A Critical Study of Zooarchaeology and its Applications and Limitations, With Specific Reference to St Dunstan's Church, Monks Risborough.

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DECLARATION

I declare that this dissertation has been composed by myself and that the work of which it is a record was performed by myself. The dissertation has not been admitted in any previous application for a degree at this or any other university. All sources of information have been specifically acknowledged.

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Abstract

This research aims to answer the questions why is it important to study zooarchaeological data and what can it tell us? As well as addressing the question of what issues may arise from studying the assemblages. Zooarchaeological research can help to answer a multitude of questions, providing an insight into domestication, migration, demography, trade, economy, husbandry and status of communities through time. As outlined in chapter two this does not come without its challenges. It is important to understand the burial environment and pressures exerted on the assemblage in order to obtain the best interpretation. The site of St Dunstan's whilst having a small assemblage has yielded a rich tapestry of information on husbandry techniques as well as herd uses. Whilst this site appears insular we have taken into account the wider archaeological landscape to analyses possible contemporaneous sites as well as travelling further afield to highlight changes in approaches with larger assemblages.

Introduction

This project is designed to answer the following research questions; why study zooarchaeological assemblages? What issues may arise? It will focus on the benefits and practicalities of using zooarchaeological methods in the field and laboratory settings and what we can gain from its use. This will be done through the presentation and analysis of a case study of a multi-phase site, St Dunstan's Church excavated in 2013 in Monks Risborough in Buckinghamshire and draw on information from the wider wealth of zooarchaeological literature.

It is vital to understand the benefits and limitations of zooarchaeological research as animal bone is not mute, such remains are often present at sites and provide more information than other artefacts as they provide a snapshot into domestic, husbandry, butchery and craft processes. This paints a detailed canvas of what life was actually like in the period the bones were from. Therefore, they are a valuable part of a sites assemblage. Zooarchaeological research is vital in permitting accurate interpretations as it can answer research questions from the local small scale to the large scale. It can inform us on domestication practices, migration patterns in the past as well as status. Therefore, it is a vital tool in the archaeologists' arsenal, one which needs to be conducted critically, with awareness of possible biases that may arise.

Taphonomy and Pathology are fundamental issues in zooarchaeology that need to be considered when dealing with an assemblage that we are attempting to extract information from, we need to be aware of factors which could create biases in the assemblages. Animal bone is no exception, the nature of the organic artefact results in some issues which need to be recognised and anticipated. Bones can alter post deposition through a variety of processes that are explained by Taphonomy. This includes processes such as weathering, leaching, carnivorous action etc. The field of Taphonomy is growing, however most research is still focused on the action of scavengers and carnivores on bone, therefore, it is important to recognise that some aspects may be limited due to lack of extensive reliable research. Bones can also exhibit pathologies that can exhibit in a similar way to taphonomic activities, therefore it is vital that we are aware of these and can identify the differences if we are to produce accurate data. Pathologies can inform us about societal thinking at the time, i.e. if an animal suffers a fracture is it cared for and nursed back to health or is it killed. This information offers more than the superficial they were using this practice or doing this task, it gives us an insight into the cognitive reasoning behind certain actions that are exhibited in the archaeological record.

The project will compare the assemblage found and analysed at St Dunstan's, with other sites in the local Chiltern Hills area and in the wider Buckinghamshire landscape and beyond, in the hopes to identify patterns at the sites such as unique herds present at or practices performed at certain sites in the area. The Chiltern Hills provides a geographical boundary, whose geology will have remained consistent since the ice age. The soils tend to be chalky and hard to excavate and therefore contain more calcium carbonate, thus making them more alkaline enabling the preservation of bones which may not have normally survived. However, at St Dunstan's the site was excavated without sieving resulting in the loss of this fragile material that may not have been noticed when hand excavating. The project will draw together conclusions on the data set from these sites and providing a central point for starting research on the bone material in the future. Consequently this project is vital to the academic community as well as local heritage groups and the general public.

St Dunstan's excavation was a community based project that occurred as a requirement of planning permission. This has resulted in a strong local community involvement and interest in the project and the outcome of further analysis of the assemblages. Subsequently it is important to recognise the human interest element that exists outside the scientific community and their thirst for further knowledge. Therefore, although you have all the problems that arise from a volunteer workforce, it was vital in this case to the timeline and actively engaged the general public. Consequently, this excavation has fostered the public's interest and enhanced public and community archaeology in this area.

This project will investigate the nature of the site by looking at it in context with other known sites in the area. To do this the case study will outline the methodology and the results of the analysis of the assemblage obtained from St Dunstan's. Much of the assemblage is fragmentary it is vital to put the small sample of identifiable bones from this site into the wider context. This will therefore, enable us to identify any similarities and differences at St Dunstan's compared with the local landscape which dates from the Neolithic though to Historic Eras.

Whilst the landscape of St Dunstan's in Monks Risborough is rich in prehistory, it is important to recognise contemporaneous sites which may have influenced St Dunstan's site use and the processes that occurred there. This case study is an ideal opportunity to assess zooarchaeological uses, procedures and highlight potential issues that may arise on such sites. The small zooarchaeological assemblage enables a manageable evaluation of the site in the broader context of the research questions addressed above.

What are the uses of zooarchaeological data to the broader discipline of archaeology? What can bones tell us about the site?

The use of bones in archaeology has enabled us to study a whole host of questions raised about the past from the artefacts themselves and has consequently removed an element of subjective interpretation. Modern analogies are useful in corroborating patterns seen in the archaeological bone, thus increasing the validity of interpretations. Zooarchaeological methods are constantly evolving, from basic typological identification, to use-wear analysis, tool mark analysis, stable isotope and DNA studies. These methods can illuminate different aspects of, or provide a cohesive picture of the life of the bone and inform us about issues like husbandry and butchery processes, status and economy.

Zooarchaeological data has the ability to help answer the wider questions in archaeology, such as domestication and demography as well as migration patterns. Thus, our understanding can be greatly improved by appreciating the faunal remains from the past and what they can tell us. Some studies that will be highlighted later in this chapter have sighted the use of zooarchaeological data in modern applications such as wildlife management. Therefore, the continued study of zooarchaeological data not only assists in the field of archaeology but actively contributes to our world in other fields.

Subsistence is crucial in archaeology; it is a key element of the hunter-gatherer shift to pastoralism and farming. This shift can be represented in the zooarchaeological record by looking at the existence and absence of certain bones on the site we can ascertain dietary changes. The detail that is obtained from the assemblage depends on the method chosen. Typological data will inform you of what species and elements are present, from this we can establish which elements are being used, i.e. one side of the animal or if the non-meat rich skeletal elements remain. If long bone shafts are broken lengthwise then this may indicate marrow extraction. Typological data will provide you with basic but very useful data on the assemblage, from this you can find interpret husbandry and butchery techniques and possibly status if compared the assemblage is large enough or can be compared with others in the region that have already be investigated. It is also important to recognise taphonomic issues as evidenced in Greenfield 1988 study into bone consumption in a contemporary village in Serbia. By recognising the potential issues that you may face with preservation of assemblages you are able to create a more comprehensive and less biased interpretation. Other issues that need to be considered is the worldview of the community you are investigating when making interpretations as some elements may be associated with ritual deposits. If budget and timescales allow it may be possible to perform stable isotope tests on the appropriate elements like teeth such as Rb-St to look at where the animal originated, and to investigate diet.

Subsistence patterns are heavily influenced by climactic factors in the region at the time as well as the quality of the soils. Soil degradation and adverse climate conditions in Iceland led to the interpretation that once the soils were no longer productive farmsteads were abandoned (Edvardsson Et Al 2004). This research identified an insular subsistence with limited trading. The diet consisted of sea mammals, birds and fishing. Therefore, the zooarchaeological record in this case has greatly increased our understanding of the site, and the technologies they had available at that time such as seal hunting equipment, which consequently provides a rich idea of what Icelandic life may have been like in the 18th Century farmstead that Edvardsson Et Al investigated. Research into the investigation of the Dordogne region in France into land use and subsistence at the Pleistocene-Holocene transition indicates shifting subsistence patterns from more local resources to those at higher altitudes. The zooarchaeological material here has supported this notion of a broader dietary transition. Therefore, inferences can be made from the evidence of the cause of this shift; it may be due to climate changes in this period or a need to exploit higher altitude due to availability or population pressure (Lena Jones 2007). As these examples have shown, bones have the ability to answer the bigger questions in archaeology.

Migration is another area where zooarchaeological data can be very useful. Studies such as dating the late prehistoric dispersal of Polynesians to New Zealand using the commensal Pacific rat, where the commensal rat can be used as a proxy of human migration and demography are useful as they highlight the unwanted human impact on the environment (Wilmshurst Et Al. 2008). Such studies have also been done on the European migration routes, where rats accompanied trade along the silk route. This form of proxy is also useful with other insects which are only found in latrine settings

(Reinhard Et Al 1986). This phenomenon of parasites relying on another species does not only exist with humans. The presence of large quantities of sheep tics can be useful in deciphering special orientation within settlements. High proportions of these types of tics can indicate wool processing areas. These parasitic studies are very useful as an interpretive tool in archaeology (Reinhard 1992). However, migration can also be tracked with morphological differences in animals as well as genetic testing as outlined later in this chapter by Larson Et Al 2005 paper into Wild Boar domestication.

Husbandry and butchery can leave clear markings on the bones. We can tell from the study of domesticated animal bone that humans have been exploiting animals routinely in farming. This is evidenced by the study by De Cupere et al Into the depressions on the bone that is caused by draught exploitation (De Cupere 2000). However, we need to be cautious when assigning causes to abnormalities in bone as you can read in chapter three. We can also see farming and industrial practices in the amount of insects that are species dependent in an area. This would require fine sieving and flotation during the excavation period. Zooarchaeology can also indicate what herd types were present on the site. The kill off patterns of sheep will result in different representations within the zooarchaeological record depending of the herd purpose, wool, meat or milk. In investigation in the Central Balkans, there was a shift noticed moving from primary kill offs for meat to secondary ones for wool and milk. This is interpreted as due to changing human populations and changes in exchange processes during the post-Neolithic period in this region (Greenfield 1988). Therefore, it is reasonable to deduce that bones and teeth can also indicate patterns of social and economic changes through the period the site was in use. Sited in Greenfields references for this paper is the observation shown by Payne in 1973 in relation to the kill off patterns in sheep and goats form the Asvan Kale. Payne put forward comparative data to illustrate the ages of the teeth found in different kill off patterns.

Trade can be identified in the archaeological record by the presence or absence of certain skeletal elements at sites. Bones can indicate primary kill sites, butchery sites, producer sites and consumer sites. We as archaeologists look at what cuts of meat were available on the site we are excavating and waste products present. Exotic animals can be identified through faunal analysis, thus we can make interpretations of the sites potential status and the form of economy present. Crabtree 1990 argues that whilst zooarchaeological data is normally synonymous with simple hunter gather sites, you can use the same principals in many more complex sites such as urban centres. Thus, giving us a greater understanding of the relations between people who occupied the site. Studies of exchange have mainly focused on three variables; range of species, relative importance of different species and the ratio between ages of species and sex of species (Maltby 1985).

