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THE MAMMALIAN REMAINS FROM THE TUDOR SITE OF BAYNARD'S CASTLE, LONDON : A BIOMETRICAL AND HISTORICAL ANALYSIS.

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ABSTRACT

The site of Baynard's Castle, London was excavated in 1972-73 by a team of archaeologists from the Guildhall Museum. Conditions for the preservation of skeletal material were highly favourable, and the three major dumps of rubbish on the site were found to contain large quantities of animal bone. Many of the specimens recovered were sufficiently intact to allow measurement, and for the first time for the city of London, it has been possible to carry out a detailed statistical analysis of mammalian bone from late medieval and early Tudor contexts. An account of this study, carried out at the British Museum (Natural History) between 1974-77, forms the subject of this thesis.

Over 11,381 mammalian bone elements were examined, and the following species have been identified:-

Domestic: Horse, cattle, sheep, goat, pig, dog, cat, and rabbit

Wild: Red deer, Fallow deer, Roe deer, hare, Black rat, hedgehog, and House mouse

Approximately 40,000 measurements were recorded, and these have been processed using the Varian computer at the BM(NH). From the results of the analysis of the data, it is apparent that there was an increase in the size of cattle during the late fourteenth and early fifteenth centuries AD, and it is at this time that long horned cattle first make their appearance. Sheep, on the other hand, show no increase in size between the late middle ages and early Tudor period, and are of similar stature and build to the Soay sheep kept on the mainland today.

New methods of treating faunal remains from archaeological sites have been devised; these include a method for the sexing of the pelves of sheep by means of absolute measurement, and a system for the classification and description of the horn cores of cattle.

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1. INTRODUCTION

1.1 Baynard's Castle

The site of Baynard's Castle, behind the Thames embankment East of Blackfriars railway bridge (O.S. Map TQ3180 N.E. Grid Ref. 809 319), had lain buried and virtually forgotten for over three hundred years until the area was excavated by a team of archaeologists from the Department of Urban Archaeology, Guildhall Museum (now part of the Museum of London), under the direction of Mr. Peter Marsden, during the summer months of 1972 and 1973 (see Marsden, 1972a; Bloice, 1974). Prior to the recent redevelopment (1974-1976) that has taken place along the northern waterfront of the River Thames, from the Fleet to the Tower, the archaeological features, including the buried foundation walls of Baynard's Castle, had been little affected by building construction. According to the survey carried out by Biddle, Hudson & Heighway (1973, p. 31) archaeological evidence from only 16% of this 900 metre strip along the Thames had been destroyed, the destruction that had taken place mainly arising from the sinking of deep basements in a number of the houses. With the recent growth in redevelopment the destruction of archaeological sites in this section of the city has become more widespread and has resulted in the irretrievable loss of important information on the Roman and medieval waterfronts. The rescue excavation at the site of Baynard's Castle was organised in response to the threat posed by the construction of the new road network in the vicinity of Blackfriars Bridge and the building of Baynard House, the G. P. O. Telecommunications Centre (see Figure 1). Most of the subsequent damage inflicted on the site occurred during the levelling of the ground in preparation for laying-out the foundations for the supporting pillars of the Blackfriars overpass; the remaining traces of the riverside frontage of the castle (see below) were completely obliterated during the construction of this section of road.

Research into the history of the castle has still not been completed and much information remains to be collected and collated; a brief outline of the main events in the history of the castle will be given here, whilst a full history will appear in the report on the excavations at Baynard's Castle (Marsden, in preparation).

The History of Baynard's Castle

This account of the history of Baynard's Castle is based on the works of Kendall (1973), Marsden (1972b, 1973, pers. comm.) and Stow (1603, reprinted 1970).

Baynard's Castle took its name from Ralph Baignard, a nobleman who fought for William, Duke of Normandy. The first castle stood in the South West corner of the city close to the site which is now occupied by Blackfriars railway station. In 1275 A D, the owner of the site, Robert Fitzwalter, granted the land to the Dominican order for the foundation of a monastery (the castle being demolished to make way for the monastic building). Fitzwalter then built a new castle at the edge of the River Thames, just east of the present Mermaid Theatre. There are no known, extant documents to provide details of the early history of this second Baynard's Castle until the year 1428 A D when it was recorded that the castle was gutted by fire and had to be rebuilt by the owner, Humphrey, Duke of Gloucester. Following the death of the Duke in 1446 A D, ownership of the building then passed into the hands of the Crown and it remained Crown property until the reign of Queen Elizabeth I.

Two prominent figures associated with the castle during its long history were King Richard III and King Henry VII. Baynard's

Castle was at one time the town residence of Richard III's mother, and Shakespeare, in his play Richard III, suggests that it was in the great courtyard of the castle that the Duke of Buckingham offered the English crown to Richard, then Duke of Gloucester (Act III, Scene VII). With the death of Richard III at the Battle of Bosworth Field in 1485 A D, Baynard's Castle passed into the hands of his successor, Henry Tudor (Henry VII). It was during the reign of the latter monarch that the castle was converted into a palace. John Stow, the Elizabethan chronicler, commented upon this transformation in his 'Survey of London' published in 1603 A D, saying that, 'Henry VII, about the year 1501, the 16th of his reign, repaired or rather new built this house, not embattled, or so strongly fortified castle like, but far more beautiful and commodious for the entertainment of any prince or great estate'. The dock basin to the west of the castle was filled in and a walled garden set out on the reclaimed land during this period of rebuilding. Baynard's Castle continued as a royal palace until the reign of Queen Elizabeth I when it became the residence of the Earl of Pembroke. Further modifications were then made to the building by the new owner, including the addition of a west wing and a round tower.

Along with many other fine and historic buildings in the city of London, Baynard's Castle was destroyed in the Great Fire of 1666 A D, and until the site was rediscovered by archaeologists from Guildhall Museum in 1972-1973, the only evidence to indicate the former existence of the castle was provided by the name of the Ward, Castle Baynard Ward, and by the name of a Victorian Public House in Queen Victoria Street.

Figure 1: Map of the western end of Upper Thames Street showing the site of Baynard's Castle.

The two newly constructed roads (shown in solid black) converge to join the Blackfriars underpass (just off the map - on the left hand side) in the vicinity of the Mermaid Theatre. Also shown is the position of the G. P. O. Telecommunications Building (still under construction, October 1976) that overlies much of the area once occupied by Baynard's Castle. To accommodate the new road network, the embankment immediately south of the G. P. O. building has been extended out onto the Thames' foreshore; a concrete revetment now runs along this section of the waterfront behind which there is a pedestrian walk-way.

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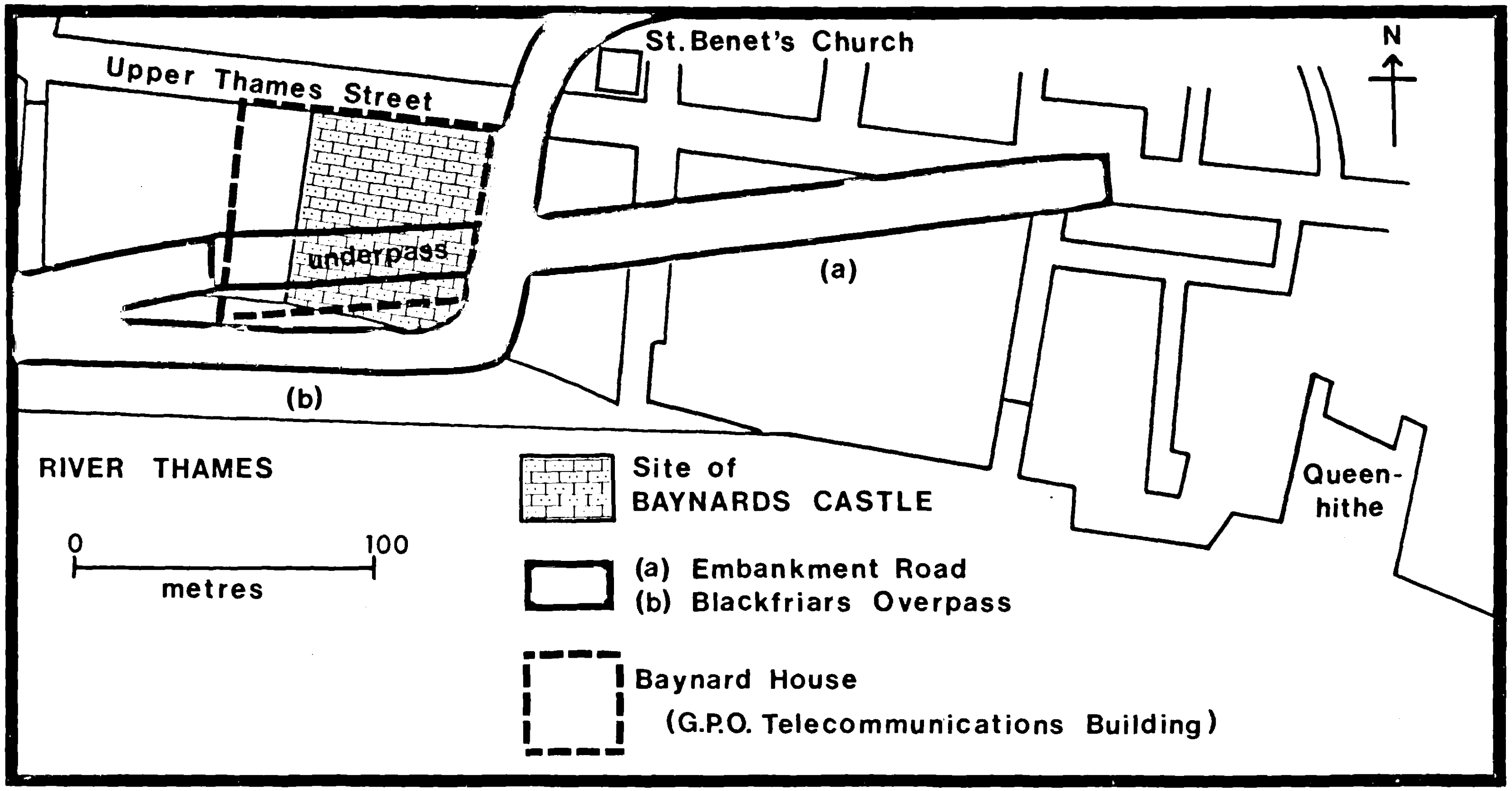
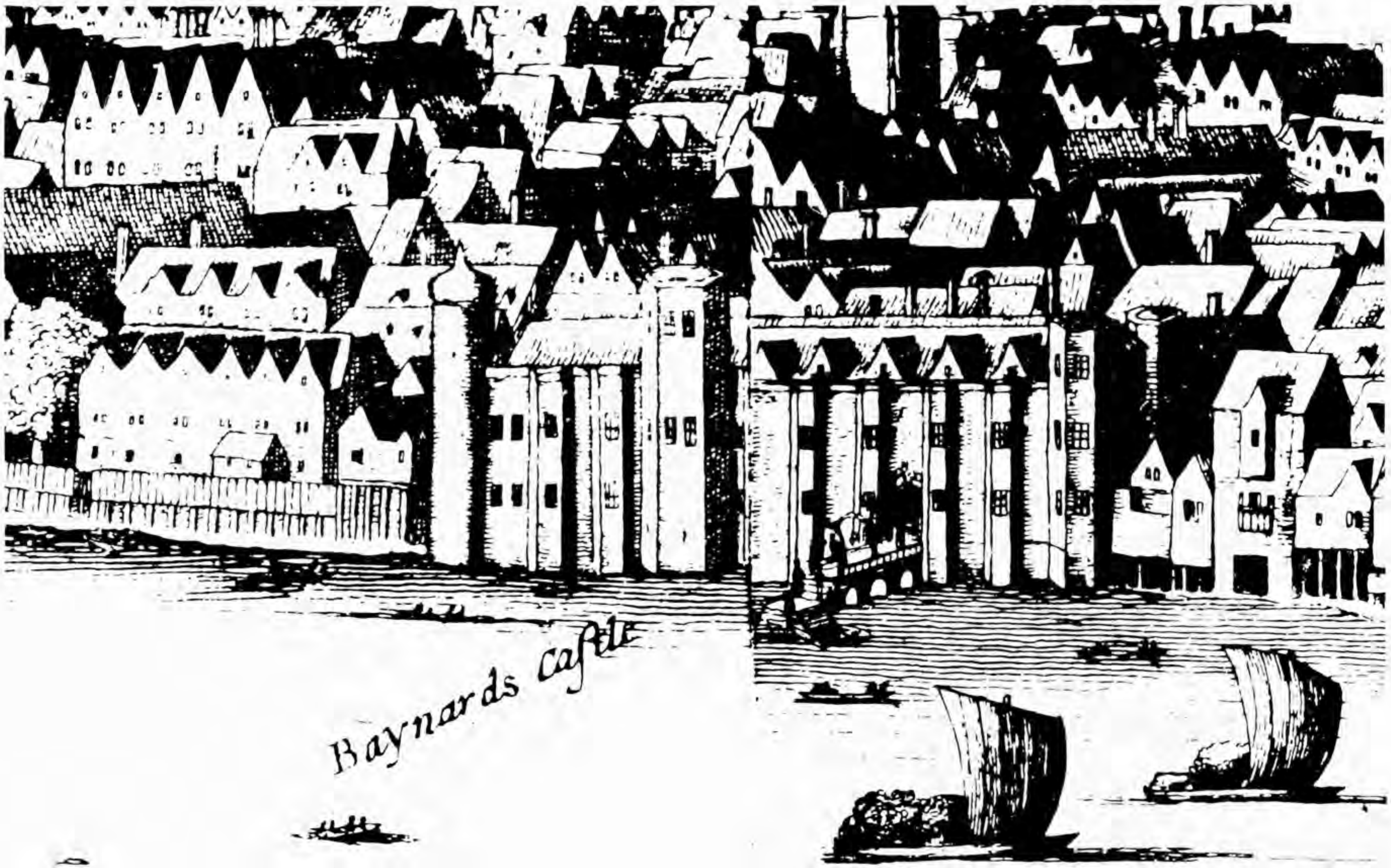


Map of the western end of Upper Thames Street showing the site of Baynard's Castle

Figure 2: Baynard's Castle, from an engraving made by Hollar just before the Great Fire of 1666 A D destroyed the building.

In this view of the castle, the two multiangular towers with the five square turrets spaced between them can be clearly seen. Before the building was converted to a palace by Henry VII in circa 1501 A D, a stone lined dock basin lay to the west of the castle (beneath the round tower and the central multiangular tower shown in this picture).


Baynards caſtle

Excavation of Baynard's Castle (1972-73)

Excavation on the site of Baynard's Castle revealed the masonry foundations of two multiangular corner towers together with the bases of five square turrets spaced between them (Marsden, 1972b, 1973). These structures once formed part of the riverside frontage of the castle and they are clearly shown in an illustration which appears in the 'Agas' woodcut map of London, circa 1561 AD (see Homes 1969, Fig. 4, p. 8; Marks, 1964, Plate IV), and in the famous engraving made by Hollar just before the Great Fire of 1666 AD (Figure 2). Unfortunately, no details of the interior lay-out of the building were forthcoming as the internal walls and partitions had been destroyed (Marsden, 1972a, p. 95). This was especially disappointing to the archaeologists as there are no contemporary plans of the castle. They did, however, discover evidence of the westward extension built onto the castle by the Earl of Pembroke in the latter half of the 16th century AD.

The deposits in which the animal bones were found

With the exception of several disturbed secondary dumps of rubbish, the deposits uncovered within the rubbish pits on the site of Baynard's Castle could be precisely dated. This is not always possible on urban sites as the stratigraphy is often confused and unclearly defined. Most of the artefacts and faunal remains were recovered from three major primary deposits of rubbish, these being:

Deposit	Date	Estimated volume of dump (cubic metres)	Description and nature of dump
1. Deposit 100	Rubbish dumped between c.1499 - 1500 AD	543 (only half of this dump was excavated)	In-fill of the stone lined dock basin which lay adjacent to the west wall of the castle. This dock basin was filled in with rubbish probably collected from the city although some of it may have originated from the castle. A walled garden adjoining the castle was then built on the reclaimed land in c. 1500 AD.
2. Deposits 1 & 23	Dumps dated to c. 1520 AD	12	In-fill of three 'robber pits' throught to have been situated inside the west walls of the palace and therefore it would seem likely that the contents represent refuse from the palace itself.
3. Deposit 250	Mid 14th century AD	48	An earlier accumulation of debris from the city, dumped for the construction of the dock basin.

Of the three dumps the dock basin deposit was by far the most prolific in its yield of artefacts. Included among the very large quantity of objects found in this deposit were the wooden planks from the keels of boats, iron knives, bronze cooking vessels, riding spurs, horse-bits, horse shoes, decorated leather dagger sheaths, leather shoes, and fragments of finely woven cloth. All of these finds were in a remarkably fine state of preservation. The almost solid deposit of rubbish was enclosed and sealed by a thick layer of waterlogged silt which had, by creating an anaerobic environment, largely prevented the natural process of decomposition, i. e. it had stopped the insidious destruction usually wrought on such material by the two processes of organic decomposition and oxidation. The discovery of such unusual finds as the hind limb of a rabbit with the skin and fur still attached, and the remains of a bird which still retained its feathers also bore testimony to the excellent conditions for preservation made possible by the waterlogged nature of the dump.

Evidence to substantiate the claim by Marsden, that the in-fill of the three 'robber pits' (deposits 1 & 23) represented refuse collected from the palace rather than from the city, was provided by the presence of fragments of stained glass windows and by the large number of potsherds of good quality redware, probably imported (perhaps from the Low Countries). Neither of these items appeared among the finds recovered from the contents of the dock basin dump, where the pottery was predominately of white Surrey ware.

Other smaller deposits of rubbish, ranging in date from the Roman period to the nineteenth century (deposits 3 to 5216), were also excavated but these were nearly all found to be of a disturbed or derived nature. The group of dumps provisionally dated to the 13th century AD (deposits numbered in the 5000 series), for example, represented refuse material dug up elsewhere in the city and subsequently redeposited on the Baynard's castle site. The contents of all the secondary dumps included sherds of Romano-British pottery and other residual items, making it difficult to assess the true age of the bone material recovered from them.

1.2 The faunal remains recovered from Baynard's Castle

Methods of recovery

Although the dumps of rubbish on the site of Baynard's Castle contained huge quantities of well preserved animal bone, only a relatively small proportion of this material was actually recovered for analysis. With limited financial support and faced with a restricted period of time in which to complete the excavation of this historic site, it was obviously impracticable to attempt a total recovery of the faunal remains. A strategy was therefore adopted (see below) employing different recovery techniques which were selected to suit the nature of each deposit. In this way the use of special methods of recovery (such as sieving), designed to provide a complete and unbiased sample of the available skeletal remains, was confined to the large primary deposits represented by the dock basin dump and the in-fill of the 'robber pits' within the castle grounds. It would have been far too costly an exercise to have sieved samples from all the rubbish dumps uncovered on the site, and would have been a wasted effort in the case of the disturbed and derived material. The different methods of recovery used for each of the deposits had important implications for the analysis of the bone material (see section 2.2) and they are therefore described in detail here:

(1) Deposits 100,88 & 89 — In-fill to stone lined dock basin c.1499-1500 AD

Excavation of the in-fill to the dock basin was carried out in a series of separate areas, each of which were originally assigned separate reference (context) numbers as follows:- 25, 34, 35, 39, 45, 46, 53, 55, 56, 68, 72, 73, 79, 83, 94, 150. As the building contractor had to move into certain parts of the dock early on during the excavation, it was necessary to excavate the dock basin as quickly as possible. The bones from all these areas were therefore collected in a 'random'* and somewhat hasty fashion. The high speed of recovery meant that there was preferential selection for the larger and more obvious bones.

In order to ease the task of handling and analysing the material, this series of bone samples was later combined to form one group which was then designated as deposit 100.

To try to obtain a more accurate and as far as possible, an inbiased sample of the animal bone (and the remains of plants and molluscs), one part of the dock dump was isolated and an attempt was made to collect all the bone (and other environmental evidence) by careful trowelling. This area was numbered as deposit 88.

A further part of the same dump was selected as being representative of the whole deposit and the volume of matrix contained within a section measuring 1m x 1m x 1.5m was extracted and sieved using a 5mm mesh sieve. It was hoped that by using a fine mesh sieve, the bones from small rodents would be recovered. This sieved sample was numbered as deposit 89.

(2) Deposits 1 & 23 — In-fill of three 'robber pits' c. 1520 AD

All the bones from the in-fill to the 'robber pits' located inside the grounds of the castle were recovered by sieving with a 5 mm mesh sieve.

(3) Deposit 250 — An accumulation of city debris and rubbish c. mid 14th century AD

Bones collected in a 'random'* fashion.

(4) Deposits 5001 to 5216 — Mainly disturbed or derived (secondary) dumps of city debris and rubbish mostly 13th century AD (pre castle phase)

'Random'* collection of samples of the bones present in these dumps.

*Footnote: Definition of the word 'random'

A clear distinction should be made between the meaning of the word 'random' as used by the archaeologist (* above) and its meaning when used by the statistician. To the latter the term 'random sampling' is a precise description of the procedure employed for investigating the properties of a population, and implies that the sample so obtained will provide an accurate and unbiased picture of that population (see Snedecor & Cochran, 1967. p.11). Whereas the sample of bone recovered through 'random collection' by the archaeologist will almost invariably be biased in favour of the larger animals; the bones of the smaller species such as rodents frequently being missed (see Payne, 1972a, p.49, 1975, p.7; Uerpmann, 1973, p.308; Watson, 1972, p.221).

The bird, fish and mammal bones

The total collection of faunal remains from the site of Baynard's Castle was presented to the BritishMuseum (Natural History) with the intention that a full analysis should be made of the material. Analysis of the bird, fish and mammal bones was carried out independantly as follows:-

(1) Bird bones by Mr. D. Bramwell

(2) Fish bones by Mr. A. C. Wheeler, Department of Zoology BM(NH)

(3) Mammal bones by Mr. P. L. Armitage, postgraduate research student, Department of Zoology, BM(NH).

The reports on the bird and fish bones have been summarised below, whilst the report of the analysis carried out on the mammalian remains is the subject of this thesis and is given in full in section 3 below.

(1) The bird bones

Identification of the bird bones was carried out by Mr. D. Bramwell, a brief summary of his report (Bramwell, 1975) is given here.

A total of 4,515 bones were analysed and the following identified:

Domestic birds

1.	*Gallus gallus*	domestic fowl
2.	*Anser anser*	domestic goose
3.	*Anas platyrhynchos*	domestic duck
4.	*Pavo cristatus*	peafowl
5.	*Columba livia*	domestic dove
6.	*Phasianus colchicus*	pheasant

Wild birds, 50 species identified, including:

1.	<u>Otis tarda</u>	great bustard, probably from the Sussex downs.
2.	<u>Grus grus</u>	crane
3.	<u>Botaurus stellatus</u>	bittern
4.	<u>Milvus milvus</u>	red kite

Birds used in the sport of falconry

1.	<u>Accipiter nisus</u>	sparrow hawk
2.	<u>Falco peregrinus</u>	peregrine falcon

The list of wild species is the most comprehensive yet to appear for late medieval and early Tudor London. From the percentages of wild birds for various habitats it is evident that the most frequently occurring species from Baynard's Castle were those that inhabited the river and its banks.

Birds	of the	river	40%
"	"	mud flats and shore	22%
"	"	marshland	4%
"	"	fields and cultivation	16%
"	"	woods or parkland	12%
"	"	chalk downs	2%
"	"	the urban area	4%

Evidence that the inhabitants of the palace enjoyed better quality food, as will be described for the mammals (section 3 in this thesis), is provided by the great diversity of wild species identified from the bird bones recovered from the three 'robber pits' (deposits 1 & 23). With the domestic birds it appeared that the flesh of goose was more important in the medieval diet than that of the fowl. The presence of bones of immature doves suggests that squabs, or fat young birds were used as a source of meat.

There is some evidence provided by the male tarso-metatarsal bones (from deposits 250 & 100) for the sport of cockfighting in mid 14th and late 15th century London.

