COLCHESTER ARCHAEOLOGICAL REPORT 12:

Animal bones from excavations in Colchester, 1971-85

ROSEMARY LUFF

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with a contribution by

Don Brothwell

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Rosemary Luff,
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1: THE ARCHAEOLOGICAL BACKGROUND

1.1 Introduction

The first half of this chapter outlines some fundamental problems in grasping and assimilating the function of different kinds of settlement in early historic Britain. While this may seem superfluous to a study of animal bones from Colchester, it is stressed that knowledge of a site's integration with the landscape is vital for any investigations concerning the economics of trade and agriculture. The emphasis is on Roman Britain since most of the bone assemblages from Colchester have emanated from this period. Further, it is evident as this section unfolds that the Romanists' interpretation of settlement types is in a state of flux, as indeed is the range of questions being asked of the bone assemblages.

In 1974, Dr Graham Webster boldly stated in his book, *Practical archaeology:* 'It is sad to note that in Britain, animal archaeology is still much in its infancy. There are very few workers in this field and little is available for research funds. The best work has been done in other countries like Holland, Poland and Russia' (Webster 1974, 104). His remark is a reasonably accurate appraisal of the situation prior to 1970. However, the emergence and growth of rescue archaeology in Britain during the 1970s led to the unearthing of huge deposits of animal bone, particularly from urban sites, for example at Colchester, Exeter, Lincoln, Southampton, Winchester and York. The interpretation of these remains caused the discipline of British zooarchaeology, that is the study of animal remains from archaeological sites, to evolve along new lines, since the immense quantity of material demanded more improved and refined methods of analysis that were essentially cost-effective.

Towns indeed are the most complicated sites to excavate being complex, multi-functional settlements, many having been in existence for thousands of years. Each town is unique, having its own set of archaeological problems and priorities, and each will deliver different types of information, depending on its geography, topography and topology.

The lack of an agreed terminology to describe excavated features can create difficulties in the understanding of a site and its subsequent interpretation. Carver has rightly emphasised the need for liaison with other specialists: '...the urban archaeologist cannot hope to make sense of it (the nature of the site) without intimate co-operation with the disciplines of biology, architecture and documentary research' (Carver 1987a, 20).

One major problem encountered by archaeologists is the difficulty of spotting residual material (surviving from a significantly earlier period) within strata. Schofield (1987, 1) suggests this 'background noise' should be identified by comparing results from the excavation of single-period sites and by the employment of various analytical tools such as Harris matrices or seriation diagrams for the finds.

Although the terms 'urban', 'town' and 'village' are adequately described in the 20th-century literature, our appreciation of their meaning with respect to the Roman and indeed medieval periods is sadly clouded by a lack of agreement among archaeologists and historians. The problem mainly centres on the fact that many urban sites reflect a rural nature, especially in late Roman Britain and medieval England, as evidenced by agricultural and horticultural activities. In order to make sensible interpretations of bone samples, it is essential for the faunal analyst to be aware of the main archaeological and historical problems of the period in question, particularly the interpretation of settlement types.

1.2 Roman Britain

Throughout the empire, perhaps the most distinctive phenomenon of Romanisation was the appearance of towns. Some exhibit clearly-definable characteristics, for example the *coloniae, municipia* and *civitas* capitals. These settlements possessed a forum and basilica, a regular grid of streets and a variety of public amenities such as public baths, theatres and amphitheatres. *Civitas* capitals can be identified via documentary evidence by the tribal suffix to their names (Rivet 1975, 111). The four towns holding the rank of *colonia* were Lincoln, Gloucester, York and Colchester, of which three (Lincoln, Gloucester and Colchester) were founded to house ex-army veterans who would promote the Roman style of living. The inhabitants of these towns held full Roman citizenship. The *municipia* were similar to the *coloniae,* the title being given to a pre-existing settlement, for example Verulamium (St Albans). Both types of settlement received a charter of independence. As the civilian administration evolved, areas of local government were demarcated which followed the lines of pre-Roman tribal divisions, and were designated *civitates;* the administrative focus of each area was the *civitas* capital (Rivet 1958).

The old school of classical scholars visualised clear demarcations between towns, villas, forts, villages and farmsteads (Richmond 1963; Rivet 1958; Collingwood & Richmond 1969). However, Todd (1970) pointed out the existence of small settlements for which he coined the term 'small town'. These were roughly 4 to 18 hectares in size, as contrasted with towns proper which were 14 to 134 hectares (Salway 1981, 593). Further, small towns differed from towns in that they exhibited no clear planning, and public buildings were generally absent, for example temples, forums, basilicas, theatres and baths. Summing up the conference proceedings on *The small towns of Roman Britain* in 1975, Rivet (1975, 111-14) pointed out the uncertainty of the definition of the term 'small town'. Millett (1990, 145) has criticised the use of the term since the size-range quite clearly overlaps with the *civitas* capitals, and also the settlements encompassed by the term illustrate a diverse range of types, their only link being a lack of public amenities. There are also problems apparent in distinguishing small towns from 'villages', particularly in the late Roman period (Rivet 1975, 114; Jones & Wacher 1987, 27; Millett 1990, 205). Salway had no doubts that nucleated settlements (villages) existed in the Roman period, due in part to Hallam's initial survey of the Fenland, and also his own later research (Hallam 1964; Salway 1970 & 1981). However, Miles (1989, 116) suggests caution in designating the term 'village' to these settlements with the exception of some road-side settlements.

While large-scale excavation is needed to understand the nature of small towns and rural sites, the latter evidently become more important in the later Roman period. Carver aptly summarises the flavour of the Romano-British urban environment: 'If the sense of urban community is common to all parts of the Roman empire, the towns themselves were extremely varied; technically varied, varied in their degree of investment, their style and above all in the function which each was called upon to exercise. If townhouses in Roman Pompeii, Gloucester and London could be tall and grand, built in brick and stone with marble fascias, and provided with a courtyard with a garden and fountain, those at Braintree and Chelmsford had thatched roofs, white-washed walls and were timbered throughout' (Carver 1987a, 22-3). Braintree and Chelmsford are examples of small towns and both are situated in the canton of the Trinovantes, as is the Roman *colonia* of Colchester (Section 7.1).

Similarly, the concept of the term 'villa' in Roman Britain is also fraught with difficulties, since, as Millett (1990, 92) points out, the term constitutes a country house in Latin and does not necessarily describe a farm. The farm or *fundus* was the symbol of agricultural exploitation in the empire while the villa represented the country establishment of a person who desired land, which in turn reflected the power of the individual. Hence the villa epitomised the show of riches and not necessarily agricultural achievements (Rivet 1958, 104). This wealth may well have emanated from booty via Rome's military conquests or possibly trade. Indeed, the evidence of architecture and artefacts indicates consumption rather than production, and Jones (1989, 129) points out that villas show an absence of evidence concerning changes in the agrarian economy during the early Roman period.

Many Romanists have come to reject the notion that there was a sharp cleavage between town and country in Roman Britain. Now, small towns are viewed as having been mainly agricultural establishments dependent on their rural environment. Rivet (1958, 32) observed that few villas were more than half-a-day's ride from a town. Salway noticed that this was true of the small towns and not the main cities. He thus proposed that the villas had a good deal of the day-to-day business with the county towns and only infrequently came into contact with cities (Salway 1981, 596). The small towns would have provided the essential services, shops and market facilities, but had nothing that would encourage the upper classes to move into them; for example, as has been mentioned, no public baths have been excavated from a small town. Salway *(ibid,* 597) concluded that the small town was essentially dependent on the countryside, either because it largely housed people who worked the land, or because it served the daily needs of the estate and/or peasant farmers of the district.

Even with the concept of towns proper, that is, cities in the Roman period, Salway claims that the term is inappropriate: 'A purely urban concept is anachronistic. It is also insular as a cursory exploration of the back-streets of many a modern French or German town of moderate size will reveal. We have to expect a proportion of the inhabitants of most ancient cities to be farming land outside the town or like the Mayor of Casterbridge, closely involved with agriculture' *(ibid,* 586).

A complete reform of the administrative system of the empire was undertaken by Diocletian (AD 284-305) with the aim of creating smaller provinces for more efficient administration and also to separate the military from the civilian sector (Frere 1974, 240). Millett (1990, 133) has pointed out that this was followed by the major administrative centres going into decline with a concomitant increase in rural establishments and hence agriculture. Villa building took off as did the development of small towns and rurally-located industries.

Throughout the Roman period, the evidence for horticulture increases. More garden and orchard crops occur, together with the advent of trenches and digging holes both in rural and urban locations (Jones 1989, 130). Agricultural activity appears prominently in later towns and there is evidence of widespread cultivation within the walls (Millett 1990, 135); indeed contemporary documentary evidence describes this for late Roman towns in Gaul (Libanius *Oration* XVIII.35, the funeral oration over Julian, pers comm C Going). Cultivated soil (tilled by hand and plough), dated to *c* AD 100-400+, was found at Culver Street inside the walls at Colchester, together with the remains of a plough-share; in the later Roman period (AD 300-400+), scant evidence of building could be observed on this site apart from a large aisled building (Building 127), possibly an agricultural barn *(CAR* **6**, 112-16).

Excavations within the walls of Cirencester, the second largest city in Roman Britain, have revealed two main dwellings of mid 4th-century date which strongly resemble countryside villas, while one of the ancillary buildings is a typical example of an aisled barn or farm-building. A plough coulter and weaving equipment were also found in the outbuildings (McWhirr 1981). At Silchester, a house near the north gate is associated with barns or byre-like buildings (Boon 1974, 179), and in the centre of Verulamium (St Albans) a small courtyard house of the late 4th century contained a corn-drying kiln (Frere 1983, 214-22). Some small towns have indications of aisled buildings, and these are more commonly seen in countryside establishments in the form of farmhouses or barns (Todd 1970, 121). In Essex, a typical winged corridor house was excavated in the small town of Great Chesterford, Essex (Richmond 1963, 78). Some farms or suburban villas were directly adjacent to the town as at Kenchester (Salway 1981, 586). Wacher (1978, 126) draws attention to the problems of describing these remains; he questions whether it is right to call the house at Barton Court (some 400 m beyond the walls at Cirencester) a villa, while denying the term to similar buildings, already described, just within the walls. According to Roman law and usage those villas inside the town were not strictly villas. It is obviously critical to excavate on a large scale both villas and farmsteads as at, for example, Gorhambury (Neal *et al* 1990), in order to find out their exact functions. As already stated, some villas might simply have been the pleasant country seats of local gentry dabbling in agriculture, and did not epitomise the mainstay of the Romano-British economy.

Indeed, Hodder and Millett (1980) have claimed that the distribution of villas was based more on social considerations than economic ones. They suggest that the administrative status of towns was the main attraction for building villas. Administratively important centres have a shallow fall-off in density of villas around them, while the small towns without administrative status have a much more rapid fall-off in villa density. In other words, the Romans were more prepared to build their villas further away from more major administrative centres than minor ones. This evidence taken together with the lack of correlation between density fall-off of villas and area of towns suggests that the villa-distribution was socially determined (Hodder & Millett 1980). Millett (1990, 192-3) re-emphasised that the villa and town relationship was not the product of marketing powers. If the economic pull of towns was the decisive force that decided the density of villas, then it would be natural to expect that the largest towns, representing the biggest markets, would attract the largest concentration of villas. This is clearly not the case.

The extensive excavation of the town of Silchester in Hampshire yielded rich iron-work hoards, revealing a plentiful supply of carpenters' tools and agricultural implements, including plough-shares and coulters. Wacher (1975, 272) claimed that their existence in the town supported the idea that many country districts depended on the services provided by towns, and indeed villages, for repairs and replacements. However, one could equally well argue that they were owned by farmers living inside Silchester. A large number of agricultural implements was also found at Caerwent (Wacher 1974, 386). George Boon (1974, 245-8) has claimed that the lack of villas around Silchester indicates that the land was farmed from the town. Certain houses within the town had large yards and outbuildings suitable for farm use, and a corn-drying oven was present. However, Boon (1974, 245-8) has concluded that for a population of twelve hundred, there was insufficient land in the form of *territoria* that could be farmed directly (up to a distance of 1.5 km from the walls) in order to sustain such a number. At a general estimate, the land could only provide between one third and one quarter of the town's needs.

One of the most startling results concerning area surveys in Roman Italy, north-eastern France and northern Syria is that the density of rural settlement is so great that the significance of towns is proportionately reduced. Most fieldwork studies show a heavy but dispersed scatter of Roman rural sites while the number of towns, most of which were already well-known, remains static. The dynamics of this pattern reduce the national importance of towns, particularly away from the Mediterranean (Greene 1986, 170).

Although British classical archaeologists have concentrated more on the art, architecture and military history of the period, it is evident that the foregoing statements are reflected in Roman Britain, particularly in the latter part of the period. Millett has claimed that rural sites in Britain do not show any marked relation to urban sites. Where detailed studies have been undertaken, these settlements have densities very high in relation to villas. 'It seems clear that in the south at least, the countryside was densely populated with what we might simply call farmsteads, which were fairly evenly and densely spread and not apparently sited with a locational preference for areas near to the towns' (Millett 1982, 423). The county of Northamptonshire illustrates this situation very well; some of these settlements are difficult to distinguish from the less well-developed small towns.

Fulford concedes the premise of Collingwood and Myers that the towns of Roman Britain were parasites on the countryside, providing that the definition of town is confined to the *coloniae, municipia* and *civitas* capitals (Collingwood & Myers 1937; Fulford 1982). Fulford claims that more was accepted by the towns than given in the way of services and manufactured articles, as well as public administration and justice. However, the lesser towns seem different, and in order to understand this it is necessary to address the fundamental problem of distinguishing between a community dependent primarily on agriculture and one dependent on craft specialisation and the provision of a range of services (Fulford 1982, 147).

Salway, quoting Todd, stated that the small towns of Chesterton, Mancetter and possibly Weston-under-Penyard are the only places yet known to have depended upon industry as the mainstay of their economic existence (Salway 1981, 595, after Todd 1970, 129). Our analysis of the bone assemblages from the small town of Chelmsford in Essex has pinpointed a substantial tanning and horning industry in the later part of the town's history. No other site in the canton has produced such firm evidence. The predominance of male cattle horn cores (bulls and castrates; normally female beasts predominate in Romano-British assemblages) is extremely interesting, and the scale of operation is suggestive of an industrial rather than cottage-craft enterprise (Luff forthcoming). A tannery has also been identified at the Roman small town of Alcester (Burnham & Wacher 1990, 6). Smithing and pottery manufacture are also attested at Chelmsford (Drury 1988, 136). Apart from ceramic manufacture and metal working, there is a lack of detailed information concerning craft activities in small towns.

Fulford (1982, 413) is also quite specific in his definition of the term 'urban' which he says embraces all classes of nucleated settlement (except military establishments) where the communities were not engaged primarily in food production. I do not agree that this definition should be applied until further research elucidates just what sorts of activities were undertaken at these sites. Fulford himself admits that the nature of the archaeological evidence is such that we can only recognise a limited range of craft specialisations, such as metal working.

One of the best and most spectacularly-preserved sites in the Roman world is Pompeii. Wilhelmina Jashemski undertook a detailed investigation of the gardens of Pompeii which had been covered by ash from the eruption of Vesuvius in AD 79. She excavated cavities in the ground where tree-root systems had existed and filled the spaces with plaster; the surrounding earth was then removed in order to expose the root system. Many large species of plants and trees have been identified, which in turn has led to determination of the garden produce. As she herself said: 'A study of land-use within the city and of the relative density of buildings in proportion to the amount of open space, is of considerable importance in making any estimate of the size of the population. The amount of open space and the amount of land under cultivation tells us a great deal about the quality of life in this ancient city. Ancient Pompeii with many open areas of green gardens, parks, vineyards, orchards and vegetable plots... must have been very beautiful indeed, and very different from the crowded overbuilt city sometimes described by modern scholars' (Jashemski 1979, 24). Here the distinction between town and country is indistinct; much commercial as opposed to ornamental gardening was being carried out in the town. This has enormous implications for Roman towns in general.

However, at present our knowledge of the use of buildings and open land within Romano-British towns is limited. Indeed, for a number of years, a layer of 'dark earth' has been recorded in the course of many British urban excavations, usually in the late Roman to medieval phases; the interpretation of these deposits has been open to much speculation (Courty *et al* 1989, 261-8; Yule 1990). In London there was a marked increase in building activity from the late 2nd century on, and many sites were covered by layers of this dark earth (Bedoyère 1992, 76). Currently excavators believe that the dark earth is indicative of cultivation, and that this material was spread across levelled building sites which had been given over to cultivation (Perring 1991, 79; Bedoyère 1992, 76). Comparable dark-earth deposits are ubiquitous at Colchester but are seen as being topsoil which accumulated to depths of up to 1.5 m in the post-Roman period *(CAR* **3**, 92 & *CAR* **6**, 122). Soil which was cultivated in the Roman period has also been identified at Colchester on several sites, but there is no suggestion that any of this material was imported *(CAR* **3**, 37, 50 & *CAR* **6**, 33, 138-41).

Salway (1981, 587) points out that the presence of farm-buildings, or even cultivated ground, within city walls should not be thought of as implying a decline or abandonment of urban life. Surviving records of medieval walled towns show many examples of orchards, kitchen gardens and closes for animals.

The animal-bone material excavated from urban contexts allows us a valuable opportunity to study such subjects as the diet of the urban community, the agricultural economy of the surrounding area, the types of stock kept, and the butchery practices carried out. This work is still in its infancy. Until recently, as Greene (1986, 71) has pointed out, excavations have been directed towards the study of architectural features; the detailed investigation of outbuildings, soils, animal bones and plant remains are still rare. He states that scientific precision and thoughtful sampling are even rarer.

That bone and seed data have not been used to their full potential has been questioned by Millett (1982, 424). In fact Millett claims that too much sampling is being used, to learn as much as possible from as little as possible; specific questions are not being accorded the right attention. He glumly sums up: 'Much of my own disillusionment with the recent work is therefore a result of the lack of new questions being asked, not the lack of answers to old questions' (Millett 1982, 422).

Shackley develops this view further: 'It is unfortunate that the smaller the scale of question the more information is likely to be available and to a certain extent this has resulted in a loss of perspective in recent years with archaeologists continually developing better and better techniques to answer smaller and smaller questions, while losing sight of the larger frames of reference within which they are working. Synthesis is often frowned upon as being premature postulation of macroscopic questions discouraged because of logistical difficulties in working on such a large scale' (Shackley 1985, 16).

Certainly few classical archaeologists ask broader questions of the bone data. These are too often left to the faunal analyst, who, while she or he may have intimate knowledge of the period under analysis, seldom possess the detailed information that is in the hands of the excavator. It is at this point that good communication is crucial if any worthwhile environmental conclusions are to be gleaned. Millett (1982, 425) has listed some of the questions that he would like answered, such as:

a) What were the normal patterns of bone refuse for farmsteads, villas and towns?
b) Was a highly-organised meat trade only organised by the army?
c) What are the differences between large- and small-town bone assemblages?

These are all basic questions that are easily answerable with the right sampling strategies.

Millett further points out that there is no assessment currently available concerning the botanical material that was brought to the towns, villages and villas, particularly with regard to quantities. He realises that seeds are a potential source of much invaluable information, but as Payne has stated: '...in the case of grain the only seeds that we find are those which were not eaten and did not germinate, but were instead preserved by some accident, usually by burning. Thus no direct comparison between plant and animal remains from a site can give any realistic measure of their relative importance' (Payne 1985, 234).

Historians and archaeologists are at loggerheads as to whether we are dealing with a monetised market economy in the Roman period. The existence of coined money and/or market buildings do not necessarily indicate a market economy; the latter may reflect more a social phenomenon. In the early and mid 1970s, Finley (1973) and Carney (1975) argued that markets were of much less significance than had generally been acknowledged. The demand of the army imposed a burden on local communities and created both long- and short-distance supply networks. Finley and Carney felt less certain that a fully-developed market economy had ever emerged outside military demand.

However, in the 1980s Gillam and Greene (1981) and Hopkins (1981) argued for a money-based market economy, while Hodder (1970) had suggested a market economy only in the late period. Reece has pointed out that in the early Roman period of Britain, a free market economy was hampered in development by coinage which was inappropriate in that it mostly consisted of large-denominational currency. From about AD 260 onwards, abundant finds of small-value copper coinage are found on many Romano-British sites, particularly those in the countryside, and Reece (1988, 61) has postulated that this may have meant the existence of a far-flung market economy. Reece (1980) and Hingley (1982) emphasised the contrast between an urban-dominated economy in the early Roman period, and a villa and village-based economy in the later Roman period during which many of the former major markets were by-passed as the towns suffered a major decline. It is still not apparent whether the 4th century was a time of decline (Reece 1980) or one of prosperity and expansion (Frere 1974; Wacher 1978; Biddle 1976). Only intensive regional studies can provide us with the answer.

Indeed, Lloyd (1986) questions the assumption made by Maltby (1979a) that there was a large-scale organised marketing of cattle in the early Roman period at Exeter. Other factors could account for the bone assemblages, including meat distributed via religious festivals and sponsored feasts, both of which are well-documented for the classical world. Further, he proposes that the Exeter cattle might have been owned by the civic authorities, and could have been slaughtered and butchered by one or two part-time butchers and subsequently the meat distributed free of charge. It is perhaps not coincidental that 'organised' slaughter of cattle on a large scale occurs when there was no small change in circulation, in other words, no real market economy. It could well be that these slaughtered beasts represent payment in kind to individuals for certain services rendered.

In conclusion of this section, it would seem likely that towns were an essential prerequisite for the development of prosperous farming, not so much because they provided a market for agricultural produce but that they would have been the first to adopt new ideas and techniques and put them into practice (Wacher 1974, 72). But it is clear that Romanists themselves are not in agreement over what merits the term 'town', and indeed Richard Reece (1988, 54) has coined the term 'TCP (things that are called towns) to emphasise this point. The agricultural flavour of these nucleated settlements is now quite apparent. However, the fact that some or indeed most of the inhabitants of a town were involved in agriculture should not negate the basic concept underlying the term 'town', that it is a centre providing specialised services and wants not met by villages.

As with villas and farmsteads, we need much more in the way of large-scale excavations in order to comprehend these sites fully. Drury and Rodwell's remarks of 1980 are still pertinent; summing up the research priorities of the Trinovantian canton they concluded: 'Small-scale excavations of large sites, particularly villas and small towns, are at best poor value for money and at worst misleading. Work in the future must concentrate on a small number of large sites chosen on the criteria of their state of preservation, availability, and the likely value of results, as well as the threat of destruction by dramatic, or more likely insidious action' (Drury & Rodwell 1980, 74). Ten years on, Burnham and

Wacher concluded from a survey of 54 out of 80 or more Romano-British small towns: '...how lamentably ignorant we are about them' (Burnham & Wacher 1990, 320).

1.3 **Medieval England**

'Bones and other environmental evidence will seldom have the same value on a medieval or an early modern site as they might have if found in a prehistoric context' (Piatt 1974, 1).

The above comment by a medievalist echoes the views of Romanists in the early 1970s *(see* opening comment, Section 1.1). However, since then much vital information concerning diet and livestock husbandry has been gained from large-scale analyses of urban faunal assemblages from, for example, Exeter, Lincoln, and York (Maltby 1979a; O'Connor 1982, 1984 & 1988). Some of these results will be synthesised in Section 7.2.

However, there is a scarcity of zooarchaeological data from the late Saxon to medieval periods in Britain, that is the 9th to the 15th centuries AD. Approximately one hundred papers have been published and hardly any describe sample sizes large enough to merit a statistical analysis (Grant 1984). Archaeologically there is a greater emphasis on the early rather than the later medieval levels. Research has concentrated on the 8th to 11th centuries rather than the 12th to 16th centuries, which are supposedly well-understood from documentary sources (Palliser 1987, 54).

The backbone of the medieval landscape was the village and the town. In his introduction to *The English medieval town,* Platt advises caution in the interpretation of the term 'town'. There was no intensive urbanisation of medieval England, and he has estimated that as much as 95 per cent of the population lived in a rural environment as late as AD 1500, and that this was not to change for at least another two centuries. Platt states: 'It was not just that the English town was small, frequently it also retained many rural characteristics that blurred its distinction from the countryside' (1976, 15). This blurring of urban and rural settlements has already been commented on in Section 1.2 with respect to Roman Britain and indeed the bank vole *(Clethrionomys glareolus)* has been identified in medieval towns, for example London (Armitage 1985). This small mammal needs a great deal of dense vegetational cover and is rarely found far from bramble thickets, hedgerows and other woody scrub. The vole reflects the occurrence of vegetation within a medieval town in much the same way as has been discussed for Roman urban sites.

Indeed, distinguishing between a small market town and large village is almost impossible (Bigmore 1982, 155). Towns have tended to be defined by their 'legalistic rather than functional role', the former depending on documentary evidence. It could be argued that the material under investigation is adequately covered by documentary evidence. However, there are scant records available for the particular topics under consideration. Postan has claimed that the history of internal trade in medieval England is not as well-served by documentary evidence as foreign trade. Such little evidence as there is throws some light on the organisation of the trade, above all on the institutions serving and regulating it. On the other hand there is next-to-no evidence to reveal its changing quantity (Postan 1986, 221). Further, one of the problems of documentary evidence is that different sources can give conflicting evidence, and so documentary evidence can be just as misleading as zooarchaeological evidence.

The majority of authors and the editors of *Urban archaeology in Britain* (Schofield & Leech 1987) claimed that archaeological and historical sources are complementary. The archae- ological evidence should be considered first, within its own framework, before it is compared and possibly integrated with hypotheses generated from documentary evidence. As Schofield so sensibly has said: 'Neither is the handmaid of the other' (1987, 5).

Although documentary evidence does not give any details concerning the different strata of society, it does provide fascinating glimpses into everyday life. In towns, the worst offenders against sanitary regulations were the butchers. Blood and entrails were frequently thrown into the streets, as the butchers were slaughtering their beasts near if not actually in the streets where their shops were. This was normally in the busiest and most crowded part of a town. During the 14th century, several unsuccessful attempts were made to force butchers to slaughter outside the city (Keene 1982, 27).

Documentary evidence also shows that large numbers of cattle, sheep, pigs, goats, and poultry were housed inside medieval towns. Loose ducks and hens caused problems in the corn market, while butchers had bulldogs which were a threat to passers-by (Keene 1982, 27). Pigs frequently attacked and injured children. However, roving pigs were also useful, for being omnivorous they could dispose of much refuse. In this capacity, kites and ravens were protected scavengers of the streets in the late medieval and early modern periods (Thomas 1987, 274). While much has been made of carnivore attrition of bone, scant research has been undertaken on kite-scavenging of carcasses and pig-gnawing of bone. Pigs might well have consumed much animal bone.

Dung and straw from stables were frequently thrown into the streets, and dead animals, especially horses and cows, were often discarded in public areas. From the 13th century, town authorities paved and cleansed the streets. There were public latrines in the late medieval period at London, Leicester, Winchester, Hull and London (Platt 1976, 71). Richard II was responsible for the 'first urban sanitary' act of 1388 after Edward III's remark in 1332, when he described

York as having an 'abominable smell abounding in the said city more than in any other city of the realm from dung and manure and other filth and dirt wherewith the streets and lanes are filled and obstructed' *(ibid,* 70).

In Southampton in the 13th century, the larger burgess houses and elsewhere were provided with stone-built cess-pits. Commonly from the 14th century onwards, building contracts specified that townhouses be provided with adequate cess-pits with or without the overlying garderobe. The growing practice of night cartage of filth freshened most living quarters in better town houses. Archaeologists have shown that cess-pit digging declined sharply in the 14th century, coinciding with the worst plagues, and was not resumed until the 16th century (Platt 1976, 72).

Tanning processes also produced many unpleasant smells. At Northampton, a bye-law was passed in 1566 reaffirming that tanners should cleanse their quarters of all manner of carrion and bones once every year. Further legislation enacted in Northampton in 1582 stated that no dead horse, mare or gelding or any hog, dog or other such carrion should be cast into the streets, ways, ditches or any ground of the town except the Marehold and that the Whitawyers shall yearly between March 6 and April 14 buy the bones that have been cast there.

A symbiotic relationship is emerging between the archaeological and historical disciplines, each making a useful contribution to the other. Historians have pointed out the vast gaps in their data, and recognise that faunal material is of major importance in providing information concerning diet, disease and animal husbandry to name but a few topics. However, since methods are still being refined and perfected in zoo-archaeology, any conclusions concerning faunal evidence should be qualified by comments concerning the overall reliability of the results. In this way past explanations of uncertain data will not be accepted as future incontrovertible fact.

1.4 **Colchester: the historical background**

Colchester was an important settlement in the Roman, medieval and post-medieval periods, being a port. It is also situated in rich farming country. Although well-documented by the standards of medieval England, the economic evidence is of low quality (Britnell 1986, 3).

During the past two decades, intensive excavation by the Colchester Archaeological Trust has yielded large assemblages of animal bone from both inside and outside the Roman and medieval town walls. *In search of Colchester's past* provides a summary of the excavations of the 1970s and 1980s together with an interesting account of the activities of earlier antiquarians and archaeologists such as Wheeler, Hawkes and Hull (Crummy 1986).

A military fortress was set up at Colchester shortly after the Roman invasion of Britain in AD 43. Later a town with the status of a *colonia* was founded, in AD 49. Subsequently the Britons, under the leadership of Boudica, revolted against Roman domination and in AD 60/1 burnt Colchester to the ground, together with the Roman towns of St Albans and London. This burnt layer is usually apparent wherever excavation has taken place in Colchester and is evidence of the wide-spread destruction caused by Boudica and her followers. It also has important implications with respect to the dating of archaeological sites, and has provided some well-preserved carbonised organic remains, for example dates, olives, wheat, seeds and nuts (Section 8.3.1; Crummy 1977 & 1986; *CAR* ***3,*** 40, 105, 108, 110; *CAR* ***6,*** 45, 330).

The town was restored after the revolt but never fully recovered the vigour of its pre-Boudican days. Gradually the street system was re-established and extended, new houses were erected, and the *colonia,* which at the time of the attack was undefended, was provided with a ditch and stone wall, possibly as early as *c* AD 75.

During the 2nd century, houses were being replaced by buildings of a quality not seen in the town before. They tended to be larger and more substantially-built and incorporated mosaics, tessellated floors and heated rooms.

Later, practically all of the extramural houses and other buildings were demolished without replacement, perhaps in some cases in favour of sites within the walled part of the town. The defences were improved with the widening of the town ditch and the closure of at least two of the gates. These changes date from the mid to late 3rd century when the Essex coast experienced increasing attacks from Germanic seafaring warriors (commonly called Saxons). Official protection was provided by the Romano-British fleet via a series of fortifications, the Saxon shore forts (Campbell 1982, 14). These were positioned around the coast of south-east Britain from the Wash to the Solent.

By AD 410, Britain had in effect ceased to be part of the Roman Empire. This is a very tricky period to interpret archaeologically, since the literary references are few and unreliable, and also the supply of Romano-British coinage ceased around this time, thus making precise archaeological dating impossible. It is thought that the main phase of Anglo-Saxon migration began in the middle of the 5th century (Cleary 1989, 162).

Three *grubenhauser* or Saxon huts have been identified inside the walls at Colchester and a Saxon cemetery has been pinpointed outside the walls. The *grubenhauser* and various Saxon artefacts indicate the collapse of the Romano- British administration and occupation by Saxons by the mid 5th century AD (*CAR* **1**, 22).

In contrast with Roman and medieval Colchester, Philip Crummy suggests that between the 5th and 11th centuries the town's population was very small, as evinced by a general lack of Anglo-Saxon finds. Indeed, scarcely any artefactual evidence from the town can be ascribed to the period AD 750-900; proof of occupation is meagre and indicates that the town housed either a relatively small population or, less likely, was deserted *(CAR* **1,** 72).

The next marked influence on town development stemmed from the Norse invasions. Following the Treaty of Alfred and Guthrum in AD 879, it seems likely that a Danish settlement was founded at Colchester (*CAR* **1,** 24-5). Essex had already become part of the Danelaw after the Treaty of Wedmore in AD 878. There may have been a re-population of Colchester by Edward the Elder in the early 10th century, and the town evidently flourished for in AD 991 it was described as 'a town known to all men' (Martin 1959, 16).

Colchester was the most important town in Essex during both the Roman and medieval periods. The only towns recorded in the Domesday survey of Essex were Colchester and Maldon. In the later medieval period, Colchester was to become the leading centre of the cloth industry, due in part to the influx of Flemish craftsmen in the 14th century (Britnell 1986, 72).

Although Essex largely escaped any serious fighting in the Civil War, the Siege of Colchester in 1648 resulted in the destruction of two hundred houses and other buildings, and the town's cloth trade suffered a setback from which it never fully recovered (Martin 1959, 59).

The Georgian prosperity of Colchester, at that time the largest town in Essex, was founded on the wealth accumulated from the cloth trade during the previous century. Fortunately the flourishing condition of Essex agriculture offset the worst effects of the declining cloth industry (Brown 1969; 49 & 111). However, documentary sources imply that Essex did not play a leading part in the improvement of livestock during this period (Vancouver 1795, 198).

1.5 Colchester: the archaeological sites and their bone asemblages

[Fig 1.1]

Bone assemblages from the Colchester sites of Balkerne Lane (BKC), Butt Road (BUTT), Culver Street (CUL or 1.81), the Gilberd School (GBS), Lion Walk (LWC), Long Wyre Street (COC) and Middleborough (MID) are described in this volume (Fig 1.1). The archaeology of the sites is described and discussed in detail in *Colchester Archaeological Reports* 3, 6, and 9. The faunal material from the smaller sites excavated between 1971 and 1985 has not been included in this study. The sites concerned are published in *CAR* **6** and *CAR* ***9.***

The Colchester bone assemblages and their respective archives (both on paper and disk) are stored in the Colchester Museums.

A key for finding the main results of the faunal analysis is provided on pages 11-12, while a glossary of zoo-archaeological terms (and abbreviations) can be consulted on p 151.

Balkerne Lane (BKC; *CAR* **3,** 93-154)

The Balkerne Lane site is an extramural area which straddles the main east-west street leading originally from the west side of the fortress and later the town and, on its east side, includes parts of the north-south military and civilian defences of Roman Colchester.

Occupation at Balkerne Lane has been divided into six periods and the site itself was excavated as a number of sub-sites. The bone assemblages examined came from a series of selected Roman pits, ditches and dumps from Sites E, G, H, J, K, L, N, T, and V.

In Period 1a the initial military occupation of Colchester led to the building of a legionary fortress, the defences of which were excavated at Balkerne Lane. A possible civilian settlement or *canabae* developed alongside the street leading from the fortress and consisted of small insubstantial buildings. The start of Period 1b corresponded with the founding of the Roman colony and was marked at Balkerne Lane with the levelling of the legionary defences. In Period 2 (the main pre-Boudican colonial phase), buildings were built on either side of the street; these were of a poorer construction than those of contemporary Lion Walk in that the roofs were thatched and not tiled and the walls were of wattle and daub. In Period 3, in the aftermath of the Boudican rebellion of AD 60/1, the colony was provided with

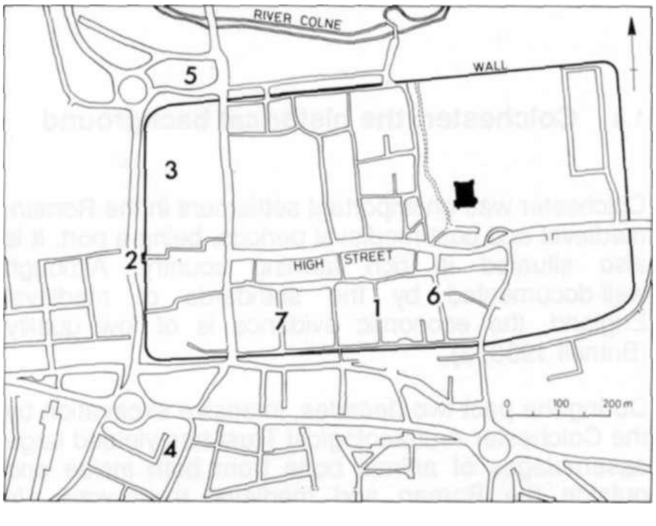


Fig 1.1 The archaeological sites at Colchester.
1: Lion Walk (LWC); 2: Balkerne Lane (BKC); 3: the Gilberd School (GBS); 4: Butt Road (BUTT); 5: Middleborough (MID); 6: Long Wyre Street (COC); 7: Culver Street (CUL).
[Pages 8-10]

defences, the ditch of which was partly excavated at Balkerne Lane. In Period 4, part of the Period 3 ditch was filled in to allow the construction of a Romano-Celtic temple and a possible shrine. Strip-houses were erected alongside the main east-west street. In Period 5 there was some upgrading and replacement of the houses but in general these never matched the quality of those inside the walls.

The start of Period 6 saw the demolition of most of the buildings and a strengthening of the defences as the suburban areas around the walled part of the town dwindled. There was much activity on site in the form of dumping and the digging of pits but there was little evidence of direct occupation.

Period 1a: c AD 44-49
Period 1b: c AD 49-50/5?
Period 2: c AD 50/57-60/1
Period 3: c AD 60/1-75/80
Period 4: c AD 75/80-125
Period 5a: c AD 100/125-150
Period 5b: c AD 150-250
Period 5c: c AD 250-300
Period 6: c AD 300-400+

Butt Road (BUTT; *CAR* **9)**

The site is situated to the south-west of the Roman town in Butt Road. At Butt Road Site E, a Roman edifice was uncovered which has been interpreted as a church on the basis of its plan and also its contemporaneity with a large Christian cemetery *(CAR* **9;** Sections 3.7.1, 5.2, & 5.4). The site yielded unusual deposits of bone which might well have emanated from funerary and/or commemorative meals. Four main assemblages of bone were examined from Butt Road, three of them being strongly associated with human burials while the fourth emanated from the vicinty of the church.

Period 1: ?1 st century AD -c 320/40 (agricultural plots with later pagan cemetery)
Period 2: *c* AD 320/40-400+ (Christian cemetery and church)

Culver Street (CUL or 1.81; *CAR* **6**, 21 -126)

Culver Street is the largest of the sites excavated inside the walls at Colchester. The site was split into a number of sub-sites, bone being analysed from the Sites A, B, C, D, E, G, H, K, and M. For the military phase six barrack blocks were located, together with two probable tribune houses (Sites E and M). Soon after the Boudican destruction the northern part of the site was developed with new housing while the southern part was left largely uncultivated.

Bone groups were examined from a variety of contexts including mainly pits, dumps and occupation layers. The groups are treated in relation to the following chronology, which is a simplified version of the excavators' phasing *(CAR 6,* 5-6).

Period 1: c AD 44-49
Period 2: *c* AD 49-60/1
Period 3: *C* AD 60/1-100
Period 4: *c* AD 100-300
Period 5: *c* AD 300-400+

Period 1 is the period of Roman military occupation. In Period 2, following the foundation of the colony, there was a civilian re-occupation of military buildings as well as the construction of new ones. In Period 3, after the Boudican destruction of the town, the street system was re-established and new houses constructed, many on plots of pre-Boudican origin. The town wall, partly examined at the south end of the site, seems to have been erected at this time. In Period 4, most of the Period 3 houses were replaced with more substantial and durable structures. Sites G and H were under extensive cultivation at this time and to the east of the site, there was a small stone granary. By c AD 325, all the buildings had been demolished. During Period 5, a probable agricultural barn was erected in the form of a large aisled building.

The Gilberd School (GBS; *CAR* **6***,* 127-39)

The Gilberd School site, on North Hill, lies inside the Roman town wall, at the north-east corner of Insula 17A. The men's quarters of a legionary barrack block were dug near the rear of the fortress, and there is some evidence that the building continued to be occupied during the early years of the *colonia* in AD 49-60/1. Evidence of post-Boudican activity was sparse, and much of the site remained an open area throughout the Roman period with occasional pit-digging and horticulture taking place. The site was primarily used for cultivation during the medieval and post-medieval periods, although in the south-east corner of the site two medieval industrial features were found, namely a bronze casting-pit and a lime kiln. The bone assemblages were retrieved mainly from pits, dumps and middens.

Period 1: c AD 44-49
Period 2: *C* AD 49-60/1
Period 3: **C** AD 60/1-250/275

Lion Walk (LWC; *CAR* **3**, 31-92)

The Lion Walk site lies in the southern part of the fortified area of the Roman and medieval town. The site was dug and recorded as a series of self-contained sub-sites. Bone was recovered from a variety of features of which pits were the most productive, in the Roman, late medieval and post-medieval periods. One Roman feature that yielded much bone was a cellar (BF70) which belonged to Building 22 on Site B. The backfill of the cellar, which was located on a street frontage, consisted of two phases. Apart from two Anglo-Saxon huts, robber trenches represent the earliest evidence of post-Roman activity on the sites. These are nearly all of 11th- or 12th-century origin although a few were of the 13th century and later. The robber trenches resulted from the retrieval of building materials from foundations dated from the 2nd to 4th centuries. Some bone was found in them. However, most of the bone recovered from Lion Walk came from post-Roman pits of late medieval to early modern date. It appears that very few, if any, were dug before *c* AD 1050/1100, and this is probably because the Lion Walk site was situated at a distance from the High Street where occupation in the town was concentrated until perhaps the 12th century.

Long Wyre Street (COC; *CAR* **6**, 355-65)

The Long Wyre Street site is situated at the northern end of Long Wyre Street and straddles Insulae 29, 30, 37 and 38a. Bone groups were examined from the 1st century AD as well as from the medieval and post-medieval periods.

The Roman material derives from a variety of sources including occupation levels, pits and dumps. In the 19th and 20th centuries, building operations along the east side of the site resulted in the destruction of almost all vestiges of medieval occupation on the Long Wyre Street frontage. The result was that all that could be dug was a series of floors and the foundations of wings or outhouses in the rear parts of the medieval and later properties. Medieval bone groups were analysed from robber trenches and pits of the 11th to 12th centuries. These had been sealed by a layer of cultivated soil during the 13th and 14th centuries. Pits associated with a timber-framed structure of the 16th and 17th centuries yielded post-medieval bone.

Middleborough (MID; *CAR* **3,** 155-209)

Middleborough was a small Roman suburb on the north side of the town, between the town wall and the river Colne. During the excavations, a road was discovered on the site leading from North Gate to Sheepen, the early industrial site which later became a sanctuary. The following bone assemblages were examined: Roman demolition debris, medieval pits, robber trenches, post-medieval pits.

2: AIMS AND METHODS

'Faunal analysis is not weak in the number of available analytic techniques but is weak in its ability to assess the reliability and validity of a particular analytic technique and the compatibility of technique' (Lyman 1982, 336).

2.1 Introduction

The Colchester bone analysis was initially started in 1977 with Balkerne Lane Site E (Luff 1982). The remaining Balkerne Lane faunal assemblages, with the exception of Site J, that is Sites G, H, K, L, N, T and V, were analysed during the early 1980s together with selected material from Lion Walk. Due to pressure from other archaeological sites in the area, work did not commence on the remaining Colchester bone assemblages (Balkerne Lane Site J, Butt Road, Culver Street, the Gilberd School, Long Wyre Street and Middleborough) until 1988. It was realised a new line of approach would have to be developed in order to cope with processing the huge amount of material, which had come from an extremely complex set of contexts.

Our major aim was to extract the minimum basic data that would allow a determination of such important topics as:

a) The town's food supply; how did this change through different periods? Which species were dominant? What was the balance between primary products (skins/hides/meat) and secondary products (milk/cheese/wool)? What was the contribution of hunting?
b) The quality of animal husbandry as reflected by the build and health of the beasts; how did this change through time?
c) Can we detect a marketing trade in livestock products? What influence did the Roman army have on these developments? Was the meat destined for the military forces?
d) Does the material show any traces of industrial activity such as tanning, horning or bone working?

2.2 Bone-recovery techniques

A substantial number of bone assemblages had been recovered during the early to late 1970s (Balkerne Lane 1973-6, Butt Road 1976-9, Lion Walk 1971-4, Long Wyre Street 1978-9, and Middleborough 1978). This was at a time when faunal analysis was just

Location of faunal results

Assemblage size	25
Species representation	26
NISP	
Main domesticates and deer (BKC, BUTT, COC, CUL, GBS, MID, LWC)	25-6
Main domesticates and bird (BUTT, COC, CUL, GBS, MID, BKC)	46
Main domestic fowl	83
Carnivores, lagomorphs, and rodents (BKCE, BKCG, BKCH, BKCK, BKCN, BKCT, BKCV, LWC)	34-5
IND	
Main domesticates and deer (BKCJ, BUTT, COC, CUL or 1.81, GBS)	28
WEIGHT	
Domestic/wild mammals and birds	30-31
Cow, S/G, Pig	
NISP/IND relative percentage representation comparing Roman intramural sites with extramural site BKCJ	32-3
NISP/IND relative percentage representation comparing medieval with post-medieval sites	32-3
Roman: tripolar graph relative percentage IND, site by site	42-3, 45
Medieval/post-medieval: tripolar graph of relative percentage IND	42-3, 45
Roman: tripolar graph relative percentage NISP, site by site	44-5
Medieval/post-medieval: tripolar graph of NISP, site by site	44-5
Cattle	
Roman: skeletal-element representation	47
Medieval/post-medieval: skeletal-element representation	52
Sheep/goat	
Roman: skeletal-element representation	49
Medieval/post-medieval: skeletal-element representation	53

continued on next page

Location of faunal results continued....

developing, hence no extensive sieving programme was initially undertaken. However, experimental results have clearly emphasised the importance of sieving with respect to the recovery of small bones/ teeth of large/medium-sized mammals and the bones/ teeth of small mammals, in particular rodents and carnivores; the recovery of immature mammal, bird and fish bones has also been much improved through the utilisation of sieving techniques (Payne 1975). The Culver Street and Gilberd School sites underwent a much more intensive sieving programme than previous sites, and this was instigated and monitored by Peter Murphy. The sampling and recovery methods are described in *CAR* **6** (p 273).

2.3 Data capture

Bone fragments were identified and counted by skeletal element for each taxon for the major domesticates: horse, cattle, sheep/goat, pig, and chicken, and the wild mammals: roe, red and fallow deer. Vertebrae, skull and rib fragments were not counted; however, each group was weighed individually. The coding system for the taxa and parts of anatomies follows that of Jones with certain modifications and refinements (Jones 1981). Where species identification was uncertain, additional categories were included, for instance 'OXO', which comprises animals of large artiodactyl and perissodactyl size, for example horse, red deer and cow, while 'SMA' consists of beasts of small artiodactyl size, such as sheep, goats, roe deer, dogs and pigs. At Colchester, since horse and red deer were both relatively scarce, it is assumed that the OXO fraction of a bone assemblage refers mainly to cattle. Likewise, the SMA fraction reflects mainly sheep, since goats and roe deer were not present in large numbers. Further, dog and cat bones were normally preserved intact in partial or complete burials, while pig bones, due to their characteristic shape and porosity, were identified reasonably well.

There is a voluminous literature covering a variety of methods for quantifying animal bones recovered from archaeological sites (Grayson 1984). Two of the more prominent methods are 'NISP' (number of identifiable bone fragments per species), and 'MNI' (the minimum number of individuals). MNI represents the most commonly-occurring anatomical element, for example six right metacarpals and two left metatarsals of a cow give a MNI of 6.

The MNI method of quantification is not in vogue for the analysis of urban assemblages and has not been used in this research. It has been criticised on the basis that it is the joint or haunch of beef that would have been the likely entity of distribution in a town (Armitage 1982, 95; O'Connor 1989, 194). Indeed O'Connor (1989, 195) has pointed out that the different parts of a carcass could be treated as taxa in themselves. However, the problem lies in determining which particular parts of a bone and bones make up the joint.

The bone-fragment count includes all the bone fragments identified and allocated to a species, minus skulls, vertebrae and ribs (NISP). However, the NISP method can be greatly affected by bone-recovery techniques. A lack of sieving can inflate the importance of large mammal bones relative to small mammal bones, and can also affect ageing profiles in that there is a bias to more mature beasts, jaw bones with fragile deciduous dentitions being more susceptible to fragmentation and hence failure of recovery than those belonging to adult animals. For these reasons we decided to use an additional method to NISP which would allow a more realistic comparison between species of differing body weight.

This involved the counting of 'indicators' (IND) which comprise the following skeletal element parts where more than 50 per cent is present: horn core, mandible tooth row, scapula glenoid cavity, distal epiphyses of humerus, radius and metacarpal, radial carpal, pelvic acetabulum, distal epiphysis of femur, proximal and distal epiphyses of tibia, distal epiphyses of the metatarsal, astragalus and the first phalanx. These particular skeletal elements were mainly chosen because they preserve well (excepting the proximal tibia), and render easier and more accurate comparisons between species, providing differences in butchery techniques are allowed for, and also the fact that different taxa are composed of different numbers of bones; these need to be weighted because, for example, a pig has four times as many metapodials as a cow or sheep.

The proximal tibia does not preserve as well as the distal tibia, being less dense and thinner-walled (Binford 1981, 217). Hence the ratio of proximal to distal tibiae was sought as a key to how well an assemblage might be preserved. In relation to this, the ratio of the numbers of loose teeth to mandible fragments was also investigated as a control on preservation. Both the radial carpal and the first phalanx were chosen in order to determine levels of bone retrieval. These bones are small, especially in sheep/goats, and can be easily overlooked. Indicators were only recorded for cattle, horse, sheep/goat, pig, and red, roe and fallow deer.

A third method of recording the bone was by weight. This method's accuracy has been criticised as a quantification technique, but was used as a general measure of the relative abundance of bone by taxon for all the species. Bones were weighed to the nearest gram using an Ohaus portable balance. This was the only method used to record the remaining wild mammals (hare, rabbit, fox, etc) and domestic beasts (dog and cat) for the post-1988 assemblages (that is Balkerne Lane Site J, Butt Road, Culver Street, the Gilberd School, Long Wyre Street and Middleborough). The remaining skeletal elements which had not been counted, that is skull, vertebrae and rib fragments were weighed by anatomy for each taxon. Pressures of time forced these constraints of working.

Before any attempt was made at quantifying the faunal remains, the degree of bone fragmentation was assessed for each assemblage (*see* Chapter 3). Bone weights were useful in this capacity since the mean fragment weight could be determined for each skeletal element per main taxon by dividing the total weight of the skeletal element by the number of fragments.

In order to cope with the immense sample size and complexity of contextual data, a database was selected which was both relational and hierarchically structured. Dr N Winder (Department of Archaeology, University of Cambridge), funded by the Ancient Monuments Laboratory, English Heritage, set up such a system using an Oracle database package on an IBM PS/2 computer. Our approach to studying the bone assemblages was executed in two tiers. In the first tier, a rapid scan was undertaken which recorded the basic bone information for each context, that is species, anatomical element, NISP, IND, handedness (left or right side of the body), part (proximal, distal, shaft), state of epiphysial fusion (fused, unfused, fusing), bone condition (burnt, eroded, pristine), metrics, and the presence/absence of butchery and pathology. The second stage or tier of the analysis permitted the ageing of mandibles and a more detailed investigation of the butchery and pathology, and indeed a closer examination of some more interesting and/or enigmatic features.

Most of the Balkerne Lane assemblages (with the exception of Site J) and those of Lion Walk were analysed by hand. The major difference in these analyses as compared with those of post-1988 is that only the NISP method of quantifying remains was used. The indicator method had not yet been conceived and none of the fragments were weighed.

2.4 Taphonomy

Taphonomy is the study of the factors affecting the degree of completeness of survival of an animal's remains from the time of the animal's demise to their excavation (Gifford 1981; Shipman 1981). Bailey and Grigson have pinpointed taphonomy as being: 'One of the most important problems in archaeozoological analysis and at present the single most insurmountable barrier to effective interpretation of faunal remains' (Bailey & Grigson 1987, 17). In order to unravel taphonomic processes they have stated the urgent need for new experimental and ethnoarchaeological research both in the field and laboratory.

Taphonomic research has tended to centre mainly in Africa and North America (Brain 1967; 1969; Isaac 1967; Binford & Bertram 1977; Behrensmeyer 1978; Gifford 1980). Scarcely any research has been undertaken in Britain although this is sorely needed since climatic conditions are so different. Taphonomic studies centre on two post-mortem periods, from the time of death until interment (biostratinomy) and from burial to re-exposure (biodiagenesis) (Shipman 1981). Research has tended to focus on the former to the detriment of the latter, where there is a tacit assumption that no further alteration in decay occurs. However, bone diagenesis can be affected by both bone size and temperature (von Endt & Ortner 1984).

Carnivore attack of bone has been one of the main areas of study and is of major relevance to the Colchester study. Major research into the differential survival of sheep and goat bones exposed to scavenging by dogs has been undertaken by Brain (1967, 1969, & 1981), Binford and Bertram (1977), and Binford (1981).

Brain made a study of the discarded goat remains of Hottentot pastoralists living by the Kuiseb River in Namibia. The goats were killed and consumed by the Hottentots in the vicinity of the villages in which they lived, and the remains were fed to scavenging dogs. Brain calculated the survival rate of the individual skeletal elements (both proximal and distal epiphyses of long bones) by counting the minimum number of individuals (MNI) per skeletal element. He then ranked the skeletal elements in order of abundance. It is quite clear that some bones preserve far better than others, for example mandibles, distal humeri, distal tibiae and proximal radii, while others preserve less well, for example phalanges, proximal humeri and proximal tibiae (Brain 1967, 1969 & 1981). However, the original number of goats fed to the dogs is not known. Further, as well as dog-gnawing, human-gnawing and weathering were other agencies at work.

The Nunamiut Eskimo keep dogs that are tethered, and Binford and Bertram (1977) noted that out of 14 caribou fed to dogs over a period of about six weeks, only a minimum number of 9 animals were recovered (Section 3.2). Payne and Munson (1985) fed a dog the heads and feet of 37 squirrels and only the remains of 14 individuals were retrieved. Binford and Bertram (1977) found that there was a definite correlation between the survival of an individual bone element, the age of the animal and the density of the bones. Since both the tibia and humerus proximal and distal epiphyses show a differential survival pattern (based on the fact that the proximal ends are less dense and the walls are thinner than the distal ends), comparison of these elements can indicate the intensity of carnivore action (Binford 1981; Haynes 1980; Brain 1981).

The relative abundance of the Colchester sheep/goat skeletal elements was contrasted and compared with that constructed by Brain for the Hottentot goat sample (*see* Section 3.5), in order to highlight the degree of bone destruction by dogs. The relative ratio of fused proximal to distal tibiae was also assessed as a possible measure of carnivore destruction. In addition, comparisons were made between the relative representation of skeletal elements for the different species cattle, sheep/goat, and pig.

It is commonly assumed that the percentage of recognisable dog-gnawed bone on a site is an accurate indicator of the level of attrition of this taphonomic factor. This is not true as modern carnivore gnawing does not always produce identifiable tooth marks on bones (Haynes 1980; Payne & Munson 1985). Further, bones ingested by dogs can be carried off the site and it is impossible to distinguish whether absence of bones reflects human or carnivore disposal (Kent 1981; Lyman 1985). In his study of wolf-packs in Minnesota, Haynes (1980) has emphasised that the degree of canid gnawing is dependent on the number of wolves, their state of hunger and the length of time they are allowed to consume a carcass; the latter point was also noted by Richardson (1980).

Weathering is a process that leads to changes in the physical properties and chemical structure of the bone via desiccation and the action of soil acids. Behrensmeyer (1978) describes a number of stages in the weathering of bone but this material is of African origin and may not be directly applicable to more temperate climates. In Britain, attempts have been made to classify degrees of weathering by recording the colour, texture, erosion, and mineral adhesions, etc of bone (Mounteney 1981; Stallibrass 1985). While this work is helping to push forward research in this area, problems still lie in the altogether unavoidably subjective nature of the bone descriptions, something which Stallibrass herself has commented on. She suggests the use of photography in order to overcome ambiguous interpretations of the visual appearance of bones (Stallibrass 1985). Also, quite commonly, bones in the same assemblage demonstrate differing weathering stages; carpals and tarsals frequently appear less weathered than other bones (Shipman 1981, 119).

Andrews and Cook (1985) stated that the Draycott cow exhibited no signs of weathering even though exposed for eight years. They claimed that trampling was the main taphonomic agent at work and strangely this resulted in no breakage or physical damage to the limb bones. However, Olsen and Shipman (1988, 536) have criticised this research on the grounds that there were periods of time when the skeleton was unobserved and therefore other factors may have been at work. Shipman, quoting Gifford, points out that dried trampled bone may show 'columnar fractures', which result in rectangular or almost-rectangular fragments of bone (Shipman 1981, 173; Gifford 1978).

Schiffer (1972 & 1976) has made us aware that while cultural processes may be responsible for refuse-disposal behaviour, non-cultural processes, especially those happening when a site is abandoned, can disturb the spatial patterning of material. Mounteney (1981) has argued that the weathered bone at Thwing was the direct result of variability in the culturally-determined patterns of refuse disposal, rather than the differential destruction of bone between contexts after being buried. There was no variation in the pH of the soil samples and indeed the alkaline calcareous environment proved favourable for bone preservation (Mounteney 1981). On the other hand, returning to carnivores, Kent (1981, 372) in her ethnoarchaeological research has warned that archaeologists who analyse the spatial distribution of faunal remains are in many cases studying dog behaviour rather than human behaviour. Her research demonstrated that bones are only gnawed until the meat has been consumed, and quite often no marks are left on the bones.

With any taphonomic research, we need to aim for objective evaluations that can be numerically quantified, rather than subjective descriptions. We are now able to evaluate bone assemblages according to their degrees of attrition; we cannot, as yet, clearly distinguish individual taphonomic signatures, for example of carnivore-gnawing and weathering. Perhaps more insight could be gained by the use of histological techniques which might better describe the interactions which have taken place between bones and their physical, chemical and biological environments (Garland 1987).

2.5 Ageing

The construction of kill-off patterns for domestic stock ranks as one of the most important parts of any faunal study. A kill-off pattern is defined as the age distribution of the archaeological assemblage, while the mortality profile is defined as the age at death of the original flock/herd (after Cribb 1984). While quantification methods (via NISP, etc) detail the relative significance of butchered species (cow, sheep, and goats), the ageing data provides additional dietary information as to whether, for example, lamb or mutton, or veal or beef were more popularly consumed. In addition, kill-off patterns provide an added bonus in that they can isolate products that are not easily identifiable in the archaeological record, for example milk and wool. However, the interpretation of ageing data can be open to much speculation.

A useful compendium of ageing techniques is provided by Hillson (1986). In the analysis of the Colchester sheep/goat jaw bones, mainly the methods of Payne (1973), and Deniz and Payne (1982), were used with regard to tooth eruption and wear patterns. Separate categories for the tooth eruption and wear were devised by CFRU (Sections 4.2.1 & 4.4.2) in order to age the cattle and pig mandibles. Wear patterns on cattle third molars were studied using Grant's method (Grant 1982).

Many researchers are becoming increasingly disenchanted with the use of long-bone epiphysial fusion data as a means of ageing, because of differential preservation of the skeletal elements, and a lack of agreement, between different authors and in the archaeological material itself, as to the sequence of fusion times. Epiphysial fusion data were thus used very cautiously with inter- and intra-site comparisons, and avoided on a purely quantitative basis. However, the patterning of fused and unfused elements between sites suggested differences that could be checked by other methodologies.

2.6 Long-bone epiphysial fusion

Most British research has utilised Silver's estimates for the sequence and timing of fusion of the long-bone epiphyses. In his paper, Silver states that there was no perfect agreement on exact fusion ages. Further, the figures given in his tables are means, and as far as he knew the data referred to 'scrub' crossbred animals (Silver 1969, 254). Grigson (1982a) has compared Silver's dates of fusion for cattle with those of the German author Habermehl (1961), whose work is used quite widely, and found fairly close agreement. Grigson pointed out that the fusion figures, and indeed those for tooth eruption and wear, represent age ranges and hence allow interpretations of the data to differ. This was also recognised by Watson (1978).

Scarcely any information is available concerning epiphysial fusion in pigs, and Bull and Payne have commented that authors rarely state what to regard as the moment of fusion. This could be the point at which the epiphysis is no longer separate from the shaft or describes the last time the fusion line is still visible. For some epiphyses, the time between these two events can be at least one year (Bull & Payne 1982, 67).

With respect to sheep, Chaix and Grant (1987) have compared the sequence developed for a prehistoric Sudanese sheep population at Kerma with that given by several authors whose work is much employed. The Kerma sheep bones have important implications for ageing and sexing methods in faunal analysis, since they consist of 55 complete skeletons and 62 assorted bones. Chaix and Grant found that with the early-fusing bone elements, up to the fusion of the distal tibia, most authors were consistent, and they gave an order that was in broad agreement with the Kerma sequence. However, Silver (1969) gave a fusion sequence for the early fusing bones that differed significantly from the rest. Currently, Chaix and Grant are undertaking an extensive ageing, sexing and metrical analysis of the material.

With regard to the later-fusing bones, the authors were in less agreement: the figures of Duerst (1926), Curgy (1965), and Tschirvinsky (1889) are compatible with Kerma but Rajtova (1974), Barone (1976), Smith (1956), and to a lesser extent Silver (1969), gave sequences that were in some details very different from that observed in the Sudanese material (after Chaix & Grant 1987). Chaix and Grant have suggested that fusion sequences from modern specialised breeds which differ from the Kerma sequence should not be used with ancient sheep populations.

Other faunal analysts have experienced similar problems in interpreting their epiphysial fusion data. At the Mesopotamian site of Tepe Farukhabad in Iran, Redding (1981, 250) proposed that Silver's fusion ages were not suitable for ageing sheep and goats during the Elamite and Jemdet Nasr phases. He found that while Silver accorded similar fusion ages for the distal humerus and proximal radius, the Iranian archaeological material favoured the proximal radius fusing prior to the distal humerus. Redding pointed out that Todd and Todd (1938) suggested that the proximal radius fused at six months, two months before fusion of the distal humerus. Redding thought that the variance in fusion ages could be due to differences in nutrition; indeed Silver (1969, 254) has stated that high planes of nutrition and sheltered conditions could tend to accelerate epiphysial fusion of the long bones. Similarly, at the Iron Age hill fort of Danebury, Grant (1984b, 504), utilising complete sheep skeletons, found that the earliest-fusing bone for sheep was the distal humerus, and not the scapula as given by Silver (1969). Chalcolithic sheep/goat material from Beersheba, Negev in the Middle East also exhibited this (Grigson 1987).

It is quite clear that epiphysial ageing data do not always match the results from tooth eruption and wear. Also the sequence of epiphysial fusion as described by Silver is not always in accord with that found in archaeological material. This is not altogether surprising in the light of what Silver himself has written. Tooth-eruption data and epiphysial fusion ages differ very significantly between individual breeds within a single species. It seems apposite to close this section with a comment from Silver: '...where it can be established that one breed of animal only is present in an excavation site, and if a reasonably complete set of bones and teeth for one or two individuals can be assembled, then relationship of tooth wear to epiphysial fusion dates may be determined and applied to the rest of the more fragmentary material from the same site' (Silver 1969, 267).

2.7 Tooth eruption and wear

The Grimthorpe Iron Age sheep mandibles were aged by dividing the eruption of each tooth into 7 phases, starting with the exposure of the crypt by bone resorption to teeth coming into full wear. Thereafter, 26 stages describe events after the eruption of the deciduous teeth to the coming into full wear of the third cusp of the third molar. Each stage was estimated as lasting a month (Ewbank *et al* 1963). These eruption phases have subsequently been modified and adopted by later researchers, and more detailed observations have been made of the patterns of dentine and enamel that are exposed when the individual teeth wear down, thus allowing the relative ageing of mature animals.

Both Payne (1973) and Grant (1975 & 1982) have produced a series of illustrations for sheep/goat of the dP4, P4 and M1-M3 which describe the stages each tooth traverses, from unworn enamel cusps to complete dentine wear to the roots. Payne's method is more detailed than that of Grant since he allows for the inclusion of loose teeth and data from partially-intact jaws. Further, he has refined his method to take into consideration anomalous wear patterns (Payne 1987). Although Grant's method allows for the use of fragmentary mandibles, there is a certain subjectivity concerning this. In assessing the age of a mandible, Grant uses a coding system whereby each tooth is attributed a value according to eruption or wear, which for M1-M3 is added together and gives the mandibular wear stage (MWS). Payne's method allows the division of the jaw data into nine stages based on the wear of the dP4, P4 and the M1-M3. The ages assigned to each stage should be used with caution since they are only rough guides.

Grant's method can also be used for pigs and cattle. We used our own methods of analysing the cattle and pig mandibles (Sections 4.2.1 & 4.4.2), which involves far fewer divisions of age-groups than Grant. This raises the question which is central to any scientific analysis — what level of accuracy is needed at the recording level in order to understand kill-off patterns? This is a problem all too often encountered in presenting histograms of data, whether of rim sizes in pottery distributions or the metrical sexing of bones. Choice of the right increment can make or break any hypothesis. The trend in many jaw analyses is to aim for broader ageing categories, and if this answers the questions raised, all well and good. The subdivision of data into smaller and smaller categories can reduce information retrieval to the plight of looking for a needle in a haystack!

There has been much controversy in the past regarding whether the modern or 'old' tooth eruption data of Silver (1969) should be used. In 1963, Ewbank *et al* (1963, 423) suggested that the relative eruption time intervals between teeth of Iron Age sheep were nearer to those noted by modern rather than 17th-century authors. At Barley, the crypt for M3 was visible in the mandible by the time that M2 came into wear, whereas Silver gave a period of about two years between the eruption dates of these teeth in semi-wild hill sheep. Hence Silver's modern dates were used.

In cattle, Grigson compared the tooth eruption data of British authors with those of German ones; early-, middle- and late-maturing (Ellenberger-Baum 1943), late maturing (Habermehl 1961), modern and 19th-century (Silver 1969), and modern (Sisson & Grossman 1975). She found all the eruption dates roughly similar except for Silver's 19th-century data (Grigson 1982a).

Payne (1985b), utilising cattle data compiled by Meitinger (1983), pointed out that the M3 eruption did not show a gradual decrease in eruption age through 19th- to 20th-century sources. There was a sharp break between the earlier sources, which gave an age of eruption of 3.5 to 5 years, and later sources, for example Simmonds (1854), which gave eruption at 2 to 2.5 years. Also, according to these earlier sources, M3 erupts after P4, while later sources showed that the M3 erupts before P4. Payne then investigated Grant's data (1982), which had been compiled from a variety of British archaeological sites; the M3 was seen to erupt before the P4, thus agreeing with the sequence provided by authors for the improved stock.

Payne gave three possible explanations for these discrepancies, one of which has been raised by other researchers, that the 19th-century authors were unreliable (Luff 1982, 23; Legge & Dorrington 1985, 130). The second possibility is that 19th-century authors did not give eruption ages as we understand them, that is not eruption through the gum' but perhaps when the tooth was in wear. Thirdly, maybe the M3 did erupt later than the P4 in the 19th-century stock. This is something that can be tested.

In his research into sheep from the Harlow Roman temple, Legge has examined the sources quoted in Silver's original paper on sheep ageing and found that much dubious information had been constantly repeated by authors (Legge & Dorrington 1985, 130). The earliest reliable records of tooth-eruption ages in sheep, from British sources, give the same ages as modern sheep. Legge also cited Brown writing in 1927: 'It is impossible to avoid the conclusion that the original version of the development of teeth was based on imperfect observation, or on the custom of one writer quoting in good faith from another' (Brown 1927, 4). The timing of tooth eruption in modern domestic pigs varies among different breeds but the overall variation is not large. The 18th-century eruption data of Silver should not be used for archaeological assemblages; data from slower-erupting modern pigs or wild boar are probably most suitable (Bull & Payne 1982).

2.8 Primary versus secondary products

'Secondary products are products for which animals may be utilised repeatedly over the course of their lifetimes. In contrast, animals used for primary products (meat, bone and hide) must be slaughtered, yielding the product only once' (Greenfield 1988, 573).

The majority of faunal assemblages have resulted from the butchery and subsequent consumption of domestic animals. However, a controversy has emerged as to the identification of secondary products in the archaeological record, especially milk and its derivatives. Indeed, there has been much discussion as to whether a dairy economy operated in the British Neolithic (Section 2.10). While this controversy may appear unconnected with Roman and medieval husbandry, an understanding of the interpretation of the prehistoric data is necessary in order to gain a well-balanced view of our historical data.

2.9 Modelling the data: sheep/goat

Several models have been proposed in order to understand the aims and strategies of early herders. Three of the best-known and well-used are Payne's models for meat, milk and wool production (Payne 1973). Ideally, if meat was the prime objective, then most of the young males would be slaughtered towards the end of their growing phase at two to three years, when optimum body-weight would have been reached. Most females would be retained as breeding stock and as an insurance against disaster. Animals in poor condition and barren ewes would also be killed. If milk was the main pursuit, young lambs would be slaughtered in high numbers, and if wool was the major objective, older mature beasts would dominate the age profile. In this latter model, males not needed for breeding would be castrated to run as wethers.

Cribb (1984, 1985 & 1987) has presented a computer-simulated model of herder exploitation techniques, which both describes the kill-off pattern of the bone assemblage and assesses the efficiency with which the animal products are produced, that is meat, wool and milk. Although the method needs much refinement, this new approach is much to be commended in that it allows easier comparisons between assemblages at an intra- and inter-site level and, more significantly, has heightened our awareness of the critical decision-making that would have been and still is, an integral part of any pastoral economy.

Briefly, Cribb (1984, 161) divides the ageing data into three categories: young (under 1 year), immature (1 to 2 years), and adults (over 2 years). These data are fed into the computer together with information concerning birth and mortality rates which was obtained from ethnographic African examples (Dahl & Hjort 1976). The major assumption made is that young males and females are killed-off annually in equal proportions, while immature males are killed-off, up to half of the original total. The data are processed via a series of BASIC programs and the output is generated in the form of a growth curve, age and mortality profiles, and a series of productivity indices for meat, wool and milk. The productivity indices are calculated on the basis of the proportions of animals present whose age and sex predispose them to certain commodities. Cribb stresses that the productivity indices are arbitrary figures and only act as crude measures. They do not encompass market demand or take into account any artificial selection of stock for milk or wool. Further, the sheep/goat plane of nutrition has not been modelled in any way.

The main aim of this research is that it informs as to whether the sample being analysed could have come from a viable flock. That is, if the age profile shows a low proportion of adults or a high proportion of adults in the mortality profile, then the herd is unable to reproduce itself.

One of the more striking findings demonstrated that a flock geared to milk production would also be relatively efficient in the production of meat and perhaps wool (Cribb 1984). This has profound implications for any interpretation of subsistence and indeed market economies. In Cribb's initial model, 70 per cent of the immature beasts are killed-off, which reflects a high level of meat production. Changing to a milk economy involves slaughtering the young with a progressive easing up on the killing of the immatures in order to compensate. There is thus an increase in milk supply. Cribb found that by the fourth or fifth cycle (when more young and fewer immatures are killed- off), the milk index levels off and sustains a decline at the sixth cycle. Strangely, productivity in wool rises. This is because the number of live adults is rising steadily as fewer immatures are killed-off. This means that more males are entering the adult category, thereby boosting wool production and consequently lowering the number of animals producing milk. Thus by increasing the immature kill-off, milk production starts to increase again. As the cycles continue, meat productivity tends to follow milk productivity on an upward scale and wool productivity remains relatively high. Cribb summarises: 'The implication for the evolution of pastoralism is that secondary products (milk and wool) should be increasingly selected for and that a flock geared to high milk production should be highly efficient in other departments as well' (Cribb 1984, 170). These results emphasise that the identification and importance of a dairy economy can be difficult to assess, since a milk age profile bears certain similarities to a meat one, that is if one just views the histograms.

In a later paper, Cribb (1987, 401) showed that Payne's model for milk production followed this format: while milk showed a high productivity index, so did meat and wool. However, Payne was well aware that his models showed theoretical situations, and stated: 'Needless to say, flocks are not usually kept for a single product, particularly in subsistence economies; the balance drawn between the conflicting requirements of the approaches described depends on the relative importance of the different products, which is determined in a subsistence economy by the needs of the family or group, or in a cash economy by market forces' (Payne 1973, 282).

Cribb has modelled archaeological data from several sites, particularly in the south of England. Two examples are the middle Iron Age sites of Balksbury and Winnall Down in Hampshire. Maltby originally analysed the jaw data and gave two contrasting opinions: 'Superficially, the observable age pattern (after Grant) fits more closely to Payne's model of milk exploitation in which in addition to natural mortalities, a high percentage of the flock are slaughtered in their first year leaving a few rams but mainly ewes for breeding purposes and their milk. Alternatively, it is possible to view the ageing patterns as evidence for a very low level of efficiency in sheep husbandry, in which only the stock selected for breeding was allowed to mature. This may indicate that there was a shortage of winter fodder for sheep or at least no incentive nor necessity to overwinter a significant proportion of the stock. In either case, although wool would have been provided by the older animals, the apparently high rates of immature mortalities suggest that wool production was not of primary importance in the exploitation of sheep at these settlements' (Maltby 1981, 173-4).

When Cribb (1985, 91) modelled the Maltby data, he found high productivity indices of wool for both sites. This he interpreted as being misleading due to a low level of individual efficiency among Iron Age sheep! The herding strategy retained the adult population and thus represented a dependence on secondary products, wool and primary products of lamb.

With regard to the Roman military fort of Portchester, Cribb (1985, 94) was in no doubt that the kill-off patterns represented a straightforward viable herding strategy based on high meat production. He simulated a flock with a birth rate of 0.9 adult females per year and kill-off rates of 21 per cent adults, 47 per cent immatures and 24 per cent young. The computer output gave a high productivity index for meat and wool but was also balanced by moderate figures for milk and wool. However, one can question the use of Cribb's models in interpreting data that has been excavated from sites where carcass redistribution is likely to have taken place. It is assumed by faunal analysts in general that any attempt at reconstructing the composition of the original flock/herd is futile when dealing with sites of this sort. Cribb's analysis of Roman and Saxon Portchester raises some fundamental and fascinating, if somewhat controversial, issues on the provisioning of these sites and indeed urban sites in general.

For instance, with respect to Portchester, Cribb questions whether the age profile reflects the herding strategies of a pastoral population, since the jaws represent the remains of redistributed carcasses *(ibid,* 98). He assumes that it does since Grant (1975b) herself could see no reason to doubt that the sample emanated from a local pastoral economy. In the light of the evidence presented in Chapter 1, it is quite clear that Roman and medieval towns exhibited much in the way of a rural nature. Is it possible that mortality profiles, while not proving absolutely conclusive evidence, could perhaps suggest whether the inhabitants of an urban conglomerate were potentially involved in pastoral activities? Other evidence could then be sought to corroborate or negate these ideas.

2.10 **Modelling the data: cattle**

Few models are available which pertain solely to the husbandry of cattle. However, with respect to the sheep/goat models already described (where meat and milk products are very much dependent on each other), one could presume that a dual economy was being practised by pastoralists in prehistoric and early historic Britain. It is generally assumed that milk (of the cow) was not an important dietary item until well into the post-medieval period, when breeding techniques improved and better feeds were available. Thus it is interesting to note that in the 16th and 17th centuries, when the cow was bred for meat and milk, the conformation of the animal was not necessarily of foremost importance: '...it is probable that in the 16th century, the Cheddar cheese-maker milked whatever milch cow came to his hand, as did his Cheshire colleague; for the secret of his cheese lay in his soil formations, not his stock' (Trow-Smith 1957, 180).

The British archaeological site of Grimes Graves in Norfolk yielded a considerable number of slaughtered calves, approximately six months old, and a high proportion of female adults (6 females:1 male). This led Legge (1981a & 1981b) to postulate that a dairy economy was being practised at Grimes Graves during the Bronze Age. This, surprisingly, caused somewhat of a stir. Initially the main criticisms levelled at Legge centred on questions concerning the lactose tolerance of prehistoric people and the ease with which ancient cattle could let down their milk (Clutton-Brock 1981, 218-20); these Legge (1981, 220-2) successfully countered. Cheese manufacture and fermentation processes destroy lactose and pastoralists generally prefer these products to fresh milk. Further, it has been pointed out that a lactose-intolerant individual can drink a fair quantity of fresh milk before an upset develops (Ryder 1983, 249).

However, at a conference of the Association of Environmental Archaeologists on *The beginnings of agriculture,* Entwistle and Grant presented a paper in which they had simulated a model of herd structure using the original Grimes Graves kill-off profiles, and additional data embracing fertility, natural mortality, birth-rates and average age at first calving, which had all been obtained from African ethnographic research, documentary evidence and knowledge of modern animals (Entwistle & Grant 1989). They found that there were not enough female adults recovered in the Grimes Grave assemblages to account for the number of immature animals identified, that is, the Grimes Graves mortality profile does not describe a viable self-perpetuating herd *(ibid,* 205). Two sets of calculations were made, one based on cows calving at two years and the other on cows calving at three years (the latter being perhaps the more realistic model). Entwistle and Grant also questioned the yields of milk in the prehistoric period since, during the medieval period, cattle were generally milked for less than six months of the year and specialised dairy herds were rare *(ibid,* 206). Much revolved around the feed available to the cows; if feed was short after calving, lactation was shortened. Also the sooner mating occurs after calving the shorter and lighter a cow's lactation will be (Sutherland 1967, 110).

In reply, Legge's strongest argument against the Entwistle/Grant model was that they had used Higham's ageing technique for the cattle teeth, which did not allow for ageing above the third molar coming into wear (Legge 1989, 228). Some of the females were obviously of quite an advanced age and would therefore have contributed many more calves to the herd. Further, earlier excavations at Grimes Graves had located many more juvenile animals. He pointed out the dangers of making parallels between the African mortality rates of Dahl and Hjort (1976) and those expected in a temperate environment.

Entwistle and Grant (1989, 206) claimed that the predominance of female cattle in the Grimes Graves assemblages was not surprising, and stated that in many animal husbandry systems a majority of female animals was the norm. Legge countered this by saying that there would have been a very small meat output from the calves, and thus other products must have been of importance. Further, he gave examples of archaeological sites where males were retained to optimum meat weight, and indeed, where this was the case, the incidence of juvenile slaughter was low (Legge 1989, 230).

Finally Legge (1989, 231) draws our attention to the interesting fact that most fused limb bones of cattle from British archaeological sites are of females, and he is quite right to say that this raises important questions as to why this should be. This is certainly true of the vast majority of our Roman and medieval sites. (This point is developed further in Section 4.2.2.)

Noddle (1990, 39) has stated that there is much evidence for cattle in the Near East and Ancient Egypt needing the presence of a calf to let down their milk; therefore absence of slaughtered calves does not preclude the existence of a milking economy.

2.11 **Sexing**

Data recovered from reconstructions of kill-off patterns should be studied, as far as possible, in conjunction with data obtained from the distinguishing of the sexual components (male, female, castrate) that make up the faunal assemblage. The Grimes Graves example in the previous section shows how much the site interpretation depended on the proportion of female cattle recovered. Sexing can be achieved by both morphological and metrical means. Horn cores and pelves can be sexed fairly successfully, but the former do not always occur in suitable numbers for analysis and the pelvis is subject to much fragmentation as a result of ancient butchery. Also there are risks of bias from differential preservation, hornlessness and horn working. Most analysts use a series of measurements for sexual separation based on a limited number of studies (some of which are described below), performed with modern comparative material. Currently research is centred on developing better statistical methods to separate clusters of measurements (from archaeological assemblages) generated by bivariate and multivariate analyses.

2.12 **Cattle sexing**

Grigson (1982a) has reviewed the literature concerning the sexual determination of bones in domestic cattle. She points out that metapodials are more suited to analysis because they more often survive in a whole state, sexual dimorphism is usually visually apparent, and research has been undertaken (albeit a small amount) on modern and wild cattle of known sex.

In the late 1960s Higham presented a number of measurements that could be used for the sexual separation of cattle. His work, which has not been superseded, was based on modern bones belonging to Red Danish (27 cows and 1 bull) and Aberdeen Angus (40 cows and 40 steers) breeds (Higham & Message 1969; Higham 1967 & 1969a & 1969b). Measurements of metacarpal distal width showed the highest degree of sexual dimorphism; indeed bones of the fore limb exhibit more sexual dimorphism than those of the hind limb. Also, measurement of length appeared less sexually dimorphic than breadth. Further Higham suggested that ageing data should be judged in accordance with the proportional representation of males/females within each age category: '...if it is accepted that the two groups [and here he was referring to clumps in the plotted measurements of the distribution] result from sexual dimorphism, then by analysing the sex ratios for anatomical bones the epiphyses of which close at different times after birth, it should be possible to determine whether or not there was differential mortality among animals of the same sex' (Higham 1969b, 143).

Higham lacked bulls and complete metapodials in his modern samples, and thus resorted to using the results of Zalkin's research (1960) which described the proportions of complete metapodials of modern Kalmyk cows, steers and bulls. Zalkin stated that the bull and cow metapodials were of similar length and that if the ratio of distal epiphysis width to total length was calculated, oxen grouped between cows and bulls. However, Grigson (1982, 11) questions the applicability of using cattle from Outer Mongolia to compare with British prehistoric material.

Plotting a metapodial index (SD/GL; Bd/GL) against length appears the most popular way to attempt a sexual separation (Schneider 1958; Mennerich 1968; Luff 1982). However, Grigson warns that Fock, who worked on the German 'Schwarzbunte' breed, found a huge amount of overlap between the sexes, especially with respect to castrates, when he used a metapodial index against length (Grigson 1982a; Fock 1966, 10). Grigson also advocated caution in the use of Howard's method, which uses the two metapodial indices (of mid-shaft width to length and distal breadth to length) to separate castrates from bulls and cows (the bulls and cows appear to separate successfully), since if one index appears male and the other female, then the bone must have come from a steer (Grigson 1982a, 11; Howard 1963).

In the Colchester study, sexual separation was attempted using Higham and Howard's methods but it should be noted that Thomas's research (1988), utilising multivariate statistics, could enable more clear distinctions. Unfortunately, our work was well in hand by the time of Thomas's publication.

2.13 Sheep/goat sexing

It is significant that the volume *Ageing and sexing of animal bones from archaeological sites* (Wilson *et al* 1982) provides no comment on the sexing of sheep and goat bones. Morphological distinctions of sheep and goat are possible with most of the anatomical elements, perhaps the easiest being the metapodials (Boessneck *et al* 1964; Prummel & Frisch 1986). However, it is notoriously difficult to separate the sexes since there is much overlapping of individual measurements. Attempts have been made in plotting metacarpal mid-shaft width against length (Pfund 1961; Haak 1965). In this study, metapodial distal width-to-length ratios and mid-shaft width-to-length ratios were used.

It is quite likely that castration of sheep/goats and cattle would delay epiphysial fusion; certainly Hatting (1983) thought this with reference to fusion studies in Gotlandic sheep.

2.14 Metrics and statistics

Most of the measurements used in this report, unless otherwise stated, are those of von den Driesch (1976). Payne (1985a) has advocated caution in the use of measurements, particularly with regard to species-size changes between samples of differing date. Measurements vary within populations, and some measurements can show more sexual dimorphism than others. Tooth dimensions are more useful than post-cranial measurements since they are not so susceptible to sex/age related changes.

Further, there is emerging a considerable corpus of findings which suggests that there can be much growth in the bones after the fusion of the epiphyses. This has serious implications for any study concerned with species-size changes through time, since the bone measurements might well be affected by the age profile of the sample. As an animal grows older, the bone is constantly being remodelled and, for instance, the long-bone epiphyses expand width-wise. If the beast becomes very aged, then the width of the epiphyses can shrink due to resorption. Legge and Rowley-Conwy (1988, 51) found unequivocal evidence for post-fusion growth of red deer bones; early-fusing bones (for example scapulae and distal humeri) showed significantly more post-fusion growth than later-fusing bones. Further, the early-fusing bones could grow up to nearly 20 per cent (distal humerus) and 47 per cent (scapulae) after fusion. Although these figures refer to red deer, Legge and Rowley-Conwy (1991) have suggested the same might well be true of caprines.

Much post-fusion growth was also recorded for Turkish wild boar (Payne & Bull 1988), and similar findings have emerged with human material (Pfeiffer 1980).

In analysing the metrical and statistical data, an empirical approach was adopted which presented the data visually and allowed any patterning to be easily seen. This exploratory data analysis or EDA method emphasises the use of non-parametrical statistics.

3: PATTERNS OF BONE FRAGMENTATION AT COLCHESTER: AN APPROACH TO QUANTIFICATION

'All things are in process of change. You yourself are ceaselessly undergoing transformation, and the decay of some of your parts, and so is the whole universe' (Marcus Aurelius, *Meditations* IX, 19).

3.1 **Introduction**

No single quantification method has been universally accepted as accurately determining the original proportional representation of taxa that have been deposited on an archaeological site. This is a topic that has been discussed and disputed more than any other in the zooarchaeological literature, and indeed, some quite ingenious theories have been proposed that incorporate the use of fairly advanced mathematical and statistical ideas (Fieller & Turner 1982; Gilbert & Singer 1982; Chase & Hagaman 1989). Grayson (1984) has summarised some of the more important methods that have been in use. However, much of this methodology has been based on the identifiable fraction of the sample. With the establishment of better methods of recovery, with respect to sieving, it is necessary to deal with even larger numbers of bone fragments, many of which are only identifiable to anatomy and not taxon.

Currently the nub of the quantification problem rests with the treatment of fragmentary material, where there has been scant consistency between analysts in recording techniques. This is a very serious matter because it is not always easy, and sometimes it is impossible, to compare results between sites which have been studied by different researchers. Perhaps this is an unavoidable problem at the moment, since the whole discipline of zooarchaeology is still evolving and is not grounded in any particular sets of standard methodology. However, it is urged that bone reports fully describe the methods used and, in particular, the reservations concerning the ultimate interpretations of the material, so that the latter are fully comprehended by non-faunal specialists who might wish to handle the results. Maltby (1985, 35) has already commented on the impossibility of using many published reports, since there is no description of the recording and analytical methods used.

The reliability of many earlier bone reports has been radically impaired by the use of inadequate databases with respect to sample size. Also, an ignorance of recovery procedures and a neglect of the taphonomical evidence from contextual features have hampered progress in the production of dependable raw data. The incorporation of unreliable data into syntheses of chronological and regional surveys, for example Roman civilian sites (King 1978), Roman military sites, and medieval sites (King 1981; Noddle 1984), has been challenged by Maltby (1981) and Burnett (1985). In a recent review of medieval sites in south-west England, Levitan (1989) lamented that he was only able to make generalisations about the fauna despite the fact that forty bone reports had been published.

Some urban deposits have yielded vast quantities of bone so that some sampling strategy has had to be initiated; for example O'Connor (1984, 3) has estimated that more than three million bones have been recovered from York. He gave priority to bone groups from closely-dated deposits or from features which could be directly related to a specific structure or activity, such as a group of pits associated with a single phase of occupation of a particular building. O'Connor (1989, 192) reckons that one of the most useful developments in assigning priorities to bone groups, is the ability to distinguish those which are 'background' or 'noise' and accord them only cursory attention.

The ideal deposit would have resulted from the rapid accumulation of material from a single source with only brief intervals between the times of deposition, and hence would reflect a clearer image of human activity on site. Conversely, with a slow accumulation of material, there is a much greater chance of an erroneous interpretation due to higher levels of 'noise' introduced by a variety of taphonomic agents. Pits usually have a greater component of deliberately-deposited material in them than do ditches, and layers of fine soil may represent intervals between active dumping (Limbrey 1975, 304).

A selective approach to bone analysis is obviously a cost-effective exercise which is an important consideration concerning rescue excavations (Coy 1989). It has been shown that small samples can answer fairly routine questions such as general species representation (Gamble 1978). Further, a selective study can focus on specific problems that need investigation and not replicate results already attained (Levitan 1989). However, with regard to sample size, there is a common fallacy that assumes all urban sites yield large bone samples which are suitable for data analysis. As a site increases in complexity and length of occupation, collective sources of bias will reject greater numbers of bones from analysis (Section 3.4). Gilbert calculated the amount of bone that could be generated for the Bronze Age urban site of Godin Tepe by employing population measures, estimates of meat consumption and the death assemblage composition. He suggested that the amount of bone recovered from the site was only a small fraction of the predicted bone sample (Gilbert 1979).

Burnett (1985, 12) has pointed out that large sample size is not in itself an assurance of accuracy; of more and considerable relevance is the sample structure, which he describes as the contribution of the various types of cultural features and contexts (pits, ditches, etc) to the faunal assemblage. At the Iron Age site of Winnall Down, Hampshire, Maltby (1981) showed that context type affected the differential preservation of bones and hence this intra-site variability could affect the overall representation of the species.

Returning to quantification techniques, several researchers have felt that precise quantification techniques should be abandoned and some sort of ranking procedure used instead (Dennell 1980; Grayson 1980; Maltby 1981). Gilbert, Singer and Perkins firmly believe that the way forward in quantitative zooarchaeology is first to gain taphonomic knowledge concerning the various depositional biases that have affected the sample (Gilbert *et al* 1981 & 1983, 93). It is to this end that part of the Colchester study has been directed.

3.2 The merits of studying bone fragmentation

The initial step in any faunal analysis is to determine the level of bone recovery from a site. Without this knowledge it is futile to describe an assemblage's state of preservation, since missing bones might be absent through poor retrieval, rather than attrition due to, for example, weathering or carnivore scavenging. While this topic has been much discussed in the literature (Payne 1972a, 1972b & 1975; Clason & Prummel 1977; Levitan 1982), it is still not given all the attention that it deserves. Watson (1972) suggested measuring the lengths of unidentifiable bone fragments as a way of determining the level of bone recovery. This was initially tested on the Colchester assemblages with special reference to Balkerne Lane (Luff 1982). In the later analyses, mean fragment weights, particularly of long-bone shaft fragments, were also utilised. This was found to be a much faster method.

When we are undertaking a quantitative comparison (that is the relative percentage taxa occurrence via NISP or IND; for these techniques consult Section 2.3) between assemblages from different sites (inter-site comparison), or indeed the same site at the contextual level (intra-site comparison), we need to be aware primarily of the differential bone fragmentation between the taxa at the level of the individual assemblage. Obviously a highly-fragmented assemblage will produce fewer identifiable bones than a more intact one. We need to question the validity of comparing and contrasting groups of bone such as these. At first sight, it would appear fallacious to analyse much smashed-up material; however, if the relative fragmentation between the taxa of each assemblage is analogous, a quantitative comparison can be made between the two groups, despite the fact that one assemblage is much more fragmentary than the other.

For example, imagine two Roman pits, each filled with the same quantity of cow and sheep bones. If the quantification method is based on IND, smashed-up cow bone in one pit increases the prominence of the more intact sheep remains, and if this pit is compared with the second one, where cow and sheep bones are more complete, then it is clear that faulty conclusions concerning quantitative measures would be reached. Similarly, if the quantification method is based on NISP, comminuted cow bone in one pit could exaggerate the importance of cattle in relation to sheep with slightly-fragmented bones; again quantitative comparisons between this pit and the other one with more complete cow and sheep bones would be negated. However, if two contexts are compared where the bone from both species is highly fragmented in one and hardly fragmented in the other, then it is proposed that comparisons between the two contexts would be justified.

One of the major problems in the interpretation of vertebrate remains from archaeological contexts is the ability to distinguish naturally-modified (biological/geological) from culturally-modified (resulting from human alteration) bone. The main potential agents that culturally modify bone are butchery, cooking, bone working, redistribution (trade), ritual, and rubbish disposal, whilst those that naturally modify bone include weathering and scavenging (carnivore gnawing), and have been discussed in Section 2.4. It is apparent that most bone deposits represent the end-product of a sequence of complex taphonomic processes and their interactions. Several researchers have outlined the stages by which dead animals are incorporated into the archaeological record, are excavated and arrive for analysis in the laboratory (Meadow 1976 & 1980; Rackham D 1983). Each of these stages represents a loss of bone and hence data for analysis.

Lyman has expressed a somewhat pessimistic view of unravelling the different taphonomic processes; he has stated that if human and destructive agents selectively remove the same skeletal parts from an assemblage, then the various frequencies of skeletal parts cannot alone shed light on which activity was the responsible process affecting the bone assemblage (Lyman 1985, 226). However, Maltby (1985, 48) has demonstrated, utilising some of Binford's methods, that it is possible to separate some taphonomic factors (attritional) from other factors of variation (human).

In a classic study of the Nunamiut Eskimo, Binford and Bertram detailed experiments, where in certain instances a known quantity of bone was fed to dogs, and the subsequent remains analysed to see which bone elements survived (Binford & Bertram 1977; Section 2.4). The later-fusing proximal epiphyses of both the tibia and humerus have a much lower density than the distal epiphyses and are among the most commonly damaged by gnawing. If proximal values are plotted against distal values for both elements, some idea of the relative bone destruction between sites can be gained (Binford 1981). Badly-preserved bone deposits should contain far less proximal epiphyses.

Initially Maltby (1985, 44) graphed plots of .the percentage number of tibia shaft fragments divided by the total number of articulations against the percentage number of loose teeth divided by the number of jaw fragments. Both percentages were found to increase if the assemblages were badly preserved. However, results were hampered by biases resulting from differential recovery rates on sites, loose teeth tend to be overlooked during excavation. Further, the relationship between the percentages can also be affected by diverse kill-off patterns and differences in the preservation and fragmentation of the long bones. Thus another method was tested by Maltby. The percentage number of tibiae shaft fragments divided by the number of articulations and shaft fragments was plotted against the percentage number of proximal articulations divided by the number of proximal and distal articulations. Maltby (1985, 48) pointed out that if the main cause of fragmentation is attrition, then a negative correlation should be expected between the two percentages.

Todd and Rapson (1988) have recorded fragmentation between assemblages by comparing the frequencies of complete bones, the percentage difference values of the proximal and distal epiphyses for each skeletal element, the length of shaft attached to the epiphyses and the ratio of the epiphyses to long-bone shaft fragments and splinters with respect to minimum number of skeletal-element counts (MAU). They stress that their approach is merely documenting patterns of differential destruction and is not an exercise in pinpointing the processes responsible. This rather epitomises the state of bone fragmentation studies in general; before we can begin to separate the effects of one attritional agent from another we need to find methods of displaying the data in a way that utilises all the fragments of an assemblage and further allows comparisons between assemblages both at an intra- and inter-site level.

3.3 Some previous methods of recording bone fragmentation

Past and current research into bone fragmentation was stimulated by Watson's fragmentation paper in 1972. This was somewhat of a landmark at the time in that he analysed both undiagnostic and diagnostic (to taxon) fragments. He demonstrated that.

a) Above a critical size there is a logarithmic relationship between bone-fragment size and frequency.
b) Histograms of fragment length for the taxa of cattle, sheep/goat and pig could pinpoint poor retrieval and sometimes the identificatory skill of the analyst.
c) Data from a sieved site could help to predict more accurately the number of bones on a site which had not been sieved.

In a later paper (Watson 1979), he put forward a method of quantification based on assigning zones to individual skeletal elements and all later quantification methods have involved some variation on this theme (Payne 1980; Luff 1982; Maltby 1985; Dobney & Reilly 1985; Rackham D 1986; Levitan 1990).

While some of these methods are laudable for their elegant design, few make use of epiphysial fragments that are less than 25 per cent intact, and unidentifiable (to taxon) pieces are generally ignored. Isolated shaft fragments rarely figure in bone reports, although, as already mentioned in Section 3.2 recent studies by Todd and Rapson (1988) have emphasised their importance and have shown ways of recording them. Indeed, if diaphysial fragments had been eliminated from the analysis of a late 2nd-century assemblage at York, 90 per cent of the identified bone would have been lost in the form of heavily-butchered cattle femora, tibiae, humeri and radii shafts (O'Connor 1989, 195).

While it is apparent that the methods already described are revealing differences in the preservation and/or recovery of bone assemblages, they do not take into account fragmentation of the unidentifiable proportion of the sample, that is bones not identified to taxon and it is this information that is so critical to the understanding of site formation processes, as Shipman (1981) has pointed out. Lack of a detailed understanding of fragmentation between sites negates any comparisons via standard quantification techniques (Gilbert *et al* 1983). As Maltby has already stated, methods need to be devised of comparing samples that have undergone substantially different degrees of destruction (Maltby 1985, 49). It is to this end that the following methods have been devised.

3.4 Methods of recording bone fragmentation at Colchester

(For additional help with the methodology, *see* Section 2.3, and Location of faunal data, pp 11-12.)

'Nearly all of the literature and most collectors fail to appreciate another source of palaeoecological and taphonomic information in any fossil assemblage: the indeterminate fragments. These are often left on the site with the rubble or are retained only if there is a need to search for broken fragments of important specimens. But there is much information to be gleaned from analysing the indeterminate fragments which include specimens of unknown taxon (anonymous bones) as well as specimens that cannot be assigned to any skeletal element (unidentifiable bones). As a class, indeterminate fragments have several characteristics in common. By definition they are pieces of bones, and they have been subject to more destructive forces than identified bones or have been more affected by those forces, which have removed the characteristics that render whole bones identifiable' (Shipman 1981, 128).

Bone fragmentation is clearly the result of many composite processes, for example primary and secondary butchery, dog gnawing, weathering, soil conditions and excavation by harassed archaeologists. In order to understand and ultimately isolate some of these mechanisms, a necessary prerequisite is the design of techniques that will allow some understanding of the degree to which bones fragment. The prime aim of this research therefore, is to present a method of describing bone fragmentation in an easy and accurate manner that allows inter- and intra-site comparisons.

A rapid scan method of faunal analysis used by CFRU was instigated primarily to assess the quality and quantity of bone (per taxon) which had been recovered from a diverse range of contexts across Colchester (Section 2.3). The essence of the method combined speed with accuracy of identification of specific bone elements to taxon. In order not to lose sight of the assemblage as a whole, a tight control was kept on our identifications so that additional categories were incorporated, primarily those of SMA (small mammal) and OXO (large mammal). Since horse and red deer occurred infrequently, it is proposed that the OXO categories comprise mainly cattle; similarly the SMA category consists mainly of sheep/goat fragments since pig bones are by their nature much easier to determine and fallow and roe deer were relatively scarce. The only other bones that could fit into this latter category were those of dog and cat; however these were excluded from SMA since most of the remains were excavated as generally intact or partial burials. Since the inception of this methodology, other categories of identification have been used, including 'LAR' (red deer/cattle) and 'RUM' (sheep/goat/roe deer).

Two main methods of quantification were used: NISP which comprises the total number of identifiable bone fragments to a taxon (skull, vertebrae and rib fragments were omitted) and IND (indicators). As described in Section 2.3, indicators were recorded for the following anatomical elements where 50 per cent or more of the bone was present: horn core, mandible tooth row, scapula glenoid cavity, pelvic acetabulum, long-bone distal epiphyses, astragalus and first toe-bone. In addition, the bone was weighed to the nearest gram for each skeletal element, and the mean fragment weight obtained by dividing the weight by the number of fragments pertaining to the anatomy concerned.

However, any economic comparisons between periods could be masked by combining different contexts which may have resulted from different on-site activities. It thus seemed sensible to examine the taxa skeletal element distribution of the contexts making up these phases. This uncovered a major problem with the Colchester assemblages in that a huge number of contexts (primarily Roman) yielded only small samples of bone. Initially, the Culver Street bone was grouped by context/phase for each sub-site. This means that we have bone groups of similar date for different sub-sites. The numerous assemblages posed something of a problem since similar deposits (that is via context/skeletal element representation) for similar time spans revealed sometimes quite considerable differences in the proportional representation of the species. This has been commented on for other Roman sites and creates somewhat of a dilemma in interpretation — for example, Maltby (1979) experienced the same problem in interpreting the Exeter bone assemblages. In trying to spot broad trends within periods from the point of view of determining economic priorities, contexts were amalgamated by site and date.

In order to isolate sites where the amalgamation of material appears to give spurious results, two fragmentation indices have been devised based on the NISP value:

$$\text{FINDEX1} = \frac{\text{OXO}}{\text{OXO+COW}}$$

$$\text{FINDEX2} = \frac{\text{SMA}}{\text{SMA+SG}}$$

FINDEX1 describes the proportion of unidentifiable large mammal (most likely cattle) in the sample, while FINDEX2 describes the proportion of unidentifiable small mammal (most likely sheep/goat). One would expect that the FINDEX1 in a sample would be higher than the FINDEX2, simply because large mammals (cattle) have larger carcasses than small mammals (sheep/goats), and hence butchery would render more fragmentation. If there is a much higher FINDEX2 than FINDEX1 in a sample, that is, if the proportion of unidentifiable sheep/goat in the form of SMA exceeds that of 0X0, we can suspect the following. Either the SMA component has suffered some severe attritional process through maybe weathering or scavenging, or the bones have resulted from secondary or tertiary deposition, whereby the smaller artiodactyl bones would have been more susceptible to breakage and hence fragmentation. It seems extremely unlikely that marrow would be extracted from sheep bones in preference to cattle. A number of bone groups are necessary with this method so that a level of norm can be assessed, and this is available with the Colchester fauna. Sites where the percentage difference between the two indices is large are further investigated by studying their component parts.

In addition another index, IND/NISP, has been calculated for cattle, sheep/goat and pigs. Plots of NISP against IND/NISP were undertaken so that any aberrant sites could be isolated. The value for pig is especially important in determining the level of fragmentation for this taxon.

The mean fragment weights of skeletal elements per taxa per site were tabulated in order to check whether the percentage of unidentifiable bone was due to heavier fragmentation or the ability of the faunal analyst to identify taxa.

3.5 The Colchester bone assemblages: the analytical results

[Figs 3.1-3.14; Tables 3.1-3.10]

For the purposes of this study, there are 66,000 mammalian bone fragments recorded from Colchester as a whole and, of these, 40,505 could be recorded to species (Tables 3.1-3.7). The bone samples used in the Colchester analysis are approximately one third of the amount of bone originally scanned, since only bone from reliable contexts was included for analysis. This number is somewhat under-represented since the smaller mammals which were analysed post-1988 were quantified solely by weight, for example dogs, cats, hares and rabbits (Table 3.5b). Time constraints forced this method of recording. The Colchester sites analysed prior to 1988 were Balkerne Lane (omitting Site J) and Lion Walk; all the remaining sites mentioned in the text were analysed during and after 1988. Approximately 1,322 kilograms of bone were analysed from the post-1988 assemblages of Balkerne Lane (Site J), Butt Road, Culver Street, the Gilberd School, Long Wyre Street, and Middleborough. *(See* Section 1.5 for a description of the sites.)

Tables 3.1-3.2 describe NISP and the relative percentage NISP of the larger mammals from the main Colchester sites, listed alphabetically. Tables 3.3-3.4 comprise the IND counts and the relative percentage counts for larger mammals from the post-1988 analyses only. Tables 3.5a-3.5b contain the relative percentage weights of mammalian and avian bone for assemblages which were analysed post-1988. Tables 3.6-3.7 reflect the same information as Table 3.5b except that the quantification method is that of NISP for the smaller mammals from Balkerne Lane and Lion Walk.

Table 3.1 Bone-fragment counts (NISP) of large and medium-sized mammals (see MTable 3.1). [Pages 25, 32, 51]

Site	Date	Horse	Cow	OXO	S/G	SMA	Pig	Red deer	Roe deer	Fallow deer
BKCJ1	60/1-150	2	178	80	106	36	69	-	2	-
BKCJ2	150-400+	7	493	510	454	324	273	5	9	-
BUTT1	C2nd-320	14	63	123	48	69	101	2	1	
BUTT2	C2nd-400+	7	66	95	47	75	88	1	6	-
BUTT3	320-400+	33	455	706	283	548	366	23	5	-
BUTT4E	320-400+	-	23	48	65	167	167	2	1	-
COC1	C1st	3	113	121	47	57	80	2	1	-
COC2	MED	2	171	204	99	114	78	7	3	-
COC3	PMED	4	84	88	74	39	37	-	2	-
CUL1	44-60/1	8	412	145	215	128	304	-	8	-
CUL2	60/1-150	10	626	482	579	730	778	37	45	-
CUL3	150-400+	17	781	722	567	561	734	39	53	-
CUL4	60/1-225	6	314	103	281	105	166	6	11	-
CUL5	100-350	1	192	163	127	220	184	4	3	-
CUL6	75-300	-	416	662	432	1301	782	13	15	-
CUL7	EMED	9	414	513	178	270	188	18	5	-
CUL8	MED	21	1009	793	621	570	599	25	21	14
GBS1	44-60/1	1	273	187	264	316	313	4	55	-
GBS2	60/1 -275	5	500	300	445	374	451	18	49	-
GBS3	49-110	-	21	61	45	33	28	-	3	-
GBS4	110-350	3	142	50	96	92	138	10	5	-
GBS5	PMED	2	43	41	36	28	21	1	2	-
MIDI	ROMAN	9	113	4	86	1	87	6	2	-
MID2	MED	32	510	290	260	183	164	12	4	5
MID3	PMED	170	791	322	668	130	283	6	2	-
MID4	C16th	10	213	121	143	59	40	4	-	1
BKC1	44-60/1	78	2905		720	-	520	1	3	-
BKC2	60/1-150	53	3310	-	1217	-	669	13	9	-
BKC3	150-400+	40	4607	-	1370	-	1018	33	5	-
BKC4	100-300	29	6813	-	692	-	438	8	2	-
LWC1	ROMAN	15	784		497	-	458	9	3	-
LWC2	C11th-14th	2	82	-	73	-	24	2	-	-
LWC3	C15th-17th	28	1435	-	1402	-	264	8	-	7
LWC4	C17th-18th	22	393	-	264	-	114	-	-	-

The domestic species comprised: cattle *(Bos taurus),* sheep/goat *(Ovis/Capra),* horse *(Equus caballus),* pig *(Sus domesticus),* dog *(Canis familiaris),* and cat *(Felis catus).* The wild species embraced red deer *(Cervus elaphus),* roe deer *(Capreolus capreolus),* fallow deer *(Dama dama),* rabbit *(Oryctolagus cuniculus),* hare *(Lepus sp),* bear *(Ursus arctos),* bottle-nosed dolphin *(Tursiops truncatus),* rat *(Rattus sp),* and fox *(Vulpes vulpes).* Out of a total sample of 6,000 avian bone fragments, 5,139 were identified, of which most are of domestic fowl *(Gallus galius domesticus).*

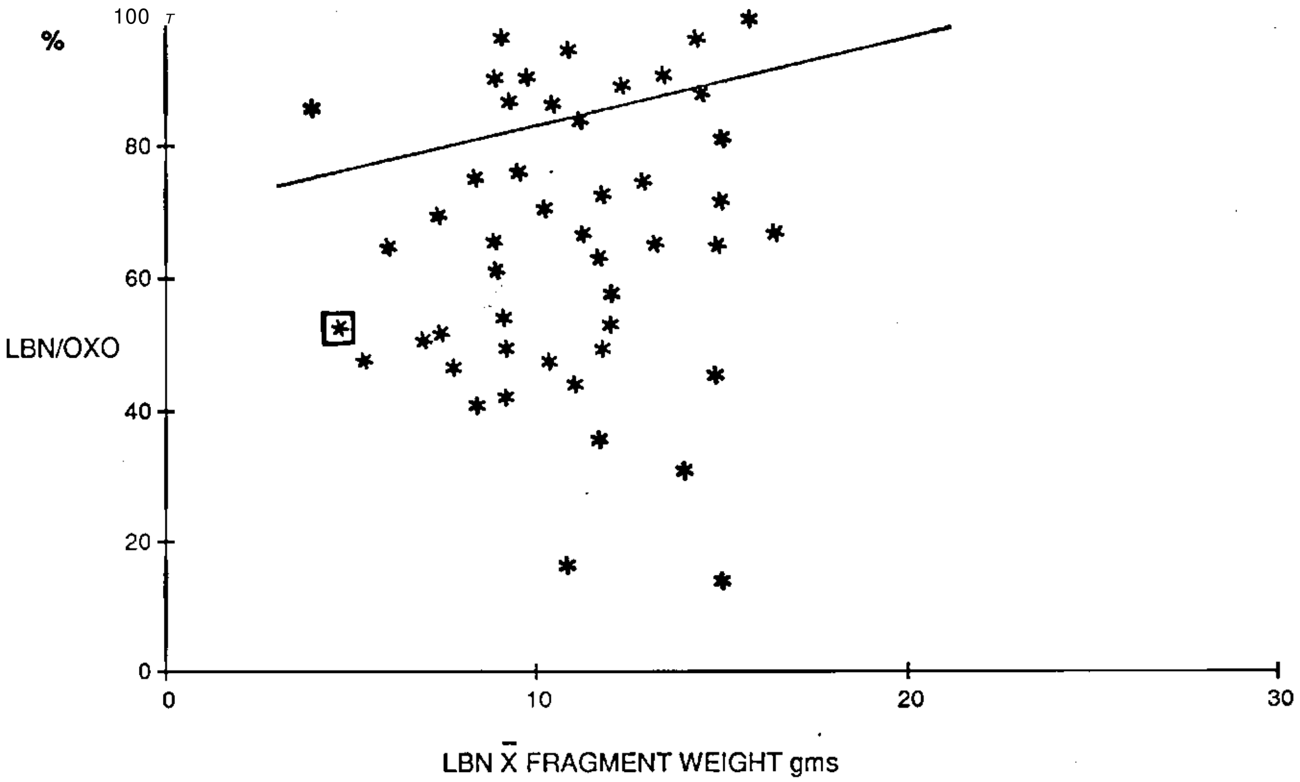
Figures 3.1a-3.1b illustrate the level of bone recovery for the major Colchester sites as reflected by the mean fragment weights of SMA and OXO long-bone shaft fragments. Most of the SMA mean fragment weights fall within a consistent range of 2 to 5 grams, while as is to be expected, those from OXO show a much wider range of variation, with most of the sites exhibiting between 10 and 20 grams. One site, GBS4, stood apart with a mean OXO long-bone fragment weight of above 25 grams. Quite clearly there are similar levels of recovery across the majority of sites, apart from GBS4.

'Correlations between sample size and relative abundance must be sought before those abundances are used as the basis of more detailed analysis' (Grayson 1981, 83).

The effect of sample size on the relative abundance of classes in archaeological assemblages has still to be recognised. In order to determine whether the percentage number of IND to NISP was a factor of sample size, NISP was plotted against IND/NISP for cattle, sheep/goat and pig as shown in Figures 3.2-3.4. All the figures show that as the sample size increases, the percentage of indicators remains reasonably constant.

