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Animal bones from late 9th-10th century levels at 16-22 Coppergate, York

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INTRODUCTION

This report presents tabulated data and a discursive account of non-human bones recovered by hand-collection during excavation at the 16-22 Coppergate site in York.

The excavation at Coppergate produced an enormous archive of well-preserved and, for the most part, closely-datable bone fragments. An estimated one-half of this archive derives from deposits dated to the Anglo-Scandinavian period of York's history, the late 9th and 10th centuries. Having such a wealth of material from a period when York was virtually a Scandinavian colony offers an opportunity to investigate many questions about the way in which the settlers adopted local practises and used local resources, and how far they imported agricultural ideas and livestock. The large volume of bones brings problems as well, notably that of deciding how much to record and to what level of detail.

It would not have been either practicable or desirable to attempt to make a detailed record of every context-group of bones from Anglo-Scandinavian levels. Apart from the huge investment of man-hours required, this would have led to much duplication of information and to the recording of a lot of redundant data. This is a different sampling problem to that discussed by Levitan (1983) and Turner (1984). These writers were concerned with procedures for sub-sampling a large, single assemblage. The problem posed by Coppergate was that of selecting some samples from the many which were potentially available. The decision was therefore taken to stop recording in full detail at a point where sufficient samples were recorded to characterise bone deposition across the site for the main phases of the Anglo-Scandinavian settlement. Where possible, the largest available samples were chosen. This was partly a matter of logistic convenience, and partly done in the belief that large context-groups, i.e. those with a high concentration of bone fragments per volume of sediment, are less likely to comprise only 'background rubbish' than are groups composed of a few fragments from a lot of sediment. To some extent, this selection was further modified by the need to obtain samples from different parts of a large and complex site.

The Archaeology

The archaeology of this complex site has been described in Hall (1984). For the purposes of the study of bones, the late 9th-10th century structures have been considered in three phases. Late 9th century settlement on the site is represented by sparse structural evidence and a series of large pits filled with refuse of all kinds. There is evidence of glass-working on the site during this period. Bones were mainly recovered from the pits and from a series of large surface spreads of debris.

The area was laid out for settlement around 920 AD by the delineation of tenement boundaries and the construction of a number of wattle-walled structures. Some of these structures clearly functioned as workshops, and there is evidence for a variety of crafts and industries, including metal working, coin minting, wood-turning, antler working, dyeing and weaving. Large quantities of rubbish, including much bone, accumulated around these buildings, and most of the bone samples from this phase came from such surface accumulations.

About 980 AD the wattle structures were replaced, within the same tenement boundaries, by a series of more substantial timber buildings. These were sunken-floored, and were constructed of planks and posts. Deposits directly associated with the buildings mainly comprise floor levels and dumps within the buildings and between building phases. These buildings appear to have remained in use into the early 11th century.

The Samples

Twenty-six samples of bones are involved in this analysis. The samples were chosen as the largest well-stratified groups available from the main phases of human activity.

CA: pre-dating the wattle buildings. Late 9th century.
    CA1 - large dump to the front of Area IV. Context 30352.
    CA2 - large dump to the back of Area V. Contexts 19719, 19739.
    CA3 - pit 27389. Contexts 27093, 27203, 27388, 27428, 28043, 34249, 27680, 27679, 34189, 31487.
    CA4 - pit 31064. Contexts 31060, 31061, 31072, 31073, 31594, 31595, 31601, 31602.
    CA5 - pit 31524. Context 31389.
    CA6 - pit 27478. Contexts 27448, 27486, 27498, 27555.
    CA7 - pit 28573. Contexts 28408, 28568.
    CA8 - pit 27920. Contexts 27915, 27919, 27921, 27943.

CB: associated with the wattle buildings. Early 10th century.
    CB1 - dump at the front of Area II. Context 18286.
    CB2 - dump at the front of Area II. Contexts 20131, 20132, 20143.
    CB3 - dump in mid-Area II. Context 8358.
    CB4 - dump on West side of Area II. Contexts 8444, 8445, 8051.
    CB5 - dump at extreme West edge of Area II. Context 26953.
    CB6 - dump on East side of Area II. Contexts 8290, 8453, 8232, 26871.
    CB7 - dump in front West corner of Area II. Context 18602.
    CB8 - dump at the front of Area IV. Context 14973.
    CB9 - pit 37089. Contexts 32570, 32571, 32105, 28904.
    CB10 - dump at the front of Area II, probably mid-10th century. Context 15173.

CC: deposits in and around the sunken-floored timber buildings. Late 10th century.
    CC1 - floor levels in Structure 5. Contexts 15470, 15471, 15475, 15634, 15638, 15639, 15640, 15644, 15645, 15650, 15652, 15685, 15686, 15688.
    CC2 - floor levels in Structure 1. Contexts 8519, 8520, 8522, 8524, 8525, 8526, 8528.
    CC3 - layers over robbed building above Structure 7. Contexts 15176, 15177, 15189.

CC4 - layers over floors in Structure 5. Contexts 13147, 13716.
CC5 - layer in front room of Structure 3. Context 7868.
CC6 - layer in front room of Structure 3. Context 14184.
CC7 - layer below Structure 3, over Building 2. Contexts 21554, 29263.
CC8 - layer below Structure 2, over Building 3. Contexts 21746, 21925.

In addition to the samples listed above, a number of more loosely-dated groups were recorded. Data from these groups have only been used for those analyses which have been undertaken for the Anglo-Scandinavian period as a whole.

The Methods.

The various techniques available for the study of archaeological bones are discussed at length in O'Connor (1984), and further detailed consideration here would be superfluous. For most analytical purposes, the procedures followed for this work are the same as those described for other York sites (see A. M. Lab. Report no.4013). Exceptions are described in the text where appropriate.

THE RESULTS

Preservation and taphonomy.

Anglo-Scandinavian deposits at Coppergate ranged in character from humic sands and silts to highly organic layers rich in a variety of fibrous plant materials - 'compost'. The one characteristic which different deposits shared to some extent was water retention, and concomitant anaerobic burial conditions. Preservation of bone was accordingly very good, with little of the leaching and softening of bone normally associated with the free movement of well-oxygenated ground water. The bones were typically hard and smooth-surfaced, and often heavily stained by mineral deposition. Although no systematic study of the minerals involved was undertaken, the red and brown oxides of iron were conspicuously absent, the predominant colours being a dark purply-brown and black. Patches of vivianite (iron phosphate) were common, and several small areas of pyrite (iron sulphide) were noted. One of these, on a cattle premolar, showed the brassy, slightly iridescent colouring typical of chalcopyrite, a mixed sulphide of iron and copper (Read, 1948, 230-2).

A small proportion of fragments in almost every sample had a markedly different appearance to that described above. These fragments were typically ochre or pinkish in colour, slightly to very friable, and had an eroded surface giving a 'grainy' appearance. The most likely explanation for these fragments is that they are residual fragments of bone of Roman date from underlying features cut into the 'natural'. Curiously enough, the largest deposits of vivianite were found on these apparently residual fragments of bone in otherwise highly organic deposits.

Attempting to model routes by which bones become incorporated in archaeological layers provides plenty of scope for a fertile imagination; too much scope to justify an exhaustive examination here. However, two taphonomic factors which will be particularly important are exposure of bones to trampling and weathering on ground surfaces, and gnawing of bones by carnivores. The former factor will affect the surface appearance of bones and will tend to increase fragmentation, whilst the latter will tend to damage and to remove particular bones or parts of bones favoured by scavenging dogs and cats. The recording of gnawing was a straightforward matter of recognition of the characteristic damage wrought by carnivore teeth. The consequences of surface abrasion were less easily recognised, however, and compromise criteria were sought. For the purposes of this work, a record was kept of specimens which appeared to show clear surface abrasion (e.g. rounding-off of angles) or which were generally much less well preserved than the rest of the bones from that context. In most samples, these abraded fragments were infrequent and easily recognised. In others, however, there were many, and the determination of what constituted 'abraded' became more subjective. Despite this, it was felt to be worth attempting some comparison of the frequency of abraded and gnawed fragments in different samples.

If bones were allowed to accumulate on active surfaces such as living floors and yard surfaces, and if dogs and cats were allowed to roam and to scavenge more or less ad lib., 'some positive correlation between gnawing and abrasion might be expected. This argument simplistically assumes that the longer a pile of bones was accessible on a surface, the greater the degree of both gnawing and abrasion which could accrete. Conversely, bones which were rapidly buried would show little or no abrasion or gnawing.

Fig. 1 shows the proportions of gnawed and abraded specimens in the samples. The distribution of points goes some way towards conforming to the simple model proposed above, with most of the samples clustered together and showing a simple positive correlation between the two attributes. However, there are outliers. Two samples show high abrasion and low gnawing, and two show high gnawing with low abrasion. Three of these four outliers are from pits, and all four are from phase CA. The occurrence of high rates of abrasion in two samples from pits (CA4 and CA6) would seem to confirm that for these two pits at least, the bones accummulated elsewhere before deposition into the pits. Samples CA1 and CA3, which show high gnawing and low abrasion, are less easy to explain. CA3 is also from a pit, CA1 from a surface accumulation. It could be argued that an exposed pile of bones will accrete gnawing damage fairly quickly, but abrasion damage more slowly. Thus the bones from CA1 and CA3 were exposed for a sufficient length of time to be 'turned over' by dogs, but were buried before a significant degree of trampling and surface abrasion occurred. Perhaps the safest interpretation of Fig. 1 is to suggest that the taphonomic factors operating during phase CA were distinctly different to those operating in CB and CC, and that samples from CA thus require interpretation based on different preconceptions.

Certain parts of bones were particularly favoured for gnawing. The vicinity of traction epiphyses such as the tuber calcis and the olecranon process were more frequently gnawed, presumably because of the thick tendons attached to these epiphyses. Other popular zones were the articulation of the scapula, and limb bone epiphyses such as the distal femur and proximal humerus which have a large volume of cancellous bone and a thin layer of compact bone. Nearly all specimens showed the blunt pitting and widely-spaced tooth marks typical of dogs, but there were several specimens of clearly cat-gnawed bone and some which were of uncertain attribution. Although many long bones had been cracked open, in none of these specimens could the cracking be attributed solely to dogs. Gnawing seems to have concentrated at the ends of bones, removing the relatively soft cancellous tissue. Dog faeces recovered from layers of this date include quantities of small bone chips, and one cow carpal exhibited a form of surface erosion which suggested it to have been passed through the gut of a dog. There is thus evidence for the role of dogs as a mechanism of sample reduction at all stages in the alimentary process.

The most important conclusions to be gained from this examination of abrasion and gnawing were that although some bone had evidently been lost as a consequence of these processes, the proportion was probably acceptably small, and that proportions of clearly residual bone were not so large as to comprise a major analytical problem. Thus, subsequent interpretation of the samples could be undertaken with a higher degree of confidence than might otherwise have been the case.

Recovery by hand during excavation proved to be an adequate procedure given the availability of numerous bulk-sieved samples as a control. Examination of 2 mm sieve residues and comparison with the assemblages recovered by hand from the same context as the residues showed that sieving was essential for the recovery of fish, amphibian and small mammal bones but that most identifiable large mammal and bird bone was recovered by hand.

Species abundance.

Table 1 presents numbers of fragments identified to the major taxa in the samples. Notwithstanding all the various biases which pertain to fragment counts, the results serve to make the point that cattle bones predominate in all samples. Fig.2 concentrates on the ratios of cattle:sheep:pig fragments, giving a very consistent result, with some indication that CA samples (late 9th century) generally show a higher proportion of cattle fragments and a lower proportion of pig. Two notable exceptions to this observation are CA1 and CA3, samples which are further characterised by high frequencies of gnawed fragments. Sample CC4 is a distinctive outlier on Fig.2, with a very high proportion of pig fragments. Disregarding CC4 for the moment, CC samples (late 10th century) appear to contain less pig fragments than CB samples (early-mid 10th century). The differences are very small, however, and the results are notable more for the similarity of all the samples than for any differences.

Returning to Table 1, species other than cattle, sheep and pig are notable mainly by their absence. Horse bones were present in most samples, but at a very low frequency, with slightly more horse on average in CA samples. The only other firm difference to come out of Table 1 is a lower overall frequency of bird bones in CA samples. With bird bones, the possibility must always be allowed that poor recovery has biased the results, although there are no grounds for thinking that this was the case in the CA samples. These samples are mainly from well-preserved pit groups, and if recovery had biased CA samples against smaller bones, a distinctly lower proportion of sheep bones might also have been expected. In fact, sheep bones are about equally abundant in CA, CB and CC. On a consideration of fragment numbers alone, then, CA samples are characterised by low abundances of pig and bird. Exceptions to this are samples CA1, CA3 and CA8, the first two of which also showed unusually high proportions of gnawed fragments. Perhaps, and this can only be a tentative suggestion, samples CA1 and CA3 (and maybe CA8) represent debris from occupation akin to that represented by CB samples, whereas the other CA samples (all from a group of juxtaposed pits) represent different and perhaps slightly earlier bone deposition.

The proportion of unidentified fragments varies considerably, being generally lower in CA samples than in CB and CC.

The figures obtained for minimum numbers of individuals (Table 2) bear out the predominance of cattle, and generally serve to confirm the trends observed in the fragment counts. Values for 'fragments per individual' (n.frags/MNI) are particularly consistent for CC samples, and overall show the usual pattern of much higher values for cattle than for sheep and pigs.

There is little to be said in detail on the subject of species abundance. Cattle predominate in terms of fragments (53-65% of identified fragments) and individuals (averaging around 40% of cattle, sheep and pigs). Sheep are next most abundant, closely followed by pigs, with little of anything else. The late 9th century CA samples are mostly typified by low proportions of pig and bird and higher proportions of cattle. Overall, horse, red deer, cat and dog are frequent, although never abundant, and goat, roe deer, wild pig, hare, bear and fox are occasional. Any more detailed analysis of the relative 'importance' of the main domesticates will have to be based on a consideration of the abundance of different parts of the carcass of these species.

CATTLE

Carcass distribution and butchery

Primary evidence of butchery procedures takes the form of cutting or chopping marks on bones: secondary evidence comprises a non-random spatial distribution of carcass elements indicating selective dispersal of dismembered carcasses. Butchery marks on cattle bones may be very common in an assemblage and will occur on almost any surface of any bone. What is important, therefore, is the location of concentrations of butchery marks and their interpretation in terms of a process of carcass reduction. All observed butchery marks in the Coppergate samples were recorded as to type of damage, degree, location and direction. Although much more or less random bone damage was inevitably recorded in this way, a clear pattern of consistent butchery was noted. This is summarised in fig.3, and was the same in all samples regardless of phase.

The observed procedure was evidently intended as the simplest way to reduce a cattle carcass to a number of smaller lumps. Removal of head and feet, and detaching the horncores from the skull, probably took place at the slaughter site when the beast was skinned and drawn. Given frequent identification of chopping through the bones of the basipodium and a high proportion of intact metapodials, it seems likely that the feet were detatched at the ankle and wrist. Decapitation was achieved by chopping through the neck between the atlas and axis, resulting in the recovery of large numbers of cut-off odontoid processes. For butchery purposes, then, the atlas functioned as part of the skull. Horncores were generally chopped away from the skull, often removing a slice of frontal bone as well. Knife-marks indicative of the head being skinned were rare. Most cattle skulls were recovered in fragmentary condition, which may indicate the method of slaughter, and two skulls from CA each bore a punched-in hole in the frontal bone, above and between the eyes, of about 50 mm diameter.

As to the main part of the carcass, although fig.3 records concentrations of butchery marks, it is evident that not all cattle carcasses were jointed - and thus not all bones were cut - in the same way. A proportion of distal femora and ulnae were intact, and not all humeri had been butchered distally. It seems likely that some carcases were 'boned-out', i.e. large blocks of steak were removed from the legs and the fore and hind quarters before any major division of the carcass took place. The vertebrae were most consistently butchered, a high proportion being chopped through in the medio-lateral or oral-aboral planes, or both. Table 3 quantifies the frequency of such butchery for seven of the largest samples. The incidence of butchery in the medio-lateral plane is insufficient to argue the systematic splitting of carcasses down the median sagittal plane. Cervical vertebrae generally show the highest incidence of butchery, possibly as a result of the neck being chopped into small pieces suitable for the stewpot. The thoracic and lumbar regions appear to have been chopped across transversely to produce joints similar to the modern top-rib and T-bone cuts.

The important point about the butchery of cattle carcasses is the lack of any clear evidence for a change in procedures during the period under study. Although reconstruction of the butchery process must be to some degree conjectural, it is clear that the same procedures were being followed. This means that analysis of the distribution of carcass elements need not take account of sample differences brought about by a change in butchery procedure. It is probably safe to interpret, for example, a high frequency of cattle metapodials in a CA sample in the same way as in a CC sample.

In order to investigate the distribution of carcass elements, they must first be quantified. The procedure chosen for this purpose is that employed by O'Connor (1984). Table 4 lists absolute numbers of skeletal elements of cattle, sheep and pigs grouped into 24 carcass components. In table 5, the cattle bones (components 1 to 9) have been standardised to allow for the number of times a given bone occurs in one individual, and then converted to percentages. The values in Table 5 thus show the abundance of a given group of elements as a percentage of total cattle elements. If each sample contained all the bones of a number of complete cattle skeletons with no recovery or taphonomic bias, then the expected value for each component in Table 5 would be 11.11%.

Several overall trends are clear in Table 5. Vertebrae and phalanges are always under-represented. Vertebrae (counted as centra) are soft and thus particularly susceptible to destruction by gnawing and abrasion. Phalanges are more robust, but are quite small and thus liable to be poorly recovered during excavation. It was noted that first phalanges generally outnumbered the smaller second phalanges. Abundances of vertebrae and phalanges are thus unlikely to be indicative of proportions as originally deposited. The only sample to show a particularly high abundance of either is CA7, with a 14.6% abundance of vertebrae. CA7 is not a small sample, and so it is possible that this high abundance represents genuinely biased deposition in this one pit.

Numbers of horncores are generally low, except for a few samples such as CA3, CA4 and CB6. High counts for horncores do not necessarily correspond with high counts for skull, and vice versa, a result which confirms that the two parts were separated early in the butchery process and were distributed separately thereafter. Values for scapula and pelvis are generally high, probably reflecting better preservation and recovery of the robust acetabulum and glenoid articulations. Front and back legs are generally well represented, particularly the fore limb elements. Only one sample, CB5, is conspicuously lacking limb bones, this being a rather small sample dominated by pieces of rib. The highest combined fore and hind limb totals are to be found in sample CA8, and this sample also gave the highest count for cattle hocks. Hocks otherwise show a close approximation to the theoretical 'random' value of 11.11%, except for low values in samples CC1 and 2. These two samples are from living floors in sunken-floored buildings in Area II. There is some suggestion of a negative correlation between values for hocks and those for ribs, beyond that which would be expected in any pair of dependent percentages. Samples CC1 and 2 both show very high values for ribs, as do CB5 and 7, and values for these two components are plotted on fig. 4. The separation of CC1 and 2 and CB5 and 7 from an otherwise fairly tight cluster of points is very obvious, and CA8 appears to be an outlier in the opposite direction.

Interpretation of fig. 4 must be approached cautiously. It would obviously be a circular argument to propose that because two samples from occupation floors are characterised by high values for cattle ribs and low values for cattle hocks, then these are the characteristics of samples from occupation floors. However, it can be argued from the butchery procedure outlined above that cattle metapodials would have been removed from the rest of the carcass at point of slaughter, and that the bones of the thorax were those most likely to be deposited on occupation floors, being involved in the last stages of carcass division. Thus the two floor samples, CC1 and 2, might theoretically have been expected to show a high-ribs-low-hocks distribution of parts, which they do. So, too, do samples CB5 and 7, which additionally have in common that they were recovered from the western edge of Area II, at the very limit of excavation in that direction. On an examination of the cattle bones, then, the following working hypothesis may be proposed. Most samples include a mixture of debris from all stages of the slaughter and butchery of cattle. Sample CA8 perhaps shows a preponderance of slaughter debris, whilst samples CB5 and 7 and CC1 and 2 differ from the rest in having a concentration of bones from the domestic stage of carcass division. Clearly, this hypothesis will have to be tested against other evidence before it can be accepted.

Age at death.

Table 6 plots the attrition stage reached by first and second molars in cattle mandibles. The absence of very young and very old animals is quite clearly shown. Most cattle were killed after an age at which the second molar was well-worn, with dentine exposure on at least three-quarters of the occlusal surface, and the third molar was erupting or already in wear. Timing such dental changes is notoriously hazardous. Silver (1969, 296) gives a range of 15-18 months for eruption of the lower 2nd molar in modern cattle, and quotes 30 months for 19th century cattle, although more recent work (Payne, 1984) has cast doubts on the accuracy of the 19th century figures. In a very detailed study, Andrews (1982, 150) found the average age for full eruption of lower M2 to be 691 days - nearly 2 years. For the lower third molar, Silver quotes 24-30 months from modern stock, 4 to 5 years from the 19th century. It would be unwise in the extreme to assume that eruption times in 10th century York cattle were the same as those for modern cattle or for 19th century cattle. Indeed, Andrews' study served to underline the great variation in timing and rate of eruption of cattle teeth. The distribution in Table 6 shows no discontinuities which would give cause to suspect an annual, seasonal cull. The pattern is that of cattle mainly being slaughtered between two approximate ages. The lower end of this age bracket would appear to be at least 2-2.5 years old. The upper end is less easy to fix, but if lower M3 is taken to have erupted at between 3 and 4 years of age, then very few cattle were being slaughtered at more than 7 years old. Between these limits there would seem to be little selection of more precisely-defined age groups. Attribution of mandibles to age groups is summarised in Table 7.