Domestication is a diverse and demanding issue to study, once again zooarchaeological data can aid in this. The use of DNA and stable isotope methods on bones and teeth can help to identify the origins of the bone donor and can indicate herding methods from the levels of isotopes. This can identify wild or domestic animals, which is vital in understanding human evolution and anthropogenic processes in the past. Genetic investigation into the origins of wild boar domestication had indicated that there are multiple centres of domestication (Larson et al 2005). The study has changed the way we think in regards to wild boar domestication originating in the Near East. The advances in genetic and morphological methods has enabled greater study into the zooarchaeological remains and resulted in a better understanding of how pigs arrived in Europe.

Status and ethnicity can be investigated through the use of zooarchaeological data. However, these are hard to establish through faunal analysis alone and needs to be supported by artefactual evidence. Crabtree 1990 highlights the difficulties of establishing ethnicity in the archaeological record but commends Langenwalter's 1989 study of the faunal remains from a mid-nineteenth century lower china store in California. Langenwalter was able to establish different butchery patterns of the Chinese and Anglo-Americans. The Chinese used cleavers and supplied the pigs to miners working in the area; in contrast the Anglo-Americans used saws and traded to the store. However, defining culture is often complex as is the way in which ethnicity may be illustrated in the archaeological record (Crabtree 1990). This is also highlighted in a palaeoethnobonical and zooarchaeological investigation into the British Columbia Plateau Keatley Creek site. Lepofsky Et Al 1996's study into 119 house depressions found rich faunal remains in the larger houses compared with medium and smaller sized houses suggested that activities may have been undertaken communally but the spatial proportions of houses suggested groups with unequal socio-economic status. However, they point out that further research would have to be done as the groups are not clearly defined. (Lepofsky Et Al 1996). Reid 1996 puts forward the notion that in investigations into archaeological remains of herds in Eastern and Southern Africa the presence of immature individuals in the archaeological record illustrates site of elite. The idea that status arose from larger and more robust herds is still in existence today and was a fundamental part of historical communities in which value of potential wives were equated to livestock values (Reid 1996). Roman elite had more robust cattle available to them due to their status and the hierarchy that is present in Roman Society. Consequently, we get an understanding of demography and the economy through the archaeological remains, but as the case studies indicate, values in relation to status and ethnicity change depending on your view point and it is important to resist projecting our ideas onto cultures in the past.

Animal bones can act as proxies for human demography. Changes in amounts of small mammal bones present at a site could be explained by the increase in population in that time period. This has been investigated with Palaeolithic population growth in the Mediterranean region, and resulted in the idea that growth pulses in this region can be identified through the assemblages that are high in small mammals which reproduce faster (Stiner et al 1999). Other research in the Levant highlights potential population increases evidence by the shift in subsistence practices to utilise smaller animals and juvenile gazelle (Davis 2005). Therefore, zooarchaeological assemblages can be useful in paleodemography.

Certain assemblages may be confusing at first and modern analogies may need to be sought in order to make sense of the remains. In certain cultures such as the tribal population of Tamil Nadu, bones have therapeutic uses and therefore, would be underrepresented in the archaeological record. The Tamil Nadu used sixteen different animal species to treat many diseases or ailment such as asthma, arthritis and leprosy (Solavan et al 2004). Therefore, we need to be less deterministic in relation to the bones being a definitive answer; they are still subject to interpretation and are useless without relevant contexts.

Zooarchaeology is a very powerful tool in regards to providing explanations to the bigger questions; however, it is vital to recognise its applications in other fields. It can be applied to modern wildlife management by understanding past faunal patterns better decisions can be made, resulting in fewer extinctions and less loss of biodiversity (Lyman 1996). This was investigated by Steadman 1995 who looked at human subsistence patterns and the way in which it affected the biodiversity of the Pacific Islands. He found that subsistence was responsible for 20% of the worldwide reduction in the number of species of birds. Which parallels the current global extinction crisis; therefore, lessons may be learned from studying this historical precedent to prevent further loss of biodiversity.

Understanding zooarchaeology assemblages and their challenges enables a more detailed and through interpretation of the site. It is important to recognise taphonomy which will be discussed in chapter three and other limitations to using zooarchaeological data without other evidence. Whilst the breadth of information that can be achieved is vast it is irrelevant if it is not considered from the context it was obtained.

How animal bones are affected in both anti and post mortem incidences?

The study of taphonomy looks at the natural and human processes which affect all materials including bones after deposition (Duhig 2003). Bones undergo many processes after deposition caused by erosion, weathering, carnivorous activity, scavenging, and other gnawing. They are also affected by the burial environment, i.e. in acidic soils bones tend to disintegrate and only soft tissues are preserved, as in the case at Sutton Hoo and with Bog Bodies such as Otzi the Iceman.

Taphonomy can be split into five taphonomic groups each with a recognisable affect in the archaeological record due to its sorting or associated materials. The first is consumption waste, such as waste produced from butchery and cooking activities and faecal matter. These assemblages tend to be obviously sorted with recognisable skeletal matter containing evidence of butchery in the form of cut marks. The second group is craft waste, and incorporates materials associated with tanning, antler working, furs and skinning. These tend to be a clear selection of specific skeletal parts such as phalanges and skulls, exhibiting clear signs of working. The third group is whole bodies, these tend to be articulated or in the same area if disturbed by animals or roots and includes anthropogenic disposal such as burials and natural deposit. The fourth group is intrusive taphonomy which includes scavenging and animals that burrow and may have died in the same location, tending to disrupt contexts; churning up the soil it was originally deposited into, making it hard to determine the original context. It may be possible to identify animals that burrowed in after deposition due to the colour of the remains. The final taphonomic group is ritual deposits tending to be identified as cooking and or consumption of either specific parts or the whole animal. These deposits can be species specific and can show signs of burning or specialised butchery. Ritual deposits tend to have a distinct archaeological context and associated materials. You need to be careful as to what you assign as ritual, all too often something that cannot be explained is deemed a ritual.

Figure 1- Taphonomic Influences on bone

Taphonomy as a sub field of archaeology is growing, with initial importance being placed on scavenging and carnivorous activities on bones. This is particularly important in Pleistocene assemblages where hominids may have been scavengers (Shipman 1981 in Moran and Connor 1991). Further research is increasing awareness of attrition of deposit assemblages before burial, noting surface damage that is characteristic of gnawing and chewing on bones exemplified by the rodent gnawing marks in figure one.

It is vitally important to study and understand the processes which have been at work after deposition to enable us to make informed interpretations of the archaeological assemblages. This is especially significant when studying zooarchaeological assemblages. Understanding of the taphonomic history gives a wider context increasing our awareness of biases, which are created for a variety of reasons, such as latent diagenesis, soil acidity, mortality and survivorship.

Soil acidity increases the risks of dissolution of bones as does anthropogenic processing for marrow extraction, obtaining gelatine, glue and soap, by boiling bones which become softer due to collagen breakdown. In life bones are resilient and strong, processes that they are subject to post mortem weaken them thus reducing their survivorship. Burnt bones are associated with anthropogenic actions, but as Stiner and Kuhn 1995 show, buried bones can be altered up to 5cm below the fire on the surface implying that deposition and burning can exist as two separate events not driven by anthropogenic actions (Steiner and Kuhn 1995). Thus changes our interpretation of a site.

Haynes 1980 study looking at gnawing in the Pleistocene suggests that the taphonomic agency exhibited by gnawing can vary depending on seasonality and types of skeletal element. Their observations in modern wolves show that similar marks on antlers and destruction of the spinous process of the vertebrae produced in the study can also be found in zooarchaeological collections. However, they also highlight that in some museum collections metapodibles were split lengthways as part of a phenomenon known as coronal fracturing, resulting from weathering processes and can commonly be confused with cultural modification associated with that of marrow extraction (Haynes 1980).

Taphonomy allows us to interpret how the individual may have lived. Mortality profiles, can be somewhat confused by the lack of survivorship of juvenile skeletal remains, may result in biases in the archaeological record. However, understanding the way in which the bones decay, what processes and burial environments they are subjected to accounts for this bias. It is believed through the use of experimental archaeology that although younger specimens are more susceptible to decaying and cooked bones survive the least due to bone composition (Munson 2003). Therefore the implications for archaeology are extensive bringing a new bias that was previously unknown. Exceptions are burnt bones which have already began the charcoalisation process changing the mineral structure making them more resistant to outside forces.

Other factors resulting in an abundance of certain skeletal elements will affect interpretations. Greenfield 1988 study indicates that a significant taphonomic agent i.e. pigs may be being ignored and have vital implications for Holocene sites. In the study only larger and medium bone fragments survived but were extensively gnawed, remaining pieces exhibited tooth marks similar to dogs. Early domestication around 8500 years ago would make it a mistake to ignore their function in the archaeological record raising questions as to whether we should correct for distribution bias caused by pig attrition. Caution is needed to avoid an overly corrected model that does not fit with the history of the site.

The context of the site can give indications into the potential taphonomic histories that buried artefacts may be subject to. Mondini's 2002 study into carnivore taphonomy and early human occupation in the Andes gives insight into how contexts can aide in taphonomic reconstructions. This study in the Argentinian Puna region recognises that the rock shelters were being shared at different times by hominids and other carnivores the largest being the Puma. The study aims to identify different impacts on the bones to categorise hominid effects, thus separating hominids from other carnivores. However, she comes across problems with equifinality because the assemblages can have the same appearance but have gone through different taphonomic histories; this includes biases arising from being influenced by analytic procedures and depositional events (Bar-Oz and Munro 2004).

Bar-Oz and Munro 2004 utilise their approach towards equifinality in the epipalaeolithic case study from Southern Levantine. They noted from observations at five assemblages that despite carnivore action in the region being a common feature in taphonomic histories of bones, in the assemblages carnivore action was rare. They suggested the reasons was due to lack of nutritional value, due to cooking or hominid marrow extraction (Bar-Oz and Munro 2004)

Anti-mortem alteration of the bone is anything that has had a lasting impact on the bone that occurred during life. Most paleopathology studies have been performed on human bone, however, it is vital to recognise abnormalities on animal bones that can enable us to answer questions about and build a picture up of the past. It is also important to be able to differentiate between actual pathological bone and pseudopathological bone as highlighted later in this chapter.

Pathological or traumatic processes affect the balance between the osteoblasts (bone forming cells) and the osteoclasts (bone destroying cells). New woven bone is produced rapidly and weak, if it is present in an archaeological assemblage it indicates that the disease or trauma was present or still healing at death, thus can inform us about societal attitudes to disease and illness. Lamellar bone is tighter knit and mechanically strong, its presence suggests that the disease was inactive or the fracture had healed. Therefore, it can tell us about the societal attitudes and care that was present in the past.

Bone is a record of an individual's life. According to Wolff's Law bone adapts to the strain it is subjected to, therefore, less strain results in thinner, weaker bones, which in turn could affect survivorship and increase bias. More strain on individual results in stronger thicker bones, therefore animals that are used routinely for industry may show denser bone structure compared to those who have not.

De Cupere et al (2000) looked at the aetiology of bone pathologies of cattle, specifically oxen in order to determine draught related anomalies. The study offers insight into the use of oxen and sterile cows as working animals i.e. pulling ploughs and carts on

Roman sites in Belgium and Turkey. They found the attachment of yokes on horns or around the neck leaves depressions in the horn cores or cause deformations of the cervical and first thoracic vertebrae. Therefore, by studying pathologies exhibited in modern herds it is possible to compare with those in the past and build an understanding of agriculture at the location studied.