Table 3.2 Relative percentage bone-fragment counts (NISP) of large and medium-sized mammals.
[Pages 25, 32, 45, 47, 51, 134]

Site	Date	Horse	Cow	S/G	Pig	Red deer	Roe deer	Fallo deer
BKCJ1	60/1-150	1	50	30	19			
BKCJ2	150-400+	1	40	37	22	1	1	-
BUTT1	C2nd-320	6	28	21	44	1	1	-
BUTT2	C2nd-400+	3	31	22	41	1		-
BUTT3	320-400+	3	39	24	31	2	1	-
BUTT4E	320-400+	-	9	25	65	1	1	-
COC1	C1st	1	46	19	33	1	1	-
COC2	MED	1	48	28	22	2	1	-
COC3	PMED		42	37	18	-	1	-
CUL1	44-60/1	1	44	23	32	-	1	-
CUL2	60/1-150	1	30	28	38	2		-
CUL3	150-400+	1	36	26	34	2		-
CUL4	60/1-225	1	40	36	21	1	1	-
CUL5	100-350	1	38	25	36	1	1	-
CUL6	75-300		25	26	47	1	1	-
CUL7	EMED	1	51	22	23	2	1	-
CUL8	MED	1	44	27	26	1	1	1
GBS1	44-60/1	1	30	29	34	1	6	-
GBS2	60/1-275	1	34	30	31	1	3	-
GBS3	49-110	-	22	46	29	-	3	-
GBS4	110-350	1	36	24	35	3	1	-
GBS5	PMED	2	41	34	20	1	2	-
MIDI	ROMAN	-	38	29	30	2	1	-
MID2	MED	3	52	26	17	1	1	1
MID3	PMED	9	41	35	15	1	1	-
M1D4	C16th	2	52	35	10	1	-	1
BKC1	44-60/1	2	69	17	12	1	1	-
BKC2	60/1-150	1	63	23	13	1	1	-
BKC3	150-400+	1	65	19	14	1	1	-
BKC4	100-300	1	85	9	6	1	1	-
LWC1	ROMAN	1	44	28	26	1	1	-
LWC2	C11th-14th	1	45	40	13	1	-	-
LWC3	C15th-17th	1	46	44	8	1	-	1
LWC4	C17th-18th	3	50	33	14	-	-	-



LBN X FRAGMENT WEIGHT gms

Fig 3.1a Scattergram: bone-fragment recovery of long-bone shaft fragment mean (X) weight in gms against the percentage number of long-bone shaft fragments in SMA. Plots above the line refer to the Gilberd School sites while the plots marked with a square refer to Butt Road. [Pages 26, 35]

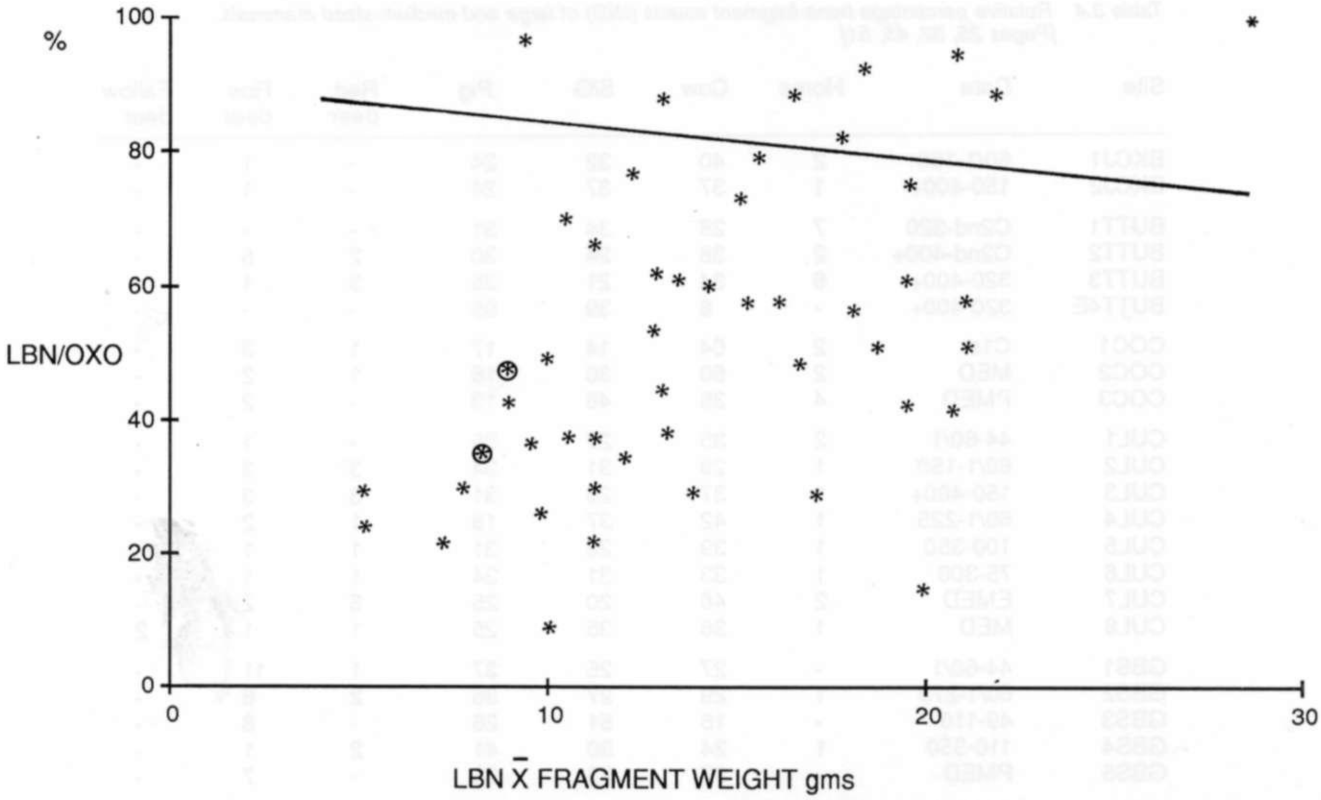


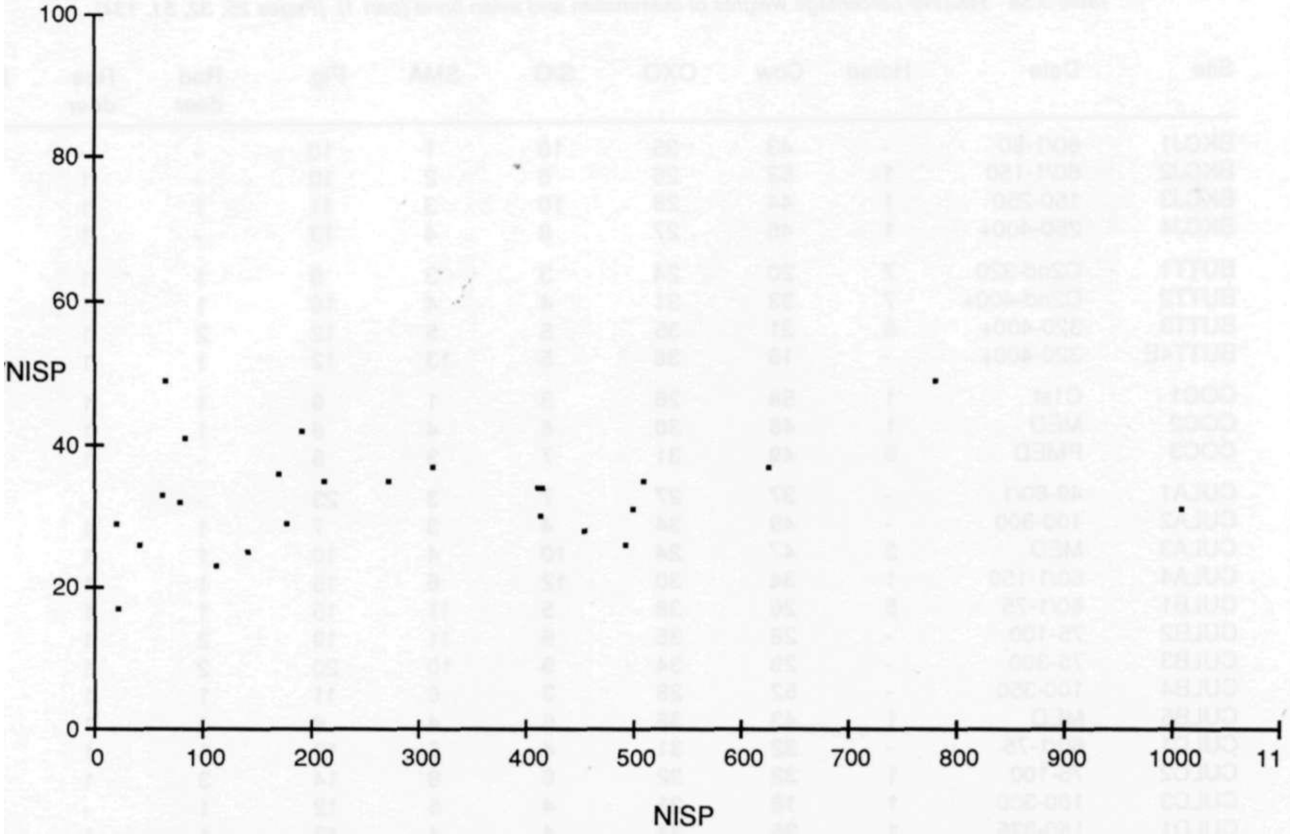
Fig 3.1b Scattergram: bone-fragment recovery of long-bone shaft fragment mean (X) weight in gms against the percentage number of long-bone shaft fragments in OXO. Plots above the line refer to the Gilberd School sites while the plots marked with a circle refer to Butt Road. [Page 26]

Table 3.3 Bone-fragment counts (IND) of large and medium-sized mammals. [Pages 25, 32, 51]

Site	Date	Horse	Cow	S/G	Pig	Red deer	Roe deer	Fallow deer
BKCJ1	60/1-150	2	51	41	30	–	2	
BKCJ2	150-400+	2	129	128	82	-	5	-
BUTT1	C2nd-320	5	21	25	23		·	
BUTT2	C2nd-400+	2	32	20	25	1	4	-
BUTT3	320-400+	22	125	78	131	12	2	-
BUTT4E	320-400+	-	4	25	36	-	-	-
COC1	C1st	3	113	24	30	1	5	
COC2	MED	2	62	38	20	1	2	-
COC3	PMED	4	34	45	13	-	2	-
CUL1	44-60/1	6	138	106	139		3	
CUL2	60/1-150	5	234	255	273	20	27	-
CUL3	150-400+	9	379	258	310	27	33	-
CUL4	60/1-225	3	115	101	49	2	6	-
CUL5	100-350	1	81	59	64	3	1	-
CUL6	75-300	1	142	131	147	5	4	-
CUL7	EMED	4	125	53	68	17	5	-
CUL8	MED	9	313	309	219	6	9	12
GBS1	44-60/1	-	96	91	134	3	38	-
GBS2	60/1 -275	3	156	145	195	12	33	-
GBS3	49-110	-	6	20	10	-	3	-
GBS4	110-350	2	35	44	59	3	2	-
GBS5	PMED	-	11	10	7	-	2	-
MIDI	ROMAN	9	26	16	18	2	1	-
MID2	MED	20	180	121	34	3	2	3
MID3	PMED	71	249	428	87	1	1	-
MID4	C16th	4	74	56	7	-	-	1

Table 3.4 Relative percentage bone-fragment counts (IND) of large and medium-sized mammals. [Pages 25, 32, 45, 51]

Site	Date	Horse	Cow	S/G	Pig	Red deer	Roe deer	Fallow deer
BKCJ1	60/1-150	2	40	32	24		1	–
BKCJ2	150-400+	1	37	37	24	-	1	-
BUTT1	C2nd-320	7	28	34	31	-	·	
BUTT2	C2nd-400+	2	38	24	30	2	5	-
BUTT3	320-400+	6	34	21	35	3	1	-
BUTT4E	320-400+	-	6	39	55	-	-	-
COC1	C1st	2	64	14	17	1	3	-
COC2	MED	2	50	30	16	1	2	-
COC3	PMED	4	35	46	13	-	2	-
CUL1	44-60/1	2	35	27	35	-	1	-
CUL2	60/1-150	1	29	31	34	3	3	-
CUL3	150-400+	1	37	25	31	3	3	-
CUL4	60/1-225	1	42	37	18	1	2	-
CUL5	100-350	1	39	28	31	1	1	-
CUL6	75-300	1	33	31	34	1	1	-
CUL7	EMED	2	46	20	25	6	2	-
CUL8	MED	1	36	35	25	1	1	2
GBS1	44-60/1	-	27	25	37	1	11	
GBS2	60/1-275	1	29	27	36	2	6	-
GBS3	49-110	-	15	51	26	-	8	-
GBS4	110-350	1	24	30	41	2	1	-
GBS5	PMED	-	37	33	23	-	7	-
MIDI	ROMAN	13	36	22	25	3	1	
MID2	MED	6	50	33	10	1	1	1
MID3	PMED	9	30	51	10	1	1	-
MID4	C16th	3	52	39	5	-	-	1



NISP

Fig 3.2 Scattergram: the number of cattle bone fragments (NISP) plotted against the percentage number of indicators (IND) in NISP. [Page 26]

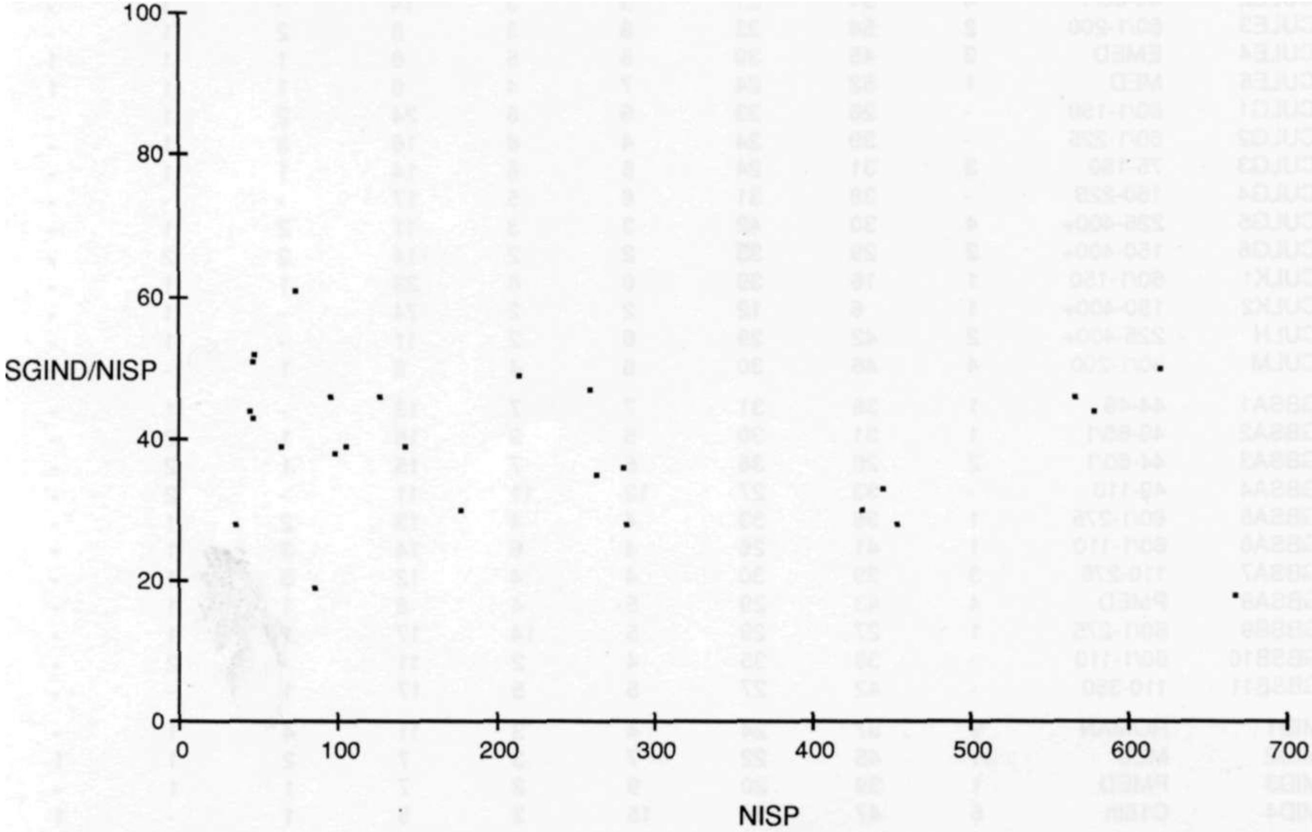


Fig 3.3 Scattergram: the number of sheep/goat bone fragments (NISP) plotted against the percentage number of indicators (IND) in NISP. [Page 26]

Table 3.5a Relative percentage weights of mammalian and avian bone (part 1). [Pages 25, 32, 51, 134]

Site	Date	Horse	Cow	OXO	S/G	SMA	Pig	Red deer	Roe deer	Fallov deer
BKCJ1	60/1 -80		43	35	10	1	10	-	-	-
BKCJ2	60/1-150	1	53	26	6	2	10	-	1	-
BKCJ3	150-250	1	44	28	10	3	11	1	1	-
BKCJ4	250-400+	1	46	27	8	4	13	-	1	-
BUTT1	C2nd-320	7	20	24	3	3	9	1	1	
BUTT2	C2nd-400+	7	33	31	4	4	16	1	1	-
BUTT3	320-400+	6	31	35	5	5	12	2	1	-
BUTT4E	320-400+	-	16	36	5	13	12	1	1	-
COC1	C1st	1	58	26	3	1	9	1	1	-
COC2	MED	1	46	30	6	4	8	1	1	-
COC3	PMED	3	49	31	7	3	5	-	1	-
CULA1	49-60/1	-	37	27	7	3	23	-		-
CULA2	100-300	-	49	34	4	3	7	1	1	-
CULA3	MED	2	47	24	10	4	10	1	1	1
CULA4	60/1-150	1	34	30	12	6	15	1	1	-
CULB1	60/1 -75	5	26	38	5	11	15	1	1	-
CULB2	75-100	-	28	35	6	11	19	2	1	-
CULB3	75-300	-	29	34	5	10	20	2	1	-
CULB4	100-350	-	52	28	3	6	11	1	1	-
CULB5	MED	1	43	36	6	4	6	4	1	-
CULC1	60/1 -75	-	32	31	4	6	12	1	1	-
CULC2	75-100	1	32	32	6	8	14	3	1	-
CULC3	100-300	1	18	21	4	5	12	1		-
CULD1	150-325	1	36	34	4	4	13	1	1	-
CULD2	EMED	3	24	21	2	2	22	3	1	-
CULE1	44-49	-	54	18	6	4	13	-		-
CULE2	49-60/1	4	51	21	5	3	14	-	1	-
CULE3	60/1-200	2	54	22	8	3	8	2	1	-
CULE4	EMED	3	45	30	5	5	8	1	1	1
CULE5	MED	1	52	24	7	4	9	1	1	1
CULG1	60/1-150	-	26	23	5	8	24	2	1	-
CULG2	60/1 -225	-	30	24	4	8	16	3	1	-
CULG3	75-150	3	31	24	6	6	14	1	1	-
CULG4	150-225	-	38	31	6	5	17	-		-
CULG5	225-400+	4	30	42	3	3	11	2	1	-
CULG6	150-400+	2	29	33	2	2	14	2		-
CULK1	60/1-150	1	16	39	6	6	23	1	1	-
CULK2	150-400+	1	6	12	2	2	74	-	1	-
CULH	225-400+	2	42	29	6	2	11	-	1	-
CULM	60/1 -200	4	46	30	6	4	8	1	-	-
GBSA1	44-49	1	38	31	7	7	13	-	1	-
GBSA2	49-60/1	1	31	30	5	9	16	1	2	-
GBSA3	44-60/1	2	26	36	5	7	15	1	2	-
GBSA4	49-110	-	33	27	12	11	11	-	2	-
GBSA5	60/1 -275	1	38	33	4	4	13	2	1	-
GBSA6	60/1-110	1	41	26	4	6	14	3	1	-
GBSA7	110-275	3	39	30	4	4	12	3	1	-
GBSA8	PMED	4	43	29	5	4	8	1	1	-
GBSB9	60/1 -275	1	27	29	5	14	17	1	1	-
GBSB10	60/1-110	-	36	35	4	2	11	-	2	-
GBSB11	110-350	-	42	27	5	5	17	1	-	-
MIDI	ROMAN	9	37	24	4	3	11	4	1	-
MID2	MED	11	45	22	7	3	7	2	1	1
MID3	PMED	1	39	20	9	2	7	1	1	-
MID4	C16th	6	47	24	15	2	5	1	-	1

Table 3.5b Relative percentage weights of mammalian and avian bone (part 2). [Pages 25, 32, 51, 134]

Site	Date	Dog	Cat	Bear	Fox	Hare	Rabbit	Bird	Tweight	UNM
BKCJ1	60/1-80	-	1	-	-		-	1	4045	-
BKCJ2	60/1-150	1	-	-	-	1	-	1	18960	1
BKCJ3	150-250	1	1	-	-	1	-	1	42641	1
BKCJ4	250-400+	1	1	-	-	1	-	1	23100	6
BUTT1	C2nd-320	5	v	-		1			22119	1
BUTT2	C2nd-400+	1		-	1		-	-	11440	3
BUTT3	320-400+	1	1	1	-	1	-	-	66997	2
BUTT4E	320-400+	1	1	-	-	1	-	13	7173	5
COC1	C1st	1		-	-	1		-	10688	1
COC2	MED	1	1	-	-	1	-	1	25758	3
COC3	PMED	**1**	**1**	-	-		1	-	22157	1
CULAI	49-60/1	-		-		1		1	4058	2
CULA2	100-300	1	-	-	-	1	-	1	7520	1
CULA3	MED	1	1	-	-	-	1	1	29806	1
CULA4	60/1-150	1	-	-	-	1	-	-	9765	1
CULB1	60/1-75	-	-	-	-	-	-	-	4483	-
CULB2	75-100	-	-	-	-	-	-	-	33391	-
CULB3	75-300	-	-	-	-	-	-	-	39693	-
CULB4	100-350	1	-	-	-	-	-	-	13031	-
CULB5	MED	-	-	-	-	-	-	-	15813	-
CULC1	60/1 -75	1	-	-	-	1	-	2	16648	1
CULC2	75-100	1	-	-	-	1	-	1	13836	2
CULC3	100-300	1	1	-	-	1	-	1	29053	1
CULD1	150-325	1	1	-	-	1	-	1	54684	5
CULD2	EMED	1	-	-	-	1	-	1	37133	43
CULE1	44-49	3	-	-	-	1	-	1	7291	1
CULE2	49-60/1	-	-	-	-	-	-	1	50902	2
CULE3	60/1 -200	1	-	-	-	-	-	1	40053	1
CULE4	EMED	1	1	-	-	1	1	1	44881	2
CULE5	MED	1	1	-	-	1	1	1	118151	2
CULG1	60/1-150	1	-	-	-	1	-	1	33027	11
CULG2	60/1 -225	1	1	-	-	1	-	1	5659	13
CULG3	75-150	1	-	-	-	1	-	1	11784	13
CULG4	150-225	-	-	-	-	-	-	1	1899	4
CULG5	225-400+	1	-	-	-	1	-	1	59558	5
CULG6	150-400+	1	-	-	-	-	-	1	6007	13
CULK1	60/1-150	1	-	-	-	1	-	1	14709	4
CULK2	150-400+	-	-	-	-	-	-	1	16742	3
CULH	225-400+	1	1	-	-	-	-	1	9806	5
CULM	60/1-200	-	-	-	-	-	-	1	3858	1
GBSA1	44-49				-		-	1	12310	3
GBSA2	49-60/1	-	-	-	-	1	-		21029	3
GBSA3	44-60/1	-	-	-	-	1	-		25153	3
GBSA4	49-110	1	-	-	-	1	-	1	4373	3
GBSA5	60/1 -275	1	-	-	-	1	-	1	45182	3
GBSA6	60/1-110	1	-	-	-	1	-		27588	2
GBSA7	110-275	2	-	-	-	1	-	1	21748	2
GBSA8	PMED	1	-	-	-	1	-	1	9889	5
GBSA9	60/1-275	2	-	-	-	1	-		21976	2
GBSB10	60/1-110	1	-	-	-	1	-	1	9340	7
GBSB11	110-350	2	-	-	-	1	-	1	7488	1
MIDI	ROMAN	1	1	-	-	1		1	22959	2
MID2	MED	1	1	-	-	1	1	1	68388	2
MID3	PMED	1	1	-	-	1	1	1	16638	1
MID4	C16th	1	-	-	-	-	-	-	22081	1

Key:
Tweight — Total weight in gms of bone per site.
UNM — Weight of unidentifiable mammalian bone.

Tables 3.1-3.2 describe the numbers and percentages of NISP (main domestic stock and deer) recovered from Balkerne Lane Site J (BKC J), Butt Road (BUTT), Long Wyre Street (COC), Culver Street (CUL), the Gilberd School (GBS), and Middleborough (MID). Data from the pre-1988 analyses (Balkerne Lane, BKC and Lion Walk, LWC) are included in this table but we shall confine the present discussion to those of the post-1988 research. Similarly, Tables 3.3-3.4 show the numbers and percentages of IND (main domestic stock and deer) recovered, while Tables 3.5a-3.5b include the weight of all the mammalian and avian taxa.

Bar charts were produced of NISP relative percentages of cattle, sheep/goat, pig, OXO and SMA together with the relative IND percentages for cattle, sheep/goat and pig. This was undertaken for the Roman, medieval and post-medieval periods across Colchester in order to get a feel for the distribution of material (Figs 3.5-3.6).

Figure 3.5 shows the Roman assemblages split into those that are intramural and those that are extramural. There were two main reasons for doing this. Firstly, the standard of living as reflected by the structural habitations was of a low level at Balkerne Lane as compared with the intramural sites (Section 1.5). Secondly, the extramural assemblages, represented by Balkerne Lane, clearly exhibited differences from the other bone groups in the relative percentage occurrence of the taxa and the skeletal element distribution. Figure 3.5 shows that with either method of quantification, NISP or IND, cattle are the predominant species at the extramural site of Balkerne Lane, with sheep/goat in second order of prominence followed by pig. However the intramural Roman sites show that pig is the most important species if the NISP method is used, while with IND cow is the dominant species but pig remains are still high.

The relative representations of the main domestic stock for the medieval and post-medieval periods are shown in Figure 3.6. In the medieval period cow is the dominant species followed by sheep/goat (by NISP and IND methods) while the post-medieval period sees a striking change in the marked increase of sheep/goat slaughter, especially via the IND method.

There is clearly a difference in pig exploitation between the Roman intramural and extramural settlements. We need to question whether the number of pig remains on the intramural sites has been boosted by high occurrences of fragmented cattle and sheep/goat bone in the 0X0 and SMA categories respectively. If this is true, the proportion of identified cattle and sheep/goat will have been reduced, thereby increasing the importance of pig. There is a higher percentage of SMA fragments on the collective intramural sites than in the extramural ones and an

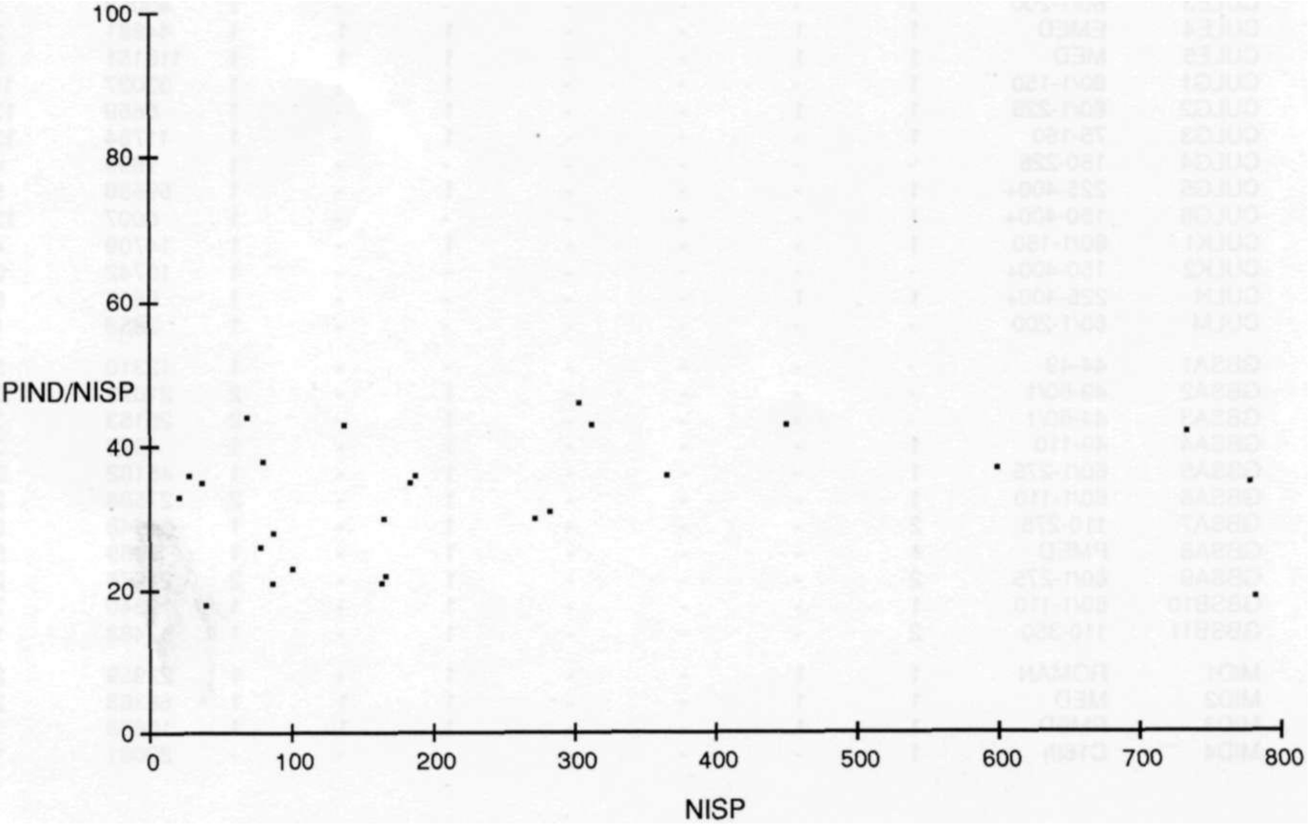


Fig 3.4 Scattergram: the number of pig bone fragments (NISP) plotted against the percentage number of indicators (IND) in NISP. [Page 26]

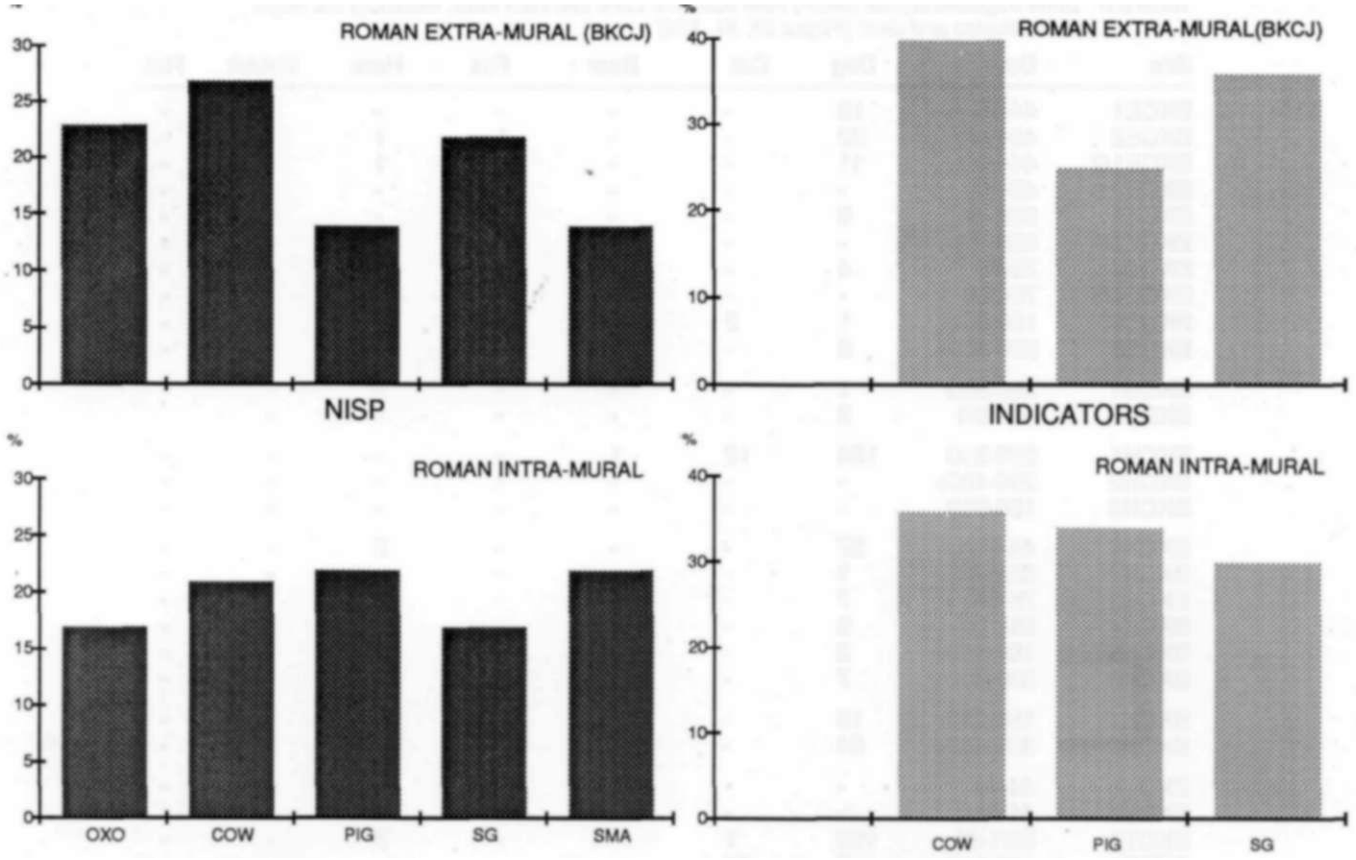


Fig 3 5 Bar charts: domestic stock relative percentage occurrences via NISP (dark grey) and IND (light grey) for the Roman intramural sites (below) and extramural Balkerne Lane Site J (above). [Page 32]

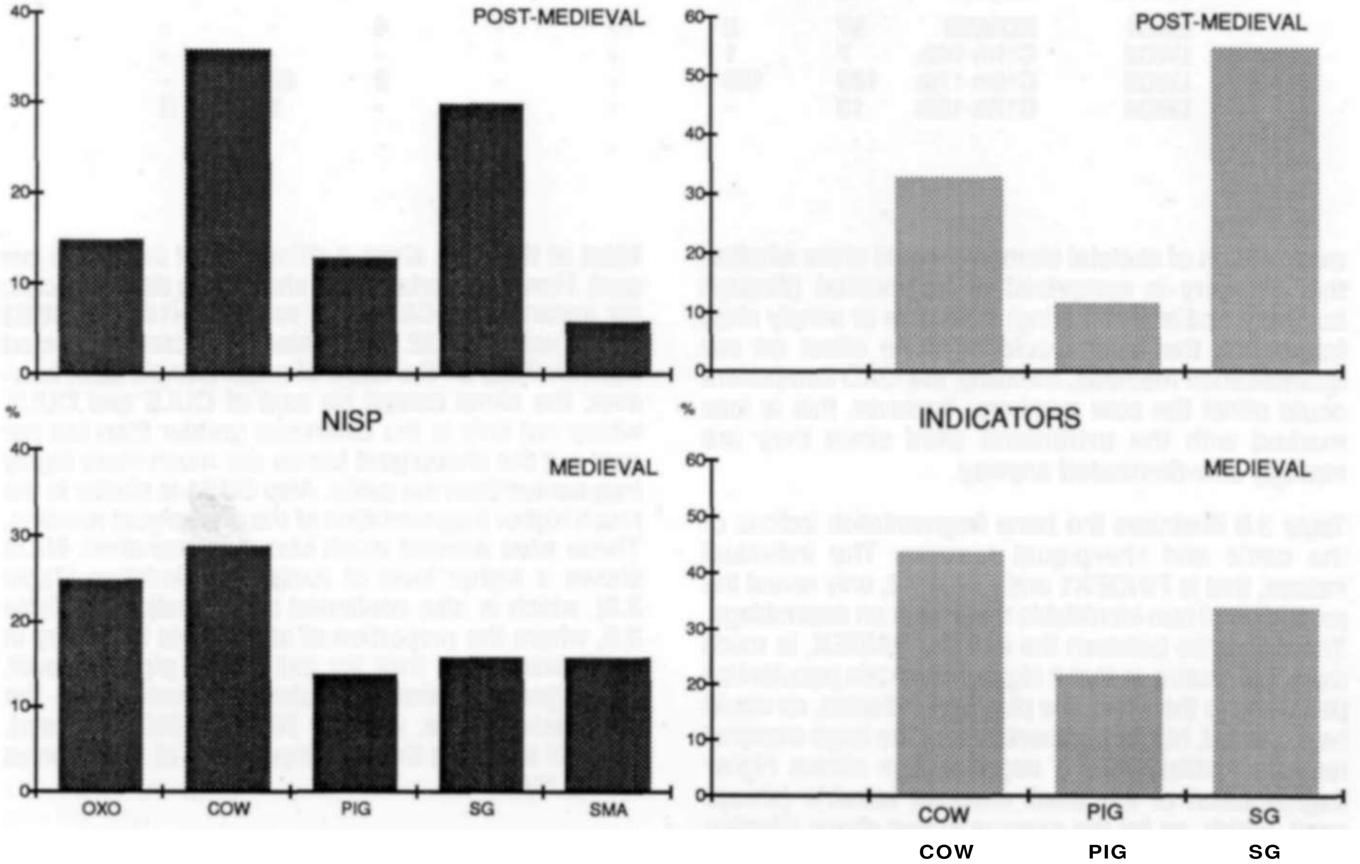


Fig 3 6 Bar charts: domestic stock relative percentage occurrences via NISP (dark grey) and IND (light grey) for the medieval sites (below) and the post medieval sites (above) [Page 32]

Table 3.6 Bone-fragment counts (NISP) from Balkerne Lane and Lion Walk, excluding the major domesticates and deer. [Pages 25, 51, 134]

Site	Date	Dog	Cat	Bear	Fox	Hare	Rabbit	Rat
BKCE1	44-55	10	-	-	-	-	-	
BKCE2	49-60/1	32	-	-	1	1		
BKCE1/2	44-60/1	11		-	-	1	-	-
BKCE2/3	49-80	-	-	-	-	-	-	
BKCE3	60/1-80	6	-	-	-	-	-	
BKCE3/4	60/1 -85	-	-	-	-	-	-	-
BKCE4	75-85	4	-	-	-	-	-	-
BKCE4/5	75-300	-	-	-	-	-	-	-
BKCE5	100-300	1	2	-	-	-	-	-
BKCE6	300-400+	6	-	-	-	-	-	-
BKCG1	250-300	1	-	-	-			-
BKCG2	44-60/1	2	-	-	-	-	-	
BKCH1	250-300	184	12	1	-			-
BKCH2	250-400+	-	-	-	-	-	-	-
BKCH3	150-300	-	-	-	-	-	-	-
BKCK1	44-60/1	37				2		
BKCK2	60/1 -80	1	-	-	-	-	-	-
BKCK3	75-85	7	-	-	-	-	-	-
BKCK4	85-100	5	-	-	-	2	-	-
BKCK5	150-400+	2	-	-	-	-	-	-
BKCK6	300-400+	7	-	-	-	-	-	-
BKCN1	150-250	15	-	-	-	-	-	-
BKCN2	300-400+	64	-	-	-	1	-	-
BKCT1	44-49	-	-	-	-	-	-	-
BKCT2	44-60/1	-	-	-	-	-	-	-
BKCT3	60/1 -80	192	1	-	-	2	-	-
BKCT5	100-300	3	33	-	-	-	-	-
BKCV1	75-100	10	-	-	-	1	-	-
BKCV2	250-300	16	-	-	-	-	-	-
BKCV3	100-300	65	1	-	-	-	-	-
LWC1	ROMAN	97	2	-	-	4	-	-
LWC2	C11th-14th	7	1	-	-	-	-	-
LWC3	C15th-17th	189	123	-	-	2	62	-
LWC4	C17th-18th	13	-	-	-	-	5	2

examination of skeletal elements would show whether this category is comprised of fragmented (through butchery and/or weathering) indicators or simply shaft fragments; the latter would have no effect on our quantification methods. Similarly, the OXO component could affect the cow numbers; however, this is less marked with the extramural sites since they are strongly cow-dominated anyway.

Table 3.8 illustrates the bone fragmentation indices of the cattle and sheep/goat remains. The individual indices, that is FINDEX1 and FINDEX2, only reveal the proportion of non-identifiable material in an assemblage. The difference between the indices, DINDEX, is much more informative in that it highlights certain peculiarities pertaining to the sites. The plus sign indicates, as would be expected, higher fragmentation of the large mammal remains (cattle) while a negative sign shows higher fragmentation of the small mammal remains (sheep/goat), which, as for the reasons stated above (Section 3.4), is a little less expected.

Most of the sites show a difference of under ten per cent. However, certain sites show large discrepancies; for instance, COC3 with a value of +16 and GBS3 with a value of +32. Both these sites can be rejected from analysis on the basis of small sample size; however, the same cannot be said of CUL5 and CUL6, where not only is the difference greater than ten per cent but the sheep/goat bones are much more highly fragmented than the cattle. Also GBS1 is similar in the much higher fragmentation of the sheep/goat remains. These sites warrant much closer examination. MID3 shows a higher level of cattle fragmentation (Table 3.8), which is also confirmed by the indices in Table 3.9, where the proportion of sheep/goat indicators in NISP was twice that for cattle and pig. However, sheep/goat remains are extremely common in the bone assemblage, whether NISP or IND are used, and this suggests that the importance of this species is very real.

The Culver Street sites CUL5 and CUL6 reflect bone

Table 3.7 Relative percentage bone-fragment counts (NISP) from Balkerne Lane and Lion Walk, excluding the major domesticates and deer. [Page 25]

Site	Date	Dog	Cat	Bear	Fox	Hare	Rabbit	Rat	TFRAG
BKCE1	44-55	1					-		1473
BKCE2	49-60/1	6	-	-	1	1	-		559
BKCE1/2	44-60/1	7	-	-	-	1	-		166
BKCE3	60/1-80	1	-	-	-	-	-		1113
BKCE4	75-85	2	-	-	-	-	-		211
BKCE5	100-300	1	1	-	-	-	-		142
BKCE6	300-400+	1		-	-	-	-		1004
BKCG1	250-300	1				-	-		512
BKCG2	44-60/1	1	-	-	-	-	-		256
BKCH1	250-300	21	1	1	-	-	-		1875
BKCK1	44-60/1	12				1	-		312
BKCK2	60/1-80	1	-	-	-	-	-		145
BKCK3	75-85	3	-	-	-	-	-		203
BKCK4	85-100	1	-	-	-	1			740
BKCK5	150-400+	1	-	-	-	-	-		1164
BKCK6	300-400+	1	-	-	-	-	-		272
BKCN1	150-250	3	-	-	-	-			572
BKGN2	300-400+	6	-	-	-	1	-		1092
BKCT3	60/1-80	16	1	-	-	1			1205
BKCT5	100-300	1	1	-	-	-	-		3917
BKCV1	75-100	1	-	-	-	1			1743
BKCV2	250-300	2	-	-	-	-	-		953
BKCV3	100-300	2	1	-	-	-	-		4028
LWC1	ROMAN	5	1	-	-	1			1869
LWC2	C11th-14th	4	1	-	-	-	-		191
LWC3	C15th-17th	5	4	-	-	1	2		3528
LWC4	C17th-18th	2	-	-	-	-	1	1	813

TFRAG: total number of mammalian bone fragments.

Note: the percentages represent the number of bone fragments (NISP) divided by the total number of mammalian bone fragments (NISP) by site/period.

assemblages from the Culver Street Site B. The bone deposits were excavated mainly from pits and dumps and Table 3.10 depicts the percentage values of NISP and IND for the two types of context. While there is a clear increase in the percentage occurrence of pig bones via NISP between dumps and pits for both phases, the proportions of SMA remain similar in both types of context. The proportion of SMA made up of shaft fragments has also been recorded in Table 3.10 (figures in brackets) and it is evident that approximately fifty per cent of SMA is comprised of fragmentary indicators. Pig bones are better preserved in pits than dumps, which is to be expected, but the same is not true of SMA, which may have undergone some form of attritional process.

If the relative percentage occurrence of the indicators is considered, dumps from both sites show the dominance of cattle together with pig. However, with respect to the pits, CUL5 shows the pre-eminence of pig followed by sheep/goat, while CUL6 shows the dominance of cattle followed by pig. CUL5 is a smaller sample of bone than CUL6, so caution is needed in interpretation. These sites have been omitted from the general synthesis leading to an overall appraisal of quantification of taxa, since the fragmentary SMA portion contains bones which could have significantly altered the ratio of species. On the other hand, the relatively large amounts of SMA from GBS1 consisted solely of long-bone shaft fragments which would have no effect on our quantification methods. This was a feature also exhibited by GBS2 and GBS4 (Fig 3.1a). Further, the OXO fraction of these Gilberd School sites also consisted of long-bone shaft fragments, as did the post-medieval cattle deposits from Middleborough.

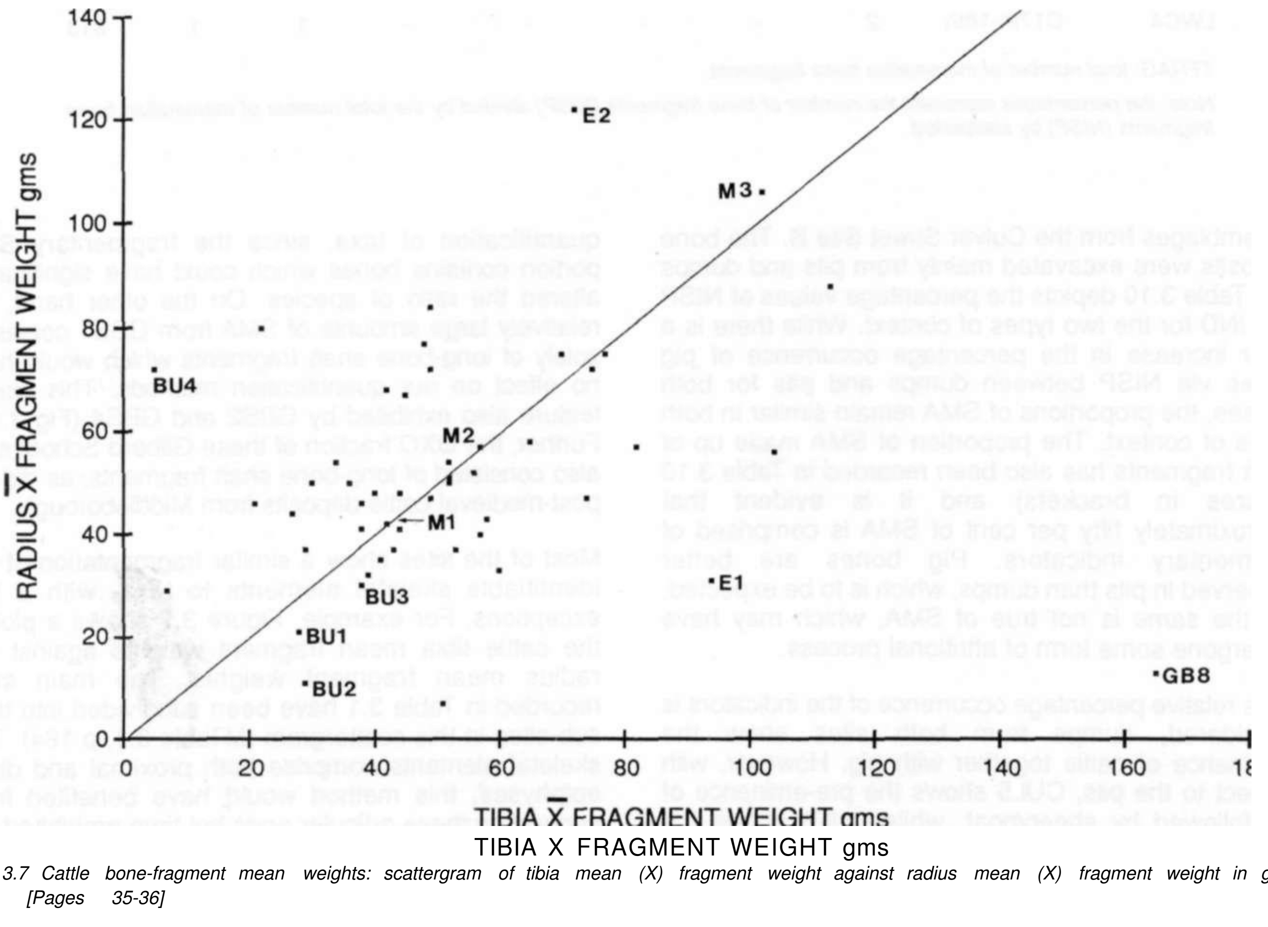
Most of the sites show a similar fragmentation of the identifiable skeletal elements to taxa, with a few exceptions. For example, Figure 3.7 shows a plot of the cattle tibia mean fragment weights against the radius mean fragment weights. The main sites recorded in Table 3.1 have been subdivided into their sub-sites in this scattergram (MTable 3.1, p 164). The skeletal elements comprise both proximal and distal epiphyses; this method would have benefited from separating these articular ends but time prohibited the exercise. The straight line through the origin shows equal fragmentation. The Butt Road sites (BUTT1-4) stand apart, as do Culver Street E1 and E2. Oddly, the Middleborough sites, M1 (Roman), M2 (medieval), and M3 (post-medieval) show equal fragmentation of the radii and tibiae; whether this is significant or not is a moot point, but they also show identical fragmentation of the scapula.

Figure 3.8 shows some correspondence with that of Figure 3.7 and demonstrates the mean fragmentation weights of sheep pelves plotted against scapulae. Again the Butt Road sites show high fragmentation with Culver Street Site E exhibiting low fragmentation. The high fragmentation of the Butt Road bones, reflected by the low mean fragmentation weights, is supported by the fragmentation indices recorded in Table 3.8. In contrast to the majority of sites, the Butt Road sites show indices of approximately 60 per cent and over. Also Culver Street 1 and 4 show low fragmentation indices, which corresponds to their high fragmentation weights. The mean fragment weights of the identifiable cattle/sheep components were always higher than those for SMA and OXO (a not altogether unexpected finding). However, they did not progressively diminish in value as the percentage of indicators decreased.

Our main purpose in this section is to have isolated certain bone assemblages for exclusion from quantification estimates. It is a momentous task to unravel the complicated strands of an assemblage's taphonomic history; however, since carnivores were present in Colchester, it would seem apposite to attempt at least some estimation of their scavenging activity with regard to animal carcasses.

Shipman has stated that: if the indeterminate and identifiable bones are of about equal size, then weathering, transport, and decay are likely to have been the destructive forces. In that case, the indeterminates have been so badly damaged, that any identifying features are gone. On the other hand, if the indeterminate bones are smaller than the identifiable bones, breakage by predators, scavengers or diagenetic events is likely. The indeterminate bones have been broken into pieces that do not retain the characteristic features of shape; they are probably pieces of bone that are especially attractive to scavengers because of the soft tissues or marrow associated with them' (Shipman 1981,129).

The main scavengers of the exposed Colchester bone assemblages would have been dogs, cats, and possibly pigs and kites (Section 1.3). Attention needs to be focused on bone attrition caused by pigs. It has already been stated that we can judge bone preservation by counting and comparing the numbers of proximal and distal tibia epiphyses which have survived in the faunal assemblage (Section 2.4). These articular elements have a differential survival rate due to the later-fusing proximal epiphysis being less dense than the earlier-fusing distal one (Binford 1981). If we then plot the percentage number of proximal tibiae divided by the number of proximal plus



TIBIA X FRAGMENT WEIGHT gms

Fig 3.7 Cattle bone-fragment mean weights: scattergram of tibia mean (X) fragment weight against radius mean (X) fragment weight in gms. [Pages 35-36]

Key: BU1-4....Butt Road; MI-3....Middleborough; E1-2....Culver Street Site E. (See Table 3.5b for dates.)

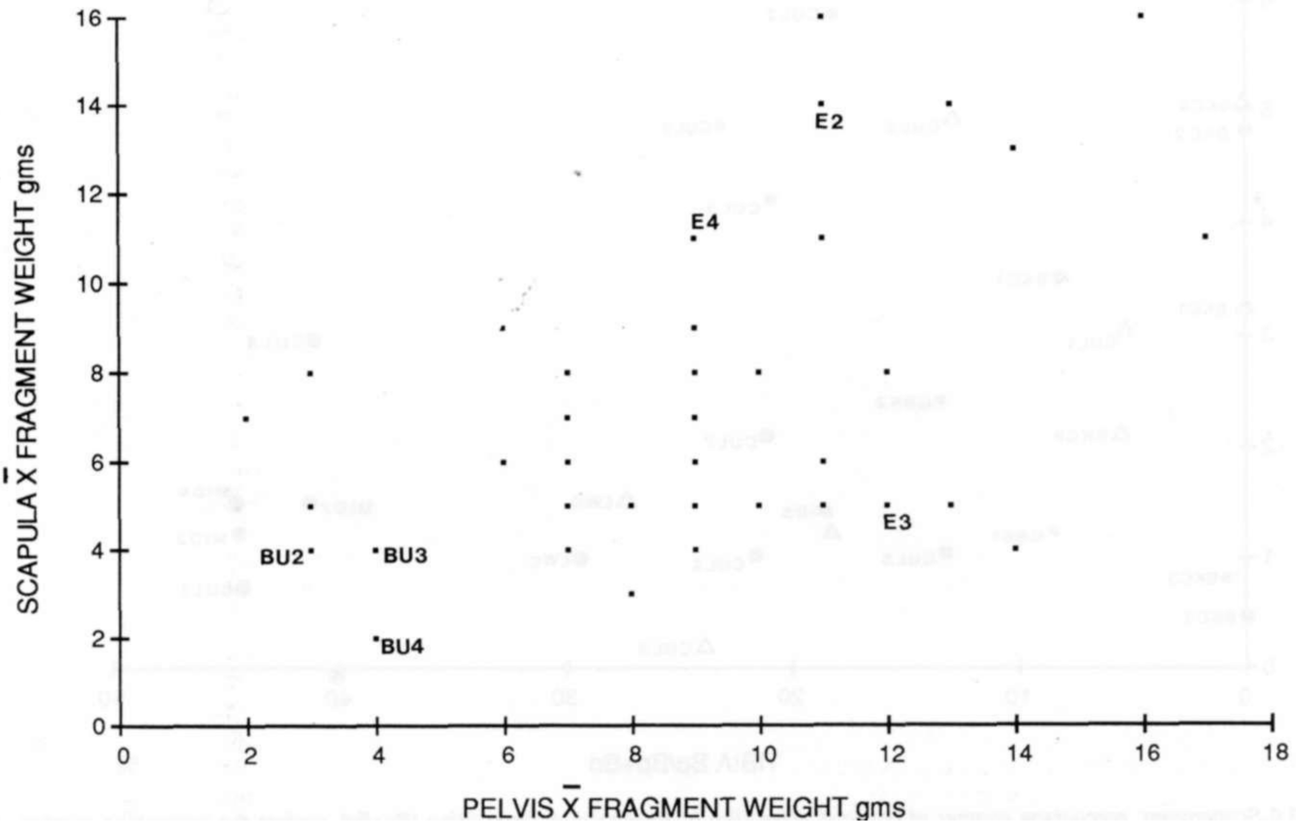


Fig 3.8 Sheep/goat bone fragment mean weights: scattergram of tibia mean (X) fragment weight against radius mean (X) fragment weight in gms. [Page 36]

Key:
BU2-4....Butt Road: £2-4....Culver Street Site E. (See Table 3.5b for dates.)

distal tibiae against the percentage number of dog-gnawed bone for the main assemblages (Balkerne Lane Site J, Butt Road, Culver Street, the Gilberd School, and Middleborough), we ought to be able to get some idea of the degree of carnivore activity in Colchester. However, there are difficulties inherent in this, as described in Section 2.4.

The assemblages were divided into those for cattle, sheep/goat, and pig. The percentage of dog-gnawed bone for all three species is low (less than 6 per cent), whilst the frequency of the proximal tibiae is again low, being mainly between 0 and 25 per cent (Fig 3.9). It would appear that dog-gnawing is not strongly correlated with the loss of the proximal tibia. Even though the proximal tibia is susceptible to carnivore attack, as is indeed the proximal humerus, modern carnivore-gnawing does not always leave identifiable traces on the bones (Section 2.4).

Another method was thus sought in order to shed light on the fragmentation and possible bone loss. Selected skeletal elements from the major assemblages of the post-1988 analyses were ranked according to the level of attrition of Brain's Hottentot goat sample, which had been subject to dog attack (Brain 1981; Section 2.4). This study of contemporary Hottentot pastoralists living in Namibia revealed that the Hottentots killed and ate goats in the villages in which they lived. They did not trade in meat, and therefore the refuse from primary and secondary butchery, and meal debris, should be present in and around the villages.

Brain's bone survival rate was estimated by counting the minimum number of individuals per skeletal element. Payne and Munson (1985, 35) have pointed out that we do not know how many goats were originally present, and that we are looking at relative survival rates and not absolute ones. Figures 3.10-3.14 demonstrate the relative frequencies of the main skeletal elements for cattle, sheep/goat, and pig from the Roman and medieval/post-medieval periods. The relative percentage representation reflects indicators which in the case of the long bones constitute the distal epiphyses only. The ordering of the skeletal elements is based on that of Brain for his survival rates of Hottentot goats, albeit without the proximal epiphyses. He found for instance that the jaw, distal humerus and distal tibia survived much more frequently than did for example the distal radius, astragalus and distal femur.

In the Roman period, a striking difference is exhibited between the profiles for cattle, sheep/goat and pig (Figs 3.10-3.12). The former shows that the metapodials are

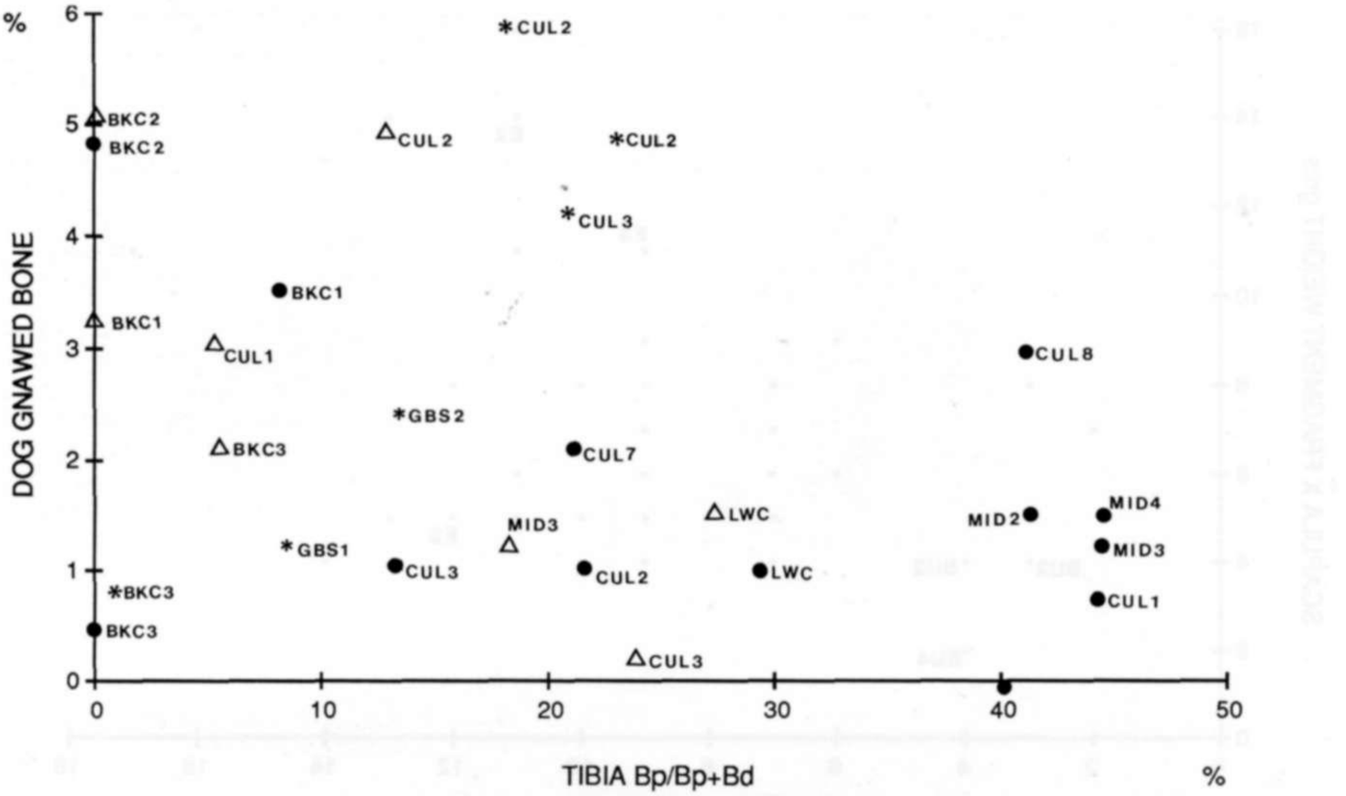


*Fig 3.9 Scattergram: percentage number of proximal tibiae (Bp) in proximal and distal tibiae (Bp+Bd) against the percentage number of gnawed bones for cattle (A), sheep/goat **f**) and pig (%). [Page 37]*
(For dates, see Table 3.5b.)

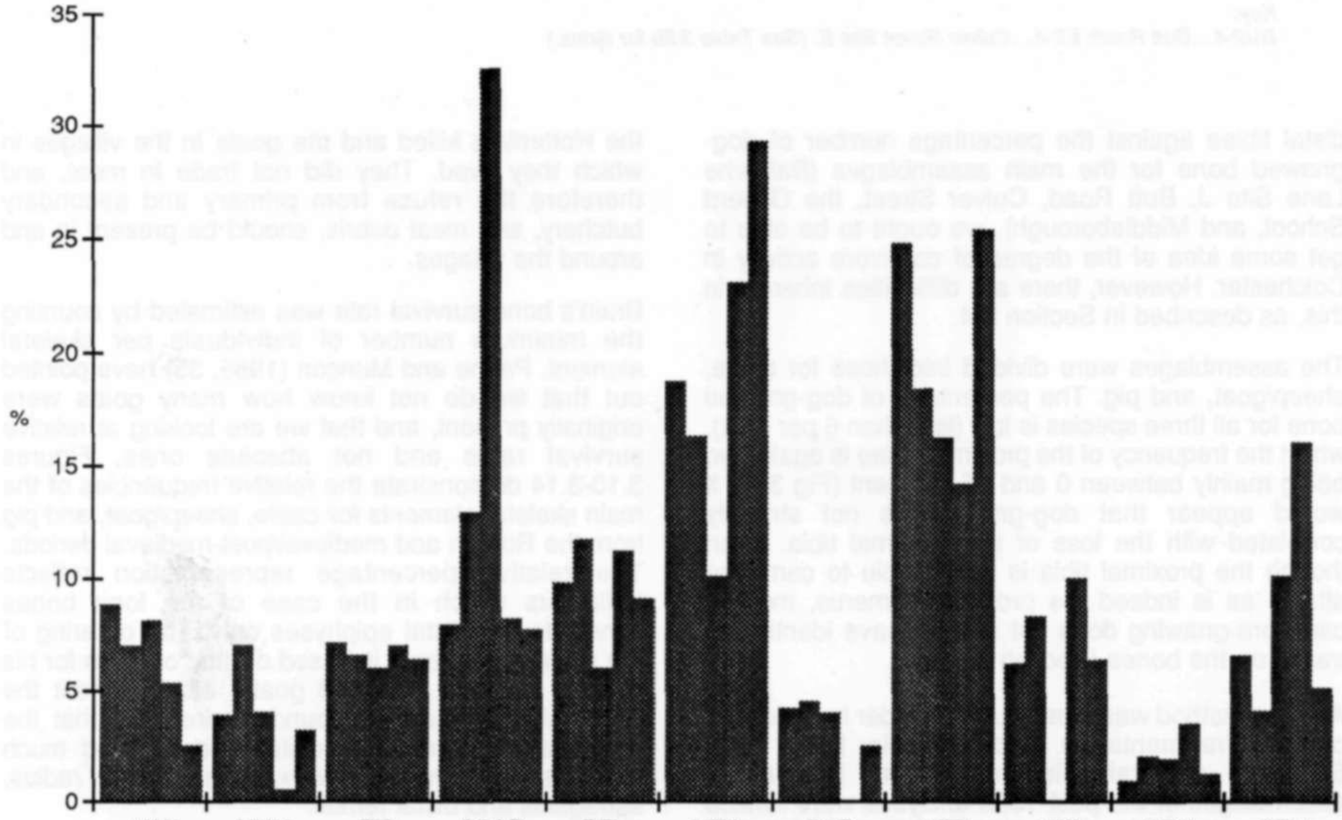


Fig 3.10 Bar chart: distribution of Roman cattle skeletal elements (ranked according to Brain 1981) from the intramural sites. The blocks represented in each category constitute the main Colchester sites (left to right); Culver Street, the Gilberd School, Long Wyre Street, Butt Road and Balkerne Lane Site J. [Pages 37,47]

Table 3.8 Bone-fragmentation indices of cattle and sheep/goat remains. [Pages 34, 36]

Site	Date	FINDEX1	FINDEX2	DINDE
		$\frac{\text{OXO}}{\text{OXO+COW}}$	$\frac{\text{SMA}}{\text{SMA+SG}}$	
BKCJ1	60/1-150	31	25	+6
BKCJ2	150-400+	51	42	+9
BUTT1	C2nd-320	66	60	+6
BUTT2	C2nd-400+	59	62	-3
BUTT3	320-400+	61	66	-5
BUTT4E	320-400+	68	72	-4
C0C1	C1st	52	55	-3
GOC2	MED	54	54	0
C0C3	PMED	51	35	+16
CUL1	44-60/1	26	37	-11
CUL.2	60/1-150	44	56	-12
CUL3	150-400+	48	50	-2
CUL4	60/1-225	25	27	-2
CUL5	100-350	46	63	-17
CUL6	75-300	61	75	-14
CUL7	EMED	55	60	-5
CUL8	MED	44	48	-4
GBS1	44-60/1	41	55	-14
GBS2	60/1-275	38	46	-8
GBS3	49-110	74	42	+32
GBS4	110-350	26	33	-7
GBS5	PMED	49	44	+5
MIDI	ROMAN	3	**1**	+2
MID2	MED	36	41	-5
M1D3	PMED	29	16	+13
MID4	C16th	36	29	+7

(The DINDEX is equal to the difference in fragmentation between FINDEX1 and FINDEX2. The plus sign denotes greater fragmentation of the cattle bones while a negative sign indicates greater fragmentation of the sheep/goat bones.)

the most commonly-surviving element; the meat-bearing bones (humeri, radii, and femora) are all low in number. It should be noted that only one site from Balkerne Lane has been included in this profile (BKCJ). So, in essence we are looking at material mainly from the interior of the settlement. This distribution of parts of the skeleton is also true for most of the medieval and post-medieval deposits (Fig 3.13).

In contrast, the Roman sheep/goat remains show a profile that is much more akin to that of Brain's goats, with the jaws and distal tibiae showing high levels of preservation (Fig 3.11). Also, the Roman and medieval/post-medieval pig profiles partially reflect the findings of Brain if we assume the same ranking of skeletal elements with respect to robustness, with the jaws, distal humeri, distal tibiae, and scapulae preserving better than the later-fusing elements of distal radii, metapodials and distal femora (Fig 3.12). It is thus quite likely that the sheep/goat and pig profiles are demonstrating some sort of attritional process. We have seen that evidence of carnivore gnawing is low and few badly-eroded bones at the macroscopic level have been recorded. The medieval/post-medieval sheep/goat skeletal elements do not exhibit this phenomenon to the same degree as the Roman deposits; however robust jaws and distal tibiae do occur more frequently (Fig 3.14).

The disposal of cattle remains is of central importance to our understanding of bone fragmentation. Clearly the latter are being treated differently to the pigs and sheep/goats, where it can be seen that the more robust elements are dominating the samples. (This point will be developed further in Section 3.7, when the remaining Balkerne Lane sites are discussed.)

Table 3.9 The percentage representation of IND in NISP for cattle, sheep/goat and pig. [Page 34]

Site	Date	Cattle	Sheep/ goat	Pig
		$\frac{\text{IND}}{\text{NISP}}$	$\frac{\text{IND}}{\text{NISP}}$	$\frac{\text{IND}}{\text{NISP}}$
BKCJ1	60/1-150	29	39	44
BKCJ2	150-400+	26	28	30
BUTT1	C2nd-320	33	52	23
BUTT2	C2nd-400+	49	43	28
BUTT3	320-400+	28	28	36
BUTT4E	320-400+	17	39	22
COC1	C1st	52	51	38
COC2	MED	36	38	26
COC3	PMED	41	61	35
CUL1	44-60/1	34	49	46
CUL2	60/1-150	37	44	35
CUL3	150-400+	49	46	42
CUL4	60/1 -225	37	36	30
CUL5	100-350	42	46	35
CUL6	75-300	34	30	19
CUL7	EMED	30	30	36
CUL8	MED	31	50	37
GBS1	44-60/1	35	35	43
GBS2	60/1 -275	31	33	43
GBS3	49-110	29	44	36
GBS4	110-350	25	46	43
GBS5	PMED	26	28	33
MIDI	ROMAN	23	19	21
MID2	MED	35	47	21
MID3	PMED	31	64	31
MID4	C16th	35	39	18

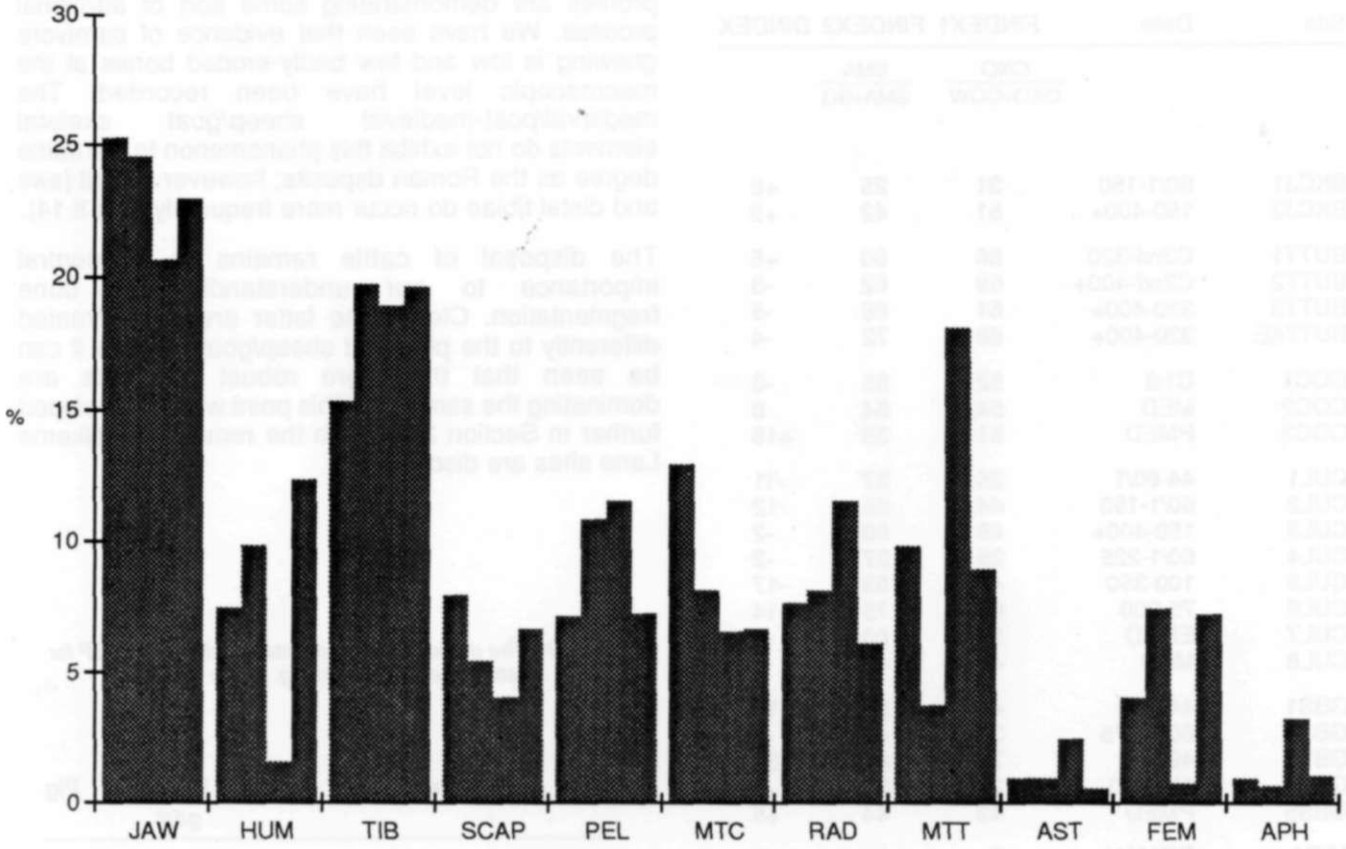


Fig 3.11 Bar chart: distribution of Roman sheep/goat skeletal elements (ranked according to Brain 1981) from the intramural sites. The blocks represented in each category constitute the main Colchester sites (loft to right); Culver Street, the Gilberd School, Butt Road and Balkerne Lane Site J. [Pages 37, 39]

Table 3.10 Culver Street Site B by context type: relative percentage representation of the major domesticates. [Page 35}

Site	Contexts	NISP					IND		
		OXO	Cow	Pig	S/G	SMA	Cow	Pig	S/G
CUL5 (AD 100-350+)	dumps	16	17	19	12	35 (51)	47	28	25
	pits	13	12	33	11	31 (35)	21	49	30
CUL6 (AD 75-300)	dumps	24	15	19	11	31 (55)	37	37	26
	pits	17	11	26	13	34 (47)	47	30	23

Note: bracketed figures are equivalent to the percentage proportions of long-bone shaft fragments in SMA.

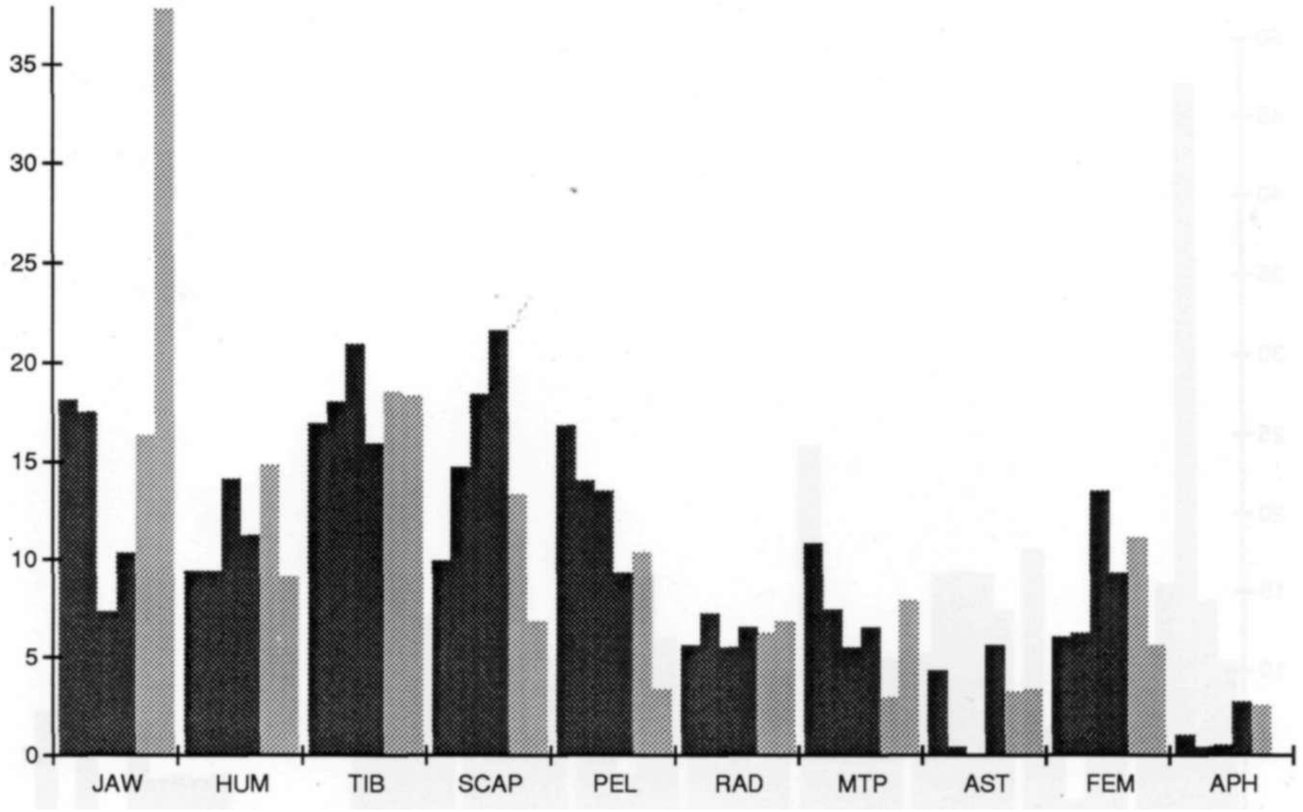


Fig 3.12 Bar chart: distribution of Roman/medieval/post-medieval pig skeletal elements from the intramural sites. The blocks represented in each category constitute the main Colchester sites (left to right); Roman (dark grey: Culver Street, the Gilberd School, Butt Road and Balkerne Lane Site J) and medieval/post-medieval (light grey: medieval Culver Street and post-medieval Middleborough). [Pages 37, 39]

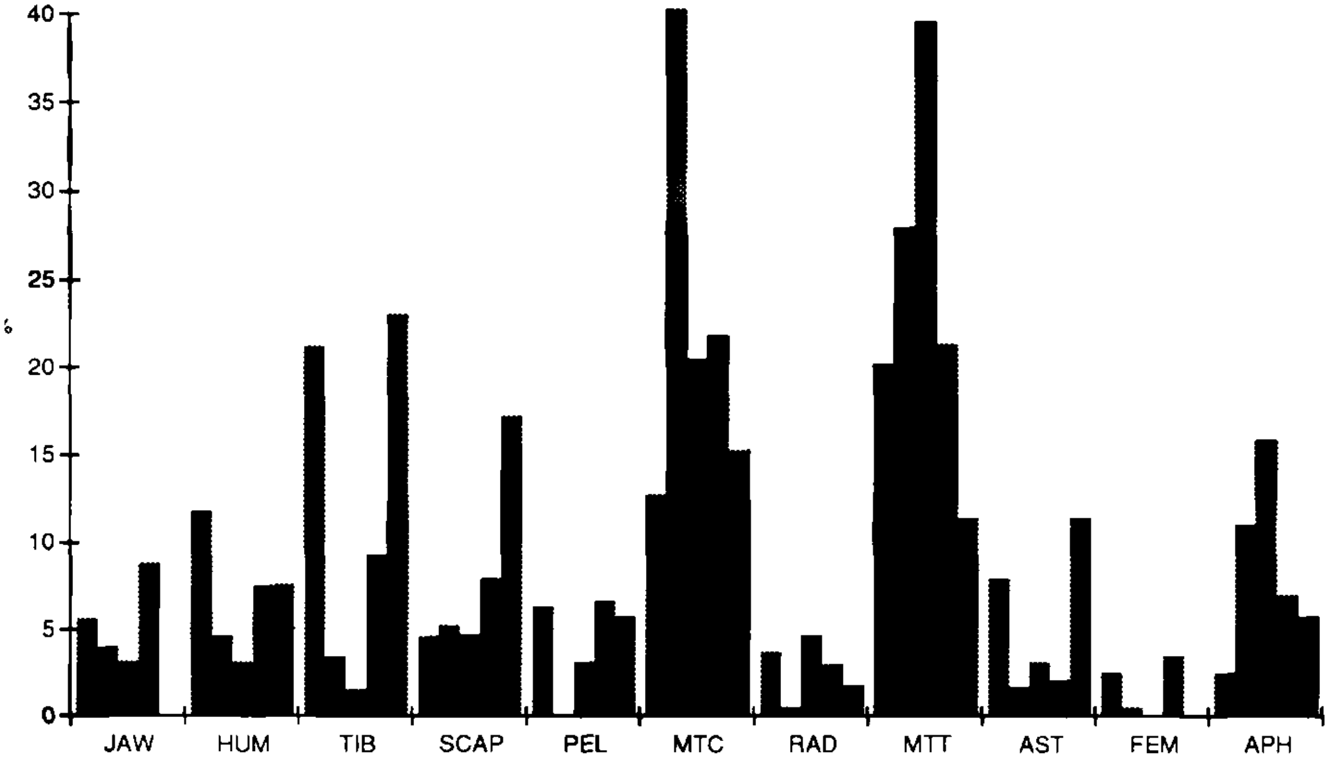
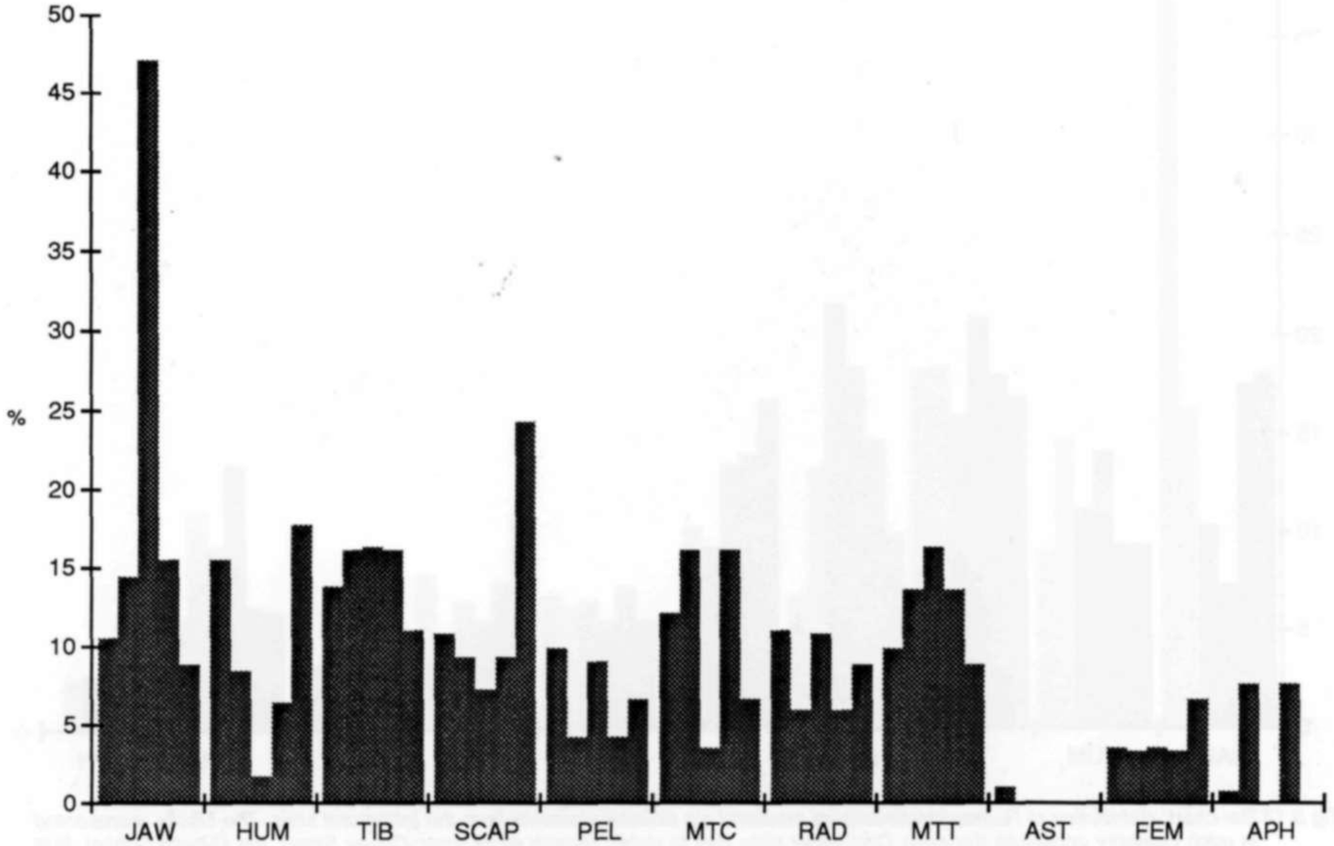


Fig 3.13 Bar chart: distribution of medieval/post-medieval cattle skeletal elements (ranked according to Brain 1981) from the intramural sites. The blocks represented in each category constitute the main Colchester sites (left to right); medieval Culver Street, medieval Middleborough, 16th-century Middleborough, post-medieval Middleborough and medieval Long Wyre Street [Pages 37, 39]



JAW HUM TIB SCAP PEL MTC RAD MTT AST FEM APH

Fig 3.14 Bar chart: distribution of medieval/post-medieval sheep/goat skeletal elements (ranked according to Brain 1981) from the intramural sites. The blocks represented in each category constitute the main Colchester sites (left to right); medieval Culver Street, medieval Middleborough, 16th-century Middleborough, post-medieval Middleborough and post-medieval Long Wyre Street. /Pages 37, 39]

3.6 **An approach to quantification**

[Figs 3.15-3.18; Table 3.11]

In attempting to quantify the relative occurrences of the main taxa in an archaeofauna, both chronologically and spatially, the following conditions need to be met:

a) Recovery procedures (Sections 2.2 & 3.2) need to be adequate.
b) The relative bone fragmentation between the taxa should be similar. If pig bones are highly fragmented compared with cattle and sheep bones, they will be over-represented in an assessment of relative quantification via NISP. This type of material is likely to be found in contexts where bone from a diverse range of activities has been dumped, or perhaps is indicative of later inclusion, having been included in a feature where earlier deposits were rapidly buried. Our methods have shown that such samples can indeed be isolated. Urban excavations tend to produce vast quantities of animal bone fragments from a multitude of different contexts. In many instances, the volume of bone recovered from individual contexts is quite small, and the analyst is forced to amalgamate groups of bone. Use of a method such as ours could obviate difficulties of including bones from unreliable contexts.
c) The composition of the OXO/SMA fraction should also be examined, to judge whether these categories dominate the archaeofauna and whether their skeletal element composition would seriously undermine a quantification estimate based solely on NISP or IND.

Figures 3.15-3.16 show the relative percentage number of indicators via tripolar graphs for cattle, sheep/goat, and pig plotted for the Roman, medieval and post-medieval periods respectively. Sites of uncertain nature have been excluded from this distribution. This is only a tentative approach at quantification and indeed may be a little premature since all the taphonomic factors have not been isolated. We have already shown the difficulties of isolating carnivore attrition. Bone groups exhibiting a high OXO and SMA fraction need not necessarily be eliminated from analysis, when compared to assemblages where there are low occurrences of these categories. It could be argued that poor retrieval is responsible for the lack of the unidentifiable fraction. Notwithstanding, an attempt will be made to summarise the data.

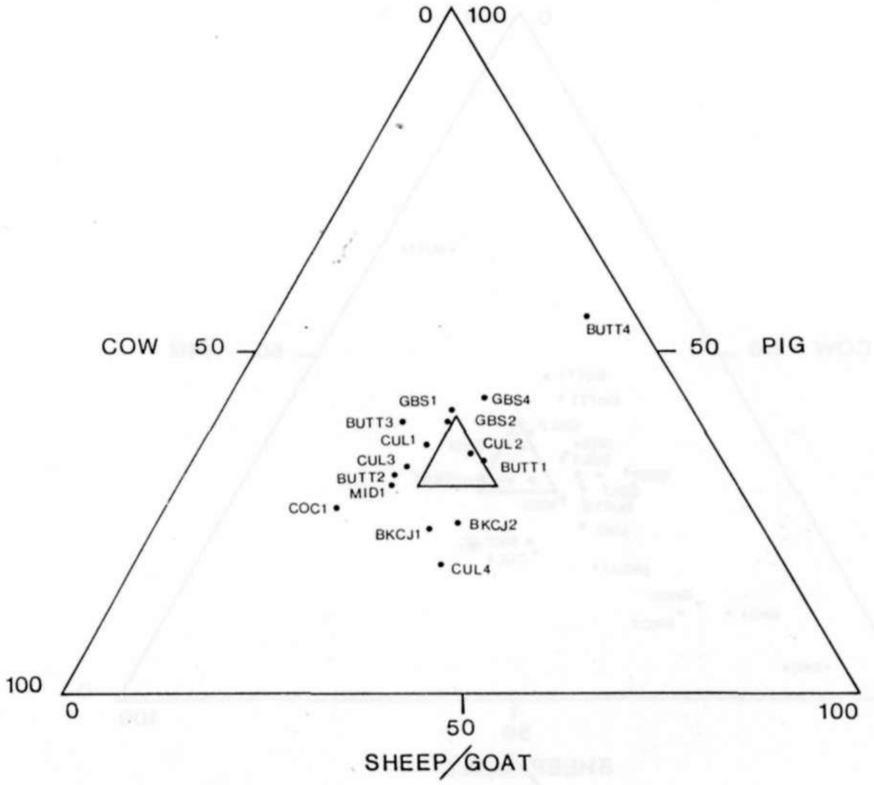


Fig 3.15 Tripolar graph: Roman relative IND percentages lor the main domestic stock. (For dates, see Table 3.5b.) [Pages 42, 45]

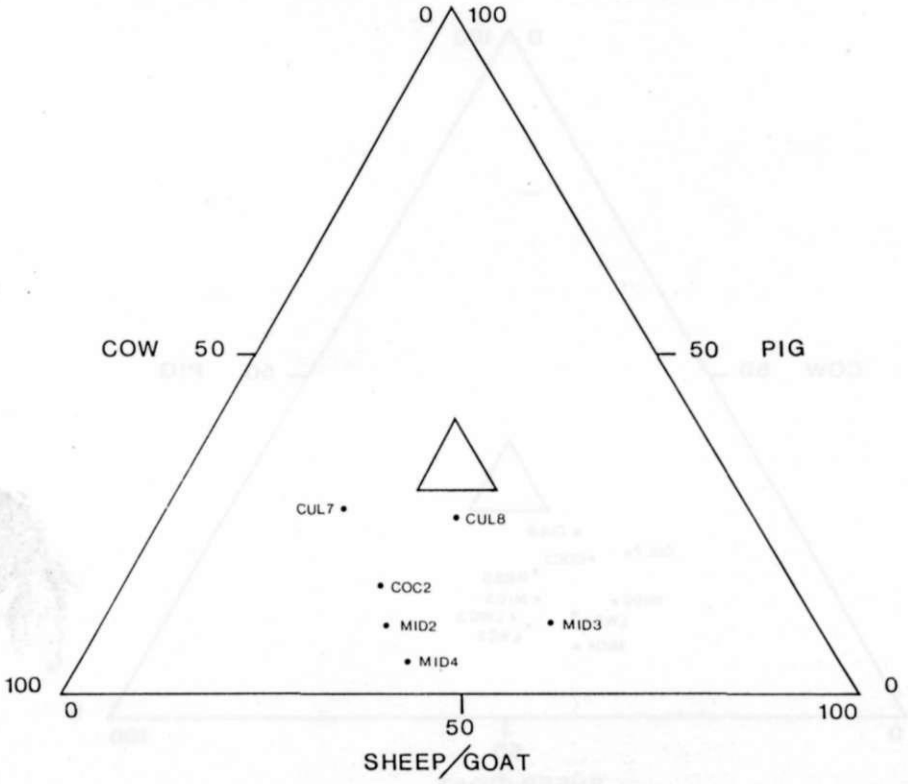


Fig 3.16 Tripolar graph of medieval/post-medieval relative IND percentages for the main domestic stock. (For dates, see Table 3.5b.) [Pages 42, 45]

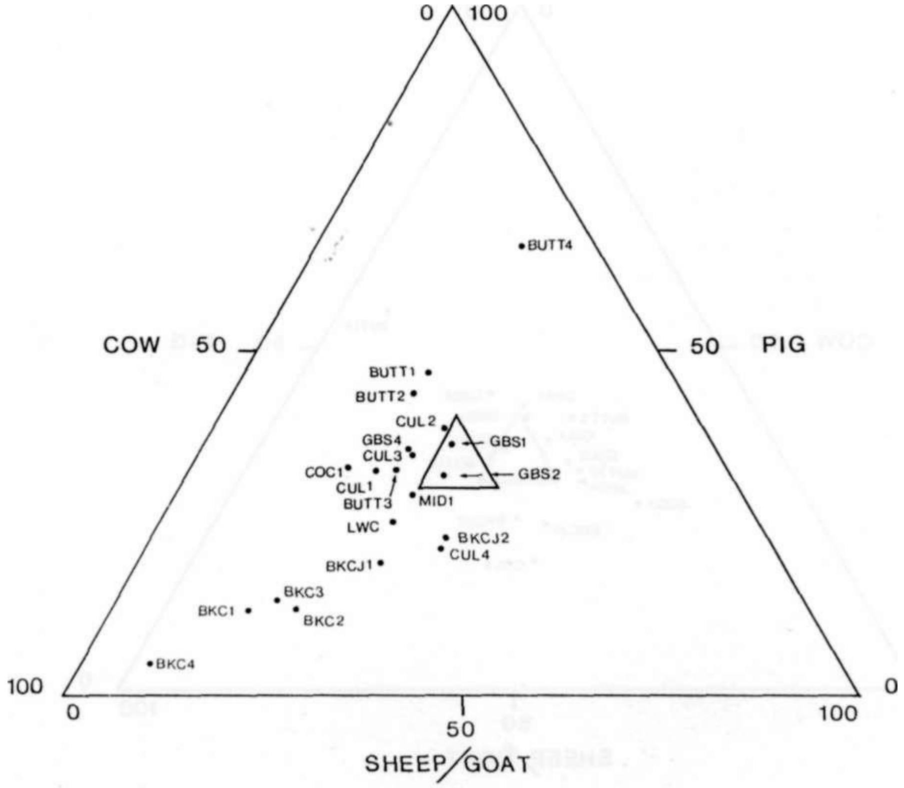


Fig 3.17 Tripolar graph: Roman relative NISP percentages for the main domestic stock. (For dates, see Table 3.5b.) [Pages 42, 45]

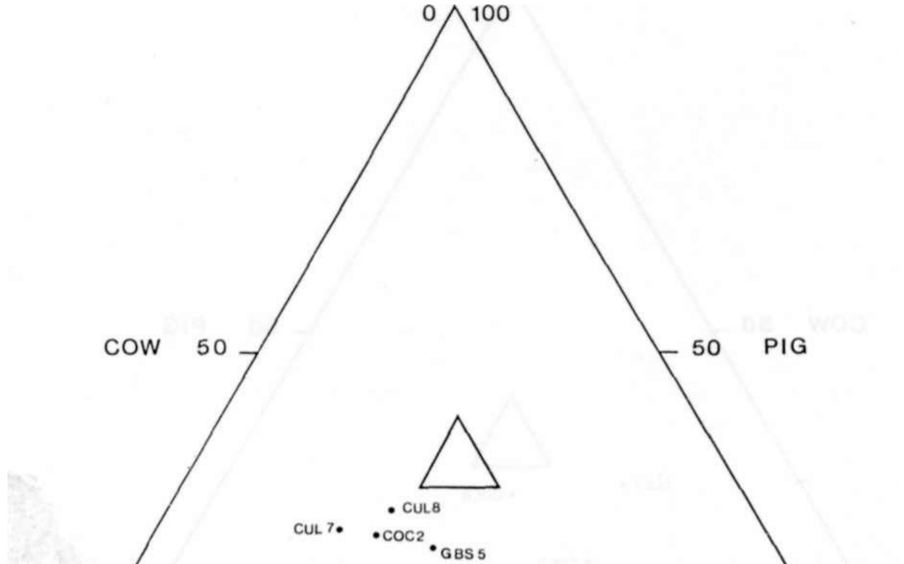


Fig 3.18 Tripolar graph: medieval/post-medieval relative NISP percentages for the main domestic stock. (For dates, see Table 3.5b.) [Pages 42, 45]

The Roman IND tripolar graph (Fig 3.15) in general demonstrates the equal importance of all three domestic stock (cattle, sheep/goat, and pig). The small black triangle denotes equal relative percentages of cattle, pig, and sheep/goat. Most sites show pig percentages of above 30 per cent, and this is extremely interesting if compared with data from other sites ih the canton and Roman Britain itself (Chapter 7). Some sites show a concentration on one particular species, for instance, COC1 which exhibits over 50 per cent of cattle and CUL4 where the cattle and sheep/goat percentages are relatively high compared with other sites. BUTT4E is also unusual in the high occurrence of pig remains. The medieval and post-medieval IND tripolar graph reveals a quite different pattern with a concentration on cattle and sheep, the latter being particularly prevalent in the post-medieval periods (Fig 3.16). Pig husbandry was of a low priority.

Tripolar graphs were also created using NISP values as depicted in Figures 3.17-3.18. Figure 3.17 utilises data from all the Balkerne Lane (BKC) sites, not just Balkerne Lane Site J as in the IND tripolar graph of Figure 3.15, where this latter site was amongst those exhibiting higher cattle percentages. The extramural Balkerne Lane sites (BKC1-4) quite clearly are separating from the intramural sites (COC, CUL, GBS), Middleborough (MIDI), and Butt Road (BUTT). They are heavily dominated by cattle remains and evidence of pig is scarce. CUL4 again shows a preponderance of cattle with lower levels of pig than the other Culver sites. (This dominance of cattle in the Balkerne Lane samples will be further discussed in Section 3.7.2.) The medieval and post-medieval results for the NISP tripolar graph are shown in Figure 3.18. Again this is quite different to the Roman period, and shows the dominance of cattle and sheep/goat with less emphasis being placed on pig. Huge numbers of bird bone were recovered from some sites (Table 3.11; Sections 3.7.1 and 5.1).

3.7 Roman Colchester, with particular reference to the Gilberd School, Culver Street and Balkerne Lane sites

3.7.1 The relative representation of the main domestic stock and deer

[Tables 3.2, 3.4 & 3.11]

The ratio of proximal to distal tibiae for the collective Roman taxa identified the Gilberd School site as one of the better-preserved at Colchester. This was further supported by the abundant bird bones, particularly those of chicken, which even dominated the mammalian species of GBS1 and GBS2 (Table 3.11). This phenomenon was also found in the later Roman period at Culver Street (CUL3) and Butt Road. Indeed, the pattern of recovery of the Gilberd School chicken bones bore a startling resemblance to that of Culver Street and is most likely related to context-type (Section 5.2). Leg bones tended to be more strongly emphasised in the Gilberd School and Culver Street assemblages while Butt Road showed the wing-bone elements preserving just as well as those of the legs. This is extremely interesting in view of the fact that the Butt Road mammalian assemblages were so highly fragmented. Therefore, a sensible and useful first step in elucidating whether a context reflects differing disposal activities in relation to individual taxa would be to compare and contrast the preservation of the avian and mammalian bone.

If the relative percentage IND counts for the Gilberd School are considered as in Table 3.4 for the main domestic stock and deer, pig appears as the most popular item of fare throughout the Roman period, with cattle and sheep/goat making important contributions. However, the larger carcasses of cattle will have provided most of the meat for consumption. The data from GBS3 has been rejected from consideration for reasons given in Section 3.5. Quantification by NISP points again to the prominence of pig but also shows the importance of cattle and sheep/goat (Table 3.2).

The Gilberd School sites are further characterised by the highest incidence of roe deer found at Colchester. The evidence of the deer suggests perhaps inhabitants of higher status, and we were keen to see if the bone groups were associated with any buildings indicative of this. Much of the material had been excavated from pits and dumps. Much of the AD 44-60/1 sample (GBS1) consisted of material dug from pits (dated to AD 49-60/1) which had been cut into a street between Barrack Blocks 1 and 2. This was the only building to which we could relate sizable bone groups. A further notable finding was that the OXO and SMA fractions of the Roman assemblages contained many long-bone shaft fragments; this was rare among the Colchester sites.

If the ratio of proximal to distal tibia is considered, the Culver Street bone assemblages showed similar levels of preservation to those from the Gilberd School, with those from Balkerne Lane being the least well-preserved. However, many of the cattle long-bone epiphyses had been quartered on this latter site and this might well account for its dissimilarity. As with the Gilberd School, few of the Culver bone deposits could be directly related to buildings. They mainly derived from sealed dumps and pits, with some samples from cess-pits, floor levels, middens, roads, and demolition debris.

With the IND method of quantification, Table 3.4 shows for Culver Street Sites CUL1 to CUL4 (CUL5 and CUL6 have been eliminated from the analysis as being unreliable) that in the early Roman period there is a strong dependence on pig rearing (that is in CUL1 and CUL2). In the later Roman period, cattle are the foremost species, followed by pig and then sheep/goat (CUL3). Results from CUL4, which spans CUL2 and CUL3, shows the dominance of cattle followed by sheep/goat.

Data from the NISP method of quantification shows that cattle are the dominant species in CUL1, closely followed by pig, while CUL2 shows the pig to be dominant followed by cattle (Table 3.2). The cattle and pig percentages of CUL3 are fairly similar, while CUL4 shows a much stronger concentration on cattle and sheep remains. Deer were not widely exploited at Culver Street; the few remains excavated consist of antler, and some show signs of having been worked (Chapter 5).

Balkerne Lane Site J was the only site from Balkerne Lane to be analysed using the IND method of quantification. The material was mainly excavated from dumps and pits. In contrast to the Gilberd School and Culver Street, both BKCJ1 and BKCJ2 at Balkerne Lane show that the main species recovered are cattle and sheep/goat. In contrast to the Gilberd School, deer bone was uncommon and perhaps reflects the lower status of this site. The NISP quantification method also supports these results. Balkerne Lane Site J fits in well with the remaining Balkerne Lane sites which were analysed solely with the NISP method, cattle being the pre-eminent beast with low numbers of pig.

Table 3.2 shows the NISP relative percentages for the domestic and wild animals recovered from all of Balkerne Lane (BKC1-4). Most of the bone originated in pits and ditches and showed little weathering or dog-gnawing, probably due to rapid burial. Throughout the Roman period the Balkerne Lane sites demonstrate the largest deposits of cattle remains found at Colchester. The second most important species to be recovered is sheep/goat, in contrast to most of the intra-mural bone assemblages where pig is more commonly exploited. Pig percentages are low on all the Balkerne Lane sites. As with BKCJ, the remaining Balkerne sites show little dependence on deer remains.

The 1st-century deposits from Long Wyre Street (COC) and Lion Walk (LWC) consist mainly of cattle remains. These sites are almost adjacent to each other and are inside the walls, close to the south side. Deer remains are again sparse. The 1st-century material from the Colchester site of Middleborough (MIDI) also shows a predominance of cattle remains

Table 3.11 Bone-fragment counts (NISP) of bird compared with the major domesticates. [Page 45]

Site	Date	Horse	Cow	SG	Pig	Bird
BUTT1	C2nd-320	14	63	48	101	-
BUTT2	C2nd-400+	7	66	47	88	-
BUTT3	320-400+	33	455	283	366	-
BUTT4E	320-400+	-	23	65	167	1037
COC1	C1st	3	113	47	80	-
COC2	MED	2	171	99	78	2
COC3	PMED	4	84	74	37	-
CUL1	44-60/1	8	412	215	304	82
CUL2	60/1-150	10	626	579	778	427
CUL3	150-400+	17	781	567	734	790
CUL4	60/1-225	6	314	281	166	-
CUL5	100-350	1	192	127	184	-
CUL6	75-300	-	416	432	782	-
CUL7	EMED	9	414	178	188	-
CUL8	MED	21	1009	621	599	422
GBS1	44-60/1	1	273	264	313	692
GBS2	60/1-275	5	500	445	451	748
GBS3	49-110	-	21	45	28	-
GBS4	110-350	3	142	96	138	-
GBS5	PMED	2	43	36	21	-
MIDI	ROMAN		113	86	87	70
MID2	MED	32	510	260	164	201
MID3	PMED	170	79	668	283	150
MID4	C16th	10	213	143	40	-
BKC1	44-60/1	78	2905	720	520	49
BKC2	60/1-150	53	3310	1217	669	98
BKC3	150-400+	40	4607	1370	1018	550
BKC4	100-300	29	6813	692	438	-
LWC1	ROM	15	784	497	458	403
LWC2	C11-14	2	82	73	24	79
LWC3	015-17	28	1435	1402	264	543
LWC4	C17-18	22	393	264	114	79

(Table 3.2). This site is situated on flat ground near the river to the north-west of the Roman town.

Like the Gilberd School site, Butt Road was also dominated by pig remains but BUTT1, 2, and 3 included much human bone, and may therefore be unreliable (Table 3.2). The percentages of loose teeth recovered were exceptionally high and the ratio of proximal to distal tibiae was low. It is therefore not surprising that Butt Road figured prominently as our most fragmented site with respect to the fragmentation indices. In contrast to the Gilberd School assemblages, Butt Road showed a low percentage of deer bones. Deposits from the Roman church at Butt Road Site E (BUTT4E) were not contaminated with human material. However, the bone still proved highly fragmented and a close look at the contextual evidence showed much of it to comprise of demolition debris which would have considerably comminuted any bone that it embodied. However, the bird bones, which mainly consist of domestic fowl, were unusually well-preserved and showed that the mammal and bird bone had been discarded in different ways (Section 5.2).

Philip Crummy describes an interesting find that Hull made in 1935 when he examined the apse of the church. He excavated a pit (EF186) which contained, amongst other finds, a 'great quantity' of bird bones and part of an iron utensil, possibly a frying-pan *(CAR* **9**). The significance of the Butt Road remains will be further commented on in Chapter 5.

3.7.2. Cattle exploitation at Colchester

[Figs 3.10 & 3.19; Table 3.12]

Cattle appear to be exploited quite differently from other domestic stock, as pointed out in Section 3.5 of this chapter. As discussed in Section 3.5, Figure 3.10 shows that the most commonly-occurring skeletal elements were those of the metapodials, which are well-known waste bones. In order to detect any economic trends, the cattle assemblages for the Gilberd School, Culver Street and Balkerne Lane were split up into their chronological periods as shown in Figure 3.19 and Table 3.12. It is immediately apparent that there are considerable differences between the sites.

The Gilberd School assemblages are dominated by scapulae and metapodials, while the Culver Street assemblages mainly consist of metapodials together with jaw bones. In the earlier part of the Roman period, Balkerne Lane shows a much greater emphasis on the butchery of meat-bearing bones than the Gilberd School or Culver Street. For instance, there are relatively high incidences of radii and femora in BKC1 and radii and humeri in BKC2. The later Roman period at Balkerne Lane saw a reduction in meat- bearing bones at the expense of waste bones, that is jaws and metapodials, which seems more in keeping with the intramural sites. However, an interesting feature of the Balkerne Lane assemblages is the high percentage of scapulae excavated from the 1st- century levels (BKC1; Section 7.10; Luff 1982).

Table 3.12 Relative percentage bone-fragment counts of Roman cattle skeletal elements.

Site	Date	J	H	T	S	P	MC	R	MT	AS	F	AP
BKC1	44-60/1	10	7	10	29	8	5	10	8	1	8	4
BKC2	60/1-150	15	11	13	10	4	5	16	19	1	2	3
BKC3	150-400+	15	6	6	9	9	14	8	18	3	6	5
BKC4	100-300	21	13	13	6	4	8	12	14	1	3	5
BUTT4E	320-400+	12	1	7	7	9	22	-	11	12	3	15
COC1	C1st	8	4	6	33	6	10	4	16	-	2	10
CUL1	44-60/1	17	2	2	12	6	20	2	25	5	1	9
CUL2	60/1-150	13	8	6	6	14	19	6	21	4	-	3
CUL3	150-400+	9	4	7	9	10	26	5	18	5	1	5
CUL4	60/1-225	15	3	7	8	4	18	3	28	4	-	8
CUL5	100-350	6	4	7	5	8	15	4	25	7	1	17
CUL6	75-300	8	3	7	8	13	14	5	27	10	2	3
GBS1	44-60/1	6	12	5	14	5	14	4	22	12	2	5
GBS2	60/1-275	12	6	7	14	12	15	6	14	6	2	5
LWC1	ROMAN	9	8	7	15	13	13	8	12	3	6	5
MIDI	ROMAN	27	1	8	9	8	9	4	18	1	8	6

Key:
J...mandible: H...humerus; T..distal tibia; S...scapula; P...pelvis; MC...distal metacarpal; R...distal radius; MT...distal metatarsal; AS...distal astragalus; F...distal femur; AP... first phalanx.

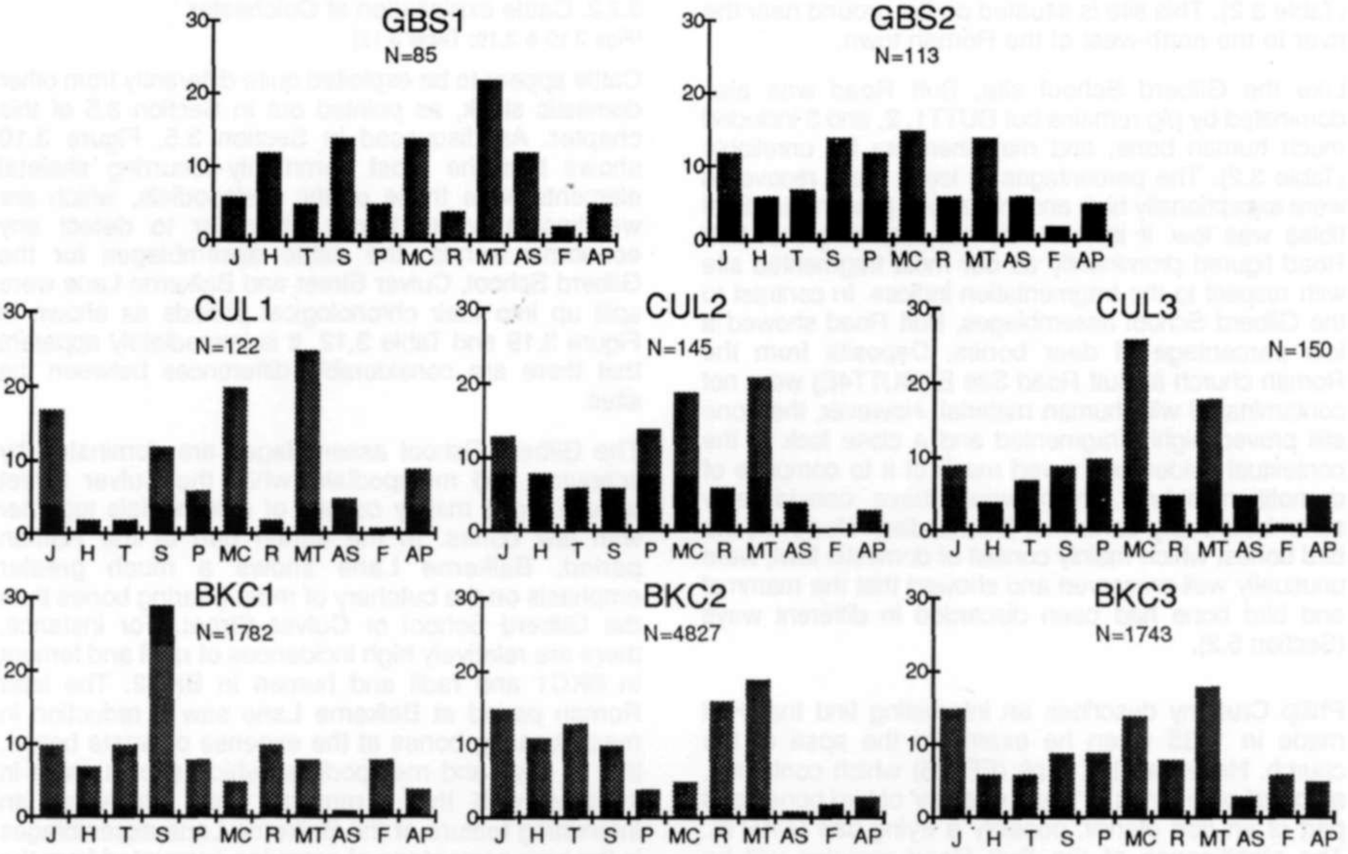


Fig 3.19 Bar charts: the relative percentage distribution of cattle skeletal elements for the Gilberd School (GBS1 44-60/1; GBS2 60/1-275), Culver Street (CUL1 44-60/1; CUL2 60/1-150; CUL3 150-400+) and Balkerne Lane (BKC1 44-60/1; BKC2 60/1-150; BKC3 150-400+). [Page 47]

Key:
J...mandible; H...distal humerus; T...distal tibia; S...scapula; P...pelvis; MC...distal metacarpal; R...distal radius; MT...distal metatarsal; AS...astragalus; F...distal femur; AP...phalanx 1.

The 1st-century samples from Long Wyre Street (COC1), and to a limited extent those from Lion Walk (LWC1), show a strong emphasis on cattle scapulae to the detriment of the other elements (Table 3.12). Both these sites exhibit higher relative percentages of metapodials and jaw bones. The Roman levels of Middleborough also yielded mainly waste bone, that is jaws and metapodials.

It would appear that refuse from the primary and secondary processing of cattle carcasses was being dumped extramurally at Balkerne Lane, especially during the early Roman period (*see* Section 7.10 for further discussion). This could be the reason why so few meat-bearing bones were found within the fortress and town. Indeed Balkerne Lane exhibited many pits with much chopped-up long bone and it could well be that the inhabitants were utilising the waste bones for stews and soups.

3.7.3 Sheep/goat and pig exploitation at Colchester

[Figs 3.20-3.21; Tables 3.13-3.14]

Figure 3.20 shows the distribution of sheep/goat skeletal elements for the Gilberd School, Culver Street and Balkerne Lane. Evidently an attritional process is at work, as discussed in Section 3.5. Most of the commonly-occurring skeletal elements are the more robust metapodials, jaw bones and distal tibiae. Brain (1981, 21) found with his Hottentot goat sample that the jaw bones and distal tibiae survived well despite much attrition by dogs. The fact that the metapodials seem to have survived so well is probably due to the intactness of the bones which escaped butchery. In general meat-bearing and non-meat-bearing bones are present.

