93

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Report 133/91

A COMPARISON OF THE MEASUREMENTS OF ROMANO-BRITISH ANIMAL BONES FROM PERIODS 3 AND 5, RECOVERED FROM EXCAVATIONS AT ANNETWELL STREET, CARLISLE

Ms Sue Stallibrass

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Summary

Measurements of animal bones recovered by hand during excavations in the early 1980s of parts of two sequential Roman timber forts at Annetwell Street, Carlisle, are presented and compared. The collections date to the site's Period 3 (*circa* AD 73/74 - AD 100/105) and Period 5 (AD 00/05 - AD 140). Both collections are dominated by the bones of domestic cattle, which are very similar in shape and size to those of the 'Celtic shorthorn' (*sensu* Jewell, 1963) that were common throughout Britain in the Iron Age. There is no evidence for any overall increase in size, nor for the admixture of larger animals in either collection. Several measurements are used in an attempt to ascertain the sex ratios represented by the cattle bones. In a comparison with collections of cattle bones from other Romano-British and/or Iron Age sites, the importance of comparable sex ratios is demonstrated. Bones of sheep and sheep/goat are quite well represented in both Annetwell Street collections (goat bones are very rare). Their measurements are very similar to those from Iron Age sites, and show no evidence of any influx of larger types. Most of the pig bones measured are from immature animals, and there is no evidence in either period for the presence of particularly large (??wild) animals. A few bones of red deer, roe deer, horse, and dog were present and their measurements are given in Appendix 1.

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LIST OF CONTENTS

MEASUREMENTS FROM ANNETWELL STREET PERIODS 3 AND 5

LIST OF TABLES

ANNETWELL STREET PERIODS 3 AND 5 MEASUREMENTS

LIST OF FIGURES

A COMPARISON OF THE MEASUREMENTS OF ROMANO-BRITISH ANIMAL BONES FROM PERIODS 3 AND 5, RECOVERED FROM EXCAVATIONS AT ANNETWELL STREET, CARLISLE

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Mrs Janet Bradley extracted and measured the animal bones from Periods 3 and 5, and input the data onto an Opus personal computer using DBASE III Plus. The identifications of these bones were checked by Ms Louisa Gidney and myself. Mrs Bradley was employed as a technician to work on the Annetwell Street material by curtesy of English Heritage, who generously transferred the money saved from my salary during a prolonged period of ill health, to enable work to continue on the Annetwell Street material.

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INTRODUCTION

The site

The first timber fort at the Annetwell Street site dates to *circa* AD73/74 - AD 100/105. This is the site's Period 3. A full specialist report on the hand-recovered and sieved animal bone collection has been written by the author, and should be available as an Ancient Monuments Laboratory report (Stallibrass, 1991). Information from the AML report has been incorporated by Mrs. J.P. Huntley into her environmental synthesis for the whole site (Huntley, in Caruana, n.d.).

Material from Period 3 was all waterlogged, and the 9000 hand-recovered and 4000 sieved bone fragments studied are nearly all in an excellent state of preservation (ie: they are robust and retain full surface details of anatomical traits and butchery evidence etc.).

A second timber fort was constructed on top of the earlier fort, after a short period of demolition (and a possible brief hiatus). This second timber fort, Period 5, was in use approximately between AD 100/105 and AD 140. The majority of this material has been waterlogged, but a substantial minority of it derives from levels that have, at least periodically, dried out. The preservation of material from these deposits is not as good as that from the waterlogged levels. Given the logistical constraints on the specialist time available, material from Period 5 was considered to be of lower priority than that from Period 3. There has, therefore, been no overall cataloguing of the material (although, like that from Period 3, the collection is clearly dominated by bones of cattle, together with those of sheep/goat and pigs).

This second timber fort was subsequently dismantled and the area disused, apart from isolated kilns etc..

A third Roman fort was built in stone in *circa* AD 320-330, above the remains of the two earlier timber forts. Material from this fort (Period 9) is poorly preserved due to the dry nature of the deposits. The bones are dry, brittle and friable, and have lost substantial areas of their surfaces. Their brittleness has also led to a relatively high degree of fragmentation. The hand-recovered collection, therefore, is probably severely biased due to the loss of smaller and thinner bones, especially those of juveniles, and the higher degree of fragmentation and surface erosion render them unsuited to metrical analysis.

The main aims of this report.

The main purposes of this analysis are to investigate:

(1) if new, larger types of cattle and/or sheep were introduced to Northwest England during the period of Roman military occupation at Carlisle in the first or early second centuries AD (as suggested by Howard, 1962 and Luff, 1982).

(2) if so: (a) when did this new introduction occur (ie: during the first timber fort's use, or sometime between then and the second timber fort?)

(b) were new types of cattle and sheep introduced simultaneously, or did cattle precede sheep, or *vice versa*?

(3) are any of the pig bones large enough to be from wild rather than domestic pigs?

The collection of animal bones from Period 3 contained very few bones identified to other species (ie: horse, red deer, roe deer, hare, dog and cat). Measurements for these species, where appropriate, are given in Appendix I.

The animal bones from Annetwell Street, Carlisle, form an important collection of early Romano-British material from a military establishment at the limits of the Roman empire. They merit a more detailed examination than is possible here, due to constraints on time and personpower. This report, therefore, will be essentially descriptive, and will confine itself to 'internal' analysis. However, additional Romano-British material from Carlisle has already been recovered and recorded (but not analysed) from the Castle Street site (Rackham, unpublished data). This material derives from an annexe to the fort, and forms an important comparison with the Annetwell Street material. Other collections have been made from other sites in Carlisle, and it is hoped that, at some time in the future, a fuller study of the Romano-British animal bone material from Carlisle may be undertaken.

Comments on the uses and abuses of measurements of animal bones.

Problems with interpreting animal bones measurements are numerous and often, as yet, unresolvable. The two main problems concern the sexes and the ages of the animals.

(1) Variation due to sex.

Besides individual variation within a herd, there is almost certain to be variation due to the presence of animals of different sexes (ie: females, entire males and castrated males). Since it is seldom possible to identify the sex of an animal from a single (probably incomplete!) element, the measurements from females, castrates and entire males cannot usually be separated by means independent of the measurements. The use of the measurements themselves to identify sex is often a circular argument. When measurements of modern animals have been studied, they have often failed to show clear differences between the known sexes, due to large areas of overlap in the ranges (eg: Higham, 1969). This problem may be exacerbated by the possibility of epiphyseal fusion being delayed in castrated animals.

(2) Variation due to age.

Variation in size can also be due to the age of the animal and the degree to which it has reached its full potential mature size. As yet, the degree to which each element continues to grow after the fusion of any epiphyses and tuberosities has been completed is not fully documented. Smaller measurements, therefore, even of fused epiphyses, may reflect the presence of young animals rather than the presence of smaller types or breeds.

(3) Variation due to nutritional status.

A third factor that may affect the final size of an element is the standard of nutrition enjoyed (or not) by the animal. Poor nutrition can prevent an animal from attaining its full potential adult size, although excessive nutrition cannot lead to an animal attaining a size greater than that permitted by its genetic constitution. Thus, the presence of many small animals may reflect their genetic predisposition for a small size, or may reflect a poor standard of nutrition. This latter should be checked through independent criteria such as indications of stress in the growth of the animal, dental disorders or excessive wear on the teeth etc. etc..

In the case of the Annetwell Street, Period 3, collection of cattle bones, there is very little externally-apparent evidence of stress or poor nutrition (Stallibrass, 1991), and the Period 5 measured collection appears similarly well-husbanded.

In order to be able to compare two collections of bone measurements, various factors need to be kept constant ie: since the size of an animal can be related to its sex, the two collections need to consist of similar sex ratios if their size distributions are to be interpreted as reflecting non-sexual characteristics such as 'breed' type. For this reason, this report contains much description of the distributions of the measurements from each period, in an attempt to establish the sex ratios. If these are not similar, any suggestion that the average size of the animals changed through time may be invalid.

The measurements of these Romano-British bones, from Annetwell Street, Periods 3 and 5 are presented here as an archive that will need re-interpretation in the future, when knowledge and understanding of the relevant effects of sex, age, nutrition etc. have increased.

The interpretations given in this report are tentative, and rest on circumstantial evidence and intelligent guesswork. Even when they appear to be plausible, they must not be taken as proven!

THE MATERIAL.

Period 3.

Of the 5176 bones identified as cattle, sheep/goat or pig in the Period 3 hand-recovered collection, 1081 (21%) are measureable to some degree. The proportions vary with the species, mainly due to the degree of butchery incurred ie: 606/3636 (17%) of the cattle bones are measureable, as are 112/641 (17%) of the pig bones and 363/899 (40%) of the sheep/goat bones. Within the category of sheep/goat, many of the more complete bones can be identified specifically to sheep or goat. The ratios of these that can be measured are: 248/280 (89%) of the sheep bones and 8/13 (62%) of the goat bones, plus 107/606 (18%) of the bones that can only be identified to sheep/goat.

