2037

Ancient Monuments Laboratory
Report 94/93

POST-MEDIEVAL CATTLE BURIALS FROM ST GILES BY BROMPTON BRIDGE, NORTH YORKSHIRE

Dr Sue Stallibrass

Ancient Monuments Laboratory Report 94/93

POST-MEDIEVAL CATTLE BURIALS FROM ST GILES BY BROMPTON BRIDGE, NORTH YORKSHIRE

Dr Sue Stallibrass

Summary

This report has aimed to do two things (1): to investigate the nature of the burials of five cattle individuals from mid-eighteenth century deposits and (2): to use these 'complete' skeletons to test current methods of ascertaining age and sex from archaeological animal bones. The animals appear to have been well nourished and looked after during life but, after their deaths, their meat, and often their hides, were not considered fit for use or consumption. These facts, together with the unceremonious nature of their burials in three pits, suggest that the cattle died suddenly of some highly contagious disease. This may have been Rinderpest, which had a virulent epidemic in Britain from 1745-58. Whilst it is clear that all five individuals were young when they died (two very young, one juvenile and two just adult), and that their ages at death probably ranged from less than 6 months to approximately four years, precise ages cannot be calculated since it is apparent that two of the standard techniques for aging bones give very disparate results. These two techniques are: the sequence of tooth eruption and epiphyseal fusion (both using Silver's (1969) data for modern cattle). Tests of sexing methods also give ambiguous results. The main problems appear to relate to (a) small sample size and (b) a lack of relevant modern data.

Author's address :-

Dr Sue Stallibrass

Biological Laboratory, Archaeology II
University of Durham
Science Laboratories, Woodside Building
South Road, DURHAM
DH1 3LE

LIST OF TABLES

LIST OF APPENDICES

LIST OF FIGURES

LIST OF PLATES

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge, North Yorkshire

INTRODUCTION

During the rescue excavation of parts of a mediaeval hospital and post-mediaeval farmstead at St. Giles by Brompton Bridge, North Yorkshire (NGR: SE 209996), five complete cattle burials were discovered and excavated. Figure 1 shows the location of the site, which is being eroded by the migration of a meander of the River Swale.

The burials were found in pits that appeared to have been dug specifically to take the corpses. In some cases, legs had been chopped through in order to force them into the confines of the pit. Two of the three pits each contained two individuals. There were no accompanying 'grave goods', nor anything to suggest 'ritual' burial. The burial pits were located at the far end of occupiable land on the river terrace, up against the river bluff (see Figure 2). One of the burials (Feature 467) was buried just outside a stone-walled post-mediaeval building, and the pit cut through a wall of a disused lean-to constructed against the gable wall (see Plate 1).

The burials are dated by pottery and structural evidence to the mid-Eighteenth Century (*circa* 1750-1760) or slightly earlier (*circa* 1720).

It seemed obvious from the fact that complete skeletons were present in 'purpose-dug' pits located away from the inhabited buildings, that these cattle had died of some cause that meant that their carcases were perceived as being in need of hasty burial and were not considered suitable for normal processing.

The soil was tested for the presence of anthrax spores by the Public Health Laboratory Service at Porton Down, but none were found. Due to the hasty excavation of the bones (related to concern about possible health problems, and to the necessity to clear the burials out of the way before the rescue excavations of the hospital and farmstead could proceed) many of the bones were damaged during excavation, which was by pick and shovel. Only the single individual in Feature 467 was excavated and recorded in detail (see Plate 1).

In particular, the skulls of the animals were badly damaged, and the tops of the skulls (including the frontals where horncores might have been present) were damaged beyond reconstruction. The soil was not sieved, but recovery of small bones such as sesamoids was good. Although no attempt was made during excavation to keep the bones of different individuals separate, this did not pose a problem for post-excavation work.

The Individuals were numbered 1 - 5 in the order in which they were examined and catalogued. Individuals 1 & 2 were buried together in context (300), Individual 3 was buried on its own in context (467) (see Plate 1) and Individuals 4 & 5 were buried together in context (332).

Although pits (300) and (332) both contained the skeletons of two individuals, it was possible to separate the remains of the two individuals in each case due to the fact that they were at very different stages of maturation. In addition to the five individuals recovered as almost complete skeletons, a few foetal calf bones were recovered from contexts (300) and (332). Context (300) also contained a few bones of various species which appear to have been redeposited (indicated by their different colour and texture and by the abrasion of their surfaces).

All measurements that were taken on the bones and that are not listed in the main Tables are presented at the end of this paper in Appendix 1.

In the figures, measurements for left and right sides of the body have been included whenever the data are available.

The bones will be stored with the rest of the site archive in the Yorkshire Museum, York.

AIMS

This paper aims to investigate:

1:(i) the relative maturation rates of dental eruption and epiphyseal fusion sequences, and

1:(ii) the precise sequence of dental eruption in these mid-18th century cattle, and

1:(iii) the ages of the individuals.

2: The conformation and stature of the cattle.

3: The sex(es) of the individuals.

4: The cause(s) of death of the animals.

These aims combine two aspects of archaeological work:

(1): the testing of current archaeozoological techniques (taking advantage of the unusual availability of complete archaeological skeletons), and

(2) the application of the results and conclusions of these tests to this particular archaeological collection.

Timespans of fusion stages

Individual No. 3 has a fusion sequence that indicates that some epiphyses may take several months to fuse. The unfused nature of many of the elements indicates that No. 3, whilst being over 6 months of age (fused atlas) was definitely less than 2-2.5 years old (unfused distal metapodials and tibia) when it died. Several other elements were actively in the process of becoming fused and this should indicate a more precise age at death. But the range of 'fused by' ages is considerable. Whilst two of these elements (the acetabulum of the pelvis and the glenoid of the scapula) are said by Silver to be fused by 7-10 months, other elements were also in the process of fusing which would not be expected to have been fully fused until considerably later. These are the distal epiphysis of the humerus and the proximal epiphysis of the radius (both fuse at *circa* 12-18 months) and the proximal epiphyses of the second phalanges (which fuse at *circa* 18 months). The partially fused nature of the second phalanges is slightly surprising, since the first phalanges (which also fuse by 18 months) are all unfused, indicating that second phalanges may fuse earlier or more slowly than first phalanges.

Iregren (1975) also found anomalies in the fusion states of the first and second phalanges in her study of modern elk skeletons, leading her to conclude that there 'may be a risk of mistaken assessment of age in animals in which the fusion in phalanx II is in progress' (Iregren, 1975: 374). It would be interesting to know if this is a general problem with ungulates.

Even disregarding the fusion ages of the phalanges, the 'real' age at death of Individual No. 3 could have been as young as 7-10 months (as indicated by the acetabula and glenoids), or as old as nearly 18 months (as indicated by the elbow joint), although these same epiphyses could also be used to suggest an age of 10-12 months. This lack of definition highlights the need for more data on modern animals.

Results: AIM 1(i): the relative maturation rates of dental eruption and epiphyseal fusion sequences:

The sequences of epiphyseal fusion evidenced by Individuals 1 - 5 appear to be consistent: (i) within an individual, (ii) between individuals and (iii) with Silver's data, apart from the one possible exception concerning the phalanges, discussed above.

However, although both the dental and the post-cranial sequences of ageing appear to be internally consistent, there is a major discrepancy between the age estimated by epiphyseal fusion and that estimated by stages of tooth eruption for each of the three younger individuals (Nos. 5, 2 and 3) (see Table 6 and Figure 3. In Figure 3, the use of two positions to mark an age or height refers to the two sides of the body).

This discrepancy is very marked and the 'dental eruption age' is always notably older than the 'epiphyseal fusion age' (*ie*: Individual No 5: *c*6-18 months *cf* <6 months; Individual No. 2: *c*15-18 months *cf* <6 months; Individual No. 3: *c*2-2.5 years *cf* *c*1-1.5 years).

For the older individuals (Nos. 1 and 4), whose bones are nearly all fully fused and whose cheek teeth are all fully erupted and in full wear, the ages estimated by the two methods are in agreement.

Skeletally, Individual No. 1 had almost attained maturity: the last epiphyses to fuse on the major limb bones were all in the process of fusing when the animal died, although the extremities of the pelvic girdle, together with the vertebral epiphyses were all unfused. Silver's epiphyseal fusion data would place this individual at 3 - 4 years, possibly 3.5 - 4 years at death. The same individual, similarly, had almost attained dental maturity: all of the permanent premolars and molars had erupted, with the last cheek teeth to erupt (P4 and M3) just coming into full wear. Again, Silver's data would indicate that the individual had reached >3 years of age, whilst the small amount of dental wear indicates that the animal was not much over 3 years. For this individual, therefore, the epiphyseal fusion age and the dental eruption ages concur at between three and four years.

Individual No. 4 was slightly older. For this animal, the two estimated ages do not conflict, although the dental eruption age is only able to give a 'greater than' age since the dental eruption sequence is completed: the epiphyseal fusion age is *circa* 3.5 - 4.5 years and the dental eruption age is >3 years. The Mandibular Wear Score is only slightly higher than that for Individual No. 1 (40-41 compared to 37-39) and this might indicate that Individual No 4 was not greatly >3 years. N.B. this hypothetical correlation between Wear Score and age in years cannot be extrapolated to any other sites, where patterns and rates of mandibular tooth wear may have differed (due to differences in diet, genetic traits *etc.*).

Discussion:

Unfortunately, there are no independent methods of ageing for these cattle. No documentary records exist for the individuals, and the use of incremental growth lines in teeth (to give an absolute age at death) requires an accurate knowledge of age at eruption -- one of the very variables in question.

There are several possible explanations for the apparent consistent discrepancies between the epiphyseal and dental age estimates *eg*:

HYPOTHESIS 1: poor nutrition, or diseases, delayed epiphyseal fusion more than they retarded tooth eruption. (McCance, 1962; Garn et al, *1965).*

HYPOTHESIS 2: Castration may have had a similar effect (Brännäng, 1971).

HYPOTHESIS 3: Silver's figures may be inappropriate for these post-mediaeval cattle, due to differing rates of growth.

HYPOTHESIS 1: poor nutrition, or diseases, delayed epiphyseal fusion more than they retarded tooth eruption. (McCance, 1962; Garn et al*, 1965).*

Since the discrepancies in ageing estimates only affect the three young individuals and not the two older ones, for nutrition or disease to have been responsible for delaying the epiphyseal fusion in comparison to tooth eruption either: (a) Individuals 1 and 4 were not affected or (b) by the time that they died, epiphyseal maturation had been able to catch up dental maturation.

Poor diet can lead to a cessation of skeletal growth (Sisson, 1971), but this need not lead to any noticeable and lasting changes in the bones themselves, particularly if malnutrition was chronic. However, seasonal malnutrition might have lead to the formation of Harris lines (lines of arrested growth) in the long bones (see Baker and Brothwell, 1980: 45). The tibiae of all five individuals were x-rayed, but none of them show any traces of Harris lines.

If dental maturation had progressed more rapidly than bone growth, one might expect the teeth to be crowded in the jaws, but this is not the case for any of the individuals.

The conclusion is, therefore, that there is no proof of any malnutrition or 'childhood' disease that might have caused a relative delay in skeletal maturation in any of the individuals.

HYPOTHESIS 2: Castration may have had a similar effect (Brännäng, 1971).

The sexes of the individuals are considered in a later section of this work (see 'Aim 3. The sex(es) of the individuals' below). The results are inconclusive, but suggest that Individuals Nos. 1, 3, 2 and probably 5 were male and that only Individual No. 4 was female. Since it was not possible to suggest whether any or all of the males were castrates rather than entire males, this hypothesis cannot be tested.

HYPOTHESIS 3: Silver's figures may be inappropriate for these post-mediaeval cattle, due to differing rates of growth.

There are records that breeders of large cattle in the Eighteenth Century aimed at retaining juvenile characteristics such as rapid rates of growth in their livestock. This would prolong the period of rapid growth normally associated with immature animals prior to the onset of sexual maturity. This would affect females as well as males. Eventually, as the animal attained 'sexual' maturity (even if castrated), ossification would be completed and the animal would have adult stages of both tooth eruption and epiphyseal fusion. Although there are some well documented records of sequences and ages for tooth eruption of cattle in the nineteenth century, which make some references to eighteenth century stock (eg: Simmonds, 1855; Brown, 1882), and references to the relatively rapid development of improved breeds such as Shorthorns, Devons, Sussex and Herefords (which permitted their fattening and slaughter or use as breeding stock at one or two years rather than the previously normal age of three years: Broad, 1890), none of these references make scientific comparisons of the relative rates of dental, epiphyseal and sexual maturation.

General conclusion:

None of the three hypotheses can be proven or disproven by the available data, although the lack of any evidence for malnutrition or disease makes Hypothesis 1 unlikely to be true.

Results AIM 1(ii): Sequence of tooth eruption.

A note on the incisors:

Many of the mandibles had been broken through the diastema during excavation (see the note on the skulls, above) and recovery of incisors or their alveoli was consequentially poor. There are too few data to study the relative sequencies or eruption of the incisors in this group of remains.

The permanent premolars and molars:

Table 7 shows that the sequence of tooth eruption and wear is consistent for all three molars on all five individuals. Also, there is good correlation between the left and right mandibles of each individual.

Discussion:

The sequence of tooth eruption given by Silver for modern cattle appears to be appropriate for these Eighteenth Century cattle, indicating little or no change in the past two hundred years.

Results AIM 1 (III): the ages of the individuals.

The three estimates of age presented in Figure 3 are consistent *ie*: the relative ages of the five individuals are always in the same sequence, whether tooth eruption, tooth wear or epiphyseal fusion is considered.

Individuals numbers 5 and 2 were very young (No. 5 being slightly younger than no. 2), No. 3 was juvenile and Nos. 1 and 4 were young adults (with No. 4 just older than No. 1).

However, the estimated age ranges for the three younger individuals are unsatisfactorily wide, due to the discrepancies between the results given by the three methods *ie*: Nos. 5 and 2 are estimated to have been between <6-18 months old, and No. 3 between 10/12-30 months old.

Discussion:

The relative ages and approximate ages of these five individuals have been ascertained, but it is worrying that the different methods produce such disparate results for the three youngest individuals. Further work using modern animals is needed to investigate the reasons for this. The results are not satisfactory for considerations of, for instance, practices of overwintering of livestock.

The results are useful, though, for demonstrating that all five of the individuals that died were young: no mature adults were recovered. This contrasts with the general cattle bone material from the site (Stallibrass, 1993). Only six mandibles dating to the post-Mediaeval period could be assessed for Mandibular Wear Scores (MWS), but these included two very young jaws (MWS = 1 and 4), possibly deriving from unintended neonatal deaths, plus two young adult scores (MWS = 35, 42) and two mature adult scores (MWS = 46, 49). This sample is far too small to suggest the main economic importance of the post-Mediaeval cattle (*ie*: whether dairy, meat or multipurpose), but it is sufficient to suggest that the age distribution of the five buried individuals was not the norm for the post-Mediaeval slaughter programme at this site.

A note on the ages of the foetal calf bones:

The foetal calf bones found in pit (300) appear to be contemporaneous with the burial of individuals Nos. 1 and 2. A pair of tibiae, a humerus and a radius were recovered. Their lengths are: 61.0mm & 62.2mm, 43.45mm and 45.77mm respectively. Using the factors given in Prummel (1989: Table 1: data taken from Bünger-Marek, 1972, pp35 & 47) their ages at death are calculated as: *c.*170 & 171, 165 and 163 days after conception respectively. Using Prummel's Table 2 (=Table 5 in Habermehl, 1975, p65, itself based on Regli, 1963), these same measurements can be used to estimate ages at death of *c.*170, *c.*163 and *c.*163 days for the tibiae, humerus and radius. These ages cluster within one week of each other, and the bones probably derive from a single individual. The average length of gestation for cattle is 280 days. It is not possible to tell whether the foetus was aborted, or whether its death was caused by that of its mother.

The foetal calf bones from pit (332) are probably contemporaneous with Individuals 4 and 5, but the surfaces of the femur and tibia were damaged during excavation and so are difficult to compare for preservation conditions. The three bones are considerably larger than those from context (300). Their lengths are: femur=75.3mm, tibia=77.8mm, ulna (broken) >63mm. Using Prummel's (1989) Table 1, these calculate out at: femur=193 days and tibia=189 days since conception. Using Prummel's Table 2, the three bones can be estimated at: *c.*192, *c.*189 and >175 days respectively. Again, these probably derive from a single individual that was either aborted or died with its mother.

Since the material from the pits was not sieved, and the recovery of very small bones is likely to have been incomplete, it is difficult to tell whether or not the two groups of foetal calf bones represent whole individuals deposited in the pits. However, the facts that (a): bones from both fore- and hind-limbs are represented in each case, and (b): the ages estimated for each bone within a group are very consistent, do lend support to the hypothesis that these bones do represent complete foetuses deposited in the pits.

AIM 2: An investigation into the conformation and stature of the individuals

Methodology

Although the application of factors calculated from adult animals may not be entirely appropriate for use with immature (*ie*: unfused) bones, they do allow rough estimates of withers heights to be calculated, even if precise heights cannot be relied upon.

All of this section discusses withers heights for the St. Giles material without attributing sexual status to any of the individuals. This is for three reasons: (1) where stated, the withers height factors tend to be available only for entire bulls and cows. Castrates, therefore, cannot be included in the calculations. (2) For the very young individuals (especially Nos. 5 and 2), sexual differences may not have started to be manifested in the bones, and (3) it is very difficult to attribute, with 100% certainty, sex to archaeological animal bones, even when a whole skeleton is present. Rather than risk applying inappropriate factors, therefore, to mis-attributed bones, all of the factors used in this section have been those calculated for modern animal regardless of sex, or means of factors calculated for entire males and females.

Results

The young ages estimated for Individual No. 5 are even more surprising in the light of the sizes of the bones. Table 8 presents the withers heights calculated on metapodial measurements for all five individuals using Zalkin's (1960) figures for bones from animals of unknown sex. These estimates are also shown on Figure 3. It is clear that all five individuals, even the very immature ones, were (or were going to be) tall, with withers heights ranging from 1.30 - 1.50 metres.

Because of damage during excavation, not all of the metapodials could be measured, which sometimes precludes comparisons between left and right sides, or between fore- and hind-limbs. Generally, differences between left and right sides (for the same bone) are very minor. The only instance in which a withers height is more than 10mm different between left and right bones concerns the metacarpals of Individual No. 2 (Left = 1.31 metres; Right = 1.35 metres). Since these bones were both unfused, and slightly damaged, this difference may be due to observer error during measurements of the bones, rather than to a genuine asymmetry of the skeleton.