Unlike the cattle remains from Balkerne Lane, the sheep/goat remains do not exhibit any real differences between sites; the sheep/goat skeletal element distribution for the Balkerne Lane 1st-century sites clearly exhibits the preservation of the more robust skeletal elements, that is jaws, tibiae and metapodials (Fig 3.20). Jaws, distal tibiae and scapulae were the most commonly-occurring elements recovered from Roman Lion Walk (Table 3.13). The Gilberd School, Culver Street and Balkerne Lane pig bone assemblages also show that an attritional process was evidently at work since the most commonly-surviving skeletal elements are those of the jaw bones, distal tibiae, scapulae and pelves (Fig 3.21). This was also reflected by Roman Lion Walk (Table

Table 3.13 Relative percentage bone-fragment counts of Roman sheep/goat skeletal elements. [Page 48]

Site	Date	J	H	T	S	P	MC	R	MT	AS	F	AP
BKC1	44-60/1	15	8	18	4	5	18	7	12	1	8	5
BKC2	60/1-150	22	9	11	8	6	15	8	14	1	5	1
BKC3	150-400+	17	7	14	7	4	15	13	15	1	5	2
BKC4	100-300	17	4	16	7	5	16	12	14	1	8	1
BUTT4E	320-400+	20	8	15	3	13	4	14	21	-	-	3
CUL1	44-60/1	29	3	15	11	3	16	6	14		3	2
CUL2	60/1-150	23	5	16	8	8	16	7	8	1	5	2
CUL3	150-400+	25	11	10	9	3	8	10	9	2	6	6
CUL4	60/1-225	36	5	12	1	8	14	5	14	-	5	1
CUL5	100-350	25	10	12	10	7	13	9	8	2	2	2
CUL6	75-300	19	9	16	9	10	7	11	9	1	5	4
GBS1	44-60/1	23	9	20	8	14	11	4	4	3	4	
GBS2	60/1 -275	27	10	18	6	10	8	9	3	-	8	1
LWC1	ROMAN	14	7	16	12	11	10	12	9	1	6	1

Key:
J...mandible; H...distal humerus; T..distal tibia; S...scapula; P...pelvis; MC...distal metacarpal; R...distal radius; MT...distal metatarsal; AS...astragalus; F...distal femur; AP...first phalanx.

Table 3.14 Relative percentage bone-fragment counts of Roman and medieval pig skeletal elements. [Pages 48, 51]

Site	Date	J	H	T	S	P	R	MP	AS	F	AP
BKC1	44-60/1	19	12	13	17	12	12	2	2	9	1
BKC2	60/1-150	21	12	20	11	11	5	3	1	14	2
BKC3	150-400+	24	16	16	9	11	10	2	2	8	2
BKC4	100-300	16	11	25	17	10	1	6	1	7	6
BUTT4E	320-400+	6	10	21	19	9	7	6	8	14	-
CUL1	44-60/1	27	10	19	10	20	5	3	-	4	1
CUL2	60/1-150	18	8	19	11	17	4	8	5	6	3
CUL3	150-400+	29	13	14	12	12	5	3	6	6	1
CUL4	60/1-225	18	6	24	6	24	9	6	-	6	-
CUL5	100-350	18	11	18	9	14	7	-	8	5	2
CUL6	75-300	15	16	18	10	15	5	8	7	5	2
GBS1	44-60/1	14	9	20	14	12	11	8	3	7	2
GBS2	60/1-275	16	9	18	17	14	6	6	6	6	2
LWC1	ROMAN	26	12	14	13	9	8	3	1	10	3
CUL8	MED	15	14	18	13	10	6	8	3	11	3
LWC3	C15th-17th	14	16	14	13	10	8	4	1	11	10
LWC4	C17th-18th	22	27	21	10	3	1	-	4	5	3
MID3	PMED	38	9	18	7	3	7	8	3	6	-

Key:
J...mandible; H...distal humerus; T. distal tibia; S...scapula; P...pelvis; R...distal radius; MP...distal metapodial; AS...astragalus; F...distal femur; AP... first phalanx.

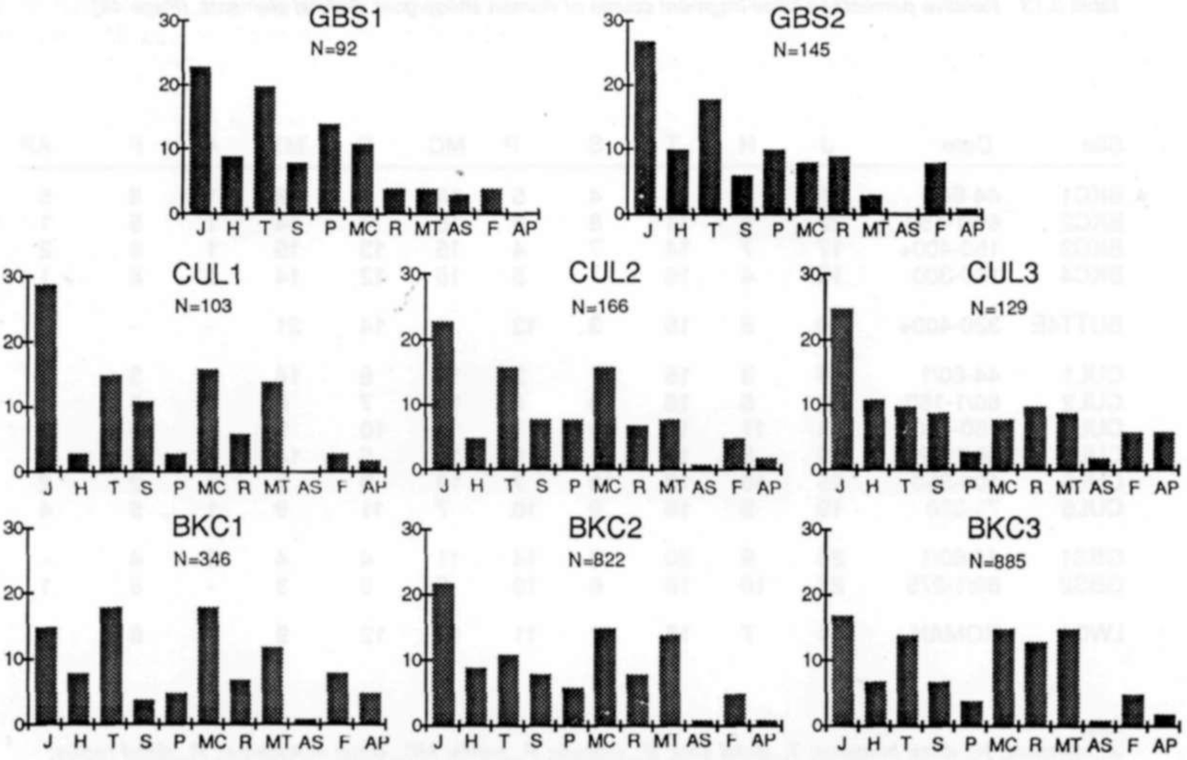


Fig 3.20 Bar charts: the relative percentage distribution of sheep/goat skeletal elements for the Gilberd School (GBS1 44-60/1; GBS2 60/1-275), Culver Street (CUL 1 AD 44-60/1; CUL2 60/1-150; CUL3 150-400+) and Balkerne Lane (BKC 1 44-60/1; BKC2 60/1-150; BKC3 150-400+). [Page 48]

Key:
J...mandible; H...distal humerus; T...distal tibia; S...scapula; P...pelvis; MC...distal metacarpal.; R...distal radius; MT...distal metatarsal; AS...astragalus; F...distal femur; AP...phalanx 1.

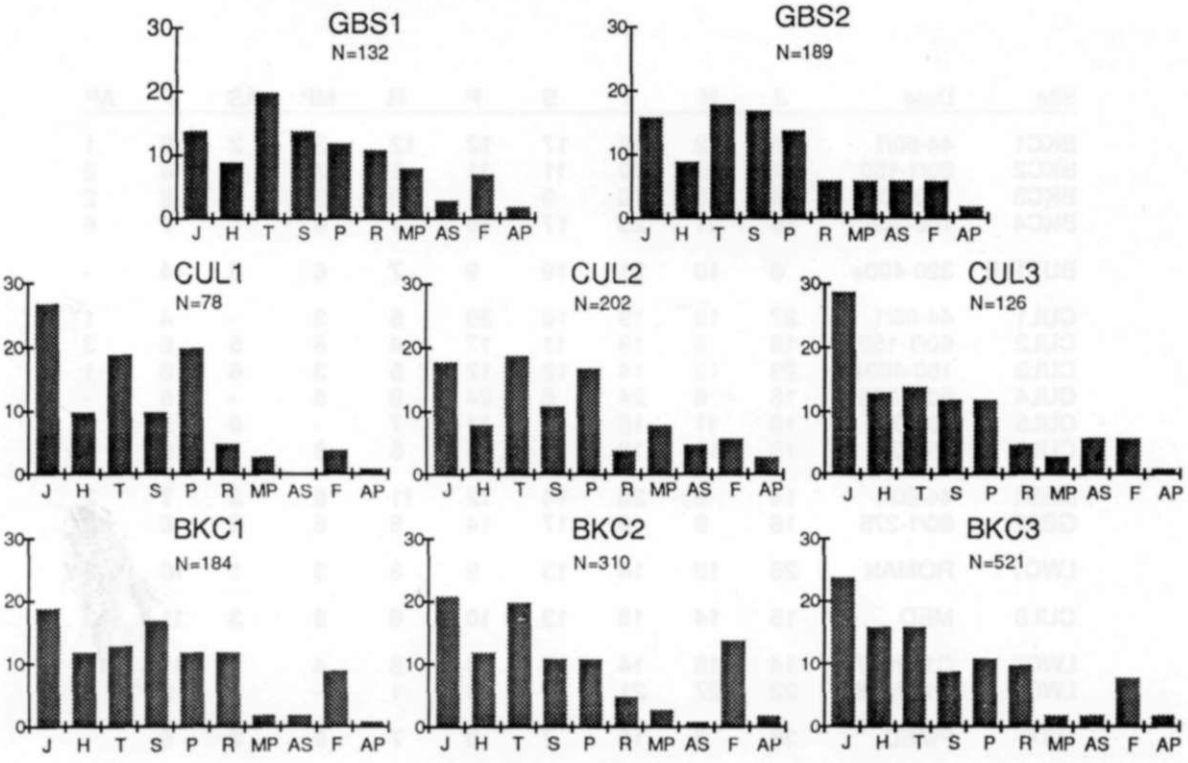


Fig 3.21 Bar charts: the relative percentage distribution of pig skeletal elements for the Gilberd School (GBS1 44-60/1; GBS2 60/1-275), Culver Street (CUL1 AD 44-60/1; CUL2 60/1-150; CUL3 150-400+) and Balkerne Lane (BKC1 44-60/1; BKC2 60/1-150; BKC3 150-400+). [Page 48]
See key tor Fig 3.20.

3.14). However, meat-bearing and non-meat-bearing bones are present in all periods. Conversely, Butt Road, while exhibiting high relative percentages of distal humeri, tibiae and scapulae, also showed reasonable quantities of distal femora which do not usually preserve as well (Table 3.14).

3.7.4 The remaining Roman taxa

[Tables 3.5-3.6]

For details of dog and cat remains, *see* Section 7.7. (See also Tables 3.5a-3.5b & 3.6.)

3.8 **Medieval and post-medieval Colchester**

3.8.1 The relative representation of the main domestic stock and deer

[Tables 3.1-3.4]

There is some evidence to suggest that the ratio of proximal to distal tibia epiphyses may not be as reliable as the ratio of proximal to distal humerus epiphyses as an indicator of preservation. The 15th- to 17th-century deposits from Lion Walk revealed a high ratio of proximal to distal humeri whereas those from the 17th- to 18th-century and Roman deposits gave a low ratio of proximal to distal humeri. However, in the 17th- to 18th-century groups, the proximal tibia survives better than the distal whereas this is not true for the Roman and 15th- to 17th-century bones. This is interesting in view of the fact that the latter sample showed good preservation of the proximal humeri.

The medieval sites of Long Wyre Street (COC), Culver Street (CUL), and Middleborough (MID) were quantified by both the IND and NISP methods (Tables 3.1-3.4). With the former method, cattle are the main species exploited at Long Wyre Street, Culver Street, and Middleborough, with sheep/goat in second order of importance. The early medieval period CUL7 at Colchester showed pig in contrast to sheep/goat to be the most important species, while the assemblages were still dominated by cattle. Post-medieval Colchester experienced a tremendous upsurge in the marketing of sheep in the form of mutton (Section 4.3.3). Bone assemblages from Middleborough yielded the main evidence concerning this via the IND quantification method. Quantification via NISP, while giving high relative quantities of sheep/goat, gave order of precedence to cattle. The 16th-century deposits from this same site followed the pattern set in the medieval period whereby cattle followed by sheep/goat were the main domestic species.

The Lion Walk sites were analysed prior to 1988 and only underwent the NISP quantification method. While the 15th- to 17th-century deposits showed cattle and sheep/goat remains to be of almost equal importance, those of the 17th to 18th centuries showed the dominance of cattle followed by sheep/goat. These are large assemblages and the marked difference between them and those from Middleborough need some explanation, which can best be effected by the skeletal-element distribution.

Remains of deer were scarce at Colchester in the medieval period although at this time no fallow deer appear to have been introduced (Table 3.2).

3.8.2 Distribution of cattle and sheep/goat skeletal elements

[Tables 3.15-3.16]

In the medieval period, the major cattle bones recovered are those of the distal tibiae and metapodials (Table 3.15). This is particularly evident with Middleborough (MID2) where there is a striking emphasis placed on these bones. Further, the 16th-century (MID4) and post-medieval (MID3) deposits from Middleborough show the same features to a very marked degree. Long Wyre Street (COC2) compares well with the previous sites while Culver Street (CUL8) shows both meat- and non-meat-bearing bones. However this is not true of Lion Walk (LWC), where the skeletal element distribution concentrates more strongly on meat-bearing elements, both for the 15th- to 17th-century and 17th- to 18th-century deposits. Similarly the sheep/goat skeletal element anatomies mirror the same findings as those from the cattle (Table 3.16). All the Middleborough sites are dominated by waste bone in the form of jaws, distal tibiae, and metapodials while Lion Walk and Culver Street demonstrate meat-bearing bones.

Clearly, the Middleborough deposits are quite different to those excavated elsewhere in Colchester and seem to be suggestive of some sort of craft or industrial activity. The most likely explanation is that Middleborough had a tanning industry in its locality. Until the middle of the 19th century, skins were brought to tanneries with horns and foot bones still attached (Thomson 1981, 162). Perhaps the Middleborough foot bones (metapodials) reflect this enterprise; the hides of cattle would have been treated by tanners and those of sheep/goat by tawyers. The location of tanneries at Middleborough would have been sensible since the River Colne is situated nearby. Documentary evidence reveals Colchester's main industrial specialisation in the medieval period was the preparation of skins by tanning and tawing (Britnell 1986, 14).

The identification of meal debris in urban deposits is generally hampered by a lack of *in situ* deposits; most of the material that has been analysed emanates from secondary and tertiary deposits which, more often than not, constitute an assortment of activities. However, data from Lion Walk shows very clearly that we are dealing with meal debris. Certain pits dated to the 15th/16th centuries contained much higher percentages of bird (mainly fowl) fragments than others, for example AF15, AF16, and CF65. In real terms, fowl would have contributed very little meat; however the bones show interesting gnawing marks which could only have been caused by a small carnivore, the cat. Whole carcasses were present in AF16 and CF65 and many bones had only been lightly gnawed, that is puncture marks were noted with no bones having been channelled or grooved. This suggests that the meal debris had been quickly rescued from these animals and buried. Butchery marks on the bones, in the form of knife-cuts, occurred in dismemberment operations.

3.9 **Cattle butchery**

There are two major limitations which dictate the methods used in butchery. Firstly, there is the limitation imposed by the animal's anatomy, size, bone structure, muscle arrangement, and tendon and ligament insertions. The second limitation is that of the tools used in butchery. Modern butchers use electric saws, knives, and choppers. Historical butchers had, with the exception of the electric saw, analogous tools. These differed mainly in their sharpness and durability. The chopper was a common tool on urban sites. Much force is applied in utilising choppers as compared with knives and saws, hence blade-sharpness is not of such paramount importance. Saws need to be very sharp to cut through bone and since production of such good-quality tools would have been expensive and time consuming their use was limited mainly to bone working.

With the aid of similar tools it is proposed that many butchery methods would be constant throughout time. A change in butchery methods could be due to taste and/or local custom, but for the major processes of slaughter and meat removal, the techniques used would be similar. However, before we embark on any major discussion, the expected variation in butchery marks must be considered. In urban areas where butchers' guilds and shops had been introduced, a high level of craftsmanship would have resulted in a distinct patterning of repeated cuts and chops on the skeleton. In more rural areas or larger houses, slaughter and butchery would have been carried out with perhaps less skill and hence a less recognisable pattern of cut- and chop-marks would occur.

This discussion will start with a general description of butchery including slaughter, primary butchery, secondary butchery, tertiary butchery and utilisation of bone for marrow and fat extraction. This will cover the entire history of Colchester and will be followed by an analysis of the specific differences between the Roman, late medieval, and early modern periods.

The first stages of butchery are slaughter and dressing. The cow would have been stunned in order to immobilise the animal whilst bleeding of the carcass was carried out. The modern method of stunning involves the use of a reusable captive bolt fired through the beast's forehead. Prior to this cattle were pole-axed with various implements. Bleeding was not necessarily practised if the carcass was to be used immediately. In a normal healthy animal the blood is in the major arteries and veins and not in the muscles. However blood is normally removed as it rapidly begins to break down after death and produces an unpleasant smell. The next procedure, more often than not, involves hide removal. Such activity can be indicated by circumferential knife-cuts on the proximal part of the metapodials. The carcass may or may not have been hung for further butchery; evidence for hung carcasses normally involves the sagittal splitting of vertebrae. In older animals with little fat it is reasonable to remove the meat at the slaughter site and, unless jointing occurs, there is no need to split the carcass. Where removal of meat occurs without jointing, the butcher is left with an intact vertebral column. This is then chopped up for use, vertebrae and sternebrae being rich sources of marrow. The earliest split vertebrae were found in the 14th- to 16th-century deposits.

The next section is a detailed account of skeletal-element butchery marks encountered at Colchester.

Skull and jaw

These remains indicate that both horning and skinning took place. The cheek meat was utilised from the zygomatic area of the skull and the medial and lateral aspects of the jaw.

Table 3.15 Relative percentage bone-fragment counts of medieval/post-medieval cattle skeletal elements. [Page 51]

Site	Date	J	H	T	S	P	MC	R	MT	AS	F	AP
COC2	MED	-	8	23	17	6	15	2	12	12	-	6
CUL8	MED	6	12	21	5	6	13	4	20	8	3	3
LWC3	C15th-17th	17	11	11	13	8	6	11	8	2	9	3
LWC4	C17th-18th	9	14	9	8	10	10	7	17	3	8	4
MID2	MED	4	5	4	5	-	40	1	28	2	1	11
MID3	PMED	9	8	9	8	7	22	3	21	2	4	7
MID4	C16th	3	3	2	5	3	21	5	40	3	-	16

Key:
J...mandible; H...distal humerus; T...distal tibia; S...scapula; P...pelvis; MC...distal metacarpal; R...distal radius; MT...distal metatarsal; AS...astragalus; F...distal femur; AP...first phalanx.

Vertebrae

Butchery marks are common on the atlas and axis, usually in a dorso-ventral direction which was associated in later phases with splitting of the carcass. Other vertebral butchery shows evidence of rib removal and the extraction of meat from the thoracic vertebral spines and lumbar transverse processes. The ribs were extensively butchered into segments of varying lengths.

Fore limb

Removal of the various elements of the fore limb is difficult to place in order. Firstly, the metacarpals and toe-bones would have been removed during skinning. Then the entire limb may have been removed by chopping down behind the scapula or, as is known to have occurred in later phases, the limb was jointed and removed from the body in segments. Meat removal via filleting would have occurred later, followed by the chopping up of the bone for marrow and fat extraction. Alternatively, filleting could have been done with the limb still attached to the main carcass although the reduced accessibility to the meat makes this highly unlikely. Butchery marks on the scapula are commonly the result of filleting, and the spinous process is either chopped into distally, or entirely removed during this operation.

Due to its fragility, the proximal humerus is rarely found on archaeological sites. Hence butchery occurring at the humerus/scapula joint is hard to describe. The few cuts and chop marks recorded on surviving elements indicate possible disarticulation, for example chopping through the distal scapula and proximal humerus to release the infraspinatus tendon. Other marks occurring on the humerus/scapula joint surface point to evidence of chopping up of epiphyses for use in broth production.

Distal butchery-marks on the humerus suggest the severing of the medial and lateral tendons of the elbow joint. Other chop-marks pass through the distal condyle into the ulna and may have been involved in breaking up the articulation after filleting, rather than disarticulation.

Hind limb

As with the fore limb, the order of limb removal, jointing and filleting is difficult to describe from the butchery marks. The pelvis was separated at the pubis by the use of a chopper. This suggests butchery of an older animal with a fused pubis, as in younger animals the unfused bone can be separated with a knife (Wood & Newman 1928). Chopping through the pelvic acetabulum and the femoral head released the hind limb; such separation can be done with a thin-bladed knife but is much easier with a chopper. Evidence for separation of the femur and tibia is limited to knife-cuts on the proximal tibia and chop marks through the distal femoral condyles.

Filleting either before or after disarticulation leaves distinctive superficial marks, very similar to those described by Binford (1981). These are concentrated on the leg bones and are a product of pulling away the muscle mass by cutting along the bone in order to free it. These marks appear as short cut-marks, generally at an oblique angle, and tend to be concentrated on the anterior and posterior aspects of the limbs in areas of muscle insertion and where the bone is irregular in shape. They therefore occur around fossae, as in the supraglenoid cavity of the femur, or around indentations as on the humerus.

In general, butchery for the later phases (14th to 16th centuries and 17th to 18th centuries) is similar in that there are mainly marks of disarticulation, with little superficial butchery associated with filleting. However, in the Roman phases the majority of the butchery marks are from filleting. This is particularly noticeable with reference to the scapula. Filleting marks on the scapula are easily seen as the musculature associated with this bone is easier to remove with the

Table 3.16 Relative percentage bone-fragment counts of medieval/post-medieval sheep/goat skeletal elements. [Page 51]

Site	Date	J	H	T	S	P	MC	R	MT	AS	F	AP
COC3	PMED	9	18	11	24	7	7	9	9	-	7	-
CUL8	MED	11	16	14	11	10	12	11	10	1	4	1
LWC3	C15th-17th	13	13	15	15	11	2	15	5	1	9	1
LWC4	C17th-18th	14	9	14	10	9	8	10	13	1	11	1
MID2	MED	15	9	16	9	4	16	6	14	-	3	8
MID3	PMED	16	6	16	9	4	16	6	14	-	3	8
MID4	C16th	47	2	16	7	9	4	11	16	-	4	-

Key:
J...mandible; H...distal humerus; T...distal tibia; S...scapula; P...pelvis; MC...distal metacarpal; R...distal radius; MT...distal metatarsal; AS...astragalus; F...distal femur; AP... first phalanx.

periosteum attached. Without the protective periosteum, chop- and cut-marks are more likely to score the bone. On Roman scapulae, filleting marks are very common, consisting of long, repeated knife-cuts running longitudinally down the medial blade and also the lateral spine. Also present are small scoop marks, where filleting has resulted in tiny slivers of bone being removed along with the muscle. This profusion of marks is not seen on scapulae of later phases where butchery is limited to the more usual disarticulation of the joint. The abundance of filleting marks during the Roman phases as opposed to later phases is also noticeable on the long bones. Scoop-marks are present on humeri, radii and tibiae. Other differences between Roman and post-14th-century deposits include a lower number of chops through the mid-shaft, and evidence of cubing of epiphyses and astragali which is not seen in later phases.

Another major difference through time, besides the abundance of filleting marks, lies in the treatment of the vertebrae. The Romans chopped laterally down the cervical vertebrae in order to remove meat from the neck, and also through the rib articulations of the thoracic vertebrae in order to remove the ribs. Butchery of the lumbar vertebrae is concentrated on the transverse processes and articular surfaces. All three types of vertebrae are split medially in the later deposits. In the 16th to 18th centuries there is more diversification; as well as medial splitting, the cervical vertebrae are split transversely and there are cuts on the spine and rib articulations of the thoracic vertebrae. In all phases transverse chops through the lumbar vertebrae are common.

As discussed earlier (p 52), medial halving of the carcass is a relatively late development in butchery techniques, first appearing in the 14th to 16th centuries. By the late 17th century it had become a very precise and much more common process (indicated by the number of identical cuts on different vertebrae). Earlier deposits contain vertebrae which have been chopped through but not split into two identical halves.

3.10 Summary

An attempt has been made in this chapter at describing the fragmentation of bone at Colchester. It is appreciated that this is only a rudimentary approach but the method does highlight differences between assemblages, which may be due to recovery procedures and/or post-depositional processes. We emphasise the need to understand the relative fragmentation between the individual taxa of an assemblage, before comparisons are made with other assemblages.

Although we cannot accurately quantify the exact species changes through time, we can identify general trends and also differences in species exploitation between sites. One major finding is the distinct lack of cattle meat-bearing bone both within the Roman fortress and town. Much more meat-bearing bone occurs outside the town walls, at Balkerne Lane, and it is suggested that part of this settlement acted as a general dump for processed cattle carcasses in the earlier part of the Roman period. It seems likely that this refuse would have resulted from an organised butchery trade. If the bone had accumulated from individual householders' intramural rubbish, one would have expected a similar patterning of sheep/goat and pig skeletal elements to those of cattle. This is clearly not the case.

4: THE ECONOMIC EXPLOITATION OF DOMESTIC LIVESTOCK

4.1 **Introduction**

The economic exploitation of any domestic stock depends on a number of interacting factors, some of which can be of a highly unpredictable nature. Early herding strategies would have been devised to seek a balance between these factors so that the survival of the herd and thus the farmer's livelihood were ensured. A good system of farm management would have made use of natural and economic advantages and thus given due consideration to the nature of the soil, type of climate, water supply (soft/hard; the latter having an increased mineral content), efficiency of the labour supply and possibly market prospects. The market demand of an urban population is subject to changing taxation and problems of inflation, not to mention periodic disruptions due to warfare. Short-term fluctuations in climate can also lead to disastrous consequences, for example, the Little Ice Age of the Middle Ages.

Perhaps the most unpredictable variable that ancient people had to cope with was that of disease, both for humans and livestock. Manpower could have been seriously depleted in the recorded epidemics of the 3rd and 4th centuries, and these are only the ones we know about (Wacher 1974, 414-15). It is self-evident from contemporary written sources that the success of Roman agricultural enterprises in Italy depended on large labour forces. Consequently, any reduction in the human population would have had serious implications for agricultural economics in general, particularly if long-distance trade was involved. Further, an emphasis on a milking rather than a meat routine would require substantial additional labour and this point is all too easily forgotten in discussing Roman and medieval husbandry techniques.

The well-known diseases in farm stock are generally species specific, and it is evident that early farmers did not practise a sole livestock specialisation but raised cattle, sheep, goats, and pigs together, each species acting as an insurance on the other, thereby promoting herd security (Section 4.3). It is as yet unknown whether, in the early historical period, pigs were reared by individual householders or specialised herders.

4.2 **Cattle exploitation**

'When animals are raised purely for meat, it is economic to slaughter when relatively young. That is the same amount of fodder (33,000 kg of hay-equivalent) would raise seven calves to 2 years as would be needed to take three of them to 3.5 years — the former strategy yields 40 per cent more meat' (Sherratt 1981, 283-4).

4.2.1 Cattle tooth eruption and wear

[Figs 4.1-4.10]

The Colchester cattle mandibles were split into age groups based on the eruption and wear of the dP4, P4 and M1 to M3, as shown in Figures 4.1-4.2. The third permanent molars were then subdivided into stages based on the wear stages illustrated by Grant (1975 & 1982; Fig 4.3). Modern ageing data (after Silver 1969) were used as an approximate guide to age at slaughter.

The differences in profile between Figures 4.1-4.2, which describe the compiled data for the whole Roman period at Balkerne Lane, are caused by inclusions of loose teeth, particularly third molars, in the latter figure. Maltby has drawn our attention to two commonly-made assumptions in the analysis of jaw bones: a) that the sample is representative of the site with respect to the original deposition of the bones, and b) that the sample is representative of the kill-off patterns of the herds that were farmed by the inhabitants of the area (Maltby 1982a).

In order to combat his first point, we have included loose teeth for analysis, and checked the archaeological contexts for preservational biases. Further, we decided to look for changes in exploitation within a broad chronological framework, using large samples, thus obviating problems of short-term fluctuations in urban supply. Additionally, the tooth-eruption data were compared with the epiphysial fusion evidence, albeit in a tentative fashion, in order to emphasise any real differences between sites and/or periods, and also to highlight any preservational biases. While it is evident that we are dealing with cattle that have been slaughtered, butchered and consumed within Colchester, we should be aware, in the light of Chapter 1, that, just as we cannot prove that the inhabitants were farming the beasts, we equally cannot dismiss the idea that they could have been involved in some pastoral husbandry.

It is evident that at Balkerne Lane most of the slaughtered beasts were mature animals of 3 years upwards, with a few beasts in the 15-36 month age span; however, no calves were identified (Fig 4.2). There is a slight increase in the proportion of older animals in the later Roman period at Balkerne Lane, that is from AD 125 onwards, as opposed to the earlier period of AD 44-125 (Fig 4.3).

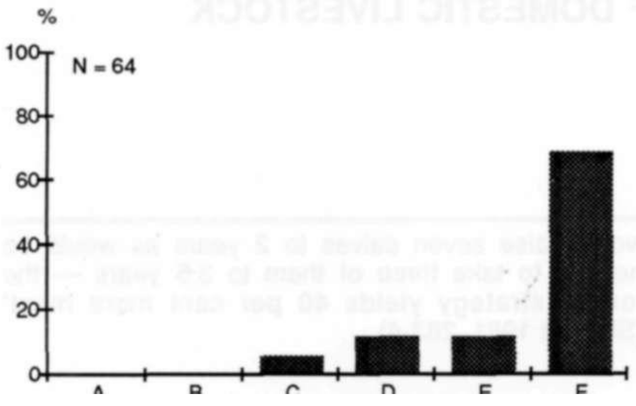


Fig 4.1 Bar chart: age profile of Roman cattle mandibles from Balkerne Lane (not including loose M3s). [Page 55]

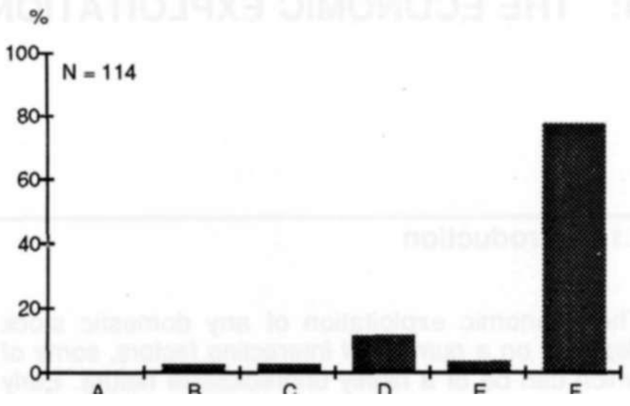


Fig 4.4 Bar chart: age profile of Roman cattle mandibles from the intramural sites. [Page 57]

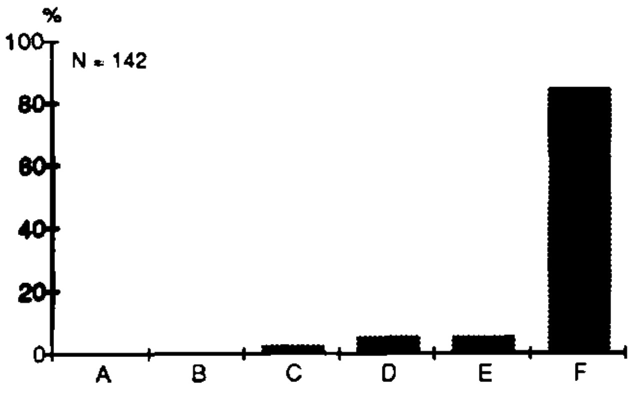


Fig 4.2 Bar chart: age profile of Roman cattle mandibles from Balkerne Lane (including loose M3s). [Page 55]

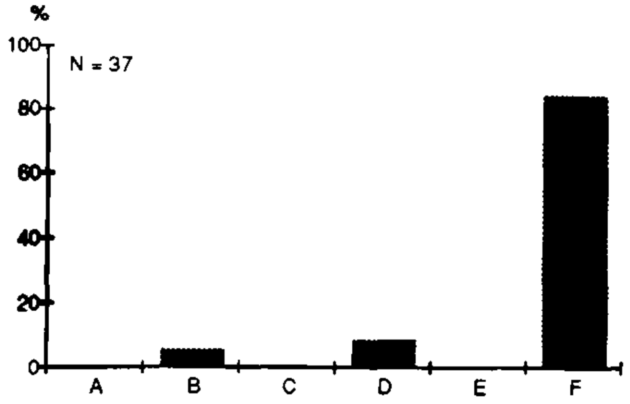


Fig 4.5 Bar chart: age profile of Roman cattle mandibles from the intramural sites, AD 44-110. [Page 57]

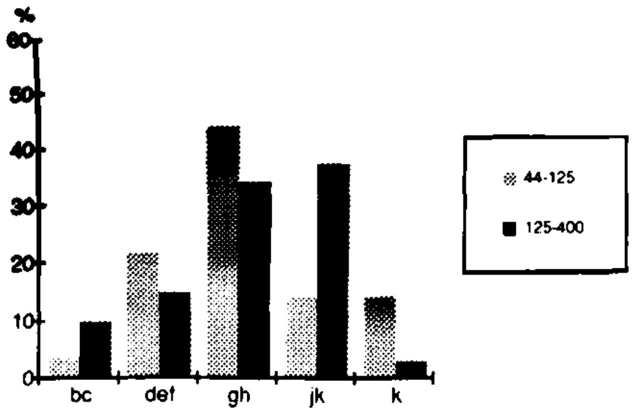


Fig 4.3 Bar chart: cattle third-molar wear stages (after Grant 1975; 1982), Roman Balkerne Lane. [Page 55]

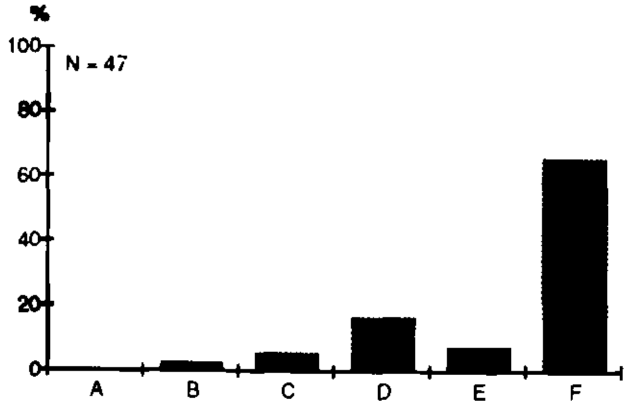


Fig 4.6 Bar chart: age profile of Roman cattle mandibles from the intramural sites, AD 60/1-300. [Page 57]

Key:

A	*dP4 unworn*	
B	*dP4 worn, Ml erupting/unworn*	*— 5 to 6 months*
C	*M1 worn, M2 erupting/unworn*	*— 75 to 18 months*
D	*M2 worn, M3 erupting/unworn*	*— 24 to 30 months*
E	*M3 worn, P4 erupting/unworn*	*— 28 to 36 months*
F	*M3 worn*	*— 3 years plus*

(after Silver 1969)

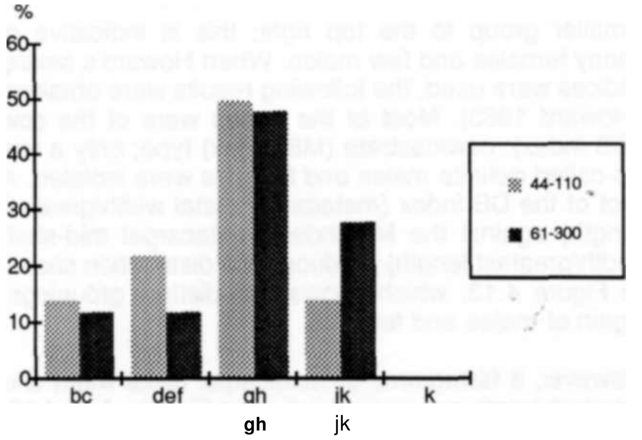


Fig 4.7 Bar chart: cattle third-molar wear stages (after Grant 1975 & 1982), Roman intramural sites.

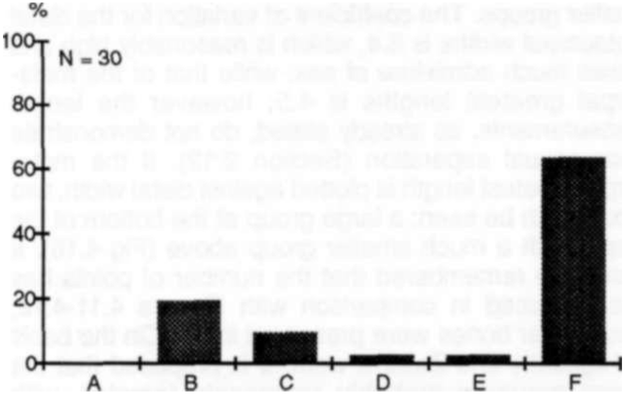


Fig 4.8 Bar chart: age profile of medieval cattle mandibles.

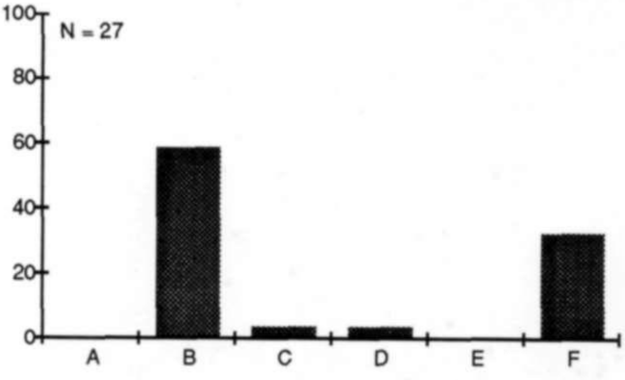


Fig 4.9 Bar chan: age profile of post-medieval cattle mandibles.

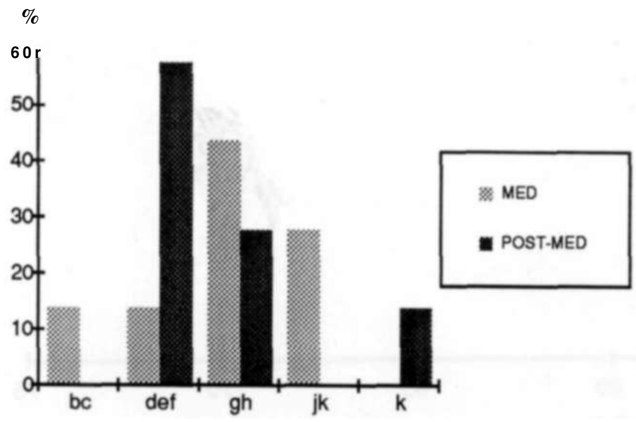


Fig 4.10 Bar chart: cattle third-molar wear stages (after Grant 1975 & 1982), medieval and post-medieval. [Page 58]

The inhabitants of Balkerne Lane, an extramural site, endured a lower standard of living than members of the populace within the walls, as reflected by their dwellings. Figure 4.4 illustrates the cattle age profile for the total Roman period from sites within the walls (intramural sites). While the bulk of the beasts were killed-off at three years old or more (the proportion has slightly decreased from 86 per cent extramurally to 78 per cent intramurally), there is a slight but definite increase in the proportion of cattle in the 24- to 30-month age bracket, and also a few calves, 5 to 6 months old, occur.

If the intra-wall sample is separated into different Roman periods, the largest samples pertain to AD 44-110 and 60/1-300 (Figs 4.5-4.6). The later Roman sample shows a reduction in the percentage of mature cattle at stage f, from 84 per cent to 66 per cent with a concomitant increase in cattle at stage d (24 to 30 months old) and to a lesser extent c (15 to 18 months old) and e (28 to 36 months old). The third-molar wear stages are similar in Figure 4.7, with the emphasis being on the longer-held wear stages gh; however, the later sample shows slightly more animals with wear stages jk.

Earlier research has demonstrated that the pre-colonial inhabitants of Colchester's Balkerne Lane Site E mainly ate mature beef, that is animals slaughtered at 3 to 4 years of age, and some younger beasts, killed at 18 months to 3 years old (Luff 1982, fig 3:3). This age profile was constructed using Grant (1975a) and bears a distinct similarity to the one generated for the early intramural sites. Since parts of Balkerne Lane were used as a primary butchery dump (Section 3.7.2), it is suggested that perhaps these jaw bones emanated from beasts that had been consumed on sites inside the fortress.

Thus, in summary, at all times in the Roman period older beasts of three years old or more dominated the samples. However, the intramural sites of the later Roman period indicate that in addition to the older animals, younger cattle were also consumed, that is animals that had reached their optimum body weight. As Sherratt has pointed out *(see* opening remark of this section), this would resemble a more meat-based economy (Sherratt 1981). Conversely, the extramural sites at Balkerne Lane show more of an emphasis on the slaughter of older animals, as evidenced by wear on the third molar. Thus this poses the question, what were the older more mature cattle being kept for? Before attempting sexing in Section 4.2.2, let us consider the tooth age profiles of the medieval and post-medieval cattle.

The medieval and post-medieval ageing profiles show a progressive reduction in the number of mature cattle with an increase in young beasts at stage B (aged approximately 5 to 6 months old; Figs 4.8-4.9). Indeed, in the post-medieval period, calves of this age dominate the sample. The medieval samples primarily emanated from Culver Street Site E and Middleborough, and the post-medieval samples pertained solely to Middleborough.

The post-medieval kill-off pattern appears indicative of a milking economy, where the calves were fattened and sold as veal at market. If one compares the M3 wear stages between the medieval and post-medieval samples, the latter show a much higher percentage in early stages of wear and are perhaps indicative of prime beef for consumption (see Fig 4.10 above).

Documentary evidence states that the majority of Essex farmers of the Stuart age did not own many cows. Over 60 per cent possessed only 1 to 3 and nearly 21 per cent only 4 to 6 animals (Fussell 1966, 4). However, in later times, as Fussell writes: 'Selling calves for veal was, of course, no new thing, Essex farmers had done this in the 17th century, and probably earlier. Thomas Fuller had declared they produced calves of the fattest, finest and fairest veal in England. He modestly added consequently in all Europe. William Ellis praised the Essex men no less. They were allowed to be the richest and best calf-sucklers of all in the early and mid 18th century' *(ibid,* 63).

4.2.2 Cattle sexing

[Figs 4.11-4.18]

Sexing methods (Section 2.12) were applied to the Roman metacarpals. Figure 4.11 and to a lesser extent Figure 4.12 demonstrate a separation into one huge group at the lower left of the graph and a much smaller group to the top right; this is indicative of many females and few males. When Howard's sexing indices were used, the following results were obtained (Howard 1963). Most of the bones were of the cow (DB index): cow/castrate (MB index) type; only a few so-called definite males and females were isolated. A plot of the DB index (metacarpal distal width/greatest length) against the MB index (metacarpal mid-shaft width/greatest length) produced the distribution shown in Figure 4.13, which shows two distinct groupings, again of males and females.

However, if histograms of metacarpal distal width and greatest length are considered, as in Figures 4.14-4.15, a trimodality is apparent, with a clear separation of much larger animals and a partial merging of two smaller groups. The coefficient of variation for the distal metacarpal widths is 8.4, which is reasonably high and shows much admixture of sex, while that of the metacarpal greatest lengths is 4.5; however the length measurements, as already stated, do not demonstrate clear sexual separation (Section 2.12). If the metacarpal greatest length is plotted against distal width, two groups can be seen; a large group at the bottom of the graph, with a much smaller group above (Fig 4.16). It should be remembered that the number of points has been reduced in comparison with Figures 4.11-4.12, since fewer bones were preserved intact. On the basis of Higham's and Zalkin's work, it is proposed that the larger grouping probably represents females, with castrates separating out above this, and bulls to the top right (Higham 1969; Zalkin 1960).

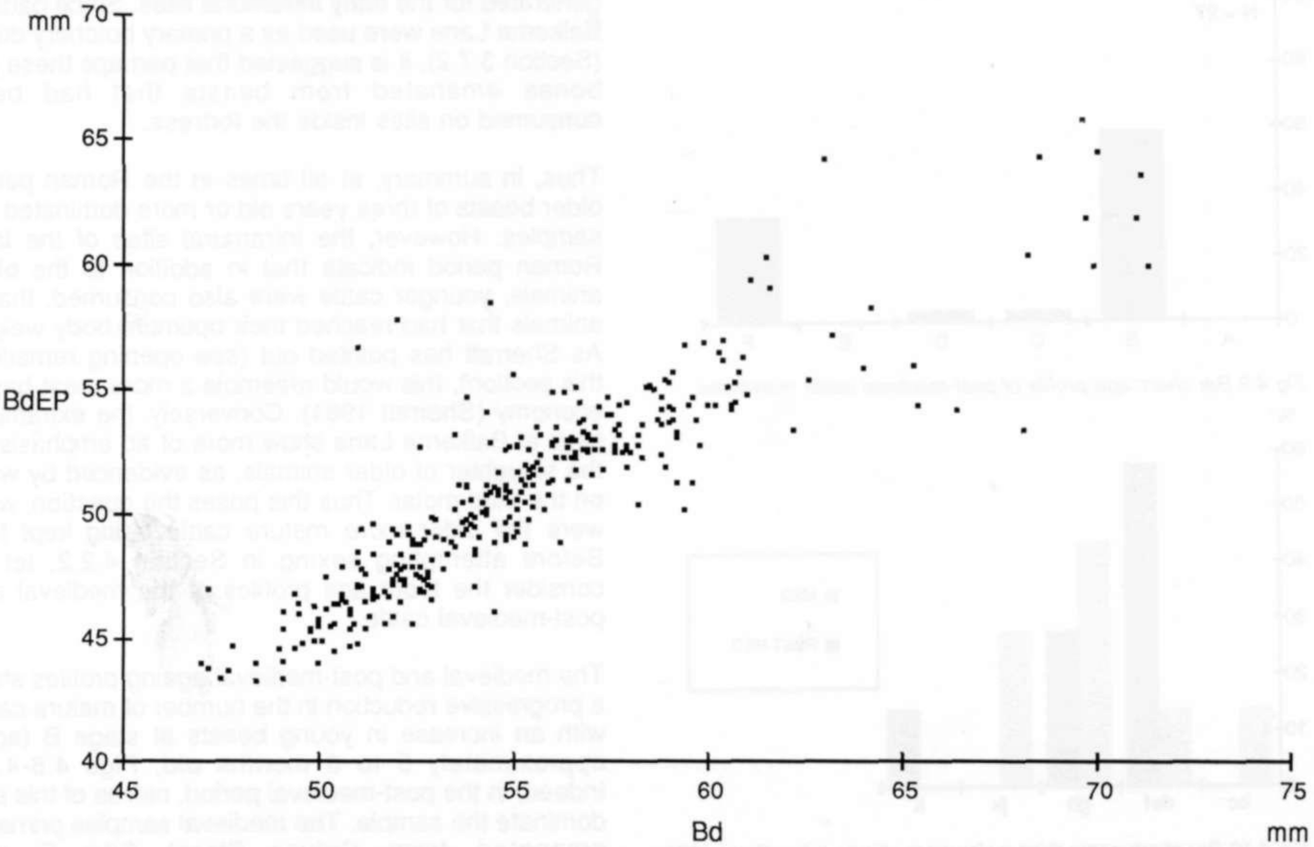


Fig 4.11 Scattergram: Roman cattle metacarpal distal width (Bd) against distal epiphysial width (BdEP).

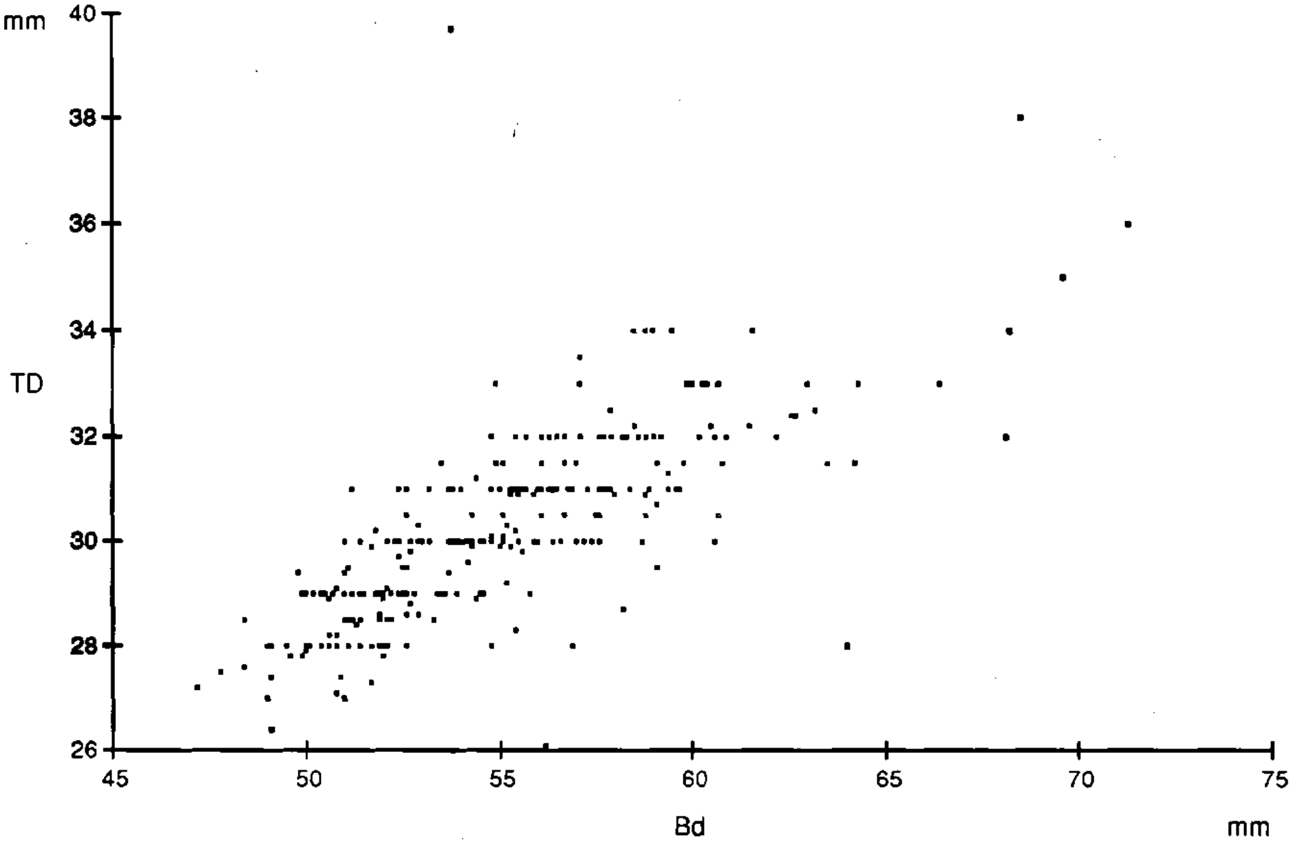


Fig 4.12 Scattergram: Roman cattle metacarpal distal width (Bd) against distal thickness (TD). [Page 58]

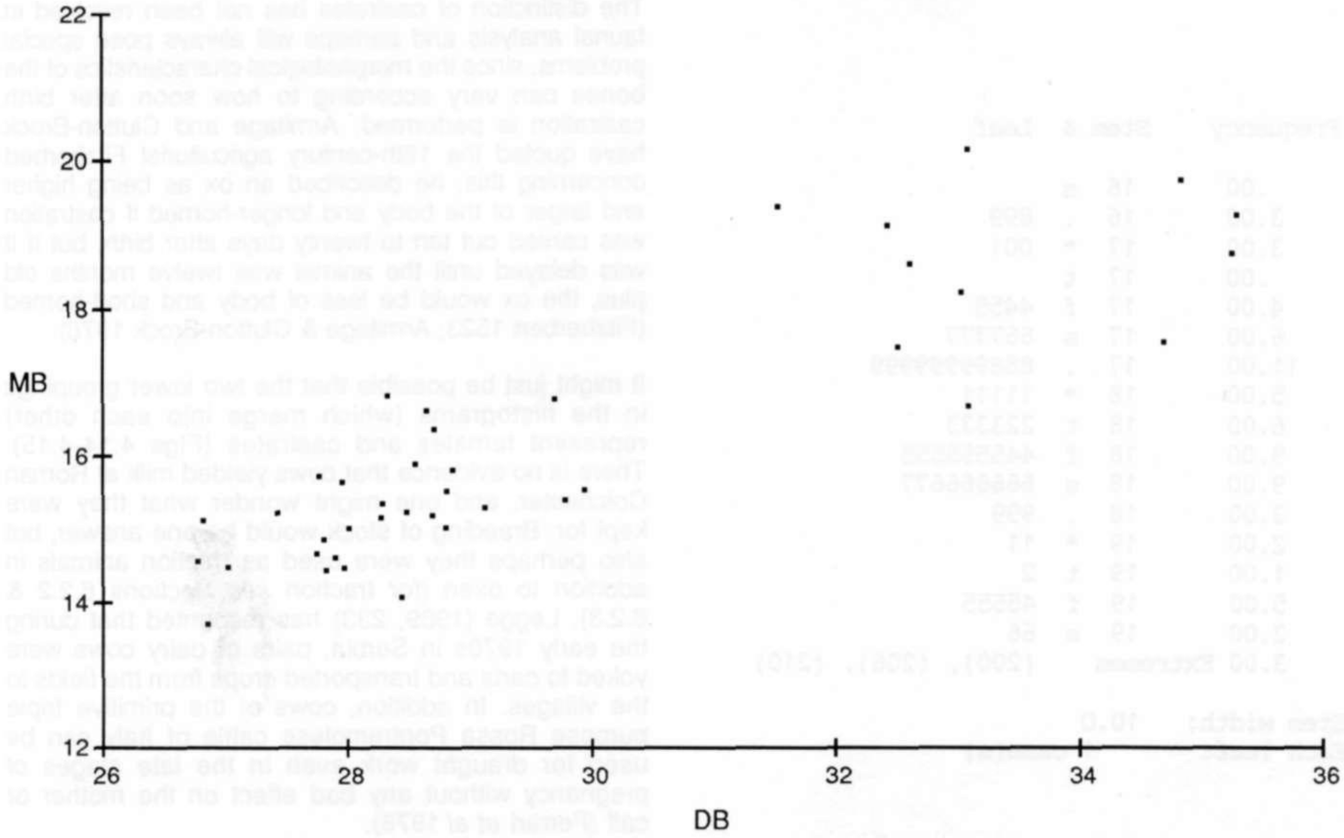


Fig 4.13 Scattergram: Roman cattle DB (distal width/greatest length) index against MB (mid-shaft width/greatest length) index (after Howard 1963). [Page 58]

```
Frequency    Stem &  Leaf

    2.00 Extremes    (42.8)
    9.00        47  .  027&
    3.00        48  .  4
   31.00        49  .  00111114458899&
   35.00        50  .  000022444566788&
   54.00        51  .  0000011223444447788899999&
   61 .00       52  .  000111222344455666677888888899
   27.00        53  .  02345578889&
   43.00        54  .  00023334555688889 9&
   36.00        55  .  011122334455679&
   35.00        56  .  001134456677899&
   26.00        57  .  0113466799&
   22.00        58  .  22356889&
   18.00        59  .  01246&&
   15.00        60  .  046789&
    9.00        61  .  015&
    5.00        62  .  6&
    3.00        63  .  &
    3.00        64  .  &
   11.00 Extremes    (65.3), (65.4), (66.4), (68.1), (68.2), (68.5)
    6.00 Extremes    (69.6), (69.7), (69.9), (70.0), (71.0), (71.1)
    1.00 Extremes    (71.3), (74.0)

Stem width:   1.0
Each leaf:       2 case(s)

& denotes fractional leaves.
```

Fig 4.14 Stem-and-leaf histogram: Roman cattle metacarpal distal width (Bd). [Pages 58-60]

```
Frequency    Stem &  Leaf

     .00        16 s
    3.00        16    899
    3.00        17 *  001
     .00        17 t
    4.00        17 f  4455
    6.00        17 s  667777
   11.00        17    88899999999
    5.00        18 *  11111
    6.00        18 t  223333
    9.00        18 f  445555555
    9.00        18 s  666666677
    3.00        18    999
    2.00        19 *  11
    1.00        19 t  2
    5.00        19 f  45555
    2.00        19 s  66
    3.00 Extremes    (200), (206), (210)

Stem width:    10.0
Each leaf:        1 case(s)
```

Fig 4.15 Stem-and-leaf histogram: Roman cattle metacarpal greatest length (GL). [Pages 58-60]

The distinction of castrates has not been resolved in faunal analysis and perhaps will always pose special problems, since the morphological characteristics of the bones can vary according to how soon after birth castration is performed. Armitage and Clutton-Brock have quoted the 16th-century agriculturist Fitzherbert concerning this; he described an ox as being higher and larger of the body and longer-horned if castration was carried out ten to twenty days after birth, but if it was delayed until the animal was twelve months old plus, the ox would be less of body and short-horned (Fitzherbert 1523; Armitage & Clutton-Brock 1976).

It might just be possible that the two lower groupings in the histograms (which merge into each other) represent females and castrates (Figs 4.14-4.15). There is no evidence that cows yielded milk at Roman Colchester, and one might wonder what they were kept for. Breeding of stock would be one answer, but also perhaps they were used as traction animals in addition to oxen (for traction *see* Sections 6.2.2 & 6.2.3). Legge (1989, 233) has recounted that during the early 1970s in Serbia, pairs of dairy cows were yoked to carts and transported crops from the fields to the villages. In addition, cows of the primitive triple purpose Rossa Pontremolese cattle of Italy can be used for draught work even in the late stages of pregnancy without any bad effect on the mother or calf (Ferrari *et al* 1978).

Bartosiewicz cautions against indiscriminate use of the metapodials for sexing (Bartosiewicz 1984). He points out that the early-fusing metapodials adapt to body-weight increase by the external widening and thickening of the compact bone by bone-remodelling. It can therefore be argued that cattle which experience a similar loading (weight-wise) on the bones, through for example traction, would demonstrate similar-shaped bones. Hence the' very real confusion in distinguishing cows and castrates in a faunal assemblage. In addition to genetic and hormonal reasons, bulls will typically have stronger metapodials due to careful feeding and also management for breeding purposes.

The medieval cattle scattergrams of metacarpal distal width measurements exhibit a different pattern to that of the Roman ones. Figure 4.17 shows metacarpal distal width against distal thickness and demonstrates at least three loose groupings. This would appear, at first sight, to represent females in the lower cluster and males in the other clusters. A plot of the metacarpal DB index against the MB index shows a separation into a male and female group and hints at a possible separation into a third group (Fig 4.18).

If Howard's indices are compared with the Roman ones, then it is quite clear, bearing in mind the limitations of Howard's work, that the medieval DB index is comprised mainly of cows as is the Roman index, while the MB index is comprised of cows/castrates as is the Roman index (Howard 1963). However, not all the bones allowed determination of these indices. Figure 4.17 shows the number of occurrences of the sexed bones via the DB index within the distal width dimensions. The lower cluster of data points is comprised of 21 females and 1 female/castrate, while 6 female/castrates, 1 female/castrate/male and 1 male occurred in the middle group, and 1 male and 1 female/male/castrate appeared in the largest group. The coefficients of variation (V) for the medieval metacarpal greatest length and distal width are 10.1 and 7.4 respectively; therefore the ranges of distribution of the length measurements are much greater than those for the Roman period, and hint at possibly a greater admixture of sex or breeds or animals of differing stature due to varying planes of nutrition. The interpretation of Figures 4.17-4.18 should be approached cautiously. However, it seems likely that, as at Exeter, we are seeing an increase in the number of male animals available for ploughing (Maltby 1979a, 35), and that the clearer separation of the sexes was largely allowed by the fact that cows, in general, were not used for traction and provided more in the way of milk. Hence the conformation of the bones of male and female beasts would differ somewhat in relation to the work that was expected of them.

The few post-medieval measurements available did not demonstrate a clear separation, and Howard's indices were of mainly the cow/castrate type. This perhaps is not surprising since the jaw age profiles show the dominance of a milking routine, and hence one would expect a predominance of mature female cattle in the assemblages.

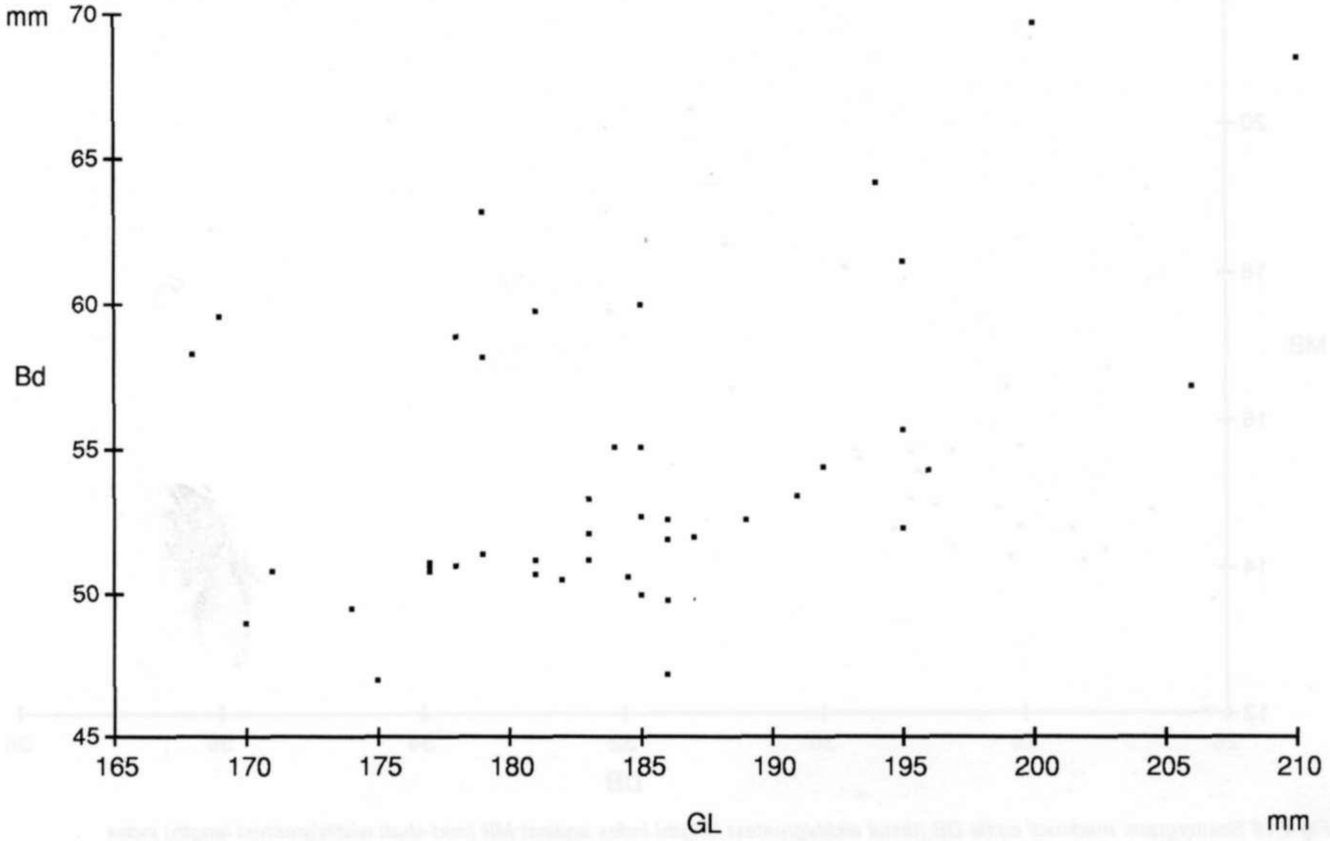


Fig 4.16 Scattergram: Roman cattle metacarpal greatest length (GL) against distal width (Bd). [Page 58]

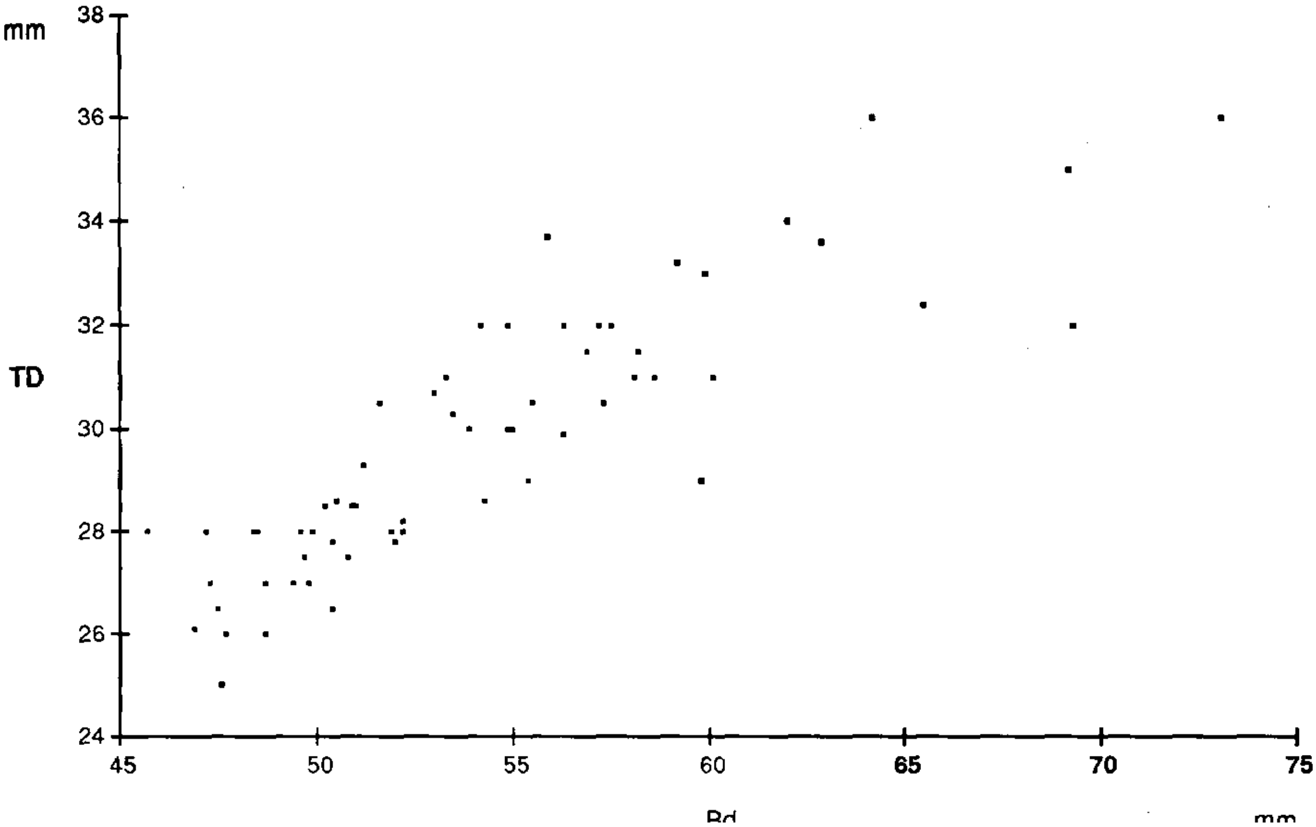


Fig 4.17 Scattergram: medieval cattle metacarpal distal width (Bdj against distal thickness (TD). [Page 61]

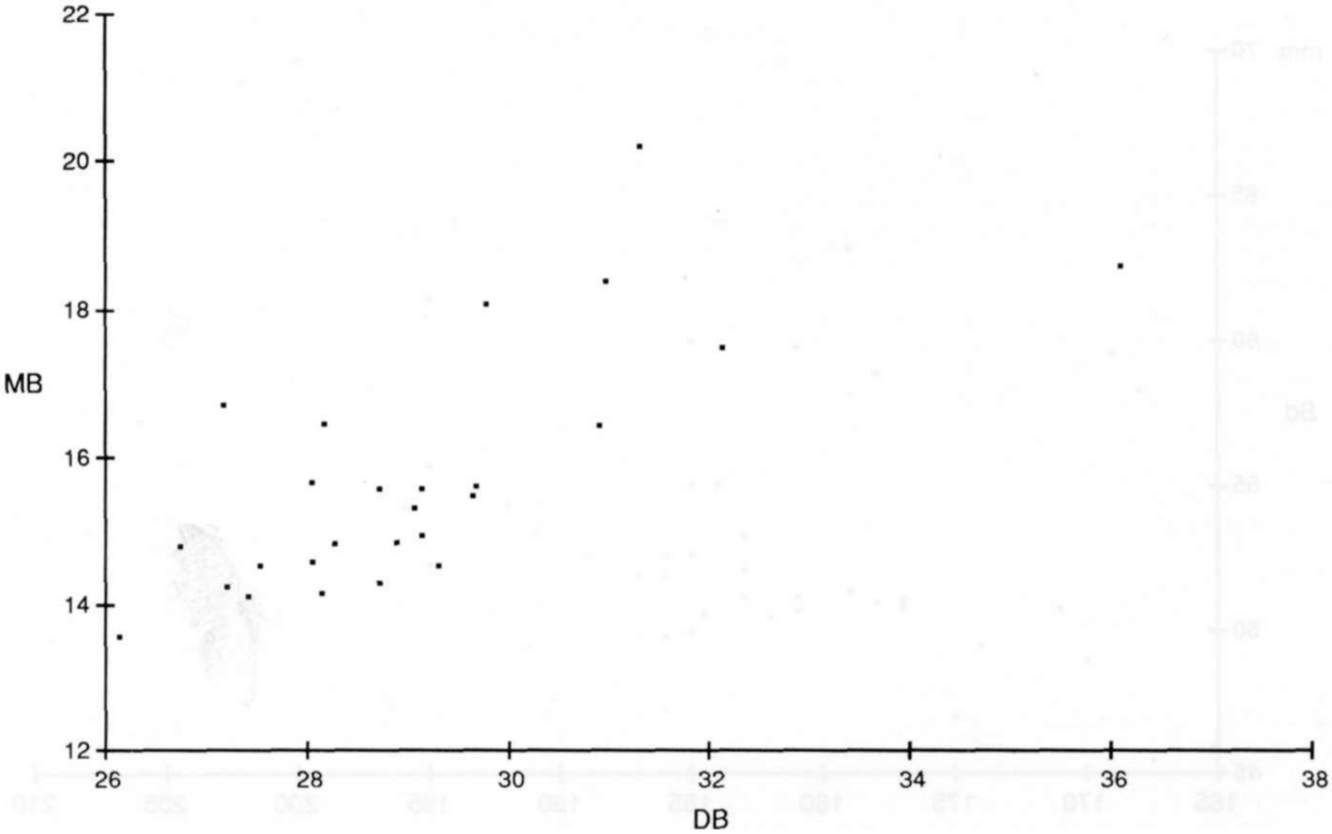


Fig 4.18 Scattergram: medieval cattle DB (distal width/greatest length) index against MB (mid-shaft width/greatest length) index (after Howard 1963). [Page 61]

4.2.3 Cattle long-bone epiphysial fusion data

[Figs 4.19-4.20]

The problems of using epiphysial fusion data as an ageing method have been discussed in Sections 2.5 and 2.6 in Chapter 2. Often faunal samples lack jaw bones and teeth, and one is forced to consider the fusion evidence. This is certainly true of cattle ageing, where, in the Romano-British period, large numbers of intact jaw bones are often absent. In this study, the fusion data provided an invaluable tool in assessing the preservation of the bones in general (taphonomy), and also gave some indication in contrasting sites and/or periods, whether there were differences in the proportion of immature as opposed to mature cattle present. No attempt is made to quantify the ageing data; it is used purely as a way of detecting the presence of young cattle. While caution is urged in any consideration of these results, our confidence in their applicability is strengthened by additional evidence from other facets of faunal analysis, as will be shown in the following description.

Most researchers cope with fusion data by dividing the fused and unfused bones into early-fusing (for example distal scapula and distal humerus), middle-fusing (for example distal tibia and distal metapodials), and late-fusing (distal radius, distal femur, and proximal tibia) groups. The fused bones are totalled, and each fused group expressed as a percentage of the total fused bones; similarly the unfused bones are totalled and each unfused group expressed as a percentage of the total unfused bones. There are obvious problems with this method, as already described in Section 2.6. The fusion order of the bone elements can vary from site to site and also the times of fusion of the later group can be quite variable. In addition, if one only considers the fused bones, then one cannot be sure whether fused humeri belong to animals in the early-fusing, middle-fusing or late-fusing groups. Similarly, unfused elements in the last-fusing group could belong to the middle or earlier groups. For this reason, it was decided that both fused and unfused bones would be totalled, and each fused or unfused group would be expressed as a percentage of the total number of unfused and fused bones. Our groups were arranged as follows, using the modern dates of fusion given by Silver (1969):

Group 1: distal scapula, fuses at 7 to 10 months
Group 2: distal humerus and proximal first phalanx, fuse at 12 to 18 months
Group 3: distal tibia and distal metacarpal, fuse at 2 to 2.5 years
Group 4: distal metatarsal, fuses at 2.75 to 3 years
Group 5: distal femur, distal radius and proximal tibia, fuse at 3.5 to 4 years

In interpreting the Colchester fusion data, two main assumptions are made:

a) Providing that the assemblages are viewed at the site level rather than the contextual level, all types of skeletal elements are represented. This obviates the problem of concentrating on particular dumps of bone that have been excavated from isolated contexts. The aim is to look for broad chronological trends.

b) Any increase in the ratio of unfused to fused elements in a particular fusion group is interpreted as a real event since taphonomical factors would tend to affect the unfused elements more than the fused ones.

If Roman Balkerne Lane, Culver Street, and the Gilberd School are compared, then the profiles from the immatures in Culver Street and Balkerne Lane are very similar; however, the adult profiles vary considerably (Fig 4.19a-c). This is mainly because a large number of scapulae were recovered from the legionary ditch at Balkerne Lane. The Gilberd School unfused profile revealed many more immature animals, particularly with the metapodial elements, while the fused profile tended to follow that of Balkerne Lane. The finding of many more immature beasts at the Gilberd School was potentially of great importance since similar findings emerged with the sheep/goat and pig fusion elements. Further, the Gilberd School site had exhibited additional peculiarities not shown by the other sites, for instance the higher relative abundance of deer bones and much more highly-fragmented long-bone shafts (Sections 3.5 & 3.7.1).

As a control, the Gilberd School was then contrasted and compared with the post-medieval sites at Middleborough. Jawbone and teeth data had already shown Middleborough to be dominated by calves, and it would be natural to suppose that the fusion data would support this. Figure 4.19d does not demonstrate an emphasis on calf slaughter. This is because the assemblage is primarily made up of metapodial elements; however, the recovery of unfused metapodials indicates a similarity to the Gilberd School profile rather than Balkerne Lane or Culver Street, where unfused elements were low in all groups. The medieval site of Middleborough also shows a similar proportion of immature animals in Groups 3 and 4, but in contrast there is a sharp rise in the number of fused metacarpal elements (Fig 4.19f). In contrast to Roman Culver Street, the assemblage from medieval Culver Street exhibits an increase in young animals, but not to the same extent as the medieval material from Middleborough (Fig 4.19b, e & f).

Since the Gilberd School assemblage consisted mainly of 1st-century material, it was compared with those of 1st-century Culver Street and Balkerne Lane (Fig 4.20a-c). Figure 4.20a again exhibits a relatively high incidence of immatures in Group 4 (metatarsal) for the Gilberd School, while Culver Street and Balkerne Lane show low occurrences in this age group (Fig 4.20b-c). In the later Roman samples of AD 60/1-150, Balkerne Lane and Culver Street show low occurrences of immature beasts; the samples are dominated by mature animals (Fig 4.20d-e). There is a slight increase in immature animals in the later samples of AD 150-400+ for both Balkerne Lane and Culver Street (Fig 4.20f-g).

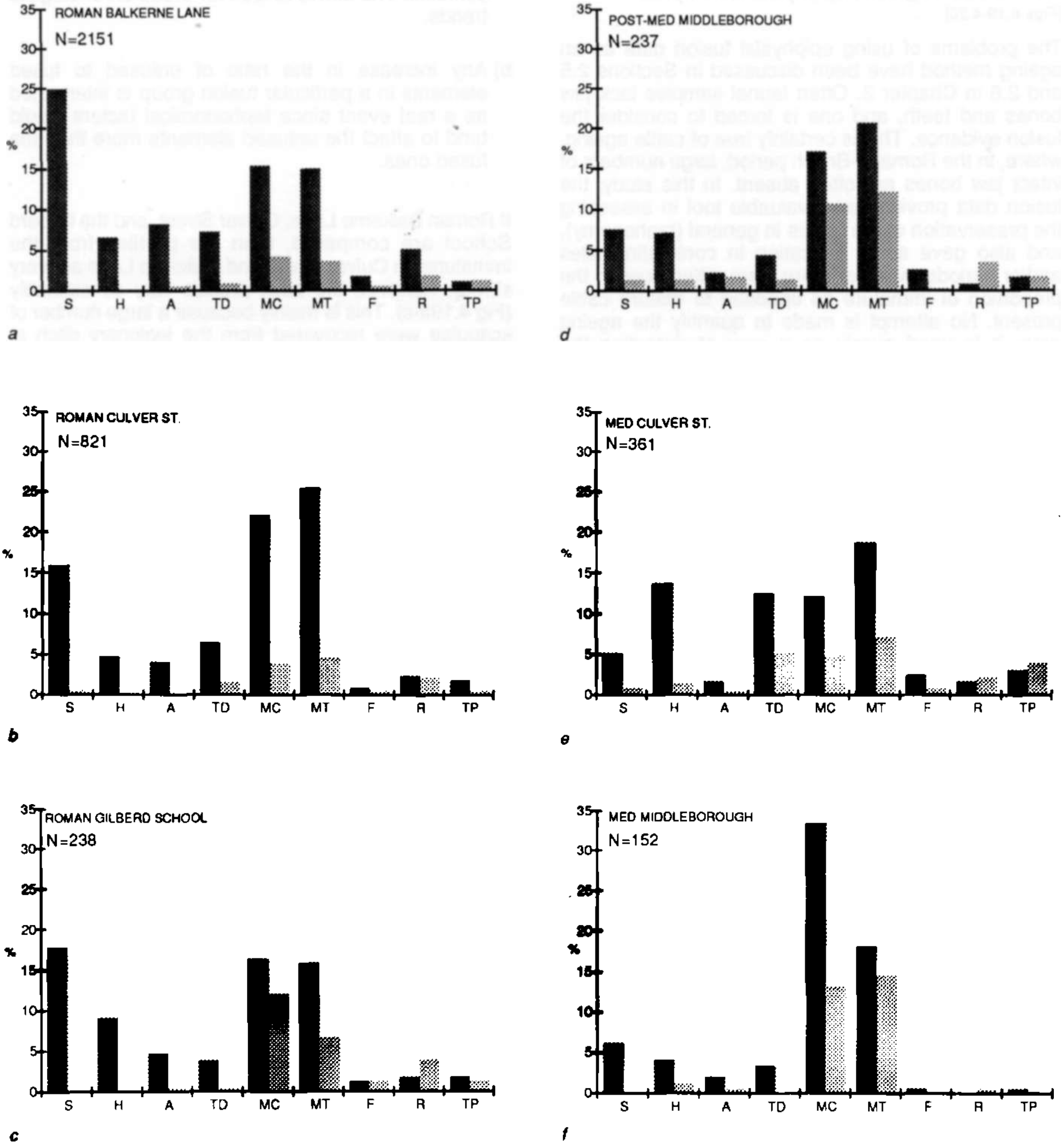


Fig 4.19 Bar charts: relative distribution of fused (dark grey) and unfused (light grey) cattle bones from Roman, medieval and post-medieval Colchester. [Page 63]

Key:
Group 1: d scapula (S) fuses at 7 to 10 months
Group 2: d humerus (H) and p 1st phalanx (A) fuses at 12 to 18 months
Group 3: d tibia (TD) and d metacarpal (MC) fuse at 2 to 2.5 years
Group 4: d metatarsal (MT) fuses at 2.75 to 3 years
Group 5: d femur (F), d radius (R) and p tibia (TP) fuse at 3.5 to 4 years
(after Silver 1969)

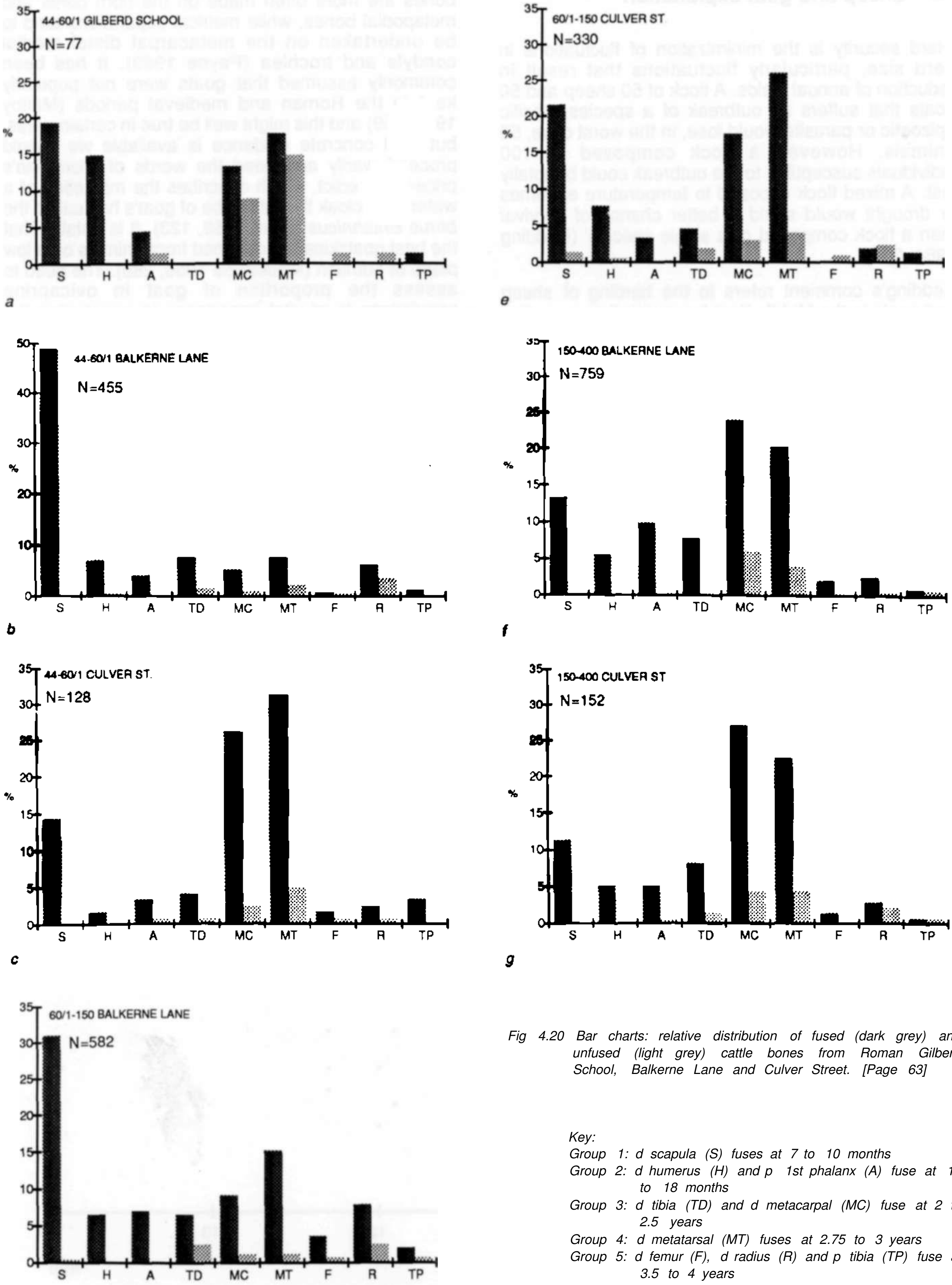


Fig 4.20 Bar charts: relative distribution of fused (dark grey) and unfused (light grey) cattle bones from Roman Gilberd School, Balkerne Lane and Culver Street. [Page 63]

Key:
Group 1: d scapula (S) fuses at 7 to 10 months
Group 2: d humerus (H) and p 1st phalanx (A) fuse at 12 to 18 months
Group 3: d tibia (TD) and d metacarpal (MC) fuse at 2 to 2.5 years
Group 4: d metatarsal (MT) fuses at 2.75 to 3 years
Group 5: d femur (F), d radius (R) and p tibia (TP) fuse at 3.5 to 4 years
(after Silver 1969)

4.3 Sheep and goat exploitation

'Herd security is the minimization of fluctuations in herd size, particularly fluctuations that result in reduction of annual yields. A flock of 50 sheep and 50 goats that suffers an outbreak of a species-specific epizootic or parasite would lose, in the worst case, 50 animals. However, a flock composed of 100 individuals susceptible to the outbreak could be totally lost. A mixed flock exposed to temperature extremes or drought would stand a better chance of survival than a flock composed of a single species' (Redding 1984, 234).

Redding's comment refers to the herding of sheep and goats in the Middle East by pastoralists operating a subsistence economy. His premise, that the goal of subsistence herding in the Middle East was probably not energy extraction (milk/meat) but herd security, is an important one and has a bearing on our interpretations of Roman and medieval husbandry activities.

4.3.1 Differentiation of sheep and goat in the Colchester assemblages

[Figs 4.21-4.24]

The management and feeding requirements of sheep and goats differ considerably, and any exposition of their exploitation must take this into account. Morphological distinctions between sheep and goat bones are more often made on the horn cores and metapodial bones, while metrical separations tend to be undertaken on the metacarpal distal medial condyle and trochlea (Payne 1969). It has been commonly assumed that goats were not popularly kept in the Roman and medieval periods (Maltby 1981, 159) and this might well be true in certain areas, but until concrete evidence is available we should proceed warily and heed the words of Diocletian's price-fixing edict, which describes the marketing of a waterproof cloak thought to be of goat's hair called the *birrus Britannicus* (Rivet 1958, 123). It is notable that the best goatskins are obtained from animals on a low plane of nutrition (Mackenzie 1956, 288). The need to assess the proportion of goat in ovicaprine populations is of vital importance in penetrating the fundamentals of Roman economics.

Only a few adult goats were spotted in the sheep/goat assemblages of the Roman period (Figs 4.21-4.22), but the deciduous dentitions of 204 identified lamb/kid jaw bones pointed to a ratio of 2.3 lambs to 1 kid occurring in the Roman period (after Payne 1985). Payne's method does not distinguish adult sheep and goat mandibles on the basis of the dentition. Figure 4.23 demonstrates that most of the medieval adult sheep/goat sample comprises sheep with just a few goats while the post-medieval sample consists solely of adult sheep (Fig 4.24). Ethnographic research confirms that a few goats are frequently herded with sheep to provide leadership and enable flock control.

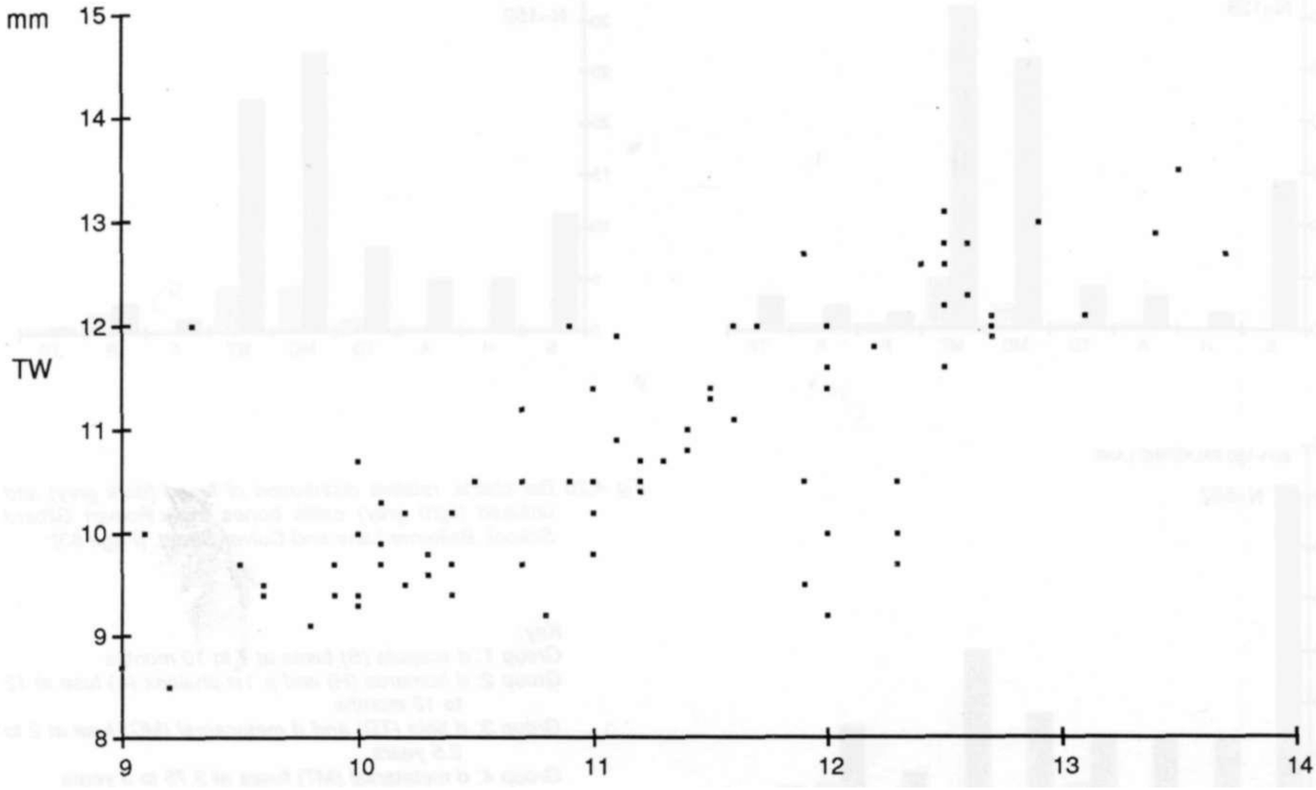


Fig 4.21 Scattergram: Roman sheep/goat metacarpal condyle width (CW) against trochlea width (TW).

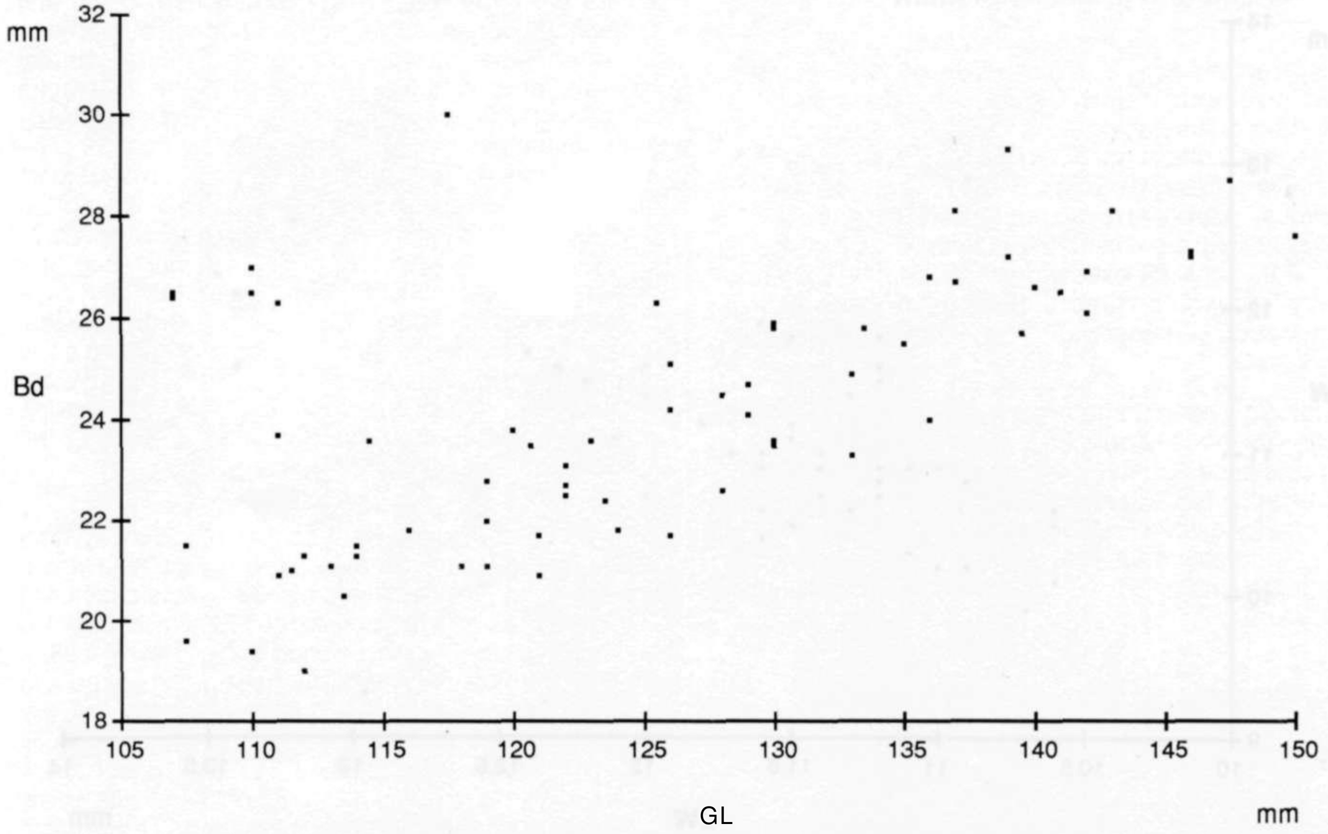


Fig 4.22 Scattergram: Roman sheep/goat metacarpal greatest length (GL) against distal width (Bd). [Page 66]

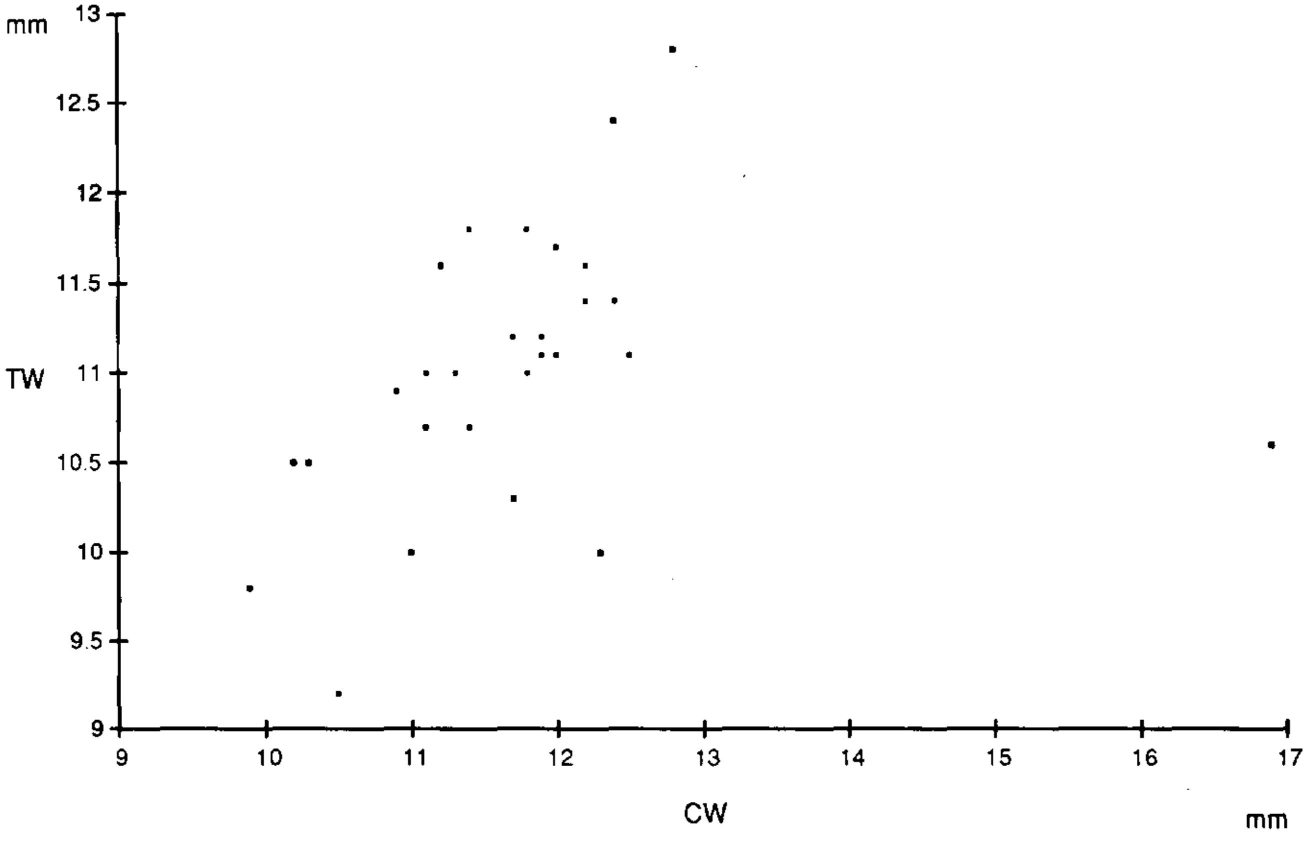


Fig 4.23 Scattergram: medieval sheep/goat metacarpal condyle width (CW) against trochlea width (TW). [Page 66]

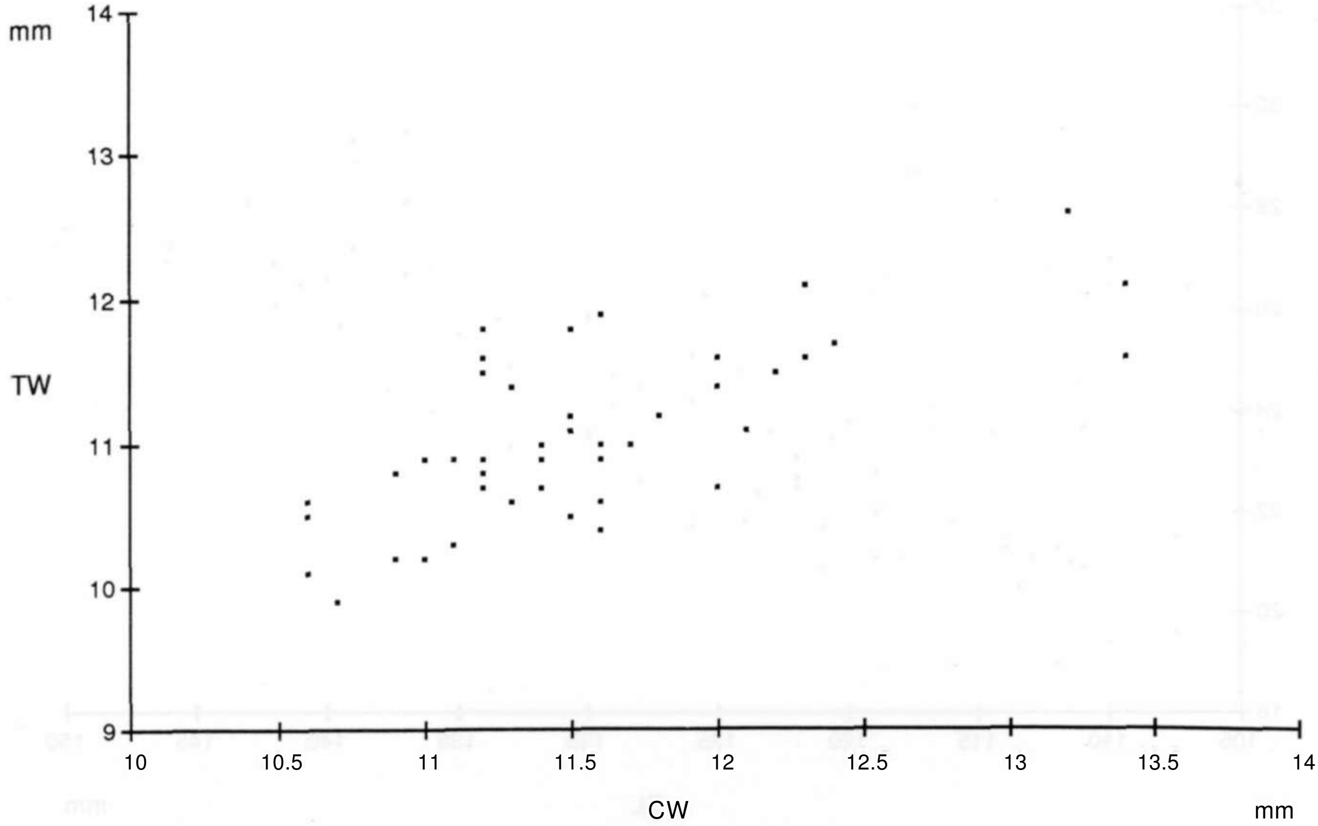


Fig 4.24 Scattergram: post-medieval sheep/goat metacarpal condyle width (CW) against trochlea width (TW). [Page 66]

4.3.2 Sheep/goat sexing

[Figs 4.25-4.27]

No clear-cut methods are available for sexing sheep bones. Zalkin (1961) found that sex differentiation was not marked when he analysed 134 domestic sheep of eleven breeds. The index for the metacarpal mid-shaft width to length is thought to vary with sex (Pfund 1961; Haak 1965). Figures 4.25-4.27 show the varied scatter-plots when the metacarpal greatest length was plotted against the mid-shaft width divided by length. Figure 4.25, for the Roman period, demonstrates a few plots separating out to the top left of the scattergram and these have been interpreted as goats while the rest of the points show no clear separation. Not so many measurements were available for the medieval plots. However, goats can be seen separating out to the top left (Fig 4.26). Figure 4.27, for the post-medieval period, does possibly show some sort of separation into two broad groups. However, the distinction is not clear and perhaps is masked by breed differences.

4.3.3 Sheep/goat tooth eruption and wear

[Figs 4.28-4 32]

Figures 4.28 and 4.29 represent the distribution of sheep/goat age stages by period, Payne's (1973) and Deniz and Payne's (1982) methods of analysis having been used. Payne emphasises that the ages assigned to the varying categories (A to I) are only tentative and with respect to the older groups are more 'guesstimates'.

The Roman intramural sites of Culver Street, the Gilberd School and Long Wyre Street have been combined for purposes of boosting the jaw samples (Fig 4.29). However, the data from Lion Walk (also an intramural site) was kept separate since Hodgson, who made a preliminary study of the Roman material (Hodgson 1980), had made no attempt to subdivide the assemblages chronologically. The extramural Balkerne Lane (BKC) sites were also isolated, partly because many of them had been analysed several years ago, and also because it was deemed likely that these sites were of a lower socioeconomic status than the intra-mural ones.

The bar charts of Roman Lion Walk (LWC) and Balkerne Lane (BKC) appear quite different (Fig 4.28). Lion Walk is represented mainly by lambs, slaughtered at less than 6 months (B) and 6 to 12 months (C), and few older animals occur. Balkerne Lane shows a concentration on the consumption of 1 - to 2-year-old beasts (D) but much more of an emphasis on older animals in the 3- to 6-year age bracket. If Balkerne Lane is split into its component parts chronologically, then the early and later samples show a striking contrast; the early Roman sample of AD 44-60/1 from BKC E is similar to the overall pattern for Roman Balkerne Lane.

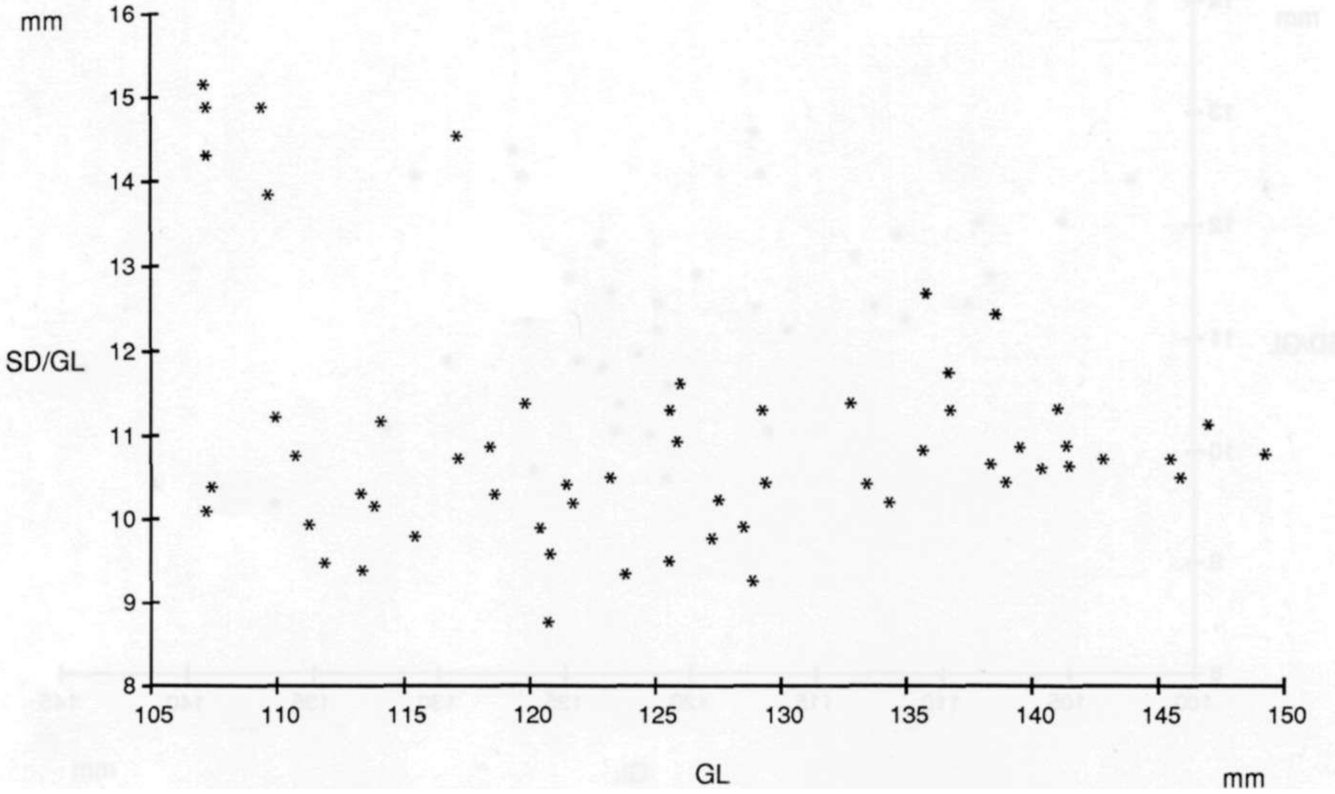


Fig 4.25 Scattergram: Roman sheep/goat metacarpal greatest length (GL) against mid-shaft width divided by greatest length (SD/GL). Note very tall sheep in Roman samples (GL> 130 mm). [Page 68]

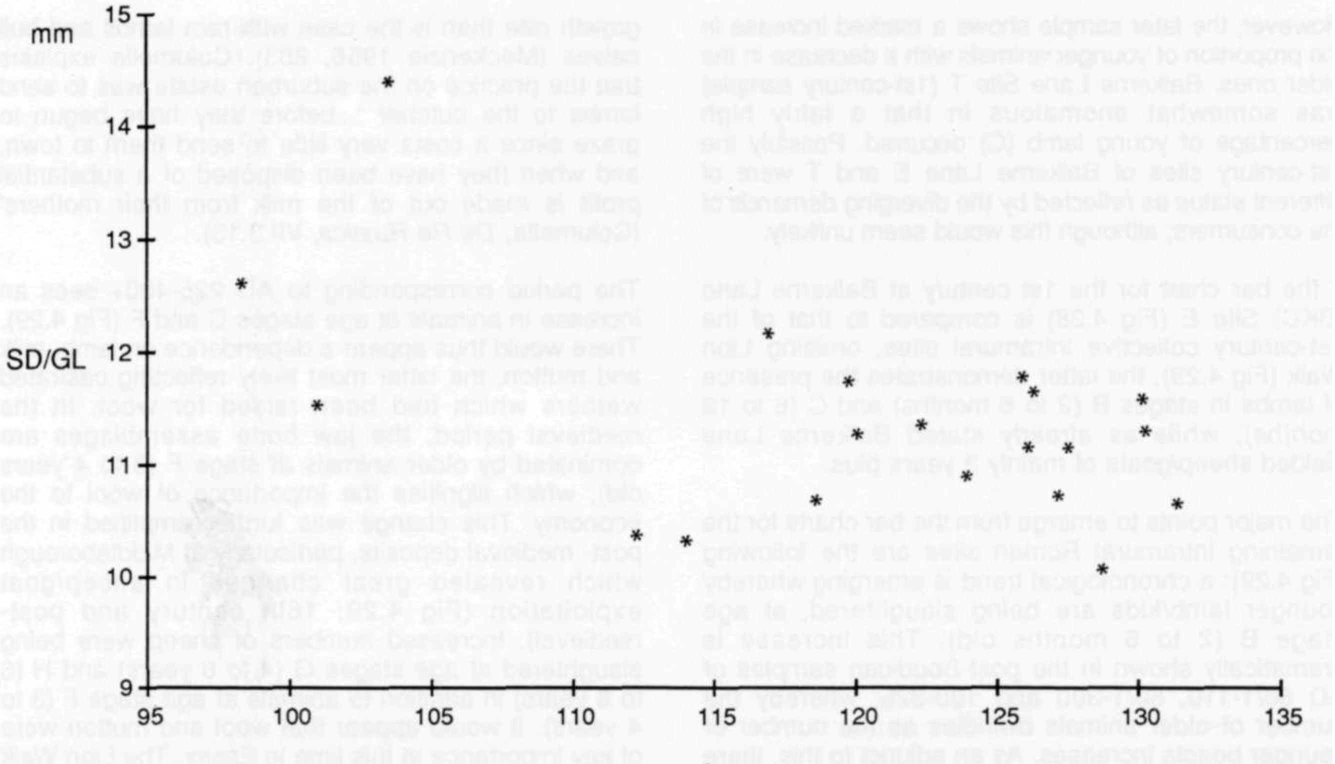


Fig 4.26 Scattergram: medieval sheep/goat metacarpal greatest length (GL) against mid-shaft width divided by greatest length (SD/GL). [Page 68]

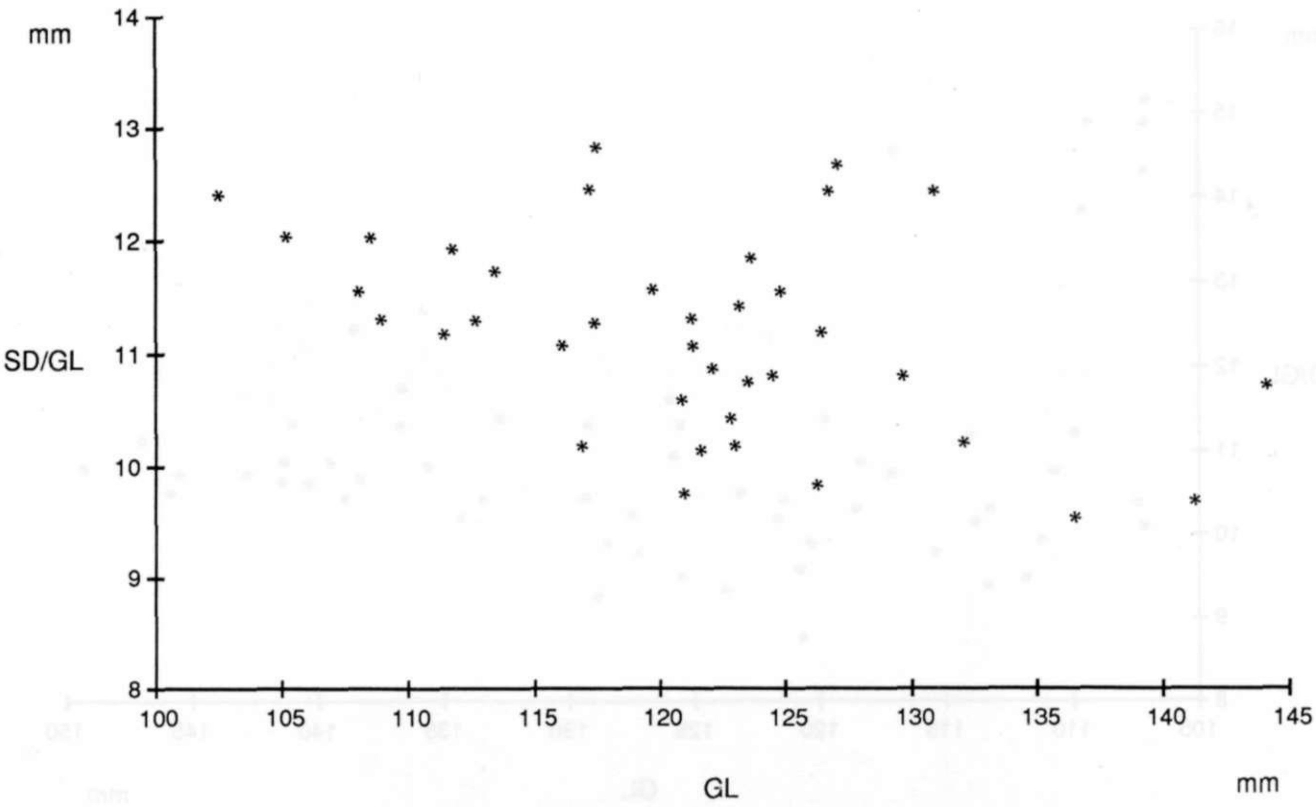


Fig 4.27 Scattergram: post-medieval sheep/goat metacarpal greatest length (GL) against mid-shaft width divided by greatest length (SD/GL). [Page 68]

However, the later sample shows a marked increase in the proportion of younger animals with a decrease in the older ones. Balkerne Lane Site T (1st-century sample) was somewhat anomalous in that a fairly high percentage of young lamb (C) occurred. Possibly the 1st-century sites of Balkerne Lane E and T were of different status as reflected by the diverging demands of the consumers, although this would seem unlikely.

