Whilst sample sizes were limited, figure 13.4 shows that Pit 1313 and Pit Complex 434 had a higher proportion of bones affected by butchery marks. Bovine and suid species were affected by butchery marks, but no evidence of butchery was recorded for any other species.

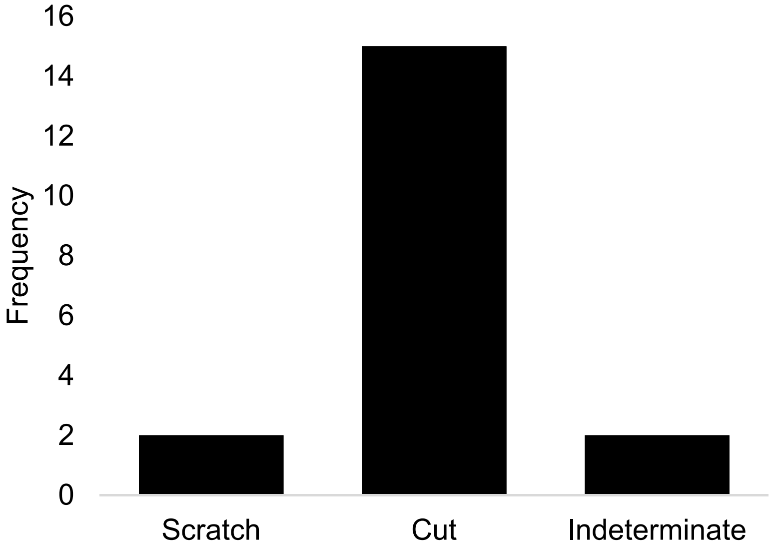

Figure 13.3: Frequency of butchery mark types from Bischoffsheim.

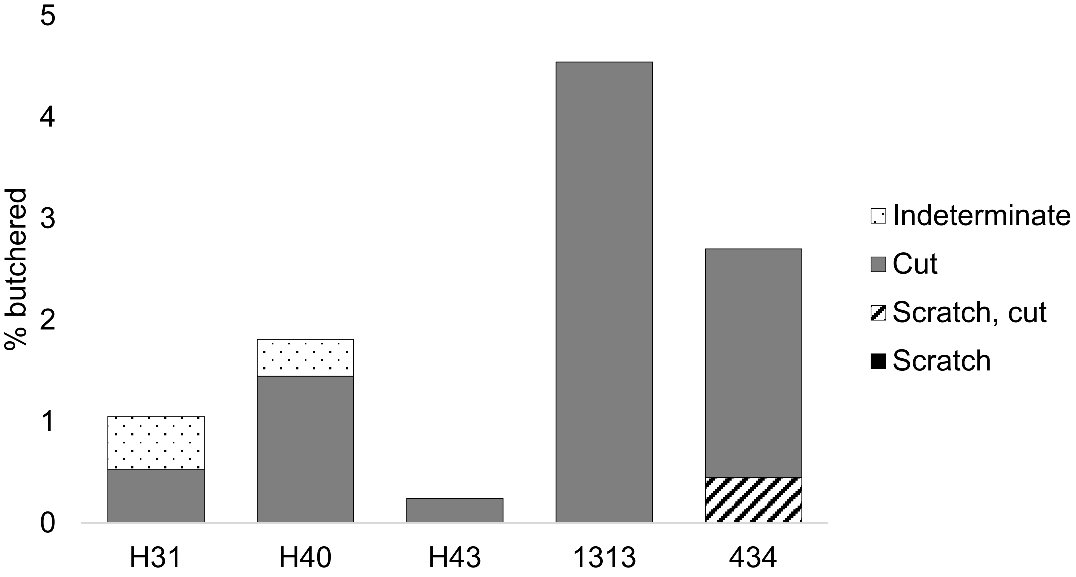

Figure 13.4: Percentage of bones in different contexts with different butchery episodes from Bischoffsheim.

13.5 Heat exposure

Evidence of heat exposure was observed on 5.0% (60/1208) of all bones in the assemblage. Roasting was the most common form of burning, with some bones also burnt at higher temperatures (carbonised and calcine; figure 13.5). Among features from the *Moyen* period (H40, 1313 and 434) the unassociated pits show higher levels of heat exposure than the house contexts. However, with no other *Moyen* house context to compare this data to we cannot draw stable conclusions (figure 13.6).

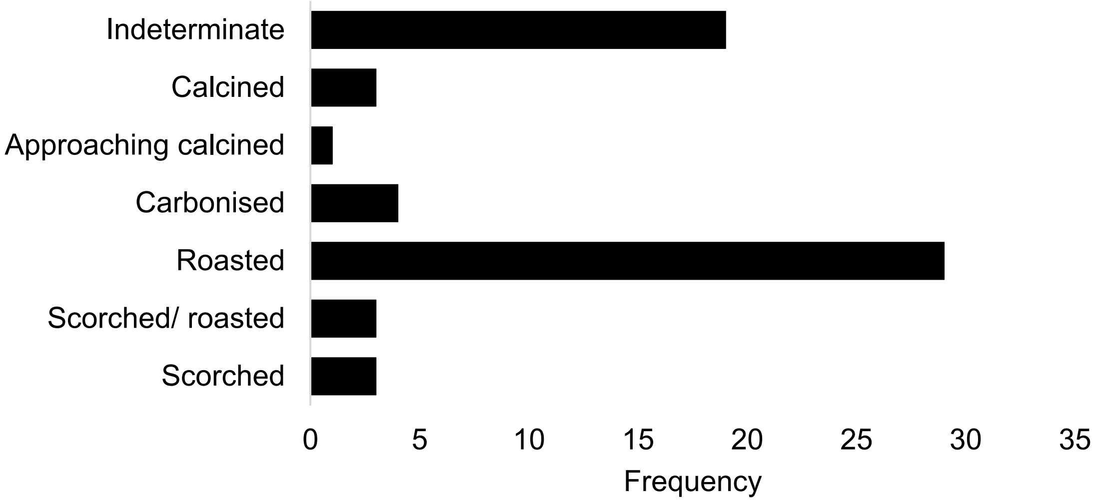

Figure 13.5: Frequency of heat exposure types from Bischoffsheim.

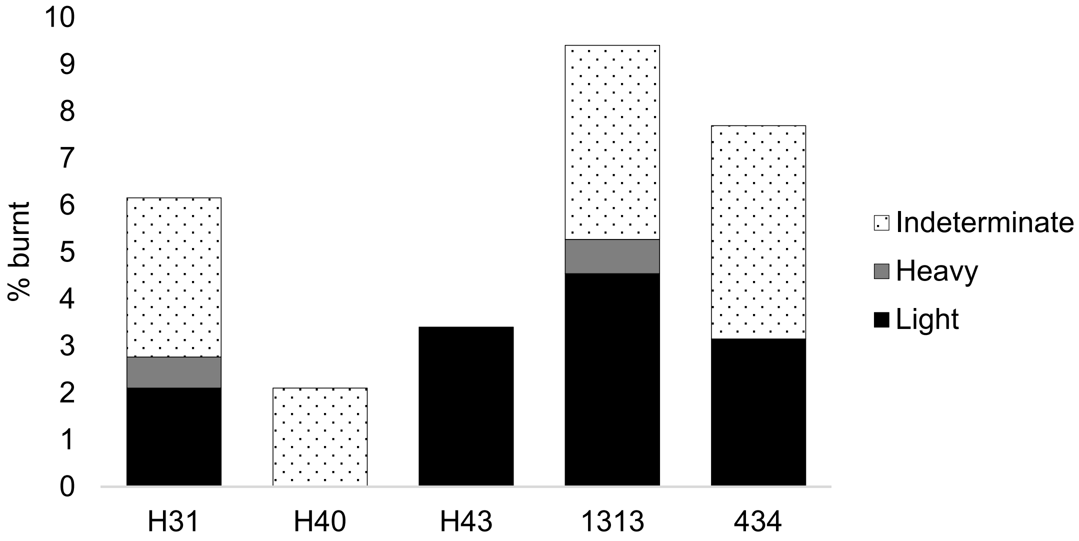

Figure 13.6: Percentage of bones from different contexts affected by different intensities of heat exposure from Bischoffsheim.

13.6 Fracture

13.6.1 Site

The fracture analysis of Bischoffsheim (figure 13.7) shows that bones were intensively exploited for marrow extraction. The site had a high proportion of fresh fracture (75.3%, 296/393) in the sampled assemblage and the mean FFI for the whole site was 2.1, which suggests that whilst there was some dry and mineralised fracture the majority of bones were fractured when fresh. The number of FFI scores suggesting bone fractured when completely dry (6) was low at this site compared to sites with higher proportions of dry fracture, and 46.4% of fractured specimens presented a completely fresh FFI score of zero (192/414; figure 13.8). The fracture freshness analysis based on yield shows that high-yield bones (43/51) were more commonly targeted by fresh fracture than low-yield bones (21/35; p=.011), although the proportions of fresh fracture remained high (figure 13.7). Secondary fracture affected 10.8% (32/296) of the freshly fractured bone.

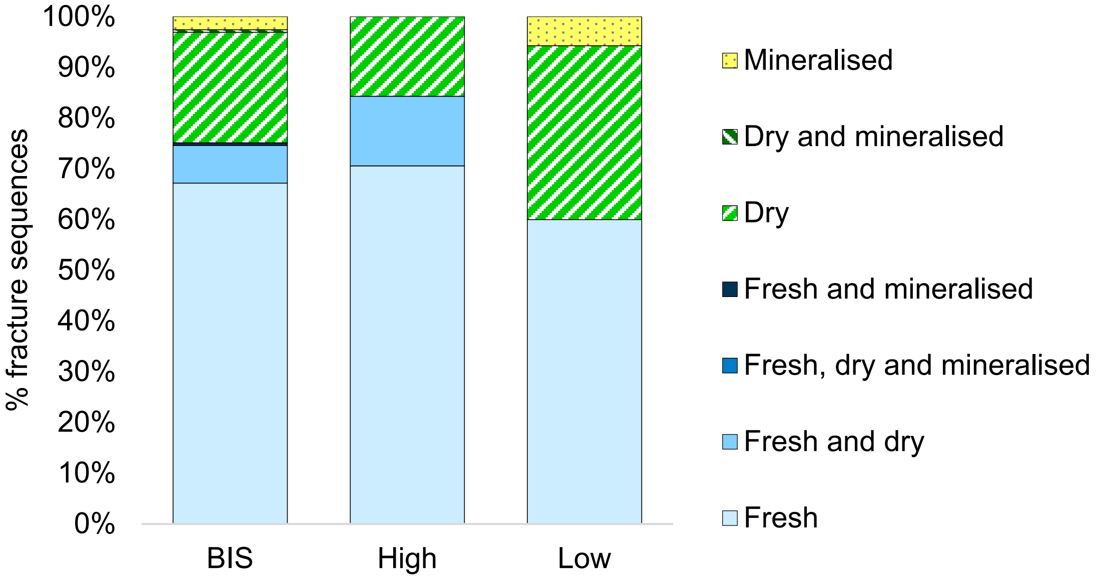

Figure 13.7: Fracture history profiles for Bischoffsheim (left; n=393) and for high- and low-yield marrow bones (right, n=66/47).

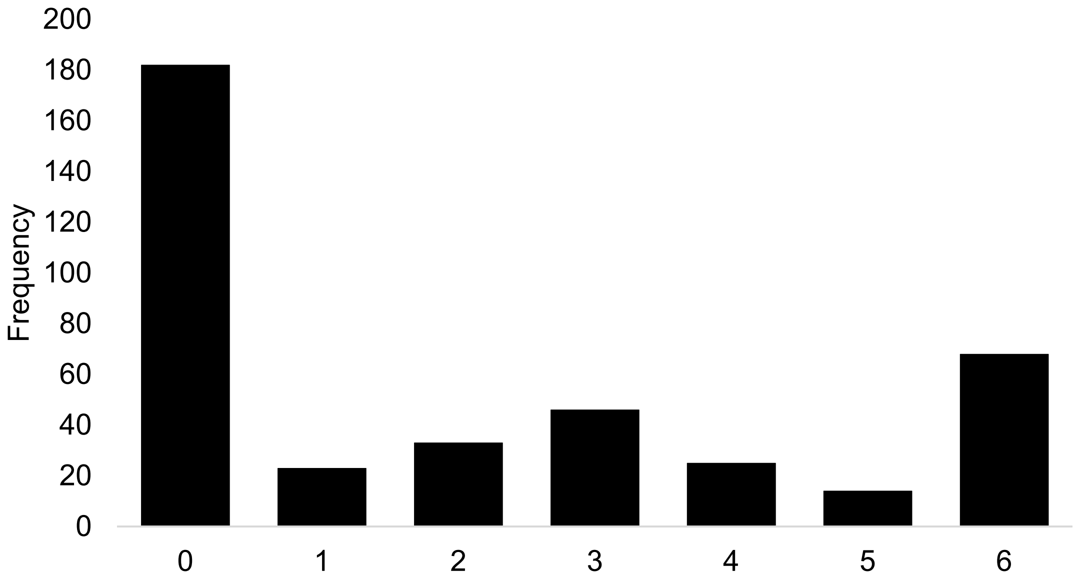

Figure 13.8: Frequency of Fracture Freshness Index scores from Bischoffsheim.

13.6.1.1 Context groups

Among the comparable contexts all contexts showed high levels of fresh fracture (figure 13.9) and likely intensive marrow processing, with only minimal variation. Secondary fracture was arguably more common in the house pits, perhaps suggesting different depositional histories related to temporary middens, or pits used over a long period of time.

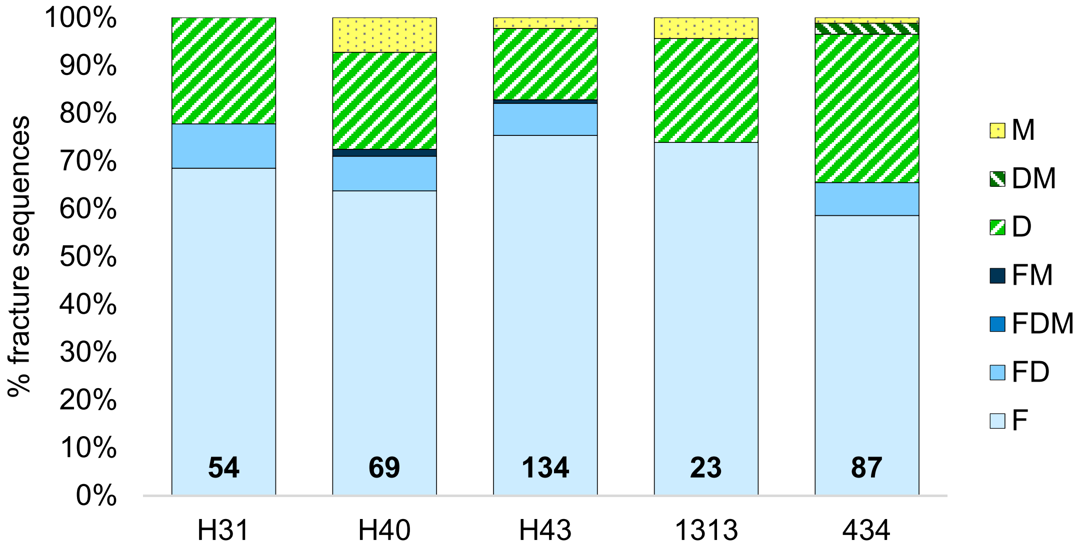

Figure 13.9: Fracture history profiles for house (H31, H40 and H43), pit (1313) and pit complex (434) contexts from Bischoffsheim.

13.6.2 Species

All species present showed evidence of fresh fracture consistent with marrow extraction (figure 13.10), including aurochs and red deer. Of the species with a viable sample size, cattle were the species most commonly affected by fresh fracture, followed by caprines and then pigs. For cattle and especially caprines the ratio of fresh fracture between high- and low-yield marrow bones was quite low, suggesting that marrow was extracted from all elements of the skeleton save the anatomically different metapodia in pigs, which have much smaller marrow cavities.

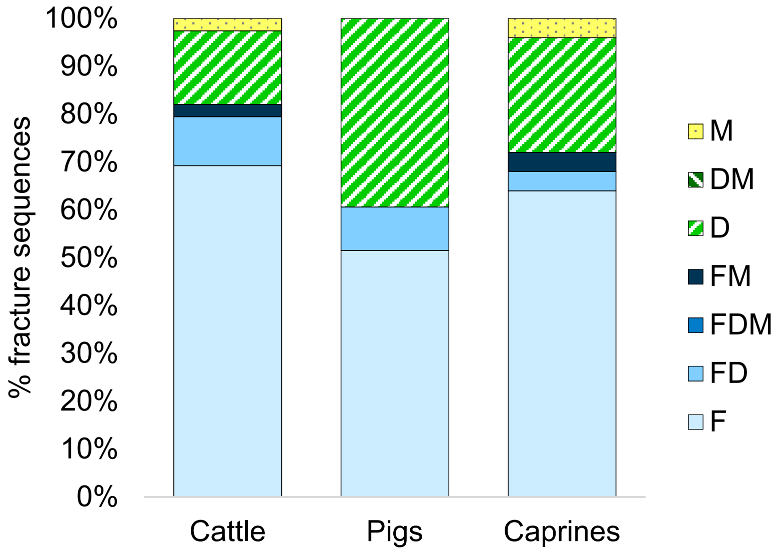

Figure 13.10: Fracture history profile for cattle (n=39), pigs (n=33) and caprines (n=25) from Bischoffsheim.

13.7 Fragmentation

The analysis of the level of fragmentation of the Bischoffsheim sample assemblage shows no evidence for intensive bone grease processing, despite the intensive exploitation of marrow. Figure 13.11 shows that there was no heavy comminution of large bones into smaller fragments for boiling, and while indeterminate cancellous material is present in the smaller size classes in figure 13.12 it does not suggest intensive repetitive processing. The unfragmented epiphyses indicate that bones were being discarded without being comminuted for bone grease, although grease processing could have taken place elsewhere on the site outside the sample.

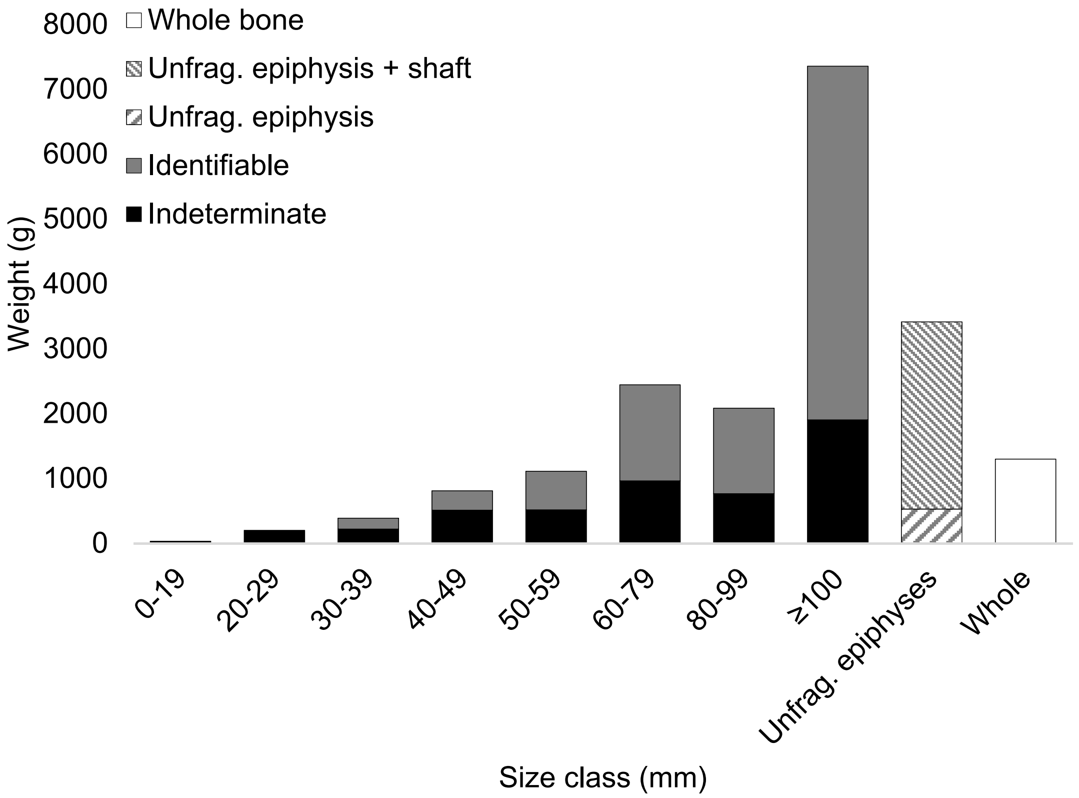

Figure 13.11: Weight by size class of all specimens from Bischoffsheim.

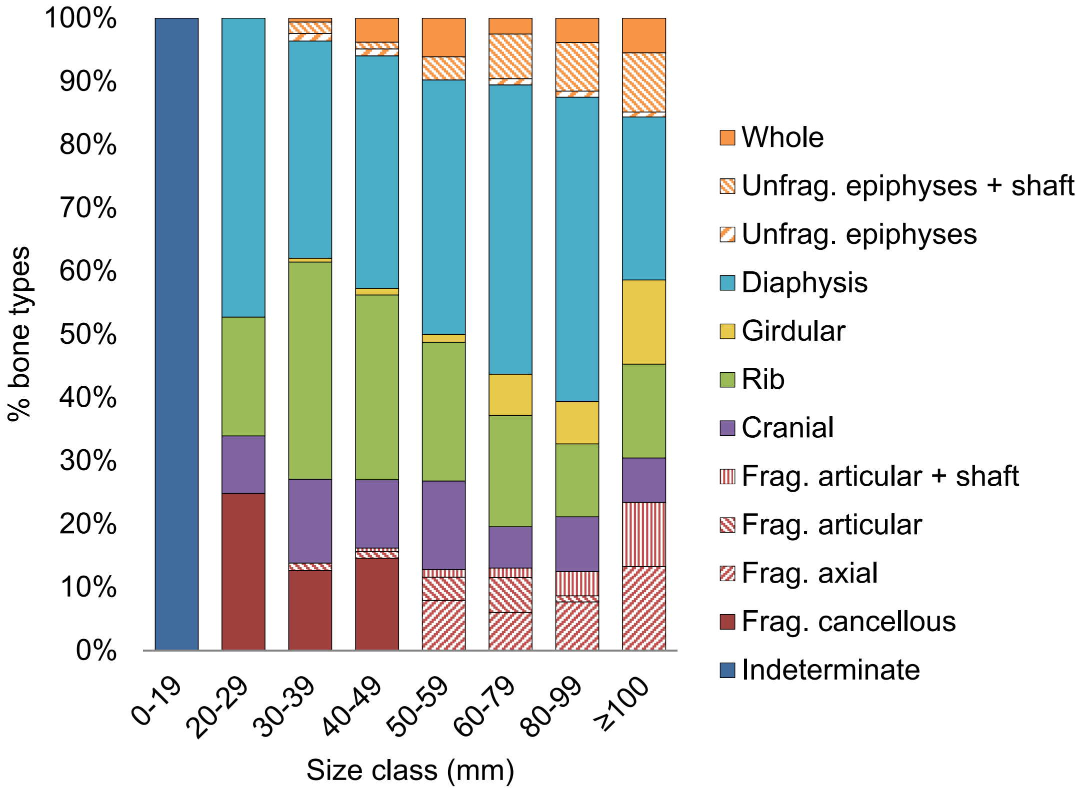

Figure 13.12: Frequency of bone types by size class from Bischoffsheim. Red series indicate fragmented cancellous bone.

13.8 Taphonomy

13.8.1 Gnawing

Evidence for gnawing was found on 4.3% (52/1208) of the Bischoffsheim sampled assemblage and was all identified as carnivore gnawing. No rodent gnawing was recorded. The comparable contexts all showed similar amounts of gnawing between them.

13.8.2 Recent breaks and taphonomic agents

Four cases of erosion and three of heavy root etching were recorded, accounting for 1.2% (56/534) of the identifiable assemblage. In some cases, cemented mud impeded analysis of bone surface modifications, and even basic species and element identification (figure 13.13). However, it only significantly affected 3 bones that were identifiable, and whilst the additional weight may have affected indeterminate bones it is likely the effect was minimal on the overall assemblage. Recent breaks affected 12.5% (67/534) of the specimens in the identifiable assemblage. For the most part contexts showed similar amounts of recent breaks apart from context 434 which showed 22.6% (26/115) of bones had recent breaks.

Figure 13.13: An example of a bone heavily affected by concreted mud from Bischoffsheim.

13.9 Food exploitation strategies

Sample sizes were too small to attempt full fusion analysis, although some trends could be detected. For cattle (n=28) there was no evidence of slaughter before two years, with likely slaughter of animals aged 2-3 years indicating meat-aged slaughter. Similarly, with caprines (n=15) there was no evidence of slaughter before 18 months, followed by possible slaughter between 18 and 30 months. While these trends could indicate meat production for all species it is also possible that they conceal mixed strategy husbandry that involved milk due to small sample sizes. Pig slaughter (n=29) suggests meat kill-off, with animals usually slaughtered between 12-30 months although one individual is suggested to have lived to fusion maturity (>42 months). Mortality profiles based on teeth are awaited.

The lipid residue analysis from Bischoffsheim is as yet incomplete, but from the sample that has been analysed 20.9% (n=43) of sherds have contained animal fats. However, none of these have been identified as milk fats.

13.10 Discussion

Whilst only a sample of the Bischoffsheim faunal assemblage was analysed the site still adds to the picture of LBK settlements in the Rhine Valley. The species diversity is immediately similar to nearby Rosheim *Sainte-Odile* and Herxheim, featuring relatively high numbers of pigs. Butchery analysis suggests skinning at the metapodia, filleting of major meat-bearing elements, disarticulation of the ankle and elbow, and intensive fragmentation for marrow (figures 13.14 and 13.15). No evidence of grease processing was detected, and with unexploited grease-rich animal bones deposited we must assume that the people of Bischoffsheim were not desperate for this resource, despite a seemingly intensive focus on marrow.

Table 13.3: Percentage of bovine, suid and caprine marrow-bearing elements fractured when fresh from Bischoffsheim.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	75	4	100	9	80	7	100	4	73	14	75	4	50	3
Suidae	100	5	22	9	71	7	83	6	17	12	-	-	-	-
Caprines	100	4	60	5	100	2	50	2	-	0	50	4	100	2

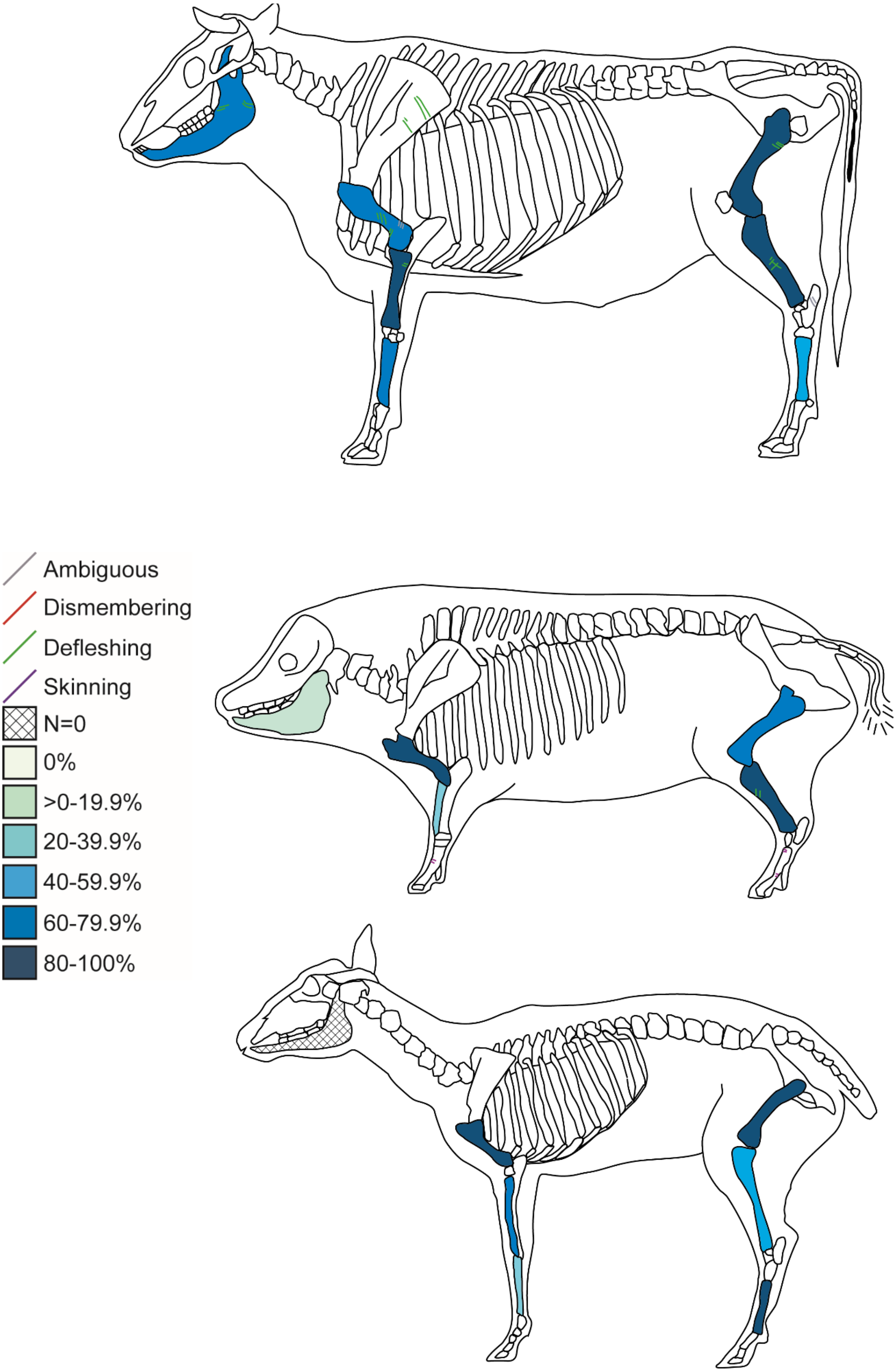

Figure 13.14: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and caprines (bottom) from Bischoffsheim. Values in table 13.3.

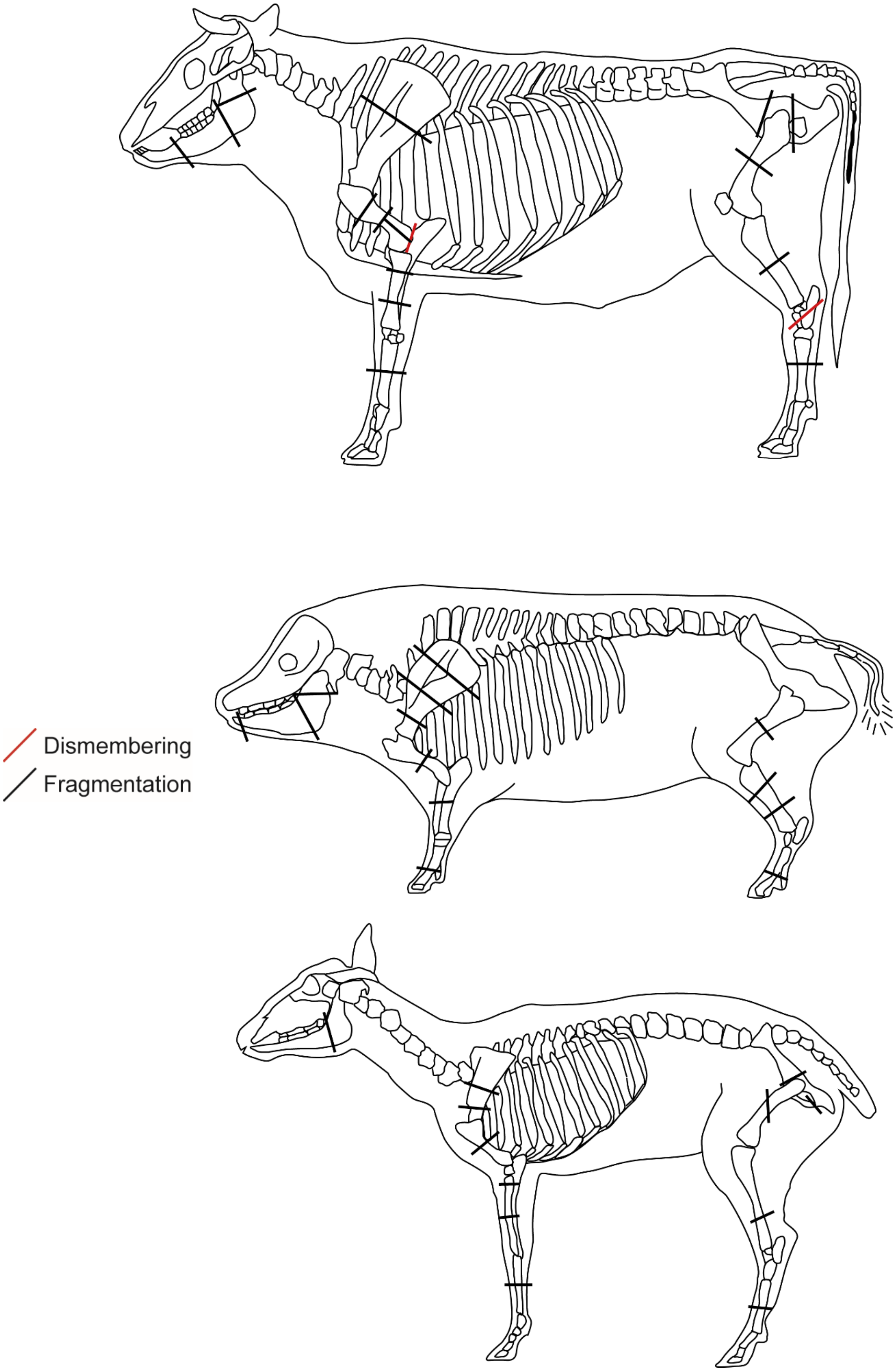

Figure 13.15: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Bischoffsheim.

Chapter 14 Rosheim *Sainte-Odile*

14.1 Introduction

Rosheim *Sainte-Odile*, situated in the Lower Rhine region in Alsace, was partially excavated in 1990/91, uncovering numerous structures dating to the final stages of the LBK, the *Rubané récent* and the *Rubané final* (Jeunesse and Lefranc 1999; Jeunesse 2011; Arbogast 2000: 51, author's translation). Two houses and an adjacent enclosure ditch were discovered (*ibid.*; figure 14.1). The ditch at Rosheim *Sainte-Odile* is the type site for the "Rosheim" ditch, a pseudo-ditch with a string of pits separated from one another (Jeunesse 2011: 31, author's translation). Unlike other *fossé discontinue* such as at Herxheim (Haack 2016)*,* the ditch at Rosheim *Sainte-Odile* was completed over a period covering many generations, rather than all at the same time (*ibid.*). The complete faunal assemblage was studied previously in greater depth by Rose-Marie Arbogast, with more attention paid to species identification (Arbogast 2000).

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of this thesis for copyright reasons

Figure 14.1: Rosheim *Sainte-Odile* site map, showing the two houses (maison I and II) and the enclosure ditch with numbered segments (Arbogast pers. comm; Jeunesse 2011: 37, figure 2).

14.2 Assemblage

14.2.1 Sample

It was possible to study the entire LBK (*Rubané*) animal bone assemblage from the excavated portion of Rosheim *Sainte-Odile*. The total number of bones analysed was 3126 (table 14.1). Any difference in values for fully identifiable specimens and species representation is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1).

Table 14.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Rosheim *Sainte-Odile* (ROS).

Fully identifiable (to species and element)	591
Partially identifiable (to species and element type)	727
Indeterminate	1808
Total	**3126**

Of the structures analysed from Rosheim *Sainte-Odile*, three context groups were selected for individual study and comparison, namely those contexts associated with the two houses and the enclosure ditch (see table 14.2). These three context groups had large enough individual assemblages to draw meaningful comparisons, although the faunal assemblage from House 2 was half the size of House 1, which should be taken into account (see also table 14.3).

Table 14.2: Number of fully identifiable, partially identifiable and indeterminate specimens from different context groupings from Rosheim *Sainte-Odile*.

Interpretation	Contexts	Fully identifiable	Partially identifiable	Indeterminate
House 1	65, 68, 85	230	360	900
House 2	28, 33	110	109	175
Enclosure	108	145	116	261

14.2.2 Methodological choices

This site was the first site analysed for this project, intended in part to be a pilot that would allow the general methodology to be tested. In-depth butchery analysis was not performed on this assemblage as timescales for analyses were unknown, thus a basic butchery analysis, recording the type(s) of butchery mark observed on identifiable bone, was implemented. For the indeterminate bones, the number of butchery marks per context was counted (see chapter 3 for full methodology).

Table 14.3: Full list of contexts analysed from Rosheim *Sainte-Odile*.

Context	Interpretation	House	Fully identifiable	Partially identifiable	Indeterminate
8			12	19	29
12			3	1	1
14			3	1	1
22			3	1	3
24			3	2	6
27			7	23	131
28	House pit	2	50	30	76
33	House pit	2	60	79	99
47			0	2	5
52			1	0	1
55			0	1	0
64			1	0	0
65	House pit	1	170	247	622
68	House pit	1	52	99	278
85	House pit	1	8	14	0
107			0	0	2
108	Enclosure		145	116	261
110			0	1	0
111			0	1	0
112			4	6	6
114			1	1	0
115			12	17	40
123			4	3	41
152			0	3	2
153			7	3	14
200			0	0	2
203			5	1	21
204			1	5	37
301			0	1	0
304			1	1	3
305			1	3	4
313			2	0	5
314			0	0	2
315			2	0	0
317			7	5	28
318			2	0	1
319			0	3	11
320			8	26	31
321			5	1	9
322			2	5	12
325			2	0	0
400			6	3	11
502			1	2	2
3,6			0	1	11

14.3 Species representation

14.3.1 Site

In the Rosheim *Sainte-Odile* faunal assemblage pigs dominated at 40.2% (233/579) of the number of identifiable specimens (NISP), followed by cattle (26.9%, 156/579) and caprines (23.5%, 136/579), indicating that the small stock had a significant role in subsistence (figure 14.2). Five caprine bone specimens were identified as sheep (n=5). Domestic dogs were present in small numbers (<1%, 5/579) but were also identifiable from evidence of their gnawing. Wild fauna made up 8.5% (49/579) of the assemblage and included aurochs (4.3%, 25/579), red deer (3.1%, 18/579), wild boar and some unidentifiable birds.

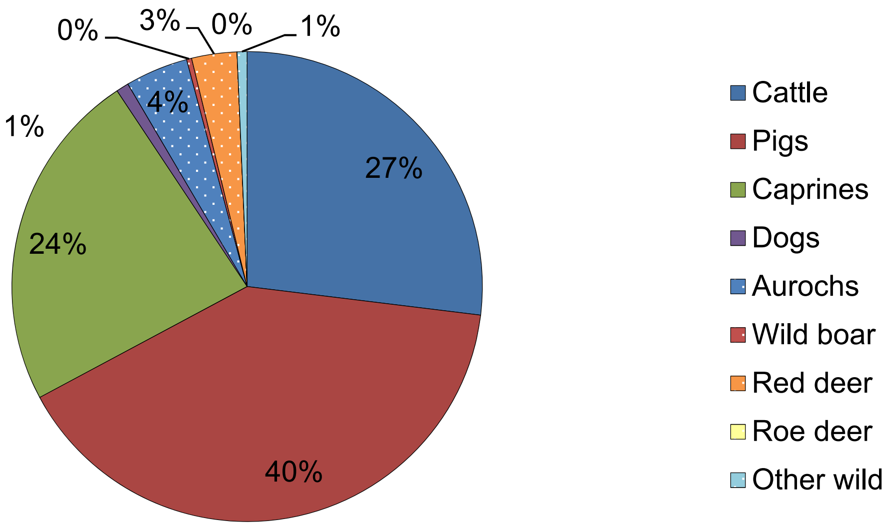

Figure 14.2: Species representation (NISP) for the fully identifiable assemblage from Rosheim *Sainte-Odile* (n=579).

14.3.1.1 Context groups

Between the two houses the species diversity was quite different (figure 14.3). In House 1 pigs made up 48.3% (111/230) of the NISP, followed by cattle and caprines. Dogs were present in a minor capacity, as were red deer, suggesting that wild animals were not contributing largely to diet. In House 2 caprines were the most dominant species. The proportion of pig bones was significantly lower in house 2 (35/111; p=.003) than in house 1, with an increase in caprines (H1 46/230, H2 36/111, p=.012) and wild animals (H1 4/230, H2 15/111, p<.001), including aurochs, red deer and birds. Provided that these two assemblages are representative of past practices it is suggested that there were different methods of subsistence in use between houses.

The enclosure contexts showed no major difference from the house contexts – in fact, for the most part the material was an accurate portrayal of the combination of the two (figure 14.3). Pigs were the most frequent species, followed by cattle and then caprines. Wild animals (aurochs, red deer and birds) comprised around 10% (15/135) of the NISP. The way that this context is representative of both house contexts could indicate that the enclosure faunal assemblage was contributed to by many different houses with different patterns of subsistence.

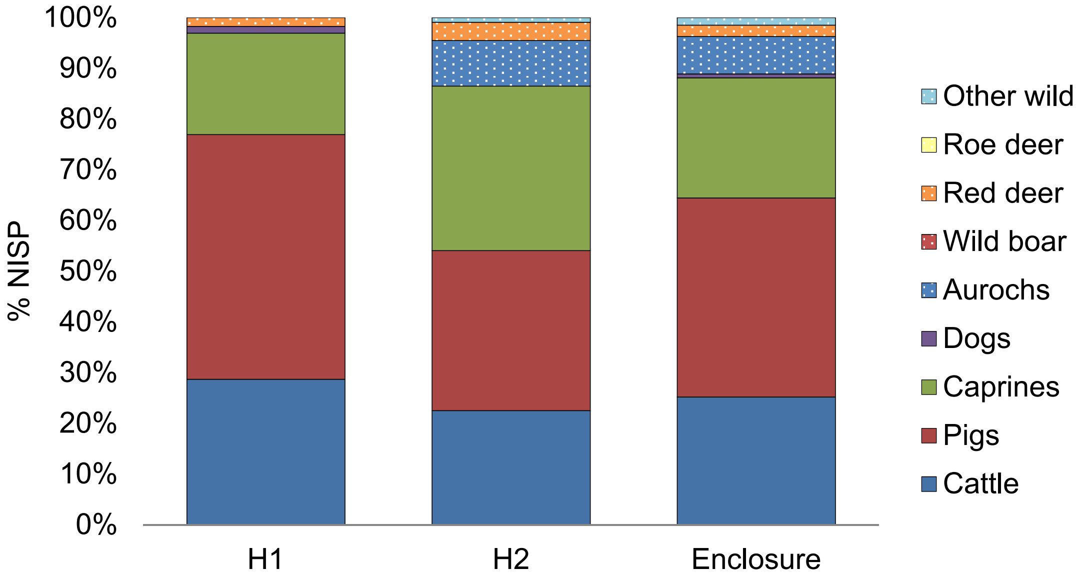

Figure 14.3: **Species representation (NISP) for House 1 (n=230), House 2 (n=111) and the Enclosure (n=135) from Rosheim *Sainte-Odile*.**

14.4 Butchery

14.4.1 Site

Of the whole assemblage, 4.4% (136/3126) of all specimens had butchery marks, and 7.1% (93/1318) of the identifiable assemblage. This is a particularly high proportion for the LBK, especially compared to nearby Bischoffsheim. The vast majority of butchery marks were cut marks, followed by chop and scratch marks (figure 14.4). House 2 (7.1%, 28/394) showed significantly increased evidence for butchery compared to House 1 (4.5%, 67/1490; p=.041) and the

Enclosure (4.8%, 25/522), although the difference with the latter was not significant (figure 14.5). Only one 'slice' mark was recorded.

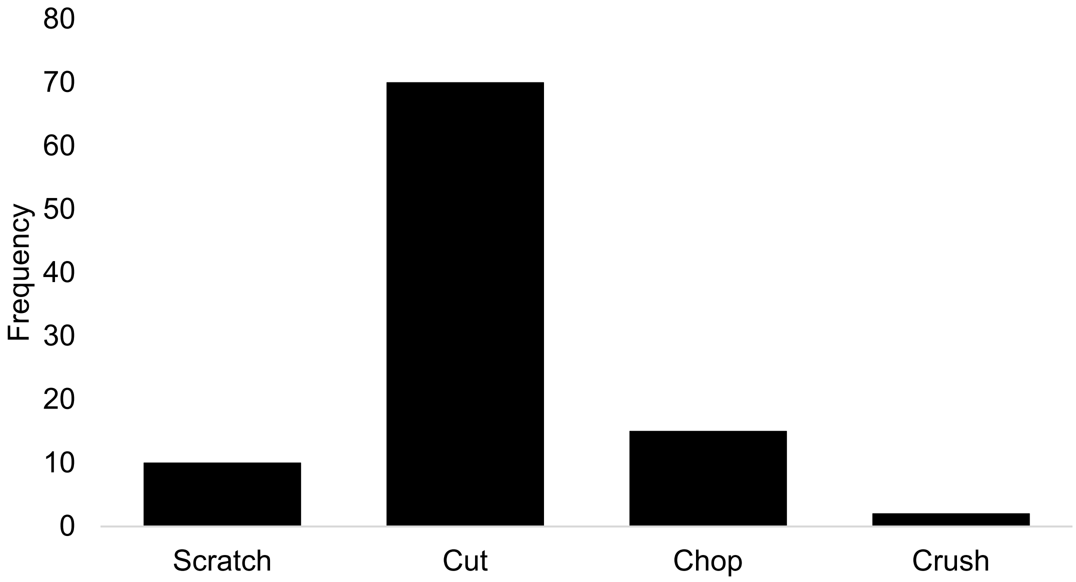

Figure 14.4: Frequency of butchery mark types from Rosheim *Sainte-Odile.*

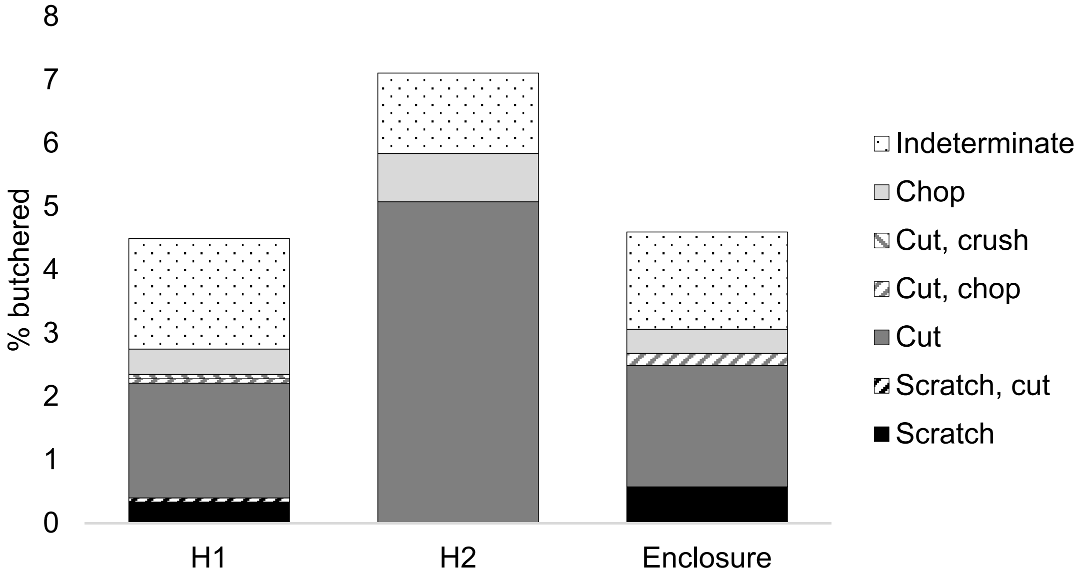

Figure 14.5**: Percentage of specimens with different butchery episodes from context groups from Rosheim *Sainte-Odile*.**

14.4.2 Species

Specimens identified as domestic cattle were most commonly observed to have butchery marks (14.7%, 23/156; figure 14.6), although butchery proportions on pigs, caprines and wild animals were high compared to many other sites. Domestic dogs showed no evidence of butchery, although sample sizes were low (n=5) and the differences between species were not significant.

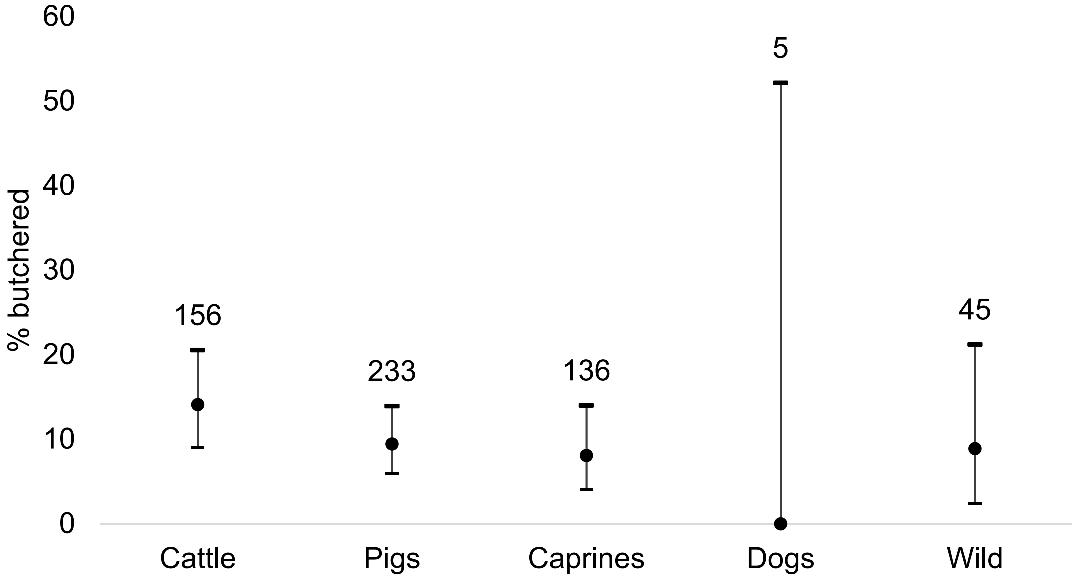

Figure 14.6: Percentage of species with evidence of butchery from Rosheim *Sainte-Odile*, with 95% confidence intervals. N values are at the top of each series.

14.4.3 Carcass butchery

The extremities, particularly the tarsals, were some of the most commonly butchered skeletal elements from Rosheim (figures 14.7 and 14.8). The astragalus showed repeated butchery, with deep cut marks in several strokes running horizontally across the anterior bone surface. It is likely that this pattern represents disarticulation of the hindlimb from the extremities (Soulier and Costamagno 2017). Most other skeletal elements from Rosheim *Sainte-Odile* were butchered in similar proportions. Butchery on the fore- and hind-limb likely suggest both dismemberment and defleshing, although as butchery diagrams for each skeletal element were not completed for Rosheim *Sainte-Odile* it is impossible to say for sure.

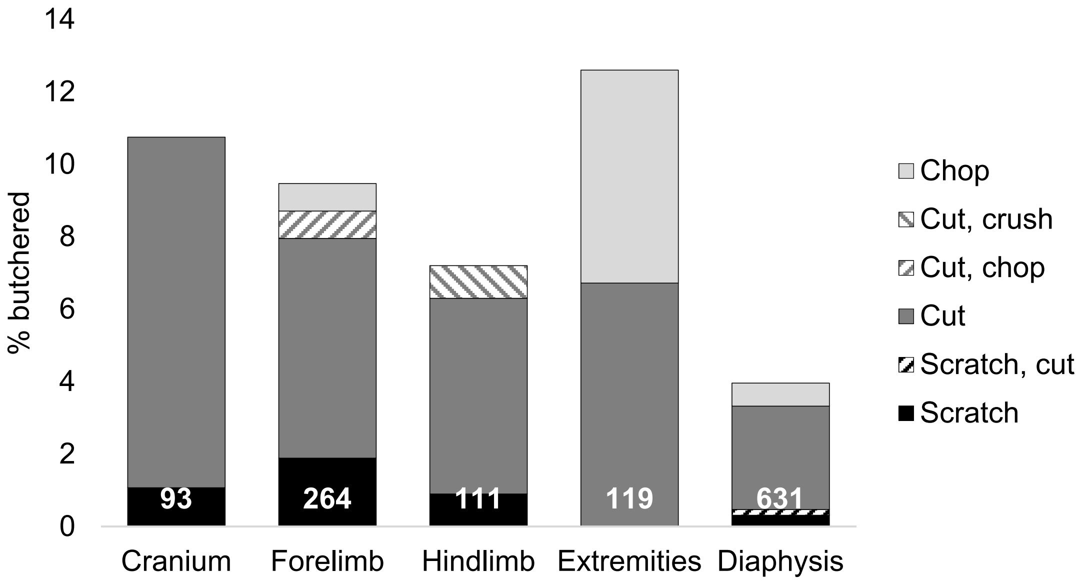

Figure 14.7: Percentage of specimens in different carcass portions affected by different butchery episodes from Rosheim *Sainte-Odile*. N values are at the base of each bar.

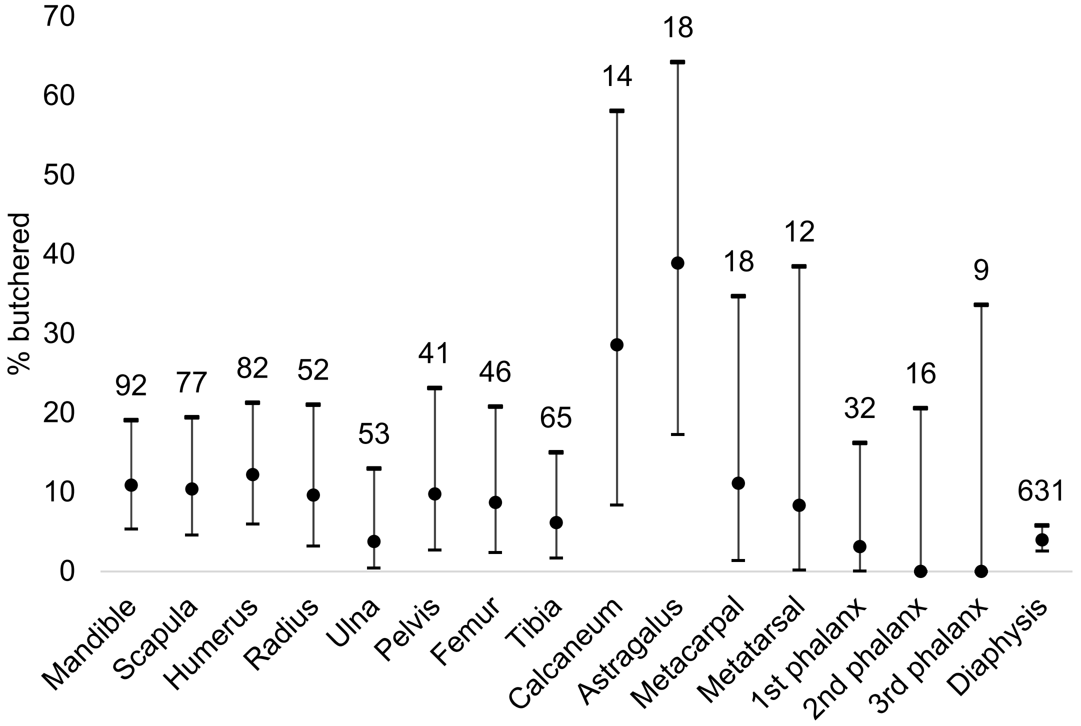

Figure 14.8: Percentage of elements with evidence of butchery from Rosheim *Sainte-Odile*, with 95% confidence intervals.

14.5 Heat exposure

14.5.1 Site

Evidence for exposure to heat affected 5.1% (160/3126) of the Rosheim *Sainte-Odile* assemblage. Roasting was the most commonly identified type of burning (figure 14.9). Of the comparable contexts, House 2 showed the least amount of burning (1.5%, 6/394) and the enclosure ditch the most (4.2%, 22/522) (figure 14.10). The indeterminate bones in the enclosure included one small bag of heavily fragmented carbonised and calcined material that was impossible to correctly count.

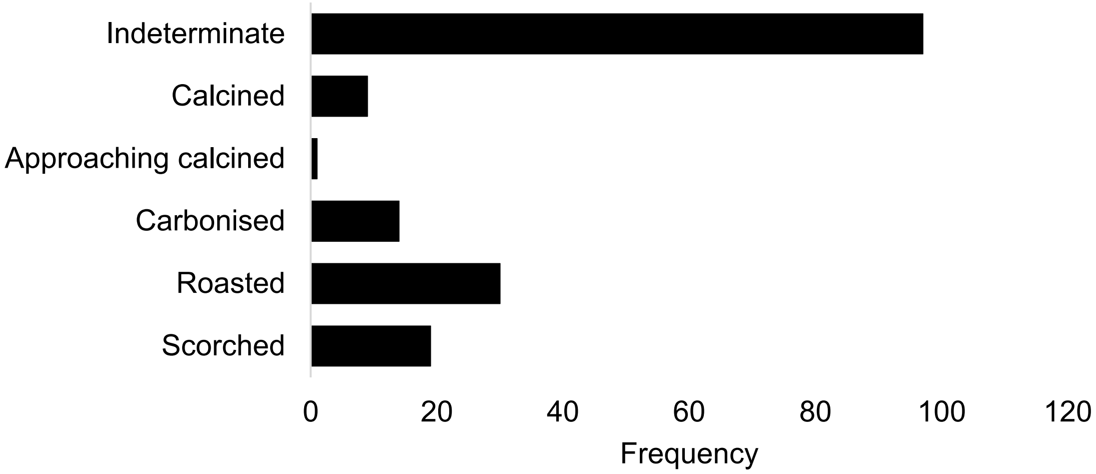

Figure 14.9: Frequency of heat exposure types from Rosheim *Sainte-Odile*.