Unfortunately, the metacarpals of Individual No. 2 were too damaged to allow total length measurements to be taken, and so these cannot be compared to the metatarsals.

Interestingly, the withers heights calculated for the other two young individuals (Nos. 3 and 5) are very similar or identical for all four bones, whereas the two individuals with fully fused metapodials (Nos. 1 and 4) both show higher estimates for hindlimbs than for forelimbs. Taking Zalkin's (1960) and Matolcsi's (1970) factors for metapodials from modern cattle of known sex, this discrepancy between withers heights calculated on fore and hind limb bones persists, regardless of which sex (*ie*: entire male or female) is allocated, or whose factors are used (see Table 9, below).

TABLE 9: Withers heights using Zalkin (1960) & Matolcsi (1970)				
	ZALKIN		MATOLCSI	
	Metacarpal	Metatarsal	Metacarpal	Metatarsal
Individual No. 1, using factors for females:				
(L)	1.44	-	1.45	-
(R)	1.42	1.47	1.44	1.47
Individual No. 1, using factors for males:				
(L)	1.50	-	1.52	-
(R)	1.49	1.53	1.51	1.55
L Left; R Right; all measurements are in metres				
Individual No. 4, using factors for females:				
(L)	1.36	-	1.37	-
(R)	1.35	1.42	1.36	1.41
Individual No. 4, using factors for males:				
(L)	1.42	-	1.44	-
(R)	1.41	1.49	1.43	1.49

This suggests that the conformation of the St. Giles Eighteenth Century cattle (*ie:* at least Individuals 1 and 4) was different to that of the cattle used by both Zalkin and Matolcsi to calculate their conversion factors. Compared to the recent stock, the Eighteenth Century cattle were relatively longer in the metatarsal compared to the metacarpal. In modern cattle, the relative lengths of the metacarpal and metatarsal are influenced by the sex of the individual animal (*ie:* bulls have relatively longer metacarpals than cows) but the discrepancies evidenced by the St. Giles Eighteenth Century cattle are notably greater than these, and are not reduced by using factors calculated from the modern males.

Similar discrepancies were noted by Ijzereef (1981) for factors given by von den Driesch & Boessneck (1974). He found that the withers heights calculated from the metatarsals were greater than those calculated from the metacarpals. Wilson (1984) found exactly the same bias when he used von den Driesch & Boessneck's factors with Romano-British cattle bones from Barton Court Farm. It would appear that the modern factors are the ones that are anomalous due to a recent change in cattle conformation.

The metapodials of Individual No. 5 show a remarkable consistency, all calculating to 1.30 metres. This is for an animal whose conditions of epiphyseal fusion indicate that it was <6 months old when it died, although its tooth eruption data suggest that it might have been anywhere between 6 and 18 months old at death.

Discussion:

One of the problems associated with the use of single bones for calculations of withers heights concerns the effects of age on absolute and relative growth rates of different elements. The absolute length of the metacarpal of a modern Hereford calf is already 87% of its final length only nineteen days after its birth, although the animal has only attained 56% of its final withers height (Guilbert & Gregory, 1952). In other words, the factors calculated from fully adult animals are not applicable to immature individuals even though their metapodials may be fully fused. In archaeological assemblages of disarticulated bones, there is no way of knowing whether a fused metacarpal derives from an animal that was only two or three years old at death (and, therefore, still growing) or from an individual that was four years old and had attained its full withers height. A distinction must be made between studies of potential withers heights and those concerned with actual withers heights,

What is obvious from Table 8 is that these animals from St. Giles, even the very young ones, were going to be tall, although it is likely that only Individuals 1 and 4 had actually attained (or were close to attaining) their final withers heights.

Unlike Zalkin, Matolcsi (1970) gives withers height calculation factors for all of the major limb bones. The results of applying these factors to the St. Giles material are presented in Table 10. Matolcsi gives different factors for metapodials from bulls and cows (but not for the other elements). To make the calculations used in this study consistent, the means of the sexually-differentiated factors have been used (*cf.* Thomas, 1989).

Two things are immediately apparent from Table 10: (1) the range of withers heights calculated for each individual vary considerably, and (2) the metapodials always give considerably greater withers height estimates than those calculated from the other bones (even for Individuals 1 and 4). A similar discrepancy regarding withers heights and metapodials was remarked upon by Prummel (1982) and is explained by Bartosiewicz (1984, 1985).

Since the metapodials attain their final length when the animal is at a relatively young age compared to other limb bones (especially the latest-fusing, most proximal elements: the humerus and femur) the withers heights calculated for bones from a single, immature individual will vary according to how close that animal is to reaching its final, adult, size. Individuals Nos. 1 and 4 should have just been reaching their final sizes (at least in bone lengths if not in bone widths). The differences in withers heights calculated for different bones within a single individual, therefore, should reflect that individual's age *ie*: the differences should be least (or non-existent) for a fully mature individual and greatest for the youngest animal. This is the case for the St. Giles animals, broadly demonstrated by the summary part of Table 10. The standard deviations of the heights for the individuals with fused bones (Nos. 1 and 4) are less than those for the heights calculated from unfused bones (Nos. 2, 3 & 5). It is not possible to say whether the differences are due to the immature state of the bones *per se*, or to the problems of measuring bones that have to be held together.

The differences in calculated withers heights should be greatest between the earliest and latest fusing bones (*ie*: humerus/femur compared to metacarpal/metatarsal) rather than between early- and middle-fusing or middle- and late-fusing bones. However, this is not the case. Table 10 shows that it is the middle-fusing bones (the radius and the tibia) that give the lowest withers heights, not the humerus and femur. IJzereef (1981:64) noted the same phenomenon for a complete mature Bronze Age cow skeleton buried at Bovenkarspel (this individual had fully fused vertebrae and, should, therefore, have had a skeleton whose long bones had all reached their full lengths). These results suggest that Matolcsi's (1970) factors may be inappropriate for archaeological material (whether Bronze Age or Eighteenth Century AD!). A similar discrepancy was noted by Bourdillon & Coy (1980) for disarticulated cattle bones from Saxon levels at Hamwih. Although they only had one measurable tibia and two measurable radii compared to 42 metacarpals and 32 metatarsals, they noted that the withers heights for these three bones were very small compared to those for the metapodials *ie*: they were just below or at the lower end of the range for the relevant metapodial. This is exactly the case for the St. Giles material: Radius: N=6, mean=1.28m *cf* Metacarpal: N=8, range = 1.32-1.49m; Tibia: N=5, mean = 1.24m *cf* Metatarsal: N=8, range = 1.30-1.50m.

On the other hand, Thomas (1989; Table 3:2) found that the withers heights calculated for humerus/femur, radius/tibia and metacarpal/metatarsal did give ascending results for his reference skeleton, a recent Chillingham bull, as did Prummel (1983: 172-3) for her mediaeval cattle bones from Dorestad. These conflicting lines of evidence suggest that, as well as sex and age, conformation may have a considerable effect on the appropriate conversion factors that should be used for calculating withers heights from bone lengths.

One worrying aspect of the results of applying Matolcsi's (1970) factors to the St. Giles material, shown clearly in Table 10, is the fact that the factors given for two different length measurements on both the humerus and the femur give notably differing results. In every case, the withers height calculated from the Greatest Length (GL) is less than that calculated from the Greatest Length from the Caput (GLC). These differences are often very marked, especially for the humerus *eg*: for Individual No. 1 (Proximal unfused, Distal fusing): withers height from GLC = 1.33 metres, from GL = 1.23 metres; Individual No. 4 (Proximal fused but visible, Distal fused): withers height from GLC = 1.39 metres, from GL = 1.35 metres).

In archaeological assemblages, the proximal trochanters are often damaged or have been removed by butchery, and so the GLC is often the only feasible length measurement for humeri. But is it the most accurate factor? Since the withers heights calculated from the GLC measurements are in closer agreement with those calculated from the measurements of the other elements, it seems parsimonious to prefer the GLC factors to those provided by Matolsci for the GL measurements. It is possible that the size and/or shape of the greater trochanter of the humerus and femur are subject to greater individual, sexual or 'breed' variation than overall length from the caput. It is also possible that the trochanter continues to grow in length after fusion has been completed. This might explain the greater degree of diversity shown by the unfused bones of Individual No. 3 compared to that shown by the fused bones of Individual No. 4 (withers heights differences of 100-110mm *cf* 40mm for the humerus and 40mm *cf* 10-20mm for the femur).

Bartosiewicz (1984, 1985) convincingly demonstrates that the best measurement for calculating withers height from a single complete long bone from archaeological assemblages is the Greatest Length (GL) of the radius. This is because the radius maintains a more or less constant relationship with the Theoretical Extremity Length (TEL) independent of the age of the individual. The TEL is the sum of the lengths of the three major long bones within a limb (*ie*: the Greatest Lengths of the metacarpal + radius + humerus = the TEL for the forelimb; The Greatest Lengths of the metatarsal + tibia + femur = the TEL for the hindlimb). Although the TEL for the forelimb is not the same as the actual withers height in life due to the stance of the animal, it is obviously closely related. Another reason for prefering to use the Greatest Length of the radius is that its contribution to the TEL is very similar for both cows and bulls. In Table 10, therefore, the withers heights calculated from the Greatest Lengths of the radii may give the best approximations to the <u>actual</u> withers heights of Individuals 1 - 5 when they died, whilst the withers heights calculated from the Greatest Lengths of the metapodials may give the best approximations to the <u>potential</u> withers heights that the individuals may have attained at full maturity (or, for the very young individuals, a <u>minimum</u> adult withers height).

Using the factors for the radius (as recommended by Bartosiewicz 1987) as giving the closest approximations to actual live withers heights, regardless of age or sex of the individual, the calculated withers heights for the St. Giles individuals range from 1.08m (for the youngest, No. 5, which was <6 months - 18 months old) to 1.43m (for one of the two young adults, No. 1).

Summary

It is clear that all of the five individuals were, or were going to be, very tall. In the case of the young adults (Nos. 1 & 4), the calculated withers heights probably reflect actual live heights, but for the young ones the withers heights are probably more an indication of their potential heights rather than of attained heights at time of death.

The discrepancies between heights calculated from different elements of the skeleton are probably due to (a) differences in conformation of the adult animals compared to the modern cattle used to obtain the conversion factors and (b) inaccuracies of factors applied to unfused bones.

Withers heights calculated from the GLC (Greatest Length from the Caput) may be preferable to those using the GL (Greatest Length) for the humerus and femur.

AIM 4: An Investigation of the Sex(es) of the Individuals

The estimates of withers heights, given above, would be more accurate if the animals could be sexed. None of the skulls are sufficiently intact for any measurements to be taken, and none of them have complete horncores (most of the frontals are completely missing or destroyed).

The pelves and the metapodials were studied in an attempt to ascertain the sex of each individual. These studies proved problematic and have stimulated the start of a longterm study of sexing characteristics of modern material.

1: Metapodials:

Introduction:

Since the withers heights have been calculated on the metapodials, it would be appropriate for the same bones to be studied for sexually-diagnostic traits. Firstly, the St. Giles bones are studied as a group, using measurements that have been shown to reflect sexual differences by other authors (*ie*: Higham, 1969; Howard, 1963; Schwartz, 1979). Then the absolute measurements are compared directly to the modern data used by some of those authors. Table 11 and Figures 4 and 5 present the measurements taken on the St. Giles metapodials.

Two facts should be borne in mind when looking at these figures: (i) the sample size is extremely small (N=5 individuals) and (ii) three of the individuals (Nos. 2, 3 and 5) were juveniles, with unfused distal epiphyses.

I: Relative size and shape within the group:

The measurements in Figure 4 (for metacarpals) and Figure 5 (for metatarsals) might be expected to reflect two factors: (1) age and (2) sex. The ages of the individuals range from the youngest: 5, through 2, 3, 1 to 4 (the oldest).

Figure 4 shows that there does appear to be a general trend for age to be related to the absolute sizes of the metacarpals except in two ways.

Individual No. 1 has metacarpals that tend to be larger than those of No. 4, despite the fact that Individual No. 4 was slightly older than No. 1 when it died. These are the two individuals that had both reached, or almost reached, skeletal maturity, and the differences in their measurements may indicate that No. 1 was male and No. 4 was female.

The second exception to the general trend concerns the measurements of the metacarpals of Individual No. 3. Although these were still distally unfused, they are often as large as those of No. 4. In fact, for the distal breadth measurements, they are already somewhat broader than those of No. 4. Since growing bones attain their final length measurements first, and then continue to grow breadth-wise (Bartosiewicz, 1987; Matolcsi, 1970), this difference in robustness cannot be explained by the difference in ages of the two individuals. Indeed, the 'adult' form of No. 3's metacarpals would clearly have been even more robust than when the animal died suggesting that Individual No. 3 was male, and that its metacarpals would have been similar to those of Individual No. 1 if it had reached maturity.

The metacarpals of No. 2 were badly damaged and only one measurement could be taken on one bone. All of the measurements for Individual No. 5 plus that of No. 2 cluster at the smallest ends of the measurement ranges. This probably simply reflects the young ages of these two individuals. It is not possible to even suggest what sex either of the individuals was and, indeed, they may have been too young for any sexual differences in bone size or shape to have started to become manifest before they died.

The metatarsal measurements shown in Figure 5 display a similar pattern, with measurements from Individual No. 1 tending to be greater than those for No. 4, particularly with regard to distal breadths. This supports the evidence from the metacarpals that Individual No. 1 was male, and Individual No. 4 was female. No attempt is made here to ascertain whether Individual No. 1 was entire or castrate. This aspect is considered later in the study of the pelves.

The similarities shown by the measurements of the metacarpals of Individuals Nos. 3 and 4 are not repeated by the metatarsals. However, the differences between their breadth measurements are very clear, again suggesting that No. 3 may have been male.

In Figure 5 the underlying, general trend shown by all of the graphs is for size to increase with the age of the individual.

I: Summary:

The measurements of the St. Giles cattle metapodials, considered as a group, suggest that Individual No. 1 was male and Individual No. 4 was female. They also suggest that, although still young, the metapodials from Individual 3 already indicate male characteristics, whilst Individuals Nos. 2 and 5 were too young for sexually-dimorphic characteristics (such as robustness of male bones) to have developed.

II: Absolute size and shape:

II(a): *cf.* Howard, 1963:

Attempts to use the absolute sizes of the St. Giles bones in comparisons with those of known-sex modern cattle measured by Higham (1969) and Howard (1963) were less successful.

Howard (1963:Table 24) gives figures for her Index 1 (distal breadth (Bd) related to greatest length (GL)) using modern *Bos taurus* measurements. For the metacarpal, the index shows that there is considerable overlap between index values for cows and steers: the range for steers (N=8) is contained completely within the range for cows (N=40). The range for bulls (N=18) overlaps very slightly with the upper end of that for the steers (32.5 compared to 32.9) and overlaps slightly more with the upper end of the range for cows (32.5 compared to 33.6).

For the metatarsals, the overlaps of the ranges are even more problematic: the range for the steers (N=8) is contained completely within the ranges of both cows (N=44) and bulls (N=18).

The St. Giles measurements are given in Table 10. By comparison with Howard's values for Index 1, the St. Giles individuals can be classified as follows, in Tables 12 and 13 (below).

TABLE 12: Sex assessments of metapodials using Howard's Index 1 (Bd*100/GL)

Individual No.	Metacarpal sex	Metatarsal sex
1	cow/steer	cow
2	n.d.	cow/steer/bull
3	cow/steer	cow/steer/bull
4	cow/steer	cow
5	cow	cow/steer/bull(L) cow(R)

[N.B. when L(eft) and R(ight) metapodials give differing results, these are indicated]

Howard's Index 2 (Howard, 1963:Table 25) compares the midshaft diameter (SD) with the greatest length (GL). By comparison with this, the St. Giles individuals can be assigned to sex as follows:

TABLE 13: Sex assessments of metapodials using Howard's Index 2 (SD*100/GL)

Individual No.	Metacarpal sex	Metatarsal sex
1	cow/steer	cow/steer
2	n.d.	cow
3	cow/steer	cow
4	cow/steer	cow
5	cow/steer (L) cow (R)	cow

Howard's indices were based on measurements from modern cattle from nine different sources. She does not state which breed(s) were used, although it seems likely that more than one was involved. For both indices, and for both the metacarpals and the metatarsals, the St. Giles measurements that fall within the ranges for both cows and steers tend to fall centrally within the ranges for cows and at the extreme smaller ends of the ranges for steers. At face value, assuming that the modern cattle studied by Howard are relevant to the 18th Century material from St. Giles, all five individuals are probably from cows. The indices are probably more applicable to the 'mature' *ie*: fully fused metapodials of Individuals Nos. 1 and 4 than to the still-growing metapodials of Individuals Nos. 2, 3 and 5.

II(a): Summary:

According to Howard's (1963) indices, all of the St. Giles metapodials could derive from females. Aternatively, (although this is less likely), all of them might derive from steers. Five of the eight relevant metatarsals could even derive from bulls (these all come from Individuals 2, 3 and 5 ie: the three young individuals).

II(b): *cf.* Higham, 1969:

Higham's (1969) paper gives graphical representation of distal widths of metapodials for known sex modern Aberdeen Angus cattle. He gives no figures for bulls, only for cows (N=40) and steers (N=40). All of the cattle died at about three years of age and all derive from the same property in Australia. Higham's Figures 1 and 2 plot the distal condyle width (Bd(c)) against the distal width at the fusion line (Bd(f)) for metacarpals and metatarsals respectively.

Figure 6 plots the St. Giles measurements onto Higham's (1969) Figures 1 and 2. It is immediately obvious that all of the St. Giles measurements, even those from the very young individuals (Nos. 5 and 2) are large compared to those of the Aberdeen Anguses. By analogy with Higham's data, it appears that Individuals Nos. 1 and 3 were bulls, that No. 2 was an extremely large steer, No. 4 was a 'normal-sized' steer and No. 5 might have been a very large female or a steer.

For the metacarpals, the St. Giles measurements fall along a similar regression line to that for the combined Aberdeen Angus measurements, although they project this line beyond the Angus range. It is possible that the large size of the Eighteenth Century bones precludes any direct comparisons between the two groups, and that the measurements for Individuals No. 2 and 5 should be discounted (due to immaturity) and No. 4 considered to be female with Nos. 1 and 3 male.

For the metatarsal, the Eighteenth Century measurements again project the Angus regression line into a larger size range and, again, the measurements of No. 4 lie some distance from those of Nos. 1 and 3, although 1 and 3 are not as similar as they were for the metacarpal.