Period 5.

Comparable statistics are not available for the Period 5 collection, since the non-measureable bones have not been catalogued.

THE MEASUREMENTS.

The measurements have been taken in accordance with von den Driesch (1976) unless stated otherwise, and Figure 70 shows how these other measurements were taken.

THE RESULTS

CATTLE BONE MEASUREMENTS:

PERIOD 3

Comments on the Period 3 hand-recovered collection of cattle bones.

The cattle bones from Period 3 show an unusually high incidence of congenital traits, which suggests that the animals derive from a restricted gene pool. In particular, there are high rates of congenital absence of the second permanent premolar in the mandible, of lower third molars with only two columns, and of articular surfaces with minor, non-pathological lesions (see Stallibrass, 1991).

Descriptions and measurements of the horncores have been given in the full report (Stallibrass, 1991). They are all either small or short (*sensu* Armitage & Clutton-Brock, 1976), and appear to be of the so-called 'Celtic' shorthorn type.

It was expected, therefore, that the measurements of other bones would show that at least a substantial portion of the cattle bone measurements would fall within a similarly restricted range. If larger cattle had been introduced in this period, they would be expected to show as a larger group, possibly not overlapping with the range of the 'local' type.

Factors that affect the sizes of bones, besides 'breed' type

(1) Sex ratios.

Due to high rates of butchery, very few of the cattle pelves retain sexually-diagnostic morphological traits. Of the 14 pelvis fragments that can be used, nine are clearly from females, and five are from males (probably castrates rather than entire males) (see Stallibrass, 1991). Each of these fourteen pelves comes from a different individual.

The measurements, therefore, are expected to demonstrate the presence of females and males (probably castrates), with females tending to outnumber males by a ratio of approximately 2:1.

The shapes and measurements of the horncores were recorded and discussed in the full Period 3 report (Stallibrass, 1991), using the methods of Armitage & Clutton-Brock (1976), but their system for identifying the sex of an animal from its horncore characteristics was found to be unsuited to this collection.

(2) Age distributions.

The analysis of the tooth wear stages of 88 cattle mandibles from Annetwell Street, Period 3, showed that the majority (ie: 68%) of jaws derive from fully mature adult animals with considerable tooth wear. This group have the third molar at Grant's (1982) wear stage 'g' or more, and Mandibular Wear Scores (MWS) of 40-52. There is also a substantial minority of jaws deriving from adolescents and young adults (MWS = 20-38), with only two jaws from a single young individual (MWS=12). Taken in conjunction with the sex ratio of 9:5 females to males (the latter probably being castrates rather than entire males), this mandibular evidence was used to suggest that the cattle bones generally derive from a larger number of fully mature females, together with a smaller number of young or 'youngish' males (probably castrates).

(3). Individual variation.

The frequencies of elements suggested that remains of entire carcases were deposited at Annetwell Street in Period 3, with the addition of 'extra' scapulae. These scapulae appear to have been brought in for systematic processing of meat.

The different elements, therefore, are expected to show similar size distributions except for scapulae, which may have 'extra' measurements superimposed upon the general pattern.

The sizes of the Period 3 cattle.

Tables 1 - 14 present the metrical data for the cattle bones from Annetwell Street, Period 3 by individual element types.

The ranges of measurements tend to be quite small, both in span and in absolute terms. Withers heights have been calculated from the metapodials, using indices based on Fock (1966) in von den Driesch & Boessneck (1974) for bones that have not been attributed to sex. This makes the results of the calculations directly comparable with those of Luff (1982), who presents data for several Roman or Late Iron Age sites (Luff, 1982, Table 3.15). The data for Annetwell Street, Period 3 are presented here:

Metacarpal: withers heights (in metres)
calculated as GL (Greatest Length) x 6.1

N	range	mean	standard deviation
10	0.970 - 1.232	1.055	0.08

Metatarsal: withers heights (in metres)
calculated as GL (Greatest Length) x 5.4

N	range	mean	standard deviation
15	0.983 - 1.139	1.050	0.04

The withers heights calculated from the metacarpals and the metatarsals are very similar, and show that the animals were very small for Romano-British collections. Using Luff (*ibid*), they are comparable to first century AD cattle measurements from Frocester (a villa), Gussage All Saints (late Iron Age) and Exeter (AD 50-300), but considerably smaller than those from other Romano-British urban or military sites such as Great Chesterford, Colchester and Corstopitum. They are also smaller than (and more tightly clustered than) those recorded by O'Connor (1988) for Roman York. More detailed comparisons are presented at the end of this report in a general discussion of the measurements.

The overall conformation of the cattle from Annetwell Street, Period 3, therefore, appears to be relatively regular, with a limited degree of variation. The animals were small, most of them were horned, and they appear to be comparable to so-called 'Celtic' shorthorns.

Detailed Results:

Metapodials

1. Metacarpals

The greatest breadths (Bd) of the distal ends of the metacarpals and metatarsals have been plotted in bar graphs (Figures 1 and 2, respectively) in an attempt to show the distributions of females, castrates and male cattle. The raw data for metacarpals are given in Table 6.

The metacarpal measurements (N=33) range between 46mm and 64mm, with a mean of 53mm and a median and a mode both of 52mm. The distribution is not normal: there is an emphasis on the smaller measurements and fewer examples in the larger range. Plotting the measurements onto logarithmic probability paper (Figure 3) shows that these measurements fall into two groups with two thirds of the bones falling into the smaller size category (Bd= 46-54mm N=25) and the remaining third having Bd= 57-64mm (N=9). The plot also shows that the group of smaller bones has a lower standard deviation than the group of larger measurements (the angle of the straight line through the points is closer to the horizontal when the standard deviation is less, and closer to the vertical when the standard deviation is greater). However, the coefficients of variation (C.V.) are very similar: the smaller measurements have a C.V.=3.98, the larger measurements a C.V.=3.53. For the whole collection (N=33) the C.V.=9.04.

It is possible to interpret these results as showing that two thirds of the cattle metacarpals derive from females and one third from males, but it is also possible that some of the smaller bones derive from young animals (of either sex) although all of the bones are fully fused.

Only ten metacarpals are complete enough to have measurements of both distal width (Bd) and greatest length (GL) taken. Three scattergrams show these measurements, following the methods of Howard, 1962 and 1963) in an attempt to distinguish bones of different sexes. Figure 4 shows a simple plot of the Bd against GL, Figure 5 plots Howard's first 'slenderness index' ie: (Bd X 100)/GL against GL, and Figure 6 plots her second index ie: (SD X 100)/GL against GL. The first two scattergrams show very similar distributions ie: there is a group of seven bones of relatively short length (GL =161-184mm) with relatively narrow distal ends (Bd=48-53mm). Three other bones stand out in contrast, two of them having much larger distal widths (Bd=59-60mm) but similarly short lengths (GL=159 & 171mm), giving them much higher first slenderness indices of 35.3 and 37.1 (compared to the range for the group of seven of 28.5 - 31.0). There is also one bone that has much greater measurements in both directions ie: Bd=61mm, GL=202mm. This has a 'normal' first slenderness index of 30.1, despite its considerably greater overall size. In Figure 6, two of these bones retain their outlying positions, but one (with GL=171mm) closes in on the ?female group.

It is tempting to identify these ten complete metacarpals as deriving from seven females and three males. Using Howard's criteria, the larger but slender bone should derive from a castrate, and the two stockier bones from entire males but this, perhaps, is pushing the interpretation into realms of conjecture. The ratio of 7:3 females:males does, however, fit that suggested by morphological criteria for the pelvis (ie: 9 female:5 male) and the simple distribution of Bd measurements, with all three ratios equalling approximately 2:1 female:male.

A further ratio of measurements has been plotted for distal metacarpals in Figure 7 ie: the height of the distal condyles (HD) measured at right angles to Bd, plotted against Bd. Legge (1981) has suggested that these measurements tend to separate females from males. Again, there is a larger group of smaller measurements (N=23), together with a smaller group of larger, more variable measurements (N=6) with two or three outlying or intermediate measurements. By plotting on the interpretations made using Howard's first index for the ten complete bones, Figure 7 suggests that the smaller bones probably all derive from females. The three bones thought to derive from males all have large Bd measurements and two of them have large HD measurements but one of the two ?bulls has a HD measurement similar to the 'female' group. Although this could be an unusually splayed female metacarpal, this is unlikely if Howard's indices are genuinely indicative of sex, since this bone is categorised as male on both indices.

Plotting the Bd measurement against that for HD does appear to distinguish between bones from females and those from males, but it does not appear to be able to distinguish between entire and castrated males.