If the bar chart for the 1st century at Balkerne Lane (BKC) Site E (Fig 4.28) is compared to that of the 1st-century collective intramural sites, omitting Lion Walk (Fig 4.29), the latter demonstrates the presence of lambs in stages B (2 to 6 months) and C (6 to 12 months), while as already stated Balkerne Lane yielded sheep/goats of mainly 3 years plus.

The major points to emerge from the bar charts for the remaining intramural Roman sites are the following (Fig 4.29): a chronological trend is emerging whereby younger lamb/kids are being slaughtered, at age stage B (2 to 6 months old). This increase is dramatically shown in the post-Boudican samples of AD 60/1-110, 60/1-300 and 100-325, whereby the number of older animals dwindles as the number of younger beasts increases. As an adjunct to this, there are hints that the ratio of kids to lambs is perhaps increasing through the Roman period, although one cannot be absolutely definite about this at present. Present-day kids castrated at birth have a greater growth rate than is the case with ram lambs and bull calves (Mackenzie 1956, 283). Columella explains that the practice on the suburban estate was to send lambs to the butcher '...before they have begun to graze since it costs very little to send them to town, and when they have been disposed of a substantial profit is made out of the milk from their mothers' (Columella, *De Re Rustica,* VII.3.13).

The period corresponding to AD 225-400+ sees an increase in animals at age stages C and F (Fig 4.29). There would thus appear a dependence on lamb, milk and mutton, the latter most likely reflecting castrated wethers which had been raised for wool. In the medieval period, the jaw bone assemblages are dominated by older animals at stage F (3 to 4 years old), which signifies the importance of wool to the economy. This change was further amplified in the post- medieval deposits, particularly at Middleborough which revealed great changes in sheep/goat exploitation (Fig 4.29; 16th century and post-medieval). Increased numbers of sheep were being slaughtered at age stages G (4 to 6 years) and H (6 to 8 years) in addition to animals at age stage F (3 to 4 years). It would appear that wool and mutton were of key importance at this time in Essex. The Lion Walk samples of the 15th to 17th centuries span the medieval and post-medieval periods, and while the emphasis is on mature sheep/goats, there is a high incidence of young animals at stage B (Fig 4.28).

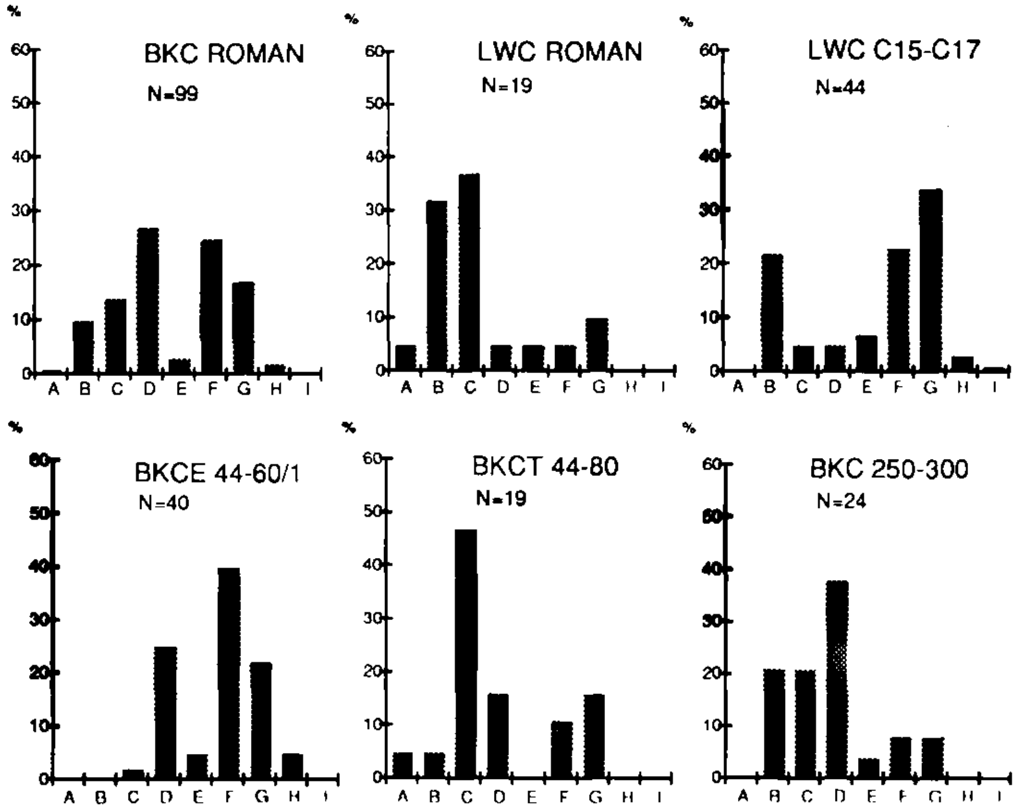


Fig 4.28 Bar charts: age profiles of sheep/goat mandibles (after Payne 1973). selected samples from Balkerne Lane and Lion Walk. [Pages 68. 70]

Key:
A —0 to 2 months *B — 2 to 6 months* *C — 6 to 12 months* *D — 1 to 2 years* *E — 2 to 3 years*
F — 3 to 4 years *G — 4 to 6 years* *H — 6 to 8 years* *I — 8 to 10 years*

The trends emerging in the bar charts for ageing are more easily comprehended by employing cumulative percentage graphs (Figs 4.30-4.32). A visual appraisal of the bar charts had suggested the following:

a) That the 1st-century extramural Balkerne Lane sheep/goat kill-off patterns differed from the 1st-century intramural ones (Fig 4.30). The 1st-century intramural sites showed a dominance of lambs at age stages B and C whilst 1st-century Balkerne Lane revealed the slaughter of much older animals.
b) That the intramural 1st-century pre-Boudican kill-off patterns differed from the intramural post-Boudican ones, in that there were higher percentages of lambs at age stage B in the later samples (Figs 4.30-4.31).
c) That the medieval and post-medieval Middleborough slaughter patterns showed a significant difference from the Roman ones, in that more adult sheep occurred in the later samples (Fig 4.32).

The Kolmogorov-Smirnov Test, a non-parametrical statistical test, was applied to the data using probability levels of 0.01 and 0.05. A significant difference was found between the sheep/goat slaughter patterns for the 1st-century extramural Balkerne Lane sites and the intramural sites at a 0.05 level of probability (Fig 4.30). While the intramural site samples of AD 44-60/1 and 60/1-110 did not differ significantly, the AD 60/1-300 sample did differ significantly from the AD 44-60/1 ones at a 0.05 level of probability (Figs 4.30-4.31). Further, a significant difference in kill-off patterns was confirmed between the intramural sites of AD 44-60/1 and 100-325 samples (Figs 4.30-4.31). Finally, the medieval and post-medieval slaughter patterns (Fig 4.32) differed significantly from the Roman ones, at the 0.01 and 0.05 levels of probability.

Thus there is strong evidence that during the 1st century, dietary differences existed between the residents of the suburbs (Balkerne Lane) and those of the interior of Colchester. Mutton was consumed at Balkerne Lane while lamb was the popular fare of the intramural inhabitants. In the post-Boudican period, there was a greater emphasis on the consumption of

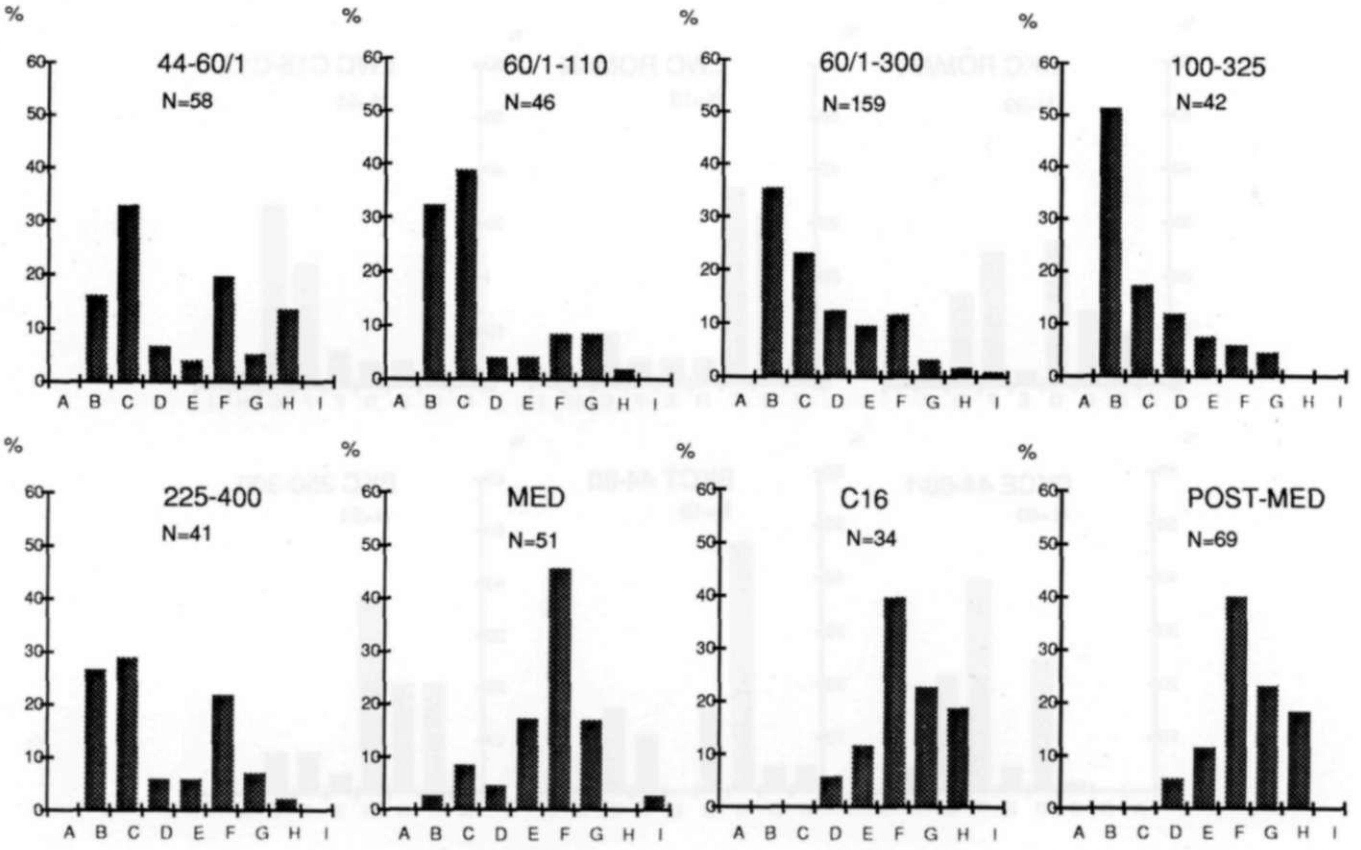


Fig 4.29 Bar charts: age profiles of sheep/goat mandibles (after Payne 1973), for the Roman intramural sites (Lion Walk omitted) viewed chronologically, and the medieval/post-medieval sites. [Pages 68, 70, 72]

Key:
A —0 to 2 months B — 2 to 6 months C — 6 to 12 months D— 1 to 2 years E — 2 to 3 years
F —3 to 4 years G — 4 to 6 years H — 6 to 8 years I —8 to 10 years

younger lamb within the town walls. The medieval and post-medieval periods are characterised by mature sheep, most likely wethers bred for wool, in contrast to the Roman period, when the emphasis was on meat and milk.

4.3.4 Sheep/goat long-bone epiphysial fusion data

[Figs **4**.33-**4**.35]

The sheep/goat epiphysial fusion data were handled in exactly the same manner as that for the cattle in Section 4.2.3. Similar premises were used for the interpretation. The following skeletal elements were used:

Group 1: scapula and distal humerus, fuse at 6 to 10 months
Group 2. proximal phalanx, fuses at 13 to 16 months
Group 3: distal tibia and metapodials, fuse at 18 to 28 months
Group 4: distal radius and femur and proximal tibia, fuse at 3 to 3.5 years

Figure 4.33 illustrates for the whole Roman period the percentage of fused and unfused indicators for Culver Street, the Gilberd School and Balkerne Lane, and also describes the medieval and post-medieval samples from Middleborough and Culver Street Site E. It is clear that all the fusion groups in the medieval and post-medieval profiles are dominated by mature sheep/goats and this compares well with the tooth eruption and wear results (Figs 4.29 & 4.33d-f). The Roman samples show the importance of immature beasts, particularly in the later-fusing groups (Fig 4.29).

Let us consider the age profiles in finer detail by period. If the Culver Street fusion data is assessed chronologically (Fig 4.34c, e & g), there appears an increase in the proportion of immature versus mature sheep/goats through time, that is Groups 3 and 4. However, the unfused skeletal elements (the scapulae and humeri) that reflect the definite presence of kid and lamb, are proportionately low in all figures. It could be argued that this is a result of poor recovery, as evidenced by the low number of phalanges, or that the unfused scapulae and humeri are not preserving as well as the other skeletal elements; tooth eruption and wear suggests that they should be present.

If the ist-century sites of Culver Street, the Gilberd School and Balkerne Lane are compared, a number of

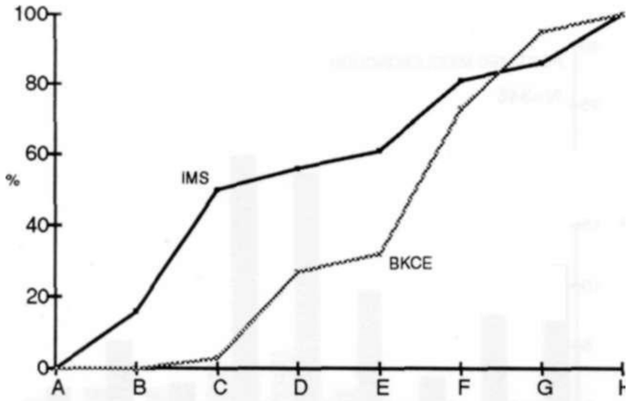


Fig 4.30 Cumulative percentage graph: sheep/goat mandibles for the 1st-century intramural sites (IMS) and the Ist-century Balkerne Lane site (BKCE). [Page 71]

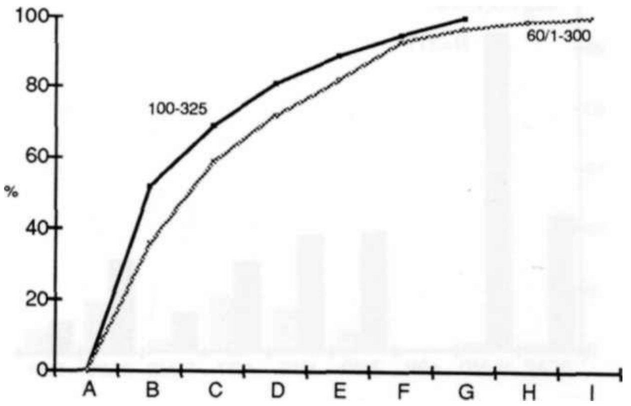


Fig 4.31 Cumulative percentage graph: sheep/goat mandibles for the intramural sites dated to AD 60/1-300 and AD 100-325. [Page 71]

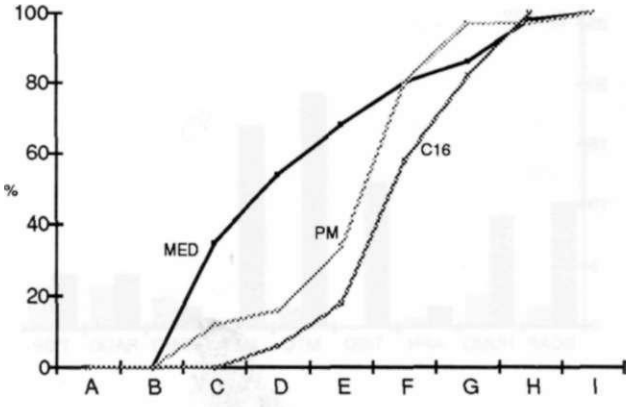


Fig 4.32 Cumulative percentage graph: sheep/goat mandibles for the medieval and post-medieval sites. [Page 71]

Key:
A — 0 to 2 months
B — 2to 6 months
C — 6 to 12 months
D— 1 to 2 years
E — 2 to 3 years
F — 3 to 4 years
G — 4 to 6 years
H — 6 to 8 years
I — 8 to 10 years

differences are apparent (Fig 4.34a-c). The Gilberd School shows a greater proportion of immature animals in Groups 3 and 4 as compared to Culver Street, and it is most interesting to note that the cattle fusion data followed the same pattern. Oddly, the Balkerne Lane 1st-century fusion data does not match that for tooth eruption and wear, and exhibits a high proportion of unfused metapodials (Fig 4.34b). Apart from the higher percentage of humeri in the AD 60/1-150 sample, the later Balkerne Lane Roman profiles are similar for the immature beasts.

Figure 4.35 represents the percentage survival of the skeletal elements (based on bone density) of a 6-month-old lamb and a 90-month-old sheep which had been subjected to 'destructive agents' (data taken from Binford 1981, 218). The adult profile bears a striking similarity to those in Figure 4.33b-c (Roman Culver Street and Gilberd School), and Figure 4.34d-f (Balkerne Lane AD 60/1-150 and 150-400+, and Culver Street AD 60/1-150) with regard to the high incidence of distal tibiae. Only a few figures showed a relatively high proportion of fused scapulae and humeri, that is Figure 4.33a (Roman Balkerne Lane), Figure 4.34a (the Gilberd School AD 44-60/1) and Figure 4.34b (Balkerne Lane AD 44-60/1). The low number of late-fusing bone in general corresponds with the tooth eruption and wear data, and this could account for their scarcity, but the low incidence of fused humeri and scapulae is odd. However, this is also reflected in the immature age profiles and demonstrates that other processes were operating besides those of attrition, possibly butchery and carcass redistribution.

4.4 Pig exploitation

'I suggest that the basis of efficient pig management and domestication lies in the ability of man to maintain a minimum proportion of the pig population (that is, at least some of the pregnant sows) in captivity for farrowing. In Europe this would mean winter captivity and the animals would have to be fed, either on wild food gathered for them or on excess agricultural produce. A secondary, and perhaps later, development would be to keep breeding animals of both sexes from the time of the rut in November-December until at least parturition, which would allow control over their breeding.

This may already have been the case in the English Neolithic, as the evidence suggests that there was little out-breeding from domestic to wild pigs. If one adds to this the difficulty that people would have encountered trying to live in the open and look after pigs in the worst of the winter weather, it seems logical to suppose that the majority would have been overwintered in captivity from November to March, and the lactating sows and the young kept in until June or early July. These animals would have had to be fed — but on what?' (Grigson 1982b, 304-5).

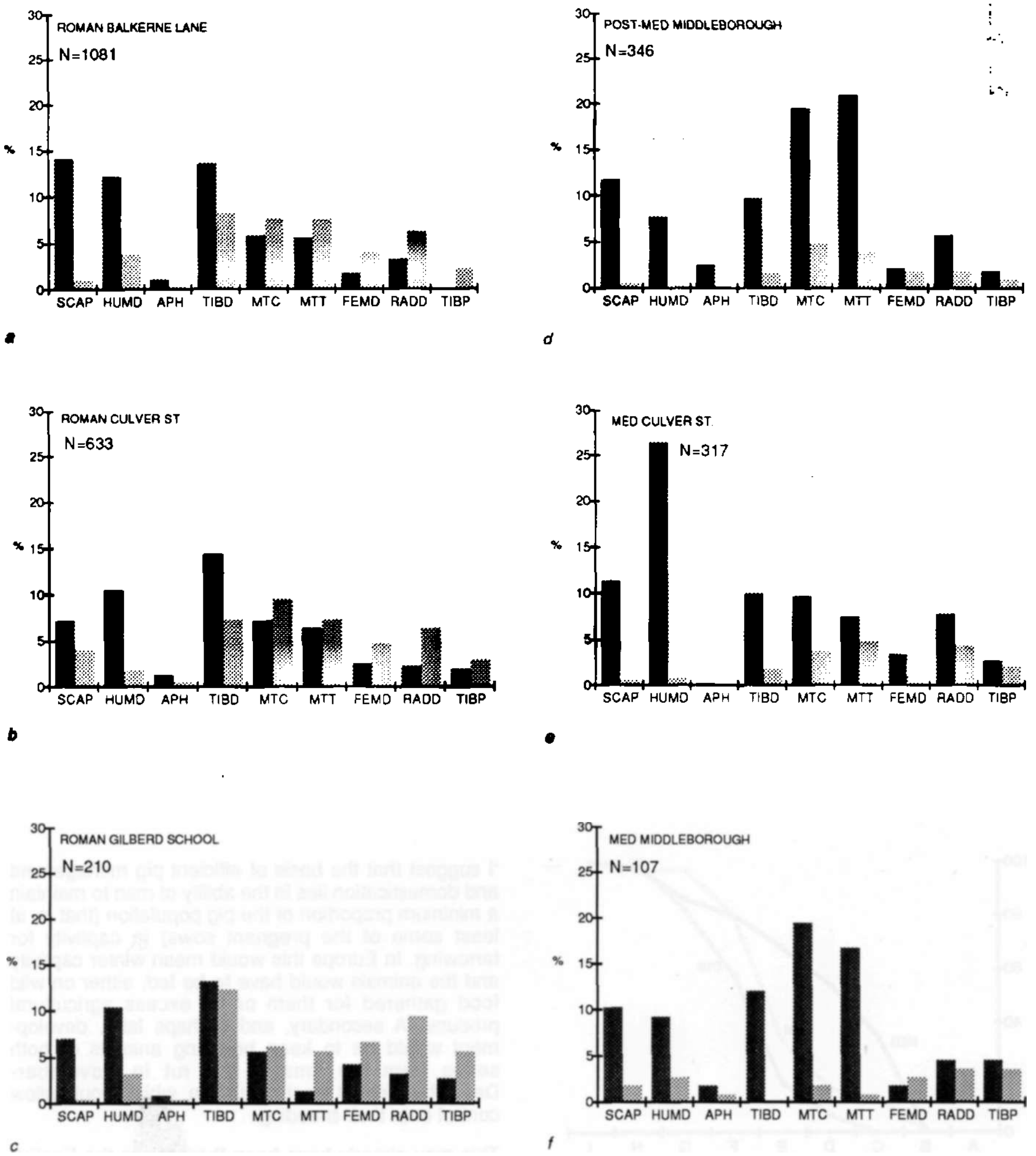
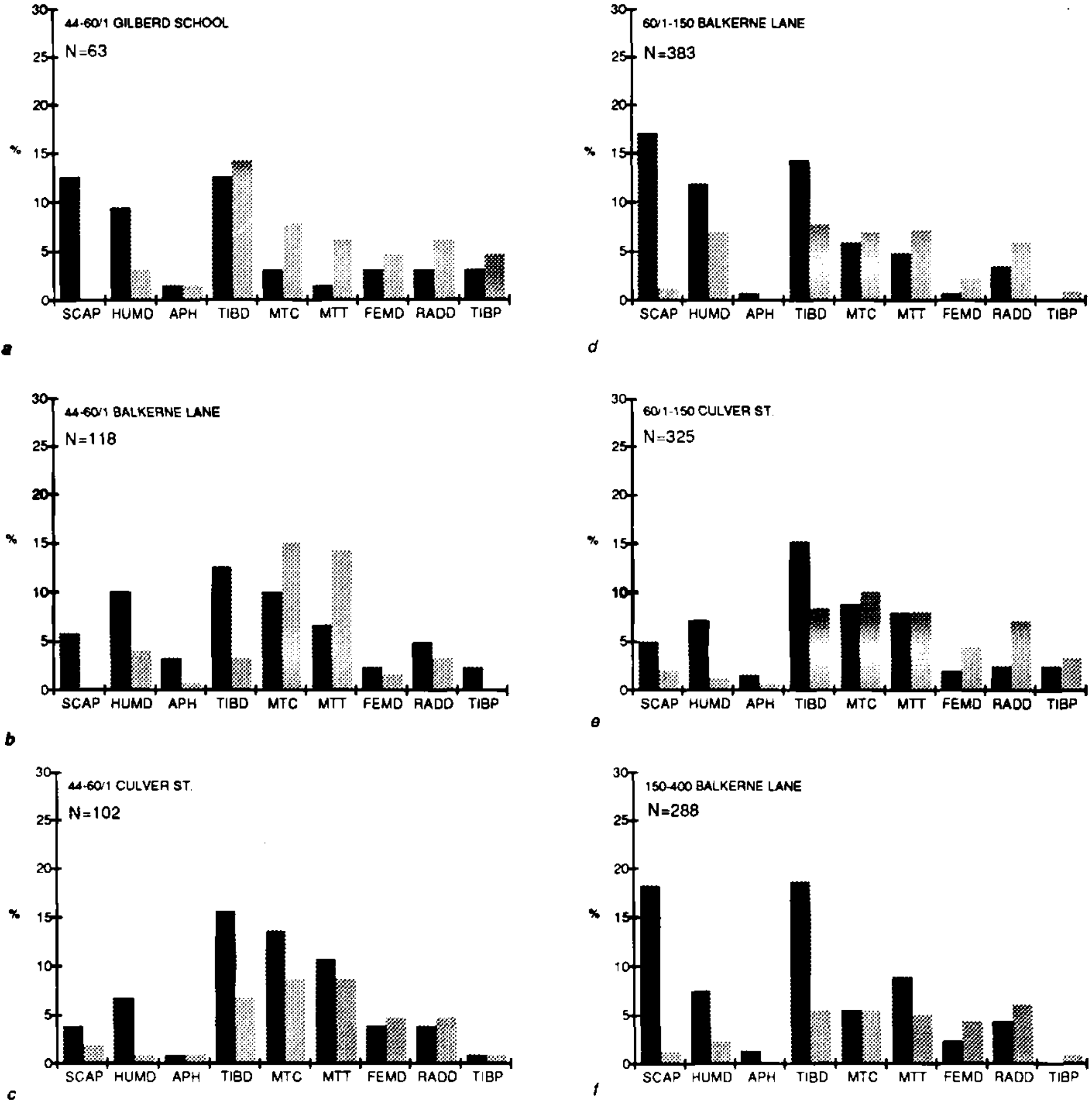


Fig 4.33 Bar charts: relative distribution of fused (dark grey) and unfused (light grey) sheep/goat bones from Roman, medieval and post-medieval Colchester. (Page 72]

Key:
Group 1: d scapula (SCAP) and d humerus (HUMD) fuse at 6 to 10 months
Group 2: p 1st phalanx (APR) fuses at 13 to 16 months
Group 3: d tibia (TIBD) and metapodials (MTC + MTT) fuse at 18 to 28 months
Group 4: d radius (RADD), d femur (FEMD) and p tibia (TIBP) fuse at 3 to 3.5 years
(after Silver 1969)



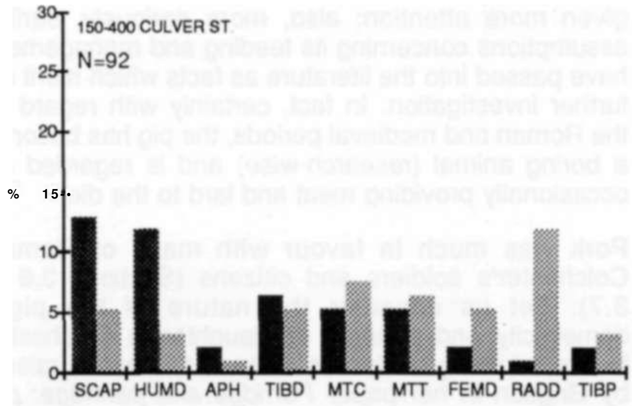


Fig 4.34 Bar charts: relative distribution of (used (dark grey) and unfused (light grey) sheep/goat bones from Roman Gilberd School, Balkerne Lane and Culver Street. [Pages 72-73]

Key:
Group 1: d scapula (SCAP) and d humerus (HUMD) fuse at 6 to 10 months
Group 2: p 1st phalanx (APH) fuses at 13 to 16 months
Group 3: d tibia (TIBD) and metapodials (MTC * MTT) fuse at 18 to 28 months
Group 4: d radius (RADD). d femur (FEMD) and p tibia (TIBP) fuse at 3 to 3.5 years
(after Silver 1969)

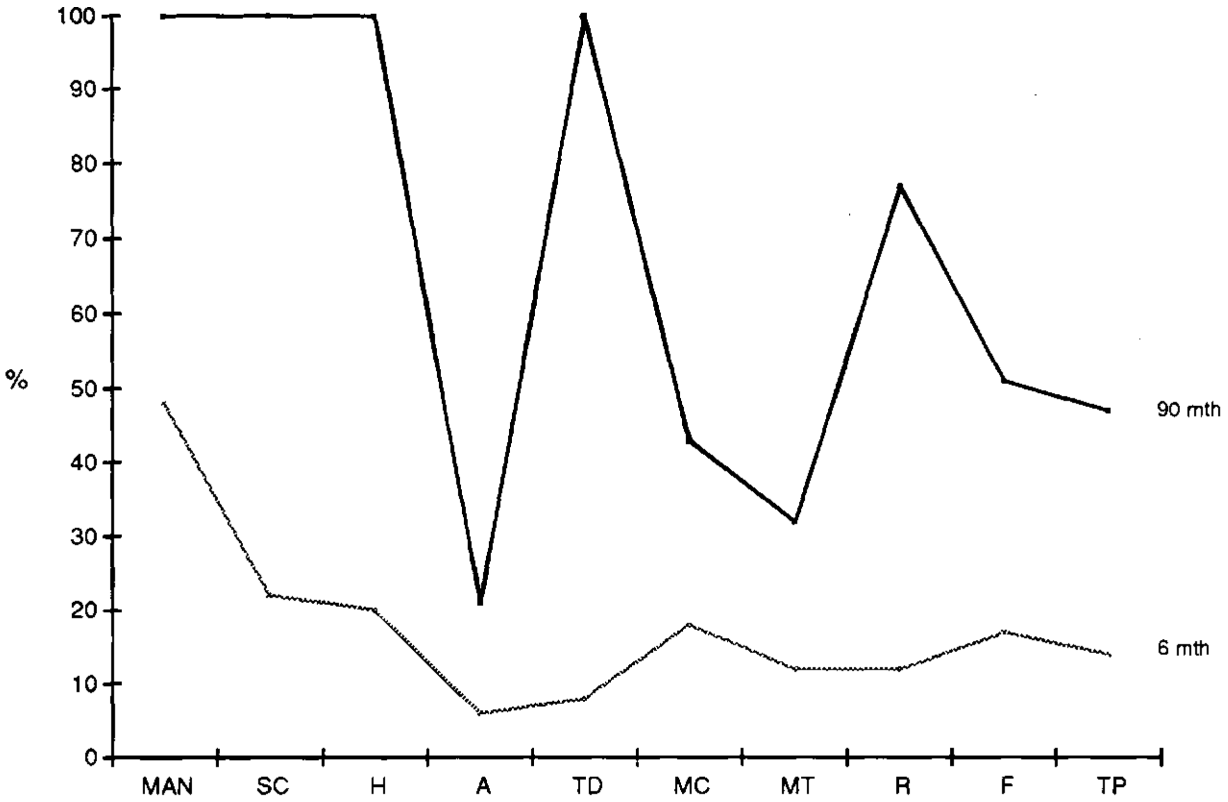


Fig 4.35 Graph: the relative percentage survival of skeletal elements of sheep (90 months) and lamb (6 months) (after Binford 1981). [Page 73]

Key:
MAN...mandible; SC...scapula; H...humerus; A... 1stphalanx; TD...distal tibia; MC...metacarpal; MT...metatarsal; R...radius; F...femur; TP...proximal tibia.

Although Grigson's statements refer to pig-keeping in the British Neolithic, they generate far-reaching repercussions with respect to later prehistoric and historic practices. The pig has been a sadly-neglected animal in faunal studies, partly because other domestic livestock (cattle and sheep) generally dominate most faunal assemblages and are therefore given more attention; also, more seriously, earlier assumptions concerning its feeding and management have passed into the literature as facts which merit no further investigation. In fact, certainly with regard to the Roman and medieval periods, the pig has become a boring animal (research-wise) and is regarded as occasionally providing meat and lard to the diet.

Pork was much in favour with many of Roman Colchester's soldiers and citizens (Sections 3.6 & 3.7). Let us consider the nature of the pigs' domesticity and patterns of slaughter in Colchester before returning to discuss some of the issues raised by Grigson in her paper *Porridge and pannage: pig husbandry in Neolithic England* (1982).

4.4.1 Domestic versus wild pig
[Fig 4.36]

Distinctions of wild and domestic pigs are usually made utilising meso-distal lengths of upper and lower permanent third molars (Flannery 1960). Confusions have occurred due to some researchers measuring at the occlusal surface and others the enamel-cementum junction. Since a large proportion of the Colchester pig jaws had no erupted third molar, and since those that did were not easy to measure, it was decided to employ one of Bull and Payne's methods which measures the width of the posterior cusps of the second mandibular molar, that is bucco-lingually (Bull & Payne 1988). The important premise of their research is that pigs exhibit low sexual dimorphism with respect to cheek-tooth width measurements and, unlike post-cranial measurements, the teeth do not show age-related changes.

Figure 4.36 compares second molar posterior cusp widths between Bull and Payne's Turkish wild boar

(Kizilcahamam) and a variety of chronological samples from Colchester using a log ratio method (Simpson et *al* 1960). All the Colchester samples show an overlap with the wild boar which is particularly evident in the post-medieval period. However, on the whole, the generally unimodal distributions of the Roman and medieval samples appear to encompass mainly domestic animals. Also marked in Figure 4.36 are the coefficients of variation (V), and the later Roman sample displays a slightly greater range of variation than the earlier samples.

4.4.2 Pig tooth eruption and wear
[Figs 4.37-4.38]

Figures 4.37 and 4.38 show the pattern of pig exploitation, as evidenced by tooth eruption (M1, M2 & M3) and wear (M3W) in the Roman, medieval and post-medieval periods. Throughout the Roman period, at least 40 per cent of the pigs were slaughtered when the M3 was in eruption and, by Silver's modern ageing data, these pigs would have been 17 to 22 months old (Silver 1969; Fig 4.37). Three definite trends are apparent: there is an increase in the proportion of pigs showing the first molar in eruption, with a concomitant increase in the number of adult pigs with worn third molars, while the proportion of animals exhibiting second-molar eruption steadily declines. In other words, there is a rise in the percentage number of 6-month- and 2-year-old plus animals during the Roman period and a decrease in the proportion of 7- to 13-month-old ones.

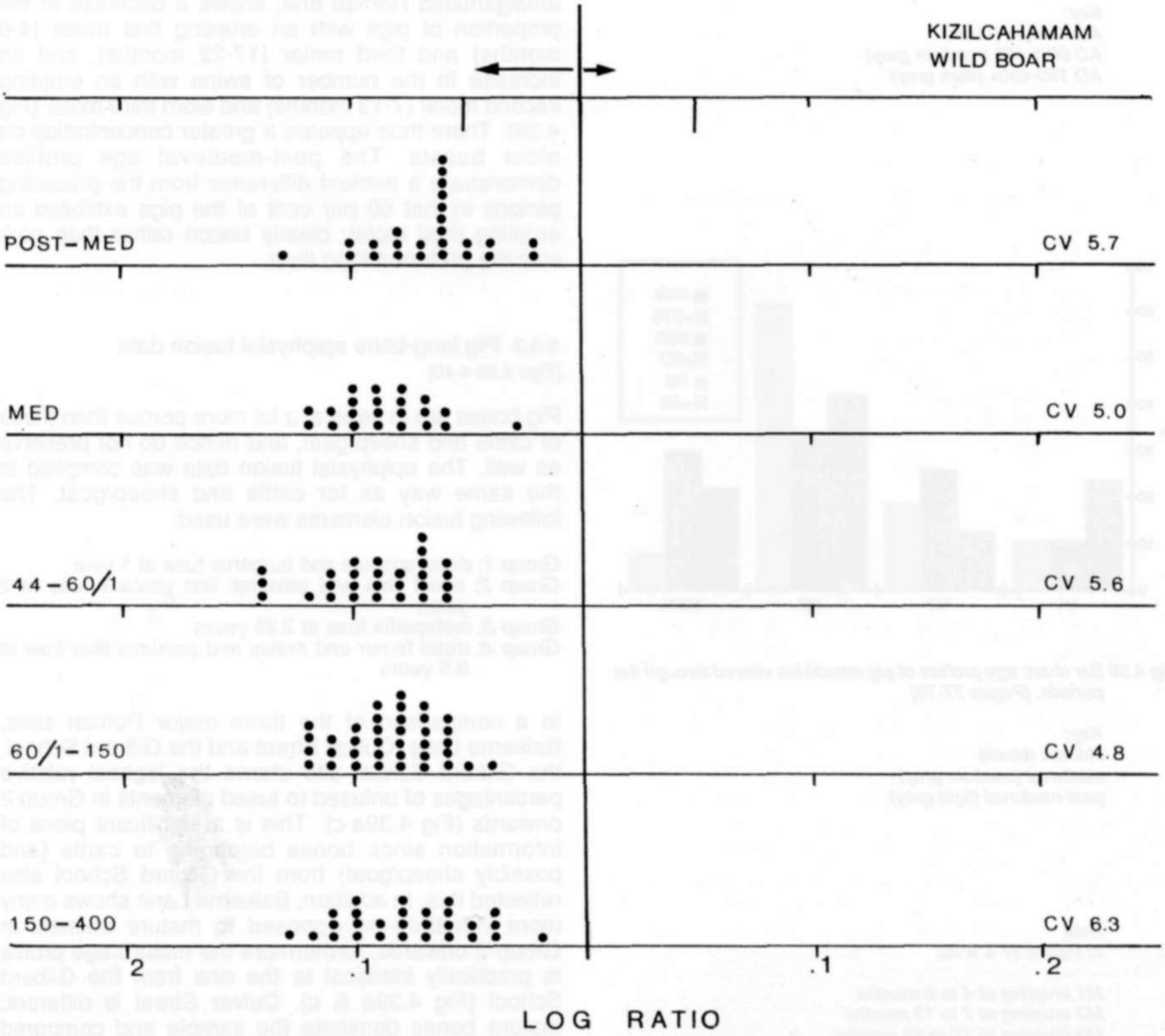


Fig 4.36 Measurements of the width of the posterior cusps of M2 in pig using a log ratio method (after Payne & Bull 1988). [Pages 76-77]

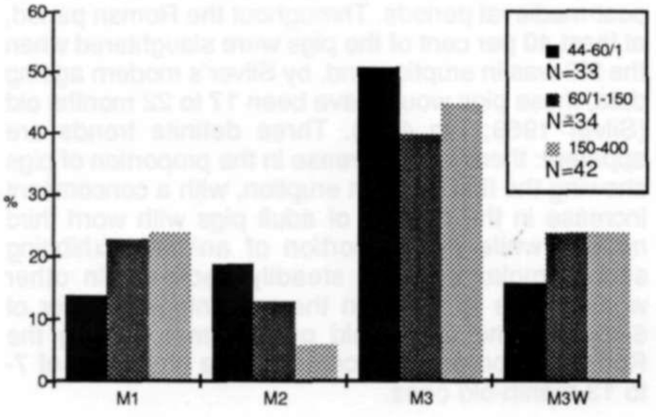


Fig 4.37 Bar chart: age profiles of pig mandibles viewed through the Roman period. [Page 77]

Key:
AD 44-60/1 (black)
AD 60/1-150 (medium grey)
AD 150-400+ (dark grey)

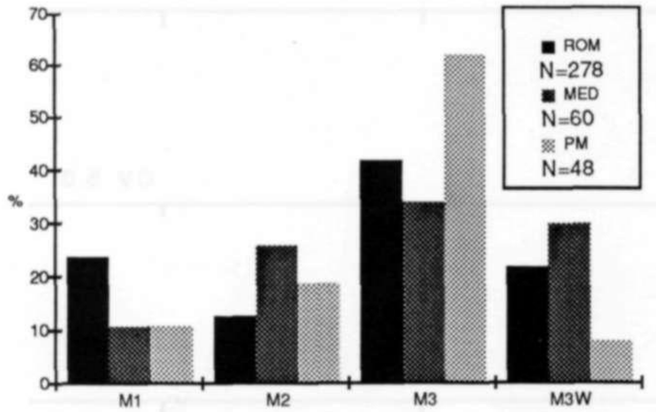


Fig 4.38 Bar chart: age profiles of pig mandibles viewed through the periods. [Pages 77-78]

Key:
Roman (black)
medieval (medium grey)
post-medieval (light grey)

Note
to Figs 4.37 & 4.38:

Ml erupting at 4 to 6 months
M2 erupting at 7 to 13 months
M3 erupting at 17 to 22 months
M3W in wear

(after Silver 1969)

This raises the possibility that pigs were allowed to farrow twice a year in order to increase the production of younger pigs. If there were two farrowings a year, rather than one, the need to slaughter pigs at 17 to 22 months would be reduced. The results of an analysis into enamel hypoplasia in pig teeth have suggested amongst other possibilities that the Roman pigs could have been farrowing twice a year (Section 6.2.1). Both Varro and Pliny recommend two farrowings a year (Varro, *De Re Rustica,* 11.4.14; Pliny the Elder, *Historia Naturalis,* VIII.250), while Columella describes the implementation of two different regimes depending on the proximity of the herd to the urban consumer site. In out-of-the-way places one litter was sensible, but in regions near a town two litters were advisable, since sucking-pig could be turned into a ready cash-profit (Columella, *De Re Rustica,* VII.9.4).

The medieval sample, in comparison with the amalgamated Roman one, shows a decrease in the proportion of pigs with an erupting first molar (4-6 months) and third molar (17-22 months), and an increase in the number of swine with an erupting second molar (7-13 months) and worn third molar (Fig 4.38). There thus appears a greater concentration on older beasts. The post-medieval age profiles demonstrate a marked difference from the preceding periods in that 60 per cent of the pigs exhibited an erupting third molar; clearly bacon rather than pork was the preferred food then.

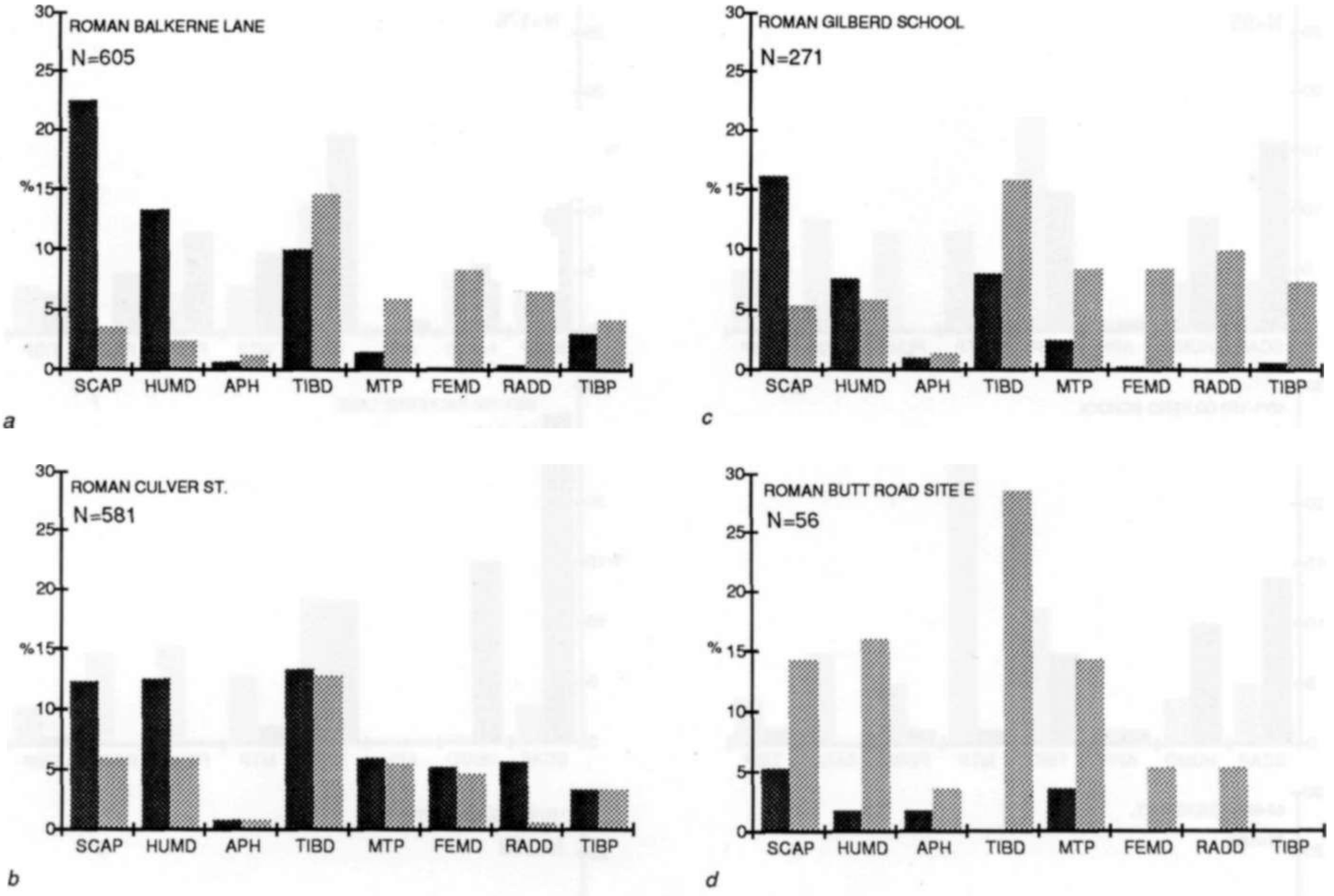
4.4.3 Pig long-bone epiphysial fusion data

[Figs 4.39-4.40]

Pig bones are in general a lot more porous than those of cattle and sheep/goat, and hence do not preserve as well. The epiphysial fusion data was compiled in the same way as for cattle and sheep/goat. The following fusion elements were used:

Group 1: distal scapula and humerus fuse at **1** year
Group 2. distal tibia and proximal first phalanx fuse at 2 years
Group 3: metapodia fuse at 2.25 years
Group 4: distal femur and radius and proximal tibia fuse at 3.5 years

In a comparison of the three major Roman sites, Balkerne Lane, Culver Street and the Gilberd School, the Gilberd School site shows the highest relative percentages of unfused to fused elements in Group 2 onwards (Fig 4.39a-c). This is a significant piece of information since bones belonging to cattle (and possibly sheep/goat) from the Gilberd School also reflected this. In addition, Balkerne Lane shows many more immature as opposed to mature animals in Group 2 onwards, furthermore the mature age profile is practically identical to the one from the Gilberd School (Fig 4.39a & c). Culver Street is different; mature bones dominate the sample and compared with Balkerne Lane and the Gilberd School there are relatively high percentages of fused bones in the Group 4 category (Fig 4.39b).



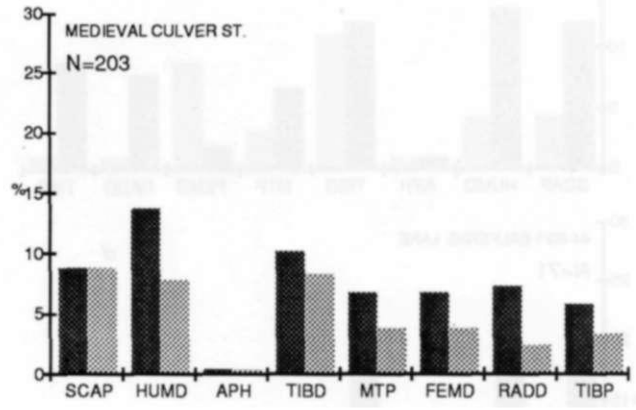


Fig 4.39 Bar charts: relative distribution of fused (dark grey) and unfused (light grey) pig bones from Roman and medieval Colchester.
[Page 78]

Key:

Group 1: d scapula (SCAP) and d humerus (HUMD) fuse at 1 year
Group 2: d tibia (TIBD) and p 1sl phalanx (APR) fuse at 2 years (TIBP) fuse at 3.5 years
Group 3: d metapodia (MTP) fuse at 2.25 years
Group 4: d femur (FEMD), d radius (RADD) and p tibia

(after Silver 1969)

Butt Road Site E epitomises the highest percentage representation of immature pigs (Fig 4.39d). The bones emanated from very young individuals, many being neonatals, and together with the large numbers of excavated chicken bones constitute the remains of meals, possibly from feasting. This site is so different from the others that it has been treated separately (Sections 5.2 & 5.4).

The bones from medieval Culver Street indicate that the beasts were mainly on the mature side (Fig 4.39e).

If the assemblages are divided into their respective periods, the 1st-century deposit from the Gilberd School (Fig 4.40a) shows a marked difference in the higher proportion of immature beasts than Balkerne Lane (Fig 4.40d), while Culver Street (Fig 4.40c) contrasts with them both in exhibiting much greater proportions of fused bones in the Group 4 category.

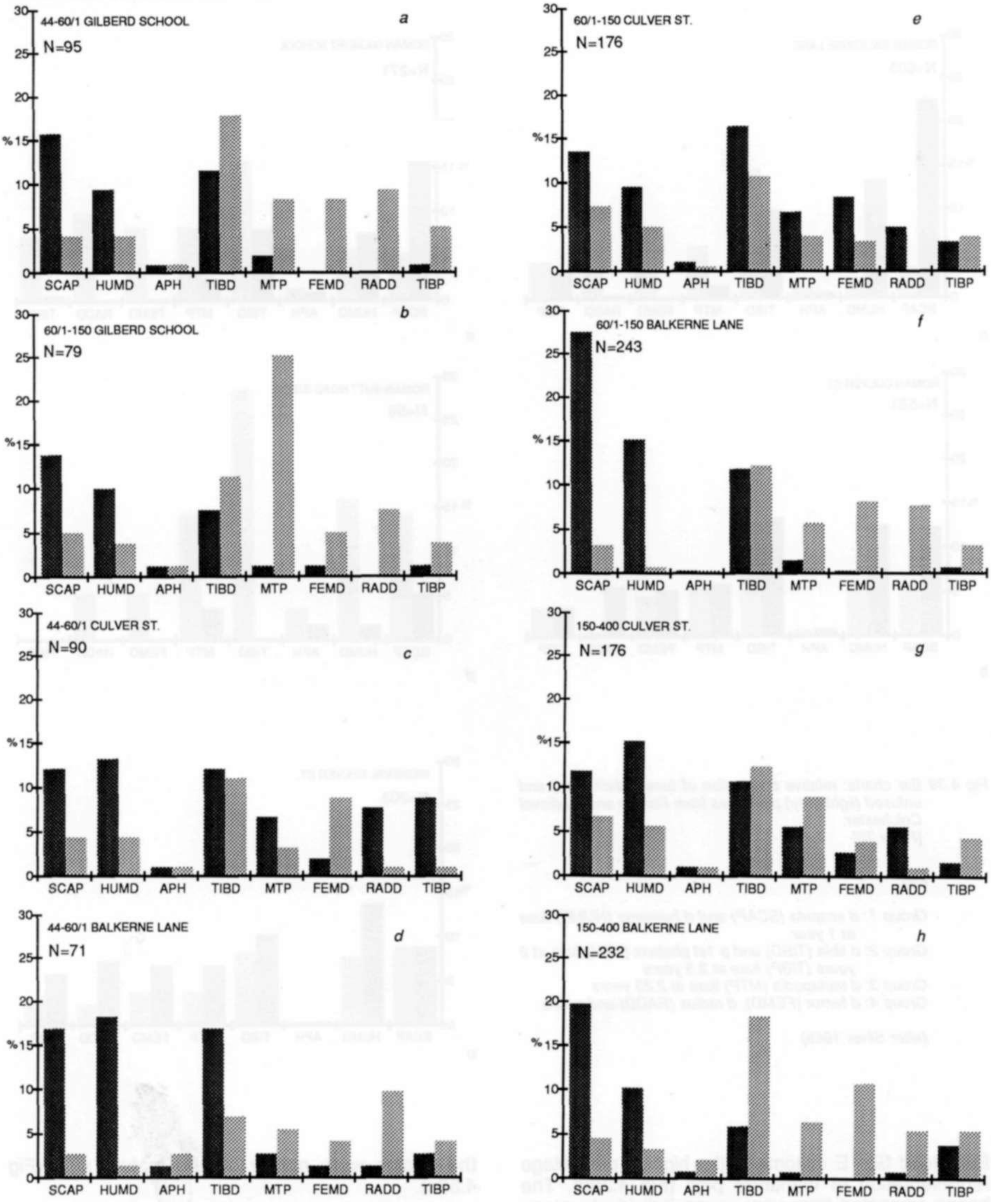


Fig 4.40 Bar charts: relative distribution of fused (dark grey) and unfused (light grey) pig bones from Roman Gilberd School, Balkerne Lane and Culver Street. [Page 79]

Key:

Group 1: d scapula (SCAP) and d humerus (HUMD) fuse at 1 year

Group 2: d tibia (TIBD) and p 1st phalanx (APH) use at 2 years

Group 3: d metapodia (MTP) fuse at 2.25 years

Group 4: d femur (FEMD), d radius (RADD) and p tibia (TIBP) fuse at 3.5 years

(after Silver 1969)

The Balkerne Lane assemblages show a steady chronological increase in the proportion of immature animals (Fig 4.40d, f & g). Similarly, the later deposit of AD 60/1-150 at the Gilberd School (Fig 4.40b) exhibits a steep increase in the proportional representation of Group 3 immature beasts as compared with the AD 44-60/1 sample (Fig 4.40a). If the Culver Street assemblages are viewed through time, then mature pigs dominate the samples in AD 60/1-150 (Fig 4.40e), while in the later period of AD 150-400+ (Fig 4.40g), the percentage of immature pigs in Group 2 increases.

In summary, the fusion data supports the results of tooth eruption and wear in that there is an increase in the number of immature pigs in the post-Boudican period. At the moment, the nature of the phasing does not allow us to pinpoint exactly when this change occurred.

4.4.4 Care and maintenance of Roman and medieval pig herds

'The swineherd should train them to do everything to the sound of the horn. After first shutting them in, he does not open the door until the horn blows, when they are taught to go out in a long line for by this method less is spoilt than if it were piled in a heap, and more pigs can get to it and with less trouble. The object we are told of bringing them together by blowing the horn is to prevent them from being lost when scattered apart in the woods' (Varro, *De Re Rustica,* 11.20).

Oliver Rackham, in his splendid book *The history of the countryside,* has rightly questioned the assumption made by many archaeologists who '...unthinkingly equate pigs with woodland' (1990, 122). He points out that, while in France or Italy pigs may depend on the acorn harvest, in medieval and modern Britain oaks only produced bountiful crops once every three years and therefore it made no sense to breed pigs on such an erratic crop *(ibid,* 122). Further he states that the livestock statistics of the Domesday survey show clearly that pig-keeping was not dependent on woodland. Indeed, aerial survey and field-walking have revealed that most of Roman Essex was covered by dense settlement.

Pigs, unlike cattle and sheep/goats, are fertile at any time and able to produce more than one litter in a year, the controlling factors being the climate and food supply (Lauwerier 1983). Accounts of the present-day rearing of piglets show that this is no light undertaking. Approximately 20 per cent of piglets die before weaning, mostly in the first two to three days of life. Problems of cold temperature hamper the survival of any newly-born animal, but piglets are especially affected since the ability to regulate their body temperature is very poorly developed (Sutherland 1967, 61). Further, sows' milk is deficient in iron and may lead to anaemia in piglets. These facts alone would argue for some specialised form of housing, and indeed even feeding, to ensure the safety of the piglets, let alone create bonding between the swineherd and his/her more adult charges.

Let us return to Grigson's initial statement where she queries what pigs would have been fed *(see* opening of Section 4.4). Figure 4.37 suggests an increasing exploitation of pigs in the Roman period. It is worth considering that the increase in sheep/goat milking during the Roman period may not be unconnected with the increase of pork production. In the manufacture of cheese, which was an important commodity in the classical world, the by-product whey was invaluable for animal feeding since it has a high vitamin content and is rich in calcium (important for sty-fed pigs). Ryder has pointed out that whey illustrates the inter-relationship of farming operations, since cheese-makers have traditionally kept pigs to consume this by-product, as is still done in Romania. The same system operates throughout the Carpathian region which extends through southern Russia, Czechoslovakia, and southern Poland (Ryder 1983, 239). Indeed, in Tudor and Stuart Britain, Trow-Smith (1957, 185) relates that only where there was considerable forest keep or the availability of dairy by-products were swine a viable commercial enterprise. Further, almost all the lactose in milk passes into the whey and not the cheese, allowing easy digestion by humans. Specialised feeding of piglets could have involved goat foster-mothering. Piglets (and lambs) reared on cows' milk at birth hardly survive, but do very well on goats' milk (Mackenzie 1956, 275). Adult pigs are extremely efficient at converting waste into meat and in an urban environment would have practised thorough garbage disposal.

4.5 Summary

The Colchester sheep/goat ageing data shows an increasing emphasis on the slaughter of lambs (2 to 6 months old) through the Roman period. As has been seen with the Cribb models (Section 2.9), the slaughter of young sheep in order to provide milk products has to be accompanied by the slaughter of immature animals (1 to 2 years), otherwise the latter beasts will swell the ranks of the adult population with non-productive males (with regard to milking). Hence, the importance of milk could be vastly underrated with reference to the Colchester samples. Certainly lamb (and to a much lesser extent kid) was a popular item of fare. The increasing supply of milk might well be connected with an increasing exploitation of the pig but the evidence for the latter is tenuous, due to the more fragmentary remains. There is no evidence that cows were milked at Roman Colchester; mature beasts (3 years old plus) were mainly consumed with younger animals (24-30 months) coming to the fore in the later periods.

In the medieval and post-medieval periods, pigs were killed for the production of bacon at mainly 17 to 22 months. However, it is the medieval and post-medieval sheep/goat kill-off patterns which differ so dramatically from the Roman period in that much older animals were being slaughtered, indicating an emphasis on exploitation for wool. Also the cattle age profiles exhibit spectacular differences, with a progressive increase in calf production, culminating in the 17th- to 18th-century samples. Cows' milk was obviously an important by-product at that time. The long-bone epiphysial fusion data has revealed that the residents of certain areas of Colchester (for example the intramural site of the Gilberd School) enjoyed the consumption of more tender joints of beef, lamb and pork.

5: POULTRY AND GAME

5.1 Poultry

[Tables 3.11 & 5.1-5.2]

Domestic fowl bones dominate all the Colchester bird-bone assemblages, which are mainly comprised of domestic fowl *(Gallus gallus dom),* domestic goose/greylag goose *(Anser dom/Anser anser),* and domestic duck/mallard *(Anas dom/Anas platyrhynchos)* (Table 5.1). There is no evidence for the presence of guinea fowl *(Numida meleagris)* in any of the archaeological contexts (MacDonald 1992 & pers comm). Indeed some sites show chicken as the major species exploited, exceeding even the major mammalian domesticates cow, sheep/goat, and pig, that is with respect to the number of bone fragments (NISP; Table 3.11 & Section 3.7.1). The Roman sites of the Gilberd School, Butt Road Site E, and Culver Street are characterised by a preponderance of fowl: that is GBS1 dated to AD 44-60/1, GBS2 dated to AD 60/1-275, BUTT4E dated to the 4th and into the 5th centuries AD, and CUL3 dated to AD 150-400+. In the medieval period, Culver Street and Middleborough do not exhibit particularly high numbers of fowl but Lion Walk, like the Gilberd School and Butt Road, shows much emphasis on the utilisation of this species. Selected pit groups dated from the 15th to 16th centuries show the dominance of sheep/goat and chicken bones in the samples (Table 5.2).

Table 5.1 Numbers of bird-bone fragments (NISP) of main species recovered from Colchester.

Site	Date	Dom. fowl	Dom. goose/ greylag goose	Dom. duck/ mallard
BKC1	44-60/1	42	-	7
BKC2	60/1-150	86	-	10
BKC3	150-400+	388	17	90
BUTT4E	320-400+	697	5	16
CUL1	44-60/1	54	6	19
CUL2	60/1-150	353	13	59
CUL3	150-400+	586	84	104
CUL7/8	MED	266	108	38
GBS1	44-60/1	557	27	76
GBS2	60/1-275	597	22	106
MIDI	ROM	37	14	19
MID2	MED	174	22	5
MID3	PM	85	30	4
MID4	C16th	20	9	-
LWC1	ROM	298	17	64
LWC2	C11th-14th	112	16	15
LWC3	C15th-17th	396	91	39
LWC4	C17th-18th	62	4	9

Table 5.2 The contents of some Lion Walk medieval/post-medieval pits (quantification based on NISP).

Species	Pits		
	AF15	AF16	CF65
Cow	35	106	130
Sheep/goat	12	203	222
Pig	3	48	116
Chicken	53	104	144

Table 5.1 demonstrates that, in almost all the Roman periods, mallard/domestic duck is the next most common species to be identified, followed by the greylag goose/domestic goose. The medieval bird-bone assemblages reveal that goose becomes a more important item of diet and is the second most commonly-occurring species after domestic fowl. However, it is not certain whether the goose, or indeed the mallard, was domesticated in Roman times. Most bone reports refer to the birds as mallard/domestic duck or greylag goose/domestic goose. Coy has claimed to distinguish between domestic and wild mallard bones by morphological means, while several researchers have compared their bones metrically with known modern wild specimens (Coy 1981; Bacher 1967; Reichstein & Pieper 1986); this presupposes that present-day measurements of wild greylag goose and mallard are the same as those from Roman and medieval times.

5.2 Bird-bone preservation with particular reference to domestic fowl

[Figs 5.1-5.9]

The first stage in any analysis is to account for bone loss through poor preservation and poor recovery. It is crucial to note the type of context where bird remains are found. In medieval Lincoln, fowl and goose bones were found more commonly in pits and structures than in dumps (O'Connor 1982, 232).

Unfortunately, there is a fundamental problem in relating the preservation of avian bone to the contextual evidence in that we do not have a clear idea of how the individual skeletal elements preserve with respect to each other. This is in dire contrast to the situation currently prevailing with the prolific studies on mammalian material. Notwithstanding there have been some valiant approaches made, which have raised interesting possibilities concerning our material (Ericson 1987; Livingston 1989).

In a study of 33 archaeological sites ranging from the Stone Age through the Iron Age, Roman, Saxon and medieval periods, Ericson (1987) demonstrated that domestic fowl legs (femora, tibiotarsi and tarsometatarsi) dominated the later samples with respect to the wing bones (humeri, ulnae and carpometacarpi) and other elements. Two modern samples of wild birds which had been collected from the Baltic region showed the converse, in that the anterior limbs or wing bones were predominant. This predominance of anterior limbs was also found with the Stone Age samples.

Ericson made the assumption that bones from the fore and hind limbs have an equal chance of being preserved and identified. He proposed several explanations for the discrepancies between the numbers of fore and hind limbs recovered. One was the possibility that fowl hind limbs are more robust and another that the presence of unfused bones rendered the anterior extremities more liable to decomposition. He rejected the latter hypothesis, on the grounds that the site of Eketorp had shown the same ratio of wing and leg bones in both adult and juvenile domestic fowl (Boessneck *et al* 1979). The third reason which Ericson (1987) proposed was that natural decomposition factors acted differently between birds prepared for consumption and those which had died naturally.

While not denying that the Ericson measure is informing on taphonomic processes, Livingston (1989) questions whether it is a reliable indicator of human activity in the depositional process. He pointed out that the South African tertiary avifauna of Rich (1980) has a lower percentage of wing bones than some of his Nevada archaeological avifaunas, and clearly the former had not resulted from human intervention *(ibid,* 537). Also, his Humboldt Lakebed archaeological site in Nevada exhibited a very high percentage of anterior elements. The ultimate thrust of Livingston's paper is an important concept which has received scant attention; the key to understanding the preservation pattern lies in the mechanics of the bird skeleton.

Livingston pointed out that American coots in the Nevada Lovelock Cave assemblages show low frequencies of wing bones *(ibid,* 543). He postulated that this may be a consequence of their poor flying ability compared with ducks like teal; coots have more lightly-built wing elements than those of teals which are considerably more robust when compared to similar-sized waterbirds. Indeed, it is not surprising then that the teal assemblage from Lovelock Cave showed a greater profusion of wing bones compared with comparable-sized waterbirds in the same assemblage. Livingston relates the relative robusticity of limb bone elements to the feeding and escape behaviour of birds. Those that feed in shallow water and initiate flight easily, for example ducks of the *Anas* genus, have stronger wing bones than birds that feed in deep water and need to generate much more momentum before taking off for flight, for example grebes and ducks of the genus *Aythya.*

An unequal robustness of different skeletal elements of the house sparrow was demonstrated by Bjordal who found that the humeri and ulnae were measurably more resistant to decay (Bjordal 1987). Coy has mentioned this in conjunction with the high incidence of humeri (and indeed tibiotarsi) from Roman and medieval St Magnus, London, and also Lerna, Greece, where fowl humeri and ulnae were exceptionally abundant (Coy 1983, quoting Armitage & Gejvall 1969). Bjordal also pointed out that bones of adult males may be over-represented in an archaeological sample as compared with those from first-year females (Bjordal 1987). The preservation of immature bird bones has not yet been satisfactorily investigated, and this point should be borne in mind with respect to this section of research.

The total mass of bird skeletons relative to body mass scarcely differs much from mammalian skeletons. However, on a relative scale, while the wing bones are lighter than the arm bones of mammals, the leg bones are heavier in birds than mammals (Schmidt-Nielson 1986, 47). Schmidt-Nielson suggests that this might be because the forces of impact during landing are absorbed by two, as opposed to four, legs in birds.

Both Ericson and Livingston gave hardly any information concerning the contextual evidence of the sites they described. With respect to mammalian bone, it is now very much evident that disparate types of context can preserve material differently and it is thus necessary to question whether the abundance of fowl remains at the Gilberd School and Butt Road is a result of better preservation on these sites. It is notable that these assemblages have already been singled out for their unusual characteristics compared with other Colchester sites.

Figures 5.1-5.2 show the proportional representation of fowl skeletal elements for Roman Gilberd School and Culver Street; this was calculated by isolating the element with the highest minimum number (MNI), and then expressing the remaining elements as a percentage of that particular element. The use of MNI is not normal practice on urban sites due to the effects of retail butchery, but this really applies to medium- and large-sized animal carcasses. It is assumed that breeding, rearing, slaughtering, cooking and consumption of fowl were generally activities that could be carried out in the average person's back-yard.

We have already commented on the rural nature of Roman and medieval urban settlements, particularly with regard to 'green areas' in towns (Section 1.2). One appalling problem which Roman and medieval men and women would have had to cope with, and one that we do not even consider, is the incidence of deleterious insects to growing plants, trees and shrubs. How did they manage even low-key market gardening before the advent of pesticides? The chicken has a natural advantage with its beak in picking parasites off vegetation. Indeed, '...what are enemies to plant life are frequently nutritious to poultry' (Brown E 1930, 167). This does not mean that there were no specialists dealing in poultry, but rather that there would be an incentive for the ordinary person to raise fowl. Further there is great manurial value to be had from wandering poultry, and pasture and arable land can be considerably improved. Contemporary classical authors rate poultry manure highly; it is rich in nitrogen and contains good percentages of phosphorus and potassium. The value of poultry manure lies in the fact that it is comprised of both a solid and liquid component, the latter containing most of the nitrogen and the former high percentages of phosphoric acid and potash (White 1970, 127). Incidentally, Varro considered the dung of turtle doves to be preferable to all others (Varro, *De Re Rustica,* III.8.3).

Returning to Figures 5.1-5.2, the relative percentage frequency of the elements is practically identical (solid line), and while there are some differences between the proportional representations, there are broad similarities. Leg bones are strongly emphasised and occur in almost identical proportions with the more fragile bones, for example clavicle, sternum and skull being barely visible. The Gilberd School has a higher occurrence of the ulnae. However, in general the emphasis would appear to be on the leg bones.

Balkerne Lane and Butt Road are illustrated in Figures 5.3-5.4. Again, the relative percentages of the skeletal elements are comparable to those in Figures 5.1-5.2. The proportional representation of the Balkerne Lane elements is similar to the Gilberd School and Culver Street, apart from the lower numbers of radii at

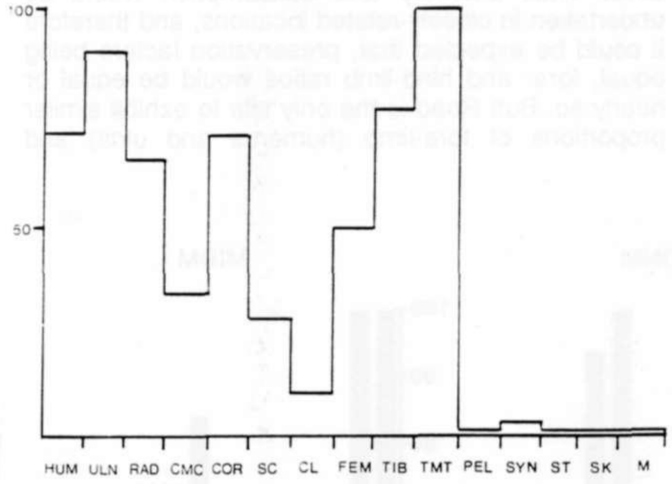


Fig 5.1 Relative percentage bar chart: distribution of domestic fowl skeletal elements from Roman Gilberd School.
[Pages 84-85]

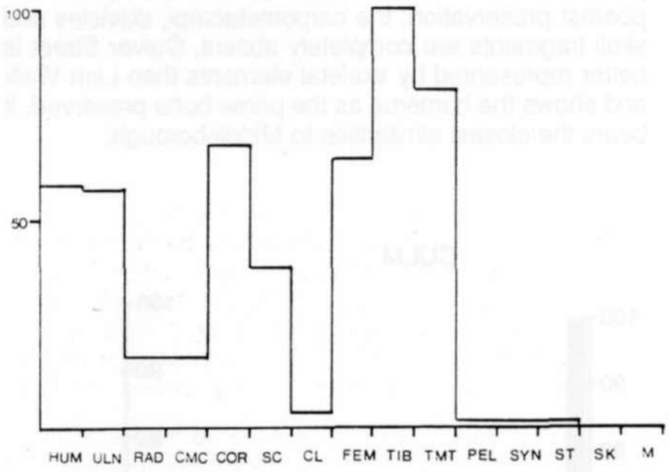


Fig 5.3 Relative percentage bar chart: distribution of domestic fowl skeletal elements from Roman Balkerne Lane.

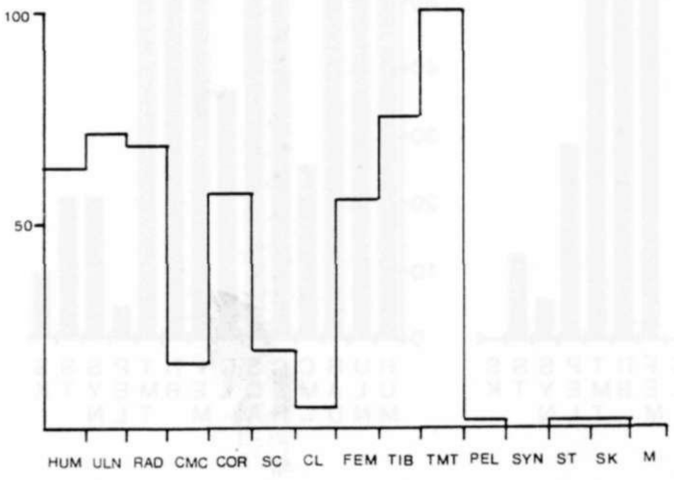


Fig 5.2 Relative percentage bar chart: distribution of domestic fowl skeletal elements from Roman Culver Street.
[Pages 84-85]

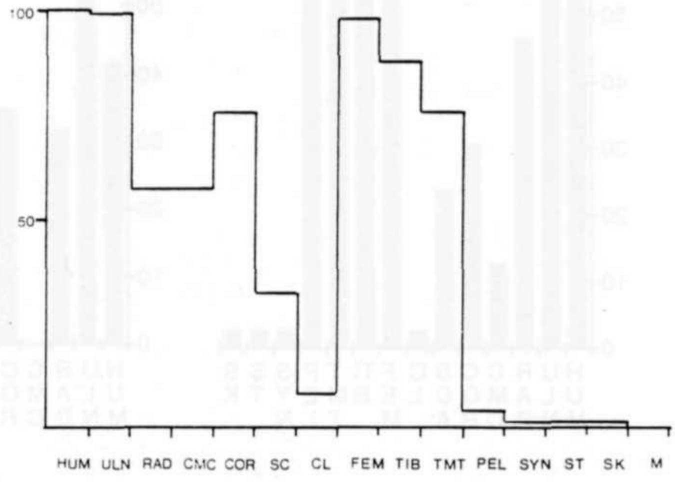


Fig 5.4 Relative percentage bar chart: distribution of domestic fowl skeletal elements from Roman Butt Road.

Key:
HUM...humerus; ULN...ulna; RAD...radius; CMC.carpometacarpus; COR...coracoid; SC...scapula; CL...clavicle; FEM...femur; TIB...tibiotarsus; TMT... tarsometatarsus; PEL...pelvis: SYN...synsacrum; ST...sternum; SK...skull; M...mandible.

Balkerne Lane. Legs are the best-preserving element. However, Butt Road is different in that the wing-bone elements (humeri and ulnae) have preserved just as well, if not slightly better than the leg bones. Even the carpometacarpus, which is quite small in the chicken, has survived well. The skull and trunk elements have not preserved well, as indeed is the case on other sites. It is curious and tantalising that the Butt Road fowl has preserved so well in view of the fact that the mammalian bone was so highly fragmented.

Figures 5.5-5.7 show the medieval assemblages of Culver Street, Lion Walk and Middleborough. Middleborough shows comparable preservation to Butt Road with respect to the wing-bone elements, the humeri and ulnae; however, the leg bones are not so strongly represented and the number of carpometacarpi is tow. The sterna and skull remains show the best preservation of all the sites. Lion Walk shows the poorest preservation; the carpometacarpi, clavicles and skull fragments are completely absent. Culver Street is better represented by skeletal elements than Lion Walk and shows the humerus as the prime bone preserved. It bears the closest similarities to Middleborough.

Figure **5.8** simply depicts the major sites which have been examined, both Roman and medieval. It is clear that the fore limbs (humerus, ulna and radius) and hind limbs (tibiotarsus and tarsometatarsus) are the major elements to preserve. Poor retrieval probably accounts for the low incidence of the carpometacarpus, while the clavicle, pelvis, and skull bones are more fragile and hence susceptible to disintegration.

It is necessary at this stage to examine the contextual evidence in order to detect whether individual features are responsible for preservation at the gross site level. Figure **5.8** is split into its component parts in Figure **5.9.** It is assumed that today's supermarket system of selling legs and wings separately was not in operation during Roman and medieval times. Without refrigeration and with the dangers of salmonella poisoning, one would expect poultry to have been sold alive. Thus butchery and consumption would be undertaken in closely-related locations, and therefore it could be expected that, preservation factors being equal, fore- and hind-limb ratios would be equal or nearly so. Butt Road is the only site to exhibit similar proportions of fore-limb (humerus and ulna) and

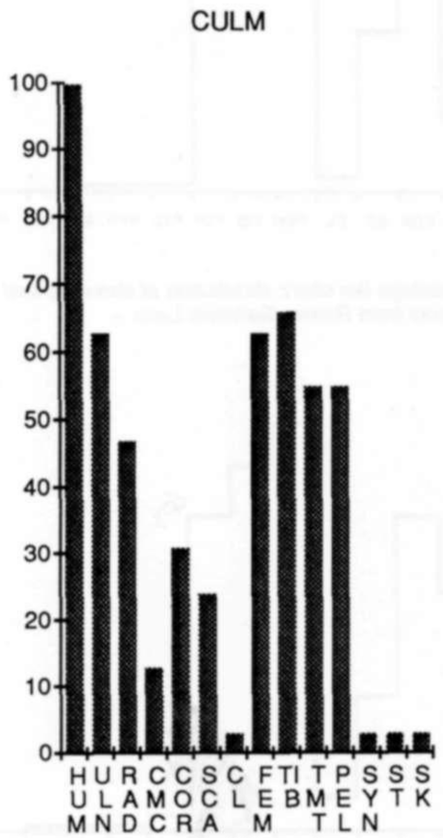


Fig 5.5 Relative percentage bar chart: distribution of domestic fowl skeletal elements from medieval Culver Street.

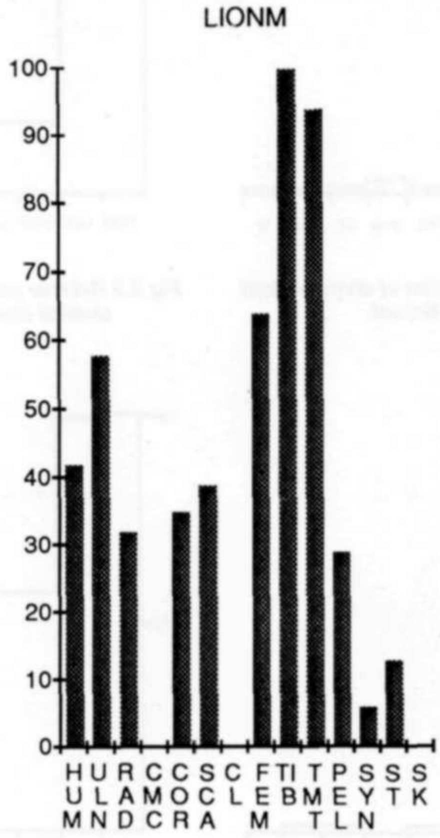


Fig 5.6 Relative percentage bar chart: distribution of domestic fowl skeletal elements from medieval Lion Walk.

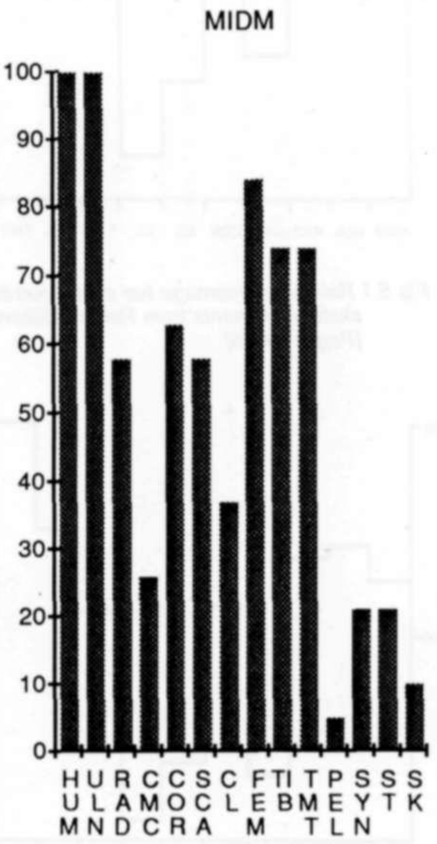


Fig 5.7 Relative percentage bar chart: distribution of domestic fowl skeletal elements from medieval Middleborough.

Key:
HUM...humerus; ULN...ulna; RAD...radius; CMC...carpometacarpus; COR...coracoid; SCA... scapula; CL...clavicle; FEM..femur; TIB. . . .tibiotarsus; TMT...tarsometatarsus; PEL...pelvis;SYN.synsacrum; ST...sternum; SK...skull.

hind-limb (femur and tibiotarsus) bones. The radius is low compared to the humerus and ulna, but this bone is notoriously misidentified by analysts and if fragmented is not easy to spot. The carpometacarpus is reasonably well represented considering its small size, but the skull is poorly represented; however, it should not be forgotten that the Butt Road sample emanated from the context type of demolition debris. Since the wing and leg bones show fairly equal abundance, it would appear most likely that the bone material has not moved far from its original place of deposition, and that the more fragile head elements have disintegrated.

There is a distinct difference in preservation between the pits and occupation levels of the Gilberd School (Fig **5.9.**a & e). In the occupation levels, the ulnae and tarsometatarsi have preserved well but the other bones are poorly represented, in particular the coracoid which has preserved much better amongst all the other groups. This is not unexpected as the bones would have suffered much from exposure and abrasion. The pits of the Gilberd School afforded improved protection for the bones; the humerus of the fore limb is the most abundant element, and the tibiotarsus and tarsometatarsus are well preserved.

The medieval pits at Culver Street (Fig **5.9d)** show an emphasis on the fore-limb element, especially the humerus, while the Roman pits of Culver Street (Fig **5.9b)** and Balkerne Lane (Fig **5.9c)** show the leg as the dominant element, as is the tarsometatarsus at Culver Street and also the tibiotarsus at Balkerne Lane. There are great similarities between the Roman dumps of the Gilberd School and Culver Street (Figs **5.9f & 5.9g).** The profiles are similar in that, while the leg dominates, there is a fairly equal representation of the fore and hind limb elements. Again the skull fragments are very poorly preserved. In conclusion, in interpreting these bar charts it must be remembered that taphonomical considerations only hold good as long as retrieval methods and levels of identification are adequate. Assuming that this is so, Butt Road, and to a certain extent the Gilberd School, evince evidence that the chicken carcasses have been butchered and consumed on site.

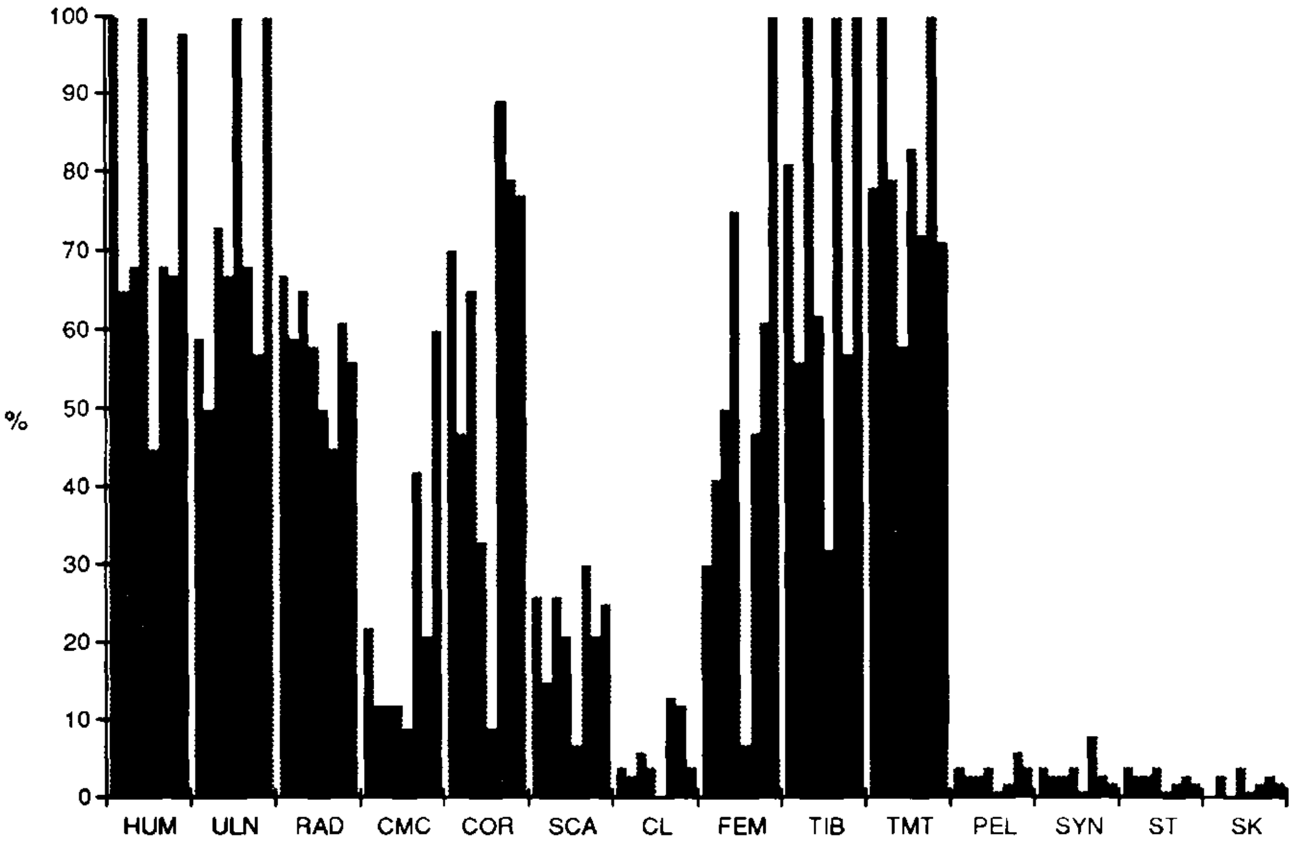


Fig 5.8 Bar chart: distribution of Roman and medieval domestic fowl skeletal elements. [Page 86}

Key:
HUM...humerus; ULN...ulna; RAD...radius; CMC.carpometacarpus; COR...coracoid; SCA...scapula; CL...clavicle; FEM...femur; TIB...tibiotarsus; TMT...tarsometatarsus; PEL..pelvis; SYN. . . . . .synsacrum; ST...sternum; SK..skull.

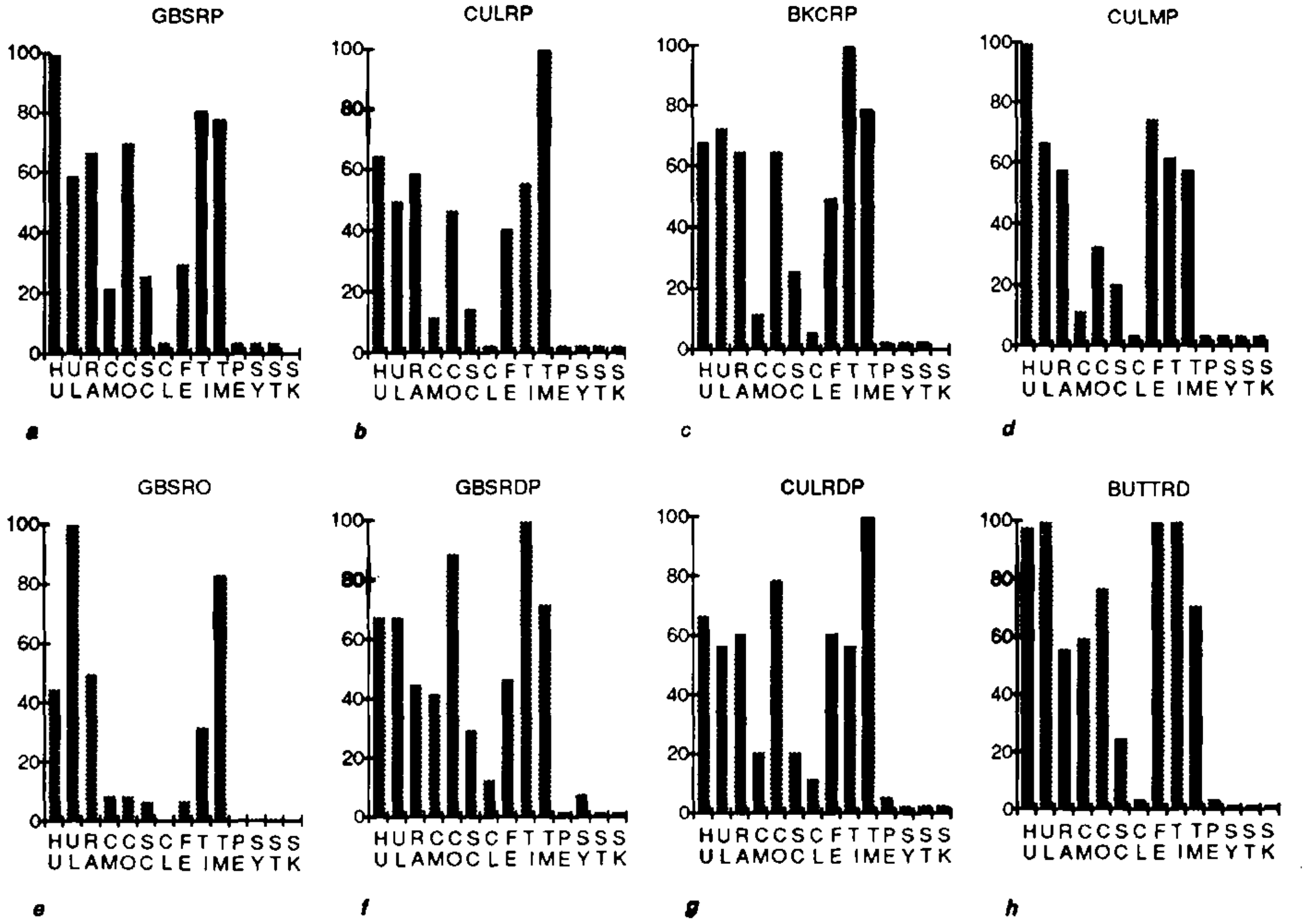


Fig 5.9 Bar charts: distribution of domestic fowl skeletal elements by context and period. [Pages 86-87]

Keys:
Roman pits (GBSRP, CULRP, BKCRP)
Medieval pits (CULMP)
Roman occupation levels (GBSRO)
Roman dumps (GBSRDP, CULRDP)
Demolition debris (BUTTRD)

HU...humerus; UL...ulna; RA...radius; CM...carpometacarpus; CO...coracoid; SC...scapula; CL...clavicle; FE...femur; TI. tibia; TM...tarsometatarsus; PEL..pelvis; SY...synsacrum; ST...sternum; SK...skull.

5.3 **Uses of domestic fowl**
[Table 5.3]

As well as providing manure and being effective eradicators of parasites, fowl provide meat, eggs, feathers, and down. If the birds were being kept for meat one might expect them to have been caponised. This could result in immature bones being found. However, we do not know at what time in life the birds were caponised. Markham, writing in the 17th century, suggested caponisation between 14 and 21 days, hence the birds killed may not have been old enough to develop a spur core (Markham 1633), while Richardson (1851) suggested caponising birds at 3 months of age.

The tarsometatarsus is the prime bone used for sexing chickens, males being spurred and females unspurred. However, it is known that occasionally females can develop spurs and some males do not develop spurs. While it would be reasonable to assume that capons would be intermediate in size between cockerels and hens, West (1982) has shown that some capons can have larger and longer spurs even than those of cockerels.

Table 5.3 compares the percentages of fused and unfused long bones for the main Colchester sites by period; the majority of bones in all periods were fused.

Egg-laying birds as opposed to meat-yielding ones can be identified by the incursion of medullary bone in the long bones. Medullary bone concentrates in the marrow spaces of bones with a good blood supply. This occurs in the fowl fourteen days before it comes into lay. Simkiss (1967) has shown that the femur is

Table 5.3 Domestic fowl long-bone fusion.
[Page 88]

Site	Date	Fused	Unfused
BKC1	44-60/1	81	19
BKC2	60/1-150	73	27
BKC3	150-400+	88	12
BUTT4E	320-400+	91	9
CUL1	44-60/1	94	6
CUL2	60/1-150	93	7
CUL3	150-400+	84	16
CUL7/8	MED	93	7
GBS1	44-60/1	96	4
GBS2	60/1-275	92	8
MID2	MED	98	2
MID3	PM	95	5
LWC	MED	86	14

The best bone to use when investigating medullary bone. Further it is a good diagnostic bone since it can be easily distinguished from the pheasant *(Phasianus colchicus)* and peacock *(Pavo cristatus).*

Unfortunately medullary bone is rarely found in the tarsometatarsus. In agreement with Driver we found that X-raying did not detect medullary bone very easily, particularly with small quantities. Thus a hand-drill was employed in making a small hole into the medulla of the long-bone shaft (femur). This was accomplished after measurements had been taken (Driver 1982). Initially, since the method was quite time-consuming, just the Lion Walk samples were analysed for medullary bone. Only two bones showed medullary bone and these were Roman; none of the later samples for the 15th to 16th centuries or 17th to 18th centuries exhibited this phenomenon. Caution must be exercised in this analysis since the samples are very small. Further, the absence of medullary bone does not necessarily mean that the birds did not produce eggs.

5.4 **A metrical study of domestic fowl**

[Figs 5 10-5.26]

A histogram of tarsometatarsus greatest length for the collective Roman chicken sample exhibits a bimodal distribution, and this most likely reflects gender (Fig 5.10).

Figure 5.11 is a histogram which presents the tarsometatarsus spur-core length and shows again a bimodal distribution, which could be a result of differences in breed, sex (cockerels and capons), and/or nutrition. Possibly some of the smaller specimens are hens; however, the vast majority of specimens are assumed to be male since spurred hens occur relatively infrequently.

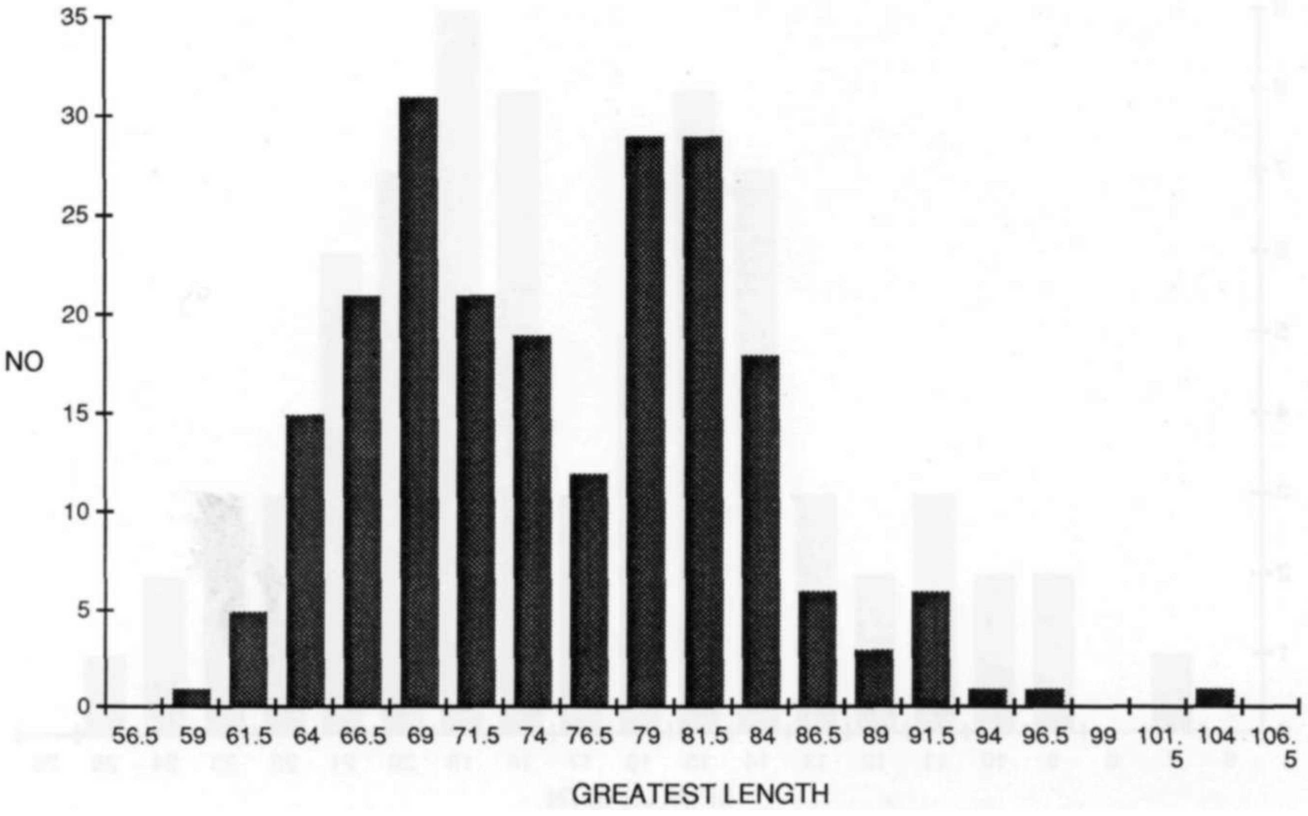


Fig 5.10 Histogram: Roman domestic fowl tarsometatarsi greatest length in mm.

If the greatest length of the Roman tarsometatarsus is plotted against spur length as in Figure 5.12, the largest bones tend to display the longest spurs. West (1982, 259) suggests that the largest tarsometatarsi with the longest spurs in an archaeological collection are fairly likely to be capons. She cites research in which the spur and spur core were measured at successive ages, the end result being that length at all ages was greater in capons than in cockerels (Quigly & Juhn 1951, after West 1982).

If Roman tarsometatarsi greatest lengths are plotted against proximal widths, a separation of females (unspurred, lower end of scale) and males (spurred, upper end of scale) can be observed (Fig 5.13). There are quite a few large unspurred specimens which occur within the lower range of the spurred ones. This is fairly characteristic of plots throughout the Roman and medieval periods, and is thought to indicate different breeds of fowl. The male plots show a greater range of variation, with a few very large specimens at the upper end of the scattergram. The scattergram also indicates that male birds are relatively abundant in the samples, although hens are the dominant sex. The abundance of male birds points to cock-fighting being a popular form of entertainment during the Roman period. Prummel analysed fowl from the Roman *castellum* Velsen 1 in the Netherlands, dated to AD 15-30 (Prummel 1987, fig 3). She explained the predominance of males by the fact that male domestic fowls have more meat than hens and that cock-fighting may have been a favourite pastime amongst the soldiers.

A tarsometatarsus with a chopped-off spur was recovered from Roman Culver Street (CUL EF1006, AD 49-60/1). Removal of spurs was probably undertaken to stop male birds fighting. Several tarsometatarsi exhibit pathological/deformed spurs and two are shown in Figures 5.14-5.15. These and other similar specimens are marked in the scattergram of spurred individuals with crosses (Fig 5.16). Classical authors have stated that burning off the spurs was a way of castrating fowl (Luff 1984, 39 after Varro, *De Re Rustica,* III.9). It seems likely that after amputation, the spur stump would have been cauterised with a red-hot iron to staunch the blood flow from the major artery in the spur core. Perhaps the individuals illustrated in Figures 5.14-5.15 are the end result of attempted caponisation by spur removal, although they could equally well have been fighting cocks. It is suggested that after spur (and core) removal, bone at the spur-core base has reacted by remodelling. Thus these birds survived the operation, unlike the individual illustrated in Figure 5.22.

In the amputation of human limb bones, Steinbock and Stewart (1976, 36) state that after several weeks to months, endosteal callus forms a cap over the medullary cavity; a complete bony cap is not always produced but in all cases there is a rounding and

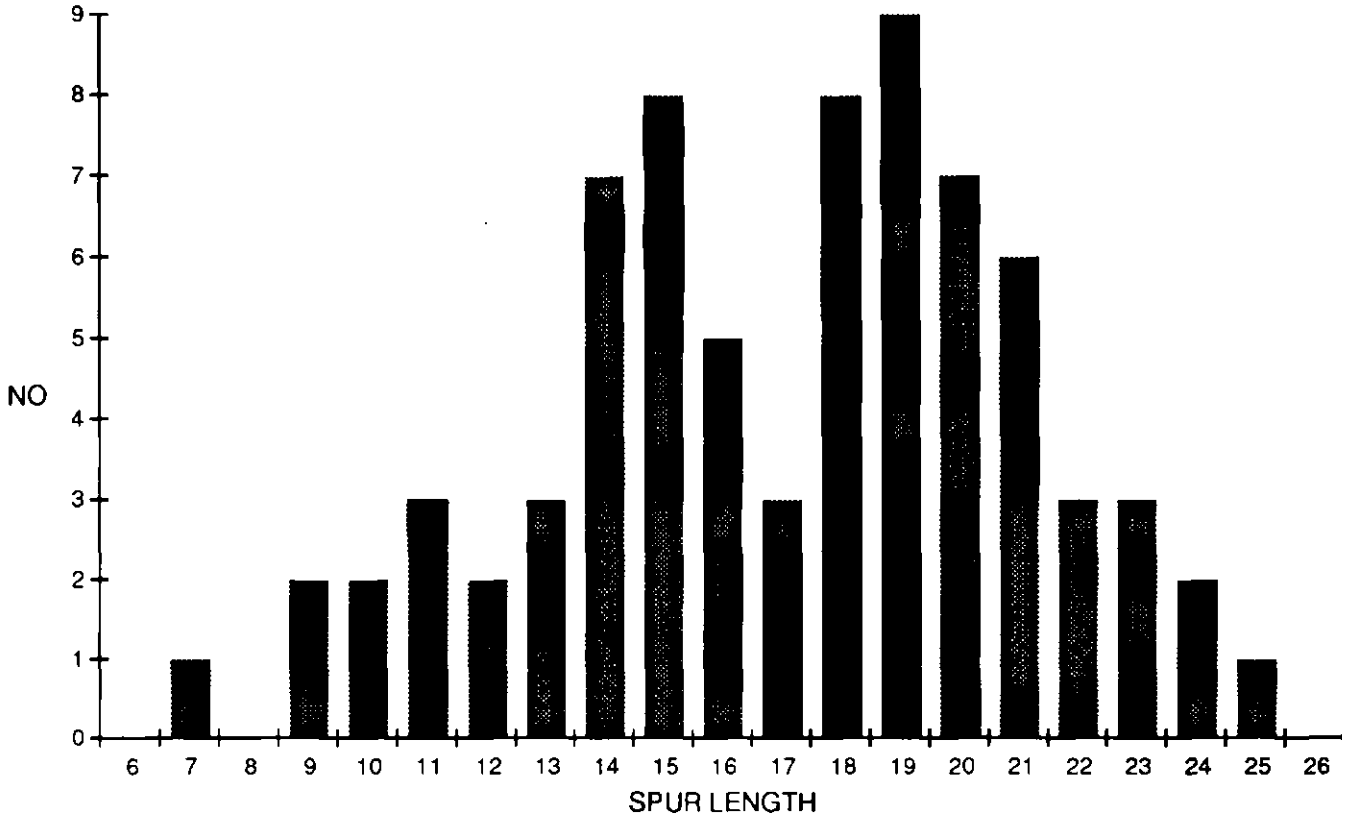


Fig 5.11 Histogram: Roman domestic fowl tarsometatarsi spur-core length in mm. [Page 89]

smoothing of the stump. The main characteristics of the spur cores illustrated in Figures 5.14-5.15 are roundedness and smoothness. However, we should be cautious in this interpretation since bone growth of the spur core might be different from other skeletal parts in the chicken and indeed other species.

An examination of scatterplots for particular Roman phases, for example AD 44-60/1 and 60/1-300, show that while there is a general separation of two groups (spurred and unspurred), spurred individuals occur among the unspurred group while some rather large unspurred specimens occur within the spurred group (Figs 5.17-5.18). The scattergram for AD 200-400+ is similar to those of AD 44-60/1 and 60/1-300, but no males are observed within the female grouping (Fig 5.19). However, all the Roman scattergrams show that the pathological specimens only occur within the larger male grouping.

Figures 5.20-5.21 are scattergrams of chicken tarsometatarsus greatest length against proximal breadth for the medieval and post-medieval periods respectively. The scattergram for the medieval period does not show the clear separation into two groups as does the one for the Roman period; however, most of the unspurred specimens congregate in the lower end of the graph and clearly hens are the dominant sex. There is less data available for the post-medieval chickens but again it would appear that the dominant group is female (Fig 5.21).

At Lion Walk, excavation of a pit (AF16) revealed the carcasses of nine adult and three immature fowl amongst which was a cock tarsometatarsus with a sawn-off spur dated to the late 15th to early 16th centuries (Fig 5.22). In modern France, spurs are sawn off so that steel replacements can be attached to aid the cock in fighting (West 1982, 260).

Box-and-whisker plots were used to view any size changes of the fowl through time (after Norusis 1988). Figure 5.23 shows the range of size for the greatest lengths of the unspurred tarsometatarsi as seen through the Roman, medieval and post-medieval periods. The asterisk in the middle of the box is the median, the measure of central tendency. The lower boundary of the box is the 25th percentile and the upper boundary is the 75th percentile. Fifty per cent of the cases have values within the box. Cases which are more than 3 box-lengths from the upper or lower edge of the box are called extreme values. On the box-plot these are designated with the letter 'E'. Cases with values between 1.5 and 3 box-lengths from the edge of the box are called outliers and are designated with the letter 'O'. The largest and smallest observed values that are not outliers are also shown. Lines are drawn from the ends of the box to these values. It is these lines which are the whiskers.

