Ancient Monuments Laboratory
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# THE ANIMAL BONE FROM THE 1984 EXCAVATIONS OF THE ROMANO-BRITISH SETTLEMENT AT PAPCASTLE, CUMBRIA.

Ingrid Mainland, Sue Stallibrass

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## Summary

Approximately 6000 fragments of animal (mainly mammal) bones were recovered from the Romano-British settlement outside the Roman fort of Papcastle. The material derives from four phases, from the late 1st century AD to the late 3rd Century AD. The earliest phase appears to have contained industrial contexts and material from some of these was waterlogged and well preserved. The bulk of the material, however, comes from phase 3 in the 3rd Century and appears to be domestic refuse. The commonest species was cattle, which would also have provided the bulk of the meat represented by the bones. Most of the other bones come from sheep/goat or pig. Bones of birds and wild mammals are scarce. An attempt was made to use half sections of the cattle teeth to ascertain absolute ages of death from counts of incremental bands in the dentine. The results were only moderately successful, probably due to the fact that most of the teeth appear to come from very old animals whose incremental bands are tightly packed or appear to have been resorbed.



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**Code used in Figure 1 for element types of cattle.**

| | |
|---|---|
| 1 | Horn Core |
| 2 | Skull |
| 3 | Mandible |
| 4 | Scapula |
| 5 | Proximal Humerus |
| 6 | Distal Humerus |
| 7 | Proximal Radius |
| 8 | Distal Radius |
| 9 | Proximal Ulna |
| 10 | Proximal Metacarpal |
| 11 | Distal Metacarpal |
| 12 | Pelvis |
| 13 | Proximal Femur |
| 14 | Distal Femur |
| 15 | Proximal Tibia |
| 16 | Distal Tibia |
| 17 | Proximal Metatarsal |
| 18 | Distal Metatarsal |

**Code used in figures 2 and 11 for element types in graphs of percentage representation of elements in cattle (Figure 2) and sheep/goat (Figure 11).**

| | |
|---|---|
| 1 | Mandible |
| 2 | Distal Humerus |
| 3 | Distal Tibia |
| 4 | Proximal Radius |
| 5 | Proximal Metatarsal |
| 6 | Scapula |
| 7 | Pelvis |
| 8 | Proximal Metacarpal |
| 9 | Axis |
| 10 | Atlas |
| 11 | Distal Metacarpal |
| 12 | Distal Radius |
| 13 | Distal Metatarsal |
| 14 | Proximal Femur |
| 15 | Ribs |
| 16 | Proximal Tibia |
| 17 | Lumbar Vertebra |
| 18 | Distal Femur |
| 19 | Cervical Vertebra |
| 20 | Thoracic Vertebra |
| 21 | Proximal Humerus |
| 22 | Sacrum |
| 23 | Phalanges |

**Code used in figure 10 for element types of sheep/goat.**

| | |
|---|---|
| 1 | Horn Core |
| 2 | Skull |
| 3 | Mandible |
| 4 | Scapula |
| 5 | Proximal Humerus |
| 6 | Distal Humerus |
| 7 | Humerus Shaft |
| 8 | Proximal Radius |
| 9 | Distal Radius |
| 10 | Radius Shaft |
| 11 | Proximal Ulna |
| 12 | Ulna Shaft |
| 13 | Proximal Metacarpal |
| 14 | Distal Metacarpal |
| 15 | Metacarpal Shaft |
| 16 | Pelvis |
| 17 | Proximal Femur |
| 18 | Distal Femur |
| 19 | Femur Shaft |
| 20 | Proximal Tibia |
| 21 | Distal Tibia |
| 22 | Tibia Shaft |
| 23 | Proximal Metatarsal |
| 24 | Distal Metatarsal |
| 25 | Metatarsal Shaft |

**Code used in figure 16 for element types of pig.**

| | |
|---|---|
| 1 | Skull |
| 2 | Mandible |
| 3 | Scapula |
| 4 | Proximal Humerus |
| 5 | Distal Humerus |
| 6 | Humerus Shaft |
| 7 | Proximal Radius |
| 8 | Distal Radius |
| 9 | Radius Shaft |
| 10 | Proximal Ulna |
| 11 | Ulna Shaft |
| 12 | Proximal Metacarpal |
| 13 | Distal Metacarpal |
| 14 | Metacarpal Shaft |
| 15 | Pelvis |
| 16 | Proximal Femur |
| 17 | Distal Femur |
| 19 | Femur Shaft |
| 20 | Proximal Tibia |
| 21 | Distal Tibia |
| 22 | Tibia Shaft |
| 23 | Proximal Fibula |
| 24 | Distal Fibula |
| 25 | Fibula Shaft |
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| 27 | Distal Metatarsal |
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## ACKNOWLEDGEMENTS

The problematic bird bones were kindly identified by Mrs Enid Allison, at the Environmental Archaeology Unit, University of York.

## INTRODUCTION

This work was undertaken at the Biological Laboratory of the Department of Archaeology, University of Durham, by Ingrid Mainland, under the supervision of Sue Stallibrass.

The animal bone studied in this report is from an area of settlement outside the walls of the Roman fort at Papcastle in Cumbria. Excavations there in 1984 revealed occupation layers spanning the late first century A.D. to the late third century A.D. Four phases were distinguished. In phase 1 (late first century to early/mid second century) an industrial area was located in the north of the site with structural remains, including a large ditch in the south. This was overlain in phase 2 by foundation layers and associated structures dating from the early to mid second century. During the third century these buildings were demolished and a massive stone structure constructed in their place (phase 3). By the mid to late third century this monumental building was out of use. Evidence from this final phase of occupation (phase 4) consists of a large pit, possibly filled with debris deriving from phase 3, and a possible structure.

## METHODOLOGY

### (1) DIVISION OF THE MATERIAL

The material was examined for species composition and skelétal distribution using the four phase divisions outlined earlier with several subdivisions.

Phase 3 was examined in three groups: phase 3 foundation layer (3fl), phase 3 pit (3p) and the remainder of phase 3 (3r) (see Appendix 1 for context numbers). The animal bone from phase 3p is derived from the fill of the pit dug in phase 4. This infill material is believed by the excavator to be redeposited phase 3 material. It was therefore decided to treat this as a separate group in order to test this hypothesis. It was also considered prudent to keep this pit assemblage separate, in case it contained a mixture of material from phases 3 and 4.

The material in the foundation layers of phase 3 (3fl) was not thought to relate to the main occupation of phase 3 and also, therefore, had to be considered separately.

The material within sub-phase 3r is derived from the deposits associated with the construction, occupation and destruction of the massive stone structure.

For phase 1, an attempt was made to examine differences between the animal bone within the "industrial" area of phase 1 and that from the structural remains. However as the contexts in the former contained very few bones it was necessary to consider phase 1 as a whole. Likewise the sample size in phase 2 made it pointless to sub-divide the material.

Very little animal bone was present in phase 4 (38 fragments). As such a small sample size makes it difficult to draw any conclusions, this phase is not considered in depth.

(2) QUANTIFICATION

The species composition and skeletal distribution were quantified within the phase groups discussed above using fragment counts and Minimum Number of Individuals (MNI). Simple fragment counts formed the basis of this study. Each bone was identified to element and then to species where possible. Distinction was made between proximal, distal and shaft fragments in order to allow some indication of the distribution of skeletal elements and also greater accuracy when calculating MNI. This was only possible for the shaft fragments which were identifiable to element and to species. Long bone shaft fragments which were not identifiable to element, and all vertebrae and ribs were not identified to species but grouped as cattle size or sheep/pig size fragments.

The use of fragment counts has many problems, the most serious being the fragmentation potential of bone. A single bone can, for example, give a fragment count of between 1 and 30 depending on how broken the bone becomes. Furthermore there is a tendency for the bones of larger animals to suffer greater fragmentation than those of smaller species. Cattle bones are more likely to be divided up for cooking whereas the bones of a sheep, which are a more manageable size, will generally stay whole. Fragment numbers can therefore overestimate the importance of species whose bones have been fragmented, in particular the larger animals.

MNI avoids this problem by calculating the minimum number of individuals that must have been present to produce the number of bones in the sample (Grayson 1984). As MNIs can be calculated in various ways it is important to discuss how the method was used. The Papcastle MNIs were calculated for each element (e.g. proximal humerus, scapula glenoid cavity) using the number of right and left sided fragments. The larger value was taken to indicate the MNI for each element within a phase ; the most common element to indicate the MNI for each phase.

Calculations of MNIs also have drawbacks, the most problematic being an overestimation of the importance of species which are represented by only a few fragments. This is particularly apparent in the Papcastle analysis when one compares the percentage representation of red deer and horse obtained from fragment counts and MNI. In phase 3(f1) , for example, 8 fragments of red deer form only 1% of the total whereas the MNI suggests a 5% presence.

Both methods can however be said to complement each other. Larger animals will tend to be overestimated by fragment counts and smaller ones by MNI. The actual percentage representation may therefore lie somewhere between the two.

The information derived from the above methods was used to evaluate differences in the percentages of species between the phases and also variations in the element types of bones present.

(3) AGEING

The age at which domesticates were slaughtered and/or died can give valuable information about husbandry practices and the general function of animals in society. To evaluate the age structure of the Papcastle animals several methods were used: the examination of epiphysial fusion, the eruption, wear and cementum layers in teeth, and through the study of horn cores. Each method is given a general discussion mentioning the processes followed and the main problems. More specific details are discussed later .

(i) Tooth eruption, wear and cementum layers

(a) General discussion of methods.

The eruption and wear stages of the cattle, sheep/goat and pig teeth were recorded using the method outlined by Grant (1982). Although useful in that it allows the division of mandibles into groups displaying similar wear from which some idea of age structure is given, this method has several drawbacks. The principal weakness is encountered when attempting to equate the Mandibular Wear Stages (MWS) with absolute age - the MWS is an indication of increasing wear and as such gives only a relative age.

In the earlier wear stages, where teeth are still erupting, mandibles can be aged through the use of eruption data derived from modern animals of a known age (Silver 1969). This is however problematic as it is known that the rate of maturity varies between breeds and can also be affected by factors such as nutrition.

It is with the later stages of wear, where eruption has ceased, that the main difficulty is found. Due to the uniform structure of the central portions of the molar teeth, a molar tooth may stay at the same wear stage for several years. Furthermore the overall wear is affected by the initial age of eruption - the earlier a tooth erupts the earlier it is subject to wear. Soil and fodder type can also affect the rate of wear (Grant 1978). It is apparent therefore that increasing wear is not solely dependent on increasing age and that any attempt to divide the MWS into possible age ranges using such an assumption could be problematic. Simple comparison of the MWS patterns between sites is also inadvisable as differences observed may be due to variation in nutrition, soil type or breed rather than to actual age structure.

An examination of the annual growth rings, or cementum layers, present in mammal teeth can overcome the problems discussed above in that an absolute, rather than a relative age can be calculated. The reliability of this method and its validity in an archaeological context has been much discussed in recent years and is in general thought to be of use in archaeology (Rackham 1986, Stallibrass 1982 ).

Within the molar pad of a tooth a layer of cementum is deposited annually. This is formed by two bands (incremental layers): a thick band which relates to the rapid period of growth in summer and a thin band relating to the cessation of growth in winter. Deposition begins during or just after eruption . The age of a tooth can therefore be calculated by adding its eruption age' to the number of cementum layers present, or half the number of bands present.

This method also has its problems. To examine the cementum layers the teeth have first to be sectioned and then examined under a microscope. This process can be time-consuming and it is, therefore, not always possible to section every tooth, as was the case for Papcastle where only 22 cattle teeth were used. No sheep or pig teeth were sectioned. The layers are not always easy to identify and count making an accurate assessment rather difficult. Furthermore the method is quite subjective: different workers may identify different numbers of layers within one tooth. Finally, the use of eruption ages is again necessary. As already discussed eruption can vary within a species and obviously will affect the age calculated for each tooth.The use of eruption ages is however unavoidable and must be accepted as an inherent problem in the ageing of archaeological animals.

(b) The method used to age the cattle mandibles and loose teeth.

The cattle mandibles were recorded for wear using the method outlined by Grant (1982). Loose third lower molars (M3s) were also recorded (Appendix 2) but loose first and second lower molars (M1s and M2s) were not due to the difficulties in distinguishing between them. Crown height was measured as it was intended to try and evaluate age using this information (Appendix 2). This was, however, impossible as the unworn height is needed for the calculation and no such examples were present amongst the Papcastle teeth.

To assign absolute ages to the MWS and tooth wear stages a selection of M1s, M2s, and M3s were sectioned and examined for cementum layers. Usually the M1 is chosen for this as it is the first tooth to erupt and is therefore closer to the actual age. Furthermore the M1 erupts within a narrower range than the M2 or M3 and its eruption age is thus more reliable. The Papcastle mandibles were however quite fragmentary, there being only eight with a complete molar row. It was decided to examine the M2 and M3 in order to age those jaws where the M1 was lost and also to age the loose M3, which formed the bulk of the evidence.

The teeth were cut in half, longitudinally, by Ms. L. Bailey, Dept.of Anthropology, Durham, using a slow saw with diamond wafering blade. The sections were then examined and counted by I.Mainland and J.Bradley. Six counts were made and the average was taken to indicate the number of incremental bands present. Age was calculated using the following formula:

$$\frac{\text{Ave. no. of incremental bands}}{2} + \text{Eruption age of tooth}$$

Several problems were encountered with the Papcastle sample. The teeth were brittle and often broke up when half sectioned. Even in those brittle teeth which survived sectioning, the condition of the tooth made it difficult to count the layers. In many of the teeth, the bands although present were very hazy and indistinct. It was therefore decided to make thin sections to try and improve visibility. The brittleness of the teeth made this difficult as even teeth which had been successfully cut in half broke up when thin sections were made. To try and prevent this a tooth was experimentally embedded in resin and then thin sectioned. Although this did seem to work the incremental bands were not any clearer and to thin section further teeth did not seem of value. Thin sections are far more destructive of the teeth than are half sections.

(ii) Epiphysial Fusion

The approximate age at which epiphyses fuse is known in modern animals (Silver 1969). These data have been correlated with the evidence of epiphysial fusion from the Papcastle material to give some indication of the age structure represented (see **CATTLE** (2)ii).

There are a number of problems involved in the use of epiphysial fusion. The ratio of fused to unfused bones can be distorted by taphonomic factors, both cultural and non-cultural, for example the preferential selection of certain bones by man and the selective destruction of elements due to preservation conditions. The most common of these is undoubtedly the differential destruction of unfused bones as compared to fused bones, especially on sites where preservation conditions are poor. Younger bones are less dense and will therefore be destroyed before the more robust adult bones (Brain 1982). This will be particularly noticeable in the smaller species. Although the preservation conditions at Papcastle were in general favourable, one would expect that the assemblages from phases in which there was some suggestion of greater destruction i.e.: phase 3(p) and phase 2, will be biased towards the older, fused bones.

The ages given to the fusion of the epiphyses can also be problematic. The age at which a bone fuses can vary within a species and also be affected by factors such as nutrition. The fusion information from modern animals may therefore be significantly different from ancient breeds. Examination of the ancient breeds reared today could be useful but until work has been done on this the established works on modern animals have to be used. For this reason Silver's data were adopted for the Papcastle domesticates although they may slightly overestimate age as modern breeds have been genetically selected for early maturation.

Criticism has also been levelled on the way in which epiphysial fusion is used. Watson points out that "there will be a considerable age-range over which the element will fuse, even in an homogeneous population " (Watson 1978), and it is therefore misleading to express the information as if it were a single point in time. To avoid this the Papcastle material was divided into groups of epiphyses which fuse within a similar age range (cf tables 6,8,10).

(iii) Horn Cores

Armitage has outlined a method through which cattle horn cores can be correlated with age (Armitage 1982). From a study of several large groups of material he discovered that horn cores can be divided into age-classes by merit of their size, shape and surface texture. Grigson's work on the Chillingham cattle is used to give an age to these classes (Armitage 1982).

The Papcastle horn cores were grouped into their respective age-classes using Armitage's classification. It must however be noted that these results can only be tentative. As Armitage himself points out, the age-classes are based on the Chillingham cattle and may therefore not hold true for other breeds. Furthermore Grigson did not have actual ages for these animals but had instead to rely on epiphysial fusion and tooth wear data. This may have affected the calculated ages bearing in mind the problems discussed earlier. Finally the attribution of a horn core to a particular group is very subjective.

(4) METRICAL ANALYSIS

Measurements were taken principally to examine whether sex and species differences occurred within the main domesticates at Papcastle. The information derived from the cattle bones was used to distinguish between cows, bulls and castrates; that from sheep/goat bones to distinguish between sheep and goats. Comparison was also made between the measurements of the Papcastle animals and those from three sites of the same date and/or area.

The various measurements taken correspond to those described by von den Driesch (1976).

(5) BUTCHERY

The examination of butchery marks can contribute to the overall understanding of an archaeological site. From such evidence it is possible to suggest whether animals were being slaughtered for meat or being used in other ways such as in the manufacture of bone artefacts or the production of leather. Furthermore some indication may be given of social organisation or cultural affinities from the way in which butchery was organised (Aird 1985, Maltby 1985).

For Papcastle the butchery marks evident were divided into two basic groups: those which apparently involved division of a bone (chop marks) and those which appeared to show slice or nick marks thought to be associated with either meat removal, if located on the shaft or muscle attachment, or disarticulation, if located on the articulation. This information was then recorded diagrammatically.

To help correlate this evidence with butchery patterns reference was made to Barone (1986). From this the areas of bone to which muscles and tendons are attached could be identified and compared with the Papcastle marks. Reference was also made to animal bone reports such as Exeter (Maltby 1979) where butchery evidence is discussed in detail.

## ANALYSIS

### (i) INTRODUCTION

Almost 6000 fragments of animal and bird bone were recovered, 4000 of which were identified to species. Of these the majority came from the domesticates cattle, sheep/goat and pig. Horse and red deer were also represented (table 1).

### (ii) PRESERVATION AND RECOVERY METHODS

Before any conclusions can be drawn from species representation etc. some consideration must be given to the preservation conditions present and the recovery methods as these may have considerably altered the patterns visible. On the whole the preservation at Papcastle appeared to be fairly good. In phase 1 some waterlogging was present but was restricted mainly to the ditch (cont. 353 ) and one or two other contexts. To assess the condition of the animal bone several points were investigated.

Table 2 shows the ratio of loose teeth against the total number of fragments found in each phase. This is a crude test for preservation based on the durability of the mandible. A high ratio of loose teeth indicates that preservation conditions were poor, resulting in the breakdown of the less robust mandible. At Papcastle the ratio is low in each phase although fluctuations do occur. The groups showing the highest percentages of loose teeth are from phases 2 and 3(fl). Those showing the lowest percentages of loose teeth are from phases 1 and 4.

A further indication was given by the rough division of the fragments into those which were burnt, chewed, mineralised, brittle and/or covered in accretion (gravel and mortar). Table 3 shows this information for each phase. The percentage of these poorer preserved fragments is low, implying that the conditions at Papcastle had not affected the animal bone to a great extent.

Differences can however be noted in the distribution of these fragments between phases. In phase 1, for example, burnt fragments were slightly more common which may relate to the industrial activities. Brittle fragments and "accretion" covered fragments were well represented in phase two, which was also noted, above (see Table 2), as having one of the higher percentages of loose teeth.

The distribution of chewed fragments was fairly consistent throughout the phases; however differences are apparent in the species affected (Table 3). This is particularly noticeable when the numbers of chewed and non-chewed fragments of each species, including cattle size and sheep/pig size, are compared, there being an emphasis on sheep/goat bones. To test whether this was significant the Chi square statistic was used. From this it is apparent that sheep/goat bones had suffered more from canid chewing than the other species ($p< 0.01$ $x^2=249$ $df=4$, where $x^2$= Chi square and df= degrees of freedom). It is therefore possible that sheep/goat will be underestimated particularly when one considers the destructive potential of canid chewing (Payne and Munson 1985). Such an emphasis on one species may indicate differential disposal practices in that the sheep/goat or smaller animal bones may have been more readily accessible to scavengers than the cattle bones.

Bulk soil samples varying in size between 3 and 14 litres were taken from 63 contexts and wet-sieved to 500 microns. Only 14 of these 63 samples contained animal bone. This material was given a brief examination but was not catalogued. The animal bone recovered in this way did not add to the information given by the hand-picked material, being composed mainly of unidentifiable cattle sized fragments. Fragments of vole size rodent were however recovered from contexts 38 (ss35) and 273 (ss47). As these were calcined it is likely that inclusion occurred when the deposit was formed. Fish bones were not evident. This may imply that little use was made of this resource despite the proximity of the river. Alternatively, fish bones may have been deposited in other (unsampled or unexcavated) areas of the site, or have been consumed by people or by dogs.

From the above it would seem that the preservation and recovery methods at Papcastle are unlikely to have considerably altered the composition of the animal bone in the excavated samples.

(iii) A DISCUSSION OF THE MATERIAL IN PHASE 3.

As discussed earlier phase 3 was divided into three sub-phases because of the possibility that phase 3(p) had been contaminated by later material and the imprecise relationship of phase 3(fl) with the use of the monumental structure. To examine whether the animal bone in either phase 3(p) or phase 3(fl) could have been derived from the phases apparent on the site, comparison was made of the type and frequency of the skeletal elements present in each phase and sub-phase. The differences were tested using Chi square.

It is apparent from this that phase 3 foundation layer was statistically significantly different from phase 1 ($p<0.01$ $x^2 = 38.48$ $df= 7$), phase 2 ($p<0.05$ $x^2= 15.42$ $df =7$), phase 3(r) ($p<0.01$ $x^2= 24.07$ $df= 7$) and phase 3(p) ($p<0.05$ $x^2 = 16.1$ $df = 7$). The origin of the material in the foundation layers of phase 3 is unknown. Chi square also showed that no difference was observable between phase 3(p) and phase 3(r) supporting the earlier suggestion for the source of this material i.e.: that the pit, although dug in phase 4, was filled with residual material from phase 3.

(iv) SPECIES ABUNDANCE

Table 1 shows the percentages of the mammals present in each phase. Birds are not included but are discussed later. Both MNI and fragment counts are listed. In all phases the major domesticates: cattle, sheep/goat and pig account for the vast majority of the identified fragments. Horse and red deer bones are present in low numbers. The emphasis was obviously on cattle which, using both the MNI and fragment counts, formed at least 70% of the total assemblage. There appears to have been little change in this dominance throughout the history of the site although the cattle MNI percentage is lower in phases 2 and 3(p). Both these contained fewer bones than other phases and the difference may be due to sample size rather than reflecting a decrease in the relative number of cattle. A similar dominance of cattle is found in most Roman military sites (King 1978).

MNI and fragment counts show the relative proportions of sheep/goat and pig to be consistently low and roughly equivalent to each other in all phases except 2 and 3(p) where the percentages calculated using MNI increase greatly. This probably reflects sample size. The abundance of sheep/goat may however have decreased slightly through time.

Red deer was present in phases 1, 3(r) and 3(fl);horse in phases 2 and 3(r).

There would appear to be an emphasis on domesticates suggesting that little reliance was put on natural resources such as wild animals and birds. The high percentage of cattle implies that this domesticate would have provided most of the meat within this area of the site.