Joint diseases, traumas, infections, metabolic disorders, congenital disorders and dental disease can all leave lasting indicators on the bones of an individual even if they have long since healed.

A common pathology shown in bones is Harris Lines also referred to as growth arrest lines which form during childhood as a result of malnutrition, diseases or trauma. They are represented as striations on the bone and post burial can be confused with gnawing marks made by scavengers. Juvenile bones tend to be more porous in areas of rapid growth and as such these areas may be mistaken for new bone formation which is initially porous until knitted together.

Osteoarthritis is another pathology that is evident in bone material. De Cupere et al (2000) suggests that diagnosis be based on three changes in bone; grooving, eburnation and polished aspect which included lipping or exostoses. This is supported by Baker and Brothwell (1980 p115). The ability to identify issues in the past gives us a greater understanding of processes people were from the remains they left behind and not just literary sources. However, we need to be careful not to project pathologies of modern herds into the past as their communities and lifestyles were different to today.

Developmental stress can also leave a record not only on the bones but in teeth, a common part of the zooarchaeological assemblage. Dobney and Ervynck 2000 study into pigs teeth aimed at demonstrating the use of Linear Enamel Hypoplasia as a new tool in interpretive archaeology to record periods of developmental stress linked with seasonal variation. Linear enamel hypoplasia occurs as a deficiency in enamel thickness during tooth crown formation (Dobney and Ervynck 2000), the lines form due to disruption in the enamel secretion matrix which is sensitive to physiological change, such as fodder shortages. Therefore, in order to build an accurate interpretation of the nature of the environment and lifestyle the teeth came from it is vitally important to look at pathologies, without them we are missing a piece of the puzzle.

Taphonomy can help to identify post mortem issues on bones that can sometimes be misinterpreted as palaeopathological issues occurring during the individual's life. This leads to pseudopathology. To avoid issues with this it is essential that the archaeologist is aware or can infer from the context the taphonomical history of the bone assemblage.

Natural features and variability in bone may be mistaken for pathological features such as lesions. Arachnoid depressions in the cranium can be misidentified as lesions. It is important to recognise that bones change in the burial environment and are affected by insects and other features of that environment. A bone that is riddled with worm activity could be mistaken for a pathological bone and thus interpreted wrongly purely down to not recognising taphonomic factors. Hackett 1981 described a form of pathological bone called tunnels; these are special forms of degradation causing the focal destruction sites through microbial activity (Child 1995).

In conclusion an understanding of processes both anti and post mortem that act on the assemblage is of vital importance to obtain an accurate interpretation of the site. Taphonomic agents will always act on deposited material and therefore change their nature. It is our role as an archaeologist to tease out the layers of information that shields interpretation. It is only by understanding pathologies and taphonomic agents that this can be achieved, thus reducing potential interpretive biases that may occur.

St Dunstan's Church excavation: a case study

The site

In June/July 2013 Chiltern Archaeology submitted a successful tenure to excavate the proposed graveyard extension area at St Dunstan's church before the development started. Previous intrusive investigations of this site were undertaken by Thames Valley Archaeological Service (TVAS) 2002; the Environment Agency, 2003; Oxford Archaeology, 2004; Chiltern Archaeology, 2005; and John Moore HS, 2012. St Dunstan's church is situated in Princes Risborough within an extensive archaeological landscape, with the Icknield Way close as well as Pulpit Hill and Whiteleaf Cross, the latter both being scheduled ancient monuments.

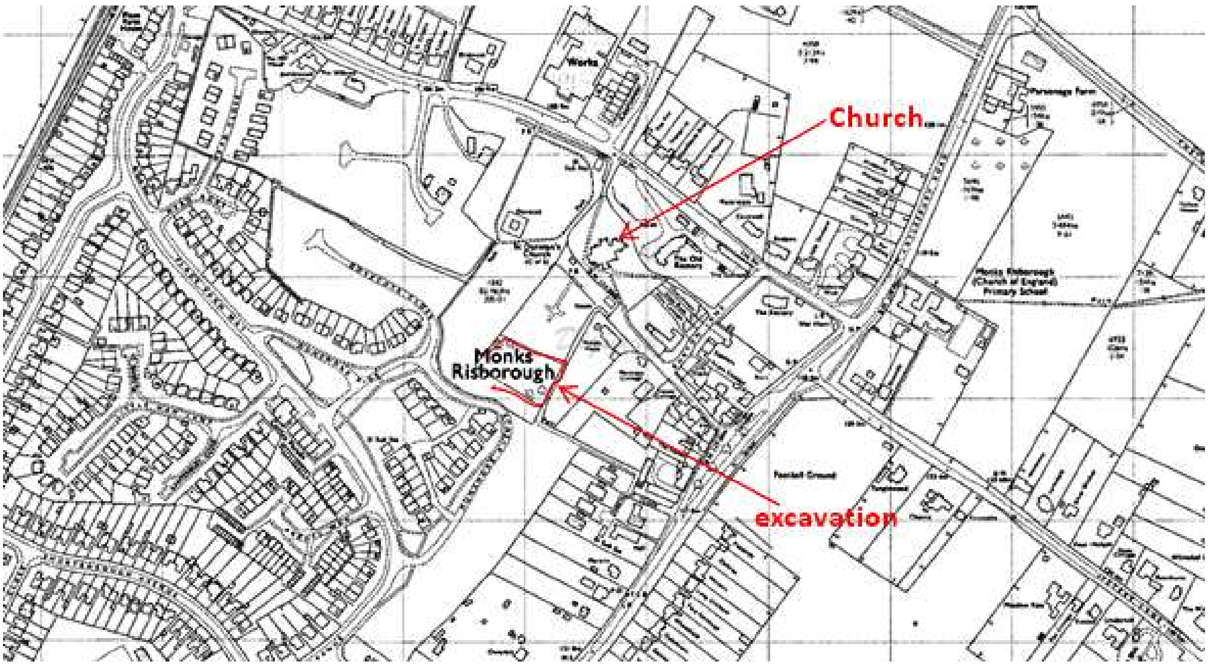


Figure 2- St Dunstan's Church graveyard excavation site

The majority of the animal bones excavated at St Dunstan's were from unstratified layers. However, the period of occupation that is most represented at this site through zooarchaeological evidence is from the late 11th to 12th Centuries. Unfortunately the general dating of the site does not provide an accurate date for the bones in the contexts that lacked other artefacts, therefore are of little interpretive value to the site as a whole.

In addition, all material was hand collected and no quantitative recovery was undertaken during the excavation. Therefore, the assemblage whilst being small and poorly preserved is likely to underrepresent small mammals, birds and fish. Thus, any comparisons of the relative frequency of the major domestic species being utilised during each period may be biased in favour of the larger species. A total of 1702 fragments were examined which can be found in Appendix 1 and a DVD containing photographs of the identifiable elements can be found under Appendix 2. Of these 2% were Iron Age, 2% were Roman,3% dated to the 5-9th centuries, 1% dated to 10th – middle 11th century, 9% date to the middle to late 11th century, 15% from late 11th to 12th century,7% date from 12th century, with a further 14% from early to middle 13th century and 2% dating from Roman to 13th Century, with a further 45% of fragments from undated contexts. The limited assemblage size will impact on the interpretation of the site; some contexts are only represented by a few bones and of those many are unidentifiable as seen in Table 1. Therefore, it would be beneficial to compare this site to others in the local landscape to answer questions such as were they using the same cattle as other sites in the area? Is there anything that stands out in this zooarchaeological assemblage compared with others?

Table 1- Fragments divided by period.

Iron Age	**Roman**	**5th-9th Century**	**10th to mid 11th Century**	**Mid to late 11th Century**
26	33	48	14	159
Late 11th to 12th Century	**12th Century**	**Early to mid 13th Century**	**Roman to 13th Century**	**Undated**
252	121	236	54	759

Methodology

Fragmented bones were examined not only as a single entity but with the intention of fitting fragments together, but with so few intact bones present, the final element totals may be distorted. It is important to recognise this bias in order to ensure the validity of the data. The identifiable bone was assessed based on what elements, species, side of the animal it came from, if there has been fusion and any taphonomic or anthropogenic actions that can be inferred from the bone. They were measured using the recognised system devised by Von Den Driesch (1976) to ensure a standardised approach to the analysis. In cases where it was not possible to use the Von Den Driesch system greatest length (GL) and breadth (Bd) were measured as shown in appendices 3-16. Teeth were identified using the above system with reference to Payne (1973) age wear stages. MNI minimum number of individuals was not calculated, instead a total fragment count TF was used to quantify the fragments.

Preservation

All bones were badly fragmented, and not complete, therefore the data set has its limitations. Not surprisingly loose teeth, which survive better in adverse conditions due to their high Enamel content and structure, were one of the most common elements recovered. In consequence, a large proportion of the bones examined were merely small unidentifiable fragments. This can be seen in Table 2, majority of the assemblage was not identifiable.

Many of the bones showed evidence of fresh breaks and scratches which may be explained the excavation methods. The washing compared with dry brushing of the bones after excavation will have damaged the integrity, thus, increasing the fragility of the bones despite how long they were left to dry.

Table 2-Bone fragment frequency for all contexts.

	Cow	Sheep	Pigs	Birds	Horse	Dogs	Unidentified Fragments
001	97	148	85	0	0	0	125
003	0	1	0	0	0	0	0
009	0	1	6	2	0	0	72
011	0	0	0	0	0	0	10
019	1	2	1	0	0	0	18
021	0	0	0	0	0	0	4
022	0	5	0	0	0	0	23
023	3	4	6	0	0	0	74
025	2	0	5	0	0	0	66
029	5	0	0	0	0	0	42
030	4	0	0	0	0	0	9
032	1	1	1	0	0	0	13
033	1	8	0	1	0	0	18
037	0	1	0	0	0	0	2
040	0	1	0	0	0	0	8
051	1	6	11	9	0	0	99
052	0	0	0	0	0	0	3
053	0	0	0	0	0	0	3
055	0	0	0	0	0	0	4
065	1	0	0	0	0	0	19
066	0	1	0	0	0	0	1
070	1	6	2	0	0	0	25
072	0	0	0	0	0	0	7
075	3	2	2	0	0	0	42
077	2	3	1	0	0	0	30
079	0	0	0	0	0	0	5
083	0	1	0	0	0	0	8
090	2	1	0	0	0	0	5
097	0	0	0	0	0	0	3
112	0	1	0	0	0	0	2

113	0	0	1	0	0	0	4
114	0	1	0	0	0	0	1
118	4	1	1	0	0	0	27
120	0	1	0	0	0	0	6
123	0	0	0	0	0	0	10
125	0	0	0	1	0	0	3
129	3	1	0	1	0	0	24
130	10	0	1	0	0	0	65
132	0	1	0	0	0	0	2
134	0	0	0	0	0	0	24
140	4	4	2	0	0	0	32
143	0	1	0	0	0	0	6
144	0	0	0	0	0	0	2
145	0	0	0	0	0	0	4
149	0	0	0	0	0	0	5
150	4	0	0	0	0	0	9
151	0	0	0	0	0	0	6
161	0	1	0	0	0	0	8
166	0	0	0	0	0	0	13
170	0	0	0	0	0	0	7
171	0	0	1	0	0	0	14
173	0	0	0	0	0	0	4
175	0	0	0	0	0	0	16
177	0	0	0	0	10	0	6
181	0	2	2	0	0	0	5
186	4	1	1	0	0	0	17
188	1	2	1	0	0	0	18
191	0	1	2	0	0	0	15
198	0	1	0	0	0	0	3
202	0	1	0	0	0	0	1
205	0	0	0	0	0	0	12
211	0	0	1	0	0	0	2
212	0	1	0	0	0	0	5

217	0	0	0	0	0	0	1
219	0	2	0	0	0	1	0
225	0	0	0	0	0	0	2
227	6	0	0	0	0	0	10
238	1	0	0	0	0	0	0
243	0	0	0	0	0	0	4
258	0	0	0	0	0	0	4
260	1	1	0	0	0	0	6
268	1	0	1	0	0	0	6
276	0	0	0	0	0	0	5
285	0	1	1	0	0	0	8

Species fragment frequency

In most periods the most frequently identified fragments were from common domestic species, with the absence of wild species. Cow, sheep and pigs were the most common species found on the site, with the punctuated appearance of birds, horses and limited dog skeletal elements.

