Livestock and Landscape: Livestock Improvement and Landscape Enclosure in Late and Post-Medieval England

By:

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Abstract

The late Medieval and early Post-Medieval periods in England are often associated with agricultural transformation and improvement. The contentious term 'Agricultural Revolution' is applied to this era, though it has been assigned broadly to numerous periods from the sixteenth to the nineteenth century. Zooarchaeological evidence from predominantly urban locations has demonstrated clear alterations in livestock size, shape and herd profiles from at least the fifteenth century, suggesting change in husbandry strategy. However, scarce data from rural areas has hitherto prevented a full assessment of livestock improvement in the primary centres of animal rearing. Livestock change is accompanied by historical evidence for widespread landscape alteration in the form of open field enclosure. This process has been proposed as the impetus for livestock improvement, as it potentially enabled greater control over livestock nutrition, disease and breeding.

Three rural case study sites were selected to assess this potential association between landscape enclosure and livestock change. The sites were chosen to represent a range of geographical locations and enclosure mechanisms, to examine how enclosure and livestock change varied across England. Zooarchaeological analyses, including species frequencies, age profiles and metric assessment were applied to the material from the sites, to assess the extent and timing of livestock change. This was compared to historic evidence for livestock management, as well as evidence for the type and timing of enclosure on each site.

In contrast to previous studies, the zooarchaeological evidence from the rural assemblages did not display a clear chronological trend in livestock management and size, but instead a more complicated picture of regional variation and exchange. In combination with the historic and landscape evidence, it indicated that enclosure may have influenced livestock change, but it more likely acted in combination with other factors like population, market demand, cropping innovations, and trade.

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1. Introduction: What is the 'Agricultural Revolution', and how is it linked to enclosure and zooarchaeology?

The term 'Agricultural Revolution' has been used to describe a number of periods in English history, and its use remains a contentious idea among agricultural historians. According to Overton (1984; 1996b), the term has been attributed to at least five periods between 1560 and 1880 which exhibited some change in agricultural production, each with arguably different significant developments. He argues, however, that no single episode of change is backed-up by enough quantitative evidence to be dubbed revolutionary. The fundamental basis of the term derives from the substantially increased English agricultural productivity between the Middle Ages and the nineteenth century (Allen 1991, 236). More specifically, Thomas (2005a, 72) defines 'Agricultural Revolution' as a "sustainable increase in agricultural productivity", highlighting the importance of technological change in increasing farming yield. Overton (1996a, 1) also emphasises technological advancement, although he admits that there is little agreement regarding precisely what the significant changes were or when they occurred. What is clear, however, is that this period of agricultural change had a profound impact on both arable and pastoral farming, which Beckett (1990) attributes to innovation, enclosure, and the distribution of land. Among the improvements associated with the idiom, a size increase of livestock is perhaps the most readily investigated quantitatively – Thomas (2005a, 72) suggests that zooarchaeological investigation of animal data may allow for the evaluation of the "conceptual validity" of the 'Agricultural Revolution'. Understanding the nature and chronology of developments in livestock improvement and land distribution could be crucial to comprehending their relationship, as well as understanding their roles in wider agricultural development. Indeed, this knowledge will aid understanding of the development of English agriculture and economy, contributing to a more comprehensive awareness of the advent and spread of modern farming.

1.1 The Timing of the 'Agricultural Revolution'

Identifying the exact timing of this so-called revolution is a contentious issue, and is dependent upon the evidence assessed. Uncertainty may stem from the relative lack of national statistics concerning agricultural productivity before 1850 (Overton 1996b, 5). Overton (1984, 127) argues that most assessments rely too heavily on published documentary evidence, resulting in generalisations based on few contemporary authors. However, it is clear that there was a considerable increase in agricultural output in terms of both land and labour before 1850, which allowed for population expansion (Deane and Cole 1967, 5; Overton and Campbell 1991, 3). With fewer people employed in agriculture as the population increased, there must have also been a significant increase in productivity per agricultural worker (Overton 1996b, 5; Overton and Campbell 1991, 2). Generally, there is less information about livestock productivity than crop yield, though it too appears to have increased between the broad period of 1300-1850, perhaps to a greater extent than arable production (Davis and Beckett 1999, 2). Pryor (2011, 471) therefore argues that the 'Agricultural Revolution' must have occurred before the Industrial Revolution to facilitate population increase. He is not alone in associating agricultural improvement with industrial development - initial accounts tie the so-called 'Agricultural Revolution' to the period between 1760 and 1830, as it was argued that the increased agricultural yield supported the growing towns of England (Beckett 1990). It was also suggested that in this relatively short period a new breed of capitalist farmers encouraged the destruction of common land, increased large-scale enclosure, and the consolidation of small farms, resulting in greater agricultural output. Ernle (1912) asserts that the large farms and widespread enclosure championed by "pioneer innovators" of the eighteenth century drastically altered the English countryside, allowing for the improved crop rotations, innovative machinery and enhanced livestock breeding often associated with increased farming output. Examples of these "practical men" given by Ernle (ibid., 171-207) include Jethro Tull, Lord Townshend, Robert Bakewell, and Coke of Norfolk. Chambers and Mingay (1966) also support the notion of revolutionary agricultural change after 1760, hastened by the Parliamentary Enclosure movement and pioneering wealthy landowners. However, they state that agricultural change should not be so readily associated with industrial transformation. In fact, they assert that the 'Agricultural Revolution' should not be considered the "agrarian side of the medal of the Industrial Revolution" (ibid. 2).

Dating the 'Agricultural Revolution' has become more uncertain since the initial scholarly discussions in the first half of the 20th century. Beckett (1990) suggests that it is no longer commonly associated with the Industrial Revolution, and probably occurred before 1750. Clark (1991, 212) concurs, arguing that output per agricultural worker became "unusually high" in sixteenth-century England and thus the substantial development of the agricultural sector occurred before the period associated with industrial progress. In the 1960s, Ernle's theory was challenged, with Kerridge's (1967) work being instrumental. He argued that agricultural improvement took place between 1560 and 1767, with the core achievements occurring before 1673. Pressures like land hunger and population on sixteenth-century resources form the basis of Kerridge's argument – he states that these factors encouraged a reorganisation and improvement of agriculture which previous historians had overlooked (Beckett 1990, 6). He was also the first to question the impact of pioneering "innovators" such as Jethro Tull, Lord Townshend and Thomas Coke. He asserted that the reputation of those pioneers could be traced back to the men themselves, and that Ernle overemphasised the importance of a number of advances underlying agricultural change in the eighteenth century (Overton 1984, 121). Chambers and Mingay (1966, 12) also suggest that the supposed pioneers operated largely by trial and error, not necessarily appreciating the underlying motivation behind their actions. Finally, Overton (1996a, 4) asserts that not only was Townshend too young to have introduced the first turnips, but Jethro Tull was not the first to invent a seed drill, and Coke's practices may have actually caused harm to the land's productivity.

Despite these arguments placing the 'Agricultural Revolution' before the seventeenth century, the notion of a later revolution persists. For example, Campbell and Overton (1991) still argue for a later transformation, stating that "most rapid and profound transformation of technology and productivity" occurred after 1750. Their assertion that 1790 to 1820 was "an almost complete break with the past...over the working lives of one generation of farmers" is enough to convince them, and others, of revolutionary change in this period. Overton (1996a, 197) also asserts that there is insufficient evidence for an 'Agricultural Revolution' before the eighteenth century, as a moderate sixteenth-century yield increase and a probable drop in labour productivity from the sixteenth to seventeenth centuries are certainly not suggestive of "agricultural triumph" (Overton 1996b, 17). This is mirrored by Mingay's (1977) assertion that, despite some farming development from the sixteenth century, improvement only gathered pace in the later eighteenth century. Hopcraft (1994) also maintains that revolutionary change did not occur until the seventeenth to eighteenth centuries, but states that rural changes in the fourteenth to sixteenth centuries, for example new technology, enclosure and emergence of small farmers, were crucial to that later development. This is echoed by Chambers and Mingay (1966, 5), who concede that the foundations of agricultural change lie in the later Medieval period.

Overall, during twentieth-century studies, the 'Agricultural Revolution' was placed in the period between 1560 and 1880, occurring in up to five stages varying in timing throughout the country. While several historians argue for a later change, the fact that significant agricultural transformation occurred much earlier cannot be ignored. Recent consensus points to this 'revolution' being a more gradual process of improvement in multiple stages varying in timing and nature (Allen 1991; Beckett 1990). For example, Thirsk (1987, 57-61) suggests that changes were slower to appear in the North of the country, so transformation which occurred in the mid-sixteenth century in East Anglia may have taken over a century to reach Northern England. This may contribute to why historians have differed so greatly in their assessment of the timing of the 'Agricultural Revolution'.

Despite a seemingly comprehensive list of factors pointing towards significant agricultural change during this period, many writers are reluctant to label it revolutionary. This may be due to the more recent suggestion that changes in productivity were gradual and complex, varying in nature across regions and terrain (Kerridge 1967). Thirsk (1987, 57-61) supports this assertion, stating that the term 'Agricultural Revolution' should be abandoned due to an array of agricultural changes occurring slowly, with innovations adapted to meet the needs of each farming region. This recognition of agricultural change as slow and variable has led Mingay (1969, 481) to describe the phrase as little more than a "convenient label", masking a multitude of developments during a very broad time period. He goes on to state that to talk of the period as revolutionary is "to risk being considered a dangerous reactionary, or at least incautious obscurantist" (Mingay 1963, 123). Perhaps then, Overton (1984, 123) is correct in stating that the expression is "best dispensed with" as it is "beyond redemption". In order to assess this further, more detailed investigation into the causes and nature of key developments of agricultural change during this period is required, and the term shall be avoided henceforth due to its ambiguity.

1.2 The Main Features and Potential Causes of Agricultural Improvement in the Late Medieval and Early Post-Medieval Periods

In addition to disputing the timing of agricultural improvement and the appropriateness of the term 'revolution', historians have sought to identify key developments in the later Medieval and post-medieval periods which may have contributed to increased farming output. For example, Kerridge (1967) gives seven key indicators of agricultural change, including up-and-down husbandry (also known as convertible husbandry or ley farming), which involved the conversion of permanent arable or pastoral land to areas alternating between temporary tillage and grass leys. He also lists fen drainage, fertilisers, floating the water meadows and new crops as developments amounting to revolutionary change. These developments contributed largely to the availability and fertility of land, increasing agricultural output. Finally, Kerridge states that new stock and systems of husbandry were vital factors in livestock change. One example of this change was an increased demand for beef from around the fifteenth century, resulting in cattle being fattened for the winter and being replaced by horses in plough-teams (Langdon 1986, 288). Kerridge also lists the appearance of the Norfolk "four-course rotation" system – a four-year crop rotation course with no fallow year, emphasising the cultivation fodder crops such as of clover and turnips. It could be easy to regard Kerridge's criteria as an exhaustive list of factors contributing to agricultural change, however, Overton (1984, 122) states that some of them are exaggerated and rely too much on accounts by eighteenth-century writers. In fact, Kerridge (1967, 32) himself casts doubt upon the importance of several factors such as clover and the Norfolk four-course system. Nonetheless, Overton (1996b, 3) lists many of the same features as crucial indicators of agricultural change, for example fodder crops, rotations, water meadows, machinery and livestock change. He also highlights the importance of increased productivity, defined by the output per unit of input.

A factor which certainly contributed to agricultural development was the population of England from the fourteenth to the nineteenth century. Campbell (1991, 146) suggests that the population decline caused by the Black Death in the fourteenth century was responsible for increased agricultural yields. Almost half of the population of England was wiped out, with the most considerable effect in rural areas (Postan 1939; Pryor 2011, 339). This led to reduced pressure on cultivating marginal land and the conversion of arable land to less labour-intensive pastoral use as village size and the number of available labourers decreased (Baker 1973, 207; Campbell 2016, 310). The demand for grain fell and demand for animal products increased, also encouraging the transfer of land into pastoral use (Campbell 2016, 363). During the seventeenth century, wool manufacture had risen to account for over two-thirds of British exports as a result of this transfer to pastoral farming (Deane and Cole 1967, 30). Furthermore, rising income per capita and decreased feudal rent may have caused higher meat and dairy consumption, promoting the intensification of animal husbandry. This is evident in the data from the period, which implies that between the fourteenth and fifteenth centuries the number of livestock units per demesne increased by 16% on average (Campbell 1991, 146). In addition, it has been suggested that from the fifteenth century there was an increased stocking density for sheep and dairy cattle, accompanied by a decline in the use of animals for draught purposes as arable land dwindled (ibid. 157). Some writers argue that the population recovery after this period also stimulated agricultural development. Hopcraft (1994, 1566) suggests that the population density recovery after the fourteenth century may have provided motivation for increased endeavour for improved agricultural yield. This theory holds true for regions which became more densely populated; however, it does not account for improvement in areas like East Anglia which still had prosperous rural economies even after reduced population density in the fourteenth century. She postulates that population decline in these regions made land more readily available to poorer but enterprising farmers, though this appears to be speculation. Nevertheless, Overton (1996b, 3) also suggests that productivity change reflected English agriculture successfully responding to provisioning for a growing population, especially in the sixteenth to seventeenth centuries. Clark (1991, 212) places particular importance on the role of population in agricultural development, and states that the increased farming output contributed to sustaining a large population outside agriculture. The increased ability of the agricultural sector to support a growing population is also recognised by Beckett (1990) as an essential criterion for distinguishing agricultural change.

Another key development recognised by most historians as crucial to increased agricultural productivity is the introduction of convertible husbandry. This system involved the alternate cultivation of grain crops and legumes or grasses, which was changed every three to four years (Mingay 1963, 129). The system was probably developed before 1560, and had spread through Midland England by 1660, though much land later reverted to pasture (Broad 1980, 77). It was adopted in both open field and enclosed land, and prevented the need for fallow periods, thus increasing land output. The shift between arable and pastoral use also allowed for the redistribution of manure from pastoral to arable land, as well as greater flexibility due to a more rapid response to changing grain and livestock prices (Overton and Campbell 1991, 43). It also facilitated the introduction of new crops like turnips, clover and grasses (Overton 1996b, 10). Therefore, land temporarily laid down to grass might not have increased arable output, but provided more fodder supplies (Baker 1973, 215). This increased the food available to livestock during the winter, avoiding the need to kill aged or worn-out animals in the autumn due to a lack of winter fodder (Ernle 1912, 14). Overton and Campbell (1991, 43) suggest that this led to a rise in stocking densities and increased livestock size. Baker (1973, 315) proposes that increased grass production “laid the foundation for a great expansion of animal husbandry”.

Another significant factor in agricultural transformation, as put forward by Overton (1996b, 4) is the organisation of land. This includes changes in property rights, farm size, and the enclosure of common land. Hopcraft (1994) evaluates a number of factors in assessing the causes and consequences of land organisation before 1600. She notes that the most productive agricultural regions in terms of arable yield did not necessarily have the best soil or climate, but that change relied more on social organisation than local ecology or specialisation. She states that this is particularly evident in Norfolk, a county which she describes as being at the forefront of agricultural progression despite apparently having poor soil and being subject to drought in the summer, as well as cold winds from the North Sea in the winter. One potential reason given for the agricultural progression of the county was a combination of new agricultural methods and changes in tenurial arrangements – a factor which Hopcraft (ibid., 1560) links to agricultural advancement due to greater consolidation of land and enclosure. The same study considered whether areas located close to urban markets were more innovative, and again the opposite was found, with areas around London seemingly not the most progressive. This suggests that it was the organisation of land, rather than its location or ecological conditions, which dictated its agricultural improvement.

A factor frequently referred to by historians is the change in rural class relations during the late Medieval period. It has been suggested that agrarian change occurred first where small peasant proprietors had the weakest property rights, allowing lords to dispossess tenants and consolidate farms. However, Brenner (1985) argues that it was primarily peasants in East and South-West counties after 1350 that were consolidating farms, leading to less common land and potentially greater improvement. A downward social distribution of land was likely caused by the population reduction during the Black Death, meaning that more peasants became landowners as the feudal system broke down (Dyer 1981). Drummond and Wilbraham (1939, 26) suggest that with fewer lords acting as a hindrance to change, new peasant landowners became increasingly invested in raising profitability of stock. Furthermore, they were more likely to be in direct contact with their animals, making them better able to take "technological initiatives" leading to livestock improvement (Allen 1991, 252). Ernle (1912, 35) agrees that this "larger scope for individual enterprise" may have been the catalyst for increased agricultural productivity. This was exacerbated by the breakup of monastic estates following the sixteenth century dissolution as it made more land available to smaller farmers (Hoskins 1992, 115). This "wealth enabling" alteration further contributed to a period of rapid and dynamic change in land ownership (Pryor 2011, 379). Therefore, it could be suggested that land organisation may have played a key role in agricultural improvement, and the specific role of enclosure merits further discussion below.

The final, yet often overlooked, feature of late Medieval agricultural development is livestock improvement. This relative neglect may be because there is less information available regarding livestock productivity than arable output; however, it is likely that the changes in livestock were more marked (Overton 1996a, 111). It has been suggested that livestock output per agricultural worker doubled from 1300 to 1860 (Clark 1991, 212), although it should be noted that calculations assume the same size and yield for all livestock. This change was accompanied by an increase in cattle, sheep and pig numbers between the fourteenth and nineteenth centuries, as well as a doubling in meat, milk and wool output (ibid., 216). Kerridge (1967) suggests that improvement in the main domesticates occurred relatively early in this period, for example, he states that Midland pasture sheep were improved by the seventeenth century. Improvement in sheep may not only have altered the quantity of products, in the case of carcass weight, but also their quality. For instance, Grant (1988, 151) suggests that sheep wool quality was improved as the Medieval wool trade expanded, which bolstered the Medieval economy (Albarella 1997a, 23). The burgeoning sixteenth-century wool trade caused estate owners to clear and enclose wasteland, as well as converting arable land to pasture (Drummond and Wilbraham 1939, 27; Jones 1965, 13). It seems that the adage "the foot of the sheep turns sand into gold" (Ernle 1912, 59) prompted many landowners to sacrifice arable land for sheep-rearing in the hopes of profit. As a result, counties like East Anglia recorded "three sheep for every human being" (Hoskins 1992, 117). There is also evidence for an increase in animal size of up to 24 percent by the seventeenth century, as well as improved stock with a reduction in bone and offal, which increased meat yields (Deane and Cole 1967, 70). This evidence certainly points towards a significant change in livestock; however, higher temporal definition, facilitated by more data and further work, is required to narrow down exactly when and how this change occurred. There have been a number of suggestions as to what caused this change in livestock production. Broadly, factors such as land enclosure, new husbandry techniques, new crops, increasing population and increased agricultural specialisation have been linked to livestock improvement (Thomas 2005a; Thomas *et al*. 2013).

Overton (1996b, 12-14) proposes two main reasons for increased animal yield: increased livestock numbers, or improvement of the livestock themselves. An increase in the numbers of livestock may have been brought about by increased density of livestock per acre, combined with an improvement in fodder supplies. Improved fodder allowed for a reliable source of grass hay, especially in April when hay was scarce and spring grass was not yet ready, which served to extend the lambing period (Kerridge 1967). This was evident in Norfolk, as in the seventeenth century livestock density doubled, perhaps due to the increased use of convertible husbandry (Overton and Campbell 1992). However, it should be noted that the number of animals is not always an accurate gauge of output, as it does not take into account the rate of maturation (Overton 1996a, 113). The introduction of new, faster growing breeds or the development of existing breeds to display this characteristic would mean a lower age of slaughter, therefore an increased turnover of animals and overall a greater meat yield (Beckett 1990, 25; Overton 1996a, 113). A zooarchaeological assessment of slaughter pattern, evaluated below, may aid in corroborating this.

Perhaps then, it was the improvement of livestock themselves that led to increased productivity, causing them to produce more food from the same input of fodder. There are various ways that different breeding strategies may have led to an increasing yield of animal products, for example either the selective breeding of existing stock, or crossing with other varieties which led to increased meat weights, especially in sheep and cattle (Overton 1984, 119). Russell (1986, 12) defines a breeding strategy as "the degree and type of selection that a breeder of animals chooses to exert on the parents from which he produces his successive generations of stock", and there is evidence that late Medieval farmers were exerting some influence on livestock breeding, though before the eighteenth century this may have focussed on preventing stock degeneration rather than promoting improvement. It is improbable that breeders before the eighteenth century were operating a totally random system of livestock mating, and they most likely attempted a form of positive breeding, in which they either selected animals displaying desired characteristics for breeding, or excluded those in which the characteristics were absent. However, it seems that in many cases these characteristics were centred on aesthetic qualities, rather than "productive attributes", as external appearance was often perceived as an indicator of genetic composition (ibid., 14). As a result, "trivial points" such as colour or horn length were often the criteria for selecting breeding animals (Mingay 1977, 28). This is demonstrated in Markham's (1664, 70) account of the features selected in bulls, which include "quick countenance", "horns the larger the better", "eyes black and large", and "nostrils crooked within, yet wide and open". Attributes favoured in breeding sheep were also aesthetic qualities like a "cheerful large eye" and "large upright neck" (ibid., 85), though there is evidence that larger animals with the best wool were selected – characteristics which may have increased productivity. Russell (1986, 15) argues that even when productivity was selected for, it was most often judged by a single morphological characteristic, for example size, which was not always an effective guide to true economic productivity. Furthermore, he states that the distinction between inherited and environmentally determined characteristics was "meaningless to many early breeders" (ibid., 15), who thought that environmental characteristics were also transferrable. Thus, any improvement in livestock productivity in the early post-Medieval period was likely the result of selection by appearance, environmental conditions and management. It was only in the nineteenth century that breeders began to select animals using breeding value, i.e. the capacity of an animal to pass on desired characteristics which it may not possess itself (for example milking capacity in bulls), suggesting an increased understanding of genetic inheritance (ibid. 18-19).

Alongside attempted selective breeding of existing stock, there is evidence of the introduction of livestock from elsewhere from the late Medieval period onwards, possibly with the aim of hybridisation to produce productive attributes (Beckett 1990, 22). For example, Trow-Smith (1957, 202) states that a pied strain of English cattle was present by at least the seventeenth century, with the tall, large, long bodies characteristic of Dutch origin. Furthermore, he points to imports of cattle to Lincolnshire in the seventeenth century with large bodies and increased milk yield. Darby (1973, 320) also states that rams and bulls were imported from elsewhere by the seventeenth century, though he does not specify where. This could represent the selection and combination of different breeds in order to produce hybrid offspring exhibiting desired phenotypes. Often males were imported as the phenotype of the male parent was considered more influential to the characteristics of the resulting offspring (Markham 1664, 69; Russell 1986, 15).

Unfortunately, it is difficult to find accurate evidence for livestock productivity changes in the historic record, as there was little in the way of official figures before the Board of Agriculture began publishing annual output statistics in 1866 (Beckett 1990, 54). This makes assessing livestock numbers complicated, and output even more so. Overton (1996b, 13) suggests that an indirect measure of animal output can be found using a comparison between the price of livestock and the price of livestock products. However, price is not always the best indicator of meat output, as it is dependent on many factors, including buyer, quality and demand (Holderness 1989, 111). Manorial accounts, tithe records and probate inventories are invaluable in estimating livestock output prior to the eighteenth century (Overton and Campbell 1991, 6; Overton 1984, 129). However, this does not easily allow for the consideration of factors like breed, age and size which would affect animal productivity (Campbell and Overton 1991, 12). This is where zooarchaeology may prove particularly useful, although values for meat, milk, wool or 'draught power' yields are still very much estimates (Campbell and Overton 1991, 12; Overton 1984, 131).

1.3 Land Enclosure and its Link to Agricultural Change

As previously mentioned, enclosure resulted in a major transformation of English landscape organisation from at least the sixteenth century. Therefore, the study of early enclosure could reveal its contribution to the process of agricultural change, particularly livestock improvement. However, a study of enclosure must start with a brief review of the definition and variations of the term. Pryor (2011, 379) provides a relatively uncomplicated definition of enclosure: an "area of ground surrounded by a landscape feature, e.g. ditch, wall, hedge, bank or fence". This essentially indicates a way of partitioning the landscape to indicate ownership by an estate or individual. The enclosure of common-field usually involved the following processes: amalgamation of scattered property and abolition of intermixing; hedging and ditching of separate properties; and the removal of common rights on that land (Yelling 1977, 5; Slater 1907, 85). After the process was complete, the previously common land was held 'in severalty', meaning that it was then reserved for the sole use of the owners or tenants (Mingay 1997, 7).

The form of enclosure most commonly discussed in relation to agricultural transformation is Parliamentary Enclosure, which started in the seventeenth century and rapidly gained pace throughout the eighteenth. As the name suggests, this form of enclosure was brought about by a number of Parliamentary Acts. It was often used in parishes with more complicated patterns of land ownership, where a large number of landowners, or common land with multiple claims, required more careful re-distribution (O'Donnell 2014, 118). The process was presided over by a commissioner, although could take years to actually carry out (Beckett 1990, 35). Initially private Acts were granted to each parish wishing to enclose, and these Acts were followed in 1801 by a General Enclosure Bill facilitating easier enclosure in parishes where over three-quarters of the landowners were amicable to the process. A further Bill following this in 1836 lowered this threshold to two-thirds, though by this point the main bulk of open fields had already been enclosed (Mingay 1997; Wittering 2013, 72). Finally, the 1845 Enclosure Act negated the need for a private Act for each enclosure, further easing the process of land reorganisation (O'Donnell 2014, 111). Overall, over 5,200 Enclosure Bills were enacted by Parliament between 1604 and 1914, affecting around a quarter of England and Wales (UK Parliament 2018; Mingay 1997, 30).

Other forms of enclosure took place before this time which may have had an equal or greater bearing on agricultural production strategies. For example, general enclosure by agreement was common in the sixteenth century, and likely foreshadowed Parliamentary Enclosure (Mingay 1997, 11). Often during this form of enclosure, land was enclosed via private agreement of landowners, although sometimes this was disputed in court. Often the principal landowners in a township reached a formal agreement for enclosure, in which both open field and common land was surveyed and re-allotted before enclosure (Williamson *et al* 2013, 134). Therefore, it is likely to have been more prevalent in parishes with land spread between relatively few owners. However, in some cases townships were enclosed by one individual who had achieved 'unity of possession' by acquiring the majority of the land in a township, which could then be enclosed in a single stroke. Yelling (1977, 18) suggests that this type of enclosure was motivated by a desire for farming improvement, and was associated with a transfer to pastoral land-use. He comments on the "impressive scale" of this enclosure by the eighteenth century, as by this time around 85 English townships were wholly enclosed and many others partially divided. Agreements such as this were often recorded in local manorial court records, especially where disputes arose. However, these records can be hard to assess for a number of reasons, including the sheer volume of records, lack of indexing, and accuracy of historical recording (Butlin 1979, 68).

Enclosure could also be achieved in a piecemeal fashion. This occurred in more than one stage as individual proprietors enclosed their own strips of land from open fields or commons in multiple private agreements, rather than whole townships acting together. As a result, it was relatively disorderly, with limited consolidation (Yelling 1977, 6). It also mainly affected open fields, having a more limited impact on commons and woodland (Williamson and Bellamy 1987, 103). However, enclosure by this method often negated the time and expense needed for the previously discussed more formal methods (O'Donnell 2014, 110). Due to the comparably slow speed of this process, smaller proportions of townships tended to be enclosed in this fashion, often with general enclosure finishing the enclosure that piecemeal methods had started (Williamson *et al* 2013, 133). Furthermore, the haphazard nature of piecemeal enclosure brought about a greater number of disputes, particularly where access to land could only be achieved by going through newly-enclosed closes owned by others (Yelling 1997, 12). It has been suggested that this form of enclosure began as early as the thirteenth century as farmers began to exchange strips of land to accumulate adjoining areas before enclosing, and continued as late as the seventeenth century in some areas (Butlin 1979, 67; Rackham 1986, 170). However, it is difficult to document and assess this enclosure before the Parliamentary Acts of the eighteenth century due to fewer records and greater variability (Beckett 1990).

Much like livestock improvement, landscape organisation and enclosure appear to have exhibited variation in methods and speed of change across the country. By the end of the sixteenth century it seems that "two countrysides" with very different enclosure characteristics had developed (Williamson 2003, 5). Midland and central regions were arranged in regular open field systems known as "champion countryside" (Williamson *et al* 2013, 8), where two or three large arable fields were divided into small, unhedged tenant-owned strips intermingled with demesne land, and subject to communal cropping rights (Rippon 2012, 113). These often 'reversed S' shaped strips were clustered into furlongs, with every farmer on each furlong growing the same crop and leaving the land fallow every few years to restore fertility (Rackham 1986, 164). Grazing typically occurred on commons and wasteland, and occasionally on arable land after harvest, where livestock manure reinstated soil nutrients (Rippon 2012, 113; Drummond and Wilbraham 1939, 19). The grazing land allotted to each farmer depended on the size of the common and the size of their holding in the open arable fields, and often came with seasonal restrictions (Mingay 1997, 34).This complex system of organising land spread between intermixed strips was highly communal as landholdings were managed by the manorial court, which decided cultivation practice and regulations (Williamson *et al* 2013, 102). The communal nature of these open fields made them more susceptible to general forms of enclosure, as fewer landowners exerted control over each parish which made enclosure by agreement or unity of possession more viable. Butlin (1979, 70) also suggests that in this area, particularly in Leicestershire and Warwickshire, enclosure by agreement for pastoral land use was common due to their distance from waterways and thus inability to efficiently engage in cereal trade. Parliamentary Enclosure also seems to have had the greatest impact on this Midland band, as open field was largely removed by Parliamentary Enclosure Acts between 1720 and 1840 (Rackham 1986, 164).

In other counties a very different pattern of land organisation was present by the sixteenth century. The counties that Rackham (1986, 161) dubs "Ancient Countryside", for example East Anglia and the South-West, exhibited more individual property rights, less communal regulation and more land enclosed in irregular fenced or hedged fields than in 'champion' areas. These areas were perhaps easier to enclose as fields were divided directly from woodland, so were never organised as open field (Hoskins 1992, 119; Rippon 2012, 113). Furthermore, these regions had an abundance of pasture, meaning that there was no covetously guarded common grazing land, and a lack of shelter may have prompted enclosure (Hoskins 1992, 120). They also had a higher frequency of private grazing and a more pastoral focus. Beresford (1961, 64) suggests that these counties were more prosperous and individualistic areas, in which agricultural development was encouraged and individual landholders could react to market demands in pursuit of personal profit (Beresford 1961, 64). As a result, much of the East and South-West was enclosed with little complaint by the fifteenth century. The method of this enclosure seems likely to have been piecemeal, as strips were not so widely dispersed, thus making consolidation and enclosure easier. Furthermore, these areas were not regulated in such a strict communal fashion as the Midland open field belt and contained more common grazing land. This may have reduced the opposition to enclosure as those excluded from fallow grazing upon the removal of open field still had access to commons (Williamson *et al* 2013, 133).

Despite this seemingly straightforward classification of farming regions into common or enclosed land, Kerridge (1967, 16) argues that this "simple world" is just not realistic. It appears that enclosure occurred first in the South West and East, and eventually reached the Midlands, then highlands (Hoskins 1992, 117). However, this is not to say that this land alteration was entirely one-way; privately enclosed fields were being incorporated back into open field strips as late as the sixteenth century in counties like Yorkshire, Northamptonshire and Cumbria (Rackham 1986, 170). Furthermore, the attention given to Parliamentary enclosure masks land reorganisation before this period. By 1500 at least 45% of the country was enclosed by agreement, which increased to 47% by 1600 and 71% by 1700 (Beckett 1990, 35; Wordie 1983). Hoskins (1992, 124) states that by the sixteenth century, hundreds of instances of enclosure by agreement had actually taken place in the Midlands, although written records may provide the best evidence for this as hedges from this period are often not distinguishable. Rackham (1986, 170) suggests that only a seventh of the country was enclosed during

Parliamentary Enclosure, and that open field had already disappeared from a number of counties, including County Durham and Sussex, before the eighteenth century. In Northamptonshire – the county most affected by Parliamentary enclosure – half of the county was already enclosed before the first Act. The same is true for Leicestershire, where three-fifths was enclosed before Parliamentary involvement (Hoskins 1992, 124). Finally, in North Buckinghamshire enclosure was widespread before the eighteenth century, but was often not officially recorded. In fact, 52 of 138 parishes were enclosed by means other than Parliamentary acts, and at least half of the remaining 86 parishes provide evidence for pre-Parliamentary enclosure (Reed 1984). This is further evidence that much enclosure had already occurred before the main Parliamentary Acts of the eighteenth century. In addition, Williamson *et al* (2013) suggest that large amounts of land in the Midland 'open field' band were subject to reorganisation and re-purposing prior to enclosure by Parliamentary Act. For example, the extension of pasture often associated with the enclosure process occurred before the start of the eighteenth century, especially on heavier soils, and large tracts of land were already used to produce fodder crops by the seventeenth. This shows that the classification into 'open' and 'ancient' countryside may not be so well-founded, as land use patterns and enclosure methods were in fact quite variable, and not always specific to certain areas of England.

Regardless of enclosure method, it seems that there were a number of key motivations for enclosure from the late Medieval period. Mingay (1997, 33) states that any single enclosure could be carried out with numerous objectives in mind, not least the notion of greater agricultural productivity and efficiency due to communal constraints. Later Enclosure Bills often discussed the flaws of open fields, and several authors have argued that enclosed agriculture was more efficient than open field farming for several varying reasons. Firstly, it seems that open fields may have limited the adaptability and entrepreneurship of landowners due to their highly communal nature. Tate (1967, 42) argues that strict regulations regarding field layout, land use and common rights meant that open fields did not lend themselves to experimentation, potentially limiting opportunities for development and the ability of landowners to respond to market demands. Mingay (1997, 37) echoes this, stating that there was a restricted choice of crops in open fields as landowners with intermingled strips were obliged to grow the same crops and observe the same fallow, though much depended on the nature of the soil and the flexibility of the landowners. It was suggested by Walter Blith in 1653 (cited in Mingay 1997, 39) and again by Arthur Young (1791) that this inflexibility generally made open field farmers more conservative and less amenable to progress. It has also been suggested that the rigidity of the divide between permanent arable and pastoral land was less pronounced in enclosed areas, increasing flexibility and therefore efficiency (Mingay 1997, 40). Enclosure also provided more opportunity for the conversion of arable land to pasture, which Butlin (1979, 76) argues allowed landowners to respond to increasing market demand for specialised products such as dairy produce or meat, therefore increasing their profits. Examples of locations where this occurred include Northamptonshire and Leicestershire in the fifteenth century, where sheep and cattle were raised for wool and meat, and East Anglia in the seventeenth, where dairying predominated (Williamson and Bellamy 1987, 96). It seems, therefore, that one of the main motivations for enclosure was the potential for increased agricultural efficiency as the "floor to the standard of farming" resulting from communal regulation was removed, and the structural and legal reforms required for agricultural progress were enacted (Mingay 1997, 40; Butlin 1979, 78).

The increased potential for development and flexibility was most likely not the only motivation for enclosure – it seems that landowners also chose to enclose in order to increase efficiency in terms of land use, labour and time, and to reduce the occurrence of disputes (Tate 1967, 42). In fact, Mingay (1997, 40) describes open field farming as a "waste of land, time and effort" as dispersed strips meant more land 'wasted' on division and access. The scattered nature of arable strips in open field landscapes could also be the source of inefficiency. However, this depended on the degree of dispersal, and was somewhat reduced by exchange or consolidation of strips as plough teams could be used more efficiently, and less time was wasted getting to remote holdings. Chambers and Mingay (1966, 79) point out that enclosure and individual land ownership removed tithes, which resulted in greater convenience to parishes, especially in cases where piecemeal enclosure had resulted in a complex distribution of small enclosures. In many cases enclosure also served to bring about a transition in land use which reduced wasted land and brought about greater efficiency and profit. For example, tired arable land could be laid to grass, which in turn reduced over-grazing on commons. Furthermore, waste could be brought in to cultivation, expanding the area of land under regular tillage and increasing the yield from previously little used areas (Chambers and Mingay 1966, 79). Enclosure may also have increased soil fertility as land previously only ploughed in one direction could be cross-ploughed, turning up new, more fertile, soil. Additionally, landowners may have enclosed land in order to reduce the frequency of disputes between holders of neighbouring strips. In open field areas disputes regarding trespass and escaped stock occurred more regularly, in addition to complaints of landowners neglecting their plots by allowing weeds to grow or not maintaining drains and ditches (Mingay 1997, 36). This could greatly affect the productivity of neighbouring strips – in the words of Ernle (1912, 64) "under the open-field system one man's idleness might cripple the industry of twenty". Therefore, it is likely that the potential for increased land efficiency, in addition to further impetus for individual development uninhibited by disputes, formed part of the many reasons why landowners chose to enclose their land.

It seems that the possibility of increased profits and rent also formed a large part of landowners' motivation for enclosure. It has been argued that enclosed fields were two or three times more profitable than open fields, especially when the land enclosed was previously waste (Mingay 1997, 33). Butlin (1979, 78) agrees with this notion, stating that enclosure was a "means of rapid transformation to lower costs per acre, higher yields, and greater profits on a larger cultivated area". The reasons for this increased profit likely relate to the previously mentioned factors which increased flexibility and efficiency, including more compact farms, which were easier to work and more likely to adopt convertible husbandry (Chambers and Mingay 1966, 79). Enclosed land also attracted higher rent as it was no longer subject to communal rights (Thirsk 1967a, 207). Even when the same husbandry methods and rotations were practised in neighbouring open fields, the enclosed areas were subject to on average double the rent, sometimes even triple (Chambers and Mingay 1966, 84). This increase was seen as early as 1450 and was augmented by the fact that enclosure created multiple, smaller parcels of land which were rented for more, especially if they were meadow or orchard (Clark 1998, 74-88). Furthermore, it was easier to find replacement tenants in enclosed areas than in expanses of small, scattered strips further from the village (Mingay 1997, 36). It has been argued that the return from enclosing was almost double that from investing in buying land or from other riskier commercial or industrial ventures, making enclosure "by far the most profitable use of capital in connection with land" (Chambers and Mingay 1966, 84; Clark 1998, 74). Increased profits and rent yield, therefore, seem logical motivations for enclosure for late Medieval landowners.

A final possible reason for enclosure is the potential benefits for livestock and husbandry strategy. In many cases enclosure brought about a conversion to pasture, often solving the problem of lack of grazing, which had previously limited the number of animals kept (Williamson and Bellamy 1987, 98). This change is displayed in South Cambridgeshire, where sheep numbers rose by 20 per cent on average after enclosure (Wittering 2013, 110-111). It has also been suggested that herding livestock, especially sheep, on large commons was not successful, and was even less so on arable land after harvest (Ernle 1912, 59). Dyer (1981) argues that an increase in enclosure may have allowed greater control over food intake of animals and breeding, potentially allowing for improvement. Perhaps, then enclosure was adopted as a method of keeping larger herds of livestock more efficiently. Furthermore, it has been argued that disease spread more easily throughout livestock intermingled on common ground; for example, liver rot in sheep was a common complaint in common pastures, especially where drainage was poor (Mingay 1997, 37-8). Another condition rife in commonly herded cattle as late as the eighteenth century was known as 'cattle plague', which was most likely rinderpest. While it could be argued that livestock mortality occurred in both common and enclosed fields due to relatively crude veterinary skills, it seems that landowners in enclosed parishes could more readily implement government-led initiatives to prevent the spread of disease, ultimately resulting in fewer losses. Finally, enclosure meant that livestock no longer had to be moved regularly between common grazing grounds, resulting in greater flexibility regarding breed choice. Individual owners could choose to rear the breed of their choice, and after enclosure many selected new breeds which were designed to gain weight rapidly as they no longer had to be moved long distances. These improved breeds with greater meat producing capabilities in combination with improved winter fodder meant that more animals could be kept in smaller areas, increasing livestock yield per acre (Wittering 2013, 110-111). Therefore, not only would enclosure potentially aid existing livestock by inhibiting the spread of disease, it also provided an opportunity to introduce new breeds which could be fattened quicker. In addition, it may have facilitated larger herds, providing a greater choice for selective breeding, ultimately increasing profits.

While it seems that there were many motivations for enclosure, the views of authors who claim that open-field farming was not wholly inefficient and inflexible should not be ignored. Some have argued that in open-field areas operating a law of common rights, agriculture was by no means as inflexible as has been suggested, and by the sixteenth century could be adjusted or developed with changing circumstances such as market demand (Thirsk 1957). Havinden (1961) highlights agricultural progress in open fields before the eighteenth century. Furthermore, Mingay (1997, 34) concedes that these areas could in fact adapt to over-grazing on commons or introduce varied or more complex crop rotation systems. It has also been suggested that by the seventeenth century some areas of common field were flexible enough to introduce new crops, especially fodder crops such as sainfoin, clover and turnips (Jones 1965). Not only was there the potential for more flexible cropping in open fields, some authors have argued that grazing on commons and fallow fields did not necessarily prevent innovation (Darby 1973, 314; Jones 1967, 161). The presence of large grazing flocks on common land may in fact have aided arable production, as the communal herd was systematically moved across the arable fields each night in order to spread manure. This process was not possible in enclosed parishes, as each farmer kept his flock separate, meaning that manure had to be imported in the form of marl, chalk, lime and 'town muck' (Mingay 1997, 40-41). In addition, the view that common field grazing did not allow for suitable control of livestock breeding and disease may not be entirely fair. Kerridge (1967, 318) asserts that care was taken to ensure the quality of animals in common field, stating that "horses with mange or fashions, distempered cattle and rotten sheep were forbidden from the commons", and animals which had died from infectious disease had to be disposed of at a distance. He also states that each common flock had access to good rams and bulls. Therefore, it may be that the notion of enclosure bringing about sudden change is somewhat generalised – change in land efficiency and yield were also affected by factors like soil, topography, markets, areas of commons, waste and open field, structure of landownership and farm sizes (Mingay 1963). Kerridge (1967, 19) argues that enclosure could also not compensate for a lack of technology which may have hindered innovation. Furthermore, the changes often associated with enclosure may have been more closely associated with price movement, industrialisation and population growth. While it seems that enclosure may have accelerated the spread of improved agricultural methods by creating more compact, individually-owned farms, it did not always have an immediate or dramatic effect, and the extent of change was often dictated by local or regional circumstances. Some changes, for example convertible husbandry, were only possible with the removal of common rights; however, it did not necessarily follow that enclosure led to this development (Kerridge 1992, 99). Overall, it seems that there were a number of motivating factors for enclosure, though the process was not always followed by drastic change and enclosure may have simply served to speed up and complete existing developments (Mingay 1963, 32). As Kerridge (1992, 96) argues, to consider open fields as right or wrong - as a "garden of Eden" compared to "sloughs of sloth and ignorance" - is perhaps too one-sided. Nevertheless, it seems that enclosure did often serve as the impetus for agricultural change, as was seen by Thirsk in Lincolnshire, where enclosure "roused ambitions in the ordinary farmer for the first time", providing fresh opportunities (1957, 296-7).

Despite this, there is evidence for innovation in enclosed parishes that cannot be overlooked. For example, Allen (1992, 112) suggests that "enclosed farms were the most progressive", stating that they were the first to replace fallow with fodder crops, and to abandon sheepfolding and adopt new sheep breeds. Furthermore, Hopcraft (1994) states that field system layout was a crucial factor in local organisation and production, and variation in this caused the differences in agrarian change across the country. She proposes that Kent, East Anglia and the South-West experienced more rapid agricultural change (as early as the thirteenth century) due to a larger proportion of private property, a lack of common land, and weaker manorial control. The study also suggests that these factors allowed for more progressive agricultural methods like convertible husbandry, crop rotation and more effective foddering. Therefore, it could be suggested that the early consolidation and enclosure of land in these areas, which were not so significantly affected by later Parliamentary Enclosure, may have led to improved livestock yield. Hopcraft's (ibid.) multivariate analysis study of factors affecting agricultural production suggests that open field is strongly negatively correlated with economic development. This evidence certainly suggests that enclosure provided the momentum for some sort of improvement, but did this specifically affect livestock? Overton (1984, 120) certainly believes so, stating that enclosure was important in preventing mingling of livestock on commons. Furthermore, much enclosure prompted the conversion from arable to pastoral land use as well as lowered employment in agriculture, potentially switching focus to efficiency in livestock rearing (Allen 1991, 238-9). Ernle (1912, 96-97) asserts that "enclosure undoubtedly assisted farming progress", as enclosed pasture meant that lambing did not have to be carefully timed to coincide with both hay production and market demand. He goes on to state that open field farmers were "impervious" to new methods. Allen (1992, 129) suggests that this interpretation may be slightly exaggerated, but nevertheless agrees that open field farmers did not adopt new methods to the same degree as enclosed farmers. Overall, it may not be argued that agricultural improvement was impossible without enclosure, as new methods were still introduced in open field systems, and parishes could achieve change within the confines of common property rights. However, it seems that enclosure accelerated the process of improvement, and provided landowners with flexibility in adapting to market pressures and pursuing individual profit (Overton 1996b, 20).

1.4 Zooarchaeological Evidence for Livestock Improvement

Before reviewing zooarchaeological evidence for potential 'Improvement', it is necessary to define the term, and therefore establish how changes in livestock might be manifested in the archaeological record. Tarlow (2007, 15) demonstrates the broad range of meanings to the term 'Improvement', which appears to have first been used in the seventeenth century, encompassing not only agricultural and livestock change, but also societal, industrial and self-improvement. Within an agricultural context, the notion of 'Improvement' was likely used to drive significant sixteenth to seventeenth century change in rural England, and may refer generally to increasing the efficient exploitation of land, for example by cultivating waste land or enclose common fields (McRae 1992, 35). This improved efficiency is often associated with greater yields, and therefore profit, though in some cases landowners made several changes regardless of economic impact for their perceived social desirability (Tarlow 2007, 35). Improvement in agriculture can be divided into several categories, including crops, soil improvements, enclosure, livestock, and labour, though changes across each area were often carried out in association with each other (ibid., 37). It therefore follows that 'Improvement' in livestock was the attempt to obtain greater yields or quality of animal products, in order to produce a greater profit. Attempts to identify these changes zooarchaeologically are limited by the animal remains preserved. As a result, tooth and bone measurements are often used to estimate meat yield though it is important to note that, in addition to body size, the speed of maturation may also have affected meat yield (Albarella 1997, 21).

It should also be noted that increased animal size identified archaeologically is not necessarily an indicator of improvement. For example, Kerridge (1967, 313-314) points out that Midland Plain pasture sheep produced larger quantities of mutton and wool, but in fact had shorter legs. Furthermore, not all improvements will be apparent in skeletal remains, for instance larger milk yield or better-quality meat or wool may not be represented in skeletal evidence alone (Thomas 2005a). Perceived 'improvement' of one product may also have meant the decline of another – Beckett (1990, 24) suggests that Bakewell's New Long-horn cattle produced fattier meat, but at the expense of milk yield. In addition, it seems that New Leicester sheep had superior growth rates, providing a greater turnover of meat, but were less hardy (ibid.). Furthermore, there is evidence that by the eighteenth to nineteenth centuries, there was a focus on reducing the size of the skeleton in relation to muscle and fat, in order to reduce waste products like "bone, horn, pelt, blood, guts, and garbage" (Culley 1786, 132), and therefore provide a higher profit. Thus, it does not always follow that the 'improvement' of an animal is manifested archaeologically as an increase in bone size.

While Davis and Beckett (1999) argue that zooarchaeological evidence for livestock improvement is harder to come by, many studies have produced significant results. Thomas (2005a, 73) promotes the use of zooarchaeological analysis as a separate line of enquiry from crop and livestock data in addressing the question of livestock improvement. Along with the study of animal size and shape, assessing mortality profiles and regional specialisation could provide further detail regarding livestock improvement in the late Medieval period (Davis and Beckett 1999; Thomas 2005a). It should be noted that animal body size is controlled by a complex relationship between genotypic and phenotypic factors, i.e. genetic vs. environmental influences (Reitz and Ruff 1994, 699; Reitz *et al*. 1987, 310). Therefore, a number of factors, including environmental adaptation, geographic origin, husbandry strategies, nutritional plane and selective breeding, can play a role in the size and appearance of an animal (Higham and Message 1969, 321). The causes of size change may be indicated by the type of change, for example tooth size is controlled largely by genotypic factors, and thus a change in tooth size is more likely to represent a genetic alteration. In contrast, the size of the post-cranial skeleton is affected by both genotypic and phenotypic factors, meaning that bone size increase without tooth change could, up to a point, represent changes like improved nutrition rather than selective breeding or the introduction of new stock (Thomas 2005a). It is also vital to consider the shape of skeletal elements alongside size when attempting to identify changes in livestock, as change does not always occur in a single plane. For example, width and depth measurements show greater correlation with body mass than length measurements, meaning that all three should be considered in combination to assess changes in livestock body mass, and therefore meat yield (Scott 1990, 301).

Nutrition may affect the size and maturity of livestock in several ways. Generally, poor nutrition tends to result in smaller animals, whereas high quality nutrition allows animals to grow more rapidly, reaching their maximum growth potential earlier in life (Popkin *et al*. 2012). This has been demonstrated zooarchaeologically for sheep (Davis 2000), though Popkin *et al*. (2012) determine that varying nutrition is manifested differently in postcranial measurements depending on sex. Therefore, changing post-cranial livestock size and/or shape could have been caused by factors which improved nutritional quantity or quality, such as improved fodder crops or supplementary fodder over winter. For example, turnips were introduced from 1565 and were widespread, alongside clover, by the seventeenth century (Jones 1965, 3-4). This allowed farmers to over-winter a greater stock of farm animals with a higher quality of nutrition, thus potentially increasing animal size, but also paving the way for higher livestock numbers (Deane and Cole 1967, 68). Nutritional plane may also affect the development of livestock, which should be considered when identifying age-at-death in zooarchaeological assemblages. While the sequences of bone fusion and tooth eruption may remain relatively similar, the timing these processes may vary based on changes in nutrition, as poor nutrition can lead to a delay in tooth eruption and/or epiphyseal fusion. The extent of this delay, however, depends on the degree and timing of nutritional change, as well as the specific element and sex of the animal (Popkin *et al*. 2012, 1776).

In addition to nutritional plane, sex can also play a significant role in the size and development of livestock. In most mammals, males are larger than females though there is often considerable overlap, particularly when castrated animals are present. Furthermore, males generally display short, stout limbs, in contrast to short, slender limbs in females and longer, more slender limbs in castrates (Davis 2000). Popkin *et al*. (2012) argue that this is generally true for sheep, though this may be an over-simplification, as nutrition can play a significant role in size, and some elements may exhibit this contrast more readily than others. For example, distal limb bones particularly exhibit the lengthening caused by castration, whereas forelimb elements demonstrate a greater shaft width in males (ibid.). This increased long bone length in relation to width in castrated animals is caused by delayed epiphyseal fusion, allowing for an extended growth period (Davis 2000). In sheep, for example, this delay ranges from a few months to over a year, depending on the timing of castration (Moran and O'Connor 1994), and Davis (2000) suggests that early castration in sheep can delay fusion by around a year in late fusing elements. This phenomenon was documented historically in cattle by Fitzherbert (1534, 39-40), who stated that upon castration, "the oxe shall be the more hyer, and the lenger of body", whereas delaying castration by a year would cause the animal to be "lesse of bodye, and shorte-horned". The timing of fusion also varies depending on sex, as fusion has been demonstrated to begin earlier and be completed sooner in females than males, likely leading to the reduced size of female long bones (Moran and O'Connor 1994; Noddle 1974). Castration can also affect the amount and quality of meat in livestock, as demonstrated by Prescott and Lamming (1964), who highlight the difference between males and castrates in terms of growth rate, efficiency of feed and carcass quality. They state that bulls and rams tend to fatten faster than steers and wethers, whereas the castration of pigs has a lesser effect on growth rate, but decreases feed efficiency and increases the ratio of fat to meat. Overall, there is a range of factors, besides deliberate improvement, which will affect the size and shape of animals. Therefore, any study of livestock size must consider the varying reactions of different bones to different stimuli, resulting in differing degrees of size change based on a combination of sex, castration status or nutrition (Popkin *et al*. 2012).

Congenital traits may aid in identifying where genetic alteration has occurred, potentially via selective breeding. Examples of this include the absence or reduction of the hypoconulid in bovid lower third molars (Albarella 1997b, 45), and the congenital absence of second premolars (Andrews and Noddle 1975). O'Connor (2000, 121) postulates that the traits may be the result of a narrow genepool, though they may also indicate the presence of limited gene-flow in livestock (ibid., 122), potentially due to the selective breeding of animals with desired characteristics.

Zooarchaeological investigation has again suggested that livestock improvement was a complex process, which varied greatly across the country. Davis (1997) argues that measurements from Medieval and post-Medieval cattle and sheep show considerable size variation across England, with those in central England tending to be larger than animals in the peripheries. For example, it has been found that sheep in counties like East Sussex were inclined to be larger than those in Cornwall and Norfolk (Davis and Beckett 1999, 6). This variation is also revealed in historic accounts – for example, in the 1720s, Defoe (1968) documented the largest sheep being present in Leicestershire, Lincolnshire and Sussex, whereas the largest cattle were from Lincolnshire and Sussex. Despite this, it is unclear how livestock improvement originated, and it appears that more peripheral sites and some areas in the north tended to display later evidence for livestock change (Thomas 2005a, 83; Davis 1997, 414; Davis and Beckett 1999, 8).

It is also uncertain how trade and exchange of livestock affected this pattern, and whether it affected the spread of improvement (Davis and Beckett 1999, 8). A factor exacerbating this issue is the relative lack of zooarchaeological evidence from rural areas. Davis (1997, 420) laments this fact, stating that most data derive from high-status or urban sites, where livestock do not necessarily originate from the local area, as by the late Medieval period animals were being traded long distances. Another obstacle to the zooarchaeological study of livestock change is that the post-Medieval constituents of assemblages are often not studied or published in detail, and rural post-Medieval assemblages are notably uncommon, reducing the reliability of results (Thomas 2009).

That is not to say, however, that studies of urban or high-status sites are not useful, as several investigations have yielded significant results regarding the nature and timing of late Medieval livestock size and shape changes (see Table 1.1 for summary of zooarchaeological data). For example, a study conducted by Albarella and Davis (1994b) on the Launceston Castle material suggests a significant cattle size increase between the fifteenth and sixteenth-seventeenth centuries for all bone and tooth measurements. They also found that this change was accompanied by an alteration in bone shape - for example metatarsal measurements show that this element became narrower distally with constant shaft width in relation to length. Furthermore, analysis of the non-metric traits of teeth showed that the 3rd molar hypoconulid development in artiodactyls became less frequent by the fifteenth century, which the authors attributed to a genetic change in the cattle population at that time, perhaps due to a change in breed. The same study also observed a smaller, but significant, sheep size increase between the fifteenth and sixteenth centuries, followed by a greater increase between 1650-1660 and 1840. This could suggest that the main improvement in sheep occurred over a century later than that of cattle, or perhaps that it was a more gradual "continuum of development" which took place over a number of centuries (Thomas 2005a, 85). This is supported by Davis and Beckett (1991), who also suggest that the improvement of sheep occurred later than cattle, along with pig and fowl size increase which is likely to have occurred no earlier than the seventeenth century (Albarella 1997a, 21). As these changes are present in tooth size and form, it is likely that they are at least partly due to a genetic change, brought about by new stock introductions or artificial selection, rather than environmental alteration (Thomas 2005a, 75).

Many other sites have yielded similar results, including Exeter, where Maltby (1979, 36) documents a size increase after the fifteenth century in cattle. In addition, Holmes (1981) has identified some mid-sixteenth century sheep size increase at Whitefriar's Church in Coventry. Another site where cattle in particular appear to have increased in size between the fourteenth and seventeenth century is Prudhoe Castle (Davis 1987a, 9). Furthermore, Albarella *et al*. (2009) identify size increase in cattle, sheep and pig bones and teeth at Norwich Castle, though somewhat later, between the sixteenth and eighteenth centuries. It also seems that in Norwich the size increase of cattle was more sudden than that of sheep and pig. At Closegate, Newcastle, Davis (1991) identified that sixteenth and seventeenth century sheep were also larger, but there is little difference between thirteenth-fourteenth and fifteenth-sixteenth century animal size. Size change is especially evident in metapodials and the distal tibia, though there are issues with context dating. Finally, despite a lack of enough material for significant results, Stallibrass (1988, 59) documents some "massive cattle bones" in the sixteenth to seventeenth century deposits from St. Frideswide's Priory, Oxford. Overall, it seems that a number of urban or high-status sites have produced comparable results suggesting a size increase of the main domesticates around the fourteenth to seventeenth centuries.

Zooarchaeological results from London have also provided evidence of livestock change during this period. Data for cattle, sheep and pig suggest an increase in size from as early as the first half of the fourteenth century, though pig size change is particularly marked in the sixteenth to eighteenth centuries, and cattle actually decrease in size by the start of the nineteenth century (Thomas *et al*. 2013). Thomas *et al*. (2013, 3320) postulate that this change in livestock size was caused by a combination of social and economic factors after the Black Death, for example the downward social distribution of access to land and rise of leasing land for cash rents, potentially providing an incentive for the improvement of stock to yield greater profits. Furthermore, much livestock restocking occurred due to an outbreak of disease in the early fourteenth century, and a crash in the grain market led to the widespread conversion to pastoral land, prompting a growing emphasis in livestock production. The London data suggest a different pattern for horse size, as they appear to have become smaller in the fourteenth to fifteenth centuries, before increasing in size in the mid-sixteenth and seventeenth centuries. Thomas *et al*. (2019) suggest that the size decrease was due to the disruption of horse breeding during the Black Death, and the resulting social upheaval in which aristocratic incomes and international trade previously vital for breeding were disrupted. This was exacerbated by outbreaks of disease and the decreasing availability of winter fodder due to harvest failures. In contrast, from the fifteenth century onwards, breeding regulations and imports of new stock enabled a greater opportunity for the selection of larger horses.

Further zooarchaeological evidence for livestock size increase has been put forward by Thomas (2005b) from the site of Dudley Castle, West Midlands. He found a significant increase in cattle, sheep, pig and domestic fowl size around the mid-fourteenth century, again suggesting an earlier date for livestock improvement in England, although a dearth of cattle and sheep teeth in the assemblage makes it difficult to assess whether the size change only occurred on post-cranial bones. However, pig tooth measurements indicate that the change in this animal was at least partly genotypic. Thomas (2005a, 84) suggests that increased pig size may have been brought about by greater control over breeding and nutrition, potentially due to increased sty farming rather than allowing them to graze free-range in woodland. This in turn may have been caused by extensive woodland clearance in the twelfth to the fourteenth centuries (Rackham 1986, 88). The presence of neonatal pig bones in urban assemblages points to them being raised in towns, again allowing for greater control over feed and breeding (Grant 1988, 158). This increased control over nutrition in the late Medieval period is supported by Hamilton and Thomas's (2012) study of carbon and nitrogen isotope values from pig remains from Dudley Castle. From the fourteenth century onwards, a reduced range of δ13C values suggests a less varied diet, possibly due to an increase in sty farming, and a reduction in the opportunistic woodland grazing of pigs. Results for nitrogen isotopes support this, as they display a decrease in δ15N values in the fourteenth century, which the authors suggest is most likely the result of an increased presence of leguminous fodder crops in pig diet. probably associated with closer human control.

Unusually, the Dudley Castle data do not suggest much biometrical variation in later post-Medieval phases. Thomas (2005a, 80) therefore suggests that the change in animal size at Dudley Castle may not herald the advent of significant livestock transformation, but instead reflects the changes in agricultural and tenurial organisation in the post-Black Death period, coupled with a change in environmental landscape. He states that early Medieval population increase caused an expansion of arable farming, forcing livestock to graze on more marginal lands. Conversely, after the Black Death in the fourteenth century, demand for food diminished and the grain market collapsed. This made animal husbandry a more viable alternative as it was less labour intensive (Hoskins 1992, 96). Thomas (2005a, 83) consequently suggests that the size increase during the fourteenth century at Dudley Castle may reflect the widespread conversion of arable land to pasture associated with population decline, and the movement of animals off marginal land.

What then, is the cause of these striking zooarchaeological results – do they represent livestock improvement? Davis and Beckett (1999, 13) consider this question. A change in size may be the result of an altered sex ratio, maybe caused by changing husbandry strategies or product emphasis. More males present on a site would certainly provide a larger average animal size, but size increase is also documented in teeth, which exhibit limited sexual dimorphism (Albarella and Davis 1996, 16). A change in slaughter age could be responsible for this size change. The increased presence of adult animals may cause a larger average size, a factor which should be minimised by the use of fused bones in the above studies, though post-fusion size change is possible, particularly for bone widths. Another potential cause of the size increase is a higher occurrence of castration as, depending on timing, it can result in delayed epiphyseal closure, and therefore longer limbs (ibid.). However, as Thomas (2005a, 79) points out, castration would not have produced the changes in width and depth of elements that also occurred. It therefore seems likely that the increased size documented in the aforementioned zooarchaeological studies was the result of a real, genotypic alteration. What is still unclear is whether this was caused by more intensive artificial selection of animals or the introduction of new breeding stock to existing populations.

Davis and Beckett (1999) suggest that new livestock breeds may not have caused an immediate increase in animal size or carcass weight, but reduced the age of slaughter which ultimately increased meat supply. Albarella *et al*. (1997, 58) concur that slaughter age patterns may have changed before animal size, and historic evidence suggests that an earlier post-Medieval fattening age of cattle caused a 25 percent increase in stock available for slaughter (Deane and Cole 1967, 70). This improvement would have served to decrease the amount of food required to sustain animals to their optimum meat weight, meaning a greater meat supply using less fodder. Changes like this may be brought about by a variety of husbandry decisions, based on consumer demand for meat, emergence of specialised farming, or a change in emphasis for particular animal products. Therefore, studies have attempted to identify this change zooarchaeologically by assessing ageing information for livestock. For example, evidence of changing slaughter age at Launceston Castle between the Medieval and post-Medieval periods has been identified by Albarella and Davis (1994b). Between the thirteenth and fifteenth centuries fewer than 20% of cattle were slaughtered before 3 years of age; conversely, in the post-Medieval period around 60% of cattle killed were under 3 years. This is suggestive of a shift in focus of livestock exploitation in the post-Medieval period, most likely to meat and dairy production (Grant 1988, 156). This is supported by the emergence of the position of butcher-grazier during this period, a role involving butchery in towns, and the lease of rural land for livestock fattening (Dyer 1981, 17). A similar pattern can be seen at Exeter, where fourteenth to fifteenth-century deposits have a higher proportion of young cattle than previous centuries (Maltby 1979, 32). This is also the case at Sandal Castle, where Griffith *et al*. (1983, 343-344) identified a greater number of cattle being killed before two years after 1600. With regards to sheep, Grant (1988, 153-4) notices changes in slaughter patterns occurring as early as the fourteenth and fifteenth centuries, with a higher proportion of older sheep found in this period than previously. This is supported by O'Connor's (1982, 23) study of age profiles from Lincoln, where late Medieval deposits contain a greater frequency of older animals. Along with an increase in sheep numbers in the fifteenth century, Grant (1988, 154) suggests that this age distribution is indicative of sheep being kept for both wool and meat in the later Medieval period, whereas previously they had been killed before providing wool (Ryder 1974, 47).

This change in slaughter pattern may have had a variety of causes. Grant (1988, 153-4) suggests that age of slaughter during the Medieval period was very much dependant on the desired products. For example, the finest quality fleeces come from castrated male sheep. However, this is not without its difficulties as male animals were also sold when young for meat as females had to be kept to ensure flock continuation, showing that a multitude of factors may determine slaughter age. Furthermore, slaughter age was also somewhat governed by regulation, for instance in the sixteenth century the threat of meat shortage prompted the government to ban the slaughter of cattle under two years old. Animal product prices may also have dictated the age at which livestock were killed, as farmers may have delayed or hastened the slaughter of animals in order to achieve the best market value (Bowden 1989, 103). Another factor which may have affected the slaughter age of cattle in particular is their changing role through time. For example, from as early as the twelfth century oxen began to be superseded as traction animals by horses. Langdon (1986, 254) states that this occurred in two main phases in the twelfth to thirteenth centuries, and from the fifteenth century onwards. By the start of the seventeenth century as much as three-quarters of traction was provided by horses, though this varies regionally (Langdon 1984, 58; Langdon 1986, 255). This change would have allowed for the release of cattle stock for fattening at an earlier age, thus causing earlier maturity in livestock (Davis and Beckett 1999). Zooarchaeological evidence supports this, as Medieval rural sites tend to be dominated by older cattle, demonstrating their use for traction during this period, with only surplus young animals being sold for meat (Grant 1988, 156). After their replacement by horses this pattern changes, with a higher frequency of young cattle in assemblages, illustrating their new role as meat providers.

Overall, the zooarchaeological evidence for significant change in the size, shape and slaughter pattern of livestock provides a compelling argument for a country-wide transformation in the late Medieval period, particularly between the fifteenth and seventeenth centuries. These changes may have been due to factors like fodder supplies or herd management. However, as already stated, the changes in tooth dimensions and bone shape are indicative of a genetic change rather than environmental conditions. Therefore, it is more likely that the zooarchaeological results support Kerridge's (1967) view of agricultural change occurring as early as the fifteenth-sixteenth centuries, and progressing in a gradual and complex manner across the country. Davis and Beckett (1999) support this assertion, suggesting that rather than a 'revolutionary' change occurring after 1760, livestock improvement was a gradual process beginning in the fifteenth-sixteenth centuries. Thirsk (1987, 57-8) judiciously asserts that changes to livestock should be considered with historical events of the period, as they may provide more detail as to the cause of change. It also must be considered that the majority of zooarchaeological studies into livestock improvement concern urban and high-status assemblages. The more urban an assemblage, the more difficult the process of deciphering animal husbandry practices becomes, due to the complex relationships between various communities (Grant 1988, 149). Therefore, rural settlements can be expected to provide a more accurate reflection of local husbandry regimes (Rippon 2012, 254). As a result, this study endeavours to assess the zooarchaeological material from rural sites, to gain a clearer understanding on livestock improvement at its source.

Table 1.1: A summary of zooarchaeological evidence for livestock improvement in cattle, sheep and pig.

Site	Cattle	Sheep	Pig
Launceston Castle (Albarella and Davis 1994b)	Size increase across all measurements from C. 16th and again in the C.17th Higher proportion of juveniles from C. 16th	Small size increase by C.16th, larger one in C. 17th	Small decrease in tooth size by C16th, and increase in C. 17th onwards
Exeter (Maltby 1979)	C. 15th size increase	Size increase from C.16th-17th	N/A
Prudhoe Castle (Davis 1987a)	Size increase C. 14th-17th	N/A	N/A
Norwich Castle (Albarella *et al*. 2009)	Size increase C. 16th-18th Higher proportion of juveniles from C.15th	Size increase C. 16th-18th	Size increase C. 16th-18th
Closegate, Newcastle (Davis 1991)	N/A	C. 17th size increase	N/A
Lincoln (Dobney *et al*. 1996)	Size increase early C. 16th	Size increase by mid-C. 17th	N/A
Dudley Castle (Thomas 2005b)	C. 14th size increase	C. 14th size increase	C. 14th size increase (including in tooth measurements)
London (Thomas *et al*. 2013)	C. 14th size increase, followed by C. 19th decrease	C. 14th size increase	C. 14th size increase, followed by larger increase C. 16th-18th

1.5 Research Questions

Based on the historical information presented here, it is clear that English agriculture underwent a significant change starting in the late Medieval period, which likely encompassed transformations in landscape organisation, farming methods and animal husbandry. Zooarchaeological studies, mainly from urban and high-status sites, seem to confirm this alteration in livestock, indicating not only the presence of larger animals from the fourteenth to the seventeenth century, but also a changing emphasis on animal products, and potentially a decrease in slaughter age. However, both the historic and zooarchaeological studies highlight the variable nature of agricultural change across England. Enclosure particularly appears to vary in terms of timing and speed, motivation, and type across the country, potentially affecting other factors like animal husbandry in different ways. There has also been little consideration of the extent of these changes on rural sites due to small samples or poor preservation, where it is likely that many of the animals found on urban sites were reared. Furthermore, the assessment of interaction between urban and rural sites could aid in better understanding the development and spread of livestock change across England, as no site is likely to have existed in isolation from the late Medieval trade network.

This study aims to address the following research questions, arising from existing historical and zooarchaeological knowledge, in order to assess the timing, nature and spread of livestock change on rural sites, and its potential association with enclosure:

1. **What type of enclosure was taking place on rural sites across England, and when?** This includes an assessment of whether sites were affected by general or piecemeal enclosure, and the motivation of the process. This question also covers an investigation into when enclosure on each site began, and how long it took to complete, as well as how it changed the landscape.

2. **Which livestock changes were occurring across England on different rural sites, and when?** This question addresses the changing species frequencies, age and size and shape of animals on rural sites, in order to understand the shifting exploitation of livestock. Information on body part representation, butchery and pathology is also used to support this, by helping to highlight any changes in the use of animals associated with improvement. It also explores when this change happened, and what might have caused it, as well as how possible trade interactions between rural and urban areas may have affected the timing and distribution of livestock change.

3. **Are there any parallels between livestock change and landscape enclosure which may suggest that the two are linked?** This encompasses an investigation into how, if at all, livestock husbandry was affected by enclosure in rural areas, including how different types of enclosure may have affected animals differently.

These questions are addressed using a variety of case study sites and methods detailed in the next chapter, which combines the assessment of historical and landscape information with an investigation of livestock frequency, age profile and size. Together, they give a clearer indication of landscape and livestock change on rural sites, as well as how they relate to urban centres.

2. Materials and Methods

2.1 Identification and Quantification

2.1.1 Zooarchaeological Recording Protocol

In order to assess the change in livestock size on archaeological sites through time, four domesticates were recorded, as they were the species exhibiting the most significant size change in previous studies and also the most common species identified on all four sites. These comprise sheep (*Ovies aries*), distinguished where possible from goat (*Capra hircus*), cattle (*Bos taurus*), pig (*Sus domesticus*) and horse (*Equus callabus*). The distinction between horses, donkeys and mules was not attempted, as horses represented the majority of equids in late to post-Medieval assemblages, and, in terms of the research questions of this study, the three fulfilled a similar role (Langdon 1986, 29). Faunal material from these species was recorded following an adaptation of the "Part of Skeleton Always Counted" recording system of Davis (1992), incorporating elements of Albarella and Davis's (1994a) method. This involved the careful examination of all specimens, but the recording and quantification of a specific set of articular ends, including teeth, and girdle, limb and foot bones. Elements were also only counted where at least 50 percent of the given part was present. 'Non-countable' elements, such as horncores, or elements displaying evidence of butchery or pathology, were recorded, but not included in counts. As this method does not record every specimen, there may be some loss of detail, though the inclusion of 'non-countable' elements allows for the consideration of modifications like butchery and pathology. Furthermore, a more streamlined approach to recording was required due to the quantity of bone material to be recorded during project, while still allowing for the detailed assessment of research questions. Bones and teeth were recorded in a MS Access Database, in two separate tables alongside their associated measurements. Table 2.1 summarises the teeth recorded for each species, and their associated measurements, while Table 2.2 records the post-cranial elements recorded.

Table 2.1: A summary of the teeth recorded for each species, and their associated measurements taken using von den Driesch (1976) unless stated otherwise.

Species	Tooth	Measurement(s)
Equids	P4, M1, M2, M3 (only when a positive identification can be made)	L_1, W_a, W_d (mandibular molars) W and L_p (maxillary molars) (Davis 1987b)
Cattle	dP_4	W
	M_1	W
	M_2	W
	M_3	L, W
Sheep	dP_4	W
	M_1	W
	M_2	W
	M_3	L, W
Pig	dP4	L, WP (Payne and Bull 1988)
	M1, M2	L, WA, WP (Payne and Bull 1988)
	M^3	L, WA, WC
	M_3	L, WA, WC, WP

Table 2.2: A summary of the post-cranial elements recorded for each species, and their associated measurements taken using von den Driesch (1976) unless stated otherwise.

Bone	Species	Measurement(s)
Horncore	Bovids	Min and max diameter of base Greatest length and curvature (taken with a measuring tape)
Scapula	All	GLP, SLC BG (sheep – Popkin *et al.* 2012)
Humerus	All	GLC, BT, SD* HTC (Davis 1992) Bd (caprines) BFT, HT (caprines, Popkin *et al.* 2012)
Radius	All	GL, SD*, Bd Bp (caprines)
Metacarpal	Caprines	GL, SD*, Bd a, b, 1, 2, 3, 4, 5, (Davis 1992) WCM, WCL, Dem, Del, Dvm, Dvl, BdFUS (Popkin *et al.* 2012)
	Cattle	GL, SD*, Bd BatF, a, b, 3 (Davis 1992)
	Pig	GL
	Equids	GL, SD*, Bd, Dd
Pelvis	Bovids	LA SDpu, SDmmpu, MRDA (Popkin *et al.* 2012)
	Equids and Pig	LAR
Femur	All	GL, SD*, DC, Bd
Tibia	All	GL, SD*, Bd, Dd
Astragalus	Bovids	GLl, GLm, Bd, DI
	Pig	GLl, GLm
	Equids	GH, GB, Bfd, LmT
Calcaneum	All	GL, GB GDde (caprines – Popkin *et al.* 2012)
Metatarsal	Caprines	GL, SD*, Bd a, b, 1, 2, 3, 4, 5, (Davis 1992) WCM, WCL, Dem, Del, Dvm, Dvl, BdFUS (Popkin *et al.* 2012)
	Cattle	GL, SD*, Bd, BatF, a, b, 3 (Davis 1992)
	Pig	GL
	Equids	GL, SD*, Bd, Dd
Phalanx 1	Equids	GL, Bp, Dp, SD*, Bd, Dd

*SD only recorded when greatest length (GL) is available.

2.1.2 Sheep-Goat Separation

Initial sheep-goat separation was carried out using traditional morphological methods during recording (see Table 2.3), and specimens were assigned to either sheep, goat, or indeterminate.

Table 2.3: Summary of sheep-goat separation criteria for each element

Element	**Method(s)**
Horncores	Salvagno and Albarella (2017)
Cranial sutures	Boessneck (1969)
dP_3, dP_4, M_1	Payne (1985)*
P_3, P_4, M_1, M_2, M_3	Halstead *et al.* (2002) Zeder and Pilaar (2010)
Scapula (distal end)	Boessneck (1969) Prummel and Frisch (1986)
Humerus (distal)	Boessneck (1969) Zeder and Lapham (2010)
Radius (proximal and distal)	Boessneck (1969) Prummel and Frisch (1986) Zeder and Lapham (2010)
Ulna (proximal articular surface)	Boessneck (1969)
Femur (proximal)	Boessneck (1969) Prummel and Frisch (1986)
Tibia	Proximal: Boessneck (1969) Distal: Kratochvil (1969) Zeder and Lapham (2010)
Astragalus	Boessneck (1969) Zeder and Lapham (2010)
Calcaneum	Boessneck (1969) Zeder and Lapham (2010)
Metapodials (distal)	Payne (1969) Boessneck (1969) Zeder and Lapham (2010)
1^{st} and 2^{nd} Phalanx	Boessneck (1969) Zeder and Lapham (2010)

*Where possible, depending on eruption and/or wear.

In addition to sheep-goat identification using traditional morphological criteria, metric separation for post-cranial elements was attempted using the method proposed by Salvagno and Albarella (2017). This required some additional measurements, which are listed in Table 2.4. These measurements were combined with the previously listed measurements for sheep, in order to calculate biometric indices based on data from the archaeological case study sites (see Table 2.5), which were then compared graphically to Salvagno and Albarella's results for known sheep and goat specimens. Any goat specimens definitely identified using this method were then removed from the analysis of sheep for each case study site.

Table 2.4: Additional measurements, after Salvagno and Albarella (2017), taken for metric sheep-goat distinction. Measurements were taken using von den Driesch (1976), unless otherwise stated.

Element	Measurement
Horncore	A B E (Salvagno and Albarella 2017) F
Humerus (distal)	BEI (Salvagno and Albarella 2017)
Radius (proximal)	BFp
Ulna (proximal)	BPC DPA SDO
Tibia (distal)	Dda Ddb (Salvagno and Albarella 2017)
Astragalus	H (Salvagno and Albarella 2017)
Calcaneum	c (Fernandez 2001) d (Fernandez 2001) B (Boessneck *et al.* 1964) DS (Salvagno and Albarella 2017)

Table 2.5: Biometric index comparisons used to distinguish sheep and goat in archaeological material (after Salvagno and Albarella 2017).

Element	Indices
Horncore	A vs. (E/F)x100 (E/F)x100 vs. (A/F)x100
Humerus	(BT/HT)x100 vs. (BT/HTC)x100 (BEI/BT)x100 vs. (BEI/Bd)x100
Ulna	(BPC/DPA)x100 vs. (BPC/SDO)x100
Tibia	Bd vs. (Dda/Ddb)x100
Metacarpal	(1/a)x100 vs. (1/2)x100 (4/b)x100 vs. (4/5)x100 (BFd/GL)x100 vs. (SD/GL)x100
Metatarsal	(1/a)x100 vs. (1/2)x100 (4/b)x100 vs. (4/5)x100 (BFd/GL)x100 vs. (SD/GL)x100
Astragalus	(Bd/DI)x100 vs. (DI/GLI)x100 (H/DI)x100 vs. (Bd/GLI)x100 (H/DI)x100 vs. (Bd/H)x100 (Bd/DI)x100 vs. (DI/GLI)x100 (Bd/H)x100 vs. (Bd/GLI)x100
Calcaneum	(c/B)x100 vs. (c/d)x100 (DS/c)x100 vs. (c/B)x100 (DS/c)x100 vs. (c/d)x100

2.1.3 Quantification

Initial assessment of species and element quantification was carried out using the Number of Identifiable Specimens (NISP), which is a raw count of all specimens assignable to species (Lyman 1994). While %NISP values are useful for ease of calculation and comparison, they do not account for fragmentation in the assemblage, or the inter-species variation in element numbers, which can lead to over-representation of certain species (Klein and Cruz-Uribe 1984). The Minimum Number of Individuals (MNI) by element was also calculated by dividing each NISP value by the number of that element in the skeleton, as side was not recorded (Lyman 2008). The MNI for each overall period was calculated using the minimum distinction method, in which the MNI was calculated for each period as one assemblage, rather than summing the value for each phase (Grayson 1973). This value can give an indication of the number of animals on a site (Chaplin 1971), but is also presented as %MNI to highlight the relative proportions of each species on the case study sites throughout time. For species frequencies, %MNI was calculated by dividing the species value by the total MNI and multiplying by one hundred, in order to provide an indication of the proportions of each species in the assemblage.

2.2 Non-Metric traits, Pathology and Butchery

2.2.1 Non-Metric Traits

The non-metric traits recorded include the congenital absence of the second permanent mandibular premolar in sheep and cattle (Andrews and Noddle 1975; O'Connor 2004, 119). Therefore, the second premolar was recorded as present, absent post- or ante-mortem, or congenitally absent. The presence, absence or reduction of the third mandibular hypoconulid in cattle was also recorded (O'Connor 2004, 120).

2.2.2 Pathology

Pathological specimens were recorded using a standard recording form, after Vann and Thomas (2006), which documented the species and element, as well as the type of pathology (i.e. bone formation or destruction, size or shape alteration, or fracture). The form was then linked to the specific database entry for ease of access. Pathological specimens regarded as 'non-countable' in the recording system (above) were recorded in order to document pathological changes, but were not included in quantification.

2.2.3 Butchery

The presence and location of cut, chop and saw marks were recorded on all specimens. This includes elements not counted during quantification, for example ribs or vertebrae. The position and number of butchery marks were documented, as well as the presence of any skull or vertebra splitting. The proportion of butchered bones was also calculated for each species and chronological period.

2.3 Ageing and Sexing

2.3.1 Fusion Ageing

The timing of post-cranial element epiphyseal fusion was one of two methods used to estimate age-at-death. Where possible, the fusion states of the proximal and distal ends of each element were identified during recording, and a general age distribution for sheep, cattle and pig was estimated using %survival. This was calculated based on the fusion stages given in Table 2.6, by expressing the number of fused elements in each stage as a percentage. Due to a low sample size for horse post-cranial elements, this analysis was not possible. Therefore, the age distribution of horse was assessed by comparing the proportion of fused and unfused bones, giving an indication of the proportions of juvenile and adult animals.

Table 2.6: The fusion stages for sheep, cattle and pig used to calculate %survival.

Species	Stage	Age Range*	Elements
Sheep	1	6-10 months	scapula, d. humerus, p. radius, pelvis
	2	13-16 months	1st phalanx, 2nd phalanx
	3	18-28 months	d. metacarpal, d. tibia, d. metatarsal
	4	30-42 months	p. humerus, d. radius, p. ulna, p. femur, d. femur, p. tibia, calcaneum
Cattle	1	7-10 months	scapula, pelvis
	2	12-18 months	d. humerus, p. radius, 1st phalanx, 2nd phalanx
	3	24-36 months	d. metacarpal, d. tibia, d. metatarsal
	4	36-48 months	p. humerus, d. radius, p. ulna, p. femur, d. femur, p. tibia, calcaneum
Pig	1	6-12 months	scapula, d. humerus, p. radius, pelvis, 2nd phalanx
	2	14-18 months	d. metacarpal, d. metatarsal, d. tibia, calcaneum
	3	30-42 months	p. humerus, d. radius, ulna, p. femur, d. femur, p. tibia

*after Silver (1969)

2.3.2 Dental Ageing

Age-at-death was also estimated for sheep, cattle and pig using dental data. Again, a small sample size meant that this analysis was not possible for horse, due to the high number of loose teeth, making identification very difficult. During recording, the wear stage of each tooth was recorded using Grant's (1982) method for cattle and pig, with O'Connor's (1988) wear stage descriptors, and Payne's (1973) system for sheep. These data were then used to calculate %survival at each mandible wear stage by expressing the number of mandibles in each stage as a percentage of the total number.

Dental ageing also been used to compare the ageing profiles on the case study sites to those on nearby urban centres, with which trade interaction was likely. Wharram Percy results were compared to sites throughout York (O'Connor 1984a, b; 1988; 1991; 1999; Scott 1985) and Shapwick to Exeter (Maltby 1979).

2.3.3 Sexing

Sexing information was recorded for pigs using the morphology of canines and alveoli (Schmid 1972, 80-81). The distinction of sex was not carried out for any other taxon or element due to low frequency or lack of preservation, though the detailed metric data obtained was be used to indicate sex ratios.

2.4 Metric Analysis

2.4.1 General Metric Assessment

Tables 2.1 and 2.2 detail the measurements taken on teeth and post-cranial elements. Measurements were taken during recording using digital calipers, to the nearest tenth of a millimetre, and an osteometric board where required, to the nearest millimetre. Both tooth and post-cranial bone measurements were taken, as tooth size tends to be more conservative and less dependent on environmental factors, age or sex, allowing for the assessment of genetic change within livestock populations (Payne and Bull 1988). Conversely, changes in post-cranial bone measurements could be indicative of alterations in environmental factors such as nutrition, or changes in the sex ratio of herds. Only fully fused bones are included in the metric analysis.

2.4.2 Log-Ratio Method

The log-ratio method was used in order to assess any change in livestock size through time at the archaeological case study sites. The log-ratio method is a size scaling index technique, which compares the relative rather than the absolute dimensions of archaeological specimens to a standard individual or population mean (Simpson *et al.* 1960). This is achieved by calculating the logarithm (base 10) of the ratio between the archaeological measurement and the standard. The log-ratio method increases the sample size for analysis by combining different measurements on the same axis, i.e. lengths, widths and depths (Meadow 1999). Length, width and depth measurements are analysed separately as there is a better correlation between measurements taken on the same axis, and combining planes may mask changes in one particular dimension (Davis 1996). Similarly, teeth and post-cranial bones are considered separately in this technique in order to distinguish between genetic or environmental induced changes (Albarella and Payne 2005). In this study, the following published standards are used for sheep, cattle, pig and horse respectively (Appendix 1): modern mean measurements from female

Shetland sheep (Davis 1996); archaeological mean measurements from late Roman to early Saxon Elms Farm, Essex (Johnstone and Albarella 2002); archaeological mean measurements from late Neolithic Durrington Walls, Wiltshire (Albarella and Payne 2005); and Mongolian Pony standard (Johnstone 2004) . In order to reduce the effects of age-related size change, only measurements from fully fused bones are used in the analysis, and all SD and scapula GLP and SLC values are excluded. Furthermore, only one measurement from each axis from each tooth or bone is used, in order to avoid over-emphasising the dimensions of a particular element.

The log-ratio method has also been used to compare the size and shape of livestock on the case study sites to those on nearby urban centres, with which trade interaction was likely. Great Linford measurements have been compared to results from London (Thomas *et al* 2013), Wharram Percy to sites throughout York (O'Connor 1984a, b; 1988; 1991; 1999; Scott 1985) and Shapwick to Exeter (Maltby 1979).

2.4.3 Coefficient of Variation

The coefficient of variation (CV) was calculated for tooth and post-cranial measurements for all species across the phases and broad periods on archaeological case study sites. This value, also known as Pearson's coefficient of variation, expresses the standard deviation of a population as a percentage of the mean, allowing for the assessment of metric variation within livestock populations through time (Payne and Bull 1988). It can also be used to assess the potential causes of variation. For example, Popkin *et al*. (2012) state that the development or introduction of a new breed would cause greater CV values than alteration in nutrition or sex ratios. Again, only fully fused elements from all species were used in this assessment, and pelvis measurements have been excluded due to a high variation for all sexes and nutritional planes, inflated by difficulties in measurement.

2.4.4 Pig M1/2 Separation

Metric separation of loose first and second mandibular pig molars was undertaken, in order to increase the sample size for both ageing and metric analysis (Appendices 4, 14 and 24). This was achieved by graphically comparing WA and WP measurements of first and second pig molars in the jaw to the same measurements from loose mandibular molars. Where possible, loose teeth were compared to identified teeth from the same time period, though reference measurements were grouped together for Great Linford, due to a lack of measurements from each phase. Loose teeth that definitely fell within the range of either first or second molar measurements were reclassified from M1/2 to M1 or M2, then included in ageing and metric analyses.

2.4.5 Statistics

In order to assess the statistical significance of observed differences in livestock size throughout time, measurements from adjacent phases and periods were compared by evaluating the difference in means between samples, testing the null hypothesis that size measurements from each time period have the same mean (Drenman 1996). The samples were first tested for normal distribution using the Shapiro-Wilk (S-W) test, the results of which are given in Appendix 2 – a value above 0.05 indicates that the sample is normally distributed. Normally distributed data were then compared using the unequal variance, or Welch's t-test, and data not displaying a normal distribution were tested using the non-parametric Mann-Whitney U test, which is shown in blue where results are given. These tests were carried out for all species between earlier, late and post-Medieval measurements for which there was greater than ten results. They were also used to evaluate the significance in the difference in mean values for third molar width and log ratio results between both individual phases and broad periods.

2.5 Archaeological Material

The archaeological sites selected for this study were chosen based on their ability to address the research questions listed in the previous chapter. In order to achieve this, priorities for suitable assemblages were established. The first priority for site choice was location. In order to assess the extent of livestock change in rural areas, the selection of rural sites was key, as was the geographic range of case studies. An attempt was made to include sites from across England, in areas of differing terrain, agricultural methods and enclosure mechanisms, to allow for the assessment of changing livestock in association with varied enclosure methods and timing. Numerous priorities were also set for the selection of sites based on the faunal assemblage. Firstly, practical considerations such as access to both the faunal material and phasing information were vital. Furthermore, assemblages were required to contain the species selected for study in large enough quantities for effective and reliable analysis. Detailed and accurate phasing associated with the faunal assemblages was also extremely important, as precise chronological information allowed for a more comprehensive assessment of changes in livestock and landscape organisation, as well as how they may be linked. Finally, the availability of detailed historic and landscape information regarding enclosure and the use of livestock was a key requirement in selecting case study sites, again to allow a better understanding of how and when enclosure occurred, and any associated livestock changes.

2.5.1 Great Linford

The site of Great Linford can be found in North Buckinghamshire (Figure 2.1), positioned between valleys of the Ouzel and Great Ouse Rivers. Once an independent parish comprising 1835 acres, it now forms part of the town of Milton Keynes. As a result, excavation of the village was carried out by the Milton Keynes Archaeological Unit, created in 1971 by the Milton Keynes Development Corporation (MKDC) prior to the construction of the 'new city'. Large-scale excavation of the main village took place between 1974 and 1977, with the investigation of the church and manor house following in 1980. In 1974, excavation directed by Dennis Mynard was carried out in the field to the south of the remaining green ('Hern's Close', containing Crofts B and D), in addition to 'Pignuts' Field (Croft A). Excavation on these sites was continued in 1975, directed by Dennis Mynard and Bob Zeepvat. In 1976, the excavation of an area to the east of the green, containing Crofts F, G, H and L was carried out. These excavations were initially undertaken via trial trenching, followed by the stripping of larger areas by hand, though this was later followed by the use of a machine excavator to remove turf and topsoil (Mynard and Zeepvat 1991). The excavated soil was not sieved.

These excavations provided suitable faunal material for this study due to the large proportions of domestic livestock, as well as detailed phasing information. The suitability of the animal bone was initially identified using the previous faunal reports based on material from the church (Holmes 1992) and village (Burnett 1992). Material from the church included only 125 fragments from Saxon contexts, while remains from the village numbered 6,577 fragments, and are documented as comprising mainly domestic livestock and fowl, making them suitable for this study. The faunal material from the village studied for this project, numbering just over 4,000 fragments, has been split in to six chronological phases, though these are also grouped in to earlier, late and post-Medieval periods (Table 2.7). Table 2.8 gives the phasing information and a description of each Croft that provided faunal material for this study.

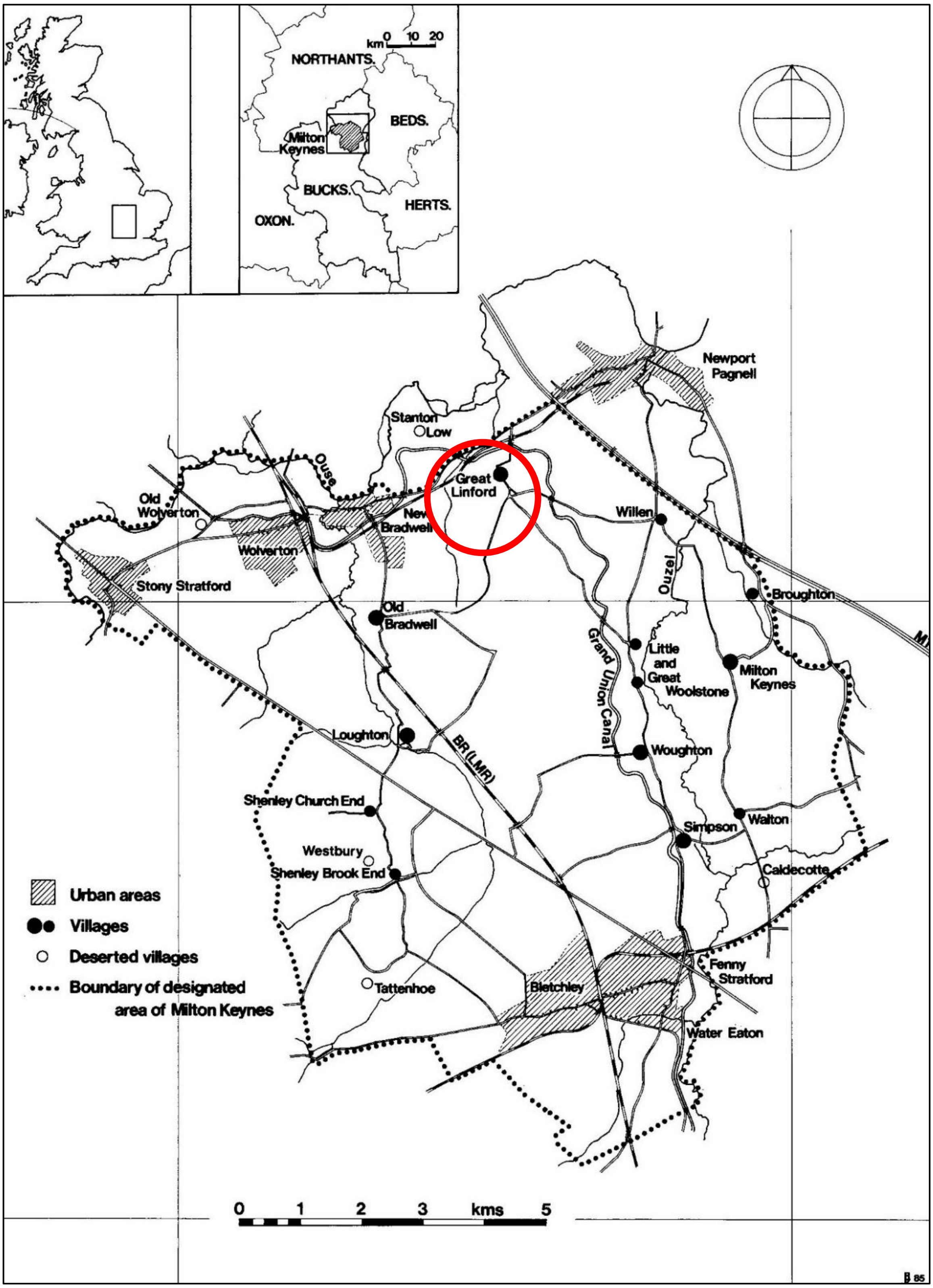

Figure 2.1: Map showing the location of Great Linford. (Mynard and Zeepvat 1992, Figure 1)

Table 2.7: The chronological phases at Great Linford.

Phase	Period
10th-13th c.	Earlier Medieval
13th-14th c.	Late Medieval
14th-15th c.	
15th-16th c.	
16th-17th c.	Post-Medieval
17th-18th c.	

Table 2.8: Description and phasing information for the crofts providing faunal material assessed in this study (Mynard and Zeepvat 1991; Croft and Mynard 1993).

Croft	Date	Description
A	13th - 17th c.	Small croft in the corner of *Great Picknuts* close, at the south end of the surviving green. Mentioned as early as 1321.
B	mid-12th- 17th c.	In the north-west corner of *Hern's Close*, on the south side of the village green. House present on the site from mid-12th century, with an attached close probably taken from open field at that time.
D	13th - early 18th c.	Croft extending from the south of the green. House present on the site from mid-12th century, with an attached close probably taken from open field at that time.
F	10th – 15th Some evidence for 17th – 18th c. activity	At the east end of the village green.
G	12th – 17th c.	To the west of Croft F
H	15th – 18th c.	To the west of Crofts F and G.
L	Late 10th – 17th c.	200m east of the high street. Accompanied by 10th -11th c. ridge and furrow.

2.5.2 Wharram Percy

Wharram Percy is a well-known deserted Medieval village in the Yorkshire Wolds, now part of North Yorkshire. It is situated 18 miles north-east of York, and seven miles south-east of the town of Malton. Excavations at the site began in 1950, after a preliminary investigation of the site by M. W. Beresford in 1948, and continued until 1990 under the authority of the Deserted Medieval Village Research Group, now the Medieval Settlement Research Group. By the end of the final excavation, around 10,000 square metres had been excavated, representing 6.5 percent of the Scheduled area (Wrathmell 2012). The extensive archaeological investigation at Wharram Percy was split into one hundred sites, and those included in this study are summarised here by published volume (see also Table 2.9 for phasing and brief descriptions). The earliest sites were 9 and 12, excavated in 1950-3 and 1960-70 respectively. Both sites were uncovered using a then controversial open area excavation technique, and were excavated in 5ft squares using arbitrary spits (Hurst 1979). The sites described in the volume edited by Treen and Atkin (2005) include 30, 67 and 71, which were all excavated in the 1970s and 80s via open area hand excavation. Also excavated during the 1970s and 80s were the sites associated with the North Manor and north-west enclosure, including Sites 45, 60, 69 and 82 (Rahtz and Watts 2004). Sites 45 and 60 were carried out via open area excavation – 45 followed a preliminary trial trench programme, while 60 was split into separate ten metre grids. Conversely, Sites 69 and 82 were excavated using only tests pits. Also excavated at a similar time were the sites from the post-Medieval farm and vicarage (Harding *et al.* 2010). This includes Sites 49, 51, 54, 73, 74 and 77, all of which were carried out using open area excavation, though at Site 54 topsoil was stripped using a machine. The only site from the South Manor area used in this study was Site 76, which was also carried out using entirely open area hand excavation, and was the only site where occasional hand-sieving was used to check finds recovery rate (Stamper and Croft 2000).

This comprehensive archaeological investigation yielded over 220,000 fragments of faunal material, largely studied by J. Richardson, with the exception of Site 76 which was recorded by S. Pinter-Bellows (in Stamper and Croft 2000), and Sites 9 and 12 which were examined by M.L. Ryder (1974), though later re-evaluated by Richardson in comparison to Sites 30 and 71. The Medieval and post-Medieval contexts studied in this research yielded ten and a half thousand specimens, grouped in to both individual phases and broad chronological phases (Table 2.10). Unlike Great Linford, the broad chronological periods include additional material which was assigned generally to earlier, late or post-Medieval periods, meaning that the combined bone frequencies for the phases do not always match the overall period total.

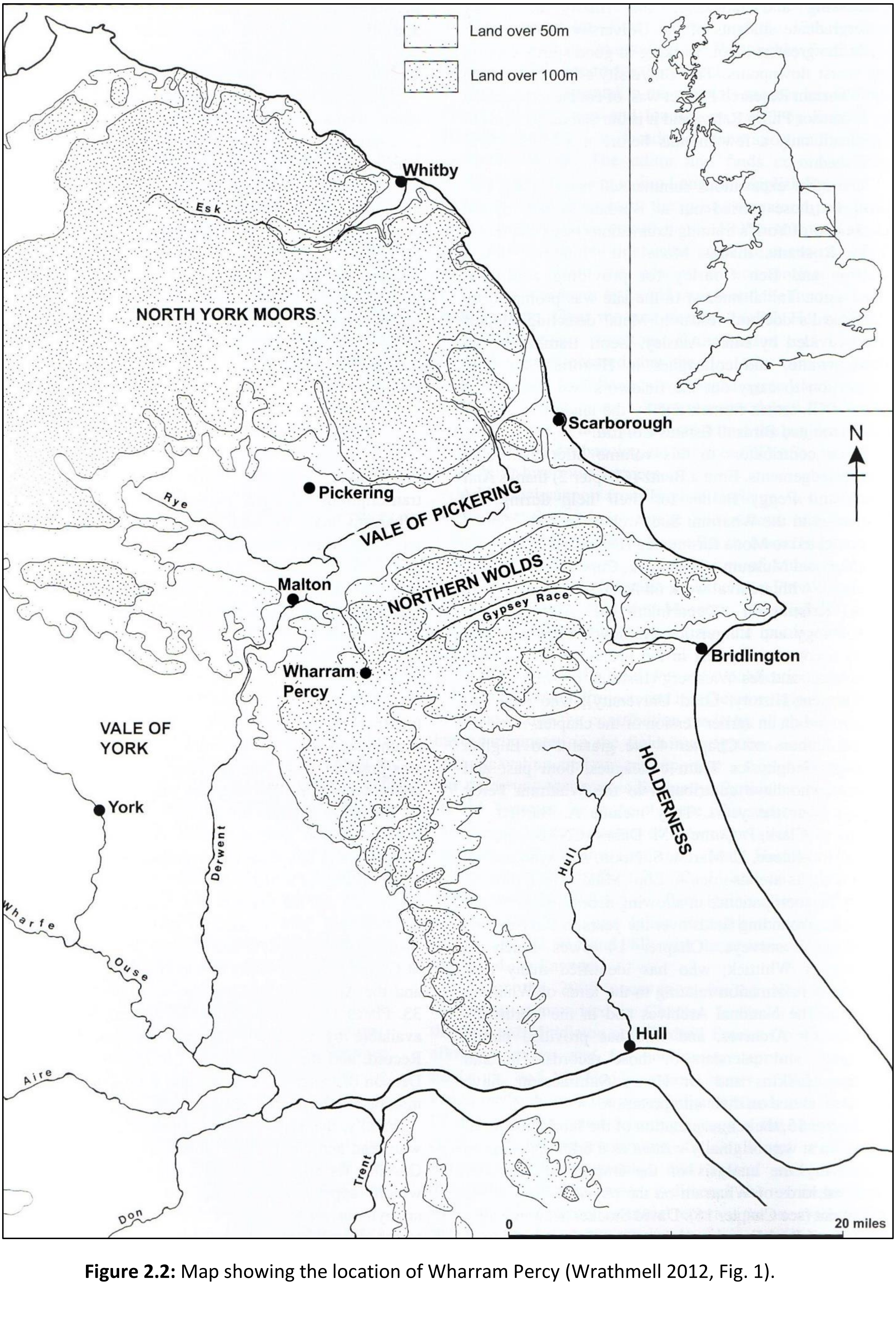

Figure 2.2: Map showing the location of Wharram Percy (Wrathmell 2012, Fig. 1).

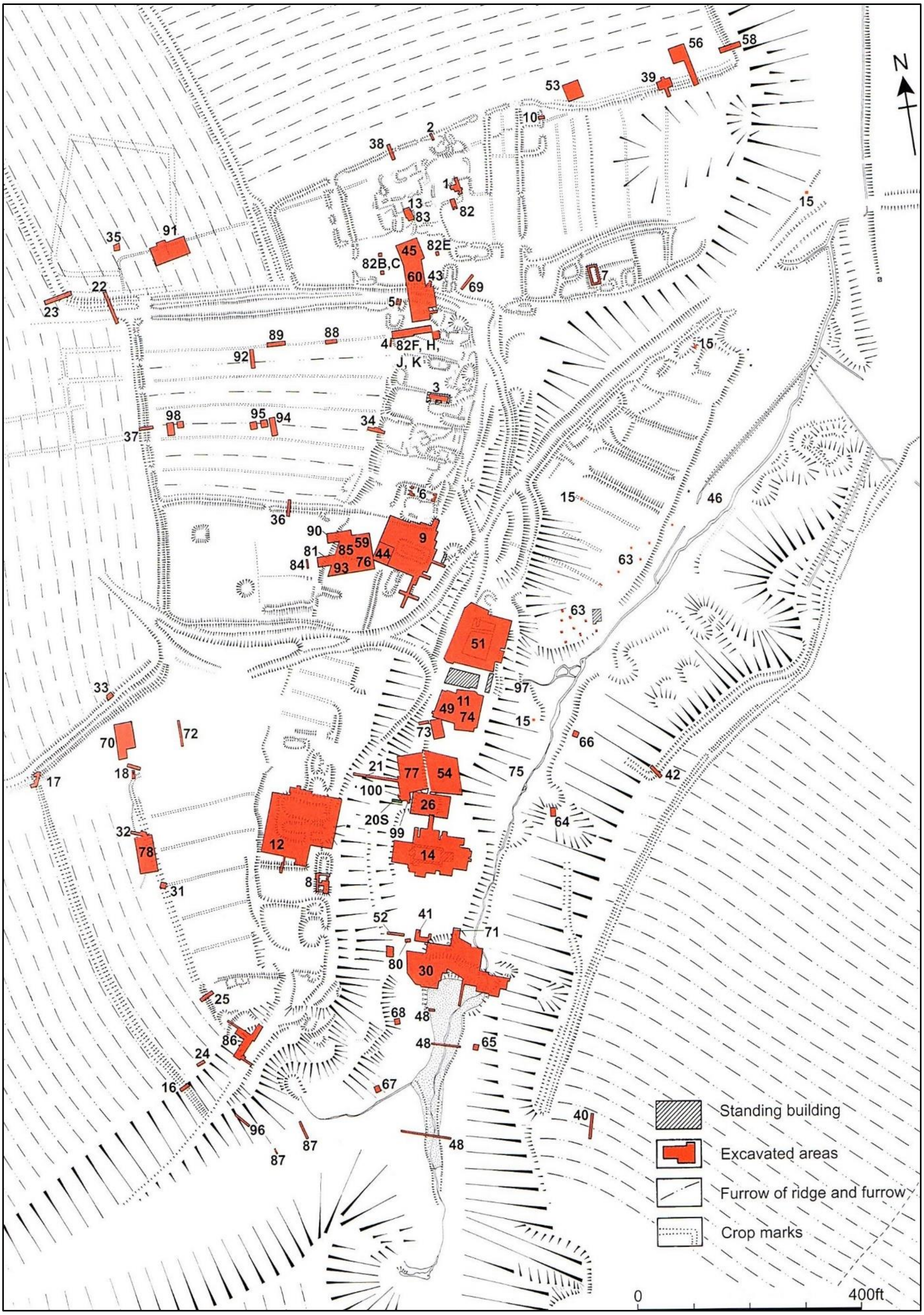

Figure 2.3: Map showing the excavated sites at Wharram Percy (Wrathmell 2012, Fig. 2).

Table 2.9: A summary of the sites from Wharram Percy studied in this project.

Site	Date	Description	Publication
9	12th - 20th c.	Also known as Area 10 Excavated 1950-3 Contained the undercroft of an early manorial complex (S. Manor), and evidence of subsequent quarrying	Wharram I (1979) Wharram VIII (2000)
12	12th – 20th c.	Also known as Area 6 Excavated 1960-70 Contained a series of domestic and ancillary buildings	Wharram I (1979) Wharram VI (1989)
30	Saxon - late Medieval	Excavated 1972-82 by C. Treen and later M. Atkin and P. Stamper Parts of a pond and dam at the southern end of the village	Wharram X (2005)
45	LIA/ early Roman – post-Medieval	Excavated 1977 by G. Milne, C. Milne and W. Burton Part of North manorial enclosure, containing a concentration of LIA and Roman finds	Wharram IX (2004)
49	17th- 20th c.	Excavated 1978-84 by J. Hurst and M. Beresford Surface and trackway excavated, with post-Medieval ditches and rubbish pits	Wharram XII (2010)
51	Medieval – 19th c.	Excavated 1978-88 by R. Daggett, G. Hutton, A. Josephs, B. van Maanem, P. Ottaway, M. Smith and S. Wrathmell 18th and 19th century outbuildings belonging to Wharram Percy Farm overlaying Medieval structures	Wharram XII (2010)
54	Roman - 20th c.	Excavated 1979-86 by C. Harding Excavation of post-Medieval vicarage, and earlier structures	Wharram XII (2010)
60	LIA/Roman – post-Medieval	Excavated 1980-5 Southern boundary of the North Manor complex, revealing Iron Age and Roman ditches, and two *Grubenhäuser*	Wharram IX (2004)
67	Early - post Medieval	Excavated 1972-83 Series of chalk surfaces excavated, probably late Medieval	Wharram X (2005)

69	LIA/Roman – 15th c.	Excavated 1983-4 by T. Ashwin and P.A. Rahtz Test pits revealed LIA/ Roman and Medieval ditches – either drainage or boundary	Wharram IX (2004)
71	Early - post Medieval	Excavated 1982-3 by C. Treen and later M. Atkin and P. Stamper Water management channels and evidence of high-status domestication	Wharram X (2005)
73	16th - 20th c.	Excavated 1983-4 by organised by J. Hurst and M. Beresford Wall fragments and surfaces disturbed by modern pits	Wharram XII (2010)
74	17th – 20th c.	Excavated 1985-9 by A. Gilmour 17th-18th century farmhouse, overlain by an early 19th century farmhouse	Wharram XII (2010)
76	Roman – 15th c.	Excavated 1981-90 by P.A. Stamper and R.A. Croft Saxon smithy, overlain by South Manor complex and later Medieval peasant houses	Wharram VIII (2000)
77	16th – 20th c.	Excavated 1984-90by M. Atkin, then J. Wood after the first year Walling and floor fragments from 15th-17th century vicarage buildings	Wharram XII (2010)
82	LIA/ Roman - late Medieval	Excavated 1985-90 by S. Roskams and J. Richards Small trenches and test pits, revealing LIA/Roman boundary ditches, and Medieval peasant buildings	Wharram IX (2004)

Table 2.10: The chronological phases at Wharram Percy.

Phase	Period
10th-13th c.	Earlier Medieval
13th-14th c.	Late Medieval
14th-15th c.	
15th-16th c.	
16th-17th c.	Post-Medieval
17th-18th c.	
18th-19th c.	

2.5.3 Shapwick

The parish of Shapwick, first recorded in the Domesday Book, lies eight kilometres west of Glastonbury and 12km east of Bridgwater. It is also on the north side of the Polden hills, and comprises 3,175 acres in total (Gerrard and Aston 2007). From 1988 to 1999 the site was subject to extensive archaeological survey and excavation, all part of the Shapwick Project. The project aimed to assess the formation and development of nucleated settlements between the eighth and thirteenth centuries, though was later extended to investigate post-Medieval aspects of the village. It included extensive fieldwalking, aerial photography, earthwork surveys, soil chemical analysis and geophysical survey, as well as excavation. Excavation took place from 1992, initially comprising small, 2m wide trenches, then expanding to trenches up to 25x25m after 1996. Multiple one metre square test-pits were also excavated in more built-up areas, in order to minimize disruption to the modern village – this was supervised by M. Costen, M. Aston and P. Gardiner, and later T. Hall and S. Fitton. Most trenches were excavated entirely by hand, with twenty percent of upper unstratified layers being sieved through a 5mm mesh in large trenches, and fifty percent of test pit material sieved through a 1cm mesh (Aston 2007). The excavation was split in to multiple sites based on the following geographic areas: Outlying parish, Church Field, Shapwick Village, Shapwick Park, Shapwick House Mansion (Table 2.11).

All of the sites at Shapwick produced faunal remains, which were studied by L. Gidney (2007). The largest proportion of animal bone comes from the late Medieval phases, consisting mainly of domestic livestock like sheep, cattle and pig, while post-medieval material largely originates from Shapwick House and associated parkland. The faunal material studied in this project comprises just over 3,500 specimens. This includes material from all sites, which is divided in to three periods (Table 2.12).

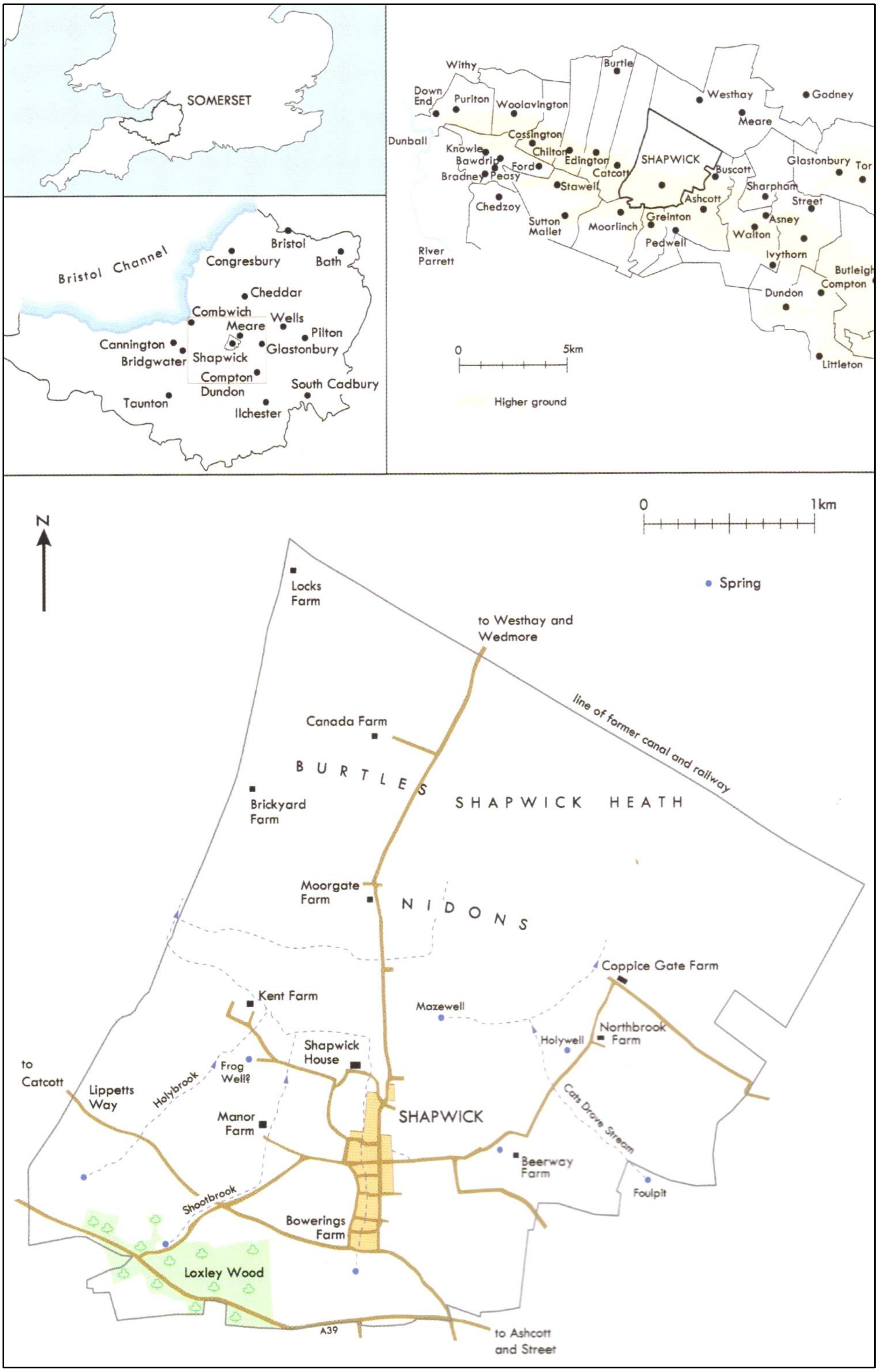

Figure 2.4: Map showing the location of Shapwick (Aston and Gerrard 2013, Fig. 1.1).

Table 2.11: A summary of the sites from Shapwick studied in this project.

Site	Date	Trench Codes	Description
Outlying parish	LIA – 19th c.	95/0024/ A-E	'Sladwick' Field 10x2m trenches
		95/1264/J-K	'Abchester' Field 10x1m trenches
		95/5885/I-IV	'Blacklands' Field 7x1.5m, 10x1.5m, 13.5x1,5m, and 19x1.5m trenches
		98/1303/X	'Sladwick' Field 20x5m trench
		99/3836/S,T	'Borgh/Chestell' Field 5x2m and 12x2m trenches
Church Field	Prehistoric – Post-Medieval	93/4016/A	Investigated earthwork on topographical surveys 11x1.5m trench
		93/4016/B	Investigated building foundations on aerial photos and topographical surveys 14x1.5m trench
		93/4016/C	Investigated site of church 22x2m trench, widened to 4m in middle
		93/4016/E	Investigated earthwork on topographical surveys 18x2m trench
		97/5729/B	Investigated geophysical survey anomalies 10x1m trench
		98/4016/Y	Investigated geophysical survey anomalies 20x10m trench
		98/4016/Z	Investigated geophysical survey anomalies 20x10m trench
		99/4016/R	Investigated geophysical survey anomalies 25x25m trench

Shapwick Village	Prehistoric – 20th c.	94/6660/F-O	Spring Site 2x2m and 5x1m trenches
		94/7722/B	Bridewell Lane 15x15m trench
		94/7722/D-H	Bridewell Lane 1x1m test pits, and 2x2m and 5x2m trenches
		97/1000/C	Bridewell Lane 10x5m plus 12x3m L-shaped trench
		97/7372/D-J	Hill Farm 10x2m, 7x1.5m and 7x2m trenches
		99/OB/P	Old Bakery 6.5x7m and 10.5x8m trenches, linked by 2x35.2m link trench
Shapwick House Mansion	Neolithic – 19th c.	93/6987/A,B	Investigated garden and earlier features indicated by geophysical survey 34x2m and 27x2m trenches
		94/6767/B,C,E,N	Investigation of Glastonbury barn and Medieval moat 12x2m, 2x2m and 10x1m trenches
		97/6477/A,F	Investigated topographical anomalies 21x1m trench

Table 2.12: The chronological periods at Shapwick.

Phase	Period
10th-13th c.	Earlier Medieval
13th-15th c.	Late Medieval
17th-18thc.	Post-Medieval

2.5.4 Battle Abbey

Battle Abbey is a Benedictine abbey built on the site of the Battle of Hastings in Battle, East Sussex. It is six miles north-west of the town of Hastings, and is situated at the southern end of the High Weald. Previous archaeological investigation of the site includes nineteenth century excavation of three eastern crypts, as well as the range to the east of the parlour. Furthermore, between 1929 and 1934 small trenches were used to investigate the walls and develop a plan of the east end of the building. The faunal material studied in this research comes from the 1978-1980 excavations of the standing eastern range, comprising the chapter house and reredorter (communal latrine). These excavations were carried out by hand, though the removal of rubble debris was achieved via machine (Hare 1985). Assessment of the faunal material from Battle Abbey was carried out by A. Locker (1985), and comprised 3,877 identified fragments. Only 558 animal bone specimens were included in this project, due to a lack of domestic livestock in appropriately phased contexts. This material has been divided in to three chronological phases: earlier Medieval (13^{th} c.), later Medieval (14^{th}-16^{th} c.) and post-Medieval (16^{th}-17^{th} c.), though a large proportion of the assemblage is attributed to the latest period.

While this assemblage was initially recorded and selected for analysis, it was later decided that the sample size was not large enough, and the site type would not contribute appropriate data to the research aims. Therefore, it has been omitted from this study.

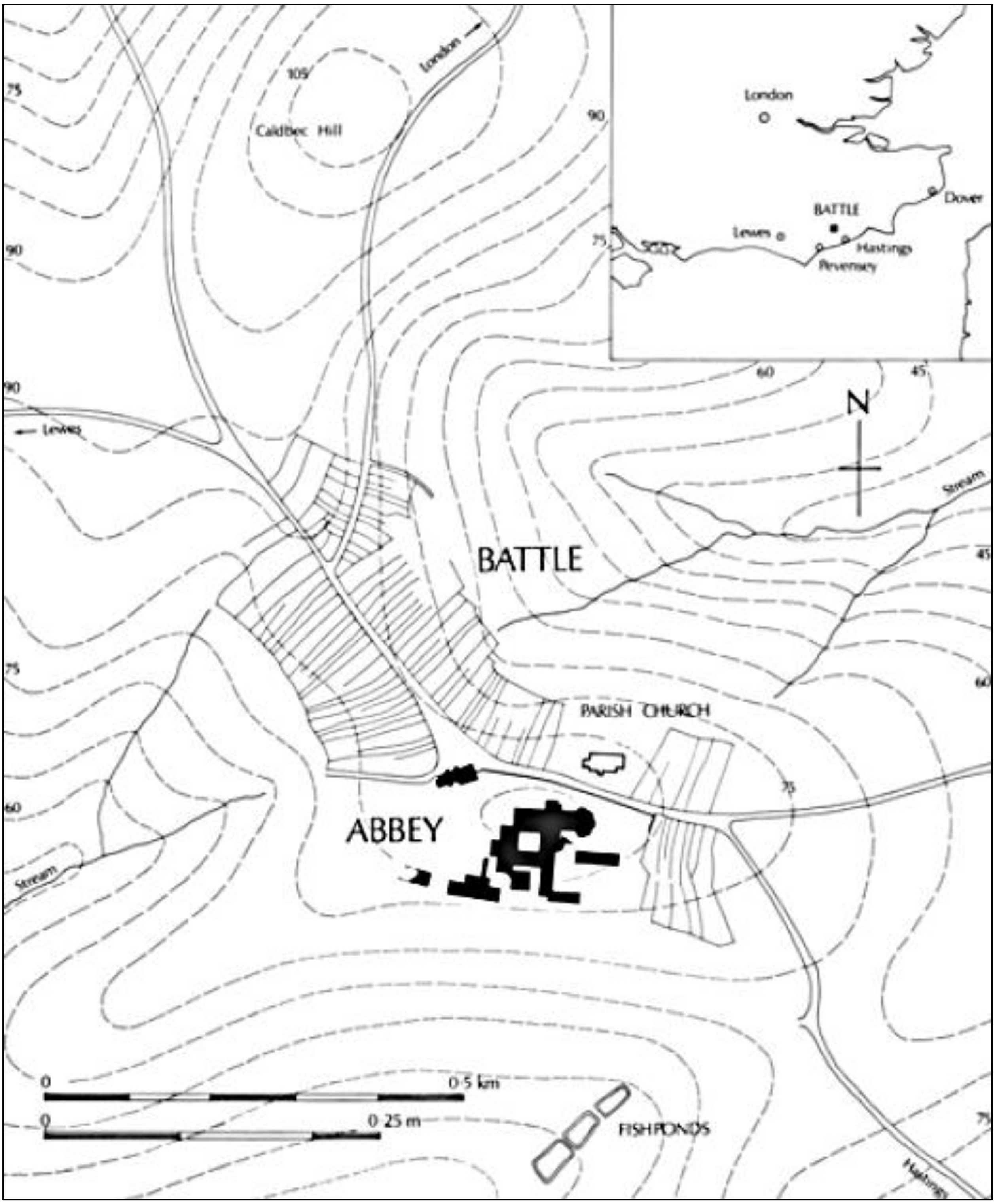

Figure 2.5: Map showing the location of Battle Abbey (Hare 1985, Fig. 1)

3. Great Linford Results

3.1 Historical and Landscape Background

3.1.1 Late Medieval Great Linford

The earliest documents referring to the landscape organisation of the parish of Great Linford come from 1449, and describe an open field system with two large fields: *Segelowfeld* (Secklow Field, named after the Secklow Mound at the southern end of the parish), and *Le Dounfeld* (probably Lower Field) (Croft and Mynard 1993; BuCRO D/U/1/103/1; BuCRO D/U/1/104/3). It is likely that this system was established at a similar time to the village itself, in the tenth to eleventh century, though Domesday evidence suggests that the land came into cultivation slowly and was not totally under plough until the twelfth century (Mynard and Zeepvat 1991; Croft and Mynard 1993). By the late Medieval period, the system had expanded to include three fields (Figure 3.1), listed in early seventeenth century documents as Wood Field, Middle Field and Newport Field (referred to as North Field in 1608 and 1626) (BuCRO D/U/1/103/1; BuCRO D/U/1/104/3). Beresford (1951-2) states that this transition from two to three large open arable fields between the thirteenth and fifteenth centuries was common in Buckinghamshire, making the open three-field system prevalent during this period. Furthermore, it is likely that this third field was produced by reclaiming waste rather than reducing the size of the existing fields, as was the case in Padbury, another Buckinghamshire parish (Gray 1915). This open field system was recorded both in 1946 RAF aerial photographs, and in a 1972 archaeological survey before destruction.

The land in the open arable fields was divided into strips, which were usually half an acre in size, though could range from ¼ acre ‘roods’ to 1 acre ‘selions’ (Blackmore 1991). These strips were grouped into furlongs separated by banks and heathland (see Figure 3.2), the names of which frequently survived enclosure (Beresford 1951-2). During the late Medieval period, the land belonging to each holder was spread throughout these furlongs, as villagers were not permitted to farm adjoining strips (Mynard and Zeepvat 1991). Each land holder had a fixed rent or service due to the manor, which had been owned by the Butler family from the mid fourteenth century, though demesne land was also included in the open fields (Croft and Mynard 1993). Strict communal regulations dictated the cultivation of the arable strips, and the parish operated a rotation between fallow and crops such as barley, wheat, rye, pease and beans (BuCRO D/U/2/17).

As was the case for most open field parishes, the open arable land at Great Linford was used for grazing after harvest, and was accompanied by common grazing land, which was also strictly governed. Areas of meadow were spread throughout the parish, and were divided into ‘doles’. These parcels of meadow were annually distributed to those with land in the arable fields, though some sections of meadow had permanent owners, and larger pieces were part of the major estates (Blackmore 1991; Croft and Mynard 1993). In the later Medieval period, some areas of land previously under plough, as shown by ridge and furrow survey, were converted to permanent pasture to provide greater opportunity for common grazing (Mynard and Zeepvat 1991). There is evidence that a large section at the south of the parish (furlong numbers 115,120,127,128 and 129 in Figure 3.2) was established as permanent common pasture by 1477 (BuCRO D/U/1/46/1’ BuCRO D/U/1/46/3). This area, known as Ley Field, became the main common grazing area for the parish, the use of which was governed by court rolls. For example, it was stated that those owning yardland (15-40 acres) were allowed two horses on the commons, four cattle on the slades, and four cattle in Ley Field. Furthermore, those with land in the open arable fields were permitted grazing for two beasts and one ‘breeder’ (under one year of age) (BuCRO D/U/2/3-6; BuCRO D/U/2/17). Sheep were the main livestock allowed to graze on Ley Field, though were also kept on peasefield, meadow, and the Morrow Leas to the North of the parish (furlong number 11), and from 1630 court orders established that no inhabitant but the two largest estates should keep over 36 sheep per yardland on the commons (Blackmore 1991). However, the names of the furlongs included in Ley Field reveal some other uses; for example, the west end of the field was divided into *Connie Burrough*, suggesting the presence of a rabbit population, and *Pigs Hill*, which is indicative of an area of pig grazing (Croft and Mynard 1991). In addition, furlong 12, named *Cow Pen*, indicates that cattle were kept there. Cattle were also able to graze on open fields after harvest, though this resulted in several regulations for their control. For example, cattle had to be tethered if grazing while crops were still present, and their owners had to appoint guardians - there was a 3s. 4d. or 6s. 8d. fine per animal for breaking these rules (Blackmore 1991).

Overall, Great Linford in the late Medieval period is described by Blackmore (1991,35) as “typical” of a Midland Open Field village, with three large open arable fields farmed in rotation accompanied by common grazing for livestock. This was certainly typical of parishes in north Buckinghamshire, which was predominantly an open field area, containing a mixture of two and three field systems (Gray 1915). However, Blackmore (1991, 33) also states that, although common grazing was plentiful in the parish, in an economy of increasing demand for animal products, particularly wool and later veal, this grazing land may not have seemed sufficient, perhaps prompting the change in land organisation seen in the seventeenth century.

3.1.2 Enclosure

Towards the end of the late Medieval period at Great Linford, considerable changes regarding land organisation and ownership were underway, which likely had a serious effect on livestock husbandry in the parish. These changes were part of the large-scale alteration of land organisation occurring from the late Medieval period onwards in Buckinghamshire, particularly in the north and west of the county (Leadam 1897). According to Reed (1984), enclosure in north Buckinghamshire was a prolonged process, starting as early as the twelfth century with small parcels of land taken from common fields. He states that only 35 percent of Buckinghamshire remained unenclosed by Parliamentary Enclosure in the eighteenth century, and that of the 138 parishes in the county, 52 were entirely enclosed without the need for an Act of Parliament – this highlights the scale of landscape change during the late Medieval period. The earliest enclosures within the area of modern Milton Keynes began in the fourteenth century, and were undertaken by individual landowners (Zeepvat 1993). The pace of these early enclosures increased by a rate of 201 percent between 1491 and 1500 – this was earlier than neighbouring counties Berkshire and Oxfordshire, where this rise in enclosure was not seen until at least 1501 (Leadam 1897). Furthermore, the 1515 Parliament Commission *The Domesday of Inclosures* showed that “few areas had been so systematically enclosed as north Bucks” (Markham 1986, 150). By the sixteenth century, enclosure was affecting most parishes in Milton Keynes, particularly enclosure by agreement, where a parish was enclosed upon the agreement of the major landowners. The first recorded enclosure by agreement in Buckinghamshire took place in Hartwell in 1551. This was followed by the first Milton Keynes enclosure by agreement in Loughton in 1584, where inhabitants decided that, due to rising grass and hay prices, it was best to enclose parts of the open fields after negotiations with their neighbours (Reed 1984). The enclosure of parts of parishes in Buckinghamshire by agreement continued into the seventeenth century, when it became the most prevalent method of enclosure, though this apparent increase may just be due to a better survival of documents. Nevertheless, the enclosure at Great Linford in 1658 was the first large-scale landscape reorganisation, in which an entire parish was enclosed with the agreement of the major landowners

– the last whole parish enclosure by agreement would be Bow Brickhill in 1790 (Zeepvat 1993). This large-scale enclosure caused the replacement of large, unenclosed fields with smaller rectangular fields, demarcated using fences or hedges.

There were numerous motivations for enclosure in Buckinghamshire, not least the desire for increased farming efficiency. Tate (1946, 11) states that many enclosures in Buckinghamshire began with "the gradually growing discontent of the leading proprietors" towards the open field system, which he describes as "rigid and inelastic" as preventing the modernisation of husbandry methods. The rise of pro-enclosure propaganda across the country emphasised the inefficiency of open field farming, and leaflets in Buckinghamshire highlighted the benefits of enclosure, including increased productivity, and greater ease of farming smaller plots not scattered across the parish (Thirsk and Cooper 1972; Tate 1946). Improved farming efficiency in the county was crucial by the sixteenth and seventeenth centuries, as increasing population pressure was putting strain on the open field system, which led to increasingly complex communal cropping and grazing laws to provide enough food for expanding parishes (Reed 1984). Furthermore, balancing arable and grazing land became an issue, as when arable land was extended it reduced the grazing land available for draught animals which were vital to arable cultivation. It is likely that as Buckinghamshire parishes began to implement enclosure to improve efficiency, landowners often visited neighbouring enclosed parishes or spoke to other landholders on market days, increasing the speed of land reorganisation throughout the county (Tate 1946). Therefore, a primary motivation for enclosure in Great Linford was likely increasing efficiency, and it may have been hastened by the earlier enclosure of nearby parishes like Loughton (enclosed 1584) and Stantonbury (enclosed early sixteenth century) (Reed 1984).

Another reason for enclosure in Buckinghamshire, and indeed across Britain, was the desire to increase grazing land, in order to respond to the increasing price of wool, hides, meat and dairy products in the late Medieval period (Reed 1984). Much early enclosure in Buckinghamshire coincided with increasing prices of wool, and up to the sixteenth century the process was motivated by the need to increase sheep grazing. This is illustrated by the fact that enclosure to pasture in the county increased by 139 percent between 1491 and 1500 as wool prices increased from 4*s*. 8 *½d*. to 6*s*. *½d.* per tod (28 pounds weight) (Tate 1946). Enclosure for pasture resulted in the depopulation of several Buckinghamshire parishes by the end of the sixteenth century, including Stantonbury, the neighbouring village to Great Linford (Markham 1986). From the sixteenth century onwards, the cloth trade was in decline and, though wool was still considered an important product in Buckinghamshire, focus shifted to keeping cattle, in combination with the improvement of both livestock and arable land (Reed 1979). In Great Linford specifically, it seems that control of livestock provided particular motivation for enclosure, as daily "spoils, trespasses and destructions" caused by escaped cattle led to disputes between neighbours in the parish (BuCRO D/U/1/48/1). This resulted in damage to the corn and grass of common fields, and became a significant argument for enclosure.

Though enclosure had started relatively early and progressed quickly in Buckinghamshire on the whole, it did not proceed entirely unopposed. Several social and economic problems were reported to have accompanied the process, including the depopulation and desertion of villages, decay of cultivable arable land, unemployment, poverty and vagrancy. These objections to enclosure led to a "vigorous pamphlet war", where publications complaining of the conversion to sheep pasture and subsequent depopulation in Buckinghamshire, Oxfordshire and Northamptonshire were circulated (Reed 1979, 151). There were also physical actions against enclosure in parishes, as in 1548 there was "riotous levelling" of enclosures in Buckinghamshire, followed by disturbances in the county linked to the agrarian rebellion in 1549 (Tate 1946, 19). This opposition caused some attempts to stop enclosure, though Reed (1984, 133) describes these measures as "half-hearted". For example, there was a royal proclamation in 1514 against the engrossing of farms, and the Wolsey Commission in 1517 assessed the extent of house demolition, conversion to pasture and wood enclosure. However, despite this opposition, by the mid-sixteenth century enclosure was viewed as less controversial within the county especially after the 1621 Commons Debate concluded that there was no lack of arable land. Furthermore, fines for enclosure which had been enforced during the reign of Charles I were abolished, leading to a reduction in government interference regarding enclosure (Blackmore 1991). This made enclosure easier to achieve in Buckinghamshire from the sixteenth century onwards, leading to an increase in land reorganisation.

Large-scale landscape change in Great Linford began in the sixteenth century, with the arrival of the Napier family. In 1589 Richard 'Sandy' Napier came to the parish as rector, and lived in a small estate outside the village, to which he added a messuage (house with outbuildings), cottage, close of three roods and twelve acres of land in 1598 (Mynard and Zeepvat 1991). Upon Napier's death in 1633, the parish passed to his nephew, Sir Richard Napier, who also possessed the advowson (right to appoint parish priest) and patronage of the living (BucRO D/U/1/32). From 1637, Sir Richard Napier rapidly started to purchase land in Great Linford, a process made easier by the relatively small number of landowners in the parish (see Table 3.1). Before this date, two main estates were owned by absentee landowners, which formed over fifty percent of the total parish acreage. The main manor, including at least 400 acres and commons, was owned by the Thompson family from 1560, and the second estate, 'Walshes Manor', comprising over 138 acres with commons, was owned by the Tyringham family from 1571 (Blackmore 1991). Napier began his purchases with these two main estates, then continued with smaller parcels of land (see Table 3.2), and by 1649, when he married Mary Kynaston, he had amassed eleven cottages, over 1,000 acres of land, and commons for 1,220 sheep and 220 cattle or horses, all listed in a detailed marriage settlement (BuCRO D/U/1/2). As a result, he was the largest landowner in the parish by the mid-seventeenth century (Figures 3.2 and 3.3), and was the prime instigator of enclosure.

Though Sir Richard Napier had amassed a large proportion of land in Great Linford during the early seventeenth century, several landholdings still did not belong to him in 1658. Therefore, although Napier was the main instigator of landscape change, it seems that enclosure in the parish was a genuine agreement, with parties to enclosure including Richard Worrall (tenant of hospital land), Richard and Thomas Kent, John Roughead, John Kent and John Knight (Reed 1984, 138; Blackmore 1991). The enclosure agreement for Great Linford was drawn up in September 1658, and was also signed by the parish rector, Theodoricus Gravius, as well as Thomas Barber, William Lewis and Elizabeth Tyms, who all had an interest in the enclosure (BuCRO D/U/1/48/1). As part of this agreement, John Hearne and four referees were tasked with dividing the parish land, ensuring that all landowners received a fair proportion, depending on the size of their existing holdings, as close to their existing property as possible. They also decided where and how land was divided, and who should be responsible for maintaining these new land divisions. After this survey, the land in the parish was re-allotted in 1659, though much of it remained with Sir Richard Napier due to his predominance in the pre-enclosure village (Blackmore 1991).

The landscape of Great Linford was transformed after enclosure – new hedges, ditches and roads were established, and a more regular pattern of closes replaced the open fields. A total of 53 new plots were established, with mostly straight field boundaries (Figure 3.4). These new enclosures were relatively small, with 35 under twenty acres, and another eleven under fifty acres, which was typical of the smaller closes produced by seventeenth century enclosure in Buckinghamshire (Reed 1984). Furthermore, many village houses, especially in the south, were demolished, and the cottages at the northern end of the village were replaced with barns as part of the manor complex (Blackmore 1991).

These changes in land structure were confirmed in 1662, when a Decree of Chancery was obtained, and the bishop of Lincoln, in his visit to Stony Stratford in July 1662, confirmed the changes to land organisation and ownership which had been made (Reed 1984). Another significant change to the landscape of Great Linford after enclosure was the conversion to pasture, which affected almost the entire parish - of the eleven farms after enclosure, only three contained any land under plough. This change in land use led to a decline in population, shown in a marked decrease in baptisms and burials from 1659 (Blackmore 1991). A reduction in the number of houses in the village further limited population, and there is evidence that the labour requirements of the parish were met by butchers, graziers and dairymen from elsewhere, whose primary concern was supplying the London market (Croft and Mynard 1993; Reed 1984). It has been suggested that the widespread conversion to pasture in Great Linford was due to the disturbance brought about by enclosure, meaning that grazing was largely adopted until new land holdings were established (Blackmore 1991). However, Sir Richard Napier had also amassed large debts by this date, meaning that a preoccupation with financial difficulty could have caused the continuity of pasture rather than the re-establishment of arable farming.

Table 3.1: Landowners in the parish of Great Linford around 1640 (Mynard and Zeepvat 1991, 34).

Landowner	**Acreage**
Trustees of Shenley Hospital	75 acres
Thomas Longeville	60 acres (Linford Wood)
Thomas Nicholls	89 acres
Ralph Smith	120 acres
Richard Wethered	80 acres
Roughhead family	approx. 80 acres
Kent family	approx. 85 acres
William Gaddesden	approx. 30 acres
Matthew Cardwell	approx. 15-40 acres
Small Landowners:	
Town of Linford (charities)	Several cottages, 4-5 acres
Rector	17 acres (glebe land)
Chowne family	15 ½ acres
John Turner	5 ½ acres
Ann Hall	2 ½ acres
Nicholas Roughhead	3 ½ acres
Nicholas Kent	Cottage and garden
Elizabeth and Mary Tyms	Cottage
Thomas Barker	Arable slades
John Uvedale	2 acres
John Knight	Cottage and close

Table 3.2: Sir Richard Napier's land purchases to 1657 (after Mynard and Zeepvat 1991, Table 1).

Date	**Seller**	**Land**	**Acres**	**Price (£)**
1638	John Tyringham	Arable Commons for 160 sheep and other commons Ley Ground Meadow Closes	105 ½ 7 10 15 1/2	1600
1640	Sir John Thompson	Manor of Great Linford	700	5250
1640	Thomas Longville	Linford Wood and freeboard	60	1000
1641	Nicholas Roughhead	Arable	2	20
1641	Edmund and Amy Roughhead	Arable Meadow Pasture	32 4 1	380
1641	William Gaddesden	Arable	1 ½	3
1642	William Gaddesden	Meadow Arable Leys and Commons	 30	320
1645	John Turner	Close Arable	1 4	62
1648/9	Matthew Cardwell	Arable, pasture, leys, meadow	30	200
1652	Thomas Kent	Close Arable and ley Meadows	3 48 ½ 7	730
1653	Ralph Smith	Messuage, 3 cottages	120	1400
1653	Thomas Nicholls	Arable Meadow	80 9	950
1657	Heirs of Wethered	Arable	15	84
1659	William Roughhead	Arable	1	-
1659	Elizabeth and Mary Tyms	Commons	-	30
1659	John Knight	Land	4	-
1659/60	Anne Hall	Land (2 ½ acres in Great Linford)	26	248
1660	Thomas Barker	Arable slades	-	40
1660	John Uvedale	Arable and commons	2	25
1663	Chowne	Close Land	½ 15	360
1675	John Kent	Close and pightle (small enclosure) Parsons Close Nicholls Close Pasture, arable, ley, meadow Enclosed land	- - - 15 14	255
TOTAL			**1363.5**	**11157**

3.1.3 Post-Medieval Great Linford

Despite his influence in late Medieval Great Linford, by the time of enclosure in 1658, Sir Richard Napier had amassed debts of £21,927, mostly in mortgages. As a result, his son sold his property in the parish after his death in 1676 to London merchant Sir William Pritchard for £18,700 (Blackmore 1991). Not only was Pritchard a wealthy merchant, but he also held the position of sheriff of London when he purchased the parish, and later became mayor from 1682 to 1687. Pritchard established the village as his principal country seat, and remodeled the manor complex into a country house with landscaped grounds, though he spent much of his time in London. However, he was keen for the estate to be profitable, and while he partially farmed the parish directly, he also rented land to nineteen tenants. Sir William Pritchard commissioned a map of Great Linford in 1678, which illustrates the new closes in the parish after enclosure (Figure 3.4). By this date the parish was still largely grazing land, though after this point mixed farming became more common as some grass was converted to arable use. This included some of the former commons and meadows, for example, Long Leas, Cowpen and Mare furlong which were sown with pease by 1680 (Mynard and Zeepvat 1991). Even after the conversion to mixed farming, animals were evidently still important to the economy of the parish, with around 870 sheep being kept on Townes End Ground, Oake Ground, Morrow Leas, Stanton Slade and Neathill in 1680. However, parish accounts show that from 1680 there appears to have been a reduction in sheep numbers, dropping to 509 in 1685 and as few as 44 in 1946. In contrast, according the parish accounts, the number of cattle slightly increase during the mid-seventeenth century, with 1018 purchased in 1678-87 (Blackmore 1991). There is also evidence that livestock were being bought and sold over a wide area, which included Leicester, Nuneaton, Ashby-de-la-Zouch, Derby, Abbot's Bromley, Leeke, London and Eltham, as well as more local markets like Woburn, Stony Stratford, Leighton Buzzard and Hanslope (Mynard and Zeepvat 1991). Overall, Blackmore (1991, 33) states that Great Linford "must have appeared a very modern estate by the prevailing standards of the area" by 1700, as it was totally enclosed and operated a mixed pattern of farming.

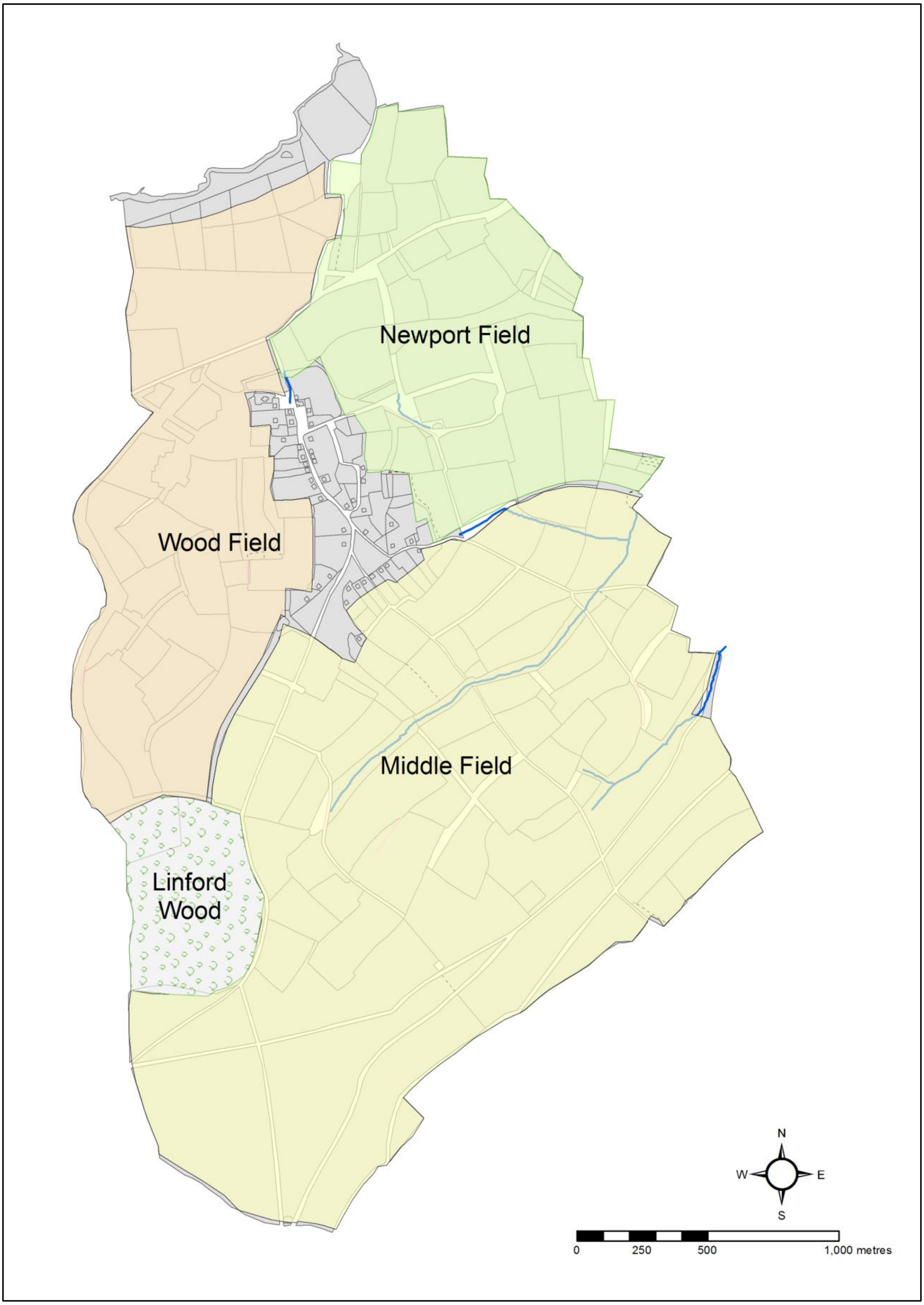

Figure 3.1: Map illustrating the open three-field system in Great Linford in the late Medieval period, after Mynard and Zeepvat (1991, Figure 3).

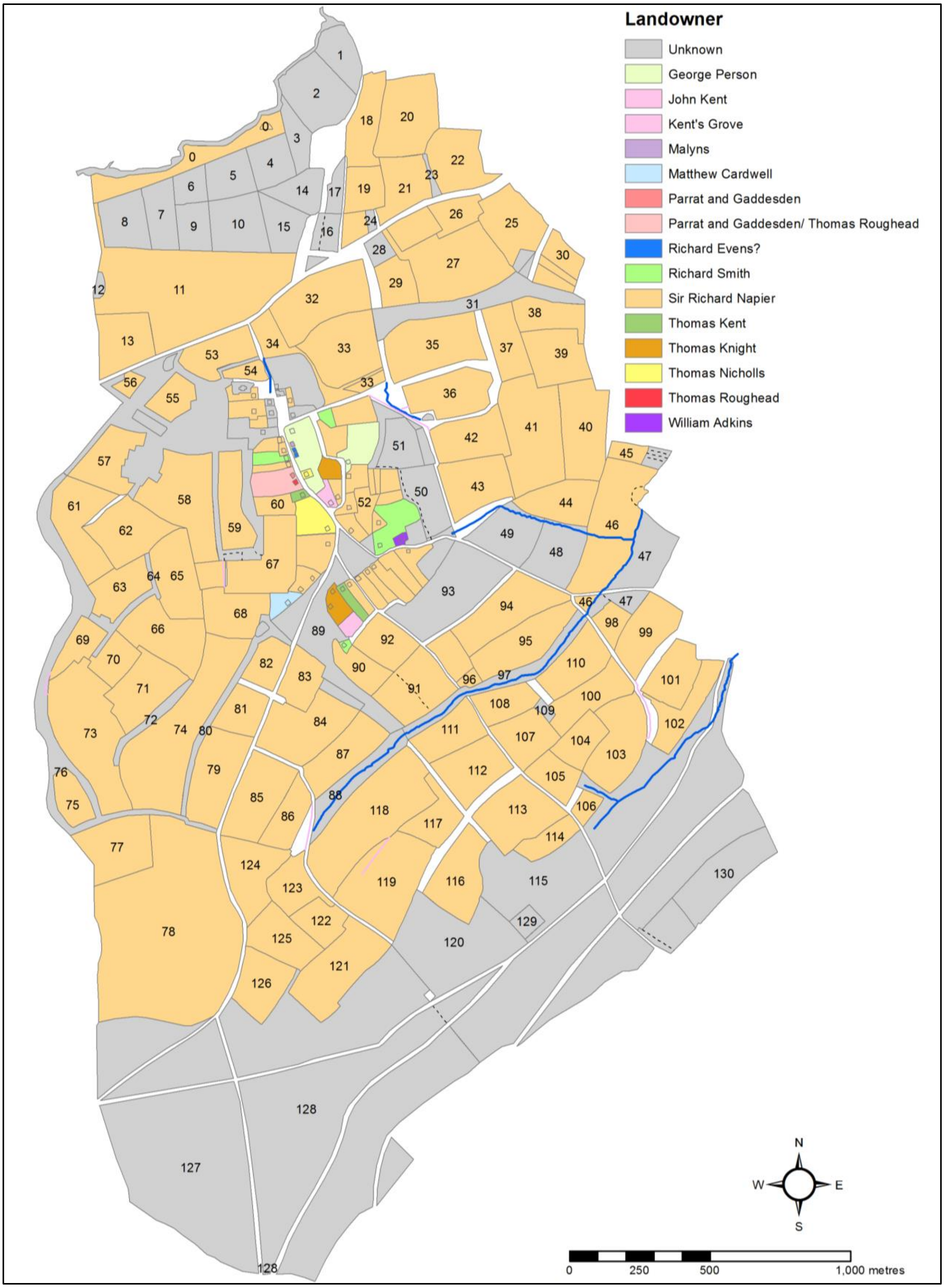

Figure 3.2: Map of Great Linford land organisation and landowners in 1641. The numbered sections represent furlongs within the open fields, the names of which are indicated below. After Mynard and Zeepvat (1991 Figure 4).

Key to Figure 3.2 Furlong Numbers:

0	Midsomer Homes
1	Furlong next Linford Bridge
2	Furlong with Great Doles
3	Furlong between the Ditch and the River
4	Furlong shooting on Lo Hill
5	Furlong on east side the Meadow
6	Tithe Meadow
7	Roody Doles
8	Furlong shooting on Twenty Lands
9	First furlong shooting on Morro Leas
10	Second furlong shooting on Morro Leas
11	Morro Leas
12	Salt Marsh Gogg
13	Salt Marsh Pees
14	First Dirty Doles
15	Second Dirty Doles
16	Short ends
17	Pits
18	Long ends furlong
19	Furlong shooting to ould Pits
20	Mare furlong
21	Furlong above Whetstone hades
22	Furlong beneath Whetstone hades
23	Whetstone Hades
24	Doggeds Furlong
25	Furlong to Newport Headland
26	Furlong shooting to Newport Willows
27	Furlong on the other side Marsh
28	Mortar Pits
29	Butts from Marsh to Mortar Pits
30	Butts at Newport Bush
31	The Common Sward of Marsh
32	Stratford Peas
33	Farland Peas
34	Dove House Leas
35	Over Path Furlong
36	Furlong between Windmill Hades
37	Long Marsh
38	Green Grove Furlong
39	Willow stub furlong
40	Blakeland
41	Bean Hill Furlong
42	Furlong on Upper Side of Windmill Hades
43	Butts to Fulwell Hades
44	Seven acres
45	Tongwell
46	Wet side caldecud Brook severall Sward
47	Sevrall sward drie side the Brook
48	Furlong shooting on the brooke
49	Fulwell hill furlong
50	France furlong
51	Furlong against the grove
52	Farm close
53	Ash Leas pees
54	Ash Leas
55	Stoney Pees
56	Butts
57	Pees against Stanton hedge
58	Long and part of short woollan
59	Linford pees
60	Linford close
61	Stone pits furlong
62	Head ditch furlong
63	Furlong under West Hill
64	West Hill hades
65	West Hill furlong
66	Garland furlong
67	Furlong at Mallens Gate
68	Pear Tree Furlong
69	Furlong under Whitsons path
70	Furlong above Whitsons path
71	Furlong under Netherley Way
72	Nether Way hades
73	Rowlo Furlong
74	Furlong between the Ley ways
75	North Hill Furlong
76	Gutter Slade
77	Wood close
78	Linford Wood
79	Furlong between Ridge Way and Ley way
80	Overley Way
81	Furlong above greene end
82	Greens end furlong fallow field
83	Greens end furlong pease field
84	Higher worse way furlong
85	The furlong under ridge way
86	The furlong under ridge way
87	Lower worse way furlong
88	Brook sward
89	Drove
90	Great Picknuts
91	Under Picknuts
92	Granes end furlong
93	Furlong at Weatherheads backside
94	The belowe hill
95	Furlongs stone hades
96	Ducks headland
97	Springe hill
98	Furlongs
99	Hither Penniland
100	Penniland Field
101	Penniland furlong barley field
102	Further field
103	Langage furlong
104	Long Dunstead
105	Short Dunstead
106	Dunstead buts
107	Elder stub furlong
108	Radge Croft
109	Moor
110	Furlong pease
111	Buts on the other side the Brooke
112	Furlong shooting to Under street hades
113	Under street furlong
114	Under street butts
115	Malzmead
116	Malzmead furlong
117	Short well
118	Long Neath hill
119	Long Lewell
120	Long layes
121	Brier hedge
122	Balland Furlongs
123	Neath hill fallow field
124	Garebroad butts
125	Balland Furlongs
126	Wood furlong
127	Connie Burrough Hill
128	Pigs Hill
129	Cow Pen
130	Down head furlong

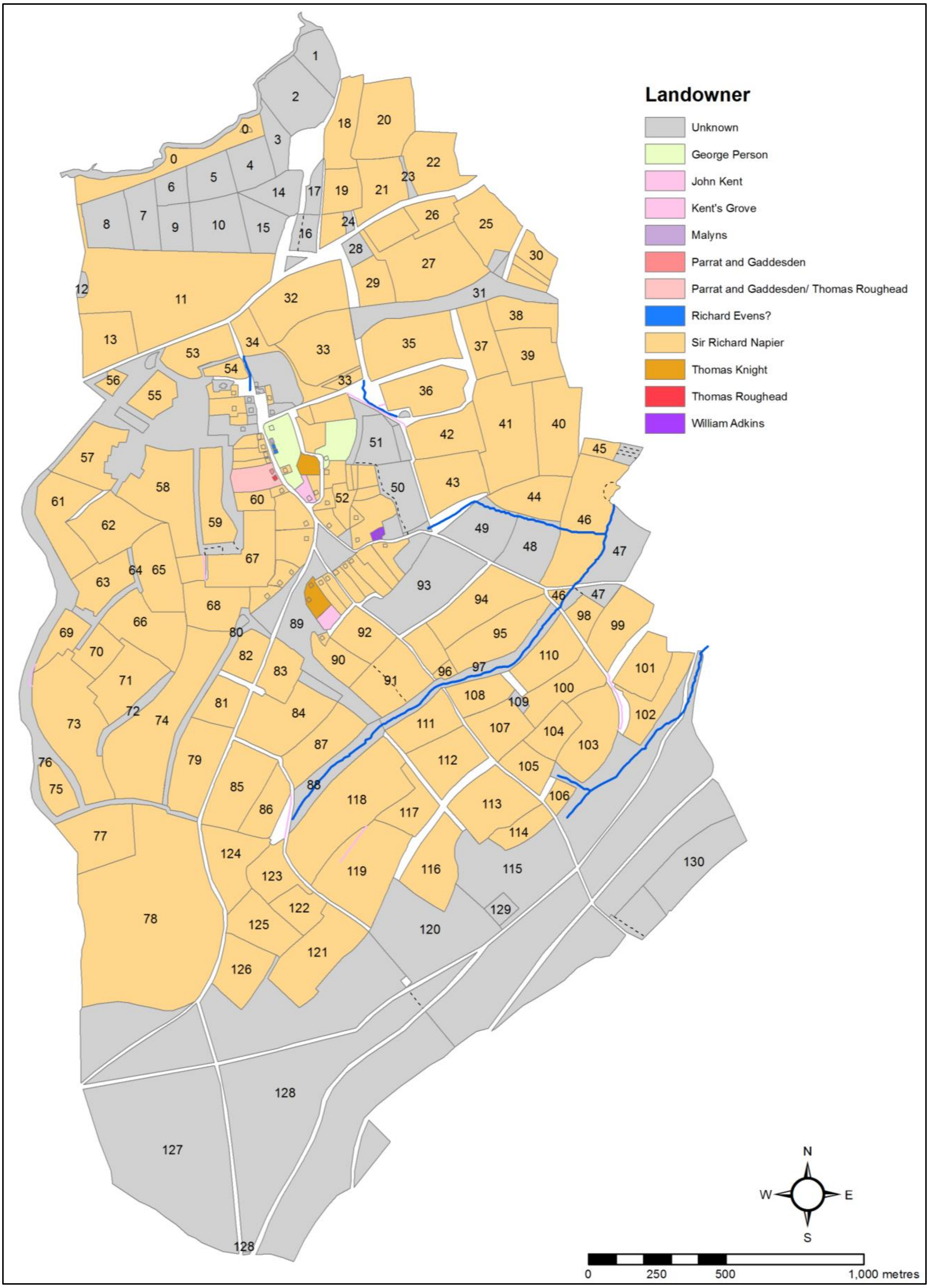

Figure 3.3: Map of Great Linford landowners in 1658, just before enclosure. The numbered sections represent furlongs within the open fields, the names of which are indicated above.

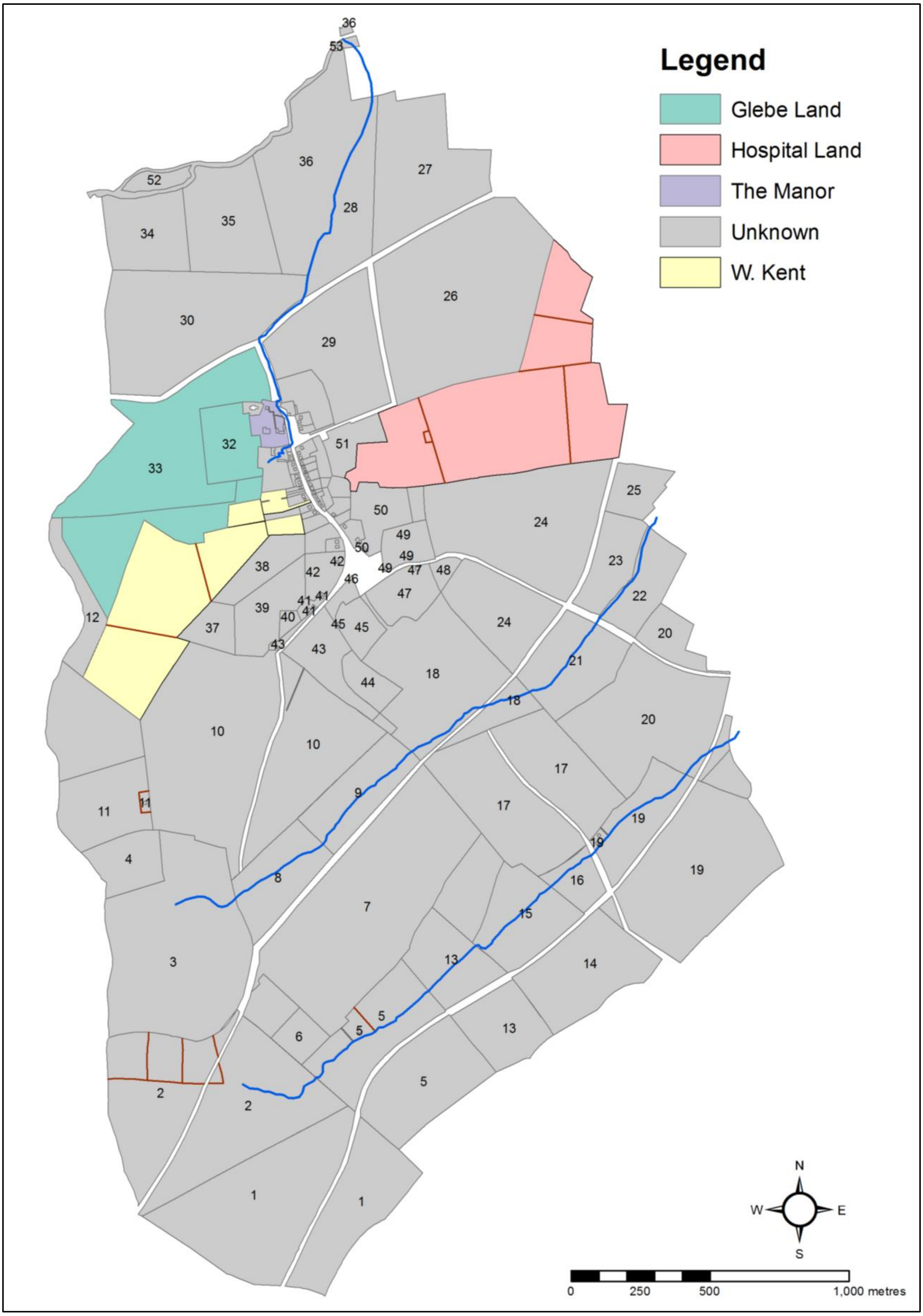

Figure 3.4: Map of Great Linford land organisation and landowners in 1678. The numbered sections represent enclosed fields, listed below. After Mynard and Zeepvat (1991, Figure 7).

Key to Figure 3.4 Field Numbers:

1	Sickley Hill	28	Shorte End
2	Kents Ground	29	Soames Field
3	Lynford Wood	30	Morral Lees
4	Wood Close	31	Ashe Lees
5	Horse Ground	32	Church Lees
6	Neath Hill Close	33	Church Lees
7	Neath Hill	34	Turnees Meadow
8	Upper Meadow	35	Townes End Meadow
9	Lower Meadow	36	Lower Meadow
10	Greate Ground	37	Kents Ground
11	Stanton Slade	38	Kents Ground
12	Little Stanton Slade	39	Newground Pastor
13	Long Lees	40	Upper Green Close
14	Charles Bush Ground	41	Upper Green Close adjoining
15	Greater Cowpen Meade	42	Hulls Close
16	Little Cowpen Meade	43	Upper Green
17	Long Ground	44	Pegnuts
18	Hetther Long Ground	45	The Grove into 2 parcils
19	Oake Ground	46	Lower Greene
20	Pennyland Field	47	Herns Close
21	Nicholas Meade	48	The Close adjoining
22	Drieside Brooke	49	Newmans Close
23	Cockel Brooke Meade	50	Taylors Close
24	Fullwell Ground	51	Hicks Shepherd
25	Tongwell Meade	52	Turners Meade totherside River
26	Marsh Ground	53	The Island
27	Mare Furlong		

3.2 Zooarchaeological Analysis

3.2.1 Species Frequencies

%NISP was assessed by individual phases and periods, in order to evaluate species frequencies on the site across both individual century-long phases and broader temporal phases. In all six phases from the tenth to the eighteenth century, the results suggest that sheep were the most common species at Great Linford (Figure 3.5), and therefore played an important economic role. It should be noted that any goat identified through morphological or metric assessment is not included in this species quantification, and therefore the term 'sheep' is used here to indicate specimens recorded as sheep (*Ovis aries*), or sheep/goat. A total of only seven goat specimens were identified across all time periods at Great Linford: two in the 13th-14th century, one in the 14th-15th century, two in the 15th-16th century, and two in the 16th-17th century (Appendix 3). The proportion of sheep increases from the tenth to the sixteenth century and, though after the sixteenth century there is a decline in numbers (Figure 3.6), sheep bones still remain above fifty percent of the total of the four main domesticates. A similar pattern is displayed in the MNI values from Great Linford. %MNI data from each phase (Figure 3.7) show that sheep are once again the most frequent species, comprising over fifty percent of the livestock from the tenth to the eighteenth century. In a similar pattern to the %NISP results, there is a slight increase in sheep numbers from the tenth to the sixteenth century, followed by a similarly small decline in the following two centuries. The sheep %MNI values for the broader periods are also similar to the %NISP results, as they show an increase in sheep frequency between the earlier and late Medieval periods (Figure 3.8). These results are also suggestive of the continued importance of sheep at the site as, unlike the %NISP values, the proportion of sheep does not drop below half the total livestock numbers in all periods, and the decrease in %MNI into the post-Medieval period is only one percent. Overall, the species frequencies for sheep suggest that this animal played an important economic role at Great Linford throughout the tenth to the eighteenth century as they remain the most prevalent animal on the site, making up around half of the livestock at any time.

The %NISP results for cattle from the tenth to eighteenth century at Great Linford directly contrast those of sheep, as cattle remains are most common in the 10th-13th centuries, exhibit a decline from the 13th-16th centuries, then recovery again in proportion after this phase. They are, however, consistently the second most prevalent species on the site, again suggesting a key economic use. Cattle remains are again the second most common throughout the three broad periods, exhibiting a peak in number during the earlier Medieval period and only a slight decline of six percent into the late Medieval period. Assessing the %NISP values for cattle by period rather than phase obscures the increase seen from the sixteenth century, as there is no apparent change in frequency between the late and post-Medieval periods. In terms of MNI, cattle are again the second most numerous species through all phases, though number considerably less than sheep. %MNI values for cattle suggest a relatively stable number from the tenth to the fifteenth century, followed by a decrease in the 15th-16th centuries and a recover in number thereafter. This decline in the 15th-16th centuries once more implies increasing popularity of sheep relative to cattle during this time, leading to a decreased proportion of cattle. Furthermore, the highest point in cattle population is the 17th-18th centuries, which is mirrored by a decline in sheep proportion. Cattle MNI by period remains relatively stable, with the highest proportion of the species being just over twenty percent in the earlier Medieval period. The slight late Medieval decrease in proportion suggested by the %NISP results can also be seen in MNI values, though there seems to be a slight recovery in number in the post-Medieval period based on MNI results – this may reflect the peak in frequency in the 17th-18th century. Overall, cattle are the second most prevalent species at Great Linford from the tenth to the eighteenth century, though number considerably less than sheep throughout this time, and seem to decrease and increase in proportion relative to the corresponding rise and decline in sheep frequency.

Pigs are the third most frequent species throughout the period studied at Great Linford. %NISP for pig is the highest in the 10th-13th centuries, where they comprise sixteen percent of the material. The frequency of pig remains relatively stable throughout all phases except the 14th-15th century, where it drops. This may suggest that pig frequency decreased alongside the rise in sheep numbers, though pig numbers do increase again slightly in the proceeding period. Across the broader periods, pig remains exhibit a gradual decrease from sixteen percent of the assemblage in the earlier Medieval period down to thirteen percent by the post-Medieval. Though this drop is not large, it may suggest a general decline in pig frequency through time. %MNI values suggest a similar pattern of pig frequency by phase, though the decrease in pig during the 14th-15th century appears greater than that initially suggested by %NISP results. Furthermore, the proportion of pig inferred by %MNI values in the 15th-16th century remains lower than the %NISP results, though both frequencies appear to be similar again by the 16th-17th century and onwards. The %MNI results by period suggest a similar pattern to the %NISP values, of a gradual decrease in pig frequency from the earlier Medieval period onwards. However, this drop only represents a decline of four percent in pig by the post-Medieval period. Overall, pig exploitation seems to be most prevalent in the earlier Medieval period at Great Linford, with a gradual decline thereafter, though there is a slight recovery in numbers around the sixteenth century.

Finally, horse is consistently the least frequent of the four species studied, though %NISP values by phase show small increases in horse remains in the 14th-15th and 17th-18th centuries to just over ten percent of the assemblage. This may reflect the increased use of horse during these centuries, as this pattern is also shown in the %MNI results by phase; however, the small sample size of horse means that this interpretation is uncertain. Both %NISP and %MNI values by period mask this variation in horse frequency, as they suggest a relatively stable occurrence of the animal throughout the earlier, late and post-Medieval periods. These results show slight increases in horse during the earlier and post-Medieval periods, though the species remains under ten percent of the total faunal material throughout. Overall, it seems that horses were present in relatively low frequencies at Great Linford throughout the period of study, though slight variation in representation across individual phases may represent a change in frequency or function of the animal.

3.2.2 Species Frequencies by Croft

As the overall species frequencies for Great Linford indicated, sheep are the most prevalent species on all crofts in the late Medieval period, though on some crofts they form a larger proportion of total livestock (Figure 3.9). The frequency of cattle is relatively similar for all crofts, at 20-30 percent. Pig frequency also ranges from 10 to 13 percent on all crofts apart from A where it is lower. Horse is the least frequent animal across all crofts, never exceeding ten percent of the remains. Overall, the results from the individual crofts in the late Medieval period largely reflect the overall site pattern. Species frequencies do not appear to significantly change with ownership. While the three crofts owned by Sir Richard Napier (B, D and G) show a consistent proportion of species, they are not remarkably different to those owned by Richard Smith (A and H) and William Adkins (F). This may suggest a similar husbandry regime was followed by the majority of landowners in the parish.

Fewer post-Medieval crofts provided a large enough sample size, though the three here may suggest a shift in species frequencies across the village (Figure 3.10). On Crofts A and G there is a decrease in sheep abundance from the late Medieval period, which reflects the description in historical accounts of a site-wide reduction in sheep numbers (Blackmore 1991). Generally, cattle numbers increase across all three sites, which may indicate the increasing demand for veal in urban centres during the post-Medieval period. While pig numbers decrease overall at Great Linford in the post-Medieval period, there is a higher proportion on Crofts A and G. This may reflect the small size of the crofts, resulting in the extinction of common grazing prompting landowners to rear pigs, which were more suited to smaller parcels of land. Horse frequency is still relatively low on all sites in the post-Medieval period, though there is a larger proportion on Croft G, which may suggest the increased use of the taxon for traction in that part of the parish. Unfortunately, there is limited data regarding land ownership after enclosure, which means that these changes in frequencies cannot be attributed to a particular landowner or tenant.

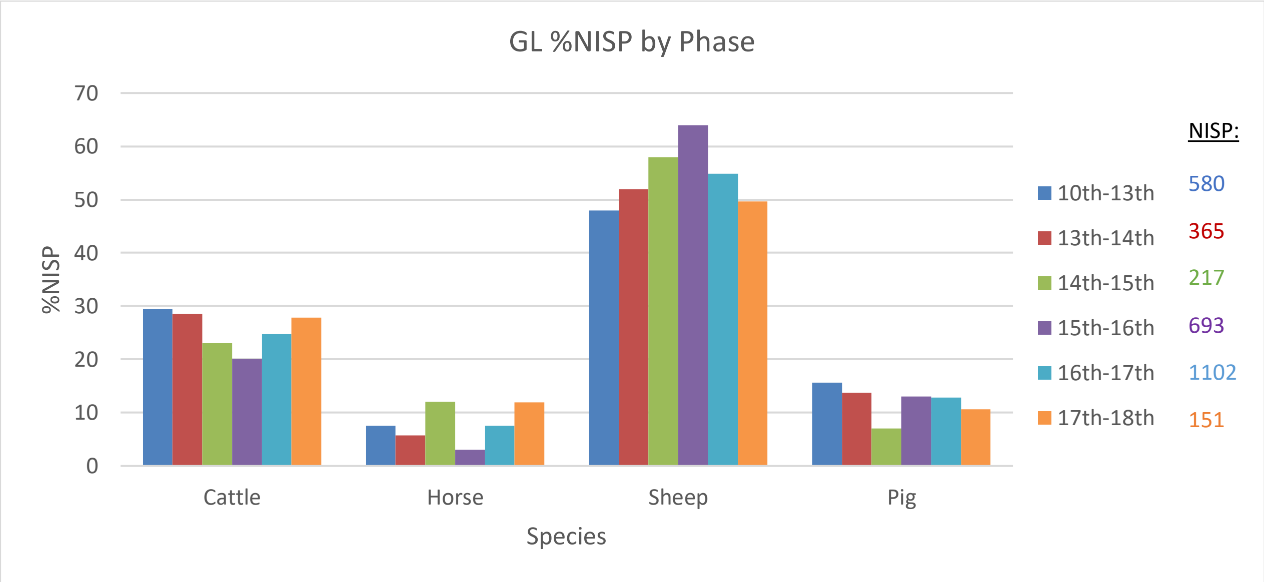

Figure 3.5: %NISP values for the main domesticates at Great Linford, divided by phase.

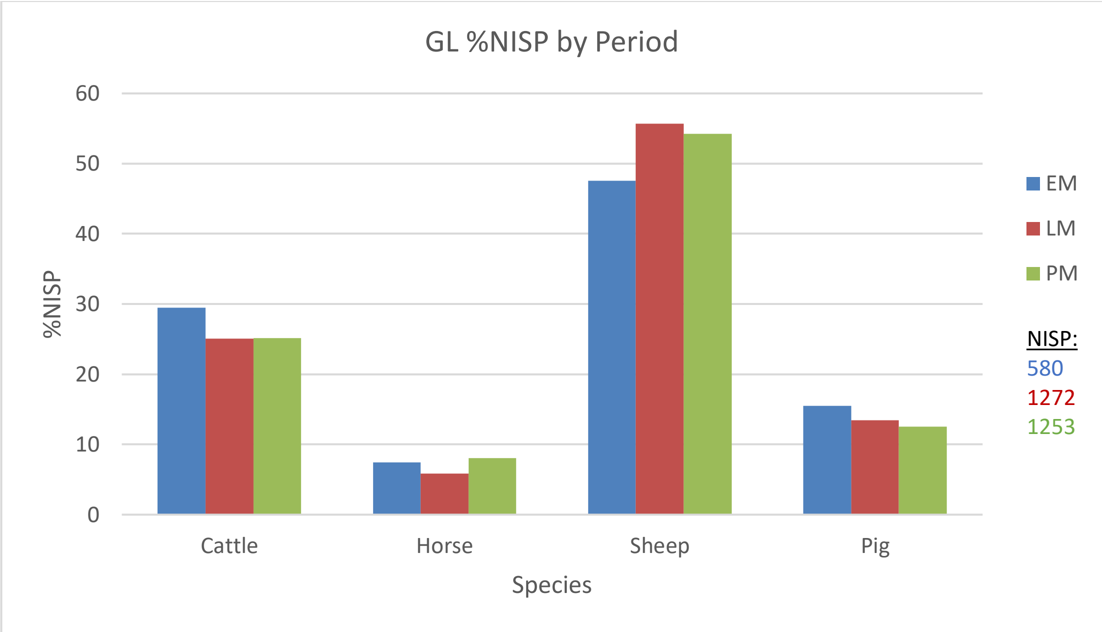

Figure 3.6: %NISP values for the main domesticates at Great Linford, divided by period.

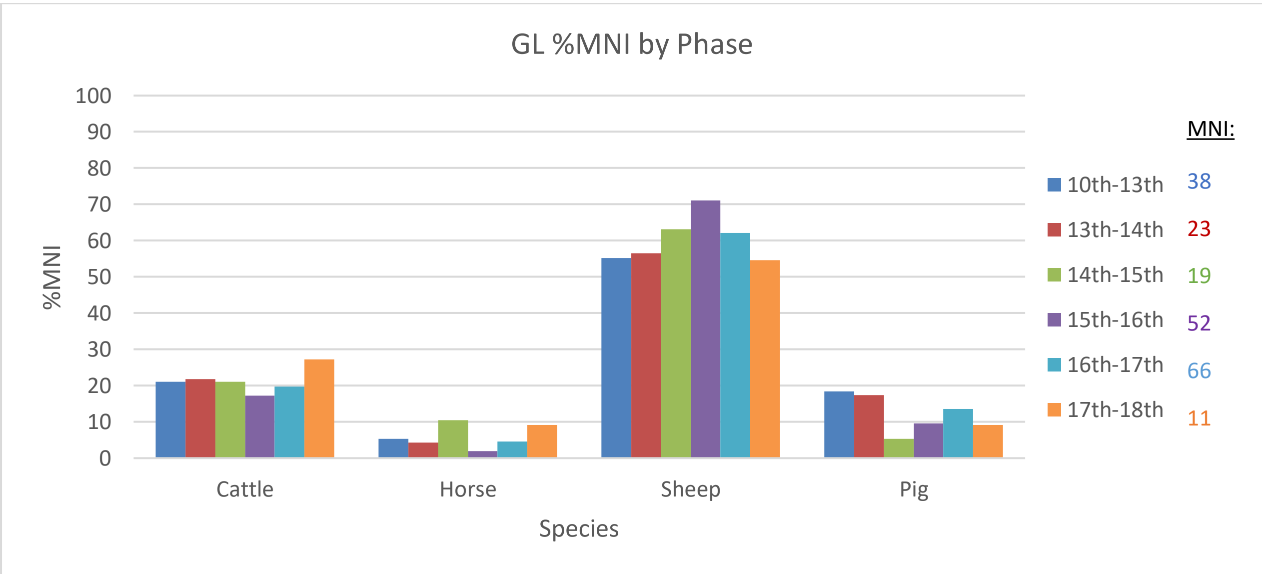

Figure 3.7: %MNI values for the main domesticates at Great Linford, divided by phase.

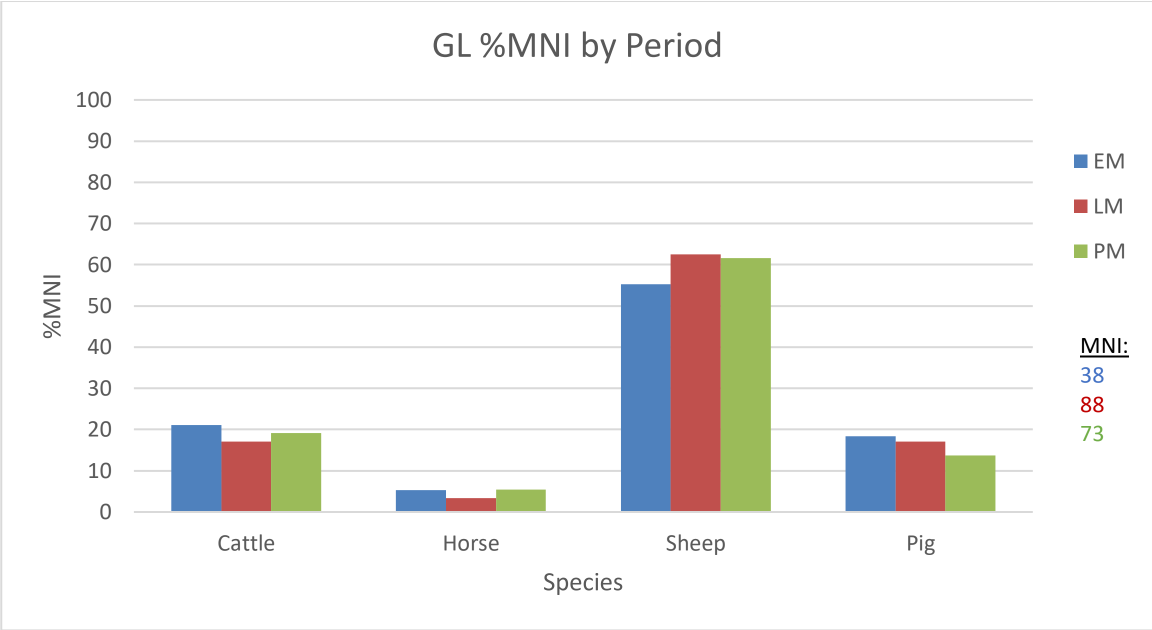

Figure 3.8: %MNI values for the main domesticates at Great Linford, divided by period.

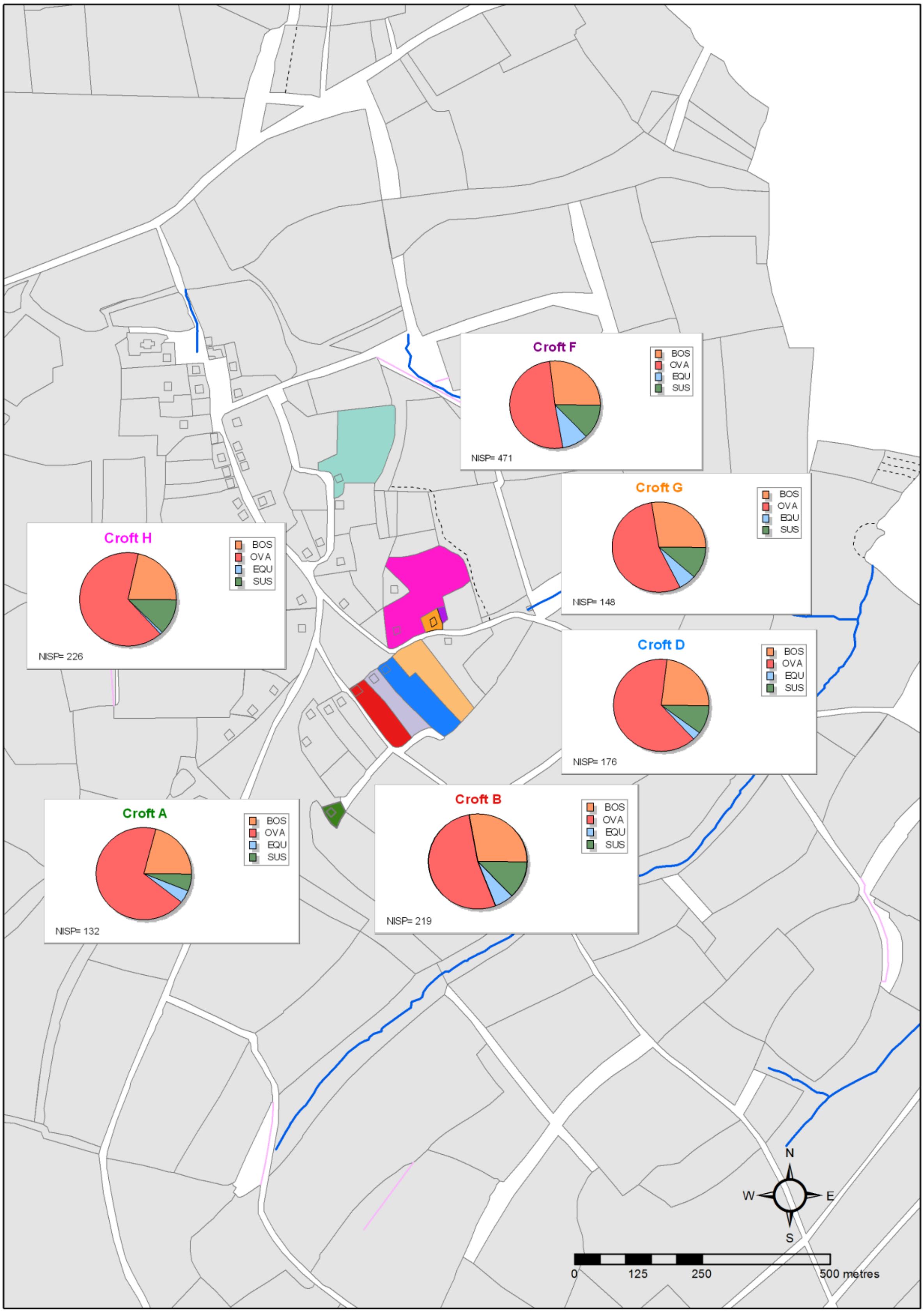

Figure 3.9: Species frequencies separated by croft in late Medieval Great Linford. Frequency is given as %NISP, and the title colour of the pie chart corresponds to the colour of the croft on the map.

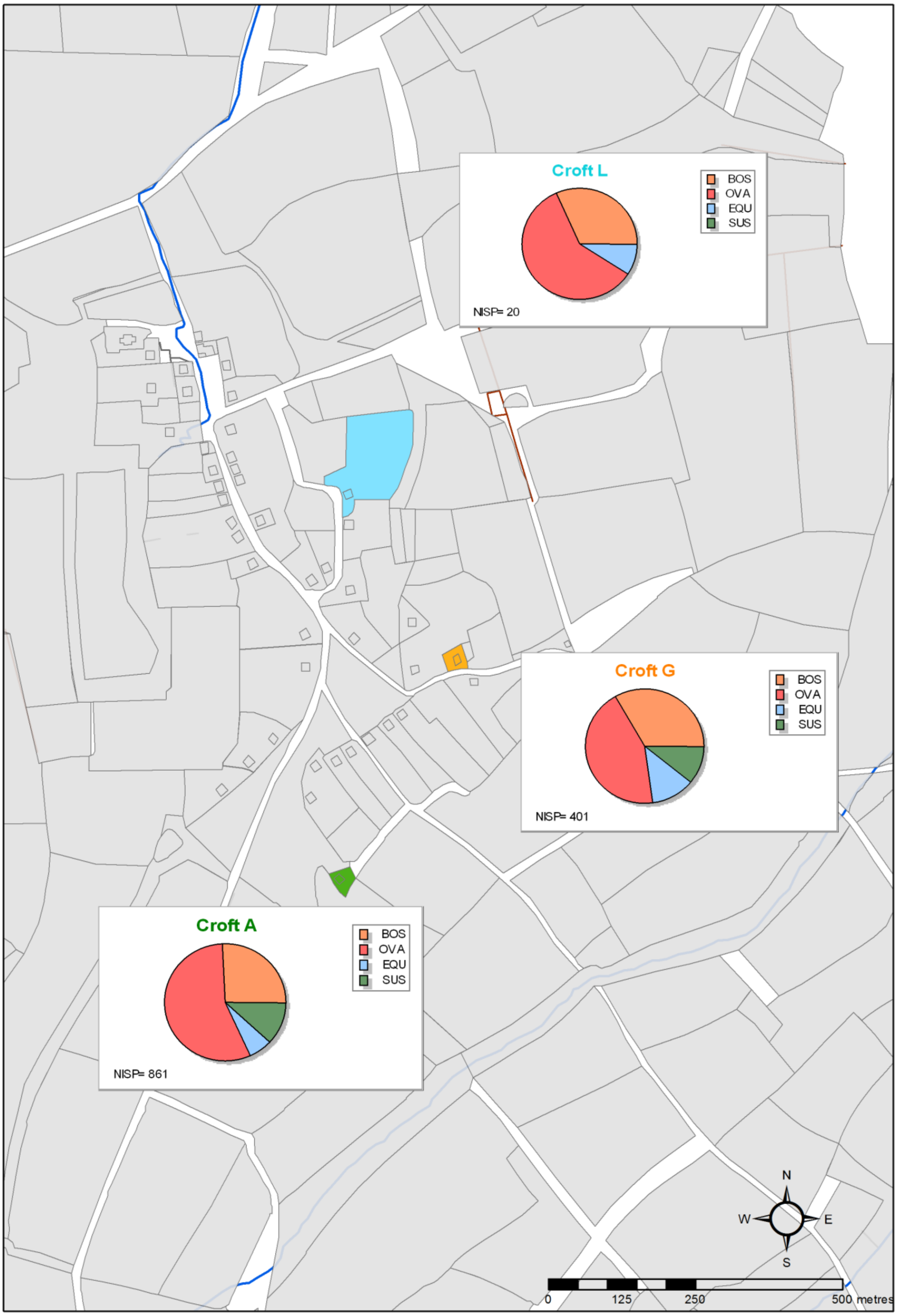

Figure 3.10: Species frequencies separated by croft in post-Medieval Great Linford. Frequency is given as %NISP, and the title colour of the pie chart corresponds to the colour of the croft on the map.

3.2.3 Butchery

Sheep

There is relatively little butchery recorded at Great Linford across all phases, especially for sheep (see Table 3.3). In the earlier Medieval period, there is no evidence of butchery on any sheep remains, and in the late Medieval period, the sheep butchery is mostly concentrated around the distal humerus and metacarpal (Figure 3.11). The chop marks in these positions are indicative of primary butchery in which the main joints are disarticulated, a practice common during the Medieval period (Seetah 2007). In contrast, the cut marks might suggest the removal of flesh from long bones, or perhaps the removal of skin, as in the case of the cut mark on the first phalanx (Reitz and Wing 2008, 126-128). In the post-Medieval period, there are fewer butchery marks, comprising chop marks on the distal humerus and tibia, as well as a cut mark on the tibia shaft (Figure 3.12). Again, these marks likely indicate primary butchery, followed by the removal of meat. However, they do not suggest the intensive butchery present in urban areas from the sixteenth century, i.e. the specialised splitting of the carcass or division into prescribed joints of meat (Rixson 1989, 54-55). It is more likely, therefore, that the butchery here represents butchery by peasant farmers who were less specialised (Rixson 2000, 95-96).

Cattle

Butchery on earlier Medieval cattle remains includes mostly chop marks, which are largely concentrated around the distal humerus, radius, tibia and metatarsal (Figure 3.13). The chop marks on the end of long bones and around the acetabulum are typical of primary butchery, in which the limbs are disarticulated. However, there are multiple chop marks on the shafts of long bones, including one instance where these are accompanied by cut marks, which might indicate the presence of tertiary butchery in which the carcass was broken down for individual households or exploited for marrow (Rixson 1989). A greater amount of butchery is present on cattle remains from the late Medieval period (Figure 3.14). Again, chop marks are present around the distal humerus, astragalus and calcaneum, which may indicate the disarticulation of major joints. Chop marks on the shafts of long bones such as the humerus, radius, tibia, and metapodials are more common in this period, again suggesting breakage for potentially marrow extraction or disposal. Numerous chop marks are found on the horns in this period, indicating the removal of this element, likely for craft purposes. Cut marks for late Medieval cattle are recorded primarily on the front limb, and again represent areas where the removal of meat may have taken place. There is a similar quantity of cattle butchery marks in the post-Medieval period, though they consist entirely of chop marks (Figure 3.15). These marks are concentrated around articulations, for example the distal humerus, distal metacarpal, distal tibia, scapula, pelvis and astragalus, which points towards the primary disarticulation of cattle for meat. However, there are many chop marks on the shafts of long bones, which again suggests deliberate breakage. Overall, butchery marks, particularly chop marks, increase in frequency throughout the study period (see Table 3.3), potentially representing an increased intensity of butchery methods.

Pig

Pig butchery in the earlier Medieval period at Great Linford consists of only five chop marks in total, all on the proximal ulna (Figure 3.16). This likely represents the separation of the elbow joint, which could suggest the use of pig front limbs for meat on the site. In the late Medieval period, there are again very few butchery marks, consisting of one chop mark on the pelvis and one on the astragalus (Figure 3.17). This indicates the separation of the hind limb, likely for the exploitation of meat. Finally, in the post-Medieval period, four chop marks are distributed across the humerus shaft and distal tibia

(Figure 3.18). These are accompanied by sawing marks in the same locations, suggesting the use of both front and hind limbs for meat. This new method could also suggest the intensification of butchery, or the import of joints professionally butchered elsewhere.

Horse

Butchery on horse remains is entirely absent, except for three late Medieval cut marks on the first phalanx. This may reflect the skinning of horses in the late Medieval period, in order to make use of the hide, which Albarella (2005, 140) suggests may be a more common practice on late Medieval rural sites than in urban centres. These marks are not suggestive of butchery of horses for meat.

Table 3.3: The proportion of butchered bones for each species in each period.