Howard (1962) uses the two indices to distinguish the sexes, and assumes that if a bone appears to be male on one index and female on the other, then it derives from a castrate. This seems naive, although possible. She also gives tables for *Bos taurus longifrons* Owen measurements divided into female, castrate and male, although she does not state how these categories have been assigned. The sample sizes are very small, and this may have led to false gaps in the distributions, where no examples happen to exist. In addition, for some of the categories, the ranges given for females and castrates overlap. Using the figures given in these tables as a rough guide, the ten complete metacarpals from Annetwell Street, Period 3 divide as follows:

Sex ratios assigned to metacarpals,
following Howard 1962, Tables 1 and 2,
using her figures for Bos taurus longifrons:

	female:	castrate:	bull	N
index 1 (Bd X 100)/GL	4 - 6	2 - 4	2	10
index 2 (SD X 100)/GL	4 - 9	0 - 6	0 - 1	10

These figures give ranges of ratios of:
female:castrate:bull

		F:	C:	B
(Bd X 100)/GL:	from	4:	4:	2
	to	6:	2:	2
(SD X 100)/GL:	from	4:	6:	0
	to	9:	0:	1

Details for each bone are given in Table 67.

Using the index that is most relevant to the measurements being plotted, the sex 'identifications' have been added to the scattergrams with some disturbing results. The cluster of small bones in Figures 4 and 5 compound bones from castrates with those from females. One of the large, robust bones is designated by Howard's Index 1 as deriving from a bull, but the other robust bone is 'identified' as female. 'Identifications' made using Index 2 lead to similar results, compounding bones from castrates and females, with a large outlier 'identified' as female rather than male. For Figure 7, Index 1 was used. Again, it appears to show that males (?probably castrates) and females cannot be separated clearly. Whilst individual variation and small sample size could explain the problems of conflicting identifications of single bones such as that from the bull/female, the indices show a disappointing inability to differentiate between females and castrates amongst the main part of the collection.

It is possible that the main cluster of measurements includes both the adult females and young males, even though all of the bones are fused.

In addition to the fused bones plotted in the figures, there are four unfused Bd measurements (see Table 6). One of these is so large (Bd=56mm) that it falls into the group of larger measurements even though it was from an immature animal, and this bone probably derives from a young male. The other three unfused bones have Bd= 31-49mm and their potential sizes (and possible sexes) cannot be assessed.

There is no point, in a meat economy, in keeping castrates alive beyond the point at which their growth curve levels out. Although this point is not usually reached until later than the age at which the distal metarcapal fuses, some of the males may have been slaughtered 'early' to satisfy the military's demand for meat.

The analysis of tooth wear data (Stallibrass, 1991) led to the conclusion that the jaws derived from a large group of fully mature females and a smaller (although substantial) group of adolescent or just adult males (probably castrates). However, this conclusion was reached on circumstantial evidence, using the known relative age ratios in conjunction with hypothetical 'good husbandry' practices. The jaws themselves could not be assigned to sex.

Similarly, the suggestion that the metacarpals derive from several mature females and fewer males (probably castrates, possibly some of them being young), also rests on circumstantial rather than direct evidence but does, at least, tend to support rather than refute the earlier suggestion.

2. Metatarsals.

Similar graphs have been prepared for the metatarsal measurements (see Table 13). Figure 2, which is a bar graph of the Bd measurements (N=42), can also be interpreted as showing two groups: one tightly clustered in the smaller size ranges and a smaller group of larger measurements; although it can also be interpreted as a single, skewed, distribution. The mean and mode both occur at 48mm, and the median at 47mm.

Figure 9 plots the cumulative percentages onto logarithmic probablity paper, and shows the same two groups: approximately 75% of the measurements fall into the smaller range of measurements (Bd= 43-49mm, N=25) and the remaining 25% consists of fewer, larger measurements (Bd=51-58mm, N=9) with a slightly higher standard deviation (SD= 2.29 *cf.* 1.70). The Coefficients of Variation (C.V.) differ, too: the smaller measurements have C.V.=3.68, the larger measurements C.V. =4.30. The C.V. for the whole collection (N=42) is C.V. =7.24. The same interpretations can be made of these figures as with those for the metacarpals i.e.: if the sizes reflect only sex differences, then they indicate a ratio of approximately 3:1 females:males. Alternatively, the smaller measurements may include some young animals of either sex. There are a further seven unfused distal metatarsals that could be measured. Two of these probably derive from young males due to their large sizes, but the sexes of the other seven cannot be estimated.

Fifteen of the cattle metatarsals are more or less complete, and the GL measurements are presented in Figures 9, 10 and 11, plotted against Bd, (Bd X 100)/GL and (SD X 100)/GL, respectively. As with the metacarpals, there is a group of smaller bones accounting for the majority of the examples (ie: 11/15) with a few outliers. The majority of the complete metatarsals fall into the following ranges: Bd= 30-49 mm, GL=182-197 mm, (Bd X 100)/GL=23.0 - 26.0, and (SD X 100)/GL= 10.0 - 12.0. Two of the outliers are long but slender, their Bd and SD values falling within the ranges shown by the main group (eg: Bd=46 & 48 mm), but with notably larger GLs (GL=208 & 211 mm respectively). These measurements give them particularly slender indices of (Bd X 100)/GL= 22.1 & 22.8, and (SD X 100)/GL= 9.9 & 10.8 and, on Howard's criteria, these two bones probably derive from castrates. In contrast, two other bones are not quite so long (GL= 196 & 204 mm) but are considerably stockier than any of the others (Bd=58 & 55 mm respectively, with (Bd X 100)/GL ratios of 29.4 & 27.0 respectively). These two bones may derive from entire males ie: bulls.

Again, the use of HD plotted against Bd (Figure 12) appears to show a larger cluster of smaller measurements, with fewer, more scattered, larger measurements. If the bones 'demonstrated' by Figures 10, 11 and 12 to derive from 'known' bulls and castrates, the two bones thought to derive from bulls have the largest measurements plotted. This seems to confirm that the larger measurements are, indeed, from males (at least some of which are entire bulls). But the two bones thought to derive from castrates lie within the main cluster thought to derive from females. For metatarsals, therefore, this ratio does not appear to separate females from males (unless the indices given by Howard have mis-identified the bones). These results cast doubt upon at least one, if not both, of these methods of attributing sex to a bone on the basis of its measurements.

Using Howard's figures for *Bos taurus longifrons* (Howard, 1962, Tables 1 & 2), the slenderness indices of the fifteen complete metatarsals show a bias in favour of females:

Sex ratios assigned to metatarsals,
following Howard 1962, Tables 1 and 2,
using her figures for Bos taurus longifrons:

	female:	castrate:	bull	N
index 1 (Bd X 100)/GL	11	3	1	15
index 2 (SD X 100)/GL	12 - 15	0 - 3	0	15

These figures give ratios in the ranges of:

		female:castrate:bull		
		F:	C:	B
(Bd X 100)/GL:		11:	3:	0
(SD X 100)/GL:	from	12:	3:	0
	to	15:	0:	0

Details for each bone are given in Table 68.

Again, the sex 'identifications' based on Howard's indices have been added to the plotted figures. They appear to be more consistent for the metatarsals than for the metacarpals, with larger measurements tending to be 'identified' as deriving from males (either entire or castrates). But there are still some 'castrate' measurements falling within the upper range of the 'female' distribution, and some unusually large 'females'. A comparison of Tables 67 and 68 shows that the 'identifications' made on metatarsals are clearer than those of metacarpals, with fewer bones having indices that fall into two possible categories for one or both indices (2/21 = 10% for metatarsals, *cf.* 6/15 = 40% for metacarpals).

Scapulae.

The scapula is the most frequent cattle element in the Period 3 collection, and there is some evidence to suggest that 'extra' scapulae were processed or deposited in this part of the site. The size and/or the sex and/or the age ranges of scapula measurements, therefore, may show differences from those of other elements due to the addition of these 'extra' scapulae which derive from animals not otherwise represented in the collection.

Figure 15 is a bar graph showing the distribution of the most frequent measurements ie: the SLC (N=119). The distribution is ambiguous. If the cumulative percentages are plotted onto logarithmic probability paper (Figure 16), this uncertainty is resolved, and there are two clear groups: the larger group consisting of almost 90% of the collection (SLC=36-48mm), and a smaller group, with a higher standard deviation, accounting for <10% of the collection, with SLCs of 49-56mm.

This ratio of 9:1 is much higher than that shown by the metapodials and pelves (approximately 2:1 to 4:1). It is possible that the larger group (of smaller measurements) compounds castrates with females, or that the 'extra' scapulae deposited at this site after filletting tended to be from 'extra' females. Both explanations are plausible, but untestable, although the relative sizes of the SLCs of females and castrates could be investigated with modern populations.