Discussion

As outlined earlier in this chapter, whilst every effort has been made to identify the assemblage, excavation methods, researcher limitation and the fragmentary nature of the zooarchaeological evidence has made this challenging and may have introduced bias.

Figure 3 below shows the changes in animal presence on the site. Despite the limited data set it is possible to draw conclusions, however, in order to validate them a comparison with other local sites will be addressed in the following chapter. Through the Iron Age to the 5th-9th Centuries there is a preference in sheep, followed by pigs. This may be due to practical considerations such as the levels of care that these species require.

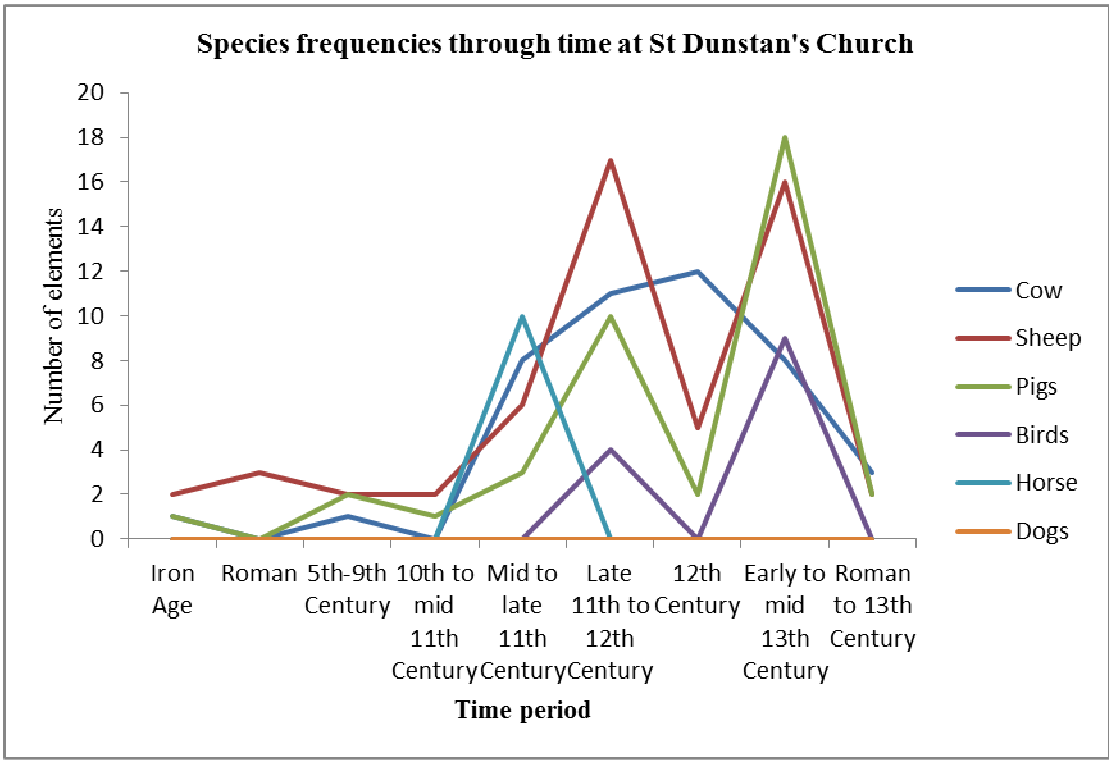


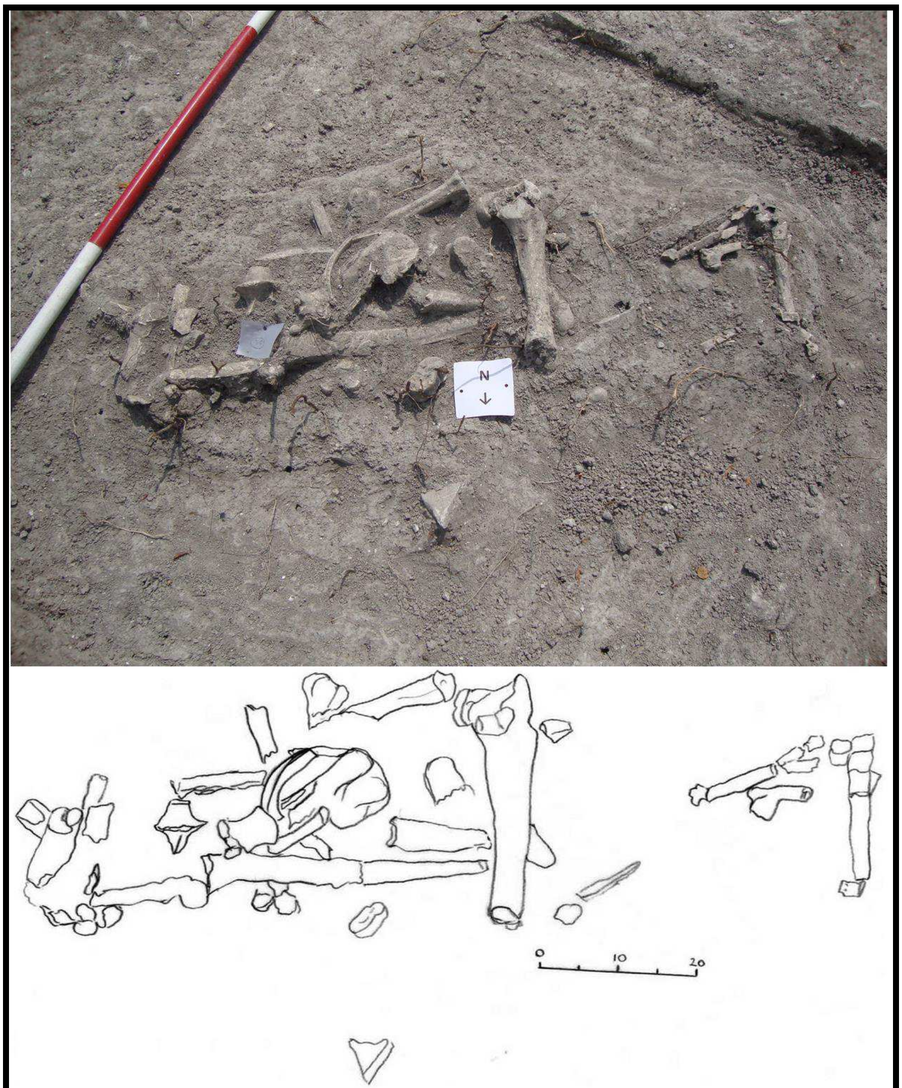
Figure 3-Species Frequencies through time at St Dunstan's Church site graph

Cows become more prevalent on the site from the 10th-mid 11th Centuries and continue through to the 13th Century before decreasing. This may indicate the levels of occupation on site. Cows are a good source of nutrition, and can be continually used over time. However, they require more care and a greater understanding. The elements of cow in the assemblage all indicate adults, from this we can reason that the population inhabiting the site were using dairying practices, possibly alongside farming. The vast quantities of pot sherds found at this site may permit lipid analysis to confirm this subsistence strategy.

The presence of sheep on the site throughout the occupation throughout the occupation of this site would be expected. However, during the late 11th-12th Century and the Early to Mid-13th Century there are two peaks in the amount of sheep skeletal elements found on the site. During the 12th Century there is a rapid fall. This fall is also seen in the pig populations and the birds, although the latter is rare in this assemblage. The rise may be explained through increased domestic populations in this period, or may indicate a period of illness affecting the sheep. The first explanation is most likely given the matching although less dramatic trends in the pig and bird populations.

The sheep elements present on the site mainly consist of adult teeth, this indicates that the sheep herds were being utilised for their wool and milk production as it is consistent with other subsistence patterns in this period (Payne 1973). This idea is also supported by the work by Greenfield et al (1988) into patterns in the Central Balkan region.

Context 130 is dated to 12th Century and exhibited a unusual pile of bones which looked as though they had been deliberately placed. Figure 4 below illustrates the find which was excavated outside a large Roman building, possibly a Villa. Therefore, the bones may have been a midden deposit that accrued over time rather than a ritual deposit.



Plan and photograph of context 130

Figure 4- Plan drawing and photograph of context 130

Other interesting deposits include that of the ten elements found at 177 contexts. They have been categorised as horse elements. The assemblage consists of both sides of the pelvis, although in fragmentary form. Element 1774 a fused section of vertebrae and 1776 a section of pelvis both indicate markings and damage associated with traction shown in Figure 5 as illustrated in Cupere et al 2000. Therefore, we can deduce that the horse that dates from mid to late 11th Century was a working animal. The stockiness of the bones and general size of the bones indicate that the animal would be fairly short but strong; it may be possible that these bones represent an Anglo Saxon Pony breed that would have been a working horse.

Figure 5- Context 177 Horse element composite photograph

Bird elements are rare, they appear in the assemblage from the mid to late 11th Centuries. However, as highlighted earlier in this chapter, the bird population may be underrepresented due to the absence of sieving and flotation methods whilst excavating. The dog element from context 219, which is a tooth, may have occurred as a contamination from the presence of dogs in the excavation area. Whilst many were well behaved, despite there being tempting bones around, one in particular cause problems for the excavation team by uprooting some context labels. However, the roots are missing, which is not unusual in this assemblage, but it is also in filled with soil associated with that context. Therefore, whilst contamination is a possibility the nature of the tooth indicates this to be unlikely.

The assemblage consists of heavily weathered or taphonomically altered bones, some exhibit evidence of cut marks and gnawing. The horse skeletal elements in 177 show straight cut markings.

Conclusions

Further investigation is required of the assemblage in order to identify fragmentary remains that were beyond the researchers abilities. Whilst this limitation is not extensive, the quantity of fragmentary bone is fairly large and may give support to the subsistence patterns and changes noted earlier in this chapter. The limited assemblage of this site means that it is necessary to put this site in the context of the wider archaeological landscape. This will be addressed in the following chapter.

St Dunstan's Church in context

St Dunstan's church in Monks Risborough sits within an extensive archaeological landscape ranging from the Neolithic to the Historic Periods. St Dunstan's Proximity to the town of Princes Risborough and status as a parish gives Monks Risborough a unique setting and access to the wider landscape in Prehistory and continuing through to the present through the ancient routes. These are the Lower Icknield Way which is of Northeast to Southwest alignment and the Upper Icknield Way which transects the Chiltern Hills to the South of the town. It is believed that these are winter and summer route ways which link Neolithic Centres East Anglia to Wessex, and later being used as a Roman road (Hepple and Doggett 1999). A Charter of Monks Risborough dating to the 10^{th} Century claims to have been bordered by Icknield Way (Baines 1981). Therefore, it is reasonable to suggest that this area would have experienced considerable footfall throughout the years which may help to explain the archaeology at the church excavation. The presence of postholes indicates structures from all periods including an Iron Age Roundhouse and potential Roman Villa (Eyres 2013). The notion that this was a route way and used as a Roman road can also be supported by the presence of elements of Roman armour at the site.