The large sizes of the bones of Individual No. 2, despite its young age, may suggest that the measurements would lie closer to those of Nos. 1 and 3 if they had reached maturity.

II(b): Summary:

Although Higham's work appears to be very useful, it may not be directly applicable to bones of cattle whose size differs from that of the Aberdeen Anguses that he studied. Because of the large sizes of the St. Giles material, they all appear to be male by direct comparison with Higham's data. Sexual dimorphism needs to be studied within one group rather than between groups, unless the groups can be shown to be directly comparable.

Discussion of the results of the three methods of 'sexing' the St. Giles metapodial measurements.

The three methods used above on the same group of measurements lead to three very different conclusions:

Method 1 (treating the measurements as coming from a group of individuals): Individual No. 1 was male, Individual No. 4 was female, Individual No. 3 was probably a young male and Individuals Nos. 5 and 2 were too young for sexual dimorphism to have affected the bones.

Method 2 (direct comparison with Howard's (1963) shape indices for modern cattle): at least the majority, if not all of the individuals were probably female. Alternatively, any or all of them may have been castrates. There is even a slight possibility that the two very young animals (Nos. 5 and 2) and the juvenile (No. 3) were all bulls.

Method 3 (direct comparison of the distal breadth measurements with Higham's (1969) measurements for modern Aberdeen Angus cows and steer): Individuals Nos. 1 and 3 were probably entire bulls, Nos. 4 and 2 were very large castrates and No. 5 was a very large female or a small steer.

The question is: which, if any, of these three methods leads to the more accurate conclusions?

The third method, using Higham's (1969) measurements for modern Aberdeen Angus cattle can probably be dismissed since the overall size of the cattle is so much smaller than the St. Giles group. The withers height of modern Aberdeen Angus yearling bulls is only 1.10 metres (with a range of 1.02 - 1.18 metres in a group of N=31, Meat & Livestock Commission, 1976), whereas the range calculated for the St. Giles group (N = 5 individuals, three of which were young) is 1.30 - 1.50 metres (using Zalkin, 1960; see Table 8) or 1.17 - 1.44 metres (using Matolcsi; see Table 10). Modern beef shorthorn cattle, with an average yearling withers height for bulls of 1.23 metres (range = 1.16 - 1.30 metres, N=13; Meat & livestock Commission, 1976) may be more directly comparable, although even these may be a bit on the small side compared to the St. Giles cattle. Unfortunately, I do not know of any collection of metapodial measurements for modern shorthorn or larger cattle. Similarly, Higham's Aberdeen Angus measurements cannot be converted or standardised for robusticity (for instance, in the way that Howard attempted to use shape indices) since he did not have complete bones.

Howard's own shape indices, whilst overcoming the problem of absolute size to some extent are still problematic, due to the great overlaps between the measurements and shapes of bones from cows and steers and steers and bulls (and even, sometimes, between cows and bulls). Not a single individual from St. Giles can be shown, unambiguously, to have been male rather than female, or *vice versa.* Ironically, whilst it might be thought that the three youngest individuals might all appear to be female (because they all might have died before the effect of male hormones could have led to any increase in robusticity), it is these three youngest individuals that have measurements that fall within the range for bulls!

Only the first method, using the St. Giles cattle bone measurements as a group, and comparing the measurements of bones from individuals within that group, appears to give useful and feasible results. But this method has no checks against known-sex standards!

Archaeozoologists have tended to utilise metapodials in preference to any other element in their attempts to assign sexual identities to bones, mainly because metapodials tend to meet two essential criteria better than other element types. That is, they tend to be (a) numerous and (b) intact, or at least far more intact than other elements (due to their comparatively high degree of robustness and to their comparatively low value as part of butchered joints of meat).

However, these logistical factors, whilst desirable from the practical point of view, have tended to overshadow their comparative unsuitability for studies of sexual characteristics. All of the methods that are in common usage for sexing cattle metapodials employ absolute measurements of size, or some ratio of such measurements. The application of the methods relies on the fact that size and shape of metapodials have been shown to be related to the sex of the individual. But sex is not the only factor to affect the size and shape of cattle metapodials. Besides genetic factors, age and nutrition also affect the size and shape of these bones. Noddle (1983) has drawn attention to the fact that malnutrition can lead to unusually narrow metapodials. Poor nutrition can also lead to an animal failing to reach its full genetic potential. Since the distinction between the bones of females, castrates and entire males relies on a distinction between their relative lengths and widths, effects of malnutrition are clearly of great relevance.

The next section considers morphological and metrical characteristics of the pelves in a second attempt to ascertain the sexes of the five post-mediaeval cattle buried at St. Giles.

2: Pelves:

Introduction:

The shape of a pelvis is far more related to sex hormones than to nutrition. It should, therefore, be a more reliable indicator of sex than the metapodials.

Three sets of measurements together with visual assessments of morphological traits were used in an attempt to ascertain the sex(es) of the five individuals from their pelves. Pelves should demonstrate greater sexual dimorphism than metapodials due to their involvement (or not) with the birth of offspring, but they have tended to be utilised less by archaeologists, simply because they seldom survive intact on archaeological sites. The presence, therefore, of complete or almost complete pairs of innominates from the five St. Giles individuals, provides an unusual opportunity to apply metrical analyses to archaeological material.

However, even the St. Giles bones had suffered some damage (see introduction) and so the most diagnostic measurements could not be taken. These reflect the degree of curvature of the complete (and fully fused) pelvis, by comparing the width across the *Tubera ischiadica* (Driesch's GBTi) with the greatest length (GL). The tighter curvatures are associated with male animals, the more open curvature (giving a wider space for the birth canal) is associated with females. Although this ratio of measurements usually gives very clear indications of sex for wild animals, it has two drawbacks for archaeological material from domestic animals: (1) the archaeological material is almost never complete due to breakage, butchery and immaturity (*ie*: when the pubes are unfused, innominates are often found singly) and (2) the domestic fauna is likely to contain an unknown quantity of bones from castrated males (and the known-sex controls of modern wild animals do not address this added variable). Although Clutton-Brock *et al* (1990) used a similar pair of measurements (*ie*: the width of the whole pelvis across the acetabula compared to the total length) in their study of Soay sheep skeletons to discrimate between females and castrates, and between females and entire rams, they did not attempt to separate the castrates from the entire rams by these measurements.

For the St. Giles material, although the innominates are all unfused, and the blades of the ilia and ischia have often been damaged (thus precluding metrical analyses), the bones are often complete enough for visual assessments of curvature to be made in comparison to modern pelves of cattle of known sex, and for the bones to be assigned, qualitatively, to male or female categories. The second problem, however, (that of distinguishing bones of castrates from those of entire males) could not be addressed by this method.

Measurements Set 1:
Pubic Breadth (PB) and Pubic Length (PL):

West (1990) published several useful groups of measurements on the pelves of domestic species of known-sex. One of these groups was a small number of Chillingham cattle (West, 1990: Figure 22). This has stimulated an ongoing project comparing West's data with more measurements from Chillingham cattle and modern Dexter cattle (in conjunction with Gidney).

West (1990) used two measurements on the pubis to discriminate between cows and bulls: the pubic breadth (PB) and the pubic length (PL). Her Figure 22 plots the pubic breadth (PB) against the pubic index ((PB x 100)/PL) and demonstrates a clear difference between the three cows and the two bulls in the small sample. The same measurements were taken on the St. Giles bones, and are listed in Table 14 and presented graphically in the same manner as West's Figure 22 in Figure 7 of this study, together with modern data for two more Chillingham bulls and five Dexter cow pelves. Figures have been plotted for only one of the innominates from any individual.

Table 14 shows how large these animals were compared to the modern Chillingham cattle: all five individuals have indices that approximate to, or exceed, those of the Chillingham bulls.

Figure 7 shows a clear separation of the cows and bulls from the Chillingham herd, and the Dexter cows fall along the same regression line, although their actual measurements are slightly larger than those of the Chillingham cows. Data are available from only two castrates. Both of these animals were young, with the fusion lines of their acetabula still visible. The Jersey x Aberdeen Angus castrate's measurements fall very close to those of the larger of the four Chillingham bulls, but the Dexter castrate's measurements fall slightly off the regression line, indicating a relatively shorter pubic length in relation to the pubic breadth. Two of the St. Giles immature (unfused) innominates have measurements that are very similar to those of this castrate. These are the from the two youngest individuals, Numbers 2 and 5. The innominate from No. 3 is partially fused and its measurements are very close to those of the largest of the Chillingham bulls. In contrast, the two innominates from adult animals (Nos. 1 and 4) lie off the regression line, very closely together. Their Pubic Breadths are very large (equivalent to those of the largest of the Chillingham bulls and the Jersey x castrate) but their Pubic Indices are equal to that of the smallest of the Chillingham bulls.

Taken as a group, the St. Giles individuals separate into young and 'old'. The high pubic indices of the three young individuals is very noticeable, and may indicate that the pubic breadth is attained, or more nearly attained, sooner than the pubic length. The two adult animals have measurements that are almost indistinguishable, which suggests that they are of the same sex; but which sex cannot be judged from the modern data, which appear to be very different, presumably because of size and conformation differences.

Measurements Set 2:
Pubic Midshaft Width (MSW) and Breadth (MSB):

This pair of measurements was suggested by Payne (n.d.) for separating male and female sheep and goats. The midshaft width (MSW) is taken in a manner similar to that for the midshaft diameter (SD) of long bones, and the midshaft breadth (MSB) is taken perpendicular to the MSW, at the same point on the pubis (see diagram on Figure 8). The measurements are listed in Table 14 and presented graphically in Figure 8. A pubic midshaft index has been calculated as the width divided by the breadth (MSW/MSB).

Figure 8 is not easy to interpret. There is no clear linear relationship, as might be expected if the measurements were age related, nor any clustering that might indicate sexual di- (or tri-) morphism. The two near-adults (Nos. 1 and 4) don't cluster together on either plot, and nor do the two youngest individuals (Nos. 2 and 5). Individuals 1 and 3, which appeared to be similar for some of their metapodial measurements, have pubic midshaft measurements that lie at opposite extremes in both plots.

Measurement Set 3:
The height of the medial rim of the acetabulum:

Several authors (*eg*: Boessneck, 1969; Grigson, 1982; Armitage, 1977; Clutton-Brock *et al* 1990) have noted that the ventro-medial border of the acetabulum of entire males is considerably (and statistically significantly) deeper in males than in females. Where castrates have been included in the study (*eg*: Clutton-Brock *et al*'s study of Soay sheep skeletons) castrates have been shown to have measurement ranges that are much closer to those of entire males than to those of females, and that there is very little overlap between the measurement ranges of females and those of either type of male. However, there is considerable overlap between the measurement ranges of entire and castrated males.

Grigson (1982) also drew attention to the fact that the ilio-pubic ridge tends to be very sharp in females, and far more indistinct in males (Grigson, 1982: Figure 1). The measurement of this medial rim height (which corresponds to Measurement 6 for the pelvis in Clutton-Brock *et al*, 1990: Figure 22) has been listed in Table 15, together with more traditional measurements using Driesch (1976). This measurement was taken simply by holding the calipers perpendicular to the outer surface of the acetabulum, and measuring the distance from the top of the acetabulum rim to the ilio-pubic ridge. On occasions, this measurement is difficult to take with certain accuracy due to one (or both) of two factors: (i) there is often a small dip in the rim of the acetabulum at this point, which may or may not be bridged over. The measurement may, or may not, therefore, include the height of this ridge; (ii) for male innominates (whether castrate or entire) the ilio-pubic ridge may be so rounded that it is difficult to determine exactly where the 'break of slope' occurs.

At a meeting of the sheep/goat measurement working party organised by Payne (n.d.), Payne suggested a different manner in which this measurement could be taken, in which one of the points of the calipers is placed in the bottom of the acetabulum and the other end is then closed towards it until they are stable: at this point, the calipers can be used like a pair of tongs to pick up the innominate. The advantage of this method is that it is easy to replicate, either by different observers or by the same observer at different times. It is, therefore, far more accurate, particularly for male innominates. However, just what it is measuring is less certain. It is certainly <u>not</u> a direct measurement of the height of the acetabulum rim as it is described by the authors mentioned above. Rather, it is more of a thickness measurement, and this has not yet been shown to relate to sex.

The heights of the medial rims of the St. Giles cattle acetabula were measured in both ways, and the results are listed in Table 15 and presented as bar graphs in Figure 9. Using the direct method (*sensu* Grigson, 1982, and Clutton-Brock *et al* 1990), the measurement for Individual No. 4 stands out as being extremely small (only 5.2 mm). This fits well with the very marked ilio-pubic ridge, both attributes suggesting that Individual No. 4 was female. In contrast, the measurement for Individual No. 1 is much greater (32.0 mm), and this is also in accord with the less-well marked nature of the ridge, which suggests that it was male. The measurements of two of the three young individuals (Nos. 3 and 5; No. 2 was too damaged to measure in this way) are intermediate, but lie much closer to that of Individual No. 1 (30.8 - 33.6 mm). Since they are already considerably larger than the proposed female, despite being immature, they are more likely to derive from young males than from young females. Their ilio-pubic ridges are also quite rounded, although more work needs to be done on modern cattle of known-sex in order to test at what age the sharpness of the female ridge becomes pronounced.

Using Payne's method of measuring the rim, the differences become much more blurred. The measurement for Individual No. 4 is still the smallest (9.2 mm), but the differences between this innominate and those of the other individuals is far less marked. It was possible to obtain an approximate measurement for Individual No. 2, and this falls close to those of the other young individuals (*c*19.7mm compared with 19.7 - 21.1 mm). However, the measurement for Individual No. 1, which was the greatest using Grigson's method, is midway between those for the youngsters and that of No. 4 (No. 1 = 14.7 mm). Figure 9 shows this reversal very clearly. Since the measurements taken using Grigson's method correspond very closely to the visual assessments made of the sharpness of the ilio-pubic ridge (which delineates the measurement, and which has been shown to be markedly sexually dimorphic), Grigson's method is regarded as being a more accurate indicator of sexual dimorphism of the pelvis, even though it can have logistical problems (mentioned above).

Other measurements, and visual assessment:

Table 15 lists various measurements described by Driesch (1976) together with the minimum width of the caudal process of the pubis. This is the minimum width between the obturator foramen and the sagittal edge (or fusion line) of the innominate (see sketch diagram on Table 15). The author's observations of modern reference material of known sex cattle skeletons (mainly Chillinghams and Dexters) lead her to suspect that this measurement is sexually dimorphic, but the measurements of the St. Giles innominates appear to reflect simply the relative ages of the individuals.

Table 15 also lists the visual assessments of sex made on the St. Giles material. These visual assessments took various factors into consideration. Due to the damage incurred by some of the bones, different combinations of attributes were present for different individuals. These attributes included (this order is random, and does not imply any weighting factors): (i) the sharpness of the ilio-pubic ridge and its depth from the rim of the acetabulum, (ii) the shape of the ilio-pectineal eminence, (iii) the shape of the pecten on the ventral border of the pubis, (iv) the degree of curvature of the pelvis around the sagittal plane, (v) the shape and twist of the shaft of the ilium. The shape of the blade of the ilium could not be used, as this part of the bone was nearly always damaged (as it is in nearly all archaeological cattle material). No attempt was made to differentiate between entire and castrated males.

Individual No. 4 appeared to be very definitely female on the grounds of the various visual attributes. Individual No. 1 was less certainly male, although it did not appear to be female. Perhaps surprisingly, considering their young ages, individuals 2, 3 and 5 also appeared to display definite male characteristics rather than female.

Discussion of methods and results of ascribing sexual characteristics to metapodials and pelves:

Summary of results:

TABLE 16: Summary of sex attributes for metapodials and pelves

	metapodials			pelves			
Indiv-idual	Howard 1963	Higham 1969	BSG	West 1990	Payne n.d.	Grigson 1982	visual assessment
No. 1	f/f/c f/f/c/c	b	m	?	?	m	m
No.2	f/c/b f	c	?	?	?	m	m
No. 3	f/c/f/f f/c/c/b	b	m	?	?	m	m
No. 4	f/c/f f/c/f	c	f	?	?	f	f
No. 5	f/f/c/b f/f/c/f/f	f/c	?	?	?	m	m

key: f=female; c=castrate; b=bull; m=male
BSG = St. Giles (comparisons within the group)

The different methods employ differing aspects of the bones. Howard's method describes shape indices, and gives very ambiguous results. Higham's method uses absolute sizes and may need to be adjusted for types of cattle that differ from the control breed (Aberdeen Angus). The comparison of the measurements within the St. Giles group (BSG) appears to be able to discriminate between male and female adults and between adults and juveniles. The two methods using measurements ratios of the pubis (West & Payne) both gave results that could not be interpreted. Only two of the methods appeared to give clear results *ie*: (i) Grigson's method of measuring the height of the rim of the acetabulum, and (ii) the visual assessments that took several morphological traits into consideration. The results from these two methods also concurred for all five individuals. The results of the within-group comparison of the metapodial measurements were also in agreement for the two adults and the juvenile, but were not diagnostic for the two youngest individuals.

The conclusions from this study are that:

(1) for metapodials, the best method utilises within-group comparisons (*cf.* Schwartz, 1979). This method ideally requires as large a sample size as possible, and may be able to group bones according to their size and shape. If there are two or three of these groups, it might be considered reasonable to allocate them to females, castrates and/or bulls, although this author would like to see more work on modern material of known age and sex in order to study the relative sizes and shapes of bones of young castrates and females compared to those of adult females. The method can even be used to suggest relative numbers of bones falling into the different groups (*cf.* Prummel, 1983) but it cannot be guaranteed to identify the sexual identity of an individual, since there is always the high probablity that the measurements of some females and castrates will overlap.

Higham's method of using an index of the degree of distal splaying of the metapodia appears to have similar restrictions: it relies on having a large sample for which within-group variation can be studied. The direct application of his data may be inappropriate to cattle of different conformation or size.

Similarly, the absolute values of shape indices such as those recorded by Howard were not found suitable, although this relates more to the fundamental problem of overlapping ranges for the modern material than to any specific problem of the St. Giles data set.

Within-group comparisons themselves can only highlight clusterings or general trends. Small samples are prone to ambiguities caused by random (individual) variations. Even large samples have problems in the areas in which measurements for different classes overlap.

All of these three methods, therefore, suffer from the problem that measurements and measurement ratios of metapodials of females, castrates and males can overlap. The chances of assigning (correctly, and with confidence) a sexual identity to a single bone are not very high.