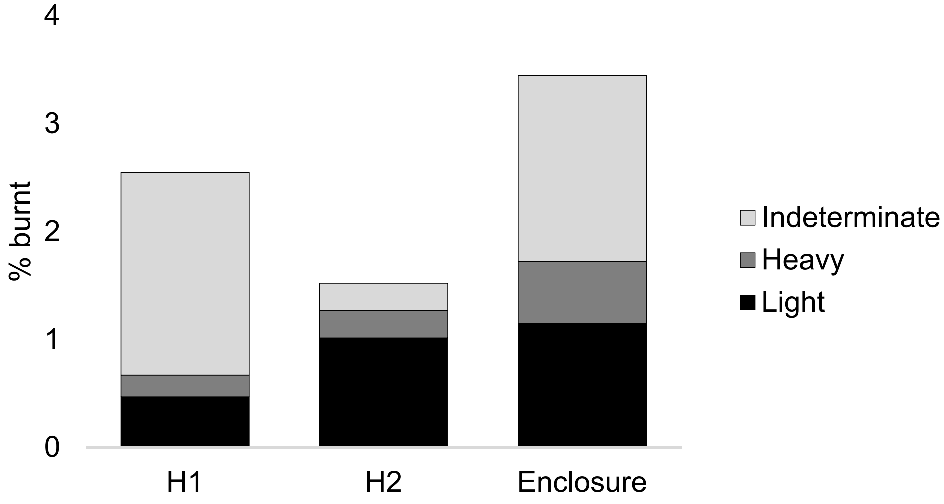

Figure 14.10: Percentage of specimens from each context group with different intensities of heat exposure from Rosheim *Sainte-Odile*.

14.5.2 Species

There were some differences in the levels of burning found on bones of different species (figure 14.11). The bones of red deer were those most commonly burnt at 16.7% (3/18) of identifiable specimens, all of which were roasted. Cattle bones were burnt in 6.4% (10/156) of cases, pigs in 3.4% (8/233) and caprines in 4.4% (6/136). No evidence for burning was found on any other identifiable species.

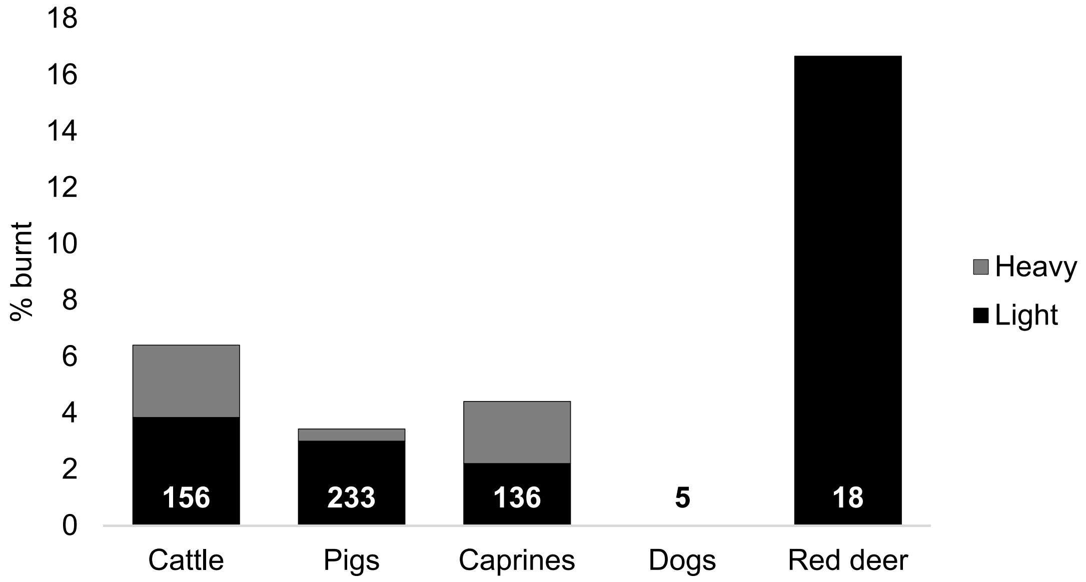

Figure 14.11: Percentage of different species affected by different intensities of heat exposure from Rosheim *Sainte-Odile*.

14.5.3 Element

Differences in the proportions of elements burnt were not significant, although the mandible (8.7%, 8/92) and metatarsal (33.3%, 4/12) showed some of the highest burning proportions (figure 14.12). There was possibly a tradition of roasting bovine and suid mandibles before fracture, as suggested by figures 14.13 and 14.14. The first and second phalanges also presented strong evidence of burning in 9.4% (3/32) and 12.5% (2/16) of cases respectively, but the calcaneum, astragalus and third phalanx showed no evidence of burning. It is possible that the extremities (the metapodia and phalanges) were roasted after separation from the tarsals, and that the third phalanx was removed during skinning.

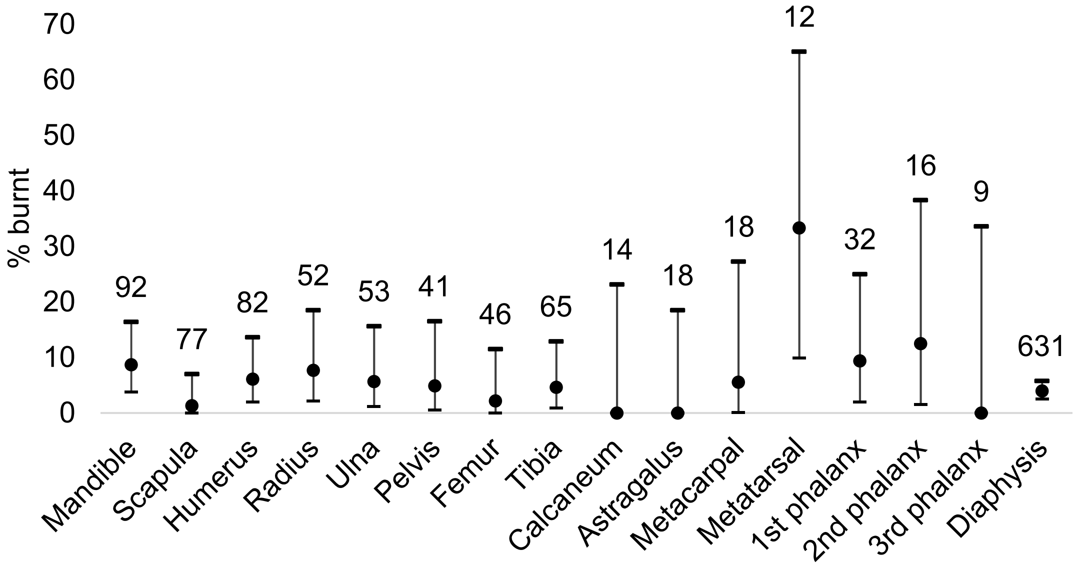

Figure 14.12: Percentage of elements with evidence of heat exposure from Rosheim *Sainte-Odile*, with 95% confidence intervals.

Figure 14.13: Buccal (left) and lingual views of a domestic pig left mandible that was likely roasted before being fractured from Rosheim *Sainte-Odile*.

Figure 14.14: Lingual view of a domestic cattle left diastema showing evidence of roasting and fracture on the tooth row, from Rosheim *Sainte-Odile*.

14.6 Fracture

14.6.1 Site

In the Rosheim *Sainte-Odile* assemblage, 62.5% (648/1036) of fractured bones were fractured when fresh, and the assemblage mean FFI was 3.2 (figure 14.15). Fractured high-yield marrow bones were more often fractured when fresh (76.9%, 163/212) than low-yield marrow bones (42.0%, 47/112). These characteristics suggest an assemblage where breaking bone for marrow was a common part of carcass processing.

Analysis also shows that dry, drying or subsequent fractures were often present at Rosheim *Sainte-Odile*. FFI scores between 2-4 (26.3%, 275/1046 of specimens) suggest fractures with both fresh and dry characteristics, and 22.9% (237/1036) of fractured bone was fractured secondarily, particularly dry fracture affecting freshly fractured bone (figure 14.16). These patterns are explored further below. Mineralised fracture was comparatively rare compared to dry fracture, suggesting material in contexts was not usually disturbed.

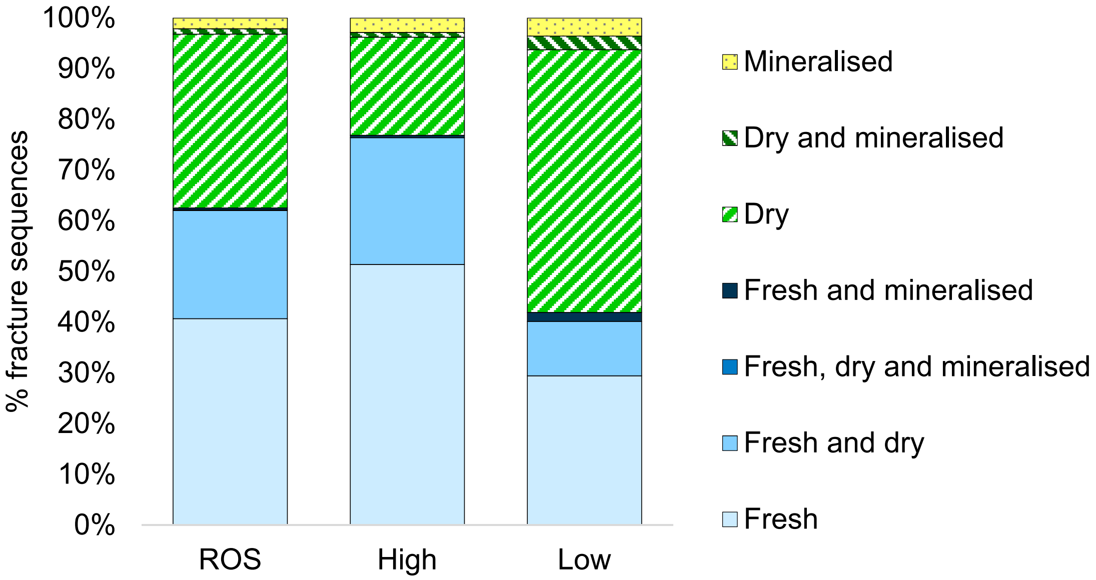

Figure 14.15: Fracture history profiles for Rosheim *Sainte-Odile* (left; n=1036) and for high- and low-yield marrow bones (right; n=212/112).

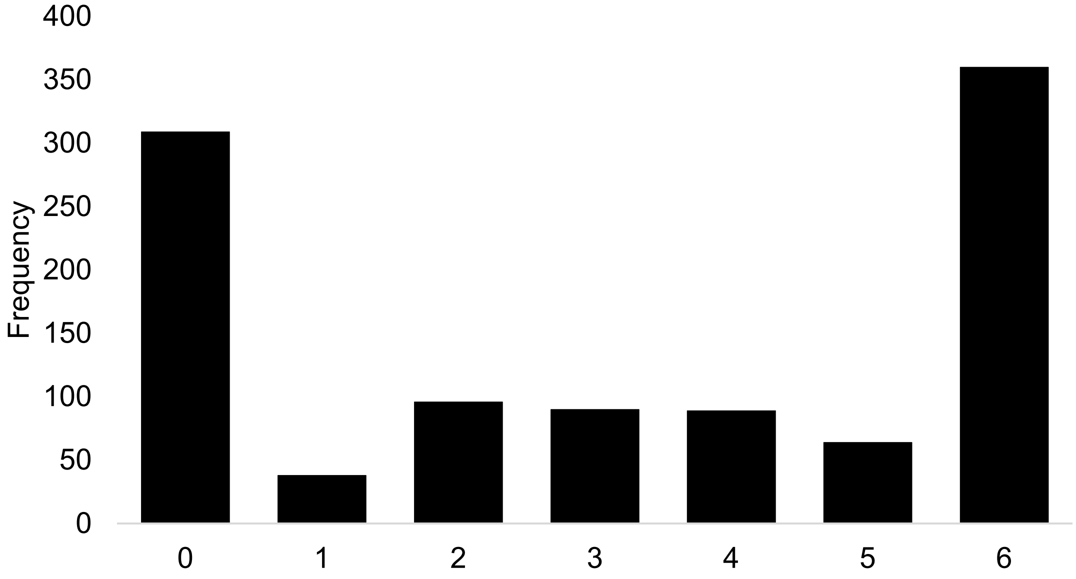

Figure 14.16: Frequency of Fracture Freshness Index scores from Rosheim *Sainte-Odile*.

The percentage of subsequent dry breakage on fresh fracture at Rosheim *Sainte-Odile* is considerably higher than at any other site (figure 14.15). Figure 14.17 attempts to identify any contributing factor to this high amount of dry fracture, showing that bones that were fractured freshly and then drily more commonly had evidence of gnawing (predominantly carnivore) and taphonomic agents (predominantly root etching), although the majority (58.6%, 130/222) had no form of modification. It is possible that freshly fractured bone, when gnawed, was fractured again when some of the moisture content of the bone was reduced. Taphonomy perhaps suggests that different deposition practices could encourage secondary fracture.

It is also probable that during this pilot study I was still familiarising myself with the methodology to describe different fracture types. Figure 14.18 shows that most bones that were recorded as fractured freshly and drily had FFI scores of 3 (29.3%, 65/222) and 4 (20.3%, 45/222), suggesting that these bones could have displayed drying fractures, as opposed to bones that had been fractured twice.

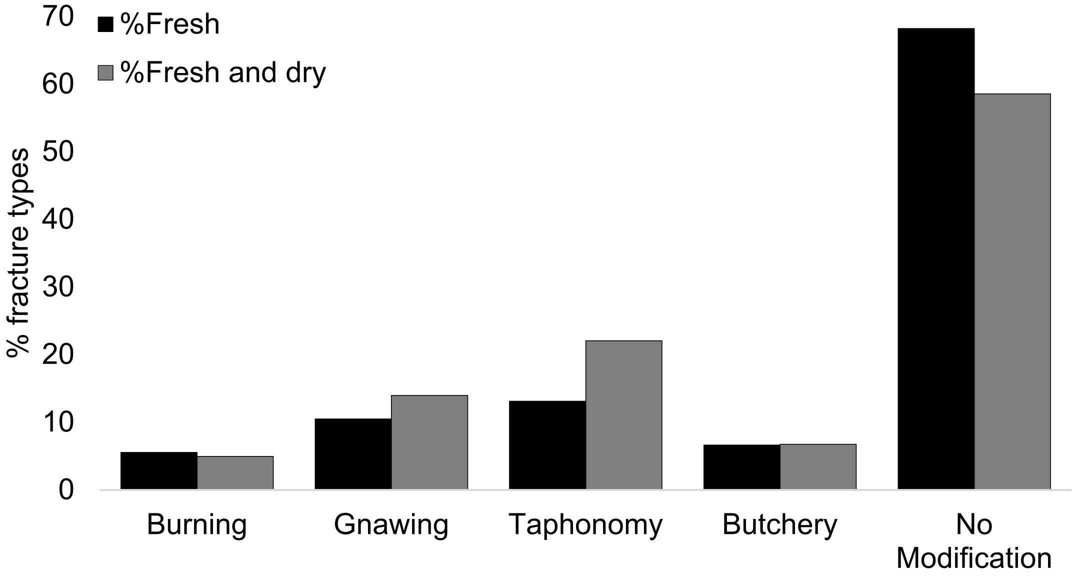

Figure 14.17: Percentage of bones displaying fresh fracture in any sequence, and those displaying both fresh and dry fractures, that were also affected by burning, gnawing, taphonomy and butchery from Rosheim *Sainte-Odile*.

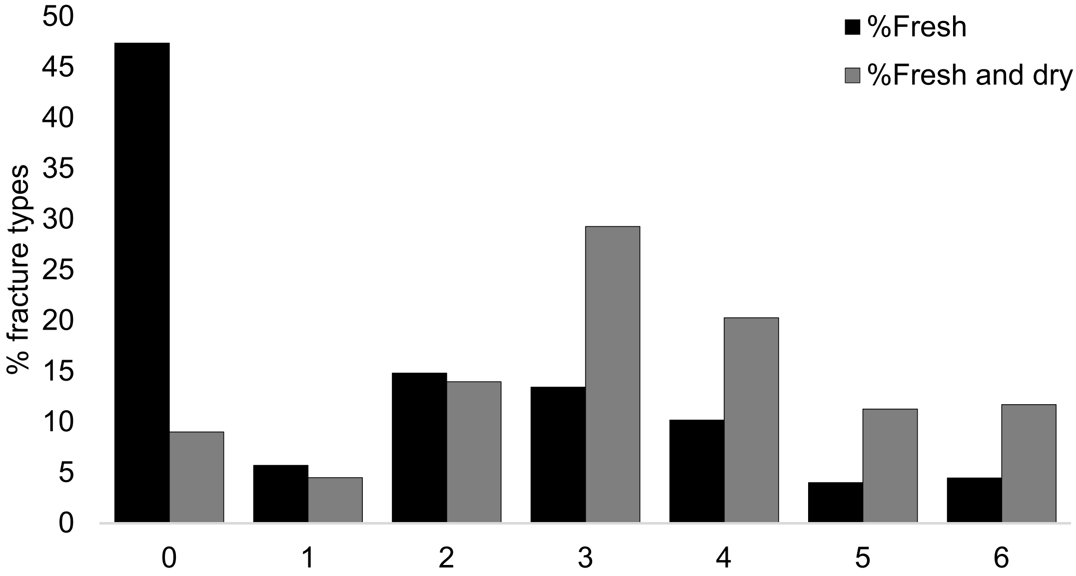

Figure 14.18: Percentage of different Fracture Freshness Index scores assigned to bones with "Fresh and dry" and "Fresh (in any sequence)" fractures from Rosheim *Sainte-Odile*.

14.6.1.1 Context groups

The three comparable contexts all showed evidence of fresh fracture consistent with marrow processing, with high levels of fresh fracture (all 56.9% or above; figure 14.19) and high-yield marrow-bearing bones more commonly fractured when fresh than low-yield bones (figure 14.21). Their mean FFI scores suggest some fractures could have been drying or that there was a mix of fractures, with dry and mineralised fracture also common (figure 14.20). The enclosure ditch was the most freshly fractured context (66.3%, 122/184), significantly more so than material from House 1 (274/482, p=.026) but the difference in House 2 was not significant. The enclosure also had a significantly higher proportion of fresh fracture on high-yield elements (40/43) than House 1 (66/96, p=.002) and House 2 (29/38, p=.035). It is possible that a greater value was placed on marrow from bones deposited in the enclosure contexts.

The house contexts were comparatively higher in dry and mineralised fracture than the enclosure contexts, particularly in the amount of secondary fracture on fresh bones. House 1 (151/483) had a significantly higher proportion of secondary fracture than House 2 (31/175) and the enclosure (19/184; both p<.001). House 2 was significantly more secondarily fractured than the enclosure (p=.032). This could suggest different deposition practices that resulted in less disturbance of freshly fractured bone in the houses, but not in the enclosure ditch.

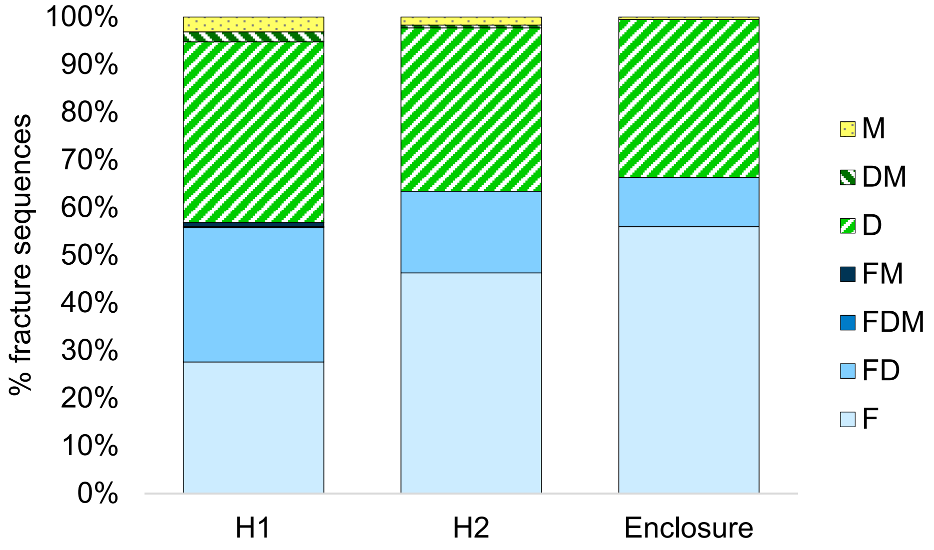

Figure 14.19: Fracture history profiles for House 1 (n=482), House 2 (n=175) and the Enclosure (n=184) from Rosheim *Sainte-Odile*.

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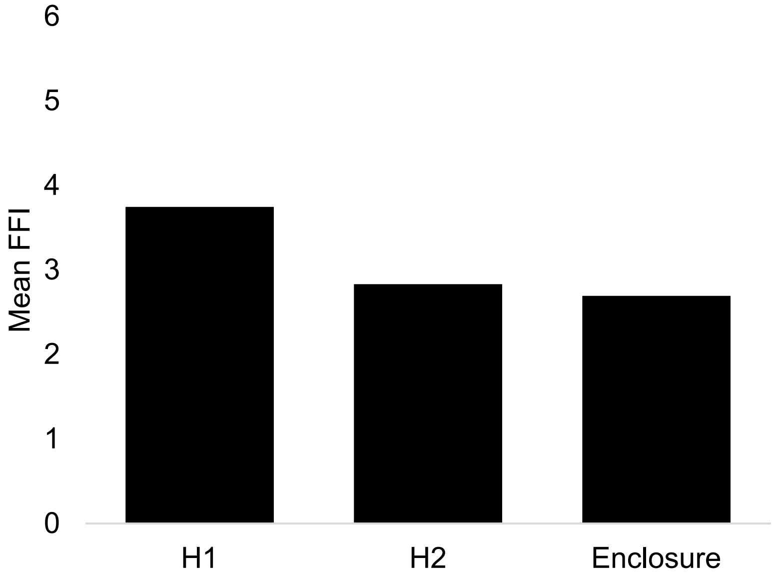

Figure 14.20: Mean Fracture Freshness Index scores for the context groups from Rosheim *Sainte-Odile*.

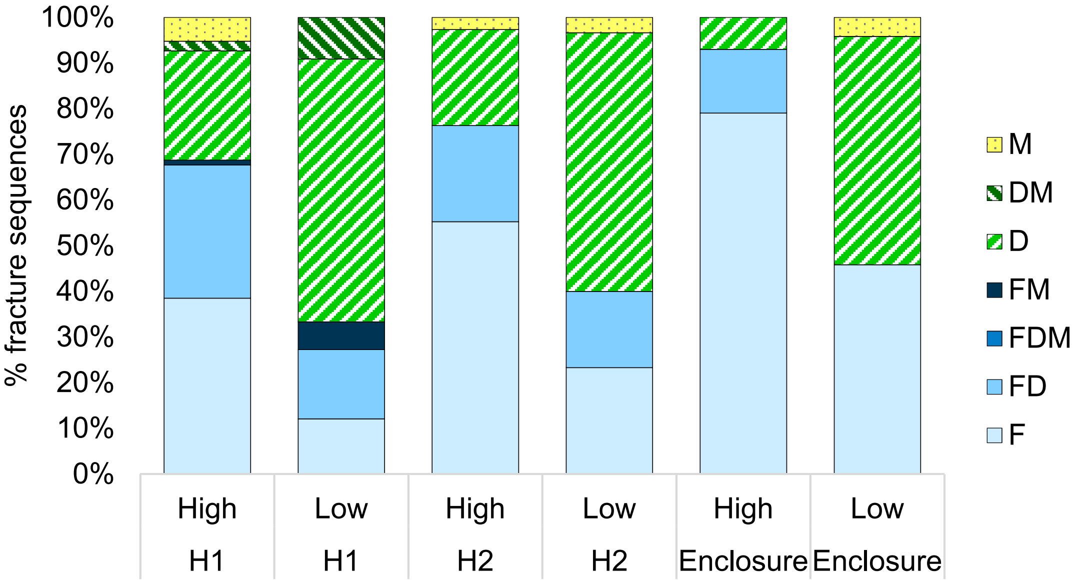

Figure 14.21: Fracture history profile for high- and low-yield marrow bones from House 1 (n=96/33), House 2 (n=38/30) and the Enclosure (n=43/24) from Rosheim *Sainte-Odile*.

14.6.2 Species

Fracture analysis by species showed that cattle were the domesticate most often affected by fresh fracture, as displayed in figure 14.22. Unusually, cattle low-yield elements were freshly fractured more commonly than high-yield elements, of which the humerus showed uncharacteristically low levels of fresh fracture (figure 14.24, see also figure 14.25). Pigs and caprines were lower in overall fracture freshness than cattle, although in pigs this could be partially due to the higher levels of heat exposure. Pig low-yield elements were represented by the mandible which was often affected by 'dry' fracture after roasting, as pictured in figure 14.13. Dog bones were not subject to fresh fracture, which suggests that dogs were not food animals in the same way as the other domesticates. In wild animals, there were high levels of fresh fracture coupled with low Fracture Freshness Index scores in aurochs, although red deer were subject to higher levels of mineralised fracture.

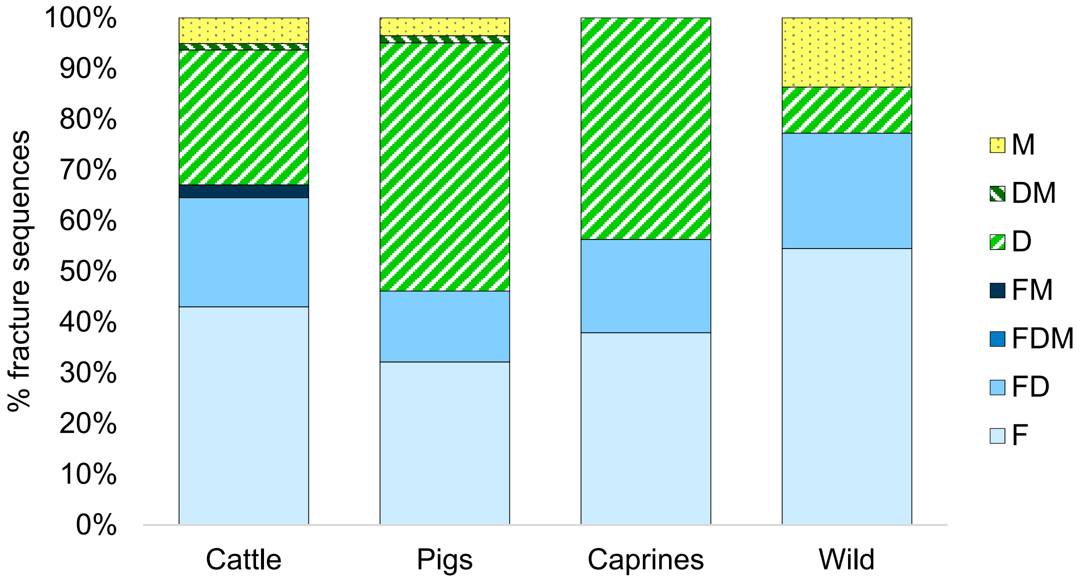

Figure 14.22: Fracture history profiles for cattle (n=79), pigs (n=143), caprines (n=87) and wild fauna (n=22) from Rosheim *Sainte-Odile*.

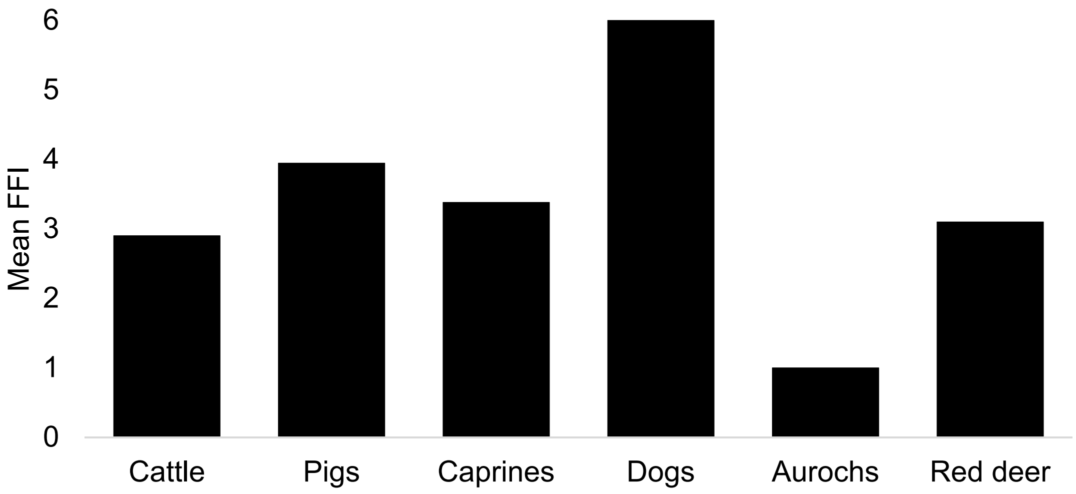

Figure 14.23: Mean Fracture Freshness Index scores for different domestic species and aurochs (n=11) and red deer (n=10) from Rosheim *Sainte-Odile*.

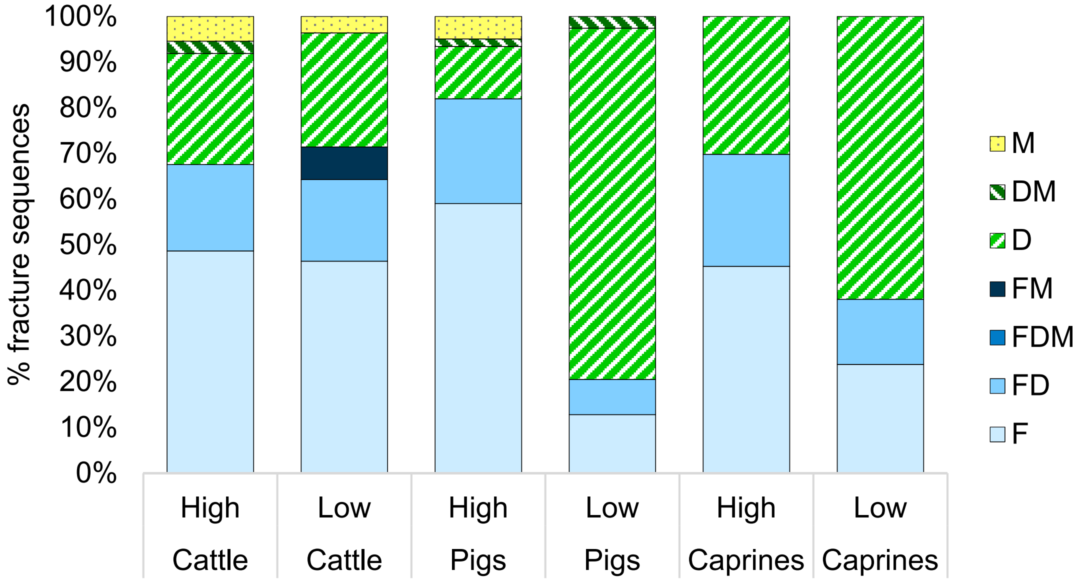

Figure 14.24: Fracture history profile for high- and low-yield marrow bones from cattle (n=37/28), pigs (n=61/39) and caprines (n=53/21) from Rosheim *Sainte-Odile*.

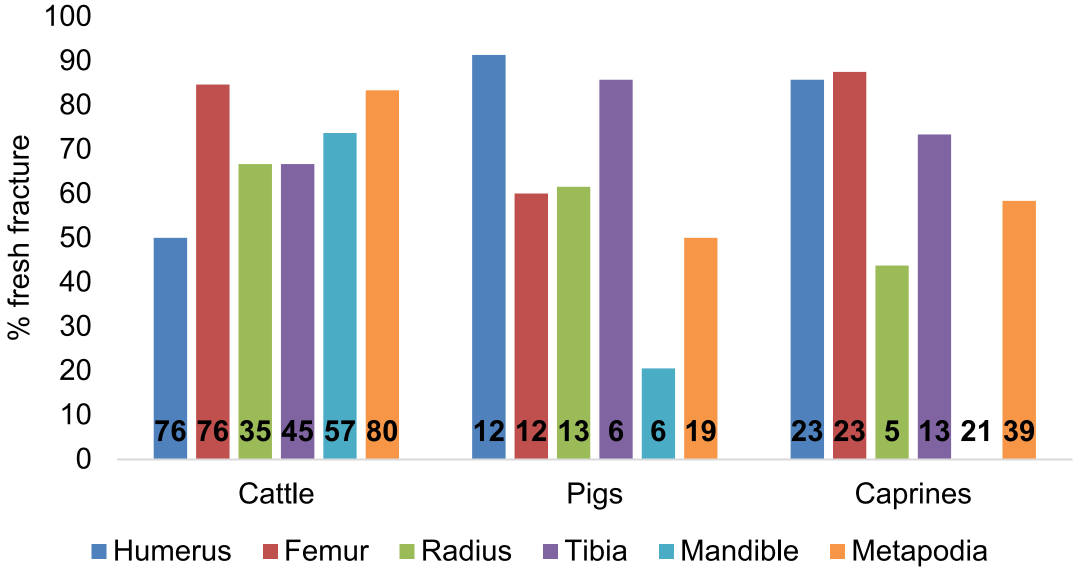

Figure 14.25: Percentage of marrow bearing elements of different species fractured freshly from Rosheim *Sainte-Odile*.

14.7 Fragmentation

14.7.1 Site

It is probable that intensive grease processing was not practised at Rosheim *Sainte-Odile*. The fragmentation analysis (figure 14.27) suggests that bone was not often highly comminuted and contained many specimens that were whole or had unfragmented epiphyses, an unexploited source of bone grease. Similarly, the proportion of fragmented cancellous material in the smaller size classes does not suggest intensive bone grease processing (figure 14.28).

7.1.1 Context groups

House contexts showed more intensive levels of fragmentation than the enclosure contexts. The smaller size classes were more heavily represented by the assemblage weight in the house contexts (figure 14.26), and the enclosure contexts had higher proportions of bones >100mm in maximum diameter, along with more unfragmented epiphyseal and whole bones. This could suggest more intensive use of bone fats in house contexts, perhaps through pot sizing rather than intensive bone grease processing. Alternatively, material in the house pits could have been subject to different deposition practices to the enclosure ditch, increasing secondary fracture and fragmentation of elements (see figure 14.19).

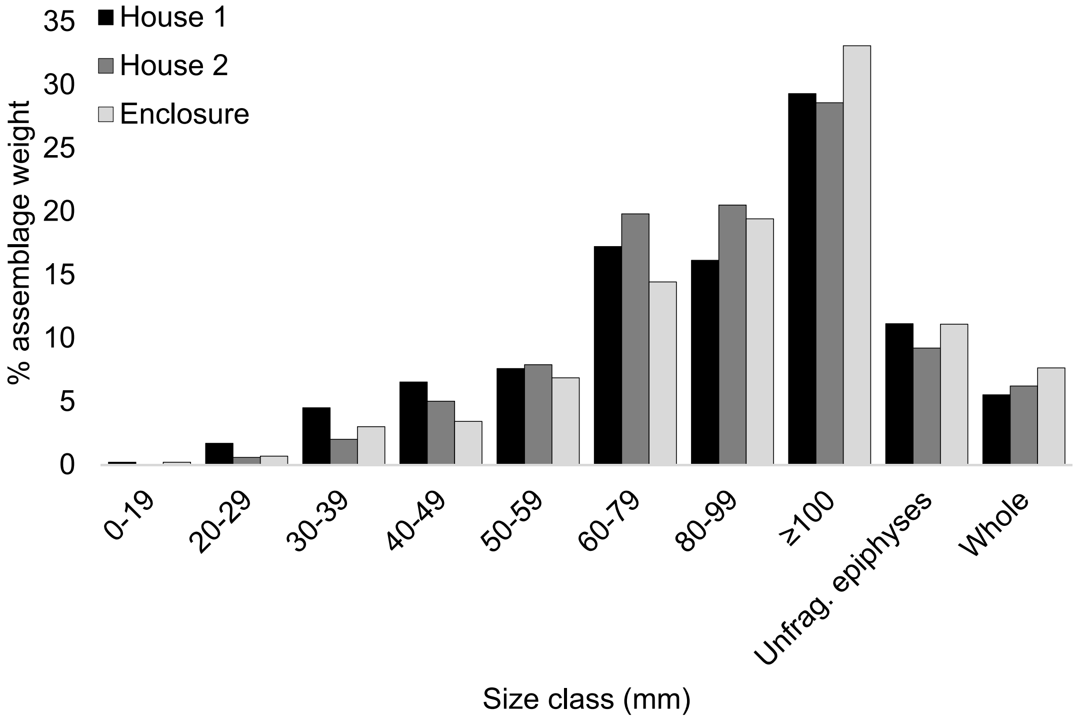

Figure 14.26: Percentage of the assemblage weight in different size or bone type classes from the context groups from Rosheim *Sainte-Odile*.

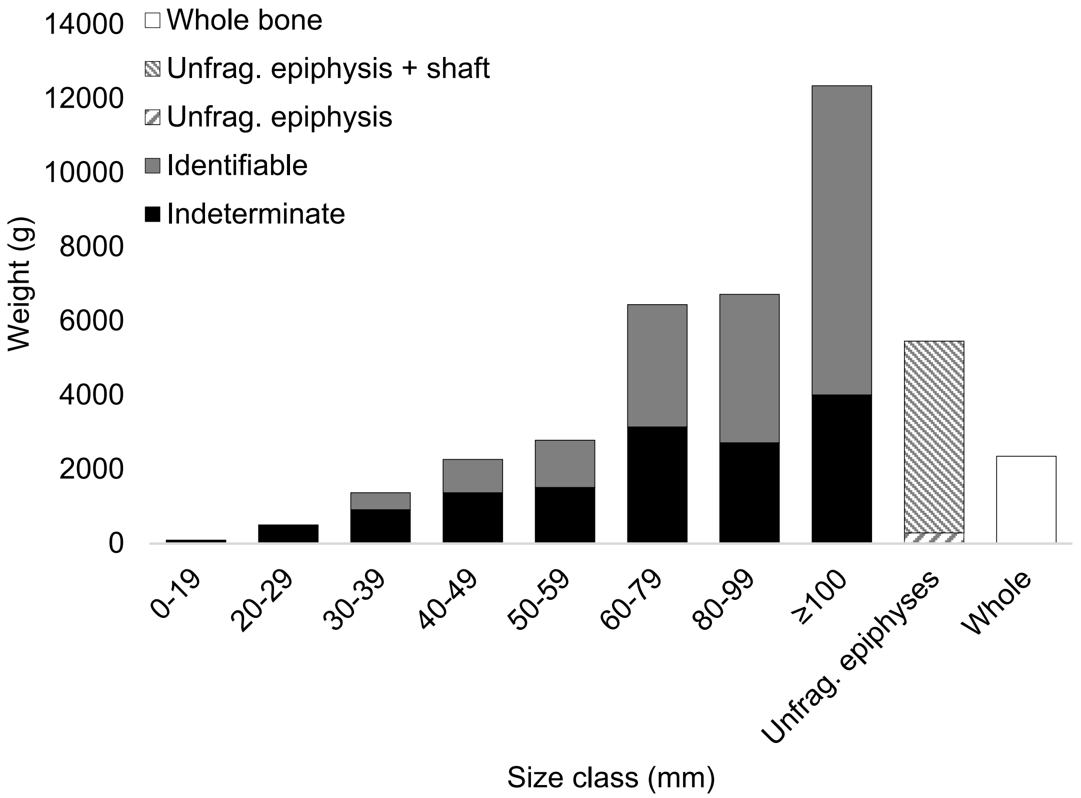

Figure 14.27: Weight by size class of all specimens from Rosheim *Sainte-Odile*.

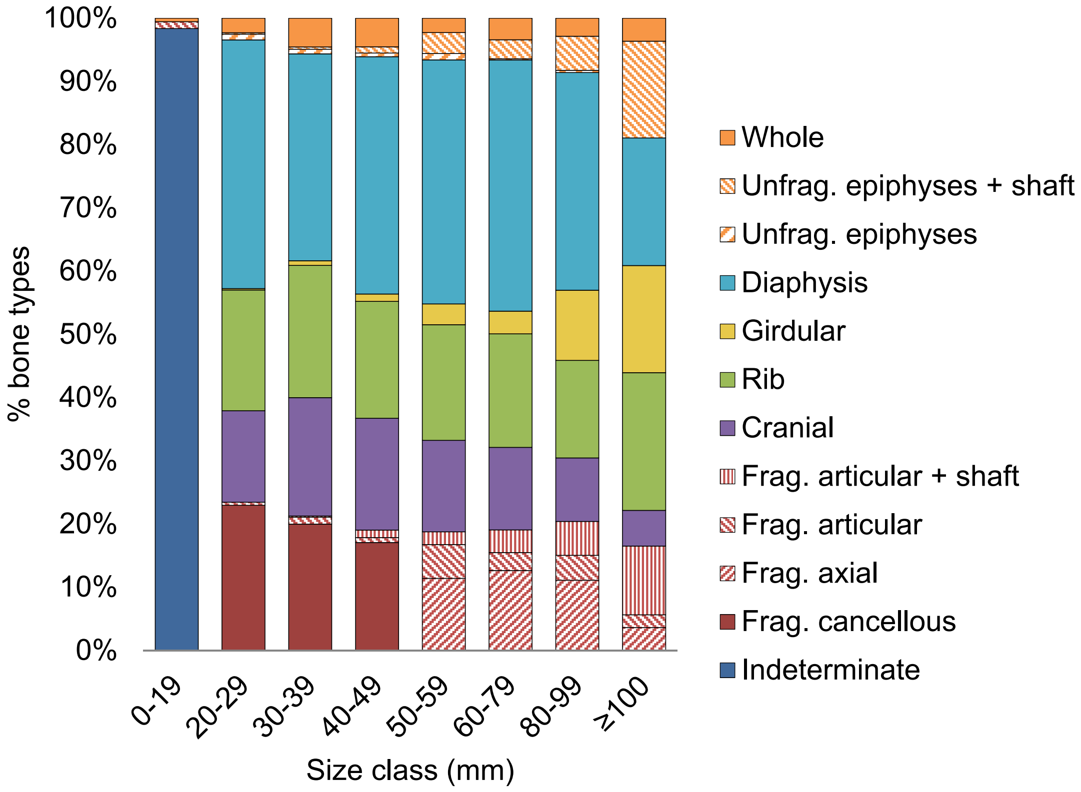

Figure 14.28: Frequency of bone types by size class from Rosheim *Sainte-Odile*. Red series indicate fragmented cancellous material.

14.8 Taphonomy

14.8.1 Gnawing

Gnawing was present on 6.2% (193/3126) of the assemblage and was canid in the vast majority, although rodent gnawing was also present at Rosheim *Sainte-Odile*. House 2 showed the highest proportion of bones affected by gnawing at 8.6% (34/394; figure 14.29). The enclosure contexts were by far the most affected by rodent gnawing and the least affected by gnawing on indeterminate bones. The higher levels of rodent gnawing in this context could suggest different deposition practices.

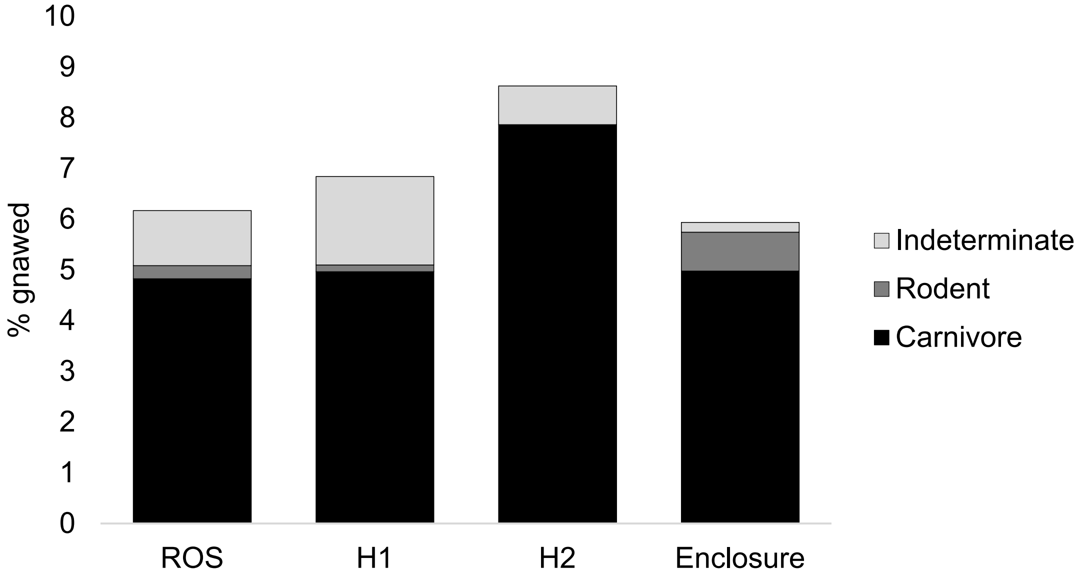

Figure 14.29: Percentage of the context groups affected by gnawing from Rosheim *Sainte-Odile*.

14.8.2 Taphonomic agents and recent breaks

Taphonomic agents including root etching, weathering and staining affected 10.8% (142/1318) of the identifiable assemblage (figure 14.30). Of these, root etching was the most common, recorded on 9.8% (129/1318) of specimens. It should be noted that only where root etching was severe was it recorded as mild root etching was very common. Evidence of weathering and brown staining was also present on bones. The brown staining could have been mistaken for roasting. These taphonomic instances, which affected the comparable contexts in similar ways, were not severe enough to have any noteworthy effect on analysis.

In general, preservation of the Rosheim *Sainte-Odile* assemblage was very good. Cemented mud affected a small proportion of the assemblage (n=2), hampering fracture and butchery analysis (and in some cases basic identification). New breaks affected 9.2% (121/1318) of the total identifiable bones on the site. The specimens from the enclosure had the least amount of recent breakages (8.0%, 21/261). Bone and fracture surface were generally well preserved.

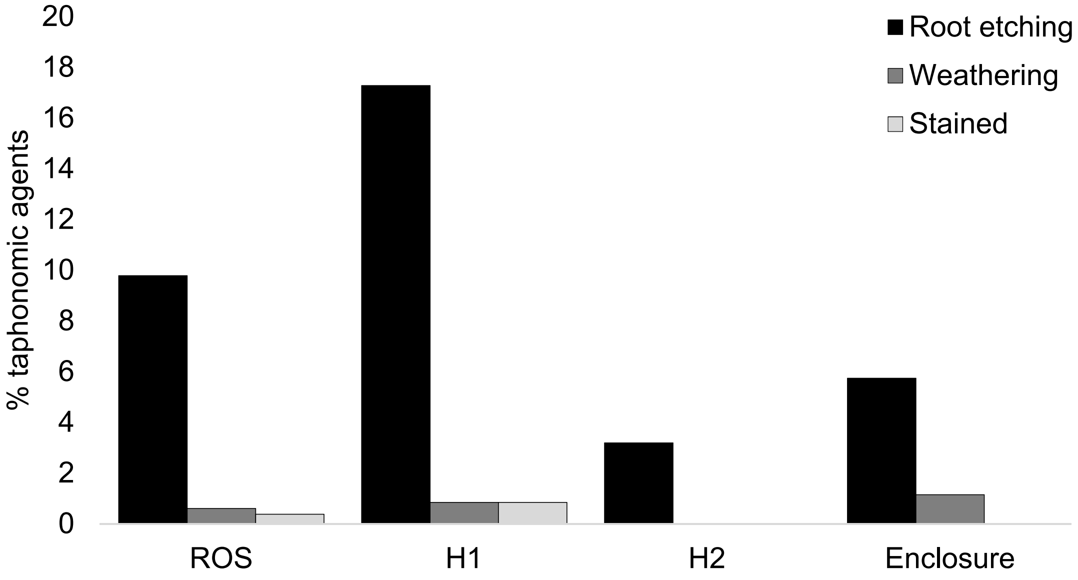

Figure 14.30: Percentage of the identifiable assemblage affected by different taphonomic agents from Rosheim *Sainte-Odile*.

14.9 Food exploitation strategies

14.9.1 Herd structure analysis

14.9.1.1 Cattle

There was no observable slaughter of cattle before one year. Some specimens were unfused in the 12-18 month age-stage, with a main slaughter event likely focussing on prime meat-age animals between 1.5 and 3 years (figure 14.31). 50.0% (12/24) of animals also survived into the fusion maturity, which could suggest that these animals were female cattle used in milking, although there is no evidence for an intensively managed dairy herd. Mortality profiles based on teeth indicate post-lactation slaughter between 6-12 months, which implies that humans shared milk yield with the calf, perhaps slaughtering the animal later for meat (Gillis unpub.a). A cull of animals between 4 and 11.5 years represents the slaughter of infertile and non-lactating cows (*ibid.*). In this way the dental ageing gives greater resolution to the fusion evidence, and suggests that cattle could have provided dairy products as well as meat.

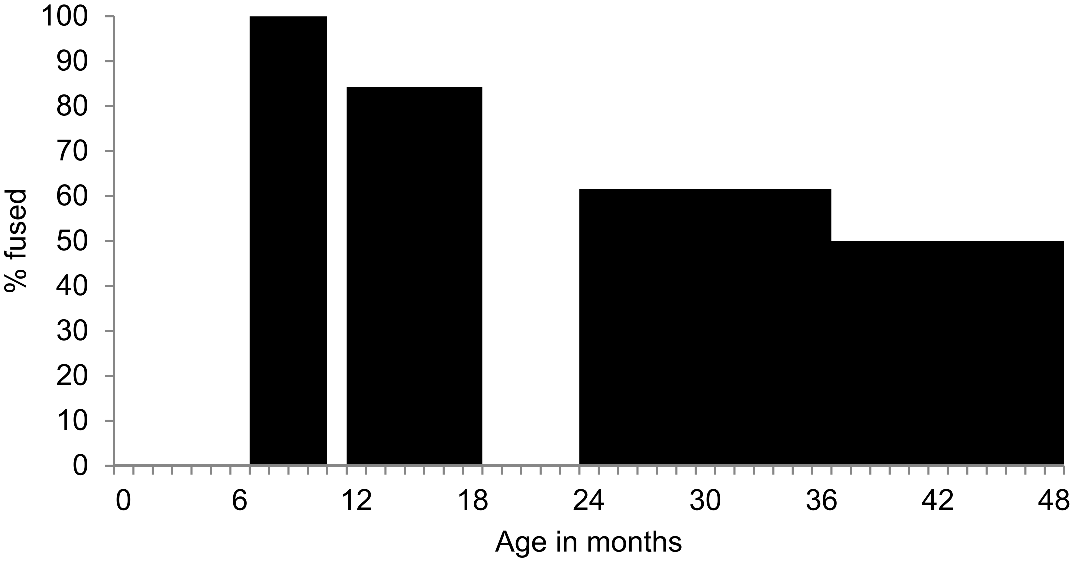

Figure 14.31: Cattle slaughter profile based on epiphyseal fusion from Rosheim *Sainte-Odile* (n=57).

14.9.1.2 Caprines

Slaughter profiles based on caprine epiphyseal fusion show minimal slaughter before 18 months, with larger slaughter events targeting animals aged 18-28 months and 30-42 months. This could suggest meat production, with some older animals that reached fusion maturity retained for breeding or perhaps dairying. Mortality profiles of teeth suggest that caprines were likely used to produce heavy lambs and kids for meat production, based on high representation of age classes covering 6 months to 2 years, but a strong presence of adults indicates a breeding herd, which could have been used to produce milk (Gillis unpub.a).

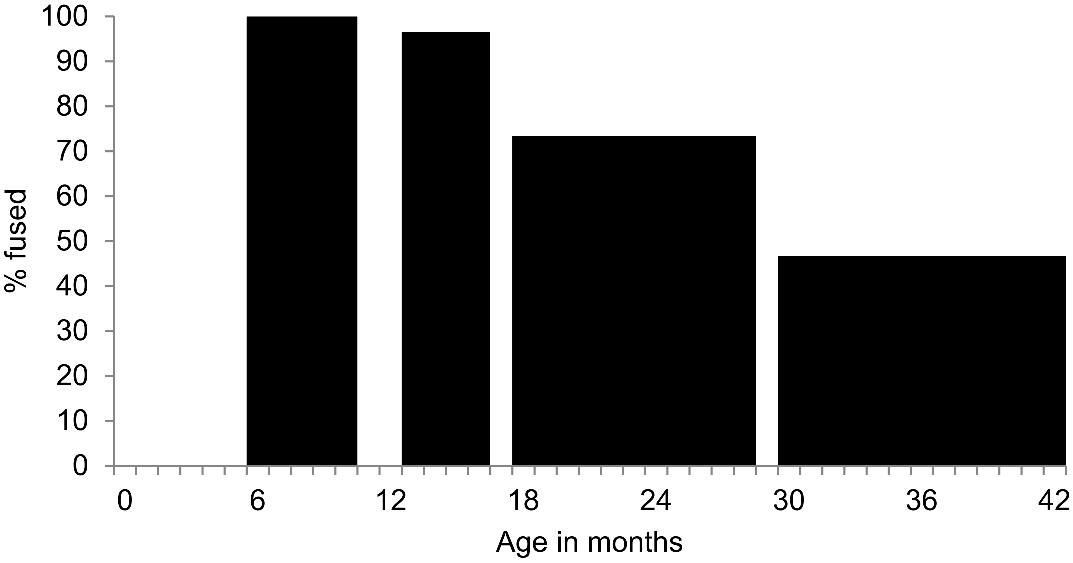

Figure 14.32: Caprine slaughter profile based on epiphyseal fusion from Rosheim *Sainte-Odile* (n=60).

14.9.1.3 Pigs

There was some very young slaughter of pigs at Rosheim *Sainte-Odile*, suggested partially by the fusion ageing (figure 14.33) and also by several instances of juvenile and neonate pig bones in the assemblage where it was not possible to assess fusion (n=11). The fusion analysis shows that slaughter of pigs was fairly continuous, affecting all age-stage classes. In the final age stage just one specimen was fused (1/23), suggesting that pigs were often slaughtered before three years. It is clear that pigs were used for meat from many different stages, with young tender meat and prime meat-weight animals exploited.

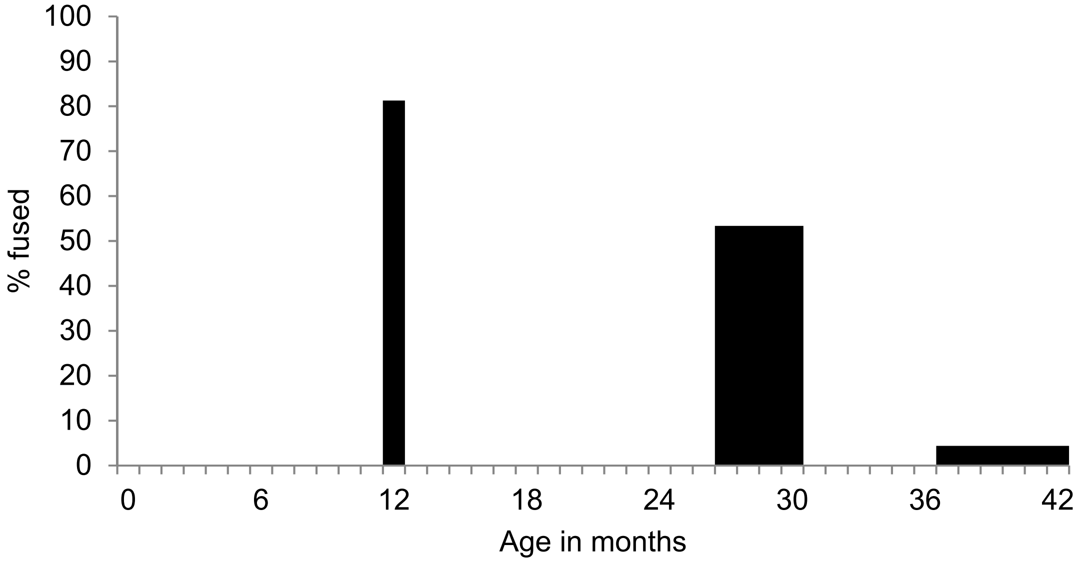

Figure 14.33: Pig slaughter profile based on epiphyseal fusion from Rosheim *Sainte-Odile* (n=54).

14.9.2 Lipid residue analysis

A total of 63 sherds have been analysed from the Rosheim *Sainte-Odile* ceramic assemblage, solely from the house contexts. Non-perforated pottery yielded animal fats in 25.4% (n=63) of sherds, none of which contained milk residues. This suggests that animal carcass products were sometimes processed in ceramic vessels but shows no direct evidence of milk consumption.

14.10 Discussion

14.10.1 Meat and fat exploitation

Patterns of meat and fat exploitation were quite intensive at *Rosheim Sainte-Odile*. It is likely that domestic animals of prime meat-age were consumed, with cattle and caprines also potentially supplying dairy products. Despite the lack of an in-depth butchery study on the site, the proportion of specimens with observable butchery was high, with repeated traditions of disarticulation and possibly meat stripping. Exploitation of animal bone fats at Rosheim *Sainte-Odile* was fairly intensive, with fragmentation and fracture patterns of bovinae, suidae and caprines suggesting high levels of marrow extraction (figure 14.34). Very few marrow-bearing bones were whole, and some were potentially roasted before fracture in patterns that have been seen elsewhere in the LBK. However, there was no evidence for bone grease processing.