## CATTLE

(1) SKELETAL DISTRIBUTION

Figure 1 shows the MNI calculated for each element in each phase. Although most of the skeleton is represented to a certain degree, specific differences do occur within and between phases. However, as bones are not equally affected by preservation due to differences in their skeletal structure, it is possible that the variation observed within phases can be attributed to differential preservation rather than cultural selection. To evaluate whether this was evident at Papcastle the percentage representation of each element was arranged according to it's durability, as detailed by Brain (1982). This showed a pattern indicative of preservation to be present in all phases except phase 1 (figures 2 & 3, and appendix 4).

Differences in the type and frequency of skeletal elements present were also visible between the phases (figures 1, 2 & 3). Variation was, however seen to occur between particular elements rather than the overall sample. For example, the relative number of metapodials, skulls and mandibles are fairly consistent throughout the site's history whereas the frequencies of scapulae, for instance, can be seen to vary considerably as do those of distal humeri to a lesser extent. Chi square was used to test the significance of these differences. A more detailed discussion of the variation between and within phases is now given.

The type and frequency of skeletal elements in phase 1 differed greatly from those in the other phases (Phase 2, $p< 0.01$ $\chi^2=38.4$ df=3; Phase 3(r), $p< 0.01$ $\chi^2=30.24$ df=3:Phase 3(fl), $p< 0.01$ $\chi^2= 38.48$ df= 8). From figure 2 it is apparent that the distribution of skeletal elements within the phase can not be explained by a differential survival of robust and fragile bones as scapulae (which are not the most durable element) obviously dominate the sample. The relative percentages of limb bones are roughly equal i.e. there is no emphasis on the distal humerus as is found in other phases.

This distribution is difficult to explain. A somewhat similar pattern was detected in the assemblage from Castle Street, Carlisle, a site similar in type, date and function to Papcastle (Rackham n.d.) Rackham suggests that the evidence at Carlisle could imply a primary butchery site. A similar function may perhaps be envisaged for phase 1 in Papcastle. The low incidence of limb bones in phase 1 is furthermore consistent with such a function. The Papcastle element percentages are however slightly different from those at Carlisle, the former having a far greater emphasis on the scapula and less of a difference between the metapodials and limb bones. It would therefore be unwise to suggest with any conviction that phase 1 Papcastle was a primary butchery site unless other evidence, for example botanical or structural, is available to support this.

Although differences are observable between phase 2 and the groups within phase 3, for example a greater frequency of horn cores in phase 3(r) and fewer mandibles in phase 3(fl) ($\chi^2=26.94$ at 18 df, $p<0.05$), figures 1 and 2 do indicate a consistent patterning in the distribution of skeletal elements within these phases. In all, the scapula is again well represented but unlike phase 1 this is nearer in proportion to the major limb bones.

The differences between phases 2 and 3(fl) are not significant ($\chi^2=15.42$ df=8 $p>0.05$ ), those apparent probably relating to sample size. The skeletal distribution in phase 2 appears to be generally consistent with a poorer preservation of fragile elements such as the proximal humerus . However, in both groups the distal tibia and proximal metacarpal occur less frequently than would be expected from the affects of preservational factors alone. This may be explained through a consideration of the butchery patterns observed which suggest that the feet and hooves may have been detached from the limbs through the distal tibia, radius, proximal metapodials and tarsals. These bones would therefore be fragmented and have a smaller chance of survival. The comparative lack of proximal radii in phase 3(r) may also be explained by butchery practices.

The percentage presence of elements in phase 3(r) can again be attributed mainly to differential preservation as demonstrated by Brain (1982). There is however a far greater emphasis on horn cores which may indicate a change in the use of this bone. The lack of horn cores in earlier phases could imply that they were being used in craftworking and deposited elsewhere. This is however difficult to prove from the evidence available. An alternative explanation may be that horned cattle were only introduced in this period, polled cattle being common before although there is no evidence of this from the cattle skulls. That horncores are present but in far smaller numbers in the other phases does however show that at least some horned animals were present in these phases.

In conclusion, the type and frequency of skeletal elements deposited in phase 1 is significantly different from the material deposited in the later phases, the emphasis being mainly on scapulae. The pattern observable in phase 1 may indicate a primary butchery site. Whatever the function behind the distribution in phase 1 it is apparent that this was no longer evident in the later phases. Here the elements represented are consistent with domestic debris, the emphasis being primarily on the major meat bones and metapodials. Minor differences do occur between these later phases but the overall pattern is consistent.

(2) <u>AGEING</u>

The epiphyseal fusion data and the information derived from the teeth were examined within phases as far as was possible. The fusion information could be studied separately for phases 1, 2 and 3. It was however impractical to divide phase 3 into its component groups. No unfused epiphyses were present in phase 4. Only the teeth in phases 1 and 3 are discussed as phases 2 and 4 had few examples. Again phase 3 is not sub-divided. There were insufficient horn cores to allow division into phases.

Figure 4 shows the M.W.S. calculated for the eight cattle mandibles with complete molar rows. The wear recorded on the loose M3s is listed in appendix 2.

(i) <u>The cementum layers</u>

The general appearance of the Papcastle incremental bands was quite poor. Some clear examples did exist, mainly in the less worn teeth, but the majority of cementum pads displayed convoluted, hazy and blotchy bands. The difficulties involved in counting such bands are shown by those teeth for which each count varies considerably (Table 4).

Indistinct and convoluted bands of this kind are often found in the more worn and older teeth (Rackham 1986). Another feature of older teeth is the redeposition of cementum resulting in an under estimation of age. On the whole, however, I.Mainland's and J.Bradley's counts compared favourably, giving them at least some credence.

The necessary use of eruption ages in this method can also cause difficulties, particularly with the M2 and M3. The results of several researchers who have examined the rate of eruption in cattle is summarised by Grigson (1982). It is apparent that eruption varies slightly in M1 (5-9 months) and more widely in the M2 (12-30 months) and M3 (2-5 years).

On the premise that ancient cattle would probably have matured later than their modern counter-parts, the ages used in this study were based on the later maturing figures in Grigson's table and the upper ranges of Andrews' figures (Andrews 1982). The latter work was thought to be useful as several, albeit modern, breeds were examined which may give a range nearer to ancient breeds. Obviously this choice is subjective and is likely to under estimate the age of the animals (although see Payne, 1984, for a discussion of the evidence for this). An M1 is therefore taken to erupt at one year (Andrews ), an M2 at two years (range= 1-2 years Andrews, 1.5-2.5 Grigson) and an M3 at three years (range=2-5 years, Grigson).

The sectioning of the three molar teeth raises some interesting points. In two examples an M1, M2 and M3 were examined from a single mandible. Thus a comparison of the ages calculated for each tooth from the same mandible can be made (Table 5). It is obvious that the ages do not tally. This could be taken to imply that either the cementum layers or the method used to derive age do not give an accurate reflection of age.

Explanations can however be suggested for these deviations. In context 40 the age difference (1 yr) is not too significant considering the probable biases encountered in deriving the ages i.e. in counting the bands and in assigning the most realistic eruption age. If anything such a small difference may suggest that the eruption ages chosen are reliable.

The difference between the M1 and M2 in context 223 is rather more problematic. From a comparison with the other M1 at a similar wear stage the cementum age of this tooth does seem to be too young. It may therefore be displaying redeposited cementum. As it was only possible to examine two mandibles in this way it is difficult to prove or disprove these explanations. The examination of further examples would have allowed a better idea of the reliability of the Papcastle cementum layers.

The M3 was used to age the Papcastle cattle in preference to Mandibular Wear Stages since there were only eight mandibles from the site with complete molar rows. Such a small sample makes it impossible to make any conclusions on mortality structure using mandibles alone. There were however forty-nine M3s, the majority of which were loose. Furthermore it was possible to divide these into phases 1 and 3. Therefore in order to give at least some indication of age from the Papcastle teeth, the wear pattern of each M3 was assigned to an age range based on the sectioned M3s (figure 4). M1 and M2 were not included as it is possible that they were originally associated with the M3 and thus individuals might be counted more than once.

This method is based on several assumptions, all of which can be questioned. The assumptions are:

(i) the cementum layers are indicative of age

(ii) the M3 erupts at approximately three years

(iii) the eruption age was consistent throughout the site's history. This is questionable due to possible changes in nutrition, breed type, etc..

It is obvious therefore that the method used to age the Papcastle teeth can only give a rough indication of the age range. This should be noted in the following discussion.

(ii)The age structure

The fusion data (table 6) show that although some cattle were slaughtered between two and four years, the majority of bones were fused. This implies that most of the Papcastle cattle had reached maturity. An increase in the proportion of younger animals present may be apparent in phase 3.

The ages derived from the teeth and horn cores agree with this as there are very few young examples. Indeed there appear to be no young animals present from the tooth information. Taking the fusion data into consideration one would ,however, have expected there to be at least some younger teeth. Their absence could be explained by the poorer preservation of young fragile jaws or indicate that the eruption age chosen for the M3 is too old. An alternative explanation may be that the Papcastle cattle bones fused later than modern cattle and the fusion ages used are an underestimate. If it is assumed that the cementum ages approximately equal actual age, then fusion of the later fusing epiphyses must have occurred between at least four and six years. Rackham has suggested a similar age of fusion for the Carlisle cattle (Rackham n.d.). As both sites are of similar type, age and location such similarities could reasonably be expected.

In modern cattle breeds, the later stages of fusion occur at approximately the same time as the eruption of the M3. The youngest M3 at Papcastle was one which had reached wear stage f: a tooth fully erupted and fairly worn. Even if the eruption ages chosen are an overestimate or the epiphysial fusion ages an underestimate one should have found newly erupted or slightly worn M3s. It seems possible therefore that preservation has affected the younger teeth or that these were being deposited elsewhere.

Figure 4 suggests that in both phases 1 and 3 most cattle were not killed until they had reached an age between eight and twelve, a fairly old age for cattle. Such an emphasis on older cattle implies that they were not bred primarily for meat. If so one would expect a higher percentage of animals which had just reached maturity as it is not economical to keep cattle for more than c.four years when their main value is meat. It could however be suggested that the absence of cattle which had just reached maturity is indicative of meat production as these animals would be removed from the settlement to be sold. This theory is difficult to prove or disprove and it is therefore suggested that the Papcastle cattle were probably used primarily for a function which necessitates live animals, such as milk, traction or breeding stock.

(3) <u>METRICAL ANALYSIS</u>

Cattle scapulae and metapodials were measured primarily to ascertain whether the population was composed of cows, bulls or bullocks. Only these bones were used as the measurable areas were in general extant, unlike for example, the distal humerus which was often sliced through. Furthermore sample sizes were thought to be large enough to reveal differences (number of scapulae = 63, number of proximal and distal metapodials = 136).

Research has shown that the sex of cattle is reflected in their skeleton: bones belonging to a cow being smaller and more slender than those of a bull (Higham and Message 1969). Obviously in young animals the difference is less marked i.e. unfused bones are less likely to give a reliable indication of the male to female ratio. The proximal epiphyses of metapodials fuse before birth and it is therefore difficult to tell whether this element came from an adult animal unless the bone is complete. The use of this bone must therefore be justified.

The majority of the measurements obtained from the Papcastle metapodials were from the proximal epiphyses, suggesting perhaps that any conclusions drawn from these will be erroneous. However it is apparent from the ageing information that very few young cattle were present (table 6 and figure 4). Consequently it is unlikely that many of the proximal metapodials came from unfused bones.

Measurements taken from the scapula were the minimum width of the neck (SLC) and the length of the glenoid cavity (LG) (figure 5 and appendix 3:i). For both the metacarpals and metatarsals the proximal width (Bp) and the distal width (Bd) were obtained (figures 6 and 7, and appendix 3:ii and 3:iii).

Sample sizes were not thought to be large enough to allow an evaluation of the ratio of males to females for each phase (see for example figure 5). The metrical data is therefore discussed for the site as a whole. The conclusions drawn from this evidence concern the total duration of settlement and as such may mask differences in the ratio through time.

In figure 6 the distribution of the proximal metacarpals and proximal metatarsals appear to be skewed towards the smaller measurements. There is however some indication that both samples, but in particular the metacarpal, form a bimodal distribution. In order to examine whether these distributions were indeed bimodal, the data was plotted on logarithicmic probability paper ( figure 7). The width of the proximal metacarpals were shown to form a bimodal distribution with approximately half the sample population in each group. The distribution of the proximal metatarsals was more complicated, having a basically bimodal distribution but with two outliers, one much larger and one much smaller. Seventy percent of the sample fell within the smaller sizes.

Assuming that cows are in general smaller than castrates and bulls the implication would be, in the case of the metacarpals, that males and females were present in roughly equivalent numbers. However, the metatarsals suggest that there was a greater emphasis on the smaller measurements, i.e. cows. This variation may be explicable through a consideration of fusion ages. The metacarpal reaches a wholly fused state earlier than the metatarsal i.e. in an animal in which the metacarpal has fused the metatarsal will still be growing. This factor may have caused the apparent emphasis on smaller measurements shown by the metatarsals. This would imply that the proximal metatarsals were derived from bones in which the distal end had not fused or had recently fused which contradicts the ageing information. A more probable explanation may be that the method used to analyse the data, namely the amalgamation of all phases, has affected the distribution.

Armitage (1982) suggests that the size, shape and robustness of horn cores can be used to indicate the sex of cattle. Appendix 3:iv lists the metrical information available from the horn cores. Figure 8 plots the maximum width of the core against the minimum width. Armitage believes the horn core of a bull to be "flattened and oval in cross-section" whereas a cow will be circular (Armitage 1982). It is possible that some patterning is visible, indicating an emphasis on cows. The identification of this group is however rather subjective.

The metrical analysis suggests therefore that both cows and castrates/bulls were present, possibly in equal numbers although there is some evidence for an emphasis on cows (metatarsals and horn cores). The age structure of the cattle bones shows that slaughter did not occur until the animals had reached eight to twelve years. A primary function as milk producers and breeding stock for the cows and traction animals for the castrates may be envisaged. Slaughter did occur until the cattle were too old to fulfill these uses.

The Papcastle measurements were compared with those from three sites: Roman Exeter (Maltby 1979), a third century ditch at the Roman fort of Piercebridge (Gidney and Rackham n.d.) and Thorpe Thewles, a late Iron age settlement in Cleveland (Rackham 1987). These sites allow the investigation of several points. Thorpe Thewles, Piercebridge and Papcastle are all in the North of England and could be used to investigate whether differences occurred in species size within the area between and during the later Iron age and the Roman period. Exeter was chosen because it provides a large sample and is of comparable date.

The element used for comparison was the proximal metacarpal. The mean and standard deviation for each site is shown in table 7. Comparing the means, the Papcastle metacarpals appear to be larger than those from all the sites in question. To examine whether this difference was statistically significant a student's t-test was used. The measurements from Exeter were shown to be significantly different at $p<0.05$. The Piercebridge data were however comparable with those from Papcastle.

That the Papcastle cattle were slightly larger than the Exeter animals correlates with Maltby's observation that the latter were smaller than average fro the Roman period in general (Maltby 1979). The difference between Thorpe Thewles and Papcastle could imply that a size increase occurred in cattle in the North of England between the later Iron age and the Roman period. This does, however, assume that no variations in size were present in the region. Comparison may perhaps have been more valid if an Iron age site nearer to Papcastle had been used. The apparent similarity between Papcastle and Piercebridge does however seem to suggest that little variation existed within this general area, at least in the third century A.D..

(4) BUTCHERY

The following discussion of butchery practices can only be tentative. The method applied was not very detailed - the patterns shown are therefore little more than a general indication. Differential preservation may also have had some effect. For example, few butchery marks appear on the proximal humerus which may be an actual reflection of butchery practice but could as easily be due to the scarcity of the proximal humerus. Problems are also caused by canid chewing which can obliterate butchery evidence (Maltby 1985). Furthermore the butchery evidence was not separated into phases although it is possible that practices had changed within the site's history. Figure 9 is a pictorial representation of the butchery evidence.

(i)The Forelimbs (scapula, humerus, radius and ulna)

The forelimb appears to have been removed from the body at the scapula. This was achieved by either chopping through the muscle on the glenoid or through the neck of the scapula. The spine of the scapula had been consistently chopped or sliced indicating the removal of meat from the shoulder blade.

The humerus may have been treated as a whole unit since the proximal epiphyses and shaft bear little evidence of butchery. This is however difficult to prove, there being very few proximal humeri in total. The distal humeri were heavily butchered. Two methods of butchery can be distinguished from these, both of which relate to disarticulation. The most common is shown by downward cuts through the proximal radius and distal humerus thus separating these bones. Less commonly disarticulation was achieved by the severance of the muscles attaching the proximal ulna to the humerus and then forcibly separating the humerus and radius using a knife. Chop marks on the ulna and knife marks on the distal humerus and proximal radius indicate this practice. The removal of meat from the humeri is shown by a heavy concentration of marks on the shaft near the distal epiphysis.

The radius may have been left as a complete unit as there are very few examples of butchery marks on the shaft or distal epiphysis. The latter may indicate that the foot was separated from the radius through the carpals or metacarpal. This suggestion can not however be said with any certainty as only one carpal and a few metacarpals gave butchery evidence although, as has already been discussed, the relative absence of these bones may be related to such a butchery practice. Nick marks on the metacarpal shaft may relate to the removal of the skin.

(ii)The hind limb (pelvis, femur and tibia)

The hind limb appears to have been removed from the body at the pelvis. The ball joint of the proximal femur was commonly found to be sliced at the point where it enters the acetabulum. Severance at this point is confirmed by the large number of acetabula displaying chop marks. Nick marks were common around the acetabulum and on the ilium, all of which indicate the filleting of meat from the pelvis.Such marks are also common on the femoral shaft.

The femur and tibia appear to have been separated in a similar way to the humerus and radius, i.e.: by chopping downwards through both bones. Gouge marks on the tibia shaft correlate with the location of muscle attachments and were probably caused by the removal of meat.

The calcaneum and astragalus are heavily butchered suggesting that the leg was separated from the foot in this area. This could be used to give further support to the suggestion that the fore limb was divided through the distal radius and carpals, especially when one considers the similarities in the methods used in the upper bones of the fore and hind limbs.

Like the metacarpal, the metatarsal has few butchery marks. Those present show splitting of the shaft and probably relate to marrow extraction.

(iii)The vertebral column, skull and mandible

None of the vertebrae show signs of having been split and there is therefore little indication as to how the spine was divided. What does seem to be shown is the removal of prominent protuberances eg.the thoracic spine. This may be consistent with the removal of meat from the vertebrae.

Separation of the skull from the body is likely to have occurred through the axis. On the skull itself very few marks were noted. This is not however surprising as skull fragments from Papcastle tended to be small and had suffered much from modern damage. A half skull from waterlogged conditions was however quite informative. This had been chopped across the frontal bones in front of the horn, possibly to remove the brain.

Horn cores were removed from the skull at the base of the core. Whether these were then used in craftworking is difficult to tell as few examples of worked bone were found at Papcastle and horn would only survive in exceptional preservation conditions.

The mandible was detached from the skull through the mandibular hinge. The removal of this may have been to allow the filleting of meat from the cheek . Nick marks on the mandible suggest the removal of the tongue.

The butchery evidence from Papcastle seems to show the processes of disarticulation and filleting of meat. There appears to be a consistency in the methods used, which may indicate some organisation in the butchery process. As the material was not divided into phases it is difficult to tell whether this uniformity and possible organisation was present throughout the history of the site, or whether it was restricted to specific periods. Some indication of change may be given by the slight differences apparent in the representation of elements between phases.

## (5) PATHOLOGY

On only a few of the Papcastle cattle bones were there signs of disease or infection. Osteo-arthritis was identified on two first phalanges, both of which displayed the characteristic extra bone formation and polishing of the articulation. Osteo-arthritis is a "degenerative disease affecting the articular cartilage" (Baker and Brothwell 1980) and can be caused by constant trauma to the joint.

Two cases of spavin were identified. Spavin is most commonly found in the lower limb where inflammation in the soft tissues around the bone has stimulated the formation of new bone, often resulting in the fusion of bones normally separate. At Papcastle the latter is apparent in one example where an astragalus and tarsal have fused together. As no exostosis is visible it is probable that the articulation was affected. Similarly a metatarsal displayed exostosis of the articulation and is probably a slightly milder case of spavin. Both are likely to be examples of what Baker terms occult spavin which is often a manifestation of osteo-arthritis. Further evidence for this is shown by the eburnation and pitting visible on the proximal metatarsal.

Like osteo-arthritis , a factor behind the development of spavin is thought to be constant trauma to the joint as a result of heavy work and/or working on hard surfaces. All the examples discussed above are unlikely to have severely affected the cattle concerned, causing only a mild degree of lameness.

Two thoracic vertebrae had apparently suffered from some form of infection. On one the spine displayed slight exostosis and pitting. The other had developed a far greater amount of extra bone and may have become fused to the adjoining vertebrae. Both these cases would have caused considerable pain.

Infection was also present on the proximal articulation of a femur. The head had fused further down the shaft than normal and displayed considerable pitting consistent with an infection. It is impossible to tell whether the bone was subject to infection before fusion thus causing disruption or alternatively if the joint had become dislocated before fusion causing an abnormal fusion and infection. In either case the animal would have been in much pain and most certainly lame.

A possible case of foul-in-the-foot or a similar infection was detected in a distal phalange which displayed considerable necrosis of the bone. This beast would also have been rather lame.

The pathological bones discussed above are on the whole consistent with the other evidence relating to the cattle. Osteo-arthritis and spavin are common in older cattle, particularly those used for heavy work. This agrees with the conclusions drawn earlier from the ageing information where it was suggested that the Papcastle cattle were fully utilised before slaughter. That there were only a few examples of pathology may imply that these cattle were quite healthy. It is however possible that crippled or diseased animals were disposed of differently.

## SHEEP/GOAT

### (1) SKELETAL SELECTIVITY

The MNI and fragment counts derived from the sheep/goat bones were arranged in a similar way to the cattle to detect differences in skeletal distribution between and within the phases (figures 10, 11 & 12:i). However the small sample sizes in phases 2, 3(p) and and 3 (fl) make it probable that the distributions visible in these phases are a reflection of fragment number rather than cultural selection or preservation and these phases are therefore not discussed in depth. The number of fragments present in phases 1 and 3(r) were thought to be large enough to allow a detailed examination.

In phases 1 and 3(r), the emphasis appeared to be on the metapodials and to a lesser extent the lower limb bones. As these bones are quite robust, an explanation for this pattern may possibly lie in preservation conditions rather than any cultural selection. However, according to the arrangement of the information using Brain (1982) there does seem to be an actual emphasis on these elements in phases 1 and 3(r) (Figure 10 and appendix 5:i & 5:iii). Here the robust bones with a high meat value occur in a lower percentage than is expected. This may indicate that the sheep/goat bones in both phase 1 and phase 3(r) were not general domestic debris. The presence of limb bone shafts does however refute this idea.

Sheep/goat bone shafts were generally complete with only the epiphyses missing. It was therefore possible to use these in MNI estimation. Figure 10 shows that the major meat bearing bones were actually present in phases 1 and 3(r). The shafts of femora and humeri do however seem to be less in number than those of tibiae and radii which may again suggest that the emphasis was not on the meaty bones. It would however be difficult to say this with any conviction due to the small sample size in question ( number of sheep/goat long bone shafts: phase 1 = 26, phase 3(r) = 23).