Butchered (%)	Sheep	Cattle	Pig	Horse
EM	0.0	9.1	3.1	0.0
LM	3.6	9.4	2.7	6.4
PM	1.5	12.9	6.0	0.0

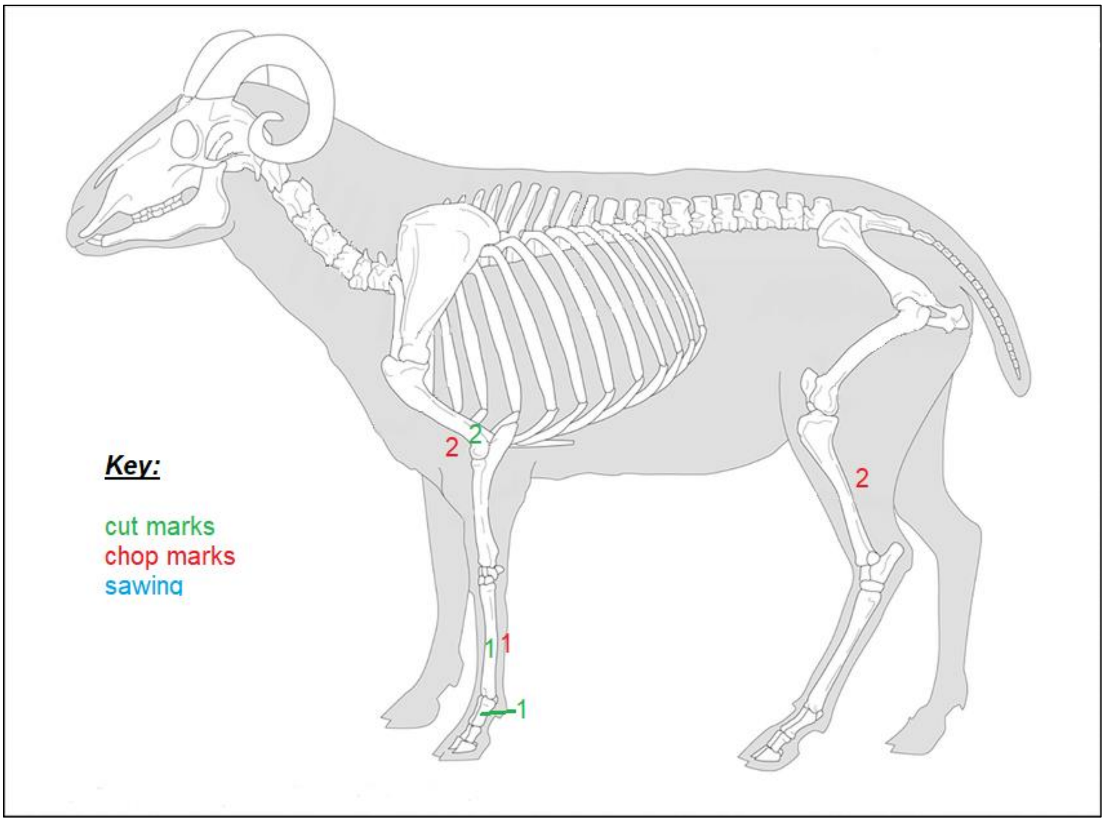

Figure 3.11: The distribution of late Medieval sheep butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

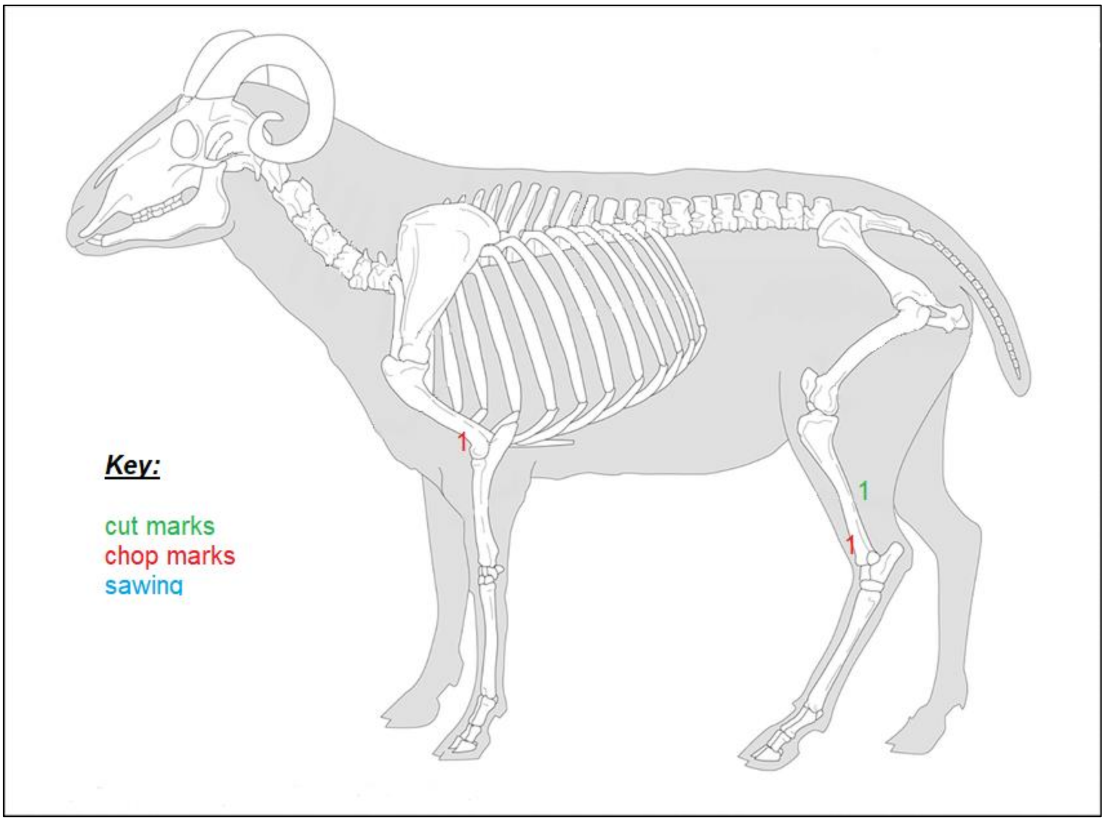

Figure 3.12: The distribution of post-Medieval sheep butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

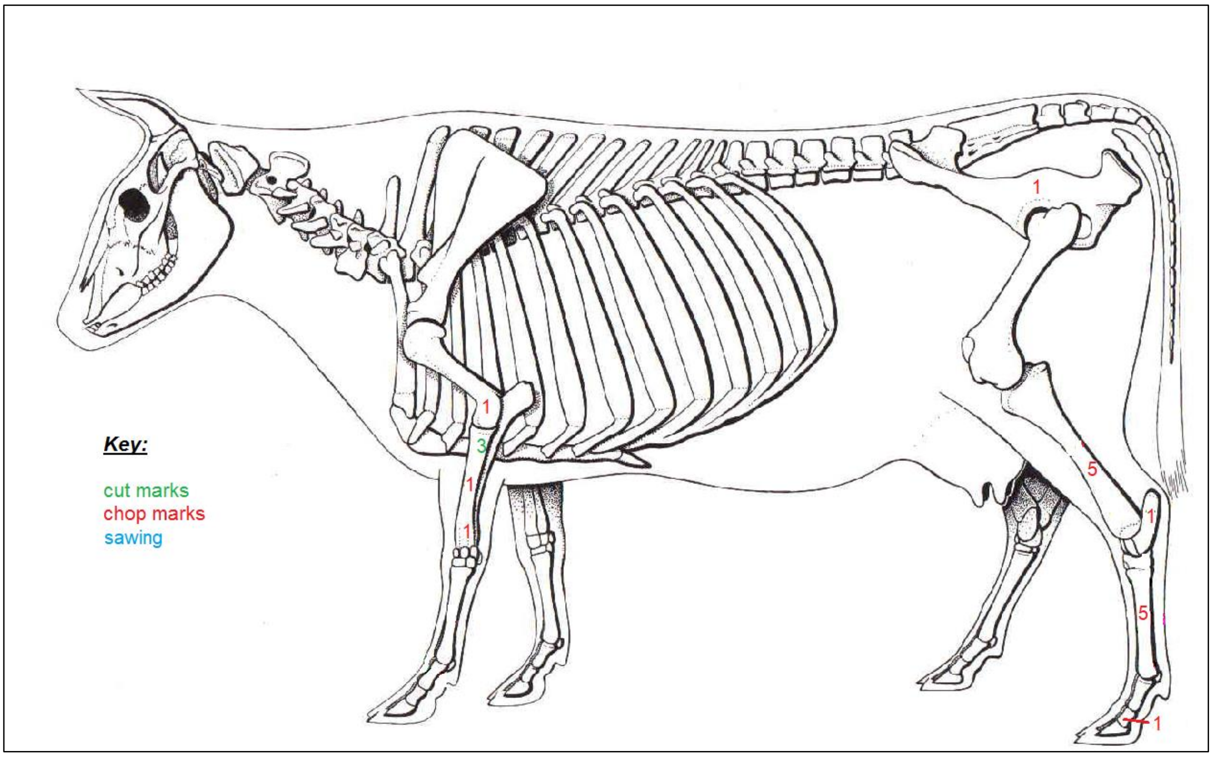

Figure 3.13: The distribution of earlier Medieval cattle butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

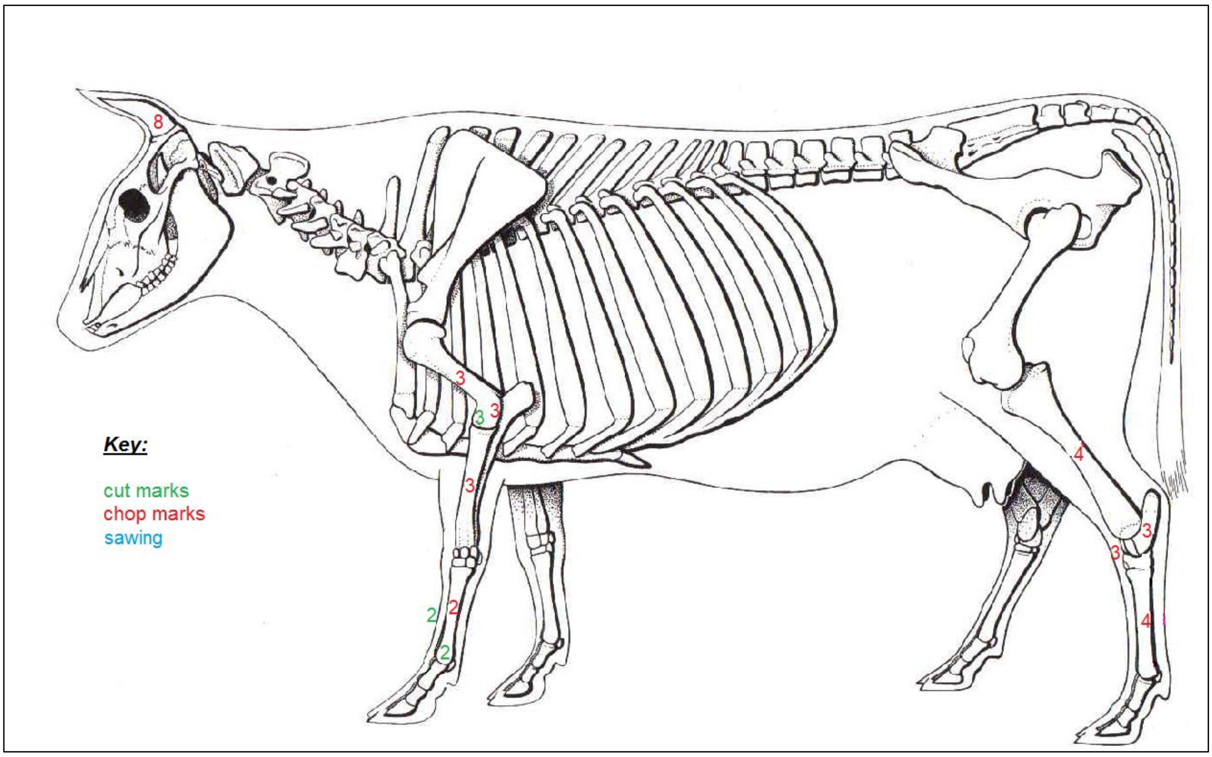

Figure 3.14: The distribution of late Medieval cattle butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

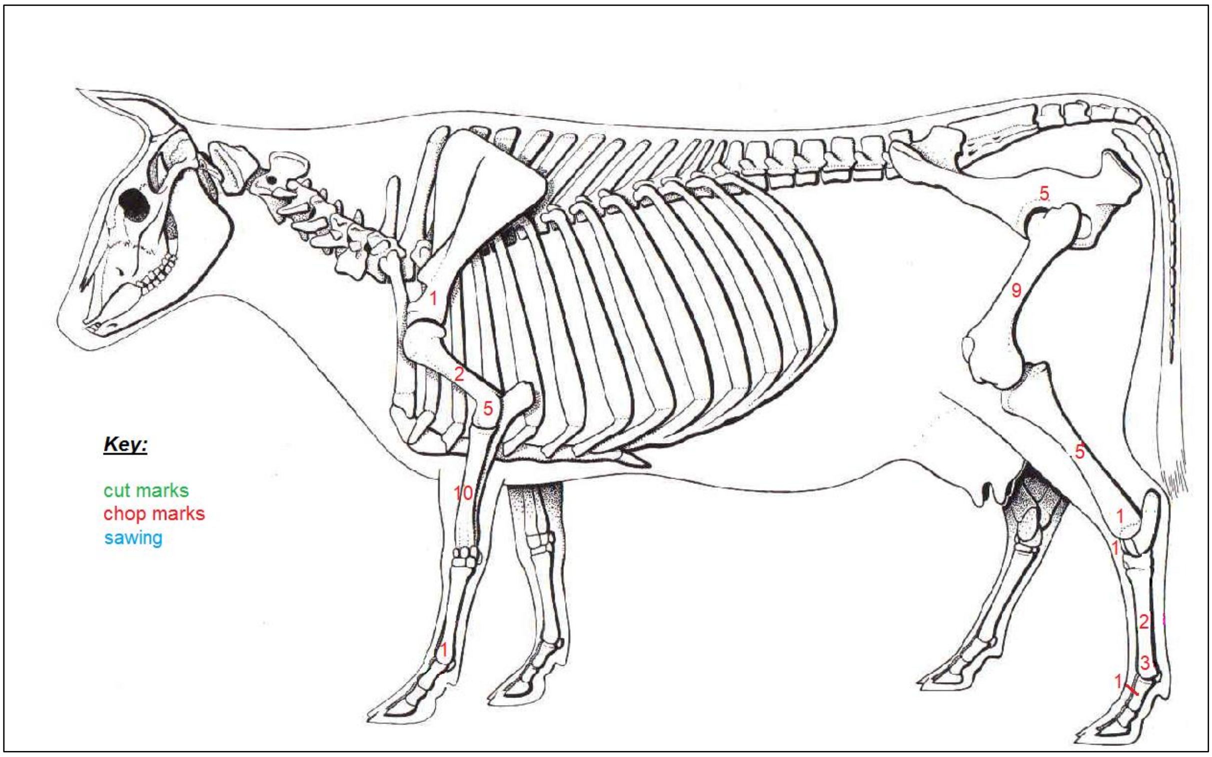

Figure 3.15: The distribution of post-Medieval cattle butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

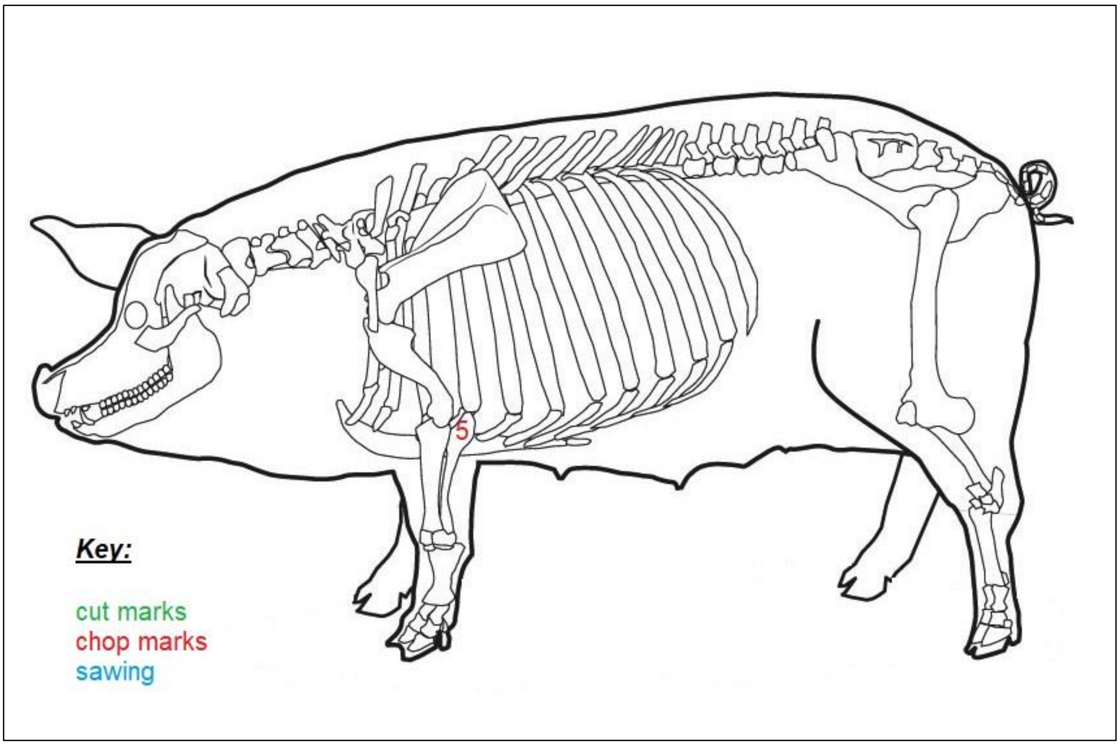

Figure 3.16: The distribution of earlier Medieval pig butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

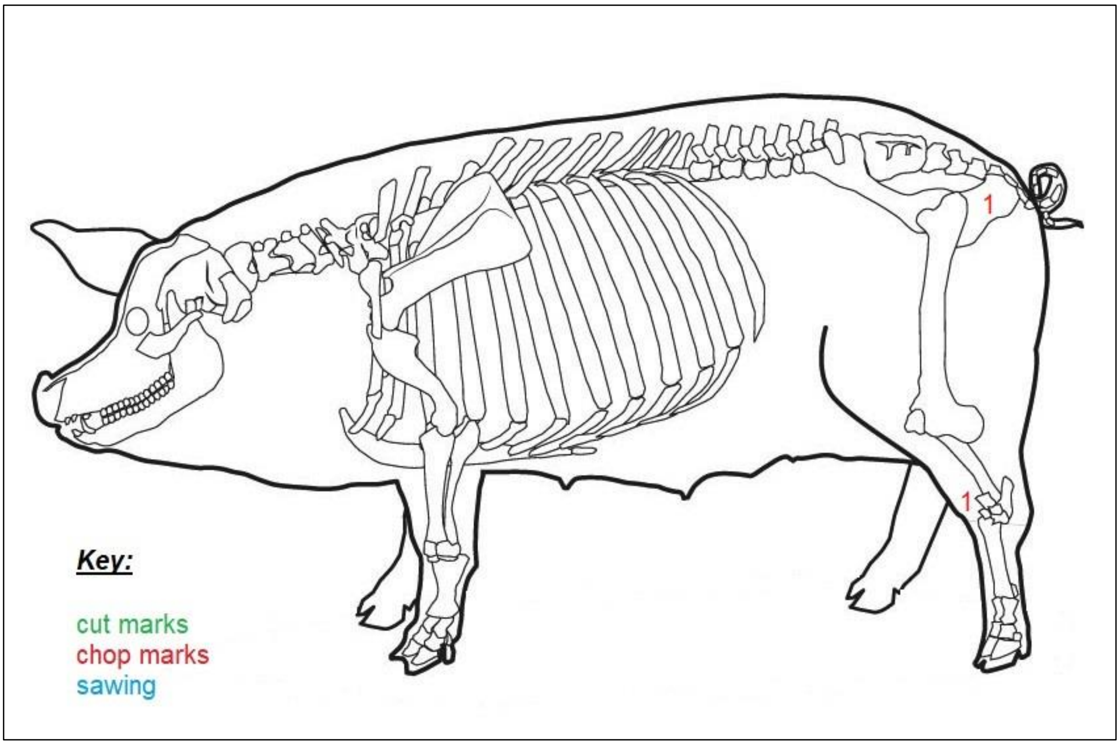

Figure 3.17: The distribution of late Medieval pig butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

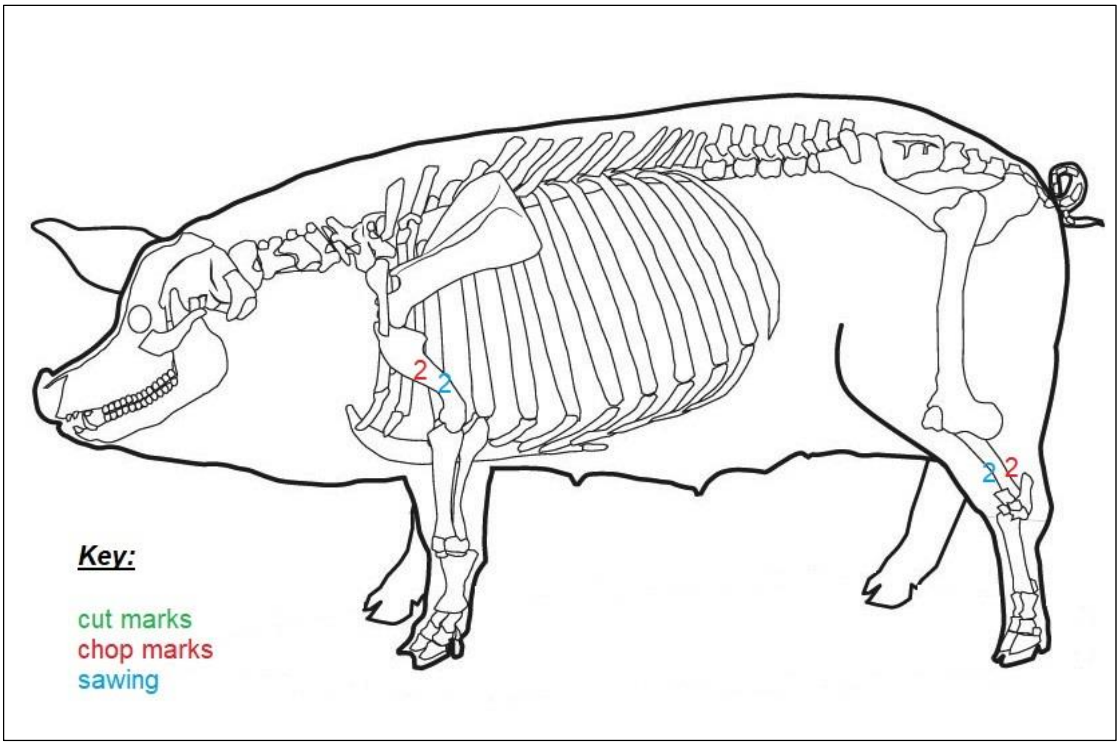

Figure 3.18: The distribution of post-Medieval pig butchery at Great Linford. The numbers represent the total amount of butchery marks recorded for each element.

3.2.5 Pathology

Only seven instances of pathology change have been recorded at Great Linford, predominantly on cattle elements. Three cattle first phalanges, dating from the tenth to the fifteenth century, show signs of osteophytes around the articulations, though the articular surfaces themselves are not affected. Similar examples are found on a cattle femur, as well as a metacarpal and metatarsal. While it is difficult to interpret the exact cause of these bone alterations, it is most likely that they were the result of idiopathic degenerative joint disease. The frequency of lower leg specimens could indicate that cattle were used for draught purpose at Great Linford between the tenth and fifteenth centuries, as these elements bear greater strain in traction animals, though these pathologies are not exclusive to draught cattle, and without a greater sample size this cannot be definitely determined (Bartosiewicz *et al* 1997). Furthermore, the lack of pathology in the following phases perhaps points to the introduction of horse for this role, though factors like age, sex and body mass may also have played a role in cattle pathologies (ibid.).

A single example of pathology is present on sheep post-cranial bone, which consists of new bone formation around the coronoid process of an ulna from the fourteenth to fifteenth century. This exostosis may be associated with a now healed fracture, or is perhaps associated with 'penning elbow' (Clark 2009), though the cause cannot be determined from this isolated example. The final example of pathological change from Great Linford was recorded on a sheep horncore from the fourteenth to fifteenth century. It takes the form of an indentation, very similar to that described by Albarella (1995, 699) as a "thumb print" found both archaeologically and in modern specimens. While the cause of this depression is still somewhat unclear, he suggests that it may be caused by calcium resorption, due to a combination of malnutrition, repeated pregnancies, and intensive milking.

3.2.5 Non-Metric Traits

The absence of the second permanent premolar was recorded in two sheep specimens (15% of recorded second premolars) from the earlier Medieval period at Great Linford, followed by three in the late Medieval period (15%). However, there are no examples from the final period. For cattle, the second premolar was absent in only one specimen in the earlier Medieval period (14%), and this trait was not recorded again in the following phases. This suggests a relative lack of this trait in both species, though the fragility of the front of the mandible means that it is likely underrepresented, and using it to assess change in livestock populations at Great Linford is not practical.

The presence, absence or reduction of the cattle third mandibular molar hypoconulid was also recorded, but again was relatively scarce. In the earlier Medieval period, only one molar with a reduced hypoconulid was recorded (8% of recorded mandibular third molars), followed by two examples in the following period (11%). Finally, in the post-Medieval period only one example of a reduced hypoconulid was found (6%). It appears that no maxillary teeth were affected, with no examples of V-shaped wear across all periods. Therefore, it appears that only the reduction of the hypoconulid occurred in cattle, with no examples of it being totally absent.

3.2.6 Ageing

Appendices 5 to 7 contain dental ageing tables, and Appendix 8 contains fusion data by element.

Sheep

The sheep fusion ageing results show relatively high survival throughout all individual phases at Great Linford, with over 70 percent of animals surviving to the final fusion stage of 30-42 months (Figure 3.19). The highest rate of survival is shown in the earlier Medieval period, as there is one hundred percent sheep survival through phases one to three, and a drop by only nine percent in the final stage (Figure 3.20). Survival is slightly lower by the final stage in the following periods, especially in the post-Medieval period, where 77 percent of sheep survive past 42 months. This suggests that there is a higher proportion of sheep being killed before 42 months in the post-Medieval period, especially in the 16^{th}-17^{th} century, perhaps due to a greater exploitation for meat. However, the high survival of this species across all periods at Great Linford is suggestive of their use primarily for wool, as sheep kept alive past 42 months will produce wool throughout their adult life.

Sheep dental ageing suggests a greater drop in survival at an earlier age than the fusion results across all three periods (Figure 3.21). In all phases, the greatest drop in sheep survival occurs around three years (Figure 3.22), which coincides with the final fusion stage, though there is also notable survival decrease before this age which was not evident in the fusion results. This may be due to the poor preservation or recovery loss of unfused juvenile bone material. Worley *et al* (2016) also propose that a variation in bone fusion based on sex may cause a discrepancy between fusion and dental ageing, with old ewes overestimated, and old males, particularly wethers, underrepresented. After the peak in kill-off at three years in all periods, there is a steady decline in survival to zero at ten years. This age distribution indicates the kill-off of between thirty and forty percent of sheep at three years across all periods, suggesting exploitation of meat at that age. However, the survival of a relatively large proportion of the herd past this stage suggests that sheep were also being used for wool – this is corroborated by the high survival rate in fusion ageing. There does not appear to be any change in this pattern across the study period at Great Linford.

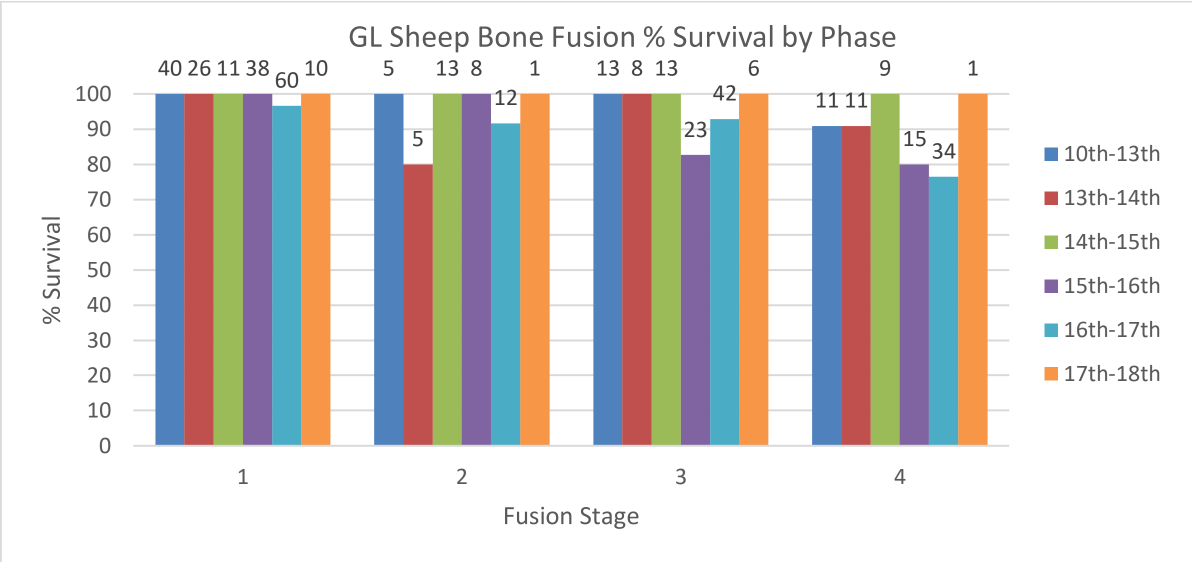

Figure 3.19: Sheep %survival by bone fusion for all phases at Great Linford. The ages for each fusion stage are as follows: Stage 1: 6-10 months, Stage 2: 13-16 months, Stage 3: 18-28 months, Stage 4: 30-42 months. The number of specimens per stage is given above the bars.

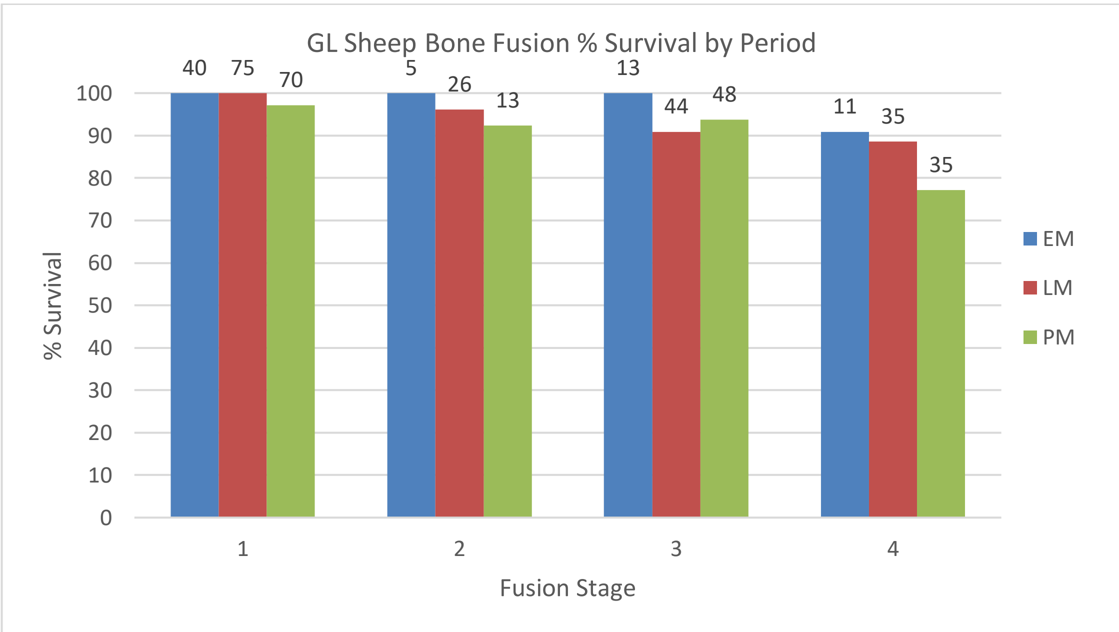

Figure 3.20: Sheep %survival by bone fusion for the three main periods at Great Linford. The ages for each fusion stage are as follows: Stage 1: 6-10 months, Stage 2: 13-16 months, Stage 3: 18-28 months, Stage 4: 30-42 months. The number of specimens per stage is given above the bars.

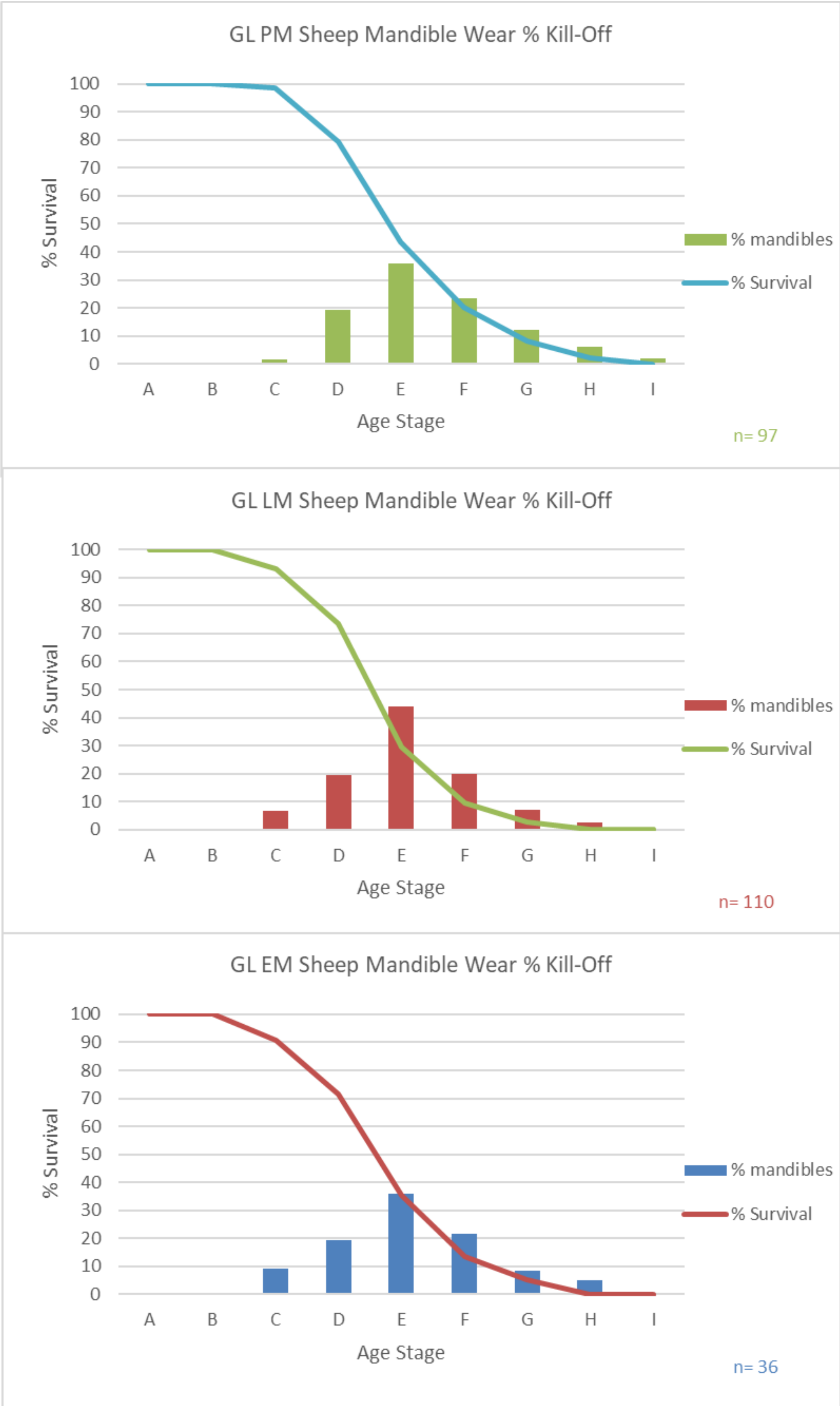

Figure 3.21: Sheep dental age profile, showing the percentage kill-off and percentage survival at each age stage for the three main periods at Great Linford.

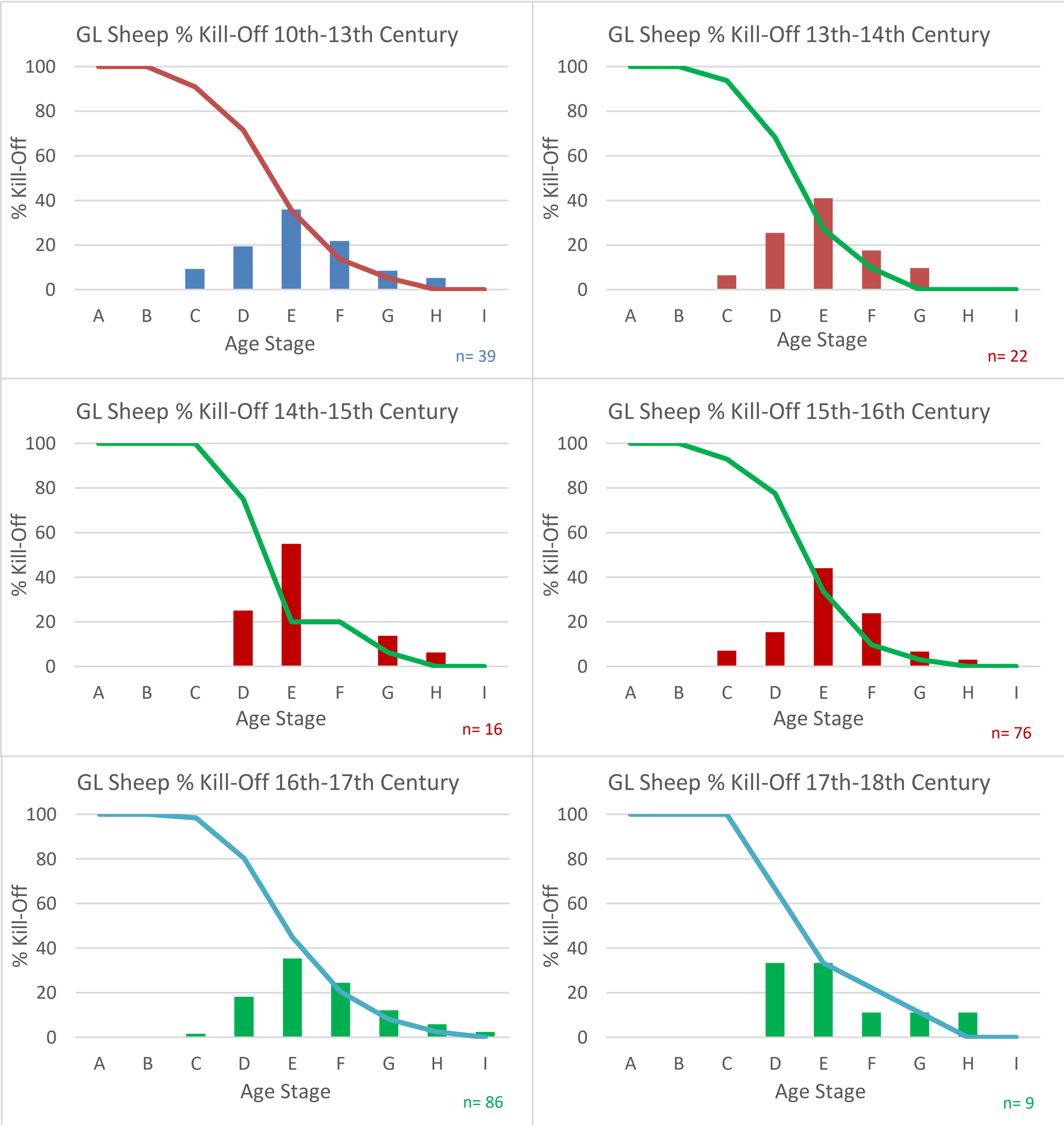

Figure 3.22: Sheep dental age profile, showing the percentage kill-off (bars) and percentage survival (lines) at each age stage for the individual phases at Great Linford.

Cattle

The assessment of cattle age using bone fusion gives a similar pattern of survival throughout all of the individual phases at Great Linford (Figure 3.23). Figure 3.24 suggests very high survival of cattle in the earlier Medieval period for the first year and a half, though the lack of unfused bones may be due to the loss of more fragile juvenile material. By 36 months survival decreased to 74 percent, and 67 percent survive past four years. This could mean that some cattle were being exploited for meat between two and three years of age at Great Linford in the earlier Medieval period, though a large proportion appear to have survived, perhaps for traction or breeding purposes. A similar pattern of mixed cattle usage is displayed in the results for the late Medieval period – cattle survival is relatively high throughout the first two stages, but decreases from 36 months. This again may suggest the exploitation of part of the herd for meat at this point. Sixty-seven percent of cattle once more survive past four years of age in the late Medieval period, suggesting their use for secondary products like traction. In the post-Medieval period cattle survival again remains above ninety percent until two years. This also suggests the exploitation of cattle around two to three years, though there is a larger survival past four years for this period, particularly in the 16^{th}-17^{th} century. This could therefore mean that in the post-Medieval period a larger proportion of cattle were kept alive for breeding or the exploitation of secondary products. Overall, the survival of cattle based on bone fusion follows a similar pattern throughout the study period at Great Linford – all phases show a larger drop in survival between two and three years, though over half of the herd survive past four years. This could indicate a continued mixed use of cattle at Great Linford, with some exploitation for meat around two years, followed by use for secondary products like traction thereafter.

The dental ageing results for cattle support this hypothesis, as throughout the study period cattle are primarily killed in the adult and elderly stages, though there is evidence for survival decrease before that (Figure 3.25). Throughout all phases, there is a lack of neonatal material, which is surprising for a rural site where livestock breeding, and therefore neonatal mortality, was likely. However, this may reflect the fragility of neonatal remains, and therefore their lack of preservation, rather than a lack of cattle breeding at Great Linford. In the earlier Medieval period, the largest proportions of cattle kill-off are in the adult and elderly stages, as around a third of the herd are killed in both (Figure 3.26). However, there is also relatively high %kill-off across the juvenile, immature and subadult stages, which may correspond with the decrease in percentage survival seen in the bone fusion results. Much like the fusion results, this pattern would suggest the use of some younger cattle for meat, whilst the remaining herd was maintained for secondary products such as traction and/or breeding. This could also be the case in the late Medieval period, as the largest proportions of cattle are again killed as adults or elderly after some small drops in survival in the three preceding stages. However, in this period, especially in the 13^{th}-14^{th} and 15^{th}-16^{th} centuries, a greater number of cattle are surviving to the elderly stage. This suggests that in the late Medieval period cattle were exploited more for secondary products, and fewer were killed for meat before adulthood. In the post-Medieval period, there appears to be a return to the pattern of the earlier Medieval, as there is a greater number of cattle being killed in the earlier stages, especially juvenile and subadult in the 16^{th}-17^{th} century. Half of the original herd are then killed as adults leaving only fifteen percent surviving to the elderly stage. This suggests that after the sixteenth century younger cattle were once again used more often for meat. However, the cattle herd profiles at Great Linford do not suggest a great emphasis on meat production in any period, meaning that the main use for cattle was likely secondary products such as traction, though perhaps with a higher turnover in the earlier and post-Medieval periods.

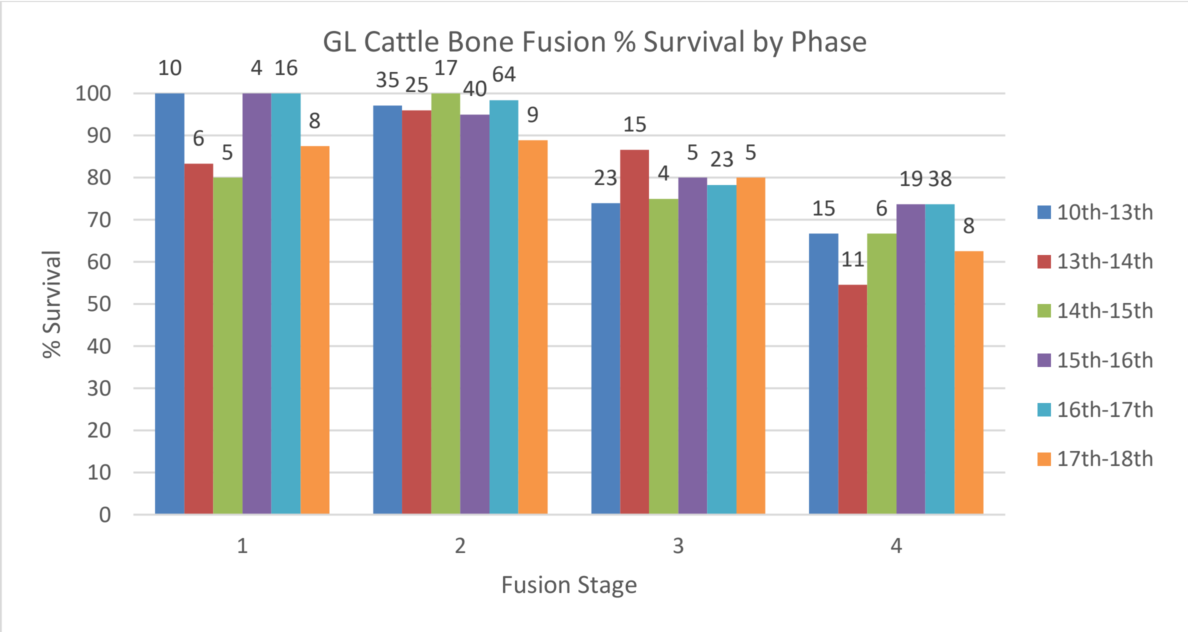

Figure 3.23: Cattle %survival by bone fusion for the individual phases at Great Linford. The ages for each fusion stage are as follows: Stage 1: 7-10 months, Stage 2: 12-18 months, Stage 3: 24-36 months, Stage 4: 36-48 months. The number of specimens per stage is given above the bars.

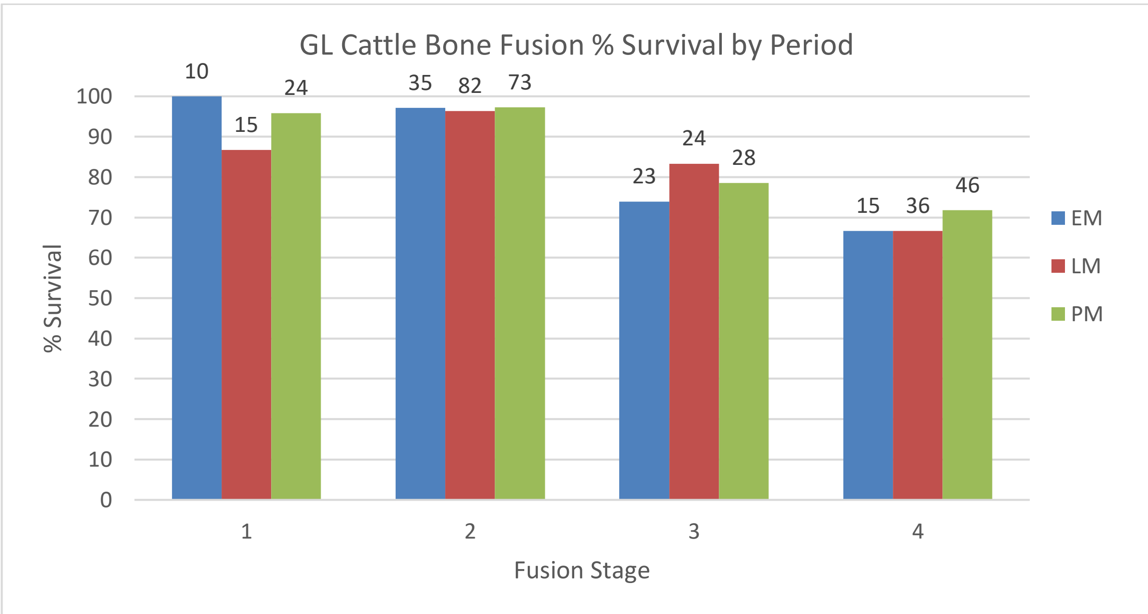

Figure 3.24: Cattle %survival by bone fusion for the three main periods at Great Linford. The ages for each fusion stage are as follows: Stage 1: 7-10 months, Stage 2: 12-18 months, Stage 3: 24-36 months, Stage 4: 36-48 months. The number of specimens per stage is given above the bars.

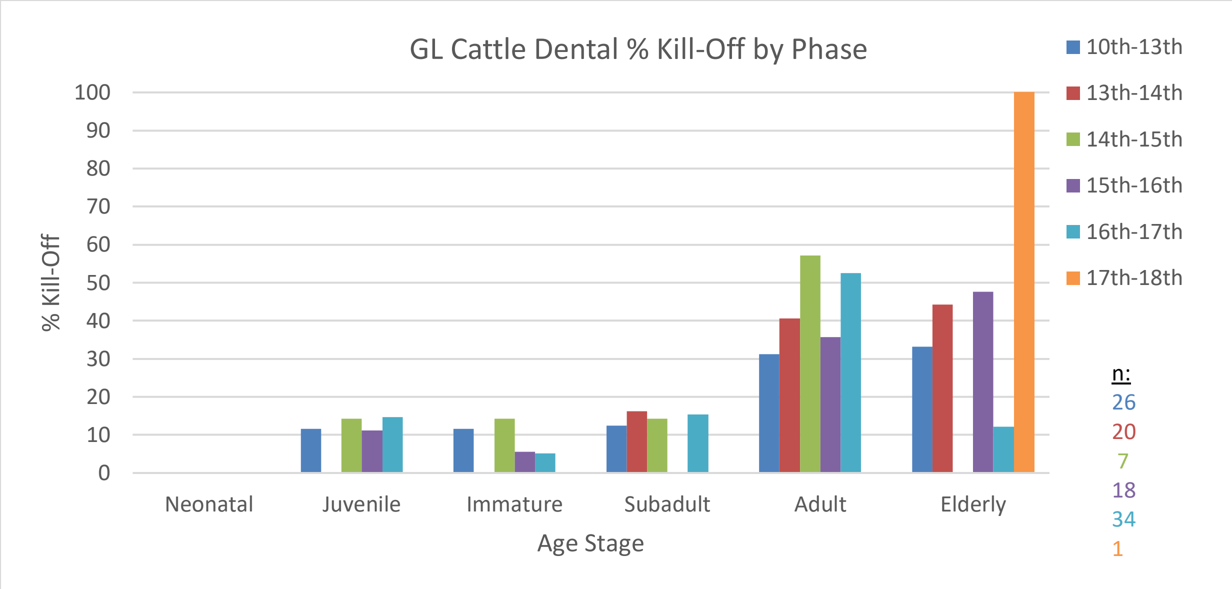

Figure 3.25: Cattle dental age profile, showing the percentage kill-off at each age stage for the individual phases at Great Linford.

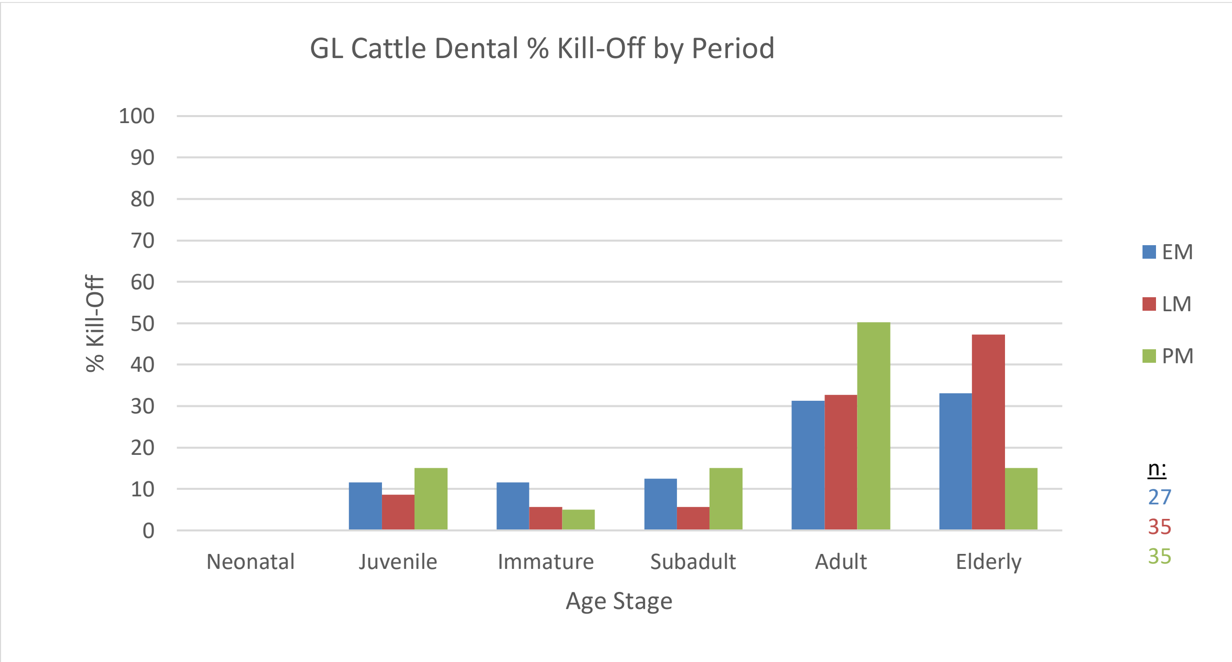

Figure 3.26: Cattle dental age profile, showing the percentage kill-off at each age stage for the three main periods at Great Linford.

Pig

Fusion ageing results for pig show that survival is relatively high up to one year of age throughout the whole study period at Great Linford, and is above eighty percent in all three broad chronological periods (Figures 3.27 and 3.28). Between fourteen and eighteen months there is a large decrease in survival in all phases. This kill-off pattern is indicative of the use of pigs for meat between fourteen and eighteen months, followed by the maintenance of breeding individuals past 42 months. There is a similar pattern in the late Medieval period, though survival at eighteen months is higher than in the previous period, particularly in the 13th-15th century. In contrast to the earlier Medieval period, there is a slight increase in pig survival in the post-Medieval period, which may be either due to an introduction of older animals to the site, or the result of the small sample size. The %survival at stage two is lowest in the post-Medieval period, suggesting a more intensive exploitation of pigs for meat in this period. However, at stage three survival increases to 56 percent, potentially reflecting the introduction of older pigs on to the site at this time. Overall, fusion ageing results suggest the use of pigs for meat between fourteen and eighteen months from the tenth to the eighteenth century.

Dental ageing for pigs at Great Linford somewhat reflects this pattern of kill-off by eighteen months (Figures 3.29 and 3.30). Once again, in all periods there are no neonatal pig dental remains – considering the lack of neonatal material for all species, this is likely caused by these smaller, more fragile remains being overlooked. In the earlier Medieval period, the majority of pig kill-off occurs in the subadult and adult stages, with only a fourteen percent drop in survival in the preceding two stages. This suggests that a large amount of pig slaughter, most likely for meat, occurred around one-and-a-half to two years, in the subadult phase. While this correlates with the survival decrease seen in the stage two for fusion ageing, it may suggest that the kill-off of pigs occurred in the latter end of the stage, closer to eighteen months. The ageing results also show a high kill-off in the adult stage in the earlier Medieval period, resulting in the total absence of elderly individuals. This may reflect the kill-off of adult pigs after they were no longer suitable for breeding. The dental ageing results are very similar for the late Medieval period, as the majority of pig kill-off is spread across the subadult and adult stages, with a shift towards more adults by the 15th-16th century. Furthermore, there is little change in herd profiles between the late and post-Medieval periods – the pattern of subadult and adult kill-off is still evident, with more adult animals in the 17th-18th century. Overall, pig dental ageing suggests that a relatively large number of animals were surviving into the subadult and adult stages at Great Linford throughout the study period. This is comparatively late for the exploitation of meat, which might mean that younger individuals were being sent elsewhere to be slaughtered, and the remains here represent meat consumption on the site after use for breeding.

Albarella (2005, 141) suggests that it was predominantly young males not required for breeding which were sold to urban centres for meat, causing a higher representation of females on rural sites like Great Linford. However, at Great Linford canine teeth indicate that males outnumbered females by a ratio of 3:2 in the earlier medieval period, 9:2 in the late Medieval period, and 6:1 in the post-Medieval, suggesting a predominance of males on the site. However, this is based on a relatively small sample size of under fifteen specimens from each period, and loose male canines tend to be more readily recovered than female, making this conclusion questionable.

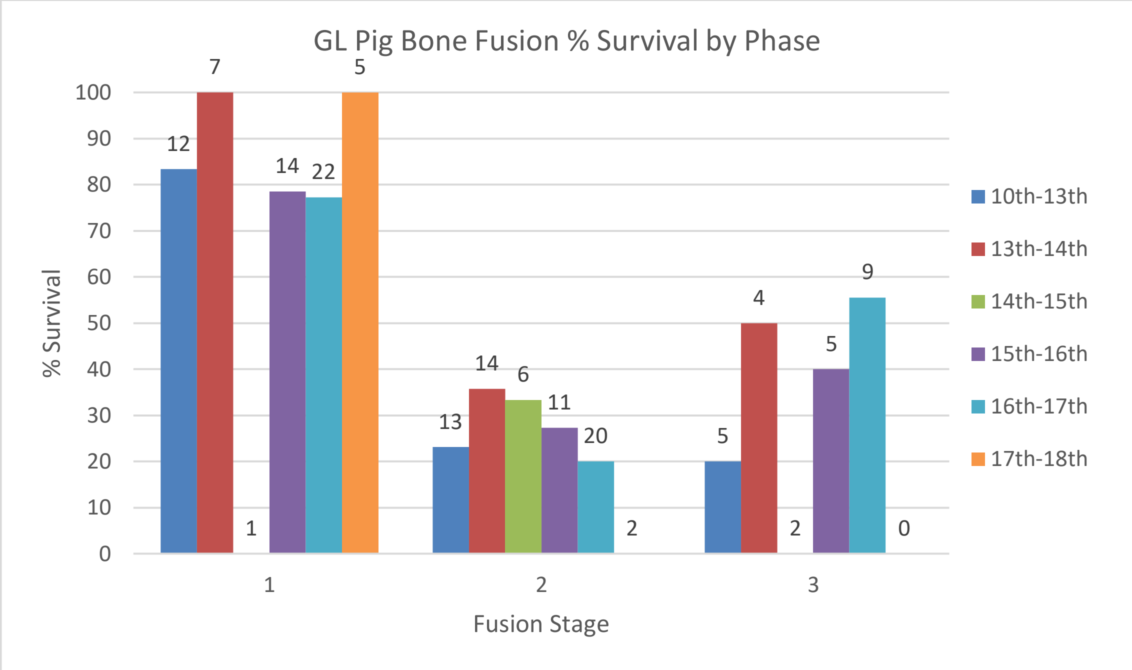

Figure 3.27: Pig %survival by bone fusion for the individual phases at Great Linford. The ages for each fusion stage are as follows: Stage 1: 6-12 months, Stage 2: 14-18 months, Stage 3: 30-42 months. The number of specimens per stage is given above the bars.

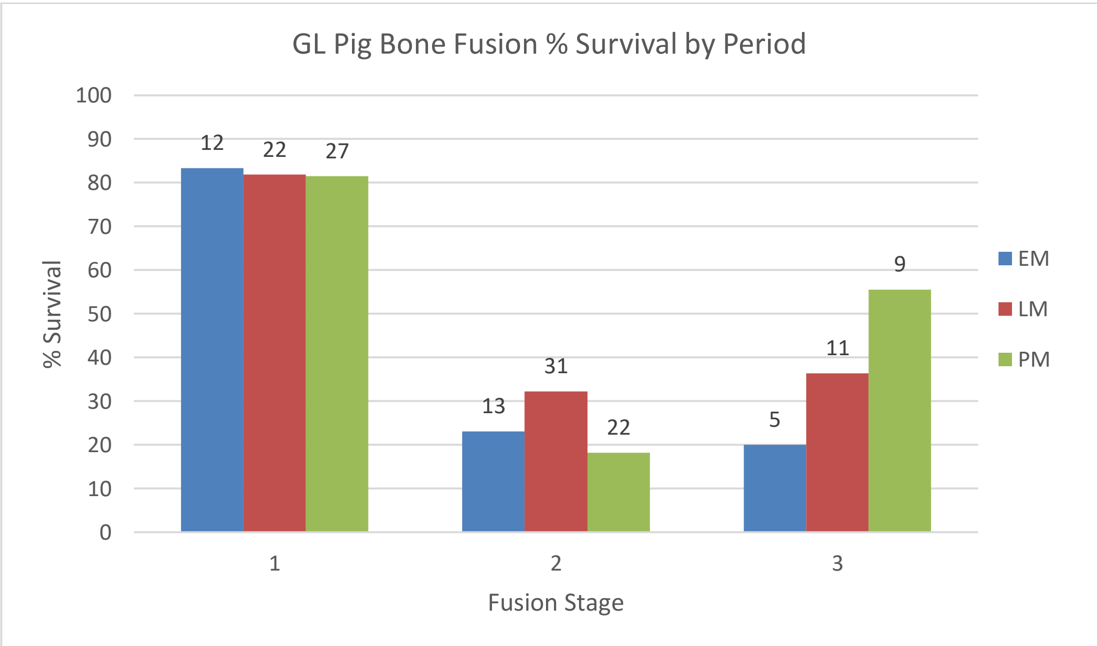

Figure 3.28: Pig %survival by bone fusion for the three main periods at Great Linford. The ages for each fusion stage are as follows: Stage 1: 6-12 months, Stage 2: 14-18 months, Stage 3: 30-42 months. The number of specimens per stage is given above the bars.

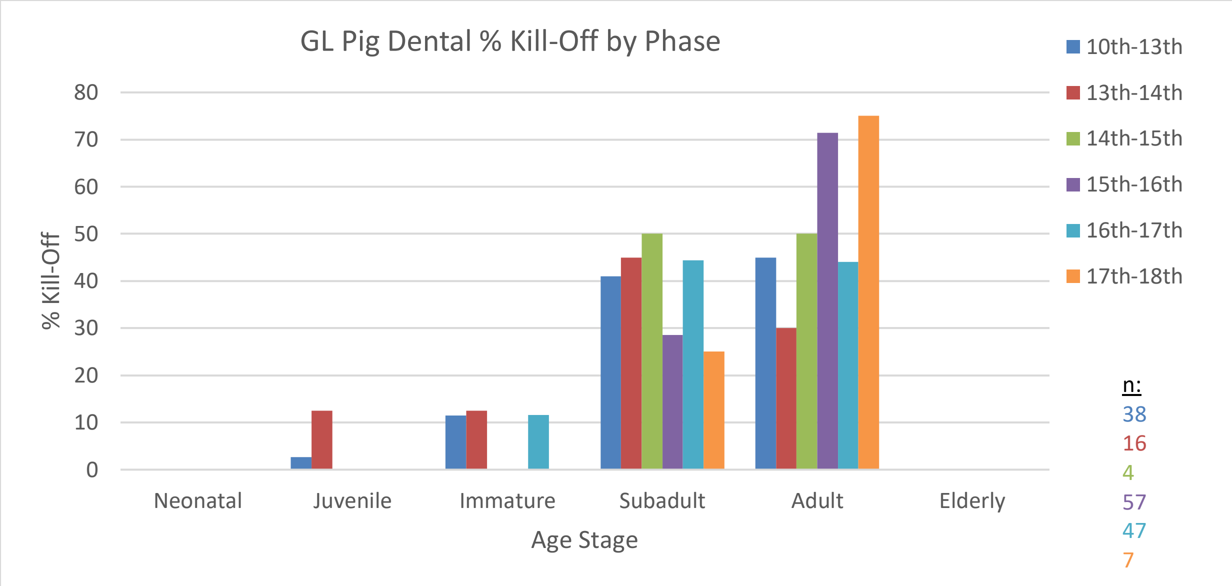

Figure 3.29: Pig dental age profile, showing the percentage kill-off at each age stage for the individual phases at Great Linford.

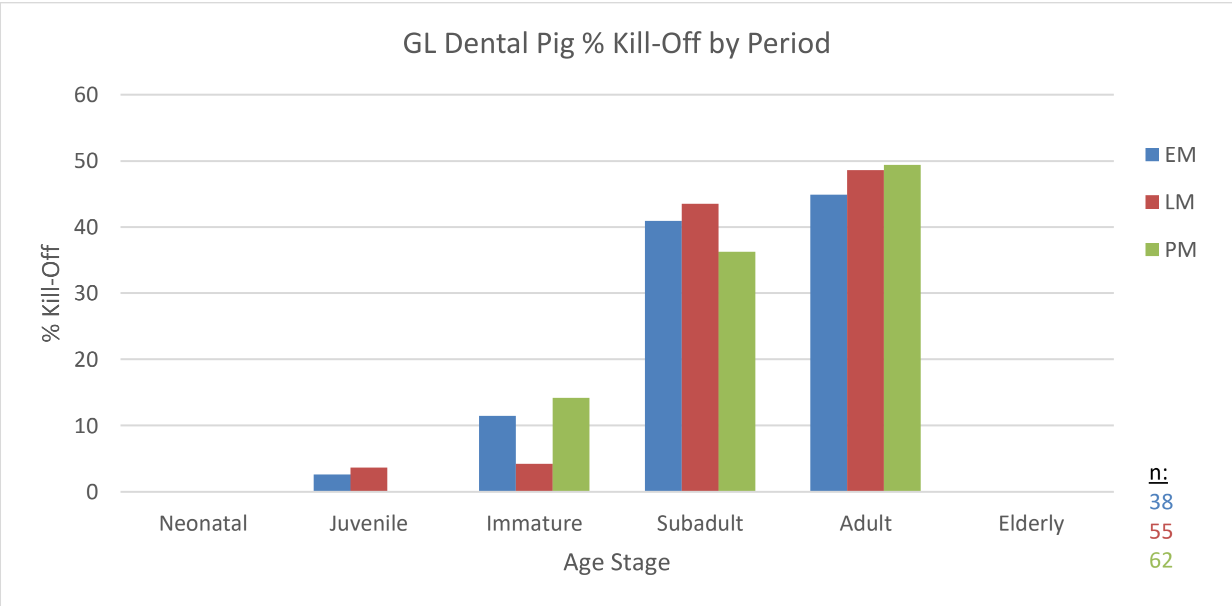

Figure 3.30: Pig dental age profile, showing the percentage kill-off at each age stage for the three main periods at Great Linford.

Horse

Due to a small sample size, horse age at Great Linford was estimated using the percentage of fused and unfused elements (Figures 3.31 and 3.32). Across the entire study period, fused bones are much more common than unfused, suggesting a predominance of adult animals. In the earlier Medieval period, unfused specimens make up only four percent of the assemblage. This increases slightly to five percent in the late Medieval period, though there were no unfused bones recovered from the 14th-15th century. Finally, the horse material in the post-Medieval period solely comprises fused specimens. This suggests that throughout all three phases at Great Linford there was a high survival of horses into adulthood, most likely for use in transport or traction. There does not appear to be any significant change in this pattern through time.

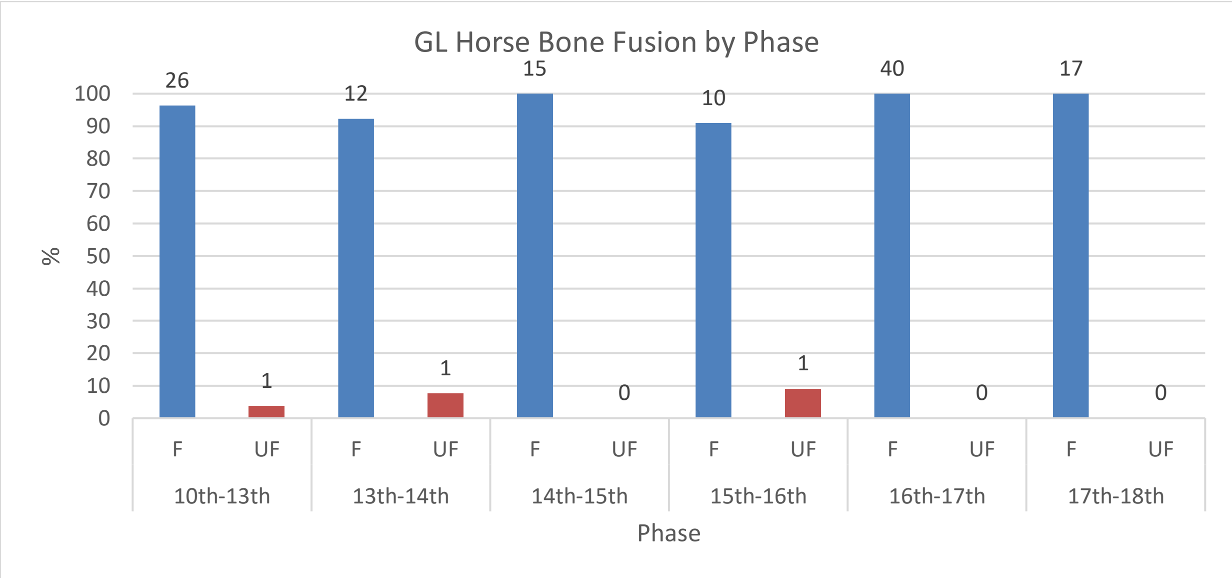

Figure 3.31: The proportion of fused and unfused horse bones from all phases at Great Linford. The numbers above the bars give the actual number of specimens.

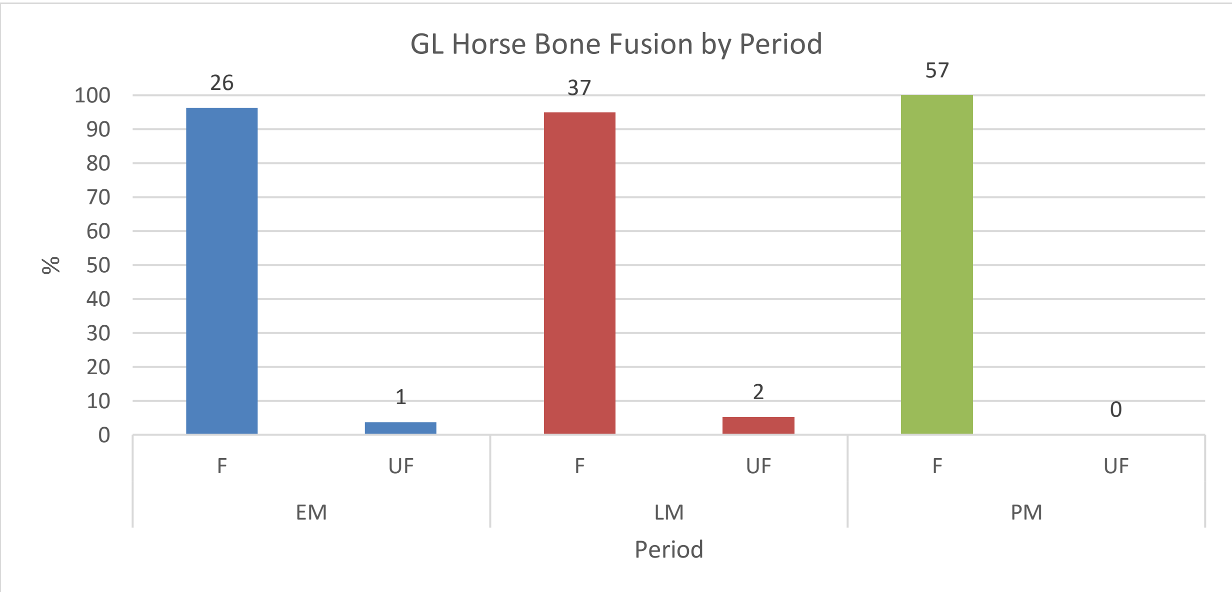

Figure 3.32: The proportion of fused and unfused horse bones from all periods at Great Linford. The numbers above the bars give the actual number of specimens.

3.2.7 Metric Results

An overview of the metric information for each species can be found in Appendices 9 to 12.

Sheep

A relatively large sample size for sheep from Great Linford has allowed the comparison of metric data from across all of the chronological phases of the site, as well as the evaluation of general trends between the earlier, late and post-Medieval periods. Tooth size has primarily been assessed by comparing mandibular third molar width measurements from all phases (Figure 3.33). The mean values and distribution for each phase are very similar, with no clear shift in any direction. Furthermore, sheep teeth are seemingly smaller in the final phase, but the small sample size makes this unreliable and therefore not representative of the size of sheep teeth in the 17th-18th century. Overall the size of sheep teeth appears to be largely constant from the tenth to the eighteenth century, with very little change. This is supported by the t-test results, as there is no significant difference between the means of any chronological phases (see Table 3.4). Similar results are shown for the sheep M_3 width across the three broad periods at Great Linford (Figure 3.34). Once again, t-test values show no significant change in mean values between the three periods. Overall, these results show that sheep tooth width did not vary significantly at Great Linford throughout the study period.

Potential changes in sheep post-cranial dimensions were investigated through the comparison of astragalus and distal humerus and tibia measurements across the earlier, late, and post-Medieval periods. The elements were selected due to their relatively large sample size, though there was not a large enough number of specimens in each phase to investigate in more chronological depth. The astragalus measurements largely overlap for all periods, and there was not a large enough sample size to distinguish any clear pattern (Figure 3.35). The post-Medieval measurements for the distal humerus are smaller than the late Medieval ones, though for this element they are similar in distribution to the earlier Medieval results (Figure 3.36). This post-Medieval decrease in humerus size is highlighted by the t-test results for individual elements, as it is the only element to exhibit a significant change between the late and post-Medieval phases (Table 3.5). This significant decrease is shown for BT, Bd, and HTC ($P<0.01$), suggesting a marked decrease in overall humerus size. However, this element is sex-dependent, meaning that a decrease in size could indicate the presence of more females in the post-Medieval period rather than smaller animals (Payne and Bull 1988; Davis 2000). The tibia measurements show a large overlap in measurements from all periods, accompanied by two much larger late Medieval examples (Figure 3.37) – this may represent the presence of some larger individuals in the late Medieval period. Overall, these post-cranial results suggest no clear chronological trend in sheep size at Great Linford, with small sample sizes hindering a more detailed assessment.

In order to mitigate the effect of small sample size, log-ratio analysis has been conducted for post-cranial sheep elements. This method allows for the combination of different measurements on the same axis, thus increasing the available sample size and allowing for the comparison of measurements across all phases at the site. Post-cranial length measurements show a considerable increase in size between the 10th-13th and 13th-14th centuries (Figure 3.38), followed by a decrease into the 14th-15th century. t-test results indicate that both of these changes are statistically significant ($P<0.01$) (Table 3.6), suggesting a marked increase in sheep bone length in the 13th-14th century. There is a subsequent increase in element length in the 15th-16th century, though to a slightly lesser extent than previously ($P<0.05$). This points towards greater post-cranial bone length again during this phase, followed by a gradual decrease in the following phases. Overall, the largest sheep post-cranial bone measurements are found in the 13^{th}-14^{th} and 15^{th}-16^{th} centuries – this contributes to the significant increase in length between the general earlier and late Medieval phases ($P<0.05$) (Figure 3.39). Furthermore, the gradual decrease in size from the 16^{th}-17^{th} century onwards is reflected in the smaller post-Medieval values, which exhibit a significant decrease from the late Medieval length results ($P<0.05$). The increased post-cranial length in the late Medieval period may represent a higher proportion of wethers in the sheep population, as castration delays epiphyseal fusion, resulting in the increased length of long bones (Davis 2000). This may reflect the increasing demand for wool, as castrates were favoured for wool production due to a finer fleece (Kiley 1976).

These changes are not reflected in the log ratio width results for sheep (Figure 3.40). The mean values across all phases are very similar for width values, with only a slight decrease in the 14^{th}-15^{th} century, which may mirror the smaller length values in this phase but is not statistically significant (Table 3.7). As a result, there is minimal change in mean values across all three broad chronological periods (Figure 3.41). Post-cranial depth measurements also show little variation throughout the chronological study period (Figure 3.42). Comparison across all phases shows a small decrease in the mean in the 13^{th}-14^{th} century, but this result is not statistically significant (Table 3.8). From the 14^{th}-15^{th} century onwards, however, the mean depth result remains similar, suggesting consistent sheep bone depths throughout much of the late Medieval period, and into the post-Medieval. This is also shown across the three broad periods, where there is only a slight increase from the earlier to the late Medieval period (Figure 3.43). Overall, the log ratio results for sheep suggest that the only marked change throughout the study period occurred in post-cranial bone lengths, which display an increase in size during the late Medieval period, especially during the 13^{th}-14^{th} and 15^{th}-16^{th} centuries. This may reflect a greater number of castrated animals, likely used for wool as the demand for wool increased in the late Medieval period.

The final data assessed for sheep is the coefficient of variation (CV) for post-cranial and tooth measurements for the individual phases and broad periods (Table 3.9). While sex ratios, castration status and nutrition can increase variation, factors like change in breed or the presence of multiple breeds typically cause much greater variation (Popkin et al 2012, 1789-90). At Great Linford, the post-cranial CVs of sheep are relatively low throughout the first three phases, ranging from 2.6 to 4.3. This is reflected in in the low CV value of 2.4 for the earlier Medieval period, suggesting homogeneity within the herd. However, from the 15^{th}-16^{th} century onwards post-cranial CV values are larger. As a result, the late Medieval CV rises to 6.7, and in the post-Medieval period reaches 7.7, which suggests increasing variation in the flock, starting in the late Medieval period. Coefficient of variation values are higher for teeth throughout the entire study period; however, they also exhibit an increase from the 15^{th}-16^{th} century onwards, causing the late Medieval and post-Medieval values to be greater than the earlier Medieval. Increased CV values in the latest Medieval phases and post-Medieval period reflect the results of Popkin et al (2012), suggesting greater heterogeneity of the herd at Great Linford towards the end of the late Medieval period. This may suggest that, despite a lack of particularly striking changes at this point in the metric results, a change in herd management or introduction of a different breed on the site increased the variation of sheep on the site. It could be that this increased variation in sheep during the late Medieval period reflects the increasing length of long bones, suggesting the presence of a different breed with longer limbs. Again, it may also reflect the presence of a larger proportion of castrated animals, likely kept for wool production as demand rose.

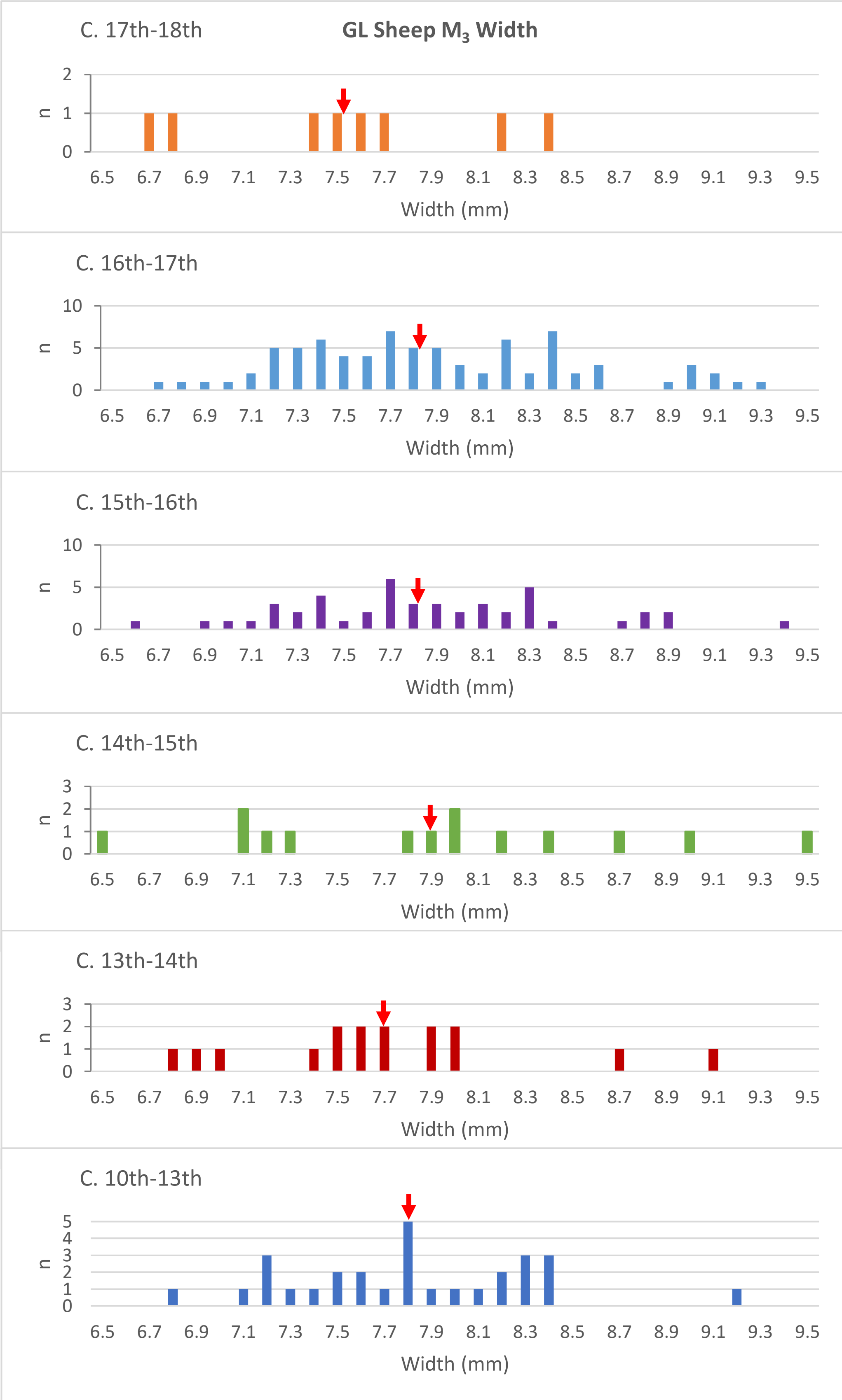

Figure 3.33: Histograms plotting width measurements of sheep mandibular third molar by phase at Great Linford. The red arrows indicate the position of the mean.

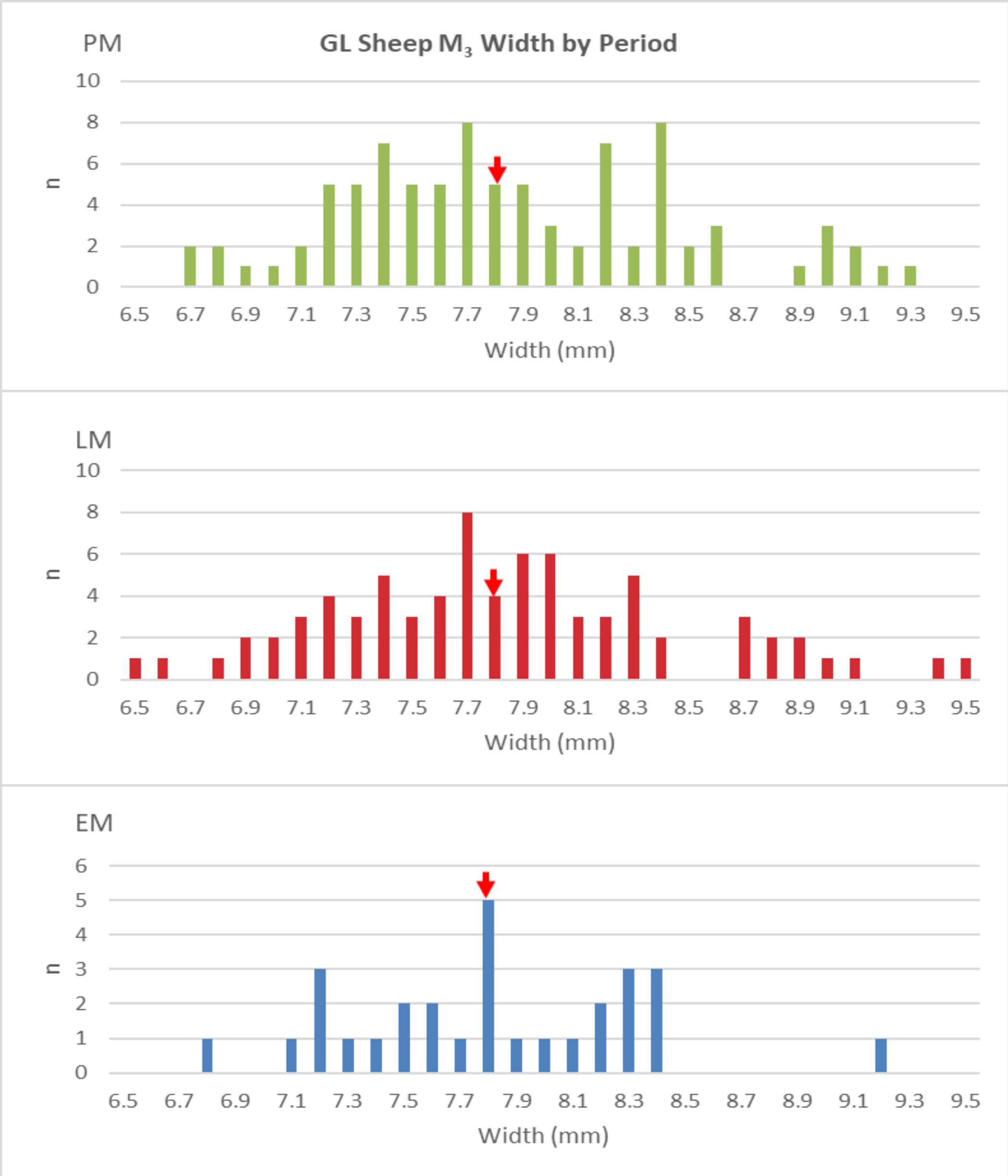

Figure 3.34: Histograms plotting width measurements of sheep mandibular third molar by period at Great Linford. The red arrows indicate the position of the mean.

Table 3.4: Statistical test results for Great Linford mandibular third sheep molar width by phases and periods.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	-0.645	0.525	P> 0.05
13th-14th vs. 14th-15th	0.316	0.755	P> 0.05
14th-15th vs. 15th-16th	0.192	0.850	P> 0.05
15th-16th vs. 16th-17th	-0.294	0.769	P> 0.05
16th-17th vs. 17th-18th	1.612	0.141	P> 0.05
Period:			
EM vs. LM	0.141	0.888	P> 0.05
LM vs. PM	-0.244	0.807	P> 0.05

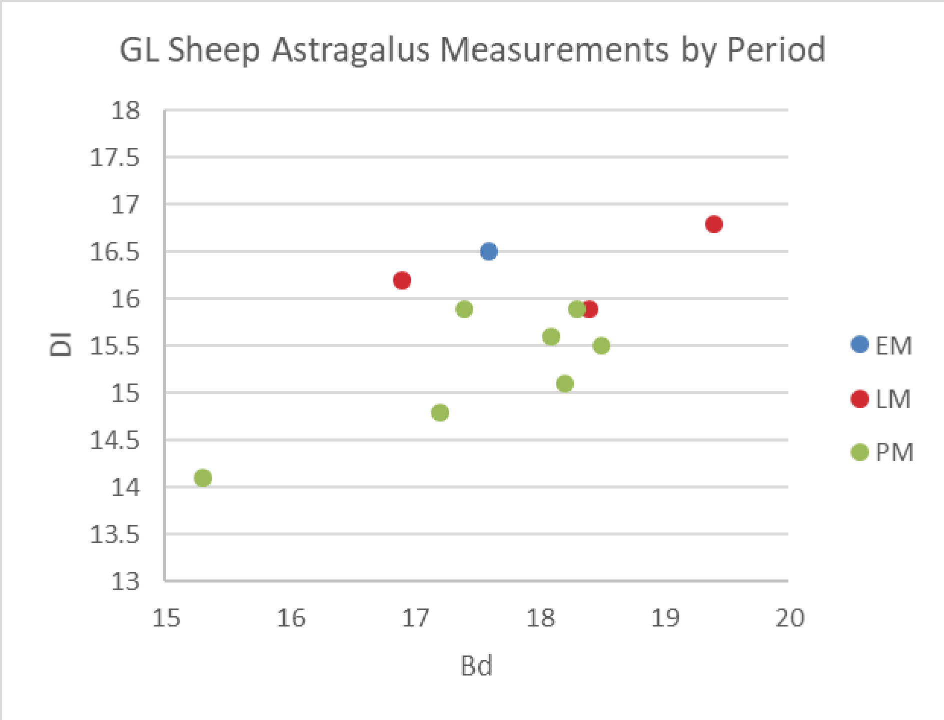

Figure 3.35: Comparison of astragalus measurements for sheep by period at Great Linford.

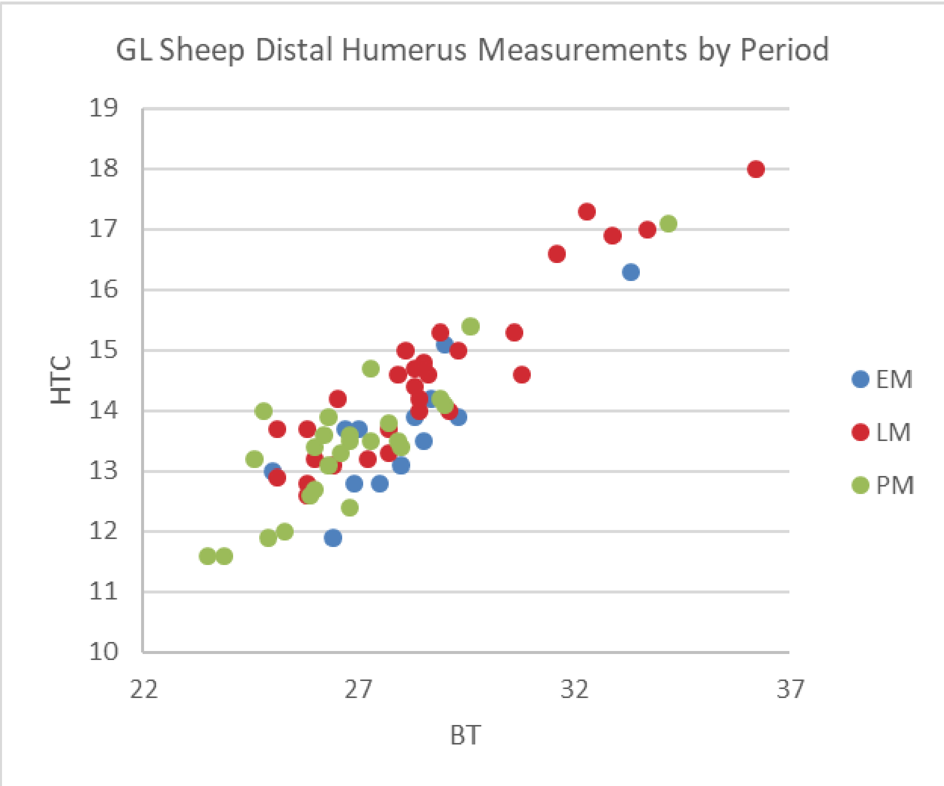

Figure 3.36: Comparison of distal humerus measurements for sheep by period at Great Linford.

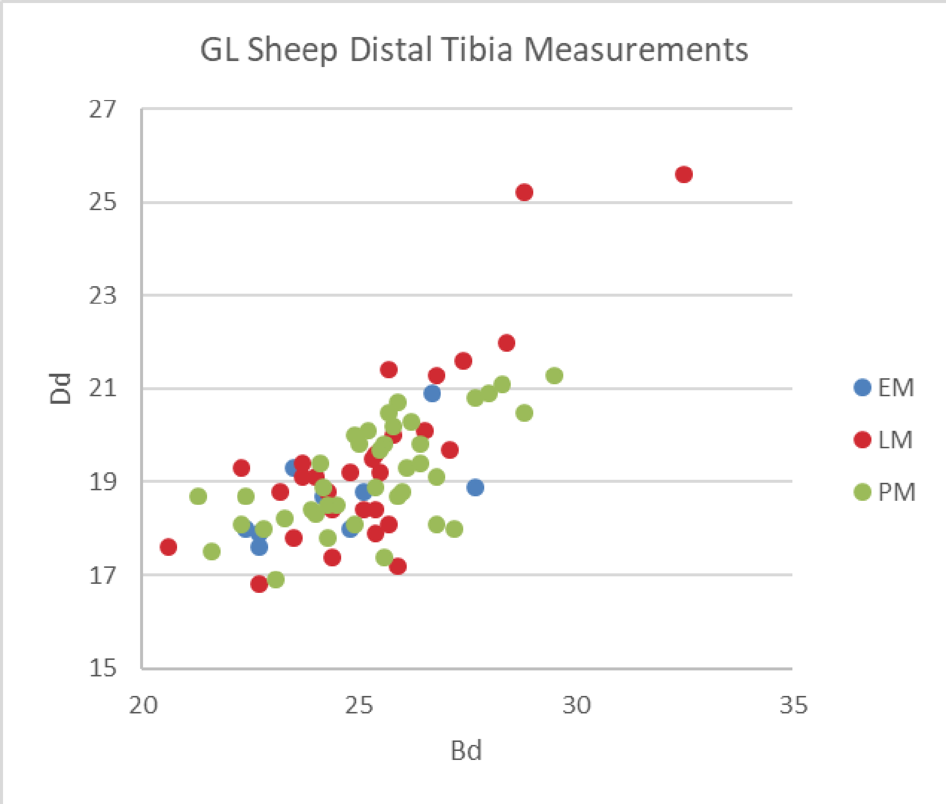

Figure 3.37: Comparison of distal tibia measurements for sheep by period at Great Linford.

Table 3.5: Statistical test results for individual sheep bone measurements between the periods at Great Linford. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t stat/ U-value**	**P value**	**Significance**	**t stat/U-value**	**P value**	**Significance**
dP_4 W	N/A	N/A	N/A	-2.011	0.054	P>0.05
M_1 W	-0.942	0.351	P>0.05	620	0.350	P>0.05
M_2 W	-0.227	0.821	P>0.05	1.134	0.261	P>0.05
M_3 L	0.231	0.818	P>0.05	1.072	0.303	P>0.05
M_3 W	-0.142	0.888	P>0.05	-0.607	0.807	P>0.05
Humerus BT	176	0.520	P>0.05	607	0.003	P<0.01
Humerus Bd	235	0.210	P>0.05	561	0.006	P<0.01
Humerus HTC	286	0.030	P<0.05	628	0.001	P<0.01
Radius Bp	1.651	0.114	P>0.05	N/A	N/A	N/A
Tibia Bd	N/A	N/A	N/A	0.210	0.835	P>0.05
Tibia Dd	N/A	N/A	N/A	609	0.729	P>0.05

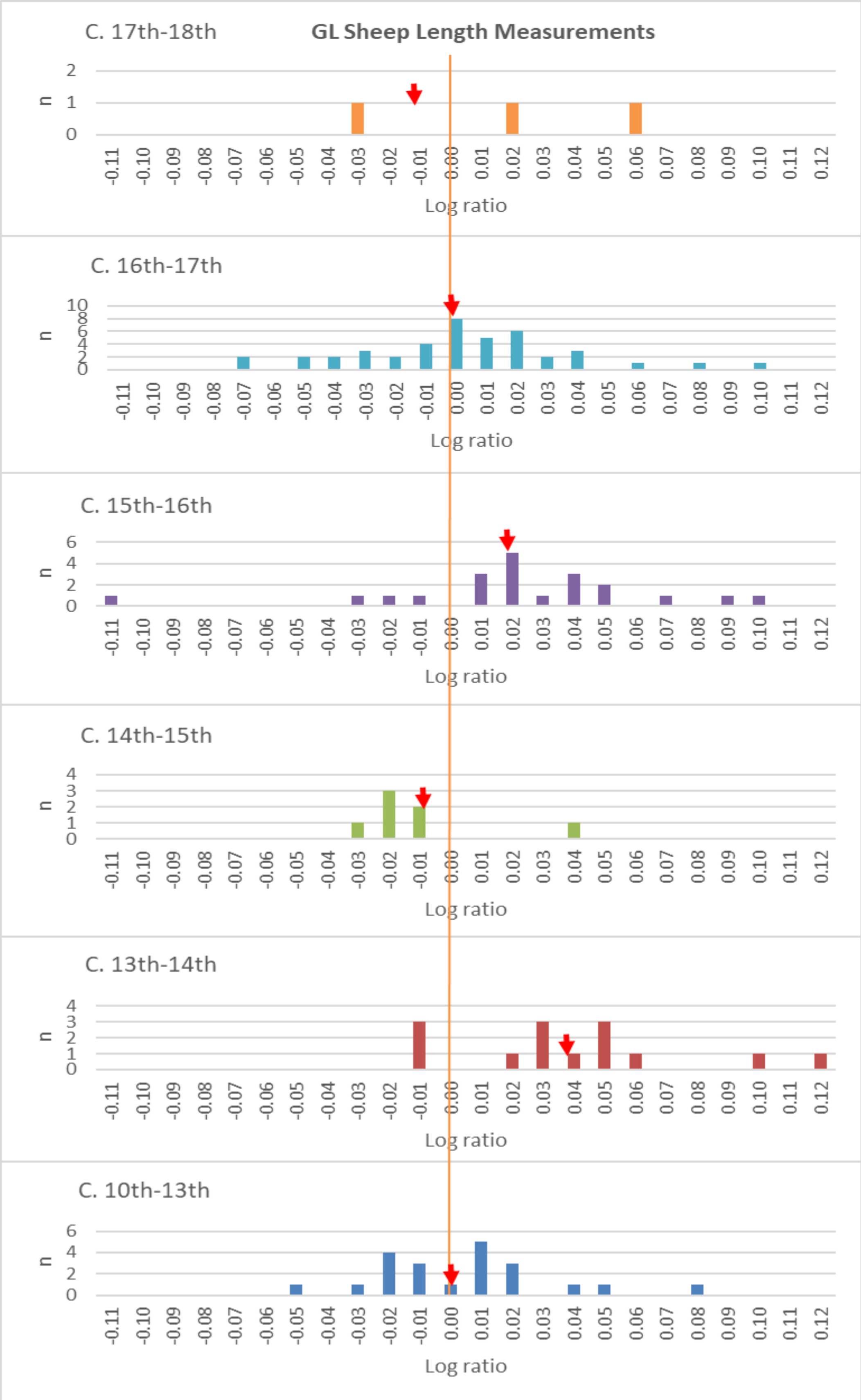

Figure 3.38: Log ratio histograms combining sheep post-cranial bone length measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

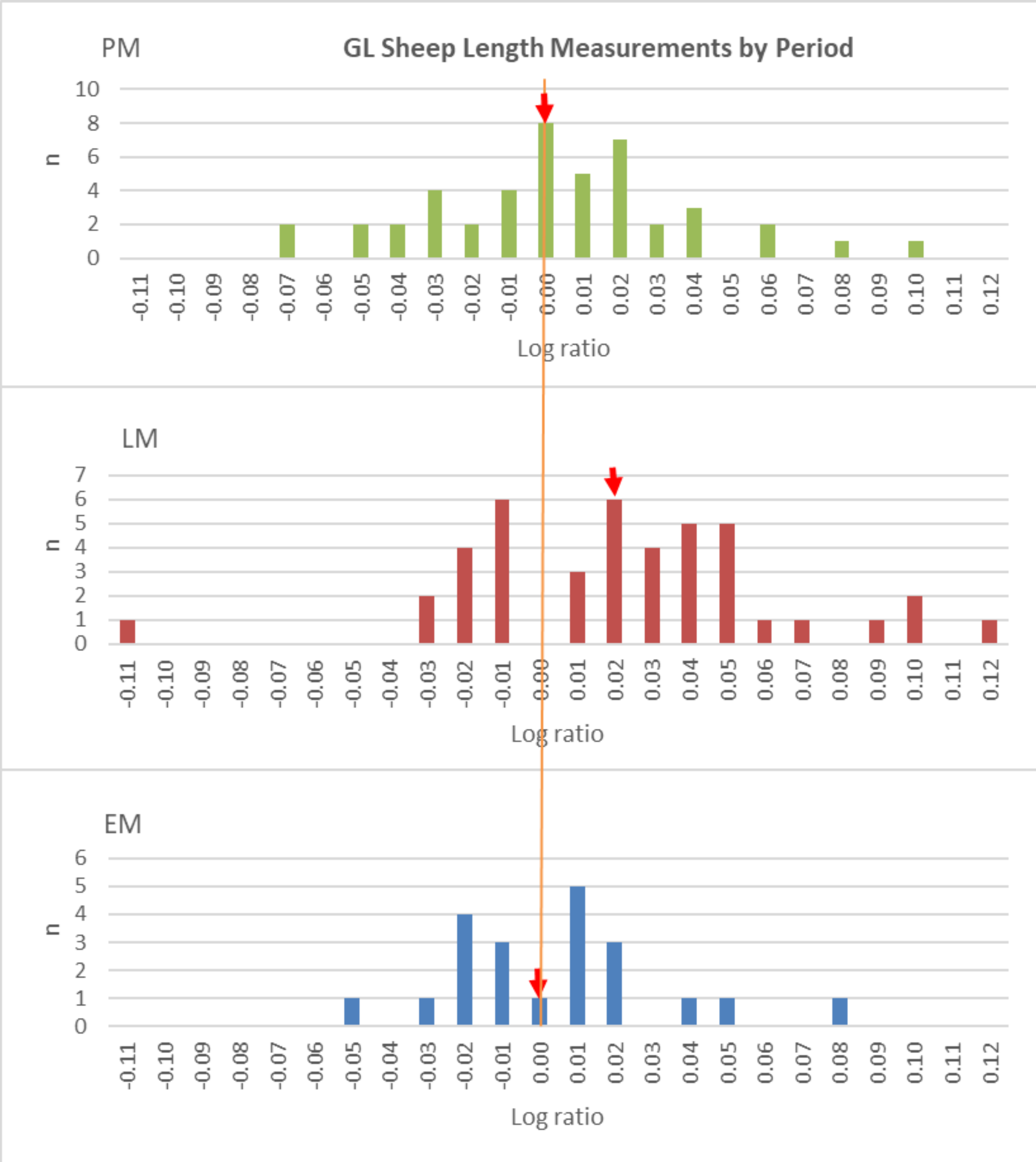

Figure 3.39: Log ratio histograms combining sheep post-cranial bone length measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.6: Statistical test results for the post-cranial log ratio length values for sheep by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	3.062	0.006	P<0.01
13th-14th vs. 14th-15th	89	0.002	P<0.01
14th-15th vs. 15th-16th	118	0.016	P<0.05
15th-16th vs. 16th-17th	1.683	0.102	P>0.05
16th-17th vs. 17th-18th	-0.421	0.715	P>0.05
Period			
EM vs. LM	2.051	0.045	P<0.05
LM vs. PM	2.326	0.022	P<0.05

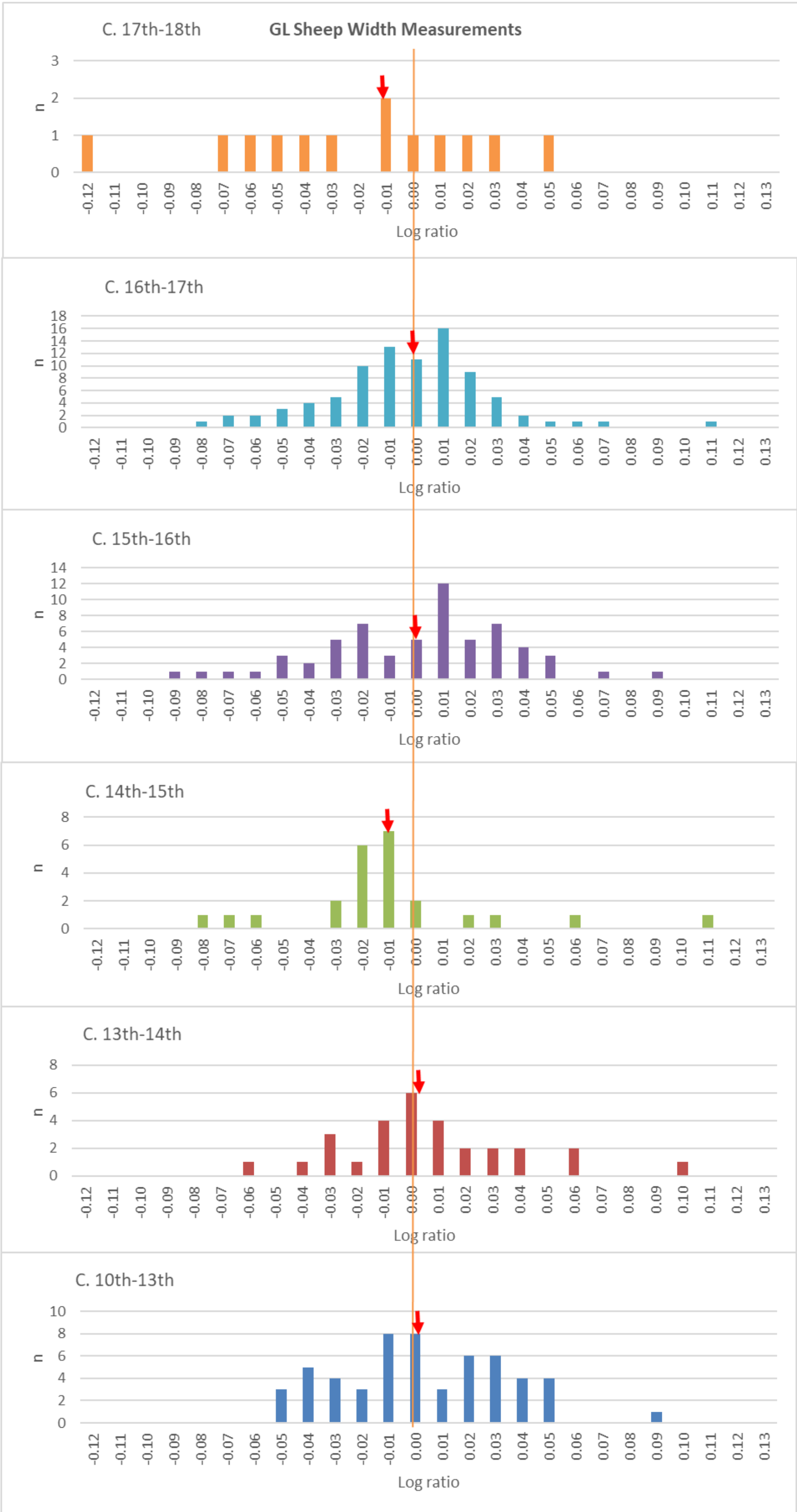

Figure 3.40: Log ratio histograms combining sheep post-cranial bone width measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

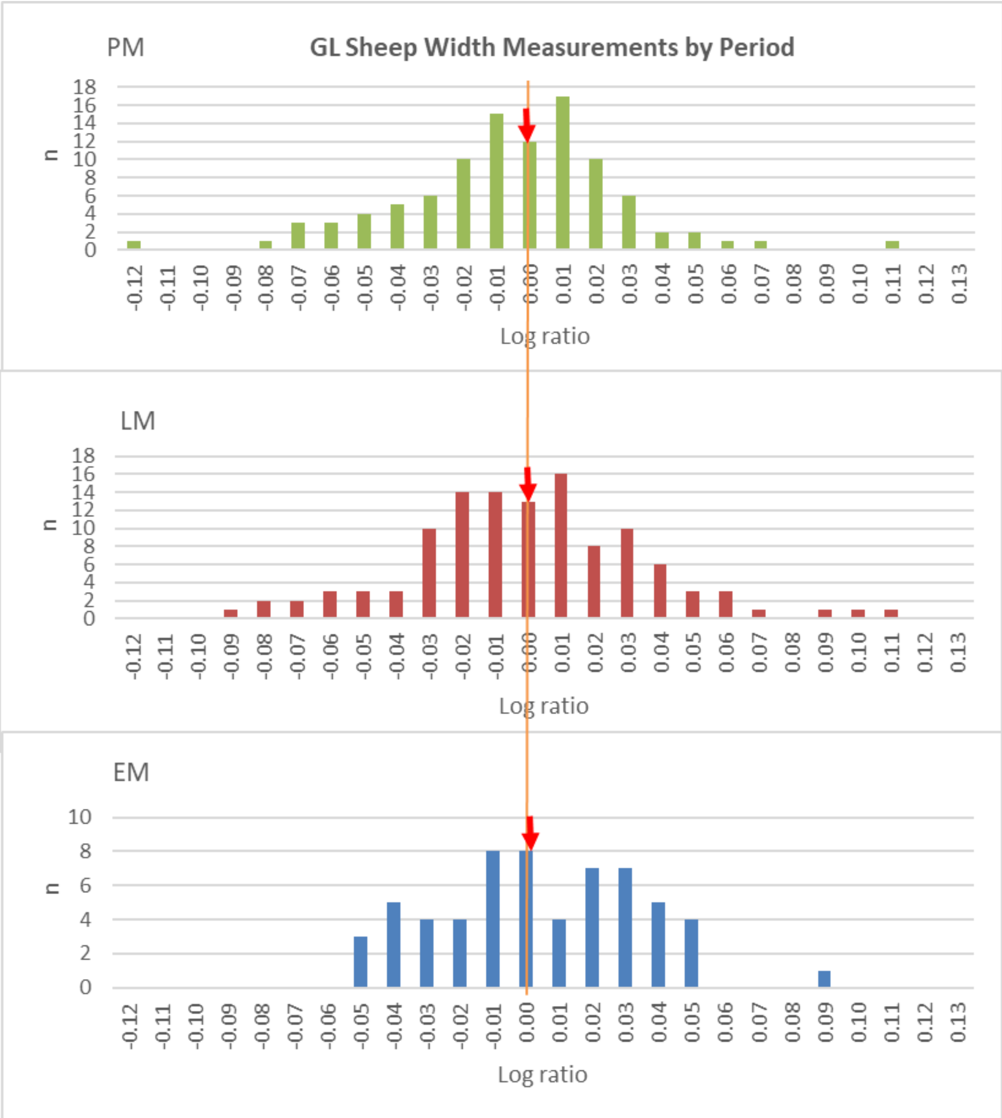

Figure 3.41: Log ratio histograms combining sheep post-cranial bone width measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.7: Statistical test results for the post-cranial log ratio width values for sheep by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	0.288	0.577	P>0.05
13th-14th vs. 14th-15th	468	0.008	P<0.01
14th-15th vs. 15th-16th	446	0.026	P<0.05
15th-16th vs. 16th-17th	0.855	0.394	P>0.05
16th-17th vs. 17th-18th	1.192	0.253	P>0.05
Period:			
EM vs. LM	0.201	0.841	P>0.05
LM vs. PM	1.070	0.286	P>0.05

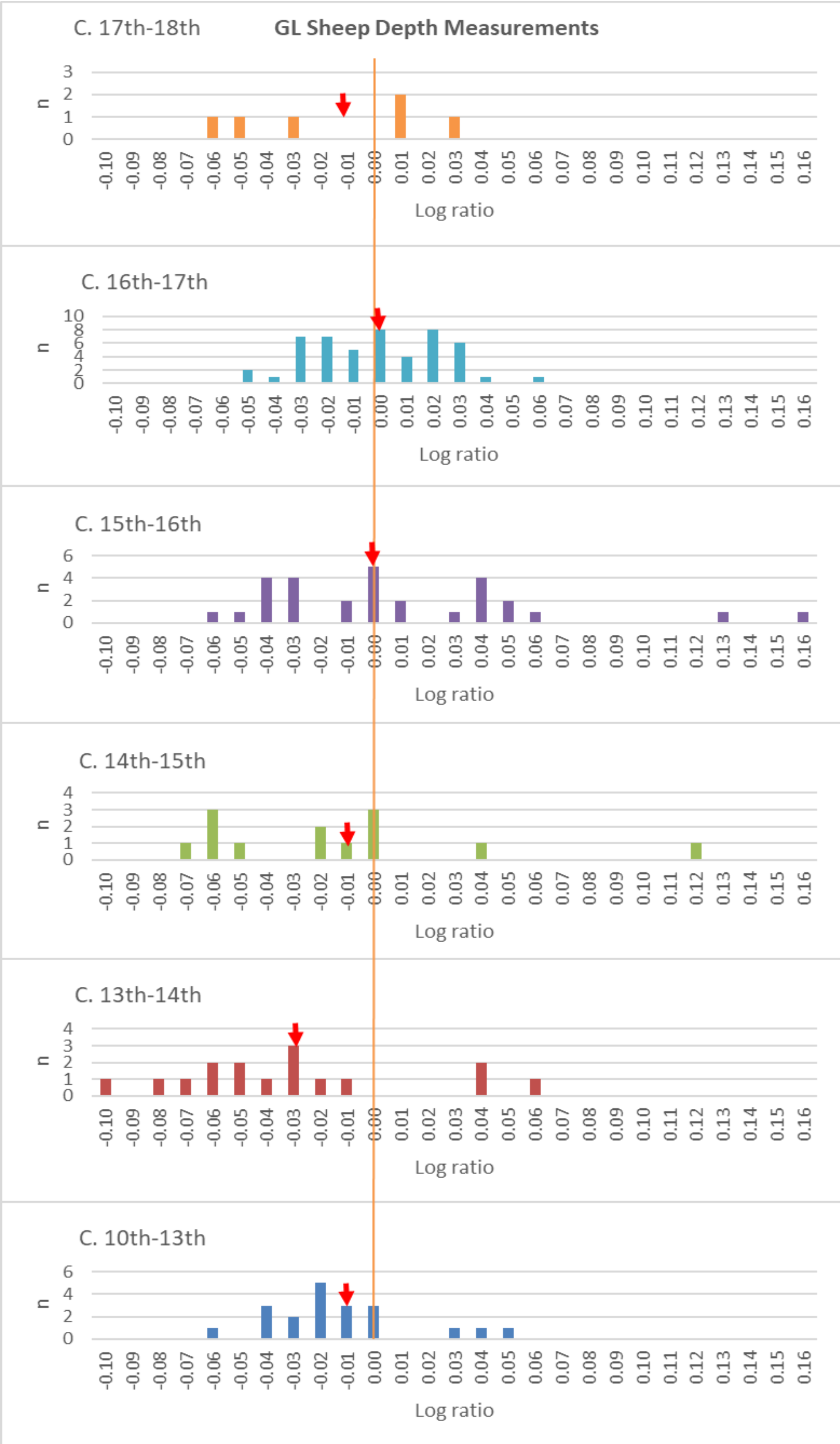

Figure 3.42: Log ratio histograms combining sheep post-cranial bone depth measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

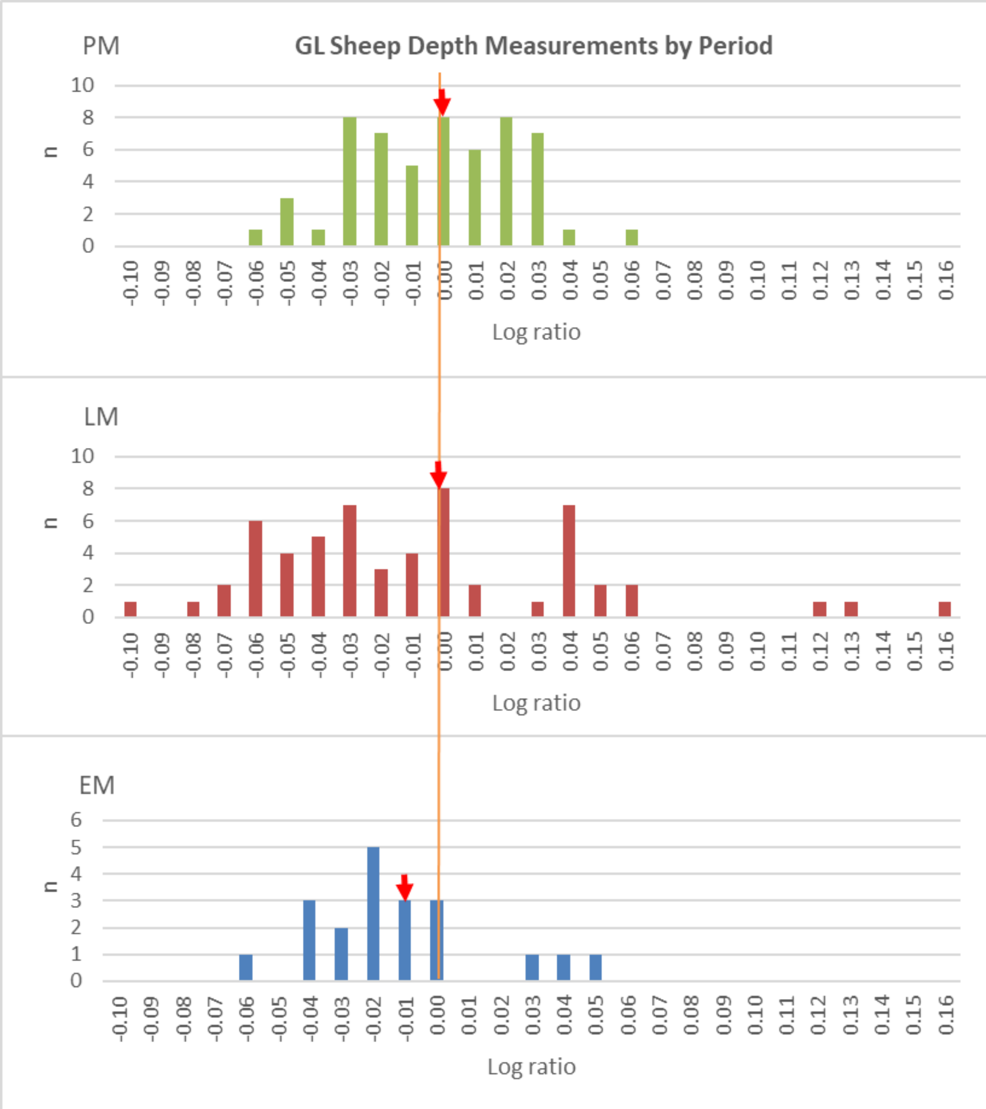

Figure 3.43: Log ratio histograms combining sheep post-cranial bone depth measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.8: Statistical test results for the post-cranial log ratio depth values for sheep by phases and periods at Great Linford.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 13th-14th	-1.345	0.192	P>0.05
13th-14th vs. 14th-15th	0.890	0.382	P>0.05
14th-15th vs. 15th-16th	133	0.131	P>0.05
15th-16th vs. 16th-17th	761	0.722	P>0.05
16th-17th vs. 17th-18th	-0.894	0.412	P>0.05
Period:			
EM vs. LM	666	0.789	P>0.05
LM vs. PM	1542	0.189	P>0.05

Table 3.9: Coefficient of variation values for sheep teeth and post-cranial elements across both the individual phases and broad periods at Great Linford.

Phase	**Post-cranial**	**Teeth**
10th-13th	2.6	6.2
13th-14th	4.3	6.7
14th-15th	3.0	6.9
15th-16th	8.3	7.3
16th-17th	7.6	7.2
17th-18th	6.4	7.0
Period		
EM	2.4	6.2
LM	6.7	7.0
PM	7.7	7.5

Cattle

The size of cattle at Great Linford across the study period was also initially assessed using third mandibular molar width, though a smaller sample size meant that only the broad periods could be evaluated (Figure 3.44). The mean tooth widths across all periods are not statistically different (Table 3.10) – this suggests that cattle tooth width remained largely constant from the tenth to the eighteenth century at Great Linford. The assessment of post-cranial size change was carried out using measurements from the distal humerus (Figure 3.45), and distal tibia (Figure 3.46) across the three broad phases. The distal humerus results suggest some larger dimensions in terms of BT and HTC in the late Medieval period compared to the previous period. The shift in BT size is significant ($P<0.05$) (Table 3.11), suggesting an increase in the late Medieval period. Post-Medieval humerus measurements are comparable in size to the preceding period, which could suggest a continuation of cattle size. As with sheep, it should be noted that distal humerus dimensions are relatively sex-dependent, meaning that the increase in size in the late Medieval period could represent an increase in male animals, rather than an overall increase in cattle size (Payne and Bull 1988). Finally, cattle distal tibia metrics show a reversal of this pattern, with slightly larger earlier Medieval Bd and Dd values than in the late and post-Medieval periods. Overall, it appears that there is not a definitive shift in cattle size between the periods shown by these post-cranial measurements.

Post-cranial cattle measurements were grouped by anatomical plane, and compared to a standard measurement using the log ratio method. Bone length sample sizes for each phase were not large enough to distinguish a chronological trend. Across the three broad periods there is a slight increase in the mean from the earlier to the late Medieval period (Figure 3.47). However, this change is not significant, suggesting a general consistency of cattle post-cranial bone length throughout the study period (Table 3.12). A similar pattern is exhibited by the post-cranial width log ratio results for cattle, though the peak in size occurs in the 15th-16th century (Figure 3.48). Otherwise, the mean width values are very similar across all phases, which is supported by the lack of significant mean value change between the phases, suggesting similar cattle bone width throughout the study period (Table 3.13). Similarly, there appears to be little change in size between the three broad periods (Figure 3.49) – the late Medieval mean is slightly larger than the other periods, but again this is not a statistically significant change. These results therefore suggest that there was little overall change in the width of cattle post-cranial bones from tenth to the eighteenth century at Great Linford. The assessment of depth log ratio values for cattle by phase also shows a slight increase through the fourteenth to sixteenth centuries (Figure 3.50). This is then followed by a decrease in size in the 16th-17th century, and a subsequent return to a larger average value in the final phase. This may suggest that the largest post-cranial bone depths were found towards the end of the late Medieval period, and again in the 17th-18th century at Great Linford. However, the differences in the mean values across all phases are not statistically significant, reducing the degree of reliability of this result (Table 3.14). Furthermore, there is no statistically significant difference between the mean depth log ratio values across the earlier, late and post-Medieval periods (Figure 3.51). Overall, this suggests that, while there may be a slight increase in the 15th-16th century, cattle post-cranial depth was relatively constant throughout the study period.

The coefficient of variation was assessed for cattle teeth and post-cranial bones for the individual phases and broad periods (Table 3.15), in order to assess whether any alteration in variation might be the result of changing sex ratios and nutrition, or a change of breed on site. Despite a relative lack of metric change, variation in cattle at Great Linford appears to be very high throughout the study period, with the lower CV values actually occurring in the post-Medieval period for both teeth and post-cranial elements. This could suggest that already by the tenth century, multiple breeds of cattle were present on the site, and the herd became more homogenous by the final period. However, these very large CV results, especially in the 14th-15th century, may be a result of relatively small sample sizes, over-emphasising any particularly large or small individuals.

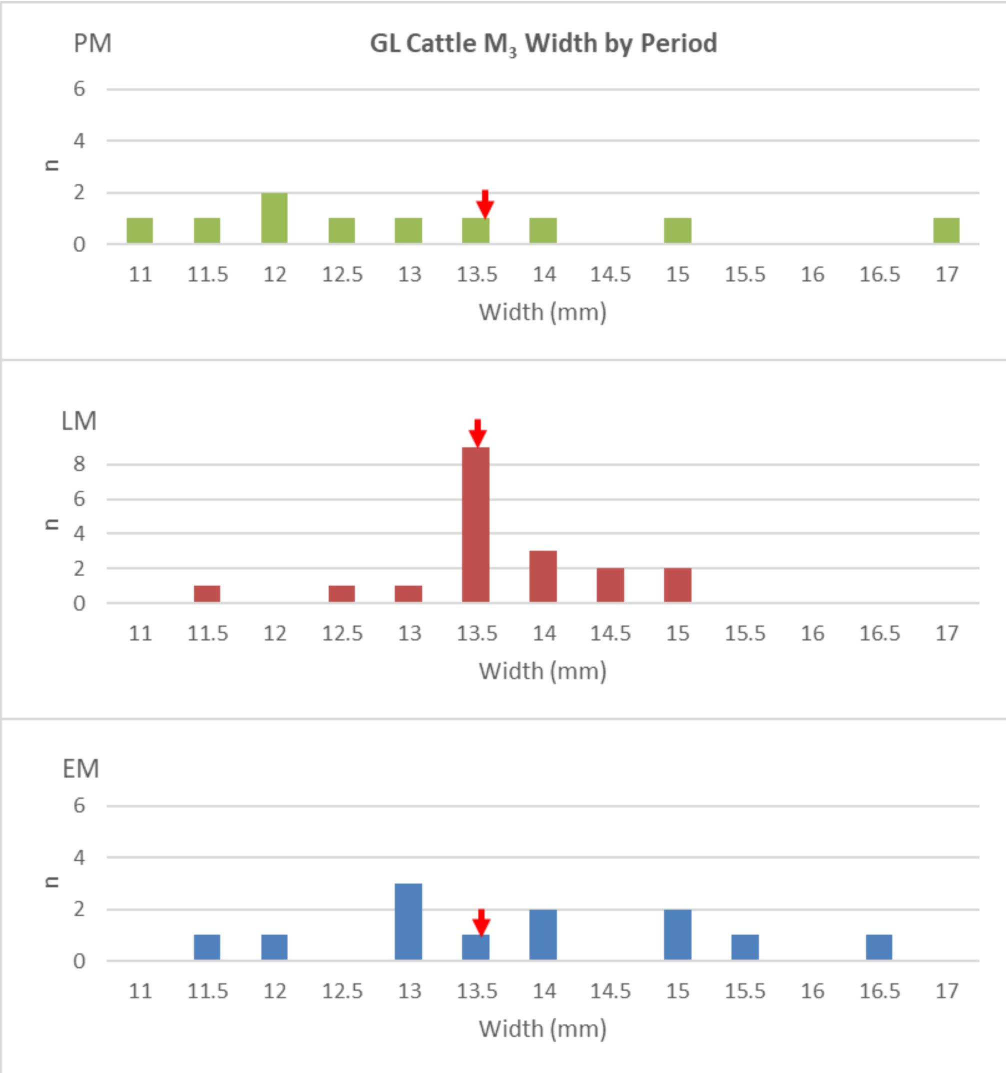

Figure 3.44: Histograms plotting width measurements of cattle lower third molar by period at Great Linford. The red arrows indicate the position of the mean.

Table 3.10: Statistical test results for the mandibular third cattle molar width by period at Great Linford.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	0.007	0.994	P> 0.05
LM vs. PM	0.182	0.857	P> 0.05

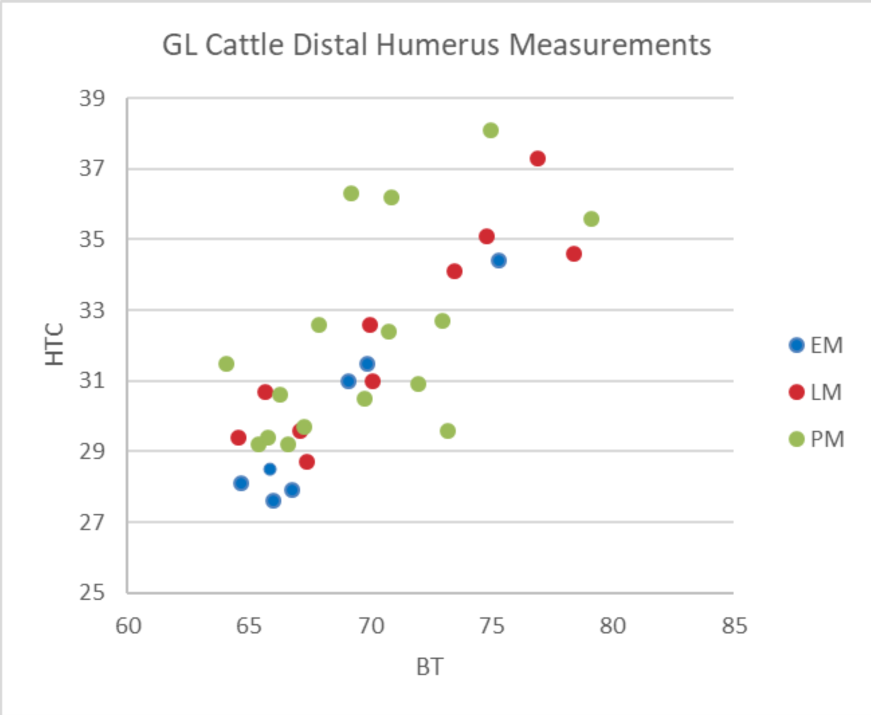

Figure 3.45: Comparison of distal humerus measurements for cattle by period at Great Linford.

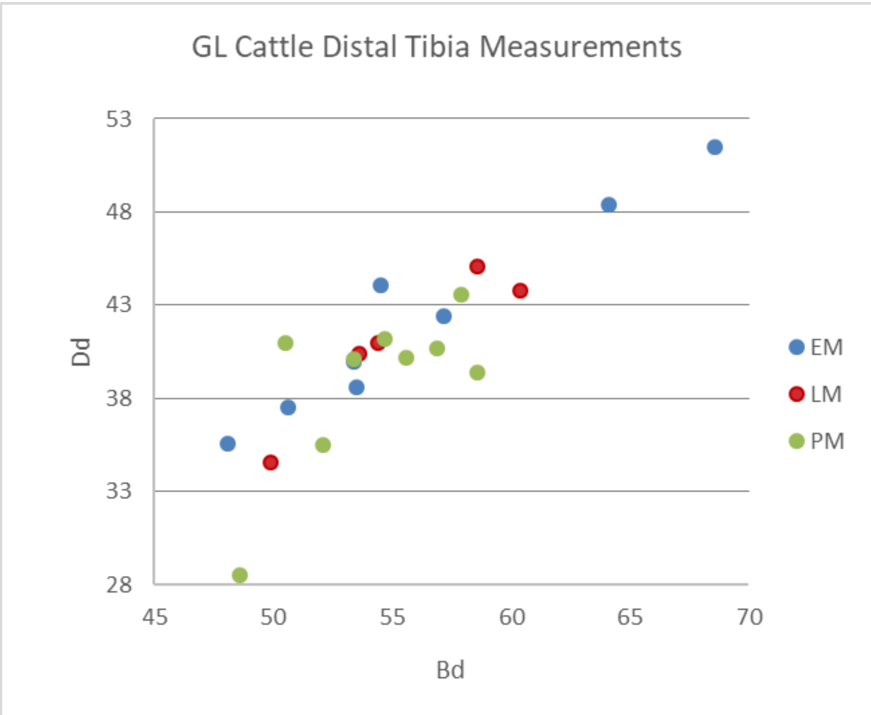

Figure 3.46: Comparison of distal tibia measurements for cattle by period at Great Linford.

Table 3.11: Statistical test results for individual cattle bone measurements between the periods at Great Linford. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t stat/ U-value**	**P Value**	**Significance**	**t stat/ U-value**	**P Value**	**Significance**
dP_4 W	0.082	0.937	P> 0.05	0.267	0.795	P> 0.05
M_2 W	0.251	0.806	P> 0.05	N/A	N/A	N/A
M_3 L	0.710	0.486	P> 0.05	1.754	0.090	P> 0.05
M_3 W	0.007	0.994	P> 0.05	0.182	0.857	P> 0.05
Scapula SLC	N/A	N/A	N/A	-1.102	0.307	P> 0.05
Humerus BT	1.274	0.222	P> 0.05	0.589	0.563	P> 0.05
Humerus HTC	2.035	0.063	P> 0.05	0.119	0.906	P> 0.05
Metacarpal Bd	-0.333	0.747	P> 0.05	0.139	0.892	P> 0.05
Metacarpal BatF	0.734	0.484	P> 0.05	0.378	0.710	P> 0.05
Metacarpal a	18	0.328	P> 0.05	23	0.408	P> 0.05
Metacarpal b	0.457	0.661	P> 0.05	0.433	0.673	P> 0.05
Metacarpal 3	-1.989	0.070	P> 0.05	0.452	0.659	P> 0.05
Tibia Bd	0.216	0.832	P> 0.05	1.014	0.334	P> 0.05
Tibia Dd	0.630	0.540	P> 0.05	-1.086	0.299	P> 0.05
Astragalus GLl	N/A	N/A	N/A	-0.095	0.928	P> 0.05
Astragalus Bd	N/A	N/A	N/A	0.619	0.556	P> 0.05
Astragalus Dd	N/A	N/A	N/A	0.348	0.737	P> 0.05

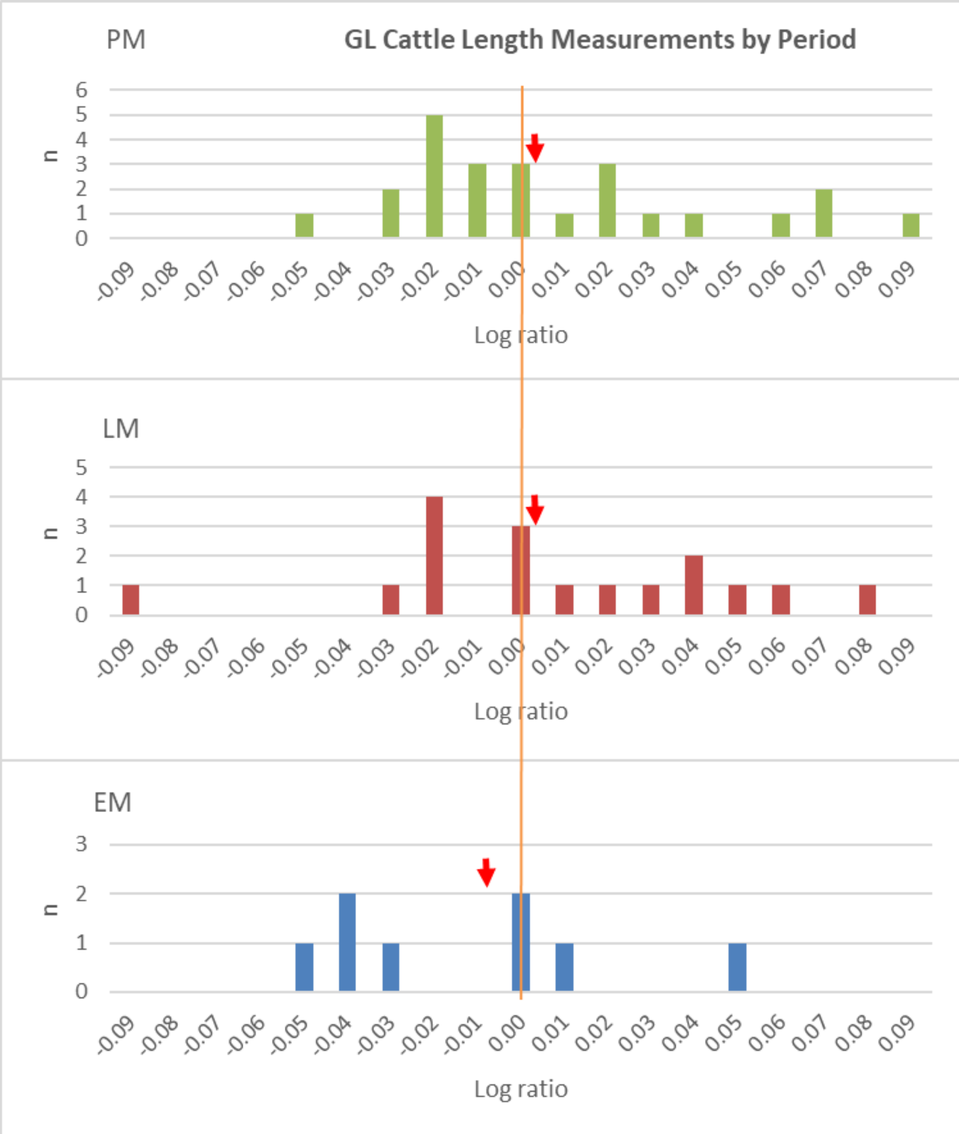

Figure 3.47: Log ratio histograms combining cattle post-cranial bone length measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.12: Statistical test results for the post-cranial log ratio length values for cattle by phases and periods at Great Linford.

Period:	t stat/ U-value	P value	Significance
EM vs. LM	1.396	0.181	P> 0.05
LM vs. PM	0.018	0.985	P> 0.05

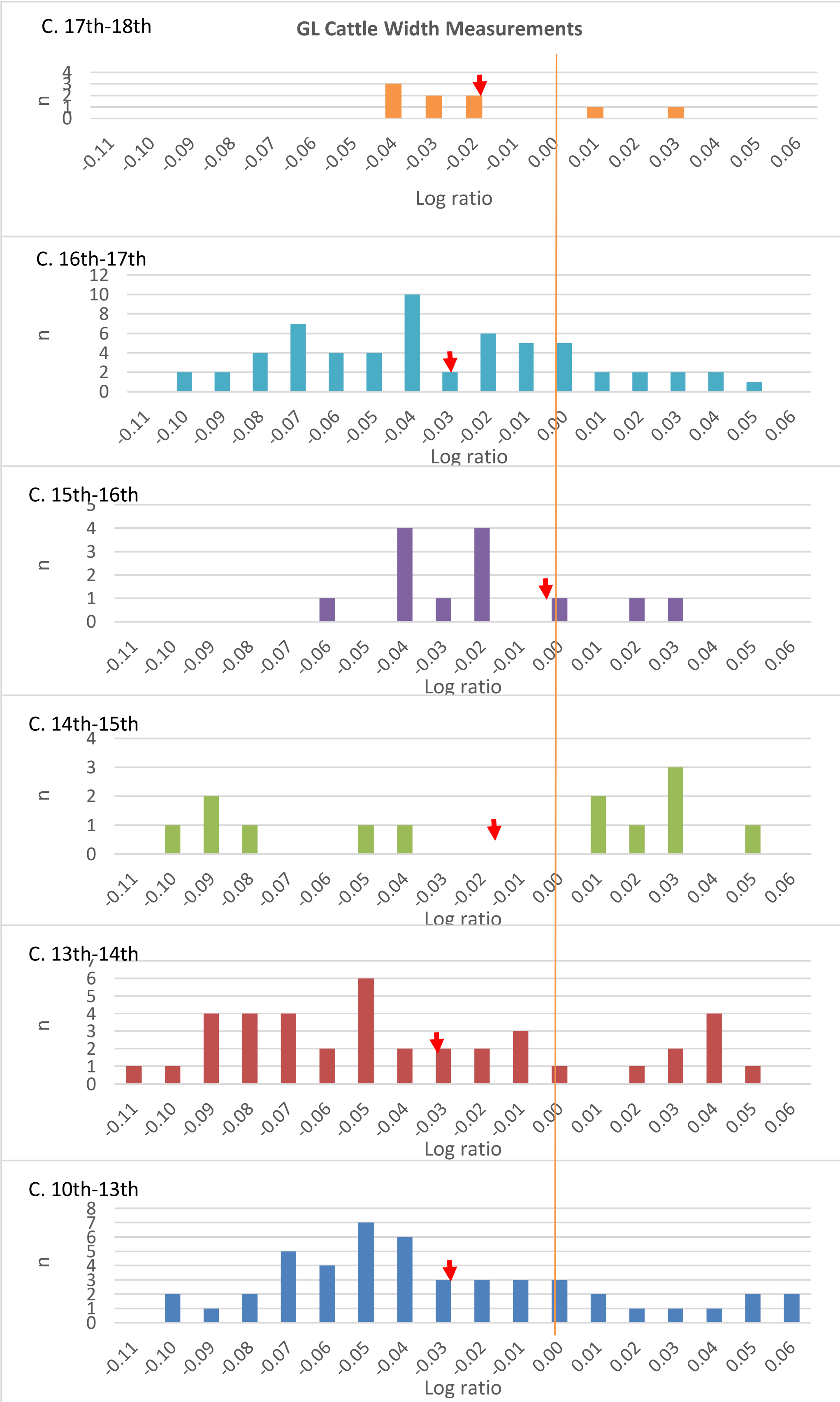

Figure 3.48: Log ratio histograms combining cattle post-cranial bone width measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

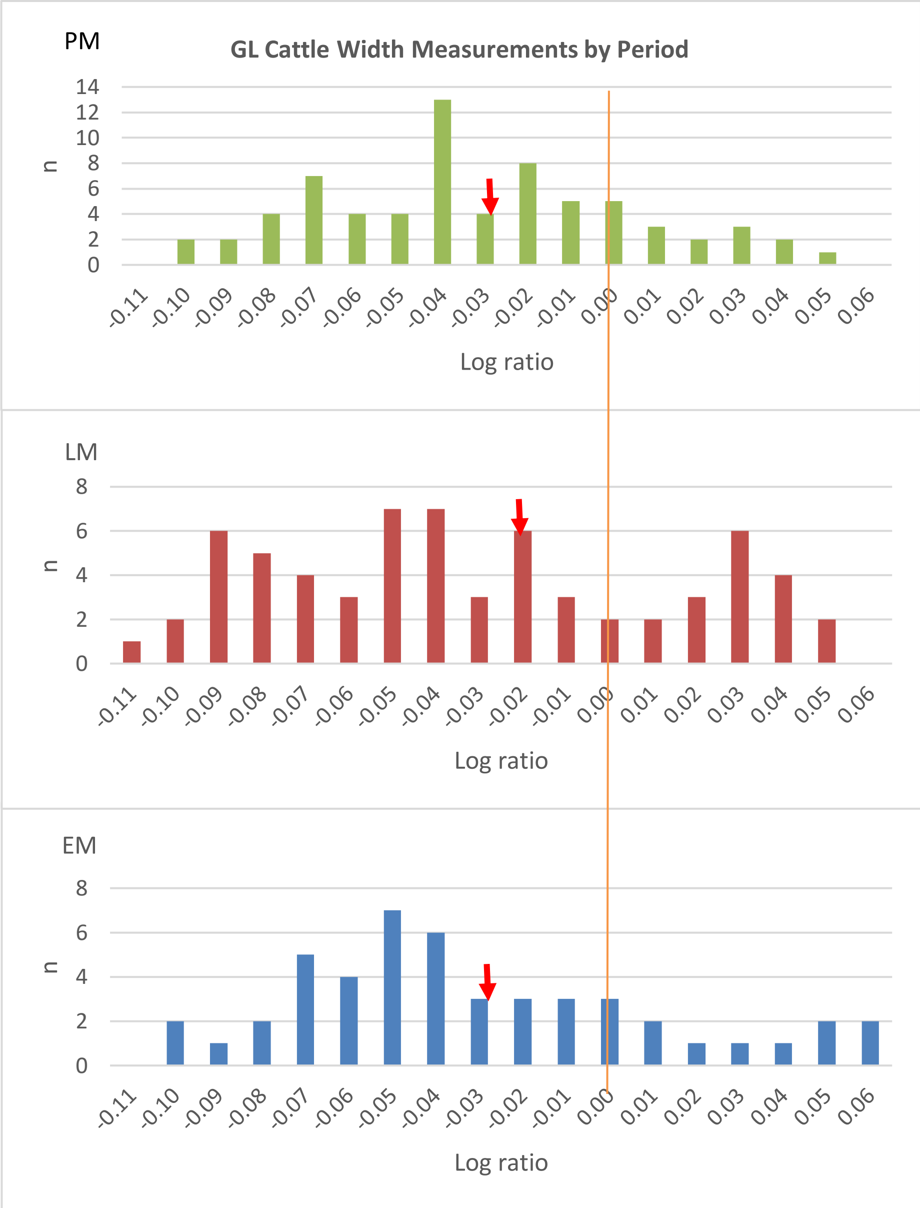

Figure 3.49: Log ratio histograms combining cattle post-cranial bone width measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.13: Statistical test results for the post-cranial log ratio width values for cattle by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	884	0.219	P> 0.05
13th-14th vs. 14th-15th	210	0.301	P> 0.05
14th-15th vs. 15th-16th	83	0.960	P> 0.05
15th-16th vs. 16th-17th	482	0.189	P> 0.05
16th-17th vs. 17th-18th	-1.336	0.203	P> 0.05
Period:			
EM vs. LM	1757	0.883	P> 0.05
LM vs. PM	-0.567	0.572	P> 0.05

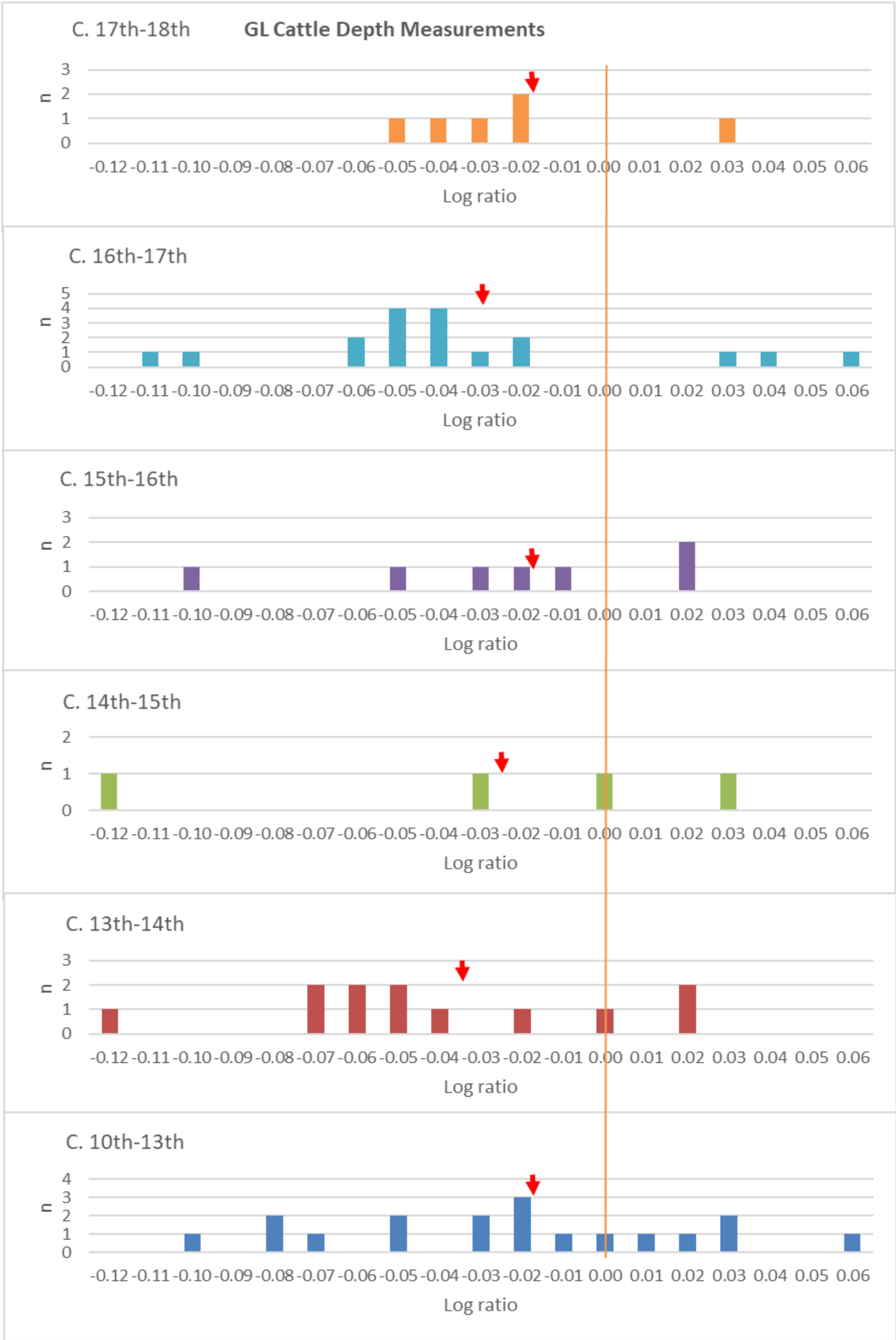

Figure 3.50: Log ratio histograms combining cattle post-cranial bone depth measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

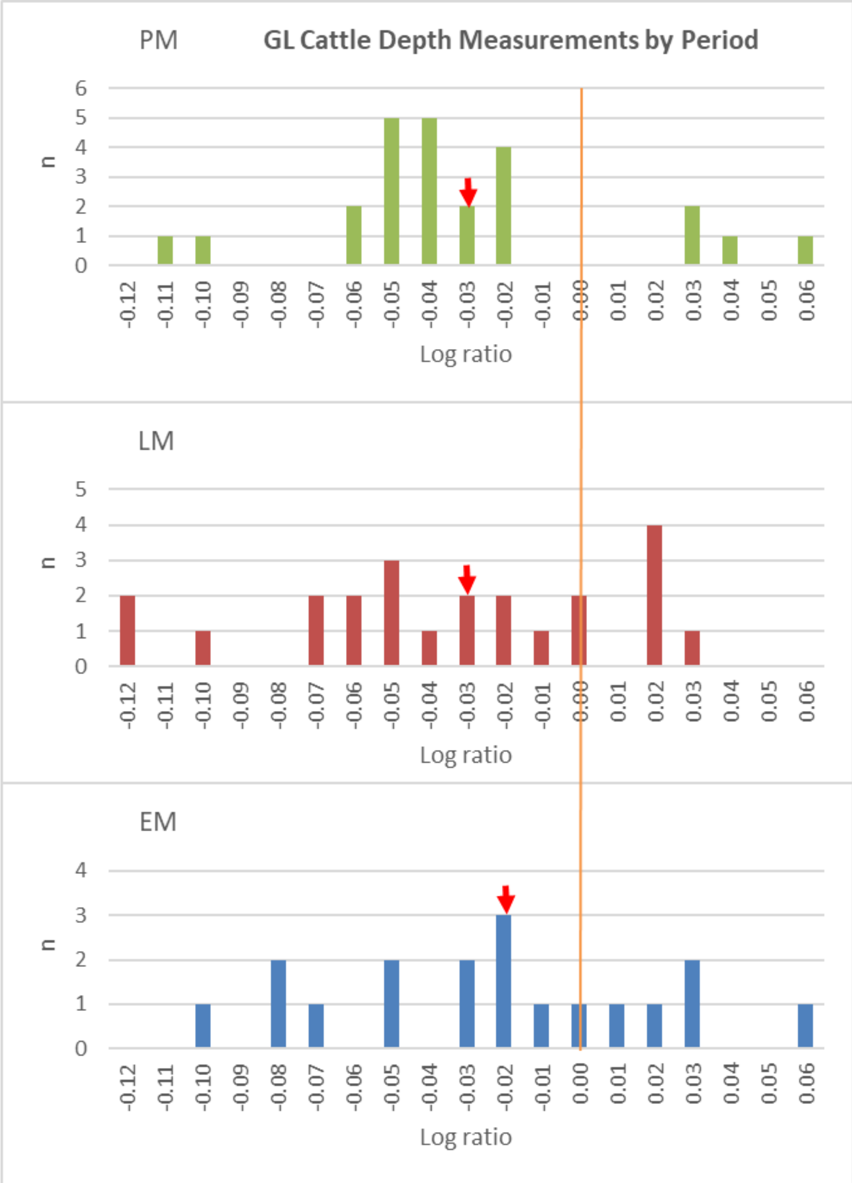

Figure 3.51: Log ratio histograms combining cattle post-cranial bone depth measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.14: Statistical test results for the post-cranial log ratio depth values for cattle by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	1.161	0.256	P> 0.05
13th-14th vs. 14th-15th	0.462	0.668	P> 0.05
14th-15th vs. 15th-16th	-0.171	0.872	P> 0.05
15th-16th vs. 16th-17th	0.574	0.578	P> 0.05
16th-17th vs. 17th-18th	-0.869	0.402	P> 0.05
Period:			
EM vs. LM	0.789	0.435	P> 0.05
LM vs. PM	-0.206	0.838	P> 0.05

Table 3.15: Coefficient of variation values for cattle teeth and post-cranial elements across both the individual phases and broad periods at Great Linford.

Phase	**Post-cranial**	**Teeth**
10th-13th	10.3	8.5
13th-14th	7.9	6.7
14th-15th	16.8	11.3
15th-16th	9.6	9.5
16th-17th	7.0	8.3
17th-18th	5.0	-
Period		
EM	10.3	8.5
LM	10.5	9.8
PM	6.6	6.5

Pig

Due to a small sample size for pig, metric assessment was carried out using entirely the log ratio method. Tooth length was compared across the individual phases (Figure 3.52), and the general periods of the site (Figure 3.53). This dimension is relatively constant across all phases at Great Linford, though there are decreases in the means for the 13th-14th and 17th-18th centuries suggesting a reduction in pig tooth length during these phases. However, it must be noted that this measurement can be affected by tooth wear, and these changes are not statistically significant (Table 3.16). There is also no significant change between the log ratio tooth length means, or between individual tooth length measurements (Table 3.18), across all three broad chronological periods. This suggests that pig tooth length remained relatively constant throughout the study period, with perhaps some reductions in the 13th-14th and 17th-18th centuries. Log ratio values for pig tooth widths are also relatively consistent throughout the study period (Figure 3.54), though there is a significant decrease in the mean in the 14th-15th century ($P<0.05$) (Table 3.17). This change in size is not evident across the broad periods at Great Linford, as the mean tooth width is very similar throughout the earlier, late and post-Medieval periods (Figure 3.55). There is also no significant change in the means of individual tooth width measurements from these three periods (Table 3.18).

The evaluation of post-cranial pig dimensions was only possible using a combination of all post-cranial measurements across the three broad periods, due to a small sample size (Figure 3.56). It shows a slight increase in mean between the earlier and late Medieval periods, followed by a decrease in the post-Medieval period. While the increase in the late Medieval period is not statistically significant, the drop in mean values in the post-Medieval period is highly significant ($P<0.01$) (Table 3.19). This may represent the introduction of a different population in the post Medieval period, or a change in the proportions of male and female animals.

The tooth and post-cranial coefficient of variation results for pig may reflect the variation shown in metric values (Table 3.20). For teeth, the highest CVs are found in the 13th-14th and 15th-16th centuries. This could be related to the decrease in average length and increase in average width respectively for these periods, suggesting not only a slight change in size, but also greater variation in pig teeth during these phases. This increase in variation during these phases is reflected in a high CV value for pig teeth during the late Medieval period, suggesting a greater range of pig tooth dimensions during this time. The lowest CV value for teeth is found in the post-Medieval period, which suggests that the pig population at Great Linford was more homogenous during the final period. Post-cranial CV values suggest greater variation during the later phases, specifically the 15th-16th and 17th-18th centuries. This may reflect the changing distribution of pig post-cranial measurements during the post-Medieval period, creating a more heterogenous population. However, across the three broad periods, the highest CV value is found in the late Medieval period, and the lowest in the post-Medieval, suggesting greater variation in pig post-cranial dimensions in the middle period. Post-cranial variation in pigs is more likely to be affected by changes in sex ratios, meaning that the higher variation in the late Medieval period may be due to varying sex ratios (Payne and Bull 1988).

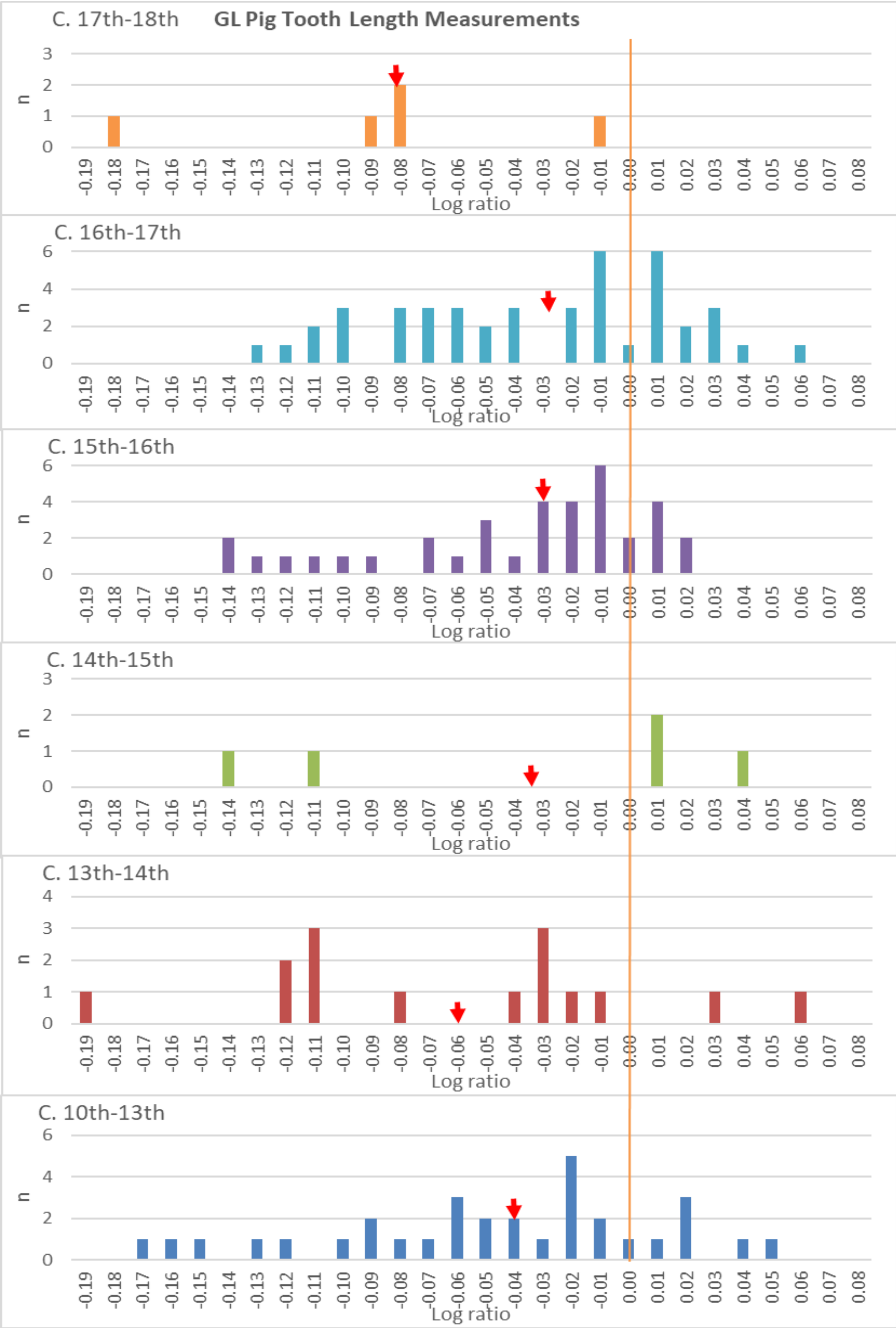

Figure 3.52: Log ratio histograms combining pig tooth length measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

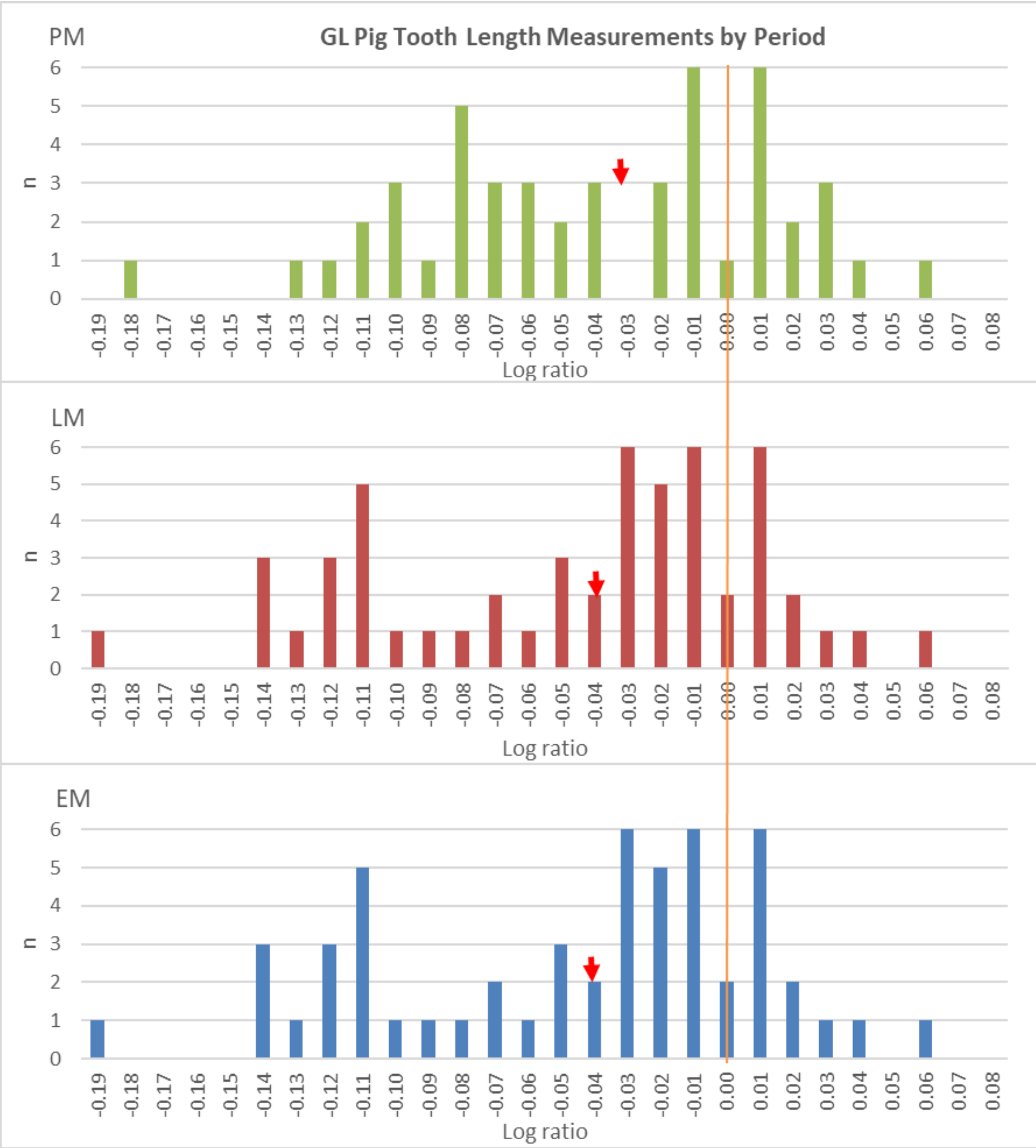

Figure 3.53: Log ratio histograms combining pig tooth length measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.16: Statistical results for the tooth log ratio length values for pig by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	-0.678	0.504	P> 0.05
13th-14th vs. 14th-15th	0.528	0.617	P> 0.05
14th-15th vs. 15th-16th	109	0.547	P> 0.05
15th-16th vs. 16th-17th	933	0.455	P> 0.05
16th-17th vs. 17th-18th	2.090	0.091	P> 0.05
Period:			
EM vs. LM	864	0.685	P> 0.05
LM vs. PM	1327	0.438	P> 0.05

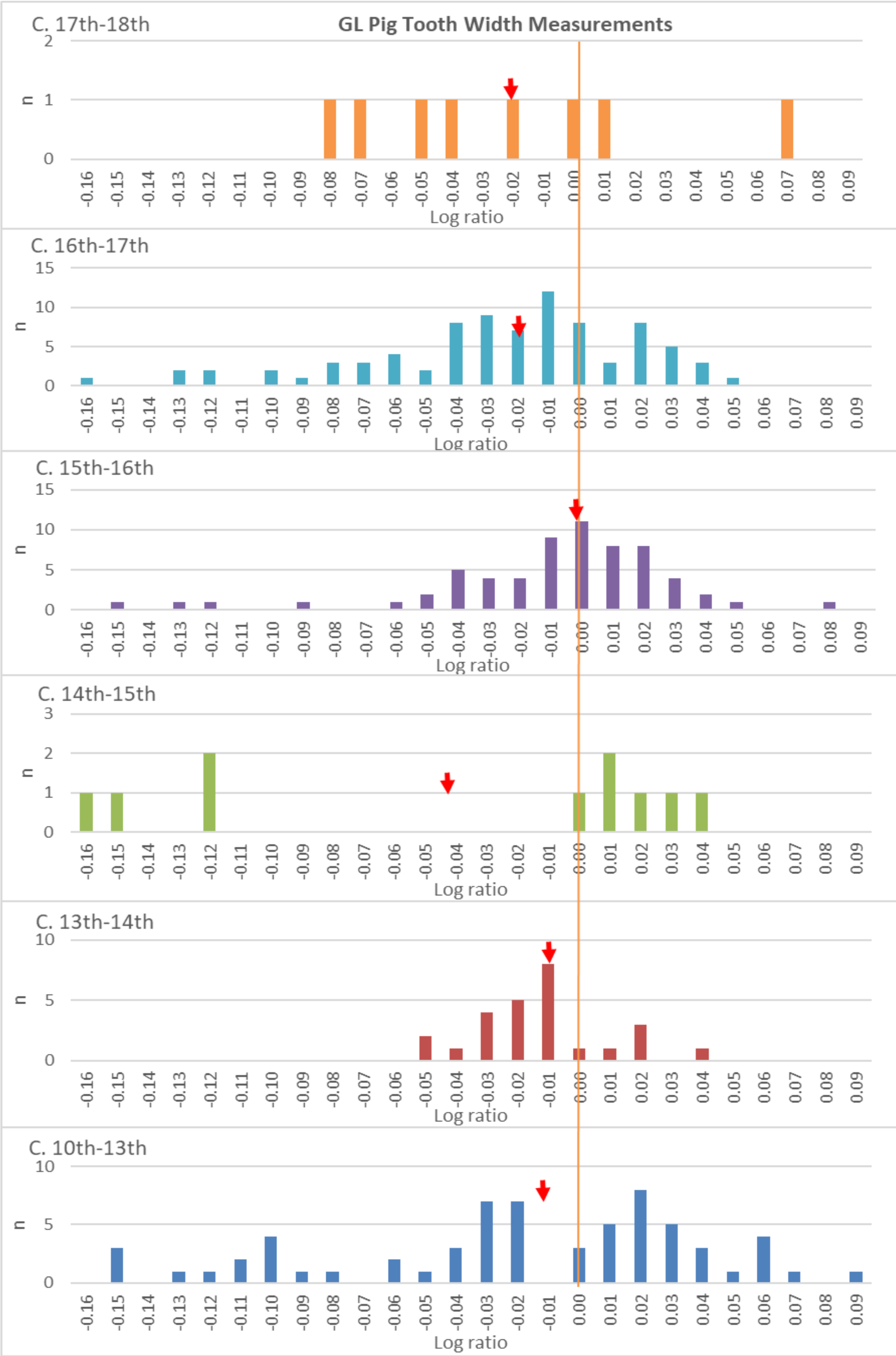

Figure 3.54: Log ratio histograms combining pig tooth width measurements by phase at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

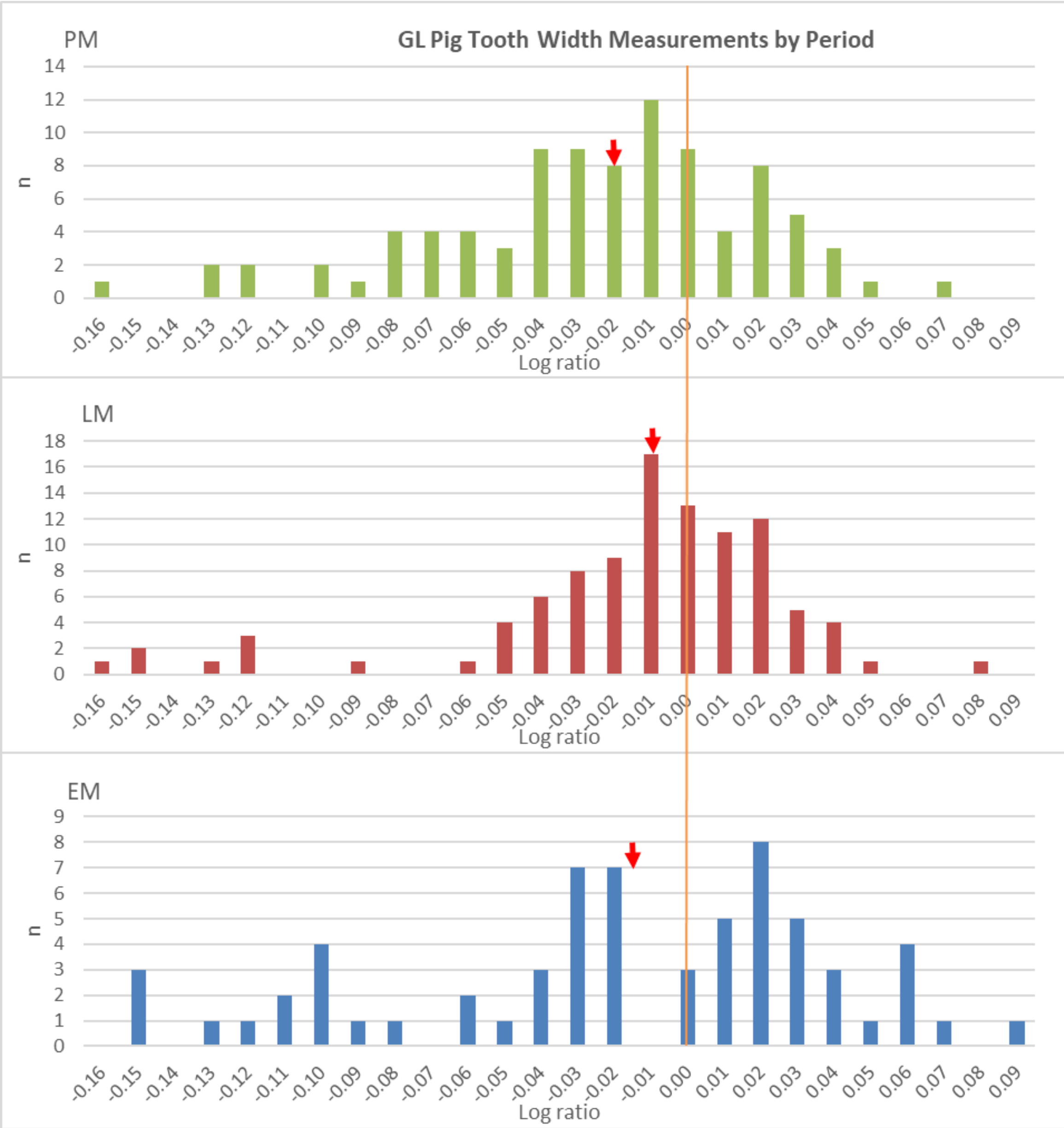

Figure 3.55: Log ratio histograms combining pig tooth width measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.17: Statistical test results for the tooth log ratio width values for pig by phases and periods at Great Linford.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	844	0.918	P> 0.05
13th-14th vs. 14th-15th	137	0.828	P> 0.05
14th-15th vs. 15th-16th	295	0.698	P> 0.05
15th-16th vs. 16th-17th	2074	0.023	P< 0.05
16th-17th vs. 17th-18th	299	0.649	P> 0.05
Period:			
EM vs. LM	3147	0.860	P> 0.05
LM vs. PM	3770	0.031	P< 0.05

Table 3.18: Statistical test results for individual pig bone measurements between the periods at Great Linford. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			**LM vs. PM**		
Measurement	**t stat/ U-value**	**P Value**	**Significance**	**t stat/ U-value**	**P Value**	**Significance**
dP_4L	N/A	N/A	N/A	-2.633	0.058	P> 0.05
dP_4 WP	N/A	N/A	N/A	-0.055	0.958	P> 0.05
M_1 L	36	0.245	P> 0.05	36	0.036	P<0.05
M_1 WA	-2.039	0.071	P> 0.05	-0.692	0.498	P> 0.05
M_1 WP	31	0.122	P> 0.05	-0.294	0.772	P> 0.05
M_2 L	-1.226	0.239	P> 0.05	-0.406	0.690	P> 0.05
M_2 WA	65	0.108	P> 0.05	57	0.644	P> 0.05
M_2 WP	1.429	0.183	P> 0.05	-0.170	0.867	P> 0.05
M_3 L	N/A	N/A	N/A	0.720	0.490	P> 0.05
M_3 WA	N/A	N/A	N/A	-0.809	0.439	P> 0.05
M_3 WC	N/A	N/A	N/A	1.728	0.110	P> 0.05
M_3 WP	N/A	N/A	N/A	1.181	0.265	P> 0.05

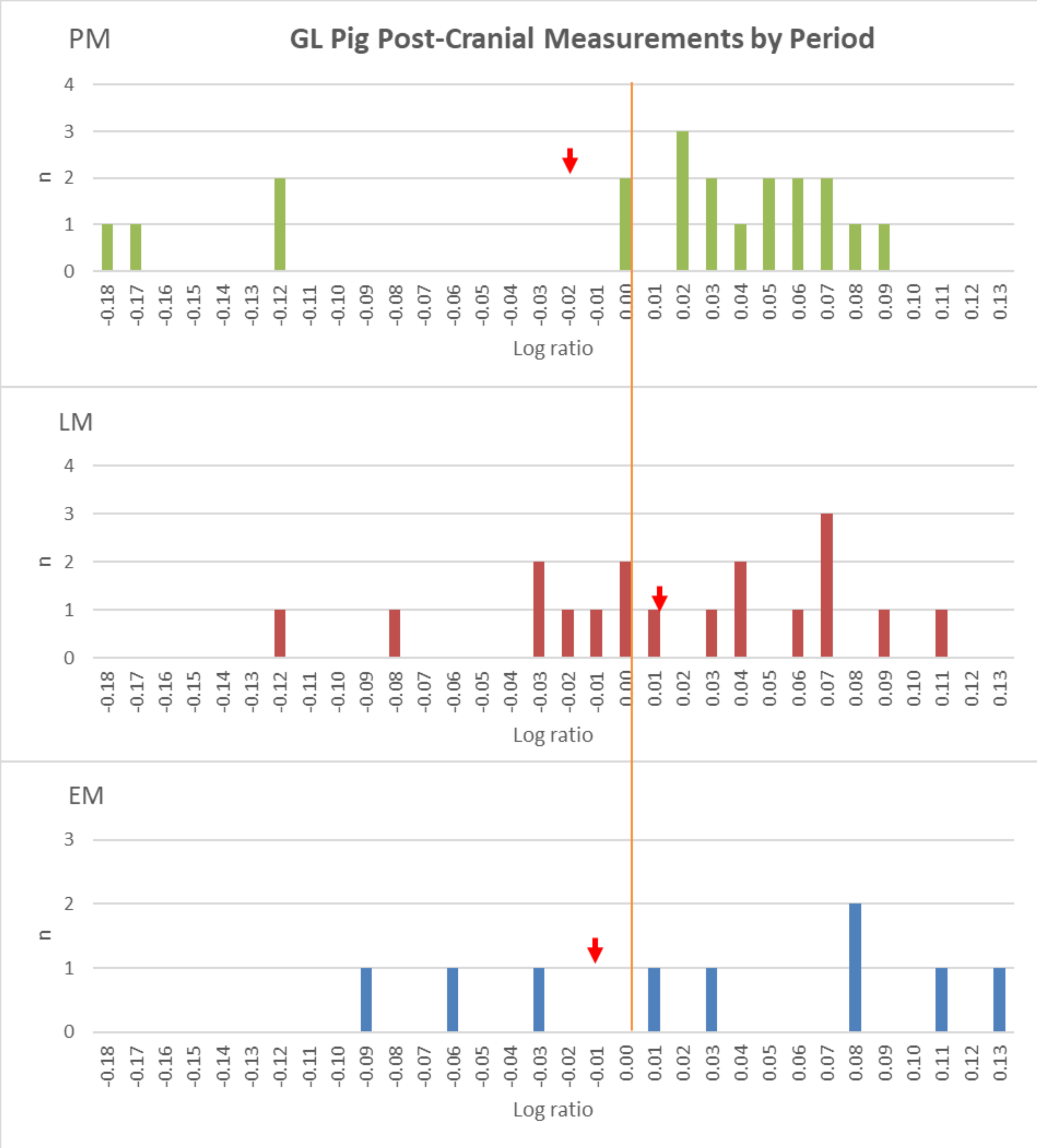

Figure 3.56: Log ratio histograms combining pig post-cranial length and width measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.19: Statistical test results for the post-cranial log ratio values for pig by phases and periods at Great Linford.

Period:	**t stat/ U-value**	**P value**	**Significance**
EM vs. LM	-1.177	0.264	P> 0.05
LM vs. PM	33	0.004	P< 0.01

Table 3.20: Coefficient of variation values for pig teeth and post-cranial elements across both the individual phases and broad periods at Great Linford.

Phase	**Post-cranial**	**Teeth**
10th-13th	6.7	8.8
13th-14th	5.4	10.9
14th-15th	N/A	N/A
15th-16th	10.3	9.1
16th-17th	4.7	7.7
17th-18th	13.7	8.4
Period		
EM	6.7	8.8
LM	8.4	9.9
PM	5.7	7.8

Horse

The metric analysis of horse at Great Linford was carried out predominantly using post-cranial measurements due to a lack of intact jaws for tooth measurements. Figure 3.57 illustrates the comparison of phalanx 1 measurements across the broad periods of the site. It shows that first phalanx size is relatively similar between the three phases, suggesting a lack of clear horse size change at Great Linford.

Log ratio analysis was carried out for post-cranial horse bone, in order to increase the sample size for each period. The average values for length measurements remained relatively similar across all three periods (Figure 3.58), though a much smaller late Medieval specimen lowers the mean for this period, which may represent the presence of a donkey or mule. However, the small sample size makes further investigation difficult – an initial assessment of first phalanx length in relation to shaft width does not indicate the presence of a more slender specimen (Johnstone 2002). Overall, there is no significant change in average log ratio length values across the three periods (Table 3.21), suggesting relatively consistent post-cranial horse bone length throughout the study period. There is also no significant change in horse log ratio width values across the three periods at Great Linford (Figure 3.59, Table 3.22), though there appears to be a slight increase in the average width measurement in the late Medieval period, followed by a decrease in the post-Medieval. This again suggests relatively constant horse post-cranial width size throughout the study period, with perhaps some slightly larger specimens in the late Medieval, and some smaller in the final period. Finally, the comparison of log ratio values for depth measurements across the three main periods (Figure 3.60) shows similar mean values in the earlier and late Medieval periods, followed by a decrease in the post-Medieval period, which may suggest an overall decrease in post-cranial depth at this time. However, this change is also not statistically significant (Table 3.23). Overall, horse post-cranial measurements remained relatively constant throughout the study period. Though there are some signs of slight variation, this does not follow a clear temporal trend.

The coefficient of variation values for horse post-cranial elements are largely similar throughout the study period (Table 3.24). CVs range from 7.6 to 9.5 in all phases except the 15th-16th and 17th-18th centuries, where they decrease to 1.4 and 4.7 respectively. This decrease in variation may reflect an extremely homogenous horse population in these phases, but the small sample size may also make these values less reliable. CV values are also similar across the three main periods, ranging from 8.3 to 9.0, which suggests that horse post-cranial measurements were similar in variation across the earlier, late and post-Medieval periods. The coefficient of variation values for horse teeth are also quite inconsistent due to small sample sizes across the individual phases – there is a relatively low CV of 5.6 in the 10th-13th century, followed by CVs between 16.4 and 28.5 in the following phases. This suggests that variation in horse tooth measurements is lowest in the earlier Medieval period, but increases through time. CV results for the late and post-Medieval periods support this, as these periods produced CVs of 17.6 and 17.0 respectively. This may point towards a more heterogenous horse population in the late and post-Medieval periods, perhaps due to the presence of smaller donkeys or mules, or larger horses bred or imported for greater traction power.

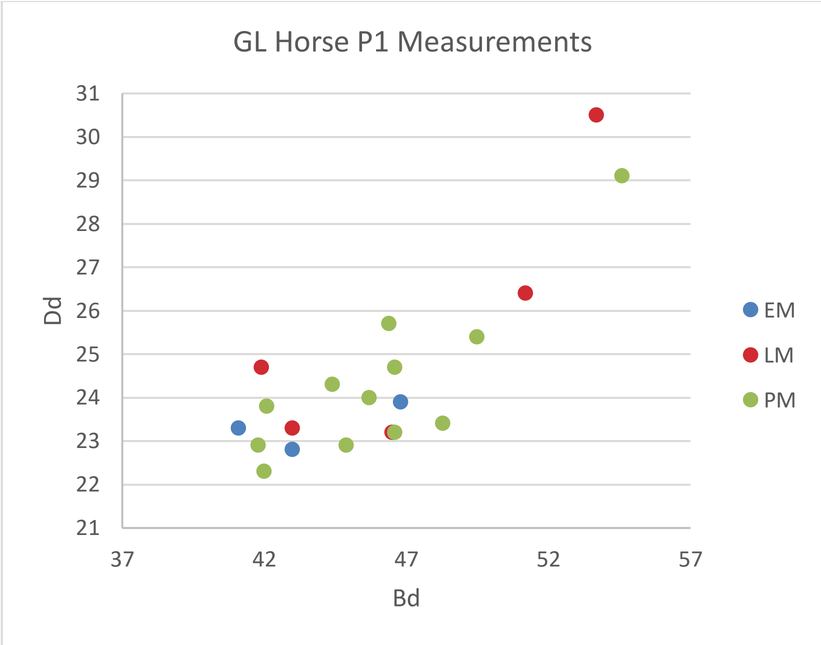

Figure 3.57: Comparison of distal phalanx 1 measurements for horse by period at Great Linford.

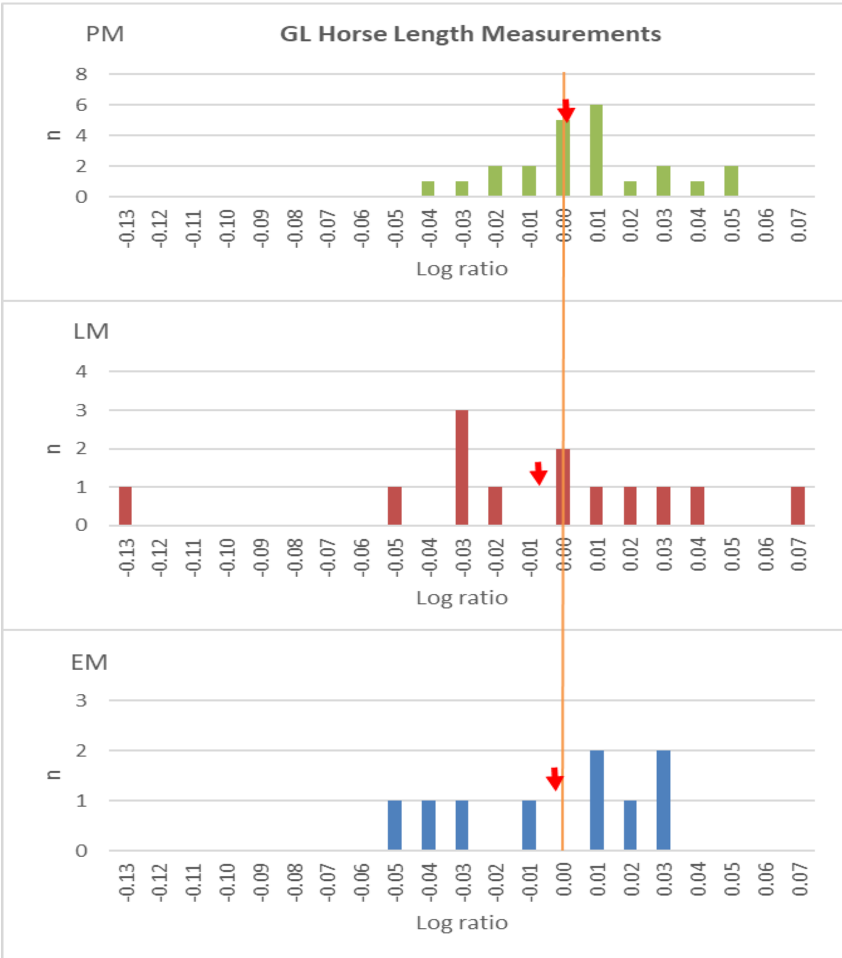

Figure 3.58: Log ratio histograms combining horse post-cranial bone length measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.21: Statistical test results for the post-cranial log ratio length values for horse by phases and periods at Great Linford.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	-0.318	0.754	P> 0.05
LM vs. PM	-1.102	0.288	P> 0.05

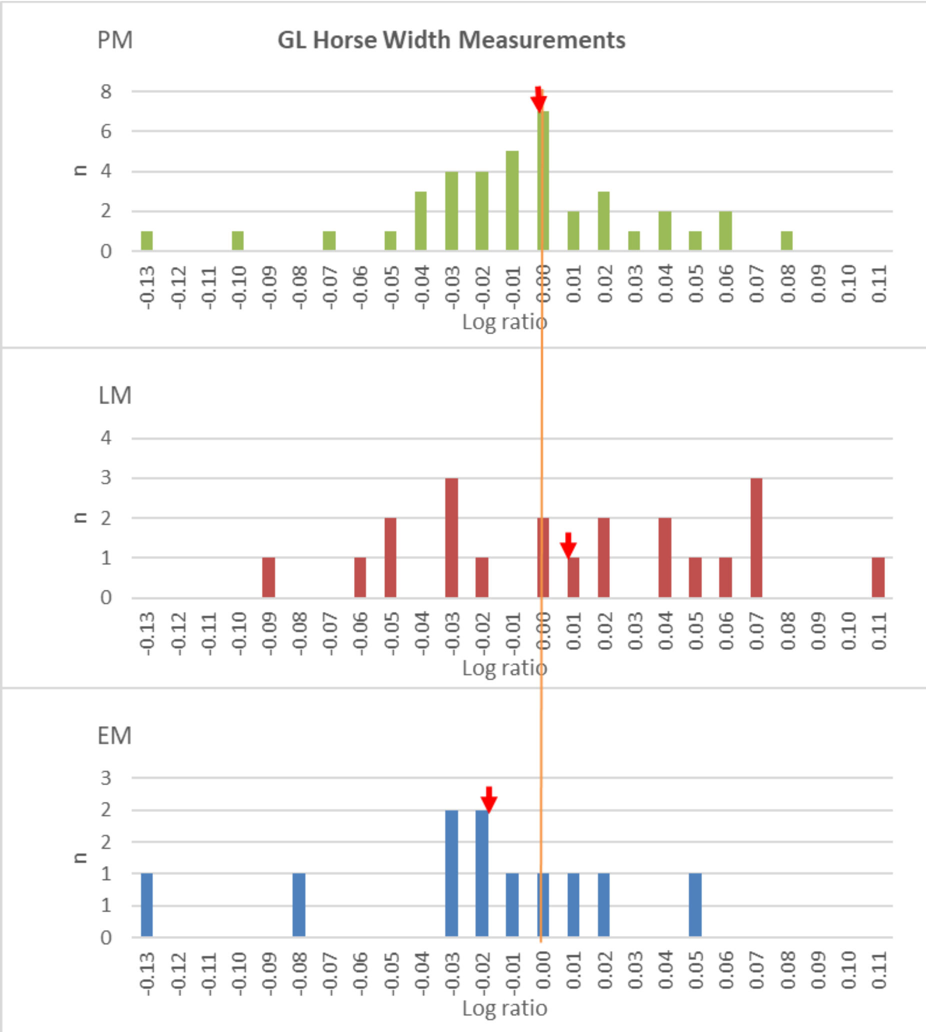

Figure 3.59: Log ratio histograms combining horse post-cranial bone width measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.22: Statistical test results for the post-cranial log ratio width values for horse by phases and periods at Great Linford.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	-0.856	0.397	P> 0.05
LM vs. PM	0.763	0.448	P> 0.05

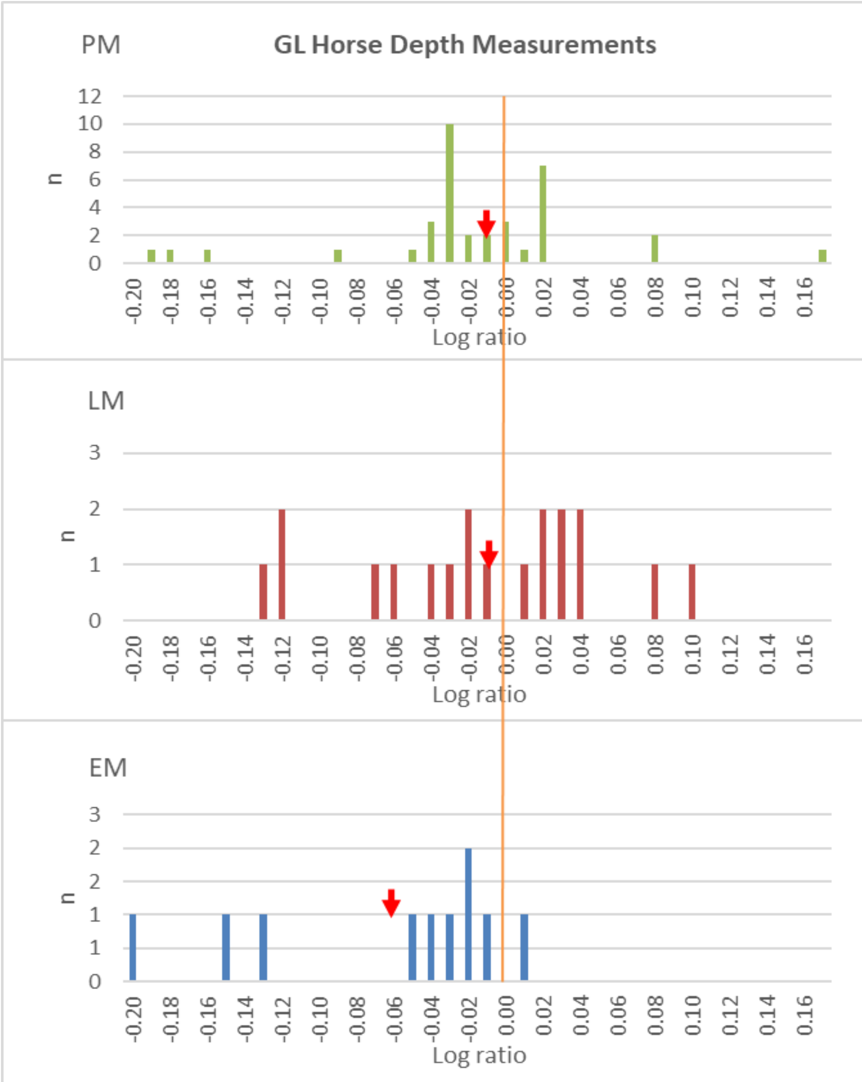

Figure 3.60: Log ratio histograms combining horse post-cranial bone depth measurements by period at Great Linford. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 3.23: Statistical test results for the post-cranial log ratio depth values for horse by phases and periods at Great Linford.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	-1.942	0.069	P> 0.05
LM vs. PM	-0.318	0.752	P> 0.05

Table 3.24: Coefficient of variation values for horse teeth and post-cranial elements across both the individual phases and broad periods at Great Linford.

Phase	Post-cranial	Teeth
10th-13th	8.3	5.6
13th-14th	7.6	28.5
14th-15th	8.0	N/A
15th-16th	1.4	21.1
16th-17th	9.5	16.4
17th-18th	4.7	N/A
Period		
EM	8.3	5.6
LM	9.0	17.6
PM	9.0	17.0

3.2.8 Comparison to London

In order to understand the Great Linford metric results within the wider context of the local area and trade connections, they have been compared to the measurements used by Thomas *et al* (2013) in their review of London animal size and shape. Figure 3.61 gives the comparison of Great Linford and London sheep length measurements by phase, though the 17th-18th century is excluded due to a very small sample size. It shows that average sheep post-cranial length is actually larger at Great Linford than London in the 13th-14th century. However, from the fourteenth century onwards, London values are noticeably larger than those at Great Linford. When data from the broader late and post-Medieval periods are compared, they show that average sheep bone length for both sites is very similar in the late Medieval period, but London values are significantly larger by the post-Medieval (Figure 3.62). This suggests that sheep post-cranial length was comparable on both sites at the start of the late Medieval period, and in fact appears to be larger at Great Linford. However, during the fourteenth to fifteenth century, London values increased markedly, meaning that by the post-Medieval period they are much larger than the Great Linford results. A similar pattern can be seen for sheep width measurements from both sites (Figures 3.63 and 3.64). The average width of sheep post-cranial elements is slightly larger at Great Linford in the 13th-14th century phase, but London values increase in the next century causing a larger average for the city. There is again some similarity in mean values in the 15th-16th century, but after this phase London width measurements increase, meaning that by the 17th-18th century they are considerably larger than those at Great Linford. As a result of these patterns shown in individual phases, there is once again a clear pattern in the comparison between general periods - the average width measurements for both sites are similar in the late Medieval period, but by the post-Medieval period London shows much larger dimensions. Furthermore, depth measurements show a similar pattern of change between the two periods, with London values increasing significantly in the post-Medieval period (Figure 3.66). However, in all phases sheep depth measurements are larger in London (Figure 3.65), with the largest difference again being seen in the final phase. Overall, measurements from both sites suggest that sheep size was similar at Great Linford and London at the start of the late Medieval period, though London livestock increase in all dimensions by the post-Medieval period.