(2) For the pelvis, since sexual dimorphism is more marked than in the metapodials, there might be more chance of identifying individual bones. However, the ratios of measurements suggested by West and Payne gave totally unusable results.

Only the measurement of the height of the medial border of the acetabulum (*cf* Grigson) gave a clear indication of the sex of the individual bone. Visual assessment of a variety of morphological characteristics supported this single measurement in every case.

Since the sex(es) of these five individuals from St. Giles are not known, even Grigson's method cannot be checked against known fact, but it does appear to give very clear, and feasible, results.

However, none of the methods tried out on the St. Giles material was able to suggest whether a male animal was a castrate or a bull.

AIM 4: the cause(s) of death of the five individuals.

Two lines of evidence can be followed to investigate cause of death: (1) direct evidence (*eg*: pathological alterations to the individual's remains) and (2) circumstantial evidence such as mode of burial.

(1) Pathological evidence:

Fractures: None of the bones show any breaks except obvious modern breaks due to hasty excavation (the different colourings of the surfaces and inner layers of the bones make all such breaks extremely obvious). The only old 'lines of breakage' are where lower limbs were chopped through in order to force the body into the burial pit. There are no examples of healed or partially-healed fractures.

Infections: There are no definite areas of bone showing infections except, perhaps in the distal femurs of Individual No. 3. Both left and right femurs have ill-defined patches of slightly pitted bone on the surfaces of the epicondyles. A patella of the same individual has a similar, though very small, area of fine pitting. The third phalanges of Individuals Nos. 3 and 4 tend to have somewhat eroded surfaces compared to the other phalanges on the same feet. The erosion looks similar to water erosion. However, Baker (pers. comm. and observation) considers that these altered surfaces are due to natural erosion in the soil and are not evidence of foot-rot or any similar infection.

Dental problems related to feeding: None of the individuals had any dental anomalies whatsoever *ie*: no overcrowding, no malocclusion, no chipped or missing teeth. There is no dental reason for any of the five individuals to have had difficulties in feeding themselves.

Conformation: All of the bones of all of the individuals are large and robust. The only skeletal abnormalities are some congenital lesions in the foot bones, mainly the phalanges (Baker & Brothwell 1980: depressions in articular surfaces, types 1, 2 & 3). Examples of these lesions occur on bones from four of the five individuals (Nos. 1, 2, 3 & 4). Interestingly, since the whole skeletons are present, it is possible to see that, at some joints (but not all), two articulating bones have lesions that correspond with each other. Examples of 'mirror-imaging' lesions are present on foot bones of Individuals Nos. 1 and 3.

Discussion:

There is no evidence from any of the bones of any of the five individuals that suggests cause of death. The only indication of any pathological alteration is the possible area of periosteal infection on the distal epicondyles of the femurs of Individual No. 3. The large size and robust nature of all of the bones, together with the good condition of all of their teeth and jaws suggest that all five animals were well fed and well looked after.

(2). Circumstantial evidence.

There are two lines of circumstantial, or indirect, evidence that hint at the possible cause(s) of death:
(i) the manner of burial and
(ii) documentary references for the period.

(i) The manner of burial.

All of the cattle were buried when still fully articulated. The pits were irregular in shape and the carcases had been forced into them (with lower legs severed if necessary, in order to get them in).

Two of the pits contained two individuals each, implying that the animals had died in very quick succession.

None of the individuals had been butchered into joints, and only two (Nos. 1 & 4) have any defleshing marks on the bones. Even then, these marks are rare: Individual No. 1 only has a few cutmarks on the outside of the ribs. The scapula and humerus of Individual No. 4 bear some possible fine knife marks, that might be due to defleshing.

Only one of the skeletons has any indications that their hides had been removed: No. 3 has skinning marks on the diastema and skull, and the skull had been severed from the body (although it had then been placed in the pit in anatomical position, see Plate 1).

All of these lines of evidence suggest that the cattle were buried quickly, that animals died in quick succession, and that their meat was regarded as unfit for human consumption. Indeed, apart from a few knife marks, there is no evidence that any meat was removed at all, even for feeding to dogs. Even the hides appear to have been forfeited in four of the five cases. The financial loss that must have accompanied the deaths of five cattle appears to have been outweighed by considerations of health and safety. The conclusion is that, either (a) the cattle were healthy and slaughtered but discarded or (b) the cattle died of some disease that killed them without leaving any alterations to the skeleton. Since, in two cases, two animals died so close together in time and place that they could be buried in the same pit, it seems likely that the cause of death was contagious.

The foetal bones found in pits (300) and (332) represent two individuals; one in each pit. Their deaths need not relate to those of Individuals Nos. 1-5: the pits may simply have been used as convenient locations for disposal. For any one of the 'complete' individuals to have died whilst pregnant it must have been (a) old enough to become pregnant and (b) female. Individual No. 3 (found in pit (467)) can be discounted as it is highly unlikely to have been buried separately from its foetus. Individuals Nos. 2 and 5 were almost certainly too young to have been carrying a 5.5 or 6.5 month old foetus. Only Individuals Nos. 1 and 4 might have been old enough to be pregnant. Individual No. 4 is thought to have been female (see Aim III, above) but No. 1 is thought to have been male. Unfortunately, the excavators did not note the position of the foetal bones during excavation and so their possible relations to Individuals Nos 1 and 4 cannot be ascertained.

(ii) documentary evidence relating to the period.

There are several records of cattle 'plagues' in England during the Eighteenth and Nineteenth centuries. These relate to epidemics of diseases such as rinderpest, tuberculosis, foot-and-mouth disease *etc.* (*eg:* Bouley, 1872). Broad (1983) records that there were three pandemics of rinderpest in Europe in the eighteenth century, all of which affected England. These occurred (in Britain) in 1714-15, 1745-1758 and, more intermittently 1768-86.

The first outbreak of rinderpest was restricted to London and the immediately surrounding counties by prompt and rigorous Government action, but the outbreak in 1745 coincided with the Jacobite rebellion and was left unchecked for six months, by which time it had got out of control. Despite attempts to contain the outbreak, the practices of long-distance droving and of frequent stock markets ensured that it spread throughout the country and took thirteen years to eradicate. It crossed the Hull-Trent line in 1747 and reached Northumberland in 1750. In the north of England, county borders, river crossings and turnpike gates were patrolled to prevent illegal movements of livestock.

Rinderpest is an acute and highly contagious virus disease of cattle. There is a high risk of an animal dying within 6 to 12 days from the onset of the disease (in the English outbreaks in the eighteenth and nineteenth centuries, mortality rates were as high as 90% [Broad, 1983]). A system of compensation from the Government encouraged farmers to declare infected livestock and slaughter it as soon as possible, but the compensation was only half the value of each beast (and that assumed that no animal was worth more than #4.00, although many animals were worth more than that) (Broad, 1983).

Although the whole of England was affected by the epidemic, Yorkshire was particularly at risk due to the very large numbers of cattle that were imported for sale at its major markets such as York. Many of these cattle came from Ireland or from Europe (Dent, 1872). The European cattle often originated from Russia, where the disease was endemic (it was often referred to as the 'Steppe murrain'). The mixing of newly bought infected stock with a home herd could easily lead to the loss of nearly every animal, 'old' or 'new'. These problems persisted into the nineteenth century, for which there are several references to the swift onset of such contagious diseases ('plagues'), followed by a rapid deterioration to death, together with the highly contagious nature of the disease(s), requiring instant burial or burning of the entire carcases (*eg*: Blackwell, 1856; Bouley, 1872; Dent, 1872; McFadyean, 1898).

Discussion:

There is no evidence of why the carcases of five healthy cattle might have been hastily buried, intact, in three pits at St. Giles in the eighteenth century. There is no indication of any ritual deposition: no accompanying grave goods, no association with human burials, no altars *etc*.. In fact, the burials are as far away from the ruined chapel as they can be within the confines of the river terrace. It seems far more likely, therefore, that they died sudden deaths caused by a highly contagious disease. Although there are no pathological alterations to the skeletons themselves and, therefore, no direct evidence for which disease might be responsible, a burial date of *circa* 1745-1758 would be in accord with the documented epidemic of rinderpest. Other possiblities include anthrax (tested for, but not found), foot and mouth disease and tuberculosis. Any of these could have occurred at any time during the eighteenth century (and, indeed, the nineteenth).

Although Individual No. 4 and even Individual No. 1 (which is thought, from measurements and morphological characteristics, to have been male) may have been pregnant when they died, the fact that each of them died at the same time as at least one other individual suggests that pregnancy was not the direct cause of death.

SUMMARY

This report has aimed to do two things (1): to investigate the nature of the burials of five cattle individuals from mid-Eighteenth Century deposits and (2): to use these 'complete' skeletons to test current methods of ascertaining age and sex from archaeological animal bones.

The animals appear to have been well nourished and looked after during life but, after their deaths, their meat was not considered fit for consumption. Indeed, even the hides were rejected in four of the five cases. These facts, together with the total and somewhat undignified nature of their burials in three pits, suggest that the cattle died suddenly of some highly contagious disease. This may have been Rinderpest, which had a virulent epidemic in Britain from 1745-58.

Whilst it is clear that all five individuals were young when they died (two very young, one juvenile and two just adult), and that their ages at death probably ranged from less than 6 months to approximately four years, precise ages cannot be calculated since it is apparent that two of the standard techniques for ageing bones give very disparate results. These two techniques are: the sequences of tooth eruption and of epiphyseal fusion (both using Silver's (1969) data for modern cattle).

Similarly, tests of sexing methods also give ambiguous or conflicting results.

The main problems appear to relate to (a) small sample size and (b) a lack of relevant modern data.

Dr. Sue Stallibrass
29th January 1993

REFERENCES

Armitage, P. 1977. The mammalian remains from the Tudor site of Baynard's Castle, London: A biometrical and historical analysis. Unpublished Ph.D. thesis. London: Royal Holloway College & British Museum (Natural History)

Baker, J. & Brothwell, D. 1980. Animal diseases in archaeology London: Academic Press

Bartosiewicz, L. 1984. Sexual dimorphism of long bone growth in cattle. Acta Veterinaria Hungarica 32: 135-146

Bartosiewicz, L. 1985. Interrelationships in the formation of cattle long bones. Zoologica Anzeiger, Jena 215: 253-262

Bartosiewicz, L. 1987. Cattle metapodials revisited: a brief review. ArchaeoZoologia I(1): 47-51

Blackwell, T.A. 1856. Contagious diseases among cattle inMecklenburg. J. Royal Agricultural Society of England XVII: 331-335

Boessneck, J. 1969. Osteological differences between sheep (*Ovis aries* Linne) and goat (*Capra hircus* Linne). In D. Brothwell & E.S. Higgs (eds.) Science in archaeology London: Thames & Hudson, pages 331 - 358

Bouley, M. 1872. Sanitary police and the cattle-plague. J. Royal Agricultural Society of England 2nd Series VIII: 179-185

Bourdillon, J. & Coy, J. 1980. The animal bones. In P. Holdsworth Excavations at Melbourne Street, Southampton. 1971-76. Southampton Archaeological Rescue Committee Report 1. Council for British Archaeology Research Report 33: 79-121

Brännäng, E. 1971. Studies on monozygous cattle twins. XXIII. The effect of castration and age of castration on the development of single muscles, bones, and special sex characters. Swedish J. Agricultural Research 1: 69-78

Broad, J. 1983. Cattle plague in eighteenth-century England. Agricultural History Review 31(II): 104-115

[Bünger-Marek, I. 1972. Beitrag zur Altersbestimmung von Feten des Deutschen Schwarzbunten Rindes insbesondere auf Grund von Lägenmassen. Hannover. Thesis] cited in Prummel, 1989. not seen

Clutton-Brock, J. *et al* 1990. Osteology of the Soay sheep. Bulletin of the British Museum of natural History (Zoology) 56(1): 1-56

Dent, J.D. 1872. The records of contagious cattle diseases in Yorkshire during the years 1870-71. J. Royal Agricultural Society of England 2nd Series VIII: 179-185

Driesch, A. von den 1976. A guide to the measurement of animal bones from archaeological sites. Harvard: Harvard University, Peabody Museum of Archaeology and Ethnology. Peabody Museum Bulletin 1

Evershed, H. 1890. The early fattening of cattle and sheep. J. Royal Agricutlural Society of England 3rd Series I: 47-69

Garn, S.M., Lewis, A.B. & Blizzard, R.M. 1965. Endocrine factors in dental development. J. Dental Research 44 supplement 243-258

Grant, A. 1982. The use of tooth wear as a guide to the age of domestic ungulates. In B. Wilson, C. Grigson & S. Payne (eds.) Ageing and sexing animal bones from archaeological sites. Oxford: British Archaeological Reports (British Series) 109: 91-108

Grigson, C. 1982. Sex and age determination of some bones and teeth of domestic cattle: a review of the literature. In B. Wilson, C. Grigson & S. Payne (eds.) Ageing and sexing animal bones from archaeological sites. Oxford: British Archaeological Reports, British Series 109: 7-23

[Habermehl, K-H. 1975. Die Altersbestimmung bei Haus- und Labortieren Berlin/Hamburg] cited in Prummel, 1989. not seen.

Howard, M.M. 1963. The metrical determination of the metapodials and skulls of cattle. In A.E. Mourant & F.E. Zeuner (eds.) Man and cattle. London: Royal Anthropological Institute of Great Britain and Ireland. Roy. Anth. Inst. Occ. Paper No. 18: 91-100

Iregren, E. 1975. Age-dependent changes in the lower extremities of the elk (*Alces alces*) in Central Sweden. In A.T. Clason (ed.) Archaeozoological Studies. Amsterdam: North Holland Publishing Company. Pages 367-380

McCance, R.A. 1962. Food, growth and time. Lancet 2: 671-676

McFadyean, J. 1898. Quarter-evil. J. Royal Agricultural Society of England 3rd Series IX: 654-666

Meat & Livestock Commission, 1976. British Beef Cattle. Milton Keynes.

Prummel, W. n.d. Withers height for cattle: metapodials give higher values than other long bones. Paper presented at the IVth International Council for ArchaeoZoology (ICAZ) conference, London. 1982

Prummel, W. 1983. Excavations at Dorestad 2. Early medieval Dorestad an archaeozoological study. Amersfoort: Rijksdienst voor het Oudheidkundig Bodemonderzoek. Nederlandse Oudheden 11; Kromme Rijn Projekt 2

Prummel, W. 1987. Atlas for the identification of foetal skeletons of Cattle, Horse, Sheep and Pig Part 1. ArchaeoZoologia I(1): 23-30

Prummel, W. 1988. Atlas for identification of foetal skeletons of Cattle, Horse, Sheep and Pig Part 3. ArchaeoZoologia II(1.2): 13-26

Prummel, W. 1989. Appendix to Atlas for identification of foetal elements of Cattle, Horse, Sheep and Pig. ArchaeoZoologia III(1.2): 71-78

Schwartz, C.A. 1979. Biological variations in Balkan neolithic cattle. Unpublished M.Phil. thesis, University of London

Silver, I.A. 1969. The ageing of domestic animals. In D. Brothwell & E. Higgs (eds.) Science in Archaeology London: Thames & Hudson. pp 283-302

Stallibrass, S.M. 1993. Animal bones from excavations at a medieval hospital and post-medieval farmstead at St. Giles by Brompton Bridge, North Yokshire, 1988-1990. Ancient Monuments Laboratory Report Series No. 95/93

West, B. 1990. A tale of two innominates. Circaea 6(2) (for 1988): 107-114

Wilson, B. 1984. Faunal remains: animal bones and marine shells. In D. Miles (ed.) Archaeology at Barton Court Farm, Abingdon, Oxon. Oxford: Oxford Archaeological Unit Report 3. London: Council for British Archaeology Research Report 50. Fiche 8: A1-G10.

IJzereef, G.F. 1981. Bronze Age animal bones from Bovenkarspel. The excavation at Het Valkje. Amersfoort: Uitgave Rijksdienst voor het Oudheidkundig Bodemonderzoek (ROB) Nederlandse Oudheden 10. Project Noord-Holland 1.

Zalkin, V.I. 1960. Metapodialia variation and its significance for the study of antient (*sic*) horned cattle. Journal of the Moscow Society of Experiments of Nature, Biology Section 65 (1): 109-126. In Russian, with English summary.

TABLE 1: AGEING DATA FOR INDIVIDUAL No. 1

FUSION AGE		EPIPHYSEAL FUSION DATA using Silver's (1969) modern data
> 6	months	ATLAS fused
> 7-10	months	ACETABULUM fused, SCAPULA (GLENOID) fused
> 12-18	months	DISTAL HUMERUS fused,
> 12-18	months	PROXIMAL RADIUS fused
> 18	months	PROXIMAL FIRST PHALANGES fused
>= 2-2.5	years	DISTAL METACARPAL fused (but line just visible)
> 2-2.5	years	DISTAL TIBIA fused
>2.25-3	years	DISTAL METATARSAL fused
> 3-3.5	years	CALCANEUM (TUBER CALCIS) fused
<= 3.5	years	PROXIMAL FEMUR fusing
< 3.5-4	years	DISTAL ULNA unfused
<= 3.5-4	years	PROXIMAL ULNA unfused (Right) and fusing (Left)
<= 3.5-4	years	PROXIMAL HUMERUS fusing,
<= 3.5-4	years	DISTAL FEMUR fusing,
<= 3.5-4	years	PROXIMAL TIBIA fusing
< 4.5	years	OS ILIUM, OS ISCHIUM, OS PUBIS all unfused
< 5	years	nearly all VERTEBRAE (CERVICALS, THORACICS and LUMBARS) proximally and distally unfused.

SUMMARY OF EPIPHYSEAL FUSION DATA: VERY CONSISTENT,
> 3 years but < 4 years.
Possibly approximately 3.5 - 4 years.