It is tentatively suggested that the sheep/goat bones in phases 1 and 3(r) were not derived from general domestic debris, having a greater emphasis on the lower limb bones (often associated with butchery waste) than on the bones usually associated with meat. It is however possible that the distribution apparent was caused by factors other than cultural behaviour. Canid chewing was shown above to be particularly prevalent on sheep/goat bones which may have considerably altered the distribution of the skeletal elements.

### (2) AGEING

There were very few sheep/goat mandibles and unfused epiphyses. This is probably a reflection of both the low percentage of sheep/goat bones in total and the poor preservation of the unfused elements in smaller animals. It was not practical to divide this material into phases and the following discussion considers this information as one group.

There were thirteen sheep/goat mandibles, five of which had complete molar rows. The wear for each was recorded using Grant (1982). Mandibular Wear Stages (MWSs) for complete molar rows are shown in Appendix 6. No sheep/goat teeth were sectioned and so Silver's eruption ages for eighteenth century sheep are used to give some indication of age.

In four of the mandibles with complete molar rows, the M3 was in the process of erupting. According to Silver's figures this would give an age of between three and four years (Silver 1969). The M3 in the other complete mandible was at a relatively early wear stage and can not be much older than five years.

The eight mandibles with incomplete molar rows were again aged using eruption information. These mandibles were also compared with the complete molar rows in an attempt to narrow the possible age ranges. Such a comparison is problematic due to the sample size and also the fact that the sample covers three centuries during which nutrition and breed may have changed.

Figure 13 shows the possible age ranges calculated for the sheep/goat mandibles. From this it is apparent that the majority of the sheep/goat had been killed between two and a half to four years. Table 8 indicates that there is an emphasis on the elements which fuse at between one and a half and two and a half years. The bones fusing within this age range are the metatarsal and tibia, both of which were the more frequent in all phases. The later fusing limb bones although present tended to be represented by shaft fragments rather than the epiphyses, many of which had been chewed. It is therefore suggested that the pattern observed within the fusion data is likely to be reflecting preservation factors rather than an actual emphasis on one and a half to two year olds.

One must conclude that the Papcastle sheep/goats were killed mainly between two and four years, perhaps with one or two older animals. Such an age range implies that sheep/goats were being kept primarily for meat. Sheep can produce both milk and wool until about the age of nine and if these products were the more important an older age range would be expected. This can however only be a very general assumption due to the small sample size involved.

(3) <u>METRICAL ANALYSIS</u>

Few measurements were taken from the sheep/goat bones. This was mainly due to the lack of epiphyses. Those which were present were often chewed thus making measurement impracticable. The metapodials were however more complete. The following discussion considers these bones only.

The width of the proximal and distal epiphyses (Bp and Bd) were recorded. Shaft width (SD) and overall length (LG) were also measured where possible (Appendix 7). This information was then used to suggest whether goats were present. Distinguishing between sheep and goats is a notorious problem in archaeology, most bones being very similar in both species. Some differences do however occur (Boessneck 1969). One of these is in the shape of the metapodials which are shorter and wider in goats.

The length of the metapodials were plotted against their proximal widths to see if such a difference was observable in the Papcastle sheep/goat bones (figure 14). One example does fall outside the general pattern of the metacarpals, being shorter and wider than the others and can therefore be identified as goat, confirming the visual impression. Another example may be apparent in the metatarsals.

The remaining proximal widths are shown in figure 15. There would appear to be a small group of larger measurements outside the general pattern, however, as mentioned before, it is difficult to tell whether these came from fused or unfused bones. A fair proportion of the Papcastle sheep/goats were not mature and it is therefore probable that some of these measurements were derived from unfused bones. The size differences observed may thus be an indication of age rather than species.

The metrical information suggests that at least one goat was present in the Papcastle material. Further evidence for this species is found in a sheep/goat size radius identified as goat using Boessneck (1969). Although no attempt was made to determine whether every sheep/goat bone was definitely goat or definitely sheep, the examples discussed above were the only fragments which appeared to be obviously different from the rest.

It was decided not to try and examine whether the sheep were ewes or rams due to the problems outlined above: sample size, probable age bias and also the difficulty in separating rams from goats particularly as there were no suitable pelves.

Comparison was made between the Papcastle sheep/goats and those from Piercebridge, Thorpe Thewles and Exeter. Only complete bone lengths (GL) were compared so as to eliminate the problems caused by unfused examples. The metacarpals only were used as at Piercebridge and Thorpe Thewles no length measurements were available for the metatarsal.

The Papcastle measurements are similar to the ranges calculated for the three sites with those Exeter and Thorpe Thewles being slightly smaller (table 9). Little further can however be reasonably concluded from this due to the small number of metacarpals available for comparison.

The skull of a four-horned sheep was found in an unstratified context. As this bone had an appearance similar to the bones found in the waterlogged deposits of phase 1, an origin in this phase may be postulated. It would however be difficult to suggest whether this skull is representative of the type of sheep kept at Papcastle as it is the only example of an almost complete sheep's skull recovered.

(4) <u>BUTCHERY</u>

There are very few butchery marks evident on the sheep/goat bones. This may be due to the smaller size of sheep/goat bones which, unlike cattle, can be more easily used in cooking without division. Even so one would expect more evidence relating to disarticulation. A more realistic explanation may be that canid gnawing has obscured or destroyed the evidence.

Chop marks on the pelvis, radius and tibia probably do relate to disarticulation. The pelvis had been chopped through the acetabulum suggesting that, like the cattle, the hind limb had been removed at this point. The radius and tibia had been chopped laterally through the shaft. This could indicate the removal of the feet from the body.

Slice marks around the neck of the scapula probably relate to the removal of meat from the shoulder blade. There was however no evidence on this bone or on the humerus to suggest how the forelimb was removed from the body. Several metapodials and one calcaneum bore nick marks which may have been caused by skinning.

It is apparent that very little can be said about the butchery practices used on the sheep/goat at Papcastle due to the lack of evidence.

## PIG

### (1) SKELETAL SELECTIVITY

Due to the small number of pig bones in the Papcastle collection (n=152) it is very difficult to say anything concerning skeletal distribution between or within phases. The following remarks are therefore of a very general and tentative nature.

There appears to be little difference between phases, all containing a fairly similar proportion of the major limb bones and metapodials (appendix 8). The humerus, mandible and pelvis are more abundant although only by a small percentage.

The overall impression is of an emphasis on the major meat bearing bones (figures 12:ii & 16). It may therefore be suggested that this skeletal distribution represents domestic debris.

The emphasis on meat bones contrasts with the pattern displayed by the sheep/goat bones (figure 12:i). This may be a further indication that the latter do not reflect general domestic debris or were disposed of in a different way to the pig and cattle (compare figures 12:i, 12:ii and 3:vi).

### (2) AGEING

The wear on the mandibles was recorded using Grant (1982). Only nine mandibles were recovered, four of which had complete molar rows. These data were treated in a similar way to those for the sheep/goat, using a combination of wear pattern and eruption stages to assign possible age ranges (appendix 9 & figure 17). As criticism has been made of Silver's ages for pig tooth eruption, the ages used were based on those outlined for later maturing breeds by Payne (1982). Silver had however to be followed for fusion ages as there is no suitable alternative.

The fusion data suggests that c70% of the population had reached maturity and were therefore greater than three and a half years old (table 10). This does not however agree with the eruption ages which implies that the majority of pigs were slaughtered between one and a half and three years of age, with only a few older examples.

This difference may be due to a loss of unfused bones. Alternatively, there may have been a loss of mandibles although one would expect poor preservation to affect the younger and more fragile jaws first. Furthermore the relative proportion of mandibles within each phase does not appear to be significantly different from the rest of the skeleton.

From the information available it is therefore only possible to say that the Papcastle pigs were being slaughtered from at least one and a half to three and a half years, although a certain percentage of the population may have lived longer.

This emphasis on immature animals would indicate that pig were bred primarily for meat. The presence of older animals may relate to those required for breeding.

(3) METRICAL ANALYSIS

As very few measurements were available from the pig bones it is not possible to say anything concerning the size of the Papcastle pigs. The measurements taken are listed in Appendix 10.

(4) BUTCHERY

There are very few butchery marks on the pig bones. Like the sheep/goat this may be a result of canid gnawing and the small size of pig bones compared to those of cattle. Only eight pig bones bear butchery marks: four pelves, three scapulae and one astragalus. From this little can be said about butchery practices.

The pelves have all been cut at the acetabulum, removing the pubis, ilium and ischium. As discussed already for the cattle and sheep this probably shows removal of the hind limb from the body. The pig scapulae also display evidence similar to those of the cattle. The muscle attachment at the glenoid cavity was sliced through, thus allowing separation from the humerus. The chop and slice marks on the scapula spine probably indicate the filleting of meat from the shoulder blade. The pig astragalus was sliced in half. This may be due to hide and/or foot removal.

**OTHER SPECIES**

RED DEER

Eleven fragments of red deer were recovered from Papcastle. The most frequent element was the antler (6); other bones represented were the pelvis (2), metapodials (2) and atlas (1). All of the antler fragments had been chopped or sliced and a use in the manufacture of artefacts may be postulated. The presence of antler does not necessarily indicate the hunting of deer as antlers can be collected when shed. That the Papcastle examples were derived from a dead animal is however suggested by two coronets which had been sliced from the skull rather than shed naturally. The metapodials, pelves and atlas would also imply that deer were hunted.

It is not uncommon to find red deer on sites of the Roman period in Britain. As at Papcastle such fragments form only a small percentage of the overall sample indicating that the exploitation of this species as a food source was negligible (King 1978).

HORSE

Thirty-one fragments of horse were identified, twenty-four of which came from phase 3(f1). It would be rather difficult to attribute this to an increased emphasis on horse by this phase as the fragments may all be derived from one animal (MNI =1).

No butchery marks were found on any of these which probably implies that horse was not being eaten (12% of the cattle bones had been butchered), as does the low percentage of fragments present in all phases. The teeth were all quite worn and are likely to have come from old animals. Both these observations suggest that horse was probably used as a working animal. However such an assumption can only be tentative due to the paucity of the evidence.

DOG

A dog tibia was recovered from phase 3(r). The shoulder height of the animal was estimated (using Harcourt, 1974) to be roughly 40 cm, about the size of a medium sized modern terrier

BIRD

Twelve fragments of bird bone were recovered from Papcastle. Little can be concluded from such a small sample and the following is merely a brief description of the species present.

The species identified were chicken (4), Barnacle goose (1),Greylag goose (1),crow (1) and crane (5). The fragments of crane were identified by E.Allison. Domestic fowl are commonly found on Roman sites, often contributing considerably to the food source (Maltby 1979). That chicken was present at Papcastle is therefore not surprising although the low representation may be.

The Greylag goose is considered to have been domesticated in Britain by the Roman period (Maltby 1979). Obviously the Papcastle example can contribute little towards this - from one fragment it would be impossible to tell whether the bird was domesticated or, like the Barnacle, wild.

Crow may have been used as a food source (Maltby 1979) although a more probable explanation is inclusion in the deposit by natural causes.

Crane is commonly found in Roman deposits in England.

# INTERPRETATION, SUMMARY and CONCLUSIONS

## (i) Interpretations

The information from an animal bone study ought to allow some insight into the function of an archaeological settlement. The following is intended as a comment on possible interpretations using the animal bone only and is obviously dependent on other archaeological information.

There is a significant difference between the animal bone present in phase 1 and that in the later phases. This has been compared with the evidence at Castle Street, Carlisle where a primary butchery area had been postulated. A similar function is tentatively suggested for phase 1 at Papcastle. Further evidence is however needed to substantiate this suggestion.

In the later phases the patterning has been interpreted as that of general domestic debris. It is probable therefore that a change in the function of the excavated area had occurred which may relate to the cessation of the industrial activities.

Animal bone can be used to try and distinguish between producer sites i.e. settlements where animals are bred and reared, often for consumption elsewhere, and consumer sites where animals are not bred but are obtained from elsewhere. This distinction is useful as it can allow some indication of how major sites such as forts or urban settlements relate to their hinterland.

The distinction between producer and consumer is however not always straightforward as is apparent from the Papcastle evidence. Here the age structure of the cattle has an emphasis on very old animals and a comparative lack of three to five year olds. This could be used to suggest that the settlement was breeding animals for consumption elsewhere, perhaps the nearby fort, i.e. that the primary function of cattle was for the production of meat. The latter age group are those which are most likely to have been removed from the site if such a function did exist as it becomes uneconomical to keep animals much older if their value is for meat. The absence of very young calves does however refute this function ,for if animals were being reared on the site some evidence of infant mortality would be expected.

The age structure of the pigs and sheep/goats implies animals reared principally for meat, there being few old animals. If these species were being bred on the site older animals ought to be present, ie.those which had fulfilled their use as breeding stock. As discussed earlier there may be several older pigs present but the size of the sample makes this difficult to say with any conviction. Furthermore, like the cattle some evidence for infant mortality should be present. The absence of very young animals may of course be explained by preservation conditions, in that the more fragile bones of infants had not survived.

From the evidence available it would be rather difficult to say with any certainty that the settlement at Papcastle was a 'producer' or a 'consumer'. Evidence from other areas of the settlement or indeed the fort itself might help clarify the picture but it is unlikely that any straightforward distinction could be made.

(ii) Summary and conclusions

At Papcastle domesticates were the main animal resource utilised. There appears to have been little reliance on natural resources such as birds, fish, or wild animals. The few examples that are present could not have contributed much to the diet. The main emphasis was on cattle, which were used primarily for breeding, milk and traction before slaughter. Sheep/goat and pig were also present but in a much smaller proportion. Both species were probably bred primarily for meat. Horse appears not to have been eaten but used presumably for traction or other forms of work.

It would be impractical to try and suggest possible breeds for the domesticates at Papcastle. The available evidence does however suggest that both the cattle and sheep were horned and slightly larger than those found in the Iron age. The sheep appear to have been two horned although a four horned example was recovered.

In conclusion, the Papcastle animal bone shows that cattle, sheep/goats, pig and to a certain extent red deer, horse and bird were exploited.

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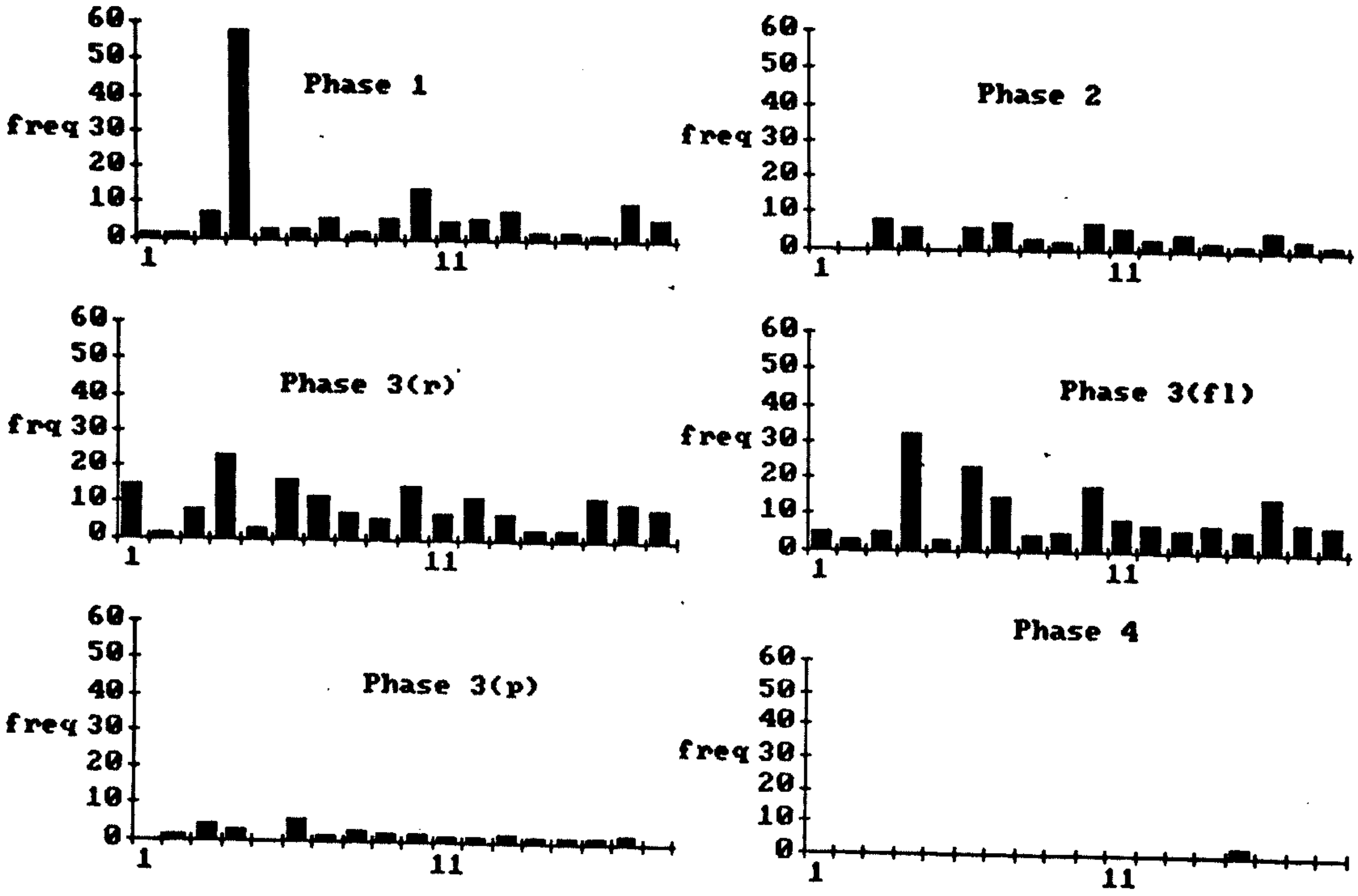



Figure 1 Minimum Numbers of Individuals, based on 18 element types, for cattle.

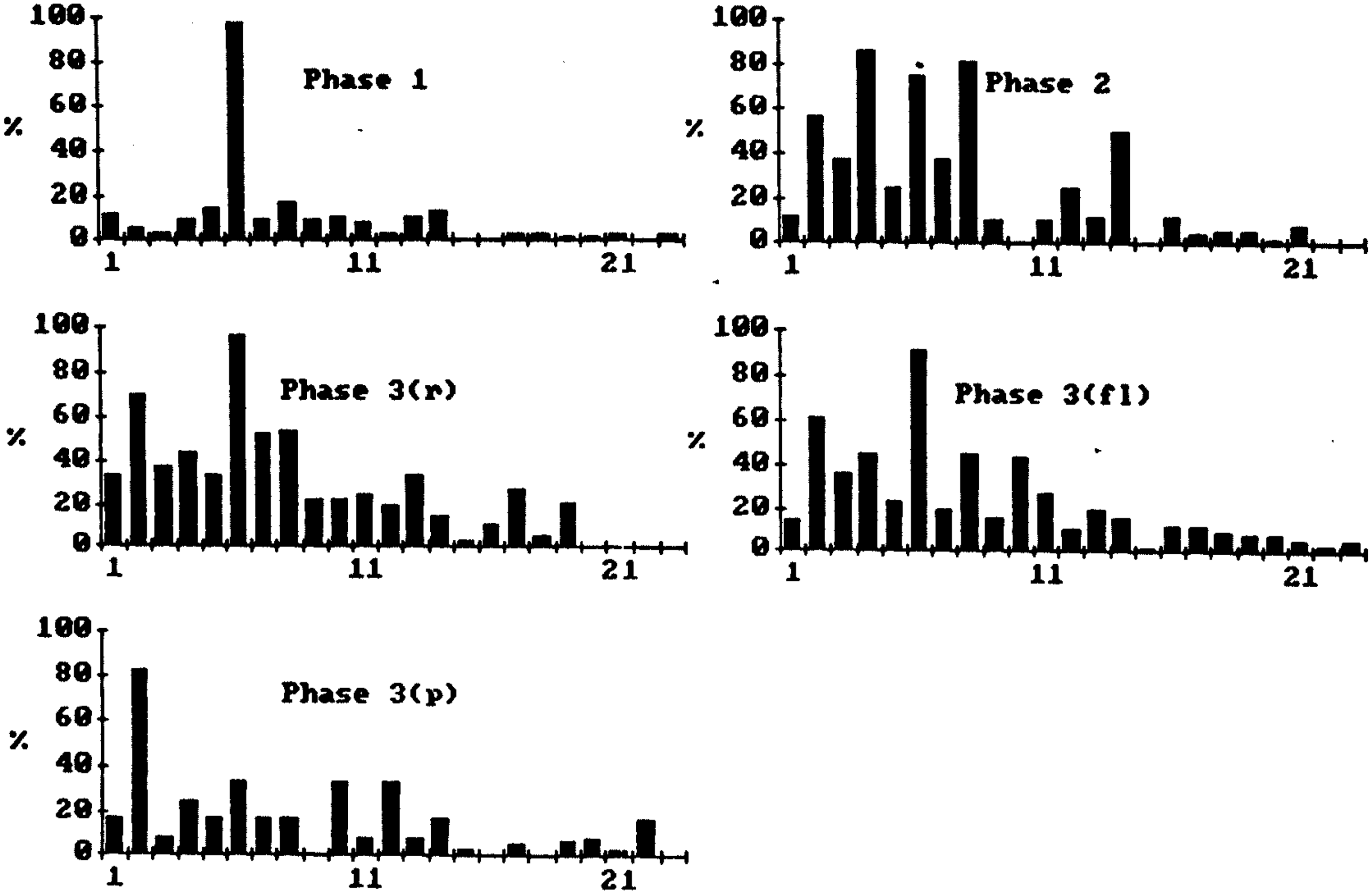
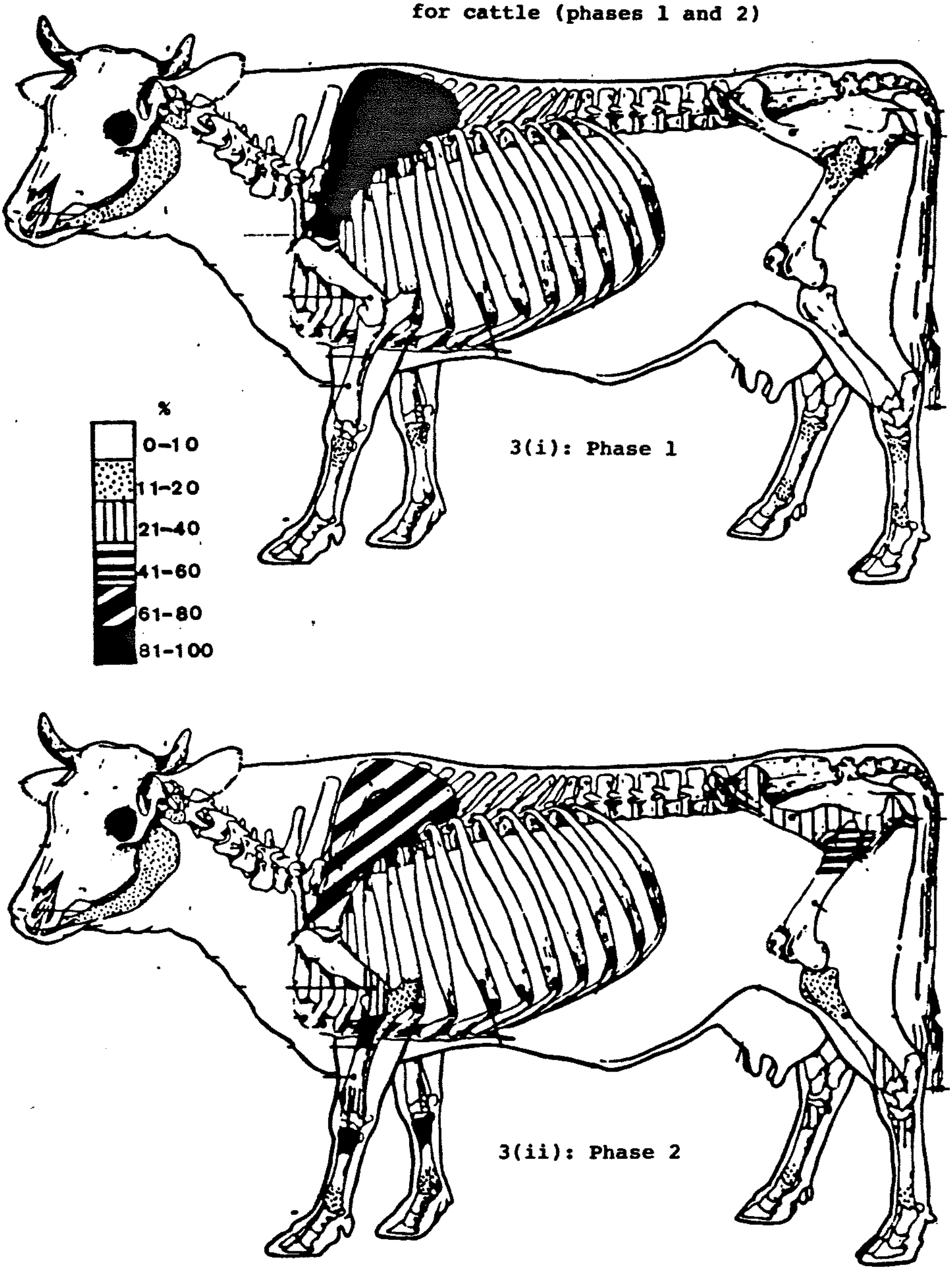