The next most frequent measurement available on the scapula is the length of the glenoid (LG, N=90). The method of butchery employed at this site tends to have chopped through the supraglenoid tuber, restricting the application of the measurement of GLP to 53 bones or fragments. Figure 17 presents a bar graph of these measurements. This shows a more regular, normal distribution of measurements, with two tails of a few very small or very large measurements. Perhaps this measurement is suited only as an indicator of general body size (possibly related to age), and does not distinguish between sexes at all. However, if the LGs are plotted against the SLC in a scattergram (Figure 18), the ratios do appear to differentiate between groups: there is a tight cluster of about 40 'middling' measurements (approx. LG=45-54mm, by SLC =39-48mm), with seven scattered, large outliers (LG=approx 53-64mm, by SLC=50-57mm) and eleven scattered smaller outliers (LG=38-47mm by SLC=35-43mm), some of which form a tight cluster around LG=45mm by SLC=35-38mm. How this distribution should be interpreted is unclear. One possibility is that the main cluster is composed of females (with or without castrates), the large outliers are males (entire and/or castrated) and the smaller outliers are young animals (possibly with the cluster being young females and the more scattered measurements being young males, either entire and/or castrated).

Due to high rates of butchery, few of the scapulae retain their full lengths. Figure 19 plots the height measured along the spine (HS) against the LG for 15 'intact' bones. Most of the bones (10) cluster in the range of HS=248-289mm by LG=46-50 mm). There are two outliers with similar lengths but wider LGs (HS=267 & 277 by GL=53 & 53 mm), and two extra large outliers which are both long and wide (HS=326 & 336, by LG =56 & 59mm), plus one small outlier (HS=231mm, LG=44 mm). This pattern fits that shown in Figure 18 by the scattergram of LG by SLC ie: a main group of ??females and one very small (?young) one plus two extra wide (?males, ?? entire males ie: bulls) plus two extra large (?males, ??castrates).

A similar scatter of 16 bones, plots the SLC against the HS (Figure 20). Again, there is a central cluster with one small outlier, but there are only two outliers (the same two as were extra large in the LG by HS plot), both with HS measurements greater than 320 mm. The two stocky outliers fall into the upper range of the SLC cluster ie: HS=277 by SLC=47 mm, and HS=267 mm by SLC=47 mm. Again, therefore, these ratios may be unable to separate all males from females, and it is unclear whether it is the measurements of entire males (bulls) or those of castrates that are clustering with those of females.

Humerus.

Although fused distal humeri are well represented in the collection, the practice of butchering the forelimb by chopping through the lateral condyle has reduced the numbers of bones that can be measured for Bd to 9, and those that can be measured for Bt to 13. In contrast, the height of the distal trochlea (HT, defined as T by Legge, 1981: Figure 58b) is measureable on 27 specimens.

Figure 21 is a bar graph of these 27 HT measurements. It shows a distribution that is almost normal, but with a slight emphasis on smaller measurements. Figure 22 plots the HT against the breadth of the distal trochlea (Bt) for 13 relatively complete distal fragments, as suggested by Legge (1981). This distribution does not show any clear distinction between groups.

Mandible.

Since several measurements could be taken on the cattle mandibles from Annetwell Street, they are presented here as an archive. Although some workers do not believe that they reflect sexual dimorphism (eg Grigson, 1982:7) they do, of course, reflect the size of the animal and can, therefore, be used to compare material between periods, provided there is other evidence to suggest that the sex ratios are similar in the two 'populations'.

The commonest measurement is that of the length of the M3 (N=83). Because of the overcrowding of many of the cattle toothrows in this collection, the length was measured at the bone level (perpendicular to the height of the tooth) NOT at the occlusal surface, since the latter was often reduced by abrasion against M2.

Figure 23 is a bar graph of the lengths of the M3s. It shows a skewed distribution with the majority of the measurements lying in the larger end of the range (i.e.: contrasting with all of the distributions discussed so far). Figure 24 plots the cumulative percentages of these measurements onto logarithmic probability paper. Most of the measurements (N=73) lie between 32-41mm, the mean length is 35mm and the Standard Deviation is 1.95 (Coefficient of Variation = 5.60). The smaller measurements (N=10) lie between 26-31mm, mean= 27mm, Standard Deviation =1.83, Coefficient of Variation = 6.68. The distribution of measurements is difficult to interpret in terms of sexual dimorphism when compared with those for the other elements, because of its emphasis on the larger rather than the smaller teeth. One possible explanation is that the length of M3 may not be a good indicator of sexual dimorphism. It is possible that the smaller measurements are for teeth that have relatively small third columns (some of the third molars, in fact, have only two columns, but these were excluded from the measurements).

Other mandibular measurements that can be taken (see Table 2) are the height (ie: depth) of the horizontal ramus, taken between P4 and M1 (= von den Driesch: 15b) (N=69), the length of the cheekteeth row (=v.d.D.: 7) (N=58) and the length of the diastema (=v.d.D.: 11) (N=33). Only eighteen mandibles retain their full length (=v.d.D.: 1).

Figure 25 is a bar graph of the length of the mandible between P4 and M1. It does not show any bimodality, nor does the plot of the cumulative percentages (Figure 26).

The length of the cheekteeth row does appear to be split bimodally into roughly equal groups in Figure 27, but this is not confirmed by the cumulative percentages in Figure 28.

The length of the diastema (Figure 30) appears to be highly variable between individuals and there are no clear groups.

The full lengths of the eighteen complete mandibles are given in Figures 31 and 32. The bar graph appears to show a distribution skewed towards the smaller end of the range, but the plot of the cumulative percentages shows that the measurements are rather variable, with many outliers and a main group (of about 40% of the collection) with lengths of 312/316 - 336 millimetres.

Since some of these measurements are strong indicators of sexual dimorphism in red deer, they have been investigated further in a variety of combinations (Figures 33-36).

Figure 33 plots the height of the mandible (vdD:15b) against the width of the M3. These (N=57) fall into a main cluster with three small outliers (very small M3, but 'average' mandible height) and a loose scatter of six larger teeth/jaws, plus a few (about 4) with 'average' M3 widths but small ramus heights.

Figure 34 plots the mandible height (vdD:15b) against the length of the diastema (vdD:11), a good index for distinguishing male from female red deer. In this collection of cattle bones, however, the distribution forms a loose cloud with no obvious distinctions.

Figure 35 plots 17 cases of M3 width against full length (vdD:1). These measurements fall into a generally linear pattern, with two or three oddities.

Figure 36 plots 17 cases of mandibular height (15b) against full length. This does appear to pull the examples apart into a tight cluster of nine jaws, with a loose scatter of six narrow jaws and two particularly wide jaws (one of which is large on both axes).

The mandibular measurements, therefore, are difficult to interpret with regard to age and/or sex distributions. Most measurements give variable distributions, and that of the M3 would seem to contradict the general trend towards smaller measurements outnumbering larger measurements, possibly due to factors that are not sexually dimorphic.

Proximal phalanges.

The Annetwell Street, Period 3 collection of cattle bones contains many more or less complete proximal phalanges: 45 anterior ones and 36 posterior ones. Higham (1969) found that the proximal widths (Bp) of male proximal phalanges are both absolutely and relatively greater (compared to total lengths) than those of females.

Figure 37 presents the proximal widths of all of the measured specimens (including one fragment, that may be from an anterior or posterior phalanx) (N=82). This bar graph shows a skewed distribution that emphasises smaller measurements, and this is true for both anterior and posterior phalanges when theyare plotted separately (see Figures 38 and 39, respectively).

Similarly, if all of the proximal widths (Bp) are plotted against the length (GLpe) (Figure 40) there are no clear groups although there is one outlier that is particularly broad for its length. If the anterior and posterior bones are separated (Figures 41 and 42, respectively), the anterior phalanges show a greater variability amongst the larger bones. There is the suggestion of a gap at about Bp=29mm, GLpe=53-57mm. The groups split roughly into 31 or 33 in the smaller-sized group, with 11 or 13 in the larger-sized group plus the one outlier. This makes a ratio of between 3:1 and 2:1 of the smaller (?female): larger (?male) bones. This ratio is similar to those suggested by the morphology of the pelves and the measurements of the metapodials.

The posterior phalanges, however, (Figure 42) do not show two clusters; rather, there is one main cluster with several scattered outliers.

Proximal phalanges are sometimes subject to intensive butchery, which precludes the use of proximal width by total length ratios and can preclude the identification of the phalange to the fore- or hindlimb. The use of proximal widths on their own does not appear to be able to distinguish between anterior and posterior phalanges. If the anterior and posterior bone measurements are grouped, the differences presumed to be due to sexual variation become obscured. Proximal phalanges, therefore, need to identified as anterior or posterior (on morphological criteria) prior to any attempt to use their measurements to distinguish between bones from males and females.