The prehistoric landscape in this region is particularly rich with extensive barrows and monumental sites as seen in figure 6. Whiteleaf Hill appears to have been occupied during the same period as St Dunstan's Church site. The site consists of Neolithic oval barrow that has been extensively investigated and radiocarbon dates have been obtained from human bone found within the barrow. Other mounds on the site have been dated to post-medieval and a knoll that supplied the Neolithic flint. The site also consists of a a cross-ridge dyke that dates to late Bronze Age or early Iron Age (Hey et al 2007). The presence of this site so close to St Dunstan's church at a contemporaneous period supports the route way theory and gives us an understanding of the landscape that they inhabited. It is possible that in the absence of modern housing the people at St Dunstan's would have had the settlement at Whiteleaf Hill in eye line. That may even have been the reason for settling at St Dunstan's. The animal bone from the Whiteleaf excavation are scarce, however, the chapter by Emma-Jayne Evans in Hey et al 2007 reports on an unshed red deer antler fragment which was noted to be common in the area as red deer were commonly hunted in the Neolithic. This is the only mention of the animal bones found, so it is not possible to draw a comparison with the bones found at our site. However, it is interesting to note that no red deer elements were found at St Dunstan's and we need to remember that Whiteleaf Hill does not have the same settlement duration as our site. Hey 2007 notes that Roman dated voltaic offering was found. This may indicate that due to the position of the site and the barrow presence the people of St Dunstan's may have viewed Whiteleaf Hill as a religious site.

Grims Ditch (HER 001400000) is situated 3km to the South of St Dunstan's Church and is believed to date to the Iron Age. Very little is known about the purpose of this structure but it would have 16 mile long linear bank and ditch structure that would have shaped the Iron Age landscape in the area and formed another geographical boundary (Historic Town Assessment 2009).

Pulpit Hill is 3km east of St Dunstan's and although it has not been excavated only surveyed, is the smallest Hillfort in the Chilterns with potential prehistoric banks (Matthews 1988). There have been no bones found here but early Iron Age pottery has been found. Therefore, this site may also have been in use during the time of our site. Consequently, we are building an image of a prehistoric landscape in the Chilterns that was defended and surrounded by ditches and Hillfort's. It is possible that this may have been the reason for the continued settlement at St Dunstan's because the geography and existing structures created an insular yet accessible environment. The Icknield Way would have supported the community and enabled trade with other centres during these periods. This is a view supported by the collator of Historic Town Assessment 2009.

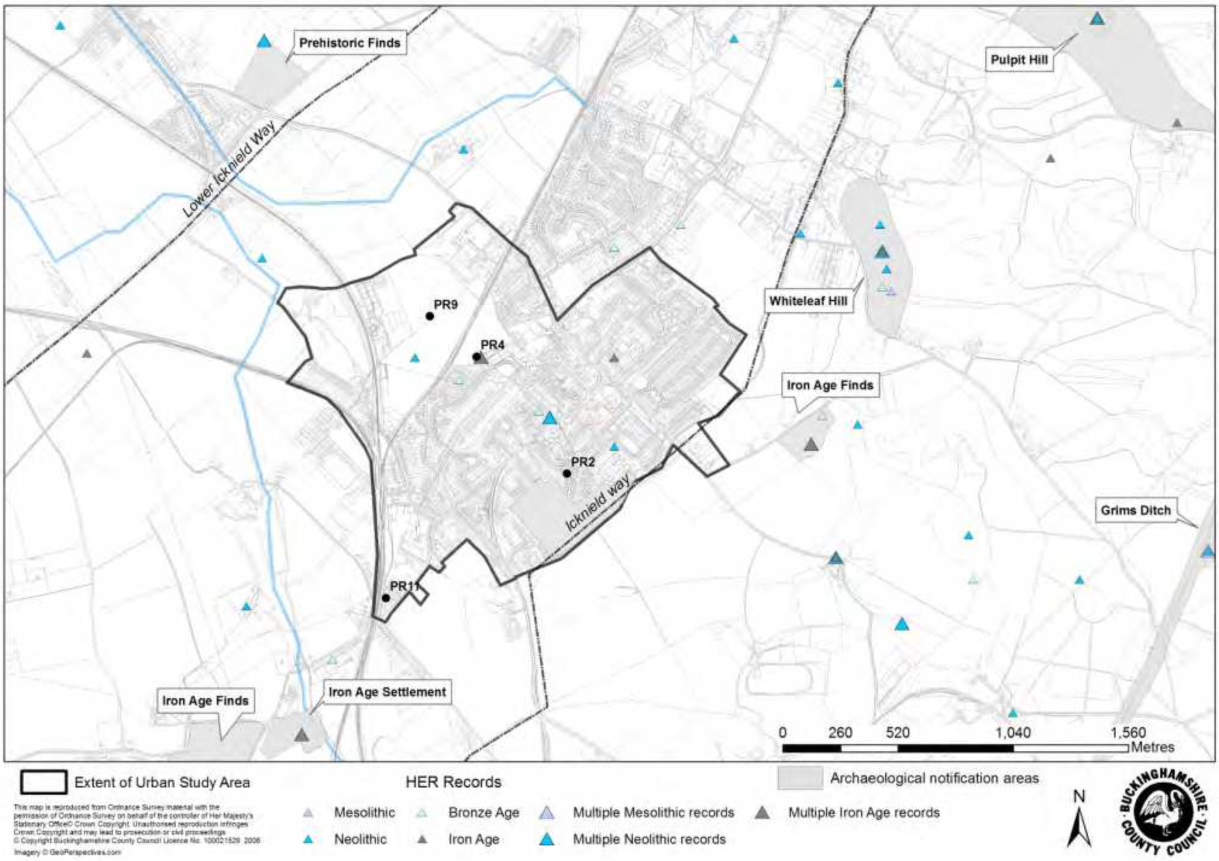


Figure 6- Prehistoric Sites near St Dunstan's Church

Roman finds in the area are somewhat scarcer than the rich prehistoric landscape that St Dunstan's is set within. Roman villas are present in the Saunderton Area and near Little Kimble which is one mile away from out site both of which are present on the Historic Environment Record (HER). However, these finds consist of coins depicting Constantine and Vespasian and fragments of Roman Pottery. St Dunstan's' appears to have the remains of a roman building possibly a Villa (Eyres 2013). Whiteleaf Hill's Roman voltaic is the only local evidence of Roman activity near our site. However, the nature of the find at Whiteleaf suggests that the site was a place of significance in the natural landscape; therefore, it is reasonable to suggest that settlement would have occurred in other areas, local but not too close to the site, somewhere like St Dunstan's Church excavation area in Monks Risborough. The Roman finds are illustrated in figure 7.

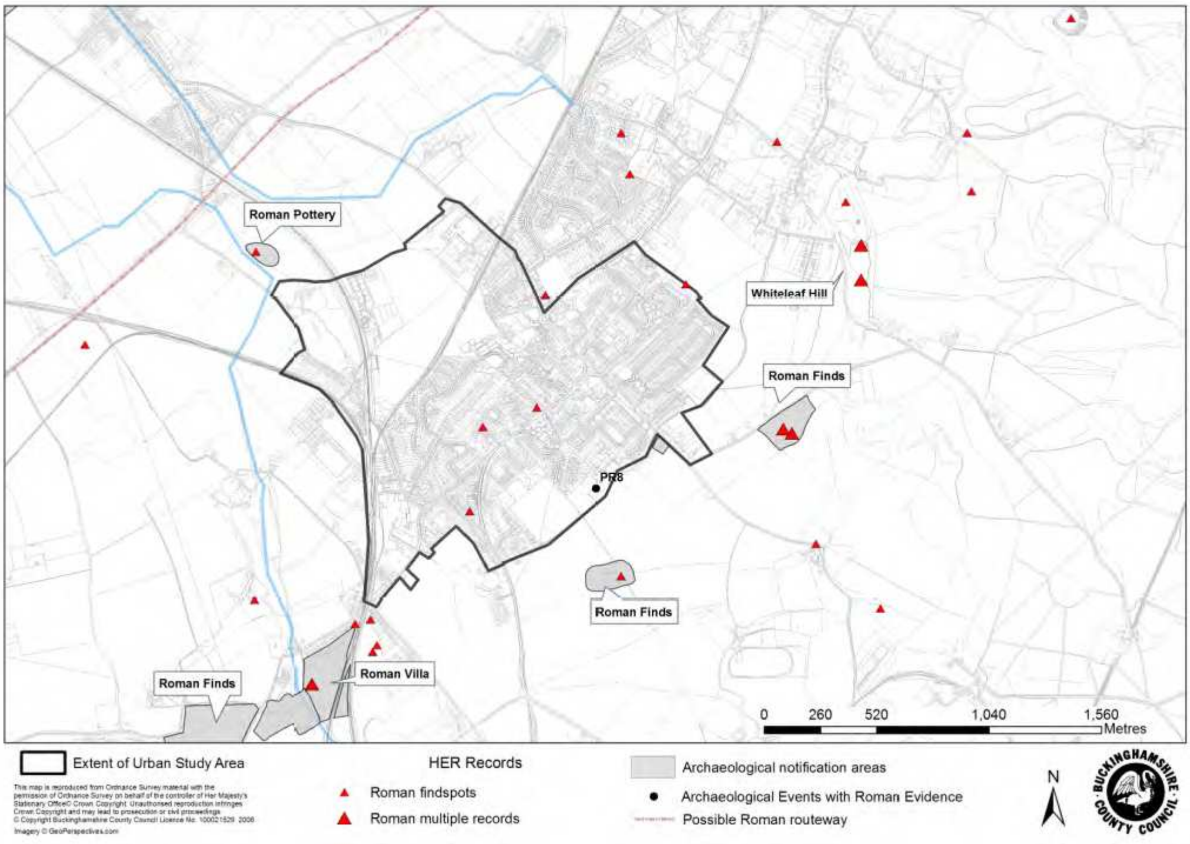


Figure 7- Roman finds near St Dunstan's Church

Expanding the area of interest further than the Chiltern Hills in Buckinghamshire to the counties boarders we come across large scale excavations which yielded substantial bone assemblages. The Williams et al 1996 investigations into the Wavendon Gate region of Milton Keynes moderate bone assemblages were analysed dating from the late Iron Age to Saxon Period. They used water flotation methods from the outset, thus enabling the recovery of smaller fragments. The use of categories to analyse ambiguous fragments allowed a more representative analysis. The MNI or minimum number of individuals was calculated based on the identifiable zones method (Dobney and Rielly 1987). 5,232 fragments were analysed and 40% were identified. This site, unlike St Dunstan's had a small amount of bones from wild animals; this is something that St Dunstan's was devoid of. The frequency of cows present at the site decreases with time period. This is also seen on a smaller scale with St Dunstan's. The wet sieving methodology at Wavendon Gate has enabled smaller more fragile bones to be collected such as birds, frogs and fish. This methodology was not employed at St Dunstan's and therefore, has possibly resulted in an underrepresentation of these species in our zooarchaeological record. This investigation looks at fusion rates, which is not possible with St Dunstan's data; neither is establishing animal height as shown in Williams Et Al 1996 table 31 pg220.