(2) The fish bones (A. C. Wheeler)

A list of the species identified, arranged in descending order of abundance, is given here:

1.	*Gadus morhua* L.	cod
2.	*Conger conger* L.	conger eel
3.	*Molva molva* L.	ling
4.	*Scophthalmus maximus* L.	turbot ('flatfish')

Also represented, but in very much smaller numbers:

1.	*Acipenser sturio* L	sturgeon
2.	*Rutilus rutilus* L.	roach
3.	*Salmo salar* L.	salmon.

The presence of bones of conger eel is interesting and suggests that medieval fishermen exploited the fish stocks in the Channel and west-coast waters as well as those in the North sea.

A more detailed report on the fish bones is in preparation and will appear in the report on the excavations at Baynard's Castle (Marsden, in preparation).

2. IDENTIFICATION, MEASUREMENT AND ANALYSIS OF THE MAMMALIAN REMAINS

2.1 Aims of the research.

The rescue excavation carried out on the site of Baynard's Castle during 1972-73 was unprecedented in London, and for the first time a very large quantity of well preserved mammalian bone from precisely dated deposits was made available for analysis. Prior to this excavation, many of the details relating to the social and economic aspects of everyday life in late medieval London had either to be based on evidence provided by historical documentation or from assumptions drawn from information supplied by archaeologists working on contemporary sites in other cities. The recovery of a very large collection of faunal remains from Baynard's Castle therefore presented a unique opportunity to study the ways in which the late medieval and early Tudor society of London exploited its animal resources, both wild and domestic.

A brief description of each of the main lines of enquiry pursued during the course of this study is given here:

(1) Identification of all the mammalian remains.

(2) Estimation of the relative numbers of the domestic and wild species represented.

(3) Determination of the ages at which the livestock were slaughtered, or died.

(4) Determination of the relative numbers of male, female and castrated individuals among the remains of the domestic livestock.

(5) Estimation of the size and conformation of medieval livestock and comparison of the results with similar information relating to modern farm animals.

(6) Comparison of the cattle, pig and sheep bones with those from other archaeological collections held in the British Museum (Natural History) and elsewhere, in order to assess the stage reached in the development of breeds of livestock in Tudor England.

(7) Assessment of the incidence of disease and deformity among medieval livestock.

(8) Examination of the small mammal bones with special reference to the remains of the Black rat Rattus rattus L. and the domestic rabbit Oryctolagus cuniculus.

(9) Investigation into the techniques associated with butchery and bone-working.

(10) Comparison of the faunal remains collected from the three 'robber pits' (thought to have been within the grounds of the castle) with the animal bones from the dump of city rubbish outside the west wall of the castle, in order to investigate possible differences between the diet of the nobility and that of the commoners.

(11) Investigation into existing methods of analysis and interpretation of numerical data relating to animal bones from archaeological sites, and the development of new statistical methods.

(12) Verification of the results obtained from the osteological study using evidence provided by historical documentation of the period.

2.2 Methods of analysis

The mammalian remains from each of the three major dumps of rubbish (deposits 1 & 23, 100, 250) and from selected secondary dumps (deposits numbered in the 5000 series) were first washed and then sorted according to the following four categories:-

I. Identifiable bone: Specimens that could be readily identified to species and part of skeleton. Ribs and vertebrae were excluded from this group.

II. Ribs and vertebrae: Ribs and vertebrae from the large as well as from the smaller mammals. With the exception of several samples of ribs and vertebrae from sheep, cattle and pig which were examined for evidence of butchery, no attempt was made to identify these bones according to species.

III. Scrap: Bone fragments that could not be identified either to species or to part of skeleton. This category represented bone that had been broken and severely fragmented through butchery or as a result of natural destructive processes.

IV. Other remains: Fur, wool, hair, and horn sheaths.

For the purposes of the statistical analysis, the first category was further sub-divided into:-

I.1 Measurable bone: Complete bones and bone fragments with at least one measurable feature, for example, a broken long bone retaining either the distal or proximal epiphysis. Although there were a number of complete extremity bones (metapodial bones and phalanges) from dog, cat and rabbit, none of these was measured as they would not have contributed any more information to that already obtained from the other, larger bones of these species.

I. 2 Non measurable bone: Specimens lacking measurable features, for example, the splintered shafts of long bones, and bones from juveniles and sub-adults with unfused (detached) epiphyses. Such speciments were still important to the study as they provided details relating to butchery practice and pathological conditions.

Acknowledgement should be made to the three students who were responsible for carrying out the preliminary sorting of the faunal remains according to species and part of skeleton. Miss Linda M. Sloan and Mr. Alistair D. Morton worked on the material on a full-time basis between 11th December, 1972 to 8th January, 1973, and Mr. Roger Jones (now at the D. o. E. Ancient Monuments Laboratory, Fortress House, London) who subsequently took over, working part-time from 22nd October, 1973 to 10th December 1973. Had it not been for their efforts, my task of analysing and interpreting the data from the material would have been very much more difficult. Although many boxes of unwashed and unsorted bone remained to be dealt with, I was able to start almost immediately with the second stage of sorting into groups of measurable and non measurable bone.

Measurements were taken from the specimens comprising group I. 1 using dial calipers (Mitutoyo no. 505 - 635, range 300mm with dial graduations of 0.05mm) and followed those described in the works by von den Driesch (1974, 1976). For linear measurements over 300mm and for measuring the horn cores of cattle and sheep, a flexible tape measure was employed. In order to establish the level of accuracy of measurement, selected specimens of sheep limb bones (radius & humerus) were measured for a second time after one year and the following results obtained:

Radius: Proximal width

Out of a sample of 30 specimens from deposit 1 :-

16 had the same measurement

9 had a 0.1mm difference between the 1st and 2nd measurement

2 had a 0.2mm " " " " "

2 had a 0.3mm " " " " "

* 1 had a 2.1mm " " " " "

Range of discrepancy (difference expressed as % original measurement):

0% to 1% (plus 1 specimen with a 7% error*)

Mean 0.21%

*Represented an error made whilst recording the data.

Humerus: Distal width

Out of a sample of 30 specimens from deposit 23 :-

3 had the same measurement

9 had a 0.1mm difference between the 1st and 2nd measurement

3 had a 0.2mm " " " " "

1 had a 0.3mm " " " " "

5 had a 0.4mm " " " " "

3 had a 0.5mm " " " " "

2 had a 0.6mm " " " " "

2 had a 0.7mm " " " " "

1 had a 0.8mm " " " " "

1 had a 1.1mm " " " " "

Range of discrepancy (difference expressed as % original measurement): 0% to 4% Mean 1%

The inconsistencies found on comparing the second set of measurements with the original data reflected the difficulties of locating and repeating the measurements on precisely the same points. With the humerus, the occasional presence of bony outgrowths (exostoses) and 'irregularities' in shape of the articular condyles meant that measurement of the width across the distal epiphysis could not always be taken with the required degree of precision, unlike measurement of the proximal width of the radius.

All the sorted bone was weighed in order that the relative proportion of material represented by each of the categories I, II and III could be calculated. The bags of scrap material, also those containing the ribs and vertebrae, were weighed in bulk using a Salter spring balance (no. 23500, range 50lb) and the weights converted to Kg. Other bone material was weighed using a Mikro-Döft balance (range 6 KG).

As the mammalian remains from Baynard's Castle were to be included in the collection of archaeozoological material held by the British Museum (Natural History), all the specimens examined, but excluding those in categories II & III (i.e. the scrap, ribs, and vertebrae), were assigned the following registration numbers:

ARC 1975.6000 to 1975. 11195

ARC 1976.6000 to 1976. 6575

A detailed list of the collection is held on file by the Electronic Data Processing Section of the BM (NH), and forms part of the computer-based catalogue currently being compiled by Dr. J. Clutton-Brock in collaboration with Dr. D.B. Williams (see Clutton-Brock, 1975).

Any bone exhibiting cracks or surface flaking was treated with P.V.A. (Vinamul 9146, 50% solution with distilled water). All the faunal remains were packed into labelled, cardboard boxes which were then stored in the osteology room at the BM (NH).

To obtain a picture of the proportions of the different species represented by the skeletal remains in the archaeological record, archaeozoologists have previously used either the number of identified specimens or estimates of the minimum number of individuals per species, as discussed by Chaplin (1971, p. 63-75). The validity of such an approach has been increasingly questioned and the limitations to such methods summarised by Payne (1972b, p. 68-71) and Uerpmann (1973). The concept of the minimum number of individuals and its basis for deriving the proportions of the different species is, I believe, particularly inappropriate to the study of faunal remains from the urban dumps such as those uncovered on the site of Baynard's Castle. There are three main reasons for this, firstly, apart from sieved samples, the often uncontrolled recovery of the bone ('random' collection) means that the samples sent to the archaeozoologist are not truly representative of the contents of the dumps, and are usually biased in favour of the larger bones from the larger species. Secondly, the very large quantities of bone from such deposits usually renders the exercise of calculating the minimum number of individuals impracticable. Thirdly, even when this value can be established, the diversity of sources of the bone (household, slaughter-yard and workshop etc.) makes interpretation of the results very difficult. Butchery practices can also be an important factor in determining the composition of bone in a rubbish dump and can, in certain instances, restrict the validity of the information relating to diet gleaned from the estimates of the minimum number of individuals for the meat-yielding species. This aspect was neatly demonstrated by Guilday (1970) in his analysis of the faunal remains from Fort Ligonier, an 18th century British army fort situated between Carlisle and Pittsburgh. The calculated value for the quantity of meat consumed, derived from the estimation of the minimum number of individuals multiplied by estimates of useable meat, would have sustained the full compliment of soldiers for just one day, whereas the contemporary records showed that the fort had been continuously occupied between 1758 and 1766. Included in the list of provisions supplied to the men at the fort during this period were large quantities of boned salt pork, an item which had left no archaeological trace.

For the reasons discussed here, I did not attempt to derive an estimate of the minimum of individuals for each of the species identified from the material from Baynard's Castle. Instead, greater emphasis was placed on the study of the animals themselves, and also on such aspects as butchery and bone-working, as well as an assessment of the relative proportions of wild and domestic animals identified, based on the weight of their skeletal remains recovered from the sieved samples.

The report on the analysis is presented below (section 3). The nomenclature used throughout to describe various features of the individual bones from the different species identified is based on that given in the works of Barone et al (1973); Hughes & Dransfield (1953); Schmid (1972) and Sisson (1964).

2.3 Processing the collected data by means of an electronic digital computer.

Before the measurements and observations collected from the mammalian bones could be interpreted, this information had first to be processed i.e. sorted, summarised and tabulated. The summary of the data is given in section 4.

To handle the large amount of data collected from the skeletal remains of cattle, sheep and pig (over 40,000 measurements) required the use of the Varian computer at the BM (NH). Although several weeks were spent planning the operational procedure to be followed, and with writing and testing the computer programs, the processing of the information by means of the computer required less effort and less time than would have been needed if manual, mechanical or punched-card data processing methods had been employed. For the much smaller quantity of bone from cat, dog, rabbit, rat and deer, however, the information collected, was processed by hand and the statistical analysis performed with the aid of a desk-top calculator.

Figure 3 shows the procedure followed in the processing of the data. Essentially the system can be subdivided into the following three sections:

1. Recording the data
2. Transcription and screening of the data
3. Processing the data by computer

Taking each of these sections in turn:

FIG.3

Procedure for processing data by computer

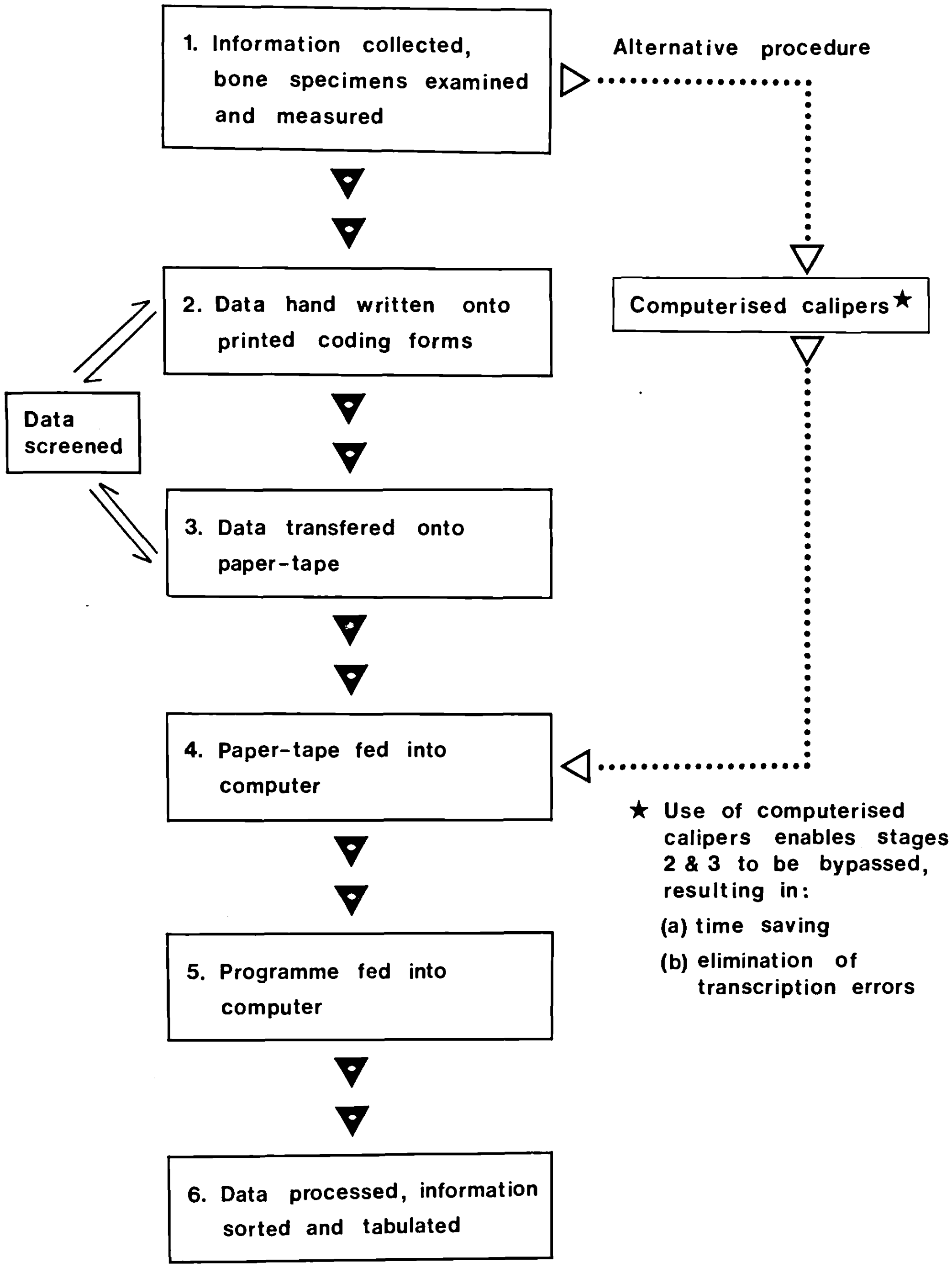


Figure 4: Fortran coding form.

4(a) Fixed format used in recording data

4(b) Example of a completed coding form

To face page 23

4a

AUTHOR	P.L.ARMITAGE	DATE OCT.,1974
JOB NUMBER		PAGE 1 OF M.S.
JOB NAME	MASTER SHEET	(Long Bones)

FORTRAN CODING FORM

Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8	Field 9	Field 10	Field 11	Field 12	Field 13	Field 14	Field 15	Field 16	Field 17	Field 18	Field 19
REG. NUMBER	SPECIES	PART of SKELETON	COMPLETENESS	LEFT / RIGHT	WEIGHT of BONE	AGE CLASS	LENGTH	PROXIMAL WIDTH	DISTAL WIDTH	PROXIMAL DEPTH	DISTAL DEPTH	WIDTH at MID-SHAFT	PATHOLOGY	BUTCHERY	BONE ALTERATION	SEX	ANY OTHER MEASUREMENT (SPECIFY)	DEPOSIT NUMBER

4b

AUTHOR	P.L. Armitage	DATE 14th Oct. 75
JOB NUMBER	B /23/1	PAGE 1 OF B/23
JOB NAME	CATTLE METACARPALS	B.C. Deposit # 23

FORTRAN CODING FORM

8556	B	21	A	1	414	R	238·3	68·2	71·8	39·3	35·1	41·6	NN	NN	M	U	75·5	23
8557	B	21	A	1	263	R	205·1	63·1	58·3	34·6	29·6	36·2	NN	NN	M	U	64·5	23
8558	B	21	A	1	284	R	201·5	61·1	58·7	34·4	27·9	37·7	NN	NN	M	U	64·6	23
8559	B	21	A	1	196	R	197·2	60·0	55·8	32·6	27·2	34·2	NN	NN	M	U	61·5	23
8560	B	21	A	1	256	R	196·2	59·4	57·9	34·1	27·5	33·5	NN	NN	M	U	65·7	23
8561	B	21	A	1	252	R	200·2	61·1	57·5	34·2	28·8	35·4	NN	NN	M	U	63·4	23
8562	B	21	A	1	222	R	188·1	60·8	56·2	33·3	27·9	33·8	NN	NN	M	U	61·2	23
8563	B	21	A	1	290	R	208·3	60·4	62·8	34·7	30·1	36·0	XM	NN	M	U	68·8	23
8564	B	21	A	1	292	R	208·2	63·2	61·9	35·6	28·7	35·1	NN	NN	M	U	66·2	23
8565	B	21	A	1	185	R	183·5	54·4	52·9	34·2	25·2	30·1	NN	NN	M	U	58·4	23
8566	B	21	A	1	250	R	198·8	59·9	61·6	33·1	31·1	34·3	NN	NN	M	U	62·9	23
8567	B	21	A	1	261	R	206·4	60·7	56·5	34·3	27·6	33·0	NN	NN	M	U	64·5	23
8568	B	21	A	1	261	R	205·6	61·6	58·2	33·9	28·6	33·6	NN	NN	M	U	67·7	23
8569	B	21	A	1	236	R	196·1	60·8	57·7	34·3	27·2	34·0	NN	NN	M	U	62·5	23
8570	B	21	A	1	242	R	189·8	59·0	60·5	32·9	30·5	35·9	NN	KP	M	U	63·0	23
8571	B	21	A	1	294	R	196·6	66·0	61·7	35·9	28·9	39·8	XM	KP	M	U	74·7	23
8572	B	21	A	1	296	R	206·8	62·5	61·7	34·1	28·9	37·4	NN	NN	M	U	65·0	23

Processing the collected data (continued)

1. Recording the data

The data collected were recorded on standard 80 column coding forms according to a fixed format (Figure 4a). The 80 columns were grouped into 19 fields, each field held either quantitative data or qualitative information (in numeric or in alphabetic code). This arrangement of fixed length fields, separated by a space after each field facilitated checking of the recorded information. Each row (there are 25 to a coding form, and each is referred to as a record) was used to hold the information relating to a single bone specimen. An example of a completed coding form, for cattle metacarpal bones from deposit 23, is shown in Figure 4b.

By coding with alphabetic characters instead of in numeric form, details of pathology, butchery and bone alteration on the record sheets and on the final computer print-out were more easily interpreted without continual reference to the keys. As I wrote my own programs, provision was made for handling the two forms of coding. A number of computer program packages currently available, however, will not readily accept data presented in this way and had these been employed, all information would have had to be encoded in numeric form with a decoding subroutine written into the main program to translate certain elements of the output into the required alphabetic code.

2. The transcription and screening of the data

Information recorded on the coding forms was transferred by means of a Flexowriter onto punched paper-tape, prior to being fed into the computer.

The accuracy of the output from any data processing system, and from any subsequent data analysis, is dependant on the reliability of the information fed into the computer and as large quantities of data will inevitably contain some errors, data processing systems must therefore incorporate some form of data screening. Apart from the occasional failure to record measurements accurately, the principal source of error lies in the transcription stage when the data are being copied from the coding forms onto punched paper-tape. It was at this stage therefore that I carried out the most stringent checking procedure, each entry on the typed copy produced by the Flexowriter during the operation of transcription was verified against the information written on the coding form, this procedure being carried out manually. A computer program to detect gross errors (see Appendix A, Program Two, gross error control), based on the method described by Naus (1975, p. 41), was however employed to screen the measurements taken from the sample of 192 complete metacarpal bones from deposits 1 and 23. For a given set of observations on a variate, one or more of these may appear to be extreme or unusual, these outliers can be readily isolated if the observations of the variate are assumed to have a normal distribution. Large bodies of data with many variables, as for example the data relating to the sample of cattle metacarpal bones, usually have to be screened by the computer as manual checking is tedious, time-consuming and, in some instances, often impractical.

Had they been considered necessary, other screening procedures could have been built into the dataprocessing system. For example, the record for a complete specimen should always contain values for all the variates while a fragmented bone will only contribute one or two values, a program can therefore be written to check that this is so. With broken or butchered specimens the record can be scanned by the computer to ensure that the available measurements taken have been placed in the correct fields on the coding form. For example, the character 'J' in field 4 (degree of fragmentation) on one of my recording sheets denoted a long bone that had lost its proximal epiphysis and part of the shaft. As such a specimen could only have provided values for fields 10 & 12 (width across the distal epiphysis and distal epiphysial depth respectively) any other measurement present in that record would be erroneous.

3. Processing the data by computer

Data fed into the BM (NH) computer were temporarily held in store by being assigned either to one of the available discs or to magnetic tape. As an asterisk (an alphabetic character) had been used to denote a missing value of variate, a special program (see Appendix A, Program One) that converted this into a numeric character (-99.9) had to be written; only when this transformation had been completed were the data accepted by the computer. Each line of information entering the computer was displayed on a Visual Display Unit. This allowed the data flow to be monitered, enabling erroneous entries to be detected and, at the same time, provided an opportunity to check to ensure that there was no malfunctioning of the paper-tape reader on the machine.

Following the instructions laid down in the prepared programs, selected elements of the data were then retrieved from storage, processed and the results made available in the form of a printed sheet produced by a Line-printer. Printed in Appendix A in this thesis are the computer programs used to process the information relating to the mammalian bone material from Baynard's Castle, all are written in standard Fortran IV. In order to set them out clearly and correctly, each of the programs shown in Appendix A was reproduced by the museum's Flexowriter from the original punched paper-tapes.

The processing was carried out in two separate steps i. e. in two runs on the computer. First the qualitative information relating to completeness of bone specimen, and evidence of butchery and bone alterations (burning and gnawing etc.) was extracted from the magnetic disc (or from the magnetic tape), sorted according to deposit, species, age of individual and part of skeleton, and then summarised (see Program Three, main sorting program). In the second step the numerical data i. e. the measurements taken from the bone specimens, were retrieved from storage, sorted as before and, using the observations on each variate, the mean, range, standard deviation and number of values recorded were calculated (see Program Four, summary program for numerical data). For the complete cattle metacarpal bones, the height at the withers was also calculated (see Program Five) using the methods of Fock and Boessneck, as described by Clason (1967, p.103) and von den Driesch & Boessneck (1974, p.336).

Future developments in the field of automatic data processing.

The recent acquisition by the Central Services Department of the BM (NH) of the components for building an electronic digital measuring device (or computerised calipers) will undoubtedly revolutionise the collection and processing of osteometric data at the museum. With electronic measuring equipment the actual sequence of data processing described previously will remain unchanged but the task of preparing measurements for input to the computer will be greatly simplified (see Figure 3, alternative procedure).

3. REPORT ON THE MAMMALIAN REMAINS

3.1 Introduction

A total of 11,381 mammalian bones were identified and measured. As the specimens were to be included in the collection of archaeozoological material held by the BM(NH), details of the remains were entered into the museum's computer-based catalogue (see section 2.2 above). I was therefore able to obtain, on request to the Electronic Data Processing Section of the BM (NH), a computer print-out which listed all the bones which had been identified, arranged according to deposit and species. Acknowledgement should be made to Dr R. F. Eastwood and Mr. G. C. MacPherson of the EDP section, BM(NH) who were responsible for processing the information and producing the print-out. Selected entries from this list have been summarised in Table 1, which shows the number of bones from each of the major dumps of rubbish. Details of the mammalian bones from the other, smaller deposits have been omitted from the table; for information on these finds see under the separate tables for each species in section 3.2 below.