Though the sample size is smaller for cattle data, a comparison of length measurements shows a similar pattern to that of sheep across the broad periods (Figure 3.67). There is a clear change between the late and post-Medieval periods. In the late Medieval period, the cattle width mean is larger at Great Linford, but by the post-Medieval period, the London values have substantially increased, making the London mean much larger than that from Great Linford. This once again suggests that, while cattle post-cranial length measurements were on average larger at Great Linford in the late Medieval period, by the post-Medieval period they had been completely overtaken by London values.

For cattle width measurements, the average London value is larger than Great Linford throughout all phases (Figure 3.68). The mean widths from both sites are most similar in the 13th-14th and 15th-16th centuries, and there is again an increase in London dimensions from the sixteenth century, causing the average city value to be much greater by the 17th-18th century. Consequently, the London average width is larger across both the late and post-Medieval periods, though the discrepancy is significantly larger in the later period (Figure 3.69). This could suggest the presence of more robust cattle at London from an earlier date, perhaps representing the larger animals sent to the urban centre for meat, while an increase in height did not occur until later. Unfortunately, due to a small sample size, depth measurements do not provide a reliable comparison of cattle size across the two sites, so are not discussed here. Overall, it appears that length is the only dimension where measurements from cattle are larger from Great Linford at the start of the late Medieval period, and by the post-Medieval period, as with width, the values from London are considerably larger.

As with the previous Great Linford results, the comparison of pig values combines measurements from length, width and depth, in order to increase the sample size, and only the broader late and post-Medieval periods have been assessed. Figure 3.70 shows that, on average, pig measurements from Great Linford were slightly larger than those from London in the late Medieval period. However, by the post-Medieval period the London average is substantially larger. This again suggests that, while Great Linford pig size may have been equal to or greater than London at the start of the late Medieval period, a significant increase in animal size at London results in a much larger mean value by the post-Medieval period.

Horse measurements from Great Linford and London are also compared over the broader periods, and show a very similar pattern to the other species. For example, horse length measurements are, on average, larger in London across the late and post-Medieval periods, but the difference is much greater in the later period due to a clear increase in London values (Figure 3.71). The average horse post-cranial width is slightly larger at Great Linford in the late Medieval period, but again the London average is much larger in the post-Medieval (Figure 3.72). Furthermore, the average horse depth measurement is greater in London throughout both periods, with a slight increase in the later period (Figure 3.73). This suggests that overall horse measurements are similar in the late Medieval period for both sites, and Thomas *et al* 2019 suggest that London horses were relatively small at around 14 hands in the late Medieval period, with a reduction in the fourteenth to fifteenth century. However, by the post-Medieval period the London values are greater for all dimensions, likely due to the increase in size documented by Thomas *et al* (2019) in the fifteenth to sixteenth and seventeenth centuries which may have been caused by changes in function or breeding.

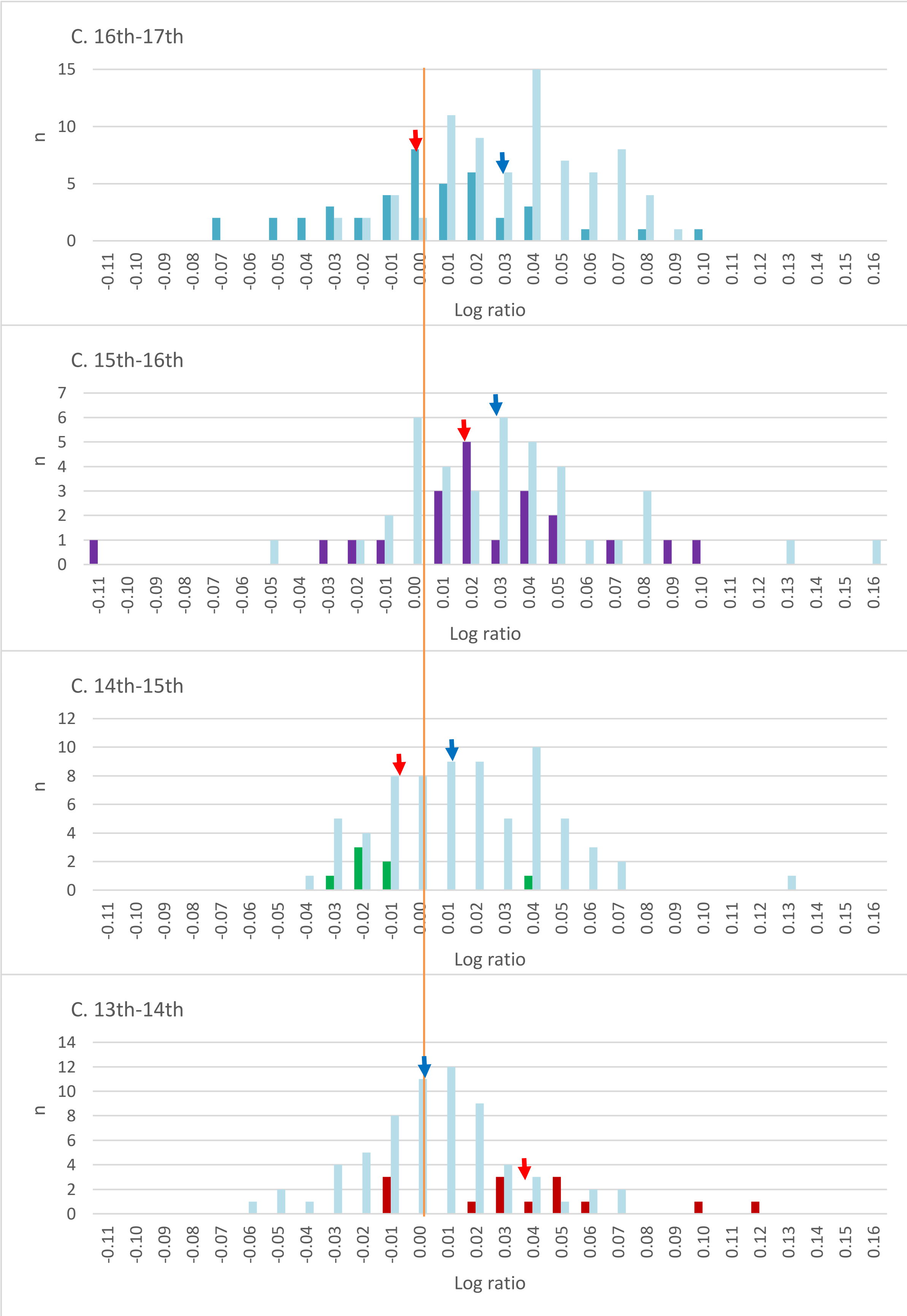

Figure 3.61: Comparison of Great Linford and London sheep length measurements by phase. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

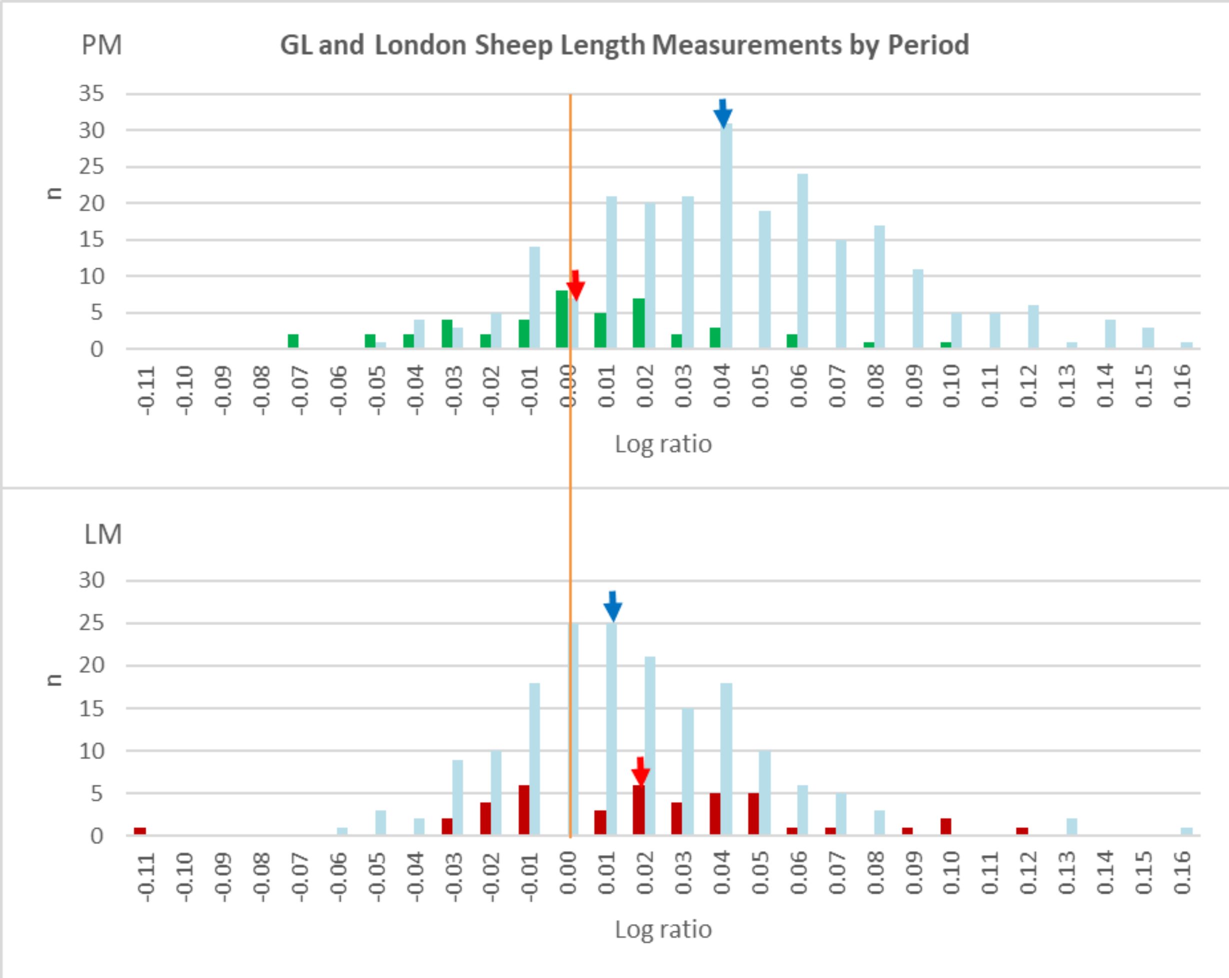

Figure 3.62: Comparison of Great Linford and London sheep length measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

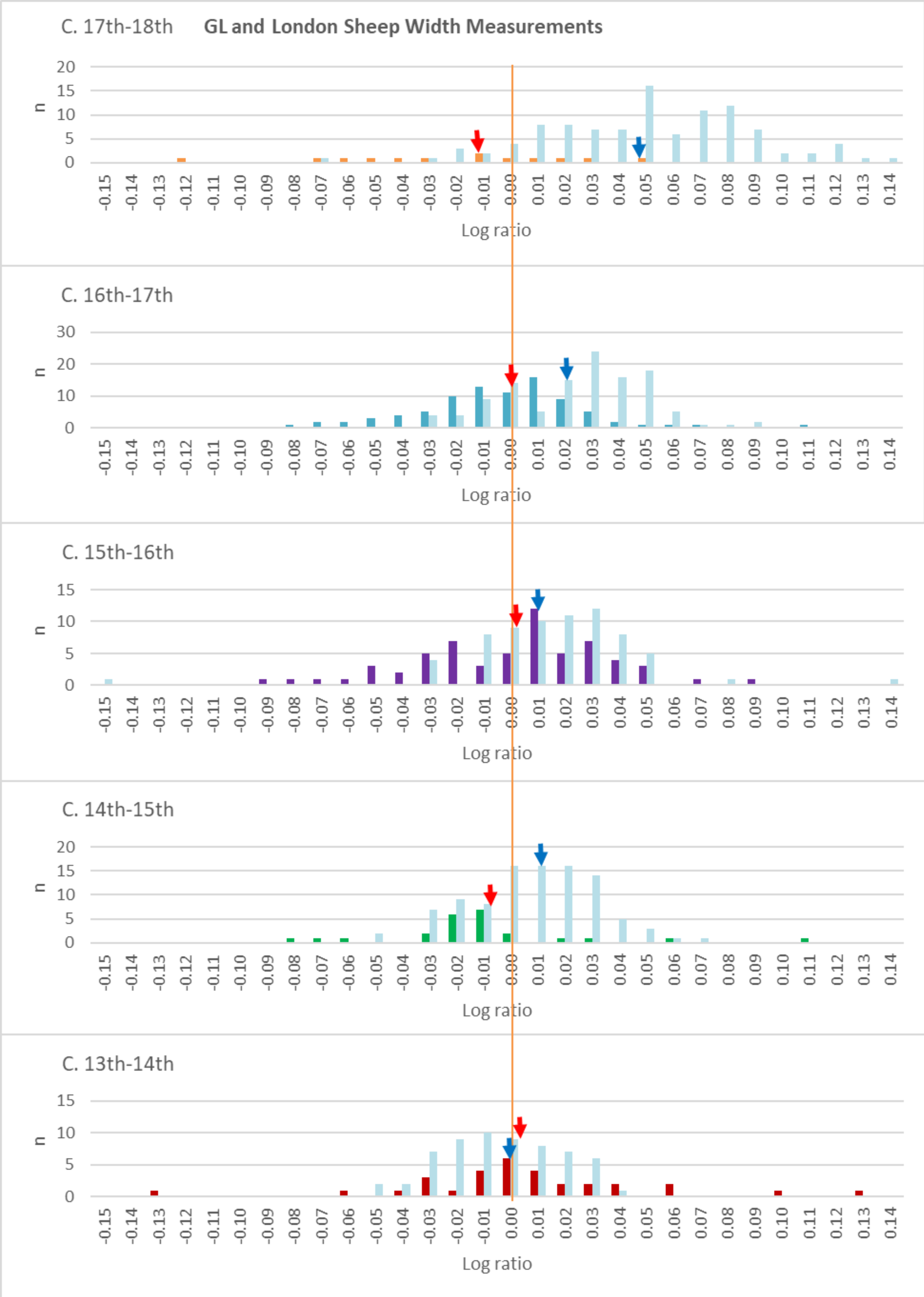

Figure 3.63: Comparison of Great Linford and London sheep width measurements by phase. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

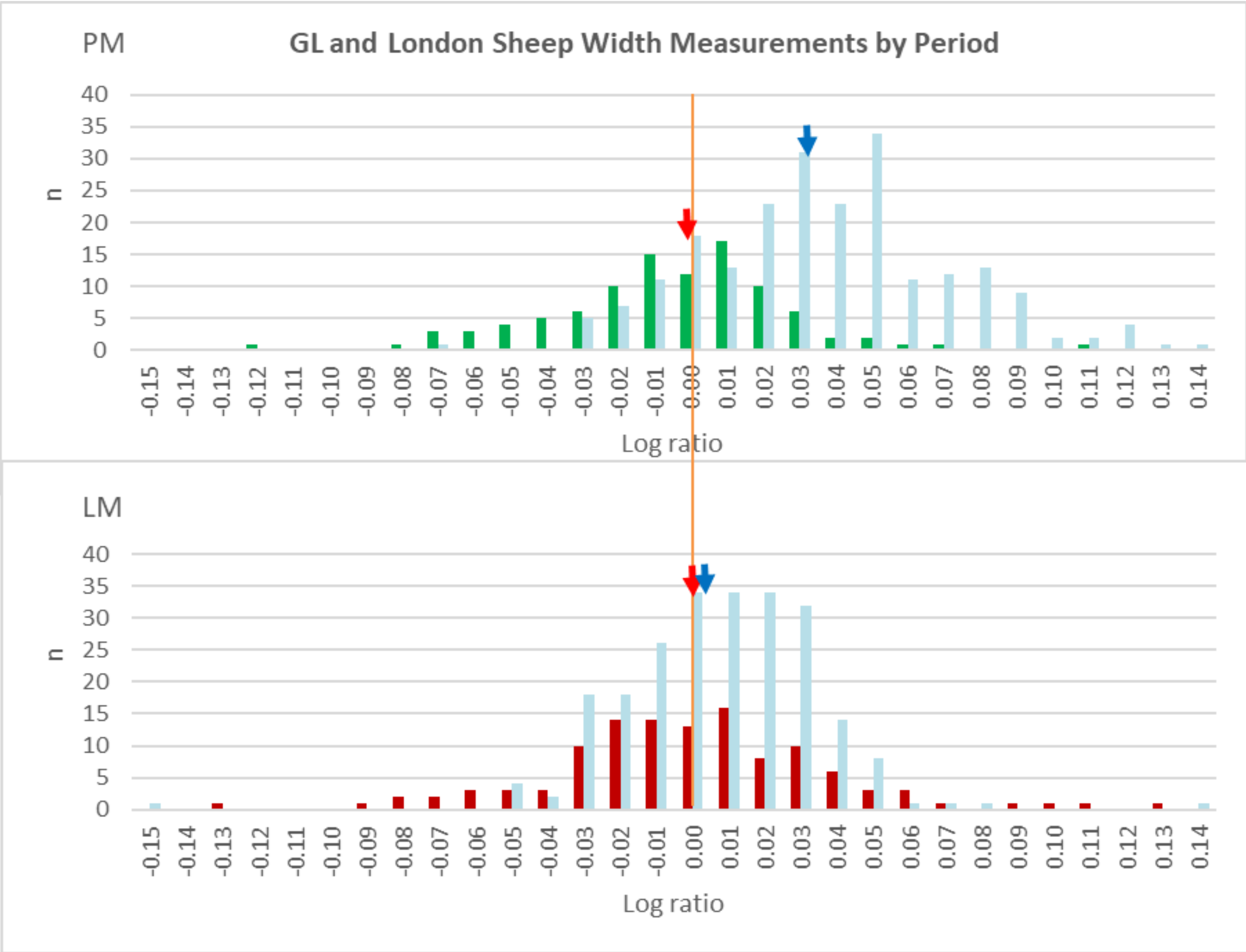

Figure 3.64: Comparison of Great Linford and London sheep width measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

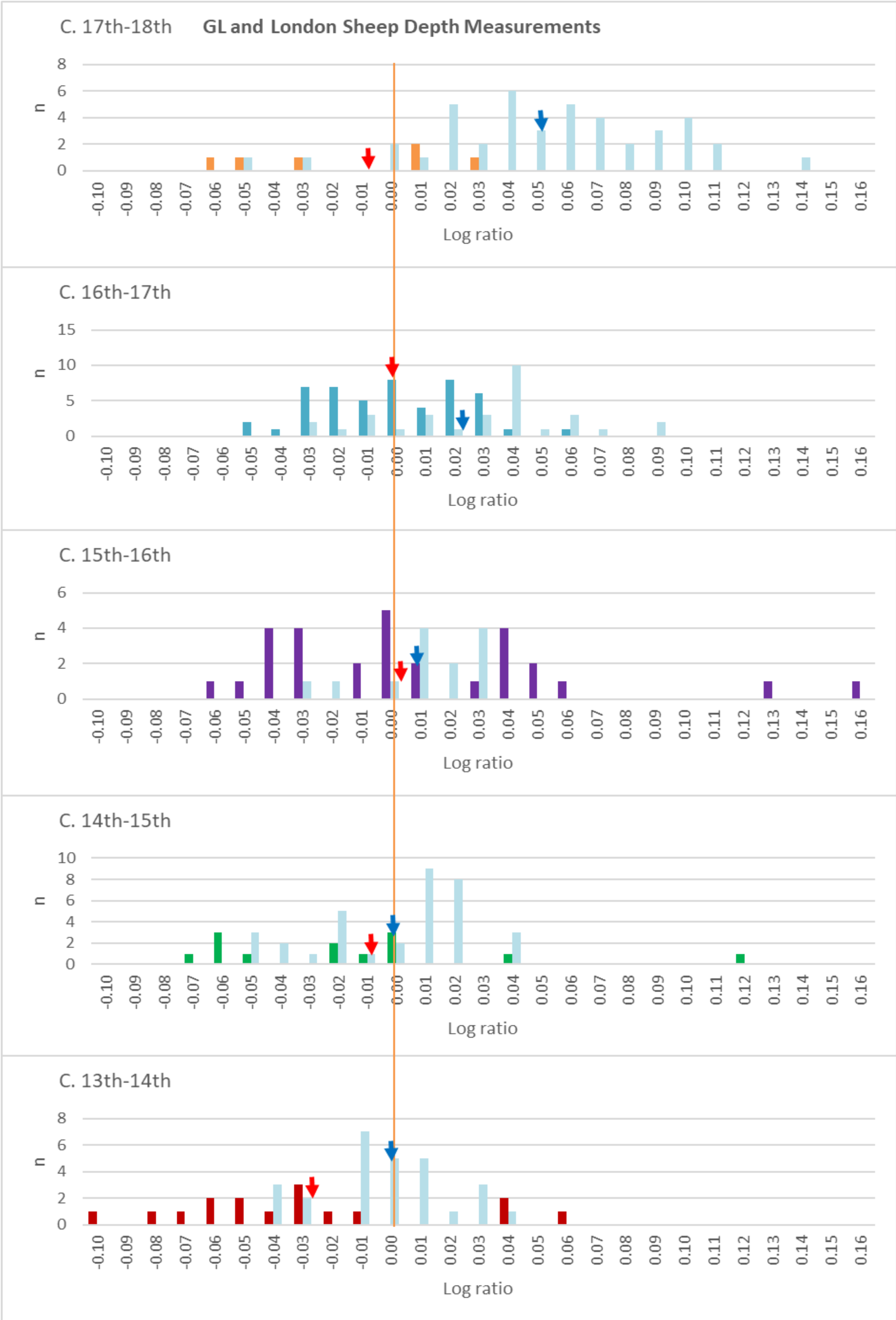

Figure 3.65: Comparison of Great Linford and London sheep depth measurements by phase. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

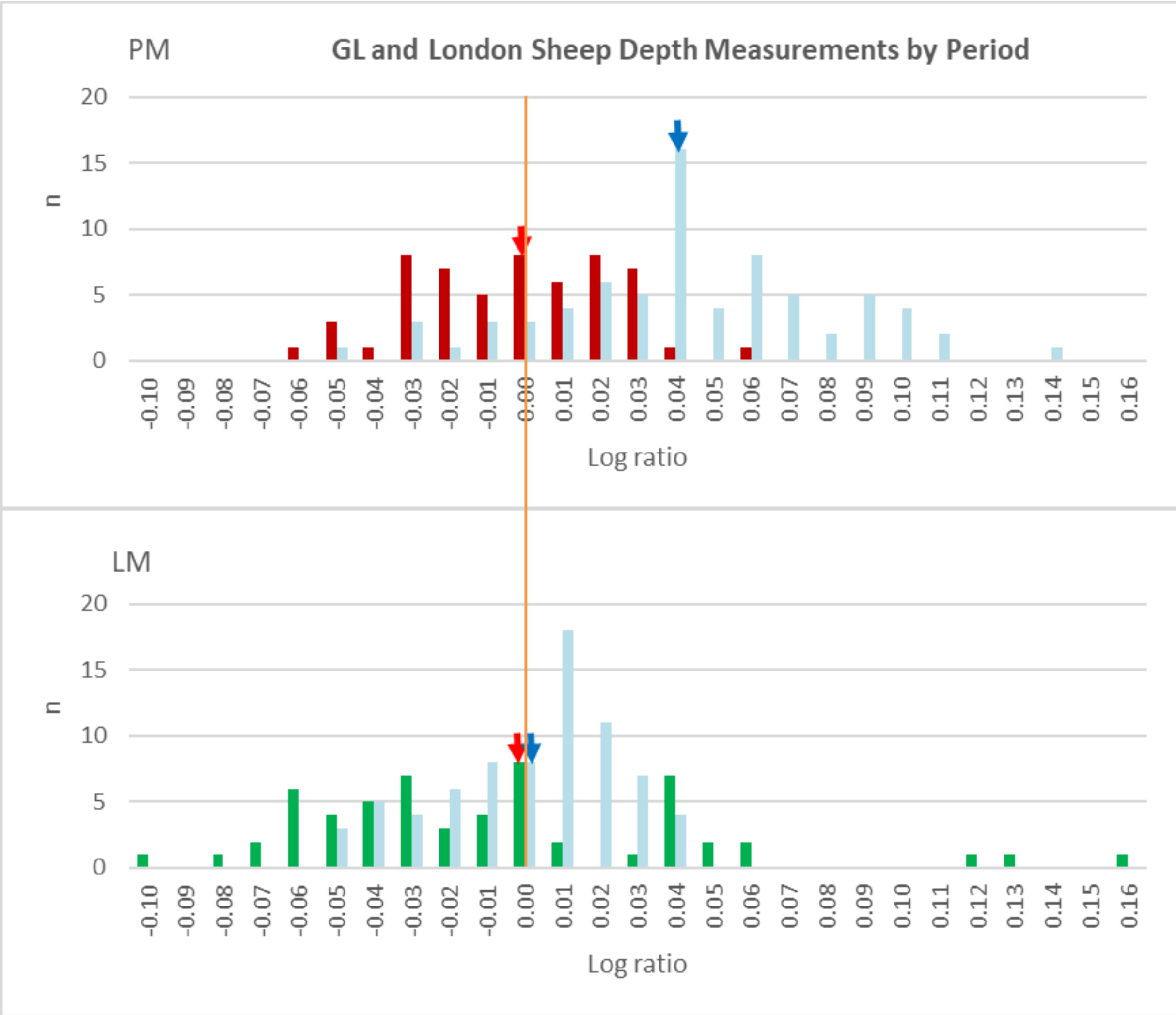

Figure 3.66: Comparison of Great Linford and London sheep depth measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

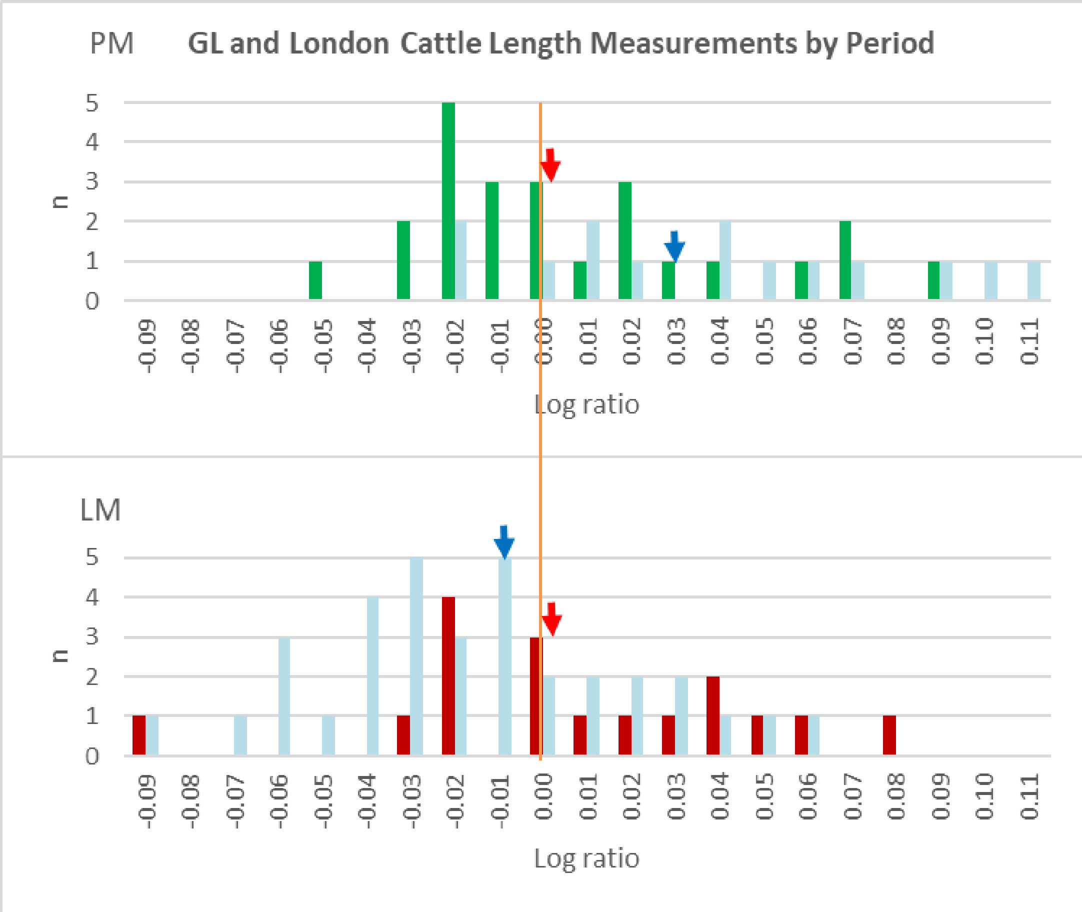

Figure 3.67: Comparison of Great Linford and London cattle length measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

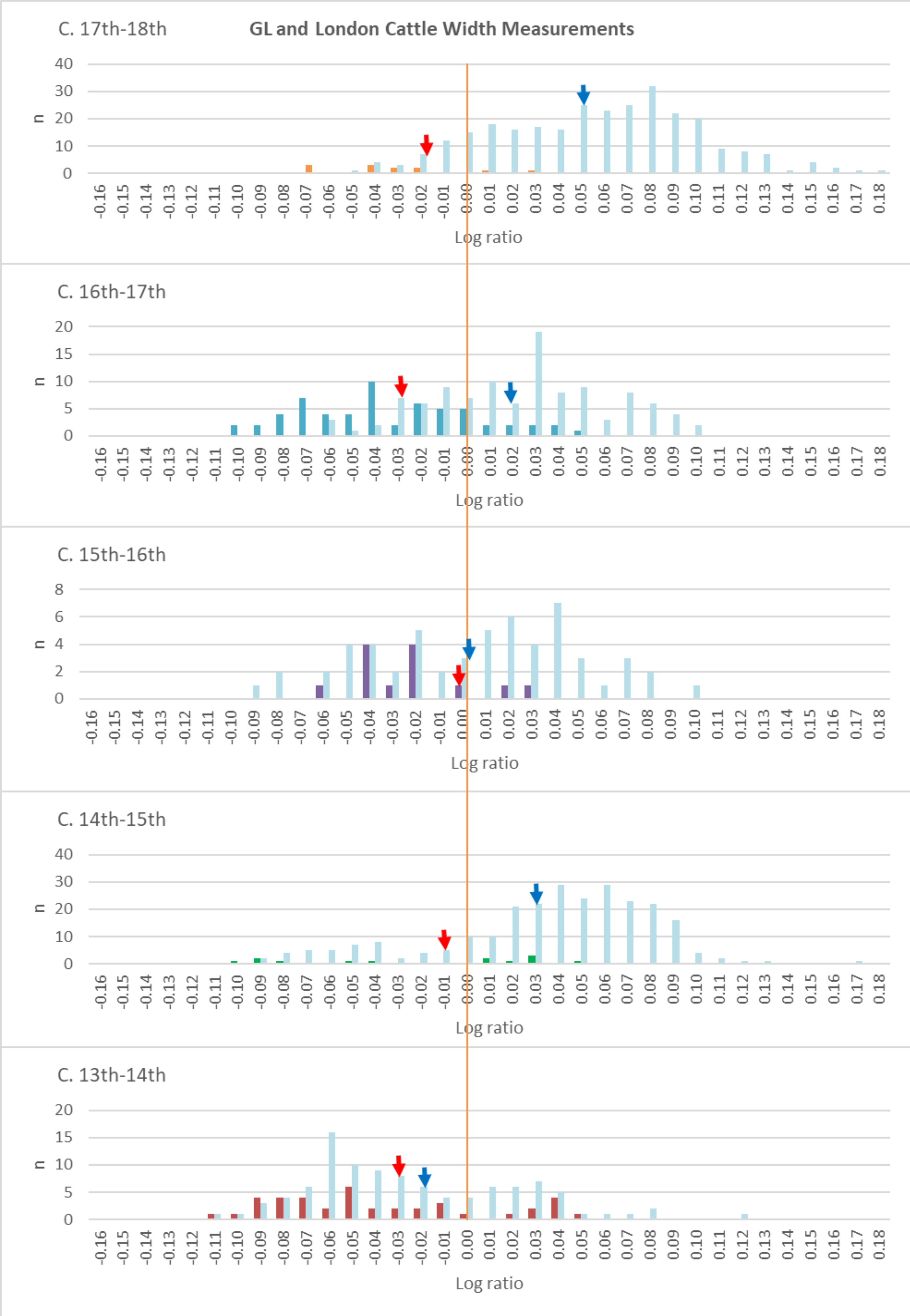

Figure 3.68: Comparison of Great Linford and London cattle width measurements by phase. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

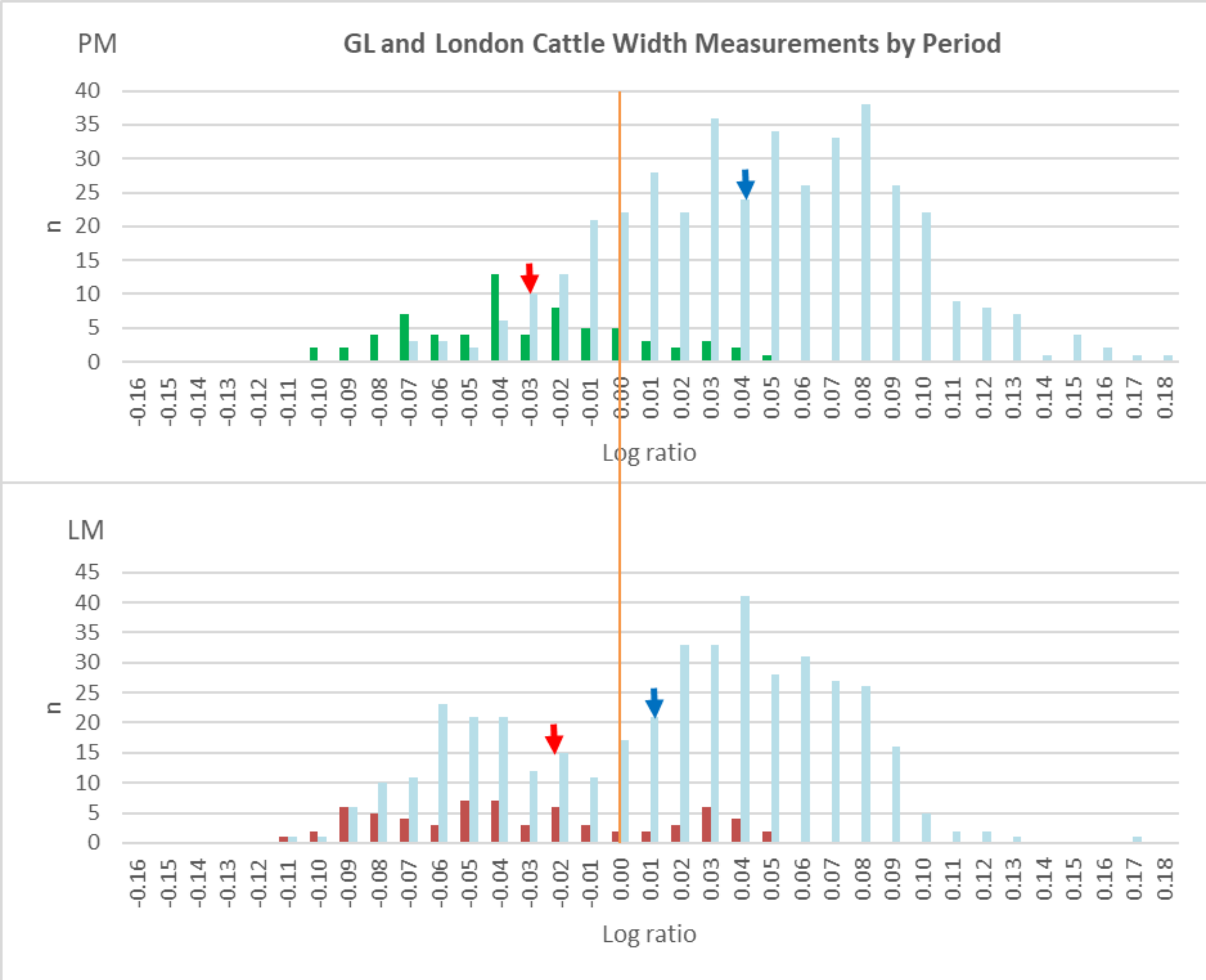

Figure 3.69: Comparison of Great Linford and London cattle width measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

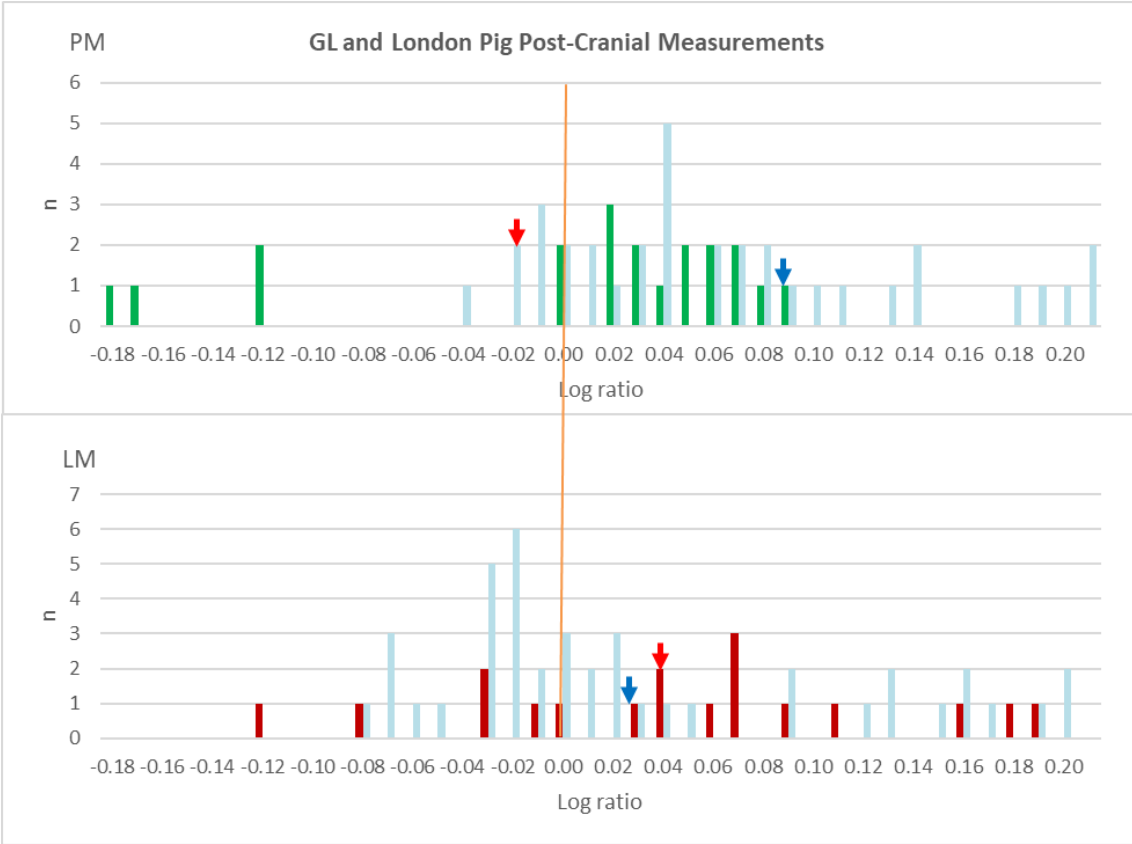

Figure 3.70: Comparison of Great Linford and London pig post-cranial measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

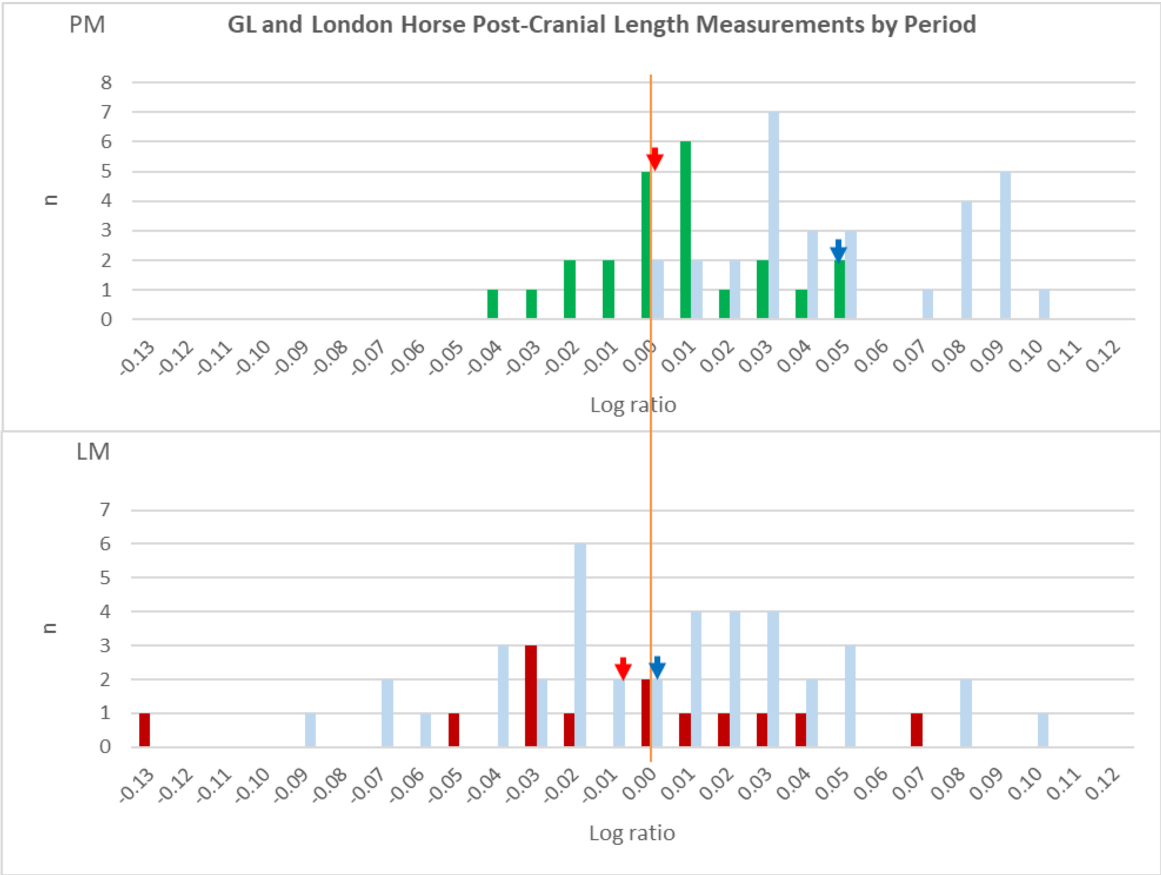

Figure 3.71: Comparison of Great Linford and London horse length measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

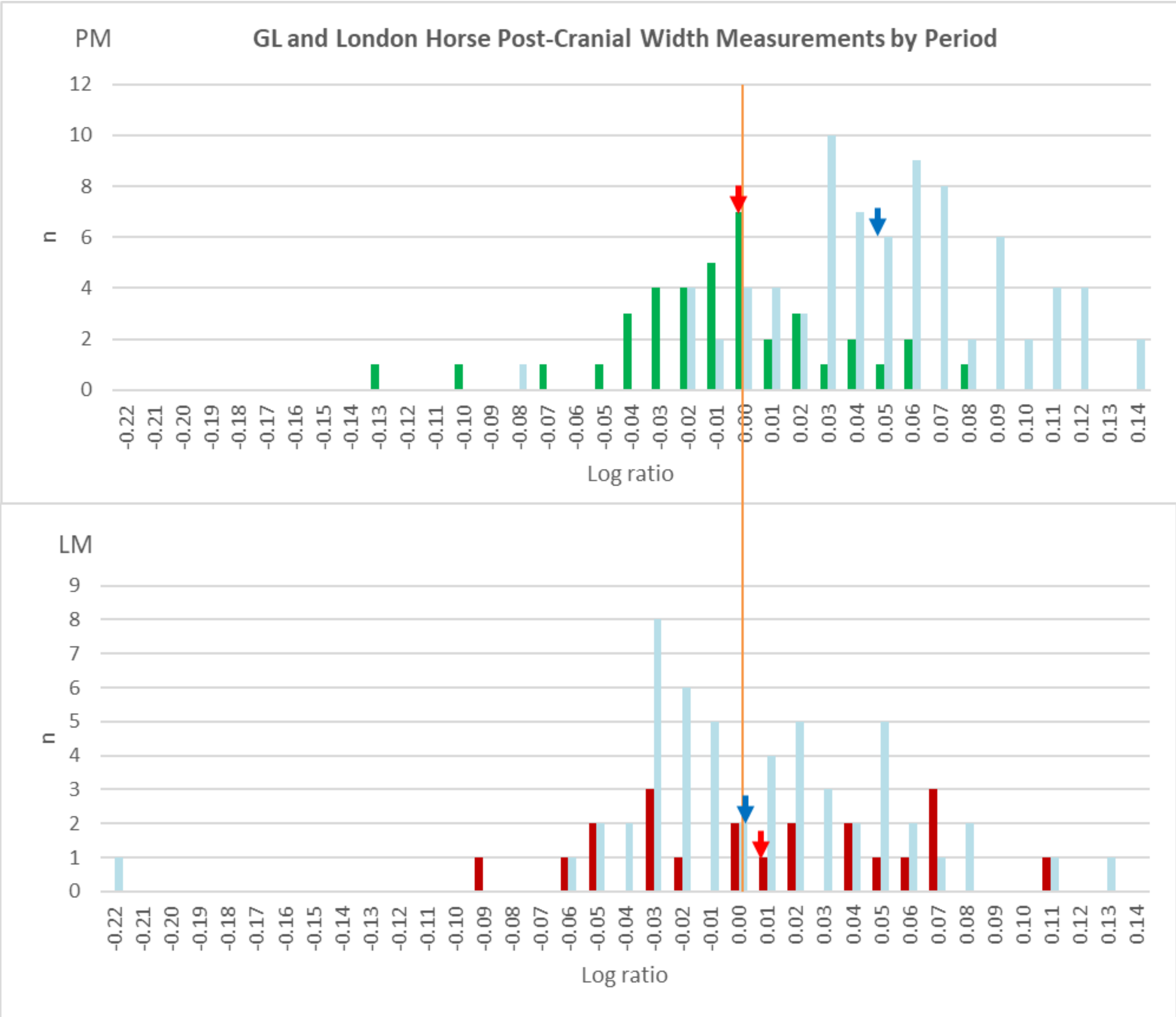

Figure 3.72: Comparison of Great Linford and London horse width measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

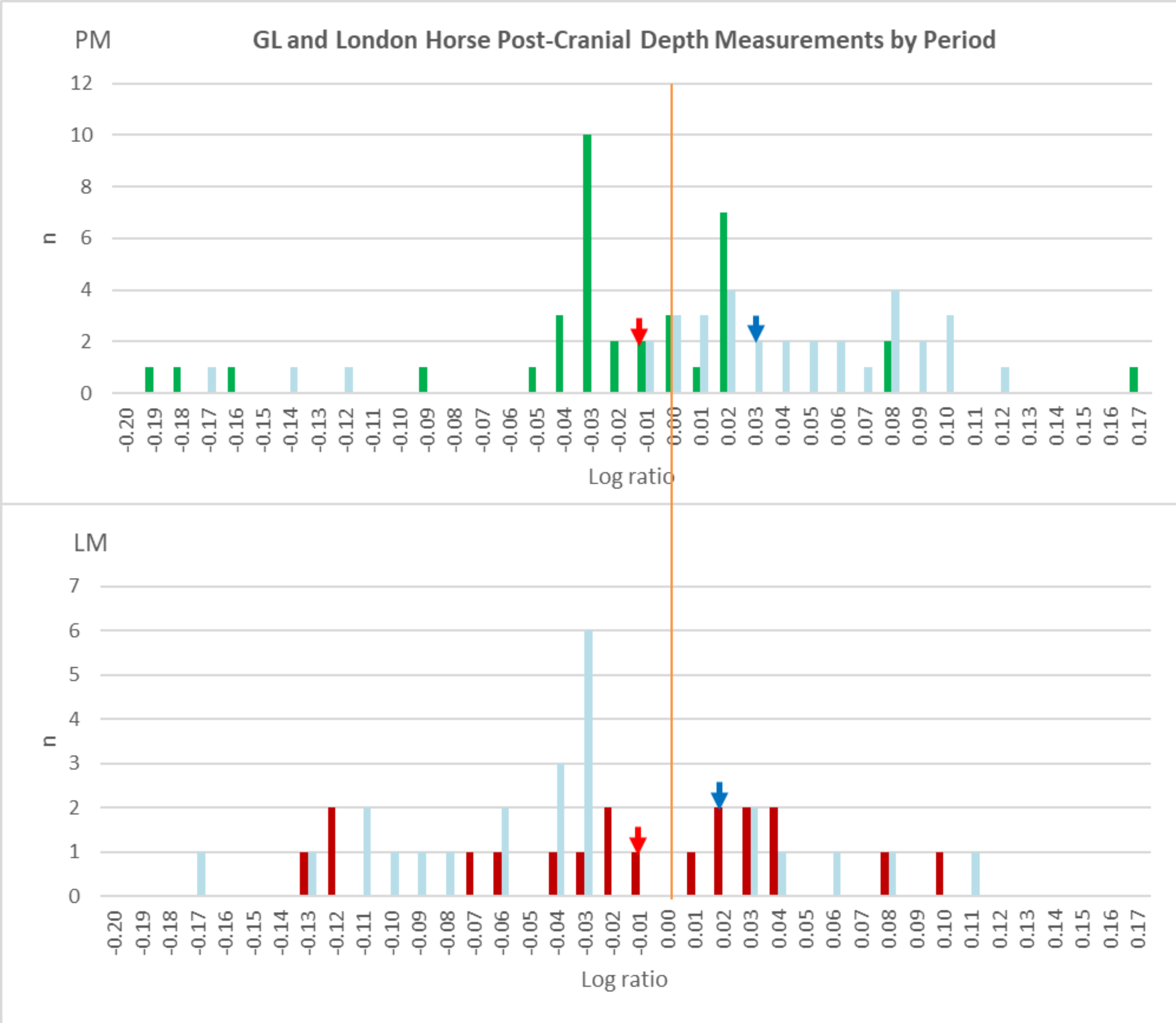

Figure 3.73: Comparison of Great Linford and London horse depth measurements by period. London measurements are shown in the light blue bars, with the Great Linford and London means represented by the red and blue arrows respectively.

3.3 Discussion

Several patterns emerge regarding animal exploitation at Great Linford throughout the Medieval to post-Medieval periods. For example, an increasing proportion of sheep is clear from the tenth century onwards, reaching a peak in the 15th-16th century (see Table 3.27 for species frequency summary). This increasing frequency of sheep appears to be at the detriment of cattle, which decline in proportion over the same period, suggesting a growing preference for sheep over cattle from the tenth to the sixteenth century. Indeed, Reed (1979,100) states that sheep were important to the economy of the parish, and landowners often had sizeable flocks in the Medieval period. This popularity could be due to the increased demand for wool during this time, which is also reflected in the ageing results for sheep. Fusion ageing shows a high survival of sheep past 42 months in all periods, especially the earlier and late Medieval, which suggests that sheep were not killed before this age for meat (see Table 3.28 for summary of ageing data). Dental ageing results indicate a peak in sheep kill-off around 2-3 years, accompanied by a relatively gradual kill-off after this age. This is similar to the dental ageing pattern that Albarella (1997a, 24) demonstrates was common on late Medieval rural sites producing wool. It is therefore possible that, while sheep were used for wool at Great Linford, the pattern of exploitation was not totally specialized, and a significant number of animals were also exploited for meat around two to three years of age. However, the butchery evidence does not indicate the specialised, organised butchery for meat observed on urban sites, as there is a distinct lack of butchery recorded throughout the study period, and no distinct evidence for the exploitation of specific meat joints (Rixson 1989; 2000). The few marks observed could indicate that sheep were only used for meat after producing several fleeces, supported by the predominance of adult animals throughout the study period. Certainly, the historic evidence from North Buckinghamshire suggests that up to the sixteenth century, much enclosure was motivated by rising wool prices. In combination with the zooarchaeological data, this would suggest that in Great Linford the increasing frequency of sheep up to the sixteenth century was the result of their increased exploitation for wool. The metric results for sheep from Great Linford show no significant change in tooth size from the tenth to the eighteenth century (see Table 3.29 for tooth metric summary). However, there is apparent change in sheep post-cranial length measurements, as the 13th-14th century average is significantly greater than the preceding and following phases (see table 3.30 for post-cranial metric summary). The 15th-16th century mean is also significantly larger than the previous phase. This results in a larger average sheep element length in the late Medieval period which could represent the increased presence of wethers for wool production, though a lack of metacarpals does not allow the assessment of sex ratios. Furthermore, the sheep coefficient of variation data show increasing CV values from the 15th-16th century, indicating some change in sheep husbandry after this point, though there is no definite evidence that this was caused by changing breed, rather than just shifting sex ratios. Therefore, it is difficult to definitively link this zooarchaeological pattern to enclosure – the increased frequency and variation in sheep from the end of the late Medieval period may have been the result of the choices of individual landowners after the abolition of common rights, though it more likely reflects the increasing demand for wool as change begins before enclosure.

As mentioned above, the frequency of sheep at Great Linford was contrasted by that of cattle. Cattle frequency declined from the tenth to the sixteenth century, but recovered at the same time as the decrease in sheep. The importance of cattle to the parish is demonstrated in the perpetuation of related field names even after enclosure – both *Greater Cowpen Meade and Little Cowpen Meade* survive on the post-enclosure map. Reed (1979) suggests that the increasing presence of cattle on the site after the sixteenth century was linked to the decline in the cloth trade, causing a shift in focus towards cattle husbandry. This changing focus may also have been linked to the rising demand for veal and dairy, and the reduction in cattle as traction animals, from the fifteenth to sixteenth centuries

(Albarella 1997a), which is somewhat reflected in the dental ageing from Great Linford. In all periods of the site, dental ageing indicates that the majority of cattle remains were adult or elderly which suggests use for traction; however, there is an increase in juvenile and subadult remains in the post-Medieval period, which points towards the exploitation of some younger cattle. However, there does not appear to be a considerable change in animal size or shape throughout the study period, as neither tooth or post-cranial measurements significantly shift. This contrasts the marked increase in cattle size demonstrated at London from the fifteenth century, and suggests that, either this improvement was not taking place at Great Linford, or larger animals were being taken elsewhere, probably to be exploited for their greater meat output. Coefficient of variation results from the site could support the latter interpretation, as they show a decrease in variability in the post-Medieval period, perhaps indicating the removal of larger individuals from the herd, thus increasing homogeneity. Overall, it seems that any change in cattle husbandry at Great Linford in the post-Medieval period was largely the result of changing market demands, particularly the increased popularity of veal. However, contemporaneous landscape change in the parish may also have contributed to this modification, as the enclosure of Great Linford resulted in a large-scale conversion to pasture, which likely enabled the exploitation of cattle for meat, as it removed the need for traction animals to plough the previously large proportion of arable land.

The presence of pigs at Great Linford in the earlier and late Medieval periods is attested through evidence of furlong names such as *Pigs Hill*, though it appears that the species declined through time, with this associated field name being lost after enclosure. Species frequencies show pigs at their most prevalent in the earlier Medieval period and the start of the late Medieval, followed by decreasing numbers in the late Medieval and post-Medieval periods. Albarella (2009) suggests that decreasing pig frequency in the late and post-Medieval periods was the result of the expanding wool trade, causing sheep frequency to increase at the detriment of pig – a process which was hastened by the increasing clearance of woodland from the fourteenth century (Hamilton and Thomas 2012). This could explain the particular decrease in pig abundance in the 14^{th}-15^{th} century, as historical evidence suggests that the wool trade had reached its peak by that time in North Buckinghamshire. Perhaps unsurprisingly, fusion ageing results from Great Linford show a substantial drop in survival around 1-2 years of age throughout the study period, indicative of exploitation for meat. In contrast, tooth ageing indicates the kill-off of many more subadult and adult individuals, suggesting that a significant amount of pigs were surviving to early adulthood in Great Linford throughout all periods. The presence of castrated animals may have caused this discrepancy between the ageing methods, as it can delay fusion, leading to an overrepresentation of young animals. Despite the appearance of new butchery methods in the post-Medieval period, butchery results from Great Linford do not suggest the specialised urban style of butchery on the site – it is more likely that older animals were butchered on-site for village subsistence, while younger individuals were sent to urban centres for slaughter and butchery. Tooth metric information does not suggest a significant change in pig size associated with landscape reorganisation at Great Linford. Post-cranial measurements, however, indicate a slight increase in size between the earlier and late Medieval periods. This was followed by a statistically significant decrease in the post-Medieval period, accompanied by a decrease in variation, though post-cranial measurements suggest the presence of two morphotypes. Therefore, it could be that the decrease in average pig size was due to the increased sale of males from Great Linford to urban centres for meat. However, it may also relate to the change in land organisation after enclosure in the parish, as following enclosure fields were considerably smaller, and large areas of specialised common grazing, such as *Pigs Hill*, had disappeared. This could mean that the pigs kept in the parish after enclosure no longer had access to the common grazing on waste and meadow present in the late Medieval village, which would have decreased their dietary diversity, though Hamilton and Thomas

(2012) suggest that this actually may have caused an increase in size. Overall, while the use of pigs apparently did not change in Great Linford with enclosure, it is apparent that the number of pigs and their size decreased in the post-Medieval period, which could be due to a combination of factors like trade and land reorganisation.

In contrast to pig frequency, the number of horses at Great Linford increases slightly in the post-Medieval period, which may reflect their increased use for ploughing as cattle were increasingly exploited for meat. However, horse numbers continue to increase despite a lack of arable land in the parish after enclosure in the seventeenth century, which suggests that they were used more for trade and transportation during that time. Furthermore, the proportion of fused bones in all periods suggests the use of adult horses for this purpose. There is no significant metric evidence to suggest that the size or shape of horses changed dramatically with this change in frequency and function, and CV values are largely consistent throughout the three main periods. This could suggest that, while the function of horses may have changed around the time of enclosure at Great Linford, this landscape reorganisation did not much affect how the animals were reared.

Table 3.25: Summary of species frequency data for Great Linford by period. The letters in blue give the crofts where the highest proportion of each species is found in each period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	Most abundant species (48% NISP)	Second most abundant species (29% NISP)	3rd most abundant species (16% NISP)	Lowest Frequency (7% NISP)
LM	Increasing abundance from C.13th to 16th (56% NISP overall) A, D, H, L	Decreased abundance (25% NISP), lowest frequency in C. 15th-16th B, F, G	Decrease to 13%NISP, under 10% in C. 14th-15th L	Slight decrease to 6% NISP, lowest frequency in C. 15th-16th B, F
PM	Slightly decreased abundance (54% NISP) A, L	Similar to LM abundance, slight increase in individual phases G, L	Remains at 13% NISP A, G	Slight increase to 8% NISP, above 10% in C. 17th-18th G

Table 3.26: Summary of ageing data and likely exploitation of species for Great Linford by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	High survival Kill-off peak at 3 years Wool, maybe some meat	Peak in adult and elderly Traction, with some meat exploitation around 2-3 years	Peaks in subadult and adult Meat at c. 1 ½ -2 years	High survival (4% unfused) Traction/ transport
LM	High survival Kill-off peak at 3 years Wool, maybe some meat	Peaks in adult and elderly, with an increase in elderly Traction?	Peaks in subadult and adult Meat at c. 1 ½ -2 years	High survival (5% unfused) Traction/ transport
PM	High survival Kill-off peak at 3 years Wool, maybe some meat	Increases in adult, subadult and juvenile Traction, with some meat exploitation around 2-3 years	Peaks in subadult and adult Increase in immature Meat at c. 1 ½ -2 years	High survival (0% unfused) Traction/ transport

Table 3.27: Summary of tooth metric data for Great Linford by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	No significant change CV: 6.2-7	No significant change CV: 8.5-9.8	No significant change in tooth length CV: 8.8-9.9	N/A CV: 5.6-17.6
LM vs. PM	No significant change CV: 7-7.5	No significant change CV: 9.8-6.5	No significant change in tooth length Significant decrease in C. 16th-17th tooth width* CV: 9.9-7.8	N/A CV: 17.6-17

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

Table 3.28: Summary of post-cranial metric data for Great Linford by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	Significant increase in length (C. 13th-14th and C. 15th-16th)** CV: 2.4-6.7	No significant change in post-cranial length, width or depth CV: 10.3-10.5	No significant change CV: 6.7-8.4	No significant change CV: 8.3-9
LM vs. PM	Decreased PM distal humerus measurements** Significant decrease in length* CV: 6.7-7.7	No significant change in post-cranial length, width or depth CV: 10.5-6.6	Significant decrease in post-cranial size** CV: 8.4-5.7	No significant change CV: 9

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

When assessing any change in animal exploitation at Great Linford, it is important to consider potential trade links the parish may have had, as it is unlikely that it existed in total isolation, and probably contributed to feeding the population of urban centres. Historic accounts suggest that the nearest markets serving the Milton Keynes area by the late Medieval period were Bedford and Northampton, though a number of smaller more local markets were present in Newport Pagnell, Olney and Hanslope (Croft and Mynard 1993). There is also evidence that Stony Stratford and Fenny Stratford, both on Watling Street, were established as market towns with weavers, fullers, tuckers, shearers and dyers by 1487 when the cloth trade was thriving (Markham 1986). Furthermore, Blackmore (1991) indicates that livestock from Great Linford was likely being sold over a very large area by the late Medieval period, which included Leicester, Nuneaton, Ashby-de-la-Zouch, Derby, Abbot's Bromley, Leeke, London and Eltham. This trade was facilitated by multiple roads serving the village, many of which originated before the late Medieval period. For example, a Roman road crossed the south of the parish, and led from Little Horwood to Willen. There were also two Saxon roads, traversing east to west through the village, passing through Oxford, Cambridge, Bedford, Newport Pagnell and Buckingham (Croft and Mynard 1993). Several other roads crossed Buckinghamshire, leading to major urban centres such as London, Bristol and Carlisle, with a "dense network of roads, lanes and ways" between them granting access (Reed 1979, 105). Zeepvat (1993) asserts that minor roads within the parish were formalised as part of the enclosure process, potentially enabling a greater volume of trade in the post-Medieval period. A greater amount of agricultural produce also made its way from North Buckinghamshire to London via the Thames from the sixteenth century onwards (Reed 1979). In fact, Reed (1984) suggests that many of the tenants of Great Linford after enclosure were butchers, graziers and dairymen involved with supplying the London market, suggesting that animal products from post-Medieval Great Linford were frequently sent to the capital, likely using local markets as 'staging posts' between producers and the city. This trade link to London may have strengthened after enclosure, when merchant Sir William Pritchard, then sheriff of London and later mayor, purchased the parish. Lisle (1757) asserts that it was possible to drive sheep and cattle fifty miles without losing much of their weight (Lisle 1757), making the fifty-mile journey to London feasible, especially as Keene (1989) considers London's supply territory to have extended fifty miles from the city. It was therefore probable that livestock from Great Linford were driven to urban centres such as London to be slaughtered and butchered, especially in the post-Medieval period (Thomas et al. 2013). This is important to consider when assessing any change in livestock size or exploitation at Great Linford, as evidence suggests that Great Linford was likely involved in supplying the London markets, altering the species frequencies, ageing and metric data remaining at the rural site.

The metric comparison between London and Great Linford livestock gives a clear pattern from the late to the post-Medieval period. For all species, the livestock dimensions are similar at both sites in earlier phases, particularly the thirteenth to fourteenth centuries. There are also several examples, such as sheep and cattle post-cranial length, where Great Linford values are greater than London in this phase. However, by the fifteenth to sixteenth century all species studied are larger in London across all dimensions, and by the sixteenth to eighteenth century a substantial increase in size can be seen in the London results, resulting in much larger averages than those at Great Linford. Perhaps, then, any improvement in terms of animal size at Great Linford is not evident as larger animals were driven to London to provide a greater meat yield and therefore profit. While not all livestock reared in Great Linford were likely destined for the London market, the metric evidence from both sites highlights the difference in rural and urban areas, as the transport of larger meat animals produced in rural areas may have inflated the size of livestock found in towns from the fifteenth century.

The exchange of animals from Great Linford to London could also explain the relative lack of juvenile animals, especially cattle and pig, recorded using dental ageing at Great Linford. It is possible that livestock to be sold for meat at urban markets represented the younger stock of prime meat age, leading to the overrepresentation of subadult, adult and, in the case of cattle, elderly, animals at Great Linford which were used for breeding. Numerous sources attest to the supply of livestock, particularly cattle, to London markets in order to cater for the rapidly expanding city population, which exceeded 500,000 in the seventeenth century, and no doubt put considerable strain on the supply of food (Armitage 1978). It has been suggested that a national network of livestock exchange supplied the city, and increasingly during the post-Medieval period as the demand for meat rose, animals were brought from further afield and fattened in the Home Counties before being sold at butchers' shops and city markets (Armitage 1978; Galloway and Murphy 1991). Therefore, Great Linford may have been one of the manors described by Keene (1989) where London graziers fattened their stock before taking them into the city, especially after the widespread switch to pasture. This is also attested by Mortimer (1712, 169), who states that "In…most places near London, they commonly fat all their calves for the butcher, because there they have a good market for them…". Therefore, the apparent lack of larger, 'improved' animals and juvenile livestock at Great Linford in the later and post-Medieval period may be the result of the parish being used to supply London markets, resulting in the most profitable animals being taken to the city, and smaller stock remaining in Great Linford for village subsistence.

Overall, it seems that any change in livestock husbandry at Great Linford was the result of both market demand and, perhaps to a lesser extent, landscape reorganisation. The prevalence of sheep at the site up to the sixteenth century most likely reflects the importance of the English wool industry, but the decline in frequency in the post-Medieval period suggests a change in function of the site after enclosure, perhaps due to the decreasing size of fields and conversion to pasture. This landscape change associated with enclosure may have enabled the parish to more effectively cater to the increasing demand for meat, particularly veal, as it entirely removed the need for older traction animals. Furthermore, the removal of common rights associated with enclosure allowed for the operation of external graziers in the parish, potentially fattening livestock for sale in local markets, or nearby urban centres like London. While this is plausible based on historic and landscape information, the zooarchaeological evidence does not point towards a clear chronological trend in livestock size at

Great Linford, which suggests that livestock husbandry displayed continuity, rather than change, after the enclosure of the parish.

4. Wharram Percy Results

4.1 Historical and Landscape Background

4.1.1 Late Medieval Wharram Percy

There are relatively few historical documents relating to Medieval Wharram Percy, owing to its rural location. However, evidence from aerial survey, geophysical survey, fieldwalking and excavation has been used in combination with the limited historical information and more general studies of farming practice in East Yorkshire to provide a picture of the village in the late Medieval period.

The very first documentary evidence of the township of Wharram Percy comes from the Domesday Book, where it is listed as 'Warron' (Oswald 2004). The township itself encompasses the parishes of Burdale, Thixendale, Raisthorpe, and Towthorpe, and the name is of Old Scandinavian origin meaning 'at the bends', which refers to the Z-bends of the valley in which the site lies (Roffe 2000). It is likely that a nucleated village at Wharram Percy came into existence around the late tenth to twelfth century, with a regular layout which is suggestive of a single planning episode (Oswald 2004). This nucleated settlement developed into what Everson and Stocker (2012) describe as a recognisable village layout, replacing a collection of smaller, dispersed settlements, each with a small-scale field system, and was associated with the formation of large open fields farmed in common. The Domesday record for Wharram Percy also gives evidence of the scale of the village, as it lists eight carucates of land, which is the area worked by eight plough teams, divided into two 'manors'. These manors are recorded as being held by tenants Lagmann and Carli from before the Conquest, and were likely associated with the West Row of the village, which was divided into north and south holdings, and later became part of the South Manor (Roffe 2000; Everson and Stocker 2012). A further carucate of land was held by Ketilbjorn, and probably located on the North Row, which was later associated with the North Manor, though in the eleventh century this land was likely attached to a third manor, probably in Wharram le Street (Wrathmell 2012b). This early settlement was accompanied by a form of arable open cultivation, which was practiced to the west of the West Row, and the north of the North Row, potentially with pasture beyond (Figure 4.1).

From the twelfth century, the parish landholders predominantly originated from the Montfort, Chamberlain and Percy (of Bolton Percy and Spofforth) families. The earliest references to the Montfort and Percy families are documented in the 1176-7 pipe roll, where William Percy (of Bolton Percy) is documented as owing Robert Montfort 100 marks for "having his right of the land of Wharram…", which is most likely referring to the right to the carucate on the North Row previously held by Ketilbjorn (Pipe Roll Soc. 1905, 26 ,78; Oswald 2004). Robert was later replaced by Henry Montford, his brother, and these payments continued until 1198. Around the same time, the South Manor was completed, though it is unknown whether it was built by the Percy family as their interest in the township increased, or by one of the other dominant families (Wrathmell 2012a). The Chamberlain interest at Wharram Percy first emerges in a feudal assessment of 1242-3, in which Henry Chamberlain is listed as holding a quarter of a knight's fee in the township (the amount of land deemed sufficient to support a knight) (Roffe 2000). By the mid-thirteenth century, the Chamberlain family were the most important landowners in the village, now known as 'South Wharram', as they held both holdings previously tenanted by Lagmann and Carli (Oswald 2004). However, in 1254 Henry Chamberlain relinquished his claim to the rights he held in the parish to Peter Percy I (of Bolton Percy), in exchange for 40 marks. Therefore, by this time the Percy family (of Bolton Percy) had acquired both the North and South Manors, though the destruction of the South Manor occurred in the mid-thirteenth century and the North Manor became the manor house of the Percy family, asserting their status in the parish (Wrathmell 2012a). From this date the manor of Wharram Percy passed through the Percy family, as when Peter Percy I died, his holdings passed to his son, Robert, along with the advowson to the church. It is likely that Robert Percy III occasionally based his household at Wharram and developed a hunting ground and park, and the name Wharram Percy was first used in 1292 due to this continued association. The Percys of Bolton Percy held the tenancy in chief for the whole of Wharram Percy into the fourteenth century, meaning that they held land in tenure directly from the king. However, in 1321 when Robert Percy died, he left no surviving male heir, meaning that his holdings in Wharram Percy were eventually transferred to Henry Percy of Spofforth, who in 1403 exchanged the manor with the Hilton family of Hylton Castle (nr. Sunderland) in return for a manor at Shilbottle (Northumberland), as it was closer to the Percy's main seat in Alnwick and Warkworth (Oswald 2004; Beresford 1979).

Several surviving inquisitions after the deaths of Percy and Hilton family members suggest a period of economic downturn at Wharram Percy from the fourteenth century. A 1323 document records that of the eight and-a-half carucates associated with manor land only one-third was cultivated, and it was claimed that a number of holdings were unoccupied (Wrathmell 2012c). Wrathmell (2012a) suggests that this downturn was due to a period of costly wardships after Robert Percy's death due to his lack of heir, though also states that there were still eighteen households still present in the township at this time. Nevertheless, as the fourteenth century progressed, the situation in Wharram did not improve, and by 1368 the North Manor House was in need of extensive repairs, and the population of the township had decreased from around 67 to 45, though it has been suggested that the land previously neglected was once again cultivated (Oswald 2004). By the fifteenth century, the number of households in the parish had dropped to sixteen, and the only reference to the manor was to the site where it was once situated. During this time a broader change in farming was taking place across the Wolds, causing a sharp decline in population and a reduction of cultivation as land was increasingly used for pasture (Wrathmell 2012c). At Wharram Percy this was accompanied by evictions, many undocumented, and the deliberate destruction of houses, probably instigated by Baron Hilton between 1488 and 1508 (Oswald 2004). Sixteenth century glebe terriers from the township demonstrate the withdrawal of land from cultivation, as cultivated glebe land was confined to a smaller area from the fifteenth century as the less fertile and higher ground was converted to pasture. However, Wrathmell (2012c, 295) argues that this change did not constitute a "wholescale recasting of the field-system's physical structure", as the basic field structure remained at Wharram Percy past this point.

It appears that, though East Yorkshire was categorized by Gray (1915) as part of the Midland Open Field belt, the topographical variation across the county prompted a much more diverse pattern of agriculture during the late Medieval period. Some areas of the region superficially displayed many characteristics of open field farming, such as two or three open arable fields farmed in rotation, and regulated cropping and communal grazing, but the Dales, Pennines and Moors contained many smaller irregular fields which were likely enclosed in a piecemeal fashion at an early date (Harris 1959; Harvey 1982). These areas however, contained large amounts of common pasture, meaning that convertible husbandry, where pasture was converted to arable use for a short period of time, was commonly practiced (Hall 2012). Conversely, in the Vales of York and Pickering, and on the Wolds, two and three field arable systems were the most common form of land use (Harris 1959). In the late Medieval period, there were ten townships in East Yorkshire displaying evidence of two field systems (Gray 1915). These included sites like Kilham on the Wolds, Marton and Brandesburton, as well as Wharram Percy (Hall 2012). However, three field systems were more common in East Yorkshire during the late Medieval period, as 25 examples have been identified (Gray 1915), including Snainton, Appleton-le-Moors, Kirkby Moorside, and Skirpenbeck. There is some geographical variation in field number, as in Holderness two field systems were more common, whereas parishes in the Wolds were much more variable, ranging from two fields in narrow villages up to four in other areas (Harris 1959). Therefore, at Wharram Percy the two-field system set out in a regular structure was relatively uncommon for a township on the Wolds, though not unusual in the context of East Yorkshire overall (Dyer 2012a).

The typical layout of a late Medieval Yorkshire two or three-field system included individual strips, or *selions*, of arable land dispersed throughout the open fields. These strips were grouped into oxgangs, which varied greatly in size between seven and twenty acres, sometimes even within a single village (Hall 2012). Oxgangs were not only a unit of land measurement, but also included a share in the common land of the parish (Harris 1959). The township of Wharram Percy contained 68 oxgangs, 27 in demesne and 41 tenanted, which were organised in groups of eight to form a carucate (Dyer 2012a). This was typical of the "simple and regular" structure of land holdings described by Hall (2012, 280) present in the Wolds and Holderness from at 1250. Accompanying the large open arable fields in the late Medieval period were common areas of meadow and pasture, which Sheppard (1973) suggests was particularly prevalent across the county in the thirteenth to fourteenth centuries. Almost all of the Wolds, except the steep-sided valleys, are covered in ploughing ridges, suggesting that much of the land was under plough at some point; however, there are several examples of permanent pasture appearing in the area surrounding Wharram Percy by the twelfth to thirteenth centuries, for example at Raisthorpe to the west, Towthorpe to the east, and Huggate to the south (Wrathmell 2012d). This was also the case in Wharram Percy, where 1250 acres were ploughed at the maximum arable extent (Figure 4.2), but areas of permanent pasture were present by the late Medieval period in the valleys of Drue Dale, Deep Dale, and Wood Dale. Landholders in Wharram Percy had access to common grazing on this permanent pasture, as well as areas of commons on the high Wolds known as intercommoned uplands, which was shared by multiple parishes. An example of one such area is 'Great Wharram' in Thixendale parish (Dyer 2012a). Those with rights of common pasture could graze as many animals on this common land as they could sustain on their own land over the winter, as in the winter livestock were kept in crofts where their diet was supplemented with straw, hay, peas and oats. Crofts at Wharram Percy lay behind the village tofts (homesteads), and exceed 100 metres in length in the northern part of the West Row (Oswald 2004). This system of livestock grazing in the township was supplemented by seasonal grazing of the 265 acres of yearly fallows, as well as land after harvest (Dyer 2012a). This in turn increased the fertility of the soil by facilitating the spread of manure, though pottery scatter evidence from fieldwalking at Wharram Percy also suggests that manure was also spread manually alongside general refuse, especially in the north of the village (Dyer 2012a; Wrathmell 2012d).

Overall, the township of Wharram Percy in the late Medieval period exhibited a regular pattern of land use which included two large open arable fields farmed in rotation with fallow periods, accompanied by common livestock grazed on permanent pasture, intercommoned uplands, and fallow arable areas. While this pattern of land use was less common in the higher Wolds, it was not infrequent generally across East Yorkshire.

4.1.2 Enclosure

Enclosure of open field villages started relatively late in East Yorkshire, with much enclosure in Holderness occurring in the sixteenth century, and parishes on the fringes of the Wolds affected by general enclosure from the sixteenth century onwards (Harris 1961). Early parishes to be enclosed in the Wolds included Kirby Underdale, which was affected as early as 1583, as well as Birdsall, Langton, Scagglethorpe and Thorpe Bassett, which were enclosed by private agreement between 1650 and 1726. Further general enclosure took place during the second half of the eighteenth century in Duggleby, the Heslertons, Kirby Grindalythe, North Grimston, Rillington, Settringham, Sherburn, Sledmere, Thixendale and Wharram-le-Street. However, some East Yorkshire parishes, such as Fimber, Helperthorpe, the Luttons, and Weaverthorpe, were not enclosed until the early nineteenth century (Wrathmell 2012e). Neave (1993,128) demonstrates the significant contraction of many Wolds villages around the seventeenth and eighteenth centuries using hearth tax returns – she states that the reduction of East Riding population by 19 percent at this time was the result of changes in land use or agricultural practice, likely linked to enclosure. A common reason for enclosure recorded in East Yorkshire was the trespass of animals onto arable land, particularly the cornfields which provided a great economic contribution in the region (Hall 2012). Dyer (2012a) lists the frequency of different livestock recorded as trespassing in Bishop Wilton, around twelve miles from Wharram Percy, between 1369 and 1380 – this included 894 sheep, 69 cattle, 67 horses and 53 geese. However, another factor which led to changing land organisation in many East Yorkshire townships was depopulation and the conversion to pasture.

Towards the end of the late Medieval period, as wool prices rose, many East Yorkshire townships suffered depopulation or even total desertion as land was given over to sheep pasture. This was certainly the case in Wharram Percy, where a 1517 Government Commission of enquiry into depopulation found that four messuages (houses) and four ploughs had been deserted between Michaelmas 1488 and 1517, most likely between 1488 and 1506 (Beresford 1979; Wrathmell 2010). Nearby Burdale was also affected by depopulation in the early sixteenth century, though other surrounding villages remained populated into the seventeenth century at least – Towthorpe and Raisthorpe were depopulated by the end of the seventeenth century, and Thixendale was recorded as still containing 28 houses in 1801 (Wrathmell 2012e). Therefore, it seems that Wharram Percy was relatively unusual within the Wolds in terms of depopulation and enclosure, as the 1517 commission found that only 41 houses had decayed in the East Riding, including the four at Wharram Percy. Furthermore, Leadam (1893, 219) describes the area of the East Riding enclosed by the sixteenth century as “absolutely insignificant”, as only 6,678 ½ acres were enclosed. Only Eastburn, to the South of Wharram Percy, appears to have been entirely depopulated and converted to pasture, though only after 1666 (Wrathmell 2012e). There is evidence for a very sparse population at Wharram Percy from the early sixteenth century, and by 1555-6 documents pertaining to a lawsuit concerning the rebuilding of the parsonage contain no witnesses giving Wharram Percy as their place of residence (Beresford 1979).

By the mid-sixteenth century, open field farming at Wharram Percy had completely disappeared (Wrathmell 2010). A 1555 law suit brought to the archbishop of York documented dilapidations at Wharram Percy vicarage, and Robert Pickering of Rainsthorpe stated the parish had been completely laid to grass in 1527 (Wrathmell 2012e). This conversion to pasture must have been carried out by the lord of the manor, Sir William Hilton, though the two oxgangs of vicarage land continued to be cultivated (Wrathmell 2010). Another witness, Thomas Marwen of Acklam, confirmed that the vicarage land was cultivated until at least the 1540s, though it was likely that the yield was reduced due to contamination from grass land. The main motivation for the conversion of the parish to grass was for the rearing of sheep to meet the demand for wool, which was a common cause for depopulation in the region. Wharram Percy has been described by Wrathmell (2012e) as a classic example of open-field enclosure in the area, with the wholesale conversion to permanent pasture. Indeed, there is evidence from a 1543-4 dispute between vicar Marmaduke Atkinson and John Thorpe of Appleton, regarding tithes of fleece, lambs and hay, that much of the pasture and hay listed in the depositions was provided by Wharram Percy (Wrathmell 2010). The parish was particularly attractive for sheep pasturing as the Wharram Beck offered free-flowing water in which to wash sheep before shearing. As a result, the entire parish was given over to sheep husbandry farmed by non-resident graziers like John Thorpe, meaning that by the mid-sixteenth century there were very few human inhabitants in Wharram Percy, but over a thousand sheep (Wrathmell 2012e). Despite this large-scale landscape reorganisation, Harris (1961) suggests that enclosure at Wharram Percy did not lead to an 'enclosed' landscape in the sense of physically delineated smaller fields, rather it remained undivided as a large sheepwalk, with occasional furlongs fenced and ploughed when required. This phenomenon was relatively common on the Wolds, but was not unique to the area, as Harris (1961, 29) also describes a number of villages in East Yorkshire as being "at once physically open yet technically inclosed". Examples of such villages include Cowlam, Croom and Arras, where early depopulation had been accompanied by the removal of common rights, as well as Eastburn, though depopulation did not occur here until the mid-seventeenth century (Neave 1993).

Overall, the sixteenth century saw a large-scale reorganisation of land use at Wharram Percy. Depopulation in the parish, motivated by supplying wool, led to the establishment of large swathes of permanent pasture which, even after the abolition of common rights, remained physically open. The earlier enclosure of Wharram Percy was relatively unusual within the county, as according to Sheppard (1973, 145) common land survived until around 1760 in a "considerable proportion" of Yorkshire townships, with the pace of enclosure increasing through the eighteenth century until under fifty Yorkshire townships still had common arable fields in 1820.

4.1.3 Post-Medieval Wharram Percy

By the mid-sixteenth century there was almost no arable cultivation at Wharram Percy; however, in the early seventeenth century the parish began to operate an infield-outfield system, in which a core area, or infield, was regularly and intensively cultivated arable land, supplemented by the occasional cultivation of pasture beyond (Figure 4.3) (Harris 1961). Much of the parish remained outfield pasture, cropped every three to seven years as required, and sheep were still kept on the chalk plateau (Harris 1959; Wrathmell 2010). Restrictions were also established during the seventeenth and eighteenth centuries in many leases which limited the extent of arable cultivation, as land newly converted to grass would provide a large yield, but that yield was not sustainable without manure application, resulting in grassland ruined for short-term gain (Harris 1961). Infield land was heavily manured to ensure a sustained yield, though it only constituted around 200 acres of the parish in order to supply the needs of the farm rather than produce a large surplus (Wrathmell 2010). There is evidence that on the Wolds, unlike other regions of England, the infield land was left fallow between crops. Documentary evidence from the late sixteenth century records the sale of the North manor to Matthew Hutton, then the Dean of York and later Archbishop, and shows that by 1573 the non-resident graziers of the 1540s had been replaced by a resident farmer who rented the whole parish, including the formerly cultivated vicarage land (Oswald 2004). Muster Rolls of 1584 list four unnamed men as residents of the township, one likely the tenant of Hutton’s messuage and land, and all probably part of the Weddell or Milner families, who appear in documents between 1598 and 1604 (Wrathmell 2010). In terms of economy, Wharram Percy was still very much a sheep farm – this is shown in the probate inventory of William Botterell in March 1699, as sheep make up around 73% of total livestock value, with draught horses and oxen making up only 17%, and dairy cows only 8%. In the inventory, the sheep flock was valued at £257, and wool at £51, demonstrating the importance of sheep to the parish economy; however, wheat and oats were also valued at £30, highlighting the return of limited arable cultivation (Oswald 204). Draught animals would have grazed the Cow Pastures on the lower, eastern half of the Medieval village, by the Beck, as well as in the Ings Brow fields in the valley further north (Figure 4.4). Druedale, also, would have been another area of permanent pasture with access to water. Both the ‘Worthy’ block east of the Beck (40 acres), and the enclosed block to the west of the Beck (250 acres) would have been used for relatively open grazing for sheep, with restricted access to water (Wrathmell 2010).

Harris (1959) suggests that the style of infield-outfield farming seen at Wharram Percy from the seventeenth century was relatively common across East Yorkshire, especially on the Wolds where population was relatively low, soils were poor, and manure was difficult to obtain. Examples of townships where the system was practiced after the seventeenth century include Kilham, Bishop Wilton, Wetwang, Walkington and Fimber (Harris 1959; Hall 2012). However, not all Yorkshire parishes were enclosed in the same way as Wharram Percy by this period – Beresford (1951) demonstrates the survival of open field systems using glebe terriers. He states that, while there were few open fields surviving in upland areas in the north-east and west of the county, the East Riding still contained between 54-80% open field, in systems which ranged from one to five fields. It appears that the greatest frequency of enclosed land in the East Riding was seen in depopulated townships, which may explain why Wharram Percy was enclosed relatively early, due to its decreased population from the late fifteenth century (Harris 1961). The prevalence of sheep documented at Wharram Percy was also common throughout East Yorkshire, especially on the Wolds, as by the 1690s the average Wold farm had three times more sheep than lowland farms, reaching flocks of 700 to 800 in many townships and increasing throughout the eighteenth century (Harris 1961). Long (1960) also uses seventeenth century probate inventories to demonstrate a far greater frequency of sheep on the Wolds than in any other region of Yorkshire, averaging 96 animals per farm, as well as a relatively high number of horses at an average of 5.4 per farm. Conversely, cattle were considered more important in the North York Moors and Dales (Hall 2012). The large sheep flocks of the Wolds were grazed on permanent pasture, as well as meadows, outfields not under cultivation, and arable infield land after harvest (Harris 1961).

During the eighteenth-century further landscape change is evident at Wharram Percy. In 1634 Matthew Hutton's nephew, also Matthew, sold the manor at Wharram Percy to Sir John Buck of Filey, and thereafter it remained with the Buck family until 1833 (Oswald 2004). In August 1773 Sir Charles Buck began the 'Improvement' of his estate, which included the conversion of much pasture back to arable use by 1779, though conversely areas of exhausted infield land were given over to grass (Figure 4.4) (Wrathmell 2010). It also involved the division of much outfield land into fenced, hedged and ditched fields to accompany new farms, which is attested by purchase records of fencing posts and rails, quickset hedging, and gates (Oswald 2004; Wrathmell 2010). Harris (1961, 62) suggests that this large-scale 'Improvement', and associated physical enclosure, was common in the Wolds in the eighteenth and nineteenth centuries, and calculates that between 1730 and 1810, 206,000 acres were divided up in the region, leaving only 20,000 acres unenclosed. However, despite this landscape change, it seems that sheep still played a very important role in the economy of Wharram Percy, as demonstrated by a 1786 inventory following the death of tenant William Monkman which records a flock of 1,310 animals (Oswald 2004).

Overall, from the sixteenth century onwards the township of Wharram Percy underwent major landscape change, which began with the termination of common grazing rights and almost complete depopulation to make way for large-scale sheep rearing on a relatively open landscape. Though arable cultivation returned during the seventeenth century in the form of the infield-outfield system, sheep still played a vital role in the economy of the township, which continued even after the physical enclosure associated with 'Improvement' in the eighteenth century. Despite the return of resident farmers in the late sixteenth century, the population of Wharram Percy never recovered, which led to the demolition of most buildings by the mid-nineteenth century, and the last residents leaving the township in the mid-1950s.

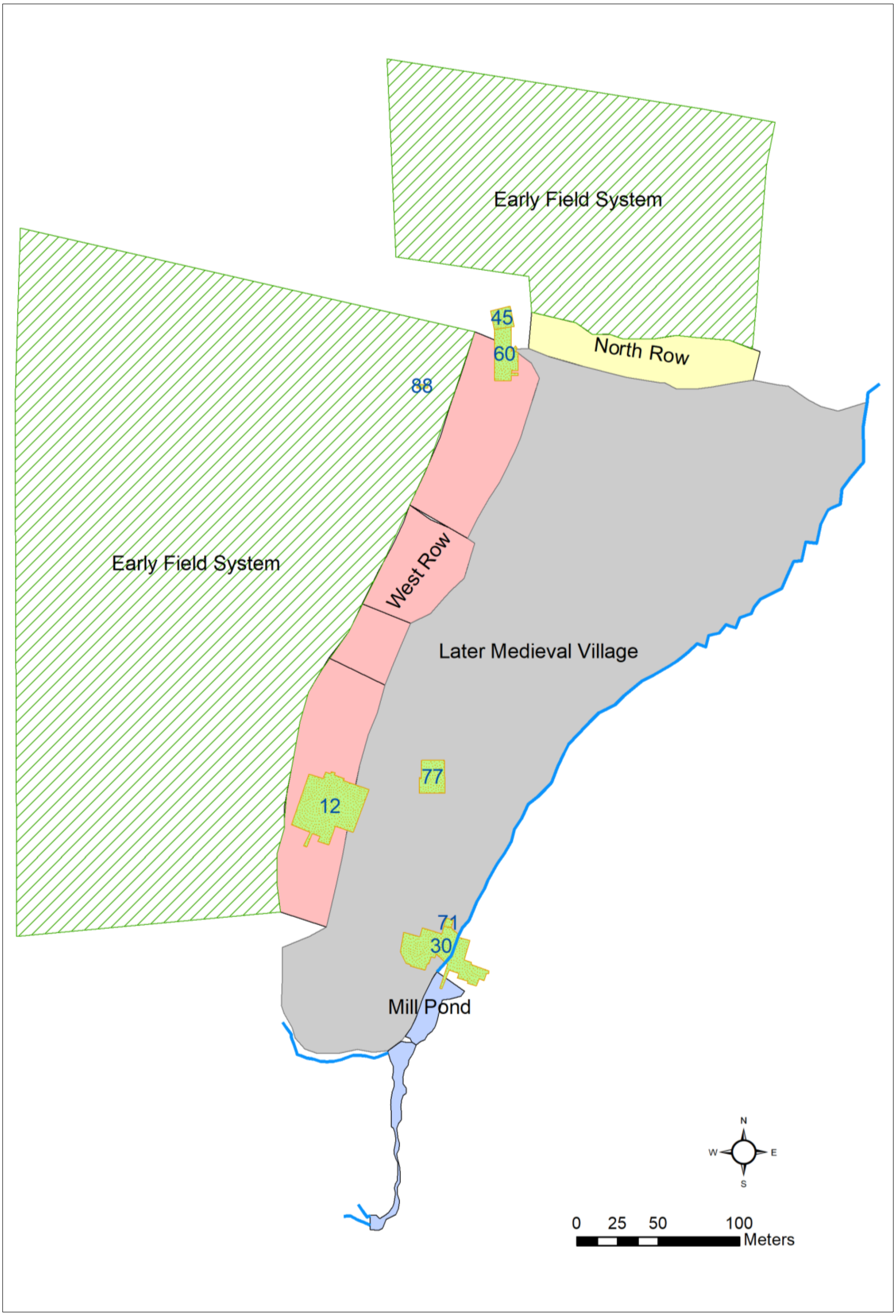

Figure 4.1: Map showing Wharram Percy village in the tenth to eleventh centuries, which highlights the land tenanted by Lagmann and Carli (pink) and Ketilbjorn (yellow). Earlier Medieval sites are labelled by site number. After Everson and Stocker (2012, Figure 81).

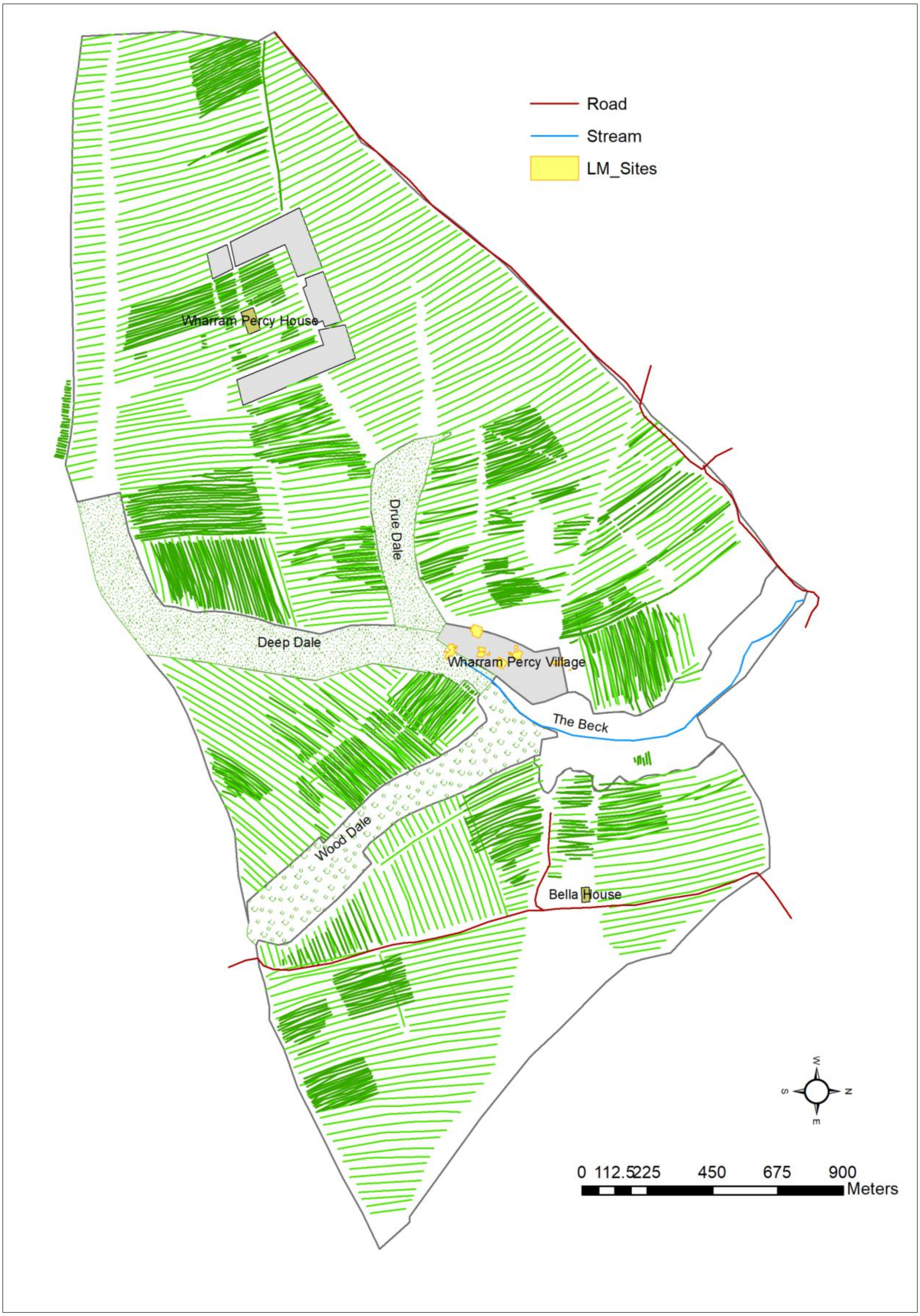

Figure 4.2: Map showing the extent of arable cultivation at Wharram Percy up to the late Medieval period. Late Medieval sites from which animal remains have been studied are highlighted in yellow. After Wrathmell 2012c, Figure 106).

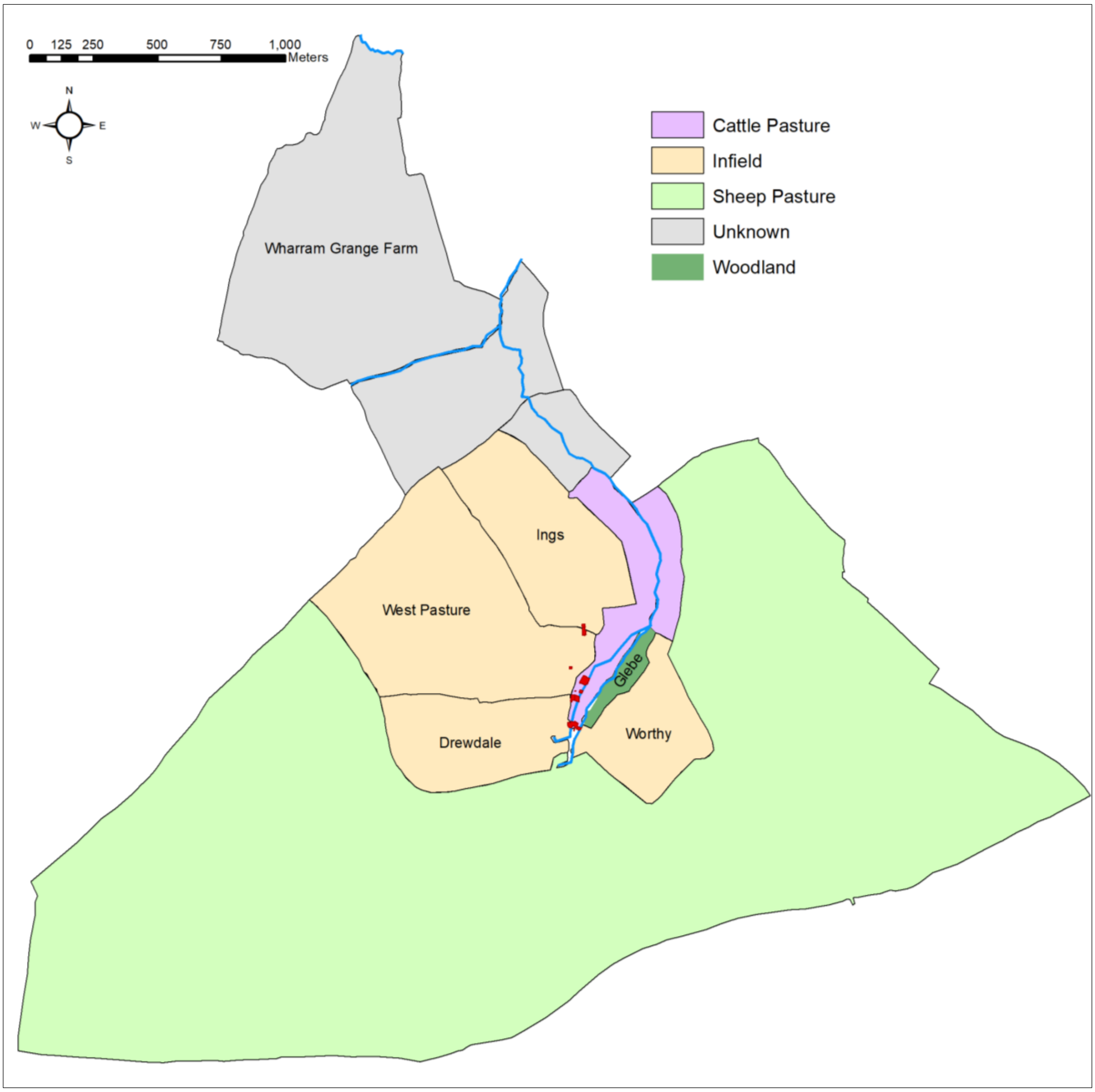

Figure 4.3: Map showing the proportion of infield and outfield land at Wharram Percy in the seventeenth century, with post-Medieval sites highlighted in red. After Wrathmell (2010, Figure 3).

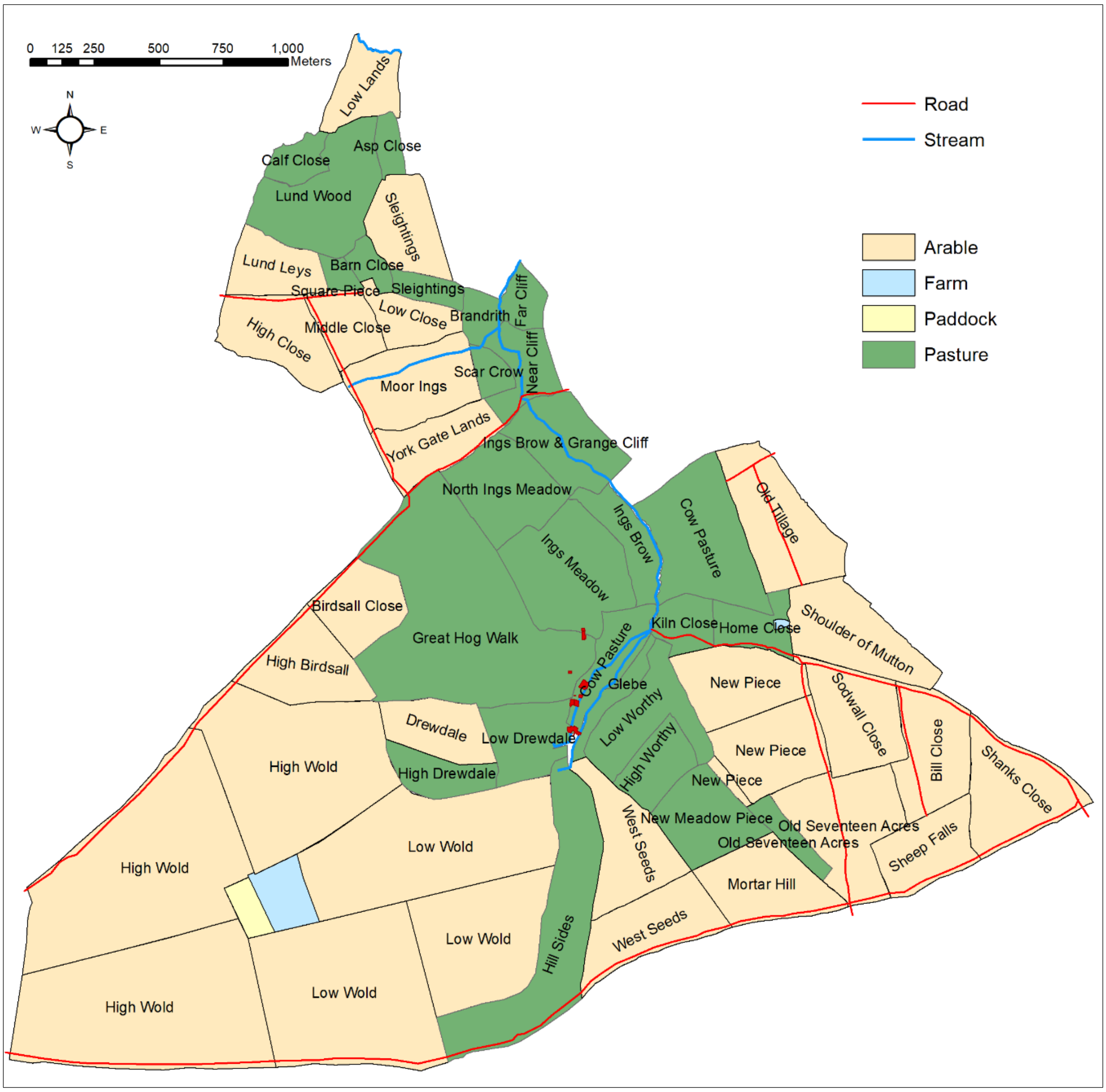

Figure 4.4: Map showing the land use and field names at Wharram Percy after eighteenth century 'Improvement', with post-Medieval sites highlighted in red. After Wrathmell (2010, Figure 4).

4.2 Zooarchaeological Analysis

4.2.1 Species Frequencies

In order to examine species frequencies through time at Wharram Percy, %NISP was assessed for both individual phases and general periods. Throughout the study period, sheep remain the most frequent animal, comprising between 45 and 65 percent of the assemblage from the tenth to the nineteenth century (Figure 4.5). It should be noted that the term 'sheep' here is used here to indicate specimens recorded as sheep (*Ovis aries*), or sheep/goat. Only one definite goat specimen was identified, which dates to the late Medieval period, which suggests minimal economic importance of this species (Appendix 13). Sheep, however, clearly contributed greatly to the economy at Wharram Percy, especially after the thirteenth century when their numbers increased by nearly 20 percent. Though this frequency declines from the fourteenth century, sheep still comprise almost 50 percent of the total assemblage in the 16th-17th centuries, increasing to 55 percent by the end of the study period. Therefore, it appears that sheep experienced sustained economic importance, particularly from the thirteenth century onwards, which is also indicated by the %NISP across the three broad phases at Wharram Percy (Figure 4.6). Across the earlier, late and post-Medieval periods, sheep represent over half the total species present. They are particularly prevalent in the earlier and late Medieval periods, and this abundance of sheep is also demonstrated by the MNI values at Wharram Percy. %MNI results across all phases (Figure 4.7) again indicate that sheep comprise over 40 percent of the total livestock numbers, with peaks of 64 and 56 percent in the 13th-14th and 17th-18th centuries respectively. Consequently, sheep %MNI throughout the three broader periods (Figure 4.8) is highest in the earlier and late Medieval periods, suggesting that the species was considered particularly important during these periods. There is a decline in frequency during the post-Medieval period, suggesting a decrease in use, though sheep still account for over half the total livestock.

The abundance of sheep at Wharram Percy seems to be in part mirrored by that of cattle throughout the study period. Cattle %NISP values start at 21 percent in the 10th-13th centuries, but decrease by the 14th-15th century, at the same time as sheep peak in frequency. There is then a recovery in cattle numbers after the 15th-16th century. This suggests that cattle contributed relatively less to the economy of Wharram Percy in the fourteenth to fifteenth centuries as sheep popularity grew, but were more commonly exploited after the fifteenth century when sheep abundance declined. This pattern is also somewhat true for %NISP values by period, which show that cattle were most prevalent in the earlier Medieval period, but experienced a decline during the late Medieval period, in contrast to the peak in sheep frequency. Cattle abundance then increased in the post-Medieval period as sheep frequency fell. %MNI results also reflect this, as cattle frequency is at its lowest in the 13th-14th century, and increases from the fourteenth century. Across the three main periods a similar pattern to the %NISP values is shown. Cattle comprise 20 percent of livestock numbers in the earlier Medieval period, but decline to 18 percent in the late Medieval period. In the post-Medieval period this figure rises, perhaps again mirroring the decline in sheep numbers in this period. Overall, cattle are the second most frequent species at Wharram Percy throughout most of the study period, and their relative frequency appears to largely contrast that of sheep.

Throughout the tenth to seventeenth centuries at Wharram Percy, pig %NISP gradually increased from eight to sixteen percent, suggesting that they progressively contributed more to the site's economy. However, during the seventeenth century this figure decreases, which may indicate a decline in exploitation. Nevertheless, %NISP values across the three broad periods show a slight increase in pig numbers between each period, which does not reflect the decrease in importance suggested by the individual phase results. %MNI results by phase echo this pattern, as they suggest an increase in pig abundance from the tenth to the fourteenth centuries, followed by a decline in the 16th-17th century and a gradual recovery thereafter. When grouped by period, they once again show a gradual increase in pig abundance from the earlier Medieval period. Overall, though the results by individual phase differ in their representation of pig abundance throughout the study period, both %NISP and %MNI results by period suggest a steady increase in pig exploitation through time at Wharram Percy.

Horse frequency is varied at Wharram Percy throughout the study period. %NISP values by phase show the greatest abundance of horse in the 10th-13th centuries, making it the second most prevalent animal during the phase. This suggests that during this phase horse were frequently exploited at the site; however, in the following century frequency drops to only six percent. This indicates a decrease in the use of the species, perhaps related to the peak in sheep numbers at this time, or a change in deposition practice, discussed in species abundance by site. In the 14th-15th century horse remains comprise 20 percent of the assemblage, though frequency once again decreases in the 15th-16th century. Between the sixteenth and nineteenth centuries, %NISP values remain between ten and fifteen percent, with an increase in the 17th-18th century. This suggests that, while there is a slight increase in frequency in the post-Medieval phases, horses were most abundant at Wharram Percy during the 10th-13th and 14th-15th centuries. In the earlier phases this pattern is largely substantiated by %MNI values, as they show a peak in the 10th-13th century, followed by a sharp decrease in the 13th-14th century and a further peak and decline in the following phases. This once again suggests a prevalence of horse in the 10th-13th and 14th-15th centuries, though small sample sizes may exaggerate the changes seen between phases. In contrast, %NISP and %MNI values for the broad periods indicate an alternative pattern of horse exploitation. Horse remains comprise eight percent of the earlier Medieval assemblage, and exhibit a gradual increase to 13 percent by the post-Medieval period. This therefore suggests that in fact horse exploitation progressively increased at Wharram Percy through time. This is also reflected in the %MNI values, which increase between the earlier and post-Medieval periods. These results by period certainly do not reflect the relatively large peaks in horse exploitation indicated by the individual phase results – rather, they suggest a gradual increase in the use of horse throughout the study period at Wharram Percy.

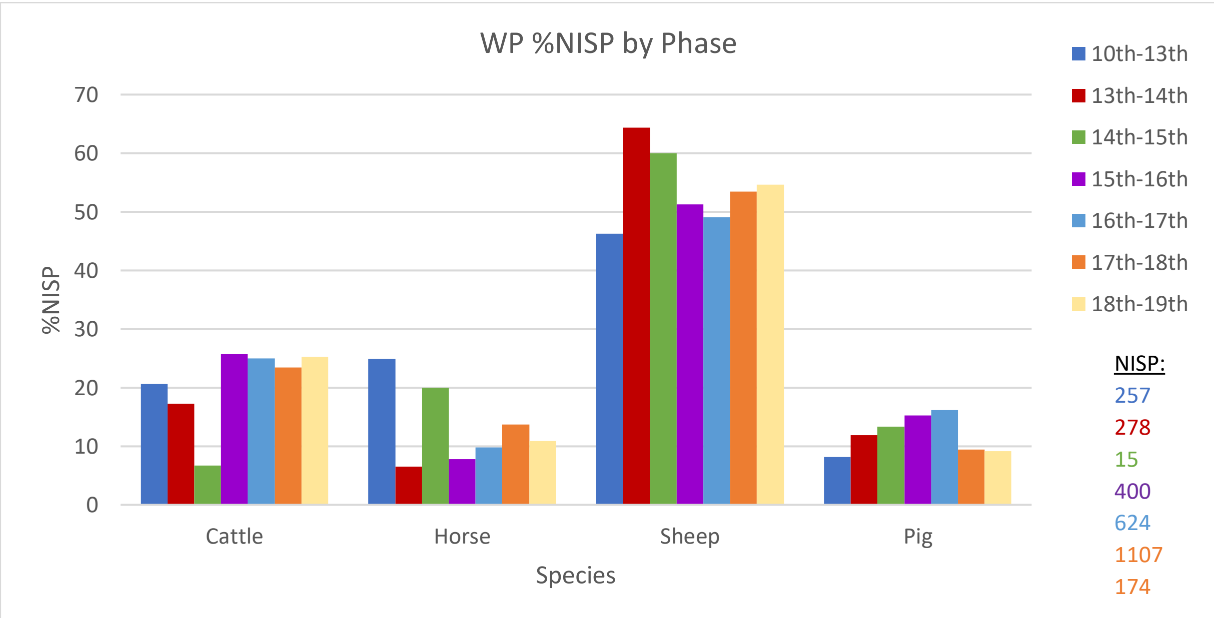

Figure 4.5: %NISP values for the main domesticates at Wharram Percy, divided by phase.

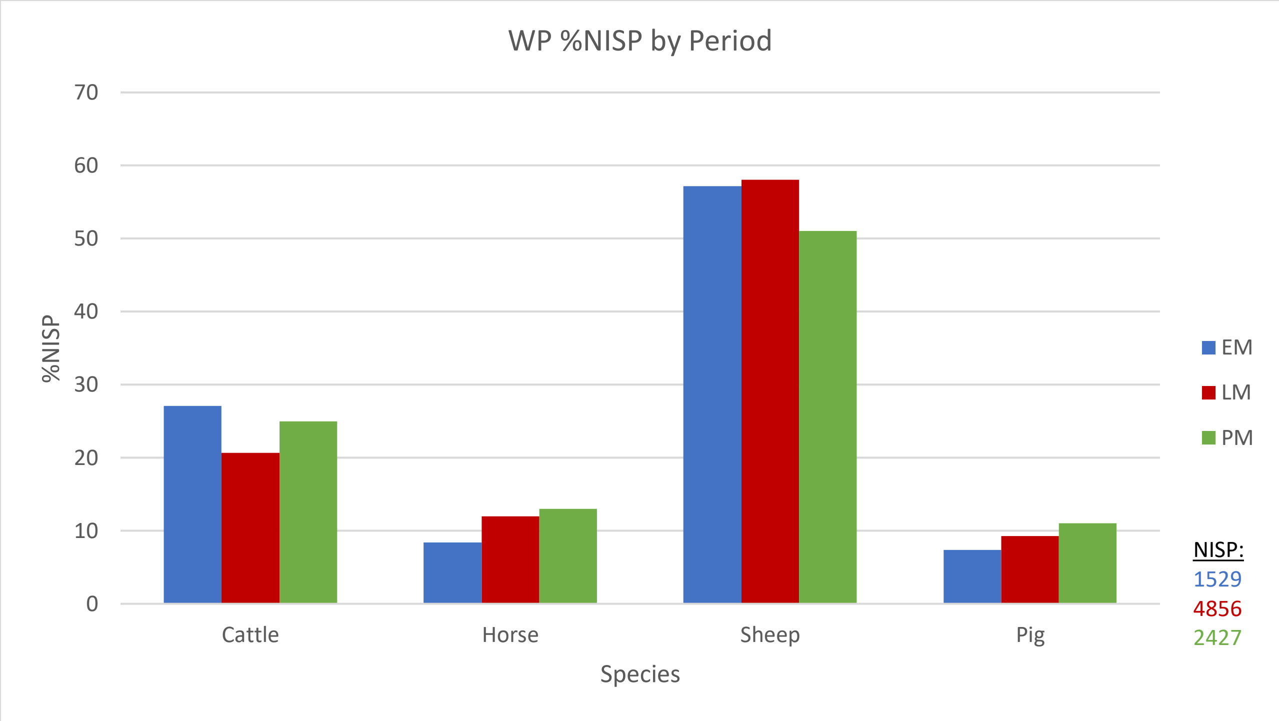

Figure 4.6: %NISP values for the main domesticates at Wharram Percy, divided by period.

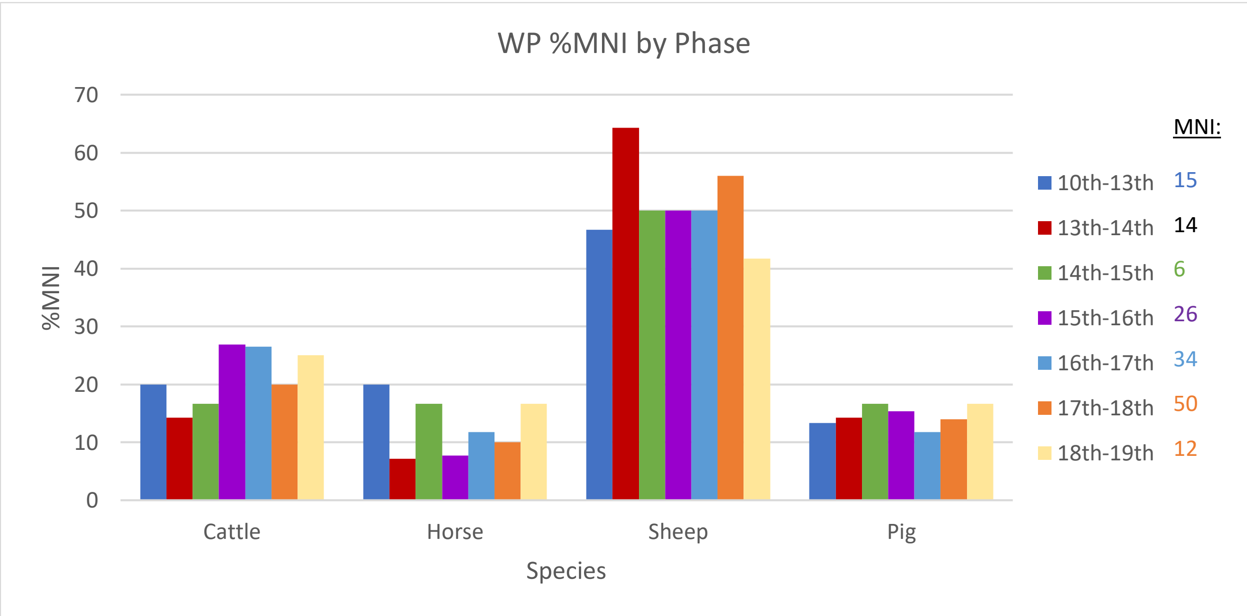

Figure 4.7: %MNI values for the main domesticates at Wharram Percy, divided by phase.

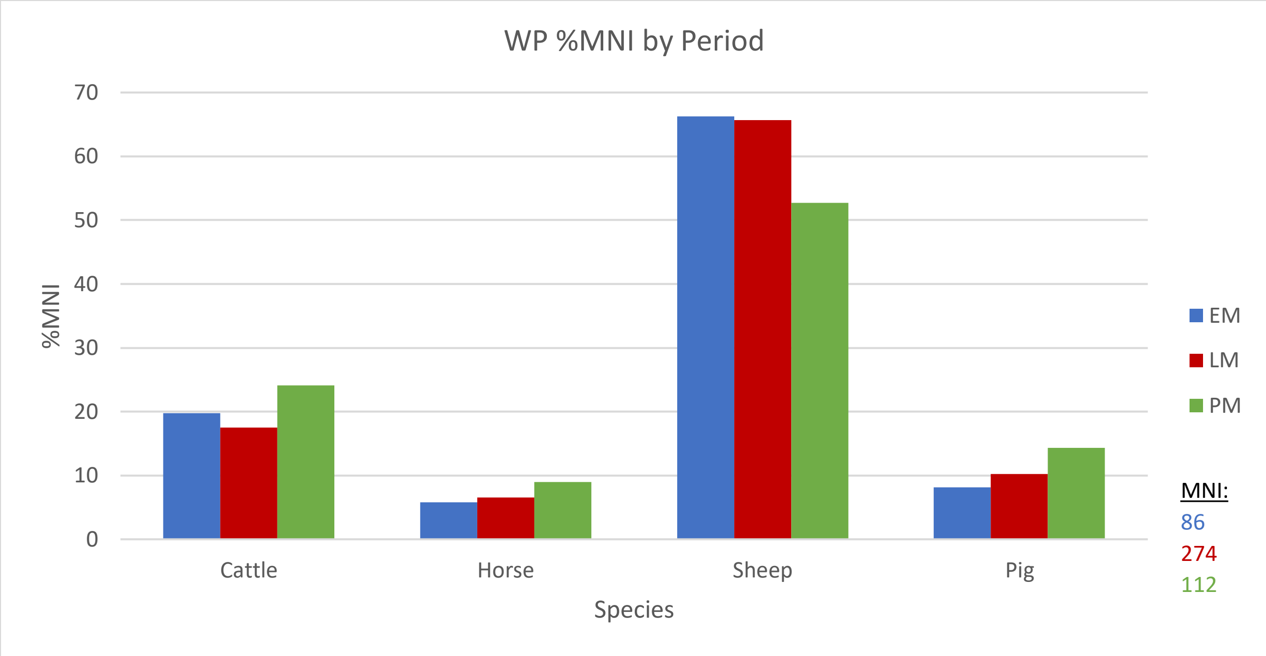

Figure 4.8: %MNI values for the main domesticates at Wharram Percy, divided by period.

4.2.2 Species Frequencies by Site

Species frequency by site was investigated using %NISP, in order to gain an understanding of species distribution across Wharram Percy. In the earlier Medieval period, sheep form the largest proportion of the assemblage on every site apart from Site 54, where cattle predominate (Figure 4.9). At Sites 45, 76 and 82, sheep constitute over half of the assemblage, which suggests that sheep were more commonly found at the sites along the West Row, perhaps in association with the fields to the west and north. However, it is worth noting that material from domestic refuse was collected and spread across arable fields, which may transport animal remains from their original location of exploitation (Dyer 2012b). On Sites 30, 54, 60 and 71, mostly situated in the area of the later Medieval village cattle are present in greater numbers. This prevalence of cattle in the Eastern sites may suggest that these areas were used more for either keeping cattle, or more likely the slaughter of animals and carcass processing. Pig frequency is also relatively high in the sites to the east of the parish, particularly on Site 54. This may also be due to the slaughter, processing or consumption of pigs more commonly in that area, especially as sites such as 54 seem to contain evidence for agricultural yards. Furthermore, horse frequency is particularly high on Sites 30 and 71, to the south of the parish. This indicates the particular presence of horse in this area, perhaps suggesting that they were kept near these sites. Another explanation may be that they were slaughtered in these areas, as Dyer (2012b) states that a 'knacker's yard' was located near the mill pond, increasing the prevalence of not only horse skeletal remains, but also horse shoes and nails.

In the late Medieval period, sheep once again comprise the largest proportion on all sites, except Site 76, where cattle constitute over 50 percent of the assemblage (Figure 4.10). Sheep frequency has increased on most sites in the late Medieval period, reflecting the greater frequency shown by %NISP results. On all sites but 30, 51 and 76 sheep comprise over half the site assemblage, which suggests that sheep became increasingly economically important across the parish. Cattle largely comprise between 21 and 31 percent of site assemblages, though they reach 56% of species frequency on Site 76. In contrast, to the north of the village, on Sites 45 and 82, cattle are much less common – on Site

82 they constitute only nine percent of the assemblage, and they are totally absent on Site 45. There is evidence that occupation ended at site 45 after the earlier Medieval period, and the site was used as pasture from that date, for sheep rather than cattle. This suggests that cattle were much less prevalent to the north of the village in the late Medieval period. Pig frequency increases on several sites in the late Medieval period, including Sites 12, 45, and 60, which show increases of nine, eleven, and two percent respectively. However, the greatest pig frequency values can be seen on Sites 9 and 82, where pig constitute over 20 percent of the total livestock identified. Both Sites contained peasant dwellings in the late Medieval period, suggesting that pigs were kept close to domestic dwellings. This suggests that pigs were increasingly exploited on many sites across the parish, particularly at the northern end, meaning that the greatest processing and consumption of this animal was likely concentrated in this area. Conversely, on other sites the abundance of pig decreased in the late Medieval, and on several pigs are totally absent. For example, Sites 73, 76 and 77 all lack any identified pig remains. These sites are situated near the centre of the village, which suggests that pigs were not present in these areas in the late Medieval period. The absence of pig on Site 76 is surprising, given its proximity to Site 9 where the species is particularly abundant. This could reflect differing uses for the sites, where 9 was potentially used more for pig slaughter, butchery or disposal. There is also evidence for a building on Site 9, interpreted as a storehouse or pig-sty, as well as on Site 12, where pig abundance increased in this period (Dyer 2012a). Unlike pig, horse is present on every site in the late Medieval period, reflecting the increased overall %NISP for the parish. Like the earlier Medieval period, horse frequency is particularly high to the south of the village, for example on Sites 12, 51, 73 and 77 where horse remains constitute between 19 and 25 percent of the assemblage. However, the highest abundance of horse can be found on Site 30, where they make up 42 percent of the total livestock identified. This again could represent the continuation of deliberate horse disposal near the mill pond from the earlier Medieval period, perhaps with some expansion onto nearby sites in the south of the village.

In the post-Medieval period, the overall decrease in sheep frequency is reflected in a decline in sheep abundance on all sites except 30, 51, and 73, reflecting the declining importance of the species (Figure 4.11). While some sites, for example, 73 and 74 still contain over 60 percent sheep, elsewhere, such as Site 77, sheep frequency has dropped as low as 30 percent. Overall, while sheep decrease on many sites, they still maintain an abundance of around 50 percent, suggesting that they were still widely exploited across Wharram Percy, though not to the extent seen in earlier phases after partial conversion of the parish back to arable use. In contrast to the decline in sheep abundance in the post-Medieval period, cattle increase in frequency across most Wharram Percy sites, reflecting the overall site increase in %NISP and establishment of specialised cattle pasture. Sites 73 and 74, both containing over 60 percent cattle remains, can both be found in this area of cattle pasture, suggesting a concentration of cattle in the central area of the previous late Medieval village. However, cattle remains comprise over 40 percent of every site assemblage, except Site 77, suggesting a relatively high frequency of cattle across post-Medieval Wharram Percy. Pig also increase in frequency on most of the sites in post-Medieval Wharram Percy. This echoes the overall post-Medieval increase in pig %NISP, and suggests that pigs were widely spread across the parish in the post-Medieval period. However, this widespread distribution must be treated with caution, as with the reintroduction of arable farming domestic waste may have been once again spread through fields as fertilizer. This may therefore obscure the pattern of pig exploitation on specific sites. Horse frequency increases on all sites but Site 30 and 73 in the post-Medieval period, again reflecting the overall increase in frequency at Wharram Percy. Several sites exhibit particularly high horse abundance; for example, 51, and 77. Despite the decrease in frequency on Site 30, there is still a relatively large proportion of horse, however horse frequency on Site 73 significantly decreases. In contrast to the preceding periods, horse abundance is no longer confined to the southern end of the parish, as sites with a high proportion of horse are spread across the length of the Wharram Percy. Therefore, it could be suggested that the disposal of horse remains took place more widely across the whole parish, and was no longer limited to specialist areas in the south, perhaps due to a change in manuring practice across arable land.

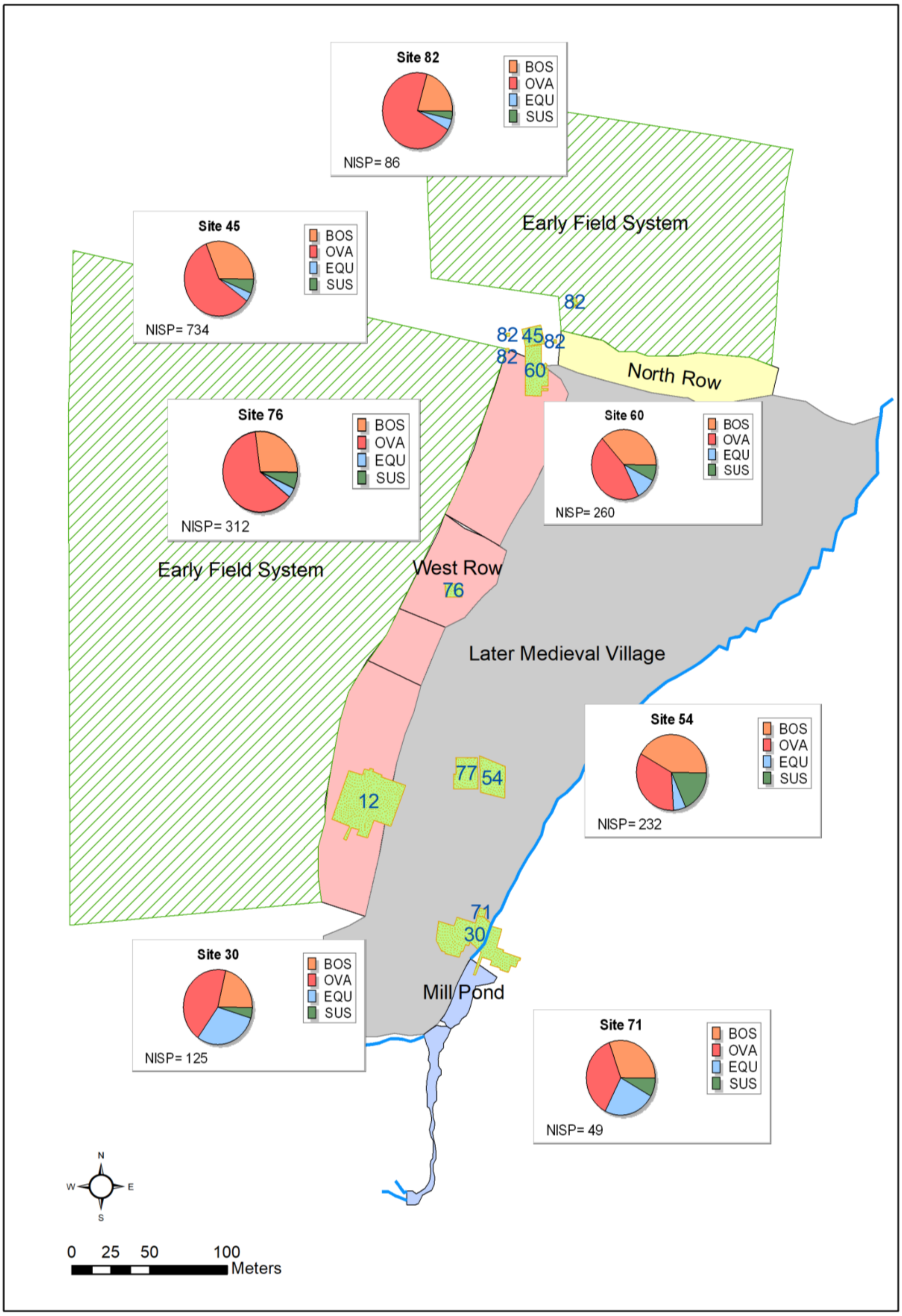

Figure 4.9: Species frequencies separated by site in earlier Medieval Wharram Percy. Frequency is given as %NISP.

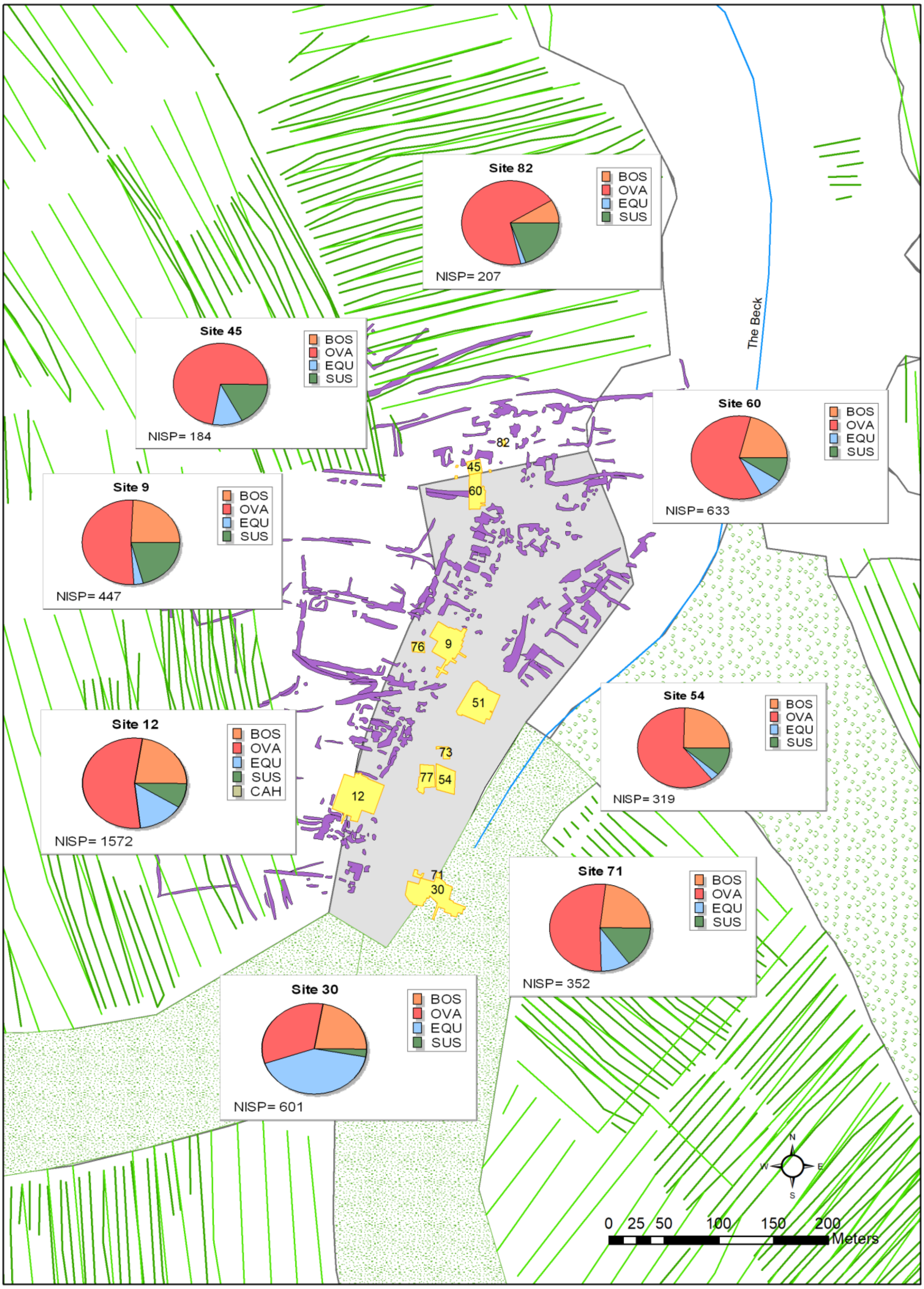

Figure 4.10: Species frequencies separated by site in late Medieval Wharram Percy. Frequency is given as %NISP.

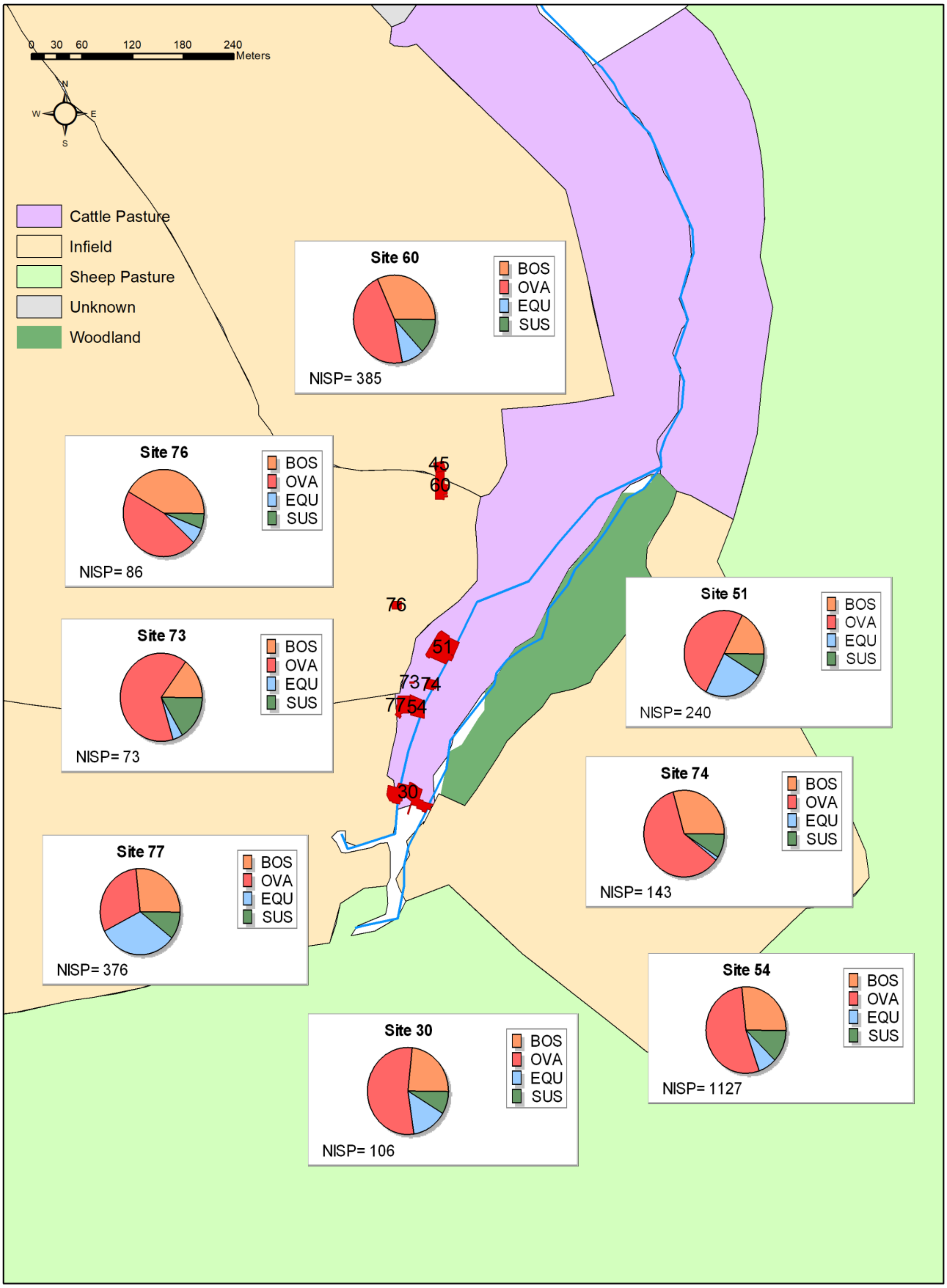

Figure 4.11: Species frequencies separated by site in post-Medieval Wharram Percy. Frequency is given as %NISP.

4.2.3 Butchery

Sheep

There is a relatively small amount of butchery in sheep remain at Wharram Percy, and it is entirely absent in the earlier Medieval period (see Table 4.1). This could indicate that sheep were not being intensively exploited for meat, or butchery was carried out using solely knives, leaving less trace. In the late Medieval period, a total of 16 butchery marks, in the form of cut and chop marks, are recorded on the front and hind limbs (Figure 4.12). The chop marks are concentrated around the scapula and humerus, as well as the proximal tibia. The position of these chop marks is indicative of primary butchery, where major joints are disarticulated. The cut marks are found on the distal humerus, as well as on the astragalus. The marks on the astragalus may indicate primary butchery, i.e. the disarticulation of the hock joint, while cuts on the humerus may reflect the removal of flesh following primary butchery. In the post-Medieval period, there are only 14 recorded butchery marks, again cut and chop (Figure 4.13). Chop marks are once again distributed around the scapula and humerus, indicating that the front limb may have been butchered for meat. The cut marks are positioned on the humerus and radius shafts, but also on the proximal femur. As in the previous period, this may reflect the removal of flesh for consumption, especially around the top of the limbs. Overall, the number of butchery marks across the study period is relatively low, suggesting that sheep were not intensively butchered. Though there is clearly still some butchery taking place on the site, the pattern of marks does not follow the urban practice of splitting the carcass, meaning that the butchery taking place at Wharram Percy was carried out by an untrained 'country butcher' (Richardson 2005, 238).

Cattle

Overall, cattle butchery is more frequent, though not in the earlier Medieval period (see Table 4.1). In the earliest period, there are only three butchery marks recorded on cattle bones, all chop marks (Figure 4.14). These chop marks are all distributed on the front limb, on the scapula and humerus, which is suggestive of the disarticulation of the front leg. This relative lack of butchery could indicate that cattle at Wharram Percy in the earlier Medieval period were not intensively exploited for meat. Butchery marks are much more abundant on cattle bones in the late Medieval period, totaling 40 chop marks and ten cut marks (Figure 4.15). On the front limb, the chop marks are most common on the humerus, followed by the scapula, radius and metacarpal. On the hind limb, chop marks are most frequent on the metatarsal, as well as the tibia, calcaneum, astragalus, proximal femur and pelvis. This distribution of chop marks is suggestive of the increased butchery of cattle in the late Medieval period, perhaps representing an increasing focus on meat production. In the post-Medieval period, the amount of butchery is reduced slightly, with 35 recorded examples (Figure 4.16). Thirty-one of these butchery marks are chop marks, which are located around the scapula, humerus, radius and ulna on the front limb, as well as the pelvis, proximal femur, and metatarsal on the hind limb. There are also five examples of chop marks on the horncore, which suggests the exploitation of this element, likely as a raw material for crafting. The general distribution of post-Medieval chop marks is indicative of the division of the carcass into major met cuts as they are located around many of the elements with the largest meat yield (Rixson 1989). There are three examples of cut marks on post-Medieval cattle bones, two on the scapula and one on the proximal femur. These may be the result of the removal of flesh for consumption or the disarticulation of the shoulder and hip joints, though the small number makes an interpretation problematic (ibid.). Finally, there is a single saw mark on the pelvis, which may again represent a new method emerging in the more intensive butchery of cattle for meat, or the import of joints from more specialised urban butchers.

Pig

There is a relatively small amount of butchery marks recorded on pig bones compared to cattle across the study period. In fact, in the earlier Medieval period there are no butchery marks recorded on any specimens. In the late Medieval period, only one butchery mark is recorded for pig, on the distal humerus (Figure 4.17). This is suggestive of meat removal, though this interpretation cannot be made confidently without further evidence and the apparent lack of pig butchery could mean that the most productive meat animals perhaps sent elsewhere. There is a greater abundance of butchery marks on pig specimens in the post-Medieval period, consisting of two chop marks, two cut marks, and four saw marks (Figure 4.18). The chop marks are distributed on the distal humerus and astragalus, while the saw marks are located on the scapula, radius and ulna. These marks are indicative of primary butchery for meat, while the cut marks on the scapula could represent the removal of flesh. It therefore appears that in the post-Medieval period pig butchery at Wharram Percy intensified.

Horse

Butchery marks on horse bones are relatively uncommon throughout the study period, and are totally absent in the earlier Medieval period, suggesting a lack of horse butchery during that period. In the late Medieval period, three chop marks are recorded, two on metapodials, and one on the proximal radius. These may be representative of butchery for meat, likely for consumption by dogs (Edwards 2007, 33; Albarella 2005, 140) though their position around elements of lower meat yield point towards carcass disarticulation for disposal (Rackham 1995, 20). Furthermore, 14 cut marks are recorded on horse phalanges, which may represent the removal of the hide, which was more common on rural sites (Albarella 2005, 140; Rackham 1995, 20). In the post-Medieval period, there is an increase in the frequency of butchery marks on horse bones, totaling 23 examples. Seven examples of chop marks are spread across two specimens, one on a proximal radius, and six on a distal metacarpal. Again, the presence of these on bones yielding a relatively low meat yield suggests that these are the result of disposal rather than butchery for consumption. There are 15 examples of cut marks, again on two specimens – nine on the lateral side of an astragalus, and six on another astragalus, on the lateral and medial sides. These are indicative of skinning for the use of the hide. Finally, there is a single example of sawing on a metapodial, which again may be representative of butchery for disposal rather than consumption.

Table 4.1: The proportion of butchered bones for each species in each period at Wharram Percy.

Butchered (%)	Sheep	Cattle	Pig	Horse
EM	0.0	1.4	0.0	0.0
LM	1.0	4.1	0.9	1.9
PM	1.2	3.8	4.6	2.9

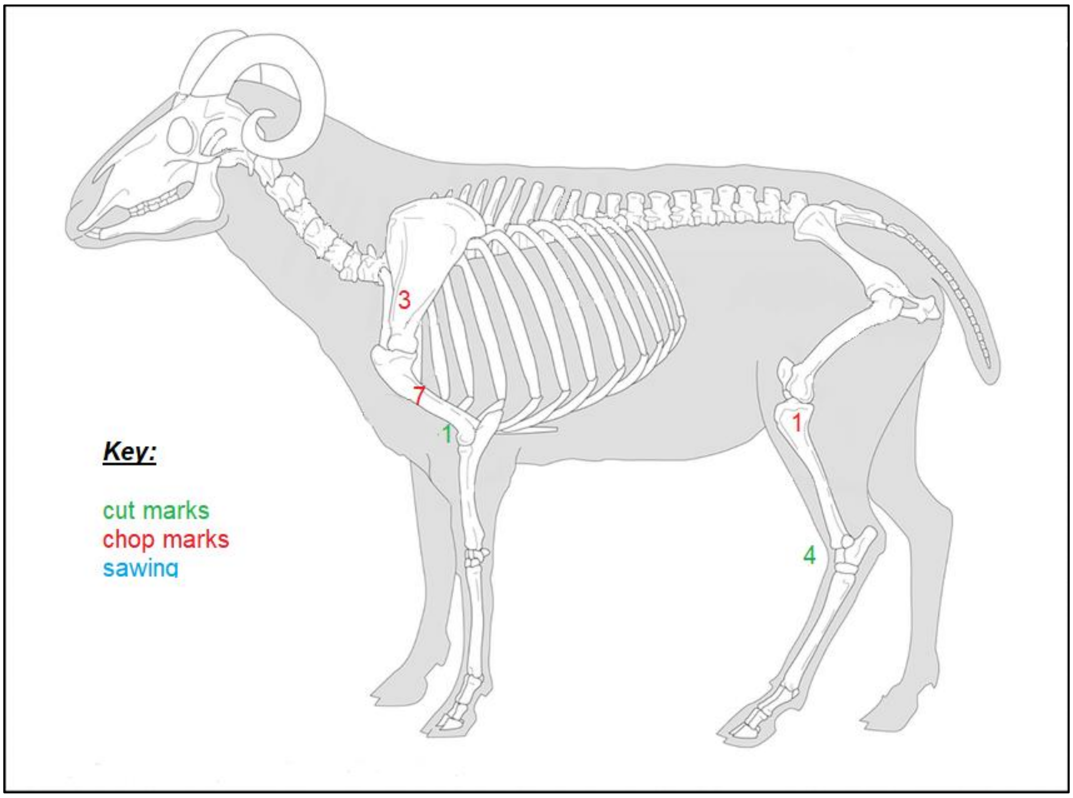

Figure 4.12: The distribution of late Medieval sheep butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

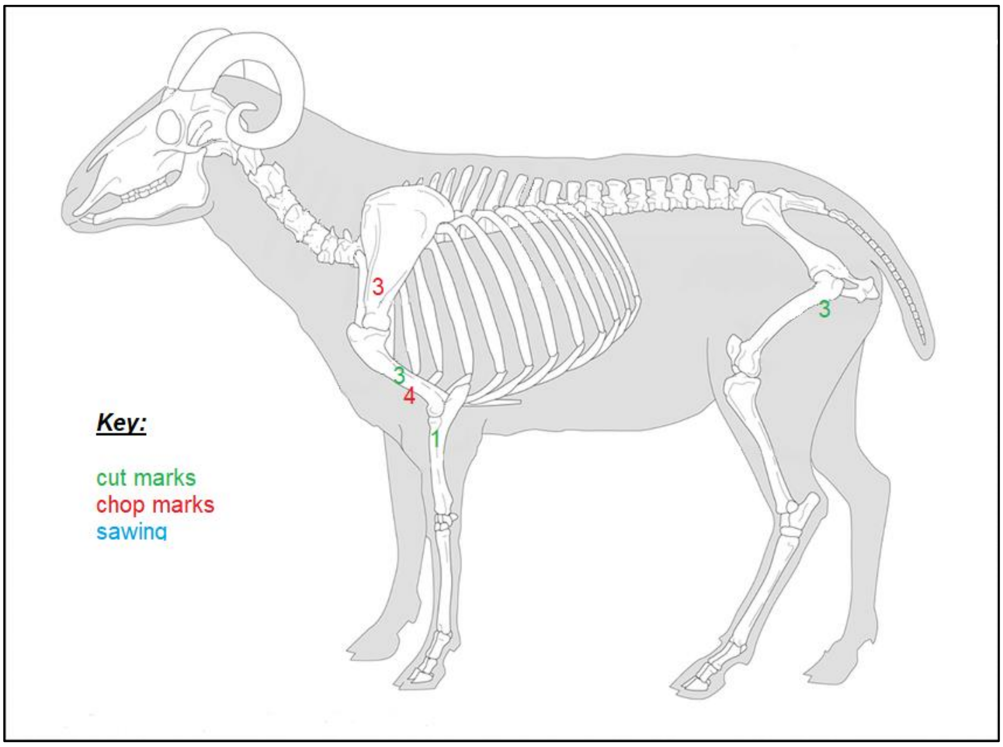

Figure 4.13: The distribution of post-Medieval sheep butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

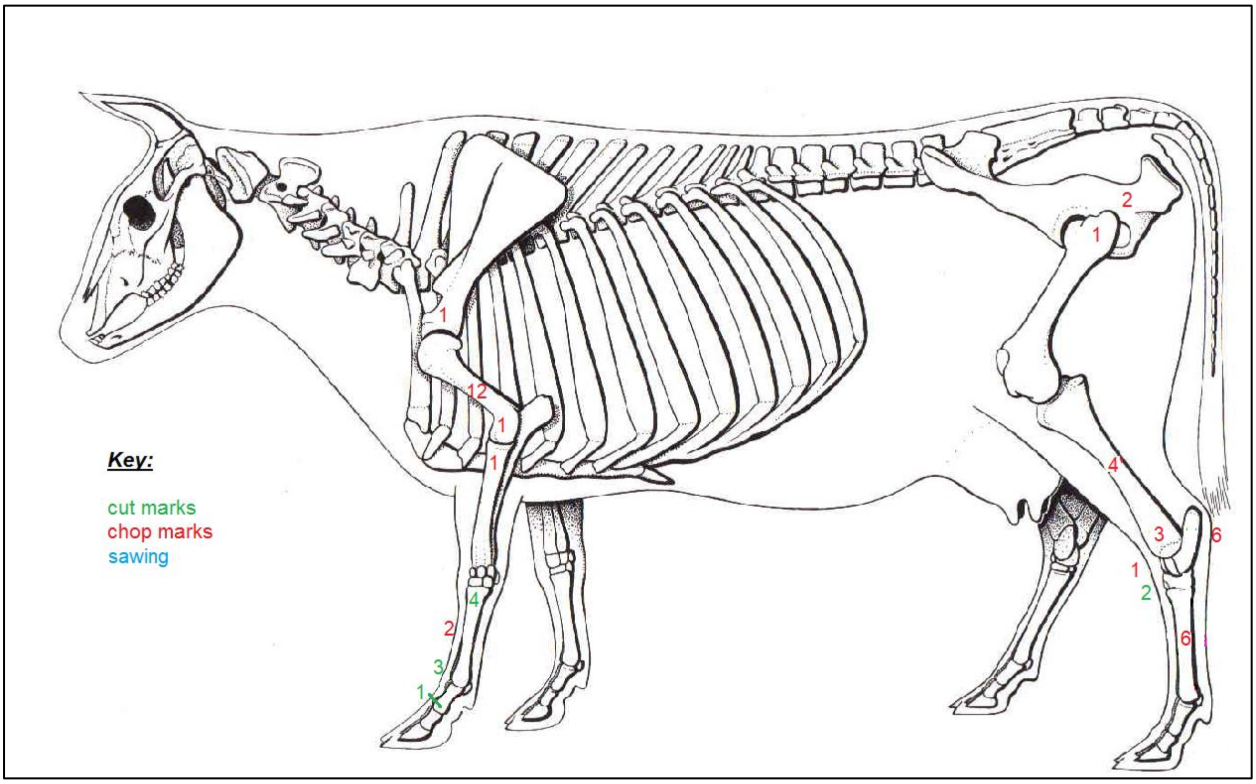

Figure 4.14: The distribution of earlier Medieval cattle butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

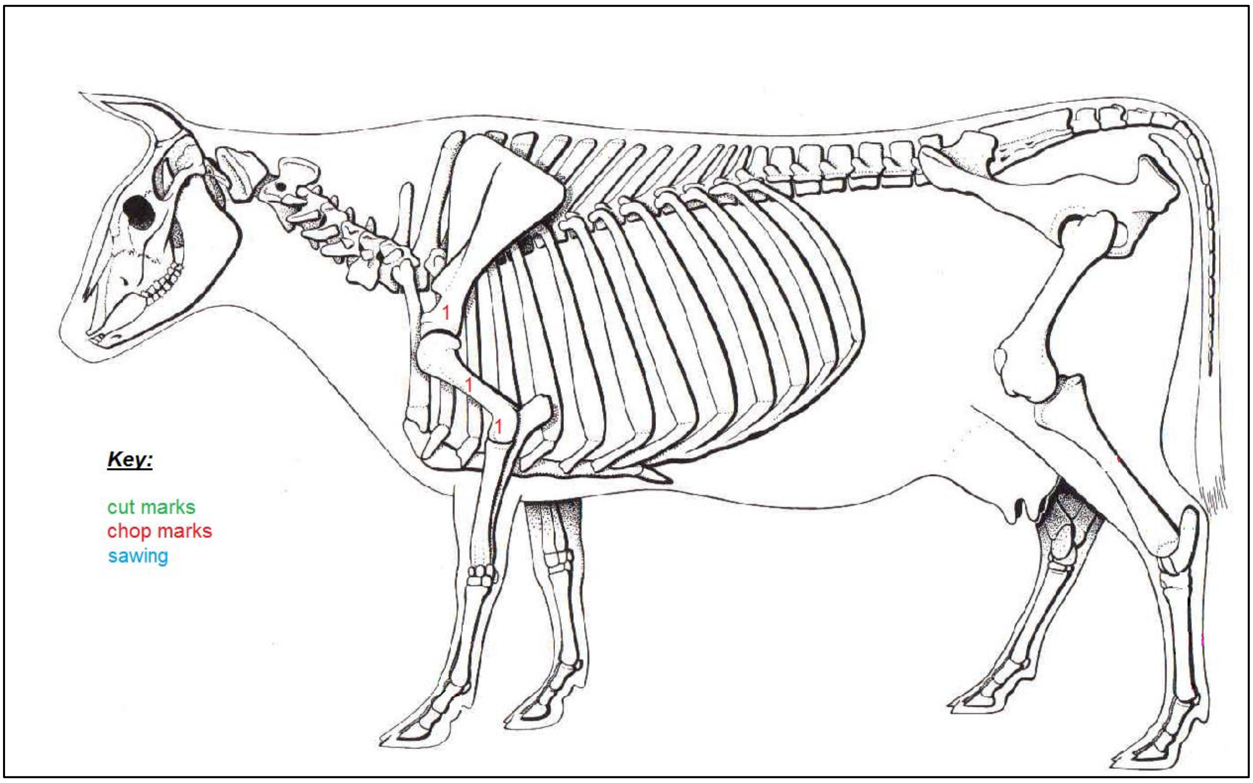

Figure 4.15: The distribution of late Medieval cattle butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

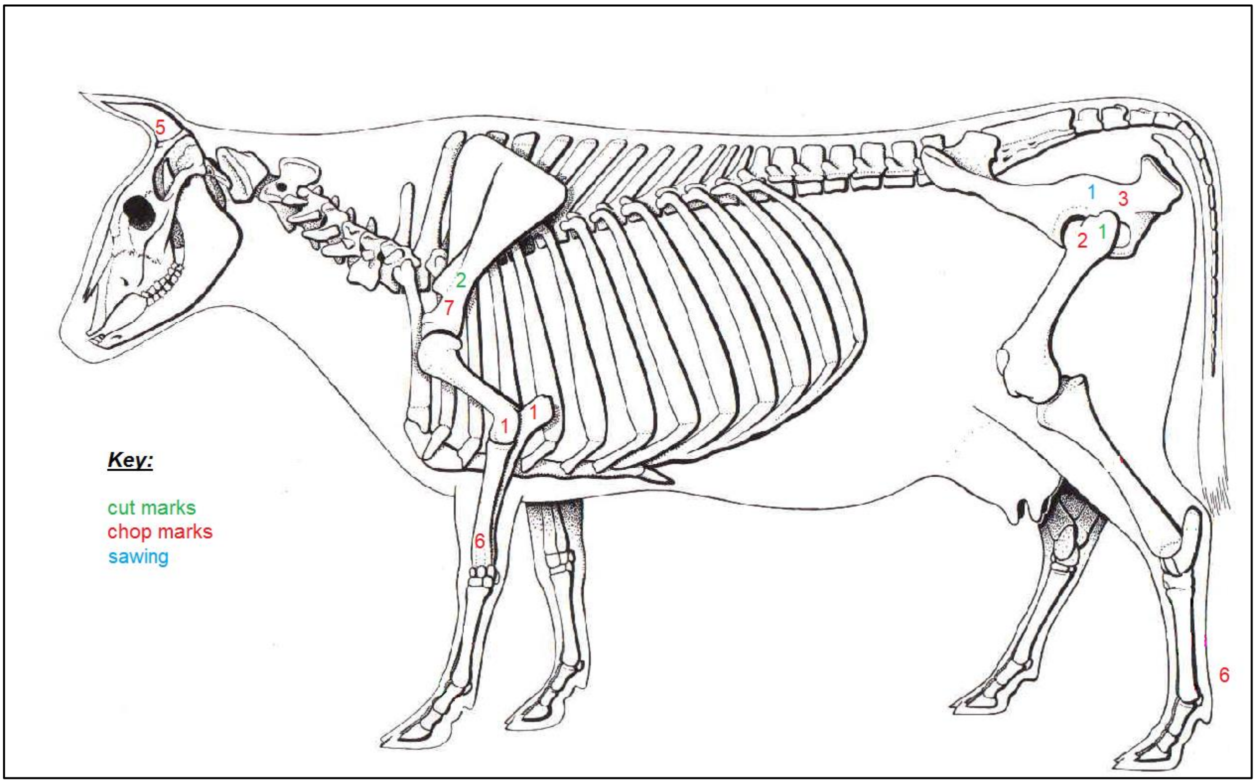

Figure 4.16: The distribution of post-Medieval cattle butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

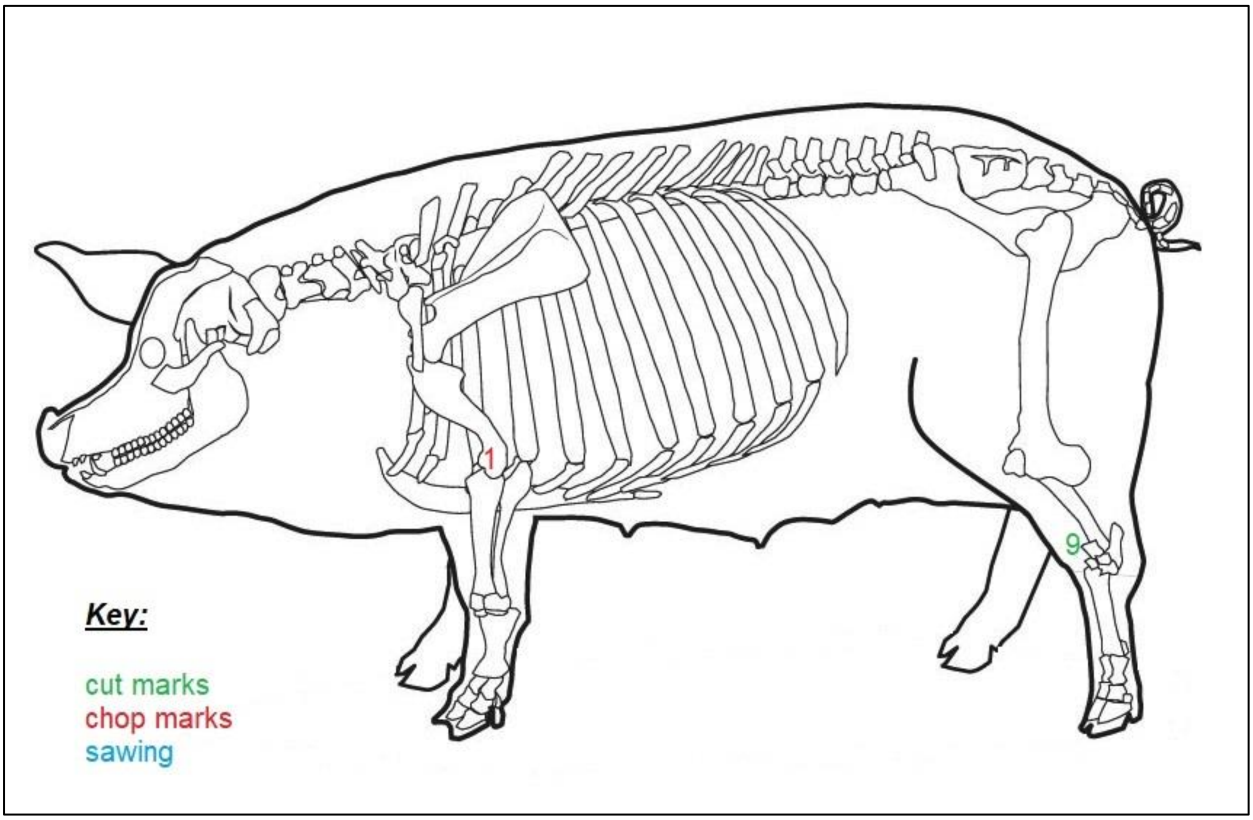

Figure 4.17: The distribution of late Medieval pig butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

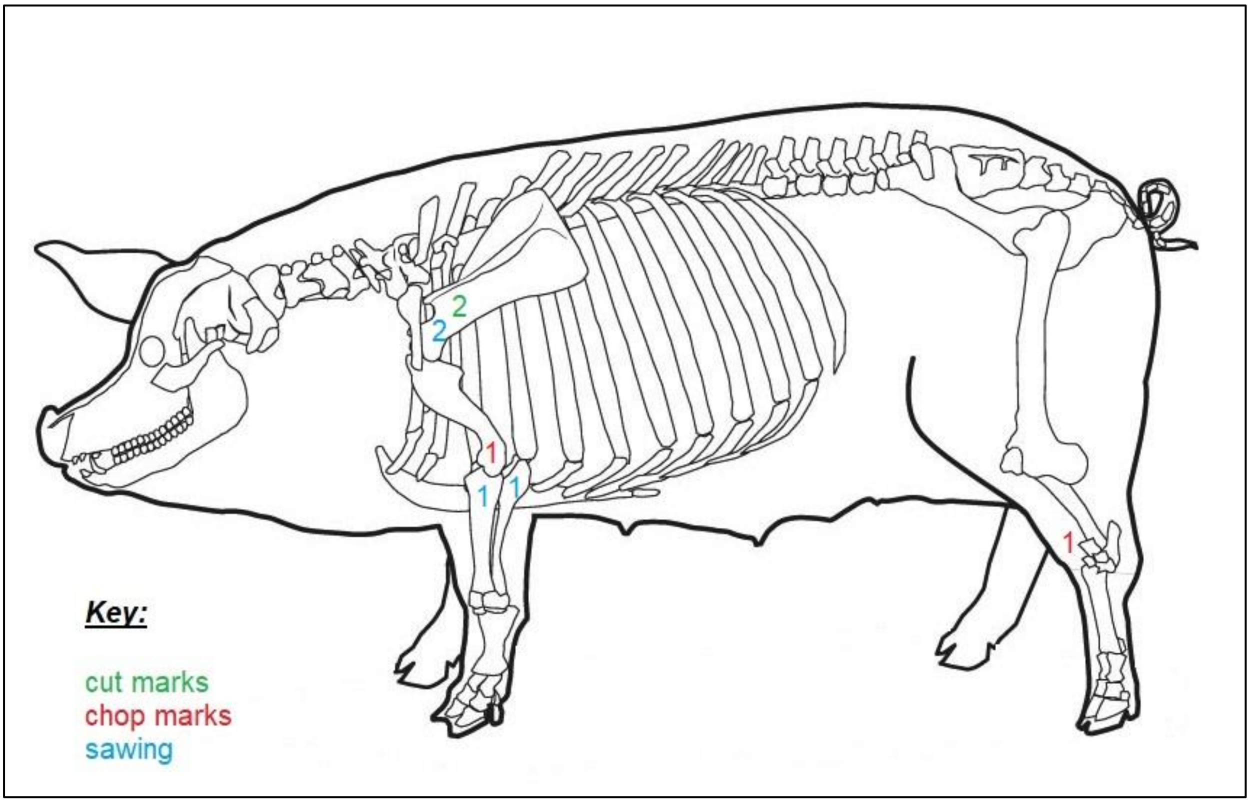

Figure 4.18: The distribution of post-Medieval pig butchery at Wharram Percy. The numbers represent the total amount of butchery marks recorded for each element.

<u>*4.2.4: Pathology*</u>

Sheep pathology is relatively uncommon at Wharram Percy throughout the study period, and is entirely absent in both the earlier and post-Medieval periods. In the late Medieval period, a single example of pathology has been identified, which takes the form of exostosis on the shaft and distal end of a first phalanx. However, it is difficult to suggest the cause of this pathological change based on a single example.

Cattle pathology is more common at Wharram Percy across all study periods. In the earlier Medieval period, there are two examples of pathological specimens. One example is a first phalanx which exhibits a periosteal reaction covering the shaft of the bone, particularly severe on the peripheral side of the proximal articulation, as well as the internal aspect of the shaft near the distal articulation, where it forms a hook-shaped projection. Due to the lack of change on the articular surfaces on the bone, it is more likely that this pathological change is the result of idiopathic inflammation, rather than a joint condition like osteoarthritis. There are also four examples of post-cranial cattle pathology recorded on specimens from the late Medieval period. These include a calcaneum displaying osteophytes around the articular surface. In addition, a metacarpal also exhibits significant exostosis surrounding the proximal articulation, and extending down the lateral side of the shaft (Figure 4.19). Further abnormal bone growth is present on two phalanges, a first phalanx with exostosis on the posterior side of the shaft, forming a hook-shaped protrusion just above the distal articulation, and a second phalanx with exostosis on the internal side of the shaft. Overall, it is difficult to ascertain the specific cause of these examples of exostosis without additional pathological indicators. In the absence of pathological change on the articular surface, inflammation rather than arthropathy is a likely cause; however, the predominance of lower leg and foot specimens could suggest that these pathologies are linked to the use of cattle for traction (Bartosiewicz *et al* 1997). In the post-Medieval period, there is a cattle first phalanx exhibiting exostosis surrounding the proximal articulation, as well as a metapodial displaying additional bone growth around the proximal articulation. Both examples are difficult to diagnose, as exostosis can be caused by many conditions, though as in the late Medieval period, the prevalence on lower leg and foot bones may link it to cattle used for traction.

In contrast to cattle at Wharram Percy, there are no recorded examples of pig pathology across the entire study period. This may reflect the fact that pigs were likely used for meat on the site, meaning that animals did not survive into adulthood, and therefore the likelihood of age-related pathology was low.

Finally, there are several examples of horse pathology at Wharram Percy. There is only one example from the earlier Medieval period, which takes the form of a second phalanx displaying exostosis around the proximal articulation and down the shaft, particularly on the posterior side. In the late Medieval period, there are three further examples of pathology of the lower leg and foot, including an astragalus exhibiting extensive osteophytosis, particularly on the posterior side, resulting in destruction of the articular surface and ankylosis to the calcaneum (Figure 4.20). A second astragalus displays porosity and pitting around the distal articulation, and a first phalanx is recorded as having severe exostosis around the distal end, causing it to fuse to the second phalanx, which also displays significant abnormal bone growth (Figure 4.21). This additional bone growth is indicative of osteoarthritis of the inter-phalangeal joint, or ring bone (Baker and Brothwell 1980; Rogers and Waldron 1995). Two post-Medieval examples of horse pathology were recorded, including a metacarpal showing slight exostosis around the proximal end, and extending down the posterior side of the shaft. The second example is a first phalanx which displays exostosis on the shaft, particularly on the posterior side. As with cattle pathologies, horse examples across all periods predominate in the lower leg and foot, which may suggest that they are linked to the use of horses for traction at Wharram Percy throughout the study period.

Figure 4.19: Late Medieval cattle metacarpal with exostosis around the proximal articulation, which extends down the lateral side of the shaft.

Figure 4.20: Late Medieval horse astragalus exhibiting severe exostosis, resulting in fusion to the calcaneum.

Figure 4.21: Late Medieval horse first phalanx with severe osteophytes around the distal end, resulting in ankylosis.

<u>4.2.5 Non-metric Traits</u>

The non-metric traits recorded include the absence of the second permanent premolar in cattle and sheep at Wharram Percy. For sheep, this trait was present in one specimen in the earlier Medieval period (6.6%), and two in the late Medieval period (8.3%), but was not recorded in the post-Medieval period. This suggests that the trait is relatively uncommon; however, the front of the jaw tends to be under-represented due to its fragility, which may result in a reduction in the recovery of the premolars. For cattle, one example in the earlier Medieval period was recorded as missing the mandibular permanent second premolar, though the sample size of second premolars in this period was very small overall. In the late Medieval period two are absent (18%), followed by one specimen in the post-Medieval period (7.6%). As with sheep, this suggests a higher prevalence of the trait in the late Medieval period, though small sample sizes make a clear chronological trend unclear.

In addition, the presence, absence or reduction of the cattle third mandibular molar hypoconulid was recorded across the study period at Wharram Percy. In the earlier Medieval period, there were no recorded mandibular third molars with either absent or reduced hypoconulids. However, the presence of the maxillary third molar worn in a V-shape implies that there was at least one individual displaying this non-metric trait (4%) (Argent, Thomas and Morris 2013). In the late Medieval period, there is one example of an absent hypoconulid and one where the hypoconulid is reduced in size. In addition, five maxillary third molars are recorded with wear patterns suggestive of a missing M_3 hypoconulid (15%). Finally, in the post-Medieval period, there are no recorded examples of absent or reduced mandibular third molar hypoconulids. Overall, this shows that the greatest frequency of this trait was present in the late Medieval period, suggesting a change in the cattle population, though a larger sample size is required to make further interpretations.

4.2.6 Ageing

Appendices 15 to 17 contain dental ageing tables, and Appendix 18 contains fusion data by element.

Sheep

Sheep fusion ageing shows a relatively high survival of sheep across the study period at Wharram Percy. In the 10th-13th century, sheep survival remains at one hundred percent until the third stage, where it decreases to 78 percent, followed by a drop to 69 percent in the final stage (Figure 4.22). This is reflected in the earlier Medieval fusion ageing pattern, in which sheep survival is 95 percent at the end of the first stage, indicating that a very high proportion of the herd lived past ten months (Figure 4.23). Sheep survival remains high in the earlier Medieval period through stages two and three, suggesting that 75 percent of sheep survived past 28 months. In the fourth stage survival drops to 52 percent, suggesting a greater kill-off of sheep after thirty months, though over half the flock survive past three and a half years. This pattern suggests that in the earlier Medieval period, sheep survival was relatively high until two and a half years. In the late Medieval period, survival in stage one is comparably low at 88 percent, due to a particularly low value in the 15th-16th century, which suggests a high neonatal mortality in this period, or greater slaughter of very young individuals. There is an increase in fused elements in stage two, indicating a higher survival between thirteen and sixteen months, though survival then decreases to 82 percent by 28 months. By the fourth stage, survival is higher in the late Medieval period than the preceding period. This indicates that, while survival was lower in the earlier stages, over half the flock survive past three and a half years. In the post-Medieval period, there is a much lower survival in the first stage, due to a particularly low survival in the 18th-19th century, meaning that only 76 percent survive past ten months in this period. This may suggest that either neonatal mortality was very high in this period, or that there was an increase in the slaughter of young sheep for lamb as the popularity of wool declined, especially in the later phases of the post-Medieval period. Survival is higher in the second stage, at 88 percent, perhaps suggesting the introduction of older animals to the site. In the final two stages there is a similar pattern to the two preceding periods, as survival gradually decreases, reaching 48 percent by stage four. This suggests that, while low survival in the first stage may represent the use of sheep for meat, nearly half the flock survives past three and a half years, for the exploitation of wool or mutton.

Sheep dental ageing largely reflects this pattern (Figure 4.24; Figure 4.25). In the earlier Medieval period, survival remains at one hundred percent until stage C, where it is reduced to 78 percent. This suggests very high survival in the earliest age stages, but a 20 percent decrease in survival by the end of the first year, perhaps representing infant mortality or the exploitation of lambs for meat. A second peak in sheep %kill-off occurs at stage E, and is continued in the next two stages, resulting in a survival of only three percent by six years. Overall, the pattern of %kill-off in the earlier Medieval period suggests high survival at earlier stages, but differs from the fusion ageing around a year, as it indicates that sheep are killed after their first year and around two to six years, most likely for the exploitation of meat. In the late Medieval period, the dental ageing results more closely follow those of fusion, as survival is very high in the first two stages and gradually decreases until stage G across all phases, where there is a peak in %kill-off. This suggests that sheep survived to an older age in the late Medieval period, until a peak in kill-off around four to six years – this may reflect the increasing emphasis on wool production during this period at Wharram Percy, meaning that sheep were kept alive longer to increase wool yield. A similar pattern can be seen in the post-Medieval period, as again survival is one hundred percent in the first stage, and gradually decreases until stage G, where a %kill-off peak of 27 percent reduces survival to just ten percent. This peak in kill-off is earlier in the 18th-19th century, at stage F, which may suggest an earlier slaughter of sheep, though the sample size is very small. Again, this suggests that sheep were kept alive past prime meat-producing age, most likely for the exploitation of wool. Overall, sheep dental ageing for the three main periods at Wharram Percy suggests that in the earlier Medieval period a more mixed strategy of sheep husbandry was likely employed, whereas in the following periods they were kept alive until around six years for the production of wool.

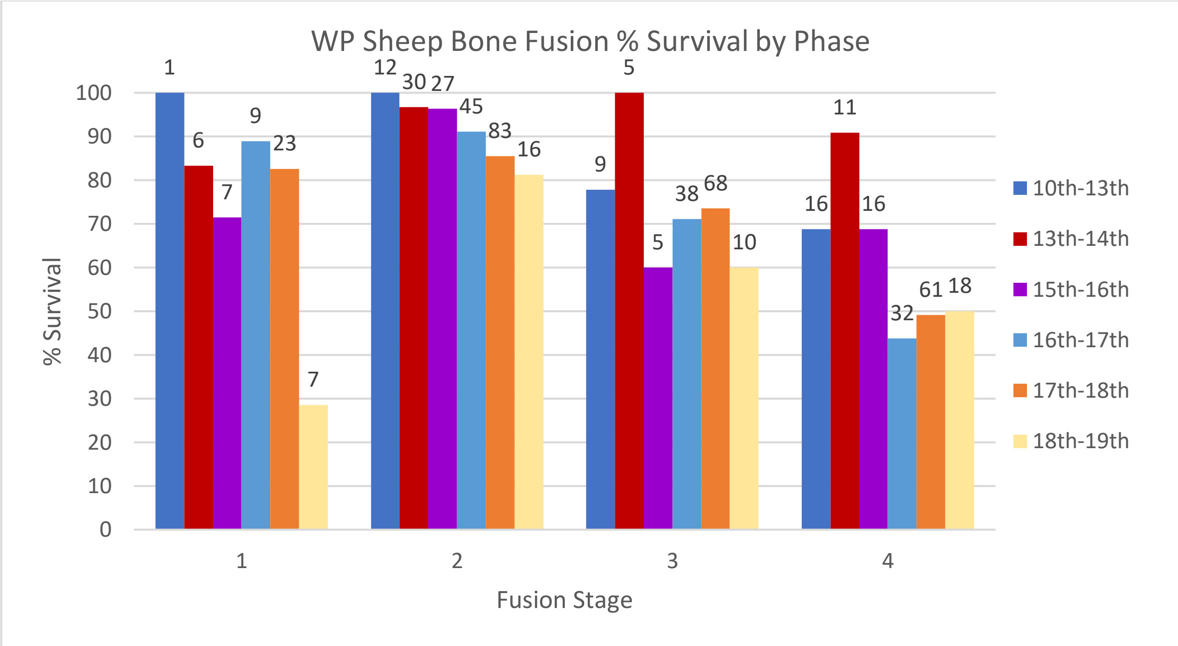

Figure 4.22: Sheep %survival by bone fusion for all phases at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 6-10 months, Stage 2: 13-16 months, Stage 3: 18-28 months, Stage 4: 30-42 months. The number of specimens per stage is given above the bars.

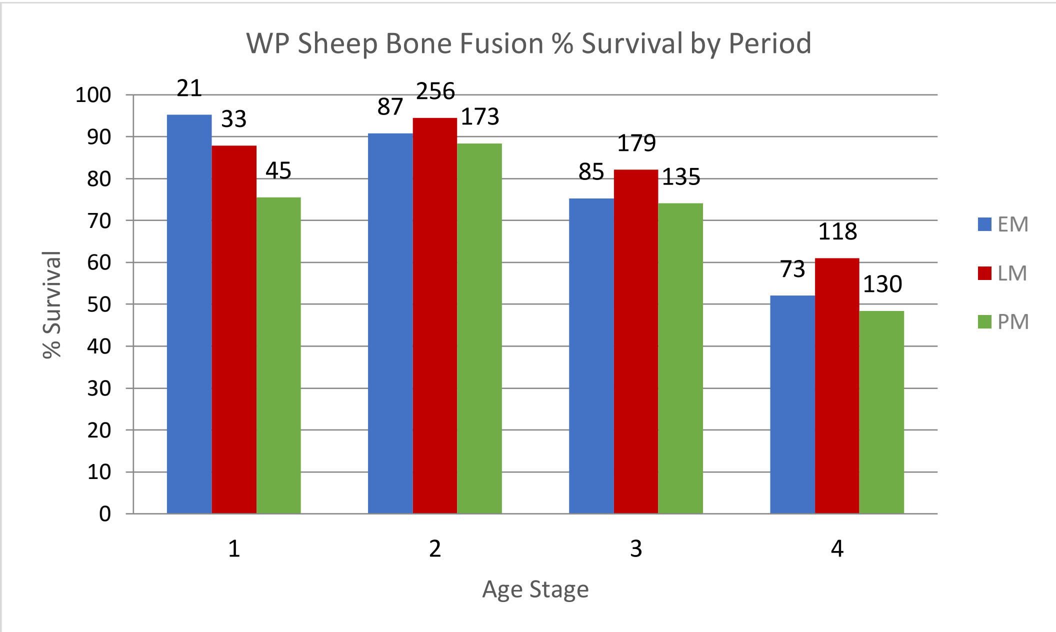

Figure 4.23: Sheep %survival by bone fusion for the three main periods at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 6-10 months, Stage 2: 13-16 months, Stage 3: 18-28 months, Stage 4: 30-42 months. The number of specimens per stage is given above the bars.

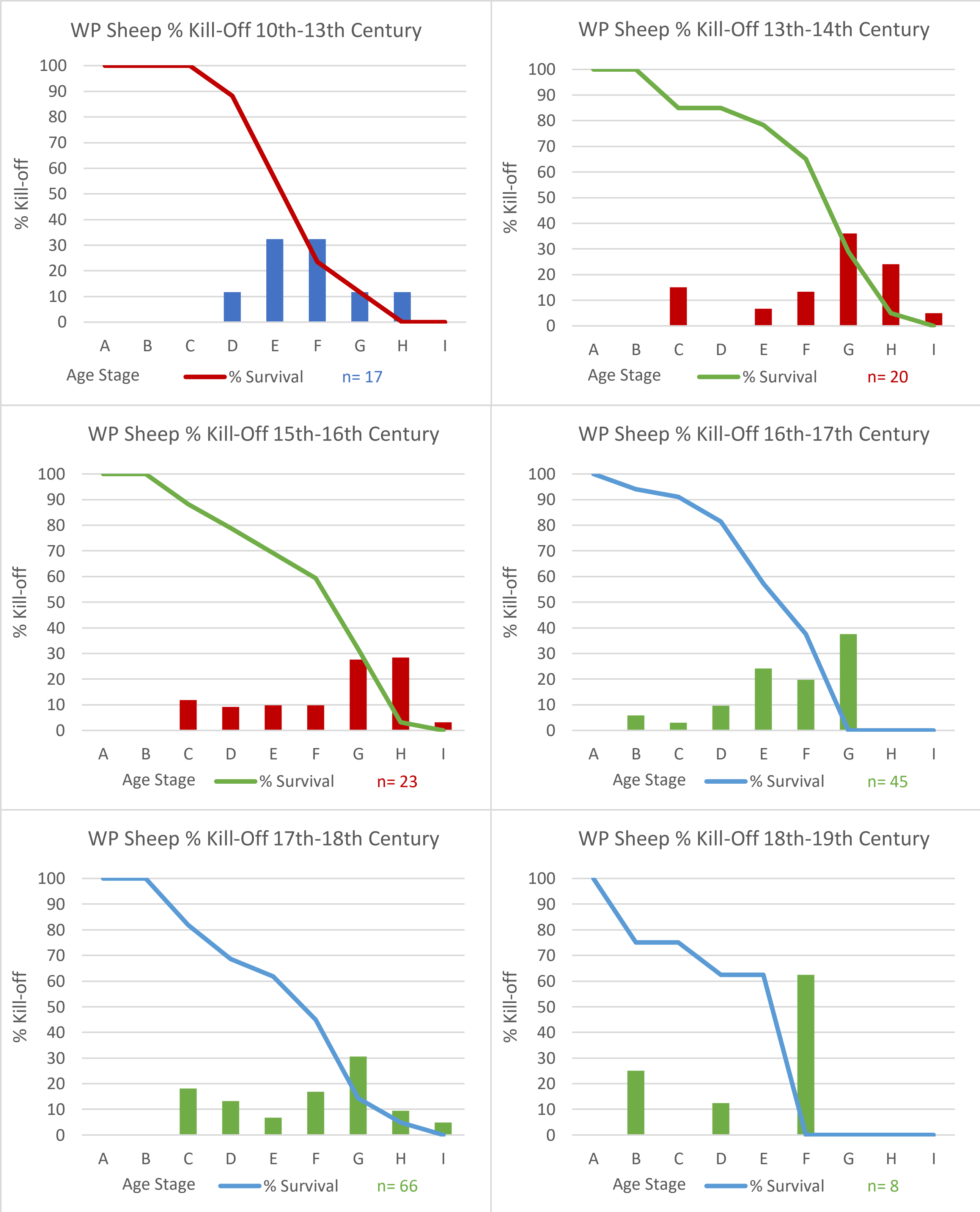

Figure 4.24: Sheep dental age profiles, showing the percentage kill-off and percentage survival at each age stage for the individual phases at Wharram Percy.

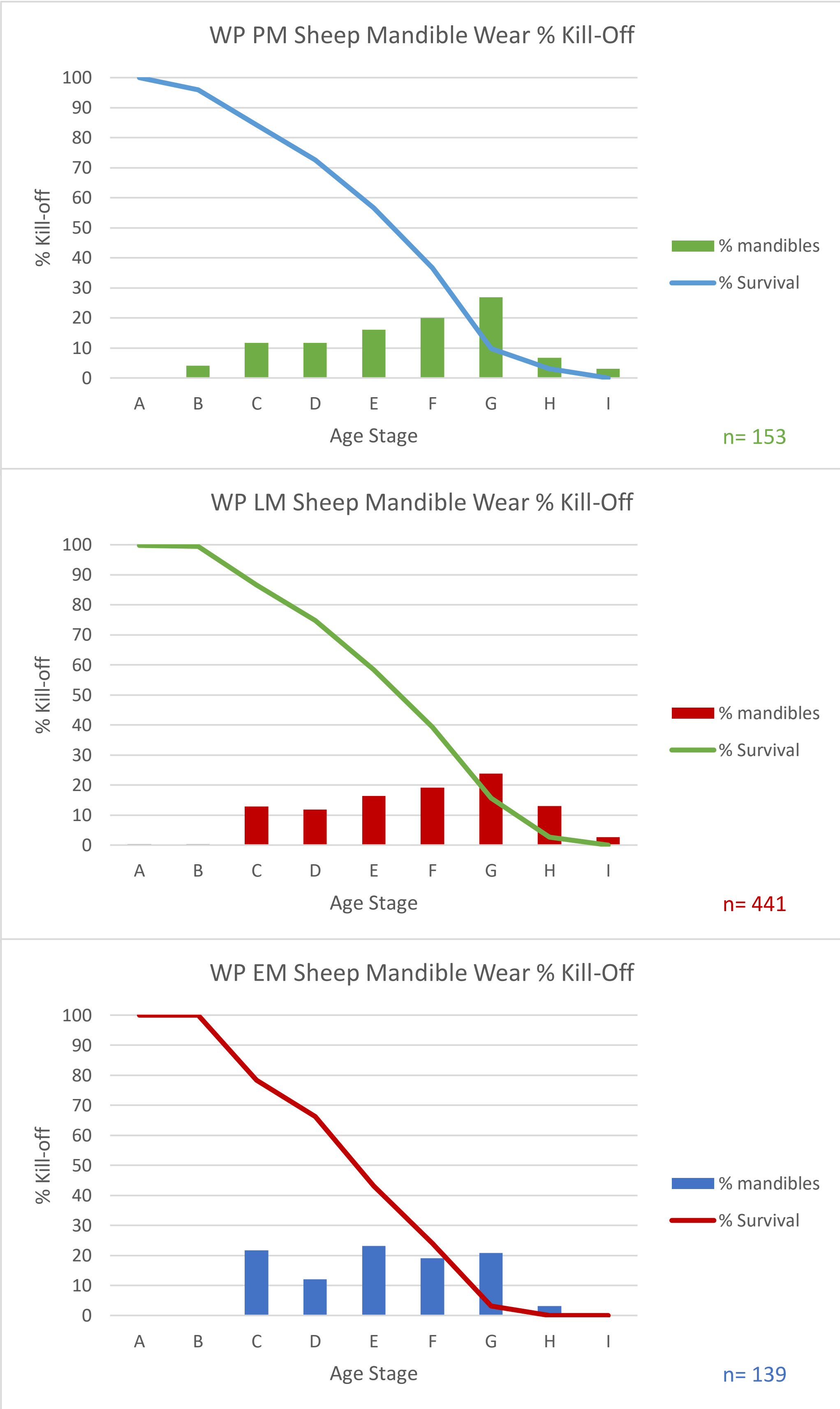

Figure 4.25: Sheep dental age profiles, showing the percentage kill-off and percentage survival at each age stage for the three main periods at Wharram Percy.

Cattle

Fusion ageing results for cattle suggest that cattle were also surviving to a relatively old age at Wharram Percy. At stages one and two, very high survival is generally shown across all the individual phases, which results in one hundred percent survival across all three broad periods in the first stage (Figure 4.26; Figure 4.27). In the second stage, survival in the earlier, late and post-Medieval periods is also very high, not dropping below 95 percent. This may suggest that a large proportion of the herd survived past 18 months across all periods, though it may also be a reflection of the lack of sieving upon recovery, meaning that often small or fragile unfused bones are under-represented. In the earlier Medieval period, %survival then almost halves to 54 percent, which suggests a large kill-off of cattle between two and three years, most likely for meat. This decrease is less pronounced in the two following periods, though this masks a significant drop at stage three in the 15th-16th century. By the fourth stage, survival is 60 percent or below for all phases, indicating further kill-off of cattle between three and four years throughout the study period. The largest drop in this stage is again during the earlier Medieval period, where only 45 percent of cattle survive past four years, whereas in the late and post-Medieval periods this figure is between 54 and 55 percent. Overall, cattle fusion ageing suggests that survival was high up to two years of age when survival decreased, particularly in the earlier Medieval period. This pattern suggests the use of around half of the herd for meat in all periods between two and four years, with the other half of the animals surviving past four years, perhaps for use as traction animals.

Cattle dental ageing results largely correlate with fusion ageing results, though some differences are evident, particularly in the post-Medieval period (Figure 4.28; Figure 4.29). There are no neonatal dental remains recorded across all phases at Wharram Percy, which reflects the high survival suggested by fusion remains, but is surprising on a rural site where livestock breeding, and therefore neonatal mortality, is likely. However, this may be the result of the fragility of neonatal remains, and therefore an under-representation during recovery, as well as the small sample size present in some phases. In the earlier Medieval period, %kill-off is relatively low in the earlier stages, however, there is a large peak in the adult stage, followed by 28 percent recorded as elderly. This suggests that in the earlier Medieval period at Wharram Percy small numbers of juvenile and subadult cattle died on the site, but a large proportion of cattle survived to adulthood, and over a quarter survived to an elderly stage. The large adult peak in kill-off could reflect the decreased survival seen in the fusion ageing from the third stage onwards, potentially pointing towards the slaughter of relatively young adults, though overall the earlier Medieval pattern is more suggestive of the use of cattle for predominantly traction rather than meat. A similar dental ageing pattern can be found in the late Medieval period, though the proportion of juvenile kill-off is lower, and instead a greater amount of subadult specimens were recorded. Nonetheless, the main peaks in kill-off are still in the adult and elderly stages. Again, this suggests that, though there is some decrease in survival in the earlier stages, over three-quarters of the herd are surviving to adulthood, once more suggesting an emphasis on cattle for traction. Finally, in the post-Medieval period there is a clear increase in the frequency of juvenile specimens recorded, particularly in the 16th-17th century. There is also a slight increase in both immature and subadult kill-off, especially between the seventeenth and nineteenth centuries. As a result, there is a reduction in the proportions of adult and elderly animals in this period. Overall, cattle dental ageing suggests that a large proportion of animals survived into the adult and elderly categories in the earlier and late Medieval period, indicating their use for secondary products such as traction. In the post-Medieval period, there is a shift towards the kill-off of younger animals, particularly juveniles. However, there is no clear indication that cattle were predominantly used for meat at Wharram Percy as over half the herd still survive past adulthood, meaning that these older animals were likely still used for traction, though perhaps with a faster turnover.

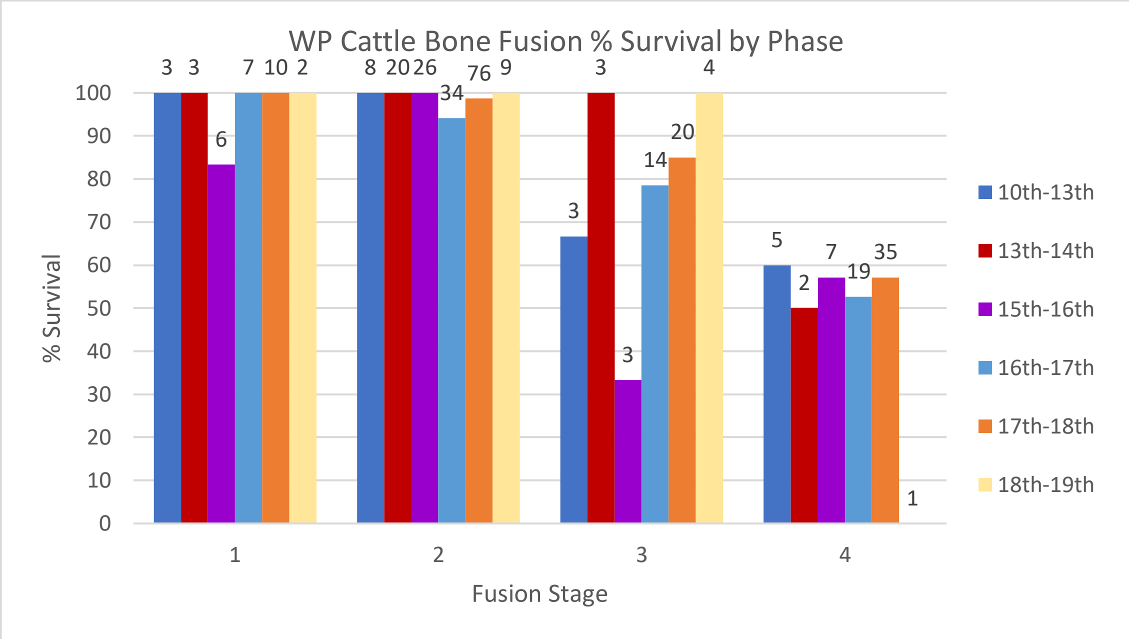

Figure 4.26: Cattle %survival by bone fusion for the individual phases at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 7-10 months, Stage 2: 12-18 months, Stage 3: 24-36 months, Stage 4: 36-48 months. The number of specimens per stage is given above the bars.