Caldecotte also near Milton Keynes was investigated between 1966-91 by Zeepvat et al. The animal bone from these excavations consisted of 10,918 fragments of which 71% were Roman. Again this site exhibits bones from wild animals. The overall assemblage was five times as big as that from St Dunstan's, this may indicate that although there appears to be a long period of occupation at St Dunstan, it may have been by a small group of individuals, or the waste from consumption was deposited elsewhere that was not excavated. A greater range of elements were present at this site, which may suggest that St Dunstan's community at any given point were restricted as to what parts of the animal they were permitted to have access to (Crabtree 1990). Again height estimations have been done at Caldecotte, as well as age estimation. St Dunstan's assemblage did not lend itself to estimating age as it is mainly comprised of teeth. However, where eruptions are in process it was noted in the description.

Investigations at Bancroft by Williams and Zeepvat 1994 unearthed 7360 fragments 94% of which were in stratified contexts. They used hand recovery methods which is identical to St Dunstan's. They note that fragmentation is high resulting in loose teeth which is typical in this region (Holmes 1989), this phenomenon was also present at our site. The assemblage at Bancroft was calculated by TF total fragment count and MNI. The first is the method utilised for the St Dunstan's assemblage.

Extrapolating zooarchaeological evidence further to a hub of activity the city of Lincoln shows the extent of zooarchaeological assemblages from excavations ranging from 1972-88. Dobney et al (1995) utilised data from over 50 excavations to construct a bone identification index. The usual methods were applied. When using past data it relies on the accuracy of the initial recording methods. This manuscript 'of butchers and breeds' summarises the nature of zooarchaeological assemblages within the city of Lincoln. Total fragment counts similar to those used with St Dunstan's assemblage were performed and the more detailed MNI. The nature of butchery remains on the bones was identified, thus producing a detailed reference to any researcher analysing zooarchaeological data. The age of death of the cattle was investigated to establish husbandry and economy within the Roman to late post-medieval period. From the extensive assemblage available in Lincoln it was possible to investigate the biometry of the herds. This is achieved through the calculation of withers heights, thus giving an idea of the physical size of the herds.

Staying in Lincolnshire, the final study that is to be discussed is that of Anglo-Saxon Flixborough (Dobney Et Al 2007). This study used the bones and teeth as well as sieving and DNA methods in order to build up an understanding of the site. The assemblage is the largest ever at 200,000 fragments to be recorded of Middle to late Saxon date in the country. The assemblage contains extensive wild and domesticate elements, obtained by hand collection and dry and wet sieving. This combination of methods reduces the possibility of underrepresenting species in the assemblage. The investigations at this site have revealed that there were significant shifts during this period. They traded and exchanged food sources and exploited birds and fish.

This chapter has put the site of St Dunstan's into its local then county wide and then country wide settings. The studies highlighted here indicate that the assemblage size can tell us just as much about the population as the elements it contains. From the zooarchaeological data we can identify; subsistence patterns, husbandry, economies of past cultures, religious beliefs and status. All of this data can help to illuminate the culture of not only the ruling elite but the everyday man or woman and the practices that they undertake. Worked bones can indicate craft works which may have been traded. Thus, enabling us to study past cultures not as insular entities but as part of a wider landscape with networks and an understanding of their natural environment.

Conclusion

This project was designed to provide an answer to the uses, benefits and potential limitations of zooarchaeological data. It is important that when asking questions of a site you consider the methods that may be used and their limitations, this enables a comprehensive investigation that provides interpretations supported by the evidence obtained.

As chapter two expresses zooarchaeological data is of fundamental importance to the discipline of archaeology. Whilst may believe that zooarchaeology is the study of bones in a limited typological context, this discipline incorporates use-wear analysis, tool mark analysis, stable isotopic methods and DNA studies to help answer a broad range of questions. It gives us the ability to question domestication processes, demographic changes as well as migration patterns. Faunal remains can indicate subsistence patterns within a region, husbandry and butchery patterns as well as trade links, status and ethnicity.

The limitations are highlighted in chapter three, taphonomy is an process that occurs to all bones in some form, by understanding the conditions the bones were buried in we can ascertain a more detailed and accurate idea of the past. Taphonomic groups can also indicate assemblage type, for example, craft waste or consumption waste. This is very useful in assisting with interpretation of the site and can give insight into the activities that were occurring in the past at the site. The issue of survivorship can introduce bias into the archaeological record, however, by understanding the burial environment and the nature of the way bones degrade, or what pressures are exerted on them in the burial environment we can attempt to remove this bias. Pathologies that can be identified from the bones are useful in identifying husbandry practices, such as traction which again provides a richer picture of the past. Periods of malnutrition can leave their mark on teeth in the form of linear enamel hypoplasia; this can indicate seasonal stresses or changes in the abundance of resources.

The site of St Dunstan’s Church excavation in 2013 in Monks Risborough provides a useful case study to highlight limitations and strengths of zooarchaeological methodologies. The relatively small assemblage in comparison to other sites such as

Bancroft in Milton Keynes allows a more intimate look at the way in which the assemblage is studied and what it can tell us. Despite being small a mere 1702 fragments, 45% of which are unidentifiable, it can still tell us a lot about the sort of practices that were being performed at the site. The high proportion of adult cattle and sheep teeth indicates the herds were being used for milk and wool production rather than meet. Some of the horse elements from context 177 exhibit markings comparable to those illustrated by Cupere's investigation into draught exploitation. Therefore, we can interpret this as the horse being used for traction, possibly to pull a plough. The study also highlights changes in animal usage over time, starting with a higher proportion of sheep then shifting into cows as time progressed.

Chapter five attempts to put St Dunstan's into a wider canvas of archaeological landscape. The local area is rich in prehistoric monuments, settlements and route ways. The geographical location and the prehistoric sites provide a form of border around St Dunstan's, indicating an insular community which may account for the small assemblage. That is not to say that the site was not participating in trade as it would have had access to the Icknield way the ancient route linking Neolithic Centres and later becoming a Roman road which is still in use today. The landscape may have evolved to be fairly heavily populated with housed today, but it is important to remember that the prehistoric landscape may have been more open and connected than is generally though. When putting the case study into the wider Buckinghamshire landscape we are drawn to the sites of Caldecotte, Bancroft and Wavendon Gate, all of which are in the Milton Keynes area and involve extensive faunal assemblages. Therefore, further analysis such as cattle height and fusion rates have been performed. The fragmentary nature of St Dunstan's assemblage meant that this was not necessarily possible. Some methodologies used at these larges sites such as diagnostic zones were ruled out for St Dunstan's, partially due to the nature of the assemblage and partly due to the abilities of the researcher.

In conclusion, you should now be aware of the benefits of zooarchaeological data to the field of archaeology and know that it can be used to investigate small and large scale sites. The value that zooarchaeological data has to the final interpretations of the sites is immense as it allows a more in-depth picture of life at specific periods of the sites occupation or use. However, we need to be aware of the issues that can arise within faunal assemblages, such as taphonomy. The burial environment is extremely important in permitting the understanding of the stresses that the bones and teeth underwent post deposition, as this can change their composition and appearance. Pathologies can be both a hindrance and a help in understanding the history of the bone. They alter the appearance, and in some cases bones can illustrate pathological tendencies but be caused by the burial environment. Therefore, an understanding of all elements within zooarchaeological research is vital when studying a faunal assemblage.

Zooarchaeology is a vital tool in understanding our past but as studies highlighted in this project show, it is also important in decision making for the future. It has applications outside of the archaeological world in biodiversity studies and wildlife management. No bone or tooth is mute; they all have a story that can be inferred by individual analysis of that element and through understanding the site as a whole. Zooarchaeology as a discipline is evolving, drawing on new techniques and methods from the sciences, such as DNA studies. Therefore, the in the future by understanding the pressures on a zooarchaeological assemblage, it will be possible to obtain more definition, thus improving our understanding of our shared past.

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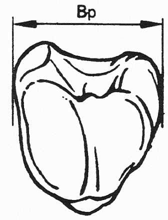

Figure 46c: Bos
Phalanx 2,
proximal view.

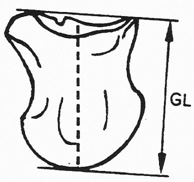

Figure 46d: Bos
Phalanx 2,
peripheral view.

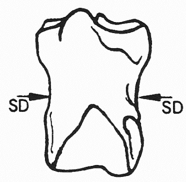

Figure 46e: Bos
Phalanx 2,
dorsal view.

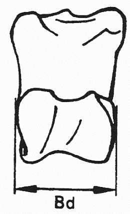

Figure 46f: Bos
Phalanx 2,
volar/plantar view.

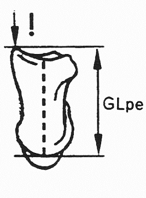

Figure 46g: Capra
Phalanx 2,
peripheral view.

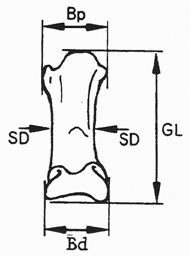

Figure 46h: Canis
Phalanx 2,
dorsal view.

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Appendix four- Metatarsal

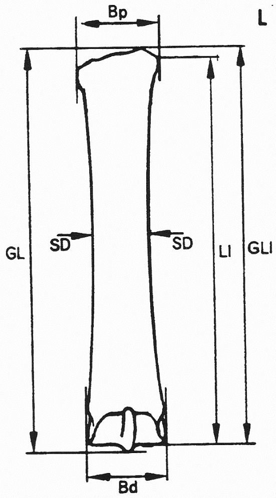

Figure 44a: Equus
Metacarpus III,
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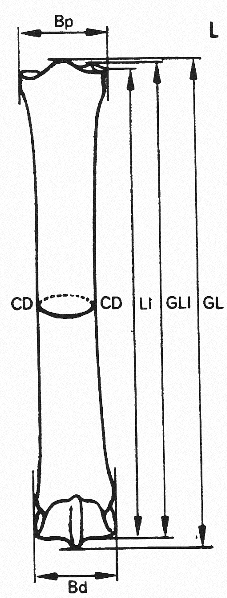

Figure 44b: Equus
Metatarsus III

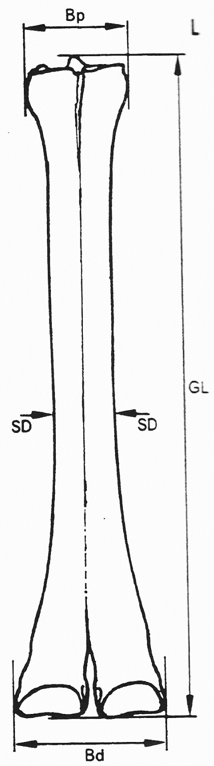

Figure 44c: Camelus
Metatarsus III+IV,
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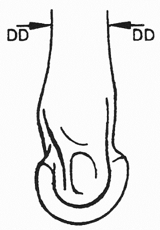

Figure 44d: Capra
Metatarsus III+IV,
side view.