All bone that had been recovered from the site through sieving was weighed, a synopsis of the recorded data being presented in Table 2.

Table 1: Number of bones from each of the mammalian species identified. Major dumps of rubbish only.

	Castle pits	Dock basin			City debris	Secondary dumps[1]
	c. 1520 AD	c. 1499-1500 AD			c. mid 14th cent. AD	mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
1. Domestic species:						
horse	2	1	1	18	0	9
cattle	973	399	78	1099	226	243
sheep	1363	524	112	1458	354	208
goat	0	0	0	4	12	8
pig	279	152	39	749	391	448
dog	138 (1)	1	2	83 (1)	2	2
cat	39	260 (3)	0	53	18	NE
rabbit	690 (1)	139 (1)	61	346 (1)	29	NE
2. Wild species						
Elk (?)	0	0	0	1	0	~~NE~~
Red deer	2	0	0	2	2	NE
Fallow deer	75	9	1	22	13	NE
Roe deer	0	0	0	0	0	1
hare	6	2	0	2	6	NE
Black rat	10	6	1	22	7	NE
hedgehog	0	1	1	0	0	NE
House mouse	0	15(1)	0	0	0	NE
3. Human:	1	0	0	2	0	2
Total:	3578	1509	296	3861	1060	921

Key:

1. Secondary dumps: Numbers of bone refer to selected samples only.

NE Bones of this species were not examined.

___ Values underlined include number of bones from articulated skeletons.

( ) Number of articulated skeletons recovered

Table 2: Weight of mammalian bone recovered. Sieved deposits only.

All weights are given in grams.

	Deposits 1 & 23 c.1520 AD	Deposit 89 c.1499-1500 AD
I. IDENTIFIABLE BONE:		
I.1 Measurable bone		
horse	258	36
cattle	103025	4662
sheep	30913	1258
pig	5464	606
dog	1528	2
cat	164	0
rabbit	934	80
Red deer	600	0
Fallow deer	3017	15
hare	16	0
Black rat	13	1
hedgehog	0	2
	145932	6662
1.2 Non measurable bone		
cattle	34719	
sheep	7444	Weights included in value for category III (scrap)
pig	2251	
dog, cat & rabbit	646	
	45 060	
II RIBS & VERTEBRAE	59835	6223
III SCRAP	69851	8750
Total weight of all bone:	320, 678	21, 635

Proportion of material represented by each category (expressed as % total weight):

Category	Deposits 1 & 23	Deposit 89
I.1 Identifiable (measurable) bone	45%	31%
II. Ribs & Vertebrae	19%	29%
I. 2 Identifiable (non measurable) bone & III. Scrap	36%	40%

3.2 The species identified

The animal remains are described in systematic order under species:

DOMESTIC SPECIES:[1]

(1) HORSE — Equus (domestic)

Compared with the large quantity of bone from cattle, sheep and pig, there were relatively few horse bones (Table 1), only 32 specimens being identified (Table 3). Most of these came from the dock basin dump (deposit 100), whilst only two were found in the 'robber pits' (deposits 1 & 23) inside the walls of the castle, and none from the city debris (deposit 250).

1. In accordance with the modification to the system of zoological nomenclature proposed by Groves (1971), I have not used subspecific names for the domestic animals.

Table 3: Horse. Number of bones identified and examined.

	Castle pits c. 1520 AD	Dock basin c. 1499-1500 AD			City debris c. mid 14th cent. AD	Secondary dumps[1] mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
skull	-	-	-	-	-	-
maxilla	-	-	-	1	-	-
mandible	-	-	-	-	-	-
tooth	-	-	1	2	-	4
scapula	-	-	-	2	-	1
humerus	-	-	-	1	-	-
radius	-	-	-	-	-	-
ulna	-	-	-	1	-	-
innominate	-	-	-	1	-	-
femur	-	-	-	-	-	-
tibia	1	-	-	-	-	1
calcaneum	-	-	-	-	-	-
talus	-	-	-	1	-	-
metapodia	-	-	-	2	-	2
phalanx 1	-	-	-	3	-	-
phalanx 2	1	1	-	1	-	-
hoof core	-	-	-	1	-	1
vertebra	-	-	-	2	-	-
Total:	2	1	1	18	0	9

Key: 1. Secondary dumps : Numbers of bone refer to selected specimens only.

Other deposits:

Deposit 80 c.15th century AD mandible 1

This scarcity of skeletal remains of horse is due in part to the fact that horse-flesh was not eaten in the late medieval period, as discussed below. It is also to be expected that an urban site such as Baynard's Castle will yield low numbers of equid bones, and is a reflection of the method of disposal of dead, or slaughtered horses. The disposal of a rotting horse carcass in a refuse dump situated close to human habitation would not have been a regular or allowable practice in medieval times. As early as the thirteenth century AD, an extensive organisation had been set up in the City of London charged with the task of improving the levels of hygiene and sanitation. Under the direction of the mayor and aldermen, the local authorities were empowered to impose severe fines on persons who had illegally dumped any obnoxious refuse which was likely to cause offence and a threat to the health of the inhabitants (Sabine, 1937). Old, redundant horses would probably therefore have been sent to the nearest knackers yard, and only a few of the discarded, defleshed bones would eventually find their way into the rubbish dumps.

Unlike the bones of cattle, sheep and pig, those of horse did not display butchery marks, and as stated above horse-meat was not an item in the diet of late medieval/early Tudor man. During the medieval period, the consumption of horse-flesh was rigorously opposed by the Roman Catholic Church (Clason, 1967, p. 60), and Fynes Moryson in 1617 AD (quoted in Wilson, 1973, p. 71) observed that 'only the wild Irish will feed upon horses dying of themselves, not only upon small want of flesh, but even for pleasure'. Horse-meat may have been fed to dogs as the following specimens from Baynard's Castle exhibited perforation holes made by the teeth of dogs (see Bonnichsen, 1973):-

Reg. No.	Bone	Description
75. 9941	humerus	proximal epiphysis partially destroyed by gnawing
75. 9948	scapula	edge of blade splintered
75. 6489	ulna	olecranon gnawed

All specimens from deposit 100

Many authors have recognised the value of the wear patterns shown by the incisor teeth when establishing the age of a particular horse, see for instance: Youatt (1855, p.194-209); Miles (1890, p.106-109); HMSO (1908, p. 35-45) and Silver (1971, p. 292-293). Using these works and by comparison with the collection of mandibles of known age at the BM (NH), the ages of the individuals represented by the fragment of premaxilla bone (specimen 75. 9946, deposit 100) and the complete mandibular ramus (specimen 75. 9945, deposit 80) were established:-

Premaxilla

Upper corner incisor (I 3) in full wear with 'Galvayne's mark' (a groove-like depression on the outer surface) just visible. Incisor long, projecting forwards and 'hooked' in appearance. Canine tip blunt (worn).

Age: Approximately 11 years.

Left mandibular ramus

Complete dentition; cheek teeth fully erupted with the biting surface (table) in wear. Table of incisor row level, corner incisor (I 3) in full wear.

Mark (infundibulum) still present in I 2 & I 3.

Age: Approximately 6 to 7 years.

Using the criteria described by Sisson (1964, p.111) and by comprison with the pelves of known sex at the BM(NH), the innominate bone (specimen 75,9947) from deposit 100 was identified as possibly male. Both the premaxilla and mandibular ramus had well developed canine teeth, which are only to be found in the male and castrate.

For each of the complete limb bones (humerus & metacarpal bone) the height at the withers was calculated after the method of Kiesewalter (1888):-

Reg. No.	Bone	Height at the withers
75.9941	humerus	139 cm = approx. 13.7 hands
75.9942	metacarpal bone	144 cm = approx. 14.2 hands

(1 hand = 101.6 mm)

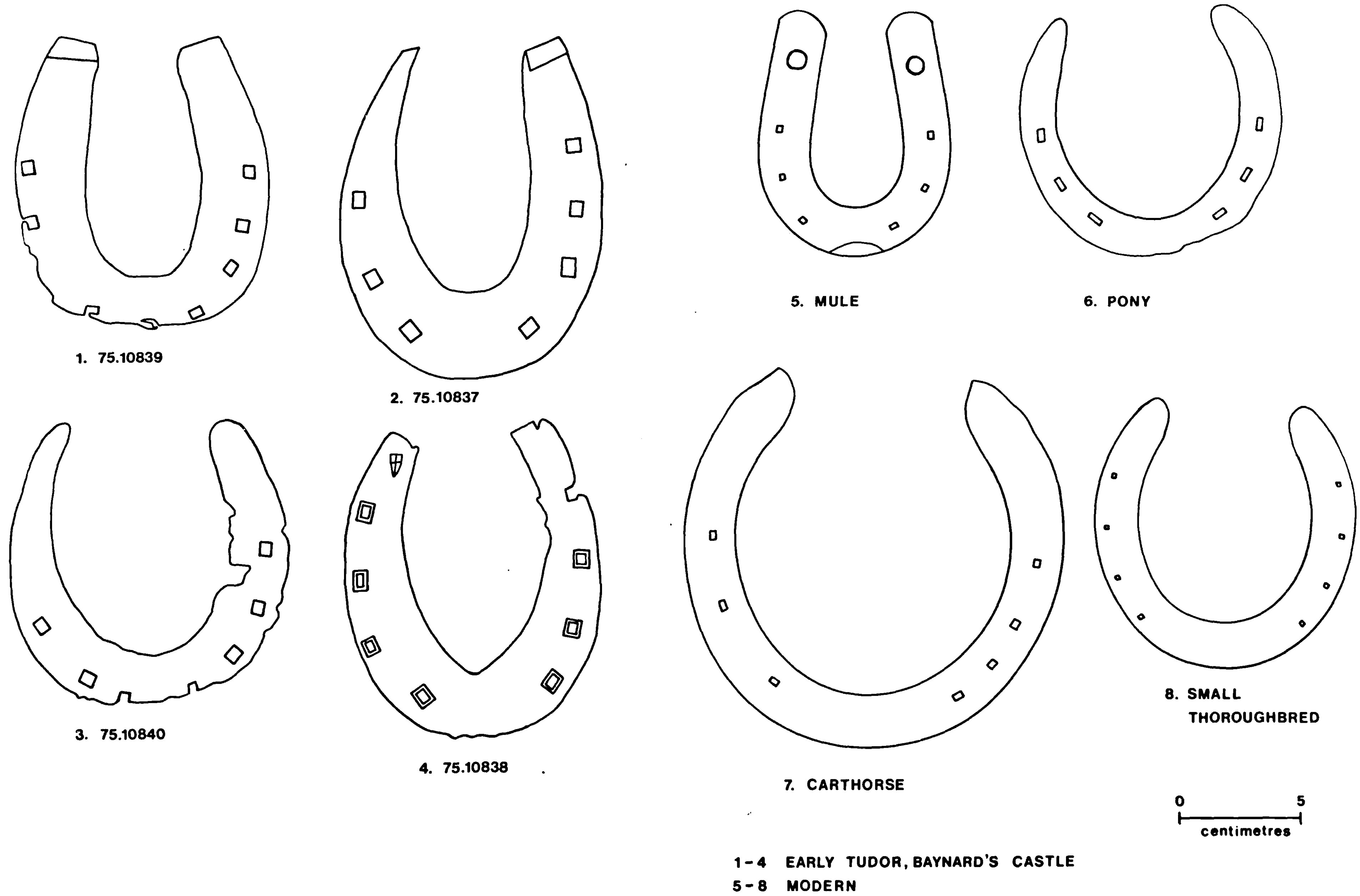
Although there is no absolute and direct relationship between hoof size and height, where size of hoof may vary even between individuals of the same height, age and breed (Littauer, 1975, pers. comm.), it was apparent from comparing the four complete horseshoes (specimens 75.10837 to 75.10840*) from the dock basin against modern examples (Figure 5) that they had belonged to small/medium sized horses.

It was during the Tudor period that repeated attempts were made to upgrade the English horse-stock. In order to prevent breeding from the undesirable animals, Henry VIII in an act of parliament (Act 27, 1536 AD) required that mares used for breeding purposes had to be at least 13 hands in stature, and served by stallions not less than 14 hands. Further legislation (Act 38, 1541 AD) prohibited the depasturing on common land of stallions over two years of age who were under 15 hands (Miles, 1890, p. 54; Trow-Smith, 1957, p. 254). In spite of these and subsequent acts aimed at restricting the breeding and rearing of small horses, these measures proved to be ineffective, and the average height at the withers, except for those animals bred from imported stock, remained at about 13 hands until well into the seventeenth century (Dent & Goodall, 1962, p.143).

In the fourteenth and fifteenth centuries AD, horses were kept in stables located in the lanes down to the waterfront of the Thames, these animals being employed to cart various merchandise to and from the wharf near Baynard's Castle and the quay at Queen-Hythe (Sabine, 1937). It is possible that some of the bones from the dock basin dump are the remains of these cart and pack-horses.

*Reg. Nos. refer to polyester resin casts held by the BM (NH), the original horseshoes are the property of the Museum of London.

FIG.5


1. 75.10839
2. 75.10837
3. 75.10840
4. 75.10838
5. MULE
6. PONY
7. CARTHORSE
8. SMALL THOROUGHBRED
0
5
centimetres
1-4 EARLY TUDOR, BAYNARD'S CASTLE
5-8 MODERN

(2) CATTLE Bos (domestic)

Over 3,014 bones of cattle were identified and examined. All parts of the skeleton are represented (Table 4.1) and, as will be discussed later, this suggests that the material recovered is the discarded bone refuse from slaughter-yard, household and workshop.

Table 4: Cattle. Number of bones identified and examined.

4.1 Major dumps of rubbish

	Castle pits	Dock basin			City debris	Secondary dumps[1]
	c. 1520 AD	c. 1499-1500 AD			c. mid 14th cent. AD	mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
horn	-	3	-	12	-	-
horn core	5	-	-	20	1	3
skull	10	7	-	96	35	1
maxilla	24	5	3	37	-	3
mandible	26	4	6	79	19	8
tooth	53	2	9	72	-	-
scapula	23	20	4	32	15	-
humerus	47	38	9	47	24	7
radius	50	21	4	56	28	16
ulna	-	1	3	11	-	-
innominate	13	2	-	41	14	8
femur	21	35	8	56	17	6
patella	4	-	-	2	-	-
tibia	18	16	7	36	8	9
calcaneum	17	10	5	37	5	17
talus	12	7	2	29	3	12
foot bone[2]	52	-	-	25	-	-
metapodia	389	110	1	223	57	87
phalanx[1]	117	15	7	60	-	65
phalanx 2	45	9	5	51	-	-
hoof core	41	17	5	62	-	1
vertebra	6+	6+	*	5+	*	*
rib	*	71+	*	10+	*	*
bone	*	*	*	*	*	*
Total:	973	399	78	1099	226	243

Key: 1. Secondary dumps: Numbers of bone refer to selected samples only.

Key (continued)

2.	Foot bone: Carpal- and tarsal - bones
+	Sample only, examined for evidence of butchery
*	Vertebrae, ribs & bone fragments (scrap); large numbers present but not examined.

4.2 Other, smaller deposits containing cattle bones

Deposit	Date	Bone	Number of bones
3	c. early 16th cent. AD	calcaneum	3
		metacarpal bone	12
		metatarsal bone	1
10	c. early 16th cent. AD	metacarpal bone	4
57 & 58	c. 15th cent. AD	horn core	2
70	c. 15th cent. AD	horn core	4
		skull	1
		mandible	1
81	c. 15th cent. AD	horn core	4
		metacarpal bone	3
		Total	35

The results of the analyses carried out on the metrical data collected from the cattle bones are presented here:-

Sex differentiation

The large samples of metapodial bones and groups of horn cores provided an opportunity to test existing methods used to distinguish the sexes.

Metacarpal bones:

Metacarpal bones (fore cannon bones) of cattle are known to exhibit marked sexual dimorphism; the bone of the male being more robust, with the shaft wider in proportion to the length than that of the female (Hammond, 1948, p. 85). This difference in size and shape is related to the greater body weight of the bull, and enables the sexes to be readily identified. The main problem with metacarpi from archaeological sites is that the bones from castrates may also be present, but most of these can be recognised by their long and slender appearance. Castration in the young bull calf results in the delayed fusion of the distal epiphysis (see Chaplin, 1971, p. 81) and the length attained by the shaft of the metacarpus of the adult ox is therefore often considerably greater than that of either the cow or bull. Studies of the metacarpal bones of modern cattle of known age, sex, breed and plane of nutrition have demonstrated the possibility of distinguishing between male, female and castrated animals either by absolute measurement (Higham, 1969) or by employing various indices of shape (Howard, 1963; Mennerich, 1968).

The successful segregation of the sexes of the cattle metapodial bones from the Trøldebjerg site achieved by Higham & Message (1969) prompted me to carry out a similar anaylsis on the 192 complete metacarpal bones from deposits 1 & 23, Baynard's Castle (Figure 6).

As the metacarpi from these deposits were all from large sized cattle, in marked contrast to the admixture of small, medium and large sized animals from deposit 100 (see Figure 11), the problem of decreased sexual dimorphism which is known to be associated with the smaller sized domestic cattle (Uerpmann, 1973, p. 314) did not arise. In order to simplify the analysis and obtain a more accurate picture of the proportion of the sexes, only the measurements relating to specimens with fused distal epiphyses (i. e. from animals over $2\frac{1}{2}$ - 3 years of age) were used; bones with unfused epiphyses are often not completely developed and as a result fail to show clear evidence of sexual dimorphism.

Figure 7 shows the two distinct groups isolated from the sample of metacarpi from deposit 1 by plotting the values of the maximum distal diaphysial width against those of the maximum distal epiphysial width. In the diagram the theoretical 95% confidence limits of each group are delineated by 95% percentile ellipses, the method of calculation is given in Appendix B. Points falling outside the ellipses are specimens with distended (extra broad) distal condyles, such bones being thought to be from draught oxen (Mennerich, 1968, p. 132; Harcourt, 1975, pers. comm.). There are apparently few bones of females in the sample. In order to verify this interpretation, the index of (maximum proximal width/length) x 100 was plotted against the index of (mid shaft width/length) x 100, as described by Mennerich (1968). In the resultant scatter diagram (Figure 8) the four specimens originally classified as cows, plus one other, are seen to lie within the boundary proposed by Mennerich for the separation of the females from the males and castrates. As this technique was not able to distinguish between entire and castrated males, a further diagram was prepared (Figure 9) in which the index of (maximum proximal width/length) x 100 was plotted against absolute length. In Figure 9 there is a large, distinct cluster to the right of the plot (separated from the scatter of specimens thought to be male and female by the broken line). The large group has been interpreted as being the metacarpi of oxen, on the basis that, as stated above, the bone of the castrate is on average much longer than that of either the male of female. A certain amount of overlapping is, however, apparent from the diagram with 11% of the specimens classified as castrates falling within the range of the males and females.

A similar analysis was conducted on the data relating to the 118 complete metacarpal bones from deposit 23. Only nine specimens were identified as females, ten as males and the rest as castrates; therefore the proportion of the sexes represented by the metacarpi of adult cattle from deposits 1 & 23 may be assessed as:-

7 % female : 9% male : 84% castrate

Unfortunately it was not possible to carry out an analysis on the metacarpi from the dock basin (deposits 88, 89 & 100) as almost all of these had been used in bone working and were therefore incomplete, the shafts having been removed by sawing through the proximal and distal ends (see section 3.4, bone working). Also, the presence of bones from small, medium and large sized cattle invalidated such an analysis; the clear segregation of the sexes being precluded by overlapping of the dimensions of the males, females and castrates from the different sized animals.

Figure 6: Cattle. Complete metacarpal bones from deposit 23, c.1520 AD.

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CMs.

FIG.7

Early Tudor cattle, Baynard's Castle (Deposit 1): Metacarpus, sex differentiation

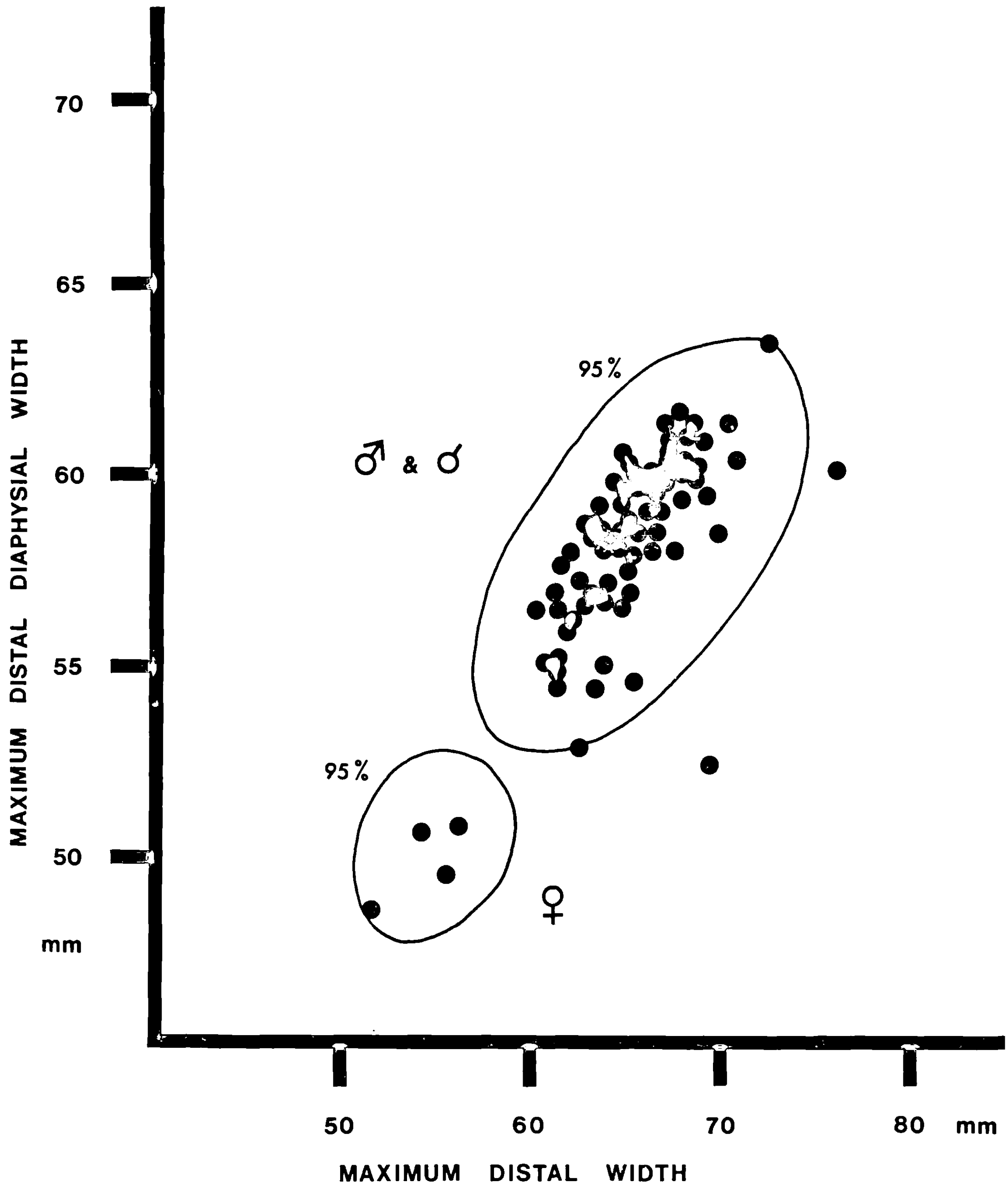
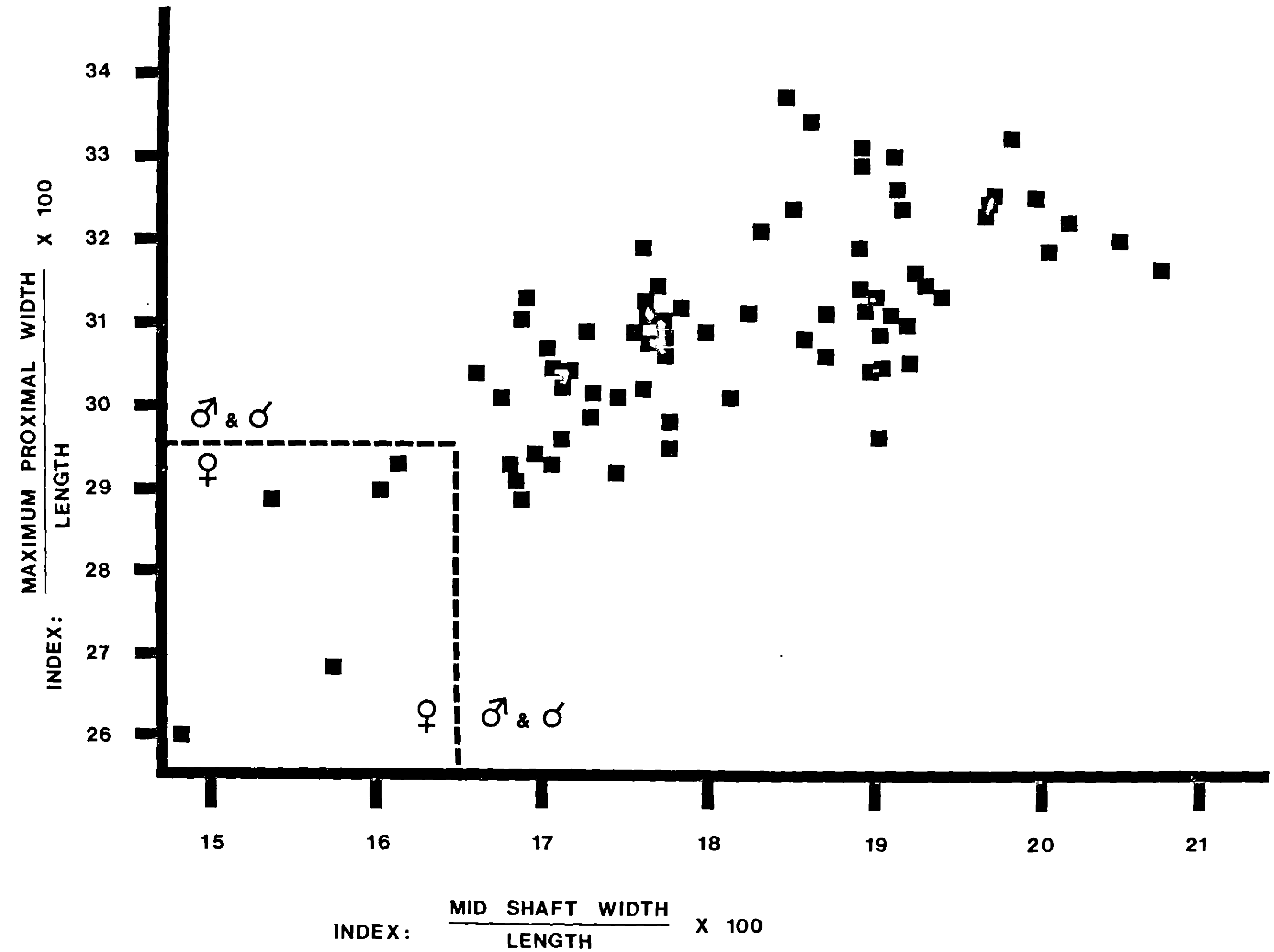