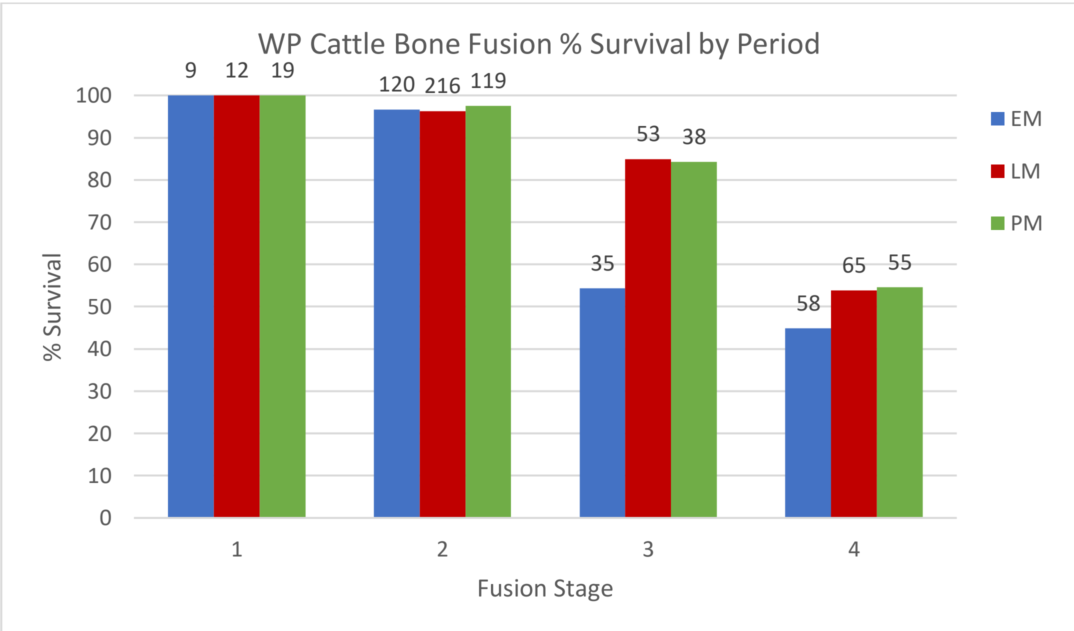

Figure 4.27: Cattle %survival by bone fusion for the three main periods at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 7-10 months, Stage 2: 12-18 months, Stage 3: 24-36 months, Stage 4: 36-48 months. The number of specimens per stage is given above the bars.

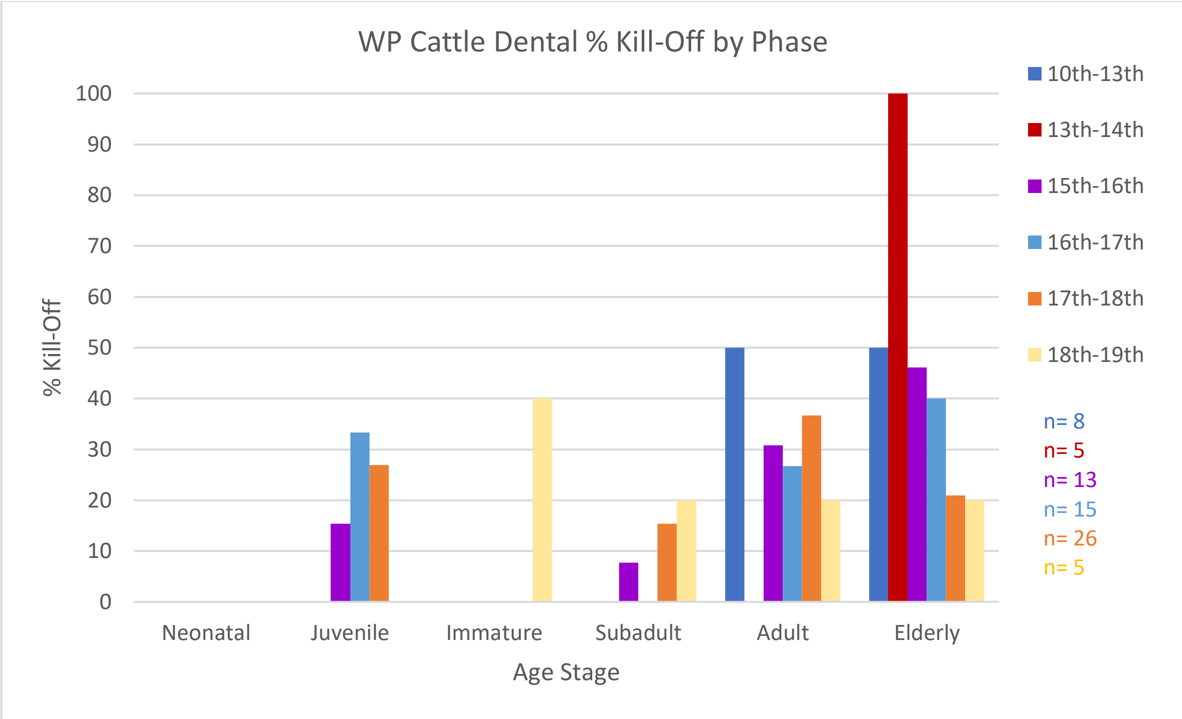

Figure 4.28: Cattle dental age profile, showing the percentage kill-off at each age stage, for the individual phases at Wharram Percy.

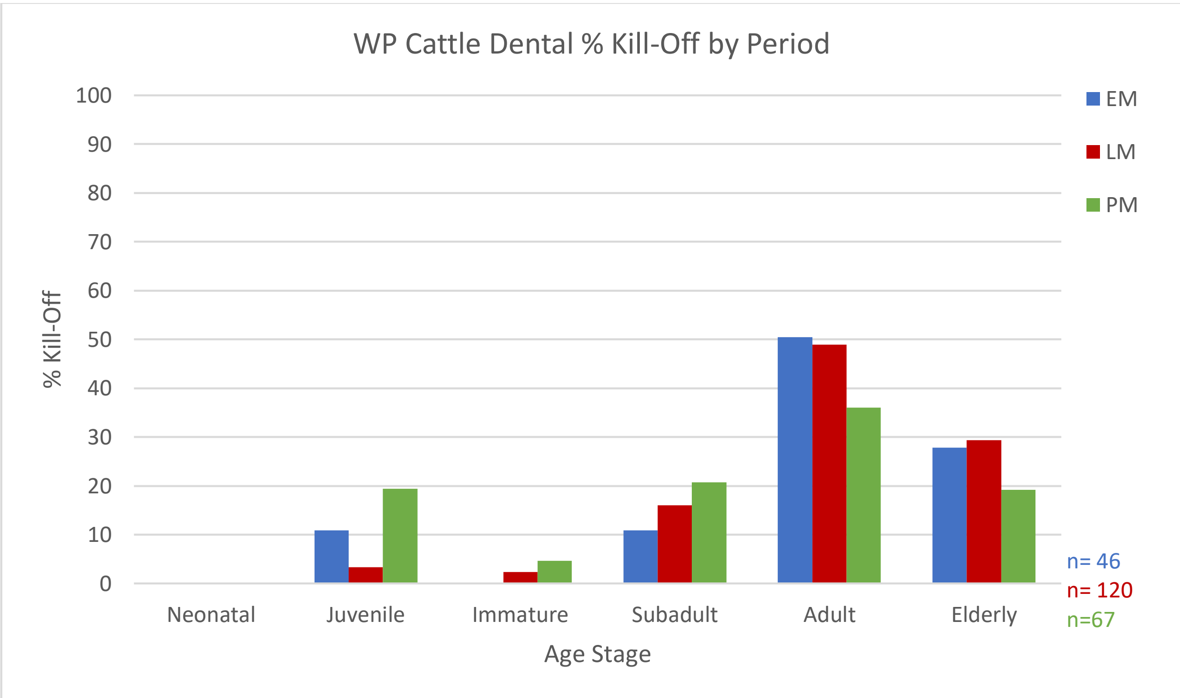

Figure 4.29: Cattle dental age profile, showing the percentage kill-off at each age stage, for the three main periods at Wharram Percy.

Pig

Pig fusion ageing results from Wharram Percy across the individual phases are very variable, due to small sample sizes, but results from the three broad phases suggest relatively high survival in stage one (Figure 4.30; Figure 4.31). In the earlier Medieval period, %survival in stage one is 73 percent, which then drops to 29 percent by 14-18 months. This suggests that some pigs died as a result of neonatal mortality in the first stage, but a much larger proportion were killed by eighteen months of age, and no pigs survive past the final stage of 30-42 months. In the late Medieval period, a similar pattern is evident, as %survival remains at 71 by 12 months, but decreases to 19 percent by stage two, and just ten percent by 30-42 months. This is also the case in the post-Medieval period, where there is a decrease between the first two stages, enhanced by the very low stage two survival in the 16th-17th century. There is a further decrease in the final stage, with only 12 percent of pigs surviving past three and a half years in the post-Medieval period. Overall, this suggests that a large proportion of pigs were killed at Wharram Percy between twelve and eighteen months of age, especially in the later periods, which likely means that they were being exploited predominantly for meat.

Pig dental ageing appears to partially support the fusion results, as they show an increase in %kill-off in the subadult stage, which reflects the decrease in survival in fusion stage two, around 14-18 months (Figure 4.32; Figure 4.33). Neonatal remains are totally absent for pig across all phases, likely due to the smaller, more fragile neonatal remains being poorly preserved or overlooked during excavation. In the earlier Medieval period, kill-off in the juvenile and immature categories is relatively low, below ten percent, suggesting that pigs were not deliberately slaughtered at these ages. However, in the subadult and adult stages, %kill-off reaches peaks of 34 and 52 percent, indicating a large increase in pig kill-off at these ages, most likely for consumption. There is a similar pattern in the late Medieval period, though juvenile kill-off is only two percent, followed by an increased immature kill-off. Again, there are peaks at the subadult and adult stages, with over half the herd killed as adults, though one percent remain to the elderly category. In the post-Medieval period, the herd profile is similar, though immature kill-off increases to 18 percent, and fewer subadults are present, especially in the 16th-17th century. This could suggest a shift towards the slaughter of younger animals, potentially indicating a more intensive exploitation of meat or faster growing animals. Overall, pig dental ageing is suggestive of pigs being slaughtered for meat as subadults; however, the consistent prevalence of adult animals across all periods is unusual, and suggests that pigs were not being intensively used for meat on the site, as that would produce an age profile dominated by younger animals. This could be the results of young individuals being sent elsewhere for slaughter – as discussed in the previous chapter, this would likely be young males not required for breeding. However, sexing results using canine teeth do not suggest a prevalence of females at Wharram Percy. In the earlier Medieval period, females outnumber males 2:1, but in the two following periods males are more common than females, in a ratio of 3:2. Unfortunately this assessment is based on a very small sample size of only 23 across all periods, meaning that a comparison to a nearby urban site may help to ascertain whether the transport of young individuals was practiced and therefore altered the age profile of pigs at Wharram Percy.

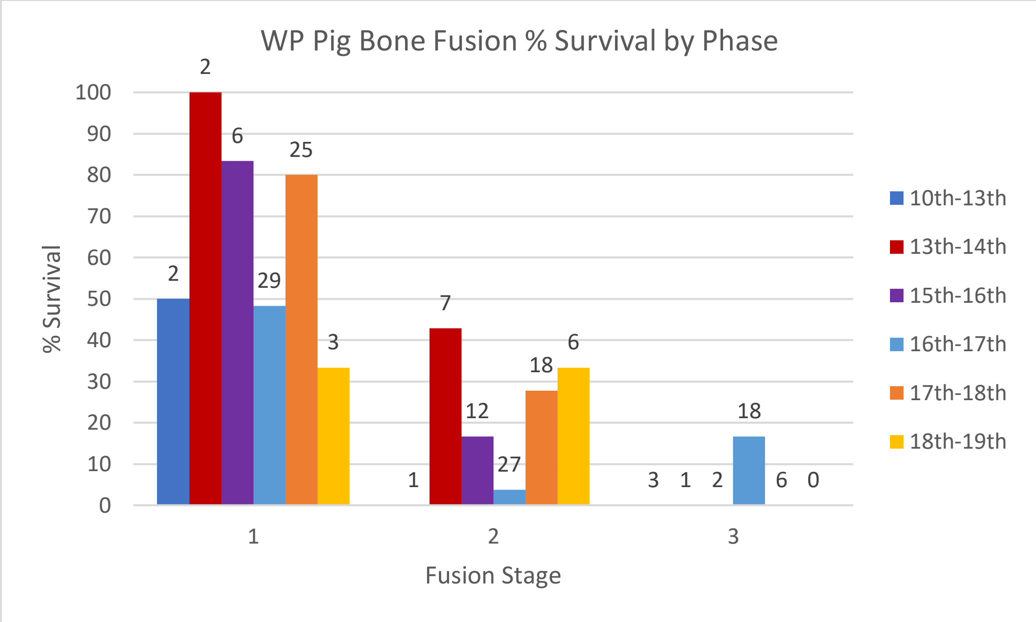

Figure 4.30: Pig %survival by bone fusion for the individual phases at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 6-12 months, Stage 2: 14-18 months, Stage 3: 30-42 months. The number of specimens per stage is given above the bars.

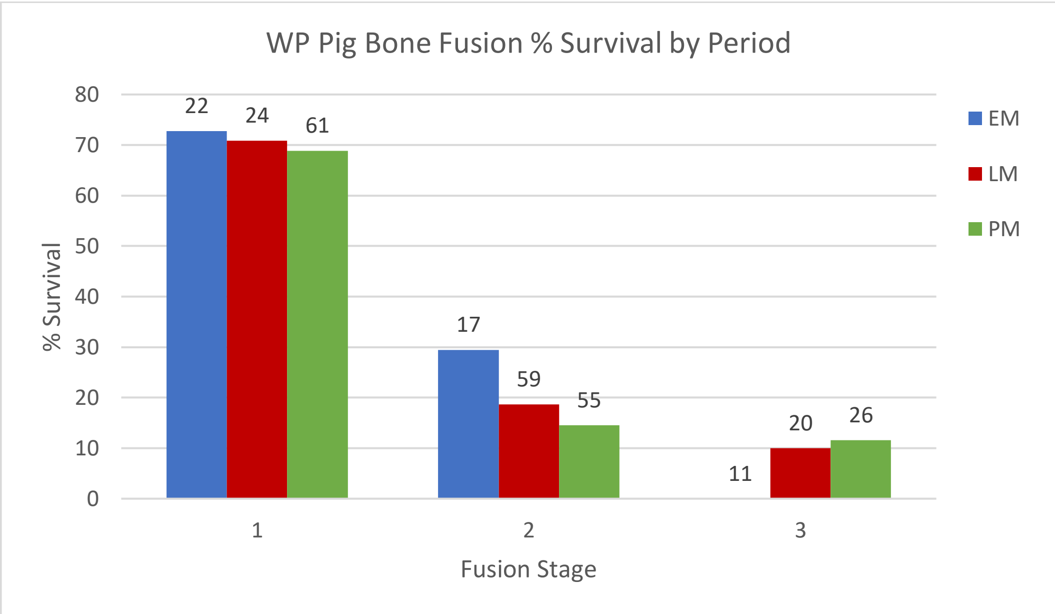

Figure 4.31: Pig %survival by bone fusion for the three main periods at Wharram Percy. The ages for each fusion stage are as follows: Stage 1: 6-12 months, Stage 2: 14-18 months, Stage 3: 30-42 months. The number of specimens per stage is given above the bars.

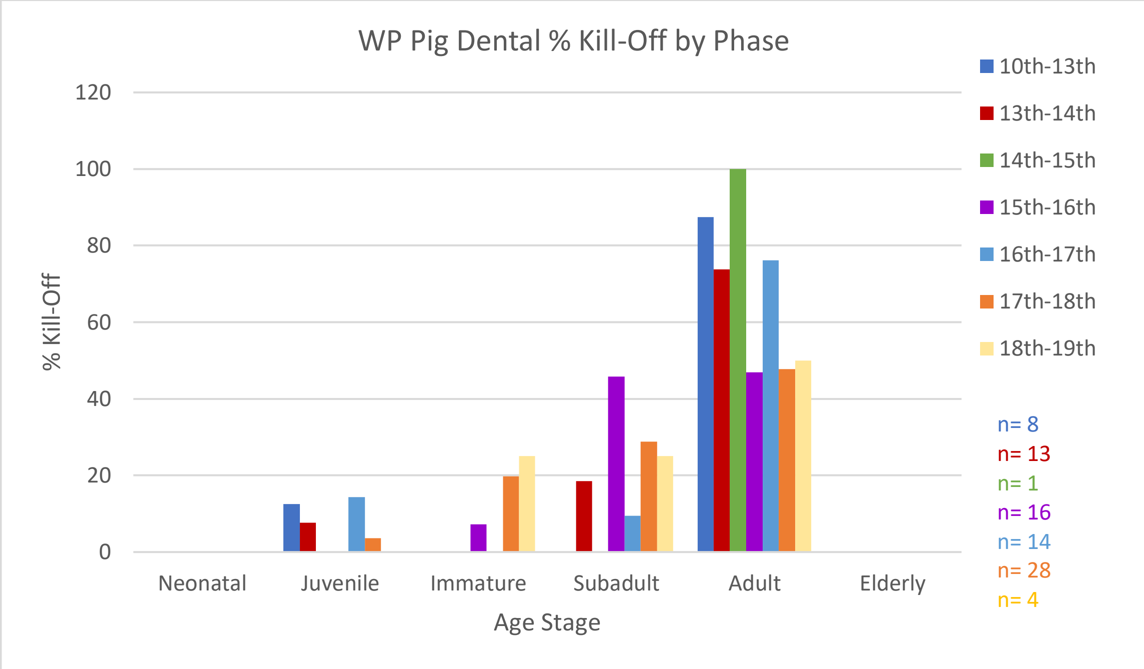

Figure 4.32: Pig dental age profile, showing the percentage kill-off at each age stage, for the individual phases at Wharram Percy.

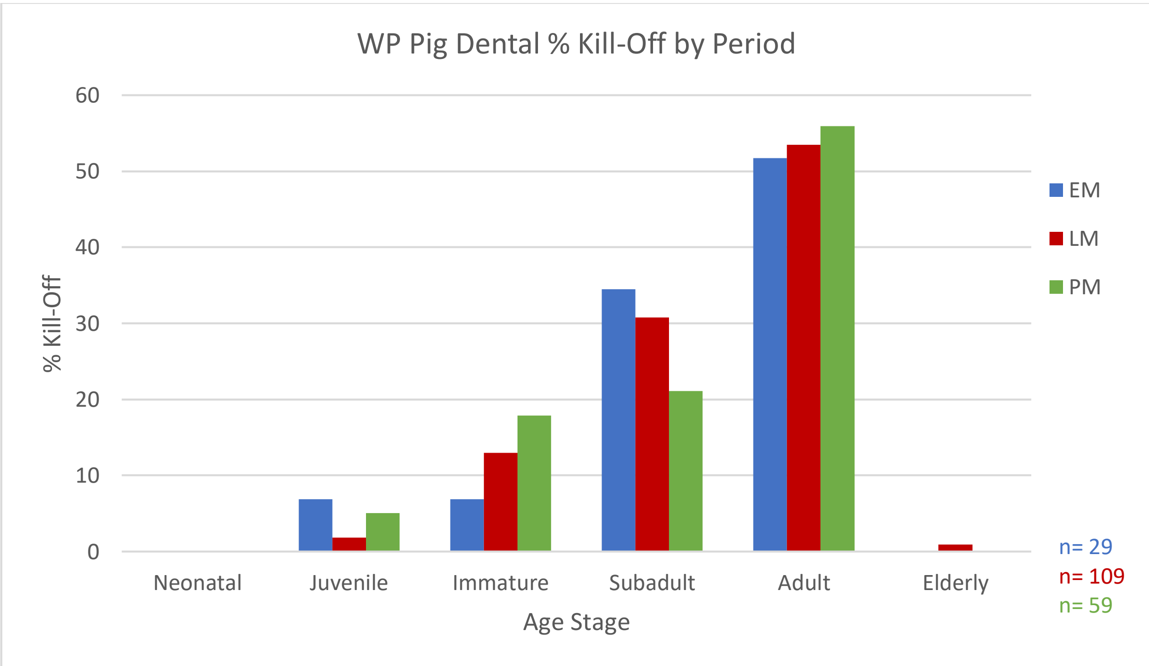

Figure 4.33: Pig dental age profile, showing the percentage kill-off at each age stage, for the three main periods at Wharram Percy.

Horse

Due to a small sample size of horse remains, horse age at Wharram Percy was estimated using the percentage of fused and unfused elements (Figure 4.58; Figure 4.59). Throughout the study period, the proportion of fused horse bones is very high, suggesting a predominance of adult animals in all phases. In the earlier Medieval period, only three percent of horse elements are unfused. This proportion reduces to one percent in the late Medieval period, and returns to three percent in the post-Medieval period, due to a greater frequency of unfused bones between the seventeenth and nineteenth centuries. Overall, this result suggests that most horses survived to adulthood at Wharram Percy across the study period, or that young animals were killed elsewhere. This is indicative of horses being used for transport or traction.

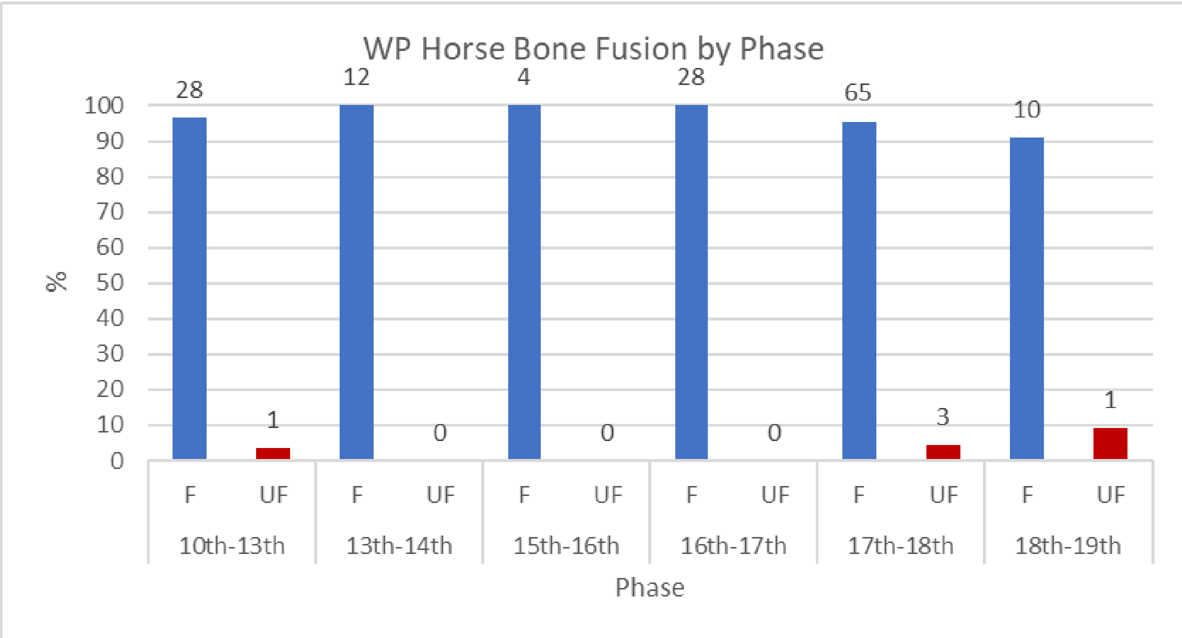

Figure 4.34: The proportion of fused and unfused horse bones from all phases at Wharram Percy. The numbers above the bars give the actual number of specimens.

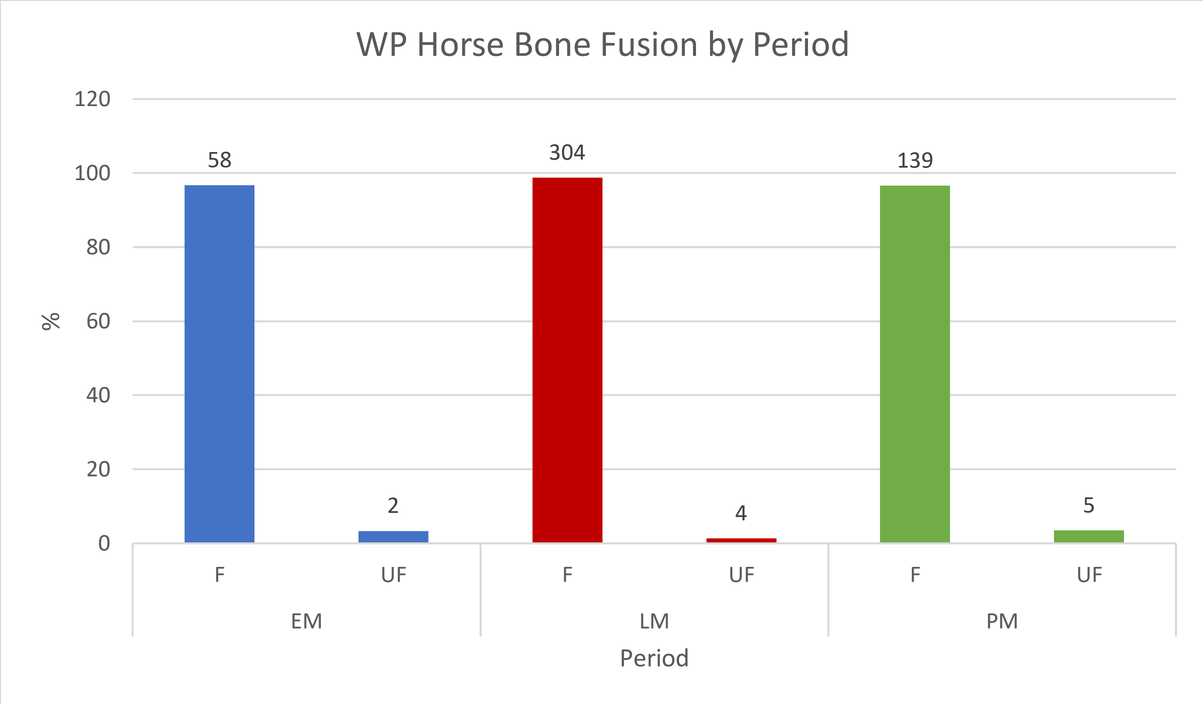

Figure 4.35: The proportion of fused and unfused horse bones from all periods at Wharram Percy. The numbers above the bars give the actual number of specimens.

4.2.7: Metric Results

An overview of the metric information for each species can be found in Appendices 19 to 22.

Sheep

A large sample size for sheep has allowed a detailed assessment of not only general size change throughout the three broad periods, but also across each individual phase on the site. Tooth size has been investigated using mandibular third molar width measurements from individual phases, though the 14th-15th century has been excluded due to a lack of measurements (Figure 4.36). The smallest mean M_3 width measurements is found in the 10th-13th century, at 7.5mm. This is followed by a relatively large increase in size to an average of 8.2mm in the following phase, a change which is highly significant ($P<0.01$) (see Table 4.4). Mean measurements remain relatively similar into the 15th-16th century, but exhibit a statistically significant decrease ($P<0.05$) in the first phase of the post-Medieval period down to 7.9mm. In the two following phases, M_3 width increases slightly, though not to a significant degree. These changes are largely reflected in the analysis from the broad site periods (Figure 4.37). The smallest average measurement is found in the earlier Medieval period, which is followed by a statistically significant increase ($P<0.05$) in the late Medieval period. However, the decrease in size seen in the 16th-17th is not apparent, as the post-Medieval average is very similar to the previous period, and there is no statistically significant change. In summary, at Wharram Percy sheep tooth size was smallest in the earlier Medieval period and increased significantly in the late Medieval period, then remained relatively constant in the final period.

An initial assessment of sheep post-cranial size change at Wharram Percy was achieved by comparing astragalus, distal humerus and distal tibia measurements across both the individual phases and broad periods of the site. These elements were selected due to the relatively large availability of measurements. There is a large overlap between astragalus measurements across all phases, except the 17th-18th and 18th-19th, which exhibit some larger measurements than the previous phases, therefore suggesting an increase in astragalus size from the seventeenth century (Figure 4.38). This is reflected in the astragalus measurements across the broad periods, as there is considerable overlap between all periods, but some larger specimens in the post-Medieval period (Figure 4.39). T-test results for individual measurements also demonstrate this increase in post-Medieval astragalus size, as all astragalus measurement show a highly significant change ($P<0.01$) in the late to post-Medieval transition (Table 4.5). A shift to larger post-cranial size in the post-Medieval period is also partly exhibited by distal humerus measurements by phase and period (Figure 4.40; Figure 4.41). Across the individual phases, specimens from the 13th-14th century cluster at the lower end of the scale, while examples from the post-Medieval period, particularly the 17th to 19th centuries, are some of the largest. This shift in size is less discernible across the broad periods, as there is a very large overlap in results, with only a small shift towards larger values in the post-Medieval period, and in fact the largest specimen coming from the earlier Medieval period. However, t-test results for all distal humerus measurements indicate that there is a statistically-significant change in the late to post-Medieval transition. Furthermore, an increase in size can also be seen in sheep distal tibia measurements. Across the individual phases, the measurements from the tenth to fourteenth centuries again cluster at the lower end of the scale, whereas the largest specimens are from the seventeenth to nineteenth centuries (Figure 4.42). As a result, in the broad periods, post-Medieval values extend beyond the earlier and late Medieval examples (Figure 4.43), and the t-test results for tibia measurements between the late and post-Medieval periods are highly significant ($P>0.01$). Overall, assessment of post-cranial sheep measurements at Wharram Percy suggest that there was an increase in sheep size in the post-Medieval period, particularly in the seventeenth to nineteenth centuries.

To investigate this trend further, log ratio analysis has been used for all recorded post-cranial sheep elements at Wharram Percy. This allows the combination of different measurements on the same axis, resulting in an increased sample size and therefore a more reliable assessment. Across the individual phases, there is very little change in average post-cranial length values until the 17th-18th century, where there is a shift towards larger measurements (Figure 4.44). This suggests that sheep bone length increased from the seventeenth century onwards, which is supported by t-test results that indicate highly statistically significant ($P<0.01$) changes between the 16th-17th and 17th-18th, and 17th-18th and 18th-19th centuries (Table 4.6). As a result, the mean post-cranial length values for the earlier and late-Medieval periods are very similar (Figure 4.45), but there is a clear increase in the post-Medieval period, again a highly significant change ($P<0.01$). Overall, this suggests that there is a considerable shift towards greater post-cranial sheep length in the post-Medieval period, particularly after the seventeenth century.

A very similar pattern is shown in the combined sheep post-cranial width measurements across the individual phases at Wharram Percy (Figure 4.46). Average log-ratio width values are extremely similar from the tenth to the seventeenth century, when they once again exhibit a sustained increase throughout the seventeenth to nineteenth centuries. Statistical test results indicate that these changes in width between the 16th-17th and 17th-18th, and 17th-18th to 18th-19th centuries are again highly significant ($P<0.01$) (Table 4.5). Furthermore, a similar shift to larger values can be seen in the general post-Medieval period (Figure 4.47), which suggests that sheep elements underwent an increase in width, in addition to length, from the seventeenth century onwards. There is also an increase in post-cranial depth size around the same time, though it is less pronounced. Once again, tenth to seventeenth century mean measurements are very similar, and there is an increase in average depth in the 17th-18th and 18th-19th centuries (Figure 4.48). However, only the change in the 17th-18th century is statistically significant (P<0.05) (Table 4.6), suggesting a less marked increase in the final phase than is seen for length or width results. Consequently, there is a shift towards larger depth values in the post-Medieval period overall, but it is not as distinct (Figure 4.49), though still statistically significant (P<0.05). In summary, sheep post cranial size clearly increased in terms of length and width from the seventeenth century onwards, and also in terms of depth, but this change was smaller. This would have resulted in generally larger sheep from this phase at Wharram Percy.

The final metric data assessed for sheep was the coefficient of variation (CV) for post-cranial and tooth measurements across the individual phases and general periods at Wharram Percy (Table 4.7). Across all phases, post-cranial variation is generally high, between 5.7 and 7.8 throughout the study period. Popkin et al (2012, 1789-90) indicate that changes in factors like sex, castration and nutrition in a single breed result in lower CV values than breed change. All post-cranial CV results except in the 13th-14th century at Wharram Percy are relatively high, suggesting heterogeneity in the flock throughout time, perhaps the result of multiple breeds at the site. The greatest post-cranial CV values are found in the 17th-18th and 18th-19th centuries, perhaps reflecting the increased size or range of post-cranial measurements in those phases. As these results range from 7.6 to 7.8 in these periods, it is likely that this variation was the result of multiple breeds on the site, rather than a change in nutrition or sex ratios. This increased variation can also be seen in the general post-Medieval results, as the CV value increase from 7.6 to 8.3, though variation in the earlier Medieval period is highest, suggesting greater flock heterogeneity in the earliest period. In contrast to post-cranial CV results, the values for teeth are lowest in the 18th-19th century, not reflecting the increased variation shown by post-cranial remains. The highest CV values for teeth can be found in the fifteenth to seventeenth century, which indicates an increased variation in the flock during the late to post-Medieval transition. However, across the three general periods, the earlier Medieval period displays the highest CV result, followed by the late Medieval, then the post-Medieval. Overall, tooth CV values are relatively high throughout the study period, perhaps suggesting the presence of multiple breeds from an early date; however, it seems that the greatest variation is found in the fifteenth to seventeenth century, earlier than the results shown by the post-cranial CVs.

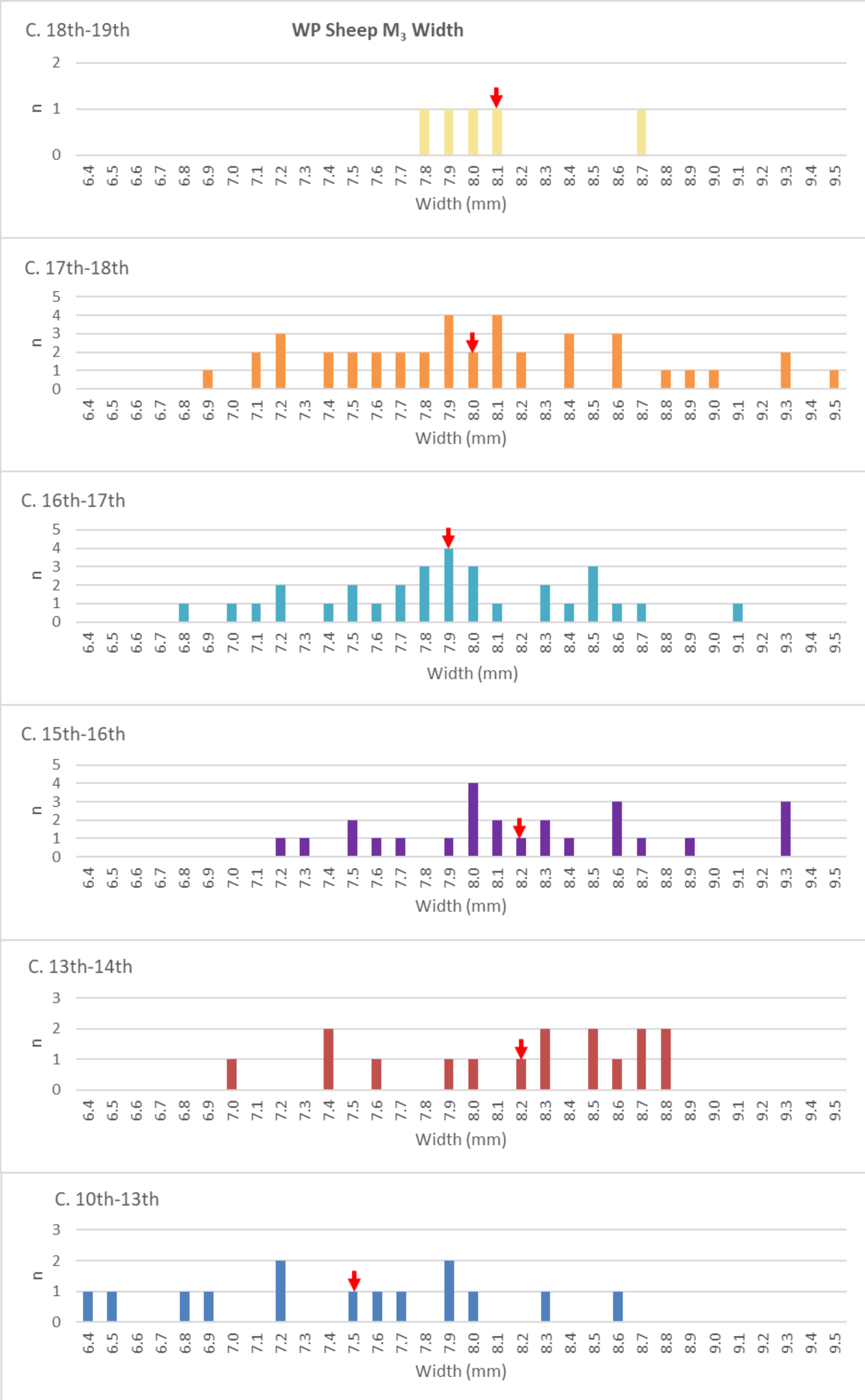

Figure 4.36: Histograms plotting width measurements of sheep mandibular third molar by phase at Wharram Percy. The red arrows indicate the position of the mean.

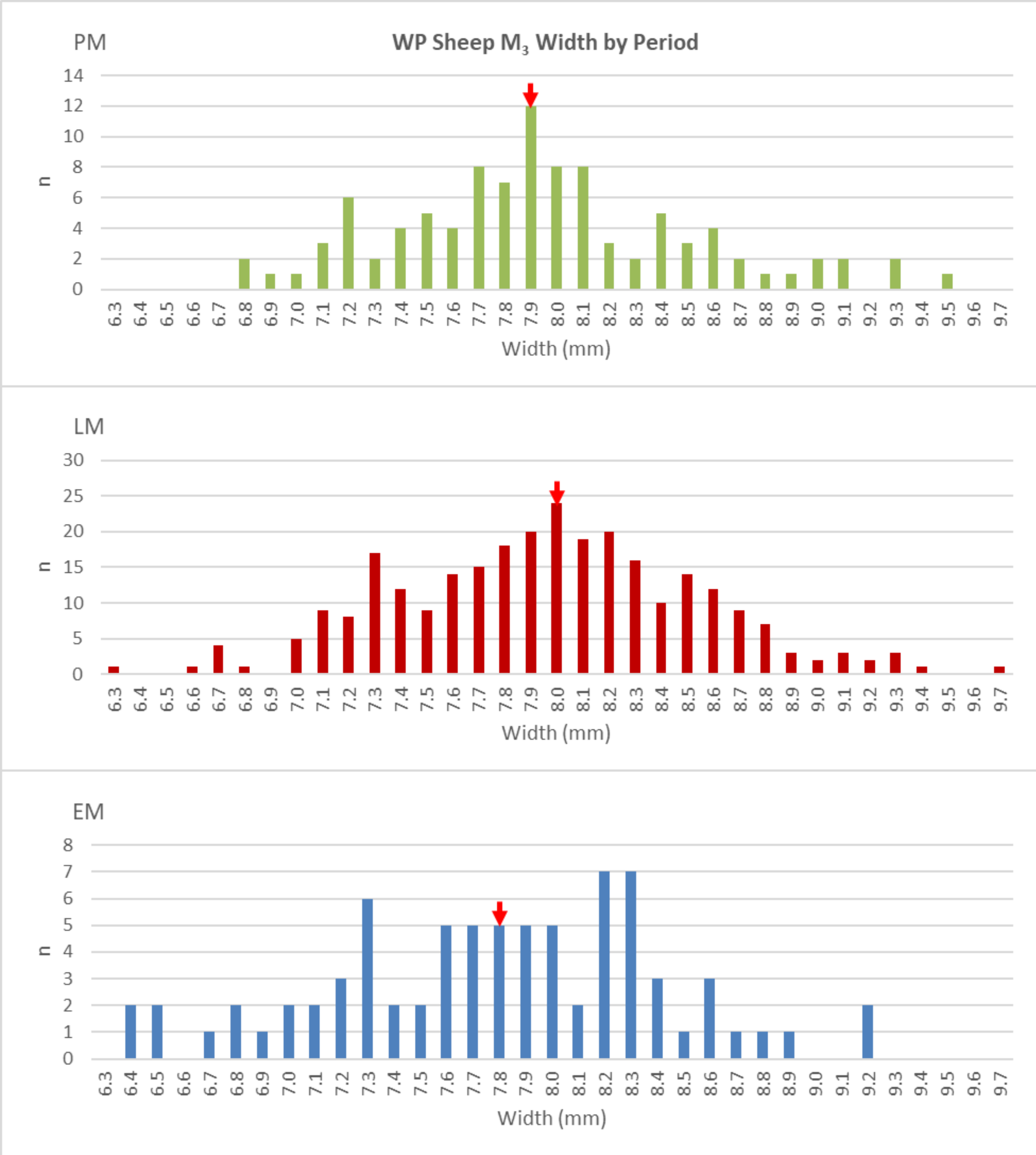

Figure 4.37: Histograms plotting width measurements of sheep mandibular third molar by period at Wharram Percy. The red arrows indicate the position of the mean.

Table 4.2: Statistical test results for Wharram Percy mandibular third sheep molar width by phases and periods.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	-3.114	0.004	P< 0.01
13th-14th vs. 15th-16th	0.256	0.800	P> 0.05
15th-16th vs. 16th-17th	2.097	0.041	P< 0.05
16th-17th vs. 17th-18th	0.916	0.363	P> 0.05
17th-18th vs. 18th-19th	-0.412	0.692	P> 0.05
Period:			
EM vs. LM	-2.233	0.027	P< 0.05
LM vs. PM	-0.306	0.769	P> 0.05

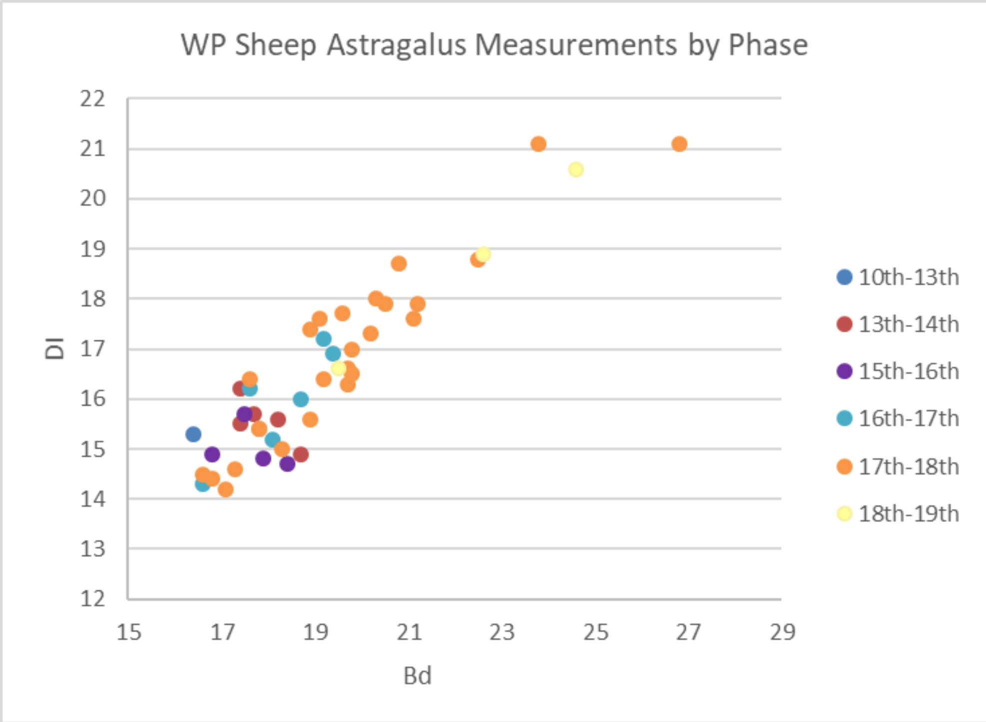

Figure 4.38: Comparison of astragalus measurements for sheep by phase at Wharram Percy.

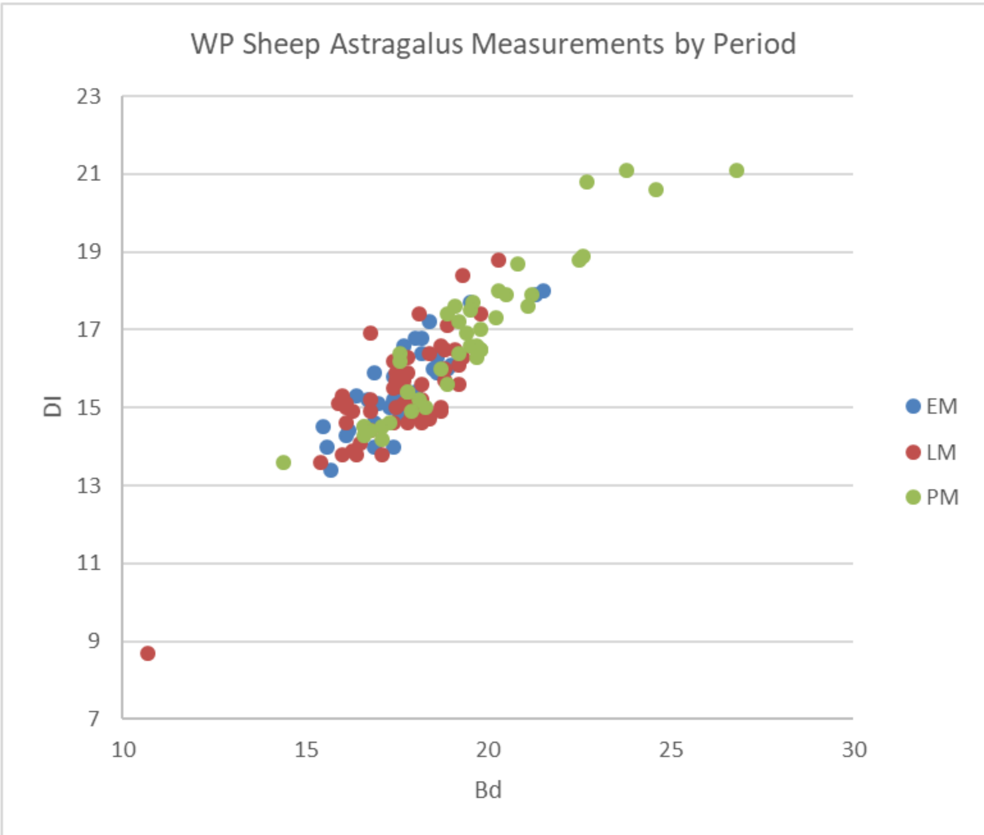

Figure 4.39: Comparison of astragalus measurements for sheep by period at Wharram Percy.

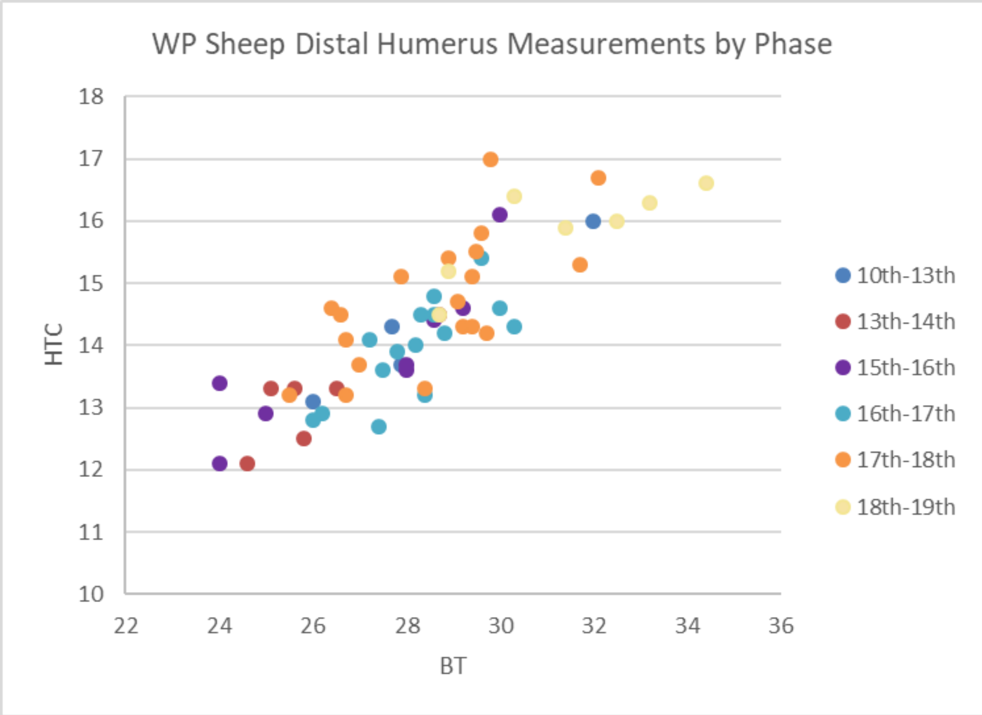

Figure 4.40: Comparison of distal humerus measurements for sheep by phase at Wharram Percy.

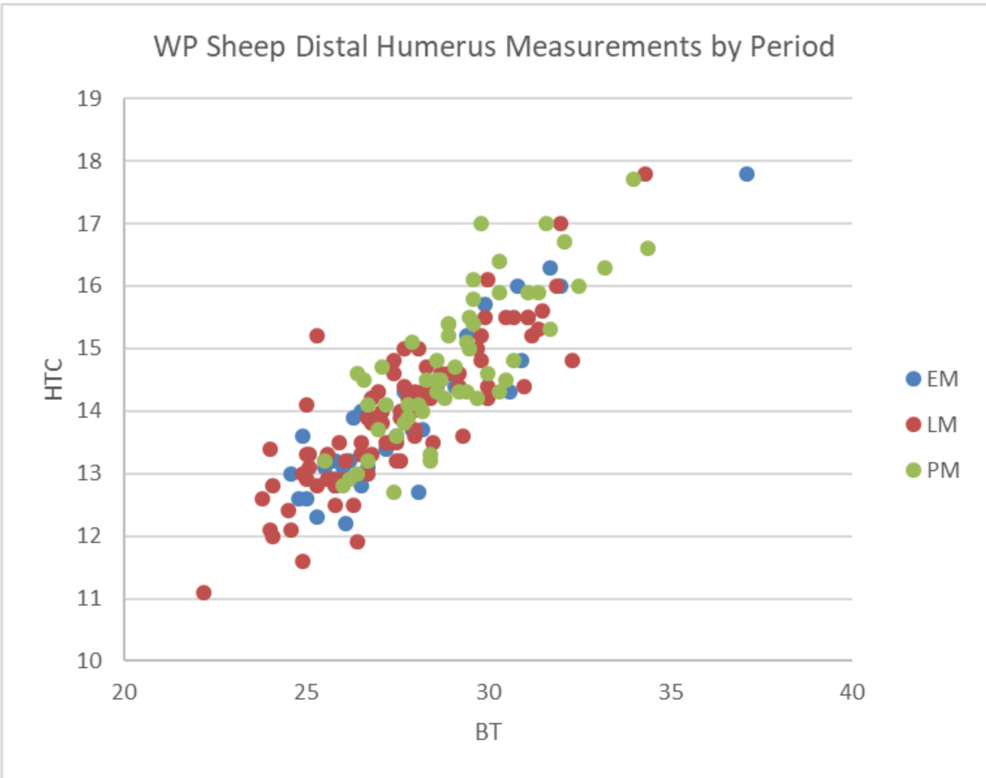

Figure 4.41: Comparison of distal humerus measurements for sheep by period at Wharram Percy.

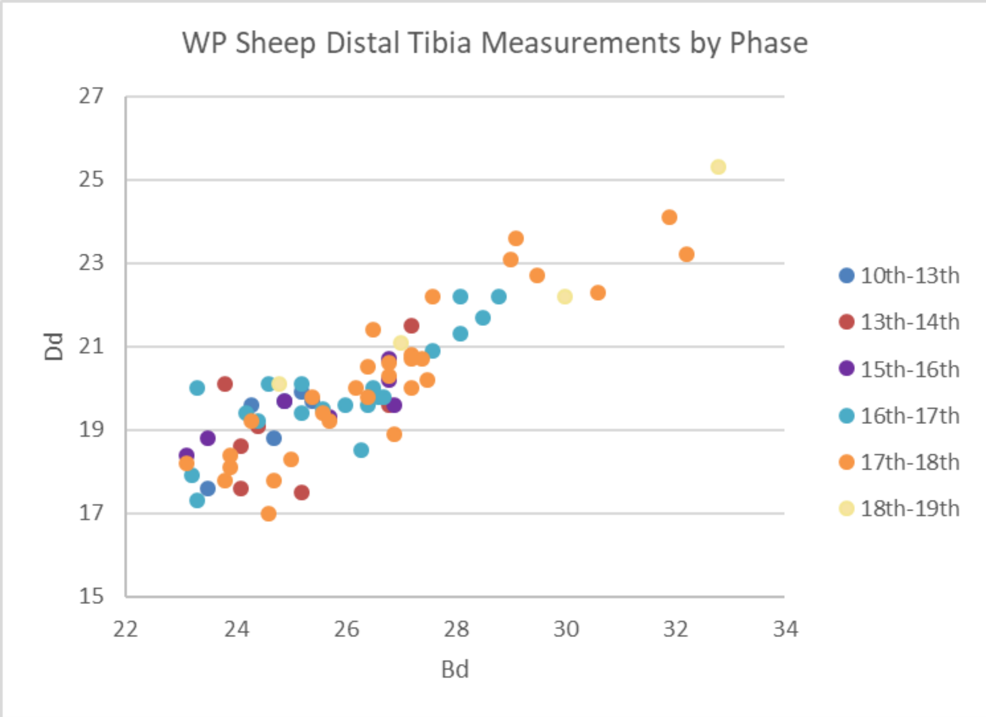

Figure 4.42: Comparison of distal tibia measurements for sheep by phase at Wharram Percy.

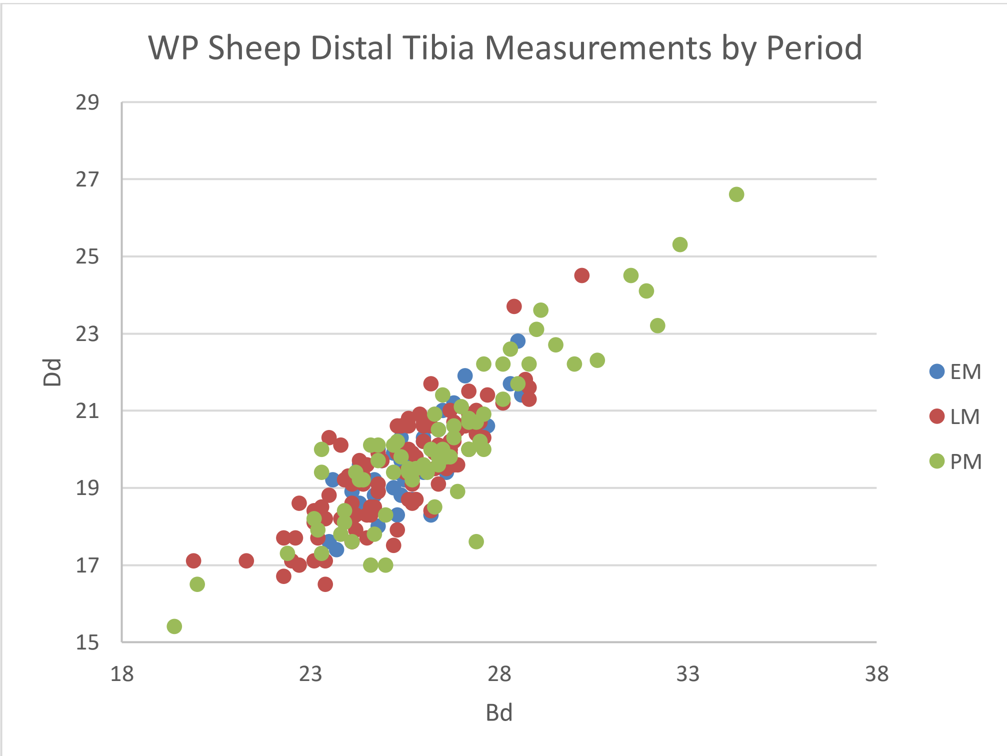

Figure 4.43: Comparison of distal tibia measurements for sheep by period at Wharram Percy.

Table 4.3: Statistical test results for individual sheep bone measurements between the earlier, late and post-Medieval periods at Wharram Percy. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t stat/ U-value**	**P value**	**Significance**	**t stat/ U-value**	**P value**	**Significance**
dP_4 W	2309	0.069	P> 0.05	1610	0.729	P> 0.05
M_1 W	384	0.005	P< 0.01	2492	0.065	P> 0.05
M_2 W	1.649	0.105	P> 0.05	0.471	0.640	P> 0.05
M_3 L	9090	0.571	P> 0.05	1.049	0.296	P> 0.05
M_3 W	8507	0.041	P< 0.05	-0.306	0.760	P> 0.05
Scapula GLP	-0.662	0.520	P> 0.05	1.935	0.062	P> 0.05
Scapula SLC	0.360	0.724	P> 0.05	-2.625	0.012	P< 0.05
Humerus BT	1478	0.756	P> 0.05	-4.241	0.000	P< 0.01
Humerus Bd	1437	0.995	P> 0.05	3167	0.000	P< 0.01
Humerus HTC	1661	0.287	P> 0.05	4.388	0.000	P< 0.01
Radius Bp	0.754	0.457	P> 0.05	1016	0.151	P> 0.05
Radius Bd	-1.143	0.264	P> 0.05	1.415	0.171	P> 0.05
Metacarpal GL	-0.036	0.641	P> 0.05	0.715	0.080	P> 0.05
Metacarpal SD	3.533	0.003	P< 0.01	-0.082	0.935	P> 0.05
Metacarpal Bd	-2.343	0.032	P< 0.05	174	0.997	P> 0.05
Metacarpal a	2.421	0.032	P< 0.05	-0.076	0.940	P> 0.05
Metacarpal b	-2.431	0.080	P> 0.05	-0.356	0.861	P> 0.05
Metacarpal 1	2.864	0.009	P< 0.01	-0.088	0.931	P> 0.05
Metacarpal 2	2.719	0.012	P< 0.05	-1.178	0.250	P> 0.05
Metacarpal 3	4.332	0.001	P< 0.01	-0.051	0.920	P> 0.05
Metacarpal 4	-3.094	0.005	P< 0.01	0.812	0.425	P> 0.05
Metacarpal 5	0.186	0.064	P> 0.05	-1.642	0.161	P> 0.05
Pelvis LA	1.575	0.131	P> 0.05	-0.677	0.508	P> 0.05
Femur DC	0.221	0.828	P> 0.05	1.178	0.258	P> 0.05
Femur Bd	1.400	0.193	P> 0.05	-1.352	0.195	P> 0.05
Tibia Bd	-1.266	0.209	P> 0.05	4807	0.003	P< 0.01
Tibia Dd	1642	0.532	P> 0.05	4375	0.023	P< 0.05
Astragalus GLl	1028	0.350	P> 0.05	3.728	0.000	P< 0.01
Astragalus GLm	-0.022	0.982	P> 0.05	1366	0.009	P< 0.01
Astragalus Bd	959	0.732	P> 0.05	1734	0.000	P< 0.01
Astragalus Dl	893	0.568	P> 0.05	1636	0.000	P< 0.01
Calcaneum GL	0.316	0.755	P> 0.05	0.087	0.931	P> 0.05
Calcaneum GB	-1.342	0.340	P> 0.05	0.117	0.556	P> 0.05
Metatarsal GL	-0.889	0.395	P> 0.05	-0.766	0.315	P> 0.05
Metatarsal SD	-0.347	0.734	P> 0.05	-0.342	0.741	P> 0.05
Metatarsal Bd	-0.540	0.595	P> 0.05	0.705	0.488	P> 0.05
Metatarsal a	-1.158	0.263	P> 0.05	0.254	0.804	P> 0.05
Metatarsal b	-0.758	0.056	P> 0.05	0.967	0.349	P> 0.05
Metatarsal 1	0.504	0.769	P> 0.05	-0.454	0.655	P> 0.05
Metatarsal 2	0.694	0.919	P> 0.05	-0.305	0.765	P> 0.05
Metatarsal 3	0.357	0.552	P> 0.05	-0.672	0.513	P> 0.05
Metatarsal 4	1.145	0.575	P> 0.05	1.465	0.167	P> 0.05
Metatarsal 5	0.465	0.658	P> 0.05	0.872	0.399	P> 0.05

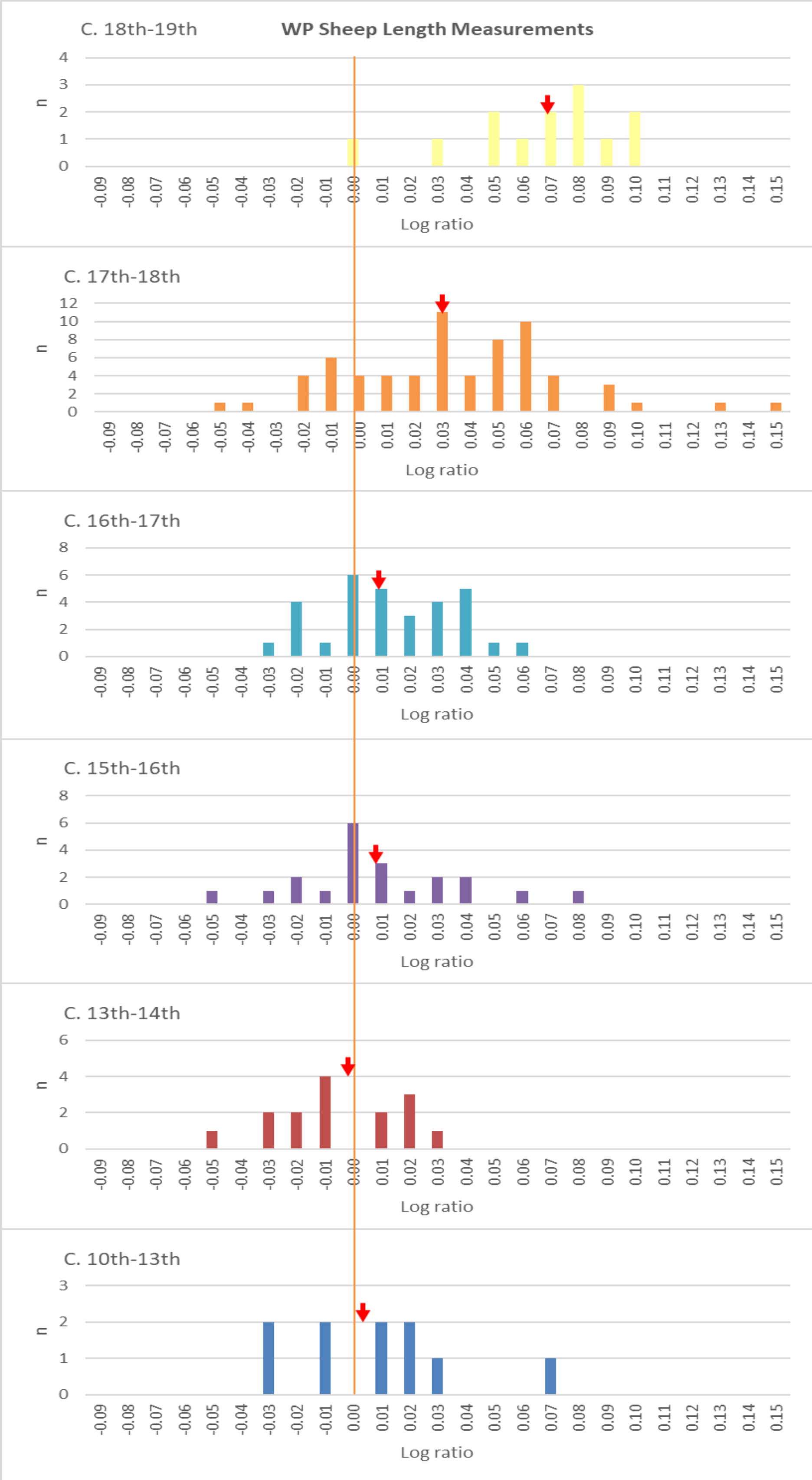

Figure 4.44: Log ratio histograms combining sheep post-cranial bone length measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

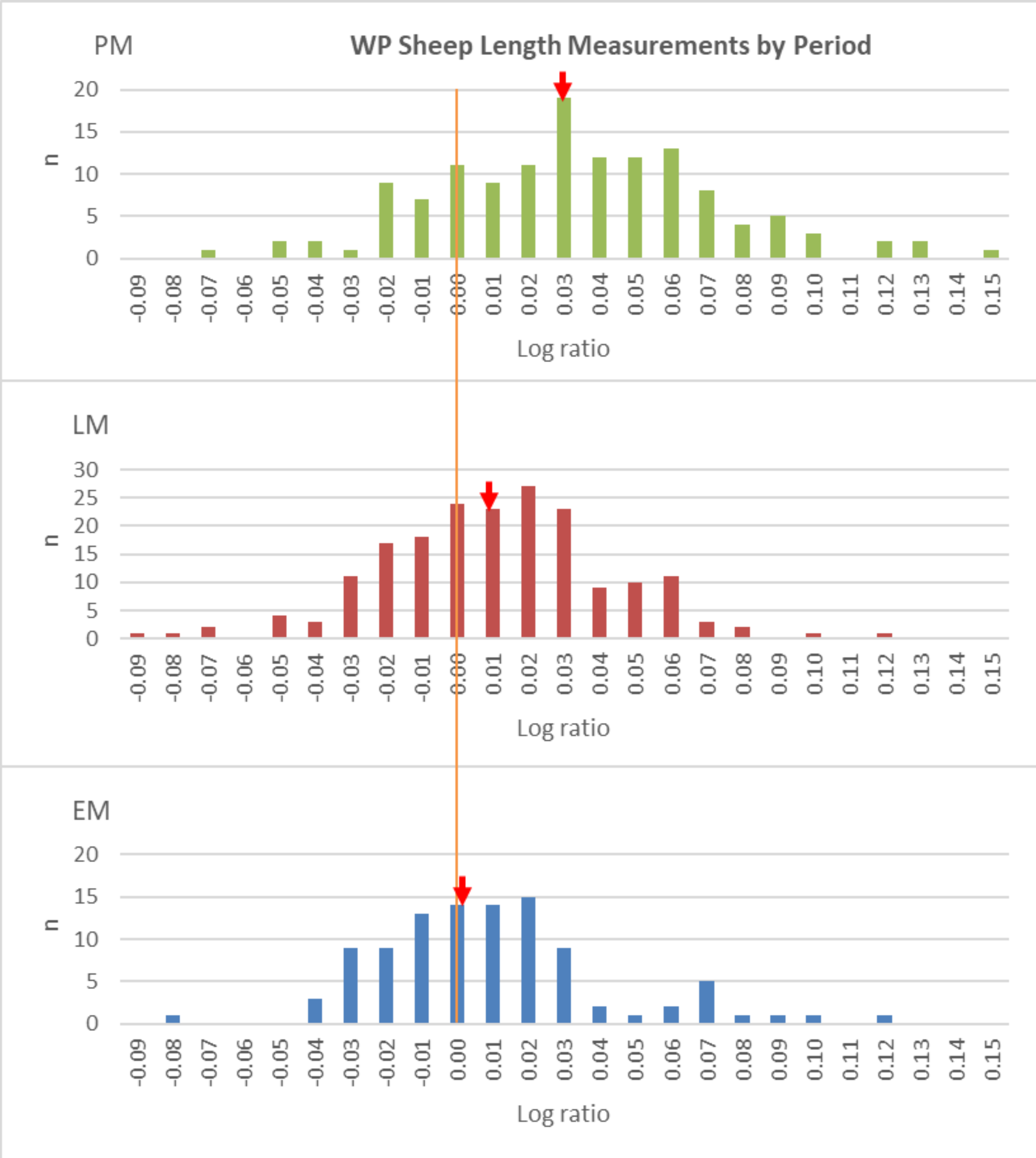

Figure 4.45: Log ratio histograms combining sheep post-cranial bone length measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.4: Statistical test results for the post-cranial log ratio length values for sheep by phases and periods at Wharram Percy.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	1.060	0.305	P> 0.05
13th-14th vs. 15th-16th	1.864	0.071	P> 0.05
15th-16th vs. 16th-17th	-0.509	0.614	P> 0.05
16th-17th vs. 17th-18th	3.339	0.001	P< 0.01
17th-18th vs. 18th-19th	-3.944	0.001	P< 0.01
Period			
EM vs. LM	10592	0.168	P> 0.05
LM vs. PM	5.507	0.000	P< 0.01

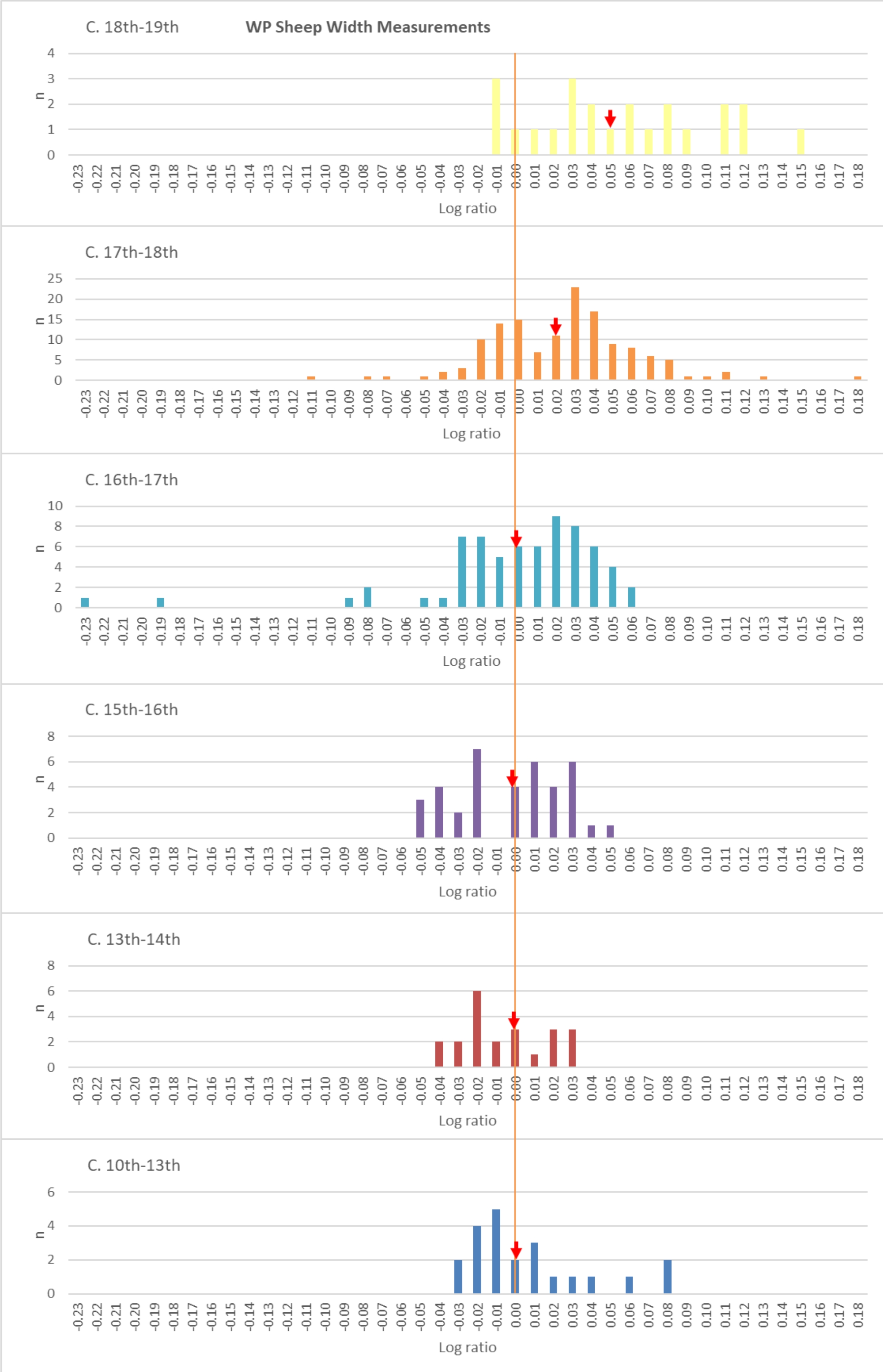

Figure 4.46: Log ratio histograms combining sheep post-cranial bone width measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

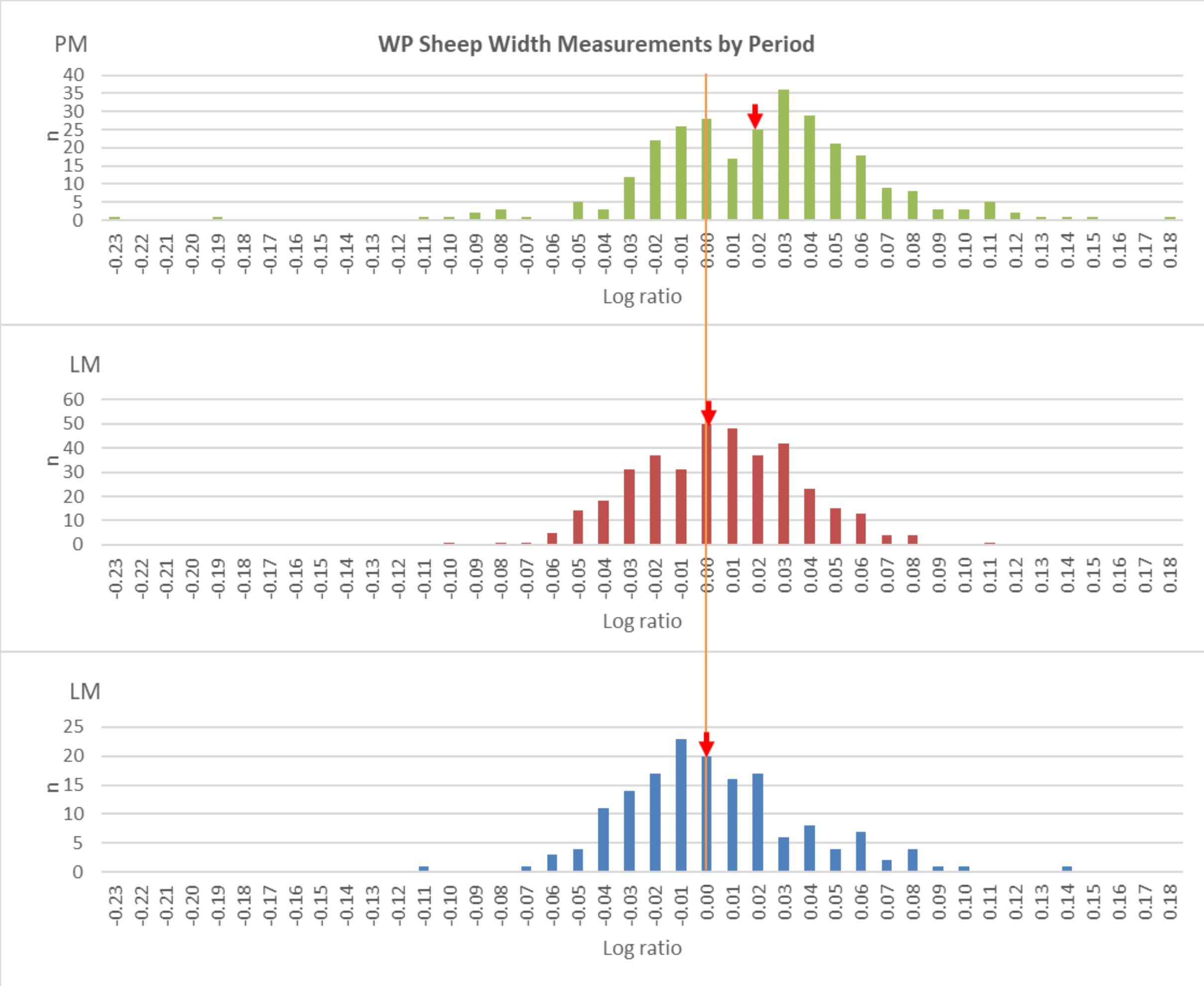

Figure 4.47: Log ratio histograms combining sheep post-cranial bone width measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.5: Statistical test results for the post-cranial log ratio width values for sheep by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 13th-14th	283	0.348	P> 0.05
13th-14th vs. 15th-16th	0.256	0.799	P> 0.05
15th-16th vs. 16th-17th	1504	0.197	P> 0.05
16th-17th vs. 17th-18th	3283	0.000	P< 0.01
17th-18th vs. 18th-19th	2249	0.002	P< 0.01
Period			
EM vs. LM	28232	0.211	P> 0.05
LM vs. PM	66779	0.000	P< 0.01

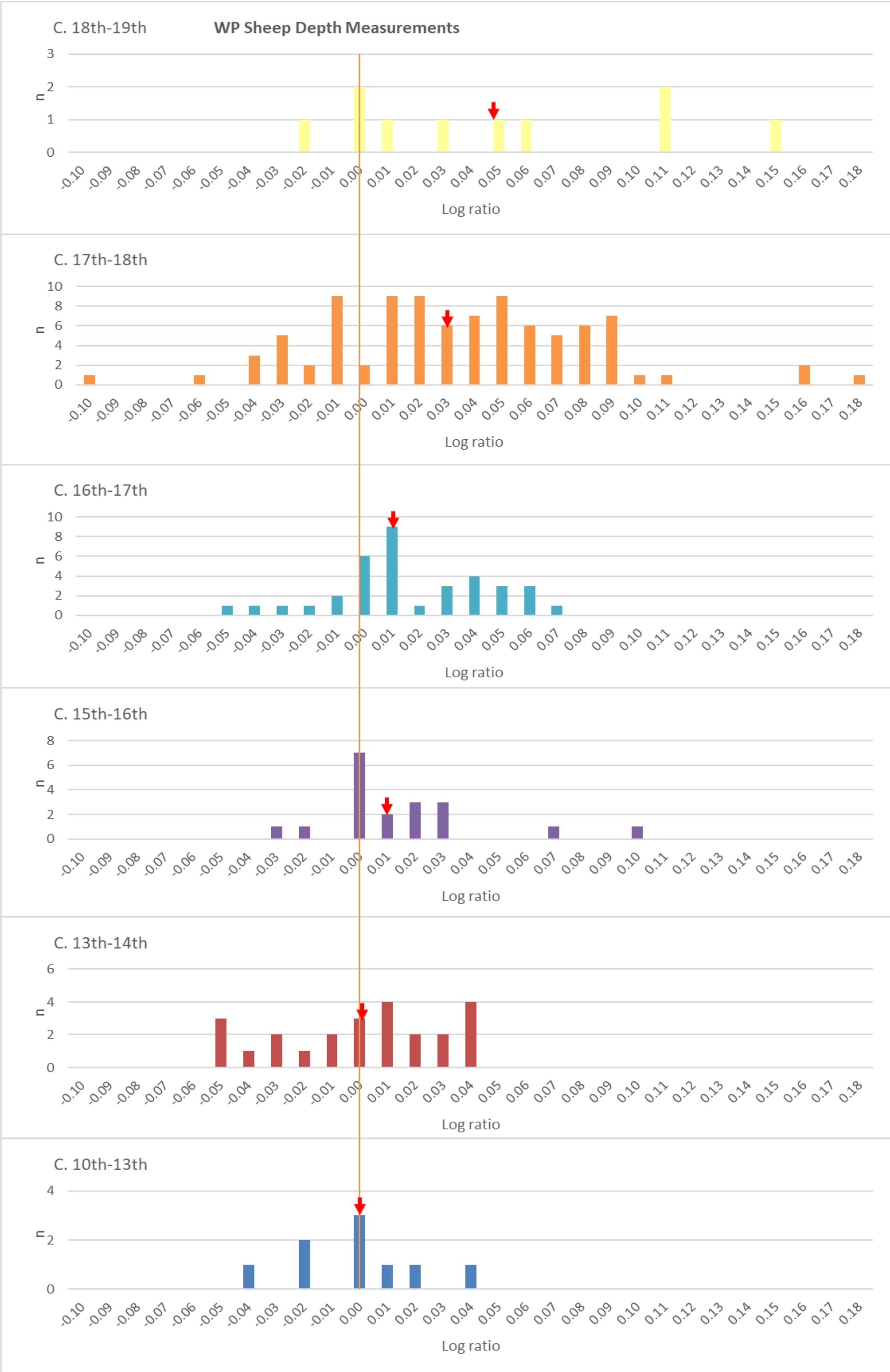

Figure 4.48: Log ratio histograms combining sheep post-cranial bone depth measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

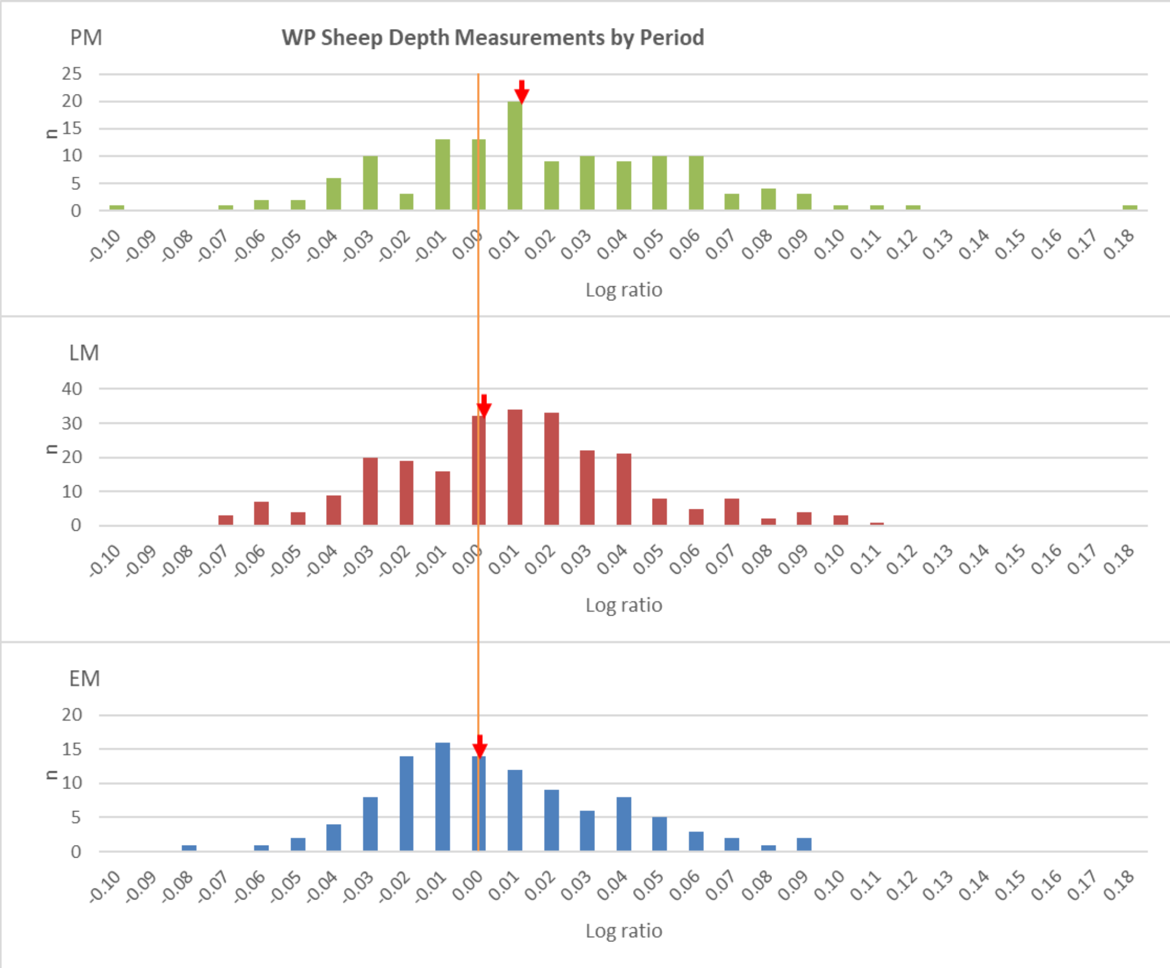

Figure 4.49: Log ratio histograms combining sheep post-cranial bone depth measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.6: Statistical test results for the post-cranial log ratio depth values for sheep by phases and periods at Wharram Percy.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	0.035	0.972	P> 0.05
13th-14th vs. 15th-16th	191	0.365	P> 0.05
15th-16th vs. 16th-17th	378	0.535	P> 0.05
16th-17th vs. 17th-18th	2.577	0.0114	P< 0.05
17th-18th vs. 18th-19th	0.900	0.389	P> 0.05
Period			
EM vs. LM	1.375	0.171	P> 0.05
LM vs. PM	2.167	0.0313	P< 0.05

Table 4.7: Coefficient of variation values for sheep teeth and post-cranial elements across both the individual phases and broad periods at Wharram Percy.

Phase	**Post-cranial**	**Teeth**
10th-13th	6.9	6.2
13th-14th	5.7	5.9
14th-15th	n/a	2.9
15th-16th	6.1	7.1
16th-17th	6.4	7.1
17th-18th	7.8	6.6
18th-19th	7.6	4.7
Period		
EM	8.4	7.4
LM	7.6	7.1
PM	8.3	6.9

Cattle

The size of cattle teeth through time at Wharram Percy was assessed using the third mandibular molar width, though a smaller sample size than for sheep means that only change throughout the broad periods could be considered (Figure 4.50). In the earlier Medieval period, the average cattle M_3 width is 13.5mm, which is followed by a slight increase to 13.9 in the late Medieval period. The mean width then decreases again in the post-Medieval period to 13.6mm. This may suggest that cattle teeth were largest in the late Medieval period; however, t-test results indicate that there was no statistically significant change in cattle M_3 width between any of the three periods (Table 4.8). This implies that, despite a slight change in means, there is no significant difference in the size of cattle M_3 measurements across the broad periods at Wharram Percy.

The initial assessment of cattle post-cranial size change at Wharram Percy was carried out by comparing measurements from the astragalus, distal humerus and distal tibia. Astragalus measurements Bd and Dl were compared across all individual phases of the site, as well as the three broad periods (Figure 4.51; Figure 4.52). The comparison between individual phases shows a large overlap between measurements from all phases, which suggests similar astragalus size throughout the study period. This is supported by the assessment of astragalus measurements from the earlier, late and post-Medieval periods, as again there is considerable overlap. However, there are two particularly large measurements from the earlier Medieval period, which may cause the statistically significant change between the earlier and late Medieval periods in GLl, GLm and Dl (Table 4.9). Due to a smaller sample size of available measurements for the cattle distal humerus, measurements are only compared across the three general periods for this element (Figure 4.53). Again, there is a lot of overlap between measurements from all periods, which implies a relatively constant size throughout the study period. Several earlier Medieval values plot at the lower end of the scale, perhaps suggesting the presence of smaller animals in the earlier Medieval period; however, statistical test results do not indicate a significant change in the earlier to late Medieval transition. Distal tibia measurements were also only compared across the three broad periods, due to a small sample size (Figure 4.54). There is mostly a large overlap between the Bd and Dd measurements for all phases, though there are some larger specimens in the earlier and post-Medieval periods. Statistical test results for individual elements show a statistically significant change ($P<0.05$) in Dd values going into the post-Medieval phase, which may suggest a real increase in this measurement during the final period. However, there is no significant change between the three periods for any other measurement, suggesting a relatively constant cattle size throughout the study period at Wharram Percy.

Post-cranial cattle size at Wharram Percy was further investigated using the log-ratio method, allowing for the combination of measurements and comparison to a standard set of measurements, thus reducing the issue of small sample size. Cattle length measurements were compared across the individual phases using this method (Figure 4.55). This comparison shows an increase in size between the 10th-13th and 13th-14th century phases, followed by an apparently large decrease in size in the 15th-16th century. Length measurements then increase in size in the 16th-17th century, and maintain their size through to the final phase. These results suggest that there is a considerable post-cranial length increase in the 13th-14th century, followed by a decrease in the following phase; however, there is no statistically significant change in mean length throughout the study period (Table 4.10). Consequently, it may be the small sample size from each phase that is over-emphasising these changes. The length log-ratio results for the three broad periods support this, as they show very little change in mean between the earlier, late and post-Medieval periods (Figure 4.56). Furthermore, there is no statistically significant change in average log-ratio values across the three periods, indicating that cattle post-cranial length remained relatively constant throughout the study period.

An assessment of cattle width measurements by phase using the log-ratio method shows a decrease in average width in the 13th-14th century, followed by an increase in the following phase (Figure 4.57). The mean width values then remain relatively constant until the 18th-19th century, where there is another increase. This suggests that cattle width measurements were at their smallest in the 13th-14th century, perhaps due to a greater proportion of females, and underwent considerable increases in the 15th-16th and 18th-19th centuries. However, as with cattle length measurements, there is no statistically significant change in average width values between any phases on the site (Table 4.11), again meaning that a small sample size may have over-represented the extent of change. Despite this, width log-ratio values across the general periods at Wharram Percy do show some considerable change (Figure 4.58). There is a highly significant ($P<0.01$) decrease in average width between the earlier and late Medieval periods, likely reflecting the smaller values seen in the 13th-14th century phase. Furthermore, there is a further statistically significant ($P<0.01$) increase in mean width in the late to post-Medieval transition, seemingly the result of some particularly large measurements in the final phase.

The comparison of cattle depth measurements across the individual phases at Wharram Percy also show a change in size between the thirteenth and sixteenth centuries (Figure 4.59). The average depth value decreases in the 13th-14th century, but once again increases in the following phase. There is also a small increase into the 16th-17th century, followed by similar mean values from the 17th-19th century. This pattern suggests a shift to smaller measurements in the thirteenth to fourteenth century, followed by a gradual increase thereafter. However, the statistical test results show no statistically significant change between any phases (Table 4.12), again suggesting that any change in the 13th-14th century is overestimated due to small sample size, or was perhaps due to a greater proportion of females rather than a smaller breed. Nonetheless, the depth log-ratio results for the three broad periods do show a significant ($P<0.05$) decrease in average in the late Medieval period, followed by a restoration to the earlier Medieval size by the post-Medieval period ($P<0.05$) (Figure 4.60). This may again indicate that cattle depth measurements, in addition to width, were smaller in the late Medieval period. Overall, the log-ratio assessment of cattle measurements suggests that, while there was no significant change in length measurements throughout the study period, both width and depth values are significantly smaller in the late Medieval period. This could indicate the presence of more gracile animals in this period.

The coefficient of variation was considered for both cattle post-cranial elements and teeth across the study period at Wharram Percy (Table 4.13), to investigate whether any change in size shown might be the result of changing sex ratios and nutrition, or multiple breeds on the site. Post-cranial elements exhibit their lowest variation in the 13th-14th century, which coincides with the recorded decrease in width and depth. In contrast, the highest post-cranial CV values can be seen in the 15th-16th and 18th-19th centuries, where increases in width and depth averages were documented. Therefore, the size decrease in the 13th-14th century may be due greater homogeneity in the herd, whereas increased width and depth in the 15th-16th and 18th-19th centuries may be the result of the introduction of new stock, causing greater variation. This is supported by the CV results for the general periods, as the lowest value is found in the late Medieval period, where width and depth measurements were reduced, and the highest variation in in the post-Medieval period, where results were the largest. Tooth coefficient of variation results suggest greater variation in the seventeenth to nineteenth centuries, resulting in the largest CV value in the post-Medieval period. When combined with the post-cranial values, this could suggest the introduction of a different breed of cattle to Wharram Percy from the seventeenth century.

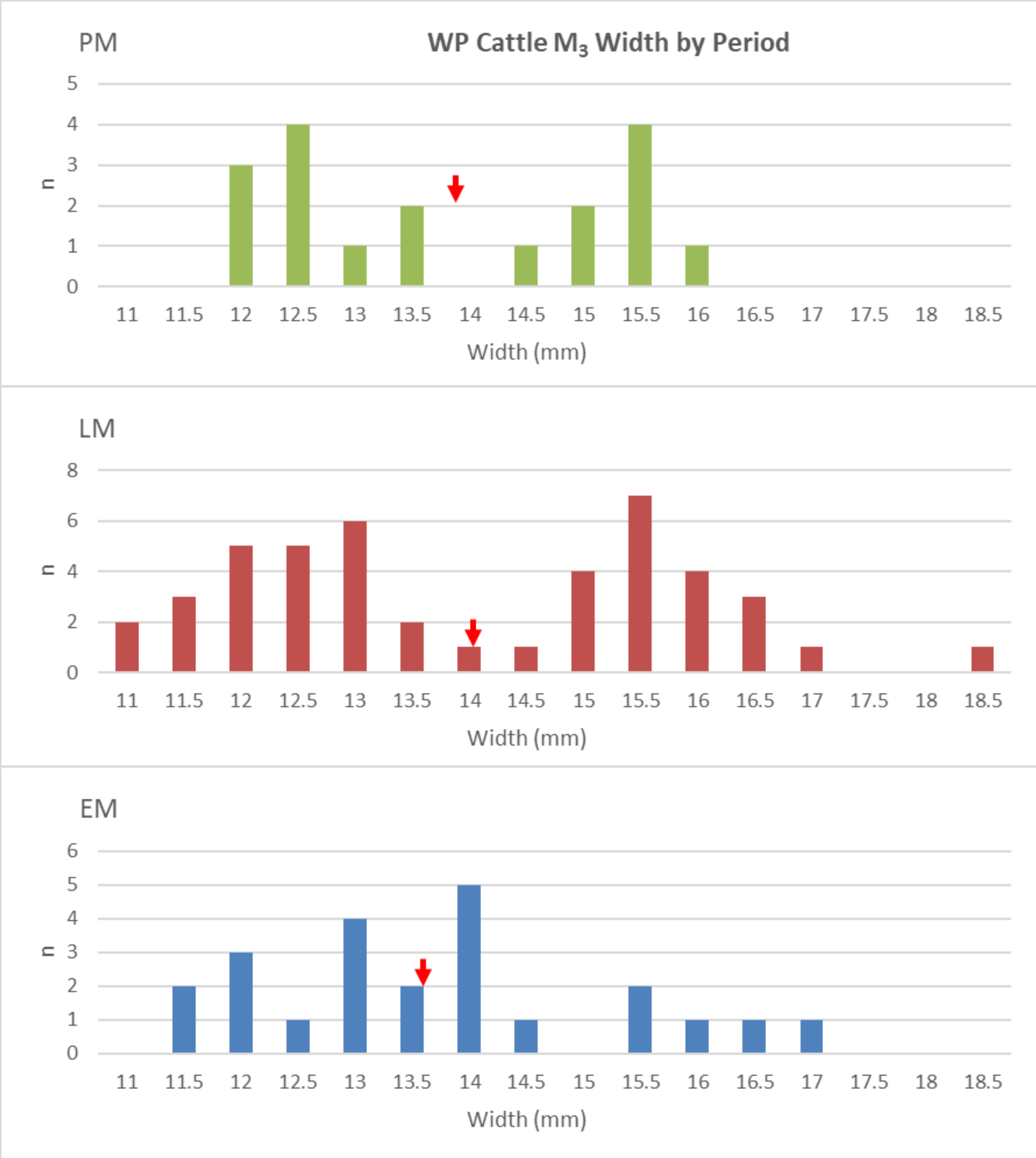

Figure 4.50: Histograms plotting width measurements of cattle lower third molar by period at Wharram Percy. The red arrows indicate the position of the mean.

Table 4.8: Statistical test results for the mandibular third cattle molar width by period at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	558	0.604	P> 0.05
LM vs. PM	455	0.691	P> 0.05

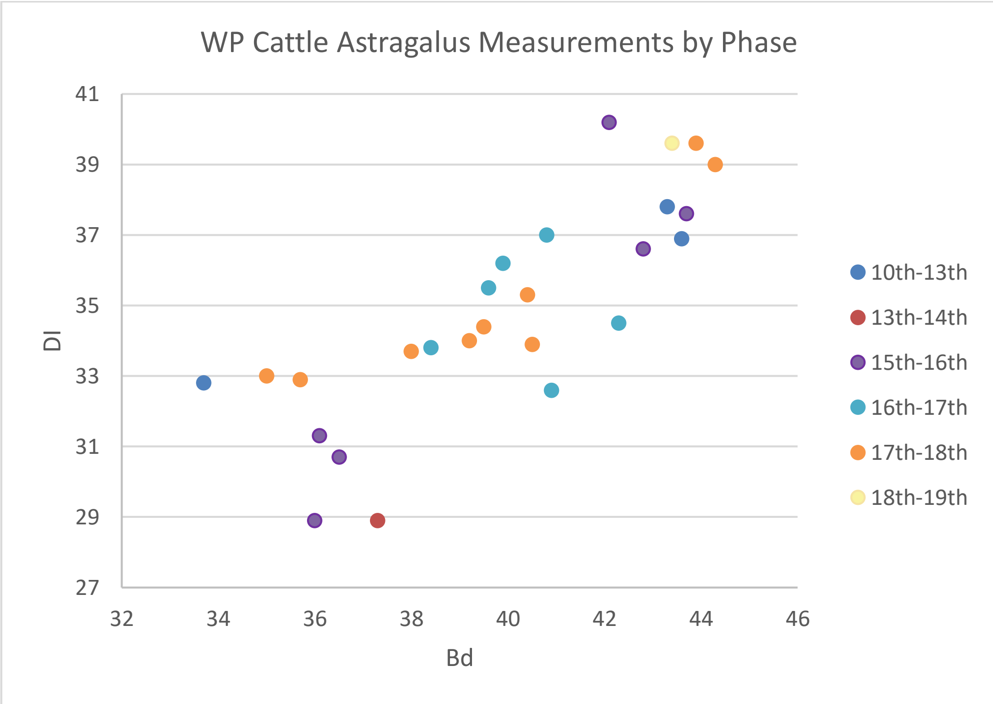

Figure 4.51: Comparison of astragalus measurements for cattle by phase at Wharram Percy.

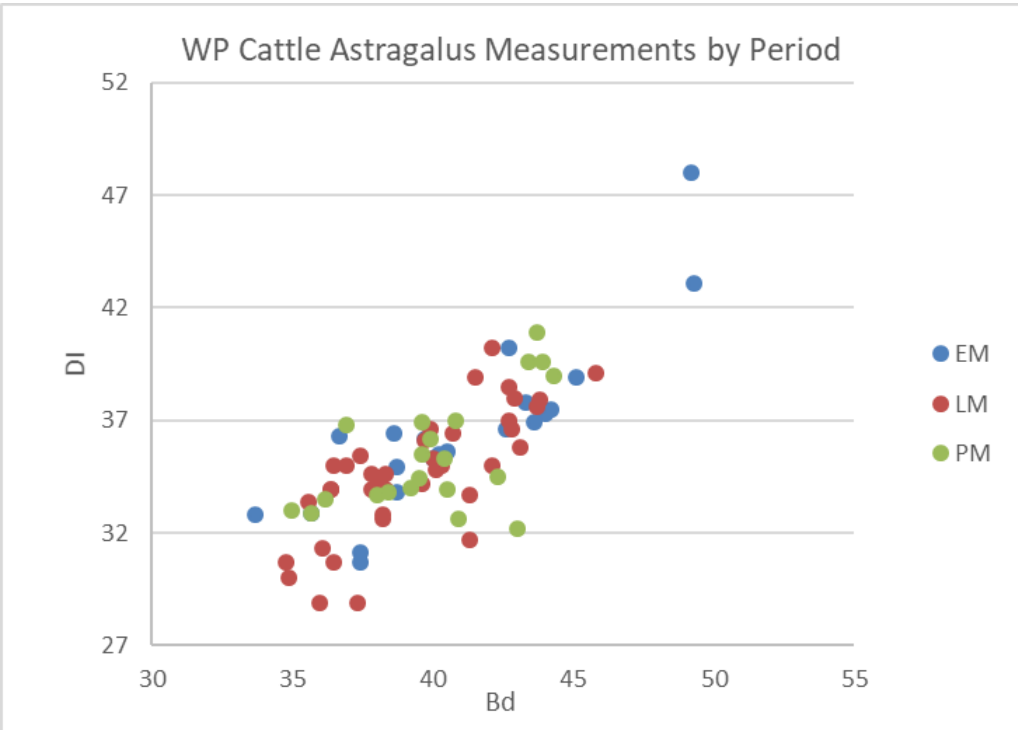

Figure 4.52: Comparison of astragalus measurements for cattle by period at Wharram Percy.

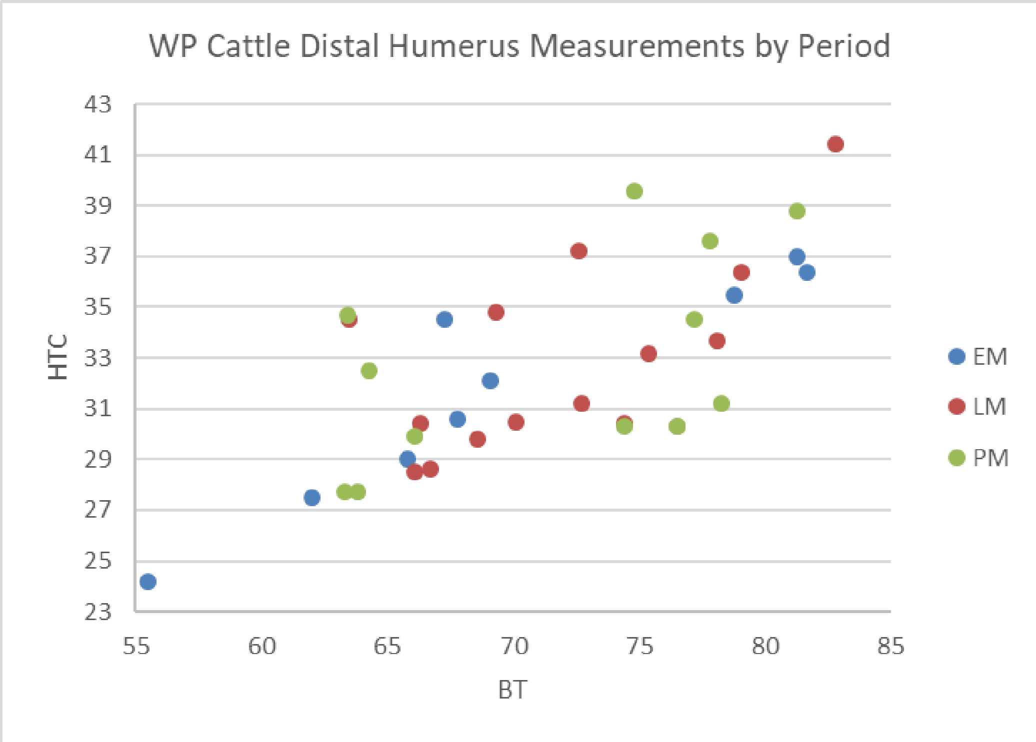

Figure 4.53: Comparison of distal humerus measurements for cattle by period at Wharram Percy.

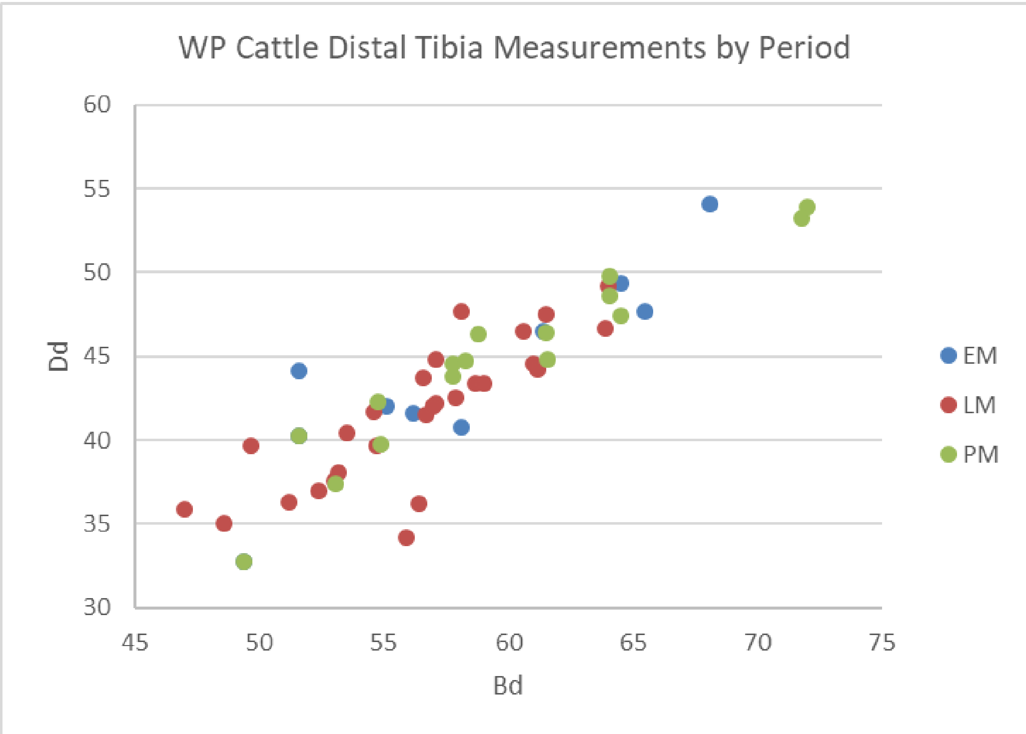

Figure 4.54: Comparison of distal tibia measurements for cattle by period at Wharram Percy.

Table 4.9: Statistical test results for individual cattle bone measurements between the earlier, late and post-Medieval periods at Wharram Percy. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	t stat/ U-value	P value	Significance	t stat/ U-value	P value	Significance
dP_4 W	-0.875	0.395	P> 0.05	151	0.015	P> 0.05
M_1 W	N/A	N/A	N/A	1.394	0.200	P> 0.05
M_3 L	0.439	0.662	P> 0.05	308	0.258	P> 0.05
M_3 W	558	0.604	P> 0.05	455	0.691	P> 0.05
Scapula GLP	-0.274	0.787	P> 0.05	47	0.695	P> 0.05
Scapula SLC	2.077	0.177	P> 0.05	0.479	0.643	P> 0.05
Humerus BT	-1.173	0.579	P> 0.05	92	0.795	P> 0.05
Humerus HTC	-1.220	0.234	P> 0.05	-0.182	0.857	P> 0.05
Radius Bd	N/A	N/A	P> 0.05	0.913	0.396	P> 0.05
Metacarpal GL	N/A	N/A	N/A	22	0.481	P> 0.05
Metacarpal SD	N/A	N/A	N/A	11	0.288	P> 0.05
Metacarpal Bd	N/A	N/A	N/A	132	0.493	P> 0.05
Metacarpal BatF	N/A	N/A	N/A	172	0.954	P> 0.05
Metacarpal a	N/A	N/A	N/A	174	0.867	P> 0.05
Metacarpal b	N/A	N/A	N/A	179	0.482	P> 0.05
Metacarpal 3	N/A	N/A	N/A	204	0.182	P> 0.05
Pelvis LA	N/A	N/A	N/A	1.390	0.412	P> 0.05
Femur DC	144	0.000	P<0.01	44	0.220	P> 0.05
Tibia Bd	0.970	0.350	P> 0.05	2.029	0.054	P> 0.05
Tibia Dd	1.571	0.137	P> 0.05	2.236	0.035	P< 0.05
Astragalus GLl	1428	0.000	P> 0.05	0.710	0.482	P> 0.05
Astragalus GLm	1353	0.000	P> 0.05	-0.790	0.433	P> 0.05
Astragalus Bd	1.698	0.099	P> 0.05	-0.445	0.658	P> 0.05
Astragalus Dl	1540	0.000	P> 0.05	449	0.639	P> 0.05
Calcaneum GB	N/A	N/A	N/A	0.729	0.283	P> 0.05
Metatarsal GL	N/A	N/A	N/A	-1.123	0.323	P> 0.05
Metatarsal SD	N/A	N/A	N/A	0.000	1.000	P> 0.05
Metatarsal Bd	N/A	N/A	N/A	0.746	0.469	P> 0.05
Metatarsal BatF	N/A	N/A	N/A	1.737	0.106	P> 0.05
Metatarsal a	N/A	N/A	N/A	1.716	0.105	P> 0.05
Metatarsal b	N/A	N/A	N/A	1.134	0.281	P> 0.05
Metatarsal 3	N/A	N/A	N/A	1.668	0.119	P> 0.05

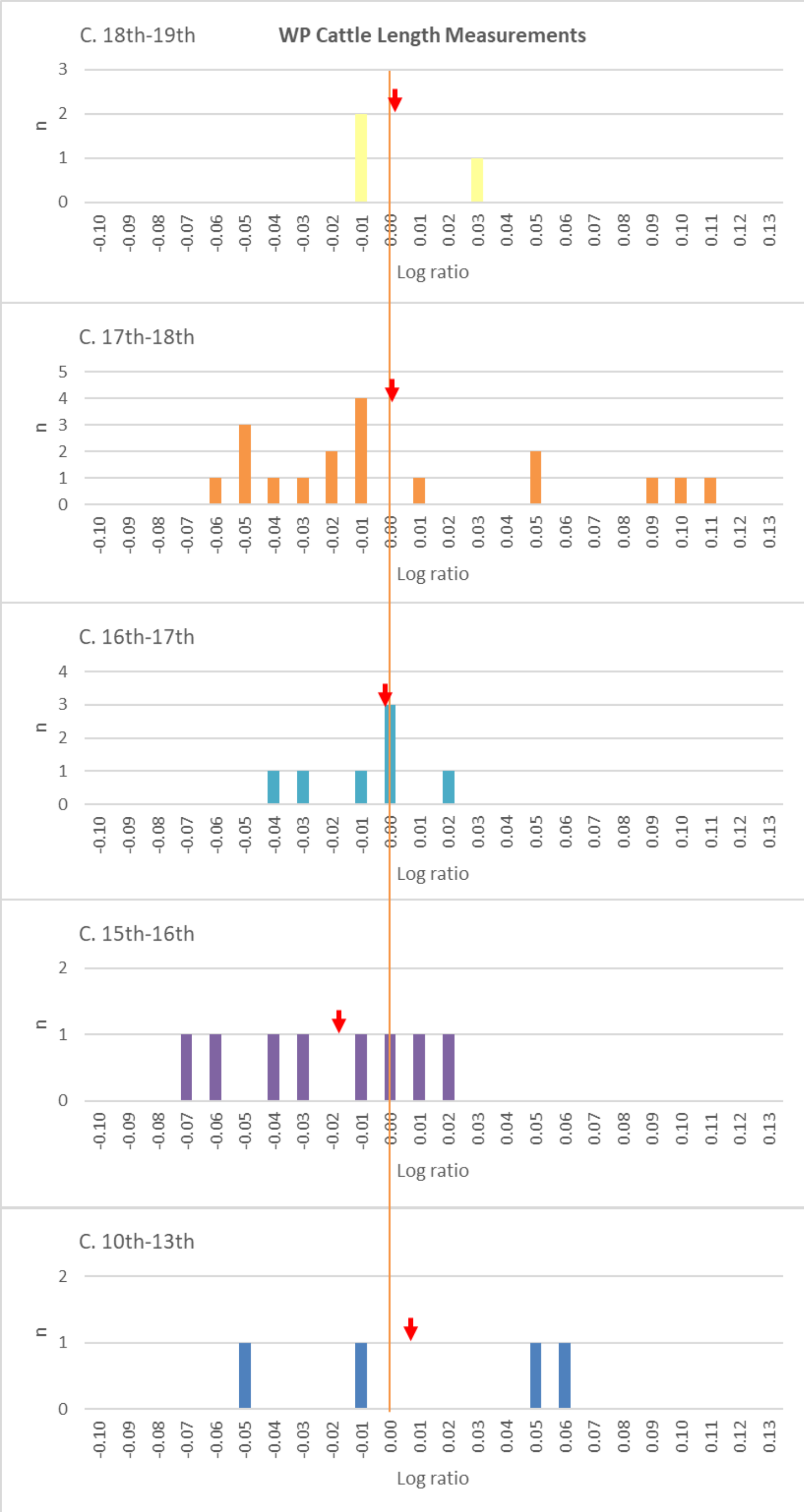

Figure 4.55: Log ratio histograms combining cattle post-cranial bone length measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

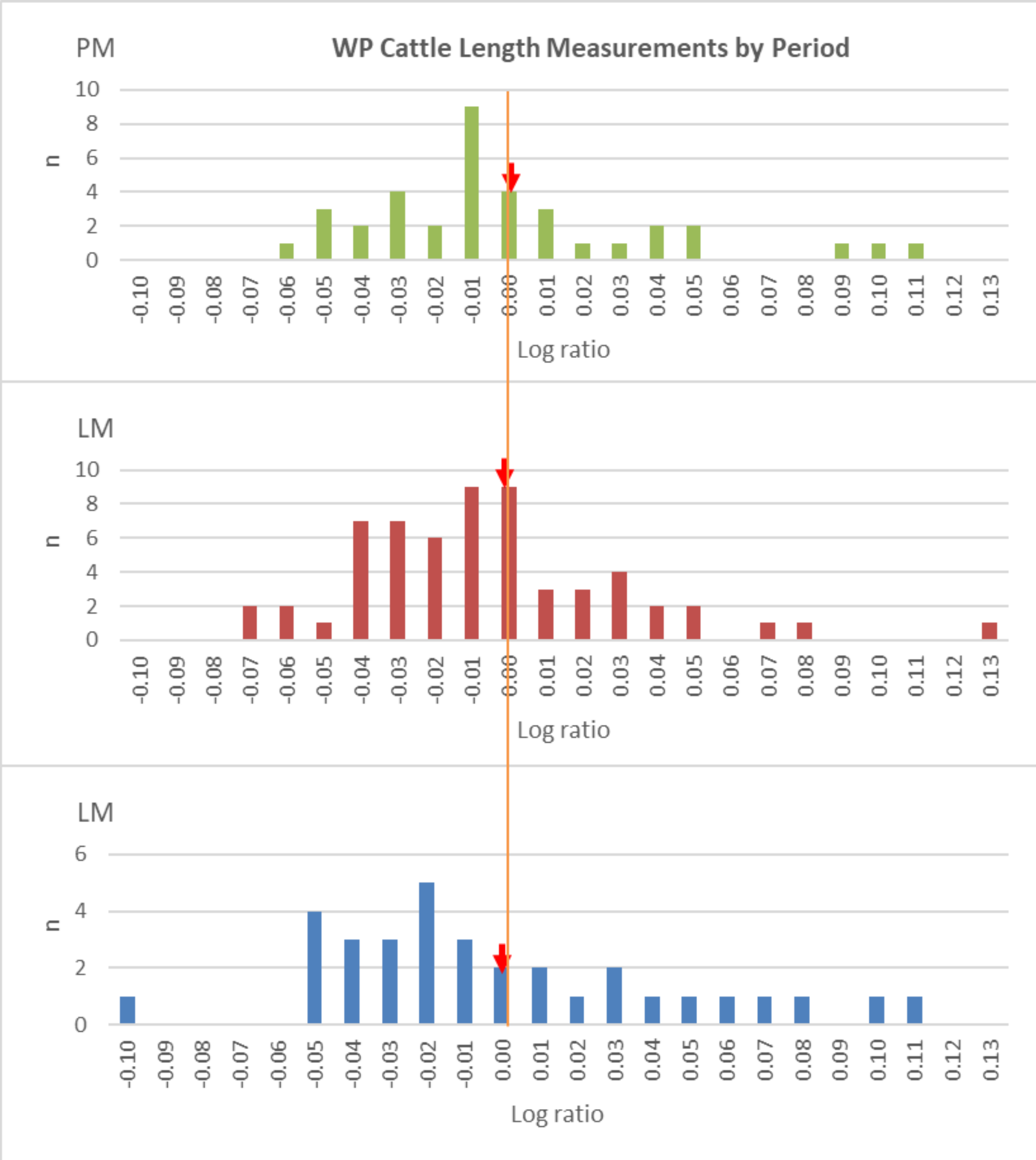

Figure 4.56: Log ratio histograms combining cattle post-cranial bone length measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.10: Statistical test results for the post-cranial log ratio length values for cattle by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 15th-16th	1.230	0.286	P> 0.05
15th-16th vs. 16th-17th	-0.949	0.361	P> 0.05
16th-17th vs. 17th-18th	59	0.825	P> 0.05
17th-18th vs. 18th-19th	20	0.510	P> 0.05
Period			
EM vs. LM	1005	0.910	P> 0.05
LM vs. PM	1190	0.557	P> 0.05

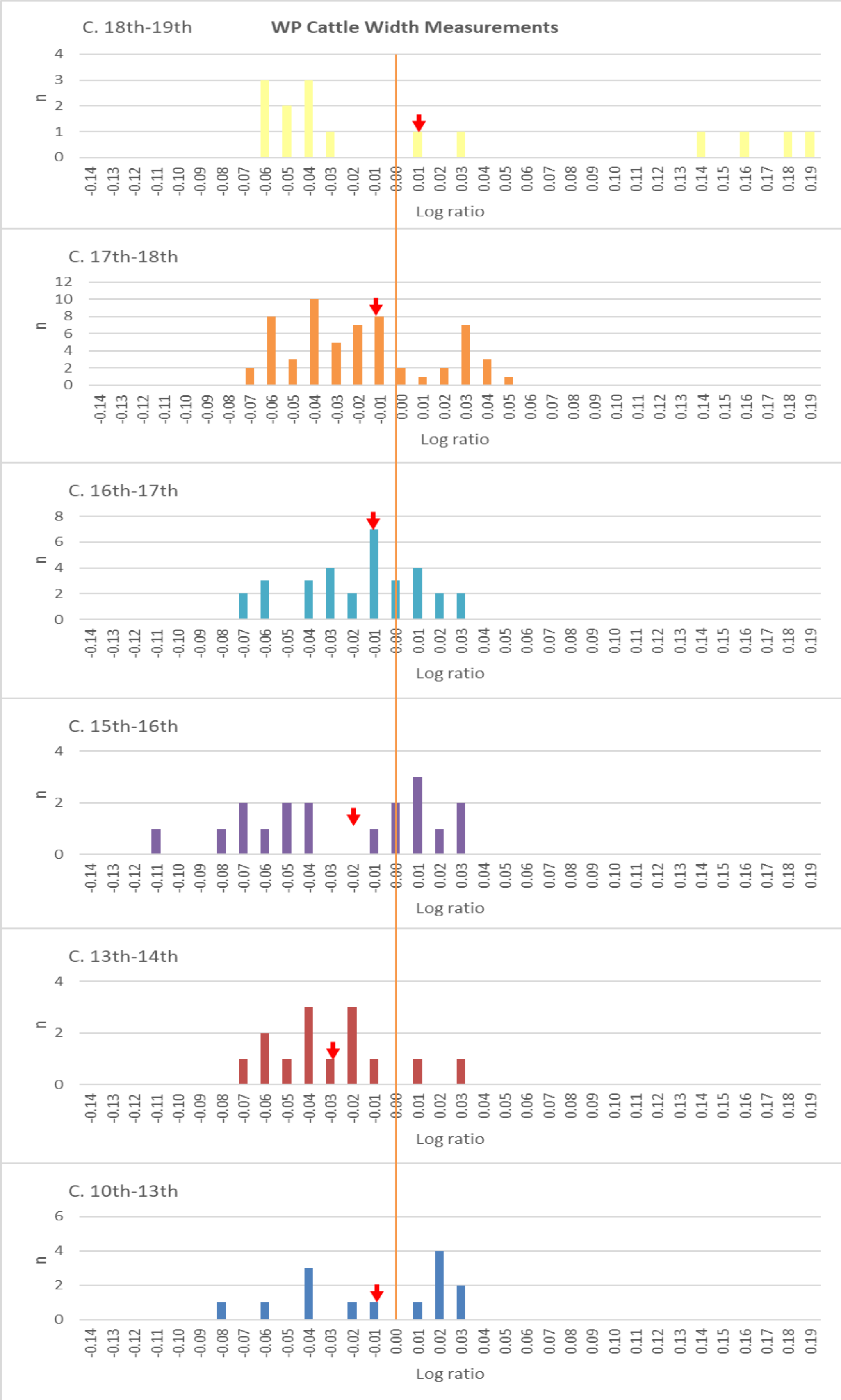

Figure 4.57: Log ratio histograms combining cattle post-cranial bone width measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

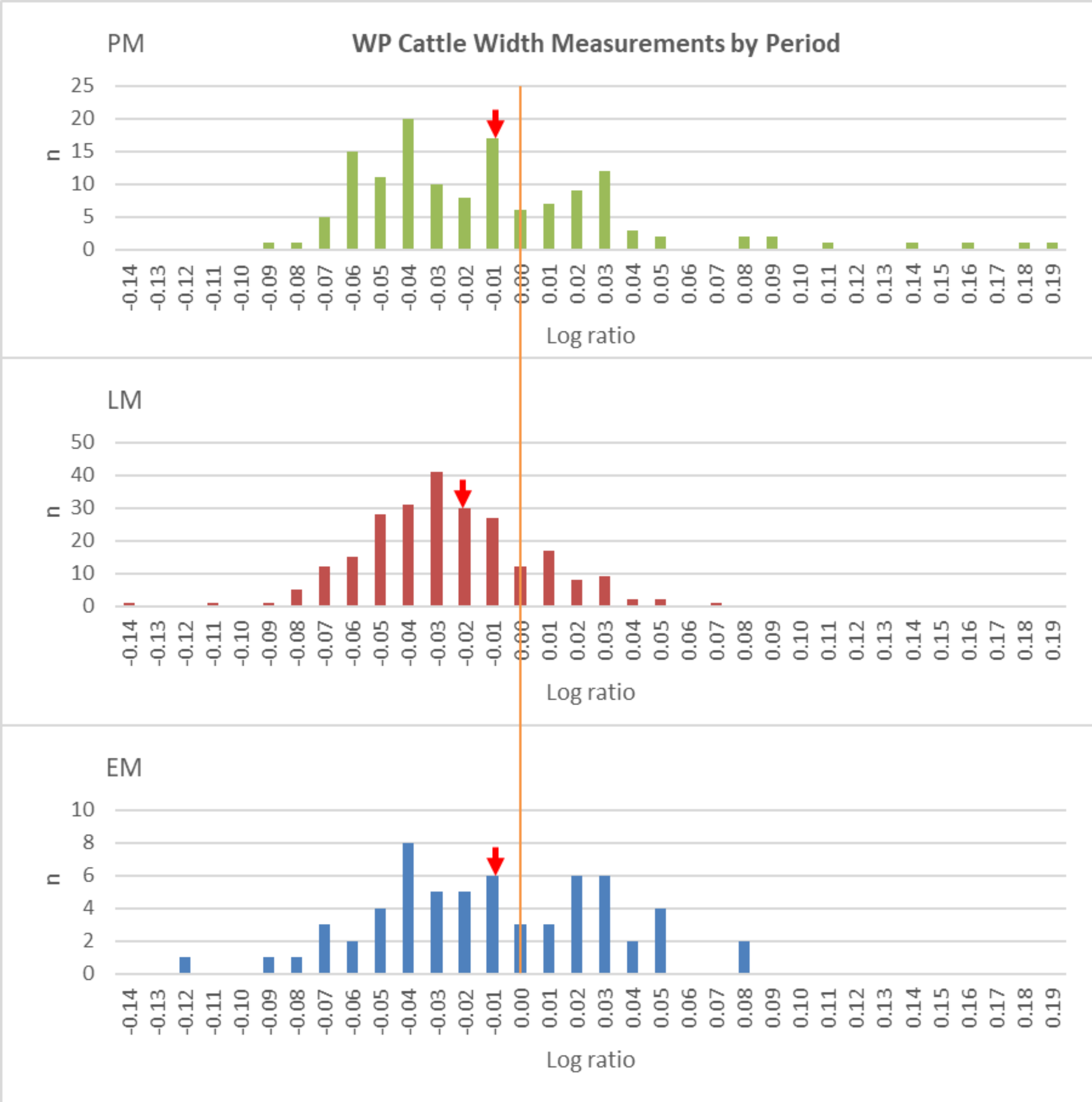

Figure 4.58: Log ratio histograms combining cattle post-cranial bone width measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.11: Statistical test results for the post-cranial log ratio width values for cattle by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 13th-14th	1.624	0.117	P> 0.05
13th-14th vs. 15th-16th	0.310	0.759	P> 0.05
15th-16th vs. 16th-17th	-0.888	0.382	P> 0.05
16th-17th vs. 17th-18th	857	0.470	P> 0.05
17th-18th vs. 18th-19th	447	0.957	P> 0.05
Period			
EM vs. LM	9330	0.004	P< 0.01
LM vs. PM	18905	0.020	P< 0.05

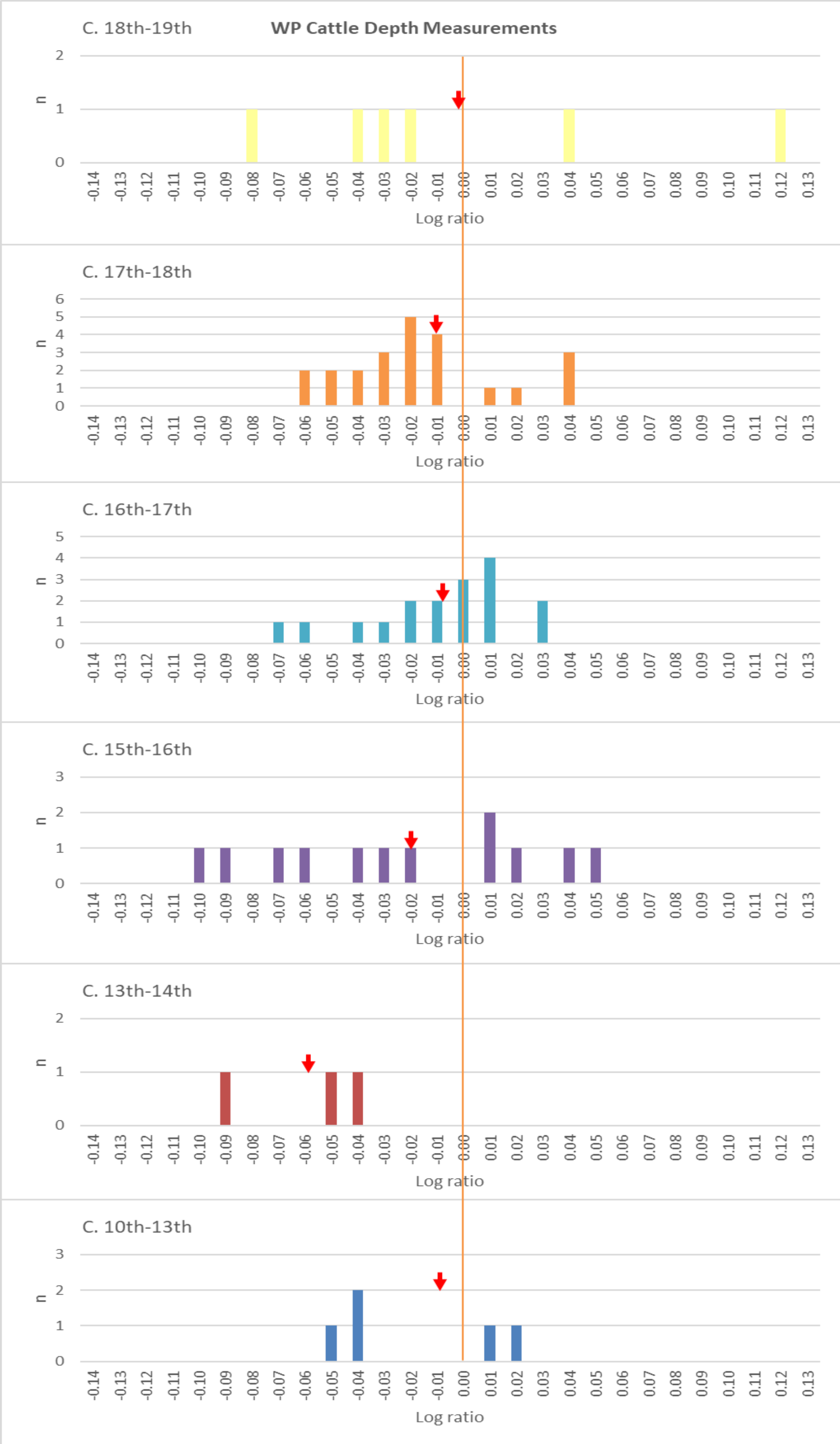

Figure 4.59: Log ratio histograms combining cattle post-cranial bone depth measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

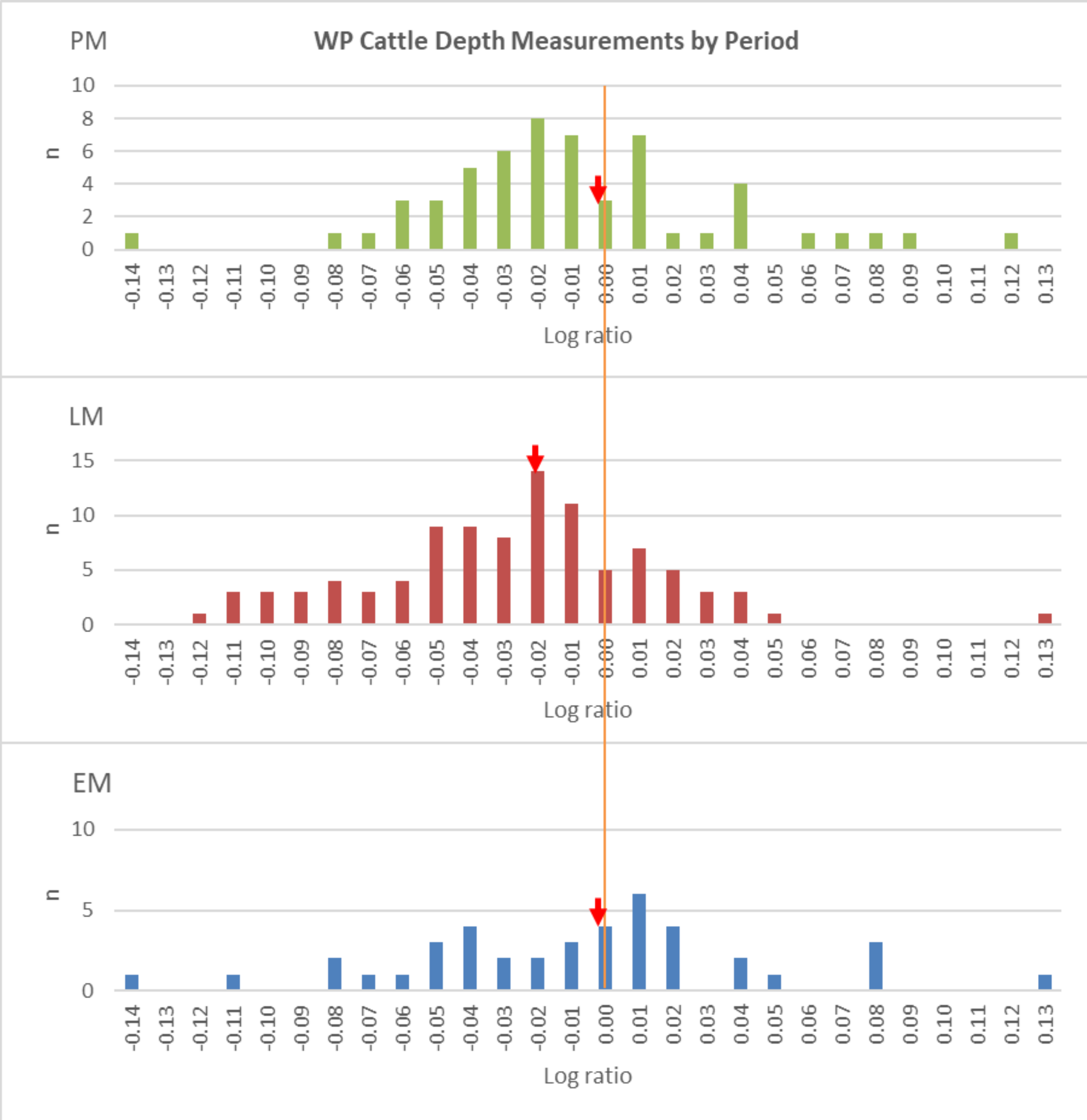

Figure 4.60: Log ratio histograms combining cattle post-cranial bone depth measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.12: Statistical test results for the post-cranial log ratio depth values for cattle by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 13th-14th	1.842	0.12484	P> 0.05
13th-14th vs. 15th-16th	1.674	0.15499	P> 0.05
15th-16th vs. 16th-17th	-0.826	0.42112	P> 0.05
16th-17th vs. 17th-18th	-0.717	0.47783	P> 0.05
17th-18th vs. 18th-19th	0.486	0.64762	P> 0.05
Period			
EM vs. LM	2447	0.033	P< 0.05
LM vs. PM	3320	0.022	P< 0.05

Table 4.13: Coefficient of variation values for cattle teeth and post-cranial elements across both the individual phases and broad periods at Wharram Percy.

Phase	Post-cranial	Teeth
10th-13th	9.9	6.7
13th-14th	5.5	n/a
14th-15th	n/a	n/a
15th-16th	12.4	7.1
16th-17th	8.5	6.5
17th-18th	8.3	10.7
18th-19th	23.0	8.6
Period		
EM	10.3	10.5
LM	7.6	10.1
PM	10.8	11.0

Pig

Due to a small sample size, metric assessment for pig at Wharram Percy was carried out entirely using the log-ratio method, as it allows for the combination of measurements on the same axis, thus increasing sample size. Tooth length was compared across both the individual phases (Figure 4.61) and general periods of the site (Figure 4.62). The average log ratio value for tooth length appears relatively variable across the individual phases – while the 10th-13th and 13th-14th means are similar, there is an increase in the 15th-16th century, followed by a decrease in the following phase. There is also an increase in average tooth length in the 17th-18th century, which is sustained in the final phase. This pattern suggests a decreased tooth size in the 13th-14th and 16th-17th centuries, with peaks in size in the 15th-16th and 17th-18th centuries. However, the only statistically significant change ($P<0.05$) is between the 16th-17th and 17th-18th centuries, indicating that this was the only time when substantial increase in tooth length occurred (Table 4.14). This is supported by the results by period, as mean length measurements for the earlier and late Medieval periods are very similar, but there is a significant ($P<0.05$) increase in size in the post-Medieval period, likely caused by the pattern seen in the 17th-18th century. Overall, these results suggest that pig tooth length was mostly consistent until the 17th-18th century, when it underwent a significant increase, which was sustained thereafter.

In contrast, pig tooth width log-ratio results across the individual phases (Figure 4.63) suggests that mean width did not markedly increase until the 18th-19th century. In this final phase there is a statistically significant ($P<0.05$) increase in tooth width, though the small sample size may limit the reliability of this result (Table 4.15). Upon first inspection, pig tooth width does not appear to noticeably change across the broad periods at Wharram Percy (Figure 4.64). However, t-test results indicate that there is a statistically significant ($P<0.05$) change between all three periods. Between the earlier and late Medieval periods, there is a decrease in tooth width, whereas the average measurement increases in the post-Medieval period. Overall, pig tooth measurements across both planes increased in the final period, though length was first to exhibit this change, in the 17th-18th century. This late change may reflect the focus on sheep husbandry from the late Medieval period at Wharram Percy, with renewed interest in profits from meat production perhaps motivating the post-Medieval improvement of pigs.

Pig post-cranial measurements were also assessed using the log-ratio method, though a small sample size required the combination of length, width and depth in one analysis, and only the three general periods were compared. There appears to be a decrease in the average post-cranial size between the earlier and late Medieval periods, with a subsequent increase in the final period (Figure 4.65). However, according to t-test results, neither change is statistically significant (Table 4.16). Furthermore, t-test results for individual measurements across the broad periods show no significant change in the average size for all elements between the earlier, late and post-Medieval periods (Table 4.17). Overall, this suggests that post-cranial pig size did not significantly change throughout the study period at Wharram Percy, though the combination of length, width and depth may mask changes in one particular axis.

Pig coefficient of variation values (Table 4.18) are extremely variable across the individual periods for both post-cranial elements and teeth. Post-cranial results suggest that the greatest variation was found in the 16^{th}-17^{th} century, which may relate to the increasing size seen in the post-Medieval period, suggesting the introduction of a new husbandry method or breed at this time. Prior to this period, post-cranial values are relatively low, between 3.6 and 5.2, indicating a more homogenous herd in the earlier and late Medieval periods. This is supported by the CV results by period, as the post-Medieval value is the greatest. However, tooth CV values suggest greater variation in the 10^{th}-13^{th} and 15^{th}-16^{th} century phases, with the lowest value in the final phase. As a result, across the three general periods, variation is greatest in the late-Medieval period, and is equal in the earlier and post-Medieval periods. Given the log-ratio data for teeth, this could suggest the gradual replacement of pig breed occurring in the late Medieval period – perhaps two distinct breeds were present in the earlier and post-Medieval periods respectively, while the late Medieval represents the gradual introduction of the larger breed in the post-Medieval, evidenced by larger tooth measurements.

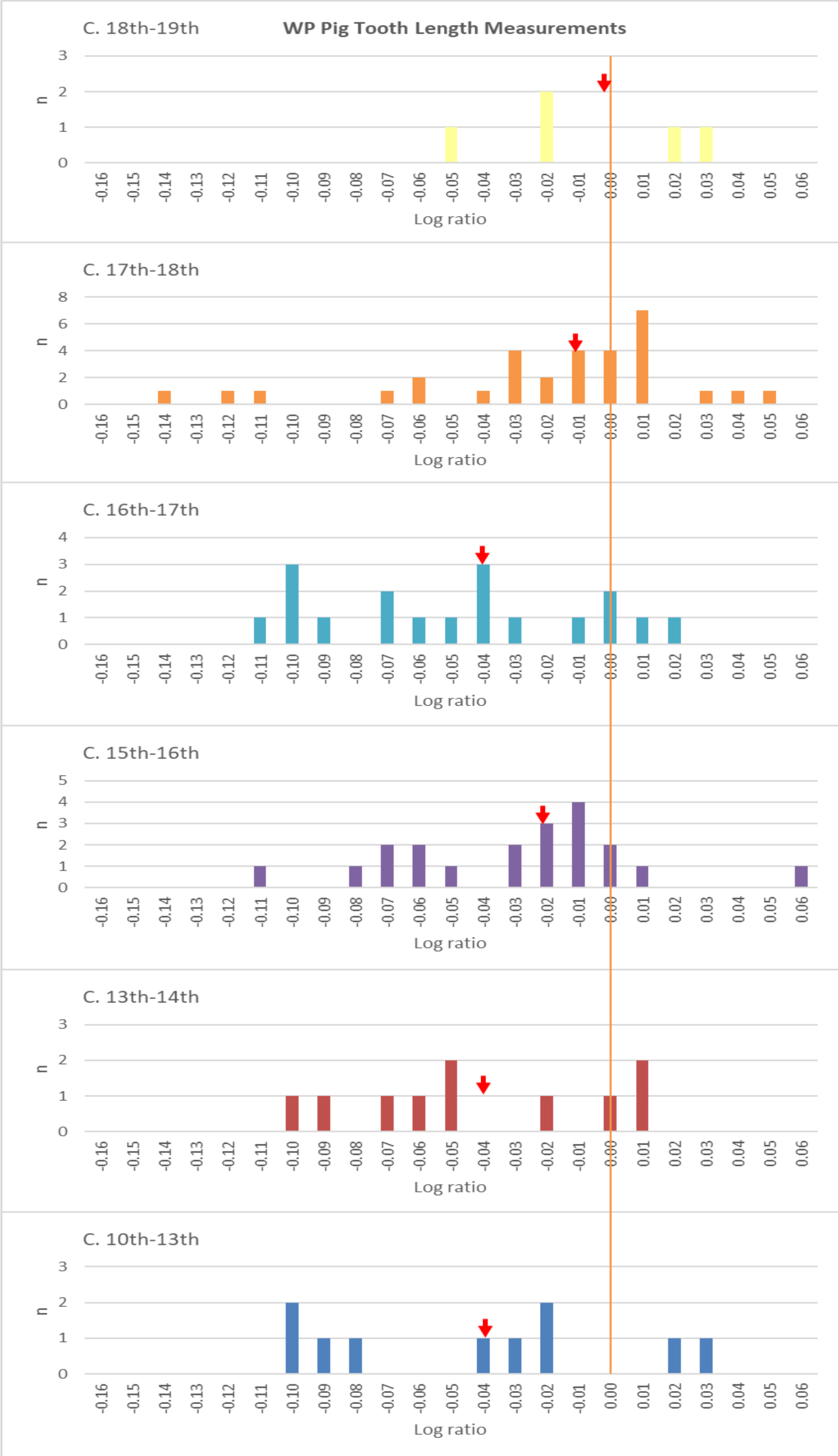

Figure 4.61: Log ratio histograms combining pig tooth length measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

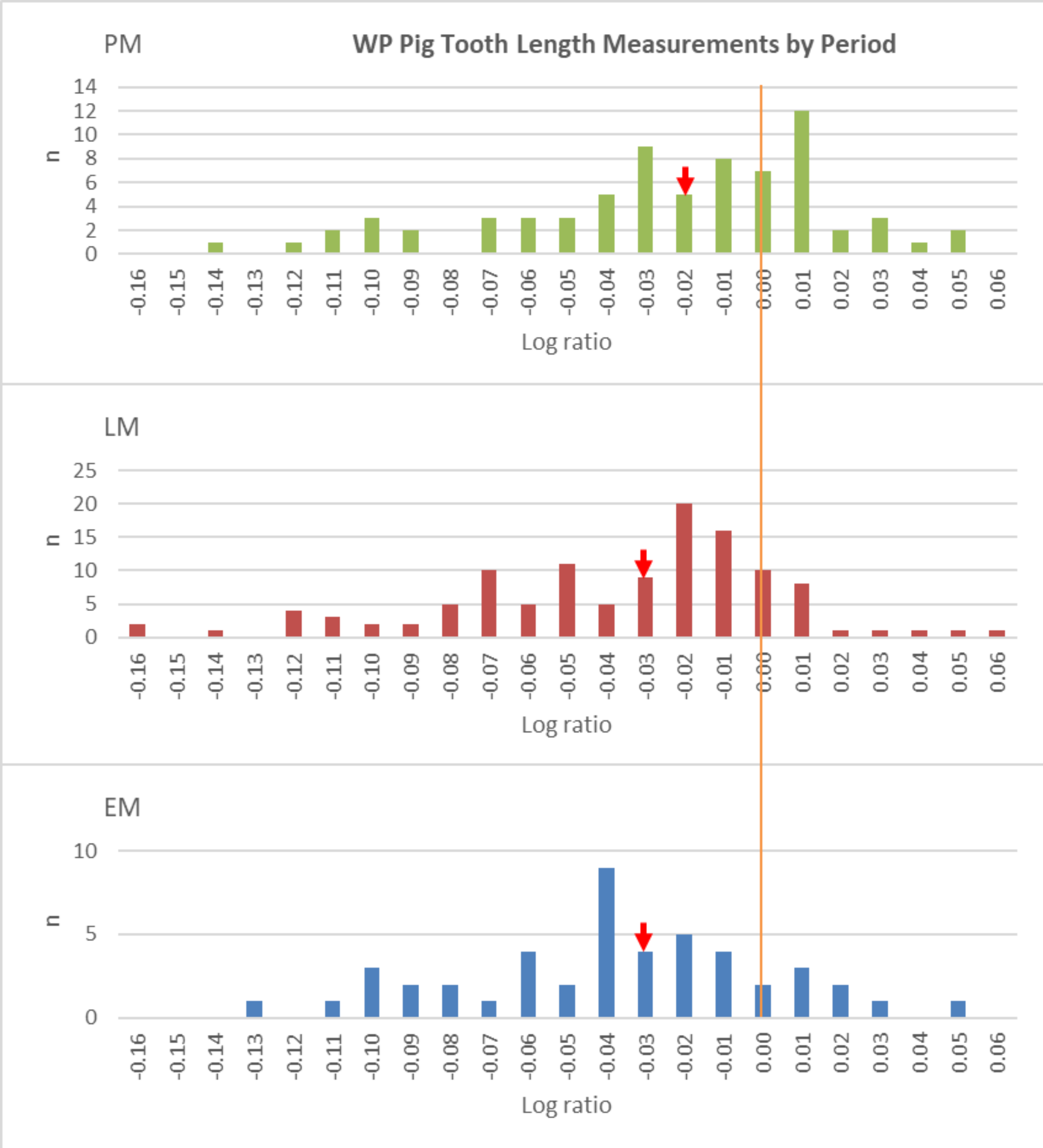

Figure 4.62: Log ratio histograms combining pig tooth length measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.14: Statistical test results for the tooth log ratio length values for pig by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
10th-13th vs. 13th-14th	0.096	0.925	P> 0.05
13th-14th vs. 15th-16th	-0.920	0.370	P> 0.05
15th-16th vs. 16th-17th	-1.404	0.169	P> 0.05
16th-17th vs. 17th-18th	403	0.021	P< 0.05
17th-18th vs. 18th-19th	72	0.740	P> 0.05
Period			
EM vs. LM	2905	0.635	P> 0.05
LM vs. PM	5116	0.018	P< 0.05

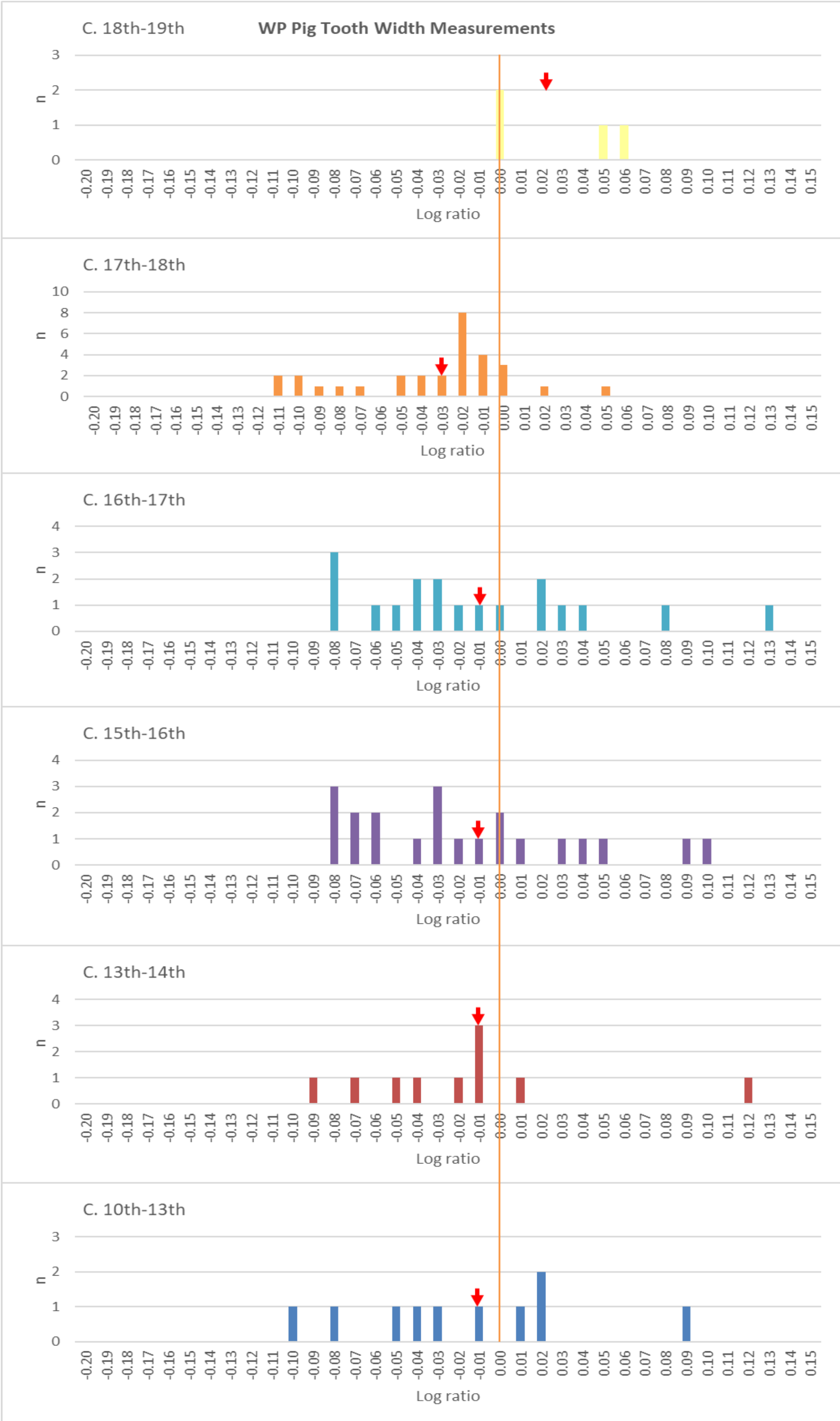

Figure 4.63: Log ratio histograms combining pig tooth width measurements by phase at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

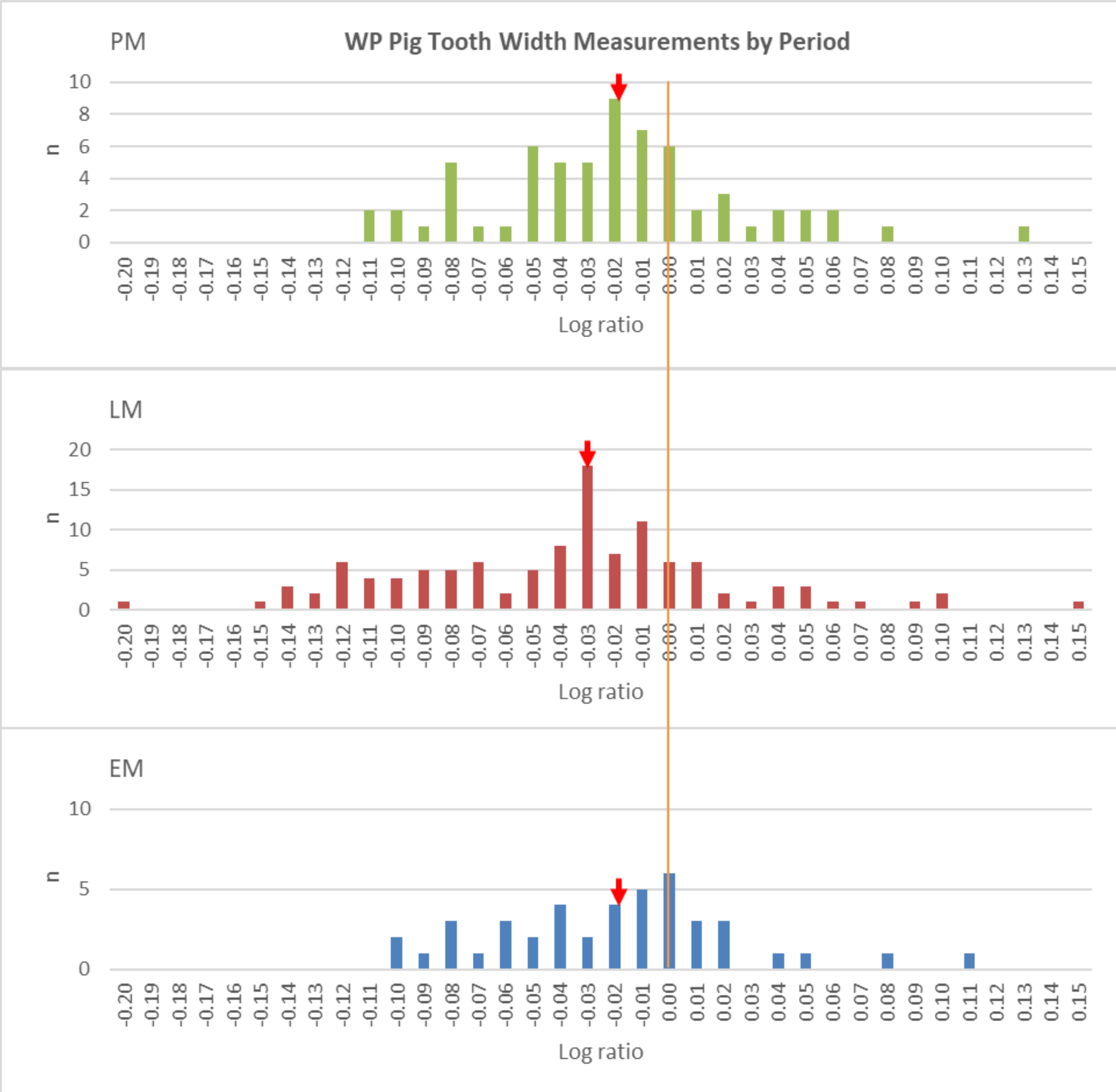

Figure 4.64: Log ratio histograms combining pig tooth width measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.15: Statistical test results for the tooth log ratio width values for pig by phases and periods at Wharram Percy.

Phase	**t stat/ U-value**	**P value**	**Significance**
10th-13th vs. 13th-14th	0.099	0.92211	P> 0.05
13th-14th vs. 15th-16th	0.004	0.99673	P> 0.05
15th-16th vs. 16th-17th	-0.224	0.82441	P> 0.05
16th-17th vs. 17th-18th	316	0.338	P> 0.05
17th-18th vs. 18th-19th	9	0.003	P< 0.01
Period			
EM vs. LM	-2.051	0.04300	P< 0.05
LM vs. PM	-2.107	0.03672	P< 0.05

Table 4.16: Statistical test results for individual pig bone measurements between the earlier, late and post-Medieval periods at Wharram Percy. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t stat/ U-value**	**P Value**	**Significance**	**t stat/ U-value**	**P Value**	**Significance**
dP_4L	-1.245	0.268	P> 0.05	0.348	0.735	P> 0.05
dP_4 WP	1.855	0.150	P> 0.05	-0.402	0.692	P> 0.05
M_1 L	0.770	0.448	P> 0.05	216	0.103	P> 0.05
M_1 WA	165	0.297	P> 0.05	289	0.880	P> 0.05
M_1 WP	197	0.900	P> 0.05	336	0.626	P> 0.05
M_2 L	112	0.354	P> 0.05	316	0.069	P> 0.05
M_2 WA	128	0.702	P> 0.05	305	0.241	P> 0.05
M_2 WP	-1.263	0.196	P> 0.05	-0.110	0.976	P> 0.05
M_3 L	0.778	0.444	P> 0.05	-1.057	0.299	P> 0.05
M_3 WA	0.299	0.706	P> 0.05	-0.088	0.741	P> 0.05
M_3 WC	-1.009	0.170	P> 0.05	-0.017	0.750	P> 0.05
M_3 WP	1.085	0.293	P> 0.05	-0.484	0.614	P> 0.05
Scapula GLP	N/A	N/A	N/A	2.109	0.068	P> 0.05
Scapula SLC	N/A	N/A	N/A	-1.770	0.095	P> 0.05
Humerus BT	0.234	0.818	P> 0.05	0.283	0.783	P> 0.05
Humerus HTC	0.140	0.891	P> 0.05	1.064	0.306	P> 0.05
Astragalus GLl	-0.497	0.637	P> 0.05	0.199	0.846	P> 0.05
Astragalus GLm	2.032	0.082	P> 0.05	-1.039	0.333	P> 0.05

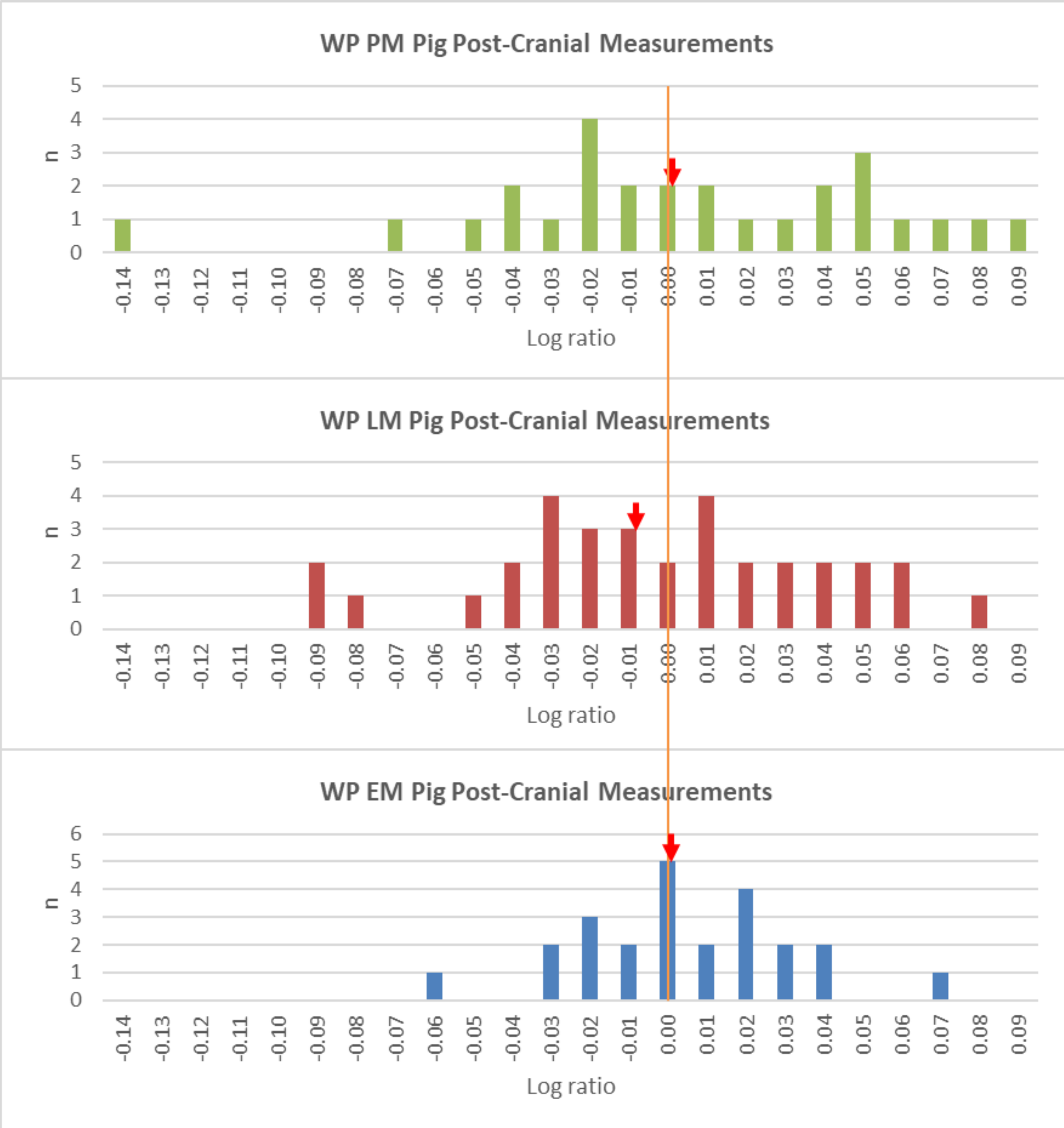

Figure 4.65: Log ratio histograms combining pig post-cranial length and width measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.17: Statistical test results for the post-cranial log ratio values for pig by phases and periods at Wharram Percy.

Period:	**t stat/ U-value**	**P value**	**Significance**
EM vs. LM	-1.669	0.101	P> 0.05
LM vs. PM	1.349	0.18330	P> 0.05

Table 4.18: Coefficient of variation values for pig teeth and post-cranial elements across both the individual phases and broad periods at Wharram Percy.

Phase	**Post-cranial**	**Teeth**
10th-13th	n/a	11.3
13th-14th	5.2	7.3
14th-15th	n/a	n/a
15th-16th	3.6	10.6
16th-17th	14.9	9.1
17th-18th	9.6	8.0
18th-19th	n/a	2.3
Period		
EM	4.6	7.8
LM	10.0	8.4
PM	12.2	7.8

Horse

A comprehensive assessment of horse tooth size at Wharram Percy was not possible, due to a lack of identifiable teeth. However, an attempt to compare horse tooth size throughout the periods of the site has been made using M_3 measurements (Figure 4.66). This comparison shows a very large overlap between M_3 length and width throughout all three periods, pointing towards consistent horse tooth size throughout the study period. This is supported by t-test results for individual measurements (Table 4.22), which show no significant change in average tooth size across the earlier, late and post-Medieval periods.

An initial assessment of horse post-cranial size was carried out through the comparison of first phalanx measurements from the earlier, late and post-Medieval periods, due to a high frequency of measurements for this element, particularly in the latter two periods (Figure 4.67). Though there is a relatively large overlap in size in terms of distal breadth, distal depth measurements are generally larger in the post-Medieval period. This pattern is supported by the individual element statistical test results, which show a significant ($P<0.01$) increase in Dd in the post-Medieval period (Table 4.22).

Post-cranial horse size change was further investigated using log-ratio assessments of length, width and depth across the broad periods at Wharram Percy. The comparison of length measurements through time shows similar average values in the earlier and late Medieval periods, followed by an increase in size in the post-Medieval period (Figure 4.68). This size increase is highly significant ($P<0.01$), suggesting a considerable increase in horse post-cranial length after the sixteenth century (Table 4.19). This pattern is not seen, however, in width measurements, as average horse post-cranial width values are comparable throughout the study period (Figure 4.69). Statistical test results support this, indicating that there is no statistically significant change in size between the earlier, late or post-Medieval periods (Table 4.20). In contrast, there does appear to be a change in horse depth measurements at Wharram Percy (Figure 4.70). As with the length results, there is a statistically significant size increase for post-cranial depth measurements in the post-Medieval period (Table 4.21). Overall, the log-ratio assessment of horse post-cranial material indicates that there is a significant increase in both length and depth during the post-Medieval period, while width measurements do not appear to change at the same time.

This change is somewhat reflected by the coefficient of variation results for horse teeth and post-cranial material (Table 4.23). Post-cranial values are lowest in the 10th-13th and 15th-16th centuries, suggesting a more homogenous population during these phases. However, they are highest in the post-Medieval period, particularly in the latest phase. This may reflect the increasing post-cranial length and depth dimensions in the post-Medieval period, perhaps indicating the introduction of new stock which exhibit these characteristics. This is also supported by a relatively high CV value for the general post-Medieval period, though the late Medieval result is slightly higher, perhaps suggesting that this change began in the previous period. Tooth variation is also highest in the 17th-18th and 18th-19th centuries, particularly in the latter phase. This again could indicate a change in husbandry strategy or stock during this time, though this was not reflected in the limited metric assessment of M_3 dimensions. Furthermore, variation is very high for horse teeth in both the late and post-Medieval periods, suggesting not only a change in the final period, but the beginnings of it in the previous period.

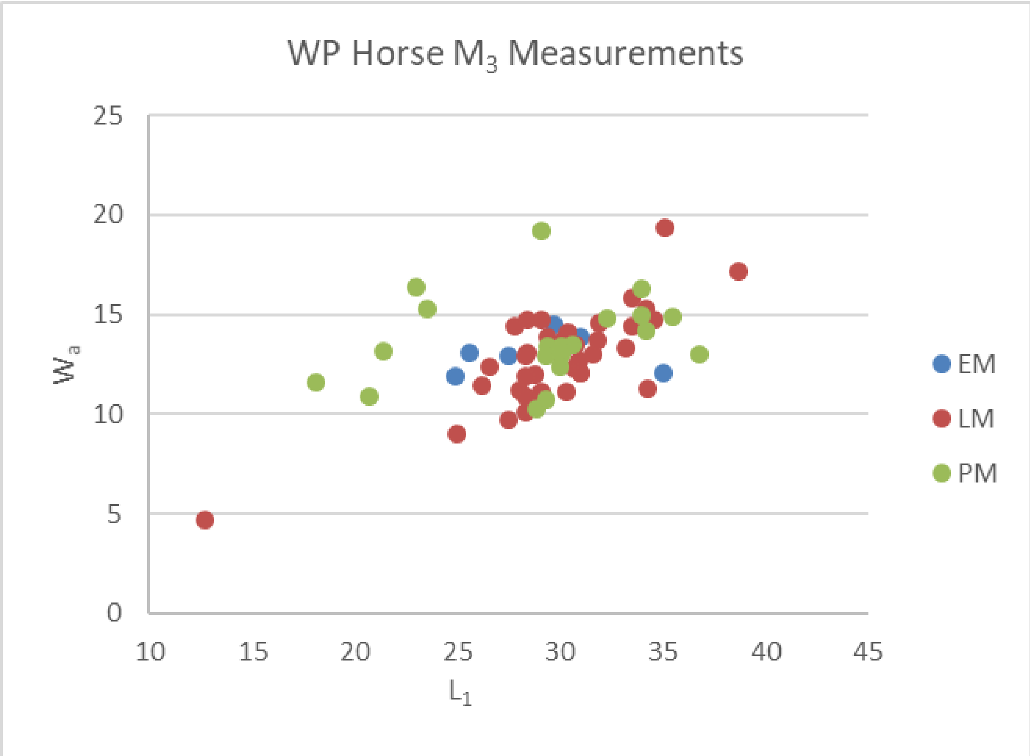

Figure 4.66: Comparison of mandibular third molar measurements for horse at Wharram Percy.

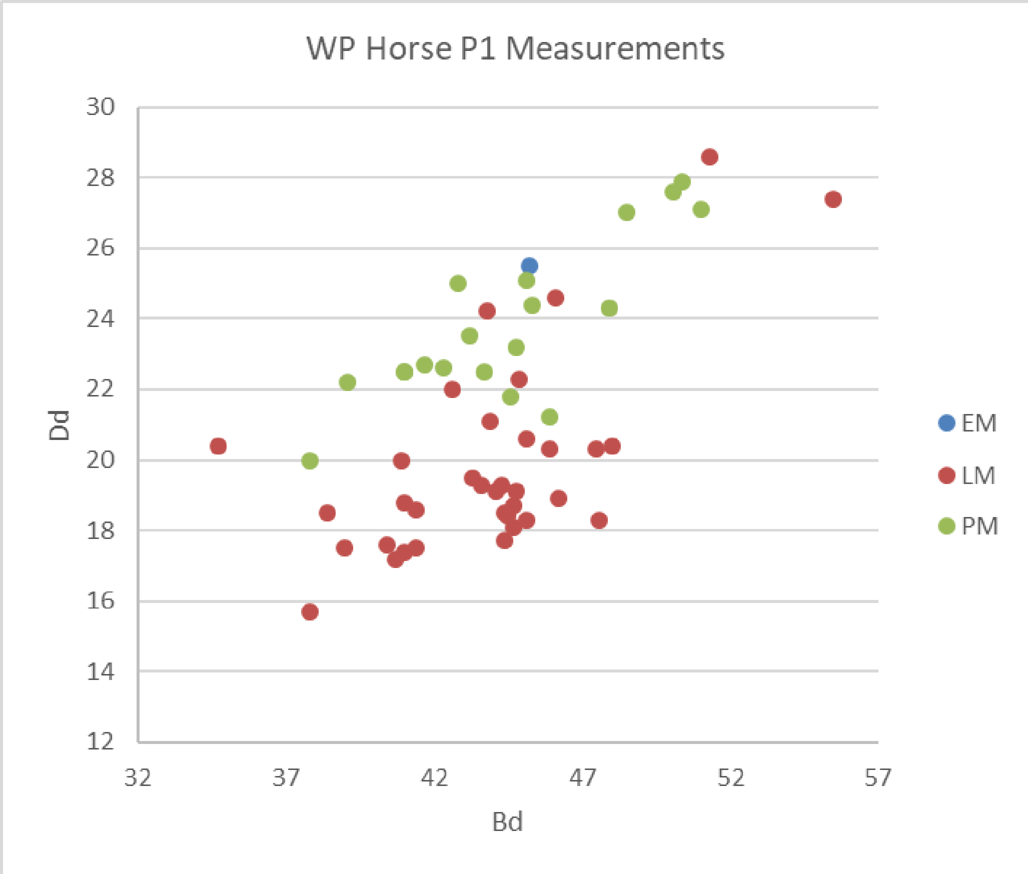

Figure 4.67: Comparison of distal phalanx 1 measurements for horse by period at Wharram Percy.

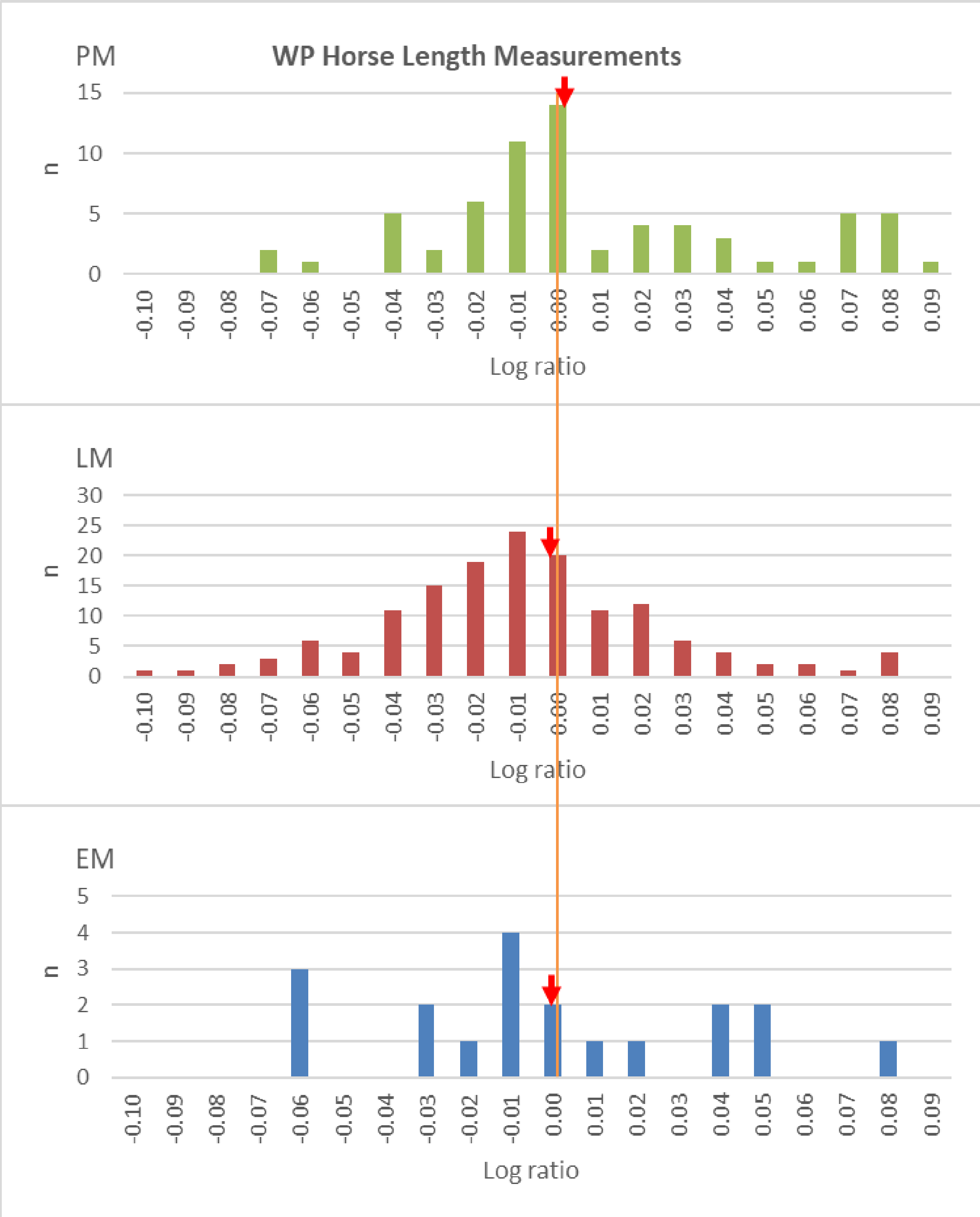

Figure 4.68: Log ratio histograms combining horse post-cranial bone length measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.19: Statistical test results for the post-cranial log ratio length values for horse by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	1434	0.600	P> 0.05
LM vs. PM	6217	0.003	P< 0.01

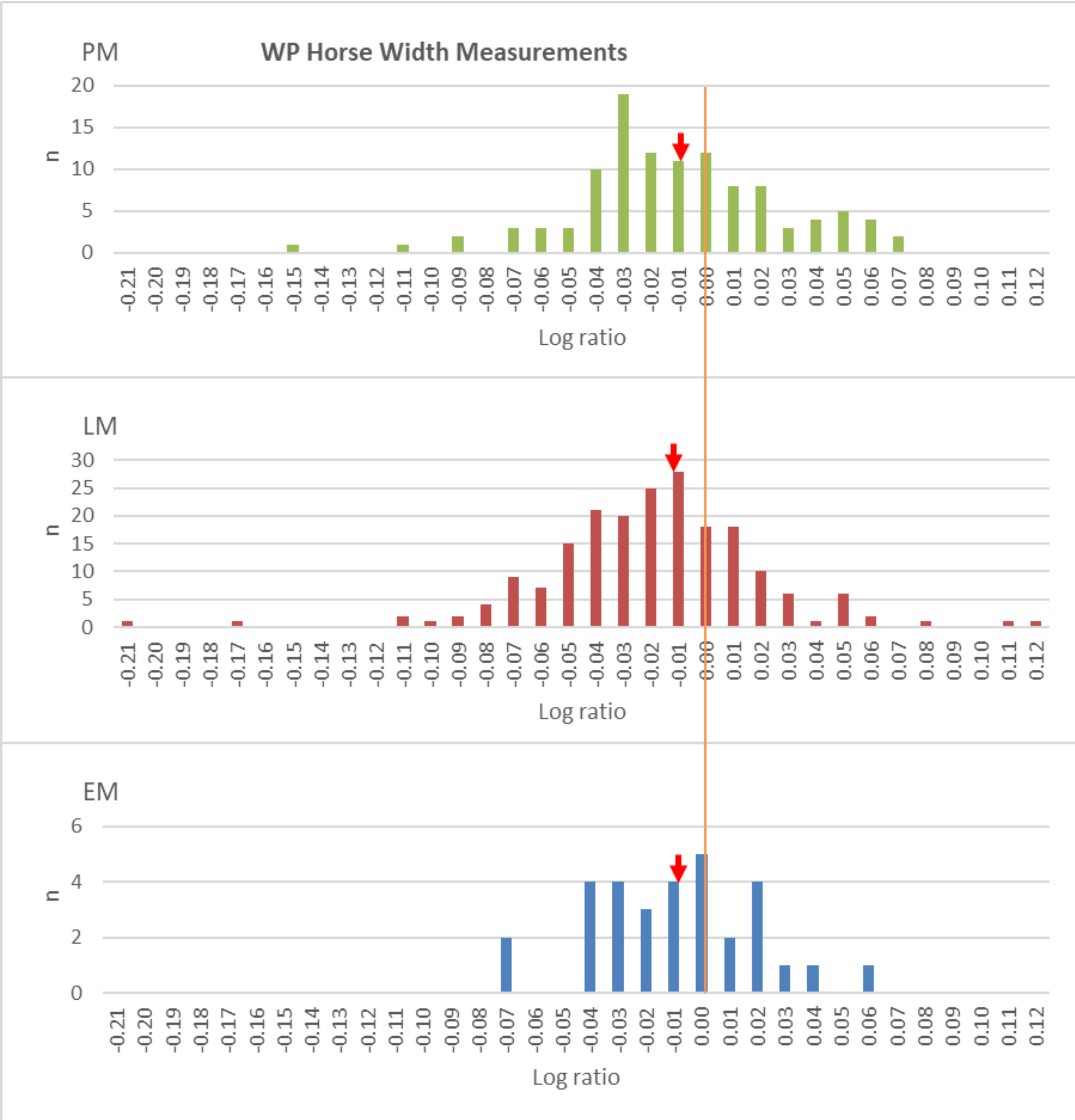

Figure 4.69: Log ratio histograms combining horse post-cranial bone width measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.20: T-test results for the post-cranial log ratio width values for horse by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	2618	0.164	P> 0.05
LM vs. PM	9698	0.065	P> 0.05

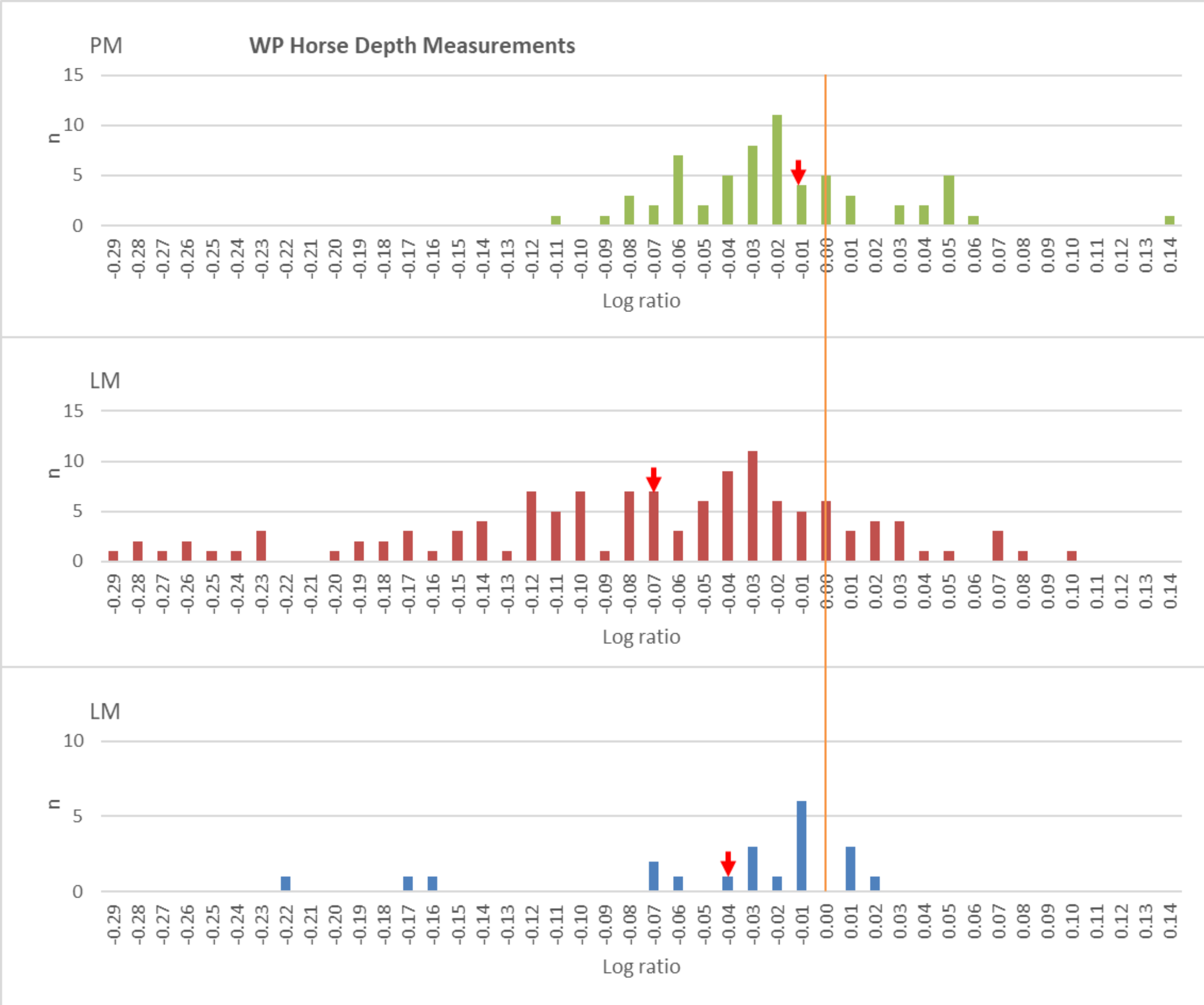

Figure 4.70: Log ratio histograms combining horse post-cranial bone depth measurements by period at Wharram Percy. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 4.21: T-test results for the post-cranial log ratio depth values for horse by phases and periods at Wharram Percy.

Phase	t stat/ U-value	P value	Significance
EM vs. LM	955	0.034	P<0.05
LM vs. PM	2377	0.000	P< 0.01

Table 4.22: Statistical test results for individual horse bone measurements between the earlier, late and post-Medieval periods at Wharram Percy. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t stat/ U-value**	**P Value**	**Significance**	**t stat/ U-value**	**P Value**	**Significance**
M_2L_1	N/A	N/A	N/A	1.436	0.194	P> 0.05
M_2W_a	N/A	N/A	N/A	-1.481	0.173	P> 0.05
M_3L_1	1.986	0.598	P> 0.05	0.569	0.504	P> 0.05
M_3W_a	-0.619	0.512	P> 0.05	1.208	0.143	P> 0.05
Scapula GLP	N/A	N/A	N/A	1.265	0.074	P> 0.05
Scapula SLC	N/A	N/A	N/A	1.940	0.230	P> 0.05
Humerus BT	N/A	N/A	N/A	236	0.206	P> 0.05
Humerus HTC	N/A	N/A	N/A	240	0.331	P> 0.05
Metacarpal GL	N/A	N/A	N/A	79	0.025	P> 0.05
Metacarpal SD	N/A	N/A	N/A	2.578	0.018	P< 0.05
Metacarpal Bd	N/A	N/A	N/A	1.724	0.123	P> 0.05
Metacarpal Dd	N/A	N/A	N/A	14	0.004	P< 0.01
Pelvis LAR	N/A	N/A	N/A	0.207	0.840	P> 0.05
Femur DC	N/A	N/A	N/A	0.985	0.339	P> 0.05
Femur Bd	N/A	N/A	N/A	76	0.000	P<0.01
Tibia Bd	85	0.354	P> 0.05	54	0.367	P> 0.05
Tibia Dd	92	0.228	P> 0.05	52	0.259	P> 0.05
Astragalus GH	0.648	0.532	P> 0.05	1.100	0.284	P> 0.05
Astragalus GB	1.917	0.104	P> 0.05	-1.344	0.191	P> 0.05
Astragalus Bfd	0.565	0.583	P> 0.05	0.906	0.573	P> 0.05
Astragalus LmT	-0.521	0.615	P> 0.05	0.319	0.638	P> 0.05
Calcaneum GB	-1.034	0.274	P> 0.05	N/A	N/A	N/A
Phalanx 1 GL	N/A	N/A	N/A	409	0.169	P> 0.05
Phalanx 1 Bp	N/A	N/A	N/A	-1.118	0.270	P> 0.05
Phalanx 1 Dp	N/A	N/A	N/A	0.723	0.474	P> 0.05
Phalanx 1 SD	N/A	N/A	N/A	1.019	0.315	P> 0.05
Phalanx 1 Bd	N/A	N/A	N/A	-0.684	0.498	P> 0.05
Phalanx 1 Dd	N/A	N/A	N/A	93	0.000	P<0.01

Table 4.23: Coefficient of variation values for horse teeth and post-cranial elements across both the individual phases and broad periods at Wharram Percy.

Phase	Post-cranial	Teeth
10th-13th	4.7	8.8
13th-14th	8.3	n/a
14th-15th	n/a	n/a
15th-16th	5.4	10.8
16th-17th	6.1	9.6
17th-18th	9.2	11.6
18th-19th	12.8	22.6
Period		
EM	7.9	9.6
LM	9.7	18.4
PM	9.6	21.3

4.2.8 Comparison to York

In order to understand the results from Wharram Percy within the wider context of local trade and livestock movement, they have been compared to livestock data from the nearest large urban centre of York. Limited availability of metric data from York has allowed only for the comparison of sheep and pig metric information, though the comparison of age profiles for sheep, cattle, and pig has also been carried out. The York metric and ageing data come from a number of sites across the city, published in the following reports: Aldwark (O'Connor 1984a), Coppergate (O'Connor 1999), Bedern (Vicar's Choral) (Scott 1985), Fishergate (O'Connor 1991), Skeldergate and Walmgate (O'Connor 1984b), and Tanner Row (O'Connor 1988).

Figure 4.71 gives the comparison of sheep post-cranial length measurements from Wharram Percy and York, using the log-ratio method, between the late and post-Medieval periods. In the late Medieval period, the larger average length measurement is shown at York, suggesting greater sheep post-cranial length on the urban site. In the post-Medieval period, there is an increase in mean length on both sites, though the change at Wharram Percy is much greater, causing the mean on the rural site to slightly exceed that of the urban site. This indicates that, while sheep post-cranial length was larger on both sites in the post-Medieval period, the greatest increase was at Wharram Percy, meaning that average values on both sites are comparable in the final period. This may represent the presence of larger animals at York in the late Medieval period, which were perhaps imported from other rural areas. A similar pattern can be seen for sheep post-cranial width measurements from Wharram Percy and York (Figure 4.72). In the late Medieval period, the average width from York is once again much larger than that from Wharram Percy, and an increase is seen on both sites in the post-Medieval period. However, the width increase at Wharram Percy is not as great as the increase in length seen previously, and therefore the sheep post-cranial width on the rural site is still smaller in the post-Medieval period. This indicates that, despite an increased average at Wharram Percy, sheep post-cranial width measurements were consistently larger at York throughout the study period. Unfortunately, a lack of post-Medieval York data means that only the late Medieval post-cranial depth measurements for sheep from York can be compared to Wharram Percy results. In contrast to length and width results, the comparison of sheep post-cranial depth measurements using the log-ratio method, shows a larger average at Wharram Percy in the late Medieval period (Figure 4.73), suggesting greater post-cranial depth on the rural site in the earlier period. This average depth value increases in the post-Medieval period and is considerably larger than the late Medieval York average, though it is not clear how post-Medieval sheep measurements would relate to this. Overall, when compared to livestock in York, it appears that Wharram Percy sheep were smaller in terms of length and width in the late Medieval period, but increased in size in the post-Medieval period, particularly in post-cranial length. This could suggest that sheep were larger on the urban site at an earlier stage, and this increased size spread to rural areas in the post-Medieval period.

Again, for pig metric comparison there is a lack of post-Medieval York data; therefore, the late and post-Medieval Wharram Percy results are compared to just the late Medieval data from York. Furthermore, a small sample size for pig on both sites necessitated the combination of length, width and depth in one analysis. The average post-cranial pig values for late Medieval Wharram Percy and York are exactly the same, suggesting similar pig size across both sites in the late Medieval period (Figure 4.74). There is a slight increase in size at Wharram Percy during the post-Medieval period. It is unclear whether this increased size was also seen at York, though it is likely, based on the late Medieval result, that pig size on both sites was comparable throughout the study period.

Age-at-death results for sheep have been compared using mandibular eruption and wear for both Wharram Percy and York. Both sites exhibit a relatively similar pattern across the late and post-Medieval periods (Figure 4.75; Figure 4.76), as both assemblages are dominated by adult individuals. This reflects the importance of wool during both periods, meaning that sheep across the region were likely kept alive into adulthood for wool production. However, in both periods there is a greater proportion of juvenile individuals at York, which could represent the greater consumption of lamb on the urban site. Nonetheless, it appears that sheep were exploited predominantly for wool throughout the late and post-Medieval periods in both rural and urban areas, with age profile reflecting the resultant culling of older animals.

Mandibular wear patterns have also been used to compare cattle herd profiles in the late and post-Medieval periods at Wharram Percy and York (Figure 4.77; Figure 4.78). In the late Medieval period, the Wharram Percy assemblage was dominated by adult and elderly individuals, suggesting that cattle were frequently surviving into adulthood on the rural site. However, at York, there is a much greater proportion of juvenile individuals, alongside a peak in adult animals, indicating a much earlier kill-off for some of the herd. This may be due to the exploitation of cattle predominantly for meat on the urban site, both as juvenile animals and as adults. This could also help to explain the lack of young animals at Wharram Percy, as it may be that juvenile individuals were taken to urban centres for consumption, while the remaining animals were kept alive longer for traction, with a relatively large proportion reaching the elderly stage. This pattern is further emphasised in the post-Medieval period, as there is an even larger peak in juvenile animals at York, accompanied by a decrease in the presence of subadult and adult individuals. This contrasts the pattern shown at Wharram Percy, where there is still a high proportion of animals surviving into adulthood. This could reflect the increasing demand for meat in the post-Medieval period, meaning that a much higher proportion of livestock were reared specifically for meat, and consumed at an early age, on urban sites. This may again explain the relative lack of younger individuals at Wharram Percy, as it is likely that juvenile cattle from rural sites were driven to urban sites like York for slaughter, and therefore produced greater profit due to the demand for veal. Surprisingly, there is a relatively large proportion of elderly animals at York in the post-Medieval period, which suggests that over 25 percent of cattle survived into the elderly stage – this could perhaps represent the sale of meat from older animals, providing cheaper cuts. In summary, age-at-death results for cattle suggest that in general there was a much greater proportion of juvenile animals at York, particularly in the post-Medieval period where veal was in higher demand. This could explain the lack of younger animals at Wharram Percy, as juvenile cattle from rural sites may have been driven to urban centres to cater for the demand for meat, leaving behind older animals for breeding and/or traction.

Finally, pig dental ageing results were compared for the two sites across the late and post-Medieval periods (Figure 4.79; Figure 4.80). In the late Medieval period, the Wharram Percy assemblage is dominated by a peak in adult animals, followed by subadult remains. In the York results, this peak occurs earlier, in the subadult stage. This suggests that, while most pigs survived into adulthood at Wharram Percy, livestock at York were killed sooner, between immature and subadult stages, for consumption. However, there is also a relatively large proportion of adult animals at York in the late Medieval period which, alongside the presence of neonatal remains, could indicate the presence of adult breeding individuals within the city. In the post-Medieval period, the age distribution of pig at Wharram Percy remains constant, with an abundance of adult animals. However, at York, there is an increase in juvenile animals, and a large peak in subadult abundance. This could reflect the increasing exploitation of young pigs for meat on the urban site, meaning that the majority of animals were killed for meat before two years of age. This could also explain the absence of younger animals at Wharram Percy, as juvenile individuals from the rural site may have been transported to the urban centre in order to supplement the demand for meat, causing a lack of young animals at Wharram Percy, and further exaggerating the presence of young pigs on sites like York.