Measurements of anterior proximal phalanges appear to distinguish between males and females ie: the ratio of smaller:larger bones observed above fits that suggested by the morphology of the pelves (ie: approximately 2:1 female:male). However, the measurements of the posterior proximal phalanges do not appear to show the same distinctions. Higham (1969) studied modern cattle bones and found that bones from the forelimb show greater sexual dimorphism in their measurements than did bones from the hindlimb. This observation appears to hold true for these Romano-British cattle.

<u>Summary of the measurements of the Annetwell Street, Period 3 cattle bone measurements.</u>

All of the cattle elements (see Tables 1-14) from Annetwell Street, Period 3, have measurements that tend to fall within the smaller end of the range known for Romano-British cattle bones.

The standard deviations are not particularly large, and do not indicate an admixture of indigenous with 'improved' (i.e.: larger) stock.

The horncores and the withers heights, in particular, suggest that the animals were of the so-called 'Celtic shorthorn' type which first appeared in Britain during the Iron Age, and which persisted through to the mediaeval period, and which are approximately represented by the modern breed of Dexter cattle.

The size variations that are apparent for some of the commoner element types, such as the metacarpals, metatarsals and proximal phalanges, are probably due to the presence of animals of different sexes rather than of different 'breed' types.

The ratios of the sexes appear to be biased towards females, but many of the measurements may derive from castrated males, and it is difficult to assign precise ratios. Estimates range between 4:6 and 15:0 females to males, although most are in the order of 2:1 or 4:1 females to males.

However, many of the interpretations given above with regard to sex ratios rest on circumstantial evidence, and the interpretations must be regarded as tentative; they should certainly not be regarded as proven. Much more work needs to be done investigating the effects of sex, age, nutrition etc on the bones of modern animals before any such effects can be studied, with any confidence, on the bones of long deceased animals.

PERIOD 5

Comments on the Period 5 hand-recovered collection of cattle bones.

Although a substantial proportion (? 50%) of the animal bones from Period 5 deposits are in excellent preservation condition, comparable to those from waterlogged deposits in Period 3, a substantial portion (?50%) come from less favourable contexts and are dry and friable. A few have projecting areas abraded, hindering the taking of accurate measurements. The young bones are likely to be underrepresented in this collection due to problems of recovering them intact. However, the majority of the measured bones (ie: those with fused epiphyses) should be directly comparable to the Period 3 material.

The measurements from Period 5 cattle elements are presented in Tables 15 - 26.

Cumulative percentages have all been plotted together with those for Period 3.

Sex ratios.

Only four cattle pelves were extracted for measuring (see Table 20). Three of these are clearly from females, judging by morphological criteria, and the fourth is probably from a castrate.

Age distribution.

The Period 5 collection has far fewer mandibles than that from Period 3, and only 29 (compared to 88) are sufficiently complete for Grant's (1982) method of relative ageing to be applied. However, despite the small sample, the distribution of Mandibular Wear Stages (MWSs) are very similar for the two collections. The Period 5 material has a main group with MWS=36-48 (ie fully mature adults), plus a smaller group of adolescents with MWS=31-33 (ie: with M3 in the process of erupting), and five outliers from younger and senile individuals.

The sizes of the Period 5 cattle.

The withers heights calculated from the metapodials from Period 5 are very similar to those calculated for the Period 3 material, ie:

Metacarpal: withers heights (in metres)
calculated as GL (Greatest Length) x 6.1

N	range	mean	standard deviation
7	0.970 - 1.129	1.048	0.06

Metatarsal: withers heights (in metres)
calculated as GL (Greatest Length) x 5.4

N	range	mean	standard deviation
7	0.950 - 1.156	1.050	0.07

Details for each bone are given in Table 67.

The horncores were not extracted from the Period 5 collection and so cannot be described here, but the similarity of the withers heights, together with the similarity of the post-cranial bone measurements (see below) suggest that the cattle from Period 5 were also of the 'Celtic shorthorn' type.

Detailed Results:

On the figures for Period 5 measurements, the figures for Period 3 have been reproduced to facilitate visual comparisons.

Metapodials:

1.Metacarpals.

Figure 43 is a bar graph presenting the distal widths (Bd) of the Period 5 metacarpals. Comparing the distributions for the two periods confirms the information presented in Tables 19 and 6 ie: there is no increase in the size of the metacarpals in Period 5, nor is there an increase in the variation: the ranges, means and standard deviations are all very similar. This similarity is emphasised in Figure 3, which shows that the cumulative percentages are extremely close, excepting that the Period 5 collection has a greater percentage of the measurements in the main group of smaller measurements ie: for Period 3 approximately 73% are in the main group with Bd<55 mm, whereas for Period 5 the percentage in this group is closer to 89%.

Howard's indices have been used in an attempt to allocate the complete bones to sex. Figure 44 presents the five complete metacarpals with Bd plotted against Gl, and Figure 45 presents the same five bones with (Bd X 100)/GL plotted against GL. Figure 46 presents (SD X 100)/GL plotted against GL (N=6). The Period 5 sample is extremely small, but appears to be similar to that for Period 3.

The indices, using Howard (1962) suggest the following sex distributions:

Sex ratios assigned to metacarpals, following Howard 1962, Tables 1 and 2, using her figures for Bos taurus longifrons:

	female:	castrate:	bull	N
index 1 (Bd X 100)/GL	3	1	1	5
index 2 (SD X 100)/GL	4	0 - 2	0 - 2	6

These figures give ratios in the ranges of:

female:castrate:bull

		F:	C:	B:
(Bd X 100)/GL:		3:	1:	1
(SD X 100)/GL:	from	4:	2:	0
	to	4:	0:	2

Details for each bone are given in Table 67.

Females are clearly in the majority, in the order of 3:2 or 4:2 female:male. The figures favour females more consistently than do the Period 3 data, which may explain the greater cumulative percentages of Bd measurements in the main group of smaller measurements for Period 5 (see Figure 3). The differences are emphasised by the small sample sizes for Period 5.

Figure 47 presents a scattergram of the height *versus* the breadth of the distal metacarpal (ie HD *vs*. Bd). This plot (N=35) clearly shows a main group of smaller measurements (N=31) with four larger outliers.

2. Metatarsals.

Figure 48 presents the distal widths of the Period 5 metatarsals (Bd). It shows a distribution that is highly skewed towards the smaller measurements. However, a comparison of Table 25 (Period 5) and Table 13 (Period 3) shows that the ranges, means and standard deviations of the two collections are very similar (although Period 5 does include one, isolated, comparatively large specimen, Bd=60.25mm). Figure 9, which presents the cumulative percentages of both collections, again emphasises their similarities.

Using Howard's (1962) indices to assess the sex of the complete metatarsals, Figures 49, 50 and 51 present Bd, (Bd X100)/GL and (SD X100)/GL plotted against GL, respectively. The sample for Period 5 is extremely small (N=6) and the scattergrams in Figures 49 and 50 are particularly difficult to interpret. That in Figure 51 appears to show three small bones, two long but slender bones, and one bone of medium length but great midshaft width.

Using Howard's indices on their own (ie: without plotting them against GL), the following sex allocations can be made:

Sex ratios assigned to metatarsals,
following Howard 1962, Tables 1 and 2,
using her figures for Bos taurus longifrons:

	female:	castrate:	bull	N
index 1 (Bd X 100)/GL	2 - 3	3 - 4	0	6
index 2 (SD X 100)/GL	4 - 5	0 - 1	1	6

These figures give ratios of:

		female:castrate:bull
(Bd X 100)/GL:		2: 4: 0
	or	3: 3: 0
(SD X 100)/GL:		4: 1: 1
	or	5: 0: 1

Details for each bone are given in Table 68.

Thus, the sex ratios for Period 5 complete metatarsals appears to be in the range of between 2:4 and 5:1 female:male. When the larger sample of distally fused (rather than complete) metatarsals is used to plot HD *vs*. Bd (see Figure 52), it seems that the latter ratio (ie: 5:1 female:male) is more likely to be closer to reality, since there is a heavy preponderance of measurements in the smaller range (as in Figures 48 and 3).

Scapulae.

The scapula, as in Period 3, is a very common element. Figure 53 is a bar graph of the SLC measurements. The distribution appears to be unimodal, and this is supported by the plot of cumulative percentages in Figure 16. Figure 16 also shows that the Period 5 collection tends to have slightly fewer examples of the smaller bones. Tables 16 and 3 confirm this: the range, minimum, maximum and mean values for SLC in Period 5 are all slightly higher than those for Period 3, although the standard deviations are very similar. Whether or not this slight difference is significant zoologically is unknown.

Other measurements, such as LG (see Figure 54) show a similar distribution ie: unimodal, without the smaller measurements seen in Period 3, although in the case of the LG, the Period 5 collection is also missing the larger measurements seen in Period 3, and thus has a smaller standard deviation.