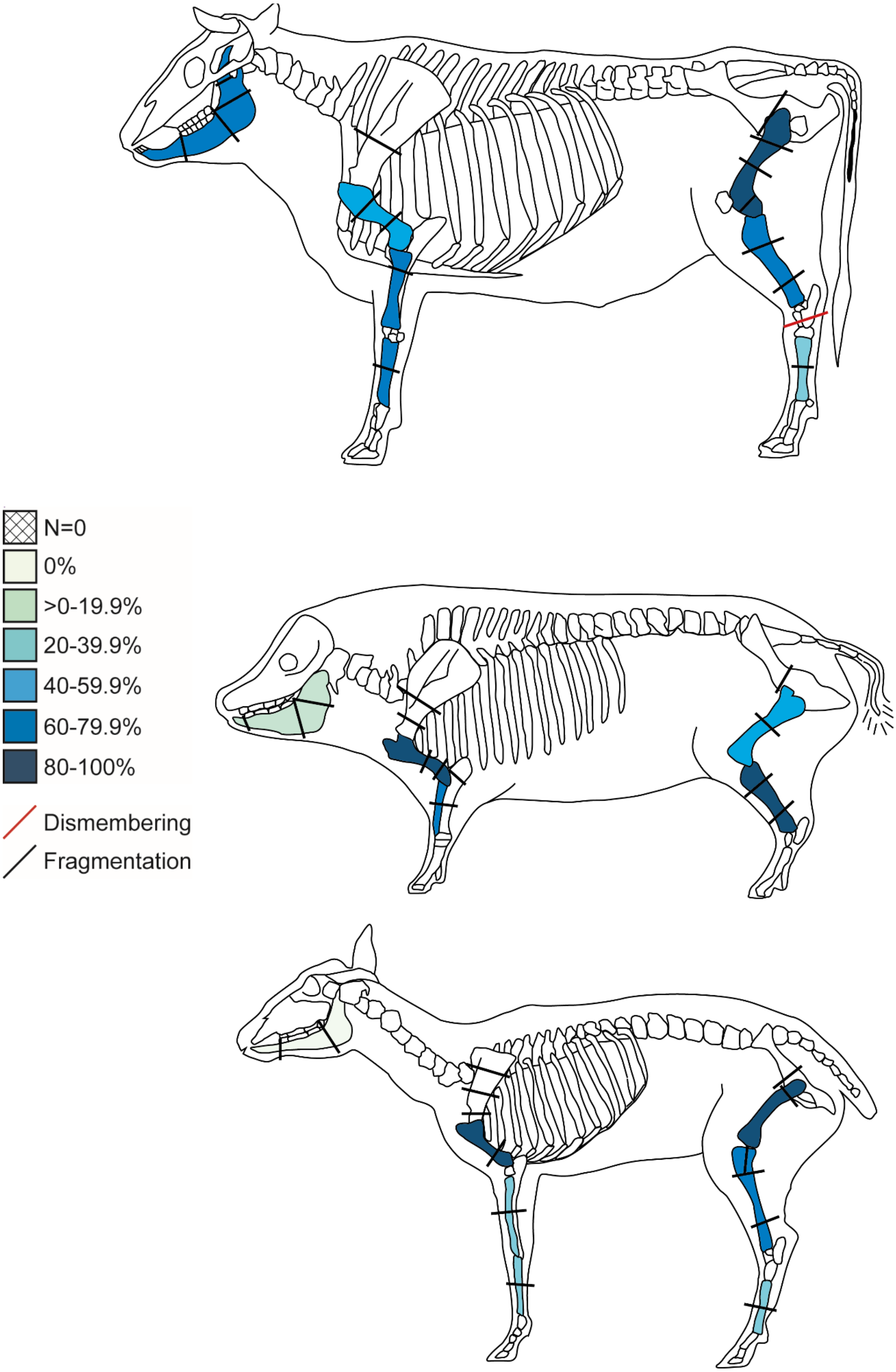

Figure 14.34: Carcass profiles showing trends in butchery, fracture freshness and fragmentation for bovinae (top), suidae (centre) and caprines (bottom) from Rosheim *Sainte-Odile*. Values in table 14.4.

Table 14.4: Percentage of bovine, suid and caprine marrow bearing-elements fractured when fresh from Rosheim *Sainte-Odile*.

	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	54	13	75	11	89	24	78	14	75	22	71	7	20	6
Suidae	91	23	64	14	43	7	86	21	20	41	-	-	-	-
Caprines	87	15	44	16	88	8	73	15	0	7	33	6	33	3

While marrow processing was suggested in all contexts it was particularly high in the enclosure ditch. Deposition practices may have contributed to higher levels of dry fracture and fragmentation in the house contexts, suggesting that pits may have been used over a number of years, a common assumption for LBK sites. This also suggests that the ditch was not left open or later reused. Jeunesse (2011: 31) has postulated that the ditch at Rosheim was completed over many generations, thus deposits must have happened quickly even if completion did not.

Chapter 15 Polgár-Csőszhalom

15.1 Introduction

For the final case study, we return to the Polgár island in North-eastern Hungary to the late Neolithic settlement of Polgár-Csőszhalom. Located on the bank of a former oxbow of the Tisza river in the Carpathian Basin, excavations on the site have revealed a tell surrounded by a multiple palisaded enclosure and a horizontal (single layer) external settlement (Raczky *et al.* 2010: 42; Raczky and Anders 2010: 143; figure 15.1). The two structural elements are suggested to be contemporary through radiocarbon dating, which places the horizontal settlement between 4940-4610BC and the tell between 4840-4530BC. At this date, it is directly preceded by the Alföld Linear Pottery Culture (ALPC) in the Carpathian Basin, including sites such as Polgár-Ferenci-hát and Polgár-Piócás-dűlő, and is thought to be a merging of Tisza-Herpaly and Lengyel culture settlements (*ibid*. 55).

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Figure 15.1: Site plan of Polgar-Csőszhalom with the enclosed tell to the left and the external settlement to the right (Raczky *et al.* 2010: 44).

Raczky *et al.* (2010: 56) have argued that there was a separation of the sacral and profane between the tell and the external settlement (*ibid*. 51-56), with differences in architecture, economy and social practice. Buildings within the tell settlement were burnt down and replaced in regular intervals, whereas none of the 79 wattle-and-daub houses in the external settlement displayed any trace of burning or superimposition (*ibid*. 50). These external settlement buildings were uniformly oriented from northeast to southwest, whereas buildings in the tell were radially orientated (*ibid.*). All houses in the external settlement were associated with elongated refuse pits, which may have been created during construction for clay extraction and were subsequently used for conscious and random rubbish disposal (*ibid.* 151). Faunal analysis has shown a clear dominance of wild animals in the tell, whilst the majority of bones in the horizontal settlement originate from domesticates (Raczky and Anders 2010: 147). In the tell, numerous open-air fireplaces and surrounding rich concentrations of animal bones suggest major communal events and ceremonial feasting (*ibid.* 147-150; Raczky *et al.* 2010: 56). These features were rarely found in the external settlement. Wells, on the other hand, were only recovered from the external settlement (*ibid.* 150). Analysis of ceramic remains from both settlement areas suggests that material in the tell was more heavily fragmented than in the external settlement (*ibid.* 151), although this may be a result of heavy, prolonged activity in the same place, including rebuilding and recutting of houses, compared to the external settlement.

15.2 Assemblage

15.2.1 Sample

It was possible to study a small sample of the Polgár-Csőszhalom faunal assemblage during analysis of the ALPC sites Polgár-Piócás-dűlő and Polgár-Ferenci-hát. Contexts 916 and 932, pits deriving from the same area of the external horizontal settlement (figure 15.2), were chosen for analysis based on previous zooarchaeological study and intended lipid residue analysis. The total number of bones analysed was 5525 (table 15.1). Any difference in values for fully identifiable specimens and species representation is due to the exclusion of *Bos sp.* and *Sus sp.* and inclusion of wild birds (*Aves*; see section 3.4.1). Context 932 had a much larger number of specimens (table 15.2). The two contexts will be compared during analysis.

Table 15.1: Number of fully identifiable, partially identifiable and indeterminate specimens from Polgár-Csőszhalom (PCS).

Fully identifiable (to species and element)	760
Partially identifiable (to type of species and element)	1443
Indeterminate	3322
Total	**5525**

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Figure 15.2: Plan of contexts 916 and 932 from Polgár-Csőszhalom. Raczky *et al.* 2015: 24, figure 3.

Table 15.2: Full list of contexts analysed from Polgár-Csőszhalom.

Object	Structure	Fully identifiable	Partially identifiable	Indeterminate
916	1994	130	243	564
932	2045	630	1200	2758

15.2.2 Methodological choices

Many specimens at Polgár-Csőszhalom were far larger than 10cm. It was decided that simply having one size class (H, >100mm) to account for so many specimens was not detailed enough, thus size class H was confined to 100-149mm and two new larger size classes were created. Size class I continued from 150-199mm, after which size class J, ≥200mm, accounted for the largest bones. The size classes H, I and J can be combined for comparison to other sites, as all specimens in these size classes would usually be recorded as class H.

15.3 Species representation

It is immediately clear that the sampled contexts from Polgar-Csőszhalom had a very different species diversity compared to Linearbandkeramik culture sites. Despite the general trend that domesticates were more common in the external settlement than wild animals (Raczky and Anders 2010: 147), in these contexts wild fauna comprised 64.2% (477/743) of the Number of Identifiable Specimens (NISP). This could indicate that these contexts are atypical. Red deer (27.9%, 207/743) and wild boar (20.5%, 152/743) were the most common species (figure 15.3), and aurochs (10.6%, 79/743), roe deer (5.0%, 37/743), hare (0.3%, 2/743) and possibly fox (*Vulpes* sp. 0.3%, 2/743) were also present. Of the domestic animals, cattle were the most common, making up 18.6% (138/743) of the NISP. The small stock were underrepresented compared to the cattle and wild animals, with pigs at 9.0% (67/743) caprines at 4.4% (33/743) of the NISP. Domestic dogs were also present in the contexts sampled (3.5%, 26/743).

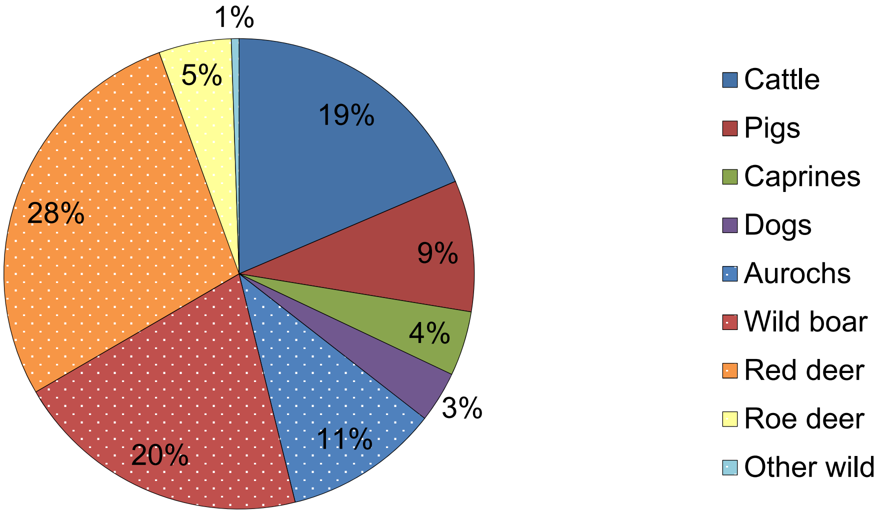

Figure 15.3: Species representation (NISP) for the fully identifiable assemblage from Polgár-Csőszhalom (n=743).

The two contexts showed a largely similar distribution of species, particularly in the ratios of domestic and wild specimens (figure 15.4). However, the proportion of caprines was significantly higher in 932 (32/617) compared to 916 (1/126, p=.029), whereas cattle were more prevalent in 916. The percentage of domestic dogs was similar in the NISP, but the specimens in context 932 represented seven individuals compared to one in 916 (MNI; table 15.3).

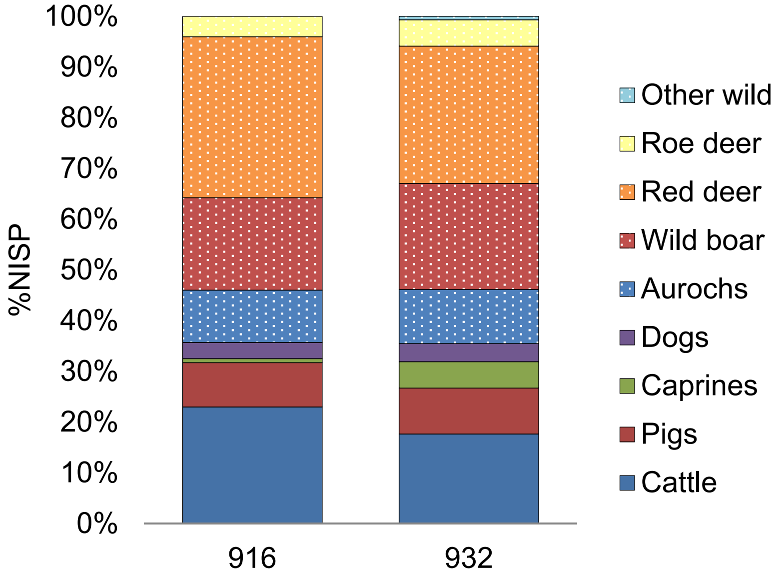

Figure 15.4: Species representation (NISP) for contexts 916 (n=126) and 932 (n=617) from Polgár-Csőszhalom.

Table 15.3: Species representation by minimum number of individuals (MNI) for the two sampled contexts from Polgár-Csőszhalom.

	Cattle	Pigs	Caprines	Dogs	Aurochs	Wild boar	Red deer	Roe deer
916	4	2	1	1	2	2	3	2
932	9	6	3	7	4	10	8	3

15.3.1 Skeletal part representation

Certain elements were far better represented than others from these two contexts (figure 15.5), although the analysis of sides shows little difference in the proportion of left (50.7%, 299/590) and right (49.3%, 291/590) elements. Overrepresentation of the mandible was likely due to heavy fragmentation of this element in food animals and ritual deposition of canid mandibles (figure 15.6), contributing to skewed proportions for dogs in the NISP and MNI. Bones of the forelimb and the distal hindlimb, including tarsals, were also well represented. Vertebral fragments were particularly low, possibly due to comminution for bone grease processing, but as the proportion of indeterminate cancellous material is low (figure 15.28) it is possible that primary butchery took place away from these two contexts, resulting in deposition of the spinal column elsewhere. The lack of extremities, particularly phalanges, could similarly suggest that they were removed from the carcass during skinning. Deposition here could have been from individual meals from the nearby houses, or perhaps, due to the lack of dry and secondary fracture in the assemblage, this was the result of a bone marrow processing episode particularly focusing on wild animals.

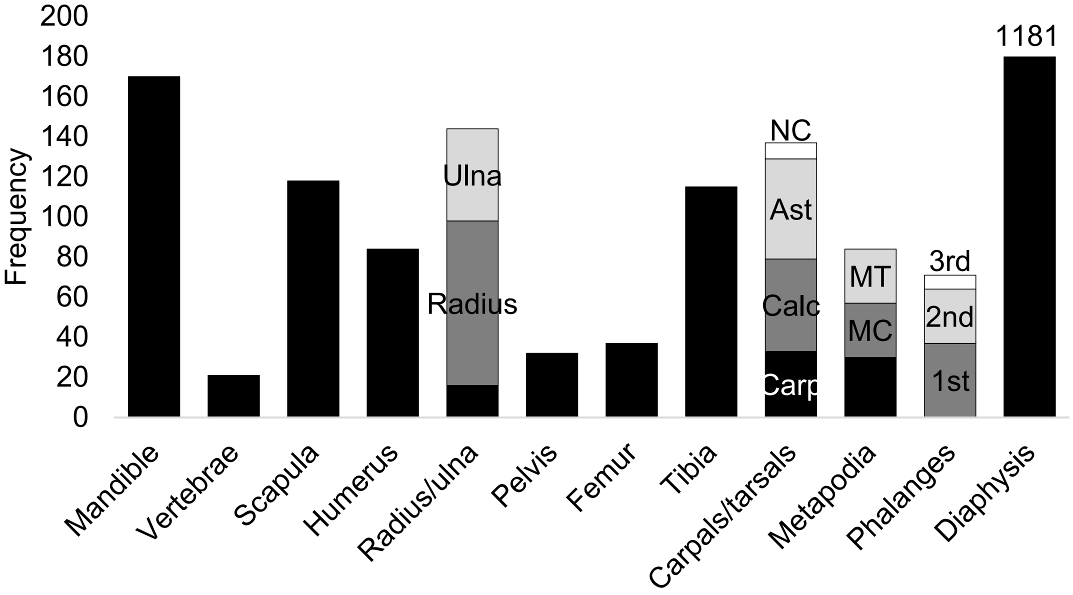

Figure 15.5: Frequency of skeletal parts from Polgár-Csőszhalom. Diaphysis fragments far exceed all other elements and thus the graph is truncated.

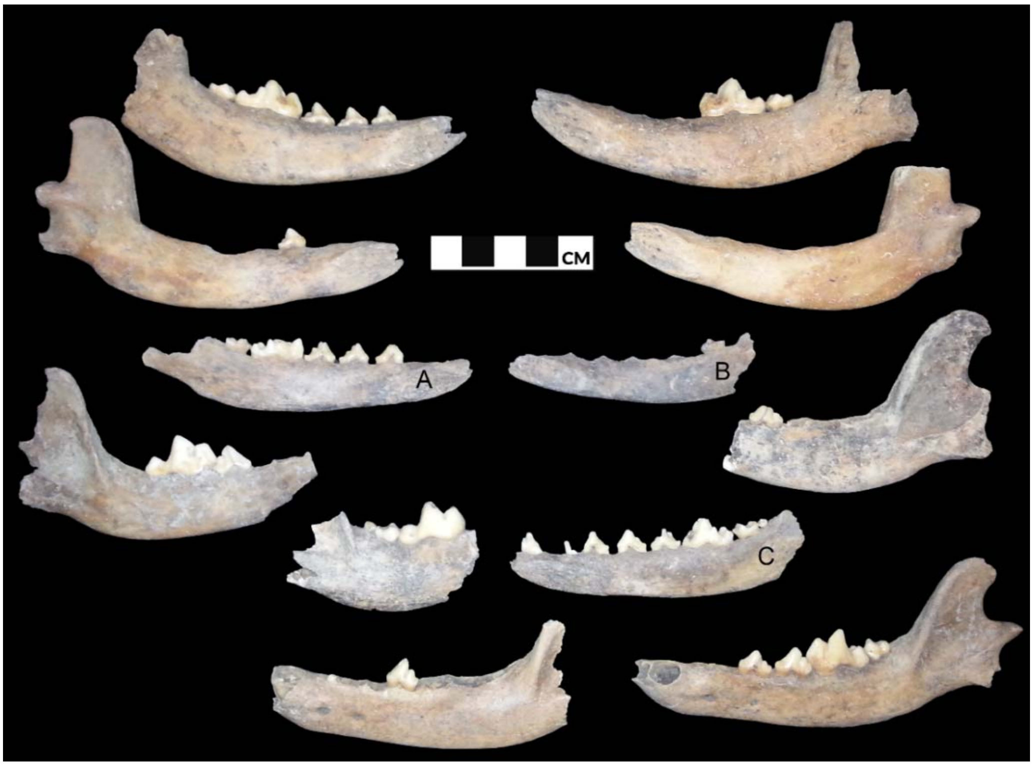

Figure 15.6: Canid mandibles from context 932 from Polgár-Csőszhalom. Originally identified as domestic dog, A, B and C are now suspected to be fox.

15.4 Butchery

Butchery was observed on 2.8% (157/5525) of the sampled Polgár-Csőszhalom assemblage, and on 5.5% (122/2203) of the identifiable assemblage. Cut marks were the most frequent butchery mark type (figure 15.7). There was little difference in butchery between the two contexts, although context 932 showed more variation in types of butchery than 916, likely due to a larger sample rather than differences in butchery tradition (figure 15.8).

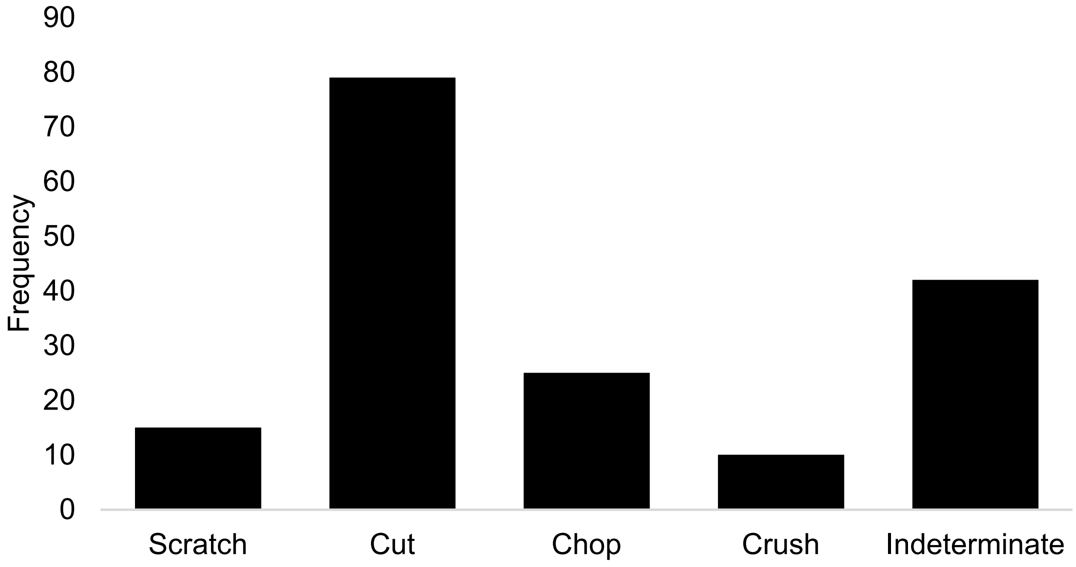

Figure 15.7: Frequency of butchery mark types from Polgár-Csőszhalom.

Figure 15.8: Percentage of contexts 916 and 932 with different butchery episodes from Polgár-Csőszhalom.

15.4.1 Species

Wild animals exhibited more evidence of butchery marks than domestic animals. Cattle and pigs showed less butchery than their wild counterparts, although the differences were not statistically significant (figure 15.9). This is could be a result of intensive but not particularly careful kill-site butchery of the larger wild animals. This would also explain why roe deer had very little butchery, as they are small enough to carry whole. Domestic dogs showed no evidence of butchery, although skeletal part abundance suggests some form of carcass processing.

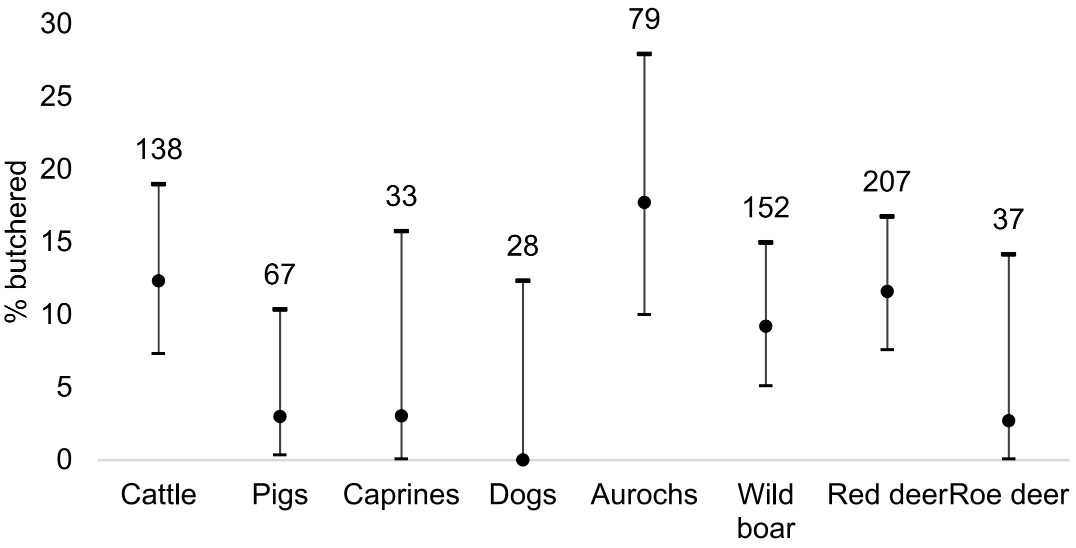

Figure 15.9: Percentage of species with evidence of butchery from Polgár-Csőszhalom, with 95% confidence intervals. N values are at the top of each series.

15.4.2 Carcass butchery

Butchery proportions varied across the carcass (figure 15.10). Meat-rich carcass parts including the forelimb and hindlimb were particularly affected by butchery, as were extremities, likely as a result of skinning and dismemberment. The mandible showed very little butchery (3.5%, 6/170), although this could be due to intensive fragmentation of this element.

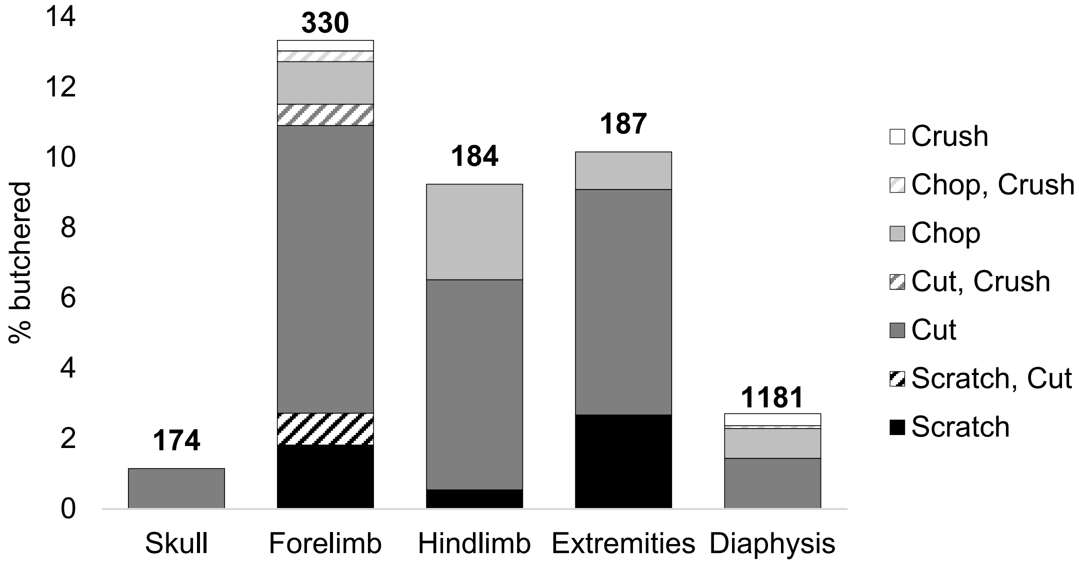

Figure 15.10: Percentage of carcass portions with different butchery episodes from Polgár-Csőszhalom.

15.4.2.1 Forelimb butchery

Multiple cut and scratch marks affecting the neck and medial and lateral blade of the scapula primarily indicate defleshing (figure 15.11; Soulier and Costamagno 2017). It is possible that butchery close to the glenoid cavity also indicates dismemberment from the humerus (Binford 1981: 122). On the humerus, butchery clustered around the distal epiphysis and shaft (figures 15.12 and 15.13). Butchery marks on the diaphysis were likely a result of defleshing (Soulier and Costamagno 2017) or possibly removal of the periosteum for marrow extraction. Dismemberment from the radius and ulna is especially suggested by characteristic horizontal cut marks on the posterior epiphysis, but also by butchery on the anterior and medial aspects (Soulier and Costamagno 2017, Binford 1981: 123; figure 15.13). Disarticulation in this location was reflected on the proximal radius and ulna (figures 15.14 and 15.15), as was defleshing and possibly stripping of the periosteum on the diaphysis (*ibid.*).

🟦 Scratch 🟩 Cut 🟥 Chop

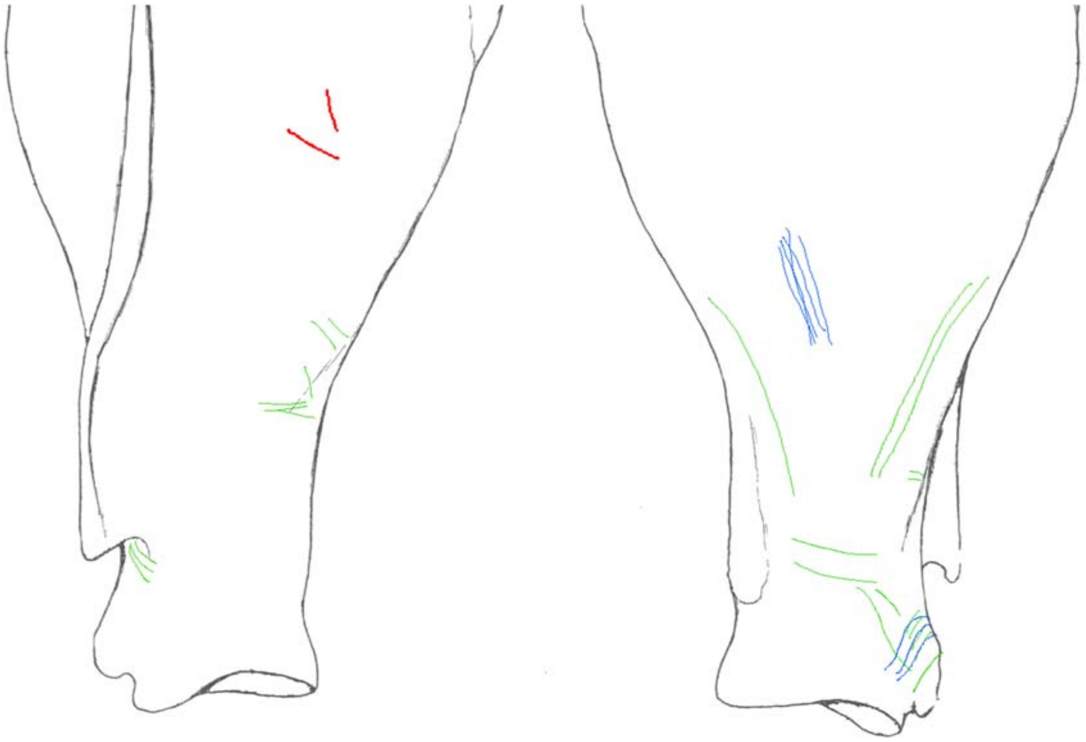

Figure 15.11: Cumulative diagram of butchery on bovine (n= 1), suid (n=2) and red deer (n=4) scapulae from Polgár-Csőszhalom. Lateral (left) and medial views.

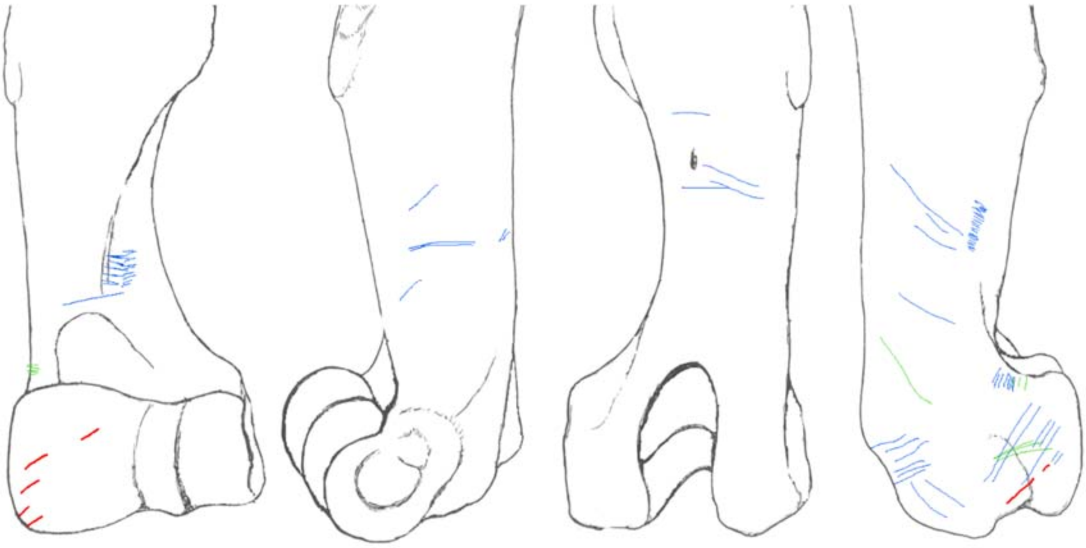

Figure 15.12: Cumulative diagram of butchery on bovine (n= 5) and red deer (n=10) humeri from Polgár-Csőszhalom. Left to right; anterior, lateral, posterior and medial views.

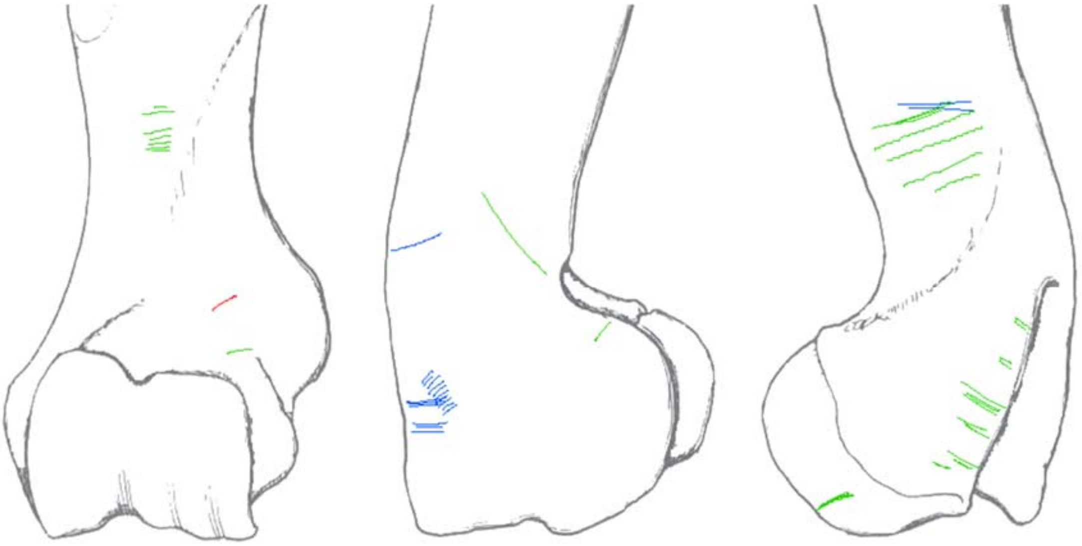

Figure 15.13: Cumulative diagram of butchery on suid (n=10) humeri from Polgár-Csőszhalom. Left to right; anterior, medial and lateral views.

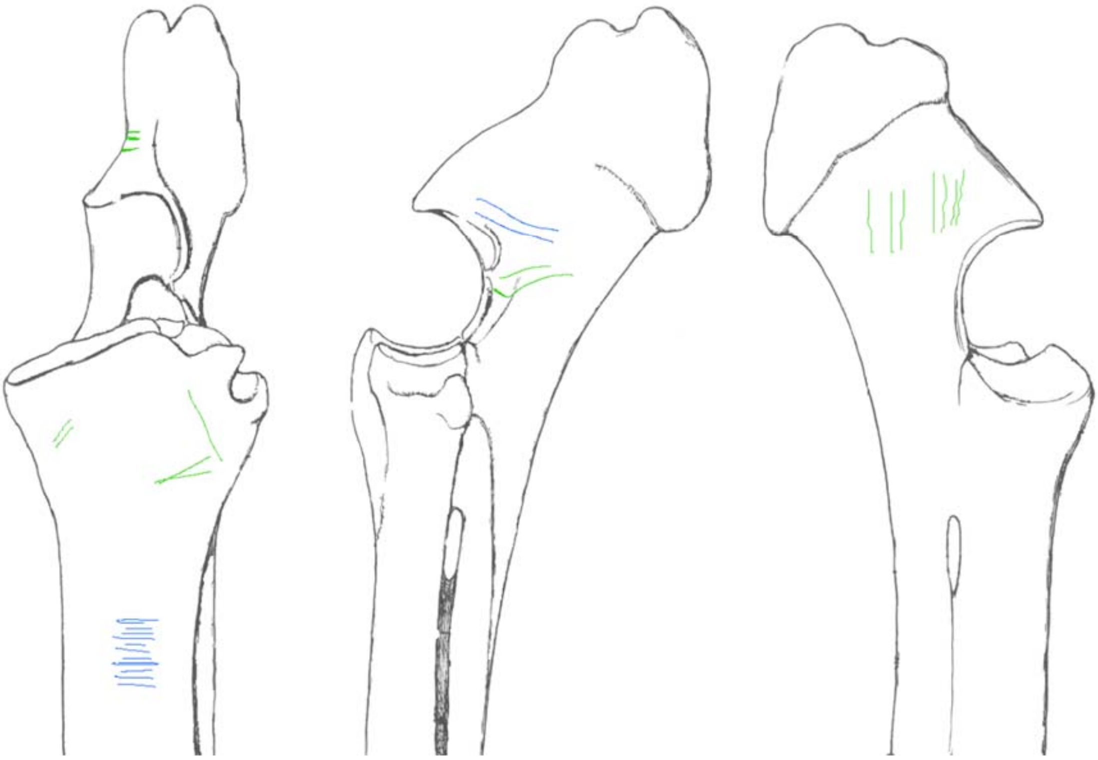

Figure 15.14: Cumulative diagram of butchery on bovine (n= 7) and red deer (n=2) radii and ulnae from Polgár-Csőszhalom. Left to right; anterior, lateral and medial views.

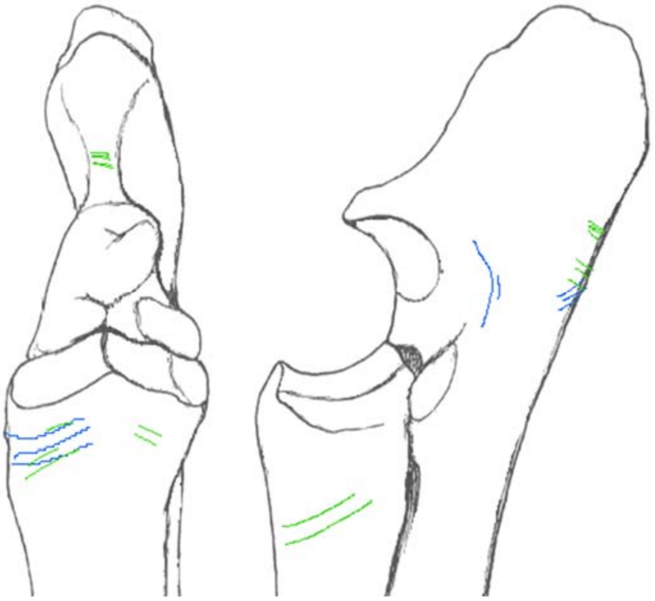

Figure 15.15: Cumulative diagram of butchery on suid (n=5) radii and ulnae from Polgár-Csőszhalom. Anterior (left) and lateral views.

15.4.2.2 Hindlimb butchery

Butchery on the hindlimb was more uncommonly recorded on butchery diagrams due to underrepresentation of the pelvis and femur compared to forelimb elements (figure 15.5). On the tibia there was evidence of defleshing, and heavy butchery in the form of chop marks, largely on suid tibia (figure 15.16).

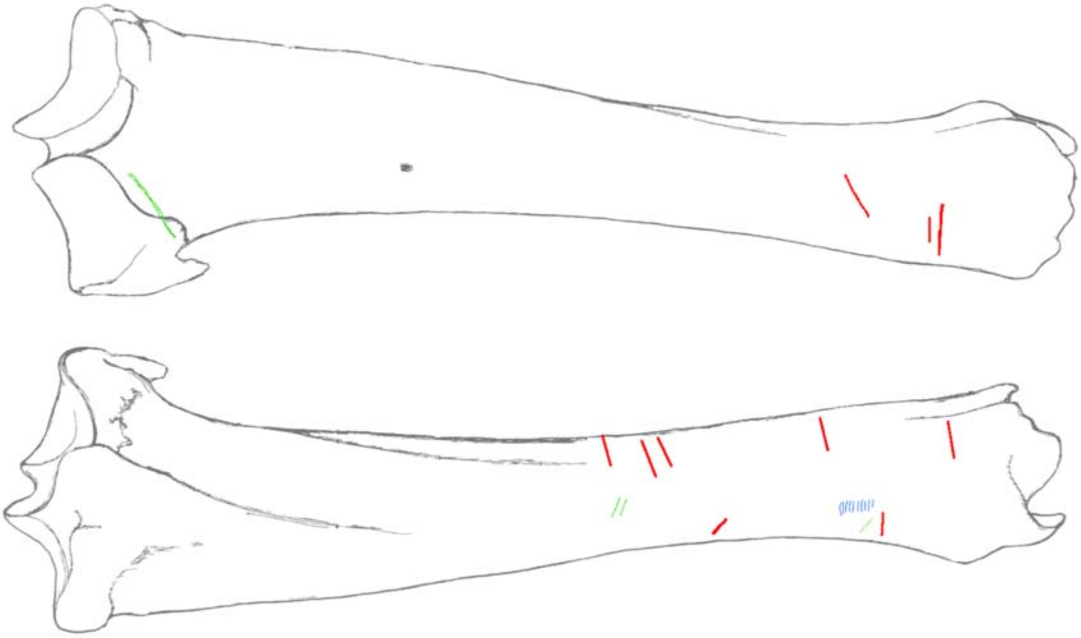

Figure 15.16: Cumulative diagram of butchery on bovine (n= 3), suid (n=3) and red deer (n=3) tibia from Polgár-Csőszhalom. Posterior (top) and anterior views.

15.4.2.3 Extremities butchery

On the tarsals and metapodia, butchery patterns suggest skinning, defleshing and disarticulation. Butchery on the calcaneum clustered above the *sustentaculum tali* and could be representative of skinning, defleshing or dismembering (figure 15.17; Soulier and Costamagno 2017). Butchery on the anterior surface of the astragalus likely represents disarticulation of the ankle joint (figure 15.17; *ibid.*). On the metapodia, butchery clustered around the distal diaphysis reflecting skinning and possibly tendon removal on the anterior and posterior aspects of the distal shaft (Soulier and Costamagno 2017).

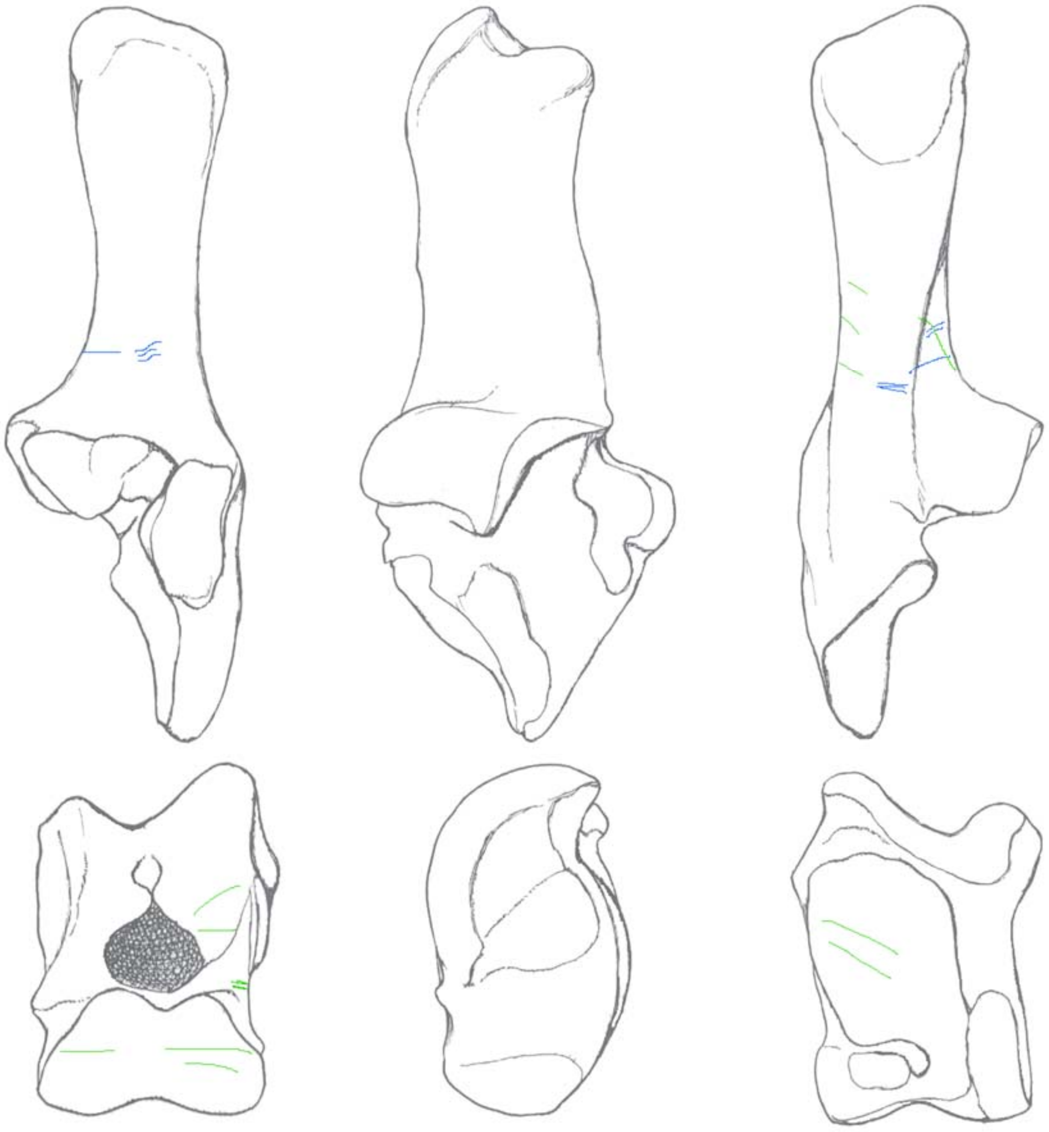

Figure 15.17: Cumulative diagram of butchery on bovine (n= 6) and suid (n=3) calcanei (top) and astragali (bottom) from Polgár-Csőszhalom. Left to right; anterior, lateral and posterior views.

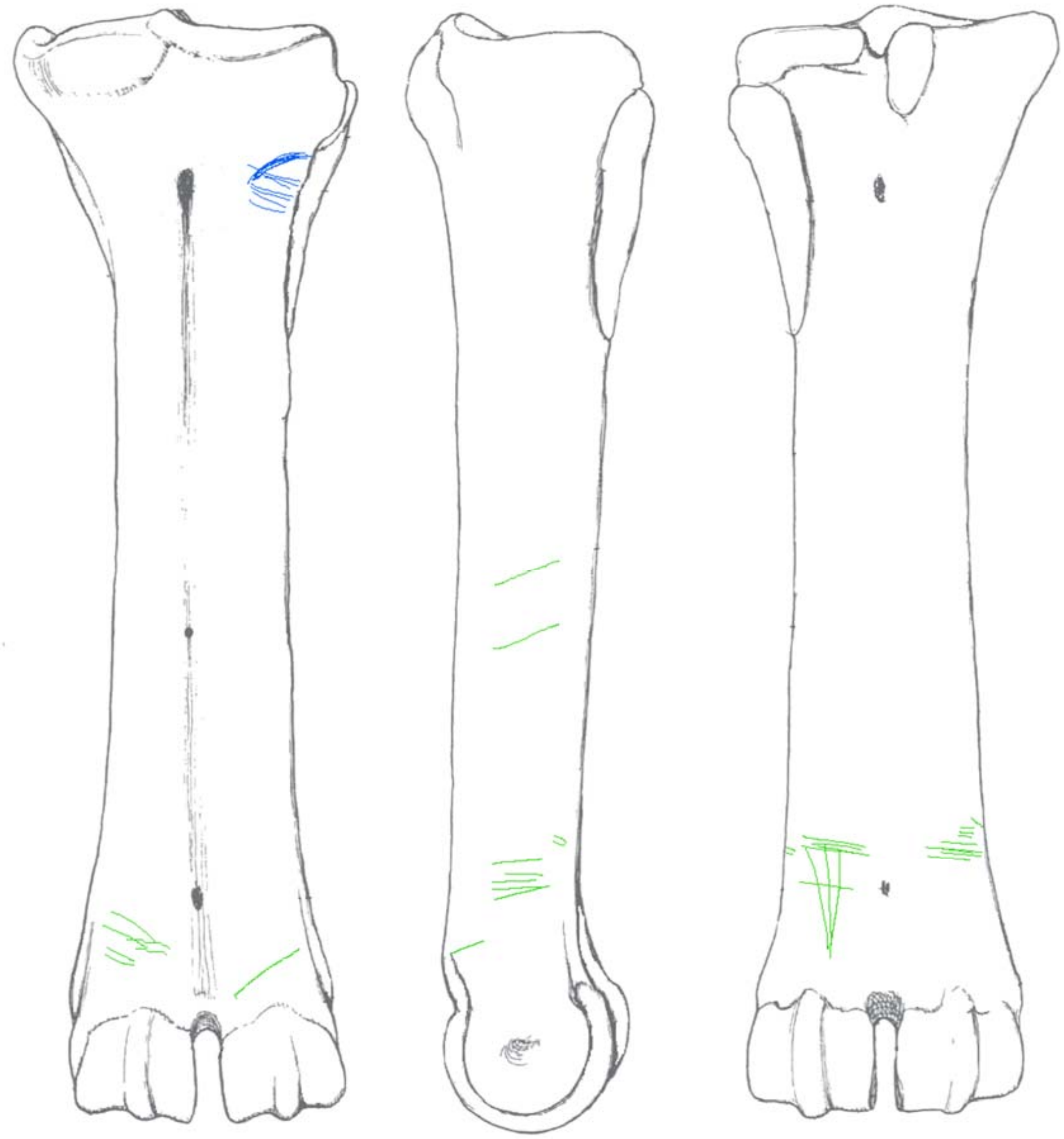

Figure 15.18: Cumulative diagram of butchery on bovine (n= 5) and cervid (n=2) metapodia from Polgár-Csőszhalom. Left to right; anterior, medial and posterior views.

15.5 Heat exposure

Evidence for burning was incredibly low in the sampled assemblage from Polgár-Csőszhalom, affecting 0.4% (21/5525) of identifiable and indeterminate bones. Both light burning (scorched, roasted) and higher-temperature burning (carbonised and calcined bones) were noted, but percentages in both contexts were low (figure 15.19). It is likely that roasting was an uncommon cooking method, at least for the waste disposed in these two contexts. In the tell settlement it was common practice to burn and replace old houses, but this was not the case in the horizontal settlement, reflected in the minimal evidence for heat exposure (Raczky *et al.* 2010: 50).

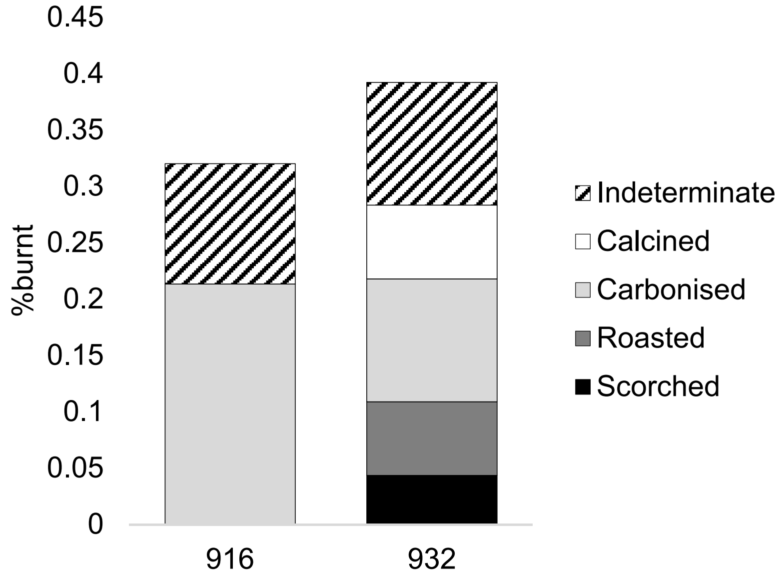

Figure 15.19: Percentage of the sampled assemblage affected by different types of heat exposure from Polgár-Csőszhalom.

15.6 Fracture

15.6.1 Sample

The sampled assemblage from Polgár-Csőszhalom presents the highest levels of fresh fracture on marrow bearing bones of all sites studied. 79.8% (1183/1483) of fractured specimens were fractured first when fresh, rising to 86.5% (230/266) when looking solely at fractured high-marrow bones across the two contexts (figures 15.20 and 15.21). The mean Fracture Freshness Index was low at 1.4, with scores of 0 making up 61.9% (918/1484) of FFI scores (figure 15.22). Secondary fractures were rare, affecting just 2.3% (34/1483) of fractured specimens. The levels of mineralised fractures were also very low.

In context 916, a significantly higher proportion of fresh fracture (85.7%, 222/259; p=.008) and a lower mean FFI score were noted (1.0) than in context 932 (78.5%, 961/1224, mean FFI 1.5). Context 932 also showed a higher proportion of mineralised fracture than context 916, although as figure 15.20 shows the differences were minimal, and these two contexts were largely similar. The fracture freshness analysis suggests an excellent example of intensive bone marrow extraction with limited evidence for post-depositional disturbance.

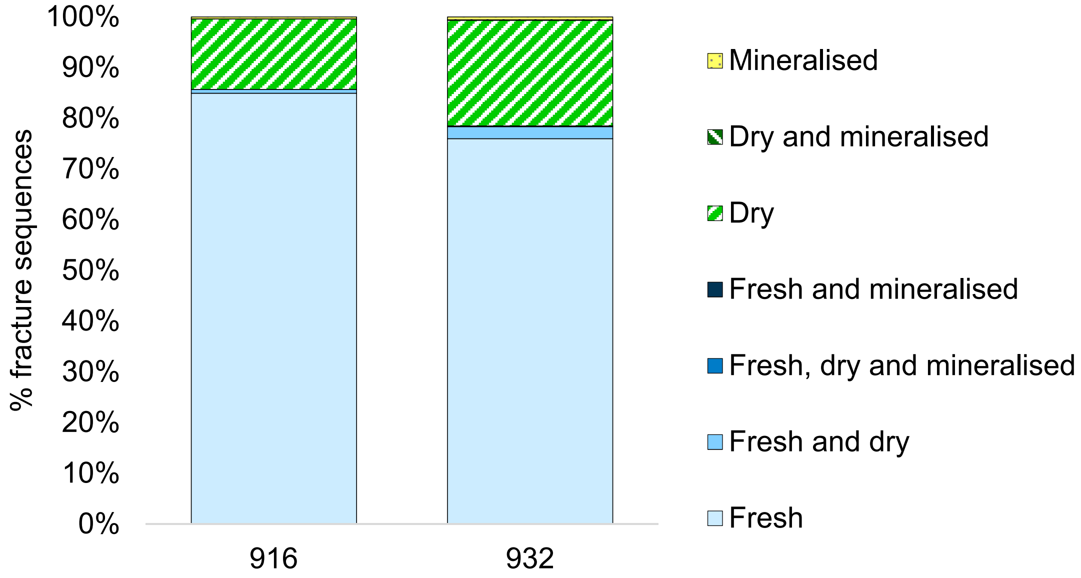

Figure 15.20: Fracture history profiles for context 916 (n=259) and 932 (n=1224) from Polgár-Csőszhalom.

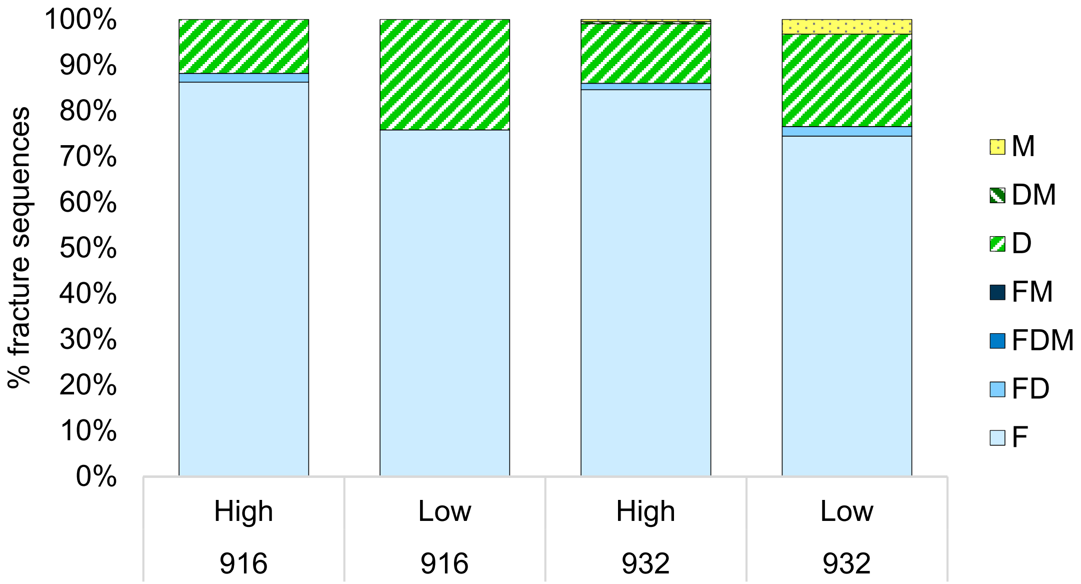

Figure 15.21: Fracture history profiles for high- and low-yield marrow bones from context 916 (n=51/29) and context 932 (n=215/94) from Polgár-Csőszhalom.

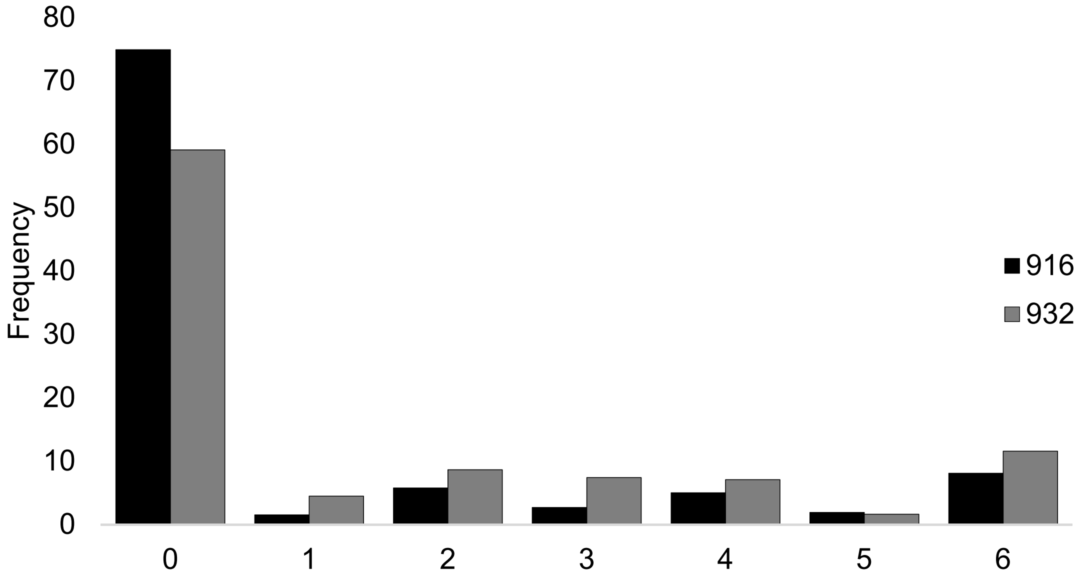

Figure 15.22: Frequency of Fracture Freshness Index scores for context 916 and 932 from Polgár-Csőszhalom.