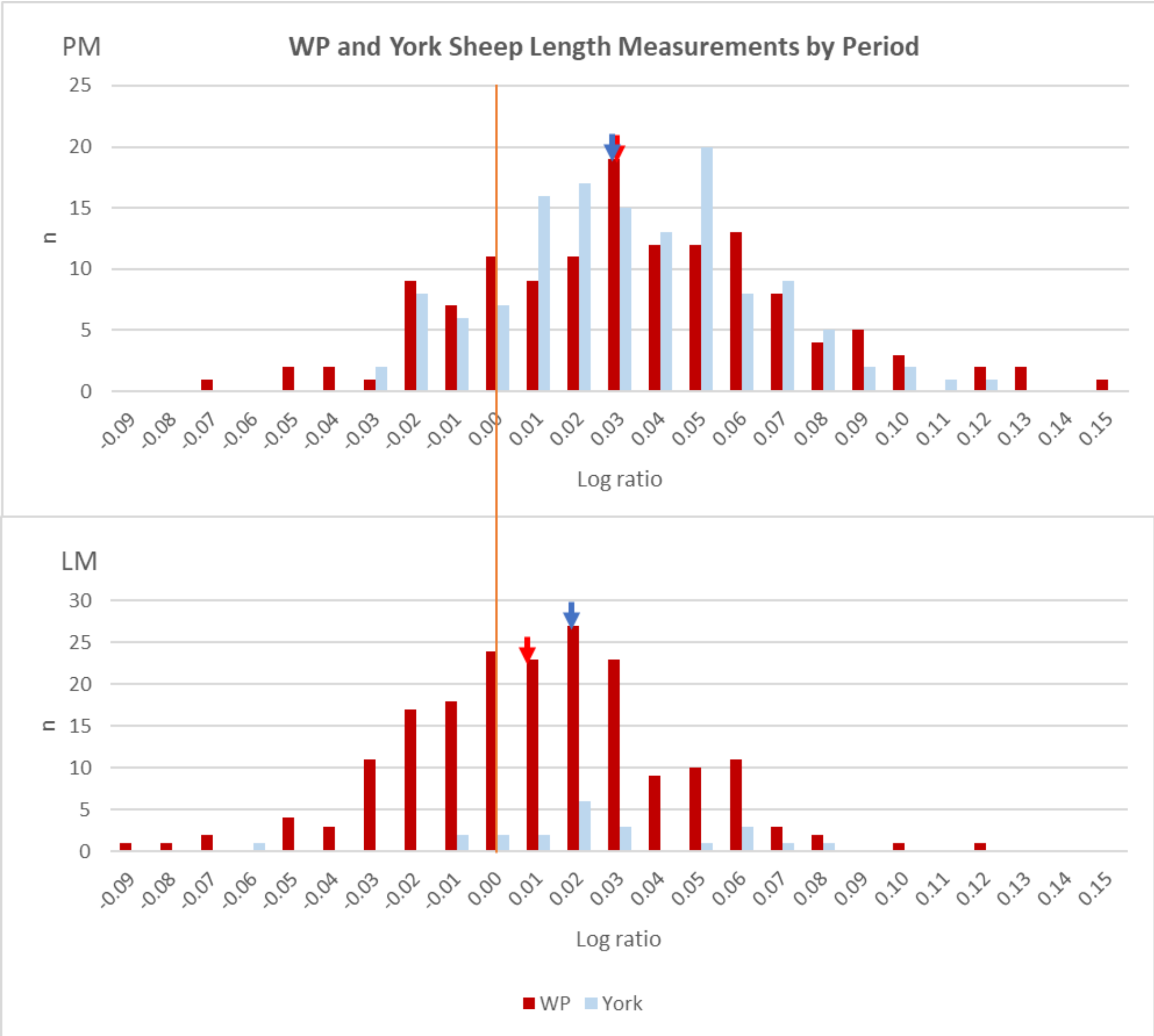

Figure 4.71: Comparison of Wharram Percy and York sheep length measurements by period. York measurements are shown in the light blue bars, with the Wharram Percy and York means represented by the red and blue arrows respectively.

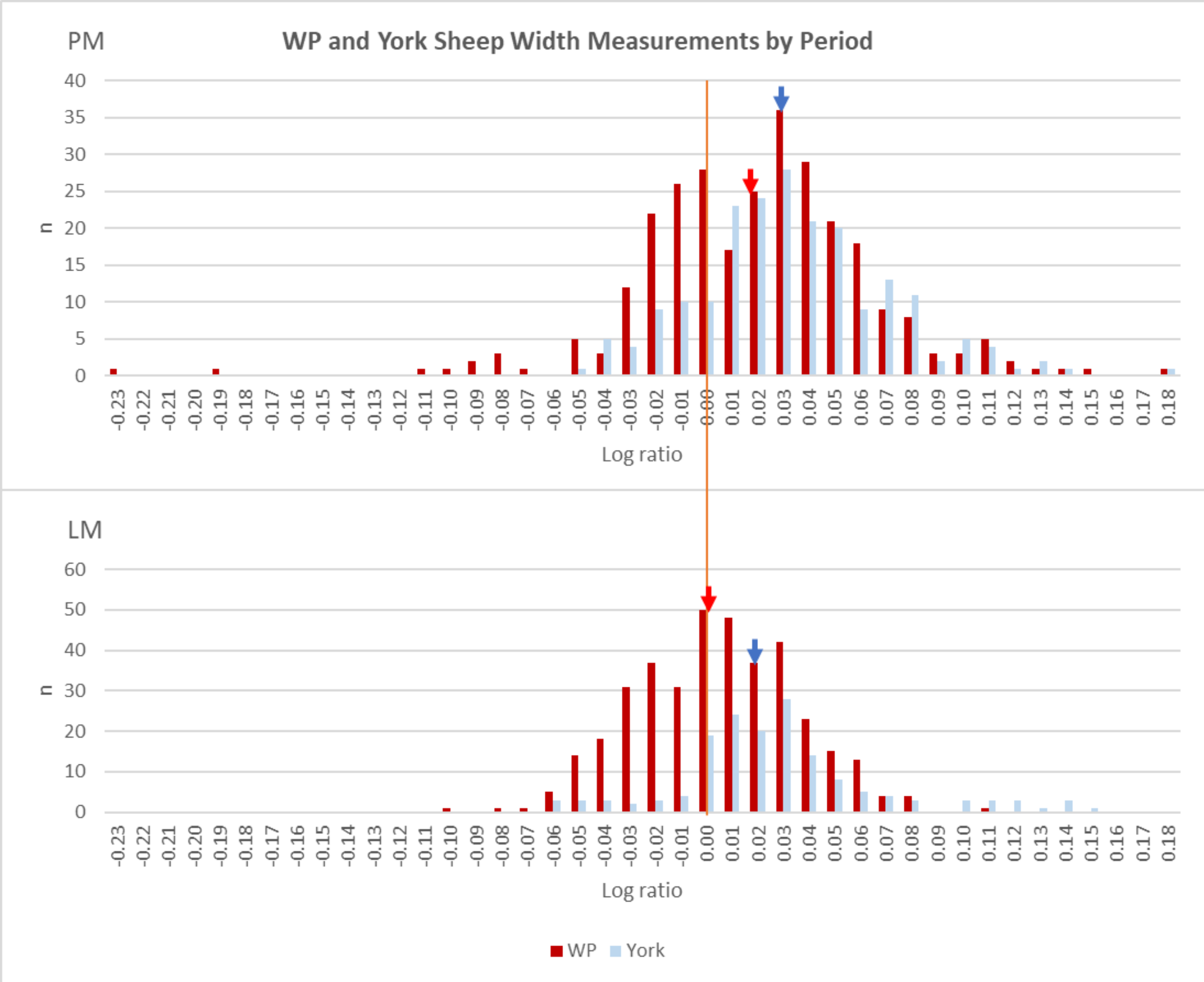

Figure 4.72: Comparison of Wharram Percy and York sheep width measurements by period. York measurements are shown in the light blue bars, with the Wharram Percy and York means represented by the red and blue arrows respectively.

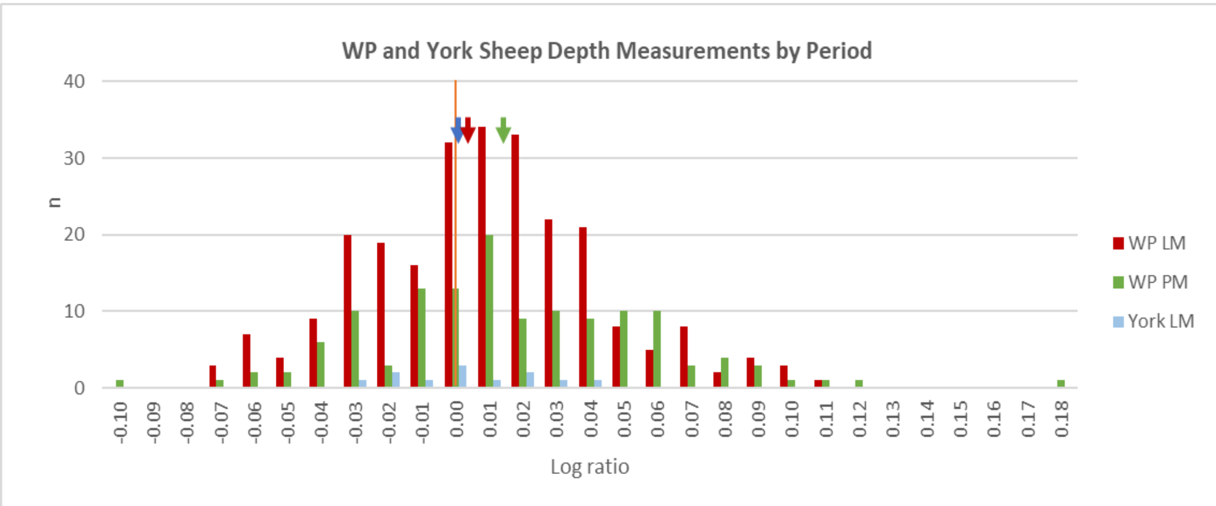

Figure 4.73: Comparison of Wharram Percy and York sheep depth measurements by period. York measurements are shown in the light blue bars, with the LM and PM Wharram Percy and York means represented by the red, green and blue arrows respectively.

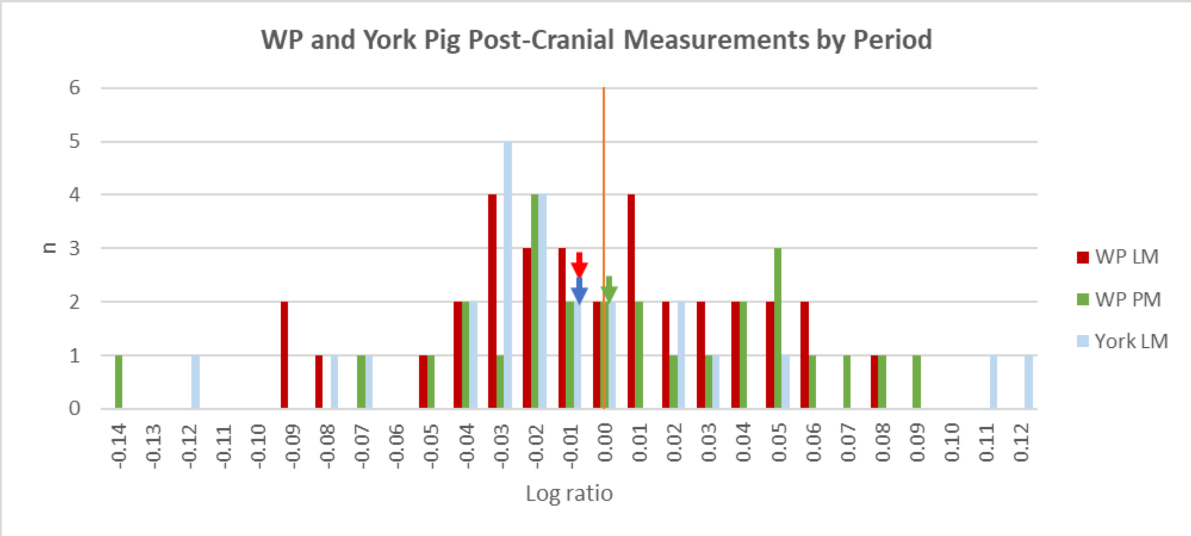

Figure 4.74: Comparison of Wharram Percy and York pig post-cranial measurements by period. York measurements are shown in the light blue bars, with the LM and PM Wharram Percy and York means represented by the red, green and blue arrows respectively.

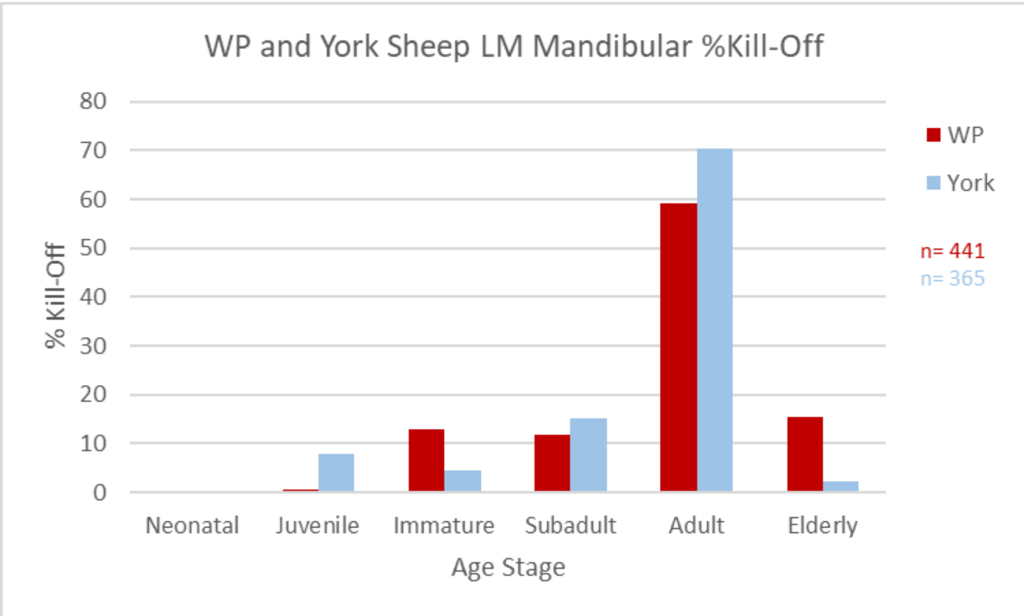

Figure 4.75: Comparison of late Medieval Wharram Percy and York sheep dental age profiles.

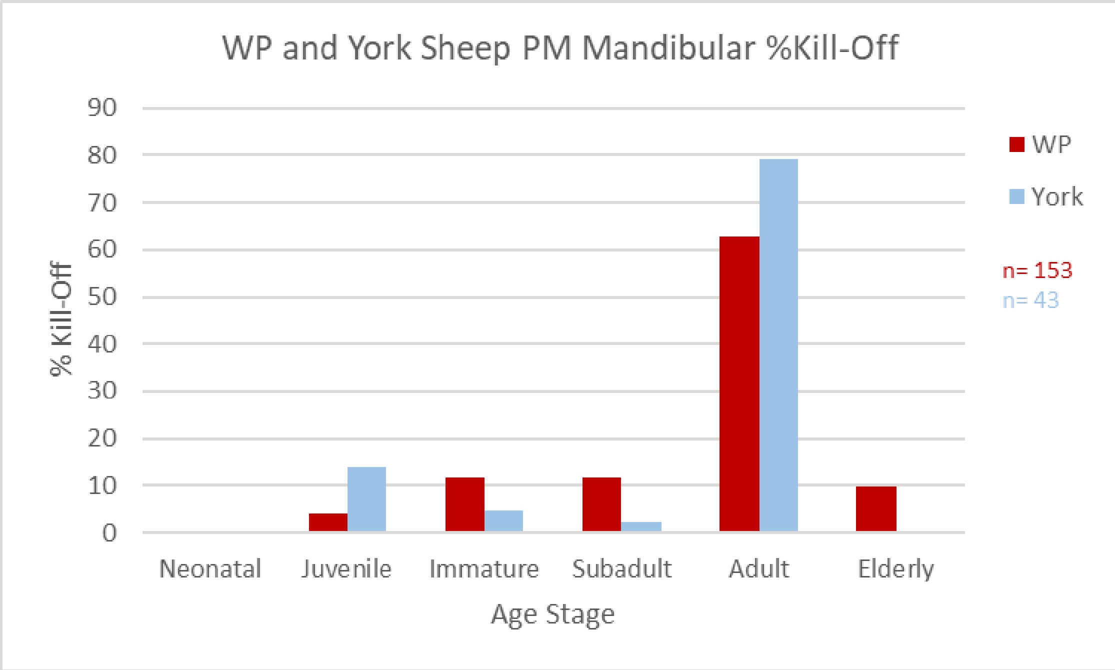

Figure 4.76: Comparison of post-Medieval Wharram Percy and York sheep dental age profiles.

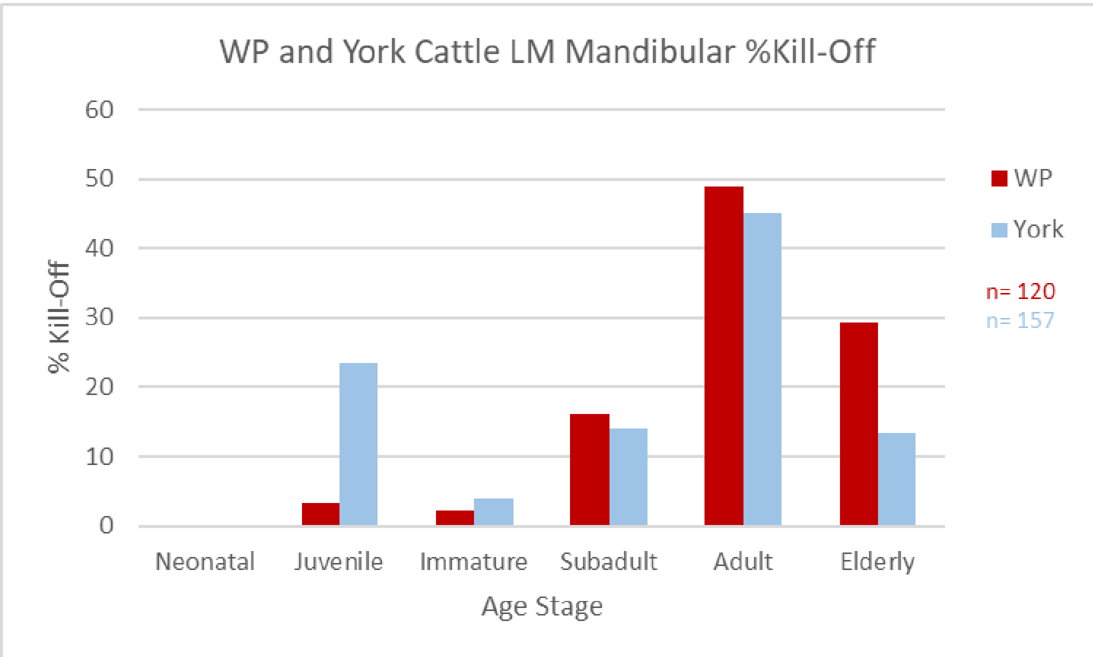

Figure 4.77: Comparison of late Medieval Wharram Percy and York cattle dental age profiles.

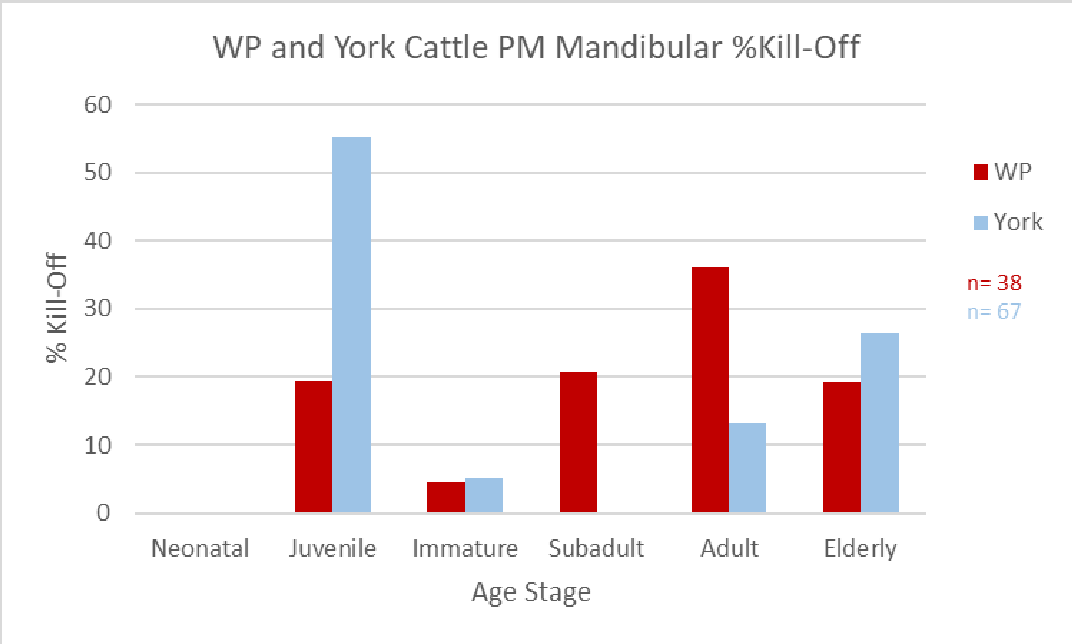

Figure 4.78: Comparison of post-Medieval Wharram Percy and York cattle dental age profiles.

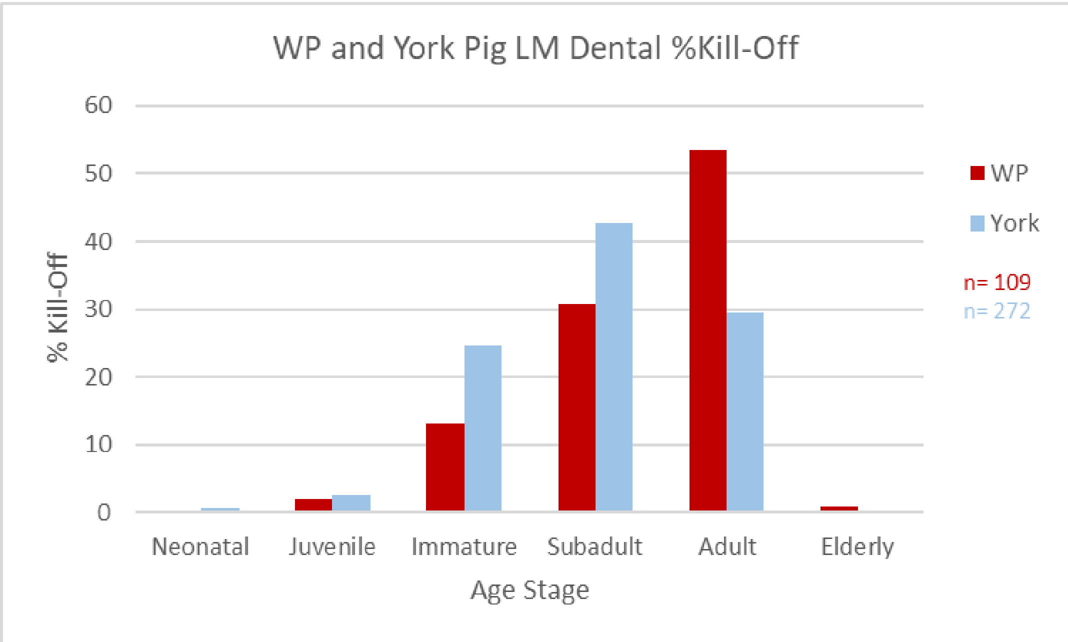

Figure 4.79: Comparison of late Medieval Wharram Percy and York pig dental age profiles.

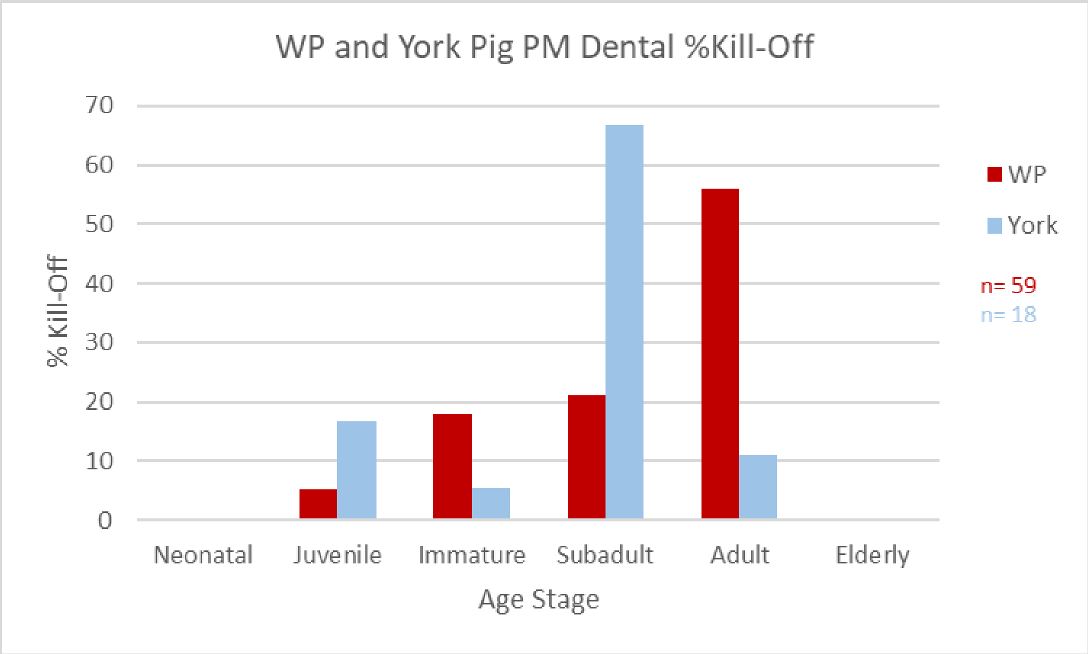

Figure 4.80: Comparison of post-Medieval Wharram Percy and York pig dental age profiles.

4.3 Discussion

Some clear changes in livestock management and size are evident between the tenth and nineteenth centuries at Wharram Percy. Of particular importance to both the economy and landscape of the site were sheep, which were by far the most prevalent species, and increased in abundance during the late Medieval period, seemingly to the detriment of cattle population (a summary of species frequency is provided in Table 4.24). This prevalence of sheep is not surprising in an area described by Dyer (2012a, 320) as a "sheep and corn region", and it is likely that by the thirteenth century large flocks were grazed on common land, as well as on corn fields after harvest, which in turn manured the soil (Harris 1959). Thirteenth century evidence from the nearby villages of Kirby Grindalythe, Mowthorpe, Thirkleby and Thixendale indicates that one oxgang could support a large number of sheep, at 15-30 adults (with lambs), compared to the smaller figures of two or three cattle or horses, one to three pigs, and four to five geese. Zooarchaeological evidence suggests that sheep frequency was particularly high in the thirteenth to fifteenth century phases, which is supported by historic evidence that shows flocks becoming larger from the fourteenth century, due to more tenants farming multiple holdings. Therefore, by this time there would have been, in Dyer's (2012a, 322) words, an "overwhelming preponderance of sheep" at Wharram Percy, with tenants owning flocks of up to one hundred animals each. The parish of Wharram Percy was particularly suited to sheep farming, as the Beck, which flowed down the centre of the village, provided free-flowing water in which to wash sheep before shearing. This particular suitability led to a large-scale reorganisation of the parish in the early sixteenth century, as nearly all of the township was converted to pasture for greater availability of sheep grazing. As discussed in the historical evidence section of this chapter, this resulted in the almost total depopulation of the parish, as homesteads made way for over one-thousand sheep, reared by non-resident graziers. In the post-Medieval period, zooarchaeological evidence shows a slight decline in sheep numbers, particularly in the 16th-17th century phase. This most likely relates to the early seventeenth century adoption of an infield-outfield system, restoring some arable land to the parish alongside permanent pasture. However, sheep were still by far the most prevalent livestock on the site, increasing again in frequency throughout the post-Medieval period. This suggests that sheep were still an important part of the economy at Wharram Percy, and historical evidence indicates that they were still widely grazed on the chalk plateau, fallow arable land, and on around three hundred acres of permanent pasture. A 1699 probate inventory also shows the continued importance of sheep, listing the species as 73% of all livestock value. This was especially the case in the Wolds, which exhibited a far greater frequency of sheep than any other region of Yorkshire, averaging 96 animals per farm (Long 1960). Conversely, other areas such as the North York Moors and Dales displayed a higher abundance of cattle (Hall 2012). Sheep prevalence is shown to continue even after eighteenth century 'Improvement', as zooarchaeological sheep abundance increases in the final phase, and a 1786 probate inventory lists a flock of 1,310 animals.

The predominance of sheep at Wharram Percy was prompted by an increased demand for wool in the late Medieval period, which is reflected in the ageing results. Across all periods of the site, there is a relatively high survival of sheep, suggesting wool as their primary use (Table 4.25). However, in the earlier Medieval period, there is a greater kill-off of sheep in earlier stages, from around a year onwards. This could suggest that sheep were reared for both meat and wool in this period, before the increased wool trade led to increased specialisation. The peaks in kill-off between stages E and G could represent the relatively late age of maturity of the native shortwool breed likely reared at Wharram Percy during this period, which Bowie (1990) states were sold to butchers between 39 months and five years. However, the lack of butchery marks on earlier Medieval sheep specimens suggests that this production of meat at the site in the earlier Medieval period was specialised. In the late and post-Medieval periods, a high survival of sheep into adulthood is displayed, evidently the result of increasing wool specialisation from the thirteenth century onwards across the country (Albarella 1997a), and the particular focus on wool production at Wharram Percy. Historic evidence suggests that wool from Wold sheep was particularly in demand from the late Medieval period, particularly in the West Riding (Harris 1959). The sheep reared in the Yorkshire Wolds were "small, hardy, compact animals, from which a short, thick, close fleece of fine clothing wool" could be obtained (Harris 1961, 32). This breed gave the wool growers of the Wolds a distinct advantage, as the fleeces were relatively heavy at around 2lbs each, so they fetched a high price (Dyer 2012a). As a result, many shortwool Wold sheep regularly passed through markets in East Yorkshire, and the local sheep and wool trade was "conducted on a considerable scale (Harris 1961, 33). That is not to say that sheep were entirely exploited for wool, as a peak in kill-off between 4-6 years is evident, coinciding with the prime meat age for shortwool Wold sheep. Furthermore, there is an increase in butchery marks in the late and post-Medieval periods, indicating the butchery of elements with the greatest meat yield. However, based on the historical information from Wharram Percy, it is more likely that sheep were predominantly kept for wool, with some exploitation of mature animals for meat.

The metric assessment of sheep remains from Wharram Percy show some clear changes in sheep size from the late Medieval period onwards (Table 4.26; Table 4.27). The first noticeable change is the increased size of mandibular third molars in the late Medieval period. This coincides with the beginning of wool specialisation, and may therefore represent the selection of different breeds for their wool-producing characteristics. However, there is no significant change in post-cranial size until the post-Medieval period. From the 17th-18th century onwards, there is a highly significant change in the length, width and depth measurements of sheep post-cranial elements, which indicates a shift to larger animals. Historically, this coincides with the period of 'Improvement' at Wharram Percy, suggesting that the change in sheep size may have been linked to the changing organisation of the parish from the eighteenth century. It has been documented that from the eighteenth century in Yorkshire, Lincoln and Leicester rams were introduced to flocks of native shortwool sheep, in an attempt to produce larger animals, with heavier fleeces, to supply the expanding east Midlands and west Yorkshire industrial areas (Harris 1959). The introduction of the Leicesters was particularly successful on the Wolds, which led to the dominance of Improved Leicesters in all but a few remaining open-field townships, and the eventual extinction of the Wold shortwool, Old Lincoln and Holderness longwool breeds by the late eighteenth century. This new breed is recorded as being faster to mature, and "fattened more readily" (Bowie 1990, 118), meaning that they were sold to butchers at 'two shear' (27 months), whereas previous shortwool breeds required between 39 months and five years to mature. Furthermore, the introduction of turnip cultivation in the Wolds at this time offered a new source of winter fodder for sheep, allowing for an increase in flock size. A system developed in which young wethers were fed with turnips in their first winter, grazed on lowland pasture during the spring and summer, then at Michaelmas (29th September) sold to butchers or graziers. This kind of practice may have been adopted at Wharram Percy after the physical enclosure of the parish and the greater abundance of arable land, perhaps used for providing winter fodder for livestock. As a result of the more rapid maturity of the Improved Leicesters, there was an increase in meat production in the Wolds generally after the eighteenth century, as well as a shift in herd composition from equal parts ewes, wethers and hogs (under two years), to a greater abundance of ewes, in order to maintain stock numbers. In addition to the benefits to meat production, the new Improved Leicesters provided more wool than previous shortwool breeds, at around 8-12lb from one ewe in good condition, compared to the 3 ½ -5lb of shortwools. Despite the price per pound of shortwool being greater, the extra weight of the longwool fleece resulted in a better return from longwool flocks, sometimes even double (Bowie 1990). This characteristic, as well as the continued expansion of the woollen industry in west Yorkshire during the 1820s and 30s, maintained the demand for wool, meaning that wool production remained an important part of the Wold economy. This certainly seems to be the case at Wharram Percy, where sheep survival remained high throughout the post-Medieval period. Therefore, it is likely that the size increase displayed by the zooarchaeological results from the 17^{th}-18^{th} century represents the introduction of the larger Improved Leicester breed at Wharram Percy, which were exploited on the site for their heavy fleeces. In summary, sheep remained extremely important to the economy of Wharram Percy throughout the study period, as the landscape of the parish was largely dictated by the increased demand for wool and therefore specialist rearing of sheep. The period of 'Improvement' in the eighteenth century appears to have brought with it a new breed of sheep, which were larger in both size and wool yield.

Cattle are the second most abundant species at Wharram Percy throughout the study period, though they constitute a relatively small proportion of the assemblage in comparison to sheep, and their abundance seems to directly contrast that of sheep (Table 4.24). For example, from the thirteenth century, cattle frequency decreases as the prevalence of sheep increases on the site, and cattle increase in frequency again in the post-Medieval period as sheep numbers decline slightly. Harris (1961) states that most farmers on the Wolds kept at least one cow with their sheep flock, though cattle numbers were much lower on Wolds sites like Wharram Percy due to a lack of available water supply. Despite the increased cattle frequency at Wharram Percy in the post-Medieval period, the average Wolds farm in the late seventeenth century had no more than eight or nine cattle, whereas the average figures in the Vale of York and Holderness were twelve and fourteen respectively. In the Wolds, Harris (1959) states that cattle were used for a variety of meat, milk and traction, in contrast to lowland areas which were more specialised to dairy production. In the earlier Medieval period at Wharram Percy, ageing data shows a peak in adult and elderly animals, suggesting that cattle were largely used for traction before the transition to predominantly sheep pasture (Table 4.25). However, the age distribution of cattle in the late Medieval period shows a high number of adult and elderly animals. This suggests the continuation of cattle exploitation for traction, which is reflected in the predominance of lower leg pathologies potentially related to heavy work, particularly in the late Medieval period (Bartosciewicz *et al* 1997). This is supported by Dyer (2012a), who states that the recovery of at least 28 ox shoes from the late Medieval village suggests the use of oxen as traction animals in late Medieval Wharram Percy, as individuals over two years were likely trained specifically for that purpose. Furthermore, he also documents that in neighbouring Wharram-le-Street both horses and oxen were used for traction, evidenced in a probate inventory of 1511, which lists eight oxen, and eight 'stotts' (plough horses). This evidence, alongside the presence of both cattle remains and four ox shoes in the last phases of Site 9, suggests that the introduction of horses as traction animals did not cause the total replacement of oxen.

The continued presence of cattle in the post-Medieval period at Wharram Percy is shown not only in zooarchaeological species abundance, but also historical landscape evidence documenting dedicated cattle pasture in the centre of the village, next to the water supply provided by the Beck, after the seventeenth century. Furthermore, after eighteenth century 'Improvement', field names such as *Cow Pasture* are present in the village, suggesting dedicated land for cattle rearing adjacent to the Beck. In the post-Medieval period, there is a relatively high abundance of adult and elderly animals, suggesting the continued use of cattle for traction, particularly given the re-establishment of arable cultivation with the adoption of an infield-outfield system in the seventeenth century. However, there is also an increased number of juvenile and subadult animals, perhaps suggesting the shift to meat exploitation, likely linked to the rising demand for veal from the fifteenth to sixteenth centuries (Albarella 1997a). In which case, the adult animals present could represent the breeding population, while young animals may have been sold to local markets to supply the largely urban demand for veal.

While tooth metric results for cattle at Wharram Percy show no change in size throughout the study period, post-cranial measurements suggest some fluctuations in cattle size (Table 4.26; Table 4.27). There is a significant decrease in post-cranial width and depth measurements in the late Medieval period, while length remains constant. This points towards a predominance of less robust animals in the late Medieval period, perhaps suggesting a greater proportion of females. Conversely, in the post-Medieval period, there is a significant increase in cattle width and depth measurements. This may reflect the re-establishment of multiple sexes in the herd, supported by the increasing coefficient of variation at this time. However, it may also represent the introduction of new breeds, particularly after the eighteenth century 'Improvement' at Wharram Percy. Harris (1959) indicates that cattle were being traded by drovers in the Wolds from at least the 1680s, particularly from the North Riding, but also potentially from further afield. This resulted in cattle of Scottish origin present on the pastures of Holderness and the lower Wolds by the early eighteenth century, and perhaps even before. This could suggest that the movement and trade of cattle from the late seventeenth century may have brought new breeds to Wharram Percy, perhaps causing the changing size from the eighteenth century onwards. However, a cattle plague outbreak in 1745-50 may have limited this movement, as the outbreak was particularly severe in neighbouring Holderness, and attempts were made to stop the transport of cattle (Harris 1959). In summary, it seems that cattle remained important for providing traction at Wharram Percy despite the changing land use associated with sheep rearing, though in the post-Medieval period they may also have been exploited for meat. It is likely that much of the size change shown was associated with varying sex ratios at the site, though increased measurements from the eighteenth century may be associated with the 'Improvement' of the township, and the trade of different breeds in the area.

Pigs are often the least abundant species at Wharram Percy throughout the study period, though they increase in abundance through time (Table 4.24). As Harris (1959) suggests, each oxgang of land at Wharram Percy was likely to support between one and three pigs in the late Medieval period – a small proportion of the total livestock compared to the large sheep flocks during that time. The continued presence of pigs at Wharram Percy in the post-Medieval period is supported not only by zooarchaeological results, but also by the establishment of field names such as *Great Hog Walk* after eighteenth century landscape reorganisation, though this may have related to sheep under two years of age. The most likely use of pig across the study period is for meat (Albarella 2009), and this is largely demonstrated by the ageing results, particularly in the earlier Medieval period, where a larger proportion of subadult individuals is present (Table 4.25). There is also a relatively high proportion of immature and subadult pigs in the late Medieval period, while in the post-Medieval the frequency of immature animals increases. Butchery evidence supports the exploitation of pigs for meat in the late and post-Medieval periods, as chop and cut marks indicate primary butchery and flesh removal, while saw marks point towards a more intensive system of butchery in the final period. However, butchery marks are absent in the earlier Medieval period, and in the two following periods their frequency is relatively low considering the primary use of pigs for meat. Therefore, it is likely that pigs exploited for meat were also sent elsewhere for specialised butchery. Ageing information could support this interpretation, as the highest proportions of animals on the site throughout the study period are adults, past the prime age for meat exploitation. Consequently, pigs may have been kept on the site to provide a meat source for residents, with any surplus being sent to local markets for slaughter and butchery, as shown by the comparison to York. Thus, the adult individuals remaining at Wharram Percy likely represent the breeding adult animals.

There is a comparatively small amount of metric change in pig remains at Wharram Percy in comparison to the previously discussed species (Table 4.26; Table 4.27). While there is no significant change in tooth length, there is an increase in width measurements from the 17th-18th century. Once again, this change may be associated with the eighteenth century 'Improvement' of Wharram Percy, in which changing land use and further physical enclosure of the site occurred. There is no sign of significant size change suggested by the post-cranial pig dimensions, though there is a high post-cranial coefficient of variation in the post-Medieval period, particularly in the 16th-17th century. In combination with the increased tooth width in the 17th-18th century, this could indicate either a change in husbandry strategy or the introduction of new stock in the post-Medieval period. Overall, pigs represent a small proportion of livestock at Wharram Percy, and were likely primarily exploited for meat throughout the study period. A size change suggested by tooth width in the post-Medieval period may represent a changing husbandry strategy, perhaps in association with the establishment of the infield-outfield system of the seventeenth century, or the following period of 'Improvement'.

Horse represents a slightly higher proportion of total livestock than pig throughout the study period, and increase in frequency, particularly in the 14th-15th century phase (Table 4.26). Dyer (2012a) indicates that horses were adopted as plough animals in the East Riding of Yorkshire at a relatively early date, as from the thirteenth century horses in teams of four are recorded as ploughing demesne land in parishes such as Wetwang. Furthermore, horses are also documented by 1403 in Market Weighton, and Langdon (1989) reports an abundance of horse-drawn vehicles in the region by the fourteenth century. The frequency of horse at Wharram Percy increases again in the post-Medieval period. Long (1960) uses seventeenth century probate inventories to demonstrate that this was not unusual for the region, as the Wolds displayed a greater abundance of horses, averaging 5.4 per farm, than any other region of Yorkshire in the post-Medieval period. This increase may reflect the shift in cattle use towards meat as veal became more popular, meaning that horses were increasingly used for traction in place of oxen. The ageing results for horse from Wharram Percy match this interpretation of horse use, as adult animals predominate the assemblage throughout the study period (Table 4.27), and all pathological changes on horse specimens occur in the lower leg, likely an indicator of stress related to traction or age. Horses would certainly have been more suited to ploughing the shallow, light chalk soil of the Wolds, and were faster than oxen. Furthermore, ridge and furrow evidence from Wharram Percy is indicative of horse-drawn teams, as there is a lack of curved lines produced by oxen, which cannot turn in tight spaces (Langdon 1982; Richardson 2009). There is also evidence that horses were ridden at Wharram Percy, as much metalwork associated with the harnessing and riding of horses, for example parts of bridles, spurs and curry combs, have been found at the site (Dyer 2012a). The metric assessment of horse remains from Wharram Percy shows relatively little change throughout the study period (Table 4.26; Table 4.27). There is no significant change in M_3 length or width between the earlier and post-Medieval periods, or in post-cranial measurements in the earlier to late Medieval transition. This is also noted by Richardson (2004; 2005), who states that late Medieval horses at Wharram Percy were small, with an average height of 12 hands, but were nonetheless capable of heavy work. However, there is a significant post-Medieval increase in the length and depth of horse bones, pointing towards the establishment of larger, more robust animals in this period. In summary, horses were present in relatively large quantities at Wharram Percy compared to other Yorkshire regions, and were primarily used for traction due to their suitability for light chalk soils. The increased robusticity suggested by metric results may be the result of changing landscape organisation from the seventeenth century onwards, increasing the amount of arable land in cultivation, and perhaps therefore the need for traction power in the township.

Table 4.24: Summary of species frequency data for Wharram Percy by period. The numbers in blue give the sites where the highest proportion of each species is found in each period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	Over 50% of assemblage 45, 76, 82	Second most abundant species (27% NISP) 54	Lowest abundance (7% NISP) 54	3rd most abundant species by NISP, but <15% 30, 71
LM	Slight increase, especially C.13th-14th 12,45, 54, 60, 71, 82	Decrease, especially in C. 13th-14th 51, 54	Increase each phase 9, 45, 71, 82	Increase, especially C. 14th-15th 30
PM	Decrease, but still over half the assemblage 30, 54, 73, 74	Increase, especially in C. 16th-17th and C. 18th-19th 60, 76	Increase 73	Increase 51, 77

Table 4.25: Summary of ageing data and likely exploitation of species for Wharram Percy by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	High survival Kill-off peak at 1 and 3 years Wool, maybe some meat	Peak in adult and elderly Traction?	Peaks in subadult and adult Meat at c. 2 years	High survival (3% unfused) Traction/ transport
LM	High survival Kill-off peak 6 years Wool	Peaks in adult, elderly Slight increase in subadult Traction?	Peaks in immature, subadult and adult Meat at 1-2 years	High survival (1% unfused) Traction/ transport
PM	High survival Kill-off peak 6 years Wool	Peaks in adult, subadult and juvenile Traction/ meat	Peaks in immature and adult Meat at 1-2 years	High survival (3% unfused) Traction/ transport

Table 4.26: Summary of tooth metric data for Wharram Percy by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	Increased LM M_3 width*, especially C.13th-14th** CV: 7.4-7.1	No significant change in M_3 width CV: 10.5-10.1	No significant change in tooth length LM decrease in tooth width* CV: 7.8-8.4	No significant change in M_3 size CV: 9.6-18.4
LM vs. PM	No change Decrease C. 16th-17th* CV: 7.1-6.9	No significant change in M_3 width CV: 10.1-11	C.17th-18th tooth length increase* C. 18th-19th tooth width increase* CV: 8.4-7.8	No significant change in M_3 size CV: 18.4-21.3

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

Table 4.27: Summary of post-cranial metric data for Wharram Percy by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	No significant change in post-cranial size CV: 8.4-7.6	No significant change in length C.13th-14th decrease in width** and depth* CV: 10.3-7.6	No significant change in post-cranial size CV: 4.6-10	No significant change in length, width or depth CV: 7.9-9.7
LM vs. PM	Increased PM astragalus, d. humerus and t. tibia size C. 17th-19th** Increased PM length, width and depth C. 17th-19th** CV: 7.6-8.3	No significant change in length PM increase in d. tibia Dd* C.18th-19th width increase** C.16th-17th depth increase* CV: 7.6-10.8	No significant change in post-cranial size CV: 10-12.2	No significant change in width PM increase in P1 Dd** PM increase in length** and depth** CV: 9.7-9.6

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

It is likely that Wharram Percy had external links to both the local area and urban centres further afield, and therefore it is important to consider livestock change within the wider context of trade. This could affect not only the number of animals on the site, but the body parts present, age distributions and size of livestock, both at Wharram Percy and connected sites. Historical records document Malton as the nearest market town, but there is also evidence of exchange within the East Riding of Yorkshire with Pocklington, Kilham, Beverley, Market Weighton, and Kirkham by the late Medieval period (Dyer 2012b; Harris 1961). Furthermore, links with York are suggested by the presence of York wares in the pottery collected at Wharram Percy, as well as finds of shoes and cloth most likely manufactured in the urban centre (Dyer 2012b). Agricultural products from Wharram Percy, such as grain and cheese, were probably taken to market by cart, but livestock would have been driven to markets to be sold to urban butchers, who then sold joints of meat back to surrounding rural settlements. Therefore, it is likely that many animals from Wharram Percy were killed for meat in nearby urban centres, and any butchery at Wharram Percy resulted in the hides and horns being sent to towns (Richardson 2005). Conversely, there is also evidence that specialist wool traders came from urban centres like Beverley and York, as well as nearby Pocklington and Malton, and sold wool to local cloth makers. It has even been suggested that the wool produced in Yorkshire was exported through Hull (Putnam 1939). Overall, it seems that Wharram Percy had connections to multiple local markets, as well as more distant urban centres and even ports, where animals and animal products were exchanged.

The comparison of ageing data from Wharram Percy and York could help to demonstrate this movement of animals between rural and urban sites. For sheep, both Wharram Percy and York age profiles are dominated by adult animals. This shows the importance of wool in the region as a whole in both the late and post-Medieval periods, meaning that sheep on both rural and urban sites were primarily wool producers. There is a slightly larger frequency of juvenile animals in both periods at York, which might also indicate the consumption of sheep around six months of age in towns, though the proportion of adults is much greater. In contrast, age profiles for cattle from Wharram Percy and York highlight the differences between rural and urban cattle exploitation. At Wharram Percy, the assemblage in the late Medieval period is dominated by adult and elderly animals, whereas at York there is a much greater abundance of juvenile individuals. This suggests that cattle were more often exploited for meat at York around six months and could reflect the transport of young cattle from rural sites like Wharram Percy to York for slaughter and butchery. Consequently, the very low proportion of juvenile cattle at Wharram Percy may reflect this movement of juvenile cattle to local urban markets for consumption. A similar pattern can be seen in the post-Medieval period, though the proportion of juvenile individuals from York is much greater, at the expense of subadult and adult individuals. This is likely due to the increased demand for veal in this period, and again may be exaggerated by the movement of a greater number of juvenile cattle from rural areas to York. A somewhat similar pattern can be seen in pig ageing results from Wharram Percy and York, as there is a prevalence of immature and subadult animals at York in the late Medieval period, in contrast to the prevalence of adults at Wharram Percy. In the post-Medieval period this pattern is more pronounced, with a far greater frequency of juvenile and subadult pigs at York. Again, this high abundance of younger animal at York may represent the movement of pigs from rural areas like Wharram Percy to urban centres for butchery and consumption between six months to two years of age. As a result of this exchange with urban markets, the remaining pig assemblage at Wharram Percy is dominated by adult animals.

The size of animals at both Wharram Percy and York can also help to demonstrate the movement of animals throughout the region during the late and post-Medieval periods. For example, sheep length and width measurements from both sites show smaller individuals at Wharram Percy in the late Medieval period, followed by similar average sizes in the post-Medieval. This suggests that larger animals were already present in urban centres like York from the late Medieval period, which may have been reared in other rural areas, and were then gradually distributed to Wharram Percy from the sixteenth century. In the case of Wharram Percy, the introduction of Improved Leicesters likely caused this increased size, which may have been introduced to the site due to trade with urban markets after the seventeenth century.

Overall, at Wharram Percy, it appears that the most striking landscape and zooarchaeological change occurred as a result of the market demand for wool, which caused the removal of common farming in the township and desertion of much of the parish, but no physical enclosure until much later. While this clearly impacted the frequency of animals, as sheep were by far the most economically important livestock throughout the study period, it seems that later developments had the greatest impact of animal size. Size increase in several species from the 17^{th}-18^{th} century suggests that livestock were subject to considerable change during the period of 'Improvement', instigated by Sir Charles Buck, which may have led to changing husbandry strategy and the introduction of new breeds. While the physical enclosure of the parish at this time no doubt impacted the management of livestock, it seems more likely that apparent improvement of animals was prompted more by the actions of the landowner, as well as trade links with local urban markets.

5. Shapwick Results

5.1 Historical and Landscape Background

3.1.1 Early to Late Medieval Shapwick

The earliest evidence for the existence of Shapwick comes from the seventh century, and lists the parish as part of the royal estate of *Pouholt* (Costen 2007). The name Shapwick may have come from 'sheep-wick', or sheep farm, suggesting that it was the location where sheep from the estate of *Pouholt* were collected to be sheared or slaughtered (Ecclestone 2007). In the eighth century the parish was granted to Glastonbury Abbey, and was still held by the Abbey by Domesday, where it was documented as comprising four ploughs of demesne arable land, and twelve farmed by tenants (Collinson 1791; Costen 2007). Around this time an expansion in arable cultivation, and a subsequent need for adequate grazing, caused many landowners to adopt an open field system, where common grazing could be carried out on fallow fields. Therefore, on many of the Abbey's manors, including Shapwick, two large open fields were established, East and West, which were fallowed in alternate years (Figure 5.1) (Ecclestone 2007).

This system of farming continued into the late Medieval period, and the open field arrangement present at Shapwick by 1325 is described by Aston and Gerrard (2013, 246) as typical of the band of "planned countryside" stretching across England from Durham throughout the Midlands to Wessex. Certainly, Shapwick did display some diagnostic features of an open field township, particularly the two large open arable fields either side of the village settlement. The first of these was known as West Field, which stretched from the village to the west boundary of the parish with Catcott, and from Loxley Wood in the south to the Nidons (moor) in the north, and comprised 70 furlongs. The second open field was named East Field, though it was divided by *Hallebrook* (today known as Cat's Drove Stream) in the thirteenth century to form a north section called East Field by Northbrook and a southern section known as East Field by Southbrook. These subsections comprised 20 and 45 furlongs respectively. The land in each of the two open fields was roughly equal in size, around five hundred acres, divided in to furlongs, which were grouped in to bundles of strips (Gerrard 2007). These cultivated strips were not hedged, instead separated just by baulks and headlands. From the twelfth century common arable land was supplemented by the occasional cultivation of both sections of the Nidons and fields at the fringes of existing open fields, likely due to increasing population and the decreasing fertility of arable land. Tenants' strips were scattered throughout the open fields. An example of this practice can be seen in the land belonging to John Pytt in 1515, whose holdings comprised a cottage and garden in the south-west of the village, but also over forty acres of scattered strips, as well as access to pasture on the Levels and in Loxley Wood (Aston and Gerrard 2013). Demesne land was also roughly equally divided between the open fields, with 245 acres in West Field and 251 ½ in East Field, accompanied by around 130 acres of meadow, and 50 acres of woodland (Corcos 2007). The arable fields were rotated biannually, with West Field sown in odd years, and the East Field sown in even years, and both fields alternating between fallow. While the land organisation of Shapwick initially appears to be typical of a classic open field system, Aston (1988) argues that no parishes in Somerset were ever completely representative of this farming system. He bases his argument on the fact that many Somerset townships, including Shapwick, contained two large open arable fields rather than three. Furthermore, many parishes, particularly to the west of the county, had a single open field which may have appeared to operate as a classic open field system, but in fact the arable land was not worked by all the farmers in the parish. Finally, while arable cultivation was communally operated in open fields, much of the pasture in the county was held in severalty, meaning that Shapwick, and many other Somerset parishes, fell short of typical open field farming.

Together the open fields at Shapwick provided around 1,400 acres of arable land on lighter calcareous soils, while the 500 acres of heavier, wetter gley soils in the parish were used for meadow, pasture and woodland. Furthermore, one thousand acres of wetland moor to the north, part of the Somerset Levels, also provided valuable common grazing, fuel and wildfowl (Ecclestone 2007). The Levels were used by parishes like Shapwick, as well as by other parishes further afield, and were important for the seasonal summer grazing of cattle, sheep, horses, and geese, as well as for supplying fuel and building materials (Aston 1988; Williams 1972). Rippon (2004) demonstrates the importance of wetland areas in the manors of Glastonbury Abbey by studying the neighbouring village of Meare, established at the same time as Shapwick and connected via droveways. He states that, though the low-lying areas around Meare and Shapwick were the most poorly-drained in the Levels, it offered multiple uses vital to the economy of the Abbey. For example, it provided areas for fishing, causing the Levels to contain the highest prevalence of fisheries in south-west England by Domesday. It could also be used for wildfowling, which included the rights to swans, herons and pheasants, as well as the collection of timber, peat and sedges for fuel, and reeds for roofing. Finally, the Levels were often used for grazing, and the intercommoning of livestock, particularly cattle and pigs, meant that many manors of the Abbey had the right to graze animals on the nearest moor. Cattle were especially prevalent at manors like Meare and Shapwick due to their position on or near wetland, whereas sheep were more common on manors situated entirely on dry land in the south and east of Somerset.

Thirteenth century manorial court rolls from Shapwick document the development of the parish under Abbey control during the late Medieval period. From the end of the twelfth century, Glastonbury Abbey began to more directly manage the demesne land on the thirty manors under its control. This led to increasing specialisation on the different manors, resulting in townships on the Polden hills being dominated by wheat cultivation, whereas legumes were more commonly favoured in entirely wetland areas, and sheep were favoured in the uplands (Rippon 2004; Gerrard 2007). As a result, Shapwick, alongside its neighbouring parishes of Ashcott, Greinton, High Hamm, Street and Walton, were largely exploited by the Abbey for wheat (Ecclestone 2007) – according to Campbell (2000) an unusual agricultural regime, which occurred on one in twenty demesnes, especially those with two open fields. The five hundred acres of arable demesne land at Shapwick were some of the best land in the parish, and were cultivated mainly for the benefit of Glastonbury Abbey. From the twelfth century, 91 percent of Shapwick's wheat crop went to the granary at Glastonbury, equating to an export of 178 quarters of wheat a year (one quarter being eight bushels), and 81 percent of the township's total arable cultivation (Aston and Gerrard 2013; Ecclestone 2007). By the fourteenth century the township was also exploited for other products such as rushes grown on the moor, as well as oats and barley used for fodder (Dunning 2004).

This relative specialisation in the cultivation of wheat led to a reduction in the amount of sheep from the twelfth century onwards (Aston and Gerrard 2013). In 1100-1135, up to 400 sheep were recorded in the parish, but there was a total absence a century later (Ecclestone 2007). This is reflected in the peasant diet at Shapwick, which was dominated by cereals, though also contained evidence for mutton, beef and pork, which increased after the fourteenth century (Aston and Gerrard 2012). Historical accounts of sheep at Shapwick increase in frequency during the fourteenth century, and include a reference to a wool sale in 1300-1, though sheep numbers remained in single figures until 1315. However, in 1334-5 there is a record of the construction of a sheep fold in the parish, and the employment of a shepherd to manage a flock of 160 animals. Furthermore, in 1352, 31 ewes and 23 lambs were sent to Glastonbury, and by 1367 121 ewes were recorded in Shapwick. This greater prevalence of sheep at Shapwick evidently continued in the late fourteenth century, as in 1389-90 18 sheep were sent to Glastonbury before shearing. In addition, 66 sheep died of disease in 1408, suggesting the continuation of a flock at Shapwick into the fifteenth century (Dunning 2004). It is likely that these animals were grazed on fallow arable land, including the demesne flock, which in turn directly provided manure for the large open arable fields (Aston and Gerrard 2013). Sheep were also often inter-manorial, transferred between the manors of Glastonbury Abbey, which can make the estimation of sheep numbers on each site problematic (Postan 1953).

According to historical records, cattle numbers from the twelfth century onwards contrasted that of sheep as demesne accounts record a greater frequency of oxen at the site by the mid-thirteenth century, increasing from around 30 to 63 (Dunning 2004). This reflects the exploitation of Shapwick by the Abbey for predominantly wheat cultivation, as oxen were important in the farming of arable land. Conversely, demesne accounts show that when the acreage of cultivated land dropped from 348 acres to 251 acres in the mid-fourteenth century, cattle frequency dropped to around 42, while sheep numbers recovered (Ecclestone 2007). This shows that cattle and sheep prevalence at Shapwick was largely determined by the acreage of arable land, which in turn was dictated by Glastonbury Abbey. Cattle were predominantly kept on dedicated pasture in the parish, as well as on 50 acres of pasture in Loxley Wood. In addition, one thousand acres of the wetland moors to the north of the parish were used for cattle grazing. It is also likely that cattle were grazed at Shapwick seasonally, and a record of 25 cows and 12 heifers being removed in 1330 suggests that they were kept at the site for summer grazing only (Dunning 2004).

There are relatively few historical references to pigs and horses in earlier and late Medieval Shapwick. Pigs and horses were both listed in the Domesday book, indicating their presence on the site in the early Medieval period. Furthermore, they were recorded alongside geese and chickens in thirteenth and fourteenth century demesne accounts (Aston and Gerrard 2013). There is also some archaeological evidence of horse exploitation at Shapwick in the late Medieval period, in the form of spurs and bridle bits. Documentary sources also state that mares were kept for traction on the site, usually to an elderly age. Furthermore, historical accounts suggest that when horses died at Shapwick they were fed to the dogs as 'kennel food', who Gerrard (2007, 985) suggests carried bone material from the village as far as the eastern churchyard boundary ditch.

3.1.2 Enclosure and Post-Medieval Shapwick

The process of enclosure began in Shapwick as early as the fourteenth century, and may have been prompted by the decline in population due to the Great Famine of 1315-17 and the Black Death in 1348 (Aston and Gerrard 2013). These factors caused the population of Shapwick to drop as low as one hundred by the mid-fourteenth century, leaving some tenements empty. Furthermore, only 37 tenants were listed as holding 50 holdings in 1325, meaning multiple holdings per tenant. This decreasing population allowed wealthier tenants to combine plots, initiating the process of engrossment. The first evidence that "active exchange and consolidation was widespread" comes from fourteenth century court rolls, which record two instances of land exchanges, in 1341 and 1346 (Corcos 2007, 103). Further fourteenth century entries list examples of arable holdings in scattered strips being sold or exchanged, then amalgamated and hedged, removing them from the common fields. However, many newly-created enclosures retained field names which reflected their origin as arable furlongs; for example, Stert Furlong, Penylond, and Wokeylond (the *-lond* element here meaning *-land* – originally applying to arable strips) (Aston and Gerrard 2013; Corcos 2007).

Furthermore, new boundaries rarely cut across ancient ones, and mostly followed the pre-existing pattern of arable strips. This process of exchange and consolidation was likely made easier by the fact that Shapwick was controlled solely by Glastonbury Abbey – the enclosure of demesne land occurred first, providing a solution to unprofitable demesne farming, and promoting enclosure on customary land. Corcos (2007) states that that this high incidence of piecemeal enclosure on both demesne and customary land is unusual of a classic Midland open-field arable system, highlighting the deviation from typical open field farming across Somerset. Overall, from the fourteenth century enclosure "steadily nibbled away at the peripheries of the common fields", though most tenants maintained a relatively equal division of arable land between the East and West fields, and continued to farm communally to a degree (Aston and Gerrard 2013, 250).

The exchange, consolidation and enclosure of individual strips continued through the fifteenth century at Shapwick. As a result, by the time of Abbot Beere's survey in 1515, about 60 percent of the upland parish had been enclosed (Figure 5.2) (Gerrard 2007). In addition to enclosure, much of the demesne and customary land in the parish was converted to pasture. By 1515, 349 of the total 804 acres of demesne land, and 276 of the 1,177 acres of customary land were pasture, 43 and 32 percent respectively compared to only 19 percent in 1325. One example of the newly enclosed demesne pasture in the parish was the 17 acres in *Sladwykesleys* held by John Whybery, which lay together in three closes. Much of this newly-created pasture had been enclosed in strips from the open arable fields, meaning that of the 450 acres of customary pastoral land in Shapwick by 1515, around 38 percent had originated in common arable fields. However, it was not just for the creation of pasture that enclosure took place – around 36 acres (3 percent) of the parish were arable closes. Furthermore, the 1515 survey records parcels of arable land as 'newly enclosed', though clearly not as frequently as pastoral areas. Many entries in the survey refer to parcels of 'newly enclosed' pasture, or land 'newly enclosed from the common fields; for example, Thomas Clark's two acres of pasture in *Holybrokemeade* were listed as 'newly enclosed in the West Field' (Corcos 2007). Overall, Beere's survey showed a parish undergoing rapid change in terms of landscape organisation. While it remained largely an open-field township, with tenants retaining a mostly equal division of arable land between the two large open fields, an increasingly specialised pastoral economy was emerging.

It is clear that by the sixteenth century at Shapwick, enclosure had been proceeding with very few obstacles and, according to Aston and Gerrard (2013, 288) had been carried out locally with enthusiasm. In 1539 Shapwick was seized by the crown after the dissolution of Glastonbury Abbey and the execution of the abbot, and thereafter the parish passed through the hands of numerous secular owners. After the dissolution of the Abbey, piecemeal enclosure of common fields gained pace as new landowners sought to increase their farming profits (Bettey 2007). Aston and Gerrard (2013) suggest that at this time enclosure was considered a process which would increase the efficiency of farming at Shapwick by providing a solution to unprofitable farming which had previously inhibited initiatives such as the intensification of cropping, the introduction of new crops, control over animal breeding, and even simple decisions concerning changes in land use. As a result, enclosure proceeded with relatively little opposition due to the small number of landowners to complicate the process, as well as the abundant pasture on moorland which meant that the loss of common grazing on the uplands was not considered an issue. Moreover, enclosure was further facilitated at Shapwick as before 1539 all tithes in the parish had been converted to money payments, rather than labour obligations, which were a significant obstacle to enclosure in other townships (Ecclestone 2007). While there was some opposition to enclosure in the county, due to the cost of fodder for overwintering stock, expense of creating distinct farms and cost of fencing, it appears that this was not the case at Shapwick, where the exchange and consolidation of land in the preceding centuries had paved the way for the creation of hedged fields managed for profit. As a result, enclosure was largely completed in the west half of the parish by the end of the sixteenth century.

Historic evidence suggests that the landscape change that had started as early as the fourteenth century was “rushing forward” by the early seventeenth century, and many instances of land exchange and conversion to pasture are recorded in manorial court rolls (Corcos 2007, 104). Often enclosure was brought about by an agreement between tenants, who exchanged land in dispersed parcels to create cohesive blocks, before enclosure and conversion to pasture. This conversion to pasture was documented in new field names present from the seventeenth century, for example ‘New Meads’ (New Meadow), which appears in 1643 (Aston and Gerard 2013). In order to carry out this exchange of land, licenses were granted by the manorial court, though this was not always the case, and tenants often decided for themselves how to re-distribute land, representing a shift in decision making towards individual landholders. One such exchange listed in the court rolls was carried out by William Cooke, who in October 1623 acquired three acres of Hollybrooke Close, in West Field, in exchange for two acres of arable land in West Field and an acre of grass (which was likely former arable land) in East Field. The resulting block of land was then converted to pasture. However, most of the exchanges recorded in the seventeenth century court rolls were not single transactions like that of Cooke, but involved multiple agreements. For example, in January 1632, a series of exchanges took place between Abraham Burrell, William Bull, and Mary Clarke, and over five separate transactions enabled Bull to consolidate his East Field holdings, particularly in Gracehay furlong, and Burrell did the same in the West Field furlong known as Crosse (Corcos 2007). In fact, many of the exchanges that took place in the seventeenth century were so complex that pieces of land were mislaid in the process (Aston and Gerrard 2013).

There are very few records of agreements between 1635 and 1685, followed by a flurry of activity from 1685 to 1700, which involved numerous exchanges of small parcels of land. This could suggest a decline in the rate of enclosure in the mid-seventeenth century; however, many exchanges likely went unrecorded as there was no fine paid to the manor upon completion, reducing the incentive for the lord to demand a written record. Also, many agreements could also have occurred privately between tenants without passing through manorial courts. Some of these private agreements can be traced through the subsequent violation of local bylaws, for example the obstruction of common paths with hedges, ditches or watercourses, which resulted in cash fines. Violations of local bylaws became increasingly common in the later seventeenth century as, according to Corcos (2007, 105), manorial control became “increasingly ineffectual”, and tenants were recorded as breaching the same regulation or failing to comply with a court order on numerous occasions. For example, in June 1677, Richard Godfrey was fined for acquiring a small piece of arable land at West Moor Corner via exchange with John Young without the lord’s license, and for obstructing a common way, but in July 1679 a similar entry occurs, this time with a greater fine. It therefore appears that during the seventeenth century, local bylaws were frequently breached, and court orders were regularly ignored. This resulted in enclosure continuing to be a commonly accepted local practice (Aston and Gerrard 2013). Consequently, the enclosure of demesne arable land from the open fields was largely complete by the mid-seventeenth century, showing a considerable change from 1515, when most of the demesne arable land was still intermixed with customary land in open fields. Furthermore, consolidation and enclosure also led to larger land parcels, suggested by a smaller number of landowners recorded per furlong. For example, in 1609 William Cooke held five acres of Millerythe Furlong in West Field, in parcels of four and one acres. Previously, in 1515, Millerythe had comprised 11 acres held by 16 tenants, meaning that each holding was no more than two acres, while less than a century later nearly half of the furlong was owned by a single tenant (Corcos 2007). Overall, the seventeenth century saw further consolidation and enclosure at Shapwick, with ditches and hedges starting to be established in order to differentiate land use. The only area of Shapwick parish which had not undergone significant consolidation and enclosure by the end of the seventeenth century was the Levels, though they were still used for fishing, fowling, and netting eels and ducks during this time. However, there was no dramatic transformation in the basic distribution of the village settlement, and the core of the old open fields remained intact after the seventeenth century, with most tenants retaining a roughly equal division of land between the East and West Field. Only in the eighteenth century did this change, as the fragmentation of the old open fields into distinct blocks began (Aston and Gerrard 2013).

By the middle of the eighteenth century, the two previous large open arable fields of Shapwick had been reduced to eight islands of arable land totaling 475 acres, each a small open field with strips and its own pattern of rotation (Figure 5.3) (Dunning 2004; Corcos 2007). Three-hundred and sixty-one acres of this remaining open arable land was used to cultivate wheat, while the remaining acreage was used to produce corn, vetches, peas, beans, barley, and oats (Dunning 2004). In the second half of the eighteenth century these islands were gradually enclosed, accelerated by the rising grain prices and scarcity of grain during the Napoleonic Wars (Williams 1972). This process of enclosure now occurred furlong by furlong, without the previously seen consolidation, putting greater pressure on tenants resisting enclosure. Evidence of the continuation of enclosure activity after 1750 can be seen in a court edict from 1754, forbidding exchanges without the lord's permission, which suggests that much illegal activity had taken place. Furthermore, many disputes relating to the maintenance of ridge and furrow, hedges and ditches, and commons byways are present in eighteenth century manorial records – this neglect of the ridge and furrow and ditches may have caused disruption in the whole drainage system (Corcos 2007). By the 1760s, East Field by Northbrook was enclosed, though some of the furlong names survived, for example *hynehull* ('henhill'), *stertt* ('stearts'), and *langhull* ('longhills') (Aston *et al.* 2007). Furthermore, the remaining open acreage had been reduced to 340 acres by 1787, creating two more fragmented blocks of open field land, and common rights on the remaining fallow were extinguished. The name Northbrook Field had also disappeared completely by this time, as it was split into 50-acre block called Eastern Inner Field, while the rest was removed to create Northbrook Farm between 1760 and 1787 (Corcos 2007). Therefore, by the second half of the eighteenth century the parish displayed a rectilinear pattern of enclosure hedges, largely following the edges of former strips, and creating small linear fields with curved boundaries reflecting the S-shaped alignment of former individual strips. The majority of new fields were laid to grass after enclosure, as Loxley Wood was no longer used for common grazing but solely for timber production. Overall, the eighteenth century saw the continued decay of the former open arable fields, as the islands of open arable land were enclosed furlong by furlong.

In 1749 the Shapwick estate passed to Denys Rolle, who was a strong advocate for enclosure and improvement (Corcos 2007). He played a key role, alongside rectory manor owner Elizabeth Strangways, in implementing the Shapwick Enclosure Bill, which was passed by Parliament in 1777, but was not granted until 1784 (Aston and Gerrard 2013). The Enclosure Award created newly-enclosed Shapwick Heath out of around 1,000 acres of the old Heath Moor pasture north of Shapwick, though did not remove the last remaining islands of open fields (Corcos 2007). The only opposition to the Act came from Messrs Bergum and Pulsford, lords of Glastonbury manors, who claimed common rights in the Heath Moor; however, they did not garner much support as they received compensation for the enclosure. In addition to promoting the enclosure of Shapwick, Rolle sought to further improve the parish. He was particularly keen to remove old customary rights, including digging peat for fuel, as it hindered his ability to raise rents, and enterprises such as draining the peat were also a way of raising profits. In the late eighteenth century, he instigated the manuring of fields, as well as drainage and reclamation of 1,015 acres of the Levels, which would have provided additional profitable arable land, though was returned to pasture once exhausted (Gerrard 2007). As a result of his efforts, the

Levels north of Shapwick were fully drained and enclosed by the end of the eighteenth century. Enclosure and reclamation were common on the Levels in the eighteenth century, as the earliest Acts of Enclosure for waste reclamation were 1719 at Baltonsborough and 1721 on Common Moor near Glastonbury (Williams 1972). This process gained pace after 1770, especially in the Brue and Axe valleys, and between 1770 and 1790 an average of nearly two Acts a year were passed, affecting an area of 417 hectares annually. This flurry of enclosure was likely due to the ease of borrowing money during the period, and though there was some attempt to cultivate this newly-reclaimed land, insufficient drainage meant that the land largely reverted to pasture, particularly for grazing dairy and meat cattle. As a result, by 1815, the Levels were some of the most valuable land in the county.

By the end of the eighteenth century at Shapwick, of the total 2,040 acres of the township, 1,150 (56 percent) were enclosed pasture, 550 (27 percent) were enclosed arable, and only 340 (17 percent) were open arable (Figure 5.4) (Corcos 2007). This open land was eventually enclosed, as the parish is totally enclosed in the 1839 tithe map, with Northbrook and Kent Farms situated outside the main settlement area. Pasture continued to dominate the land use, with only 16 percent of land under arable cultivation, and 520 acres of dedicated meadow (Aston and Gerrard 2013). This was typical of the county as a whole, as Billingsley (1798, 119) describes the grassland of Somerset as displaying "almost a perpetual verdure", particularly in the rich marsh land around the Bristol Channel. The enclosure of Shapwick was also typical of one of two types of enclosure which occurred in Somerset. The first, known as assarting, was the direct enclosure of land from woodland, waste, or pasture in areas which had never established open field arable farming. This process produced irregularly-shaped fields, and was common in the north and west of the county as early as the ninth century, as well as around the royal forests of Neroche and Selwood. In contrast, in the centre, south and south-east of Somerset, including Shapwick, small linear fields indicate the piecemeal enclosure of former arable strips via the agreement of landholders (Aston 1988). The process is poorly documented across much of the county, making Shapwick a valuable tool in understanding when and how it came about.

Overall, it seems that enclosure at Shapwick was a very slow process, starting in the fourteenth century with piecemeal exchange and enclosure, which continued to at least the end of the eighteenth century and facilitated widespread conversion to pasture. However, as Aston and Gerrard (2013) state, there was no single moment of common rights removal – even the 1784 Enclosure Bill did not remove the last remaining islands of open fields, meaning that Shapwick was not totally enclosed until the start of the nineteenth century.

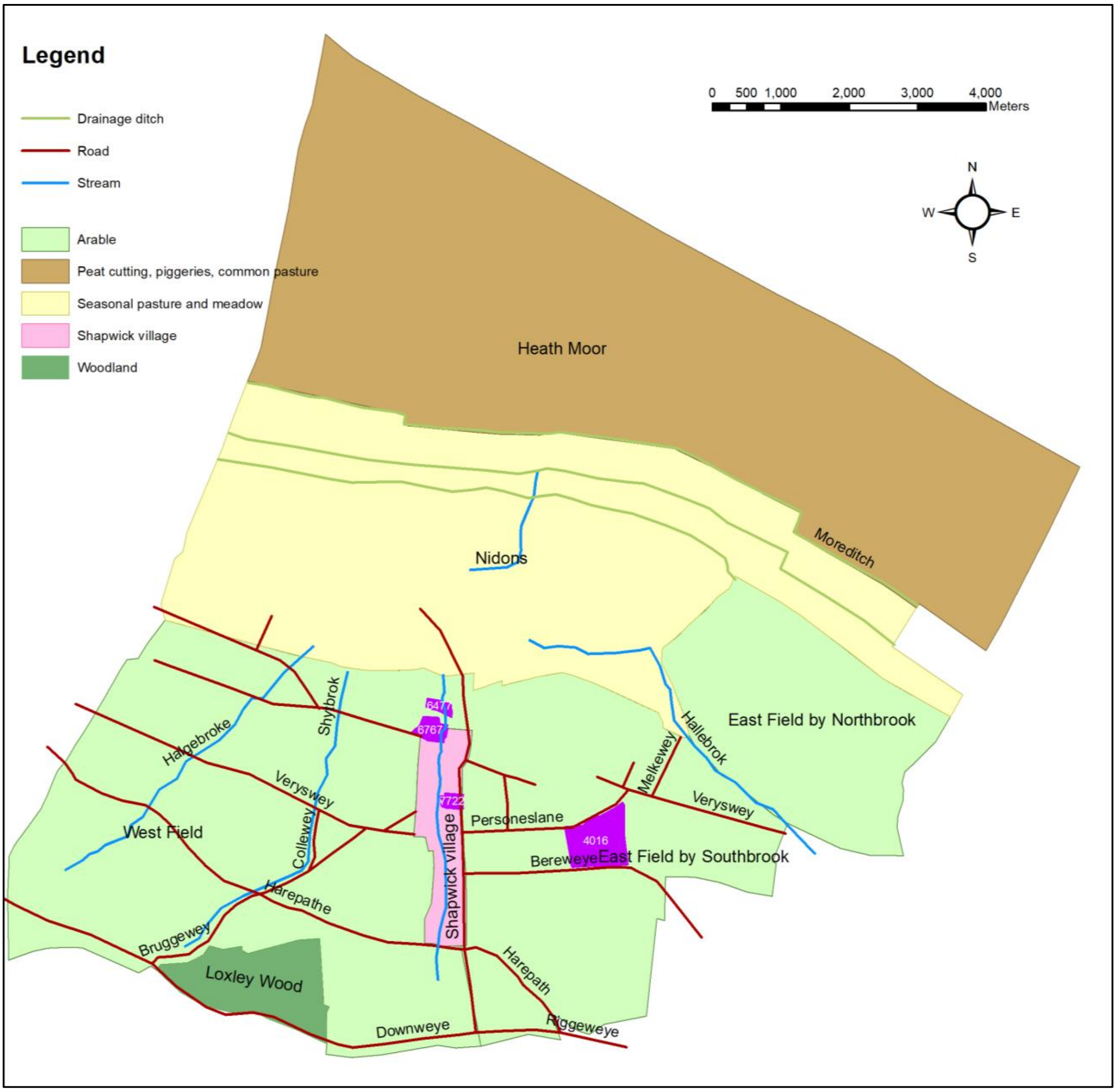

Figure 5.1: Map showing the open field system of Shapwick before 1515, containing West Field, to the west of the village and East Field to the east. Earlier Medieval sites are highlighted in purple (after Gerrard 2007, Fig. 2.34)

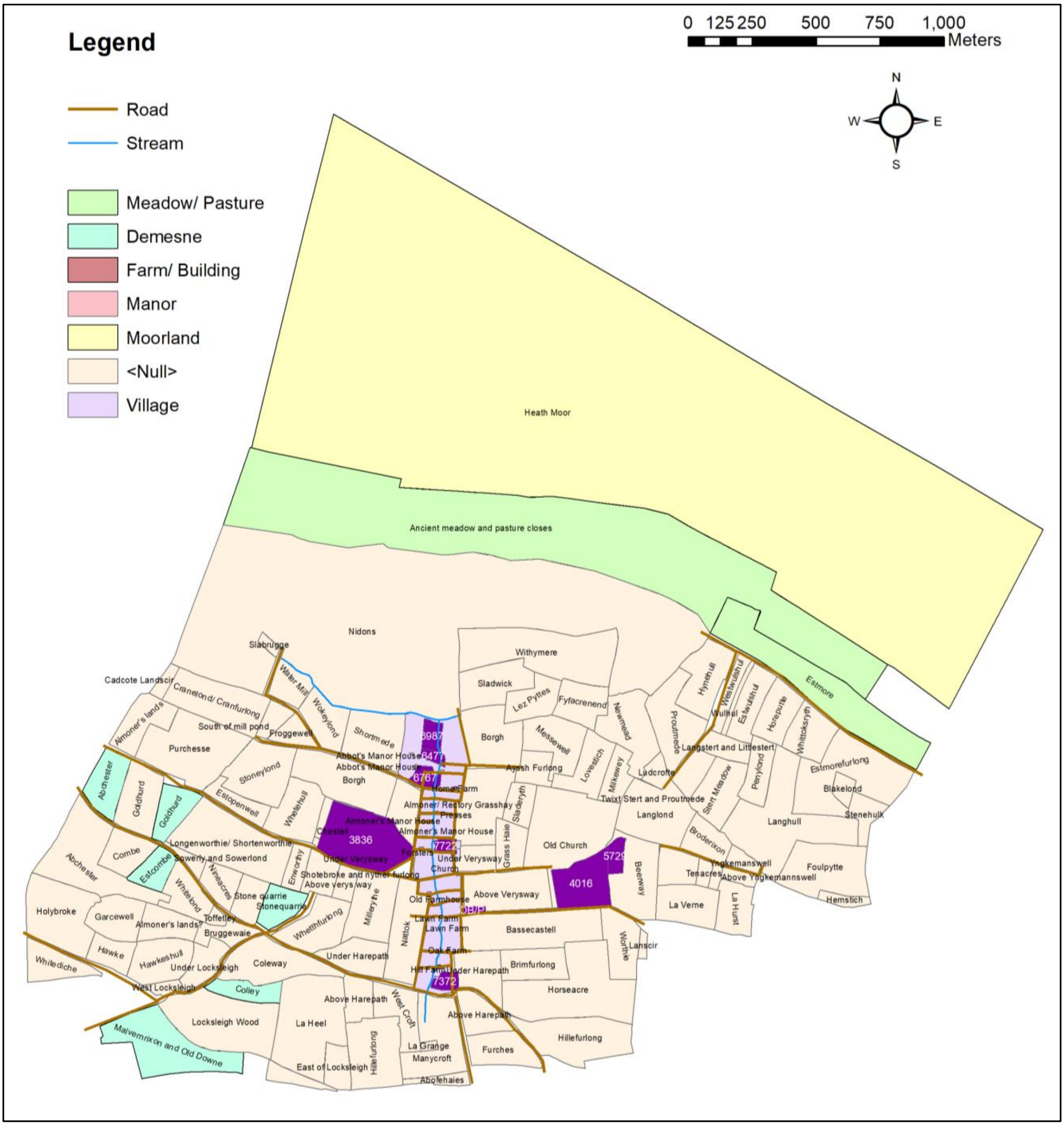

Figure 5.2: Map showing Shapwick in c.1515, after a century of piecemeal exchange and enclosure. Late Medieval sites are highlighted in purple (after Gerrard 2007, Figs 2.31, 2.34, 2.42, 2.48 and 2.55).

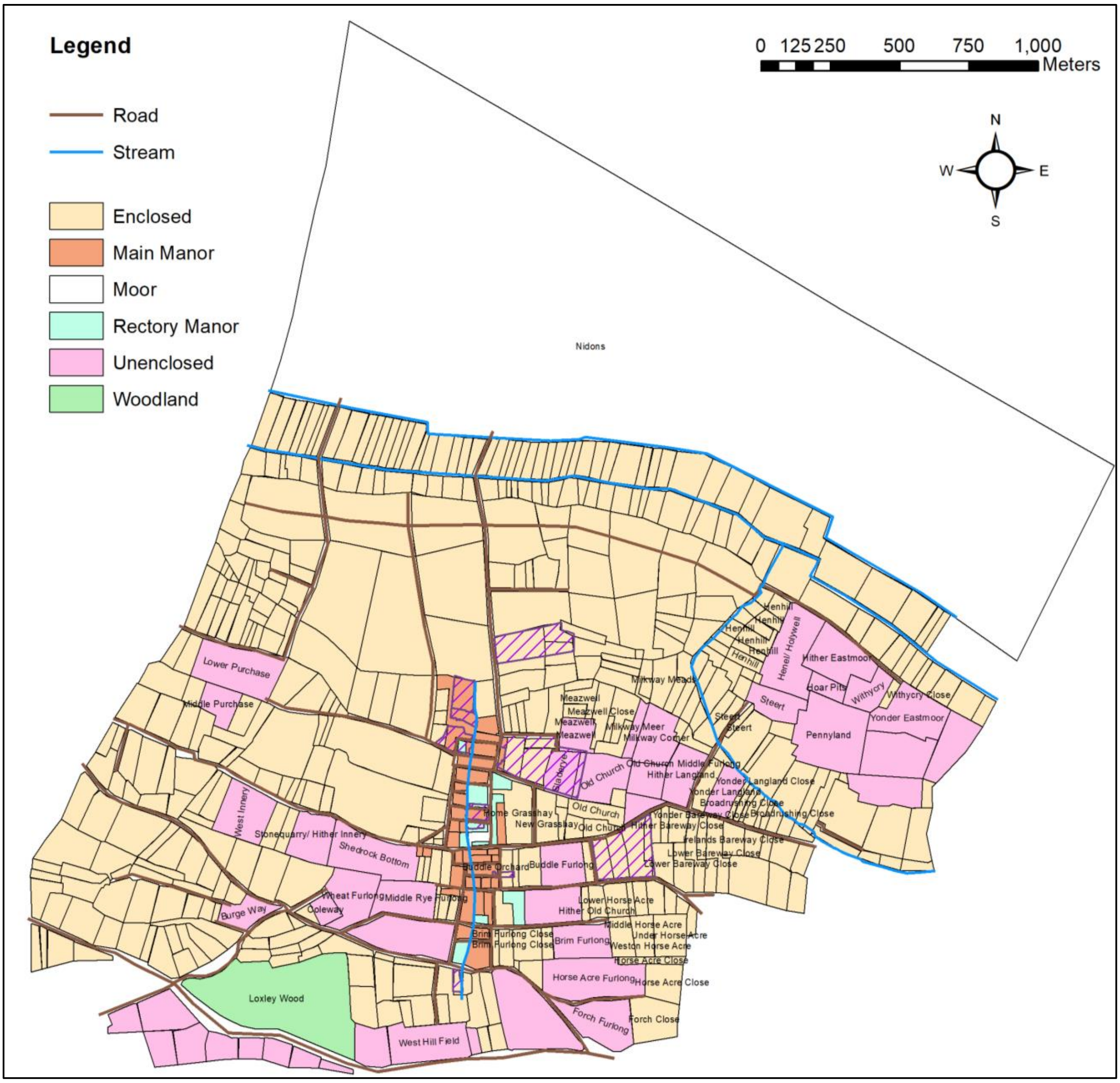

Figure 5.3: Map of Shapwick in c. 1750, showing the extent of enclosure, and the islands of unenclosed land. Post-Medieval sites are highlighted in purple hatching (after Gerrard 2007, Figs 2.10, 2.23, 2.41, 2.47, 2.54 and 2.58).

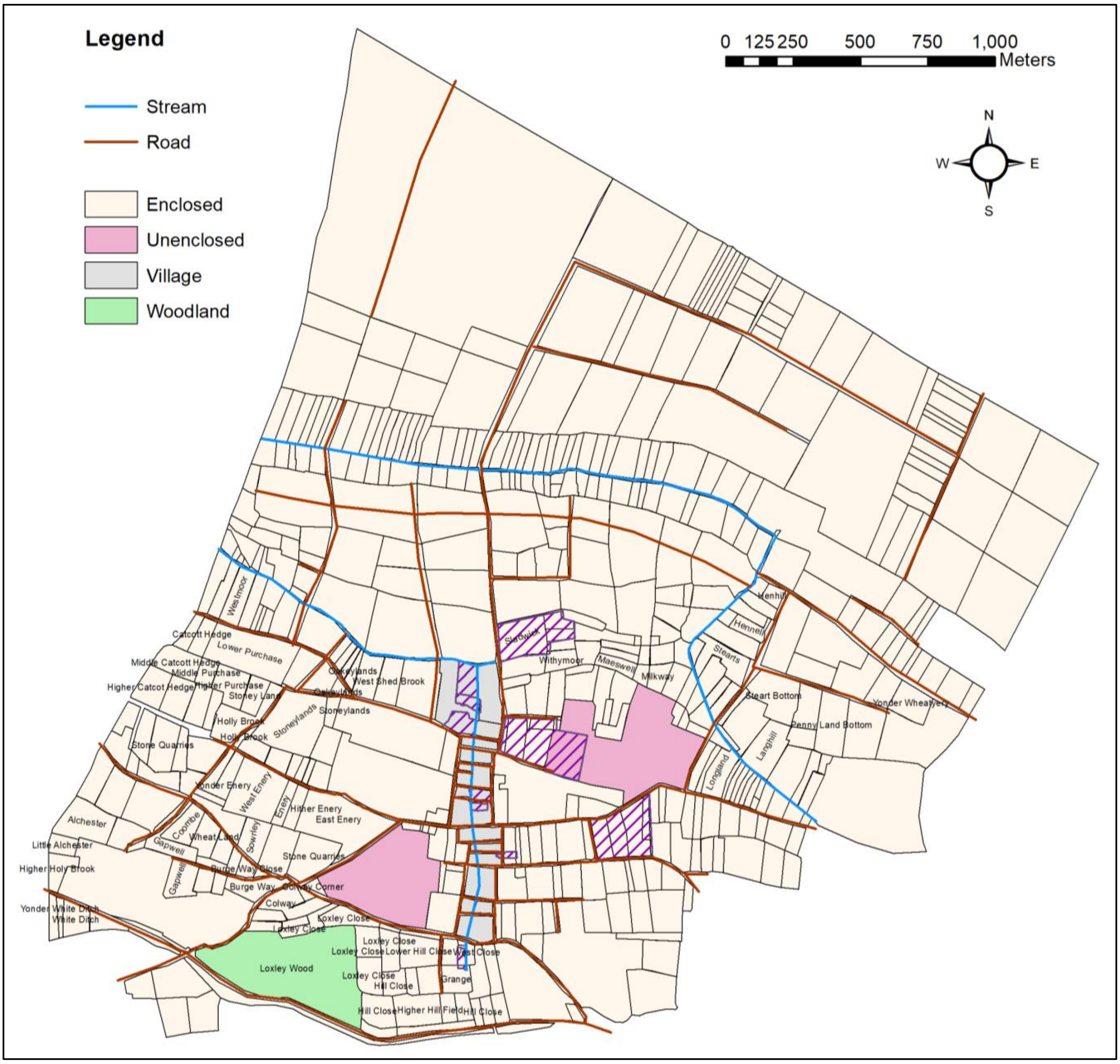

Figure 5.4: Map of Shapwick after the 1784 Enclosure Act, showing the large area of enclosed land, including the moor to the north, as well as the remaining small islands of open field. Post-Medieval sites are highlighted in purple hatching (after Gerrard 2007, Figs 2.9, 2.20, 2.40, 2.46 and 2.53).

5.2 Zooarchaeological Analysis

5.2.1 Species Frequencies

Both %NISP and %MNI were assessed across the three periods at Shapwick, in order to investigate species frequencies through time. In the earlier Medieval period (C.10th-13th), cattle are by far the most frequent species (Figure 5.5; Figure 5.6), comprising over 60 percent of the %NISP. Sheep are far less frequent in this period, reaching only 20 percent of the %NISP. The frequency of sheep at Shapwick does not include specimens positively identified as goat by either morphological or metric assessment, and therefore the term 'sheep' is used here to indicate specimens recorded as sheep (*Ovis aries*), or sheep/goat. There were no goat specimens identified in the earlier or late Medieval periods at Shapwick; however, there were two from the post-Medieval period, an astragalus and a metatarsal (Appendix 21). In terms of %NISP, pig are the third most prevalent species at Shapwick at 14 percent, though %MNI results suggest a higher frequency than sheep, perhaps indicating a greater economic value of pig over sheep in earlier Medieval Shapwick. Horse are the least common species in the earlier Medieval period, reaching only three percent of the total NISP. This could suggest that there were very few horses at Shapwick in the earlier Medieval period, likely not playing such an important economic role as the other species.

In the late Medieval period, there is a clear change in species frequencies, particularly in cattle and sheep. The frequency of cattle, in terms of %NISP, drops by over 35 percent in the thirteenth to fifteenth centuries, indicating a dramatic drop in their frequency on the site. Furthermore, the abundance of sheep increases in this period by 33 percent, making them the most common species. The frequency of pig with regard to %NISP also increases slightly after the thirteenth century, though the %MNI value is reduced. The abundance of horse elements also slightly increases in the late Medieval period, while the MNI value remains the same, again implying a scarcity of horses in the late Medieval period. Overall, the most striking change in the late Medieval period at Shapwick is the increase in the abundance of sheep, seemingly to the detriment of cattle.

The high frequency of sheep at Shapwick is maintained in the post-Medieval period. Relative sheep abundance remains over 50 percent of the total NISP, while cattle abundance is the lowest yet at 23 percent. This suggests the continuation of the importance of sheep into the seventeenth and eighteenth centuries at Shapwick. Again, the number of pig specimens identified increases in the post-Medieval period, though %MNI decreases. Furthermore, the frequency of identified horse elements increases slightly, though the MNI value remains constant. Overall, across the three periods at Shapwick, cattle are dominant up to the thirteenth century, and likely played an important economic role. In the two following periods, sheep are predominant and cattle substantially decline in abundance. The frequency of identified pig elements increases across the study period, though this is contrasted by a decrease in %MNI. Finally, horse abundance is very low throughout the study period, suggesting that horses played a relatively small part in the economy at Shapwick from the tenth to the eighteenth century.

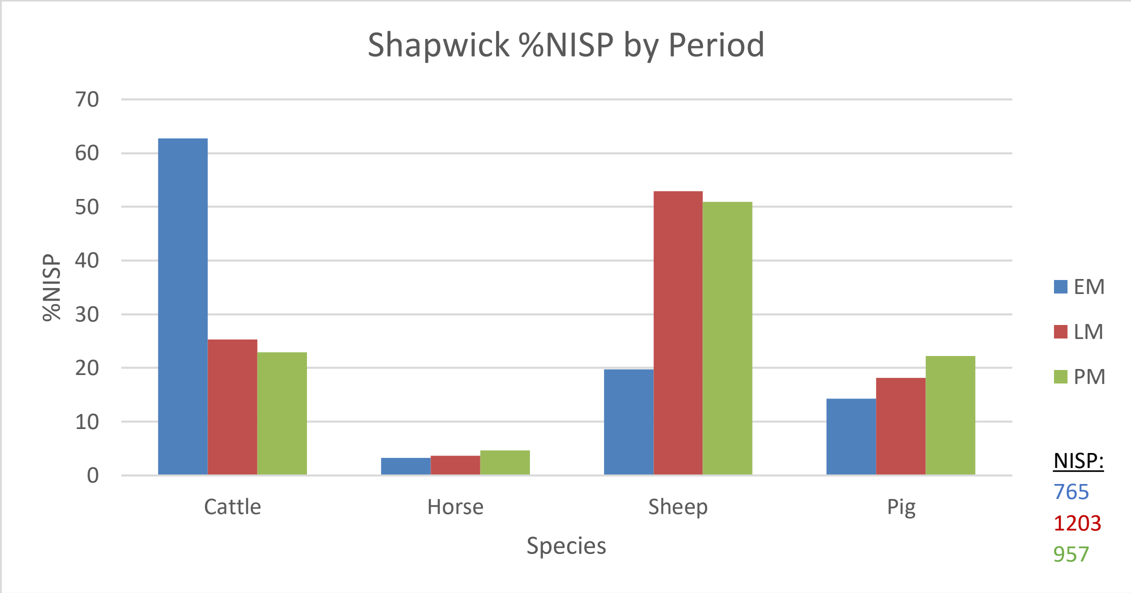

Figure 5.5: %NISP values for the main domesticates at Shapwick, divided by period.

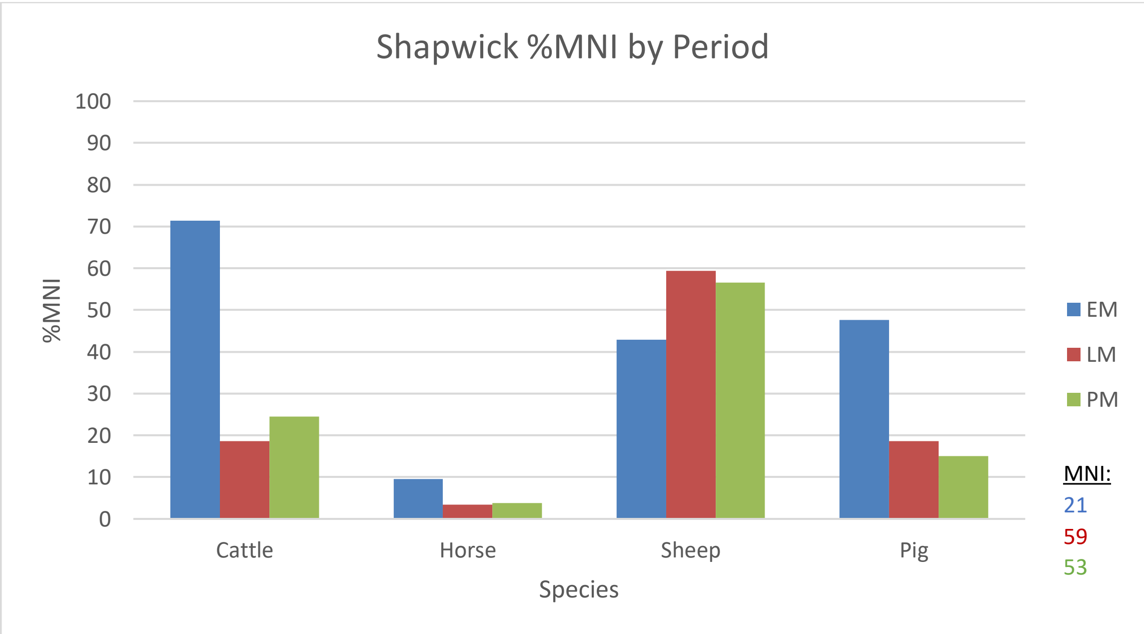

Figure 5.6: %MNI values for the main domesticates at Shapwick, divided by period.

5.2.2 Species Frequencies by Site

The species frequency by site for earlier Medieval Shapwick is shown in Figure 5.7. It indicates that the majority of the earlier Medieval material comes from Old Church, Site 4016, meaning that the other two sites have relatively low sample sizes, particularly Shapwick Park (6477), preventing a meaningful comparison. The earlier Medieval species frequency from Old Church largely follows the overall site pattern, with a predominance of cattle, followed by a lower frequency of sheep and pig and a very low abundance of horse, though the largest found in this period. The earlier Medieval layers of Site 4016 contained the remnants of eleventh to twelfth century lime kilns, which produced a large amount of articulated animal bone from the top of one of the firing chambers. This included the remains of six cattle, two horse, and two pigs. Gerrard (2007) suggests that these animals all died in the same catastrophic event, such as a disease epidemic. The stables for horses and byres for cattle and pigs were likely close by, meaning that upon death from these animals were probably brought over to the kilns for disposal, potentially to avoid further spread of disease.

In the late Medieval period, Old Church (4016) once again provides the largest faunal assemblage, though there is also a greater abundance of material from North of Bridewell Lane (7722) (Figure 5.8), while the remaining late Medieval sites do not provide a large enough sample size for reliable comparison. The late Medieval contexts from Bridewell Lane contain a relative abundance of animal bone as they contain the continuation of domestic waste pits, which include two partial first-year lamb skeletons which Gerrard (2007) suggests were the result of deliberate slaughter and skinning. Furthermore, Old Church produced a substantial assemblage of 'kennel waste' mixed with human household waste, as well as evidence for horse exploitation in the form of a bridle bit and horseshoe. Again, the sites reflect the overall sitewide pattern, with sheep dominant on both, though cattle, pig and horse comprise a larger proportion of the assemblage from Old Church.

The post-Medieval assemblage from Shapwick is divided between a larger number of sites, though again many do not provide a large enough sample size for meaningful comparison (Figure 5.9). In this period, Shapwick Park (6477) and Old Church (4016) produce the greatest abundance of faunal material from the infilling of the late Medieval moat and robber trenches respectively. In addition, Shapwick Park (6767), North of Bridewell Lane (7722), and Spring Site (6660) all contain over one hundred specimens. Many post-Medieval sites follow the general sitewide pattern of sheep abundance in this period, including Shapwick Park (6477 and 6767), and Old Church. However, there is a greater variation in species frequencies across the parish in this period. For example, on sites such as North of Bridewell Lane and Spring Site, pig remains are much more frequent, and comprise as much as two-thirds of the assemblage on the Spring Site. These sites are dispersed throughout the centre of the parish, which may suggest the exploitation of pig at certain sites spread about the village. Much of the faunal remains from these sites come from domestic waste, perhaps indicating the consumption of pig, though Gerrard (2007, 492) points to the "opportunistic disposal of farmyard carcasses" on site 7722, including the partial skeleton of a young lamb. Furthermore, the frequency of pig is inflated on Site 6660 by the recovery of two articulated pig skeletons, aged 4-6 months or younger. They perhaps died from disease and were buried behind the nearby pigsty.

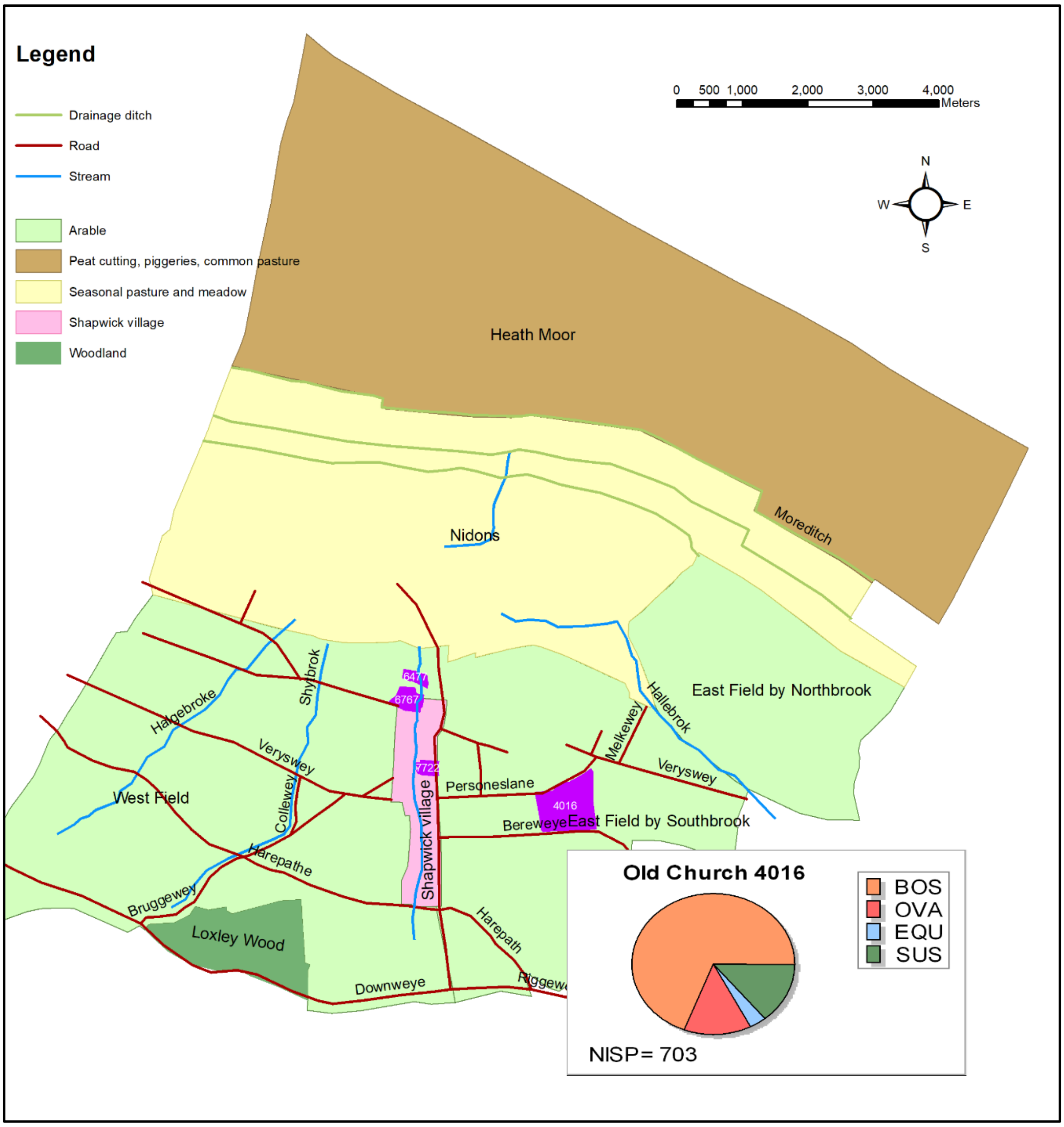

Figure 5.7: Species frequencies separated by site in earlier Medieval Shapwick. Frequency is given as %NISP.

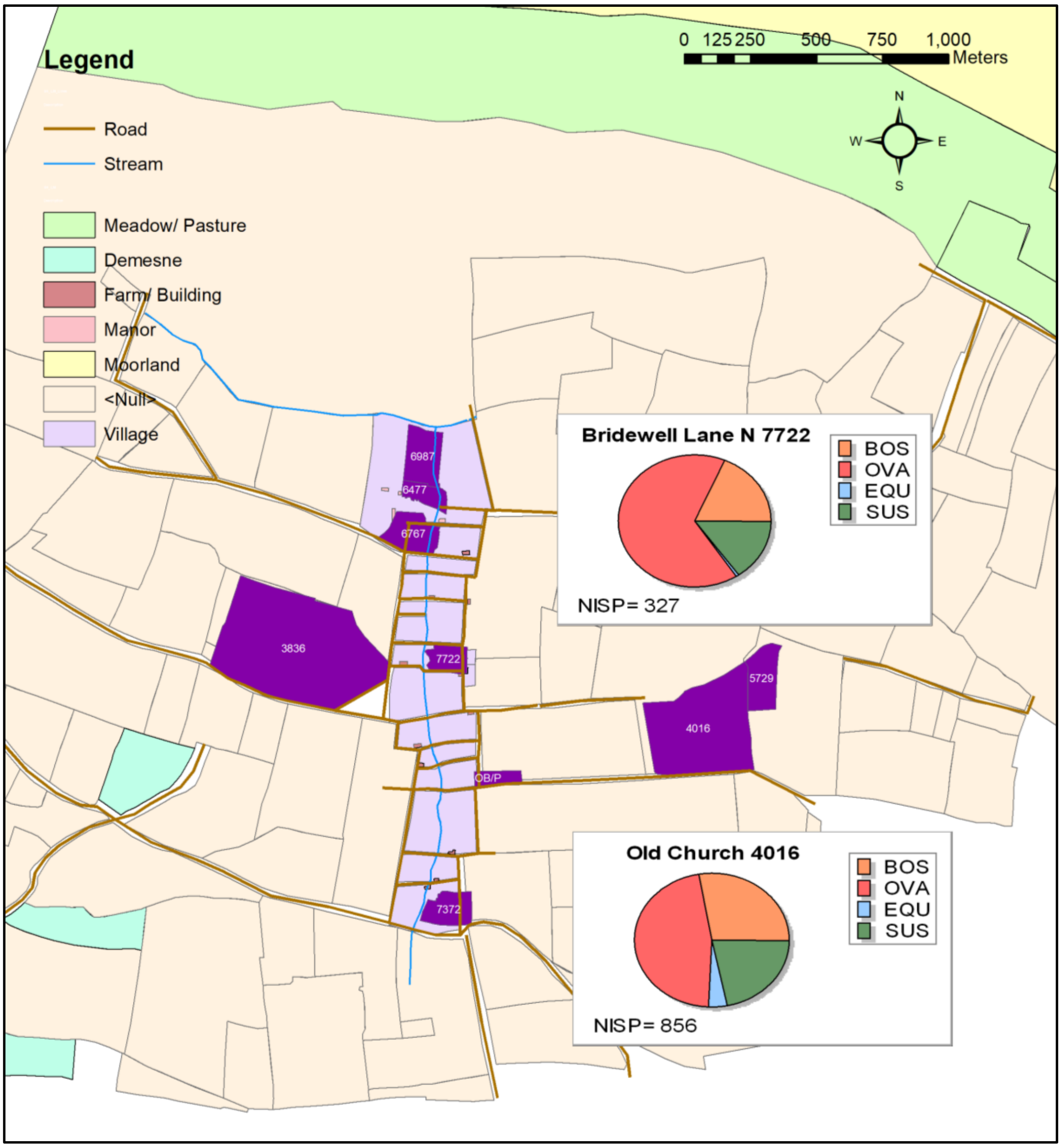

Figure 5.8: Species frequencies separated by site in late Medieval Shapwick. Frequency is given as %NISP.

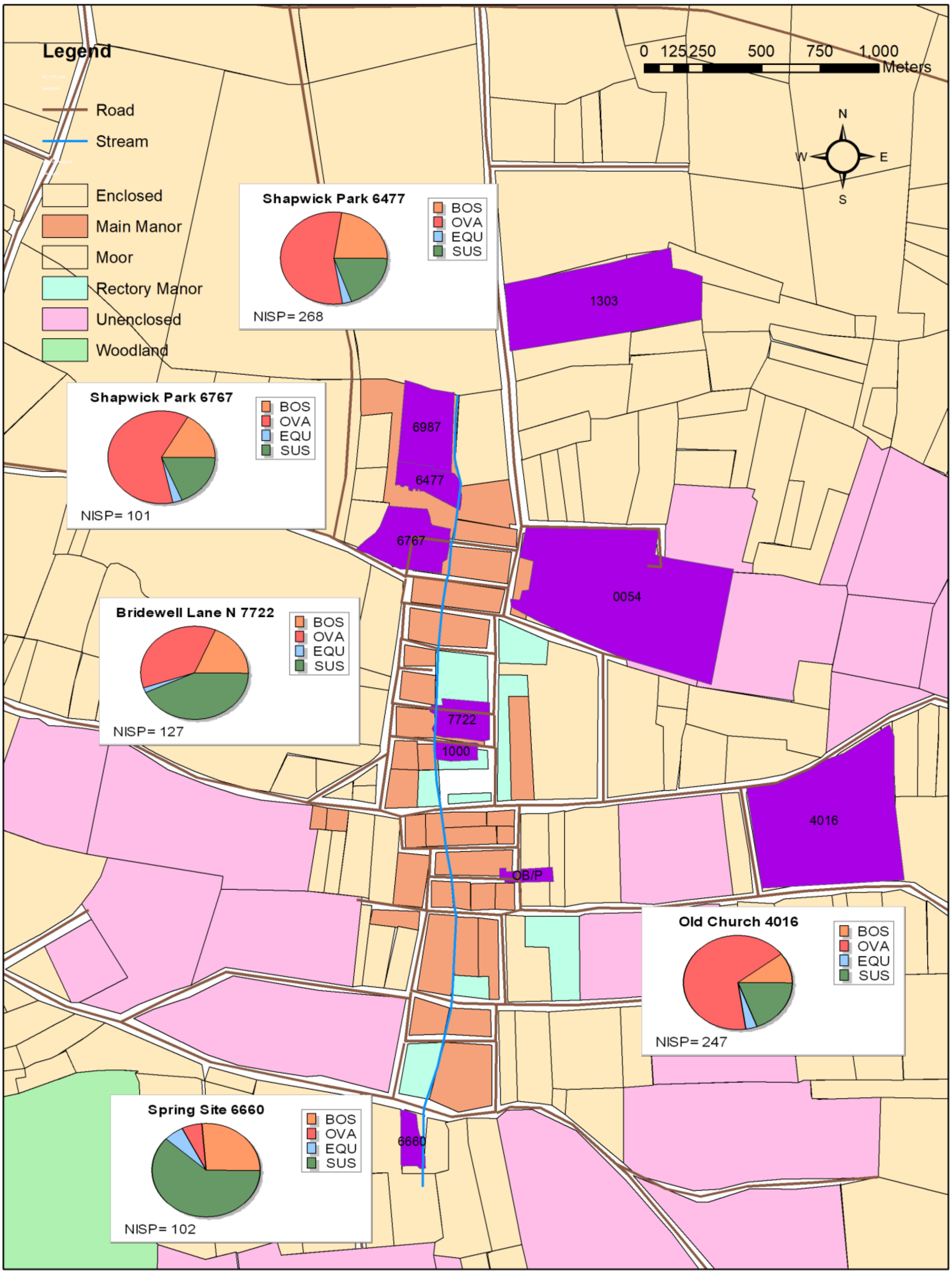

Figure 5.9: Species frequencies separated by site in post-Medieval Shapwick. Frequency is given as %NISP.

5.2.3 Butchery

Sheep

A relatively low amount of butchery was recorded across all phases at Shapwick, and evidence for sheep butchery was totally absent from the earlier Medieval material (see Table 5.1). In the late Medieval period, chop marks are recorded solely on radii, while cut marks were found on astragalus specimens (Figure 5.10). Butchery marks on sheep bone in the post-Medieval period are also scarce, with only one recorded chop mark on a tibia shaft (Figure 5.11). Overall, these results suggest a lack of specialised sheep butchery on site across all periods, or the use of butchery techniques which left minimal trace.

Cattle

In the earlier Medieval cattle assemblage, only two cut marks were recorded, on an astragalus and calcaneum (Figure 5.12). Butchery marks on cattle specimens are more common in the late Medieval period. They include cut marks on the astragalus and chop marks primarily on the front limb (Figure 5.13). The chop marks likely represent primary butchery of the carcass, dividing it into smaller sections, while cut marks could indicate the subsequent removal of meat or skin. Also, sawing marks on the pelvis and ulna are recorded in this period, which suggest intensification of butchery practices. In the post-Medieval period, there are no cut marks recorded on cattle specimens, but chop marks are found on the radius, proximal femur, distal tibia and astragalus, which suggest the disarticulation of the skeleton, particularly the hind leg (Figure 5.14). Furthermore, saw marks are also recorded in the post-Medieval period, on the proximal radius and femur shaft. This suggests the continuation of the more intensive butchery methods first seen in the late Medieval period, though there is no evidence for practices such as the splitting of vertebrae, which was practiced in urban centres by this time (Albarella 2005).

Pig

There are fewer butchery marks recorded for pig across the study period. In the earlier Medieval assemblage, only two cut marks on astragali, and a chop on a distal humerus were recorded (Figure 5.15). In the late Medieval period, a single chop mark is present on a tibia shaft (Figure 5.16). This pattern is suggestive of a relatively low amount of butchery activity at Shapwick in the earlier and late Medieval periods, though could also be the result of poor surface preservation of bone. However, in the post-Medieval period, though butchery marks are still scarce, a saw mark is recorded on a pelvis specimen (Figure 5.17). This change in technique could indicate an intensification of butchery in post-Medieval Shapwick, though again no splitting of vertebrae is recorded.

Table 5.1: The proportion of butchered bones for each species in each period at Shapwick.

Butchered (%)	Sheep	Cattle	Pig	Horse
EM	0.0	0.7	6.1	0.0
LM	0.5	4.0	0.9	0.0
PM	0.8	6.6	0.8	5.3

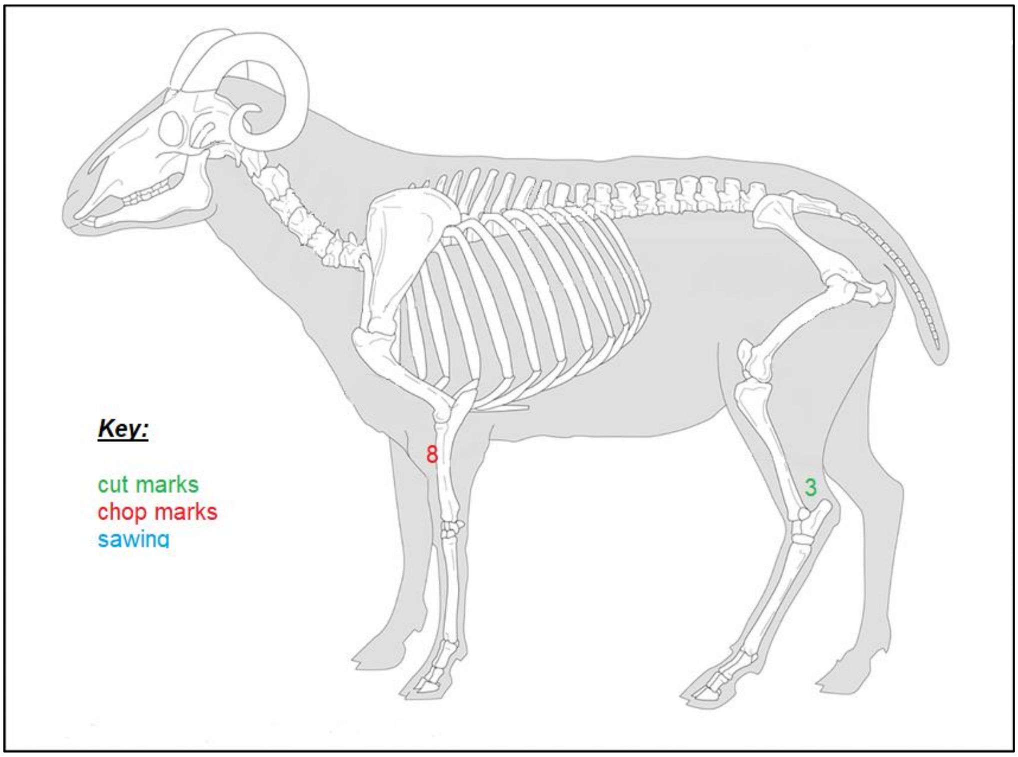

Figure 5.10: The distribution of late Medieval sheep butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

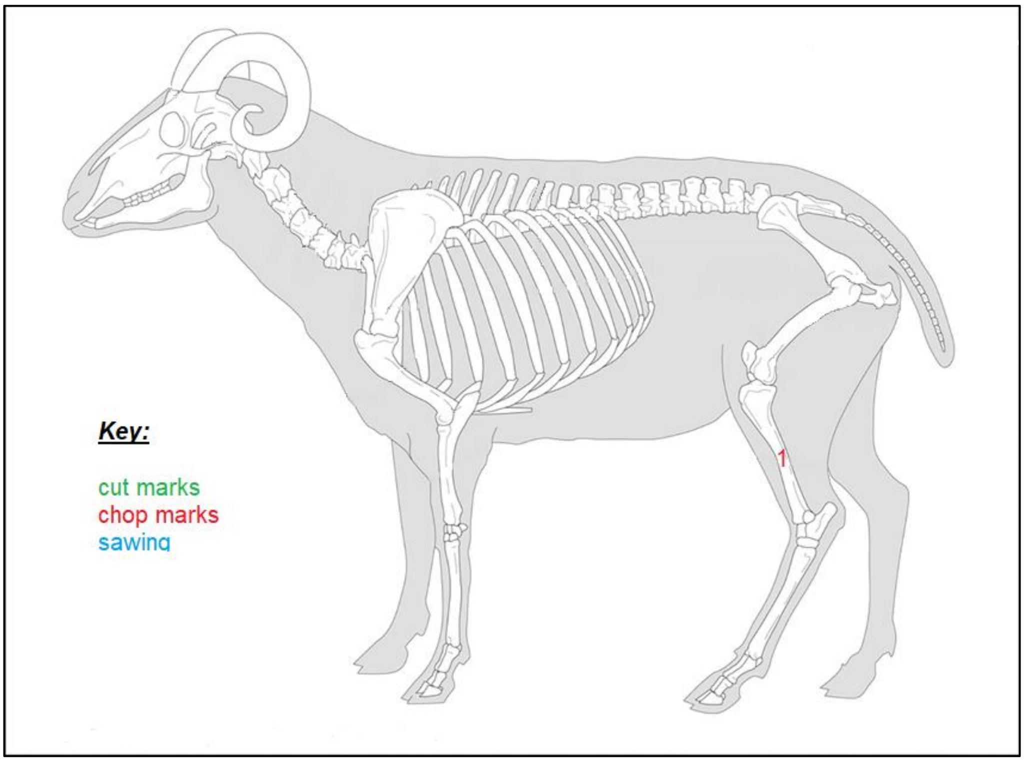

Figure 5.11: The distribution of post-Medieval sheep butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

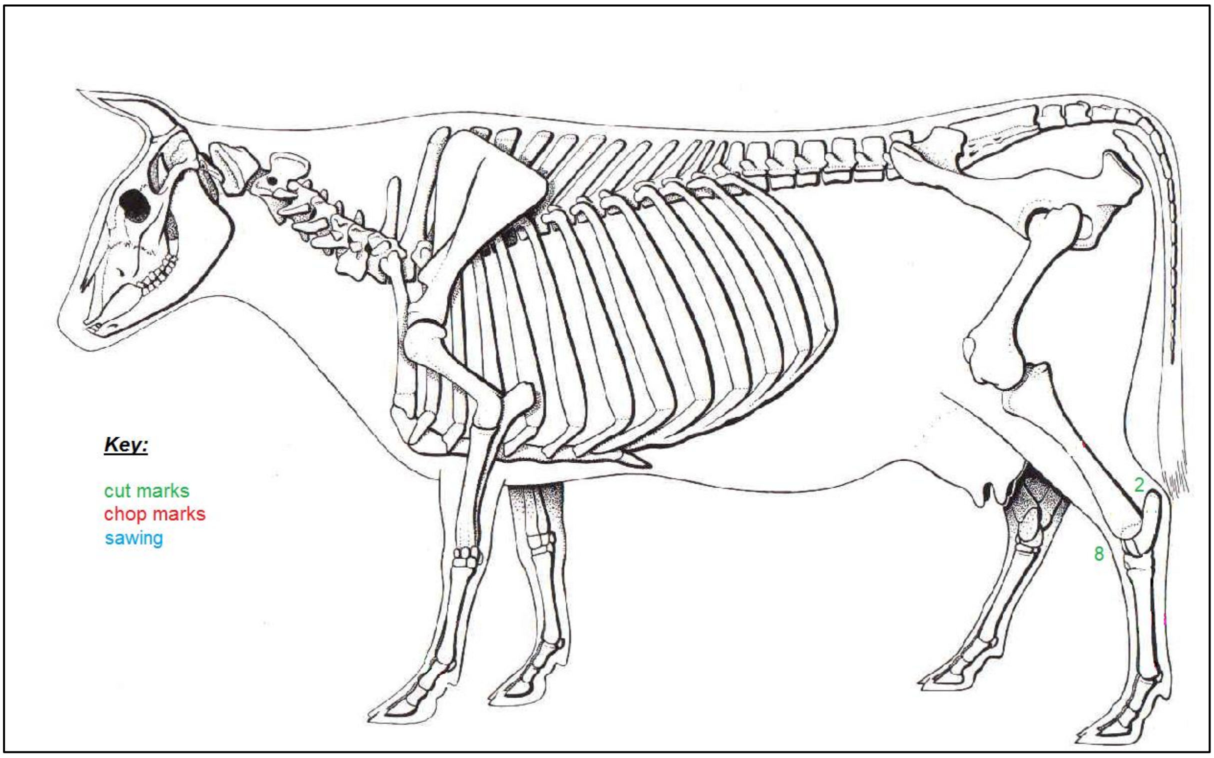

Figure 5.12: The distribution of earlier Medieval cattle butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

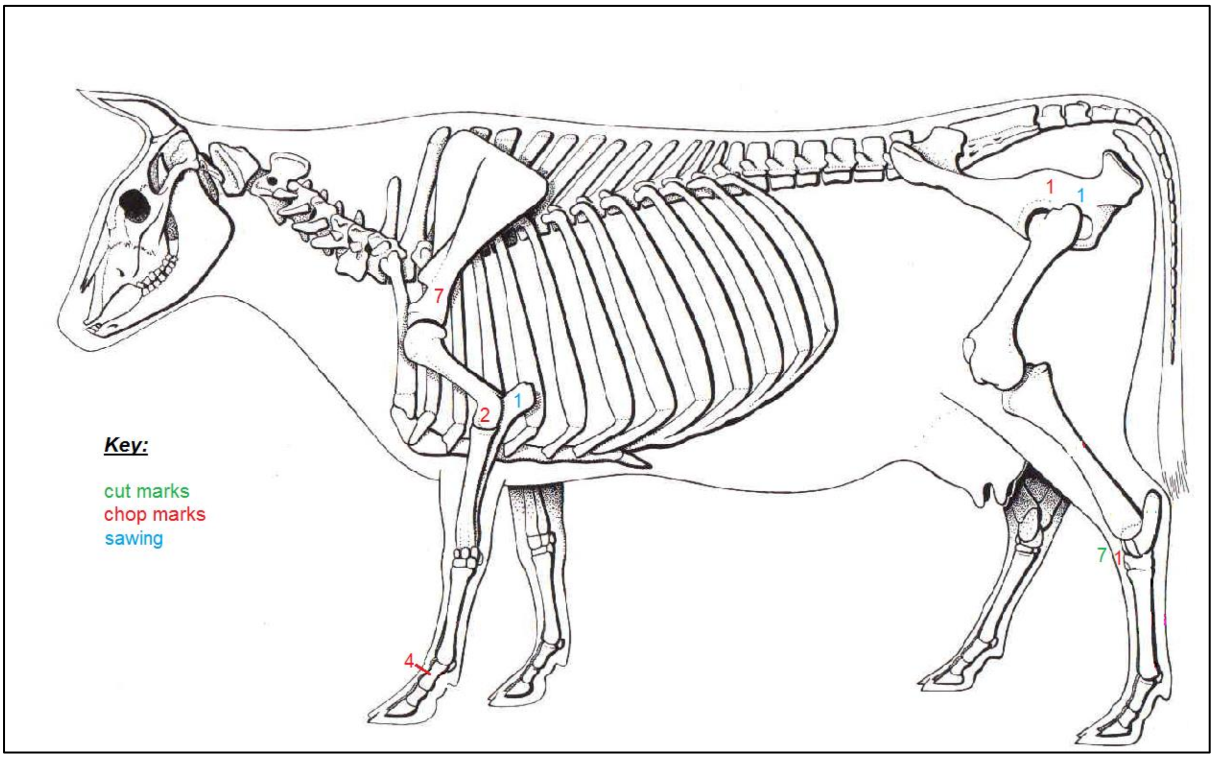

Figure 5.13: The distribution of late Medieval cattle butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

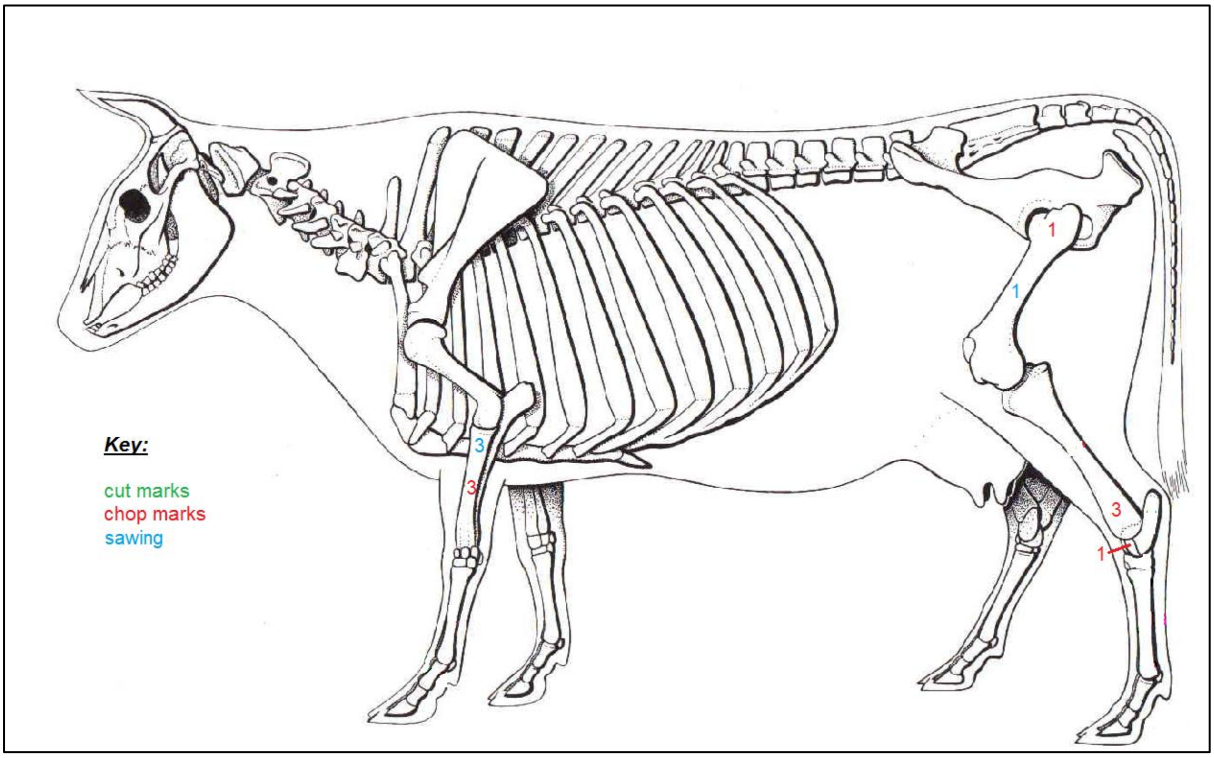

Figure 5.14: The distribution of post-Medieval cattle butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

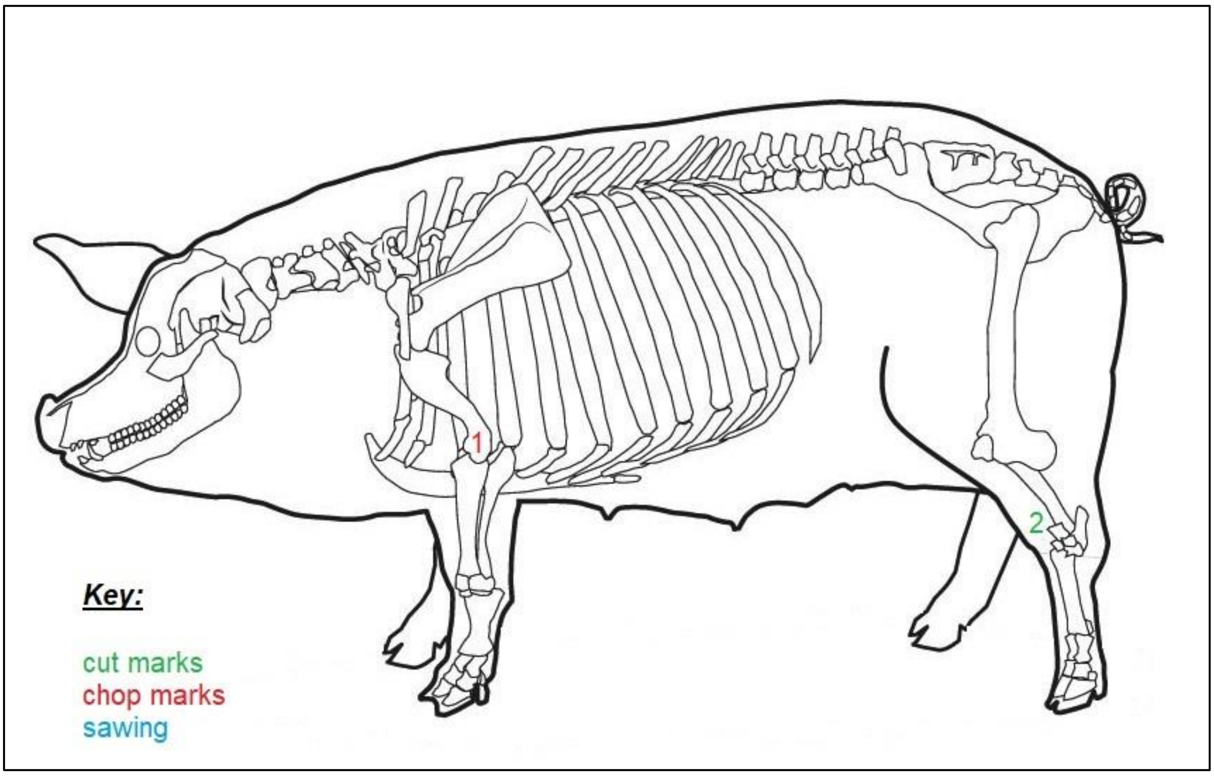

Figure 5.15: The distribution of earlier Medieval pig butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

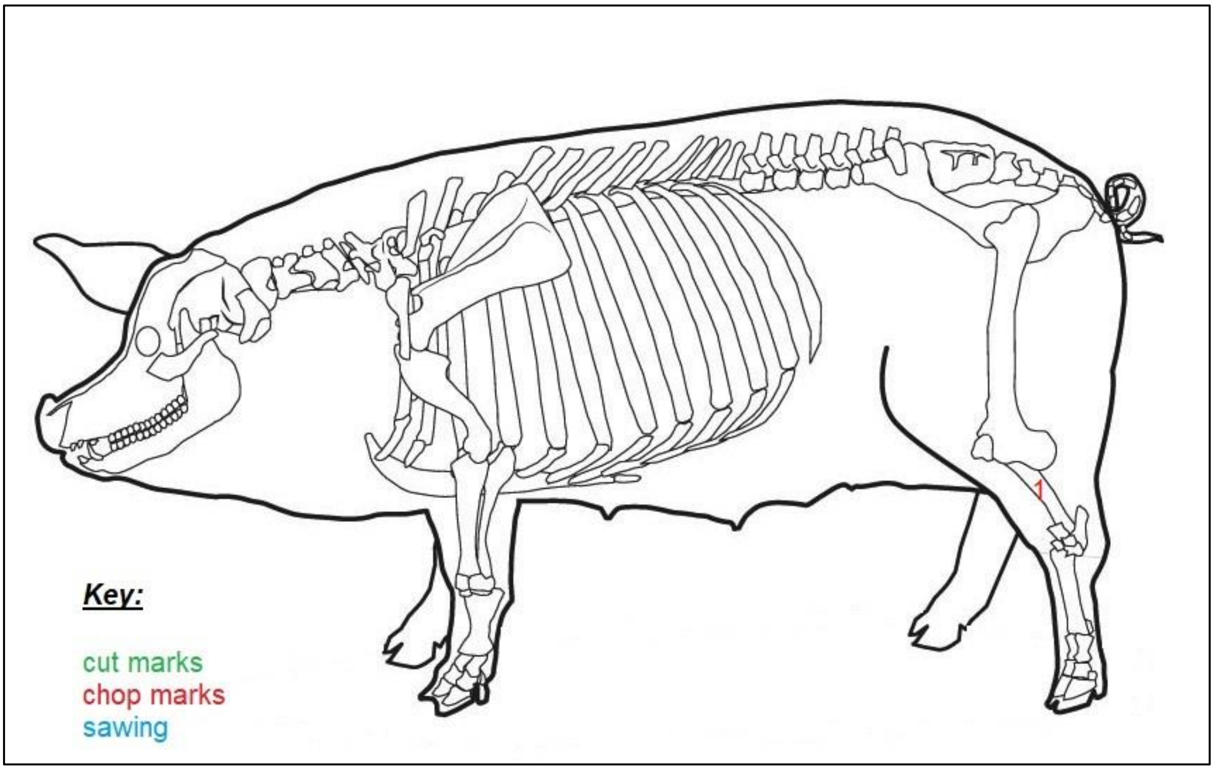

Figure 5.16: The distribution of late Medieval pig butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

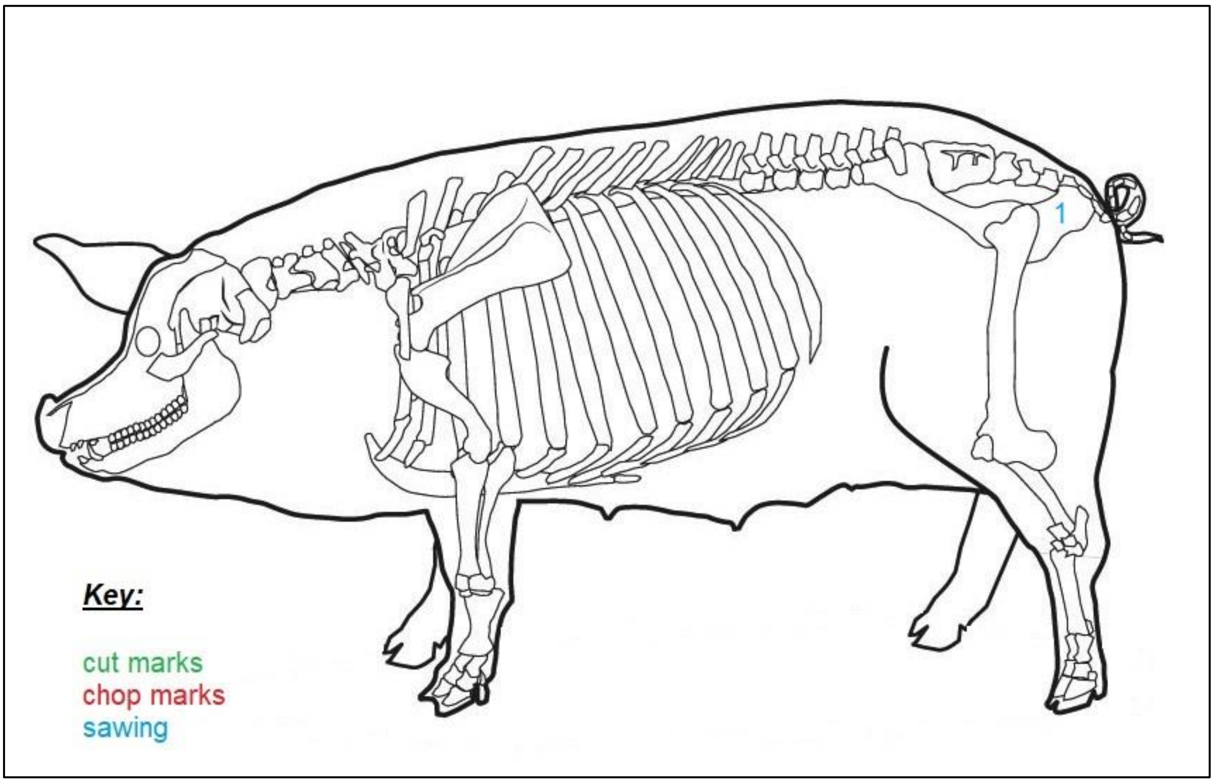

Figure 5.17: The distribution of post-Medieval pig butchery at Shapwick. The numbers represent the total amount of butchery marks recorded for each element.

5.2.4 Pathology

There is only a single specimen showing pathological change recorded from the Shapwick assemblage, which is a cattle second phalanx from the earlier Medieval period. This specimen exhibits exostosis on the distal end and lower shaft, likely caused by idiopathic inflammation. Pathologies of the lower legs in cattle could represent the use of cattle for traction, though without other specimens or corresponding information on age, sex or body mass, further interpretation cannot be determined (Bartosiewicz *et al* 1997).

5.2.5 Non-Metric Traits

The non-metric traits recorded include the absence of the second permanent premolar in sheep and cattle throughout the study period at Shapwick. In the earlier Medieval period, there were no instances of this trait recorded for cattle, out of thirteen second premolars, and sheep second premolars were totally absent. However, two examples of sheep jaws displaying the trait were found in the late Medieval period (18%). In the post-Medieval period, this number drops to only one recorded specimen, of only three second premolars (33%). For cattle, there is only one example of a missing second premolar in the late Medieval period, though again out of only three records (33%), and a total absence of the trait in the post-Medieval period.

The presence, absence, or reduction of the third mandibular molar hypoconulid for cattle was also recorded across the study period at Shapwick. In the earlier Medieval period, two third molars were recorded as having a reduced hypoconulid. In addition, a maxillary third molar was worn in a V shape, which implies the absence of the hypoconulid on the mandibular tooth. This therefore indicates that around 16 percent of the cattle population in the earlier Medieval period displayed a reduced or missing third molar hypoconulid. In the late Medieval period, there are no examples of third molars with reduced or missing hypoconulids, though the sample size is very small with only four recordable third molars. There are, however, two examples of V-shaped maxillary molars, implying that the trait was present in the population. Finally, in the post-Medieval period, of eight mandibular third molars recorded, only one displayed a reduced hypoconulid. There was also one example of a V-shaped maxillary third molar, suggesting that the trait was present in around 22 percent of the population. Overall, it appears that the trait was more common in the post-Medieval period, though small sample sizes mean that these results should be used with caution.

5.2.6 Ageing

Appendices 25 to 27 contain dental ageing tables, and Appendix 28 contains fusion data by element.

Sheep

The sample size of sheep post-cranial material with recordable fusion stages was very small for the earlier Medieval period at Shapwick, so only the late and post-Medieval periods are discussed here. In the late Medieval period 95 percent of sheep survive past ten months, but this figure drops to 68 percent by 16 months, perhaps suggesting the exploitation of young sheep for meat in this period (Figure 5.18). However, 59 percent of animals survive past 42 months. In the post-Medieval period, survival past the first stage is lowest, at 89 percent, which could suggest that infant mortality was higher in this period, or that lambs under a year were more commonly exploited for meat. However, survival then remains above 70 percent, until it drops to 55 percent in the final stage, suggesting that once again over half the flock survived past 42 months. Overall, the sheep fusion data from all periods at Shapwick could suggest the exploitation of young sheep for meat, especially in the late Medieval period, though over half the flock survive past 42 months, likely kept for wool.

The dental ageing results for sheep largely support the fusion data (Figure 19), though again the sample size for the earlier Medieval period is too small to draw a meaningful conclusion. In the late Medieval period, as suggested by fusion results, there is a peak in kill-off around one year, indicating that young sheep may have been killed for meat at this point. There is also a peak at stage G, around 4-6 years, which may reflect the kill-off of older animals which have perhaps been kept alive longer to produce wool. A similar pattern is also seen in the post-Medieval period. Overall, it appears that in the late and post-Medieval periods at Shapwick, sheep were likely slaughtered around a year for meat, though the kill-off of older animals also suggests meat exploitation after the production of wool.

Cattle

Earlier Medieval cattle bone fusion data from Shapwick suggest that cattle survival is very high until around three years, when it drops substantially (Figure 5.20). This suggests that cattle were kept up to around three years, when they were largely exploited for meat. A similar pattern can be seen from fusion ageing in the late Medieval period, as survival is high up to around two years, when it decreases, though nearly half the herd survives past the last fusion stage. This again suggests the use of cattle for meat around 2-3 years, though could also indicate the continuation of a larger proportion of the herd after four years, for breeding or perhaps for traction or milk. In the post-Medieval period, survival in the first three stages is lower, perhaps indicating higher infant mortality, or the intensification of veal production. However, survival remains at 45 percent after four years, again suggesting the use of adult animals for traction or milk.

The dental ageing results for cattle mostly corroborate the pattern shown by fusion data (Figure 5.21). In the earlier Medieval period, there is little or no kill-off until the adult stage, where 62 percent of cattle are slaughtered, leaving only 33 percent surviving into the final stage. In combination with fusion results, this is indicative of cattle being killed for meat around three years. In the late Medieval period, dental ageing again shows little kill-off before adulthood, though there is a decrease in survival around six months not clear in the fusion results. Nevertheless, the dental ageing also shows a greater kill-off in the adult stage relative to the previous stages, which may reflect the survival decrease at 3-4 years shown by fusion data, and a greater proportion of elderly individuals. There is also a large proportion of elderly animals, which could indicate that, while some cattle were killed around six months for meat, many late Medieval cattle were kept alive to around three years, also for meat, while the individuals surviving to the elderly stage were exploited for milk or traction. Finally, in the post-Medieval period, dental ageing shows a greater proportion of subadult and adult individuals, indicating a slight shift towards younger animals. In combination with the fusion data, this could suggest that cattle were again exploited for meat around six months, but primarily killed between one and three years. According to dental ageing, just under 15 percent of cattle survive to the elderly stage, likely used for breeding, but perhaps also for traction or milk. Overall, cattle predominantly appear to have been exploited for meat around 3-4 years, though there appears to be a shift towards younger animals in the post-Medieval period.

Pig

Fusion ageing suggests a very low pig survival in the earlier Medieval period, with only 33 percent of animals surviving past the first fusion stage (Figure 5.22).This suggests that in earlier Medieval Shapwick, a large proportion of pigs were killed before a year of age, likely for meat; however, the sample size for this period is very small, which may affect the reliability of this interpretation. In the late Medieval period, pig survival up to the first year is much higher, but decreases by 14-18 months, with only seven percent of pigs surviving past 42 months. While survival is initially higher, this suggests that a large proportion of pigs were killed, likely for meat, around one and a half to three years. The post-Medieval fusion results are similar to that of the earlier Medieval period, suggesting that the exploitation of pigs for meat by three years continued into the post-Medieval period.

The pig dental ageing results from Shapwick somewhat reflect this pattern (Figure 5.23). In the earlier Medieval period, dental ageing shows that 30-40 percent of pigs were killed as immature, subadult, and adult animals. There are no animals surviving past the adult stage, which indicates that all pigs on the site had likely been slaughtered or moved elsewhere from two years onwards, which is also suggested by the fusion results. Dental ageing for the late Medieval period shows a small proportion of juvenile, immature and subadult animals, but a peak in kill-off during the adult stage. In combination with the fusion results, this indicates that pigs were mostly kept alive until around two years of age, when they were likely killed for meat or transported elsewhere, as again no animals survive at Shapwick into the elderly stage. Finally, in the post-Medieval period, there is again a high kill-off from around two years of age. This deviates from the fusion results, where a larger decrease in survival before six months is likely caused by the recovery of two piglet skeletons from site 6660, inflating the amount of unfused bones during this period. Therefore, it is likely that the dental ageing is more reliable for this period, which suggests that pigs were again exploited for meat or moved elsewhere around two years and onwards.

Horse

Due to a small sample size of horse material from Shapwick, age-at-death was assessed by comparing the proportion of fused and unfused elements across the three periods (Figure 5.24). In the earlier Medieval period over 92 percent of horse bones came from adult animals. There is an increase in unfused bones in the late Medieval period, suggesting an increased presence of younger animals. In the post-Medieval phase this proportion decreases. Overall, there is a much larger proportion of adult horses at Shapwick throughout all phases, particularly the earlier Medieval period. This could mean that horses were predominantly used for transport or traction.

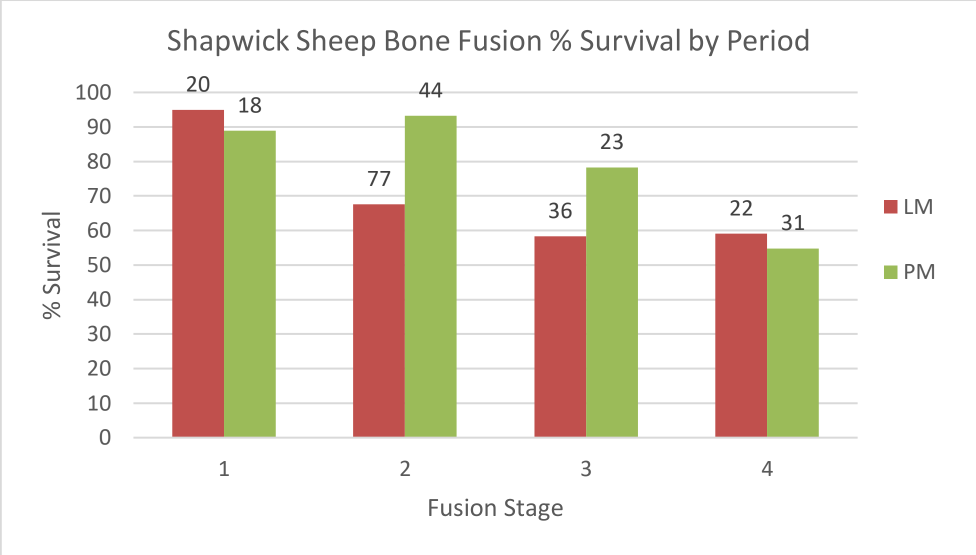

Figure 5.18: Sheep %survival by bone fusion for the late and post-Medieval periods at Shapwick. The ages for each fusion stage are as follows: Stage 1: 6-10 months, Stage 2: 13-16 months, Stage 3: 18-28 months, Stage 4: 30-42 months. The number of specimens per stage is given above the bars.

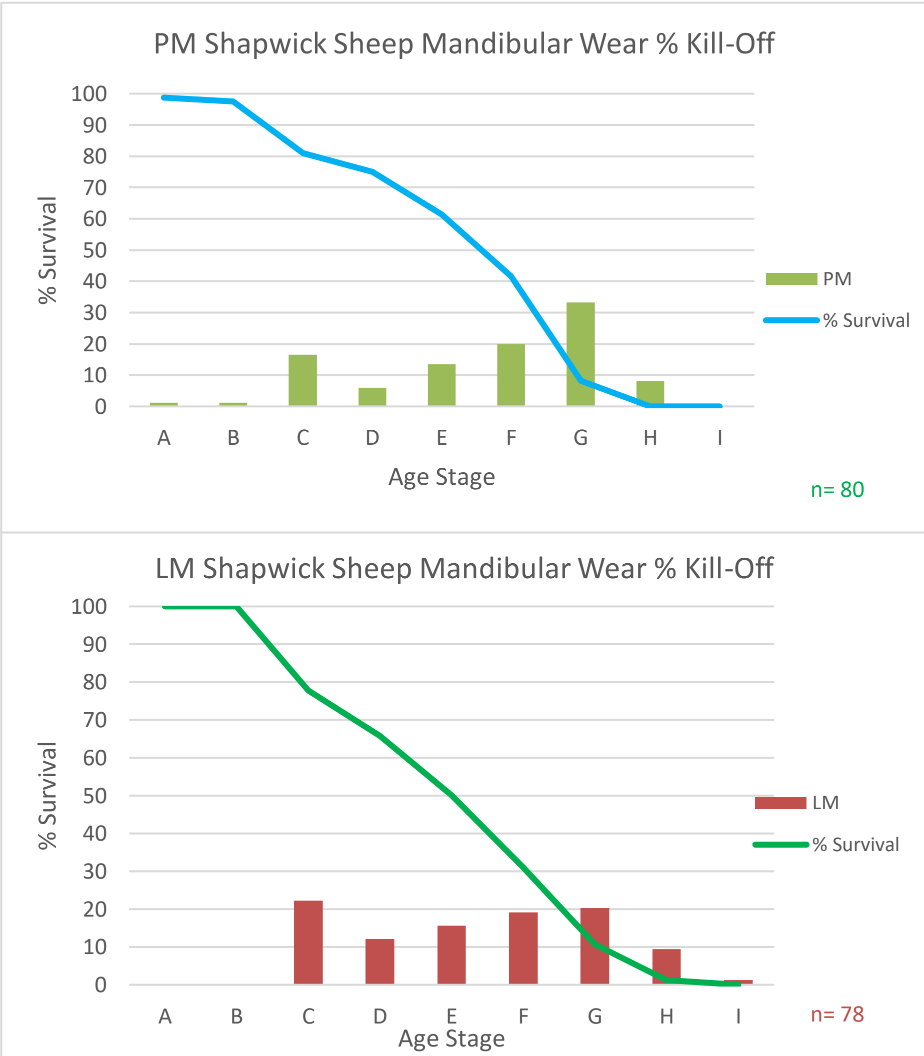

Figure 5.19: Sheep dental age profile, showing the percentage kill-off and percentage survival at each age stage for the late and post-Medieval periods at Shapwick.

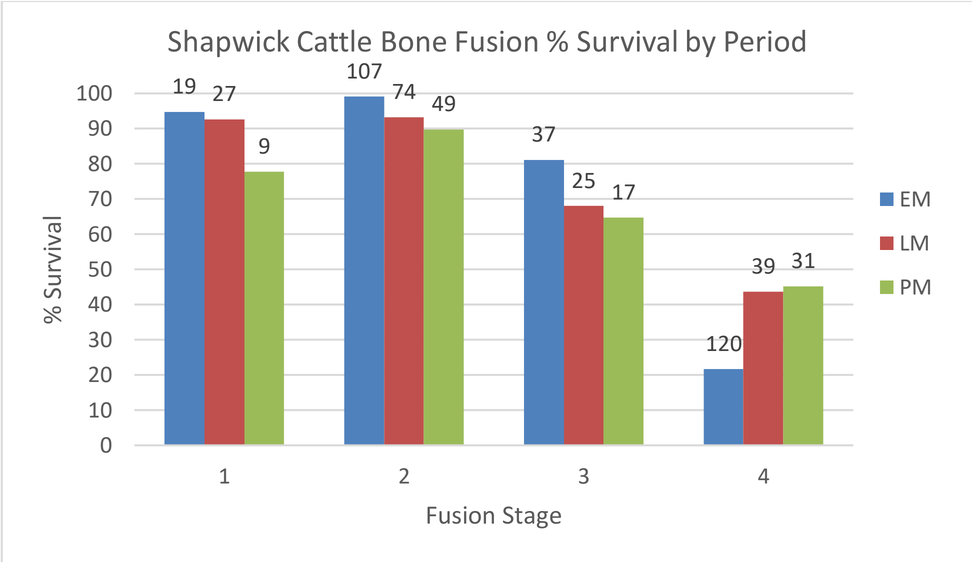

Figure 5.20: Cattle %survival by bone fusion for the three main periods at Shapwick. The ages for each fusion stage are as follows: Stage 1: 7-10 months, Stage 2: 12-18 months, Stage 3: 24-36 months, Stage 4: 36-48 months. The number of specimens per stage is given above the bars.

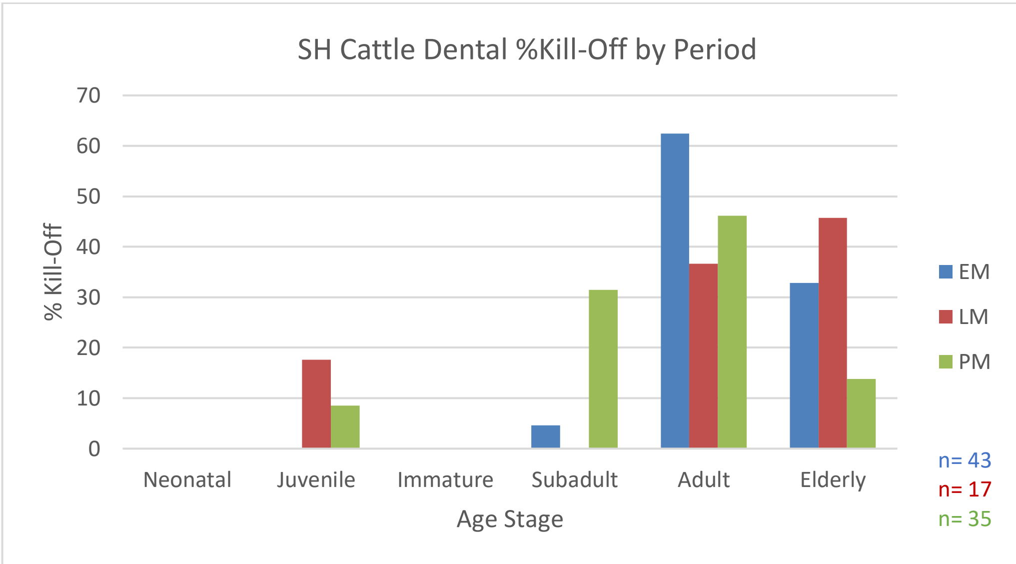

Figure 5.21: Cattle dental age profile, showing the percentage kill-off at each age stage for the three main periods at Shapwick.

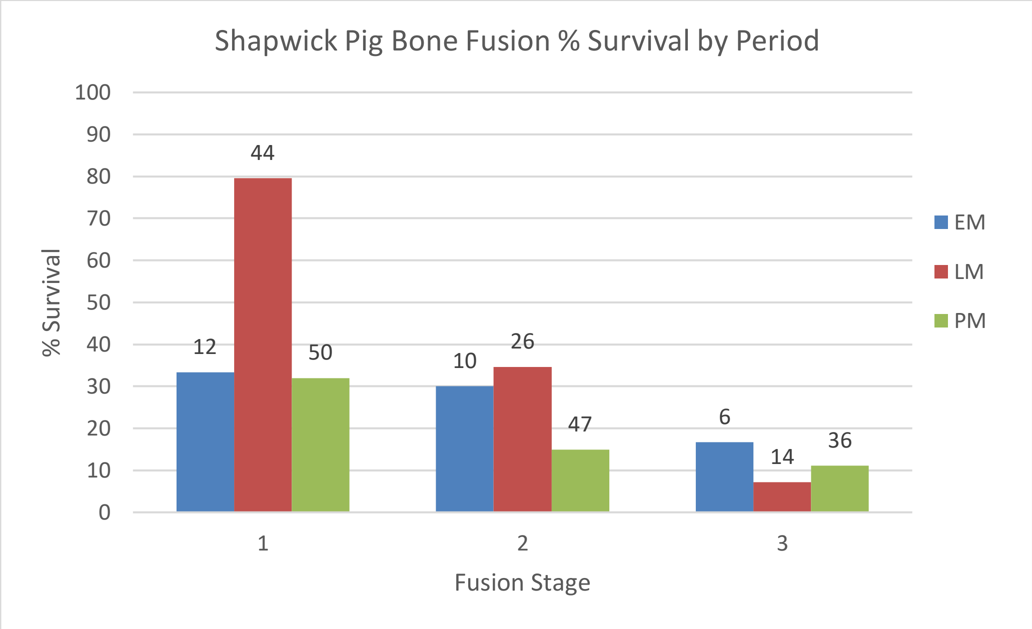

Figure 5.22: Pig %survival by bone fusion for the three main periods at Shapwick. The ages for each fusion stage are as follows: Stage 1: 6-12 months, Stage 2: 14-18 months, Stage 3: 30-42 months. The number of specimens per stage is given above the bars.

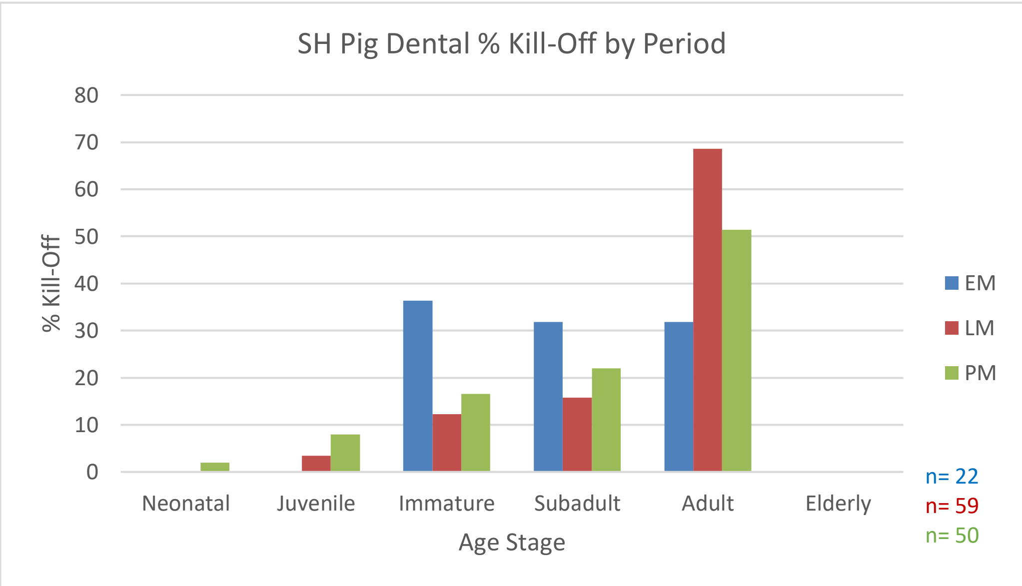

Figure 5.23: Pig dental age profile, showing the percentage kill-off at each age stage for the three main periods at Shapwick.

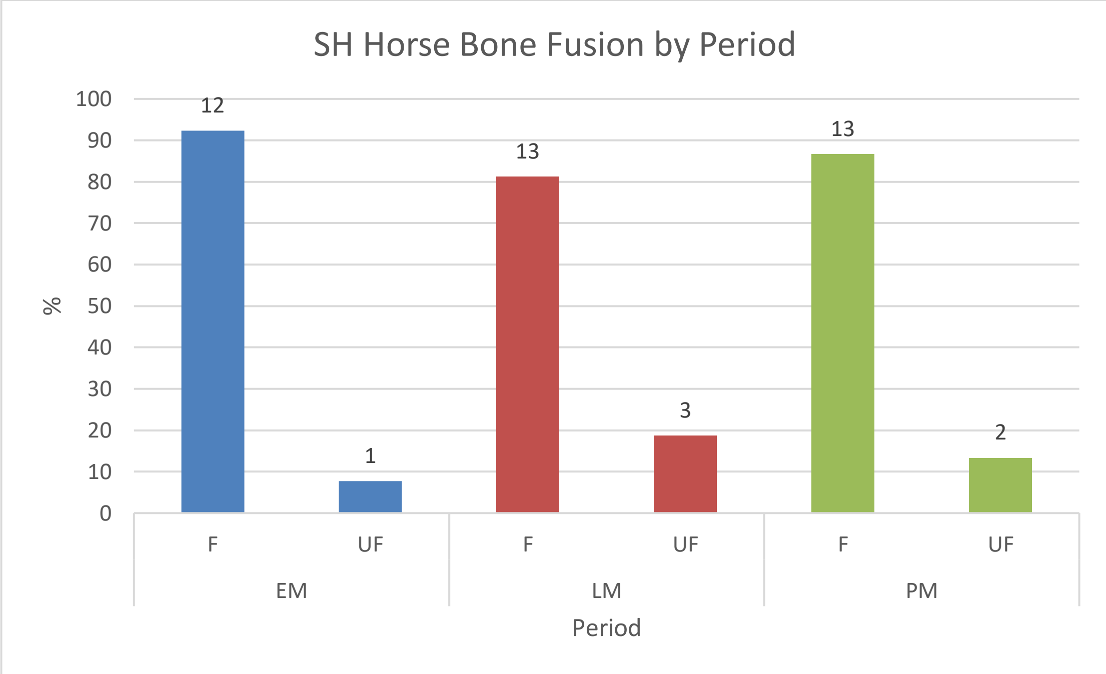

Figure 5.24: The proportion of fused and unfused horse bones from all periods at Shapwick. The numbers above the bars give the actual number of specimens.

5.2.7 Metric Results

An overview of the metric information for each species can be found in Appendices 29 to 32.

Sheep

Tooth size for sheep has been assessed using mandibular third molar width across the three phases at Shapwick (Figure 5.25). Overall, there appears to be very little change in tooth size throughout the study period. This is also indicated by the t-test results, which suggest no significant change in average size across the three periods (Table 5.2). The statistical test results for individual elements also show no significant change in the width of dP_4, M_1 and M_2. However, there is a significant decrease in M_3 length ($P<0.05$) between the earlier and late Medieval periods (Table 5.3), though this may be associated with change in tooth wear.

Post-cranial sheep size change was initially assessed using scatter plots of astragalus, distal humerus and distal tibia measurements (Figures 5.26, 5.27 and 5.28). The measurements in each figure overlap in size, indicating no clear size change throughout time. Furthermore, the statistical test results for individual elements show no significant change between the three periods (Table 5.3). In order to increase the sample size, therefore making the assessment of post-cranial size more reliable, the log ratio method was used to investigate changes in length, width and depth of sheep post-cranial elements. Post-cranial length measurements show minimal change from the earlier to the post-Medieval period (Figure 5.29). Furthermore, statistical test results show no significant change in sheep length measurements across the three periods (Table 5.4). This suggests that the length of sheep post-cranial elements remained relatively constant throughout the study period. Similarly, there is little change in sheep post-cranial width measurements from the earlier Medieval period onwards (Figure 5.30). The average late and post-Medieval length measurements are slightly larger than the earlier Medieval value, though t-test results show that there is no significant change in width measurements throughout the study period (Table 5.5). Moreover, mean post-cranial depth measurements across the study period are very similar, with a slight increase between each period (Figure 5.31). However, these increases are not statistically significant (Table 5.6). Overall, there is no significant size change in sheep post-cranial elements between the earlier, late and post-Medieval periods.

The lack of change in post-cranial sheep measurements at Shapwick throughout the study period is paralleled in the coefficient of variation (CV) values (Table 5.7). Post-cranial CV values are between 7.5 and 7.9 across the three periods, suggesting similar variability throughout the study period. The CV values for teeth are more varied, with the highest value of 10.4 in the earlier Medieval period, and the lowest of 5.9 in the late Medieval period. This suggests that the greatest heterogeneity in the sheep flock was in the earlier Medieval period. This result could indicate the presence of multiple breeds of sheep at Shapwick in the earlier Medieval period, perhaps coming from multiple estates of Glastonbury Abbey. CV values are lower in the late and post-Medieval periods, suggesting that this variation decreased as Abbey control was removed, and a more homogenous flock from the late Medieval period.

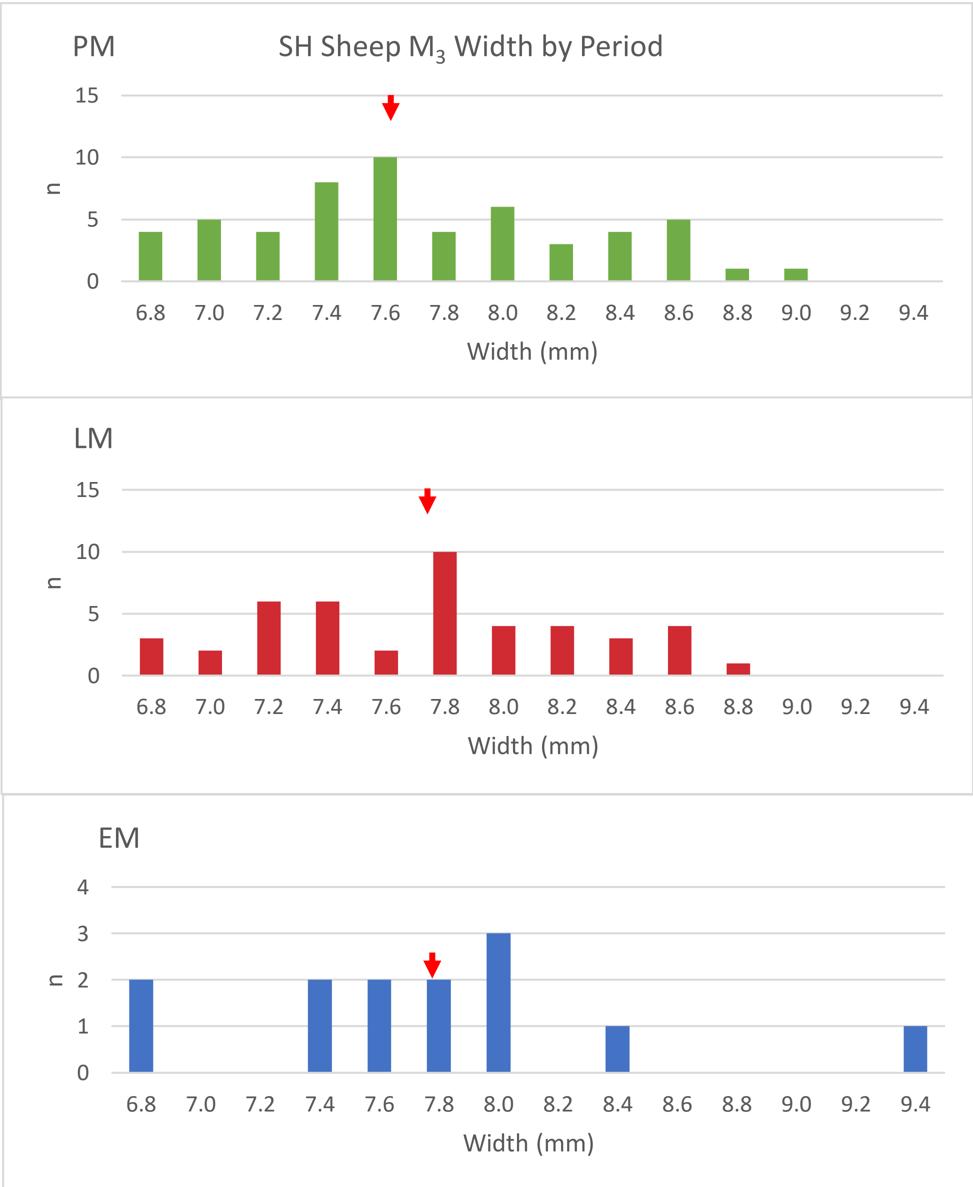

Figure 5.25: Histograms plotting width measurements of sheep mandibular third molar by phase at Shapwick. The red arrows indicate the position of the mean.

Table 5.2: Statistical test results for Shapwick mandibular third sheep molar width by period.

Period	t-stat/ U value	P value	Significance
EM vs. LM	0.158	0.876	P>0.05
LM vs. PM	-0.263	0.793	P>0.05

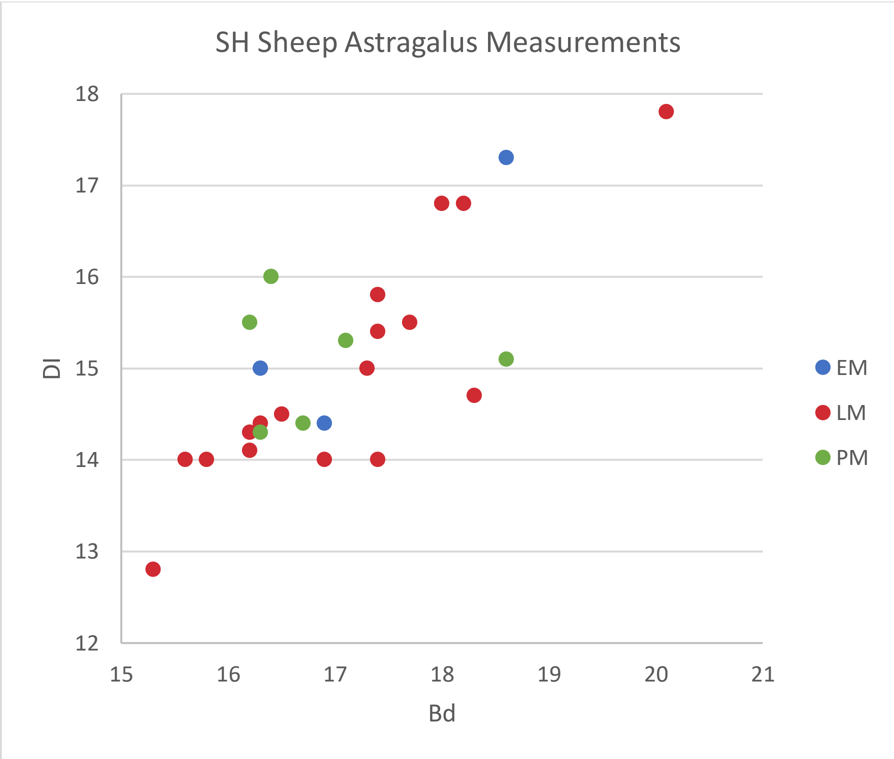

Figure 5.26: Comparison of astragalus measurements for sheep by period at Shapwick.

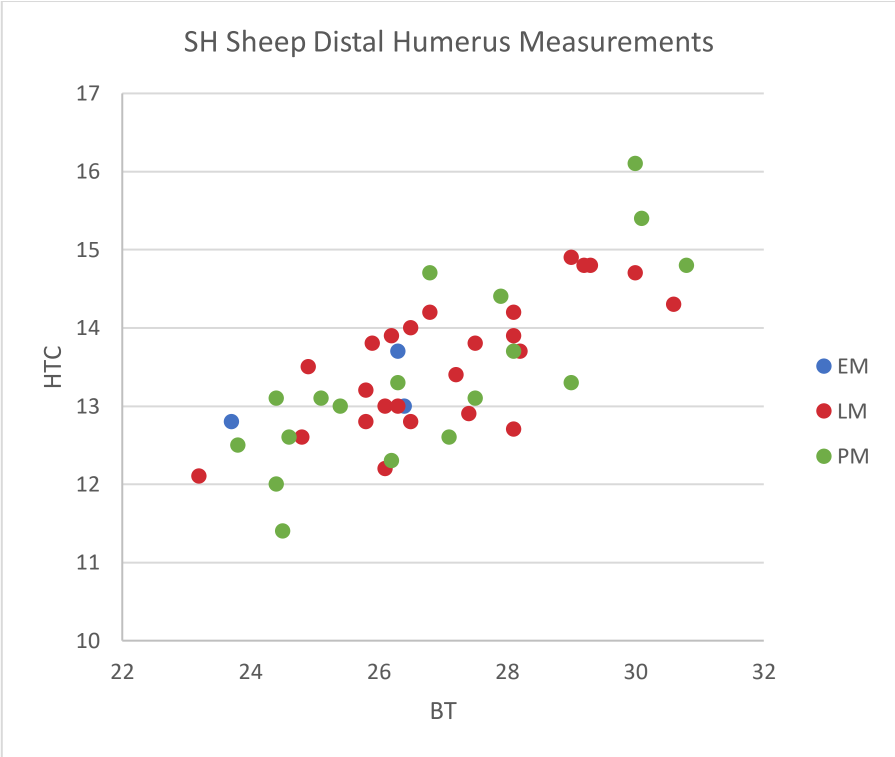

Figure 5.27: Comparison of distal humerus measurements for sheep by period at Shapwick.

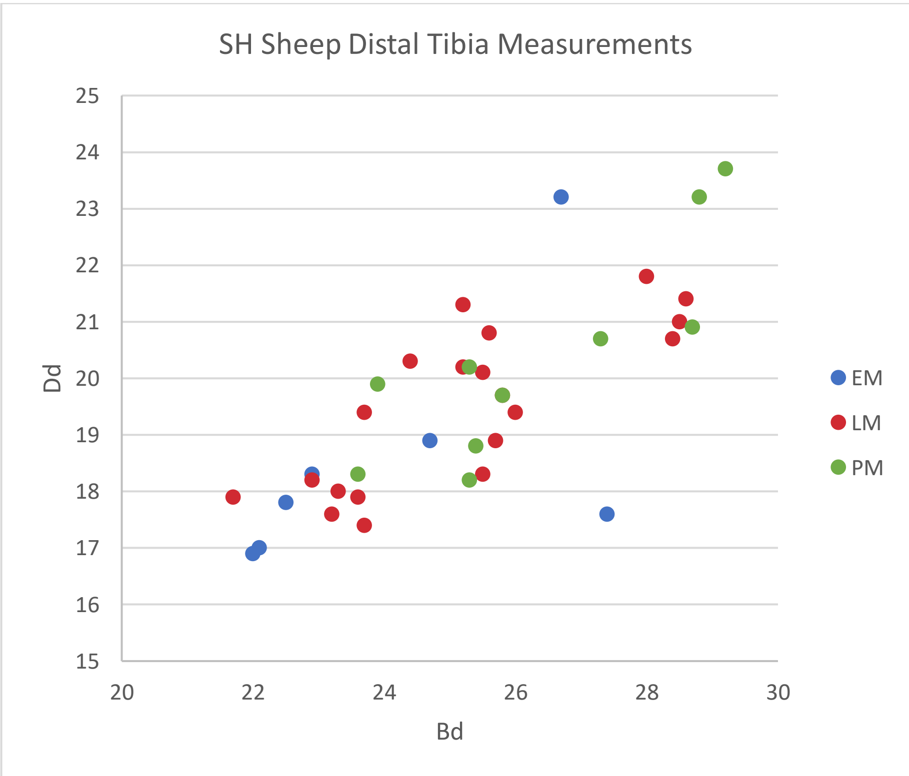

Figure 5.28: Comparison of distal tibia measurements for sheep by period at Shapwick.

Table 5.3: Statistical test results for individual sheep bone measurements between the earlier, late and post-Medieval periods at Shapwick. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t-stat/ U value**	**P value**	**Significance**	**t-stat/ U value**	**P value**	**Significance**
dP_4 W	N/A	N/A	P>0.05	-1.515	0.141	P>0.05
M_1 W	N/A	N/A	P>0.05	0.645	0.530	P>0.05
M_2 W	N/A	N/A	P>0.05	84	0.407	P>0.05
M_3 L	-2.609	0.021	P<0.05	-0.643	0.522	P>0.05
M_3 W	0.158	0.876	P>0.05	-0.263	0.793	P>0.05
Scapula GLP	N/A	N/A	P>0.05	-0.738	0.091	P>0.05
Scapula SLC	N/A	N/A	P>0.05	1.796	0.471	P>0.05
Humerus BT	N/A	N/A	P>0.05	-0.524	0.604	P>0.05
Humerus Bd	N/A	N/A	P>0.05	-0.843	0.407	P>0.05
Humerus HTC	N/A	N/A	P>0.05	-0.602	0.552	P>0.05
Radius Bp	N/A	N/A	P>0.05	-0.401	0.692	P>0.05
Radius Bd	N/A	N/A	P>0.05	1.318	0.220	P>0.05
Tibia Bd	-1.232	0.249	P>0.05	-1.515	0.145	P>0.05
Tibia Dd	38	0.074	P>0.05	0.885	0.389	P>0.05
Astragalus GLl	N/A	N/A	P>0.05	0.933	0.373	P>0.05
Astragalus GLm	N/A	N/A	P>0.05	0.5479	0.599	P>0.05
Astragalus Bd	N/A	N/A	P>0.05	73	0.916	P>0.05
Astragalus Dl	N/A	N/A	P>0.05	-0.861	0.401	P>0.05

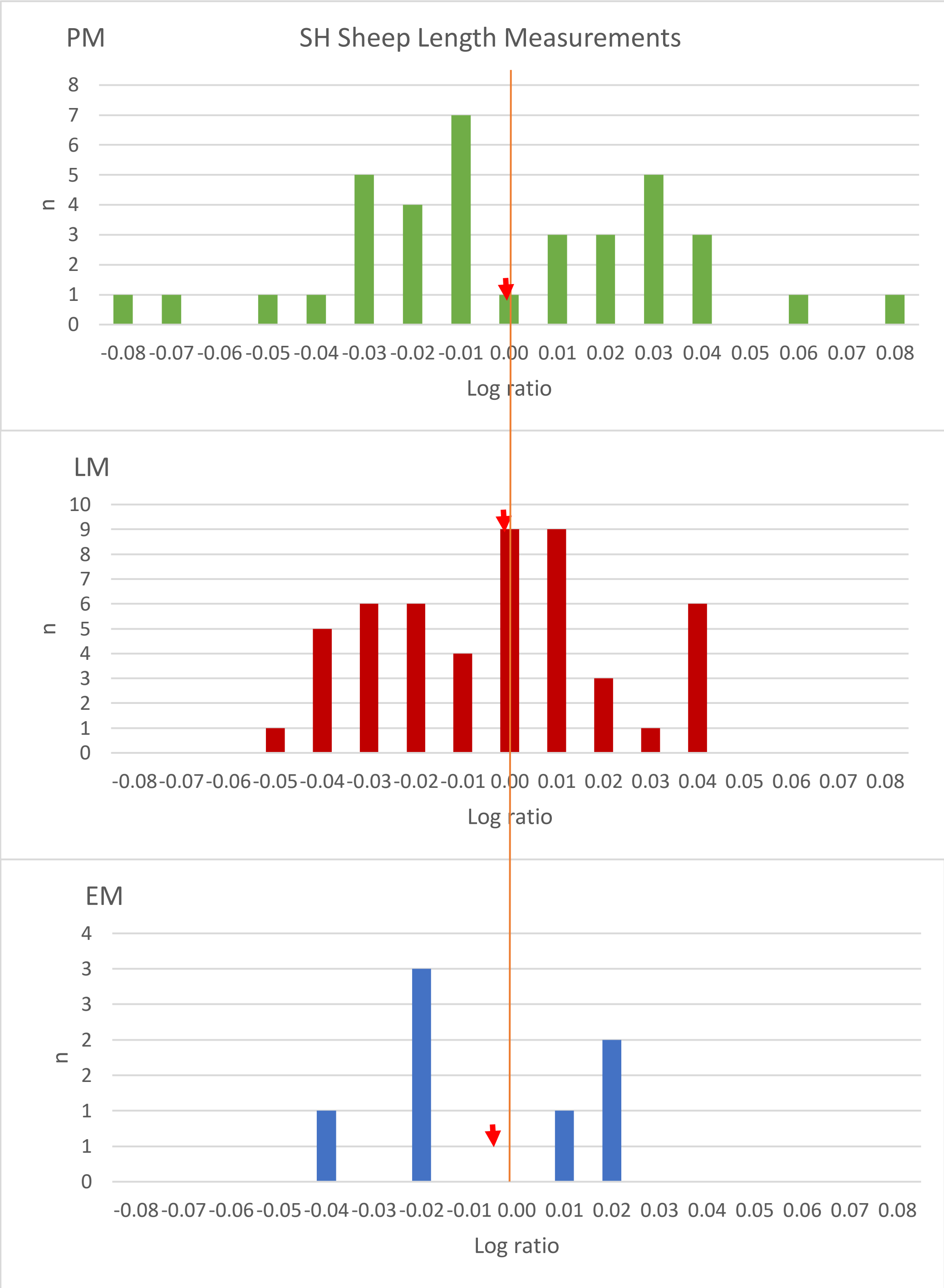

Figure 5.29: Log ratio histograms combining sheep post-cranial bone length measurements by period at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.4: Statistical test results for the post-cranial log ratio length values for sheep at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	0.297	0.774	P>0.05
LM vs. PM	0.307	0.760	P>0.05

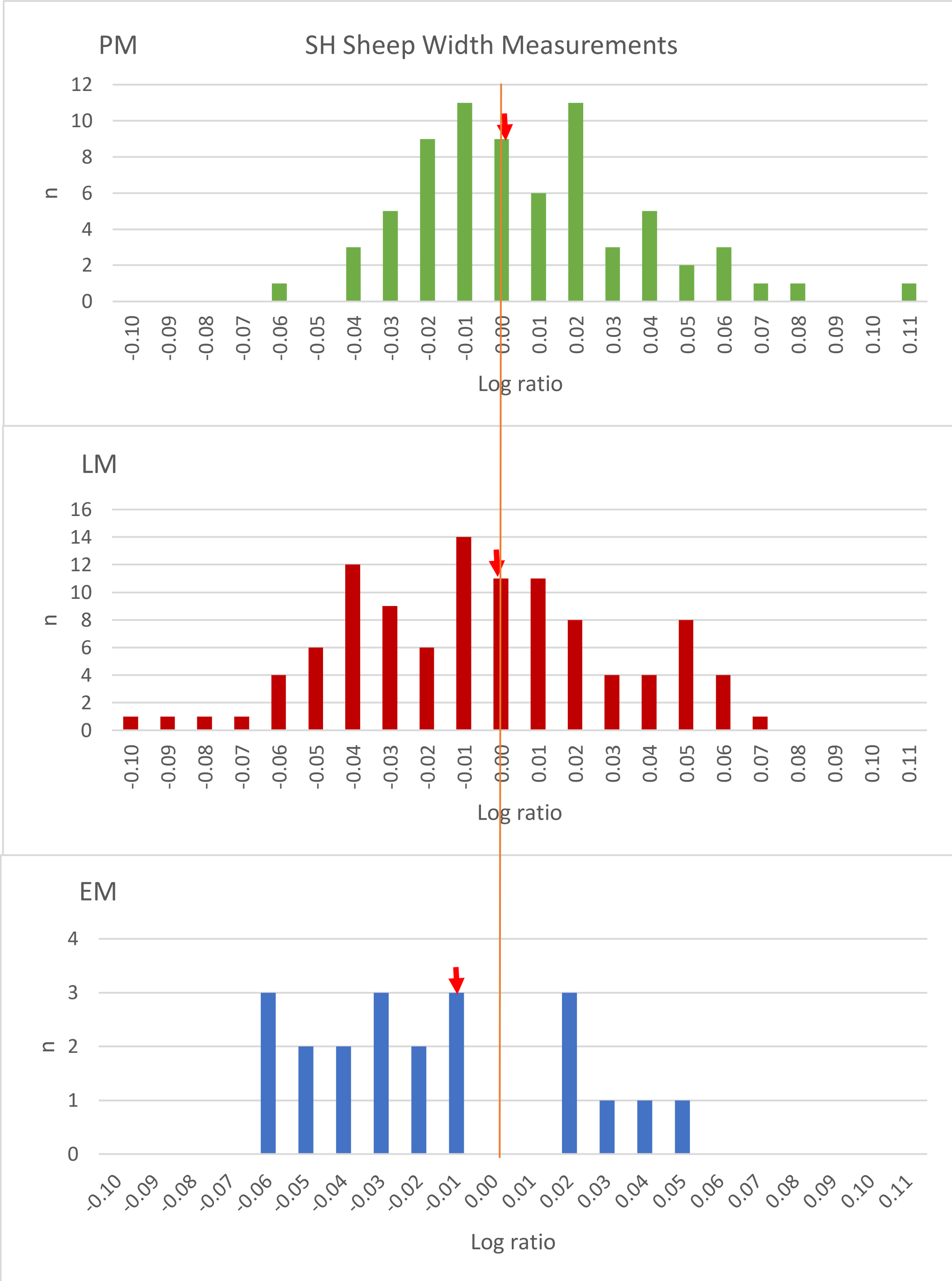

Figure 5.30: Log ratio histograms combining sheep post-cranial bone width measurements by period at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.5: Statistical test results for the post-cranial log ratio width values for sheep at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	1.160	0.255	P>0.05
LM vs. PM	3798	0.297	P>0.05

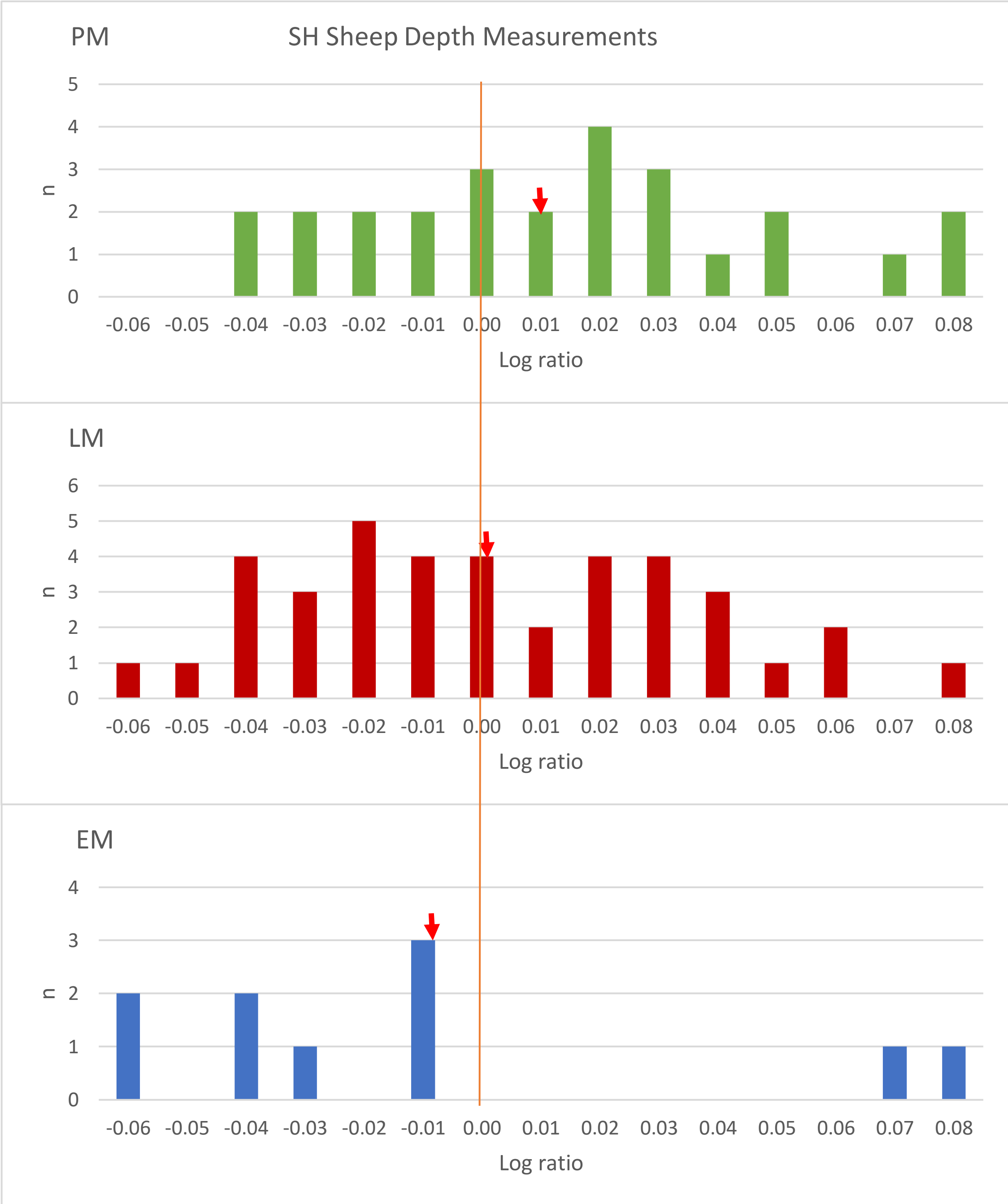

Figure 5.31: Log ratio histograms combining sheep post-cranial bone depth measurements by period at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.6: Statistical test results for the post-cranial log ratio depth values for sheep at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	-0.741	0.474	P>0.05
LM vs. PM	1.330	0.189	P>0.05

Table 5.7: Coefficient of variation values for sheep teeth and post-cranial elements at Shapwick.

Period	Post-cranial	Teeth
EM	7.8	10.4
LM	7.5	5.9
PM	7.9	6.7

Cattle

Cattle tooth size at Shapwick was initially assessed by comparing third mandibular molar width across the three periods (Figure 5.32). The average M_3 width is slightly larger in the earlier Medieval period, though the late and post-Medieval sample sizes are very small. Statistical test results (Table 5.8) indicate no significant change between the three periods.

An assessment of cattle post-cranial size was carried out by comparing measurements from the astragalus, distal humerus, and distal tibia across the three chronological periods. There is a large overlap between astragalus measurements from the earlier, late and post-Medieval periods (Figure 5.33), suggesting that there was little change in the size of this element. T-test results for astragalus measurements do not indicate significant change (Table 5.9). However, distal humerus measurements show some larger post-Medieval values (Figure 5.34), which are substantiated by a significant t-test result for HTC between the late and post-Medieval periods ($P<0.05$). This suggests an increase in cattle humerus size in the post-Medieval period, though it should be noted that this measurement is relatively sex-dependent (Payne and Bull 1988), and therefore an increase in size may be caused by an increased proportion of males. In contrast, tibia distal breadth measurements show an increase in size between the earlier and late Medieval periods (Figure 5.35). Again, this is demonstrated by t-test values which indicate a significant change in tibia Bd between these periods ($P<0.05$).

These apparent changes in cattle post-cranial dimension were investigated further using the log ratio method to assess potential changes in length, width and depth measurements throughout the study period. Length measurements show similar average values during the earlier and late Medieval periods but increase in the post-Medieval (Figure 5.36). This change is statistically significant (Table 5.10) ($P<0.01$), which suggests a real increase in cattle post-cranial bone length. This is also the case for width measurements, which show a slight, but not significant, increase in the late Medieval period, but a highly significant ($P<0.01$) increase in the post-Medieval period (Figure 5.37; Table 5.11). However, this change is not evident in the depth results, where the mean values across all three periods are very similar, and no statistically significant change is indicated by statistical test values (Figure 5.38; Table 5.12). Overall, there seems to be a significant increase in cattle post-cranial length and width in the post-Medieval period at Shapwick though depth remains relatively constant, indicating a potential change in cattle build through time.

These post-Medieval changes are also paralleled by cattle coefficient of variation (CV) values from across the three periods (Table 5.13). In the earlier and late Medieval periods, CV values are the same, followed by an increase in the following period. This suggests a greater post-cranial variation in the post-Medieval cattle herd. A post-Medieval change is also suggested by tooth CV results, as the value from the final period is much higher than the previous two. Overall, CV values suggest a greater heterogeneity in the post-Medieval cattle population at Shapwick, perhaps caused by the development or introduction of a new breed with greater post-cranial length and width dimensions.