TOOTH ERUPTION AND WEAR DATA

using Silver's (1969) modern data and Grant (1982)

	TOOTH ERUPTION AGE
I_1 up & in wear	>14-25 months
I_2 up & in wear	>17-36 months
I_3 up & in wear (no evidencefor I_4)	>22-40 months
M_1 up & in wear	> 5- 6 months
M_2 up & in wear	>15-18 months
P_3 up & in wear	>18-30 months
P_2 up & in wear	>24-30 months
M_3 up & in wear (third column just coming into wear)	>24-30 months
P_4 up & in slight wear (Grant 'c') (but not a lot >28-36 months)	>28-36 months

MANDIBULAR WEAR SCORES:

Left:	**M_1k, M_2j, M_3e**	**MWS = 39**
Right:	**M_1k, M_2h, M_3d-e**	**MWS= 37-38**

SUMMARY OF TOOTH ERUPTION DATA:
>3 years, but not a lot >3 years

TABLE 2: AGEING DATA FOR INDIVIDUAL No. 2

EPIPHYSEAL FUSION DATA
using Silver's (1969) modern data

FUSION AGE		
< 6	months	ATLAS unfused
< 7-10	months	ACETABULUM unfused,
< 7-10	months	SCAPULA (GLENOID) unfused
< 12-18	months	DISTAL HUMERUS unfused,
< 12-18	months	PROXIMAL RADIUS unfused
< 18	months	PROXIMAL FIRST PHALANGES unfused
< 2-2.5	years	DISTAL METACARPAL unfused
< 2-2.5	years	DISTAL TIBIA unfused
<2.25-3	years	DISTAL METATARSAL unfused
< 3-3.5	years	CALCANEUM (TUBER CALCIS) unfused
< 3.5	years	PROXIMAL FEMUR unfused
< 3.5-4	years	DISTAL ULNA unfused
< 3.5-4	years	PROXIMAL ULNA unfused
< 3.5-4	years	PROXIMAL HUMERUS unfused,
< 3.5-4	years	DISTAL FEMUR unfused,
< 3.5-4	years	PROXIMAL TIBIA unfused
< 4.5	years	OS ILIUM, OS ISCHIUM, OS PUBIS all unfused
< 5	years	all VERTEBRAE (CERVICALS, THORACICS and LUMBARS) proximally and distally unfused.

SUMMARY OF EPIPHYSEAL FUSION DATA: VERY CONSISTENT, individual very young, <6months

TOOTH ERUPTION AND WEAR DATA
using Silver's (1969) modern data and Grant (1982)

	TOOTH ERUPTION AGE
all deciduous premolars up & in wear	> 3 weeks
dp_4 in wear on both cusps (Grant L & R: 'g')	
M_1 up & in wear	> 5- 6 months
M_2 erupting	*c* 15-18 months

MANDIBULAR WEAR SCORES:

Left:	**M_1f, M_2erupting, (M_3)**	**MWS = 15**
Right:	**M_1e, M_2erupting, (M_3)**	**MWS = 14**

(both M_1s very close to 'e/f'. L just = 'f' and R just = 'e' but little difference in reality M_3 not present, but there is a small area of crypt within the bone, suggesting that a small cap of enamel had begun to form

SUMMARY: young, about 15-18 months

TABLE 3: AGEING DATA FOR INDIVIDUAL No. 3

EPIPHYSEAL FUSION DATA

using Silver's (1969) modern data

FUSION AGE		
> 6	months	ATLAS fused
<= 7-10	months	ACETABULUM just starting to fuse,
<= 7-10	months	SCAPULA (GLENOID) fusing
<= 12-18	months	DISTAL HUMERUS fusing,
<= 12-18	months	PROXIMAL RADIUS fusing
<= 18	months	PROXIMAL SECOND PHALANGES fusing
< 18	months	PROXIMAL FIRST PHALANGES unfused
< 2-2.5	years	DISTAL METACARPAL unfused
< 2-2.5	years	DISTAL TIBIA unfused
<2.25-3	years	DISTAL METATARSAL unfused
< 3-3.5	years	CALCANEUM (TUBER CALCIS) unfused
< 3.5	years	PROXIMAL FEMUR unfused
< 3.5-4	years	PROXIMAL ULNA unfused
< 3.5-4	years	DISTAL ULNA unfused
< 3.5-4	years	PROXIMAL HUMERUS unfused,
< 3.5-4	years	DISTAL FEMUR unfused,
< 3.5-4	years	PROXIMAL TIBIA unfused
< 4.5	years	OS ILIUM, OS ISCHIUM, OS PUBIS all unfused
< 5	years	all VERTEBRAE (CERVICALS, THORACICS and LUMBARS) proximally and distally unfused.

SUMMARY OF EPIPHYSEAL FUSION DATA: slight discrepancies:
>6 months but <18 months
but also <=7-10 months whilst <=12-18 months and <=18 months
overall probably *c*10/12 - 18 months

TOOTH ERUPTION AND WEAR DATA

using Silver's (1969) modern data and Grant (1982)

	TOOTH ERUPTION AGE	
all deciduous premolars up & in wear	> 3	weeks

dp_4 in heavy wear on both cusps (Grant L: 'k', R: 'j')
deciduous premolars all being pushed out by permanent premolars

M_1 up & in wear	> 5- 6	months
M_2 up & in wear	> 15-18	months
P_3 in crypt	<= 18-30	months
M_3 half up	*c* 24-30	months
second column not quite fully visible above bone level		
P_4 in crypt	<= 28-36	months

MANDIBULAR WEAR SCORES:

Left:	**M_1g, M_2f, M_3half up**	**MWS = 27**
Right:	**M_1g, M_2f M_3half up**	**MWS = 27**

SUMMARY: CONSISTENT, *c* 24-30 months

TABLE 4: AGEING DATA FOR INDIVIDUAL No. 4

EPIPHYSEAL FUSION DATA
using Silver's (1969) modern data

FUSION AGE		
> 6	months	ATLAS fused
> 7-10	months	ACETABULUM fused,
> 7-10	months	SCAPULA (GLENOID) fused
> 12-18	months	DISTAL HUMERUS fused,
> 12-18	months	PROXIMAL RADIUS fused
> 18	months	PROXIMAL FIRST PHALANGES fused
> 2-2.5	years	DISTAL METACARPAL fused,
> 2-2.5	years	DISTAL TIBIA fused
>2.25-3	years	DISTAL METATARSAL fused
> 3-3.5	years	CALCANEUM (TUBER CALCIS) fused
>= 3.5	years	PROXIMAL FEMUR fused (but line visible)
> 3.5-4	years	DISTAL RADIUS fused,
> 3.5-4	years	PROXIMAL ULNA fused,
> 3.5-4	years	DISTAL ULNA fused
>= 3.5-4	years	PROXIMAL HUMERUS fused (but line visible),
>= 3.5-4	years	DISTAL FEMUR fused (but line visible),
>= 3.5-4	years	PROXIMAL TIBIA fused (but line visible),
< 4.5	years	OS ISCHIUM, OS PUBIS both unfused
< 5	years	all VERTEBRAE (CERVICALS, THORACICS and LUMBARS) proximally and distally unfused or fusing.

SUMMARY OF EPIPHYSEAL FUSION DATA: CONSISTENT:
>3.5-4 years but <4.5 years
also >=3.5 years and >=3.5 -4 years
***ie*: *c* 3.5-4.5 years (?closer to 4-4.5 years)**

TOOTH ERUPTION AND WEAR DATA
using Silver's (1969) modern data and Grant (1982)

	TOOTH ERUPTION AGE
all permanent premolars and molars erupted & in full wear	
M_1 up & in wear	> 5-6 months
M_2 up & in wear	>15-18 months
P_3 up & in wear	>18-30 months
P_2 up & in wear	>24-30 months
M_3 up & in wear	>24-30 months
N.B. no pillar between columns one & two	
P_4 up & in wear (Grant L & R: 'f')	>28-36 months

MANDIBULAR WEAR SCORES:

Left:	**M_1f, M_2h, M_3g/h**	**MWS = 40-41**
Right:	**M_1f, M_2h, M_3g/h**	**MWS = 40-41**

SUMMARY: >3 years,
but how much >3 years not possible to assess

TABLE 5: AGEING DATA FOR INDIVIDUAL No. 5

EPIPHYSEAL FUSION DATA
using Silver's (1969) modern data

FUSION AGE		
>=	birth	3 of the 13 THORACIC VERTEBRAE still have fusion lines visible for the BODY + ARCH
<=	?	PROXIMAL portion of AXIS still in process of fusing with the main body
< 6	months	ATLAS unfused
< 7-10	months	ACETABULUM unfused,
< 7-10	months	SCAPULA (GLENOID) unfused
< 12-18	months	DISTAL HUMERUS unfused,
< 12-18	months	PROXIMAL RADIUS unfused
< 18	months	PROXIMAL FIRST PHALANGES unfused
< 2-2.5	years	DISTAL METACARPAL unfused
< 2-2.5	years	DISTAL TIBIA unfused
<2.25-3	years	DISTAL METATARSAL unfused
< 3-3.5	years	CALCANEUM (TUBER CALCIS) unfused
< 3.5	years	PROXIMAL FEMUR unfused
< 3.5-4	years	DISTAL ULNA unfused
< 3.5-4	years	PROXIMAL ULNA unfused
< 3.5-4	years	PROXIMAL HUMERUS unfused,
< 3.5-4	years	DISTAL FEMUR unfused,
< 3.5-4	years	PROXIMAL TIBIA unfused
< 4.5	years	OS ILIUM, OS ISCHIUM, OS PUBIS all unfused
< 5	years	all VERTEBRAE (CERVICALS, THORACICS and LUMBARS) proximally and distally unfused.

SUMMARY OF EPIPHYSEAL FUSION DATA: VERY CONSISTENT, individual very young:
<6months, possibly <<6 months
N.B. GLENOID considerably less well ossified than that of Individual No. 2. (which was estimated as <6 months)

continued...

TABLE 5: AGEING DATA FOR INDIVIDUAL No. 5 (continued)

TOOTH ERUPTION AND WEAR DATA
using Silver's (1969) modern data and Grant (1982)

all jaws very badly broken up during excavation.

		TOOTH ERUPTION AGE
dp_3 up & in wear	>	birth- 3 weeks
dp_4 in heavy wear (Grant R: 'j')	>	birth- 3 weeks
M_1 up & in very light wear	>	5- 6 months
M_2 in crypt	<	15-18 months

N.B. although dp_4 is already at Grant's wear stage 'j', there is no indication that P_4 has begun to form, let alone to push dp_4 out of its alveoli (in either mandible)

MANDIBULAR WEAR SCORE:
Right: M_1b, M_2crypt **MWS = 8**

SUMMARY: a surprising mixture of evidence:

the very light wear on M1 suggests that the individual was only just >5-6 months old,

yet the heavy wear on dp_4 might be taken to suggest that the individual was somewhat older than this.

The fact that M_2 was beginning to form might also suggest that the individual was considerably older than 5-6 months (*eg*: ?perhaps closer to 12 months??). It is not known how long teeth take to form in the crypt before erupting.

These apparent discrepancies might be explicable if the Right M_1 did not have a Right M^1 in opposition (thus relieving it from wear). Unfortunately, due to the fragmentary state of the bones, the Right M^1 was not recovered. However, both dp^3s were recovered, and these are at Grant's wear stages 'f' and 'f/g'. The Left maxilla was recovered almost intact, and the sequence of tooth eruption and wear on this jaw is extremely similar to that of the Right mandible, ie:

Left maxilla:
dp^3 up & in wear
dp^4 up & in heavy wear (Grant 'j')
M^1 half up (Grant 'half up')
M^2 in crypt (Grant 'crypt')

Since the Left maxilla and the Right mandible show such extremely similar states of tooth eruption and wear, it is unlikely that the wear pattern of the Right mandibular cheek tooth row is due to any malocclusion.

All that can be said is that the individual appears to have been young *ie*:
>5-6 months <15-18 months
***ie*: *c* 6 - 18 months**

TABLE 6: A COMPARISON OF THE AGEING ESTIMATES PRESENTED IN TABLES 1 - 5

INDIVIDUAL No.	EPIPHYSEAL FUSION AGE (Silver 1969)	DENTAL ERUPTION AGE (Silver 1969)	MANDIBULAR WEAR SCORE (Grant 1982)
5	<6 months	6-18 months	8
2	<6 months	*c*15-18 months	14-15
3	*c*10/12-18 months	*c*24-30 months	27
1	3 - 4 years (poss. 3.5-4 years)	just over 3 years	37-39
4	*c*3.5 - 4.5 years (?*c*.4 - 4.5 years)	>3 years	40-41

These data are presented graphically in Figure 3, together with the estimated withers heights of the five individuals (for which the raw measurements plus conversion factors are given in Table 8).

TABLE 7: THE MANDIBULAR WEAR SCORES OF INDIVIDUALS 1 - 5

using Grant 1982

INDIVIDUAL (SIDE)	dp_4	P_4	M_1	M_2	M_3	MWS
No. 5(R)	j		b	crypt	none	7
No. 2(L)	g	-	f	erupting	crypt	15
(R)	g	-	e	erupting	crypt	14
No. 3(L)	k		g	f	half up	27
(R)	j	crypt	g	f	half up	27
No. 1(L)	-	c	k	j	e	39
(R)	-	c	k	h	d/e	37/38
No. 4(L)	-	f	k	h	g/h	40/41
(R)	-	f	k	h	g/h	40/41

MWS Mandibular Wear Score (*sensu* Grant 1982)

L Left
R Right

TABLE 8: ESTIMATES OF WITHERS HEIGHTS

BASED ON METAPODIAL MEASUREMENTS

(using Zalkin, 1960)

METACARPALS

INDIV-IDUAL	SIDE	GREATEST LENGTH (GL) (in mm)		FACTOR (x GL)	WITHERS HEIGHT (in metres)
1	Left	240		6.12	1.47
	Right	238		6.12	1.46
3	Left	227	(UF)	6.12	1.39
	Right	228	(UF)	6.12	1.40
4	Left	227		6.12	1.39
	Right	226		6.12	1.38
5	Left	213	(UF)	6.12	1.30
	Right	213	(UF)	6.12	1.30

METATARSALS

INDIV-IDUAL	SIDE	GREATEST LENGTH (GL) (in mm)		FACTOR (x GL)	WITHERS HEIGHT (in metres)
1	Right	275		5.47	1.50
2	Left	240	(UF)	5.47	1.31
	Right	246	(UF)	5.47	1.35
3	Left	255	(UF)	5.47	1.39
	Right	256	(UF)	5.47	1.40
4	Right	265		5.47	1.45
5	Left	238	(UF)	5.47	1.30
	Right	238	(UF)	5.47	1.30

N.B. Measurements of bones marked '(UF)' are for the greatest length including the unfused distal epiphysis (held in place manually during measurement).

SUMMARY OF ESTIMATED WITHERS HEIGHTS

INDIVIDUAL	METACARPALS		METATARSALS	
1	1.46	1.47	1.50	
2(UF)			1.31	1.35
3(UF)	1.39	1.40	1.39	1.40
4	1.38	1.39	1.45	
5(UF)	1.30	1.30	1.30	1.30

N.B. The factors used here are Zalkin's (1960) factors for bones from animals of undetermined sex. Factors given by Zalkin for known sex bones are:

	Female	Castrate	Male
Metacarpal	5.98	6.13	6.24
Metatarsal	5.34	5.49	5.58

TABLE 10: WITHERS HEIGHTS USING COMPLETE LONG BONES AND MATOLCSI'S (1970) FACTORS

all measurements are given in metres

Element		HUMERUS	HUMERUS	RADIUS	M/CARPL	FEMUR	FEMUR	TIBIA	M/TARSL
Measure		GLC	GL	GL	GL	GLC	GL	GL	GL
Factor		x 4.77	x 4.14	x4.30	x 6.19[1]	x 3.47	x 3.23	x 3.45	x 5.45[1]
IND.	SIDE								
1	L	1.44		1.41	1.49	1.40		1.38	
1	R	1.48		1.43	1.47			1.41	1.50
2	L					1.17*			1.31*
2	R								1.34*
3	L	1.33*	1.23*		1.41*	1.26*	1.22*		1.39*
3	R	1.33*	1.22*		1.41*				1.40*
4	L	1.39	1.35	1.35	1.41	1.33	1.31		
4	R			1.33	1.40	1.32	1.33	1.32	1.44
5	L	1.15*		1.08*	1.32*			1.04*	1.30*
5	R			1.08*	1.32*	1.06*		1.03*	1.30*

[1] mean value for female + male factors

M/CARPL	METACARPAL
M/TARSL	METATARSAL
GL	Greatest Length
GLC	Greatest Length from Caput
IND.	INDIVIDUAL
L	Left
R	Right
*	unfused epiphysis/epiphyses held in place during measurement

SUMMARY OF WITHERS HEIGHT ESTIMATES:

Individual No.	Range	N	mean	Standard Deviation
1	1.38 - 1.50	10	1.44	0.0396
2*	1.17 - 1.34	3	1.27	0.0741
3*	1.22 - 1.41	10	1.32	0.0771
4	1.31 - 1.44	12	1.36	0.0407
5*	1.03 - 1.32	10	1.17	0.1200

TABLE 11: CATTLE METAPODIAL MEASUREMENTS

Measurements taken from von den Driesch (1976) except where stated.
All measurements in millimetres.