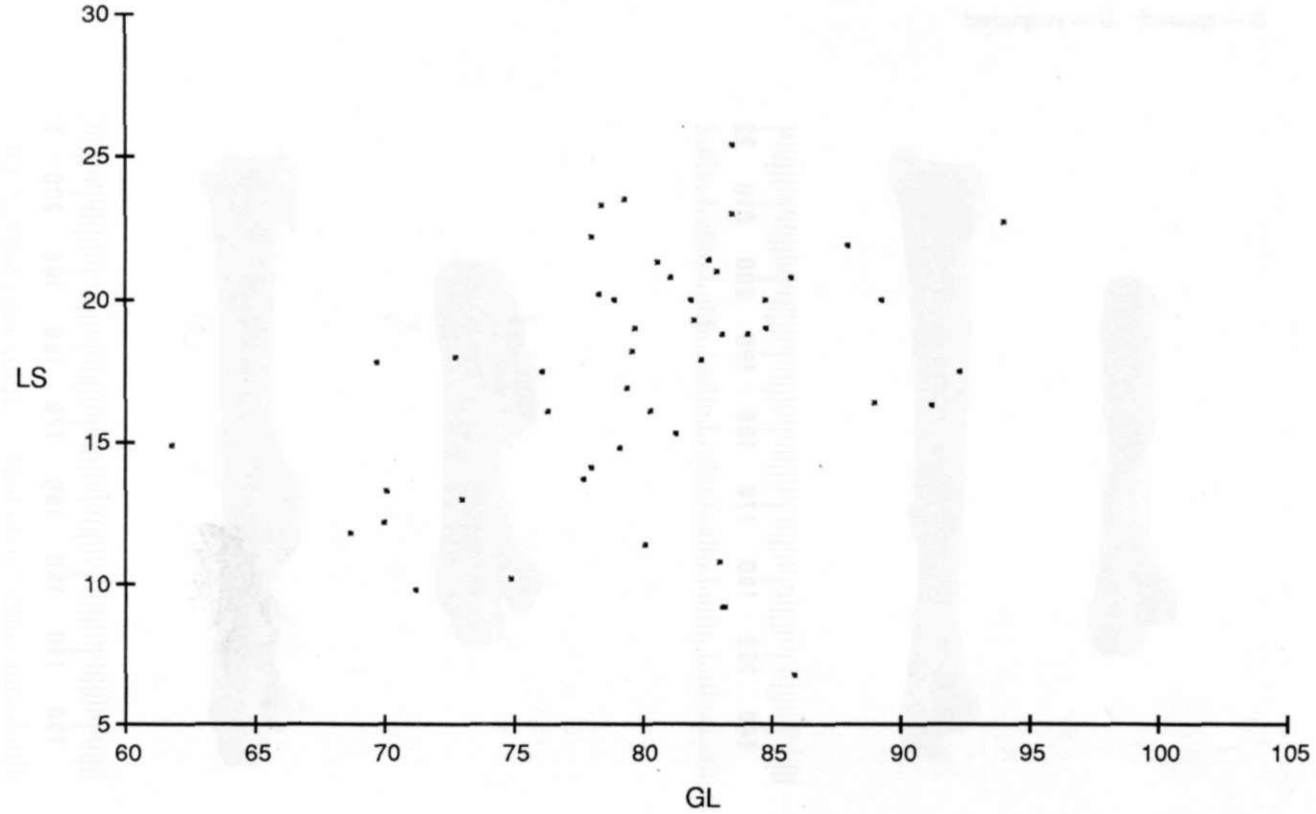


Fig 5.12 Scattergram: Roman domestic fowl tarsometatarsi greatest length (GL) against spur-core length (LS) in mm. [Page 90]

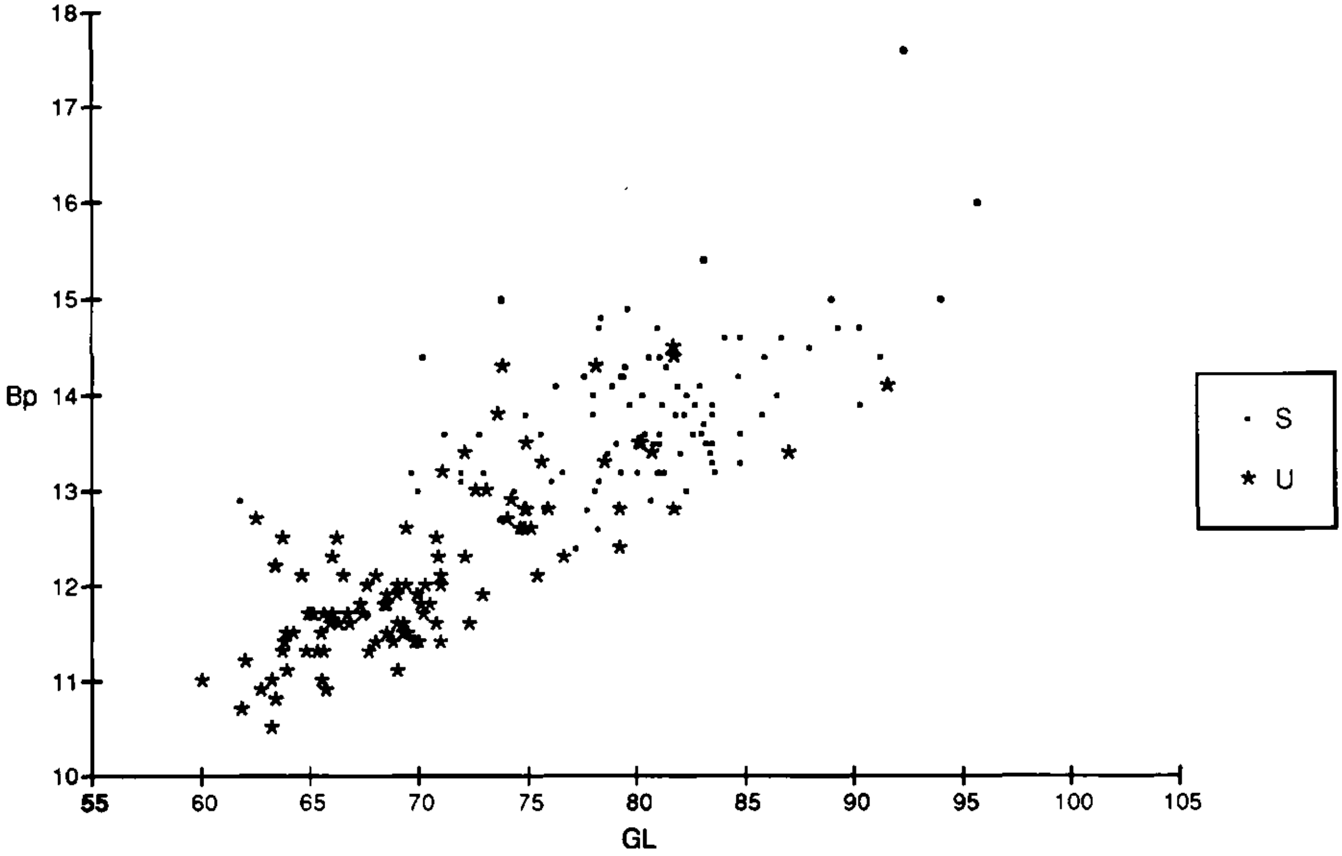


Fig 5.13 Scattergram: Roman domestic fowl tarsometatarsi greatest length (GL) against proximal tibia (Bp) in mm. [Pages 90. 97]

S — spurred; U — unspurred

Fig 5.14 Domestic fowl tarsometatarsi with pathological/deformed spur core (Roman period) — medial view. [Pages 90-91]

Fig 5.15 Domestic fowl tarsometatarsi with pathological/deformed spur core (Roman period) in Fig 5.14 — anterior view [Pages 90-91]

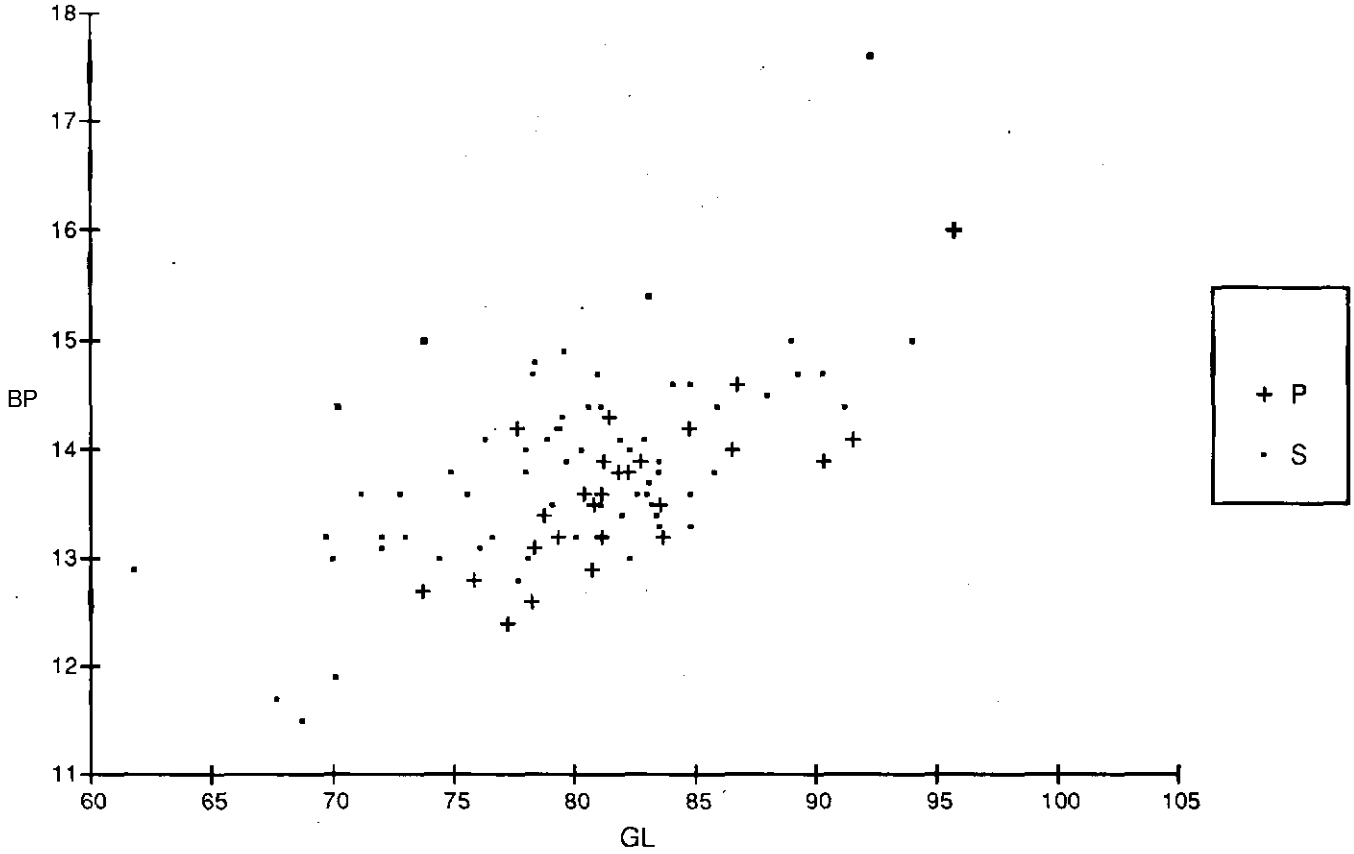


Fig 5.16 Scattergram: Roman domestic fowl spurred tarsometatarsi greatest length (GL) against proximal width (Bp). A view of the upper cluster of points in Fig 5.13. [Page 90]
P — pathological/deformed spurs; S — spurred

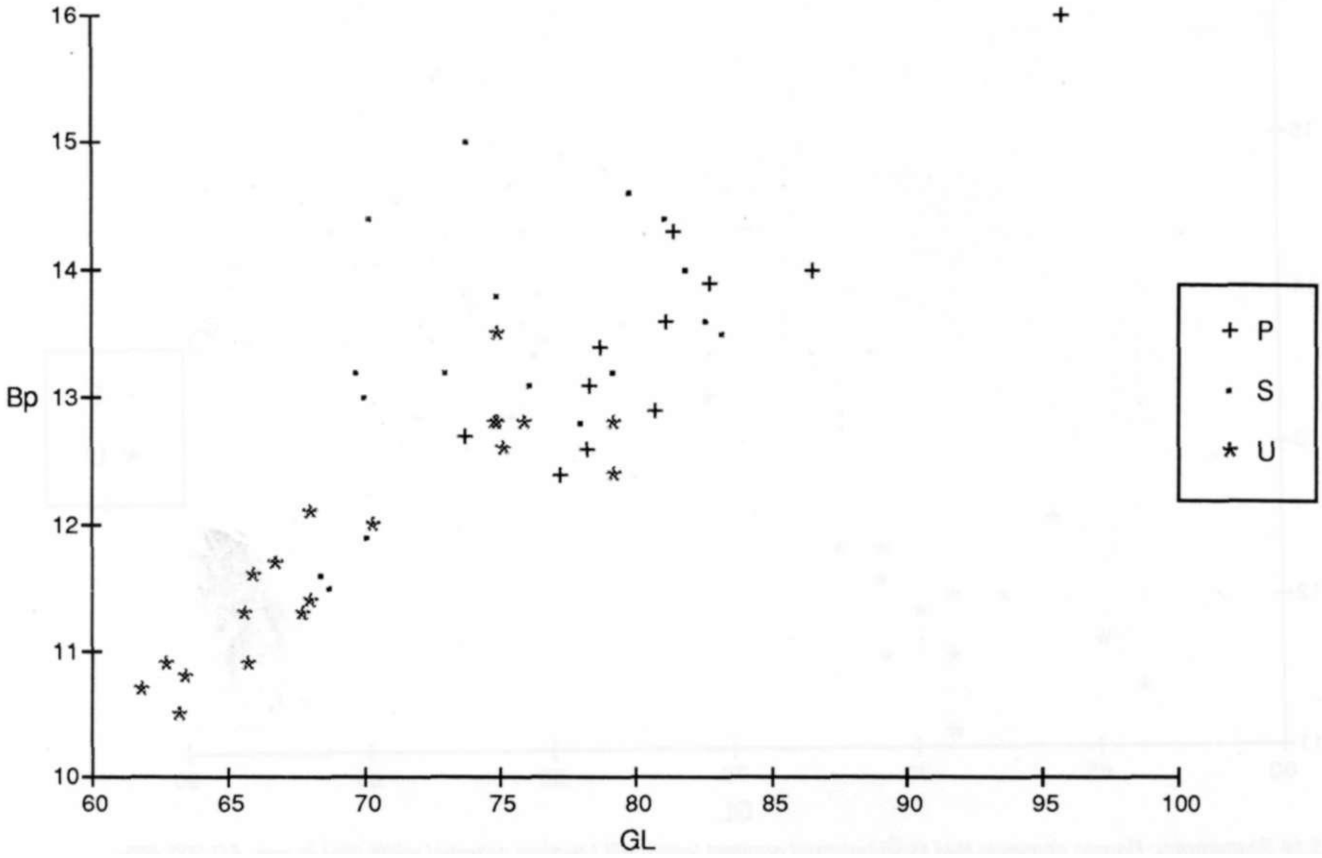


Fig 5.17 Scattergram: Roman domestic fowl tarsometatarsi greatest length (GL) against proximal width (Bp) in mm, AD 44-60/1. [Page 91]
P — pathological/deformed spurs; S — spurred; U — unspurred

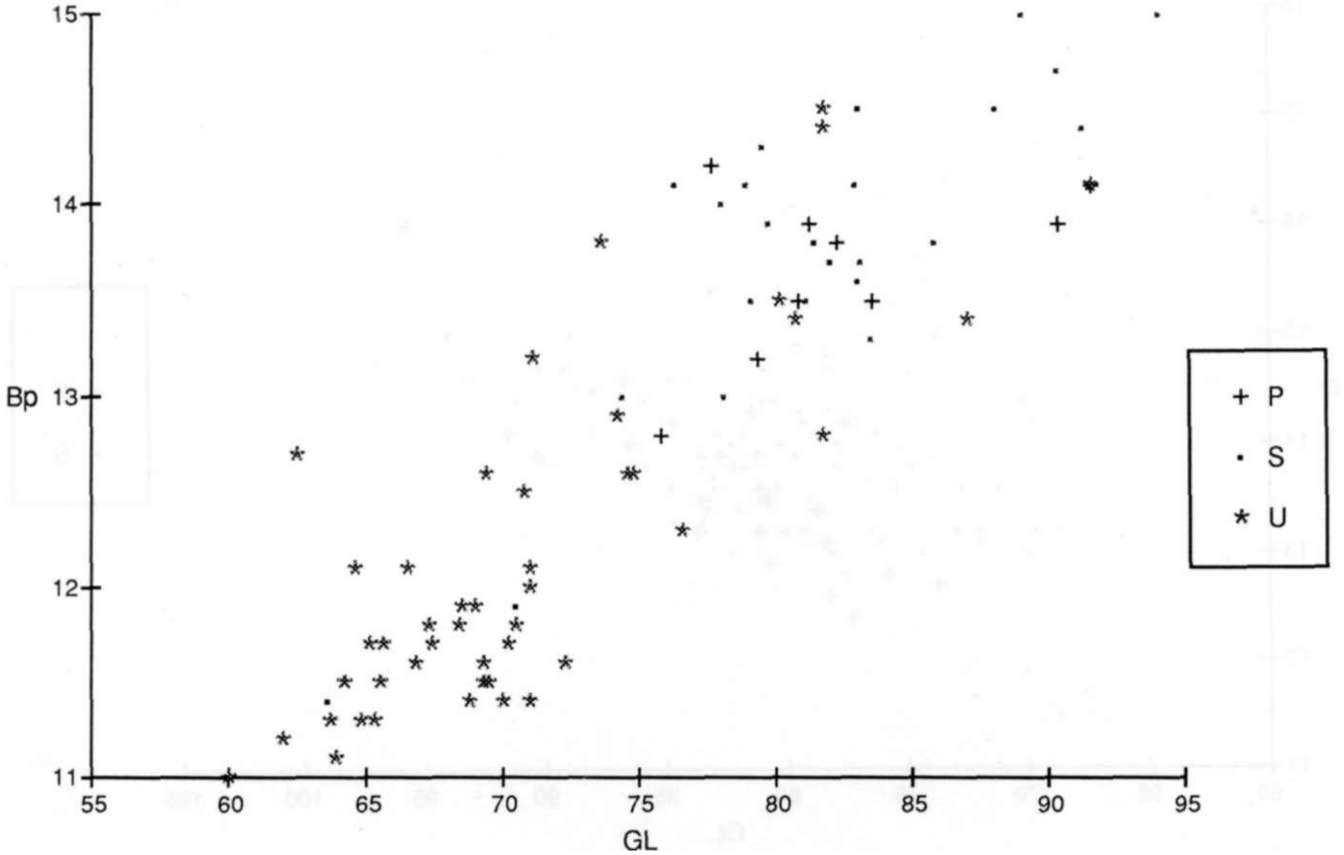


Fig 5.18 Scattergram: Roman domestic fowl tarsometatarsi greatest length (GL) against proximal width (Bp) in mm, AD 60/1-300. [Page 91]
P — pathological/deformed spurs; S — spurred; U — unspurred

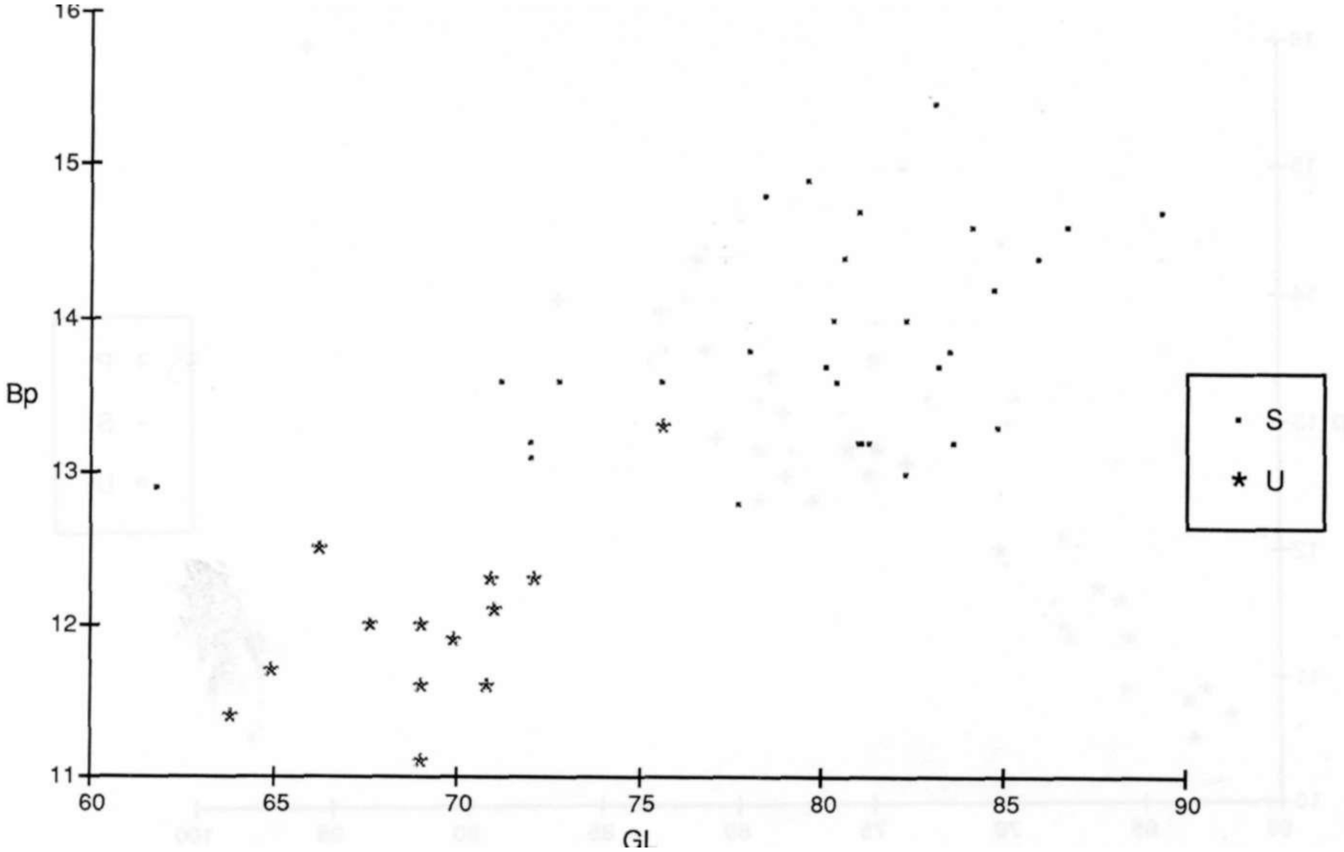


Fig 5.19 Scattergram: Roman domestic fowl tarsometatarsi greatest length (GL) against proximal width (Bp) in mm, AD 200-400+. [Page 91]
S — spurred; U — unspurred

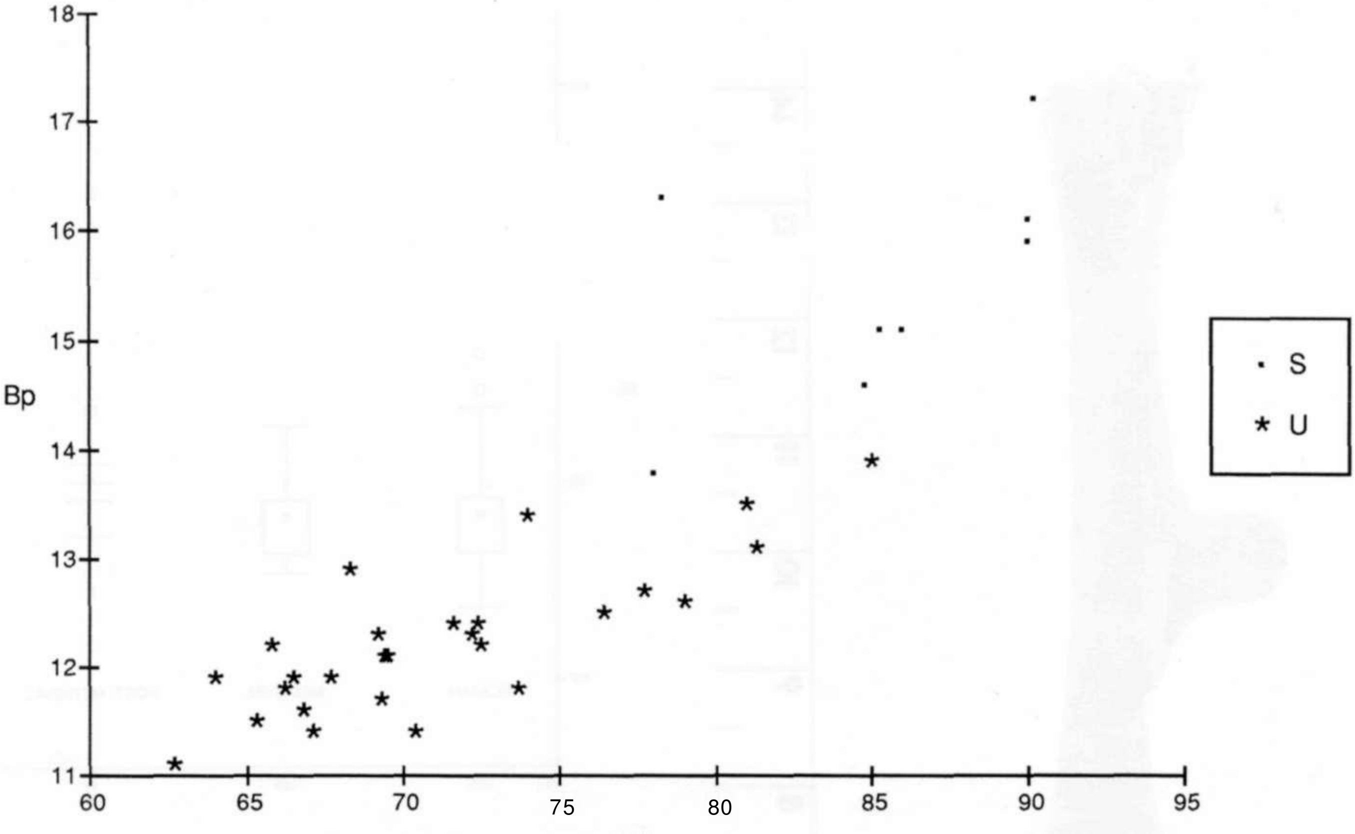


*Fig 5.20 Scattergram of medieval domestic fowl tarsometatarsi greatest length (GL) against proximal width (Bp) in mm. [Page 91]
S — spurred; U — unspurred*

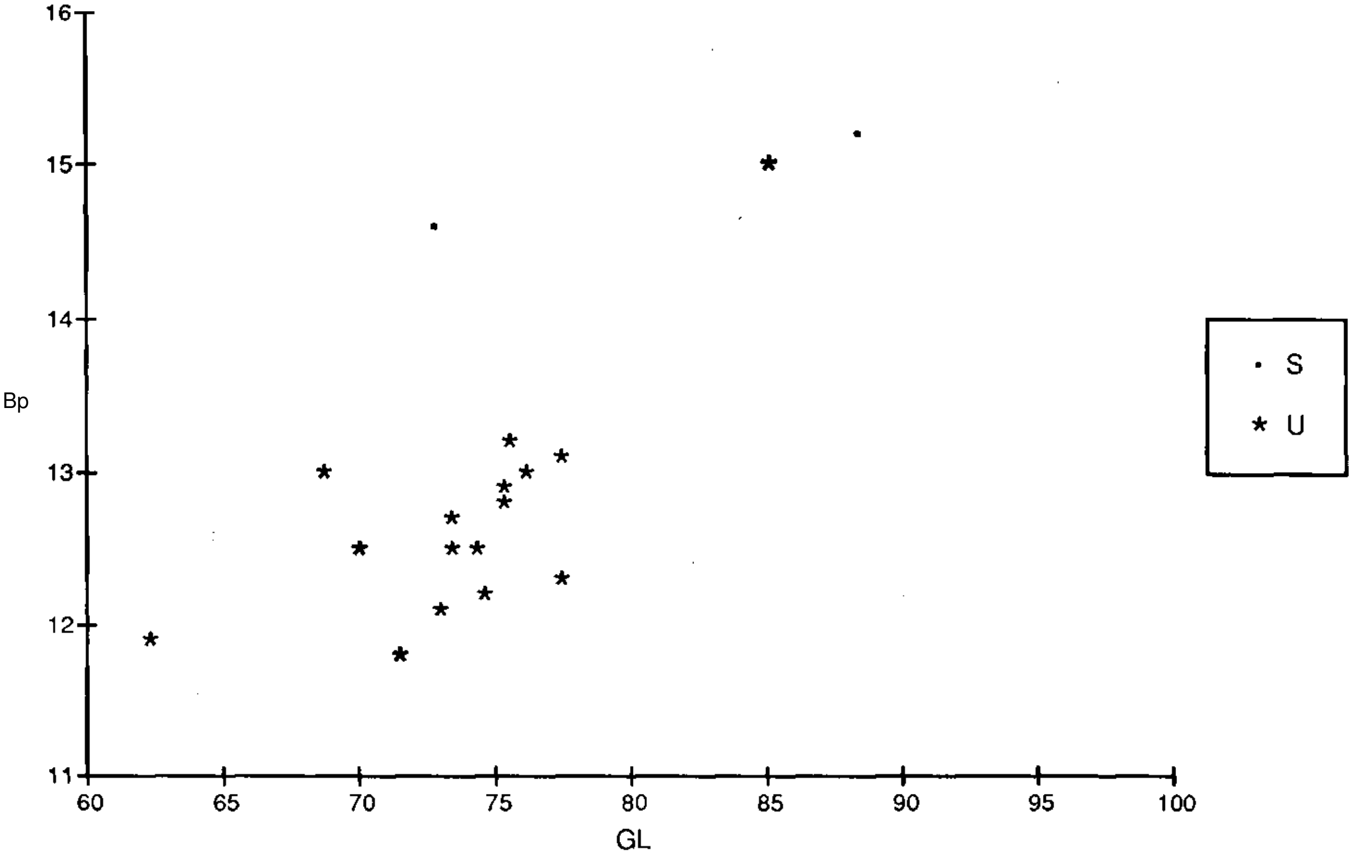


*Fig 5.21 Scattergram of post-medieval domestic fowl tarsometatarsi greatest length (GL) against proximal width (Bp) in mm. [Page 91]
S — spurred; U — unspurred*

Fig 5.22 Domestic fowl tarsometatarsus (LWC AF16; 15th to early 16th centuries) showing sawn-otf spur core — posterior view. [Pages 90-91]

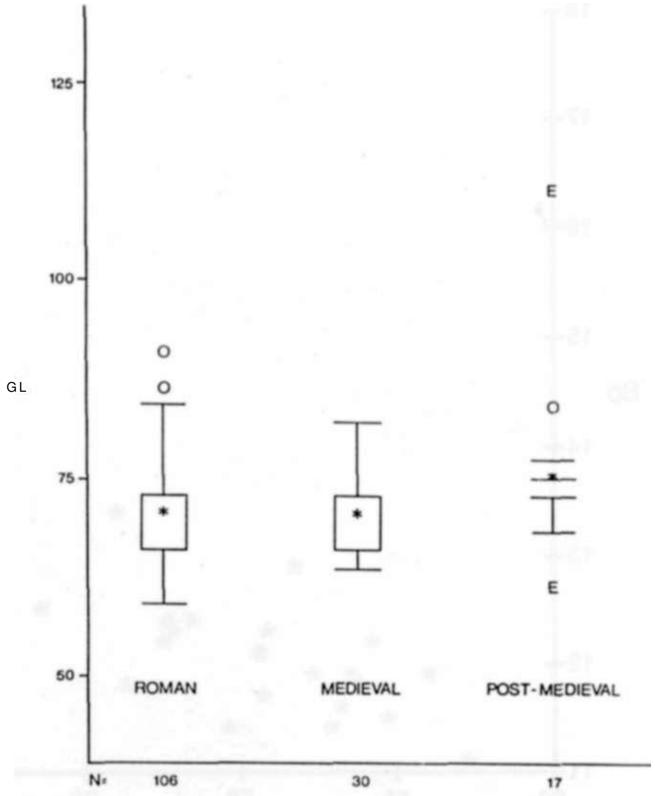


Fig 5.23 Box-and-whisker plots of Roman, medieval and post-medieval domestic fowl tarsometatarsi greatest length (GL) in mm, unspurred individuals.

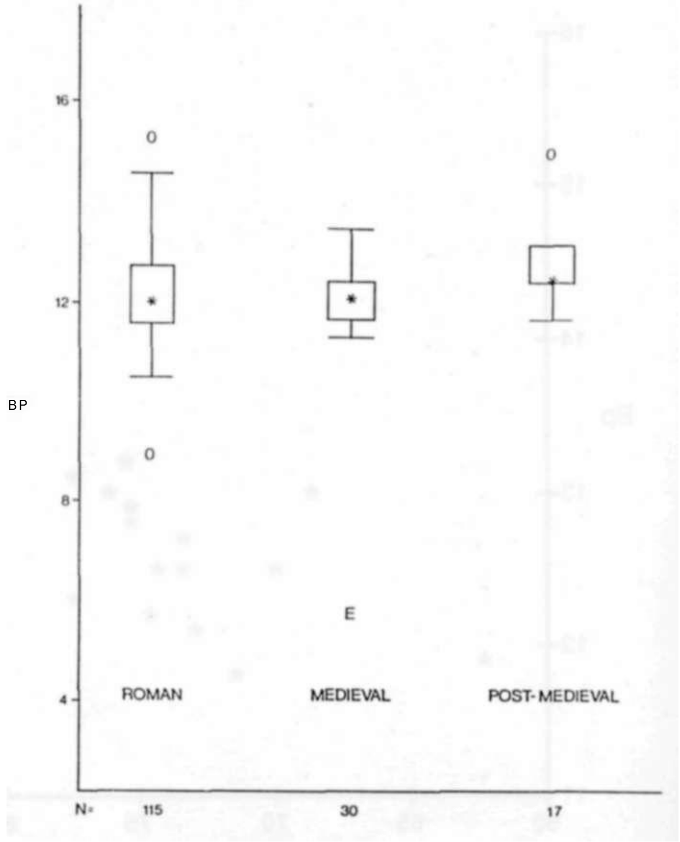


Fig 5.24 Box-and-whisker plots of Roman, medieval and post-medieval domestic fowl tarsometatarsi proximal width (Bp) in mm, unspurred individuals.

In Figure 5.23, the Roman sample shows the greatest range of variation, which is not surprising since it is comprised of the greatest number of bones. The median is much higher placed in the post-medieval period. If the proximal width is considered, again the Roman sample shows a greater range of points but the post-medieval tarsometatarsi appear slightly larger (Fig 5.24). In order to test whether there was a significant difference in size between the Roman, medieval and post-medieval birds, the non-parametrical Mann-Whitney U Test was employed. This did indeed confirm that there was a significant difference at 0.05 probability level between the Roman and post-medieval birds, both for greatest length and proximal width. There were not enough spurred individuals in the medieval and post-medieval groups for the same comparison.

A wide variation in size is indicative of poultry breeds. Identification of different varieties of chicken is tricky, but an attempt was made by Eastham with the Roman Fishbourne bones where she plotted length against distal width measurements for the ulnae, humeri and

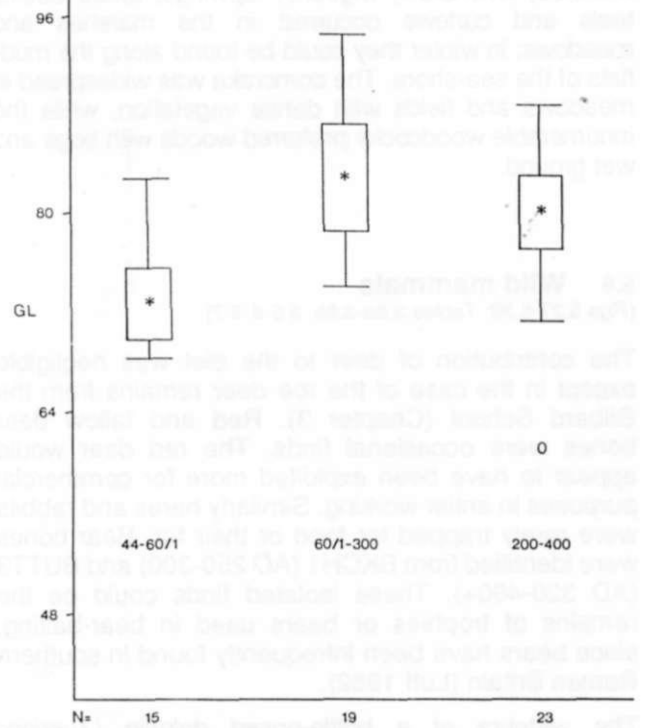


Fig 5.25 Box-and-whisker plots of Roman domestic fowl tarsometatarsi greatest length (GL) in mm, spurred individuals.

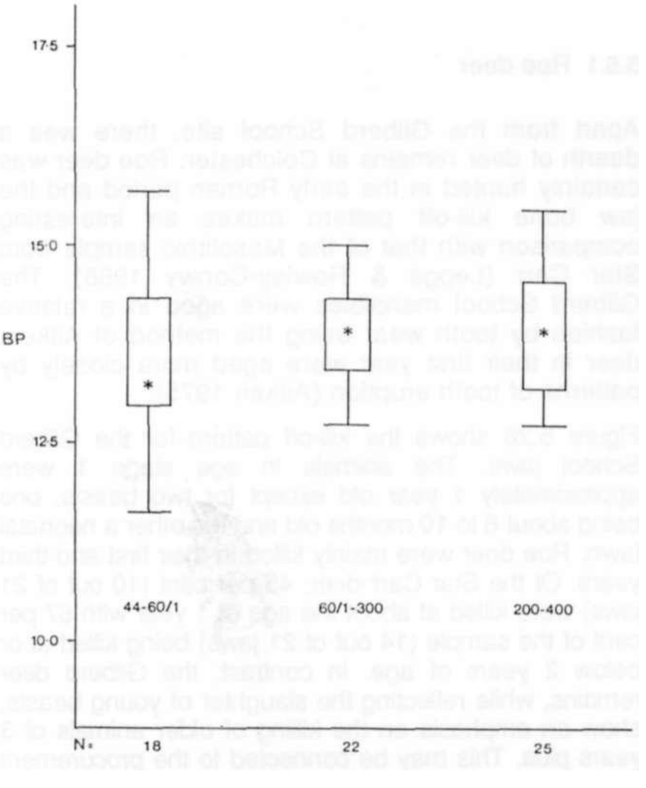


Fig 5.26 Box-and-whisker plots of Roman domestic fowl tarsometatarsi proximal width (Bp) in mm, spurred individuals.

femora. No clear conclusions could be drawn from this, the apparent separation into two groups being a result of small samples and/or sexing (Eastham 1971). However, the Colchester Roman samples of spurred and unspurred tarsometatarsi show evidence for at least two Roman breeds of fowl (Fig 5.13).

The Roman sample of spurred tarsometatarsi was subdivided into the phases: AD 44-60/1, 60/1 -300 and 200-400+. Figures 5.25-5.26 demonstrate box-and-whisker plots for these phases pertaining to greatest length and proximal width respectively. There appears to be a distinct size change between the AD 44-60/1 and 60/1 -300 samples, both for greatest length and proximal width. This was checked using the Mann-Whitney U Test which confirmed our observations at 0.01 probability level for greatest length. No differences were found with the AD 60/1-300 and 200-400+ samples.

The unspurred or spurless tarsometatarsi did not reflect the same findings as the spurred bones; indeed there were no significant differences in size between the groups.

In summary, the spurred birds exhibit an increase in size through the Roman period. Whether this is due to the introduction of new breeds via stalwart cockerels or an increase in the practice of caponisation is a moot point. There are scant detailed references in the literature to the skeletal differences of capons, cocks and hens. Further, our knowledge of the exact effects of castration on the male bird is hampered by a lack of research in this area.

It has already been shown that the Gilberd School and Butt Road yielded the highest numbers of chicken bones. Butt Road shows the best evidence for preservation of limb-bone elements (wings and legs) and, due to differential preservation of these parts, it is proposed that the Butt Road sample was deposited in the vicinity of an area where food was prepared and consumed.

The comminuted nature of the mammalian bone suggests a different origin and at this stage is thought to be unrelated to the chicken deposits of the church of Butt Road (Sections 1.5 & 3.7.1). The feast organisers at the church showed a preference for the slaughter and consumption of large-sized birds; the means of the greatest length and distal width of the tarsometatarsi were considerably higher than those from the other sites. Indeed this was significant at 0.05 probability for the greatest length and 0.01 probability for the distal width, utilising the Mann-Whitney U Test.

5.5 **Wild birds**

[Table 5.4]

Colchester has not yielded large numbers of wild birds, which is surprising considering its proximity to an estuarine environment. Wild birds can be informative about diet and also the surroundings in which they occur.

In the literature, measures of species diversity have the capability to delineate socioeconomic differences in faunal material for historic period sites (Rothschild 1989). However, caution is advocated in the interpretation of any wild avian fauna, particularly with regard to distinctions of natural and human site formation processes. Coy (1983 & 1989) has drawn our attention to this particular problem and stresses that an in-depth appraisal of the contextual evidence is absolutely vital if any sensible conclusions are to be reached. While butchery marks reflect human activity, all too often they are missing on small carcasses and hence other evidence has to be sought if fowling is suspected. Also, wild species are frequently represented by just a few bones or in some instances a sole bone. Some urban assemblages may have resulted from owl roosts and even carnivore activity, as anyone with a voracious pet cat might know. An act of Parliament in 1533 required that parishes should be equipped with nets in order to catch rooks, choughs and crows, which were considered agricultural pests (Thomas 1987, 274).

Table 5.4 shows the representation of the wild avian fauna at Colchester. It is evident that Colchester was situated near marshes with densely-vegetated meadowland. The common crane (*Grus grus),* now extinct in Britain, inhabited bogs and wooded swamps and outside the breeding season could be found in marshes and on sand-banks. Black-tailed godwits, mallards, whimbrels, wigeons, lapwings, tufted ducks, teals and curlews occurred in the marshes and meadows; in winter they could be found along the mud-flats of the sea-shore. The corncrake was widespread in meadows and fields with dense vegetation, while the innumerable woodcocks preferred woods with bogs and wet ground.

Table 5.4 The occurrence of wild bird species at Colchester.

Species	Rom	Med
Teal *(Anas crecca)*	+	+
Wigeon *(Anas penelope)*	+	+
Tufted duck *(Aythya fuligula)*	+	+
Swan *(Cygnus sp)*	+	
Crane *(Grus grus)*	+	
Partridge (*Perdix perdix)*	+	
Pheasant *(Phasianus colchicus)*	+	+
Snipe (*Gallinago gallinago)*	+	
Woodcock *(Scolopax rusticola)*	+	+
Bar-tailed godwit *[Limosa lapponica)*	+	+
Black-tailed godwit *(Limosa limosa)*	+	+
Curlew *(Numenius arquata)*	+	
Whimbrel (*Numenius phaeopus)*	+	
Dunlin *(Calidris alpina)*	+	
Golden plover (*Pluvialis apricaria)*	+	
Golden/grey plover *(Pluvialis apricaria* or *squatarola)*	+	
Greyshrike *(Lanius excubitor)*	+	
Corncrake *(Crex crex)*	+	
Lapwing *(Vanellus vanellus)*	+	
Mistle thrush *(Turdus viscivorus)*	+	
Redwing (*Turdus iliacus)*	+	+
Carrion crow *(Corvus corone)*	+	
Jackdaw *(Corvus monedula)*	+	
Raven *(Corvus corax)*	+	+
Rook *(Corvus frugilegus)*	+	
Stock dove/rock dove *(Columba oenas/C. livia)*	+	
Buzzard *(Buteo buteo)*	+	
Sparrowhawk *(Accipiter nisus)*	+	

5.6 Wild mammals

(Figs 5.27-5.30; Tables 3.5a-3.5b, 3.6 & 3.7)

The contribution of deer to the diet was negligible except in the case of the roe deer remains from the Gilberd School (Chapter 3). Red and fallow deer bones were occasional finds. The red deer would appear to have been exploited more for commercial purposes in antler working. Similarly hares and rabbits were rarely trapped for food or their fur. Bear bones were identified from BKCH1 (AD 250-300) and BUTT3 (AD 320-400+). These isolated finds could be the remains of trophies or bears used in bear-baiting, since bears have been infrequently found in southern Roman Britain (Luff 1982).

The vertebra of a bottle-nosed dolphin *(Tursiops truncatus)* was found in a post-medieval pit (F65) at Lion Walk Site C, dated to AD 1475-1525. The vertebra shows evidence of butchery and perhaps represents a hunted beast or more likely a stranded individual which subsequently ended up in the stew-pot (Fig 5.27).

5.6.1 Roe deer

Apart from the Gilberd School site, there was a dearth of deer remains at Colchester. Roe deer was certainly hunted in the early Roman period and the jaw bone kill-off pattern makes an interesting comparison with that of the Mesolithic sample from Star Carr (Legge & Rowley-Conwy 1988). The Gilberd School mandibles were aged in a relative fashion by tooth wear using the method of Aitken; deer in their first year were aged more closely by patterns of tooth eruption (Aitken 1975).

Figure 5.28 shows the kill-off pattern for the Gilberd School jaws. The animals in age stage 1 were approximately 1 year old except for two beasts, one being about 6 to 10 months old and the other a neonatal fawn. Roe deer were mainly killed in their first and third years. Of the Star Carr deer, 45 per cent (10 out of 21 jaws) were killed at about the age of 1 year with 67 per cent of the sample (14 out of 21 jaws) being killed at or below 2 years of age. In contrast, the Gilberd deer remains, while reflecting the slaughter of young beasts, show an emphasis on the killing of older animals of 3 years plus. This may be connected to the procurement of antler, although the deer on the Gilberd School sites consisted of mainly post-cranial bones. The antler could have been processed in other quarters of the settlement; indeed, a sawn-off piece of roe deer antler was found in

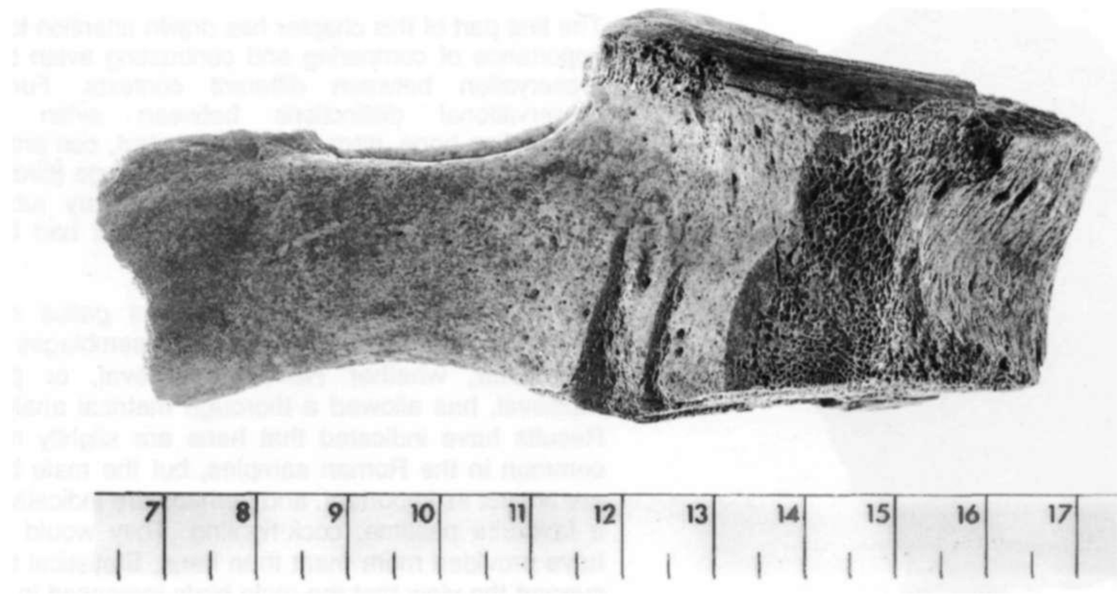


Fig 5.27 Bottle-nosed dolphin showing butchery marks (Tursiops truncatus) vertebra (LWC CF65). [Page 98]

the military levels of Culver Street Site B (B2372/L487). However, exploitation of roe deer antler must have been very restricted, since the only other known example from Colchester is that depicted in *CAR* **2**, figure 211 (Nina Crummy pers comm). There is no evidence for the working of the Star Carr roe deer antler (Legge & Rowley-Conwy 1988, 26).

Legge and Rowley-Conwy have given reasons why the Star Carr assemblage comprised mainly young roe deer. A roe deer population naturally contains many young since since female roe can give birth at two years old and normally give birth to twin kids. In addition, yearling males are driven out of the adult male territories during the summer and even the yearling does are vanquished when the mother gives birth. Thus these sub-adult subdominant animals would be a prime target for hunters *(ibid,* 42).

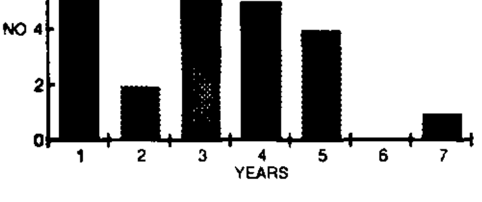


Fig 5.28 Bar chart: Roman roe deer kill-off profile, from the Gilberd School. [Page 98]

5.6.2 Red deer

The number of red deer bones recovered from the Gilberd School and indeed elsewhere is low in comparison to those of the roe deer, and perhaps this is a reflection of the local early historical environment. The roe deer *(Capreolus capreolus)* is the most widely-distributed European deer and is more woodland-adapted than the red deer *(Cervus elaphus).* However Legge and Rowley-Conwy have pointed out that although red deer are commonly thought to inhabit open countryside, it has been shown that very few populations habitually occupy open ground (Legge & Rowley-Conwy 1988, 13).

Most of the recorded red deer remains at Colchester were of antler, and some show evidence of working (Figs 5.29-5.30; *CAR* **2**, 149, *CAR* **6,** 197-8, 243-4), the main tool used being the saw. Nina Crummy's research has shown that red deer antler was exploited as a material throughout the Roman period. Evidence from London, Southampton, and York (Riddler forthcoming) indicates that shed antler was often used in the late Roman and Middle Saxon periods, which in turn suggests that few deer were being hunted and butchered for food. Red deer crania, complete with sawn-off antlers, were excavated from CUL A659 (AD 75-100; Fig 5.29), CUL EL54 (AD 60/1-200), and also Middleborough F44 (early medieval), which shows that the technique of working antler had not changed through time. The red deer antler object (CUL B484, AD 100-350+) in Figure 5.30 has the main beam shaved parallel to the long axis, thus allowing the antler to be nailed flat against a wall (Building 112, Room 1),with the brow tine providing a more-than-adequate hook. Indeed one can still see the nail driven through the main beam.

Fig 5.29 Red deer cranium with sawn-oll antlers — posterior view. [Page 99}

5.7 Summary

The first part of this chapter has drawn attention to the importance of comparing and contrasting avian bone preservation between different contexts. Further, preservational distinctions between avian and mammalian bone, from the same context, can provide enlightenment as to whether the assemblage (bird and mammal) originated from secondary/tertiary rubbish disposal or whether some elements of it had been discarded *in situ*.

The fact that domestic fowt *(Gallus gallus dom)* dominates all the bird-bone assemblages at Colchester, whether Roman, medieval, or post-medieval, has allowed a thorough metrical analysis. Results have indicated that hens are slightly more common in the Roman samples, but the male birds are almost as important, and perhaps are indicative of a favourite pastime, cock-fighting. They would also have provided more meat than hens. Statistical tests support the view that the male birds increased in size during the Roman period, while there was no change in the size of the females; one reason for this could be that there was an increase in the caponisation of fowl, the large birds being capons. Clearly hens dominate the medieval and post-medieval samples and would have supplied eggs as well as meat. Finally, there is evidence for different breeds of chicken in the Roman period at Colchester.

The contribution of fowling and hunting to the townspeople's diet was negligible.

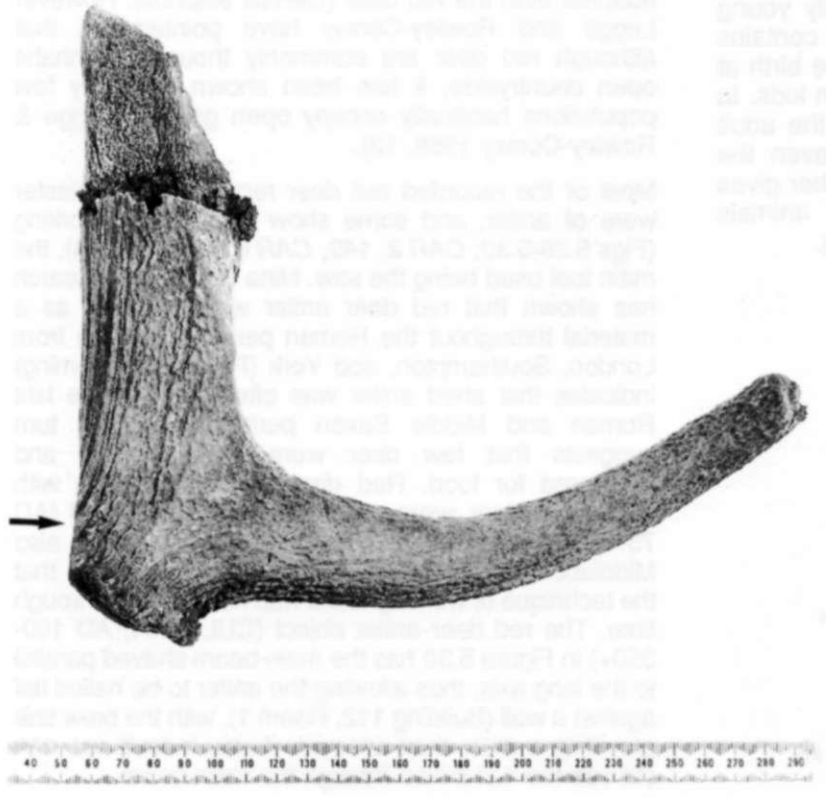


Fig 5.30 Red deer antler (CUL B434; AD 100-350+) with shaved main beam (arrow) and brow tine. Note nail driven into upper part ol main beam (possible ?hook). [Page 99]

6: HEALTH AND WELFARE

by Rosemary Luff and Don Brothwell

6.1 The implications of palaeopathology for zooarchaeology

'Food shortages of less than famine proportions were a regular occurrence. Possible endemic under-nourishment or malnutrition underlay these periodic shortages just as it underlies famine that affects developing nations today' (Garnsey 1989, 1).

Garnsey's statement concerning food shortages in the Graeco-Roman world is of fundamental importance in understanding the quality of human diet and nutrition; while it is the Mediterranean area which is specifically mentioned, any province under imperial control would surely have been subject to similar constraints. Further, any serious disruption of victuals, particularly grain, would affect the feeding of domestic stock with the possibility of concomitant ill-health. In addition, it might be expected that in an urban setting which reflected a consumer society, random culling of stock, as opposed to slaughter at very specific ages, would be supporting evidence of a breakdown in trade forced by dwindling food supplies.

In 1976, Siegel published a paper entitled *Animal palaeopathology: possibilities and problems* (1976), which summarised the then current state of animal palaeopathology. It was evident that the study of diseased animal bone was a much overlooked research area in zooarchaeology. Although this laudable account states the main types of pathology that had been diagnosed for various archaeological specimens, no detailed descriptions of the bone lesions are given. This is undertaken in *Animal diseases in archaeology* (Baker & Brothwell 1980) which reviewed the importance of the subject. Later, Brothwell (1981) emphasised the significance of including palaeopathology within the whole range of subjects embraced by the term 'environmental archaeology'.

However, animal palaeopathology is still very much neglected, as evidenced by the 1987 Archaeological Science Committee Report on *Research priorities in archaeological science:*

'The effects that husbandry practices, such as traction, confinement, and variation in diet, have on the structure, ageing, and pathology of bones are poorly understood. Research is needed into the recognition of osteological indicators of differing husbandry practices. The pathology of bone needs more study, the production of a detailed guide to the recognition of pathological symptoms is badly needed, and so is research on the anthropological implications of animal disease... there is a need for good control data from modern animals with known life histories' (Bailey & Grigson 1987, 18).

Animal palaeopathology is viewed with suspicion by many archaeologists, who in an age of quantification accuse the subject of being non-empirical, and offering scant information of direct relevance to animal husbandry. But even one specimen can be greatly informative, as demonstrated by the domestic fowl skull from the Romano-British temple site of Uley in Gloucestershire, which showed a genetically-determined severe anomaly called cerebral hernia (Brothwell 1979 & 1981). This occurs only in certain breeds of so-called crested fowl and could indicate the occurrence of this variety by Roman times. Some attempt at quantification has been made with diseased bone, for example arthropathic lesions (O'Connor 1989).

It is also implicitly assumed that the low incidence of pathological bone recovered from archaeological contexts reflects a general well-being of animals. However, this potentially erroneous view is based on the gross macroscopic external examination of the specimens, and does not take into account the wealth of information available from radiographic, histological and histochemical techniques. Human palaeopathology incorporates a wide variety of these methods in its discipline and some interesting progress has been made (Garland 1988).

Some understanding of human palaeopathological research can be of great benefit to the specialist working with animal bone. The bone of both humans and other vertebrates reacts to stress (disease) in similar ways by bone remodelling; an understanding of this phenomenon is vital for any interpretations of bone disease. Further, there is a voluminous literature concerning human palaeopathology, perhaps the best-known and most well-used book being *Identification of pathological conditions in human skeletal remains* (Ortner & Putschar 1985). However, as these authors have pointed out, the discipline is not without its problems in that much work has concentrated on describing individual pathological specimens, and scant work is available concerning demographic patterns, which might reveal the epidemiology of disease.

While anthropologists and osteoarchaeologists are mainly responsible for the analysis of ancient diseased human bone, faunal analysts or zooarchaeologists are generally responsible for the interpretation of diseased animal bone. As is quite often the case, many, without proper training themselves, have to resort to the advice of a veterinary anatomist or animal pathologist. More often than not, these specialists are unable to offer more than tentative guesses as to the condition observed. This is because some prehistoric and early historic beasts were slaughtered at fairly advanced ages, as compared with present-day farm stock that is culled when relatively young; hence some conditions manifested in the past which are age-related are not commonly seen in modern farm animals, and are therefore difficult to identify. Also, vets are not used to examining dry bone pathology.

We are obviously in a very preliminary stage of evaluating ancient disease in animals and it is therefore not surprising that much of the current research (which is not very much) is descriptive and not empirical. In the evolution of the discipline we should first and foremost describe clearly the nature of the bone lesions and only diagnose the disease if reasonably certain. Further, we are hampered by only dealing with dry bone specimens, and much valuable information is lost through the decay of soft tissue.

It is useful if zooarchaeologists publish fully-illustrated descriptions of their diseased specimens, although it is appreciated that research funds might not always extend to this. In this way a corpus of information can be built up which can be synthesised at a later date. We should even encourage the publication of diseased specimens lacking precise diagnosis and the location of such specimens in collections, so that much feedback can be attained between researchers.

In any study of the history of disease, we need to establish a baseline to work from, that is, what constitutes normality. We also need to distinguish between the changes due to the ageing process, use-related disease, and disease proper. We should be aware that the medical fraternity is in a state of flux concerning the correct choice of pathological terms which simply describe the lesions observed in bone. 'Arthritis' typifies this dilemma, as also does 'periodontal disease', which is one of the most ubiquitous diseases known to man and other mammals.

In the living animal, bone is in a dynamic state and constantly interacts with its environment in providing calcium, potassium and other mineral requirements from its rich bank. Bone is continually being remodelled, albeit more slowly as the animal ages, and this is reflected in bone being laid down by osteoblasts and bone being resorbed by osteoclasts. When the balance is broken between the activities of these two types of bone cell, the following can happen:

a) more bone is made
b) less bone is made
c) dead bone occurs
d) deformed bone occurs.

Thus abnormal bone morphology is the result of a disturbance in the activity of these two distinct cell types (Hackett 1976).

6.2 **The Colchester palaeopathology**

Palaeopathological research on the Colchester bones has primarily focused on answering questions related to the care and well-being of the domestic stock. In this respect, we wondered whether the teeth and/or bones of a species would exhibit any noticeable changes that could be associated with stress. Further, can the degree of stress be assessed and can logical arguments be put forward concerning a possible cause or causes? 'Stress' is defined as the physiological disruption of an organism resulting from environmental perturbation. The degree of physiological disruption is a function of both the severity of the environmental stressors and the adequacy of the host response (Huss-Ashmore *et al* 1985, 396). Great caution is advocated concerning interpretation, since, at the macroscopic level, many diseases have a similar appearance. A clearer picture may be gained by utilising radiographic and histological techniques. Also, in any disease it is quite common for several processes to occur simultaneously, thus masking the initial assailant. It should also be recognised that the dry bone itself imposes limitations in the absence of soft tissue which makes diagnosis fairly hazardous.

6.2.1 Oral pathology, with special reference to enamel hypoplasia in the Colchester pigs

[Figs 6.1-6.2]

Teeth are very important indicators of stress, since unlike bone there is no remodelling of the enamel once it is formed, and thus any interruptions of the enamel matrix formation are indelibly preserved, unless lost through attrition. Hence the enamel of a tooth acts like a mirror of past events which happened when the animal was in its foetal/juvenile phase.

We have looked particularly at enamel hypoplasia in pig teeth. Hypoplasia is most easily seen in the teeth of humans, pigs and dogs. Enamel hypoplasia is simply a defect in enamel thickness and structure due to the disruption of ameloblast activity, the ameloblasts being the cells which secrete the enamel matrix. This defect in the enamel thickness can be seen by the naked eye and sometimes occurs as an indented horizontal line. Hillson has summarised the various types of hypoplastic lesions and these include a single sharp line, a single furrow or groove and isolated pits instead of grooves. These lesions have one feature in common: they are found in localised bands running around the tooth crown and not over the entire crown surface (Hillson 1986, 129). In severe cases, some or all of the enamel may be totally absent from the tooth surface suggesting a hereditary origin or permanent disturbance in the ameloblast activity.

Knowing the rate of enamel formation for each tooth enables one to determine at what time in an animal's development the lesions occurred. This has been carefully documented for humans, where most of the work on enamel hypoplasia has been undertaken (Hillson 1986), and also for modern domestic pigs

(McCance *et al* 1961). The developmental timing of these insults can thus be assessed and allows the construction of a chronological chart of stressful events, which have happened in the pig's life history. In humans and pigs, it is not clearly apparent which teeth are most sensitive to environmental stress. Huss-Ashmore *et al* (1985) have shown that the relative sensitivities change with developmental age.

Methods of recording hypoplasia are described in Hillson (1986, 132). We have concentrated on the identification and recording of linear hypoplastic lesions, that is distinct incised lines, with the aim of discovering any patterning. Latex impregnated with Indian ink was used to make moulds on the buccal and lingual surfaces of the teeth. This was because the highly reflective surface of the enamel made it difficult to observe the lesions directly under a binocular microscope.

Of 143 second molars that could be studied, 61 showed hypoplastic lesions (approximately 50 per cent of the Roman pig sample). Also 8 per cent of the deciduous fourth premolars showed defects which almost certainly resulted from stress to the pregnant sow. It was apparent that most of the lesions or insults focused on the second mandibular molar surface (Fig 6.1). Further, the insults concentrated in a particular position on the second molar, that is in bands around the top half of the crown surface. Assuming that the rate of enamel formation is constant, data from modern pigs (McCance *et al* 1961) suggests that these lesions formed two to four months after birth. This is supported by the fact that scarcely any insults were found on the first and third molars. Hillson advocates caution in the use of McCance and his colleagues' data since the times of enamel formation may have been considerably different in ancient pigs (1986, 207).

The causes of hypoplasia in human enamel have been summarised by Pindborg (1982), and include congenital defects, neonatal disturbances, infectious disease and nutritional deficiencies. Human hypoplasia studies have focused on the relationship between peak incidences of hypoplasia and a society's typical weaning age. In present-day pigs, weaning occurs at approximately eight weeks. We propose the possibility that there were two farrowings at Colchester, based on the fact that only half the sample showed hypoplastic lesions which were specific to the top half of the second molar crown. If these lesions occurred randomly, one would expect more incidences on the earlier-formed crown of the first molar and the later-formed crown of the third molar. Both Pliny and Varro recommended two farrowings, while Columella advocated this for regions near towns (Pliny the Elder, *Historia Naturalis,* VIII.250; Varro, *De Re Rustica,* 11.4.14; Columella, *De Re Rustica,* VII.9.4; Section 4.4.2). Thus it would appear that piglets from the second litter suffered several months of stress after weaning. It is not clear what this stress might have been, although malnutrition may have been a primary cause.

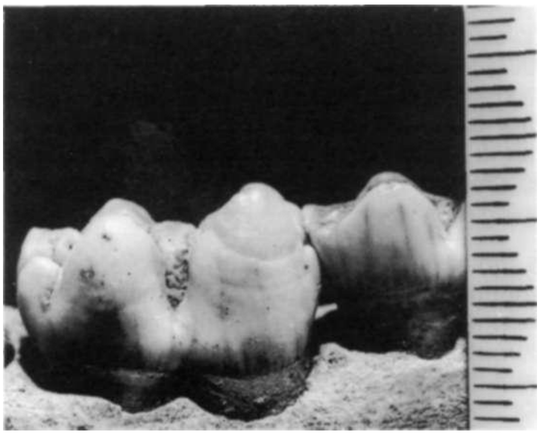


Fig 6.1 Pig second molar (Roman) from the mandible, with enamel hypoplasia on the buccal surface.

Teeth are less severely affected by environmental stresses than the jaw bones in which they are located, thus crowding of teeth may be an indicator of general stress and/or specific stress. Modern piglets fed on an inadequate plane of nutrition exhibited tooth development which was only slightly retarded, but the alveolar bone which holds the teeth was noticeably affected. There was hardly any space for the teeth to develop and they exhibited much crowding and impaction (Widdowson & McCance 1964). Huss-Ashmore *et al* suggest that the appearance of such a pattern in archaeological populations may indicate acute or severe nutritionally-based stress (1985, 449). However, this phenomenon was not observed in the pig jaw sample.

Pregnant rats subjected to artificially-induced fever produced offspring with enamel defects (Kreshover & Clough 1953), while Mellanby (1929) also induced hypoplasia in beagle dogs by feeding them on diets deficient in vitamins A and D. A deficiency in vitamin D can produce changes in the skeleton during the growing phase of life; it is necessary for the growth of bone and its deficiency can cause a softening of the bone and hence the condition of rickets. The less calcified leg bones react to mechanical stress and become bent and deformed. However, no post-cranial pig bones exhibited this phenomenon.

Experimental work carried out on dogs and rats has demonstrated that a deficiency of vitamin A promotes excessive osteoclastic activity on bone surfaces next to the marrow cavity, and excess osteoblastic activity on non-marrow surfaces. This produces an enlargement of the marrow cavity and an increase in the total diameter of the bone, with bone length not being affected. Increases in diameter are most noticeable in the skull vault, mandible, long bones and vertebral neural arches (Huss-Ashmore *et al* 1985, 405).

Research undertaken by Dickerson and McCance (1961) has shown that the chief effect of underfeeding piglets and cockerels was a slowing or even a cessation of growth. The humeri were noticeably short and thin with the ratio of length to width remaining the

Fig 6.2 Pig second mandibular molar (CUL EF14; 1450-1550/80) with root erosion — lingual view.

same; however the bone cortex was much thinner. If stress was not experienced until after weaning, normal growth could be induced by refeeding. Therefore it is quite likely that this would not be reflected in the adult skeleton.

In conclusion, we cannot rule out the notion that these young animals were probably quite prone to infectious disease. However, the hypoplasias were probably caused by a combination of different agents, probably including malnutrition.

Oral pathology is the most commonly-encountered disease category at archaeological sites (Siegel 1976, 361). There is modern clinical evidence to suggest that the health of gums and alveolar bone is related to some extent to dietary health (Brothwell 1981, 239). Gum diseases are aggravated by overgrazing and this can precipitate feeding difficulties and malnutrition (Grant 1988, 154). Notwithstanding, it should be acknowledged that the essential pathogenesis of periodontal disease is not well understood even in man (Schluger *et al* 1977).

Ancient sheep populations show considerable variability concerning the extent to which the animals succumbed to the disease. The Roman Portchester sheep (Grant 1975) were prone to periodontal disease as were those at Saxon Wicken Bonhunt in Essex where the disease was rife (Levitan 1977). However, the flocks at Saxon Hamwih were remarkably disease-free (Bourdillon & Coy 1980). Scarcely any periodontal disease was recorded in the Roman sheep sample from Colchester, although another anomaly was noted, that of tooth crowding. This was certainly a major characteristic of the Colchester sheep jaws in the Roman period since approximately 80 per cent demonstrated this phenomenon. However, there is a need to be cautious in the overall interpretation of this as a stress-induced phenomenon. It would seem sensible to look for other evidence of stress within the population before further interpretation is made.

One mature pig jaw (CUL EF14; AD 1450-1550/80), illustrated in Figure 6.2, exhibits what may be described as toothbrush erosion', whereby the roots of the second molar on the buccal side show deep erosion. The cause of this anomaly is not yet well understood.

6.2.2 Arthropathies (joint-abnormalities)
[Figs 6.3-6.4)

Pathological changes involving the joints are frequently seen in skeletal material examined by zooarchaeologists, although precise descriptions of the lesions are rare in publications. This is the main barrier to research on osteoarthropathic lesions; there is too much diagnosis and too little description of the pathologies.

Little information has been published on the arthropathies in present-day animals and indeed modern reference material rarely occurs. In the case of domestic livestock, one reason for this is that present-day animals are generally slaughtered at earlier ages than their prehistoric and historic counterparts, which tended to serve dual or triple purposes. Hence bone lesions would have had a greater chance of occurring in mature beasts from earlier times.

Contemporary medical research on humans has highlighted problems concerning the terminology, diagnosis and aetiology of the arthropathies (Rogers *et al* 1987). Indeed, rheumatologists tend to emphasise in their research into human arthropathies that they are looking at processes, not diseases. Osteoarthritis, therefore, is not a specific disease but a reaction pattern to a damaged joint, and the term 'degenerative joint disease' is now out of vogue with human palaeopathologists.

This confusion of terminologies is all too apparent in animal bone research. For example, Olsson and Siegel differentiate between the terms 'arthropathy', by which they mean joint changes of a non-infectious degenerative origin, and 'arthritis', which they use to describe joint changes of infectious origin (Olsson 1971; Siegel 1976). However, in a recent paper, van Wijngaarden-Bakker and Krauwer (1979, 37) state that chronic arthritis and chronic arthrosis cannot be distinguished from one another, even though arthritis is caused by infection while arthrosis originates from old age or chronic over-stress. In their research all joint lesions have therefore been described as 'arthritis/arthrosis'. However, none of these researchers have described the visual appearance of these lesions.

Baker and Brothwell (1980, 223) define the term 'arthropathy' as an abnormality of the joint while they reserve the term 'osteoarthritis' *(ibid,* 115) for a pathology which demonstrates three out of four of the following changes:
a) grooving of the articular surface
b) eburnation
c) extension of the articular surface by new bone formation
d) exostoses around the perimeter of the bone.

Rogers *et al* (1987, 185) state that osteoarthritis in humans is characterised by:
a) the formation of true, marginal osteophytes
b) subchondral bone reaction
c) pitting of joint surfaces
d) alteration in the joint contours, in severe cases.

In the absence of a) and b), joint-changes cannot be classified as being osteoarthritic, but the presence of osteophytes alone may be the result of a less specific age change, although long-term stress may still be a factor.

The aetiology of osteoarthritis is not completely understood. With regard to animal remains, Baker and Brothwell (1980, 115) state that it can commonly result from constant trauma to the joint, which steps up the normal ageing process, although additional factors may well contribute.

While advances have been made in the human fields of reactive and rheumatoid arthritis, the onset of osteoarthritis is poorly understood. Prolonged or repeated over-use of any joint or group of joints has been related to an increased frequency of osteoarthritis in coal-miners, bus-drivers and foundry-workers. However, not all studies have demonstrated a consistent relationship between osteoarthritis and trauma; for example pneumatic-hammer drillers did not show an increased risk of osteoarthritis of the elbow (Moskowitz 1987, 6). Further, there is an increasing body of evidence which suggests that osteoarthritis may even be caused or aggravated by inactivity; the implications being that lack of activity may be as harmful as severe trauma (Altman 1987, 67).

Some attempt at quantifying arthropathies in archaeological bone samples has been made. For example, O'Connor (1989, 197) has quantified the occurrence of arthropathies in cattle, in particular osteoarthritis in the metapodio-phalangeal and hip joints; he found the frequency of occurrence to be one to two per cent of all acetabula or metapodia examined, and speculated that the lesions were use-related and had therefore resulted from the work that the animals had done, in, for instance, hauling carts and ploughs.

As already stated, the cause of osteoarthritis, particularly that of the interphalangeal joints, is uncertain. It may be due to heavy draught work, but may also, as with spavin, be associated with use of the beast on hard unyielding surfaces, thus resulting in traumatic injury to the articular cartilage. Further, there are difficulties in distinguishing use-related from age-related changes. However, the minor lesions observed in the pelvic acetabulum, which appear to stem from the over-rotation of the hip, are almost certainly due to the use of the animal for traction (Baker 1984, 254).

Figure 6.3 shows a typical example of this type of lesion which has been recorded for the Colchester cattle bones. Lesions in the pelvic acetabula always occur in the same place (that is the medial edge, aligned with the pubic ridge) and are characterised by eburnation and some slight pitting; grooving and osteophyte growth were generally absent. Approximately one per cent of the Romano-British sample of cattle acetabula exhibited this pathology, while none were observed in later periods. (Incidentally, the labelling of bones with clear PVA is not a good idea if eburnation is to be scored for.)

Since the Colchester Romano-British cattle were mainly mature, possibly these lesions are age-related; however, they are always found in a very specific area in the acetabulum, where the force would be on the pelvis when the limbs were in the direction of maximum thrust. Also there was no osteophytic growth around the edges of the acetabula. Thus it is considered that these lesions reflect the use to which the animals were put, rather than their age.

Arthropathic lesions were not found on the scapulae and perhaps this is indicative of the type of harnessing used on the cattle. Possibly they were harnessed around the horns. Published veterinary accounts of osteoarthritis in the fore limbs of modern cattle are, however, infrequent (Greenough *et al* 1972).

Evidence of use-related injury was found in 82 bovids and three horses of Roman/medieval date from Winchester. In the majority of cases, this was in the

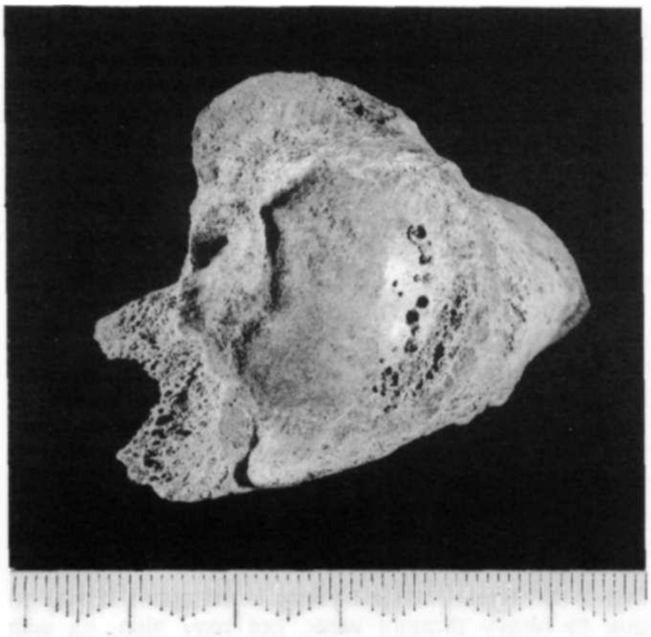


Fig 6.3 Cattle pelvic acetabulum (Roman) with arthropathy, showing eburnation and pitting. [Page 105]

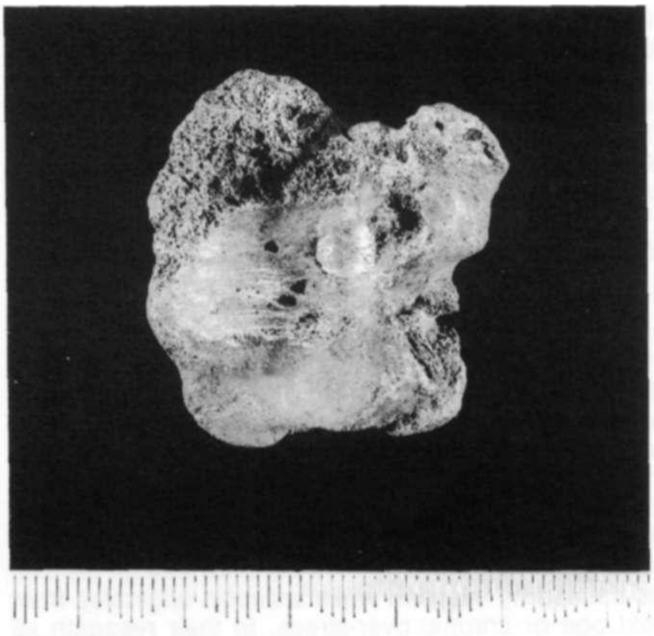


Fig 6.4 Cattle second phalanx (BKC AF6; AD 300-400+) with proximal joint sudace showing eburnation, grooving, and exostoses typical of osteoarthritis.

form of pelvic joint-changes (eburnation within the acetabulum), the result of repeated over-rotation of the femur head, perhaps in an attempt on the part of the animal to move heavily-laden carts on bad surfaces or ploughs in heavy soil (Baker cited by Brothwell 1981).

An analysis of the Roman bones from Portchester Castle revealed that osteoarthritis was relatively common, particularly in the hip and hock joints of cattle, but rare in pig and sheep bones (Grant 1975). This variation in prevalence could perhaps be attributed to the following: either few bones from old sheep and pigs were found or sheep and pigs were not used for draught purposes (Baker & Brothwell 1980, 117).

Arthropathy lesions recorded for Neolithic cattle at Etton, Maxey, in Cambridgeshire were said to be suggestive of cattle used for traction (Armour-Chelu & Clutton-Brock 1985). However, the pathological sample is very small (only seven out of fifteen acetabula showed pathological deformities) and the pathologies of each individual hip-joint were not consistent. For instance, only three specimens showed eburnation. Pathologies of the scapulae were mentioned but these were not enumerated. Armour-Chelu and Clutton-Brock state by reference to the veterinary literature that cows are generally only susceptible to osteoarthritis at around 8 years old or more; since most of the Etton cows were less than 6 to 7 years old, and exhibited bony growth and remodelling of the scapulae, it was proposed that the beasts had been used for traction.

Scarcely any distal cattle metapodia exhibited arthropathies at Colchester. A 1st-century bovine metatarsal demonstrates the typical burnishing, grooving and exostoses of osteoarthritis (LWC C428, AD 49/55-c 80?), as do the distal joint surface of a cattle first phalanx (CUL A246, AD 60/1-7100/150), and the proximal joint surface of a Roman cattle second phalanx (BKC AF6, AD 300-400+; Fig 6.4).

6.2.2.1 Examples of specific arthropathies

[Figs 6.5-6.18)

BKC J296 (AD 60/1-150)

This is part of a cattle sacrum including the sacrolumbar joint Both the first sacral body and right neural arch facet show severe osteoarthritic changes, with some eburnation (Fig 6.5).

CUL K360 (AD 60/1-400+)

Part of the articular area of a cattle mandible can be seen in this illustration; there are chew-marks on the ramus. The condyle is noticeably flattened and splayed out, and there is also some central fissuring and marginal lipping. Clearly the condyle is severely arthritic, but this may be trauma-related rather than linked to age and attrition (Fig 6.6).

CUL D635 (AD 150/200-275/325)

A pig metacarpal demonstrates severe osteoarthritic changes in and surrounding the proximal joint (Fig 6.7).

CUL EF206 (early medieval)

A medieval dog humerus distal medial epiphysis exhibits grooving and burnishing, and clearly shows an age-related change.

CUL EF206 (early medieval)

The proximal humerus of another medieval dog shows advanced osteoarthritic changes with expansion of the head, burnishing over most of the surface and extensive exostoses at the perimeter (Fig 6.8).

CUL G630 (early medieval)

Part of the base of the spinous process of a post-Roman cattle thoracic vertebra has the caudal articular surfaces flattened, pitted and clearly displaying early osteoarthritis.

LWC C137 *(post-medieval)*

Severe osteoarthritis is exhibited in this illustrated cattle lumbar vertebra, where the caudal centrum is heavily grooved and pitted with osteophytic growth around the perimeter (Fig 6.9).

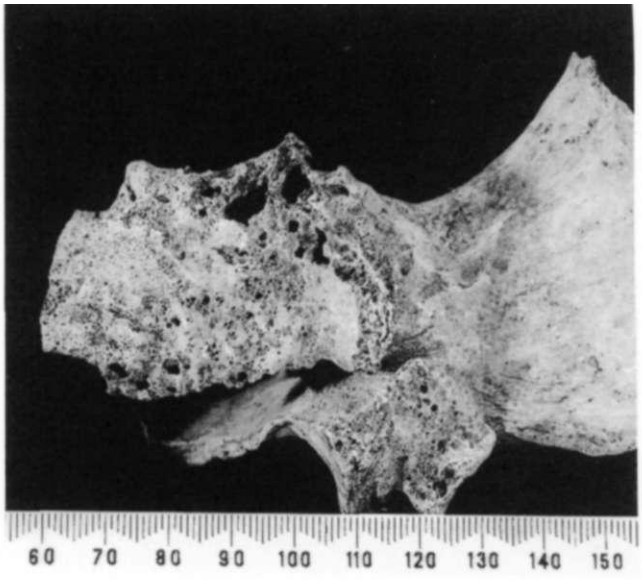


Fig 6.5 Cattle sacrum (BKC J296; AD 60/1-150) showing severe osteoarthritic changes — cranial view. (Page 106)

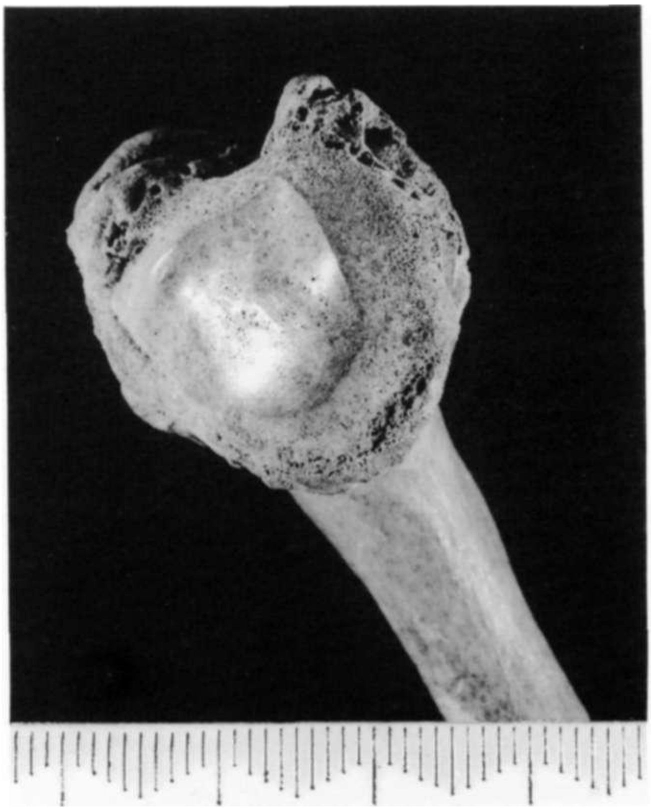


Fig 6.8 Dog proximal humerus (CUL EF206; early medieval) with posterior surface of head exhibiting advanced osteoanhritis. [Pages 106]

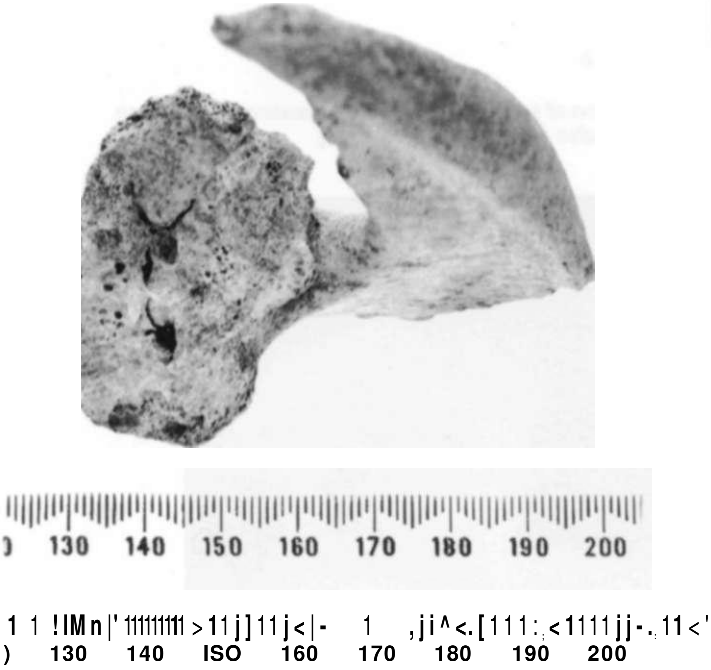


Fig 6.6 Cattle mandibular condyle (CUL K360; AD 60/1-400+) with osteoarthritic changes. [Page 106]

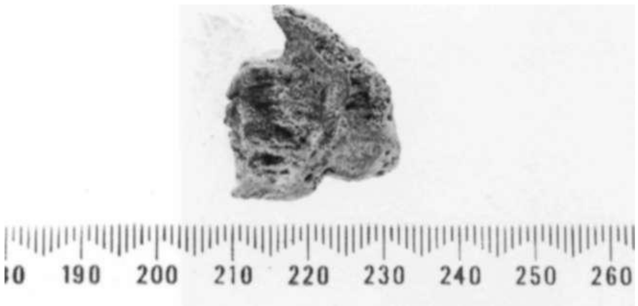


Fig 6.7Pig metacarpal (CUL D635; AD 150/200-275/325) with the proximal joint surface showing severe osteoarthritic change. [Page 106]

Fig 6.9 Cattle lumbar vertebra (LWC C137; post-medieval) with severe osteoarthritis — caudal view. [Page 106]

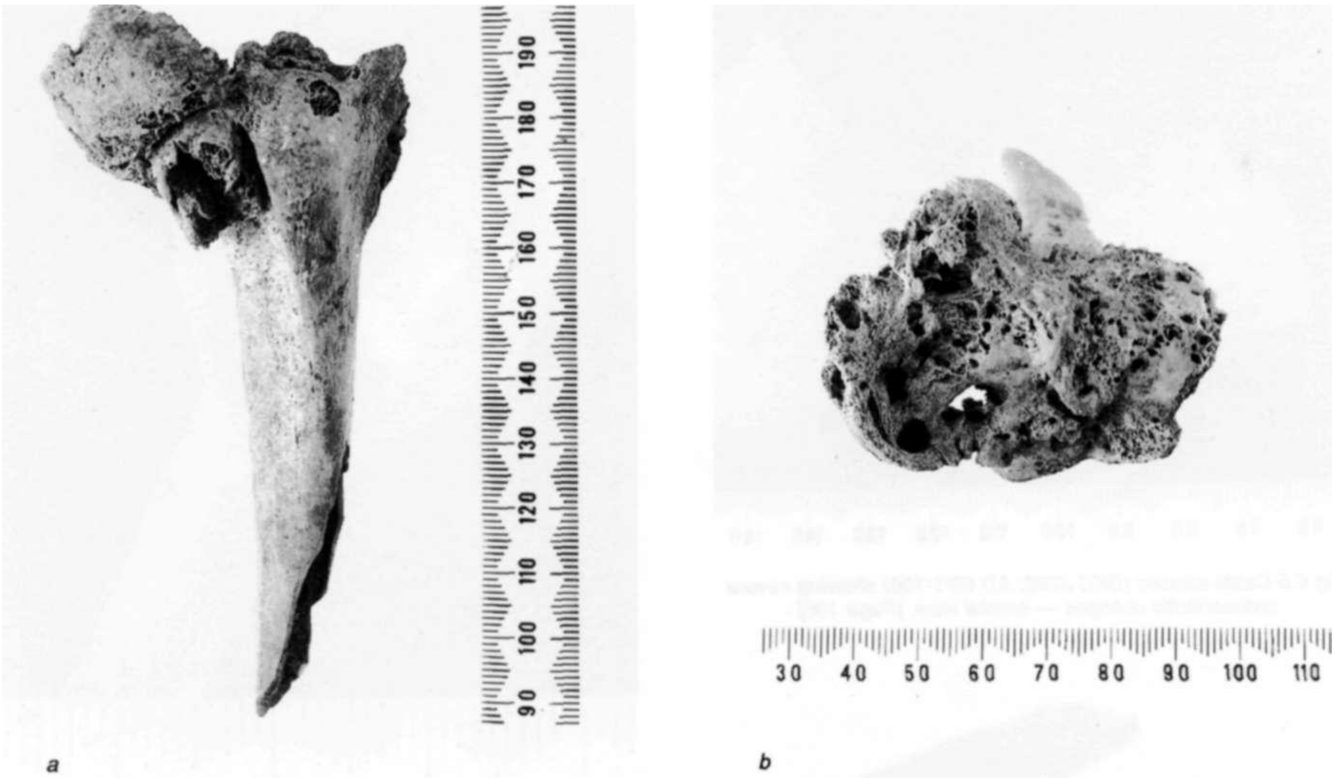


Fig 6.10a-b Caprine tibia (LWC C125; possibly 16th century) showing expansion of spongy bone from the proximal joint surface. Left: anterior view (see also below left). Right: proximal view (see also below right). [Page 109]

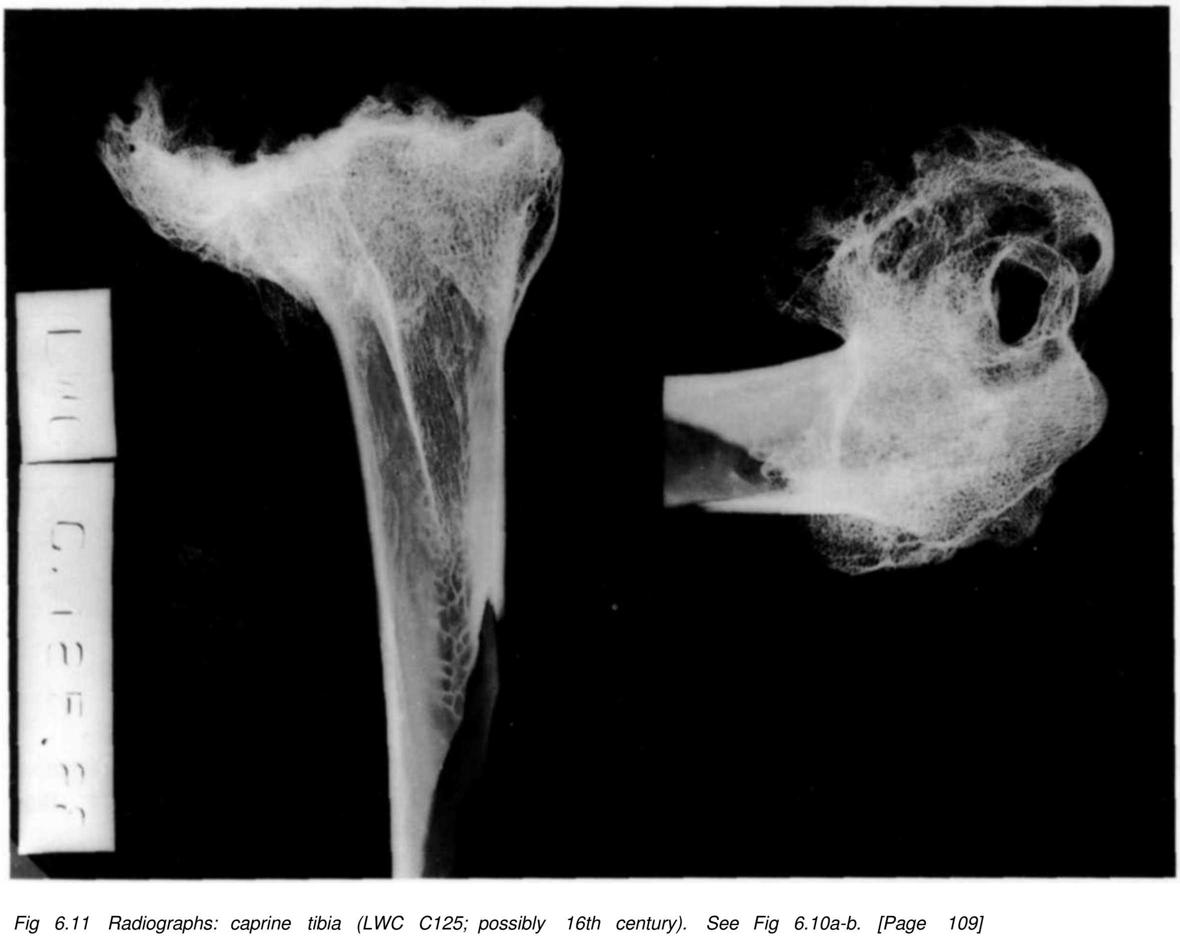


Fig 6.11 Radiographs: caprine tibia (LWC C125; possibly 16th century). See Fig 6.10a-b. [Page 109]

CUL D421 (early medieval)

Low ring bone was observed in a bovid second phalanx. Ring bone is a form of exostosis which affects the interphalangeal joints and nearly always causes some form of lameness (Baker &Brothwell 1980, 120-21).

LWC C125 (possibly 16th century)

The proximal articular end of a post-Roman caprine tibia (Fig 6.10a-b), displays massive joint surface destruction, with some ebumation and considerable expansion of coarse spongy bone along at least 33 mm of the joint margin. The radiographs (Fig 6.11) reveal that the extra bone is coarsely spongy, possibly witn a sinus aperture in a ditterent skeletal location, this might be suggestive of an osteochondroma; however, in this case, the severe joint involvement points more certainly to a long-established joint infection, resulting from a direct injury or Wood-borne condition such as tuberculosis. Bacterial infections of joints are relatively common in current animal populations, especially in neonatal ruminants and also in pigs of all ages *(ibid,* 123).

LWC L161 (late medieval to 16th century)

A medieval pig metacarpal (Fig 6.12) exhibits severe proximal arthropathic changes. The joint is totally destroyed and there is some marginal reaction extending onto the shaft. The distal joint is healthy.

CUL EF1006 (AD 49(/55)-60/1)

The part of a cattle skull illustrated shows an inflammatory infection of the tempero/mandibular joint (Fig 6.13).

BKC V67 (AD 250-300)

This shows two-thirds of a caprine (?deer) calcaneum without the tuber calcis which appears to have been chewed off. Above the articular area the bone appears swollen, but it is relatively smooth, though mildly striated and pitted. The articular facets and associated bone show irregularity and change indicating some degree of arthropathy. Above the sustentaculum is an irregular crater (15 x 12 mm) with a raised margin. This could have been the primary focus of trauma and/or infection, and would help to explain the old swollen bone and joint changes (Fig 6.14).

CUL G1380 (AD 225-275/325); CUL H459 (AD 225-275/325); CUL EF163 (medieval and later); COC F241 (16th century)

A group of four pig metatarsals displays punched-out lesions of the proximal joint surface (suggestive of osteochondritis dissecans). These probably have traumatic origins (Fig 6.15).

MID78 F396 (post-medieval)

This shows spavin in the tarsus of a post-medieval horse. Essentially, the small bones of the inner lower aspect of the joint are affected, producing exostoses which limit movement (Baker & Brothwell 1980, 117). While spavin generally does not severely incapacitate the beast, it will manifest itself with a moderate degree of lameness. Spavin was particularly common in town draught-horses during the last century and the early years of this century. Causes of this condition are multifactorial but the principal initiating factor is heavy traction on hard surfaces (Fig 6.16; Baker 1984, 253).

BKC E881 (AD 60/1-75/80)

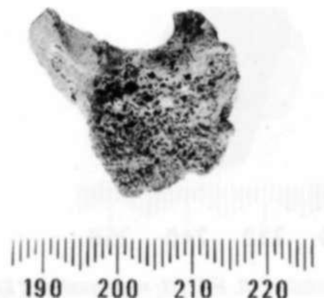
The proximal cattle metatarsal illustrated here is also indicative of spavin (Fig 6.17).

BKC V151 (AD 100/125-300); BKC V214 (AD 100/125-400+); COC F206 (11th to 14th centuries)

Three further cattle proximal metatarsals exhibiting spavin were recovered.

LWC R43 (medieval); CUL A142 (medieval and later); CUL D141 (early medieval)

Three sheep radii demonstrate exostoses at the lateral edge of the proximal joint surface (Fig 6.18). Baker and Brothwell state that exostoses around the elbow joint can severely reduce the mobility of the joint, and commonly occur. They start on the lateral aspect of the joint, and shepherds who have seen this condition think that it is due to trauma caused when the animals are put through races or pens (Baker & Brothwell 1980, 127). Much evidence comes from the Roman and medieval sheep at Winchester, where the large number of cases indicate penning over a long period of time (Baker cited by Brothwell 1981).



iHflllll'I'lllllH'I'llllll'I'lllll

190 200 210 220

Fig 6.12 Pig metacarpal (LWC L161; late medieval to 16th century) with anhropathic changes in the proximal epiphysis.

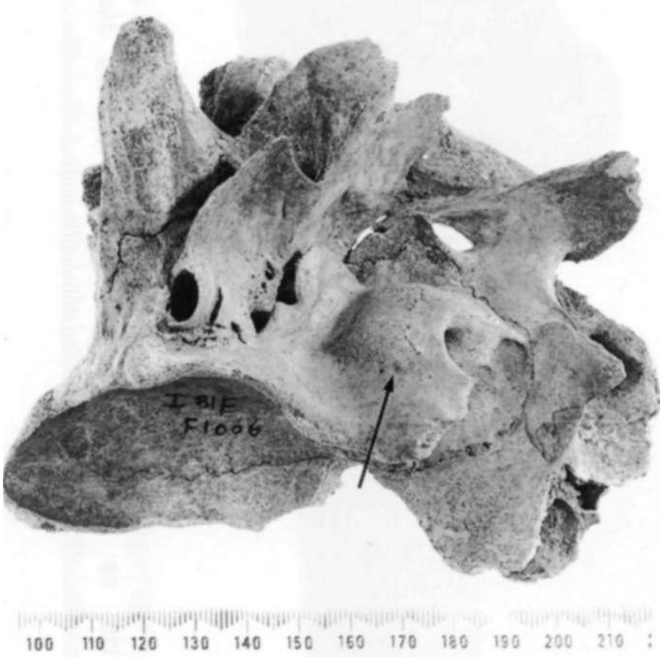


Fig 6.13 Cattle skull (CUL EF1006; AD 49(/55)-60/1) with tempero/mandibular joint infection (arrow).

Fig 6.14 Caprine calcaneum (BKC V67; AD c 250-300) exhibiting lesion above the sustentaculum — lateral view.

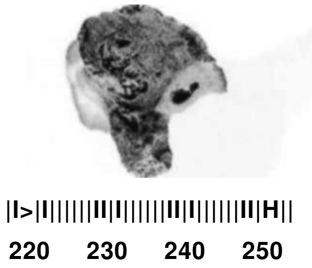


Fig 6.15 Pig metatarsal (CUL EF163; medieval and later) with lesions in the proximal joint surface suggestive of osteochondritis dissecans. [Page 109]

Fig 6.16 Horse tarsus (MID 78 AF396; post-medieval) exhibiting spavin — anterior view. [Page 109]

Fig 6.17 Cattle metatarsal (BKC E8B1; AD 60/1 -c 75/80) showing spavin — anterior view. [Page 109]

Fig 6.18 Sheep radius (LWC R43; medieval) showing an exostosis at the lateral edge of the proximal epiphysis — anterior view. [Page 109]

6.2.3 Determination of use-related pathologies

In proposing that some arthropathies are caused by an overloading of the joints due to work, certain criteria need to be met:

a) The lesions need to form a distinct pattern both with respect to the individual joint and also to the symmetry of the animal; one would expect, for example, that traction would produce a bilateral series of hip arthropathies.

b) One needs to look for differences in the patterns of arthropathies between species of different body weights, and to evaluate them in relation to bio-mechanical, environmental and genetic parameters.

c) A relatively high incidence of the disease should be found (Baker 1984).

There is a great need for research into the lesions produced by traction in present-day animals.

Greene has summarised some of the more important research concerning ancient harnessing methods (Greene 1986; Raepsaet 1979; Spruytte 1983), and has pointed out, in contradiction to previous work, that perfectly good traction could be obtained from horses as well as oxen in the Roman period; indeed, a carving from Langres shows mules with an effective traction point on their chests rather than on their necks (Molin 1984, 114 after Greene 1986). Since the technology was available, Molin suspects that there was little need for heavy haulage in the Roman period. The site of the most common arthropathic lesion in the Gussage All Saints horse-bone assemblage is that of the proximal metatarsal; Harcourt (1974) therefore proposed that the Iron Age horses had been used for draught.

Documentary and pictorial evidence for the Roman period suggests that there was a general reliance upon oxen rather than horses for pulling very heavy loads, and this made the development of better horse-harnessing unnecessary. Artistic representations for the Roman period show a range of vehicles, including slow solid-wheeled carts drawn by oxen and light horse-drawn passenger vehicles. However, this is not reliable evidence for viewing haulage, since the scenes became so standardised (Greene 1986, 37).

The economies of Roman and indeed post-Roman Britain were essentially controlled by transport costs. There is a striking agreement between ratios of sea to river to land transport costs of 18th-century England (1:5:23) and the Roman empire (1:5:28) (Duncan-Jones 1974, 366-9).

For long journeys water transport was obviously preferable to that by land.

6.2.4 Examples of other joint variation

[Figs 6.19-6.20]

BKC VI51 (AD 100/125-300); BKC E241 (AD 300-40Q+); CUL G222 (post-Roman); CUL G630 (early medieval); CUL G2908 (post-Roman)

Two Roman and three post-Roman cattle mandibles show changes in the surface of the articular condyle of the mandible. In two of the medieval mandibles and in the two Roman mandibles, a deep cleft runs antero-posteriorly, separating off the medial third of the condyle (Fig 6.19).

This condition was observed by Baker and Brothwell in specimens from Skara Brae, Dun Ardtreck and the Mote of Mark, and was thought to be a minor, non-pathological variation from the normal (1980, 113-4). The other post-Roman mandible (CUL G2908) exhibits pitting running antero-posteriorly instead of the deep cleft, and again has been considered to be a non-pathological variant. This was also found at Skara Brae.

One of the most common joint lesions observed amongst the Colchester cattle bones pertained to depressions in the articular surfaces of the phalanges, especially the first. Baker and Brothwell (1980, 109-11) have classified these lesions as three distinct types. Type 3 was observed in two cattle third phalanges:

Fig 6.19 Cattle mandibular condyle (BKC V151; AD 100/125-300) showing a deep cleft running anteroposterior^.

BKC V665 (AD 100-400+); CUL G3005 (?post-Roman)

The incised lesion runs slightly obliquely in a medio-lateral direction Baker and Brothwell state that these lesions have previously been almost exclusive to the Scottish Neolithic and especially to Skara Brae (*ibid.* 111).

BKC G343 (AD 250-300)

The specimen photographed here (Fig 6.20) is a typical example of a lesion which is commonly mentioned in human palaeopathology, and sometimes termed 'myositis ossificans'. This figure shows a sheep metatarsal with ossified tendons extending longitudinally along the posterior surface.

6.2.5 Trauma including fractures and hunting injuries

[Figs 6 21-6.28]

Trauma is one of the more common pathologies to be observed in ancient material, and is a term used to embrace any bodily injury or wound. Let us consider fractures. The three major causes of fractures are those of injury, stress/repeated loading, and weakening due to pathology. We need to understand what has caused the fracture and to be able to assess the state of healing of the fractured bone. Topics of research which are particularly relevant to healing in archaeological populations are diet, hygiene and living conditions. The skeletal evidence for an open fracture is superficial infection, osteitic pitting, and irregularity of the bone surface and fracture site.

Primates shot in the wild have furnished numerous examples of well-healed fractures (Duckworth 1912; Schultz 1939), and this was thought to indicate that fractures need not be a serious threat to life (Ortner & Putschar 1985, 64). However, a recent study of adult wild primates does not support this view and shows that long-bone fractures are rare and usually fatal (Bulstrode *et al* 1986).

The Colchester material did not reveal an excessive amount of fractured bone. The number of fractures in cattle was low and it was evident that the individual

Fig 6.20 Sheep metatarsals (BKC G343; AD 250-300), one normal (left) and one with ossified tendons (right) — posterior view. [Page 111]

specimens had healed well, for instance a cattle metatarsal (BKC A72 F16, AD 300-400+) and a cattle pelvis (BKC E1316, AD 49-60/1); the same was true of the early Roman sheep/goat metacarpal (CUL A337, medieval and later). An immature caprovid metapodial shows swelling and slight shaft deformity above the midline (BKC N211, AD 150-250). An X-ray demonstrated that the cortex is deeply involved, possibly as a result of an old greenstick fracture.

With respect to pigs, a well-healed double fracture of an early Roman pig fibula was observed (GBS A1383, AD 60/1 -c 100/125). Meandering ante-mortem cracks were observed, especially in X-ray, of a pig calcaneum (LWC K502, medieval and later) in the region of its association with other tarsal bones. In the outer non-articular surface of the bone, in the region of the crack, is a mound of smooth bone up to 4 mm thick. This is clearly fracture callus associated with the bone injury. Another pig calcaneum, which is much eroded, exhibits anomalous irregularity of the bone, obscured by post-mortem erosion, but probably indicates healed trauma (BKC D375, AD 100/125-400+). The extra bone near the distal articular end of a pig tibia could be the result of trauma and may be fracture callus (GBS A1618, AD 44-60/1).

Pig metapodials commonly showed traumatic injuries. The following are three examples.

CUL EF1266 (AD 60/1-90/100)
An immature pig metatarsal with shaft swollen by fracture callus. In X-ray, the bone is clearly broken.

GBSA2361 (AD 44-60/1)
The distal half of a lateral pig metapodial with a fracture callus midway along the shaft.

CUL G3201 (AD 60/1-225)
This pig metapodial exhibits a swollen shaft which an X-ray confirmed had been broken but subsequently healed well.

CUL B511 (AD 100/125-275/325)
An immature pig tibia exhibits a minor distal exostosis, probably of traumatic origin.

BUTT AF157 (2nd century AD to c AD 320)
Two dog femora from a partial dog burial were excavated from Butt Road. The right femur is noticeably shorter than the left and has a well-healed oblique fracture (Fig 6.21).

GBS A183 (AD 44-60/1); GBS BL69 (AD 49-60/1); GBS A575 (AD 100/125-25O275); CUL G3209 (AD 225-275325); BUTT E604 (AD 320-400+); CUL EF274 (medieval and later)
The shafts of five small chicken tarsometatarsi are noticeably deformed and show callus formation, indicative of fracture or other forms of trauma. In one case (GBS BL69, AD 49-60/1), the distal articular end is abnormally angled to the axis of the shaft, and could have resulted from the fowl's leg being trodden on (Fig 6.22).

LWC A37 (17th century)
These photographs (Fig 6.23a-b) exhibit a subluxation of a chicken hip joint, possibly through trauma, whereby the head of the femur was destroyed. There is ebumation around the base of the head and acetabulum rim, plus bony outgrowths around the perimeter of the joint.

CUL H444 (AD 225-275/325)
A well-preserved cat radius, dated to AD 225-400+ (Fig 6.24), displays substantial extra bone in the middle of the shaft. A radiograph (not illustrated) reveals a fairly simple fracture mid-shaft, the swollen bone being fracture callus. No inflammatory changes are present, and because there is such good alignment, presumably the ulna was unfractured and acted as a splint during recovery.

Fig 6.21 Two dog femora from a partial dog burial (BUTT AF157; 2nd century to c 320); the dog's right femur demonstrates a healed oblique fracture.

Fig 6.22 Roman domestic fowl tarsometatarsus (GBS BL69; AD 49-60/1) showing trauma — anterior view. [Page 112]

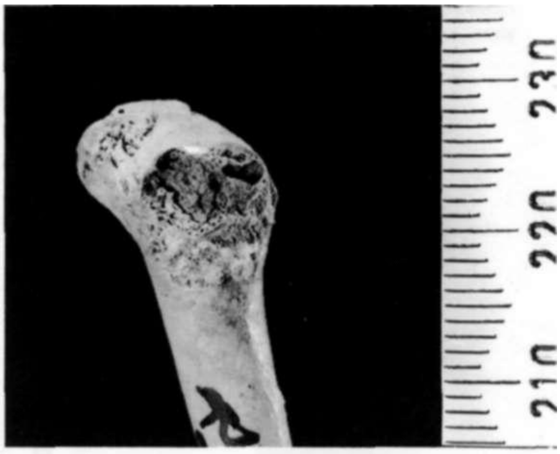


Fig 6.23a Domestic fowl proximal femur (LWC A37; 17th century) showing destruction of femoral head and eburnation round joint base. [Page 112]

Fig 6.23b Domestic fowl pelvic acetabulum (LWC A37; 17th century) showing burnishing and bony outgrowths around the perimeter of the joint. [Page 112]

Fig 6.24 Cat radius (CUL H444; AD 225-275/325) with fracture — anterior view. [Page 112]

CUL C271 (AD 65/75-100/125)

This photograph (Fig 6.25) shows the neurocranium of a roe deer skull with the antler bases worn away which was found in Room 2 of Building 96, dated to AD 75-100. About midway between the antlers, along the sagittal suture in the median plane, is a rounded perforation through the skull, approximately 3 x 4 mm. Surrounding the hole is an irregular raised area, about 5 mm in diameter. This extra bone is slightly eroded post-mortem, but was at least 1 mm deep. From the evidence of the X-rays and by direct internal examination, there is also restricted extra bone internally, close to the perforation. The appearance of this extra marginal bone suggests considerable remodelling and healing While the possibility of a congenital abnormality was considered, the hole and raised area seem most likely to be due to a hunting

Fig 6.25 Roe deer skull neurocranium (CUL C271; AD 65/75-100/125) showing possible hunting injury (arrow) — superior view. [Page 112]

injury, the projectile point just penetrating the skull and causing this rounded hole on healing. Bows, arrows, knives and hunting spears were used in Roman stag hunts and part of a weathered relief from Jarrow shows an archer with his bow and arrow stalking a stag (Liversidge 1973, 365).

CUL G1735 (AD 225-275/325)

This photograph (Fig 6.26) shows part of a roe deer antler still attached to the skull which was found inside Building 116. Even though there is some postmortem erosion, there is clear evidence of malformation of the antler. Towards the top of the deformed area is an apparent sinus opening. The most likely explanation of this anomaly is that during antler growth, trauma occurred in the area of bone proliferation, possibly with some inflammation. This affected growth along about 60 mm of the antler, before normal growth was resumed.

CUL K21 (Anglo-Saxon)

Part of the distal end of a cattle tibia was recovered from the Anglo-Saxon levels of Colchester. About 10 mm above the articular margin is an area of irregular bone (60 x 35 mm) extending to a prominence of about 15 mm. The bone is well-formed and appears to mark the site of an old injury, possibly mainly to the soft tissues, with subsequent ossification.

GBS B242 (AD 60/1-250/275)

Illustrated is a proximal third of a pig tibia shaft (Fig 6 27) which shows on the posterior aspect a small cigar-shaped mound of spongy new bone in association with more extensive thin sub-periosteal new bone extending anteriorly. This could have resulted from a small penetrating injury, leading to direct localised inflammation.

COC F325 (AD c 49-100)

Illustrated is a well-preserved Roman pig calcaneum (Fig 6.28) which displays an abnormal epiphysis of the tuber calcis. Posteriorly, this epiphysis is flattened and irregular in shape. This appears to be best explained as the result of some form of trauma to the posterior aspect of the limb in this area, resulting in damage to the epiphysis.

Fig 6.26 Malformed roe deer antler (CUL G1735; AD 225-275/325) with sinus opening (arrow).

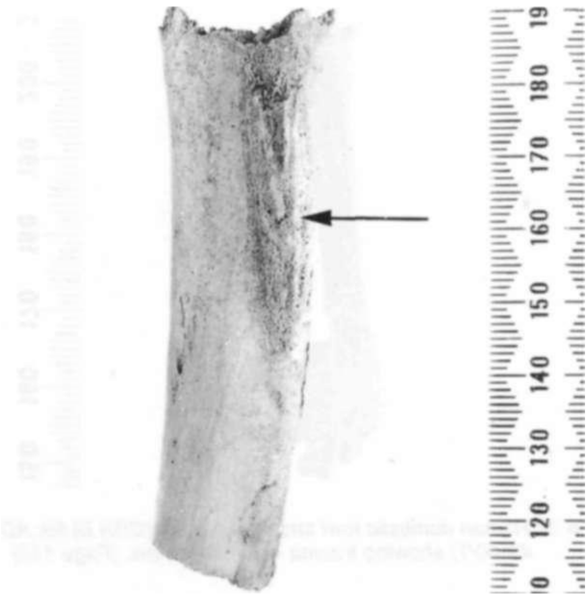


Fig 6.27 Pig tibia shaft (GBS B242; AD 60/1-250/275) showing raised area of new bone formation (arrow) — posterior view.

Fig 6.28 Roman pig calcaneum (COC F325; AD 49-100) displaying an abnormal epiphysis of the tuber calcis — lateral view.

6.2.6 Inflammation and infection

[Figs 6.29-6.33]

Most inflammations are the result of infection, and the role of infection has always been of immense importance in the care of wounds.

CUL B447 (AD 100-350)

The shaft of a cattle metatarsal displays widespread sub-periosteal new bone, indicative of a well-established infection. Whether this resulted from trauma is uncertain (Fig 6.29).

Fig 6.29 Cattle metatarsal (CUL B447; AD 100-350) showing subperiosteal new bone, indicative of well-established infection — anterior view. [Page 114]

Fig 6.30 Caprine tibia (BKC V214; AD 100/125-400+) with swollen shaft — anterior view.

BKC V214 (AD 100/125-400+)
The proximal half of a caprine tibia has the shaft noticeably swollen with somewhat porous bone. The X-ray does not reveal clear evidence of fracture and this may indicate a healing inflammatory process (Fig 6.30).

Inflammation is one of the most common abnormalities of pig bones, both in modern animals and excavated bones. Modern investigation suggests that these infections result from abrasions and are probably more common in housed pigs (Baker 1984, 256).

CUL EF123 (medieval and later)
This figure (Fig 6.31) shows much of the shaft of an immature medieval pig tibia, chewed proximally by a carnivore. The medial aspect displays a widespread subperiosteal reaction, with two raised areas; very slight evidence of periostitis is also seen on the anterior margin. While there is no certain aetiology, direct injury with resultant infection seems probable. No internal changes were noted in the bone X-rays.

CUL K445 (AD 60/1-150)
The incomplete ischium of a pig displays considerable irregular new bone which has partly eroded post-mortem. These deposits vary from a fine layer to a mass 7 mm thick. Insufficient pathology remains to do more than tentatively suggest that this may be evidence of an infection spreading out from the acetabulum (Fig 6.32).

MID78 92 (early medieval)
An early medieval pig ulna shows the region of the proximal semilunar notch with the olecranon area chewed off. Around the joint, but apparently not involving it, is extensive irregular new bone, varying to a height of 5 mm from the original cortical surface. Some post-mortem damage has occurred to this pathological bone. Insufficient remains to allow more than a tentative suggestion that this is an advanced periostitis.

Fig 6.31 Immature pig tibia (CUL EF123; medieval and later) with subperiosteal reaction — medial view.

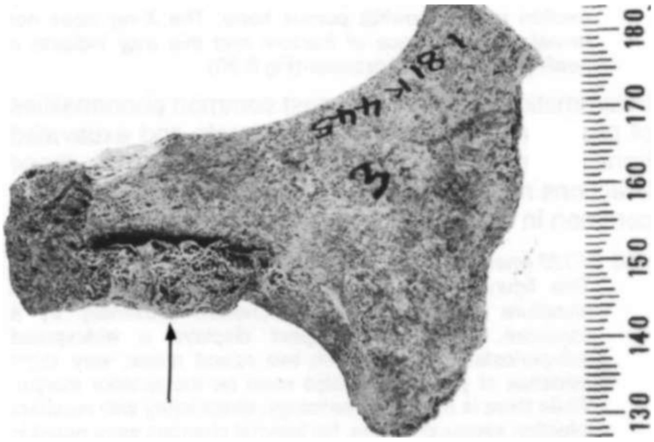


Fig 6.32 Pig ischium (CUL K445; AD 60/1-150) with irregular new bone formation (arrow). [Page 115]

COC 564 (11th-14th centuries)

Part of a bear skull was retrieved from the 11th- to 14th-century levels at Colchester. Figure 6 33 shows the right maxilla with clear evidence of butchery at the front of the right zygomatic arch. Over much of the surface of the maxilla is pitted and irregular new bone, with some limited remodelling. Bone in the right maxillary sinus area is also pitted and roughened, and there appears to be some thickening of bone, especially near the nasal aperture. The right upper canine was lost some time before death, there being some bone infilling, but with clear evidence still of a sinus (aperture) at the root apex into the maxillary sinus. Considering all these factors together, the following sequence of events could well have occurred:

a) The canine was accidentally broken, or intentionally broken by humans to render the animal less dangerous. No other canine evidence remains.

b) Infection spread via the pulp chamber to the root apex, causing abscess formation and eventual perforation into the maxillary sinus. This resulted in a chronic sinus infection. The broken tooth was shed.

c) Infection within the root cavity spread to the outer maxillary surface and might have affected the infraorbital nerve.

d) At this point, the animal may have been difficult to handle and was thus put out of its misery.

6.2.7 Osteodystrophies

(Figs 6.34-6.36]

Vitamin D deficiency can show up as a growth defect in the bones; radiographs of long-bone shafts show a generalised rarefaction with frequent deformities such as bowing or twisting. This defect is commonly known as rickets. Three bones were suggestive of rickets.

BKC N77 (AD 300-400+); LWC B27 (?17th century)

A bovine rib (BKC N77, AD 300-400+) and a chicken synsacrum (LWC B27, ?17th century) indicate rickets. Figure 6 34 depicts the rib, which exhibits marked flaring at the costochondral junction; this is highly suggestive of rickets (Baker & Brothwell 1980, 50). The incomplete chicken synsacrum in Figure 6.35 displays marked curvature in the region of its connection with the pelvis. The bone is smooth and normal in appearance, and the X-ray does not reveal evidence of trauma. Although congenital abnormality must be considered, the most likely cause of this deformity appears to be rickets, which is known to produce marked breast and pelvic anomalies (Hungerford 1969).

CUL D440 (medieval)

An early medieval dog radius showed an unusual degree of shaft curvature (Fig 6.36). There is no evidence of callus formation and the X-ray does not show any clear evidence of fracture. Two possible alternative explanations are that this is indicative of a greenstick fracture when the bone was still immature, or that this is a minor deformity from immature rickets. No Harris lines occur to support this latter possibility.