Figure 5.32: Histograms plotting width measurements of cattle lower third molar at Shapwick. The red arrows indicate the position of the mean.

Table 5.8: Statistical test results for the mandibular third cattle molar width at Shapwick.

Phase	t-stat/ U value	P value	Significance
EM vs. LM	-0.490	0.642	P> 0.05
LM vs. PM	0.011	0.991	P> 0.05

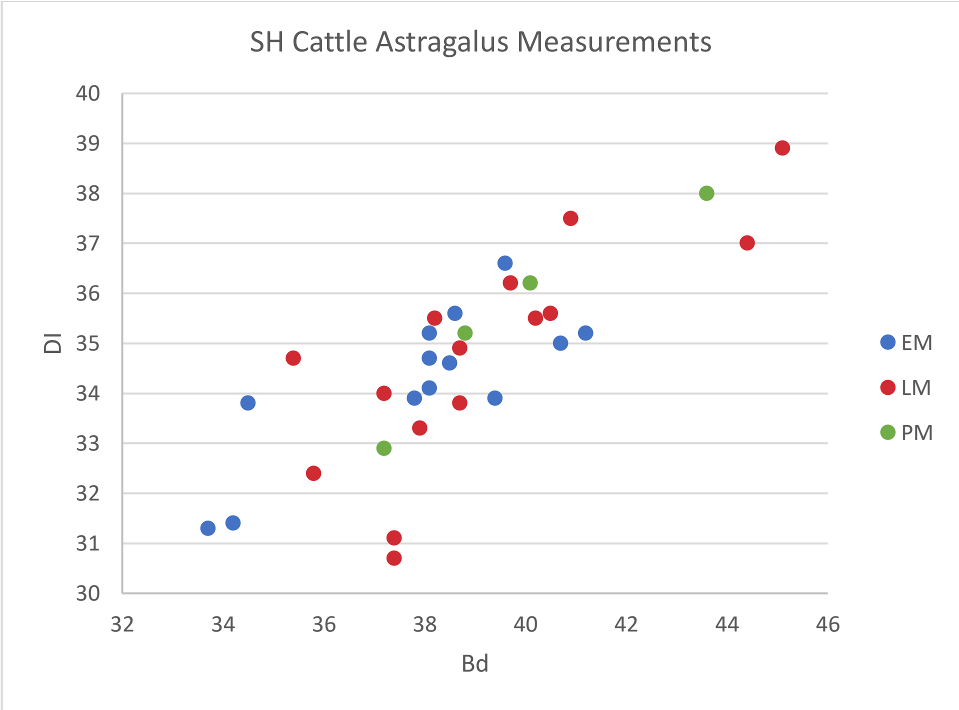

Figure 5.33: Comparison of astragalus measurements for cattle at Shapwick.

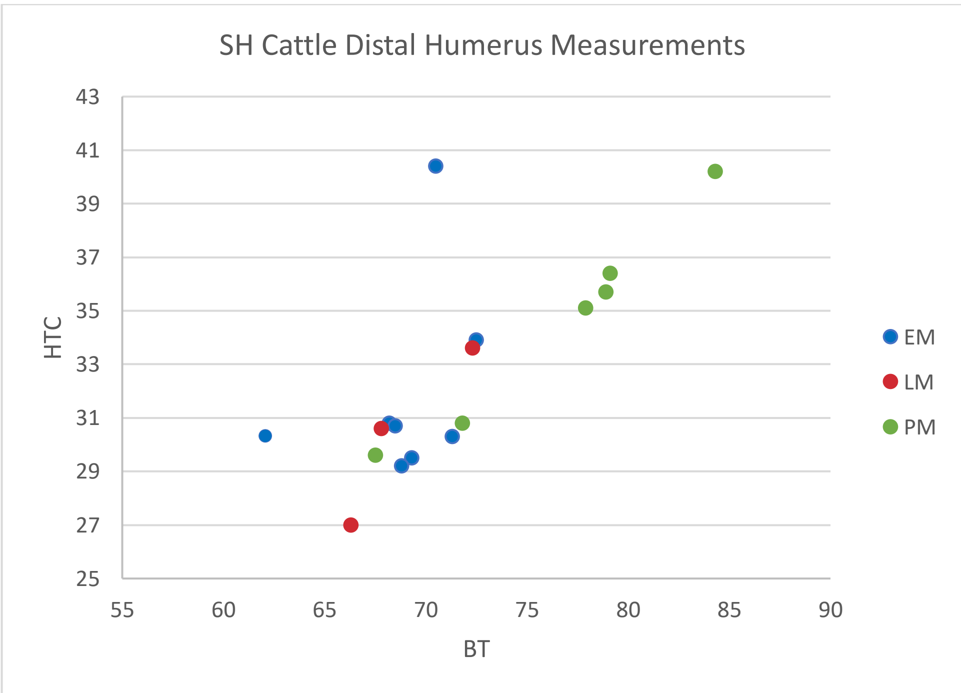

Figure 5.34: Comparison of distal humerus measurements for cattle at Shapwick.

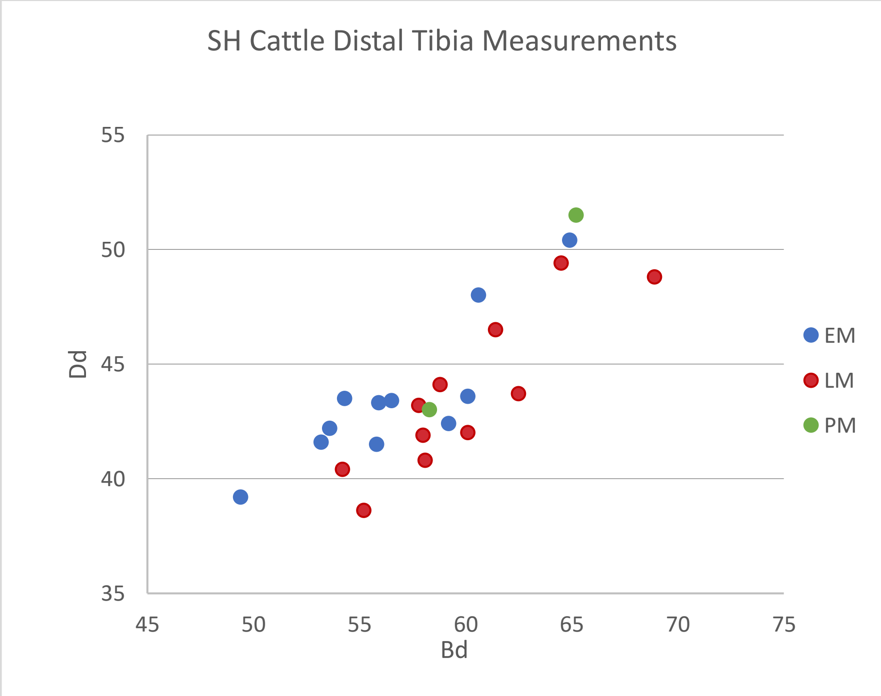

Figure 5.35: Comparison of distal tibia measurements for cattle at Shapwick.

Table 5.9: Statistical test results for individual cattle bone measurements at Shapwick. Elements with over five specimens were selected for the tests – N/A indicates that the number was under this threshold.

	EM vs. LM			LM vs. PM		
Measurement	**t-stat/ U value**	**P value**	**Significance**	**t-stat/ U value**	**P value**	**Significance**
M_3 W	-0.490	0.642	P> 0.05	0.011	0.991	P> 0.05
Scapula GLP	1.303	0.225	P> 0.05	N/A	N/A	P> 0.05
Scapula SLC	1.719	0.105	P> 0.05	N/A	N/A	P> 0.05
Humerus HTC	31	0.800	P> 0.05	2.978	0.016	P< 0.05
Tibia Bd	-2.233	0.0454	P< 0.05	N/A	N/A	P> 0.05
Tibia Dd	0.170	0.565	P> 0.05	N/A	N/A	P> 0.05
Astragalus GLl	1.961	0.061	P> 0.05	-1.195	0.286	P> 0.05
Astragalus GLm	1.343	0.190	P> 0.05	1.087	0.131	P> 0.05
Astragalus Bd	1.012	0.320	P> 0.05	1.681	0.303	P> 0.05
Astragalus Dl	0.243	0.810	P> 0.05	N/A	N/A	P> 0.05

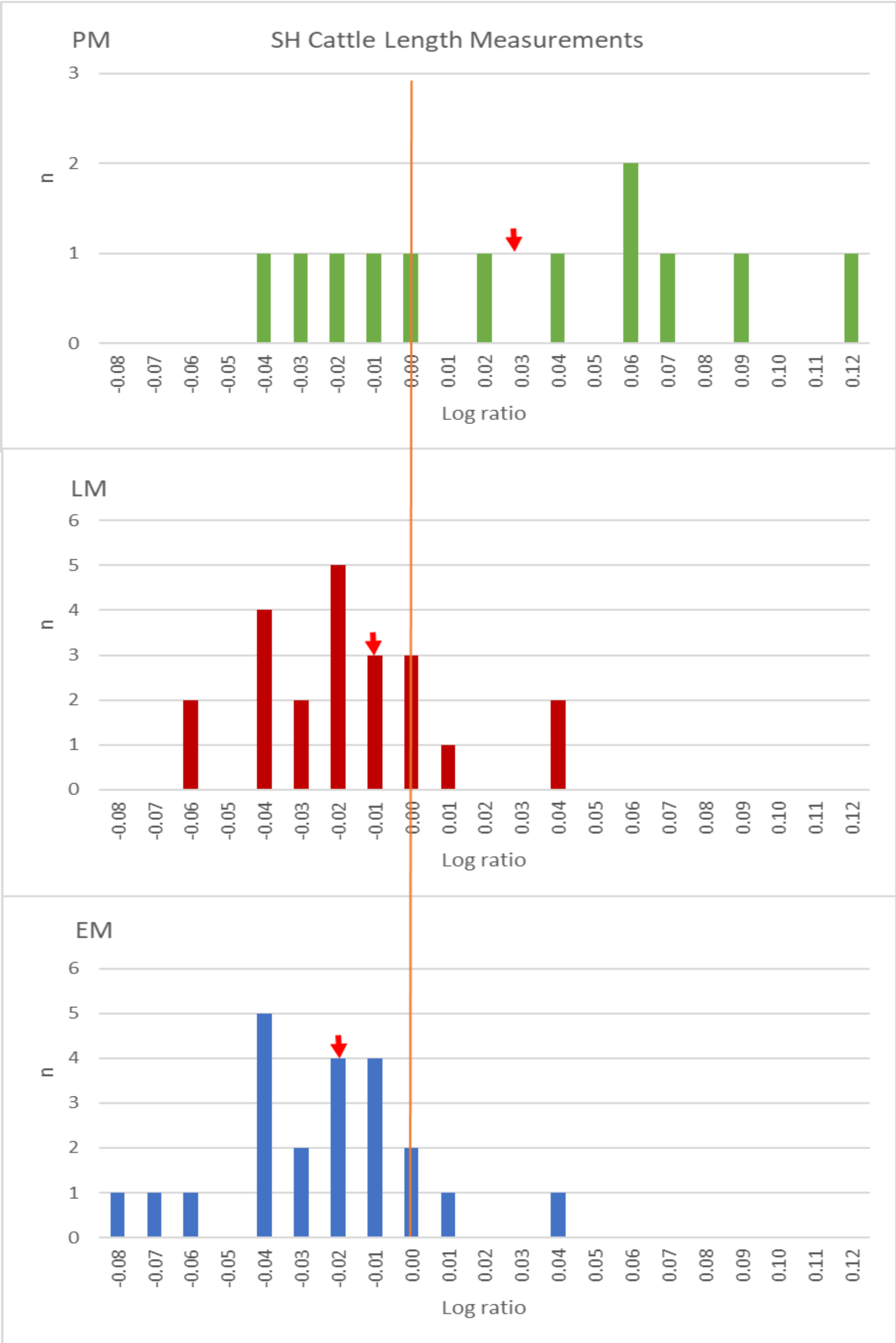

Figure 5.36: Log ratio histograms combining cattle post-cranial bone length measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.10: Statistical test results for the post-cranial log ratio length values for cattle at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	-0.047	0.963	P> 0.05
LM vs. PM	3.132	0.007	P< 0.01

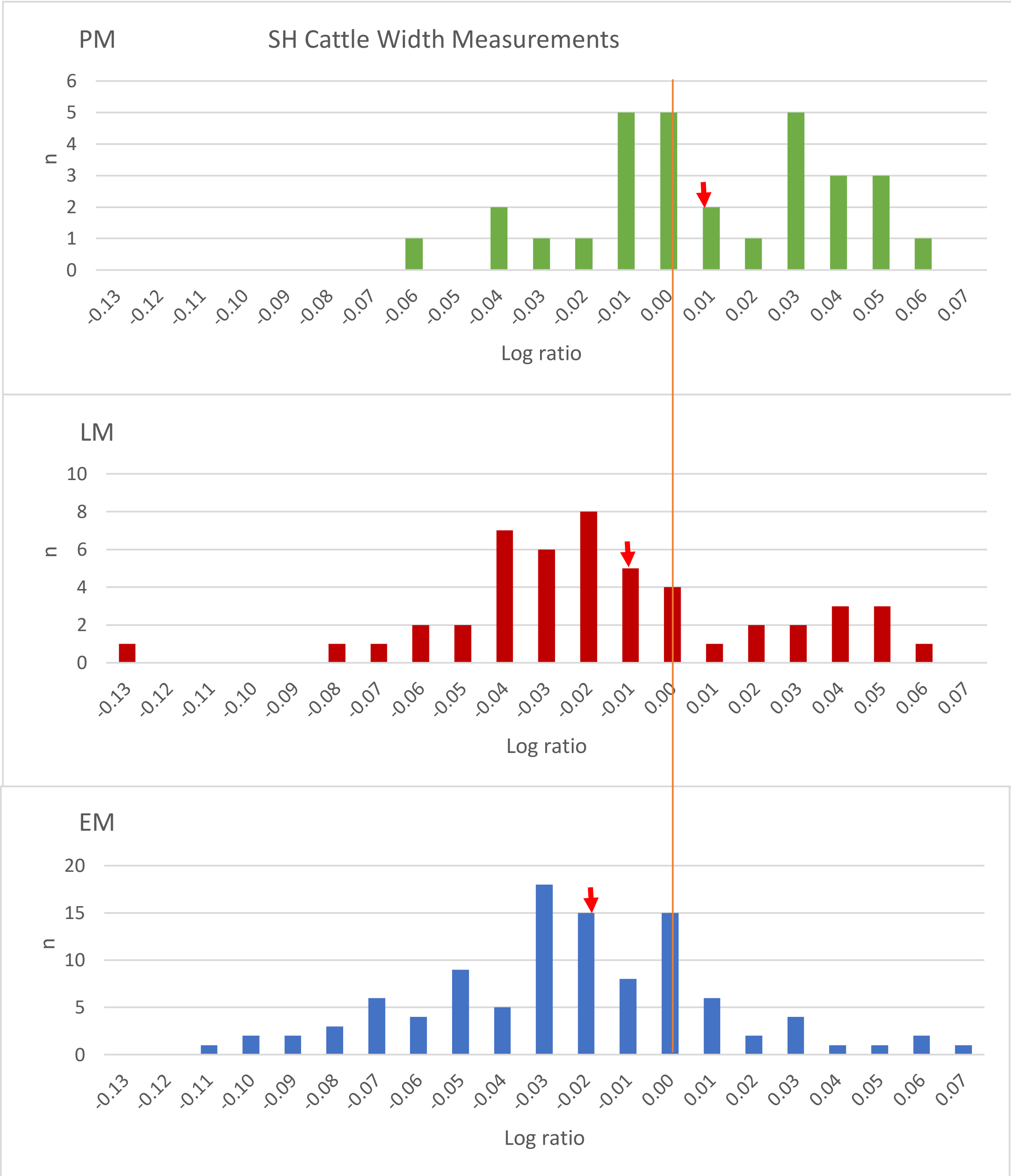

Figure 5.37: Log ratio histograms combining cattle post-cranial bone width measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.11: Statistical test results for the post-cranial log ratio width values for cattle at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	1.215	0.227	P> 0.05
LM vs. PM	-3.299	0.002	P< 0.01

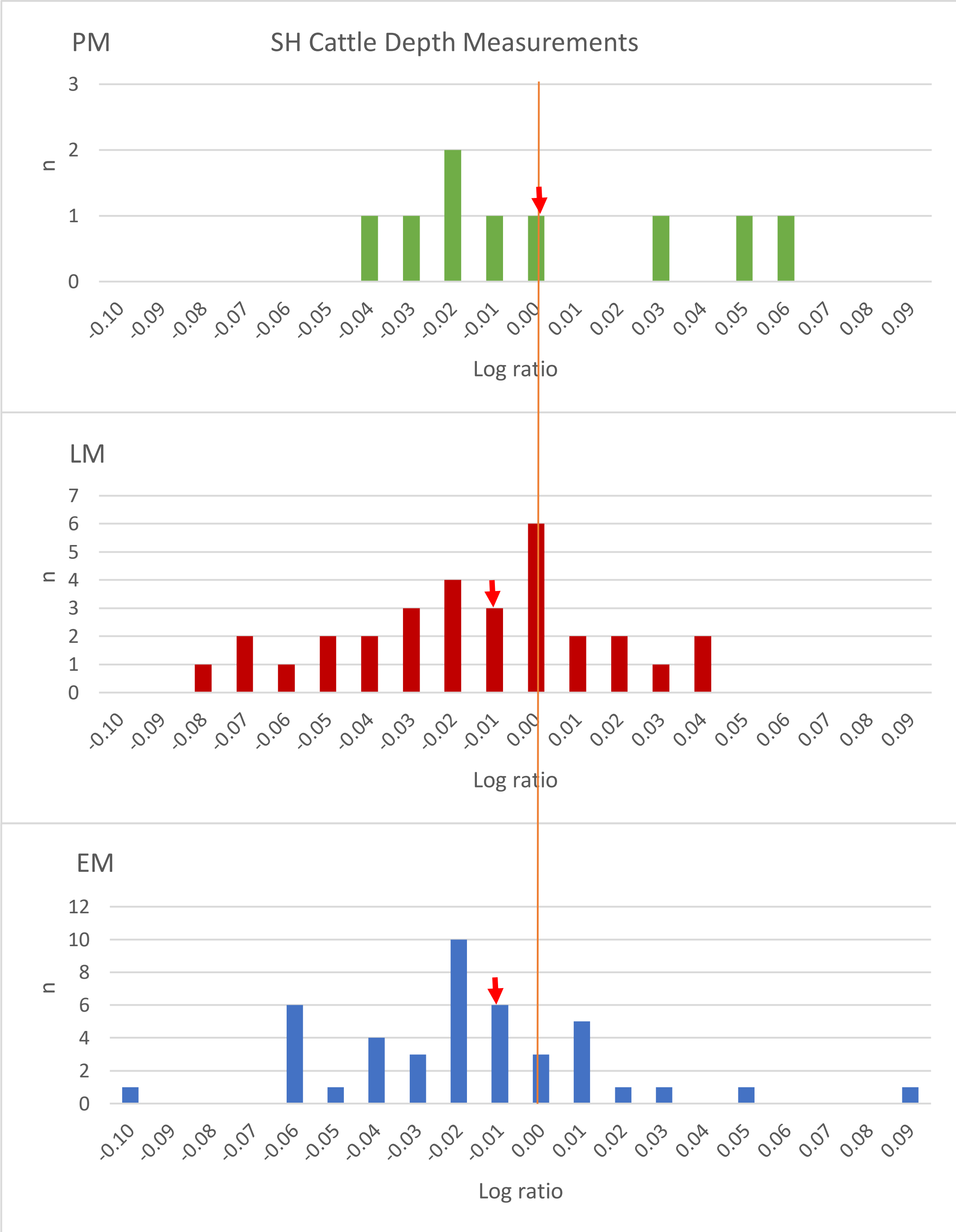

Figure 5.38: Log ratio histograms combining cattle post-cranial bone depth measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.12: Statistical test results for the post-cranial log ratio depth values for cattle at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	-0.282	0.778	P> 0.05
LM vs. PM	1.507	0.158	P> 0.05

Table 5.13: Coefficient of variation values for cattle teeth and post-cranial elements at Shapwick.

Period	Post-cranial	Teeth
EM	7.3	7.5
LM	7.3	8.6
PM	8.5	10.7

Pig

The log ratio method was used to assess both tooth and post-cranial size change for pigs at Shapwick as the sample size was too small to analyse measurements individually. Tooth length measurements show little change over the three periods (Figure 5.39), and t-test results also indicate no significant change (Table 5.14). Similarly, for tooth width measurements, there is little change in average size throughout the three periods (Figure 5.40). Again, statistical test values show that there was no significant change in tooth length (Table 5.15). Overall, these results suggest that pig tooth size did not distinctly change between the earlier, late and post-Medieval periods at Shapwick.

The measurements for length, width and depth have been combined for the log ratio assessment of post-cranial pig size, due to a small sample size, though the earlier Medieval period is not included due to a lack of data (Figure 5.41). Post-cranial elements show a slight increase in size during the post-Medieval period, though statistical test results indicate that there is no significant change (Table 5.16).

Coefficient of variation (CV) values indicate the variation within the pig population at Shapwick through time (Table 5.17). The CV values for teeth are relatively low in comparison to those from post-cranial material. This suggests a relatively homogenous population through time, though the value increases in the post-Medieval period, which may indicate a change in husbandry such as altered sex ratio or nutritional plane, or perhaps the introduction of a new breed. Variation is also highest for post-cranial material in the post-Medieval period, at 12.2. This is much higher than the previous phase, which may suggest the development or introduction of a different breed not evident in the metric results above. Finally, the post-cranial CV is also high in the earlier Medieval period, reaching 11.2, which could again suggest the presence of multiple breeds on the site between the tenth and thirteenth centuries, or the presence of both male and female animals, as pigs show substantial sexual dimorphism.

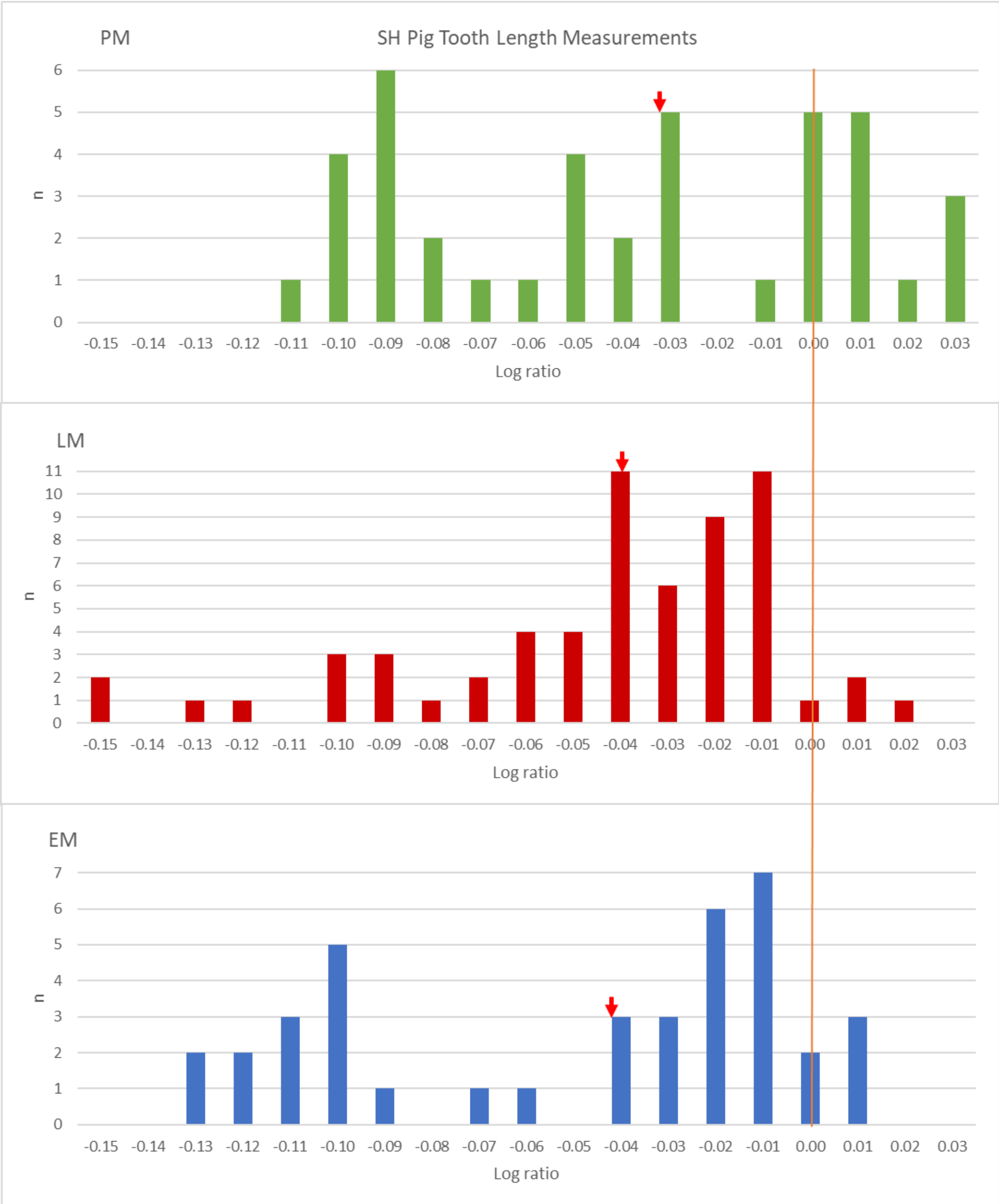

Figure 5.39: Log ratio histograms combining pig tooth length measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.14: Statistical test results for the tooth log ratio length values for pig at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	1186	0.875	P> 0.05
LM vs. PM	1345	0.620	P> 0.05

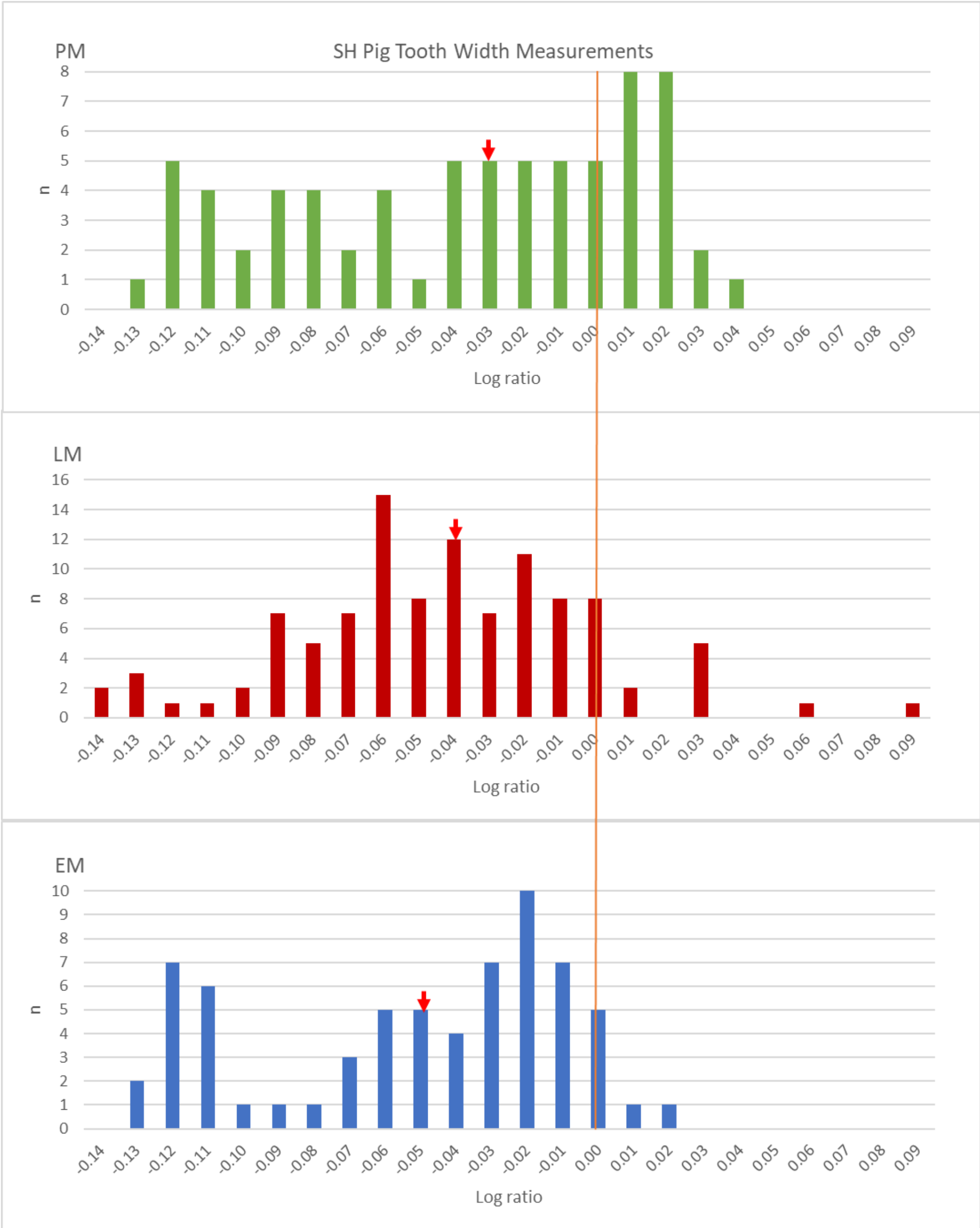

Figure 5.40: Log ratio histograms combining pig tooth width measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.15: Statistical test results for the tooth log ratio width values for pig at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	3291	0.515	P> 0.05
LM vs. PM	4414	0.255	P> 0.05

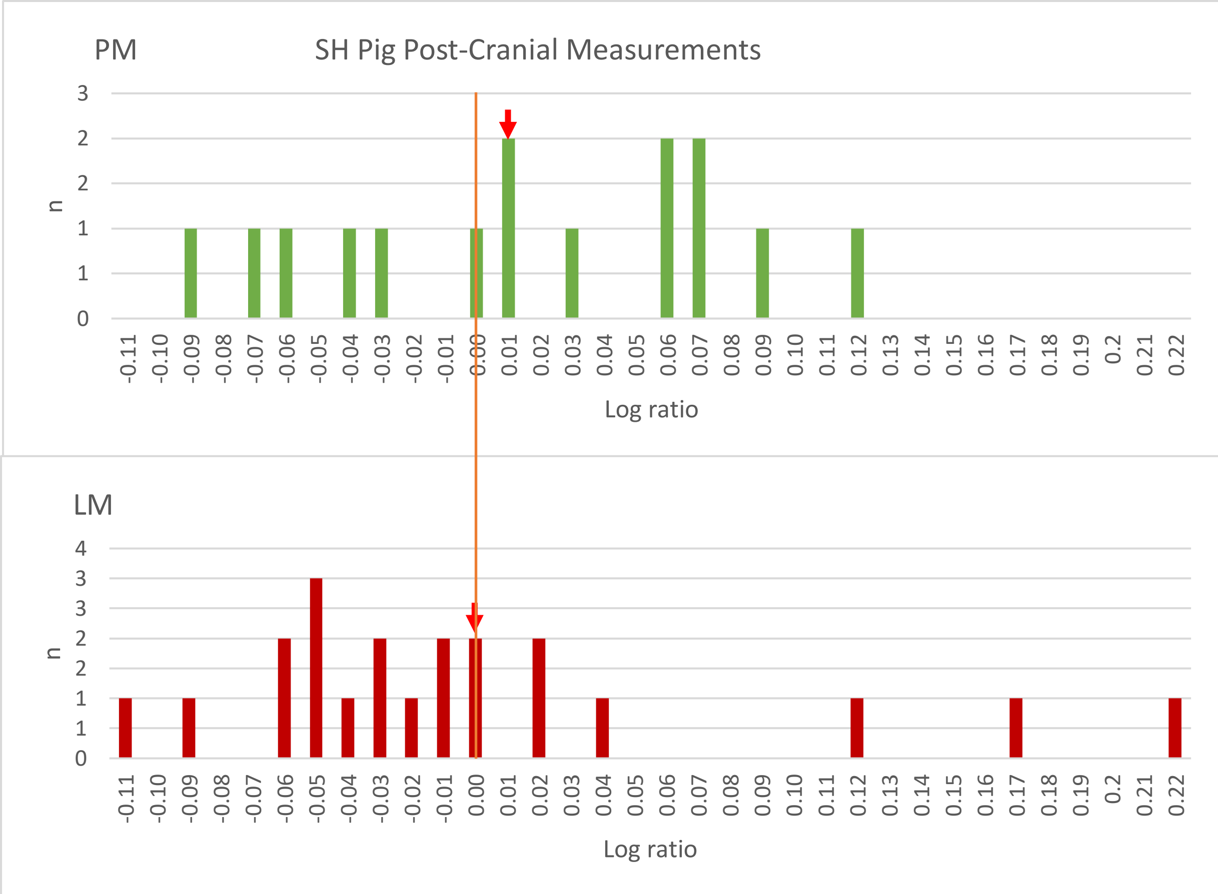

Figure 5.41: Log ratio histograms combining pig post-cranial length and width measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.16: Statistical test results for the post-cranial log ratio values for pig at Shapwick.

Period	t-stat/ U value	P value	Significance
LM vs. PM	123	0.269	P> 0.05

Table 5.17: Coefficient of variation values for pig teeth and post-cranial elements at Shapwick.

Period	Post-cranial	Teeth
EM	11.2	6.7
LM	6.7	6.5
PM	12.2	7.1

Horse

Unfortunately, there were too few positively identified horse teeth from all phases at Shapwick to assess changes in horse tooth size through time. An initial assessment of horse post-cranial size was carried out by comparing phalanx one measurements across the three periods (Figure 5.42), though again a small sample size makes reliability an issue. This comparison shows a large overlap between the P1 measurements from all three periods, suggesting that a change in horse size is not apparent. This is supported by the log ratio assessment of horse post-cranial measurements, once again combining length, width and depth due to a small sample size (Figure 5.43). The average values across all three periods are very similar, suggesting a relatively constant horse size throughout time. The statistical test results show no significant change in horse post-cranial size at Shapwick between the earlier, late and post-Medieval periods (Table 5.18).

Coefficient of variation (CV) results for horse are extremely variable, likely rather random due to the very small sample sizes (Table 5.19). For post-cranial measurements, variation is highest in the earlier and post-Medieval periods, reaching 14.5 in the final period. This could suggest a more heterogenous population in these periods, potentially due to alterations in husbandry strategy or breed. Conversely, tooth variation is relatively low in the earlier Medieval period, followed by a value of 20.6 in the late Medieval, though this reduces to 14.2 in the final period. The value for the late Medieval period is extremely high, perhaps suggesting a mixture of breeds, or the presence of donkeys or mules alongside horses at the site.

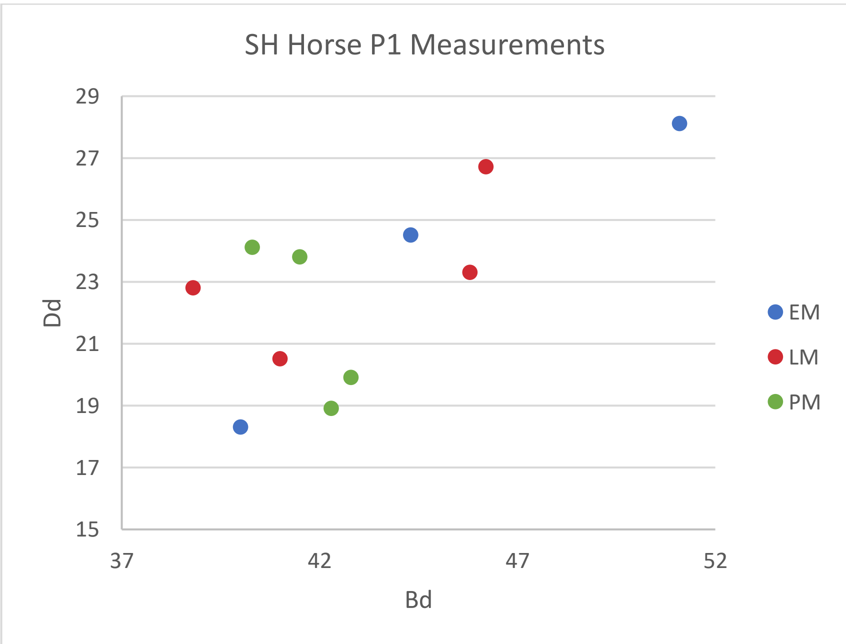

Figure 5.42: Comparison of distal phalanx 1 measurements for horse at Shapwick.

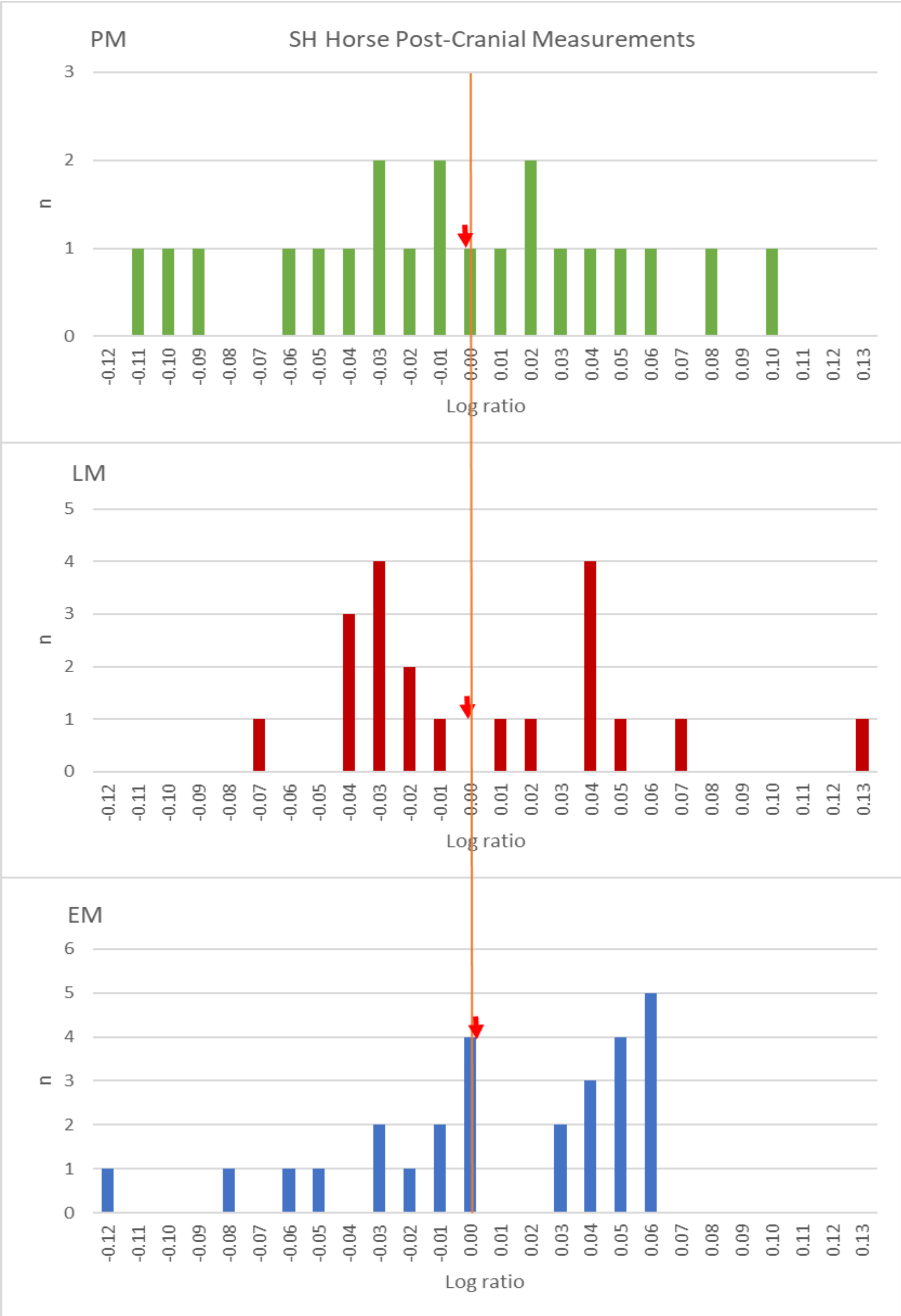

Figure 5.43: Log ratio histograms combining horse post-cranial bone length, width and depth measurements at Shapwick. The red arrow represents the mean, and the vertical line indicates the mean of the standard sample.

Table 5.18: Statistical test results for the post-cranial log ratio values for horse at Shapwick.

Period	t-stat/ U value	P value	Significance
EM vs. LM	319	0.300	P> 0.05
LM vs. PM	-0.540	0.592	P> 0.05

Table 5.19: Coefficient of variation values for horse teeth and post-cranial elements at Shapwick.

Period	Post-cranial	Teeth
EM	11.0	5.2
LM	7.6	20.6
PM	14.5	14.2

5.2.8 Comparison to Exeter

In order to investigate the Shapwick faunal results within the wider context of the region and possible trade connections, they have been compared to the Exeter metric data from Maltby (1979) and Lauritsen (pers comm.). Exeter was selected due to an availability of metric data, and to provide a comparison to an urban centre in the West Country, outside the central band of open field farming.

Sheep Metrics

Figure 5.44 shows the log ratio comparison of sheep length measurements from Shapwick and Exeter. In the late Medieval period, the average length measurements from Shapwick are slightly larger than those from Exeter, suggesting that sheep on both sites were of a similar size. In the post-Medieval period, both sites again show a similar sheep length average, though by this time the Exeter average had increased to exceed the Shapwick value. This suggests that sheep at Shapwick were a similar size to those in Exeter throughout the late and post-Medieval periods, though Exeter sheep were slightly larger in the latter.

A similar pattern can be seen in the sheep width measurements from both sites, though Shapwick values appear to be slightly larger across both periods (Figure 5.45). In the late Medieval period, the average width value for Shapwick is larger than that of Exeter, suggesting larger sheep size on the Somerset site during this period. In the following period, there is an increase in the average measurement from Exeter while the Shapwick mean remains relatively constant, indicating a very similar size on both sites. This overall suggests that sheep were slightly larger, in terms of post-cranial width, at Shapwick in the late Medieval period, but in the following period Exeter size increased, making the two sites comparable.

Similarly, the sheep post-cranial depth results suggest a similar trend in the late and post-Medieval periods (Figure 5.46). The average depth measurement for Exeter is smaller than that of Shapwick in both the late and post-Medieval periods, though it is a more comparable size in the post-Medieval.

This suggests that sheep were larger, in terms of post-cranial depth, at Shapwick in both periods, despite a slight increase at Exeter in the later phase.

Overall, the log ratio comparison of sheep measurements from both sites indicate that sheep at Shapwick were generally larger than those at Exeter in the late Medieval period, though a size increase at Exeter resulted in similar sheep size on both sites in the post-Medieval period. However, there is not a substantial change in sheep size on either site.

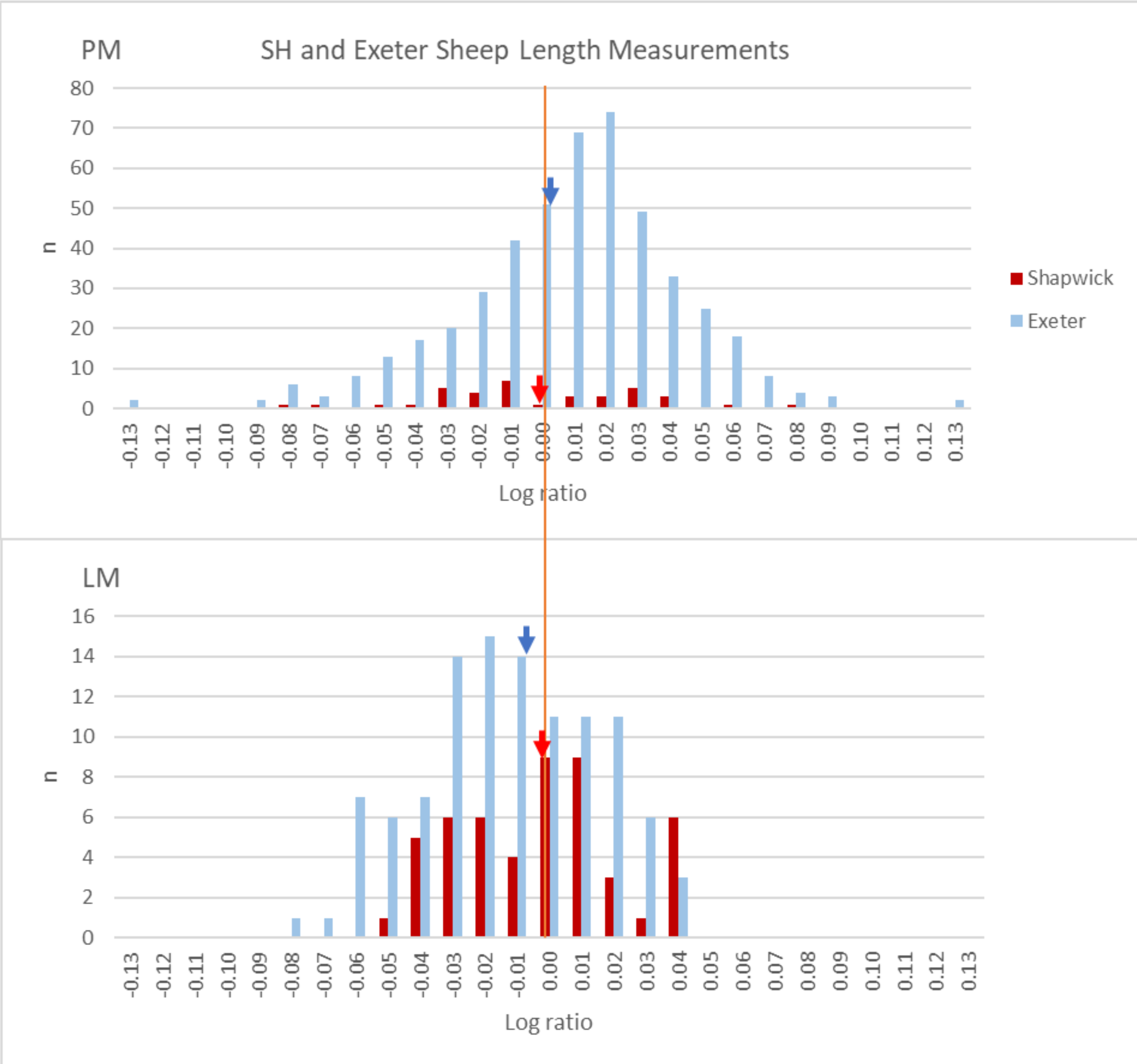

Figure 5.44: Comparison of Shapwick and Exeter sheep length measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

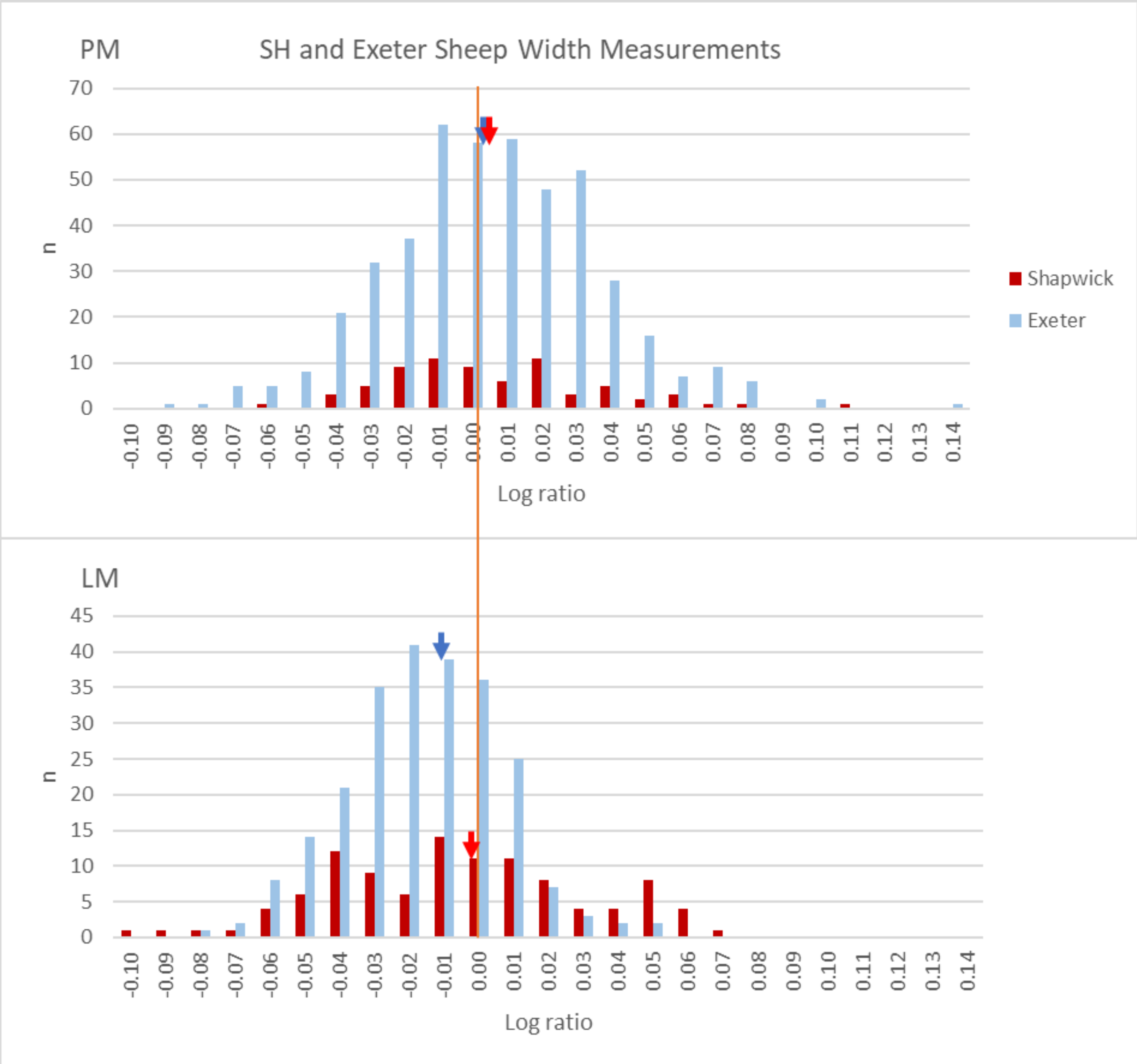

Figure 5.45: Comparison of Shapwick and Exeter sheep width measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

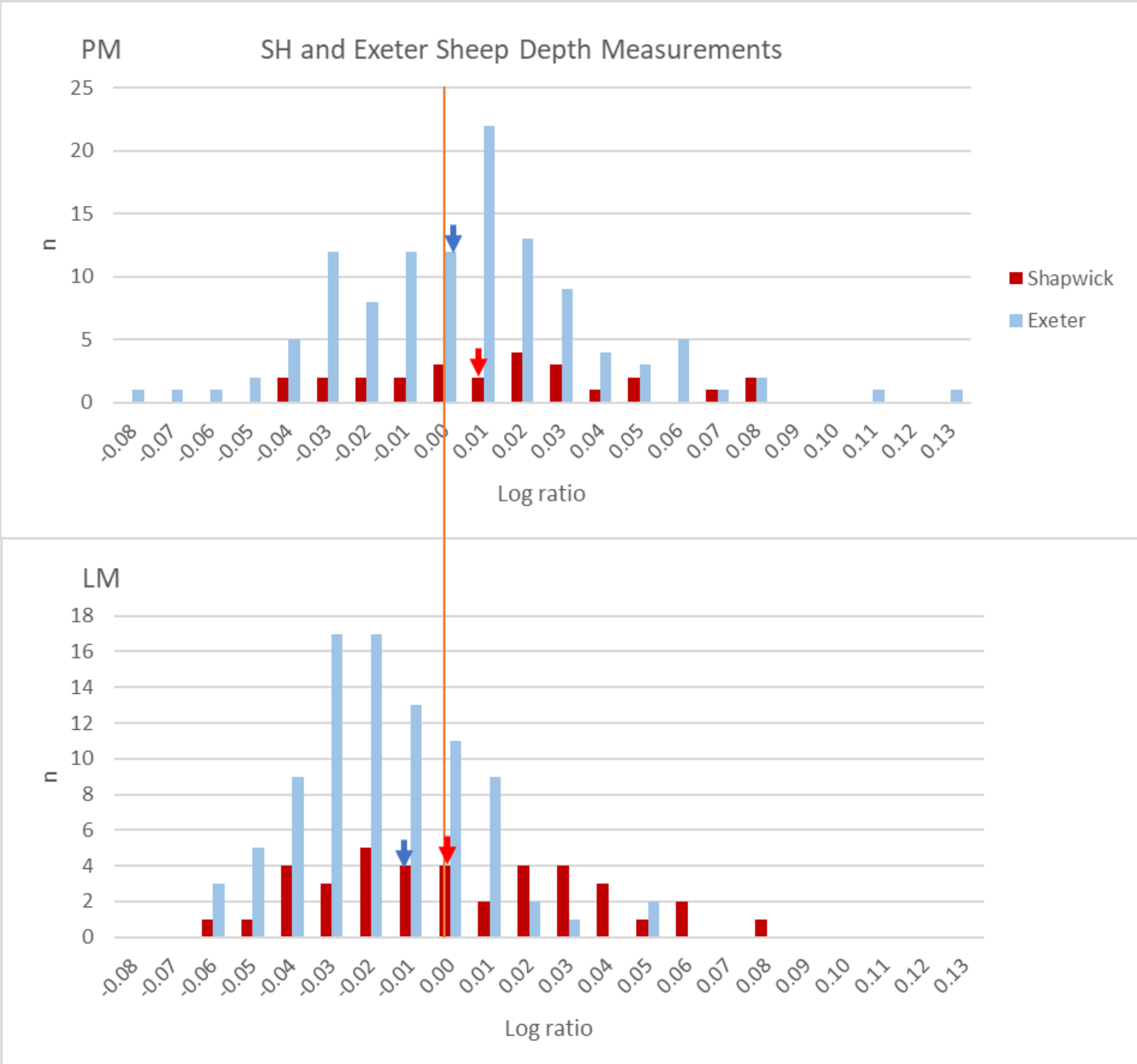

Figure 5.46: Comparison of Shapwick and Exeter sheep depth measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

Cattle Metrics

Figure 5.47 shows the comparison between Shapwick and Exeter cattle log ratio length measurements, though the sample size in both periods is limited. In the late Medieval period, the average Exeter value appears to be substantially smaller than the Shapwick value, suggesting the presence of smaller cattle in the urban area. This may reflect the potential use of cattle for traction at Shapwick, requiring large animals. However, this is also the case for the post-Medieval period – the average length of cattle bones on both sites increases in this period, again resulting in a larger Shapwick value. This suggests that, while cattle post-cranial length increased both in the urban and rural area, cattle continued to be taller at Shapwick in the post-Medieval period.

A similar pattern can be seen in cattle width measurements from both sites (Figure 5.48). In the late Medieval period, the average Shapwick cattle width measurement is again considerably larger than the Exeter value. The average Shapwick width increases slightly in the post-Medieval period, while the Exeter value increases to a greater extent, but is still smaller. This again suggests that cattle size, in terms of width, was smaller in Exeter during both periods, though it shows a greater increase in size into the post-Medieval period.

Once again, the comparison of depth measurements from both sites shows a greater average at Shapwick in both periods (Figure 5.49). The mean Exeter depth value increases in the post-Medieval period, while the Shapwick result does not significantly increase. However, cattle depth is still greater at Shapwick in the later period.

Overall, it appears that the length, width and depth results for cattle all show an increased average for both Shapwick and Exeter in the post-Medieval period, though the Shapwick values are consistently larger. This suggests that cattle were larger at Shapwick in the late and post-Medieval periods, perhaps due to the site's specialisation in corn, and therefore the need for large animals for traction.

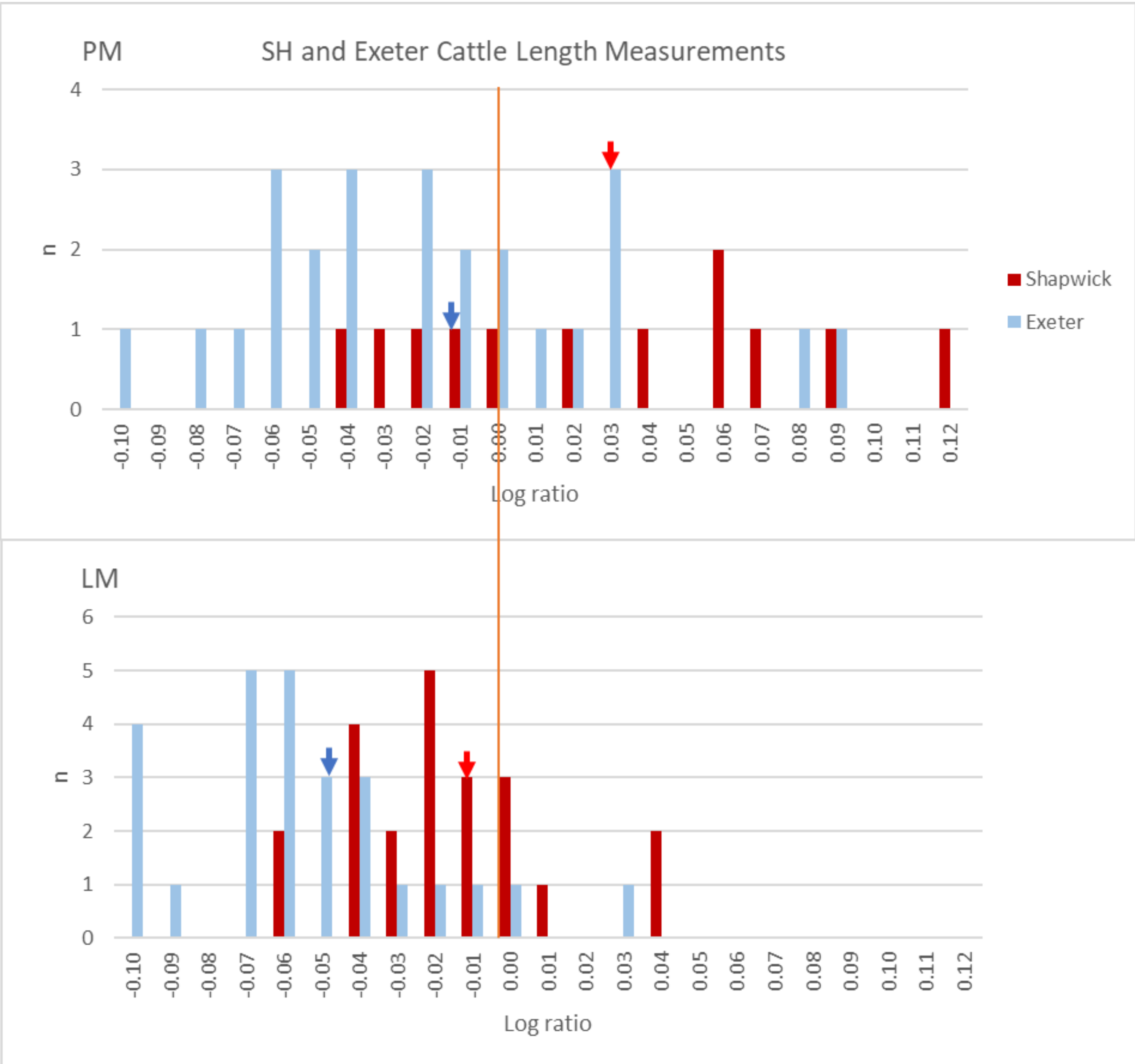

Figure 5.47: Comparison of Shapwick and Exeter cattle length measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

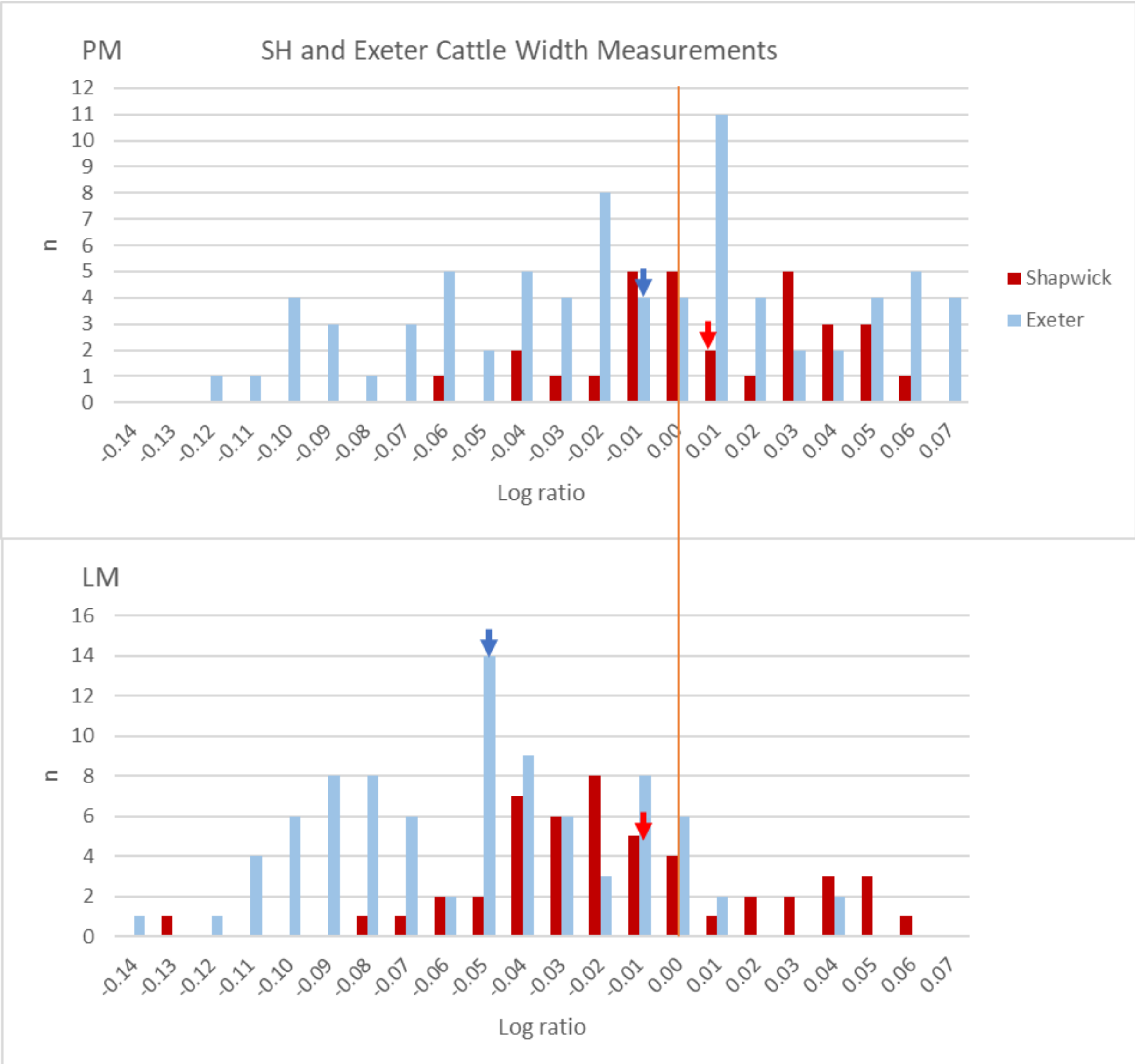

Figure 5.48: Comparison of Shapwick and Exeter cattle width measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

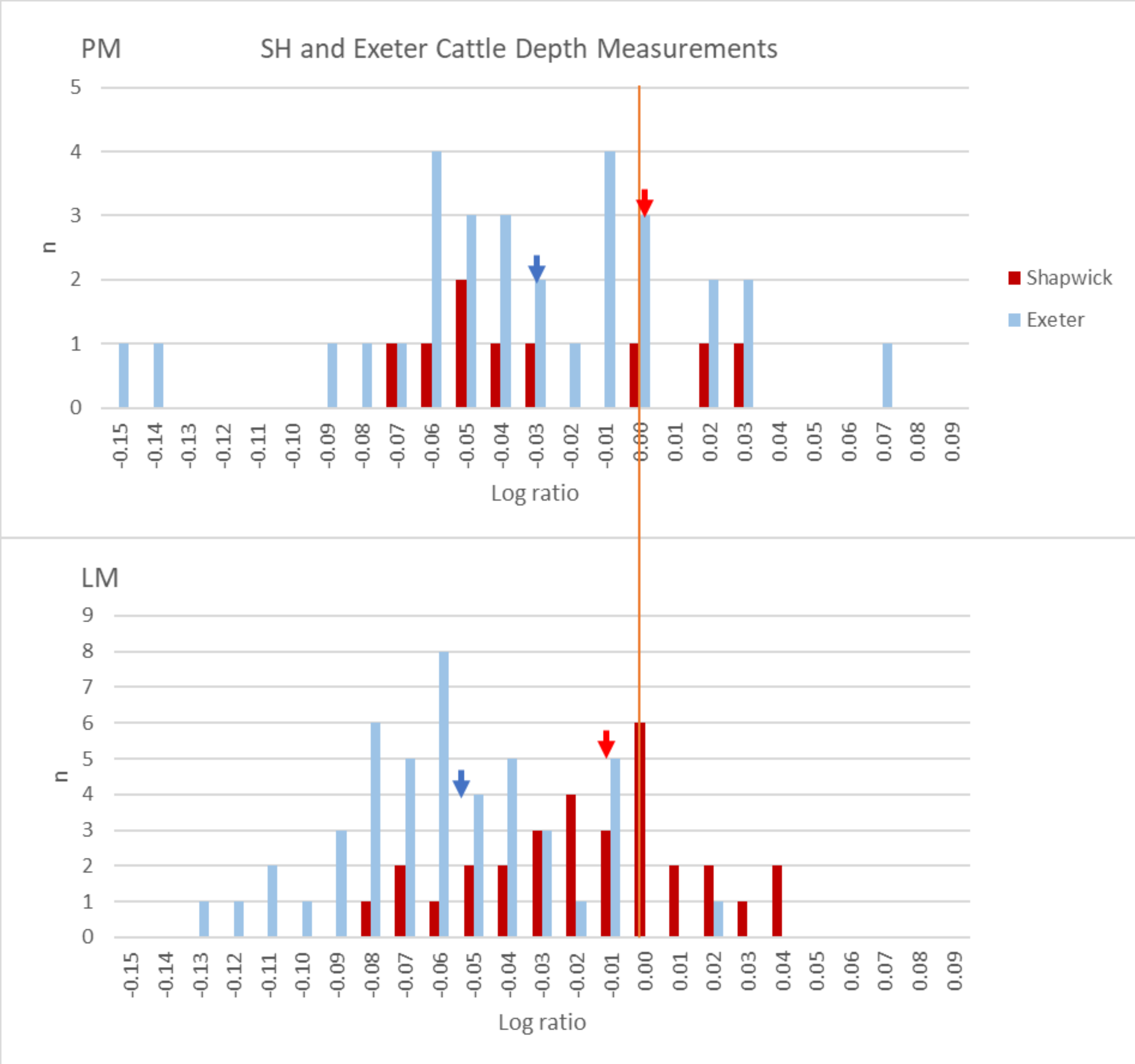

Figure 5.49: Comparison of Shapwick and Exeter cattle depth measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

Pig Metrics

As with the previous Shapwick metric results, pig length, width and depth measurements from Shapwick and Exeter were combined in the same log ratio assessment due to a small sample size (Figure 5.50). In the late Medieval period, the average pig measurement from Exeter is larger than the Shapwick value. However, in the post-Medieval period the Exeter value has reduced, while the Shapwick average shows a slight increase. These results suggest the presence of larger pigs at Exeter in the late Medieval period, but by the post-Medieval period the average Exeter pig population had diminished in size below the Shapwick average. This is unusual given the opposite trend in pig size recorded on other urban sites, and is perhaps due to the increasing exploitation of young animals (below).

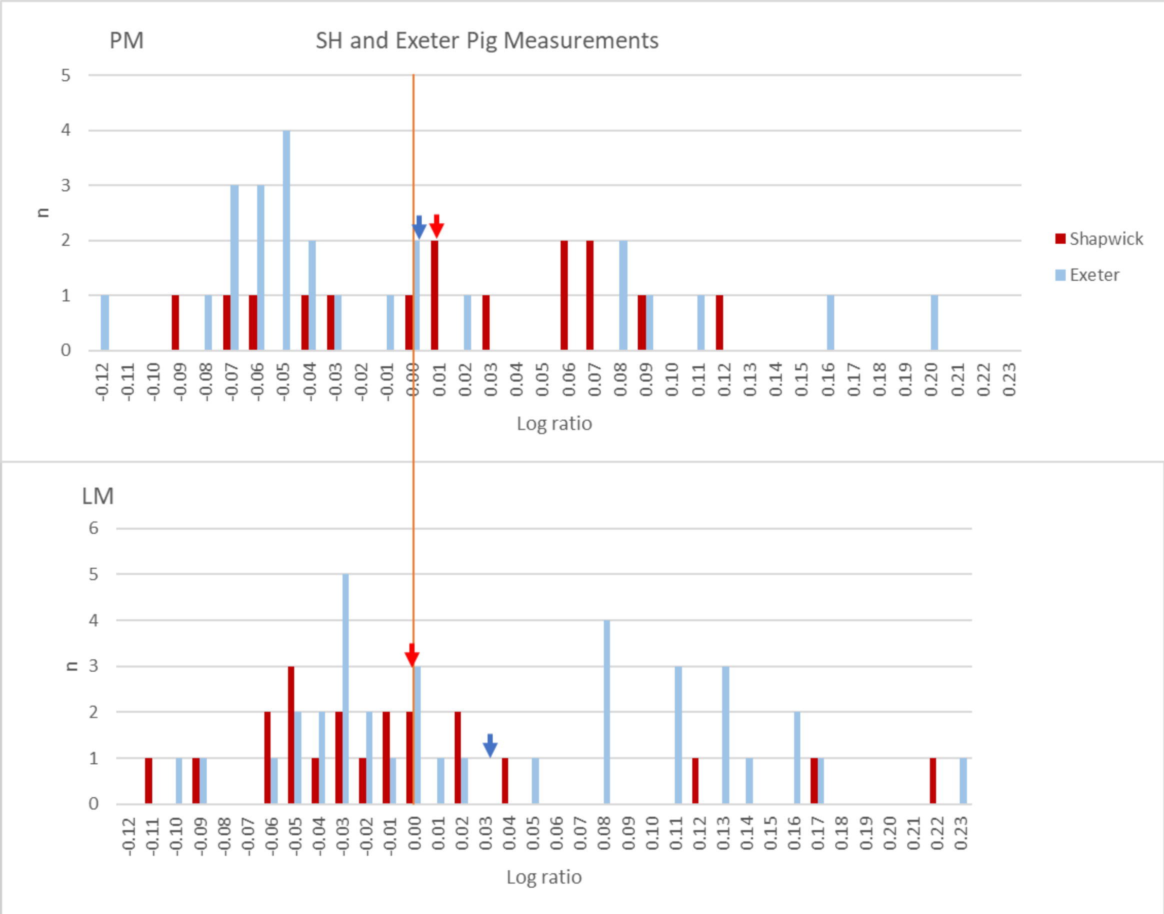

Figure 5.50: Comparison of Shapwick and Exeter pig measurements by period. Exeter measurements are shown in the light blue bars, with the Shapwick and Exeter means represented by the red and blue arrows respectively.

Age Profiles

Further to the metric assessment, a comparison of the herd age profiles from Shapwick and Exeter was carried out, in order to investigate the differing exploitation and potential trade of livestock between urban and rural areas. This was achieved using dental ageing data from both sites.

In the sheep ageing results from late Medieval Exeter (Figure 5.51), the highest proportion of kill-off occurs between six months and two years, indicating a lower rate of sheep survival past two years of age, which is suggestive of the slaughter solely for meat in the urban area. This somewhat contrasts the Shapwick data, which show higher survival until after four years, which is indicative of a mixed sheep exploitation for meat and wool. The post-Medieval results indicate a shift on both sites towards the survival of older sheep (Figure 5.52). At Exeter, while there is still a relatively high proportion of the flock killed at 6-12 months, there is a more even distribution of ages, with a particular increase in the amount of sheep surviving to four years. Similarly, at Shapwick, while there is still above a 15 percent kill-off between six months and a year, there is also a larger proportion of animals surviving past four years of age.

Overall, this suggests that in the late Medieval period, sheep were taken to the urban area to be exploited primarily for meat, whereas at Shapwick a mixed use of meat and wool is more likely. However, in the post-Medieval period, there is a shift away from young animals at both sites, meaning that a greater proportion of sheep on both urban and rural sites were surviving past four years, likely due to their role in the thriving wool trade.

Cattle ageing from late Medieval Exeter (Figure 5.53) shows a greater kill-off by 22 months compared to Shapwick where the majority survive past 22 months of age. This suggests that at Exeter cattle were more likely to be killed before reaching two years, though a considerable proportion do make it to the last age stage. Therefore, it is likely that a greater percentage of cattle in the urban area were exploited for meat before 22 months, likely taken there from rural areas for slaughter. The post-Medieval ageing results show a greater proportion of young individuals on both sites, but particularly at Exeter (Figure 5.54). This is likely due to the increasing popularity of veal in the post-Medieval period, resulting in a greater proportion of cattle under six months being slaughtered in urban centres like Exeter. The trade with rural areas could also exaggerate the pattern seen on urban sites, as young cattle may have been taken to urban centres for slaughter.

Pig dental ageing from Shapwick and Exeter show contrasting patterns from both sites across both periods. In the late Medieval period, there is a clear prevalence of older pigs surviving past 22 months at Shapwick (Figure 5.55). In contrast, at Exeter the highest proportion of pigs are slaughtered in the first two stages. This clearly indicates the presence of much younger animals at the urban site, suggesting the exploitation of very young pigs for meat, whereas at Shapwick pigs were allowed to mature further before slaughter, and some would have remained for breeding. This is also the case in the post-Medieval period (Figure 5.56). Overall, pig ageing results show the contrasting patterns of exploitation at both sites, with a much greater proportion of younger animals being killed at Exeter before 16 months, likely for meat. However, this frequency of young animals may be inflated by trade with rural sites such as Shapwick, as young animals may have been taken there for slaughter and subsequent sale of the meat.

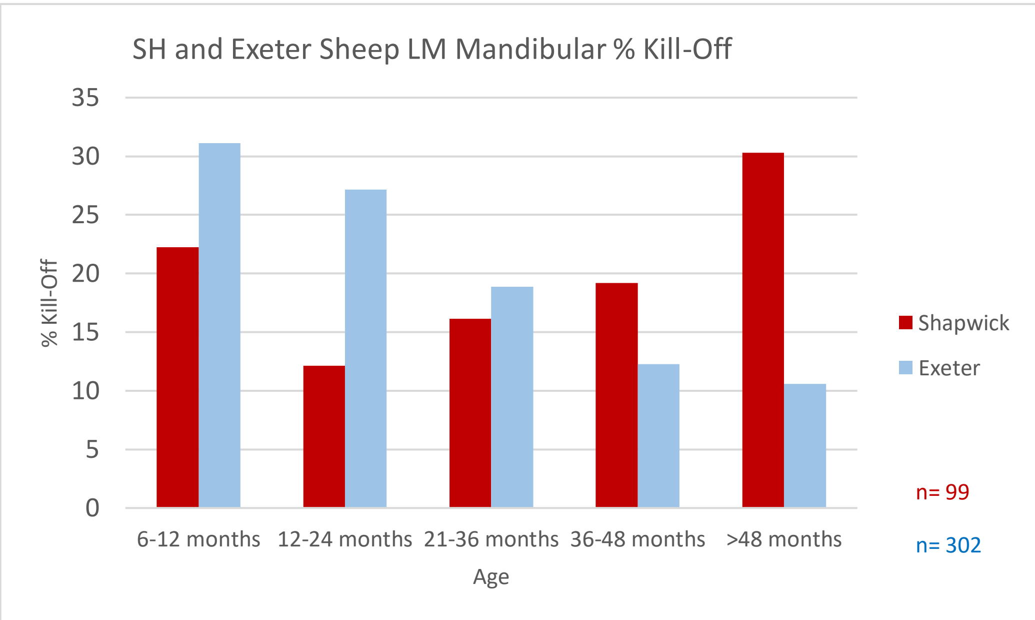

Figure 5.51: Comparison of late Medieval Shapwick and Exeter sheep dental age profiles.

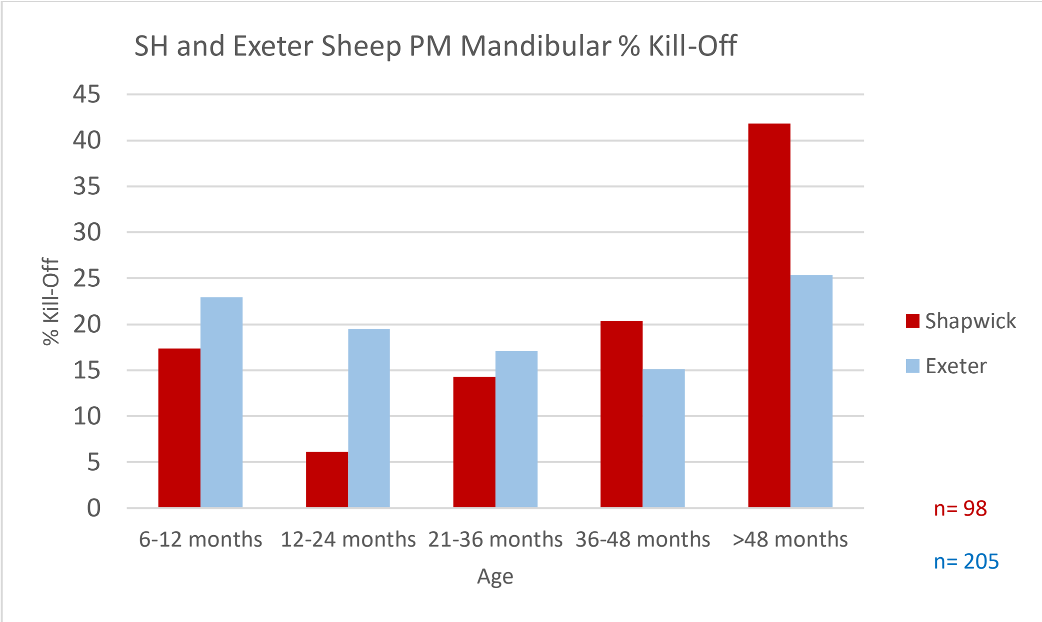

Figure 5.52: Comparison of post-Medieval Shapwick and Exeter sheep dental age profiles.

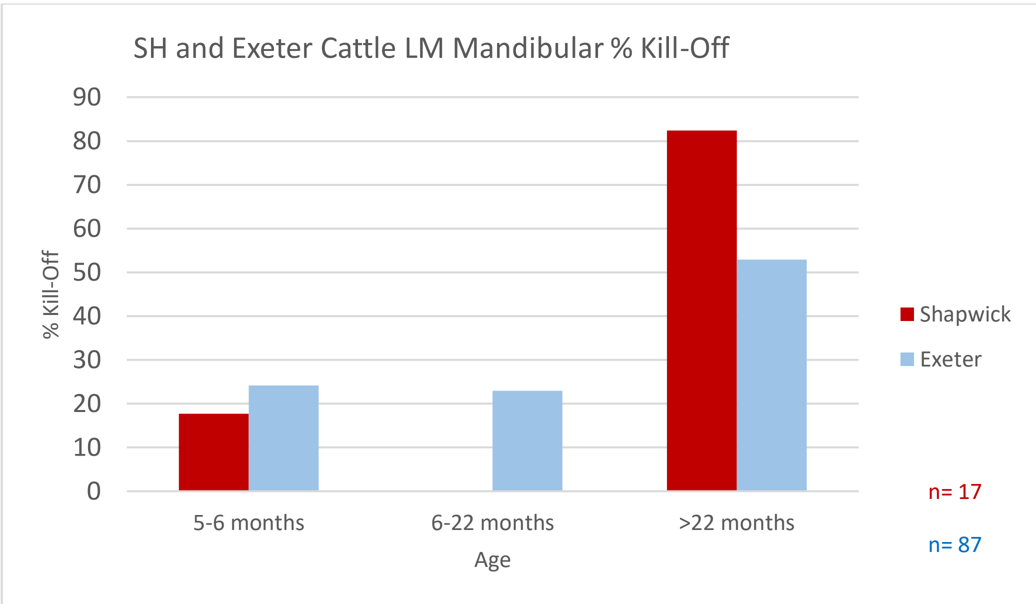

Figure 5.53: Comparison of late Medieval Shapwick and Exeter cattle dental age profiles.

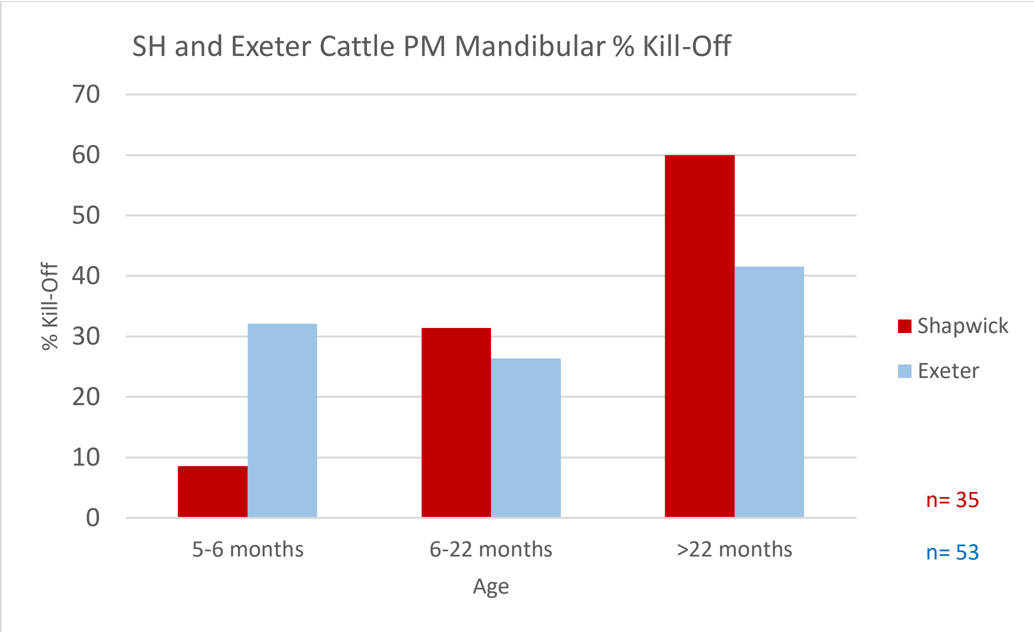

Figure 5.54: Comparison of post-Medieval Shapwick and Exeter cattle dental age profiles.

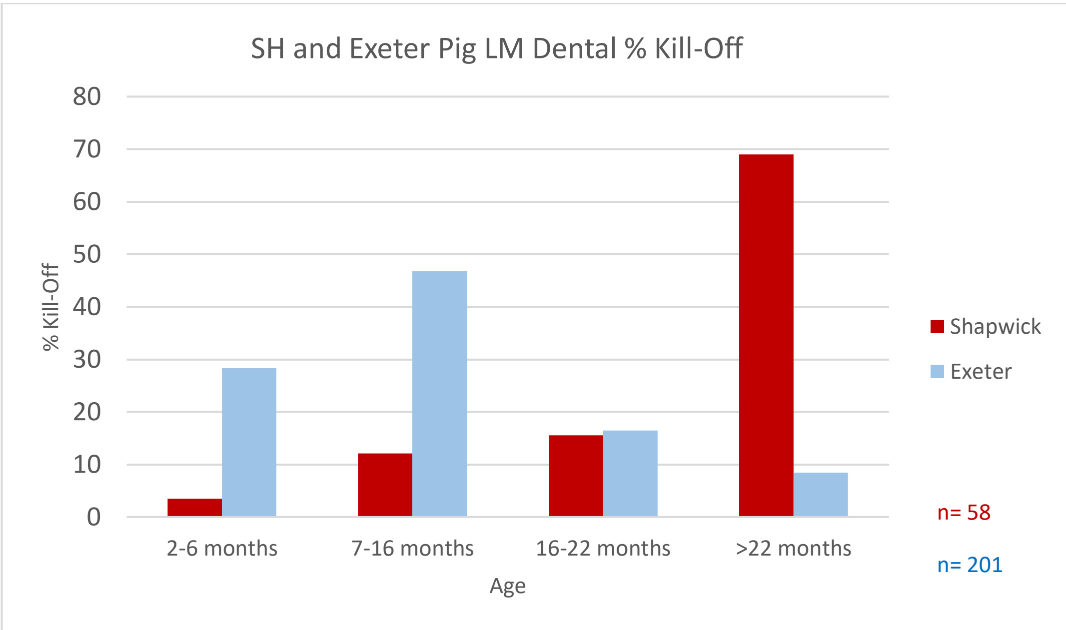

Figure 5.55: Comparison of post-Medieval Shapwick and Exeter pig dental age profiles.

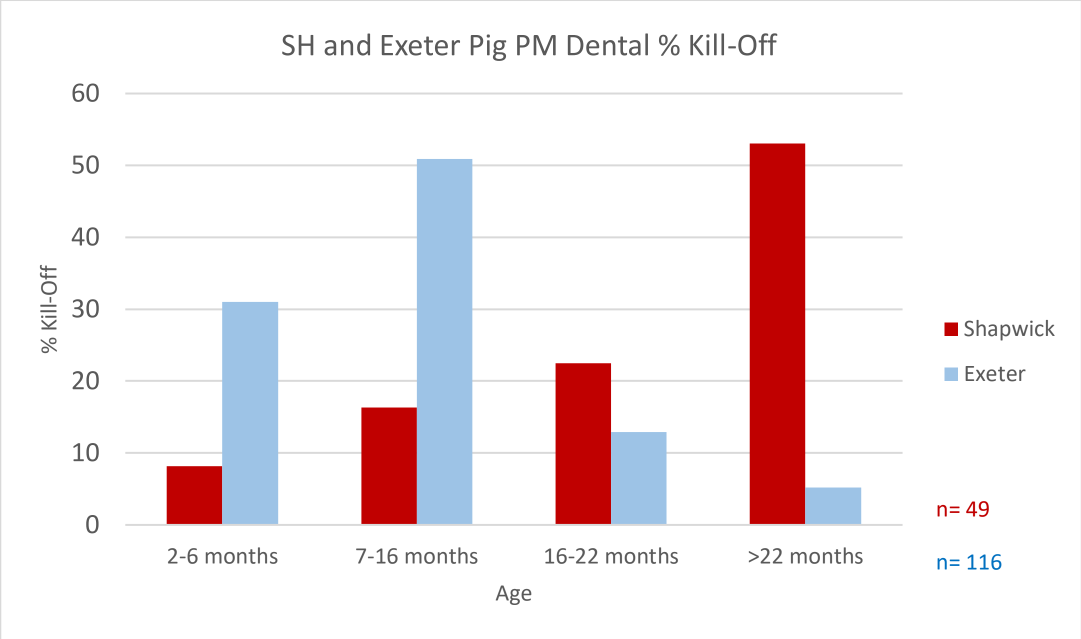

Figure 5.56: Comparison of post-Medieval Shapwick and Exeter pig dental age profiles.

5.3 Discussion

A number of patterns emerge regarding the changes in landscape organisation and livestock at Shapwick from the tenth to eighteenth centuries. A particularly striking change can be seen in the frequency of sheep at the site, as the species doubled in abundance during the late Medieval period and sustained this abundance until the end of the study period (see Table 5.20 for species frequency summary). This suggests a shift in husbandry strategy after the thirteenth century towards the importance of sheep products. Historic evidence supports these results, as it indicates that sheep were uncommon, and at times totally absent, at the site until an increase in population from the fourteenth century. The earlier Medieval scarcity of sheep was likely due to the control of Glastonbury Abbey, as its manors operated specialised farming practices. At Shapwick, which possessed land more suited to arable cultivation, wheat production was the primary focus, while upland sites contained greater numbers of sheep. Around the fourteenth century, when sheep increased in numbers, there are records of wool sales, and the transport of animals to Glastonbury before shearing. This suggests that sheep were re-introduced to the site primarily for wool production, likely motivated by the increasing demand for wool during the late Medieval period. This is mostly supported by the sheep ageing results from the late Medieval period, which show a greater survival of animals to 4-6 years (see Table 5.21 for summary of ageing data). However, the abundance of younger sheep specimens, particularly around one year, also points towards the exploitation of lambs for meat, suggesting a mixed exploitation of sheep in the late Medieval period, perhaps with the yearly cull of weak animals. This is supported by the limited butchery marks recorded from late Medieval Shapwick, which are indicative of some primary butchery of meat-bearing areas of the body. This trend continues into the post-Medieval period, indicating that sheep husbandry was never totally specialised at Shapwick. The increased prevalence of sheep at the site coincides with the beginning of piecemeal enclosure at Shapwick, and therefore may be linked to the gradual exchange and enclosure of common land strips. Most newly enclosed land was converted to pasture, perhaps providing more opportunity for keeping livestock. Furthermore, the parish was still under the control of Glastonbury Abbey until the end of the late Medieval period, meaning that the transfer of sheep between manors after the creation of enclosed demesne pasture was likely, as flocks were grazed on an inter-manorial basis.

The sheep metric results from Shapwick however, show no indication of size change in either teeth or post-cranial elements (see Tables 5.22 and 5.23 for metric summaries). Coefficient of variation values for the earlier Medieval teeth suggest a greater variation in that period, perhaps due to the inter-manorial mixing of sheep flocks, but caution in interpretation is needed due to the small sample size. Otherwise, variation in sheep size remains relatively constant throughout the study period. Within Somerset, Billingsley (1798) documented larger sheep in the north-east area, around Bath, but also a native Mendip breed which was hardy, thrived on poor soils and produced good wool and meat. He also records an improved Dorset breed in the south-east of the county. Furthermore, while the larger breeds of Leicestershire and Lincolnshire had been introduced elsewhere, they were not successful on Somerset land, as they were predisposed to developing 'foot-rot' on the wet pasture and displayed relative immobility. It is not clear which breed of sheep was present at Shapwick, though CV values, especially for post-cranial elements, may suggest a single breed at the site throughout the study period. Furthermore, metric results suggest that there was little change from the earlier Medieval period, meaning that the native Mendip breed may have endured. However, Shapwick had trade links with sites to the east, including Bath (see below), suggesting that the site had access to the larger breed recorded around the city. Overall, the lack of metric change exhibited by sheep throughout the study period may suggest that, despite altering landscape organisation from the fourteenth century, they did not undergo any size change. The only significant change in husbandry appears to have been the increased sheep frequency, relative to other species, in the late Medieval period, potentially caused by the establishment of additional pasture as the result of piecemeal enclosure, or as a reaction to the increasing demand for wool.

A contrasting change can be seen in the number of cattle at Shapwick, as they form the majority of the assemblage in the earlier Medieval period, but significantly decrease in frequency in the late Medieval period as sheep become more prevalent. Aston (1988) states that cattle and sheep were the main livestock across Somerset, making Shapwick relatively typical of the county, though the reason for these species frequency changes must be assessed. The high prevalence of cattle in the earlier Medieval period is likely due to the specialisation of the parish in corn production in order to supply the Abbey. Oxen were seen as superior to horses for ploughing (Billingsley 1798), meaning that draught cattle often formed a large part of manorial herds (Billingsley 1798; Postan 1953). Therefore, it is likely that the cattle in the earlier Medieval period at Shapwick were predominantly used for traction, to enable the extensive arable production for Glastonbury Abbey. This is largely supported by the ageing results, which suggest the survival of the majority of cattle into adulthood in the earlier Medieval period. However, in the late Medieval period, there is a slight shift in the herd profile, with a greater proportion of juvenile animals in the assemblage, which continues into the post-Medieval period. This pattern, alongside the clear reduction in cattle abundance, suggests a decline in their use for traction around the thirteenth to fourteenth centuries. As with sheep, this change may have been caused by the beginning of piecemeal enclosure in the fourteenth century, gradually creating pasture from open arable fields, potentially reducing the corn-producing capacity of the parish. As a result, cattle were required less for ploughing, and the higher presence of younger individuals suggests a shift to meat production. However, a large proportion of the herd still survived to adulthood, which could indicate that they were kept alive for milk or traction. Billingsley (1798) indicates that cattle in Somerset were predominantly used for dairying, stating that the cattle producing the best milk were selected and kept until around 15 years of age. This could mean that the older cattle at Shapwick were kept alive for milk production. Furthermore, while Thirsk (1967b) attests to the use of cattle in the marshland of Somerset for meat after 1500, the main breed recorded in the county during the post-Medieval period was the red Somerset and Gloucestershire cattle, which were tall, with large bodies, and small horns (Markham 1664, 70). This breed was particularly good for milking, suggesting the continuation of a dairy emphasis in the post-Medieval period. In combination with the ageing data from Shapwick, this suggests that cattle around six months to a year were exploited for meat, while older animals were likely used for dairy production in the late and post-Medieval periods. As a result, and accordingly to Billingsley (1798), carcass size was not always a priority.

However, cattle post-cranial length and width both increase in the post-Medieval period, after the sixteenth century. This could represent the introduction of a new breed, perhaps the red Somerset cattle, though the lack of tooth size change raises questions about the presence of genetic change and perhaps instead suggest altered nutritional plane or sex ratios. That being said, the CV values are highest for teeth in the post-Medieval period, indicating the presence of greater variation, perhaps with this introduction of this new breed. The increasing size of cattle may have been associated with a number of changes at Shapwick which were recorded in historical records. For example, the dissolution of the Abbey in 1539, and therefore greater control exerted over the parish by the local landowners, may have prompted a change in husbandry methods or livestock breeds. Similarly, the influence of Denys Rolle, an influential advocate of farming improvement, may also have prompted the size increase in cattle, again potentially with the introduction of new breeds or increased effectiveness of existing husbandry. However, without greater chronological detail, it is very difficult to ascertain exactly when in the post-Medieval period this change occurred, and why. Overall, cattle at Shapwick became much less prevalent after the earlier Medieval period, likely due to a decline in the amount of arable land reducing the need for traction animals. Historical and zooarchaeological evidence suggest that cattle were then likely used for meat and dairy production, while a size increase in the post-Medieval could indicate the introduction of a new breed, possibly brought about by either the dissolution of the Abbey or the ownership of Denys Rolle.

Unlike cattle, pigs appear to become slightly more common at Shapwick throughout the study period, increasing from 14 percent of the assemblage in the earlier Medieval period to 22 percent in the post-Medieval, almost as abundant as cattle. It is likely that pigs were exploited throughout the study period for meat at around two years of age, as suggested by the ageing results. As with cattle, the introduction of sawing marks is indicative of the intensification of butchery, though in pigs this occurs in the post-Medieval period. Historical evidence suggests that the relative prevalence of pigs at Shapwick was typical to the county overall, as Billingsley (1798) states that many pigs were reared in Somerset, with most bought at Bristol markets or from itinerant drovers. In contrast to cattle, pig do not appear to undergo any significant size change during the study period in either tooth or post-cranial elements, suggesting a consistent pig size from the earlier Medieval period. However, elevated post-cranial coefficient of variation values in the earlier and post-Medieval periods may suggest a greater heterogeneity of the pig population, potentially due to a mixture of breeds. There were a number of pig breeds present in Somerset by the post-Medieval period, including the native white, with large ears and a long body, and the Berkshire, which was black and white, as well as mixtures of several breeds (Billingsley 1798). However, there is no record of which of these breeds were present at Shapwick and whether this changed through time. Overall, pigs underwent little change at Shapwick in terms of exploitation or size. They may have become more common as the result of increasing pasture after the fourteenth century, though generally they show consistency despite gradual landscape change during the study period.

Horses are by far the least common of the main domesticates at Shapwick throughout all chronological periods, reaching only five percent of the assemblage by the post-Medieval period. Aston and Gerrard

(2013) state that both horses and oxen were a common sight in the village, though zooarchaeological and historical data suggest that cattle were likely favoured for traction. Horses do slightly increase in number by the post-Medieval period, perhaps due to increasing trade within the region, though they are still relatively infrequent at Shapwick. It seems that this is not unusual for a Somerset parish, as Billingsley (1798) suggests that even by the post-Medieval period few horses were bred in the county. It is likely that the horses present on the site were used for traction or transport, as ageing results show that the majority of animals on the site throughout the study period were adult. As with pigs, metric data for horses show no significant change in post-cranial size from the earlier Medieval period. This suggests that horses did not change in size throughout the study period, though coefficient of variation results indicate a very high variation in tooth and post-cranial measurements, which could be due to a mixture of horses, donkeys or mules, but there is no historical record of this.

Table 5.20: Summary of species frequency data for Shapwick by period. The text in blue give the sites where the highest proportion of each species is found in each period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	20% (NISP) of assemblage 7722	Over 60% (NISP) of assemblage 4016	14% (NISP) of assemblage 6477	Only 3% (NISP) of assemblage 4016
LM	Large increase to over 50% 5729, 7372, 7722	Large decrease to 25% 6477	Increase to 18% 6767	Increase to 4% 5729, 7372
PM	Still over 50% of assemblage 1000, 4016, 6477, 6767	23% of assemblage 0054, 6987	Increase to 22% OB, 6660, 7722	Increase to 5% 0054

Table 5.21: Summary of ageing data and likely exploitation of species for Shapwick by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM	Half of the flock killed before 4 years – meat? Absence of animals >4-6 years	High survival until around 3 years Traction/ meat (?)	Peaks in immature, subadult and adult Meat at c. 2 years onwards	High survival Traction/ transport
LM	Peaks in kill-off around 1 and 4-6 years Meat and wool?	Kill-off at six months and around 3-4 years - meat Larger proportion of the herd surviving past 4 years – traction/ milk?	Peak in adult kill-off Meat at c. 2 years onwards	High survival Traction/ transport
PM	Peaks in kill-off around 1 and 4-6 years Meat and wool?	Kill-off at six months and 1-3 years Meat	Peak in adult kill-off Meat at c. 2 years onwards	High survival Traction/ transport

Table 5.22: Summary of tooth metric data for Shapwick by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	No significant change CV: 10.4-5.9	No significant change CV: 7.5-8.6	No significant change CV: 6.7-6.5	N/A CV: 5.2-20.6
LM vs. PM	No significant change CV: 5.9-6.7	No significant change CV: 8.6-10.7	No significant change CV: 6.5-7.1	N/A CV: 20.6-14.2

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

Table 5.23: Summary of post-cranial metric data for Shapwick by period.

Species/ Period	Sheep	Cattle	Pig	Horse
EM vs. LM	No significant change CV: 7.8-7.5	Increase in tibia Bd* No significant change in length, width or depth CV: 7.3	No significant change CV: 11.2-6.7	No significant change CV: 11-7.6
LM vs. PM	No significant change CV: 7.5-7.9	Increase in humerus HTC* Increase in length** and width** CV: 7.3-8.5	No significant change CV: 6.7-12.2	No significant change CV: 7.6-14.5

*Statistically significant change (P<0.05)

** Highly statistically significant change (P<0.01)

In order to fully understand any change in livestock at Shapwick, it is important to assess potential trade links the parish may have had both locally and across a wider area, as it is likely that the site supplied not only Glastonbury Abbey and its manors in the earlier Medieval period, but also other urban areas in the following periods. Shapwick's link to local markets is suggested by the road name *Veryswey*, meaning 'road to the fair', which ran through the middle of the parish, on the same line of the modern Northbrook road (Aston and Gerrard 2013). Historic evidence suggests that markets in Somerset had developed from the Saxon period onwards, in towns like Frome and Bruton (Aston 1988). Frome was noted for wool production, alongside Shepton Mallet, though cloth production was also noted around Yeovil, Chard and Crewkerne (Billingsley 1798). Furthermore, sheep were sold to suppliers as far afield as the Bath and even London markets. Therefore, sheep from Shapwick may have supplied the local wool trade, but also larger urban centres like Bath or London. Cattle from Shapwick were also likely to have been traded further afield, with Somerton, Bath and Frome noted by Everitt (1967) for particularly thriving cattle fairs by the post-Medieval period. Cattle were also driven to markets in Salisbury and Bristol, as well as London, as the "red oxen of Somerset and Devon" were favoured both for traction and meat over "North-country" animals (Billingsley 1798, 242). Conversely, stock was also purchased for fattening in Somerset from across the West Country, including towns like Bristol, Taunton, Exeter and Okehampton. Overall, it is likely that cattle were exchanged across the West Country, as well as north and east to Bath, Bristol and London.

The comparison of Shapwick and Exeter data was carried out in order to compare the size and age profiles of livestock between the urban site and a potential rural production site. For sheep, metric data show that animals at Shapwick were larger, in terms of post-cranial length, width and depth, in the late Medieval period, but an increase in size at Exeter made them more comparable in the post-Medieval period. This suggests that sheep at the rural site were in fact larger than those in the urban centre in the late Medieval period, though they do not exhibit the same post-Medieval size increase. This may have been due to Shapwick's link to other sites such as Bristol, Bath and London, which may have provided larger breeds. Furthermore, the late Medieval age profiles for both sites show a greater prevalence of young animals at Exeter, which may reduce the average animal size. This abundance of young animals at Exeter in the late Medieval period indicates the slaughter of lambs for meat in the city, which contrasts the Shapwick ageing pattern, where a larger proportion of animals survive to an older age. However, it may be that the younger sheep from Shapwick were sent to urban areas like Exeter for slaughter, removing a proportion of younger animals from the herd profile. In the post-Medieval period, the shift to older animals at Exeter likely reflects the rise of the wool trade from the sixteenth century, with the city's three dedicated markets making it the wool centre of the south-west (Exeter Memories 2013). As a result, it was likely that both wool and sheep from the surrounding region were traded at Exeter, making it plausible that wool produced from sheep at post-Medieval Shapwick was taken to Exeter for export.

Cattle measurements show a striking pattern between the two sites, as it appears that cattle from Shapwick were larger than those found at Exeter across both chronological periods, with a post-Medieval increase in size seen on both sites. It may be that larger animals were selectively bred at Shapwick, or that trade with sites to the east allowed Shapwick to obtain larger breeds. Younger animals exploited for meat at Exeter may also have decreased the average size there. The late Medieval ageing results do show a greater proportion of cattle under 22 months at Exeter, which may suggest that animals were taken there for slaughter. This may explain the relative absence of cattle under 22 months, and indeed the dramatic overall decrease in cattle abundance, at Shapwick, suggesting that they were taken to urban markets for slaughter and sale of meat. There is an even greater proportion of cattle between five and six months old at Exeter in the post-Medieval period, which may reflect the increasing urban demand for veal, resulting in the slaughter of cattle up to six months of age. This pattern may have been exaggerated in areas like the West Country, where the dairy exploitation of cattle was common, as male calves may have been sent for slaughter in urban centres. Therefore, at Shapwick the older cattle recorded in the post-Medieval ageing results may have been predominantly used for dairying, while a relative lack of very young cattle may have been caused by the transport of male calves to urban centres for meat production.

In contrast to sheep and cattle, the pig metric results indicate that animals at Exeter were larger in the late Medieval period, but appear to decrease in size in the post-Medieval period to a size comparable to Shapwick. This suggests a decrease in the size of pigs at Exeter in the post-Medieval period, though a small sample size makes this questionable. The ageing results show a clearer pattern, as in both the late and post-Medieval periods pigs at Exeter are predominantly killed between two and 16 months, whereas a large proportion of pigs at Shapwick survive past 22 months. This contrast is likely due to the slaughter of pigs at a young age for meat in Exeter, which may include pigs raised in the city, but could also be exaggerated due to pigs brought in from rural areas for slaughter. This may also explain the lack of pigs younger than 22 months at Shapwick, as they may have been transported to urban areas for slaughter, leaving the older breeding population at the rural site.

Overall, the historical and landscape evidence from Shapwick suggest a parish undergoing gradual change, from the arable specialism dictated by Glastonbury Abbey in the earlier Medieval period, through the piecemeal exchange and enclosure of common land which progressed from the fourteenth century onwards, resulting in a largely enclosed, pastoral site by the eighteenth century. While much of the zooarchaeological data, particularly the metric results, suggest a lack of livestock change during this period, some developments, particularly concerning cattle and sheep, seem to have coincided with the gradual landscape change. For instance, the significant increase in sheep abundance from the late Medieval period may represent the incremental increase of pasture due to piecemeal enclosure, though it also likely stemmed from the development of the wool trade, making sheep farming a more profitable venture. Furthermore, the increase in cattle size seen in the post-Medieval period may have been the result of the increasing abundance of enclosed, private land, allowing for a greater selection of stock. However, it was more likely the result of the dissolution of the Abbey in 1539, which removed ecclesiastical control from the manors, thereby allowing wealthy landowners such as Denys Rolle to introduce improved husbandry methods and breeds. In summary, there appears to have been a complicated mixture of factors affecting livestock husbandry and the extent of change at Shapwick across the study period. Gradual piecemeal enclosure may have been one of these factors; however, it is unlikely that what little livestock change is demonstrated would have been present without other factors such as Abbey control, market demand, and the actions of individual landowners.

6. Discussion

The following chapter revisits the research questions set out in Chapter 1, in light of the historic and zooarchaeological evidence presented in the results chapters. Section 6.1 and 6.2 discuss the landscape and livestock changes occurring across England, with a focus on evidence from the case study sites, while section 6.3 explores the potential link between these concurrent changes.

6.1 Type and Timing of Enclosure in Rural England

As described in the first chapter, enclosure occurred throughout England in various different forms during the late Medieval period, and at varying speeds. While Parliamentary enclosure has often been discussed alongside improvement in farming methods, it is clear that a significant amount of the country had already been enclosed by the time this method gained pace in the seventeenth and eighteenth centuries. In fact, by 1700 only about a quarter of the country was left unenclosed, causing Butlin (1979, 75) to assert that Parliamentary enclosure was not as crucial to agricultural improvement as previously suggested. Enclosure prior to this is largely grouped into two main types: general enclosure by agreement, and piecemeal enclosure, which were applied to differing geographical regions throughout England. The case study sites discussed in this thesis provide an insight into how, when and why enclosure came about in the different farming 'countries' across England, including the arable south-Midlands, sheep-corn fields of the Wolds, and the stock-fattening and dairy pastures of the south-west (Wrightson 2000, 88).

Great Linford is a typical example of the late Medieval 'Champion' Midland landscape, as discussed in Chapter 3, with strict communal control of three open fields and common grazing for livestock, mainly sheep and cattle. Like much of the Midland open field band of countryside, Great Linford was subject to general enclosure by agreement in the seventeenth century, though the road to enclosure began earlier in the previous century, when Sir Richard Napier inherited holdings in the parish and began to amalgamate land. While other parishes in Buckinghamshire were enclosed as early as the sixteenth century, the agreement at Great Linford took place in 1658, with Napier as the primary instigator. There were many motivating factors behind the enclosure at Great Linford, including the desire for more efficient farming and an increasing demand for grazing land due to the rising value of animal products like wool. Greater control over livestock was also sought through enclosure, as escaped stock on arable land was documented in late Medieval Great Linford. Furthermore, the increasing population in Buckinghamshire in the sixteenth and seventeenth centuries had caused overly complex cropping regulations to meet the demand for food, which could be removed with enclosure. As a result, the three large open arable fields and common grazing land of the late Medieval period were replaced with new smaller and more regularly-shaped land parcels, delineated by hedges, ditches and roads relatively soon after the enclosure agreement. A drastic change in land use also accompanied enclosure, as the majority of the land in the parish was converted to pasture, a trend common to all case study sites assessed.

Despite its location in a different farming region dominated by sheep and corn, Wharram Percy exhibits some similarities to Great Linford in the late Medieval period, though the site experienced a more prolonged enclosure process with varied causes, discussed in detail in Chapter 4. In the early to late Medieval period, Wharram Percy displayed the characteristics of an open-field township, with two large open arable fields accompanied by areas of permanent common grazing. Much like in Buckinghamshire, the trespass of livestock onto the common arable land was an issue which may have contributed to enclosure. However, unlike Great Linford, the parish also had access to areas of intercommoning on the high Wolds, which meant that pasture was not in short supply, which appears to have been a motivating factor at Wharram Percy. The site was particularly suited to sheep pasturing, due to the free-flowing water running through the parish, which could be used to wash sheep before shearing. As a result, in the fourteenth and fifteenth centuries, as wool prices rose, land in Wharram Percy was increasingly dominated by sheep pasture, starting with the conversion of the less fertile areas and uplands first. This resulted in the destruction of houses, and eventually the depopulation of the village, which suggests a significant change in land use before the commencement of enclosure. By 1527, Wharram Percy had been totally laid to grass and given over to sheep husbandry overseen by non-resident graziers. Like Great Linford, the parish was enclosed in the sense that all common rights had been removed; however, unlike the Buckinghamshire parish, the landscape of the Wolds was not physically enclosed with newly-delineated land parcels, but remained a large-scale sheepwalk. Furthermore, Wharram Percy underwent a continued process of landscape change in the post-Medieval period, which began with the introduction of the infield-outfield system in the seventeenth century, still heavily focussed on sheep with arable not producing a surplus. Enclosure in the traditional sense of the physical segregation of land did not occur in the parish until the eighteenth century, when Sir Charles Buck's programme of 'Improvement' resulted in the conversion of much pasture back to arable land, and the delineation of new hedged or fenced fields to accompany new farms. Therefore, while Wharram Percy shared some similarities with Great Linford, particularly the parish structure during the late Medieval period, it appears that the process of enclosure at Wharram Percy was much more prolonged, with its origins in the fourteenth century but physical segregation of land parcels not occurring until four centuries later. Furthermore, the motivation for the removal of common rights at Wharram Percy appears to have been predominantly the large-scale rearing of sheep so prevalent in the Wolds, which led to the eventual depopulation of the parish – a phenomenon not seen at Great Linford.

At Shapwick, a different pattern of land use and enclosure is evident, as discussed in further detail in Chapter 5. While the parish did implement an open farming system from the early Medieval period, not all farmers were involved in farming the common arable land, and much pasture was held in severalty, unlike Great Linford or Wharram Percy. However, there was no lack of grazing at Shapwick due to the extensive moors to the north, on which livestock were intercommoned. In contrast to the other study sites, Shapwick was not controlled by secular landholders, but was a manor of Glastonbury Abbey. As a result, changes in landscape and land use were largely dictated by the Abbey until its dissolution in the sixteenth century, and the site was predominantly exploited for wheat. It appears that a major motivator for enclosure at Shapwick was increased efficiency, allowing for increased livestock breeding control, as well as increased cropping intensity and the introduction of new crops. However, it is likely that the Great Famine of 1315-17 and the Black Death brought about the beginnings of enclosure at Shapwick as early as the fourteenth century due to decreases in population. This resulted in many empty tenements, which landowners amalgamated into their existing holdings. Thus began the process of piecemeal enclosure at Shapwick, as small parcels of land were exchanged and enclosed from common fields, and often converted to pasture. This process continued through the fifteenth to eighteenth centuries, gaining pace after the dissolution of the Abbey, which resulted in over the half of the parish being enclosed in a piecemeal fashion and converted to pasture as an increasingly specialised pastoral economy emerged. By the seventeenth century, all of the parish except the Levels had been affected by consolidation and enclosure. In contrast to the other sites, where enclosure created regularly shaped new enclosures, piecemeal enclosure at Shapwick resulted in small, linear fields which followed the edges of former strips. The final phase of enclosure at Shapwick was carried out by Denys Rolle, who was fundamental in the development of the Shapwick Enclosure Bill in 1777, which finally enclosed Shapwick Heath, as well as the late eighteenth century drainage of the Levels. Overall, Shapwick represents an example of what Dyer (2000, 165) refers to as an 'old enclosed' area common to the south-west of England, where early piecemeal enclosure resulted in areas of open field mixed with enclosures, and total enclosure of the parish was very gradually achieved through the exchange and consolidation of strips rather than the simultaneous removal of all common rights.

In summary, the three rural case study sites highlight a number of similarities across the country, as well as several differences in the timing and mechanism of enclosure across England. It seems that across all three regions the motivations for enclosure were relatively similar, with the control of livestock particularly emphasised at Great Linford and Wharram Percy, while the conversion to pasture in order to take advantage of rising animal product prices features across the country (Wrightson 2000, 13). The case study sites also all feature influential landowners at the forefront of the process of enclosure, though in the cases of Wharram Percy and Shapwick they were a later influence and certainly not the impetus. While the motivation for enclosure may have been somewhat aligned, the timing and results of this landscape change differs across the sites, demonstrating the variation across England. For example, enclosure at both Great Linford and Wharram Percy ultimately resulted in regularly-shaped enclosures, though at Wharram Percy the delineation of new enclosures did not occur simultaneously with the removal of common rights. Furthermore, enclosure at Wharram Percy was accompanied by depopulation, not a feature shared by the other sites, and began three centuries before the agreement at Great Linford. Like Wharram Percy, enclosure at Shapwick was also a gradual process spanning four centuries, but took place very differently in a piecemeal fashion producing irregular, linear fields, rather than the regular fields seen in the other regions. This highlights the particular prevalence of piecemeal enclosure in the south-west of England, where land was gradually removed from common fields. Ultimately, by the end of the eighteenth century, all of the case study sites had experienced the removal of common rights, and the physical delineation of new land parcels, though the mechanism of this change and resulting landscape organisation clearly varied greatly across the country.

6.2 Livestock Changes Across Rural England

As discussed in Chapter 1, a number of key livestock changes occurred in England during the late and post-Medieval periods, which have been documented on a countrywide scale, but can also be seen to varying degrees on the three case study sites. These changes include the increasing demand for wool production, the shift to horses for traction power, the expanding market for meat, especially veal, and the size increase of domesticates. However, these phenomena have previously been largely studied on urban sites, so here the rural case studies are assessed within the wider countrywide trend. This includes the assessment of how trade with urban centres may affect the spread and archaeological manifestation of livestock change.

Wool Production

There was a general trend towards increasing sheep frequency, at the expense of cattle and pig, in the early to late Medieval transition (Albarella 1997a, 24; Sykes 2006, 58). This likely reflects the burgeoning wool trade, which started to develop in England from the twelfth century, starting a shift from small-scale husbandry to "a vast network of industry and commerce founded upon a humble sheep" (Trow-Smith 1957, 132). An increasing frequency of sheep is certainly evident across all three case study sites, as numbers rise during the late Medieval period. This is particularly clear at Shapwick, where sheep more than double in frequency, replacing cattle as the most prevalent species. This is typical of the countrywide pattern during the early to late Medieval transition, as sheep increased in numbers throughout the country from the twelfth century, peaking in the fourteenth century, by which time sheep husbandry played a "disproportionately large part in the pastoral scene" (Trow-Smith 1957, 89). This was particularly the case on rural sites, where Sykes (2006, 61) argues that sheep formed a significant part of the meat consumed, alongside their use for wool. Regional animal types had also developed by this period, selected for the quality of their wool. For example, Lincoln sheep were recorded from the thirteenth century in Wiltshire and Yorkshire, which were said to produce wool "of a strength, softness and length unequalled elsewhere in Europe" (Trow-Smith 1957, 166). However, the particularly significant increase in sheep frequency at Shapwick in the late Medieval period seems unusual in the south-west of England, where Trow-Smith states that cattle predominated. This may have been caused by the control of Glastonbury Abbey, which resulted in the specialisation of individual manors, and potentially the transfer of sheep to Shapwick from another manor (Ecclestone 2007, 30). It may also stem from Shapwick's connection to urban sites in the east, such as Bath and London, allowing access to the burgeoning wool trade in these areas. This interpretation is supported by fourteenth century historical evidence for wool sales in the parish. Sheep continued to be the dominant species across all three sites in the post-Medieval period, reflecting a continuation of their economic importance. Again, this appears to have been a countrywide trend, as by the eighteenth century there were 11 million sheep recorded in England, rising to 26 million by the end of the century, which were producing 94 million lbs of wool (Deane and Cole 1967, 68-74). According to Trow-Smith (1957, 133-134), this production of wool was centred around towns in the north and east midlands, which supported the international trade of high-quality cloth to Flemish and Italian buyers, while large cities in the south such as London, Oxford and Winchester produced large quantities of cheaper, lower quality woollen cloth. Therefore, it may be that the wool produced at Wharram Percy was included in the high-quality cloth production of the north, while sheep at Shapwick and Great Linford produced the cheaper cloth sold through cities like London. However, Dyer (2014, 17) states that rural cloth-making developed across the country, in Devon, Somerset, Wiltshire, Berkshire, Gloucestershire, Kent, Essex, East Anglia, the West Riding of Yorkshire, Lancashire, and the Lake District. This shows the increasing importance of sheep as wool producers countrywide from the late Medieval period.

In addition to the quantity of sheep, herd profiles also demonstrate the increasing reliance on wool production. A predominance of older sheep in the review of central English sites by Albarella (2019) indicates that the main product from sheep was wool. Though the peak in the wool trade was historically in the 13th-14th century (Albarella 1997a, 23-4), mortality profiles show a continuation of older animals throughout the Late Medieval period. Trow-Smith (1957, 151) states that there was no specific Medieval guidance on when to cull sheep, though "so long as it had the teeth to eat and thrive" it was kept for wool, with diseased, weak or old sheep being fattened for meat. However, it is likely that sheep were slaughtered after two or more fleeces had been produced, particularly after the fourteenth century, when sheep mortality peaked after three years of age (Albarella 1997a, 24; Sykes 2006, 63). The age profiles from the case study sites appear to support this throughout the late Medieval period, with a continuation into the post-Medieval. This suggests an emphasis on wool in rural areas across the country, though not a total specialisation as there was some kill-off at earlier ages. This continued into the post-Medieval period, as evidence from Smithfield market in London suggests that sheep kept for wool were not killed for urban meat consumption until at least three years, though older animals may also have been consumed in rural areas and not sent to the London market (Deane and Cole 1967, 71). The presence of older animals in the rural case study sites reflects this, likely consumed when they were no longer fit for wool or breeding. Overall, a significant increase in the frequency of sheep, as well as herd mortality profiles, suggest a countrywide shift to wool production from around the thirteenth century, though even in rural areas sheep husbandry was not totally specialised.

Traction Power

Another key change in the late Medieval period was the gradual replacement of cattle for traction, which Langdon (1986, 254) argues had begun by at least the twelfth century, though again showed geographical variation. The frequency of horses is useful in highlighting this change throughout the country, though disposal practices may have had a bearing on numbers (Albarella 1997a, 22). Historic evidence suggests that in the early Medieval period, work horses in England comprised on average c.5 percent of livestock, which equated to one horse for every 19 oxen, showing the clear preference for all-oxen plough teams, though horses may have been used for carrying, transporting people or harrowing (Langdon 1986, 29; 1989, 33). There were records of large stud farms in the Anglo-Saxon period at Burton Abbey in Staffordshire, Troston in Suffolk, and Ongar in Essex, though horses remained a "luxury beast" in the early Medieval period, for military use or riding animals for the wealthy (Langdon 1986, 22-6). It appears that the frequency of horses varied throughout England, with fewer generally in the west, while peasant farms tended to use horses more than demesne land, particularly in areas like East Anglia and the Home Counties, as they were cheaper to purchase (Langdon 1989, 34; 1986, 187). This is evident in the early Medieval horse frequencies at the study sites, as horses are poorly represented at Shapwick in the west, but more common at Great Linford and Wharram Percy during this period. From the twelfth century, a gradual increase in the frequency of horses began, though again with some regional variation, with the first instance of horses for ploughing in a mixed team being recorded at Ramsey Abbey, Cambridgeshire. This increase in work horses may have been due to a more robust horse apparently introduced by the Normans, better plough design, and an increased demand for beef (Trow-Smith 1957, 92). However, horses largely remained in mixed teams with oxen as this increased ploughing speed whilst retaining the strength of the oxen. It seems that they were particularly common in East Anglia, but also recorded across the East Midlands, Kent, Buckinghamshire and Berkshire, though remained below ten percent of the total livestock in the south, south-west, West-Midlands and the north (Langdon 1986, 38-53). Therefore, it is probable that the horses found at sites like Great Linford and Wharram Percy in the early Medieval period were part of mixed plough teams when not used for other traction purposes. The regional variation seen in horse frequency is likely due to variation in fodder and soil types. For example, horses fared better on lighter soils, which were more common in the east, while oxen were better-suited to the rough pasture and heavier soils found more often in the north and west (Edwards 2007, 183). Furthermore, in areas like East Anglia where pasture was less common, traction animals were fed more grain, which was more suitable for horses (Langdon 1982, 33; 1986, 159-160). Despite this geographical disparity, Langdon (1986, 19) states that from the Anglo-Saxon period onwards there was a "substantial, even massive, introduction of the horse to general draught work".

By the thirteenth to fourteenth centuries the overall average frequency of work horses in England on demesne land had risen to c.27 percent, which represents a significant rise from the twelfth century, though oxen still numbered between two and three per horse. However, in some counties, such as Hertfordshire, Essex and Norfolk, greater proportions of working horses were present, in contrast to the counties in the west and north (Langdon 1986, 87; Edwards 2007, 183). This was certainly the case at Shapwick, where horse frequency remained below five percent in the late Medieval period, though further north at Wharram Percy there was an increase to 12 percent. After the Black Death, the proportion of horses increased further as all-horse plough teams became more common, though Langdon (ibid., 212) argues that this led to a polarisation across the country, where some farms in areas like Norfolk and Dorset converted entirely to horse teams, while other sites in the west and north reverted to oxen only. It is therefore somewhat surprising that the most northerly site, Wharram Percy, exhibits the highest proportion of horse by the post-Medieval period, which may suggest the transition to all-horse plough teams, though this phenomenon was also recorded in nearby Wetwang and Market Weighton. The post-Medieval increase in Great Linford, though later and less substantial, may also reflect the shift towards the use of horses for traction. A higher occurrence of pathologies like spavin in the post-Medieval period may be linked to increasing traction stress in horses (Albarella 2019), meaning that a greater proportion of lower leg pathology from Wharram Percy from the late Medieval site could also reflect the shift to horses for traction, though these conditions may also be age-related. This evidence, coupled with a decrease in similar pathological changes in cattle, supports the argument of a greater use of work horses across England from the late Medieval period. However, the consistently low frequency of horse at Shapwick appears to be typical of the west of England, where it is likely that oxen remained the predominant work animal.

There are a variety of reasons why horses became more common in some regions of England during the late Medieval period; for example, they were more versatile than oxen, as they could be used for hauling, harrowing, riding and as pack animals (Edwards 2007, 184). Furthermore, as they did not have the same meat value as oxen, they could be bought more cheaply (Trow-Smith 1957, 93; Langdon 1982, 40; 1989, 35). However, a number of factors may explain the variation in horse distribution across England which is seen in the case study sites. Preferences were largely based on soil type and terrain, as horses were more suited to light soils or stony land, meaning that they gained more purchase in areas like Norfolk, the Chilterns and the Yorkshire Wolds (Langdon 1986, 256-259). This may explain the particular prevalence at Wharram Percy from the 14^{th}-15^{th} century. Furthermore, horses were more commonly introduced in drier areas with less pasture, as they could be effectively fed on grain, reflecting the scarcity of work horses at Shapwick, which neighbours the wetlands of the Somerset Levels. The proximity of large urban markets closer to Wharram Percy and Great Linford might also explain the presence of horse on these sites, as the development of markets allowed for the sale of unwanted bullocks, which had previously been used for traction (Langdon 1989, 36). Finally, land holdings featured in the spread of work horses; for example, in the east of England, holdings were smaller and more fragmented from an early date, making horses more suitable as they could be employed in smaller teams (Langdon 1982, 40). This may imply that enclosure aided the spread of work horses, potentially explaining the increases at Wharram Percy and Great Linford in the post-Medieval period. Particularly on the Yorkshire Wolds, holdings were very large even after enclosure, which Edwards (2007, 184) argues necessitated the use of a greater number of working horses. However, on the site with the smallest and earliest enclosures horses were least frequent, again suggesting that the wet soil conditions caused the continuation of oxen as plough animals. Overall, while it is clear that work horses became more common from the late Medieval period, the sites studied here demonstrate a regional variation in their adoption. Their prevalence at Wharram Percy reflects the suitability of horses to lighter, stony soils, and the potential establishment of all-horse plough teams, while the heavier clay soils at Great Linford seem to have somewhat limited their introduction. Finally, the continued lack of horses at Shapwick highlights the limited use of horses in the West Country, and the likely reversion to all-oxen teams.

The Market for Meat

From the fifteenth century at least, an increased level of meat consumption in England has been demonstrated, particularly in urban areas (Dyer 2002, 323; Woolgar 2006). Pigs were likely used for meat throughout the study period, but there is evidence for the intensification of meat production from the end of the late Medieval period, as the increasing presence of younger animals in zooarchaeological data could represent the development of faster-growing animals. This trend has been identified at sites like Norwich, Exeter and Lincoln (Albarella 1997a), where pigs were slaughtered within their first year. The results from the case study sites do suggest that pigs were killed for meat, though not until around one to two years across all chronological periods. However, the comparison of Wharram Percy and Shapwick to nearby urban sites highlights how trade with towns may affect how change occurring on rural sites is manifested archaeologically. In both cases there are post-Medieval increases in younger animals on the urban sites, which are not observed in the rural case studies. This therefore suggests that, while the increasing demand for meat after the fifteenth century may have led to the development of faster-growing pigs, these animals are predominantly recorded on urban sites where they were likely bred or taken for slaughter.

A similar pattern can be seen for cattle from the late Medieval period onwards as the increasing use of horse for traction allowed a greater exploitation of cattle for meat. Studies of urban and high-status sites, for example Norwich, Exeter, Lincoln and Leicester, have shown an increase in juvenile cattle bones from the fifteenth century, which could suggest an increase in veal production at that time (Albarella *et* al 2009; Maltby 1979; Dobney *et al* 1996; Gidney 1991a). Furthermore, Deane and Cole (1967, 70) postulate that an earlier maturation and fattening rate by the eighteenth century had increased the annual supply of cattle for slaughter by 25 percent. However, on rural sites like West Cotton in Northamptonshire there is a decline in elderly cattle, though no substantial increase in juvenile stock (Albarella and Davis 1994a, 9-10). This is also true for the rural case study sites, which do not exhibit the abundance of juvenile cattle seen in urban areas from the fifteenth century. Nonetheless, the urban demand for meat by the end of the late Medieval period had led to the development of trade networks, for example the trade in cattle from northern England into the Midlands and London (Dyer 2002, 323). Therefore, as with pig, it is likely that the transport of young cattle to urban centres for slaughter inflated the presence of juvenile animals in towns. This can certainly be seen in the comparisons of Wharram Percy and Shapwick to urban centres, as in both cases the urban centre exhibits a significant increase in juvenile animals during the post-Medieval period. As a result of the increased production of veal in the post-Medieval period, the proportion of cattle used for dairying also likely increased as male calves were killed, which allowed the milk produced by cows to be consumed by humans (Albarella 2019). Dairy production became particularly important after the fourteenth century, when dairying with cattle became more widespread (Woolgar 2006, 95), although Trow-Smith (1957, 122-123) suggests that in many areas of the country milk was a secondary use for cows after the production of plough oxen. Despite this, there is evidence that dairy products, particularly cheese, consistently formed part of the peasant diet alongside mainly grain, especially when meat was scarce (Woolgar 2006, 97). In the West Country dairying became particularly important and, due to an abundance of good pasture, Somerset in particular became famous from the sixteenth century for its cheese using cows' milk. This means that the cattle surviving into adulthood at Shapwick were likely cows used for dairy production. However, according to Woolgar (ibid., 96) there was little trade of dairy products beyond a local level in the late Medieval period; for example, cheese bought in Exeter was only transported three miles for Pinhoe for sale. Therefore, the dairy products produced at Shapwick may have formed part of the peasant diet at the site, or was traded via local markets.

Further evidence indicating the expanding meat market from the late Medieval period is the intensification of butchery displayed in zooarchaeological analyses. This is particularly the case on urban sites, where butchery was more specialised and likely carried out by professional butchers (Albarella 2005, 137-138; Rixson 2000). From the late Medieval period, butchery which had been previously absent, such as sawing, had appeared, starting a trend which escalated in the post-Medieval period (Albarella 2019). This can be seen on all three case study sites, where a general increase in the abundance of butchery from the late Medieval period is followed by the first examples of sawn cattle and pig bones in the post-Medieval period, suggesting increased specialisation of butchery tools and methods on rural sites. Specific butchery patterns, like split skulls and vertebrae, also became more common, predominantly in urban areas, from the late Medieval period onwards (ibid.). However, this pattern is less frequent in rural areas, and was not apparent on the rural case study sites. This indicates that, while the intensification of butchery did take place on rural sites, it was in urban areas that specific, professional butchery practices had developed by the end of the late Medieval period, in order to supply the growing demand for meat.

Size Change

A change documented by both historical sources and zooarchaeological investigations during the study period is the size increase of domesticates. By the sixteenth century, zooarchaeological research shows that cattle and sheep, as well as pig and horse to a certain extent, had already started to increase in size (Davis 1997; Thomas 2005a; Grau-Sologestoa and Albarella 2018), potentially as the result of a post-Black Death change in animal husbandry. The sixteenth century also saw the advent of manuals on effective livestock husbandry, published by writers such as Markham (1664) and Fitzherbert (1534), which may have prompted farmers to increase stock size (Trow-Smith 1957, 234).

For sheep, it certainly seems that size increase was taking place by the sixteenth century in England, with numerous examples recorded. While some size increase in the late Medieval period has been documented at Dudley Castle, London and Norwich, the majority of sites, including Coventry, Lincoln, Launceston Castle and Kings Lynn, exhibit an increase in sheep post-cranial length, width and depth in the post-Medieval period (Thomas 2005b; Thomas *et* al 2013; Albarella *et* al 1997; Homes 1981; Dobney *et al* 1996; Albarella and Davis 1994b; Albarella 2019). This is also the case at The Shires (Leicester), Little Pickle (Bletchingley, Surrey), and Exeter, where width measurements also become more variable, suggesting breeds of varying robusticity after the sixteenth century (Gidney 1991a and b; Grau-Sologestoa and Albarella 2018). It is likely that new sheep breeds were developed in the post-Medieval period, such as the New Leicester which was larger, and the Southdown which was more robust and matured faster. However, O'Connor (1995, 83) states that these morphotypes would not be seen archaeologically until the mid-eighteenth century. So far, the assessment of sheep size increase has mainly concerned urban and high-status sites, and the rural sites studied here display a slightly different trend. The only rural site which seems to somewhat follow the countrywide pattern is Wharram Percy, where sheep teeth increased in size in the late Medieval period, and post-cranial measurements were larger in the post-Medieval period, particularly from the seventeenth century. In contrast, at Great Linford there was no change in tooth measurements and, while sheep post-cranial length measurements increased in the 13th-14th and 15th-16th centuries, this was followed by a significant decrease in length in the following period. Finally, at Shapwick there was no discernible sheep size change. Therefore, it appears that the sheep size increase demonstrated on post-Medieval urban sites was not as clear in rural areas. This may have been affected by trade links with towns, which is discussed below.

Cattle also seem to have undergone size increase predominantly in the post-Medieval period. Some evidence for late Medieval size increase can be found at Dudley Castle, alongside an increase in variation at Castle Mall and Shrewsbury Abbey (Thomas 2005b; Albarella 2019), though more studies document post-Medieval size change. For example, in London post-cranial cattle size increase was seen from the fourteenth to the seventeenth centuries, and an increase in post-Medieval size was recorded at Dudley Castle, The Shires, Little Pickle, Launceston Castle and Exeter (Thomas *et* al 2013; Albarella and Davis 1994b; Thomas 2005b; Grau-Sologestoa and Albarella 2018). A similar phenomenon is also recorded at Town Wall (Coventry), Lincoln, Kings Lynn and Norwich in the sixteenth and seventeenth centuries. Furthermore, the change at Norwich is seen in tooth measurements, which suggests an actual genetic change in the cattle population, rather than just improved nutrition (Albarella *et al* 2009; Albarella 2019). Historical accounts support this pattern of cattle size increase across the country; for example, at Smithfield Market in London, bullocks killed at the end of the seventeenth century weighed on average 370lb, compared to animals a century later, which weighed 800lb (Deane and Cole 1967, 69). Armitage (1980) documents the transition from relatively small short-horned cattle in the twelfth and thirteenth centuries to larger long-horned cattle by the late fourteenth to fifteenth centuries, suggesting the development of a new breed, predominantly in the south-east of England. He records this larger animal in Baynard's Castle and Tudor Street in London, Kingston upon Thames, Surrey, and West Ham in Essex, while Thomas *et al*

(2013, 3314) also attest to their presence in London by the mid-sixteenth century. Again, there is abundant evidence for size increase on urban and high-status sites, though fewer data from rural sites, where these cattle would have been reared.

The sites studied here provide an insight into the rural pattern, which is less straightforward. While much size increase has been found in London, at nearby Great Linford there is no evidence of tooth or post-cranial change, perhaps suggesting a lack of 'improved' animals. Furthermore, none of the rural sites show cattle tooth size change, which may refute the development of new breeds. Increasing robusticity at Wharram Percy from the sixteenth century may provide more northerly evidence for the trend recorded by Grau-Sologestoa and Albarella (2018) throughout the Midlands and southern England, though without tooth size change it is difficult to rule out sex ratios as a potential cause. The significant increase in length and width of cattle post-cranial bones after the sixteenth century at Shapwick may also be the result of improved nutrition or altered sex ratios, though an increased variation in tooth measurements makes the presence of different breeds more likely. Overall, while urban and high-status sites appear to show a clear increase in cattle size from around the sixteenth century, potentially caused by the development of new breeds, rural evidence indicates a much more varied pattern across England. In contrast to the previous studies, the greatest changes occurred on the case studies on the south-west and the north, though perhaps the proximity of Great Linford to large urban markets in London affected the size of cattle on the site, a factor which is discussed in more detail below.

Larger pigs have also been recorded during the late to post-Medieval period in zooarchaeological studies on urban and high-status sites throughout England, as early as the fourteenth century at Dudley Castle (Thomas 2005b). For example, Thomas *et al* (2013) describe an increasing average post-cranial size from the sixteenth century in London, and Albarella (2019) draws attention to the presence of larger pigs at sixteenth century Hereford and seventeenth century Norwich and Lincoln in his regional review. Once again, the size change seen in London is not present at Great Linford, as there was a significant decrease in post-cranial size on the Buckinghamshire site in the post-Medieval period. This may suggest a lack of pig improvement in the area, though the proximity to London markets may have affected the size of pigs remaining at Great Linford. It could also be that decreased pig size could be caused by overstocking or poor nutrition (Albarella 2019). However, pigs at Wharram Percy and Shapwick also show no post-cranial size increase in the post-Medieval period, which could suggest that the phenomenon was confined to urban sites. In contrast to the post-cranial results, it appears that tooth size in some urban studies decreased in the post-Medieval period, as highlighted at Launceston Castle (Albarella and Davis 1994b, 13). This was the case at Great Linford, where teeth decreased in size after the sixteenth century, and is a change that has been associated with the shortening of the snout as modern pig breeds developed (Albarella *et al* 2006, 217). The presence of this characteristic after the sixteenth century could be associated with the introduction of new short-snouted breeds, similar to modern breeds like the Berkshire or British Saddleback (Grau-Sologestoa and Albarella 2018). In contrast, there was no change in pig teeth at Shapwick, and at Wharram Percy they increased in size after the seventeenth century. This could indicate that modern breeds with shorter snout were developing in the south of England, around London, by the sixteenth century, but that this change had not spread to the south-west or north. Overall, an increase in pig post-cranial size is evident across the country on urban sites, which may relate to improved feeding or management, though this is not apparent in rural areas. A decrease in tooth size, representing a genetic change and perhaps the beginnings of modern breeds, is present in Buckinghamshire but not on the other sites, suggesting that this phenomenon may have originated in the south of England.

Zooarchaeological and artefactual evidence suggests that English horses were no larger than ponies until the fifteenth century, though from the thirteenth century onwards stallions were imported from the Low Countries, Italy, Spain, France, and Germany (Trow-Smith 1957; Clark 1990; MacGregor 1999; Edwards 2007). From the thirteenth century, a network of aristocratic estates established a breeding programme primarily aimed at supplying military animals (MacGregor 1999). Certainly, by the thirteenth century the term *magnus equus* or *grant cheval* was recorded in both England and France, with some horses as tall as 18 hands by the fourteenth to fifteenth centuries (Davis 1989). However, using skeletal evidence and artefacts like bits and horseshoes, Rackham (1995) argues that even the largest Medieval horses were small by modern standards. The efforts of aristocratic breeding networks were also largely negated by the War of the Roses from 1455 to 1485, which drastically reduced the stock of horses (MacGregor 1999). Other factors such as decreasing aristocratic income after the Black Death in the fourteenth century resulted in the reduced aristocratic investment in breeding and less rigorous selection of breeding animals, as well as a breakdown in international horse trade (Davis 1989; Edwards 1988). This may have resulted in a decreased average horse size in the late Medieval period, documented by Thomas *et al* (2019) in London in the fourteenth to fifteenth centuries. As a result, a 1539 survey of horse stock documented the lack of animals suited to breeding or military function (MacGregor 2012). The subsequent two centuries therefore witnessed the introduction of laws and propaganda aimed at stopping the export of breeding horses, increasing the number of large stallions, controlling the selection of breeding animals, and destroying small or unprofitable horses (MacGregor 1999; 2012). This resulted in an increased average horse size to around 15 hands in height (Rackham 1995) – a modification Langdon (1986, 18) attributes to the development of the warhorse. Zooarchaeological evidence from London reflects this change, as the study by Thomas *et al* (2019) demonstrates periods of size increase in the fifteenth to sixteenth and seventeenth centuries. However, the stud system developed by these reforms concentrated on an aristocratic network centred on specialised sites such as Hampton Court, Eltham, Malmesbury and Tutbury for primarily military and racing animals (MacGregor 1999). This may have caused the increasing horse size seen in urban and high-status centres, though the animals most likely found on rural sites were the ‘stott’ (peasant workhorse), or *equus carectarius* (cart-horse) (Rackham 1995). Illustrative sources such as the Luttrell Psalter attest to the smaller size of these equines in relation to the humans they are depicted with (ibid., 27), suggesting smaller breeds of working horses remained in rural areas. Fussell (1937, 212-213) also suggests that even if larger horses were in use on rural sites, they often performed a number of roles, working on farms from the age of two or three and then being sold for use as urban coach horses at around six years. This certainly could be case for the rural sites studied here, particularly in the comparison between horse measurements from Great Linford and London, where Great Linford animals are consistently smaller across all anatomical planes. The larger average size displayed on urban sites like London could therefore either represent animals introduced as coach horses from rural sites, or horses used for other functions such as military or riding purposes, selected carefully for their size or shape (Brooks *et al* 2010). The only evidence for size change on the rural sites comes from Wharram Percy, where post-cranial length and depth increased in the post-Medieval period. This may reflect the increasing use of horse for traction and/or riding in the area, as discussed above, where larger animals would have offered a distinct advantage.

Overall, the presence of larger animals in urban centres and high-status sites points towards the development of larger morphotypes in rural areas, as the large-scale rearing of livestock in towns is unlikely. However, the lack of size change documented on the rural sites studied here suggests that there was not a straightforward link between the selective breeding of larger animals in rural areas and those transported to towns. Therefore, it may have been that rural sites were practicing a system of negative breeding, in which the largest animals were selected to be sold to towns for the greatest meat profit, meaning that the smaller animals left on the site were used as breeding stock (Russell 1986, 13). There is also evidence that breeding males were not common on rural sites – in the case of cattle, bulls were often 'shared' by small landowners from the fifteenth century onwards (ibid. 1986, 150). Both methods would have potentially resulted in an inflation of larger animals in urban areas, sold to produce the greatest meat yield and therefore profit, and an apparent lack of 'improved' animals in rural areas, exacerbated by the relative lack of larger breeding males. In the case of cattle, the effects of negative breeding strategies or common bulls may have been compounded by the castration of larger males, as the largest bull calves were perceived to produce the best traction animals. This may have had the unintentional result of selecting smaller animals for breeding (Payne 1972), resulting in the smaller livestock documented zooarchaeologically in rural areas.

Trade with Urban Centres

Much of the historical and zooarchaeological evidence has highlighted the differences in the extent and timing of livestock improvement on urban and rural sites, therefore necessitating an assessment of trade connections. As Wrightson (2000, 93) points out, despite aspects of autonomy, "rural and urban economies were in no sense separate spheres", as areas of trade connection centred around towns, which were dependant on the countryside for food, raw materials, and custom. The development of more intense market activity began around the twelfth and thirteenth centuries, coinciding with the rise in horse-drawn haulage (Langdon 1989, 34). Most trading was largely local, but there were several examples of larger-scale networks of food and raw material exchange, especially in cities like London, where the dense population could not be supplied by the immediate hinterland alone (Wrightson 2000, 95). In particular, the droving of livestock formed a large network, as animals reared in the pastoral north and west were driven south and east, meaning that wool from Leicestershire and Lincolnshire supplied areas like Wiltshire and East Anglia. However, much informal exchange also took place, outside towns or formal markets and often directly between the producer and buyer (Dyer 1994, 258; 2014, 16). This intensification of market activity also led to increased specialisation, particularly in urban areas (Dyer 2002, 169). Furthermore, the amount of international trade increased in the late Medieval period. Between 1275 and 1500, international trade was worth over £250,000 per annum (Dyer 1994, 257) - a figure which expanded in the post-Medieval period and comprised largely the export of woollen goods (Deane and Cole 1967, 30).

The increase in market activity presumably had a significant impact on livestock husbandry in both towns and rural areas. While a small proportion of animals were pastured on the outskirts of towns, the majority of livestock supplying larger markets like London would have come from much further afield. The particular demand for meat in urban centres also likely led to an imbalance in species frequencies and age distribution between urban and rural sites. For example, Albarella (2005, 133-4) documents a higher frequency of cattle remains at urban sites, as beef was more frequently consumed in towns, while sheep were more common in rural areas. Moreover, the cattle in urban areas were more likely to be young individuals sold to urban meat markets, whereas in rural areas adult cattle were dominant, killed closer to the end of their working lives. The higher incidence of cattle in urban areas was particularly pronounced by the fifteenth century, as demand for veal increased (ibid., 136). This trend can be seen in the comparison of Wharram Percy to York, which was a focal point for trading, linking the north of England to towns in the south like London (Wrightson 2000, 96). In both the late and post-Medieval periods, young cattle were more prevalent at York than at Wharram Percy, with an increasing frequency after the sixteenth century, likely due to higher demand for veal. This pattern is also true for pigs, as there are significantly more immature and juvenile animals at York than Wharram Percy, particularly in the post-Medieval period. Furthermore, at Exeter many more young cattle are present in the post-Medieval period, in contrast to Shapwick where adults predominate. Pigs are also much younger at Exeter than Shapwick, especially after the sixteenth century. Overall, this apparent imbalance of herd profiles between rural and urban sites likely represents the transport of younger meat animals to towns for slaughter and distribution. It highlights the exchange operating across the country, as well as the caution required when interpreting changing husbandry patterns on rural sites, which by no means operated in isolation.

The same applies for assessing size change on rural sites, as size increase may be more apparent in different areas due to the rise in trade activity. This includes the movement of animals within England; for example, Trow-Smith (1957, 110-111) documents the introduction of new sheep types to many districts from "centralized pools of sheep maintained by the great wool-producing estates". Furthermore, there is also evidence of international exchange, such as historical accounts of a "persistent tradition of large exports" of cattle from Holland to England. This resulted in the long-legged short-horned Dutch cattle being found in Kent, Lincolnshire, Yorkshire and Durham by the seventeenth to eighteenth centuries, providing a greater meat and milk yield and breeding with British cattle (ibid., 203). Therefore, the movement and import of animals may have affected the distribution of size change throughout England, which is illustrated by comparison between Great Linford and London. By the sixteenth century the population of London had reached 55,000, resulting in a massive demand for food which could not be provided by its immediate hinterland (Wrightson 2000, 97). In 1725 the consumption of meat in London was estimated to be 98,000 cattle, 60,000 calves, 70,000 sheep and lambs, 187,000 pigs, and 52,000 suckling pigs, meaning that the animals reared at Great Linford were likely to have supplied the city's demand for meat (Thomas *et al* 2013, 3323). Metric results were particularly striking, showing that animals were similar sizes on both sites in the late Medieval period, but from around the fifteenth century the livestock in London were considerably larger than those at Great Linford. This was initially surprising, given that rural sites like Great Linford probably reared the animals found at London, but may actually represent the deliberate selection of larger animals for urban markets, as they would produce the greatest meat yield and therefore the most profit. Overall, the comparison of metric data from urban and rural sites once again highlights the caution required when assessing livestock change in rural areas, as trade with towns undoubtably affected the size of animals remaining in the countryside.

6.3 Association between Livestock Change and Landscape Enclosure

The landscape, historical and zooarchaeological data assessed in this thesis clearly indicate a number of large-scale changes in both livestock management and landscape organisation from the late Medieval period. Therefore, the potential links between these occurrences should be assessed, in order to establish whether the landscape reorganisation associated with enclosure provided the impetus for livestock improvement, or whether it was caused by other changes occurring at the same time.

Enclosure

The main effects of enclosure on animal husbandry were likely the increasing proportion of pasture which accompanied the process, and the greater control over livestock. Certainly, peaks in enclosure activity occurred around the times when a greater profit could be made from animal products, and often began with land better suited for pasture such as wet areas or heavy clay (Williamson *et al* 2013, 136-7). There is also evidence that the mixing of livestock on common pasture was not conducive to improvement due to the "indiscriminate mixing of animals" and overstocking by rich landowners (Warde 2001, 130). This intermixing meant a lack of opportunity for controlled breeding, and according to Williamson *et al* (2013, 137) made open field farming "inherently unproductive", as farmers could not exercise choice over what animals were introduced. While stock belonging to different landowners were still grazed in common farmers had very little incentive to improve their animals, as "good and indifferent" stock was mixed on common pasture (Armitage 1980, 4). Enclosure may have alleviated these problems, allowing for a greater degree of control in a number of areas of livestock management. For example, it allowed the breeding of selected stock for the first time, as well as greater control over nutrition and the ability to specialise in certain products (Armitage 1980, 8; Thomas *et al* 2013, 3320). Furthermore, it may have encouraged the more rapid introduction of horses as traction animals, as they could be more easily manoeuvred in the smaller land parcels created by enclosure (Langdon 1982, 40). The greater control over stock selection caused by enclosure may be illustrated at Shapwick, as land was gradually removed from common fields from the fourteenth century, which coincided with the increase in sheep frequency and size. This could reflect the greater flexibility caused by enclosure, allowing farmers to respond to the increased demand for wool, as well as conducting more selective sheep breeding, though changes in other species are absent until the post-Medieval period. At Wharram Percy, the increasing proportion of young cattle and pig also coincides with enclosure, perhaps indicating that the process allowed landowners to respond more readily to the market demand for meat at that time, though there was a lack of physical enclosure until the eighteenth century so stock were perhaps still grazed together up to that point.

However, there is also evidence that changes were taking place before the start of enclosure in many areas; for example, the expansion of pasture and the transition to three-course rotation systems, which allowed greater fodder production. This is highlighted by Williamson *et al* (2013, 154), who state that enclosure for pasture did not represent a revolution in farming, but "an intensification of existing trends", as the pre-enclosure economy was increasingly geared towards livestock production. This is evident at Great Linford, where areas of land previously under plough, including Ley Field at the south of the parish, were converted to pasture around 1477 – before enclosure. Furthermore, at Wharram Percy, land was increasingly converted to pasture by the fifteenth century, starting with the less fertile areas and uplands, which resulted in the destruction of houses and shift towards livestock farming before enclosure. Therefore, the adoption of improved agricultural methods may have been possible in open field areas, while enclosure was not always followed by an improvement in cropping or livestock husbandry.

Improved nutrition

Another potential cause of livestock size increase from the late Medieval period is improved nutritional plane, which may have occurred due to improvements in winter fodder production. Both the introduction of leguminous fodder crops and improved hay-making techniques meant that livestock could be provided with better quality food year-round (Armitage 1980, 9). The new crops introduced from the sixteenth and seventeenth centuries include turnips, which were vital for over-wintering stock, legumes for summer grazing, and new grass species (Trow-Smith 1957, 255). Before these developments, overwintering livestock had been difficult, limiting meat and milk yields and resulting in smaller individuals with lower food requirements being kept alive (Armitage 1980, 4). Trow-Smith (1957, 257) argues that this change occurred slowly by modern standards, but rapidly compared to previous changes, and resulted in an increased stock carrying capacity. The effects of fodder improvement can potentially be seen at some of the rural case study sites. For example, at Wharram Percy the reintroduction of arable cultivation in the parish during the seventeenth century coincides with an increase in the size of sheep, cattle and horse. While there is no historical record of what crops were produced on this new arable land, post-cranial size increase indicates that an increase in nutritional plane may have occurred, suggesting the potential introduction of new fodder crops. Furthermore, at Shapwick, a post-cranial increase in cattle size occurred in the post-Medieval period, which could imply enhanced nutritional plane. At the same time, the remaining arable land in the parish is recorded as producing vetch, peas and oats – all fodder crops which may have been responsible for the improved feeding regime. However, in their investigation of cattle management at Dudley Castle, Fisher and Thomas (2012) found no significant change in isotope values which would indicate that a change in size was associated with changing fodder crops, though winter feed may be more difficult to detect.

It is likely that changes in fodder crops were made much easier by enclosure, as in areas of open field complicated cropping agreements had to be introduced before new crops or techniques could be established. Indeed, Trow-Smith (1957, 257) argues that new fodder crops could only be cultivated in areas where "enclosure had paved the way for such an enlightened and improving policy of cropping…". Nonetheless, the relationship between enclosure and improved fodder crops is not straightforward, as open field farmers did sometimes develop agreements allowing them to cultivate new crops within their existing system (Williamson 2000, 67). For example, in 1784 at Ashley, near Scunthorpe, landowners allowed each farmer to fence off some strips in the open fields to sow turnips and clover. Therefore, it seems that improved livestock nutrition, due to the introduction of new fodder crops like turnips, may have contributed to the increasing size of animals in the post-Medieval period, but the development of these new crops was likely facilitated by enclosure. Therefore, enclosure may have indirectly led to the increased size of livestock by enabling an improved feeding regime to be adopted.

Market demand

Another factor which likely played a significant role in livestock change during the late and post-Medieval periods is market demand. As discussed above, the rise in trade and urbanisation, causing increasing demand for animal products in towns and high-status sites, occurred around the same time as enclosure was gaining pace in some areas, and may have also influenced livestock husbandry decisions which led to animal improvement. A prime example of this was the development of the wool trade from the thirteenth century, which undoubtably led to an increase in sheep numbers, as well as a change in herd age profiles. While an increase in sheep frequency is seen on all rural case study sites, it is particularly evident at Shapwick in the late Medieval period, making sheep the prevalent species. Furthermore, on all sites in the late Medieval period sheep exhibit high survival, indicative of wool exploitation. Therefore, it is likely that the burgeoning wool trade from the start of the late Medieval period influenced the decisions of landowners, causing a change in sheep frequency and husbandry before the start of enclosure.

From the fifteenth century, the market for meat increased due to rising populations in expanding urban centres like London (Dyer 2002, 323). As discussed above, pigs and cattle were particularly affected by this, again causing a change in age profiles, and in some cases potentially animal size, before enclosure. The evidence for the intensification of meat production is particularly evident when the rural case studies are compared to nearby urban sites. The data from London highlight the increasing pig and cattle size from as early as the fourteenth century which (while this is not evident at Great Linford) could indicate the breeding of larger animals in the countryside around London to yield the greatest profit in the growing meat market during the post-Medieval period. Herd age profiles from both rural and urban sites also demonstrate the change in cattle exploitation, which was largely caused by shifting market demand. In the early Medieval period, the use of cattle for traction is evident on the rural sites in their high survival to adulthood. Payne (1972) also states that cattle remained relatively small due to the accidental selection caused by the castration of the largest bulls for traction. However, from the fifteenth century, as demand for veal increased, there is a widespread change in cattle age profiles as younger animals dominate assemblages (Albarella 1997, 22). This was evident at Great Linford, Wharram Percy and Shapwick, where a greater proportion of subadult and juvenile cattle were present from around the fifteenth century, before the process of enclosure had been completed. Furthermore, the comparison to urban sites demonstrates a post-Medieval abundance of cattle around six months of age, showing the increasing veal exploitation in towns.

Alongside the developing market for meat, the specialist role of the butcher-grazier became more prevalent in rural-urban relations from the fifteenth to sixteenth centuries (Russell 1986). Graziers typically used pasture near urban centres, and purchased young, lean livestock to fatten and either sell on, or butcher for sale in urban markets (Fitzherbert 1534; Rixson 2000). Sweetinburgh (2011, 106-107) provides the example of John Honywoode, the most prominent butcher-grazier in Hythe, Kent. From the late fifteenth century, his transactions list the acquisition of cattle, predominantly steers and calves, which were either fattened or butchered and sold to urban markets in Kent, or even the Calais export market. His records also list the purchase of both live and dead sheep, predominantly shearlings (shorn once), which he fattened for urban meat markets which favoured juvenile animals (ibid., 108). The lack of wool recorded in his transactions indicates that he was solely concerned with supplying the meat market, and multiple sales of lamb suggest a focus on urban or high-status clients, who could afford the more expensive products. The operation of butcher-graziers from the fifteenth century may cause the zooarchaeological patterns displayed on rural and urban sites, as they would likely have purchased larger animals with the greatest potential for meat production from rural sites at a young age, and sold them to urban or high-status markets. This would reduce the proportion of young animals on rural sites, and inflate the amount found in urban areas, as seen in the comparison between Wharram Percy and York, and Shapwick and Exeter by the post-Medieval period. While there is a lack of historical records for dealings with butcher-graziers from the rural case study sites, evidence from Wharram Percy does suggest that after the conversion to pasture, sheep husbandry in the parish was overseen by non-resident graziers, supplying local and urban markets (Dyer 2012a). This may also have produced the patterns in livestock size shown on urban and rural sites, as the selection of larger, more readily-fattened animals by graziers may have inflated the size of animals found on urban or high-status sites.

Overall, it is likely that the increasing urban demand for meat, particularly veal, led to a change in the exploitation of livestock, and in some cases an increase in size as farmers modified their livestock management to gain the greatest profit. In some areas, this change had begun before enclosure had been completed, suggesting that market demand may have exerted more influence on livestock change than landscape reorganisation. However, it could be argued that enclosure may have hastened this process in the post-Medieval period, as it allowed farmers greater freedom to selectively breed animals for greater wool or meat yields, outside the communal regulation of open fields. It also allowed for the emergence of the specialised butcher-grazier, who used pasture in urban hinterlands to fatten stock for town and high-status markets. Certainly, Williamson (2000, 57) argues that enclosure and capitalism were broadly linked, as greater specialisation emerged in reaction to national markets.

Population and Social Change

The population of England in the late and post-Medieval periods and associated social change may have also had an impact on the changing management of livestock. During the fourteenth century the population was drastically reduced by a series of famine and plagues, most notably the Black Death, from around 5-6 million in 1300, to 2-3 million by the start of the fifteenth century (Campbell 2016; Dyer 2014, 8; Russell 1986, 53). This led to a decline in the demand for food, resulting in a crash in the grain market. As a result, pastoral farming became more profitable, as rearing livestock required less human labour – this provoked an increase in the amount of land under grass between 1325 and 1520, as well as the movement of livestock off marginal land (Dyer 2014, 136). Thomas *et al* (2013, 3320) suggest that this transition to pastoral land use may have caused the fifteenth century sheep size increase seen in London, as a greater proportion of pasture and less human demand for grain led to improved feeding regimes for livestock, and therefore greater size.

Alongside this population change in the mid- to late-fourteenth century, a change in tenurial arrangement also occurred, as landholders moved away from direct management and contractual, rather than customary, relationships developed between landlords and tenants. This led to the reduction of direct farming by manorial estates and large farms controlled by great landlords, as demesnes were increasingly divided among several tenant farmers for cash rents by the second half of the fourteenth century (Hopcraft 1994). In combination with rising wages, this led to a downward social distribution of land access, as more peasants became landowners and contributed to the emergence of the 'yeoman', or substantial small farmer (Dyer 1981; Hopcraft 1994). Drummond and

Wilbraham (1939, 26) suggest that with fewer lords acting as a hindrance to change, new peasant landowners became increasingly invested in raising profitability of their land and stock, particularly when leasing for cash rent. Furthermore, they were more likely to be in direct contact with their animals, making them better able to take "technological initiatives" leading to livestock improvement (Allen 1991, 252). Ernle (1912, 35) agrees that this "larger scope for individual enterprise" may have been the catalyst for increased agricultural productivity. This was exacerbated by the breakup of monastic estates following the sixteenth century dissolution as it made more land available to smaller farmers (Hoskins 1992, 115). This "wealth enabling" alteration further contributed to a period of rapid and dynamic change in land ownership (Pryor 2011, 379). Therefore, it could be suggested that the impact of the Black Death period on population, and the subsequent emergence of new landowners, may have played a key role in agricultural improvement.

The results of decreasing fourteenth century population are particularly evident at Wharram Percy. A reduction in population by the fifteenth century had led to the desertion and decay of properties, alongside widespread conversion of land to pasture (Wrathmell 2012c). While the post-cranial size increase documented for the London animals is not apparent here, an increase in sheep frequency suggests a shifting focus to sheep husbandry and wool production brought about by the increasing proportion of pasture (Wrathmell 2012c). Indeed, as with many other nearby parishes, a combination of depopulation and focus on pastoral husbandry led to the eventual desertion of the township. This was partly due to the greater return from renting to graziers rather than open-field tenants, which made the parish very attractive for commercial sheep farming (Wrathmell 2012e). This attracted rich graziers or 'sheep-masters' such as John Thorpe, who lived twelve miles away in Appleton and pastured flocks on a long-term basis in the parish by the mid-sixteenth century. Wrathmell (ibid., 358) even postulates that Thorpe may have been involved in the conversion of the parish to grass and subsequent depopulation. Certainly, at Wharram Percy it seems that the population decrease associated with the Black Death period, and associated conversion to pasture, heavily benefitted non-resident graziers on large sheep farms primarily producing wool for market (Hopcraft 1994), while the parish itself was apparently entirely depopulated.

Changing farming methods due to population fluctuation and changes in land ownership could also be evident at Shapwick, as a decline in population by the fourteenth century resulted in an increasing number of empty tenements, leading to a conversion to pasture and significant increase in the frequency of sheep. This suggests that the post-Black Death population decline at Shapwick prompted an increase in pastoral farming, particularly for wool production, though may have also laid the foundation for piecemeal enclosure, as it facilitated the exchange and consolidation of land. This is supported by Dyer (2014, 8), who states that the lowered population made consolidation, enclosure and conversion to pasture more feasible for wealthier tenants. However, at Shapwick the control of Glastonbury Abbey also likely had a significant influence on agricultural management and productivity, as from the late twelfth century the Abbey directly managed the demesne land on the thirty manors it controlled. As a result, over ninety percent of Shapwick's wheat crop, equating to 81 percent of the township's total arable cultivation, was sent to the granary at Glastonbury (Aston and Gerrard 2013; Ecclestone 2007). Furthermore, many resources, for example livestock, were often inter-manorial and were regularly transferred between the manors of Glastonbury Abbey (Postan 1953). As a result, the productivity, and therefore profit, of the township was likely governed by the control of the Abbey, which largely dictated the agricultural management at Shapwick. After the dissolution of the Abbey in 1539, Shapwick was briefly seized by the crown, before being passed on to numerous secular owners.

Piecemeal enclosure significantly increased after this period, aided by the conversion of all tithes to cash payments before 1539 (Ecclestone 2007). These new landowners potentially operated more direct management of their holdings, perhaps resulting in the increased cattle size seen at Shapwick in the post-Medieval as landholders displayed more individual enterprise to increase their profits.

At Great Linford there is little evidence for the impact of the Black Death, though a third of the population of the parish was likely wiped out (Mynard and Zeepvat 1991). There is, however, more information about the later changes in social structure and land ownership which suggests a shift from direct estate management to indirect administration after enclosure. Before Sir Richard Napier's amalgamation of land from 1637 the parish consisted of two main estates held by absentee landlords, the Thompson and Tyringham families. These estates were rented in large farms and formed over half the total land in Great Linford, though several small landowners held properties ranging in size from cottages to seventeen acres (Blackmore 1991). This suggests that the emergence of new small landowners had already started in Great Linford by the seventeenth century, before enclosure, though a significant proportion of the parish was owned by large landowners. Unfortunately, there is scant evidence regarding leases from the parish, though by the time Napier was amalgamating land to enclose in the seventeenth century, it appears that most tenants were paying cash rents, and the decline in customary tenure likely made Napier's amassing of land easier (ibid., 35). Despite owning the majority of the parish, there is evidence in his marriage settlement of 1647 that Napier was farming his estate directly, and this continued immediately after enclosure in 1658, with motivation to improve productivity perhaps stemming from his amassed debt. However, this pattern of ownership appears to have changed with the arrival of Sir William Pritchard in 1676, a merchant who was heavily involved with business in London, and was elected Lord Mayor in 1685. As a result, he spent little time at Great Linford, and was limited to a short visit each summer. It is therefore likely that he had little time or interest in farming the estate directly (ibid., 40). His estate was managed by a steward, who partly farmed it directly as grazing land, and partly rented to farmers, with nineteen tenants paying up to £50 a year. This combination of absentee landlord and cash tenants after enclosure may have prompted greater motivation for agricultural improvement, as tenants sought to gain profit after rent payment; however, at Great Linford the lack of post-Medieval animal size change may indicate a lack of increased productivity at this time, perhaps caused by the absence of new small landowners described above, and an apparent lack of interest in the affairs of the estate by Sir William Pritchard.

6.4 Conclusions and Further Work

Overall, it is clear that large-scale landscape reorganisation had occurred across England by the end of the post-Medieval period. The variation in this process is highlighted by the rural sites assessed in this study, which range from a 'champion' Midland site enclosed by general agreement, to an upland site converted to an open sheepwalk, and a West Country parish gradually enclosed by the piecemeal removal of open fields. Each site was relatively typical of the region it is found in, but varied considerably in terms of type and timing of enclosure. While the piecemeal enclosure at Shapwick in the south-west of the country began as early as the fourteenth century, the general enclosure which took place at Wharram Percy and Great Linford did not take place until the sixteenth to seventeenth centuries. Nonetheless, all of the sites had undergone significant landscape reorganisation by the end of the eighteenth century, and were totally enclosed, meaning that common rights had been removed, and newly-delineated parcels of land had been established. On all sites, enclosure was also accompanied by large-scale conversion to pasture, though at Great Linford and Wharram Percy mixed farming had been re-established by the end of the study period.

There is also evidence from the rural case studies for some of the livestock changes previously recorded across the country in urban sites. For example, the late Medieval increase in wool production is illustrated on all sites by a dominance in sheep during that period, accompanied by a prevalence of adult animals. The shift to horse for traction is also evident on some of the sites, particularly Wharram Percy, where an increasing number of adult horses were recorded, in contrast to Shapwick where all-oxen plough teams likely continued. Furthermore, the increased demand for meat seen previously in urban areas is somewhat evident on the rural sites in the form of younger cattle and pigs recorded in the post-Medieval period, as well as some evidence for the intensification of butchery. This is particularly the case for cattle as the market for veal grew in the post-Medieval period. However, this trend is more distinct when the rural sites are compared to nearby towns; for example, at York and Exeter the prevalence of young cattle and pigs significantly increased in the post-Medieval period, suggesting that animals from rural sites like Wharram Percy and Shapwick were taken there for slaughter.

The pattern of increasing animal size recorded in previous studies is less clear on the rural case study sites, and there is certainly no widespread trend. While sheep and horse apparently underwent size increase at post-Medieval Wharram Percy, only cattle increased in size at Shapwick, and sheep and pig actually decreased in size at Great Linford. Furthermore, the majority of the change seen at these sites is in post-cranial size, which could have been affected by shifting sex ratios and nutritional regimes, as well as by the introduction or development of new breeds, making the cause(s) of these changes difficult to identify. Nonetheless, the comparison between Great Linford and London demonstrates the vital importance of considering trade links while assessing animal size change, as it showed a dramatic increase in animal size at London, starting from around the fifteenth century. This suggests that the animals from the rural sites surrounding London, such as Great Linford, were already larger by the start of the post-Medieval period, and the largest of those animals were likely transported to the city for the greatest possible meat profit. Therefore, the increased livestock size in London could be inflated by the influx of larger animals reared in the countryside, and conversely the apparent lack of larger stock at rural sites could be the result of this movement. The emerging role of butcher-graziers may support this interpretation, as they often purchased young livestock with the greatest fattening potential from rural areas, either to butcher or sell as live animals in urban meat markets. Therefore, the scarcity of 'improved' animals on the rural case studies may reflect the selection of the largest animals by graziers in order to provide the greatest profit in urban markets.

While much of the enclosure and livestock change occurring on the rural sites did coincide, there is little definitive evidence for a link between the two processes. The most likely connection is the creation of new pasture associated with enclosure on all sites, which likely allowed for an increasing focus on pastoral farming, and potentially facilitated the improved nutrition and more selective breeding of livestock. However, there is evidence that this increase in grazing land began before enclosure on some sites, and in some areas was facilitated by the decrease in population after the Black Death in the fourteenth century. The apparent improvement in livestock control brought about by enclosure may have also played a role in the livestock change occurring in the late Medieval period, as animals were no longer grazed communally so greater control could be exerted over nutrition and breeding selection. Nonetheless, it seems that open field systems were not totally inflexible, with enclosure only serving to intensify processes already underway in many areas. Other factors may have also contributed to livestock change from the late Medieval period, including improved nutritional regimes as the result of new fodder crops, which may have caused some of the post-cranial size changes seen zooarchaeologically. Livestock management may also have benefitted from changes in tenurial relationships, as customary leases declined and a rise in cash rents facilitated the emergence of new small landowners, who more directly managed their holdings and perhaps demonstrated greater motivation for individual enterprise. In addition, market demand clearly played a role in the decisions of landowners from the thirteenth century onwards, particularly the increasing demand for wool and milk, which likely dictated the exploitation of sheep and cattle in many areas. However, enclosure may have facilitated these processes, offering landowners greater flexibility outside of communal cropping and husbandry regulations to adopt new fodder crops or alter the animal products they produced to react to market demand.

In summary, the rural historical and zooarchaeological evidence combined in this study suggests that there was no single cause or moment of agricultural change from the late Medieval period in England. As Deane and Cole (1967, 40) state, the occurrence of apparent 'revolutions' in every century from the thirteenth to the twentieth make the label invalid. Perhaps then, 'agricultural evolution' would be a more appropriate term to describe the varied timing and mechanism of change across England, in terms of enclosure methods and livestock exploitation. Certainly, enclosure was a component in this agricultural change, though it likely acted in combination with other factors like population, market demand, improved cropping and trade networks to bring about livestock change.

In order to further investigate the significance of these factors on livestock management across England, additional landscape, historical and zooarchaeological data from rural sites in other regions should be added to the evidence discussed here. The assessment of a site from Norfolk would be of particular use, as the county displayed a unique form of enclosure not covered by the other case study sites, and appears to have adopted new agricultural techniques at a relatively early date. According to Langdon (1989, 32), the county also displayed "efficient and progressive agricultural regimes" before many other areas of England, for example, it was one of the earliest areas to introduce horses to plough teams. Furthermore, some of the earliest urban livestock size increase has been recorded at late Medieval Castle Mall in Norwich (Albarella 2019), suggesting an earlier date for livestock improvement in the region. Unfortunately, an assessment of this county was not possible during this project due to access issues, but it would provide a better indication of how enclosure and livestock improvement progressed across England.

Finally, isotopic or genetic studies may aid in the assessment of livestock improvement in the late Medieval period (Albarella (2005, 143). It became clear during this research that trade connections played a huge role in animal management from the late Medieval period, with livestock transported great distances on the hoof to supply growing populations in cities like London. Therefore, these techniques, in particular strontium isotope analysis, could be useful in assessing the origin of livestock slaughtered in urban areas, generating a clearer picture of the extent of trade networks, and how they may have affected the spread of livestock improvement. This would aid in more confidently placing the rural sites assessed here within the wider context of trade and exchange, as the urban comparisons made here are largely based on available data and postulated geographical links. These analyses may also help to address the issue of whether improvement was caused by the development of new breeds in England, or the import of animals from the Continent.

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Abbreviations

BuCRO Buckinghamshire County Records Office

Pipe Roll Soc. Publications of the Pipe Roll Society

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Appendix 1: *Standard Measurements used for log-ratio analysis:*

Sheep (Davis 1996):

	Measurement	Standard (mm)
Lengths	Humerus GLC	116.3
	Humerus HTC	13.5
	Radius GL	136.6
	Metacarpal GL	111.8
	Femur GLC	155.2
	Tibia GL	184.8
	Calcaneum GL	52.4
	Astragalus GL	26.7
	Metatarsal GL	121.4
Widths	Humerus BT	26.8
	Radius BP	30.0
	Radius BfP	26.9
	Metacarpal WCM	11.3
	Metacarpal WCL	10.9
	Tibia Bd	25.1
	Astragalus Bd	17.6
Depths	Metacarpal DEM	10.1
	Metacarpal DEL	9.5
	Metacarpal DVM	15.3
	Metacarpal DVL	14.8
	Pelvis MRDA	3.1
	Tibia Dd	19.5
	Astragalus Dl	14.7

Cattle (Johnstone and Albarella 2002):

	Measurement	Standard (mm)
Lengths	Humerus HTC	30.8
	Astragalus GLl	63.3
Widths	Humerus BT	73.2
	Metacarpal Bd	56.6
	Metacarpal BatF	52.9
	Metacarpal a	27.0
	Metacarpal b	27.1
	Tibia Bd	60.3
	Astragalus Bd	40.9
	Metatarsal Bd	54.2
	Metatarsal BatF	51.2
	Metatarsal a	25.9
	Metatarsal b	25.2
	Horncore Bd	68.7

Depths	Horncore Dd	38.6
	Metacarpal 3	28.4
	Tibia Dd	45.3
	Astragalus Dl	35.8
	Metatarsal 3	27.9

Pig (Albarella and Payne 2005):

	Measurement	**Standard (mm)**
Lengths (dental)	dP_4L	18.9
	M_1L	17.3
	M_2L	21.8
	M_3L	34.5
	M^1L	17.1
	M^2L	22.1
	M^3L	32.9
Lengths (post-cranial)	Humerus HTC	19.7
	Metacarpal III GL	73.9
	Calcaneum GL	79.3
	Metatarsal III GL	83.0
	Astragalus GLl	40.8
Widths (dental)	dP_4WA	6.3
	M_1WA	10.3
	M_2WA	13.7
	M_3WA	15.7
	M^1WA	13.7
	M^2WA	17.0
	M^3WA	18.5
Widths (post-cranial)	Humerus BT	31.3
	Radius Bd	34.0
	Tibia Bd	30.7

Horse (Johnstone 2004):

	Measurement	**Standard (mm)**
Lengths	Humerus GLC	267.70
	Humerus HTC	36.07
	Radius GL	316.33
	Metacarpal GL	216.17
	Femur GL	383.0
	Tibia GL	383.0
	Astragalus GH	55.53
	Calcaneum GL	107.23
	Metatarsal GL	258.07
	P1 GL	80.25
Widths	Humerus Bd	81.70
	Humerus BT	72.90

	Radius Bd	74.47
	Metacarpal Bd	44.7
	Femur Bd	92.03
	Tibia Bd	71.63
	Astragalus BFd	50.67
	Calcaneum GB	50.73
	Metatarsal Bd	47.27
	P1 Bp	54.32
Depths	Metacarpal Dd	35.3
	Femur DC	57.63
	Tibia Dd	45.23
	Metatarsal Dd	36.9
	P1 Dp	37.02
	P1 Dd	24.32

Appendix 2: *Shapiro-Wilk Tests for Normality:*

Significance values are given for the Shapiro-Wilk (S-W) test – below 0.05 indicates that the sample is not normally distributed, and this is indicated in blue.