At Polgár-Csőszhalom fracture history was also analysed by size class due to the two additional classes (figure 15.23). Generally, as bone fragments increased in size the proportion of fresh fracture increased, with a statistically significant difference in fresh fracture between bones measuring 30-39mm (69/102) in length and 150-199mm in length (55/59; p<.001). Larger bones might have been subject to less taphonomic fragmentation than smaller bones, which could have caused this pattern.

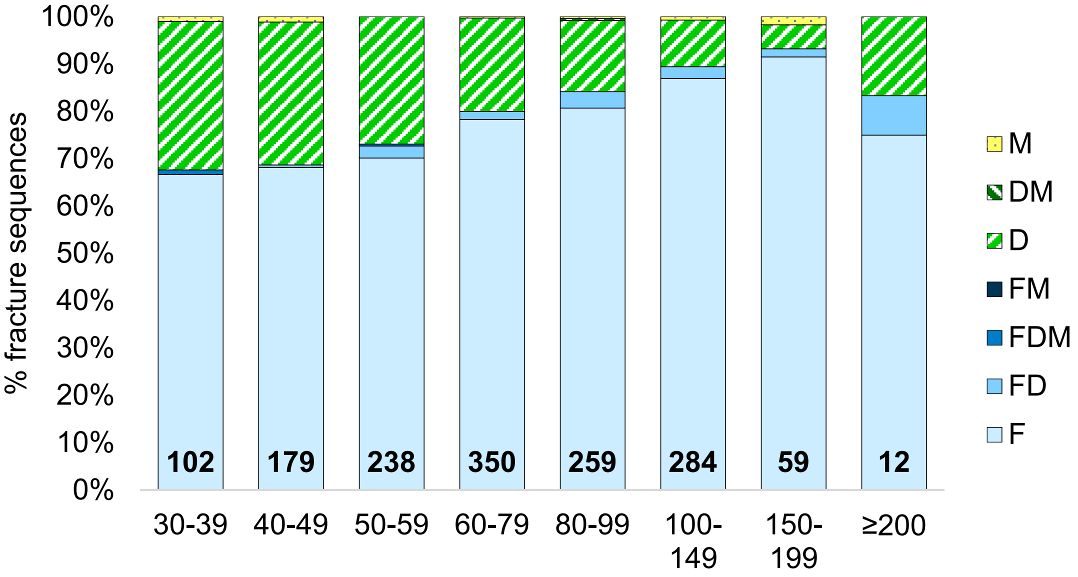

Figure 15.23: Fracture history profiles for marrow-bearing bone fragments by size class from Polgár-Csőszhalom. N values are at the base of each bar. Fracture analysis was not completed for bones <30mm in maximum dimensions.

15.6.2 Species

The marrow-bearing bones of all species, save domestic dog, showed high levels of fresh fracture and low mean Fracture Freshness Index scores (figures 15.24 and 15.25). The analysis of high- and low-yield marrow bones indicates a slight but consistent favouring of high-yield bones for fresh fracture in bovinae, suidae and cervids (figure 15.26). These patterns suggest intensive marrow exploitation. Wild animals had a higher percentage of fractured bones that were fractured when fresh (89.8%, 177/197) compared to domestic food species (85.2%, 69/81), although the difference was not significant. Based on the number of wild large marrow bones coming into the site diligent marrow exploitation of domestic species was perhaps not necessary.

Domestic dog bones were only fractured when dry (mean FFI = 4), and thus were not used as a food resource in the same way as other domestic animals in these contexts. Despite this, analysis of skeletal part abundance above has clearly suggested some form of carcass processing of domestic dogs, as they were not buried intact.

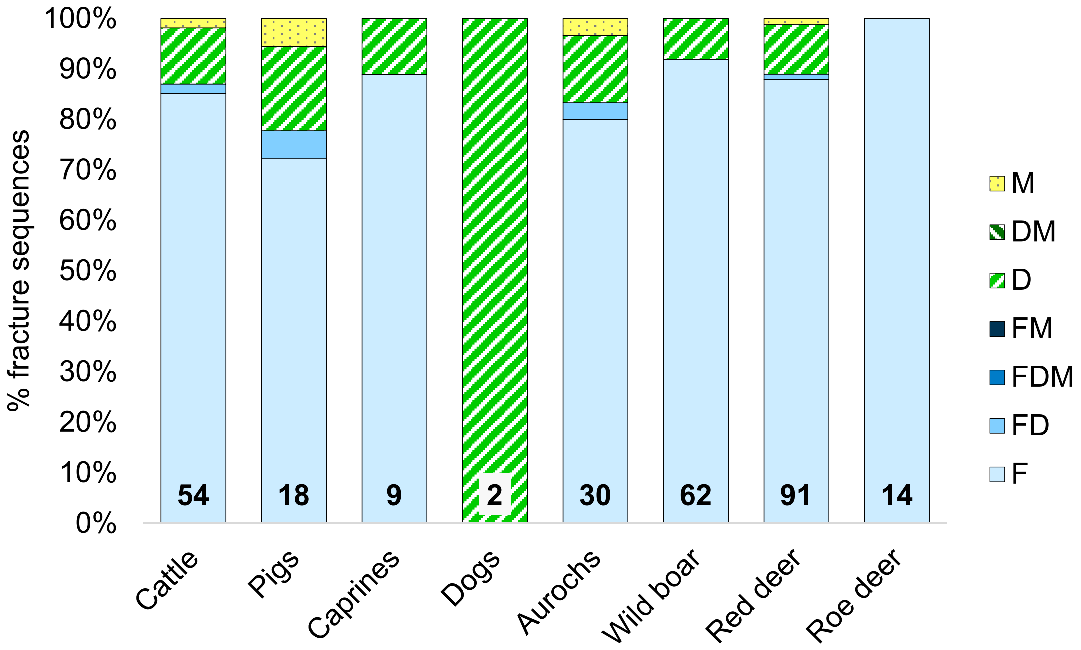

Figure 15.24: Fracture history profiles for species from Polgár-Csőszhalom.

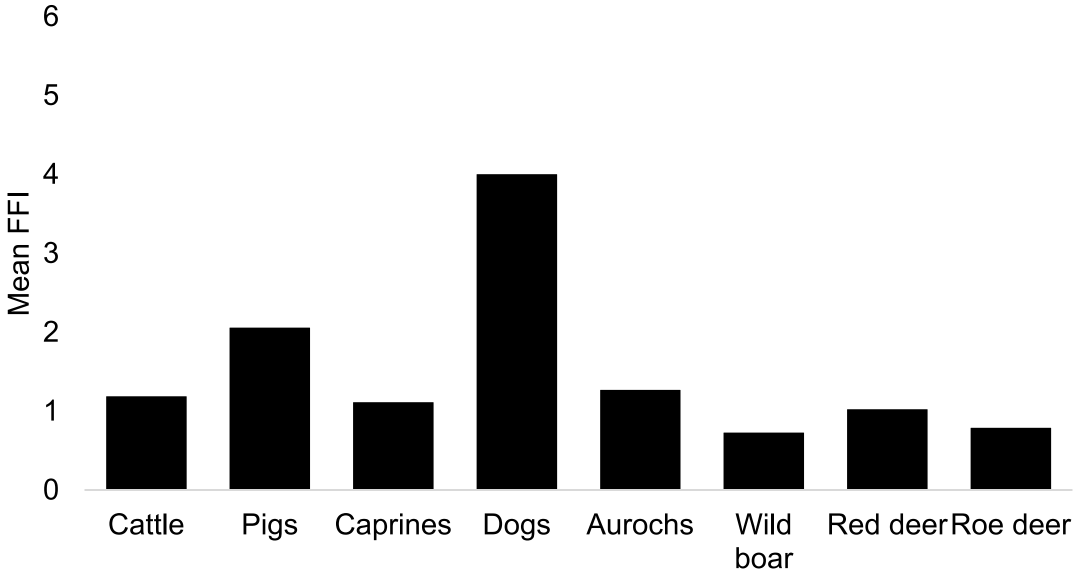

Figure 15.25: Mean Fracture Freshness Index scores for species from Polgár-Csőszhalom. N values as above.

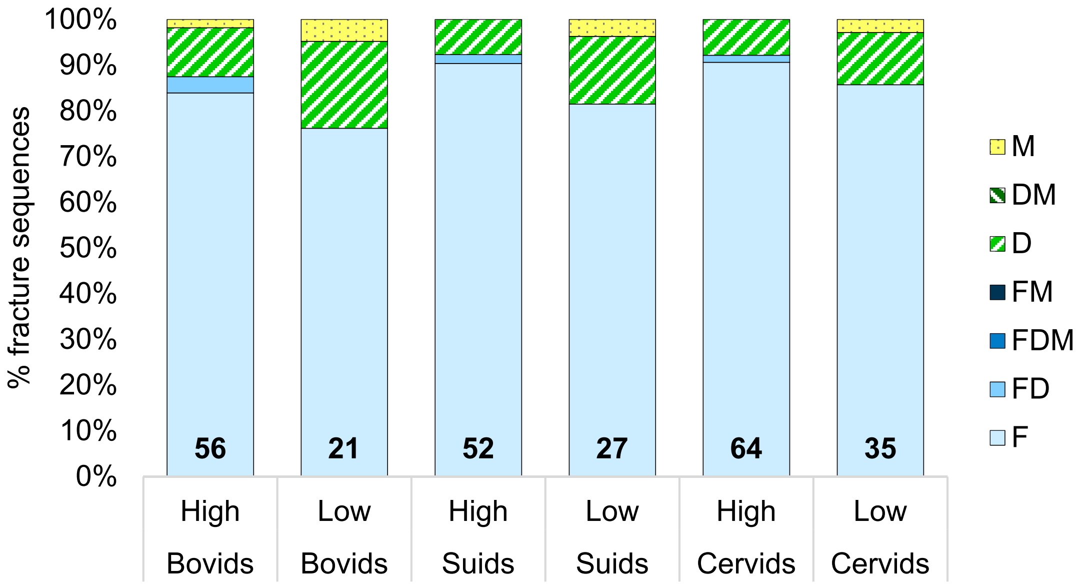

Figure 15.26: Fracture history profiles for high- and low-yield marrow bearing elements from bovinae (cattle and aurochs), suidae (pigs and wild boar) and cervids (red and roe deer) from Polgár-Csőszhalom.

15.7 Fragmentation

The fragmentation levels of the sample do not suggest intensive grease processing in these contexts, although it could have taken place elsewhere on the site. Figure 15.27 shows very low proportions of the assemblage weight in the smallest size classes (under 40mm), and figure 15.28 indicates that a very small proportion of that weight was contributed by small fragments of cancellous bone. The fragmentation analysis also shows that these contexts contained a large amount of whole bones (largely carpals, tarsals, phalanges and some vertebrae) and shaft bones with whole epiphyses, suggesting that these bones were not comminuted and boiled for bone grease. This does not match a heavily fragmented, cancellous rich bone grease processing feature, but does further lend support that large amounts of marrow bearing bones were split at midshaft.

The high proportion of identifiable bones, the addition of the largest size classes and the presence of large diaphysis, cranial and rib fragments, suggest that the assemblage was in good condition and that levels of fragmentation were not solely caused by taphonomy. However, figure 15.28 showed that fragmentation of the cranium and the ribs was high in the smallest size classes, which could suggest some other carcass processing or deposition practice causing fragmentation of these elements.

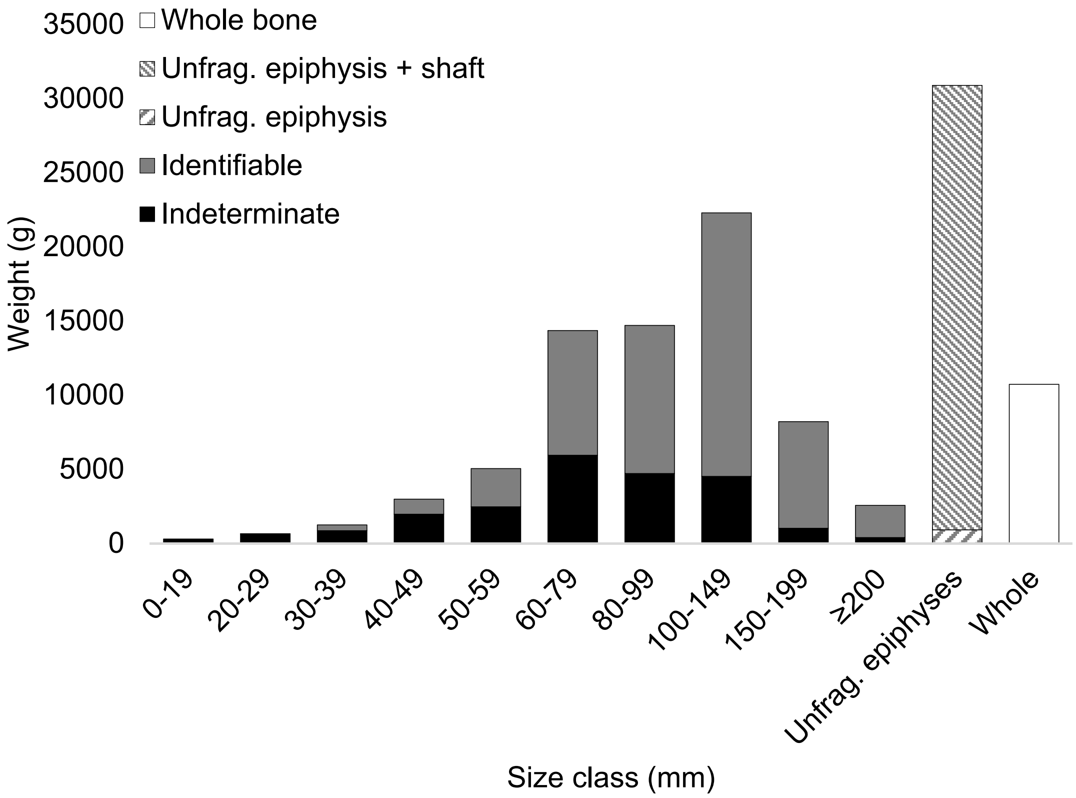

Figure 15.27: Weight by size of all specimens from Polgár-Csőszhalom.

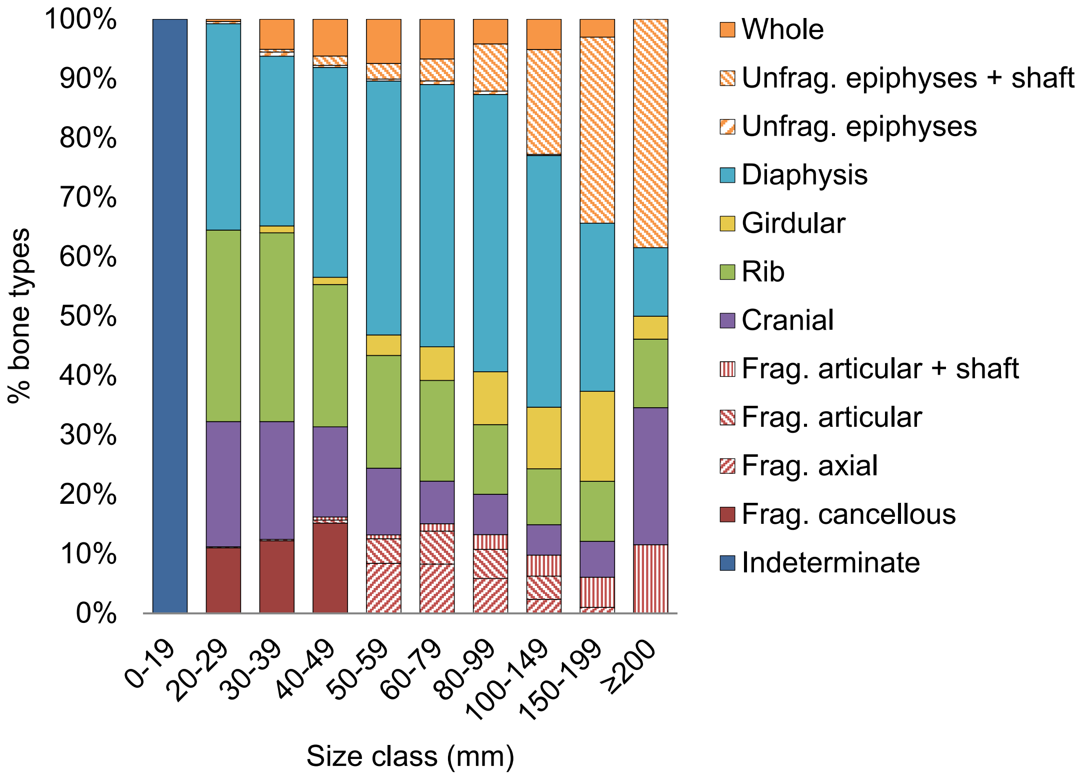

Figure 15.28: Frequency of identifiable and indeterminate bone types by size class from Polgár-Csőszhalom. Red series indicate fragmented cancellous bone.

The two sampled contexts had very negligible differences in their levels of fragmentation, as shown in figure 15.29. Context 932 showed higher levels of fragmentation in specimens sized between 60 and 100mm, while Context 916 showed more abundance of assemblage weight in the largest size classes (over 100mm). While there is little evidence for bone grease processing in these contexts there is the possibility that it was practised elsewhere on site, perhaps involving the missing vertebrae.

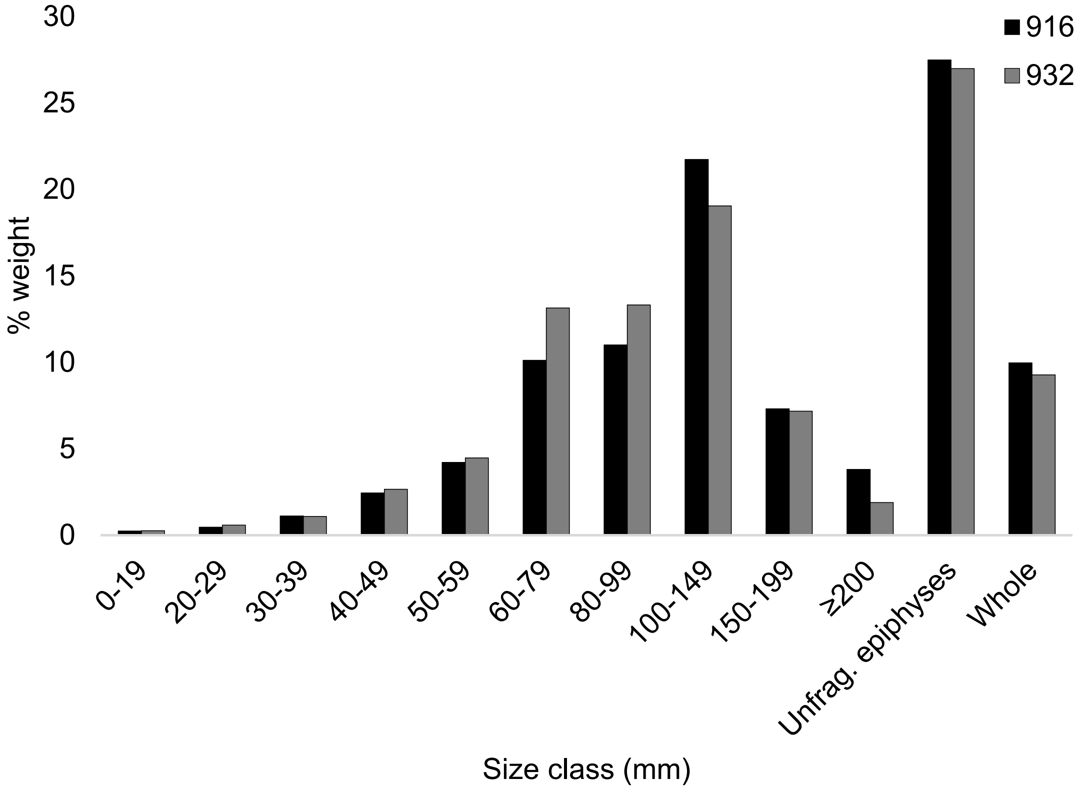

Figure 15.29: Percentage weight by size class for context 916 (total weight 2111.5g) and 932 (92903.2g) from Polgár-Csőszhalom.

15.8 Taphonomy

15.8.1 Gnawing

Gnawing affected 5.3% (291/5525) of the overall sample, and rose to just over 12% (116/937) in context 916, significantly more than 932 (175/4588; p<.001; figure 15.30). Only one identifiable bone was noted to have evidence of rodent gnawing, but 233 identifiable specimens exhibited the pitting and scarring associated with canid gnawing. Both wild and domestic animals were subject to gnawing by domestic dogs, but certain carcass parts seem to have been preferentially gnawed. On domestic cattle 30.3% (20/66) of bones belonging to the hindlimb, (femur, tibia, calcaneum, astragalus and metatarsal) showed evidence of gnawing, especially affecting the extremities. Pigs were particularly affected in their forelimb (scapula, humerus, radius, ulna). The heightened gnawing in these areas might indicate that these parts of the carcass were thrown preferentially to dogs, and could also suggest that dogs did not have access to all bones to show a similar level of gnawing on similar elements of other species.

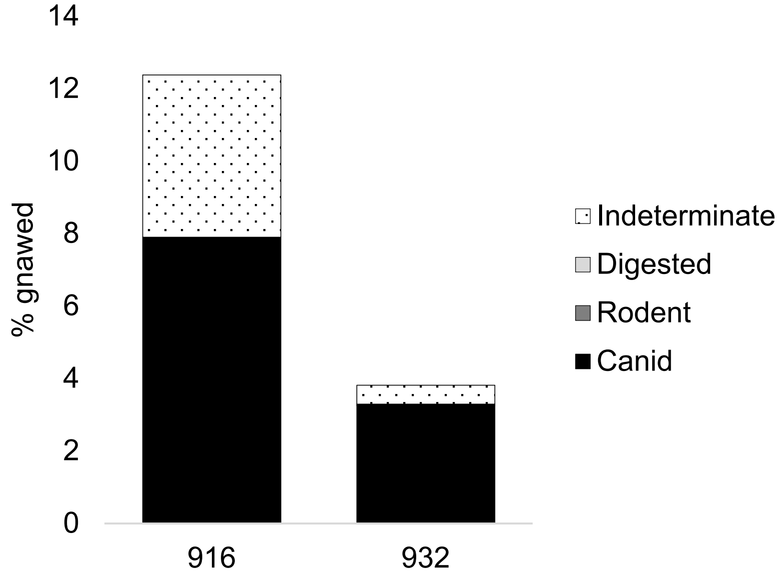

Figure 15.30: Percentage of specimens with different types of gnawing from the sampled contexts from Polgár-Csőszhalom.

15.8.2 Taphonomic agents and recent breaks

A low proportion of the identifiable assemblage showed evidence of taphonomic agents (figure 15.31). Erosion was recorded on 1.3% (23/1830) of the identifiable assemblage from context 932 and was not identified in context 916, suggesting different depositional histories perhaps related to secondary deposition. Root etching was only identified in two instances. Cemented mud, which is more an indicator of soil type rather than depositional practices, affected 21 bones from the Polgár-Csőszhalom identifiable sample. This concreted soil can conceal bone and fracture surfaces, although its low prevalence means it likely did not affect analysis.

Context 932 was also more affected by recent breaks than 916, at 15.9% (291/1830) of the identifiable sample. This could be due to the method of storage, as the faunal remains from these large contexts are kept in giant rubble sacks. The necessity for larger size classes could also indicate that very long bones were susceptible to being broken, which could account for some of the rib and cranial fragmentation in figure 15.28.

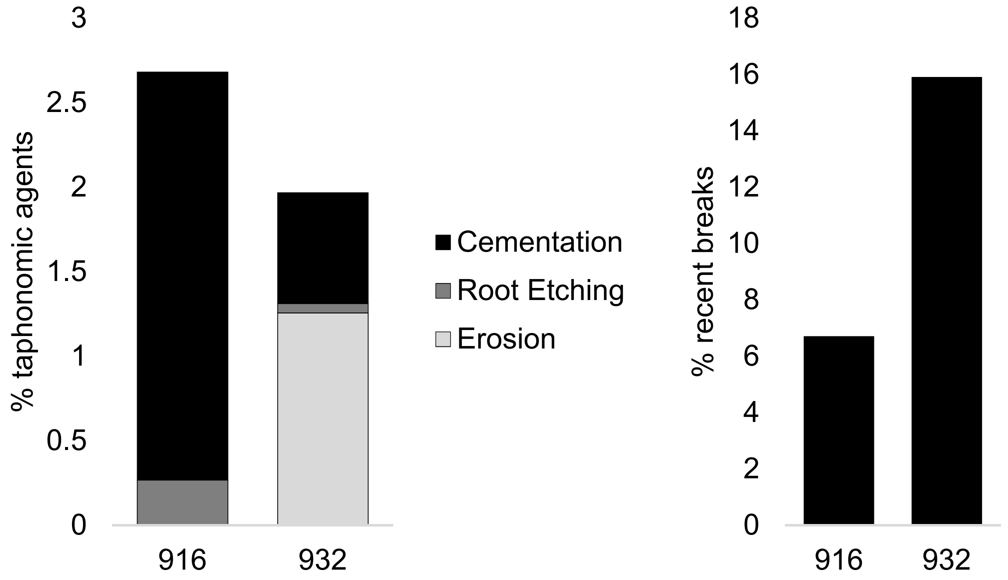

Figure 15.31: Percentage of the identifiable assemblage affected by different taphonomic agents (left) and recent breaks (right) from Polgár-Csőszhalom.

15.9 Food exploitation strategies

15.9.1 Herd structure analysis

15.9.1.1 Cattle

Cattle fusion profiles indicate a slaughter at 3 years whereupon 50% of the population survived until fusion maturity (figure 15.32). This survival of a large proportion of the stock could indicate milk-producing dairy females and slaughter of meat-bearing males at adult size, although there is no young slaughter represented here. As this data is based solely on the assemblage from two contexts younger specimens could be deposited elsewhere.

Analysis of mortality through dental remains was carried out for the whole site assemblage, including the two contexts here, by Roz Gillis. Her analysis showed little slaughter of animals between 0-15 months, but a significant peak between 15-26 months followed by further slaughter at 26-36 months (Gillis unpub.b). The peak at 15 months could suggest slaughter of target weight bullocks or castrates raised for meat production. Presence of adults, well represented between 3 and 8 years, could suggest a herd of lactating females. While the patterns of dental and fusion mortality do not perfectly align, this is likely a result of sampling as the fusion data only comes from two contexts.

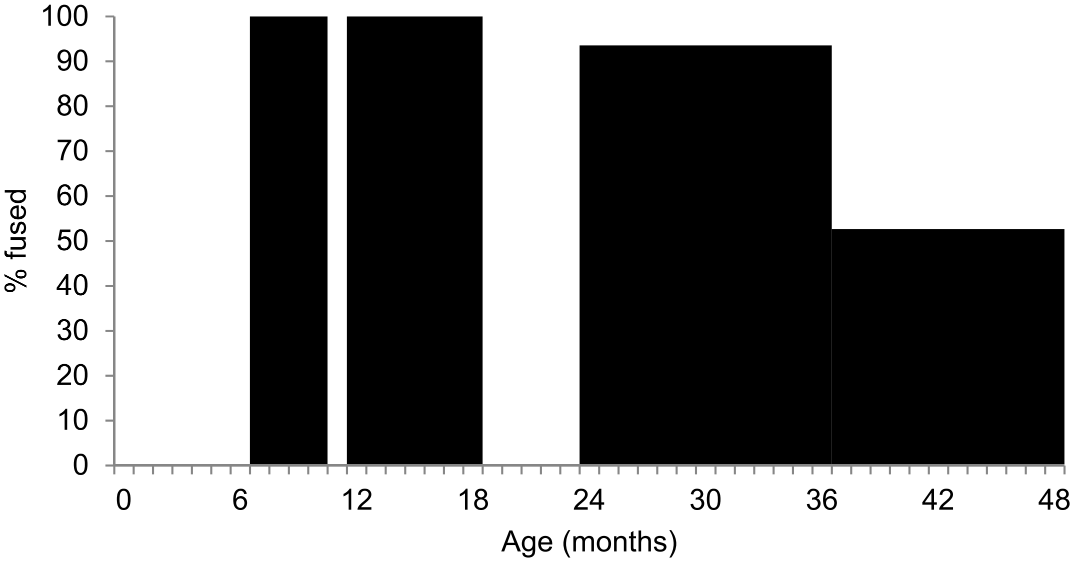

Figure 15.32: Cattle slaughter profile based on epiphyseal fusion from Polgár-Csőszhalom (n=81).

15.9.1.2 Caprines

The caprine slaughter profile had a small sample size, but showed some animals slaughtered between 13-16 months and a further slaughter of meat-age animals in 30-42 months (figure 15.33). The dental mortality profile shows peaks at age 6-12 for sheep and goats and further slaughter age 12-24 in sheep. It appears that the sheep and goats were thus slaughtered for meat, and Gillis postulates that they were probably brought to the site due to the underrepresentation of other age classes. Some adults may have been kept for breeding and milk production.

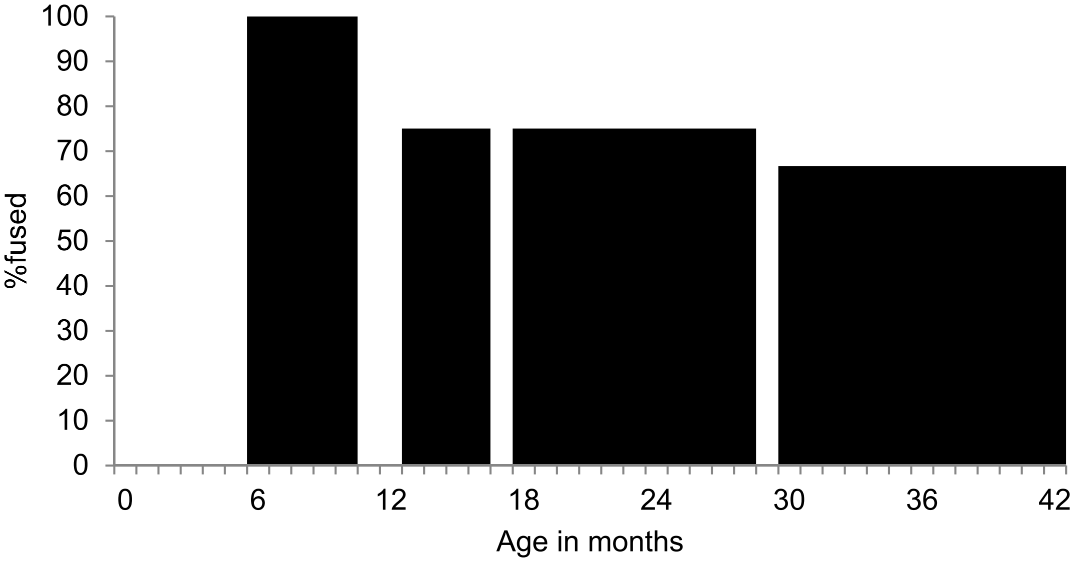

Figure 15.33: Caprine slaughter profile based on epiphyseal fusion from Polgár-Csőszhalom (n=17).

15.9.1.3 Suidae

Despite a small sample size, the domestic pigs from Polgár-Csőszhalom showed fairly intensive slaughter before their first year, with further kill-off before 2.5 years and no survival into fusion maturity (figure 15.34). This young meat slaughter contrasts with the wild boar fusion data, which shows that the animals were taken from all age classes, but the majority were from animals that were mature specimens (figure 15.35). Unlike the domestic pig profile, 71.4% (5/7) of the specimens included in fusion analysis of stage 3 reached full maturity. This suggests that hunters were targeting the largest individuals specifically, perhaps for prestige. This is corroborated by the red deer analysis, which showed that 93.2% (138/148) of bones analysed for fusion were fused.

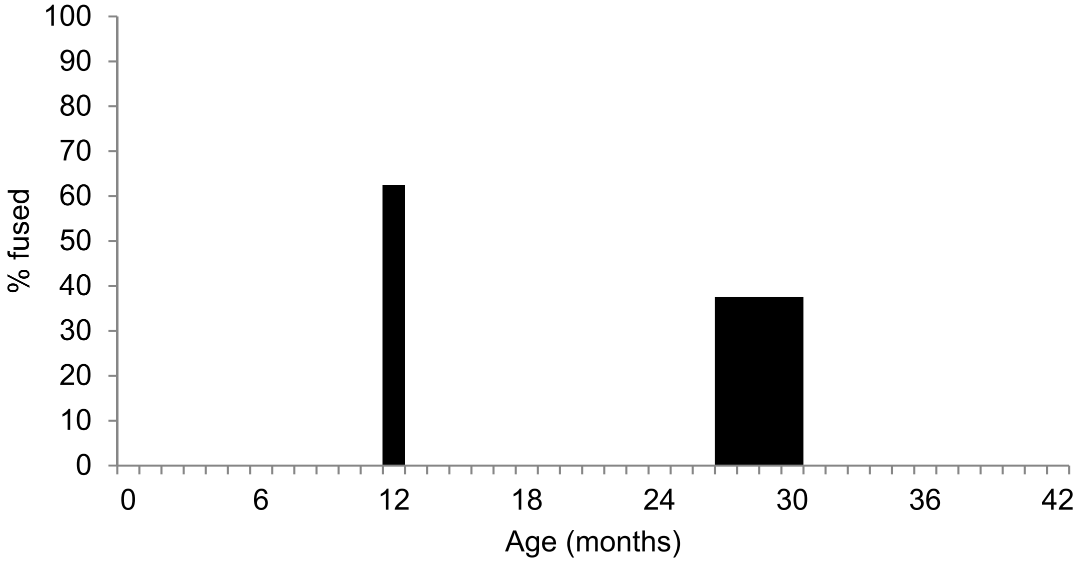

Figure 15.34: Domestic pig slaughter profile based on epiphyseal fusion from Polgár-Csőszhalom (n=19).

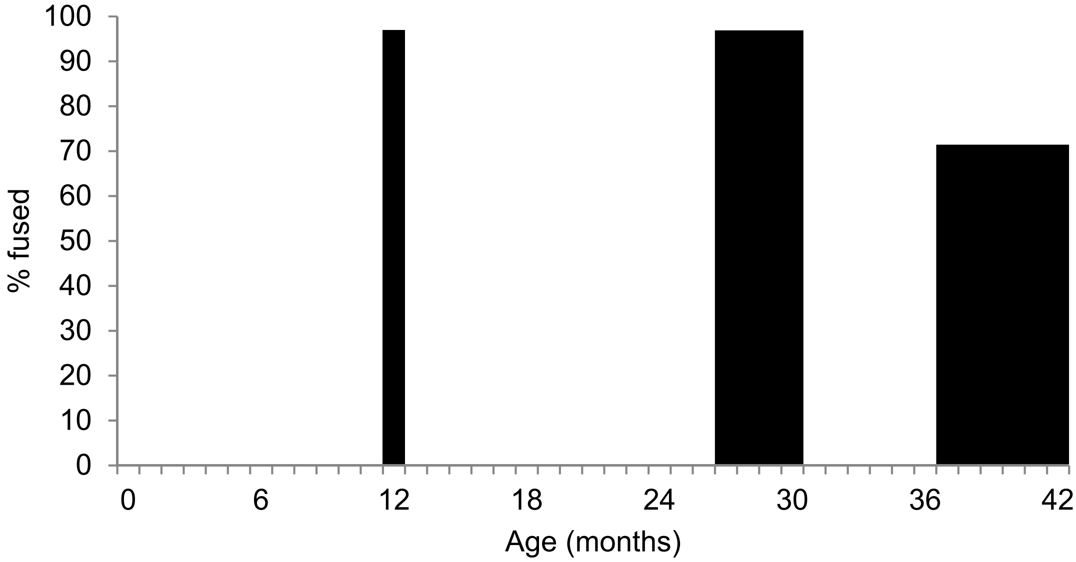

Figure 15.35: Wild boar slaughter profile based on epiphyseal fusion from Polgár-Csőszhalom (n=72).

15.9.1.4 Summary of age-at-death analysis

In summary the age-at-death analysis suggests meat consumption from domestic animals and targeting of adult-size animals for hunting. Cattle and possibly caprine dairying at the site was likely, although it is also suggested that animals could have come from the surrounding environment to be slaughtered at Polgár-Csőszhalom. Whilst cattle and caprine dairying was possible there was a much clearer focus on management for meat.

15.9.2 Lipid residue analysis

Lipid residue analysis from Polgár-Csőszhalom has revealed evidence of animal fats in pottery. From the horizontal settlement, where contexts 916 and 932 are located, 48.1% (59/106) of non-perforated sherds had evidence of animal fats. The animal fats identified were largely adipose fats (40.6% of sherds, 51/106), but 7.5% (8/106) of sherds showed evidence of milk fats. In context 932, 41.7% (23/48) of sherds had evidence of adipose fats, and 6.3% (3/48) contained milk fats. There is currently no evidence of milk fats from sherds originating from the tell, although 39.5% (15/38) of sherds contained adipose fats. This suggests that people living at Polgár-Csőszhalom had access to dairy fats, either through the presence of a dairy cattle herd or through milk being brought into the site, as may have happened with caprines.

15.9.3 Archaeobotanical analysis

Archaeobotanical material from the site was very rich, reflecting a farming community with an excellent knowledge of plant cultivation including cereals and legumes (Gyulai 2013: 887-8). Wild species such as plum and cherry species were also identified and likely gathered for consumption (*ibid.* 888). This adds to an increasingly rich picture of food exploitation at Polgár-Csőszhalom.

15.10 Discussion

While the Polgár-Csőszhalom sample does not conform to the usual trends of the Linearbandkeramik culture, it is still an extremely interesting study for this project. The two sampled contexts suggest a high reliance on wild meat, with large, adult-sized individuals preferentially targeted. In addition to wild meat, domestic cattle were also slaughtered at full adult size, alongside younger meat from domestic pigs and caprines. A possibly dairy economy is also suggested through lipid residue analysis, in addition to intensive crop cultivation and use of wild plants (Gyulai 2013: 887-8).

Despite the rich and extensive resource base, butchery and fracture analysis suggests intensive carcass processing. Butchery of bovinae, suidae and cervids shows systematic skinning, disarticulation and defleshing, which particularly focussed on the meaty upper limb bones (figures 15.36 and 15.37). Fracture analysis shows intensive exploitation for marrow, with high levels of fresh fracture and fragmentation on long bones, attesting to the continued exploitation of within-bone nutrients into later periods (figure 15.36). Given the high reliance on wild meat, it is possible that fat on the site was only abundant at certain times of the year, although the patterns of agriculture suggest that farming was well established and that bone marrow processing would not have been necessary to diet.

The skeletal part representation suggests that primary butchery likely happened outside of these two contexts, perhaps centrally. It is possible that bone grease processing may have been practised elsewhere, or that elsewhere bone fats were not such a heavily exploited resource. The specimens in these two contexts could represent the remains of shared meals from centrally distributed carcass portions, or could alternatively indicate an intensive bone marrow processing event. While Raczky and Anders highlight the evidence for communal consumption in the tell (2010: 147-150; Raczky *et al.* 2010: 56), the contexts here analysed suggest that communal food processing and possibly consumption was taking place in the external settlement. An investigation into other contexts in the horizontal settlement, and into food exploitation strategies in the tell, is necessary to confirm this.

Table 15.4: Percentage of bovine, suid and red deer marrow-bearing elements fractured when fresh from Polgár-Csőszhalom.

	HUM		**RAD**		**FEM**		**TIB**		**MAND**		**MC**		**MT**	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Bovinae	91	11	94	24	80	13	86	35	100	13	75	8	75	10
Suidae	100	25	100	9	100	4	56	18	32	50	-	-	-	-
Red deer	93	14	67	27	43	7	78	23	64	14	80	10	71	7

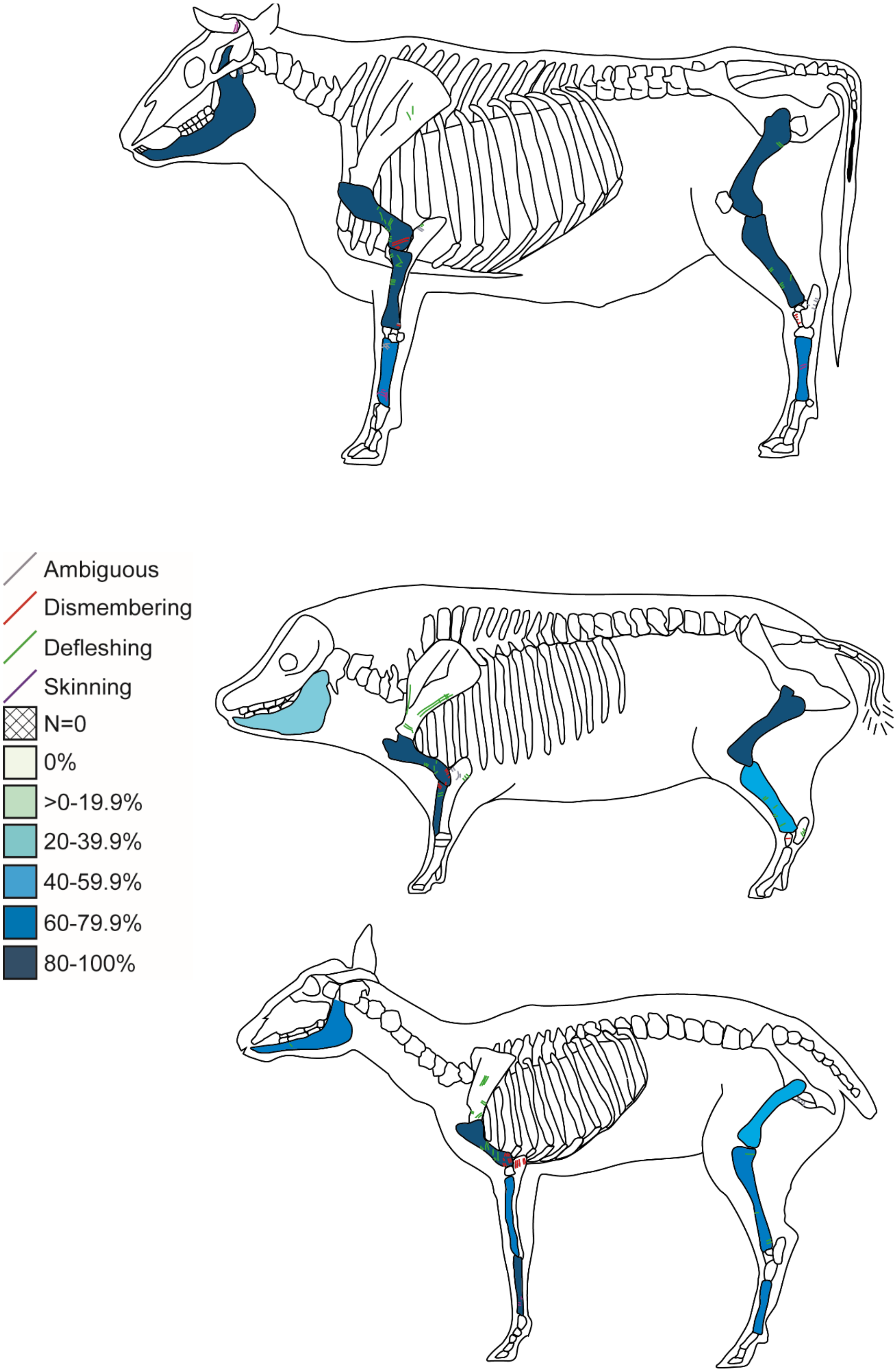

Figure 15.36: Carcass profiles showing trends in butchery and fracture freshness for bovinae (top), suidae (centre) and red deer (bottom) from Polgár-Csőszhalom. Values in table 15.4.

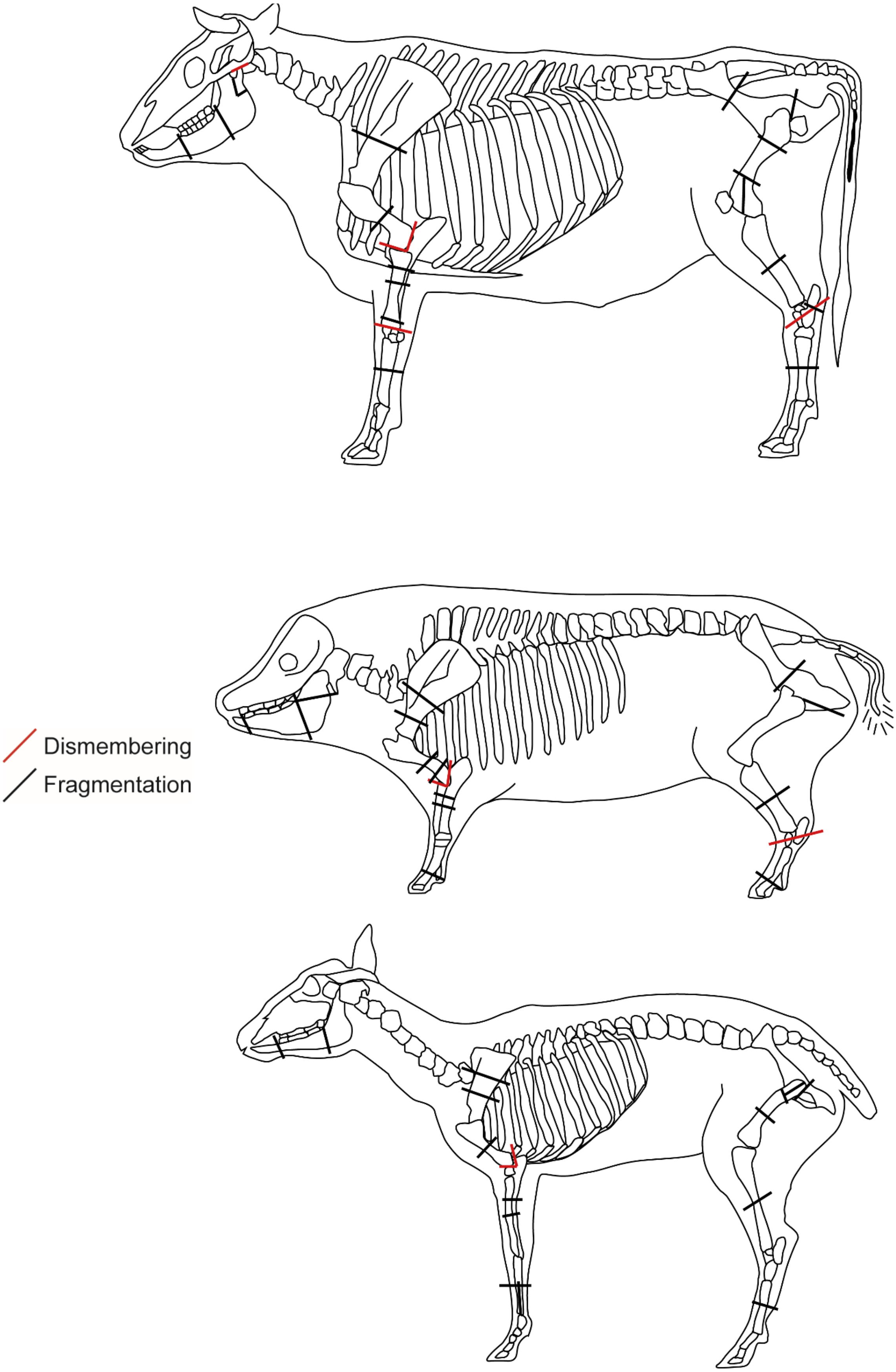

Figure 15.37: Carcass profiles showing trends in dismembering and fragmentation based on butchery patterns and bone identification zones (Dobney and Rielly 1988) from Polgár-Csőszhalom.

Chapter 16 Discussion

16.1 Introduction

This thesis aimed to better understand meat and fat exploitation strategies at central European Neolithic sites. Additionally, it targeted variation in these strategies that could be attributed to the adoption of dairying. In-depth zooarchaeological analyses of butchery, fracture and fragmentation patterns, still something of rarity in zooarchaeological analysis, were undertaken on twelve Neolithic sites in conjunction with herd structure and lipid residue analyses. These data will be brought together in this chapter to answer the two research questions highlighted in chapter 1, which are explained in more depth below.

1. *What was the nature of butchery and bone fat processing among early Neolithic farming societies in central Europe?*
2. *Did the adoption and intensification of milking practices affect meat and fat exploitation?*

Throughout this thesis these questions have been addressed on individual sites, the conclusions of which are now incorporated to form a detailed picture of animal exploitation in Neolithic societies in Europe. The prevailing attributes of each site in terms of location, date range and settlement type can be found detailed in table 16.1 and figure 16.1. Variations in carcass processing will be assessed, and then examined in conjunction with evidence for milking economies to attempt to identify patterns in dairy product use and carcass processing practices in Neolithic Europe. For the first research question, it was hypothesised that variation in butchery and bone fat exploitation would be present but minimal, perhaps on a regional scale. It was also hypothesised that an increase in the intensification of milking would have reduced the need for intensive bone fat processing. This chapter concludes by identifying avenues for further work, both within the NeoMilk project and beyond, and presents some final thoughts.

Table 16.1: Sites analysed for the project in rough chronological and geographic order, including the culture represented, the phases of occupation and the settlement structure. Throughout this discussion site codes are used in figures to increase legibility.

Code	**Site**	**Area**	**Site culture, phases and description**	**Number of Specimens**
FUG	Füzesabony-Gubakút	Hungary	ALPC phases I-V Two house rows facing each other built on both banks of a stream	4491
PPD	Polgár-Piócás-dűlő	Hungary Polgár region	ALPC phase I Two houses, some pits, postholes, wells and graves	2753
PFH	Polgár-Ferenci-hát	Hungary Polgár region	ALPC phase I-IV Enclosed settlement with intensive activity, dispersed exterior settlement	2907
APC	Apc-Berekalja I	Hungary	TLPC Archaic LBK – Zeliezovce 20-30 houses in 10-15 settlement rows	1255
TES	Těšetice-Kyjovice Sutny	Czech Republic	LBK early - middle Settlement with houses in rows	5252
LDW	Ludwinowo	Poland	LBK Kuyavian phase I-III Settlement with houses in rows	13429
STE	Stephansposching	Germany Lower Bavaria	LBK Ältere – Jüngste Settlement with enclosure ditch	2451
DST	Dillingen-Steinheim Wickenpoint	Germany Lower Bavaria	LBK Ältere – Mittlere Settlement with enclosure ditch	611
HER	Herxheim	Germany Rhine Valley	LBK Ältere – Jüngste Settlement with double ditch enclosure	8000
BIS	Bischoffsheim	Alsace Basse-Alsace	Rubané Ancien – Récent Settlement	1215
ROS	Rosheim *Sainte-Odile*	Alsace Basse-Alsace	Rubané Récent - Final Settlement with enclosure ditch	3126
PCS	Polgár-Csőszhalom	Hungary Polgár region	Tizsa-Herpaly and Lengyel Tell and external settlement	5525

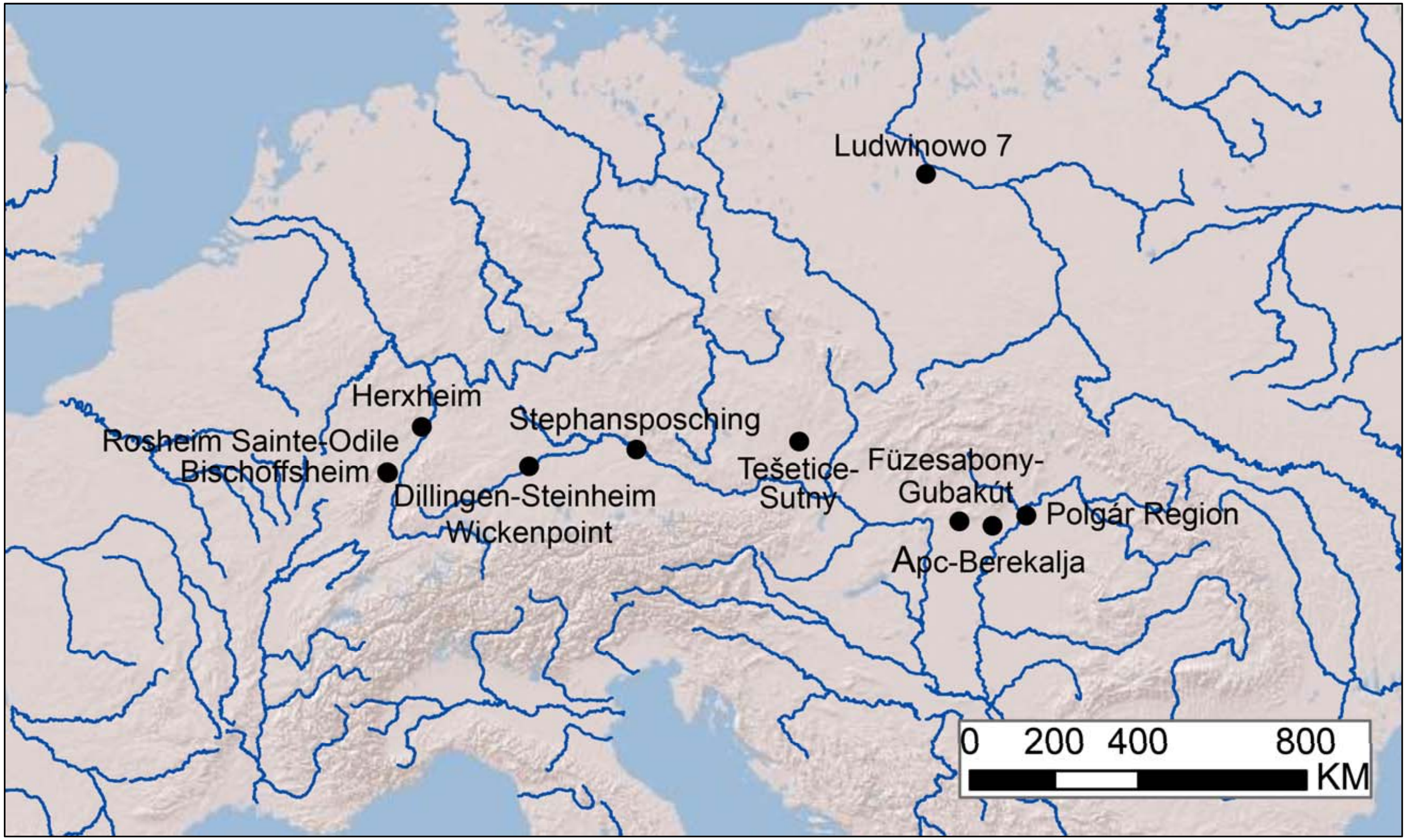

Figure 16.1: Map of all sites studied. All Polgár sites are represented by the Polgár region place mark. Map copyright Esri 2014, data supplied by Penny Bickle and Jessica Smyth.

16.2 Research question 1

What was the nature of butchery and bone fat processing among early Neolithic farming societies in central Europe?

This rather broad question tracks trends in carcass processing across the geographical and chronological spread of the LBK. Trends in butchery practices are generally expected to mirror the largely homogenous, but regionally varying, material culture of the LBK across Europe (Bickle and Whittle 2013). Variation in carcass processing practices may have ensured alignment with the requirements of the human community in terms of nutritional necessity, taste and dietary preference, and crucially social rules governing life on LBK settlements. The zooarchaeological evidence may identify the major influences of butchery decisions, particularly focussing on nutritional necessity and culturally preferences. This question will be explored through analysis of individual aspects of food acquisition and butchery, including bone fat processing, to form a picture of meat and fat exploitation across the LBK through the lens of cultural butchery practices.

16.2.1 Species representation

16.2.1.1 Cattle

On almost all sites studied cattle were best represented in the number of identifiable specimens (NISP), a typical trend in the Linearbandkeramik culture (Bickle and Whittle 2013: 13). Particularly high proportions of cattle were documented at Ludwinowo 7, Apc-Berekalja I and Stephansposching (figures 16.2, 16.3 and 16.4). Only at Rosheim *Sainte-Odile* and Bischoffsheim was the number of identifiable cattle bones less well represented than another domestic species (pigs). This high dominance of cattle has traditionally been explained by the environmental suitability of this species to the cool and wet climate of central Europe (Bickle and Whittle 2013: 13; Bogucki 1988; Halstead 1989; Lüning 2000: 108; Uerpmann and Uerpmann 1997), although more recently nutritional and cultural preferences are favoured explanations. Cattle were significant nutritional contributors to LBK life as the biggest producers of meat and likely milk (Bogucki 1988; Marciniak 2005; Salque *et al.* 2013). Bickle and Whittle have suggested that there was a social preference of cattle, related to longhouse life (2013: 13), and it is possible that this preference extended into the ritual sphere and feasting

(Marciniak 2005; 2011). The importance of cattle as the main milk producer, both nutritionally and symbolically, is reflected in accounts of ritual feasting in ethnographies (Dahl and Hjort 1976; Blackburn 1982: 296).