Turning to the epiphyses, Fig. 5 plots the proportion of fused epiphyses in different age categories, from data given in Table 8. Differences between CA, CB and CC samples are small. If anything, the results suggest cattle to have been killed at a generally earlier age in the early 10th century (CB) than in the late 10th century (CC). Taking the early group of epiphyses to fuse at about 12 months, only 7% of cattle were slaughtered below this age. Even allowing for the friability of calf bones militating against their recovery, this clearly shows that only small numbers of young calves were slaughtered. On the other hand, about one-third of vertebrae were found to be fully fused. From modern data we may project an age of about 5 to 6 years for fusion of the vertebral epiphyses, so two-thirds of the cattle in these samples can be taken as younger than 5-6 years. Of the remaining one-third, the mandibular data indicate most to have been under 7 years or so. The epiphyseal fusion data do not permit a very detailed interpretation: such data never do. However, the two sources on information on age at death of cattle broadly agree. Although there does not seem to have been any precise selection of cattle of a particular age, most cattle were youngish adults when slaughtered. This result implies a multi-purpose role for the cattle. Clearly this age distribution is atypical of the by-product of a dairy herd. Dairying tends to bring to market surplus calves (mostly male) and excess or worn-out dairy stock which will be mostly female and often old. These cattle were not, on the other hand, slaughtered as soon as adult body size was attained. Even allowing for a slow rate of maturation in 10th century cattle, such a concentration on beef-producing criteria would have brought all but breeding animals to slaughter by their third year. The results suggest that cattle were important as a source of meat but that their role as providers of haulage and milk was also appreciated, making it worth keeping adult cattle for a couple of years beyond the 'earliest economic slaughter' point. Such an interpretation is consistent with extensive rather than intensive farming procedures, and would be theoretically predicted for a system based on independent small farmers.

Disease and injury.

The diagnosis of disease and injury from the traces left on bones is not a simple matter, and often the cause of some bone abnormality can only be guessed at. However, certain forms of disease and injury do leave distinctive traces on the skeleton, and a number of such disorders were noted. The numbers of cases noted in each sample are listed in Table 9.

To summarise the results, arthropathies, mainly attributable to osteoarthritis, were most common among the cattle bones. The incidence of lower-limb arthritis in archaeological cattle remains has been discussed elsewhere in connection with the use of cattle as draught animals (e.g. in O'Connor 1982), and a similar interpretation can probably be placed upon the specimens from Coppergate. A number of cases of osteoarthritis of the hip-joint were observed, and it is possible that this condition was also predisposed for by the strain placed on the hind legs of a draught ox. The most frequent symptom of this disease was the presence of an area of eburnation, often with associated grooving of the bone, near the pubic margin of the acetabulum. These limb arthropathies were, for the most part, not far advanced and would not have immobilised the affected animal. Sample CA3 included a cattle occipital bone with small areas of eburnation on the occipital condyles. It is unfortunate that the rest of the neck of this individual could not be located among the fragments recovered. It is an intriguing possibility, and certainly nothing more, that the condition was caused by the use of the horns to yoke draught oxen causing excessive strains in the neck, with resultant damage to joint surfaces.

Several instances were noted of abnormalities of the mandibular condyle. Although the possibility of arthritis at this joint cannot be excluded, these cases all appeared to comprise developmental abnormalities, most commonly pitting or grooving near the centre of the condyle dividing the articular surface into two parts. This incipient doubling of the condyle has been discussed by Baker and Brothwell (1980, 112-4), who stress the difficulty of distinguishing between condyle abnormalities caused by disease and what they term 'non-pathological variations from the normal'. In the absence of associated arthrosis, it seems likely that the latter interpretation can be applied to most, if not all, of the Coppergate specimens.

Patches of periostitis on metapodial shafts occurred in four specimens, and a number of causes can be proposed. The condition may have been caused by infection of the periosteum following an injury to the lower part of the limb. A similar origin is likely for the metatarsal from CC1 which showed inflammatory enlargement of the medullary cavity with an associated draining sinus; a mild case of osteomyelitis.

One trend which is apparent from Table 9 is a higher frequency of lower limb arthritis in CC samples. If the association of this condition with the use of cattle for draught purposes is accepted, then this result could be used to indicate an increased use of cattle for traction in the late 10th century. A striking feature of Table 9 is the low frequency of periodontal disease and other oral disorders. Only one definite case of periodontal disease was noted, a frequency which is more akin to that seen in modern cattle herds than the very high frequency which was noted by Siegel (1976) in her review of archaeological bone pathology. This does not mean that the cattle suffered no oral disease, because short-lived low grade gum infections will not necessarily have advanced to a point where the bone was affected. However, this low frequency does indicate a good state of oral health. Indeed, the cattle generally seem to have been healthy, with most symptoms limited to stress-related arthroses.

Non-metrical traits.

Two non-metrical traits were recorded systematically for cattle mandibles; the presence or absence of the second premolar and the absence of the distal column of the third molar. The lower second premolar is occasionally absent in mandibles of many ruminant species (Andrews and Noddle, 1975). Archaeological records of this trait have, in the main, been limited to noting specimens in which the premolar is absent. For the Coppergate bones, a count was also made of the number of jaws in which the second premolar was present, so as to give some measure of frequency. The results are listed in Table 10. It is not possible to argue for any difference between phases from these figures. Overall, the frequency of jaws lacking P2 is 9 out of 163 (5.5%). By way of comparison, a survey of modern American cattle by Garlick (cited in Andrews and Noddle, op. cit.) found a frequency of about 1%, and Meek and Gray (1911) found a frequency of 6.9% among Roman cattle mandibles from Corstopitum. A sample of 54 mandibles from post-medieval levels in Walmgate, York, included 3 with no second premolar, an incidence of 5.6% (O'Connor 1984, 44). The aetiology of the condition is not fully understood, but it seems likely that a simple congenital anomaly may be resposible. It could be argued that such anomalies are more likely to be expressed at a high frequency in samples drawn from a small gene-pool, where an individual sire or dam carrying a particular gene will have greater influence. Thus higher frequencies might be expected in archaeological samples, representing the livestock populations of small communities, than in modern, highly exogamous, herds. Whatever the explanation or interpretation of this condition, the frequency at Coppergate agrees quite well with that observed for Roman Corstopitum and for Walmgate. Sample CA2 stands out as having a particularly high frequency (4 jaws out of 22). This sample also yielded three of the six specimens of anomalous mandibular condyles, although a jaw-by-jaw correlation between the two conditions could not be made, owing to fragmentation of the jaws.

Seven lower third molars were recovered which lacked the distal column. Insufficient records of the condition have been published to permit any interpretation, although Maltby (1979, 40) reports the condition in 10 out of 76 cattle mandibles from Roman Exeter. His subsequent speculation that this abnormality may have been more common in the Roman period than it was subsequently lacks supporting evidence.

Biometry

Measurements taken from large series of 10th century cattle and pig bones have been the subject of a detailed biometrical study, the results of which will be published in 'The Archaeology of York', vol.15. For the purposes of this report, sufficient biometrical results have been utilised to permit an estimate to be made of the body weight and size of the cattle represented by these bones, so that comparisons may be made with material from other sites and with modern cattle.

The data used for the calculations are summarised in Table 11. Two methods were used to calculate the original liveweight. The first utilised results published by Noddle (1973), based on a study of bones of cattle of known fat-free carcass weight. The second used an allometric equation obtained by Reitz and Cordier (1983) which relates a measurement on the astragalus of ungulates in general to total body weight.

Noddle explored the correlations between carcass weight and a number of different skeletal measurements or combinations thereof. The modern database included bulls, cows and steers from a variety of different breeds. The correlation between weight and any one measurement was not stated in the original paper, but the diagrams presented make it clear that some measurements were much more closely correlated with weight than were others. For the present purpose, two have been chosen: the width of the distal trochlea of the humerus, and the product of the minimum medio-lateral diaphysis width and corresponding antero-posterior depth of the metatarsal. This latter figure gives an approximation to the cross-sectional area of the metatarsal diaphysis. The figures presented in Table 11 show no significant difference between the three phases, and comparison with results presented by Noddle indicate fat-free carcass weight to have ranged between 100 and 140 kg. Allowing 15% for carcass fat and assuming a dressing-out percentage of 40%, this would convert to liveweights in the range 160-225 kg.

Applying Reitz and Cordier's method to the lateral length of the astragalus gives a much higher result, around 290 kg. This is a newly developed procedure, applied to ungulates as a whole, and not specific to cattle. Noddle's work requires assumptions about the percentage of body fat and dressing out ratios to be made. Neither can be seen as likely to give a very accurate result, and the disparity is not really surprising.

To provide some other basis for estimation, calculations were made of shoulder height, based on lengths of metatarsals and using the factors recommended by von den Driesch and Boessneck (1974). The reconstructed shoulder heights range between 1.10 and 1.15 m (Table 11). If comparison is made with modern cattle, it is clear that for a beast of shoulder height 1.10 m to have a liveweight of 160 kg, the animal would need to have a body conformation closer to that of a deer than an ox. One of the smallest modern British breeds (excluding the dwarfish Dexter) is the Shetland. Adult Shetland cows today weigh around 330 kg, but are recorded as having weighed as little as 205 kg in the early years of this century (Alderson 1976, 127-8). Kerry cattle are a little taller than Shetlands, but very `leggy', and an adult Kerry cow will weigh about 370 kg (ibid., 118-9). If 10th century cattle are postulated to have had a shoulder height of 1.10-1.15 m and a very lean conformation, an average liveweight in the region of 220 kg would seem likely. For a heavier conformation, this average could be raised to around 270 kg In short, calculations based on the work of Noddle have produced a result which appears unreasonably low, while the equation derived by Reitz and Cordier gives a result which may be rather high.

Two measurements from adult horncores are plotted on Fig. 6. Some possible subdivision into groups may be seen, in particular five specimens which show a high basal circumference in proportion to length. The remaining cases nearly all fall into two groups separated by size, the circumference and length being of a similar proportional relationship in each. One case is distinctive for having a very long core. Taking the criteria for sexing cattle horncores given by Armitage and Clutton-Brock (1976), the first group, being short in proportion to basal circumference, could be assigned to bulls, the group of smallest cores (which are actually proportionally longer) to cows, and the similarly-proportioned but larger cores to oxen. This would give a ratio of 5 bulls, 12 cows and 9 oxen. The outlying long specimen is probably a bull or ox of a different genotype.

This attribution of sex can only be applied to complete specimens, and for the majority of cores only the basal measurements were available. Examination of specimens in CC samples showed that incomplete cores with a high basal circumference were concentrated in 2 out of the 8 samples; CC3 and CC4. Fig. 7 shows this concentration. If Fig. 6 is taken to indicate that a high basal circumference (over 150 mm) can be equated with oxen or bulls, then the implication of Fig. 7 is that there was a concentration of cores of bulls and oxen in two deposits from late in phase CC at the front of Area II, whilst most of the cores from other late 10th century samples were of cows. Whether this represents a change in husbandry practice or merely a chage in disposal procedures is a debatable point. There is no clear evidence to support either interpretation.

The results described here show the cattle of the late 9th and 10th centuries to have been similar in size and build to the smallest dual-purpose breeds of recent times. The general consistency in size, and the clarity with which sexual dimorphism can apparently be demonstrated in the horncores, argue for genetic homogeneity rather than great variety.

SHEEP

Carcass distribution and butchery.

In general, butchery marks were uncommon on sheep bones. The obvious explanation for this is the the relatively small carcass of a sheep can be taken apart by means of a knife, disarticulating the joints by cutting through ligaments. There is little need to chop through bones, and a skilled butcher equipped with a sharp knife could joint a sheep leaving little or no trace on the skeleton. Such butchery marks as were noted were mainly knife-cuts, singly or in groups, distributed about the shafts of the limb-bones. Some vertebrae had been chopped through in the medio-lateral plane, but most centra were intact. The most frequent site for butchery marks was on the os innominatum, where many specimens had been chopped through perpendicular to the long axis of the ilium, either through the acetabulum or across the ilium at its narrowest point. The lack of butchery marks may also indicate that sheep carcasses were distributed in large pieces, such as whole quarters, rather than in smaller joints.

The distribution of sheep carcass components has been quantified in the same way as for cattle (Tables 4 and 5). The proportions of different components vary considerably between samples, but a few trends can be distinguished. As with the cattle, vertebrae and phalanges are always under-represented, a consequence of taphonomic loss. Scapulae and pelves are generally over-represented, and fore-limbs are generally better represented than hind limbs. Proportions of ribs vary considerably. Fig.8 plots proportions of ribs against metapodials for all samples, a comparison analogous to that undertaken for the cattle bones (Fig.4). Samples CB5, CB7 and CC4 stand out as having particularly high proportions of sheep ribs, and CA samples generally show low proportions of ribs. CB5 and CB7 were also distinguished by high proprtions of cattle ribs, and by a low proportion of sheep hind limb elements. Clearly these two samples differ markedly from other samples in the same phase, a point which will be considered in more detail in the Discussion.

The numbers of sheep metapodials recovered varied considerably, and showed no obvious correlation with the abundance of any other part of the skeleton. As with the cattle bones, proportions of horncores and of skull elements were not closely correlated, and sheep horncores were therefore evidently removed early in the butchery process, probably at the point of slaughter.

Age at death.

The attribution of mandibles to age categories is given in Table 7, while Table 12 crosstabulates the wear stages shown by the lower first and second molars. Most sheep were slaughtered after the second molar had come into wear, but there are few very old individuals, a pattern similar to that seen for the cattle mandibles. Timing the eruption of sheep teeth is no more straightforward than it is for cattle. Figures given by Silver (1969, 297), indicate that the lower 2nd molar is likely to have erupted around the age of 12-18 months, and the lower 3rd molar at 2-3 years. Referring to Table 7, this would indicate a substantial minority of sheep (perhaps as many as one third) to have been killed during their second year or early in their thrid year; i.e. these are the sheep in the 'sub-adult' category in Table 7. The distribution of cases in Table 12 suggests that most of the 'adult' sheep were slaughtered as third or fourth year animals, with few older ones. Thus it can be argued that sheep were mainly selected for slaughter between the ages of about 18 months and 4 years, with no indication of a concentration on any one age-group.

The data obtained from epiphyseal fusion are summarised in Fig. 9. The results generally support the interpretation offered for the mandibles, although the presence of up to 30% unfused epiphyses in the Intermediate 1 group suggests that the proportion of roughly 9-18 month old sheep may have been under-represented by the mandibles, at least for CB and CC samples. CA samples appear to differ in this respect, with less than 10% of epiphyses unfused in this age group.

It was proposed above that the age distribution of cattle indicated that they were kept as multi-purpose animals, and the same interpretation can be offered for the sheep. Delaying slaughter to 18 months would enable one year's wool clip to be obtained: retaining some stock to 4 or 5 years would permit them to be used for breeding, as well as yielding 2 or 3 annual clips. It must be stressed that these sheep are at the 'consumer' end of the system. This age distribution shows clearly that sheep were not being bred in the Viking town. There were no bones of perinatal lambs, no obviously culled surplus lambs of weaning age, and few bones attributable to aged breeding or milking ewes, all of which would have been expected at a 'producer' site. Clearly it was economically viable to send at least some second year sheep to slaughter, which suggests that the value of a sheep as meat was high enough not to be outweighed by the potential value of another couple of years' wool. Circumstances may have been rather different in the late 9th century, and the lower proportion of young sheep in CA samples may reflect a lower relative value for sheep as meat during this period.

Disease and injury.

Symptoms indicative of disease and injury are tabulated in Table 9. The only disorder which was noted with any regularity was the presence of exostoses around the elbow joint. These exostoses were generally on the lateral aspect of the joint, and took the form of either a strap-shaped outgrowth from the proximal end of the radius or of a narrower growth from the distal end of the humerus arising from the lateral aspect near the epiphyseal line. In either case, the cause was evidently ossification of the ligaments which surround the elbow joint. The same condition has been described in sheep bones from elsewhere in York (O'Connor 1984), and the same interpretation can be offered, namely that the ossification of the ligaments is a reaction to a traumatic injury of the elbow, probably a sprain or dislocation. Ten instances were noted in total, making this disorder pro rata as common in sheep as the various limb arthropathies were in cattle. Three cases were noted of raised areas of dense bone on metapodial shafts, apparently a form of osteoperiostitis with no associated infection or inflammation. Again, this distinctive condition has been recorded, in greater abundance, from elsewhere in York (O'Connor op. cit.). Specimens from late 17th-early 18th century levels at Walmgate were thought to result from the prolonged hobbling of sheep, and the same explanation can be offered for these 10th century specimens. There are a variety of reasons why a sheep might be hobbled, amongst them a need to keep a particular sheep in one place without recourse to walls or fences, or a desire to prevent a ram from mating by tying a length of rope between a front and a back leg. In unsophisticated sheep-keeping communities today, hobbling is by no means unusual, and if the observed symptoms are a consequence of prolonged hobbling, then the condition should be expected to occur routinely in archaeological samples.

An unusual horncore abnormality was noted in sample CC8. A left frontal bone was found which was evidently from a four-horned sheep. To complicate matters, the posterior core had split almost to its base, giving the appearance of two and a half left cores. It is debatable whether the two parts of the posterior core would each have borne a horn sheath or whether one sheath would have covered both. It is also quite possible that the two cores on the right side of the skull were not abnormal in any way. The variability and possible causes of polycerate skulls in sheep have been discussed by Noddle (1980), and the little that is known with any degree of certainty indicates that multiple cores or divided cores may occur in almost any population of sheep. Apart from this abnormal specimen, two other 'normal' polycerate skulls were found, and one polled specimen.

Only one definite case of periodontal disease in sheep mandibles was noted, a low frequency which matches the results from cattle jaws.

Non-metrical traits.

Three non-metrical traits were recorded for the sheep bones, and the results are summarised in Table 10. The lower 2nd premolar was congenitally absent in a lower proportion of jaws than was noted for the cattle bones, being absent in 4 mandibles out of 133 (3%). Three of the 4 cases were in phase CA but this result cannot be used to argue for a difference between phases. Only one abnormal third molar was noted, the distal column being completely missing.

The location of the nutrient foramen in the sheep femur was discussed by Noddle (1978), who drew attention to a possible relationship between breed phylogeny and the frequency of occurrence of the foramen at each of three positions. In the samples from Coppergate, the foramen was present at the proximal position in 20 out of 24 cases (83%), at the midshaft position in 2 out of 19 cases (10.5%), and in the distal position in 12 out of 24 cases (50%). The proximal position is by far the commonest in modern breeds, and there is some evidence that a high frequency of distal foramina is a trait of breeds originating in Northern Britain (Noddle pers. comm.). By way of comparison, post-medieval samples from Walmgate (O'Connor 1984) gave frequencies of proximal 87.5%, midshaft 14.3%, distal 44.4%; remarkably similar figures.

Sheep biometry

Although all types of sheep bone were measured, most did not yield sufficient specimens to permit a detailed metrical analysis. However, enough measured metacarpals were obtained from each phase to allow some reconstruction of size and weight, and to allow comparison with results from other ancient and modern samples (principally with those in O'Connor 1982b). The metacarpal measurements are summarised in Table 13.

The first point to be made is that there is no evidence of a change in size from phase to phase, and that variation in size within phases is not great. Values of the coefficient of variation (V = 100*S.D./mean) are generally low, around 4-5%. Mean values for the measured variates are similar to those obtained for samples of modern Welsh Mountain and Finnish Landrace Cross sheep (O'Connor 1982b, 257). Ewes of these breeds will reach 40-50 kgs. liveweight (Alderson 1976, 48, 86). The 10th century sheep woud have been lighter than this only if their carcass conformation was markedly more primitive, and there is no evidence that this was the case. In an attempt to quantify 'average size of bone' for metacarpal samples, O'Connor (1982b, 235-7) standardised the means of each of eight variates and then took the sum of the standardised means for the sample. Performing this calculation for specimens from Coppergate gave results of 163.9 for CA samples, 164.0 for CB and 160.4 for CC. These figures are close to the figures of 161 and 167 obtained respectively for Welsh Mountain and Finnish andrace Cross samples. For comparison, primitive Soay and Orkney breeds gave results around 150, whilst a modern Southdown/Kent Cross sample gave 179. These figures show the 10th century sheep to have been considerably larger than the most primitive extant breeds although well short of the size attained by modern commercial breeds. Values in the range 160-165 were also obtained for Saxon and early medieval samples from Winchester and Lincoln.

As a further test of Rietz and Cordier's allometric method, the mean lateral length of the astragalus for all samples (25.53 mm) was converted to give a liveweight of 33.2 kg. This is evidently rather a low figure. Regression factors recommended by von den Driesch and Boessneck (1974) may be used to reconstruct shoulder height. The three sample means for maximum length of the metacarpal are all close to 120 mm, which converts to a shoulder height of 0.59 m. Performing the same calculation using the greatest and least recorded lengths of metacarpals gives a range of 0.54-0.65 m. Such shoulder heights would be quite inconsistent with a body weight as low as 33 kg.