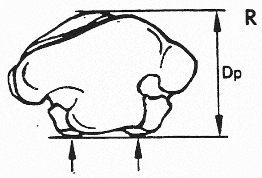

Figure 44e: Equus
Metacarpus III,
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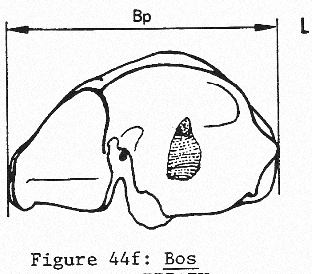

Figure 44f: Bos
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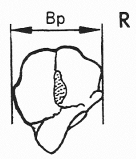

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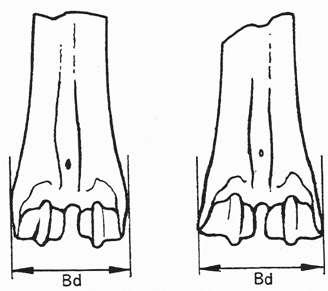

Figure 44h: Bos
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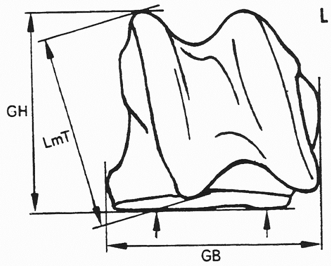

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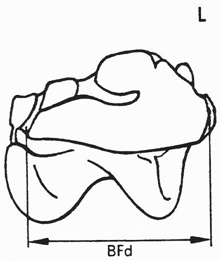

Figure 41b: Equus astragalus, distal view.

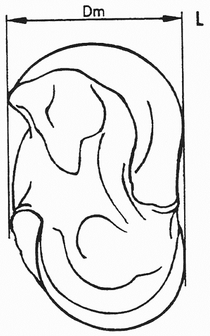

Figure 41c: Bos astragalus, medial view.

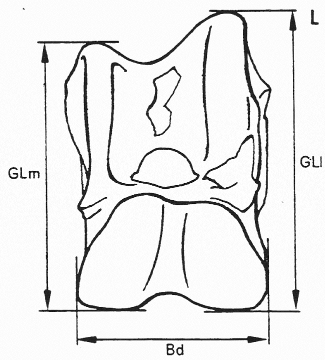

Figure 41d: Bos astragalus, dorsal view.

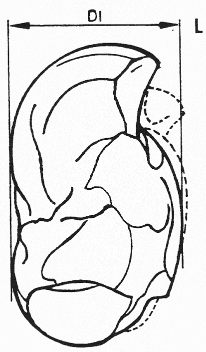

Figure 41e: Bos astragalus, lateral view.

Appendix Six- Tibia

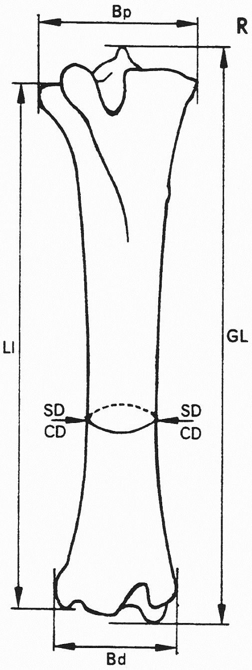

Figure 37a:
Equus tibia,
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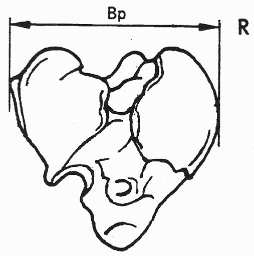

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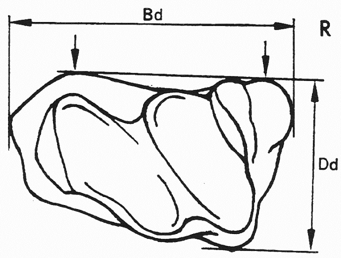

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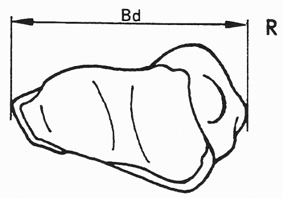

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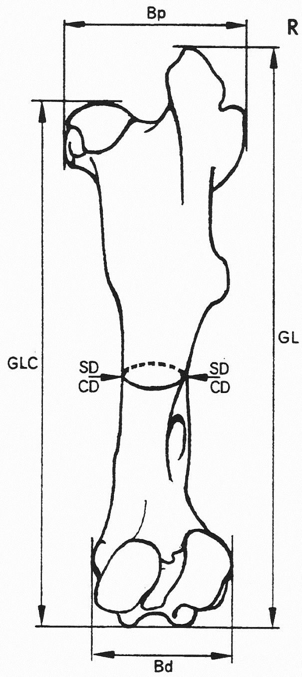
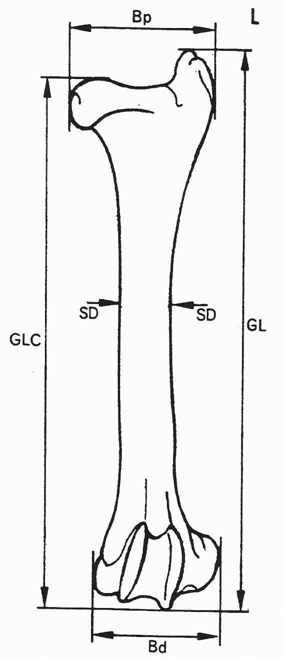


Figure 35a: Equus femur, caudal view.



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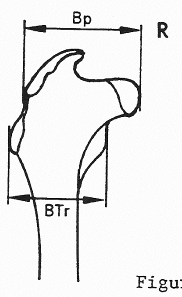


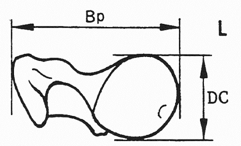


Figure 35d: Canis femur, proximal view.

Figure 35c: Lepus femur, proximal end, cranial view.

Appendix Eight- Humerus

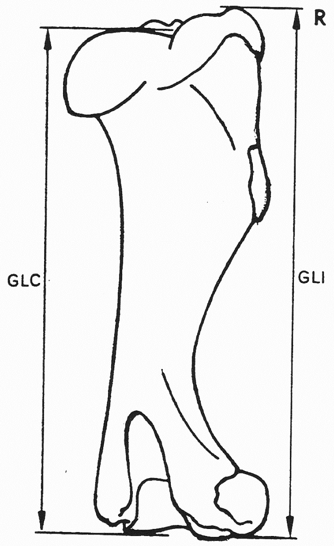


Figure 32a: *Equus* humerus, caudolateral view.

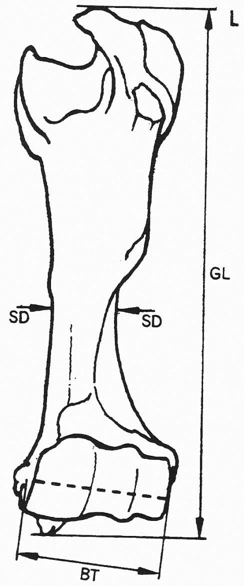


Figure 32b: *Bos* humerus, cranial view.

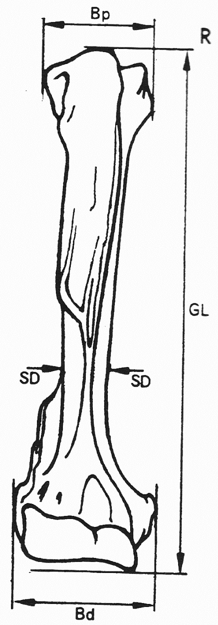


Figure 32c: *Ursus* humerus, cranial view.

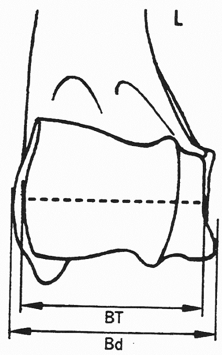


Figure 32d: *Cervus* humerus, distal end, cranial view.

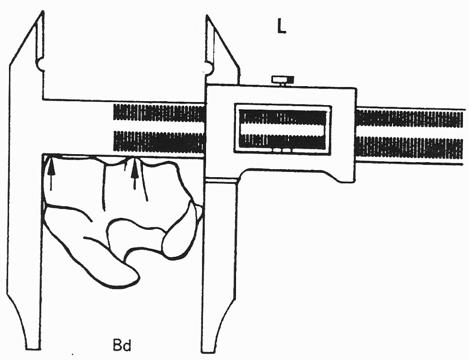
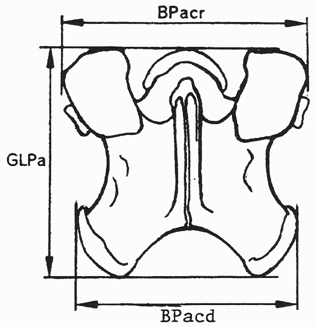


Figure 32e: *Bos* humerus, distal view

Appendix Nine- Vertibrae



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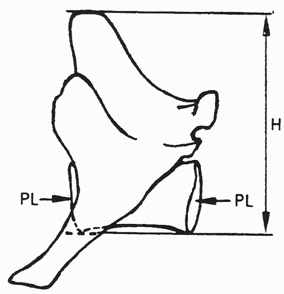

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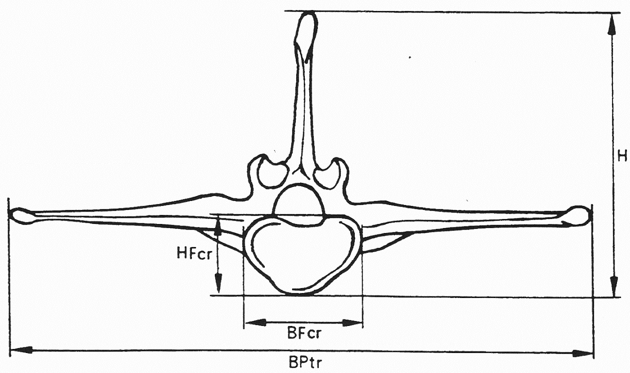

Figure 30c: *Equus* lumbar vertebra, cranial view.

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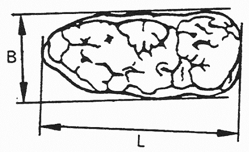
Appendix Ten- Sus Mandible

Figure 22a: Sus M_3



Length (L) and breadth (B) near the base of the crown. (see M 10)

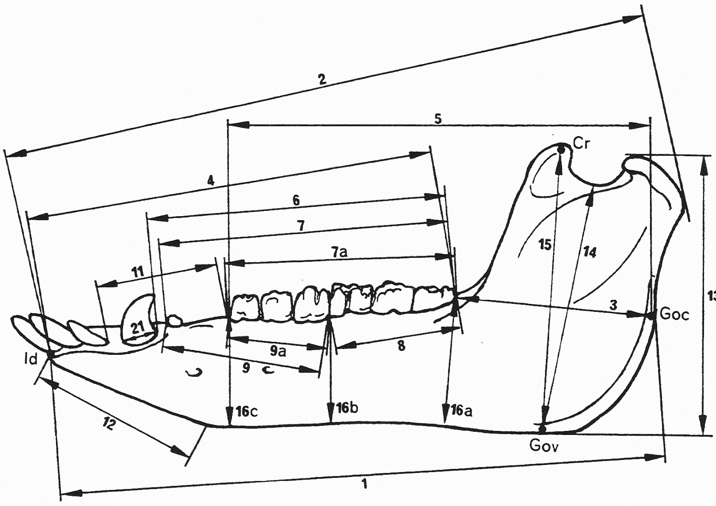


Figure 22b: Sus mandible, left side, lateral view.