FIG.8

Early Tudor cattle, Baynard's Castle (Deposit 1): Metacarpus, sex differentiation



Early Tudor cattle, Baynard's Castle (Deposit 1): Metacarpus, sex differentiation.

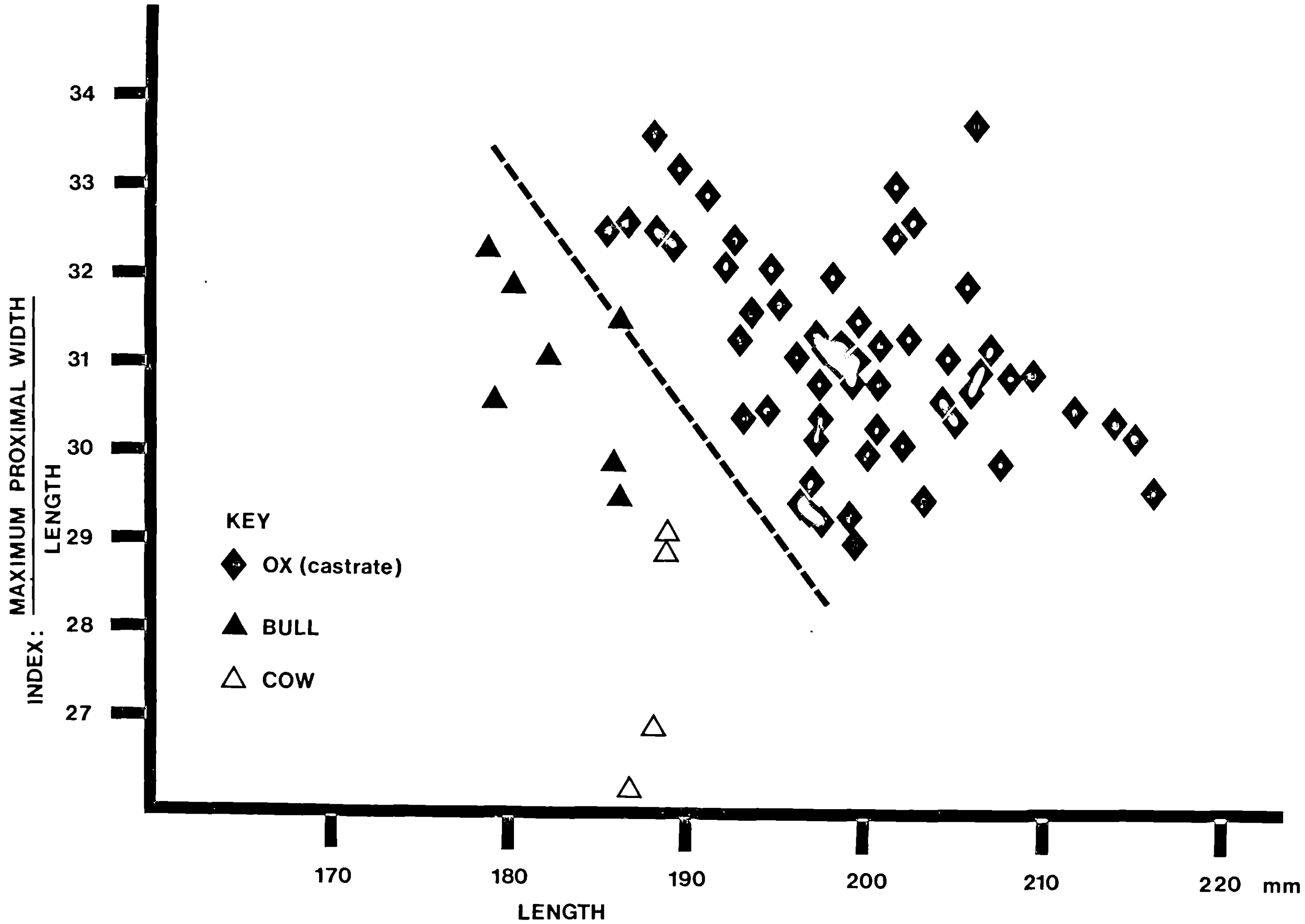


FIG.9

Horn cores:

Thirty six horn cores of cattle were recovered (Tables 4.1 & 4.2), ranging in the length of the posterior-dorsal (outer) curve from 64 to 400 mm, there was also considerable variation in shape of the specimens. These differences in length and shape were found to be associated with size and sex of individual cattle, as discussed below.

Various workers have identified the cores of bulls, cows and oxen on the basis of size and shape differences (see Mennerich, 1968; Kuhnhold, 1971), either by absolute measurement (Chaplin, 1971; Ekman, 1973) or by employing the index of (minimum diameter at the base/maximum diameter at the base) x 100 plotted against basal circumference (Knecht, 1966; Clason, 1967). A recent investigation into 98 horn cores from the Roman level, Angel Court, London (Clutton-Brock & Armitage, in press) led to the development of a new system for the classification and description of cattle horn cores from archaeological sites (Armitage & Clutton-Brock, 1976). From the start of the investigation it was apparent that sex could not be determined without an initial sorting into groups based on length of the outer curve, and the following groups were therefore proposed:-

	Length	Group
1.	Less than 96mm	Small horned
2.	From 96 - 150 mm	Short horned
3.	From 150 - 200 mm	Medium horned
4.	More than 200 mm	Long horned

It should be understood that the limits of the ranges in length adopted represent arbitrary values taken for convenience so that the horn cores may be described precisely; there is no relationship between the divisions as defined in the system for classification and the modern breed titles of cattle. After the cores have been assigned to their respective groups, the sex can be determined by a visual appraisal of the size, shape, curvature and angle of attachment of the core to the frontal bone.

It is not always possible to distinguish clearly between the horn cores of oxen and those of either cows or bulls. Although castration in young bull calves leads to the development of a distinctive horn in the adult, the degree of modification depends very much on the age at which the animal was castrated. The effects are greater when the animal has been operated on during the first weeks after birth whilst castration on an older animal will have little influence on the size or shape of the horns. The sixteenth century writer on agriculture, Fitzherbert (1523), commented on this by saying that if the usual practice of castration at 10 - 20 days after birth was followed then the 'ox shall be the more higher and the longer of body and the longer horned'. If however, castration was delayed until the animal was over one year of age, 'he shall be less of body and shorter horned'.

With broken specimens, the cores from juveniles (with very light, porous bone) and smaller sized cattle it is often not possible to recognise the sexes, whilst in the cores from large cattle, sexual differences can be very marked (Figure 10).

The cattle horn cores from Baynard's Castle are listed below according to the newly devised system[1]:

<u>Deposits 1 & 23</u>	c. 1520 AD	
Long horned group:		1 adult, bull (?) 2 adult, cow 2 adult, ox
<u>Deposits 57 & 58</u>	c. 15th cent. AD	
Long horned group:		1 adult, bull
Medium horned group:		1 adult, ox 1 adult, sex?
<u>Deposit 81</u>	c. 15th cent. AD	
Long horned group:		1 adult, cow/ox
Short horned group		1 adult, cow
<u>Deposit 100</u>	c. 1499 - 1500 AD	
Long horned group:		2 adult, bull 2 adult, cow 1 adult, ox 4 adult, ox/cow 2 adult, sex?
Medium horned group:		1 adult, cow 2 adult, ox
Short horned group:		2 adult, cow 1 adult, ox 2 juvenile, bull/ox
Small horned group:		1 adult, ox
<u>Deposit 250</u>	c. mid 14th cent. AD	
Short horned group:		1 adult, bull/ox
<u>Deposit 5000</u>	c. 13th cent. AD	
Short horned group:		1 adult, cow 1 adult, ox

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1. <u>Footnote</u>: In order to test the classification based on the visual appraisal, data from the horn cores from Baynard's Castle were employed in a numerical analysis, carried out in collaboration with Miss Kathleen M. Shaw, Dept. Central Services, BM(NH) - see Armitage & Clutton-Brock (1976, Appendix A). From the results of the analysis it was evident that the categories based on length and assessment of sex did separate out as expected, although the clusters were not always discrete.

Figure 10: Cattle, long horned group. Horn core of an ox (top), bull (centre) and cow (bottom). Dock basin dump, c.1499-1500 AD.

Specimens: BM(NH) Reg. Nos. 75.8278, 75.8291 & 75.8279


CMS

Size

Metacarpal bone:

For the complete metacarpal bones, the heights at the withers were calculated after the methods of Boessneck (1956) and Fock (1966), in which the maximum length is multiplied by a given factor. As analysis of the metacarpi from deposits 1 & 23 revealed that the majority were of oxen (see above), the factors used to derive this value were:-

Boessneck	6.40
Fock	6.13

These same factors can also be used when the sex has not been established (see Clason, 1967. p. 103) and so they were also applied to the specimens from the other dumps.

Although it is now known that the factors advocated by Boessneck produce estimates which are too large (von den Driesch & Boessneck, 1974) the factor for metacarpi was employed to enable a comparison to be made between the cattle from Baynard's Castle and those from other sites, the information on which has been published in earlier works, and whose authors based their estimates of stature on the method of Boessneck.

Table 5 shows the calculated values for the height at the withers, values are given in cm.

Table 5: Cattle. Height at the withers.

Deposit	Method	No. specimens	Mean	Range
Baynard's Castle:				
1	Boessneck	74	126.0	114.5 - 138.2
	Fock	74	120.4	109.5 - 132.2
23	Boessneck	118	128.7	113.6 - 158.1
	Fock	118	123.1	108.6 - 151.1
88 & 100	Boessneck	8	115.3	105.3 - 127.5
	Fock	8	110.8	100.8 - 122.1
250	Boessneck	1	-	112.1
	Fock	1	-	107.5
5000	Boessneck	4	113.2	108.9 - 119.0
	Fock	4	108.4	104.3 - 114.0
Modern cattle:				
Chillingham, cow & bull	Boessneck	7	115.1	111.5 - 117.6
	Fock	7	110.2	106.8 - 112.7
Chartley, bull	Boessneck	2	-	133.3 - 135.9
	Fock	2	-	127.7 - 130.2
Red Danish, cow	Boessneck	32	137.6	126.2 - 146.1
	Fock	32	131.6	120.7 - 139.7

Comparison with the metacarpi of modern cattle held by the BM(NH) revealed that the cattle from deposits 88 & 100, 250 and 5000 were similar in stature to present day Chillingham cattle, whilst those from deposits 1 & 23 were much larger, being of similar size to Chartley cattle.

The difference in the size of the cattle from the dock basin dump (deposits 88 & 100) and those from one of the 'robber pits' within the castle grounds (deposit 23) is further illustrated by reference to the scatter diagram of metacarpal bones (Figure 11), in which the values for the maximum distal diaphysial width are plotted against those for the maximum distal epiphysial width. Although the range in size of the cattle from the city dump extends up into that for the cattle from the castle pit, the majority of the animals are smaller. With the exception of five specimens with abnormally broad distal ends and one of a female, only two other bones from the castle are seen to be located outside the 95% ellipse drawn around the metacarpi from deposit 23. These two outliers (Figure 11, small circle) are from a very large beast whose size must have been similar to that of the auroch Bos primigenius Boj., and probably this individual came from a different cattle population (breed ?) than the rest of the sample.

Phalanx 1:

Identification of the phalanges from the fore and hind extremities was based on differences in their morphology and size. The phalanx of the fore limb appearing the more robust of the two, being relatively shorter and broader than that from the hind limb. When viewed from above, the proximal articular surface appears square in the fore and rectangular in the hind phalanx. The hind bone can also be distinguished by the two prominent facets which form the proximoplanter peripheral edge, in the fore bone the proximodorsal and proximovolar peripheral edges are level (see von den Driesch, 1976, p. 86).

After segregating the fore from the hind phalanges, each group was measured separately, a summary of the data is given in section 4. Values for the proximal width of the fore-phalanx were then used to construct the histograms shown in Figure 12. On the diagram, the location of the mean for each sample is shown by the vertical bar.

Figure 11: Scatter diagram of cattle metacarpal bones from the palace (deposit 23) and city (deposit 100) rubbish dumps.

Cattle metacarpal bones. Maximum distal diaphysial width plotted against maximum distal epiphysial width.

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SCATTER DIAGRAM OF CATTLE METACARPALS

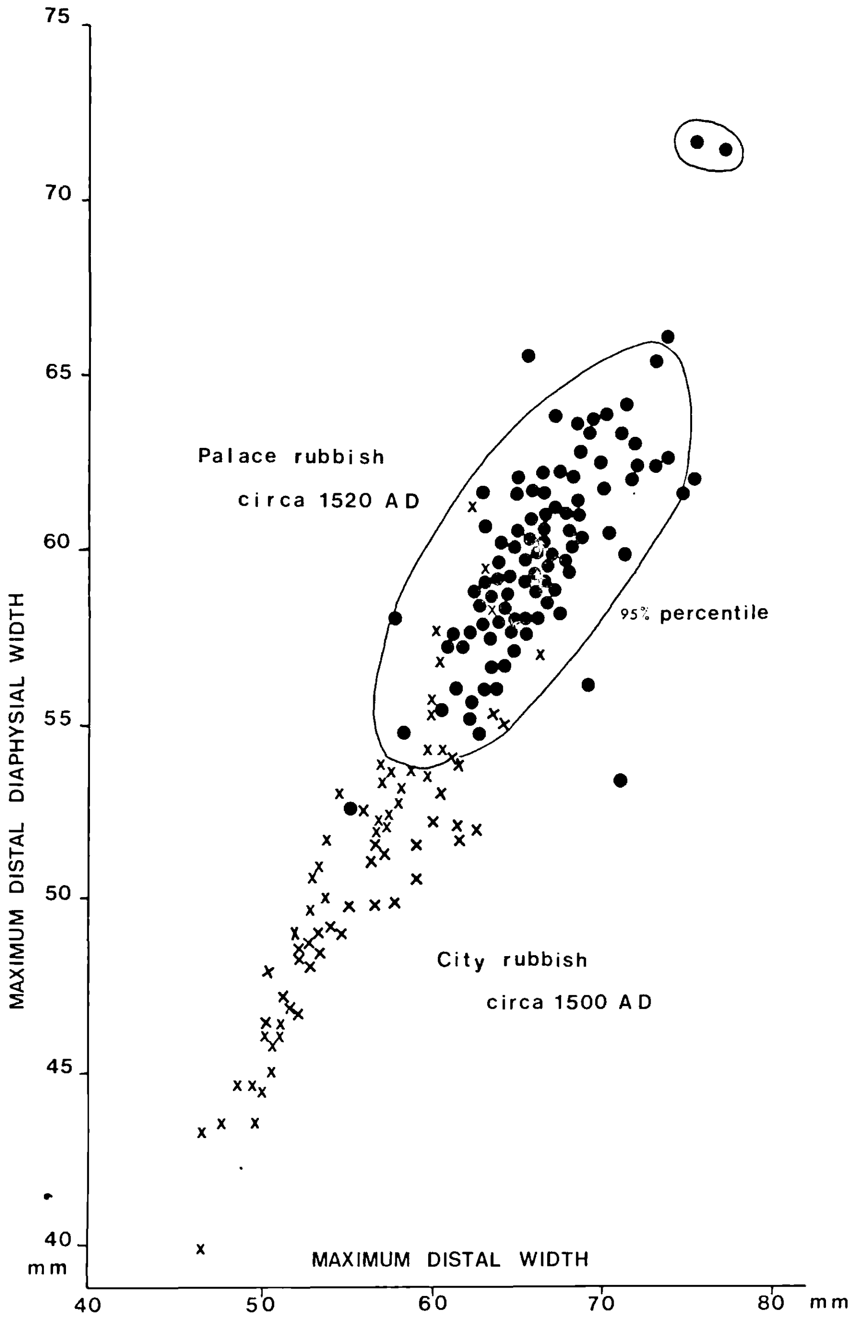
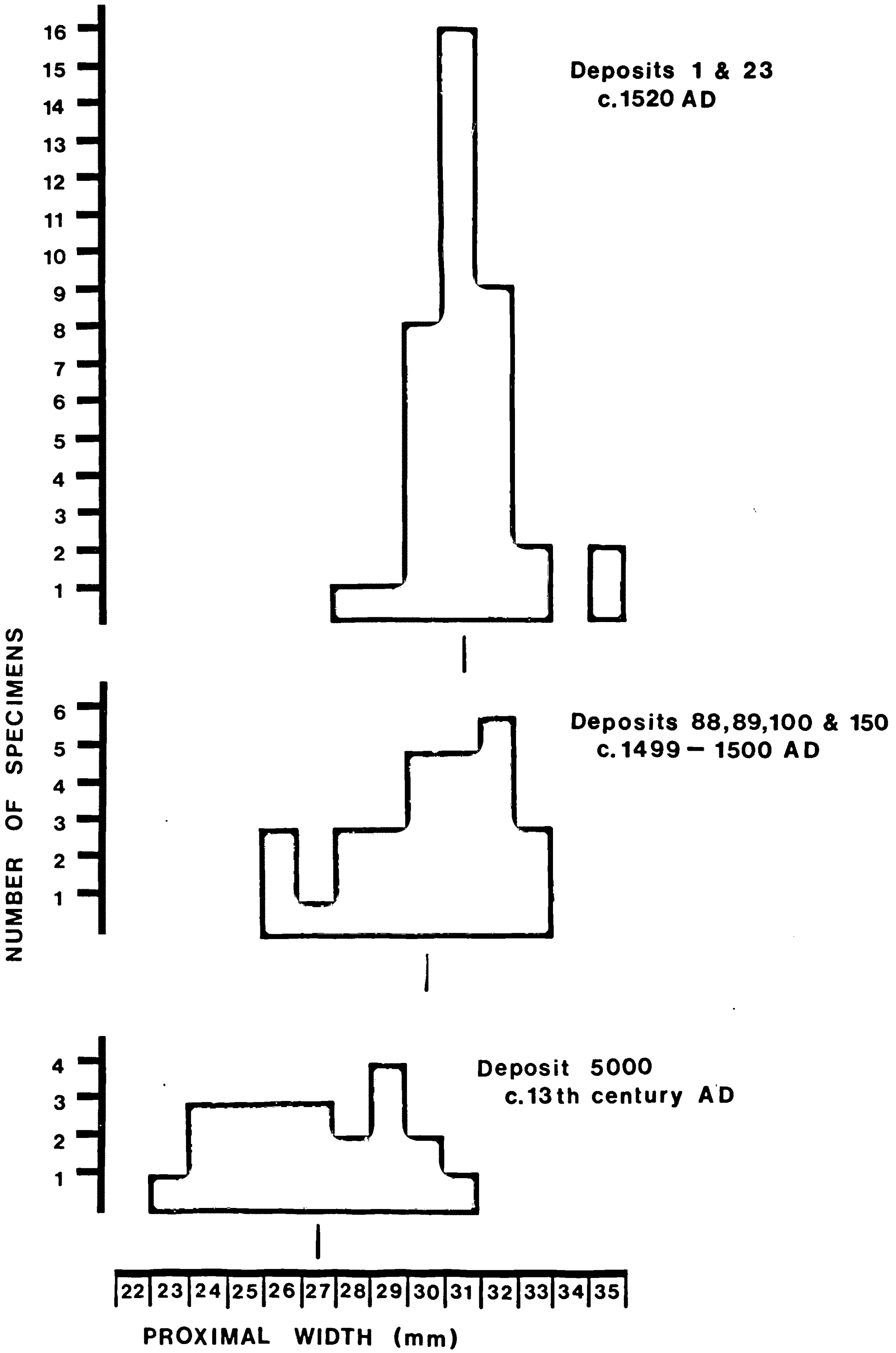


FIG.12

Medieval and early Tudor cattle: Phalanx 1 (fore), maximum proximal width.



Phalanx 1 (continued)

From Figure 12 it is clear that there is a difference in the average size between the cattle from the thirteenth century deposit and those from the two other, later deposits, also, the configuration of the histogram drawn for the bones from the dock basin (deposits 88, 89 & 100) does not appear to follow that expected for a normal (uniform) distribution. The large variance for the specimens from the dock basin (see section 4) suggested that the sample was heterogeneous, possibly representing an admixture of bones from different sized animals and sexes.

To confirm that the distribution was non-normal, the test for normality described by Shapiro & Wilk (1965) was applied to the data:

Results of the analysis of variance test for normality:-

Null hypothesis: For each deposit, the phalanges represent a sample from a normal distribution.