Although only a modest number of measurable sheep horncores were recovered from the samples, the results show a wide size range (Fig.10). Specimens from CB and CC samples fall into two distinct size groups, similar to the groupings seen in sheep horncores from Flaxengate, Lincoln (O'Connor 1982, 29-30). However, cores from CA samples do not fall into these size groups but rather occupy the area between the two groups. Several explanations may be advanced. If the 'large' and 'small' groups are respectively rams and ewes, then CA samples are mainly composed of wethers, presuming these to have an intermediate size of horn, although such an assumption is probably erroneous. However, if the `large' and `small' cores represent two different genotypes of sheep, as was argued with respect to Flaxengate, then the `middle' cores from CA samples could be a third type or a cross-breed. In the former case, the CA metacarpal samples should have been characterised by the presence of many specimens having the long, slender morphology typical of wethers, such specimens being rare in CB and CC samples. This was not the case, and the possibility must be allowed that sheep butchered near the site in the late 9th century were more diverse genetically than were those of the 10th century.

PIGS

Butchery and carcass distribution

Little specific butchery was observed on pig bones, and the same conclusions can probably be drawn as were reached for sheep. The majority of vertebral centra were recovered intact, with only a few chopped through in either the medio-lateral or oral-aboral plane. A minority of carcasses had been butchered by chopping through the hip, knees, shoulder and elbow joints, but the majority bore no marks of butchery or a few indiscriminate knife cuts. Four skulls showed a possible means of slaughter, two each from phases CA and CC. Each bore a round hole in the frontal bone situated between the eyes, just anterior to bregma. The diameters of the holes were 25 mm, 28 mm, and two of 30 mm. These holes would seem to to indicate a slaughter procedure similar to that which produced 50 mm diameter holes in two cattle skulls referred to above. The tool used for this purpose has not yet been identified.

Examination of Tables 4 and 5 shows that the proportions of different pig carcass components vary considerably. As with cattle and sheep, vertebrae are consistently under-represented, although the high count for pig vertebrae in CA1 should be noted. Skull bones are the most consistently abundant, and it is quite likely that this was because the relatively robust jaws have been preserved and recovered preferentially rather than the more friable (because immature; see below) bones of the post-cranial skeleton. The acetabulum and scapular articulation are also quite robust, and these, too, are well-represented. Perhaps the most striking feature of Table 5 is the high abundance of pig metapodials in some CC samples, especially CC1 and CC4. Evidently late 10th century activity on the site included some butchery or distribution procedure which resulted in the accumulation of pig metapodials. Whatever this procedure was, it was most marked in its effects in the building at the front of Area II (Structure 5), and least effective in the building immediately behind it (Structure 1). The sample from floors in Structure 1 (CC2) shows a distribution of pig bones quite unlike the other samples, with low counts for head and metapodial bones and high counts for leg bones and limb girdles. A simple explanation for the increase in metapodials in CC samples would be to suppose that changing tastes led to the adoption of pig's trotters as a favoured delicacy, in which case there was something unusual about the route by which pig bones came to be deposited in Structure 1.

Age at death

Table 14 crosstabulates attrition on lower first and second molars, and Table 7 lists the attribution of pig mandibles to age classes. Both tables show that a higher proportion of young pigs were killed than was generally the case for cattle or sheep. Nearly one quarter of the cases in Table 14 represent pigs slaughtered between the time of eruption of the first molar and the coming into wear of the second molar, that is, between 6-12 months and 18-24 months. The remaining three-quarters are mainly concentrated into the time represented by the early stages of wear of the second molar, about 2-3 years of age. Thus most pigs were slaughtered between 9 months and 3 years of age, a result entirely consistent with the keeping of pigs for meat alone.

The epiphyseal fusion data give results consistent with the dentition, although fig. 11 indicates a smaller proportion of 1-2 year old pigs in CA samples than in CB or CC, and a higher proportion of 2-3 years olds in CB than in CA or CC. In other words, the concentration on 1-3 year old pigs is the same in all three phases, but there was a tendency to slaughter late within that age range in the late 9th century shifting to an earlier slaughter in the early-mid 10th century.

Although perinatal pigs were not represented in the hand-recovered samples in Table 7, a number of specimens of perinatal and foetal pig bones were recovered from bulk-sieved soil samples from 10th century levels. The presence of such immature piglets strongly suggests that at least some pig breeding was taking place at the site, or very nearby. The recovery of wondrously preserved dung attributable to pigs (A. Jones, pers. comm.) lends support to this theory.

Lauwerier (1983) raised the possibility of identifying seasonal culling in pigs from a detailed examination of age at death, assuming a spring farrowing. Table 14 indicates the beginning of the 'preferred slaughter age' to have coincided with the eruption and coming into wear of the lower first molar. Silver (1969) times this event at about 4-6 months in modern pigs, and quotes 12 months for 18th century sources. Despite the latter figure, Bull and Payne (1982, 56) quote a variety of sources for eruption times in wild and domestic pigs which centre around 6 months for the lower first molar. If 6 months is accepted as the beginning of the slaughter period, and if a spring farrowing is assumed, then slaughtering of pigs began as each year's piglets came to their first autumn. There is, however, no evidence for a routine autumn culling of 2nd or 3rd year pigs.

Sex ratios

The pronounced sexual dimorphism in the canine teeth of pigs allows an examination of whether either sex was particularly selected for slaughter in any one age-group. In Table 15, numbers of male and female mandibles in different age groups are listed. Theory would predict more adult females than males, because of the keeping of breeding sows. In fact this is not the case, and in CC samples adult males greatly outnumber a solitary adult female. The results show that males and females were equally likely to be slaughtered at any particular age, and that roughly equal numbers of males and females were slaughtered overall.

Disease and injury

Few specimens of pathological interest were noted among the pig bones (Table 9). Only one case of crowding and rotation of teeth was found. Such rotation is usually attributable to truncation of the maxilla, which may be a symptom of malnutrition or may be a consequnce of selective breeding, as in some modern breeds of pig. That only one case was noted suggests that neither causal factor was a feature of pig husbandry during the period represented. Two cases were found of an infection involving the skeleton. One was a superficial ulceration of a metapodial shaft, possibly as a result of a penetrating wound. The other involved the medullary cavity of an ulna. Generally, the low incidence of disease and injury among the pig bones matches the results from cattle and sheep bones.

Biometry

The mainly immature and fragmentary nature of the pig bones has effectively precluded detailed biometrical analysis. However, by using the regression factors obtained for wild and domestic pigs by Teichert (1969), it has been possible to make some reconstruction of body size. From all three phases, 13 astragali and 4 calcanea gave a mean reconstructed shoulder height of 0.69 m, with a range from 0.64 m to 0.76 m. Considering the reconstructed heights individually, there was some hint of bimodality, with 7 cases between 0.64 and 0.67 m, and the remaining 10 all over 0.69 m. The simple interpretation would be to suggest that the smaller individuals were females, and the larger ones males, both boars and barrows. Comparison with figures given by Teichert (1969) for other archaeological groups shows the pigs from Coppergate to have been much the same size as domestic pigs from elsewhere in medieval Europe. None of the wild pig bones recovered from Coppergate could be used to give a comparable size estimate, but it was evident that the wild pigs were sufficiently larger than domestic pigs for there not to have been any confusion in identification.

Further samples of pig bones are included in an analysis of cattle and pig biometry currently being undertaken.

Other mammals

The scarcity of bones of other mammal species has already been commented on.

Horse bones were most frequent in CA samples, particularly in CA2. The bones were nearly all those of adult horses of small stature. Two complete metacarpals from CA samples indicate a shoulder height of about 1.4 m (nearly 14 hands), and there were no specimens of particularly large or small horses. Horse bones appear to have been butchered and disposed of in much the same way as cattle bones. Many specimens bore marks of butchery, including humeri and radii which had been split in half lengthways. Marks of gnawing were not infrequent, and, apart from CA2, there was no obvious concentration of horse in any particular part of the site. The evidence clearly indicates that horse formed an occasional minor part of the diet and that the bones became part of the general urban rubbish. That being so, it is possible that the scarcity of horse bones genuinely reflects the status of the species in 10th century York; an occasional means of transport as an alternative to the much more commonly-used cattle.

Goat bones were uncommon. The problems of distinguishing goat bones from those of sheep have been discussed at length in the literature (e.g. Boessneck 1969; Spahn 1978). It is fair to say that reliable non-metrical criteria for the separation of the two species can be found on most parts of the skeleton, and that in British post-Roman assemblages, at least, the much greater robusticity of goat bones makes their identification at least possible, if not straightforward. Most parts of the skeleton are represented among the goat bones identified from Coppergate and it is thought that few, if any, goat specimens have been misidentified as sheep, or vice versa. Eight goat horncores were found, attributable on grounds of size to four males and four females. It seems likely that small numbers of goats were kept for dairying and that they formed a minor part of the diet, much as did horses.

Deer were represented by numerous pieces of worked red deer antler, and a few bones each of red deer and roe deer. The worked antler fragments were waste from the manufacture of artefacts, probable mostly combs of which many examples were recovered from the site (see AML Report no. 4264). Prummel (1983) refers to the trading of antler over considerable distances in The Netherlands during the early medieval period, and it is clear from the assemblages at Coppergate that red deer was far more important as a source of antler than as potential meat. Some of the antler bases had skull bone attached, but most were collected as shed antlers during the winter months. Such a lack of exploitation for meat suggests that the supply of meat from domestic species was both adequate and reliable.

Cat bones were present in many samples, but were never abundant. Only one specimen was attributable to wild cat (Felis sylvestris), a very robust humerus shaft from CB1. The remaining specimens were all of rather small domestic cats, with a high proportion of immature individuals. Tenth century levels at Flaxengate, Lincoln (O'Connor 1982, 38), also showed a very low abundance of cat and a high proportion of immatures. Cats were probaby tolerated but not tended to any extent, hence the high mortality of young ones. Evidence from other bone assemblages on the site suggests that cat skins were routinely collected. Bones from bulk soil-samples from 10th and 11th century levels included groups of cat phalanges, apparently divorced from the rest of the cat, and deposits not otherwise included in this analysis have yielded four specimens of cat skulls with repeated parallel knife cuts immediately above and between the eyes.

Dog bones were generally more abundant than cat bones, although this may in part be an artefact of recovery. A considerable size range was represented, from small, fox-sized animals to very large dogs which were certainly big enough to be wolf (Lupus lupus), but cannot with certainty be ascribed to that species. The large specimens concerned were two metapodials and a damaged radius. Despite a search of the literature and examination of specimens in the British Museum (Natural History), it was not possible to reach a firm identification of these specimens. Since there was no other evidence for the presence of wolf in the samples, the large specimens have been presumed to be large dogs. Intact limb bones were few, but four specimens could be used to reconstruct shoulder height using the regression equations published by Harcourt (1974). These four specimens gave reconstructed shoulder heights of 0.52 m, 0.56 m, 0.59 m and 0.70 m. Examination of the dog bones as a whole showed the majority to belong to dogs of 'collie-size' or a little larger. These would have stood about 0.5-0.6 m at the shoulder. The remaining specimens were divided between small, 'terrier-size' dogs, and the few very large bones referred to above. One of the latter group, a third metacarpal, was 87.4 mm in length. For comparison, other third metacarpals measured 49.0, 52.2 and 48.1 mm. A third metatarsal of 97.8 mm similarly contrasts with others of 73.7 and 68.4 mm. The possibility of wolf being present in the samples cannot be excluded, but, lacking a complete skull or mandible, cannot be proven.

I am grateful to Dr. Philip Armitage and to Dr. Juliet Clutton-Brock for their comments on these large dog bones.

The dog bones were mainly those of adults, with few indications of disease or injury. This would argue for a well-tended existence, reflecting a valued role in the community. The large dogs could be seen as hunting dogs, although in view of the scarcity of bones from game species, one wonders what they were hunting. Given the close proximity in which the people of Coppergate were living, dogs may also have fulfilled a role as guard dogs and defenders of territory.

Other mammals were poorly represented. Brown hare was noted in several samples, but was evidently only a minor element in the diet, taken for food when opportunity arose but not hunted systematically. Fox was represented by a single canine tooth, and would appear not to have been a regular scavenger around the site. Two samples yielded third phalanges of brown bear, and further bear third phalanges have been recovered from soil samples. The status of bear in Northern England during the 10th century is not known with any certainty (Corbet 1974). Small numbers of bears may still have been found in the area, depending on the degree of woodland clearance effected during the Roman period. The phalanges, found in the absence of any other bear bones, are most likely to have arrived on the site as claws attached to imported bear skins. Whether the skins were imported from elsewhere in Britain, or from Scandinavia or somewhere else in Europe, cannot be determined. Certainly literary accounts describe Scandinavians of this period as trading many commodities, including skins, throughout Europe and beyond, and there is plenty of evidence of international trade among the artefacts from Coppergate (Hall 1984). In short, the phalanges were probably attached to skins, and the skins could have come from almost anywhere.

BIRDS

Bird bones from the deposits at Coppergate and elsewhere in York have been made the subject of a major study, the results of which will be published in detail elsewhere (Allison, in prep.). This section is concerned only to summarise the bird bones recovered from the 26 phased samples. Most specimens were identified by E. P. Allison.

Comparisons of the abundance of taxa from different phases are complicated by two factors. First, recovery by hand will have biased the results to some extent against the smaller species, and, second, the numbers of bird bones recovered from phase CA was much less than from CB and CC, thus reducing the number of taxa represented. With these caveats borne in mind, Table 16 lists the taxa present and gives the percentage abundance of each in each phase. The abundance of fowl and goose bones is remarkably consistent, and the main difference between phases is the much larger number of taxa identified in phase CC. This phase also yielded the most bird bone, but even allowing for this it would probably be fair to say that the late 10th century saw a greater diversity of bird species being brought onto Coppergate, mostly for food.

Fowl obviously greatly outnumbered geese, although their respective meat yields were probably about the same, allowing that one goose will give about as much meat as three fowls. The abundance of comminuted egg-shell and fragments of egg-shell membrane recovered from soil samples indicates that eggs were an important product, and at least some of this shell is clearly derived from goose eggs. Of the wild species, wild geese were evidently routinely taken, in particular barnacle geese. Black grouse and golden plover were both frequent in CB samples but not in phase CC, a difference which might reflect a long-term change in exploitation. Overall, the species show a concentration on wetland areas, with some woodland birds (wood pigeon, woodcock), moorland species (golden plover, black grouse) and two cliff-nesting coastal birds (guillemot and razorbill). These last two species would only have been available during the summer, at a distance of some 60 km from York. Other species would only have been available during the winter, notably barnacle, brent, pink-footed and white-fronted geese, and grey plover. Jackdaw, raven and white-tailed eagle can be seen as likely scavengers on the urban refuse, and the goshawk might have been kept as a hawking bird. Certainly goshawks were highly regarded by hunters later in the medieval period, although the species is still seen wild in the York area today and may formerly have been more common when woodland was more widespread. Its status in the 10th century must therefore remain uncertain.

Apart from the razorbill and guillemot, the species represented are those which are found at most medieval sites in lowland England. Wild birds were probably only taken as an occasional addition to the diet, and, like the wild mammals, were not a significant component of the urban meat supply. Hens and geese were probably kept around the houses, and were exploited for eggs as well as meat.

FISH

Only a very small percentage of the fish bones present in an excavated deposit will be successfully recovered by hand. Accordingly, only a few bones of large fish species were present in these samples, and such bones will be totally unrepresentative of fish exploitation through the 9th and 10th centuries. Large assemblages of fish bones have been recovered from soil samples, and these will form part of a detailed study of fish bones from York (Jones in prep.). The following summary of the hand-recovered fish bones is based on identifications made by A.K.G. Jones.

Phase CA (late 9th century) yielded one bone of cod (*Gadus morhua*), several pieces of bony plates (scutes) from the skin of sturgeon (*Acipenser sturio*), and fin rays of an unidentified salmonid. Fish bones from CB (early-mid 10th century) were mostly of cod, with two bones of salmon (*Salmo salar*), and one each of haddock (*Melanogrammus aeglefinus*) and pike (*Esox lucius*). Phase CC (late 10th century) produced rather more fish bone, nearly all of it cod, and three bones of salmon. The presence of salmon and sturgeon is noteworthy, implying cleaner rivers than are to be found around York today.

DISCUSSION

For the purposes of this report, two matters require discussion; diachronic changes in livestock exploitation and spatial variation in bone deposition within phases.

Diachronic changes.

Phase-to-phase differences in thses samples are small and for the most part subtle. Late 9th century samples differ from the 10th century samples in having lower overall proportions of bird and pig, and slightly higher proportions of cattle and horse. Perhaps more important than this is the greater variability shown by CA samples, with samples CA1 and CA3 showing a number of characteristics which differ from the other samples from this phase. Considering the figures in Tables 4 and 5 in more detail, CA samples generally show lower abundances of cattle and sheep ribs and pig metapodials. Bearing in mind what has already been said about the characteristics of domestic debris, and the danger of a circular argument, some of the 'distinctiveness' of CA samples can be explained by viewing CB and CC samples, most of which were directly associated wth structures, as containing a higher proportion of 'domestic' debris (ribs, pigs' trotters, bird bones) than CA samples. This hypothesis would argue that the site was not used primarily for habitation in the late 9th century, and that most of the bone deposited in that period derived from slaughter and butchery rather than from household rubbish. The lower relative abundance of pig metapodials does not alone account for the lower overall abundance of pig bones or higher abundance of cattle bones, which features remain characteristic of this period.

Examination of age at death has shown that pigs and sheep were generally older in CA samples, in the sense that a greater proportion of each was slaughtered as adults rather than as first or second year beasts. A small difference was apparent between CB and CC samples, with a slightly higher proportion of young cattle and pigs in CB samples. The only other difference between these two phases which is worthy of note is in the occurrence of bird taxa. CC samples are characterised by the predominance of fowl and domestic goose bones, with frequent barnacle goose and just an odd bone or two of a lot of other taxa. CB samples have less taxa overall, but in addition to fowl, goose and barnacle goose, golden plover, black grouse and mallard bones were present in some numbers. CB samples thus show a lower diversity than CC samples, but a higher number of 'frequent' taxa. This difference is summarised in Table 17.

Changes in bone deposition from phase to phase should not be exaggerated, and the results are notable more for their consistency than for any dramatic chronological changes. Such variation as can be observed is probably attributable to the Coppergate area being basically waste ground with some industrial function in the late 9th century, becoming a residential area with craft workshops in the 10th century. The concentration on domestic species probably relects a stable farming economy on the one hand, and a lack of 'leisure' time for hunting (which may indicate low social status) on the other.

Variation within phases.

To investigate sample-to-sample differences for another site in York, a procedure was developed which generated a percentage measure of similarity between pairs of samples. This procedure is described in full in A.M. Lab. Report 4103 and in O'Connor 1984. Using this procedure and the database given in Table 4, similarlity matrices were prepared for each of the three phases (Tables 18, 19 and 20), and dendrograms were derived from these matrices (Figs. 12, 13 and 14).

The results for CA samples (Table 18, Fig. 12) show that variation within the phase is not simply a matter of the two surface deposits (CA1 and CA2) differing from the six pits. Although the differences are not great, there is variation in the content of the pits sufficient to show that the bones in them did not all derive from one source, a conclusion which is supported by the variation shown by the incidence of abraded and gnawed specimens in these samples (Fig. 1). Even so, the lowest branch of the dendrogram is at 72.1%, a decidedly high score.

The CB samples are remarkable for their similarity to each other (Table 19, Fig. 13). Only one, CB5, shows any clear differentiation. This sample of bones comes from one edge of the excavated area, and is marked by high proportions of cattle and sheep ribs. If, as has been argued above, such a concentration of ribs indicates a mainly domestic origin for the sample, then it is possible that CB5 derives from a building of this phase beyond the limits of excavation. The remaining samples can probably all be seen as mixed debris from several sources accumulating over a large area of the site, possibly as part of a general raising of ground level. Certainly a large volume of bone-bearing sediment accumulated during the early-mid 10th century, of which these ten samples are the largest available groups. Apart from CB5, the samples appear to be 'everybody's rubbish' disposed of across ground surfaces around the buildings.

The late 10th century samples are more diverse (Table 20, Fig. 14). One sample, CC4, is clearly distinct from the rest. This sample was characterised by high counts for sheep ribs, pig skull bones, and, in particular, pig metapodials. The last-named element, apart from comprising a high proportion of the pig bones (over 40%) also made up a high proportion of the total of skeletal elements (15.6%). Similar characteritics are shown by CC1, with the addition of a substantial proportion of cattle ribs. These two samples are both from within structure 5, a sunken-floored building on the street frontage of the site, thought to have been used for domestic occupation (Hall, 1984). CC1 is from layers thought to be floors, CC4 from overlying debris. There is a high degree of similarity between the samples from around structures 2 and 3, adjacent buildings in Area IV of the site. The differences between samples CC1 and CC2 show that whatever process led to the accumulation of pig metapodials within structure 5 was limited to that structure and was not operating elsewhere in the same tenement.