Figure 2 Percentage Representation of Elements for Cattle
(after Brain 1982)

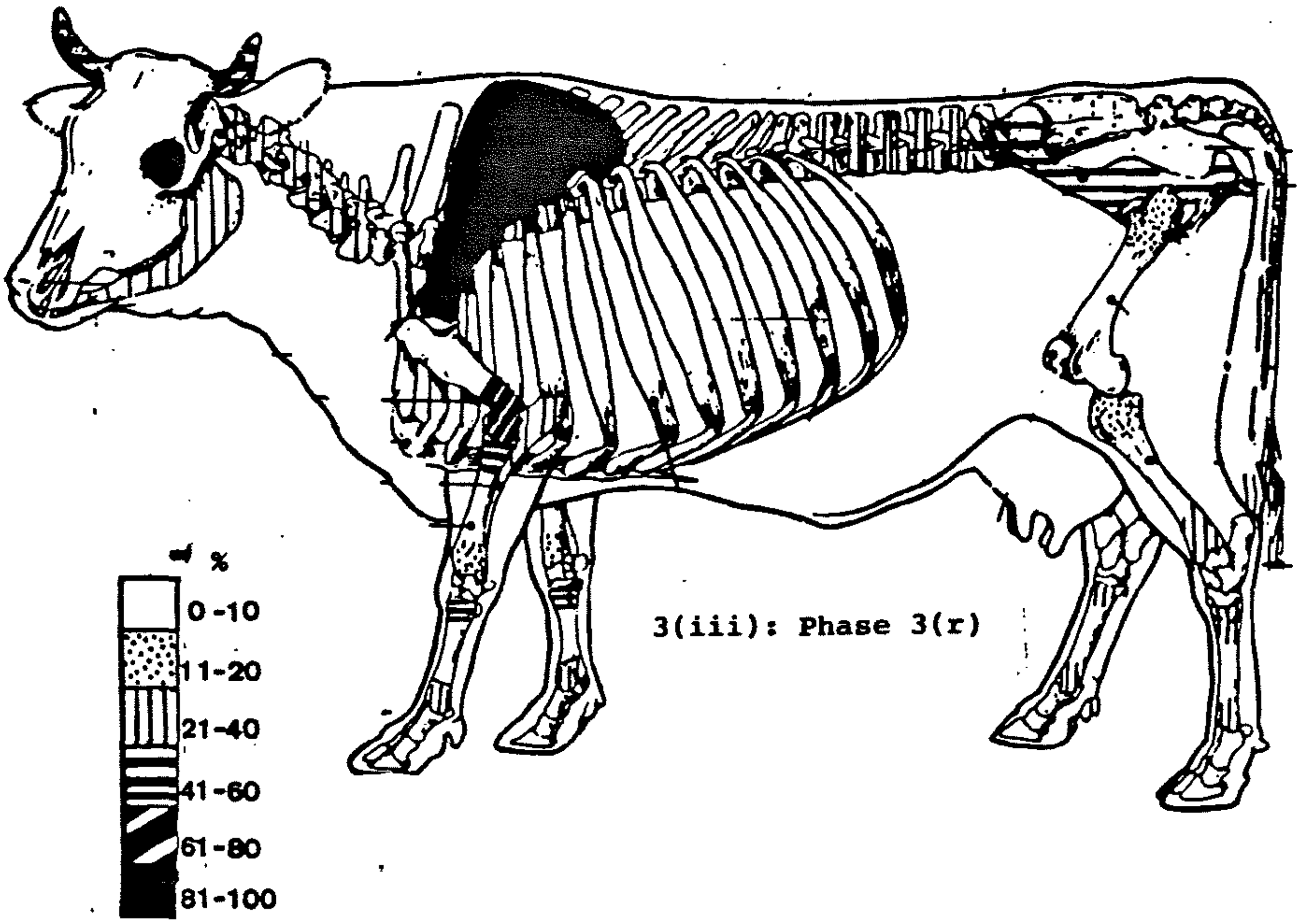
Figure 3: i and ii  Percentage Representation of Elements for cattle (phases 1 and 2)



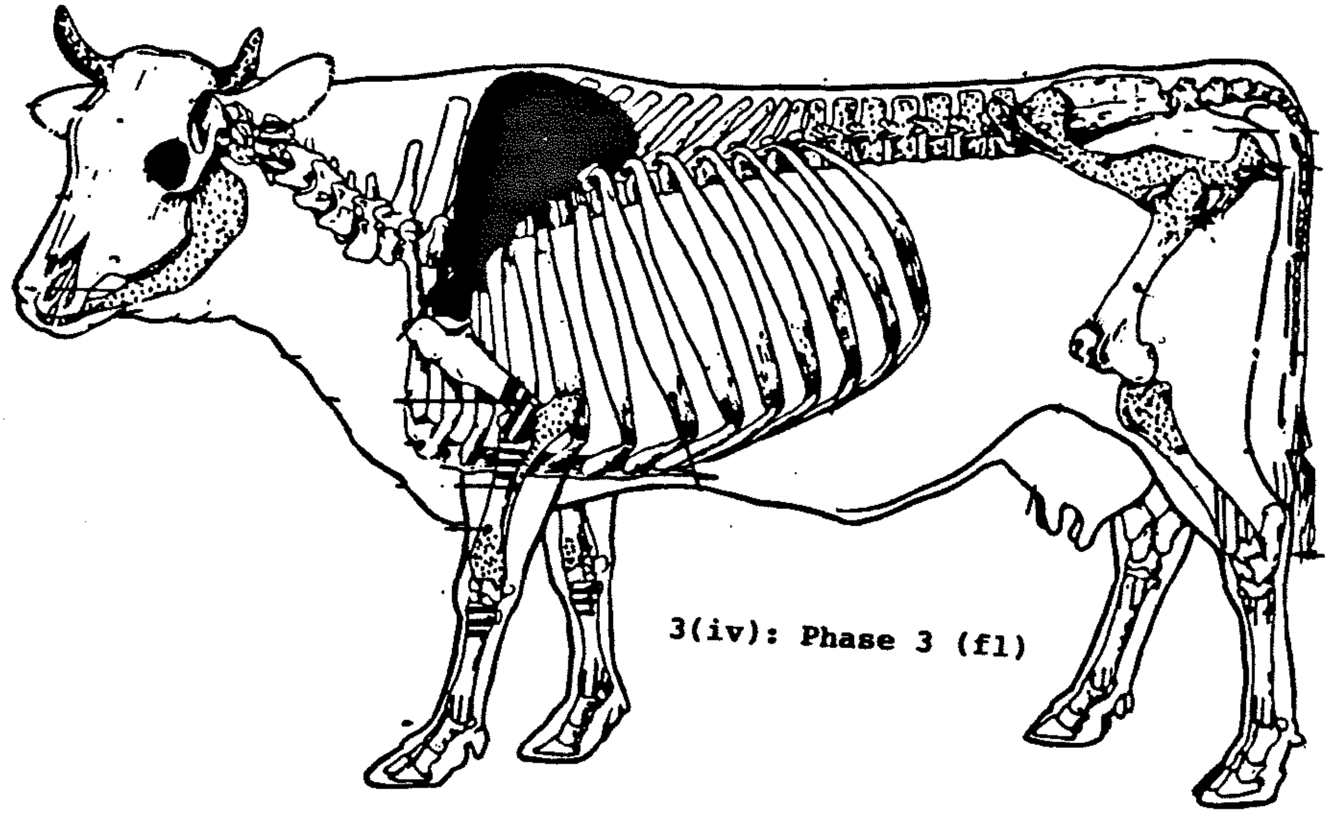

3(i): Phase 1

3(ii): Phase 2

**Figure 3: iii and iv** **Percentage Representation of Elements for cattle (phases 3(r) and 3 (fl))**

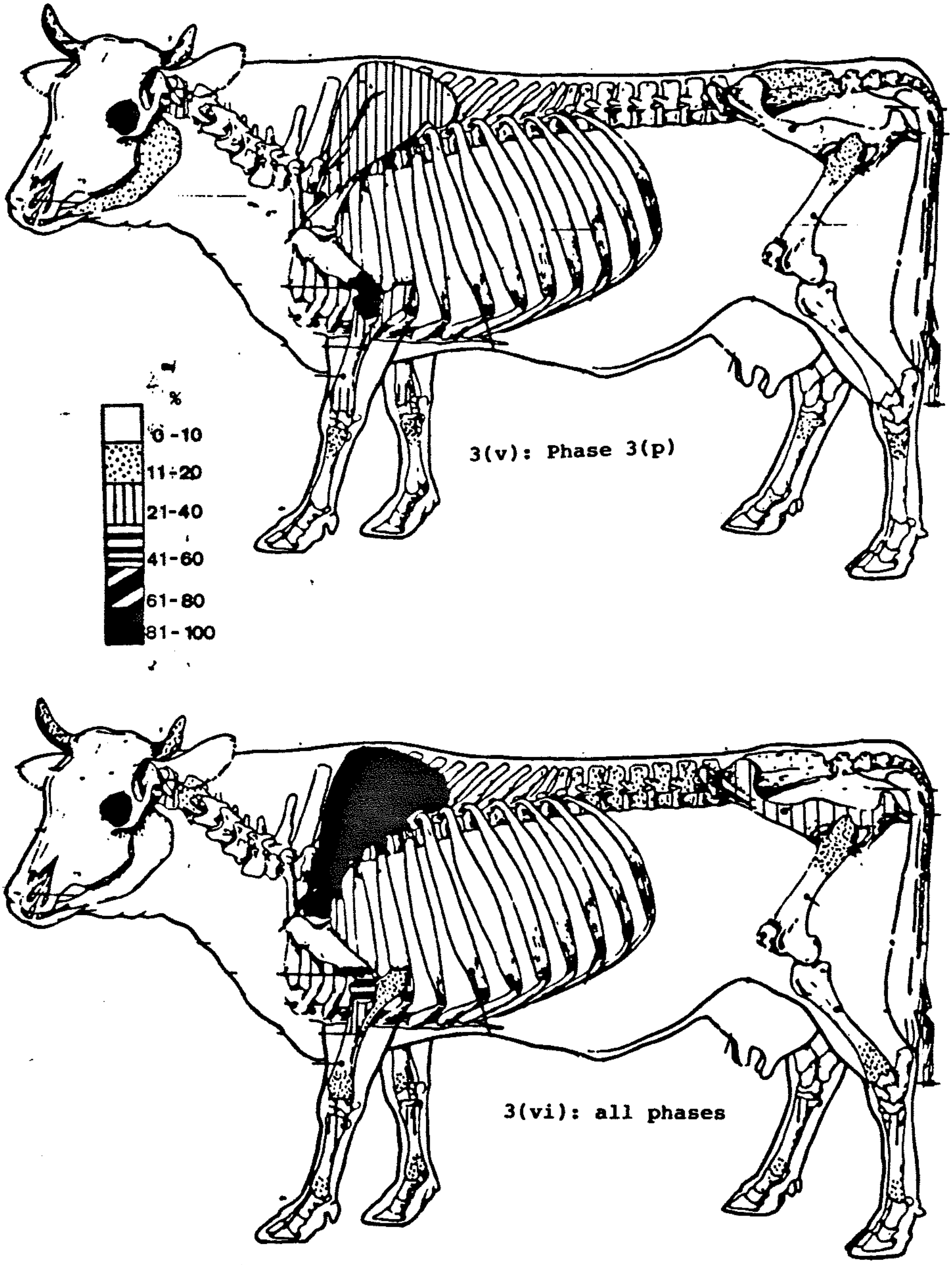



3(iii): Phase 3(r)



3(iv): Phase 3 (fl)

Figure 3 : v and vi  Percentage Representation of Elements for cattle (phase 3(p) and all phases).



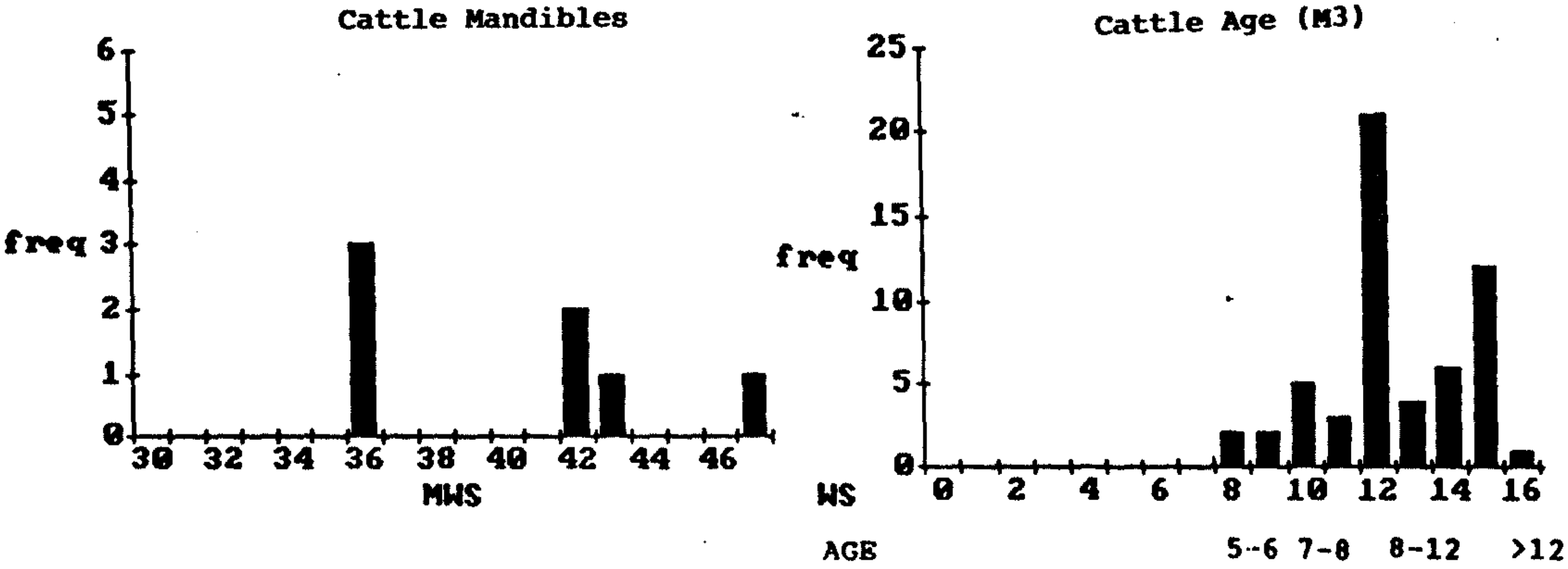



Figure 4 Cattle Mandibular Wear Stages (MWS) and the age structure of the cattle, calculated from the cementum layers and wear stages of the third molars (M3)

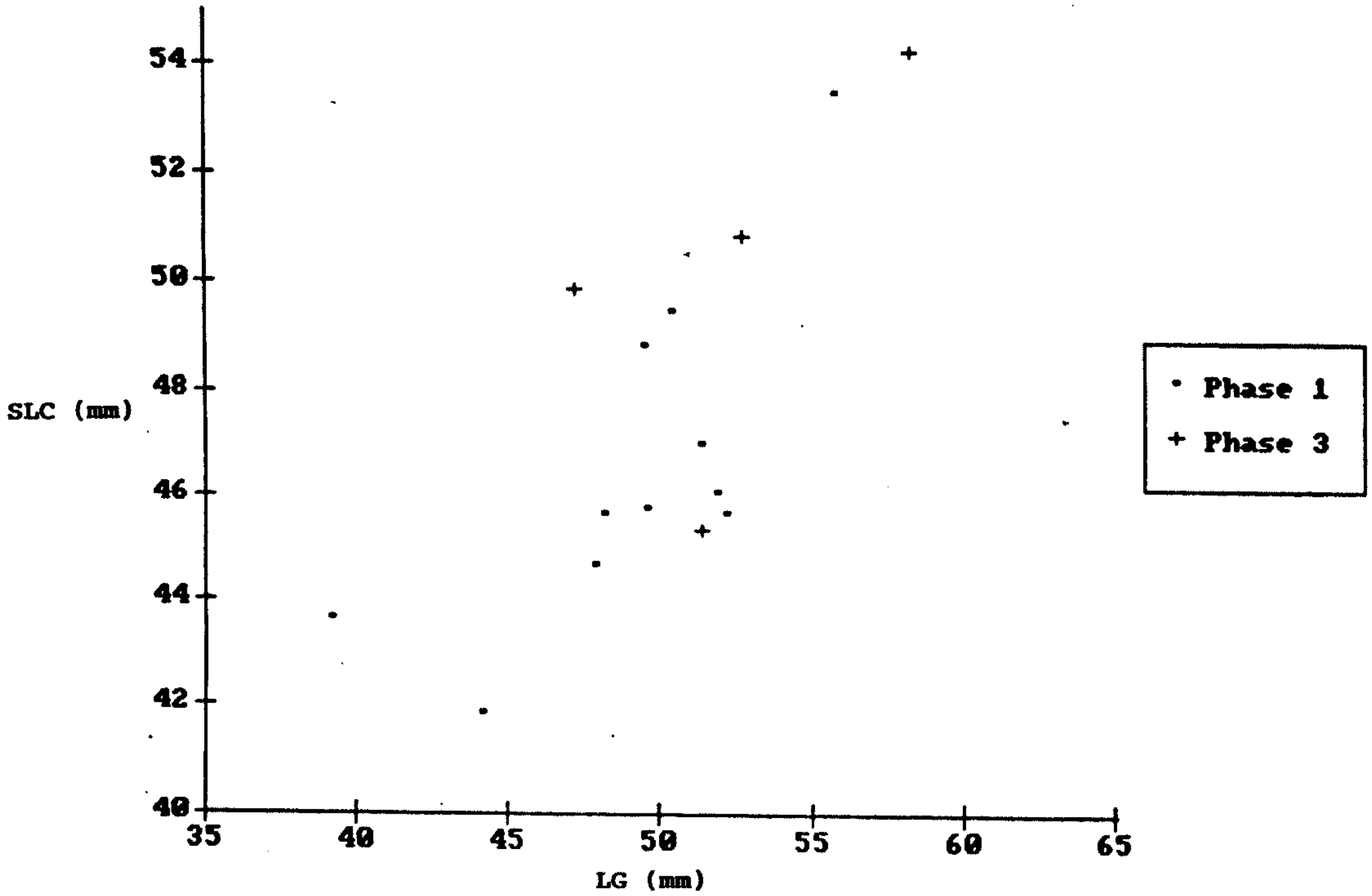



Figure 5 Cattle scapula glenoid width (LG) against neck width (SLC)

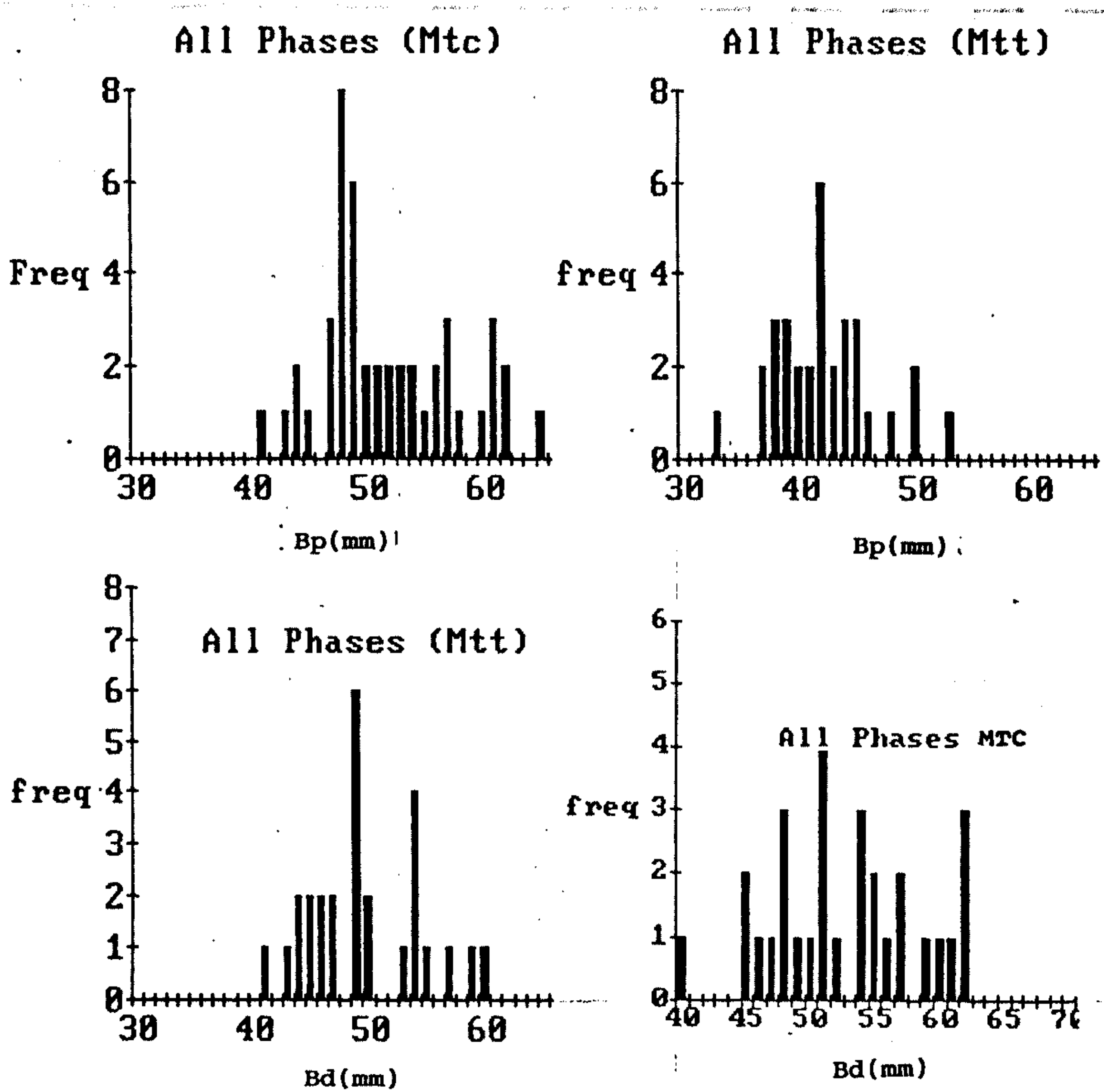



Figure 6 Cattle metapodials, proximal and distal widths (Bp and Bd).