Deposits 1 & 23

Mean	31,274
Standard deviation	1,278
$\Sigma (X - \bar{X})^2$	62.074

$N = 39 = 2 \times 19 + 1$
$K = 19$
$b = 7.729$
$w = 0.9625$ not significant ($P > 0.05$), Null hypothesis accepted

Deposits 88, 89 & 100

Mean	29.9483
Standard deviation	2.1011
$\Sigma (X - \bar{X})^2$	123.612

$N = 29 = 2 \times 14 + 1$
$K = 14$
$b = 10.6202$
$w = 0.9124$ significant at 5% ($P_{0.02} = 0.910$, $P_{0.05} = 0.926$)
Null hypothesis rejected.

Deposit 5000

Mean	26.8227
Standard deviation	2.3094
$\sum (X - \bar{X})^2$	111.9986

N = 22 = 2 x 11
K = 11

b = 10.4497
w = 0.9750 not significant ($P > 0.05$), Null hypothesis accepted

From the results, for the sample from deposits 88, 89 & 100 the Null hypothesis is rejected and the initial interpretation that the sample is heterogeneous adopted as the likely explanation of the observed data.

Age at Slaughter

From the samples of mandibles from the castle pits (deposits 1 & 23) and the dock basin dump (deposits 88, 89 and 100), the age at which the cattle were slaughtered was established using information on the sequence of tooth eruption in nineteenth century cattle (Silver, 1971, Table D, p. 296). The specimens were found to fall into two distinct groups:-

(1) Adults: Individuals aged five years and over. Third molar erupted, with the accessory pillar in wear (see Grigson, 1974, p. 358)

(2) Juveniles: Animals aged less than nine months. Fourth deciduous premolar erupted, first molar visible in crypt.

Statistical analysis (Table 6) showed that the samples of mandibles taken from the two dumps contained equal numbers of adults and juveniles:

Table 6: Cattle. Mandible, age at slaughter

Numbers of adult and juvenile specimens, expressed as a percentage of the total number of bones from each of the two main dumps of rubbish, are shown in ( ).

	Adult	Juvenile
Deposits 1 & 23	14 (54%)	12 (46%)
Deposits 88, 89 & 100	53 (60%)	36 (40%)

Result of chi-square test:-	
Null hypothesis:	Each of the two main dumps of rubbish contain equal numbers of adults and juveniles.
Deposits 1 & 23	not significant at 5%, Null hypothesis accepted
Deposits 88. 89 & 100	not significant at 5%, Null hypothesis accepted

Cattle in late medieval and early modern Britain

In what is widely regarded as a classic paper, Jewell (1963) demonstrated the changes in size that have occurred in domestic cattle in Britain from the neolithic through to the present-day. At the time he was compiling the evidence for these changes there was a lack of available skeletal material from late medieval and post-medieval archaeological sites. With the recent recovery of the large collection of bone from the site of Baynard's Castle it is now possible to follow more closely the increase in size of cattle that occurred at the end of the middle ages and the beginning of the Tudor (early modern) period. In order to appreciate more fully the significant advance which seems to have been made in the field of cattle breeding during the fourteenth and fifteenth centuries AD it is first necessary to review what is known about cattle of the preceding two centuries.

From the remains of cattle found in the archaeological record, it would appear that cattle in the high middle ages (i. e. twelfth

& thirteenth centuries AD) were very small (McKenny Hughes 1896; Jewell, 1963; Bökönyi, 1974), and in some instances they were even smaller than those from the Iron Age (Dergebøl), 1963, p. 77). According to Bökönyi (1974, p. 136), these small cattle formed a uniform population that was distributed throughout Europe, from the Urals to England, and their small size indicates the existence of very primitive conditions of livestock husbandry during this period, which was exacerbated by an ignorance of even the most basic elements of animal breeding. Payne (1972b) has argued, for example, that because the largest and strongest of the bull calves were usually chosen to be castrated, as they were thought to make the best draught animals, there was an unintentional selection for smaller sized cattle. It should be stated, however, that this lack of understanding of the practices required for successful livestock breeding may not have been universal; Fraser (1972, p. 114) maintains that some form of selection must have operated in the farming communities of medieval England, 'at least as far as the bull was concerned'. The question of whether or not selection, intentional or unintentional, was being practised can only be resolved by an extensive study of contemporary documents, especially those written by members of the monastic orders whose economies were often largely based on livestock husbandry and who most certainly carried out rigorous selection of the horses kept for breeding purposes (see Dent, 1976).

Bone elements of small sized cattle were found in the thirteenth, fourteenth and fifteenth century dumps at Baynard's Castle (see above). As well as the cores of small and short horned individuals, the dock basin dump (deposits 88, 89 & 100) also contained the massive cores of long horned cattle (Figure 10), similar cores being found in association with the large metacarpal bones in the early sixteenth century pits (deposits 1 & 23).

Recent excavation of a late fourteenth century AD pit (containing the discarded waste from a horn working industry) at Kingston, Surrey has produced 144 cores of long horned cattle (Armitage, 1977, in prep.). Other pits on the site, dated to the fourteenth and fifteenth centures AD, yielded horn cores of small, short and medium horned cattle. The cores assigned to the small and short horned groups are reminiscent of those more typically associated with the small, Iron Age cattle; an observation which has been made by McKenny Hughes as early as 1896 (p. 29) for the cores of cattle from other medieval sites in Britain.

On the basis of the evidence presented here, the cattle population of Britain in the late medieval period was apparently very diverse and included both small and large varieties, with the large sized, long horned cattle first making their appearance in the late fourteenth century AD.

To account for the presence of long horned animals, the earlier writers, among them McKenny Hughes (1896, p. 34), believed them to be the offspring of cattle imported to this country from Holstein and the Low Countries in later medieval times. The introduction of Dutch cattle to England in the late middle ages and Tudor period remains unsubstantiated, the earliest documents known to exist attesting to such imports of livestock are from the eighteenth century (Trow-Smith, 1957, p. 203). An alternative, and possibly more plausible, explanation for the appearance of these cattle has been proposed by Bökönyi (1974, p. 142), and although he was concerned with the origins of the long horned, Hungarian white cattle, his comments are equally valid when applied to the large, long horned cattle of late medieval England. As in the British case, previous workers had argued that the long horned cattle must have been introduced from outside the country, but Bökönyi rejected this assertion as unproven, concluding that this distinctive breed was created through selective breeding from the local cattle population in the fourteenth to fifteenth century.

Thus the presence of large, long horned cattle in Europe during the late fourteenth century may reflect the existence of a high standard of livestock husbandry, and a better understanding of the elements of animal breeding. It should be stated that the discussion presented here is based on a limited quantity of skeletal material from one region of the country, and much more research on the remains from other sites needs to be carried out before the picture can be clarified, and the factors behind the changes that occurred in the cattle of this period identified.

The metacarpi from the castle pits (deposits 1 & 23) which were identified as those of castrated animals (see above) are certainly the remains of plough oxen.

Although More (1516, reprinted 1971, p. 48) mentions the buying of store cattle for fattening, this practice was not as widespread as he implies in his book. It was only after the population of London had increased so dramatically in the second half of the sixteenth century (from 60,000 in 1534 to 120,000 in 1582, Everitt 1967, p. 514) that the demand for meat reached the level when it was more profitable to rear cattle for the food market than for the plough (see Fisher, 1935; von Bath, 1966, p. 290). Prior to the expansion of the London food market, there was no real incentive for farmers to produce fat cattle, and the arable areas immediately around London could supply sufficient animals, in the form of culled draught oxen, to meet the demand for beef. After 1570, cattle were sent 'on the hoof' from the Midlands, Wales and

Scotland to be fattened on pastures in Hertfordshire, Middlesex and Essex before finally being sent into the city for slaughter (see Trow-Smith, 1957, p. 215; Everitt 1967, p. 509); the era of the great cattle droves had begun.

In the early Tudor period, oxen were put to the plough when three to five years of age, were worked until they reached ten, and then fattened for slaughter (Fussell, 1952, p. 63). Trow-Smith (1957, p. 70) considers that it was likely that cows were also occasionally included as part of the plough team, bulls, however, because of their temperament, were excluded (Cornwall, 1954, p. 73). The issues raised in the debate over whether the horse or the ox was the best animal to pull the plough have been much discussed (see Fitzherbert, 1523; White, 1971, p. 62; Creasey, 1974, p. 3), it may be mentioned however, that the replacement of oxen by horses was taking place on the lighter soils of eastern England and the Midlands as early as the late twelfth century (White, 1971, p. 65), whilst on the heavy, clay soils of Hertfordshire, Middlesex and Essex, teams of oxen were still to be found well into the early modern period.

The carcass of an ox was not only valued as a source of flesh-meat but also for its hide; evidence that the hides were being removed from the cattle at Baynard's Castle is provided by the presence of knife marks across the proximal ends of metapodial bones from deposits 1 & 23 (see section 3.3, butchery). The fat content was also considered to be important, and Fitzherbert (1523) advises the potential buyer of 'fatte catell' to ensure that the animal is 'wel talowed'.

The presence of bone elements of calves, many with signs of butchery, amongst the cattle bone material from Baynard's Castle indicates that veal was eaten in the late middle ages. Contemporary recipes show that all parts of the calf were used, their feet being boiled to make calve's foot jelly and the flesh from their heads stewed with herbs and wine to make 'hashe' (Wilson, 1976, p. 84 & 92).

(3) SHEEP *Ovis* (domestic)

Identification of the bones of sheep and goat

Since the publication of the results of the survey on modern skeletons of sheep and goat carried out by Boessneck *et al* (1964), see also Boessneck (1971), it is now possible to identify and separate the bones of these two genera. The criteria described by Boessneck were used on the material from Baynard's Castle, and the only specimens identified as certainly goat were twenty four horn cores (listed below), the remaining bones were all assessed as coming from sheep. The numbers of sheep bones from each of the dumps of rubbish are shown in Table 7.

Horn cores of goat *Capra* (domestic)

Deposit	BM(NH) Reg. No.	Number of cores
100	75.8146 & 75.8147	2
100	75.9955 & 75.9956	2
250	75.8148 to 75.8159	12
5000	75.9957 to 75.9964	8

There were no goat horn cores recorded from the castle pits (deposits 1 & 23).

The lack of bone from goats can be explained in part by the fact that this animal held a low status in the agricultural economy of late medieval Britain. It was to the sheep that the livestock farmer looked in order to make a living, and the contemporary writers on agriculture, such as Fitzherbert (1523), considered that sheep are 'the most profitable cattle that any man can have'. Where goats were kept, they were few in number and were usually run with the sheep flock (Bökönyi, 1974, p.198). On some estates there were apparently no goats kept, see for instance the inventory of livestock for Merton College, Oxford for the years 1333 to 1336 (referred to by von Bath, 1966, p. 180). The presence of horn cores of goat and the noticeable absence of any associated postcranial elements at Baynard's Castle can be accounted for by the fact that this material represents part of the discarded waste from horn workers' shops, as will be discussed in section 3.4, bone and horn working. It would seem that only the horns, with their cores, were imported into the city, the goats being slaughtered and butchered elsewhere.

Table 7: Sheep. Number of bones identified and examined.

	Castle pits	Dock basin			City debris[1]	Secondary dumps[1]
	c. 1520 AD	c. 1499-1500 AD			c. mid. 14th cent. AD	mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
horn core	8	-	-	5	8	3
skull	127	2	2	17	6	8
maxilla	25	27	-	24	16	-
mandible	207	23	10	116	20	45
tooth	42	5	-	-	-	-
scapula	141	49	9	207	34	-
humerus	143	58	11	79	42	50
radius	154	65	13	216	58	-
ulna	50	31	4	84	11	-
innominate	65	54	10	138	17	24
femur	68	45	12	60	18	-
tibia	134	67	18	163	54	-
calcaneum	68	16	7	34	10	-
talus	27	9	3	10	2	-
foot bone[2]	-	-	-	-	-	16
metapodia	72	39	9	272	45	62
phalanx 1	26	5	4	32	13	-
palanx 2	-	-	-	-	-	-
hoof core	-	-	-	1	-	-
vertebra	6+	*	*	*	*	*
rib	*	29+	*	*	*	*
bone	*	*	*	*	*	*
Total:	1363	524	112	1458	354	208

Key: 1. Deposits 250 & 5000: Numbers of bone refer to selected samples only.

2. Foot bone: Carpal- and tarsal- bones

\+ Sample only, examined for evidence of butchery

* Vertebrae, ribs & bone fragments (scrap); large numbers present but not examined.

Use of the Soay sheep as a model for medieval sheep

Soay sheep which are found feral on the remote island of St. Kilda in the outer Hebrides are a relic population of the earliest domestic sheep of Britain. They are also considered to be the most primitive breed of sheep surviving in Europe today, and they therefore provide information of value to archaeozoological research (Jewell, 1975). As early as the 1880's, General Pitt-Rivers compared the skeletons of Soay sheep to those recovered by excavation from Iron Age sites (Thompson, 1977), and it has now become a standard practice to use the dimensions obtained from the skeletons of Soay sheep as the basis for comparison with the bones from prehistoric sites.

From evidence provided by histological examination of wool fibres extracted from the few available textile remains, Ryder (1971) was able to confirm that the Soay sheep with its brown pigmented fleece is the closest living relative of the prehistoric sheep. In respect of type and colouration of the fleece, animals belonging to the Soay breed do not resemble medieval sheep, which were mostly white-woolled (Ryder 1964). This does not invalidate the use of the Soay sheep as a model for medieval sheep from the point of view of the osteologist, as the Soay and medieval sheep are similar in their skeletal and muscular attributes, both showing the traits characteristic of unimproved animals, as discussed below.

Like the wild mouflon, the body proportions of a fully grown, adult Soay (Figure 13A) are similar to those of a lamb from one of the improved breeds of today, a condition which arises as a result of the relatively slow growth rate of these animals (see Hammond, 1948, p. 74 - 77). A similar body conformation is to be found in medieval sheep, and can be clearly seen in Figure

13B which shows a drawing of a ewe of the mid fifteenth century AD, based on details taken from contemporary depictions of sheep engraved on the monumental brasses to wool merchants (see Armitage & Goodall, 1977). Both the Soay and medieval sheep have small, compact bodies, long necks and long, fine-boned limbs, and to the modern livestock farmer, used to judging and selecting each animal according to its merit as a potential meat-producer, both would appear to be badly shaped and unsuited to his needs. These same features would not have seemed undesirable, however, to the medieval farmer as it was the fleece and not the carcass that was considered important, and the quality of the fleece would not have been seriously impaired by poor body conformation.

Starting with the selective breeding carried out by Bakewell, Ellman, and their contemporaries in the late eighteenth and early nineteenth centuries, sheep in Britain have been systematically modified to fit them for the role of meat-producers. This means that the breeds of today bear little resemblance to their medieval counterparts, which were kept primarily as wool-producers. The opinion held by agricultural historians of these early livestock breeders and the changes they wrought has been succinctly stated by Power (1941, reprinted 1969), who writes 'Bakewell may have his meed of praise from the economist, but to the historian he is an arch-iconoclast who defaced an irreplaceable collection of walking documents'. Only the Soay sheep remains today to remind us what the original, unimproved sheep may have looked like, and for this reason the skeleton of the Soay sheep was adopted as the standard against which data relating to the bones from Baynard's Castle could be compared. To ensure that the full range in size of Soay sheep was used in the comparative study, measurements were taken from individuals of both island (St. Kilda) and mainland (Babraham, Cambs.) flocks. The Soay sheep on St. Kilda are specialised for living under harsh environmental conditions, and are smaller than the 'improved' Soay sheep kept on the mainland (Jewell et al, 1974). The island sheep are also smaller than most sheep from archaeological sites (Jewell, 1975) and this has to be taken into account if they are used as comparative material in archaeozoological research, and as a model for medieval sheep it is therefore better to use Soay sheep which have been bred on the mainland.

Figure 13:

(A) Soay sheep. Polled ewe from the flock at Royal Holloway College.

(B) Drawing of a late medieval polled ewe, based on depictions of sheep that appear on monumental brasses.

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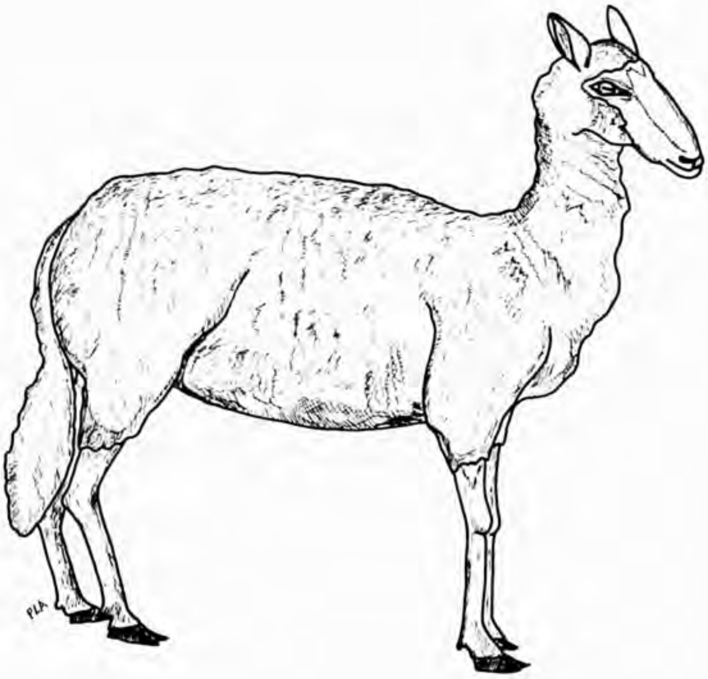
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Size and conformation

Although Bökönyi(1974, p.188) believes that sheep in Europe became larger towards the end of the middle ages through selective breeding, no evidence of this change was forthcoming from the analysis of the metrical data relating to the specimens from Baynard's Castle. Unlike the cattle, there was no difference in the size of the sheep from the castle pits (deposits 1 & 23) and those from the other dumps (deposits 88, 89 & 100; 250; 5000); individuals from all groups would have been similar in stature and build to the Soay sheep kept on the mainland today. Unfortunately there is a lack of readily available material from post medieval sites and therefore it is not, as yet, possible to follow the changes that are known to have taken place in British sheep during the latter half of the eighteenth century (see Trow-Smith, 1959, p. 36 & p. 45). The only specimens of sheep known to me are from Porchester Castle, Hampshire, and date from 1790 to 1820 AD. Interestingly, measurements from these bones fall within the ranges in size established for those from Baynard's Castle (Grant, 1977, pers. comm.). Research into the changes in size of sheep that have occurred from the neolithic to the present day is continuing in collaboration with Miss A. Grant.

Calculation of the index of (height of the neck/ minimum length of neck) x 100 reveals that the scapulae of medieval sheep are slender and almost goat-like, similar to those of the Soay, in contrast with scapulae of modern, improved sheep which are stout and blocky (Table 8). Although the values of the index for the specimens from Baynard's Castle are high they still fall within the range (78 to 133) established for sheep by Boessneck, only those for the juveniles overlap into the values for goat (i. e. are greater than 133).

The limb bones are also slender like those of the Soay (Table 9) and, as stated above, this reflects the unimproved nature of medieval sheep. Sheep belonging to the modern breeds which have been improved for meat-production have stouter, more robust leg bones (see Hammond, 1948, Figure 56, p. 82).

Table 8: Late medieval and modern sheep. Scapula, index of neck height to minimum length of neck.

		Number of specimens	Range
1.	Modern:		
1.1	Adult		
	Romney Marsh (m & c)	3	68.8 - 81.4
	Clun Forest (m, f & c)	7	74.9 - 96.0
	Norfolk Horn (m & f)	3	88.2 - 91.3
	Soay (m, f & c)	5	96.0 - 131.6
1.2	Juvenile		
	Norfolk Horn (m)	1	122.6
	Soay (m & f)	4	125.7 - 146.3
2.	Baynard's Castle:		
2.1	Adult		
	Deposits 1 & 23	97	81.3 - 124.0
	Deposit 100	68	87.8 - 125.7
	Deposit 250	18	96.5 - 122.9
2.2	Juvenile		
	Deposits 1 & 23	9	113.8 - 139.8
	Deposits 100	-	-
	Deposit 250	-	-

Key: Sex:-
m male
f female
c castrate

Note: The Soay sheep are from island and mainland flocks.

Table 9: Late medieval and modern sheep. Fore limb bones, index of minimum shaft width to length.

		Number of specimens	Range
HUMERUS			
1.	Modern:		
	Soay (m, f & c)	4	9.5 - 11.3
	Clun Forest (m, f & c)	6	11.8 - 13.6
	Norfolk Horn (m & f)	2	12.1 - 12.5
	Romney Marsh (m & c)	3	13.7 - 14.6
2.	Baynard's Castle:		
	Deposits 1 & 23	3	11.1 - 11.8
	Deposit 100	6	10.1 - 11.2
	Deposit 250	-	-
RADIUS			
1.	Modern:		
	Soay (m, f & c)	40	9.4 - 12.5
	Clun Forest (m, f & c)	9	11.1 - 15.4
	Norfolk Horn (m & f)	2	12.1 - 13.2
	Romney Marsh (m & c)	3	14.4 - 15.2
2.	Baynard's Castle:		
	Deposits 1 & 23	16	10.5 - 12.5
	Deposit 100	25	10.2 - 12.2
	Deposit 250	8	10.3 - 11.8

Key: Sex:- m male
f female
c castrate

Note: The Soay sheep are from island and mainland flocks.

The cranial material from Baynard's Castle include the remains of horned and polled sheep:

Deposit	Date	Description
1 & 23 'robber pits'	c.1520 AD	Fragments of cranium: 23 from horned sheep, 3 from polled sheep; plus 8 horn cores
100 'dock basin'	c.1499 - 1500 AD	Fragments of cranium: 11 from horned sheep, 19 from polled sheep; plus 5 horn cores
250 City debris	mid 14th Cent. AD	Fragments of cranium: 2 from horned sheep, 2 from polled sheep; plus 8 horn cores

The question of why the remains of horned and polled sheep are found together on archaeological sites has been discussed by Armitage & Goodall (1977), therefore only a brief summary is presented here. There are two alternative explanations, the first supposes that there were two distinct breeds of sheep present in England during the late medieval and early Tudor periods, one horned and the other polled, whilst the second is based on the belief that sheep at this time were similar to Soay sheep of today, where horned rams and ewes, polled ewes, and wethers with small, stunted horns, are to be found. There is not as yet, sufficient evidence available to enable archaeozoologists to determine which of the two explanations is correct, or whether, on certain sites, both hold true.

With the exception of the specimen (reg. no. 75.8306) described below, and a small, rudimentary core (specimen 75.10881, deposit 23), the horn cores from Baynard's Castle closely resemble those from male, female and castrate Soay sheep.

The small, cylindrical, goat-like horn core (75.8306), recovered from a gravel layer (deposit 81) which formed part of the floor to the dock basin (deposit 100), does not belong to the series of sheep horn cores known from medieval sites in Britain. It resembles the cores more typically associated with the female sheep identified and described by Rütimeyer from prehistoric lake dwellings in Switzerland (see Lydekker, 1912, p.144; Bökönyi, 1974, p.157) and the skulls from the peat deposits in the Lea valley, north of London, BM(NH) reg.nos. 75.5134 & 75.5140. The specimen from Baynard's Castle is therefore probably residual in origin (prehistoric ?), and predates the other items found in the deposit, which were assessed as being of fourteenth to fifteenth century AD date. The brown staining and abraded surfaces of this particular core mark it apart from the other bone from the same lèvel, and further testify to its antiquity.