Fig.15 plots the summed percentages of cattle and sheep ribs and pig metapodials, the figures being taken from Table 5. The results show the greater tendency for these elements to be abundant in later samples, and the distinctiveness of samples CC1, CC4, CB5 and CB7. It has been argued above that a high abundance of these elements indicates domestic occupation rather than mixed rubbish and Fig.15 would thus indicate domestic occupation within structure 5 and at the Western edge of excavation of Area II. Otherwise, the samples mainly comprise a mixture of rubbish from all stages of the slaughter and butchery process. Livestock were evidently slaughtered and dismembered on or near the site, although the virtual absence of puparia of flesh-feeding flies from deposits of this period (Phipps pers. comm.) argues against the use of one of the excavated tenements as a slaughteryard and would further suggest that much of the bone had been subjected to cooking before deposition, thus reducing the availability of rotting raw flesh as an egg-laying medium.

SUMMARY

The results appear to show a shift from mainly butchering waste in the late 9th century deposits to mixed debris in the early-mid 10th century (apart from the mainly domestic deposits CB5 and CB7), with an increasingly domestic element during the late 10th century, particularly within structure 5. Well-marked though this trend is, the emphasis is on consistency rather than on great variation between samples. The pattern of butchery seen on cattle bones suggests two separate stages; dismemberment of the carcass into large pieces, followed by much less systematic reduction of the bones into small chunks. The first stage was presumably undertaken by the butcher, the second much less systematic stage was probably carried out in the home, utilising bones for stock or broth. Such domestic usage of bones would account for the blurring of the distinction between 'butcher's waste' and 'household waste'. It is, of course, possible to argue that individual households purchased livestock on the hoof, and slaughtered, butchered and ate the beasts without the intervention of a specialist butcher. Such an explanation is unlikely given the emphasis on beef: even for a large household, the prospect of munching through a defatted beef carcass of 140 kg would be daunting. Meat could be salted or smoked, but even allowing for some long-term storage of meat it seems far more likely that specialist butchers supplied the community. Such an interpretation would fit with the historical evidence for the Anglo-Scandinavian peoples being traders and craftsmen, and rests more easily with the archaeological evidence of rather small, crowded tenements: a slaughteryard would have required more space than would appear to have been available on the average tenement.

There were few changes in the livestock over the period represented. Farming supplied the food, with wildfowling adding a little variety, and fish evidently an important minor element (Jones in prep.); the subsistence pattern, in fact, of any small English town before the Industrial Revolution.

REFERENCES

Alderson, G. L. H. 1976. Observer's Book of Farm Animals. Warne, London.

Allison, E. P. in prep. Bird bones from archaeological sites in York. D.Phil. thesis, University of York.

Andrews, A. H., 1983. 'The use of dentition to age young cattle', in R. Wilson, C. Grigson and S. Payne (eds.) Ageing and Sexing Animal Bones from Archaeological Sites, B.A.R. Brit. Series 109, 141-154

Andrews, A. H. and Noddle, B. A. 1975. 'Absence of premolar teeth from ruminant mandibles found at archaeological sites', J. Archaeol. Sci. 2, 137-44

Armitage, P. L. and Clutton-Brock, J. 1976. 'A system for the classification and description of the horncores of cattle from archaeological sites'. Journal of Archaeological Science 3, 329-48.

Baker, J. R. and Brothwell, D. R., 1980. Animal Diseases in Archaeology (London)

Binford, L. R. 1981. Bones: ancient men and modern myths. Academic Press, London.

Boessneck, J. 1969. 'Osteological differences between sheep and goats', in D. R. Brothwell and E. S. Higgs (eds.) Science in Archaeology, 331-58. Thames and Hudson, London.

Bull, G. and Payne, S. 1982. 'Tooth eruption and epiphyseal fusion in pigs and wild boar', in B. Wilson, C. Grigson and S. Payne (eds.) Ageing and Sexing animal bones from archaeological sites, 55-71. B. A. R. British Series 109, Oxford.

Corbet, G. 1974. 'The distribution of mammals in historic times', in D. L. Hawksworth (ed.) The changing flora and fauna of Britain, 179-202. Academic Press, London.

von den Driesch, A., 1976. A Guide to the Measurement of Animal Bones from Archaeological Sites , Peabody Mus. Bull. 1, (Harvard)

von den Driesch, A. and Boessneck, J. A., 1974. 'Kritische Anmerkungen zur Wiederisthoherberchnung aus Langenmassen vor- und fruhgeschichtlicher Tierknochen', Saugtierkundliche Mitteilungen 22, 325-48

Hall, R. A. 1984. The Viking Dig. Bodley Head, London.

Harcourt, R. A., 1974. 'The dog in prehistoric and early historic Britain', J. Archaeol. Sci. 1, 151-76

Jones, A. K. G. in prep. Fish bones from archaeological sites in York. Archaeology of York vol. 15.

Lauwerier, R. C. G. M. 1983. 'Pigs, piglets and determining the age iof slaughter', Journal of Archaeological Science 10, 483-88.

Levitan, B. 1983. 'Reducing the work-load: subsampling animal bone assemblages', Circaea 1(1), 7-12.

Maltby, J. M., 1979. The Animal Bones from Exeter 1971-1975, Exeter Archaeological Reports 2 (Sheffield)

Meek, A. and Gray, R. A. H. 1911. 'Animal remains', in R. H. Forster and W. H. Knowles 'Corstopitum - Report on the excavations in 1910', Archaeologia Aeliana 3rd series (7), 220-67.

Noddle, B. A. 1973. 'Determination of the bodyweight of cattle from bone measurements', in J. Matolcsi (ed.) Domestikations Forschung und Geschichte der Haustiere, 377-89. Hungarian Academy of Sciences.

Noddle, B. A., 1978. 'Some minor skeletal differences in sheep', in D. Brothwell, K. D. Thomas, and J. Clutton-Brock (eds.) Research Problems in Zooarchaeology, Inst. of Archaeol. Occ. Pubs. 3, 133-41

Noddle, B. A. 1980. 'Polycerate sheep', Ark, 156-64. Rare Breeds Survival Trust.

O'Connor, T. P., 1982. Animal Bones from Flaxengate, Lincoln, c 870-1500, Archaeology of Lincoln 18/1 (London)

O'Connor, T. P. 1982b. Archaeozoological interpretation of morphometric variability in British sheep limb bones. Ph.D. thesis, University of London.

O'Connor. T. P. 1984. Selected groups of animal bones from Skeldergate and Walmgate. Archaeology of York 15/1. Council for British Archaeology, London.

Payne, S. 1984. 'The relationship between the eruption of M3 and P4 in cattle, and the use of early 19th century data in ageing cattle', Circaea 2(2).

Prummel, W. 1983. Early medieval Dorestad, an archaeozoological study. Nederlandse Ouheiden 11, Rijksdienst voor het Oudheidkundig Bodermonderzoek, Amersfoort.

Read, H. H. 1948. Rutley's elements of mineralogy, 24th ed. Thomas Murray, London.

Reitz, E. J. and Cordier, D. 1983. 'The use of allometry in zooarchaeological research', in C. Grigson and J. Clutton-Brock (eds.) Animals and Archaeology:2 Shell middens, fishes and birds, 237-51. B. A. R. International Series 183, Oxford.

Shipman, P. L., 1981. Life History of a Fossil: An introduction to Taphonomy and Palaeoecology, Harvard University Press.

Siegel, J. 1976. 'Animal palaeopathology: possibilities and problems', Journal of Archaeological Science 3, 349-84.

Silver, I. A., 1969. 'The ageing of domestic animals', in D. Brothwell and E. Higgs (eds.) Science in Archaeology, 282.-302. Thames and Hudson, London.

Spahn, N. 1978. 'Untersuchungen an grossen Rohrenknochen von Schafen und Ziegen aus der fruhmittelalterlichen Siedlung, Haithabu', Schriften aus der Arch- Zoo- Arbeitsgruppe Schleswig-Kiel. Kiel.

Teichert, M. 1969. 'Osteometrische Untersuchungen zur Berchnung der Widerristhohe bei vor- und fruhgeschichtliche Schweinen', Ethnographische-Archaeologische Zeitschrift 10, 517-25.

Turner, A. 1984. 'Sub-sampling animal bones assemblages: reducing the work-load or reducing the information?', Circaea 2(2).

Relevant Ancient Monuments Laboratory Reports.
By T. P. O'Connor.

3958 (1982) Small mammal and amphibian bones from 16-22 Coppergate, York.

4013 (1983) Selected groups of animal bones from Skeldergate and Walmgate, York.

4034 (1983) Progress report on the animal bones from 16-22 Coppergate, York, to the end of July 1983.

4036 (1983) Report on the animal bones from 12 Viking Age pits at 16-22 Coppergate, York.

4099 (1983) Coding system used for bone records at EAU, York University.

4264 (1984) Osseous artefacts from 16-22 Coppergate, York.

**** (1984) Bones from 16-22 Coppergate: catalogues of samples from late 9th and 10th century layers. (Copy lodged with A. M. Laboratory, not in AML Report Series).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CC1	0	280	137	0	3	0	60	0	1	4	0	2	0	2	24	513	227	740	7	6
CC2	1	213	105	0	1	0	48	0	1	1	0	0	0	3	35	408	292	700	2	7
CC3	1	695	364	1	3	0	176	0	4	5	0	0	0	3	73	1325	390	1715	11	42
CC4	4	1436	549	3	1	1	1033	1	6	5	0	0	0	31	399	3474	2000	5474	4	24
CC5	2	351	141	1	3	0	92	0	1	2	0	1	0	0	23	617	250	867	11	18
CC6	2	745	243	0	4	0	163	0	0	5	0	0	0	0	65	1227	400	1627	13	37
CC7	3	1491	558	8	2	0	365	0	3	34	4	0	0	0	130	2598	695	3293	19	51
CC8	7	1499	356	0	10	0	315	0	3	14	0	4	1	2	130	2341	700	3041	45	70
SUM	20	6710	2453	13	27	1	2252	1	19	70	4	7	1	41	879	12503	4954	17457	112	255
CB1	4	418	127	1	1	0	73	1	3	4	0	0	0	1	10	643	300	943	15	12
CB2	3	628	242	0	5	1	172	0	1	1	1	3	1	3	42	1103	575	1678	10	13
CB3	1	190	37	0	4	0	49	0	0	1	0	0	0	0	21	303	100	403	4	5
CB4	4	481	182	0	5	0	177	0	1	4	0	1	0	10	69	934	450	1384	14	35
CB5	0	277	71	0	1	0	65	0	0	0	0	0	0	0	38	452	150	602	4	6
CB6	8	1274	366	3	7	2	299	0	5	16	0	1	0	2	92	2075	535	2610	35	61
CB7	1	323	139	0	0	0	101	0	0	2	0	0	1	0	67	634	135	769	0	15
CB8	2	675	374	0	2	0	278	0	1	4	0	1	0	0	145	1482	600	2082	21	43
CB9	0	386	111	0	1	0	61	0	5	1	0	0	0	5	35	605	130	735	13	22
CB10	3	296	72	1	2	0	86	0	2	3	0	0	0	0	9	474	120	594	9	11
SUM	26	4948	1721	5	28	3	1361	1	18	36	1	6	2	21	528	8705	3095	11800	125	223
CA1	1	1162	480	0	13	0	304	2	2	0	0	0	0	0	50	2014	250	2264	18	107
CA2	38	1451	349	5	6	1	150	0	0	19	0	0	0	0	31	2050	320	2370	29	67
CA3	3	547	193	0	3	0	120	1	0	4	3	1	0	2	32	909	165	1074	3	53
CA4	7	471	152	4	8	1	53	0	4	0	0	1	0	0	16	717	280	997	37	11
CA5	1	172	39	0	0	0	11	0	0	0	0	2	0	0	5	230	82	312	4	4
CA6	7	162	66	1	0	0	15	0	1	0	0	0	0	0	10	262	61	323	10	5
CA7	4	640	184	1	1	0	38	0	0	1	1	1	0	25	9	905	311	1216	13	15
CA8	0	270	61	1	3	0	53	0	0	0	1	0	0	0	24	413	92	505	10	17
SUM	61	4875	1524	12	34	2	744	3	7	24	5	5	0	27	177	7500	1561	9061	124	279

Table 1. Numbers of fragments.

1 = horse
2 = cattle
3 = sheep
4 = goat
5 = red deer
6 = roe deer
7 = domestic pig
8 = wild pig
9 = cat

10 = dog
11 = hare
12 = human
13 = other mammal
14 = fish
15 = bird
16 = total identified
17 = unidentified
18 = TOTAL
19 = number of abraded fragments
20 = number of gnawed fragments

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CC1	0	4	3	0	1	0	3	0	1	1	0	1	70.0	45.7	20.0
CC2	1	3	4	0	1	0	3	0	1	1	0	0	71.0	26.3	16.0
CC3	1	9	8	1	1	0	6	0	1	1	0	0	77.2	45.5	29.3
CC4	1	15	6	1	1	1	35	1	1	1	0	0	95.7	91.5	29.5
CC5	1	5	4	1	1	0	4	0	1	1	0	1	70.2	35.3	23.0
CC6	1	11	7	0	1	0	9	0	0	1	0	0	67.7	34.7	18.1
CC7	1	18	14	2	1	0	10	0	1	3	1	0	82.8	39.9	36.5
CC8	1	17	7	0	1	0	8	0	1	2	0	1	88.2	50.9	39.4
CB1	1	6	5	1	1	0	2	1	2	1	0	0	69.7	25.4	36.5
CB2	1	6	5	0	1	1	5	0	1	1	1	1	104.7	48.4	34.4
CB3	1	5	2	0	1	0	1	0	0	1	0	0	38.0	18.5	16.3
CB4	4	13	4	0	1	0	6	0	1	1	0	1	37.0	45.5	29.5
CB5	0	2	1	0	1	0	2	0	0	0	0	0	138.5	71.0	32.5
CB6	1	16	13	1	1	1	8	0	1	2	0	1	79.6	28.2	37.4
CB7	1	6	4	0	0	0	4	0	0	1	0	0	53.8	34.8	25.3
CB8	1	10	8	0	1	0	7	0	1	1	0	1	67.5	46.8	39.7
CB9	0	7	5	0	1	0	3	0	1	1	0	0	55.1	22.2	20.3
CB10	1	5	2	1	1	0	4	0	1	2	0	0	59.2	36.0	21.5
CA1	1	18	19	0	2	0	19	1	1	0	0	0	64.6	25.3	16.0
CA2	4	23	11	1	1	1	7	0	0	2	0	0	63.1	31.7	21.4
CA3	1	9	5	0	1	0	9	1	0	1	1	1	60.8	38.6	13.3
CA4	1	10	6	1	2	1	4	0	1	0	0	1	47.1	25.3	13.3
CA5	1	5	2	0	0	0	1	0	0	0	0	1	34.4	19.5	11.0
CA6	1	4	2	1	0	0	3	0	1	0	0	0	40.5	33.0	5.0
CA7	2	13	6	1	1	0	2	0	0	1	1	1	49.2	30.7	19.0
CA8	0	5	3	1	1	0	5	0	0	0	1	0	54.0	20.3	10.6

Table 2. Minimum numbers of individuals based on the most numerous non-reproducible skeletal element.

Key: columns 1-12 as Table 1, then
13 = number of frags cattle/MNI cattle
14 = number of frags sheep/MNI sheep
15 = number of frags pig/MNI pig

	cervical					thoracic					lumbar				
	I	!	T	!+T	other	I	!	T	!+T	other	I	!	T	!+T	other
CA1	6	7	9	-	-	14	1	11	-	-	12	8	9	-	-
CA2	14	9	8	1	3	59	6	10	1	-	42	2	17	-	-
CB6	3	7	4	6	2	21	2	12	1	3	12	12	13	-	-
CB8	1	2	4	5	2	11	1	9	-	-	10	2	9	-	-
CC4	2	9	9	-	2	20	3	28	1	-	24	10	22	-	2
CC7	10	10	4	-	-	26	6	8	-	1	21	4	4	-	1
CC8	7	15	7	2	1	10	6	16	2	2	16	11	10	3	1
CA1	.27	.32	.41	-	-	.54	.04	.42	-	-	.41	.28	.31	-	-
CA2	.40	.26	.23	.03	.09	.77	.08	.13	.01	-	.69	.03	.28	-	-
CB6	.14	.32	.18	.27	.09	.54	.05	.31	.03	.08	.32	.32	.35	-	-
CB8	.07	.14	.29	.36	.14	.52	.05	.43	-	-	.48	.09	.43	-	-
CC4	.09	.41	.41	-	.09	.38	.06	.54	.02	-	.41	.17	.38	-	.03
CC7	.42	.42	.16	-	-	.63	.15	.20	-	.02	.70	.13	.13	-	.03
CC8	.22	.47	.22	.06	.03	.28	.17	.44	.06	.06	.39	.27	.24	.07	.02

Table 3. Butchery of cattle vertebrae in seven samples: absolute values above, ratios below.

Key.

I - number of intact centra
! - number of centra chopped through in medio-lateral plane
T - number of centra chopped through in oral-aboral plane
!+T - number of centra chopped in both m-l and o-a planes
other - centra chopped through oblique to m-l and o-a planes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CC1	2	5	17	9	11	12	7	16	51	0	5	12	7	6	7	9	2	38	5	5	3	4	3	17
CC2	1	4	16	2	10	11	5	10	47	0	3	11	4	9	4	8	4	27	1	7	4	6	7	3
CC3	15	17	54	19	35	32	36	35	118	8	17	23	16	27	17	28	2	113	12	14	12	17	12	24
CC4	27	54	146	39	62	54	78	126	119	6	12	40	12	11	13	17	6	232	72	125	23	29	42	191
CC5	1	8	27	16	10	25	18	23	54	1	3	21	5	2	5	10	1	45	4	12	4	8	9	8
CC6	6	18	46	34	38	44	46	33	144	1	13	12	12	19	14	28	0	78	13	10	6	14	24	29
CC7	10	40	121	51	76	79	96	78	280	1	17	56	19	55	30	52	4	142	36	17	29	44	24	51
CC8	4	35	131	53	57	87	89	105	203	5	10	20	14	26	25	26	8	107	20	27	16	43	30	29
CB1	1	8	33	15	17	17	19	33	61	2	2	7	5	13	10	20	1	29	4	6	4	8	8	4
CB2	4	9	53	17	18	27	30	55	74	1	6	25	9	25	13	10	11	45	11	9	9	21	17	4
CB3	1	7	11	7	14	10	14	9	22	0	3	1	3	2	5	1	1	14	3	3	4	6	6	3
CB4	1	8	34	23	24	30	33	30	70	2	1	21	4	16	14	13	3	56	14	4	7	16	19	7
CB5	1	3	16	6	2	5	8	10	77	0	1	5	2	3	1	4	1	33	4	10	4	7	7	4
CB6	3	24	108	48	61	79	95	91	179	3	13	30	22	29	42	34	3	111	22	44	19	21	38	25
CB7	0	5	19	9	19	17	15	16	69	0	3	9	5	13	4	1	4	52	8	5	5	15	11	4
CB8	1	13	61	20	36	29	26	57	101	2	10	29	20	28	12	21	18	83	12	24	13	20	28	11
CB9	4	8	29	11	29	26	27	17	77	3	3	11	4	13	8	8	2	29	3	5	2	7	14	4
CB10	2	11	16	14	10	18	17	14	50	0	1	2	2	8	10	8	0	30	10	5	6	9	7	4
CA1	9	31	85	56	67	87	83	58	181	6	35	20	27	42	49	85	1	124	43	21	23	37	47	19
CA2	19	73	180	62	96	112	123	89	145	4	26	43	33	42	39	50	3	61	19	15	12	23	22	3
CA3	6	12	50	13	32	54	49	14	105	1	1	11	12	27	16	16	2	52	20	4	11	19	33	5
CA4	7	10	27	13	31	36	48	15	74	0	6	16	10	12	7	10	1	30	5	6	5	12	9	1
CA5	2	11	25	5	16	6	14	8	14	0	2	9	4	3	2	5	0	6	0	3	1	0	1	0
CA6	1	9	14	10	15	10	11	8	21	0	4	12	2	5	4	5	0	14	2	0	4	3	6	0
CA7	3	16	121	24	46	44	37	30	79	0	9	25	9	11	10	14	9	41	3	4	2	4	8	1
CA8	2	8	30	4	23	25	35	3	38	2	7	5	6	10	6	8	0	11	8	1	5	13	17	2

Table 4. Numbers of skeletal elements grouped by carcass component.