The aetiology of rickets is not as straightforward as in man, where it is usually caused by a lack of vitamin D. Dogs, cats and chickens do not need vitamin D if the calcium-phosphorus ratio in the diet is satisfactory (Baker & Brothwell 1980, 47).

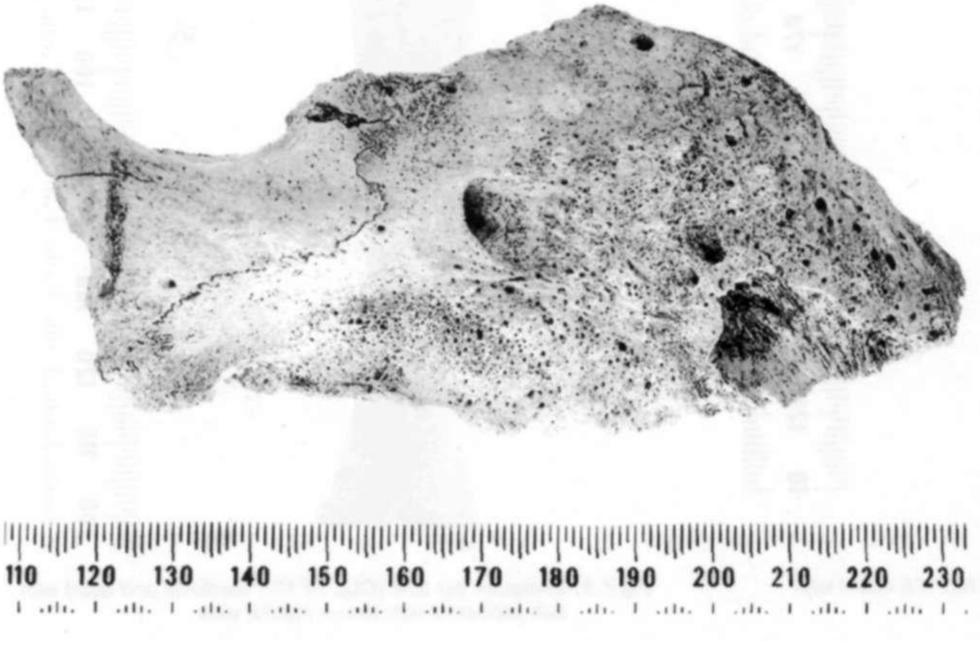


Fig 6.33 Bear right maxilla (COC 564; 11th-14th centuries) showing pitting and irregular new bone formation.

Fig 6.34 Bovine rib (BKC N77; AD 300-400) exhibiting marked flaring at the costochondral junction. [Page 116]

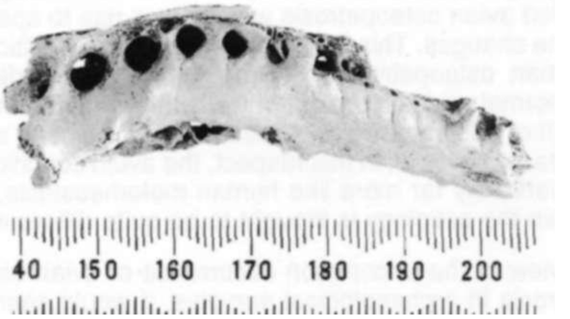


Fig 6.35 Deformed domestic fowl synsacrum (LWC B27; ?17th century). (Page 116]

6.2.8 Neoplasia

(Figs 6.37-6.40]

Few cases of neoplasia have been recorded in faunal reports; this is not surprising since, in modern animal material, skeletal tumours are seldom found (Baker & Brothwell 1980, 98-9).

LWC C163 (post-Roman)

Figure 6.37 shows a chicken sacrum, dated to the medieval period, which exhibits spongy outgrowths of new bone suggestive of a myeloma. It compares very well with a similar specimen from the Roman cemetery at Lankhills *(ibid,* fig 6, 104). A myeloma is essentially a tumour of bone marrow and related cells and one of its main characteristics is that it produces multiple spongy growths of new bone simultaneously in a number of sites.

CUL D730 (AD 150/200-275/325)

Another possible example of a neoplastic growth is that of the goose humerus (Fig 6.38). The proximal posterior head of the humerus bears four spongy outgrowths of bones strongly suggestive of this condition.

CUL G2546 (AD 225-275/325)

A pig pelvis exhibits considerable new bone extending out in all directions from the acetabulum. The joint surface does not appear to be involved, although some detail is obscured by post-mortem changes. The extra masses of bone have the internal texture of cancellous bone, and in outer appearance have a somewhat globular form (Fig 6.39). The osteophyte-like appearance of much of the new bone is strongly suggestive of hypertrophic pulmonary osteopathy (usually secondary to a pulmonary tumour), rather than osteosarcoma or osteomyelitis.

Fig 6.36 Deformed dog radius (CUL D440; medieval) — anterior view. [Page 116)

GBS A1273 (AD 49-60/1)

Another possible example of hypertrophic pulmonary osteopathy from earlier Roman levels is that of a pig tibia which shows considerable shaft expansion, together with a limited spread of more globular bone (70 x 22 mm) of a cancellous texture (Fig 6.40).

Fig 6.37 Domestic fowl sacrum (LWC C163; post-Roman) with possible myeloma.

Fig 6.38 Goose humerus (CUL D730; AD 150/200-275/325) with the posterior proximal surface exhibiting possible neoplastic growths. [Page 117]

6.2.9 Congenital abnormalities

[Figs 6.41-6.42)

MID78 204 (late or post-Roman)
Figure 6.41 shows two lumbar vertebrae of a Roman horse with the neural arches completely united. In X-ray the spines appear to be totally fused into one block, and this strongly suggests a congenital anomaly. However, there are some slight osteoarthritic changes at the anterior neural arch facets, and the posterior face of the second vertebral body displays moderate lipping which also involves the rib facets.

BKC V80 (AD 250-300)
An eroded and incomplete immature vertebra of a cow shows the posterior articular surface of the vertebral body to be slightly anomalous in shape; this is probably indicative of a slight congenital abnormality.

CUL E931 F834 (AD 49(/55)-60/1)
Two cattle thoracic vertebrae display smoothly-united neural spines (Fig 6.42). The vertebral bodies are not involved While this might have resulted from trauma before death, the smoothness of the bone uniting the spines equally argues for this being a minor congenital abnormality.

CUL EL205 (AD 49/55-60/1)
An immature pig femur displays two small exostoses along the posterior aspect of the shaft, possibly of congenital origin.

6.2.10 Examples of miscellaneous skeletal disease

MID F15 (post-medieval)
A post-medieval horse lumbar vertebra shows marked osteophyte-development on the left posterior side. The limited but severe changes are not typical of osteoarthritis.

MID78 443 (16th to 19th century)
A somewhat damaged Roman cattle lumbar vertebra shows evidence of massive osteophyte development on the right anterior aspect of the neural arch.

CUL C199 (AD 65/75-100/125); LWC K568 (medieval); LWC H55 (medieval/post-medieval)
There are three complete tarsometatarsi with marked spur development. Extending to a varying degree above and below the spur is a bone crest, curved in two instances. This extra bone is not indicative of osteopetrosis or inflammation, but is most probably extra-ossification associated with ageing.

6.2.11 Avian osteopetrosis

[Figs 6.43-6.45]

Of the bird bones studied at Colchester, a series of 31 domestic fowl deserved special study. In all these cases some form of abnormality was noted, although in five cases this was not marked. Of considerable interest is a series of 26 bones which may indicate, in varying degrees of development, a viral condition called avian osteopetrosis which gives rise to specific bone changes. This is an entirely different condition to human osteopetrosis. Both in fact result in dense abnormal ossification, but in fowls this is mainly in the form of additional bone, especially on long-bone shaft surfaces. Indeed, in this respect, the avian condition is superficially far more like human melorheostosis, but again the aetiology is thought to be quite different.

In view of the uncommon occurrence of avian osteopetrosis in archaeological samples, it would seem of value to provide brief descriptions of each possible instance of the disease. It can be seen in the photographs and X-rays (Figs 6.43 & 6.45) that the bones with evidence of this condition are usually found to have areas of dense bone extending from the normal long-bone shaft cortex.

BKC JF13 (AD 150-250)
A complete right ulna with much of the shaft covered in dense new bone deposits (Figs 6.44-6.45). The bone surfaces of the swollen area are relatively smooth, with irregular masses, and this rather suggests that some

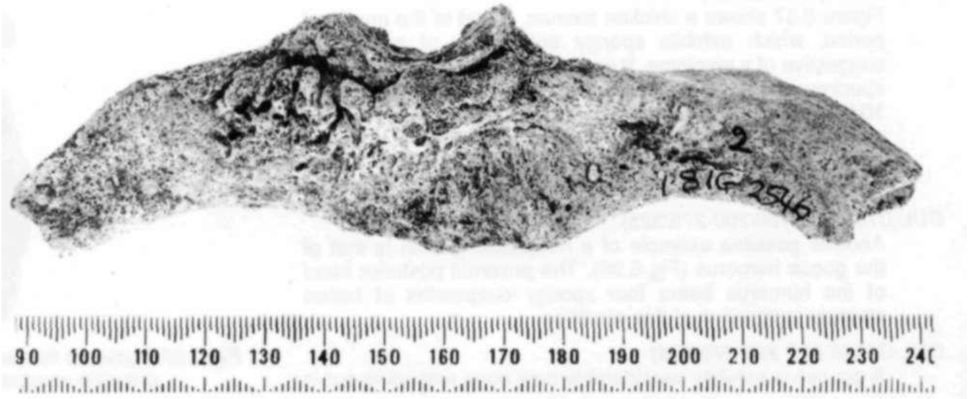


Fig 6 39 Pig pelvis (CUL G2546; AD 225-275/325) showing possible hypertrophic pulmonary osteopathy — medial view. [Page 117]

Fig 6.40 Pig tibia (GBS A1273; AD 49-60/1) showing possible hypertrophic pulmonary osteopathy on the medial surface — anterior view. [Page 117]

Fig 6.42 Cattle thoracic vertebrae (CUL E931; AD 49(/55)-60/1) with congenital abnormality. [Page 118]

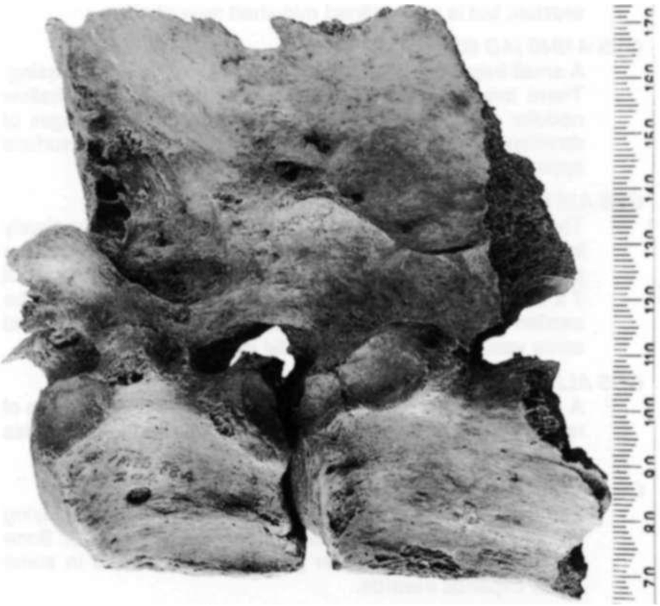


Fig 6.41 Horse lumbar vertebrae (MID 204; late or post-Roman) with congenital anomaly. [Page 120]

ossification could have occurred into the soft tissues over the bone. Additional pathological bone is at least 3 mm thick at some points along the shaft. The joints are not affected.

BKC JF13 (AD 150-250)
Much of the shaft, without articular ends, of a tibiotarsus. The shaft is greatly expanded, with a probable maximum mid-shaft diameter of 13.4 mm (normally about 7.5 mm). In X-ray, the bone appears dense, with a faint 'sun rays' appearance. Externally, the bone must have been relatively smooth at death, but perhaps with some surface pitting.

BKC JF34 (AD 150-250)
The proximal two-thirds of a right femur. The shaft looks slightly expanded, but there are no clear pathological changes on the surface. In the X-ray, the medial region of the shaft shows some degree of cortical thickening. This does not appear to be typical of the extra ossification associated with the early egg-laying period.

BKC JF34 (AD 150-250)
A complete right tibiotarsus, with irregular areas of new bone extending along much of the shaft. The bone surface in these regions displays some pitting, striations and a few vascular impressions. The joints are not involved. A few butchery marks also occur on the shaft.

BKC V148 (AD 100-400+)
Much of the shaft of a tibiotarsus is considerably swollen and deformed. The X-ray shows most of the shaft to be solid bone.

Fig 6.43 A normal domestic fowl humerus (left) and one (right) (CUL GF1863; AD 60/1-275) illustrating osteopetrosis. [Page 118]

Fig 6.44 A normal domestic fowl ulna (right) and one (left) (BKC JF13.AD 150-250) illustrating osteopetrosis. [Page 118]

GBSA30 (post-Roman). CUL G2747 (AD 150-225)
These are both fragments of humerus shaft and both show areas of expansion, but with one showing more pitted and less mature bone.

GBS A668 (AD 100/125-250/275)
For about 20 mm in the mid-shaft area of an incomplete left humerus, there is smooth irregularity with possibly slight shaft thickening. Post-mortem erosion obscures some surface detail.

GBS A890 (AD 100/125-250/275)
A right fibula is united along much of its length to the shaft of the tibiotarsus. Much of the fibula shaft appears to be swollen, as well as fused to the other bone. This could be early evidence of osteopetrosis, although it is surprising that the tibiotarsus is not more involved.

Fig 6.45 Radiographs: domestic fowl ulna (left — BKC JF13; AD 150-250) and domestic fowl humerus (right — CUL GF1863; AD 60/1-275) exhibiting osteopetrosis. [Page 118]

GBSA915 (AD 60/1-250/275)
A left tarsometatarsus, with damaged articular ends. Along the shaft are patches of irregular new bone in varying degrees of remodelling. This could well be the early stages of osteopetrosis.

GBS A956 (AD 60/1-250/275);
A complete right ulna, with early bone changes and expansion along much of the shaft. It is relevant to the diagnosis of these bone lesions being listed that, in the early stages of bone formation, the subperiosteal new bone is not the finely pitted and striated bone typical of periostitis. Instead, it appears to be denser and perhaps more slowly growing. No joint changes occur.

GBS A956 (AD 60/1-250/275)
A damaged proximal half of a right ulna. The additional new bone appears to have undergone some post-mortem erosion, but is well-defined mid-shaft nevertheless.

GBS A1840 (AD 60/1-250/275)
A small fragmented left humerus, with articular ends missing. There are three areas of the shaft which display shallow nodular expansion. These appear to be in three stages of development, judging from the slightly different surface appearance ot each one.

GBS A2212 (?Roman)
The distal half of a mature left humerus. Bone swelling clearly involves much of the shaft, but not as markedly as in the previous specimen. There appears to be one small area (about 7 x 7 mm) displaying active inflammatory change. Much of the swollen bone is fairly rounded but with some large pits and some vascular grooves. The distal joint is not affected.

GBS AL289 (AD 44-60/1)
A small complete left tarsometatarsus, displaying one area of raised new bone towards the proximal end of the shaft. This could represent an early lesion of osteopetrosis.

GBS B36 (AD 60/1-275)
The distal two-thirds of a right tibiotarsus, displaying irregular, but smooth-surfaced, expansion of the shaft. Bone thickness has increased in parts to 6.4 mm and in some areas expands inwards.

GBS B204 (AD 60/1-275)
The proximal 39 mm of a left ulna. There is a considerable swelling between 10 and 14 mm in length and major cortical thickening (up to 5 mm) in the mid-shaft area. The

radiograph confirms that this is dense bone. There are no changes to the rest of the remaining bone, and the pathology suggests a low grade chronic response to infection.

CUL B305 (AD 100/125-275/325)
The distal half of a left tibiotarsus, displaying slight shaft swelling. Although post-mortem changes obscure some detail, the expanded surfaces appear to have been relatively smooth, with some vascular impressions. One deep butchery cut is present. The distal joint is not involved.

CUL EF166 (eady medieval)
Much of the humerus except the proximal end. Along two-thirds of the shaft is an irregular spread of new bone.

CUL G2809 (AD 150-225)
A very swollen shaft of a tibiotarsus, indicative of late stage osteopetrosis.

CUL GF1863 (AD 60/1-275)
A complete left humerus with most of the shaft displaying some swelling (Fig 6.43). Maximum shaft width is 15 mm (normal maximum 12 mm?). In X-ray the pathological bone is seen to be dense, and also to have expanded into the medullary cavity (Fig 6.45). The external surface of the pathological new bone varies from smooth, with some vascular impressions, to pitted and striated, and in one area to irregular and pitted. The impression from this is of pathological bone which was still actively growing at the time of death. The joints are not affected.

GBS A249 (AD 60/1-350); BKC J186 (AD 150-250); CUL G511 (eady medieval)
These are all fragments of tibiotarsus shaft, displaying noticeable external expansion. In two cases there is also very considerable infilling of the medullary cavity. The bone surface is relatively smooth, but with some fine pitting and vascular channels.

LWC B573 (AD 60/1-90);
A complete left humerus with most of the shaft swollen and thickened.

LWC C450 (AD 60/1-80)
A complete humerus with a smooth swollen mass of new bone near the tuberculum dorsale. This is probably indicative of an early stage of osteopetrosis.

Unlikely further evidence of osteopetrosis: some examples

GBS A647 (AD 60/1-110); CUL EF413 (AD 90/100-150/200); GBS A623 (AD 60/1-275); CUL G510 (12th century); CUL B14 (medieval)
Five bones were submitted to further examination but display minimal pathology and are not indicative of osteopetrosis. In all these cases, small projections of additional bone are probably to be interpreted as limited ossification into associated soft tissue, perhaps as result of stress or trauma.

GBS A86 (post-Roman)
The anterior margins of the sternal crest appear to be thickened and slightly asymmetrical. The bone in this area is relatively smooth, but with some large pits and vascular grooves. These changes are not incompatible with those of osteopetrosis, although this part of the skeleton is not so typically affected.

Conclusions on avian osteopetrosis at Colchester

The evidence presented here establishes without doubt that the viral condition producing avian osteopetrosis became established in the poultry reared at Colchester in the Roman period. The evidence presented here is far more than has been previously noted. The findings are compatible with this diagnosis in a number of respects. Of the 31 bones affected, possibly each indicative of different birds, the tibiotarsus is the most commonly affected, as in modern cases of the disease. The more advanced and extensive the bone changes, the more dense the bone appears. Finally, while the bone changes are considerable, they are not typical of normal inflammatory reactions, which again suggests a diagnosis of osteopetrosis, for the virus stimulates new bone formation without a true inflammatory reaction (Baker & Brothwell 1980).

6.3 The range in cattle size at Colchester

[Figs 6.46-6.51]

'The size of a mature bone is determined by its genetic inheritance, its sex and its nutritive status during the growing period... However the influence of nutrition has been underestimated; the magnitude of size differences in the domestic pig using littermates on different rations has been spectacularly demonstrated by McCance and his colleagues (McCance era/1960). A group of Aberdeen Angus cows kept under range-conditions and given winter rations inadequate in energy and/or protein content averaged 8 cm less in withers height at the time of second calving (about 4 years old) than their fully-fed contemporaries (Wiltbank *et al* 1965)' (Noddle 1983, 212).

Noddle's comments are very pertinent in any discussion concerning size distinctions of the major domestic stock. However, Huss-Ashmore warns that the detection of malnutrition from bone pathology is fraught, with a voluminous literature which is somewhat inconsistent (1985, 399).

The large number of cattle metapodia excavated from Colchester allowed a comparison of cattle size through the town's history, and also an understanding of the husbandry tactics in vogue via sexual differentiation of the metacarpal bones (Section 4.2.2). The long bones of the fore and hind limbs were not used in the estimation of shoulder height, since Prummel has found that the multiplication factors of Matolcsi are unreliable (Prummel 1983, 173). Prummel pointed out that both the medieval sites of Hamwih and Haithabu revealed the same difference between cattle shoulder heights which had been calculated from the metapodia and the long bones, thus suggesting that the factors alone were questionable. Matolcsi used a small sample, eleven skeletons of Hungarian steppe cattle, in contrast to the much greater number of skeletons that he and other researchers had used in determining the metapodial factors (Matolcsi 1970).

In Section 4.2.2, a difference was found in the sexual separation of cattle metacarpal bones between the Roman and medieval periods. In the Roman period, metacarpal distal width measurements showed one major cluster of points which together with other methods of analysis indicated a mainly female component (with possibly some castrated beasts). In contrast, the medieval results demonstrated a separation into males and females with a much larger proportion of males than in the preceding Roman period. In addition, the greatest-length measurements of the medieval metacarpals showed a wider range of variation than those of the Roman period, with some bones exhibiting much splaying of the distal condyles, a condition thought to be indicative of traction beasts. It is possible that some of the medieval inhabitants had to resort to consuming their aged beasts in times of hardship. Maltby reported similar findings with the Roman and medieval metacarpals at Exeter (1979a, 35). No in-depth study has been published concerning the effects of traction on long-bone epiphyses, and care should be exercised in the identification of this phenomenon (Sections 6.2.2 & 6.2.3).

In order to determine size-changes through time, we decided to adopt an empirical approach which would present the data visually and allow any patterning to be easily seen. This exploratory data analysis or 'EDA' method emphasises the use of non-parametric statistics.

To display the data concerning shoulder heights of cattle and indeed sheep, box-and-whisker plots were used (Norusis 1988). The box-and-whisker plot is a very useful way of displaying a single variable. Figure 6.46 illustrates cattle shoulder heights through the Roman, medieval and post-medieval periods (after Fock in von den Driesch & Boessneck 1974). The asterisk in the middle of the box is the median, the measure of central tendency. The lower boundary of the box is the 25th percentile and the upper boundary is the 75th percentile. Fifty per cent of the cases have values within the box. Cases which are more than 3 box-lengths from the upper or lower edge of the box are called 'extreme values'. On the box-plot these are designated with the letter 'E'. Cases with values between 1.5 and 3 box-lengths from the edge of the box are called 'outliers' and are designated with the letter 'O'. The largest and smallest observed values that are not outliers are also shown. Lines are drawn from the ends of the box to these values. It is these lines which are the 'whiskers'.

Figure 6.46 represents the withers heights of cattle in the collective Roman, medieval, and post-medieval samples. The position of the asterisk or median is important and the medieval sample shows a slight positive skewing. Clearly there is an increase in cattle height through time with both the medieval and post-medieval groups exhibiting wider size ranges. Use of the Mann-Whitney U Test showed a significant difference in size between the Roman and medieval periods at 0.05 probability. The coefficients of variation for the Roman, medieval and post-medieval cattle shoulder heights are 4.2, 7.1 and 8.1 respectively and this could be a result of the medieval and post-medieval animals showing more admixture of the sexes and breeds.

Figure 6.47 shows box-and-whisker plots through the Roman periods. The Mann-Whitney U Test showed a significant difference in size between the AD 44-60/1 and 60/1 -300 samples and also the AD 60/1 -300 and 225-400+ samples. Since the bones showed no definite grouping into males and females, it is assumed that sex differences will not affect the overall size of the beasts.

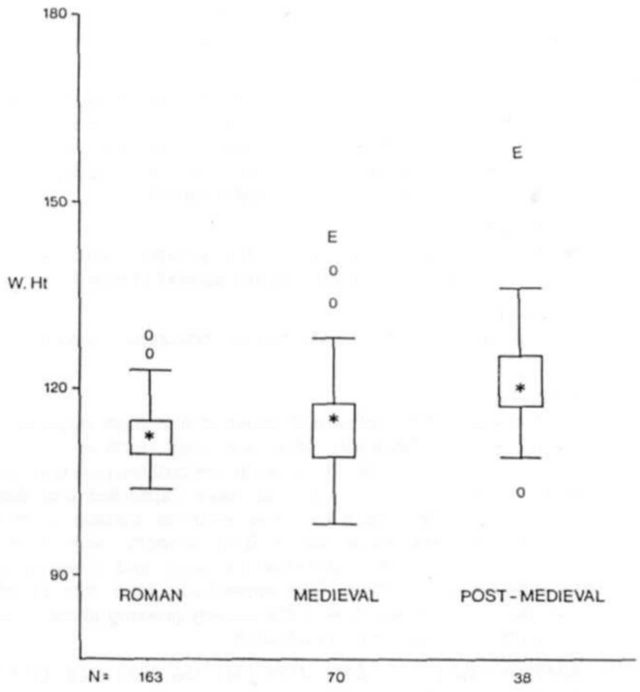


Fig 6.46 Box-and-whisker plots: Roman, medieval and post-medieval cattle withers heights (W Ht) in cm.

If just the metacarpal greatest length is considered as in Figure 6.48, then the late Roman sample of AD 225-400+ shows a much greater increase in size and indeed in the range of measurements. The distal width measurements of the metacarpal are shown in Figure 6.49. As with greatest length, there is an increase in size in the Roman period as evidenced by the AD 60/1-300 sample.

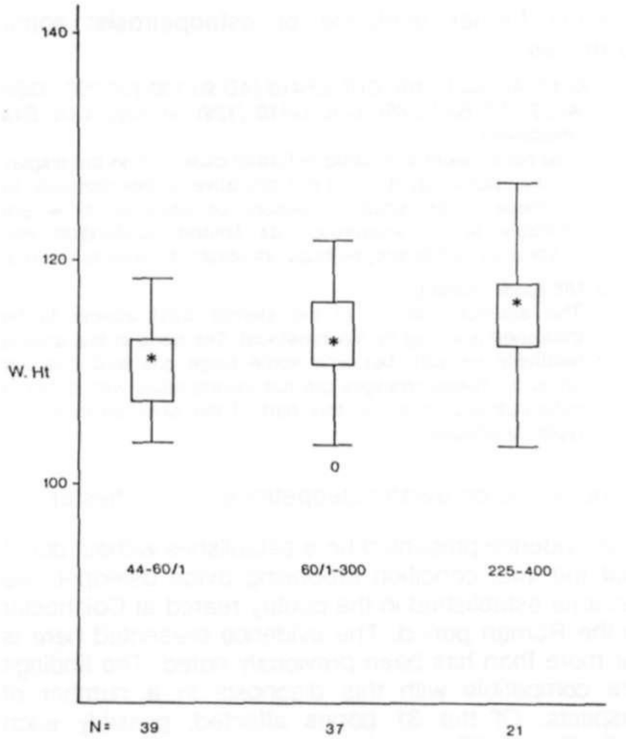


Fig 6.47 Box-and-whisker plots: Roman cattle withers heights (W Ht) in cm.

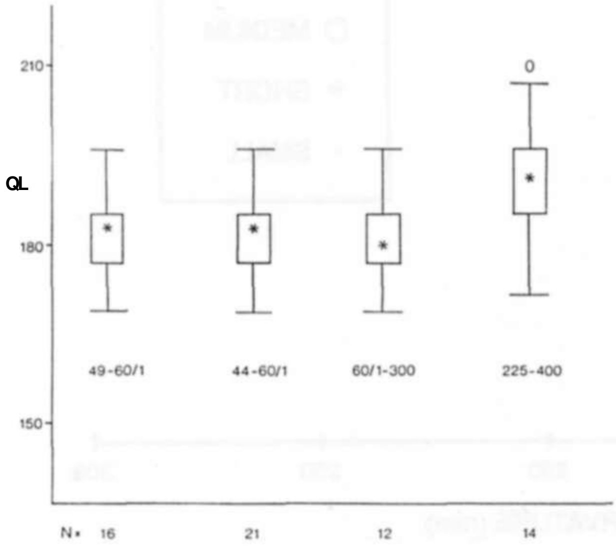


Fig 6.48 Box-and-whisker plots: Roman metacarpal greatest length (GL) in mm. [Page 122]

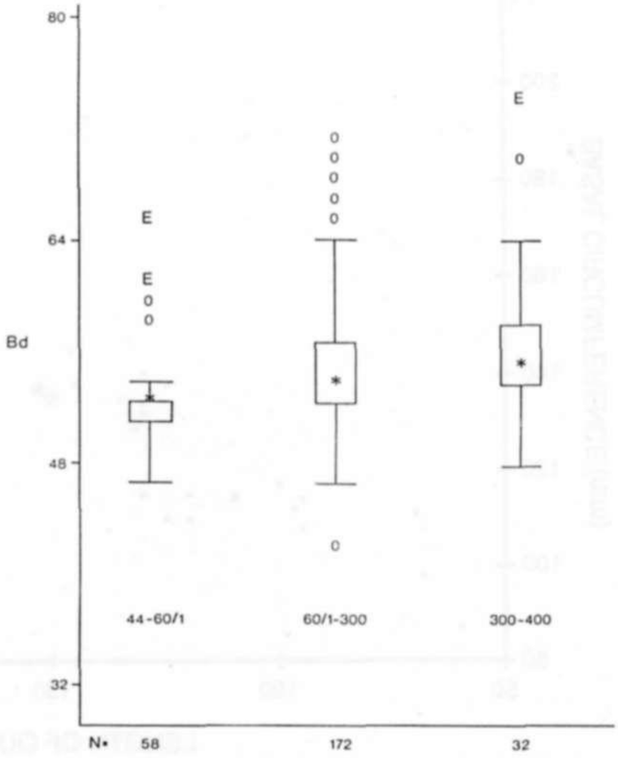


Fig 6.49 Box-andwhisker plots: Roman metacarpal distal width (Bd) in mm. [Page 122]

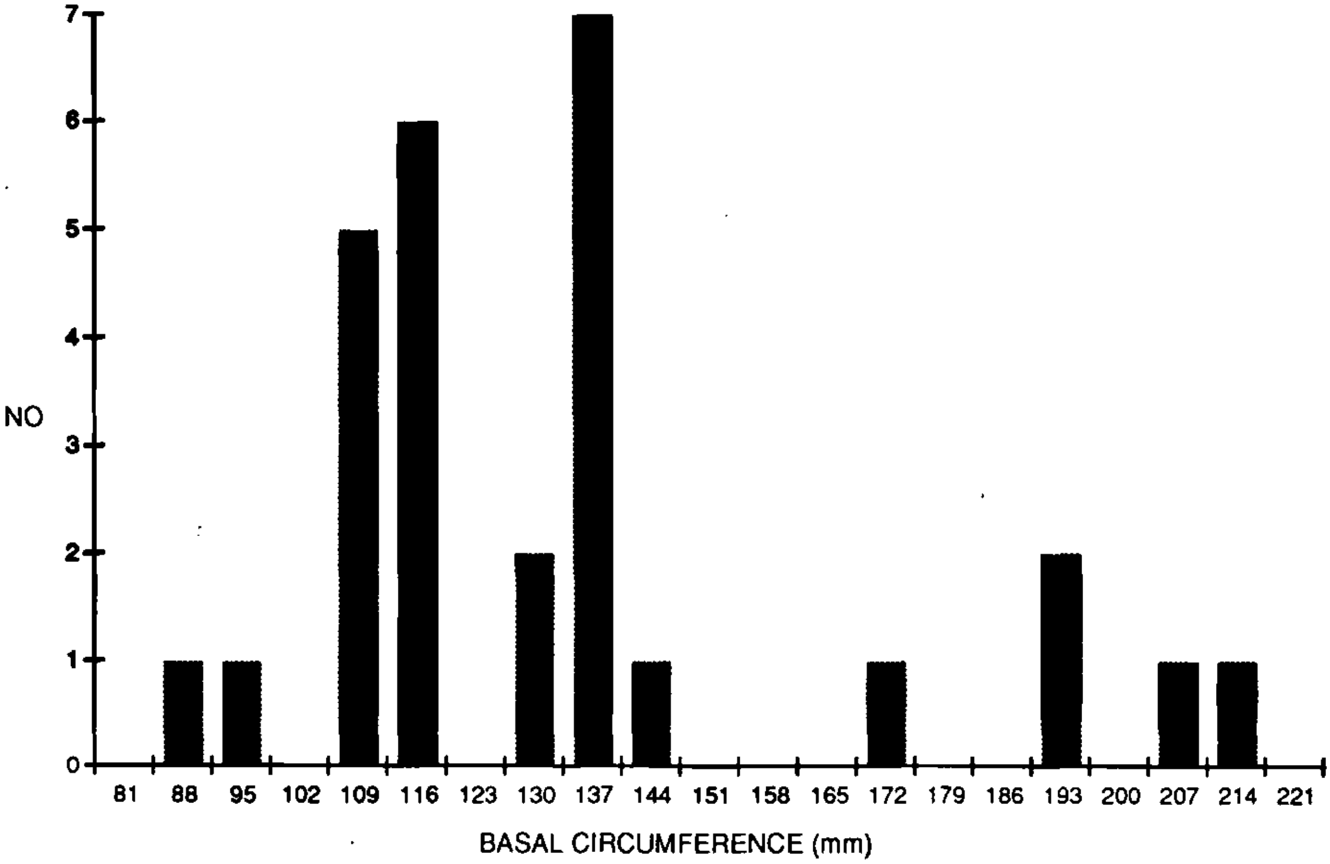


Fig 6.50 Histogram: Roman cattle horn-core basal circumference in mm. [Page 124]

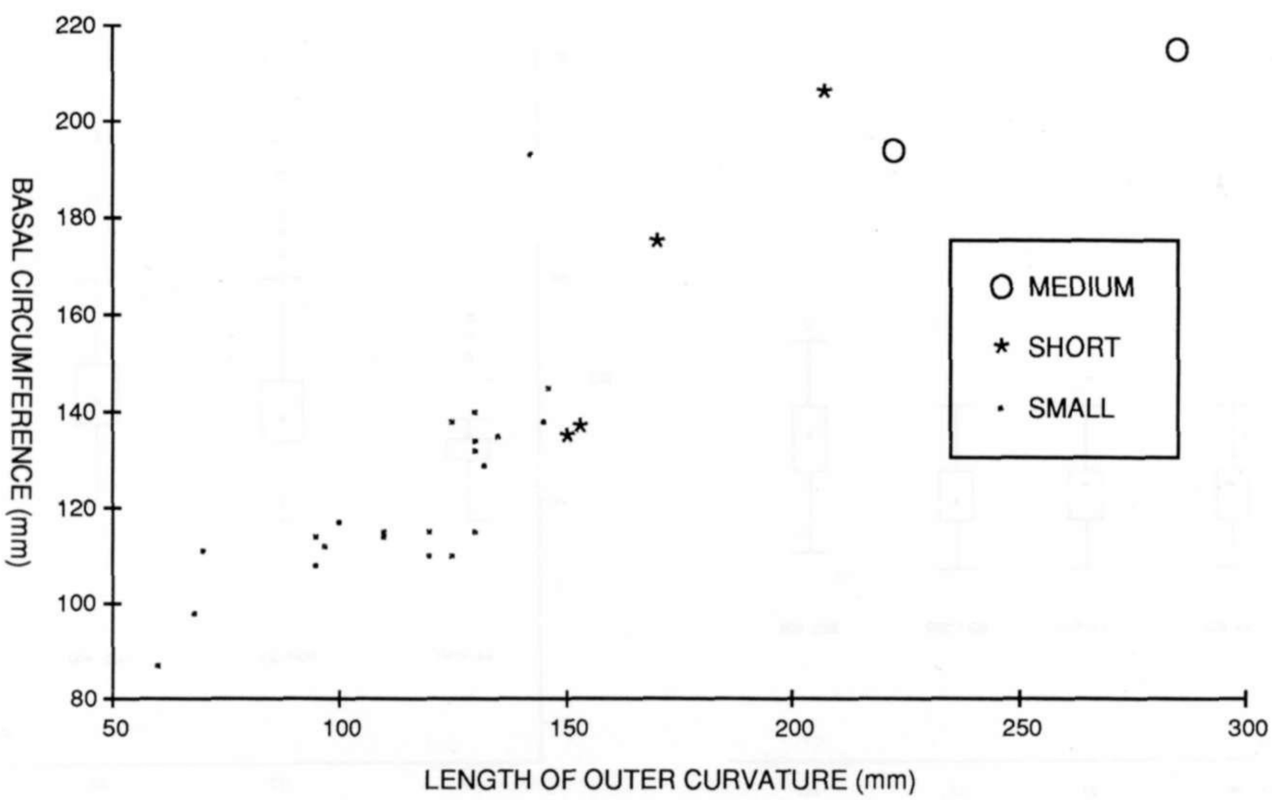


Fig 6.51 Scattergram: Roman cattle horn-core length of outer curvature against basal circumference in mm.

Only 28 cattle horn cores were available for analysis and these were excavated from the Roman levels. Figure 6.50 shows a histogram of basal circumference. Most of the horn cores centre in the 109 to 137 mm range which is at the lower end of the size range exhibited by the vast collection from Roman Chelmsford (100-219 mm; Luff forthcoming). The Chelmsford horn cores were sexed via the methods of Armitage and Clutton-Brock (1976) and are comprised of mainly males, that is bulls and castrates with a few females. The Colchester sample fits within the range for females. Figure 6.51 demonstrates a plot of horn-core length of outer curvature against basal circumference and the separation shows that the majority of horn cores were of the small-horn type, that is less than 150 mm (short-horn, 150-220 mm; medium-horn, 221-360 mm; and long-horn, greater than 360 mm).

6.4 **The range in sheep size at Colchester**

[Figs 6.52-6.54]

As has already been shown in Section 4.3.1, scarcely any adult goat was identified in the Roman, medieval and post-medieval assemblages. It is quite apparent that goat appeared to be more predominant in the younger age groups. Thus, henceforward in this discussion the caprine remains will be referred to as sheep.

Figure 6.52 shows the distribution of sheep shoulder heights (after Teichert in von deDreish & Boessneck 1974) through the Roman, medieval and post-medieval periods. The median, which is the measure of central tendency, occurs at a similar position in all three groups, and while the Roman shoulder heights demonstrate a greater range of variation, there would seem to be no definite increase in the size of the animals. The post-medieval samples, not surprisingly, exhibit two outliers at the upper end of the size range. The coefficients of variation (V) for the Roman, medieval and post-medieval periods are 9.8, 6.9 and 7 respectively and again emphasise the wider range of variation in the Roman period.

Figure 6.53 illustrates sheep shoulder heights viewed through the Roman period. As one progresses through time the asterisk value is seen to increase. The Mann-Whitney U Test showed a significant difference in size of sheep between AD 44-60/1, 60/1-110 and 60/1-300 samples at 0.05 levels of probability. This is also reflected in the coefficients of variation for the AD 44-60/1, 60/1-110 and 60/1-300 groups (6.6, 9.6 and 8). This indicates, as with the cattle shoulder heights, that there was an increase in size of the sheep in the post-Boudican period. Use of the Mann-Whitney U Test showed that there was also a significant difference in size between the AD 60/1-110 and 300-400+ samples at 0.05 level of probability. However, the coefficients of variation for both these samples is similar, being 9.6 for the AD

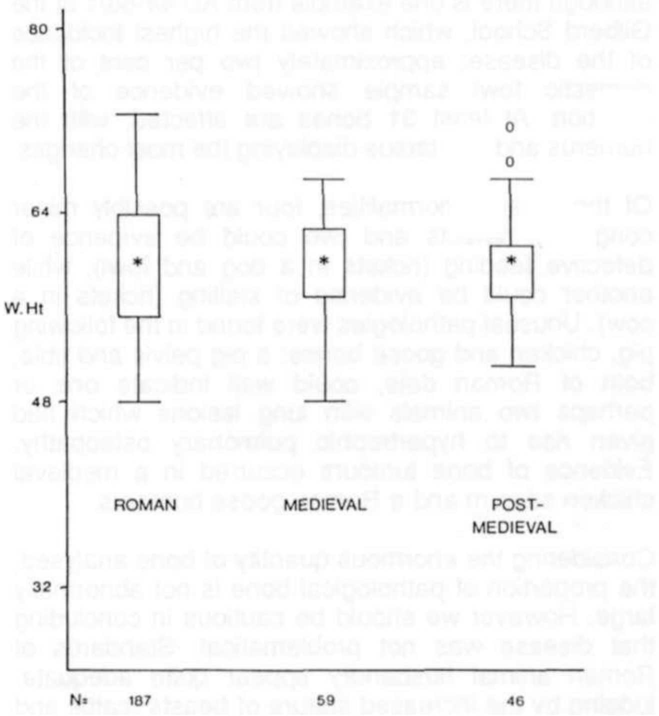


Fig 6.52 Box-and-whisker plots: Roman, medieval and post-medieval sheep/goat withers heights (W Ht) in cm. [Page 124]

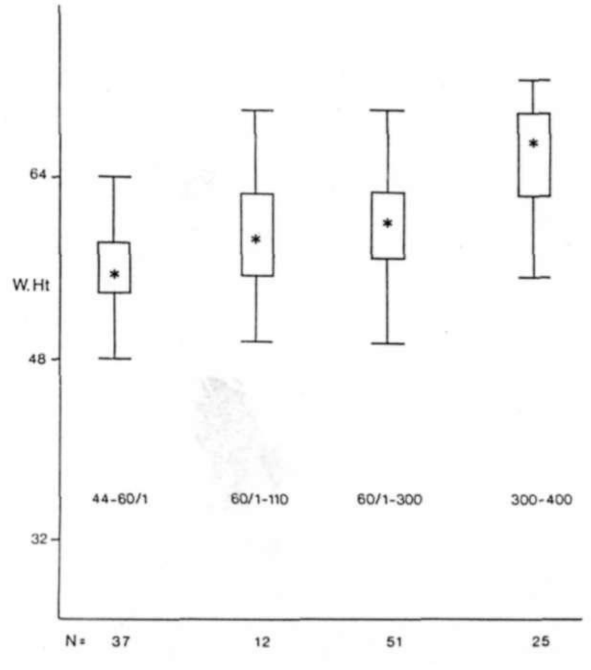


Fig 6.53 Box-and-whisker plots: Roman sheep/goat withers heights (W Ht) in cm. [Page 124]

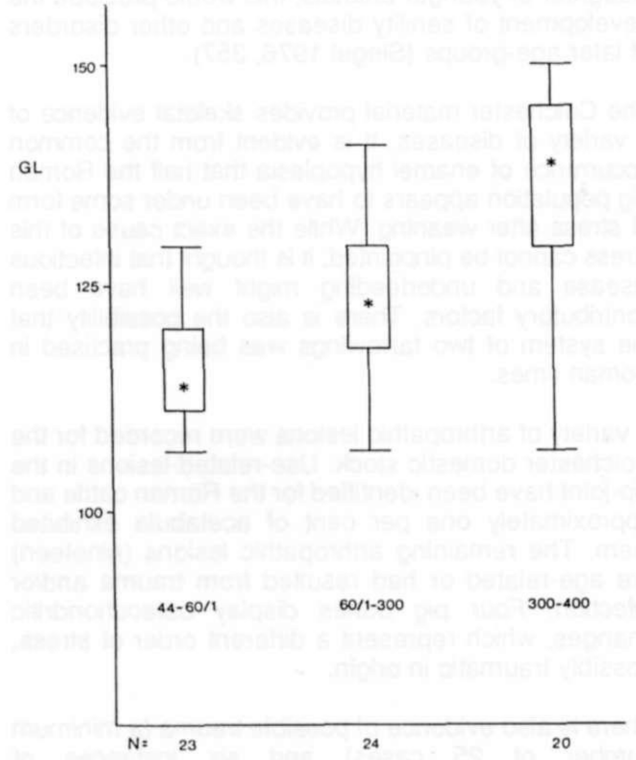


Fig 6.54 Box-and-whisker plots: Roman sheep/goat metacarpal greatest length (GL) in mm.

60/1-110 group and 9.2 for the AD 300-400+ group. Long-bone greatest length and distal width measurements supported these results, in particular those of the tibia, the distribution of which showed the nearest to normality. Figure 6.54 demonstrates a definite increase in size of the greatest length of the metacarpal for the whole Roman period.

It is interesting to note that the late Roman sheep shoulder heights are significantly greater than those from the medieval and post-medieval periods at a 0.01 level of probability, using the Mann-Whitney U Test.

6.5 A summary of the Colchester palaeopathology

In concluding this general survey of the Colchester palaeopathology, we should be aware that most of the specimens described reflect long-term chronic disease. It is impossible to deduce how many animals died through more acute illnesses, especially those of a viral nature. Most pathology first leaves its imprint in the soft tissues. Further, in any comparison of pathologies between sites it is well to be aware of the age structure of the individual species. Where economic factors and dietary preference result in the slaughter of younger animals, this would preclude the development of senility diseases and other disorders of later age-groups (Siegel 1976, 357).

The Colchester material provides skeletal evidence of a variety of diseases. It is evident from the common occurrence of enamel hypoplasia that half the Roman pig population appears to have been under some form of stress after weaning. While the exact cause of this stress cannot be pinpointed, it is thought that infectious disease and underfeeding might well have been contributory factors. There is also the possibility that the system of two farrowings was being practised in Roman times.

A variety of arthropathic lesions were recorded for the Colchester domestic stock. Use-related lesions in the hip-joint have been identified for the Roman cattle and approximately one per cent of acetabula exhibited them. The remaining arthropathic lesions (nineteen) are age-related or had resulted from trauma and/or infection. Four pig bones display osteochondritic changes, which represent a different order of stress, possibly traumatic in origin.

There is also evidence of possible trauma (a minimum number of 25 cases) and six instances of inflammatory change which could similarly be of traumatic origin. Only one case can be explained with confidence as a hunting injury, although it is not possible to rule out a hunting injury to explain the damaged antler.

The viral condition avian osteopetrosis became established mainly in the post-Boudican period, although there is one example from AD 44-60/1 at the Gilberd School, which showed the highest incidence of the disease; approximately two per cent of the domestic fowl sample showed evidence of the infection. At least 31 bones are affected, with the humerus and tibiotarsus displaying the most changes.

Of the other abnormalities, four are possibly minor congenital defects and two could be evidence of defective feeding (rickets in a dog and fowl), while another could be evidence of stalling (rickets in a cow). Unusual pathologies were found in the following pig, chicken and goose bones: a pig pelvis and tibia, both of Roman date, could well indicate one or perhaps two animals with lung lesions which had given rise to hypertrophic pulmonary osteopathy. Evidence of bone tumours occurred in a medieval chicken sacrum and a Roman goose humerus.

Considering the enormous quantity of bone analysed, the proportion of pathological bone is not abnormally large. However we should be cautious in concluding that disease was not problematical. Standards of Roman animal husbandry appear quite adequate, judging by the increased stature of beasts (cattle and sheep) during the Roman period, particularly after the Boudican rebellion of AD 60/1. Indeed, the late Roman sheep were significantly larger than those of the following medieval period; however, the medieval cattle were significantly larger than the Roman beasts.

7: A SYNTHESIS OF THE FAUNAL DATA WITH REFERENCE TO OTHER SITES

7.1 The hinterland of Colchester

[Fig 7.1]

The principal Essex sites mentioned in this chapter are illustrated in Figure 7.1.

Essex, southern and eastern Suffolk, and possibly the borders of Hertfordshire and Cambridgeshire, comprised the territory of the Trinovantes, a pre-Roman Iron Age tribe, who had requested Julius Caesar to come to their aid in their struggle for supremacy against a neighbouring tribe, the Catuvellauni. The northern and western parts of the area consist of boulder clay while London clay dominates the south-east, with lighter soils being found in the valleys of the small eastward-flowing rivers. This region was one of the most populous and

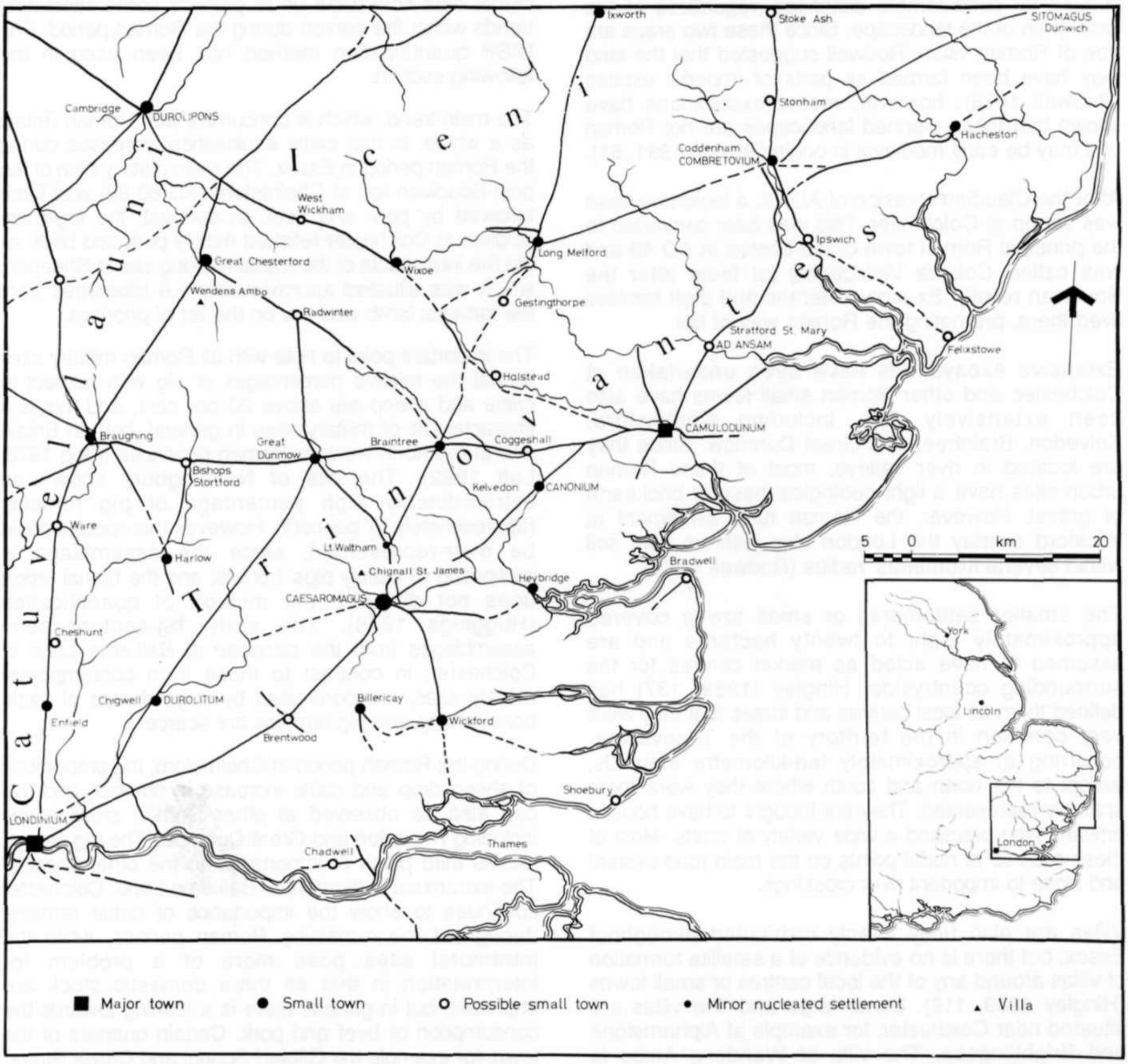


Fig 7.1 Roman and medieval bone assemblages in Essex. Reproduced by courtesy of P J Drury.

prosperous areas in the late Iron Age and Romano-British periods, while throughout the Middle Ages the Essex Marshes provided important pasture for sheep, and later cattle, (Trow-Smith 1957, 193).

It has been suggested that over some areas of central and northern Essex a system of land division, originating in or by the late Iron Age, continued to form the basis of the present landscape (Drury *et al* 1976; Rodwell 1978). Over this early pattern, a network of strategic roads was superimposed in the Roman period, and with it some areas were subsequently re-planned, or were newly brought under cultivation.

However, in two large areas in the southern part of the county, namely the Dengie peninsula and the area around Thurrock, a quite different pattern of rectilinear landscape division exists, based on axes which run straight for considerable distances, regardless of the local grain of the landscape. Since these two areas are free of Roman villas, Rodwell suggested that the land may have been farmed as parts of imperial estates (Rodwell 1978); however, recent excavations have shown that these planned landscapes are not Roman and may be early medieval in origin (Rippon 1991, 51).

After the Claudian invasion of AD 43, a legionary base was set up at Colchester. This was later converted to the principal Roman town of the canton in AD 49 and was called *Colonia Victricensis* (at least after the Boudican revolt). Ex-army veterans and their families lived there, promoting the Roman way of life.

Extensive excavations have been undertaken at Colchester, and other Roman small towns have also been extensively dug, including Chelmsford, Kelvedon, Braintree, and Great Dunmow. Since they are located in river valleys, most of these Roman urban sites have a light geological base of brickearth or gravel. However, the Roman rural settlement at Wickford overlay the London clay with no light soil within several kilometres' radius (Rodwell 1975).

The smaller settlements or small towns covered approximately eight to twenty hectares and are assumed to have acted as market centres for the surrounding countryside. Hingley (1989, 137) has defined them as local centres and states that they were very common in the territory of the Trinovantes, occurring at approximately ten-kilometre intervals, except to the north and south where they were more sparsely represented. They are thought to have housed artisans who practised a wide variety of crafts. Most of these sites lie at nodal points on the main road system and close to important river crossings.

Villas are also fairly evenly distributed throughout Essex, but there is no evidence of a satellite formation of villas around any of the local centres or small towns (Hingley 1989, 119). Some large and fine villas are situated near Colchester, for example at Alphamstone and Brightlingsea. The villa of Wendens Ambo is located by Great Chesterford while the villa of Chignall St James is in close proximity to Chelmsford.

7.2 The main domestic stock of historic Essex

A number of bone reports have been compiled or are being prepared from a variety of Roman sites in Essex: the *colonia* and legionary fortress of Colchester (Luff 1982); the industrial site of Sheepen at Colchester (Luff 1985); the 1st-century Roman fort at Chelmsford (Luff 1982 & 1988); the Roman small town of Chelmsford (Luff 1988a & in progress); the Roman small towns of Great Dunmow (Luff 1988b), Kelvedon (Luff 1988c), and Braintree (Luff 1976); the rural settlements of Wickford (Douglass unpublished) and Nazeingbury (Huggings 1978); the Roman temples of Chelmsford (Luff 1992), Harlow (Legge & Dorrington 1985), and Witham (Luff in progress); and the villas of Wendens Ambo (Halstead *et al* 1982) and Chignall St James (Luff in progress). The faunal data now allow us to pinpoint some interesting trends within the canton during the Roman period. The NISP quantification method has been used in the following section.

The main trend, which is concurrent with Roman Britain as a whole, is that cattle exploitation increases during the Roman period in Essex. The main dietary item of the post-Boudican fort at Chelmsford (AD 60-80) was lamb followed by pork and beef. In contrast, the legionary soldiers at Colchester relished mainly pork and beef, as did the inhabitants of the metal-working site at Sheepen, which was situated approximately 1.6 kilometres from the fortress; lamb was low on the list of priorities.

The important point to note with all Roman military sites is that the relative percentages of pig with respect to cattle and sheep are above 20 per cent, and this is a characteristic of military sites in general, both in Britain and in the north-western Roman provinces (King 1978; Luff 1982). The site of Nazeingbury shows an extraordinarily high percentage of pig remains (approximately 77 per cent). However, this species could be over-represented, since the assemblage is comprised of mainly pigs' trotters, and the faunal report does not describe the method of quantification (Huggings 1978). The early 1st-century bone assemblages from the *canabae* at Balkerne Lane in Colchester, in contrast to those from contemporary military sites, are dominated by large dumps of cattle bone; sheep and pig remains are scarce.

During the Roman period at Chelmsford, the proportions of sheep drop and cattle increase in number, and this can also be observed at other Roman small towns including Kelvedon and Great Dunmow. The pig always retains third place of importance to the other species. The extramural settlement at Balkerne Lane, Colchester continues to show the importance of cattle remains throughout the remaining Roman periods, while the intramural sites pose more of a problem for interpretation in that all three domestic stock are important, but in general there is a leaning towards the consumption of beef and pork. Certain quarters of the town, for example the Gilberd School and Culver Street, exhibit some relatively high percentages of pig remains. Certainly some degree of social differentiation is apparent here (Section 3.7.1).

The villa of Wendens Ambo, while revealing a dominance of sheep in the early Roman period, switches to a preference for cattle in the later period (Halstead *et al* 1982). Conversely, the villa of Chignall St James is dominated by cattle throughout the Roman period, and indeed some of the cattle bones are of a very large size. The rural settlement of Wickford shows that cattle are the main species being bred throughout the Roman period, with approximately 80 per cent of the remains being those of cattle.

The Roman temples of Chelmsford and Harlow revealed high percentages of lambs being sacrificed. However, they differ in that cattle at Chelmsford and pigs at Harlow are the main secondary species. Witham was quite different; mainly cattle were sacrificed, together with high percentages of horse.

Equine remains are generally sparse on all the sites, except at the villa of Chignall St James where horses constitute 13 per cent of the sample. The greatest variation in horse size was observed at Witham Roman temple, and the largest horses were recovered from both Witham and the early phase of the Roman temple at Chelmsford (14 to 15 hands). The horses from Roman Colchester ranged in height from 11 to 14 hands.

There is a shortage of published faunal reports for medieval/post-medieval Essex. Results from sites in Colchester have shown that pig husbandry was of low priority, and that cattle and sheep were the most important domestic stock in the medieval period. Wool was an important commodity, and its production continued into the post-medieval period which also saw a dramatic increase in veal and milk production. Again pigs were not of great importance.

7.3 Cattle

[Table 7.1]

In 1978 King proposed that there was, in general, an increase of cattle on Roman sites from the early to later periods (King 1978). Now that more sites with larger databases are available, this still holds good and is also true of the Essex sites mentioned in the previous section. The heaviest concentrations of adult cattle appear on military and urban sites.

In any interpretation of animal exploitation we must be very wary of assigning dietary trends to faunal assemblages. Perhaps the single most important point to emerge from Roman bone analyses at the moment is that the dominance of cattle in the faunal record is related primarily to the intensity of the arable agriculture. The extensive cultivation of the land necessitated an input of traction power which could only be supplied by oxen. Thus vast quantities of cattle bones on an urban site do not necessarily indicate a dependence on cattle as a food item. The age structures (and indeed the pathologies) of the individual samples under analysis provide the vital clues in assessing whether the beasts were primarily raised for food or haulage.

Indeed, O'Connor (1984) has commented on the relatively small quantities of bone recovered from the Roman levels of York; he suggests that this might be in part a consequence of the organised refuse disposal of the time and also a reflection of the fact that large parts of the settlement have remained unexcavated. It should also be considered that large sectors of the population might well have been vegetarian and this, perhaps, could well be a reason for a dearth of bone.

In contrast to the Roman period, the medieval period, particularly the later part, is characterised by an increase in the husbandry of sheep.

During the Romano-British period there would appear to have been an increase in the numbers of mature cattle, but we have very imprecise information on ages at death (Maltby 1981; Noddle 1984; Grant 1989). It has been suggested that cattle ageing forms two distinct patterns: a) villas and rural sites demonstrate mandibles of all ages, while b) urban sites demonstrate more mature animals (Maltby 1981). However, the interpretation of cattle kill-off patterns is greatly hampered by a lack of faunal evidence, which is related to the poor recovery of jaw bones.

Noddle, in her 1984 survey of those Roman archaeological sites which are situated mostly in the western part of Britain, suggested that military sites have more juvenile specimens than urban ones; this may have been the result of an increased military demand for leather (Noddle 1984). Late Roman cattle mandibles from Portchester show that while most of the beasts are mature, some assemblages show peak killings between 1.5 and 2.5 years and also 3 and 3.5 years of age (Grant 1975b). Documentary evidence for the Roman period describes veal as being an important commodity to the Roman army (Walker in Toynbee 1973, 325), but so far no faunal investigations have detected this.

In Roman Essex, most of the slaughtered cattle were mature animals, being 3 years old or more. However, some sites show a concentration of older animals; for example, the Sheepen cattle were older than those from nearby Balkerne Lane, and perhaps reflected not so much the diet of the metal-workers but the use of animals to provide traction and hides (Luff 1982, 15). The fact that these beasts were later consumed does not mean that they were the mainstay of the diet and perhaps vegetables were equally important. There is a trend on the later Roman (as opposed to early Roman) intramural sites of Colchester for younger cattle to be consumed. However, the Balkerne Lane beasts show an increase in the proportion of older animals (Section 4.2.1). More immature cattle were slaughtered in Exeter during the later Roman period, and this has been connected to a possible decline in arable farming as a result of a decrease in demand for grain (Maltby 1979a, 90). The later Roman period may well have been a time of agricultural stagnation. At the rural settlement of Wickford, although most of the animals were fully mature, being 4 years old, much younger animals had been slaughtered (which perhaps is indicative of breeding at the site). Similarly the Roman temple at Witham showed a concentration on mature animals of 4 years plus. Newborn calves were noted in Wells 5 and 6 in the Roman small town of Neatham, Hampshire, and it would appear likely that cattle were bred in the vicinity. Most of the cattle jaws exhibited scant wear on the fourth premolar and were dubbed young adults (Done 1986).

Mature cattle tend to dominate early medieval urban bone assemblages while more juvenile cattle were killed-off in the later medieval period, in order to supply the urban market (Maltby 1979a). At North Elmham over 20 per cent of the medieval and post-medieval samples were less than a year old, and Noddle (1980) interpreted this particular kill-off pattern as resulting from casualties or perhaps the utilisation of beasts for vellum production. The medieval cattle of York were all adult (3 to 4 years old) with a third of the beasts exhibiting marked wear on the third molar. O'Connor (1984) interpreted this pattern of slaughter as the kill-off of adults in their prime as suppliers of milk and haulage, but probably past their best as suppliers of tender beef. He identified the cattle as a multi-purpose resource.

The most striking change in the post-medieval Exeter cattle assemblages was the discovery of large quantities of calf bones (Maltby 1979a). From the 16th century onwards, veal was very common, and this can be related to the emergence of a dairy industry. Incidentally, a greater number of pigs were culled in their first year and Maltby suggests that they were fattened up on the surplus whey from the dairies *(ibid,* 83). Similarly, York developed an organised veal industry in the 16th/17th centuries (O'Connor 1988, 86). In medieval Colchester there was an increase in the butchery of young cattle aged between 5 to 6 months old, but most of the cattle were slaughtered when mature, at 3 years plus. However, a thriving veal and milk industry was supported in post-medieval Colchester (Section 4.2.1).

Jewell (1963) initially demonstrated that small Iron Age cattle were present together with much larger beasts in the Roman period. Although Armitage (1982) was adamant in his assertion that an increase in bovine size was due solely to improved husbandry standards, Noddle (1984) stated that he must account for the introduction of the circular horn core of the Roman and later animals and the loss of the distinctive Celtic conformation. The Roman period, as compared with the pre-Roman Iron Age, is generally characterised by larger animals which exhibit a broader variation in the range of size. The largest cattle to be bred in Roman Essex were found at Great Chesterford followed by Chignall St James, late Roman Colchester, and Witham. Colchester and Chignall St James show the greatest variation in range of size for cattle, and it is curious that the larger cattle of Chignall have not been found in the nearby small town of Chelmsford. It would appear that Chelmsford was not receiving its cattle from the Roman villa of Chignall St James; perhaps Chignall was supplying the Roman temple at Witham. The Colchester cattle remains embrace small and large animals as compared with samples from other parts of the country (Luff 1982); however, the coefficients of variation (V) for the withers heights do not vary much through the Roman period, and figures for the medieval and post-medieval periods are much higher. As pointed out in Section 4.2.2, this could be a result of a greater admixture of males and females in these later periods (Table 7.1).

Grant (1989) has pointed out that in the Roman period mature cattle were sold on the urban and military markets as females, that is they were no longer good breeders. Conversely, on the farms castrates and bulls were retained until they could work no more.

During the early medieval period cattle in Colchester assumed a dwarf stature which was not unique to Britain since small short-horned cattle were common throughout western and eastern Europe in the 12th and 13th centuries. Initially it was thought that this phenomenon reflected a primitive type of livestock husbandry in the medieval period as opposed to former times (Bokonyi 1974). Noddle (1975), referring to the 14th century, thought that the single legal price for cattle at market did not provide the incentive to experiment with the blood-stock. However, Armitage proposed that the smaller cattle were probably preferred and thereby selected for, since they would not require as much feed as a larger beast and consequently would be less of a burden to the farming community (Armitage 1982). Certainly at this time more land was under arable agriculture and pasture would have been a valuable resource.

However, a larger long-horned variety emerged in south-eastern Britain during the late 14th and early 15th centuries, for example at Kingston upon Thames (14th century), Baynard's Castle (1499-1500), West Ham, London (late 15th to early 16th century), and Tudor Street, London (14th to 16th century) (Armitage 1980). Armitage (1980) linked the following events to account

Table 7.1 Colchester cattle withers heights (cm).

Period	x	s	min	max	v
ROM	112.2	4.8	102.5	128.1	4.2
MED	114.3	8.2	99.4	144.0	7.1
PM	121.3	9.8	103.1	158.6	8.1
44-60/1	110.5	3.8	103.1	119.0	3.5
60/1-300	112.8	4.5	102.5	121.2	4.0
225-400+	116.4	5.7	104.3	128.1	4.9

Key:
x — mean
s — standard deviation
v — coefficient of variation

for the emergence of this beast in the late medieval period. The evolution of the enclosure system allowed greater variability to occur in larger herds through controlled breeding; the three-crop rotation (including legumes) increased soil productivity, and new improvements in techniques for making and storing hay made sure plenty of better-quality feed was available all year round. The Tudor cattle improvements were given a further boost by the huge expansion of the London meat markets in the mid 17th century, which provided an important stimulus to the development of British cattle husbandry (Armitage 1982).

7.4 Sheep/goats

[Table 7.2]

Goats were not widely exploited in the Roman or medieval periods for hair and meat, although a few sites have turned up small deposits of horn cores, which are the remnants of horn working. For example at the medieval site of Exe Bridge in Devon, goat horn cores were twice as numerous as the post-cranial sheep-bones, and perhaps there was a possible trade in this commodity (Levitan 1989). Sheep-breeding became less important during the Roman period as new sites were located which were more suitable to the raising of cattle and pigs (King 1978).

In general, Romano-British urban, rural and military archaeological sites show that the main trend in sheep exploitation was to kill the animals between their second and third years, presumably for meat (Maltby 1981). However, the peak age of slaughter of sheep in Roman Essex was between 6 and 12 months. Some early Roman sites, particularly those of the military, are characterised by the consumption of first-year lambs, for example the military deposit at *Margidunum* (Harman 1969, 101). This was also evident for the 1st- to 2nd-century fortress levels at Blake Street, York where, in addition, a relatively high proportion of adult sheep occurred (O'Connor 1987). However, the later 2nd- to 3rd-century deposits at Tanner Row, York, also yielded young lambs and this was thought to have been a characteristic typifying the *colonia* of York, rather than just pertaining to early Roman sites in general (O'Connor 1984). However, it could not be determined whether the secondary products obviously available were mainly milk or wool. York differs from the general overall peak kill-off pattern of 2 to 3 years of age for Romano-British sites. Most sheep were slaughtered at between 4 and 6 years old, and O'Connor considered that the town would have obtained its livestock from many different farms, each practising a different farming regime.

The Roman sheep from Fishbourne palace were mainly killed at 1 to 2 years, and 2 years plus, as were those from the Roman settlement of Neatham, where the peak killings were approximately 18 months and 3 to 4 years old during AD 75-250 (Grant 1971; Done 1986). However, in the later Roman period at Neatham, the kill-off profiles are more spread out, although there is still a concentration on killing animals for meat. In both periods much older sheep (up to 8 years old) occur which Done suggests represents the maintenance of a breeding flock (Done 1986).

At 3rd- to 4th-century Winchester, the age at which the killing of sheep peaked was between 2 and 4 years, while at nearby Owslebury more neonatal and other young sheep were represented as would be expected on a rural settlement rearing its own flocks (Maltby 1987a & 1987c). Maltby named a number of sites where there are relatively high numbers of mature animals, for example Barton Court Farm (Hamilton 1978, 129), the later levels of Fishbourne (Grant 1971a, 129), and Shakenoak Farm (Cram 1978, 128-35), and he wondered whether this pattern was typical of rural settlements (Maltby 1981). Currently we need many more samples from rural sites to test this hypothesis.

With regard to the exploitation of the Essex sheep, many Roman sites demonstrate a peak age of slaughter at between 6 and 12 months of age. As already shown, this is true of Roman Colchester, which also exhibited a trend towards killing even younger lambs in the later Roman period (Section 4.3.3). Sheepen, the post-Boudican fort at Chelmsford, and the small town of Great Dunmow all exhibited this. Later samples from Chelmsford (Site S) show the emphasis on killing to have shifted to beasts 3 years old or more, but the samples are small and may not therefore be truly representative. A larger sample from Chelmsford (Site AG) showed the 6- to 12-month slaughter pattern occurring throughout the four centuries of occupation (Luff unpublished). Chelmsford (phase IV) and the Harlow Roman temples also showed that the majority of sheep were dispatched as lambs at this age stage; however, the later phase of the Chelmsford temple (phase VI) displays sheep mainly killed at 3 to 4 years old, although the second peak of killing is still 6 to 12 months. The Roman villa of Chignall St James shows a totally different pattern in that the peak age of killing was at 4 to 6 years, with a second peak at 1 to 2 years, and thus probably represents a farming economy dependent on wool. The Wendens Ambo villa shows the peak age of killing in the early Roman phase to have been between 1 and 2 years.

As with cattle, the size of Romano-British sheep shows a wider range of variation as compared with the pre-Roman Iron Age. Also there is considerable variation in the size of sheep between different localities, which may reflect the grazing available and the standard of animal husbandry practised.

The explosion in the rearing of sheep livestock during the medieval period evolved at different times in disparate parts of the country. A startling increase in sheep numbers was noted at Barnard Castle, County Durham, in the late 15th and early 16th centuries (Jones *et al* in press), while sheep became more common at Prudhoe Castle, Northumberland from the mid 16th century (Davis 1987). However, at Flaxengate, Lincoln sheep predominated from the mid

12th century (O'Connor 1982), while at Exeter, sheep numbers increased in deposits later than the 13th century (Maltby 1979a).

One needs to be cautious in making generalised economic interpretations from the faunal assemblages of castles and religious establishments, since the bones often show the dietary preferences of the aristocracy (Grant 1988, 151). In fact, Grant has stated that the best sites for understanding sheep husbandry may well be towns, where in the 12th and 13th centuries, sheep bones were on a par with those of cattle; the animals are mainly juvenile, having provided one or at the most two fleeces (Maltby 1979a; Grant 1979; Cartledge 1983; O'Connor 1982 & 1984). The sheep numbers fell in the 14th century to increase in the 15th century, and at several sites there is a higher proportion of older animals (Armitage 1977; Maltby 1979a; O'Connor 1982). Medieval York shows a kill-off pattern of more mature sheep, which was typical of medieval England as a whole. The primary product was wool, but dairying in certain regions was prospering by the end of the medieval period (Trow-Smith 1957, 193). In general, mature cattle and younger sheep tend to dominate medieval urban bone assemblages, while mature sheep are more common on rural settlements (Grant 1989, 140).

The peak age of slaughter at Exeter was the same as in the generalised pattern for the Roman period, ie the second to third year (Maltby 1979a). At Lincoln during AD 1200-1550, 68 per cent of the sheep were mature animals at least three years of age and probably over four. In the earlier periods younger sheep were killed for meat (O'Connor 1982). At North Elmham, Norfolk 73 per cent of the sheep were mature, while in contrast at Wharram Percy the proportion was only 15 per cent (Noddle 1980; Ryder 1974). At King's Lynn more mature sheep were being slaughtered by the 13th century, and at Exeter the mature animals only increased in percentage during the 16th century (Noddle 1977; Maltby 1979a).

The late 18th-century population growth and market demands caused an impetus in stock-breeding, so that both sheep and cattle were commercially bred for their meat.

In the medieval period at Colchester the jaw bone assemblages are dominated by older sheep, 3 to 4 years old, which reflect the significance of wool to the economy. In the post-medieval period greater numbers of sheep were being slaughtered at 4 to 6 years and 6 to 8 years in addition to those at 3 to 4 years. Wool had become increasingly important.

Although the average size of sheep increased slightly between the Roman and medieval periods at Exeter, scant effort was made to improve the stock, with the result that it was well below that from other areas of Britain (Maltby 1979a). During the medieval period itself there is no evidence of an increase in sheep size; the sheep were generally smaller in the medieval period than they had been in the Roman period (Grant 1984a, 183). In fact, at Portchester, Grant found that there was a significant reduction in size from the Roman to the medieval periods, and this was also found at Colchester (Section 6.4). Grant claims that we should not expect to see a size change in the medieval period since attempts at improving sheep may have concentrated on the wool yield and quality rather than on size increases to improve the meat. However, she does make one important observation, and that is, if there were any major improvements in sheep nutrition in the Middle Ages, this should be reflected in the sheep size (Grant 1984a, 183). It is quite likely, as stated in Section 7.3 for the cattle, that the expansion of the arable in the early part of the medieval period may have had a detrimental effect on the sheep size, and this could have affected breeding for some time.

Comparing sites with respect to the size of the sheep can suggest sources of supply, providing that sexing is taken into consideration. Most of the sheep (and pigs) at urban Roman Winchester represented larger animals than at nearby rural Owslebury (Maltby 1987a). The mean size of sheep measurements is considerably greater at Winchester. Grant has demonstrated that the mutton supply to the Portchester Roman fort was met by the purchase of stock from several localities. The variety of tooth wear visible on the sheep mandibles indicates that different pastures had been grazed by the sheep and hence different environments had been exploited. In addition, there were possibly genetic differences between individuals in the flock (Grant 1982).

Documentary evidence provides more emphasis on the importance of sheep with respect to wool than does the archaeological evidence, and Grant (1988) draws our attention to the fact that the historical and archaeological evidence often appear contradictory.

If the shoulder heights of sheep are considered, some large-sized animals were bred at Witham Roman temple and Roman Colchester. Colchester shows the greatest range in variation for the Roman period, and in later phases yielded very large beasts. In contrast with the medieval and post-medieval periods, a much wider range of variation is found in the Roman sheep withers heights (Table 7.2), and this is contrary to what was found with the cattle remains, where a wider range of variation was found with the medieval and post-medieval measurements (Section 7.3). Also the range of variation increases throughout the Roman period, which suggests that perhaps the Roman inhabitants of Colchester were exploiting beasts from a wider area and/or promoting the breeding of larger animals. The mandible kill-off patterns do not suggest a dramatic change in the economic exploitation of the sheep; the emphasis was on lambs slaughtered for meat. Undoubtedly there would have been a great incentive to breed larger stock in order to satisfy the growing urban market.

In general, if the results from Essex are compared with those from other geographical areas, very large

Table 7.2 Colchester sheep withers heights (cm). [Page 132]

Period	x	s	min	max	v
ROM	59.5	5.8	48.6	73.8	9.8
MED	59.0	4.1	48.2	67.1	6.9
PM	59.0	4.2	50.4	70.9	7.Q
44-60/1	56.2	3.7	48.6	63.6	6.6
60/1-300	59.7	4.8	49.0	70.4	8.0
225-400+	62.6	6.6	52.7	72.6	10.6

Key:
x — mean
s — standard deviation
v — coefficient of variation

sheep are emerging in the late Roman period, particularly at Colchester (Luff 1982). Since they do not occur in very large numbers they could possibly represent rams introduced to promote the vitality of the bloodstock.

7.5 **Pigs**

As stated in Section 7.2, high levels of pig bones have been excavated from sites with known Roman military connections, that is 20 per cent or more of the main domestic stock (King 1978). King has related this to the spread of Romanisation while Grant (1989, 137) refers to the immediate need of feeding a rapidly-increasing population. The main purpose of keeping pigs is for their meat; they can produce large litters and are relatively easy to feed. High percentages of pig bones are found on the early military sites of Sheepen (Luff 1985), Caerleon (O'Connor 1983 & 1986), Fishbourne (Grant 1971a), Exeter (Maltby 1979a), Leicester (Brown A 1985), York (O'Connor 1987), and Cirencester (Maltby 1984a). Pre-Roman Iron Age sites do not have such high percentages.

It is interesting to note that the Roman deposits of the *colonia* at York always showed a fairly high abundance of pig compared with Roman sites elsewhere, and O'Connor (1986) has related this to the topography of the York area. He comments that a low-lying, seasonally-flooded river valley would not have been ideal sheep country but would have served pigs and cattle. Towards the end of the Roman period the pig declined in importance.

It is well known from classical sources that the Romans enjoyed suckling-pig; however, there is scant evidence for this from Britain (White 1970, 320). Some Romano-British sites exhibit a high incidence of first-year mortalities (Maltby 1979a, 57; Grant 1971a, 383), for example the legionary levels of Exeter (which also showed a particularly high culling of first-year sheep) and Fishbourne. The late Roman levels of Winchester revealed that pigs had been killed between their first and second years. However, most Romano-British pigs were not slaughtered until they were at least two years old, and hence the intensity of pig husbandry was never particularly high by modern standards. At both late Roman Exeter and Fishbourne there was a high incidence of mandibles with a worn third molar, which suggests a culling age of about two years. The Roman and Saxon mandibles from Portchester did not exhibit intensive killing of young pigs; they mainly represent the slaughter of animals in their second and third years. Throughout the Roman period at Colchester, the peak age of slaughter was in the second year, although there was some evidence for an increased slaughter of very young individuals of six months of age (Section 4.4.2). Maltby (1981) has summarised our lack of knowledge concerning Romano-British pig husbandry: the intensity of exploitation is virtually unknown as is the system of husbandry; we do not know whether the pigs were sty-fed or allowed to range freely through the streets and/or forests.

In the medieval period, pork was consumed more by those of higher status than by those eking out a living on rural settlements (Grant 1989, 142). In general, pig bones are more widespread on rural than urban sites and are particularly dominant at castles and monastic sites (Grant 1988, 158), for example Barnard Castle, County Durham (Jones *et al* 1981), Okehampton Castle, Devon (Maltby 1982b), and Middleton Stoney Castle, Oxfordshire (Levitan 1984). Pigs were less numerous at Lincoln and more abundant at York (although at both sites cattle was the dominant species), and this has been related to the topography of the sites (O'Connor 1982 & 1984).

Prior to the 11th century at Lincoln, pigs were slaughtered at 2 to 3 years old, while after the 11th century the culling of 1- to 2-year-old pigs predominated. This coincided with a decline in the sheep kill-off pattern (O'Connor 1982). No neonatal mortalities were found on the site and hence it was deduced that pig breeding had been carried out off the site. In general, pigs were at least one year old when slaughtered at both Lincoln and York (O'Connor 1982). At Okehampton and Exeter medieval pigs were killed in their second year (Maltby 1979a & 1982b). Pigs can be slaughtered at any age, but are not considered adult baconers or porkers until they are rising two years old (Trow-Smith 1957, 128). Medieval and post-medieval samples from Colchester showed a peak age of slaughter in the second year, as did the Roman sample.

7.6 **Horses**

[Table 3.2]

Horse bones are sparse amongst Romano-British faunal assemblages and on some sites may have been accorded special treatment. Records of horse butchery are rare, and probably most marks have resulted from the knackering of horses rather than food preparation. Horse bones were fairly well-represented at Easton Lane, Hampshire, and Maltby has claimed that these animals were exploited for meat in the early Roman period, in contrast to the nearby town of Winchester, which produced far fewer remains (Maltby 1987c).

In fact, Romano-British rural sites in Hampshire have produced relatively large numbers of horse bones. At Owslebury, horse represented between 10 and 20 per cent of the total number of horse and cattle bones while at Winchester less than 10 per cent of the total cattle and horse remains were of horse (Maltby 1987a). Few excavated rural Romano-British sites in Essex have revealed substantial bone assemblages; however, 13 per cent of the bone assemblage at the villa of Chignall St James was horse (Section 7.2). The horse percentages recorded for Roman Colchester were mainly under 5 per cent (Chapter 3; Table 3.2, p 26).

The medieval period shows evidence of greater numbers of horse bones, but the percentages are still low in comparison with the other domestic stock. High percentages of horse were found at Portchester (Grant 1985), Upton, Gloucestershire (Noddle 1969), Lyveden, Northamptonshire (Grant 1971b), Walton, Buckinghamshire (Noddle 1976), and Wharram Percy, Yorkshire (Ryder 1974).

Romano-British horse size in the Roman north-western provinces generally ranged between 12 and 14 hands (Luff 1982). Data concerning horse withers height is scarce in the medieval period; the average height of horses was approximately 14 hands and no difference in size has been demonstrated between sites of dissimilar economic and social status (Grant 1988, 177-8).

Few mules and donkeys have been recorded in Roman Britain; however, research needs to be channelled into isolating the criteria that will separate the bones/teeth of mules from other equids.

7.7 Dogs and cats

[Figs 7.2-7.3; Tables 3.5a-3.5b & 3.6-3.7]

Dog and cat remains were much more prevalent at Balkerne Lane than at the other Colchester sites, as evidenced by Sites BKC H1, BKC N2, and BKC T3 (Table 3.6, p 34). However, dogs were much more common than cats, which generally increased in numbers during the medieval period. This was found at Lincoln, where the number of cat remains rose markedly in deposits dated to the immediate post-conquest period (O'Connor 1982), as indeed is the case at York, where the animals were much more common in post-Norman deposits than in Roman or Anglo-Scandinavian ones. This is curious since it has been shown that rats and mice were more common by the 3rd century (O'Connor 1986b). Rodents in general were scarce at Colchester. The Colchester dog and cat bones were usually excavated as whole or partial burials. A partial burial of a dog was dug from the silt of the legionary ditch (BKC KF126, AD 50-55) on Site K, while BKC TF124 (AD 60/1-75/80) revealed the complete skeletons of eight dogs; these beasts ranged from short squat dogs to tall slender creatures. A rubbish pit on Site H (HF33, dated to c AD 250-300) contained the remains of two adult cats and a kitten, while on the same site a pit (HF94, dated to *c* AD 250-300) yielded two dog skeletons and a piglet skeleton together with the remains of a bear and a cat. An adult cat burial occurred with a child burial at BKC TF25 (c AD 250-300).

The great variability in the size of dogs from Roman times may mean that selective breeding was practised; skull shapes show a much greater variation in shape and size (Fig 7.2). The appearance of the smallest dogs hitherto seen in the country coincided

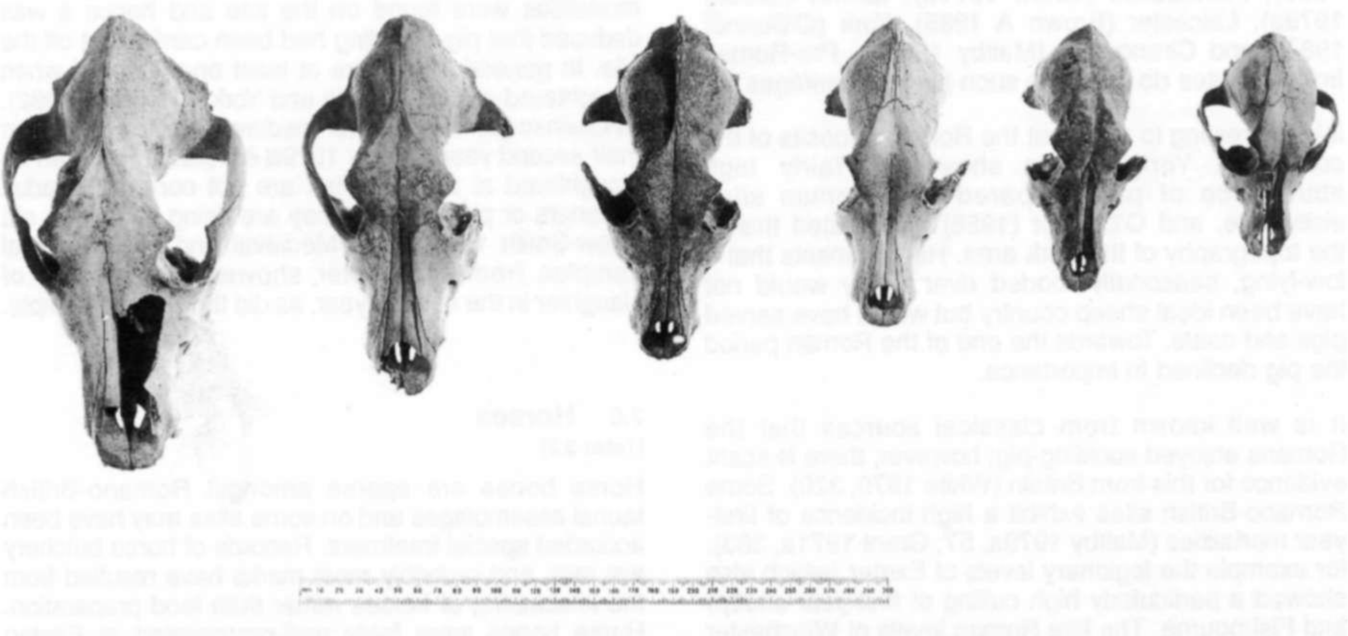


Fig 7.2 Roman dog skulls.

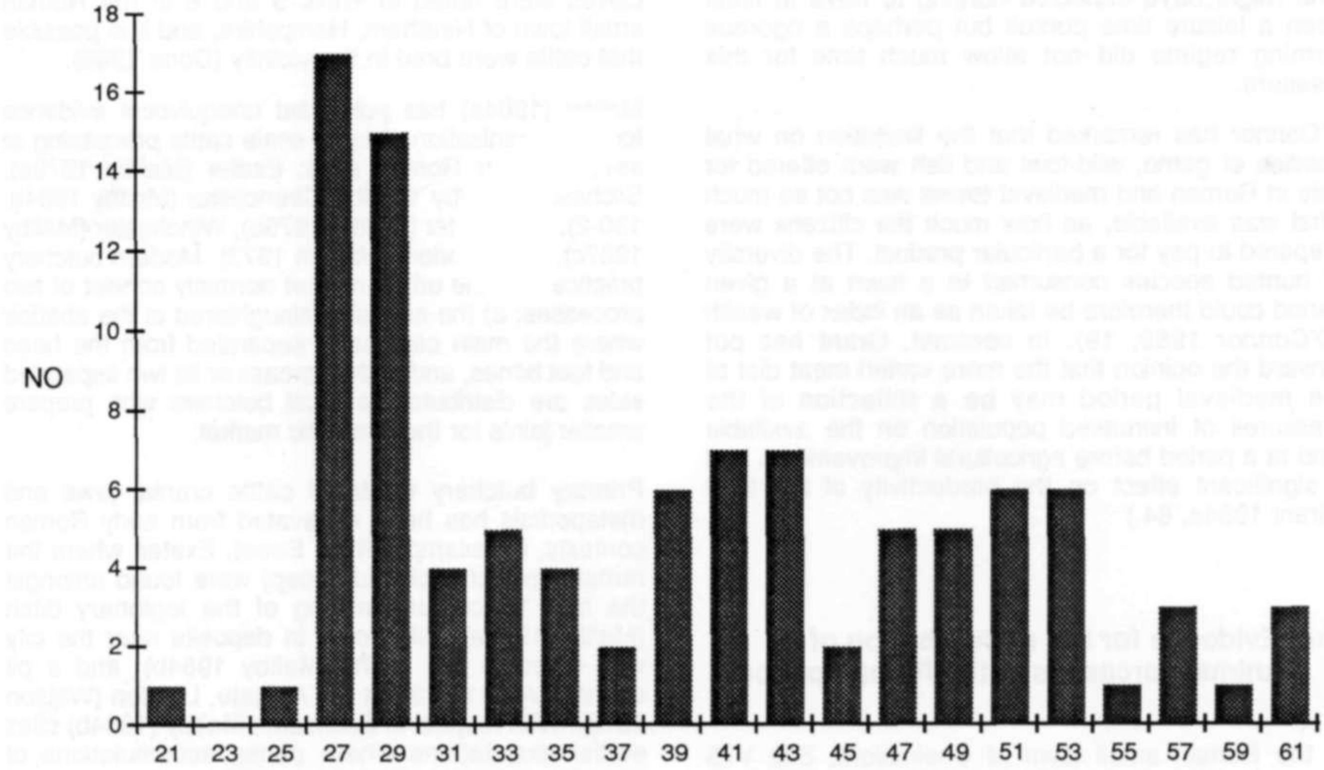


Fig 7.3 Histogram: Roman dog shoulder heights in cm.

with the Roman occupation and it seems reasonable to suppose that the Romans must have introduced some of these breeds (Maltby 1979a). Figure 7.3 illustrates the range of dog size found at Colchester, and it is interesting to note the predominance of these very small individuals, most likely lap-dogs. The range of variation mostly fits with that recorded by Harcourt for Roman Britain (Harcourt 1974), apart from one dwarf individual of 21 cm shoulder height.

7.8 **Domestic fowl**

In the Roman period, the domestic chicken is slightly more common on military and urban sites than on rural settlements (including villas). The Roman fort at Portchester yielded large numbers of birds, mainly domestic chicken, which Grant (1985) commented on as being both interesting and unusual. Further, a predominance of domestic fowl was found in a 1st-century drain of the Roman fortress baths at Caerleon, Gwent together with mutton chops, pork ribs and pigs trotters, which O'Connor delightfully interpreted as light snacks being served to bathers (O'Connor 1986a). At Fishbourne palace, high percentages of chicken bones were recovered from the early Roman levels (Grant 1971).

At York, in all periods, the domestic fowl were mainly adults and most of the tarsometatarsi were unspurred. Hence, not surprisingly, much egg shell was found at York (O'Connor 1986a). This is in contrast to Roman Colchester, where many spurred birds were found in addition to a substantial number of unspurred birds (Section 5.4).

Chicken and geese remains are ubiquitous on rural and urban medieval sites, with geese occurring less commonly than chicken (Grant 1988, 163). Medieval chickens were kept for their eggs as much as for their flesh, as evidenced by the high proportion of bones belonging to mature birds (Levitan 1984). Although the Colchester samples were small, both the medieval and post-medieval groups consisted mainly of unspurred individuals. This perhaps reflects a greater importance on egg-laying (and meat) than in the Roman period where egg-shell remains were not ubiquitous.

7.9 **Wild mammals**

Wild animal fauna is sparsely represented on most pre-Roman Iron Age and Romano-British sites in Britain. It seems logical to conclude that arable agriculture and pastoral farming were in the main successful, and hence communities did not have to resort to hunting in order to supplement their diets. One might have expected hunting to have at least been a leisure time pursuit but perhaps a rigorous farming regime did not allow much time for this pleasure.

O'Connor has remarked that the limitation on what species of game, wild-fowl and fish were offered for sale in Roman and medieval towns was not so much what was available, as how much the citizens were prepared to pay for a particular product. The diversity of hunted species consumed in a town at a given period could therefore be taken as an index of wealth (O'Connor 1989, 19). In contrast, Grant has put forward the opinion that the more varied meat diet of the medieval period may be a reflection of the pressures of increased population on the available land at a period before agricultural improvements had a significant effect on the productivity of the land (Grant 1984a, 84.)

7.10 Evidence for the redistribution of animal carcasses in the Roman period

In the Roman small town of Chelmsford, Site V75 revealed dumps of cattle horn cores (184 belonging to 94 cattle) as did Site V72, which yielded 106 cattle horn cores representing 42 animals (phases VI and VII, AD 120/125-410/20). The horn cores were mainly of male animals, which is interesting since metrical analyses of post-cranial material from sites in Essex have predominantly denoted female beasts. Extensive remains of a horning industry were found together with some evidence of a tannery (Luff unpublished). The sites were located in the northern part of the town away from the centre. One would presuppose that in keeping with Roman thoroughness and town planning, all smelly activities would have been confined to similar quarters of the town. The sites are located near a major road leading out of the town, and the River Can is only 200 metres away; thus this would have been an ideal location for a tannery. These finds are immensely important since they show that one of the functions of a small town was that of craft specialisation; indeed, we could use the term industry in this connection since adjacent sites to Site V, that is Sites AG, R and Cables Yard (across the road) produced sizable numbers of horn cores and metapodials *(ibid).* One striking fact concerning the cattle skeletal element distribution of Colchester is the relative scarcity of horn cores; perhaps they were transported to other settlements like Chelmsford for processing.

Todd (1976, 99) emphatically states that small towns should be studied in close relation to their rural environment; he suggested that they were very strongly linked to agricultural activities. In this connection it is interesting to note that a well (F31) on Site AR at Chelmsford contained, amongst other finds, the complete remains of seven foetal lambs (Luff 1982, 176). An incidence of foetal/neonatal animals signifies a rural flavour to a site. Newborn calves were noted in Wells 5 and 6 in the Roman small town of Neatham, Hampshire, and it is possible that cattle were bred in the vicinity (Done 1986).

Maltby (1984a) has published unequivocal evidence for the organisation of large-scale cattle processing at several major Roman sites: Exeter (Maltby 1979a), Silchester (Maltby 1984b), Cirencester (Maltby 1984a, 130-2), Gloucester (Maltby 1979b), Winchester (Maltby 1987c), and London (Watson 1973). Modern butchery practices for the urban market normally consist of two processes: a) the animal is slaughtered at the abattoir where the main carcass is separated from the head and foot bones, and b) the carcass or its two separated sides are distributed to local butchers who prepare smaller joints for the domestic market.

Primary butchery waste of cattle crania, jaws and metapodials has been excavated from early Roman contexts, for example Rack Street, Exeter, where the remains (which included sheep) were found amongst the late 1st-century infilling of the legionary ditch (Maltby 1979a); Silchester, in deposits near the city wall dated to AD 40-70 (Maltby 1984b); and a pit dated to AD 110-120 at the Aldgate, London (Watson 1973). With respect to Silchester, Maltby (1984b) cites earlier excavations where dense accumulations of mandibles and also separate deposits of horn cores of 1st-century date were found. Maltby has pointed out that the primary butchery deposits of Silchester, Exeter and London are located some distance from the centre of the towns; hence there is a possibility that the carcasses were taken to a more central location before further butchery.

It is not known if the individual assemblages were deposited rapidly in one operation or amassed over a longer time. Nor is it obvious if the beef and other products were destined for sale on the open market or for supply to the military forces. Further, it is impossible to determine whether the initial slaughter and butchery was organised by a central administration or whether these particular operations were under the control of a number of independent slaughterers/butchers. It is deemed likely that some sort of central control, whether civilian and/or military, was necessary since the evidence for a flourishing monetised market economy (using small-denominational currency) appears to be lacking in the early Roman period (Section 1.2). Maltby (1984a) has suggested that the early date of the Silchester deposits indicates that this system of butchery was introduced and initially organised by the Roman military forces, who would themselves have made a great demand on the food supply.

Primary butchery waste was also found in a 3rd-century midden at Tower Street, Cirencester, together with waste from disjointing, filleting and marrow-extraction (Maltby 1984a, 130). Here the two operations were carried out side by side. Since the assemblages were near the southern edge of the basilica and forum, the meat may have been sent for sale in the markets and shops in the heart of the town. Similar deposits of cattle bone were found at the extramural site of Balkerne Lane, and these have been interpreted as representing the waste from primary and secondary butchery operations which were undertaken on intramural sites (Sections 3.5, 3.7.2 & 3.10; *CAR* **3**, 102;' Luff 1982, 99-108).

An extramural site at Winchester has revealed 3rd- to 4th-century dumps of cattle-butchery and bone-working waste, with much of the bone demonstrating a very systematic butchery technique which is quite different from that of the nearby rural settlement of Owslebury (Maltby 1987a) and also the early Roman rural site of Abbotstone Down (Maltby 1986).

The 4th-century bone samples from Roman Gloucester constitute cattle carcass-trimming, that is the deposit mainly contained fragments of scapulae, pelves and femora (Maltby 1979b); unlike Cirencester, primary butchery had been undertaken elsewhere. The Gloucester assemblage is important in that it shows that major towns were continuing to function as markets for animal produce until the late 4th century.

However, the same was not true of Exeter in the later Roman period. Maltby found differences between the 1st/2nd- and 4th-century bone samples; the latter show no sign of large-scale primary butchery unlike the earlier samples. Further, in the earlier periods at Exeter, sheep and cattle were killed at specific ages for their meat, while later samples revealed that the cattle had been slaughtered at a variety of ages. There is also evidence for the presence of farmyards and stock enclosures in association with some of the later Roman houses within the walls of the town. This shows that some of the inhabitants were directly involved in animal husbandry. Maltby (1981, 195) suggested that all these factors could signify the collapse of the former system of stock-supply.

The results from Exeter partially support Reece's premise that town life degenerated in the later Roman period. He stated that at that time the economy revolved more around rural settlements, villas and villages than urban structures, towns and cities (Reece 1980). Peck has claimed that there was a change in butchery procedure between the early and late Roman levels in certain Hampshire villas, but his hypothesis still needs to be tested with larger samples (Peck 1986). However, it is quite clear from Gloucester, Winchester and Exeter that not all urban sites were behaving in the same way. We need many more urban bone samples to elucidate these points.

Organised slaughter and butchery were not confined to the larger urban sites. Maltby refers to Towcester (Payne 1980), a smaller Roman settlement where cattle (and sheep) limb-bone extremities and mandibles occurred; he makes the point that Roman small towns were indeed related to the marketing of agricultural produce (Maltby 1984).

Similarly, at the General Accident site (Tanner Row, York), large dumps of processed cattle bone were retrieved from the late 2nd-century levels in the centre of the Roman civilian town (O'Connor 1988). Many smashed-up cattle long-bone shaft fragments occurred by Building 5. Perhaps the most interesting feature of these assemblages was the occurrence of numerous cattle scapulae from contexts dated from the late 2nd to early 3rd centuries; quite a large number were unusually intact and the butchery marks suggested that several whole or partial fore-limb joints had been suspended, possibly for the smoking or curing of beef. Similar scapulae were found in the late 1st-century legionary deposits from Blake Street, York (O'Connor 1987), Augustica Raurica, Augst, Switzerland (Schmidt 1976), the Valkenburg fort, Netherlands (van Mensch & Ijzereef 1977); and Nijmegen fort (Lauwerier 1988). Cattle scapulae were also noted in the 3rd-century deposits at Caerleon, Gwent (O'Connor 1983 & 1986a), and at Balkerne Lane, Colchester (Luff 1982); however, these scapulae do not have the same butchery marks as those from the preceding sites. It would appear that the scapulae were fleshed out intact so that the beef could be used for stewing.

In contrast to the Roman period, there is no hard evidence pointing towards large-scale redistribution of beef in the medieval period, even though an organised butchery trade was prevalent in the early Middle Ages. No large butchery-waste deposits have been found at Exeter (Maltby 1979a) or Bedford (Grant 1979 & 1981). Grant (1984a) has suggested that a butchery trade could only develop where the townspeople had a substantial involvement in commercial and/or industrial activities. However, documentary evidence shows for much of the medieval and indeed post-medieval periods that individual butchers undertook their own slaughtering and butchery, and this would therefore account for the fairly small-scale accumulation of waste material (Maltby 1982b).

7.11 Summary

One of the most salient points to emerge from the above synthesis is the difference in sheep exploitation between the *colonia* at Colchester and indeed Roman Essex as a whole, as compared with most Romano-British sites (the *colonia* at York excepted). In the Trinovantian canton lambs were commonly slaughtered in the first year of life, in contrast to other sites where older animals were killed between their second and third years. Although the slaughter pattern does not radically change when viewed chronologically, metrical evidence shows that there is an increasing variation in the size of sheep through the Roman period which is not apparent with the cattle. The latter is perhaps not so surprising, since first and foremost cattle would have been suppliers of traction and manure. The variation in sheep size could reflect the pull of the market system; a flourishing market like Colchester would have attracted animals from fairly far-flung rural establishments in order to cope with the growing demands of an ever-increasing populace. This is abundantly apparent in the post-medieval period with respect to the London meat markets.

8: A SUMMARY OF THE MAIN BIOARCHAEOLOGICAL RESULTS

8.1 Additional bioarchaeological data

'Certainly, said Fundanius, the feeding of stock is one thing, tilling the land is another, yet they are related, just as the right-hand flute, though different from the left-hand one, is yet in a sense united to it since the song is the same, of which the one leads and the other accompanies the tune... Agriculture, therefore, plays second to the pastoral life in that it is lower like a left-hand flute in relation to the stops of the right-hand one' (Varro, *De Re Rustica,* I.II.15-16).

The faunal evidence should not be viewed in isolation. However, the welding together of faunal and floral data in an excavation report is still not standard practice; where integration has been successful, more often than not the research project has been designed to answer questions of an environmental rather than an economic nature.

Plant remains fall into two groups: macro-fossils (for example charcoal, seeds and plant parts) which can generally be seen with the naked eye, although they are examined with low-power microscopes, and micro-fossils (for example phytoliths, pollen and digested plant parts from coprolites) which can only be studied with high-magnification microscopes. In an urban environment, bioarchaeological remains can reflect the supply and demand of organic commodities, as controlled by agricultural and mercantile economics; however, there are radical problems in trying to compare and contrast differing types of organic remains. For example, one of the major problems in economic archaeology has been, and still is, how to evaluate the relative contributions of plant and animal foods to the diet. Before any consideration is given to devising methods of relative quantification between the different plant and animal taxa, the following questions need to be addressed:

a) How can we be sure that we have equivalent preservation between plant and animal remains at the contextual level?
b) What activities have resulted in the deposition of animal and plant remains when viewed at the contextual level, and are these activities comparable?

With respect to the first question, more than ten years ago Dennell (1980, 40) stated that '...the quality of information from archaeobotanical data is unlikely to match that obtained by faunal analysts until more attention is paid to the archaeological factors that resulted in the preservation and composition of each sample'. Thus the scarcity of particular plant taxa may not be directly related to their unimportance, but may depend on their preservation, which depends greatly on the way the plants were used and their individual characteristics *(ibid).* More recently, Hastorf (1988, 121) points out the stagnant state of taphonomical research in archaeobotany, where much more work is needed in order to understand the differential preservation of the different plant taxa.

In answer to the second question, we need to be aware that botanical remains are not often used for the investigation of food consumption; they are more suitable for modelling food production and processing (Hastorf 1988,121-2). In fact, in contrast to faunal data, production cannot be distinguished from consumption with generally aggregated plant data. However, an examination of data from specific contexts can occasionally reveal different activities, and hence aid a more cautious interpretation of the plant-distribution in the archaeological record (Hastorf 1988).

If difficulties in assessing the relative preservation between plant and animal taxa are surmounted, then any comparison has to be made at the contextual level. This can be a problem because, as already stated in Sections 3.1 and 3.4, urban contexts quite often reveal just a few scraps of animal bone; hence pressure is placed on the faunal analyst to consider amalgamating contexts in order to boost the sample, and clearly this is detrimental to any archaeobotanical analysis.

Before 1982, sampling for the Colchester archaeobotanical samples was on a limited scale, with the emphasis being on the Boudican destruction levels and a small number of other contexts, mainly Roman cess-pits and rubbish pits (Murphy 1984). In 1985 an extensive sampling and sieving program was put into operation by Peter Murphy, particularly on the Culver Street and Gilberd School sites. The detailed description of the sampling technique together with the environmental remains is described in *CAR* **6** (p 273). In addition to the plant macrofossils which were analysed by Peter Murphy, sieving recovered fish, freshwater and marine invertebrates and parasites which were examined by Alison Locker (fish) and Peter Murphy (parasites and shellfish). Some of the more salient features of their work will be integrated into the overall conclusions from the faunal results.

8.2. Evidence for localised agriculture within the vicinity of Roman Colchester

The main aim in writing Chapter 1 of this book was to highlight the rural essence of Roman towns. Animal plant fertilisers and fodder resources are two issues that affect both the animal and plant husbandry of a community, and should be investigated by an integrated consideration of the botanical and faunal data.

It is apparent that the Culver Street marine invertebrate assemblages contain some material which had not been consumed by the Roman inhabitants, for example, very tiny mollusc shells, mature oyster- and cockle-shells *(Ostrea* and *Cerastoderma sp)* and indeterminate fragments of bivalve shells. These larger shells have an encrustation of bryozoans on their interior surfaces, which indicates that the shells were empty when collected. Further, numerous barnacle shell plates were found but none of the recovered mollusc shells show barnacle attachments on them. Murphy suggests that these specimens were brought to the site with seaweed or strand-line detritus for use as organic manure and lime *(CAR* **6**, 277).

Archaeobotanical remains of animal fodder can be hard to recognise (Greig 1988,119). Concretions from Culver Street Site G (pit GF626 of AD *c* 225-275/325; burnt deposit GL1745 of AD c 60/11-225; dump or burnt deposit GL2520 of AD *c* 60/1-225; & pit GF3064 of AD *c* 65/80-150) were found associated with carbonised plant material, which has been interpreted as burnt animal fodder *(CAR* **6**, 275). Possibly these concretions represent animal dung which was cleared out of byres, and later burnt with the spilt fodder and litter. The dung most likely emanated from ruminants, that is cattle rather than horses, since there was no large tissue present in the concretions. Some of the carbonised residues were placed in pits (GF626, GF2594, & GF3064), while others were left as spreads (GL1745 & GL2520). The deposits occur in contexts dating from the 1st to the 4th centuries, and it is likely that animals, probably cattle, were kept on or very close to the site throughout the Roman period; most of the evidence comes from Site G Period 3 (AD 60/1-c 225).

The above carbonised plant material represents animal fodder because it is characterised by high frequencies of seeds from grassland and wetland plants, and in addition six-row hulled barley was found in some deposits *(CAR* **6**, 282). It is interesting to note that hay from more than one type of grassland was gathered in order to feed the animals; this is known from the range of grassland and wetland ecotypes. A recent approach to the history of grasslands is through the study of snail shells, since it is possible to distinguish pasture from meadow molluscan assemblages (Greig 1988, 122). With contexts GF626 and GF3064 (pits of AD 225-275/325), shells are associated with seeds of the grassland plants, grains of barley and carbonised grass culm fragments. The molluscs are found in grassland, marsh and freshwater habitats, and it is thought that most of these shells arrived at the site with hay, which had been cut in wet meadows. Shells of the aquatic snail (*Valvata cristata* from GF626) probably relate to river flooding of this wet grassland.

A burnt layer (GBS BL39) within the reused barrack block at the Gilberd School produced fruits and seeds of grassland plants, and these were associated in some samples with carbonised culm fragments of grasses. However, no faecal concretions occurred. These carbonised assemblages have been interpreted as fodder for animals housed in some of the buildings or as hay used for domestic flooring *(CAR* **6**, 288).

There is no evidence of hay or tools for hay-collection in the pre-Roman period; however, in the early Roman period, immediately after the conquest, scythes suitable for hay-cutting appeared on military sites, and macrofossil evidence of hay has been excavated at military contexts at Lancaster, Papcastle, York, and Carlisle (Jones M K 1989, 131). At Culver Street, a ploughshare was found in the soil, which also showed evidence of hand-tilling and ploughing (AD 100-300), while in the later Roman period, a large aisled building (Building 127) was built, which could have been an agricultural barn (Section 1.2).

Chapters 5 and 6 (Sections 5.4, 6.3, & 6.4) have described a significant increase in size of the major domesticates, cattle and sheep (with also an increase in size of cockerels) during the Roman period after the Boudican rebellion of AD 60/1. Apart from selective breeding, the most likely explanation for cattle increase in size is better treatment of the animals in the form of extra feeding of hay, other agricultural by-products or foliage in the lean season.

The percentage of identified pathological bone is low in all periods but, as O'Connor has pointed out, the rates of pathology of animals coming to market may not have been the same as for the original population (1989, 32). As well as the presence of cattle within Roman Colchester, goats were kept inside the medieval town, as demonstrated by possible goat droppings found in two pits from Culver Street Site G (GF163 & GF557). There is no evidence that any animals were actually bred within Colchester with the possible exception of the chicken, which would have been a valuable supplier of manure.

8.3 The town's food supply

8.3.1 Plant resources

In comparing and contrasting the available plant and animal foodstuffs in Roman and medieval Colchester, we are handicapped in only being able to define the range of plant resources, not their relative numbers with respect to the faunal data. This is because only a limited number of contexts were sampled prior to 1982 but more importantly, in general, the animal bones recovered from contexts where the plant material was abundant, scarcely merited attention, being of a highly fragmentary nature and few in number. Further, as pointed out in Section 8.1, there are great difficulties in estimating the relative contributions of plant and animal foods.

Balkerne Lane and Culver Street produced large quantities of carbonised cereals and other crops indicative of food storage within granaries on the sites (Murphy 1984). The wheat had been fully processed, and the remains show that the Roman grain-cleaning techniques were very efficient and storage conditions good. The wheat had caught fire during the Boudican rebellion. At the Gilberd School, few cereal remains were found and there was no evidence for use of any of the buildings as a granary.

The Roman samples from Culver Street show that the main cereal grown was wheat, that is spelt *(Triticum spelta).* However a free-threshing wheat *(Triticum aestivum/compactum)* was also grown, and possibly an emmer wheat *(Triticum dicoccum),* together with six-row hulled barley *(Hordeum vulgare),* rye *(Secale cereale),* the common oat *(Avena sativa),* and oats *(Avena sp)(CAR* **6**, 280).

Pulses were not commonly recovered from Culver Street. One seed of a horse-bean *(Vicia faba var. minor)* was recovered from a Roman corn dryer, and a carbonised lentil seed *(Lens esculenta)* was found in a Roman pit at Culver Street *(CAR* **6**, 281).

A deposit of malt ready for brewing was found in Room 8, Building 79 in the burnt debris (JL222) from the Boudican fire at Balkerne Lane. The sample consists mainly of carbonised wheat grains with some barley, and almost all the cereal grains had germinated before being carbonised *(CAR* **6**, 282).

It is not possible, as yet, to ascertain whether the Roman Colchester populace depended more on a vegetarian as opposed to a meat diet. As already stated in Section 7.3, an increase in the proportion of cattle remains has been demonstrated during the Roman occupation, and this is generally accepted for Roman Britain as a whole. Its significance reflects more the arable husbandry being practised than the rearing of beef primarily for home consumption. This evidence thus highlights the increasing importance of cereal-growing in the Roman period, both at Colchester and in general.

The cereal and pulse remains so far described in this section have been preserved by carbonisation and mineralisation; they have not been consumed by Roman men, women or children. The best contexts for obtaining a more personal viewpoint of dietary habits are undoubtedly the latrine pits *(CAR* **6**, 283).

EF900 *military latrine-pit contents:*

scraps of unidentifiable tissue
phytoliths
angular sand grains
a few ova of the parasitic nematode *(Trichuris sp)*
small ovoid coprolites
fragments of cereal periderm (bran)
mineralised remains of opium poppy
  (Papaver somniferum)
elderberry *(Sambucus nigra)*
raspberry *(Rubus cf idaeus)*
grape *(Vitis vinifera)*
fig *(Ficus carica)*
cherry *(Prunus sp* possibly *Prunus avium)*
high proportion of unidentifiable fish

Bran and trichurid ova are common and characteristic components of human faecal material from archaeological deposits *(CAR* **6**, 283).

CF138: *military latrine-pit contents:*

mineralised remains of opium poppy
  (Papaver somniferum)
elderberry *(Sambucus nigra)*
raspberry *(Rubus cf idaeus)*
grape *(Vitis vinifera)*
fig *(Ficus carica)*
cherry *(Prunus sp,* possibly *Prunus avium)*
high proportion of unidentifiable fish

In addition, remains of the following carbonised/ mineralised fruits were found: walnut *(Juglans regia),* hazelnut *(Corylus avellana),* olive *(Olea europaea),* dates *(Phoenix dactylifera),* mulberry *(Morus nigra),* sloe *(Prunus spinosa)* and plum *(Prunus domestica subsp domestica).*

The plum is a common find on Roman sites, although the early find of AD 44-60/1 is unusual. However, finds of olive, mulberry and walnut are rare on Roman sites. The olive is dated to the 2nd to 3rd centuries, and probably represents an imported commodity from the Mediterranean, as does the date *(CAR* **3**, 40) which has been found in early contexts of AD 49-60/1. Remains of olives of mid 2nd-century to early-to-mid 3rd-century date were excavated from the General Accident site at York (Hall & Kenward 1990, 405). The remaining crops, while of Mediterranean origin, could well have been grown in and around Colchester.

Medieval pits at Culver Street Site G produced small assemblages of cereals including free-threshing wheats *(Triticum species),* rye *(Secale cereale),* and grains of barley *(Hordeum vulgare)* and oats *(Avena sp).* In addition there was evidence for the horse-bean *(Vicia faba var. minor),* grape *(Vitis vinifera),* mulberry *(Morus nigra),* apple *(Malus sylvestris/domestica),* cherry *(Prunus sp),* bramble *(Rubus fruticosus),* and elder *(Sambucus nigra).*

8.3.2 Animal resources

An analysis of the animal bones has pinpointed some major differences in the utilisation of animal products between Colchester and other major, and indeed minor, Roman sites (Chapter 7). This is borne out by the dietary evidence, which, certainly for the intramural sites, shows a demand for tender meat (from young animals) which increases throughout the Roman period. This is particularly noticeable with lamb and to a lesser degree with beef and pork (Sections 7.3 and 7.4).