Sex differentiation

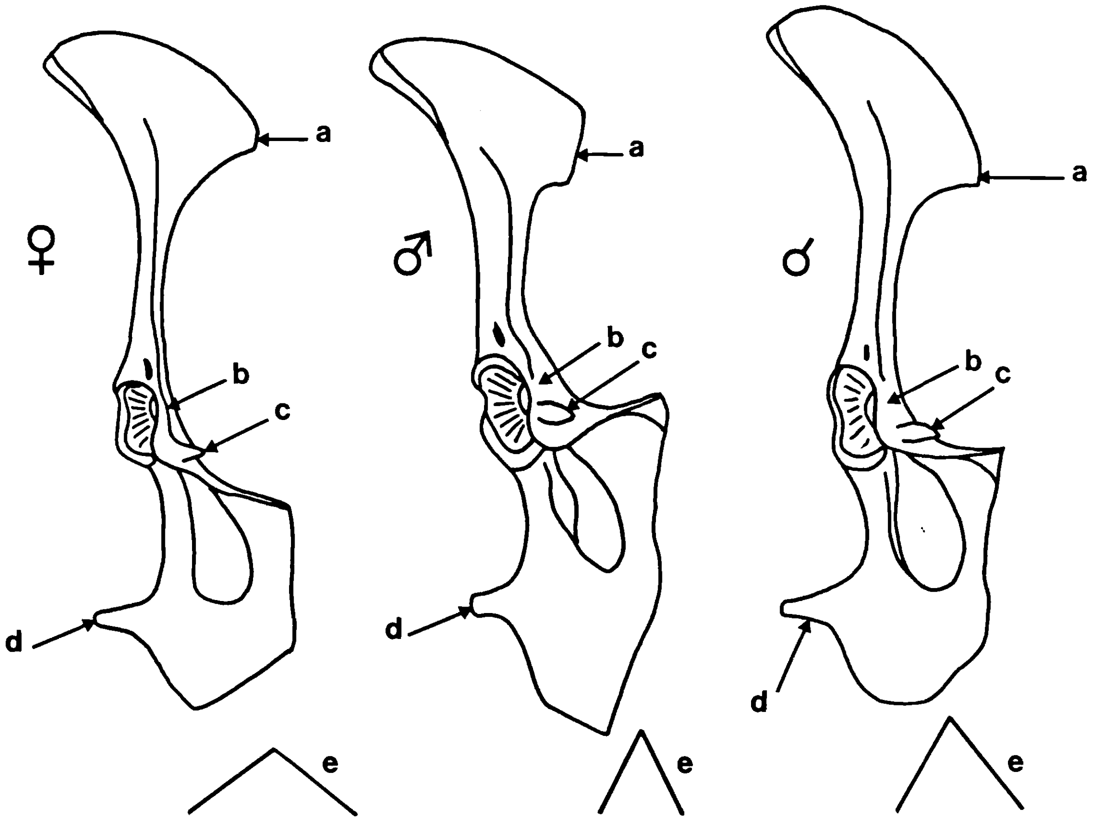
1. Pelvic girdle:

   The criteria which may be used to distinguish between the pelvis of a male and that of a female sheep have been described by Boessneck (1971, p. 344). In order that the differences between a male and a castrated animal could be established, a six year old Soay wether from the flock at Babraham was, at my request, slaughtered, and with the assistance of Mr. A. Redfern at the BM(NH) a skeleton made from the carcass.

   A drawing of the innominate bone of the Soay castrate is shown in Figure 14(A), together with those of a female and a male, the differences in morphology are tabulated below in Table 10.

FIG.14

(A) Soay sheep: Innominate, adult ewe, ram and wether (castrate).



(B) Sheep: Innominate, measurement of the thickness (depth) of medial rim of the acetabulum.

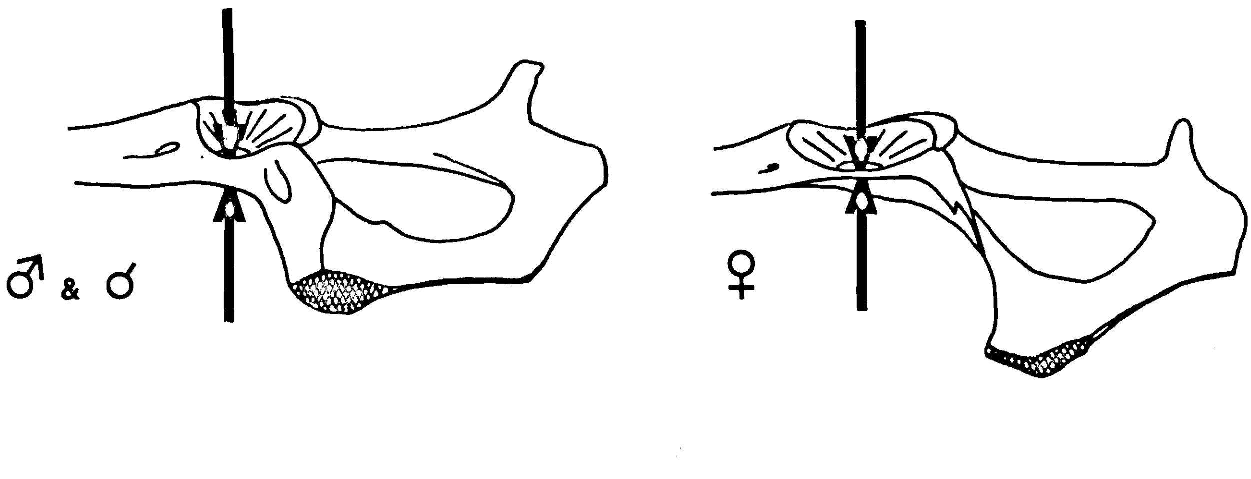


Table 10: Soay sheep. Innominate bone, sex differentiation

	Feature*	Female	Male	Castrate
a.	Sacral tuberosity	Ends in a point	Blunt-ended	Intermediate in shape between male & female
b.	Depth of medial border (rim) of acetabulum	Half the depth of the male	Twice the depth of the female	Intermediate in depth between male & female
c.	Ilio-pectineal eminence	Sharp-edged, with pectin ossis pubis present	Pad-shaped, pectin ossis pubis absent. Pubic branch strongly developed	Sharp-edged, pubic branch less strongly developed than that of the male
d.	Ischial tuberosity	Long, cylindrical	Bulbous	Long, cylindrical
e.	Ischial arch	Open 'V' shaped	Narrow 'V' shaped	Intermediate in shape between male & female

*Features a to e, as marked on Figure 14(A)

The problem with specimens recovered from archaeological sites is that they are often fragmented or butchered. It is therefore not always possible to identify the sex using the criteria described above. Where the acetabulum remains intact the sex may be determined by absolute measurement.

Lemppenau (1964, p.17) has demonstrated how measurement of the depth of the medial rim of the acetabulum can be used to separate the sexes in Roe deer (Capreolus capreolus). In a recent analysis carried out on a group of 57 innominate bones of Soay sheep of known sex, I found that it was possible to segregate the sexes in sheep by means of this measurement. As expected, the histogram produced from the data on the Soay sheep (Figure 15) shows a bi-modal distribution, with very little overlap between the two component distributions (male and female). The data relating to each of the distributions were plotted separately as cumulative percentages on probability paper (Figure 15, straight lines, male & female), after the method described by Harding (1949). From these lines estimates of the means and standard deviations for the male and female populations were obtained, these values closely approximate those derived from the data by calculation (Table 11).

Table 11: Soay sheep. Innominate bone, depth of the medial rim of the acetabulum. Sex differentiation.

	No. specimens	Mean	Range	Standard deviation
Male:				
Calculated	27	6.86	4.3 - 9.9	1.22
Estimated[1]	27	7.20	4.3 - 9.9	1.30
Female:				
Calculated	30	2.75	1.1 - 5.2	0.93
Estimated[1]	30	2.80	1.1 - 5.2	1.10

1 Values obtained by graphical means from the lines plotted on probability paper (Figure 15), after the method of Harding (1949).

As the distribution was bi-modal, the cumulative percentages of the combined male and female data when plotted on the probability paper produced a sigmoidal curve (Figure 15, CF). Had the distribution been normal, the points would have fallen on a straight line (Harding, 1949, p.142).

The histograms produced from the data on the innominate bones from Baynard's Castle (deposits 1 & 23; 88, 89 and 100) are shown in Figure 16, together with their cumulative frequencies (CF) as plotted on probability paper. Both distributions are apparently normal, an observation which, in the light of the analysis on the Soay material, is unexpected. This can be explained, however, if the two apparently 'normal' distributions are each made up of three component populations, themselves normally distributed (Figure 16, model of polymodal distribution), with the size ranges of the distributions overlapping. Examination of the more complete specimens from the castle and dock basin dumps, using the criteria described previously in Table 10, revealed that male, female and castrated animals were represented, with a predominance of castrates (Table 12). Thus verifying the interpretation that both distributions are in fact polymodal rather than normal, and include castrates as well as males and females.

Table 12: Late medieval and early Tudor sheep. Innominate bone, proportions[1] of male, female and castrated animals.

Deposits 1 & 23		
c.1520 AD	Male & castrate[2]	45 (86%)
	Female	7 (14%)
	Sex unknown[3]	13
Deposit 100		
c.1499 - 1500 AD	Male & castrate[2]	93 (85%)
	Female	17 (15%)
	Sex unknown[3]	28

Key:
1. Proportions expressed as % of total number of sexed specimens.
2. Mostly castrates, only a few entire males present.
3. Specimen too fragmented to allow the sex to be determined.

Although the absolute numbers of males, females and castrates cannot be determined with any degree of accuracy from the data, there is evidence that the greatest proportion of innominate bones from Baynard's Castle come from wethers (castrated sheep). Wether sheep produce a heavier fleece, of better quality than the ewe, and therefore flocks of sheep in the late medieval period had a high proportion of castrated animals. The list of sheep owned by Owston Abbey, Leicestershire for the year 1388 (referred to by Trow-Smith, 1957, p. 149), for instance, shows that there were 158 wethers, 5 rams and 131 ewes.

FIG.15

Soay sheep: Innominate, thickness of medial rim of the acetabulum.

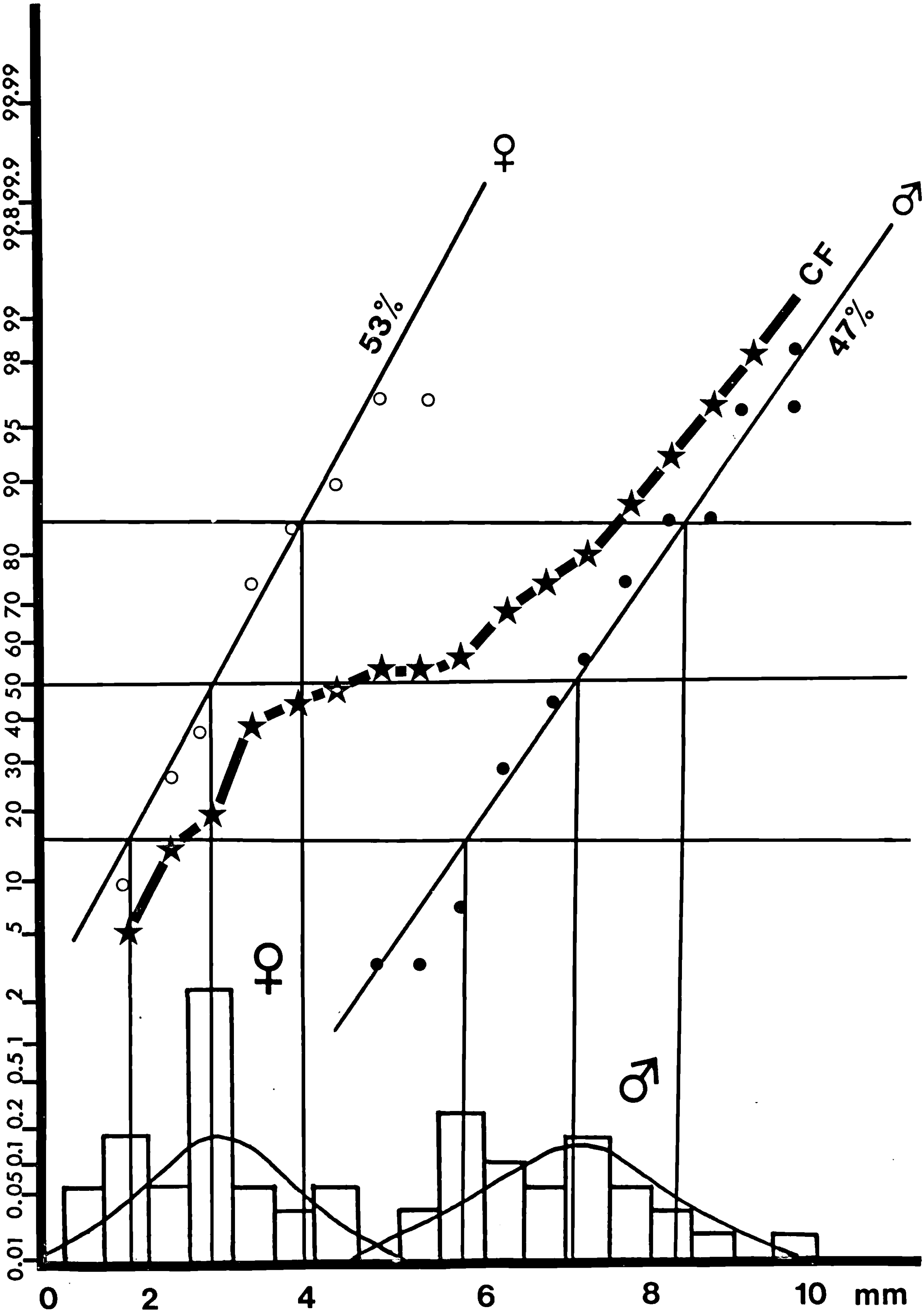
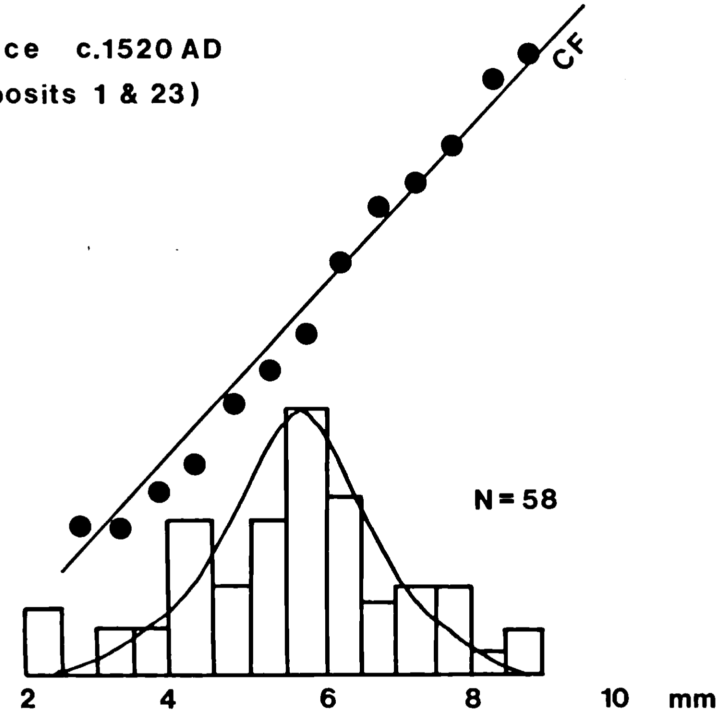


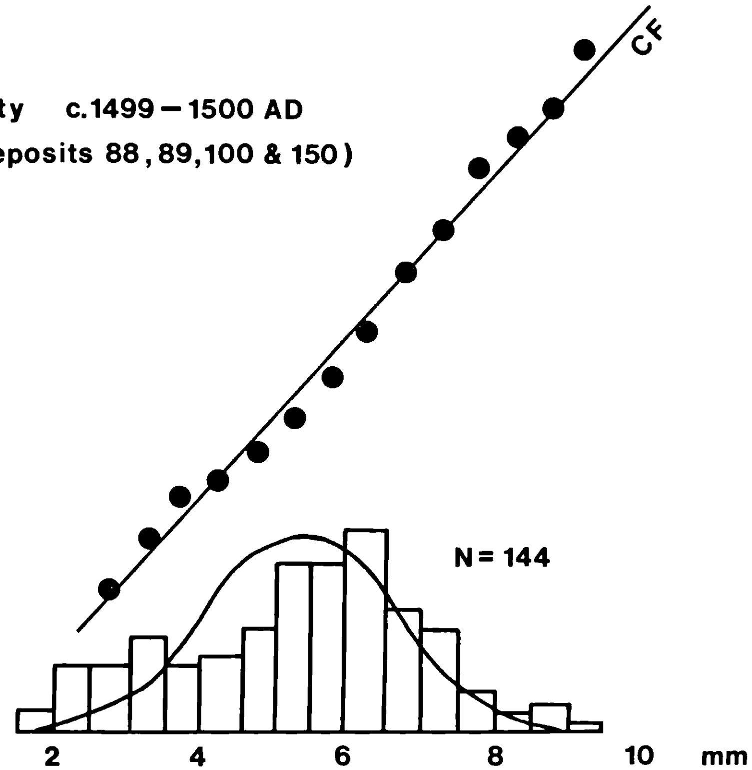
FIG.16

Late medieval and early Tudor sheep from Baynard's Castle: Innominate, thickness of rim of the acetabulum.

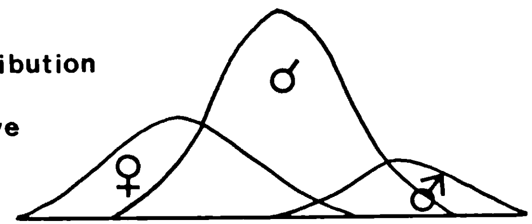
Palace c.1520 AD
(deposits 1 & 23)



City c.1499 – 1500 AD
(deposits 88, 89, 100 & 150)



Model of polymodal distribution
of ewes, wethers and rams
to explain the results above



II. Horn cores:

Horn cores of sheep are known to exhibit marked sexual dimorphism, with the core of the male being larger and more robust compared to that of the female. It is therefore possible to separate the cores of females from those of males by means of absolute measurement, particularly on the basis of the length of the posterior-dorsal (outer) curve and the minimum diameter of the base, as demonstrated by Pollock (1976, p.101).

The main problem with bone material from archaeological sites is that horn cores from castrated sheep may also be present, and these can be difficult to identify as their size and shape depends very much at what age castration was carried out. If a ram lamb is castrated soon after birth there is a marked slowing up of horn growth (Ibsen, 1944; Fraser, 1955) and the horns develop to resemble those of the female, the cores being shorter and less curved than those of the male (see Figure 17, core no. 8), When the time of castration is delayed until the animal is older, the effect on growth and development is less severe, the cores of the adult wether being similar to those of the entire, adult male (see Hatting, 1975, Figure 9, p. 351).

Contemporary descriptions of livestock husbandry suggest that during the sixteenth century a male animal that was not going to be kept for breeding purposes was usually castrated 10 to 20 days after birth. Therefore it is to be expected that the cores of wether sheep from early Tudor sites will be similar to those of the ewes, but slightly more robust, with a minimum diameter at the base intermediate between that of the male and the female.

Before attempting to establish the sex of the specimens from Baynard's Castle, the collection of horn cores of male, female and castrated Soay sheep at the BM(NH) was examined, in order to determine, in greater detail, the differences between the sexes. Each core was measured and then X-rayed to enable the extent of the cavity to be determined (Figure 17), this feature has been shown by Hatting (1975) to be diagnostic of the sex of the core. Using a planimeter (Haff planimeter no. 317) the following values(cm^2) were obtained from the radiographic plates:-

a. the area of the cavity, projected in one plane (medio-lateral)

b. the total area of the core, projected in the same plane.

The relative size of the cavity, expressed as a percentage of the overall size of the horn core, was calculated from the index of (a/b) x 100

Information relating to the cores of the Soay sheep has been summarised below in Table 13. The Soay horn cores were used as type specimens against which the cores from Baynard's Castle could be compared.

Table 13: Soay sheep. Horn core.

No.[1]	Sex	Age (years)	Measurements[2] LOC	BC	MXD	MND	Index[3]
1	female	2+	51	71	25	16	39.0
2	female	5+	68	77	27	16	44.3
3	female	5+	77	77	25	17	27.8
4	female	5+	32	43	19	14	39.0
5	male	4 mnths.	-	-	-	-	-
6	male	1	75	86	30	24	14.2
7	male	3+	235	143	47	40	19.4
8	castrate	6+	135	116	43	26	23.9

Key:
1. Number as in Figure 17
2. Measurements (mm):-
   - LOC Length of outer curve
   - BC Basal circumference
   - MXD Maximum diameter at base
   - MND Minimum diameter at base.
3. Index: (area of cavity/total area of core) x 100.

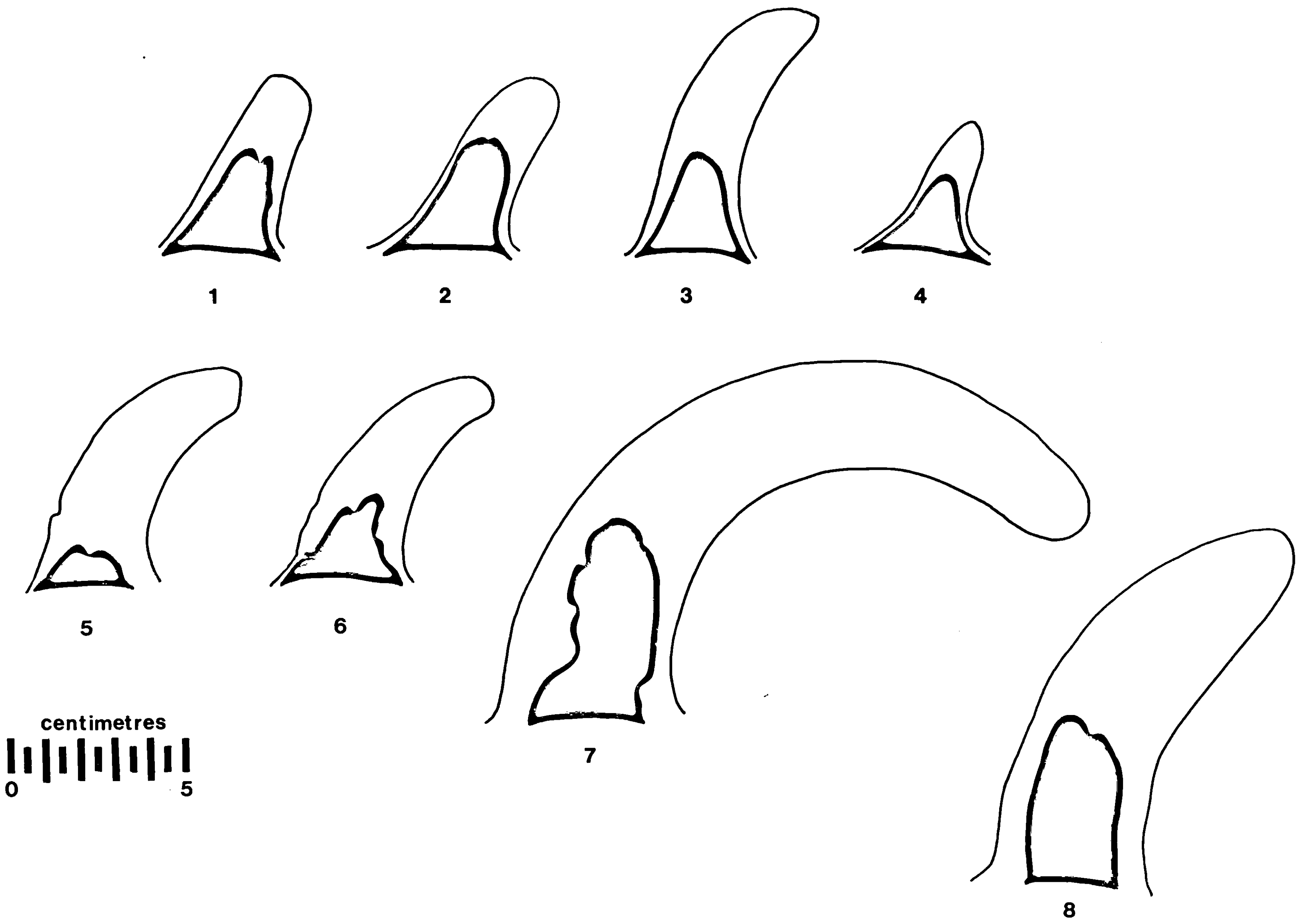
Note: The Soay sheep are from island and mainland flocks:-

1, 2, 3, 4, 6 & 7	island flock
5 and 8	mainland flock

Animal number eight was castrated at two weeks of age.

FIG.17

Soay sheep: Horn cores, tracings taken from radiographic plates. Cavities shown as solid black parts.