16.2.1.2 Small stock

Regional variation is better represented in the proportions of caprines (sheep and goat) and pigs (figures 16.2, 16.3 and 16.4). Relatively high levels of caprines were present in early Neolithic Hungarian sites, namely Polgár-Ferenci-hát and Füzesabony-Gubakút, and Těšetice-Kyjovice in the Czech Republic. Caprines were also the dominant secondary domesticate at Polgár-Piócás-dűlő and Apc-Berekalja I. On sites where caprines were abundant they may have contributed to a dairy economy, especially goats. Pigs were particularly common on sites in the Rhine Valley region, resulting in the separation of Rosheim *Sainte-Odile*, Bischoffsheim and Herxheim in figure 16.4. High proportions of pigs could relate to environmental suitability, a continued Mesolithic tradition (Bickle and Whittle 2013: 14; Lüning 2000; Uerpmann and Uerpmann 1997), and feasting practices (Marciniak 2005; 2011; see also Albarella and Serjeantson 2002; Madgwick and Mulville 2015a). Like cattle, cultural and nutritional preferences are likely the factor most attributing to the proportions of small stock.

16.2.1.3 Domestic dogs

Domestic dogs were present on almost all sites. Figure 16.2 shows that both Polgár-Piócás-dűlő and Herxheim had high proportions of dog identifiable specimens, and the sites were also similar in the minimum number of individuals (PPD=4; HER=5). Both sites feature special treatment of dog remains, in two near-complete burials in Polgár-Piócás-dűlő and the enclosure ditches at Herxheim. The sample from Polgár-Csőszhalom also had an interesting concentration of dog mandibles (MNI=8). Domestic dog remains on many other sites were rare, usually single bones or discrete articulations, usually deposited among domestic refuse. It is likely that domestic dogs were not part of diet in the LBK, although their carcasses may have been processed posthumously. Domestic dog bones very often showed minimal evidence of butchery and heat exposure compared to other domestic animals, and no evidence of fracture for marrow (figure 16.36). Patterns of spatial distribution also indicate that carcass processing practices on dog carcass related more to ritual applications.

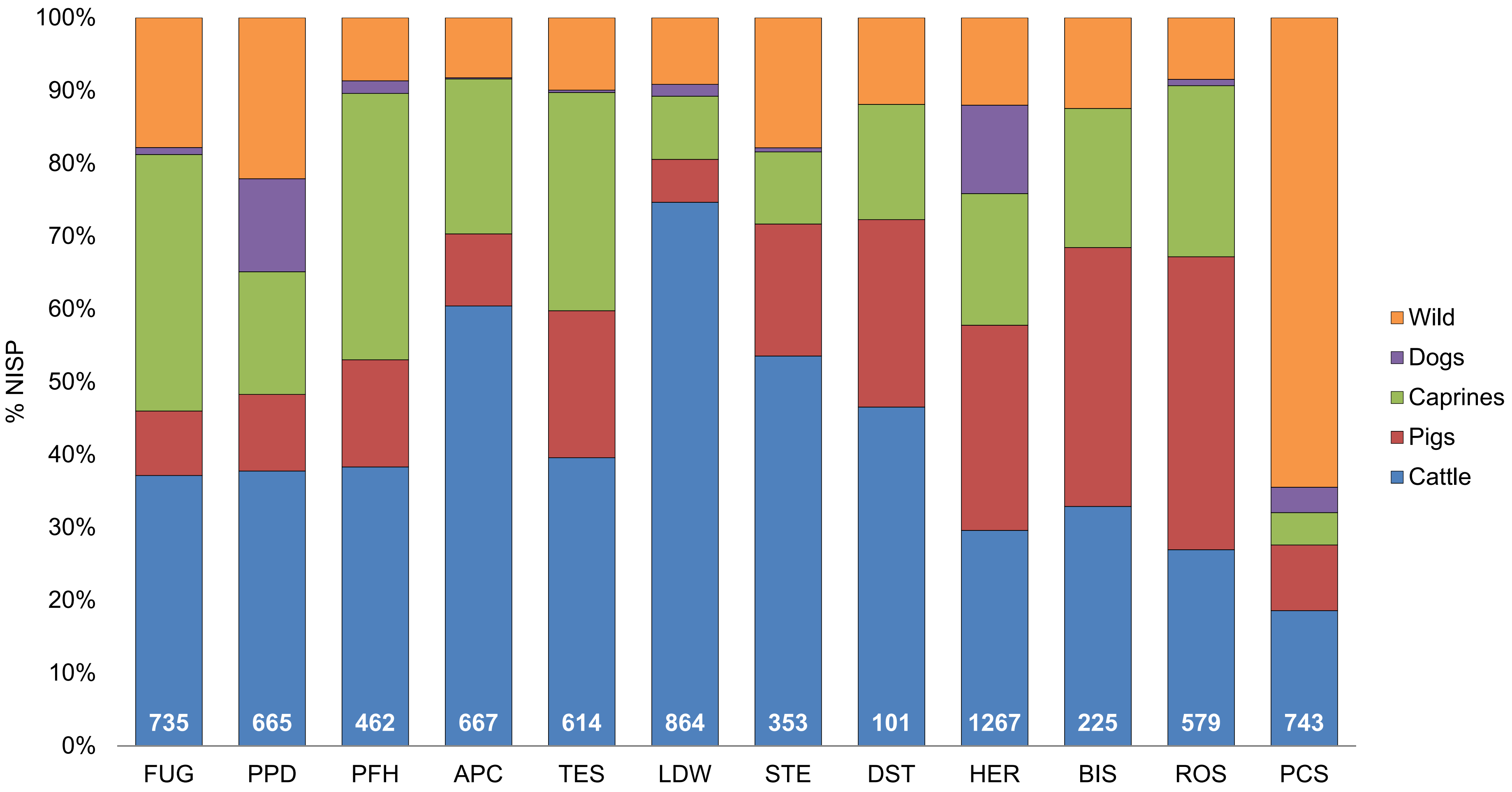

Figure 16.2: Species representation (NISP) for each site studied. N values are at the base of each bar. Wild animal species representation is analysed in more detail in figure 16.5. Site codes can be found in table 16.1.

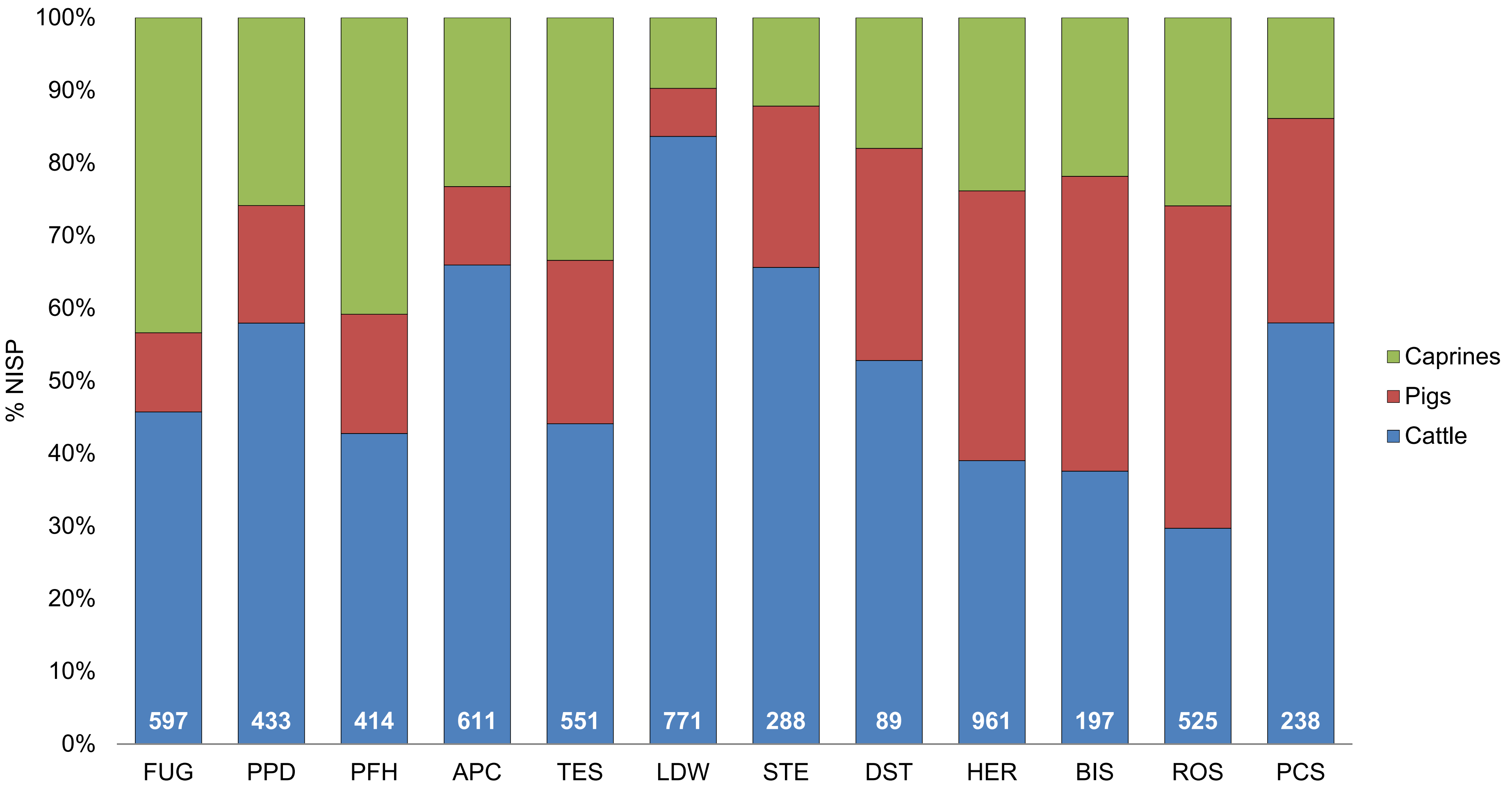

Figure 16.3: Species representation (NISP) of the main three food domesticates for all sites studied.

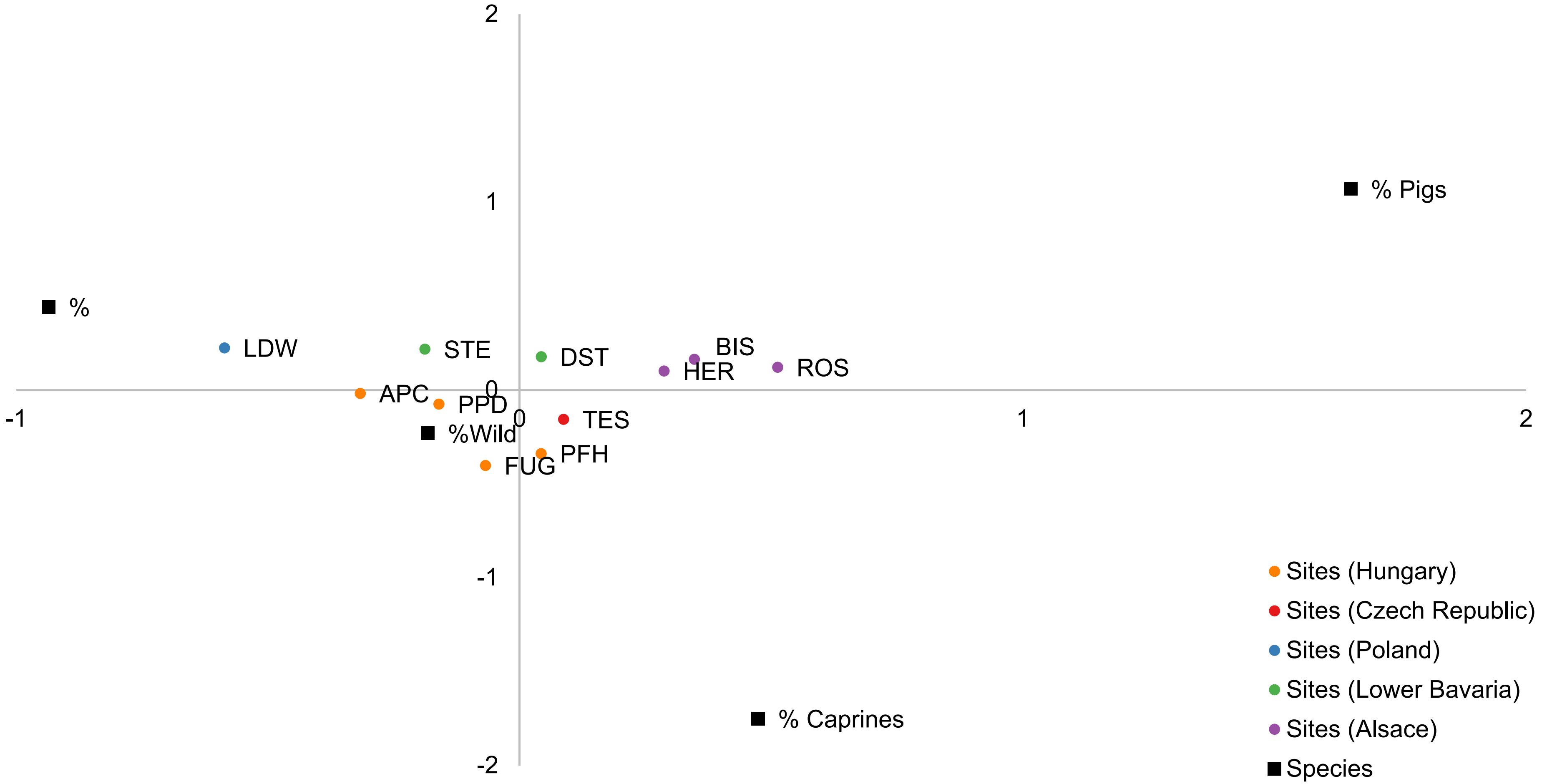

Figure 16.4: Correspondence analysis of sites based on the relative proportions of each domestic food species (cattle, pigs and caprines) and the proportion wild animals in the overall NISP. Sites are coloured based on region. Polgár-Csőszhalom is not included in this analysis due to the unusually high proportions of wild animals.

16.2.1.4 Wild animals

All sites studied showed exploitation of wild fauna, but there was variation in the proportions of wild animals contributing to the total NISP (figure 16.2, table 16.2). On most sites, wild animals represented a typical 10% of the NISP (Lüning 2000: 113), although others such as Füzesabony-Gubakút, Polgár-Piócás-dűlő, Stephansposching and Polgár-Csőszhalom had much higher proportions. Aurochs and red deer were the most commonly hunted species, along with wild boar (figure 16.5). Roe deer did not often contribute a significant amount to wild species representation, and were most common at Füzesabony-Gubakút, Polgár-Ferenci-hát and Herxheim. Wild horse was best represented at Ludwinowo 7, and also in evidence at Füzesabony-Gubakút, Polgár-Ferenci-hát and Apc-Berekalja I. Of the ‘other wild’ specimens, hare and wild birds were well represented. Other wild animals represented were foxes, small rodents and one instance of possible bear. Unlike domestic animals, sites do not clearly regionally group in correspondence analysis of the relative proportions of different wild species (figure 16.6).

The proportions and representation of wild fauna on these Neolithic sites could be nutritionally determined. For sites with abundant wild animals these species may have supplemented diet when domestic crops and animals could not be relied upon for subsistence. Similarly, varying proportions of wild fauna in different spaces within a settlement could indicate higher reliance on hunted game on a household basis, particularly seen at Těšetice-Kyjovice, Ludwinowo 7 and Rosheim *Sainte-Odile*. It has been postulated that houses with high proportions of wild animals could be those of lower socioeconomic status belonging to ‘newcomers’ to the settlement that traded hunted surplus for domestic crops, meat and material culture (Gomart *et al.* 2015: 244-246). These newcomers could include individuals from indigenous hunter-gatherer groups that were used to a high reliance on wild fauna, were specialist hunters, or who had connections with extant Mesolithic groups.

Table 16.2: Number and percentage NISP of wild animals for all sites.

	FUG	**PPD**	**PFH**	**APC**	**TES**	**LDW**	**STE**	**DST**	**HER**	**BIS**	**ROS**	**PCS**
N	132	147	40	54	50	79	63	12	152	25	49	477
%	17.3	22.3	8.7	8.1	8.3	9.1	17.9	11.9	12.1	11.3	8.5	64.2

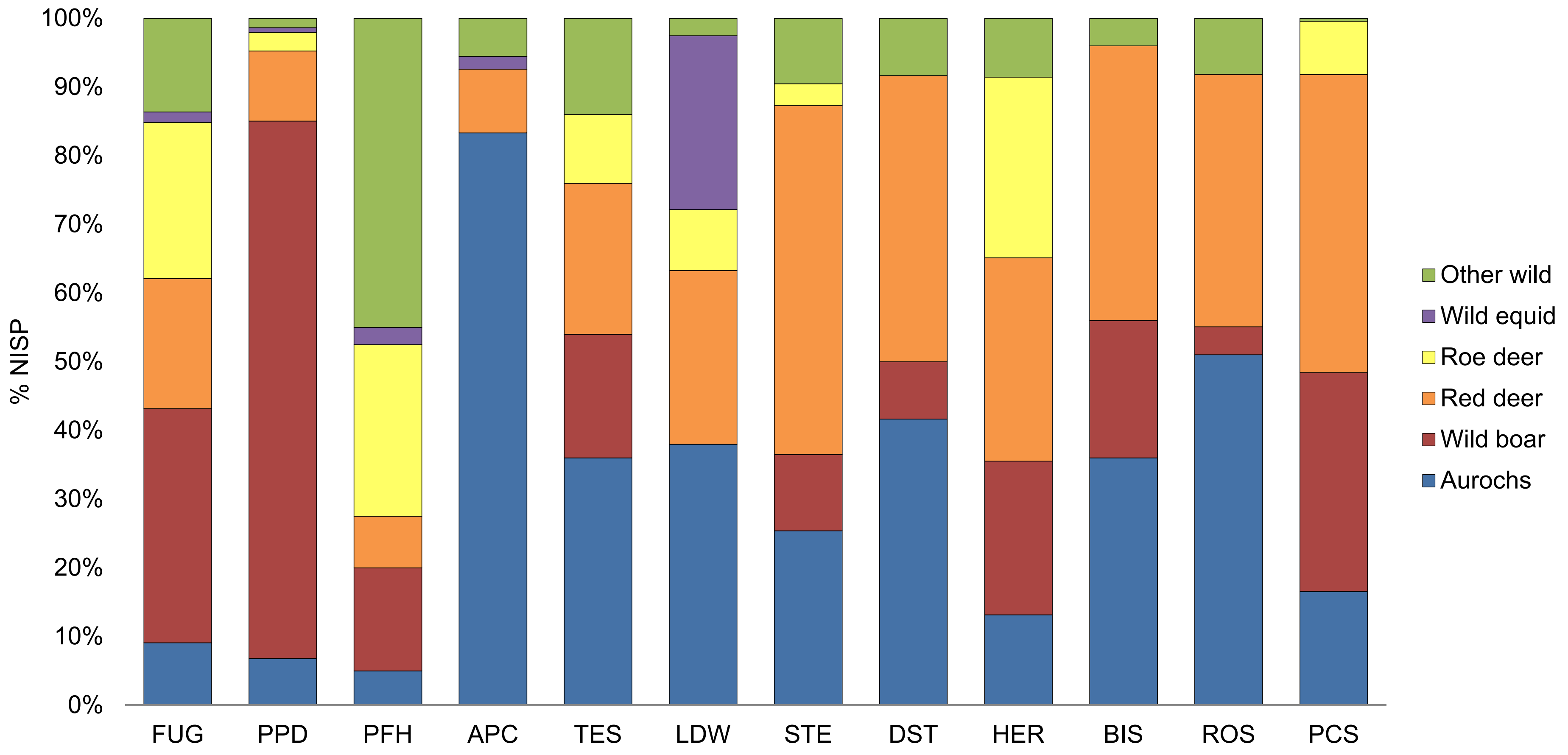

Figure 16.5: Wild animal species representation (NISP) from all sites studied. N values and percentages of the total NISP can be found in table 16.2.

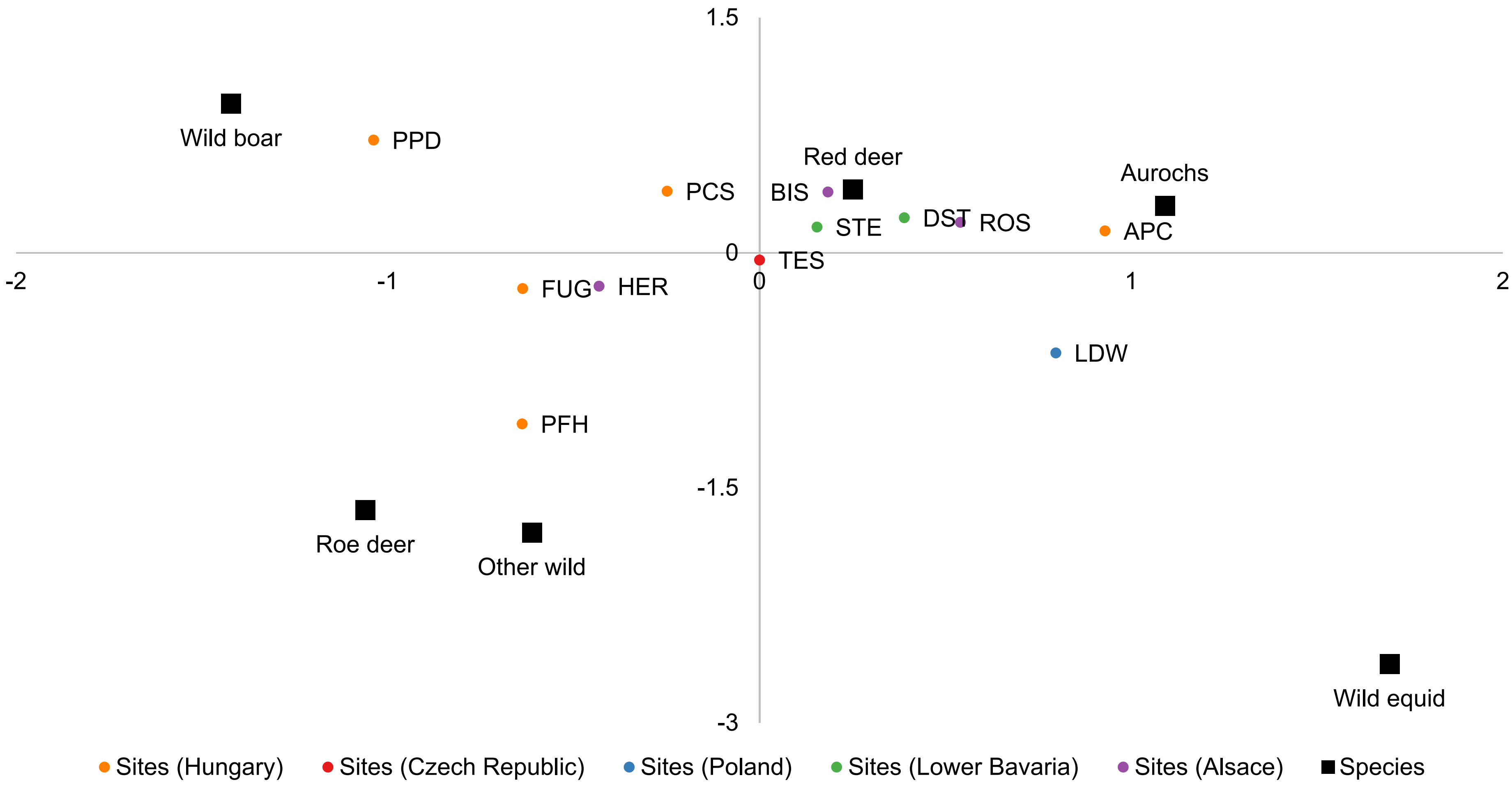

Figure 16.6: Correspondence analysis of all sites based on the relative proportions of each wild species (%NISP). Sites are coloured based on region.

While it is possible that proportions of wild animals relate specifically to nutrition, they alternatively and additionally may have indications for social structure and cultural preference. Domestic meat products may have been readily available and wild animals targeted despite this, perhaps as an aspect of big game hunting related to prestige (Boyle 2006). Isotopic analysis has suggested that LBK society was patrilocal (Bentley *et al.* 2012; Bentley 2013), likely with groups of high-power individuals on LBK sites (Pavlů 2012; van de Velde 1990; Květina 2010; Coudart 2015), thus hunting large mammals could elevate social standing (Bickle 2009: 137).

As sites do not clearly group regionally based on the relative proportions of wild animals (figure 16.4) this indicates that settlements targeted certain species. Nearby sites, with arguably the same access to wild species, may have exploited one species above others so as not to impeach upon another site's hunting territory or to share resources based on specialised hunting techniques. The choice of which animals to hunt could have been determined by taste preferences or other symbolic or practical value placed upon certain animals, such as fur quality. The LBK doctrines governing hunting could conceivably have been more relaxed than those determining domestic species proportions, as hunting is a less controllable, unpredictable activity. Perhaps in addition, hunting was carried out by people from indigenous hunter-gatherer societies, who may have been less constrained by LBK rules.

16.2.1.5 Species representation summary

These patterns of food animal representation fit well into patterns set out for the LBK culture by Lüning (2000: 109; Bickle and Whittle 2013: 13). While environmental determinism has been used to explain the prevalence of certain domestic animals in the past, it is highly likely that cultural decisions based both on nutrition and symbolic meaning were influential in species representation. This is especially true of cattle, with their high nutritional and symbolic value on LBK sites as producers of meat and milk. Proportions of wild animals could relate to nutritional need at times when domestic stock could not be slaughtered, and may have contributed to social stratification and prestige. Regional groups in the proportional representation of domestic species are not reflected for wild species, which suggests that domestic and wild species representation was culturally determined. Perhaps the domesticates on site were controlled by LBK decision makers, but wild animals were acquired in a more ad-hoc manner as the unpredictability of hunting demanded.

16.2.2 Butchery

Variation in the way in which a carcass is skinned, defleshed and dismembered can be connected to cultural differences in food preferences, preparation and consumption practices or social and ritual behaviour (White 1953, 1954; Lyman 1987, 1994: 296), and therefore represents variation in material culture (Milner and Miracle 2002; Seetah 2008). In this section, butchery patterns from all sites will be analysed by element (figures 16.7-16.24, table 16.3), and presented as typical trends in butchery at carcass level for bovinae (figure 16.26) and suidae (figure 16.27). The number of specimens represented in each butchery diagram can be found in table 16.3.

Table 16.3: Number of specimens with recordable butchery episodes of bovinae (BOS), suidae (SUS), caprines (CAP), cervids (CER) and equids (EQ) per element per site, corresponding to figures 16.7-16.24. PID = partially identifiable.

Element		Sp.	FUG	PPD	PFH	APC	TES	LDW	STE	DST	HER	BIS	ROS	PCS	Total
Mandible		BOS	1		1		3	5	1			1		1	13
		SUS			2		1	4	1		1				9
		CER									1			1	2
		PID												2	2
Vertebrae	Atlas	PID							1		1				2
	Axis	PID		1			1				1				3
	Cervical	PID					2		1		2				5
	Thoracic	PID		1			2				1				4
	Lumbar	PID				1	2				2				5
Pelvis		PID	1	1	2	1	1		1		1			1	9
Scapula		BOS	2	5	2	2	3	8	1		5	1		1	30
		SUS		3					1		5			2	11
		CER		1							1			4	6
Humerus		BOS		1	3	4	1	12	2	1	9	1		5	39
		SUS		3							4			10	17
		CAP				1									1
		CER							1		1			10	12
Radius and ulna		BOS	3	7	2	4		17	2	1		1		7	44
		SUS		3				1	3		1			5	13
		CAP						1			1				2
		CER						1			3			2	6
		EQ						1							1
Femur		BOS	1		1			10	1		1	1		1	16
		SUS						1	1		4				6
		CAP			1						2				3
		CER		1											1
Tibia		BOS		1				5						3	9
		SUS	1		1			1				1		3	7
		CAP						1							1

	CER					1				1			3	5
Calcaneum	BOS	1	1		1	1	3	1		2	1		3	14
	SUS		2							3			2	7
	CER		1											1
Astragalus	BOS		1	1	4	1	6	1		4			2	20
	SUS									5			1	6
	CAP	1												1
	CER						1			1				2
Naviculo-cuboid	BOS				1		1	1	1	3				7
Metacarpal	BOS		2	2			5	2	1	1			3	16
	SUS		3	1						7	1			12
	CAP				1		2		1	1				5
	CER		2										2	4
Metatarsal	BOS	2	1	1	2	1	4	3		2			2	18
	SUS		1	1			3			5	2			12
	CER						1	1						2
Phalanges	BOS	2	3	1			7	6		2			1	22
	CAP			1										1
	CER							2					2	4

16.2.2.1 Element butchery

16.2.2.1.1 Axial skeleton

Butchery on the skull was only recorded on fully identifiable fragments of bucrania, resulting in butchery patterns that largely correspond to skinning. Incisions on the parietal bone circling around horn cores are highly suggestive of this activity, well represented at Herxheim (figure 12.12). Butchery on the mandible reflects defleshing of the masseter muscle on the buccal surface and the *mylo-hyoid* muscle on the lingual surface for removal of the tongue (figure 16.7; Binford 1981: 109). On the mandibular ramus, butchery could result from disarticulation of the mandible from the skull (*ibid.*), which was not evident in suidae (see figure 16.26).

Butchery on the cervical vertebrae suggests removal of the head and stripping of neck meat (figure 16.8; Binford 1981). On the thoracic vertebrae, practices such as defleshing the tenderloin, rib removal and segmentation of the vertebral column were represented (figure 16.9; *ibid.* 111). Tenderloin butchery is reflected again in the lumbar vertebrae on the dorsal spines and transverse processes, and segmentation is likely represented on vertebral bodies (*ibid.*). On the pelvis, disarticulation of the hindlimb is indicated by marks clustering around the acetabulum (*ibid.* 116, figure 16.10). Butchery on the iliac wings could indicate removal of the sacrum from the pelvis (*ibid.*)

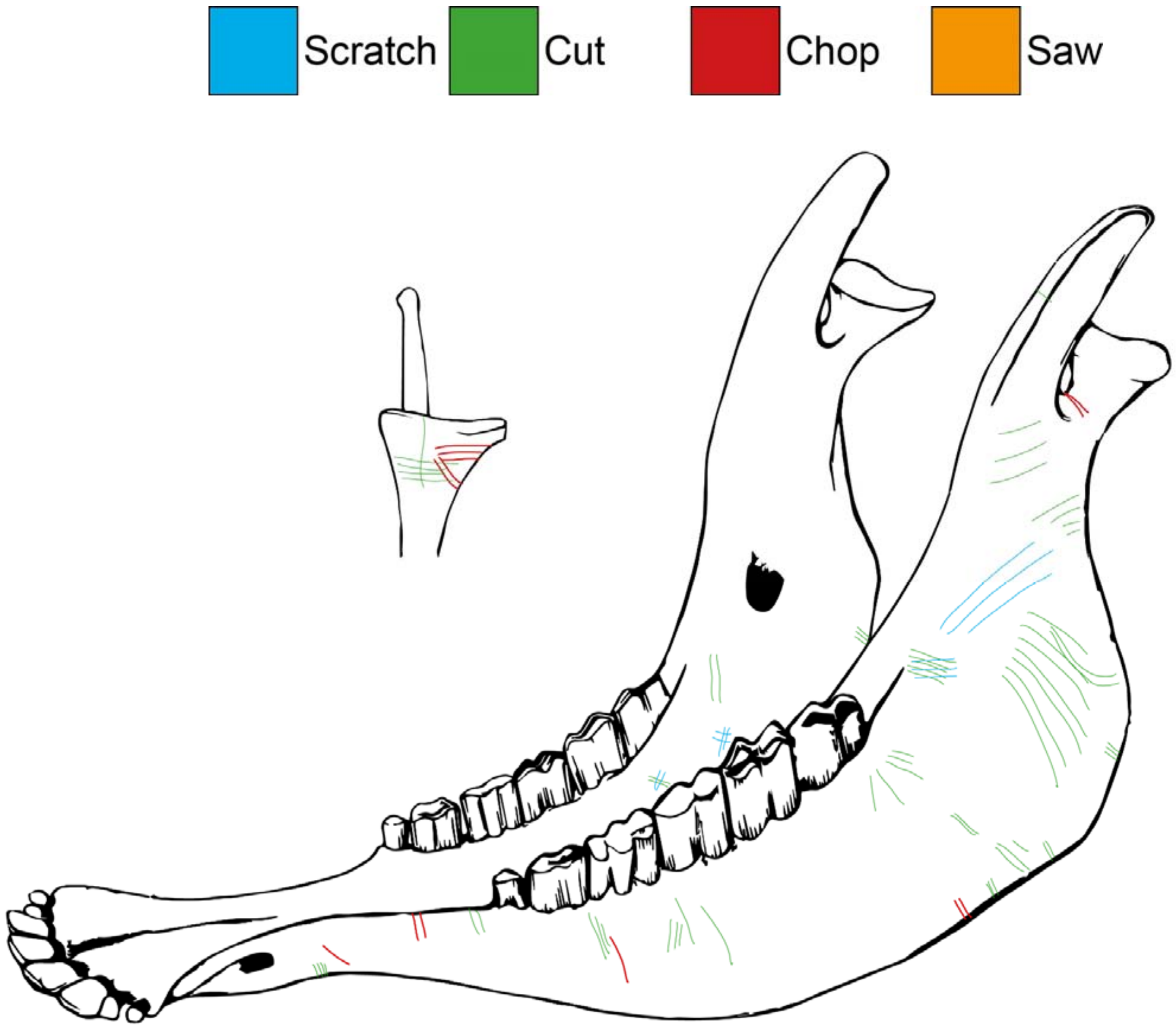

Figure 16.7: Cumulative diagram of butchery on the mandible (n=26) from all species and sites. Posterior (top) and lateral views.

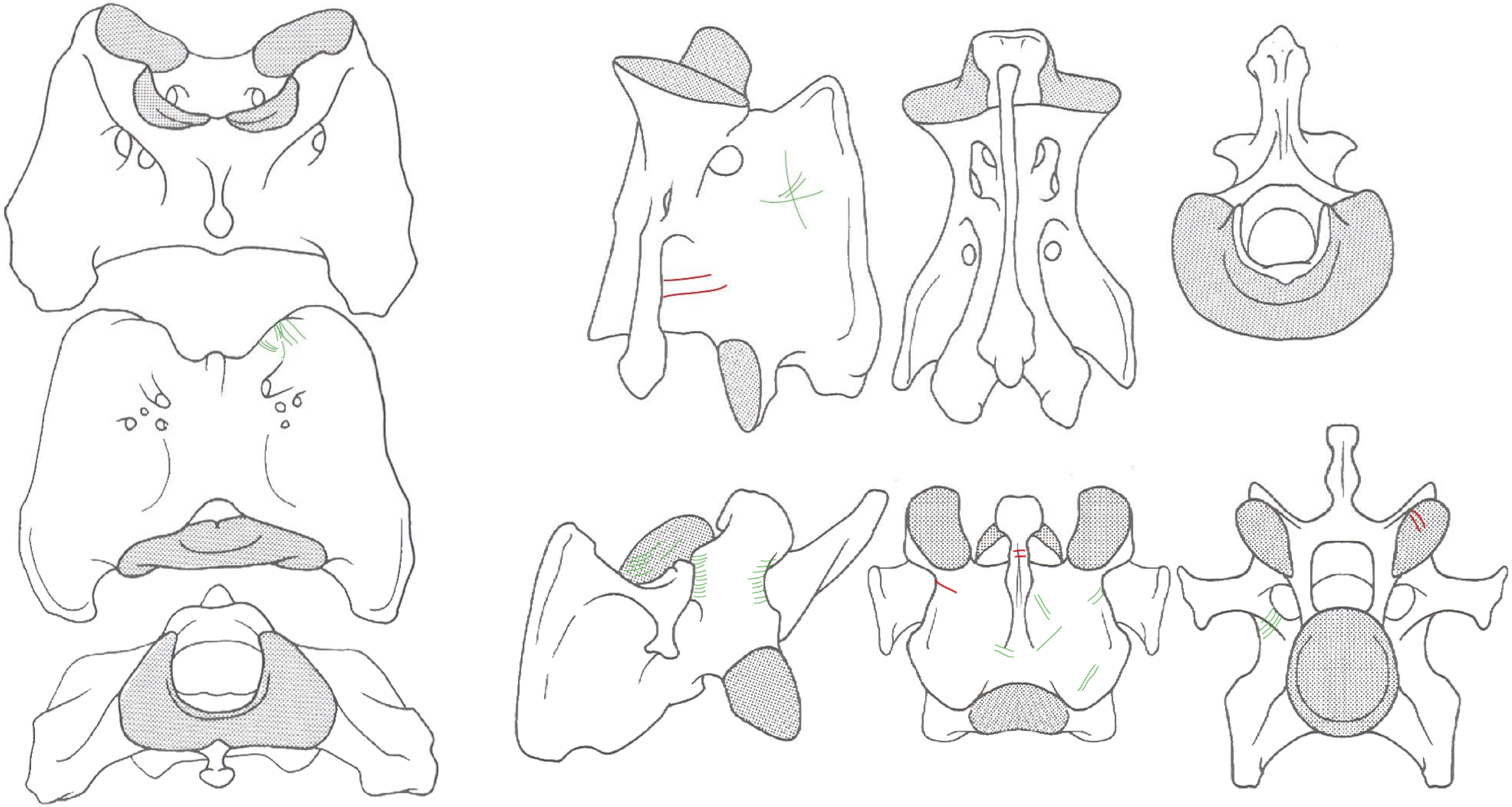

Figure 16.8: Cumulative diagram of butchery the atlas (left; ventral, dorsal and caudal views; n=2), axis (top right; lateral, dorsal and cranial views; n=3) and all other cervical vertebrae (bottom right; n=5) of all species and sites.

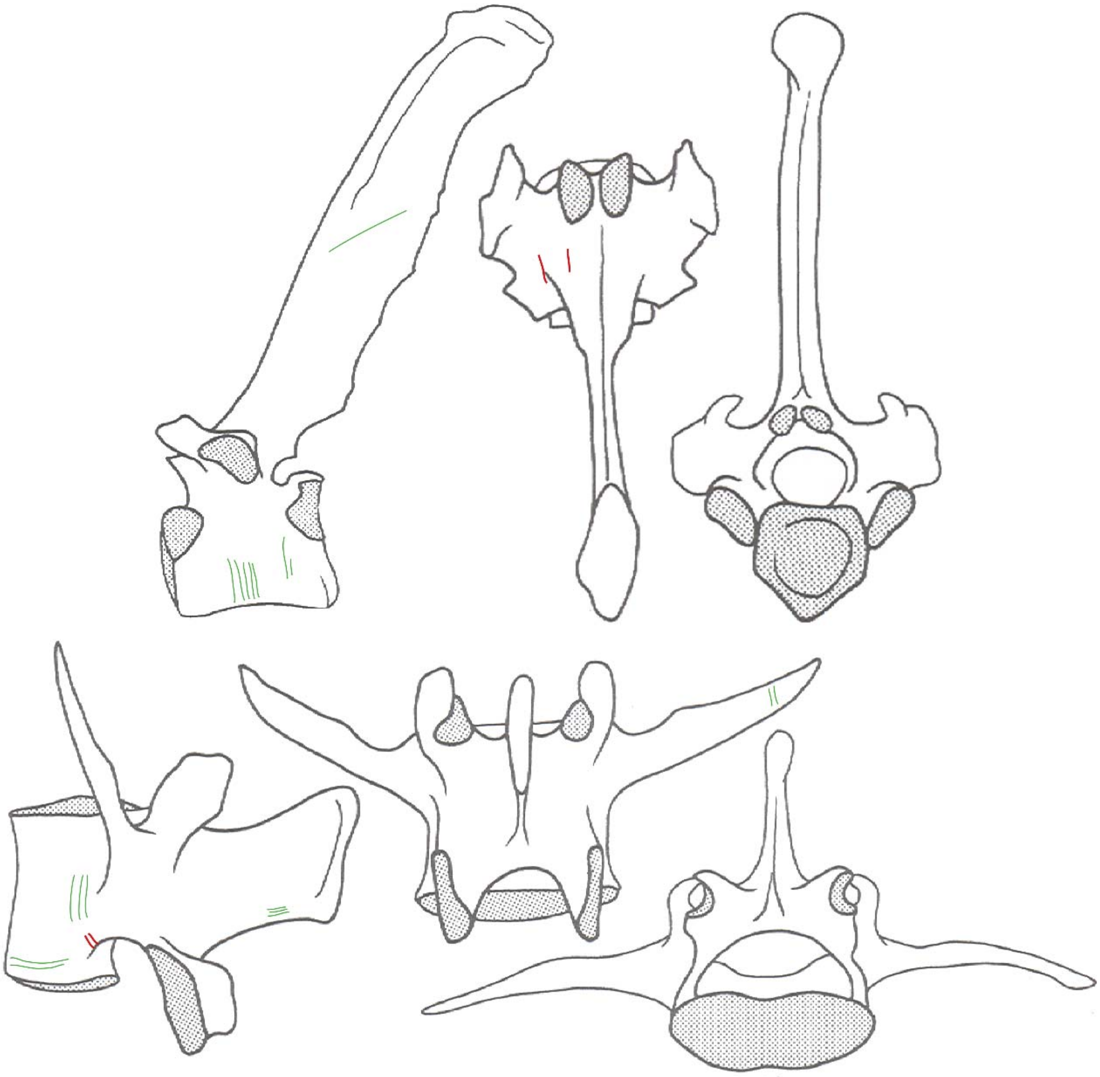

Figure 16.9: Cumulative diagram of butchery on thoracic (top; n=4) and lumbar (bottom; n=5) vertebrae from all species and sites. Left to right; lateral, dorsal and caudal views.

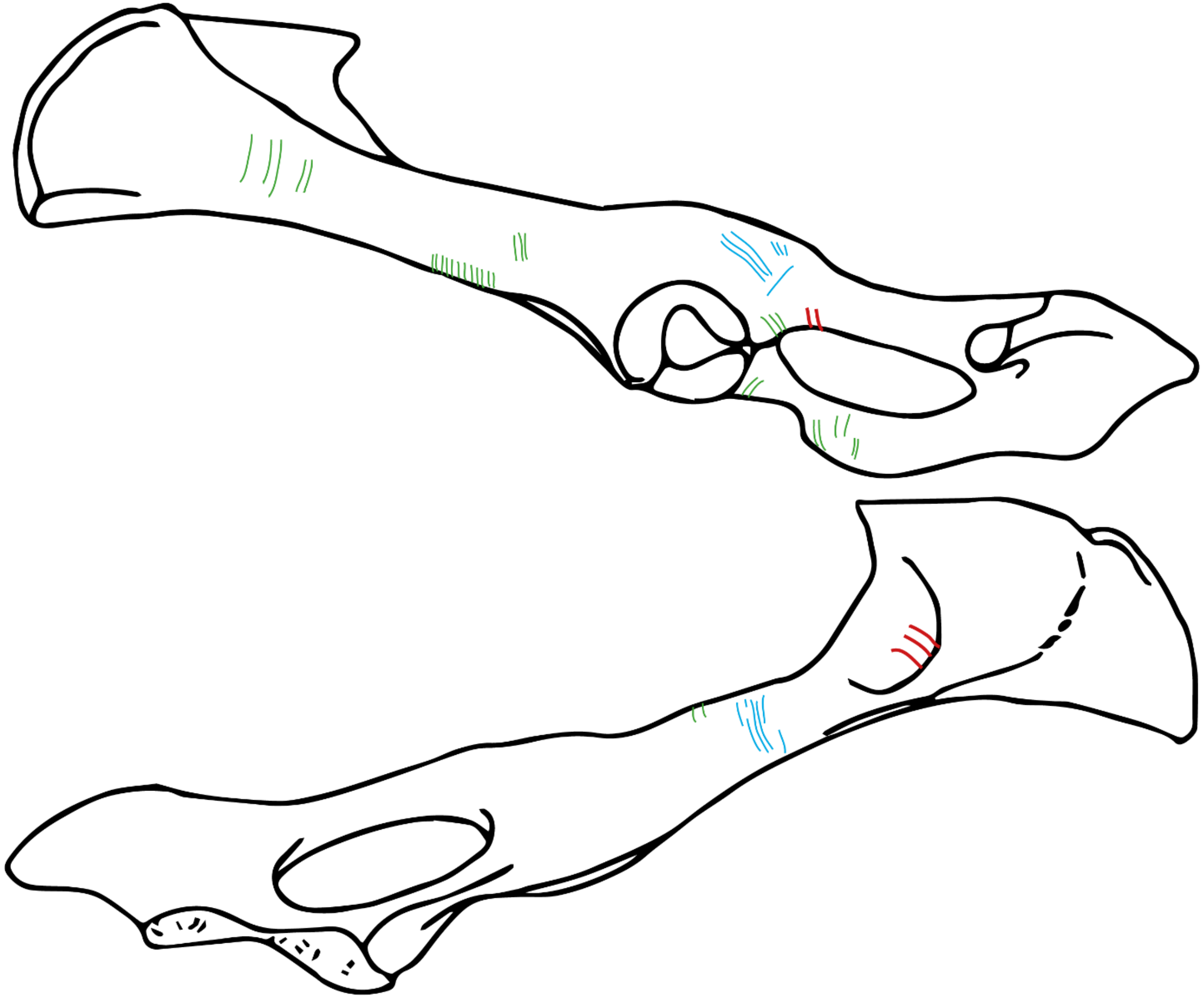

Figure 16.10: Cumulative diagram of butchery on the pelvis (n=9) from all species and sites. Lateral (top) and medial views.

16.2.2.1.2 Forelimb

Butchery patterns on the medial surface of artiodactyl scapula (figures 16.11 and 16.12) largely suggest defleshing (Soulier and Costamagno 2017). Most marks were horizontal in trajectory, although longitudinal cut marks better following the muscle anatomy were also noted on suidae. At the neck and glenoid cavity butchery could reflect dismemberment of the humerus, targeting the insertion of the *biceps brachii* muscle (Binford 1981: 122). This butchery pattern was not present on suid scapulae, suggesting that disarticulation of the scapula and humerus was less common in suidae than in ruminants.

Separation of the humerus from the scapula was reflected in some butchery patterns at the proximal articulation of ruminant humeri (figure 16.13; Soulier and Costamagno 2017; Binford 1981: 123), but due to poor preservation of the proximal articulation butchery marks cluster at the distal epiphysis and shaft. Disarticulation of the humerus from the radius and ulna is strongly represented on the distal epiphysis, a trend commonly found throughout the sites studied (figure 16.13 and 16.14). Cut marks on all faces of the distal articulation reflect this practice, which removes the less meat-rich radius and ulna (Soulier and Costamagno 2017; Binford 1981: 123). Repeated, transverse butchery episodes at midshaft indicate defleshing of the humerus and possibly removal of the periosteum for marrow processing (*ibid.*). These marks were particularly common at Polgár-Csőszhalom, where marrow processing was intensive.

Unsurprisingly, butchery on the radius and ulna reflects the disarticulation of the humerus on the medial olecranon process of the ulna and proximal articulation of the radius (figures 16.15 and 16.16; Soulier and Costamagno 2017). The prevalence of butchery on the posterior face of the olecranon suggests approaching disarticulation of the elbow from the rear of the joint (Binford 1981: 124). Other butchery at the proximal articulations of the radius and ulna indicates defleshing at insertion points of muscles on the humerus, and defleshing and possibly periosteum stripping on the radius shaft (Soulier and Costamagno 2017). Disarticulation of the carpals and metacarpals of the radius was occasionally suggested by butchery at the distal articulation of the radius of ruminants, but was absent from suid radii. This could also be a result of poor preservation of the late-fusing distal epiphysis in the generally juvenile pigs.

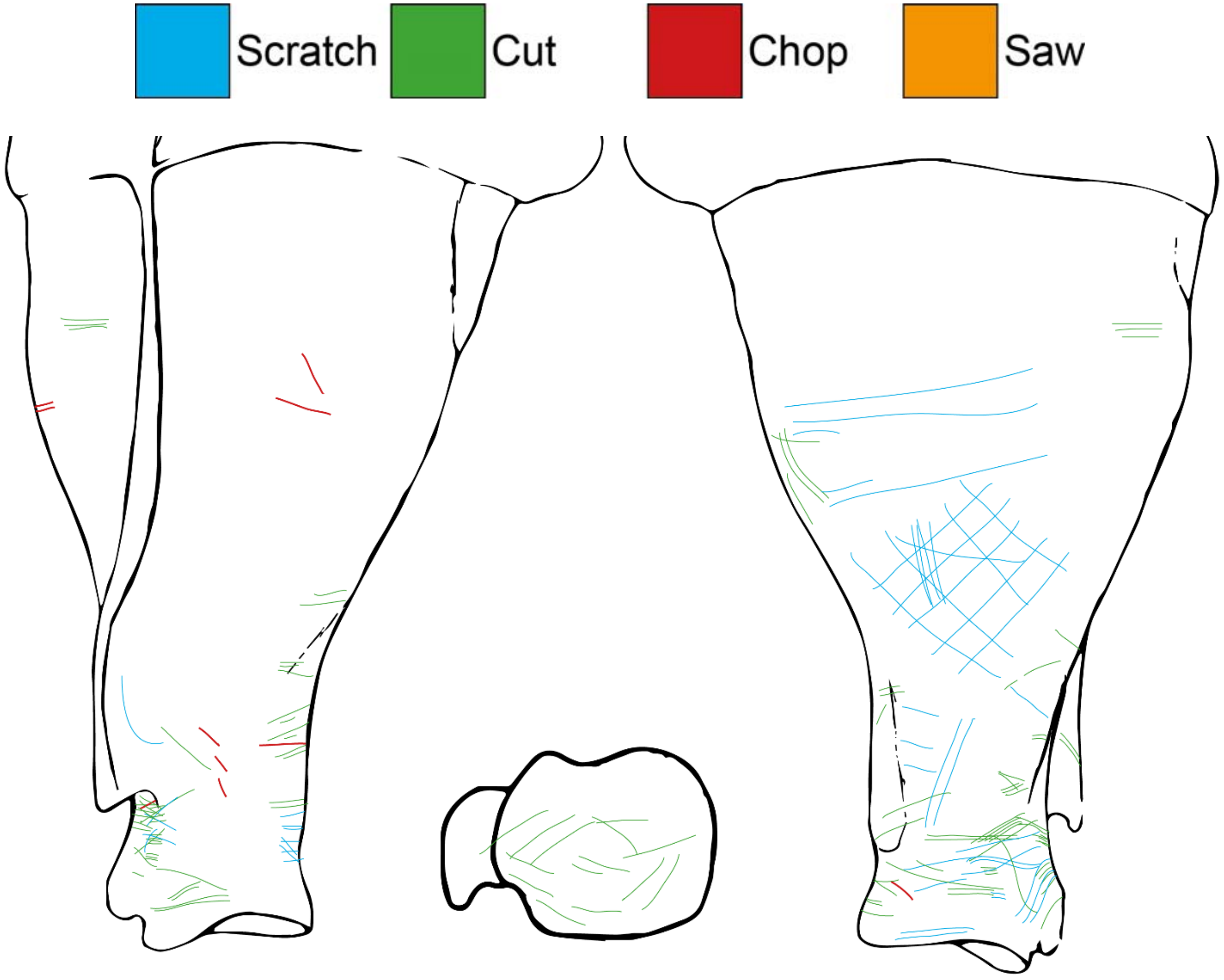

Figure 16.11: Cumulative diagram of butchery on ruminant scapulae (n=36) from all sites. Left to right; lateral, distal and medial views.

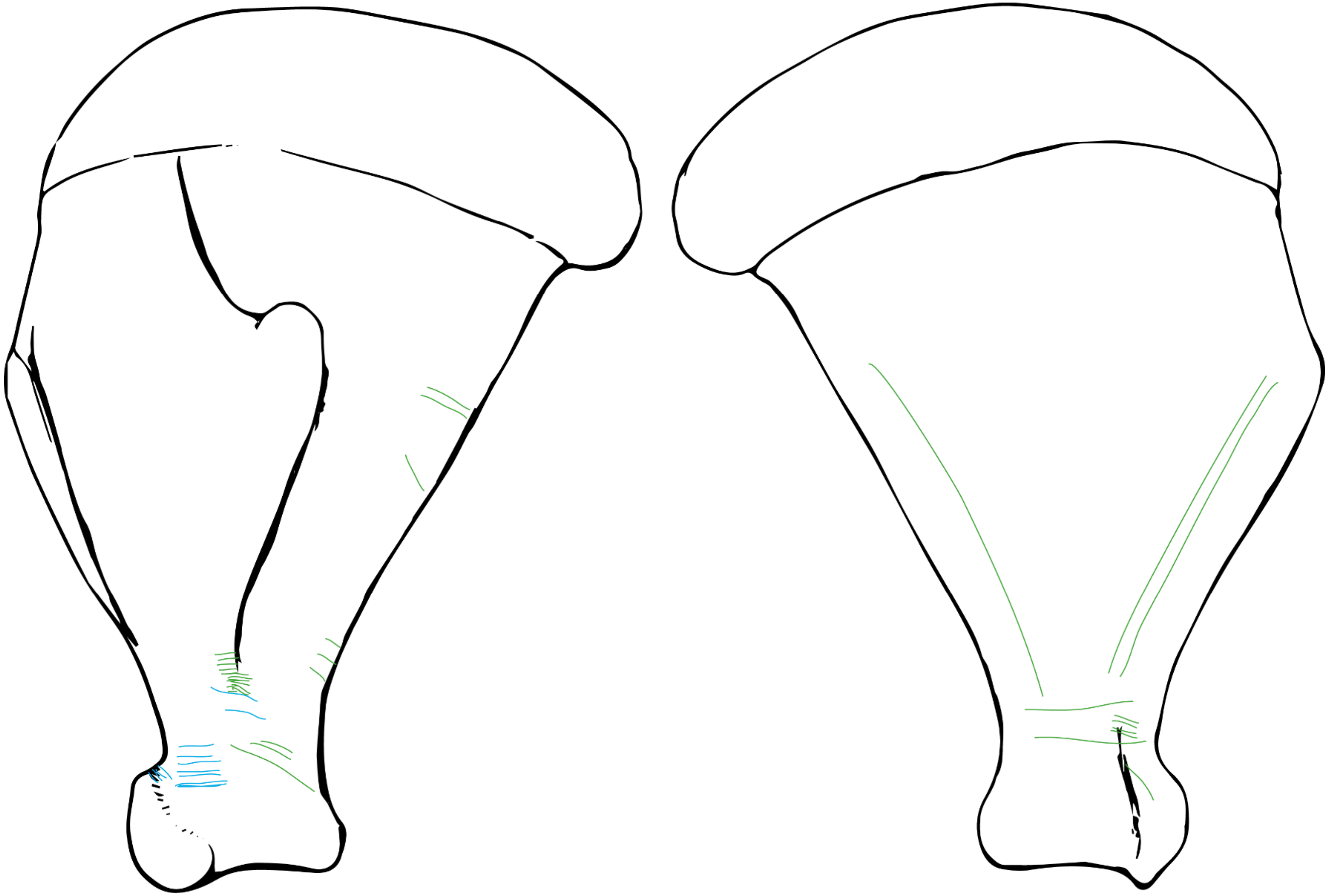

Figure 16.12: Cumulative diagram of butchery on suid scapulae (n=11) from all sites. Lateral (left) and medial views.

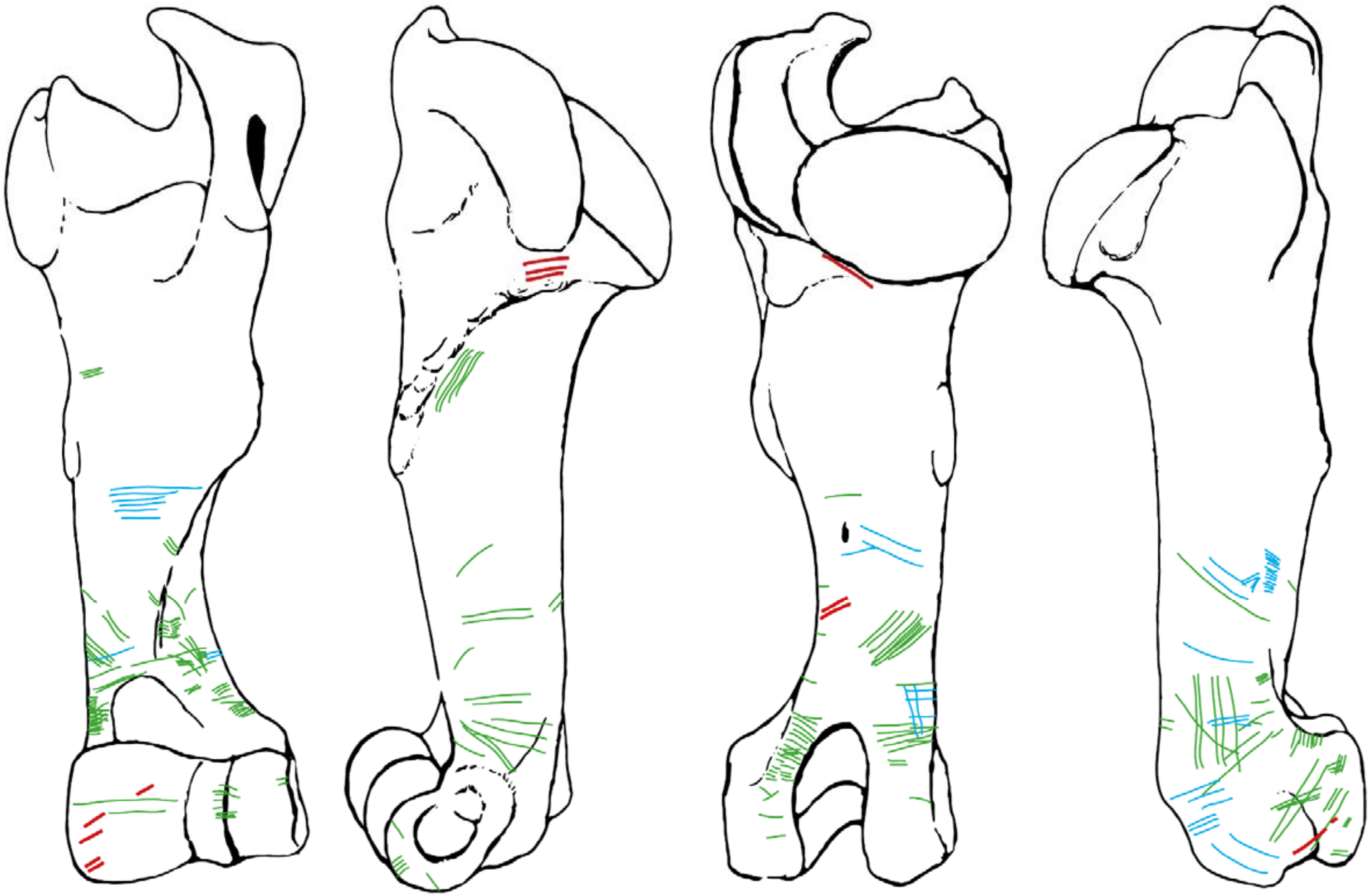

Figure 16.13: Cumulative diagram of butchery on ruminant humeri (n=52) from all sites. Left to right; anterior, lateral, posterior and medial views.