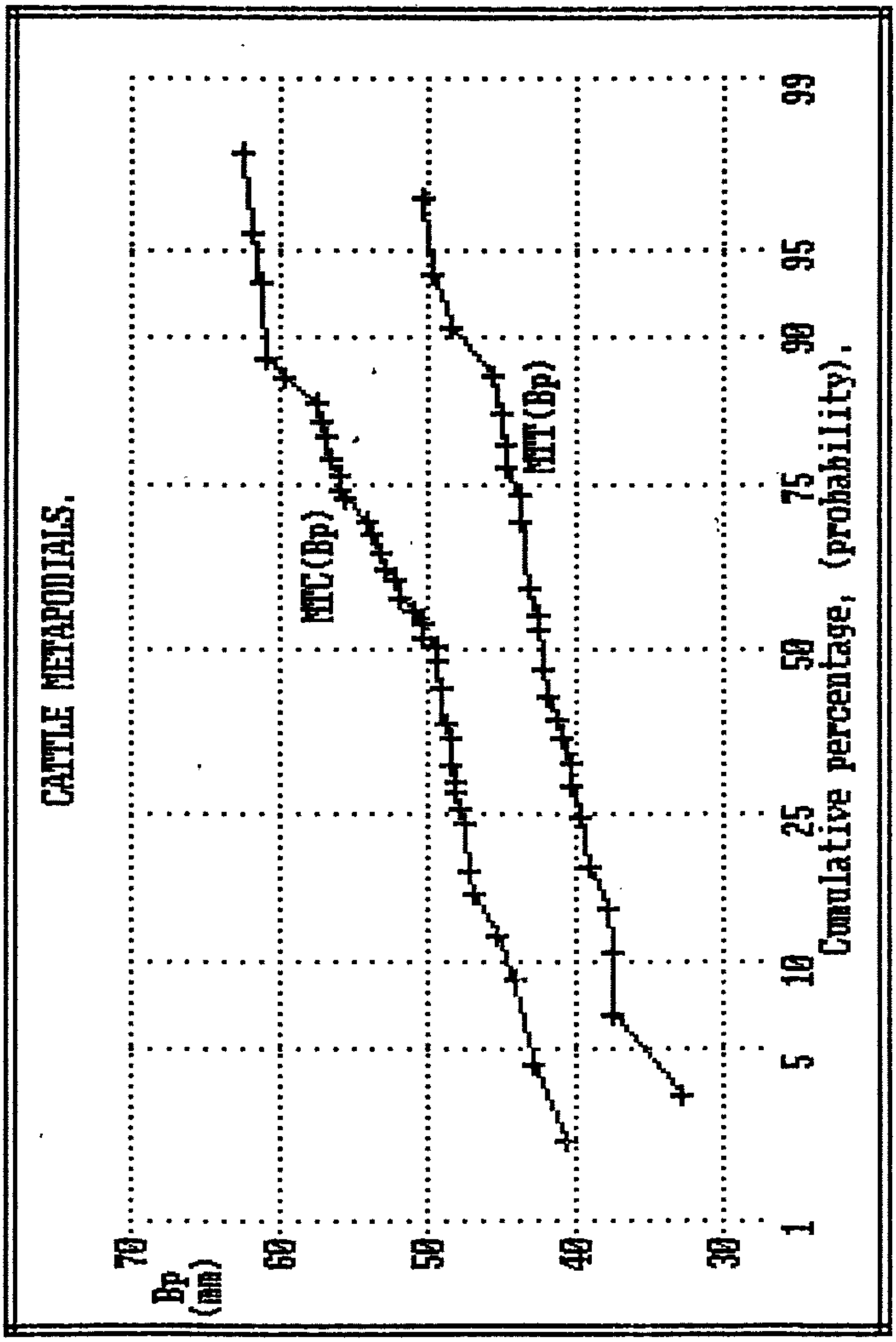



Figure 7 Cattle metapodials, proximal widths (Bp) plotted on logarithmic probability paper.

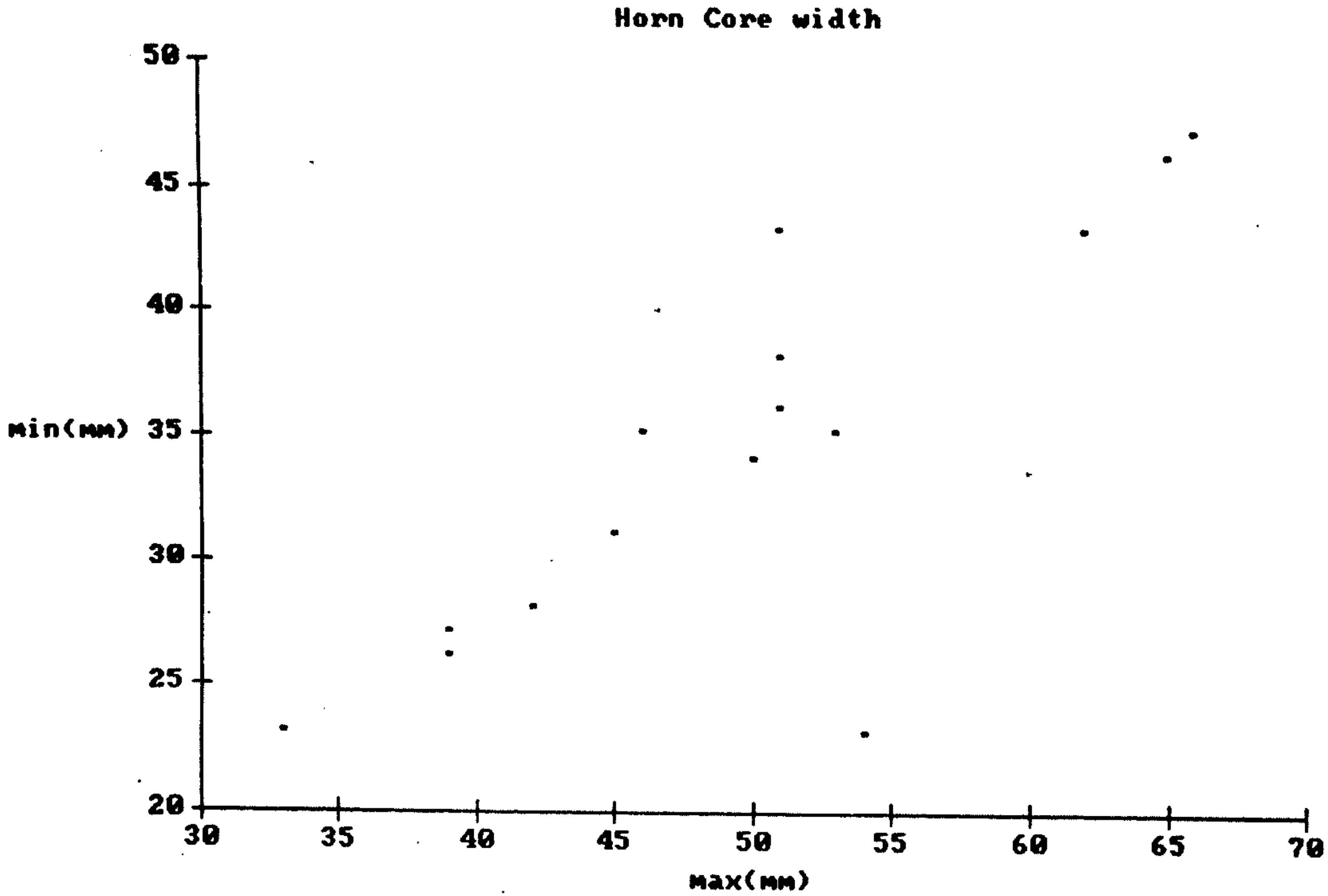
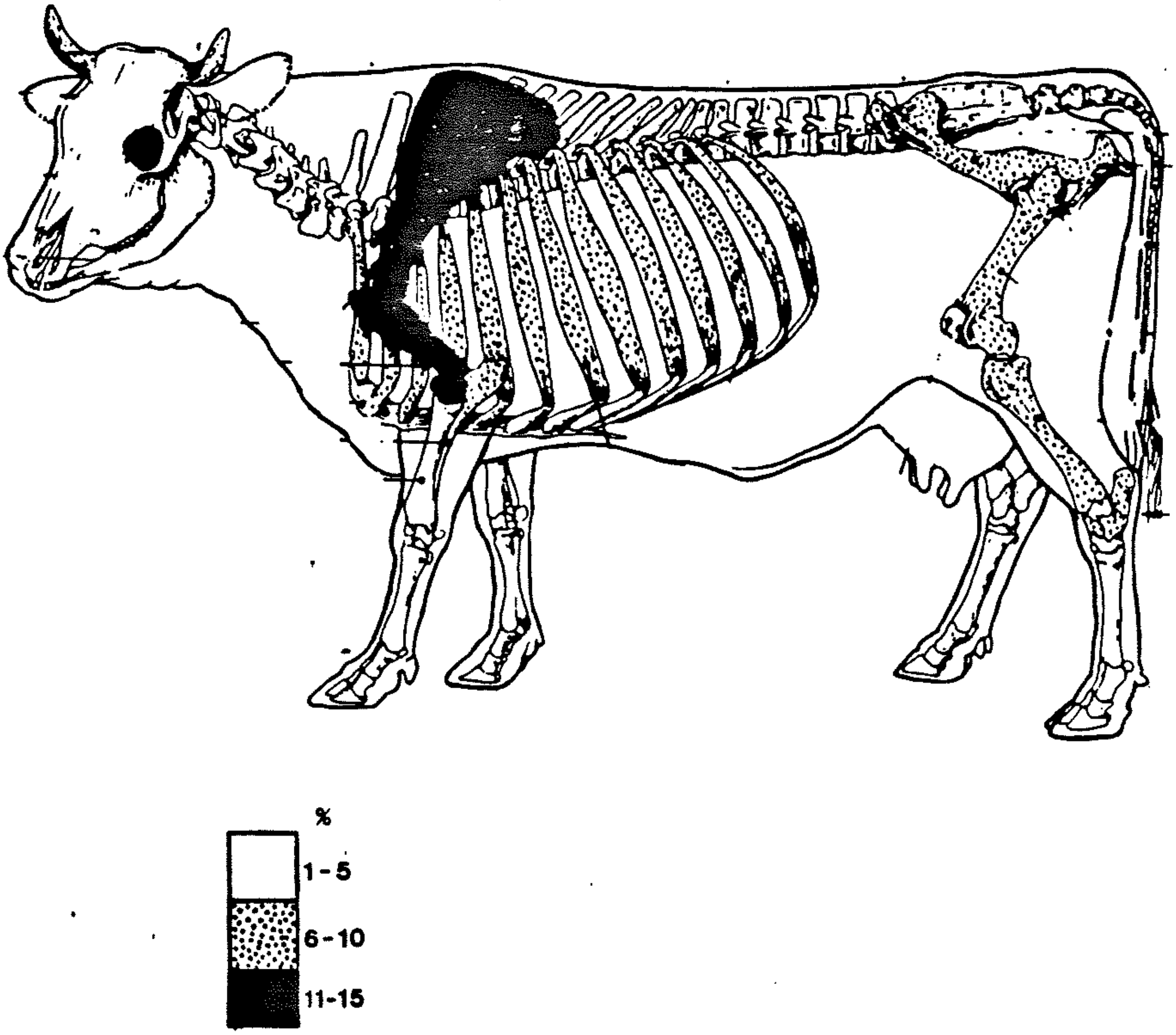



Figure 8 Cattle horn cores : the minimum basal width (min) against the maximum basal width (max)

Figure 9 The percentage of cattle bones butchered (all phases)



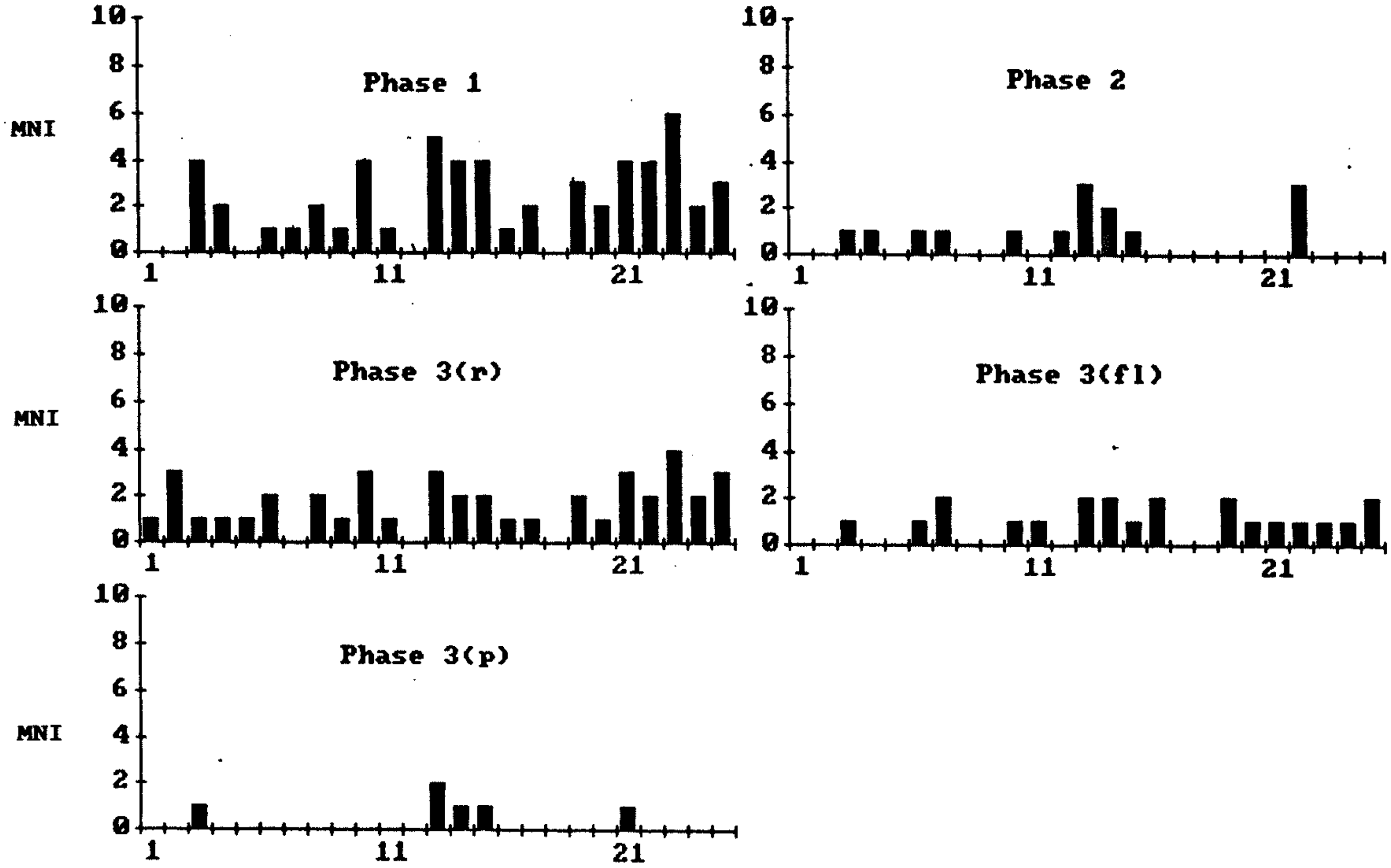



Figure 10 The Minimum Number of Individuals based on 25 element types for sheep/goat.

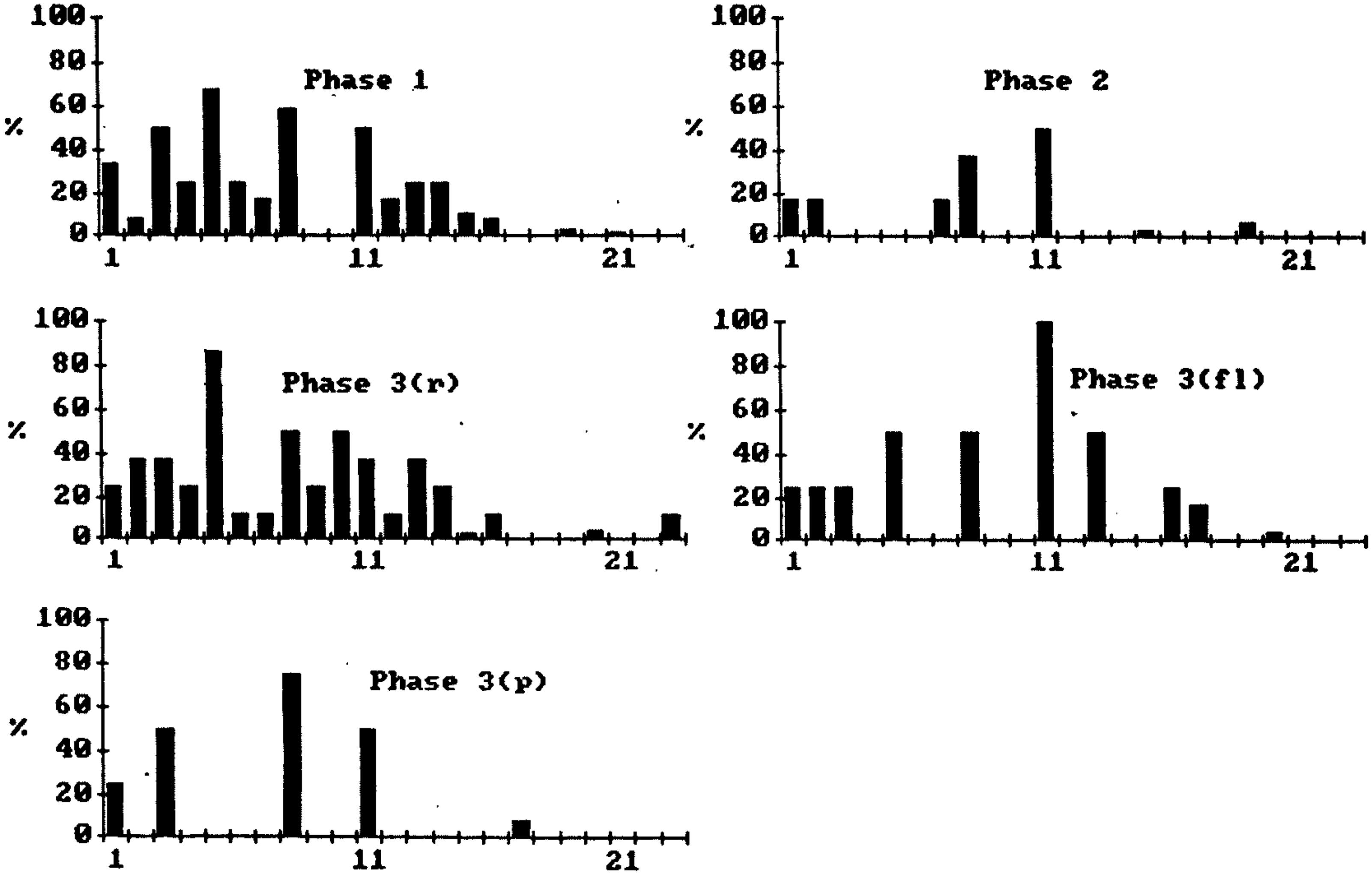
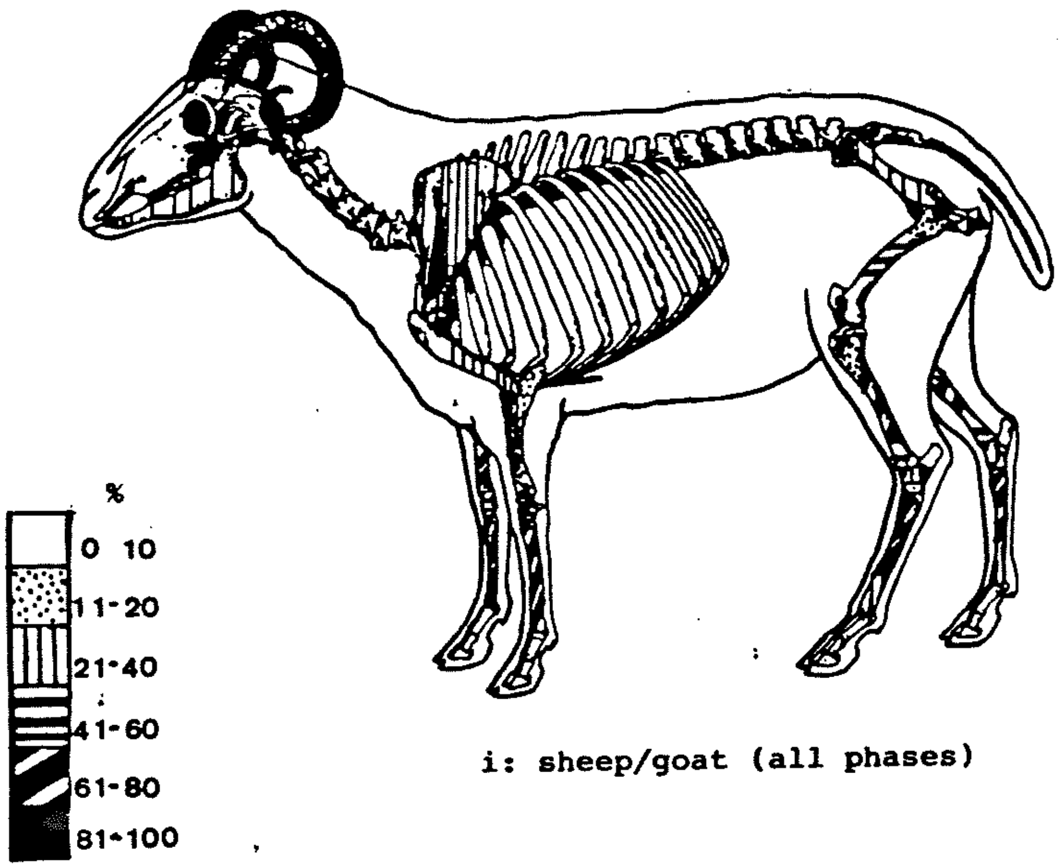
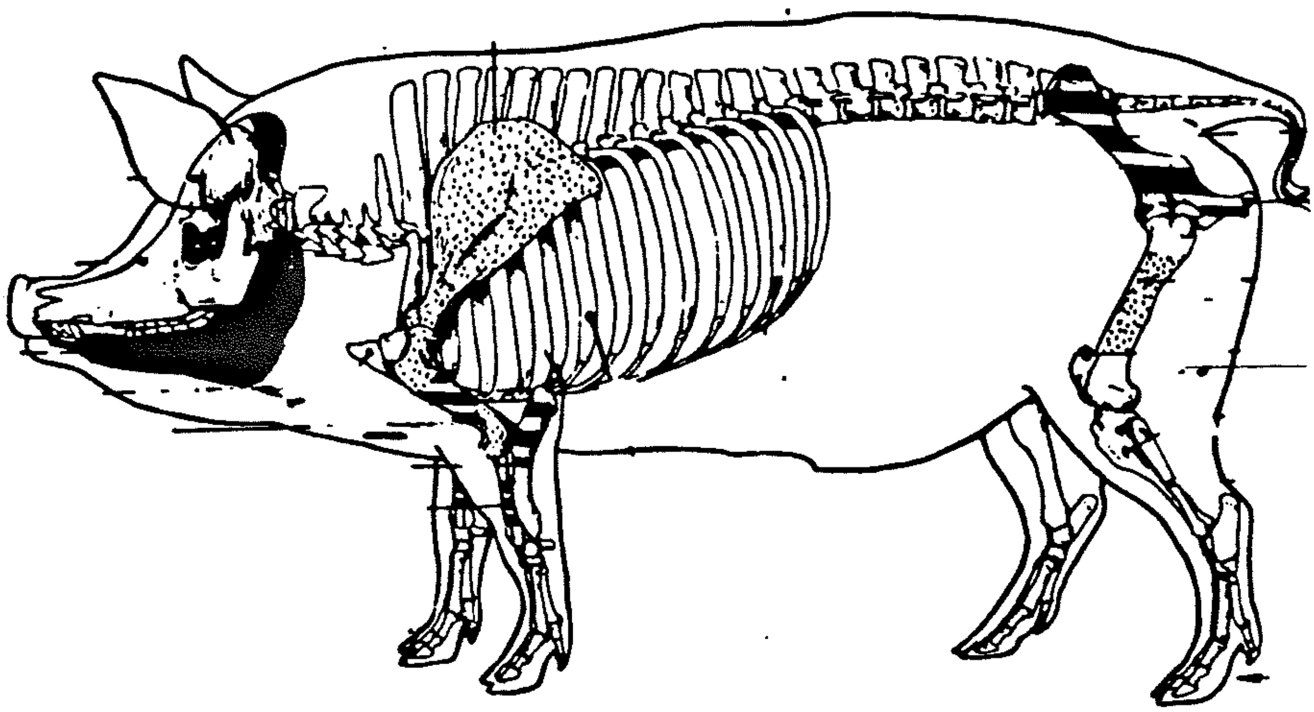



Figure 11 Percentage Representation of Elements, sheep/goat
(after Brain 1982)

Figure 12 Percentage Representation of Elements for
i: sheep/goat (all phases) and ii: pig (all phases).