Figure 55 plots LG against the length of the complete scapula (HS) for ten bones from Period 5. Figure 55 appears to show three groups, but this may be due to the small sample size, bearing in mind the lack of grouping in the measurements of LG on their own (N=107). The groups are placed in the same relative positions as those for Period 3, but the actual measurements are larger. Figure 56 plots the SLC against the HS (N=13) and appears to show two groups. If these are compared to those shown by the Period 3 data, the separation distances are similar, but the Period 5 measurements are larger than those in Period 3.

Interpreting these scattergrams is difficult. Either the groupings are more apparent than real, and are due to the small sample sizes, or the ratios of a width measurement (whether LG or SLC) against the total length of the bone does indicate some difference that is not exemplified by the width measurement alone.

A scattergram of SLC against LG for Period 5 shows a distribution that is very similar to that shown in Figure 18 for the Period 3 material (but cannot be plotted on the computer package used for this report, since it exceeds the permissable number of points to be plotted!).

Humerus.

The sample size of measurable humeri from Period 5 is much smaller than that for Period 3 (N=18, compared to N=88) (see Table 17 and compare it with Table 4). The measurements ie: mean, minimum, maximum and range, and the standard deviations are very similar for all the measurements taken.

Mandible.

The sample of cattle mandibles that can be measured from Period 5 is also very small (see Table 15 and compare it with Table 2).

Figure 57 is a bar graph of the length of the Period 5 M3s (measured at bone level, perpendicular to the height of the tooth). The distributions are very similar, although the smaller sample from Period 5 (N=26 *cf.* N=83 for Period 3) lacks any particularly large examples.

Figure 24 shows the cumulative percentages for both collections. The curves are similar, apart from the greater percentage in the smaller end of the range, noted above.

Similarly, cumulative percentages for other Period 5 mandibular measurements are given with those for Period 3 data in Figures 26 and 28 (ie: vdD 15b: height of mandible between P4 and M1, and vdD 7: length of cheekteeth row, respectively). Figure 26 shows almost identical distributions for the two collections. Figure 28 shows that the distributions are very similar, except for the lack of small measurements in the Period 5 collection, which may be due to the small sample size (N=19, compare to N=58 for Period 3). The sample size for vdD measurement 11: the length of the diastema, is so small (N=7) that is has not been given in Figure 30. Similarly, there are only five measurements of vdD 1 (the full length of the mandible) for Period 5, and these have not been plotted on Figure 32.

Proximal phalanges.

The measurements for these are given in Table 26 (compare with Table 14 for Period 3). The measurements for Period 5 are very similar to those for Period 3, although the bones tend to be approximately one millimetre wider and longer on average. This is unlikely to be a significant difference.

Summary of the Period 5 cattle bones measurements and a comparison betwen the Period 3 and Period 5 data.

All of the measurements taken for the Period 5 cattle bone collection fall within the same general ranges as those for Period 3 ie: they are similar to the small, so-called 'Celtic shorthorn', cattle that are known from the Iron Age through to the mediaeval period in Britain.

The sex ratios of the two collections appear to be comparable, although there are occasional hints that the Period 5 collection may include a greater proportion of bones from females than does the Period 3 collection.

The metrical distinctions between females and castrates, and between castrated and entire males, are sometimes unclear. This report has attempted to experiment with a variety of measurements, some of which appear to distinguish groups with different sizes and/or conformations whilst others do not. Some of these groupings are believed to be due to sexual dimorphism, by analogy with known differences in modern cattle skeletons, but other groups have unknown aetiologies. It is hoped that more information regarding the use of measurements to distinguish bones from different sexes of cattle will become available, and that the archive data presented here may then be subjected to reinterpretation.

SHEEP/GOAT BONE MEASUREMENTS:

PERIOD 3

Comments on the Period 3 hand-recovered collection of sheep/goat bones.

Sheep/goat are the second most common 'species' represented in the Annetwell Street Period 3 hand-recovered collection. Of the 5176 fragments identified as cattle, sheep/goat or pig, 3636 (70%) are from cattle, 899 (17%) from sheep/goats and 641 (12%) from pigs.

Of the 899 sheep/goat bones, 280 have been identified specifically as sheep, and only 13 as goat. This gives a ratio of 22:1 sheep:goats. The remaining 606 fragments could only be identified as sheep/goat. The 13 goat bones come from various parts of the skeleton and are not restricted to the extremities (as might be expected if the remains represented skin- or horn-processing).

The ages of the sheep/goat appear to be more diverse than those of the cattle, which show a predominance of fully mature adult animals. The archive report for Period 3 (Stallibrass, 1991) discusses the Mandibular Wear Scores (MWS) of the sheep/goat mandibles (N=48) following Grant (1982). In particular, there is a more even spread of sheep/goat mandibles with MWS= 20 - 42 (ie: with M3 erupting and coming into full wear, Grant stages 0 - 11). There is also a higher proportion (19% of sheep/goat *cf.* 2% of cattle) of young jaws with MWS = 5 - 15 (ie: with M1 just erupted to M2 just erupted). For modern sheep, these early stages are approximately equivalent to ages of 3 months - 9/12 months (Silver, 1969).

The collection includes 31 deciduous fourth premolars (either *in situ* or loose). All of these have been identified as sheep, following Payne (1985). No attempt has been made to identify the older jaws specifically as sheep or goat.

Like the cattle jaws, many of the sheep/goat mandibles have crowded tooth rows, and so the length of the M3 has been measured at the bone level rather than at the (laterally worn) occlusal surface. Oral pathology, however, is very rare.

Only five sheep/goat pelves could be measured. Of these, three have been identified as females and two as castrates (following Boessneck, 1969, and Grigson, 1982). A further five pelvic fragments could be identified to sex, although they are not complete enough to be measured. The identifications of these five are: one male (either entire or castrate), one castrate and three female. The overall ratio, therefore, is six female to four male (of which at least three, if not all four, are from castrates). This ratio, albeit from a very small sample, does suggest that the female: male ratio is more even than that identified for the cattle (for which the 14 pelves gave a ratio of approximately 2:1 female:male).

A few skull and horncore fragments were recovered (representing six sheep and one or two goats). These indicate that the sheep were horned (there are no fragments from polled skulls). Most of the horncores are broken or chopped through, but they appear to have been quite short, and very flattened at the back. One of the skulls may be from a four-horned individual. One definite goat horncore has been chopped through.

In Tables 27-37, specific identifications have been recorded whenever possible. For the statistics, known goat bones have been excluded. The statistics, therefore, refer to sheep bones and sheep/goat bones (most of which probably derive from sheep, since the identified ratio is 280:13 (= 22:1) sheep:goat).

The sizes of the Period 3 sheep/goat.

Tables 27-37 present the measurements of the Period 3 sheep/goat bones.

Withers heights for sheep (but not for goats) have been calculated from the lengths of the metapodials, using Teichert (n.d., in von den Driesch & Boessneck, 1974).

Metacarpal: withers heights (in millimetres)
calculated as GL (Greatest Length) X 4.89

N	range	mean	standard deviation
17	533-645	568	24.72

Metatarsal: withers heights (in millimetres)
calculated as GL (Greatest Length) X 4.54

N	range	mean	standard deviation
23	523-634	577	27.27

The mean of the withers heights calculated from the metacarpals is considerably lower than that calculated for the metatarsals. The small number of metacarpal measurements has a distribution that is skewed towards the smaller measurements, whereas the larger number of metatarsal measurements has a more normal distribution (see Tables 31 and 37). This fact may be sufficient to explain the apparent discrepancy. Alternatively, it is quite possible that the conformation of these Romano-British sheep was different to that of the modern sheep used by Teichert (n.d.). In particular, the relative heights of the fore- and hind-limbs may differ.

A comparison of the withers heights shows that, like the cattle, the sheep from Annetwell Street, Period 3 are in the smaller half of the range for Romano-British animals. The Annetwell Street Period 3 measurements are very similar to those of three modern Soay sheep skeletons in the Cambridge University collection (Luff, 1982:19. Unfortunately, Luff does not state the sexes of the Cambridge skeletons). The Annetwell Street measurements are also very similar to those found in contemporaneous collections from Exeter (Maltby, 1979) and Corstopitum (Hodgson, 1968), but are smaller than those found at more 'Romanised' sites such as Colchester (Luff, 1982. Table 3:21).

Detailed results:

Metapodials

Metacarpals

The Period 3 collection has quite a large number of metacarpals (N=54, of which 4 = goat and 46 = sheep). Measurements of the 17 complete sheep metacarpals have been plotted in Figures 58-61. The ten pelvic fragments (see above) that can be used for sex assessments suggest that the sex ratio is approximately 6:4 (ie 3:2) female:male (most of the males probably being castrates rather than entire). Since sheep skeletons are very similar to those of cattle, and the metapodials of cattle have been shown to be sexually dimorphic (Howard, 1962, 1963; Higham, 1969), measurements for sheep have been plotted in similar ways to those used for cattle (compare Figures 1 and 3-8, for cattle, with Figures 58-61 for sheep).