METACARPALS

IND.	FUSION	SIDE	Bp	SD	Bd(f)	Bd(c)	GL	HWARD'S IND 1 Bd(c) *100/ GL	HWARD'S IND 2 SD *100/ GL	Bd(c) *100/ Bd(f)
1	PF DF	L	78.4	41.1	70.4	72.0	240	30.0	17.1	97.6
1		R	79.0	40.5	70.3	72.8	238	30.6	17.0	103.6
2	PF DUF	L	70.5	32.9	66.8					
2		R		32.8						
3	PF DUF	L	72.2	37.6	70.4	70.4	227	31.0	16.6	100.0
3		R	71.0	37.5	70.6	70.1	228	30.7	16.4	99.3
4	PF DF	L	72.9	38.3	63.4	67.2	227	29.6	16.9	106.0
4		R	71.3	38.5	63.7	67.7	226	30.0	17.0	106.3
5	PF DUF	R	68.6	30.8	59.7	60.2	213	28.3	14.5	100.8
5		L	70.0	29.7			213		13.9	

HWARD'S IND	HOWARD'S INDEX
IND.	INDIVIDUAL
L	LEFT
R	RIGHT

METATARSALS

IND.	FUSION	SIDE	Bp	SD	Bd(f)	Bd(c)	GL	HWARD'S IND 1 Bd(c) *100/ GL	HWARD'S IND 2 SD *100/ GL	Bd(c) *100/ Bd(f)
1	PF DF	L		35.5	66.6	67.6				
1		R	63.4	36.1	67.2	68.6	275	24.4	13.1	102.1
2	PF DUF	L	56.1	28.5	62.2	66.1	240	25.9	11.9	106.3
2		R	55.9	28.8	63.4	64.1	246	25.8	11.7	101.1
3	PF DUF	L	59.7	31.6	68.6	65.5	255	26.9	12.4	95.5
3		R	58.1	31.5	67.7	64.8	256	26.4	12.3	95.7
4	PF DF	R	61.2	33.3	60.7	63.3	265	22.9	12.6	104.3
5	PF DUF	L	56.7	25.8	59.2		238	24.9	10.8	
5		R	56.8	26.1	58.3		238	24.5	11.0	

Bd(f) distal breadth across fusion surface of metaphysis
Bd(c) distal breadth across condyles

Howard's Index 1: taken from Howard (1963: 92). Originally stated as DB/L this is the same as

$$\frac{Bd(c) \times 100}{GL}$$

Howard's Index 2: taken from Howard (1963: 93). Originally stated as MB/L this is the same as

$$\frac{SD \times 100}{GL}$$

$\frac{Bd(c) \times 100}{Bd(f)}$ is a measure of the degree of splaying shown by the distal metapodial

TABLE 14: PUBIC MEASUREMENTS AND INDICES

(all measurements are in millimetres)

INDIVID.	FUSION STATE	SIDE	PB	PL	PB*100 /PL	MSW	MSB	MWS /MSB
1	ACET Fsd	L	39.0	97.6	40.0	28.0	20.1	1.39
2	ACET UF	L	32.5	*c*57.0	*c*57.0	29.5	15.7	1.88
3	ACET Fsg	L	35.2	66.4	53.0	33.2	16.4	2.09
		R	36.6	68.1	53.7	33.6	16.1	2.02
4	ACET Fsd	L	*c*38.2	101.5	*c*37.6	30.8	20.9	1.47
		R	39.5	100.6	39.3	32.0	21.8	1.47
5	ACET UF	R	32.9	54.1	60.8	28.0	18.7	1.50

PB	Pubic Breadth (West, 1990)
PL	Pubic Length (West, 1990)
MSW	Midshaft (pubic) Width (see text & Table 15)
MSB	Midshaft (pubic) Breadth (see text & Table 15)
INDIVID.	INDIVIDUAL
ACET	ACETABULUM
Fsd	Fused
Fsg	Fusing
UF	Unfused
L	Left
R	Right

TABLE 15: PELVIS MEASUREMENTS

all measurements are in millimetres
and follow the methods of von den Driesch (1976)

IND.	FUSION	SIDE	LA	LFo	SH	SB	SB*100 /SH	ACET. MED.RIM Grigson	ACET. RIM Payne	MIN.WIDTH CAUDAL PUBIS	VISUAL ASSESSMENT
1	A.Fsd	L	89.9	108.9	55.4	38.0	68.6	32.0	14.7	22.7	male
2	A.UF	L			41.7	26.8	64.3	>17.0	c19.7	12.8	male
3	A.UF	L	91.2		43.9	30.5	69.0	21.1	21.1		male
3		R	92.9		45.7	30.9	67.6	21.8	20.6	16.7	male
4	A.Fsd	L	86.9		53.0	34.7	62.3				female
4		R	87.4	103.4	54.4	33.4	62.9	5.2	9.2	24.5	female
5	A.UF	L			38.4	24.4	63.5	20.9	19.8	<19.8	male
5		R			38.4	24.6	64.1	20.1	19.7		male

KEY:

IND.	INDIVIDUAL
ACET. MED.RIM	ACETABULUM MEDIAL RIM
A	ACETABULUM
Fsd	FUSED
UF	UNFUSED
L	LEFT
R	RIGHT

Grigson (1982); Payne (n.d.)

NOTE: see text for which morphological characteristics were used in the visual assessments.

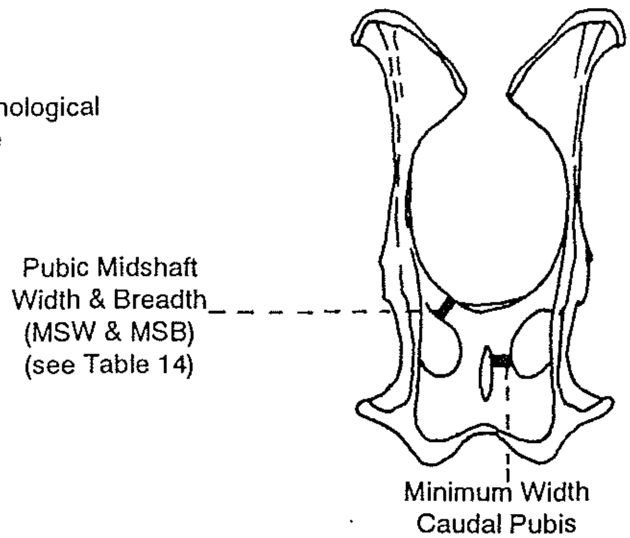


FIGURE 1: Location map of St. Giles by Brompton Bridge, North Yorkshire

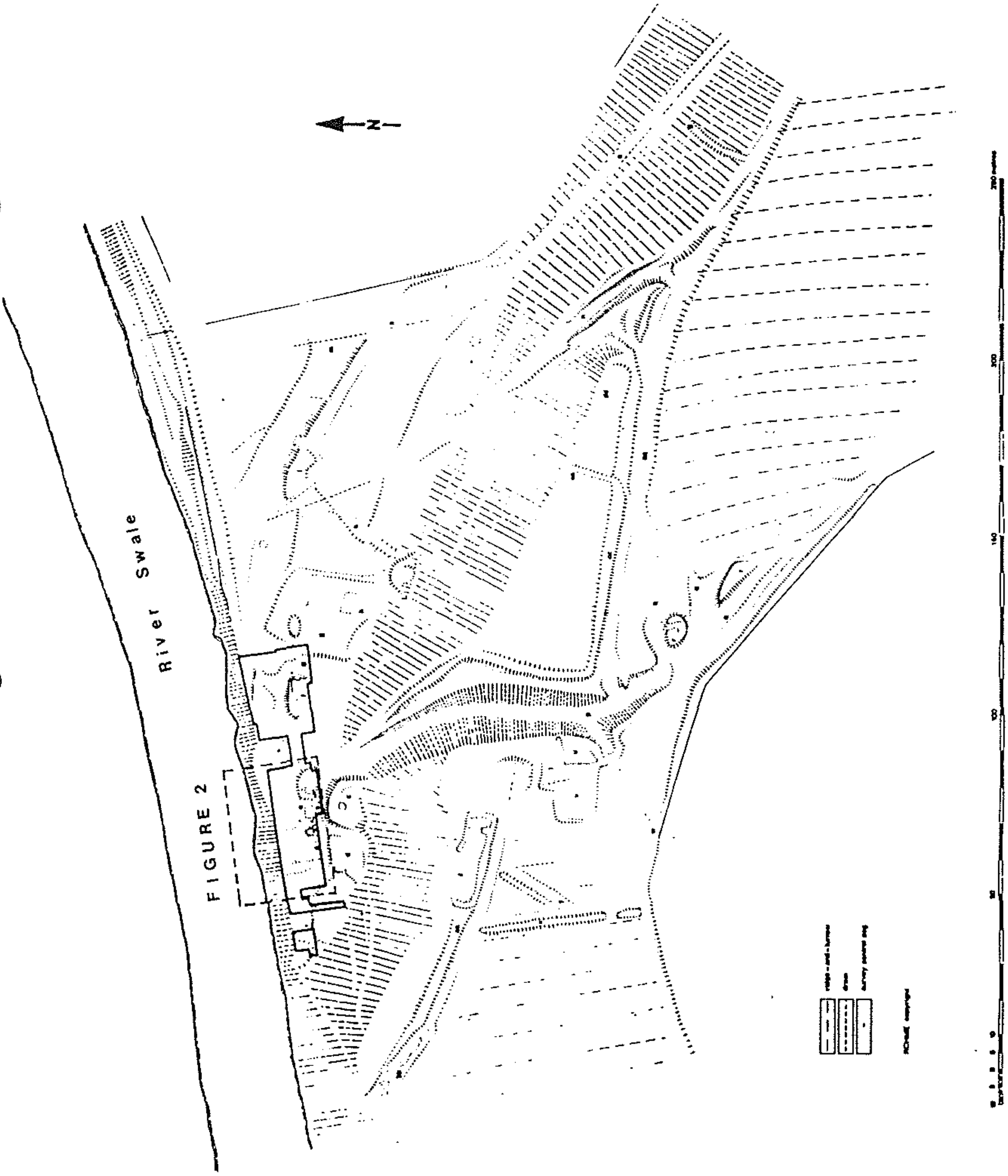


FIGURE 2: SUMMARY SITE PLAN SHOWING LOCATION OF RIVER,
MAJOR STONE BUILDINGS AND THE BURIAL PITS

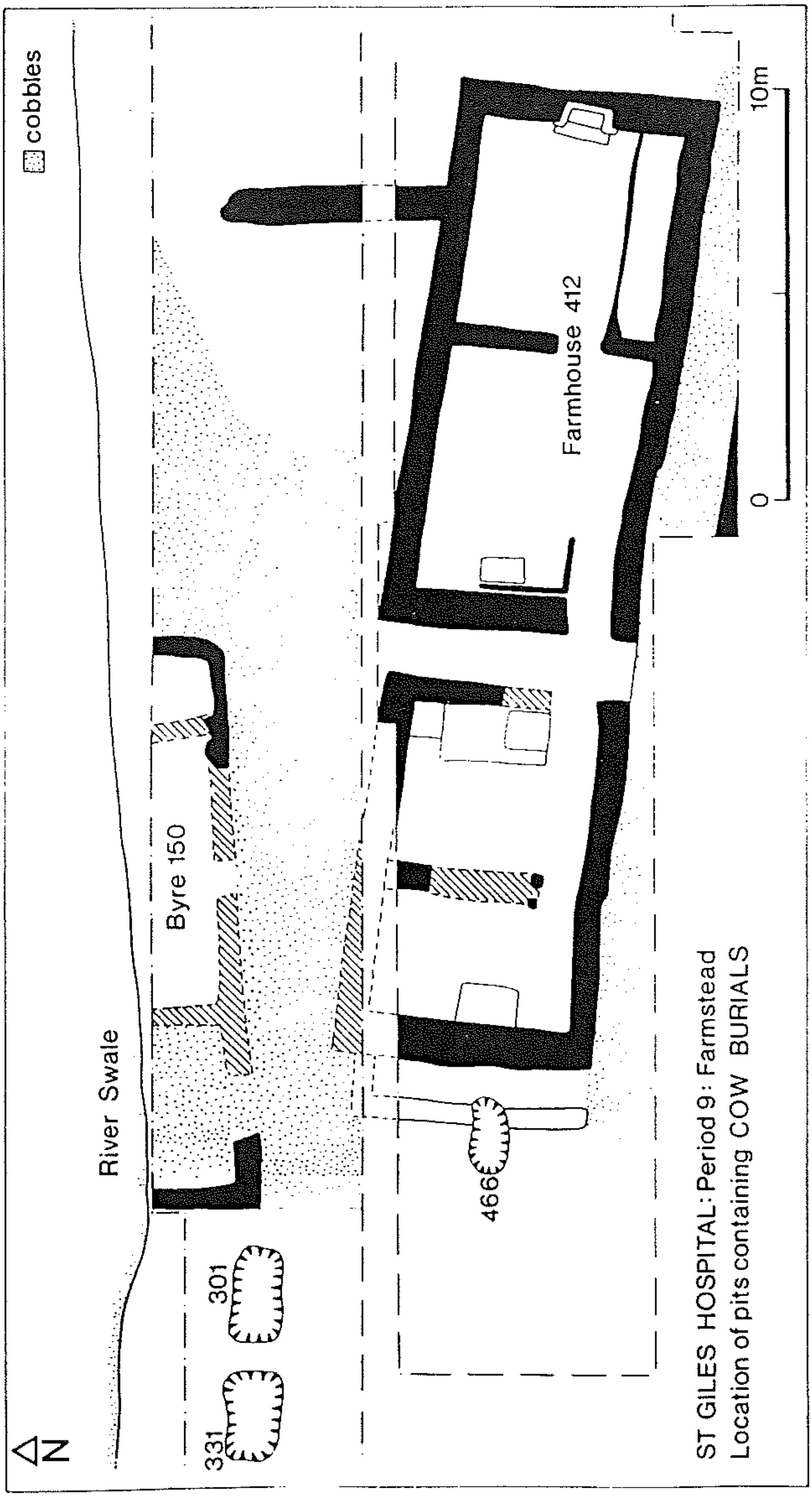
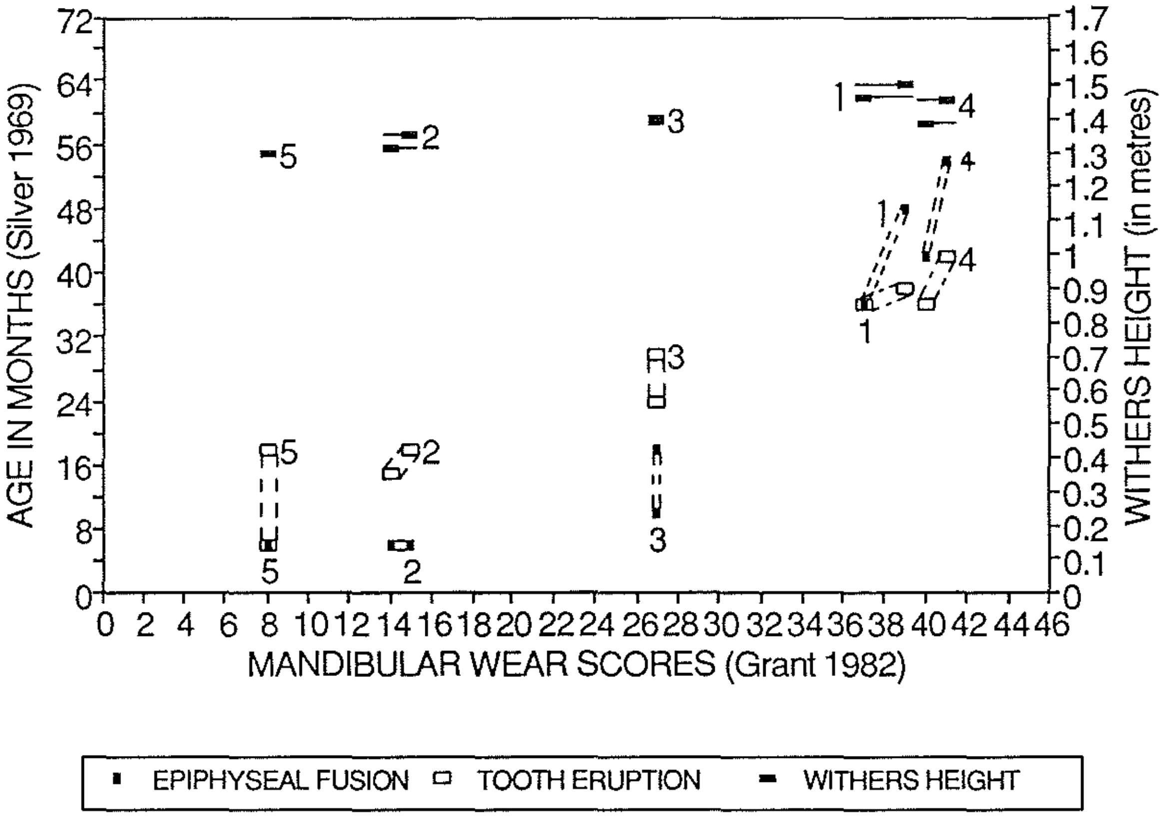


FIGURE 3: ESTIMATES OF AGE AT DEATH AND WITHERS HEIGHTS

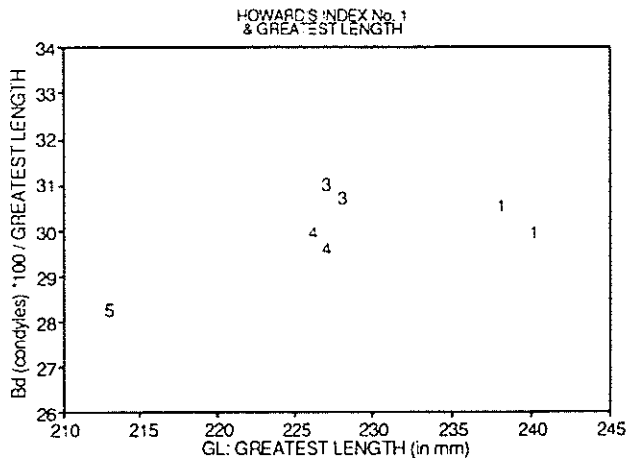


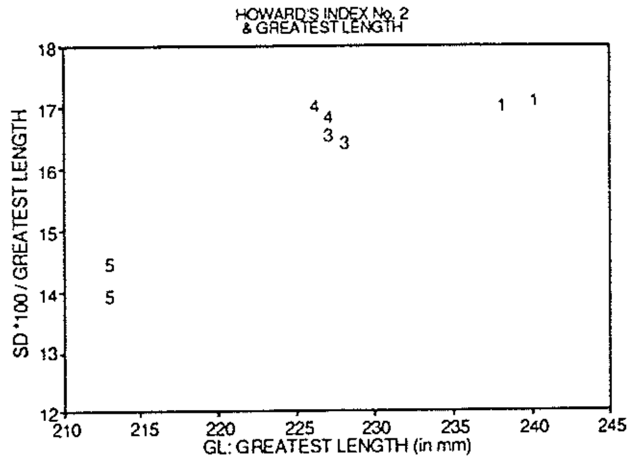
ages for epiphyseal fusion and tooth eruption are all taken from Silver's (1969) modern data,

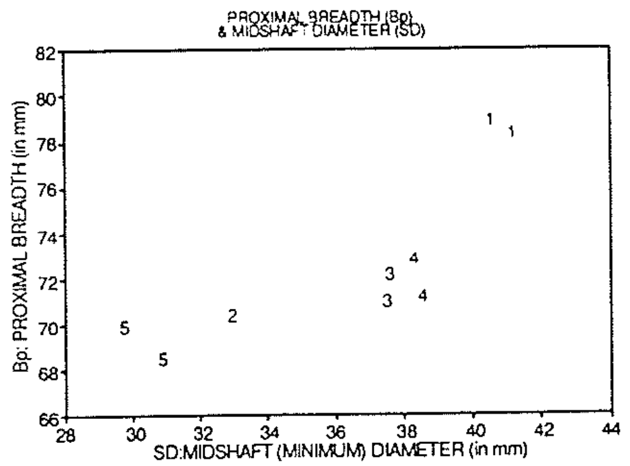
Mandibular Wear Scores are taken from Grant (1982),

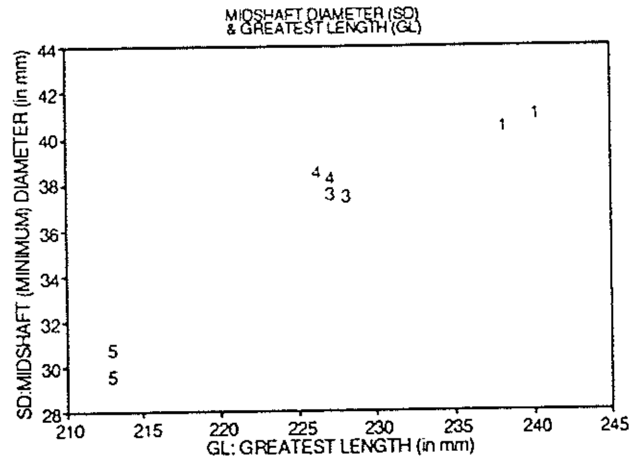
and withers heights are calculated according to Zalkin (1960)

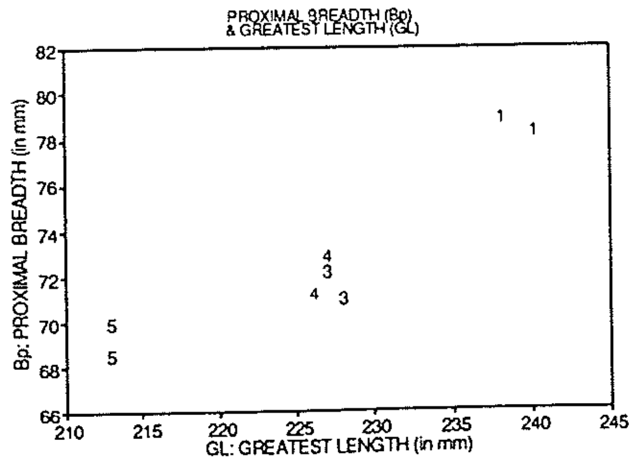
FIGURE 4: MEASUREMENTS OF METACARPALS (continued...)