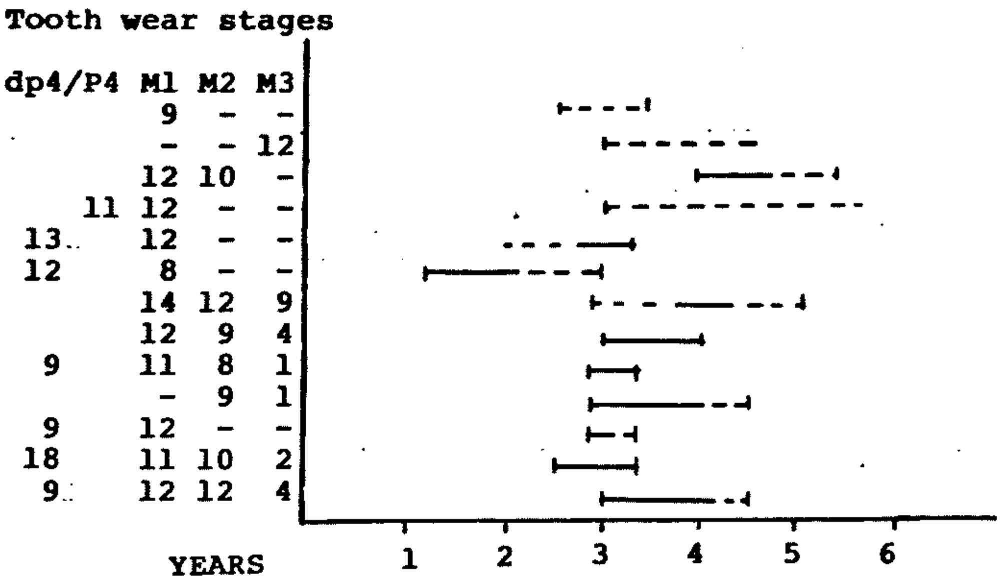



i: sheep/goat (all phases)



ii: pig (all phases)

Figure 13 The estimated age range for the sheep/goat mandibles (dotted line indicates possible age range).




CODE

d=deciduous

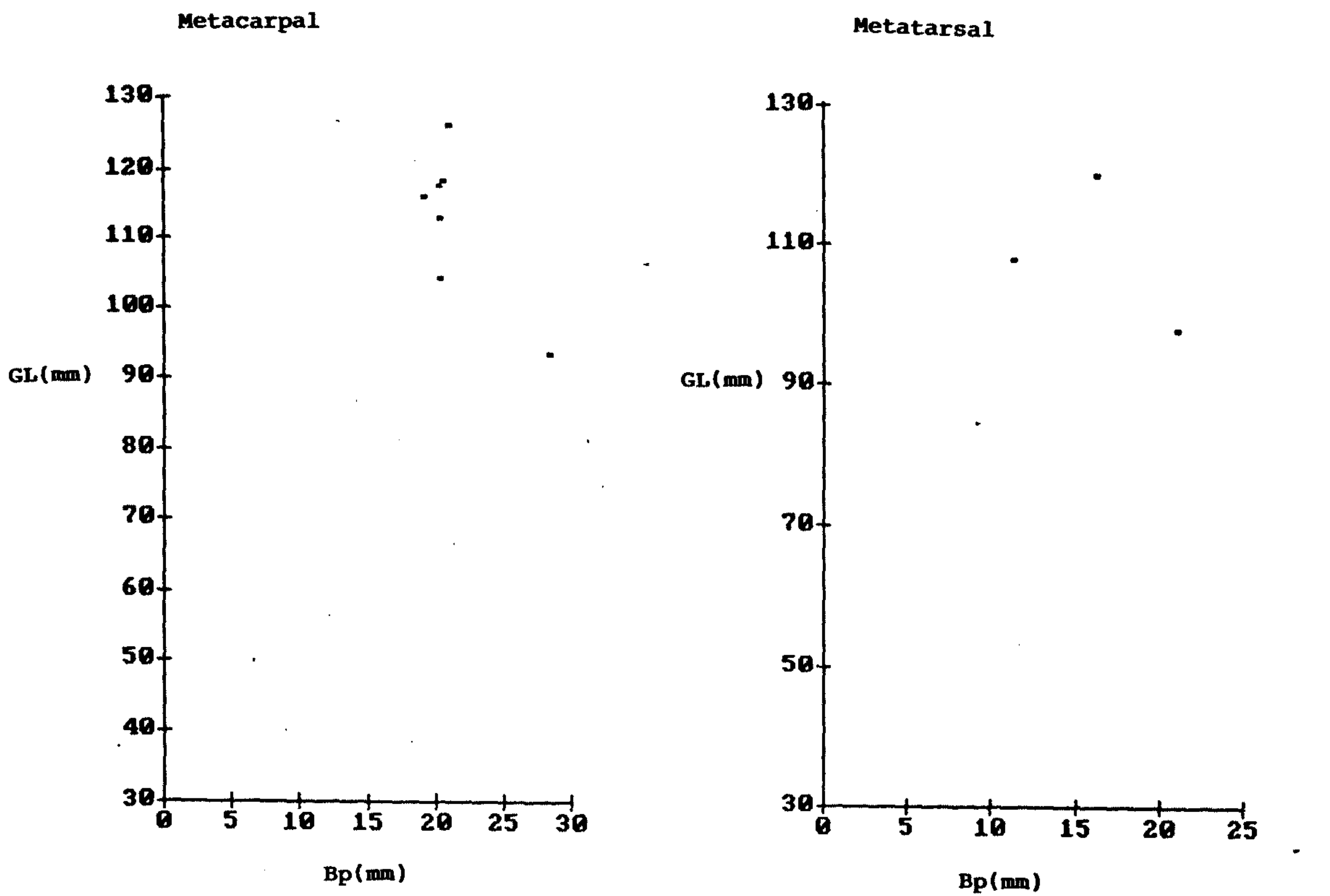



Figure 14 Sheep/goat metapodials, shaft length (GL) against proximal width (Bp).

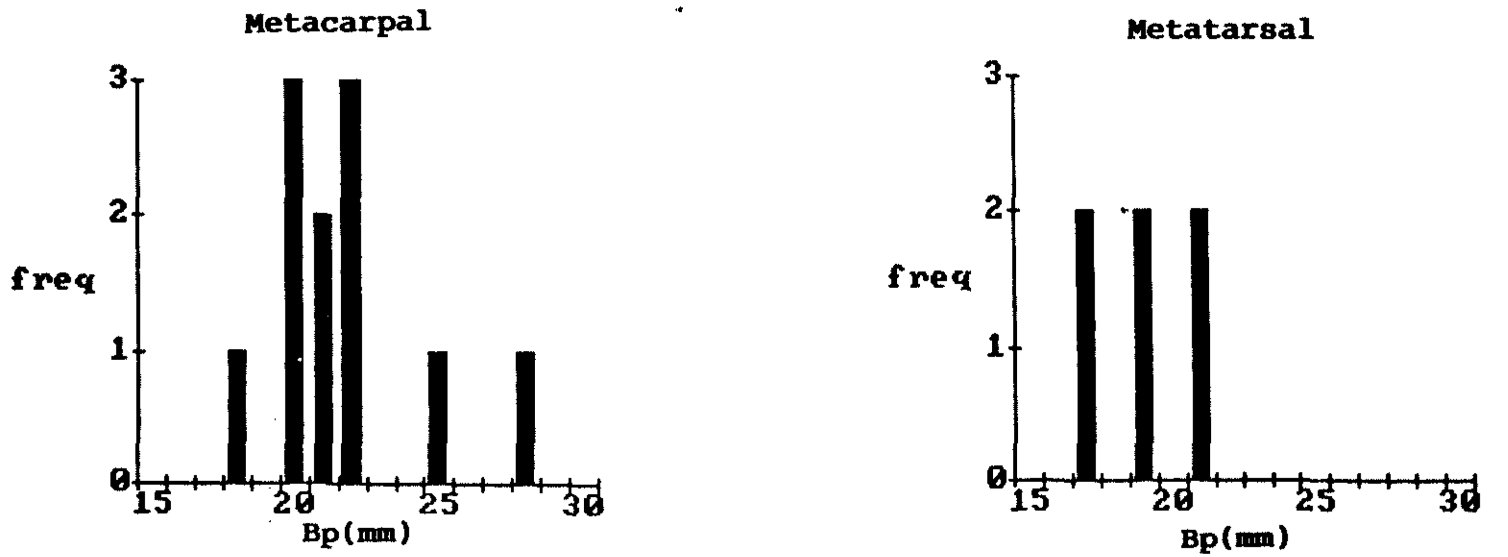



**Figure 15 Sheep/goat metapodials, proximal width (Bp)**

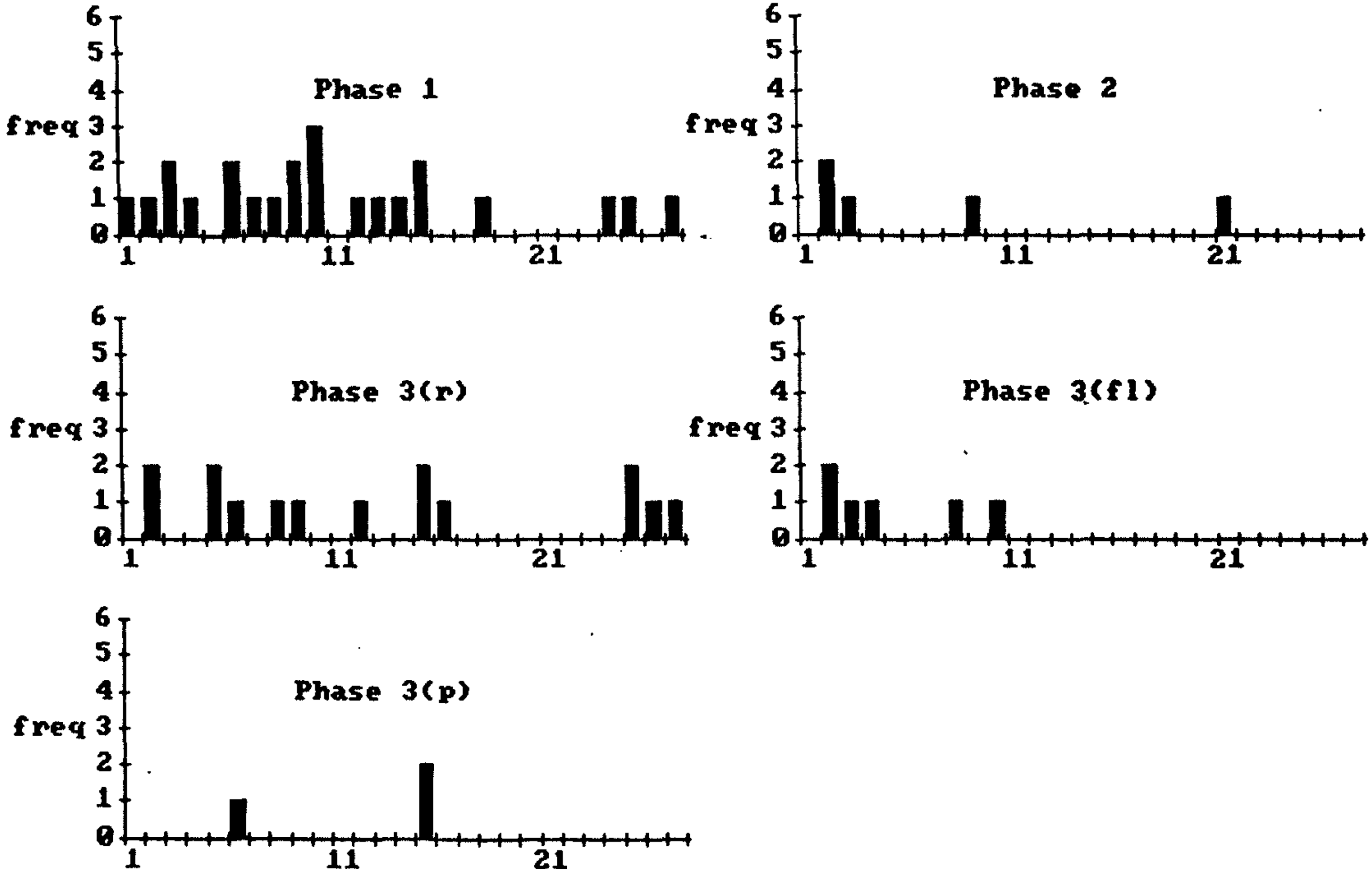
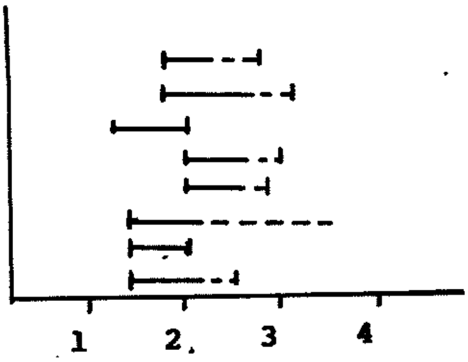



Figure 16 The Minimum Number of Elements for Pig.

Figure 17 The estimated age range for the pig mandibles (dotted line indicates possible age range).

Tooth wear stages

| /P4 | M1 | M2 | M3 |
|---|---|---|---|
| | - | - | 7 |
| 10 | 15 | 10 | 8 |
| 13 | 11 | 7 | 1 |
| | 17 | 13 | 9 |
| | 15 | 10 | 8 |
| 9 | 14 | - | - |
| | - | - | 4 |
| | - | 13 | 8 |




YEARS

CODE
d=deciduous

Table 1 The Percentage of Mammals Present

| Phase | Species | Fragments N | Fragments % | MNI N | MNI % |
|---|---|---|---|---|---|
| 1 | Cattle | 769 | 84.0 | 58 | 85.3 |
| | Sheep/goat | 86 | 9.4 | 6 | 8.8 |
| | Pig | 58 | 6.4 | 3 | 4.4 |
| | Red Deer | 2 | 0.2 | 1 | 1.5 |
| | Cattle s | 232 | | | |
| | Sheep/pig s | 84 | | | |
| | Unid. | 315 | | | |
| 2 | Cattle | 268 | 89.0 | 8 | 53.3 |
| | Sheep/goat | 22 | 7.3 | 3 | 20.0 |
| | Pig | 7 | 2.3 | 2 | 13.3 |
| | Horse | 3 | 1.0 | 2 | 13.3 |
| | Cattle s | 113 | | | |
| | Sheep/pig s | 10 | | | |
| | Unid. | 140 | | | |
| 3(r) | Cattle | 991 | 88.0 | 23 | 70.0 |
| | Sheep/goat | 86 | 7.6 | 4 | 12.0 |
| | Pig | 46 | 4.1 | 2 | 6.0 |
| | Red Deer | 2 | 0.2 | 1 | 3.0 |
| | Horse | 4 | 0.3 | 2 | 6.0 |
| | Dog | 1 | 0.08 | 1 | 3.0 |
| | Cattle s | 369 | | | |
| | Sheep/pig s | 37 | | | |
| | Unid | 468 | | | |
| 3(fl) | Cattle | 928 | 91.0 | 32 | 82.0 |
| | Sheep/goat | 22 | 2.1 | 2 | 5.0 |
| | Pig | 38 | 3.7 | 2 | 5.0 |
| | Red Deer | 8 | 0.8 | 2 | 5.0 |
| | Horse | 24 | 2.3 | 1 | 2.5 |
| | Human | 1 | | | |
| | Cattle s | 306 | | | |
| | Sheep/pig s | 38 | | | |
| | Unid. | 259 | | | |
| 3(p) | Cattle | 102 | 92.7 | 6 | 60.0 |
| | Sheep/goat | 4 | 3.6 | 2 | 20.0 |
| | Pig | 3 | 2.7 | 1 | 10.0 |
| | Cattle s | 59 | | | |
| | Sheep/pig s | 2 | | | |
| 4 | Cattle | 11 | 100.0 | 2 | 100.0 |
| | Cattle s | 16 | | | |
| | Sheep/pig s | 1 | | | |

Table 2 The Percentage of loose teeth present in each phase.

| Phase | Number of loose teeth | Total number of fragments | Percentage % |
|---|---|---|---|
| 1 | 47 | 1546 | 3 |
| 2 | 42 | 563 | 7 |
| 3(r) | 103 | 2004 | 5 |
| 3(fl) | 140 | 1600 | 8 |
| 3(p) | 13 | 242 | 5 |
| 4 | 1 | 50 | 2 |
| <u>Totals:</u> | 346 | 6005 | <u>Average:</u> 5.8 |

Table 3 The preservation condition of fragments showing the number of fragments (Total) and the percentage of the total in each category.

| Phase | Total | Burnt | Brittle | Chewed | Accretion | Mineralized |
|---|---|---|---|---|---|---|
| **Phase 1** | | | | | | |
| Cattle | 769 | 1.3 | 0.5 | 0.6 | | 0.9 |
| Cattle s | 232 | 10 | 0.3 | 1.7 | | 0.9 |
| Pig | 58 | | 0.06 | 7 | | 1.7 |
| Sheep | 86 | 1.2 | | 19.8 | | 1.7 |
| S/Ps | 84 | 7.1 | | 3.6 | | 2.4 |
| Unid | 315 | 4.4 | 0.3 | | | 1.2 |
| Total | 1544 | 3.5 | 0.9 | 2.1 | | 1.1 |
| **Phase 2** | | | | | | |
| Cattle | 268 | 0.4 | 13.8 | 0.7 | 5.2 | 1.1 |
| Cattle s | 113 | | 4.4 | 0.9 | 1.8 | 1.8 |
| Pig | 7 | | | 14.2 | 14.2 | |
| Sheep | 22 | | | 4.5 | 4.5 | |
| S/Ps | 10 | | 20 | 10 | 10 | 10 |
| Unid | 140 | 1.4 | 5.7 | | 9 | |
| Total | 563 | 0.5 | 9 | 1 | 12.4 | 1 |
| **Phase 3 (r)** | | | | | | |
| Cattle | 991 | 0.1 | 3.2 | 1.6 | 1 | 0.8 |
| Cattle s | 396 | 2.8 | 2.5 | 0.7 | 1 | 0.2 |
| Pig | 46 | | | 6.5 | | |
| Sheep | 86 | | 1.7 | 15 | | |
| S/P s | 37 | 11 | | 2.7 | | |
| Unid | 468 | | | | | |
| Total | 2031 | 0.8 | 2.1 | 1.8 | 1.3 | 0.8 |
| **Phase 3 (fl)** | | | | | | |
| Cattle | 928 | 0.4 | 1.4 | 1.9 | | 0.4 |
| Cattle s | 306 | 0.3 | | 1.3 | | 0.3 |
| Pig | 22 | | | 13 | | |
| Sheep | 38 | | | 13 | | |
| S/P s | 38 | | 2.6 | | | |
| Unid | 259 | | | | | 1.1 |
| Total | 1600 | 0.3 | 0.9 | 1.9 | | 0.5 |
| **Phase 3 (p)** | | | | | | |
| Cattle | 102 | 0.9 | 1.9 | 1 | | 3.9 |
| Cattle s | 59 | | 1.7 | | | 4.8 |
| Pig | 3 | | | | | |
| Sheep | 4 | | | 25 | | |
| S/P s | 2 | | | | | |
| Unid | 72 | | | | | 1.4 |
| Total | 243 | 0.4 | 1.2 | 0.8 | | |

Table 4 Cattle Cementum Counts and Age

| Phase | Tooth | Wear Stage | Counts 1 | 2 | 3 | 4 | 5 | 6 | Ave. | Description | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | M1 | 12 | 5 | 6 | 4 | 5 | 5 | 5 | 5.8 | convoluted | 4 |
| 3 | M1 | 12 | 5 | 13 | 9 | 15 | 15 | 12 | 11.5 | mottled | 7 |
| 3 | M1 | 15 | 10 | 12 | 12 | 14 | 13 | 15 | 12.7 | hazy | 7 |
| 3 | M1 | 14 | | | | | | | | not visible | |
| 3 | M1 | 16 | 19 | 21 | 16 | 20 | 18 | 22 | 19.3 | hazy | 10 |
| 3 | M1 | 15 | | | | | | | | crumbled | |
| 3 | M1 | 15 | | | | | | | | unreliable | |
| 3 | M1 | 12 | | | | | | | | hazy | |
| 3 | M1 | 17 | | | | | | | | blotchy | |
| 1 | M1 | 13 | 7 | 11 | 13 | 12 | 10 | 9 | 10.3 | | 6 |
| 1 | M1 | 17 | 22 | 17 | 28 | 30 | 25 | 32 | 25.7 | | 14 |
| 3 | M2 | 14 | 11 | 12 | 10 | 14 | 14 | 15 | 12.6 | convoluted | 8 |
| 3 | M3 | 15 | | | | | | | | blotchy | |
| 3 | M3 | 15 | 16 | 13 | 19 | 20 | 27 | 20 | 19.2 | | 12 |
| 1 | M3 | 15 | | | | | | | | hazy | |
| 1 | M3 | 10 | | | | | | | | not visible | |
| 3 | M3 | 12 | | | | | | | | no lines | |
| 3 | M3 | 8 | 3 | 5 | 4 | 3 | 4 | 4 | 3.8 | | 5 |
| 3 | M3 | 14 | 6 | 8 | 10 | 17 | 13 | 17 | 11.8 | convoluted | 9 |
| 3 | M3 | 12 | 10 | 8 | 10 | 12 | 10 | 12 | 10.3 | indistinct | 8 |
| 3 | M3 | 14 | 10 | 13 | 14 | 13 | 15 | 12 | 12.8 | convoluted | 9 |
| 3 | M3 | 15 | | | | | | | | not visible | |
| 3 | M3 | 15 | | | | | | | | not visible | |