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Appendix Eleven- Bos Mandible

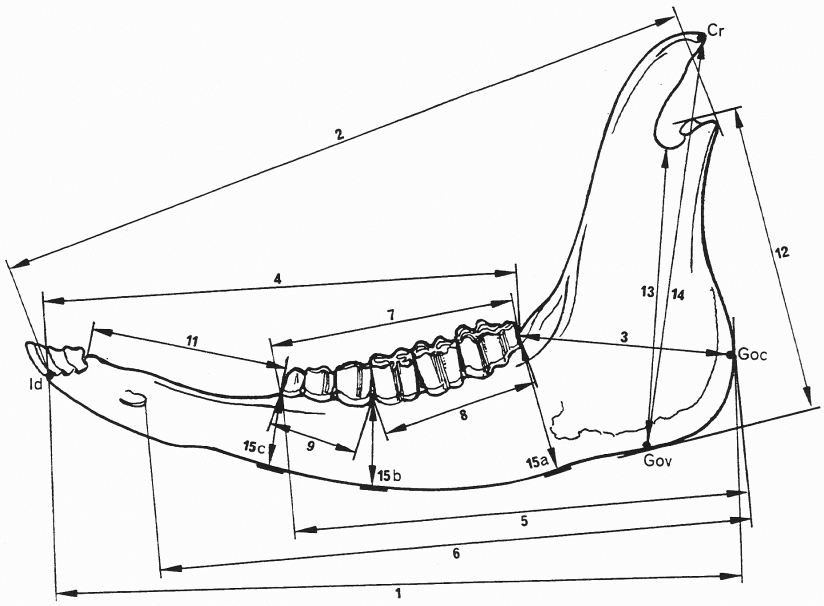
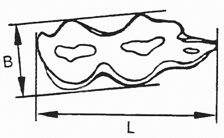


Figure 21a: Bos mandible, left side, lateral view.

Figure 21b: Bos M_3



Length (L) and breadth (B)
at the biting surface.
(see M 10)

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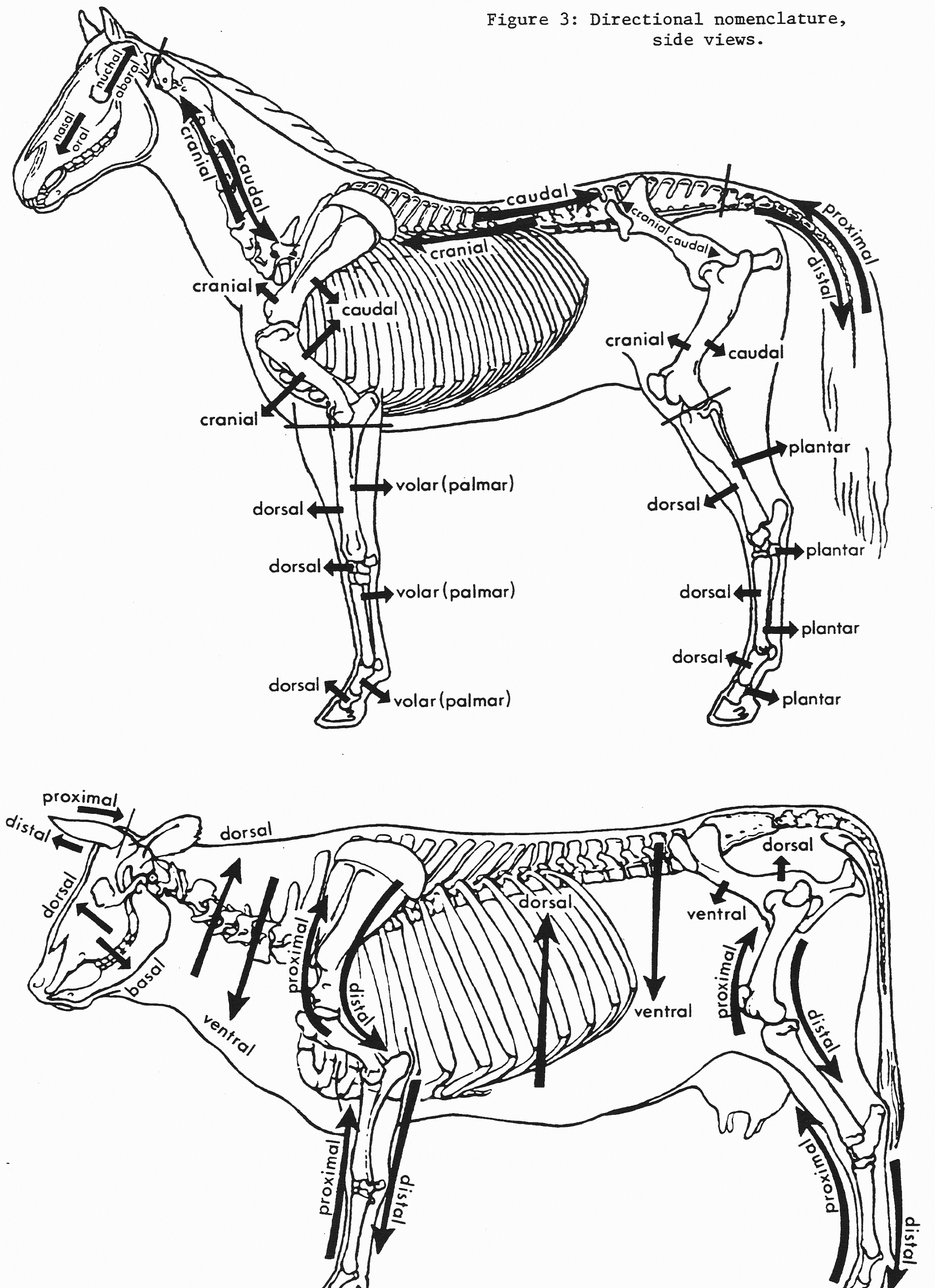
Appendix Twelve- Proximal and Distal

Figure 3: Directional nomenclature, side views.



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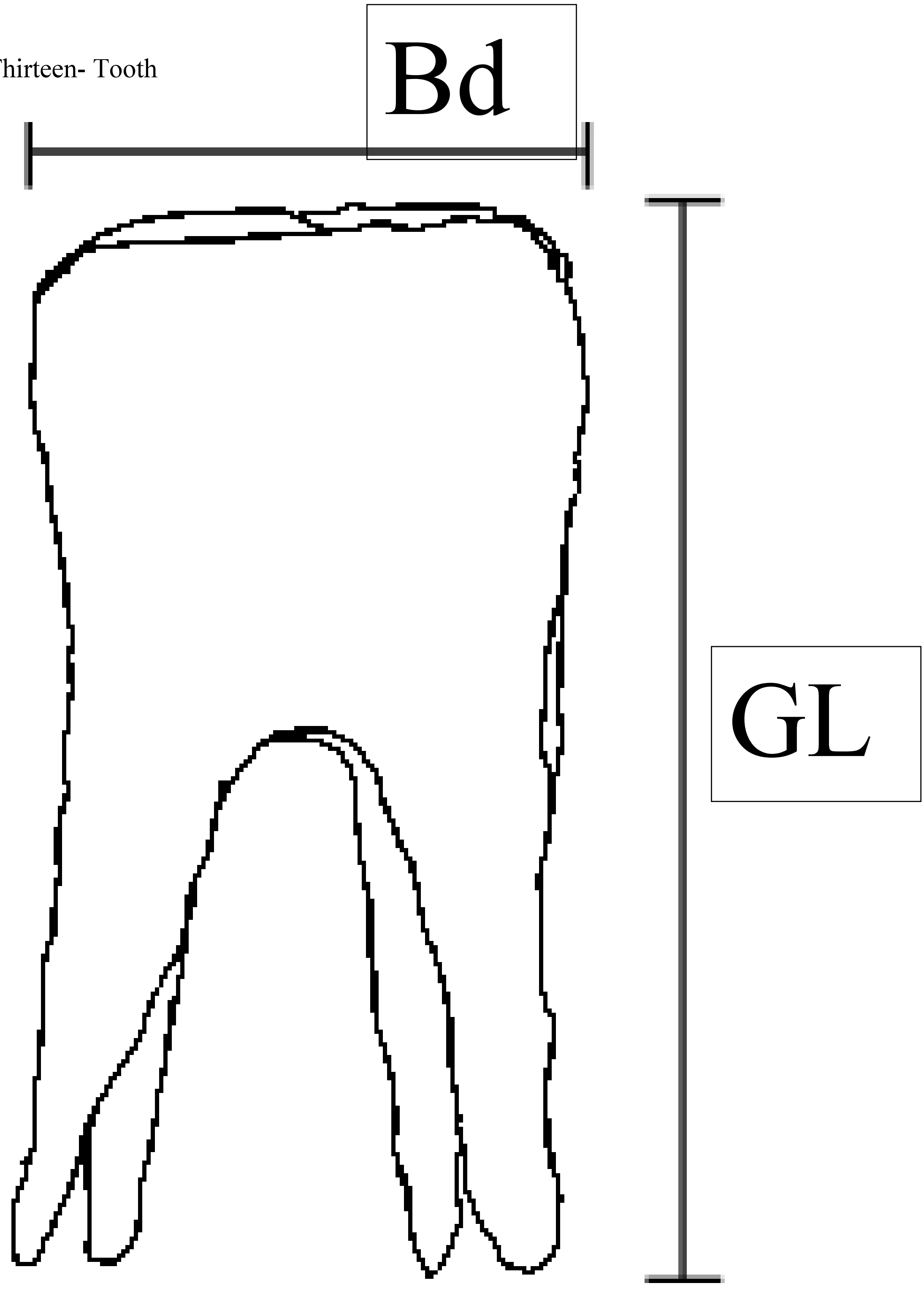

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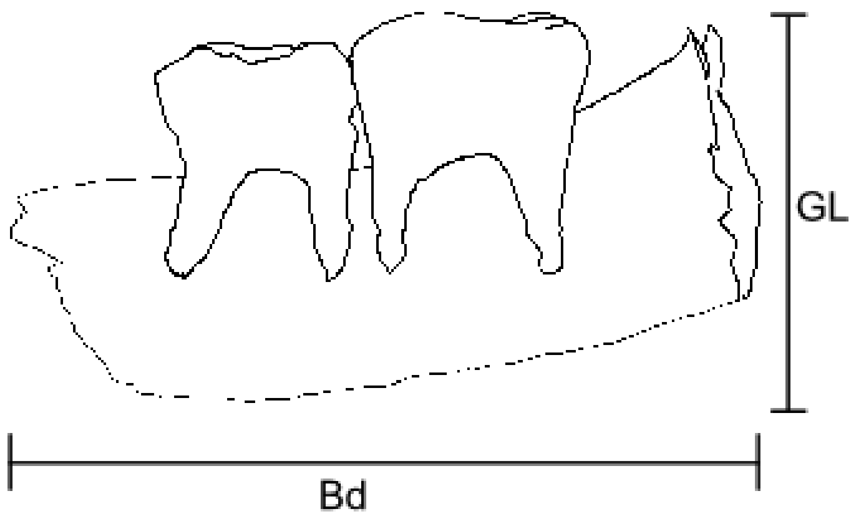

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