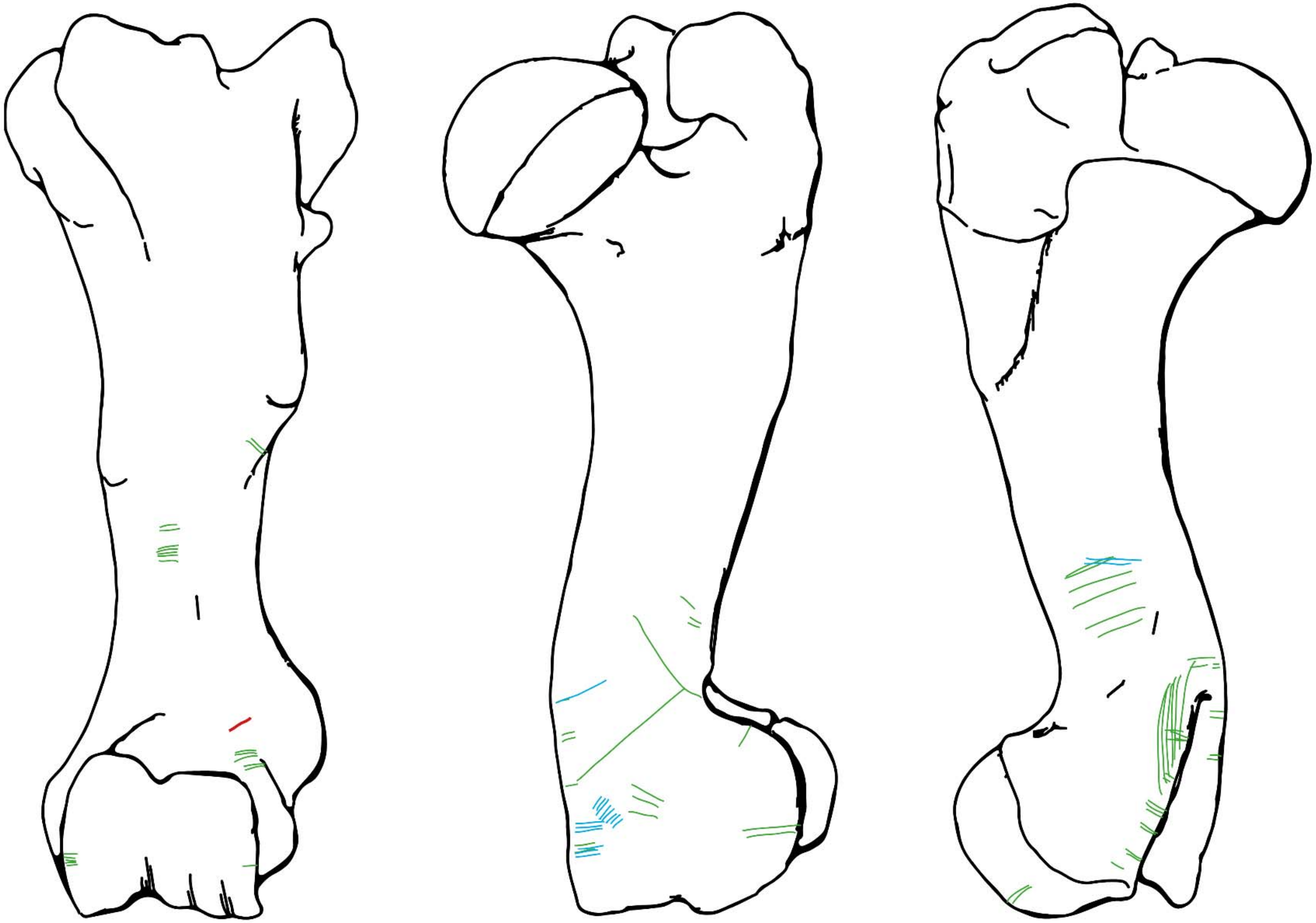

Figure 16.14: Cumulative diagram of butchery on suid humeri (n=17) from all sites. Left to right; anterior, medial and lateral views.

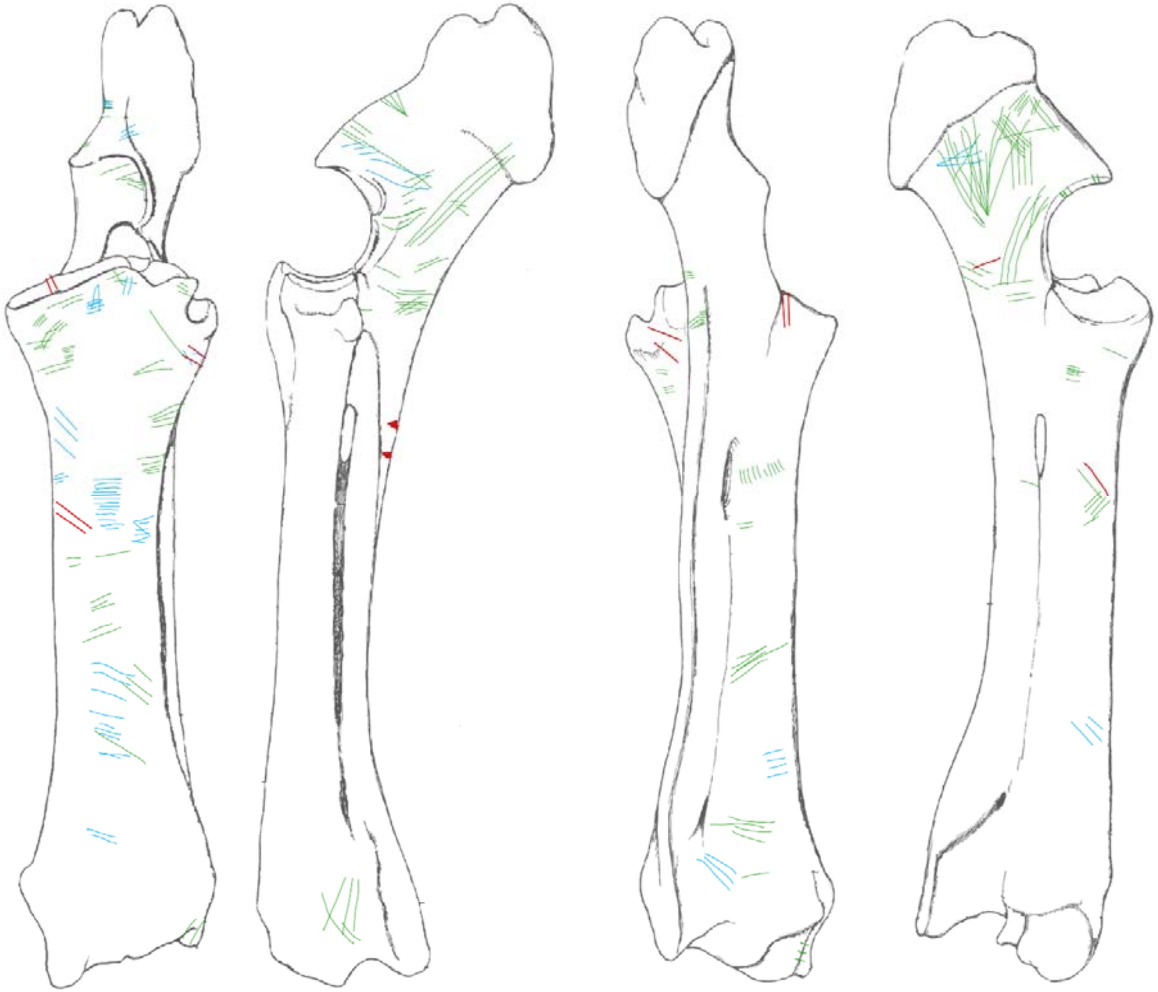

Figure 16.15: Cumulative diagram of butchery on ruminant radii and ulnae (n=53) from all sites. Left to right; anterior, lateral, posterior and medial views.

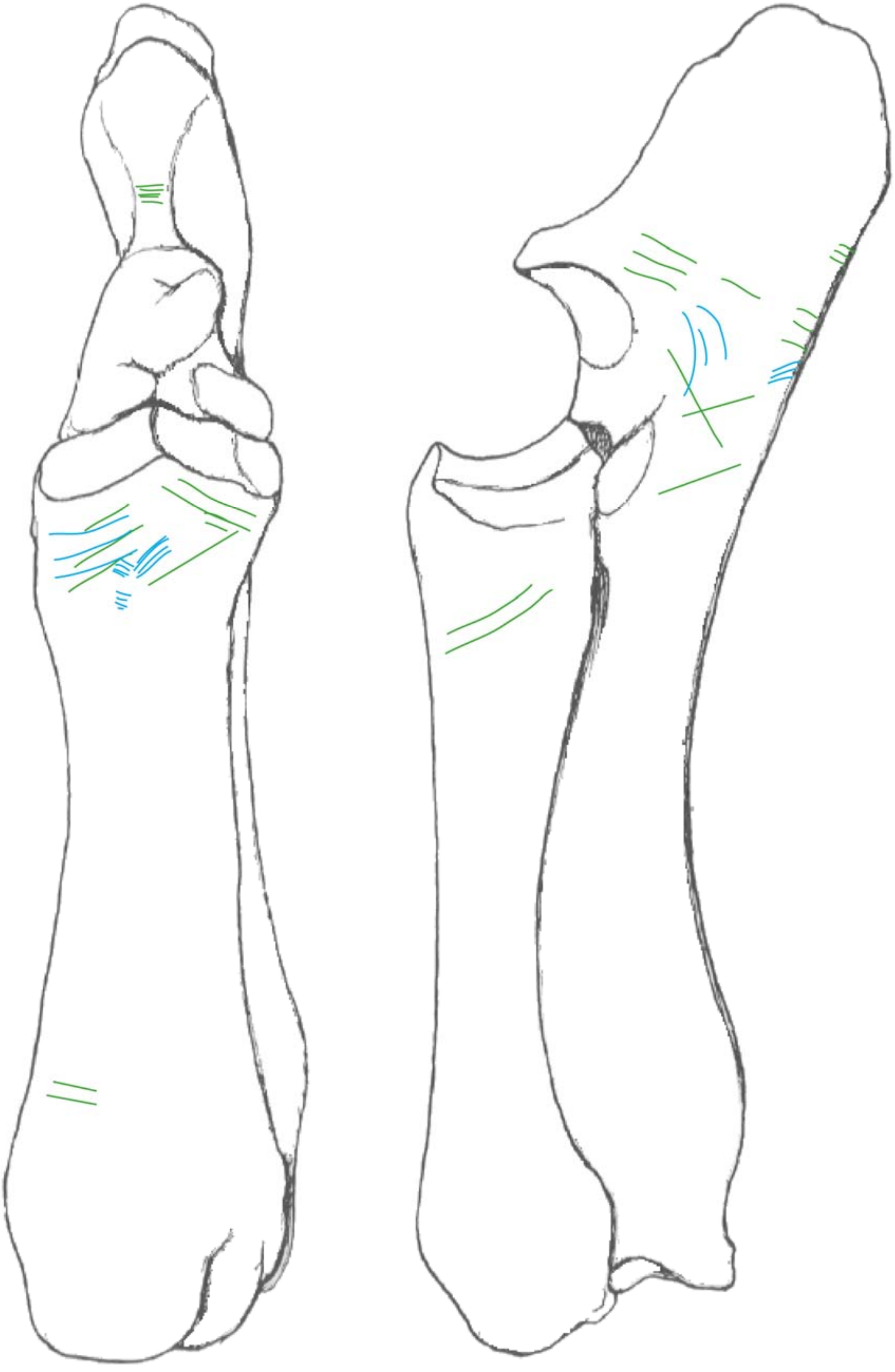

Figure 16.16: Cumulative diagram of butchery on suid radii and ulnae (n=13) from all sites. Anterior (left) and lateral views.

16.2.2.1.3 Hindlimb

Butchery on the proximal femur reflects dismemberment butchery on the pelvis due to removal of the hindlimb (figure 16.17). Butchery indicating disarticulation was also present on the distal epiphysis and femoral shaft, with further marks on the diaphysis suggesting muscle stripping and defleshing (Binford 1981: 177; Soulier and Costamagno 2017). Defleshing is also indicated by butchery patterns on the tibia (figure 16.18; Soulier and Costamagno 2017), and it is likely that disarticulation butchery of this element targeted the distal femur and the tarsals rather than the tibia itself.

Butchery on the tarsals, particularly the astragalus (figures 16.19 and 16.20) and navicular cuboid (figure 16.21), presents a strong pattern for disarticulation of the metapodia and phalanges from many sites. This includes Rosheim *Sainte-Odile*, which was not represented in the butchery diagrams. The horizontal cut, chop and scratch marks across the anterior face of bovine and suid astragali is typical of this disarticulation butchery (Soulier and Costamagno 2017). On the calcaneum it is likely that many butchery practices are represented, including skinning, dismembering and defleshing. Skinning and dismemberment butchery largely clusters around the *sustentaculum tali* and the distal portions of the calcaneum, whereas defleshing butchery more often affects the area above the *sustentaculum tali* and the *tuber calcanei* (Soulier and Costamagno 2017).

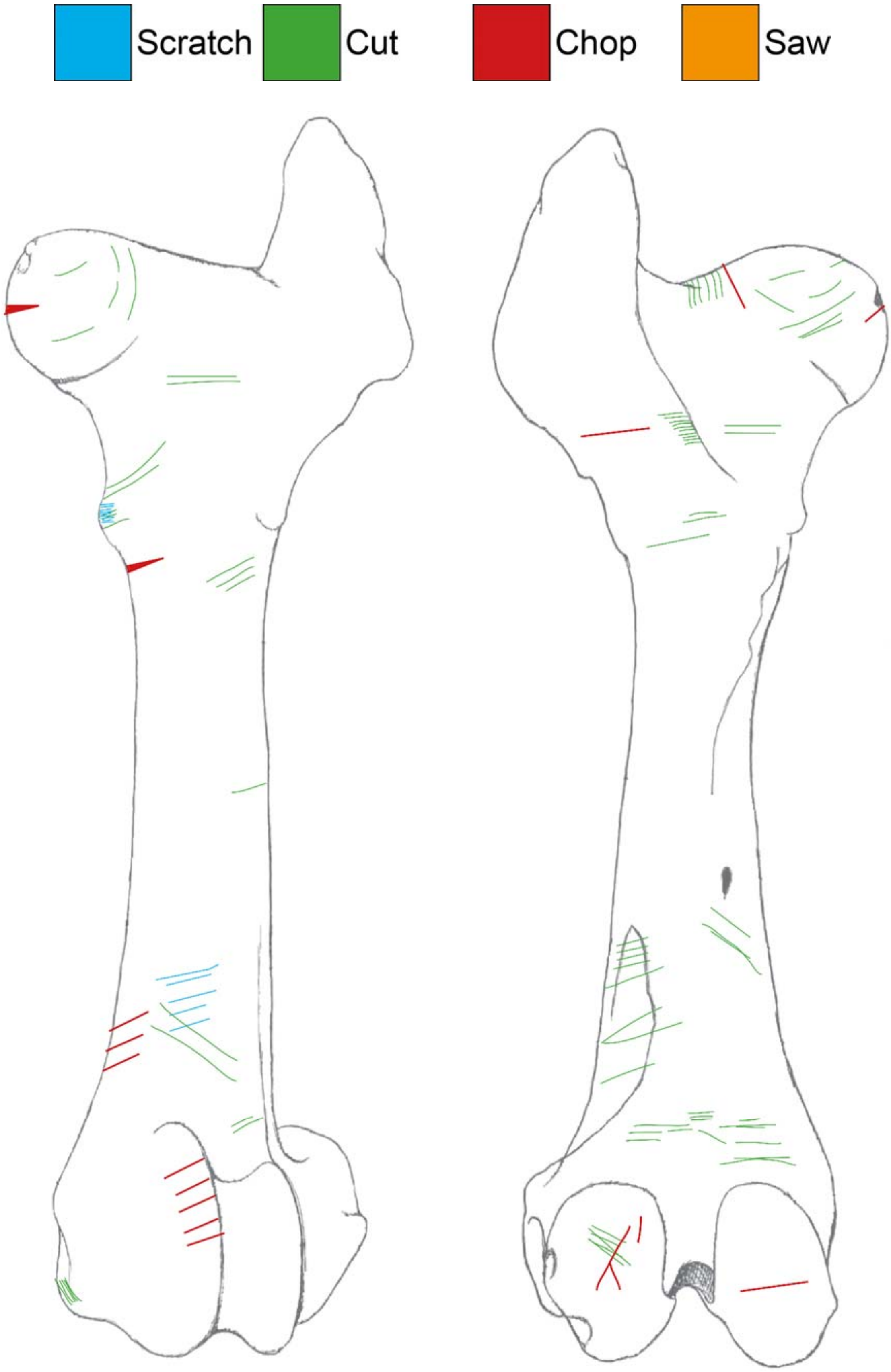

Figure 16.17: Cumulative diagram of butchery on the femur (n=26) from all species and sites. Anterior (left) and posterior views.

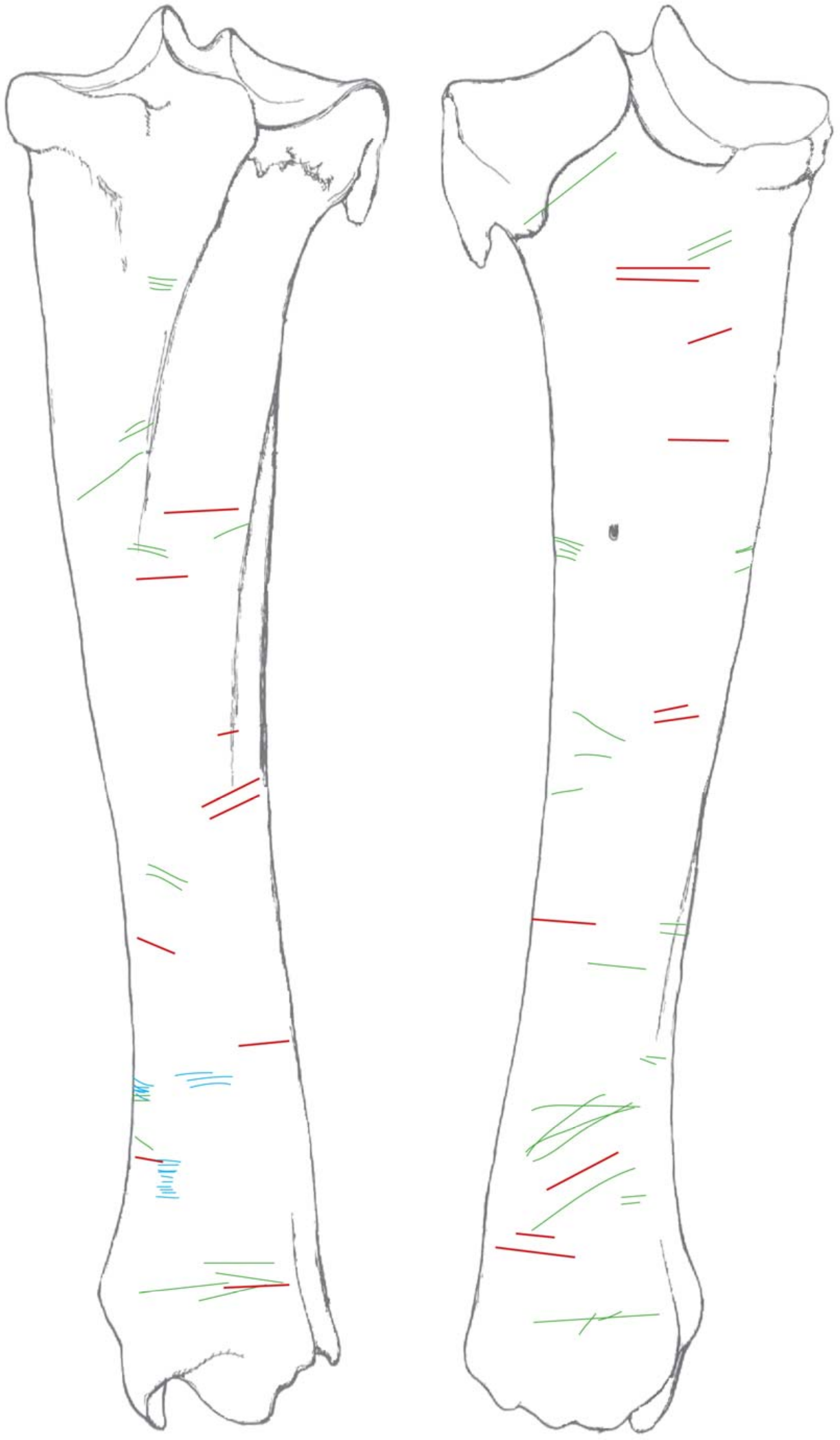

Figure 16.18: Cumulative diagram of butchery on the tibia (n=22) from all species and sites. Anterior (left) and posterior views.

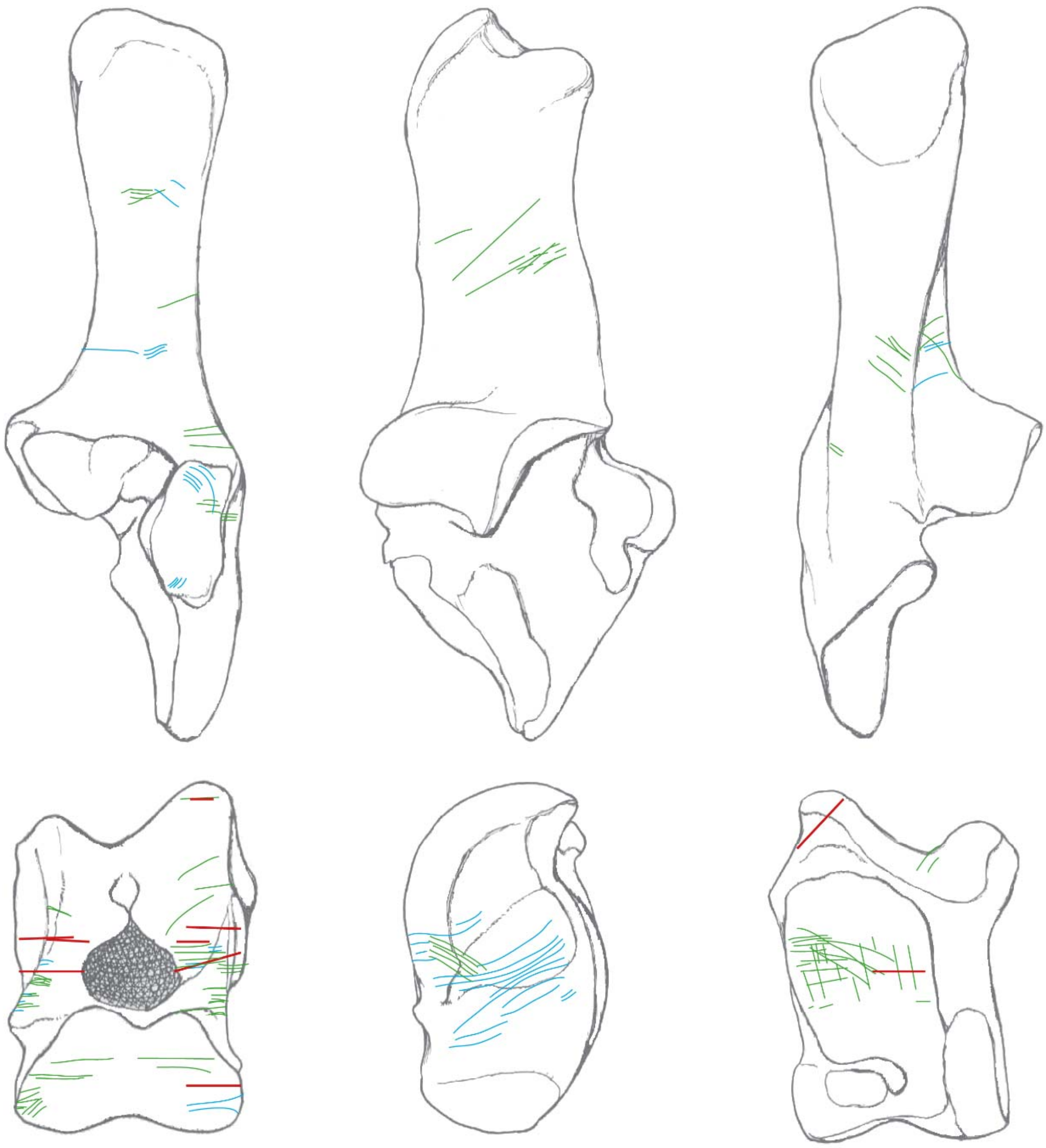

Figure 16.19: Cumulative diagram of butchery on ruminant calcanei (top, n=15) and astragali (n=23) from all sites. Left to right; anterior, medial and posterior views.

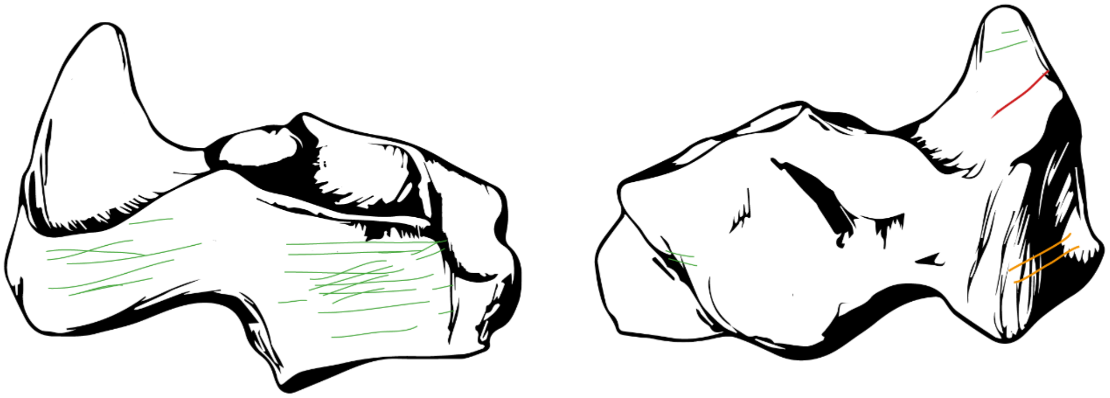

Figure 16.20: Cumulative diagram of butchery on bovine navicular cuboids (n=7) from all sites. Anterior (left) and posterior views.

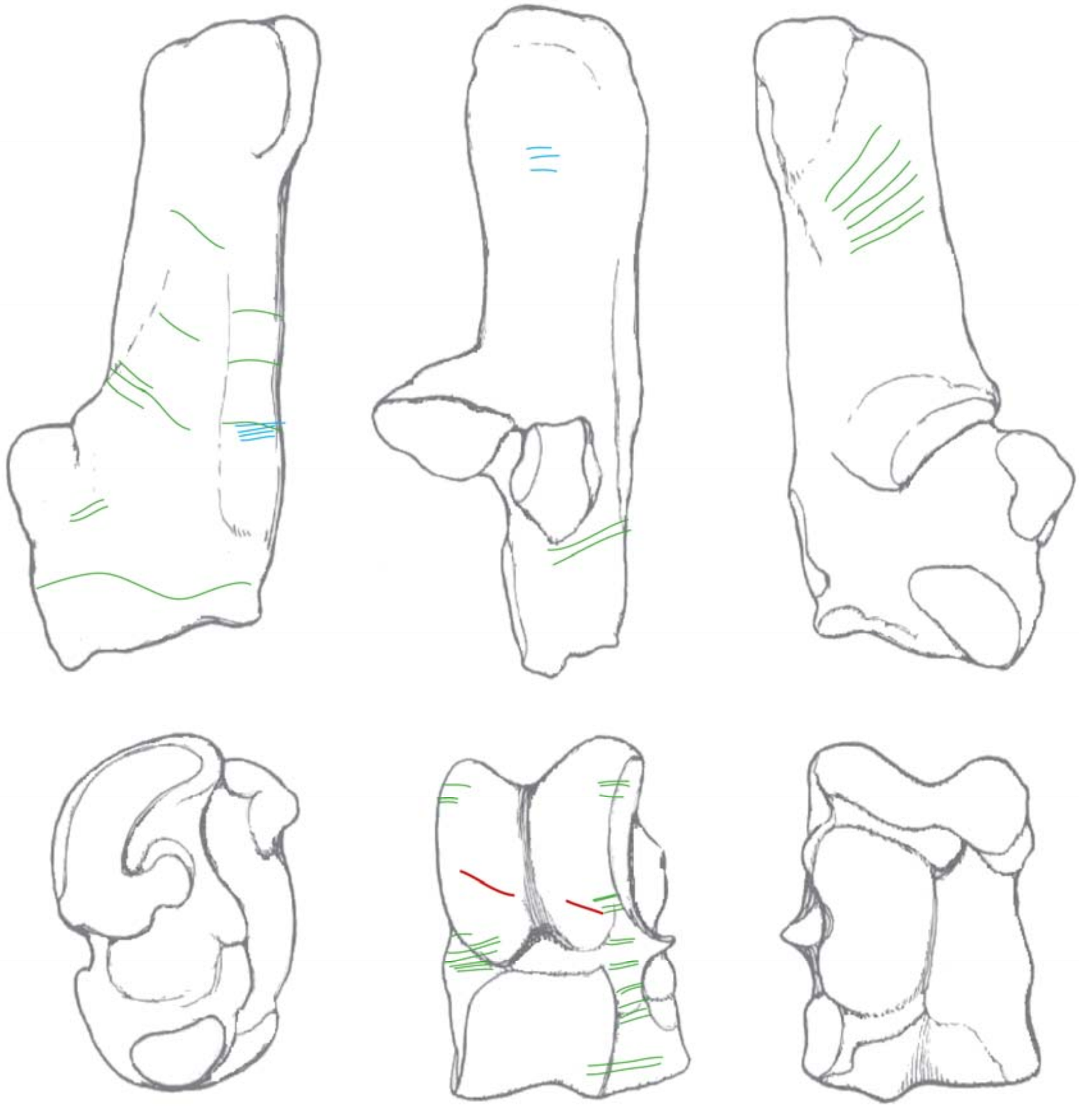

Figure 16.21: Cumulative diagram of butchery on suid calcanei (top, n=7) and astragali (n=6) from all sites. Left to right; anterior, medial and posterior views.

16.2.2.1.4 Extremities

Skinning was the most prevalent butchery pattern indicated on ruminant metapodia, with horizontal incisions favoured more than longitudinal (figure 16.22; Soulier and Costamagno 2017). Butchery marks at the proximal and distal epiphysis could result from disarticulation, and were particularly common on the metatarsal. It is possible that some butchery marks on the shaft of ruminant metapodia could be due to tendon removal (Soulier and Costamagno 2017; Binford 1978). Tendons can be used to make glue, thread, or ropes, or for consumption (Soulier and Costamagno 2017: 798). Suid metapodia show butchery evidence related to skinning, with horizontal multiple butchery episodes affecting the anterior faces (figure 16.23).

Butchery on the phalanges could similarly represent skinning, dismemberment and tendon removal (figure 16.24; Soulier and Costamagno 2017). Butchery on the first phalanx reflects disarticulation from the metapodia on the proximal articulation. The distal articulation of phalanx one and the proximal articulation of phalanx two featured evidence of skinning practices (*ibid.*). Butchery at midshaft and on the distal condyle of the first phalanx possibly indicates tendon removal (*ibid.*).

Figure 16.22: Cumulative diagram of butchery on ruminant metacarpals (n=25) and metatarsals (n=20) from all sites. Left to right; anterior, lateral and posterior views.

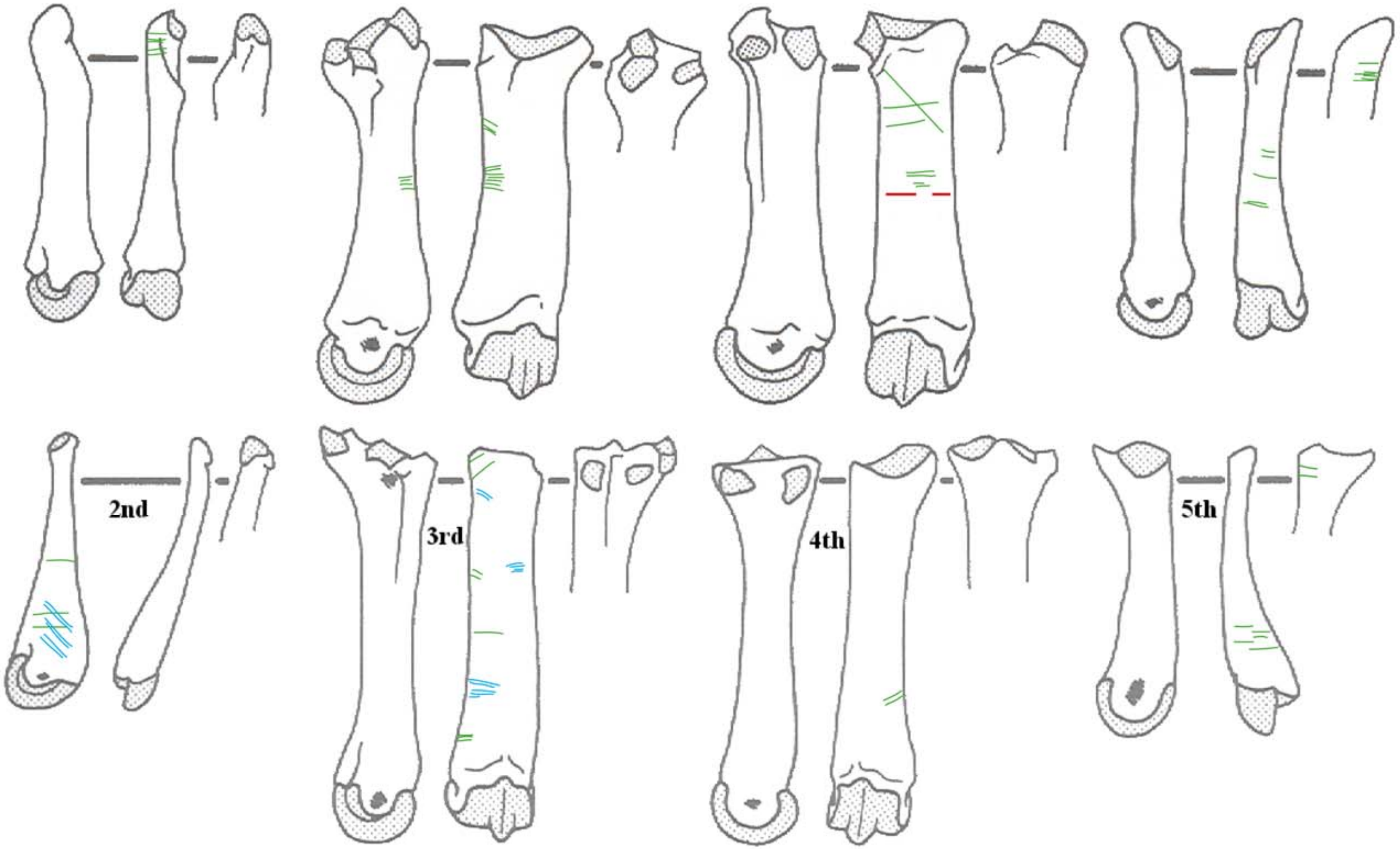

Figure 16.23: Cumulative diagram of butchery on suid metacarpals (top, n=12) and metatarsals (n=12) from all sites. Left to right; medial, anterior and lateral views.

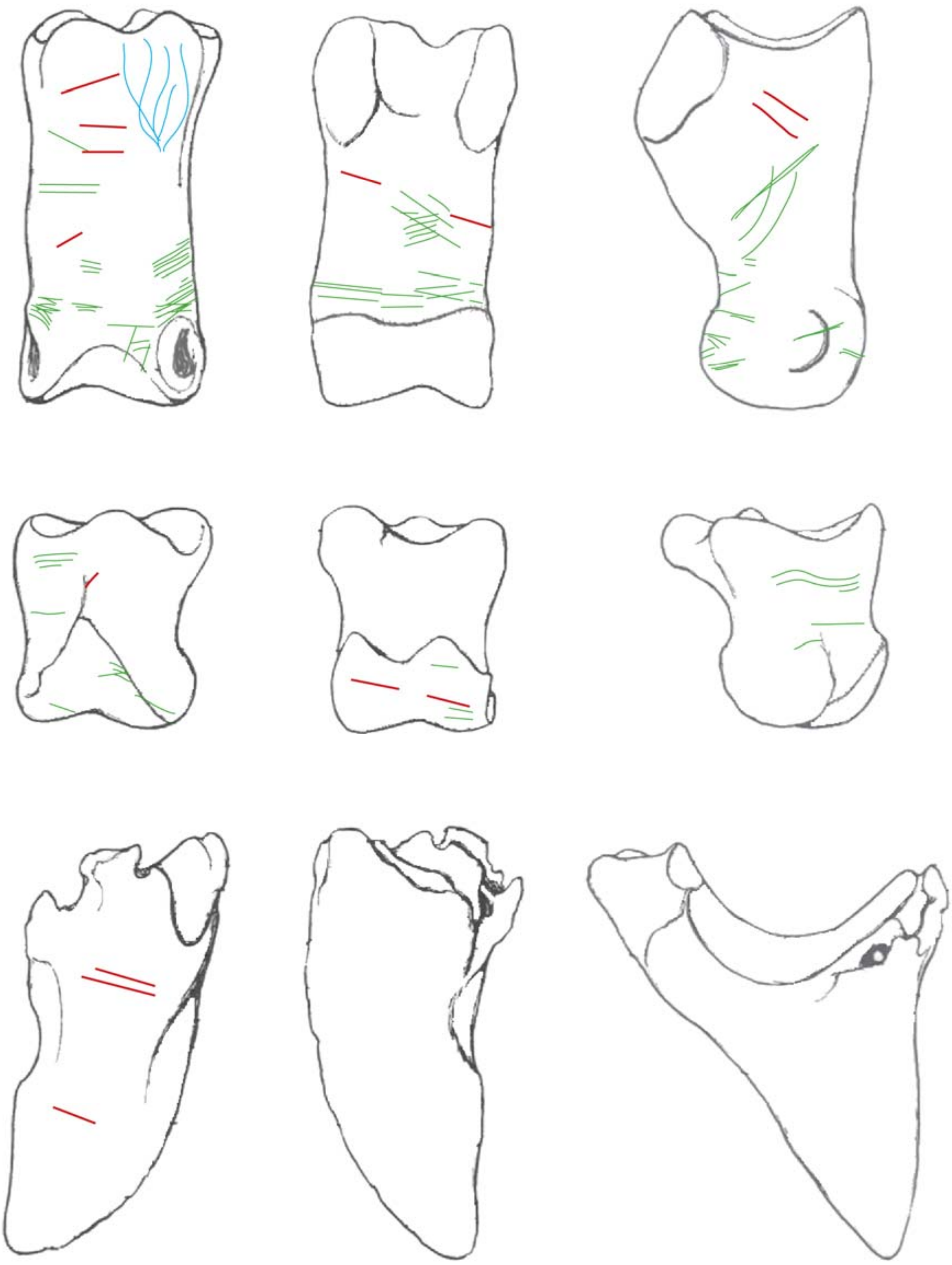

Figure 16.24: Cumulative diagram of butchery on first (top), second (middle) and third (bottom) phalanges (n=27) from all species and sites. Left to right, dorsal, plantar and axial views.

16.2.2.2 Carcass butchery

16.2.2.2.1 Elements

Across the carcass there was variation in butchery prevalence on different elements (figure 16.25). The most commonly butchered elements were the humerus and astragalus due to pervasive dismembering of meat-poor elements at these articulations, also reflected in butchery proportions on the radius and ulna. Meat-rich carcass portions such as the vertebrae, scapula and femur were also commonly butchered, representing muscle stripping and disarticulation. The metapodia (10.0%; 77/768) were significantly more affected by butchery than the phalanges (3.4%; 32/931; $p<.001$; figure 16.25), especially considering the number of phalanges per foot compared to metapodia. This suggests skinning insertions were commonly made on the metapodia while the phalanges were removed with the hide, leaving the skin with ‘handles’ and making hide processing easier.

16.2.2.2.2 Bovine carcass

Bovine carcass butchery (figure 16.26) was reflective of butchery of all other ruminant species, which were comparatively poorly represented across the LBK (figure 16.2). Butchery patterns related to skinning were present on the cranium around the horn cores, phalanges and metapodia. In addition, some butchery on the metapodia and phalanges of ruminants could represent targeting of the tendons (Soulier and Costamagno 2017). Butchery marks related to defleshing were prevalent on all meat-bearing bones, particularly the forelimb and hindlimb. Butchery on the axial skeleton also indicated defleshing, qualitatively including the ribs although butchery was not recorded on these elements. In the case of the mandible it is likely that the masseter muscle (buccal surface) and tongue (lingual) were targeted for removal. Dismemberment butchery was present at almost every major articulation of long bones in ruminant carcasses, again particularly prevalent at the elbow and ankle, (although see section 16.2.3.2). Butchery patterns related to dismemberment were also occasionally detected at the shoulder, hip and knee joints. Butchery on the cervical vertebrae suggests removal of the head from the carcass. The mandible of bovinae was subject to butchery on the mandibular ramus, likely during detaching the mandible from the cranium.

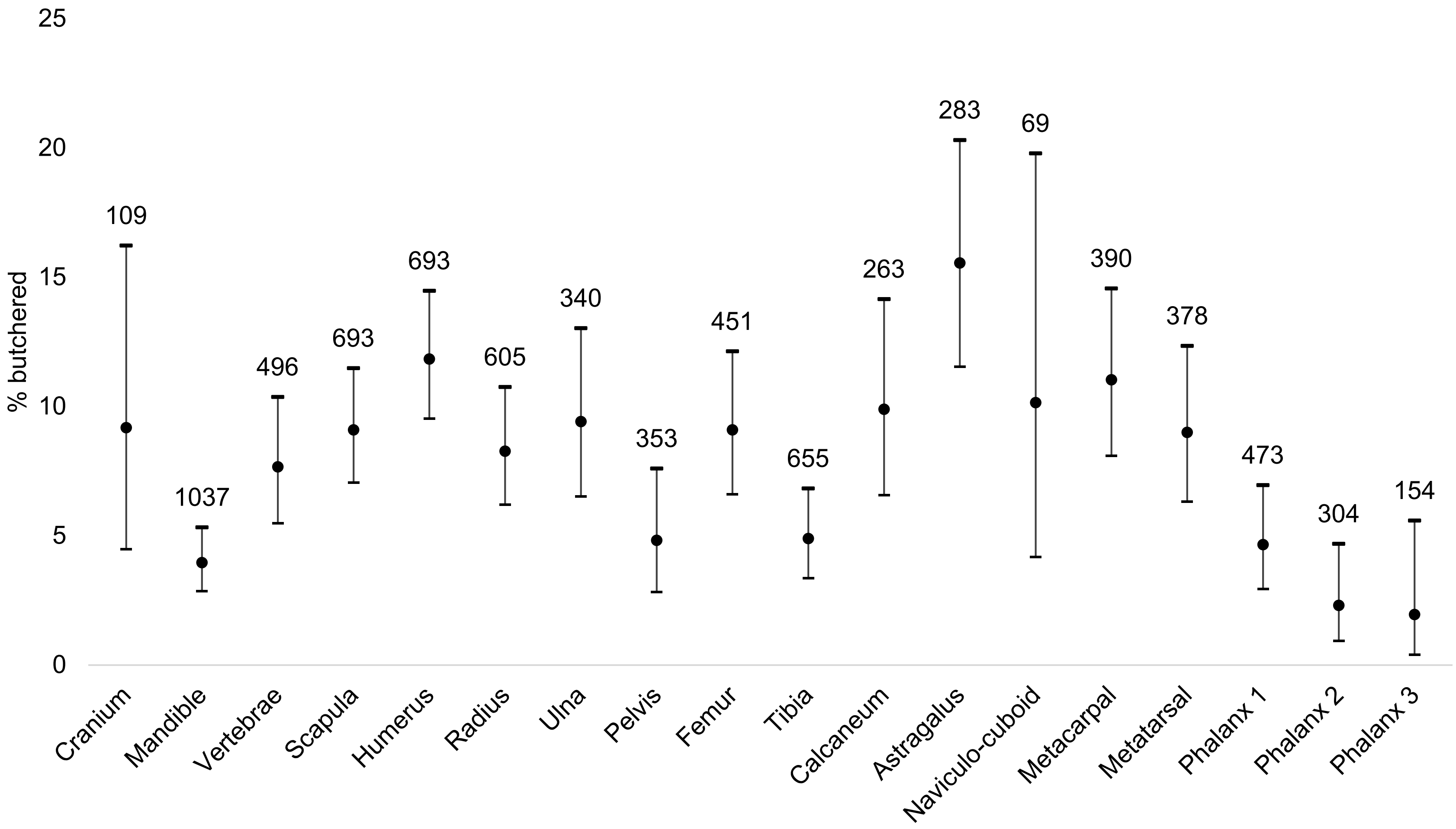

Figure 16.25: Percentage of different elements affected by butchery from all sites studied, with 95% confidence intervals. N values are at the top of each series.

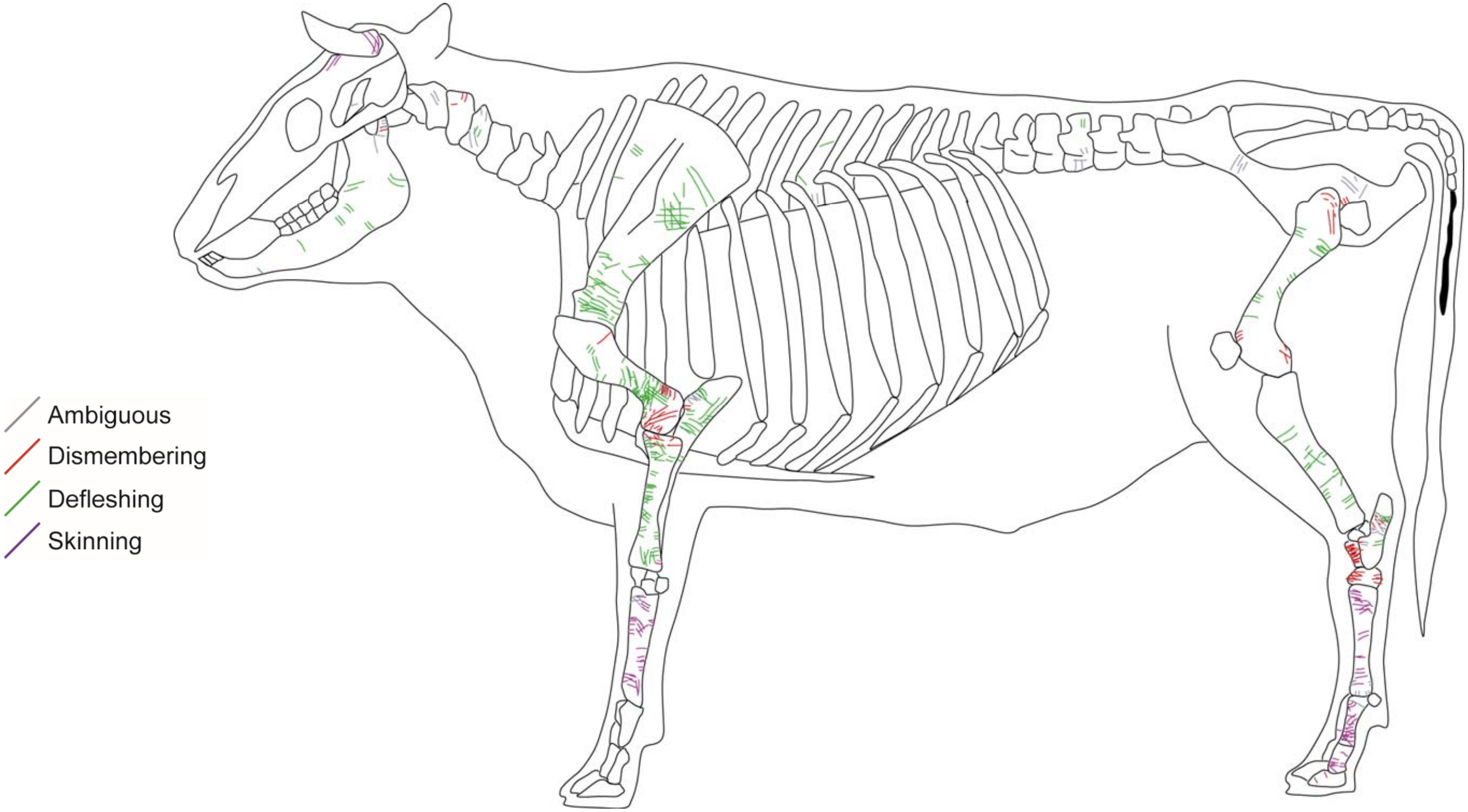

Figure 16.26: Carcass profiles showing trends in butchery on bovine elements from all sites studied. Ribs were not included in detailed butchery analysis. Butchered vertebrae are representative of cervical, thoracic and lumbar butchery patterns, save the atlas and axis. The phalanges on the hindlimb represent butchery of all phalanges.

16.2.2.2.3 Suid carcass

Butchery on suid carcasses largely followed similar patterns to bovinae, although there were some differences (figure 16.27). Skinning was reflected on the metapodia, but no butchery was identified on suid phalanges. This is likely a result of the differing anatomy of suid extremities, with a possible avoidance of the complex suid foot, and the lower marrow-bearing capacities of the metapodia. Disarticulation targeted the elbow and ankle joints, with further evidence suggested on the neck, hip and knee joints, although this additional disarticulation was much less prevalent on suid carcass than on ruminant carcasses. As with ruminants, defleshing was common on the major meat-bearing elements, largely the scapula, distal humerus and proximal ulna, femur and tibia. The mandible was particularly affected by defleshing butchery, more so than in ruminants, and did not show evidence of disarticulation. Again, this likely relates to the differential anatomical distribution of meat and fat around the suid skeleton.

16.2.2.3 Summary

The butchery analysis highlights some inter-site butchery trends, some of which indicate intensive carcass processing practices. On meat bearing elements defleshing butchery was particularly common, and possible preparation of the bone for marrow extraction through removal of the periosteum was noted. Disarticulation butchery often occurred in the same locations between sites and often species, although it must be remembered that this is likely anatomically, as well as culturally, determined. Further analysis of butchery practices and variations between different sites can be found in section 16.3.3.1.

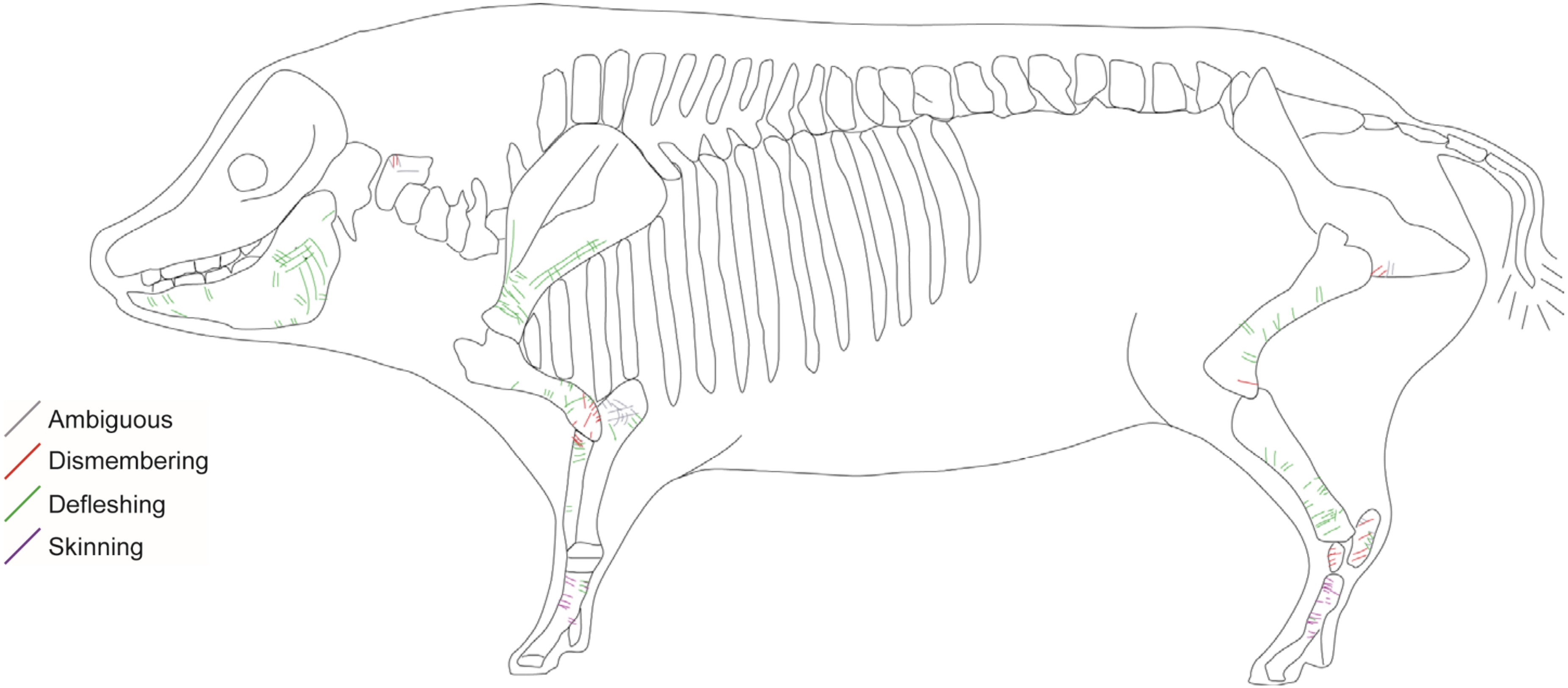

Figure 16.27: Carcass profile showing trends in butchery for suid bones for all sites studied. Exemptions and patterns as above.

16.2.3 Heat exposure

The ways in which bones were exposed to heat, particularly as pertaining to cooking and consumption, varied among the sites studied (figure 16.28). It can be argued that while butchery can be largely dictated by function, cooking methods are an expression of culture (Levi-Strauss 1970; Goody 1982; Serjeantson 2011: 60). Identifiable specimens from Ludwinowo 7 were significantly more affected by evidence of roasting than all other sites studied (p<.001; N values in table 16.4), suggested by Marciniak to be part of ritualised consumption of cattle (2005; 2011). Proportions of roasting were also significantly higher in the Stephansposching assemblage[6] and the sample from Bischoffsheim[7] compared to other sites, although the differences were not as great as at Ludwinowo 7. These patterns of heat exposure could indicate differences in the way in which carcass parts were cooked between sites.

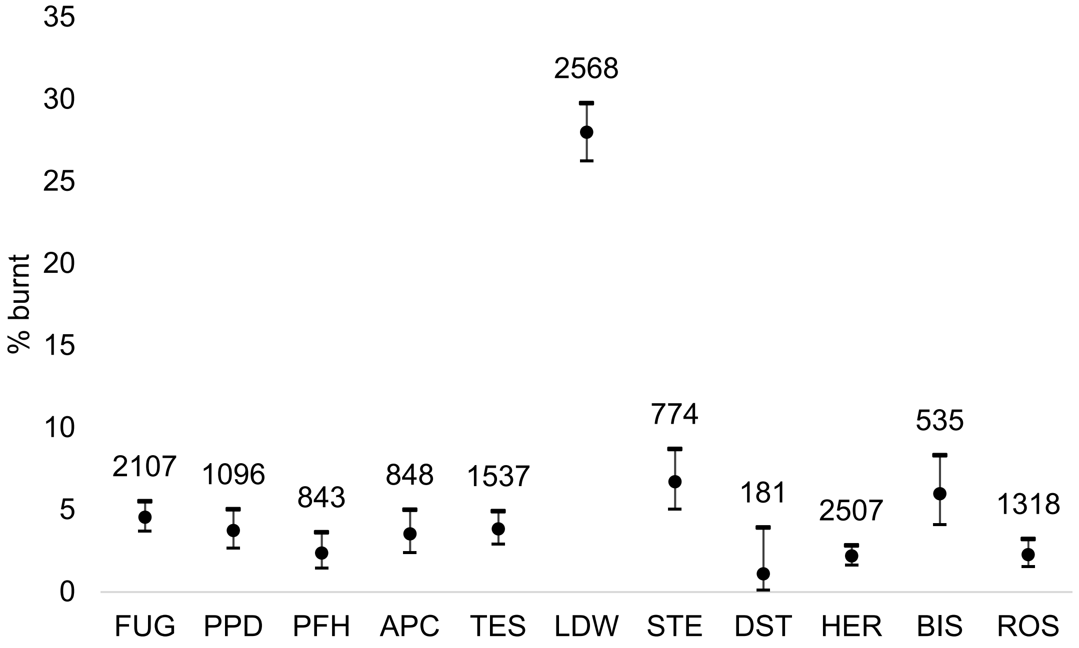

Figure 16.28: Percentage of identifiable bones affected by roasting from LBK sites, with 95% confidence intervals. N values are at the top of each series.

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[6] Identifiable material from Stephansposching was significantly more roasted than that from FUG (p=.010), PPD, APC (p=.004), TES (p=.002), DST (p=.003), PFH, HER, ROS and PCS (p<.001).

[7] Identifiable material from Bischoffsheim was significantly more roasted than that from PPD (p=.040), APC (p=.033), DST (p=.008), PFH, HER, ROS and PCS (p<.001).