Cattle
1 = horncores
2 = skull
3 = vertebrae
4 = scapula + pelvis
5 = fore limb
6 = hind limb
7 = hocks
8 = phalanges
9 = ribs [= n.articular ends + (n.non-articular frags/3)]

Sheep
10 = horncores
11 = skull
12 = vertebrae
13 = scapula + pelvis
14 = fore limb
15 = hind limb
16 = metapodials
17 = phalanges
18 = ribs [counted as for cattle]

Pig
19 = skull
20 = vertebrae
21 = scapula + pelvis
22 = fore limb
23 = hind limb
24 = metapodials 3+4

CC1	9.3	9.3	6.3	21.0	12.9	11.2	5.4	6.3	18.3	0	16.5	5.8	23.2	9.9	9.3	15.0	1.1	19.3	24.7	3.8	14.8	9.9	4.9	42.0
CC2	6.7	10.8	8.6	6.7	16.8	14.8	5.7	5.7	24.3	0	12.7	7.0	17.0	19.2	6.8	17.0	2.8	17.6	7.8	8.1	31.1	23.3	18.0	11.8
CC3	21.8	9.9	6.3	13.8	12.7	9.3	8.7	4.3	13.2	15.3	16.3	3.3	15.3	13.0	6.5	13.4	0.3	16.7	23.7	4.1	23.7	16.8	7.9	23.7
CC4	19.5	15.6	8.4	14.1	11.2	7.8	9.4	7.6	6.6	12.3	12.3	6.1	12.3	5.6	5.3	8.7	1.0	36.5	30.3	7.8	9.7	6.1	5.9	40.2
CC5	3.2	10.3	7.0	25.9	8.1	16.2	9.7	6.2	13.5	7.1	10.6	11.1	17.7	3.6	7.1	17.7	0.6	24.5	19.3	8.5	19.3	19.3	14.5	19.3
CC6	8.1	9.8	5.0	23.1	12.9	11.9	10.4	3.8	15.0	2.9	18.6	2.5	17.2	13.6	8.0	20.0	0	17.2	26.0	3.0	12.0	14.0	16.0	29.0
CC7	7.1	11.4	6.9	18.2	13.6	11.3	11.4	4.6	15.4	1.5	12.7	6.2	14.1	20.5	8.9	19.4	0.5	16.3	29.3	2.1	23.6	17.9	6.5	20.7
CC8	3.2	11.1	8.3	21.1	11.3	13.8	11.8	7.0	12.4	11.0	11.0	3.3	15.4	14.3	11.0	14.3	1.5	18.2	23.3	4.7	18.6	25.0	11.6	16.9
CB1	3.1	9.8	8.1	23.0	13.1	10.4	9.7	8.5	14.4	10.8	5.4	2.8	13.4	17.5	10.8	26.9	0.4	12.0	22.8	5.0	22.8	22.8	15.3	11.4
CB2	8.8	7.9	9.3	18.7	9.9	11.9	11.0	10.1	12.5	3.8	11.5	7.1	17.2	23.9	9.9	9.9	3.5	13.2	27.8	3.3	22.8	26.6	14.4	5.1
CB3	5.4	15.2	4.8	18.9	18.9	10.8	12.7	4.1	9.2	0	25.0	1.3	25.0	8.3	16.7	4.3	1.3	18.0	21.6	3.2	28.8	21.6	14.4	11.0
CB4	2.3	7.3	6.2	26.3	13.7	13.7	12.6	5.7	12.3	9.7	2.4	7.5	9.7	19.3	13.5	15.8	1.3	20.8	35.5	1.5	17.8	20.3	16.0	8.9
CB5	6.2	7.5	8.0	18.7	3.1	6.2	8.3	5.2	36.8	0	7.7	5.9	15.5	11.8	3.1	15.5	1.2	39.3	23.1	8.6	23.1	20.3	13.4	11.6
CB6	26.4	8.5	7.6	21.2	13.5	13.9	14.0	6.7	12.1	5.4	11.7	4.0	19.8	13.0	15.1	15.3	0.5	15.4	26.4	7.8	22.8	12.6	15.2	15.0
CB7	0	7.9	6.0	17.8	18.8	13.4	9.9	5.3	20.9	0	11.3	5.0	18.8	24.5	6.0	2.0	2.6	30.0	29.7	2.8	18.6	27.9	13.7	7.4
CB8	1.9	9.9	9.3	19.0	17.1	11.0	8.2	9.0	14.7	4.8	12.0	5.1	24.0	16.8	5.8	12.6	3.6	15.3	22.5	6.7	24.3	18.7	17.5	10.3
CB9	10.2	8.1	5.9	14.0	18.5	13.2	11.4	3.6	15.1	18.1	9.1	5.0	12.1	19.7	9.7	12.1	1.0	13.5	18.8	4.8	12.5	22.1	29.3	12.5
CB10	7.0	15.4	4.5	24.5	8.7	12.6	9.9	4.1	13.4	0	5.0	1.4	10.1	20.1	20.1	20.1	0	23.1	39.1	3.0	23.4	17.7	9.1	7.8
CA1	7.8	10.1	5.5	22.8	13.6	14.2	11.2	3.9	11.3	6.7	19.5	1.7	15.1	11.7	11.0	23.7	0.1	10.6	38.1	27.7	20.4	16.4	13.9	8.4
CA2	10.6	16.3	8.0	17.3	13.4	12.5	11.5	4.1	6.2	5.5	18.0	4.4	22.8	14.5	10.8	17.3	3.6	6.5	35.5	4.2	22.4	21.5	13.7	2.8
CA3	10.4	8.4	7.0	11.3	13.9	18.8	14.2	2.0	14.1	3.8	1.9	3.1	22.7	25.6	12.1	15.1	6.1	15.1	36.6	1.1	20.1	17.4	20.1	4.6
CA4	14.2	8.1	4.4	13.1	15.7	14.5	16.1	2.5	11.5	0	16.3	6.4	27.1	16.3	7.6	13.5	0.4	12.5	24.5	4.3	24.5	29.4	14.7	2.6
CA5	9.9	21.8	9.9	12.4	19.8	6.0	11.6	3.3	5.4	0	15.3	10.1	30.6	11.6	6.1	19.3	0	7.0	0	25.0	56.8	0	18.2	0
CA6	4.9	17.5	5.4	24.3	18.3	9.7	8.9	3.2	7.9	0	24.2	10.6	12.1	15.2	9.7	15.2	0	13.0	21.0	0	42.0	16.0	21.0	0
CA7	4.5	9.7	14.6	18.2	17.4	13.3	9.3	3.8	9.2	0	19.5	8.1	19.5	12.0	8.7	15.2	3.3	13.7	27.8	5.6	18.5	18.5	24.8	4.8
CA8	6.8	10.9	8.2	6.8	19.6	17.0	19.9	0.8	9.9	12.9	22.6	2.5	19.3	16.8	7.3	12.9	0	5.4	30.4	0.6	19.0	24.7	21.6	3.8

Table 5. Carcass component counts from Table 4 reworked as percentages of total components per species (e.g. standardised count for sheep ribs/total of standardised counts for sheep). Key to carcass components is as for Table 4. Note that counts for cattle and sheep are based on 9 components each, whereas those for pig are based on 6 and are thus not directly comparable with cattle and sheep. For randomly distributed carcasses with no taphonomic or recovery bias, expected values for each component are 11.1% for cattle and sheep and 16.7% for pig.

	LOWER FIRST MOLAR								
	8	9	10	11	12	13	14	15	16
1	–	–	–	–	–	–	–	–	–
2	–	1	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–
7	–	–	1	–	2	–	–	–	–
8	–	–	–	–	–	1	–	–	–
9	–	–	–	–	2	–	–	–	–
10	–	–	–	–	1	–	1	–	–
11	–	–	–	–	1	1	–	–	–
12	–	–	–	–	–	2	1	2	–
13	–	–	–	–	1	1	1	–	–
14	–	–	–	–	–	–	–	–	–
15	–	–	–	–	–	–	–	4	9
16	–	–	–	–	–	–	–	–	3

LOWER SECOND MOLAR

Table 6. Dental eruption and attrition stages of cattle mandibles plotted as a cross-tabulation of the wear stage reached by first and second lower molars. Stages are those defined by Grant (1982), stage 5 being equivalent to Grant's stage a, 6 to Grant's b, and so on.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CC1	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0
CC2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC3	0	0	0	1	6	1	0	0	3	3	3	0	0	0	0	2	2	0
CC4	0	0	0	1	6	1	0	0	0	3	3	0	0	0	2	5	5	0
CC5	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
CC6	0	0	0	3	4	1	0	0	0	2	4	0	0	0	0	1	4	0
CC7	1	0	0	2	7	1	0	0	1	3	7	0	0	0	2	15	2	0
CC8	0	0	1	5	11	0	0	0	0	1	4	0	0	0	3	4	1	0
CB1	0	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
CB2	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	3	2	0
CB3	0	0	0	1	2	0	0	0	0	0	2	0	0	0	0	1	1	0
CB4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	3	0
CB5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0
CB6	0	0	0	2	11	0	0	1	1	1	3	0	0	1	2	2	3	0
CB7	0	0	0	0	1	0	0	0	0	0	2	0	0	0	1	2	2	0
CB8	0	0	0	0	0	0	0	0	0	1	5	0	0	0	3	5	0	0
CB9	0	0	0	4	1	0	0	0	0	1	1	0	0	0	0	1	1	0
CB10	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	3	2	0
CA1	-	1	1	4	9	0	0	0	0	4	22	0	0	1	7	8	12	0
CA2	0	0	3	5	8	1	0	0	0	2	18	0	0	0	0	5	1	0
CA3	1	0	0	2	2	0	0	0	0	1	0	0	0	0	0	4	6	0
CA4	0	1	0	1	2	1	0	0	0	2	4	0	0	1	0	0	1	0
CA5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CA6	0	0	0	1	3	0	0	1	0	0	1	0	0	0	0	0	0	0
CA7	1	0	0	3	2	1	0	0	0	0	3	0	0	0	0	2	0	0
CA8	0	0	0	2	1	0	0	0	1	2	4	0	0	0	2	2	0	0

Table 7. Mandibles grouped according to tooth eruption and attrition.

Cattle
1 = perinatal
2 = juvenile [M1 not yet in wear]
3 = immature [M1 in wear, M2 not yet in wear]
4 = sub-adult [M2 in wear, M3 not yet in wear]
5 = adult [M3 in wear]
6 = senile [showing very advanced wear on M3]

Sheep
7-12 as for cattle

Pig
13-18 as for cattle

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CC1	14/1	3/5	2/4	5/14	2/0	4/0	4/1	1/4	1/8	1/1	2/12	0/7	0/3	1/4
CC2	12/2	2/0	7/2	1/14	2/0	3/3	2/2	1/3	0/6	2/2	0/5	0/2	1/8	0/5
CC3	34/2	20/8	16/11	24/25	10/0	5/1	10/11	4/5	5/15	6/0	4/12	2/5	1/6	0/10
CC4	101/0	33/12	31/20	62/70	5/0	6/2	6/5	0/3	2/35	9/1	39/122	20/120	0/12	4/80
CC5	18/2	8/11	6/0	7/17	0/0	1/4	5/2	1/2	4/12	3/2	3/6	0/3	0/7	0/11
CC6	39/1	30/17	14/17	24/21	9/0	3/1	13/8	2/1	0/7	3/0	2/16	5/17	0/6	0/10
CC7	84/12	45/24	39/23	44/59	26/5	8/5	16/11	6/13	14/36	12/3	7/20	12/34	0/10	0/12
CC8	104/10	42/21	32/20	10/31	15/3	10/3	9/3	10/9	6/10	18/1	1/19	1/9	0/17	1/23
CB1	31/1	9/7	2/4	8/23	8/0	5/3	3/3	0/3	3/1	4/0	0/6	0/0	0/4	0/5
CB2	47/9	11/16	4/15	14/36	10/2	8/4	7/9	3/7	5/15	5/1	2/8	0/6	1/9	0/9
CB3	13/3	4/3	6/5	5/5	1/0	1/2	2/0	1/1	0/1	1/1	1/3	0/1	1/1	0/3
CB4	34/2	12/10	16/12	13/18	8/0	7/0	7/2	4/4	2/16	7/1	0/4	0/7	0/10	0/4
CB5	7/0	3/1	0/3	3/12	1/0	2/0	3/0	1/0	1/2	2/0	0/2	0/3	0/4	0/7
CB6	84/8	47/23	28/32	35/64	15/0	6/2	26/6	6/9	12/16	6/2	3/16	1/18	1/14	0/36
CB7	22/0	10/1	9/5	3/14	7/0	3/1	2/0	0/2	4/4	6/0	0/2	0/2	2/9	0/6
CB8	48/9	8/19	6/23	14/44	16/2	17/7	8/4	3/7	4/25	7/2	2/13	0/9	0/7	0/22
CB9	29/1	5/11	10/11	5/20	10/0	3/0	4/1	5/3	6/3	4/0	0/10	1/1	0/7	0/3
CB10	10/0	4/4	6/9	5/11	4/0	0/2	8/0	0/6	1/1	2/2	0/4	0/3	0/4	0/4
CA1	73/4	31/38	27/38	27/50	17/0	17/2	27/8	13/5	3/12	14/1	14/10	5/12	0/17	0/16
CA2	120/8	50/31	41/25	77/94	21/2	14/2	25/11	8/12	8/27	6/2	2/4	0/2	2/19	0/14
CA3	26/1	26/15	26/19	15/32	13/1	3/1	11/3	4/8	2/6	7/0	9/5	0/4	1/9	0/3
CA4	21/5	9/6	15/9	5/21	6/0	2/0	8/1	1/1	2/6	4/2	2/1	0/1	0/6	0/4
CA5	16/2	5/1	6/2	19/16	1/1	2/0	1/2	0/1	2/6	0/0	0/0	0/0	0/0	0/3
CA6	8/2	8/1	9/4	5/9	1/2	1/0	4/1	0/4	2/10	1/2	0/3	0/0	0/3	0/0
CA7	36/6	23/9	18/28	16/56	4/0	11/0	3/4	2/5	9/12	0/0	2/0	0/2	1/2	0/2
CA8	12/0	12/12	12/14	15/13	4/0	1/0	3/2	3/4	1/4	7/0	3/3	0/3	0/10	0/1

Table 8. Ratio of fused/unfused epiphyses grouped sequentially.

Cattle
1 = early [humerus distal, radius proximal, phalanges 1+2 proximal]
2 = intermediate [metacarpal and metatarsal distal, tibia distal, tuber calcis]
3 = late [humerus proximal, radius distal, olecranon tuberosity, femur proximal and distal, tibia proximal]
4 = vertebrae

Sheep
5 = early [humerus distal, radius proximal]
6 = intermediate 1 [phalanges 1+2 proximal, metacarpal distal]
7 = intermediate 2 [tibia distal, metatarsal distal, olecranon tuberosity, femur proximal, tuber calcis]
8 = late [radius distal, humerus proximal, femur distal, tibia proximal]
9 = vertebrae

Pig
10 = early [humerus distal, radius proximal]
11 = intermediate 1 [metacarpal distal, tibia distal]
12 = intermediate 2 [metatarsal distal, tuber calcis]
13 = late [olecanon tuberosity, humerus proximal, radius distal, femur proximal and distal, tibia proximal]
14 = vertebrae

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	*	@
CC1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CC2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CC3	-	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CC4	-	4	-	-	-	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CC5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CC6	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CC7	2	3	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
CC8	-	1	-	-	-	-	-	-	-	1	1	-	1	1	-	-	1	-	-	1	-	-	-	-	1	-	-	-
SUM	4	12	-	1	-	-	1	1	2	6	2	1	1	1	-	-	1	1	1	1	-	-	-	-	1	-	1	-
CB1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CB2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CB3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CB4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CB5	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CB6	-	5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
CB7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
CB8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CB9	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CB10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUM	4	5	-	1	1	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	1
CA1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CA2	1	2	-	3	-	1	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
CA3	2	2	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
CA4	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CA5	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CA6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CA7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CA8	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
SUM	6	4	1	4	-	3	-	-	-	3	-	-	-	-	1	1	-	-	-	-	1	-	3	1	-	-	-	-

Table 9. Summary of disease and injury symptoms.

CATTLE
A - hip arthropathies
B - lower limb arthorpathies
C - occipital condyle arthropathy
D - mandibular condyle abnormality
E - exostoses on rib articulations
F - metapodial shaft periostitis
G - possible osteomyelitis in metatarsal
H - periodontal disease
I - non-inflammatory exostosis

SHEEP
J - exostoses at elbow c.f. luxation.
K - sterile osteoperiostitis on metapodial shafts
L - impacted lower P2
M - division of horncore
N - depressions in horncore
O - periodontal disease
P - arthropathy ofatlas articulation

PIG
Q - crowding and tooth rotation in maxilla
R - osteoarthritis of metatarsal proximal articulation
S - infected ulceration of metapodial shaft
T - healed fracture of tibia
U - partial fusion of fibula shaft to tibia
V - infection of medullary cavity of ulna c.f. osteomyelitis

W - HORSE - lumbar arthropathy
X - HORSE - periostitis on tibia shaft
Y - DOG - partial fusion of fibula shaft to tibia
Z - CAT - spiral fracture of femur proximal end
* - GOAT - periostitis on metacarpal shaft
@ - BEAR - third phalanx arthropathy

	A1	A2	B	C1	C2	D	E1	E2	E3	E4	E5	E6
CC1	2	1	–	–	–	–	–	–	–	–	–	–
CC2	1	–	–	1	–	–	–	–	–	–	–	–
CC3	8	–	1	12	–	–	3	2	1	2	2	1
CC4	16	–	–	5	–	–	–	–	–	–	–	–
CC5	–	–	–	3	–	1	–	–	–	–	–	–
CC6	4	1	–	7	–	–	2	–	–	1	–	–
CC7	22	–	–	12	–	–	2	1	–	1	3	1
CC8	13	2	1	5	–	–	–	–	–	1	2	2
SUM	66	4	2	45	–	1	7	3	1	5	7	4
CB1	3	–	1	1	–	–	1	–	–	–	–	–
CB2	3	–	1	5	–	–	3	–	–	–	–	–
CB3	2	–	–	1	–	–	–	–	–	–	–	–
CB4	2	–	–	3	–	–	–	–	–	–	–	–
CB5	1	–	–	1	–	–	–	–	–	–	–	–
CB6	12	1	3	9	–	–	1	–	–	–	–	–
CB7	1	–	–	2	–	–	–	–	–	–	–	–
CB8	4	–	–	8	1	–	–	–	–	–	–	–
CB9	5	–	–	2	–	–	1	–	–	–	–	–
CB10	5	–	–	–	–	–	–	–	–	–	–	–
SUM	38	1	5	32	1		6			3		2
CA1	11	–	–	17	2	–	–	–	–	–	–	–
CA2	18	4	–	20	–	–	3	–	–	4	1	4
CA3	5	–	–	1	–	–	1	1	1	1	1	1
CA4	5	–	–	6	1	–	1	–	–	1	1	–
CA5	–	–	–	–	–	–	–	–	–	–	–	–
CA6	2	–	–	2	–	–	2	–	–	2	1	1
CA7	7	–	–	3	–	–	–	–	–	–	–	–
CA8	2	–	–	7	–	–	–	–	–	1	1	–
SUM	50	4	–	56	3	–	7	1	1	9	5	6

Table 10. Incidence of some nonmetrical traits in cattle and sheep bones.

Table 10. Key.

CATTLE
A1 – number of jaws with lower P2 present
A2 – number of jaws with lower P2 absent

B – incidence of absent distal column on lower M3

SHEEP
C1 – number of jaws with lower P2 present
C2 – number of jaws with lower P2 absent

D – incidence of absent distal column on lower M3

E1–6 – position of nutrient foramen on femora
E1 – proximal position present
E2 – proximal position absent
E3 – midshaft position present
E4 – midshaft position absent
E5 – distal position present
E6 – distal position absent

Humerus - width of distal trochlea

	mean	S.D.	n	S.E.	.95 C.I.
CA	65.5	5.86	11	1.77	64.0-70.1
CB	65.8	5.28	4	2.64	60.7-71.0
CC	66.6	5.47	14	1.46	63.7-69.5

Metatarsal - product of minimum shaft medio-lateral breadth and antero-posterior depth at same place.

	mean	S.D.	n	S.E.	.95 C.I.
CA	621.6	107.6	18	25.4	571.9-671.3
CB	678.1	132.7	14	35.5	642.6-713.6
CC	599.9	99.8	19	22.9	55.0-644.8

Taken together and compared with figures given in Noddle (1973), the results correspond to a fat-free carcass weight of 100-140 kg., liveweight = 160-225 kg.

Astragalus - lateral length

	mean	S.D.	n	S.E.	.95 C.I.
CA	61.1	3.84	23	0.80	59.5-62.7
CB	60.2	2.89	23	0.60	59.0-61.4
CC	60.5	3.04	34	0.52	59.5-61.5

Using the general allometric equation given by Reitz and Cordier (1983) for ungulates, the results indicate a liveweight of about 290 kg.

Reconstructed shoulder height from factors given by von den Dreisch and Boessneck (1974).
Metatarsal GL*5.45

	mean	S.D.	n	S.E.	.95 C.I.
CA	1131.3	62.6	13	17.36	1097.3-1165.3
CB	1133.8	40.6	13	11.26	1111.7-1155.9
CC	1108.8	48.9	13	13.56	1082.2-1135.4

Thus reconstructed shoulder height = 1.10-1.15 m.

Table 11. Summary of cattle biometrical data.
Note - .95 C.I. = .95 Confidence Intervals (= mean +/- 1.96*S.E.)

							LOWER FIRST MOLAR			
	8	9	10	11	12	13	14	15	16	17
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	1	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-
9	-	-	-	1	9	-	-	-	-	-
10	-	-	-	2	17	1	-	-	-	-
11	-	-	-	2	5	2	1	1	-	-
12	-	-	-	-	8	15	5	-	-	-
13	-	-	-	-	-	-	-	3	1	2
14	-	-	-	-	-	-	-	-	-	1
15	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	1	-
LOWER SECOND MOLAR										

Table 12. Attrition in sheep mandibles plotted as a crosstabulation of the wear stages reached by lower first and second molars.