Eight horn cores from Baynard's Castle (Figure 18) were examined in detail, following the procedure adopted for the Soay material, information on these specimens is given in Table 14.

Table 14: Late medieval and early Tudor sheep. Horn core.

No.[1]	Deposit	Sex	Measurements[2] LOC	BC	MXD	MND	Index[3]
1	23	castrate?	88	-	31.7	-	29.4
2	1	castrate	77	80	26.4	23.7	28.6
3	23	castrate	122	86	31.6	22.9	28.1
4	1	castrate	125	93	37.8	23.6	45.2
5	100	female/ castrate?	111	88	31.0	23.8	37.5
6	100	male	-	121	43.0	34.1	9.7
7	250	male	190	135	52.0	31.7	28.2
8	100	female	97	77	29.3	19.1	20.5

Key: 1. Number as in Figure 18

BM(NH) Reg. Nos: 1-75.10882; 2-75.8275; 3-75.8271; 4-75.8274; 5-75.10884; 6-75.8277; 7-75.8161; 8-75.8168

2. Measurements (mm):-
- LOC Length of outer curve
- BC Basal circumference
- MXD Maximum diameter at base
- MND Minimum diameter at base

3. Index: (area of cavity/total area of core) x 100

Having identified the cores of male, female and castrated animals from this group of eight specimens it was then possible to sort the remaining, incomplete (broken) specimens according to sex. The number of male, female and castrated sheep represented by the horn cores from Baynard's Castle may be assessed as:-

Deposits 1 & 23

1	right,	castrate ?
3	left,	castrate
1	left,	castrate ?

1 rudimentary core, sex ?
2 juvenile, sex ?

Deposit 100

1	right,	male
1	left,	female
1	right,	female/castrate ?

2 juvenile, sex?

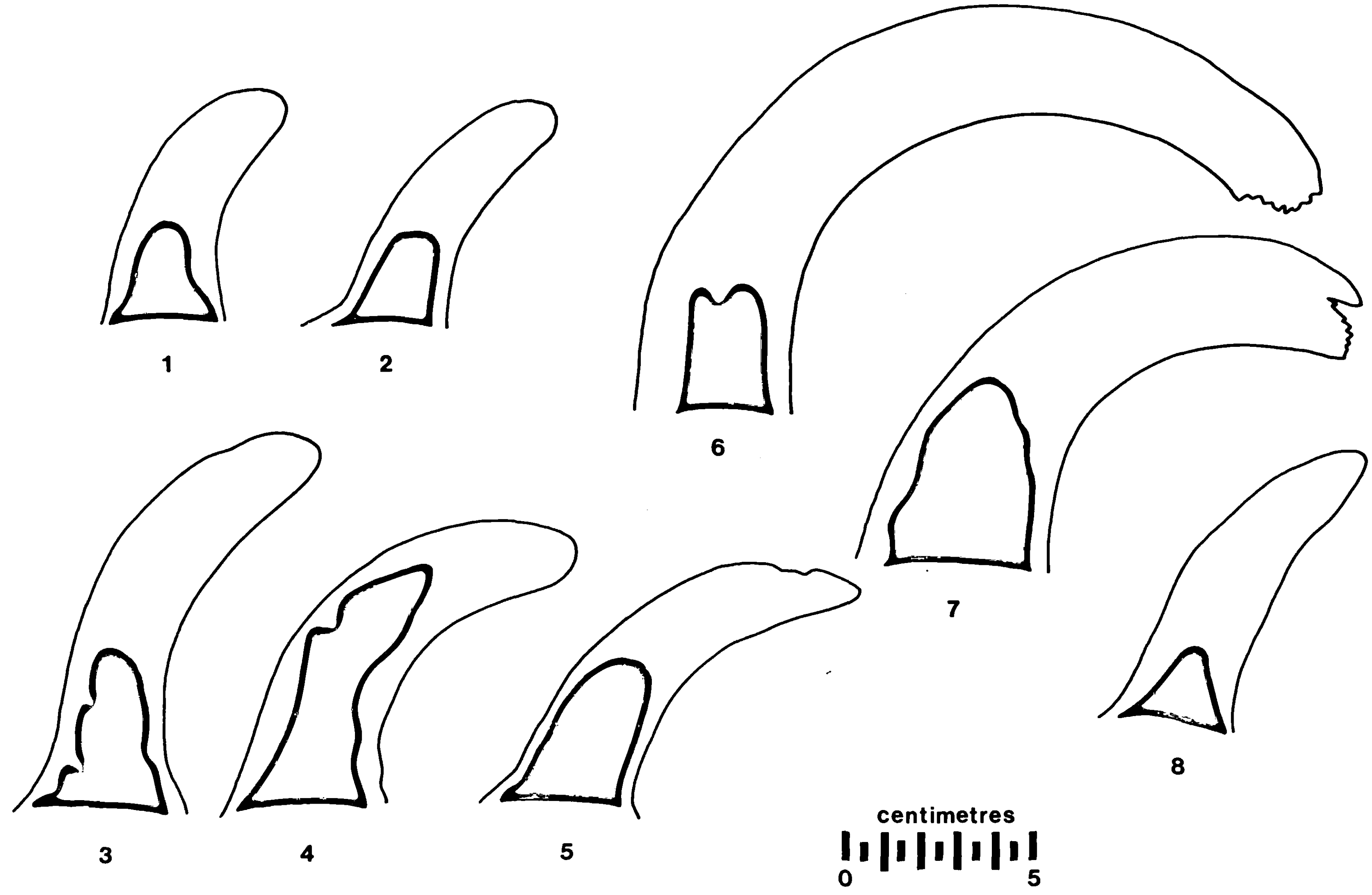
Deposit 250

2	right,	male
1	left,	male

4 juvenile, sex?

FIG.18

Late medieval and early Tudor sheep from Baynard's Castle: Horn cores, tracings taken from radiographic plates. Cavities shown as solid black parts.



Age at slaughter

The relative number of animals killed at each age (i. e. the kill-off pattern) was established using data on eruption and wear of the teeth in the mandibles, after the method of Payne (1973) where nine wear stages are used, the stage reached being defined by the extent to which the enamel has been worn away to expose the dentine.

Figure 19 shows the kill-off pattern established for the 75 complete mandibles from the dock basin dump (deposits 88, 89 & 100). The same pattern was found in the 161 complete mandibles from the castle pits (deposits 1 & 23). Two peaks of slaughtering are discernible from the diagram, one at age 2 to 6 months (wear stage B) and another at 4 to 6 years. (stage G). This pattern fits very well the picture we have of late medieval and early Tudor livestock husbandry based on contemporary documentation. In the early Tudor period the fattening and sale of animals was not the principal reason for sheep farming, as it is today, instead, sheep were kept primarily as producers of wool and the meat market was mainly supplied with old, weak and sick animals (Bowden, 1967). By modern standards the sheep were kept to a relatively late age, and most were sold as mutton when 4 to 6 years of age. A number of sucking and very young lambs were, however, purchased and hand reared in the larger households for the table, (see Wilson, 1973, p. 91) and this may explain the first peak at 2-6 months in the kill-off pattern for Baynard's Castle.

For comparison with the medieval slaughter pattern, the kill-off pattern for a modern mixed (arable & livestock) farm in Herefordshire is also given in Figure 19, and is based on my own, unpublished records of the numbers of sheep (fat lambs & culled ewes) sent off to market and slaughter, for the years 1968 to 1969. As these modern wethers and surplus ewe lambs were finished on swedes and kale (i. e. were folded) during the late autumn and early winter months, the fat stock were sent off to market at age

9 to 12 months. This is, by most present day standards, a somewhat outdated practice (see Fraser, 1947, p. 112) for the majority of lowland farmers fatten their lambs up to market requirements by 6 months of age (see ADAS, 1971). In spite of the fact that the Hereford data is not entirely representative of modern sheep farming, the essential, and striking differences between a wool (medieval) and a meat (modern) producing economy are demonstrated in Figure 19.

Sample of leg hair

A metatarsal bone (specimen 76. 6561), from a juvenile (distal epiphysis unfused and detached), with wool and hair fibres still attached was recovered from the city debris (deposit 250). Using the automatic measuring equipment built by Dr W. A. Sands, Centre for Overseas Pest Research, one hundred fibres were measured and the following range of diameter size (microns) recorded:-

No. measured	Mean	Range	Standard deviation	Distribution
100	48.4	12 - 98	22.8	symmetrical

Fine wool fibres (under 30 microns) were non-medullated.

Coarse wool fibres (50 to 60 microns) and hair (over 60 microns) with medulla (non-latticed).

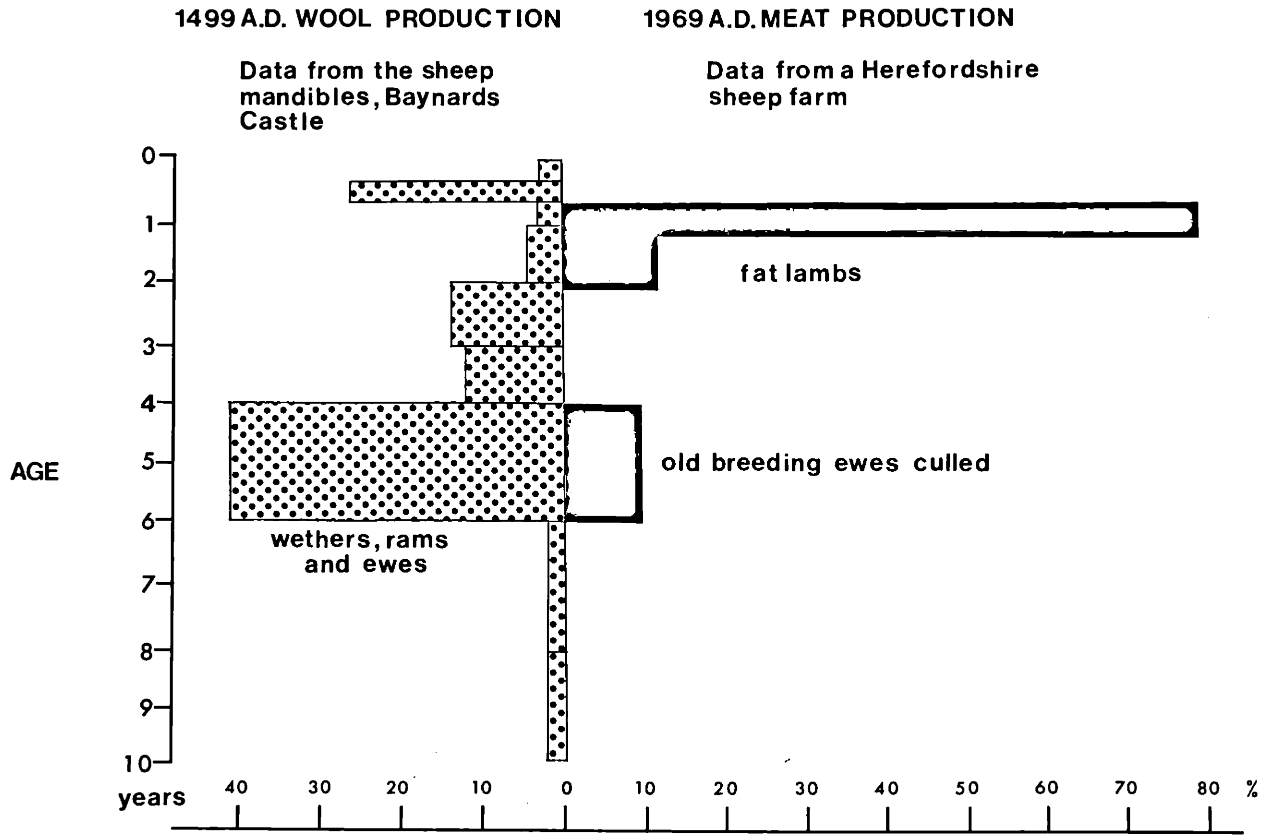
Several casts of fibres were made in polyvinyl acetate using the semi-embedding and extraction technique described by Wildman (1954), in order to view the scale patterns, these were all of the irregular waved, mosaic type.

A sample of fibres was sent for examination to Dr. M. L. Ryder, Animal Breeding Research Organisation, Midlothian. In his report he says that although the granules are not very clear, the hairs have natural brown pigment, more like the Shetland breed of sheep than the Soay, and this is what he would have expected in a medieval sheep (Ryder, 1976, pers. comm.).

FIG.19

ANCIENT AND MODERN SLAUGHTER PATTERNS FOR SHEEP.

(Percentage frequency of animals slaughtered in each age class)



(4) PIG Sus (domestic)

A total of 2,058 bones of pig was identified and examined (Table 15). Measurements taken from most of these bones fall within the ranges in size proposed by Clason (1967, p. 63) for the domestic pig. There are, however, several specimens (details of which are given in section 4, summary of the data) whose dimensions overlap those for the wild pig (Sus scrofa), but these are probably from very large domestic males. All the bones from Baynard's Castle are therefore believed to be from domestic pigs.

Table 15: Pig. Number of bones identified and examined.

	Castle pits		Dock basin		City debris	Secondary dumps[1]
	c. 1520 AD		c. 1499-1500 AD		c. mid 14th cent. AD	mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
skull	8	3	4	13	3	-
maxilla	26	4	-	34	14	28
mandible	35	7	1	87	50	72
tooth	82	17	1	119	54	30
scapula	18	10	2	32	25	20
humerus	9	10	4	67	22	29
radius	9	10	4	52	28	41
ulna	5	21	4	49	36	46
innominate	4	4	-	17	10	6
femur	6	9	3	22	8	7
tibia	6	21	5	56	23	39
fibula	3	9	-	26	18	6
calcaneum	10	10	1	17	-	10
talus	9	4	-	5	1	4
foot bone[2]	15	1	-	32	29	-
metapodia	34	12	8	121	70	103
phalanx	-	-	2	-	-	7
vertebra	*	*	*	*	*	*
rib	*	*	*	*	*	*
bone	*	*	*	*	*	*
Total:	279	152	39	749	391	448

Key:	1.	Secondary dumps: Numbers of bone refer to selected samples only
	2.	Foot bone: Carpal - and tarsal - bones
	*	Vertebrae, ribs & fragmented bone (scrap); large numbers present but not examined.

Age at slaughter

The relative numbers of animals killed at each age (i.e. the kill-off pattern) was established using data on eruption of the teeth in the mandibles, the age at which each tooth erupts being based on data for pigs of the late eighteenth century (Silver, 1971, Table G, p. 298 - 299). The kill-off patterns for the castle pits (deposits 1 & 23) and the dock basin dump (deposits 88, 89 & 100) are given in Table 16.

Table 16: Late medieval and early Tudor pig. Mandible, kill-off pattern.

	Age at Slaughter (years)	No mandibles	Cumulative frequency
Deposits 1 & 23			
castle pits c. 1520 AD	less than 1	8	0%
	$1\frac{1}{2}$ - 2	3	36%
	2 - 3	7	50%
	over 3	4	82%
Deposits 88, 89 & 100			
dock basin dump c. 1499-1500 AD	less than 1	17	0%
	$1\frac{1}{2}$ - 2	9	26%
	2 - 3	32	40%
	over 3	7	89%

The kill-off patterns show that in the late middle ages very few of the pigs slaughtered for meat had reached maturity at time of death. Over one third of the animals from the castle pits (deposits 1 & 23) had, for instance, been killed-off as sucking or very young pigs (under one year old), and only 18% were adult, aged three years and over (with the third molar fully erupted and in wear). The same picture, with only very slight differences in the values for the cumulative frequencies, also holds true for the pigs from the dock basin dump (deposits 88, 89 and 100).

Sex ratio.

The relative numbers of male, female and castrated pigs were established by measurement and examination of the samples of lower canine teeth (tusks). Canine teeth in the pig show marked sexual dimorphism, with the tooth of the male being larger than that of the female. The sexes can also be distinguished by the amount of enamel covering the tooth and by the differences in root structure; in the female the enamel covers only the crown, and the root is closed, whilst in the male the whole of the tooth including the root is covered in enamel, and the root is open (see Schmid, 1972, p. 81). Castration retards the normal growth and development of the canines, and by comparison with the large tusks of the entire male, those of the castrate appear dwarfed and stunted (Youatt, 1847, p. 106), but they still retain the complete enamel covering and open root as in the male.

Taking the specimens from the dock basin dump (deposits 88, 89 & 100), values of the width across the base of the canine were plotted against those for height (distance from the point of the canine to the posterior edge of the alveolus). From the resultant scatter diagram two groups, one of twenty and the other of five specimens, were discernible. The 95% confidence limits (delineated by 95% percentile ellipses) of the two groups did not overlap, thus verifying the presence of two distinct (separate) clusters. The canines from the largest cluster (with twenty specimens) were not fully developed as they were from immature pigs, and it was therefore not possible to separate the sexes by means of absolute measurement. I found, however, that the sexes could be distinguished using the differences in root stucture and enamel cover discussed above. Where the canine could not be removed for inspection from the mandible without causing damage to the specimen, the structure of the root was determined by radiography. Eighteen of the specimens had open roots and the whole of the tooth covered by enamel, and these were therefore identified as coming from either young males or, alternatively, young castrated pigs. Only two of the teeth were from females, with closed roots and enamelled crowns. The sex ratio for the young and sub-adult pigs from the dock basin deposit is therefore assessed as:- 1 female: 9 male/castrate

The five large sized specimens from the other, smaller cluster were all identified as coming from adult males.

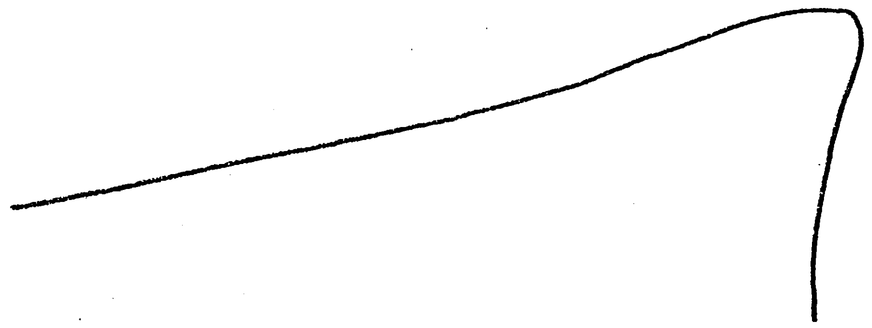
Size and conformation

As almost all the limb bones of pig from Baynard's Castle are from immature individuals, with unfused and detached epiphyses, no comparison of size can be made with the bones from other archaeological sites, or with modern skeletons.

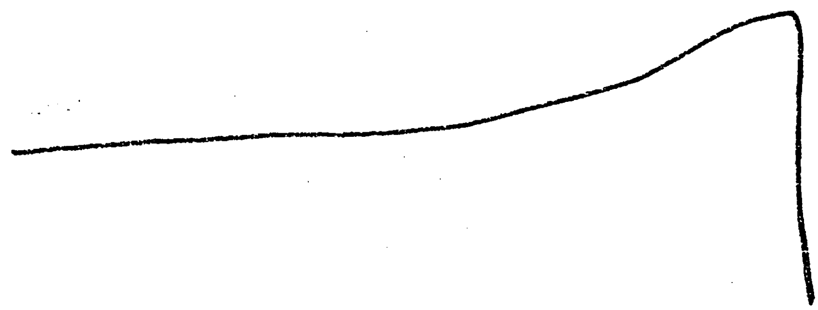
Comparison was made, however, of skull number 75.10332 (deposit 23) with specimens of modern pigs held by the BM(NH). The skull of the early Tudor pig is very different in shape from that of a modern Large White, Yorkshire boar (BM(NH) reg. no. P3) Pigs in the medieval and Tudor periods were of a primitive type, similar to that represented by a skull of a pig from south east Bulgaria (BM(NH) reg. no. 1937. 6. 28. 1.) which resembles that of the European wild boar, except that it is smaller (Clutton-Brock, 1962, p. 143). Drawings made of the sagittal profile of the three pig skulls (see below) show that in the Baynard's Castle and Balkan specimens there is a continuity of line along the frontal and nasal bones, whilst in the highly improved pig the cranio-facial angle is obtuse, which gives the modern animal its characteristic dished (or bulldog) face with a short snout and high forehead. The changes which have occurred in the domestic pig in Britain date from the eighteenth century, and are the result of crossing the largely unimproved, indigenous animals with imported Chinese, Siamese and Neapolitan pigs, as discussed below.

Diagrams showing the shape of the skull along the sagittal line in unimproved (1 & 2) and improved (3) pigs.

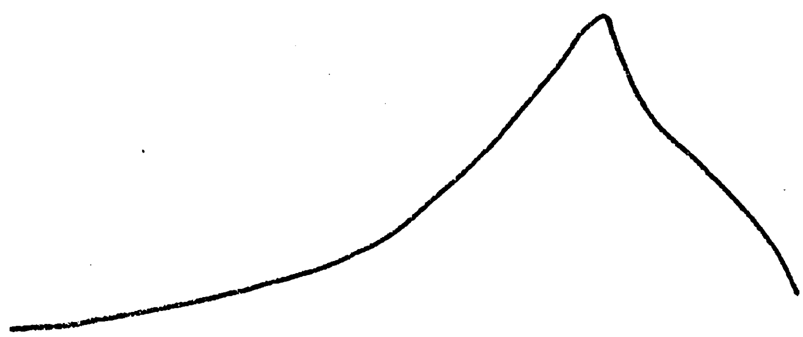
(1) Early Tudor pig from Baynard's Castle (BM(NH) reg. no. 75.10332)



(2) South east Balkan pig (BM(NH) reg. no. 1937. 6. 28. 1)



(3) Large White Yorkshire boar (BM(NH) reg. no. P3)



The pig in late medieval and early modern Britain

In the early medieval (Saxon) period, very large herds of pigs were maintained under free-range conditions in all areas of woodland, and a certain amount of inter-breeding between wild and domestic pigs undoubtedly took place (see Clutton-Brock, 1976a). By the close of the middle ages this picture of the predominance of the pig over the other classes of domestic livestock had altered. The rapid rise in population during the twelfth and thirteenth centuries meant that the area under cultivation had to be expanded to meet the increased demand for food, and many of the lowland woods and forests were clear-felled (von Bath, 1966). As pigs were still largely kept under free-range conditions, and left to fend for themselves in woodland, relying mainly on beech mast and acorns for their survival during the 'lean' autumn and winter months, (see Trow-Smith, 1957, 1959), this meant the reduction in the acreage of woodland was accompanied by a reduction in the numbers of domestic pigs. It was not until the late eighteenth century that large scale pig fattening enterprises, based on the byproducts of the distilling and malting industries were established in the home-counties and elsewhere (see Trow-Smith, 1959, p.220; Thirsk, 1967, p.192-193), and a regular source of supply of bacon, pork and lard was then made available to the markets of London and the other major cities. Unfortunately there are no known extant documents to provide information on the sources of supplies of pig-meat to London during the medieval and Tudor periods, but the presence of many bones of sucking and very young pigs amongst the refuse on the site of Baynard's Castle may indicate that hand-feeding of pigs for the table was a common practice in many of the larger households in the city. The other, older animals (which were mainly slaughtered under three years of age) were probably raised on farms located close to London, and sent into the city for slaughter after they had been fattened on dried peas or split beans (Thirsk, 1967, p.193).

The lack of bone from wild pig at the site further indicates that all pig-meat consumed in the city came from domestic animals, and this confirms the observation made by many authors (see for instance, Dent, 1974, p. 73) that the wild pig had by the late medieval period been hunted to extinction in the forests of southern Britain.