Table 16.4: Proportions of identifiable bones (ID) affected by roasting (RST) from each case study site.

	FUG	PPD	PFH	APC	TES	LDW	STE	DST	HER	BIS	ROS	PCS
RST	96	41	20	30	59	719	52	2	55	32	30	3
ID	2107	1096	843	848	1537	2568	774	181	2507	535	1318	2203
%	4.6	3.7	2.4	3.5	3.8	28.0	6.7	1.1	2.2	6.0	2.3	0.1

16.2.3.1 Boiling

Where evidence of heat exposure was not particularly strong meat may have been filleted from bone prior to cooking, or fleshed or defleshed bones were cooked in stews. Lipid residue analysis has suggested that animal fats were processed in ceramic vessels on LBK sites, particularly Kümpfe (Salque *et al.* 2013; Roffet-Salque and Evershed 2015). The majority of LBK ceramic vessels would have been less than 5 litres in capacity (Bogucki 1984; Pechtl 2015), yet could conceivably hold whole or cracked bones depending on the size of the carcass. Figure 16.29 shows that bovine high-yield marrow-bearing bones (the humerus, radius, femur and tibia) more often had fragmented epiphyses compared to suidae and caprines. This could be due to the necessity of pot-sizing large bovine bones and not for smaller carcasses, and cracked bones release within-bone nutrients in boiling without the extensive labour, time and fuel required for bone grease processing. High proportions of bones cracked at midshaft, especially where the epiphysis was also split, could indicate this practice but could also be a signature of marrow extraction (Madgwick 2014: 164; Oliver 1994; Pearce and Luff 1994; Roberts *et al.* 2002).

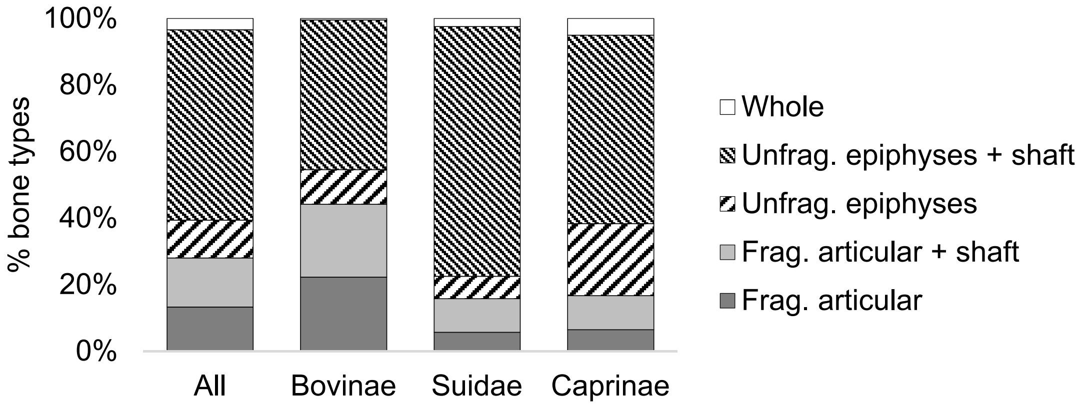

Figure 16.29: Proportion of high-yield marrow-bearing bones with articulations from all sites assigned to different bone type categories.

16.2.3.2 Roasting

Roasting is a much less efficient form of cooking meat in terms of nutrient retention, but may be particularly palatable in terms of taste or ritual feasting (Marciniak 2005; 2011; Serjeantson 2011: 64; Albarella and Serjeantson 2002). Roasting fleshed joints protects bone somewhat from the archaeological signatures of roasting (Roberts *et al.* 2002: 489), and as such heavy roasting is more often caused when articulated meat includes a ‘handle’ of meat-free bone that emerges from the joint, discussed further below (Outram pers. comm.; Albarella and Serjeantson 2002; figure 16.31). Bones can also be roasted when defleshed before being cracked for marrow, a “peculiar” practice identified in the Kuyavian Neolithic (2005; 2011; Marciniak and Pollard 2015: 754, figure 16.31). Marrow is easiest to extract from long bones when it is in solid form, and roasting or boiling bones makes them both difficult to break cleanly and liquefies the marrow, causing it to exude from the bone in an uncontrollable manner when fractured (Outram 1998). Roasting of individual bones thus suggests a cultural preference for warm marrow, which may be sucked from roasted and cracked bones (Binford 1978), rather than nutritional retention of marrow.

On many sites, the low marrow yielding mandible and metapodia showed more evidence of roasting than high-yield marrow-bearing elements, regardless of the overall prevalence of heat exposure. Another related pattern was the lack of roasting on cattle phalanges (35/469), significantly less affected by roasting than cattle metapodia (84/323, $p<.001$, figure 16.30). Using the hindlimb as an example, this pattern may be related to skinning and disarticulation butchery, and the insulating effect (or lack thereof) of meat on roasted bone. Lack of roasting on the phalanges suggests removal with the hide during skinning. A negative relationship between the percentage of butchered astragali and the proportions of roasted metatarsals (figure 16.32) suggests that sites with high levels of roasting on low-yield elements were often roasting the largely meat-free metapodia in articulation with meaty elements. In addition, as above, a preference for the warm marrow of these low-yield elements could also cause increased roasting. It is likely that on sites such as Ludwinowo 7, where many bones were roasted but low-yield elements more commonly, that jointed meat and defleshed bones were roasted, attested to in ethnographic literature (Bartram Jr and Marean 1999: 13; Kent 1993b: 336; Browman 1974; see chapter 2).

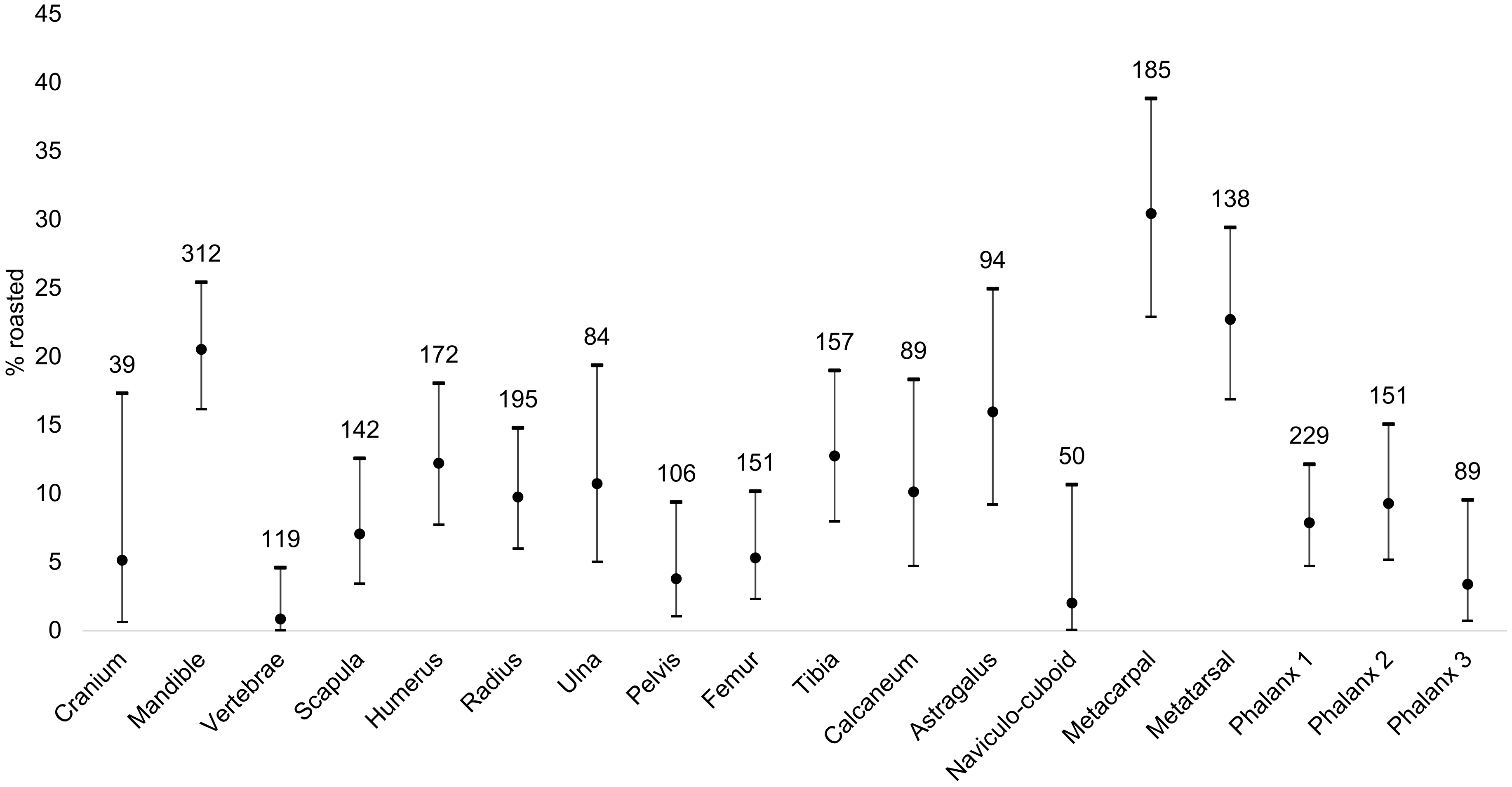

Figure 16.30: Proportion of cattle elements with evidence of roasting from all sites studied, with 95% confidence intervals. The proportions are influenced by Ludwinowo 7, which had an especially large assemblage and high rate of burning. N values are at the top of each series.

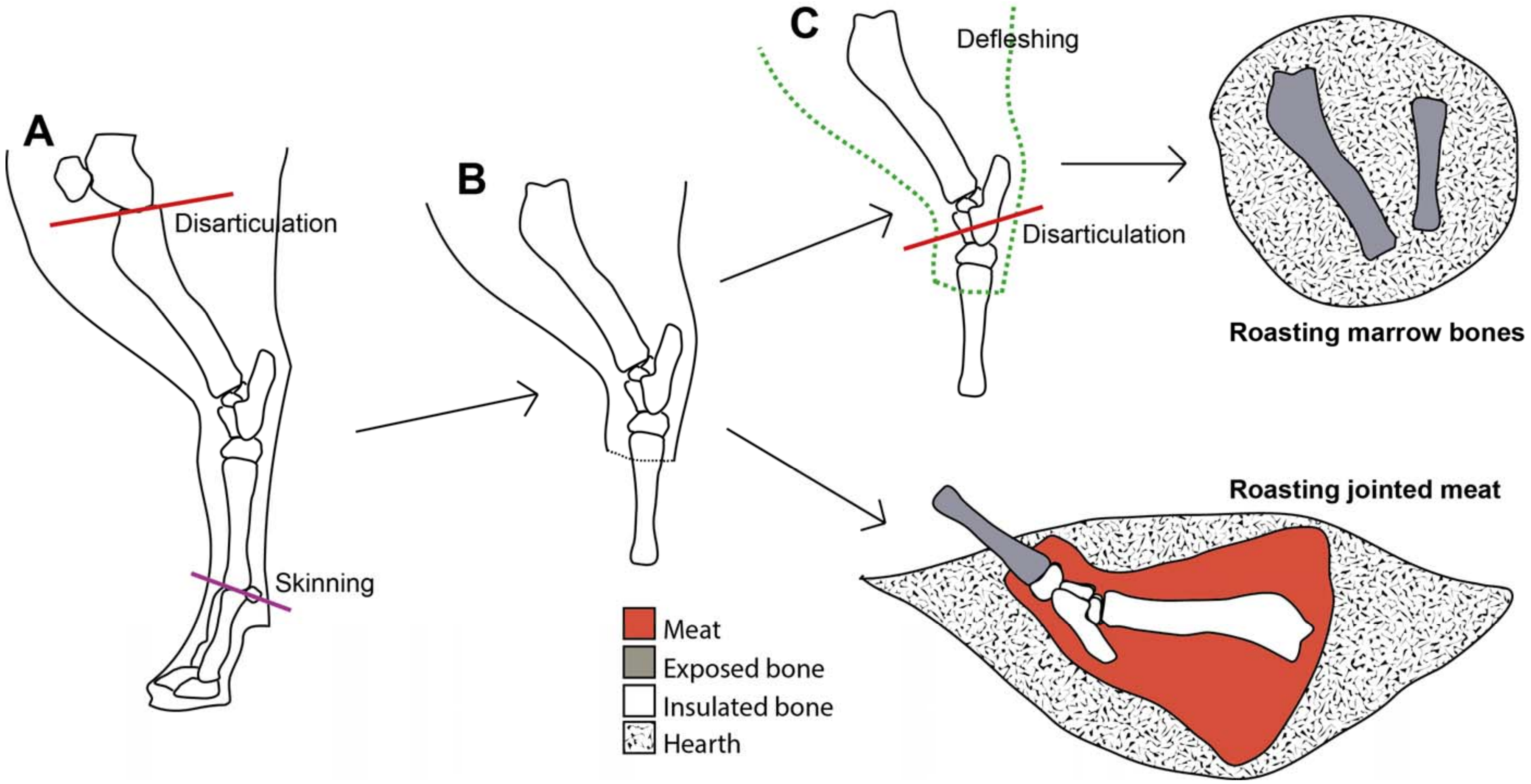

Figure 16.31: Schematic representation of the processes of skinning, disarticulation, defleshing and roasting that could have caused patterns of roasting on archaeological distal hindlimb bones.

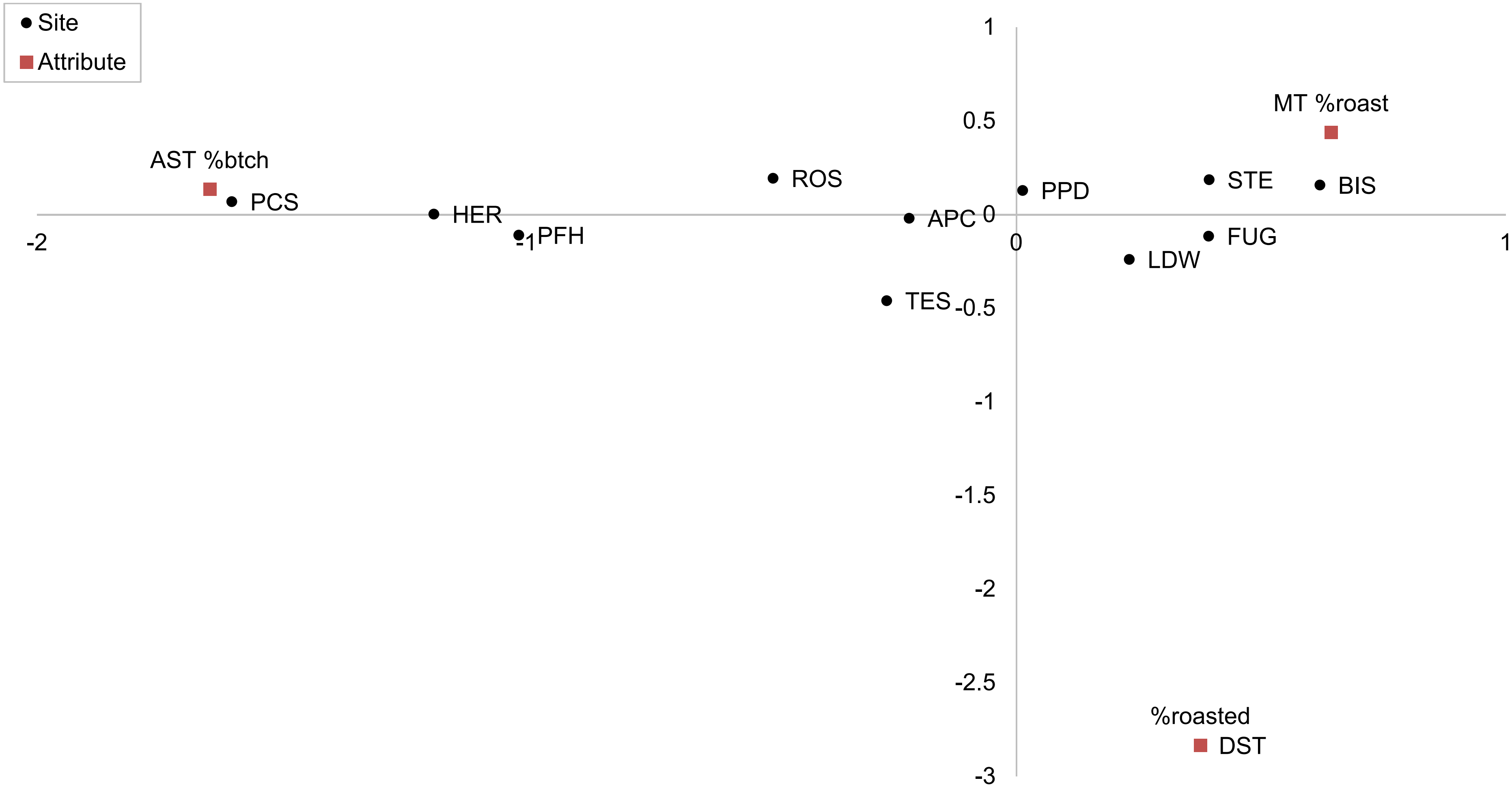

Figure 16.32: Correspondence percentage of astragali with evidence of butchery and metatarsals affected by roasting of all species from all sites.

16.2.3.3 Summary

Evidence for heat exposure suggests that preference for roasted meat and marrow-bearing bones was more important culturally than the nutritional acquisition of marrow. Whilst there was some correlation between high marrow exploitation and low roasting on sites such as Polgár-Csőszhalom, Herxheim and Rosheim *Sainte-Odile*, some high-intensity marrow sites do not fit with this trend, particularly Stephansposching and Bischoffsheim (see below). The same is true for sites with high likelihoods of milk economies (see section 16.3.2) – some, such as Ludwinowo 7, show common roasting of metapodia, but others, like Polgár-Ferenci-hát, show little evidence of roasting. Therefore, it can be suggested that roasting bones on sites was determined by cultural choice or patterns of ritualistic consumption (Marciniak 2005; 2011; Marciniak and Pollard 2015).

16.2.4 Fracture and fragmentation

16.2.4.1 Trends in bone marrow exploitation

Fracture freshness analysis gives an indication of the intensity of bone fat processing on archaeological sites, in addition to analysing deposition and post depositional fractures related to taphonomic processes. All sites show some fresh fracture, preferentially targeting high-yield marrow bones, and thus evidence of marrow processing (figures 16.33 and 16.34). As with the species representation these proportions differed between sites and possibly region. In Hungary, Füzesabony-Gubakút, Polgár-Ferenci-hát and Apc-Berekalja I showed similarly low proportions of fresh fracture, although fresh fracture was more common at nearby Polgár-Piócás-dűlő. Whilst proportions are not as low as the Hungarian sites, Ludwinowo 7 also showed reduced levels of fresh fracture, particularly compared to German and Alsatian sites. Sites in Germany (Stephansposching and Dillingen-Steinheim Wickenpoint) and the Alsace regions (Herxheim, Bischoffsheim and Rosheim *Sainte-Odile*) have relatively high levels of fresh fracture. The later Neolithic site of Polgár-Csőszhalom showed fresh fracture in abundance, in proportions unmatched by any site in the Linear pottery cultures.

This pattern suggests some regional trends but surprisingly it could also represent a temporal shift *towards* an intensification of bone marrow exploitation over time. It had been expected that over time, as agricultural practices became more familiar, efficient, productive and perhaps more intensive (including dairying), that bone marrow exploitation may have decreased in intensity due to reduced necessity for this source of fat. While the pattern is by no means linear, Füzesabony-Gubakút and Polgár-Ferenci-hát present earlier date ranges but lower fresh fracture proportions than *Rubané* sites in Alsace. This may be related to the expansion of the LBK culture into different regions. In most regions, the LBK presented the first Neolithic communities, but Alföld Linear Pottery culture sites like Polgár-Ferenci-hát and Polgár-Piócás-dűlő and Transdanubian Linear Pottery culture sites such as Apc-Berekalja I were preceded by the early Neolithic Körös and Starčevo cultures respectively (Bánffy 2004; 2008; Whittle 2007). These preceding farming cultures may have resulted in better established agricultural traditions in these early ALPC and TLPC settlements than were found later in the LBK, resulting in less reliance on bone fats. However, the continued intensive use of bone marrow throughout the LBK and into the later Tisza-Herpaly culture at Polgár-Csőszhalom suggests the continued exploitation and importance of bone marrow throughout the LBK, which may imply that marrow was chosen to be used on sites where it may not have been nutritionally necessary. More in-depth analysis is needed in relation to newly published (and as-yet unpublished) radiocarbon dates, and in some cases on larger samples of studied assemblages, to assess the true nature of changes over time.

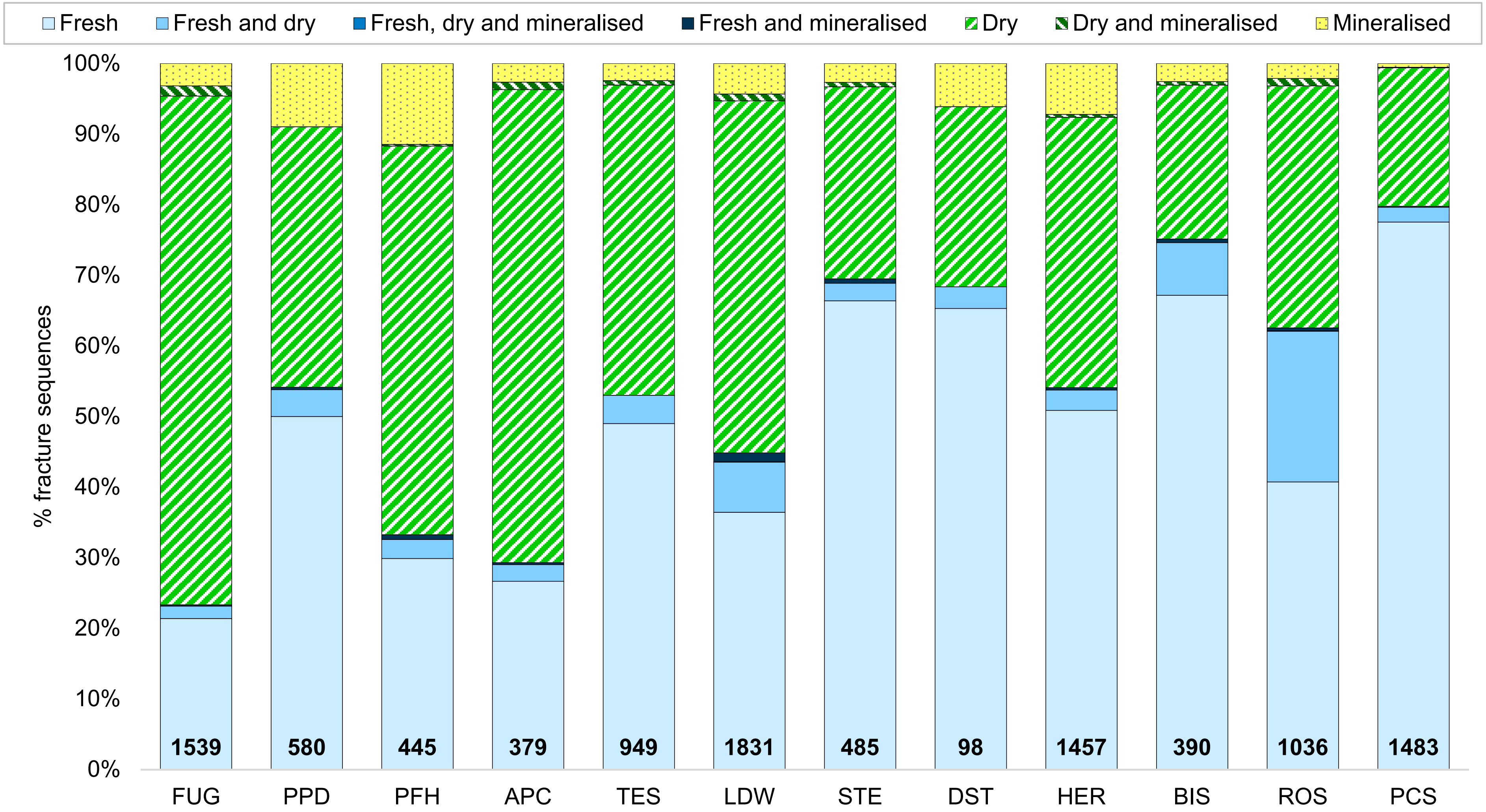

Figure 16.33: Fracture history profiles for all sites. N values are at the base of each bar.

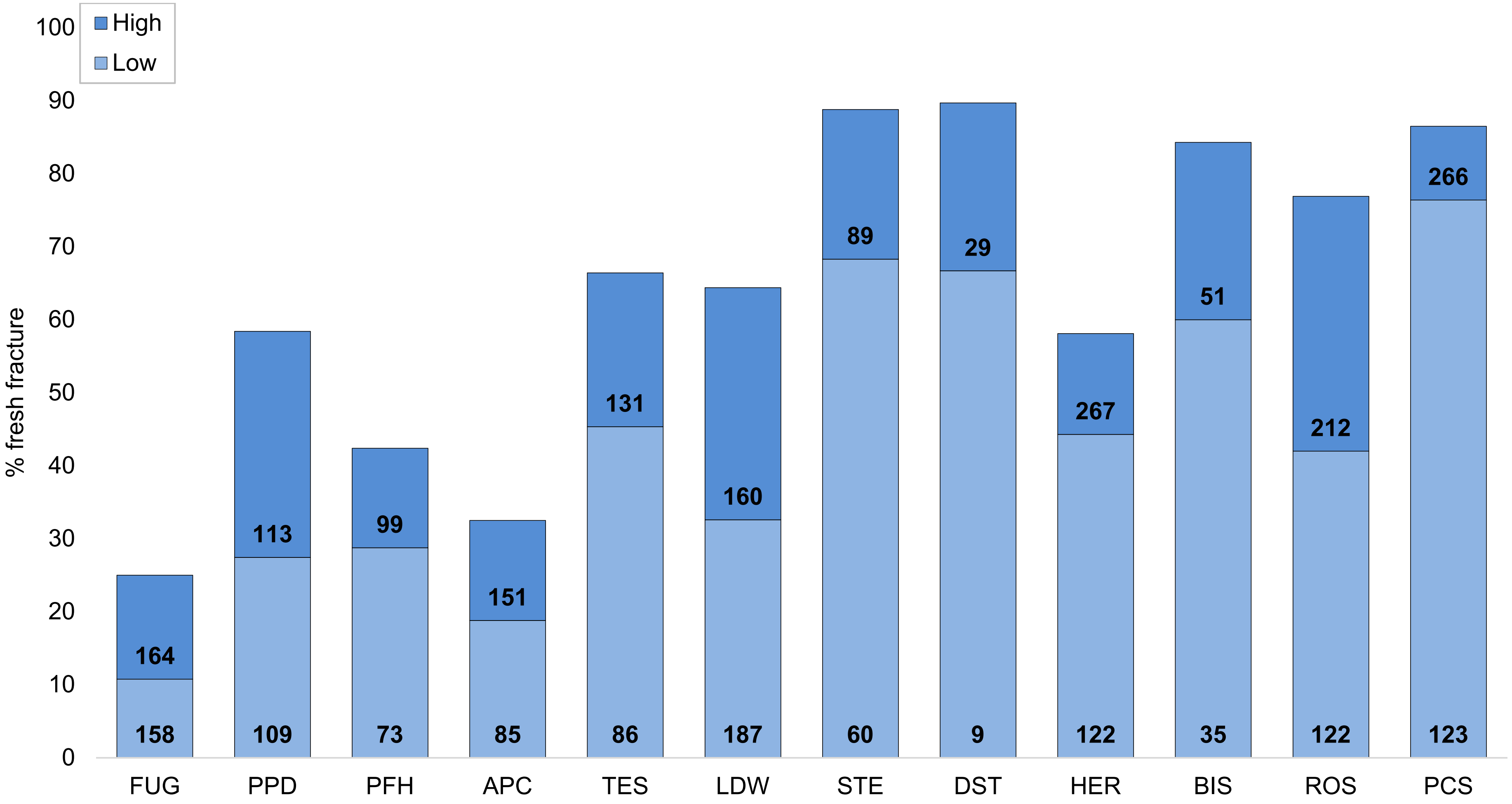

Figure 16.34: Percentage of high- and low-yield marrow bones fractured when fresh from all sites studied. The height of the bar represents the percentage of fresh fracture on high-yield bones, and within that is the low-yield percentage. N values are at the base of each bar.

Principle component analysis shows that sites cluster based on the proportion of first fresh, dry and mineralised fracture, but regional groupings are less defined than domestic species representation (figure 16.35). Sites with high levels of marrow extraction, such as Rosheim *Sainte-Odile*, Bischoffsheim, Stephansposching and particularly Polgár-Csőszhalom, are split from other sites where the proportion of fresh fracture was not so high. This is highlighted by Ludwinowo 7, Füzesabony-Gubakút and Apc-Berekalja I. Sites where post-depositional disturbance in the form of mineralised fracture was more common respect the divisions between 'fresh' sites and 'dry' sites but group closer to the top of the chart, including Polgár-Ferenci-hát and Polgár-Piócás-dűlő. Těšetice-Kyjovice, a site with low mineralised fracture and almost equal fresh and dry first fracture proportions, sits between the 'fresh' and 'dry' division. This analysis also shows that unlike the proportions of cattle, caprines and pigs the three fracture types are not weighted equally. Fresh and dry fracture relate strongly to one another, whereas mineralised fracture levels do not particularly depend on the levels of fresh or dry fracture.

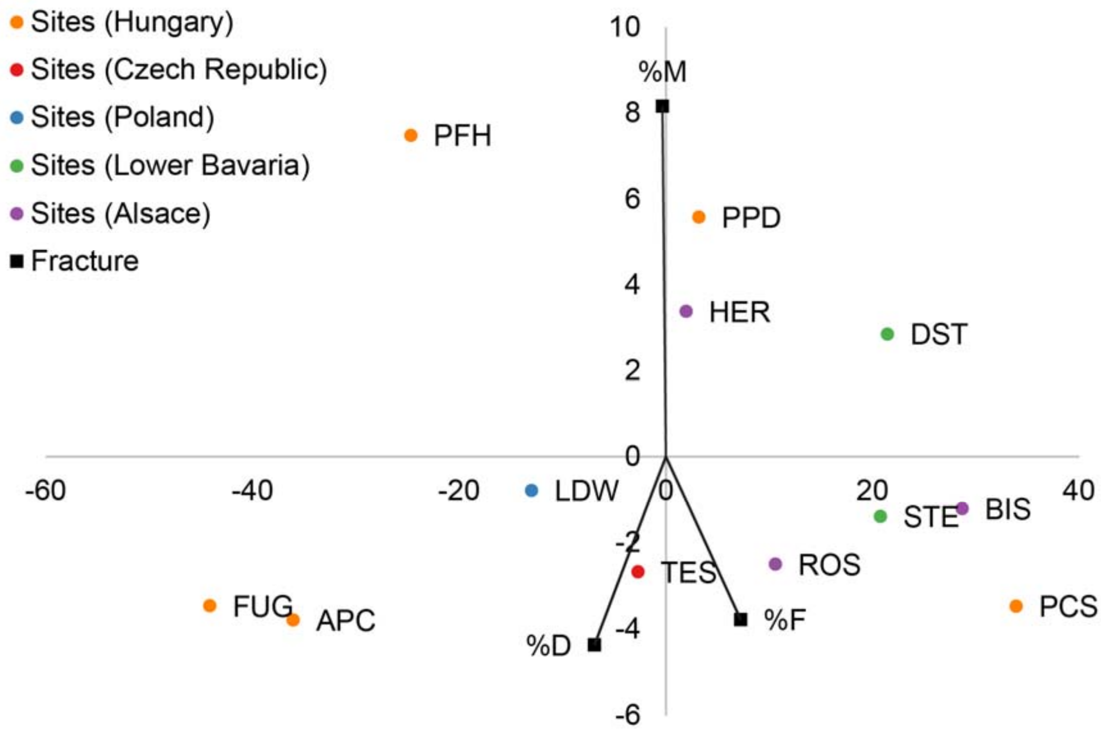

Figure 16.35: Principle component analysis of the proportions of fresh, dry and mineralised first fracture from all sites. Sites are coloured based on region.

16.2.4.2 Bone marrow exploitation and species representation

On all sites, all food animals showed evidence of marrow exploitation, although proportions varied in accordance with the site wide proportions of fresh fracture. Cattle were often the domesticate more commonly freshly fractured, followed by pigs and caprines (figure 16.36). Wild animals typically showed high proportions of fresh fracture, and domestic dogs showed no evidence of fresh fracture on any sites. This evidence suggests that both large domesticates (cattle) and large wild animals were preferentially targeted for marrow extraction compared to smaller species, which may relate to higher marrow yields from these animals. Low-yield marrow-bearing bones of cattle and wild species also showed lower disparities in the proportions of fresh fracture compared to high-yield elements, suggesting that the marrow in these elements was also commonly exploited (figure 16.37). Pigs were also commonly fractured for marrow as a fat-rich species. On early Neolithic Hungarian sites pigs were more often fractured when fresh than cattle, whereas at all other sites the opposite is true (figure 16.38). This trend is unrelated to the species representation groups or the fracture proportions from individual sites as identified above (figure 16.33) and can be suggested instead to relate to a cultural preference for pig marrow in the early Hungarian Neolithic. Domestic dogs were clearly not processed in the same way as other animals, as they showed no evidence of fresh fracture, although there was some evidence of butchery and burning from some sites including Herxheim and Ludwinowo 7.

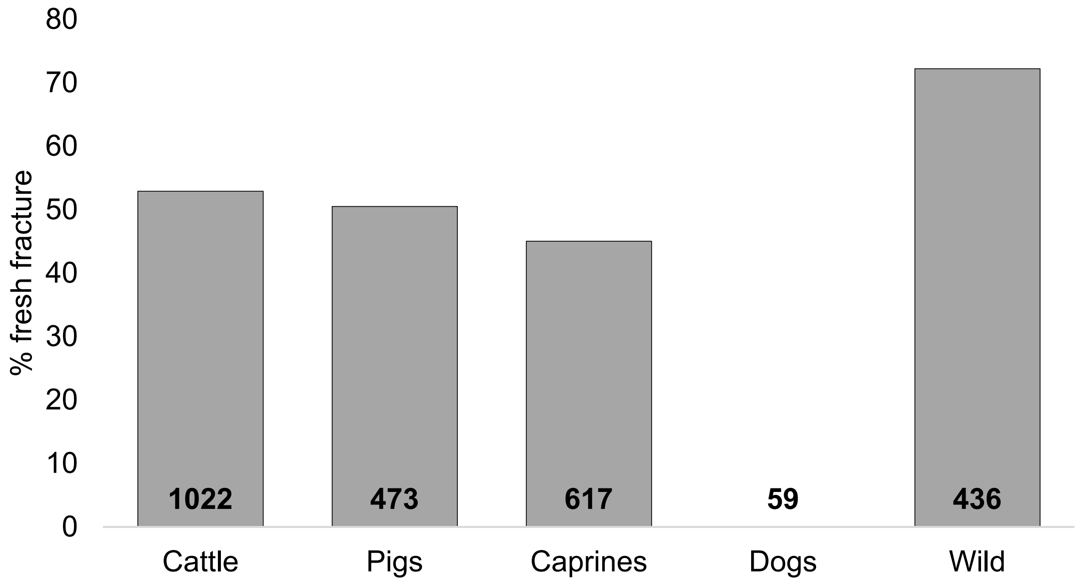

Figure 16.36: Percentage of all cattle, pig, caprine, dog and wild (aurochs, wild boar, red and roe deer) marrow bones fractured when fresh from all sites. N values are at the base of each bar.

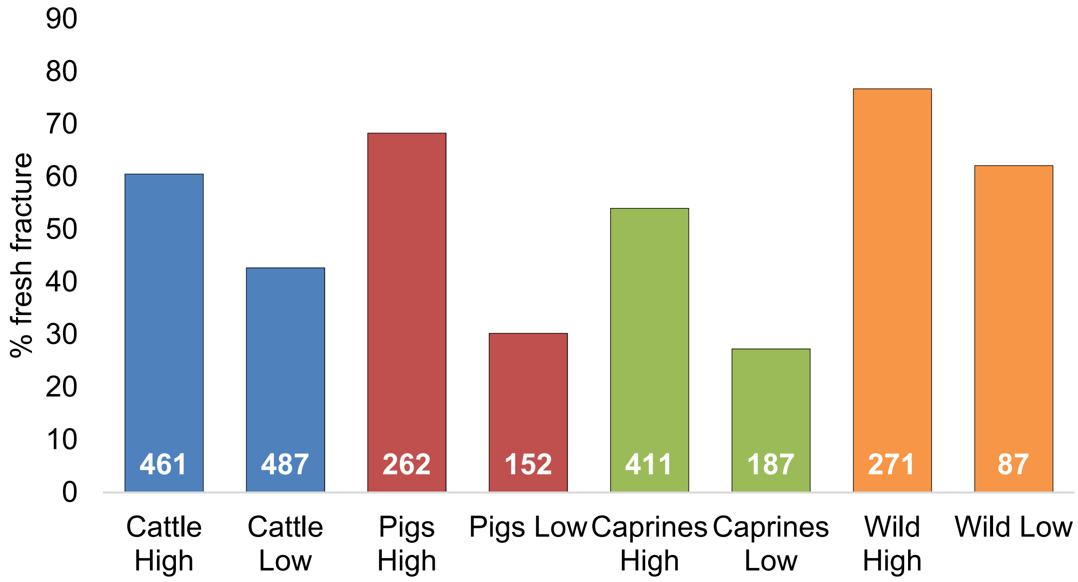

Figure 16.37: Percentage of all cattle, pig, caprine and wild high- and low-yield marrow bones fractured when fresh from all sites.

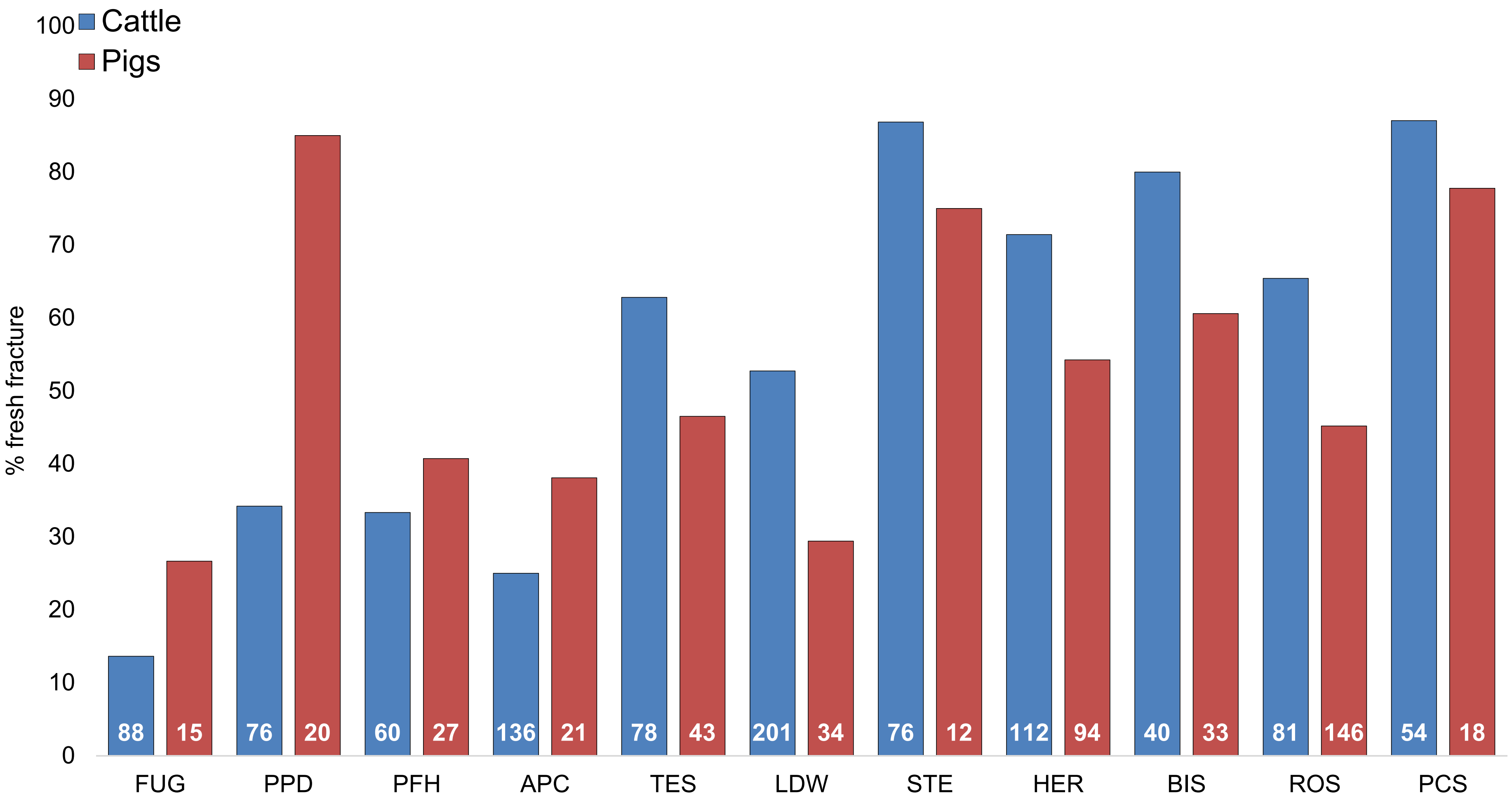

Figure 16.38: Percentage of cattle and pig marrow bones fractured when fresh from all sites studied, save Dillingen-Steinheim Wickenpoint, where sample sizes were too low.

The overall proportions of fresh fracture on individual sites relate to the proportions of different species (figure 16.39). Sites with high proportions of pigs (like Rosheim *Sainte-Odile*, Herxheim and Bischoffsheim) correspond with high levels of fresh fracture. Some high cattle sites show high levels of fresh fracture, such as Stephansposching and Dillingen-Steinheim Wickenpoint, but sites with high cattle often also show high levels of dry fracture, particularly Ludwinowo 7, Apc-Berekalja I and Füzesabony-Gubakút. Sites with relatively high proportions of caprines often also have high proportions of dry and mineralised fracture, although again mineralised fracture proportions do not correspond strongly with any particular species or site, showing variation throughout LBK sites, similar to wild animals. However, this graph shows that mineralised fracture is also likely to be more common on sites with high levels of dry fracture. Polgár-Csőszhalom, as a site with very high levels of wild species and fresh fracture, was excluded from this analysis. This suggests that sites where pigs were particularly abundant were more often exploiting bone marrow. This could be related to the availability of dairy fat on sites, as sites with relatively low proportions of cattle and caprines may have had less capacity for milk production.

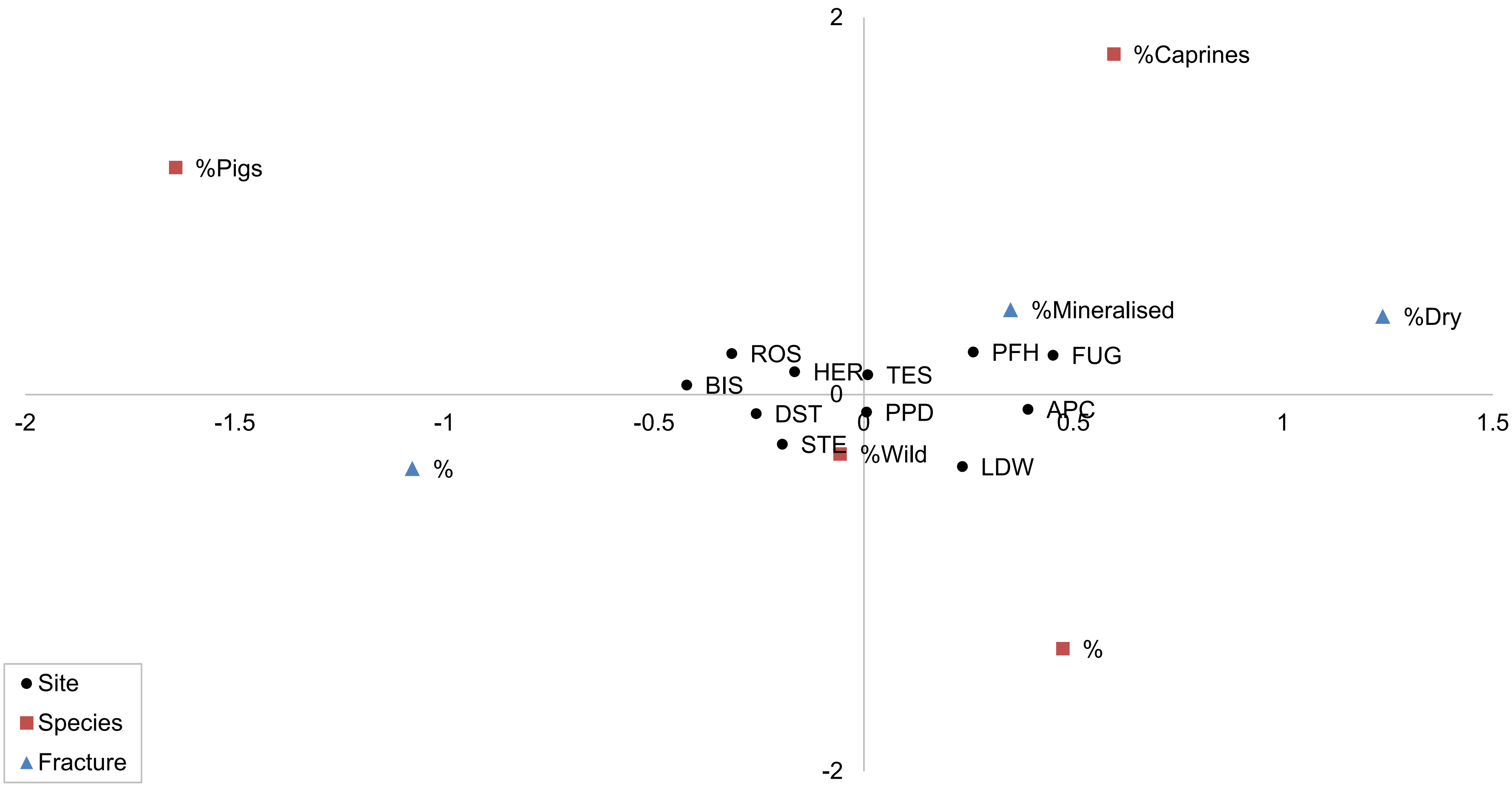

Figure 16.39: Correspondence analysis of the proportions of food animals (cattle, pigs, caprines and wild) and the proportions of first fracture (fresh, dry and mineralised) for all early Neolithic sites.

16.2.4.3 Bone grease processing

High levels of fresh fracture on archaeological sites can also be related to bone grease processing, which involves heavy comminution and boiling of cancellous elements, both articular and axial. As well as high levels of fresh fracture on marrow-yielding bones, sites where bone grease processing was intensive should show evidence of high levels of fragmentation, particularly of cancellous material. As a result of this low proportions of whole bones and unfragmented articular bone should be expected where bone grease was intensively rendered.

The level of fragmentation on most sites was very low, with small proportions of assemblage weights in the 0-39mm size classes, rising amongst bones of 40-79mm in maximum dimensions and best represented by those equal to or larger than 80mm (figure 16.40). Bones with unfragmented epiphyses, suggesting that they were not comminuted for bone grease processing, were usually well represented, as were whole bones. These patterns are reflected in the correspondence analysis of assemblage weight proportions, where sites cluster particularly with size classes larger than 40mm (figure 16.41). Some sites were more fragmented than others, with Ludwinowo 7, Stephansposching, Těšetice-Kyjovice and Füzesabony-Gubakút showing a slight deviation towards the smaller size classes. For Füzesabony-Gubakút this could be related to the depositional practices on site causing increased fragmentation, which may also be true for Ludwinowo 7, although poor preservation also may have an effect at this site. At the opposite end of the spectrum, sites like Dillingen-Steinheim Wickenpoint and Apc-Berekalja I show high levels of whole and unfragmented material. This is particularly to be expected from Apc-Berekalja I as it is likely that not all bones were retained from excavation with a bias towards the recovery of whole, fully identifiable bone. In summary, figures 16.40 and 16.41 do not indicate intensive bone grease processing at any site.

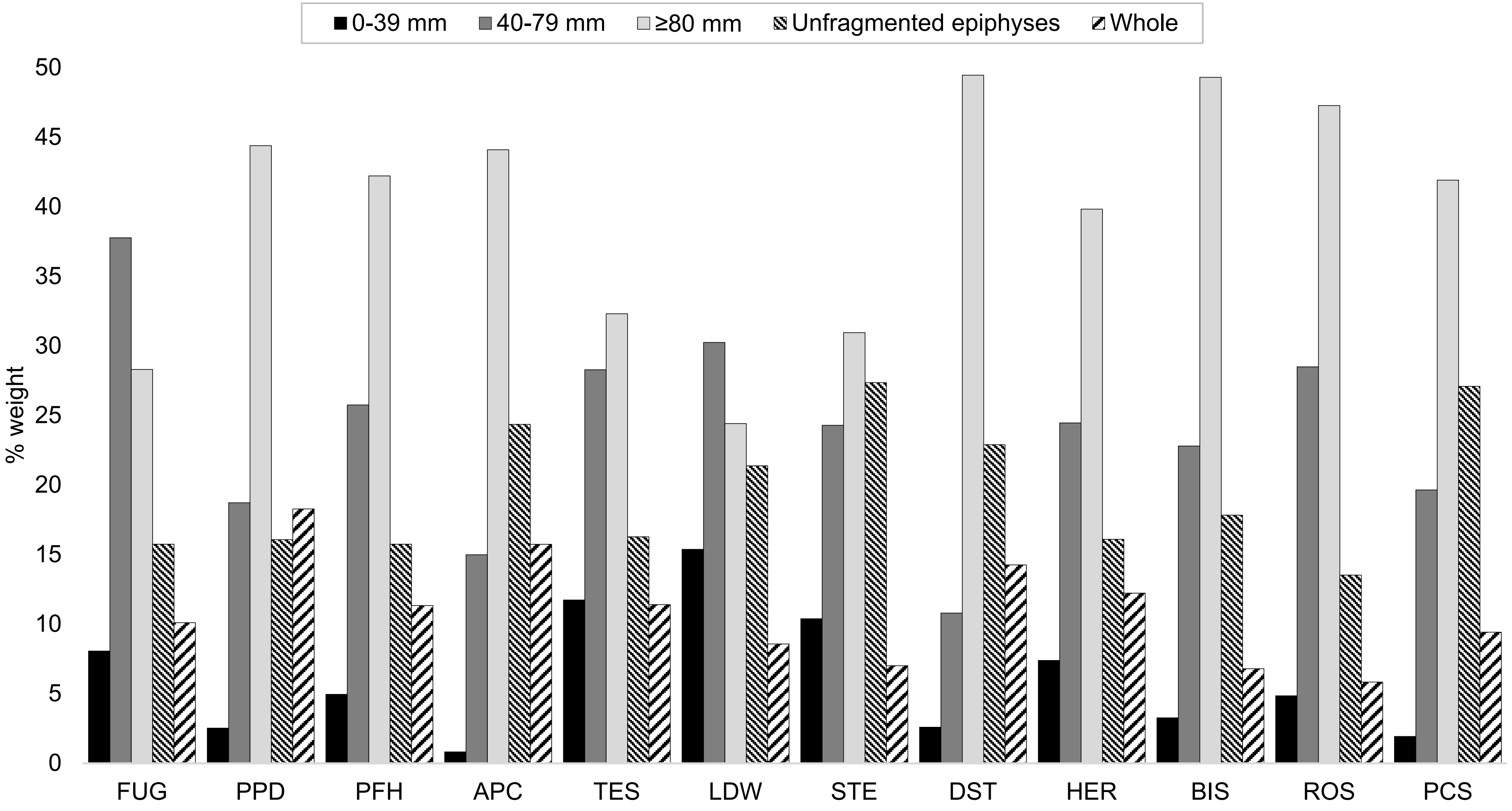

Figure 16.40: Proportion of the assemblage weight in different classes based on maximum dimensions or bone type. Size classes have been combined for legibility. High representation in the 0-39mm size class indicate a highly fragmented assemblage.

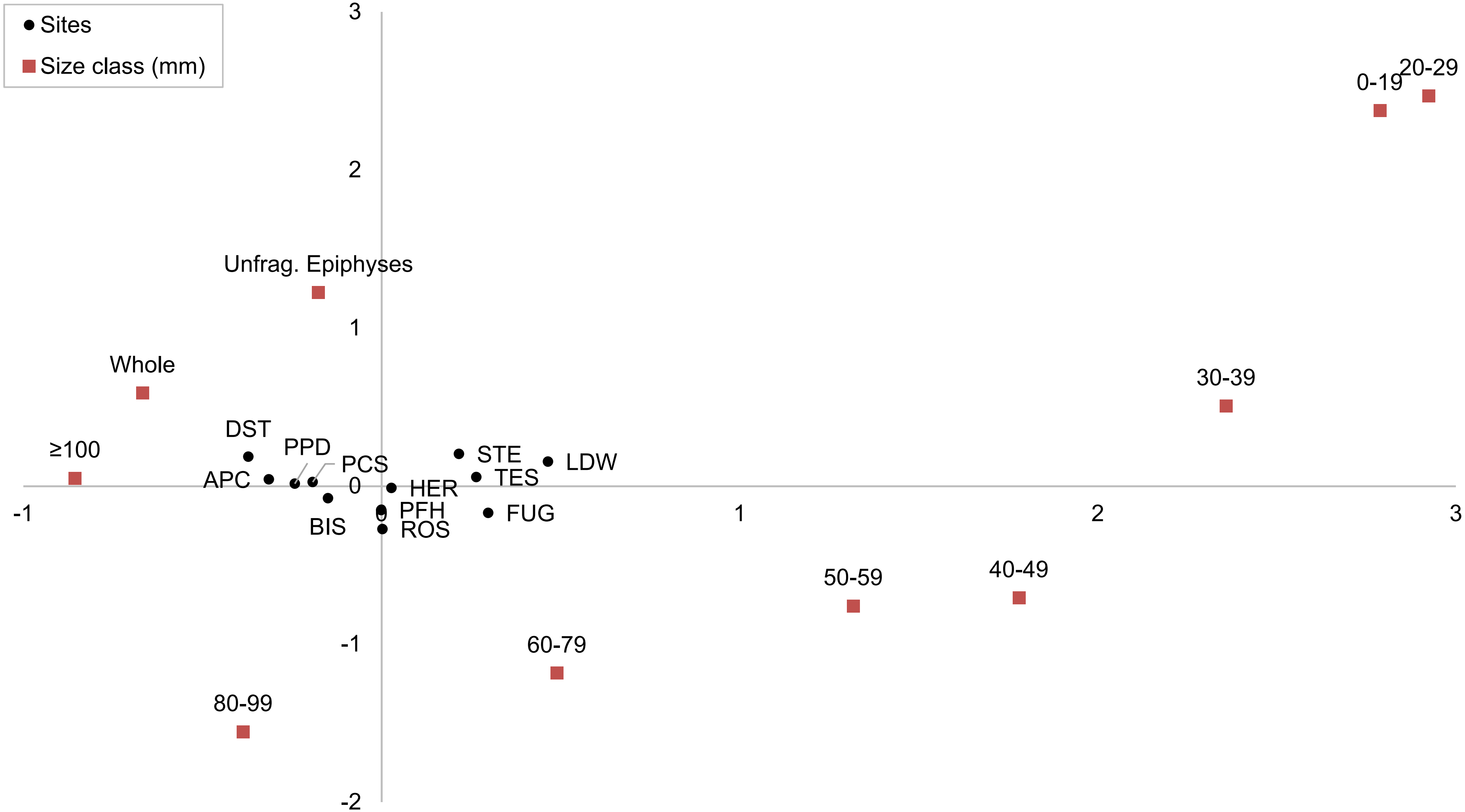

Figure 16.41: Correspondence analysis of the percentage of assemblage weight in the ten size or bone type classes from all sites studied.

This pattern continues when combining fragmentation data with bone type and fracture freshness data. The percentage of fresh fracture on sites does not correspond to the proportions of the assemblage weight in the smallest (<40mm) size classes, or to the percentage of the smallest size classes represented by cancellous bone (figure 16.42). In other words, highly fragmented assemblages were often those that had low proportions of fresh fracture, and the fragmented material was not that which would be associated with bone grease processing. That these three hallmarks of bone grease processing do not align suggests that heavy fragmentation of assemblages was more to do with deposition practices than intensive bone grease processing. This supports the qualitative data that there was no evidence of intensive bone grease processing on any site studied.

Whilst some sites such as Těšetice-Kyjovice and Herxheim showed potential bone grease processing on a small, possibly ad-hoc, scale, the overall picture from sites studied is that bone grease processing was not an intensive part of subsistence. The lack of grease exploitation on LBK sites is not surprising, as ethnographic evidence for bone grease rendering is only common amongst hunter gatherer societies where the food base is unpredictable or low in carbohydrates (chapter 2). Periods of dietary instability, malnutrition and starvation have been suggested on linear pottery culture sites through the presence of stress-related pathologies such as enamel hypoplasia (Hedges *et al.* 2013: 371; Bickle and Whittle 2013). Despite this, the lack of bone fat processing on a large scale indicates that the supply of domestic meat and crops, possibly in addition to milk, rendered this carcass processing practice largely unnecessary.