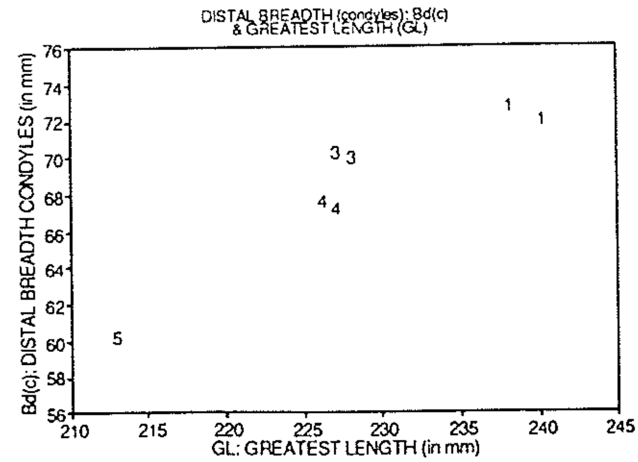
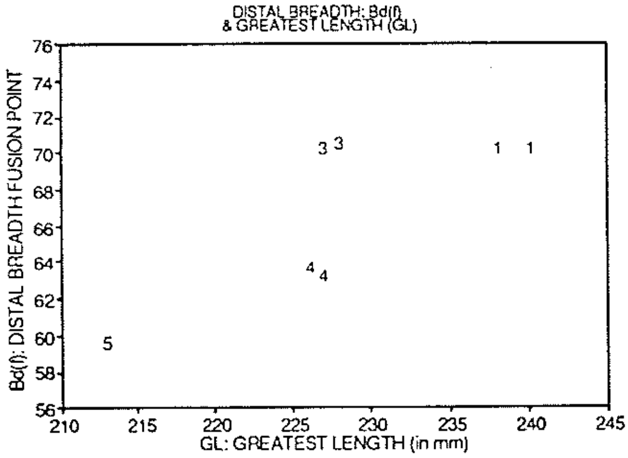
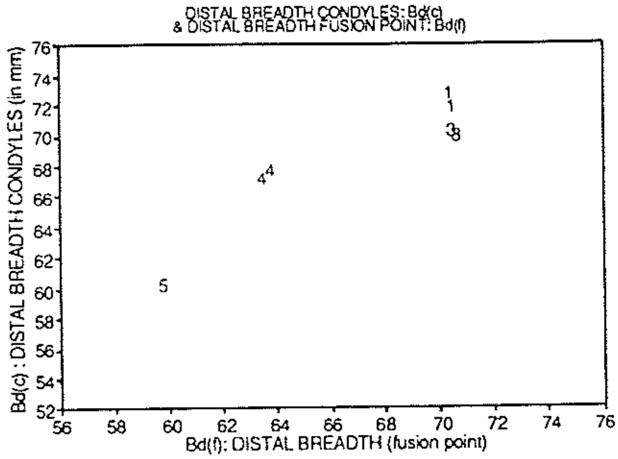


FIGURE 4: MEASUREMENTS OF METACARPALS (...continued)





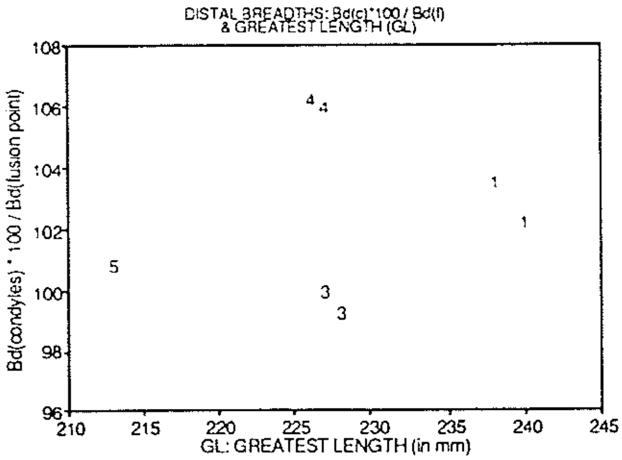


FIGURE 5: MEASUREMENTS OF METATARSALS (continued...)

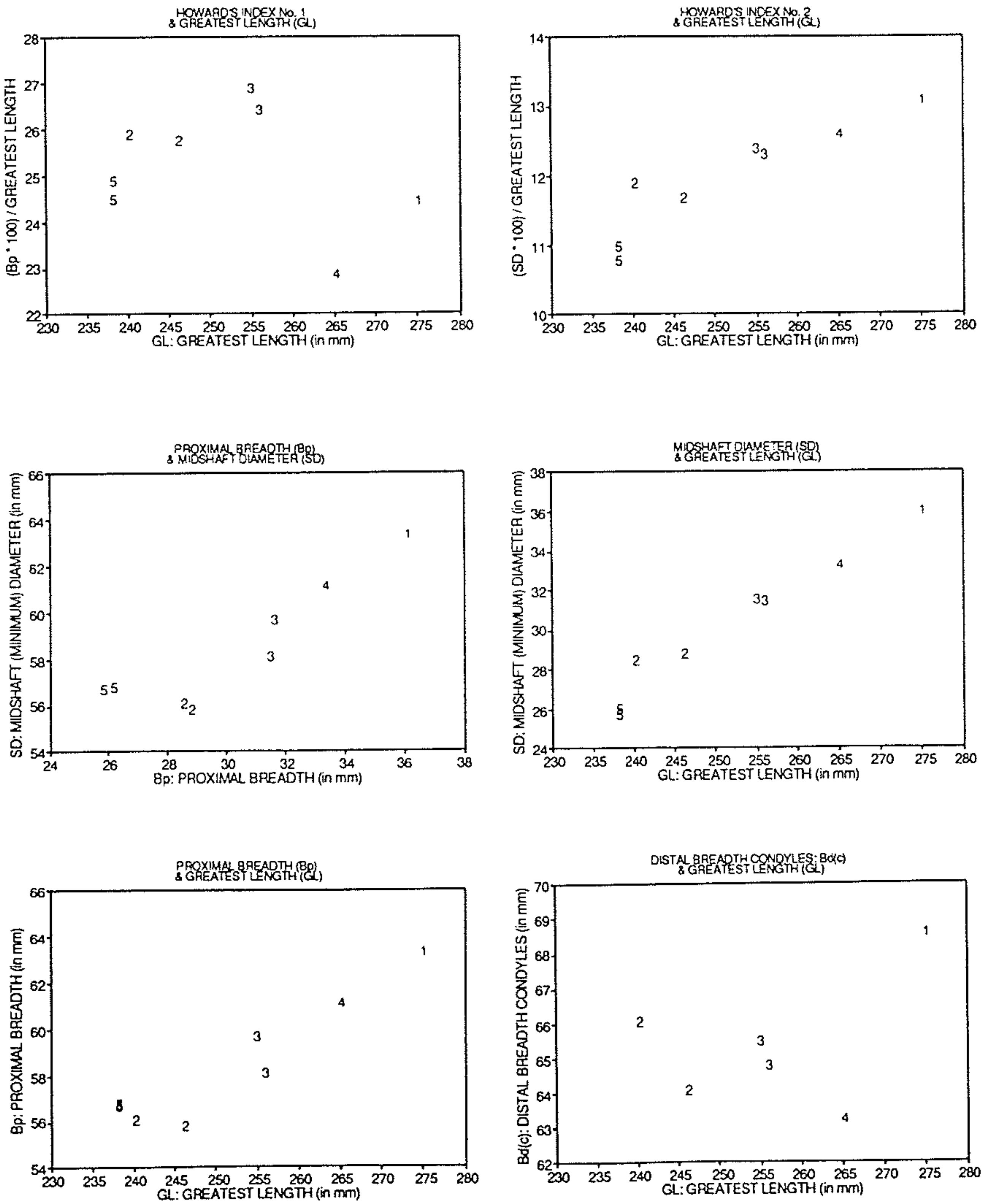
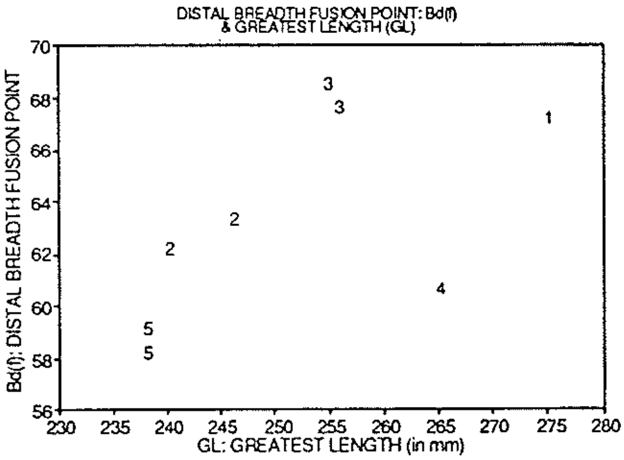
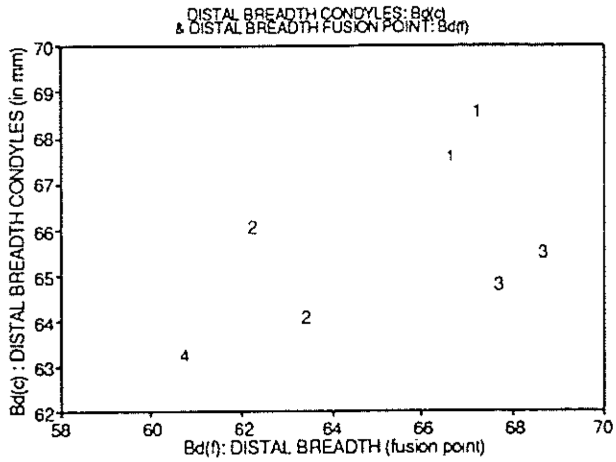


FIGURE 5: MEASUREMENTS OF METATARSALS (...continued)





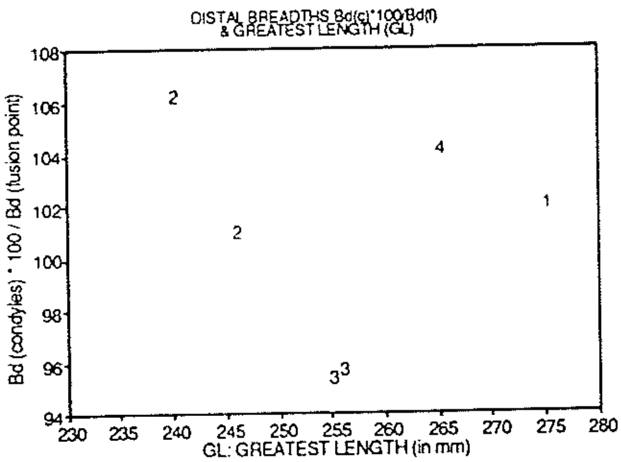
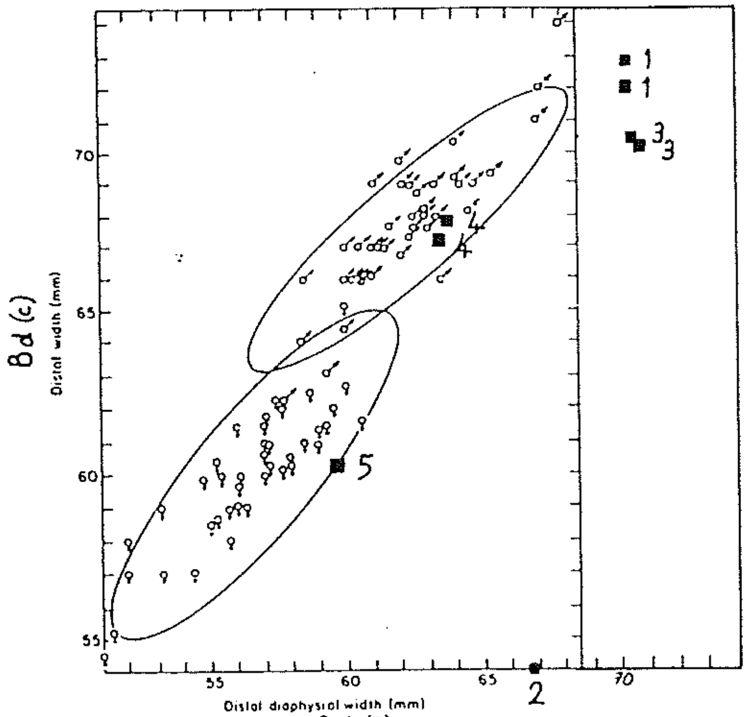
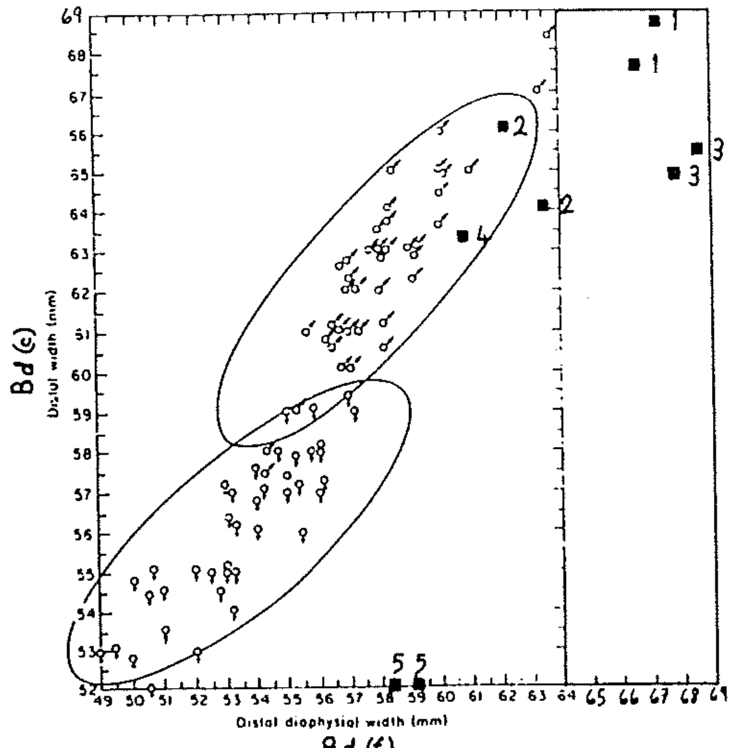


FIGURE 6: A comparison of the St. Giles distal metapodial breadths with Higham's (1969) measrements of metapodials from modern Aberdeen Angus cows and steers

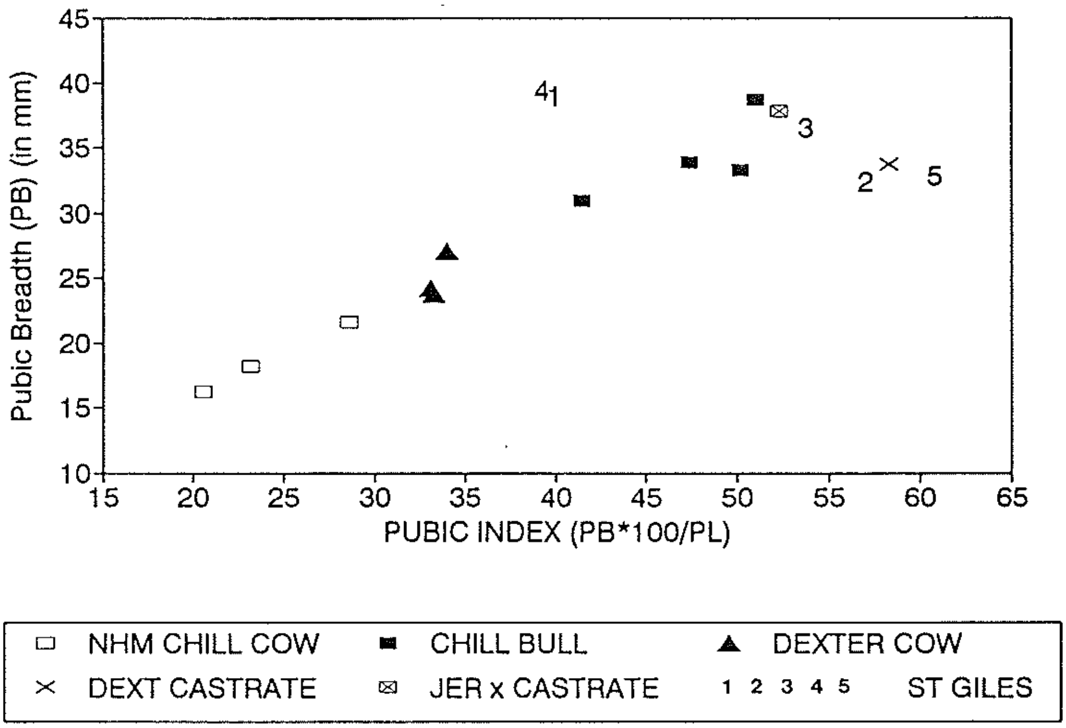


Aberdeen Angus metacarpals from cows and steers: scatter diagram of distal width against distal diaphysial width. The equal probability ellipses are calculated with $P = 0.05$.