The sheep consumed were not the by-products of a husbandry technique focusing primarily on the production of wool. Clearly it would be more economic for farmers to sell the sheep when the beasts had reached their maximum body weight. However, the animals were being bred to satisfy the demands of an increasing urban populace, which had the means of purchase, and this rather suggests a certain affluence on the part of some of the citizens.

The sheep kill-off pattern concentrates on 6- to 12-month-old beasts together with an increasing emphasis on the slaughter of 2- to 6-month-old lambs and kids. Data from a variety of Essex sites, including some of the small towns, indicates that a peak killing at 6 to 12 months was a fairly general pattern for Roman Essex, but outside the canton, the overall trend for Roman Britain demonstrates sheep killed mainly between their second and third years (Section 7.4).

O'Connor has commented that the first-year killings at York not only epitomise the fortress but indeed the *colonia* itself (O'Connor 1984). The similarities between York and Colchester are obviously indicative of the political and administrative status accorded these two sites, and perhaps explain why they stand out from the norm. Naturally they would have attracted a percentage of residents who would have been of high status.

The increased slaughter of lambs (2 to 6 months old) during the Roman period could well have released a reservoir of milk for cheese production. A ratio of approximately two lambs to one kid occurred. Pigs were slaughtered mainly when mature, at 17 to 22 months old, although there appears a greater emphasis on the killing of young pigs (6 months old in the later periods) and perhaps this is not unconnected with the increasing supplies of ovicaprid milk available.

Pork is a popular item of fare on the intramural sites throughout the Roman period as indicated by both the IND and NISP methods of quantification; lamb is also favoured but the larger carcasses of cattle would have provided much of the meat consumed (Section 3.8.1). If the extramural sites of Balkerne Lane are considered, the excavated dumps of bone are comprised mainly of cattle bones, and these assemblages have been interpreted as the waste from the primary and secondary processing of cattle carcasses.

Domestic fowl bones dominate the Colchester bird-bone assemblages, and some sites show chicken as the major species exploited, exceeding the major mammalian domesticates, for example the Gilberd School (AD 44-60/1) and Butt Road Site E (4th to 5th centuries AD) (Section 3.7.1). Most of the long bones were fused, which indicates more of an emphasis on egg-laying; however, the large number of male birds in the Roman period certainly reflects a strong interest in cock-fighting, whereas the reverse is true of later periods. Murphy found avian eggshell fragments on a number of the Culver Street sites, though never in large quantities. At Culver Street Site G, measurements of shell thickness were used to distinguish the main size-categories of the birds; samples were retrieved from three Roman pits at Site G (GF79, GF2218, & GF2594; AD 60/1-c 225) and one Roman hearth (GF360; AD *c* 225-275/325). Murphy showed that the dimensions were comparable to those obtained from modern domestic fowl *(CAR* **6**, 280).

Although sexing of the metacarpal bones indicates that most of the Roman cattle were cows, there is no evidence that cows were milked at Roman Colchester; adult beasts were mainly consumed at about 3 years old plus with younger animals of 24 to 30 months being more popular in the later periods.

In the medieval and post-medieval periods, mature sheep were slaughtered, showing an emphasis on the exploitation of wool and the consumption of mutton. Also the kill-off patterns for cattle showed striking differences with a progressive increase in calf production from the medieval period to the 17th to 18th centuries. Cows' milk was an important item at that time.

Pigs were killed for the production of bacon at mainly 17 to 22 months during the medieval and post-medieval periods.

With respect to the use of cattle for dairying, O'Connor cites Whitlock, who links this activity with the increased use of horses for haulage in the medieval period, suggesting that a new economic justification for existence of the cow (O'Connor 1989, 17; Whitlock 1965, 106-7). However, in Section 6.2.3, it has been shown that horses could be used for traction in the Roman period. Indeed, dairy cattle today are subject to many forms of disease, which have an important influence on the milk supply. Due to disease, the average productive life of a dairy cow is limited to 4.5 years; the diseases include tuberculosis, mastitis and contagious abortion (which is very infectious), and can cause annual losses of many millions of pounds (Harvey & Hill 1952, 136). It would seem apposite to ask what differences in animal husbandry techniques enabled medieval and post-medieval farmers in the Colchester area to risk such a hazardous enterprise.

The hunting of wild mammals and birds was minimal throughout the Roman, medieval and post-medieval periods. The Gilberd School sites are characterised by the highest incidence of roe deer found at Colchester, particularly during AD 44-60/1. Red and roe deer were exploited more for commercial purposes in antler working. The neurocranium of a roe deer skull, with what has been interpreted as a hunting injury, was found at Culver Street (CUL C217) and is dated to AD 65/75-100/125 (Section 6.2.5, Fig 6.25). Certainly there was a greater variety of bird recovered in Roman times, but it is impossible to say whether these birds had been actively pursued by man, or indeed beast, or had simply dropped dead on site.

The use of faunal material as an indicator of socio-economic status has been limited in scope. Ageing evidence has intimated that the residents of certain areas of Colchester, such as the intramural site of the Gilberd School, enjoyed the consumption of more tender joints of beef, lamb and pork. In addition this site was singled out by the relatively high number of roe deer bones.

The shells of land and freshwater molluscs are not common in deposits at Culver Street *(CAR* **6**, 276). Those that do occur are mainly marine and show that the Romans mainly consumed mussels *(Mytilus edulis)* and oysters *(Ostrea edulis)* followed by whelks *(Buccinum undatum),* carpet shells *(Venerupis decussata* and *V. rhomboides),* and cockles

(Cerastoderma sp), while medieval men and women mainly ate mussels *(Mytilus edulis)* and oysters *(Ostrea edulis).* The low numbers of shells could be related to the fact that shells were used in lime production in the medieval period, when they were roasted in kilns to produce calcium oxide or quick lime *(CAR* **3**, 30).

Fish remains are better represented in the medieval than the Romano-British periods at Culver Street. The Roman assemblages revealed in order of importance, eel *(Anguilla anguilla),* herring *(Clupea harengus),* plaice *(Pleuronectes platessa),* and flounder *(Platichthys flesus),* but the numbers recovered did not allow a breakdown for the different Roman periods. In the medieval period, eel *(Anguilla anguilla),* herring *(Clupea harengus),* and to a lesser extent cod *(Gadus morhua),* were recorded. The flatfish were less important and mullet was not found. The mackerel *(Scomber scombus)* was not as common as in the Roman period. Only two freshwater species were exploited in both Roman and medieval times, the eel and the salmonids (salmon or trout). Most of the species are inshore or shallow-water species that could have been caught locally in the Colne and its estuary and environs *(CAR* **6**, 278-9).

Since the same bulk sieving procedures had been applied to both the Roman and medieval contexts, the low number of fish bones in the Roman period is perhaps significant and may be related to the manufacture of fish sauce *(garum).* Excavations on the north bank of the Thames have found that a Spanish amphora was reused in the late 3rd or early 4th century to contain a local brew of fish sauce consisting of some sprat, a few bass, flatfish and sand eel. These fish could well have been caught in the Thames estuary (Perring 1991, 85).

Locker has stated that the increased importance of some species may reflect a more specialised medieval fishing industry involving the development of herring-fleets in the 13th and 14th centuries and off-shore line fisheries for cod *(CAR* **6**, 279).

Since Colchester is situated within easy reach of river and sea resources, it is likely that fish would have been eaten fresh most of the year. Out of season salted and dried fish may have been consumed during the Roman period, as well as pickled and smoked fish during the medieval period. This would have been an important source of protein during winter months *(CAR* **6**, 279).

8.4 **Conclusion**

Both O'Connor and Carver have commented on the lesser amounts of rubbish found on Roman urban sites as opposed to medieval ones, and this perhaps is related to a public refuse-disposal system being in operation in the Roman period (O'Connor 1989; Carver 1987). Classical authors have described this for the imperial city of Rome and we should be aware that perhaps a large proportion of Roman rubbish was carted out of some towns. The lack of cattle meat-bearing elements in the interior of Roman Colchester may bear witness to this fact; however it is thought unlikely that these bones had been gathered up by refuse-collectors since the same did not apply to the sheep/goat and pig skeletal elements (Sections 3.7.2, 3.7.3 & 3.10).

The significant lack of meat-bearing bone within both the Roman fortress and town contrasts with Balkerne Lane, where considerably more meat-bearing (and waste) bone occurs outside the town walls. It has been suggested that part of this settlement acted as a general dump for processed cattle carcasses in the earlier part of the Roman period.

Maltby has drawn our attention to the fact that with the development of large-scale redistribution or marketing systems there is likely to be greater variability in the type and size of the animals represented at settlements (Maltby 1985, 65). This is certainly true of the sheep from Roman Essex.

In a seminal paper on the development of crop husbandry, Martin Jones has demonstrated that the major period of new crop introductions appears to have been, not at the beginning of the Roman occupation, but between 1000 and 500 BC (Jones, M 1981). He states that Romano-British agriculture was torpid in the early Roman period; a return to agricultural investment came only in the later Roman period. However, Greene (1986) points out that this is not compatible with a view of conquest and taxation stimulating production and coin-based markets promoting 'capitalist' agriculture for profit.

Whether there was a monetised market economy in the early Roman period is certainly open to argument. However, with regard to the development of improved standards of animal husbandry (as evidenced by size-improvements in the animals), it is proposed that the seeds were sown in the early Roman period and that the process continued throughout the Roman occupation.

The Rhine is one of the main keys to the importance of Colchester (and its hinterland) in the early Roman period. Large permanent garrisons on the Rhine would have stimulated agricultural production in the Colchester area (Salway 1985), and the river itself would surely have enabled the transmission of new agricultural ideas and perhaps even domestic stock. Certainly, as early as AD 44-60/1, there is evidence for at least two breeds of domestic fowl and by AD 60/1-110 the intramural citizens of Colchester were consuming lambs, 6 to 12 months old, which contrasts starkly with most other Romano-British sites in Britain, where much older animals were being consumed. In addition, a significant difference in size was found between the sheep of AD 44-60/1 and 60/1-110. Viewed in this light, it is difficult to conceive of Roman Colchester and its environs as being unprogressive. Certainly, with regard to some aspects of animal husbandry, it has to be regarded as something of a modest success.

GLOSSARY AND ABBREVIATIONS

See also keys and explanatory notes to figures, General index (pp 155-8), Palaeopathology index (p 154), and Location of faunal results (pp 11-12).

Acute disease disease of rapid onset, and generally of short duration.

AEA Association of Environmental Archaeology.

Aetiology the branch of pathology that deals with the causes of disease.

Arthropathy (arthropathic) joint abnormality.

Assemblage, bone a collection of bones/frags in close association with each other.

Attrition wearing down.

Box-and-whisker plots a display that summarises information about the distribution of values. Instead of plotting the actual values, a boxplot displays summary statistics for the distribution. It plots the median, the 25th percentile, the 75th percentile, and values that are far removed from the rest. (See p 91).

Bryozoan pertaining to the lowest class of molluscs.

Callus hard tissue formed at the site of a broken bone, gradually converted into new bone.

Capon castrated cockerel.

CFRU Cambridge Faunal Remains Unit.

Chronic disease disease of long duration, often of gradual onset.

Collagen the fibres and fibrilles constituting the major protein constituent of connective tissue, cartilage, and bone.

Congenital defect present from birth, not necessarily hereditary.

Coprolite fossil faeces.

DINDEX is equal to the difference in fragmentation between the FINDEX1 and FINDEX2.

dP4 deciduous (milk) third molar.

Demography the study of population statistics.

Diaphysis shaft of a long bone.

DB index metacarpal distal width/greatest length.

Eburnation burnishing.

Ecotype group of plants within a species, adapted genetically to a particular habitat but able to cross freely with other ecotypes of the same species.

EDA exploratory data analysis which is characterised by visual displays of data.

Enamel hypoplasia defect in the enamel thickness and structure of a tooth due to the disruption of ameloblast activity (the ameloblasts being the cells which secrete the enamel matrix).

Endosteal relating to the endosteum or medullary membrane, which is the thin membrane lining the inner surface of bone in the central medullary cavity.

Epidemiology the study of the distribution of disease.

Epiphysis/epiphysial fusion separately-ossified end of growing bone. Epiphysis is separated from rest of bone (diaphysis) by cartilage plate (epiphysial cartilage). Growth in length of the whole bone occurs by encroachment into this plate of new bone from the diaphysis side and formation of new cartilage on the epiphysis side. When growth is complete, the epiphyses and diaphysis fuse; that is epiphysial fusion.

Exostosis a bony outgrowth springing from the surface of a bone.

FINDEX1 fragmentation index, the number of OXO fragments divided by the number of OXO plus COW fragments (see p 24).

FINDEX2 fragmentation index, the number of SMA fragments divided by the number of SMA plus sheep/goat fragments (see p 24).

Foetal pertaining to a partially- or fully-formed individual within womb.

Greenstick fracture an incomplete fracture where the bone has cracked without separation of the bone fragments.

Harris lines 'lines of retarded growth' which can only be seen by radiological examination; they are parallel to the epiphysial plate and indicate previous systemic illness or other factors which have temporarily inhibited growth, for example malnutrition.

Hind limb femur/tibia/metatarsal.

Hypertrophic pulmonary osteopathy (Maries disease) although nearly always associated with a pulmonary mass, usually primary or secondary pulmonary neoplasia, skeletal manifestations commence in the lower limbs and spread to the upper limbs. The primary bone lesion is a thickening of the periosteum where new bone is formed (osteophytes).

Indicator (IND) skeletal element parts which preserve well (proximal tibia excepted) and where more than 50 per cent is present. Indicators were scored for the following bones: horn core, mandible tooth row, scapula glenoid activity, distal epiphyses of humerus, radius, and metacarpal, radial carpal, pelvic acetabulum, distal epiphysis of femur, proximal and distal epiphyses of the metatarsal, astragalus, and the first phalanx.

Kill-off pattern the age distribution of an archaeological assemblage.

Kolmogorov-Smirnov two sample test is a test of whether two independent samples have been drawn from the same population.

Lactose by-product of cheese-making, rich in calcium and vitamins.

Lesion a wound or any morbid physical change.

Mann-Whitney U test is one of the most powerful of the non-parametrical tests and may be used to test whether two independent groups have been drawn from the same population.

Mastitis inflamation of the udder.

MB index metacarpal mid-shaft width/greatest length.

MAU count of the minimum number of skeletal elements.

Metapodial a metacarpal or metatarsal bone.

Medulla marrow cavity.

MNI minimum number of individuals.

M1, M2, M3 first, second, and third permanent molars.

Mortality profile the age at death of the original flock/herd.

MWS mandibular wear stage.

Myeloma a primary tumour of the bone marrow with a tendency to appear simultaneously in several places.

Neurocranium brain-box.

Neonatal at the time of birth.

Neoplasm a new and abnormal growth which may be benign or malignant.

NISP number of identified specimens (bone fragments) *(see* pp 12-13).

Osteitis inflammation of the soft tissue contained in compact bone.

Osteoarthritis (osteoarthrosis) destruction of the joint surface.

Osteoblast bone-forming cell.

Osteochondritis defective growth of part of a bone.

Osteochondritis dissecans irregular, shallow, punched-out lesions on the joint surface of a bone.

Osteochondroma benign cartilaginous neoplasm.

Osteoclast bone-absorbing cell.

Osteomyelitis inflammation of the marrow cavity of a bone.

Osteopetrosis the bone cortex shows a proliferation of osteophytes which fuse, the cortex is removed and is replaced by woven bone which infiltrates the marrow cavity, the end result being dense hard bone.

Osteophyte bony projection of new bone from bone surface and frequently occurs at the edges of vertebrae.

Osteosarcoma a highly-malignant tumour chiefly affecting the ends of long bones.

Osteodystrophy a disease of bone in which the composition of all or part of the skeleton is abnormal.

OXO large mammal of horse/cow/red deer size *(see* p 12).

P4 fourth permanent pre-molar.

Pathogenesis the processes by which a disease develops.

Periosteum membrane covering the outer surface of a bone.

Periostitis inflammation of the periosteum.

Primary products are those which result from the death of an animal, eg meat, bones, and hide.

Pseudopathology post-mortem changes to archaeological bone which mimic true pathology.

Rarefaction decrease in mineral content in bone.

Residual surviving from significantly earlier period.

Rheumatoid arthritis chronic joint disorder, usually affecting many joints and also characterised by involvement of connective tissue throughout the body.

Robber trench trench left after the removal of a foundation or other structure so that its building materials can be reused.

Rheumatoid arthritis chronic joint disorder, usually affecting many joints.

Secondary products are those for which animals may be utilised repeatedly over the course of their lifetimes, eg milk and wool.

Sexual dimorphism differences between the sexes.

S/G Sheep/goat.

Sinus a cavity especially one of the bone cavities of the head that connects with the nose, affected in sinusitis (inflammation of this).

Skeletal element anatomical part, eg humerus, radius.

SMA small mammal of sheep/goat/roe deer size.

Spavin disease of the tarsus of a horse although it can affect trek oxen; typically affects the small bones of the inner lower aspect of the joint causing exostoses which limit movement.

Stem-and-leaf histogram graphical method of integrating exact data values into a histogram.

Subchondral sub-cartilaginous, beneath or below the cartilages.

Subluxation severe sprain usually of a joint leading to partial dislocation.

Sub-periosteal beneath the periosteum.

Taphonomy a study of the factors affecting the degree of completeness of survival of an animal's remains from the time of demise to its being excavated.

Taxon general term for a taxonomic group whatever its rank.

Taxonomy science of the classification of organisms according to their resemblances and differences.

Trauma a wound, damage to the tissues by any physical agency.

Tumour a swelling, often applied to neoplasm.

Weathering process leading to changes in the physical properties and chemical structure of bone via dessication and action of some acids.

Wether castrated sheep.

Whey watery part of milk.

Vascular of vessels, especially blood vessels.

Woven bone collagen fabric is random, formed when bone is needed in a hurry, for example in building a foetus or in reparative reactions.

Zones/zoning specific parts of a bone with a diagnostic feature.

BIBLIOGRAPHY

ABBREVIATIONS

AML	Ancient Monuments Laboratory
Antiq J	Antiquaries Journal
BAR	British Archaeological Reports
CAR	Colchester Archaeological Reports
CAR **1**	Philip Crummy, *Aspects of Anglo-Saxon and Norman Colchester,* CBA Res Rep, **39**, 1981
CAR **2**	Nina Crummy, *The Roman small finds from excavations in Colchester 1971-9,* 1983
CAR **3**	Philip Crummy, *Excavations at Lion Walk, Balkerne Lane and Middleborough, Colchester, Essex,* 1984
CAR **6**	Philip Crummy, *Excavations at Culver Street, the Gilberd School and other sites in Colchester 1971-85,* 1992
CARS	Nina Crummy, Philip Crummy, & Carl Crossan, *Excavations of Roman and later cemeteries, churches, and monastic sites in Colchester,* forthcoming
CBA	Council for British Archaeology
EAA	£asf *Anglian Archaeology*
CM	Colchester Museums
ECC	Essex County Council
EH	English Heritage
HMSO	Her Majesty's Stationery Office

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M TABLE 3.1 BONE FRAGMENT COUNT (NISP) OF LARGE AND MEDIUM SIZED MAMMALS (OMITTING BALKERNE LANE AND LION WALK

SITE	PERIOD	HORSE	COW	OXO	SG	SMA	PIG	RED	ROE	FAL
BUTT1	C2-320	14	63	123	48	69	101	2	1	
BUTT2	C2-450	7	66	95	47	75	88	1	6	
BUTT3	320-450	33	455	706	-283	548	366	23	5	
BUTT4	320-450		23	48	65	167	167	2	1	
C0C1	C1	3	113	121	47	57	80	2	1	
C0C2	MED	2	171	204	99	114	78	7	3	
C0C3	PMED	4	84	88	74	39	37		2	
GBSA1	44-49		61	21	67	37	59		7	
GBSA2	49-60/1	1	99	49	102	149	128	3	23	
GBSA3	44-60/1		113	117	95	130	126	1	25	
GBSA4	49-110		21	61	45	33	28		3	
GBSA5	60/1-275		233	111	200	149	156	8	20	
GBSA6	60/1-110	1	133	69	101	89	130	8	9	
GBSA7	110-275	3	104	33	67	79	91	9	3	
GBSA8	PMED	2	43	41	36	28	21	1	2	
GBSB10	60/1-110		45	64	30	30	46		9	
GBSB11	110-350		38	17	29	13	47	1	2	
GBSB9	60/1-275	1	89	56	114	106	119	2	11	
181A1	49-60/1		22	23	17	17	36			
181 A2	100-300		46	27	19	34	34	1	1	
I81A3	MED	7	186	120	157	105	103	2	3	
181 A4	60/1-150	2	50		73		54	1	3	
I81B1	60/1-75	1	20	22	18	46	35	4	1	
I81B2	75-100		96	173	144	344	186	10	6	
I81B3	75-300		416	662	432	1301	782	13	15	
I81B4	100-350		65	60	35	50	54	1	2	
I81B5	MED		67	83	53	51	54	8	1	
I81C1	60/1-75		79	26	63	54	55	1	3	
I81C2	75-100	1	67	52	59	84	69	5	3	
I81C3	100-300	1	81	76	73	136	96	2	.	
I81D1	150-325	5	211	209	184	180	211	12	15	
I81D2	EM	3	109	157	46	46	26	18	5	
I81E1	44-49		37	9	29	18	30			
I81E2	49-60/1	8	353	113	169	93	238		8	
I81E3	60/1-200	5	283	80	182	66	1 11	4	10	
I81E4	EM	6	305	356	132	224	162	7	7	
I81E5	MED	12	756	590	411	414	442	15	17	10
I81G1	60/1-150		116	93	113	126	273	10	19	
I81G2	60/1-225		14	15	44	26	41	2		
I81G3	75-150	3	60	50	49	48	75	2	6	
I81G4	150-225		64	27	39	45	96	1	3	
I81G5	225-400	10	432	362	273	275	331	24	15	
I81G6	150-400	1	26	61	16	28	34	2	6	
I81H	225-400	1	40	51	36	15	36		5	
I81K1	60/1-150	3	138	66	60	28	106	4	4	

MTABLE 3.1 (CONTIN)

SITE	PERIOD	HORSE	COW	OXO	SG	SMA	PIG	RED	ROE	FAL
I81K2	150-400		34	12	19	18	26		9	
I81M	60/1-200	1	17	8	55	13	14		1	
MIDI	ROM		113	4	86	1	87	6	2	
MID2	MED	32	510	290	260	183	164	12	4	5
MID3	PM	170	791	322	668	130	283	6	2	
MID4	C16	10	213	121	143	59	40	4		1

MTABLE 3.2 RELATIVE PERCENTAGE BONE FRAGMENT COUNTS OF LARGE AND MEDIUM SIZED MAMMALS (OMITTING BALKERNE LANE AND LION WALK)

SITE	PERIOD	HORSEP	COWP	OXOP	SGP	SMAP	PIGP	REDP	ROEP	FALP
BUTT1	C2-320	3	15	29	11	16	24	1	1	
BUTT2	C2-450	2	17	25	12	19	23	1	2	
BUTT3	320-450	2	19	29	12	23	15	1	1	
BUTT4	320-450		5	10	14	35	35	1	1	
C0C1	C1	1	26	28	11	13	18	1	2 1	
C0C2	MED	1	25	30	15	17	11	1	1	
C0C3	PMED	1	26	27	22	12	11		1	
GBSA1	44-49		24	8	27	15	23		3	
GBSA2	49-60/1	1	18	9	18	27	23	1	4	
GBSA3	44-60/1		19	19	16	21	21	1	4	
GBSA4	49-110		11	32	24	17	14		2	
GBSA5	60/1-275	1	26	13	23	17	18	1	2	
GBSA6	60/1-110	1	25	13	19	16	24	2	2	
GBSA7	110-275	1	27	8	17	20	23	2	1	
GBSA8	PMED	1	25	23	20	16	12	1	1	
GBSB1&	60/1-110		20	28	13	13	20		4	
GBSB11	110-350		26	13	30	9	9	4	9	
GBSB9	60/1-275	1	18	11	23	21	24	1	2	
181A1	49-60/1		19	20	15	15	31			
I81A2	100-300		31	18	13	23	15	1	1	
181A3	MED	1	27	18	23	15	15	1	1 1	
181A4	60/1-150	1	18	14	26	21	19	1	1	
I81B1	60/1-75	1	14	15	12	31	24	1	1 1	
I81B2	75-100		10	18	15	36	19	1	1	
I81B3	75-300	-	12	18	12	36	22	1	1 1	
I81B4	100-350	-	24	23	13	19	20	1	1	
I81B5	MED	1	21	26	17	16	17	3	1	
I81C1	60/1-75	-	28	9	23	19	20	1	1	
I81C2	75-100	1	20	15	17	25	20	2	1	
I81C3	100-300	1	17	16	15	29	21	1	-	
I81D1	150-325	1	21	20	18	18	21	1	2	
I81D2	EMED	1	27	38	11	11	6	4	1	
I81E1	44-49	-	29	7	25	14	24			
I81E2	49-60/1	1	36	12	18	9	24		1	
I81E3	60/1-200	1	38	11	25	9	15	1	1	
I81E4	EMED	1	25	30	11	19	13	1	1	
I81E5	MED	1	28	22	16	16	17	1	1 1	
I81G1	60/1-150		15	12	15	17	36	1	3	
I81G2	60/1-225		10	11	31	18	29	1		
I81G3	75-150	1	21	17	17	16	26	1	2	
I81G4	150-225		23	10	14	16	35	1	1	
I81G5	225-400	1	26	21	16	16	19	1	1	1

MTABLE 3.2 (CONTIN)

SITE	PERIOD	HORSEP	COWP	OXOP	SGP	SMAP	PIGP	REDP	ROEP	FALP
I81G6	150-400	1	15	35	9	16	20	1	3	
I81H	225-400	1	22	28	20	8	20		3	
I81K1	60/1-150	1	34	16	15	7	26	1	1	
I81K2	150-400		29	10	16	15	22		8	
I81M	60/1-200	1	15	7	50	12	13		1	
MIDI	ROM									
MID2	MED	2	28	29	14	15	9	1	1	1
MID3	PM	7	31	14	27	9	11	1	1 -	
MID4	C16	2	36	20	24	10	7	1		1

MTABLE3.3BONE FRAGMENT COUNTS(NISP)OF LARGE AND MEDIUM SIZED MAMMALS FROM BALKERN LANE AND LION WALK

SITE	PERIOD	HORSE	COW	SG	PIG	RED	ROE	FAL
BKCD	AS		89	38	23			
BKCE1	44-55	4	1025	221	212		1	
BKCE1/2	44-60/1		102	13	35			
BKCE2	49-60/1		366	86	72		1	
BKCE2/3	49-80	1	34	3	4		1	
BKCE3	60/1-80		795	164	147	1		
BKCE3/4	60/1-85	2	90	27	13			
BKCE4	75-85	2	191	11	3			
BKCE4/5	75-300	2	24	10	2			
BKCE5	100-300		115	13	11			
BKCE6	300-400	2	644	228	121	2	1	
BKCG1	250-300		231	160	120			
BKCG2	44-60/1	3	195	42	14			
BKCH1	250-300	6	439	103	123	6	1	
BKCH2	250-400	1	108	50	30	1		
BKCH3	150-300		499	117	132			
BKCK1	44-60/1		181	47	43	1	1	
BKCK2	60/1-80	2	102	26	14			
BKCK3	75-85	2	113	50	30		1	
BKCK4	85-100		631	70	31	1		
BKCK5	150-400		1111	39	12			
BKCK6	300-400	1	159	68	36	1		
BKCN1	150-250	5	247	164	129	12		
BKCN2	300-400	4	556	264	189	11	3	
BKCT1	44-49	42	378	51	60			
BKCT2	44-60/1	20	429	123	63			
BKCT3	60/1-80	11	369	423	207			
BKCT5	100-300	11	3147	414	306	1	2	
BKCV1	75-100	25	1019	446	224	10	8	
BKCV2	250-300	21	613	177	126			
BKCV3	100-300	18	3551	265	121			
BKCV4	44-60/1	9	229	137	21		1	
LWC1	ROM	15	784	497	458	9	3	
LWC2	C11-14	2	82	73	24	2		
LWC3	C15-17	28	1435	1402	264	8	8	7
LWC4	C17-18	22	393	264	114			

MTABLE3.4 BONE FRAGMENT COUNTS (NTSP) OF SMALLER MAMMALS AT BALKERNE LANE AND LIONWALK

SITE	PERIOD	DOG	CAT	RABBIT	HARE	RAT	FOX	BEAR
BKCD	AS							
BKCE1	44-55	10						
BKCE1/2	44-60/1	11			1			
BKCE2	49-60/1	32			1			
BKCE2/3	49-80							
BKCE3	60/1-80	6						
BKCE3/4	60/1-85							
BKCE4	75-85	4						
BKCE4/5	75-300							
BKCE5	100-300	1						
BKCE6	300-400	6						
BKCG1	250-300	1						
BKCG2	44-60/1	2						
BKCH1	250-300	184	12					
BKCH2	250-400							
BKCH3	150-300							
BKCK1	44-60/1	37						
BKCK2	60/1-80	1						
BKCK3	75-85	7						
BKCK4	85-100	5						
BKCK5	150-400	2						
BKCK6	300-400	7						
BKCN1	150-250	15						
BKCN2	300-400	64						
BKCT1	44-49							
BKCT2	44-60/1							
BKCT3	60/1-80	192	1					
BKCT5	100-300	3	33					
BKCV1	75-100	10						
BKCV2	250-300	16						
BKCV3	100-300	65	1					
BKCV4	44-60/1							
LWC1	ROM	97	2		4			
LWC2	C11-14	7	1					
LWC3	C15-17	189	123	62				
LWC4	C17-18	13		5		2		

MTABLE 3.5 RELATIVE PERCENTAGE BONE FRAGMENT COUNTS (NISP) OF MAJOR DOMESTICATES AT BALKERNE LANE AND LION WALK

SITE	PERIOD	COWP	SGP	PIGP
BKCD	AS			
BKCE1	44-55	70	15	15
BKCE1/2	44-60/1	68	9	23
BKCE2	49-60/1	70	16	14
BKCE2/3	49-80			
BKCE3	60/1-80	72	15	13
BKCE3/4	60/1-85			
BKCE4	75-85	93	5	2
BKCE4/5	75-300			
BKCE5	100-300	83	9	8
BKCE6	300-400	65	23	12
BKCG1	250-300	45	31	24
BKCG2	44-60/1	70	15	15
BKCH1	250-300	66	16	19
BKCH2	250-400	57	27	16
BKCH3	150-300	67	16	18
BKCK1	44-60/1	67	17	16
BKCK2	60/1-80	72	18	10
BKCK3	75-85	59	26	16
BKCK4	85-100	86	10	4
BKCK5	150-400	96	3	1
BKCK6	300-400	60	26	14
BKCN1	150-250	46	30	24
BKCN2	300-400	55	26	19
BKCT1	44-49	77	10	12
BKCT2	44-60/1	70	20	10
BKCT3	60/1-80	37	42	21
BKCT5	100-300	81	11	8
BKCV1	75-100	60	26	13
BKCV2	250-300	67	19	14
BKCV3	100-300	90	7	3
BKCV4	44-60/1	59	35	5
LWC1	ROM	45	29	26
LWC2	C11-14	46	41	13
LWC3	C15-17	44	42	14
LWC4	C17-18	51	34	15

MTABLE 3.6 BONE FRAGMENT COUNTS (INDICATORS) OF LARGE AND MEDIUM SIZED MAMMALS

SITE	PERIOD	HORSE	COW	SG	PIG	RED	ROE	FAL
BKCJ1	60/1-80		6	7	6			
BKCJ2	60/1-150	2	45	35	24		2	
BKCJ3	150-250	1	80	79	60		2	
BKCJ4	250-400	1	49	49	22		3	1
BUTT1	C2-320	5	21	25	23			
BUTT2	C2-450	2	32	20	25	1	4	
BUTT3	320-450	22	125	78	131	12	2	
BUTT4	320-450		4	25	36			
C0C1	C1	3	113	24	30	1	5	
C0C2	MED	2	62	38	20	1	2	
C0C3	PMED	4	34	45	13		2	
GBSA1	44-49		30	28	25		4	
GBSA2	49-60/1		31	32	49	2	13	
GBSA3	44-60/1		35	31	60	1	21	
GBSA4	49-110		6	20	10		3	
GBSA5	60/1-275	2	81	69	71	5	13	
GBSA6	60/1-110	1	34	35	53	5	7	
GBSA7	110-275	2	23	28	36	2	2	
GBSA8	PMED		11	10	7		2	
GBSB10	60/1-110		15	9	25		8	
GBSB11	110-350		12	16	23	1		
GBSB9	60/1-275		26	32	46	2	5	
181 A1	49-60/1		5	9	20			
181 A2	100-300		14	7	9		1	
I81A3	MED	2	69	88	38	1	1	3
I81A4	60/1-150	1	15	28	23	1	2	
I81B1	60/1-75	1	9	9	12			
I81B2	75-100		33	66	28	5	2	
I81B3	75-300	1	142	131	147	5	4	
I81B4	100-350		41	17	20	1	1	
I81B5	MED	1	26	23	19	3		
I81C1	60/1-75		30	21	23	1	3	
I81C2	75-100	1	30	27	30	5	2	
I81C3	100-300	1	26	35	35	2	-	
I81D1	150-325	2	94	81	83	8	8	
I81D2	EMED	1	41	13	14	12	1	
I81E1	44-49		16	14	16			
I81E2	49-60/1	6	117	83	103		3	
I81E3	60/1-200	2	94	86	33	2	5	
I81E4	EMED	3	84	40	54	5	4	1
I81E5	MED	6	218	1 98	162	2	8	9
I81G1	60/1-150		57	58	90	7	13	
I81G2	60/1-225		13	7	14			
I81G3	75-150	1	18	24	21	1	5	
I81G4	150-225		49	14	27	1	1	
I81G5	225-400	5	190	127	171	16	10	1

MTABLE 3.6 (CONTIN)

SITE	PERIOD	HORSE	COW	SG	PIG	RED	ROE	FAL
I81G6	150-400	1	12	6	17	2	3	
I81H	225-400	1	19	20	17		3	
I81K1	60/1-150	1	42	22	46			
I81K2	150-400		15	10	12		8	
I81M	60/1-200	1	8	8	2		1	
MIDI	ROM	9	26	16	18	2	1	1
MID2	MED	20	180	121	34	3	2	3
MID3	PMED	71	249	428	87	1	1	
MID4	C16	4	74	56	7			1

MTABLE 3.7 RELATIVE PERCENTAGE BONE COUNTS (INDICATORS) OF LARGE AND MEDIUM SIZED MAMMALS

SITE	PERIOD	HORSEP	COWP	SGP	PIGP	REDP	ROEP	FALP
BKCJ1	60/1-80		32	37	32			
BKCJ 2	60/1-150	2	42	32	22		2	
BKCJ 3	150-250	1	36	36	27		1	
BKCJ4	250-400	1	39	39	18		2	
BUTT1	C2-320	7	28	34	31			
BUTT2	C2-450	2	38	24	30	1	5	
BUTT3	320-450	6	34	21	35		1	
BUTT4	320-450		6	38	55			
COC1	C1	2	64	14	17	1	3	
C0C2	MED	2	50	30	16	1	2	
C0C3	PMED	4	35	46	13		2	
GBSA1	44-49		34	32	29		5	
GBSA2	49-60/1		24	25	39		10	
GBSA3	44-60/1		24	21	40	1	14	
GBSA4	49-110		15	51	26		8	
GBSA5	60/1-275	1	34	29	29		5	
GBSA6	60/1-110	1	25	26	39	1	1	
GBSA7	110-275		25	30	39		2	
GBSA8	PMED		37	33	23		7	
GBSB10	60/1-110		26	16	44		14	
GBSB11	110-350		23	31	44	2		
GBSB9	60/1-275		23	29	41	2	5	
181 A1	49-60/1		15	26	59			
I81A2	100-300		45	22	29		3	
I8 1A3	MED	1	34	44	19	1	1	
181 A4	60/1-150	1	21	40	33	1	3	
I81B1	60/1-75		29	29	39			
I81B2	75-100		25	49	21	4	1	
I81B3	75-300	1	33	30	34	1	1	
181B4	100-350		51	21	25	1	1	
I81B5	MED	1	36	32	26	4		
I81C1	60/1-75		38	27	29	1	4	
I81C2	75-100	1	32	28	32	5	2	
I81C3	100-300	1	26	35	35	2		
I81D1	150-325	1	34	29	30	3	3	
I81D2	EMED	1	50	16	17	15	1	
I81E1	44-49		35	30	35			
I81E2	49-60/1		38	27	33		1	
I81E3	60/1-200	1	42	39	15	1	2	
181E4	EMED		44	21	28	3	2	1
I81E5	MED	1	36	33	27	1	1	2
I81G1	60/1-150		25	26	40	3	6	
I81G2	60/1-225		38	21	41			
I81G3	75-150	1	26	34	30	1	7	
I81G4	150-225		53	15	29	1	1	
I8 1G5	225-400	1	36	24	32	3	2	1
I81G6	150-400	1	29	15	41	5	7	
I81 H	225-400	2	32	33	28		5	

MTABLE 3.7 (CONTIN)

SITE	PERIOD	HORSEP	COWP	SGP	PIGP	REDP	ROEP	FALP
I81K1	60/1-150	1	38	20	41			
I81K2	150-400		33	22	27		18	
I81M	60/1-200	5	40	40	10		5	
MIDI	ROM	12	36	22	25	3	1	1
MID2	MED	6	50	33	9	1	1	1
MID3	PMED	8	30	51	10	1	1	
MID4	C16	3	52	39	5			1

(Key to period codes on page 197. All measurements are according to von den Driesch 1976 except TD distal thickness, SHT shoulder height, and TEp distal epiphysial thickness.)

MTABLE 4.1 CATTLE METRICS, ROMAN

iod	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
1.0	MTC	GBSA	F268			50.4	28.0	44.5	24.0	
1.0	MTC	I81A	L277			50.0		44.0		
1.0	MTC	I81B	L429			52.8	29.0	49.3	27.0	
1.0	MTT	GBSA	F259	206.0	23.6	48.5	29.1	42.3	27.3	111.24
1.0	MTT	GBSA	LI56			47.3	28.0	43.4	25.0	
1.0	MTT	I81E	F1006	219.0	24.2	49.6	46.4	28.0		118.26
1.0	MTT	I81E	F1006	201.0	21	744.6	26.0	43.6	25.0	108.54
1.0	MTT	I81E	F1006	209.0	22.0	47.1	28.0	43.6	26.0	112.86
1.0	MTT	I81E	F1006	203.0	22.8	46.0	26.0	42.5	24.0	109.62
1.0	MTT	I81E	F1006			46.3	29.0	43.6	26.0	
1.0	MTT	I81E	F1100	211.5	23.1	46.9	27.9	44.5	25.9	114.21
1.0	MTT	I81E	F1207			49.4	27.4	42.1	25.7	
1.0	MTT	I81E	F900			46.7	28.3	44.6	25.8	
1.0	MTT	I81E	L166					44.2		
2.0	FEM	I81E	L149			92.0				114.67
2.0	HUM	BKCV	F267		26.0					
2.0	MTC	BKCK	F121			51.9	28.5	47.2	25.0	
2.0	MTC	BKCK	F121	169.0	31.7	59.6	31.0	51.3	23.5	103.09
2.0	MTC	BKCK	L125			65.3		56.0		
2.0	MTC	BKCV	F267		28.6	49.4		46.8	25.0	
2.0	MTC	BKCV	L79			50.4		46.4		
2.0	MTC	BKCV	L93			52.5		47.6		
2.0	MTC	BKCV	L93	170.0	26.4	49.0	27.0	44.6	24.0	103.70
2.0	MTC	GBSA	L110		27.8	51.0	29.4	47.2	25.6	
2.0	MTC	GBSA	L135			50.0	29.0	45.6	25.0	
2.0	MTC	GBSA	L151			58.8	30.9	52.4	27.2	
2.0	MTC	GBSA	L61			52.9	30.3	46.6	27.2	
2.0	MTC	GBSA	L93	179.0	29.3	51.4	28.5	46.8	23.2	109.19
2.0	MTC	GBSB	F110			48.4	27.6	44.0	24.7	
2.0	MTC	I81E	F1006	186.0	27.1	49.8		45.4	25.0	113.46
2.0	MTC	I81E	F1006	177.0	26.6	51.0	27.0	44.8	25.0	107.97
2.0	MTC	I81E	F1006	175.0	24.0	47.0		44.0	24.0	106.75
2.0	MTC	I81E	F1006					44.3	24.0	
2.0	MTC	I81E	F1006	181.0	27.2	50.7	29.0	46.5	26.0	110.41
2.0	MTC	I81E	F1034	186.0		47.2	-	47.0	26.0	113.46
2.0	MTC	I81E	F1037			51.2	31.0	47.6	27.0	
2.0	MTC	I81E	F1037	182.0	26.7	50.5	29.0	46.4	25.0	111.02
2.0	MTC	I81E	F1164	185.0	26.8	50.0	27.9	45.5	24.3	112.85
2.0	MTC	I81E	F1250			51.9	29.0	47.2	25.0	
2.0	MTC	I81E	F1250			54.0	30.0	48.6	26.0	
2.0	MTC	I81E	F1329			51.9	29.0	45.9	26.0	
2.0	MTC	I81E	F745	191.0	29.9	53.4	29.0	48.9	27.0	116.51
2.0	MTC	I81E	F824	186.0	27.2	51.9	28.6	47.4	26.1	113.46
2.0	MTC	I81E	F824			51.0	29.0	48.5	26.0	
2.0	MTC	I81E	F824			49.4		44.6	25.0	
2.0	MTC	I81E	F834			52.8		47.5		
2.0	MTC	I81E	F834			61.0		54.8	28.0	
2.0	MTC	I81E	L121			52.7	28.8	49.0	25.9	
2.0	MTC	I81E	L138			50.6	28.9	46.6	24.7	
2.0	MTC	I81E	L149			49.8	29.4	45.3	25.3	
2.0	MTC	I81E	L149	178.0	29.7	58.9	31.0	51.9	25.9	108.58

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
2.0	MTCT		L222	176.0	35.6					107.36
2.0	MTC	I81K	F391	183.0		52.1	29.1	48.4	25.6	111.63
2.0	MTC	LWCJ	F373	195.0	37.8	61.5	32.2	60.3	32.2	118.95
2.0	MTC	LWCK	F316			54.0		47.1	27.0	
2.0	MTT	BKCE				46.8				
2.0	MTT	BKCE				43.4		40.6		
2.0	MTT	BKCJ	F129			48.8	28.9	45.5	26.3	
2.0	MTT	BKCJ	F235			53.0	30.0	47.4		
2.0	MTT	BKCK	F121			48.0	29.0	46.9	28.0	
2.0	MTT	BKCV	F248			45.9	27.0	42.9		
2.0	MTT	BKCV	F267	202.0		46.8	27.0	44.8	26.0	109.08
2.0	MTT	BKCV	F267	201.0		47.6	27.0	44.8	26.0	108.54
2.0	MTT	BKCV	F267	198.0		46.4	27.0	44.0	26.0	106.92
2.0	MTT	BKCV	L113			39.6	39.0			
2.0	MTT	BKCV	L67			46.4		45.3	28.0	
2.0	MTT	BKCV	L79			45.3	29.0	43.6	27.0	
2.0	MTT	BKCV	L93			49.7		46.1	26.0	
2.0	MTT	BKCV	L93	214.0	22.7	48.7		45.3	27.0	115.56
2.0	MTT	GBSA	F202	213.0	28.4	54.6	31.0	50.2	28.0	115.02
2.0	MTT	GBSA	F202			47.2	29.0	44.2	38.0	
2.0	MTT	GBSA	F202			48.9	30.0	45.4		
2.0	MTT	GBSA	F202	213.0	28.4	54.6	31.0	50.2	28.0	115.02
2.0	MTT	GBSA	L101			49.8		46.1		
2.0	MTT	GBSA	L236			48.7	28.4	45.4	27.6	
2.0	MTT	GBSA	L236			48.1		44.8		
2.0	MTT	GBSA	L47			45.9				
2.0	MTT	GBSB	F18			57.8	31.8	51.9	31.6	
2.0	MTT	GBSB	F72	198.0	21.9	45.8	26.1	42.3	25.1	106.92
2.0	MTT	I81E	F1037	193.0	22.3	46.8	28.0	42.4	26.0	104.22
2.0	MTT	I81E	F1037			47.3	29.0	44.7	27.0	
2.0	MTT	I81E	F1164	205.0	21.2	47.3	27.7	44.3	25.2	110.70
2.0	MTT	I81E	F1164	200.0	21.8	46.2	27.6	42.6	25.8	108.00
2.0	MTT	I81E	F1164	199.0	22.1	45.6	27.7	41.7	26.0	107.46
2.0	MTT	I81E	F1164			50.1	27.5	46.8	25.5	
2.0	MTT	I81E	F1250			46.0	27.0	44.7	26.0	
2.0	MTT	I81E	F1250			49.1	30.0	45.4	28.0	
2.0	MTT	I81E	F439			46.1	29.0	42.9	27.0	
2.0	MTT	I81E	F824			46.1		42.7	26.0	
2.0	MTT	I81E	F824			45.8	27.0	42.8	26.0	
2.0	MTT	I81E	F824			48.0	29.0	44.3	27.0	
2.0	MTT	I81E	F834			47.5	29.0	45.0	27.0	
2.0	MTT	I81E	F834			47.4	29.0	44.5	26.0	
2.0	MTT	I81E	F856			45.5	26.0	43.6		
2.0	MTT	I81E	F877			46.8	26.5	45.3	25.0	
2.0	MTT	I81E	F877	204.0	24.0	46.2	29.0	42.0	27.0	110.16
2.0	MTT	I81E	L138			48.5	29.2	45.2	26.1	
2.0	MTT	I81E	L138			46.7		44.1		
2.0	MTT	I81E	L2			49.2	30.0	46.9	28.0	
2.0	MTT	I81E	L2			46.4	29.0	44.4	27.0	
2.0	MTT	I81E	L2			46.9	28.0	45.0	27.0	
2.0	MTT	I81E	L2			46.0	27.0	44.0	26.0	
2.0	MTT	I81E	L98					45.0	26.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
2.0	MTT	I81J	L222			52.2	31.2	49.1	30.3	
2.0	RAD	BKCV	F267	244.0						104.92
2.0	RAD	GBSA	L135			58.0				
2.0	TIB	BKCV	F267			52.4				
2.0	TIB	BKCV	F267			53.5				
2.0	TIB	BKCV	F267			57.4				
2.0	TIB	BKCV	L79			53.2	28.0	46.0	28.0	
2.0	TIB	I81C	L43			54.7				
2.0	TIB	I81C	L49			52.4				
2.0	TIB	I81E	L136			51.8	38.0			
2.0	TIB	I81E	L149	338.0	34.0	59.4				116.61
2.0	TIB	LWCJ	B1011			51.0	39.5			
3.0	FEM	I81E	L149	355.0	34.0	92.0				114.67
3.0	HUM	BKCV	F267		26.0					
3.0	HUM	LWCB	F158			69.0	63.2			
3.0	MTC	BKCE				60.7	30.5	54.5	24.0	
3.0	MTC	BKCE				52.0	28.0	49.2	26.5	
3.0	MTC	BKCE				60.6	30.0	54.2	24.5	
3.0	MTC	BKCE				52.0	28.0	49.2	27.0	
3.0	MTC	BKCK	F121			51.9	28.5	47.2	25.0	
3.0	MTC	BKCK	F121	169.0	31.7	59.6	31.0	51.3	23.5	103.09
3.0	MTC	BKCK	L124			48.4	28.5	43.3	25.0	
3.0	MTC	BKCK	L124	184.5	28.1	50.6	28.0	46.8	24.5	112.55
3.0	MTC	BKCK	L125			65.3		56.0		
3.0	MTC	BKCV	F267		28.6	49.4		46.8	25.0	
3.0	MTC	BKCV	L79			50.4		46.4		
3.0	MTC	BKCV	L93			52.5		47.6		
3.0	MTC	BKCV	L93	170.0	26.4	49.0	27.0	44.6	24.0	103.70
3.0	MTC	BUCB	L2			54.5		49.6		
3.0	MTC	GBSA	F268			50.4	28.0	44.5	24.0	
3.0	MTC	GBSA	L110		27.8	51.0	29.4	47.2	25.6	
3.0	MTC	GBSA	L112			49.6	27.8	44.8	23.9	
3.0	MTC	GBSA	L132			52.6	31.0	47.5	26.0	
3.0	MTC	GBSA	L132	178.0	29.6	51.0	29.0	56.7	23.0	108.58
3.0	MTC	GBSA	L135			50.0	29.0	45.6	25.0	
3.0	MTC	GBSA	L151			58.8	30.9	52.4	27.2	
3.0	MTC	GBSA	L230			52.0	27.8	48.0		
3.0	MTC	GBSA	L61			52.9	30.3	46.6	27.2	
3.0	MTC	GBSA	L93	179.0	29.3	51.4	28.5	46.8	23.2	109.19
3.0	MTC	GBSB	F110			48.4	27.6	44.0	24.7	
3.0	MTC	181A	L277			50.0		44.0	-	
3.0	MTC	I81B	F12			52.6	28.0	48.8	25.0	
3.0	MTC	I81B	L429			52.8	29.0	49.3	27.0	
3.0	MTC	I81C	F175			60.6	32.0	54.4		
3.0	MTC	I81C	F175			51.5	29.0	46.7		
3.0	MTC	I81E	F1006	186.0	27.1	49.8	-	45.4	25.0	113.46
3.0	MTC	I81E	F1006	177.0	26.6	51.0	27.0	44.8	25.0	107.97
3.0	MTC	I81E	F1006	175.0	24.0	47.0		44.0	24.0	106.75
3.0	MTC	I81E	F1006					44.3	24.0	
3.0	MTC	I81E	F1006	181.0	27.2	50.7	29.0	46.5	26.0	110.41
3.0	MTC	I81E	F1019	186.0	28.2	52.6	29.0	46.9	26.1	113.46
3.0	MTC	I81E	F1019	183.0	26.5	51.2	28.5	46.5	25.0	111.63
3.0	MTC	I81E	F1019	185.0	28.2	52.7	29.8	46.9	26.2	112.85

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
3.0	MTC	I81E	F1034	186.0		47.2		47.0	26.0	113.46
3.0	MTC	I81E	F1037			51.2	31.0	47.6	27.0	
3.0	MTC	I81E	F1037	182.0	26.7	50.5	29.0	46.4	25.0	111.02
3.0	MTC	I81E	F1164	185.0	26.8	50.0	27.9	45.5	24.3	112.85
3.0	MTC	I81E	F1250			51.9	29.0	47.2	25.0	
3.0	MTC	I81E	F1250			54.0	30.0	48.6	26.0	
3.0	MTC	I81E	F1329			51.9	29.0	45.9	26.0	
3.0	MTC	I81E	F745	191.0	29.9	53.4	29.0	48.9	27.0	116.51
3.0	MTC	I81E	F824	186.0	27.2	51.9	28.6	47.4	26.1	113.46
3.0	MTC	I81E	F824			51.0	29.0	48.5	26.0	
3.0	MTC	I81E	F824			49.4		44.6	25.0	
3.0	MTC	I81E	F834			52.8		47.5		
3.0	MTC	I81E	F834			61.0		54.8	28.0	
3.0	MTC	I81E	L121			52.7	28.8	49.0	25.9	
3.0	MTC	I81E	L138			50.6	28.9	46.6	24.7	
3.0	MTC	I81E	L149			49.8	29.4	45.3	25.3	
3.0	MTC	I81E	L149	178.0	29.7	58.9	31.0	51.9	25.9	108.58
3.0	MTC	181 J	L222	176.0	35.6					107.36
3.0	MTC	I81K	F391	183.0		52.1	29.1	48.4	25.6	111.63
3.0	MTC	LWCB	B166			51.8	29.0	48.9	26.0	
3.0	MTC	LWCJ	F373	195.0	37.8	61.5	32.2	60.3	32.2	118.95
3.0	MTC	LWCK	F316			54.0		47.1	27.0	
3.0	MTT	BKCE				46.8				
3.0	MTT	BKCE				43.4		40.6		
3.0	MTT	BKCE				45.5		•		
3.0	MTT	BKCE				44.9		42.4		
3.0	MTT	BKCE				55.8	26.0	51.7	30.0	
3.0	MTT	BKCE				46.1	28.0	43.4	27.0	
3.0	MTT	BKCE				46.6	27.5	43.0	26.5	
3.0	MTT	BKCE				48.4	28.5	45.4	26.5	
3.0	MTT	BKCE				48.7 -		44.9		
3.0	MTT	BKCE				49.6	29.0	47.3	27.0	
3.0	MTT	BKCE				49.0		45.4		
3.0	MTT	BKCE				55.5	30.0	51.1	26.0	
3.0	MTT	BKCG	B284							
3.0	MTT	BKCJ	F129			48.8	28.9	45.5	26.3	
3.0	MTT	BKCJ	F235			53.0	30.0	47.4		
3.0	MTT	BKCK	F121			48.0	29.0	46.9	28.0	
3.0	MTT	BKCK	L122	202.0	24.1	48.7	27.0	45.4	25.5	109.08
3.0	MTT	BKCK	L123			46.6	29.0	44.0	29.0	
3.0	MTT	BKCV	F248			45.9	27.0	42.9		
3.0	MTT	BKCV	F267	202.0		46.8	27.0	44.8	26.0	109.08
3.0	MTT	BKCV	F267	201.0		47.6	27.0	44.8	26.0	108.54
3.0	MTT	BKCV	F267	198.0		46.4	27.0	44.0	26.0	106.92
3.0	MTT	BKCV	L113			39.6	39.0			
3.0	MTT	BKCV	L67			46.4		45.3	28.0	
3.0	MTT	BKCV	L79			45.3	29.0	43.6	27.0	
3.0	MTT	BKCV	L93			49.7		46.1	26.0	
3.0	MTT	BKCV	L93	214.0	22.7	48.7		45.3	27.0	115.56
3.0	MTT	GBSA	F202			47.2	29.0	44.2	38.0	
3.0	MTT	GBSA	F202			48.9	30.0	45.4		
3.0	MTT	GBSA	F259	206.0	23.6	48.5	29.1	42.3	27.3	111.24
3.0	MTT	GBSA	L101			49.8		46.1		

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
3.0	MTT	GBSA	L130			45.9	28.0	42.3	26.0	
3.0	MTT	GBSA	L142	197.0	22.5	48.6	28.0	42.7	27.0	106.38
3.0	MTT	GBSA	L157			46.4	27.5	43.3	26.2	
3.0	MTT	GBSA	L236			48.7	28.4	45.4	27.6	
3.0	MTT	GBSA	L236			48.1		44.8		
3.0	MTT	GBSA	L250			48.8	28.9	45.3	27.4	
3.0	MTT	GBSA	L250			46.8	27.8	42.5	25.5	
3.0	MTT	GBSA	L264			49.0		46.5		
3.0	MTT	GBSA	L47			45.9				
3.0	MTT	GBSA	LI56			47.3	28.0	43.4	25.0	
3.0	MTT	GBSB	F18			57.8	31.8	51.9	31.6	
3.0	MTT	GBSB	F72	198.0	21.9	45.8	26.1	42.3	25.1	106.92
3.0	MTT	I81B	F282	-	-	47.8	28.0	44.6	26.0	
3.0	MTT	I81E	F1006	219.0	24.2	49.6	46.4	28.0		118.26
3.0	MTT	I81E	F1006	201.0	21.7	44.6	26.0	43.6	25.0	108.54
3.0	MTT	I81E	F1006	209.0	22.0	47.1	28.0	43.6	26.0	112.86
3.0	MTT	I81E	F1006	203.0	22.8	46.0	26.0	42.5	24.0	109.62
3.0	MTT	I81E	F1006			46.3	29.0	43.6	26.0	
3.0	MTT	I81E	F1019			47.3	28.3	44.6	25.8	
3.0	MTT	I81E	F1037	193.0	22.3	46.8	28.0	42.4	26.0	104.22
3.0	MTT	I81E	F1037			47.3	29.0	44.7	27.0	
3.0	MTT	I81E	F1100	211.5	23.1	46.9	27.9	44.5	25.9	114.21
3.0	MTT	I81E	F1164	205.0	21.2	47.3	27.7	44.3	25.2	110.70
3.0	MTT	I81E	F1164	200.0	21.8	46.2	27.6	42.6	25.8	108.00
3.0	MTT	I81E	F1164	199.0	22.1	45.6	27.7	41.7	26.0	107.46
3.0	MTT	I81E	F1164			50.1	27.5	46.8	25.5	
3.0	MTT	I81E	F1207			49.4	27.4	42.1	25.7	
3.0	MTT	I81E	F1250			46.0	27.0	44.7	26.0	
3.0	MTT	I81E	F1250			49.1	30.0	45.4	28.0	
3.0	MTT	I81E	F439			46.1	29.0	42.9	27.0	
3.0	MTT	I81E	F824			46.1		42.7	26.0	
3.0	MTT	I81E	F824			45.8	27.0	42.8	26.0	
3.0	MTT	I81E	F824			48.0	29.0	44.3	27.0	
3.0	MTT	I81E	F834			47.5	29.0	45.0	27.0	
3.0	MTT	I81E	F834			47.4	29.0	44.5	26.0	
3.0	MTT	I81E	F856			45.5	26.0	43.6	-	
3.0	MTT	I81E	F877			46.8	26.5	45.3	25.0	
3.0	MTT	I81E	F877	204.0	24.0	46.2	29.0	42.0	27.0	110.16
3.0	MTT	I81E	F900			46.7	28.3	44.6	25.8	
3.0	MTT	I81E	L138			48.5	29.2	45.2	26.1	
3.0	MTT	I81E	L138			46.7		44.1		
3.0	MTT	I81E	L166					44.2		
3.0	MTT	I81E	L2			49.2	30.0	46.9	28.0	
3.0	MTT	I81E	L2			46.4	29.0	44.4	27.0	
3.0	MTT	I81E	L2			46.9	28.0	45.0	27.0	
3.0	MTT	I81E	L2			46.0	27.0	44.0	26.0	
3.0	MTT	I81E	L98					45.0	26.0	
3.0	MTT	I81J	L222			52.2	31.2	49.1	30.3	
3.0	MTT	LWCJ	F429			46.0	27.6	42.7	24.5	
3.0	RAD	BKCK	F12			65.0				
3.0	RAD	BKCV	F267	244.0						104.92
3.0	RAD	GBSA	L135			58.0				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
3.0	TIB	BKCV	F267			52.4				
3.0	TIB	BKCV	F267			53.5				
3.0	TIB	BKCV	F267			57.4				
3.0	TIB	BKCV	L79			53.2	28.0	46.0	28.0	
3.0	TIB	I81B	F282			60.0				
3.0	TIB	I81B	F282			56.8				
3.0	TIB	I81B	F282			64.2				
3.0	TIB	I81C	L43			54.7				
3.0	TIB	I81C	L49			52.4				
3.0	TIB	I81E	L136			51.8	38.0			
3.0	TIB	I81E	L149	338.0	34.0	59.4				116.61
3.0	TIB	LWCJ	B1011			51.0	39.5			
3.0	TIB	LWCJ	F495			62.5	46.0			
4.0	MTC	BKCK	F122			52.8				
4.0	MTC	BKCK	F125			52.2		47.4	26.0	
4.0	MTC	BKCK	L154			49.1	28.0	46.1	26.0	
4.0	MTC	BKCK	L40			49.9	29.0	44.9	25.5	
4.0	MTC	BKCV	F58			61.1		59.4	30.0	
4.0	MTC	GBSA	L31			52.8	29.0	47.7	26.0	
4.0	MTC	GBSA	L38	179.0	20.1	42.8	29.0	37.8	27.0	109.19
4.0	MTC	GBSA	L52			54.3	30.5	50.0		
4.0	MTC	GBSA	L66			51.3	28.4	45.9	24.9	
4.0	MTC	GBSA	L8			54.2	30.0	50.1	26.0	
4.0	MTC	GBSB	L11			51.1	29.5	47.8	25.7	
4.0	MTC	I81B	F364			51.4	29.0	48.4	27.0	
4.0	MTC	I81B	F410			50.4	29.0	45.6	24.0	
4.0	MTC	I81B	L309			52.8	29.0			
4.0	MTC	I81B	L364	179.0	31.3	58.2	28.7	50.4	28.1	109.19
4.0	MTC	I81B	L390			49.1	26.4	44.1	22.2	
4.0	MTC	I81B	L409			54.8	28.0	49.0	26.0	
4.0	MTC	I81B	L671			50.2	29.0	47.5	26.0	
4.0	MTC	I81B	L671			49.0	28.0			
4.0	MTC	I81C	L32			51.8	30.2	47.8	26.5	
4.0	MTC	I81C	L41			51.7	28.0	45.6	26.0	
4.0	MTC	I81C	L43			50.0	28.0	45.8	25.0	
4.0	MTC	I81C	L45			51.4	28.0	46.6	25.0	
4.0	MTC	I81C	L45			49.1	28.0	43.4	25.0	
4.0	MTT	BKCE				46.9		43.3		
4.0	MTT	BKCK	F125			47.0	28.0	44.8	26.0	
4.0	MTT	BKCK	F125			45.6	28.0	44.4	27.0	
4.0	MTT	BKCK	F125			45.8	26.5	42.9	26.0	
4.0	MTT	BKCK	L40			50.2	29.5	47.4	28.0	
4.0	MTT	BKCK	L40			48.5	28.5	44.8	27.0	
4.0	MTT	BKCK	L70			49.2	28.0	45.2	25.5	
4.0	MTT	BKCK	L82			58.4	30.5	53.7	28.0	
4.0	MTT	GBSA	F95			48.8	27.2	43.9	24.2	
4.0	MTT	GBSA	L188			50.0	30.5	48.1	26.4	
4.0	MTT	GBSA	L48			45.3	26.5	42.3	25.2	
4.0	MTT	GBSA	L66			48.5	-	44.0	26.8	
4.0	MTT	GBSA	L9			49.6	29.0	45.1	28.0	
4.0	MTT	GBSA	L9			48.9	28.0	47.6	28.0	
4.0	MTT	GBSA	L9			45.0	27.0	43.3		

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
4.0	MTT	GBSA	L9			54.5			49.1	
4.0	MTT	GBSA	L9			46.6	27.5	47.1	27.7	
4.0	MTT	GBSA	L9			50.7	29.9	46.8	28.0	
4.0	MTT	GBSA	L9			48.5	27.6	44.6		
4.0	MTT	GBSA	L9			53.4	31.0	48.9	27.8	
4.0	MTT	GBSA	L9			52.1	28.6	45.4	24.2	
4.0	MTT	GBSA	L9			53.6	28.1	47.0	25.1	
4.0	MTT	GBSB	L11			51.2	30.0	47.2	28.1	
4.0	MTT	I81B	F192			48.5	27.0	46.1	27.0	
4.0	MTT	I81B	F302			49.0	28.0	44.6	26.0	
4.0	MTT	I81B	F367			49.8	31.0	48.7	28.0	
4.0	MTT	I81B	L215			45.7	28.2	42.5	24.6	
4.0	MTT	I81B	L309			48.8	29.0	44.9	27.0	
4.0	MTT	I81B	L390			47.0	27.9	44.7	26.1	
4.0	MTT	I81C	L20			52.5	29.3	48.9	27.2	
4.0	MTT	I81C	L20			60.0	31.8	53.1	27.5	
4.0	MTT	I81C	L34			50.2	25.4	45.6	26.6	
4.0	MTT	I81C	L34	223.0	27.2	60.6	33.2	55.2	30.6	120.42
4.0	MTT	I81C	L36			47.4	28.0	44.9	26.9	
4.0	MTT	I81C	L36	205.0	22.3	48.5	28.1	45.0	26.5	110.70
4.0	MTT	I81C	L36	210.0	24.3	49.0	29.5	46.5	27.1	113.40
4.0	MTT	I81C	L39			54.3	30.9	50.1	28.9	
4.0	MTT	I81C	L39			44.8	26.9	45.3	26.7	
4.0	MTT	I81C	L45			60.1	32.0	56.6	33.0	
4.0	MTT	I81C	L45			46.8	28.0	45.6	28.0	
4.0	MTT	I81C	L49			47.4	28.5	44.8	25.0	
4.0	MTT	LWCB	B244			50.2	28.9	45.8	25.2	
4.0	MTT	LWCK	B210			58.4	32.5	51.8	29.0	
4.0	MTT	LWCK	B213			49.7		45.9		
4.0	MTT	LWCK	B277			55.3	30.0	-		
4.0	MTT	LWCK	B434	214.0	27.1	55.1	31.0	56.3	33.0	115.56
4.0	MTT	LWCK	F202			45.5	26.5	42.0	25.0	
4.0	MTT	LWCK	F256			45.5	27.0	43.1	26.5	
4.0	MTT	LWCL	B437			49.0		45.2		
4.0	RAD	BKCV	L17							
4.0	RAD	GBSA	L9	241.0		61.6				103.63
4.0	RAD	GBSA	L9	257.0	37.9	66.0				110.51
4.0	TIB	GBSA	L9			56.1	47.1			
4.0	TIB	I81B	L12			54.1				
4.0	TIB	I81B	L462			52.8				
4.0	TIB	LWCB	F190			50.4	45.6			
4.0	TIB	LWCB	F195			62.1				
4.0	TIB	LWCK	F294			61.6	45.0			
5.0	MTC	BKCK	F122			52.8				
5.0	MTC	BKCK	L154			49.1	28.0	46.1	26.0	
5.0	MTC	BKCK	L40			49.9	29.0	44.9	25.5	
5.0	MTC	BKCV	F130			66.4	33.0	54.2	29.0	
5.0	MTC	BKCV	F130			52.4	29.0	47.9	26.0	
5.0	MTC	BKCV	F130	196.0		54.3		51.2		119.56
5.0	MTC	BKCV	F24			60.9	32.0	56.3	30.0	
5.0	MTC	BKCV	F247			57.9	31.0	54.5	29.0	
5.0	MTC	BKCV	F31	174.0	24.5	49.5		46.0	28.0	106.14

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
5.0	MTC	BKCV	F31			62.6				
5.0	MTC	BKCV	F441			57.1	33.0	52.6	29.0	
5.0	MTC	BKCV	F441			52.2	29.0	47.9	25.0	
5.0	MTC	BKCV	F55			55.3	•	48.8	26.5	
5.0	MTC	BKCV	F58			61.1		59.4	30.0	
5.0	MTC	BKCV	F78	185.0	35.4	60.0	33.0	54.4	28.0	112.85
5.0	MTC	BKCV	F8			52.8	•	47.2	26.0	
5.0	MTC	BKCV	F8			52.1	30.0	46.5		
5.0	MTC	BKCV	L145			51.9	28.0	49.4	27.0	
5.0	MTC	BKCV	L63			51 0	30.0	48.1	27.0	
5.0	MTC	BKCV	L64			51.1	28.5	49.4	27.0	
5.0	MTC	BKCV	L72			68.2	34.0	60.4	32.0	
5.0	MTC	BKCV	L72	181.0	27.8	51.2	29.0	45.4	24.0	110.41
5.0	MTC	I81B	F364			51.4	29.0	48.4	27.0	
5.0	MTC	I81B	F410			50.4	29.0	45.6	24.0	
5.0	MTC	I81B	L309			52.8	29.0		•	
5.0	MTC	I81B	L364	179.0	31.3	58.2	28.7	50.4	28.1	109.19
5.0	MTC	I81B	L390			49.1	26.4	44.1	22.2	
5.0	MTC	I81B	L409			54.8	28.0	49.0	26.0	
5.0	MTC	I81B	L671			50.2	29.0	47.5	26.0	
5.0	MTC	I81B	L671			49.0	28.0			
5.0	MTC	I81C	L32			51.8	30.2	47.8	26.5	
5.0	MTC	I81C	L41			51.7	28.0	45.6	26.0	
5.0	MTC	I81C	L43			50.0	28.0	45.8	25.0	
5.0	MTC	I81C	L45			51.4	28.0	46.6	25.0	
5.0	MTC	I81C	L45			49.1	28.0	43.4	25.0	
5.0	MTT	BKCG	B434			46.9	29.0	44.4	27.0	
5.0	MTT	BKCG	B434			60.0	•			
5.0	MTT	BKCK	F125			47.0	28.0	44.8	26.0	
5.0	MTT	BKCK	F125			45.6	28.0	44.4	27.0	
5.0	MTT	BKCK	F125			45.8	26.5	42.9	26.0	
5.0	MTT	BKCK	L40			50.2	29.5	47.4	28.0	
5.0	MTT	BKCK	L40			48.5	28.5	44.8	27.0	
5.0	MTT	BKCK	L70			49.2	28.0	45.2	25.5	
5.0	MTT	BKCK	L82			58.4	30.5	53.7	28.0	
5.0	MTT	BKCV	B614			59.6				
5.0	MTT	BKCV	F125	210.0	24.6	46.4	27.0	44.5	26.0	113.40
5.0	MTT	BKCV	F125			47.1	29.0	43.0	26.0	
5.0	MTT	BKCV	F130			51.0	30.0	46.9	29.0	
5.0	MTT	BKCV	F130			48.9		48.6	30.0	
5.0	MTT	BKCV	F24			53.9	31.0	50.5	27.0	
5.0	MTT	BKCV	F25			53.5	31.0	51.5	30.0	
5.0	MTT	BKCV	F31	220.0		48.9	30.0	45.1	27.0	118.80
5.0	MTT	BKCV	F31	218.0	28.0	56.1	32.0	50.9	29.0	117.72
5.0	MTT	BKCV	F31	214.0	28.0	51.1	29.0	48.2	28.0	115.56
5.0	MTT	BKCV	F39	210.0		48.6	28.0	46.7	27.0	113.40
5.0	MTT	BKCV	F39			48.8	29.0	44.2	28.0	
5.0	MTT	BKCV	F503			47.4	28.0	44.7	28.0	
5.0	MTT	BKCV	F8					46.2	28.0	
5.0	MTT	BKCV	F8					47.3	-	
5.0	MTT	BKCV	F8			48.0	29.0	45.5	28.0	
5.0	MTT	BKCV	F82			55.5		53.2	32.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
5.0	MTT	BKCV	L160			48.9		45.7		
5.0	MTT	BKCV	L18					46.7		
5.0	MTT	BKCV	L63					46.7		
5.0	MTT	I81B	F192			48.5	27.0	46.1	27.0	
5.0	MTT	I81B	F302			49.0	28.0	44.6	26.0	
5.0	MTT	I81B	F367			49.8	31.0	48.7	28.0	
5.0	MTT	I81B	L215			45.7	28.2	42.5	24.6	
5.0	MTT	I81B	L309			48.8	29.0	44.9	27.0	
5.0	MTT	I81B	L390			47.0	27.9	44.7	26.1	
5.0	MTT	I81C	L20			52.5	29.3	48.9	27.2	
5.0	MTT	I81C	L20			60.0	31.8	53.1	27.5	
5.0	MTT	I81C	L34			50.2	25.4	45.6	26.6	
5.0	MTT	I81C	L34	223.0	27.2	60.6	33.2	55.2	30.6	120.42
5.0	MTT	I81C	L36			47.4	28.0	44.9	26.9	
5.0	MTT	I81C	L36	205.0	22.3	48.5	28.1	45.0	26.5	110.70
5.0	MTT	I81C	L36	210.0	24.3	49.0	29.5	46.5	27.1	113.40
5.0	MTT	I81C	L39			54.3	30.9	50.1	28.9	
5.0	MTT	I81C	L39			44.8	26.9	45.3	26.7	
5.0	MTT	I81C	L45			60.1	32.0	56.6	33.0	
5.0	MTT	I81C	L45			46.8	28.0	45.6	28.0	
5.0	MTT	I81C	L49			47.4	28.5	44.8	25.0	
5.0	MTT	LWCL	B437			49.0		45.2		
5.0	TIB	BKCV	F8			44.7				
5.0	TIB	I81B	L12			54.1				
5.0	TIB	I81B	L462			52.8				
6.0	HUM	BKCN	F2			69.0	60.0			
6.0	HUM	I81G	F2695			79.5				
6.0	MTC	BKCE				58.6				
6.0	MTC	BKCE				60.8	31.5	55.7	29.0	
6.0	MTC	BKCG	B345			52.6	29.5			
6.0	MTC	BKCG	B429			55.7	32.0	51.8	28.0	
6.0	MTC	BKCG	B429			57.0		51.6	26.5	
6.0	MTC	BKCG	F24			47.8	27.5	44.7	24.5	
6.0	MTC	BKCG	F61			55.4	31.0	51.8	30.0	
6.0	MTC	BKCG	F61			56.5	32.0	53.1	30.0	
6.0	MTC	BKCG	F61			53.5	31.5	50.2	26.0	
6.0	MTC	BKCJ	F13			53.6	29.0	51.2		
6.0	MTC	BKCJ	F13			50.8	28.2	46.0	24.8	
6.0	MTC	BKCJ	F13			50.6	28.2	47.9	25.5	
6.0	MTC	BKCJ	F13			52.6	28.6	47.9	25.9	
6.0	MTC	BKCJ	F13			59.4	31.3	50.2	27.7	
6.0	MTC	BKCJ	F13			55.0	29.9	49.1	28.5	
6.0	MTC	BKCJ	F31			53.8	30.0	51.2	27.0	
6.0	MTC	BKCJ	F36			52.2		47.2		
6.0	MTC	BKCJ	F43			57.1	32.0	53.0	28.0	
6.0	MTC	BKCJ	L27			55.1		50.2	27.0	
6.0	MTC	BKCK	F122			52.8				
6.0	MTC	BKCK	F125			52.2		47.4	26.0	
6.0	MTC	BKCK	L154			49.1	28.0	46.1	26.0	
6.0	MTC	BKCK	L40			49.9	29.0	44.9	25.5	
6.0	MTC	BKCN	B6	189.0	26.8			46.4		115.29
6.0	MTC	BKCN	B6			59.2	32.0	51.3	26.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTC	BKCN	F2					55.6	29.0	
6.0	MTC	BKCN	F75			59.0	32.0	54.3	28.0	
6.0	MTC	BKCN	F75			70.0		64.5	34.5	
6.0	MTC	BKCN	F75			56.5	31.0	53.0	29.0	
6.0	MTC	BKCN	L94			57.0	31.5	53.0	28.0	
6.0	MTC	BKCN	L94			52.2	28.5	47.3		
6.0	MTC	BKCV	F130			66.4	33.0	54.2	29.0	
6.0	MTC	BKCV	F130			52.4	29.0	47.9	26.0	
6.0	MTC	BKCV	F130	196.0		54.3		51.2		119.56
6.0	MTC	BKCV	F24			60.9	32.0	56.3	30.0	
6.0	MTC	BKCV	F247			57.9	31.0	54.5	29.0	
6.0	MTC	BKCV	F31	174.0	24.5	49.5		46.0	28.0	106.14
6.0	MTC	BKCV	F31			62.6				
6.0	MTC	BKCV	F441			57.1	33.0	52.6	29.0	
6.0	MTC	BKCV	F441			52.2	29.0	47.9	25.0	
6.0	MTC	BKCV	F55			55.3		48.8	26.5	
6.0	MTC	BKCV	F58			61.1		59.4	30.0	
6.0	MTC	BKCV	F59			54.0	31.0	48.4	24.5	
6.0	MTC	BKCV	F61			59.2	32.0	53.3	29.0	
6.0	MTC	BKCV	F78	185.0	35.4	60.0	33.0	54.4	28.0	112.85
6.0	MTC	BKCV	F8			52.8		47.2	26.0	
6.0	MTC	BKCV	F8			52.1	30.0	46.5		
6.0	MTC	BKCV	L14			53.1				
6.0	MTC	BKCV	L14			61.0				
6.0	MTC	BKCV	L14			53.3	28.5			
6.0	MTC	BKCV	L14			71.3	36.0	60.0	30.0	
6.0	MTC	BKCV	L145			51.9	28.0	49.4	27.0	
6.0	MTC	BKCV	L15			54.9		52.7		
6.0	MTC	BKCV	L15			56.4		52.7		
6.0	MTC	BKCV	L15			54.5		49.6		
6.0	MTC	BKCV	L15			54.5		51.1	28.0	
6.0	MTC	BKCV	L15			53.0	30.0	49.1	29.0	
6.0	MTC	BKCV	L15			54.8	30.0	50.7		
6.0	MTC	BKCV	L15			55.5		50.3	28.0	
6.0	MTC	BKCV	L15					58.4		
6.0	MTC	BKCV	L15			56.0		54.9		
6.0	MTC	BKCV	L15			59.5	34.0	54.4	30.0	
6.0	MTC	BKCV	L15			56.9	31.0	52.5	28.0	
6.0	MTC	BKCV	L15			56.8		53.8	30.0	
6.0	MTC	BKCV	L15					47.0		
6.0	MTC	BKCV	L15			57.6	32.0	52.5	28.0	
6.0	MTC	BKCV	L15			53.8	26.0	49.4		
6.0	MTC	BKCV	L15			57.8	31.0	52.5	29.0	
6.0	MTC	BKCV	L15			56.6	30.0	52.5	27.0	
6.0	MTC	BKCV	L15					50.6	28.0	
6.0	MTC	BKCV	L15			56.4	31.0	51.4	29.0	
6.0	MTC	BKCV	L15			58.9		55.4	29.0	
6.0	MTC	BKCV	L15			57.0	30.0	53.0	28.0	
6.0	MTC	BKCV	L15			53.2	31.0	49.0	27.0	
6.0	MTC	BKCV	L15			54.8	32.0	52.6	31.0	
6.0	MTC	BKCV	L15			55.4	32.0	52.6	31.0	
6.0	MTC	BKCV	L15			52.0	29.0	57.8	26.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTC	BKCV	L15			55.9	30.0	50.8	27.0	
6.0	MTC	BKCV	L15			53.2	30.0	47.8	26.0	
6.0	MTC	BKCV	L15			54.3	30.0	50.2	27.0	
6.0	MTC	BKCV	L15			59.4	31.0	56.8	30.0	
6.0	MTC	BKCV	L15			52.9		48.2	24.0	
6.0	MTC	BKCV	L15			56.9	31.0	53.2	28.0	
6.0	MTC	BKCV	L15			54.0		49.9	29.0	
6.0	MTC	BKCV	L15			54.8		51.0		
6.0	MTC	BKCV	L15			58.2		52.8		
6.0	MTC	BKCV	L15			56.6		53.0		
6.0	MTC	BKCV	L15			56.6	30.0	55.1	30.0	
6.0	MTC	BKCV	L15			55.8	29.0	50.2	28.0	
6.0	MTC	BKCV	L27			60.4	33.0	56.2	31.0	
6.0	MTC	BKCV	L27			60.7	33.0	55.3	30.0	
6.0	MTC	BKCV	L27			59.6		54.7	29.5	
6.0	MTC	BKCV	L27			53.8	30.0	51.1	28.0	
6.0	MTC	BKCV	L27			58.4	31.0	55.1		
6.0	MTC	BKCV	L38			54.8	31.0	49.2	27.0	
6.0	MTC	BKCV	L38			53.5				
6.0	MTC	BKCV	L38			54.0		49.5	26.0	
6.0	MTC	BKCV	L38			56.9	28.0	52.6		
6.0	MTC	BKCV	L39			59.0		53.7		
6.0	MTC	BKCV	L39			53.5		48.7	28.0	
6.0	MTC	BKCV	L39			56.7		54.5	30.0	
6.0	MTC	BKCV	L39			52.3		49.2	26.0	
6.0	MTC	BKCV	L63			51.0	30.0	48.1	27.0	
6.0	MTC	BKCV	L64			51.1	28.5	49.4	27.0	
6.0	MTC	BKCV	L72			68.2	34.0	60.4	32.0	
6.0	MTC	BKCV	L72	181.0	27.8	51.2	29.0	45.4	24.0	110.41
6.0	MTC	GBSA	F128			60.5	32.2	55.1	29.4	
6.0	MTC	GBSA	F171			51 4	29.0	47.0	26.0	
6.0	MTC	GBSA	F237	177.0	26.9	50.8	28.0	45.4	24.0	107.97
6.0	MTC	GBSA	F27			59.1	30.7	53.8	26.4	
6.0	MTC	GBSA	F27			58.5	32.2	55.1	28.8	
6.0	MTC	GBSA	F27			54.8		49.7	26.7	
6.0	MTC	GBSA	F27			55.9	30.9	51.3	26.2	
6.0	MTC	GBSA	F27			55.2	29.2	50.9	26.7	
6.0	MTC	GBSA	F292			65.4		54.4	27.0	
6.0	MTC	GBSA	F292			58.8	34.0	54.7	30.0	
6.0	MTC	GBSA	L124			55.3	30.9	51.2	28.8	
6.0	MTC	GBSA	L178			51.7	27.3	46.9	24.9	
6.0	MTC	GBSA	L27			53.9	30.0	50.0	27.0	
6.0	MTC	GBSA	L27			56.6		52.3	28.0	
6.0	MTC	GBSA	L27			64.3	33.0			
6.0	MTC	GBSA	L27			56.7	32.0	53.7	29.0	
6.0	MTC	GBSA	L31			52.8	29.0	47.7	26.0	
6.0	MTC	GBSA	L38	179.0	20.1	42.8	29.0		27.0	109.19
6.0	MTC	GBSA	L44			50.9	27.4	45.6	24.7	
6.0	MTC	GBSA	L52			54.3	30.5	50.0		
6.0	MTC	GBSA	L66			51.3	28.4	45.9	24.9	
6.0	MTC	GBSA	L8			54.2	30.0	50.1	26.0	
6.0	MTC	GBSB	L11			51.1	29.5	47.8	25.7	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTC	I81B	F364			51.4	29.0	48.4	27.0	
6.0	MTC	I81B	F410			50.4	29.0	45.6	24.0	
6.0	MTC	I81B	L104			62.7	32.4		28.2	
6.0	MTC	I81B	L104			55.4		51.5	25.6	
6.0	MTC	I81B	L309			52.8	29.0			
6.0	MTC	I81B	L364	179.0	31.3	58.2	28.7	50.4	28.1	109.19
6.0	MTC	I81B	L390			49.1	26.4	44.1	22.2	
6.0	MTC	I81B	L409			54.8	28.0	49.0	26.0	
6.0	MTC	I81B	L671			50.2	29.0	47.5	26.0	
6.0	MTC	I81B	L671			49.0	28.0			
6.0	MTC	I81B	L89			54.4	31.2	50.9	29.1	
6.0	MTC	I81B	L96			49.9	27.8	46.3	25.1	
6.0	MTC	I81C	F12					51.0		
6.0	MTC	I81C	F8			59.9	33.0	56.9	29.6	
6.0	MTC	I81C	F8			57.7	32.0	53.2	29.0	
6.0	MTC	I81C	L14			54.4	28.9	58.5	25.3	
6.0	MTC	I81C	L32			51.8	30.2	47.8	26.5	
6.0	MTC	I81C	L41			51.7	28.0	45.6	26.0	
6.0	MTC	I81C	L43			50.0	28.0	45.8	25.0	
6.0	MTC	I81C	L45			51.4	28.0	46.6	25.0	
6.0	MTC	I81C	L45			49.1	28.0	43.4	25.0	
6.0	MTC	I81E	F1266			49.1	27.4	45.4	24.4	
6.0	MTC	I81E	F650	177.0	28.0	51.1	28.0	47.1	25.3	107.97
6.0	MTC	I81E	F685	187.0	27.8	52.0	28.9	48.0	26.2	114.07
6.0	MTC	I81E	F788			52.4	31.0	48.3	27.0	
6.0	MTC	I81E	F788			50.2	29.0	46.2	25.0	
6.0	MTC	I81E	F788			52.1	28.0	47.4	24.0	
6.0	MTC	I81E	F788			49.5	28.0	46.4	25.0	
6.0	MTC	I81E	L22	183.0	28.0	53.3		48.4		111.63
6.0	MTC	I81E	L27		29.5	58.3		53.6		102.48
6.0	MTC	I81E	L27			50.1	28.0	44.9	24.0	
6.0	MTC	I81G	F2363			47.5		43.4		
6.0	MTC	I81G	F79			55.5	30.0	50.7	25.3	
6.0	MTC	I81G	L1568			52.6	30.5	47.5	26.1	
6.0	MTC	I81G	L1945			52.9	28.6	49.9	26.4	
6.0	MTC	I81G	L2024			52.4	29.7	45.6	25.5	
6.0	MTC	I81G	L2185			53.7	31.0	49.7	27.8	
6.0	MTC	I81G	L2781			62.6	32.4	55.4	28.0	
6.0	MTC	I81G	L3125			51.4	30.0	49.6	26.6	
6.0	MTC	I81G	L3549			71.0		61.9		
6.0	MTC	I81G	L3716			54.2	29.6	50.5		
6.0	MTC	I81K	F112			47.2	27.2	43.8	24.2	
6.0	MTC	I81K	F233			51.7	29.9	46.9	27.4	
6.0	MTC	I81K	F411			59.1	29.5	55.7	28.0	
6.0	MTC	I8IG	F79			55.4	30.2	49.8	27.4	
6.0	MTC	LWCJ	B588			56.6		51.8		
6.0	MTC	LWCJ	B588			51.8		46.7		
6.0	MTC	LWCJ	B588			51.8		46.7	25.0	
6.0	MTC	LWCL	B374			54.9	33.0	49.9	29.0	
6.0	MTT	BKCE				46.9		43.3		
6.0	MTT	BKCE				47.6	28.0	45.0	27.5	
6.0	MTT	BKCE		206.5		45.8	27.5	43.3	27.0	111.51

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	BKCE				44.7	27.0	41.5	25.5	
6.0	MTT	BKCE				48.6	28.0	45.8	27.0	
6.0	MTT	BKCE				48.7	30.0	46.8	28.0	
6.0	MTT	BKCE				49.5	30.0	46.4	27.5	
6.0	MTT	BKCE				47.8	28.0	44.7	26.0	
6.0	MTT	BKCG	B274			52.2	30.0	48.4	27.5	
6.0	MTT	BKCG	B274			47.3	29.0	45.3	27.0	
6.0	MTT	BKCG	B429			51.1				
6.0	MTT	BKCG	B429			49.4	28.0			
6.0	MTT	BKCG	B429			47.1	27.0	44.5	26.0	
6.0	MTT	BKCG	B429			53.4	31.0	50.9	31.0	
6.0	MTT	BKCG	B434			46.9	29.0	44.4	27.0	
6.0	MTT	BKCG	B434			60.0				
6.0	MTT	BKCG	F61			58.5	32.0	51.8	31.0	
6.0	MTT	BKCG	F61			51.4	30.0	50.4	28.0	
6.0	MTT	BKCH	L12			52.4	30.5	51.8	29.0	
6.0	MTT	BKCH	L12			52.8	32.5	49.4	30.0	
6.0	MTT	BKCJ	F13			54.1	30.0	48.9	28.0	
6.0	MTT	BKCJ	F13			62.6	32.4	54.9	24.0	
6.0	MTT	BKCJ	F13			60.3	32.2	53.5	30.0	
6.0	MTT	BKCJ	F13			50.4	28.5	47.8	26.3	
6.0	MTT	BKCJ	F13			54.0	31.6	49.7	29.4	
6.0	MTT	BKCJ	F286			52.9		49.5	29.0	
6.0	MTT	BKCJ	F31			48.9	29.0	45.2	27.0	
6.0	MTT	BKCJ	F34			48.0		44.0		
6.0	MTT	BKCJ	F34			54.6		52.4		
6.0	MTT	BKCJ	F36			48.5	28.0	44.5	26.0	
6.0	MTT	BKCJ	F36			58.1	32.0	55.8	31.0	
6.0	MTT	BKCJ	F36			56.7	33.0	53.2	31.0	
6.0	MTT	BKCJ	F41			52.7		51.5	31.0	
6.0	MTT	BKCJ	F49			50.9	29.0	49.8	29.0	
6.0	MTT	BKCJ	F53			58.5	33.0	52.3	29.0	
6.0	MTT	BKCJ	F85			55.9	30.0	44.7	28.0	
6.0	MTT	BKCJ	L33			51.1	30.0	48.3	30.0	
6.0	MTT	BKCJ	L33	205.0	23.4	46.3	26.9	44.6	25.5	110.70
6.0	MTT	BKCJ	L6			49.7	27.8	46.7	25.5	
6.0	MTT	BKCK	F125			47.0	28.0	44.8	26.0	
6.0	MTT	BKCK	F125			45.6	28.0	44.4	27.0	
6.0	MTT	BKCK	F125			45.8	26.5	42.9	26.0	
6.0	MTT	BKCK	L40			50.2	29.5	47.4	28.0	
6.0	MTT	BKCK	L40			48.5	28.5	44.8	27.0	
6.0	MTT	BKCK	L70			49.2	28.0	45.2	25.5	
6.0	MTT	BKCK	L82			58.4	30.5	53.7	28.0	
6.0	MTT	BKCN	B529				30.0	47.3		
6.0	MTT	BKCN	F75			50.5	30.0	47.5	27.5	
6.0	MTT	BKCN	F97			55.1	33.0	52.8	31.0	
6.0	MTT	BKCV	B614			59.6				
6.0	MTT	BKCV	F125	210.0	24.6	46.4	27.0	44.5	26.0	113.40
6.0	MTT	BKCV	F125			47.1	29.0	43.0	26.0	
6.0	MTT	BKCV	F130			51.0	30.0	46.9	29.0	
6.0	MTT	BKCV	F130			48.9		48.6	30.0	
6.0	MTT	BKCV	F24			53.9	31.0	50.5	27.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	BKCV	F25			53.5	31.0	51.5	30.0	
6.0	MTT	BKCV	F31	220.0		48.9	30.0	45.1	27.0	118.80
6.0	MTT	BKCV	F31	218.0	28.0	56.1	32.0	50.9	29.0	117.72
6.0	MTT	BKCV	F31	214.0	28.0	51.1	29.0	48.2	28.0	115.56
6.0	MTT	BKCV	F39	210.0		48.6	28.0	46.7	27.0	113.40
6.0	MTT	BKCV	F39			48.8	29.0	44.2	28.0	
6.0	MTT	BKCV	F499			47.5	29.0	45.1	28.0	
6.0	MTT	BKCV	F503			47.4	28.0	44.7	28.0	
6.0	MTT	BKCV	F8					46.2	28.0	
6.0	MTT	BKCV	F8					47.3		
6.0	MTT	BKCV	F8			48.0	29.0	45.5	28.0	
6.0	MTT	BKCV	F82			55.5		53.2	32.0	
6.0	MTT	BKCV	L13			53.4	31.0	49.1		
6.0	MTT	BKCV	L14			53.8		50.1		
6.0	MTT	BKCV	L14			53.4	29.0	49.1		
6.0	MTT	BKCV	L15			52.3	30.0	49.2		
6.0	MTT	BKCV	L15			53.2	30.0	49.2	29.0	
6.0	MTT	BKCV	L15			53.8	32.0	51.2	31.0	
6.0	MTT	BKCV	L15			51.5		47.6	28.0	
6.0	MTT	BKCV	L15			65.9		59.3		
6.0	MTT	BKCV	L15			53.7	32.0	53.2	30.0	
6.0	MTT	BKCV	L15			53.5	31.0	50.6	30.0	
6.0	MTT	BKCV	L15			54.9	32.0	52.1	32.0	
6.0	MTT	BKCV	L15			52.7	32.0	50.6	29.0	
6.0	MTT	BKCV	L15			63.1	34.0	58.8	34.0	
6.0	MTT	BKCV	L15					49.1		
6.0	MTT	BKCV	L15			53.6		49.1		
6.0	MTT	BKCV	L15			50.4		49.9	31.0	
6.0	MTT	BKCV	L15			63.1		62.9	29.0	
6.0	MTT	BKCV	L15			65.9		59.5		
6.0	MTT	BKCV	L15			65.9		56.4	33.0	
6.0	MTT	BKCV	**L15**			56.0		49.9		
6.0	MTT	BKCV	L15			50.2	29.0	48.0	29.0	
6.0	MTT	BKCV	L15			49.0		46.6	28.0	
6.0	MTT	BKCV	L15			50.5	31.0	45.9		
6.0	MTT	BKCV	L15			69.0		57.5		
6.0	MTT	BKCV	L15			51.7		49.2		
6.0	MTT	BKCV	L15			52.3		48.6	29.0	
6.0	MTT	BKCV	L15			53.2		50.2		
6.0	MTT	BKCV	L15			51.6		47.9		
6.0	MTT	BKCV	L15			50.6		48.9	29.0	
6.0	MTT	BKCV	L15					53.3	30.0	
6.0	MTT	BKCV	L15			53.8	32.0	49.5	31.0	
6.0	MTT	BKCV	L15			53.6		49.5	29.0	
6.0	MTT	BKCV	L15			53.2	31.0	50.5	30.0	
6.0	MTT	BKCV	L15			56.8	33.0	53.7	31.0	
6.0	MTT	BKCV	L15			49.8	28.0	47.4		
6.0	MTT	BKCV	L15			52.3	28.0	49.4	30.0	
6.0	MTT	BKCV	L15			50.5	29.0	47.8	27.0	
6.0	MTT	BKCV	L15			52.3	30.0	49.2		
6.0	MTT	BKCV	L15			50.0		46.4	27.0	
6.0	MTT	BKCV	L15			63.0		57.6		

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	BKCV	L15			53.6	30.0	50.8	29.0	
6.0	MTT	BKCV	L15			53.0		51.2		
6.0	MTT	BKCV	L160			48.9		45.7		
6.0	MTT	BKCV	L18					46.7		
6.0	MTT	BKCV	L27			53.1	31.0			
6.0	MTT	BKCV	L27			55.1		52.9		
6.0	MTT	BKCV	L27			54.6	31.0	51.0	31.0	
6.0	MTT	BKCV	L34			50.5	31.0	47.4		
6.0	MTT	BKCV	L38			50.5				
6.0	MTT	BKCV	L39			50.0				
6.0	MTT	BKCV	L39			66.2		54.5		
6.0	MTT	BKCV	L46			50.9	30.0	50.3	29.5	
6.0	MTT	BKCV	L46			49.4		46.8	27.0	
6.0	MTT	BKCV	L50			47.7		45.7		
6.0	MTT	BKCV	L63					46.7		
6.0	MTT	GBSA	F102			55.2	31.5	52.0	29.8	
6.0	MTT	GBSA	F102			48.6	28.2	44.6	26.6	
6.0	MTT	GBSA	F121			52.8	31.3	50.5	28.6	
6.0	MTT	GBSA	F27			53.6	32.0	50.1	31.0	
6.0	MTT	GBSA	F27			53.3	29.7	50.2	30.1	
6.0	MTT	GBSA	F95			48.8	27.2	43.9	24.2	
6.0	MTT	GBSA	L188			50.0	30.5	48.1	26.4	
6.0	MTT	GBSA	L40			49.0		47.6	27.9	
6.0	MTT	GBSA	L48			45.3	26.5	42.3	25.2	
6.0	MTT	GBSA	L66			48.5		44.0	26.8	
6.0	MTT	GBSA	L9			49.6	29.0	45.1	28.0	
6.0	MTT	GBSA	L9			48.9	28.0	47.6	28.0	
6.0	MTT	GBSA	L9			45.0	27.0	43.3		
6.0	MTT	GBSA	L9			54.5			49.1	
6.0	MTT	GBSA	L9			46.6	27.5	47.1	27.7	
6.0	MTT	GBSA	L9			50.7	29.9	46.8	28.0	
6.0	MTT	GBSA	L9			48.5	27.6	44.6		
6.0	MTT	GBSA	L9			53.4	31.0	48.9	27.8	
6.0	MTT	GBSA	L9			52.1	28.6	45.4	24.2	
6.0	MTT	GBSA	L9			53.6	28.1	47.0	25.1	
6.0	MTT	GBSB	F28			52.5	30.4	50.0	28.7	
6.0	MTT	GBSB	L11			51.2	30.0	47.2	28.1	
6.0	MTT	GBSB	L8			48.6	26.9	43.4	27.3	
6.0	MTT	I81B	F185		27.0	53.9	32.0	51.0	31.0	
6.0	MTT	I81B	F192			48.5	27.0	46.1	27.0	
6.0	MTT	I81B	F193			61.1	*m*	55.7		
6.0	MTT	I81B	F302			49.0	28.0	44.6	26.0	
6.0	MTT	I81B	F367			49.8	31.0	48.7	28.0	
6.0	MTT	I81B	L124	210.0	24.7	49.7	29.1	47.8	27.8	113.40
6.0	MTT	I81B	L182			51.9	31.2	48.1	28.6	
6.0	MTT	I81B	L210			50.5	29.2	47.4	27.3	
6.0	MTT	I81B	L210			48.5	29.3	45.8	22.2	
6.0	MTT	I81B	L215			45.7	28.2	42.5	24.6	
6.0	MTT	I81B	L222			48.9		44.3		
6.0	MTT	I81B	L309			48.8	29.0	44.9	27.0	
6.0	MTT	I81B	L341			49.0	28.0	46.8	27.0	
6.0	MTT	I81B	L390			47.0	27.9	44.7	26.1	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	I81B	L61			61.3	34.1	57.6	32.6	
6.0	MTT	I81B	L96			46.2	26.9	47.1	29.4	
6.0	MTT	I81C	F8	224.5	24.7	50.6	30.6	48.5	29.9	121.23
6.0	MTT	I81C	L13			50.8	30.1	47.2	28.1	
6.0	MTT	I81C	L20			52.5	29.3	48.9	27.2	
6.0	MTT	I81C	L20			60.0	31.8	53.1	27.5	
6.0	MTT	I81C	L34			50.2	25.4	45.6	26.6	
6.0	MTT	I81C	L34	223.0	27.2	60.6	33.2	55.2	30.6	120.42
6.0	MTT	I81C	L36			47.4	28.0	44.9	26.9	
6.0	MTT	I81C	L36	205.0	22.3	48.5	28.1	45.0	26.5	110.70
6.0	MTT	I81C	L36	210.0	24.3	49.0	29.5	46.5	27.1	113.40
6.0	MTT	I81C	L39			54.3	30.9	50.1	28.9	
6.0	MTT	I81C	L39			44.8	26.9	45.3	26.7	
6.0	MTT	I81C	L45			60.1	32.0	56.6	33.0	
6.0	MTT	I81C	L45			46.8	28.0	45.6	28.0	
6.0	MTT	I81C	L49			47.4	28.5	44.8	25.0	
6.0	MTT	I81E	F443	214.0	26.7	50.2	31.0	46.4		115.56
6.0	MTT	I81E	F560	215.0	26.4		33.5		29.8	116.10
6.0	MTT	I81E	F560			63.6		56.7	34.1	
6.0	MTT	I81E	F592			54.8	29.9	50.4	29.1	
6.0	MTT	I81E	F592			48.3	28.8	44.5	25.1	
6.0	MTT	I81E	F592			45.6	28.2	42.1	25.0	
6.0	MTT	I81E	F650	193.0	23.4	52.4	27.4	49.5	26.1	104.22
6.0	MTT	I81E	F685	220.0	23.9	48.1	28.9	46.1	26.7	118.80
6.0	MTT	I81E	F788			46.8	26.0	43.4	26.0	
6.0	MTT	I81E	F788			50.5	30.0	46.3	28.0	
6.0	MTT	I81E	F788			49.7	30.0	47.0	27.0	
6.0	MTT	I81E	L15	221.0	23.1	49.7		46.0	29.5	119.34
6.0	MTT	I81E	L232			46.5	28.9	45.2	26.3	
6.0	MTT	I81E	L24			46.1	29.0	42.9	27.0	
6.0	MTT	I81E	L24			56.1		53.9	32.0	
6.0	MTT	I81E	L24			50.4	30.0	48.1	28.0	
6.0	MTT	I81E	L24			48.0		44.3		
6.0	MTT	I81E	L27	201.0	26.7	46.1	27.8	44.8	26.4	108.54
6.0	MTT	I81E	L40	207.0	24.0	53.0	31.0	50.2	29.0	111.78
6.0	MTT	I81E	L40			45.9	29.0	42.6	27.0	
6.0	MTT	I81E	L54	205.0	22.6	45.9	27.9	41.8	26.4	110.70
6.0	MTT	I81E	L54	206.5	24.1	53.6	30.2	49.2	26.8	111.51
6.0	MTT	I81E	L54	211.5	22.6	48.5	28.2	44.8	27.0	114.21
6.0	MTT	I81G	F2210			51.8	29.3	49.4	29.0	
6.0	MTT	I81G	F2292			65.9	34.5	62.3	33.5	
6.0	MTT	I81G	F79			60.8	32.2	58.5	31.2	
6.0	MTT	I81G	L1760			59.6	31.5	54.8	28.9	
6.0	MTT	I81G	L1814			50.5	30.3	46.4	28.5	
6.0	MTT	I81G	L1825			47.7	29.1	47.8	29.2	
6.0	MTT	I81G	L2084			48.9	38.9	46.9	26.7	
6.0	MTT	I81G	L2374			47.8	27.2	44.1	26.4	
6.0	MTT	I81G	L2677			49.2	28.9	46.5	27.3	
6.0	MTT	I81G	L2966			49.2	28.9	46.5	27.3	
6.0	MTT	I81G	L4240			48.4	28.8	46.9	26.4	
6.0	MTT	I81G	L4255			45.4	25.7	42.3	24.0	
6.0	MTT	I81H	L565			50.1	29.6	48.2	27.8	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	I81K	F233	210.0	26.1	57.0	32.1	52.5	29.2	113.40
6.0	MTT	I81K	F233			54.8	28.8	50.5	28.2	
6.0	MTT	I81K	F233			47.9		45.6	28.1	
6.0	MTT	I81K	F233			48.2	28.1	46.1	26.6	
6.0	MTT	I81K	F233			48.7	29.4	45.4	29.4	
6.0	MTT	I81K	F233			54.2	28.8	49.5	26.5	
6.0	MTT	I81K	F233			52.6	31.3	48.5	27.7	
6.0	MTT	I81K	F233			47.4	28.2	44.5	26.5	
6.0	MTT	I81K	F91	211.0	23.4	48.7	28.0	45.3	26.3	113.94
6.0	MTT	I81K	L60			52.2	28.8	47.9	26.8	
6.0	MTT	I81K	L60			46.8		43.2	24.1	
6.0	MTT	LWCB	B244			50.2	28.9	45.8	25.2	
6.0	MTT	LWCJ	B370			50.6	29.0	48.2	28.0	
6.0	MTT	LWCK	B210			58.4	32.5	51.8	29.0	
6.0	MTT	LWCK	B213			49.7		45.9		
6.0	MTT	LWCK	B277			55.3	30.0			
6.0	MTT	LWCK	B434	214.0	27.1	55.1	31.0	56.3	33.0	115.56
6.0	MTT	LWCK	F202			45.5	26.5	42.0	25.0	
6.0	MTT	LWCK	F256			45.5	27.0	43.1	26.5	
6.0	MTT	LWCL	B379			51.4	30.0	48.1	29.0	
6.0	MTT	LWCL	B437			49.0		45.2		
6.0	MTT	LWCL	B540			53.9	31.0	51.0		
6.0	MTT	LWCL	B698			51.7	31.0	48.9	27.5	
6.0	RAD	BKCJ	F36			67.0				
6.0	RAD	BKCJ	F85			80.0				
6.0	RAD	BKCJ	F85			60.0				
6.0	RAD	BKCV	L17							
6.0	RAD	BKCV	L39			59.0				
6.0	RAD	GBSA	L9	241.0		61.6				103.63
6.0	RAD	GBSA	L9	257.0	37.9	66.0				110.51
6.0	RAD	I81G	F79	271.0	37.4	63.5				116.53
6.0	TIB	BKCG	F24			53.8	39.0			
6.0	TIB	BKCJ	F13			52.7				
6.0	TIB	BKCJ	L33			56.9				
6.0	TIB	BKCN	F9			67.5	46.0			
6.0	TIB	BKCV	F8			44.7				
6.0	TIB	GBSA	F79			71.0	52.0			
6.0	TIB	GBSA	L9			56.1	47.1			
6.0	TIB	I81B	L12			54.1				
6.0	TIB	I81B	L462			52.8				
6.0	TIB	I81C	F158			58.9				
6.0	TIB	I81E	F390			54.0				
6.0	TIB	I81E	F394			65.0				
6.0	TIB	I81E	L1746			65.1				
6.0	TIB	I81G	F2139			58.4				
6.0	TIB	I81G	L1643			59.4				
6.0	TIB	LWCB	F190			50.4	45.6			
6.0	TIB	LWCB	F195			62.1				
6.0	TIB	LWCJ	B506			61.0	49.0			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	TIB	LWCK	F294			61.6	45.0			
7.0	HUM	BKCH	F161			84.0				
7.0	HUM	I81G	F31			81.0				
7.0	HUM	I81G	F50			87.5				
7.0	HUM	I81G	F96		33.2	74.0				
7.0	HUM	I81G	F96		35.0	85.0				
7.0	HUM	I81G	F96		30.3	80.0				
7.0	HUM	I81G	F96		34.8	83.0				
7.0	HUM	I81G	L119			74.5				
7.0	HUM	I81G	L6			71.0				
7.0	MTC	BKCG	F108			52.4	30.0	48.8	27.0	
7.0	MTC	BKCG	F11			54.6	30.0	51.7	28.0	
7.0	MTC	BKCG	F11			56.7	30.5	51.1	28.5	
7.0	MTC	BKCG	F11			56.0	30.0	52.9	28.0	
7.0	MTC	BKCG	F11			52.1	28.5	47.8	25.0	
7.0	MTC	BKCG	F20			57.6	31.0	53.4	31.0	
7.0	MTC	BKCH	F113			58.8	32.0	54.2	30.0	
7.0	MTC	BKCH	F113			56.1	30.5			
7.0	MTC	BKCH	F120			55.5	31.0	51.6	27.0	
7.0	MTC	BKCH	F120					56.0	31.0	
7.0	MTC	BKCH	F120	179.0	34.5	63.2	32.5	57.2	28.0	109.19
7.0	MTC	BKCH	F161			54.5	29.0	46.1	27.5	
7.0	MTC	BKCH	F169			57.7	32.0	54.4	28.0	
7.0	MTC	BKCH	F33			56.9	31.0	53.1	28.0	
7.0	MTC	BKCH	F33	194.0	39.1	64.2	31.5	58.3	29.0	118.34
7.0	MTC	BKCH	F33	200.0	39.5	69.7		61.9		122.00
7.0	MTC	BKCH	F33	195.0	31.0	55.7	32.0	53.2	28.5	118.95
7.0	MTC	BKCH	F33	192.0	32.3	54.4		52.9	30.0	117.12
7.0	MTC	BKCH	F33	206.0	32.4	57.2	30.0	54.3	29.5	125.66
7.0	MTC	BKCH	F33	184.0	28.6	55.1	30.5	49.6	27.0	112.24
7.0	MTC	BKCH	F33			56.5		52.3	28.0	
7.0	MTC	BKCH	F33	185.0	28.5	55.1	30.0	49.3	27.5	112.85
7.0	MTC	BKCH	F33			52.6	28.0	52.7	28.0	
7.0	MTC	BKCH	F33			56.4		53.0	29.5	
7.0	MTC	BKCH	F33			50.3		45.5	25.0	
7.0	MTC	BKCH	F33			56.0		52.8	29.0	
7.0	MTC	BKCH	F57			57.3	31.0	51.8	28.5	
7.0	MTC	BKCH	F68			58.3	32.0	52.3	29.5	
7.0	MTC	BKCH	F68			58.7	30.0	53.8	32.0	
7.0	MTC	BKCH	F68			59.7	31.0	53.8	29.0	
7.0	MTC	BKCH	F68			58.5	34.0	55.2	30.5	
7.0	MTC	BKCH	F68			51.0	28.5	47.1	25.0	
7.0	MTC	BKCH	F76			57.3	31.0	52.6	29.5	
7.0	MTC	BKCH	F94			56.8	31.0	53.3	28.5	
7.0	MTC	BKCH	F94			56.3	31.0	54.9	29.0	
7.0	MTC	BKCH	F94			54.9		50.9		
7.0	MTC	BKCH	F94			59.1	31.5	54.2	29.0	
7.0	MTC	BKCH	F94			57.5	30.5	54.0	28.5	
7.0	MTC	BKCH	F94			59.2		53.1		
7.0	MTC	BKCH	F94			55.7	31.0	52.4	28.5	
7.0	MTC	BKCH	F94			58.2	32.0	53.2	29.0	
7.0	MTC	BKCH	F94			61.6	34.0	59.1	32.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
7.0	MTC	BKCH	F94			56.1	31.5	53.0	29.0	
7.0	MTC	BKCH	F94			63.0	33.0	64.2	34.0	
7.0	MTC	BKCH	L13			54.3	30.5	50.8	28.0	
7.0	MTC	BKCH	L13			53.9		49.6	29.5	
7.0	MTC	BKCH	L13			55.3	31.0	50.5	27.5	
7.0	MTC	BKCH	L13			56.4	30.0	51.4	28.0	
7.0	MTC	BKCJ	F32			58.0	30.9	52.5	28.3	
7.0	MTC	BKCJ	F44			52.9	30.0	47.1	26.0	
7.0	MTC	BKCJ	F44			56.3	32.0	52.3	29.0	
7.0	MTC	BKCV	F18			71.1		63.6		
7.0	MTC	BKCV	L11	185.0	29.7					112.85
7.0	MTC	BKCV	L22			52.5	29.5	48.8		
7.0	MTC	BKCV	L22			65.3				
7.0	MTC	BKCV	L5			60.2	32.0	54.4	29.0	
7.0	MTC	BKCV	L5			53.5	29.0	49.3	27.0	
7.0	MTC	BKCV	L5			62.2	32.0	53.4	28.0	
7.0	MTC	BKCV	L5			55.2		51.4		
7.0	MTC	BKCV	L5			55.6	31.0	52.1	27.0	
7.0	MTC	BKCV	L5			55.2				
7.0	MTC	BUCC	G243			68.1	32.0	53.4	26.0	
7.0	MTC	BUCE	L36			57.9		52.8	27.0	
7.0	MTC	I81B	L10			56.7	31.5	53.7	29.6	
7.0	MTC	I81B	L7			53.8	39.7	54.7	29.6	
7.0	MTC	I81D	F242			55.1		52.7	28.0	
7.0	MTC	I81E	F223			47.7		43.7		
7.0	MTC	I81G	F14	210.0	39.1	68.5	38.0	64.3	32.0	128.10
7.0	MTC	I81G	F14			55.1	30.0	51.7	28.0	
7.0	MTC	I81G	F14			57.6	30.0	52.6	28.0	
7.0	MTC	I81G	F14	195.0	29.5	52.3	30.0	49.5	28.0	118.95
7.0	MTC	I81G	F14			55.0	31.0	55.6	31.0	
7.0	MTC	I81G	F14			57.7	31.0	53.6	29.0	
7.0	MTC	I81G	F14			54.6	30.0	50.8	26.0	
7.0	MTC	I81G	F14			56.1	32.0	52.3	27.0	
7.0	MTC	I81G	F14			56.8	31.0	52.6	27.0	
7.0	MTC	I81G	F3050			56.2	26.1	48.9		
7.0	MTC	I81G	F478	171.0	28.7	50.8	27.1	44.7	23.3	104.31
7.0	MTC	I81G	L119			55.6	29.8	53.5	30.0	
7.0	MTC	I81G	L119			54.8	30.1	51.2	27.7	
7.0	MTC	I81G	L1332			55.5	30.9	51.9	28.1	
7.0	MTC	I81G	L1446			54.3	29.9	54.1	30.4	
7.0	MTC	I81G	L1701			55.1	30.1	50.6	28.0	
7.0	MTC	I81G	L1702			55.2	30.3	53.1	30.4	
7.0	MTC	I81G	L1747			50.8	29.1	46.2	25.1	
7.0	MTC	I81G	L1762			53.7	29.4	49.2	26.5	
7.0	MTC	I81G	L2474	189.0	27.3	52.6		47.0	26.2	115.29
7.0	MTC	I81G	L581			55.4	28.3	52.6	25.8	
7.0	MTC	I81G	L605			55.3	29.9	52.0	28.2	
7.0	MTC	I81G	L644			54.9	31.5	50.5	28.3	
7.0	MTC	I81G	L644			69.9	37.6	60.0	29.2	
7.0	MTC	I81G	L784			57.6	30.5	52.8	27.0	
7.0	MTC	I81H	F59	189.0	31.0					115.29
7.0	MTC	I81H	L78			60.4	33.0	57.0	30.0	

Period	**Bone**	**Site**	**Context**	**GL**	**SD**	**Bd**	**TD**	**BdEp**	**TEp**	**SHT**
7.0	MTT	BKCV	L5			54.7	33.0	51.6	31.0	
7.0	MTT	BKCV	L5			51.8		51.5		
7.0	MTT	BKCV	L5			75.8	39.0	65.4		
7.0	MTT	BKKV	L11			59.9		53.9	33.0	
7.0	MTT	BUCA	G20			52.3	29.0	49.7		
7.0	MTT	BUCA	G27			54.1	30.0	49.7	30.0	
7.0	MTT	BUCA	G34			56.4	33.0	54.1	33.0	
7.0	MTT	BUCA	G36			51.5		49.6		
7.0	MTT	BUCC	G23					49.7		
7.0	MTT	BUCC	G25			62.2		59.4		
7.0	MTT	I81B	F39			54.1	30.5	49.9	25.6	
7.0	MTT	I81B	F92			47.4	28.7	44.0	25.8	
7.0	MTT	I81B	L7			56.9		52.8		
7.0	MTT	I81C	F19			51.9	30.0	48.8		
7.0	MTT	I81G	F14			53.9				
7.0	MTT	I81G	F14			46.5	27.0	42.8	25.0	
7.0	MTT	I81G	F14			49.3	30.0	45.7	29.0	
7.0	MTT	I81G	L1050			54.9	32.9	53.0	30.4	
7.0	MTT	I81G	L119	220.0	20.9	61.4	33.4	56.4	32.2	118.80
7.0	MTT	I81G	L1462			50.0		44.7		
7.0	MTT	I81G	L1762			48.1	28.8	44.9	27.2	
7.0	MTT	I81G	L1762			50.8	29.6	46.2	27.6	
7.0	MTT	I81G	L1766			49.8	30.9	46.2	29.0	
7.0	MTT	I81G	L209			49.8	30.1	46.9	28.1	
7.0	MTT	I81G	L209			53.8	30.3	48.5	30.2	
7.0	MTT	I81G	L209			52.3	30.9	50.5	29.8	
7.0	MTT	I81G	L209			51.0	29.2	46.2	27.2	
7.0	MTT	I81G	L2483			49.8	30.0	46.4	28.1	
7.0	MTT	I81G	L327			56.6	33.5	52.6	31.5	
7.0	MTT	I81G	L36			62.8		59.1	33.0	
7.0	MTT	I81G	L581			52.8	31.8	50.2	28.9	
7.0	MTT	I81G	L754			53.5	31.9	51.2	29.2	
7.0	MTT	I81G	L983			53.7	32.2	51.8	30.8	
7.0	MTT	I81G	L989			62.8	34.3	54.8	31.9	
7.0	MTT	I81H	F59	209.0	25.5	52.6	28.9	48.4	26.9	112.86
7.0	MTT	I81H	F59		26.2	53.4	31.3	51.6	29.3	
7.0	RAD	BKCJ	F283		33.9	65.9				
7.0	RAD	BKCV	L11			76.0				
7.0	RAD	I81G	L177			82.6				
7.0	RAD	I81H	F59			62.7				
7.0	TIB	BKCG	F141			58.0				
7.0	TIB	BKCG	F32			60.0	45.0			
7.0	TIB	BKCH	F33			63.5	44.0			
7.0	TIB	BKCH	F33			63.9				
7.0	TIB	BKCH	F33			52.5	39.0			
7.0	TIB	BKCH	F68			71.0				
7.0	TIB	BKCH	**L13**			67.5				
7.0	TIB	BKCJ	F32			54.2				
7.0	TIB	BKCJ	F32			62.7				
7.0	TIB	BKCV	L11			63.7	44.0			
7.0	TIB	BKCV	L5			55.2	41.0			
7.0	TIB	I81E	F334			55.1				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
7.0	TIB	I81G	F14			57.4				
7.0	TIB	I81G	L119		34.5	59.8				
8.0	MTC	BKCE				58.8	30.5	53.6	29.0	
8.0	MTC	BKCE				57.9	32.0	52.6	29.0	
8.0	MTC	BKCE				54.1	30.0	49.1	28.0	
8.0	MTC	BKCE				56.1	31.0	53.5	29.0	
8.0	MTC	BKCE				57.9	32.5	51.9	29.0	
8.0	MTC	BKCH	F28	181.0	33.0	59.8	31.5	52.8	26.5	110.41
8.0	MTC	BKCK	F12			52.5	29.0	48.8	26.0	
8.0	MTC	BKCK	F15			52.7	30.0	47.4	26.5	
8.0	MTC	BKCK	F15			54.6	29.0	51.0	26.0	
8.0	MTC	BKCK	F15			52.0	29.0	47.6	25.0	
8.0	MTC	BKCK	F15			55.5	31.0	51.2	28.5	
8.0	MTC	BKCK	L18			57.4	30.0	54.7	28.0	
8.0	MTC	BKCN	F12			53.7	30.0	50.5	28.0	
8.0	MTC	BKCN	F12	187.0	28.2			50.0		114.07
8.0	MTC	BKCN	F21			53.9	29.0	50.6	25.0	
8.0	MTC	BKCN	F33			52.4	30.0	49.0	26.0	
8.0	MTC	BKCN	F47			53.5		53.2	28.5	
8.0	MTC	BKCN	F76			60.8				
8.0	MTC	BKCN	F92					58.7	32.5	
8.0	MTC	BKCN	L3			55.1	31.5	52.8	29.5	
8.0	MTC	BKCN	L5			74.0				
8.0	MTC	BKCN	L7			63.5	31.5			
8.0	MTC	BKCN	L8			69.6	35.0	65.8	35.0	
8.0	MTC	BKCN	L8			60.3	33.0	56.5	31.0	
8.0	MTC	BKCN	L8			54.5	29.0			
8.0	MTC	BKCN	L8			53.0	30.0	49.8	28.0	
8.0	MTC	BKCN	L8			54.5	30.0	48.9	26.5	
8.0	MTC	BKCN	L8			57.4		54.0	29.5	
8.0	MTC	BKCN	L9			57.1	33.5	53.5	31.0	
8.0	MTC	BKCN	L9			53.8	31.0	49.8	28.0	
8.0	MTC	BKCN	L9			56.0	31.0	51.4	29.5	
8.0	MTC	I81B	L10			56.7	31.5	53.7	29.6	
8.0	MTC	I81B	L7			53.8	39.7	54.7	29.0	
8.0	MTC	I81E	F223			47.7	|	43.7		
8.0	MTT	BKCE				47.9				
8.0	MTT	BKCE				55.3	32.0	52.8	30.0	
8.0	MTT	BKCE				49.2		45.9		
8.0	MTT	BKCE				64.8	34.0	56.8	36.5	
8.0	MTT	BKCH	F28			54.8	32.5	54.5	31.5	
8.0	MTT	BKCH	F28			54.9		54.7	32.0	
8.0	MTT	BKCK	F15					45.9	28.0	
8.0	MTT	BKCK	F6			52.5	28.0	48.0	29.5	
8.0	MTT	BKCN	B327			58.7	31.0	52.8	31.5	
8.0	MTT	BKCN	F21			50.2	30.0	47.5	28.5	
8.0	MTT	BKCN	F28		21.7	49.2	28.5	43.3	24.5	
8.0	MTT	BKCN	F33			54.6	30.5	50.8	29.0	
8.0	MTT	BKCN	F42			53.5	30.5			
8.0	MTT	BKCN	F86			50.6		46.4		
8.0	MTT	BKCN	F92			55.9	32.5	54.0	32.0	
8.0	MTT	BKCN	L11			52.5	30.0	51.5		

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
8.0	MTT	BKCN	L11			50.6	30.5	48.6	30.0	
8.0	MTT	BKCN	L3			52.9	30.0	49.7	29.0	
8.0	MTT	BKCN	L7			50.6	28.5	47.3	27.0	
8.0	MTT	BKCN	L8			50.4	30.5	52.1	31.0	
8.0	MTT	BKCN	L8			52.8	32.0	50.3	31.0	
8.0	MTT	BKCN	L8			53.0	32.0	50.5	29.0	
8.0	MTT	BKCN	L8			53.4	30.0	51.5	29.5	
8.0	MTT	BKCN	L8			53.3	32.5	48.8	30.0	
8.0	MTT	BKCN	L8			53.2	32.0	49.0	28.5	
8.0	MTT	BKCN	L8			47.6	28.5	45.1	27.0	
8.0	MTT	BKCN	L8			52.2	31.0	50.0	28.5	
8.0	MTT	BKCN	L8			53.7	31.0	50.0	28.5	
8.0	MTT	BKCN	L8			51.9	32.5	48.1		
8.0	MTT	BKCN	L8			54.1		55.5		
8.0	MTT	BKCN	L9			51.8	30.0	50.8	29.0	
8.0	MTT	BKCN	L9		29.0	52.2	30.5	50.1	28.5	
8.0	MTT	I81C	F19			51.9	30.0	48.8		
8.0	RAD	BKCN	L11			87.0				
8.0	RAD	BKCN	L7			71.0				
8.0	RAD	BKCN	L8			74.0				
8.0	TIB	BKCH	F28			53.7	38.5			
8.0	TIB	BKCH	L5			67.5	48.0			
8.0	TIB	BKCK	F6			62.0				
8.0	TIB	BKCN	B146			55.6	41.5			
8.0	TIB	BKCN	B245			55.0	42.0			
8.0	TIB	BKCN	F86			57.0	44.0			
8.0	TIB	BKCN	L7			66.0				
8.0	TIB	BKCN	L8			66.0				
8.0	TIB	I81E	F334			55.1				

KEY:
P 1 44-49
2 49-60/1
3 44-60/1
4 60/1-110
5 75-125
6 60/1-300
7 225-400
8 300-400

(Key to period codes on page 203. All measurements are according to von den Driesch thickness, SHT shoulder height, and TEp distal epiphysial thickness.)