		1	2	3	4	5	6	7	8	9	10
CC	mean	118.8	21.8	16.1	13.6	??	24.5	24.0	15.5	15.0	10.5
	S.D.	7.12	1.46	0.97	0.87	0.74	1.24	1.35	0.75	0.67	0.44
	n	11	28	27	27	27	12	11	12	11	11
	S.E.	2.15	0.28	0.19	0.17	0.14	0.36	0.41	0.22	0.20	0.13
CB	mean	120.3	22.4	16.5	13.8	10.9	25.3	25.2	15.9	15.4	10.6
	S.D.	6.25	1.18	0.98	0.79	0.72	1.04	1.13	0.82	0.86	0.54
	n	10	16	16	12	12	11	9	13	??	??
	S.E.	1.80	0.26	0.22	0.20	0.18	0.30	0.33	0.25	0.29	0.15
CA	mean	120.4	22.4	16.4	13.9	11.1	25.1	25.0	15.7	15.2	10.6
	S.D.	6.30	0.98	0.84	1.00	0.84	1.20	1.29	0.68	0.67	0.50
	n	28	39	38	38	33	30	29	27	26	29
	S.E.	1.19	0.16	0.14	0.16	0.15	0.22	0.24	0.13	0.13	0.09

Table 13. Measurements of sheep metacarpals.

Key.
1 - maximum length
2 - medio-lateral breadth proximal articulation
3 - antero-posterior depth proximal articulation
4 - minimum medio-lateral breadth diaphysis
5 - antero-posterior depth diaphysis at same place as 4
6 - maximum medio-lateral breadth distal diaphysis
7 - medio-lateral breadth distal condyles
8 - antero-posterior depth medial distal verticillus
9 - antero-posterior depth lateral distal verticillus
10 - antero-posterior depth lateral element of medial distal condyle

	LOWER FIRST MOLAR													
	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	1	1	3	-	-	-	-	-	-	-	-	-
3	-	-	-	-	1	-	-	-	-	-	-	-	-	-
4	-	-	-	2	1	-	1	-	-	-	-	-	-	-
5	-	-	-	-	-	1	1	-	-	-	-	-	-	-
6	-	-	-	1	4	1	2	3	1	-	-	-	-	-
7	-	-	-	-	-	2	1	1	3	2	1	-	-	-
8	-	-	-	-	-	-	2	3	2	1	1	-	-	-
9	-	-	-	-	-	1	1	2	3	1	1	-	-	-
10	-	-	-	-	-	-	-	-	1	1	-	-	-	1
11	-	-	-	-	-	-	-	-	-	-	1	1	-	1
12	-	-	-	-	-	-	-	-	-	-	1	1	1	1
13	-	-	-	-	-	-	-	-	-	-	1	-	-	-
14	-	-	-	-	-	-	-	-	-	-	1	-	1	1
LOWER SECOND MOLAR														

Table 14. Attrition in pig mandibles plotted as a crosstabulation of wear stages of lower first and second molars.

		I	SA	AD	S	TOTAL
CC	M	1	12	7	-	20
	F	1	10	7	-	18
CB	M	4	4	8	-	16
	F	1	7	1	-	9
CA	M	1	7	7	-	15
	F	3	3	10	-	16

Table 15. Sex attribution of mandibles based on canine morphology.

Key.
I - immature
SA - sub-adult
AD - adult
S - very old

M - male
F - female

		CA	CB	CC
mute swan	Cygnus olor	–	–	0.1
indet. goose	Anser/Branta sp.	–	2.2	1.9
pink-footed goose	Anser brachyrhynchus	–	0.2	0.1
white-fronted goose	Anser albifrons	–	–	0.1
domestic/greylag goose	Anser anser	22.3	18.0	21.1
barnacle goose	Branta leucopsis	–	2.7	2.0
brent goose	Branta bernicla	2.1	–	0.3
duck species	Anas/Aythya species	–	–	0.1
mallard	Anas brachyrhynchus	1.1	1.5	0.6
white-tailed eagle	Haliaeetus albicilla	–	–	0.1
goshawk	Accipiter gentilis	–	0.2	–
black grouse	Tetrao tetrix	–	1.7	0.3
domestic fowl	Gallus gallus dom.	71.3	68.1	69.3
crane	Grus grus	–	–	0.6
plover	Pluvialis sp.	–	–	0.4
golden plover	Pluvialis apricaria	–	3.5	0.6
grey plover	Pluvialis squatarola	–	–	0.4
woodcock	Scolopax rusticola	–	–	0.1
guillemot	Uria aalge	–	–	0.1
razorbill	Alca torda	–	–	0.1
dove species	Columba sp.	–	–	0.6
wood pigeon	Columba palumbus	2.1	1.0	0.3
jackdaw	Corvus monedula	–	0.5	–
raven	Corvus corax	1.1	0.2	0.4

Table 16. Relative abundance of bird taxa, expressed as a percentage of total bird fragments.

	ABUNDANT		NOT ABUNDANT	
	CB	CC	CB	CC
frequent	fowl dom. goose	fowl dom. goose	barnacle goose golden plover black grouse mallard	barnacle goose
			CB	CC
NOT FREQUENT			other wild geese goshawk wood pigeon jackdaw raven	mute swan other wild geese white-tailed eagle crane golden plover black grouse mallard grey plover woodcock guillemot razorbill dove sp. woodpigeon raven

Table 17. Differences in occurrence of bird taxa in early-mid and late 10th century samples.

	1	2	3	4	5	6	7	8
CA 1	–	78.6	81.0	77.3	63.5	79.4	73.4	80.5
2		–	75.7	83.5	82.1	82.8	82.8	77.1
3			–	81.6	61.7	71.1	71.1	83.3
4				–	75.2	77.2	79.8	81.4
5					–	73.9	77.5	64.7
6						–	81.9	74.6
7							–	72.4
8								–

Table 18. Matrix of percentage similarity for late 9th century samples.

	1	2	3	4	5	6	7	8	9	10
CB 1	-	82.7	76.6	84.4	69.3	86.2	76.0	81.8	81.4	80.3
2		-	79.9	82.9	75.8	85.1	83.0	85.8	78.7	80.3
3			-	78.5	70.3	83.8	78.7	77.4	78.1	81.9
4				-	73.3	87.3	81.6	82.8	79.2	87.0
5					-	73.3	77.7	74.2	68.2	73.6
6						-	79.3	86.1	81.0	81.7
7							-	82.5	77.3	76.3
8								-	76.3	74.6
9									-	74.4
10										-

Table 19. Matrix of percentage similarity for early-mid 10th century samples.

	1	2	3	4	5	6	7	8
CC 1	–	78.3	82.7	70.5	78.3	85.8	84.1	76.5
2		–	76.5	59.1	75.8	77.5	80.2	73.4
3			–	72.8	76.4	81.7	81.6	75.8
4				–	69.3	67.6	70.0	68.9
5					–	84.4	82.3	88.0
6						–	88.8	85.5
7							–	85.9
8								–

Table 20. Matrix of percentage similarity for late 10th century samples.

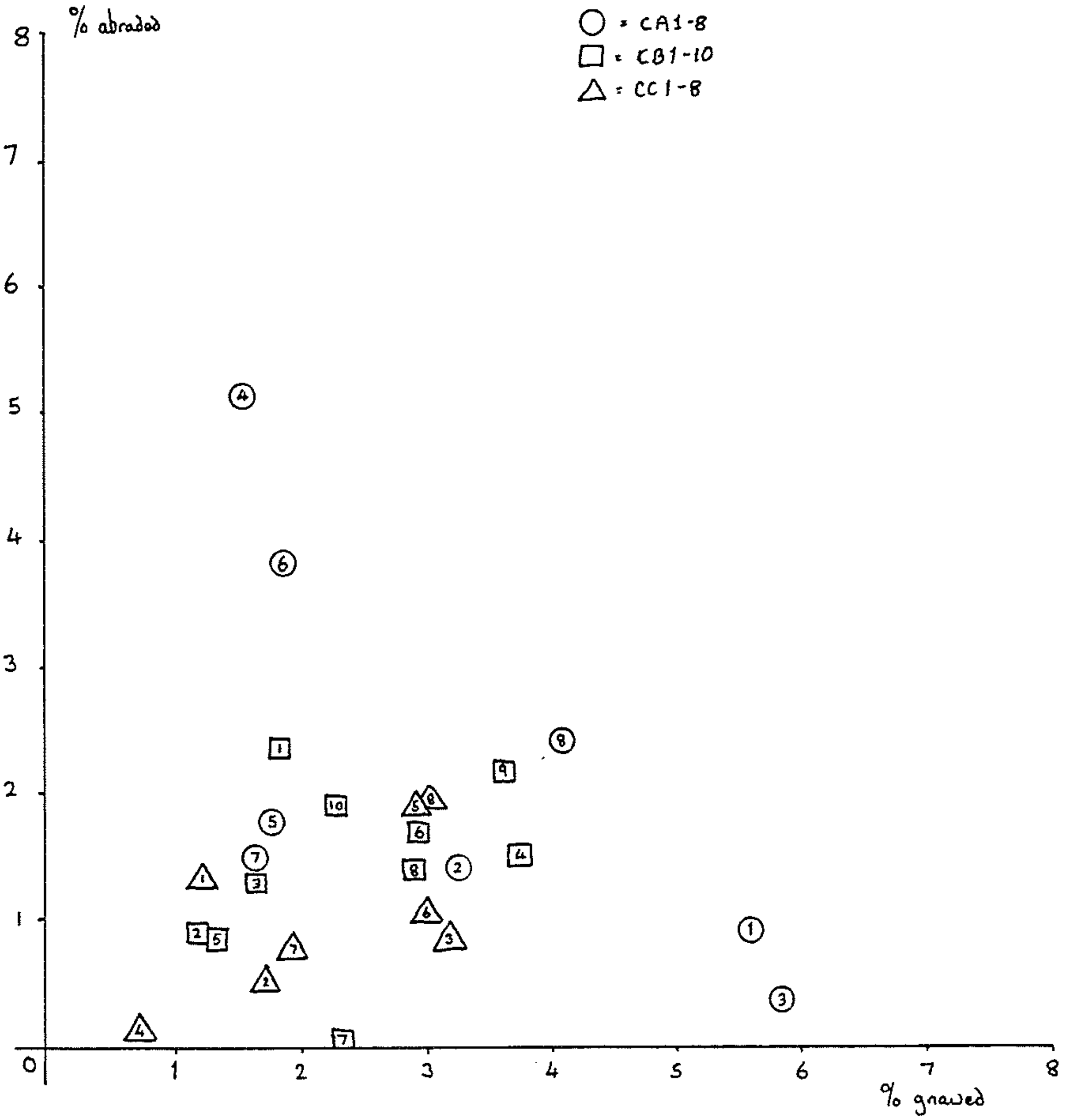

Fig.1. Proportions of gnawed and abraded fragments expressed as a percentage of total identified fragments.

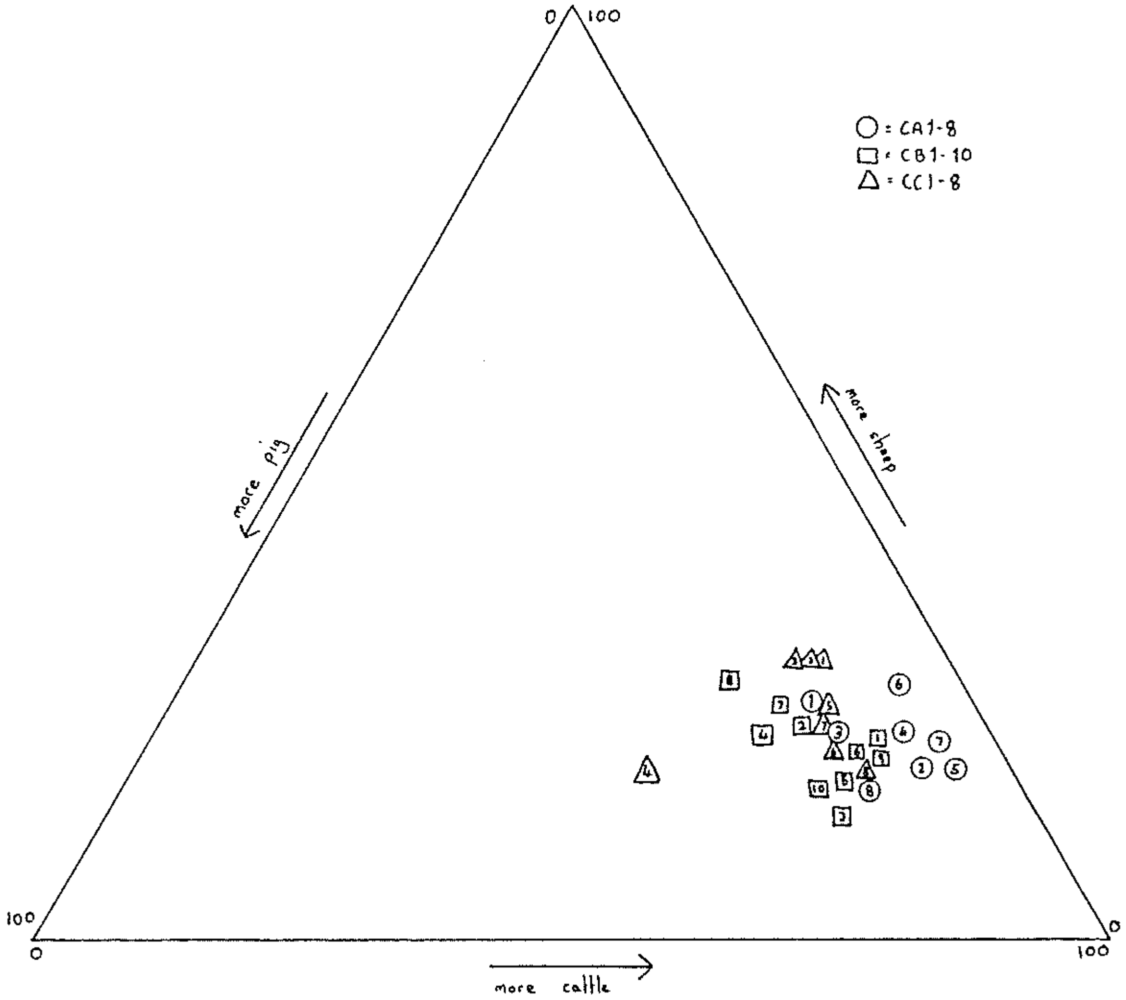

Fig. 2. Ratios of cattle, sheep and pig fragments.

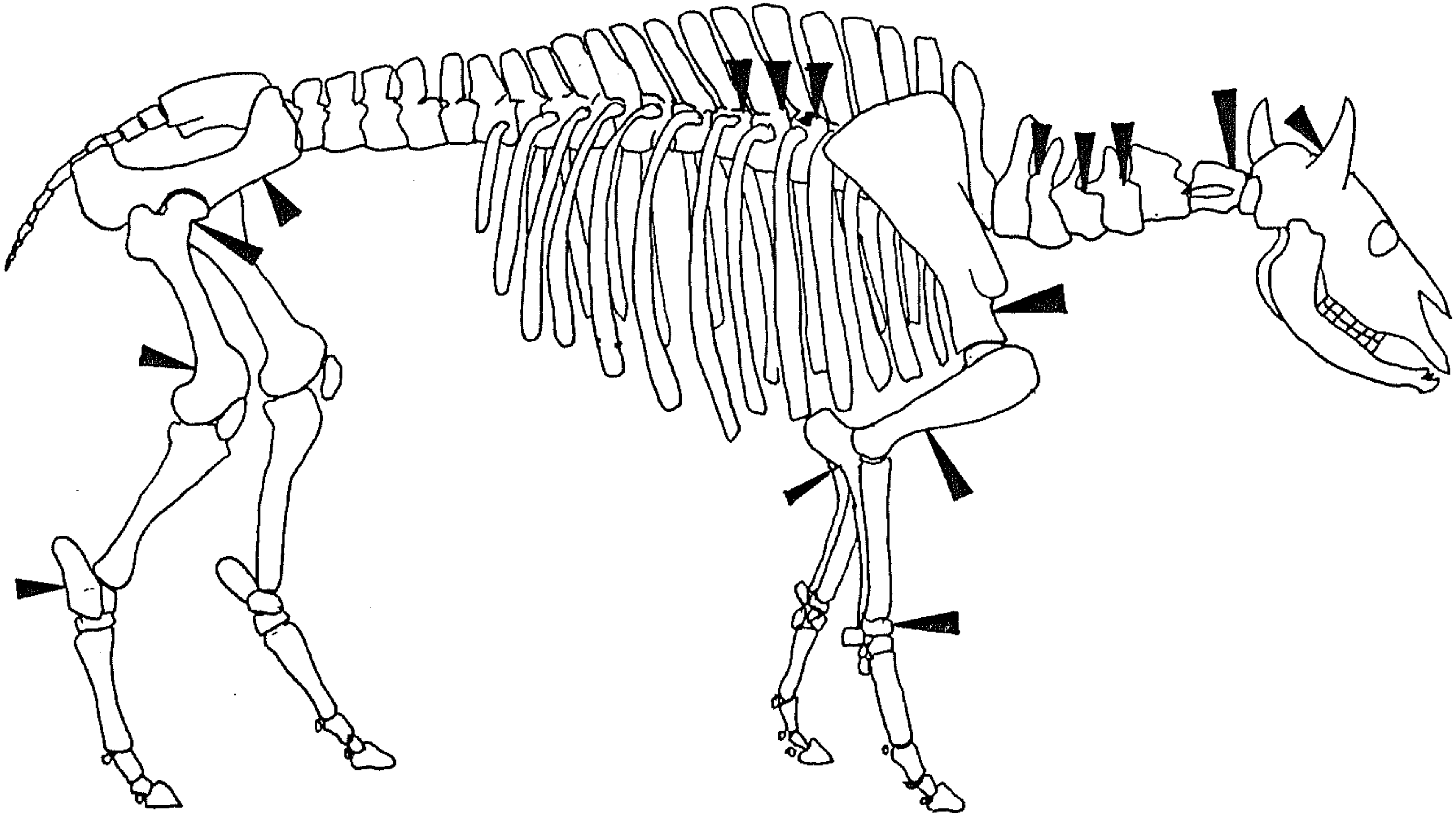

Fig. 3. Cattle skeleton showing main zones of butchery.

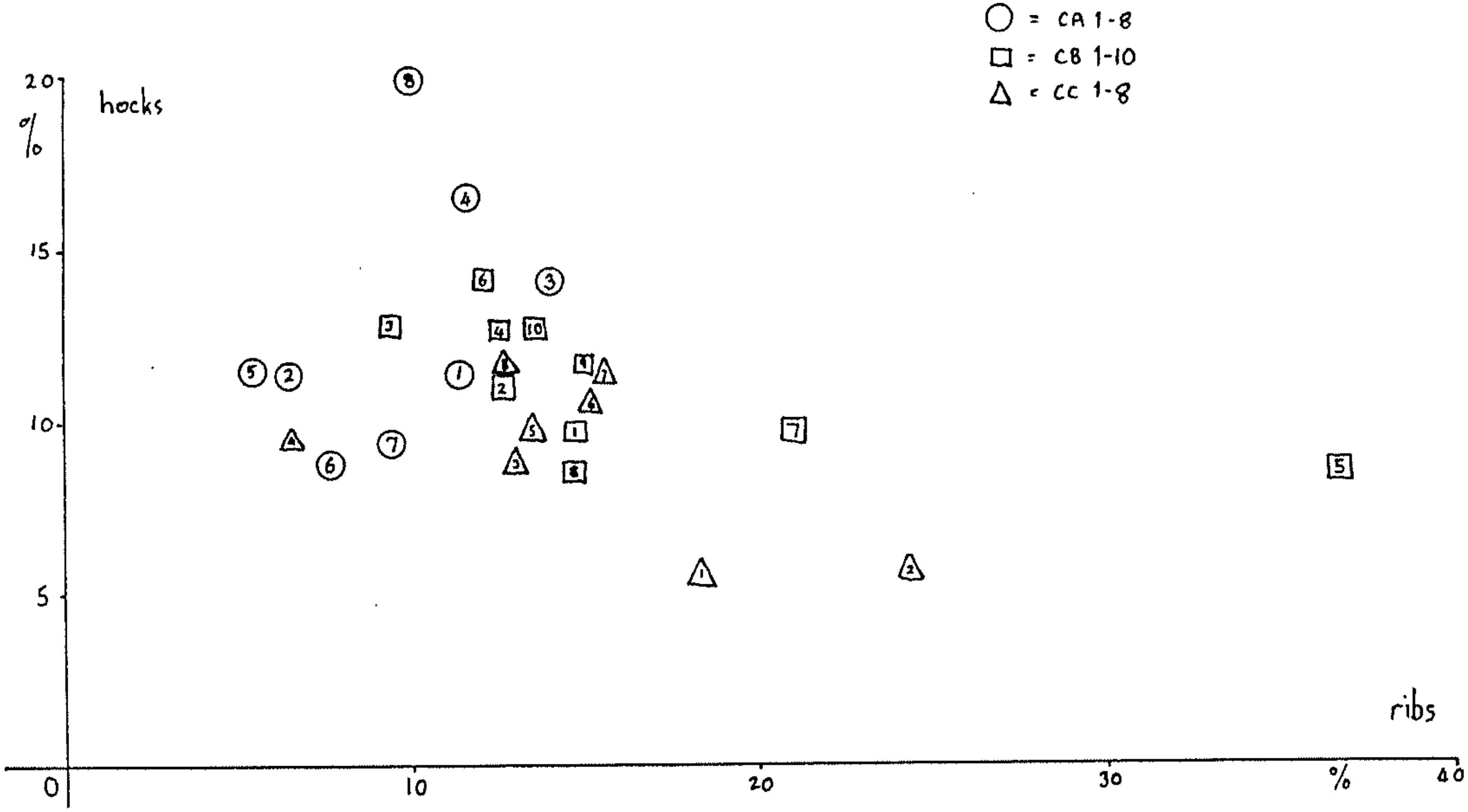

Fig. 4. Ratios of cattle hocks:cattle ribs. Data drawn from Table 5.