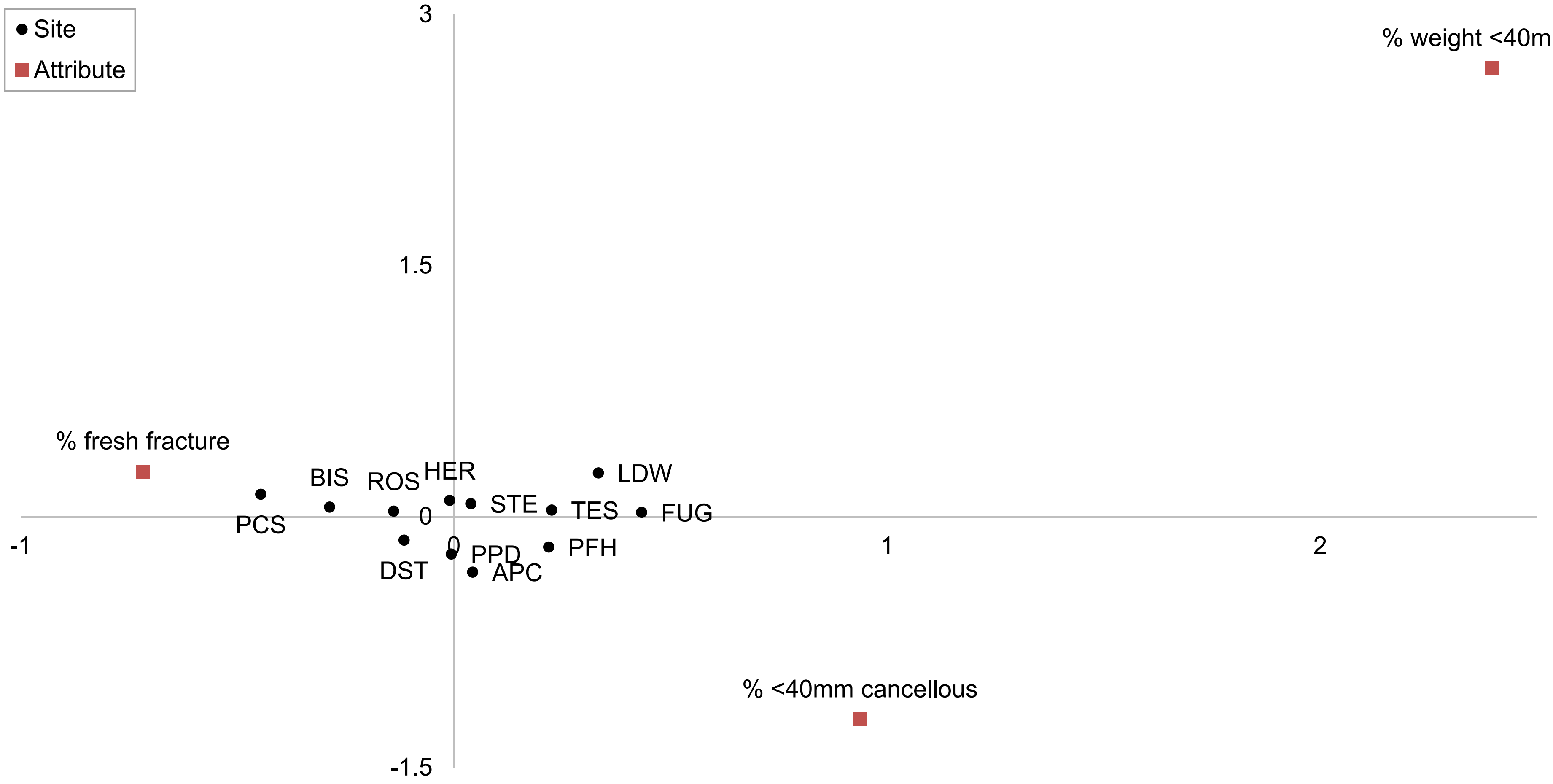

Figure 16.42: Correspondence analysis of the percentage of marrow bones fractured when fresh, the percentage of the assemblage weight less than 40mm in maximum dimensions, and the percentage of the <40mm assemblage composed of fragmented cancellous bones from all sites studied.

16.2.5 Deposition practices

Throughout the course of this thesis, bone fracture analysis has also been used to establish taphonomic histories of archaeological contexts. The evolution of fracture history profiles, a method of displaying sequences of fracture freshness that have affected bone specimens, was developed as a direct consequence of attempting to untangle taphonomic fracture from signatures of bone marrow processing (Johnson *et al.* 2016). The use of fracture freshness in deciphering depositional differences and taphonomic histories is displayed well at four sites – Füzesabony-Gubakút, Apc-Berekalja I, Ludwinowo 7 and Herxheim.

Both Füzesabony-Gubakút and Apc-Berekalja I presented particularly low levels of fresh fracture, especially compared to higher percentages at sites in Alsace and even later sites in Hungary, such as Polgár-Csőszhalom. This was due to a combination of low intensity marrow extraction at the sites, and breakages caused by depositional practices. Domboróczki (2009) argues that at Füzesabony-Gubakút pottery fragmentation indicates that waste was often strewn on walking surfaces and trampled before eventual deposition in settlement pits. It is likely that this could have been the case at other sites with low fresh fracture, such as Apc-Berekalja I, Polgár-Ferenci-hát and possibly Ludwinowo 7. The lack of secondary breaks at Apc-Berekalja I and Füzesabony-Gubakút also suggests that the bones were not fractured when fresh (i.e. for marrow exploitation) before they were fractured during deposition processes.

Contextual differences in deposition have been highlighted at Ludwinowo 7 and Herxheim. At Ludwinowo 7 differences in fracture freshness between contexts indicated possible differential deposition between house pits, isolated pits and clay pits (Johnson *et al.* 2016). The house pits were shown to contain a fair amount of freshly fractured specimens, but also relatively high levels of dry fracture, possibly caused by contexts being open or reused over a long period of time. These traits were shown even more clearly by the isolated pits, B156 and G64, which showed heightened levels of dry and mineralised fracture and taphonomic agents. The clay pits on the other hand showed high levels of fresh fracture and little evidence of taphonomic disturbance, and were therefore interpreted as single-use feasting contexts that were covered quickly. At Herxheim, contextual differences between pits in the settlement and the two enclosure ditches in fracture analysis suggests that animal bones in the ditches were fractured when mineralised more often than those in the settlement pits and were also more commonly affected by erosion. This pattern could be caused by intercutting of contexts, however, archaeological excavation found no evidence of intercutting of the enclosure ditches (Haack 2016). More likely material in the ditches was deposited secondarily in the ditches, possibly originating from temporary deposits or, based on pottery seriation older pits disturbed during ditch construction and later used as infill material (Johnson in prep.; Haack 2016).

These examples from this project highlight the many uses of fracture freshness analysis. It is not just an incredibly useful tool for assessing the intensity of bone fat processing, but it also indicates depositional histories of bone specimens and, by extension, the contexts that they originate from. This analysis is especially useful when corroborated with other archaeological data. As indicated above, evidence from pottery refitting and seriation can give indications of spread and disturbance of refuse, and careful excavation can indicate evidence of recutting contexts (Domboróczki 2009; Haack 2016). This relationship works both ways, as bone fracture analysis can be used to identify depositional histories for material with no equivalent diagnostic features to determine time of breakage (Johnson *et al.* 2016).

16.2.6 Summary: meat and fat exploitation in the LBK

Analysis of species representation and carcass processing practices among the Neolithic cultures of central Europe suggests inter- and intra-regional variation in many aspects of subsistence. It may be possible to highlight certain areas of meat and fat representation that were culturally and nutritionally determined, although again it is likely that these two factors impacted each other.

Inter-regional variation in the representation of the main three domesticates, and intra-regional variation in the representation of wild species, was likely culturally determined. Regionally distinct groups of the LBK may have focussed their subsistence on certain species, yet within the same regions different wild species were targeted with perhaps looser cultural control. The decision to focus on cattle based agriculture may have stemmed from the nutritional reliance on cattle meat and milk (Bogucki 1988).

Cooking practices may also have been determined by cultural taste preferences. Roasting, a less-efficient cooking method in terms of nutrient retention but arguably tastier seems to have been practised despite possible reliance on bone fats at certain sites, suggesting this practice was not nutritionally determined. Some sites may have also incorporated roasting into ritual feasting. The cooking of bones in stews, a far more nutrient retentive form of cooking, is possibly reflected in butchery patterns of intensive filleting and removal of the periosteum, perhaps in preparation for marrow processing, and fragmentation of grease-rich epiphyses.

The continuing use of marrow as a resource may have been determined based on cultural preference, as it may be expected that later sites should have been more established in terms of farming practices than their earlier counterparts. This suggests use of marrow where it was not nutritionally necessary, although this may be related to the intensity of milking on individual sites. It is also possible that marrow fat was an important component of craft and fuel activities as well as food (Outram 1998). The lack of intensive bone grease rendering on all sites was likely nutritionally determined, as due to the high levels of animal fat and plant carbohydrate available, both of which may have had storable components, going to the effort of processing bone grease was likely not necessary. The majority of these trends do suggest that the nutritional needs of the settlement were already being met, in order to make decisions based on what was most desired.

Overall the analysis of meat and fat exploitation in early Neolithic Europe suggests that the nature of carcass use was complex. It implies that people made choices about what (and how) they were eating based on a combination of cultural preference, ritual significance, and nutritional necessity. The nutritional aspect of this argument becomes particularly pertinent when dealing with the likelihood of dairying on sites, and the nutritional benefits that may have come as a result.

16.3 Research question 2

Did an intensification of milking practices affect meat and fat exploitation?

The introduction, adoption and intensification of dairying practices likely had a profound effect on Neolithic subsistence. If dairy products became readily available on LBK sites this may have impacted the necessity for the intensive exploitation of other forms of fat, particularly that which required time and effort to extract. The analysis of the milking revolution in Neolithic temperate Europe is still ongoing, with pottery sherds for lipid residue analysis for many sites still awaiting study, and as such, the intensity of milking practices at certain sites is largely unknown or poorly understood. The ever-growing body of lipid residue analysis can be evaluated in conjunction with herd structure analysis based on fusion and dental eruption and wear to identify sites with a strong milking signature. Evidence for intensive carcass processing practices, particularly bone fat extraction, will be analysed in conjunction with this data to see if there is a relationship between dairying and meat and fat exploitation in the Neolithic of central Europe.

16.3.1 Detecting dairying

16.3.1.1 Age-at-death: Fusion

Fusion analysis of cattle, caprine and pig bones was undertaken on all sites and slaughter profiles drawn based on the fused bones per age stage where sample sizes permitted (after Silver 1969; table 3.6). For cattle and caprines these profiles can indicate herd management for dairy through culling of young males and high adult survival of lactating females (Payne 1973; Vigne and Helmer 2007). Based on physiology goats are often the main caprine dairy producer, with sheep more commonly kept for meat (Greenfield and Arnold 2015). Herd management for dairy certainly does not preclude the consumption of cattle and caprine meat, and indeed specialised exploitation solely for secondary products in pre-industrial cultures is highly unlikely (*ibid.*). Therefore, a mixed herd structure profile indicating some meat slaughter in addition to possible dairying is plausible. Pig fusion profiles cannot represent a ‘herd’ optimised for dairying, as their physiology prevents milk storage (Ellendorff *et al.* 1982). Meat consumption of both pigs and ruminants can target animals either when young and ‘tender’ or at maximum weight, usually before fusion maturity.

As indicated in chapter 3, age-at-death analysis can be affected by taphonomic and depositional bias. This may be caused by the loss of very young bone, which more susceptible to taphonomic destruction (Payne 1973; Halstead 1989; Outram *et al*. 2012). Depositional bias may also occur if animals of certain age classes were deposited in unexcavated locations or sent to other sites (*ibid.*). A lack of intensification along with the above taphonomic and depositional biases may result in poor representation of this practice in the post-cranial fusion.

16.3.1.1.1 Cattle

No pattern of intensive cattle herd management for dairy was detected from fusion analysis, summarised using correspondence analysis in figure 16.43. Slaughter under one year was very low on all sites, with only Těšetice-Kyjovice showing >10% slaughter of animals less than one year of age (87.5% 14/16). However, some sites did show a particularly high survival into adulthood, such as Polgár-Piócás-dűlő, Polgár-Ferenci-hát and Stephansposching, which showed 68.2% (15/20), 68.9% (20/29) and 76.2% (16/21) survival into fusion maturity respectively (figure 16.43). Some sites suggested a possible mixed meat and milk herd management strategy, with still considerable survival into adulthood (>50%) but some obvious meat-age slaughter of animals at stage 3 (including Apc-Berekalja I, Ludwinowo 7, Herxheim and Rosheim *Sainte-Odile*) and 4 (Polgár-Csőszhalom). Some adult survival is of course required for herd viability even in strict meat models, and at Füzesabony-Gubakút and Těšetice-Kyjovice was between 40% and 50%, and could suggest meat management with slaughter of stage 4 and 3 animals respectively.

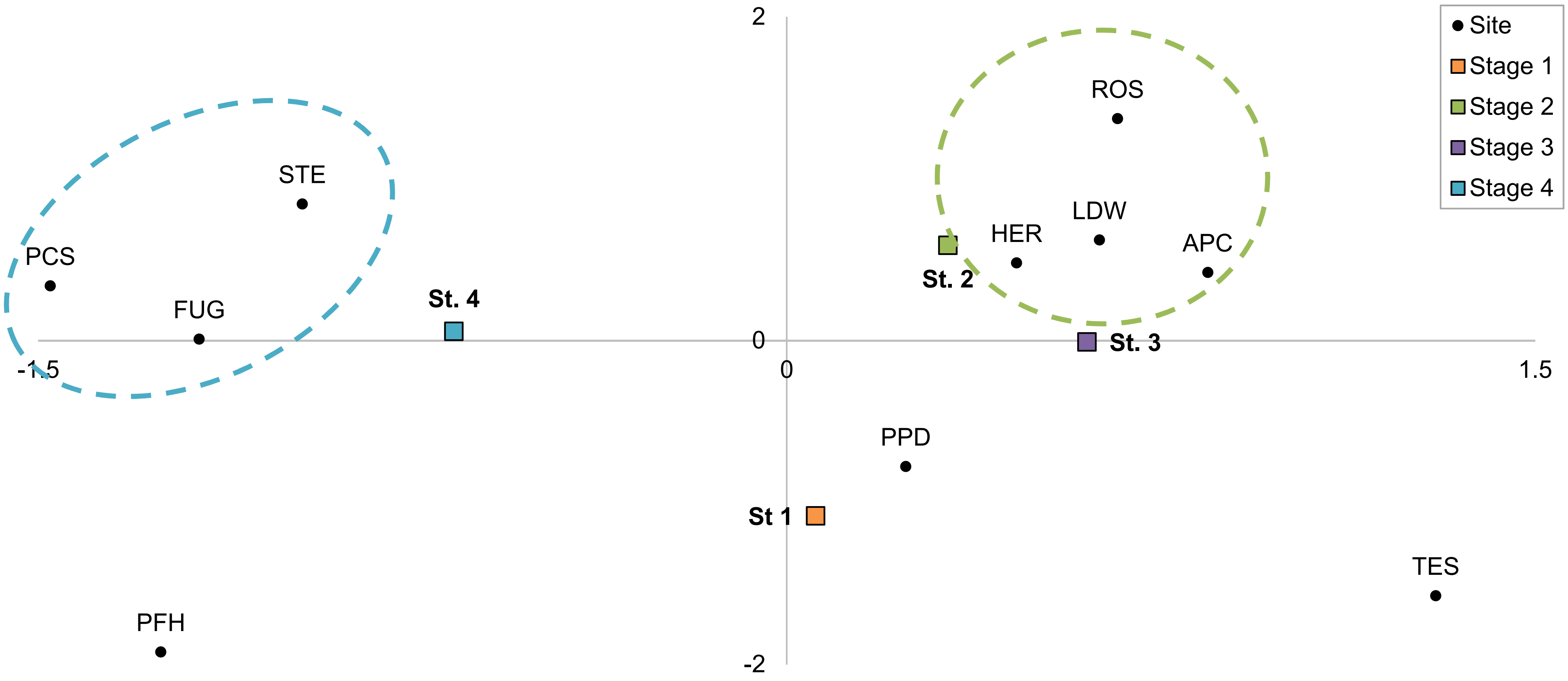

Figure 16.43: Correspondence analysis of the percentage drop in survival of each age-stage of cattle fusion from all sites with cattle fusion profiles. Green group = main slaughter after stage 2, some slaughter in final stage; blue group = minimal slaughter before final stage, some high adult survival.

16.3.1.1.2 Caprines

The fusion profiles for caprines were far more variable than for cattle, and sites do not group based on common herd structures (figure 16.44). Young slaughter was more common in caprine herds, with some sites, particularly Füzesabony-Gubakút and Polgár-Ferenci-hát, showing high slaughter of animals under 1 year (<80% fused). Low adult survival (<50%) was common, especially at Polgár-Ferenci-hát (18.9%, 7/37). The presence of a dairy herd was suggested most strongly at Herxheim, where 66.7% (22/33) of specimens in the final fusion stage reached adulthood. However, it is extremely likely that these fusion profiles smooth a pattern of mixed meat and milk that targeted goat milk and sheep meat.

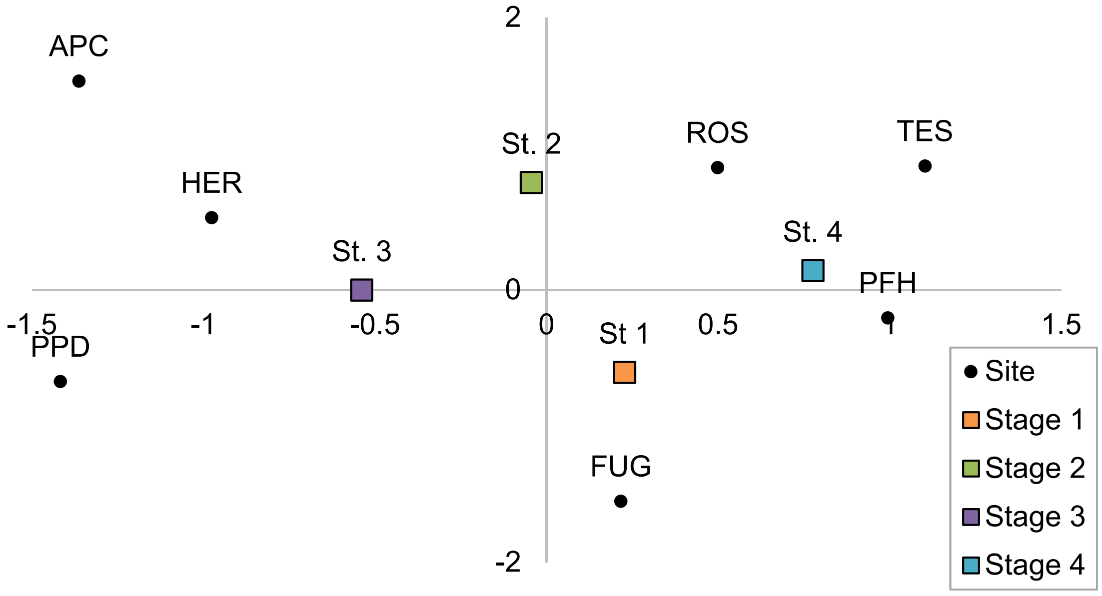

Figure 16.44: Correspondence analysis of the percentage drop in survival of each age-stage of caprine fusion from all sites with caprine fusion profiles.

16.3.1.1.3 Pigs

Whilst herd-structure analysis for pigs can only show management for meat, different patterns emerged across the LBK related to preferences for different aged animals (figure 16.45). Slaughter before 1 year was common, especially at Füzesabony-Gubakút, Polgár-Ferenci-hát, Těšetice-Kyjovice and Polgár-Csőszhalom. The only sites that showed no young slaughter were Polgár-Piócás-dűlő and Bischoffsheim. This suggests that pigs were commonly bred for young, tender meat on some sites while others favoured slightly older animals. Pigs are particularly good animals for producing young meat as they have large litters. Using data for modern wild boar, a gestation period of 112-120 days produces a litter of between 3-8 piglets, with usually one litter per year (Wild boar website). This data was used due to the unknown reproductive capabilities of early Neolithic domestic pigs.

Kill-off after one year was variable, with some sites showing large slaughter events of animals (around 50% drop) between 1-2 years, such as Polgár-Piócás-dűlő and Polgár-Ferenci-hát, Stephansposching, Herxheim and Bischoffsheim. Others showed a preference for animals between 2-3 years old, particularly Apc-Berekalja I, Rosheim *Sainte-Odile* and Polgár-Csőszhalom. Most sites showed only minimal survival of adults into fusion maturity, with Stephansposching, Polgár-Piócás-dűlő and Polgár-Csőszhalom showing no fused bones in stage 3. Large litters of pigs mean a high turnover of animals is possible, and therefore pigs are not required to survive past prime meat age for breeding, useful if young meat was preferred.

The pig slaughter profiles show variation even in meat management in the LBK, with animals of different ages exploited at different sites. These data also show that juvenile suid bones under one year were surviving in the archaeological record on many sites, although the elements that fuse in stage one are more numerous for suidae than the ruminants (table 3.6).

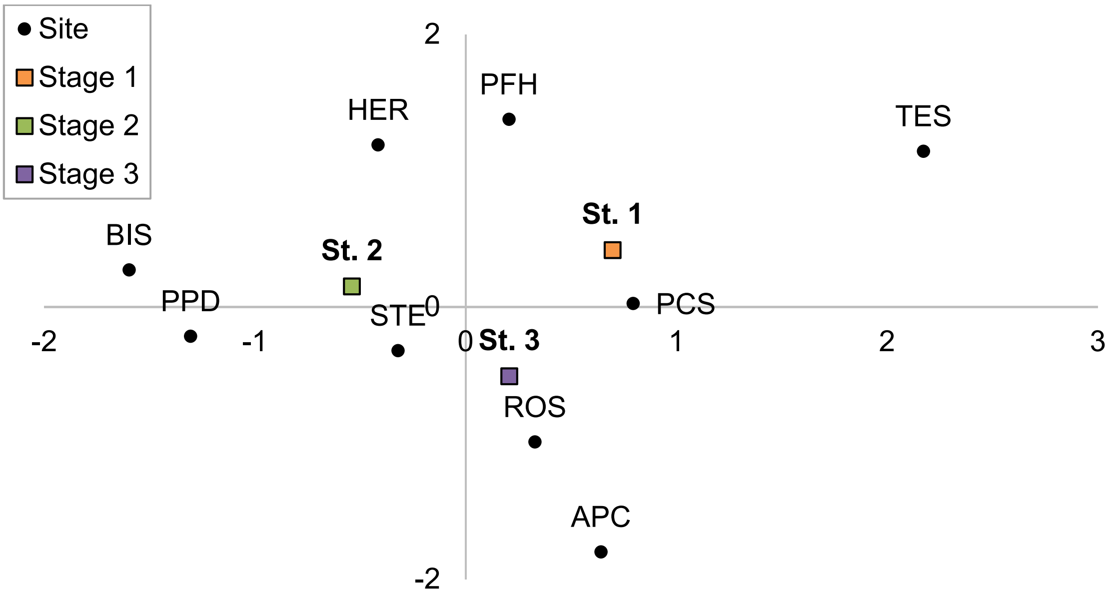

Figure 16.45: Correspondence analysis of the percentage drop in survival of each age-stage of pig fusion from all sites with domestic pig fusion profiles.

16.3.1.2 Age-at-death: Dental eruption and wear

Construction of mortality profiles based on cattle and caprine dental eruption and attrition was carried out by Roz Gillis as described in the case study chapters, and is as yet unpublished. Gillis's initial interpretations are summarised heavily in table 16.5, and should not be taken as a direct representation of herd structures at these sites. Dental age-at-death analysis can add greater resolution to fusion data, particularly in the adult age classes, which are not represented in fusion analysis. The dentition also gives a direct age-at-death rather than indicating a maximum or minimum age class, as is the case with fusion ageing. However, herd structure analysis using dentition often suffers from poor sample sizes, which has been addressed recently by Gerbault *et al.* (2016). The relationship between fusion and dental age-at-death analysis remains poorly understood (see future work), as highlighted by contrasting results in table 16.5, although they also corroborate and support other data.

16.3.2 Assessing the likelihood of a dairy economy

To qualitatively assess the presence of a dairying economy on case study sites a scoring system was created based on four categories – cattle and caprine herd structures suggesting milk exploitation, analysis of sieves, and presence of milk residues in ceramic sherds. A score of 1 was assigned to each attribute if there was any evidence of dairying. In herd structure analysis, this was indicated by either the fusion or dental age-at-death analysis presenting a dairy or mixed signal. Further points were assigned for presence of sieves analysed for lipid residues, suggested to be evidence of cheese making (Bogucki 1984, Salque *et al.* 2009), and milk residues in any sherd type. This resulted in a score out of four, where higher scores indicate a higher likelihood of a dairying economy (table 16.5). It is admitted and fully understood that the data from age-at-death analysis is often contradictory, which is why any possible evidence of dairying from either profile is used. Lipid residue analyses are given equal weight in this scoring system. Based on this analysis four sites had a particularly strong milking signature - Füzesabony-Gubakút, Polgár-Ferenci-hát, Apc-Berekalja I and Ludwinowo 7. However, dairying was possibly present on all sites, although the signatures based on currently available data were less strong.

Table 16.5: Summary of dairy indicators from all sites studied. Unpublished dental herd structure analysis data from Roz Gillis (unpub.a; unpub.b; in prep.) and lipid residue data from NeoMilk researchers in the Organic Geochemistry Unit from Bristol University. NP non perforated, P perforated; A adipose, M milk.

	Cattle ageing		Caprine ageing		# Sherds		% lipids	
Site	*Fusion*	*Dental*	*Fusion*	*Dental*	*NP*	*P*	*A*	*M*
FUG	Meat st. 4	Milk	Mixed meat milk	Mixed meat milk	11	9	20	5
PPD	Milk	Meat	Meat st. 3	Mixed meat milk	0	0	NA	NA
PFH	Milk	Meat	Mixed meat milk	Mixed meat milk	84	0	25	4.8
APC	Meat st. 3	Milk	Meat st. 3	Meat	10	6	18.8	12.5
TES	Meat st. 3; milk?	Milk	Meat tender, st. 4	Tender meat	45	0	26.7	0
LDW	Meat st. 3; milk	Milk	NA	NA	321	37	50	13.7
STE	Milk	Mixed meat milk	NA	NA	44	0	34.1	0
DST	NA	NA	NA	NA	40	0	22.5	2.5
HER	Meat st. 3; milk?	Mixed meat milk	Meat st. 3, milk?	Mixed meat milk	23	0	0	0
BIS	NA	Mixed meat milk	NA	Tender meat	290	0	20.3	1.4
ROS	Meat st. 3; milk?	Meat, milk?	Meat st. 3, milk?	Mixed meat milk	63	0	25.4	0
PCS	Meat st. 4; milk?	Meat	Meat st. 2, 4	Meat	144	0	10.4	0

Table 16.6: Characterisation of sites based on herd structures, ceramics and lipids. Herd structure analyses were coded (M=meat, D=dairy, X=mixed, ?=NA). The presence of sieves and milk lipids in any vessel was noted. Per column a point was assigned for evidence for dairying, and categorised as strong (3-4) or possible (0-2) milking.

	Cattle Fusion/Dental	Caprine Fusion/Dental	Sieves analysed	Milk lipids	Dairy Score	Dairy signature
FUG	MD	XX	Y	Y	4	Strong
PPD	DM	MX	N	?	2	Possible
PFH	DM	XX	N	Y	3	Strong
APC	MD	MM	Y	Y	3	Strong
TES	XD	MM	N	N	1	Possible
LDW	XD	??	Y	Y	3	Strong
STE	DM	??	N	N	1	Possible
DST	??	??	N	Y	1	Possible
HER	XX	XX	N	N	2	Possible
BIS	?X	?M	N	Y	2	Possible
ROS	XX	XM	N	N	2	Possible
PCS	XM	MM	N	N	1	Possible

16.3.3 Dairy economies and carcass processing

Indicators of carcass processing are analysed below in relation to the likelihood of dairying economies on the sites studied. Patterns of butchery and fracture analysis reveal some of the most significant variations between sites with “possible” and “strong” dairy economies (table 16.6). They suggest that carcass processing practices, particularly bone marrow extraction, were more intensive where dairy economies were not so well established.

16.3.3.1 Butchery

Butchery patterns for sites with a “possible” or “strong” dairy signal as identified in table 16.6 were combined on carcass profiles for bovinae and suidae (figure 16.46). While sites with “possible” dairy signatures were more numerous than those with “strong” signatures (eight compared to four), Rosheim *Sainte-Odile* was not included in butchery analysis, and Dillingen-Steinheim Wickenpoint had a very small sample size and thus limited butchery evidence. This resulted in a more equal distribution of sites. However, suid butchery was far better represented by “possible” dairying as these sites had typically higher proportions of domestic pigs, particularly Herxheim, and wild boar at Polgár-Csőszhalom.

Figure 16.46 shows that there were some considerable differences in butchery patterns between sites with “strong” and “possible” dairy signatures. Defleshing was arguably more intensive at “possible” sites, particularly on the forelimb, although defleshing of the hindlimb was more comparable. On all sites with a “possible” dairy signature butchery was found on the lateral and medial aspect of the blade of the scapula in bovinae and suidae, whereas on sites with a “strong” dairy signature only the neck and glenoid cavity were affected. Butchery related to defleshing was also arguably more common on the shaft of the humerus and radius on sites with a “possible” dairy signal, particularly true of suid butchery. Defleshing of the tenderloin was also identified only at “possible” dairy sites. Dismemberment butchery was present in similar locations throughout the bovine carcasses for both groups, although disarticulation of the extremities from the hindlimb at the tarsals was much better represented by “possible” dairy signature sites.

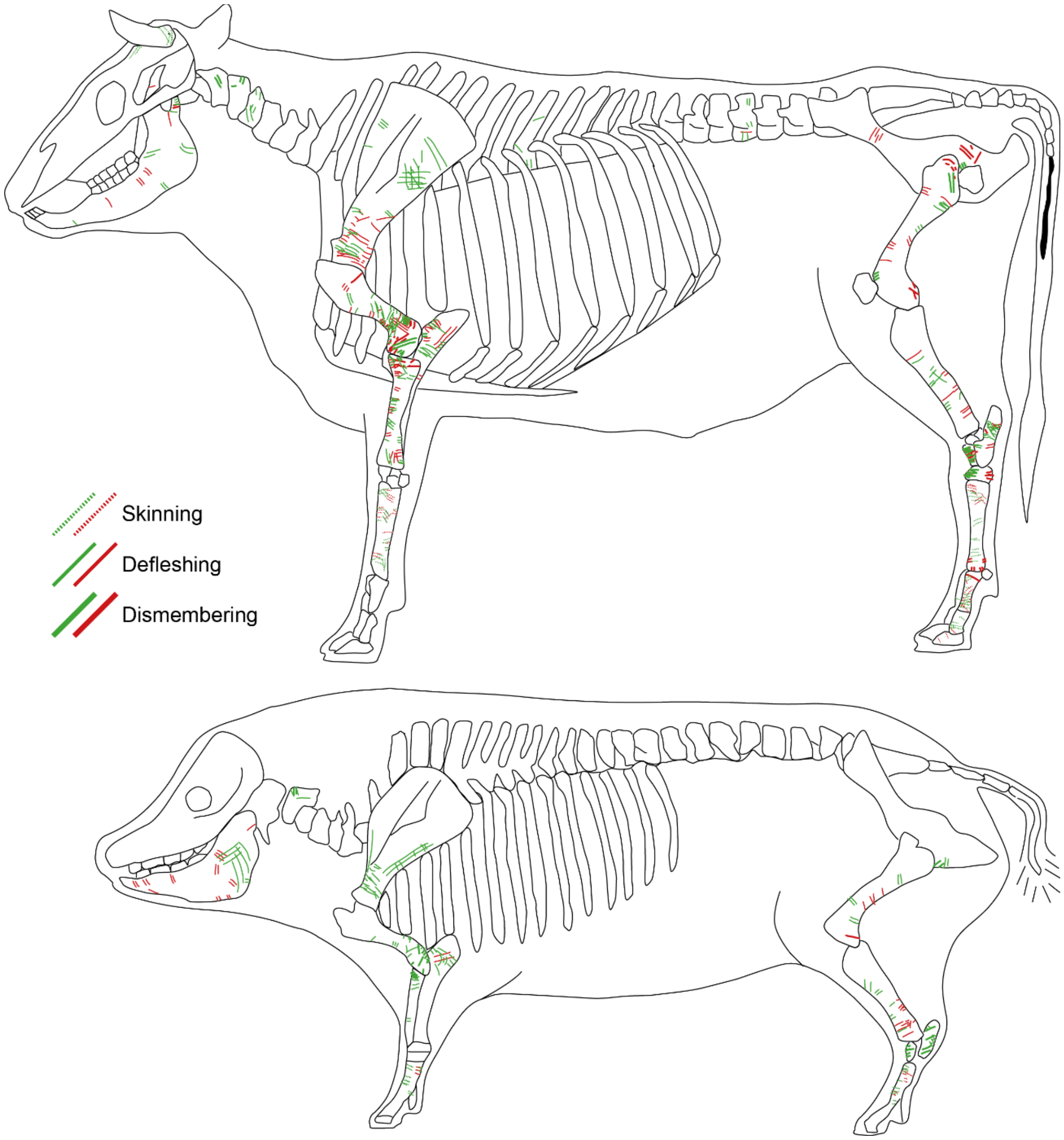

Figure 16.46: Carcass profiles showing trends in butchery for bovinae (top) and suidae (centre) from all sites where butchery analysis was completed, divided into those with a possible dairy signal (green) and a strong dairy signal (red). See figure 16.26 for exceptions.

These patterns could indicate more intensive defleshing of carcasses on sites where evidence for dairying economies was scant. This could reflect intensive marrow exploitation through careful filleting of meat and perhaps the periosteum before breakage of raw bones, which is most efficient in terms of nutrient retention (Outram 1998). This also suggests that meat was often removed from the bone prior to cooking on “possible” sites, and could have been included in stews after marrow processing. However, as was shown in section 16.2.3, cooking practices are not so obviously separable by the likelihood of dairying economies as they likely relate more to cultural preference for roasted carcass parts.

16.3.3.2 Fracture

One of the key markers of the intensity of meat and fat exploitation at the sites studied is the proportion of fresh fracture (figure 16.33), which is indicative of the intensity of bone marrow extraction. As suggested in figure 16.33 but shown in correspondence analysis in figure 16.47 sites cluster in their dairying likelihood groups based on the proportions of first fracture types. The disparity between fracture freshness on bovine and suid bones from all sites in each dairy group is displayed in figure 16.48, where "possible" sites have much higher proportions of fresh fracture.

Table 16.7: Proportion of bovine elements fractured when fresh from sites with "possible" and "strong" dairy signatures.

BOS	HUM		RAD		FEM		TIB		MAND		MC		MT	
	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Pos.	78	82	76	93	81	58	76	72	61	104	60	67	57	72
Str.	51	67	39	75	26	39	47	58	16	83	34	65	35	80

Table 16.8: Proportion of suid elements fractured when fresh from sites with "possible" and "strong" dairy signatures.

SUS	HUM		RAD		FEM		TIB		MAND	
	%	N	%	N	%	N	%	N	%	N
Pos.	86	124	58	65	76	46	68	66	38	103
Str.	52	27	36	11	0	8	60	15	21	38

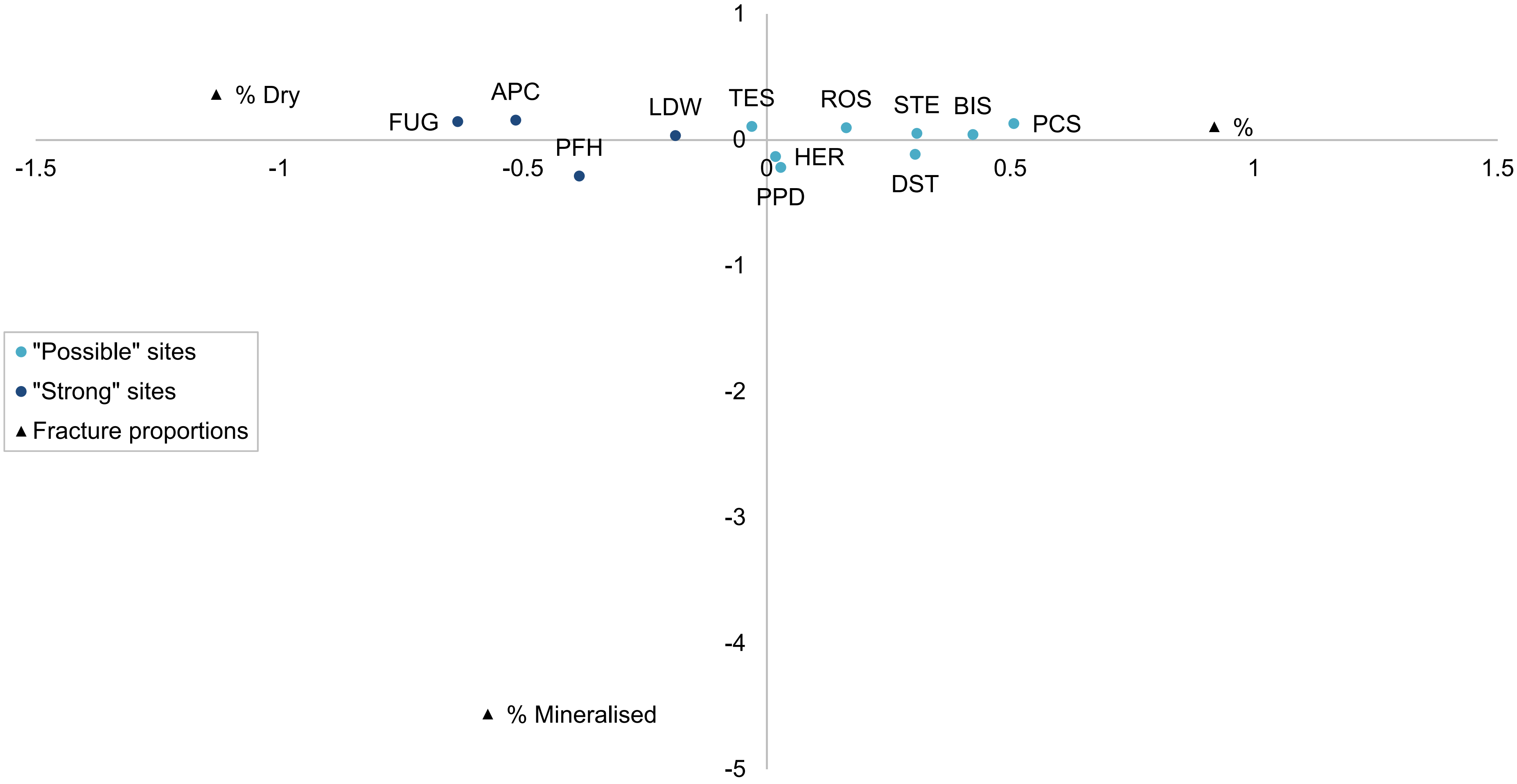

Figure 16.47: Correspondence analysis of the proportions of first fracture types (fresh, dry or mineralised) from all sites studied, coloured based on likelihood of dairying.

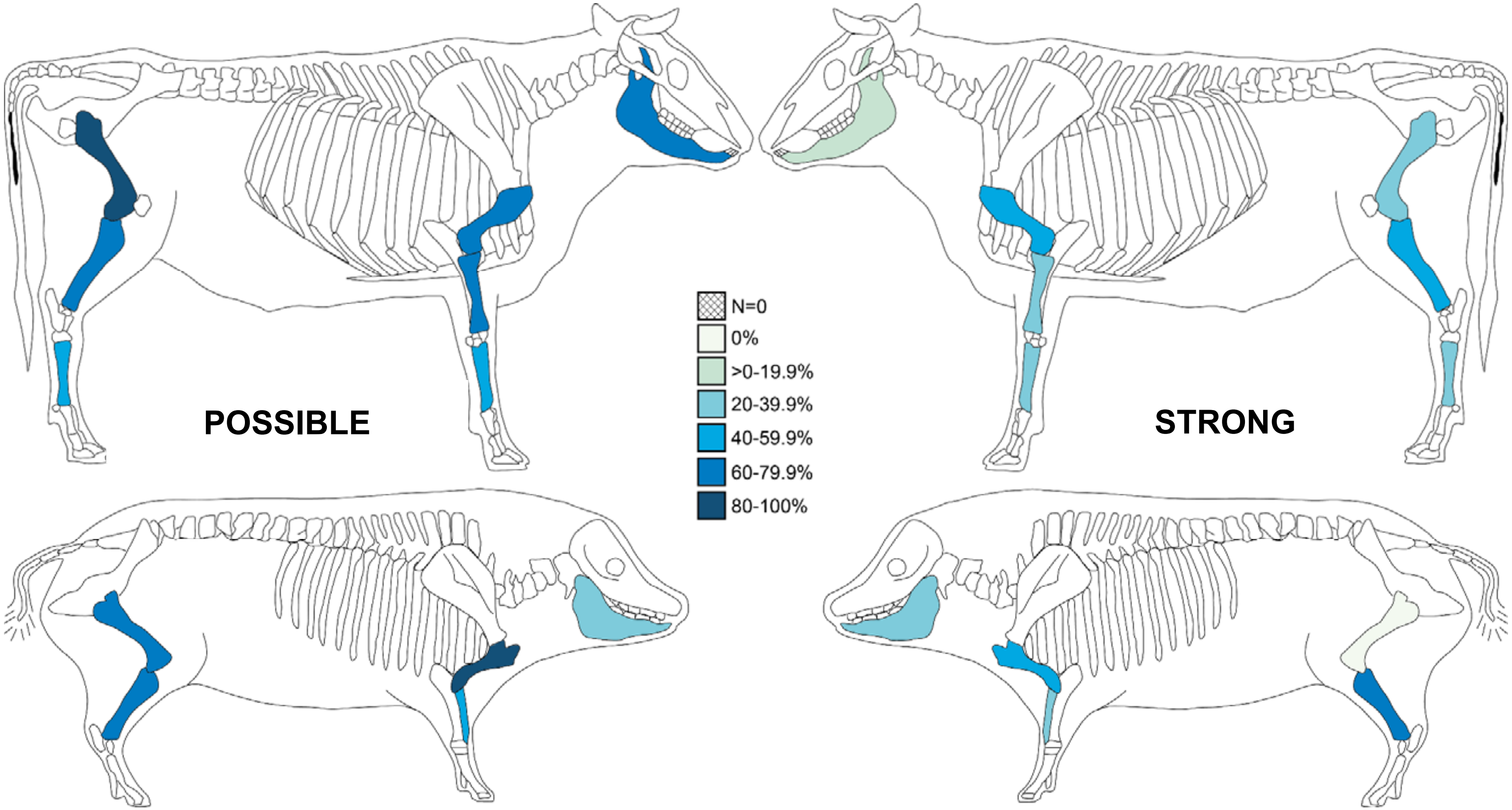

Figure 16.48: Carcass profiles showing fresh first fracture percentages for bovine (top) and suid (bottom) elements. The diagrams are separated into sites with "possible" (left) and "strong" (right) dairy signatures. N values are in tables 16.6 and 16.7.

The relationship between marrow exploitation and dairying is further represented by the negative association of the percentage of sherds containing milk lipids and the percentage of fractured bones fractured when fresh (figures 16.49 and 16.50). Sites with “strong” dairying signatures have high proportions of cattle and caprines, low levels of fresh fracture, and group most closely with higher percentages of milk residues found in pottery sherds (figure 16.49). The opposite is true for sites that show little evidence of an economy targeting dairy production, which have high levels of fresh fracture and typically higher proportions of pig bones. These patterns indicate that societies were more intensively processing marrow on sites where dairy fat was not so readily available.

This is an incredibly interesting conclusion indicates that access to dairy products reduced the necessity for bone fat processing. This aligns with the hypothesis set out in chapter 1, and implies that people of the LBK were consciously or unconsciously making dietary decisions based on fat intake. While bone fats were not abandoned in their entirety, and taphonomic fracture caused by deposition practices likely exacerbated the amount of dry fracture, it is clear that early ALPC and TLPC sites in Hungary, and the LBK in Kuyavia at Ludwinowo 7, had less reliance on this resource that was heavily exploited at other sites. This immediate uptake of exploitation of dairy at the start of the Neolithic has been seen elsewhere, for example in Britain (Cramp *et al.* 2014), and adoption of dairy fat into diet has been seen in ethnographic accounts of the !Kung San (Schrire 1980; May 1978; Lee 1993: 129-30, 92). Another largely lactose intolerant group (Jenkins *et al.* 1974: 23), the San have actively and enthusiastically embraced milk and its products (Lee 1993: 129-30, 92), leading to increased fertility and decreased child mortality (Schrire 1980; May 1978). Access to dairy products can therefore be beneficial to populations despite lactose intolerance. Where available and acceptable in terms of cultural constraints milk seems to be readily adopted, possibly in detriment to other dietary elements once necessary for subsistence.

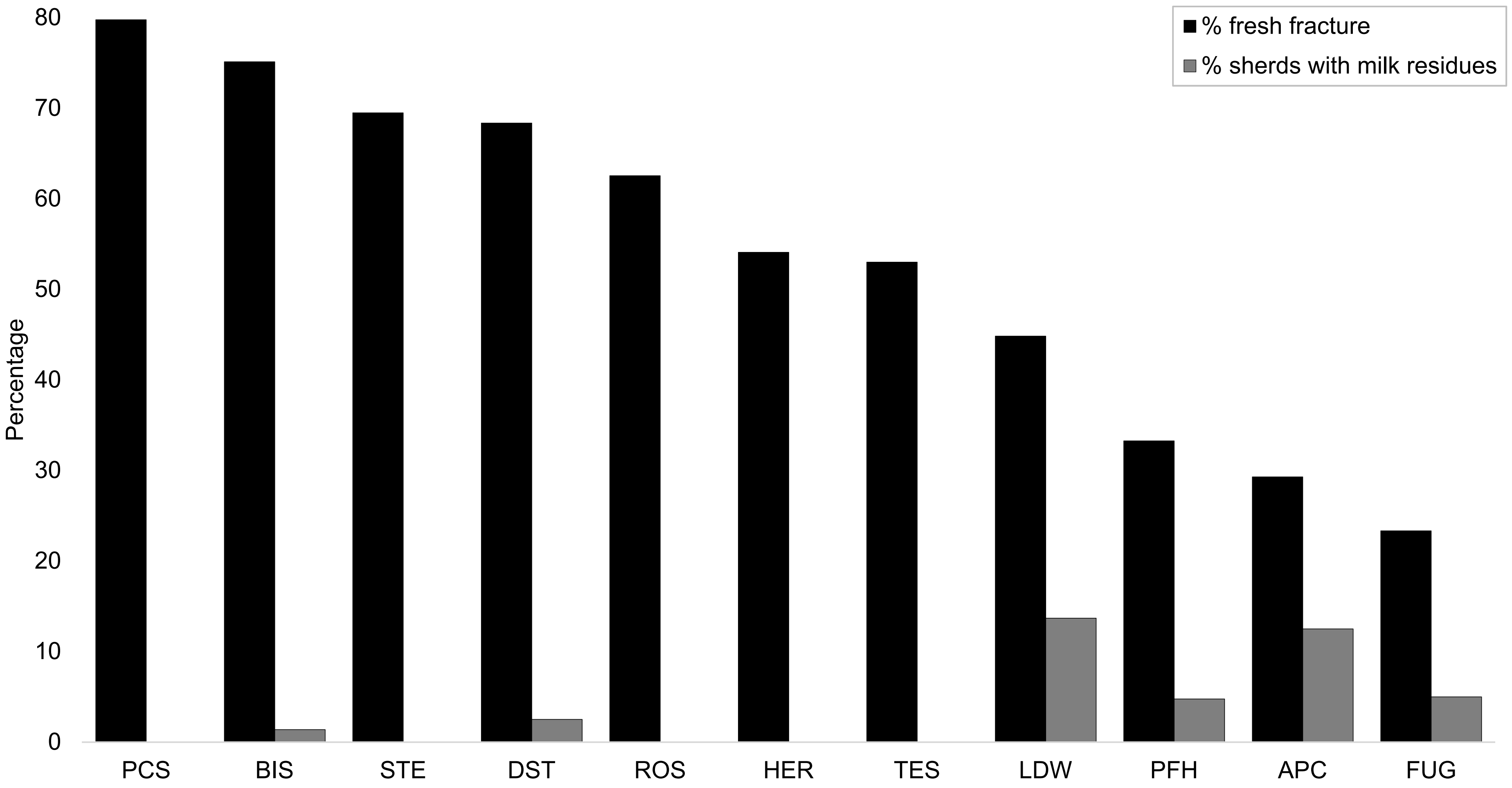

Figure 16.49: Percentage of fresh first fracture and percentage of analysed sherds with milk residues from all sites where lipid residue analysis has been undertaken. In this graph sites are sorted based on the proportions of fresh first fracture.

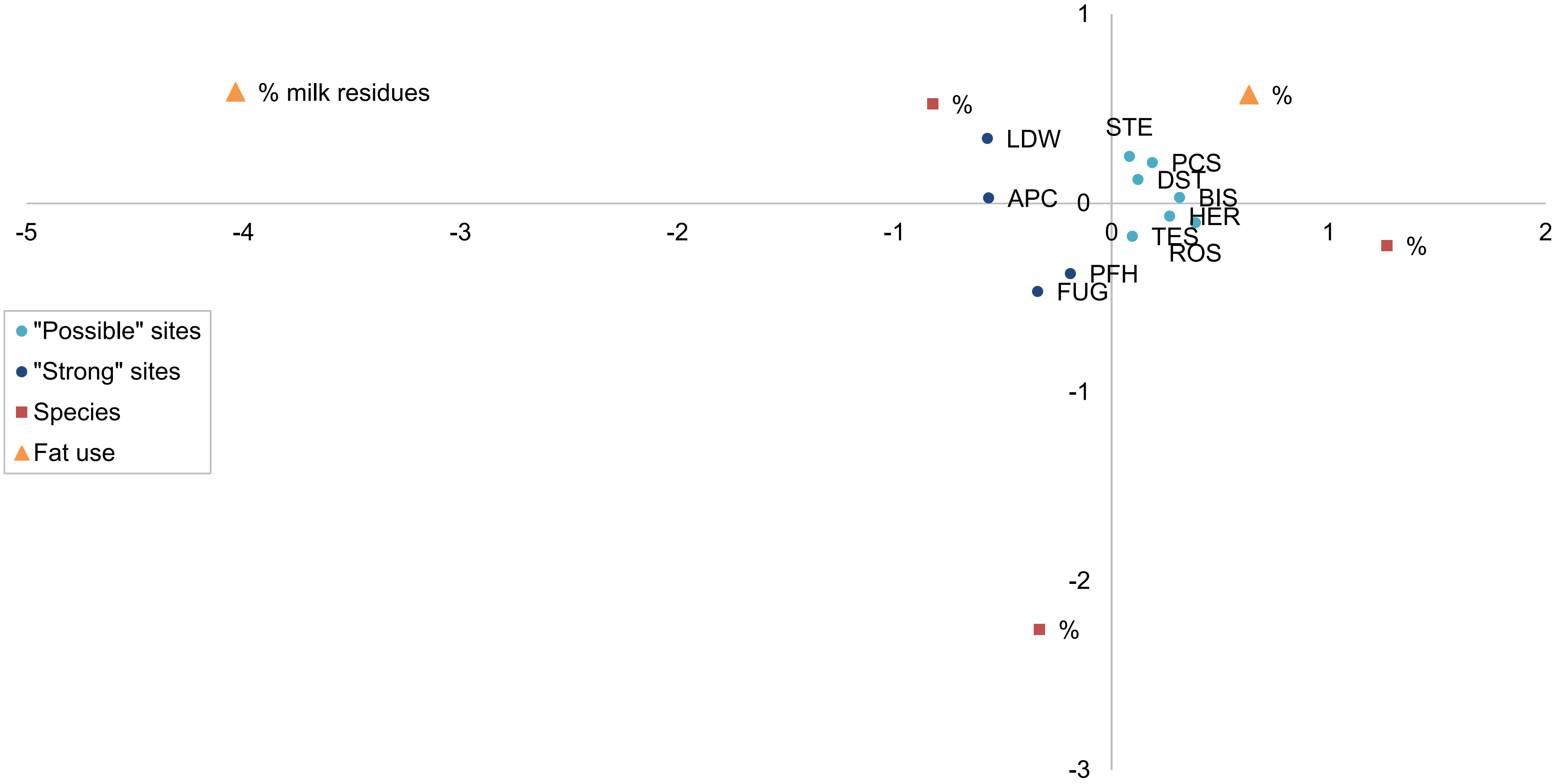

Figure 16.50: Correspondence analysis of the proportion of main three domesticates (cattle, caprines, pigs, NISP), percentage of fresh first fractures, and percentage of all analysed sherds (perforated and non-perforated) with milk residues on sites where lipid residue analysis has been undertaken. Sites are coloured based on the likelihood of dairying.

16.3.4 The nature of meat and fat exploitation, and its relation to dairying

The relationship between dairying, meat and fat exploitation presented here suggest that the adoption of dairying did indeed have an impact on the way people used animal primary products in the European Neolithic. On sites where dairy fat may have been readily available there was less intensive marrowfat exploitation, suggesting a conscious or subconscious decision to exploit one form of animal fat above the other. Marrow extraction was certainly not abandoned altogether on sites with dairy economies, and may have played a particularly important role in times of hardship. At Ludwinowo 7 marrow extraction may have become ritualised as part of communal feasting of cattle (Marciniak 2005; 2011; Marciniak and Pollard 2015). The adoption of dairying caused a significant cultural shift that affected the relationship between people and their animals in ways that still impact modern day farming and consumption practices.

16.4 Future work

Avenues of future work primarily concern the ongoing investigations of the NeoMilk project and the results thereof, which will obviously impact, and perhaps strengthen, the conclusions of this thesis. In addition to this, several gaps in the literature were identified during this project, which could be addressed.

16.4.1 Monitor NeoMilk results

Although this part of the NeoMilk project is completed, analysis in other project areas is ongoing. Data concerning the intensity of dairying on LBK sites continue to be analysed and interpreted, the conclusions of which should be closely monitored. This includes lipid residue and dental eruption and attrition data awaiting analysis, interpretation, dissemination and publication. Trends in dairying intensity may change in the presence of a larger sample size, and the conclusion of this thesis should be updated in the face of this new evidence. In terms of the herd structure analyses of LBK sites, the project could benefit from a study that combines age-at-death analysis of the cranial and postcranial skeleton. The contradictions of the fusion and dental age-at-death analysis need to be addressed to see if greater clarity and understanding can be gained concerning herd structures in the LBK culture.

Further zooarchaeological analysis of Linearbandkeramik culture sites studied for this project could contribute significantly to the picture of meat and fat exploitation regionally and chronologically. Material from Bischoffsheim would benefit from additional analysis, as the sample was taken from houses of different time periods to increase the temporal range of the analysis, but using single houses to represent time periods cannot be advised. The sample from Füzesabony-Gubakút was analysed in a very limited time frame, leaving some contexts only partly analysed. This incredibly interesting early site would be an excellent candidate for further study. Finally, material from Polgár-Csőszhalom originated from just two contexts from the horizontal settlement. It would be useful to target other settlement contexts to see if the sampled assemblage was typical for the site, and to target the tell settlement to further assess the disparity there.

In addition to further analysis on cultures already studied, a stronger understanding of meat and fat exploitation and its relation to dairying would be gained by analysing sites from other contemporary cultures. Hunter-gatherer sites would provide an ideal baseline for meat and fat exploitation in the absence of domesticated crops and animals. While originally focussing on the Linearbandkeramik culture the NeoMilk project has since targeted later Neolithic sites in the search for the intensification of dairying (Roffet-Salque and Evershed 2015). It would be useful to analyse the zooarchaeological assemblages from these sites and others to see if trends identified in the early Neolithic continue into later periods.

16.4.2 Bone fracture analysis

Whilst the applications of fracture freshness analysis in zooarchaeology are increasing, the full utility of this form of evidence is not yet realised. New techniques of recording, such as the fracture freshness index (Outram 1998; 2001), and of presenting data, like fracture history profiles (Johnson *et al.* 2016), have continued to make analysis of fracture types quick, efficient and informative. Continued work in this field should aim to promote this form of analysis and to further make it accessible to all.

Another avenue of zooarchaeology that is not adequately understood is the relationship between different cooking methodologies and the signatures on archaeological bone. Although many papers address changes in surface colour, bone moisture content and other indicators there is little study concerning breakage types after certain heating activities, particularly in terms of marrow processing (although see Outram 1998; 2001; 2002; 2012). Through using experimental archaeology, archaeological signatures of breaking marrow-bearing bone after boiling and roasting would be especially useful to an understanding of cooking and marrow exploitation practices.

16.5 Final thoughts

The question of how humans react to the introduction of a new foodstuff has relevance for the whole of human history. The case of the LBK, and indeed, other societies in more modern times, shows that since their introduction people have often readily accepted and embraced dairy products into their diet, despite the perceived barrier of lactose intolerance. People quickly developed a method for reducing the effects of lactose intolerance by making cheese and other milk products, making dairy fats more consumable and storable over longer periods of time. This, and the changing attitudes towards bone fat processing, show that the people of the Neolithic were very much aware of their nutritional needs, particularly in terms of fat. In the face of readily available dairy fat the necessity for extracting the relatively harder to access bone marrow, and certainly bone grease, reduced. These decisions may have been made subconsciously at first, but as dairy economies became more complex bone marrow may have been reintroduced as a foodstuff eaten in ritual feasting, such as at Ludwinowo 7.

Our own attitude to fat in the modern Western world may echo these trends. Eating bone marrow in the United Kingdom of the twenty-first century is now practically unheard of, perhaps as it is not necessary to diet – or, indeed, detrimental to *a* diet. A reduced need and desire for bone fats in the modern Western world, coupled with a heavy standardisation of butchery, has relegated our reliance on animal products to what is available at the supermarket. These modern butchery and consumption practices, in the light of the findings of this thesis, seem incredibly wasteful.

On a more positive note, this thesis has demonstrated the value of interdisciplinary collaboration. The NeoMilk project is an excellent example of cooperation between academics of many different universities and disciplines, and shows the exciting results that can be gained when combining all these data. This is particularly true of the often-under-used fracture and fragmentation analysis, which has proven to be an excellent source of information about dietary and depositional decisions made in past societies. It is hoped that work in this field will become more and more common as its value is recognised.

Appendix

See back cover for attached CD containing all zooarchaeological data analysed in this thesis.

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