Aberdeen Angus metatarsals from cows and steers: scatter diagram of distal width against distal diaphysial width. The equal probability ellipses are calculated with $P = 0.05$.

FIGURE 7: Pubic Breadth and Pubic Index measurements of pelves (*sensu* West, 1990)



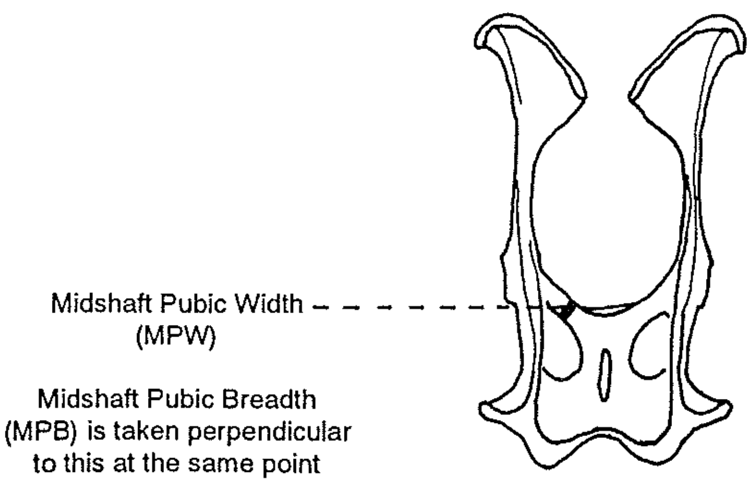
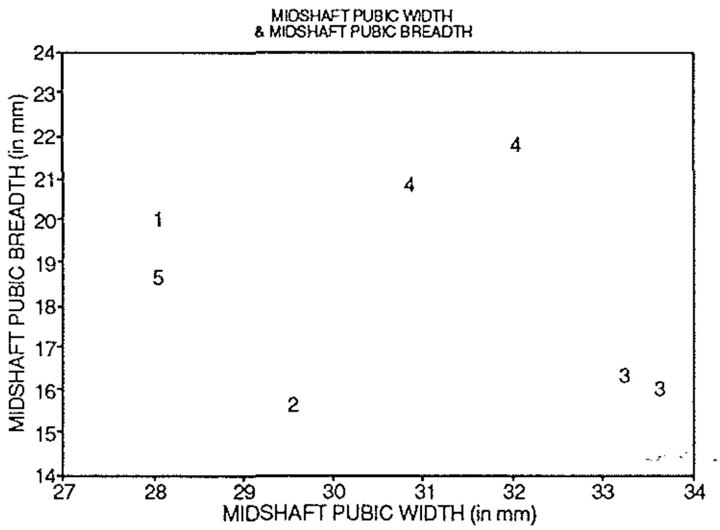
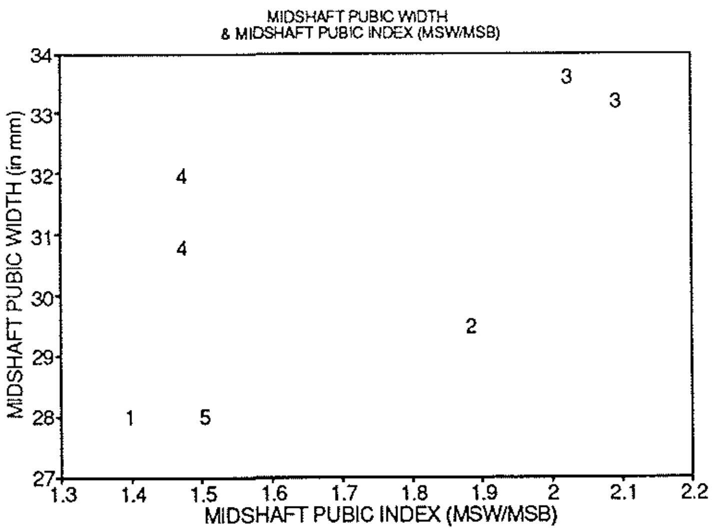


FIGURE 8: MIDSHAFT PUBIC WIDTH AND BREADTH MEASUREMENTS





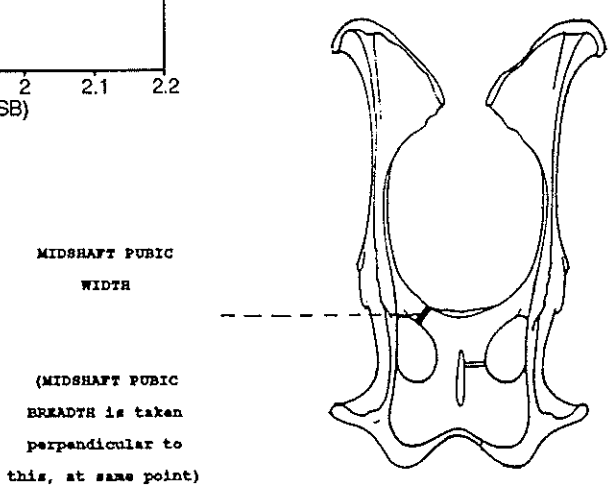
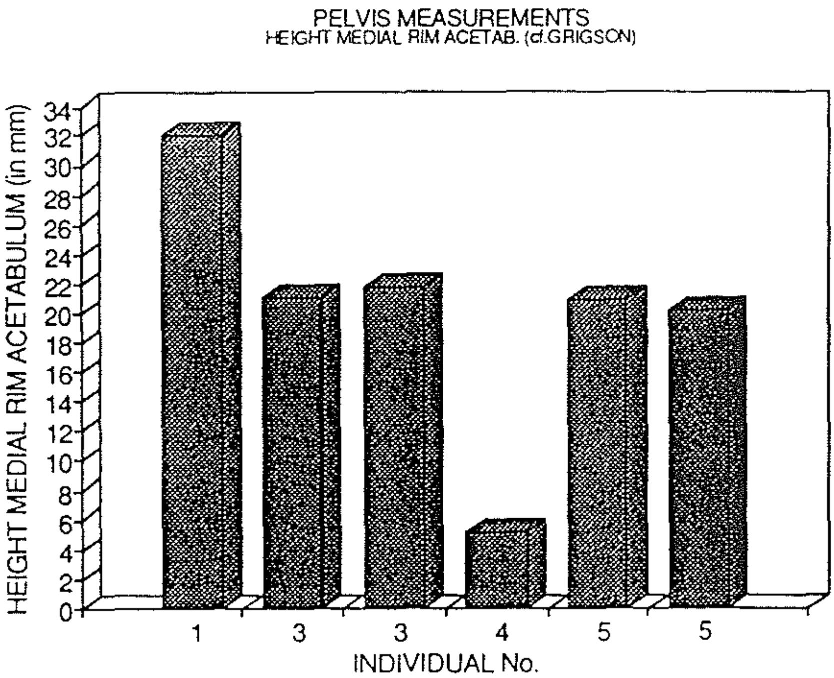
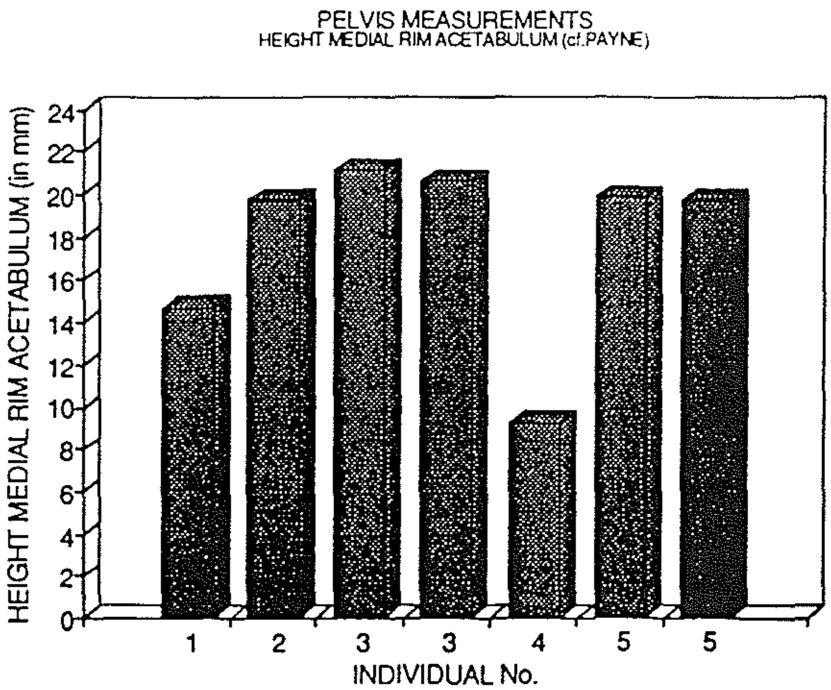


FIGURE 9: HEIGHTS OF THE MEDIAL RIM OF THE ACETABULUM
(*sensu* Grigson, 1982, and Payne, n.d.)





APPENDIX 1: MEASUREMENTS OF THE BONES OF THE POST-MEDIAEVAL CATTLE BURIALS

all measurements are in millimetres except for withers heights (which are in metres)

all measurements follow von den Driesch (1976) unless stated otherwise

SCAPULA

IND.	FUSION	SIDE	GLP	LG	SLC	NECK HEIGHT	HS	DHA
1	PF	L	87.0	73.9	67.5	51.4	370	
1	PF	R	87.2	73.6	67.7	56.8	367	
2	UF	L			c61.6	49.5		280
2	UF	R				50.1		280
3	Fsg	L	87.7	71.6	54.8			315
3	Fsg	R	89.5	74.6	57.1			
4	PF	L	85.5	68.6	64.8		379	383
4	PF	R	83.8	66.9	66.0		386	427
5	UF	L			44.4			
5	UF	R			47.3	43.2		242

HUMERUS

IND.	FUSION	SIDE	Bp	SD	Bd	BT	HT	GLC	GL	WITHERS HEIGHT (GLC x 4.77)	WITHERS HEIGHT (GL x 4.14)
1	PFsg DF	L	134.5	46.9	102.0	91.9	56.1	301		1.44	
1	PFsg DF	R	128.0	48.0	103.3	90.8	56.9	c311		c1.48	
2	PUF DUF	L		39.3	[81.2]						
2	PUF DUF	R		38.9	[88.9]						
3	PUF DFsg	L		43.5	105.2	90.6	58.4	279	296	1.33	1.23
3	PUF DFsg	R		43.6	105.5	90.7	58.6	278	295	1.33	1.22
4	Pvis DF	L	128.5	44.8	103.5	89.5	54.3	291	326	1.39	1.35
4	Pvis DF	R	128.9	45.3		91.0	54.1				
5	PUF DUF	L		33.7		86.6	51.6	241		1.15	
5	PUF DUF	R		33.6				241		1.15	

IND.: INDIVIDUAL; NECK HEIGHT: height from glenoid to start of spine;
P: PROXIMAL; D: DISTAL;
F: FUSED; UF: UNFUSED;
Fsg: FUSING; vis: FUSION LINE STILL VISIBLE;
L: LEFT; R: RIGHT
HT: maximum height of distal trochlea (measured on the medial edge perpendicular to BT)
[ ]: unfused bone measured

factors for calculations of withers heights are taken from Matolcsi, 1970

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge

RADIUS

IND.	FUSION	SIDE	Bp	BFp	SD	Bd	BFd	HD	GL	WITHERS HEIGHT (GL x 4.30)
1	PF Dvis	R	99.9	89.7	52.9	94.1	85.3	61.4	329	1.41
1	PF DFvis	L	103.3	91.7	52.1	95.2	84.2	62.0	333	1.43
2	PUF DUF	L		[78.3]	41.6	[78.8]				
2	PUF	R		[79.4]	41.9					
3	PFsg DUF	L	96.9	88.9	45.3	88.0	84.2			
3	PFsg DUF	R	97.3	87.9	44.8	83.8	84.9			
4	PF DF	L	98.6	90.6	52.5	88.6	85.7		313	1.35
4	PF DF	R	100.3	91.4	51.2	90.1	85.5		310	1.33
5	PUF DUF	L		81.6	37.7	80.1	82.1	53.1	250	1.08
5	PUF DUF	R	85.6	82.3	37.3	78.6	82.5	52.2	250	1.08

ULNA

INDIVIDUAL	FUSION	SIDE	SDO	GL RADIUS + ULNA
1	PFsg DUF	L	67.2	
1	PFsg DUF	R	66.5	440
4	PF DF	L	62.9	427
4	PF DF	R	62.6	420
5	PUF	R	57.3	

IND.:	INDIVIDUAL;		
P:	PROXIMAL;	D:	DISTAL;
F:	FUSED;	UF:	UNFUSED;
Fsg:	FUSING;	vis:	FUSION LINE STILL VISIBLE;
L:	LEFT;	R:	RIGHT
HD:	maximum height of distal end (measured perpendicular to BFd)		
[ ]:	unfused bone measured		

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge

FEMUR

IND.	FUSION	SIDE	DC	SD	Bd	GLC	GL	WITHERS HEIGHT (GLC x 3.47)	WITHERS HEIGHT (GL x 3.23)
1	PFsg DFsg	L	60.3	45.6	113.0	404	>411	1.40	>1.33
2	PUF DUF	L	57.1	35.2	107.6	337		1.17	
2	PUF DUF	R			106.2				
3	PUF DUF	L	58.4	39.7	108.3	362	378	1.26	1.22
3	PUF DUF	R	59.3	38.9	108.				
4	Pvis Dvis	L	60.4	45.7	113.0	382	407	1.33	1.31
4	Pvis Dvis	R	60.9	44.8	113.0	380	412	1.32	1.33
5	PUF DUF	R				306		1.06	

TIBIA

IND.	FUSION	SIDE	Bp	SD	Bd	Dd	GL	WITHERS HEIGHT (GL x 3.45)
1	PFsg DF	L	123.7	52.4	81.9		400	1.38
1	PFsg DF	R	122.2	52.6	80.4		408	1.41
2	PUF DUF	L	106.2		72.3			
2	PUF DUF	R	109.5		71.2			
3	PUF DUF	L	109.4	44.2	74.2	56.9		
3	PUF DUF	R	110.1	44.1	74.5	55.7		
4	Pvis DF	R	117.0	48.1	79.4	59.0	382	1.32
5	PUF DUF	L		37.5	[63.6]	[42.1]	300	
5	PUF DUF	R	105.2	37.1	[62.0]	[42.7]	299	

PATELLA

INDIVIDUAL	SIDE	GB	GL
1	L	65.1	79.0
1	R	66.7	78.7
3	L	60.9	72.6
3	R		73.0
4	R	66.3	74.6

IND.: INDIVIDUAL;
P: PROXIMAL; D: DISTAL;
F: FUSED; UF: UNFUSED;
Fsg: FUSING; vis: FUSION LINE STILL VISIBLE;
L: LEFT; R: RIGHT
Dd: depth of distal end (measured perpendicular to Bd)
[ ]: unfused bone measured

factors for calculations of withers heights are taken from Matolcsi, 1970

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge

OS MALLEOLARE

INDIVIDUAL	SIDE	GD
2	L	40.1
2	R	40.1
3	L	39.9
3	R	40.1
4	L	42.0

ASTRAGALUS

INDIVIDUAL	SIDE	Bd	GLl
1	L	54.7	86.6
1	R	57.5	84.6
2	L	51.2	82.8
2	R	52.8	83.8
3	L	52.8	84.6
3	R	52.3	84.3
4	L	56.4	83.8
4	R	56.3	84.2
5	L	52.0	83.8
5	R	52.1	83.1

CALCANEUM

INDIVIDUAL	FUSION	SIDE	SD	GL
1	F	L	38.6	168
1	F	R	40.1	169
2	UF	L	34.6	144
2	UF	R	34.7	145
3	UF	L	34.0	154
3	UF	R	34.1	155
4	F	L	37.3	163
5	UF	L	32.8	
5	UF	R	32.3	[125]

F:	FUSED;	UF:	UNFUSED;
Fsg:	FUSING;	vis:	FUSION LINE STILL VISIBLE;
L:	LEFT;	R:	RIGHT
[125]:	is an approximate measurement		

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge

NAVICULO-CUBOID

INDIVIDUAL	SIDE	GB
1	L	74.1
2	L	66.0
2	R	65.4
3	L	67.3
3	R	65.6
4	L	69.3
4	R	71.2
5	L	68.1
5	R	66.8

ATLAS

INDIVIDUAL	GB	GL	BRcr	BFcd
1	170.5	109.7	120.5	113.8
3			108.0	115.2
4	180.0		108.3	123.9

AXIS

INDIVIDUAL	BRcr	BFcd
1	111.1	[58.7]
4	106.4	

[ ]: unfused bone measured

Post-Mediaeval cattle burials from St. Giles by Brompton Bridge

ANTERIOR FIRST PHALANGES

INDIVIDUAL	FUSION	POSITION	Bp	GLpe
1	F	medial	35.8	70.4
1	F	medial	37.5	71.7
1	F	lateral	34.8	72.2
2	UF	lateral	32.8	
3	UF	medial	35.9	72.8
3	UF	medial	35.7	73.1
3	UF	lateral	34.4	72.5
3	UF	lateral	34.5	72.2
4	F	medial	33.5	66.8
4	F	medial	34.3	66.4
4	F	lateral	34.4	66.5
4	F	lateral	33.9	68.4

POSTERIOR FIRST PHALANGES

INDIVIDUAL	FUSION	POSITION	Bp	GLpe
1	F	medial	35.4	72.8
1	F	lateral	35.3	73.0
2	UF	medial	31.6	70.1
2	UF	lateral	31.6	69.3
3	UF	medial	32.4	76.2
3	UF	medial	34.1	76.7
3	UF	lateral	32.1	77.1
3	UF	lateral	32.2	75.6
4	F	medial	32.2	68.5
4	F	medial	32.0	70.3
4	F	lateral	32.4	70.7
4	F	lateral	31.6	69.7

?anterior or posterior first phalanges

INDIVIDUAL	FUSION	POSITION	Bp	GLpe
5	UF	?	31.9	
5	UF	?	30.3	62.2
5	UF	?	30.0	63.5
5	UF	?	30.5	63.0

F: FUSED; UF: UNFUSED;