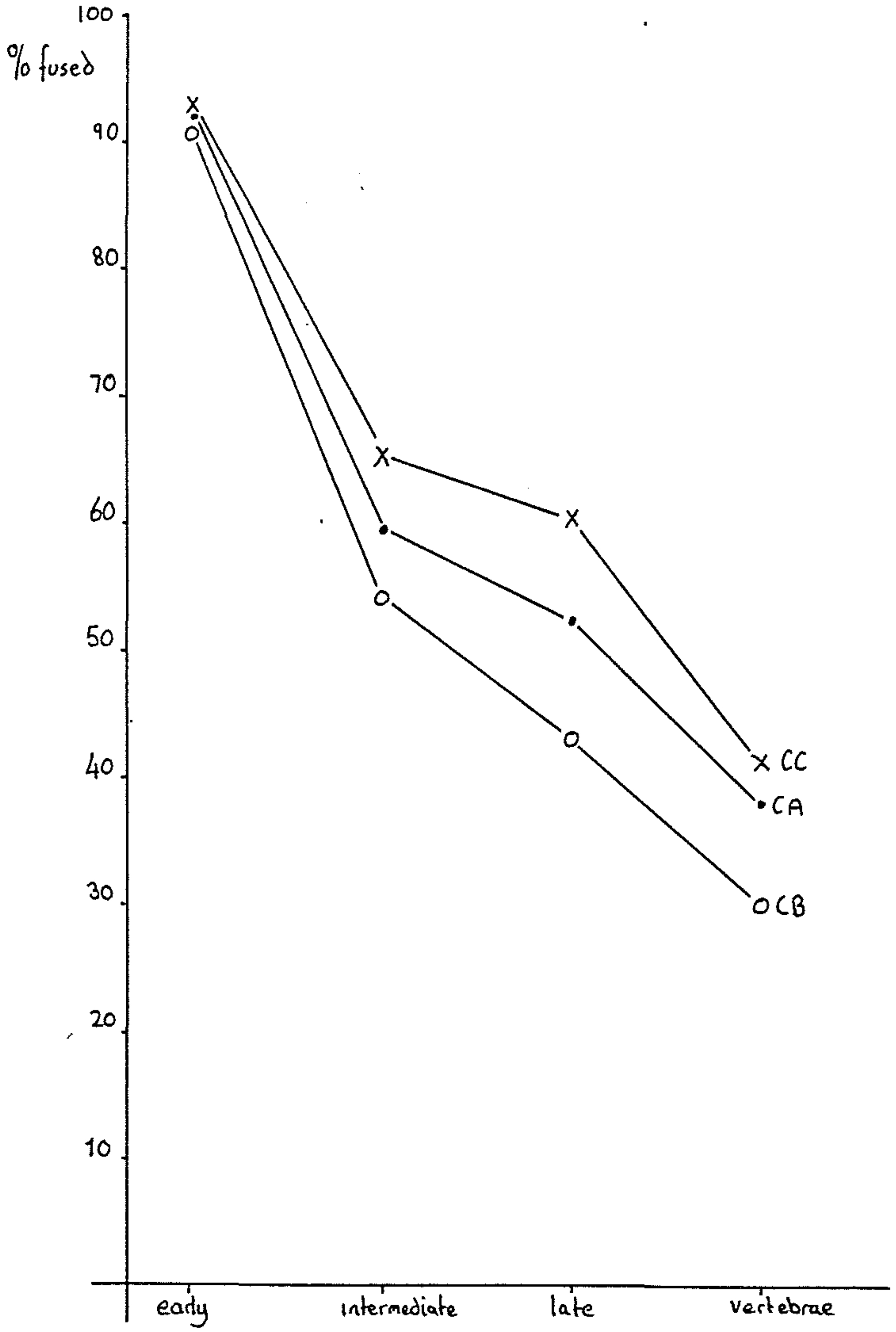

Fig. 5. Proportions of fused cattle epiphyses. Data drawn from Table 8.

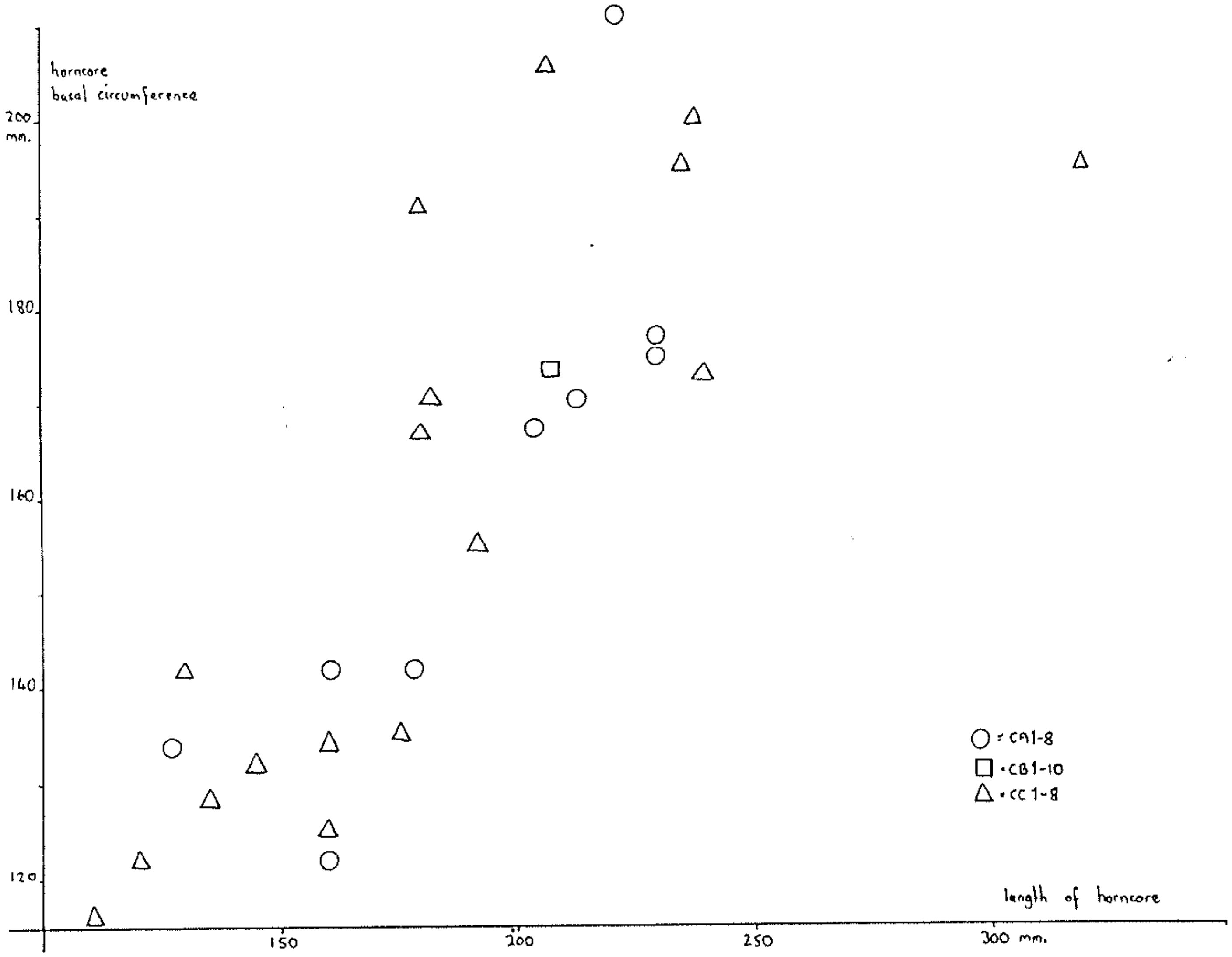

Fig. 6. Cattle horncores: plot of basal circumference and length showing possible sex sub-groups.

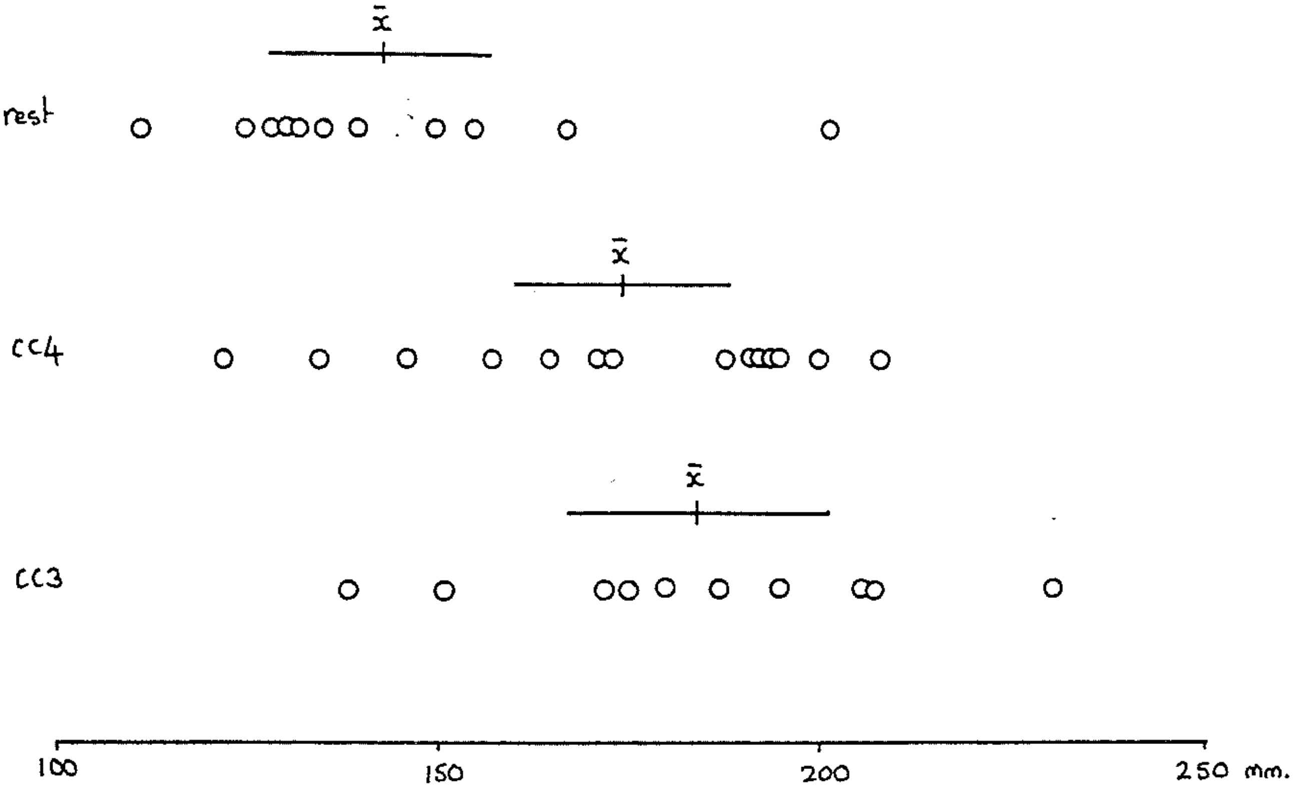

Fig. 7. Basal circumference of cattle horncores from CC samples. Plot gives individual cases, and mean and .95 confidence intervals.

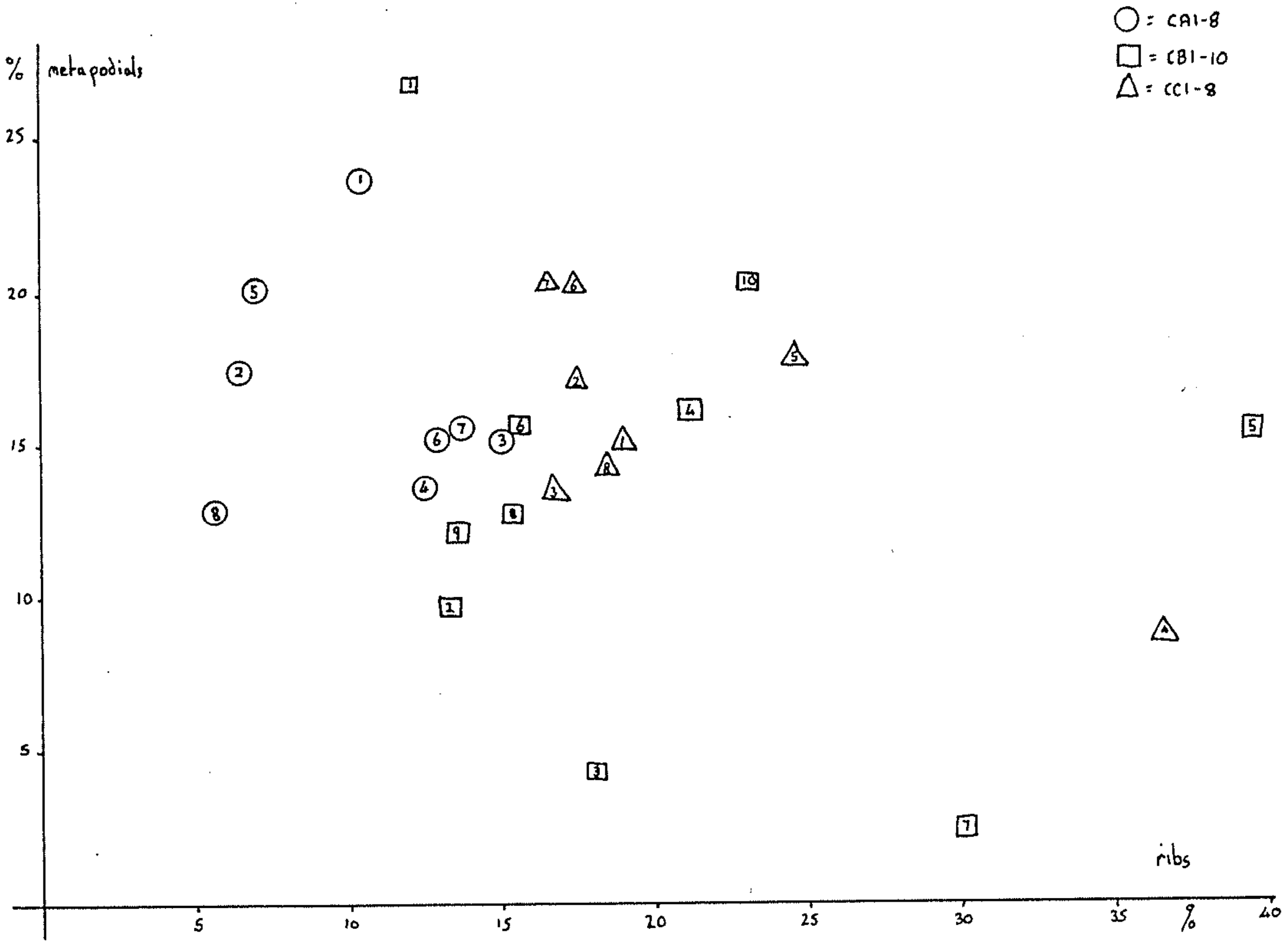

Fig. 8. Ratios of sheep metapodials:sheep ribs. Data drawn from Table 5.

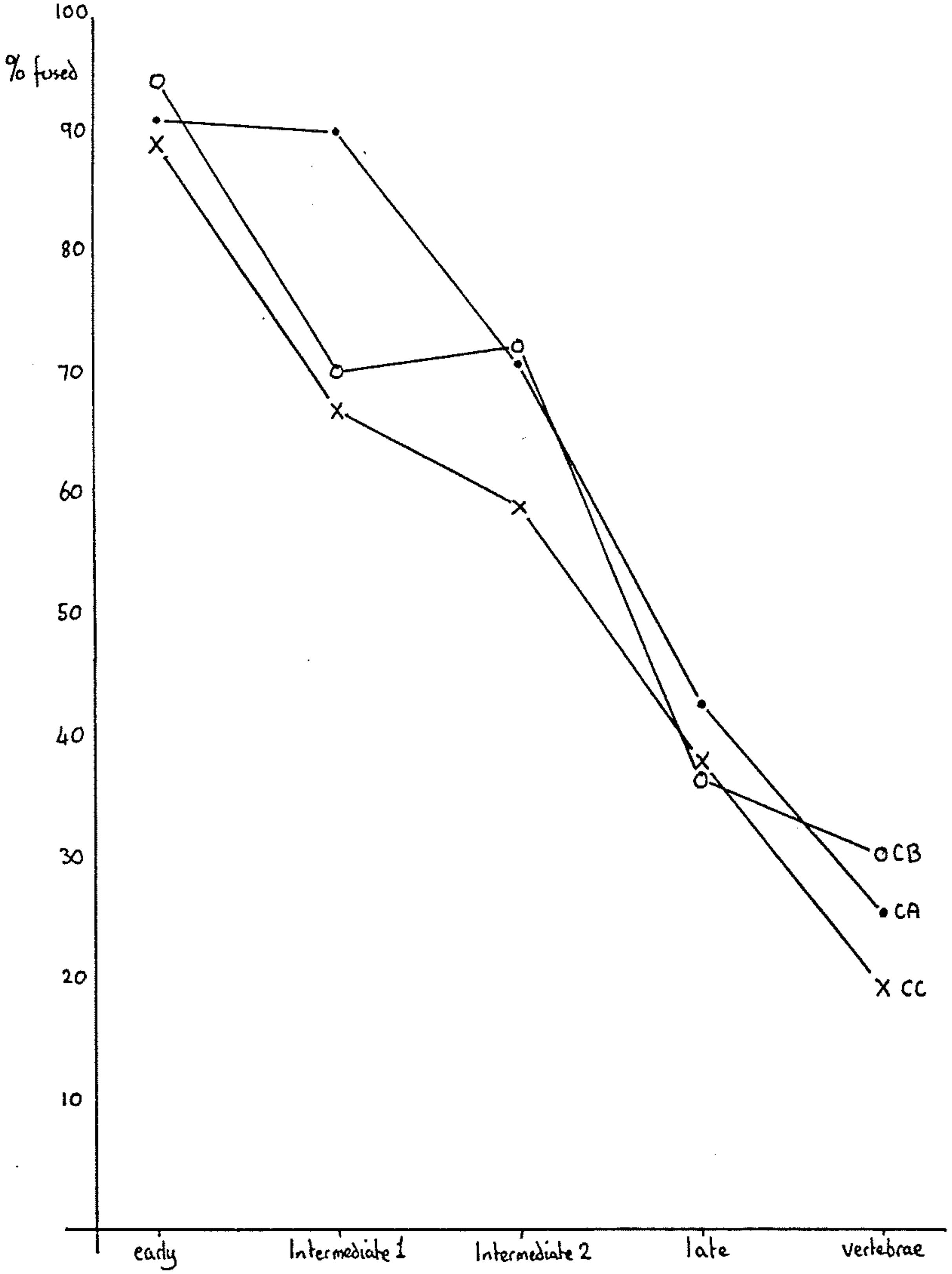

Fig. 9. Proportions of fused sheep epiphyses. Data drawn from Table 8.