MTABLE 4.2 CATTLE METRICS, MEDIEVAL/POST-MEDIEVAL

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
9.0	MTC	I81B	F2			59.9	33.0	55.8	29.0	
9.0	MTC	I81B	F72			63.9		59.7		
9.0	MTC	I81C	F4			58.6	31.0	55.9	30.0	
9.0	MTC	I81C	F4			58.6	31.0	55.9	30.0	
9.0	MTC	I81D	F224			56.1		52.6	28.0	
9.0	MTC	I81D	F224			56.1		52.6	28.0	
9.0	MTC	I81D	F258		27.3					
9.0	MTC	I81D	F259			55.0	30.0	50.6	26.0	
9.0	MTC	I81D	F259			54.9	32.0	52.2	29.0	
9.0	MTC	I81D	F259	186.0	27.8	54.2	32.0	49.3	28.0	113.46
9.0	MTC	I81D	F259			55.4	29.0	50.9	26.0	
9.0	MTC	I81D	F259			57.4		51.8	29.0	
9.0	MTC	I81D	F259			58.5		54.5	29.0	
9.0	MTC	I81D	F259			55.0	30.0	50.6	26.0	
9.0	MTC	I81D	F259			54.9	32.0	52.2	29.0	
9.0	MTC	I81D	F259	186.0	27.8	54.2	32.0	49.3	28.0	113.46
9.0	MTC	I81D	F259			55.4	29.0	50.9	26.0	
9.0	MTC	I81D	F259			57.4		51.8	29.0	
9.0	MTC	I81D	F259			58.5		54.5	29.0	
9.0	MTC	I81D	F278	198.0	40.0	62.0	34.0	59.0	32.0	120.78
9.0	MTC	I81D	F30			69.2	35.0	60.0	31.0	
9.0	MTC	I81D	F30			69.2	35.0	60.0	31.0	
9.0	MTC	I81D	F37			52.2	28.2	47.9	25.9	
9.0	MTC	I81D	F37			52.2	28.2	47.9	25.9	
9.0	MTC	I81D	F91			57.5	32.0	51.9	29.0	
9.0	MTC	I81D	F91			57.5	32.0	51.9	29.0	
9.0	MTC	I81D	L60	192.0	35.7	69.3	32.0	57.8	28.0	117.12
9.0	MTC	I81E	F10			54.3	28.6	50.2	27.3	
9.0	MTC	I81E	F10			54.3	28.6	50.2	27.3	
9.0	MTC	I81E	F104			46.9	26.1	41.3	21.9	
9.0	MTC	I81E	F104			46.9	26.1	41.3	21.9	
9.0	MTC	I81E	F106			50.5		46.1	26.2	
9.0	MTC	I81E	F108			51.4				
9.0	MTC	I81E	F108			56.3	29.9	49.5	26.8	
9.0	MTC	I81E	F113			53.9	30.0	51.2	27.9	
9.0	MTC	I81E	F113			53.9	30.0	51.2	27.9	
9.0	MTC	I81E	F117			64.2	36.0	61.1	35.0	
9.0	MTC	I81E	F117					48.8	26.0	
9.0	MTC	I81E	F117			64.2	36.0	61.1	35.0	
9.0	MTC	I81E	F117					48.8	26.0	
9.0	MTC	I81E	F15	172.0	26.8	49.4		44.7	24.0	104.92
9.0	MTC	I81E	F15	195.0	32.6	53.0	30.7	49.2	26.7	118.95
9.0	MTC	I81E	F15			55.9	33.7	51.8	27.9	
9.0	MTC	I81E	F15	172.0	26.8	49.4		44.7	24.0	104.92
9.0	MTC	I81E	F15	195.0	32.6	53.0	30.7	49.2	26.7	118.95
9.0	MTC	I81E	F15			55.9	33.7	51.8	27.9	
9.0	MTC	I81E	F168	236.0	43.4	73.1	36.0	69.4		143.96
9.0	MTC	I81E	F172	171.0	25.4	49.4	27.0	42.1	23.0	104.31
9.0	MTC	I81E	F231			60.9		54.7	30.0	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
9.0	MTC	I81E	F231			60.9		54.7	30.0	
9.0	MTC	I81E	F240			53.3	31.0	48.0	26.0	
9.0	MTC	I81E	F278			63.0		53.5		
9.0	MTC	I81E	F3			54.9	32.0	51.3	31.0	
9.0	MTC	I81E	F9	200.0	29.6	53.5	30.3	51.3	28.4	122.00
9.0	MTC	I81E	F9			59.2	33.2	56.5	30.2	
9.0	MTC	I81E	F9	200.0	29.6	53.5	30.3	51.3	28.4	122.00
9.0	MTC	I81E	F9			59.2	33.2	56.5	30.2	
9.0	MTC	I81E	F95	191.5		62.9	33.6	57.4	28.0	116.81
9.0	MTC	LWCB	F45	186.0	29.5			49.9	26.5	113.46
9.0	MTC	LWCB	F45	183.0	33.1	54.5		52.1	26.1	111.63
9.0	MTC	LWCB	F46	180.0	28.2	50.5	28.6	54.9	24.5	109.80
9.0	MTC	LWCB	F75			56.3	32.0	53.0	30.7	
9.0	MTC	LWCH	F32			65.5	32.4			
9.0	MTC	LWCL	F261	197.0	30.5	58.4		53.8	29.0	120.17
9.0	MTC	MID	MED			55.5	30.5	52.4	27.5	
9.0	MTC	MID	MED			57.2	32.0	54.6	28.0	
9.0	MTC	MID	MED			56.9	31.5	52.3	28.0	
9.0	MTC	MID	MED			51.6	30.5	45.9	26.0	
9.0	MTC	MID	MED			51.2	29.3	44.4	25.0	
9.0	MTC	MID	MED			58.2	31.5	56.4	30.5	
9.0	MTC	MID	MED			57.3	30.5	49.2	25.7	
9.0	MTC	MID	MED			60.5		51.2	26.7	
9.0	MTC	MID	MED	168.5	24.1	48.4	28.0	43.1	27.3	102.79
9.0	MTC	MID	MED	163.0	25.4	47.5	26.5	43.5	23.1	99.43
9.0	MTC	MID	MED	180.5	24.5	47.2	28.0	42.5	24.1	110.10
9.0	MTC	MID	MED	179.0	25.5	48.7	27.0	44.6	23.1	109.19
9.0	MTC	MID	MED		27.9	52.0	27.8	47.8	24.0	
9.0	MTC	MID	MED		25.4			45.5		
9.0	MTC	MID	MED	183.0	26.6	50.4	27.8	43.0	22.6	111.63
9.0	MTC	MID	MED	182.0	25.7	49.9	28.0	44.5	24.7	111.02
9.0	MTC	MID	MED	188.0	30.9	58.1	31.0	51.6	26.0	114.68
9.0	MTC	MID	MED			52.2	28.0	46.7	23.0	
9.0	MTC	MID	MED	172.0	25.0	50.4	26.5	44.8	22.8	104.92
9.0	MTC	MID	MED	185.0	28.9	54.9	30.0	49.6	27.0	112.85
9.0	MTC	MID	MED	170.0	24.8	47.7	26.0	44.5	24.5	103.70
9.0	MTC	MID	MED			51.9	28.0	46.9	25.5	
9.0	MTC	MID	MED			50.8	27.5	45.6	24.7	
9.0	MTC	MID	MED			47.6	25.0	44.1	22.6	
9.0	MTC	MID	MED			50.2	28.5	45.8	26.1	
9.0	MTC	MID	MED		24.4	47.3	27.0	43.1	23.6	
9.0	MTC	MID	MED		30.2					
9.0	MTC	MID	MED	180.0	26.7	50.9	28.5	45.7	25.0	109.80
9.0	MTC	MID	MED	187.0	32.7	60.1	31.0	55.1	27.9	114.07
9.0	MTC	MID	MED	171.0	26.2	49.7	27.5	45.3	24.0	104.31
9.0	MTC	MID	MED			48.5	28.0	48.8	27.3	
9.0	MTC	MID	MED			49.6	28.0	44.4	24.5	
9.0	MTC	MID	MED	181.0	29.8	51.0	28.5	47.0	25.0	110.41
9.0	MTC	MID	MED	171.0	24.9		26.0	45.5	25.1	104.31
9.0	MTC	MID	MED	173.0	24.5	48.7	26.0	43.3	23.9	105.53
9.0	MTC	MID	MED			45.7	28.0	42.9	24.3	
9.0	MTC	MID	MED			59.8	29.0	53.1	25.2	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
9.0	MTC	MID	MED			57.5	32.0	54.4	30.0	
9.0	MTC	MID	MED			49.8	27.0	45.7	23.0	
9.0	MTC	MID	MED			48.4		41.9	22.4	
9.0	MTT	I81B	F52			48.0		43.6	25.7	
9.0	MTT	I81B	F52			52.4	31.9	50.9	30.1	
9.0	MTT	I81B	F562			50.8	30.0	48.9	29.0	
9.0	MTT	I81B	F72			47.1		43.9	26.0	
9.0	MTT	I81B	F73			47.2	38.3	43.7	26.3	
9.0	MTT	I81B	F73			47.2	38.3	43.7	26.3	
9.0	MTT	I81C	F4			48.0		45.6		
9.0	MTT	I81C	F4			48.0		45.6		
9.0	MTT	I81C	F9			50.5	30.0	46.3	29.0	
9.0	MTT	I81C	L9			50.3	28.7	48.1	27.6	
9.0	MTT	I81D	F259			55.3				
9.0	MTT	I81D	F259			51.4		48.8	26.0	
9.0	MTT	I81D	F259			55.7	33.0	54.4	32.0	
9.0	MTT	I81D	F259	218.0	26.6	49.7	30.0	48.2	29.0	117.72
9.0	MTT	I81D	F259			55.3				
9.0	MTT	I81D	F259			51.4		48.8	26.0	
9.0	MTT	I81D	F259			55.7	33.0	54.4	32.0	
9.0	MTT	I81D	F259	218.0	26.6	49.7	30.0	48.2	29.0	117.72
9.0	MTT	I81D	F278	213.0	24.0	49.5		45.1	27.0	115.02
9.0	MTT	I81D	F278	203.0	24.9	47.6	28.0	46.4	27.0	109.62
9.0	MTT	I81D	F38			53.5	31.5	51.3	29.5	
9.0	MTT	I81D	F38			53.5	31.5	51.3	29.5	
9.0	MTT	I81D	F403	213.0	26.2	48.5	28.0	45.4	28.0	115.02
9.0	MTT	I81D	F43			59.2	33.1	57.1	33.0	
9.0	MTT	I81D	F498	211.0	24.5	48.6	28.0	47.1	27.0	113.94
9.0	MTT	I81D	F498	211.0	24.5	48.6	28.0	47.1	27.0	113.94
9.0	MTT	I81D	F577			52.2	31.0	50.0	30.0	
9.0	MTT	I81D	F577			52.2	31.0	50.0	30.0	
9.0	MTT	I81D	F90			53.6	32.0	49.3	30.0	
9.0	MTT	I81D	F90			53.6	32.0	49.3	30.0	
9.0	MTT	I81D	F91			58.9		57.5		
9.0	MTT	I81D	F91			58.9		57.5		
9.0	MTT	I81D	L684			54.6	33.0	52.6	31.0	
9.0	MTT	I81D	L684			54.6	33.0	52.6	31.0	
9.0	MTT	I81E	F102			57.0	30.9	52.9	28.8	
9.0	MTT	I81E	F102			57.0	30.9	52.9	28.8	
9.0	MTT	I81E	F108			53.0	32.1	50.6		
9.0	MTT	I81E	F117			55.4	30.0	53.6		
9.0	MTT	I81E	F117	225.0	29.2	.		52.8	29.0	121.50
9.0	MTT	I81E	F117			46.1	29.0	43.2	27.0	
9.0	MTT	I81E	F117		23.0	48.6	29.0	44.1	27.0	
9.0	MTT	I81E	F117			55.4	30.0	53.6		
9.0	MTT	I81E	F117	225.0	29.2			52.8	29.0	121.50
9.0	MTT	I81E	F117			46.1	29.0	43.2	27.0	
9.0	MTT	I81E	F117		23.0	48.6	29.0	44.1	27.0	
9.0	MTT	I81E	F123			45.7	26.8	43.2	25.7	
9.0	MTT	I81E	F134	239.0	31.2	60.3	31.8	55.9		129.06
9.0	MTT	I81E	F134	212.0	23.8	49.0	29.0	46.2		114.48
9.0	MTT	I81E	F137	232.0	25.6	56.2	32.5	50.9	28.6	125.28

Period	Bone	Site	Context	GL	SD	Bd	TD	BeiEp	TEp	SHT
9.0	MTT	I81E	F141			49.1	29.5	46.1	27.3	
9.0	MTT	I81E	F155	215.0	24.0	46.7	28.7	43.6	28.7	116.10
9.0	MTT	I81E	F164			65.8	33.9	58.8	30.0	
9.0	MTT	I81E	F167		30.0	59.0		51.3		
9.0	MTT	I81E	F168		27.0	54.0	31.0	51.9	30.0	
9.0	MTT	I81E	F2			46.0	26.8	43.8	25.8	
9.0	MTT	I81E	F2					50.1	29.1	
9.0	MTT	I81E	F209			55.8				
9.0	MTT	I81E	F21	201.5	23.9					108.81
9.0	MTT	I81E	F226			51.8	31.0	49.4	30.0	
9.0	MTT	I81E	F23			51.9	31.5	49.6		
9.0	MTT	I81E	F23			51.9	31.5	49.6		
9.0	MTT	I81E	F240			50.3		48.0	28.0	
9.0	MTT	I81E	F240			55.6	30.0	51.5	30.0	
9.0	MTT	I81E	F25	215.0	25.0	49.9	30.2	47.6	28.2	116.10
9.0	MTT	I81E	F25	215.0	25.0	49.9	30.2	47.6	28.2	116.10
9.0	MTT	I81E	F255			47.0	28.0	43.3	26.0	
9.0	MTT	I81E	F293	208.0	25.3	49.2	29.0	46.3	27.0	112.32
9.0	MTT	I81E	F293	210.0	22.0	46.6	29.0	44.0	27.0	113.40
9.0	MTT	I81E	F294			51.2			•	
9.0	MTT	I81E	F4			51.4	30.9	49.0	29.6	
9.0	MTT	I81E	F9			51.6	29.3	48.1	28.6	
9.0	MTT	I81E	F9			51.6	29.3	48.1	28.6	
9.0	MTT	I81E	F96	217.5	26.0	55.4	32.1	52.2		117.45
9.0	MTT	LWCB	F11			50.2	29.5	47.3	26.3	
9.0	MTT	LWCB	F11			52.5	31.5	60.6	29.8	
9.0	MTT	LWCB	F15			51.1	31.5	48.8	28.6	
9.0	MTT	LWCB	F26			51.7	28.5	47.4	27.4	
9.0	MTT	LWCB	F45			51.6	31.4	47.5	39.3	
9.0	MTT	LWCB	F56			50.4	29.0	47.6	28.0	
9.0	MTT	LWCB	F64			51.1	30.2	48.1	29.0	
9.0	MTT	LWCB	F64			51.1	30.2	48.1	29.0	
9.0	MTT	LWCB	F70			52.7		51.8		
9.0	MTT	LWCB	F97	194.0	23.7	47.3	26.8	43.0	24.9	104.76
9.0	MTT	LWCH	F17			49.6	27.2	47.9	27.4	
9.0	MTT	LWCJ	B265			62.3		58.7		
9.0	MTT	LWCK	F18	222.0	24.0	49.1		49.2		119.88
9.0	MTT	LWCK	F18	234.5	28.8	55.4	31.7	54.0	32.4	126.63
9.0	MTT	LWCK	F18	249.5	33.8	64.4	37.3	63.1	38.0	134.73
9.0	MTT	LWCK	F18	202.0	25.5	61.5	33.2	56.1	30.8	109.08
9.0	MTT	LWCK	F18	197.5		46.7	26.6	44.8	24.9	106.65
9.0	MTT	MID	MED	195.0	21.9	45.7	26.5	42.9	25.0	105.30
9.0	MTT	MID	MED	227.0	25.8	55.6	29.0	50.9	28.2	122.58
9.0	MTT	MID	MED			51.9	30.0	49.8	28.0	
9.0	MTT	MID	MED			44.9	26.5	41.1	23.7	
9.0	MTT	MID	MED			53.0	31.5	48.8	29.0	
9.0	MTT	MID	MED			48.4	30.0	45.7	25.7	
9.0	MTT	MID	MED	206.0	22.5	48.0	28.0	43.9	24.9	111.24
9.0	MTT	MID	MED	220.0	24.7	55.7	30.0	49.9	28.0	118.80
9.0	MTT	MID	MED	260.0	24.2	47.2	26.0	44.7	24.4	140.40
9.0	MTT	MID	MED			47.0	28.0	43.8	25.0	
9.0	MTT	MID	MED			46.4	28.0	43.5	24.3	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
9.0	MTT	MID	MED	199.0	23.0	46.4	28.0	43.7	25.5	107.46
9.0	MTT	MID	MED	197.0	19.7	44.8	27.0	40.1	24.0	106.38
9.0	MTT	MID	MED	204.0	22.6	46.9	28.5	43.8	25.1	110.16
9.0	MTT	MID	MED	209.0	22.6	47.0	28.0	43.6	24.2	112.86
9.0	MTT	MID	MED	209.5	24.1	50.4	29.0	46.3	25.6	113.13
9.0	MTT	MID	MED	214.0	22.2	48.4	29.0	43.2	25.9	115.56
9.0	MTT	MID	MED	210.5	23.6	47.8	28.0	44.3	25.5	113.67
9.0	MTT	MID	MED			54.6	30.8	48.8	27.0	
9.0	MTT	MID	PM			43.3	26.0	39.9	23.3	
10.0	MTC	GBSA	F42			48.6	27.9	43.5	24.7	
10.0	MTC	GBSA	F42			56.3	31.1	51.0	27.4	
10.0	MTC	GBSA	F42			50.6	27.7	50.4	27.2	
10.0	MTC	GBSA	F7			50.9	28.8	47.5		
10.0	MTC	LWCA	F3	218.0	29.2	66.9	36.5	61.7	29.2	132.98
10.0	MTC	LWCA	F3			58.6	30.8	56.4	29.2	
10.0	MTC	LWCA	F4	201.0	34.9	59.3		56.7		122.61
10.0	MTC	LWCA	F4	203.5	23.7	59.7	32.6	56.3	28.0	124.14
10.0	MTC	LWCB	F2			53.0	29.7	48.6	26.1	
10.0	MTC	LWCB	F6	217.0	38.9	69.8	35.8	65.6	29.9	132.37
10.0	MTC	LWCC	F65			54.0	30.0	52.4	28.0	
10.0	MTC	LWCC	F65	170.0	27.1	54.5		48.1	25.0	103.70
10.0	MTC	LWCC	F9			67.5	33.5	66.8	35.5	
10.0	MTC	LWCN	F18			56.6				
10.0	MTC	LWCR	F18	183.5	31.6	62.5	32.5	55.2	28.4	111.93
10.0	MTC	LWCR	F18	223.0	27.7	72.2	35.5			136.03
10.0	MTC	LWCR	F18	204.0	39.4	65.8		62.1	30.5	124.44
10.0	MTC	LWCR	F18	211.0	34.2	60.2	32.1	56.0	31.8	128.71
10.0	MTC	LWCR	F18			59.0		54.7		
10.0	MTC	LWCR	F18	185.0	36.7	66.5	33.0	67.5	28.8	112.85
10.0	MTC	LWCR	F18			65.8	31.2	59.3	29.3	
10.0	MTC	MID	PM	260.0	32.5	57.7	32.5	55.9	30.9	158.60
10.0	MTC	MID	PM	191.0	29.6	53.6	30.7	51.3	31.0	116.51
10.0	MTC	MID	PM			59.0	30.5	54.0	28.0	
10.0	MTC	MID	PM	180.0		56.9	31.0	51.5	27.5	109.80
10.0	MTC	MID	PM	196.0	28.9	55.5	29.5	50.9	27.1	119.56
10.0	MTC	MID	PM	197.0	30.1	56.3	30.0	51.4	28.9	120.17
10.0	MTC	MID	PM			59.7	32.5	57.6	29.9	
10.0	MTC	MID	PM			52.8	29.0	46.5	26.5	
10.0	MTC	MID	PM	196.5	33.8	56.8	32.0	54.5	27.9	119.86
10.0	MTC	MID	PM	215.0	39.8	69.9	35.0	62.6	31.0	131.15
10.0	MTC	MID	PM			60.9	31.0	53.4	27.0	
10.0	MTC	MID	PM	199.0	35.9	65.5	34.0	60.8	30.9	121.39
10.0	MTC	MID	PM	169.0	24.6	53.0	27.5	44.2	24.6	103.09
10.0	MTC	MID	PM							
10.0	MTT	LWCA	F13			60.0	33.0	57.9	32.0	
10.0	MTT	LWCA	F4	248.0	26.7	53.5	32.9	52.3	30.7	133.92
10.0	MTT	LWCA	F4	201.0		54.3	28.6			108.54
10.0	MTT	LWCA	F6	239.0	27.2	54.3	29.5	53.4	29.0	129.06
10.0	MTT	LWCA	F6	225.0		51.6	30.0	50.8	26.9	121.50
10.0	MTT	LWCA	F6	232.0	31.4	62.4	35.5	59.6	34.2	125.28
10.0	MTT	LWCB	B62			60.2	34.0			
10.0	MTT	LWCB	F30			60.5				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
10.0	MTT	LWCB	F6			60.9	35.1	58.0	32.3	
10.0	MTT	LWCB	F6			50.8	28.9	47.8	27.8	
10.0	MTT	LWCC	B12	216.0	27.0	55.2	31.5	49.9	29.0	116.64
10.0	MTT	LWCC	F65	212.0	22.5	46.5	27.5	42.6	26.0	114.48
10.0	MTT	LWCC	F87	217.5	26.0	53.1		49.3		117.45
10.0	MTT	LWCC	F98			44.5	26.5	42.4	26.0	
10.0	MTT	MID	PM	220.5	25.4	50.7	28.1	48.1	27.0	119.07
10.0	MTT	MID	PM		28.6		31.5	52.6	29.1	
10.0	MTT	MID	PM	224.5	25.2	50.9	30.0	48.9	29.4	121.23
1 .0	MTT	MID	PM	217.0	25.5	49.9	29.9	47.9	28.8	117.18
10.0	MTT	MID	PM	228.0	24.9	50.1	31.0	45.7	27.8	123.12
10.0	MTT	MID	PM	219.0	24.8	52.3	30.0	48.7	26.9	118.26
10.0	MTT	MID	PM	210.0	22.4	44.7	28.0	42.5	26.7	113.40
10.0	MTT	MID	PM			49.9	29.5	46.5	26.7	
10.0	MTT	MID	PM	213.0	26.8	51.1	30.5	50.7	28.1	115.02
10.0	MTT	MID	PM	221.0	23.3	50.2	29.0	46.8	28.7	119.34
10.0	MTT	MID	PM	226.0	29.8	58.6	33.0	54.6	30.8	122.04
10.0	MTT	MID	PM	225.0	26.1	49.9	31.0	48.5	29.5	121.50
10.0	MTT	MID	PM			48.1	28.0	42.8	25.3	
10.0	MTT	MID	PM	230.0	27.2	60.4	32.5	59.2	32.7	124.20
10.0	MTT	MID	PM	223.0	28.3	59.8	31.5	60.5	31.5	120.42
10.0	MTT	MID	PM			49.5	29.0	47.0	27.5	
11.0	MTC	MID	16C			51.2	28.0	44.7	23.4	
11.0	MTC	MID	16C			53.8	29.0	49.5	25.5	
11.0	MTC	MID	16C			50.0	27.7	45.5	25.6	
11.0	MTC	MID	16C			55.8	28.0	49.4	24.6	
11.0	MTT	MID	16C			52.6	28.0	50.2	27.2	
11.0	MTT	MID	16C				28.0	42.9	25.4	
11.0	MTT	MID	16C			48.1	27.9	45.1	25.2	
11.0	MTT	MID	16C				31.0	52.7	27.1	
11.0	MTT	MID	16C			47.3	29.0	45.2	27.1	
11.0	MTT	MID	16C			48.3	29.0	44.2	25.3	

KEY:

P	9	medieval
	10	post-medieval
	11	16th-century

(Key to period codes on page 216. All measurements are according to von den Driesch 1976 except TD distal thickness, SHT shoulder height, and TEp distal epiphysial thickness.)

MTABLE 4.3 SHEEP/GOAT METRICS, ROMAN

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
1.0	HUM	BKCE				24.6				
1.0	HUM	I81B	L429			27.2				
1.0	MTC	BKCE		114.5	12.7	23.6			55.99	
1.0	MTC	BKCE		114.0	11.5	21.5			55.75	
1.0	MTC	BKCE		113.0	10.6	21.1			55.26	
1.0	MTC	BKCE		130.0	14.6	25.9			63.57	
1.0	MTC	BKCE		130.0		25.8			63.57	
1.0	MTC	I81E	L166	107.5	11.1	19.6			52.57	
1.0	MTC	I81E	L188	113.5	11.6	20.5			55.50	
1.0	MTT	BKCE		114.0	8.4	18.9			51.76	
1.0	MTT	GBSA	L302			20.8				
1.0	MTT	I81E	F900	127.0	9.5	10.7			57.66	
1.0	TIB	BKCE				22.9				
1.0	TIB	BKCE				23.4				
1.0	TIB	BKCE				22.1				
1.0	TIB	BKCE				23.1				
1.0	TIB	BKCE				24.3				
1.0	TIB	GBSA	F213			24.7	19.3			
1.0	TIB	GBSA	F213			23.5	19.3			
1.0	TIB	GBSB	F85			25.0	19.2			
1.0	TIB	I81B	L518			26.7	19.7			
1.0	TIB	I81E	F900			22.3	17.6			
1.0	TIB	I81E	L298			22.7	18.9			
2.0	HUM	BKCE				25.5				
2.0	HUM	BKCK	F121			26.5				
2.0	HUM	BKCV	L93		11.6	25.0				
2.0	HUM	GBSA	L93			25.3				
2.0	HUM	I81E	F651				26.2			
2.0	HUM	I81E	L138			25.5				
2.0	HUM	LWCR	B196		12.0	29.0				
2.0	MTC	BKCE			15.1	26.3				
2.0	MTC	BKCE				24.2				
2.0	MTC	BKCE			15.1	26.3				
2.0	MTC	BKCE				21.8				
2.0	MTC	BKCE		123.5		22.4			60.39	
2.0	MTC	GBSA	F210	121.0	11.6				59.17	
2.0	MTC	I81E	F1239	116.0	11.4	21.8			56.72	
2.0	MTC	I81E	F1250	112.0	11.6	21.3			54.77	
2.0	MTC	I81E	F1250			26.7				
2.0	MTC	I81E	F1329	126.0	13.8	24.2			61.61	
2.0	MTC	I81E	L138	118.0	12.7	21.1			57.70	
2.0	MTC	I81E	L149	111.0	12.5	23.7			54.28	
2.0	MTC	I81J	L222	122.0	12.6	22.7			59.66	
2.0	MTT	BKCE			11.5	21.6				
2.0	MTT	BKCE		118.0	10.7	20.5			53.57	
2.0	MTT	BKCE		120.0		20.5			54.48	
2.0	MTT	BKCE			11.5	21.6				
2.0	MTT	BKCK	F121	127.5	10.9				57.89	
2.0	MTT	BKCV	F327			20.2				
2.0	MTT	GBSB	L90	107.0	12.4	23.3			48.58	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
2.0	MTT	I81E	F1035	119.0	10.1	19.3			54.03	
2.0	MTT	I81E	F651	127.0	9.0	21.2			57.66	
2.0	MTT	I81E	L1250	134.0		22.0			60.84	
2.0	MTT	I81E	L138	111.0	12.2	21.3			50.39	
2.0	MTT	I81E	L138	111.0	11.4	22.3			50.39	
2.0	MTT	I81E	L138	112.0	11.9	22.0			50.85	
2.0	RAD	BKCT	B546			24.1				
2.0	RAD	BKCT	L52			23.3				
2.0	RAD	BKCV	L81			27.3				
2.0	TIB	BKCJ	L46			21.7	16.9			
2.0	TIB	BKCT	B475			21.8	16.6			
2.0	TIB	BKCV	L79			22.2				
2.0	TIB	BKCV	L93			23.0				
2.0	TIB	GBSA	L93			22.4	27.6			
2.0	TIB	GBSA	L93			21.1	16.4			
2.0	TIB	GBSB	L57			22.4	17.9			
2.0	TIB	I81E	F1006			23.6	17.3			
2.0	TIB	I81E	F219			27.7	21.1			
2.0	TIB	I81E	L222			25.0	18.7			
2.0	TIB	LWCR	B191			21.9	17.1			
3.0	HUM	BKCE				24.6				
3.0	HUM	BKCE				25.5				
3.0	HUM	BKCG	B322			26.5	23.0			
3.0	HUM	BKCK	F121			26.5				
3.0	HUM	BKCV	L93		11.6	25.0				
3.0	HUM	GBSA	L142			28.2				
3.0	HUM	GBSA	L257			26.2				
3.0	HUM	GBSA	L81			25.3				
3.0	HUM	GBSA	L93			25.3				
3.0	HUM	I81B	L429			27.2				
3.0	HUM	I81E	F651				26.2			
3.0	HUM	I81E	L138			25.5				
3.0	HUM	LWCJ	B1705			26.0				
3.0	HUM	LWCR	B196		12.0	29.0				
3.0	MTC	BKCE		114.5	12.7	23.6			55.99	
3.0	MTC	BKCE		114.0	11.5	21.5			55.75	
3.0	MTC	BKCE		113.0	10.6	21.1			55.26	
3.0	MTC	BKCE		130.0	14.6	25.9			63.57	
3.0	MTC	BKCE		130.0		25.8			63.57	
3.0	MTC	BKCE			15.1	26.3				
3.0	MTC	BKCE				24.2				
3.0	MTC	BKCE			15.1	26.3				
3.0	MTC	BKCE				21.8				
3.0	MTC	BKCE		123.5		22.4			60.39	
3.0	MTC	BKCE		113.0	10.6	21.1			55.26	
3.0	MTC	BKCE		130.0	14.6	25.9			63.57	
3.0	MTC	BKCV	F325	119.0		21.1			58.19	
3.0	MTC	BKCV	F325	111.0					54.28	
3.0	MTC	BKCV	F325	110.0		19.4			53.79	
3.0	MTC	GBSA	F210	121.0	11.6	21.7			59.17	
3.0	MTC	GBSA	L179	112.0	10.7	19.0			54.77	
3.0	MTC	GBSA	L224			22.7				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
3.0	MTC	I81B	F282	114.0	11.5	21.3				55.75
3.0	MTC	I81E	F1019	111.0	11.9	20.9				54.28
3.0	MTC	I81E	F1239	116.0	11.4	21.8				56.72
3.0	MTC	I81E	F1250	112.0	11.6	21.3				54.77
3.0	MTC	I81E	F1250			26.7				
3.0	MTC	I81E	F1329	126.0	13.8	24.2				61.61
3.0	MTC	I81E	L138	118.0	12.7	21.1				57.70
3.0	MTC	I81E	L149	111.0	12.5	23.7				54.28
3.0	MTC	I81E	L166	107.5	11.1	19.6				52.57
3.0	MTC	I81E	L188	113.5	11.6	20.5				55.50
3.0	MTC	I81J	L222	122.0	12.6	22.7				59.66
3.0	MTT	BKCE		114.0	8.4	18.9				51.76
3.0	MTT	BKCE			11.5	21.6				
3.0	MTT	BKCE		118.0	10.7	20.5				53.57
3.0	MTT	BKCE		120.0		20.5				54.48
3.0	MTT	BKCE			11.5	21.6				
3.0	MTT	BKCK	F121	127.5	10.9	21.1				57.89
3.0	MTT	BKCV	F325	123.0		19.6				55.84
3.0	MTT	BKCV	F327			20.2				
3.0	MTT	GBSA	L302			20.8				
3.0	MTT	GBSB	L90	107.0	12.4	23.3				48.58
3.0	MTT	I81E	F1035	119.0	10.1	19.3				54.03
3.0	MTT	I81E	F651	127.0	9.0	21.2				57.66
3.0	MTT	I81E	F900	127.0	9.5					57.66
3.0	MTT	I81E	L1250	134.0		22.0				60.84
3.0	MTT	I81E	L138	111.0	12.2	21.3				50.39
3.0	MTT	I81E	L138	111.0	11.4	22.3				50.39
3.0	MTT	I81E	L138	112.0	11.9	22.0				50.85
3.0	MTT	LWCB	B643			20.9				
3.0	MTT	LWCJ	B1300			20.5				
3.0	MTT	LWCK	B575	129.0	11.6	21.4				58.57
3.0	RAD	BKCT	B546			24.1				
3.0	RAD	BKCT	L52			23.3				
3.0	RAD	BKCV	L81			27.3				
3.0	RAD	GBSA	L112			24.1				
3.0	RAD	GBSA	L232			29.6				
3.0	TIB	BKCE				22.9				
3.0	TIB	BKCE				23.4				
3.0	TIB	BKCE				22.1				
3.0	TIB	BKCE				23.1				
3.0	TIB	BKCE				24.3				
3.0	TIB	BKCJ	L46			21.7	16.9			
3.0	TIB	BKCT	B475			21.8	16.6			
3.0	TIB	BKCT	B501			27.0	21.3			
3.0	TIB	BKCT	B517			21.1	17.0			
3.0	TIB	BKCT	B617			24.6	18.4			
3.0	TIB	BKCT	L36			23.5	18.7			
3.0	TIB	BKCV	F325			23.0	18.6			
3.0	TIB	BKCV	L79			22.2				
3.0	TIB	BKCV	L93			23.0				
3.0	TIB	GBSA	F208			23.4	18.1			
3.0	TIB	GBSA	F213			24.7	19.3			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
3.0	TIB	GBSA	F213			23.5	19.3			
3.0	TIB	GBSA	L112			23.7				
3.0	TIB	GBSA	L120			22.6	17.8			
3.0	TIB	GBSA	L179			23.3	18.2			
3.0	TIB	GBSA	L250			30.4	27.5			
3.0	TIB	GBSA	L262			26.6	20.4			
3.0	TIB	GBSA	L89			27.7	27.6			
3.0	TIB	GBSA	L93			22.4	27.6			
3.0	TIB	GBSA	L93			21.1	16.4			
3.0	TIB	GBSB	F85			25.0	19.2			
3.0	TIB	GBSB	L57			22.4	17.9			
3.0	TIB	I81B	F282		12.4	23.1	18.3			
3.0	TIB	I81B	L518			26.7	19.7			
3.0	TIB	I81E	F1006			23.6	17.3			
3.0	TIB	I81E	F219			27.7	21.1			
3.0	TIB	I81E	F900			22.3	17.6			
3.0	TIB	I81E	L222			25.0	18.7			
3.0	TIB	I81E	L298			22.7	18.9			
3.0	TIB	LWCB	B637			23.1	17.6			
3.0	TIB	LWCB	B643			24.9	18.0			
3.0	TIB	LWCJ	B1705			22.7	18.0			
3.0	TIB	LWCL	F286			25.3	19.4			
3.0	TIB	LWCR	B191			21.9	17.1			
4.0	FEM	I81C	L41			35.7				
4.0	FEM	LWCB	F195	183.5	15.2	37.5		64.78		
4.0	FEM	LWCK	B427			34.0				
4.0	HUM	BKCT	F131			26.0				
4.0	HUM	BKCT	L43			27.5				
4.0	HUM	BKCV	F24			26.5	24.7			
4.0	HUM	BKCV	F470			25.6	24.2			
4.0	HUM	GBSA	L66			27.7				
4.0	HUM	I81B	F359			28.1				
4.0	HUM	I81E	F557		12.3	26.8				
4.0	MTC	BKCE		111.5	11.1	21.0		54.52		
4.0	MTC	GBSA	L205	133.0	13.7	23.3		65.04		
4.0	MTC	I81B	L359			24.6				
4.0	MTC	LWCK		117.5	17.1	30.0		57.46		
4.0	MTT	BKCK	L92			22.3				
4.0	MTT	GBSA	L66	122.0	11.0	20.8		55.39		
4.0	MTT	GBSA	L66		9.6	20.0				
4.0	MTT	I81B	L671	108.0	12.5	23.2		49.03		
4.0	MTT	I81C	F114	130.0	11.3	22.0		59.02		
4.0	MTT	I81C	F56	136.0	12.4	24.8		61.74		
4.0	MTT	I81C	L50	129.0	11.6	21.4		58.57		
4.0	MTT	LWCK	B479			23.2				
4.0	RAD	BKCK	L119			23.3				
4.0	RAD	BKCK	L35			26.5				
4.0	RAD	BKCT	B217			27.5				
4.0	RAD	BKCT	F238			28.7				
4.0	RAD	GBSA	F95			23.9				
4.0	RAD	GBSA	L60			23.1				
4.0	RAD	I81C	L36			25.4				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
4.0	RAD	I81C	L36	150.0					60.30	
4.0	RAD	LWCK	B430			24.8				
4.0	TIB	BKCJ	L35			23.7	17.5			
4.0	TIB	BKCK	F125			22.3	17.8			
4.0	TIB	BKCK	L117			22.0	17.8			
4.0	TIB	BKCK	L119			21.6	16.3			
4.0	TIB	BKCK	L28			19.9	16.0			
4.0	TIB	BKCK	L61			24.5	18.0			
4.0	TIB	BKCT	L2			25.0	19.0			
4.0	TIB	BKCT	L2			25.6	20.2			
4.0	TIB	BKCT	L2			21.7	17.0			
4.0	TIB	BKCT	L6			25.2	20.0			
4.0	TIB	GBSA	L188			23.1	16.8			
4.0	TIB	GBSA	L66			27.7	20.6			
4.0	TIB	GBSA	L9	234.0	15.3	26.0	20.7		70.43	
4.0	TIB	I81B	L215			22.9	17.6			
4.0	TIB	I81B	L275			21.5				
4.0	TIB	I81B	L309			21.4	16.9			
4.0	TIB	I81B	L357			24.9	18.9			
4.0	TIB	I81B	L389			21.4	16.6			
4.0	TIB	I81B	L399			21.3	19.3			
4.0	TIB	I81C	F56			26.6	20.1			
4.0	TIB	I81C	L36			26.0	30.4			
4.0	TIB	I81C	L39			23.7	18.0			
4.0	TIB	I81C	L43	183.0	13.0	22.7	17.8		55.08	
4.0	TIB	LWCB	F190			23.6	19.5			
4.0	TIB	LWCB	F195			25.4	20.2			
5.0	FEM	LWCB	F195	183.5	15.2	37.5			64.78	
5.0	MTC	BKCV	F130	119.0	12.3	22.0			58.19	
5.0	MTC	BKCV	F130	122.0		22.5			59.66	
5.0	MTC	BKCV	F24	121.0	10.4	20.9			59.17	
5.0	MTC	BKCV	F31	123.0	12.7	23.6			60.15	
5.0	MTC	BKCV	F503			22.6				
5.0	MTC	BKCV	L64	110.0	16.3	26.5			53.79	
5.0	MTT	BKCN	L119	131.0	12.4	23.0			59.47	
5.0	MTT	BKCV	F55			23.8				
5.0	MTT	BKCV	F78	134.0		22.2			60.84	
5.0	MTT	BKCV	L63			25.3				
5.0	MTT	BKCV	L63			20.5				
5.0	MTT	BKCV	L64	123.0	10.2	21.7			55.84	
5.0	MTT	BKCV	L64	119.0		23.3			54.03	
5.0	MTT	I81B	L671	108.0	12.5	23.2			49.03	
5.0	RAD	BKCV	F78			27.6				
5.0	RAD	BKCV	F8			23.8				
5.0	TIB	BKCV	F143			21.9	17.8			
5.0	TIB	BKCV	F24			24.9	20.1			
5.0	TIB	BKCV	F30			22.2	17.3			
5.0	TIB	BKCV	F75			23.1	18.1			
5.0	TIB	BKCV	F78			22.3	16.7			
5.0	TIB	BKCV	F78			23.0	17.4			
5.0	TIB	BKCV	L56			26.1	21.4			
5.0	TIB	BKCV	L59			22.4				

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
5.0	TIB	BKCV	L70			22.3	17.1			
5.0	TIB	I81B	L215			22.9	17.6			
5.0	TIB	I81B	L275			21.5				
5.0	TIB	I81B	L309			21.4	16.9			
5.0	TIB	I81B	L357			24.9	18.9			
5.0	TIB	LWCB	F190			23.6	19.5			
6.0	FEM	BKCT	L38			39.0				
6.0	FEM	BKCV	L55			31.0				
6.0	FEM	GBSA	F90			34.0				
6.0	FEM	GBSA	L55			31.4				
6.0	FEM	I81C	L41			35.7				
6.0	FEM	I81K	F418			29.6				
6.0	FEM	LWCB	F195	183.5	15.2	37.5				64.78
6.0	FEM	LWCK	B427			34.0				
6.0	HUM	BKCJ	F13			29.6				
6.0	HUM	BKCT	F131			26.0				
6.0	HUM	BKCT	L38		10.3	24.5				
6.0	HUM	BKCT	L43			27.5				
6.0	HUM	BKCV	F24			26.5	24.7			
6.0	HUM	BKCV	F470			25.6	24.2			
6.0	HUM	BKCV	L38			27.2				
6.0	HUM	GBSA	L66			27.7				
6.0	HUM	I81B	F359			28.1				
6.0	HUM	I81B	L148			26.1				
6.0	HUM	I81B	L210			25.6				
6.0	HUM	I81C	F34		15.6	30.7				
6.0	HUM	I81C	F34			25.9				
6.0	HUM	I81C	F8			28.8				
6.0	HUM	I81C	F8			30.8				
6.0	HUM	I81E	F557		12.3	26.8				
6.0	HUM	I81E	L64			24.9				
6.0	HUM	I81G	F2362		25.4					
6.0	HUM	I81G	F2362		13.5	27.3				
6.0	HUM	I81G	L1436			28.5				
6.0	HUM	I81G	L1746			28.7				
6.0	HUM	I81K	F411			27.3				
6.0	HUM	LWCJ	B292			29.5				
6.0	HUM	LWCJ	F182			26.5				
6.0	HUM	LWCJ	F506			27.0				
6.0	HUM	LWCK	B425			31.0				
6.0	HUM	LWCL	F33			31.0				
6.0	HUM	LWCR	B196		12.0	29.0				
6.0	HUM	LWCR	F22			25.5				
6.0	MTC	BKCE		111.5	11.1	21.0				54.52
6.0	MTC	BKCE				21.8				
6.0	MTC	BKCJ	F32			22.0				
6.0	MTC	BKCN	F122	107.0	16.1	26.5				52.32
6.0	MTC	BKCN	F75	128.0	13.0	24.5				62.59
6.0	MTC	BKCN	F75			25.4				
6.0	MTC	BKCN	L111	137.0	15.4	26.7				66.99
6.0	MTC	BKCT	L38	128.0	12.6	22.6				62.59
6.0	MTC	BKCV	F130	119.0	12.3	22.0				58.19

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTC	BKCV	F130	122.0		22.5		59.66		
6.0	MTC	BKCV	F24	121.0	10.4	20.9		59.17		
6.0	MTC	BKCV	F31	123.0	12.7	23.6		60.15		
6.0	MTC	BKCV	F500			24.4				
6.0	MTC	BKCV	F503			22.6				
6.0	MTC	BKCV	L46			22.8				
6.0	MTC	BKCV	L46			24.3				
6.0	MTC	BKCV	L64	110.0	16.3	26.5		53.79		
6.0	MTC	BUCB	F119	120.0	13.5	23.8		58.68		
6.0	MTC	GBSA	F107	126.0	12.1	21.7		61.61		
6.0	MTC	GBSA	F172		11.5	22.3				
6.0	MTC	GBSA	F243	120.7	11.8	23.5		59.02		
6.0	MTC	GBSA	F66		11.8	21.8				
6.0	MTC	GBSA	L205	133.0	13.7	23.3		65.04		
6.0	MTC	GBSB	L8	126.0	14.4	25.1		61.61		
6.0	MTC	I81B	L173			22.0				
6.0	MTC	I81B	L200	107.0	15.8	26.4		52.32		
6.0	MTC	I81B	L27	133.0	15.1	24.9		65.04		
6.0	MTC	I81B	L28		12.2	24.2				
6.0	MTC	I81B	L359			24.6				
6.0	MTC	I81E	F592	124.0	11.5	21.8		60.64		
6.0	MTC	I81E	L27	141.0	15.9			68.95		
6.0	MTC	I81E	L28			21.0				
6.0	MTC	I81E	L37			21.7				
6.0	MTC	I81E	L37			22.4				
6.0	MTC	I81G	F2875	130.0	13.4	23.5		63.57		
6.0	MTC	I81G	F2875	130.0	13.1	23.6		63.57		
6.0	MTC	I81K	F233	110.0	15.3	27.0		53.79		
6.0	MTC	I81K	L60			27.0				
6.0	MTC	LWCJ	B367	141.0				68.95		
6.0	MTC	LWCJ	B477			26.6				
6.0	MTC	LWCK		117.5	17.1	30.0		57.46		
6.0	MTC	LWCK	F55		13.2	23.7				
6.0	MTT	BKCE				22.6				
6.0	MTT	BKCE				20.6				
6.0	MTT	BKCE		142.5	12.0	23.8		64.70		
6.0	MTT	BKCG	F61		11.6	22.2				
6.0	MTT	BKCG	L29		10.5	20.7				
6.0	MTT	BKCK	L92			22.3				
6.0	MTT	BKCN	F75			24.5				
6.0	MTT	BKCN	L119	131.0	12.4	23.0		59.47		
6.0	MTT	BKCV	F55			23.8				
6.0	MTT	BKCV	F78	134.0		22.2		60.84		
6.0	MTT	BKCV	L15			22.9				
6.0	MTT	BKCV	L46			22.6				
6.0	MTT	BKCV	L63			25.3				
6.0	MTT	BKCV	L63			20.5				
6.0	MTT	BKCV	L64	123.0	10.2	21.7		55.84		
6.0	MTT	BKCV	L64	119.0	1	23.3		54.03		
6.0	MTT	GBSA	L66	122.0	11.0	20.8		55.39		
6.0	MTT	GBSA	L66		9.6	20.0				
6.0	MTT	GBSB	L6	119.0	14.6	24.6		54.03		

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	MTT	I81B	F297	128.0	10.0	20.9			58.11	
6.0	MTT	I81B	L671	108.0	12.5	23.2			49.03	
6.0	MTT	I81C	F114	130.0	11.3	22.0			59.02	
6.0	MTT	I81C	F133	119.0	13.1	24.5			54.03	
6.0	MTT	I81C	F56	136.0	12.4	24.8			61.74	
6.0	MTT	I81C	L50	129.0	11.6	21.4			58.57	
6.0	MTT	I81E	F592			23.0				
6.0	MTT	I81E	F592			20.2				
6.0	MTT	I81E	L21			20.0				
6.0	MTT	I81E	L52			22.5				
6.0	MTT	I81E	L77			24.2				
6.0	MTT	I81G	F2362			21.0				
6.0	MTT	I81G	F2875	144.5	11.7	22.8			65.60	
6.0	MTT	I81G	F3064	147.0	13.1	24.3			66.74	
6.0	MTT	I81G	L1746	135.0	10.4	22.8			61.29	
6.0	MTT	I81G	L3624	132.0	14.8	23.6			59.93	
6.0	MTT	I81K	F411	130.0	11.1	23.7			59.02	
6.0	MTT	LWCJ	B1278	129.0	10.0	19.3			58.57	
6.0	MTT	LWCJ	F59	114.0	12.3	22.1			51.76	
6.0	MTT	LWCK	B479			23.2				
6.0	RAD	BKCG	F61	140.0		24.9			56.28	
6.0	RAD	BKCH	L12			27.8				
6.0	RAD	BKCJ	F32			28.9	18.1			
6.0	RAD	BKCK	L119			23.3				
6.0	RAD	BKCK	L35			26.5				
6.0	RAD	BKCT	B217			27.5				
6.0	RAD	BKCT	F238			28.7				
6.0	RAD	BKCV	F78			27.6				
6.0	RAD	BKCV	F8			23.8				
6.0	RAD	GBSA	F171			23.8				
6.0	RAD	GBSA	F79			26.8				
6.0	RAD	GBSA	F95			23.9				
6.0	RAD	GBSA	L60			23.1				
6.0	RAD	I81B	L129	148.0	16.5	27.8			59.50	
6.0	RAD	I81B	L129	148.0	16.5	27.8			59.50	
6.0	RAD	I81B	L217			27.0				
6.0	RAD	I81B	L217			27.0				
6.0	RAD	I81B	L285			25.8				
6.0	RAD	I81C	L36			25.4				
6.0	RAD	I81C	L36	150.0		_			60.30	
6.0	RAD	LWCK	B430			24.8				
6.0	TIB	BKCG	B277			27.2	21.0			
6.0	TIB	BKCG	F61			26.3	21.5			
6.0	TIB	BKCJ	F13			24.8				
6.0	TIB	BKCJ	F13			26.5				
6.0	TIB	BKCJ	F18			25.2				
6.0	TIB	BKCJ	L33			21.3				
6.0	TIB	BKCJ	L35			23.7	17.5			
6.0	TIB	BKCK	F125			22.3	17.8			
6.0	TIB	BKCK	L117			22.0	17.8			
6.0	TIB	BKCK	L119			21.6	16.3			
6.0	TIB	BKCK	L28			19.9	16.0			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0	TIB	BKCK	L61			24.5	18.0			
6.0	TIB	BKCN	F154			21.2				
6.0	TIB	BKCT	B263							
6.0	TIB	BKCT	L2			25.0	19.0			
6.0	TIB	BKCT	L2			25.6	20.2			
6.0	TIB	BKCT	L2			21.7	17.0			
6.0	TIB	BKCT	L38			22.8	18.5			
6.0	TIB	BKCT	L38			22.8	18.5			
6.0	TIB	BKCT	L6			25.2	20.0			
6.0	TIB	BKCV	F10		15.3	26.0	21.2			
6.0	TIB	BKCV	F10							
6.0	TIB	BKCV	F143			21.9	17.8			
6.0	TIB	BKCV	F24			24.9	20.1			
6.0	TIB	BKCV	F30			22.2	17.3			
6.0	TIB	BKCV	F499			21.7	17.0			
6.0	TIB	BKCV	F499			23.0	17.9			
6.0	TIB	BKCV	F499		12.4	22.0	17.1			
6.0	TIB	BKCV	F50			24.0	18.4			
6.0	TIB	BKCV	F50			26.2	19.4			
6.0	TIB	BKCV	F62			25.3	19.5			
6.0	TIB	BKCV	F62			23.6	18.3			
6.0	TIB	BKCV	F75			23.1	18.1			
6.0	TIB	BKCV	F78			22.3	16.7			
6.0	TIB	BKCV	F78			23.0	17.4			
6.0	TIB	BKCV	L27			25.2	18.9			
6.0	TIB	BKCV	L27			24.1	18.3			
6.0	TIB	BKCV	L27			23.7				
6.0	TIB	BKCV	L39			26.2	20.0			
6.0	TIB	BKCV	L39		12.8	22.8	17.4			
6.0	TIB	BKCV	L39			24.9	19.7			
6.0	TIB	BKCV	L39		14.6	25.7	19.4			
6.0	TIB	BKCV	L45		12.1	21.6				
6.0	TIB	BKCV	L56			26.1	21.4			
6.0	TIB	BKCV	L59			22.4				
6.0	TIB	BKCV	L70			22.3	17.1			
6.0	TIB	BUCA	G507			28.0	21.2			
6.0	TIB	GBSA	F107			23.6	18.2			
6.0	TIB	GBSA	F121			24.4	19.2			
6.0	TIB	GBSA	F121			22.5	18.2			
6.0	TIB	GBSA	F237			27.1				
6.0	TIB	GBSA	F27			27.6	20.9			
6.0	TIB	GBSA	F27			23.9				
6.0	TIB	GBSA	F79			23.6	18.7			
6.0	TIB	GBSA	F79			23.0	18.6			
6.0	TIB	GBSA	F84			29.2	22.5			
6.0	TIB	GBSA	F90			26.2	21.3			
6.0	TIB	GBSA	L188			23.1	16.8			
6.0	TIB	GBSA	L37			25.6	20.1			
6.0	TIB	GBSA	L66			27.7	20.6			
6.0	TIB	GBSA	L9	234.0	15.3	26.0	20.7	70.43		
6.0	TIB	GBSB	L12			25.2	20.3			
6.0	TIB	GBSB	L7			23.9	18.9			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
6.0-	TIB	GBSB	L8			22.2	18.3			
6.0	TIB	I81B	L142			23.3	18.9			
6.0	TIB	I81B	L147			23.8	18.9			
6.0	TIB	I81B	L173			28.5	21.8			
6.0	TIB	I81B	L215			22.9	17.6			
6.0	TIB	I81B	L217			23.3	17.8			
6.0	TIB	I81B	L25			24.5	18.9			
6.0	TIB	I81B	L275			21.5				
6.0	TIB	I81B	L309			21.4	16.9			
6.0	TIB	I81B	L33			27.1				
6.0	TIB	I81B	L357			24.9	18.9			
6.0	TIB	I81B	L389			21.4	16.6			
6.0	TIB	I81B	L399			21.3	19.3			
6.0	TIB	I81B	L58		14.0	25.8	20.0			
6.0	TIB	I81C	F56			26.6	20.1			
6.0	TIB	I81C	L36			26.0	30.4			
6.0	TIB	I81C	L39			23.7	18.0			
6.0	TIB	I81C	L43	183.0	13.0	22.7	17.8			55.08
6.0	TIB	I81E	F503		12.8	22.6	16.3			
6.0	TIB	I81E	F592			26.3	20.1			
6.0	TIB	I81E	F890			20.3	16.4			
6.0	TIB	I81E	F890			20.3	16.4			
6.0	TIB	I81E	L24		14.1	24.6	18.3			
6.0	TIB	I81E	L54			20.8	17.1			
6.0	TIB	I81E	L54			21.3	16.5			
6.0	TIB	I81G	F2362			25.1	18.5			
6.0	TIB	I81G	F2362			22.3	16.0			
6.0	TIB	I81G	F2875			22.9	17.5			
6.0	TIB	I81G	L1746			21.9	18.2			
6.0	TIB	I81G	L1767			24.1	18.9			
6.0	TIB	I81G	L2820			24.3	18.6			
6.0	TIB	I81G	L2966			25.2	19.8			
6.0	TIB	I81K	F233			24.1				
6.0	TIB	I81K	F91			23.8	18.2			
6.0	TIB	LWCB	F190			23.6	19.5			
6.0	TIB	LWCB	F195			25.4	20.2			
7.0	FEM	BKCG	F1			35.5				
7.0	FEM	BKCG	F1			35.5				
7.0	FEM	BKCJ	F17			36.4				
7.0	FEM	I81G	L1439			44.0				
7.0	HUM	BKCG	F12			26.0	24.0			
7.0	HUM	BKCG	F181			27.5	24.0			
7.0	HUM	BKCG	F181			28.0	17.0			
7.0	HUM	BKCV	L22			30.3				
7.0	HUM	BKCV	L5		13.0	27.0	26.4			
7.0	HUM	I81G	F57			30.9				
7.0	HUM	I81G	L1043			27.8				
7.0	HUM	I81G	L1744			27.5				
7.0	HUM	I81G	L1762	127.5	12.4	26.6				54.57
7.0	HUM	I81G	L1894			29.3				
7.0	MTC	BKCG	F11	139.0	14.7	27.2				67.97
7.0	MTC	BKCG	F11	141.0	14.9	26.5				68.95

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
7.0	MTC	BKCG	F11			26.6				
7.0	MTC	BKCG	F141	142.0	15.5	26.1			69.44	
7.0	MTC	BKCH	F129	122.0	12.2	23.1			59.66	
7.0	MTC	BKCH	F33	136.0	17.2	26.8			66.50	
7.0	MTC	BKCH	F33			25.4				
7.0	MTC	BKCH	F94	139.0	17.2	29.3			67.97	
7.0	MTC	BKCJ	F34	135.0		25.5			66.02	
7.0	MTC	BKCV	L5			26.6				
7.0	MTC	BKCV	L9	111.0		26.3			54.28	
7.0	MTC	I81B	L7	125.5	14.1	26.3			61.37	
7.0	MTC	I81E	L7	139.5	14.4	25.7			68.22	
7.0	MTT	BKCG	B375	158.0	14.7	26.8			71.73	
7.0	MTT	BKCG	F11	144.0	12.5	23.4			65.38	
7.0	MTT	BKCG	F11			22.6				
7.0	MTT	BKCG	F11			23.5				
7.0	MTT	BKCG	F11			27.1				
7.0	MTT	BKCG	F11			23.4				
7.0	MTT	BKCG	F141	127.0	9.9	20.0			57.66	
7.0	MTT	BKCJ	F32		11.4	22.8				
7.0	MTT	BKCT	L67	149.0	12.5	25.4			67.65	
7.0	MTT	BKCV	F117	137.5	11.4	25.7			62.43	
7.0	MTT	BKCV	L11	117.0	14.0	25.5			53.12	
7.0	MTT	BKCV	L11	121.0	11.0	23.1			54.93	
7.0	MTT	BKCV	L5	116.0	12.9	»			52.66	
7.0	MTT	I81G	L1043	145.5	12.6	24.7			66.06	
7.0	MTT	I81G	L1447	141.0	11.7	23.3			64.01	
7.0	MTT	I81G	L605	160.0	13.7	27.7			72.64	
7.0	MTT	I81G	L762	116.0	10.1	22.2			52.66	
7.0	MTT	I81G	L762	122.0	9.5	20.2			55.39	
7.0	RAD	BKCG	F11			29.2				
7.0	RAD	BKCV	L9			28.9				
7.0	RAD	GBSA	L6			26.0				
7.0	RAD	I81E	F60			25.2				
7.0	RAD	I81E	F60			27.0				
7.0	RAD	I81E	F60			27.0				
7.0	TIB	BKCG	F141			22.9	17.8			
7.0	TIB	BKCG	F2		12.6	22.9	17.5			
7.0	TIB	BKCG	F4			23.1	18.0			
7.0	TIB	BKCH	F192			23.4	18.3			
7.0	TIB	BKCH	F33			26.1	20.0			
7.0	TIB	BKCH	L13			27.5	20.5			
7.0	TIB	BKCH	L9			27.0	21.2			
7.0	TIB	BKCJ	F32		13.6	24.8	19.3			
7.0	TIB	BKCJ	F32			25.7				
7.0	TIB	BKCT	F117			26.1	22.0			
7.0	TIB	BKCT	F159			26.4	20.4			
7.0	TIB	BKCV	L11			23.9	18.6			
7.0	TIB	BKCV	L11			25.3	18.5			
7.0	TIB	BKCV	L22			23.2				
7.0	TIB	BKCV	L5			26.5	19.9			
7.0	TIB	BKCV	L5			25.6	20.2			
7.0	TIB	I81G	F32			25.0	20.0			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
7.0	TIB	I81G	L644				21.1			
7.0	TIB	I81H	L283			25.6				
7.0	TIB	LWCR	F35			19.1	15.5			
8.0	HUM	BKCE				27.6				
8.0	HUM	BKCH	F28			32.5				
8.0	HUM	BKCK	F15		10.6	23.0				
8.0	HUM	BKCK	F28		12.7	27.5				
8.0	MTC	BKCE		146.0	15.5	27.3		71.39		
8.0	MTC	BKCE		107.5	10.8	21.5		52.57		
8.0	MTC	BKCE		133.5	13.4	25.8		65.28		
8.0	MTC	BKCE		146.0	15.2	27.2		71.39		
8.0	MTC	BKCE		133.5	13.4	25.8		65.28		
8.0	MTC	BKCE		107.5	10.8	21.5		52.57		
8.0	MTC	BKCE		146.0	15.5	27.3		71.39		
8.0	MTC	BKCE		146.0	15.2	27.2		71.39		
8.0	MTC	BKCH	F28	140.0	15.2	26.6		68.46		
8.0	MTC	BKCK	F12	142.0	15.1	26.9		69.44		
8.0	MTC	BKCK	F15		11.8	21.5				
8.0	MTC	BKCK	F6	119.0	12.9	22.8		58.19		
8.0	MTC	BKCN	B216	147.5	16.3	28.7		72.13		
8.0	MTC	BKCN	F30	137.0	16.0	28.1		66.99		
8.0	MTC	BKCN	L11	136.0	14.7	24.0		66.50		
8.0	MTC	BKCN	L11	150.0	16.1	27.6		73.35		
8.0	MTC	BKCN	L4	143.0	15.3	28.1		69.93		
8.0	MTC	BKCN	L7			26.5				
8.0	MTC	BKCN	L7	129.0	12.0	24.7		63.08		
8.0	MTC	BKCN	L8	129.0	12.8	24.1		63.08		
8.0	MTC	I81B	L7	125.5	14.1	26.3		61.37		
8.0	MTC	I81E	F61	139.5	14.4	25.7		68.22		
8.0	MTT	BKCE		149.0		24.3		67.65		
8.0	MTT	BKCE		149.0	12.6	24.3		67.65		
8.0	MTT	BKCE				22.6				
8.0	MTT	BKCN	F12	144.0	12.7			65.38		
8.0	MTT	BKCN	L7	123.0	12.4	25.2		55.84		
8.0	MTT	BKCN	L7	128.0	10.6	21.0		58.11		
8.0	RAD	BKCN	B152			27.7				
8.0	RAD	I81E	F60			25.2				
8.0	RAD	I81E	F60			27.0				
8.0	RAD	I81E	F60			27.0				
8.0	TIB	BKCE				26.5				
8.0	TIB	BKCE				26.5				
8.0	TIB	BKCE				22.3				
8.0	TIB	BKCE				27.6				
8.0	TIB	BKCE				24.3				
8.0	TIB	BKCE				24.2				
8.0	TIB	BKCH	F28			25.6	20.5			
8.0	TIB	BKCH	F28			26.5	19.8			
8.0	TIB	BKCK	F12		13.7	23.2	19.0			
8.0	TIB	BKCK	F15			26.6	19.5			
8.0	TIB	BKCN	B152			27.7	21.5			
8.0	TIB	BKCN	F13			26.3	20.0			
8.0	TIB	BKCN	F92			26.6	20.1			

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
8.0	TIB	BKCN	F96			27.6	21.6			
8.0	TIB	BKCN	L11			27.4	21.5			
8.0	TIB	BKCN	L11			29.1	21.5			
8.0	TIB	BKCN	L3			25.8				
8.0	TIB	BKCN	L3			26.1				
8.0	TIB	BKCN	L7			26.6	20.9			
8.0	TIB	BKCN	L8			25.8	20.0			
8.0	TIB	BKCN	L8			25.9	20.5			

KEY:

P	1	44-49
	2	49-60/1
	3	44-60/1
	4	60/1-110
	5	75-125
	6	60/1-300
	7	225-400
	8	300-400

(Key to period codes on page 219. All measurements are according to von den Driesch thickness, SHT shoulder height, and TEp distal epiphysial thickness.)

MTABLE 4.4 SHEEP/GOAT METRICS, MEDIEVAL/POST-MEDIEVAL

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
10.0	MTC	I81B	F76			24.4				
10.0	MTC	I81C	F9			26.9				
10.0	MTC	I81D	F20	130.0	14.7	25.3				63.57
10.0	MTC	I81D	F278	113.0	11.8	22.3				55.26
10.0	MTC	I81D	L1772	120.0	13.6	24.0				58.68
10.0	MTC	I81E	F108			25.5				
10.0	MTC	I81E	F14	119.0	12.8	22.7				58.19
10.0	MTC	I81E	F14	122.0	13.9	25.5				59.66
10.0	MTC	I81E	F14	130.0	15.1	25.7				63.57
10.0	MTC	I81E	F14	127.0	14.2	25.7				62.10
10.0	MTC	I81E	F164	116.5		25.9				56.97
10.0	MTC	I81E	F167			25.6				
10.0	MTC	I81E	F19	128.5	13.0	24.1				62.84
10.0	MTC	I81E	F19	124.0	13.5	25.3				60.64
10.0	MTC	I81E	F219	127.0	13.8	26.2				62.10
10.0	MTC	I81E	F240	120.0	14.2	25.3				58.68
10.0	MTC	I81E	F94	114.0	11.9	23.2				55.75
10.0	MTC	LWCA	F29	130.5	13.9	26.3				63.81
10.0	MTC	LWCB	F62	135.0	12.5	26.3				66.02
10.0	MTC	LWCL	F260	129.5		25.0				63.33
10.0	MTC	LWCL	F70			23.3				
10.0	MTC	LWCL	F70	126.0	14.7	24.9				61.61
10.0	MTC	MID	MED	126.0	14.1	24.7				61.61
10.0	MTC	MID	MED			24.6				
10.0	MTC	MID	MED		13.8	24.1				
10.0	MTC	MID	MED	98.5	12.4	21.7				48.17
10.0	MTC	MID	MED	104.0	15.1	26.7				50.86
10.0	MTC	MID	MED	101.0	11.7	21.3				49.39
10.0	MTC	MID	MED		«	22.6				
10.0	MTT	I81D	F278	132.0	12.5	22.6				59.93
10.0	MTT	I81E	F133	121.0	13.5	22.8				54.93
10.0	MTT	I81E	F14	131.0	11.4	23.8				59.47
10.0	MTT	I81E	F14	137.0	12.7	25.1				62.20
10.0	MTT	I81E	F165	114.0	12.2	22.0				51.76
10.0	MTT	I81E	F172			19.1				
10.0	MTT	I81E	F90	124.5	11.4					56.52
10.0	MTT	I81E	F94	122.0	12.2	22.0				55.39
10.0	MTT	I81E	F95	123.5	10.0	20.3				56.07
10.0	MTT	LWCB	F45	122.0	12.1	22.9				55.39
10.0	MTT	LWCB	F46	133.0	10.1	22.8				60.38
10.0	MTT	LWCB	F46	127.0	12.8	23.5				57.66
10.0	MTT	LWCB	F46	137.0	12.9	23.9				62.20
10.0	MTT	LWCL	F33			22.1				
10.0	MTT	MID	PM	125.0	11.7	25.6				56.75
10.0	RAD	I81B	F31	140.0	18.1	28.9				56.28
10.0	RAD	I81D	F278	155.0	16.9	31.4				62.31
10.0	RAD	I81E	F106	135.5	14.6	26.7				54.47
10.0	RAD	I81E	F133			29.2				
10.0	RAD	I81E	F19	161.0	18.3	30.3				64.72
10.0	RAD	I81E	F19	158.0	17.9	30.3				63.52
10.0	RAD	I81E	F235	141.0	17.3	28.8				56.68

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
10.0	RAD	I81E	F240	155.0	16.5	28.5			62.31	
10.0	RAD	I81E	F240	147.0	17.0	30.3			59.09	
10.0	RAD	I81E	F278			27.1				
10.0	RAD	I81E	F293	152.0	16.6	29.3			61.10	
10.0	RAD	I81E	F7	153.0	16.0	28.3			61.51	
10.0	RAD	I81E	F7	155.0	16.2	27.5			62.31	
10.0	RAD	LWCB	B183			25.7				
10.0	RAD	LWCB	F26	158.0	16.0	30.8	26.4		63.52	
10.0	RAD	LWCB	F26	167.0	19.7	30.0	25.9		67.13	
10.0	RAD	LWCB	F45	143.0	16.0	23.4			57.49	
10.0	RAD	LWCB	F45	150.0	16.2	28.0			60.30	
10.0	RAD	LWCB	F45	134.0	15.3	25.7	23.2		53.87	
10.0	RAD	LWCB	F45	142.0	15.6	27.8	24.5		57.08	
10.0	RAD	LWCB	F45			29.1	24.9			
10.0	RAD	LWCB	F46			26.7	23.1			
10.0	RAD	LWCB	F49	136.0	16.7	27.9			54.67	
10.0	RAD	LWCB	F74			30.0				
10.0	RAD	LWCL	F260	136.0		28.1			54.67	
10.0	RAD	LWCL	F33	148.0	17.5				59.50	
10.0	RAD	LWCL	F33	144.0		26.0			57.89	
10.0	RAD	LWCL	F33	142.0	14.7	27.9			57.08	
10.0	RAD	LWCL	F33	139.0	14.9	25.1			55.88	
10.0	RAD	MID	MED			25.9				
10.0	RAD	MID	MED			26.7				
11.0	MTC	MID	16C	123.0	13.4	24.8			60.15	
11.0	MTC	MID	PM	124.0	14.8	25.4			60.64	
11.0	MTC	MID	PM	117.5	13.3	24.9			57.46	
11.0	MTC	MID	PM	114.5	12.7	23.0			55.99	
11.0	MTC	MID	PM		11.5					
11.0	MTC	MID	PM	141.0	13.8	24.3			68.95	
11.0	MTC	MID	PM	122.0	13.5	25.0			59.66	
11.0	MTC	MID	PM			23.0				
11.0	MTC	MID	PM		13.6	25.6				
11.0	MTC	MID	PM	122.0	12.3	23.8			59.66	
11.0	MTC	MID	PM	112.0	13.4	24.9			54.77	
11.0	MTC	MID	PM	112.5	12.8	24.3			55.01	
11.0	MTC	MID	PM	123.0	13.1	24.1			60.15	
11.0	MTC	MID	PM	117.0	13.0	24.5			57.21	
11.0	MTC	MID	PM	136.5	13.1	25.6			66.75	
11.0	MTC	MID	PM	112.0	13.4	24.9			54.77	
11.0	MTC	MID	PM	121.0	12.7	23.2			59.17	
11.0	MTC	MID	PM	122.0	13.5	23.9			59.66	
11.0	MTC	MID	PM	122.0	12.4	23.8			59.66	
11.0	MTC	MID	PM	120.5	12.0	23.2			58.92	
11.0	MTC	MID	PM	126.0	12.5	24.0			61.61	
11.0	MTC	MID	PM	122.0	13.3	24.8			59.66	
11.0	MTC	MID	PM	124.0	13.4	25.8			60.64	
11.0	MTC	MID	PM	103.0	12.7	22.8			50.37	
11.0	MTC	MID	PM	121.0	12.1	24.0			59.17	
11.0	MTC	MID	PM	145.0	15.0	28.2			70.91	

Period	Bone	Site	Context	GL	SD	Bd	TD	BdEp	TEp	SHT
11.0	MTC	MID	PM	118.0	14.8	26.9			57.70	
11.0	MTC	MID	PM	132.0	13.7	25.9			64.55	
11.0	MTC	MID	PM	130.0	14.2	25.7			63.57	
11.0	MTC	MID	PM	127.0	14.1	26.1			62.10	
11.0	MTC	MID	PM	131.0	16.0	28.4			64.06	
11.0	MTC	MID	PM		15.0	28.7				
11.0	MTC	MID	PM	105.0	12.6	24.1			51.34	
11.0	MTC	MID	PM	115.0	13.4	24.2			56.23	
11.0	MTC	MID	PM	110.0	12.6	23.8			53.79	
11.0	MTC	MID	PM	109.0	12.7	24.0			53.30	
11.0	MTC	MID	PM	120.0	13.9	24.9			58.68	
11.0	MTC	MID	PM	117.0	11.9	22.6			57.21	
11.0	MTC	MID	PM	109.0	13.1	24.5			53.30	
11.0	MTC	MID	PM	128.0	15.7	25.9			62.59	
11.0	MTC	MID	PM	128.0	15.9	26.0			62.59	
11.0	MTC	MID	PM	114.0	13.4	25.7			55.75	
11.0	MTC	MID	PM	118.0	15.1	25.3			57.70	
11.0	MTC	MID	PM	123.5	13.3	24.4			60.39	
11.0	MTC	MID	PM	118.0	15.2	25.3			57.70	
11.0	MTC	MID	PM	123.0	14.0	24.4			60.15	
11.0	MTC	MID	PM	122.0	13.6	25.2			59.66	
11.0	MTC	MID	PM	113.0	12.9	25.6			55.26	
11.0	MTC	MID	PM	125.0	14.5	25.4			61.13	
11.0	RAD	MID	16C			30.4				
11.0	RAD	MID	16C			25.4				
11.0	RAD	MID	16C			28.3				
11.0	RAD	MID	16C			30.3				
11.0	RAD	MID	PM			27.8				
11.0	RAD	MID	PM			28.0				
11.0	RAD	MID	PM			27.0				
11.0	RAD	MID	PM			27.4				
11.0	RAD	MID	PM			29.0				
11.0	RAD	MID	PM			29.3				
11.0	RAD	MID	PM			27.1				
11.0	RAD	MID	PM			27.1				
11.0	RAD	MID	PM			31.4				

KEY:

10	medieval
11	post-medieval

MTABLE 5.1 DOMESTIC FOWL METRICS, ROMAN, MEDIEVAL AND POST-MEDIEVAL

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
100-300	I81A	L5	83.1	13.7		12.8	9.2	S
100-350	I81B	L60	65.3	11.3	5.4	11.0		U
150-400	LWCL	B284	66.0	12.3	5.7	12.4		U
150-400	LWCL	B287	66.0	11.7	5.7	11.3		U
150-400	LWCL	B287	74.0	12.7	6.5	12.6		U
150-400	LWCL	F144	79.4	14.2		13.9	16.9	S
150-400	LWCL	F144	68.5	11.5	5.4	11.4		U
150-400	LWCL	F144		9.3				
150-400	LWCL	F144	103.0	16.3	8.1	16.2		
150-400	LWCL	F144	78.1	14.3	7.0	14.0		u
200-450	BKCG	B459	81.0	13.2	.	13.2		S
200-450	BKCG	F11	66.2	12.5	5.5	11.6		u
200-450	BKCG	F11	67.6	12.0	5.6	11.6		u
200-450	BKCG	F11	64.9	11.7	5.7	11.5		u
200-450	BKCG	F11	81.0	14.7		13.5		s
200-450	BKCH	F48		11.9				
200-450	BKCH	L9	75.6	13.6		13.0		s
200-450	BKCJ	F32	75.6	13.3	6.0	12.8		u
200-450	BKCK	L8	82.3	14.0	7.0	13.4		s
200-450	BKCN	F42		13.6				
200-450	BKCN	F87	71.0	12.1	5.8	11.5		u
200-450	BKCN	F87	71.0	12.1	5.8	11.6		u
200-450	BKCN	F88	72.0	13.2		12.6		s
200-450	BKCN	F88	72.0	13.1		12.7		s
200-450	BKCN	L7		12.0				
200-450	BKCN	L8	69.0	11.1	5.7	11.9		u
200-450	BKCT	F117				13.7		
200-450	BKCT	L67		14.0	7.7		19.4	s
200-450	BUCA	G11		13.5	6.9			
200-450	BUCA	G283	80.3	14.0	7.1	13.2	16.1	s
200-450	BUCE	F110		13.6				
200-450	BUCE	F212	77.7	12.8	7.3	12.8	13.7	s
200-450	BUCE	F38	86.7	14.6	7.4	14.3		P
200-450	BUCE	F76			7.1	13.5	10.5	s
200-450	BUCE	F76	80.6	14.4	9.3	14.1	21.3	s
200-450	BUCE	F76	78.4	14.8	7.6	13.9	23.3	s
200-450	BUCE	F76	79.6	14.9	6.9	13.5	18.2	s
200-450	BUCE	L54		13.4				
200-450	181A	F35			4.9	11.4		u
200-450	I81B	L102	*12 A*	12.3	5.8	11.9		u
200-450	I81B	L120	83.1	15.4	7.5	15.6	18.8	s
200-450	I81B	L129		14.8	7.3			
200-450	I81B	L189		11.4	5.5			
200-450	I81B	L3	*m*	14.7	8.2	14.6	21.6	s
200-450	I81B	L66	84.1	14.6	7.7	13.6	18.8	s
200-450	I81D	F203	83.2	13.7	6.5	13.7		
200-450	I81D	L1436				13.4		
200-450	I81G	F2370				13.0		

PHASE	SITE	CONTEXT	CL	BP	SC	BD	LS	SPUR
200-450	I81G	F266	84.8	13.3	7.6			S
200-450	1816	L119	69.9	11.9	5.7	11.9		U
200-450	1816	L1 19			6.4		21.4	S
200-450	1816	L1195	61.8	12.9	7.8	12.9	14.9	S
200-450	1816	L1224	63.8	11.4	5.3	11.1		U
200-450	1816	L1391	70.9	12.3	6.4	12.7		U
200-450	1816	L1660	70.7		5.8	11.7		U
200-450	1816	L177	81.3	13.2	6.8	12.8	15.3	S
200-450	1816	L1894	69.0	12.0	6.0	11.6		U
200-450	1816	L3191	84.7	14.2	6.4	12.7		P
200-450	1816	L3193		12.1				
200-450	1816	L365		9.2	4.7	9.0		U
200-450	1816	L644		14.3	7.2			
200-450	1816	L781	83.5	13.8	7.5	14.4	25.4	S
200-450	I81H	L382	81.1	13.2	6.8	13.3		P
200-450	LWCB	B287				11.4		
200-450	LWCB	B373				10.8		
200-450	LWCJ	B350	69.0	11.6	5.8	12.4		U
200-450	LWCJ	F188	69.0	11.6	5.8	12.4		U
225-400	1816	L1439	70.8	11.6	5.8	11.8		U
225-400	1816	L1477	82.3	13.0	7.0	13.5	17.9	S
300-450	BUCE	F38				14.4		
320-450	BUCE	L16		13.4				
320-450	BUCE	L16			6.7	12.9	16.5	S
320-450	BUCE	L16			6.7	13.0	14.4	S
320-450	BUCE	L16			7.0	13.8		U
320-450	BUCE	L16			6.6			
320-450	BUCE	L16		13.7				
320-450	BUCE	L16		13.3	8.4			
320-450	BUCE	L16			7.1	14.2	16.5	S
320-450	BUCE	L16	89.3	14.7	8.4	15.0	20.0	S
320-450	BUCE	L16				14.1	13.9	S
320-450	BUCE	L16		13.7				
320-450	BUCE	L16	72.8	13.6	6.4		18.0	S
320-450	BUCE	L16			7.6		16.3	S
320-450	BUCE	L16			6.5	12.9		U
320-450	BUCE	L16		13.4	6.9			U
320-450	BUCE	L16		14.3				
320-450	BUCE	L16	78.0	13.8	7.5	13.4	14.1	s
320-450	BUCE	L16		12.9				
320-450	BUCE	L22		13.8	7.8			
320-450	BUCE	L29	83.6	13.2	6.2	12.9		P
320-450	BUCE	L29	85.9	14.4	7.9	14.6	6.8	s
320-450	BUCE	L29		13.3	6.8			
320-450	BUCE	L29		13.1				
320-450	BUCE	L29		13.7				
320-450	BUCE	L29					13.5	s
320-450	BUCE	L29		12.9	6.0			
320-450	BUCE	L29		13.4				
320-450	BUCE	L29	80.1	13.7	7.2	14.1		
320-450	BUCE	L33	71.2	13.6	6.8	12.7	9.8	s
320-450	BUCE	L51		13.3				

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
320-450	BUCE	L9	80.4	13.6	7.0	13.9		P
320-450	BUCE	L9				13.2		
44-49	181 A	L98	83.2	13.5		12.9	9.2	S
44-60/1	BKCJ	L46		14.4	7.1			
44-60/1	GBSA	F210		11.3	5.3			
44-60/1	GBSA	F213	73.8	15.0	7.1	13.6		S
44-60/1	GBSA	F310	81.1	14.4	7.9	13.5	20.8	S
44-60/1	GBSA	L101	74.9	12.8	5.9			U
44-60/1	GBSA	L103		13.0				
44-60/1	GBSA	L103		13.1	6.7			
44-60/1	GBSA	L103				21.5	15.0	S
44-60/1	GBSA	L103		12.6				
44-60/1	GBSA	L103	76.1	13.1	6.6	12.6	17.5	S
44-60/1	GBSA	L103	65.6	11.3	5.0	10.9		U
44-60/1	GBSA	L103		12.8				
44-60/1	GBSA	L103		10.9				
44-60/1	GBSA	L103		12.7				
44-60/1	GBSA	L103			6.4	12.6		
44-60/1	GBSA	L103			5.7	12.2		U
44-60/1	GBSA	L103			5.4	11.3		
44-60/1	GBSA	L111		14.3			14.5	S
44-60/1	GBSA	L128	78.3	13.1	6.5	12.8		P
44-60/1	GBSA	L128	73.7	12.7	6.8	12.7		P
44-60/1	GBSA	L128	62.7	10.9	5.7			U
44-60/1	GBSA	L146	79.8	14.6	8.7	13.2		
44-60/1	GBSA	L146		11.6				
44-60/1	GBSA	L146		11.7				
44-60/1	GBSA	L156		13.6	6.1	12.2		
44-60/1	GBSA	L168	70.3	12.0	6.2	11.5		U
44-60/1	GBSA	L171	74.9	13.8	6.9	12.6	10.2	S
44-60/1	GBSA	L190	78.0	12.8	6.7	12.7		
44-60/1	GBSA	L190	81.9	14.0	6.7	12.8		
44-60/1	GBSA	L190	68.4	11.6	5.9	12.4		
44-60/1	GBSA	L250		15.7	8.0		20.3	S
44-60/1	GBSA	L250			7.8		17.9	S
44-60/1	GBSA	L250		13.1	6.6			
44-60/1	GBSA	L250		13.4				
44-60/1	GBSA	L250		14.3				
44-60/1	GBSA	L250		13.1	6.2			
44-60/1	GBSA	L250		12.8	6.0			
44-60/1	GBSA	L250		12.2	6.3			
44-60/1	GBSA	L250		11.9				
44-60/1	GBSA	L250		13.1	6.8			
44-60/1	GBSA	L250		13.1				
44-60/1	GBSA	L250		10.8				
44-60/1	GBSA	L250			6.3	13.9		
44-60/1	GBSA	L250			6.1	12.9	14.7	S
44-60/1	GBSA	L250			6.2	12.9		
44-60/1	GBSA	L250	81.1	13.6	6.8	12.6		P
44-60/1	GBSA	L250	82.7	13.9	7.0	14.1		P
44-60/1	GBSA	L250		13.6	6.5			U
44-60/1	GBSA	L250	79.2	12.8	6.3			U

PHASE	**SITE**	**CONTEXT**	**GL**	**BP**	**SC**	**BD**	**LS**	**SPUR**
44-60/1	GBSA	L250	77.2	12.4	6.4	12.8		P
44-60/1	GBSA	L250		12.1	5.8			U
44-60/1	GBSA	L250		11.6	5.6		14.4	S
44-60/1	GBSA	L255	79.2	12.4	6.0			U
44-60/1	GBSA	L257			6.4	13.1		
44-60/1	GBSA	L258	63.4	10.8		10.7		u
44-60/1	GBSA	L262	74.8	12.8	6.1	12.8		u
44-60/1	GBSA	L263	67.7	11.3	5.7	11.5		u
44-60/1	GBSA	L69	74.9	13.5	5.6	12.3		u
44-60/1	GBSA	L69		11.0	5.2			
44-60/1	GBSA	L69		12.6	5.7			
44-60/1	GBSA	L89	86.5	14.0	7.2	13.6		P
44-60/1	GBSA	L89	95.7	16.0	8.9	16.5		P
44-60/1	GBSA	L89	78.2	12.6	6.8	13.1		P
44-60/1	GBSA	L89	75.9	12.8	6.6	13.3		u
44-60/1	GBSA	L89	68.0	11.4	5.5	10.7		u
44-60/1	GBSA	L94	70.1	11.9	6.1		13.3	s
44-60/1	GBSA	L96	79.2	13.2	7.1			
44-60/1	GBSA	L96	69.7	13.2	6.5	12.6	17.8	s
44-60/1	GBSA	L96	65.9	11.6	5.3			u
44-60/1	I81B	L464					15.2	s
44-60/1	I81C	F138			6.4	12.8		P
44-60/1	I81C	F138	82.6	13.6	7.2	14.5	21.4	s
44-60/1	I81C	F138	78.7	13.4	6.4	12.8		P
44-60/1	I81C	L63	81.4	14.3	6.8	13.6		P
44-60/1	I81C	L70	63.2	10.5	5.0			u
44-60/1	I81C	L70	61.8	10.7	5.2	11.1		u
44-60/1	I81E	F1006				13.3		
44-60/1	I81E	L148		11.0				
44-60/1	LWCB	B642	68.0	12.1	5.9	12.1		u
44-60/1	LWCB	F6		13.0				u
44-60/1	LWCJ	B1456	70.0	13.0		12.2		s
44-60/1	LWCJ	F419	73.0	13.2		13.0	13.0	s
44-60/1	LWCJ	F419	68.7	11.5		11.7	11.8	s
44-60/1	LWCJ	F419	66.7	11.7	5.5	11.7		u
44-60/1	LWCJ	F419	70.2	14.4		13.8		s
44-60/1	LWCJ	F419				10.9		
44-60/1	LWCJ	F419	73.0	13.2		13.0	13.0	s
44-60/1	LWCJ	F419	68.7	11.5		11.7		s
44-60/1	LWCJ	F419	66.7	11.7	5.5	11.7		u
44-60/1	LWCJ	F419	70.2	14.4		13.8		
44-60/1	LWCJ	F419				10.9		u
44-60/1	LWCJ	F488	70.0	13.0		12.2	12.2	s
44-60/1	LWCK	B334				10.6		
49-110	GBSB	L26	72.9	11.9	5.8	12.1		u
49-60/1	GBSA	L202	75.1	12.6	6.0	12.8		u
49-60/1	GBSA	L202	65.7	10.9	5.1	10.9		u
49-60/1	I81C	L60	80.7	12.9	7.1			P
60/1-110	GBSA	F117	63.7	11.3	5.1	10.8		u
60/1-110	GBSA	F117	69.3	11.6				u
60/1-110	GBSA	F117	81.1	13.5	7.0	13.6		s
60/1-110	GBSA	F95	80.7	13.4	6.5	13.4		u

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
60/1-275	GBSA	F34	87.0	13.4	6.4			U
60/1-275	GBSA	L166	63.9	11.1	5.2	10.9		U
60/1-300	BKCG	F24	70.2	11.7	5.4	11.9		U
60/1-300	BKCG	F61	79.5	14.3		13.2		S
60/1-300	BKCG	F61	65.5	11.5		11.5		U
60/1-300	BKCJ	F13	83.0	14.5	8.1	14.7		
60/1-300	BKCJ	F13	69.0	11.9	5.7	12.1		U
60/1-300	BKCJ	F13		12.8	6.5		15.4	S
60/1-300	BKCJ	F13		13.2	6.7		14.4	s
60/1-300	BKCJ	F13					23.6	s
60/1-300	BKCJ	F13	82.2	13.8	7.4	13.6		P
60/1-300	BKCJ	F21			7.3	13.2	18.8	s
60/1-300	BKCJ	F34				14.6	19.0	s
60/1-300	BKCJ	L26	78.9	14.1	6.5	13.0	20.0	s
60/1-300	BKCN	B323	71.0	12.0	5.7	11.9		u
60/1-300	BKCN	F97	69.3	11.5	5.7	11.7		u
60/1-300	BKCN	F97	71.0	12.1	5.6	11.9		u
60/1-300	BKCN	F97	69.5	11.5	5.7	11.7		u
60/1-300	BKCT	L38				13.5	20.0	s
60/1-300	GBSA	F121		11.8				
60/1-300	GBSA	F121	63.6	11.4	5.0	10.7		
60/1-300	GBSA	F121	81.4	13.8	5.9	14.0		
60/1-300	GBSA	F121	81.2	13.9	6.8	13.4		P
60/1-300	GBSA	F66	88.0	14.5	7.2	13.3	21.9	s
60/1-300	GBSA	F66	78.0	14.0	7.2	14.0	22.2	s
60/1-300	GBSA	F95	66.5	12.1	5.9	11.1		u
60/1-300	GBSA	L10		13.4	6.6			
60/1-300	GBSA	L10			7.9	14.9		
60/1-300	GBSA	L10				12.4		
60/1-300	GBSA	L10	71.0	11.4	5.2	11.9		u
60/1-300	GBSA	L10		12.8				
60/1-300	GBSA	L11	67.3	11.8	5.3	11.5		u
60/1-300	GBSA	L140	76.3	14.1	6.7	12.9	16.1	s
60/1-300	GBSA	L165	89.0	15.0	8.5	14.9	16.4	s
60/1-300	GBSA	L41	62.5	12.7	5.2	11.3		u
60/1-300	GBSA	L42		13.6	7.0			
60/1-300	GBSA	L66				13.3		
60/1-300	GBSA	L66		13.4				
60/1-300	GBSA	L9	74.8	12.6	6.1	12.7		u
60/1-300	GBSA	L9		15.1				u
60/1-300	GBSB	F23	69.4	12.6	6.1	12.0		u
60/1-300	GBSB	F28	90.3	13.9	7.3			P
60/1-300	GBSB	L10	94.0	15.0	8.0	15.1	22.7	s
60/1-300	GBSB	L166	64.2	11.5	5.4	10.8		u
60/1-300	GBSB	L7	85.8	13.8	7.8	14.9	20.8	s
60/1-300	GBSB	L7	68.8	11.4	5.7			u
60/1-300	GBSB	L8	81.7	14.5	6.2			u
60/1-300	GBSB	L8	81.7	14.4	6.5	14.6		u
60/1-300	GBSB	L8	68.4	11.8	5.5	11.4		u
60/1-300	GBSB	L82		13.8				
60/1-300	GBSB	L82	76.6	12.3	5.6	11.8		u
60/1-300	181A	F100	90.3	14.7	7.4	14.9		s

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
60/1-300	I81A	L138	74.4	13.0	6.3	12.3		S
60/1-300	I81A	L138				12.0		U
60/1-300	I81A	L189				12.1		U
60/1-300	181A	L2	82.0	13.7	7.1	12.6		
60/1-300	I81B	F250		12.7				
60/1-300	I81B	F275	80.1	13.5	7.4	13.0		U
60/1-300	I81B	F333	70.8	12.5	6.6	12.3		U
60/1-300	I81B	L133	74.2	12.9	5.8	12.9		U
60/1-300	I81B	L133	70.5	11.8	5.5	11.9		U
60/1-300	I81B	L133	83.5	13.5	7.0	13.1		P
60/1-300	I81B	L145	74.6	12.6	6.2	12.7		u
60/1-300	I81B	L159	83.0	13.6	7.1	13.6	10.8	s
60/1-300	I81B	L169	77.8		7.3	16.5		u
60/1-300	I81B	L340	64.6	12.1	6.3	11.1		u
60/1-300	I81B	L343	65.1	11.7	5.5	10.7		u
60/1-300	I81B	L343		13.4	6.3			u
60/1-300	I81B	L39	91.5	14.1	6.9			u
60/1-300	I81B	L399	91.5	14.1	6.9			P
60/1-300	I81C	F115	79.3	13.2	6.6	13.4		P
60/1-300	I81C	F33				14.8		s
60/1-300	I81C	F56	62.0	11.2	5.4	11.5		u
60/1-300	I81C	F56	75.8	12.8	6.5	13.0		P
60/1-300	I81C	F57	73.6	13.8		13.1		u
60/1-300	I81C	L14		12.6	6.0	12.8		u
60/1-300	I81C	L36		11.6		11.4		u
60/1-300	I81C	L55	77.6	14.2	7.2	13.1		P
60/1-300	I81E	L21	83.5	13.3	7.3	13.4		s
60/1-300	I81G	F2362	71.1	13.2	5.9	12.2		u
60/1-300	I81G	F2362	60.0	11.0	5.3	10.4		u
60/1-300	I81G	F2695	78.1	13.0	6.4			s
60/1-300	I81G	F2695	79.7	13.9	6.8	13.8	19.0	s
60/1-300	I81G	F3404				11.1		u
60/1-300	I81G	F4001	64.8	11.3	5.8			u
60/1-300	I81G	L1423		14.3	7.3		19.1	s
60/1-300	I81G	L1760	68.5	11.9	5.6	11.9		u
60/1-300	I81G	L2024	81.7	12.8	7.1	13.6		u
60/1-300	I81G	L2966	80.8	13.5	6.9	12.9		P
60/1-300	I81G	L3945			7.7			
60/1-300	I81G	L3985						
60/1-300	I81G	L4218	79.1	13.5	7.1	14.0	14.8	s
60/1-300	I81G	L478	65.6	11.7	5.8	12.4		u
60/1-300	I81K	F141	70.0	11.4	5.5	11.8		u
60/1-300	I81K	L60	82.9	14.1	6.9	13.7	21.0	s
60/1-300	LWCA	B292	67.4	11.7		11.8		u
60/1-300	LWCB	B409		11.9				
60/1-300	LWCB	F195	91.2	14.4	7.5	14.4	16.3	s
60/1-300	LWCC	B351	66.8	11.6	5.2			u
60/1-300	LWCC	B358		12.6				
60/1-300	LWCC	B434	72.3	11.6	6.0	12.2		u
60/1-300	LWCJ	F273		11.7				
60/1-300	LWCJ	F273		11.7				
60/1-300	LWCK	F99	70.5	11.9	5.8	11.7		

PHASE	**SITE**	**CONTEXT**	**GL**	**BP**	**SC**	**BD**	**LS**	**SPUR**
MED	I81D	F1790	85.0	13.9	6.4	13.8		U
MED	I81D	F259				13.1		U
MED	I81D	F278			6.3	13.0		U
MED	I81D	F30	85.3	15.1	7.6	13.9		S
ROM	BKCG	B392	66.3	11.6	5.3	10.6		U
ROM	BKCJ	F41			6.9	13.4		S
ROM	BUCE	L46	72.6	13.0	6.7	12.8		U
ROM	BUCE	L46	73.8	14.3	6.4	12.6		u
ROM	BUCE	L46	80.1	13.2	7.7	13.9	11.4	s
ROM	BUCE	L46	73.1	13.0	6.3			u
ROM	GBSA	F17	68.5	11.8	5.5	11.1		u
ROM	GBSA	F178	65.5	11.0	5.8	11.1		u
ROM	GBSA	F292	78.5	13.3	5.6	12.6		u
ROM	GBSA	L13		14.2				
ROM	GBSA	L13			5.1	10.8		
ROM	I81B	L25	78.3	14.7	6.3	12.3	20.2	s
ROM	I81B	L31		11.1				u
ROM	I81B	L35	69.4	12.0	6.4			u
ROM	I81C	F24		13.5	6.8			s
ROM	I81C	F27		13.2	6.8			
ROM	I81C	F27		14.3				u
ROM	I81C	F27			6.7	14.5		u
ROM	I81D	F1492				14.1		
ROM	I81D	F196	81.8	13.8	7.4	13.0		P
ROM	I81D	F22	80.2	13.5		12.9		u
ROM	I81D	F582				13.6		
ROM	I81D	F624	75.4	12.1	5.8	11.9		u
ROM	I81D	F624	70.1	11.8	5.8	12.6		u
ROM	I81D	F624	72.1	13.4	6.7	13.6		u
ROM	I81D	F686	84.8	13.6	7.2	13.4	20.0	s
ROM	I81D	L1214	83.4	13.4	6.8	13.5		s
ROM	I81D	L1367	63.9	11.5	5.1	11.1		u
ROM	I81D	L1818				13.3		s
ROM	I81D	L200	63.4	12.2	5.7	11.6		u
ROM	I81D	L200	63.7	12.5	5.6	11.5		u
ROM	T81D	L267	86.4		7.5	14.8		s
ROM	I81D	L475				13.8		
ROM	I81D	L641	78.5	14.1		13.9		
ROM	I81D	L641	81.9	14.1	7.1	14.6	20.0	s
ROM	I81D	L641	69.8	11.4	5.5			u
ROM	I81D	L641		13.6				s
ROM	I81G	L1403	82.0	13.4	6.9	12.7	19.3	s
ROM	I81H	L540		11.4				
ROM	I81K	F121	84.8	14.6	7.5	14.5	19.0	s
ROM	I81K	F121	83.5	13.9	7.2	13.7	23.0	s
ROM	I81K	F121	79.3	14.2	7.5	14.9	23.5	s
ROM	I81K	F169	63.2	11.0	5.2	11.0		u
ROM	LWCA	B180	67.7	11.7		11.8		s
ROM	LWCB	B125	76.6	13.2	7.0	12.7		s
ROM	LWCB	F105				12.0		
ROM	LWCB	F14		14.0				
ROM	LWCB	F197		11.4				

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
ROM	LWCB	F70	92.3	17.6	8.8	16.8	17.5	S
ROM	LWCK	B420	71.0	11.7	5.7	12.0		
ROM	LWCM	B114		11.2	5.4			
ROM	MID	L215	66.0	11.6	6.2	11.8		
ROM	MID	L239		13.2	6.5		17.8	S
MED	GBSB	F11	73.7	11.8	5.9	12.5		U
MED	I81A	F46	87.0	14.1	7.4	14.5		
MED	181A	F46	69.0		5.2	12.5		U
MED	181A	F66	90.0	16.1	8.5	16.6	20.5	S
MED	181A	F66	90.0	15.9	8.5	16.6		s
MED	I81D	F30				12.9	19.2	s
MED	I81D	F30		5.8	2.8			u
MED	I81D	F38				11.8		u
MED	I81D	F577	70.4	11.4	5.6	11.5		u
MED	I81D	F91	69.4	12.1	5.9	12.2		u
MED	I81E	F102	71.6	12.4	5.6	12.2		u
MED	I81E	F126		12.3				
MED	I81E	F133	69.2	12.3	5.8	12.3		u
MED	I81E	F134	76.8	12.8	6.7	13.2		
MED	I81E	F137	76.4	12.5	6.3	13.4		u
MED	I81E	F141	62.7	11.1	5.2	11.3		u
MED	I81E	F155		12.2				u
MED	I81E	F164		14.8	7.3			
MED	I81E	F164				15.3		
MED	I81E	F19				13.4		u
MED	I81E	F7	84.8	14.6	7.1	15.0	17.7	s
MED	IBIB	F3	64.6		5.4			u
MED	LWCA	F16	67.7	11.9	5.8	12.5		u
MED	LWCA	F16	79.0	12.6	6.6			u
MED	LWCA	F16	86.0	15.4	7.6			P
MED	LWCA	F16	74.0	13.4	6.6	14.1		u
MED	LWCA	F16	65.8	12.2	5.7	12.4		u
MED	LWCA	F16	72.4	12.4	6.2	13.1		u
MED	LWCA	F16	78.3	16.3		14.0		s
MED	LWCA	F26	90.2	17.2		16.3	18.3	s
MED	LWCA	F26	77.7	12.7	5.3	13.0		u
MED	LWCB	F18		14.2				
MED	LWCB	F260	77.8	13.8		13.4		
MED	LWCB	F260	66.2	11.8		11.5		u
MED	LWCB	F260	78.0	13.8	6.6	13.6		s
MED	LWCB	F260	66.5	11.9	5.7	11.8		u
MED	LWCB	F266		12.2				
MED	LWCB	F46	71.9	12.0		12.8		P
MED	LWCB	F46	69.3	11.7	5.0	11.6		u
MED	LWCB	F80	66.8	11.6	5.2			u
MED	LWCJ	B269	86.0	15.1		15.4	19.9	s
MED	LWCJ	F135	64.0	11.9	5.6	11.7		u
MED	LWCJ	F135	64.0	11.9	5.6	11.7		u
MED	LWCJ	F188	86.0	15.1		15.4	19.9	s
MED	LWCK	B450	79.0	13.6		13.8		
MED	LWCK	B491		15.1			18.1	s
MED	LWCK	B491	75.0	13.3	6.1	12.8		

PHASE	SITE	CONTEXT	GL	BP	SC	BD	LS	SPUR
MED	LWCK	F100	82.0	13.9		14.3		
MED	LWCK	F18		8.1	15.3	24.8		
MED	MID	F108	68.3	12.9	5.7	13.2		U
MED	MID	F135	91.3	14.8	7.7	15.3		P
MED	MID	F296			10.0	20.3	22.7	S
MED	MID	F44		12.8	5.7			
MED	MID	F87	81.0	13.5	6.5	14.3		U
MED	MID	F87	81.0	13.5	6.5	13.3		U
MED	MID	F87	81.3	13.1	6.3	13.3		U
MED	MID	F87	72.2	12.3	5.9			U
MED	MID	F87	72.5	12.2	5.8	14.1		U
MED	MID	F87	67.1	11.4	5.2	12.2		U
MED	MID	F87		12.5				
MED	MID	F87			7.1	14.4		U
MED	MID	F87			6.7	14.7		U
MED	MID	L4	69.5	12.1	5.7	12.0		U
MED	MID	L4	65.3	11.5	5.3	11.1		U
MED	MID	L4		12.0	5.7			
PM	GBSA	F42	62.3	11.9	5.0	10.6		U
PM	GBSA	F42		14.6	7.8			
PM	GSBA	F42	71.5	11.8	5.7	12.3		U
PM	I81B	F1	70.0	12.5	6.2	11.9		U
PM	I81B	F50	72.8	14.6	5.6	13.0	6.0	S
PM	I81B	F96	86.8	14.3	6.8	14.7		P
PM	LWCA	F119	76.1	13.0	6.4	13.2		U
PM	LWCA	F119	73.4	12.7	5.9	12.6		U
PM	LWCA	F119	75.5	13.2	6.3	13.4		U
PM	LWCA	F119	73.4	12.5	6.0	12.5		U
PM	LWCA	F119	77.4	12.3	6.4	13.2		U
PM	LWCA	F1 19		11.8	6.2			U
PM	LWCA	F119			6.2	13.7		U
PM	LWCA	F119		12.3	6.4			
PM	LWCA	F12	95.3	16.3		16.7		s
PM	LWCA	F12		16.6				
PM	LWCA	F1 2	111.8		5.8	11.6		u
PM	LWCA	F12		12.7				
PM	LWCA	F12		12.6		13.9		
PM	LWCB	F14						
PM	LWCB	F14				10.7		
PM	LWCC	F65				13.4		u
PM	LWCC	F65	73.0	12.1	5.8	12.5		u
PM	LWCC	F65		12.5				
PM	LWCC	F65	74.6	12.2	5.6	13.2		u
PM	LWCC	F65	85.1	15.0	7.3			u
PM	LWCC	F65		14.2				
PM	LWCC	F65	75.3	12.8	6.6	13.5		u
PM	LWCC	F65	77.4	13.1	6.0	13.7		u
PM	LWCC	F65		14.3				
PM	MID	F121	71.2	12.0	5.9			
PM	MID	F45	88.4	15.2	7.8	16.3	17.4	s

PHASE	**SITE**	**CONTEXT**	**GL**	**BP**	**SC**	**BD**	**LS**	**SPUR**
PM	MID	F45	75.3	12.9	5.9	12.9		U
PM	MID	F45	68.7	13.0	6.1	12.3		U
PM	MID	F45	74.3	12.5	7.0	14.0		U
PM	MID	F63		11.7				
PM	MID	F667		13.2				
PM	MID	L15		11.5				
PM	MID	L6 1/2	65.3	11.7	5.4			