Table 5 Comparison of the ages calculated for different teeth in the same mandible.

| Context | M1 | | M2 | | M3 | |
|---|---|---|---|---|---|---|
| | wear | age | wear | age | wear | age |
| 040 | 14 | - | 14 | 8 | 14 | 9 |
| 223 | 12 | 4 | damaged | | 12 | 7 |

Table 6 Cattle Fusion Data (after Maltby 1979)

| Fusion Age | Phase 1 NF | Phase 1 F | Phase 2 NF | Phase 2 F | Phase 3 NF | Phase 3 F |
|---|---|---|---|---|---|---|
| 7-18 months | | | | | | |
| Scapula DF | | 114 | | 9 | | 99 |
| Humerus DF | | 6 | | 11 | 2 | 66 |
| Radius PF | | 9 | | 15 | | 48 |
| TOTAL | | 129 | | 35 | 2 | 213 |
| % unfused | | | | | 0.9 | |
| 24-36 months | | | | | | |
| Mtc DF | | 9 | | 6 | | 1 |
| Tibia DF | 1 | 4 | | 6 | 3 | 39 |
| Mtt DF | 2 | 12 | | | 1 | 23 |
| TOTAL | 3 | 25 | | 12 | 5 | 88 |
| % unfused | 11 | | | | 5.4 | |
| 36-42 months | | | | | | |
| Calcaneum | 1 | 10 | | | | |
| TOTAL | 1 | 10 | | | | |
| % unfused | 9 | | | | | |
| 42-48 months | | | | | | |
| Humerus PF | | 3 | | | 3 | 5 |
| Radius DF | 1 | | | 4 | | 14 |
| Ulna PF | | 7 | | 3 | | 19 |
| Femur PF | 2 | 15 | 1 | 9 | 7 | 17 |
| Femur DF | | 3 | | 1 | 6 | 9 |
| Tibia PF | | 1 | | 2 | 3 | 13 |
| TOTAL | 3 | 32 | 1 | 19 | 19 | 77 |
| % unfused | 8.6 | | 5 | | 19.8 | |
| GRAND TOTAL | 7 | 196 | 1 | 67 | 26 | 416 |
| % of total unfused | 3.6 | | 1.5 | | 6.2 | |

NF - not fused
F - fused
DF - distal fusion
PF - proximal fusion

Table 7 Comparison of the cattle measurements from Papcastle, Thorpe Thewles, Exeter and Piercebridge

| Site | Number | Proximal Metacarpal mean (mm) | Standard Deviation |
|---|---|---|---|
| Papcastle | 45 | 51.9 | 5.8 |
| Exeter | 30 | 48.8 | 3.7 |
| Piercebridge | 11 | 51.6 | 3.7 |
| Thorpe Thewles | 18 | 50.3 | 3.5 |

Sources:

Exeter........................Maltby, 1979
Piercebridge..................Gidney and Rackham, n.d.
Thorpe Thewles................Rackham, 1987

Table 8 Sheep/goat Fusion Data (after Maltby 1979)
(All Phases)

| Fusion Age | NF | | F |
|---|---|---|---|
| 6-10 months | | | |
| Scapula DF | | | 5 |
| Humerus DF | 1 | | 5 |
| Radius PF | | | 4 |
| TOTAL | 1 | | 14 |
| % unfused | | 6 | |
| 13-24 months | | | |
| Mtc DF | 3 | | 24 |
| TOTAL | 3 | | 24 |
| % unfused | | 11 | |
| 20-24 months | | | |
| Tibia DF | 2 | | 8 |
| TOTAL | 2 | | 8 |
| % unfused | | 20 | |
| 20-28 months | | | |
| Mtt DF | 2 | | 10 |
| TOTAL | 2 | | 10 |
| % unfused | | 17 | |
| 30-36 months | | | |
| Ulna PF | | | 2 |
| Femur PF | 1 | | 3 |
| Calcaneum | | | 1 |
| TOTAL | 1 | | 6 |
| % unfused | | 14.3 | |
| 36-42 months | | | |
| Radius DF | | | 3 |
| Humerus PF | | | 1 |
| Femur DF | | | |
| Tibia PF | 1 | | 3 |
| TOTAL | 1 | | 3 |
| % unfused | | 12.5 | |
| GRAND TOTAL | 9 | | 69 |
| % of total unfused | | 11 | |

NF - not fused
F - fused
DF - distal fusion
PF - proximal fusion

Table 9 Comparison of the sheep/goat measurements from Papcastle, Thorpe Thewles, Exeter and Piercebridge.

| Site | Number | Length of metacarpal range (in mm) |
|---|---|---|
| Papcastle | 5 | 117 - 125 |
| Exeter | 3 | 112 - 127 |
| Piercebridge | 3 | 118 - 127 |
| Thorpe Thewles | 3 | 112 - 125 |

Sources:

Exeter.............Maltby, 1979
Piercebridge........Gidney & Rackham, n.d.
Thorpe Thewles......Rackham, 1987

Table 10 Pig Fusion Data (after Maltby 1979)
(All Phases)

| Fusion Age | NF | | F |
|---|---|---|---|
| **12 months** | | | |
| Scapula DF | | | |
| Humerus DF | | | 1 |
| Radius PF | | | 1 |
| TOTAL | | | 2 |
| % unfused | | | |
| **24 months** | | | |
| Mtc DF | 2 | | 2 |
| Tibia DF | 1 | | 1 |
| TOTAL | 3 | | 3 |
| % unfused | | 50 | |
| **24-30 months** | | | |
| Mtt DF | 1 | | 3 |
| Calcaneum PF | 3 | | 3 |
| TOTAL | 4 | | 6 |
| % unfused | | 40 | |
| **36-42 months** | | | |
| Ulna PF | | | 4 |
| Humerus PF | 1 | | 4 |
| Radius DF | 1 | | 2 |
| Femur PF | | | 1 |
| Femur DF | 2 | | |
| Tibia PF | 1 | | |
| Fibula PF | | | |
| TOTAL | 5 | | 11 |
| % unfused | | 31.5 | |
| GRAND TOTAL | 12 | | 22 |
| % of total unfused | | 35 | |

NF - not fused
F - fused
DF - distal fusion
PF - proximal fusion

## Appendix 1 Contexts containing animal bone and their associated phases.

**Phase 1**

19 25 100 101 105 118 134 139 142 144 145 148 151 152 153
154 156 158 161 162 163 165 166 171 173 174 175 176 179 184
188 196 200 202 203 206 207 208 213 217 218 220 222 227 232
233 239 240 243 244 250 252 252 253 255 311 338 340 343 344
345 347 348 351 353 358 359

**Phase 2**

7 9 10 51 71 80 82 88 90 92 94 95 98 110 111
198 231 262 267 269 272 274 275 278 285 304 322 325 330 332
333 334 335 336 337

**Phase 3(r)**

6 16 27 30 38 47 49 52 53 56 62 63 64 65 68
73 83 84 86 89 120 122 124 127 130 131 204 211 212 249
266 273 288 292 294 295 297 299 301 302 303 313

**Phase 3(fl)**

_17 40 210 221 223 224 256 260 263 264 265 283 312 324 316
318 319 323 324 331

**Phase 3(p)**

300 306 308 327 328 329 346

**Phase 4**

4 41 42 45 50 54 55 57 286

Appendix 2 · Papcastle cattle teeth, wear and crown height.

| P4 WEAR | M1 WEAR | M2 WEAR | M3 WEAR | IN BONE | SECT-IONED | CROWN HEIGHT M1(mm) | CROWN HEIGHT M2(mm) | CROWN HEIGHT M3(mm) | CONTEXT |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 13 | 0 | 0 | | | 11.2 | 0.0 | 0.0 | 266 |
| 13 | 17 | 0 | 0 | YES | M1 | 0.0 | 0.0 | 0.0 | 62 |
| 13 | 17 | 15 | 0 | YES | | 0.0 | 0.0 | 0.0 | 204 |
| 0 | 12 | 12 | 0 | YES | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 15 | 0 | YES | | 0.0 | 0.0 | 0.0 | 224 |
| 10 | 16 | 16 | 0 | YES | M1 | 7.9 | 0.0 | 0.0 | 314 |
| 0 | 0 | 12 | 0 | YES | | 0.0 | 0.0 | 0.0 | 346 |
| 8 | 13 | 0 | 0 | YES | M1 | 19.2 | 0.0 | 0.0 | 351 |
| 8 | 0 | 11 | 0 | YES | | 0.0 | 0.0 | 0.0 | 134 |
| 8 | 12 | 12 | 0 | YES | M1 | 15.4 | 28.7 | 0.0 | 204 |
| 0 | 15 | 15 | 0 | YES | | 0.0 | 0.0 | 0.0 | 221 |
| 0 | 0 | 0 | 8 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 13 | 12 | 8 | | | 0.0 | 0.0 | 0.0 | 212 |
| 0 | 0 | 0 | 8 | | M3 | 0.0 | 0.0 | 0.0 | 313 |
| 0 | 0 | 0 | 9 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 9 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 10 | | M3 | 0.0 | 0.0 | 0.0 | 221 |
| 0 | 0 | 0 | 10 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 10 | | | 0.0 | 0.0 | 0.0 | 313 |
| 0 | 0 | 0 | 10 | YES | | 0.0 | 0.0 | 28.6 | 266 |
| 0 | 0 | 11 | 10 | YES | | 0.0 | 0.0 | 0.0 | 19 |
| 0 | 0 | 11 | 10 | YES | M3 | 0.0 | 37.4 | 0.0 | 208 |
| 0 | 0 | 0 | 11 | | | 0.0 | 0.0 | 0.0 | 37 |
| 0 | 0 | 0 | 11 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 11 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 11 | | | 0.0 | 0.0 | 0.0 | 213 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 17 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 40 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 42 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 60 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 204 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 208 |
| 0 | 15 | 14 | 12 | | | 0.0 | 0.0 | 0.0 | 212 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 213 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 221 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 263 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 263 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 263 |
| 0 | 0 | 0 | 12 | | M3 | 0.0 | 0.0 | 29.8 | 302 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 308 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 312 |
| 0 | 0 | 0 | 12 | | | 0.0 | 0.0 | 0.0 | 330 |
| 0 | 12 | 12 | 12 | YES | | 0.0 | 0.0 | 0.0 | 47 |
| 0 | 0 | 0 | 12 | YES | M3 | 0.0 | 0.0 | 22.7 | 52 |
| 0 | 0 | 0 | 12 | YES | | 0.0 | 0.0 | 0.0 | 204 |
| 0 | 0 | 0 | 12 | YES | | 0.0 | 0.0 | 0.0 | 208 |
| 0 | 0 | 0 | 12 | YES | | 0.0 | 0.0 | 0.0 | 208 |
| 0 | 12 | 12 | 12 | YES | M1 | 16.2 | 21.2 | 31.6 | 223 |

Appendix 2 (continued)

| P4 WEAR | M1 WEAR | M2 WEAR | M3 WEAR | IN BONE | SECT-IONED | CROWN HEIGHT M1(mm) | CROWN HEIGHT M2(mm) | CROWN HEIGHT M3(mm) | CONTEXT |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 15 | 15 | 12 | YES | M1 | 13.9 | 15.7 | 22.8 | 224 |
| 0 | 0 | 0 | 12 | YES | M3 | 0.0 | 0.0 | 0.0 | 231 |
| 12 | 12 | 12 | 12 | YES | M1 | 13.6 | 20.5 | 23.4 | 16 |
| 12 | 12 | 12 | 12 | YES | | 16.9 | 22.9 | 34.1 | 266 |
| 0 | 0 | 12 | 12 | YES | M3 | 0.0 | 0.0 | 41.6 | 17 |
| 0 | 0 | 0 | 13 | | | 0.0 | 0.0 | 0.0 | 16 |
| 0 | 0 | 0 | 13 | | | 0.0 | 0.0 | 0.0 | 223 |
| 0 | 0 | 13 | 13 | YES | | 0.0 | 0.0 | 0.0 | 38 |
| 9 | 15 | 15 | 13 | YES | M1 | 16.0 | 20.9 | 23.8 | 221 |
| 0 | 0 | 0 | 14 | | | 0.0 | 0.0 | 0.0 | 316 |
| 0 | 0 | 0 | 14 | YES | M3 | 0.0 | 0.0 | 23.6 | 38 |
| 0 | 14 | 14 | 14 | YES | M1 | 15.8 | 25.8 | 30.9 | 40 |
| 0 | 0 | 14 | 14 | YES | | 0.0 | 0.0 | 0.0 | 134 |
| 0 | 0 | 0 | 14 | YES | | 0.0 | 0.0 | 0.0 | 221 |
| 0 | 0 | 0 | 14 | YES | | 0.0 | 0.0 | 0.0 | 263 |
| 0 | 0 | 0 | 14 | YES | | 0.0 | 0.0 | 0.0 | 312 |
| 0 | 0 | 0 | 15 | | M3 | 0.0 | 0.0 | 25.1 | 206 |
| 0 | 0 | 0 | 15 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 14 | 15 | | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 15 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 15 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 15 | | | 0.0 | 0.0 | 0.0 | 224 |
| 0 | 0 | 0 | 15 | | | 0.0 | 0.0 | 0.0 | 322 |
| 0 | 0 | 0 | 15 | | M3 | 0.0 | 0.0 | 20.6 | 323 |
| 0 | 0 | 0 | 15 | YES | | 0.0 | 0.0 | 0.0 | 204 |
| 0 | 17 | 15 | 15 | YES | M1 | 7.8 | 14.1 | 23.6 | 208 |
| 0 | 0 | 0 | 15 | YES | | 0.0 | 0.0 | 13.8 | 231 |
| 0 | 0 | 0 | 15 | YES | M3 | 0.0 | 0.0 | 11.2 | 263 |
| 0 | 0 | 0 | 15 | YES | M3 | 0.0 | 0.0 | 0.0 | 38 |
| 0 | 0 | 15 | 15 | YES | | 0.0 | 0.0 | 0.0 | 206 |
| 0 | 0 | 0 | 16 | | | 0.0 | 0.0 | 0.0 | 223 |

## Appendix 3 Cattle Measurements (cm)

### 3(i) Cattle Scapula

| Phase | SLC | LG |
|---|---|---|
| 1 | 4.69 | 5.14 |
| | | 4.88 |
| | 4.36 | 3.92 |
| | 4.54 | |
| | 5.34 | 5.58 |
| | 4.41 | |
| | | 5.16 |
| | | 4.7 |
| | 4.68 | |
| | 4.62 | |
| | 4.44 | |
| | 3.65 | |
| | 4.18 | 4.42 |
| | 4.39 | |
| | | 5.04 |
| | 4.94 | 5.04 |
| | | 5.66 |
| | 4.74 | |
| | 4.57 | 4.96 |
| | 3.81 | |
| | 4.54 | |
| | | 5.26 |
| | | 5.92 |
| | | 5.6 |
| | 4.42 | |
| | | 5.12 |
| | | 4.74 |
| | | 5.08 |
| | | 5.49 |
| | 4.72 | |
| | | 6.25 |
| | | 5.44 |
| | | 4.94 |
| | 4.09 | |
| | | 4.58 |
| | | 4.92 |
| | 4.88 | 4.95 |
| | 4.27 | |
| | 4.1 | |
| | 4.6 | 5.19 |
| | 4.69 | |
| | 4.46 | 4.79 |
| | 4.56 | 4.82 |
| | 4.58 | |
| | 4.52 | |
| | 4.56 | 5.22 |

3(i) Cattle Scapula (continued)

| Phase | SLC | LG |
|---|---|---|
| 2 | 5.34 | |
| | | 4.91 |
| 3 | 5.08 | 5.27 |
| | | 5.78 |
| | | 5.69 |
| | 5.96 | 6.18 |
| | | 5.07 |
| | | 4.69 |
| | | 4.93 |
| | | 5.04 |
| | | 4.76 |
| | 4.98 | 4.72 |
| | 4.79 | |
| | 4.92 | |
| | 5.42 | 5.82 |
| | 4.53 | 5.14 |
| | 5.46 | |

TOTAL 63 Cattle scapula

3(ii) Cattle Metacarpal

| Phase | Sd | Bp | Bd |
|---|---|---|---|
| 1 | | 4.94 | |
| | | 4.84 | |
| | | 4.81 | |
| | | 5.04 | |
| | | 6.18 | |
| | | 5.12 | |
| | | 4.89 | |
| | | 5.28 | |
| | | 5.42 | |
| | | 5.58 | |
| | | 4.27 | |
| | | 5.21 | |
| | | | 4.84 |
| | | | 5.36 |
| | | | 5.5 |
| | | | 5.68 |
| | | | 5.39 |
| | | | 5.32 |
| | | | 6.09 |
| | | | 4.84 |
| | | | 5.28 |
| | | | 4.81 |
| 2 | | 4.92 | |
| | | 4.93 | |
| | | 5.32 | |
| | | 5.69 | |
| | | 4.52 | |
| | | 5.18 | |
| | | 4.83 | |
| | | | 5.14 |
| | | | 6.08 |
| | | | 4.87 |
| | | | 6.04 |
| | | | 5.59 |
| | | | 4.56 |

3(ii) Cattle Metacarpal (continued)

| | Phase | Sd | Bp | Bd |
|---|---|---|---|---|
| | 3 | | 6.14 | |
| | | | 6.09 | |
| | | | 5.59 | |
| | | | 4.76 | |
| | | | 5.76 | |
| | | | 4.42 | |
| | | | 4.69 | |
| | | 3.36 | 5.67 | |
| | | | 4.42 | |
| | | | 4.69 | |
| | | | 5.08 | |
| | | | 4.76 | |
| | | | 5.55 | |
| | | | 4.82 | |
| | | | 4.72 | |
| | | | 4.06 | |
| | | | 4.78 | |
| | | | 5.02 | |
| | | | 5.36 | |
| | | | 6.14 | |
| | | | 5.96 | |
| | | | 5.73 | |
| | | | 6.26 | |
| | | | 6.46 | |
| | | | 4.84 | |
| | | | 4.93 | |
| | | | 4.92 | |
| | | | | 4.39 |
| | | | | 5.29 |
| | | | | 5.12 |
| | | | | 5.02 |
| | | | | 6.48 |
| | | | | 5.84 |
| | | | | 4.54 |
| | | | | 4.74 |
| | | | | 4.46 |
| | | | | 6.08 |
| | | | | 4.58 |
| | | | | 5.12 |
| | | | | 5.59 |
| | | | | 5.86 |
| | | | | 5.19 |
| TOTAL | | 1 | 45 | 33 |
| Mean | | | 5.25 | 5.3 |

### 3(iii) Cattle Metatarsal

| | Phase | Sd | Bp | Bd |
|---|---|---|---|---|
| | 1 | | 4.24 | |
| | | | 4.83 | |
| | | | 4.36 | |
| | | | 4.02 | |
| | | | 4.12 | |
| | | | 4.36 | |
| | | | 4.39 | |
| | | | 4.32 | |
| | | | 3.96 | |
| | | | 3.74 | |
| | | | 4.04 | |
| | | | 4.46 | |
| | | | 4.18 | |
| | | | 3.76 | |
| | | | | 5.43 |
| | | | | 5.42 |
| | | | | 4.59 |
| | | | | 4.79 |
| | | | | 5.62 |
| | | | | 4.98 |
| | | | | 4.24 |
| | | | | 4.44 |
| | 2 | | 4.22 | |
| | | | 4.36 | |
| | | | | 4.76 |
| | | | | 4.52 |
| | | | | 4.99 |
| | | | | 5.56 |
| | 3 | | 4.51 | |
| | | | 4.48 | |
| | | | 3.96 | |
| | | | 3.27 | |
| | | | 5.04 | |
| | | | 4.08 | |
| | | | 3.91 | |
| | | 2.64 | 4.24 | |
| | | | 3.79 | |
| | | | 4.24 | |
| | | | 4.56 | |
| | | | 5.36 | |
| | | 2.09 | 3.77 | |
| | | | 4.96 | |
| | | | 4.26 | |
| | | | | 5.76 |
| | | | | 4.86 |
| | | | | 6.03 |
| | | | | 4.92 |
| | | | | 4.89 |
| | | | | 5.88 |
| | | | | 5.28 |
| | | | | 4.91 |
| | | | | 4.96 |
| | | | | 4.96 |
| | | | | 4.52 |
| | | | | 5.43 |
| TOTAL | | 2 | 32 | 26 |
| MEAN | | | 4.29 | 5.03 |

## 3(iv) Horn Core Measurements

| Maximum Basal Diameter | Minimum Basal Diameter |
| --- | --- |
| 3.3 | 2.3 |
| 3.9 | 2.6 |
| 3.9 | 2.7 |
| 4.2 | 2.8 |
| 4.5 | 3.1 |
| 4.6 | 3.5 |
| 5.0 | 3.4 |
| 5.1 | 3.6 |
| 5.1 | 3.8 |
| 5.1 | 4.3 |
| 5.3 | 3.5 |
| 5.4 | 2.3 |
| 6.2 | 4.3 |
| 6.5 | 4.6 |
| 6.6 | 4.7 |

## Appendix 4  Percentage Representation of elements, Cattle

### Appendix 4(i) Cattle Phase 1 (MNI 58, scapula)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 116 | 3 | 2.6 |
| Skull | 58 | 2 | 3.4 |
| Mand. | 116 | 14 | 12.0 |
| Cervic.V. | 290 | 6 | 2.1 |
| Thor. V. | 754 | 17 | 2.2 |
| Lumb V | 348 | 12 | 3.4 |
| Axis | 58 | 5 | 8.6 |
| Atlas | 58 | 6 | 10.3 |
| Sacrum | 58 | - | - |
| Scapula | 116 | 114 | 98 |
| Humerus P. | 116 | 3 | 2.6 |
| Humerus D. | 116 | 6 | 5.2 |
| Radius P. | 116 | 10 | 8.6 |
| Radius D. | 116 | 3 | 2.6 |
| Ulna P. | 116 | 7 | 6.0 |
| Mtc P. | 116 | 20 | 17.2 |
| Mtc D. | 116 | 9 | 7.7 |
| Pelvis | 116 | 11 | 9.5 |
| Femur P. | 116 | 15 | 13.0 |
| Femur D. | 116 | 3 | 2.6 |
| Tibia P. | 116 | 1 | 0.9 |
| Tibia D. | 116 | 4 | 3.4 |
| Mtt P | 116 | 17 | 14.6 |
| Mtt D. | 116 | 12 | 10.3 |
| Phalan. | 1392 | 29 | 2.1 |
| Ribs | 1508 | 23 | 1.5 |