Great Linford:

Sheep:

Element	**Phase/ Period**	**S-W sig.**
M_3 W	10^{th}-13^{th}	0.536
	13^{th}-14^{th}	0.239
	14^{th}-15^{th}	0.955
	15^{th}-16^{th}	0.739
	16^{th}-17^{th}	0.080
	17^{th}-18^{th}	0.650
	EM	0.536
	LM	0.339
	PM	0.086
dP_4 W	EM	0.346
	LM	0.214
	PM	0.573
M_1W	EM	0.510
	LM	0.390
	PM	0.001
M_2W	EM	0.355
	LM	0.142
	PM	0.056
M_3L	EM	0.546
	LM	0.455
	PM	0.264
M_3W	EM	0.536
	LM	0.492
	PM	0.086
HUM BT	EM	0.093
	LM	0.034
	PM	0.006
HUM Bd	EM	0.032
	LM	0.112
	PM	0.028
HUM HTC	EM	0.356
	LM	0.021
	PM	0.045
RAD Bp	EM	0.281
	LM	0.722
TIB Bd	LM	0.092
	PM	0.946
TIB Dd	LM	0.001
	PM	0.439
LR Lengths	10^{th}-13^{th}	0.685
	13^{th}-14^{th}	0.217
	14^{th}-15^{th}	0.018
	15^{th}-16^{th}	0.092
	16^{th}-17^{th}	0.299
	17^{th}-18^{th}	0.806

	EM	0.685
	LM	0.264
	PM	0.400
LR Widths	10th-13th	0.185
	13th-14th	0.517
	14th-15th	0.001
	15th-16th	0.771
	16th-17th	0.149
	17th-18th	0.972
	EM	0.185
	LM	0.248
	PM	0.132
LR Depths	10th-13th	0.102
	13th-14th	0.169
	14th-15th	0.080
	15th-16th	0.011
	16th-17th	0.670
	17th-18th	0.451
	EM	0.102
	LM	0.002
	PM	0.778

Cattle:

Element	**Phase/ Period**	**S-W sig.**
M_3 W	EM	0.894
	LM	0.551
	PM	0.352
dP_4 W	EM	0.116
	LM	0.422
	PM	0.286
M_2W	EM	0.365
	LM	0.557
M_3L	EM	0.908
	LM	0.453
	PM	0.442
M_3W	EM	0.894
	LM	0.551
	PM	0.352
SCA SLC	LM	0.841
	PM	0.901
HUM BT	EM	0.181
	LM	0.533
	PM	0.580
HUM HTC	EM	0.137
	LM	0.651
	PM	0.053
MC Bd	EM	0.195
	LM	0.179
	PM	0.233
MC BatF	EM	0.186
	LM	0.199
	PM	0.057
MC a	EM	0.450

	LM	0.009
	PM	0.521
MC b	EM	0.025
	LM	0.185
	PM	0.759
MC 3	EM	0.091
	LM	0.588
	PM	0.311
TIB Bd	EM	0.187
	LM	0.942
	PM	0.640
TIB Dd	EM	0.894
	LM	0.418
	PM	0.206
AST GLl	LM	0.621
	PM	0.959
AST Bd	LM	0.107
	PM	0.269
AST Dl	LM	0.326
	PM	0.363
LR Lengths	EM	0.264
	LM	0.775
	PM	0.060
LR Widths	10th-13th	0.019
	13th-14th	0.012
	14th-15th	0.065
	15th-16th	0.004
	16th-17th	0.468
	17th-18th	0.067
	EM	0.026
	LM	0.248
	PM	0.171
LR Depths	10th-13th	0.946
	13th-14th	0.470
	14th-15th	0.559
	15th-16th	0.463
	16th-17th	0.108
	17th-18th	0.336
	EM	0.946
	LM	0.364
	PM	0.068

Pig:

Element	**Phase/ Period**	**S-W sig.**
LR Tooth Lengths	10th-13th	0.389
	13th-14th	0.604
	14th-15th	0.139
	15th-16th	0.002
	16th-17th	0.089
	17th-18th	0.565
	EM	0.406
	LM	0.006

	PM	0.132
LR Tooth Widths	10th-13th	0.016
	13th-14th	0.406
	14th-15th	0.022
	15th-16th	0.000
	16th-17th	0.003
	17th-18th	0.733
	EM	0.007
	LM	0.000
	PM	0.018
LR PC	EM	0.600
	LM	0.461
	PM	0.016
dP_4 L	LM	0.678
	PM	0.871
dP_4 WP	LM	0.361
	PM	0.322
M_1 L	EM	0.720
	LM	0.007
	PM	0.037
M_1 WA	EM	0.909
	LM	0.904
	PM	0.881
M_1 WP	EM	0.062
	LM	0.225
	PM	0.895
M_2 L	EM	0.284
	LM	0.143
	PM	0.522
M_2 WA	EM	0.930
	LM	0.004
	PM	0.893
M_2 WP	EM	0.788
	LM	0.455
	PM	0.421
M_3 L	LM	0.431
	PM	0.585
M_3 WA	LM	0.539
	PM	0.593
M_3 WC	LM	0.161
	PM	0.065
M_3 WP	LM	0.700
	PM	0.155

Horse:

LR Lengths	EM	0.251
	LM	0.407
	PM	0.510
LR Widths	EM	0.333

	LM	0.354
	PM	0.145
LR Depths	EM	0.056
	LM	0.483
	PM	0.002

Wharram Percy:

Sheep:

Element	**Phase/ Period**	**S-W sig.**
M_3 W	10^{th}-13^{th}	0.914
	13^{th}-14^{th}	0.104
	15^{th}-16^{th}	0.383
	16^{th}-17^{th}	0.939
	17^{th}-18^{th}	0.349
	18^{th}-19th	0.154
	EM	0.460
	LM	0.469
	PM	0.087
dP_4 W	EM	0.206
	LM	0.001
	PM	0.147
M_1W	EM	0.621
	LM	0.004
	PM	0.807
M_2W	EM	0.588
	LM	0.097
	PM	0.938
M_3L	EM	0.033
	LM	0.713
	PM	0.102
M_3W	EM	0.005
	LM	0.518
	PM	0.078
SCA GLP	EM	0.380
	LM	0.915
	PM	0.628
SCA SLC	EM	0.260
	LM	0.827
	PM	0.079
HUM BT	EM	0.001
	LM	0.319
	PM	0.063
HUM Bd	EM	0.006
	LM	0.321
	PM	0.006
HUM HTC	EM	0.013
	LM	0.345
	PM	0.342
RAD Bp	EM	0.058
	LM	0.652
	PM	0.031
RAD Bd	EM	0.791

	LM	0.199
	PM	0.718
MC GL	EM	0.277
	LM	0.134
	PM	0.367
MC SD	EM	0.971
	LM	0.586
	PM	0.812
MC Bd	EM	0.137
	LM	0.209
	PM	0.008
MC a	EM	0.460
	LM	0.488
	PM	0.080
MC b	EM	0.055
	LM	0.302
	PM	0.487
MC 1	EM	0.347
	LM	0.123
	PM	0.373
MC 2	EM	0.966
	LM	0.110
	PM	0.596
MC 3	EM	0.733
	LM	0.697
	PM	0.213
MC 4	EM	0.250
	LM	0.773
	PM	0.431
MC 5	EM	0.895
	LM	0.470
	PM	0.489
PEL LA	EM	0.521
	LM	0.636
	PM	0.159
FEM DC	EM	0.464
	LM	0.096
	PM	0.242
FEM Bd	EM	0.302
	LM	0.962
	PM	0.863
TIB Bd	EM	0.156
	LM	0.816
	PM	0.033
TIB Dd	EM	0.624
	LM	0.035
	PM	0.000
AST GLl	EM	0.007
	LM	0.452
	PM	0.082
AST GLm	EM	0.088
	LM	0.360
	PM	0.019
AST Bd	EM	0.043

	LM	0.425
	PM	0.026
AST DI	EM	0.556
	LM	0.022
	PM	0.040
CAL GL	EM	0.285
	LM	0.818
	PM	0.747
CAL GB	EM	0.085
	LM	0.235
	PM	0.312
MT GL	EM	0.104
	LM	0.638
	PM	0.123
MT SD	EM	0.580
	LM	0.131
	PM	0.681
MT Bd	EM	0.069
	LM	0.286
	PM	0.780
MT a	EM	0.901
	LM	0.692
	PM	0.662
MT b	EM	0.299
	LM	0.523
	PM	0.490
MT 1	EM	0.682
	LM	0.188
	PM	0.450
MT 2	EM	0.323
	LM	0.118
	PM	0.855
MT 3	EM	0.585
	LM	0.306
	PM	0.297
MT 4	EM	0.065
	LM	0.283
	PM	0.056
MT 5	EM	0.240
	LM	0.642
	PM	0.312
LR Lengths	10th-13th	0.245
	13th-14th	0.853
	15th-16th	0.892
	16th-17th	0.368
	17th-18th	0.333
	18th-19th	0.798
	EM	0.000
	LM	0.286
	PM	0.883
LR Widths	10th-13th	0.007
	13th-14th	0.166
	15th-16th	0.076
	16th-17th	0.000

	17th-18th	0.008
	18th-19th	0.616
	EM	0.002
	LM	0.702
	PM	0.000
LR Depths	10th-13th	0.769
	13th-14th	0.108
	15th-16th	0.006
	16th-17th	0.625
	17th-18th	0.198
	18th-19th	0.478
	EM	0.369
	LM	0.073
	PM	0.098

Cattle:

Element	**Phase/ Period**	**S-W sig.**
M_3 W	EM	0.303
	LM	0.024
	PM	0.063
dP_4 W	EM	0.632
	LM	0.460
	PM	0.032
M_1 W	LM	0.084
	PM	0.754
M_3 L	EM	0.360
	LM	0.617
	PM	0.014
SCA GLP	EM	0.107
	LM	0.570
	PM	0.030
SCA SLC	EM	0.559
	LM	0.130
	PM	0.155
HUM BT	EM	0.058
	LM	0.804
	PM	0.001
HUM HTC	EM	0.847
	LM	0.231
	PM	0.254
RAD Bd	LM	0.864
	PM	0.216
MC GL	LM	0.022
	PM	0.995
MC SD	LM	0.098
	PM	0.031
MD Bd	LM	0.098
	PM	0.000
MC BatF	LM	0.465
	PM	0.000
MC a	LM	0.084

	PM	0.001
MC b	LM	0.541
	PM	0.002
MC 3	LM	0.084
	PM	0.004
PEL LA	LM	0.492
	PM	0.157
FEM DC	EM	0.037
	LM	0.005
	PM	0.287
TIB Bd	EM	0.589
	LM	0.513
	PM	0.574
TIB Dd	EM	0.911
	LM	0.351
	PM	0.936
AST GLl	EM	0.001
	LM	0.920
	PM	0.576
AST GLm	EM	0.003
	LM	0.474
	PM	0.383
AST Bd	EM	0.517
	LM	0.212
	PM	0.424
AST DI	EM	0.040
	LM	0.001
	PM	0.040
CAL GB	LM	0.052
	PM	0.313
MT GL	LM	0.984
	PM	0.398
MT SD	LM	0.815
	PM	0.528
MT Bd	LM	0.189
	PM	0.969
MT BatF	LM	0.164
	PM	0.363
MT a	LM	0.175
	PM	0.978
MT b	LM	0.512
	PM	0.566
MT 3	LM	0.135
	PM	0.989
LR Lengths	10^{th}-13^{th}	0.467
	15^{th}-16^{th}	0.720
	16^{th}-17^{th}	0.490
	17^{th}-18^{th}	0.016
	18^{th}-19^{th}	0.000
	EM	0.104
	LM	0.004
	PM	0.004
LR Widths	10^{th}-13^{th}	0.067
	13^{th}-14^{th}	0.605

	15^{th}-16^{th}	0.204
	16^{th}-17^{th}	0.190
	17^{th}-18^{th}	0.003
	18^{th}-19^{th}	0.001
	EM	0.633
	LM	0.002
	PM	0.000
LR Depths	10^{th}-13^{th}	0.112
	13^{th}-14^{th}	0.363
	15^{th}-16^{th}	0.703
	16^{th}-17^{th}	0.237
	17^{th}-18^{th}	0.058
	18^{th}-19^{th}	0.457
	EM	0.658
	LM	0.032
	PM	0.046

Pig:

Element	**Phase/ Period**	**S-W sig.**
LR Tooth Lengths	10^{th}-13^{th}	0.271
	13^{th}-14^{th}	0.382
	15^{th}-16^{th}	0.514
	16^{th}-17^{th}	0.297
	17^{th}-18^{th}	0.002
	18^{th}-19^{th}	0.544
	EM	0.717
	LM	0.000
	PM	0.005
LR Tooth Widths	10^{th}-13^{th}	0.912
	13^{th}-14^{th}	0.086
	15^{th}-16^{th}	0.096
	16^{th}-17^{th}	0.181
	17^{th}-18^{th}	0.024
	18^{th}-19^{th}	0.100
	EM	0.239
	LM	0.102
	PM	0.147
LR PC	EM	0.908
	LM	0.787
	PM	0.379
dP_4 L	EM	0.153
	LM	0.997
	PM	0.197
dP_4 WP	EM	0.503
	LM	0.688
	PM	0.486
M_1 L	EM	0.948
	LM	0.130
	PM	0.006
M_1 WA	EM	0.002
	LM	0.000
	PM	0.008
M_1 WP	EM	0.065

	LM	0.004
	PM	0.086
M_2 L	EM	0.786
	LM	0.001
	PM	0.807
M_2 WA	EM	0.087
	LM	0.001
	PM	0.048
M_2 WP	EM	0.235
	LM	0.326
	PM	0.243
M_3 L	EM	0.206
	LM	0.524
	PM	0.425
M_3 WA	EM	0.982
	LM	0.705
	PM	0.625
M_3 WC	EM	0.988
	LM	0.402
	PM	0.829
M_3 WP	EM	0.811
	LM	0.568
	PM	0.965
SCA GLP	LM	0.687
	PM	0.681
SCA SLC	LM	0.551
	PM	0.768
HUM BT	EM	0.750
	LM	0.605
	PM	0.797
HUM HTC	EM	0.344
	LM	0.784
	PM	0.141
AST GLl	EM	0.758
	LM	0.314
	PM	0.575
AST GLm	EM	0.963
	LM	0.965
	PM	0.262

Horse:

M_2L_1	LM	0.871
	PM	0.796
M_2W_a	LM	0.438
	PM	0.233
M_3L_1	EM	0.757
	LM	0.184
	PM	0.104
M_3W_a	EM	0.854
	LM	0.370
	PM	0.510
SCA GLP	LM	0.098

	PM	0.837
SCA SLC	LM	0.823
	PM	1.000
HUM BT	LM	0.043
	PM	0.233
HUM HTC	LM	0.211
	PM	0.020
MC GL	LM	0.010
	PM	0.520
MC SD	LM	0.871
	PM	0.282
MC Bd	LM	0.380
	PM	0.473
MC Dd	LM	0.001
	PM	0.351
PEL LAR	LM	0.998
	PM	0.387
FEM DC	LM	0.050
	PM	0.474
FEM Bd	LM	0.106
	PM	0.011
TIB Bd	EM	0.233
	LM	0.034
	PM	0.273
TIB Dd	EM	0.204
	LM	0.017
	PM	0.583
AST GH	EM	0.322
	LM	0.745
	PM	0.326
AST GB	EM	0.391
	LM	0.947
	PM	0.087
AST BfD	EM	0.464
	LM	0.547
	PM	0.408
AST LmT	EM	0.632
	LM	0.535
	PM	0.213
CAL GB	LM	0.276
	PM	0.381
P1 GL	LM	0.012
	PM	0.016
P1 Bp	LM	0.320
	PM	0.558
P1 Dp	LM	0.771
	PM	0.448
P1 SD	LM	0.070
	PM	0.745
P1 Bd	LM	0.102

	PM	0.748
P1 Dd	LM	0.000
	PM	0.191
LR Lengths	EM	0.650
	LM	0.032
	PM	0.008
LR Widths	EM	0.891
	LM	0.000
	PM	0.013
LR Depths	EM	0.000
	LM	0.002
	PM	0.018

Shapwick:

Sheep:

Element	**Phase/ Period**	**S-W sig.**
	EM	0.387
	LM	0.235
	PM	0.196
dP_4 W	LM	0.653
	PM	0.798
M_1W	LM	0.353
	PM	0.641
M_2W	LM	0.040
	PM	0.745
M_3L	EM	0.675
	LM	0.053
	PM	0.923
M_3W	EM	0.387
	LM	0.235
	PM	0.196
SCA GLP	LM	0.473
	PM	0.652
SCA SLC	LM	0.194
	PM	1.000
HUM BT	LM	0.879
	PM	0.242
HUM Bd	LM	0.406
	PM	0.060
HUM HTC	LM	0.649
	PM	0.235
RAD Bp	LM	0.778
	PM	0.744
RAD Bd	LM	0.732
	PM	0.437
TIB Bd	EM	0.111
	LM	0.184
	PM	0.345
TIB Dd	EM	0.011
	LM	0.192
	PM	0.350

AST GLl	LM	0.212
	PM	0.301
AST GLm	LM	0.413
	PM	0.370
AST Bd	LM	0.351
	PM	0.033
AST Dl	LM	0.307
	PM	0.762
LR Lengths	EM	0.556
	LM	0.192
	PM	0.912
LR Widths	EM	0.128
	LM	0.409
	PM	0.047
LR Depths	EM	0.101
	LM	0.729
	PM	0.695

Cattle:

Element	**Phase/ Period**	**S-W sig.**
M_3 W	EM	0.093
	LM	0.964
	PM	0.322
SCA GLP	EM	0.578
	LM	0.986
SCA SLC	LM	0.665
	PM	0.731
HUM HTC	EM	0.003
	LM	0.983
	PM	0.675
TIB Bd	EM	0.942
	LM	0.629
TIB Dd	EM	0.060
	LM	0.567
AST GLl	EM	0.344
	LM	0.161
	PM	0.619
AST GLm	EM	0.120
	LM	0.137
	PM	0.638
AST Bd	EM	0.094
	LM	0.156
	PM	0.932
AST Dl	LM	0.119
	PM	0.976
LR Lengths	EM	0.696
	LM	0.409
	PM	0.645
LR Widths	EM	0.295
	LM	0.096
	PM	0.596

LR Depths	EM	0.106
	LM	0.768
	PM	0.382

Pig:

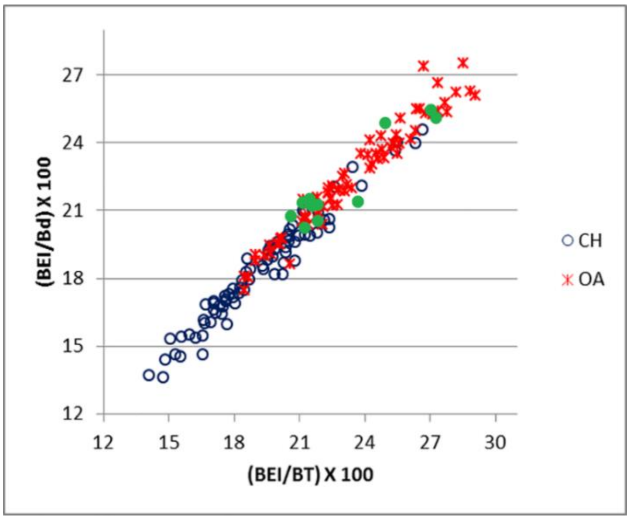
Element	**Phase/ Period**	**S-W sig.**
LR Tooth Lengths	EM	0.000
	LM	0.047
	PM	0.005
LR Tooth Widths	EM	0.000
	LM	0.397
	PM	0.001
LR PC	LM	0.003
	PM	0.729

Horse:

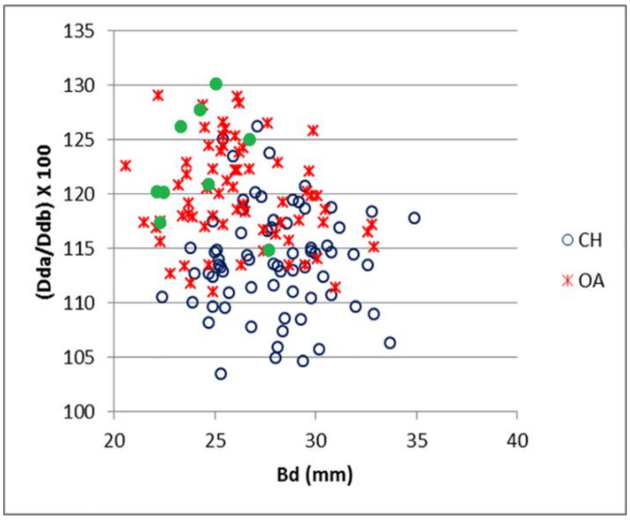
LR PC	EM	0.011
	LM	0.167
	PM	0.964

Appendix 3: *Great Linford Sheep/Goat Metric Separation Graphs:*

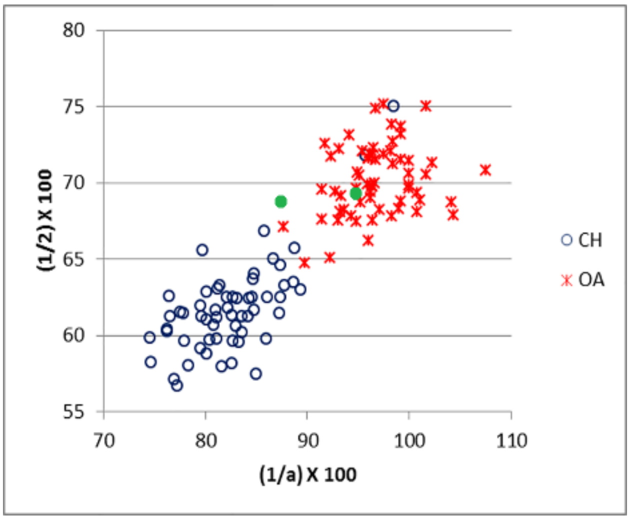
Early Medieval:



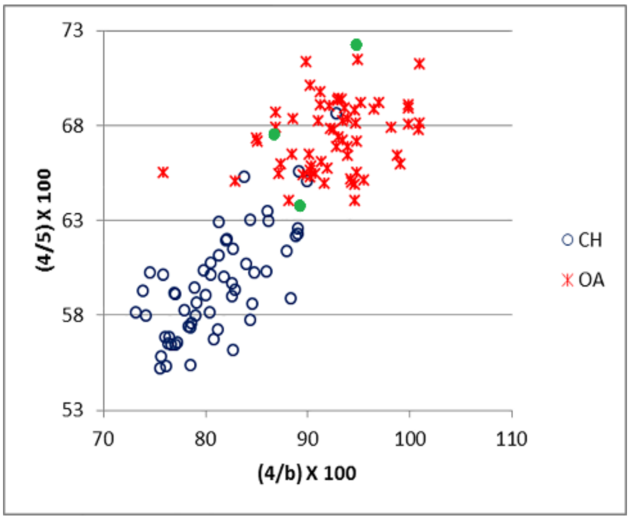
Humerus BEl/BT vs. BEl/Bd



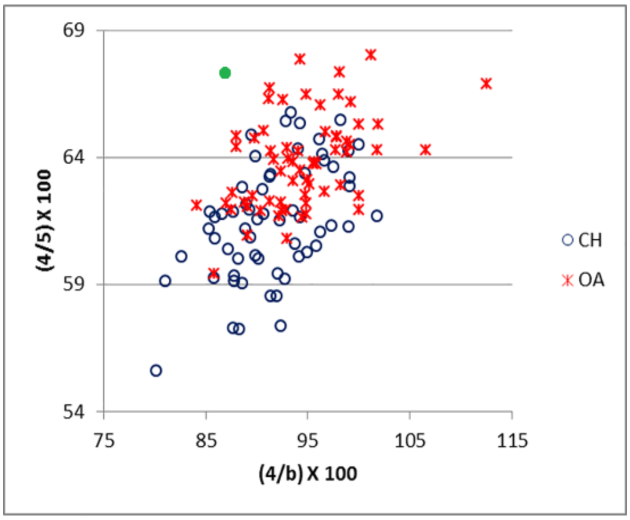
Tibia Bd vs. Dda/Ddb



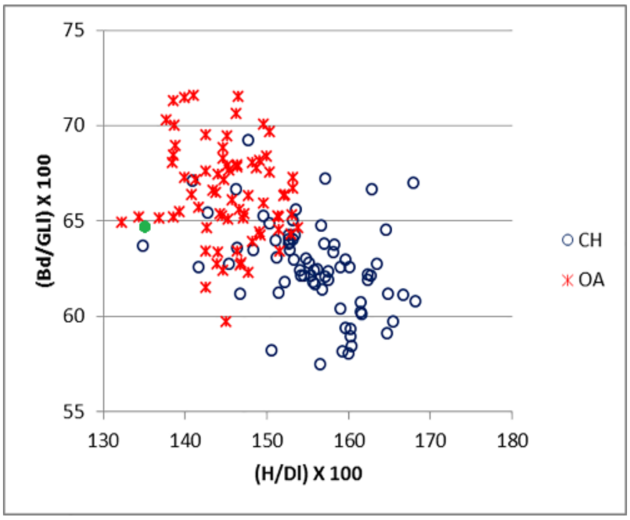
Metacarpal 1/a vs. 1/2



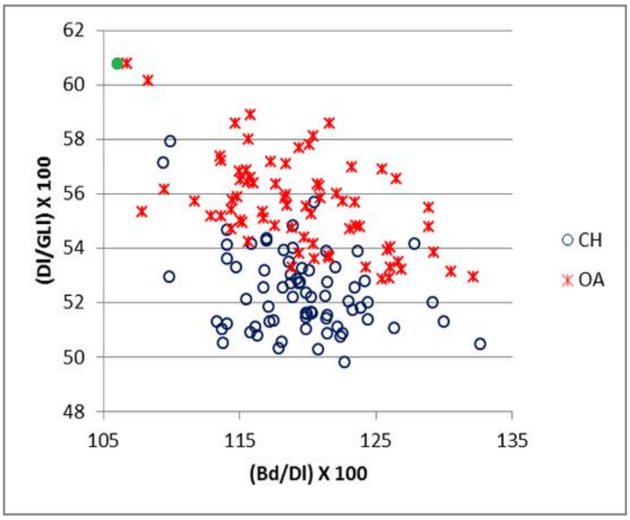
Metacarpal 4/b vs. 4/5



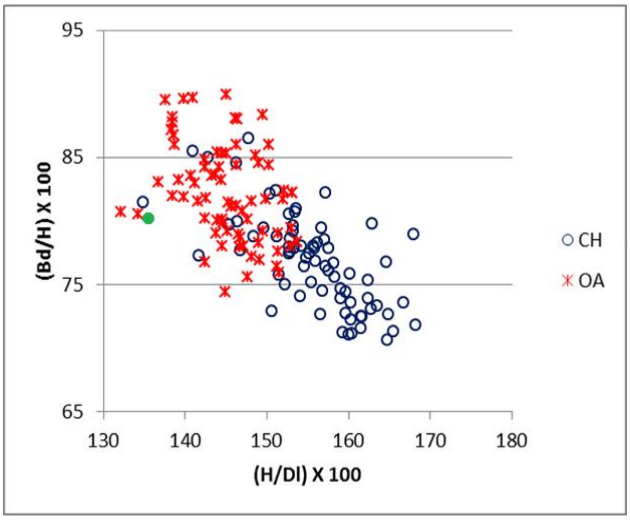
Metatarsal 4/b vs. 4/5



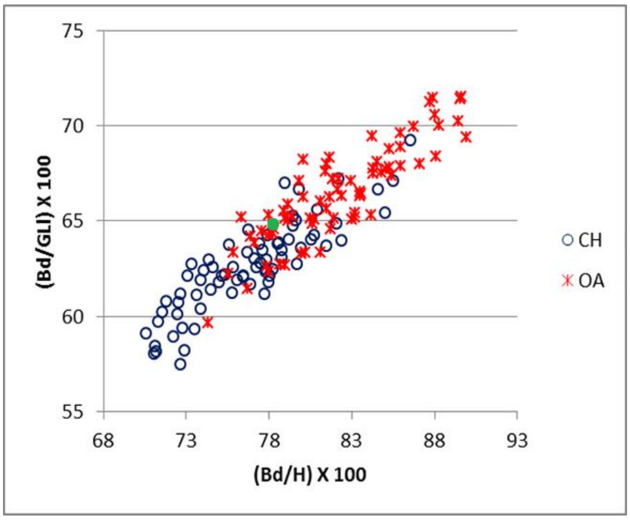
Astragalus H/Dl vs. Bd/GLI



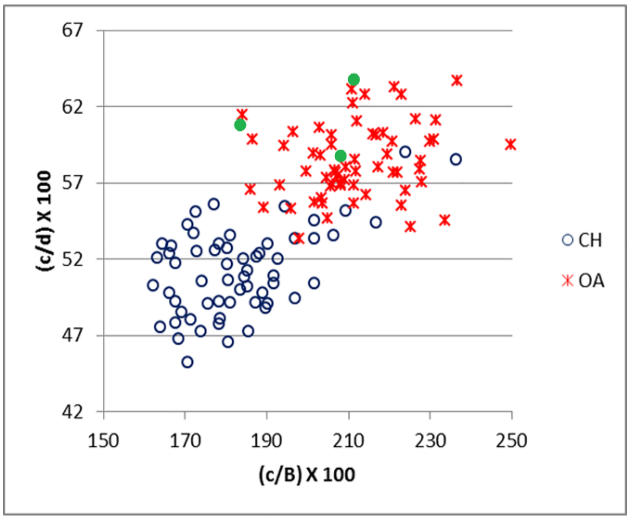
Astragalus Bd/DI vs. DI/GLl



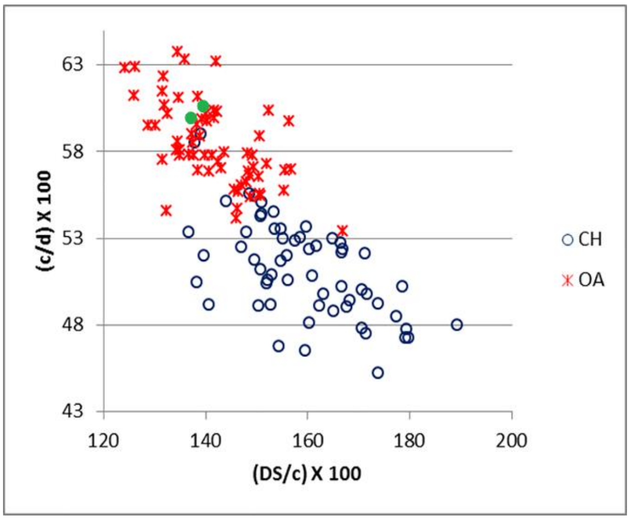
Astragalus H/DI vs. Bd/H



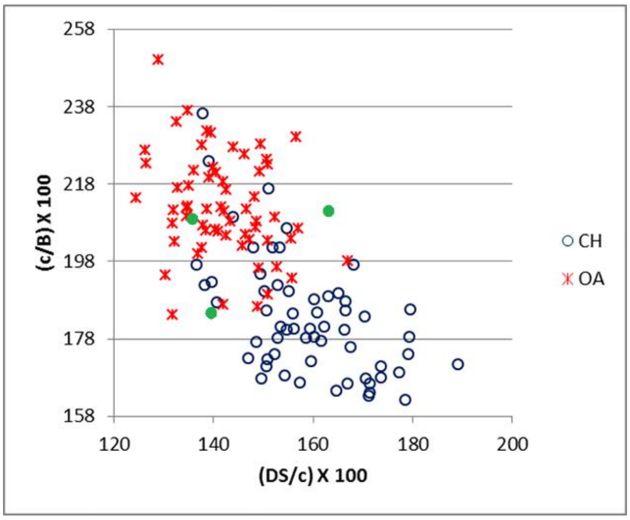
Astragalus Bd/H vs. Bd/GLl



Calcaneum c/B vs. c/d

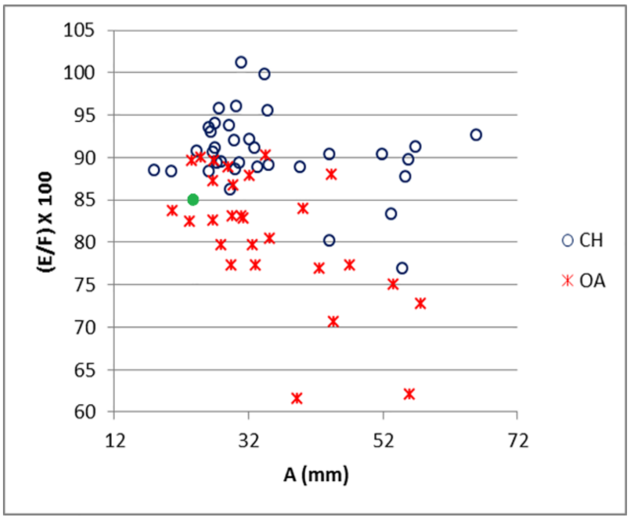


Calcaneum DS/c vs. c/d

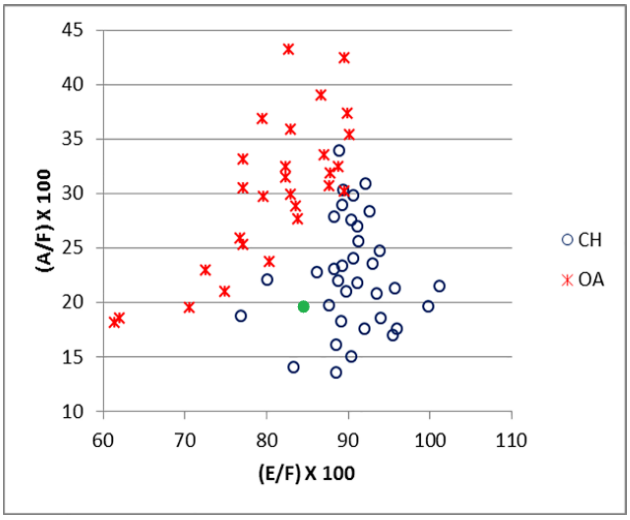


Calcaneum DS/c vs. c/B

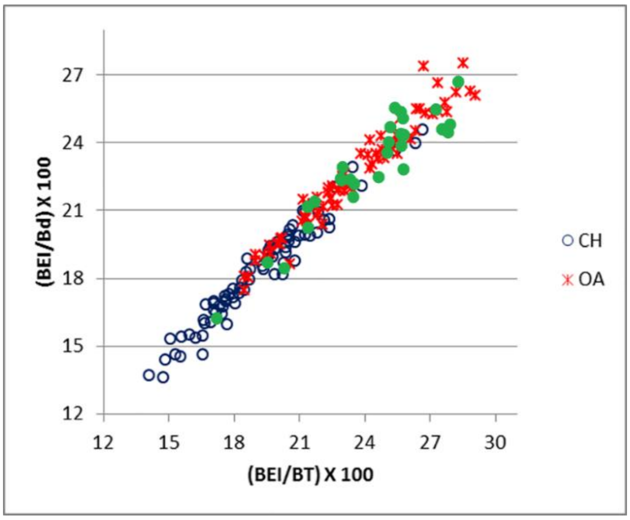
Late Medieval:



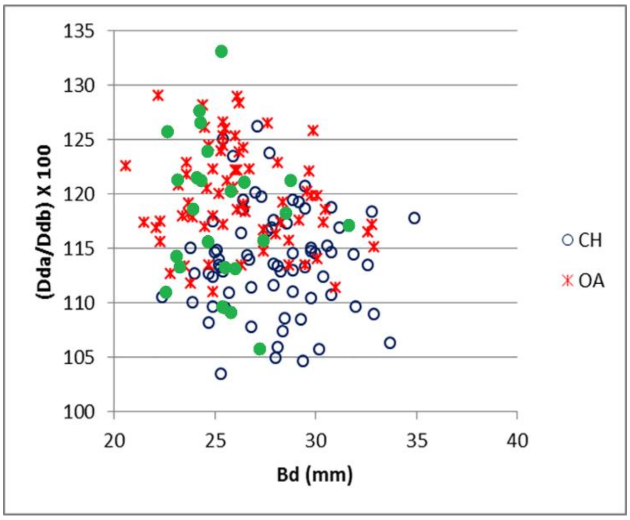
Horncore A vs. E/F



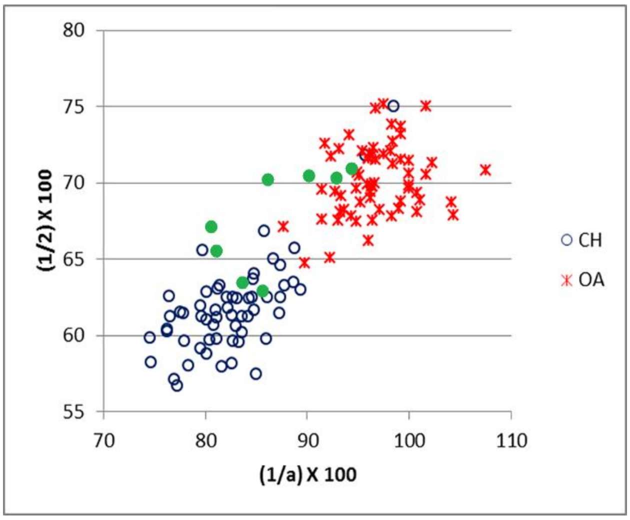
Horncore E/F vs. A/F



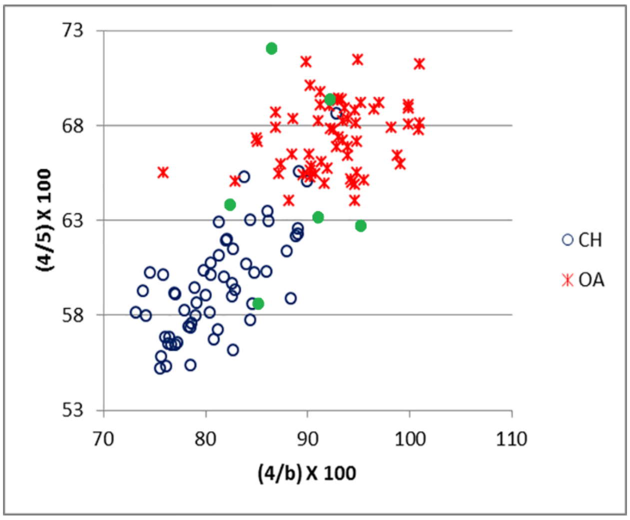
Humerus BEI/BT vs. BEI/Bd



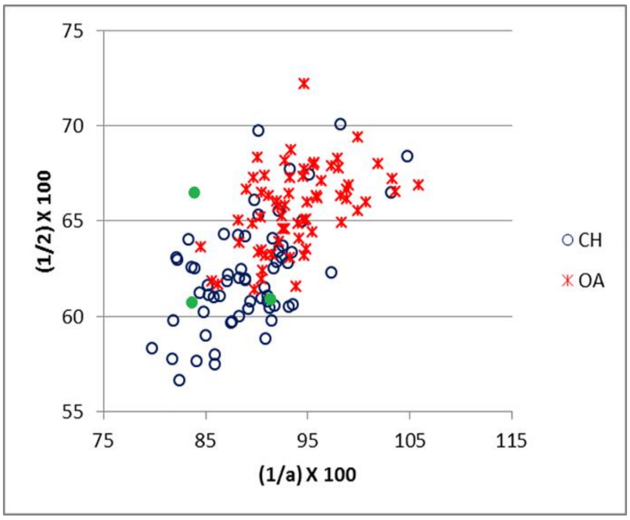
Tibia Bd vs. Dda/Ddb



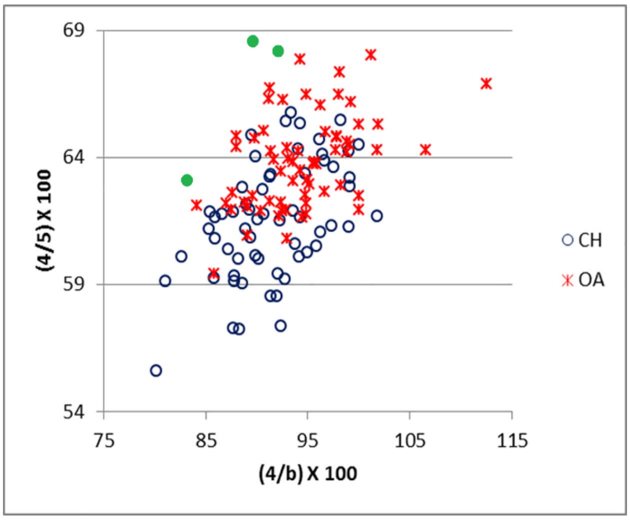
Metacarpal 1/a vs. 1/2



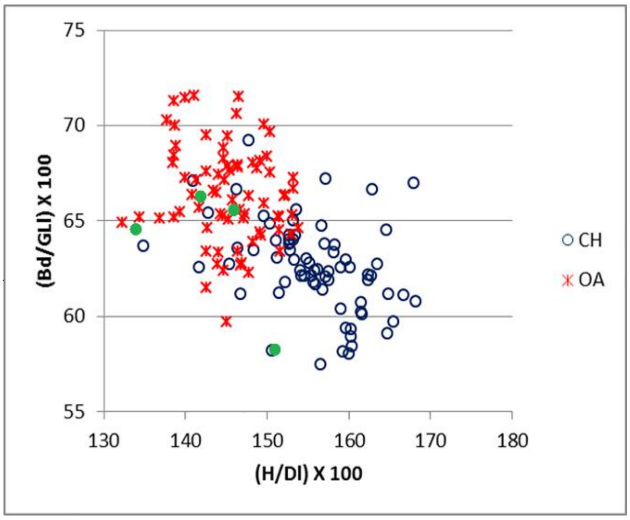
Metacarpal 4/b vs. 4/5



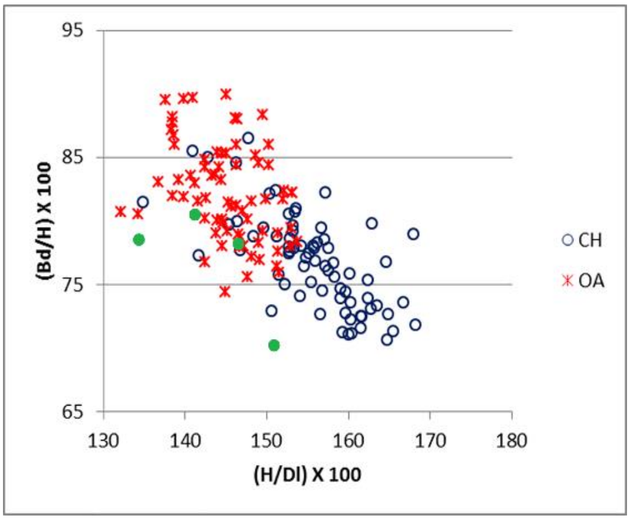
Metatarsal 1/a vs. 1/2



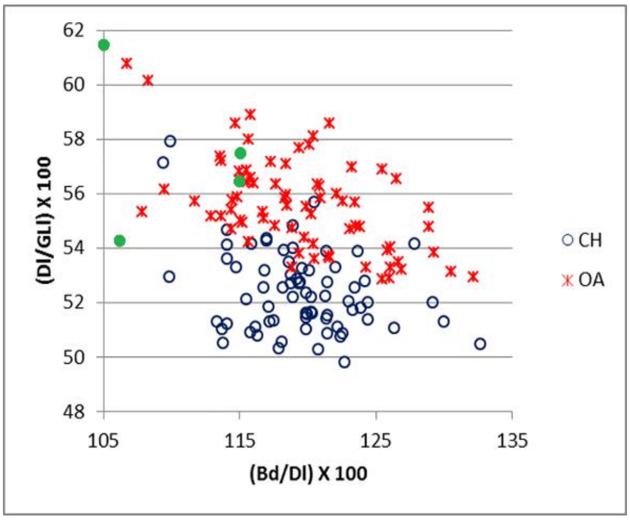
Metatarsal 4/b vs. 4/5



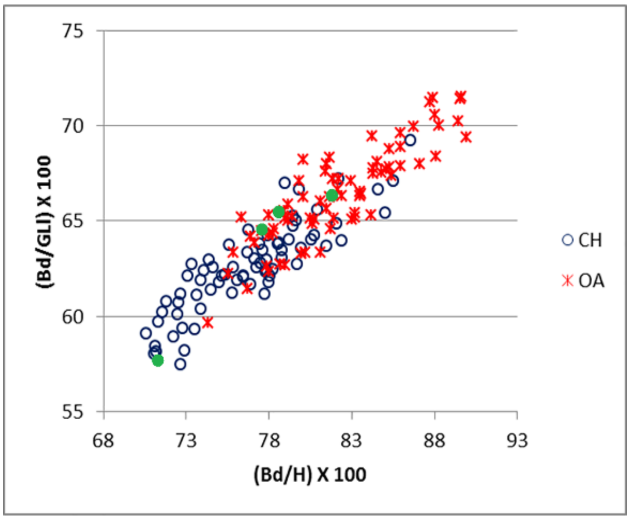
Astragalus H/Dl vs. Bd/GLl



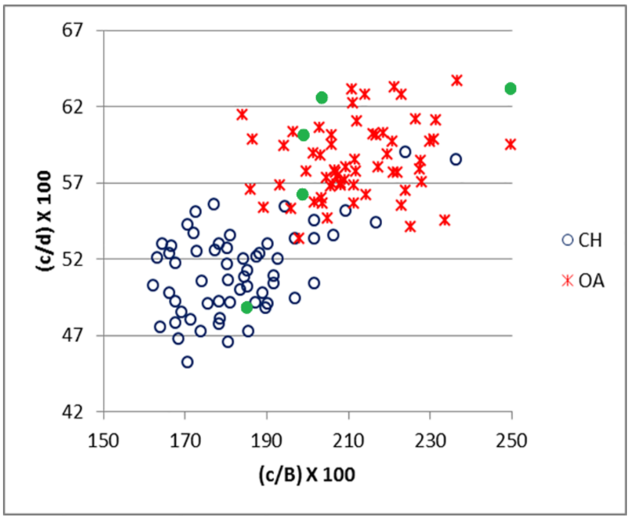
Astragalus H/Dl vs. Bd/H



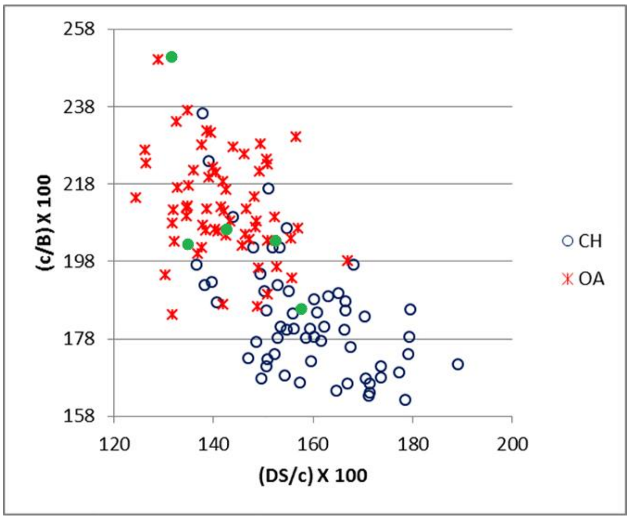
Astragalus Bd/Dl vs. Dl/GLl



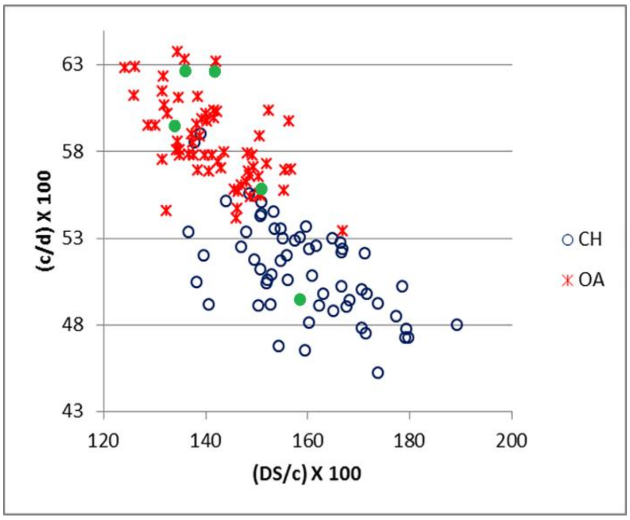
Astragalus Bd/H vs. Bd/GLl



Calcaneum c/B vs. c/d

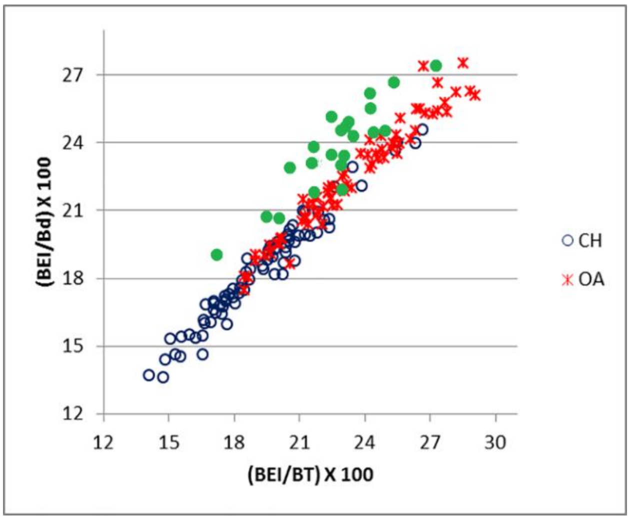


Calcaneum DS/c vs. c/B

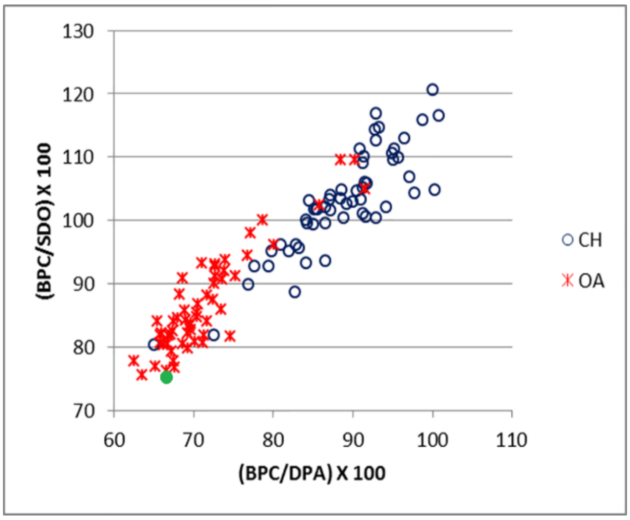


Calcaneum DS/c vs. c/d

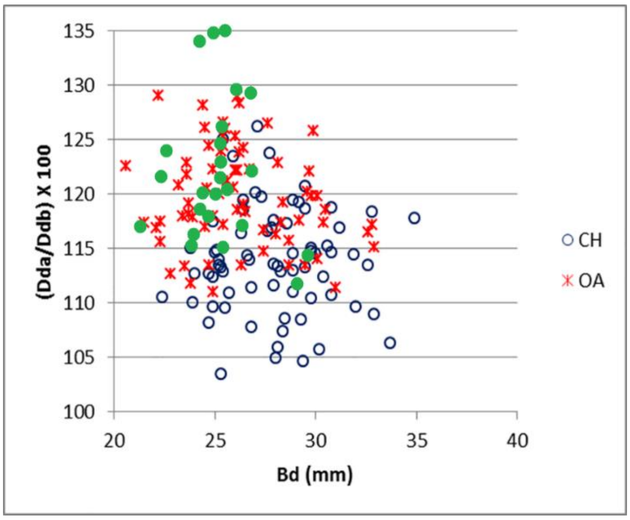
Post Medieval:



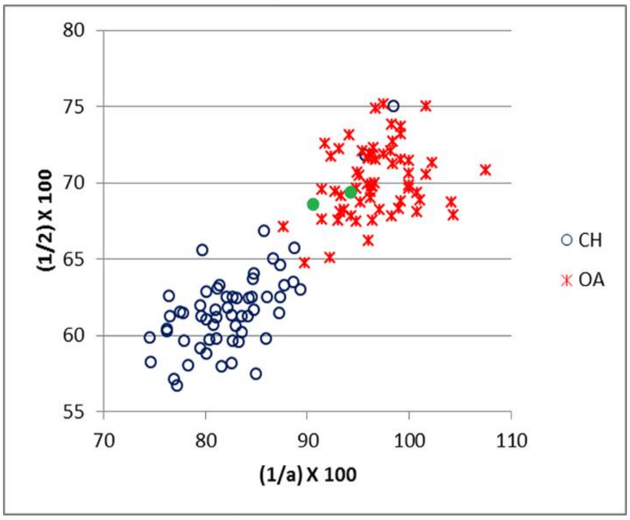
Humerus BEl/BT vs. BEl/Bd



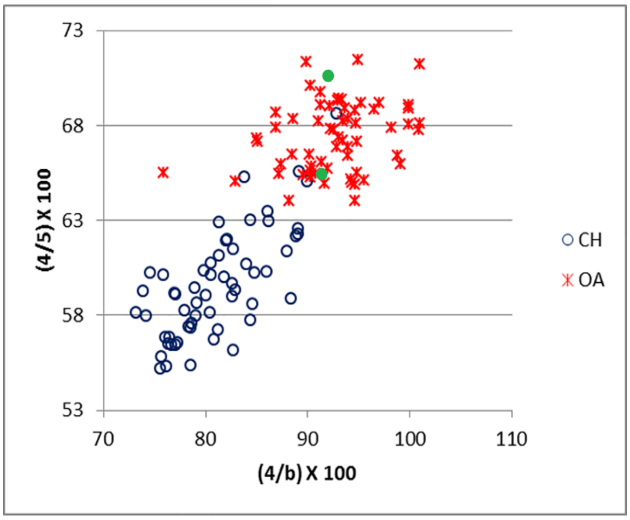
Ulna BPC/DPA vs. BPC/SDO



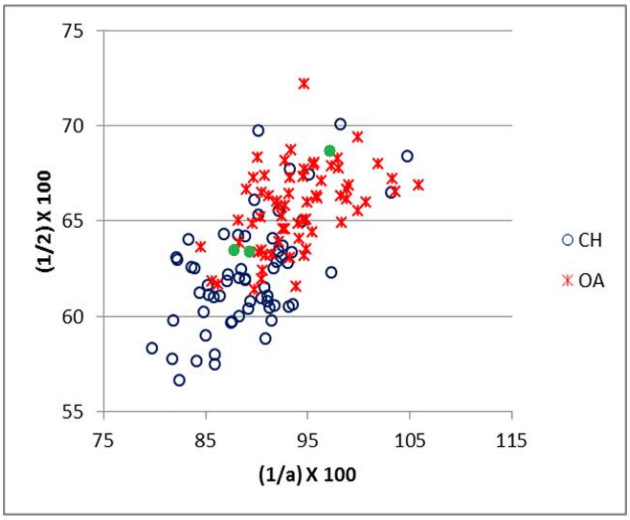
Tibia Bd vs. Dda/Ddb



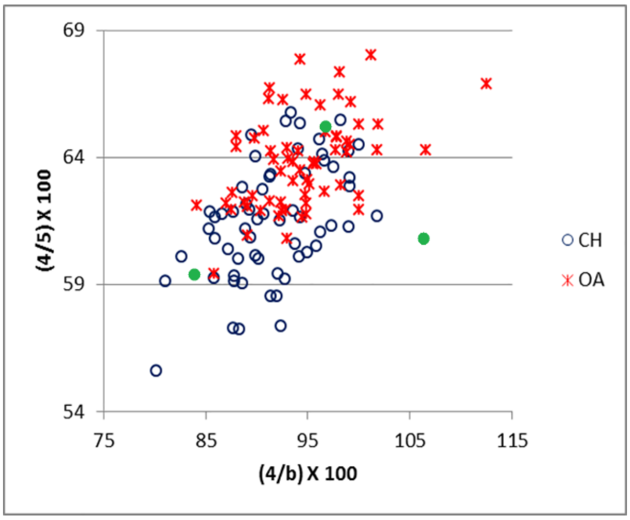
Metacarpal 1/a vs. 1/2



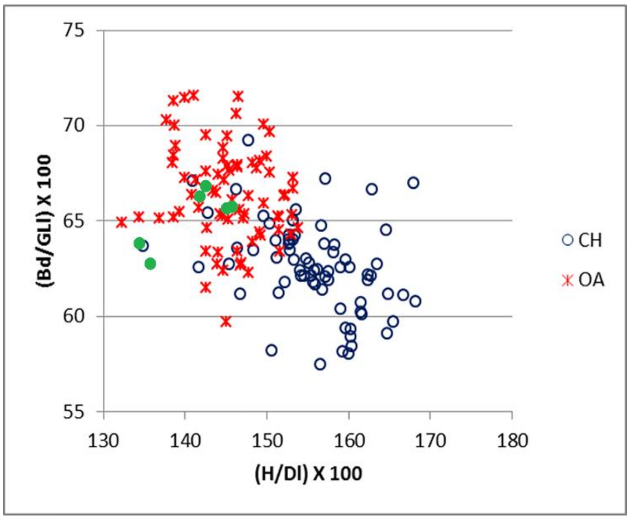
Metacarpal 4/b vs. 4/5



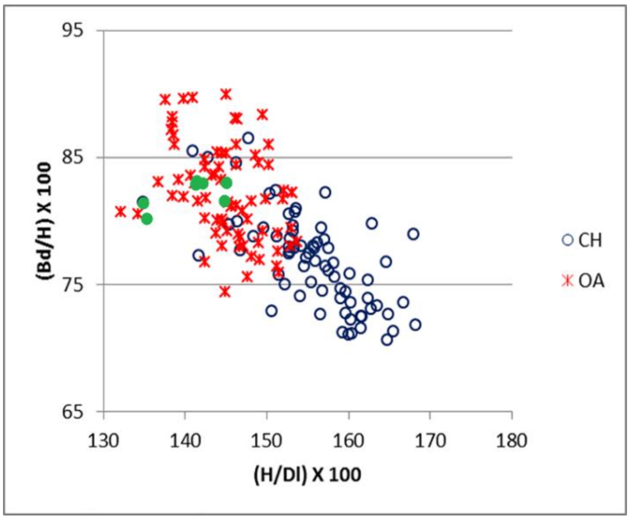
Metatarsal 1/a vs. 1/2



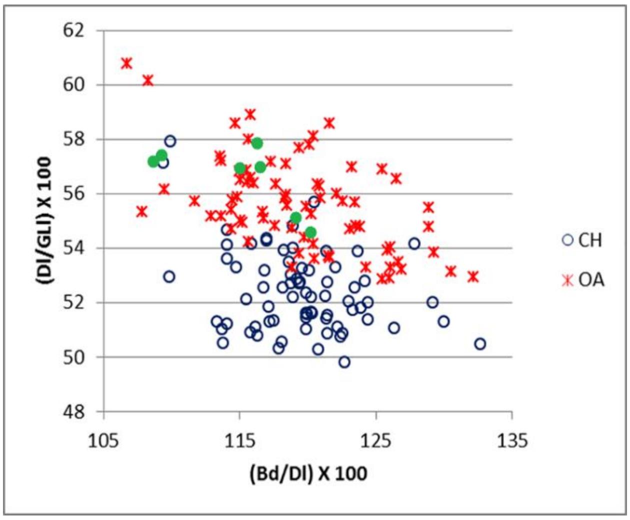
Metatarsal 4/b vs. 4/5



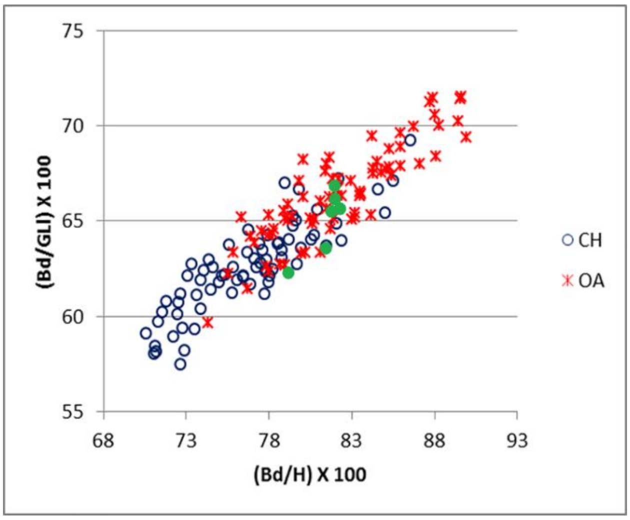
Astragalus H/Dl vs. Bd/GLl



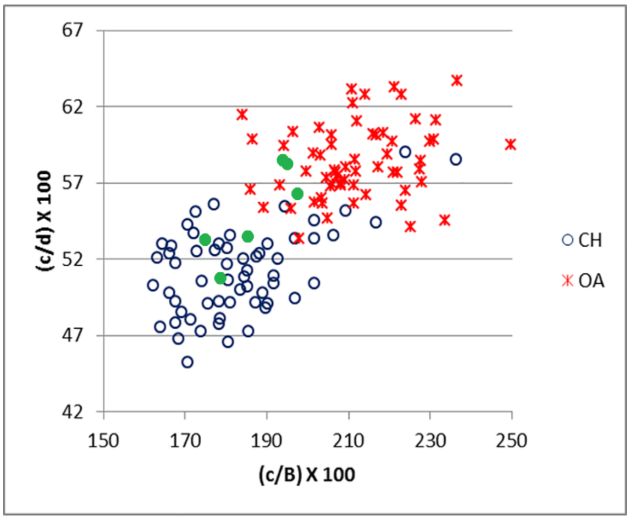
Astragalus H/Dl vs. Bd/H



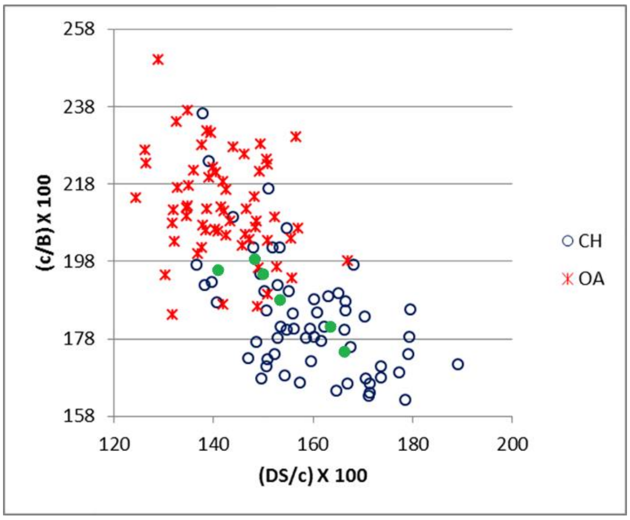
Astragalus Bd/Dl vs. Dl/GLl



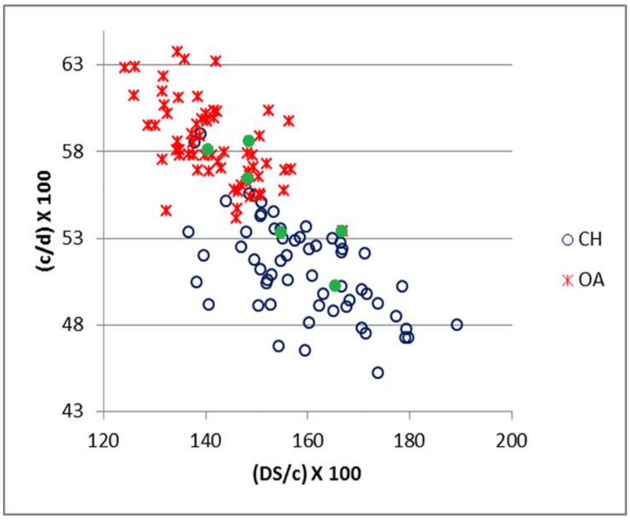
Astragalus Bd/H vs. Bd/GLl



Calcanuem c/B vs. c/d



Calcaneum DS/c vs. c/B

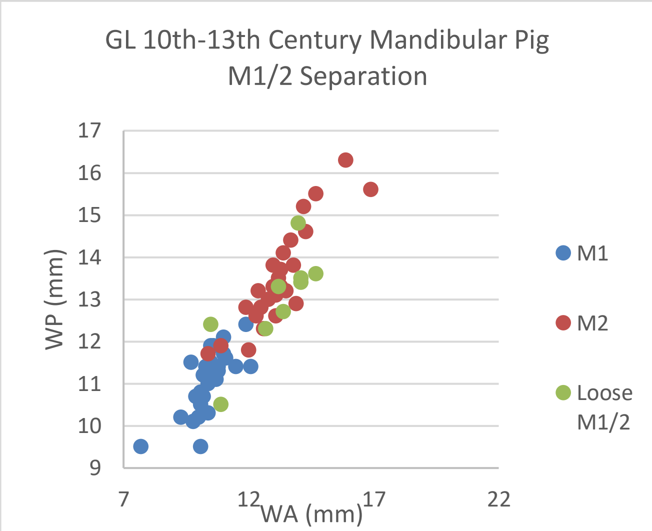


Calcaneum DS/c vs. c/d

Appendix 4: *Great Linford Pig M12 Separation:*

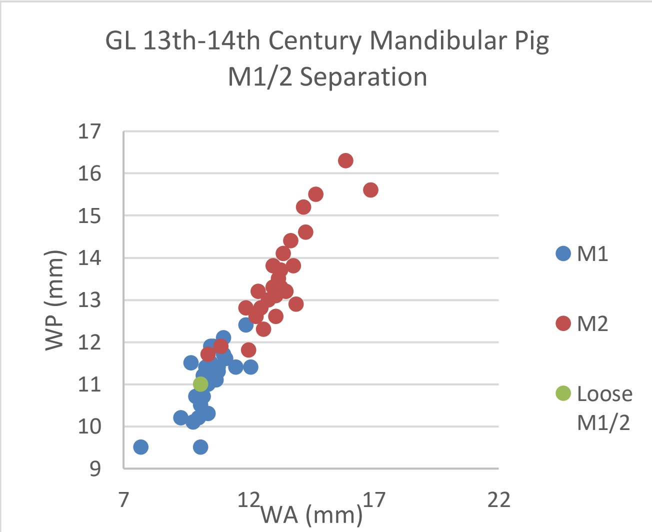
10th-13th century (EM):

ID no.	WA	WP	M1/2
332	13.2	13.3	M2
331	14.1	13.4	M2
330	14.7	13.6	M2
1823	14.1	13.5	M2
1822	14.0	14.8	M2
1821	10.5	12.4	M1
1820	13.4	12.7	M2
1819	12.7	12.3	M2
117	10.9	10.5	M1



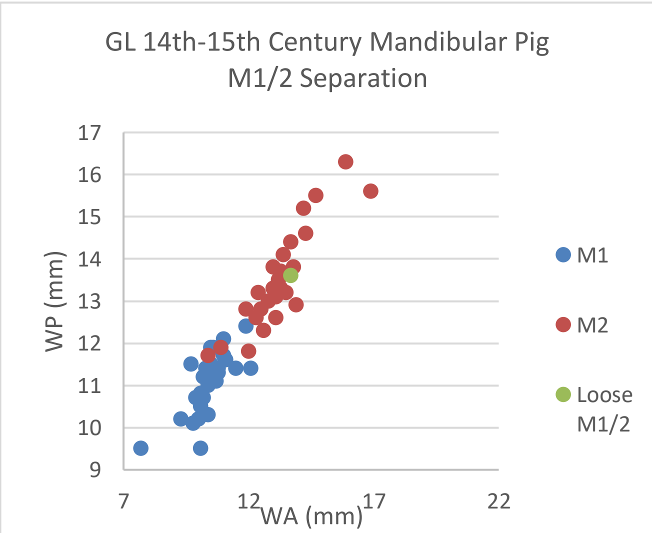
13th-14th century:

ID no.	WA	WP	M1/2
2303	10.1	11.0	M1



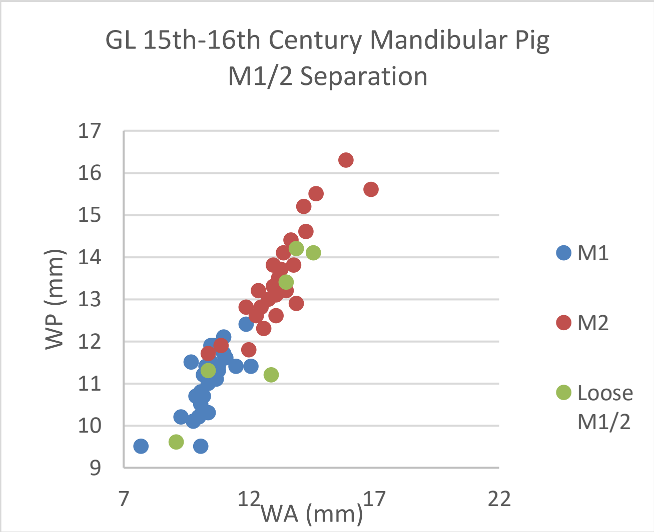
14th-15th century:

ID no.	WA	WP	M1/2
1471	13.7	13.6	M2



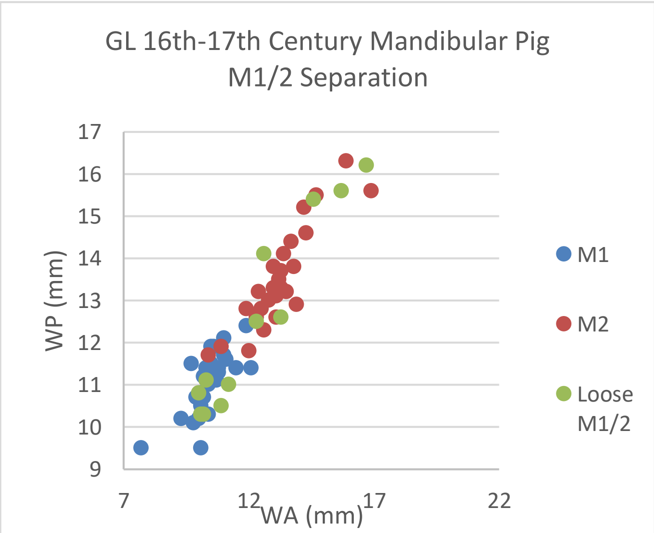
15th-16th century:

ID no.	WA	WP	M1/2
182	13.5	13.4	M2
195	13.9	14.2	M2
2073	14.6	14.1	M2
2205	10.4	11.3	M1
2206	12.9	11.2	M1
2223	9.1	9.6	M1



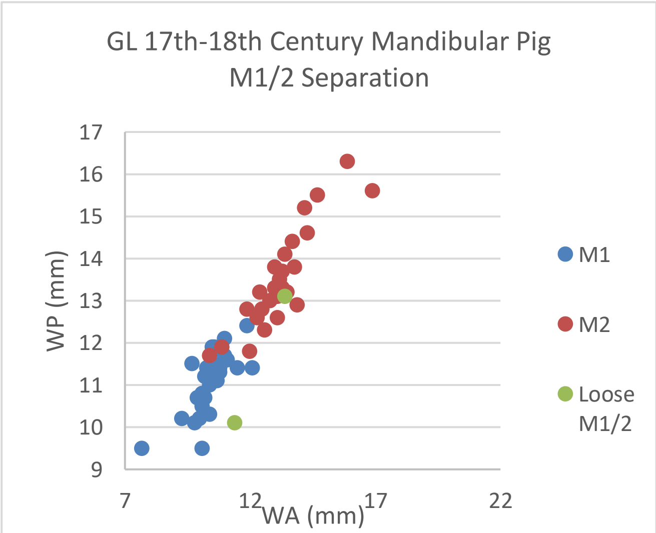
16th-17th century:

ID no.	WA	WP	M1/2
1328	10.1	10.3	M1
1691	12.3	12.5	M2
1406	12.6	14.1	M2
1407	13.3	12.6	M2
1189	14.6	15.4	M2
1721	10.9	10.5	M1
2051	10	10.8	M1
2031	10.2	10.3	M1
561	15.7	15.6	M2
922	10.3	11.1	M1
886	16.7	16.2	M2
1428	11.2	11	M1



17th-18th century:

ID no.	WA	WP	M1/2
1712	11.4	10.1	M1
1713	13.4	13.1	M2



M1/2 in jaw reference measurements:

M1		M2	
WA	**WP**	**WA**	**WP**
12.1	11.4	16.9	15.6
11.5	11.4	14.3	14.6
10.4	10.3	13.1	12.6
10.6	11.4	12.6	12.3
11.0	11.7	13.2	13.5
9.7	11.5	13.7	14.4
10.8	11.4	14.7	15.5
11.9	12.4	15.9	16.3
10.6	11.4	13.0	13.3
9.8	10.1	12.3	12.6
10.8	11.3	13.3	13.7
10.0	10.7	13.4	14.1
10.1	10.8	13.9	12.9
10.6	11.9	13.3	13.3
10.2	10.7	13.5	13.2
10.3	11.4	12.5	12.8
11.1	11.6	13.0	13.8
10.7	11.1	10.9	11.9
10.2	11.2	11.9	12.8
10.5	11.5	14.2	15.2
10.1	9.5	12.8	13.0
9.9	10.7	13.1	13.1
7.7	9.5	12.4	13.2
11.0	12.1	13.8	13.8
10.4	11.0	12.0	11.8
10.3	11.4	10.4	11.7
10.1	10.5		
10.7	11.3		
10.0	10.2		
9.3	10.2		
10.5	11.9		
10.4	11.4		

Appendix 5: *Great Linford sheep dental ageing table:*

Tooth	Phase	C	V	E	H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
dP_4	10																		1	2		2		2					
	13																					3							2
	14																		1					1					
	15																	1		2		4	2		1				1
	16																			1		5							
	17																					1							2
P_4	10			1							3		2	5	1			5			1								
	13					1								1	2			1											
	14			1							1				2			5											
	15th-					1		1		2	3		5	10	6			8			1								
	16th-			2		4				4	3		1	6	8			13											
	17													2	1														
M_1	10th-										1			2	17		1	1			2								
	13										1		1		4			1		1	1								
	14														4			1			1								
	15th-			1								2		1	20	1	2	1			3								
	16th-													2	15	2	1	1		1	7								
	17														3		1												
M_2	10th-											2	3	2	11	1	1												
	13			1											7														
	14									1			2		2	1													
	15th-		1								2		2	8	13	1	1												
	16th-												1	5	17	2	1	2		1									
	17th-18th														2		1												
M_{12}	10th-13th									2			4	2	25	2		2			1								
	13th-14th					1	1	1			1	1	8	2	18														
	14th-15th												2	1	8	1													
	15th-16th					3		3	1	1	3	4	10	10	45	9	1			1									

	16th-17th					2	1	1		1	1	5	12	14	50	10	1				4								
	17th-18th										1		1	1	4														
M3	10th-13th	2		1		1				1	4	2	2	1	3	3	11												
	13th-14th					1		1			1	2		3	3		5												
	14th-15th			1		1		1			1		1	2			7												
	15th-16th					2		1	3	3	3	1	1	6	8	4	15												
	16th-17th			2		6		3		4	7		2	6	10	7	33	2											
	17th-18th					1								1		3	3												

Appendix 6: *Great Linford cattle dental ageing table:*

Tooth	Phase	C	V	E	H	a	b	c	d	e	f	g	h	j	k	l	m	n	o	p
dP_4	10th-13th					2	1		2				1	2	2	1				
	13th-14th																			
	14th-15th								1		1				1					
	15th-16th							1			1									
	16th-17th							3		1	1			3	3					
	17th-18th																			
P_4	10th-13th									1	1	1								
	13th-14th										1	1	1							
	14th-15th			2							2									
	15th-16th									1				1						
	16th-17th					2			1	1	1	2			1					
	17th-18th																			
M_1	10th-13th											1		1	3	3				
	13th-14th																	1		
	14th-15th																			
	15th-16th						1								2					
	16th-17th														2					
	17th-18th																			
M_2	10th-13th												2	1	3					
	13th-14th															1				
	14th-15th																			
	15th-16th												1	2	1					
	16th-17th														1					
	17th-18th																			
M_{12}	10th-13th						2	1				2		3	6	1				
	13th-14th					1		1	1		2	3			4	1		1	1	
	14th-15th						1					2			2			1		
	15th-16th								3	2	3	2		4	7	3	1			
	16th-17th						3	2	1	1	2	3		12	19	3	1	1		
	17th-18th																			
M_3	10th-13th								1		3	1	1	2	5					
	13th-14th									1				2	2	2				
	14th-15th																			
	15th-16th						1	1				1		4	2	1				
	16th-17th					1		1	2		1	6	1		3					
	17th-18th													1						

Appendix 7: *Great Linford pig dental ageing table:*

Tooth	Phase	C	V	E	H	w 1	w 2	w 3	w1/w1	w2/w1	w2/w2	w3/w2	w3/w3	w4/w3	w3-w3	w4-w3	w4-w4	w1/w1/w1	w2/w1/w1	w2/w2/w2	w3/w2/w2	w3/w3/w2	w3/w3-w3	w3-w3-w3
dP4	10th-13th																							
	13th-14th						1																	
	14th-15th																							
	15th-16th																							
	16th-17th																							
	17th-18th																							
P4	10th-13th					2	3	1																
	13th-14th						2																	
	14th-15th																							
	15th-16th					2	7	1																
	16th-17th			1		1	3	1																
	17th-18th					1	1																	
M1	10th-13th												2		3									
	13th-14th			1											1									
	14th-15th									1			1											
	15th-16th									1		3	2		1		1							
	16th-17th										3	1	1		2		1							
	17th-18th										2													
M2	10th-13th										5													
	13th-14th										1													
	14th-15th								1			1												
	15th-16th								2		2	1	1											
	16th-17th								3		1				2									
	17th-18th								1															
M12	10th-13th								1															
	13th-14th																							
	14th-15th																							
	15th-16th																							
	16th-17th								1	3	1		1											
	17th-18th																							

M3	10th-13th			2															1					
	13th-14th																							
	14th-15th																							
	15th-16th																	1	1					
	16th-17th																			2				
	17th-18th																							

Appendix 8: *Great Linford Fusion Data by Element:*

Sheep:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	4	0	4	0	1	0	4	0	5	0	2	0	4	0	9	0	7	0
Humerus, p	0	0	0	0	0	0	2	0	5	0	0	0	0	0	2	0	5	0
Humerus, d	16	0	14	0	4	0	19	0	28	0	4	0	16	0	37	0	32	0
Radius, p	15	0	3	0	4	0	10	0	9	2	2	0	15	0	17	0	11	2
Radius, d	6	1	2	0	3	0	2	1	4	2	0	0	6	1	7	1	4	2
Ulna	1	0	0	0	3	0	4	0	3	0	0	0	1	0	7	0	3	0
Metacarpal, d	3	0	2	0	2	0	5	2	2	0	0	0	3	0	9	2	2	0
Pelvis	5	0	5	0	2	0	5	0	18	0	2	0	5	0	12	0	20	0
Femur, p	0	0	3	0	0	0	1	0	5	0	0	0	0	0	4	0	5	0
Femur, d	1	0	1	0	0	0	2	0	8	3	0	0	1	0	3	0	8	3
Tibia, p	0	0	2	1	2	0	2	1	3	3	1	0	0	0	6	2	4	3
Tibia, d	8	0	6	0	8	0	17	2	35	1	6	0	8	0	31	2	41	1
Calcaneum	3	0	3	0	1	0	2	1	6	0	0	0	3	0	6	1	6	0
Metatarsal, d	2	0	0	0	3	0	1	0	5	2	0	0	2	0	4	0	5	2
P1	5	0	5	1	12	0	5	0	10	1	1	0	5	0	22	1	11	1
P2	0	0	0	0	1	0	3	0	2	0	0	0	0	0	4	0	2	0

Cattle:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	7	0	1	0	2	1	3	0	12	0	3	0	7	0	6	1	15	0
Humerus, p	0	0	0	0	0	0	3	2	0	0	1	0	0	0	3	2	1	0
Humerus, d	10	0	4	0	5	0	10	2	20	0	4	0	10	0	19	2	24	0
Radius, p	7	1	3	0	3	0	6	0	17	1	4	0	7	1	12	0	21	1
Radius, d	4	3	4	2	2	2	2	1	10	4	0	0	4	3	8	5	10	4
Ulna	2	1	2	0	1	0	5	0	13	0	1	0	2	1	8	0	14	0
Metacarpal, d	8	2	9	1	2	0	0	0	9	2	0	0	8	2	11	1	9	2
Pelvis	3	0	5	1	3	0	1	0	4	0	5	1	3	0	9	1	9	1
Femur, p	4	1	2	1	0	0	3	1	7	3	0	0	4	1	5	2	7	3
Femur, d	0	0	1	1	1	0	0	0	2	0	3	2	0	0	2	1	5	2
Tibia, p	2	0	1	1	1	0	1	0	5	2	2	1	2	0	3	1	7	3
Tibia, d	11	1	5	1	1	0	1	0	10	1	4	0	11	1	7	1	14	1
Calcaneum	3	0	1	0	1	0	5	1	1	1	1	0	3	0	7	1	2	1
Metatarsal, d	4	3	1	0	1	1	4	1	4	2	1	1	4	3	6	2	5	3
P1	12	0	14	1	6	0	14	0	22	0	1	1	12	0	34	1	23	1
P2	6	0	4	0	3	0	10	0	5	0	0	0	6	0	17	0	5	0

Pig:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	3	0	0	0	0	0	1	0	7	2	2	0	3	0	1	0	9	2
Humerus, p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humerus, d	3	0	2	0	1	1	4	1	4	1	2	0	3	0	7	2	6	1
Radius, p	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	4	1
Radius, d	0	0	1	1	1	1	1	1	1	1	0	0	0	0	3	3	1	1
Ulna	1	0	2	0	0	0	2	0	6	1	0	0	1	0	4	0	6	1
Metacarpal, d	0	0	3	3	1	1	4	4	2	1	1	1	0	0	8	8	3	2
Pelvis	5	2	2	0	0	0	6	0	5	0	0	0	5	2	8	0	5	0
Femur, p	3	3	0	0	0	0	1	1	1	1	0	0	3	3	1	1	1	1
Femur, d	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0
Tibia, p	1	1	1	1	0	0	1	1	1	1	0	0	1	1	2	2	1	1
Tibia, d	4	2	0	0	1	1	2	1	4	4	0	0	4	2	3	2	4	4
Calcaneum	2	1	2	2	2	0	4	3	4	3	0	0	2	1	8	5	4	3
Metatarsal, d	3	3	2	2	0	0	1	0	2	1	0	0	3	3	3	2	2	1
P1	4	4	7	2	2	2	0	0	8	7	1	1	4	4	9	4	9	8
P2	1	0	3	0	0	0	3	2	2	1	1	0	1	0	6	2	3	1

Appendix 9: *Great Linford Sheep metric overview:*

V = coefficient of variation

10th-13th century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.0	5.8	5.4	6.4	7	0.345033
M_1 W	7.3	7.0	6.4	8.2	24	0.509831
M_2 W	7.8	5.6	7.0	8.6	20	0.440663
M_3 L	20.5	6.0	18.2	23.7	28	1.230278
M_3 W	7.8	6.6	6.8	9.2	29	0.517121
Scapula GLP	29.2	19.8	22.5	32.8	3	5.781292
Scapula SLC	19.7	2.6	19.2	20.2	3	0.503322
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.0	7.1	25.0	33.3	12	1.985202
Humerus Bd	29.3	8.9	25.9	36.5	13	2.620286
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.7	0.0	11.9	16.3	13	
Radius GL	146.4	1.8	144.5	148.3	2	2.687006
Radius Bp	29.8	7.7	27.2	33.8	12	2.283720
Radius SD	15.9	0.0	15.9	15.9	1	0
Radius Bd	26.5	8.1	23.4	30.4	7	2.14298
Metacarpal GL	103.8	0.0	103.8	103.8	1	0
Metacarpal SD	13.7	0.0	13.7	13.7	1	0
Metacarpal Bd	23.3	3.3	22.7	23.8	2	0.777817
Metacarpal a	10.6	0.7	10.5	10.6	2	0.070711
Metacarpal b	10.5	4.9	9.9	10.9	3	0.513160
Metacarpal 1	9.7	6.6	9.2	10.1	2	0.636396
Metacarpal 2	14.0	6.1	13.4	14.6	2	0.848528
Metacarpal 3	12.2	2.9	11.9	12.4	2	0.353553
Metacarpal 4	9.5	7.6	8.9	10.3	3	0.721110
Metacarpal 5	14.0	1.4	13.8	14.2	3	0.200000
Pelvis LA	26.4	1.9	26.0	26.7	2	0.494975
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	29.0	0.0	29.0	29.0	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	24.4	7.6	22.4	27.7	9	1.852551
Tibia Dd	18.7	5.4	17.6	20.9	9	1.004711
Astragalus GLl	27.0	0.0	27.2	27.2	1	0.0
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	17.6	0.0	17.6	17.6	1	0
Astragalus Dl	16.5	0.0	16.5	16.5	1	0
Calcaneum GL	52.4	4.7	50.7	55.2	3	2.443358
Calcaneum GB	15.5	3.0	15.1	16.0	3	0.458258
Metatarsal GL	115.1	0.0	115.1	115.1	1	0.0
Metatarsal SD	10.4	0.0	10.4	10.4	1	0
Metatarsal Bd	21.2	0.0	21.2	21.2	1	0
Metatarsal a	9.8	0.0	9.8	9.8	1	0
Metatarsal b	8.8	0.0	8.8	8.8	1	0
Metatarsal 1	9.2	0.0	9.2	9.2	1	0
Metatarsal 2	14.0	0.0	14.0	14.0	1	0
Metatarsal 3	11.7	0.0	11.7	11.7	1	0
Metatarsal 4	8.3	0.0	8.3	8.3	1	0
Metatarsal 5	13.2	0.0	13.2	13.2	1	0

13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.2	8.9	5.2	6.5	5	0.545894
M_1 W	6.7	4.8	6.1	7.1	8	0.318198
M_2 W	7.7	4.5	7.1	8.1	7	0.348807
M_3 L	20.4	7.7	18.0	23.3	18	1.562259
M_3 W	7.7	7.6	6.8	9.1	18	0.585249
Scapula GLP	30.0	4.7	28.4	31.0	3	1.422439
Scapula SLC	19.2	5.0	18.1	20.3	4	0.955685
Humerus GLC	-	-	-	-	0	-
Humerus BT	29.7	10.6	26.4	36.2	11	3.146200
Humerus Bd	32.1	12.4	26.6	38.1	10	3.977562
Humerus SD	-	-	-	-	0	-
Humerus HTC	15.18	0.0	13.1	18	11	1.601136
Radius GL	-	-	-	-	0	-
Radius Bp	29.7	5.1	28.0	30.9	3	1.513275
Radius SD	-	-	-	-	0	-
Radius Bd	25.8	3.6	25.1	26.4	2	1
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	22.8	13.0	20.7	24.9	2	2.969848
Metacarpal a	10.8	12.5	9.8	11.7	2	1.343503
Metacarpal b	9.4	19.6	8.1	10.7	2	1.838478
Metacarpal 1	8.9	8.8	8.3	9.4	2	0.777817
Metacarpal 2	13.6	4.7	13.1	14.0	2	0.636396
Metacarpal 3	12.0	8.9	11.2	12.7	2	1.060660
Metacarpal 4	8.4	9.3	7.8	8.9	2	0.777817
Metacarpal 5	13.2	8.1	12.4	13.9	2	1.060660
Pelvis LA	28.6	0.7	28.4	28.7	2	0.212132
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	17.5	6.0	16.5	18.6	3	1.053565
Femur Bd	31.0	0.0	31.0	31.0	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.2	5.7	23.2	27.4	6	1.440370
Tibia Dd	18.9	7.9	17.2	21.6	6	1.494546
Astragalus GLl	26.7	4.8	24.4	29.5	3	1.300000
Astragalus GLm	26.0	10.2	23.0	27.9	3	2.650157
Astragalus Bd	16.8	15.8	14.1	19.4	3	2.651415
Astragalus Dl	15.4	12.5	13.2	16.8	3	1.928730
Calcaneum GL	59.3	0.7	59.0	59.6	2	0.424264
Calcaneum GB	19.2	2.3	18.7	19.8	4	0.450000
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-
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14th-15th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.4	5.6	6.1	6.6	2	0.353553
M_1 W	7.3	2.3	7.1	7.5	5	0.167332
M_2 W	8.1	8.2	7.1	8.7	6	0.656506
M_3 L	21.3	7.9	18.4	24.1	11	1.685877
M_3 W	7.9	10.4	6.5	9.5	14	0.825986
Scapula GLP	26.6	0.0	26.6	26.6	1	0.000000
Scapula SLC	21.8	0.0	21.8	21.8	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	26.5	4.6	25.8	28.3	4	1.220314
Humerus Bd	27.2	2.4	26.8	28.0	3	0.665833
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.3	7.1	12.6	14.7	4	0.950000
Radius GL	-	-	-	-	0	-
Radius Bp	28.0	4.8	26.1	29.1	4	1.352775
Radius SD	-	-	-	-	0	-
Radius Bd	31	10.1	27.6	33.8	3	3.000000
Metacarpal GL	107.4	0.0	107.4	107.4	1	0.000000
Metacarpal SD	12.7	0.0	12.7	12.7	1	0.000000
Metacarpal Bd	23.4	1.5	23.1	23.6	2	0.353553
Metacarpal a	11.1	3.8	10.8	11.4	2	0.424264
Metacarpal b	9.0	0.0	9.0	9.0	1	0.000000
Metacarpal 1	9.6	14.7	8.6	10.6	2	1.414214
Metacarpal 2	13.9	6.6	13.2	14.5	2	0.919239
Metacarpal 3	11.8	7.2	11.2	12.4	2	0.848528
Metacarpal 4	8.8	9.6	8.2	9.4	2	0.848528
Metacarpal 5	13.0	0.0	13.0	13.0	2	0.0000000
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	26.4	12.6	23.7	32.5	7	3.327500
Tibia Dd	20.7	15.7	17.4	25.6	7	3.265913
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	-	-	-	-	0	-
Astragalus Dl	-	-	-	-	0	-
Calcaneum GL	51.3	0.0	51.3	51.3	1	0.000000
Calcaneum GB	18.1	0.0	18.1	18.1	1	0.000000
Metatarsal GL	115.6	0.0	115.6	115.6	1	0.000000
Metatarsal SD	10.9	0.0	10.9	10.9	1	0.000000
Metatarsal Bd	22.8	7.1	21.6	23.9	2	1.626346
Metatarsal a	10.4	9.5	9.7	11.1	2	0.989949
Metatarsal b	10.3	1.1	10.2	10.4	3	0.115470
Metatarsal 1	9.2	3.9	8.9	9.4	2	0.353553
Metatarsal 2	14.3	2.0	14.1	14.5	2	0.282843
Metatarsal 3	12.5	5.7	12.0	13.0	2	0.707107
Metatarsal 4	9.1	5.7	9.4	8.5	3	0.519615
Metatarsal 5	13.7	0.4	13.7	13.8	3	0.057735

15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.2	7.7	5.2	7.1	12	0.475697
M_1 W	7.3	7.0	5.9	8.7	30	0.513675
M_2 W	7.8	7.5	6.8	8.7	27	0.583706
M_3 L	20.4	7.1	17.6	23.9	46	1.450907
M_3 W	7.8	7.0	6.6	8.9	46	0.544330
Scapula GLP	30.9	4.4	28.9	31.9	4	1.369915
Scapula SLC	19.0	10.0	17.0	20.8	4	1.900000
Humerus GLC	127.4	0.0	127.4	127.4	1	0.000000
Humerus BT	28.5	7.6	25.1	32.9	16	2.155883
Humerus Bd	30.3	9.2	25.3	34.9	16	2.774647
Humerus SD	14.0	0.0	14.0	14.0	1	0.000000
Humerus HTC	14.5	7.6	12.9	16.9	16	1.096030
Radius GL	130.1	0.0	130.1	130.1	1	0.000000
Radius Bp	28.4	7.4	24.9	31.5	10	2.095498
Radius SD	14.4	0.0	14.4	14.4	1	0.000000
Radius Bd	26.2	0.0	26.2	26.2	1	0.000000
Metacarpal GL	110.4	5.2	106.3	114.4	2	5.727565
Metacarpal SD	13.3	10.6	12.3	14.3	2	1.414214
Metacarpal Bd	24.7	6.6	23.2	26.6	4	1.643928
Metacarpal a	11.5	8.3	10.4	12.7	4	0.956992
Metacarpal b	11.7	8.8	10.1	12.5	4	1.032796
Metacarpal 1	10.4	10.6	9.7	12.0	4	1.099621
Metacarpal 2	15.1	9.3	13.8	16.9	4	1.402379
Metacarpal 3	13.2	5.0	12.5	13.9	4	0.660808
Metacarpal 4	10.4	12.8	8.6	11.7	4	1.332604
Metacarpal 5	14.9	8.8	14.0	16.8	4	1.309898
Pelvis LA	24.4	15.6	21.7	27.1	2	3.818377
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.8	0.0	18.8	18.8	2	0.000000
Femur Bd	35.6	0.0	33.3	37.9	2	3.252691
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	24.9	7.6	20.6	28.4	16	1.898069
Tibia Dd	19.3	7.6	16.8	22.0	16	1.459909
Astragalus GLl	27.7	0.0	27.7	27.7	1	0.000000
Astragalus GLm	26.5	0.0	26.5	26.5	1	0.000000
Astragalus Bd	18.4	0.0	18.4	18.4	1	0.000000
Astragalus Dl	15.9	0.0	15.9	15.9	1	0.000000
Calcaneum GL	53.0	0.0	53.0	53.0	1	0.000000
Calcaneum GB	18.7	5.7	17.9	19.4	2	1.060660
Metatarsal GL	113.5	0.0	113.5	113.5	1	0.000000
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	23.9	8.3	22.5	25.3	2	1.979899
Metatarsal a	11.2	6.3	10.7	11.7	2	0.707107
Metatarsal b	10.1	9.2	9.5	11.2	3	0.929157
Metatarsal 1	10.2	16.6	9.0	11.4	2	1.697056
Metatarsal 2	15.1	4.7	14.6	15.6	2	0.707107
Metatarsal 3	12.7	6.1	12.1	13.2	2	0.777817
Metatarsal 4	9.2	11.2	8.3	10.3	3	1.026320
Metatarsal 5	13.5	8.3	12.5	14.7	3	1.123981

16th-17th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.5	3.4	6.3	6.9	7	0.221467
M_1 W	7.4	8.3	6.5	9.6	29	0.616546
M_2 W	8.0	8.4	6.9	10.0	29	0.672947
M_3 L	20.9	8.1	16.6	25.2	77	1.698962
M_3 W	7.9	7.7	6.7	9.3	80	0.604695
Scapula GLP	28.9	12.2	25.9	32.8	3	3.536948
Scapula SLC	19.5	5.9	17.8	20.5	5	1.157584
Humerus GLC	123.0	2.6	120.7	125.2	2	3.181981
Humerus BT	26.8	8.1	23.5	34.2	25	2.167810
Humerus Bd	28.3	9.6	24.2	36.3	25	2.713282
Humerus SD	14.7	6.3	14.0	15.3	2	0.919239
Humerus HTC	13.4	8.9	11.6	17.1	25	1.195505
Radius GL	-	-	-	-	0	-
Radius Bp	29.0	3.5	28.0	30.8	6	1.00995
Radius SD	-	-	-	-	0	-
Radius Bd	25.9	3.8	25.2	26.6	2	0.989949
Metacarpal GL	116.4	3.8	113.3	119.5	2	4.384062
Metacarpal SD	13.2	5.4	12.7	13.7	2	0.707107
Metacarpal Bd	24.6	5.7	23.6	25.6	2	1.414214
Metacarpal a	11.2	1.3	11.1	11.3	2	0.141421
Metacarpal b	11.3	7.5	10.7	11.9	2	0.848528
Metacarpal 1	10.4	2.0	10.2	10.5	2	0.212132
Metacarpal 2	15.1	0.9	15.0	15.2	2	0.141421
Metacarpal 3	12.9	4.4	12.5	13.3	2	0.565685
Metacarpal 4	10.3	8.2	9.7	10.9	2	0.848528
Metacarpal 5	15.2	2.3	14.9	15.4	2	0.353553
Pelvis LA	28.0	8.8	24.2	32.1	10	2.475233
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	20.9	12.9	19.1	24.9	4	2.701080
Femur Bd	33.3	13.8	27.2	38.3	4	4.586484
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.1	7.6	21.3	29.5	35	1.905247
Tibia Dd	19.2	5.5	17.4	21.3	34	1.059214
Astragalus GLl	26.9	4.7	24.6	28.1	7	1.259441
Astragalus GLm	25.5	5.3	23.0	27.3	7	1.361896
Astragalus Bd	17.5	6.1	15.3	18.5	8	1.063350
Astragalus Dl	15.2	4.6	14.1	15.9	8	0.696932
Calcaneum GL	52.5	7.3	48.8	57.4	6	3.836882
Calcaneum GB	16.9	11.5	14.7	19.9	6	1.945936
Metatarsal GL	147.0	0.0	147.0	147.0	1	0.000000
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	25.7	15.7	21.4	29.4	3	4.026578
Metatarsal a	12.3	19.5	10.6	14.0	2	2.404163
Metatarsal b	10.7	25.9	8.7	12.6	2	2.757716
Metatarsal 1	11.6	25.6	9.5	13.7	2	2.969848
Metatarsal 2	17.5	19.9	15.0	19.9	2	3.464823
Metatarsal 3	14.8	19.7	12.7	16.8	2	2.899138
Metatarsal 4	10.8	19.1	9.3	12.2	2	2.050610
Metatarsal 5	16.9	14.2	15.2	18.6	2	2.404163

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17th-18th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.4	7.8	5.9	6.9	4	0.499166
M_1 W	7.3	2.0	7.2	7.5	4	0.150000
M_2 W	7.8	8.4	7.1	8.4	3	0.655744
M_3 L	19.9	8.7	17.7	22.1	8	1.736530
M_3 W	7.5	7.9	6.7	8.4	8	0.595069
Scapula GLP	27.0	17.8	23.6	30.4	2	4.808326
Scapula SLC	18.6	9.1	17.4	19.8	2	1.697056
Humerus GLC	-	-	-	-	0	-
Humerus BT	26.9	4.2	26.1	27.7	2	1.131371
Humerus Bd	27.1	5.5	26.3	28.4	2	1.484924
Humerus SD	-	-	-	-	0	-
Humerus HTC	1.1	100.0	14.1	12.5	2	1.131371
Radius GL	-	-	-	-	0	-
Radius Bp	26.0	2.2	25.6	26.4	2	0.565685
Radius SD	-	-	-	-	0	
Radius Bd	-	-	-	-	0	
Metacarpal GL	-	-	-	-	0	
Metacarpal SD	-	-	-	-	0	
Metacarpal Bd	-	-	-	-	0	
Metacarpal a	-	-	-	-	0	
Metacarpal b	-	-	-	-	0	
Metacarpal 1	-	-	-	-	0	
Metacarpal 2	-	-	-	-	0	
Metacarpal 3	-	-	-	-	0	
Metacarpal 4	-	-	-	-	0	
Metacarpal 5	-	-	-	-	0	
Pelvis LA	-	-	-	-	0	
Femur GL	-	-	-	-	0	
Femur SD	-	-	-	-	0	
Femur DC	-	-	-	-	0	
Femur Bd	-	-	-	-	0	
Tibia GL	210.0	0.0	210.0	210.0	1	0.000000
Tibia SD	15.6	0.0	15.6	15.6	1	0.000000
Tibia Bd	26.0	7.7	23.1	28.3	5	1.995745
Tibia Dd	18.9	9.1	16.9	21.1	6	1.719011
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	-	-	-	-	0	-
Astragalus Dl	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-

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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.2	6.6	5.2	7.1	19	0.410165
M_1 W	7.2	6.7	5.9	8.7	43	0.480472
M_2 W	7.8	7.1	6.8	8.7	40	0.556339
M_3 L	20.5	7.0	17.6	24.1	103	1.444225
M_3 W	7.8	7.8	6.5	9.5	78	0.609117
Scapula GLP	30.0	6.2	26.6	31.9	8	1.856600
Scapula SLC	19.4	7.5	17.0	21.8	9	1.445491
Humerus GLC	127.4	0.0	127.4	127.4	1	0.000000
Humerus BT	28.7	9.1	25.1	36.2	31	2.615401
Humerus Bd	30.6	11.0	25.3	38.1	29	3.361547
Humerus SD	14.0	0.0	14.0	14.0	1	0.000000
Humerus HTC	14.6	9.3	12.6	18.0	31	1.353960
Radius GL	130.1	0.0	130.1	130.1	1	0.000000
Radius Bp	28.5	6.5	24.9	31.5	17	1.857596
Radius SD	14.4	0.0	14.4	14.4	1	0.000000
Radius Bd	24.9	13.9	25.1	33.8	6	3.457022
Metacarpal GL	109.4	4.0	106.3	114.4	3	4.393556
Metacarpal SD	13.3	8.0	12.3	14.3	3	1.058301
Metacarpal Bd	23.9	7.6	20.7	26.6	8	1.804756
Metacarpal a	11.2	7.9	9.8	12.7	8	0.883176
Metacarpal b	10.4	14.5	8.1	12.5	7	1.515161
Metacarpal 1	9.8	11.6	8.3	12.0	7	1.136332
Metacarpal 2	14.4	8.8	13.1	16.9	8	1.262650
Metacarpal 3	12.5	7.7	11.2	13.9	8	0.958328
Metacarpal 4	9.5	14.6	7.8	11.7	8	1.380217
Metacarpal 5	14.1	9.9	12.4	16.8	8	1.395742
Pelvis LA	26.5	12.3	21.7	28.7	4	3.258195
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.0	5.7	16.5	18.8	5	1.030534
Femur Bd	34.1	10.3	31.0	37.9	3	3.513308
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.3	8.9	20.6	32.5	29	2.246009
Tibia Dd	19.5	10.6	16.8	25.6	29	2.078568
Astragalus GLl	27.0	8.1	24.4	29.5	4	2.170253
Astragalus GLm	26.2	8.3	23.0	27.9	4	2.176388
Astragalus Bd	17.2	13.4	14.1	19.4	4	2.307957
Astragalus Dl	15.5	10.3	13.2	16.8	4	1.594522
Calcaneum GL	55.7	7.5	51.3	59.6	4	4.193149
Calcaneum GB	18.9	3.7	17.9	19.8	7	0.697615
Metatarsal GL	114.6	1.3	113.5	115.6	2	1.484924
Metatarsal SD	10.9	0.0	10.9	10.9	1	0.000000
Metatarsal Bd	23.3	7.0	21.6	25.3	4	1.621471
Metatarsal a	10.8	7.8	9.7	11.7	4	0.840635
Metatarsal b	10.2	5.8	9.5	11.2	6	0.596657
Metatarsal 1	9.7	12.1	8.9	11.4	4	1.170114
Metatarsal 2	14.7	4.3	14.1	15.6	4	0.637704
Metatarsal 3	12.6	4.9	12.0	13.2	4	0.613052
Metatarsal 4	9.1	8.0	8.3	10.3	6	0.728469
Metatarsal 5	13.6	5.3	12.5	14.7	6	0.726636
					624	

PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.5	5.1	5.9	6.9	11	0.331936
M_1 W	7.4	7.8	6.5	10.0	33	0.578932
M_2 W	8.0	8.3	6.9	10.0	32	0.663538
M_3 L	20.8	8.3	16.6	25.2	85	1.717819
M_3 W	7.9	7.7	6.7	9.3	88	0.609207
Scapula GLP	28.1	12.9	23.6	32.8	5	3.621878
Scapula SLC	19.2	6.5	17.4	20.5	7	1.251475
Humerus GLC	123.0	2.6	120.7	125.2	2	3.181981
Humerus BT	26.8	7.8	23.5	34.2	27	2.094648
Humerus Bd	28.2	9.3	24.2	36.3	27	2.634669
Humerus SD	14.7	6.3	14.0	15.3	2	0.919239
Humerus HTC	13.4	8.7	11.6	17.1	27	1.170470
Radius GL	-	-	-	-	0	-
Radius Bp	28.3	5.8	25.6	30.8	8	1.644037
Radius SD	-	-	-	-	0	-
Radius Bd	25.9	3.8	25.2	26.6	2	0.98995
Metacarpal GL	116.4	3.8	113.3	119.5	2	4.384062
Metacarpal SD	13.2	5.4	12.7	13.7	2	0.707107
Metacarpal Bd	24.6	5.7	23.6	25.6	2	1.414214
Metacarpal a	11.2	1.3	11.1	11.3	2	0.141421
Metacarpal b	11.3	7.5	10.7	11.9	2	0.848528
Metacarpal 1	10.4	2.0	10.2	10.5	2	0.212132
Metacarpal 2	15.1	0.9	15.0	15.2	2	0.141421
Metacarpal 3	12.9	4.4	12.5	13.3	2	0.565685
Metacarpal 4	10.3	8.2	9.7	10.9	2	0.848528
Metacarpal 5	15.2	2.3	14.9	15.4	2	0.353553
Pelvis LA	28.0	8.8	24.2	32.1	10	2.475233
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	20.9	12.9	19.1	24.9	4	2.701080
Femur Bd	33.3	13.8	27.2	38.3	4	4.586484
Tibia GL	210.0	0.0	210.0	210.0	1	0.000000
Tibia SD	15.6	0.0	15.6	15.6	1	0.000000
Tibia Bd	25.2	7.6	21.3	29.5	40	1.916619
Tibia Dd	19.1	6.1	16.9	21.3	40	1.157761
Astragalus GLl	26.9	4.7	24.6	28.1	7	1.300000
Astragalus GLm	25.5	5.3	23.0	27.3	7	1.361896
Astragalus Bd	17.5	6.1	15.3	18.5	8	1.063350
Astragalus Dl	15.2	4.6	14.1	15.9	8	0.696932
Calcaneum GL	52.5	7.3	48.8	57.4	6	3.836882
Calcaneum GB	16.9	11.5	14.7	19.9	6	1.945936
Metatarsal GL	147.0	0.0	147.0	147.0	1	0.000000
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	25.7	15.7	21.4	29.4	3	4.026578
Metatarsal a	12.3	19.5	10.6	14.0	2	2.404163
Metatarsal b	10.7	25.9	8.7	12.6	2	2.757716
Metatarsal 1	11.6	25.6	9.5	13.7	2	2.969848
Metatarsal 2	17.5	19.9	15.0	19.9	2	3.464823
Metatarsal 3	14.8	19.7	12.7	16.8	2	2.899138
Metatarsal 4	10.8	19.1	9.3	12.2	2	2.050610
Metatarsal 5	16.9	14.2	15.2	18.6	2	2.404163
					528	

Appendix 10: *Great Linford cattle metric overview:*

V = coefficient of variation

10^{th}-13^{th} century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.3	6.8	10.3	12.2	7	0.76902
M_1 W	14.3	9.5	12.8	16.6	8	1.36218
M_2 W	15.0	9.0	13.7	17.1	6	1.35117
M_3 L	33.7	6.4	29.8	36.9	10	2.17268
M_3 W	13.8	10.7	11.5	16.9	12	1.47915
Scapula GLP	57.2	13.7	47.8	64.6	4	7.84278
Scapula SLC	44.2	2.7	42.9	45.8	4	1.21209
Humerus GLC	-	-	-	-	0	-
Humerus BT	68.2	5.3	64.7	75.3	7	3.61564
Humerus SD	0.0	0.0	0.0	0.0	0	
Humerus HTC	29.9	8.5	27.6	34.4	7	2.53302
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	65.1	14.6	55.8	77.7	4	9.52449
Metacarpal GL	216.0	25.9	176.5	255.5	2	55.8614
Metacarpal SD	29.4	10.4	27.2	31.5	2	3.04056
Metacarpal Bd	53.8	11.4	48.8	63.9	5	6.14858
Metacarpal BatF	49.5	11.3	45.0	58.4	5	5.61142
Metacarpal a	25.7	11.8	22.8	30.8	6	3.02352
Metacarpal b	24.9	13.0	22.8	30.6	5	3.24777
Metacarpal 3	27.5	4.8	26.4	29.8	5	1.32552
Pelvis LA	60.7	5.1	58.5	62.7	2	3.11127
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	42.6	1.3	42.2	43.0	2	0.56569
Femur Bd	-	-	-	-	0	
Tibia GL	299.5	0	299.5	299.5	1	0.00000
Tibia SD	34.4	0.0	34.4	34.4	1	0.00000
Tibia Bd	56.0	11.6	48.1	68.6	9	6.49085
Tibia Dd	42.7	12.4	35.6	51.5	9	5.28112
Astragalus GLl	63.1	0.0	63.1	63.1	1	0.00000
Astragalus GLm	58.3	1.3	57.7	58.8	2	0.77782
Astragalus Bd	39.7	2.8	38.5	40.7	3	1.10604
Astragalus Dl	34.3	10.7	31.7	36.9	2	3.67696
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	34.9	6.9	31.3	36.3	4	2.38939
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	50.4	12.8	45.8	54.9	2	6.43467
Metatarsal BatF	46.6	13.8	42.0	51.1	2	6.43467
Metatarsal a	23.7	3.9	23.0	24.3	2	0.91924
Metatarsal b	23.1	18.4	20.1	26.1	2	4.24264
Metatarsal 3	26.6	17.5	23.3	29.9	2	4.66690

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13th-14th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	12.3	0.0	12.3	12.3	1	0.000000
M_1 W	15.6	0.0	15.6	15.6	1	0.000000
M_2 W	15.7	0.0	15.7	15.7	1	0.000000
M_3 L	32.7	7.4	29.3	34.6	7	2.407231
M_3 W	13.8	6.0	11.9	14.8	9	0.821246
Scapula GLP	-	-	-	-	0	-
Scapula SLC	44.5	0.0	44.5	44.5	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	69.4	6.5	64.6	73.5	3	4.483674
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.0	7.5	29.4	34.1	3	2.400690
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	64.0	0.0	64.0	64.0	1	0.000000
Metacarpal GL	173.3	0.6	172.5	174.0	2	1.060660
Metacarpal SD	26.1	4.6	25.2	26.9	2	1.202082
Metacarpal Bd	52.3	11.6	46.2	63.3	6	6.053566
Metacarpal BatF	46.7	10.0	40.9	55.7	8	4.649117
Metacarpal a	24.1	12.2	21.9	29.9	7	2.929408
Metacarpal b	24.0	11.6	21.3	29.1	7	2.792609
Metacarpal 3	25.7	7.1	24.4	29.4	7	1.832770
Pelvis LA	68.7	9.6	61.4	74.2	3	6.573685
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	41.9	0.0	41.9	41.9	1	0.000000
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	54.1	6.6	49.9	58.6	4	3.569664
Tibia Dd	40.3	10.7	34.6	45.1	4	4.321555
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	38.6	0.0	38.6	38.6	1	0.000000
Astragalus Dl	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	59.3	0.0	59.3	59.3	1	0.000000
Metatarsal BatF	56.5	0.0	56.5	56.5	1	0.000000
Metatarsal a	28.1	0.0	28.1	28.1	1	0.000000
Metatarsal b	27.2	0.0	27.2	27.2	1	0.000000
Metatarsal 3	29.5	0.0	29.5	29.5	1	0.000000
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14th-15th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.1	11.3	10.2	12.5	3	1.250333
M_1 W	-	-	-	-	0	-
M_2 W	-	-	-	-	0	-
M_3 L	-	-	-	-	0	-
M_3 W	-	-	-	-	0	-
Scapula GLP	44.3	0.0	44.3	44.3	1	0.00000
Scapula SLC	54.5	0.0	54.5	54.5	1	0.00000
Humerus GLC	-	-	-	-	0	-
Humerus BT	73.0	9.0	65.7	78.4	3	6.545482
Humerus SD	-	-	-	-	0	-
Humerus HTC	33.6	5.9	30.7	35.1	4	1.984943
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	53.5	19.0	46.3	60.7	2	10.18234
Metacarpal BatF	49.5	17.7	43.3	55.7	2	8.768124
Metacarpal a	26.2	20.5	22.4	30.0	2	5.374012
Metacarpal b	24.8	17.4	21.7	27.8	2	4.313351
Metacarpal 3	24.9	20.2	21.3	28.4	2	5.000000
Pelvis LA	65.7	4.0	62.7	67.8	3	2.650157
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	55.6	0.0	55.6	55.6	1	0.000000
Tibia Dd	42.3	0.0	42.3	42.3	1	0.000000
Astragalus GLl	65.0	0.0	65.0	65.0	1	0.000000
Astragalus GLm	60.8	0.0	60.8	60.8	1	0.000000
Astragalus Bd	43.8	0.0	43.8	43.8	1	0.000000
Astragalus Dl	38.5	0.0	38.5	38.5	1	0.000000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	38.0	0.0	38.0	38.0	1	0.000000
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal BatF	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
					32	

15th-16th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.3	0.0	11.3	11.3	1	0.000000
M_1 W	12.5	11.6	11.0	13.9	3	1.452584
M_2 W	15.4	15.1	13.1	18.6	4	2.318764
M_3 L	33.6	5.1	31.0	36.9	10	1.699706
M_3 W	13.9	6.4	12.6	15.4	10	0.890942
Scapula GLP	63.7	5.7	61.1	66.2	2	3.606245
Scapula SLC	48.5	17.6	39.7	56.7	3	8.500000
Humerus GLC	-	-	-	-	0	-
Humerus BT	70.4	6.5	67.1	76.9	4	4.554393
Humerus SD	-	-	-	-	0	-
Humerus HTC	31.6	10.7	28.7	37.3	5	3.369420
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal BatF	-	-	-	-	0	-
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	40.5	2.8	39.7	41.3	2	1.131371
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	60.4	0.0	60.4	60.4	1	0.000000
Tibia Dd	43.8	0.0	43.8	43.8	1	0.000000
Astragalus GLl	60.0	10.8	51.7	67.5	4	6.466001
Astragalus GLm	56.5	6.5	53.5	60.6	3	3.675595
Astragalus Bd	38.7	9.0	36.0	43.8	4	3.473111
Astragalus Dl	33.9	11.6	28.5	37.6	5	3.918546
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	40.2	14.7	33.4	44.2	3	5.896044
Metatarsal GL	223.0	0.0	223.0	223.0	1	0.000000
Metatarsal SD	27.7	0.0	27.7	27.7	1	0.000000
Metatarsal Bd	51.9	0.0	51.9	51.9	1	0.000000
Metatarsal BatF	48.8	0.0	48.8	48.8	1	0.000000
Metatarsal a	24.6	0.0	24.6	24.6	1	0.000000
Metatarsal b	22.9	0.0	22.9	22.9	1	0.000000
Metatarsal 3	26.3	0.0	26.3	26.3	1	0.000000

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16th-17th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.5	12.7	9.9	14.5	12	1.463806
M_1 W	14.5	0.5	14.4	14.5	2	0.070711
M_2 W	14.4	0.0	14.4	14.4	1	0.000000
M_3 L	34.5	7.0	31.4	38.4	15	2.418323
M_3 W	13.9	12.9	11.3	17.2	15	1.789839
Scapula GLP	62.2	5.1	57.7	66.8	6	3.163964
Scapula SLC	50.6	11.5	42.7	58.9	8	5.824272
Humerus GLC	-	-	-	-	0	-
Humerus BT	68.8	18.9	64.1	73.2	13	3.065942
Humerus SD	-	-	-	-	0	-
Humerus HTC	31.4	7.8	29.2	36.3	13	2.436870
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	69.4	10.2	60.4	75.1	5	7.048617
Metacarpal GL	184.0	0.0	184.0	184.0	2	0.000000
Metacarpal SD	26.2	1.4	25.9	26.4	2	0.353553
Metacarpal Bd	52.2	8.9	47.8	61.1	7	4.652035
Metacarpal BatF	46.4	9.9	41.6	56.5	8	4.596408
Metacarpal a	25.0	7.6	23.2	28.5	7	1.894478
Metacarpal b	23.6	7.3	21.5	25.7	5	1.714060
Metacarpal 3	26.1	9.3	22.7	30.8	7	2.433399
Pelvis LA	67.2	0.0	67.2	67.2	1	0.000000
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	41.3	3.2	39.5	42.8	5	1.325519
Femur Bd	107.5	0.0	107.5	107.5	1	0.000000
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	52.6	6.8	48.6	58.6	8	3.591433
Tibia Dd	37.5	12.9	28.5	41.0	5	4.854963
Astragalus GLl	62.1	6.1	57.0	66.1	4	3.765081
Astragalus GLm	59.0	2.7	57.8	60.8	3	1.569501
Astragalus Bd	39.1	5.4	37.1	41.3	4	2.114237
Astragalus Dl	33.1	4.6	31.0	34.5	4	1.532699
Calcaneum GL	103.8	0.0	103.8	103.8	1	0.000000
Calcaneum GB	39.8	0.0	39.8	39.8	1	0.000000
Metatarsal GL	236.0	0.0	236.0	236.0	1	0.000000
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	58.4	2.7	57.3	59.5	2	1.555635
Metatarsal BatF	51.8	0.8	51.5	52.1	2	0.424264
Metatarsal a	25.7	5.4	23.7	26.8	4	1.388944
Metatarsal b	28.2	2.3	27.7	28.6	2	0.636396
Metatarsal 3	27.8	18.3	20.3	31.7	4	5.093378
					180	

17th-18th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	-	-	-	-	0	-
M_1 W	-	-	-	-	0	-
M_2 W	-	-	-	-	0	-
M_3 L	36.9	0.0	36.9	36.9	1	0.000000
M_3 W	14.8	0.0	14.8	14.8	1	0.000000
Scapula GLP	63.5	5.7	60.9	66.0	2	3.606245
Scapula SLC	51.4	8.4	48.3	54.4	2	4.313351
Humerus GLC	252.0	0.0	252.0	252.0	1	0.000000
Humerus BT	74.0	7.7	67.9	79.1	3	5.666569
Humerus SD	34.1	0.0	34.1	34.1	1	0.000000
Humerus HTC	35.0	7.0	32.6	38.1	4	2.447448
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal BatF	-	-	-	-	0	-
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Pelvis LA	64.9	11.4	59.6	70.1	2	7.424621
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	81.8	2.1	80.6	83.0	2	1.697056
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	56.1	2.9	54.7	57.9	3	1.650253
Tibia Dd	41.7	4.2	40.2	43.6	3	1.747379
Astragalus GLl	60.2	2.0	59.2	61.5	3	1.193035
Astragalus GLm	54.2	3.7	53.4	57.4	3	2.013289
Astragalus Bd	38.0	3.0	36.9	39.2	3	1.153256
Astragalus Dl	33.8	8.2	33.1	38.4	3	2.762245
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	51.2	0.0	51.2	51.2	1	0.000000
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	55.3	0.0	55.3	55.3	1	0.000000
Metatarsal BatF	55.7	0.0	55.7	55.7	1	0.000000
Metatarsal a	26.7	0.0	26.7	26.7	1	0.000000
Metatarsal b	25.4	0.0	25.4	25.4	1	0.000000
Metatarsal 3	28.2	0.0	28.2	28.2	1	0.000000
					43	

LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.4	9.1	10.2	12.5	5	1.033441
M_1 W	13.3	14.7	11.0	15.6	4	1.951709
M_2 W	15.4	13.1	13.1	18.6	5	2.014200
M_3 L	33.3	6.0	29.3	36.9	17	2.003471
M_3 W	13.9	6.0	11.9	15.4	19	0.838789
Scapula GLP	57.2	20.0	44.3	66.2	3	11.459058
Scapula SLC	46.3	15.1	39.7	56.7	6	7.005141
Humerus GLC	-	-	-	-	0	-
Humerus BT	70.9	6.8	64.6	78.4	10	4.819693
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.4	8.2	28.7	37.3	12	2.670192
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	64.0	0.0	64.0	64.0	1	0.000000
Metacarpal GL	173.3	0.6	172.5	174.0	2	1.060660
Metacarpal SD	26.1	4.6	25.2	26.9	2	1.202082
Metacarpal Bd	52.6	12.2	46.2	63.3	8	6.425493
Metacarpal BatF	47.3	10.9	40.9	55.7	10	5.171761
Metacarpal a	24.6	13.4	21.9	30.0	9	3.300295
Metacarpal b	24.2	11.3	21.3	29.1	9	2.735924
Metacarpal 3	25.5	8.9	21.3	29.4	9	2.257880
Pelvis LA	65.6	7.9	58.5	74.2	8	5.160011
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	41.0	2.8	39.7	41.9	3	1.137248
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	55.4	6.7	49.9	60.4	6	3.735461
Tibia Dd	41.2	8.9	34.6	45.1	6	3.672057
Astragalus GLl	61.0	9.9	51.7	67.5	5	6.033821
Astragalus GLm	57.6	6.4	53.5	60.8	4	3.691770
Astragalus Bd	39.6	8.6	36.0	43.8	6	3.402205
Astragalus Dl	34.7	11.5	28.5	38.5	6	3.976263
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	39.6	12.5	33.4	44.2	4	4.934487
Metatarsal GL	223.0	0.0	223.0	223.0	1	0.000000
Metatarsal SD	27.7	0.0	27.7	27.7	1	0.000000
Metatarsal Bd	55.6	9.4	51.9	59.3	2	5.232590
Metatarsal BatF	52.7	10.3	48.8	56.5	2	5.444722
Metatarsal a	26.4	9.4	24.6	28.1	2	2.474874
Metatarsal b	25.1	12.1	22.9	27.2	2	3.040559
Metatarsal 3	27.9	8.1	26.3	29.5	2	2.262742
					182	

PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.5	12.4	9.9	14.5	12	1.422626
M_1 W	14.5	0.5	14.4	14.5	2	0.070711
M_2 W	14.4	0.0	14.4	14.4	1	0.000000
M_3 L	34.6	7.0	30.5	38.4	16	2.414643
M_3 W	14.0	12.5	11.3	17.2	16	1.743942
Scapula GLP	63.1	4.8	57.7	66.8	8	3.009716
Scapula SLC	50.7	10.5	42.7	58.9	10	5.343958
Humerus GLC	252.0	0.0	252.0	252.0	1	0.000000
Humerus BT	70.0	5.7	64.1	79.1	16	4.024343
Humerus SD	34.1	0.0	34.1	34.1	1	0.000000
Humerus HTC	32.2	8.8	29.2	38.1	17	2.825982
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	69.3	10.2	60.4	77.4	5	7.04862
Metacarpal GL	184.0	0.0	184.0	184.0	2	0.000000
Metacarpal SD	26.2	1.4	25.9	26.4	2	0.353553
Metacarpal Bd	52.2	8.9	47.8	61.1	7	4.652035
Metacarpal BatF	46.4	9.9	41.6	56.5	8	4.596408
Metacarpal a	25.0	7.6	22.8	28.5	7	1.894478
Metacarpal b	23.6	7.3	21.5	25.7	5	1.714060
Metacarpal 3	26.1	9.3	22.7	30.8	7	2.433399
Pelvis LA	65.6	8.3	59.6	70.1	3	5.422484
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	41.3	3.2	39.5	42.8	5	1.325519
Femur Bd	90.4	16.5	80.6	107.5	3	14.88635
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	53.5	6.5	48.6	58.6	11	3.494931
Tibia Dd	40.2	5.7	35.5	43.6	8	2.273724
Astragalus GLl	61.3	4.8	57.0	66.1	7	2.900000
Astragalus GLm	57.2	4.6	53.4	60.8	6	2.619733
Astragalus Bd	38.6	4.5	36.9	41.3	7	1.730125
Astragalus Dl	34.0	6.7	31.0	38.4	7	2.265476
Calcaneum GL	103.8	0.0	103.8	103.8	1	0.000000
Calcaneum GB	45.5	17.7	39.8	51.2	2	8.061017
Metatarsal GL	236.0	0.0	236.0	236.0	1	0.000000
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	57.4	3.7	55.3	59.5	3	2.100794
Metatarsal BatF	53.1	4.3	51.5	55.7	3	2.271563
Metatarsal a	25.9	4.9	23.7	26.8	5	1.279453
Metatarsal b	27.2	6.1	25.4	28.6	3	1.650253
Metatarsal 3	27.9	15.8	20.3	31.7	5	4.415088
					223	

Appendix 11: *Great Linford pig metric overview:*

V = coefficient of variation

10^{th}-13^{th} century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	15.8	17.3	12.7	17.9	3	2.740438
dP_4 WP	8.4	5.4	8.0	9.0	4	0.450925
M_1 L	17.0	9.8	14.8	19.4	8	1.676519
M_1 WA	11.0	7.3	9.7	12.1	8	0.803563
M_1 WP	11.4	5.0	10.3	12.4	8	0.573056
M_2 L	21.0	8.6	18.3	22.9	8	1.802181
M_2 WA	13.8	14.1	10.2	16.9	9	1.946864
M_2 WP	14.0	12.4	11.1	16.3	9	1.736695
M_3 L	29.6	7.0	27.3	31.3	3	2.066398
M_3 WA	14.8	5.0	14.4	15.9	4	0.734847
M_3 WC	13.6	7.5	12.3	14.6	4	1.023067
M_3 WP	11.7	5.6	11.0	12.3	3	0.655744
M^3L	31.2	0.0	31.2	31.2	1	0.000000
M^3WA	17.3	0.0	17.3	17.3	1	0.000000
M^3WC	15.5	0.0	15.5	15.5	1	0.000000
Scapula GLP	31.2	4.8	30.1	32.2	2	1.484924
Scapula SLC	25.0	13.0	22.1	28.5	3	3.251666
Humerus GLC	-	-	-	-	0	-
Humerus BT	37.7	0.0	37.7	37.7	1	0.000000
Humerus SD	-	-	-	-	0	-
Humerus HTC	21	0.0	21	21	1	0.000000
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	27.6	0.0	27.6	27.6	1	0.000000
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	27.0	3.9	26.2	27.7	2	1.060660
Tibia Dd	24.3	5.0	23.4	25.1	2	1.202082
Astragalus GLl	44.4	0.0	44.4	44.4	1	0.000000
Astragalus GLm	43.7	0.0	43.7	43.7	1	0.000000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
					85	

13th-14th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	15.2	19.7	12.2	17.8	3	2.821347
dP_4 WP	8.3	48.2	8.1	8.4	4	0.141421
M_1 L	15.2	32.9	13.0	16.9	5	1.904468
M_1 WA	10.3	48.7	9.8	10.8	5	0.421900
M_1 WP	10.9	46.0	10.1	11.4	5	0.522494
M_2 L	35.9	5.6	32.5	39.3	2	4.808326
M_2 WA	12.9	23.3	12.3	13.3	3	0.513160
M_2 WP	13.2	22.7	12.6	13.7	3	0.556776
M_3 L	35.9	5.6	32.5	39.3	2	4.808326
M_3 WA	15.7	12.8	14.2	17.1	2	2.050610
M_3 WC	16.0	12.5	14.0	18.0	2	2.828427
M_3 WP	12.1	16.5	10.1	14.1	2	2.828427
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	36.6	2.7	36.6	36.6	1	0.000000
Humerus SD	-	-	-	-	0	-
Humerus HTC	24.0	4.2	24.0	24.0	1	0.000000
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	37.9	2.6	37.9	37.9	1	0.000000
Astragalus GLm	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	18.5	10.8	18.4	18.6	2	0.141421
Metatarsal GL	-	-	-	-	0	-
					40	

14^{th}-15^{th} Century

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	-	-	-	-	0	-
dP_4 WP	-	-	-	-	0	-
M_1 L	17.7	0.0	17.7	17.7	1	0.000000
M_1 WA	10.6	0.0	10.6	10.6	1	0.000000
M_1 WP	11.9	0.0	11.9	11.9	1	0.000000
M_2 L	19.8	0.0	17.0	22.6	0	0.000000
M_2 WA	-	-	-	-	0	-
M_2 WP	-	-	-	-	0	-
M_3 L	-	-	-	-	0	-
M_3 WA	-	-	-	-	0	-
M_3 WC	-	-	-	-	0	-
M_3 WP	-	-	-	-	0	-
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	31.4	0.0	31.4	31.4	1	0.000000
Tibia Dd	28.4	0.0	28.4	28.4	1	0.000000
Astragalus GLl	47.8	0.0	47.8	47.8	1	0.000000
Astragalus GLm	45.4	0.0	45.4	45.4	1	0.000000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
					7	

15th-16th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	16.1	20.2	13.8	18.4	2	3.252691
dP_4 WP	9.0	1.6	8.9	9.1	2	0.141421
M_1 L	16.2	9.8	12.9	17.6	7	1.587301
M_1 WA	10.4	3.4	10.1	11.1	7	0.355233
M_1 WP	11.0	6.6	9.5	11.6	7	0.725718
M_2 L	20.0	12.9	15.9	22.9	7	2.579683
M_2 WA	12.1	18.7	8.0	13.9	7	2.257474
M_2 WP	13.1	6.2	11.5	14.1	7	0.814160
M_3 L	30.9	12.0	27.4	36.5	5	3.701756
M_3 WA	16.3	10.2	14.7	18.5	5	1.659217
M_3 WC	15.0	5.2	14.3	16.0	5	0.779102
M_3 WP	12.2	9.4	10.8	13.2	4	1.144188
M^3L	31.0	12.8	28.2	33.8	2	3.959798
M^3WA	17.7	6.4	16.9	18.5	2	1.131371
M^3WC	15.8	0.9	15.7	15.9	2	0.141421
Scapula GLP	40.5	0.0	40.5	40.5	1	0.000000
Scapula SLC	28.2	0.0	28.2	28.2	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	34.5	17.9	26.1	40.7	4	6.185130
Humerus SD	-	-	-	-	0	-
Humerus HTC	18.9	20.7	14.9	22.7	3	3.903844
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	28.9	21.2	24.4	25.9	3	6.123997
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	30.3	3.0	29.6	30.9	2	0.919239
Tibia Dd	24.1	12.3	22.0	26.2	2	2.969848
Astragalus GLl	42.6	4.8	41.1	44.0	2	2.050610
Astragalus GLm	40.7	2.6	39.9	41.4	2	1.060660
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	21.2	11.0	19.5	22.8	2	2.333452
Metatarsal GL	77.2	0.0	77.2	77.2	1	0.000000

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16th-17th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.74	3.5	17.9	19.5	5	0.650385
dP_4 WP	8.5	4.9	8.1	9.2	5	0.414729
M_1 L	17.0	9.5	13.8	18.5	11	1.612113
M_1 WA	9.8	12.2	7.1	11.0	12	1.198357
M_1 WP	10.9	7.2	9.5	12.1	11	0.790052
M_2 L	20.1	10.3	16.1	22.7	10	2.07635
M_2 WA	12.5	9.6	10.4	14.2	10	1.194664
M_2 WP	13.0	8.3	11.7	15.2	10	1.082230
M_3 L	30.9	6.5	28.4	33.7	5	1.996246
M_3 WA	14.5	14.4	12.6	17.4	4	2.083267
M_3 WC	13.9	10.8	11.4	15.5	5	1.505656
M_3 WP	10.8	13.5	8.4	12.3	5	1.46014
M^3L	26.6	3.5	25.9	27.2	2	0.919239
M^3WA	16.1	1.3	15.9	16.2	2	0.212132
M^3WC	13.7	0.0	13.7	13.7	2	0.00000
Scapula GLP	33.4	5.6	30.4	35.7	6	1.870829
Scapula SLC	24.2	12.3	20.1	28.0	7	2.985521
Humerus GLC	-	-	-	-	0	-
Humerus BT	36.9	1.6	36.5	37.6	3	0.608276
Humerus SD	-	-	-	-	0	-
Humerus HTC	21.7	8.3	19.6	22.8	3	1.792577
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	37.5	0.0	37.5	37.5	1	0.000000
Metacarpal GL	91.1	0.0	91.1	91.1	1	0.000000
Pelvis LAR	33.2	12.4	29.3	37.5	3	4.110150
Femur GL	-	-	-	-	0.0	-
Femur SD	-	-	-	-	0.0	-
Femur DC	-	-	-	-	0.0	-
Femur Bd	-	-	-	-	0.0	-
Tibia GL	-	-	-	-	0.0	-
Tibia SD	-	-	-	-	0.0	-
Tibia Bd	-	-	-	-	0.0	-
Tibia Dd	-	-	-	-	0.0	-
Astragalus GLI	43.6	0.7	43.2	43.8	3	0.321455
Astragalus GLm	41.8	1.8	40.8	42.3	3	0.763763
Calcaneum GL	82.8	4.8	80.0	85.6	2	3.959798
Calcaneum GB	23.3	2.4	22.9	23.7	2	0.565685
Metatarsal GL	92.2	0.0	92.2	92.2	1	0.000000

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17th-18th Century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	-	-	-	-	0	-
dP_4 WP	-	-	-	-	0	-
M_1 L	-	-	-	-	0	-
M_1 WA	-	-	-	-	0	-
M_1 WP	-	-	-	-	0	-
M_2 L	-	-	-	-	0	-
M_2 WA	-	-	-	-	0	-
M_2 WP	-	-	-	-	0	-
M_3 L	31.2	10.0	29.0	33.4	2	3.111270
M_3 WA	16.6	15.0	14.8	18.3	2	2.474874
M_3 WC	14.5	3.9	14.1	14.9	2	0.565685
M_3 WP	12.2	4.6	11.8	12.6	2	0.565685
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	39.9	0.0	39.9	39.9	1	0.000000
Scapula SLC	27.8	13.7	25.1	30.5	2	3.818377
Humerus GLC	-	-	-	-	0	-
Humerus BT	35.4	0.0	35.4	35.4	1	0.000000
Humerus SD	-	-	-	-	0	-
Humerus HTC	20.5	0.0	20.5	20.5	1	0.000000
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	15.6	16.8	12.2	18.4	5	2.620687
dP_4 WP	8.5	4.5	8.1	9.1	6	0.382971
M_1 L	15.6	12.7	12.9	18.5	13	1.981582
M_1 WA	10.4	3.5	7.1	11.1	13	0.367074
M_1 WP	11.0	6.0	9.5	12.1	13	0.655548
M_2 L	19.7	14.4	32.5	39.3	9	2.825204
M_2 WA	13.0	15.6	0.0	16.9	19	2.028971
M_2 WP	13.1	5.5	11.5	14.1	10	0.718022
M_3 L	32.3	13.5	27.4	39.3	7	4.363103
M_3 WA	16.1	10.1	14.2	18.5	7	1.620112
M_3 WC	15.3	9.2	14.0	18.0	7	1.402379
M_3 WP	12.2	12.7	10.1	14.1	6	1.545855
M^3L	31.0	12.8	28.2	33.8	2	3.959798
M^3WA	17.7	6.4	16.9	18.5	2	1.131371
M^3WC	15.8	0.9	15.7	15.9	2	0.141421
Scapula GLP	40.5	0.0	40.5	40.5	1	0.000000
Scapula SLC	28.2	0.0	28.2	28.2	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	34.9	15.6	26.1	40.7	5	5.436267
Humerus SD	-	-	-	-	0	0.000000
Humerus HTC	20.2	20.2	14.9	24.0	4	4.081973
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	28.9	21.2	24.4	35.9	3	6.123997
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	30.6	3.0	29.6	31.4	3	0.929157
Tibia Dd	25.5	12.7	22.0	28.4	3	3.251666
Astragalus GLl	42.7	9.9	37.9	47.8	4	4.215052
Astragalus GLm	42.2	6.7	39.9	45.4	3	2.843120
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	19.8	10.3	18.4	22.8	4	2.040221
Metatarsal GL	92.2	0.0	92.2	92.2	1	0.000000
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PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.74	3.5	17.9	19.5	5	0.650385
dP_4 WP	8.5	4.9	8.1	9.2	5	0.414729
M_1 L	17.0	9.5	13.8	18.5	11	1.612113
M_1 WA	9.8	12.2	7.1	11.0	12	1.198357
M_1 WP	10.9	7.2	9.5	12.1	11	0.790052
M_2 L	20.1	10.3	16.1	22.7	10	2.076348
M_2 WA	12.5	9.6	10.4	14.2	10	1.194664
M_2 WP	13.0	8.3	11.7	15.2	10	1.082230
M_3 L	31.0	6.7	28.4	33.7	7	2.071576
M_3 WA	15.2	14.6	12.6	18.3	6	2.221711
M_3 WC	14.1	9.2	11.4	15.5	7	1.286931
M_3 WP	11.2	12.4	8.4	12.6	7	1.388559
M^3L	26.6	3.5	25.9	27.2	2	0.919239
M^3WA	16.1	1.3	15.9	16.2	2	0.212132
M^3WC	13.7	0.0	13.7	13.7	2	0.000000
Scapula GLP	34.3	8.7	39.9	40.5	7	2.992053
Scapula SLC	25.0	13.3	25.1	30.5	9	3.320768
Humerus GLC	-	-	-	-	0	-
Humerus BT	36.5	2.5	26.1	40.7	4	0.899537
Humerus SD	-	-	-	-	0	-
Humerus HTC	21.4	7.4	19.6	22.8	4	1.575595
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	37.5	0.0	37.5	37.5	1	0.000000
Metacarpal GL	91.1	0.0	91.1	91.1	1	0.000000
Pelvis LAR	33.2	12.4	29.3	37.5	3	4.11015
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	47.8	0.0	47.8	47.8	3	0.000000
Astragalus GLm	45.4	0.0	45.4	45.4	3	0.000000
Calcaneum GL	-	-	-	-	2	-
Calcaneum GB	-	-	-	-	2	-
Metatarsal GL	-	-	-	-	1	-
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Appendix 12: *Great Linford horse metric overview:*

V = coefficient of variation

10th-13th century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	24.0	0.0	24.0	24.0	1	0.000000
M_1W_a	14.2	0.0	14.2	14.2	1	0.000000
M_1W_d	3.2	0.0	3.2	3.2	1	0.000000
M_2L_1	26.0	0.0	26.0	26.0	1	0.000000
M_2W_a	12.6	0.0	12.6	12.6	1	0.000000
M_2W_d	3.1	0.0	3.1	3.1	1	0.000000
M_3L_1	35.1	7.1	33.3	36.8	2	2.474874
M_3W_a	12.2	4.1	11.8	12.5	2	0.494970
M_3W_d	2.5	43.3	1.7	3.2	2	1.060660
Scapula GLP	85.9	8.1	79.8	92.3	4	6.964852
Scapula SLC	62.8	12.7	57.1	68.4	4	7.99031
Humerus GLC	-	-	-	-	0	-
Humerus BT	71.9	7.4	68.1	75.6	2	5.303301
Humerus SD	-	-	-	-	0	-
Humerus HTC	35.5	7.2	33.7	37.3	2	2.545584
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	62.4	0.0	62.4	62.4	1	0.000000
Metacarpal GL	224.5	0.0	224.5	224.5	1	0.000000
Metacarpal SD	34.2	0.0	34.2	34.2	1	0.000000
Metacarpal Bd	46.8	10.1	43.4	50.1	2	4.737615
Metacarpal Dd	27.2	20.9	22.2	33.4	3	5.695612
Pelvis LAR	67.4	0.0	67.4	67.4	1	0.000000
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	69.0	0.0	69.0	69.0	1	0.000000
Tibia GL	338.5	0.0	338.5	338.5	1	0.000000
Tibia SD	36.0	0.0	36.0	36.0	1	0.000000
Tibia Bd	66.9	0.0	66.9	66.9	1	0.000000
Tibia Dd	41.1	0.0	41.1	41.1	1	0.000000
Astragalus GH	56.4	0.0	56.4	56.4	1	0.000000
Astragalus GB	61.4	0.0	61.4	61.4	1	0.000000
Astragalus Bfd	52.4	0.0	52.4	52.4	1	0.000000
Astragalus LmT	56.3	0.0	56.3	56.3	1	0.000000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	81.6	9.7	72.5	86.2	3	7.880990
Phalanx 1 Bp	52.7	3.0	51.6	54.5	3	1.571623
Phalanx 1 DP	34.9	6.6	33.3	37.5	3	2.294196
Phalanx 1 SD	33.3	7.0	30.6	34.8	3	2.343075
Phalanx 1 Bd	43.6	6.7	41.1	46.8	3	2.902298
Phalanx 1 Dd	23.3	2.4	22.8	23.9	3	0.550757

13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	23.8	30.9	16.0	30.2	4	7.349546
M_1W_a	10.7	27.2	6.6	13.2	4	2.904451
M_1W_d	3.1	27.4	2.5	3.7	2	0.848528
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	-	-	-	-	0	-
M_3W_a	-	-	-	-	0	-
M_3W_d	-	-	-	-	0	-
Scapula GLP	81.0	0.0	81.0	81.0	1	0.000000
Scapula SLC	54.0	8.3	51.4	59.2	3	4.50333
Humerus GLC	-	-	-	-	0	-
Humerus BT	64.7	0.0	64.7	64.7	1.0	0.000000
Humerus SD	-	-	-	-	0	-
Humerus HTC	33.4	0.0	33.4	33.4	1	0.000000
Radius GL	-	-	-	-	0	0.000000
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	75.3	0.0	75.3	75.3	1	0.000000
Tibia Dd	47.8	0.0	47.8	47.8	1	0.000000
Astragalus GH	51.5	0.0	51.5	51.5	1	0.000000
Astragalus GB	59.9	0.0	59.9	59.9	1	0.000000
Astragalus Bfd	47.5	0.0	47.5	47.5	1	0.000000
Astragalus LmT	46.4	0.0	46.4	46.4	1	0.000000
Calcaneum GL	78.6	0.0	78.6	78.6	1	0.000000
Calcaneum GB	44.3	0.0	44.3	44.3	1	0.000000
Metatarsal GL	280.0	0.0	280.0	280.0	1	0.000000
Metatarsal SD	36.0	0.0	36.0	36.0	1	0.000000
Metatarsal Bd	52.6	9.0	49.2	55.9	2	4.737615
Metatarsal Dd	27.9	2.0	27.5	28.3	2	0.565685
Phalanx 1 GL	75.5	0.0	75.5	75.5	1	0.000000
Phalanx 1 Bp	47.4	11.0	43.7	51.1	2	5.23259
Phalanx 1 DP	31.6	0.0	31.6	31.6	1	0.000000
Phalanx 1 SD	34.3	0.0	34.3	34.3	1	0.000000
Phalanx 1 Bd	46.5	0.0	46.5	46.5	1	0.000000
Phalanx 1 Dd	23.2	0.0	23.2	23.2	1	0.000000

14th-15th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	24.2	0.0	24.2	24.2	1	0.000000
M_1W_a	13.8	0.0	13.8	13.8	1	0.000000
M_1W_d	3.2	0.0	3.2	3.2	1	0.000000
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	21.8	0.0	21.8	21.8	1	0.000000
M_3W_a	12.1	0.0	12.1	12.1	1	0.000000
M_3W_d	-	-	-	-	0	-
Scapula GLP	108.9	0.0	108.9	108.9	1	0.000000
Scapula SLC	84.2	0.0	84.2	84.2	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	72.3	5.2	69.6	74.9	2	3.747666
Humerus SD	-	-	-	-	0	-
Humerus HTC	35.4	2.8	34.7	36.1	2	0.989949
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	84.1	5.0	81.1	87.0	2	4.171930
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	51.6	3.4	50.3	52.8	2	1.767767
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	85.7	11.0	79.0	92.3	2	9.404520
Tibia Dd	51.8	8.7	48.6	55.0	2	4.525483
Astragalus GH	59.8	0.0	59.8	59.8	1	0.000000
Astragalus GB	65.5	0.0	65.5	65.5	1	0.000000
Astragalus Bfd	59.5	0.0	59.5	59.5	1	0.000000
Astragalus LmT	59.5	2.9	58.3	60.7	2	1.700000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	86.5	8.2	81.1	94.5	3	7.068239
Phalanx 1 Bp	58.2	11.7	50.4	63	3	6.814690
Phalanx 1 DP	38.3	8.9	34.5	41	3	3.403430
Phalanx 1 SD	38.3	11.1	34.1	42.6	3	4.250098
Phalanx 1 Bd	49.3	11.4	43	53.7	3	5.597321
Phalanx 1 Dd	26.7	13.5	23.3	30.5	3	3.611556

15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	25.8	0.0	25.8	25.8	1	0.000000
M_2W_a	10.9	0.0	10.9	10.9	1	0.000000
M_2W_d	0.0	0.0	0.0	0.0	0	0.000000
M_3L_1	25.2	25.8	21.2	32.7	3	6.500000
M_3W_a	9.4	16.3	8.2	11.1	3	1.530795
M_3W_d	2.0	0.0	2.0	2.0	1	0.000000
Scapula GLP	78.2	1.1	77.6	78.8	2	0.848528
Scapula SLC	56.3	1.6	55.6	56.9	2	0.919239
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	39.9	0.0	39.9	39.9	1	0.000000
Metacarpal Dd	27.0	0.0	27.0	27.0	1	0.000000
Pelvis LAR	61.1	0.0	61.1	61.1	1	0.000000
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	342.5	0.0	342.5	342.5	1	0.000000
Tibia SD	39.6	0.0	39.6	39.6	1	0.000000
Tibia Bd	72.2	0.0	72.2	72.2	1	0.000000
Tibia Dd	44.6	0.0	44.6	44.6	1	0.000000
Astragalus GH	-	-	-	-	0	-
Astragalus GB	-	-	-	-	0	-
Astragalus Bfd	-	-	-	-	0	-
Astragalus LmT	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	49	0.0	49	49	1	0.000000
Metatarsal Dd	21.6	0.0	21.6	21.6	1	0.000000
Phalanx 1 GL	81.2	0.0	81.2	81.2	1	0.000000
Phalanx 1 Bp	54.4	0.0	54.4	54.4	1	0.000000
Phalanx 1 DP	38.5	0.0	38.5	38.5	1	0.000000
Phalanx 1 SD	33.4	0.0	33.4	33.4	1	0.000000
Phalanx 1 Bd	41.9	0.0	41.9	41.9	1	0.000000
Phalanx 1 Dd	24.7	0.0	24.7	24.7	1	0.000000

16th-17th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	25.5	0.0	25.5	25.5	1	0.000000
P_4W_a	15	0.0	15	15	1	0.000000
P_4W_d	4.6	0.0	4.6	4.6	1	0.000000
M_1L_1	25.4	7.3	23.4	27.8	4	1.851801
M_1W_a	13.9	11.6	12.6	16.2	4	1.601041
M_1W_d	3.4	27.8	2.3	4.5	4	0.932738
M_2L_1	22.9	1.5	22.6	23.1	2	0.353553
M_2W_a	13.6	8.3	12.8	14.4	2	1.131371
M_2W_d	3.6	47.1	2.4	4.8	2	1.697056
M_3L_1	29.0	11.5	24.3	32.6	5	3.350075
M_3W_a	11.1	8.2	9.9	12.2	5	0.913780
M_3W_d	3.4	24.4	2.0	4.0	5	0.820366
Scapula GLP	80.5	24.6	66.8	103.2	3	19.77608
Scapula SLC	60.9	27.7	48.4	80.1	3	16.87868
Humerus GLC	-	-	-	-	0	-
Humerus BT	65.8	0.0	65.8	65.8	1	0.000000
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.8	0.0	32.8	32.8	1	0.000000
Radius GL	326.0	5.4	313.5	338.5	2	17.67767
Radius SD	36.2	15.5	32.2	40.1	2	5.586144
Radius Bd	72.5	13.9	63.5	83.4	3	10.07588
Metacarpal GL	221.8	9.9	200.0	244.0	3	22.00189
Metacarpal SD	30.2	11.5	27.7	32.6	2	3.464823
Metacarpal Bd	45.8	8.3	42.1	51.5	5	3.815757
Metacarpal Dd	20.8	10.4	19.2	24.2	5	2.157545
Pelvis LAR	66.0	5.5	61.8	68.2	3	3.611556
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	70.6	2.5	69.3	71.8	2	1.767767
Tibia Dd	43.8	5.0	42.2	45.3	2	2.192031
Astragalus GH	59.6	2.3	58.5	61.1	3	1.345362
Astragalus GB	61.1	2.0	60.0	62.4	3	1.205543
Astragalus Bfd	49.6	2.4	48.3	50.7	3	1.200000
Astragalus LmT	58.6	2.6	56.8	59.6	3	1.500000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	252.2	2.4	246.5	258.5	3	6.027714
Metatarsal SD	28.2	3.0	27.6	28.8	2	0.848528
Metatarsal Bd	43.9	3.1	42.5	45.2	3	1.350309
Metatarsal Dd	26.5	22.2	23	33.3	3	5.889822
Phalanx 1 GL	81.8	5.6	76	90.8	7	4.556994
Phalanx 1 Bp	54.1	9.2	49.2	65.5	8	4.962142
Phalanx 1 DP	37.4	21.5	30.1	54.6	8	8.041855
Phalanx 1 SD	34.8	10.0	30.9	42.9	9	3.466987
Phalanx 1 Bd	45.8	9.1	41.8	54.6	9	4.172829
Phalanx 1 Dd	24.28889	8.5	22.3	29.1	9	2.055143

17th-18th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	-	-	-	-	0	-
M_3W_a	-	-	-	-	0	-
M_3W_d	-	-	-	-	0	-
Scapula GLP	96.9	3.0	94.8	98.9	2	2.899138
Scapula SLC	66.9	0.0	66.9	66.9	1	0.000000
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	69.1	0.0	69.1	69.1	1	0.000000
Metacarpal GL	218.3	3.4	213.0	223.5	2	7.424621
Metacarpal SD	31.4	6.1	30.0	32.7	2	1.909188
Metacarpal Bd	46.7	6.2	43.7	49.5	3	2.902298
Metacarpal Dd	34.3	6.1	32.9	36.7	3	2.088061
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	75.3	0.0	75.3	75.3	1	0.000000
Tibia Dd	45	0.0	45	45	1	0.000000
Astragalus GH	-	-	-	-	0	-
Astragalus GB	-	-	-	-	0	-
Astragalus Bfd	-	-	-	-	0	-
Astragalus LmT	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	46.8	0.0	46.8	46.8	1	0.000000
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	84.8	6.4	81	91	3	5.392897
Phalanx 1 Bp	55.2	1.4	54.4	55.9	3	0.750555
Phalanx 1 DP	38.8	0.9	38.4	39.1	3	0.360555
Phalanx 1 SD	37.7	9.9	37.9	41.4	3	3.752777
Phalanx 1 Bd	46.8	2.9	45.7	48.3	3	1.345362
Phalanx 1 Dd	24.4	4.9	23.4	25.7	3	1.193035

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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	23.9	26.7	16.0	30.2	5	6.367731
M_1W_a	11.3	25.5	6.6	13.8	5	2.877499
M_1W_d	3.1	19.2	2.5	3.7	3	0.602771
M_2L_1	25.9	0.5	25.8	26.0	2	0.141421
M_2W_a	11.8	10.2	10.9	12.6	2	1.202082
M_2W_d	3.1	0.0	3.1	3.1	1	0.000000
M_3L_1	24.4	22.9	21.2	32.7	4	5.572851
M_3W_a	10.1	18.4	8.2	12.1	4	1.852030
M_3W_d	2.0	0.0	2.0	2.0	1	0
Scapula GLP	86.2	17.3	77.6	108.9	3	14.94977
Scapula SLC	59.8	16.6	51.4	84.2	7	9.916000
Humerus GLC	-	-	-	-	0	-
Humerus BT	72.3	5.2	69.6	74.9	2	3.747666
Humerus SD	-	-	-	-	0	-
Humerus HTC	34.7	3.9	33.4	36.1	3	1.350309
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	84.1	5.0	62.4	87.0	2	4.171930
Metacarpal GL	224.5	0.0	224.5	224.5	1	0.000000
Metacarpal SD	34.2	0.0	34.2	34.2	1	0.000000
Metacarpal Bd	39.9	0.0	39.9	39.9	1	0.000000
Metacarpal Dd	27.0	0.0	27.0	27.0	1	0.000000
Pelvis LAR	64.3	6.9	61.1	67.4	2	4.454773
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	51.6	3.4	50.3	52.8	2	1.767767
Femur Bd	69.0	0.0	69.0	69.0	1	0.000000
Tibia GL	340.5	0.8	338.5	342.5	2	2.800000
Tibia SD	37.8	6.7	36.0	39.6	2	2.545584
Tibia Bd	79.7	11.1	66.9	92.3	4	8.847975
Tibia Dd	47.4	10.9	41.1	55.0	5	5.169333
Astragalus GH	55.9	7.5	51.5	59.8	3	4.172529
Astragalus GB	62.3	4.7	59.9	65.5	3	2.898850
Astragalus Bfd	53.1	11.4	47.5	59.5	3	6.000000
Astragalus LmT	55.4	11.3	46.4	60.7	4	6.300000
Calcaneum GL	78.6	0.0	78.6	78.6	1	0.000000
Calcaneum GB	44.3	0.0	44.3	44.3	1	0.000000
Metatarsal GL	280.0	0.0	280.0	280.0	1	0.000000
Metatarsal SD	36.0	0.0	36.0	36.0	1	0.000000
Metatarsal Bd	51.4	7.6	49.0	55.9	3	3.927255
Metatarsal Dd	27.6	13.3	21.6	28.3	3	3.659235
Phalanx 1 GL	82.8	8.9	72.5	94.5	8	7.335011
Phalanx 1 Bp	53.4	11.6	43.7	63	9	6.184991
Phalanx 1 DP	35.9	9.7	31.6	41	8	3.491623
Phalanx 1 SD	35.6	10.7	30.6	42.6	8	3.809637
Phalanx 1 Bd	46.5	9.9	41.1	53.7	8	4.612922
Phalanx 1 Dd	24.8	11.3	22.8	30.5	8	2.796256

PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	25.5	0.0	25.5	25.5	1	0.000000
P_4W_a	15.0	0.0	15.0	15.0	1	0.000000
P_4W_d	4.6	0.0	4.6	4.6	1	0.000000
M_1L_1	25.4	12.3	23.4	27.8	4	3.111270
M_1W_a	13.9	11.6	12.6	16.2	4	1.601041
M_1W_d	3.4	27.8	2.3	4.5	4	0.932738
M_2L_1	22.9	1.5	22.6	23.1	2	0.353553
M_2W_a	13.6	8.3	12.8	14.4	2	1.131371
M_2W_d	3.6	47.1	2.4	4.8	2	1.697056
M_3L_1	29.0	11.5	24.3	32.6	5	3.350075
M_3W_a	11.1	8.2	9.9	12.2	5	0.913780
M_3W_d	3.4	24.4	2.0	4.0	5	0.820366
Scapula GLP	87.1	19.1	66.8	103.2	5	16.65887
Scapula SLC	62.4	22.6	48.4	80.1	4	14.10414
Humerus GLC	-	-	-	-	0	-
Humerus BT	72.1	5.2	68.1	75.6	1	3.756328
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.8	0.0	32.8	32.8	1	1.64560
Radius GL	326.0	5.4	313.5	338.5	2	17.677670
Radius SD	36.2	15.5	32.2	40.1	2	5.586144
Radius Bd	71.7	11.7	63.5	83.4	3	8.404116
Metacarpal GL	220.4	7.3	200.0	244.0	5	16.114430
Metacarpal SD	30.8	7.8	27.7	32.7	4	2.386769
Metacarpal Bd	46.1	7.2	42.1	51.5	8	3.305731
Metacarpal Dd	25.9	28.1	19.2	36.7	8	7.261038
Pelvis LAR	66.0	5.5	61.8	68.3	3	3.611556
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	72.1	4.2	72.2	92.3	3	3.013857
Tibia Dd	44.2	3.9	42.2	45.3	3	1.709776
Astragalus GH	59.6	2.3	58.6	61.1	3	1.345362
Astragalus GB	61.1	2.0	60.0	62.4	3	1.205543
Astragalus Bfd	49.6	2.4	48.3	50.7	3	1.200000
Astragalus LmT	58.6	2.6	56.8	59.6	3	1.500000
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	46.8	0.0	46.8	46.8	1	0.000000
Metatarsal GL	252.2	2.4	246.5	258.5	3	6.027714
Metatarsal SD	28.2	3.0	27.6	28.8	2	0.848528
Metatarsal Bd	43.9	3.1	42.5	45.2	3	1.350309
Metatarsal Dd	26.5	22.2	23.0	33.3	3	5.889822
Phalanx 1 GL	82.7	5.7	76.0	91.0	10	4.732206
Phalanx 1 Bp	54.4	7.7	49.2	65.5	11	4.194867
Phalanx 1 DP	37.8	17.9	30.1	54.6	11	6.761925
Phalanx 1 SD	35.6	10.1	30.9	42.9	12	3.608691
Phalanx 1 Bd	46.1	7.9	41.8	54.6	12	3.630959
Phalanx 1 Dd	24.3	7.5	22.3	29.1	12	1.825306

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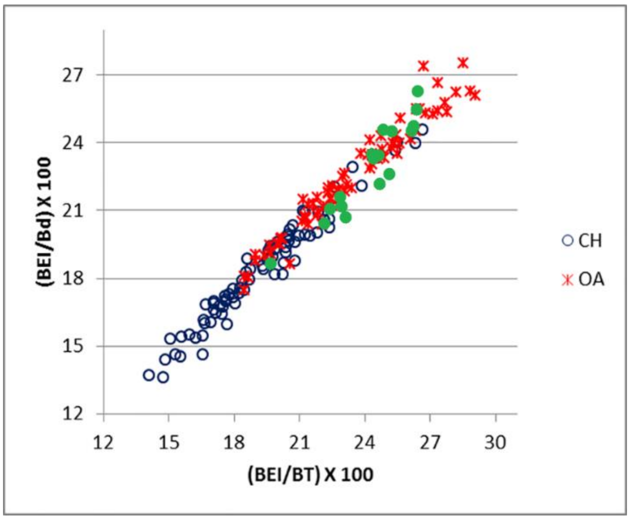
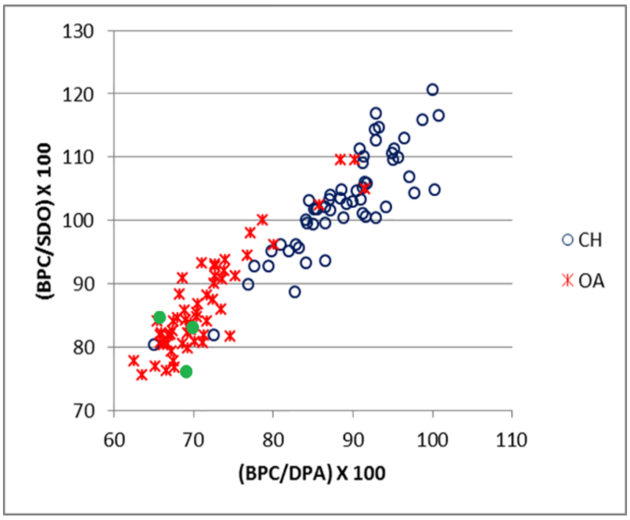
***Appendix 13:** Wharram Percy Sheep/Goat Metric Separation Graphs:*

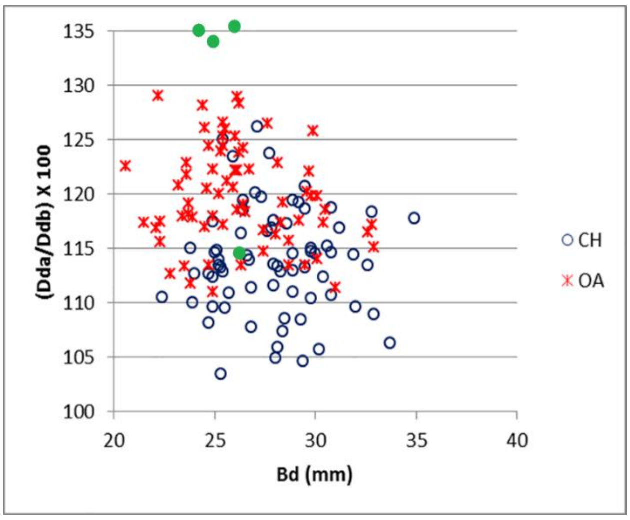
Early Medieval:



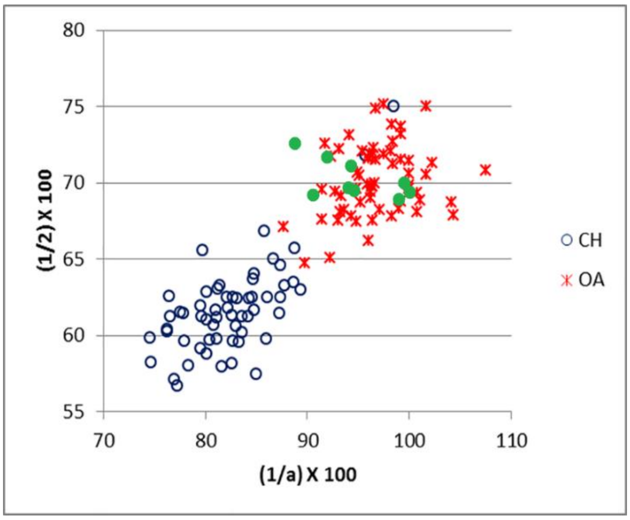
Humerus BEl/BT vs. BEl/Bd



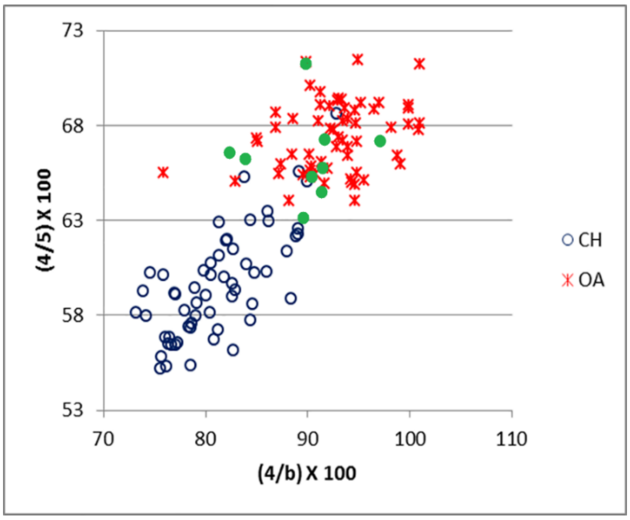
Ulna BPC/DPA vs. BPC/SDO



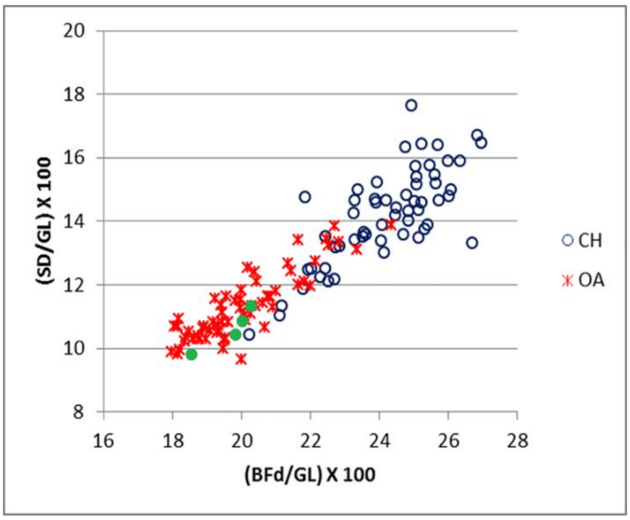
Tibia Bd vs. Dda/Ddb



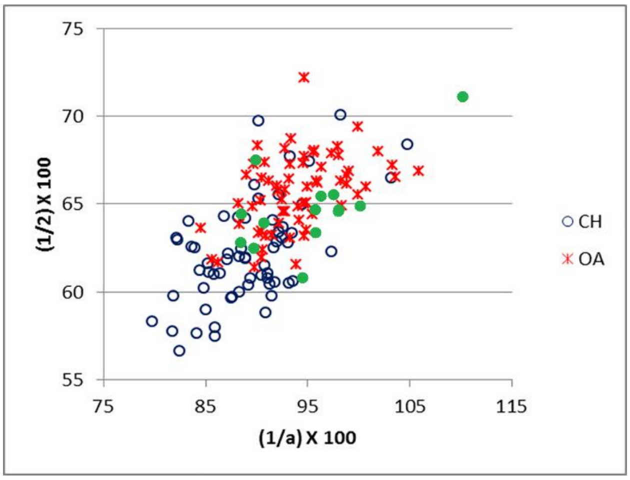
Metacarpal 1/a vs. 1/2



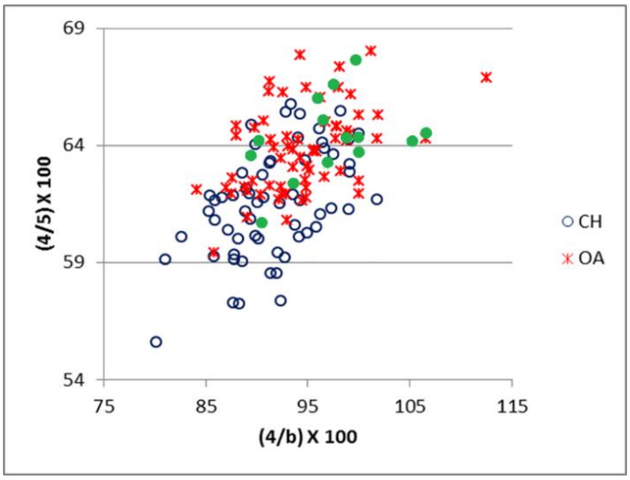
Metacarpal 4/b vs. 4/5



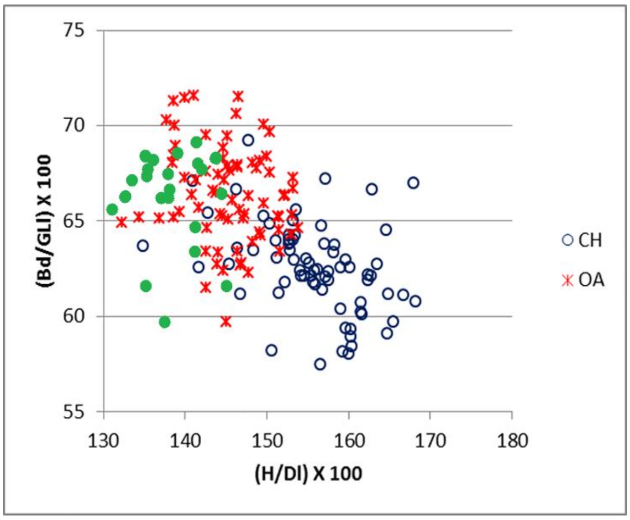
Metacarpal BFd/GL vs. SD/GL



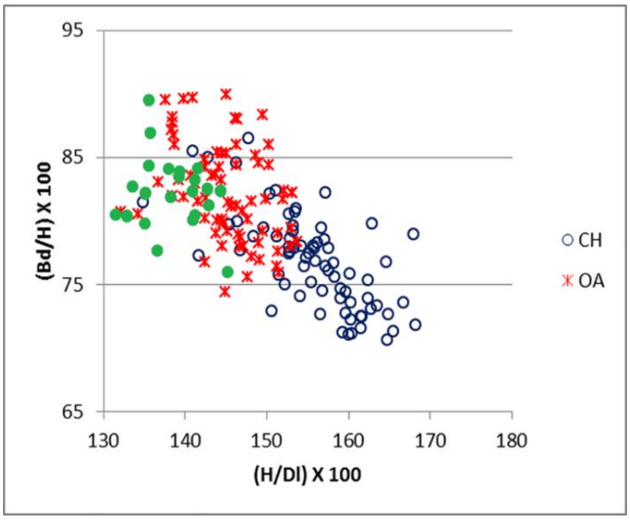
Metatarsal 1/a vs. ½



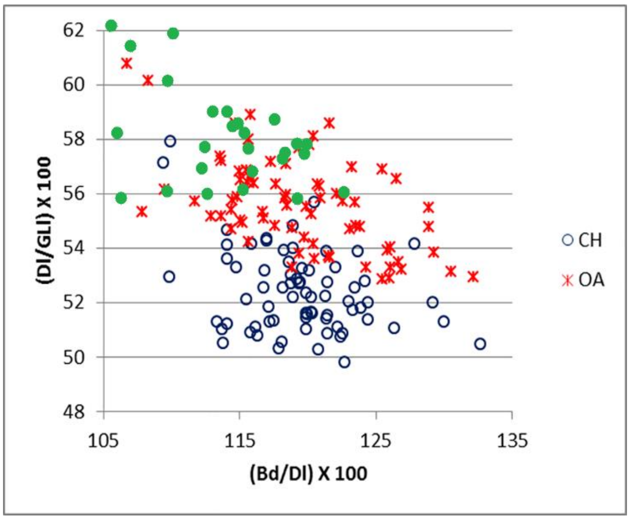
Metatarsal 4/b vs. 4/5



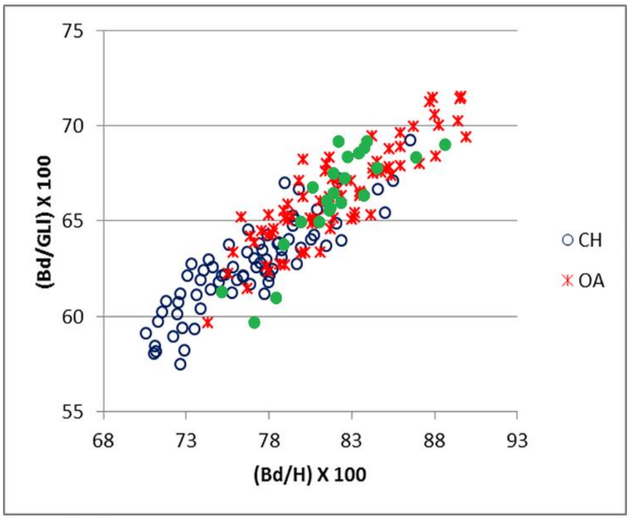
Astragalus H/DI vs. Bd/GLI



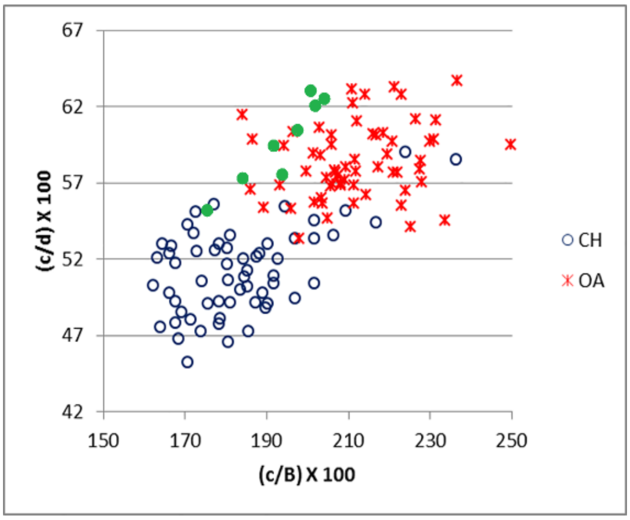
Astragalus H/DI vs. Bd/H



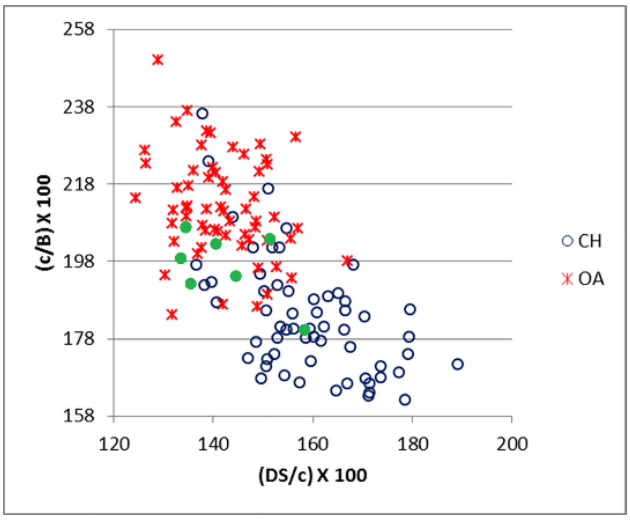
Astragalus Bd/DI vs. DI/GLI



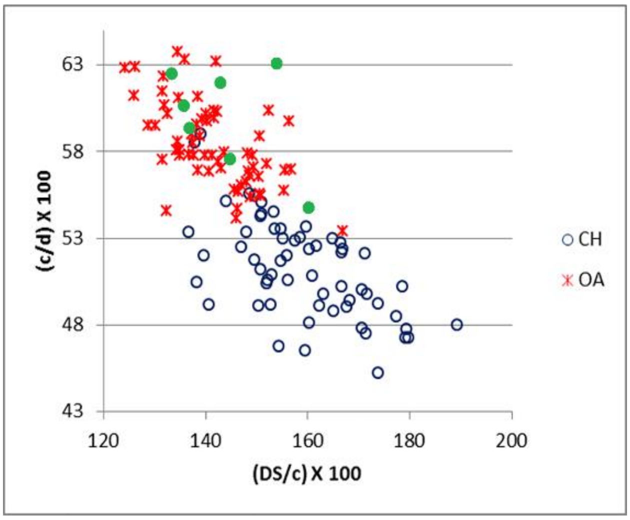
Astragalus Bd/H vs. Bd/GLI



Calcaneum c/B vs. c/d

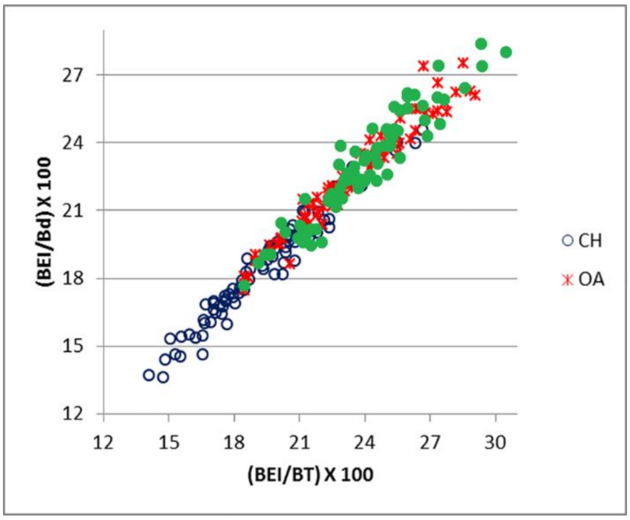


Calcaneum DS/c vs. c/B

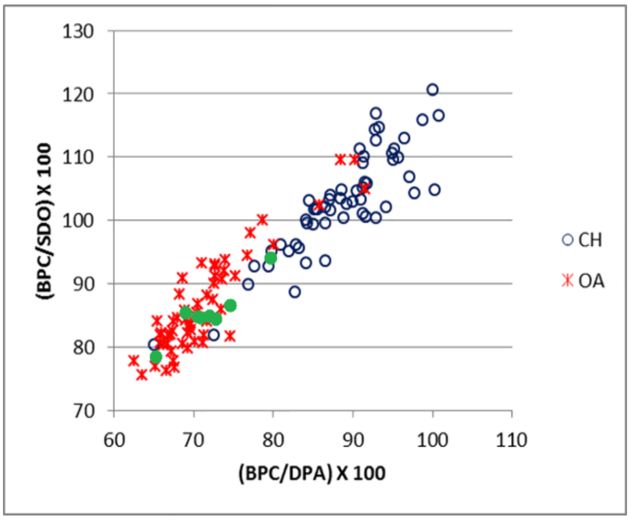


Calcaneum DS/c vs. c/d

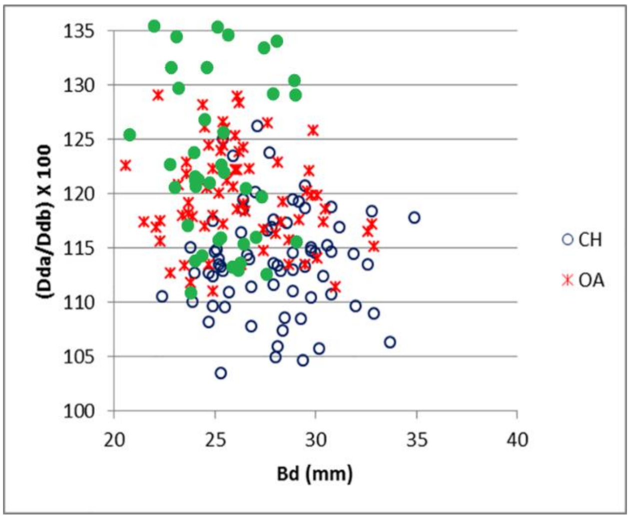
Late Medieval:



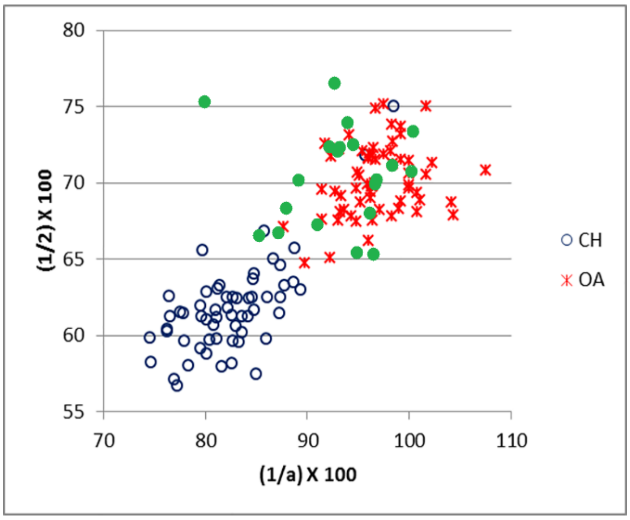
Humerus BEI/BT vs. BEI/Bd



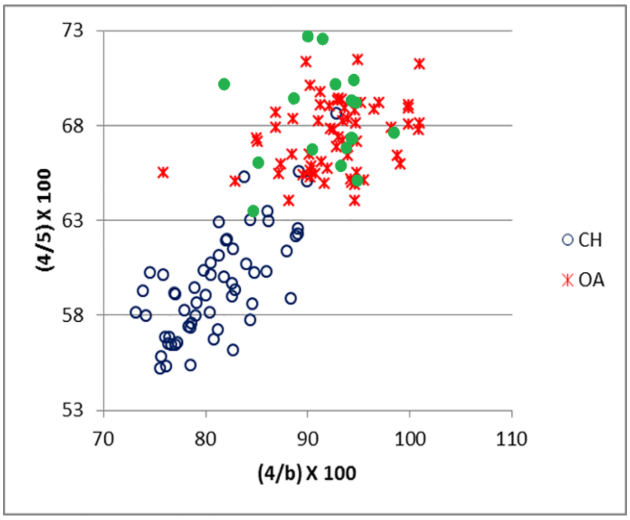
BPC/DPA vs. BPC/SDO



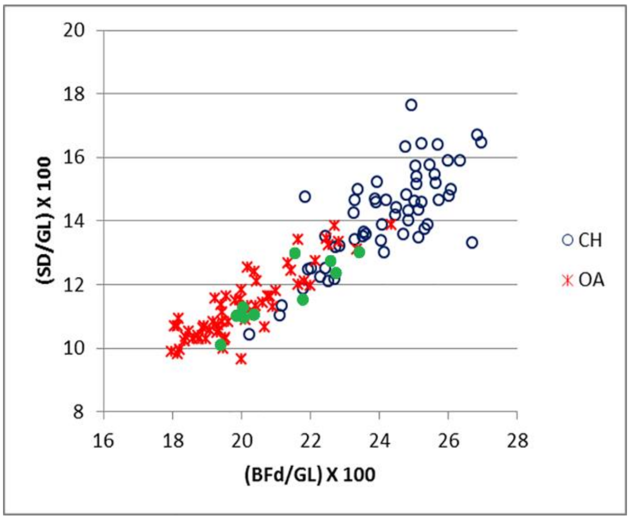
Tibia Bd vs. Dda/Ddb



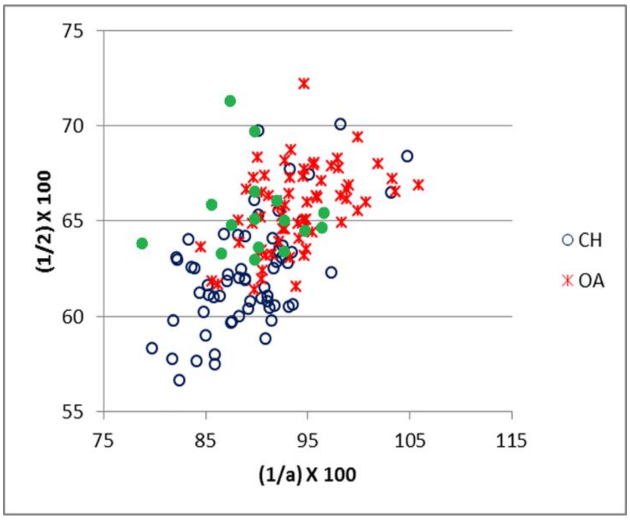
Metacarpal 1/a vs. ½



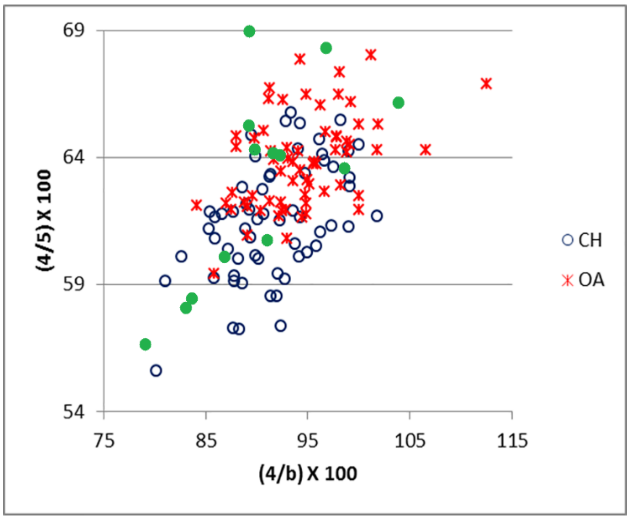
Metacarpal 4/b vs. 4/5



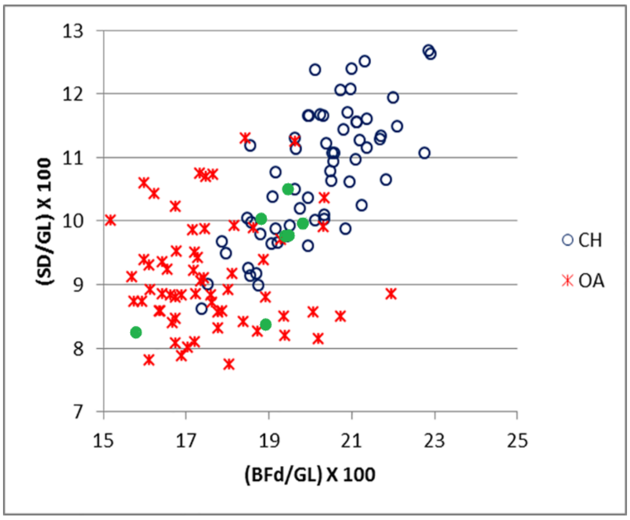
Metacarpal BFd/GL vs. SD/GL



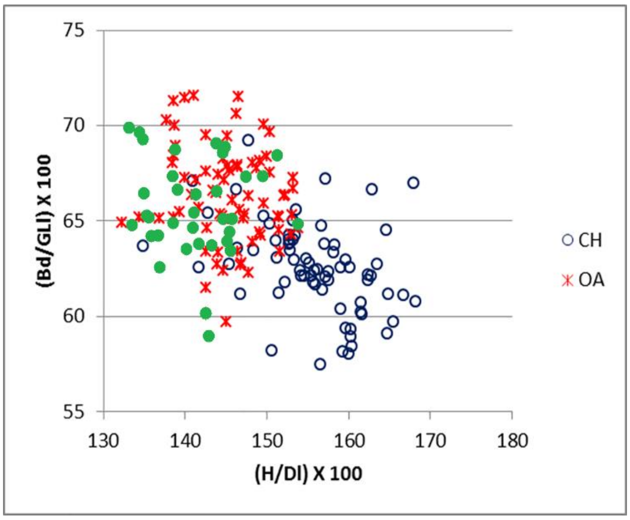
Metatarsal 1/a vs. 1/2



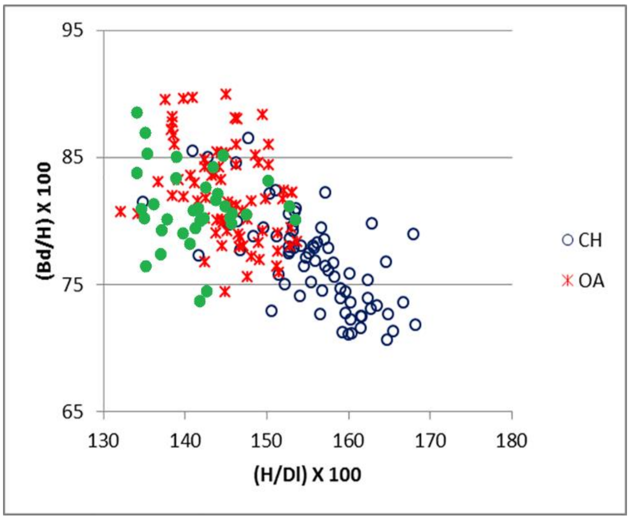
Metatarsal 4/b vs. 4/5



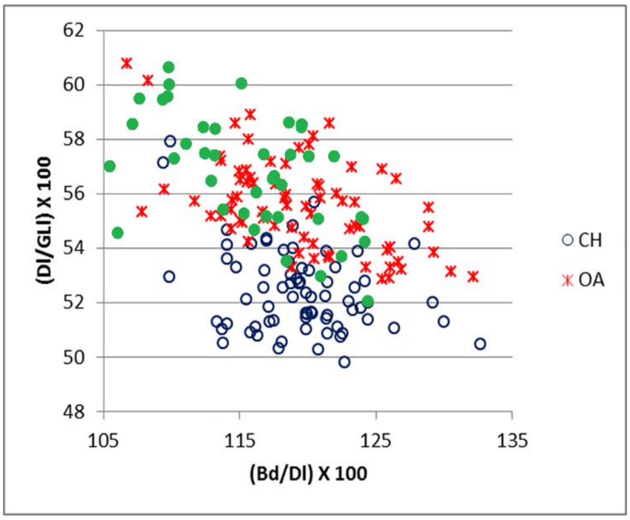
Metatarsal BFd/GL vs. SD/GL



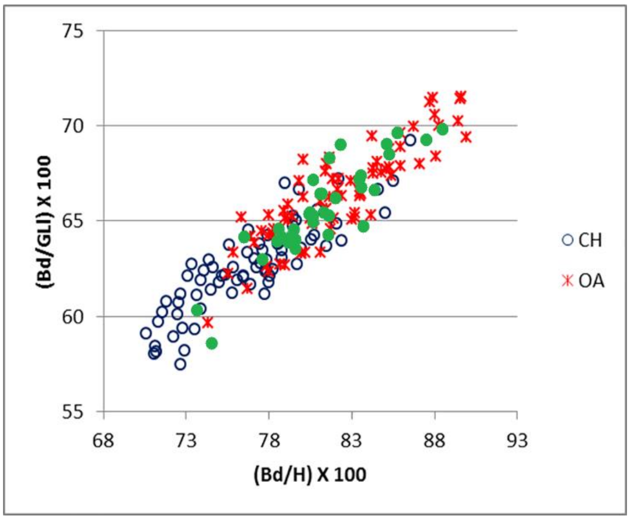
Astragalus H/Dl vs. Bd/GLl



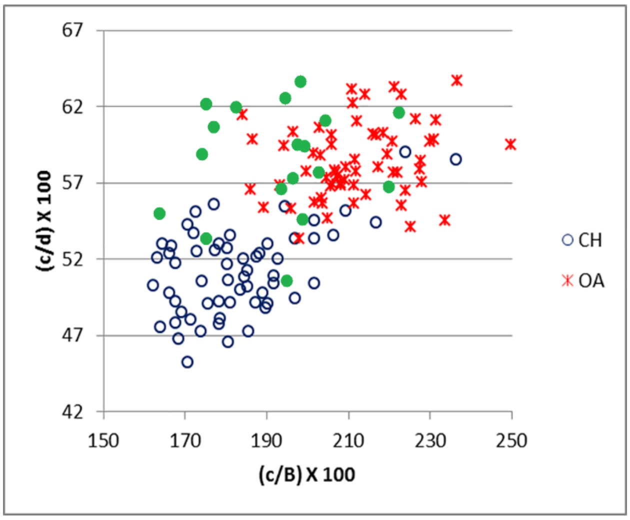
Astragalus H/Dl vs. Bd/H



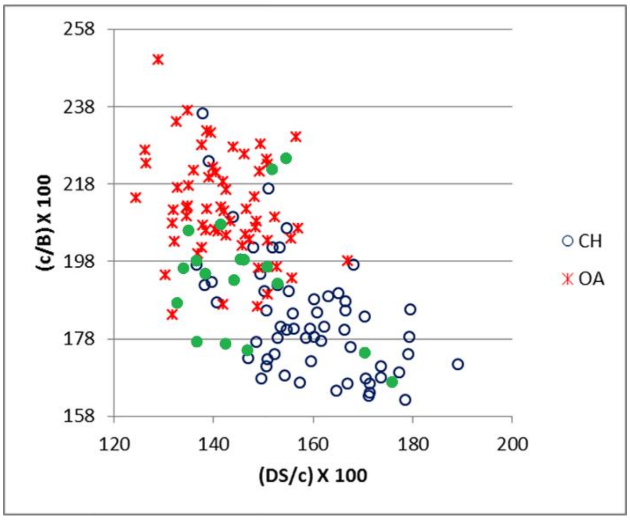
Astragalus Bd/Dl vs. Dl/GLl



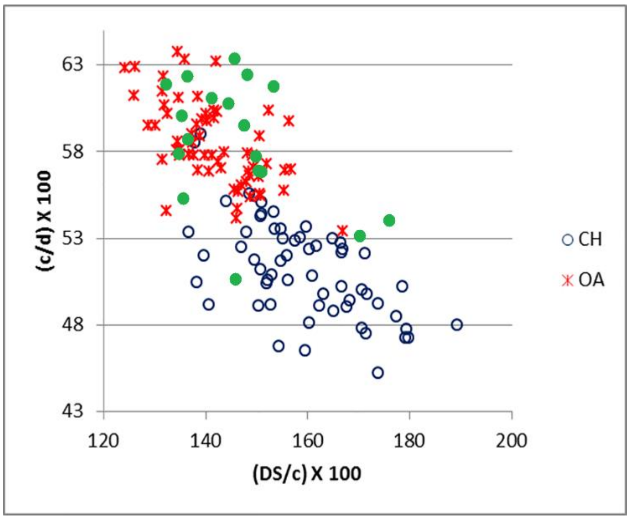
Astragalus Bd/H vs. Bd/GLI



Calcaneum c/B vs. c/d

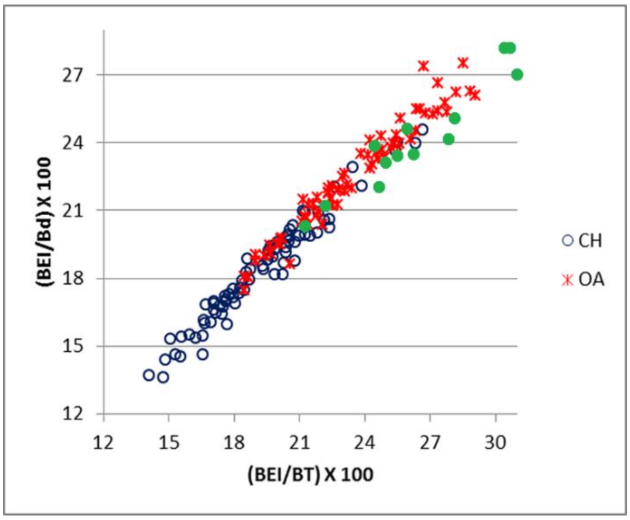


Calcaneum DS/c vs. c/B

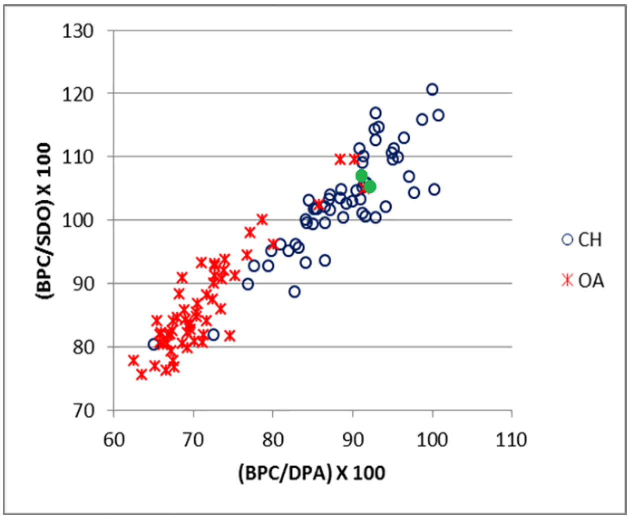


Calcaneum DS/c vs. c/d

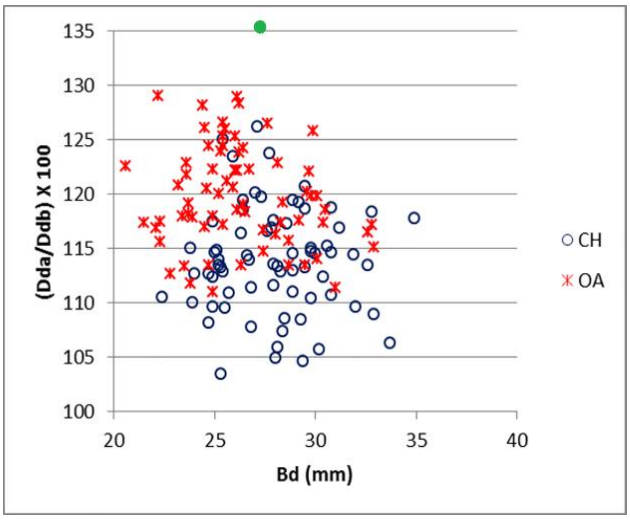
Post-Medieval:



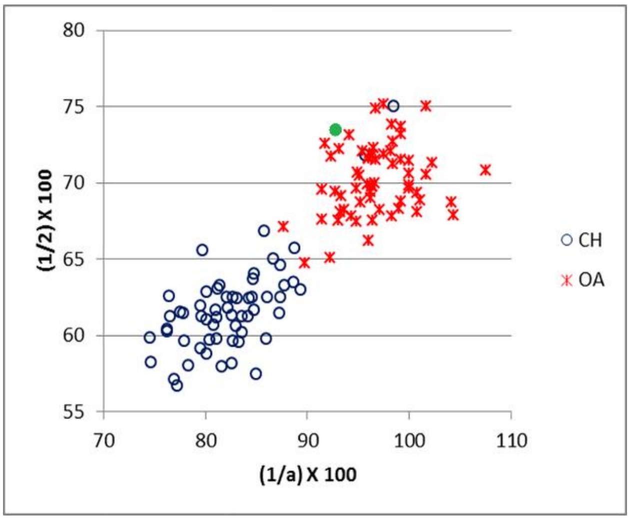
Humerus BEI/BT vs. BEI/Bd



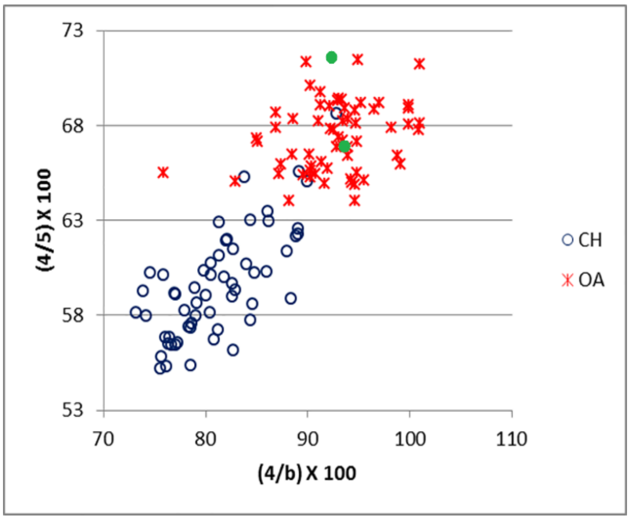
Ulna BPC/DPA vs. BPC/SDO



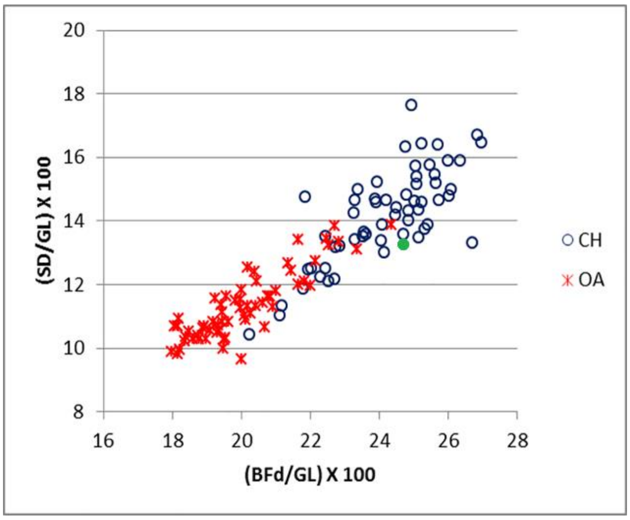
Tibia Bd vs. Dda/Ddb



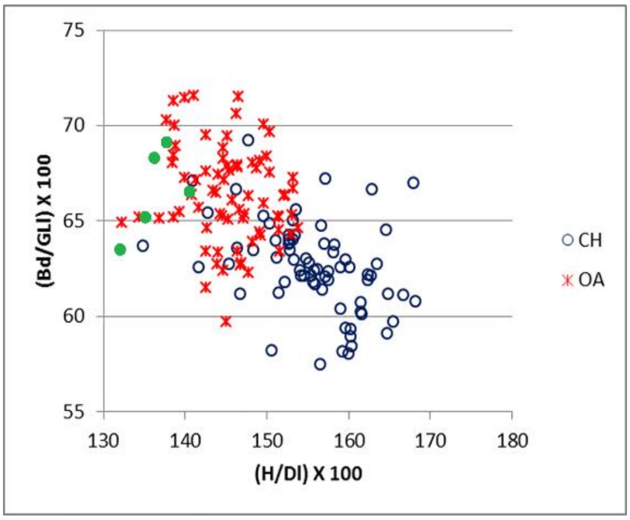
Metacarpal 1/a vs. ½



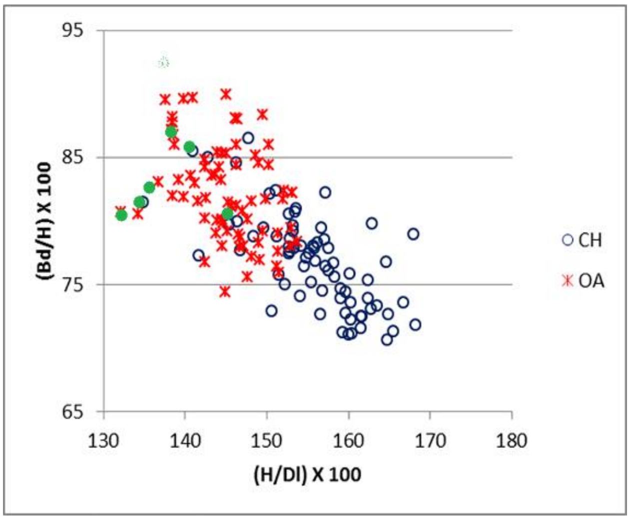
Metacarpal 4/b vs. 4/5



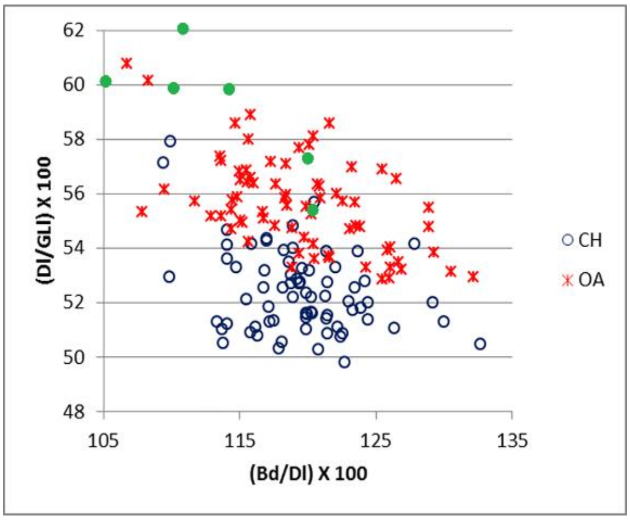
Metacarpal BFd/GL vs. SD/GL



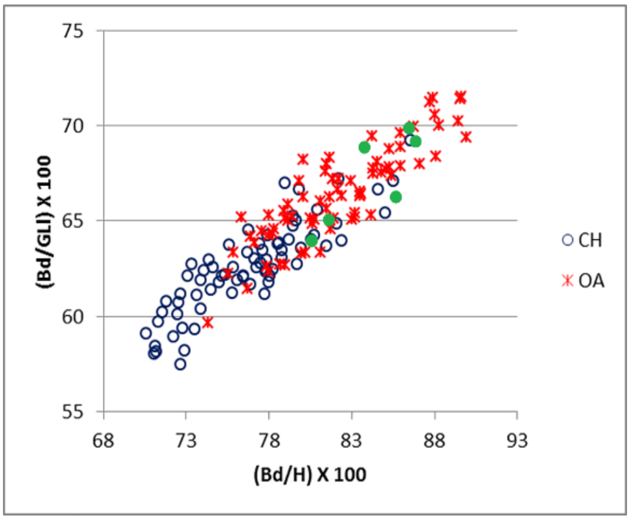
Astragalus H/Dl vs. Bd/GLl



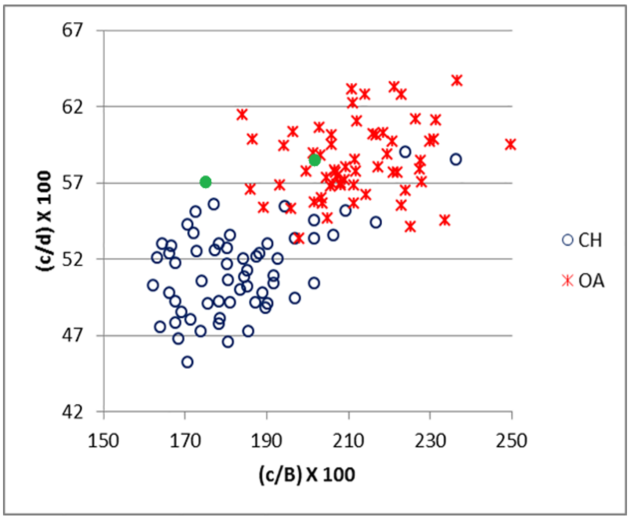
Astragalus H/Dl vs. Bd/H



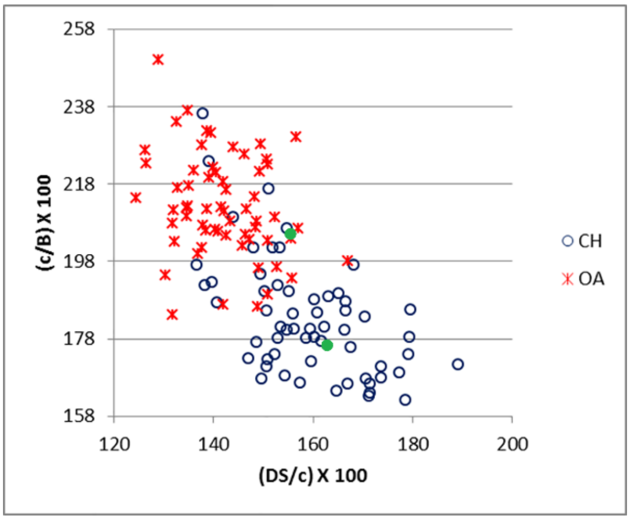
Astragalus Bd/Dl vs. Dl/GLl



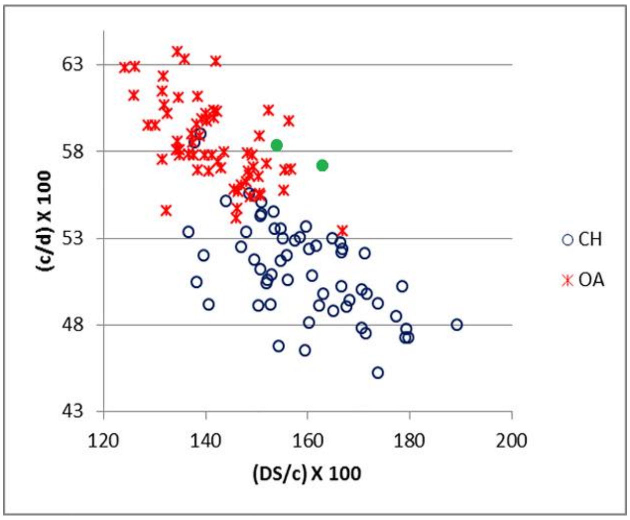
Astragalus Bd/H vs. Bd/GLl



Calcaneum c/B vs. c/d



Calcaneum DS/c vs. c/B

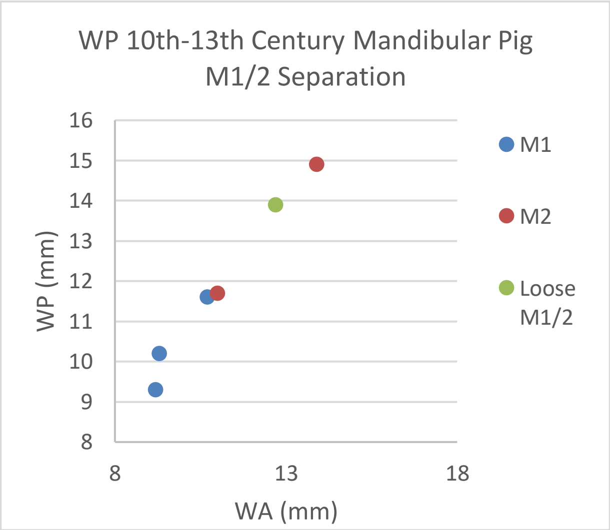


Calcaneum DS/c vs. c/d

Appendix 14: *Wharram Percy Pig M12 Separation:*

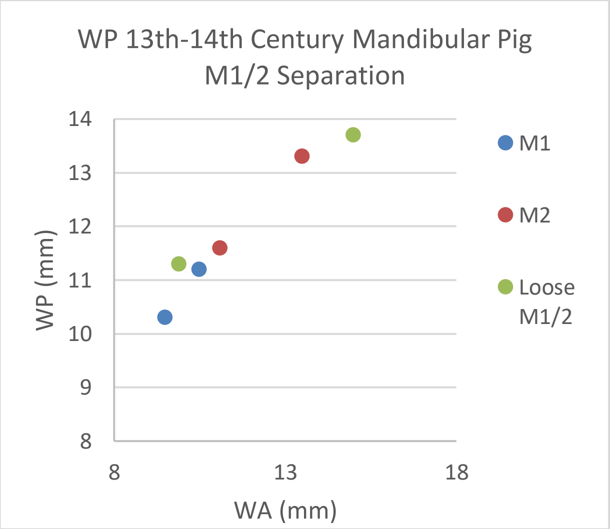
10th-13th century:

ID no.	WA	WP	M1/2
5745	12.7	13.9	M2



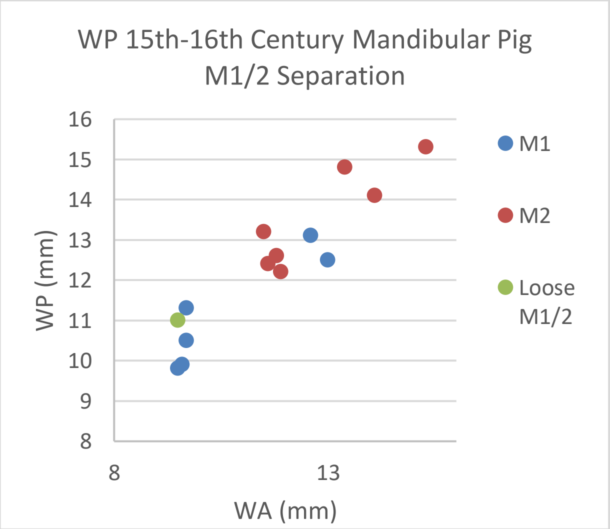
13th-14th century:

ID no.	WA	WP	M1/2
5220	15	13.7	M2
5221	9.9	11.3	M1



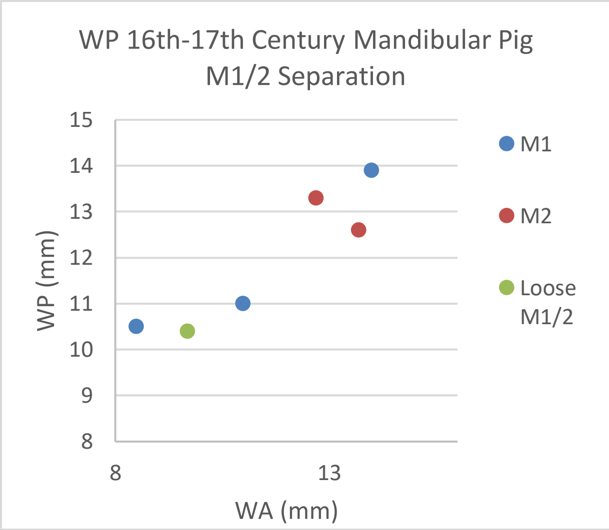
15th -16th century:

ID no.	WA	WP	M1/2
5167	9.5	11	M1



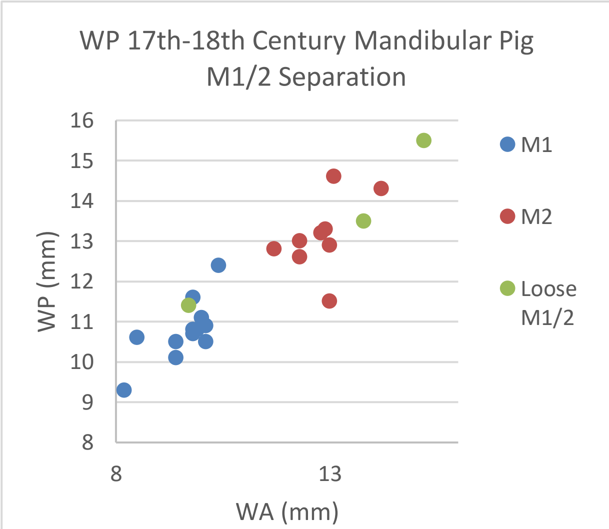
16th-17th century:

ID no.	WA	WP	M1/2
5519	9.7	10.4	M1



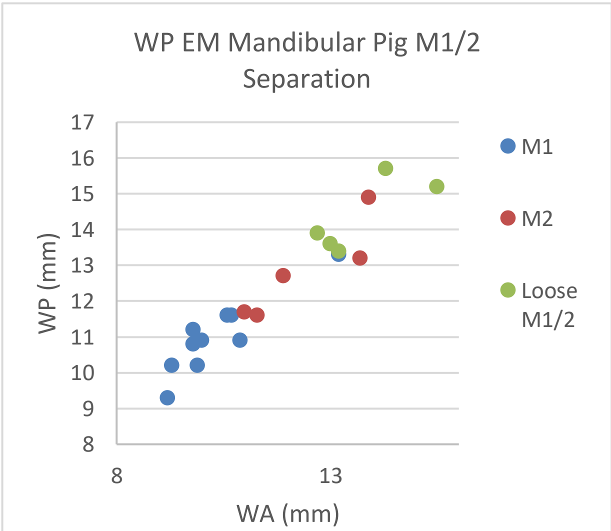
17th-18th century:

ID no.	WA	WP	M1/2
4978	13.8	13.5	M2
5657	9.7	11.4	M1
5932	15.2	15.5	M2



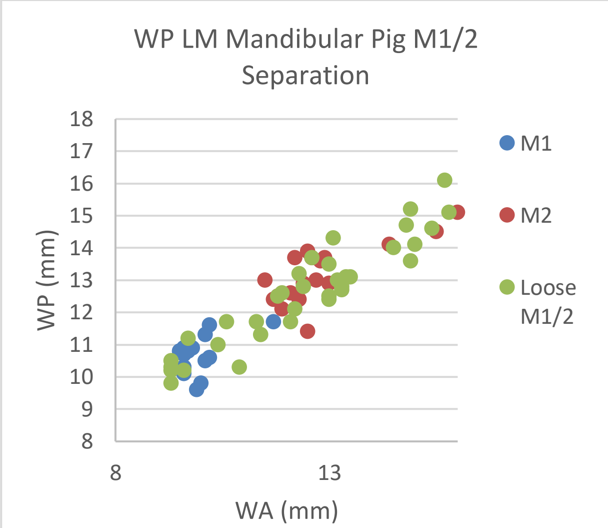
EM:

ID no.	WA	WP	M1/2
8098	13	13.6	M2
7672	15.5	15.2	M2
6754	13.2	13.4	M2
6761	14.3	15.7	M2



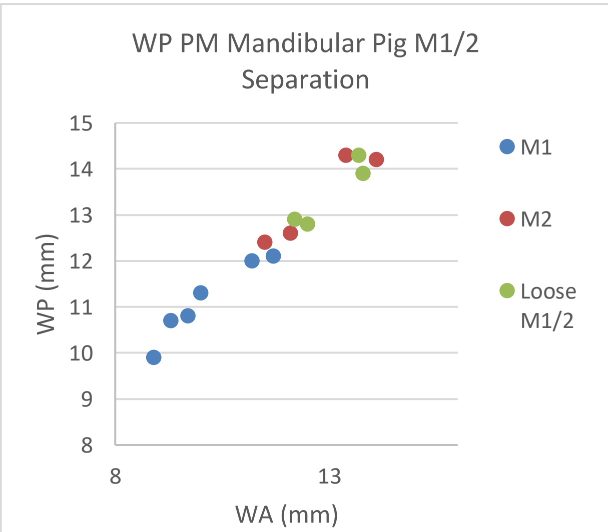
LM:

ID no.	WA	WP	M1/2
8209	12.6	13.7	M2
7248	15	14.1	M2
7266	9.3	10.5	M1
6780	13	12.5	M2
6321	13	12.4	M2
3191	9.7	11.2	M1
2432	12.1	11.7	M2
2433	13	13.5	M2
2599	16.5	16.6	M2
3472	10.6	11.7	M1
3474	9.3	10.2	M1
3473	12.3	13.2	M2
3498	14.8	14.7	M2
6907	11.3	11.7	M1
7586	13.5	13.1	M2
7585	13.4	13.1	M2
7583	9.6	10.2	M1
7090	12.2	12.1	M2
3047	12.4	12.8	M2
3653	11.4	11.3	M1
3190	14.9	13.6	M2
3901	10.9	10.3	M1
3932	9.3	9.8	M1
3927	13.2	13	M2
3742	11.9	12.6	M2
4176	11.8	12.5	M2
2825	9.3	10.3	M1
2808	13.3	12.8	M2
2416	10.4	11	M1
3476	15.4	14.6	M2
3475	15.8	15.1	M2
3126	13.1	14.3	M2
2522	15.7	16.1	M2
2559	13.3	12.7	M2
3348	14.5	14	M2
2721	14.9	15.2	M2



PM:

ID no.	WA	WP	M1/2?
5488	12.5	12.8	M2
5473	13.8	13.9	M2
7020	12.2	12.9	M2
7456	9.2	7.9	M2
5388	13.7	14.3	M2



M1/2 in jaw reference measurements:

Phase/ Period	M1		M2	
	WA	WP	WA	WP
C. 10th-13th	10.7	11.6	13.9	14.9
	9.3	10.2	11	11.7
	9.2	9.3		
C. 13th-14th	10.5	11.2	11.1	11.6
	9.5	10.3	13.5	13.3
C. 15th-16th	9.5	9.8	11.6	12.4
	9.7	10.5	13.4	14.8
	9.6	9.9	15.3	15.3
	9.7	11.3	11.8	12.6
	13	12.5	11.9	12.2
	12.6	13.1	11.5	13.2
			14.1	14.1
C. 16th-17th	8.5	10.5	12.7	13.3
	11	11	13.7	12.6
	14	13.9	16.4	14.3
C. 17th-18th	10.1	10.5	13	12.9
	10	11.1	13	11.5
	9.8	10.7	12.9	13.3
	10.4	12.4	14.2	14.3
	8.5	10.6	11.7	12.8
	10.1	10.9	12.3	13
	9.4	10.1	12.8	13.2
	9.9	10.8	13.1	14.6
	8.2	9.3	12.3	12.6
	9.8	11.6		
	9.8	10.8		
	9.4	10.5		
EM	10.7	11.6	13.9	14.9
	9.3	10.2	11	11.7
	9.2	9.3	11.9	12.7
	9.9	10.2	11.3	11.6
	10	10.9	16.5	14.6
	9.8	11.2	13.7	13.2
	10.6	11.6		
	13.2	13.3		
	10.9	10.9		
	9.8	10.8		
LM	10	9.8	12.7	13
	9.6	10.3	12.8	13.6
	10.2	11.6	12.2	13.7

	9.5	10.8	12.6	13.7
	9.6	10.9	14.4	14.1
	11.7	11.7	15.5	14.5
	9.8	10.9	11.5	13
	9.9	9.6	16.3	15.4
	10.1	10.5	12.1	12.6
	9.6	10.1	16	15.1
	9.6	10.7	12.5	11.4
	9.5	10.8	11.8	12.5
	10.1	11.3	13	12.9
	9.6	10.9	11.7	12.4
	9.6	10.3	12.3	12.4
	10.2	10.6	11.9	12.1
	9.7	10.8	12.9	13.7
	9.6	10.7	12.4	12.9
			12.5	13.9
PM	8.9	9.9	14.1	14.2
	10	11.3	12.1	12.6
	11.2	12	11.5	12.4
	11.7	12.1	13.4	14.3
	9.3	10.7		
	9.7	10.8		

***Appendix 15:** Wharram Percy sheep dental ageing table:*

Tooth	Phase	C	V	E	H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
dP4	10th-13th																		1			1							
	13th-14th																			1		1							
	14th-15th																												
	15th-16th												1						1	1		2				1	1		
	16th-17th																		2	1		1	1						
	17th-18th																		5	5		3	1					1	
	18th-19th																		1										
	EM																1	1	8	17		5	3					1	
	LM												1	2			2		12	24		24	5	5	1	2	1	3	2
	PM																		12	7		3	3					1	
P4	10th-13th													4	3			1											
	13th-14th										1				1			1		1	1								
	14th-15th													1															
	15th-16th														3			9		2									
	16th-17th					1					2			2	5			2											
	17th-18th					1				1				6	5			4		1									
	18th-19th							1																					
	EM			2		3		2		1	2	1	2	6	9		1	1											
	LM			1	1	5		6		1	3		4	19	32		6	29		7	5								
	PM					2		1		2	2			8	11			6		1									

M_1	10th-13th														5	1					1								
	13th-14th														1		1	1		1	2		1						
	14th-15th														1														
	15th-16th											2		1	4			1	2	1	6								
	16th-17th	1		1											5		1				2								
	17th-18th									4			2	8	9					1	9		1						
	18th-19th														1														
	EM	1						1		1			2	8	16	2	2	2			2								
	LM	1						3		1		4	3	6	39	9	5	11	2	5	23	1	1						
	PM	1		1		1		1		4	1		2	8	17		1			1	11		1						
M_2	10th-13th													1	6	1													
	13th-14th														4		1				1								
	14th-15th														1														
	15th-16th	1		2							1				6	1	3	2											
	16th-17th										1		1		5			1											
	17th-18th												2		14			2		2	2								
	18th-19th											1																	
	EM	1		4				2				3	1	4	17	1													
	LM	1		8		2					4	4	2	6	60	5	5	6		1	3								
	PM	1								1	1	1	3		20			3		2	2								
M_{12}	10th-13th					1							4	2	4	1													
	13th-14th					1				1			1		11	1	1			1	1								

	14th-15th					1								1	1														
	15th-16th										2			1	8	1	2		1		1								
	16th-17th							4			2	2	7	1	17		1	1			2								
	17th-18th					3	1	2		1	3	4	9	10	22	1	2	2			1								
	18th-19th					1								2	6	1		1											
	EM			1		2		7		1	4	10	20	16	63	3		3			1								
	LM					20		14	1	7	13	29	39	54	263	17	17	5	4	4	10								
	PM					5	1	9	1	3	10	8	18	20	65	2	4	4			5								
	10th-13th					1		1		1	1	2	1	2		1	4												
	13th-14th										1				1	1	12			1									
	14th-15th							1							1														
	15th-16th	1						1				1			1	1	18	1											
M3	16th-17th			2		1	1	3		1	2		2	1		4	17												
	17th-18th	1				4		2			3			2	2	2	23	2	1										
	18th-19th	1													3	1													
	EM	3		2		5		9	2	9	3	5	1	2	6	7	29												
	LM	2	1	3	1	9	2	15	2	7	12	7	3	11	32	16	147	9	2	1									
	PM	2		2		6	1	7		2	7	1	2	6	7	8	46	2	2										

Appendix 16: *Wharram Percy cattle dental ageing table:*

Tooth	Phase	C	V	E	H	a	b	c	d	e	f	g	h	j	k	l	m	n	o	p
dP_4	10th-13th													1						
	13th-14th																			
	14th-15th																			
	15th-16th						1				1				1					
	16th-17th						3	1			1		1	1						
	17th-18th						2	4			1		1		1	2				
	18th-19th													1	1					
	EM					1	2	1			1		1	1	4					
	LM						2	1				2	1	7	6	3				
	PM					1							3	8	3					
P_4	10th-13th											1	1							
	13th-14th										3	1								
	14th-15th																			
	15th-16th					2														
	16th-17th					1					3	2								
	17th-18th					1		1	1		2	2								
	18th-19th																			
	EM			1		3		2			2	4	1							
	LM					5	3	5	2	1	1 4	1 1	4	2						
	PM			1		3		2			8	5								
M_1	10th-13th																1			
	13th-14th																1			
	14th-15th																			
	15th-16th														1		1			
	16th-17th																			
	17th-18th	1		1										1		1				
	18th-19th										1	1								
	EM	1												1		1	1			
	LM								1		1	2	1	1	2		3	1	1	

	PM															3				
M_2	10th-13th													1		1				
	13th-14th																			
	14th-15th																			
	15th-16th													1	1	1				
	16th-17th																			
	17th-18th											1				1				
	18th-19th			2																
	EM										1			1		1				
	LM			1			1		1	1	1	2		12	3	6				
	PM			2								1			1	1				
M_{12}	10th-13th					1	1	1			1	2	1			1				
	13th-14th													1	1	1				
	14th-15th																			
	15th-16th							1							2	4				
	16th-17th						2		1	1		1	1	2		1	1			
	17th-18th					3		1		1	3	4		2	3	2	1			
	18th-19th															1				
	EM					5	3	1	1	1	7	9	1	7	7	8	4		1	
	LM					5	6	7	3	3	9	18	1	13	22	17	2	2	1	
	PM					4	5	2	1	2	7	13	1	7	9	5	4	1		
M_3	10th-13th									1	1	1			1					
	13th-14th													1						
	14th-15th																			
	15th-16th											2		3	3					
	16th-17th			1								1		1	1	1				
	17th-18th					1	2		2						3	1				
	18th-19th			1							1			1						
	EM					2	4			1	2	4		3	6					
	LM			2		1	2		5	2	3	12		9	5	4	2			
	PM			2		1	2		2		1	2		2	4	2				

Appendix 17: *Wharram Percy pig dental ageing table:*

Tooth	Phase	C	V	E	H	w1	w2	w3	w1/w1	w2/w1	w2/w2	w3/w2	w3/w3	w4/w3	w3-w3	w4-w3	w4-w4	w1/w1/w1	w2/w1/w1	w2/w2/w2	w3/w2/w2	w3/w3/w2	w3/w3-w3	w3-w3-w3	w4-w4-w4
dP4	10th-13th																					1			
	13th-14th																		1						
	14th-15th																								
	15th-16th																					1			
	16th-17th																		2						
	17th-18th																			1		1		1	
	18th-19th																								1
	EM																					3			
	LM																	1		1	2	3	4	1	1
	PM																				1			2	
P4	10th-13th						3																		
	13th-14th					2	4																		
	14th-15th																								
	15th-16th						6																		
	16th-17th						5	1																	
	17th-18th						2																		
	18th-19th																								
	EM					3	7																		
	LM					5	28	1																	
	PM						10																		
M1	10th-13th								1			1	1												
	13th-14th										1	2	1		1		1								
	14th-15th																								
	15th-16th										3	2	1		1		2								
	16th-17th								2		3	1			1		1								
	17th-18th									1	2	8	1		2										
	18th-19th											1													
	EM								1	1	3	2	2		3										
	LM								3	1	18	15	9		5		6								

	PM								2	2	7	9	4		3		1								
	10th-13th										1	1	1												
	13th-14th										2				1										
	14th-15th																								
	15th-16th								1	1	3	1	2												
M 2	16th-17th								1	2					1										
	17th-18th								2	3	5	1					1								
	18th-19th										1														
	EM								2	1	5	2													
	LM			1					19	4	14	17	9	1	2										
	PM								3	5	7	3					1								
	10th-13th																								
	13th-14th										1														
	14th-15th												1												
	15th-16th																								
M 12	16th-17th																								
	17th-18th										2	2													
	18th-19th																								
	EM										1		1												
	LM								1	2	3		1		1		1								
	PM								2		5	4	1												
	10th-13th																	1	1	2					
	13th-14th																		1		1				
	14th-15th																	1							
	15th-16th																	2		1	1				
M 3	16th-17th																	3	1	3					
	17th-18th																	2	1	2					
	18th-19th																	1	1						
	EM																	3	3	2					
	LM			2														11	8	6	3			1	
	PM																	7	5	5					

Appendix 18: *Wharram Percy Fusion Data by Element:*

Sheep:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		C. 18th-19th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	1	0	5	0	0	0	3	1	7	1	16	2	6	4	11	1	17	1	33	8
Humerus, p	1	0	1	0	0	0	0	0	2	1	5	4	4	2	5	3	6	4	12	7
Humerus, d	7	0	6	0	0	0	9	1	16	0	27	5	9	1	34	2	104	6	67	6
Radius, p	5	0	1	0	0	0	6	0	6	0	25	2	4	1	18	2	36	2	43	3
Radius, d	5	3	2	0	0	0	4	1	7	5	13	4	3	2	21	12	32	10	29	14
Ulna	0	0	0	0	0	0	0	0	1	0	2	0	0	0	5	4	0	0	6	1
Metacarpal, d	1	0	3	0	0	0	4	1	6	3	13	4	3	2	15	2	34	8	25	10
Pelvis	0	0	1	1	0	0	4	0	2	0	7	2	1	1	10	0	16	3	12	3
Femur, p	4	1	0	0	0	0	1	1	5	1	12	10	2	1	11	4	20	13	23	14
Femur, d	4	0	2	1	0	0	3	1	5	4	6	4	3	2	10	4	20	9	17	13
Tibia, p	1	1	2	0	0	0	1	1	5	3	9	4	1	1	3	2	3	1	15	8
Tibia, d	7	1	8	0	0	0	7	0	26	6	44	9	5	1	45	13	115	13	91	17
Calcaneum	1	0	4	0	0	0	7	1	7	4	14	5	5	1	18	6	37	9	28	10
Metatarsal, d	1	1	2	0	0	0	1	1	6	2	11	5	2	1	25	6	30	11	19	8
P1	0	0	15	1	0	0	12	0	19	4	20	5	3	1	31	4	88	4	47	11
P2	0	0	8	0	0	0	0	0	4	0	11	0	0	0	4	0	28	2	16	0

Cattle:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		C. 18th-19th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	1	0	1	0	0	0	4	0	3	0	6	0	0	0	4	0	5	0	9	0
Humerus, p	0	0	0	0	0	0	1	1	1	0	4	0	0	0	4	2	6	4	5	0
Humerus, d	3	0	2	0	0	0	0	0	2	0	10	0	1	0	14	0	19	0	13	0
Radius, p	1	0	1	0	0	0	2	0	2	0	6	0	0	0	17	2	3	0	8	0
Radius, d	0	0	0	0	0	0	1	0	4	2	5	3	0	0	17	11	1	0	9	5
Ulna	1	1	0	0	0	0	0	0	1	0	5	3	0	0	4	2	0	0	6	3
Metacarpal, d	1	1	3	0	0	0	2	1	3	2	6	1	3	0	6	4	33	3	12	3
Pelvis	2	0	2	0	0	0	5	0	4	0	4	0	2	0	5	0	7	0	10	0
Femur, p	3	1	1	1	0	0	0	0	6	4	9	3	1	1	11	5	27	15	16	8
Femur, d	1	0	1	0	0	0	0	0	2	1	2	1	0	0	8	4	10	3	4	2
Tibia, p	0	0	0	0	0	0	2	1	3	2	4	2	0	0	3	3	2	1	7	4
Tibia, d	0	0	0	0	0	0	4	1	5	0	8	1	1	0	23	9	4	1	14	1
Calcaneum	0	0	0	0	0	0	3	1	2	0	6	3	0	0	11	5	19	7	8	3
Metatarsal, d	2	0	0	0	0	0	1	1	6	1	6	1	0	0	6	3	16	4	12	2
P1	3	0	8	0	0	0	12	0	17	2	33	0	4	0	39	1	109	6	54	2
P2	1	0	9	0	0	0	12	0	13	0	27	1	4	0	50	1	85	2	44	1

Pig:

Element	C. 10th-13th		C. 13th-14th		C. 14th-15th		C. 15th-16th		C. 16th-17th		C. 17th-18th		C. 18th-19th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	1	0	0	0	0	0	0	0	5	3	5	0	1	1	3	1	3	1	12	1
Humerus, p	0	0	0	0	0	0	0	0	4	1	0	0	0	0	4	4	2	1	4	1
Humerus, d	0	0	0	0	0	0	1	1	6	3	3	1	1	0	8	3	11	4	11	4
Radius, p	1	1	0	0	0	0	3	0	6	2	11	0	0	0	5	2	6	2	18	2
Radius, d	1	1	0	0	0	0	0	0	3	3	2	2	0	0	3	3	5	5	6	6
Ulna	1	1	1	1	0	0	2	2	3	3	2	2	0	0	1	1	3	3	5	5
Metacarpal, d	0	0	1	1	0	0	4	4	8	8	4	3	0	0	1	1	20	19	13	12
Pelvis	0	0	1	0	0	0	2	0	3	2	2	2	1	1	2	0	3	0	7	5
Femur, p	1	1	0	0	0	0	0	0	2	2	0	0	0	0	1	1	6	5	2	2
Femur, d	0	0	0	0	0	0	0	0	3	3	1	1	0	0	0	0	3	3	5	5
Tibia, p	0	0	0	0	0	0	0	0	3	3	1	1	0	0	2	2	1	1	4	4
Tibia, d	0	0	0	0	0	0	4	3	4	3	5	3	3	2	5	3	15	11	13	9
Calcaneum	0	0	3	0	0	0	3	3	4	4	2	2	1	1	3	3	12	9	7	7
Metatarsal, d	1	1	2	2	0	0	0	0	4	4	2	2	0	0	2	1	9	8	7	7
P1	0	0	1	1	0	0	1	0	7	7	5	3	2	1	6	4	3	1	15	12
P2	0	0	1	0	0	0	0	0	9	5	4	2	0	0	4	0	1	0	13	7

Appendix 19: *Wharram Percy sheep metric overview:*

V = coefficient of variation

10th-13th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.6	1.1	6.5	6.6	2	0.070711
M_1 W	7.5	5.6	7.0	8.4	8	0.420034
M_2 W	7.9	7.1	7.2	9.0	8	0.561726
M_3 L	19.6	8.3	17.7	22.7	13	1.623703
M_3 W	7.5	8.8	6.4	8.6	14	0.661708
Scapula GLP	-	-	-	-	0	-
Scapula SLC	17.9	7.1	17.0	18.8	2	1.272792
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.4	9.0	26.0	32.0	4	2.546894
Humerus Bd	30.0	10.4	27.1	34.4	4	3.116622
Humerus SD	-	-	-	-	0	-
Humerus HTC	14.0	7.7	12.6	16.0	7	1.07526
Radius GL	128.5	0.0	128.5	128.5	1	-
Radius Bp	30.6	9.0	28.5	34.2	5	2.752635
Radius SD	15.4	0.0	15.4	15.4	1	-
Radius Bd	28.2	2.5	27.7	28.7	2	0.70711
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal a	11.5	0.0	11.5	11.5	1	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 1	10.8	0.0	10.8	10.8	1	-
Metacarpal 2	14.8	0.0	14.8	14.8	1	-
Metacarpal 3	12.6	0.0	12.6	12.6	1	-
Metacarpal 4	-	-	-	-	0	-
Metacarpal 5	-	-	-	-	0	-
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.8	4.6	17.9	19.6	3	0.862168
Femur Bd	31.7	8.8	28.6	34.6	4	2.799256
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	24.7	2.8	23.5	25.4	6	0.688961
Tibia Dd	19.2	4.6	17.6	19.9	6	0.879583
Astragalus GLl	25.9	0.0	25.9	25.9	1	-
Astragalus GLm	25.0	0.0	25.0	25.0	1	-
Astragalus Bd	16.4	0.0	16.4	16.4	1	-
Astragalus Dl	15.3	0.0	15.3	15.3	1	-
Calcaneum GL	53.4	0.0	53.4	53.4	1	-
Calcaneum GB	16.4	0.0	16.4	16.4	1	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-

100

13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP$_4$ W	6.4	4.8	6.1	6.7	3	0.305505
M$_1$ W	7.1	5.8	6.6	7.5	6	0.409878
M$_2$ W	8.0	5.8	7.5	8.9	7	0.467007
M$_3$ L	21.4	6.1	19.5	24.0	16	1.303265
M$_3$ W	8.2	6.9	7.0	8.8	16	0.564173
Scapula GLP	30.4	6.9	27.8	33.3	5	2.106419
Scapula SLC	18.1	13.6	14.0	20.5	5	2.463331
Humerus GLC	-	-	-	-	0	-
Humerus BT	26.1	5.6	24.6	28.7	6	1.44879
Humerus Bd	27.9	7.0	25.7	31.1	6	1.959337
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.20	6.3	12.1	14.5	6	0.826236
Radius GL	140.2	0.0	140.2	140.2	1	0
Radius Bp	29.9	0.0	29.9	29.9	1	0
Radius SD	15.3	0.0	15.3	15.3	1	0
Radius Bd	27.0	0.3	26.9	27.0	2	0
Metacarpal GL	106.4	0.0	106.4	106.4	1	0
Metacarpal SD	13.3	0.0	13.3	13.3	1	0
Metacarpal Bd	24.5	5.1	23.1	25.5	3	1.249
Metacarpal a	11.3	7.2	10.4	11.9	3	0.814453
Metacarpal b	11.0	6.1	10.2	11.4	3	0.665833
Metacarpal 1	10.4	5.5	9.9	11.0	3	0.568624
Metacarpal 2	14.2	9.8	13.3	15.8	3	1.389244
Metacarpal 3	12.7	6.0	12.0	13.5	3	0.763763
Metacarpal 4	9.7	6.4	9.2	10.4	3	0.6245
Metacarpal 5	14.3	6.9	13.7	15.4	3	0.981495
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	36.0	8.1	33.9	38.0	2	2.899138
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.0	5.2	23.8	27.2	8	1.310875
Tibia Dd	19.1	7.4	17.5	21.5	7	1.417577
Astragalus GLl	26.9	4.1	25.5	28.0	5	1.098636
Astragalus GLm	26.0	4.1	24.2	27.0	5	1.067708
Astragalus Bd	17.9	3.1	17.4	18.7	5	0.563028
Astragalus Dl	15.6	3.0	14.9	16.2	5	0.465833
Calcaneum GL	51.4	8.1	48.4	54.3	2	4.17193
Calcaneum GB	17.1	12.9	15.4	19.6	3	2.211334
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	23.2	4.0	22.5	23.8	2	0.919239
Metatarsal a	11.2	3.8	10.9	11.5	2	0.424264
Metatarsal b	10.0	4.2	9.7	10.3	2	0.424264
Metatarsal 1	9.8	1.4	9.7	9.9	2	0.141421
Metatarsal 2	15.4	4.6	14.9	15.9	2	0.707107
Metatarsal 3	13.2	5.9	12.6	13.7	2	0.777817
Metatarsal 4	9.0	0.8	8.9	9.0	2	0.070711
Metatarsal 5	14.5	3.4	14.1	14.8	2	0.494975

14^{th}-15^{th} century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	-	-	-	-	0	-
M_1 W	7.7	0.0	7.7	7.7	1	0
M_2 W	8.1	0.0	8.1	8.1	1	0
M_3 L	19.0	0.7	18.9	19.1	2	0.141421
M_3 W	7.2	10.9	6.6	7.7	2	0.777817
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus Bd	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius Bp	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 1	-	-	-	-	0	-
Metacarpal 2	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Metacarpal 4	-	-	-	-	0	-
Metacarpal 5	-	-	-	-	0	-
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	-	-	-	-	0	-
Astragalus Dl	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-

15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	6.1	5.8	6.9	7	0.387298
M_1 W	7.1	9.3	5.9	8.2	17	0.659657
M_2 W	8.0	6.6	6.9	8.7	13	0.529998
M_3 L	21.0	6.3	18.5	23.1	25	1.333229
M_3 W	8.2	7.3	7.2	9.3	25	0.59769
Scapula GLP	29.2	8.7	27.4	31.0	2	2.545584
Scapula SLC	17.3	8.0	15.7	18.2	3	1.389244
Humerus GLC	-	-	-	-	0	-
Humerus BT	27.1	8.9	24.0	30.0	8	2.400000
Humerus Bd	28.5	10.9	24.4	33.1	8	3.118808
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.9	8.7	12.1	16.1	8	1.20594
Radius GL	137.6	0.0	137.6	137.6	1	0
Radius Bp	29.1	5.5	26.6	31.0	7	1.613337
Radius SD	15.1	0.0	15.1	15.1	1	0
Radius Bd	29.1	10.5	26.9	31.2	2	3.040559
Metacarpal GL	111.5	1.7	110.1	112.8	2	1.909188
Metacarpal SD	13.2	4.3	12.8	13.6	2	0.565685
Metacarpal Bd	24.7	7.2	23.4	25.9	2	1.767767
Metacarpal a	11.6	6.7	11.0	12.1	2	0.777817
Metacarpal b	11.3	9.4	10.5	12.0	2	1.06066
Metacarpal 1	11.0	7.1	10.4	11.5	2	0.777817
Metacarpal 2	15.9	3.1	15.5	16.2	2	0.494975
Metacarpal 3	13.7	2.1	13.5	13.9	2	0.282843
Metacarpal 4	9.8	10.1	9.1	10.5	2	0.989949
Metacarpal 5	15.4	5.1	14.8	15.9	2	0.777817
Pelvis LA	27.4	2.4	26.6	27.8	3	0.665833
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	0.000000
Femur Bd	33.8	1.9	33.3	34.2	2	0.636396
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.4	6.3	23.1	26.9	7	1.602528
Tibia Dd	19.5	4.0	18.4	20.7	7	0.786796
Astragalus GLl	26.4	3.6	25.1	27.3	4	0.956992
Astragalus GLm	25.3	2.6	24.4	25.9	4	0.648074
Astragalus Bd	17.7	3.8	16.8	18.4	4	0.675771
Astragalus Dl	15	3.0	14.7	15.7	4	0.457347
Calcaneum GL	55.4	6.3	50.5	59.8	5	3.472319
Calcaneum GB	18.0	7.8	15.8	19.4	5	1.397498
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-

16th-17th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	8.0	5.5	6.9	8	0.502671
M_1 W	7.3	6.1	6.8	8.0	8	0.448609
M_2 W	7.8	8.6	6.7	8.9	8	0.673875
M_3 L	20.8	6.1	18.6	24.0	30	1.258758
M_3 W	7.9	6.8	6.8	9.1	31	0.538477
Scapula GLP	30.2	7.6	27.6	33.0	5	2.293905
Scapula SLC	18.4	9.8	15.7	20.7	7	1.801719
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.0	4.9	25.5	30.3	16	1.372832
Humerus Bd	30.2	6.3	27.8	34.2	15	1.900551
Humerus SD	-	-	-	-	0	-
Humerus HTC	14.0	5.6	12.7	15.4	15	0.789816
Radius GL	138.3	0.0	138.3	138.3	1	0
Radius Bp	28.6	9.4	24.4	31.6	5	2.685517
Radius SD	16.1	0.0	16.1	16.1	1	0
Radius Bd	29.0	2.9	28.4	29.6	2	0.848528
Metacarpal GL	104.5	10.1	94.3	113.8	4	10.54467
Metacarpal SD	13.1	8.1	12.3	13.8	2	1.06066
Metacarpal Bd	23.8	5.4	22.9	25.3	3	1.28582
Metacarpal a	10.9	6.5	10.3	11.7	3	0.70946
Metacarpal b	10.3	9.4	9.2	11.1	3	0.971253
Metacarpal 1	10.2	11.9	8.9	11.3	3	1.212436
Metacarpal 2	15.8	5.8	15.1	16.4	2	0.919239
Metacarpal 3	12.8	11.8	11.1	13.8	3	1.504438
Metacarpal 4	9.7	11.9	9.8	10.8	3	1.153256
Metacarpal 5	15.3	1.4	15.1	15.4	2	0.212132
Pelvis LA	28.2	5.8	27.0	29.3	2	1.626346
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	19.4	9.7	17.0	21.6	4	1.88326
Femur Bd	36.1	0.0	36.1	36.1	1	0
Tibia GL	207.5	0.0	207.5	207.5	1	0
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.9	6.8	23.2	28.8	20	1.752322
Tibia Dd	19.9	6.4	17.3	22.2	20	1.276044
Astragalus GLl	27.5	5.4	25.6	29.4	6	1.481103
Astragalus GLm	25.9	6.0	23.9	27.6	6	1.542725
Astragalus Bd	18.0	6.0	16.6	19.4	8	1.078027
Astragalus Dl	16.0	6.7	14.3	17.2	6	1.07827
Calcaneum GL	52.5	3.3	50.6	54.0	3	1.724336
Calcaneum GB	16.9	11.6	15.7	19.2	3	1.965536
Metatarsal GL	129.5	4.6	122.7	133.1	3	5.892368
Metatarsal SD	11.9	2.2	11.6	12.1	3	0.264575
Metatarsal Bd	24.0	1.9	23.5	24.6	4	0.454606
Metatarsal a	11.3	2.6	11.0	11.5	3	0.288675
Metatarsal b	10.5	2.9	10.2	10.8	3	0.300000
Metatarsal 1	10.2	6.0	9.8	10.9	3	0.608276
Metatarsal 2	15.5	5.2	14.8	16.4	3	0.808290
Metatarsal 3	13.0	4.4	12.4	13.5	3	0.568624
Metatarsal 4	9.3	4.8	8.8	9.7	3	0.450925
Metatarsal 5	14.7	4.0	14.0	15.1	3	0.585947

17th-18th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	5.3	5.5	6.8	16	0.331097
M_1 W	7.0	6.1	6.4	8.1	23	0.428528
M_2 W	7.8	6.1	7.0	8.6	21	0.478440
M_3 L	20.8	7.2	17.5	24.2	39	1.500558
M_3 W	8.0	8.1	6.9	9.5	40	0.647079
Scapula GLP	32.1	7.4	28.0	35.2	11	2.371689
Scapula SLC	20.3	5.8	18.2	21.8	12	1.175765
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.8	6.7	25.5	32.4	20	1.929003
Humerus Bd	30.2	5.9	27.1	33.2	16	1.788563
Humerus SD	-	-	-	-	0	-
Humerus HTC	14.8	7.5	13.2	17.0	20	1.116326
Radius GL	136.8	13.8	121.9	158	3	18.85656
Radius Bp	31.2	8.9	24.8	35.6	21	2.764167
Radius SD	16.2	0.0	16.2	16.2	1	0
Radius Bd	28.0	9.0	24.6	31.5	9	2.51098
Metacarpal GL	111.0	6.3	112.0	130.5	7	6.955299
Metacarpal SD	13.3	7.5	11.7	14.7	7	1.002378
Metacarpal Bd	24.6	4.1	23.2	26.0	9	1.011325
Metacarpal a	11.5	5.0	10.9	12.5	9	0.569600
Metacarpal b	11.1	7.1	10.0	12.2	9	0.792149
Metacarpal 1	10.9	4.7	10.1	11.5	9	0.512619
Metacarpal 2	15.4	4.7	14.3	16.6	8	0.718630
Metacarpal 3	13.4	5.5	12.3	14.7	9	0.742930
Metacarpal 4	10.5	10.1	8.9	11.9	9	1.06432
Metacarpal 5	15.5	7.8	13.6	17.0	8	1.210003
Pelvis LA	27.4	6.8	25.2	29.0	4	1.867262
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	19.3	18.7	16.1	23.2	3	3.601389
Femur Bd	34.9	1.8	34.4	35.3	2	0.636396
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	26.4	9.5	19.4	32.2	34	2.519443
Tibia Dd	20.4	12.9	15.4	29.6	32	2.621636
Astragalus GLl	29.4	10.2	24.3	37.3	26	3.002432
Astragalus GLm	27.6	9.8	23.9	34.9	24	2.715535
Astragalus Bd	19.7	11.5	16.6	26.8	26	2.260456
Astragalus Dl	16.9	10.8	14.2	21.1	26	1.820769
Calcaneum GL	55.3	8.3	49.5	61.6	8	4.616256
Calcaneum GB	18.8	12.7	14.0	22.4	15	2.38641
Metatarsal GL	126.1	4.4	122.1	130.0	2	5.586144
Metatarsal SD	12.2	9.9	11.3	13.0	2	1.202082
Metatarsal Bd	23.6	5.7	22.1	25.0	4	1.352467
Metatarsal a	11.3	8.1	10.6	12.6	4	0.920145
Metatarsal b	10.2	7	9.5	11.0	4	0.716473
Metatarsal 1	10.1	2.1	9.9	10.4	4	0.216025
Metatarsal 2	15.9	5.7	14.9	16.7	3	0.907377
Metatarsal 3	13.5	7.2	12.6	14.6	4	0.977667
Metatarsal 4	9.6	7.4	8.9	10.5	4	0.707107
Metatarsal 5	15.1	3.4	14.5	15.5	3	0.51316

18th-19th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	0.0	6.3	6.3	1	0
M_1 W	7.6	0.0	7.6	7.6	1	0
M_2 W	7.6	0.0	7.6	7.6	1	0
M_3 L	21.4	4.9	20.3	23.1	5	1.058301
M_3 W	8.1	4.4	7.8	8.7	5	0.353553
Scapula GLP	37.1	0.0	37.1	37.1	1	0
Scapula SLC	21.9	1.6	21.6	22.1	2	0.353553
Humerus GLC	130.9	0.0	130.9	130.9	1	0
Humerus BT	31.9	7.9	28.7	35.6	8	2.50813
Humerus Bd	32.9	6.4	29.1	35.3	7	2.097958
Humerus SD	19.1	0.0	19.1	19.1	1	0
Humerus HTC	15.8	4.7	14.5	16.6	7	0.745782
Radius GL	-	-	-	-	0	-
Radius Bp	32.8	5.2	31.0	34.4	3	1.708801
Radius SD	-	-	-	-	0	-
Radius Bd	30.4	0.0	30.4	30.4	1	0.00000
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	23.6	0.0	23.6	23.6	1	0
Metacarpal a	11.0	0.0	11.0	11.0	1	0
Metacarpal b	10.6	0.0	10.6	10.6	1	0
Metacarpal 1	10.2	0.0	10.2	10.2	1	0
Metacarpal 2	14.6	0.0	14.6	14.6	1	0
Metacarpal 3	12.7	0.0	12.7	12.7	1	0
Metacarpal 4	9.3	0.0	9.3	9.3	1	0
Metacarpal 5	13.9	0.0	13.9	13.9	1	0
Pelvis LA	28.5	0.0	28.5	28.5	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.0	0.0	18.0	18.0	1	0
Femur Bd	36.6	0.0	36.6	36.6	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	28.7	12.2	24.8	32.8	4	3.492373
Tibia Dd	22.2	10.1	20.1	25.3	4	2.252961
Astragalus GLl	32.2	12.4	27.9	35.8	3	3.996248
Astragalus GLm	30.4	10.6	27.0	33.4	3	3.22542
Astragalus Bd	22.2	11.6	19.5	24.6	3	2.569695
Astragalus Dl	18.7	6.4	16.6	20.6	3	1.202082
Calcaneum GL	61.9	3.5	60.3	63.4	2	2.192031
Calcaneum GB	19.9	6.4	19.0	20.8	2	1.272792
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	22.6	0.0	22.6	22.6	1	0
Metatarsal a	10.2	0.0	10.2	10.2	1	0
Metatarsal b	9.4	0.0	9.4	9.4	1	0
Metatarsal 1	9.5	0.0	9.5	9.5	1	0
Metatarsal 2	13.9	0.0	13.9	13.9	1	0
Metatarsal 3	12.6	0.0	12.6	12.6	1	0
Metatarsal 4	9.0	0.0	9.0	9.0	1	0
Metatarsal 5	13.3	0.0	13.3	13.3	1	0

EM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.2	4.8	5.5	6.8	42	0.296994
M_1 W	7.0	8.8	5.5	8.4	38	0.619371
M_2 W	7.6	7.2	6.7	9.0	29	0.54806
M_3 L	20.5	7.9	17.2	23.6	68	1.619554
M_3 W	7.8	8.1	6.4	9.2	75	0.631766
Scapula GLP	28.6	12.9	24.0	33.4	6	3.699955
Scapula SLC	18.4	13.6	14.7	21.4	8	2.511367
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.1	10.8	24.6	37.1	22	3.046878
Humerus Bd	29.5	10.5	25.7	37.1	23	3.105045
Humerus SD	-	-	-	-	0	-
Humerus HTC	14.1	10.2	11.3	17.8	30	1.441539
Radius GL	134.5	6.3	128.5	140.4	2	8.414571
Radius Bp	30.6	8.5	27.6	36.3	17	2.607469
Radius SD	15.6	1.4	15.4	15.7	2	0.212132
Radius Bd	27.1	7.0	23.2	29.4	9	1.90970
Metacarpal GL	113.1	5.8	105.7	120.5	6	6.569221
Metacarpal SD	11.8	5.5	11.0	12.7	5	0.653452
Metacarpal Bd	22.9	8.1	20.7	27.2	10	1.866339
Metacarpal a	10.6	8.3	9.7	12.6	11	0.882455
Metacarpal b	10.2	9.0	8.9	12.4	10	0.917484
Metacarpal 1	10.1	6.0	8.8	10.8	11	0.607977
Metacarpal 2	14.2	6.0	12.7	15.6	10	0.853490
Metacarpal 3	12.3	3.7	11.6	13.1	11	0.451261
Metacarpal 4	9.3	5.6	8.7	10.4	9	0.522015
Metacarpal 5	14.0	5.9	12.6	15.6	9	0.829156
Pelvis LA	25.6	6.5	23.7	28.8	9	1.668832
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.8	3.9	17.9	19.6	6	0.725029
Femur Bd	32.1	8.0	28.6	34.6	5	2.565151
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.6	4.8	23.5	28.5	31	1.224841
Tibia Dd	19.7	6.0	17.6	22.8	32	1.177956
Astragalus GLl	27.0	6.1	24.6	31.2	27	1.648992
Astragalus GLm	25.7	7.4	20.2	29.5	25	1.896901
Astragalus Bd	17.9	7.9	15.5	21.5	26	1.419556
Astragalus Dl	15.7	6.8	14.3	18.0	27	1.065357
Calcaneum GL	54.8	4.3	52.2	59.6	8	2.338956
Calcaneum GB	17.9	8.2	15.8	19.6	8	1.463301
Metatarsal GL	129.2	7.9	117.9	153.0	10	10.25632
Metatarsal SD	11.4	19.9	9.5	17.1	9	2.26740
Metatarsal Bd	22.8	12.2	20.3	31.1	14	2.783241
Metatarsal a	10.7	12.0	8.9	14.1	14	1.282083
Metatarsal b	9.8	12.0	8.8	13.2	14	1.171362
Metatarsal 1	10.2	12.7	8.4	13.7	14	1.300127
Metatarsal 2	15.7	11.1	13.7	20.9	14	1.740658
Metatarsal 3	13.1	9.5	11.9	16.9	14	1.245056
Metatarsal 4	9.6	12.6	8.4	13.3	14	1.205596
Metatarsal 5	14.8	10.8	13.0	19.7	14	1.598299

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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.4	6.8	5.3	8.1	86	0.432846
M_1 W	7.2	7.9	5.5	8.2	109	0.568511
M_2 W	7.8	7.3	6.1	8.9	98	0.569134
M_3 L	20.7	6.2	17.0	24.4	263	1.28071
M_3 W	8.0	7.1	6.3	9.7	279	0.571075
Scapula GLP	30.0	7.9	25.0	33.8	15	2.375129
Scapula SLC	18.5	10.2	14.0	22.5	21	1.877917
Humerus GLC	-	-	-	-	0	-
Humerus BT	27.5	8.3	22.2	34.3	93	2.280302
Humerus Bd	29.0	8.6	23.9	37.5	86	2.492879
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.9	8.2	11.1	17.8	94	1.133955
Radius GL	138.6	1.0	137.6	140.2	3	1.422439
Radius Bp	30.1	6.9	26.0	34.5	43	2.087091
Radius SD	14.2	11.8	12.3	15.3	3	1.677299
Radius Bd	27.5	5.6	25.8	31.2	12	1.553491
Metacarpal GL	114.7	6.3	106.4	130.0	13	7.229516
Metacarpal SD	13.5	9.9	11.7	16.0	13	1.33282
Metacarpal Bd	24.5	7.2	22.0	28.6	23	1.774301
Metacarpal a	11.5	6.4	10.3	13.1	25	0.736388
Metacarpal b	11.0	8.0	9.5	12.8	23	0.875061
Metacarpal 1	10.7	5.7	9.8	11.7	25	0.608495
Metacarpal 2	15.2	7.4	13.2	16.9	25	1.126307
Metacarpal 3	13.2	5.8	11.5	14.5	25	0.770022
Metacarpal 4	10.0	7.3	8.7	11.4	23	0.734632
Metacarpal 5	14.8	7.2	12.8	16.7	23	1.066393
Pelvis LA	26.9	7.2	24.2	30.7	14	1.945183
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.8	7.3	17.4	22.0	12	1.37367
Femur Bd	34.2	10.3	27.6	40.1	14	3.518835
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.3	7.1	19.9	30.2	111	1.797313
Tibia Dd	19.4	7.3	16.5	24.5	109	1.418291
Astragalus GLl	27.0	5.6	24.1	31.6	56	1.509778
Astragalus GLm	25.7	6.0	20.9	29.5	55	1.531637
Astragalus Bd	17.5	8.6	10.7	20.3	58	1.497714
Astragalus Dl	15.4	7.1	13.6	18.8	57	1.087713
Calcaneum GL	54.7	7.4	44.7	63.4	29	4.020459
Calcaneum GB	17.9	8.0	14.6	20.2	30	1.43036
Metatarsal GL	123.6	11.4	100.1	140.2	7	14.10424
Metatarsal SD	11.8	14.6	9.9	13.8	7	1.719358
Metatarsal Bd	23.3	8.3	20.4	27.2	17	1.930388
Metatarsal a	11.1	5.3	10.0	12.1	18	0.592105
Metatarsal b	10.2	8.0	8.8	11.6	19	0.813806
Metatarsal 1	10.0	6.2	8.5	11.0	21	0.624424
Metatarsal 2	15.1	7.5	12.8	16.8	21	1.136934
Metatarsal 3	13.0	5.9	11.0	14.1	21	0.770467
Metatarsal 4	9.2	8.0	7.0	10.4	19	0.736556
Metatarsal 5	14.5	8.0	12.3	16.8	18	1.153001

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PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	5.7	5.5	6.9	43	0.356167
M_1 W	7.0	7.2	5.7	8.1	39	0.504795
M_2 W	7.8	7.1	6.7	9.0	36	0.551420
M_3 L	20.9	7.0	17.5	24.3	111	1.455575
M_3 W	7.9	7.6	6.7	9.5	116	0.603409
Scapula GLP	31.6	8.4	27.6	37.1	19	2.650587
Scapula SLC	19.8	8.2	15.7	22.1	25	1.627196
Humerus GLC	138.8	8.0	130.9	146.6	2	11.10158
Humerus BT	28.9	8.4	23.7	35.6	65	2.418193
Humerus Bd	30.9	9.0	24.9	40.8	55	2.790275
Humerus SD	19.7	4.3	19.1	20.3	2	0.848528
Humerus HTC	14.7	8.9	11.4	17.7	62	1.305657
Radius GL	140.7	11.1	121.9	158.0	5	15.54841
Radius Bp	30.6	10.9	19.3	35.9	43	3.333441
Radius SD	16.2	0.4	16.1	16.2	2	0.070711
Radius Bd	-	-		-	0	-
Metacarpal GL	120.1	5.5	112.0	130.5	10	6.644371
Metacarpal SD	13.5	9.6	11.7	16.2	10	1.297904
Metacarpal Bd	24.6	7.3	22.7	29.8	15	1.791036
Metacarpal a	11.5	11.3	10.3	13.9	15	0.924945
Metacarpal b	10.9	8.4	9.2	12.4	15	0.918436
Metacarpal 1	10.7	9.5	8.9	12.9	15	1.011976
Metacarpal 2	15.6	6.0	14.3	17.6	12	0.941429
Metacarpal 3	13.2	9.8	10.1	15.2	15	1.298827
Metacarpal 4	10.3	10.7	8.5	11.9	15	1.102724
Metacarpal 5	15.3	7.3	13.6	17.0	13	1.119066
Pelvis LA	27.3	6.0	25.2	29.3	9	1.640122
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	20.0	13.3	16.1	23.2	10	2.666021
Femur Bd	35.6	2.7	34.4	36.6	4	0.962635
Tibia GL	207.5	0.0	207.5	207.5	1	0
Tibia SD	-	-	-	-	0	-
Tibia Bd	26.4	9.9	19.4	34.3	74	2.622824
Tibia Dd	20.3	11.6	15.4	26.6	72	2.347178
Astragalus GLl	29.0	11.1	22.6	37.3	41	3.231701
Astragalus GLm	27.2	10.2	22.4	34.9	39	2.784212
Astragalus Bd	19.3	12.3	14.4	26.8	44	2.373714
Astragalus Dl	16.8	11.5	13.6	21.1	42	1.931288
Calcaneum GL	55.0	9.4	46.3	63.4	14	5.184958
Calcaneum GB	18.3	13.2	20.8	14.0	22	2.423443
Metatarsal GL	130.0	5.1	122.1	139.5	6	6.676052
Metatarsal SD	12.0	5.4	11.3	13.0	5	0.644205
Metatarsal Bd	23.7	4.1	22.1	25.0	9	0.982486
Metatarsal a	11.2	6.6	10.2	12.6	8	0.736304
Metatarsal b	10.4	8.4	9.4	12.2	9	0.876071
Metatarsal 1	10.1	4.2	9.5	10.9	8	0.424054
Metatarsal 2	15.4	6.4	13.9	16.7	7	0.991392
Metatarsal 3	13.2	6.0	12.4	14.6	8	0.790569
Metatarsal 4	9.7	9.9	8.8	11.8	9	0.961769
Metatarsal 5	15.0	8.8	13.3	17.8	8	1.324427
					1209	

Appendix 20: *Wharram Percy cattle metric overview:*

V = coefficient of variation

10th-13th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	10.4	0.0	10.4	10.4	1	0
M_1 W	14.5	0.0	14.5	14.5	1	0
M_2 W	14.5	8.8	13.6	15.4	2	1.272792
M_3 L	34.5	3.6	33.5	36.2	4	1.250333
M_3 W	13.3	7.6	12.0	14.2	4	1.004573
Scapula GLP	71.7	0.0	71.7	71.7	1	0
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	73.1	11.1	67.3	78.8	2	8.131728
Humerus SD	-	-	-	-	0	-
Humerus HTC	33.1	10.2	29.2	35.5	3	3.38575
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal BatF	-	-	-	-	0	-
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Pelvis LA	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	44.6	13.6	40.3	48.9	2	6.081118
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	59.6	7.5	56.4	62.7	2	4.454773
Astragalus GLm	57.3	8.1	51.1	63.8	5	4.651881
Astragalus Bd	40.3	11.4	33.7	43.6	4	4.598913
Astragalus Dl	34.9	8.4	31.9	37.8	4	2.933144
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	218.5	0.0	218.5	218.5	1	0.0
Metatarsal SD	27.1	0.0	27.1	27.1	1	0.0
Metatarsal Bd	53.1	9.5	49.5	56.6	2	5.020458
Metatarsal BatF	50.1	10.3	46.4	53.7	2	5.16188
Metatarsal a	25.9	7.1	24.6	27.2	2	1.838478
Metatarsal b	23.9	12.1	21.8	25.9	2	2.899138
Metatarsal 3	25.5	0.0	25.5	25.5	1	0

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13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	-	-	-	-	0	-
M_1 W	12.7	0.0	12.7	12.7	1	0
M_2 W	-	-	-	-	0	-
M_3 L	33.4	0.0	33.4	33.4	1	0
M_3 W	12.5	0.0	12.5	12.5	1	0
Scapula GLP	63.1	0.0	63.1	63.1	1	0
Scapula SLC	48.3	0.0	48.3	48.3	1	0
Humerus GLC	-	-	-	-	0	-
Humerus BT	63.5	0.0	63.5	63.5	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	33.3	5.1	32.1	34.5	2	1.69706
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	177.5	0.0	177.5	177.5	1	0
Metacarpal SD	27.6	0.0	27.6	27.6	1	0
Metacarpal Bd	54.3	7.0	50.8	58.4	3	3.827967
Metacarpal BatF	49.3	5.6	46.2	51.4	3	2.740438
Metacarpal a	26.4	8.4	24.7	28.9	3	2.230097
Metacarpal b	24.4	4.4	23.2	25.2	3	1.078579
Metacarpal 3	25.7	2.2	25.3	26.1	2	0.565685
Pelvis LA	62.7	0.0	62.7	62.7	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	58.9	0.0	58.9	58.9	1	0
Astragalus GLm	-	-	-	-	0	-
Astragalus Bd	37.3	0.0	37.3	37.3	1	0
Astragalus Dl	28.9	0.0	28.9	28.9	1	0
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	35.5	0.0	35.5	35.5	1	0
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal BatF	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-

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14th-15th century:

No measurements recorded

15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.1	5.6	10.4	11.6	3	0.6245
M_1 W	13.8	0.5	13.7	13.8	2	0.070711
M_2 W	15.3	11.5	13.9	17.8	4	1.753093
M_3 L	34.7	7.1	31.3	37.8	8	2.452404
M_3 W	14.6	11.0	12.0	16.1	8	1.60796
Scapula GLP	65.6	11.5	60.2	70.9	2	7.566043
Scapula SLC	53.8	19.3	46.4	61.1	2	10.39447
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	52.8	0.0	52.8	52.8	1	0.00000
Metacarpal GL	-	-	-	-	-	-
Metacarpal SD	-	-	-	-	-	-
Metacarpal Bd	57.3	0.0	57.3	57.3	1	0
Metacarpal BatF	52.5	0.0	52.5	52.5	1	0
Metacarpal a	27.9	0.0	27.9	27.9	1	0
Metacarpal b	26.3	0.0	26.3	26.3	1	0
Metacarpal 3	26.7	0.0	26.7	26.7	1	0
Pelvis LA	65.2	6.5	59.9	70.2	4	4.250882
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	57.2	15.7	47.0	64.0	3	8.995554
Tibia Dd	43.9	16.0	35.9	49.2	3	7.030173
Astragalus GLl	60.6	7.2	54.3	66.3	8	4.356604
Astragalus GLm	55.0	7.4	50.5	60.7	7	4.043278
Astragalus Bd	39.2	8.9	36.0	43.7	7	3.472957
Astragalus Dl	34.2	13.2	28.9	40.2	6	4.518149
Calcaneum GL	122.1	0.0	122.1	122.1	1	0
Calcaneum GB	38.3	12.5	32.1	43.8	4	4.802343
Metatarsal GL	201.0	0.0	201.0	201.0	1	0
Metatarsal SD	23.6	0.0	23.6	23.6	1	0
Metatarsal Bd	46.3	0.0	46.3	46.3	1	0
Metatarsal BatF	46.6	0.0	46.6	46.6	1	0
Metatarsal a	21.9	0.0	21.9	21.9	1	0
Metatarsal b	21.2	0.0	21.2	21.2	1	0
Metatarsal 3	25.6	0.0	25.6	25.6	1	0

16th-17th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	10.4	8.5	9.7	12.0	7	0.878852
M_1 W	-	-	-	-	0	-
M_2 W	-	-	-	-	0	-
M_3 L	34.5	1.2	34.1	34.9	3	0.416333
M_3 W	14.6	9.8	13.0	15.7	3	1.436431
Scapula GLP	61.8	5.5	58.5	65.3	3	3.40196
Scapula SLC	46.9	10.9	42.5	54.1	4	5.1329
Humerus GLC	-	-	-	-	0	-
Humerus BT	64.3	0.0	64.3	64.3	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.5	0.0	32.5	32.5	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	71.8	15.0	64.2	79.4	2	10.748023
Metacarpal GL	178.0	0.0	178.0	178.0	1	0
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	53.1	0.0	53.1	53.1	1	0
Metacarpal BatF	49.4	0.0	49.4	49.4	1	0
Metacarpal a	25.5	0.0	25.5	25.5	1	0
Metacarpal b	24.9	0.0	24.9	24.9	1	0
Metacarpal 3	26.8	0.0	26.8	26.8	1	0
Pelvis LA	57.7	8.5	54.2	61.1	2	4.879037
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	44.0	14.8	39.4	48.6	2	6.505382
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	60.2	5.8	54.9	64.1	5	3.496713
Tibia Dd	45.2	7.3	39.8	48.6	5	3.298788
Astragalus GLl	61.6	4.2	58.2	64.0	6	2.565151
Astragalus GLm	55.9	3.8	53.3	58.2	6	2.146315
Astragalus Bd	40.3	3.3	38.4	42.3	6	1.331791
Astragalus Dl	34.9	4.6	32.6	37.0	6	1.619465
Calcaneum GL	125.7	0.0	125.7	125.7	1	0
Calcaneum GB	33.4	0.0	33.4	33.4	1	0
Metatarsal GL	217.0	11.5	188.5	235.5	3	25.04496
Metatarsal SD	25.3	14.9	21.2	28.6	3	3.764306
Metatarsal Bd	52.4	8.6	46.9	57.8	4	4.532108
Metatarsal BatF	49.7	7.8	44.4	53.7	4	3.865553
Metatarsal a	25.5	10.0	22.1	28.8	5	2.554799
Metatarsal b	23.9	8.5	21.4	26.0	4	2.029778
Metatarsal 3	26.6	8.6	23.7	29.8	5	2.277499

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17th-18th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.0	10.8	9.7	12.8	11	1.188353
M_1 W	14.2	12.2	12.7	16.1	3	1.734935
M_2 W	12.4	14.8	11.1	14.5	3	1.835756
M_3 L	33.9	4.1	30.9	35.2	9	1.376388
M_3 W	13.1	11.4	11.6	15.1	9	1.498332
Scapula GLP	74.5	22.4	70.3	92.9	3	16.65843
Scapula SLC	52.5	13.4	46.1	60.0	3	7.014984
Humerus GLC	222.0	0.0	222.0	222.0	1	0
Humerus BT	71.6	10.2	63.3	81.3	9	7.291738
Humerus SD	29.3	0.0	29.3	29.3	1	0
Humerus HTC	33.0	14.0	27.7	39.6	10	4.607000
Radius GL	244.5	0.3	244.0	245.0	2	0.707107
Radius SD	33.9	1.0	33.6	34.1	2	0.353553
Radius Bd	61.3	0.1	61.2	61.3	2	0.07071
Metacarpal GL	178.8	4.5	173.5	188.0	3	7.973916
Metacarpal SD	29.8	14.0	26.5	34.5	3	4.163332
Metacarpal Bd	54.6	7.7	51.2	61.9	5	4.225873
Metacarpal BatF	50.1	9.2	46.3	57.8	5	4.590969
Metacarpal a	26.2	7.8	24.4	29.6	5	2.04817
Metacarpal b	25.7	8.1	23.8	29.2	5	2.082547
Metacarpal 3	26.1	7.2	24.6	29.0	5	1.876966
Pelvis LA	78.4	12.0	71.7	85.0	2	9.40452
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	47.4	16.3	40.3	58.2	6	7.718225
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	58.4	8.7	51.6	64.5	6	5.091431
Tibia Dd	44.7	7.7	40.3	49.8	6	3.442092
Astragalus GLl	60.0	5.0	55.7	65.4	9	2.985567
Astragalus GLm	55.6	4.9	52.4	60.4	9	2.725273
Astragalus Bd	39.2	7.7	35	44.3	11	3.018037
Astragalus Dl	35.1	7.1	32.9	39.6	9	2.496219
Calcaneum GL	129.9	10.3	114.4	145.5	4	13.33701
Calcaneum GB	42.0	14.0	35.2	49.3	4	5.883876
Metatarsal GL	213.5	7.9	201.5	225.5	2	17.0
Metatarsal SD	23.8	11.3	21.9	25.7	2	2.7
Metatarsal Bd	50.4	5.0	48.1	53.1	3	2.516611
Metatarsal BatF	50.1	7.2	46.0	54.8	4	3.610171
Metatarsal a	24.9	5.5	23.4	26.0	3	1.361372
Metatarsal b	22.9	6.5	21.9	24.6	3	1.479865
Metatarsal 3	25.8	3.1	25.0	26.6	3	0.802081

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18th-19th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	12.3	0.0	12.3	12.3	2	0
M_1 W	12.9	13.2	11.7	14.1	2	1.697056
M_2 W	-	-	-	-	0	-
M_3 L	38.7	6.0	37.0	40.3	2	2.333452
M_3 W	14.0	15.2	12.5	15.5	2	2.12132
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	74.4	0.0	74.4	74.4	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	30.3	0.0	30.3	30.3	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	181.5	0.0	181.5	181.5	1	0
Metacarpal SD	27.4	0.0	27.4	27.4	1	0
Metacarpal Bd	61.5	28.9	51.0	82.0	3	17.75528
Metacarpal BatF	59.5	33.9	47.7	82.8	3	20.17895
Metacarpal a	29.9	30.3	24.3	40.4	3	9.073221
Metacarpal b	28.2	28.7	23.4	37.5	3	8.083522
Metacarpal 3	29.9	21.4	25.8	37.3	3	6.395571
Pelvis LA	85.1	33.2	65.1	105.0	2	28.21356
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	53.1	0.0	53.1	53.1	1	0
Tibia Dd	37.4	0.0	37.4	37.4	1	0
Astragalus GLl	65.3	7.5	61.8	68.7	2	4.879037
Astragalus GLm	61.9	0.0	61.9	61.9	1	0
Astragalus Bd	43.4	0.0	43.4	43.4	1	0
Astragalus Dl	36.9	10.3	34.2	39.6	2	3.818377
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal BatF	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-

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EM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.4	12.0	9.3	13.5	11	1.367546
M_1 W	14.2	11.3	13.9	16.1	4	1.611159
M_2 W	13.3	12.3	11.7	15.4	4	1.638088
M_3 L	33.9	5.3	29.3	36.6	20	1.806246
M_3 W	13.5	11.4	11.4	16.8	22	1.543181
Scapula GLP	66.6	9.2	59.3	71.7	5	6.137019
Scapula SLC	45.3	6.6	40.5	48.5	5	3.009153
Humerus GLC	-	-	-	-	0	-
Humerus BT	71.2	13.2	55.5	81.7	9	9.415428
Humerus SD	-	-	-	-	0	-
Humerus HTC	31.8	13.5	24.2	37.0	11	4.307773
Radius GL	111.5	0.0	111.5	111.5	1	0.000000
Radius SD	-	-	-	-	0	-
Radius Bd	65.8	5.9	61.8	70.0	4	3.902456
Metacarpal GL	195.5	11.9	179.0	212.0	2	23.334524
Metacarpal SD	31.9	7.3	30.2	33.5	2	2.333452
Metacarpal Bd	60.4	8.8	56.6	64.1	2	5.303301
Metacarpal BatF	55.1	10.8	50.9	59.3	2	5.939697
Metacarpal a	29.0	6.6	27.6	30.3	2	1.909188
Metacarpal b	28.2	9.0	26.4	30.0	2	2.545584
Metacarpal 3	29.1	12.4	26.5	31.6	2	3.606245
Pelvis LA	60.2	5.9	55.0	62.6	4	3.564992
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	42.8	9.4	39.6	48.9	5	4.009115
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	57.2	11.9	49.4	68.1	8	6.827204
Tibia Dd	43.6	14.2	0.0	0.0	8	6.189392
Astragalus GLl	64.5	13.2	56.3	81.0	12	8.524559
Astragalus GLm	60.3	11.2	51.1	73.9	16	6.768872
Astragalus Bd	41.7	11.0	33.7	49.3	14	4.580201
Astragalus Dl	37.4	11.3	31.9	48.0	14	4.224601
Calcaneum GL	130.0	16.9	114.4	145.5	2	21.991021
Calcaneum GB	45.0	16.4	0.0	0.0	4	7.371341
Metatarsal GL	218.5	0.0	218.5	218.5	1	0
Metatarsal SD	27.1	0.0	27.1	27.1	1	0
Metatarsal Bd	52.0	7.6	49.5	56.6	3	3.962743
Metatarsal BatF	48.9	8.5	46.4	53.7	3	4.158125
Metatarsal a	25.0	8.1	23.2	27.2	3	2.029778
Metatarsal b	23.3	9.6	21.8	25.9	3	2.236813
Metatarsal 3	26.0	2.7	25.5	26.5	2	0.707107

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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.8	8.8	10.1	13.7	24	1.043814
M_1 W	12.8	8.5	10.7	14.0	15	1.093487
M_2 W	13.5	12.7	11.4	17.8	20	1.720733
M_3 L	34.0	7.0	29.3	38.8	44	2.365247
M_3 W	13.8	13.5	10.9	18.4	47	1.867503
Scapula GLP	64.7	7.8	57.3	74.0	14	5.035784
Scapula SLC	49.8	9.2	45.1	61.1	13	4.572479
Humerus GLC	-	-	-	-	0	-
Humerus BT	71.3	7.6	63.5	82.8	13	5.441531
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.7	9.9	28.5	41.4	17	3.227125
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	63.7	9.3	52.8	72.2	10	5.94833
Metacarpal GL	187.6	11.2	172.2	242.0	10	21.03944
Metacarpal SD	28.9	5.0	27.4	31.9	8	1.446177
Metacarpal Bd	54.0	5.8	49.0	62.7	30	3.112481
Metacarpal BatF	50.2	6.5	45.2	57.9	20	3.259416
Metacarpal a	26.0	7.5	22.8	31.8	21	1.937168
Metacarpal b	24.7	5.7	22.6	28.6	19	1.405773
Metacarpal 3	26.3	6.5	23.9	30.2	20	1.699001
Pelvis LA	64.1	5.5	59.1	70.5	15	3.541146
Femur GL	377.0	0.0	377.0	377.0	1	0
Femur SD	39.9	0.0	39.9	39.9	1	0
Femur DC	43.1	15.5	36.0	60.6	16	6.663579
Femur Bd	89.7	13.0	75.9	105.1	5	11.65333
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	56.4	7.5	47.0	64.0	29	4.233167
Tibia Dd	41.3	10.2	34.2	49.2	30	4.231335
Astragalus GLl	60.7	5.7	54.3	68.9	44	3.453197
Astragalus GLm	55.7	5.7	50.5	63.1	43	3.165041
Astragalus Bd	39.2	7.4	33.7	45.8	46	2.893478
Astragalus Dl	34.8	9.6	28.9	48.7	46	3.339007
Calcaneum GL	121.0	8.7	106.1	133.1	4	10.51047
Calcaneum GB	38.0	10.0	32.1	46.9	24	3.782509
Metatarsal GL	205.5	1.7	201.0	210.0	5	3.427827
Metatarsal SD	24.8	3.6	24.1	23.6	5	0.903881
Metatarsal Bd	50.8	5.8	46.3	54.5	12	2.945297
Metatarsal BatF	47.8	6.6	40.3	52.8	14	3.16464
Metatarsal a	24.1	7.0	21.9	27.8	13	1.685724
Metatarsal b	23.0	5.1	21.2	25.0	12	1.167846
Metatarsal 3	25.5	6.5	21.7	28.4	13	1.655023
					722	

PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.3	10.4	9.7	13.4	29	1.17916
M_1 W	13.9	11.2	11.7	16.1	5	1.559487
M_2 W	13.2	16.9	11.1	15.7	4	2.229163
M_3 L	34.7	5.7	30.9	40.3	16	1.966119
M_3 W	13.5	10.9	11.6	15.7	17	1.476507
Scapula GLP	71.7	20.9	58.5	92.9	7	14.96512
Scapula SLC	52.3	19.7	42.5	73.4	8	10.27778
Humerus GLC	222.0	0.0	222.0	222.0	1	0
Humerus BT	72.1	9.0	63.3	81.3	14	6.514801
Humerus SD	29.3	0.0	29.3	29.3	1	0
Humerus HTC	32.5	11.1	27.7	39.6	17	3.600163
Radius GL	244.5	0.3	244.0	245.0	2	0.707107
Radius SD	33.9	1.0	33.6	34.1	2	0.353553
Radius Bd	66.6	10.8	61.2	79.4	6	7.16296
Metacarpal GL	168.0	14.8	113.8	188.0	7	24.84329
Metacarpal SD	28.9	11.1	26.5	34.5	5	3.220559
Metacarpal Bd	55.6	16.8	50.2	82.0	11	9.345675
Metacarpal BatF	53.4	21.1	46.0	82.8	12	11.27066
Metacarpal a	27.3	18.1	23.8	40.4	12	4.954421
Metacarpal b	26.5	17.1	23.2	37.5	12	4.519721
Metacarpal 3	28.3	14.7	24.6	37.3	11	4.164613
Pelvis LA	67.5	15.5	54.2	85.0	6	10.46418
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	46.9	14.5	39.4	58.2	9	6.792418
Femur Bd	93.5	17.4	82.0	105.0	2	16.26346
Tibia GL	375.8	0.3	375.0	376.5	2	1.06066
Tibia SD	43.4	1.1	43.0	43.7	2	0.494975
Tibia Bd	59.8	10.9	49.4	72.0	16	6.524617
Tibia Dd	44.8	12.3	32.8	53.9	16	5.51156
Astragalus GLl	61.6	5.6	55.7	69.1	22	3.431317
Astragalus GLm	56.3	4.9	52.2	62.1	26	2.736649
Astragalus Bd	39.8	6.4	35.0	44.3	24	2.557158
Astragalus Dl	35.5	6.8	32.2	40.9	24	2.422236
Calcaneum GL	129.0	9.1	114.4	145.5	5	11.70013
Calcaneum GB	40.9	23.1	29.8	60.2	9	9.435674
Metatarsal GL	203.1	9.2	142.8	235.5	7	18.62704
Metatarsal SD	24.7	11.2	21.2	28.6	6	2.768935
Metatarsal Bd	52.0	5.7	46.9	57.8	9	2.940724
Metatarsal BatF	51.0	9.9	44.4	62.7	11	5.061979
Metatarsal a	25.4	7.3	22.1	28.8	10	1.861302
Metatarsal b	23.6	6.6	21.4	26.0	9	1.562139
Metatarsal 3	26.8	6.7	23.7	29.8	9	1.805393
					423	

Appendix 21: *Wharram Percy pig metric overview:*

V = coefficient of variation

10^{th}-13^{th} century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	17.9	0.0	17.9	17.9	1	0
dP_4 WP	7.8	0.0	7.8	7.8	1	0
M_1 L	16.3	14.0	13.8	18.3	3	2.281082
M_1 WA	9.7	8.6	9.2	10.7	3	0.838650
M_1 WP	10.4	11.1	9.3	11.6	3	1.159023
M_2 L	20.5	20.7	17.5	23.5	2	4.242641
M_2 WA	12.5	16.5	11.0	13.9	2	2.05061
M_2 WP	13.3	17.0	11.7	14.9	2	2.262742
M_3 L	30.1	6.9	27.9	32.1	4	2.063977
M_3 WA	14.8	8.8	13.2	16.3	4	1.298717
M_3 WC	14.4	4.8	13.6	15.2	4	0.697615
M_3 WP	10.5	4.7	9.9	11.1	4	0.493288
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	35.0	0.0	35.0	35.0	1	0
Scapula SLC	22.5	0.0	22.5	22.5	1	0
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
					34	

13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.9	0.0	18.9	18.9	1	0
dP_4 WP	8.3	0.0	8.3	8.3	1	0
M_1 L	15.0	2.8	14.7	15.3	2	0.424264
M_1 WA	10.0	7.1	9.5	10.5	2	0.707107
M_1 WP	10.8	5.9	10.3	11.2	2	0.636396
M_2 L	18.3	5.4	17.6	19.0	2	0.989949
M_2 WA	12.3	13.8	11.1	13.5	2	1.697056
M_2 WP	12.5	9.7	11.6	13.3	2	1.202082
M_3 L	31.3	18.8	27.1	35.4	2	5.868986
M_3 WA	14.3	7.4	13.5	15.0	2	1.06066
M_3 WC	13.4	1.1	13.3	13.5	2	0.141421
M_3 WP	10.6	0.7	10.5	10.6	2	0.070711
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	36.8	0.0	36.8	36.8	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	39.6	5.1	39.3	39.9	2	0
Astragalus GLm	37.65	5.3	36.6	38.7	2	1.484924
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
					26	

14^{th}-15^{th} century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	-	-	-	-	0	-
dP_4 WP	-	-	-	-	0	-
M_1 L	-	-	-	-	0	-
M_1 WA	-	-	-	-	0	-
M_1 WP	-	-	-	-	0	-
M_2 L	-	-	-	-	0	-
M_2 WA	-	-	-	-	0	-
M_2 WP	-	-	-	-	0	-
M_3 L	29.8	0.0	29.8	29.8	1	0
M_3 WA	17.7	0.0	17.7	17.7	1	0
M_3 WC	15.4	0.0	15.4	15.4	1	0
M_3 WP	9.6	0.0	9.6	9.6	1	0
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-

4

15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	-	-	-	-	0	-
dP_4 WP	10.8	0.0	10.8	10.8	1	0
M_1 L	16.5	7.9	14.5	17.6	6	1.30499
M_1 WA	10.7	15.4	9.5	13.0	6	1.646107
M_1 WP	11.2	12.3	9.8	13.1	6	1.374651
M_2 L	20.4	7.8	16.9	21.7	7	1.600893
M_2 WA	12.8	11.6	11.6	15.3	7	1.485485
M_2 WP	13.5	9.1	12.2	15.3	7	1.230757
M_3 L	33.9	11.5	30.1	39.3	4	3.903417
M_3 WA	15.4	10.1	13.0	17.6	5	1.56301
M_3 WC	14.8	8.5	13.4	16.1	5	1.259762
M_3 WP	11.5	11.5	10.2	13.7	5	1.320227
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	28.4	0.0	28.4	28.4	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	15.9	0.0	15.9	15.9	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	35.3	12.2	32.2	38.3	2	4.313351
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	28.6	0.0	28.6	28.6	1	0
Tibia Dd	27.0	0.0	27.0	27.0	1	0
Astragalus GLl	41.3	0.0	41.3	41.3	1	0
Astragalus GLm	41.4	3.6	40.3	42.4	2	1.484924
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	25.3	0.0	25.3	25.3	1	0
Metatarsal GL	-	-	-	-	0	-

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<u>16th-17th century:</u>

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	19.1	0.4	19.0	19.1	2	0.070711
dP_4 WP	8.6	0.8	8.5	8.6	2	0.070711
M_1 L	15.2	15.2	13.8	17.9	3	2.311565
M_1 WA	11.2	24.6	8.5	14.0	3	2.753785
M_1 WP	11.8	15.6	10.5	13.9	3	1.835756
M_2 L	19.9	14.9	17.1	23.0	3	2.967041
M_2 WA	14.3	13.4	12.7	16.4	3	1.913984
M_2 WP	13.4	6.4	12.6	14.3	3	0.854400
M_3 L	30.4	8.1	27.5	34.0	5	2.457031
M_3 WA	15.7	9.4	13.9	17.3	5	1.479189
M_3 WC	14.0	2.6	13.5	14.4	5	0.357771
M_3 WP	11.0	9.9	9.2	11.8	5	1.087658
M^3L	30.5	0.0	30.5	30.5	1	0.000000
M^3WA	16.7	3.8	16.2	17.1	2	0.636396
M^3WC	13.4	2.6	13.1	13.6	2	0.353553
Scapula GLP	34.1	20.7	29.1	39.1	2	7.071068
Scapula SLC	22.1	17.9	19.3	24.9	2	3.959798
Humerus GLC	-	-	-	-	0	-
Humerus BT	31.5	13.9	26.5	34.4	3	4.373023
Humerus SD	-	-	-	-	0	-
Humerus HTC	20.2	0	18.5	22.1	3	1.814754
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	34.7	0.0	34.7	34.7	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	32.3	0.0	32.3	32.3	1	0
Tibia Dd	26.1	0.0	26.1	26.1	1	0
Astragalus GLl	36.6	17.3	29.3	40.3	3	6.322183
Astragalus GLm	33.8	19.7	26.3	39.0	3	6.655073
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-

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17^th^-18^th^ century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18	8.3	16.3	19.1	3	1.493318
dP_4 WP	8.3	9.4	7.2	8.9	4	0.778888
M_1 L	17.1	9.0	13.1	19.1	12	1.531686
M_1 WA	9.6	6.8	8.2	10.4	12	0.657590
M_1 WP	10.8	7.0	9.3	12.4	12	0.754532
M_2 L	21.5	7.3	18.6	24.3	9	1.578765
M_2 WA	12.8	5.4	11.7	14.2	9	0.693622
M_2 WP	13.1	7.0	11.5	14.6	9	0.913783
M_3 L	32.1	5.9	30.3	34.7	4	1.883923
M_3 WA	15.1	14.6	12.4	17.8	4	2.205108
M_3 WC	14.6	#DIV/0!	13.1	15.4	4	#DIV/0!
M_3 WP	11.1	7.5	10.2	12.1	4	0.828654
M^3L	31.9	0.0	31.9	31.9	1	0
M^3WA	16.9	14.7	15.1	18.6	2	2.474874
M^3WC	13.6	2.6	13.3	13.8	2	0.353553
Scapula GLP	37.7	8.5	34.2	40.5	3	3.207803
Scapula SLC	25.9	12.2	21.9	29.9	5	3.148333
Humerus GLC	-	-	-	-	0	-
Humerus BT	32.5	10.4	30.1	34.9	2	3.394113
Humerus SD	-	-	-	-	0	-
Humerus HTC	18.05	4.3	17.5	18.6	2	1
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	75.7	0.0	75.7	75.7	1	0
Pelvis LAR	27.6	17.7	24.1	31.0	2	4.879037
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	29.7	6.4	28.3	31.0	2	1.909188
Tibia SD	-	-	-	-	0	-
Tibia Bd	29.7	6.4	28.3	31.0	2	1.909188
Tibia Dd	24.2	19.0	20.9	27.4	2	4.596194
Astragalus GLl	45.0	0.0	45.0	45.0	1	0
Astragalus GLm	42.9	0.0	42.9	42.9	1	0
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	23.1	0.0	23.1	23.1	1	0
Metatarsal GL	-	-	-	-	0	-
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18th-19th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.2	0.0	18.2	18.2	1	0
dP_4 WP	9.2	0.0	9.2	9.2	1	0
M_1 L	18.0	0.0	18.0	18.0	1	0
M_1 WA	10.3	0.0	10.3	10.3	1	0.0
M_1 WP	12.5	0.0	12.5	12.5	1	0
M_2 L	23.1	0.0	23.1	23.1	1	0
M_2 WA	13.6	0.0	13.6	13.6	1	0
M_2 WP	14.0	0.0	14.0	14.0	1	0
M_3 L	31.8	3.8	30.9	32.6	2	1.202082
M_3 WA	18.0	1.2	17.8	18.1	2	0.212132
M_3 WC	14.5	0.0	14.5	14.5	2	0
M_3 WP	11.6	4.3	11.2	11.9	2	0.494975
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	26.6	0.0	26.6	26.6	1	0
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	22.8	0.0	22.8	22.8	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	31.2	0.0	31.2	31.2	1	0
Tibia Dd	29.9	0.0	29.9	29.9	1	0
Astragalus GLl	-	-	-	-	0	-
Astragalus GLm	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
					19	

EM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18	4.9	17.2	19.5	5	0.875785
dP_4 WP	8.2	5.3	7.8	8.9	5	0.432435
M_1 L	16.6	9.4	13.8	19.3	15	1.566464
M_1 WA	10.2	9.4	9.2	13.2	15	0.955186
M_1 WP	10.9	8.2	9.3	13.3	15	0.896554
M_2 L	20.0	8.3	17.5	23.5	10	1.653951
M_2 WA	12.7	12.8	11.0	16.5	10	1.627404
M_2 WP	12.7	9.6	11.2	14.9	10	1.222429
M_3 L	30.2	5.5	27.9	32.1	8	1.651352
M_3 WA	15.5	9.2	13.2	17.8	9	1.430035
M_3 WC	14.9	5.2	13.6	16.3	9	0.771362
M_3 WP	10.9	5.6	9.9	11.7	8	0.611643
M^3L	32.3	0.0	32.3	32.3	1	0
M^3WA	18.3	0.0	18.3	18.3	1	0
M^3WC	15.2	0.0	15.2	15.2	1	0
Scapula GLP	32.7	7.6	30.1	35.0	3	2.470493
Scapula SLC	23.1	4.3	22.3	24.5	4	0.994569
Humerus GLC	-	-	-	-	0	-
Humerus BT	31.7	5.6	29.1	34.0	8	1.764278
Humerus SD	-	-	-	-	0	-
Humerus HTC	18.7	5.5	16.6	19.9	8	1.032940
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	68.2	0.0	68.2	68.2	1	0
Pelvis LAR	28.6	17.7	24.1	34.1	3	5.064912
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	29.8	1.2	29.5	30.0	2	0.353553
Tibia Dd	26.4	0.0	26.4	26.4	2	0.000000
Astragalus GLl	40.0	6.6	35.9	43.0	5	2.639508
Astragalus GLm	37.1	5.7	34.1	39.7	5	2.105232
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
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LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.5	2.4	17.8	19.3	12	0.445856
dP_4 WP	8.7	7.9	7.9	10.8	13	0.685752
M_1 L	16.2	9.4	12.6	18.8	27	1.529045
M_1 WA	10.2	12.1	9.5	14.4	27	1.231681
M_1 WP	10.9	9.0	9.6	13.9	27	0.986071
M_2 L	20.2	7.2	16.5	23.4	28	1.450575
M_2 WA	12.8	11.6	9.9	16.3	30	1.488330
M_2 WP	13.2	8.1	11.4	15.4	31	1.070665
M_3 L	30.9	10.2	23.8	39.3	25	3.155165
M_3 WA	15.6	11.2	12.7	19.7	25	1.744812
M_3 WC	14.4	8.2	12.5	17.7	28	1.184171
M_3 WP	11.2	9.1	9.4	13.7	26	1.018634
M^3L	28.0	0.0	28.0	28.0	1	0
M^3WA	16.0	3.1	15.6	16.3	2	0.494975
M^3WC	16.1	0.0	16.1	16.1	1	0
Scapula GLP	32.4	9.6	28.8	37.1	7	3.112724
Scapula SLC	22.5	18.3	17.1	30.3	10	4.116957
Humerus GLC	-	-	-	-	0	-
Humerus BT	32.0	8.3	28.4	35.9	9	2.667396
Humerus SD	-	-	-	-	0	-
Humerus HTC	18.8	10.7	15.9	21.6	8	2.016185
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	77.8	0.0	77.8	77.8	1	0
Pelvis LAR	35.9	8.0	32.2	40.2	7	2.880807
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	20.7	0.0	20.2	21.2	2	0.707107
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	28.1	7.2	25.0	30.2	5	2.021633
Tibia Dd	25.3	6.7	22.7	27.0	5	1.697940
Astragalus GLl	41.1	11.0	36.6	48.6	5	4.505885
Astragalus GLm	40.4	7.3	36.6	44.1	5	2.959223
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	21.4	10.7	18.4	25.3	6	2.282688
Metatarsal GL	77.8	0.0	77.8	77.8	1	0.0
					374	

PM:

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.4	5.3	16.3	19.5	9	0.980363
dP_4 WP	8.6	7.6	7.2	9.7	10	0.653962
M_1 L	16.8	9.8	13.1	19.1	22	1.64722
M_1 WA	10.0	12.3	8.2	14.0	22	1.234041
M_1 WP	11.0	9.3	9.3	13.9	23	1.024444
M_2 L	21.3	8.6	20.2	24.3	17	1.829999
M_2 WA	13.1	8.7	11.5	16.4	18	1.134097
M_2 WP	13.3	6.5	11.5	14.6	17	0.866662
M_3 L	31.9	8.3	27.5	38.4	14	2.643341
M_3 WA	15.8	11.1	12.4	18.1	13	1.759043
M_3 WC	14.5	6.0	13.1	16.5	14	0.868117
M_3 WP	11.4	9.2	9.2	13.1	14	1.052992
M^3L	31.2	3.2	30.5	31.9	2	0.989949
M^3WA	16.8	8.8	15.1	18.6	4	1.479865
M^3WC	13.5	2.3	13.1	13.8	4	0.310913
Scapula GLP	37.4	13.5	29.1	43.3	6	5.048432
Scapula SLC	25.6	13.8	19.3	29.9	9	3.530227
Humerus GLC	-	-	-	-	0	-
Humerus BT	32.4	11.6	26.5	37.6	7	3.770878
Humerus SD	-	-	-	-	0	-
Humerus HTC	19.9	10.9	17.5	22.8	8	2.16527
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	75.7	0.0	75.7	75.7	1	0
Pelvis LAR	32.2	19.6	24.1	39.0	4	6.312422
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	30.7	5.5	28.3	32.3	4	1.699019
Tibia Dd	26.1	14.5	20.9	29.9	4	3.793306
Astragalus GLl	41.8	16.7	29.3	50.3	7	6.982836
Astragalus GLm	37.5	16.6	26.3	43.3	6	6.206368
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	22.1	6.4	21.1	23.1	2	1.414214
Metatarsal GL	-	-	-	-	0	-

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Appendix 22: *Wharram Percy horse metric overview:*

V = coefficient of variation

10th-13th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	27.8	0.0	27.8	27.8	1	0
M_1W_a	16.2	0.0	16.2	16.2	1	0
M_1W_d	3.6	0.0	3.6	3.6	1	0
M_2L_1	28.0	0.0	28.0	28.0	1	0
M_2W_a	14.2	0.0	14.2	14.2	1	0
M_2W_d	5.0	0.0	5.0	5.0	1	0
M_3L_1	27.7	10.5	25.6	29.7	2	2.899138
M_3W_a	13.8	7.2	13.1	14.5	2	0.989949
M_3W_d	5.5	0.0	5.5	5.5	1	0
Scapula GLP	87.7	0.0	87.7	87.7	1	0
Scapula SLC	48.1	11.8	44.1	52.1	2	5.65685
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	346.5	0.0	346.5	346.5	1	0
Radius SD	37.7	0.0	37.7	37.7	1	0
Radius Bd	76.5	2.0	75.4	77.6	2	1.555635
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	1	-
Femur SD	-	-	-	-	0	-
Femur DC	53.1	4.5	50.3	54.7	3	2.409011
Femur Bd	-	-	-	-	0	-
Tibia GL	330.5	0.0	330.5	330.5	1	0.0
Tibia SD	-	-	-	-	0	-
Tibia Bd	72.2	4.0	70.1	74.2	2	2.899138
Tibia Dd	44.2	4.5	42.2	46.2	3	2.000000
Astragalus GH	54.1	2.9	52.3	55.3	3	1.569501
Astragalus GB	57.8	1.8	57.1	59	3	1.021437
Astragalus Bfd	48.1	3.9	46.6	50.2	3	1.890326
Astragalus LmT	53.3	4.8	50.7	55.8	3	2.551470
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	53.9	9.1	48.4	57.8	3	4.916638
Metatarsal GL	253.0	0.0	253.0	253.0	1	0
Metatarsal SD	27.3	0.0	27.3	27.3	1	0
Metatarsal Bd	48.0	4.0	46.6	49.3	2	1.909188
Metatarsal Dd	36.9	3.4	36.0	37.8	2	1.272792
Phalanx 1 GL	-	-	-	-	0	-
Phalanx 1 Bp	-	-	-	-	0	-
Phalanx 1 Dp	31.3	0.0	31.3	31.3	1	0
Phalanx 1 SD	-	-	-	-	0	-
Phalanx 1 Bd	-	-	-	-	0	-
Phalanx 1 Dd	-	-	-	-	0	-

13th-14th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	30.7	0.0	30.7	30.7	1	0
M_3W_a	12.3	0.0	12.3	12.3	1	0
M_3W_d	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	65.0	7.8	61.4	68.6	2	5.091169
Humerus SD	-	-	-	-	0	-
Humerus HTC	32.5	8.7	30.5	34.5	2	2.828427
Radius GL	297.5	0.0	297.5	297.5	1	0
Radius SD	27.9	0.0	27.9	27.9	1	0
Radius Bd	60.0	0.0	60.0	60.0	1	0
Metacarpal GL	193.0	0.0	193.0	193.0	1	0
Metacarpal SD	24.3	0.0	24.3	24.3	1	0
Metacarpal Bd	37.9	0.0	37.9	37.9	1	0
Metacarpal Dd	29.0	0.0	29.0	29.0	1	0
Pelvis LAR	67.1	0.0	67.1	67.1	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	48.7	0.0	48.7	48.7	1	0
Femur Bd	75.4	0.0	75.4	75.4	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GH	-	-	-	-	0	-
Astragalus GB	-	-	-	-	0	-
Astragalus Bfd	-	-	-	-	0	-
Astragalus LmT	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	47.5	0.0	47.5	47.5	1	0
Metatarsal GL	253.5	0.0	253.5	253.5	1	0
Metatarsal SD	27.3	0.0	27.3	27.3	1	0
Metatarsal Bd	44.7	0.0	44.7	44.7	1	0
Metatarsal Dd	34.8	0.0	34.8	34.8	1	0
Phalanx 1 GL	70.3	0.0	70.3	70.3	1	0
Phalanx 1 Bp	25.4	0.0	25.4	25.4	1	0
Phalanx 1 Dp	27.2	0.0	27.2	27.2	1	0
Phalanx 1 SD	25.4	0.0	25.4	25.4	1	0
Phalanx 1 Bd	34.7	0.0	34.7	34.7	1	0
Phalanx 1 Dd	20.4	0.0	20.4	20.4	1	0

14th-15th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	29.3	0.0	29.3	29.3	1	0
P_4W_a	14.5	0.0	14.5	14.5	1	0
P_4W_d	-	-	-	-	0	-
M_1L_1	27	0.0	27	27	1	0
M_1W_a	14.5	0.0	14.5	14.5	1	0
M_1W_d	4.6	0.0	4.6	4.6	1	0
M_2L_1	26.8	0.0	26.8	26.8	1	0
M_2W_a	12.6	0.0	12.6	12.6	1	0
M_2W_d	4.6	0.0	4.6	4.6	1	0
M_3L_1	25.0	0.0	25	25	1	0
M_3W_a	9.0	0.0	9	9	1	0
M_3W_d	3.5	0.0	3.5	3.5	1	0
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GH	-	-	-	-	0	-
Astragalus GB	-	-	-	-	0	-
Astragalus Bfd	-	-	-	-	0	-
Astragalus LmT	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	-	-	-	-	0	-
Phalanx 1 Bp	-	-	-	-	0	-
Phalanx 1 Dp	-	-	-	-	0	-
Phalanx 1 SD	-	-	-	-	0	-
Phalanx 1 Bd	-	-	-	-	0	-
Phalanx 1 Dd	-	-	-	-	0	-
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15th-16th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	31.4	8.4	29.1	34.3	3	2.64071
M_3W_a	12.9	13.2	11.3	14.7	3	1.708801
M_3W_d	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	71.1	0.0	71.1	71.1	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	37.2	0.0	37.2	37.2	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GH	54.5	2.2	53.2	55.6	3	1.205543
Astragalus GB	57.6	7.6	55.0	62.6	3	4.359281
Astragalus Bfd	48.3	4.3	45.9	49.7	3	2.088061
Astragalus LmT	54.3	1.5	53.4	54.9	3	0.793725
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	50.0	11.6	45.9	54.1	2	5.798276
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	-	-	-	-	0	-
Phalanx 1 Bp	-	-	-	-	0	-
Phalanx 1 Dp	-	-	-	-	0	-
Phalanx 1 SD	-	-	-	-	0	-
Phalanx 1 Bd	-	-	-	-	0	-
Phalanx 1 Dd	-	-	-	-	0	-

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16th-17th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	30.9	7.4	29.3	34.2	4	2.294014
M_3W_a	13.0	11.9	10.7	14.2	4	1.54164
M_3W_d	-	-	-	-	0	-
Scapula GLP	94.4	0.0	94.4	94.4	1	0
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	75.3	7.4	68.7	82.9	5	5.590438
Humerus SD	-	-	-	-	0	-
Humerus HTC	37.1	8.9	34.5	43	6	3.294086
Radius GL	306.0	0.2	305.5	306.5	2	0.707107
Radius SD	33.2	2.1	32.7	33.7	2	0.707107
Radius Bd	71.7	3.8	69.8	75.7	4	2.759831
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	61.4	0.0	61.4	61.4	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	54.8	6.6	52.2	57.3	2	3.606245
Femur Bd	83.0	0.0	83.0	83.0	1	0
Tibia GL	382.0	0.0	382.0	382.0	1	0
Tibia SD	40.8	0.0	40.8	40.8	1	0
Tibia Bd	75.8	0.0	75.8	75.8	1	0
Tibia Dd	51.3	0.0	51.3	51.3	1	0
Astragalus GH	54.6	8.7	47.4	58.8	6	4.729799
Astragalus GB	59.0	6.1	52.6	63.0	6	3.59912
Astragalus Bfd	48.2	7.7	41.3	51.8	6	3.690890
Astragalus LmT	52.9	9.8	46.1	58.9	6	5.192687
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	255.5	0.0	255.5	255.5	1	0
Metatarsal SD	28.6	0.0	28.6	28.6	1	0
Metatarsal Bd	47.1	0.0	47.1	47.1	1	0
Metatarsal Dd	33.9	0.0	33.9	33.9	1	0
Phalanx 1 GL	83.2	0.0	83.2	83.2	1	0
Phalanx 1 Bp	52.7	0.0	52.7	52.7	1	0
Phalanx 1 Dp	35.1	0.0	35.1	35.1	1	0
Phalanx 1 SD	33.8	0.0	33.8	33.8	1	0
Phalanx 1 Bd	45.3	0.0	45.3	45.3	1	0
Phalanx 1 Dd	24.4	0.0	24.4	24.4	1	0

17^th^-18^th^ century:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	28.4	0.0	28.4	28.4	1	0
P_4W_a	14.3	0.0	14.3	14.3	1	0
P_4W_d	-	-	-	-	0	-
M_1L_1	21.9	18.1	19.1	24.7	2	3.959798
M_1W_a	14.1	7.5	13.3	14.8	2	1.06066
M_1W_d	4.9	19.0	4.2	5.5	2	0.919239
M_2L_1	23.1	10.1	21.4	24.7	2	2.333452
M_2W_a	13.2	7.5	12.5	13.9	2	0.989949
M_2W_d	4.3	13.2	3.9	4.7	2	0.565685
M_3L_1	31.4	7.9	28.4	35.5	9	2.490538
M_3W_a	13.6	9.1	12.1	15.4	9	1.239736
M_3W_d	-	-	-	-	0	-
Scapula GLP	98.0	17.4	79.1	118.0	4	17.047189
Scapula SLC	66.9	16.6	55.7	80.8	4	11.077116
Humerus GLC	-	-	-	-	0	-
Humerus BT	67.2	4.6	65.0	69.4	2	3.111270
Humerus SD	-	-	-	-	0	-
Humerus HTC	34.5	6.1	33.0	36.0	2	2.121320
Radius GL	347.0	0.0	347.0	347.0	1	0
Radius SD	38.7	0.0	38.7	38.7	1	0
Radius Bd	75	9.3	68.6	85.3	5	6.942406
Metacarpal GL	221.4	4.2	211.0	229.5	4	9.321793
Metacarpal SD	32.9	3.2	31.6	33.8	4	1.062623
Metacarpal Bd	46.9	8.1	42.4	51.7	4	3.818377
Metacarpal Dd	33.0	7.9	29.4	35.7	4	2.613427
Pelvis LAR	63.1	5.4	60.7	65.5	2	3.394113
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	55.8	9.6	50.6	61.3	3	5.353815
Femur Bd	89.8	10.6	80.8	102.1	6	9.490627
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	70.8	3.9	68.4	73.8	3	2.749545
Tibia Dd	45.0	8.6	41.8	49.3	3	3.869108
Astragalus GH	57.9	10.3	52.4	67.0	6	5.948025
Astragalus GB	62.5	4.7	59.4	67.4	6	2.958153
Astragalus Bfd	51.9	5.3	48.6	55.1	6	2.769115
Astragalus LmT	57.7	11.3	51.3	69.0	6	6.530161
Calcaneum GL	102.0	0.0	102.0	102.0	1	0
Calcaneum GB	41.25	19.0	35.7	46.8	2	7.848885
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	83.0	10.3	72.5	98.4	15	8.543876
Phalanx 1 Bp	52.4	7.5	46.5	60.5	15	3.936968
Phalanx 1 Dp	35.3	13.3	30.4	50.9	18	4.679677
Phalanx 1 SD	33.2	10.2	27.3	39.1	17	3.398021
Phalanx 1 Bd	45.0	8.5	39.1	51	15	3.834704
Phalanx 1 Dd	24.2	9.4	21.2	27.9	15	2.280351

18th-19th century:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	24.1	0	24.1	24.1	1	0
M_2W_a	14.5	0	14.5	14.5	1	0
M_2W_d	4.2	0	4.2	4.2	1	0
M_3L_1	32.7	12.11848	28.9	36.8	3	3.962743
M_3W_a	12.7	17.83425	10.3	14.8	3	2.264950
M_3W_d	3.6	37.84515	2.6	4.5	2	1.343503
Scapula GLP	88.4	0	88.4	88.4	1	0
Scapula SLC	68.0	0	68.0	68.0	1	0
Humerus GLC	-	-	-	-	0	-
Humerus BT	70.8	5.182545	68.5	75.0	3	3.669242
Humerus SD	-	-	-	-	0	-
Humerus HTC	34.1	4.962284	32.7	36.0	3	1.692139
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	69.6	0	69.6	69.6	1	0
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	90.4	0	90.4	90.4	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GH	61.5	12.64744	56.0	67.0	2	7.7781746
Astragalus GB	63.8	20.96364	54.3	73.2	2	13.364318
Astragalus Bfd	52.1	12.09078	47.6	56.5	2	6.2932504
Astragalus LmT	60.2	21.14273	51.2	69.2	2	12.727922
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	-	-	-	-	0	-
Phalanx 1 Bp	-	-	-	-	0	-
Phalanx 1 Dp	-	-	-	-	0	-
Phalanx 1 SD	-	-	-	-	0	-
Phalanx 1 Bd	-	-	-	-	0	-
Phalanx 1 Dd	-	-	-	-	0	-

EM:

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	27.8	0.0	27.8	27.8	1	0
M_1W_a	16.2	0.0	16.2	16.2	1	0
M_1W_d	3.6	0.0	3.6	3.6	1	0
M_2L_1	28.0	0.0	28.0	28.0	1	0
M_2W_a	14.2	0.0	14.2	14.2	1	0
M_2W_d	5.0	0.0	5.0	5.0	1	0
M_3L_1	29.1	11.9	24.9	35.0	7	3.469596
M_3W_a	13.1	7.2	11.9	14.5	7	0.94138
M_3W_d	4.1	50.6	2.6	5.5	2	2.05061
Scapula GLP	83.3	12.8	87.7	91.0	3	10.66505
Scapula SLC	53.4	15.2	44.1	63.8	4	8.091714
Humerus GLC	-	-	-	-	0	-
Humerus BT	77.4	15.9	68.7	86.1	2	12.30366
Humerus SD	-	-	-	-	0	-
Humerus HTC	37.3	23.1	31.2	43.4	2	8.626703
Radius GL	319.3	7.5	301.5	346.5	3	23.90781
Radius SD	34.9	7.0	33.4	37.7	3	2.454248
Radius Bd	72.9	5.8	69.2	77.6	4	4.226405
Metacarpal GL	210.5	0.0	210.5	210.5	1	0
Metacarpal SD	30.3	0.0	30.3	30.3	1	0
Metacarpal Bd	46.6	0.0	46.6	46.6	1	0
Metacarpal Dd	21.3	0.0	21.3	21.3	1	0.0
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	54.5	6.3	50.3	58.7	4	3.435477
Femur Bd	-	-	-	-	0	-
Tibia GL	333.0	1.1	330.5	335.5	2	3.535534
Tibia SD	38.2	0.0	38.2	38.2	1	0
Tibia Bd	69.3	6.1	61.2	74.2	9	4.20684
Tibia Dd	43.2	5.0	38.9	46.2	10	2.172965
Astragalus GH	56.4	5.7	52.3	61.8	8	3.233309
Astragalus GB	57.2	4.0	52.9	59.8	8	2.285357
Astragalus Bfd	49.2	5.0	46.1	53.7	8	2.475559
Astragalus LmT	54.9	8.2	49.0	63.8	8	4.505869
Calcaneum GL	-	-			0	-
Calcaneum GB	51.2	10.1	45.9	57.8	5	5.164494
Metatarsal GL	253.0	0.0	253.0	253.0	1	0
Metatarsal SD	27.3	0.0	27.3	27.3	1	0
Metatarsal Bd	48.0	4.0	46.6	49.3	2	1.909188
Metatarsal Dd	36.9	3.4	36.0	37.8	2	1.272792
Phalanx 1 GL	79.1	7.8	74.7	83.4	2	6.151829
Phalanx 1 Bp	51.9	0.0	51.9	51.9	1	0
Phalanx 1 Dp	35.2	15.5	31.3	39.0	2	5.444722
Phalanx 1 SD	31.0	1.6	30.6	31.3	2	0.494975
Phalanx 1 Bd	45.2	0.0	45.2	45.2	1	0
Phalanx 1 Dd	25.2	1.7	24.9	25.5	2	0.424264

LM:

Measurement	Mean	V	Min.	Max.	N	s.d.
P_4 L_1	26.2	11.5	23.3	29.3	3	3.008876
P_4W_a	15.2	7.8	14.5	16.6	3	1.184624
P_4W_d	15.2	1.9	4.0	4.4	2	0.282843
M_1L_1	25.5	14.8	20.6	31.6	6	3.768112
M_1W_a	15.8	6.0	14.5	17.0	6	0.953764
M_1W_d	4.2	34.7	3.0	6.6	5	1.458767
M_2L_1	24.5	24.7	14.9	32.7	6	6.05863
M_2W_a	15.2	17.9	12.6	19.8	6	2.718394
M_2W_d	4.3	47.0	2.2	6.9	4	2.020726
M_3L_1	30.0	13.4	12.7	38.7	38	4.006763
M_3W_a	13.0	16.1	9.0	19.4	37	2.09191
M_3W_d	3.6	24.5	2.0	5.2	15	0.882906
Scapula GLP	86.6	11.1	73.2	109.7	10	9.642176
Scapula SLC	62.9	11.6	52.9	76.5	10	7.309697
Humerus GLC	256.6	3.1	253.0	268.5	4	7.972609
Humerus BT	70.9	7.5	61.4	83.3	27	5.346157
Humerus SD	32.7	4.2	31.4	34.1	3	1.357694
Humerus HTC	35.6	9.1	30.5	43.7	27	3.256398
Radius GL	313.8	5.5	297.5	334.5	8	17.29368
Radius SD	34.5	9.2	27.9	38.1	8	3.179398
Radius Bd	71.4	6.7	60.0	79.5	20	4.756964
Metacarpal GL	212.2	7.0	190.0	258.5	19	14.93828
Metacarpal SD	29.7	10.7	23.3	35.1	19	3.165494
Metacarpal Bd	44.8	7.6	37.9	50.1	20	3.420107
Metacarpal Dd	23.3	23.9	18.0	35.7	19	5.575662
Pelvis LAR	58.4	9.8	50.3	67.1	6	5.734108
Femur GL	414.5	3.1	405.5	423.5	2	12.72792
Femur SD	36.3	18.9	31.4	41.1	2	6.858936
Femur DC	56.7	9.1	48.7	62.4	14	5.136745
Femur Bd	81.3	12.3	57.4	94.7	11	9.960157
Tibia GL	331.6	7.9	303.5	382.0	9	26.16468
Tibia SD	37.4	13.7	32.8	45.8	7	5.138973
Tibia Bd	68.7	12.0	55.1	92.1	24	8.271129
Tibia Dd	42.8	11.4	35.1	56.3	25	4.886045
Astragalus GH	55.5	5.3	50.1	61.7	33	2.922107
Astragalus GB	59.2	6.4	51.9	68.0	34	3.776493
Astragalus Bfd	49.8	5.2	43.4	54.5	34	2.568146
Astragalus LmT	55.8	5.6	46.6	63.0	35	3.120364
Calcaneum GL	105.1	6.9	97.5	112.0	3	7.275301
Calcaneum GB	48.1	11.2	34.4	56.9	16	5.374384
Metatarsal GL	257.0	9.0	236.0	313.0	9	23.16787
Metatarsal SD	29.4	11.2	26.2	37.0	9	3.305089
Metatarsal Bd	46.3	13.3	41.3	61.8	9	6.161665
Metatarsal Dd	30.4	21.9	21.1	43.4	10	6.661173
Phalanx 1 GL	79.3	8.0	67.7	97.0	35	6.322990
Phalanx 1 Bp	50.7	7.4	42.6	62.5	39	3.747336
Phalanx 1 Dp	34.1	11.2	25.5	43.8	23	3.828058
Phalanx 1 SD	32.1	8.8	25.4	41.2	38	2.832583
Phalanx 1 Bd	43.9	8.6	34.7	55.5	36	3.787208
Phalanx 1 Dd	19.8	13.7	15.7	28.6	37	2.720515

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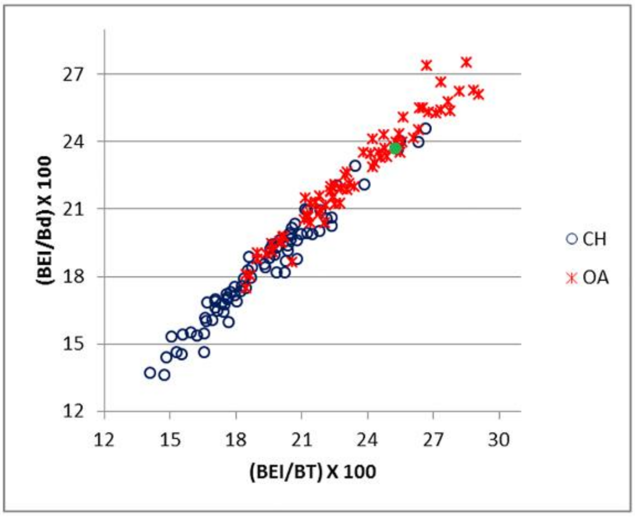
PM:

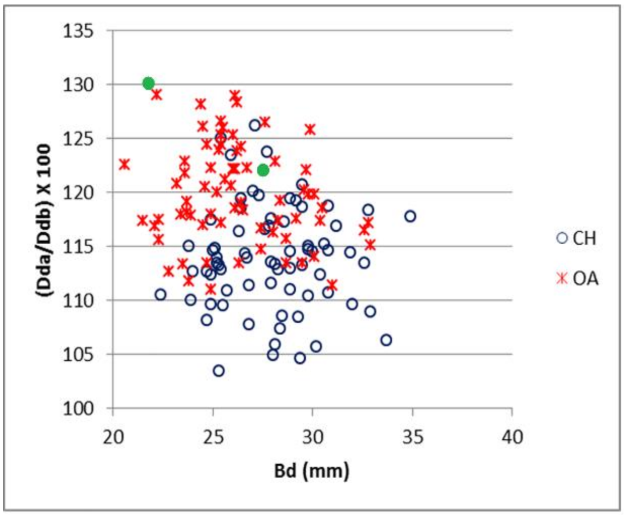
Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	28.2	1.3	27.9	28.4	2	0.353553
P_4W_a	17.5	25.5	14.3	20.6	2	4.454773
P_4W_d	-	-	-	-	0	-
M_1L_1	18.0	40.3	10.3	24.7	3	7.259017
M_1W_a	16.5	25.8	13.3	21.3	3	4.25245
M_1W_d	4.9	19.0	4.2	5.5	2	0.919239
M_2L_1	20.5	13.5	17.4	24.7	5	2.761702
M_2W_a	17.8	24.4	12.5	22.0	5	4.351207
M_2W_d	4.3	13.2	3.9	4.7	2	0.565685
M_3L_1	29.0	17.8	18.1	36.8	21	5.176188
M_3W_a	13.7	15.7	10.3	19.2	20	2.15250
M_3W_d	3.6	37.8	2.6	4.5	2	1.343503
Scapula GLP	97.1	13.0	79.1	118.0	8	12.62002
Scapula SLC	67.8	12.3	55.7	80.8	7	8.31714
Humerus GLC	313.0	0.0	313.0	313.0	1	0
Humerus BT	73.3	8.2	65.0	86.0	14	5.985904
Humerus SD	38.2	0.0	38.2	38.2	1	0
Humerus HTC	36.6	9.1	32.7	43.4	15	3.314571
Radius GL	326.8	7.3	305.5	348.0	4	23.96699
Radius SD	35.8	8.4	32.7	38.7	4	3.014824
Radius Bd	72.9	6.6	68.2	85.3	13	4.834505
Metacarpal GL	227.6	7.1	211.0	252.5	5	16.09115
Metacarpal SD	32.4	4.1	30.7	33.8	5	1.339029
Metacarpal Bd	47.7	7.9	42.4	52.4	6	3.750955
Metacarpal Dd	32.2	9.5	27.6	35.7	6	3.048278
Pelvis LAR	59.1	10.2	49.3	65.5	5	6.019385
Femur GL	313.0	0.0	313.0	313.0	1	0
Femur SD	38.2	0.0	38.2	38.2	1	0.0
Femur DC	54.7	7.1	50.6	61.3	7	3.904881
Femur Bd	87.7	8.2	80.8	102.1	12	7.198921
Tibia GL	353.8	11.3	325.5	382.0	2	40.0
Tibia SD	50.8	27.8	40.8	60.8	2	14.1
Tibia Bd	69.3	9.0	57.9	75.8	6	6.231666
Tibia Dd	44.9	10.1	39.4	51.3	6	4.53582
Astragalus GH	57.1	9.9	47.4	67.0	17	5.627062
Astragalus GB	61.2	9.5	52.6	74.6	18	5.812011
Astragalus Bfd	50.4	7.4	55.2	49.3	18	3.707425
Astragalus LmT	56.6	12.0	46.1	69.2	17	6.775138
Calcaneum GL	102.0	0.0	102.0	102.0	1	0
Calcaneum GB	41.9	13.5	35.7	46.8	3	5.663038
Metatarsal GL	270.8	4.9	255.5	280.0	3	13.36351
Metatarsal SD	30.9	8.0	28.6	33.5	3	2.463737
Metatarsal Bd	50.5	5.9	47.1	52.7	3	2.986637
Metatarsal Dd	38.2	10.1	33.4	41.3	3	3.843176
Phalanx 1 GL	82.0	10.0	69.8	98.4	19	8.178295
Phalanx 1 Bp	51.8	7.3	46.5	60.5	20	3.759686
Phalanx 1 Dp	35.0	12.4	30.4	50.9	22	4.33549
Phalanx 1 SD	32.9	10.0	27.3	39.1	21	3.296405
Phalanx 1 Bd	44.5	8.5	37.8	51.0	19	3.767288
Phalanx 1 Dd	23.8	9.5	20.0	27.9	19	2.260867

Appendix 23: _Shapwick Sheep/Goat Metric Separation Graphs:_

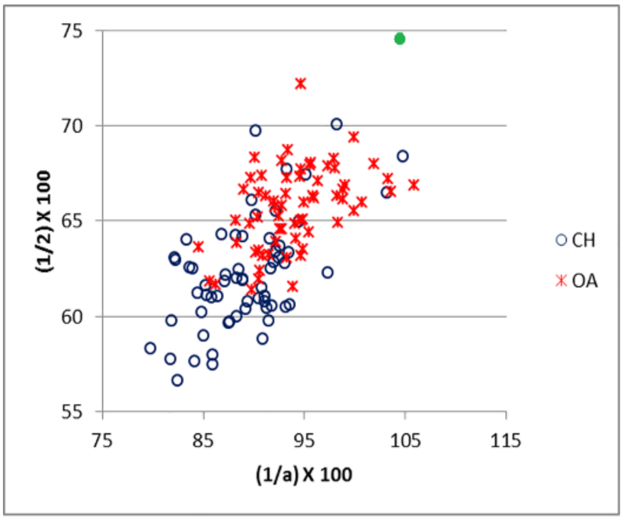
Early Medieval:



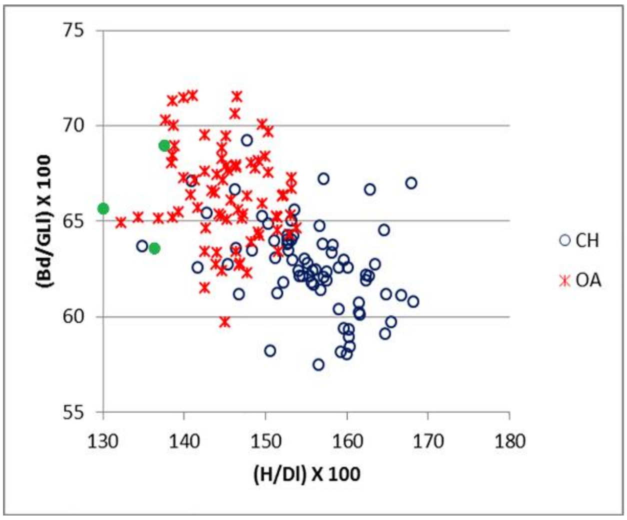
Humerus BEl/BT vs. BEl/Bd



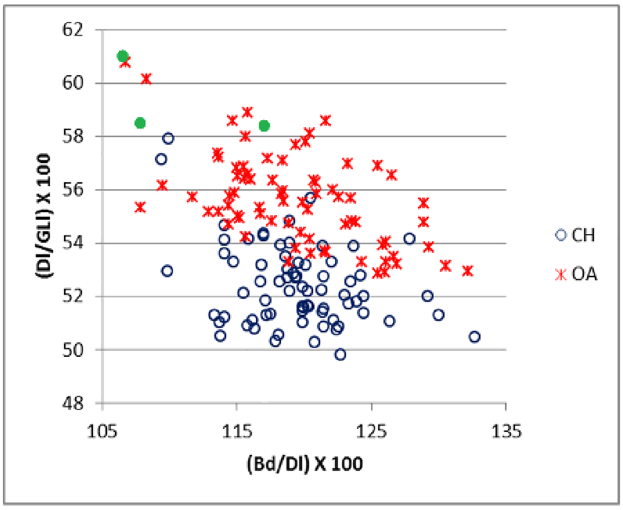
Tibia Bd vs. Dda/Ddb



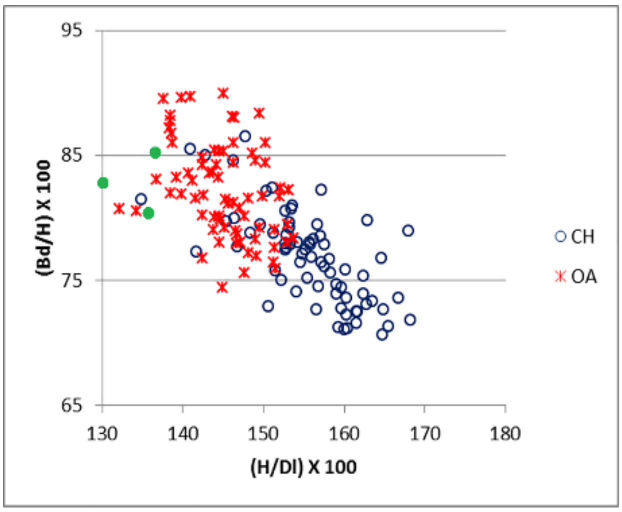
Metatarsal 1/a vs. 1/2



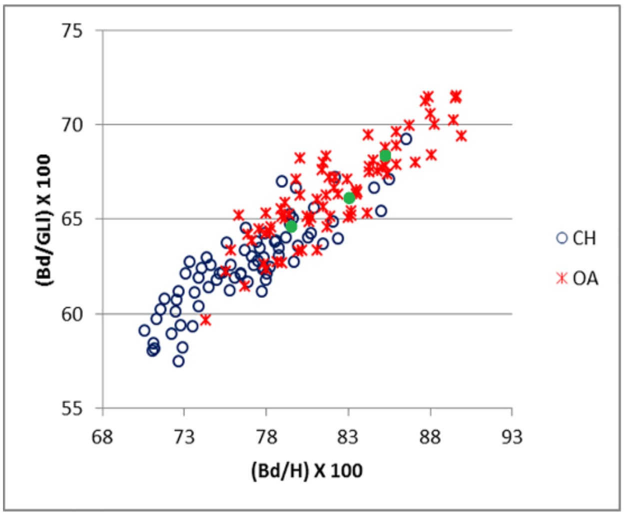
Astragalus H/Dl vs. Bd/GLl



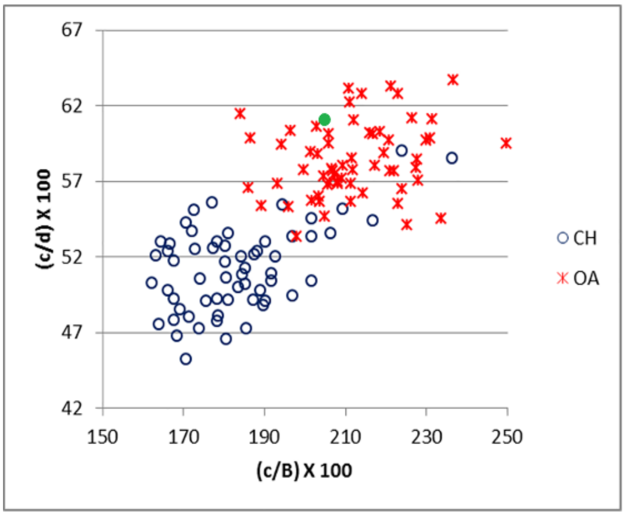
Astragalus Bd/Dl vs. Dl/GLl



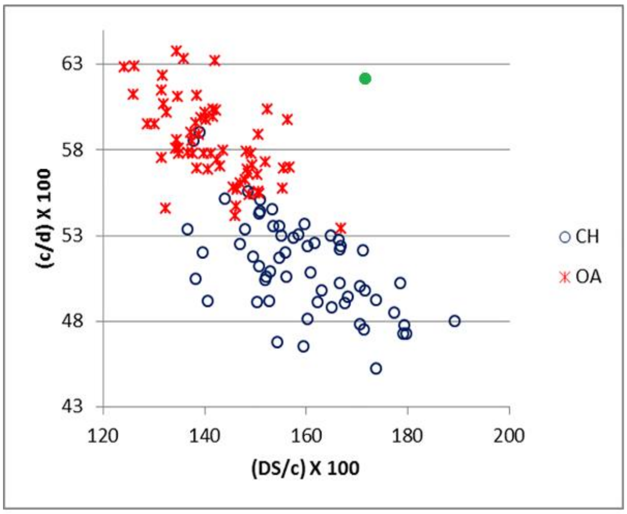
Astragalus H/Dl vs. Bd/H



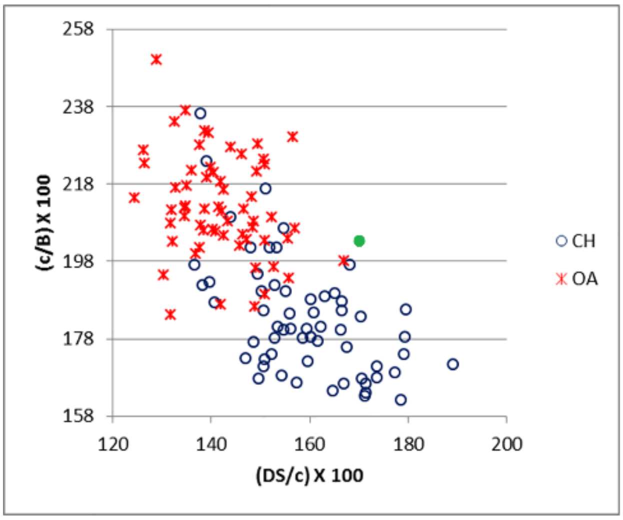
Astragalus Bd/H vs. Bd/GLl



Calcaneum c/B vs. c/d

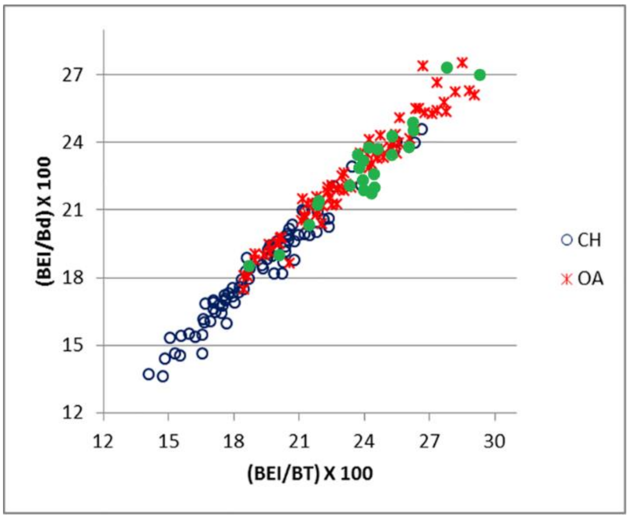


Calcaneum DS/c vs. c/d

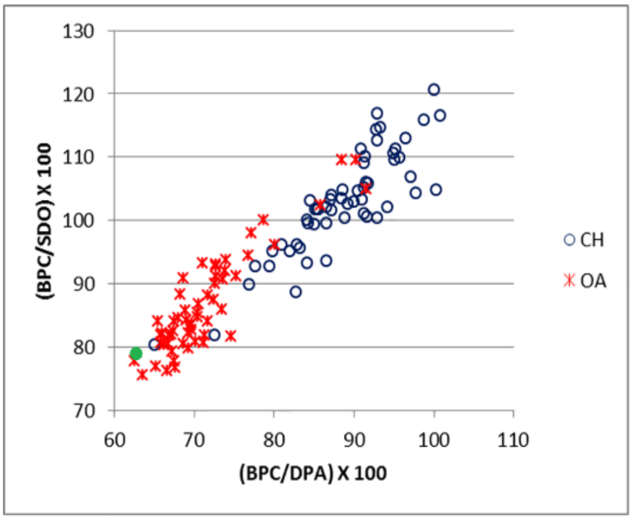


Calcaneum DS/c vs. c/B

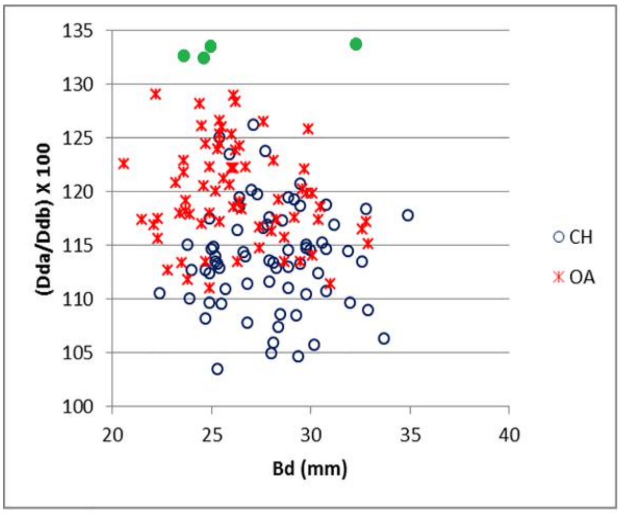
Late Medieval:



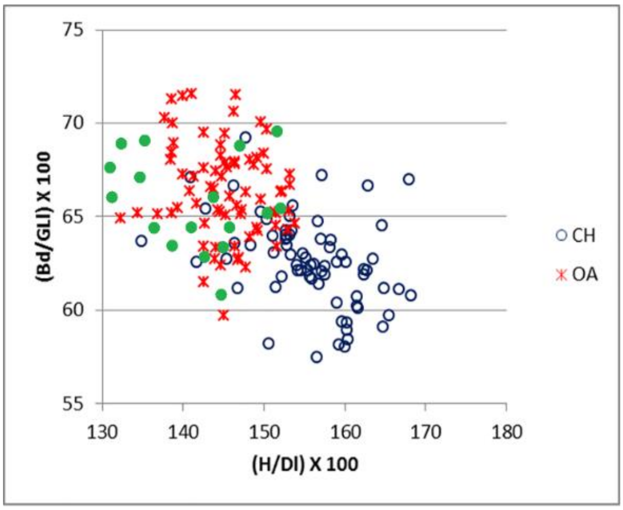
Humerus BEl/BT vs. BEl/Bd



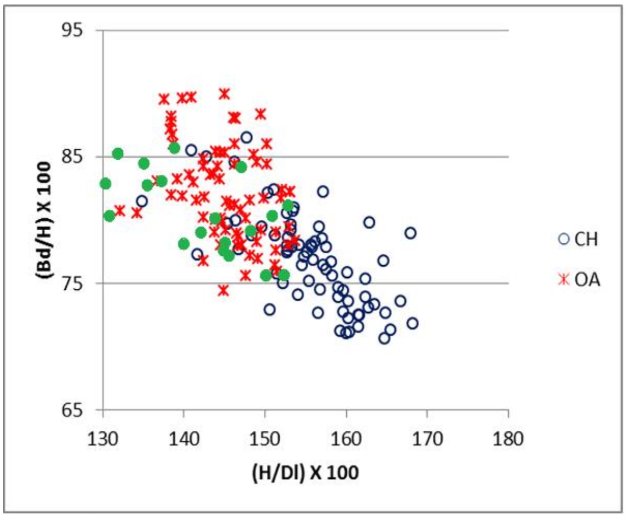
Ulna BPC/DPA vs. BPC/SDO



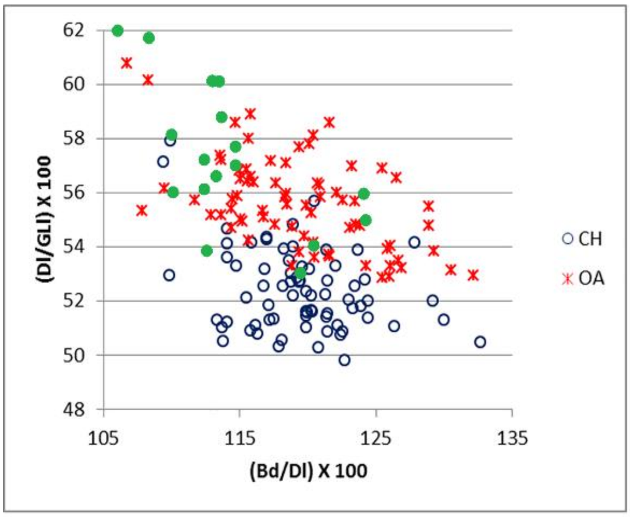
Tibia Bd vs. Dda/Ddb



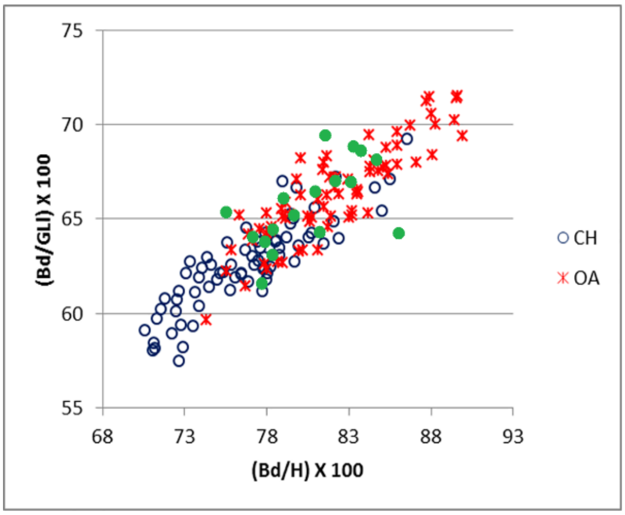
Astragalus H/Dl vs. Bd/GLl



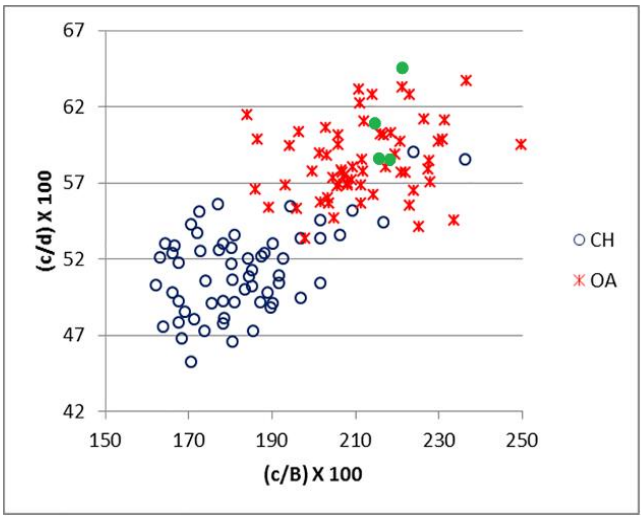
Astragalus H/Dl vs. Bd/H



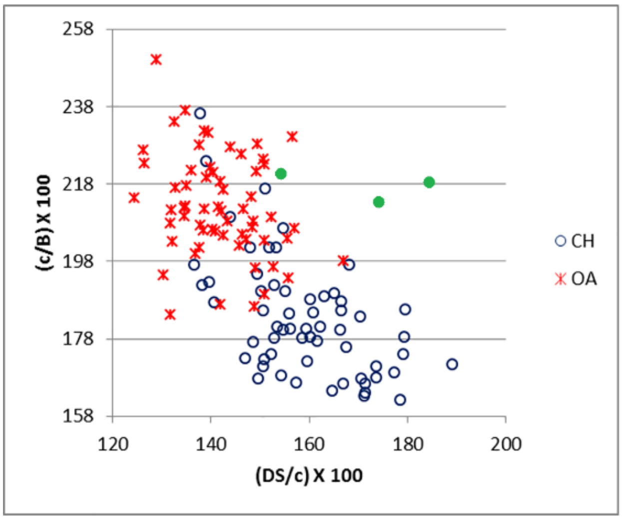
Astragalus Bd/Dl vs. Dl/GLl



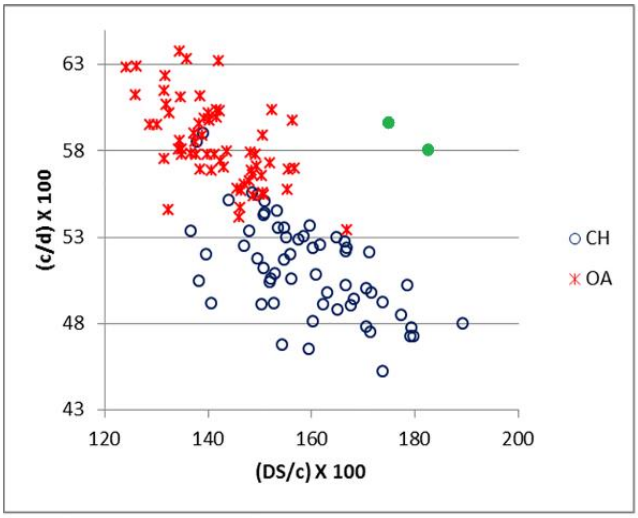
Astragalus Bd/H vs. Bd/GLI



Calcaneum c/B vs. c/d

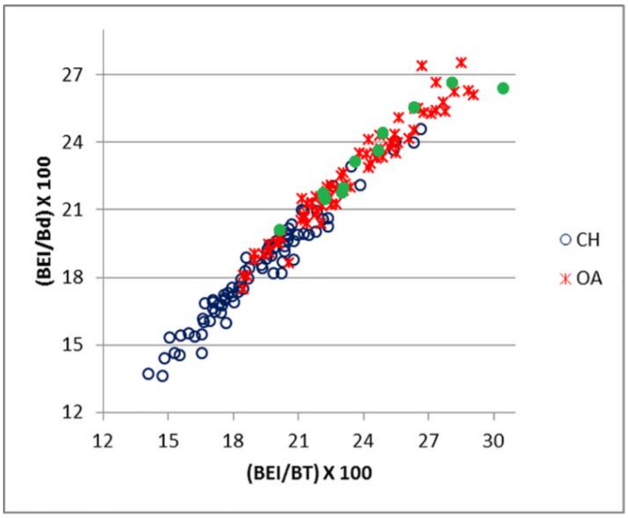


Calcaneum DS/c vs. c/B

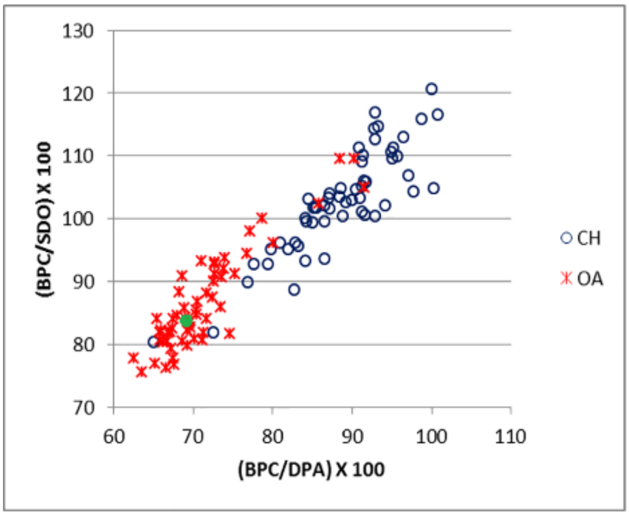


Calcaneum DS/c vs. c/d

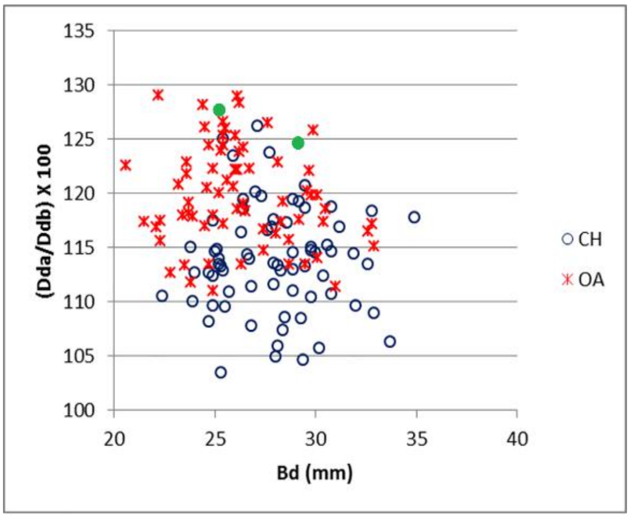
Post-Medieval:



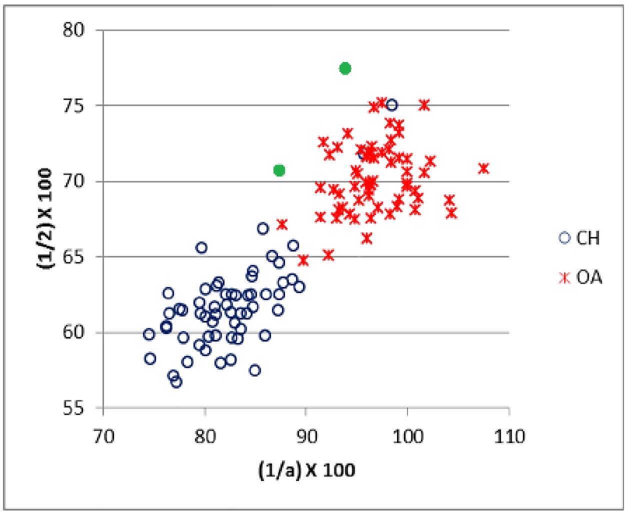
Humerus BEI/BT vs. BEI/Bd



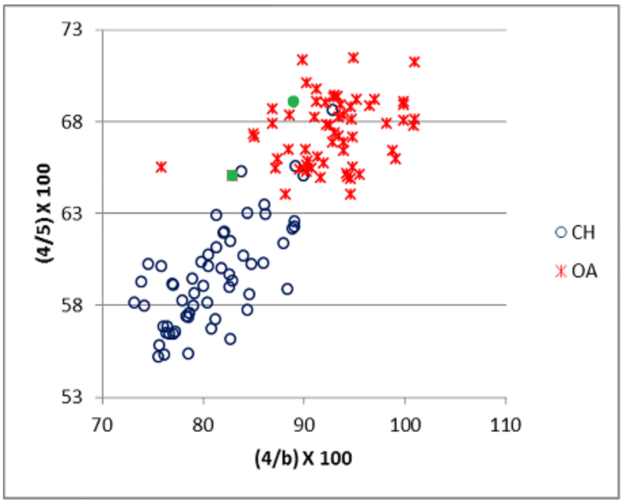
Ulna BPC/DPA vs. BPC/SDO



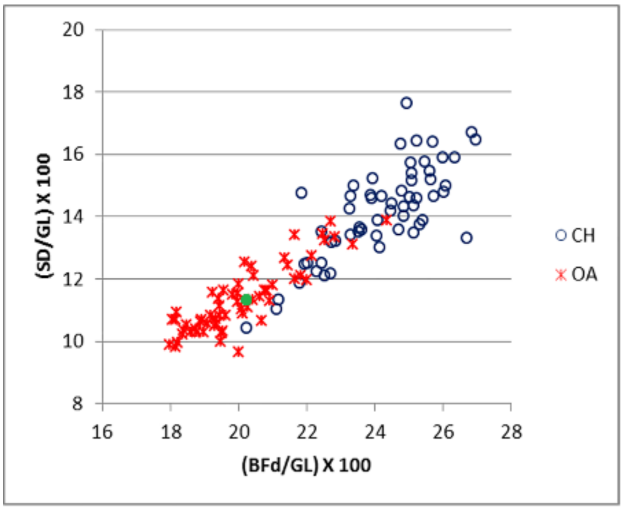
Tibia Bd vs. Dda/Ddb



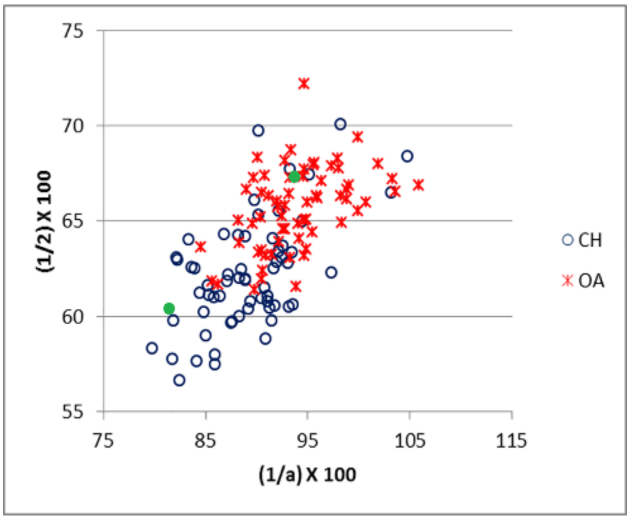
Metacarpal 1/a vs. ½



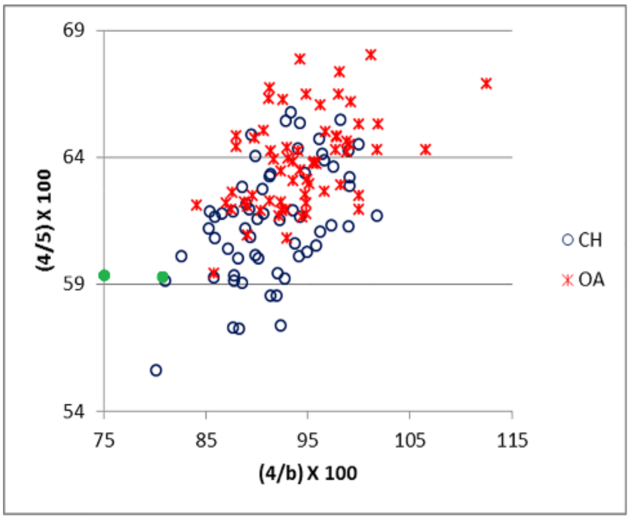
Metacarpal 4/b vs. 4/5



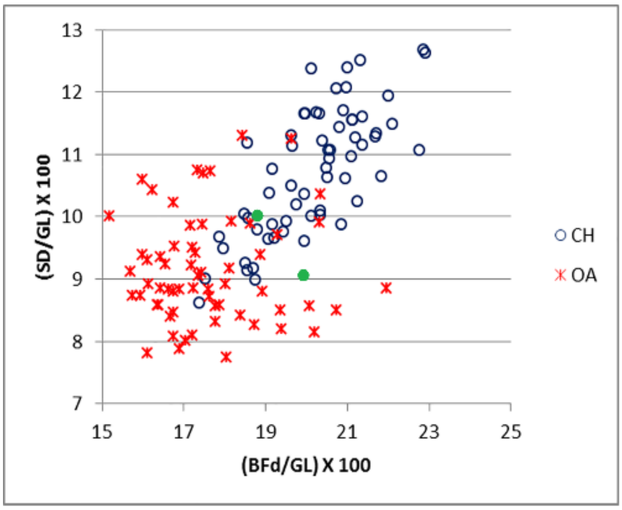
Metatarsal BFd/GL vs. SD/GL



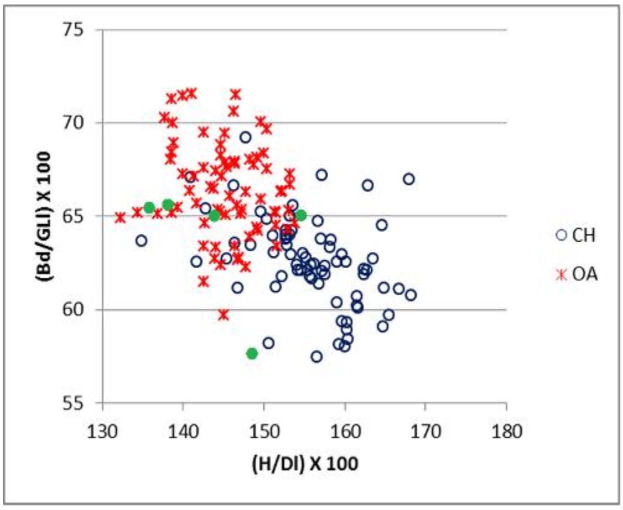
Metatarsal 1/a vs. ½



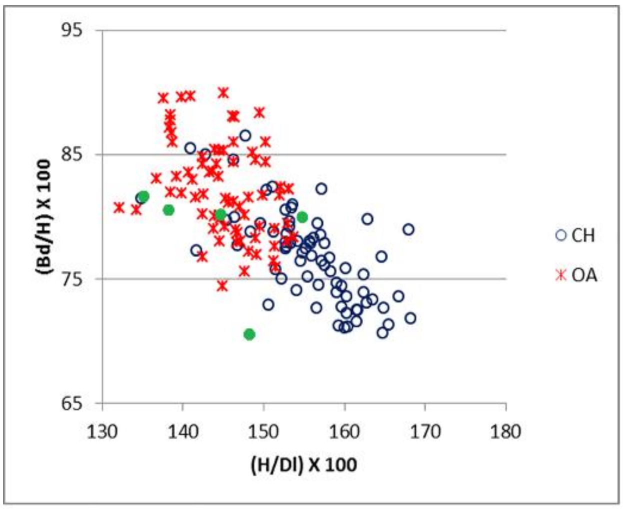
Metatarsal 4/b vs. 4/5



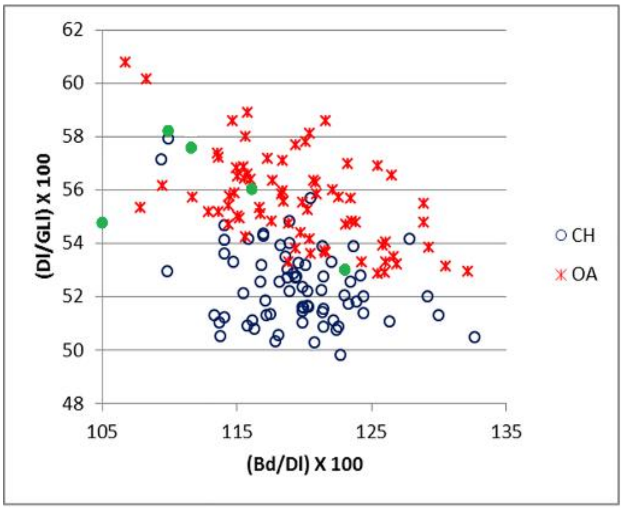
Metatarsal BFd/GL vs. SD/GL



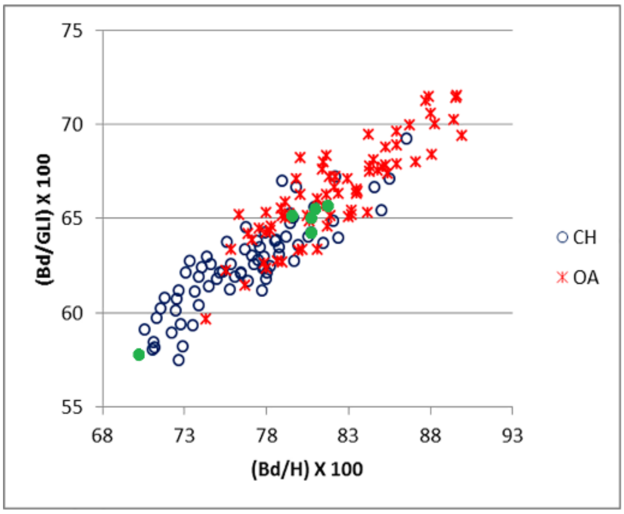
Astragalus H/DI vs. Bd/GLI

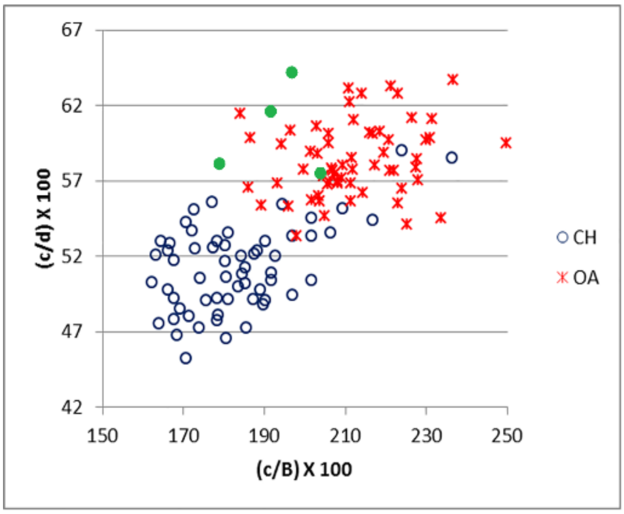


Astragalus H/DI vs. Bd/H



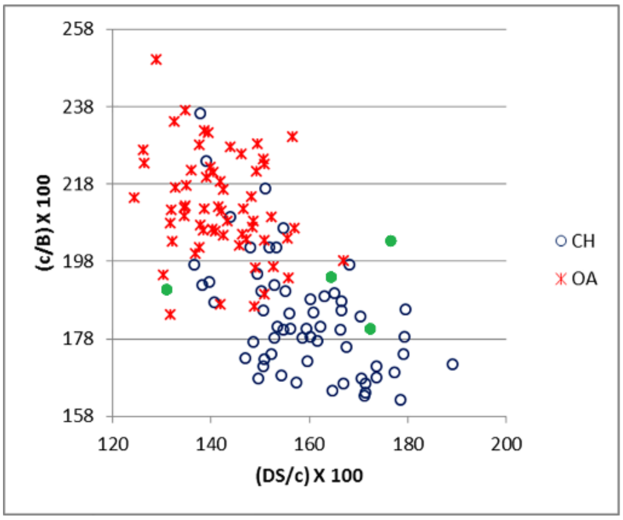
Astragalus Bd/DI vs. DI/GLI

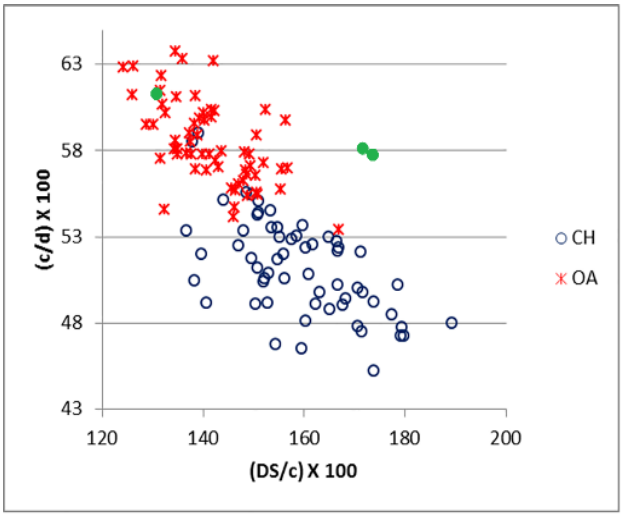




Astragalus Bd/H vs. Bd/GLI

Calcanuem c/B vs. c/d





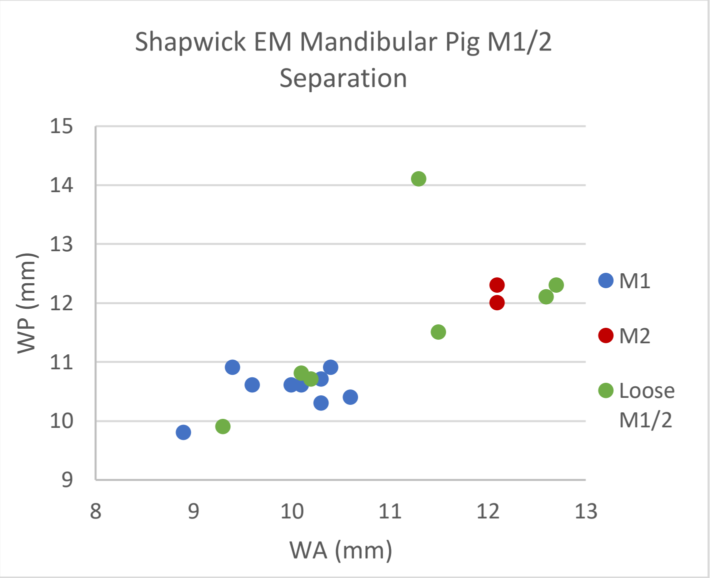
Calcaneum DS/c vs. c/B

Calcaneum DS/c vs. c/d

Appendix 24: *Shapwick Pig M12 Separation:*

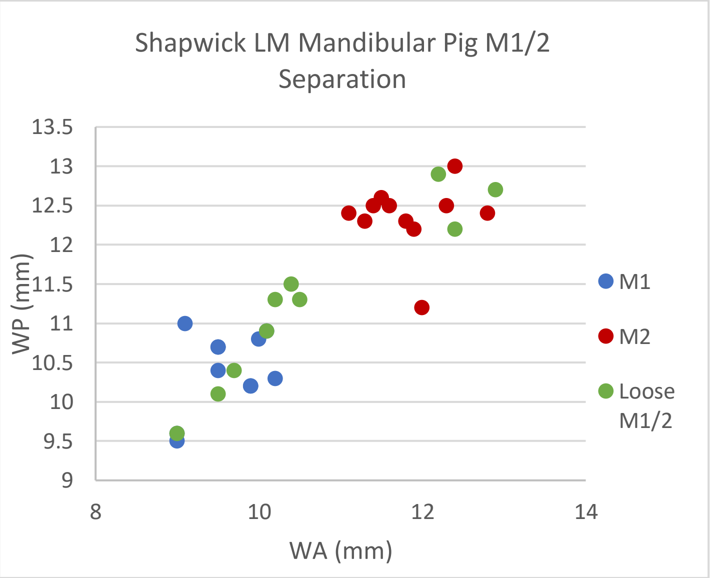
10th-13th century (EM):

ID no.	WA	WP	M1/2
9080	11.5	11.5	M2
8557	11.3	14.1	M2
8543	12.6	12.1	M2
9365	12.7	12.3	M2
9024	9.3	9.9	M1
9363	10.2	10.7	M1
9126	10.1	10.8	M1



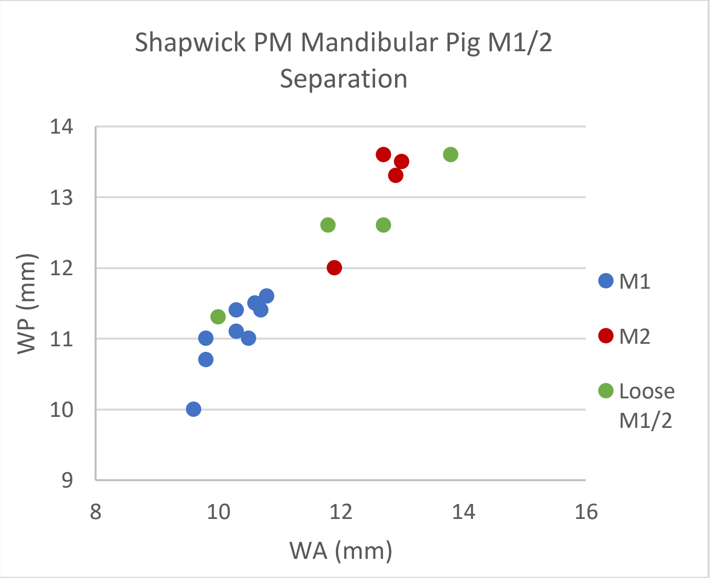
13th-15th century (LM):

ID no.	WA	WP	M1/2
10175	9	9.6	M1
8427	10.4	11.5	M1
10014	12.2	12.9	M2
10001	10.1	10.9	M1
10000	10.2	11.3	M1
9949	12.4	12.2	M2
8989	12.9	12.7	M2
10179	9.7	10.4	M1
10016	10.5	11.3	M1
8900	9.5	10.1	M1



17th-18th century (PM):

ID no.	WA	WP	M1/2
8470	12.7	12.6	M2
8599	11.8	12.6	M2
8459	10	11.3	M1
8439	13.8	13.6	M2



M1/2 in jaw reference measurements:

Period	**M1**		**M2**	
	WA	**WP**	**WA**	**WP**
EM	10.4	10.9	12.1	12.3
	10.6	10.4	12.1	12
	8.9	9.8		
	9.6	10.6		
	9.4	10.9		
	10	10.6		
	10.3	10.3		
	10.1	10.6		
	10.3	10.7		
LM	10	10.8	11.6	12.5
	9	9.5	11.3	12.3
	9.1	11	11.5	12.6
	10.2	10.3	12.8	12.4
	9.9	10.2	12	11.2
	9.5	10.7	11.8	12.3
	9.9	10.2	11.9	12.2
	10.1	10.9	12.3	12.5
	9.5	10.4	12.4	13
	9.5	10.7	11.1	12.4
	9	9.6	11.4	12.5
PM	9.6	10	12.7	13.6
	9.8	10.7	11.9	12
	10.7	11.4	12.9	13.3
	10.3	11.1	13	13.5
	10.3	11.4		
	10.5	11		
	10.8	11.6		
	9.8	11		
	10.6	11.5		

Appendix 25: *Shapwick sheep dental ageing table:*

Tooth	Phase	C	V	E	H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
dP_4	10th-13th																			2				1					
	13th-15th																1		2	6		13	1						
	17th-18th													1						9		2	1						
P_4	10th-13th												1		3		1	1											
	13th-15th			2		1						1		7	3		2	6											
	17th-18th			1		2								2	8			3		2									
M_1	10th-13th												1		1			1											
	13th-15th							1				5			8	1	1	2			4								
	17th-18th			1								1			4					2	3								
M_2	10th-13th													1	1														
	13th-15th	3		1							1		1	2	11	1	1												
	17th-18th											1		1	5	1													
M_{12}	10th-13th										1		2	4	16	1													
	13th-15th					1		4		2	3	7	12	10	62	5	3	1	1		3								
	17th-18th					3		4			2	10	9	9	52	1	2			1	2								
M_3	10th-13th					1				2	1				1	1	7												
	13th-15th	1				3		2	1	2	2	4		3	1	3	21	1											
	17th-18th	1		1		1		4		4	1	4	2	3	4	3	32												

Appendix 26: *Shapwick cattle dental ageing table:*

Tooth	Phase	C	V	E	H	a	b	c	d	e	f	g	h	j	k	l	m	n	o	p
dP_4	10th-13th						1							1			1			
	13th-15th						1		1		1									
	17th-18th							3					1	5	5	1	1			
P_4	10th-13th						1	3	1	1	11	6		1			1			
	13th-15th										3	1	3	2						
	17th-18th								1	1	3	3	1							
M_1	10th-13th													1	5	4				
	13th-15th													1						
	17th-18th																			
M_2	10th-13th											3		2	10					
	13th-15th																			
	17th-18th																			
M_{12}	10th-13th					1		1			2	5	2	3	7	4				
	13th-15th					2	2	2		2	2	1		3	5	3	2			
	17th-18th						1		2			4		1	8					
M_3	10th-13th			1		1			1		2	6	1	8	2	1				
	13th-15th					1	2							1	1					
	17th-18th					1	1		1			4		3						

Appendix 27: *Shapwick pig dental ageing table:*

Tooth	Phase	C	V	E	H	w1	w2	w3	w1/w1	w2/w1	w2/w2	w3/w2	w3/w3	w4/w3	w3-w3	w4-w3	w4-w4	w1/w1/w1	w2/w1/w1	w2/w2/w2	w3/w2/w2	w3/w3/w2	w3/w3/w3	w3-w3-w3
dP4	10th-13th																		1	2	2	2		
	13th-15th																		2	1			3	1
	17th-18th																	1		6			1	1
P4	10th-13th					3	4	3																
	13th-15th					5	11	4																
	17th-18th					7	15	3																
M1	10th-13th								1	2	10	2	2											
	13th-15th										2	4	9		1		1							
	17th-18th								3	4	7	1	2				2							
M2	10th-13th									3	5		1											
	13th-15th								1	2	15	1	1											
	17th-18th								1	1	4		1		1									
M12	10th-13th								5	2	7	2			1									
	13th-15th								2	3	14	3	7											
	17th-18th									3	6		7											
M3	10th-13th																	5						
	13th-15th																	13	1	1	2			
	17th-18th																	5	1		1			

Appendix 28: *Shapwick Fusion Data by Element:*

Sheep:

	C. 10th-13th		C. 13th-15th		C. 17th-18th		EM		LM		PM	
Element	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**
Scapula	1	0	0	0	9	0	1	0	12	1	15	1
Humerus, p	1	0	0	0	0	0	1	0	0	0	2	1
Humerus, d	4	0	2	0	10	0	4	0	27	0	22	2
Radius, p	4	0	0	0	8	0	4	0	0	0	12	0
Radius, d	1	1	0	0	5	2	1	1	0	0	9	3
Ulna	0	0	0	0	2	2	0	0	0	0	3	2
Metacarpal, d	1	1	1	1	3	1	1	1	7	6	5	2
Pelvis	2	0	1	0	1	0	2	0	8	0	3	1
Femur, p	0	0	3	2	2	1	0	0	10	6	8	5
Femur, d	0	0	0	1	0	0	0	0	4	1	0	0
Tibia, p	0	0	0	0	2	2	0	0	3	0	2	2
Tibia, d	7	0	0	0	4	0	7	0	23	3	14	1
Calcaneum	1	0	0	0	3	0	1	0	5	2	7	1
Metatarsal, d	2	1	0	0	1	0	2	1	6	6	4	2
P1	8	1	0	0	2	0	8	1	27	18	7	1
P2	4	0	1	0	0	0	4	0	23	7	3	0

Cattle:

	C. 10th-13th		C. 13th-15th		C. 17th-18th		EM		LM		PM	
Element	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**	**NISP**	**UF**
Scapula	13	1	0	0	2	0	13	1	16	0	5	0
Humerus, p	18	17	0	0	1	0	18	17	6	5	3	1
Humerus, d	9	0	0	0	2	0	9	0	10	2	7	0
Radius, p	12	0	0	0	3	0	12	0	8	0	8	1
Radius, d	21	19	0	0	2	2	21	19	7	4	2	2
Ulna	6	6	0	0	0	0	6	6	0	0	1	0
Metacarpal, d	9	0	0	0	1	0	9	0	4	2	6	2
Pelvis	6	0	0	0	0	0	6	0	11	2	4	2
Femur, p	26	18	0	0	2	1	26	18	10	6	12	7
Femur, d	17	13	0	0	0	0	17	13	8	4	2	1
Tibia, p	17	14	0	0	1	1	17	14	2	1	5	3
Tibia, d	16	4	0	0	5	1	16	4	16	4	10	3
Calcaneum	14	7	1	0	1	1	15	7	6	2	6	3
Metatarsal, d	12	3	0	0	0	0	12	3	5	2	1	1
P1	41	1	1	0	5	0	41	1	31	3	19	4
P2	45	0	2	0	6	0	45	0	25	0	15	0

Pig:

Element	C. 10th-13th		C. 13th-15th		C. 17th-18th		EM		LM		PM	
	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF	NISP	UF
Scapula	2	2	0	0	2	0	2	2	12	2	10	6
Humerus, p	2	2	0	0	0	0	2	2	0	0	5	5
Humerus, d	4	3	0	0	0	0	4	3	11	3	10	6
Radius, p	2	1	0	0	1	0	2	1	4	0	5	4
Radius, d	2	2	1	1	0	0	2	2	2	2	6	6
Ulna	0	0	0	0	1	0	0	0	3	2	6	4
Metacarpal, d	0	0	0	0	1	0	0	0	4	3	11	9
Pelvis	1	1	0	0	1	0	1	0	5	1	6	4
Femur, p	1	1	1	1	0	0	1	1	4	4	8	8
Femur, d	0	0	0	0	0	0	0	0	1	1	7	5
Tibia, p	1	0	0	0	1	1	1	0	4	4	4	4
Tibia, d	2	2	1	1	1	1	2	2	6	2	4	4
Calcaneum	3	3	0	0	0	0	3	3	4	2	3	3
Metatarsal, d	3	2	0	0	2	0	3	2	3	3	7	5
P1	2	0	0	0	1	0	2	0	9	7	22	19
P2	3	1	2	2	2	1	3	2	12	3	19	14

Appendix 29: *Shapwick sheep metric overview:*

V = coefficient of variation

10^{th}-13^{th} century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.4	6.5	6.1	6.9	3	0.416333
M_1 W	6.8	11.1	6.0	7.5	3	0.754983
M_2 W	7.8	22.8	6.5	9.0	2	1.767767
M_3 L	21.4	3.1	20.3	22.1	7	0.652833
M_3 W	7.8	8.6	6.8	9.4	13	0.667275
Scapula GLP	29.4	0.0	29.4	29.4	1	0
Scapula SLC	17.7	9.2	16.5	18.8	2	1.626346
Humerus GLC	-	-	-	-	0	-
Humerus BT	25.5	6.0	23.7	26.4	3	1.530795
Humerus Bd	26.2	2.7	25.7	26.7	2	0.707107
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.2	3.6	12.8	13.7	3	0.472582
Radius GL	-	-	-	-	0	-
Radius Bp	28.5	8.4	26.4	31.1	3	2.400694
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 1	-	-	-	-	0	-
Metacarpal 2	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Metacarpal 4	-	-	-	-	0	-
Metacarpal 5	-	-	-	-	0	-
Pelvis LA	25.8	0.0	25.8	25.8	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	24.0	9.4	22.0	27.4	7	2.250820
Tibia Dd	18.5	11.8	16.9	23.2	7	2.175404
Astragalus GLl	26.1	7.1	24.6	28.2	3	1.858315
Astragalus GLm	25.8	8.9	23.3	28.1	4	2.294014
Astragalus Bd	17.9	9.1	16.3	19.9	4	1.637834
Astragalus Dl	15.6	9.8	14.4	17.3	3	1.530795
Calcaneum GL	54.3	0.0	54.3	54.3	1	0
Calcaneum GB	18.3	0.0	18.3	18.3	1	0
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	20.3	0.0	20.3	20.3	1	0
Metatarsal a	9.1	0.0	9.1	9.1	1	0
Metatarsal b	8.7	0.0	8.7	8.7	1	0
Metatarsal 1	9.5	0.0	9.5	9.5	1	0
Metatarsal 2	12.7	0.0	12.7	12.7	1	0
Metatarsal 3	11.4	0.0	11.4	11.4	1	0
Metatarsal 4	10.0	0.0	10.0	10.0	1	0
Metatarsal 5	13.0	0.0	13.0	13.0	1	0

13th-15th century (LM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.3	4.4	5.8	6.8	22	0.279339
M_1 W	6.9	6.1	6.1	7.5	22	0.422833
M_2 W	7.7	6.2	6.6	8.3	17	0.474264
M_3 L	20.5	5.7	18.6	23.9	38	1.170977
M_3 W	7.8	7.0	6.8	8.8	45	0.544736
Scapula GLP	29.1	11.5	24.8	34.6	10	3.340259
Scapula SLC	18.5	12.8	16.0	23.3	10	2.360414
Humerus GLC	-	-	-	-	0	-
Humerus BT	27.1	6.4	23.2	30.6	25	1.736971
Humerus Bd	28.9	7.7	23.8	33.0	25	2.221283
Humerus SD	-	-	-	-	0	-
Humerus HTC	13.6	5.7	12.1	14.9	28	0.773366
Radius GL	132.8	0.0	132.8	132.8	1	0
Radius Bp	29.5	9.9	24.4	35.3	15	2.922197
Radius SD	-	-	-	-	0	-
Radius Bd	26.7	4.7	25.0	28.0	5	1.246194
Metacarpal GL	103.7	0.0	103.7	103.7	1	0
Metacarpal SD	14.0	0.0	14.0	14.0	1	0
Metacarpal Bd	24.0	0.0	24.0	24.0	1	0
Metacarpal a	-	-	-	-	0	-
Metacarpal b	-	-	-	-	0	-
Metacarpal 1	-	-	-	-	0	-
Metacarpal 2	-	-	-	-	0	-
Metacarpal 3	-	-	-	-	0	-
Metacarpal 4	-	-	-	-	0	-
Metacarpal 5	-	-	-	-	0	-
Pelvis LA	27.2	8.6	25.8	30.7	4	2.337199
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	18.4	3.2	17.7	18.8	4	0.590903
Femur Bd	32.2	0.0	32.2	32.2	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	25.2	7.9	21.7	28.6	20	1.986236
Tibia Dd	19.5	7.2	17.4	21.8	20	1.413199
Astragalus GLl	26.1	5.3	24.1	29.5	17	1.395950
Astragalus GLm	25.2	6.3	22.7	28.6	17	1.589858
Astragalus Bd	17.1	7.1	15.3	20.1	20	1.212859
Astragalus Dl	14.9	8.7	12.8	17.8	19	1.29865
Calcaneum GL	52.3	8.5	48.0	56.9	3	4.461315
Calcaneum GB	16.3	6.7	15.4	17.5	3	1.096966
Metatarsal GL	103.7	0.0	103.7	103.7	1	0.00000
Metatarsal SD	14.0	0.0	14.0	14.0	1	0.000000
Metatarsal Bd	24.0	0.0	24.0	24.0	1	0
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 1	-	-	-	-	0	-
Metatarsal 2	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
Metatarsal 4	-	-	-	-	0	-
Metatarsal 5	-	-	-	-	0	-

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17th-18th century (PM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	6.1	4.8	5.6	6.8	14	0.292018
M_1 W	7.0	7.8	6.1	8.0	10	0.545283
M_2 W	7.8	8.5	6.8	8.7	8	0.662786
M_3 L	20.7	5.1	18.0	22.9	43	1.052424
M_3 W	7.8	7.3	6.8	9.0	55	0.567154
Scapula GLP	31.4	7.8	27.2	35.1	10	2.442244
Scapula SLC	19.2	9.3	16.0	22.8	14	1.77957
Humerus GLC	127.3	0.0	127.3	127.3	1	0
Humerus BT	26.8	8.2	23.8	30.8	18	2.190234
Humerus Bd	27.9	9.8	24.7	34.5	16	2.727995
Humerus SD	16.4	0.0	16.4	16.4	1	0
Humerus HTC	13.4	9.0	11.4	16.1	19	1.210166
Radius GL	136.1	6.0	129.0	145.0	3	8.161699
Radius Bp	29.9	5.5	27.1	32.2	12	1.633086
Radius SD	16.9	9.9	15.0	18.2	3	1.665333
Radius Bd	27.7	5.1	26.2	30.0	6	1.41197
Metacarpal GL	118.7	0.0	118.7	118.7	1	0
Metacarpal SD	13.4	0.0	13.4	13.4	1	0
Metacarpal Bd	26.1	8.7	24.5	27.7	2	2.262742
Metacarpal a	11.9	5.9	11.4	12.4	2	0.707107
Metacarpal b	11.3	8.2	10.6	11.9	2	0.919239
Metacarpal 1	10.8	0.7	10.7	10.8	2	0.070711
Metacarpal 2	14.5	6.8	13.8	15.2	2	0.989949
Metacarpal 3	13.2	2.1	13.0	13.4	2	0.282843
Metacarpal 4	9.7	2.2	9.5	9.8	2	0.212132
Metacarpal 5	14.3	5.9	13.7	14.9	2	0.848528
Pelvis LA	25.2	5.6	24.2	26.2	2	1.414214
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	19.9	12.0	17.2	21.8	3	2.386071
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	26.3	7.4	23.6	29.2	11	1.937149
Tibia Dd	20.1	9.8	17.6	23.7	11	1.963901
Astragalus GLl	26.7	5.7	24.8	28.6	7	1.51595
Astragalus GLm	25.7	7.0	23.4	28.0	6	1.791089
Astragalus Bd	16.9	4.9	16.2	18.6	7	0.824043
Astragalus Dl	15.3	5.1	14.3	16.4	7	0.773366
Calcaneum GL	53.8	1.7	52.9	54.8	4	0.917878
Calcaneum GB	17.4	2.0	16.9	17.7	4	0.355903
Metatarsal GL	113.2	14.6	101.5	124.8	2	16.47559
Metatarsal SD	11.1	22.4	9.3	12.8	2	2.47487
Metatarsal Bd	22.5	11.9	20.6	24.4	2	2.68701
Metatarsal a	10.5	5.4	10.1	10.9	2	0.56569
Metatarsal b	10.8	12.5	9.8	11.7	2	1.34350
Metatarsal 1	9.3	16.1	8.2	10.3	2	1.48492
Metatarsal 2	14.4	8.8	13.5	15.3	2	1.27279
Metatarsal 3	11.8	7.2	11.2	12.4	2	0.84853
Metatarsal 4	8.1	10.5	7.5	8.7	2	0.84853
Metatarsal 5	13.7	9.8	12.7	14.6	2	1.34350

Appendix 30: *Shapwick cattle metric overview:*

V = coefficient of variation

10^{th}-13^{th} century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.7	11.6	10.2	12.8	3	1.361372
M_1 W	13.6	4.0	12.3	14.4	12	0.547723
M_2 W	14.1	6.1	12.2	15.3	15	0.856794
M_3 L	34.1	6.3	29.9	36.9	20	2.143029
M_3 W	13.7	9.7	11.3	17.0	22	1.327147
Scapula GLP	61.4	5.0	57.0	67.1	10	3.042459
Scapula SLC	45.2	4.5	42.0	49.4	10	2.051801
Humerus GLC	-	-	-	-	0	-
Humerus BT	69.2	4.4	62.1	72.5	9	3.021635
Humerus SD	-	-	-	-	0	-
Humerus HTC	30.8	11.3	29.2	40.4	9	3.487119
Radius GL	270.0	0.0	270.0	270.0	1	0.000000
Radius SD	38.1	0.0	38.1	38.1	1	0.000000
Radius Bd	63.7	6.3	60.8	66.5	2	4.030509
Metacarpal GL	182.9	3.3	173.0	189.0	8	6.040045
Metacarpal SD	28.5	10.7	25.1	35.3	8	3.035034
Metacarpal Bd	57.1	7.5	49.7	65.4	9	4.267025
Metacarpal BatF	50.2	6.5	45.2	57.0	9	3.281175
Metacarpal a	27.8	8.4	23.7	32.0	9	2.346688
Metacarpal b	26.6	8.3	23.1	31.3	9	2.219297
Metacarpal 3	28.0	5.5	24.9	29.6	9	1.552417
Pelvis LA	60.9	9.4	55.1	66.5	3	5.702631
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	38.1	9.7	34.7	43.6	6	3.704277
Femur Bd	82.2	10.8	75.9	88.4	2	8.838835
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	56.0	8.5	48.0	64.9	12	4.783962
Tibia Dd	44.6	10.3	39.2	55.7	12	4.593540
Astragalus GLl	58.5	4.6	52.6	62.1	14	2.668168
Astragalus GLm	53.9	3.7	50.9	56.9	14	2.016648
Astragalus Bd	37.8	6.2	33.7	41.2	14	2.326637
Astragalus Dl	34.3	4.4	31.3	36.6	13	1.509203
Calcaneum GL	117.8	13.7	106.1	136.6	3	16.166117
Calcaneum GB	37.0	8.5	33.9	40.4	5	3.161171
Metatarsal GL	205.3	3.8	196.5	217.0	6	7.820912
Metatarsal SD	23.7	9.9	20.4	27.0	6	2.340726
Metatarsal Bd	51.5	5.9	47.4	54.6	7	3.059879
Metatarsal BatF	45.1	7.0	40.2	48.9	9	3.170568
Metatarsal a	24.8	7.6	21.3	27.8	9	1.886428
Metatarsal b	23.0	6.8	20.6	25.0	8	1.565704
Metatarsal 3	25.5	7.1	22.4	28.4	9	1.804162

13th-15th century (LM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.0	9.0	10.3	12.1	3	0.986577
M_1 W	10.2	0.0	10.2	10.2	1	0
M_2 W	-	-	-	-	0	-
M_3 L	33.7	6.0	32.3	36.0	3	2.007486
M_3 W	13.3	11.0	11.4	15.4	5	1.460137
Scapula GLP	64.6	10.0	54.3	75.0	8	6.441481
Scapula SLC	47.5	8.0	42.1	54.8	11	3.798181
Humerus GLC	-	-	-	-	0	-
Humerus BT	68.8	4.5	66.3	72.3	3	3.122499
Humerus SD	-	-	-	-	0	-
Humerus HTC	30.2	7.0	27.0	33.6	7	2.121994
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	62.9	0.0	62.9	62.9	1	0
Metacarpal GL	198.0	0.0	198.0	198.0	1	0
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	57.5	13.7	51.9	63.0	2	7.848885
Metacarpal BatF	52.1	7.7	49.2	54.9	2	4.030509
Metacarpal a	27.5	14.7	24.6	30.3	2	4.030509
Metacarpal b	27.0	14.4	24.2	29.7	2	3.889087
Metacarpal 3	28.1	9.3	26.2	29.9	2	2.616295
Pelvis LA	56.0	27.9	44.9	67.0	2	15.62706
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	40.3	3.9	38.7	42.3	4	1.566312
Femur Bd	97.5	0.0	97.5	97.5	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	60.0	7.0	54.2	68.9	11	4.221697
Tibia Dd	43.6	7.9	38.6	49.4	11	3.435642
Astragalus GLl	60.7	5.5	54.8	69.4	15	3.315734
Astragalus GLm	55.1	4.9	51.7	62.2	16	2.682008
Astragalus Bd	38.7	7.6	34.0	45.1	18	2.93688
Astragalus Dl	34.4	7.3	29.9	38.9	16	2.511275
Calcaneum GL	123.2	0.1	123.1	123.3	2	0.141421
Calcaneum GB	40.7	10.1	37.7	46.4	4	4.106093
Metatarsal GL	214.7	5.3	201.5	222.0	3	11.427306
Metatarsal SD	24.3	4.8	23.1	25.4	3	1.159023
Metatarsal Bd	54.6	8.2	51.4	57.7	2	4.454773
Metatarsal BatF	48.1	2.4	47.3	48.9	2	1.131371
Metatarsal a	26.7	12.7	24.3	29.1	2	3.394113
Metatarsal b	24.7	4.3	23.9	25.4	2	1.06066
Metatarsal 3	27.7	0.5	27.6	27.8	2	0.141421
					169	

17th-18th century (PM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4 W	11.9	10.2	10.1	13.7	16	1.214753
M_1 W	12.1	0.0	12.1	12.1	1	0
M_2 W	12.1	0.0	12.1	12.1	1	0
M_3 L	33.6	7.6	30.7	37.4	5	2.544209
M_3 W	13.3	14.2	11.1	17.4	10	1.895052
Scapula GLP	62.5	19.7	53.8	71.2	2	12.30366
Scapula SLC	49.0	0.0	49.0	49.0	1	0
Humerus GLC	-	-	-	-	0	-
Humerus BT	76.6	7.8	67.5	84.3	6	5.972744
Humerus SD	-	-	-	-	0	-
Humerus HTC	35.1	10.7	29.6	40.2	7	3.74363
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	201.0	7.7	190.0	212.0	2	15.55635
Metacarpal SD	31.6	8.5	29.7	33.5	2	2.687006
Metacarpal Bd	59.5	6.9	56.4	64.1	3	4.082075
Metacarpal BatF	53.5	7.9	49.4	59.3	4	4.21693
Metacarpal a	28.6	5.5	27.2	30.3	3	1.563117
Metacarpal b	27.9	6.8	26.3	30.0	3	1.90000
Metacarpal 3	28.5	9.4	26.6	31.6	3	2.685765
Pelvis LA	70.9	0.0	70.9	70.9	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	45.6	14.6	39.5	55.9	5	6.672106
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	62.4	5.8	58.3	65.7	4	3.649087
Tibia Dd	47.3	12.7	43.0	51.5	2	6.010408
Astragalus GLl	63.5	7.5	58.5	69.9	5	4.771059
Astragalus GLm	57.5	5.5	54.2	62.6	6	3.177683
Astragalus Bd	40.3	8.3	35.8	45.1	7	3.343508
Astragalus Dl	35.6	6.0	32.9	38.0	4	2.126617
Calcaneum GL	133.2	4.0	127.2	137.5	3	5.340724
Calcaneum GB	41.9	6.5	37.9	43.7	4	2.703547
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal BatF	-	-	-	-	0	-
Metatarsal a	-	-	-	-	0	-
Metatarsal b	-	-	-	-	0	-
Metatarsal 3	-	-	-	-	0	-
					110	

Appendix 31: *Shapwick pig metric overview:*

V = coefficient of variation

10th-13th century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.2	4.7	16.6	19.4	7	0.85049
dP_4 WP	8.2	4.4	7.9	9.0	7	0.359232
M_1 L	16.4	9.2	13.4	17.8	10	1.502775
M_1 WA	9.9	6.2	8.9	10.6	10	0.616892
M_1 WP	10.5	3.2	9.8	10.9	9	0.339116
M_2 L	18.8	14.0	16.9	20.6	2	2.616295
M_2 WA	12.1	0.0	12.1	12.1	2	0.000000
M_2 WP	12.2	1.7	12.0	12.3	2	0.212132
M_3 L	28.4	11.2	25.5	31.8	3	3.179623
M_3 WA	14.0	9.6	12.9	15.5	3	1.345362
M_3 WC	13.5	4.6	12.7	14.1	4	0.623832
M_3 WP	10.7	11.3	9.4	11.9	4	1.212092
M^3L	27.9	0.0	27.9	27.9	1	0
M^3WA	11.7	0.0	11.7	11.7	1	0
M^3WC	14.7	0.0	14.7	14.7	1	0
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	112.4	0.1	112.3	112.5	2	0.141421
Humerus BT	35.0	22.2	29.5	40.5	2	7.778175
Humerus SD	-	-	-	-	0	-
Humerus HTC	20.95	20.6	17.9	24	2	4
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Pelvis LAR	31.3	0.0	31.3	31.3	1	0
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	34.8	6.6	32.2	38.3	5	2.284075
Astragalus GLm	33.1	6.3	30.4	36.1	5	2.090933
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	76.5	0.0	76.5	76.5	1	0
					84	

13th-15th century (LM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.1	4.0	17.2	19.3	7	0.727684
dP_4 WP	8.3	6.4	7.6	9.2	7	0.534522
M_1 L	16.1	8.0	14.0	18.3	12	1.295768
M_1 WA	9.7	4.9	9.0	10.4	12	0.478872
M_1 WP	10.4	4.8	9.5	11.0	12	0.497874
M_2 L	20.0	3.5	19.1	21.2	11	0.691375
M_2 WA	11.8	4.4	11.1	12.8	11	0.517863
M_2 WP	12.4	3.5	11.2	13.0	11	0.436723
M_3 L	30.4	8.7	24.4	34.0	13	2.653469
M_3 WA	15.6	12.2	12.9	19.3	15	1.908178
M_3 WC	14.2	7.8	12.4	16.6	15	1.112055
M_3 WP	11.4	9.9	8.7	13.0	13	1.130747
M^3L	28.9	0.0	28.9	28.9	1	0.000000
M^3WA	16.3	0.0	16.3	16.3	1	0.000000
M^3WC	13.4	0.0	13.4	13.4	1	0.000000
Scapula GLP	31.7	6.0	28.6	33.1	6	1.887856
Scapula SLC	23.0	6.3	20.1	24.5	10	1.457547
Humerus GLC	-	-	-	-	0	-
Humerus BT	32.0	4.9	31.1	34.0	5	1.570669
Humerus SD	-	-	-	-	0	-
Humerus HTC	18.6	5.4	17.0	19.6	5	1.011435
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	68.2	0.0	68.2	68.2	1	0.000000
Pelvis LAR	29.6	5.7	27.7	30.7	3	1.677299
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	30.3	11.5	27.1	34.0	3	3.470351
Tibia Dd	26.3	9.5	23.7	28.7	3	2.502665
Astragalus GLl	35.9	0.0	35.9	35.9	2	0.000000
Astragalus GLm	32.8	9.6	28.2	35.1	4	3.153173
Calcaneum GL	69.4	0.0	69.4	69.4	1	0.000000
Calcaneum GB	21.8	0.0	21.8	21.8	1	0.000000
Metatarsal GL	-	-	-	-	0	-
					186	

17th-18th century (LM):

Measurement	Mean	V	Min.	Max.	N	s.d.
dP_4L	18.7	4.1	17.3	19.7	9	0.766485
dP_4 WP	8.5	3.7	7.8	8.9	9	0.315348
M_1 L	16.6	10.2	13.9	18.6	11	1.698716
M_1 WA	10.1	7.4	8.3	10.9	11	0.750151
M_1 WP	11.0	5.3	9.9	11.6	11	0.583095
M_2 L	20.1	10.9	17.7	23.1	6	2.195146
M_2 WA	12.1	8.4	10.3	13.0	6	1.017841
M_2 WP	12.9	6.9	11.5	13.6	6	0.886942
M_3 L	30.9	5.4	28.2	32.4	5	1.657408
M_3 WA	15.3	8.9	13.9	17.1	5	1.369185
M_3 WC	14.4	5.4	13.5	15.4	6	0.773089
M_3 WP	11.8	8.0	10.4	12.8	6	0.939503
M^3L	-	-	-	-	0	-
M^3WA	-	-	-	-	0	-
M^3WC	-	-	-	-	0	-
Scapula GLP	37.3	17.2	30.0	43.0	4	6.430137
Scapula SLC	24.9	11.0	21.2	26.6	4	2.746513
Humerus GLC	-	-	-	-	0	-
Humerus BT	35.3	12.0	31.1	41.0	4	4.24215
Humerus SD	-	-	-	-	0	-
Humerus HTC	20.0	15.4	17.1	24.2	4	3.076118
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	75.2	22.2	63.4	87.0	2	16.68772
Pelvis LAR	43.2	13.4	39.1	47.3	2	5.798276
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	46.8	5.9	44.8	48.7	2	2.757716
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GLl	49.7	1.7	49.1	50.3	2	0.84853
Astragalus GLm	44.3	0.0	44.3	44.3	1	0
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	84.9	0.0	84.9	84.9	1	0.0
					117	

Appendix 32: *Shapwick horse metric overview:*

V = coefficient of variation

10^{th}-13^{th} century (EM):

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	32.2	3.0	31.3	33.2	3	0.960902
M_3W_a	13.5	7.4	12.7	14.6	3	1.001665
M_3W_d	-	-	-	-	0	-
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	72	0.0	72	72	1	0
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	66.6	0.0	66.6	66.6	1	0
Tibia Dd	52.3	0.0	52.3	52.3	1	0
Astragalus GH	60.6	0.0	60.6	60.6	1	0
Astragalus GB	69.2	0.0	69.2	69.2	1	0
Astragalus Bfd	57.6	0.0	57.6	57.6	1	0.0
Astragalus LmT	57.5	0.0	57.5	57.5	1	0.0
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	54.2	0.0	54.2	54.2	1	0
Metatarsal GL	274.7	5.7	258.0	289.0	3	15.63117
Metatarsal SD	31.0	9.4	27.8	33.5	3	2.91376
Metatarsal Bd	51.2	7.3	47.0	54.0	3	3.72335
Metatarsal Dd	39	8.1	35.4	41.3	3	3.157531
Phalanx 1 GL	79.5	14.0	71.4	92.2	3	11.11635
Phalanx 1 Bp	53.1	14.0	45.4	60.3	3	7.459446
Phalanx 1 DP	36.6	12.0	32.2	41	3	4.400379
Phalanx 1 SD	33.7	6.2	31.9	36	3	2.084067
Phalanx 1 Bd	45.1	12.4	51.1	40	3	5.596725
Phalanx 1 Dd	23.6	21.0	18.3	28.1	3	4.95715

<u>13th-15th century (LM):</u>

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	25.3	0.0	25.3	25.3	1	0
M_1W_a	15.2	0.0	15.2	15.2	1	0
M_1W_d	4.3	0.0	4.3	4.3	1	0
M_2L_1	25.7	0.0	25.7	25.7	1	0
M_2W_a	15.5	0.0	15.5	15.5	1	0
M_2W_d	4.2	0.0	4.2	4.2	1	0
M_3L_1	36.3	11.0	30.8	40.9	5	4.010611
M_3W_a	15.9	22.0	12.1	20.5	5	3.50214
M_3W_d	3.7	28.6	2.9	4.9	3	1.058301
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	-	-	-	-	0	-
Humerus SD	-	-	-	-	0	-
Humerus HTC	-	-	-	-	0	-
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	-	-	-	-	0	-
Metacarpal SD	-	-	-	-	0	-
Metacarpal Bd	-	-	-	-	0	-
Metacarpal Dd	-	-	-	-	0	-
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	-	-	-	-	0	-
Femur Bd	-	-	-	-	0	-
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	65.7	1.6	64.9	66.4	2	1.06066
Tibia Dd	41.4	1.5	40.9	41.8	2	0.636396
Astragalus GH	60.1	9.5	54.1	65.5	3	5.723635
Astragalus GB	60.3	11.4	55.5	68.2	3	6.89420
Astragalus Bfd	52.2	7.1	49.8	56.5	3	3.70720
Astragalus LmT	59.4	9.3	54.1	65.1	3	5.51090
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	50.6	0.0	50.6	50.6	1	0
Metatarsal GL	242.0	0.0	242.0	242.0	1	0
Metatarsal SD	30.6	0.0	30.6	30.6	1	0
Metatarsal Bd	44.7	0.0	44.7	44.7	1	0
Metatarsal Dd	33.8	0.0	33.8	33.8	1	0
Phalanx 1 GL	83.2	0.0	83.2	83.2	1	0
Phalanx 1 Bp	55.1	0.0	55.1	55.1	1	0
Phalanx 1 DP	40.7	0.0	40.7	40.7	1	0
Phalanx 1 SD	32.6	8.2	30.7	34.5	2	2.687006
Phalanx 1 Bd	43.0	8.5	38.8	46.2	4	3.638223
Phalanx 1 Dd	23.3	11.0	20.5	26.7	4	2.559134

17th-18th century (PM):

Measurement	Mean	V	Min.	Max.	N	s.d.
$P_4 L_1$	-	-	-	-	0	-
P_4W_a	-	-	-	-	0	-
P_4W_d	-	-	-	-	0	-
M_1L_1	-	-	-	-	0	-
M_1W_a	-	-	-	-	0	-
M_1W_d	-	-	-	-	0	-
M_2L_1	-	-	-	-	0	-
M_2W_a	-	-	-	-	0	-
M_2W_d	-	-	-	-	0	-
M_3L_1	31.3	7.7	28.8	31.4	3	2.402776
M_3W_a	13.7	5.4	12.9	14.3	3	0.737111
M_3W_d	4.3	29.6	3.4	5.2	2	1.272792
Scapula GLP	-	-	-	-	0	-
Scapula SLC	-	-	-	-	0	-
Humerus GLC	-	-	-	-	0	-
Humerus BT	88.9	0.0	88.9	88.9	1	0
Humerus SD	-	-	-	-	0	-
Humerus HTC	45.4	0.0	45.4	45.4	1	0
Radius GL	-	-	-	-	0	-
Radius SD	-	-	-	-	0	-
Radius Bd	-	-	-	-	0	-
Metacarpal GL	219.3	11.8	201.0	237.5	2	25.8094
Metacarpal SD	28.9	0.0	28.9	28.9	1	0
Metacarpal Bd	47.8	17.5	41.9	53.7	2	8.34386
Metacarpal Dd	36.0	16.1	31.9	40.1	2	5.798276
Pelvis LAR	-	-	-	-	0	-
Femur GL	-	-	-	-	0	-
Femur SD	-	-	-	-	0	-
Femur DC	53.9	14.1	45.5	60.3	3	7.613365
Femur Bd	81.6	0.0	81.6	81.6	1	0
Tibia GL	-	-	-	-	0	-
Tibia SD	-	-	-	-	0	-
Tibia Bd	-	-	-	-	0	-
Tibia Dd	-	-	-	-	0	-
Astragalus GH	-	-	-	-	0	-
Astragalus GB	57.5	0.0	57.5	57.5	1	0
Astragalus Bfd	49.2	0.0	49.2	49.2	1	0.0
Astragalus LmT	-	-	-	-	0	-
Calcaneum GL	-	-	-	-	0	-
Calcaneum GB	-	-	-	-	0	-
Metatarsal GL	-	-	-	-	0	-
Metatarsal SD	-	-	-	-	0	-
Metatarsal Bd	-	-	-	-	0	-
Metatarsal Dd	-	-	-	-	0	-
Phalanx 1 GL	82.3	0.0	82.3	82.3	1	0
Phalanx 1 Bp	52.0	34.5	47.2	56.7	2	17.94666
Phalanx 1 DP	37.8	8.2	35.6	40	2	3.11127
Phalanx 1 SD	34.3	13.1	30	39	3	4.50925
Phalanx 1 Bd	41.7	2.6	40.3	42.3	4	1.090489
Phalanx 1 Dd	21.7	12.3	18.9	24.1	4	2.661297