If the sheep bones do derive from approximately 3:2 females:males, this ratio might be expected to be reflected in dimorphic distributions of metapodial measurements. Figure 58, however, which is a bar graph of the Bd measurements of 20 metacarpals, has a distribution that is distinctly skewed towards the smaller measurements.

Figure 59 is a scattergram of Bd against GL for the 17 complete sheep metacarpals. The main scatter, of 16 bones, forms a rather loose cluster, with one particularly large outlier. It is possible that the main cluster is an amalgamation of two groups ie: one group of smaller measurements containing 10-12 bones, plus a second group of 4 - 6 larger bones. However, a distinction between the two groups is not clear.

In Figure 60, the Bd/GL ratio has been plotted against GL. This pulls out the main cluster but does not clarify the two postulated sub-groups. Rather, it isolates a second, rather broad, bone, and redistributes the remaining 15 bones into two different sub-groups.

It was noticed, whilst recording the bones, that some are very much more slender than others. However, plotting SD/GL against GL (see Figure 61) does not indicate any discrete groupings on this characteristic. The extra large bone (which is definitely sheep and not goat) is still isolated (GL=132mm) whilst 12 bones form a neat continuum in the scattergram. Three others are slightly slender for their length and one (with SD/GL<9.5) is particularly slender.

Apart from the extra large bone, which is isolated in all three plots, the 17 complete sheep metacarpals do not form two consistent groups. It is not possible, therefore, to suggest that these bones show sexual dimorphism. If bones of different sexes are represented, the measurements of males (probably castrates) and those of females must either form a continuum or overlap to such a degree that dimorphism is obscured.

Since the sexual dimorphism of cattle bones is known to be greater for forelimbs than for hindlimbs (Higham, 1969:64), no attempt has been made to repeat this investigation with the metatarsal measurements.

Tibiae

Sheep/goat distal tibiae are quite well represented in the Period 3 collection (N=31 for fused distal tibiae of sheep or sheep/goat). The Bd measurements of these have been plotted as a bar graph in Figure 62. This suggests a split at Bd=23mm between two roughly equal groups, with 16 bones with Bd< 23mm, one at 23mm, and 12 bones with Bd>23mm. This distribution of 16/17 : 12/13 is similar to that shown by the 10 pelves of 6:4 females to males (ie: approximately 3:2). However, this apparent bimodality may be fortuitous and due to the small sample size.

In Figure 63, the depth of the distal end (Dd) has been plotted against the breadth (Bd). This does not show a clear bimodality, but a general continuum with a few (circa 5) 'oddities' that have relatively narrow Bd measurements (Bd = c. 21.7mm) but varying Dd measurements (Dd = c. 17.8-18.6mm).

Summary of the measurements of Annetwell Street Period 3 sheep/goats.

The measurements of sheep/goat bones for Annetwell Street Period 3 do not present any clear evidence for the presence of larger types of sheep.

The distributions of metacarpal and tibia measurements appear to support the sex ratio assessed on the small collection (N=10) of pelvis fragments ie: bones of both females and males are present, with those of females slightly outnumbering those of males, many of which may have been castrates (wethers) rather than entire rams. Although one metacarpal is particularly long (GL=132mm) and broad at the distal end (Bd=25.2mm), its slenderness indices (Bd/GL=19.1, SD/GL=9.9) are both similar to the modes for the collection. It is probably from a large male rather than a different type of sheep.

PERIOD 5

Comments on the Period 5 hand-recovered collection of sheep/goat bones.

Of the 146 sheep/goat bones that have been measured from the Period 5 deposits, 102 are definitely from sheep and eight are definitely, or very probably, from goats. This gives an identified ratio of 102:8 = 13:1 sheep:goats. This ratio differs from that in Period 3 (which was 280:13 = 22:1) but this difference is probably due to the tiny sample sizes of goat bones (only 13 and 8!) rather than to any significant differences in the ratios of the two species.

As with the Period 3 collection, the goat bones consist of a variety of element types.

Horncores and skull fragments were not extracted from the collection and so cannot be commented upon.

The distribution of relative ages of the Period 5 sheep/goat mandibles is very similar to that in Period 3, although the collection of mandibles is very small (N=17, including one pair with MWS=44). The Mandibular Wear Scores (MWS) are spread out between MWS=12-46, with a small cluster at 32-36. None of the mandibles have been identified as goat, whilst one is definitely from a sheep (MWS=12).

Eight pelvic fragments can be measured and assessed for sex. Of these, three are from females, three from castrates, and two more from males (whether entire or castrated could not be determined from the fragments). This gives a ratio of 3:5 females:males, which reverses the ratio seen in Period 3, in which females slightly outnumber males.

As with Period 3 material, measurements of identified goat bones have been excluded from the statistics in the tables, and have not been plotted in any of the figures.

The sizes of the Period 5 sheep/goats.

Tables 38-46 present the measurements of the Period 5 sheep/goat bones.

Withers heights for sheep (but not for goats) have been calculated from the lengths of the metapodials, using Teichert (n.d., in von den Driesch & Boessneck, 1974).

Metacarpal: withers heights (in millimetres)
calculated as GL (Greatest Length) X 4.89

N	range	mean	standard deviation
6	552-636	586	25.07

Metatarsal: withers heights (in millimetres)
calculated as GL (Greatest Length) X 4.54

N	range	mean	standard deviation
5	559-652	591	32.57

The samples are very small, but show the same discrepancy as do the Period 3 measurements ie: the withers heights calculated from the GLs of the metatarsals tend to be larger than those calculated from the metacarpals. This may support the suggestion made earlier that the conformation of these sheep differed from that of the sheep examined by Teichert (n.d.), whose formulae have been used in these calculations.

The withers heights calculated for the (tiny) collection from Period 5 tend to be larger than those for the Period 3 collection. Although this might be interpretated as demonstrating an increase in size due to the presence of different types of livestock in the later period, it is far more likely to reflect a greater proportion of males in the collection (as suggested by the analysis of the pelvis fragments).

Detailed results:

Metacarpals

Figures 58-61 plot various measurements for the Period 5 metacarpals together with those for Period 3. The Bd values for metacarpals are very similar in Periods 3 and 5. However, the six complete metacarpals (from which the withers heights have been calculated) from Period 5 all tend to be larger than those in Period 3. In particular, they tend to be longer, although they have narrower slenderness indices. Using Howard's (1962 & 1963) comments regarding the effects of castration on the growth of bones, it seems highly probable that most of the six complete sheep metacarpals from Period 5 derive from males, and probably from castrated males (ie: wethers).

Tibiae

The collection of sheep and sheep/goat tibiae is not as large as that for Period 3 (N=27, *cf.* N=50) and the measurements are less informative. Figure 62 plots the Bd measurements for Period 5 tibiae. The range is the same as for the Period 3 collection (ie: Bd=21 - 25 mm). Again, there appears to be a cut-off point at approximately Bd=23 mm, which might be used to separate the measurements into a ratio of 8:5 (=3:2) smaller (?female):(?male) larger bones, but this is probably over-interpreting the data.

Figure 63 plots the Bd:Dd measurements for 13 distal tibiae from Period 5. In comparison to the Period 3 material, nine of these 13 bones appear to be relatively broad (ie: for a given Dd, the Bd is greater). Does this indicate a greater proportion of bones from males in Period 5? The scatter is rather dispersed, however, and does not form any clear groups.

Summary of the Period 5 sheep/goat bone measurements, and a comparison between the Period 3 and Period 5 data.

All of the sheep/goat measurements for the Period 5 collection are very similar to those for the Period 3 collection. Slight differences in the distributions of some of these measurements can be interpreted as reflections of differing sex ratios rather than as indications of the presence of larger types of sheep. In the Period 3 collection, female sheep appear to outnumber male sheep slightly, in a ratio of approximately 3:2 female:male whereas, in the (smaller) Period 5 collection, some elements indicate that this ratio is reversed, so that bones from males slightly outnumber those from females. In both collections, most of the bones from males appear to derive from castrates (wethers) rather than from entire males (rams).

There is no evidence for any overall increase in size for the Period 5 collection, as compared to the Period 3 collection. Nor is there any evidence to suggest an admixture of larger sheep/goats in the later period.

Both collections are dominated by bones of sheep rather than of goats, and the sheep bones are slender and gracile, their measurements being similar to those of modern Soay sheep.

PIG BONE MEASUREMENTS:

PERIODS 3 AND 5

Comments on the Periods 3 and 5 hand-recovered collections of pig bones.