Appendix 4 (ii) Cattle Phase 2 (MNI 8, distal radius)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn core | 16 | - | - |
| Skull | 16 | 1 | 6.2 |
| Mand | 16 | 2 | 12.5 |
| Cervic. V. | 40 | 2 | 5.0 |
| Thor. V. | 104 | 2 | 1.9 |
| Lumb. V. | 48 | 2 | 4.2 |
| Axis | 8 | 2 | 25.0 |
| Atlas | 8 | - | - |
| Sacrum | 8 | - | - |
| Scapula | 16 | 12 | 75.0 |
| Humerus P. | 16 | - | - |
| Humerus D. | 16 | 9 | 56.2 |
| Radius P. | 16 | 14 | 87.5 |
| Radius D. | 16 | 4 | 25.0 |
| Ulna P. | 16 | 3 | 18.7 |
| Mtc P. | 16 | 13 | 81.0 |
| Mtc D. | 16 | 12 | 12.75 |
| Pelvis | 16 | 6 | 37.5 |
| Femur P. | 16 | 8 | 50.0 |
| Femur D. | 16 | 1 | 6.25 |
| Tibia P. | 16 | 2 | 12.5 |
| Tibia D. | 16 | 6 | 37.5 |
| Mtt P. | 16 | 4 | 25.0 |
| Mtt P. | 16 | 2 | 12.5 |
| Phalan. | 192 | 16 | 8.3 |
| Ribs | 208 | - | - |

Appendix 4 (iii) Cattle Phase 3(r) (MNI 23, scapula)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 46 | 26 | 56.5 |
| Skull | 46 | 1 | 2.0 |
| Mand | 46 | 15 | 32.6 |
| Cervic V. | 115 | 24 | 20.8 |
| Thor V. | 299 | 28 | 9.4 |
| Lumb V. | 138 | 38 | 27.0 |
| Atlas | 23 | 5 | 21.7 |
| Axis | 23 | 5 | 21.7 |
| Sacrum | 23 | 1 | 4.3 |
| Scapula | 46 | 44 | 95.6 |
| Humerus P. | 46 | 2 | 4.3 |
| Humerus D. | 46 | 32 | 69.6 |
| Radius P. | 46 | 20 | 43.4 |
| Radius D. | 46 | 9 | 19.6 |
| Ulna P. | 46 | 11 | 24.0 |
| Mtc P. | 46 | 25 | 54.3 |
| Mtc D. | 46 | 11 | 24.0 |
| Pelvis | 46 | 24 | 52.0 |
| Femur P. | 46 | 7 | 15.0 |
| Femur D. | 46 | 3 | 6.5 |
| Tibia P. | 46 | 5 | 10.8 |
| Tibia D. | 46 | 17 | 37.0 |
| Mtt P. | 46 | 15 | 33.0 |
| Mtt D. | 46 | 16 | 34.8 |
| Phalang. | 552 | 55 | 9.9 |
| Ribs | 598 | 19 | 3.0 |

Appendix 4 (iv) Cattle Phase 3(f1) (MNI 32, scapula)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 64 | 7 | 10.97 |
| Skull | 64 | 3 | 4.7 |
| Mand | 64 | 9 | 14.0 |
| Cervic V. | 160 | 13 | 8.1 |
| Thor V. | 416 | 34 | 8.2 |
| Lumb.V. | 192 | 23 | 12.0 |
| Axis | 32 | 5 | 15.6 |
| Atlas | 32 | 14 | 43.7 |
| Sacrum | 32 | 1 | 3.0 |
| Scapula | 64 | 59 | 92.1 |
| Humerus P. | 64 | 3 | 4.7 |
| Humerus D. | 64 | 39 | 60.9 |
| Radius P. | 64 | 29 | 45.3 |
| Radius D. | 64 | 7 | 10.9 |
| Ulna P. | 64 | 9 | 14.0 |
| Mtc P | 64 | 29 | 45.3 |
| Mtc D. | 64 | 17 | 26.6 |
| Pelvis | 64 | 13 | 20.3 |
| Femur P. | 64 | 10 | 15.6 |
| Femur D. | 64 | 6 | 9.4 |
| Tibia P. | 64 | 8 | 12.5 |
| Tibia D. | 64 | 23 | 36.0 |
| Mtt P. | 64 | 15 | 23.4 |
| Mtt D. | 64 | 13 | 20.0 |
| Phalan. | 768 | 49 | 6.4 |
| Ribs | 832 | 13 | 1.6 |

Appendix 4 (v) Cattle Phase 3(p) (MNI 6, distal humerus)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 12 | - | - |
| Skull | 12 | 1 | 8.3 |
| Mand | 12 | 2 | 16.7 |
| Cervic V. | 30 | 2 | 6.7 |
| Thor. V. | 65 | 5 | 7.7 |
| Lumb V. | 36 | 2 | 5.5 |
| Axis | 6 | - | - |
| Atlas | 6 | 2 | 33.3 |
| Sacrum | 6 | 1 | 16.7 |
| Scapula | 12 | 4 | 33.3 |
| Humerus P. | 12 | - | - |
| Humerus D. | 12 | 10 | 83.3 |
| Radius P. | 12 | 3 | 25.0 |
| Radius D. | 12 | 4 | 33.3 |
| Ulna P. | 12 | 3 | 25.0 |
| Mtc P. | 12 | 2 | 16.7 |
| Mtc D. | 12 | 1 | 8.3 |
| Pelvis | 12 | 2 | 16.7 |
| Femur P | 12 | 2 | 16.7 |
| Femur D. | 12 | - | - |
| Tibia P. | 12 | - | - |
| Tibia D. | 12 | 1 | 8.3 |
| Mtt P | 12 | 2 | 16.7 |
| Mtt D. | 12 | 1 | 8.3 |
| Phalanges | 144 | 5 | 3.5 |
| Ribs | 156 | 4 | 2.6 |

Appendix 5 Percentage Representation of elements, sheep/goat.

Appendix 5 (i) Sheep/goat Phase 1 (MNI 6, proximal metacarpal)

| Element | Expected no. of elements | Actual no. of elements | Percentage representation (%) |
|---|---|---|---|
| Horn Core | 12 | - | - |
| Skull | 12 | - | - |
| Mand | 12 | 4 | 33.3 |
| Cervic V. | 30 | 1 | 3.3 |
| Thor V. | 78 | 1 | 1.3 |
| Lumb V. | 36 | - | - |
| Axis | 6 | - | - |
| Atlas | 6 | - | - |
| Sacrum | 6 | - | - |
| Scapula | 12 | 3 | 25 |
| Humerus P. | 12 | - | - |
| Humerus D. | 12 | 1 | 8.3 |
| Radius P. | 12 | 3 | 25 |
| Radius D. | 12 | 2 | 16.7 |
| Ulna P. | 12 | 1 | 8.3 |
| Mtc P. | 12 | 7 | 58.3 |
| Mtc D. | 12 | 6 | 50.0 |
| Pelvis | 12 | 2 | 16.7 |
| Femur P. | 12 | 3 | 25.0 |
| Femur D. | 12 | - | - |
| Tibia P. | 12 | 1 | 8.3 |
| Tibia D. | 12 | 6 | 50.0 |
| Mtt P. | 12 | 8 | 66.7 |
| Mtt D. | 12 | 3 | 25.0 |
| Phalang | 144 | 3 | 2.1 |
| Ribs | 156 | 15 | 9.6 |

Appendix 5 (ii) Sheep/goat Phase 2 (MNI 3, distal metacarpal)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 6 | - | - |
| Skull | 6 | - | - |
| Mand | 6 | 1 | 16.6 |
| Cervic V. | 15 | 1 | 6.6 |
| Thor V. | 39 | - | - |
| Lumb V. | 18 | - | - |
| Axis | 3 | - | - |
| Atlas | 3 | - | - |
| Sacrum | 3 | - | - |
| Scapula | 6 | - | - |
| Humerus P. | 6 | - | - |
| Humerus D. | 6 | 1 | 16.6 |
| Radius P. | 6 | - | - |
| Radius D. | 6 | - | - |
| Ulna P. | 6 | - | - |
| Mtc P. | 6 | 2 | 33.6 |
| Mtc D. | 6 | 3 | 50.0 |
| Pelvis | 6 | 1 | 16.6 |
| Femur P. | 6 | - | - |
| Femur D. | 6 | - | - |
| Tibia P. | 6 | - | - |
| Tibia D. | 6 | - | - |
| Mtt P. | 6 | - | - |
| Mtt D. | 6 | - | - |
| Phalang | 72 | - | - |
| Ribs | 78 | 2 | 3 |

Appendix 5 (iii) Sheep/goat Phase 3(r) (MNI 4, distal metatarsal)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 8 | 1 | 12.5 |
| Skull | 8 | 5 | 62.0 |
| Mand | 8 | 2 | 25.0 |
| Cervic V. | 20 | - | - |
| Thor V. | 52 | 2 | 3.8 |
| Lumb V. | 24 | - | - |
| Axis | 4 | 1 | 25.0 |
| Atlas | 4 | 2 | 50.0 |
| Sacrum | 4 | - | - |
| Scapula | 8 | 1 | 12.5 |
| Humerus P. | 8 | 1 | 12.5 |
| Humerus D. | 8 | 3 | 37.5 |
| Radius P. | 8 | 2 | 25.0 |
| Radius D. | 8 | 1 | 12.5 |
| Ulna P. | 8 | 2 | 25.0 |
| Mtc P. | 8 | 4 | 50.0 |
| Mtc D. | 8 | 3 | 37.5 |
| Pelvis | 8 | 1 | 12.5 |
| Femur P. | 8 | 2 | 25.0 |
| Femur D. | 8 | - | - |
| Tibia P. | 8 | 1 | 12.5 |
| Tibia D. | 8 | 3 | 37.5 |
| Mtt P. | 8 | 7 | 87.5 |
| Mtt D. | 8 | 3 | 37.5 |
| Phalang | 96 | - | - |
| Ribs | 104 | 3 | 3.0 |

Appendix 5 (iv) Sheep/goat Phase 3 (p) (MNI 2 distal metacarpal)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 4 | - | - |
| Skull | 4 | - | - |
| Mand | 4 | 1 | 25.0 |
| Cervic. V. | 10 | - | - |
| Thor V. | 26 | - | - |
| Lumb. V. | 12 | 1 | 8.0 |
| Axis | 2 | - | - |
| Atlas | 2 | - | - |
| Sacrum | 2 | - | - |
| Scapula | 4 | - | - |
| Humerus P. | 4 | - | - |
| Humerus D. | 4 | - | - |
| Radius P. | 4 | - | - |
| Radius D. | 4 | - | - |
| Ulna P. | 4 | - | - |
| Mtc P. | 4 | 3 | 75.0 |
| Mtc D. | 4 | 2 | 50.0 |
| Pelvis | 4 | - | - |
| Femur P. | 4 | - | - |
| Femur D. | 4 | - | - |
| Tibia P. | 4 | - | - |
| Tibia D. | 4 | 2 | 50.0 |
| Mtt P. | 4 | - | - |
| Mtt D. | 4 | - | - |
| Phalang | 48 | - | - |
| Ribs | 52 | - | - |

Appendix 5 (v) Sheep/goat Phase 3(fl) (MNI 2, distal metacarpal)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Horn Core | 4 | - | - |
| Skull | 4 | - | - |
| Mand | 4 | 1 | 25.0 |
| Cervic V. | 10 | - | - |
| Thor V. | 26 | 1 | 4.0 |
| Lumb V. | 12 | 2 | 17.0 |
| Axis | 2 | - | - |
| Atlas | 2 | - | - |
| Sacrum | 2 | - | - |
| Scapula | 4 | - | - |
| Humerus P. | 4 | - | - |
| Humerus D. | 4 | 1 | 25.0 |
| Radius P. | 4 | - | - |
| Radius D. | 4 | - | - |
| Ulna P. | 4 | 1 | 25.0 |
| Mtc P. | 4 | 2 | 50.0 |
| Mtc D. | 4 | 4 | 100.0 |
| Femur P. | 4 | - | - |
| Femur D. | 4 | - | - |
| Tibia P. | 4 | 1 | 25.0 |
| Tibia D. | 4 | 1 | 25.0 |
| Mtt P. | 4 | 1 | 25.0 |
| Mtt D. | 4 | 2 | 50.0 |
| Phalang | 48 | - | - |
| Ribs | 52 | - | - |

## Appendix 6 Sheep/goat Mandibles - eruption and wear (after Grant 1982)

| Ph | cont. | S | dP2 /P2 | dP3 /P3 | dP4 /P4 | M1 | M2 | M3 | MWS |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 105 | R | d.vw | d.vw | d.n | f | e | V | 23 |
| 1 | 19 | L | d.- | d.vw | d.- | f | c | C | 20 |
| 1 | 134 | R | - | sw | sw | g | d | 0.5 | 25 |
| 1 | 184 | L | - | - | - | j | g | e | 36 |
| 1 | 220 | L | d.- | d.- | d.- | g | - | - | |
| 3 | 70 | R | - | - | - | g | g | 0.5 | 28 |
| 3 | 313 | R | - | - | - | - | d | c | |
| 3 | 221 | R | d.- | d.- | d.- | c | - | - | |
| 3 | 30 | L | d.- | d.vw | d.- | g | - | - | |
| 3 | 346 | L | d.- | d.- | d.d | d | - | - | |
| 3 | 297 | L | - | w | f | g | - | - | |
| 3 | 323 | L | - | - | - | - | g | e | |

d. - deciduous
w. - worn
sw. - slightly worn
vw. - very worn

Appendix 7 Sheep/goat Measurements (cm)

7(i) Metacarpal

| (all phases) | GL | SD | Bp | Bd |
|---|---|---|---|---|
| | 12.24 | 1.27 | 2.04 | |
| | 11.72 | 1.2 | 2.03 | |
| | | 1.29 | 2.07 | |
| | | 1.29 | 2.84 | |
| | | | 1.76 | |
| | | | | 2.18 |
| | | | | 2.42 |
| | | | 2.49 | |
| | | | | 2.08 |
| (unf) | 10.36 | 1.32 | 2.04 | 2.78 |
| | 12.55 | 1.31 | 2.12 | 2.48 |
| (unf) | 11.77 | 1.32 | 2.06 | |
| | | 1.31 | | |
| | | | 2.24 | |
| | | | | 2.61 |
| | | | | 2.12 |
| | | | 2.19 | |
| | | 1.18 | | |
| | 11.54 | 1.14 | 1.92 | |
| | | 1.14 | 1.96 | |
| | | 1.26 | | 2.15 |
| | | | | 1.91 |
| | | | 2.04 | |
| | | | 2 | |
| | | | 2.24 | |
| | | | 2.09 | |
| | 9.24 | | 2.84 | |

## 7(ii) Sheep/goat Metatarsal

| (all phases) | GL | Sd | Bp | Bd |
|---|---|---|---|---|
| | | 1.02 | 1.73 | |
| | | 1.38 | 2.06 | |
| | 10.76 | 1.09 | 1.14 | |
| | | 1.02 | 1.92 | |
| | | 1.01 | | |
| | | (unf)1.22 | 1.95 | |
| | | 1.07 | 1.7 | |
| | | 1.18 | | |
| | 11.98 | 1.01 | 1.64 | 1.96 |
| | | 1.05 | | |
| (unf) | 9.72 | 1.49 | 2.12 | |
| (unf) | 9.22 | 1.55 | | |
| TOTAL | 4 | 12 | 8 | 2 |
| MEAN | 10.42 | 1.17 | 1.78 | 2.01 |

## 7(iii) Sheep/goat Scapula

| (all phases) | SLC | LG |
|---|---|---|
| | 1.7 | |
| | 1.74 | 2.72 |
| | 1.56 | |
| TOTAL | 3 | 1 |
| Mean | 1.6 | |

Appendix 8 Percentage Representation of Elements, pig.

Appendix 8 (i) Pig Phase 1 (MNI 3, proximal ulna)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Skull | 3 | 1 | 33.3 |
| Mandible | 6 | 1 | 16.7 |
| Atlas | 3 | - | - |
| Axis | 3 | - | - |
| Sacrum | 3 | - | - |
| Scapula | 6 | 2 | 33.3 |
| Humerus P. | 6 | 1 | 16.7 |
| Humerus shaft | 6 | 1 | 16.7 |
| Humerus D. | 6 | - | - |
| Radius P. | 6 | 1 | 16.7 |
| Radius shaft | 6 | 3 | 50.0 |
| Radius D. | 6 | 1 | 16.7 |
| Ulna P. | 6 | 3 | 50.0 |
| Ulna D. | 6 | - | - |
| Mtc. P. | 48 | 1 | 2.1 |
| Mtc. D. | 48 | 1 | 2.1 |
| Pelvis | 6 | 2 | 33.1 |
| Femur P. | 6 | - | - |
| Femur shaft | 6 | 2 | 33.3 |
| Femur D. | 6 | 1 | 16.7 |
| Tibia P. | 6 | - | - |
| Tibia shaft | 6 | - | - |
| Tibia D. | 6 | - | - |
| Mtt. P. | 48 | 1 | 2.1 |
| Mtt. D. | 48 | - | - |
| Phalanges | 144 | 2 | 1.4 |

Appendix 8 (ii) Pig Phase 2 (MNI 2, mandible)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Skull | 2 | - | - |
| Mandible | 4 | 2 | 50.0 |
| Atlas | 2 | - | - |
| Axis | 2 | - | - |
| Sacrum | 2 | - | - |
| Scapula | 4 | 1 | 25.0 |
| Humerus P. | 4 | - | - |
| Humerus shaft | 4 | - | - |
| Humerus D. | 4 | - | - |
| Radius P. | 4 | - | - |
| Radius shaft | 4 | 1 | 25.0 |
| Radius D. | 4 | - | - |
| Ulna P. | 4 | - | - |
| Ulna D. | 4 | - | - |
| Mtc. P. | 32 | - | - |
| Mtc. D. | 32 | - | - |
| Pelvis | 4 | - | - |
| Femur P. | 4 | - | - |
| Femur shaft | 4 | - | - |
| Femur D. | 4 | - | - |
| Tibia P. | 4 | - | - |
| Tibia shaft | 4 | 1 | 25.0 |
| Tibia D. | 4 | - | - |
| Mtt. P. | 32 | - | - |
| Mtt. D. | 32 | - | - |
| Phalanges | 96 | - | - |

Appendix 8 (iii) Pig Phase 3 (r) (MNI 2, mandible, distal humerus and pelvis)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Skull | 2 | - | - |
| Mandible | 4 | 2 | 50.0 |
| Atlas | 2 | 2 | 100.0 |
| Axis | 2 | - | - |
| Sacrum | 2 | - | - |
| Scapula | 4 | - | - |
| Humerus P. | 4 | - | - |
| Humerus shaft | 4 | 1 | 25.0 |
| Humerus D. | 4 | 2 | 50.0 |
| Radius P. | 4 | - | - |
| Radius shaft | 4 | 1 | 25.0 |
| Radius D. | 4 | 1 | 25.0 |
| Ulna P. | 4 | - | - |
| Ulna D. | 4 | - | - |
| Mtc. P. | 32 | 1 | 3.1 |
| Mtc. D. | 32 | - | - |
| Pelvis | 4 | 2 | 50.0 |
| Femur P. | 4 | 1 | 25.0 |
| Femur shaft | 4 | - | - |
| Femur D. | 4 | - | - |
| Tibia P. | 4 | - | - |
| Tibia shaft | 4 | - | - |
| Tibia D. | 4 | - | - |
| Mtt. P. | 32 | 2 | 6.2 |
| Mtt. D. | 32 | 1 | 3.1 |
| Phalanges | 96 | - | - |

Appendix 8 (iv) Pig Phase 3(f1) (MNI 2, mandible)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
| --- | --- | --- | --- |
| Skull | 2 | - | - |
| Mandible | 4 | 2 | 50.0 |
| Atlas | 2 | - | - |
| Axis | 2 | - | - |
| Sacrum | 2 | - | - |
| Scapula | 4 | 1 | 25.0 |
| Humerus P. | 4 | 1 | 25.0 |
| Humerus shaft | 4 | - | - |
| Humerus D. | 4 | - | - |
| Radius P. | 4 | - | - |
| Radius shaft | 4 | - | - |
| Radius D. | 4 | 1 | 25.0 |
| Ulna P. | 4 | 1 | 25.0 |
| Ulna D. | 4 | - | - |
| Mtc. P. | 32 | - | - |
| Mtc. D. | 32 | - | - |
| Pelvis | 4 | - | - |
| Femur P. | 4 | - | - |
| Femur shaft | 4 | - | - |
| Femur D. | 4 | - | - |
| Tibia P. | 4 | - | - |
| Tibia shaft | 4 | - | - |
| Tibia D. | 4 | - | - |
| Mtt. P. | 32 | - | - |
| Mtt. D. | 32 | - | - |
| Phalanges | 96 | 1 | 1.0 |

Appendix 8 (v) Pig Phase 3 (p) (MNI 1, pelvis)

| Element | Expected no. of elements | Actual no. of elements | Percentage Representation (%) |
|---|---|---|---|
| Skull | 1 | - | - |
| Mandible | 2 | - | - |
| Atlas | 1 | - | - |
| Axis | 1 | - | - |
| Sacrum | 1 | - | - |
| Scapula | 2 | - | - |
| Humerus P. | 2 | - | - |
| Humerus shaft | 2 | 1 | 50.0 |
| Humerus D. | 2 | - | - |
| Radius P. | 2 | - | - |
| Radius shaft | 2 | - | - |
| Radius D. | 2 | - | - |
| Ulna P. | 2 | - | - |
| Ulna D. | 2 | - | - |
| Mtc. P. | 16 | - | - |
| Mtc. D. | 16 | - | - |
| Pelvis | 2 | 2 | 100.0 |
| Femur P. | 2 | - | - |
| Femur shaft | 2 | - | - |
| Femur D. | 2 | - | - |
| Tibia P. | 2 | - | - |
| Tibia shaft | 2 | - | - |
| Tibia D. | 2 | - | - |
| Mtt. P. | 16 | - | - |
| Mtt. D. | 16 | - | - |
| Phalanges | 48 | - | - |

Appendix 9 Pig Mandibles - eruption and wear
(after Grant 1982)

| Ph | Cont. | S | dP1 /P1 | dP2 /P2 | dP3 /P3 | M1 | M2 | M3 | MWS |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 153 | L | - | w | - | k | e | c | 33 |
| 1 | 353 | L | - | w. | h | f | b | C | 19 |
| 1 | 358 | L | w | w | e | k | e | c | 33 |
| 1 | 208 | L | - | - | - | k | b | - | |
| 2 | 267 | | - | - | - | - | - | b | |
| 3 | 266 | R | - | - | - | - | h | c | |
| 3 | 283 | L | - | - | - | - | - | 0.5 | |
| 3 | 16 | R | - | - | d | j | - | - | |
| 3 | 204 | L | - | - | - | m | h | d | 39 |
| 3 | 211 | R | - | - | g | - | b | C | |

d. - deciduous
w. - worn
sl. - slightly worn
vw. - very worn

## Appendix 10 Pig Measurements

| Measurements<br>Pig<br>(all phases) | | |
|---|---|---|
| Scapula | SLC | LG |
| | 1.99 | |
| Total | 1 | |