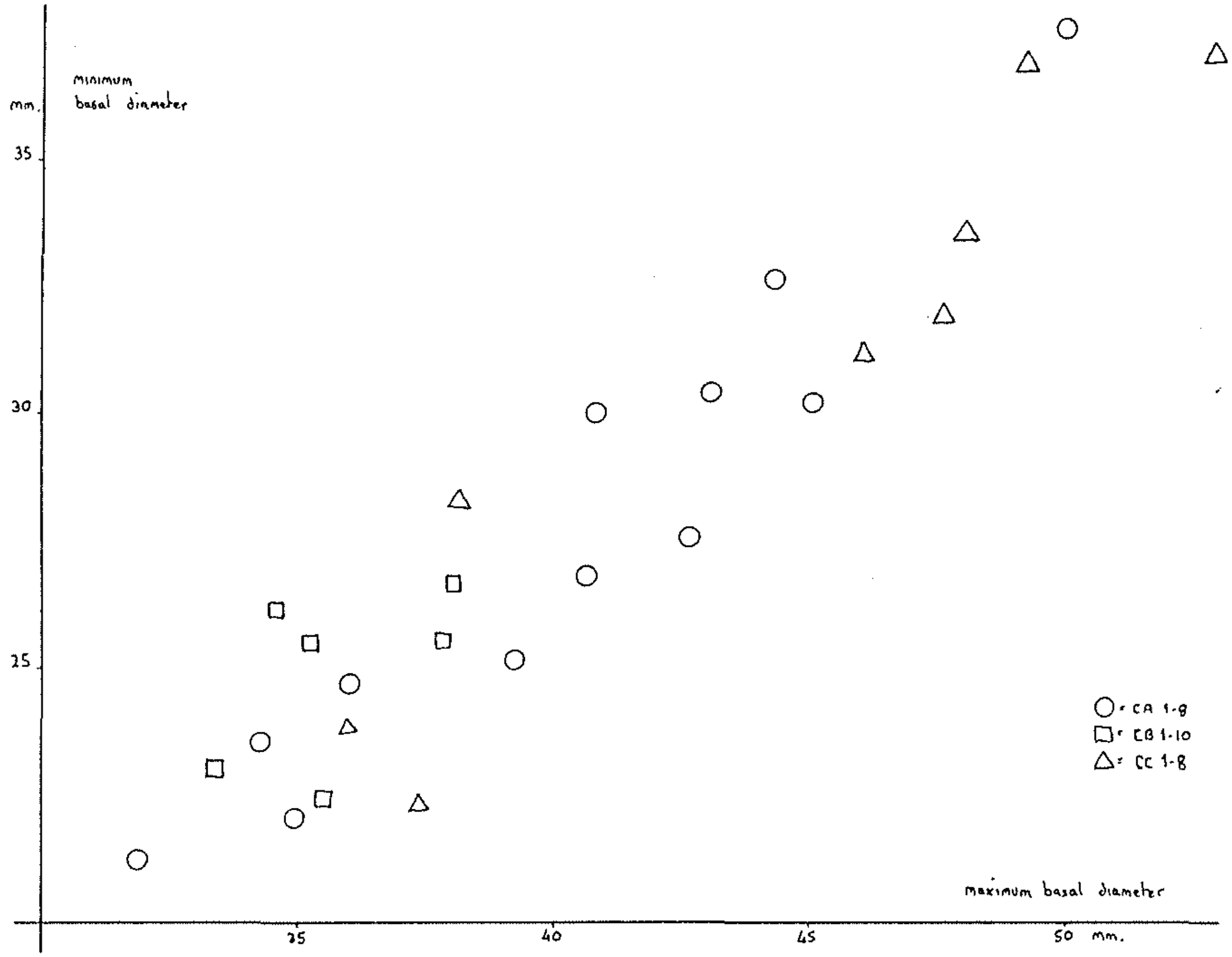

Fig. 10. Sheep horncores: plot of maximum and minimum basal diameters showing size variation.

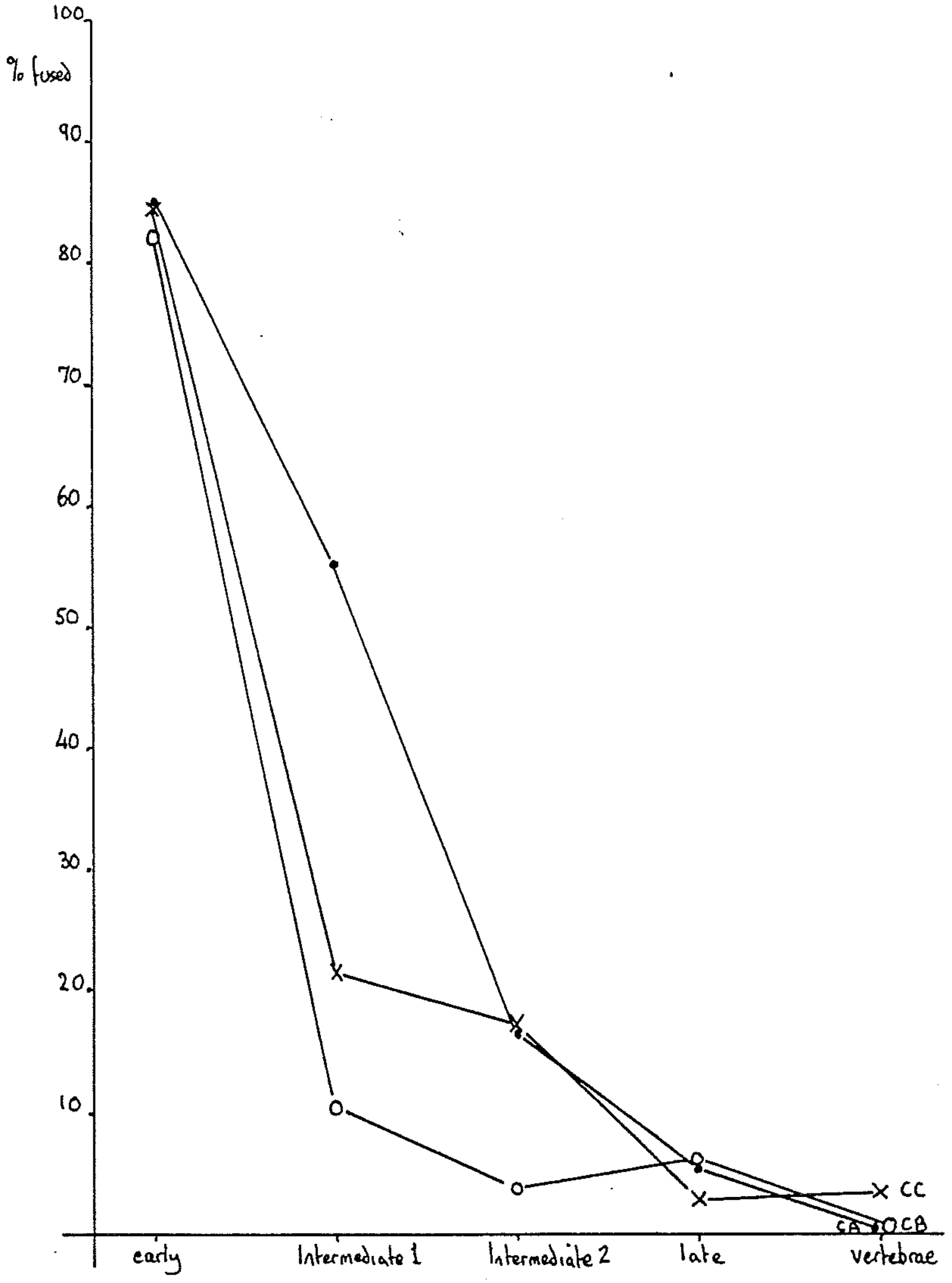

Fig. 11. Proportions of fused pig epiphyses. Data drawn from Table 8.

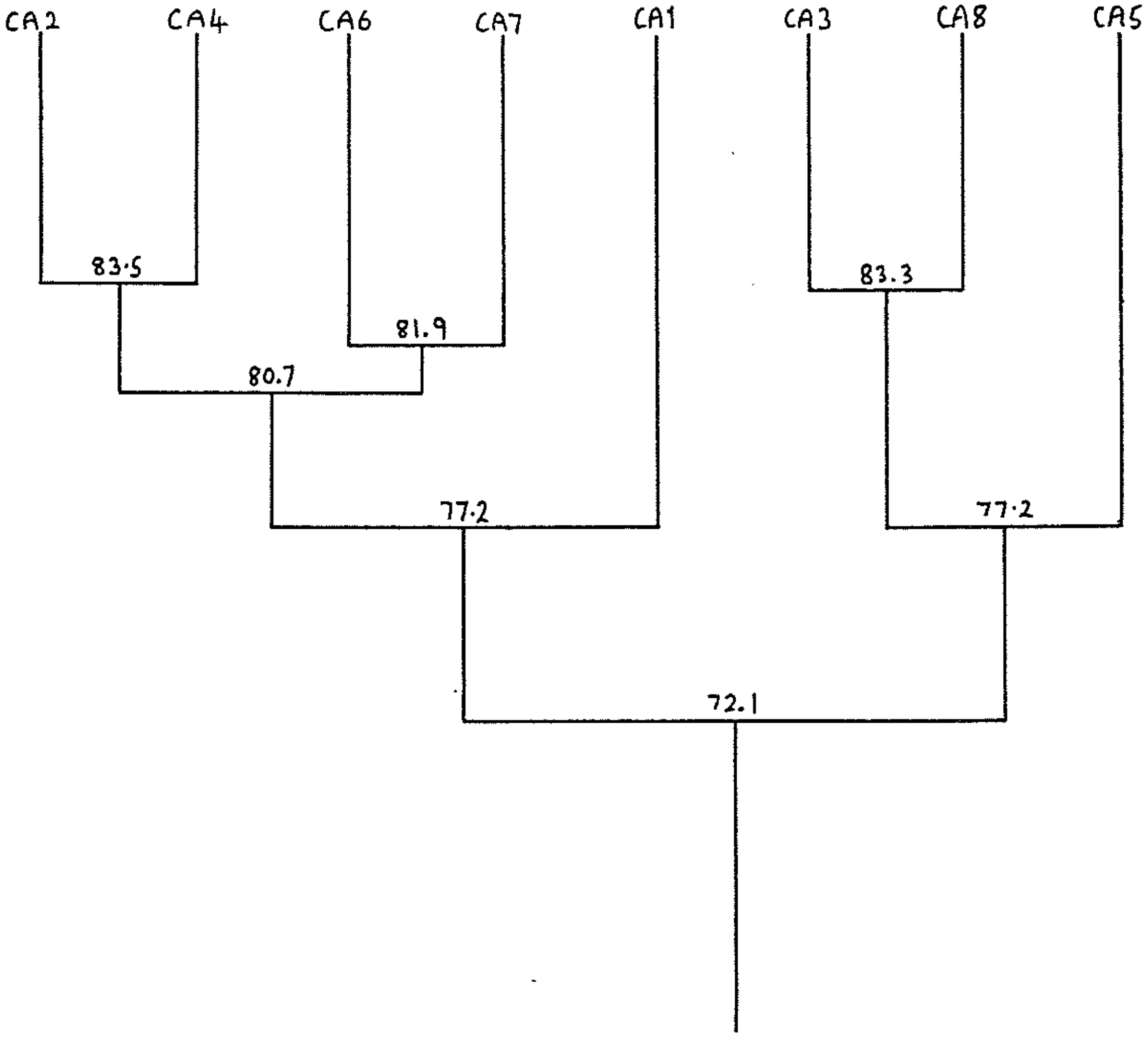

Fig. 12. Dendrogram showing percentage similarity of late 9th century samples.

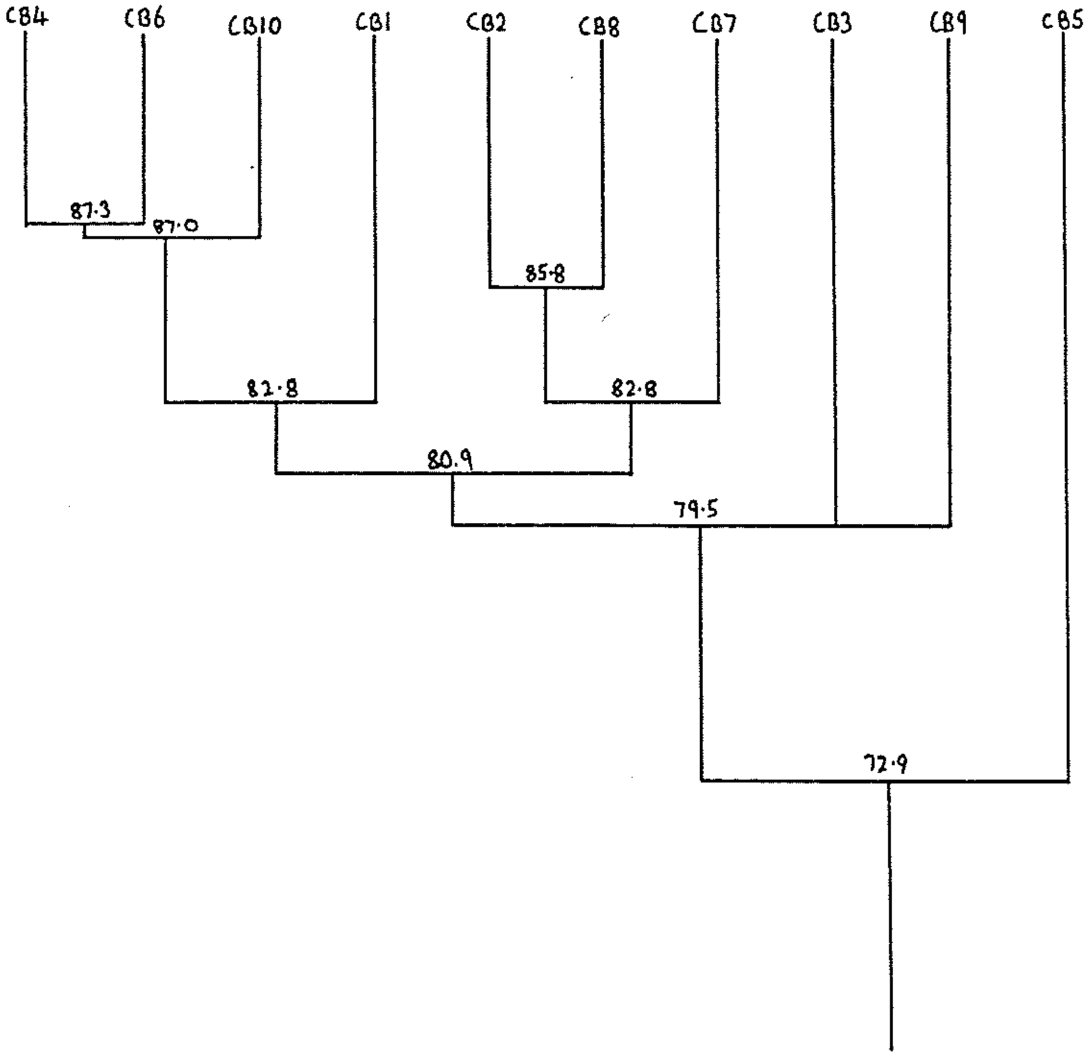

Fig. 13. Dendrogram showing percentage similarity of early-mid 10th century samples.

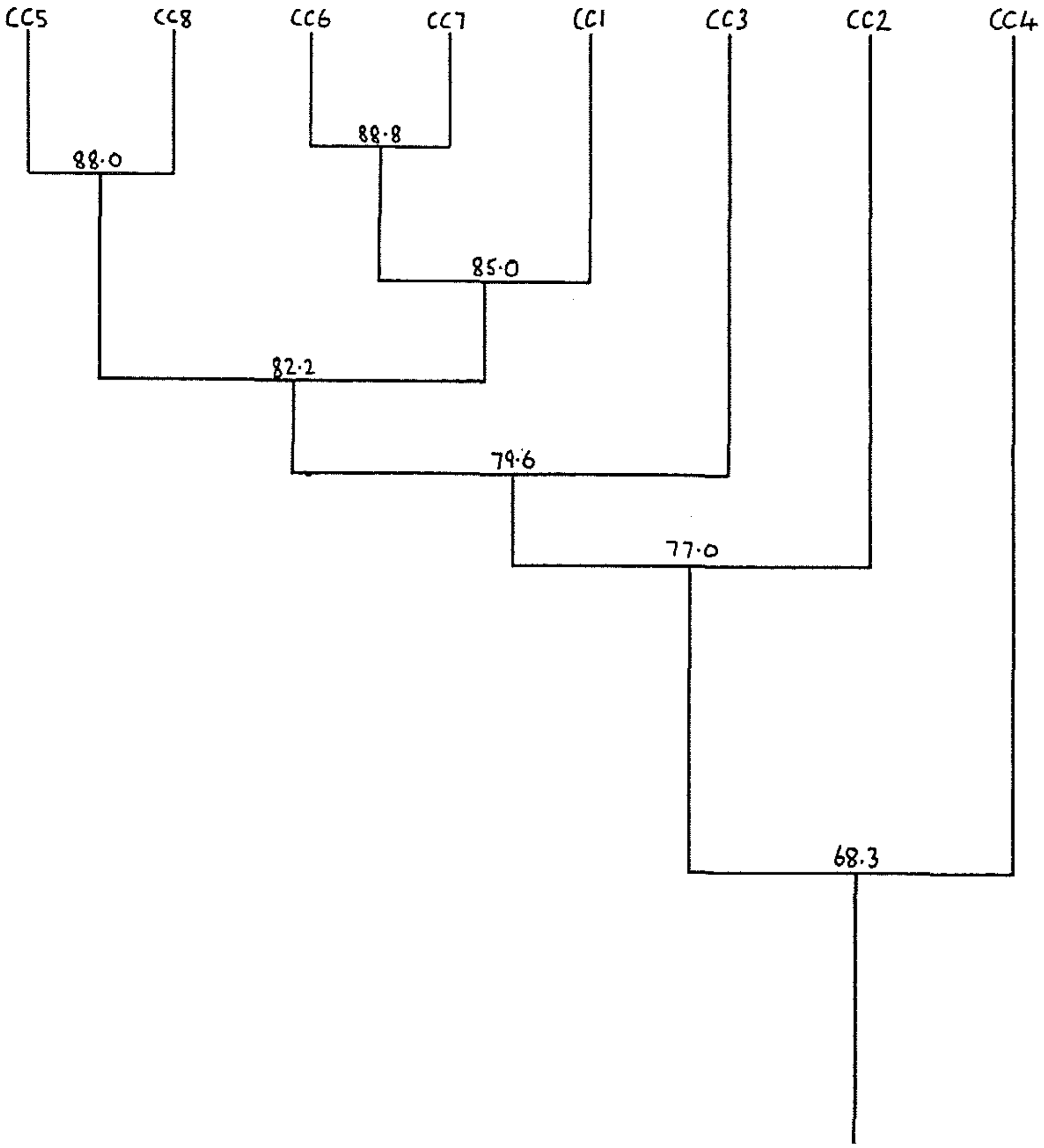

Fig. 14. Dendrogram showing percentage similarity of late 10th century samples.

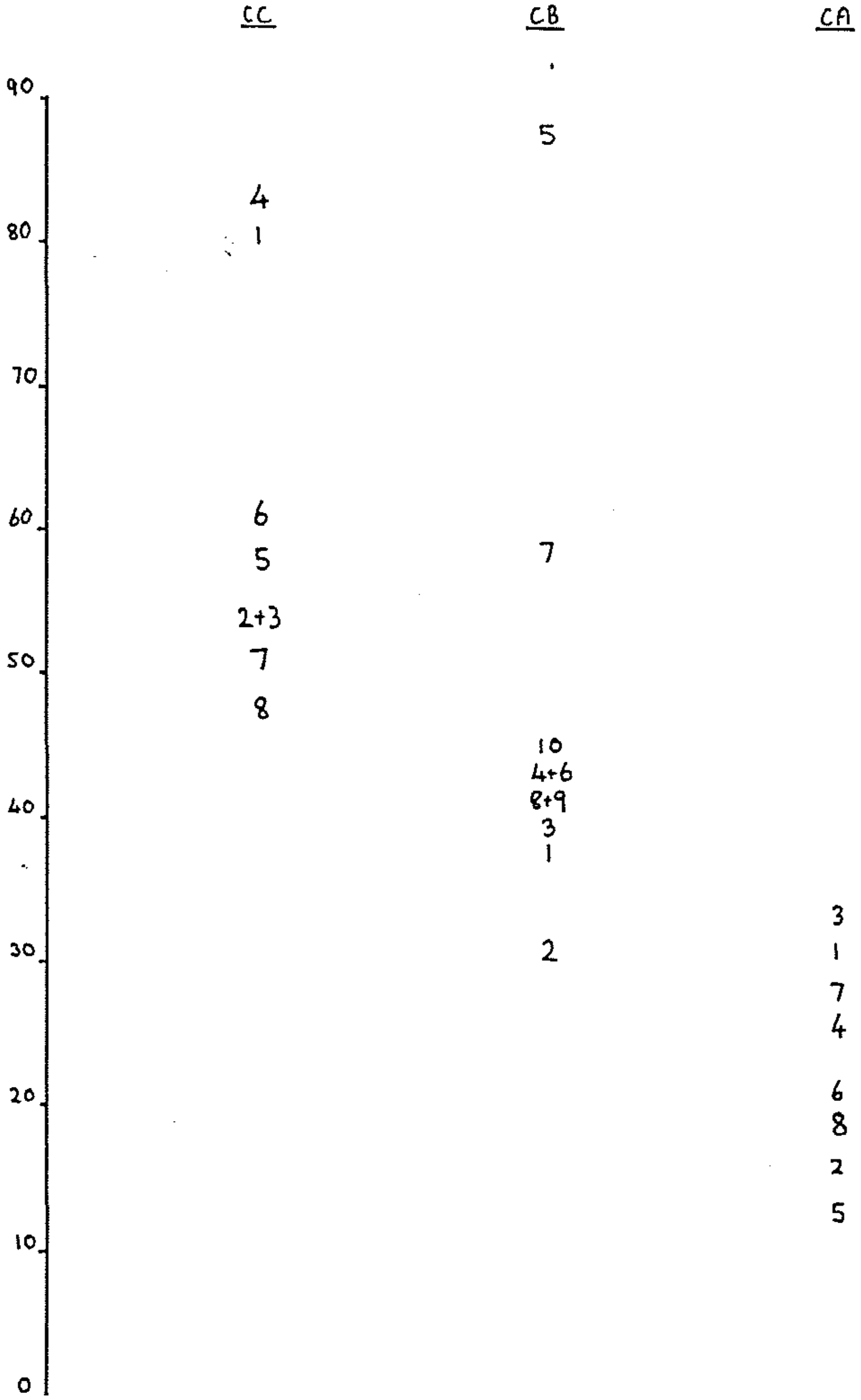

Fig. 15. Proportions of cattle and sheep ribs and pig metapodials expressed by summing the percentages of these three elements from Table 5.