The collections of pig bones from both periods are quite small, and the vast majority of the bones are from juveniles or sub-adults.

Although the numbers of mandibles are very small (Period 3: N=19; Period 5, N=9), the Mandibular Wear Scores (MWS) are spread out over a large range (Period 3: MWS=8-41; Period 5: MWS=9-36). The M3 begins to erupt at approximately MWS=20 in these collections, which indicates that approximately half of each collection derives from pigs of less than 17-22 months of age (Silver, 1969: modern data).

The measurements for Period 3 pig bones are given in Tables 47-55, and those for Period 5 pig bones in Tables 56-64. Selected summary measurements are given in Table 70.

Since nearly all of the measurements are from unfused bones, they have not been plotted in any figures. None of the bones is particularly large, and there is no indication of the presence of wild boars.

MEASUREMENTS OF BONES OF RARER SPECIES

Measurements of the few bones that were both identifiable to other species and measureable are listed in Appendix I.

GENERAL DISCUSSION OF THE ANIMAL BONE MEASUREMENTS FROM ANNETWELL STREET, CARLISLE, PERIODS 3 AND 5

The cattle from both Periods 3 and 5 conform to the small, short-horned cattle often refered to as 'Celtic shorthorns' (*sensu* Jewell, 1963) that were common throughout Britain in the Iron Age and Romano-British periods.

There is no evidence for an increase in overall stature, nor for any admixture of larger animals in the later period (ie: Period 5). Certainly, if the Romans did introduce larger types of cattle into northern Britain, there is no evidence for this happening in Carlisle during the later 1st and early-mid 2nd Centuries AD.

Table 65 presents summary statistics for measurements of the greatest breadth of the distal end of the metacarpal (von den Driesch, 1976: Bd) for 10 collections of cattle bones dating to the late Iron Age and/or the Romano-British period.

The collection from Papcastle, Cumbria, is from a Roman fort, and is the only comparable collection available for the north-west of England [current excavations (1989-90) by the Lancaster University Archaeology Unit are recovering useful material from the Roman fort at Ribchester, but this material is not yet available for study]. Other collections of Romano-British or Iron Age material from northern England tend to be from the north-east (eg: Piercebridge, Corstopitum, Thorpe Thewles, Catcote and York).

The collection from Exeter has been included for two reasons: (1) it is well recorded and well published, and (2) it comes from a location that may be comparable to that of Carlisle ie: it was at the limit of Roman occupation, on the border with a 'highland' zone.

The collection from Chichester Cattlemarket has been included because it, too, is well recorded and published, and also because it comes from a contrasting situation ie: it derives from a civilian settlement in the heart of a 'Romanised' southern lowland region.

The mean widths of the distal metacarpals are quite similar from all 10 collections. Those of Annetwell Street:Period 3, Annetwell Street:Period 5 and Papcastle are all extremely similar (mean Bd=52-53mm) as are the overall ranges (44/45/46 - 64/65 mm). These measurements are slightly larger than those for York:General Accident Site and Exeter (mean Bd=49mm for both; ranges = 43/45 - 56/61 mm). If the raw data are plotted on identical scales in histograms (see Figure 65) it is clear that both of these collections contain bones whose measurements are not normally distributed (both distributions are skewed towards the smaller measurements), and that both collections lack any particularly large bones. O'Connor (1988) and Maltby (1979) both interpret these distributions as bimodal, and indicating the presence of females and males. In both collections the smaller (?female) bones outnumber the larger (?male) bones (in a ratio of 39:12 [=3:1] at York, and of 21:7 [= 3:1] at Exeter). I would suggest that the ?male bones probably derive from castrates and that a lack of bones from bulls (whose Bd measurements would be expected to be greater than those of castrates) contributes towards the small mean sizes of the bones in these collections (although it does not explain it entirely, since the modes are also rather small).

The problem of distinguishing bones of bulls from those of castrates is difficult to resolve when only a fragment of the bone is present (ie: when the length is not retained). Table 66 lists, subjectively, some apparent groupings of Bd measurements from the ten collections presented in Table 65 and Figure 65. It attempts to separate the measurements of females, castrates and bulls as 'smaller', 'middling' and 'larger' groupings of measurements.

The lower ends of the ranges tend to be very similar for all ten collections (ie: Bd approximately = 45-46 mm). The Catcote collection has a higher starting point (48 mm) but this is probably due to the very small sample size (N=10). The 'cut-off' points between the smaller and the middling groups of measurements are far more difficult to ascertain, especially for the larger collections (ie: Piercebridge, Corstopitum and Chichester:Cattlemarket). In the case of the larger collections, the distinctions between large ?female and small ?castrate measurements is probably obscured slightly due to a natural slight overlap in sizes, the smaller collections simply being less likely to contain bones of unusually large females or unusually small castrates due to sample size.

What is more surprising is the fact that York appears to have a 'middling' group of measurements that falls entirely within the ranges of other collections' 'smaller' measurements. Using O'Connor's (1988) Table 37 to calculate Howard's indices for complete metacarpals from Periods 3-7, all eight complete bones are demonstrated to be from females (on both indices; there are no ambiguous index values). However, all eight of these bones have Bd measurements that fall within York's 'smaller' group (Bd=41-51mm). The sexes of the bone fragments with measurements in the 'middling' group cannot be investigated using these methods.

O'Connor describes two types of horncore at York (1988:92-97) and concludes that two types of cattle are represented ie: "Celtic shorthorn-like cattle" and "a more heavily horned morphotype". Unfortunately, the measurements of the metacarpals cannot be linked directly to the horncore types. If the broader metacarpals are derived from the same type of animal as the heavier horncores, do these suggest the presence of a larger type of animal, or simply a different sex group?

Maltby (1979:33-34) used Howard's indices to ascertain the sex of five complete metacarpals from the AD 55- AD 300 collection (see Maltby's Figure 5) and found that these did fall into the expected clusters in his Figure 6 (in a ratio of 4 female:1 male), but it is not possible to identify the sexed bones in Figure 6 to find out their Bd measurements (which are not listed in any tables), nor to ascertain whether the larger grouping contains a mixture of castrates and entire males.

A summary of the Annetwell Street:Periods 3 & 5 sex data, using Howard's (1962) indices, is given in Table 67 (these data are taken from Tables 6 and 19 of this report). It is clear that, even when complete metacarpals are measured, they may not be easy to sex.

The simplest explanation of the different means and modes of the York and Exeter collections is that (a) they include few measurements from males and/or (b) the cattle tended to be slightly smaller in those parts of the country.

However, the measurements from York are not typical for the north of England, since they are smaller than those for other sites in the region, both from the Iron Age and from the Romano-British period.

The two collections from Iron Age sites in the north-east of England do not show any major differences from the Romano-British sites in the north. That from Thorpe Thewles, which combines Iron Age with very late Iron Age/early Romano-British material, has metrical attributes that are very similar to those of Annetwell Street:Periods 3 & 5, and Papcastle. The small standard deviation and the relatively restricted range (47-59mm) may reflect the absence of males from this small collection (N=20).

The collection from Iron Age deposits at Catcote, Cleveland, is even smaller (N=10). However, the range appears to include bones from the middle of the 'standard' range ie: 51-61mm, missing both the very small and the large bones.

The largest collections used in this comparison tend to cover long time periods from the early to late Roman period i.e.: Piercebridge, Corstopitum and Chichester (see Table 65iii). Despite this, the measurements from these three collections show very similar distributions to those from the other sites.

The cattle bones from Annetwell Street Periods 3 and 5 seem to fit a general pattern that is widespread throughout Roman Britain.

The overall conclusions from this comparison are:

(1): there is no indication of a change in average size of cattle between the Iron Age and the Romano-British periods in northern Britain, and

(2): in order to compare measurements from different collections, the sex ratios concerned must be known, and the distributions of measurements must be demonstrated in detail rather than given (only) in summary statistics. Although number, mean, range and standard deviation are necessary, they are not sufficient. Modal values may be more relevant than means, which can be affected by the presence of a few exceptionally large (probably male) bones. Full graphical representation would be of immense benefit.

The measurements for sheep/goat bones from Annetwell Street: Periods 3 & 5 also show no evidence for the introduction of larger types of sheep. Table 66 presents comparable data for 9 of the 10 sites used in Table 65. Again, the differences between the measurements at all 9 sites are very small.

The sex ratios of the sheep and/or sheep/goat bones are difficult to ascertain.

The measurements of the pig bone collections from Annetwell Street are unsuited to comparisons with other sites since nearly all of them derive from immature animals.

The measurements of the other species represented at Annetwell Street, Carlisle, in Periods 3 & 5 (ie: those for red deer, roe deer, horse and dog) are too few for any site-specific analyses to be valid, but are included in Appendix 1 so that future synthetic studies may make use of them.

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