Pigs in the late middle ages and early Tudor period were long-legged, with long, sharp snouts and curved backs which were covered in coarse, bristly hairs, and they embody all the features associated with 'primitive', unimproved animals (Youatt, 1847, p. 54; Hammond, 1948, p. 102; Zeuner, 1963, p. 267). These features are clearly discernible in the carved figures of domestic pigs that are commonly found in churches and cathedrals, either carved in wood as decoration on misericords or in stone on roof-bosses and corbels (see Sillar & Meyler, 1961). It is only since the late eighteenth century, that the pig in Britain has been greatly modified and improved through crossing with imported foreign stock, principally with the Chinese pig, but also including Siamese and Neapolitan pigs (Trow-Smith, 1959, p. 41). The influence of the new imported breeds on livestock husbandry was such that within half a centry after the first introduction of these pigs to this country, hardly any of the original, unimproved type remained (Darwin, 1905, Vol. I, p. 87), and contemporary writers such as Bewick (1790, reprinted 1970, p. 164) commented that 'The Chinese or black breed is now very common in England. They are smaller, have shorter legs, and their flesh is whiter and sweeter than the common kind'. The changes that have taken place in the conformation of the pig following the crossings with imported animals are clearly demonstrated in the group of models made by George Garrard in circa 1800 AD (see Clutton-Brock, 1976b) which are of a wild boar, old English boar, and half-bred Siamese and English sow (BM(NH) reg. no. 73.1611, 73,1609 & 73.1610 respectively). Although there are no longer any truly 'primitive' pigs left in Britain today, animals of a similar type to those once common to the medieval and Tudor periods still survive in a number of outlying country districts in Europe, for instance, near Granada, Spain where Zeuner (1963, Fig. 10.17, p. 268) encountered high-legged pigs with lop-ears that he believed resemble in their external appearance the early European pig.

(5) DOG *Canis* (domestic)

A total of 228 bone elements of dog, including those from two partially-complete, articulated skeletons, was identified and examined (Tables 17 & 18).

Table 17: Dog, Number of bones identified and examined.

	Castle pits	Dock basin			City debris	Secondary dumps[1]
	c.1520 AD	c.1499 - 1500 AD			c. mid 14th cent. AD	mostly c. 13th cent. AD
	1 & 23	88	89	100	250	5000
skull	2	-	-	2	-	-
maxilla	1	-	-	1	-	-
mandible	13	1	-	3	-	-
tooth	*	-	1	*	-	-
scapula	11	-	-	1	-	-
humerus	12	-	-	3	1	-
radius	13	-	1	2	-	1
ulna	*	-	-	*	-	-
innominate	10	-	-	1	1	-
femur	11	-	-	-	-	-
tibia	12	-	-	3	-	1
calcaneum	*	-	-	*	-	-
talus	*	-	-	*	-	-
metapodia	*	*	*	*	-	-
phalanx 1-3	*	*	*	*	-	-
vertebra	*	*	*	*	-	-
Total:	85	1	2	16	2	2

Key: 1. Secondary dumps: Numbers of bone refer to <u>selected</u> specimens only

* Present but not counted

Table 18: Dog. List of the parts of articulated skeletons found.

Deposit	BM(NH) Reg. No.	Parts of skeleton		Description
1	76.6085	skull	1	Parts of articulated skeleton. Adult dog.
		mandible	2	
		scapula	1	
		innominate	1	
		vertebra	26	
		rib	22	
100	76.6107	scapula	2	Parts of articulated skeleton. Adult dog.
		humerus	1	
		radius	1	
		ulna	1	
		innominate	2	
		femur	2	
		vertebra	28	
		rib	28	
		metapodia*		
		phalanx 1-3 *		
	76.6196	humerus	1	Also part of skeleton 76.6107
	76.6197	radius	1	

Key: *Present but not counted

To estimate the sizes of the dogs, I employed two different approaches, both of which gave values for the height at the shoulder. The first estimate was derived from the maximum length of each, complete long bone, after the method of Harcourt (1974), and the following range in size was recorded:-

shoulder height of smallest dog	approx. 25 cm
shoulder height of largest dog	approx. 48 cm

In the second method, the forelimb from the partially complete skeleton of an adult dog (BM(NH) reg.no. 76.6107) found in the dock basin dump (deposit 100) was reconstructed. A length of wire bent to the required shape ensured that the correct angle was made at each joint between two articulating bones, the angles adopted were taken from von den Driesch & Boessneck (1974). The height at the shoulder was obtained by measurement, and with an allowance made for the additional height of the soft tissues came to 34.7 cm. This compares with the estimates for the same animal, based on the method of Harcourt, of:-

humerus	35.3 cm
radius	37.6 cm

There is agreement between the value based on the length of the humerus and that derived from the reconstruction of the limb, but the height at the shoulder calculated from the length of the radius shows a discrepancy of + 2.9 cm.

The largest dog from Baynard's Castle is only slightly taller than the modern fox terrier, there being no bones from large sized dogs. The remains of large sized dogs, have, however, been recovered from other parts of the city of London, a number of these being held in the collection at the BM(NH), and include the skulls of mastiff-like dogs (BM(NH) reg. no. 1969.396, 20 specimens) from a pit on the site of the Lion Tower at the Tower of London, dated to the fourteenth and seventeenth centuries AD (see BM (NH) General letter file, Dr. Fraser, May 8th, 1939), and two skulls of greyhound-like dogs (BM(NH) reg. nos. 1954.12.19.1. & 1954.12.19.2) from a sixteenth century AD pit, Walbrook.

Figure 20 shows one of the large, mastiff-like skulls from the Lion Tower site, and one of the greyhound-like skulls from the Walbrook, together with the two complete specimens from Baynard's Castle. Measurements taken from the skulls from these three archaeological sites are shown in Figure 21, where values of the maximum zygomatic width are plotted against those of the length of the skull. From the scatter diagram, the wide variation in size in late medieval and Tudor dogs is apparent.

Included in the regulations laid down for the Royal household by Henry VIII is a proclamation which strictly forbids the keeping of greyhounds, mastiffs and other hounds in court, and the only dogs permitted are 'some small spaniels for the ladies' (Ash, 1927, Vol. II, p. 674). This may explain the absence of skeletal remains of large dogs from the pits located within the castle grounds (deposits 1 & 23, circa 1520 AD), and that only the smaller types of dog were allowed to be kept at Baynard's Castle, the large dogs used in hunting being housed in kennels elsewhere.

Specimen 76.6081 from Baynard's Castle is of particular interest, as the small size, dome-like cranium, and short snout identifies it as the skull of a pet lap dog, possibly a toy spaniel. Contemporary sources indicate that the lap dog had by the later middle ages become both popular and fashionable amount the ladies of the nobility and the wealthier classes. The earliest reference to such a dog in Britain appears in The Book of Saint Alban written by Juliana Barnes in 1486, in which the toy dog is listed as a 'small ladies popis' (quoted in Vesey-Fitzgerald, 1957, p. 80-81). The lap dog, in the form of a small, playful-looking dog with a belled collar, is frequently encountered on monumental brasses, usually at the feet of a lady. Two examples of lap dogs are shown in Figure 22, and are taken from the brass to Agnes Salmon (1430 AD) at Arundel, Sussex.

Figure 20: Dog skulls from archaeological sites in London.

From left to right:

BM(NH)Reg. No.	Site	Date	Description
76.6081	Baynard's Castle	c.1499-1500 AD	toy spaniel
76.6085	Baynard's Castle	c.1520 AD	mongrel dog
54.12.19.1	Walbrook	c.1500 AD	greyhound-like dog
69.396	Tower of London	14th-17th cent. AD	mastiff-like dog

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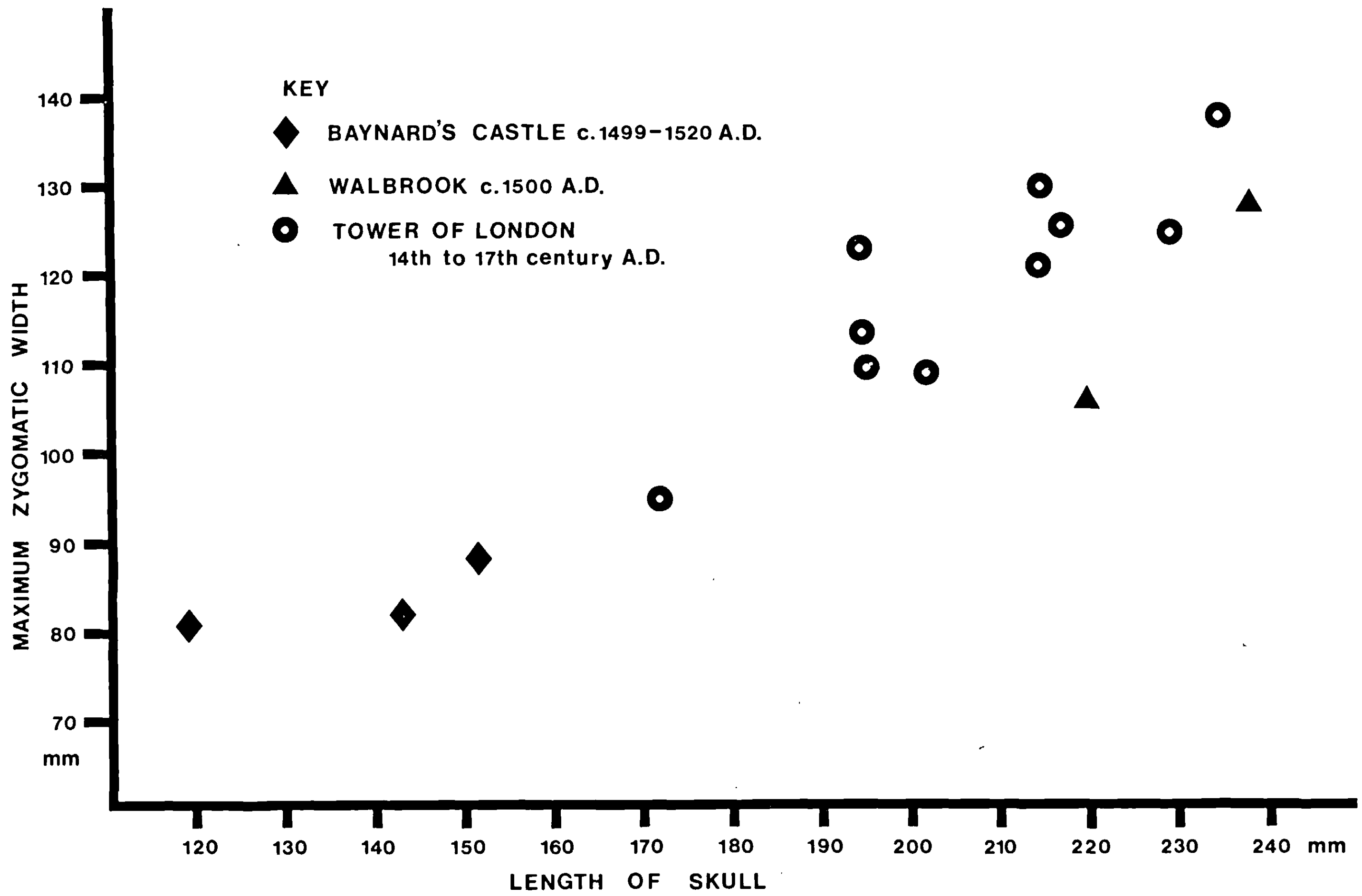
FIG. 21

Late medieval and early *Tudor* dogs: Skull, maximum zygomatic width plotted against length



Lap dogs (Toy spaniels) from the brass to Agnes Salmon (1430 A.D.), Arundel, Sussex.

FIG.22

(6) CAT *Felis* (domestic)

Five partially complete, articulated skeletons, and 136 separate bone elements of cat were recovered from the site (Tables 19 & 20). Both adult and juvenile cats were represented by the material. Comparison of the bones of the adults with the skeletons of modern domestic cats held in the BM(NH) indicates that cats were smaller in the late medieval and early Tudor periods (see section 4, summary of the data).

Table 19: Cat. Number of bones identified and examined.

	Castle pits	Dock basin			City debris
	c. 1520 AD	c. 1499-1500 AD			c. mid 14th cent AD
	1 & 23	88	89	100	250
skull	1	8	-	-	-
maxilla	-	-	-	3	-
mandible	6	2	-	6	7 (1f)
tooth	*	*	-	*	*
scapula	3	-	-	-	1
humerus	10	1	-	18	3
radius	2	1	-	9	1
ulna	*	1	-	*	*
innominate	5	4	-	2	2
femur	6	4	-	8	2
tibia	6	1	-	7	1
calcaneum	*	2	-	*	1
talus	*	2	-	*	*
metapodia	*	*	-	*	*
phalanx 1-3	*	*	-	*	*
vertebra	*	*	-	*	*
rib	*	*	-	*	*
Total	39	26	-	53	18

Key: (f) Skin & fur still attached to bone

* Present but not counted.

Other deposits: Deposit 5000 mostly c. 13th century AD not examined

Table 20: Cat. Articulated skeletons found

Deposit	BM(NH)Reg. No.	Description
83	76.6344	Skull & skeleton of kitten. Complete except for 1 scapula, 1 pelvis, 1 femur, 1 tibia, 64 metapodial bones & phalanges, 39 vertebrae and 7 ribs.
83	76.6345	Skeleton of kitten. Complete except for the skull, 1 scapula, 1 humerus, 1 radius, 1 pelvis, 44 metapodial bones & phalanges and 22 vertebrae.
88	76.6341	Skull & skeleton of kitten. Skin & fur still attached to bones. Complete except for the bones of the hind limbs, 31 vertebrae and 5 ribs
88	76.6342	Skeleton of adult cat. Complete except for the skull, 1 humerus, 1 radius, 1 talus, 50 metapodial bones & phalanges and 35 vertebrae.
88	76.6343	Skull & skeleton of adult cat. Complete except for 1 pelvis, 2 femora, 34 metapodial bones & phalanges and 28 vertebrae

Deposit 83 c.15th century AD
Deposit 88 c.1499-1500 AD

The cat today is a common household pet, but in the medieval period the majority of cats to be found in a town or city would be feral, semi-wild scavengers. In this respect, the present day cat populations of Rome and Venice are not far removed from that of London in the later middle ages. Ownership of a cat, particularly if it was black, in the middle ages was on occasion viewed with suspicion. As the black cat was associated with Satan, the possession of such an animal could be cited as final proof of collaboration with the devil in the trial of a suspected witch or heretic against the established church. A frequent feature of the trials of witches which took place in the thirteenth, fourteenth and fifteenth centures, as discussed by Russell(1972), was the charge brought against the accused that they had participated in meetings during which a black cat was used as the focus for the practice of obscene rituals. In some trials the inquisitors appointed by the church even went as far as to suggest that the accused was guilty of invoking demons, who it was believed commonly appeared in the guise of black cats. Cats were themselves at times persecuted in the sixteenth century because of their alleged connection with the forces of evil, and incidents are recorded where cats were burnt alive or hurled down from high towers (Simpson, 1903, p. 8; Bökönyi, 1974, p. 312).

(7) DOMESTIC RABBIT * <u>Oryctolagus cuniculus</u>

A total of 1,265 bones of rabbit were identified and measured. Tables 21 and 22 show the number of bones identified from each of the three major dumps of rubbish.

Table 21: Rabbit. Number of bones identified and examined

	Castle pits c.1520 AD	Dock basin c.1499-1500 AD			City debris c. mid 14th cent. AD
	1 & 23	88	89	100 & 150	250
skull	2	1	1	5	-
maxilla	10	-	2	-	-
mandible	62	10	9	19	5
tooth	85	8	16	3	-
scapula	90	8	2	26	3
humerus	107	23	8	69	4
radius	20	4	1	12	2
innominate	122	27	5	58	3
femur	77	24	10	63	6
tibia	92	23	5	57	6
calcaneum	3	1	2	3	-
metapodial bone	+	+	+	1f	+
phalanx	+	+	+	+	+
rib	+	+	+	+	+
vertebra	+	+	+	+	+
Total	670	129	61	316	29

Key: + Present but not counted
f Skin & fur still attached to bone

*Footnote: The word 'rabbit' is used here in the modern sense to denote both young and adult animals. In medieval times and until well into the seventeenth century, however, only the young animal of less than one year of age was referred to as a rabbit, the adult being called a coney.

Table 22 : Rabbit. List of the parts of articulated skeletons found

Deposit	BM(NH)Reg. No.	Number of bones	Description
1	76.6073	20 +	Skull plus limb bones from one articulated skeleton
88	76.6190	10 +	One hindlimb with skin & fur still attached, tibia chopped through
150	76.6091	30 +	Fore- and hind-limbs plus vertebrae & ribs from one articulated skeleton

Generally, the bones of rabbits, together with those of rats and other burrowing animals, when found in an archaeological context have to be treated with caution by the zoologist. Such bones are not always contemporary with the rest of the associated faunal remains and may, in some instances, post-date them by a considerable period of time. As the large collection of rabbit bone from Baynard's Castle came from well defined, stratified deposits it is highly unlikely that this material was intrusive, and therefore it provides valuable information relating to late medieval rabbits and their exploitation as a source of fleshmeat.

The humeri and tibiae from the 'robber pits' within the castle grounds (deposits 1 & 23) and the dock basin dump (deposits 88, 89, 100 & 150) were aged by the methods of Hale (1949) and Watson & Tyndale-Biscoe (1953), as quoted by Thompson & Worden (1956, p. 36-39). Table 23 provides a summary of the analysis.

Table 23: Rabbit. Kill-off pattern

Numbers of fused and unfused specimens, expressed as a percentage of the total number of bones from each of the two main dumps of rubbish, are shown in ( ).

(1) Humerus. Proximal epiphysis

	Fused (adult)	Unfused (young, under 9 months)
Deposits 1 & 23	19 (27%)	52 (73%)
Deposits 88, 89, 100 & 150	46 (57%)	35 (43%)

Result of chi-square test:-

Null hypothesis: Each of the two main dumps of rubbish contain equal numbers of adults and young.

Deposits 1 & 23 — significant difference, $P < 0.01$, Null hypothesis rejected.

Deposits 88-150 — no significant difference, Null hypothesis accepted.

(2) Tibia. Proximal epiphysis and apophysis

	Fully fused[1]	Partially fused[2]	Unfused[3]
Deposits 1 & 23	28 (39%)	17	26
		43 (61%)	
Deposits 88-150	34 (54%)	22	7
		29 (46%)	

Key:
1. Fully fused: Proximal epiphysis and apophysis completely fused to head of shaft. Adult.
2. Partially fused: Proximal epiphysis and apophysis joined, but the apophysis has not fused with the shaft. Young, under $9\frac{1}{2}$ months.
3. Unfused: Both proximal epiphysis and apophysis unfused and detached from shaft. Very young rabbit.

Result of chi-square test:-

Null hypothesis: Each of the two main dumps of rubbish contain equal numbers of adults and young.

Deposits 1 & 23 — not significant at 5%

Deposits 88-150 — no significant difference, Null hypothesis accepted.

The kill-off pattern established for the sample of humeri revealed that there was a difference between the rabbit meat supplied to the castle and that eaten by the commoners; the inhabitants of the castle apparently had a greater preference for fleshmeat from young animals in their diet. A chi-square test performed on the data from the humeri supports the observation that the castle material contains a higher proportion of bone from young rabbits, whilst that from the city dump has equal numbers of bones from adults and young. Paradoxically, the result of the same test applied to the data relating to the tibiae is not as clear. Comparison of the numbers of tibiae from very young rabbits (with detached proximal epiphyses & apophyses) in Table 23 does, however, suggest that there is a marked difference between the two dumps, with the castle material having a much higher proportion of bone from very young individuals.

In medieval and Tudor times the flesh of rabbit was considered to be a great delicacy and easy to digest; rabbits therefore frequently appeared on the menus at important feasts and banquets. At the feast held by George Nevill, Archbishop of York, in 1465, for example, 4,000 rabbits were consumed (Thompson & Worden, 1956, p.13). Contemporary writers indicate that the meat from very young rabbits was held in particularly high esteem, Topsell (1607, reprinted 1967), for instance, commented on this aspect, saying that 'Their flesh is very white and sweet, especially of the young ones, being fourteen and twenty days old'. This perhaps explains the occurence of the large quantity of bone of very young animals amongst the refuse from the castle.

When being prepared for eating, the rabbit was commonly parboiled, larded and roasted whole on a spit, usually with the head left on, and then served up with various sauces (Wilson, 1976, p.78, 86 & 101). Several of the limb bones from Baynard's

Castle have been clearly chopped through (see section 3.3, butchery) indicating that a few rabbits had been disjointed (possibly with a large knife) rather than roasted whole, and these had probably been served up in a stew or pie.

Even though the available evidence suggests that the rabbit was first introduced to this country by the Normans in the late twelfth century, this animal was still relatively scarce and was to be found in only a few localities until well into the fifteenth century (Fitter, 1959, p.114; Corbet, 1974, p.186). Rabbit meat at this time must have been considered a luxury as a single rabbit would have cost as much as four to five chickens (Veale, 1957, p.89). When coneygarths (warrens) became more widespread in the late medieval period, the price of rabbits dropped, and rabbit meat then became a regular feature of the diet of both the nobility and the commoner folk. To meet the high demand for this animal, the London markets were supplied from warrens set up in Epping Forest, Reading and Hertfordshire, and records show that one London Poulterer obtained his rabbits from warrens in Wiltshire (Fitter, 1945, p.45; Everitt, 1967, p.509).

Comparison of the dimensions of the limb bones of the rabbits from Baynard's Castle against specimens held in the BM(NH) revealed that the late medieval adult animal was of similar size to the modern wild rabbit (Table 24, see also section 4).

Table 24: Comparison of the size of medieval and modern wild & domestic rabbits.

(1) Humerus. Length

	N	Range
Modern:		
British wild	2	60.9 - 66.1
Domestic	3	69.5 - 77.0
Medieval, Baynard's Castle:		
Deposits 1 & 23 (c.1520 AD)	36	57.3 - 65.5
Deposit 88 (c.1500 AD)	8	61.0 - 65.7
Deposit 100 (c.1500 AD)	23	58.5 - 65.6
Deposit 250 (c. mid 14th century AD)	2	61.0 - 64.8

(2) Femur. Length

	N	Range
Modern:		
British wild	2	78.1 - 85.9
Domestic	3	90.4 - 102.8
Medieval, Baynard's Castle:		
Deposits 1 & 23 (c.1520 AD)	27	75.4 - 83.5
Deposit 88 (c.1500 AD)	6	77.0 - 82.4
Deposit 100 (c.1500 AD)	15	75.7 - 83.3
Deposit 250 (c. mid 14th century AD)	1	82.5

Key: N = Number of specimens measured
Range = Observed size range (mm) of adult specimens

WILD SPECIES:

(1) ELK *Alces alces*

One fragment of antler identified as that of elk was recovered from the dock basin dump (specimen reg.no. 76, 6436, deposit 150, circa 1499 - 1500 AD). The edges of the palm segment show closely set, oblique lines made by the teeth of a saw, indicating that this piece is the discarded waste from a bone-working industry (see section 3.4).

The elk in Britain was hunted to extinction in the mesolithic period (Corbet, 1974), and therefore the antler found at Baynard's Castle must have been imported, most probably from one of the Scandinavian countries. Evidence for the existence of the elk in Sweden in the medieval period is provided by skeletal remains from Lund (Bergquist & Lepiksaar, 1957, p. 27; Ekman, 1973, p. 49), and in Scandinavia in the early modern period, by the contemporary account of the distribution of this animal which appears in Topsell (1607, reprinted 1967, p. 165).

(2) RED DEER *Cervus elaphus*

The Red deer is represented by three fragments of antler, one skull (male), and three metapodial bones (Table 25). The scarcity of bones of Red deer from the site is interesting, especially when it is considered that the hunting of the hart (Red deer stag) was a popular pursuit in medieval England (Baille-Grohman, 1904; Savage, 1933), but, as discussed below, this may reflect the relatively small numbers of this animal compared to those for Fallow deer in the forests round London.

Table 25: Red deer. Number of bones identified and examined

	Castle pits	Dock basin			City debris
	c. 1520 AD	c. 1499-1500 AD			c. mid 14th cent. AD
	1 & 23	88	89	100	250
antler	-	-	-	2	-
skull	1	-	-	-	-
metapodia	1	-	-	-	2
Total	2	0	0	2	2

Other deposits:

Deposit 81	c. 15th century AD	antler	1
Deposit 5000	mostly c. 13th century AD not examined		

(3) FALLOW DEER *Dama dama*

The numbers of bone of Fallow deer (Table 26) show that this animal was a much more important source of flesh-meat than Red deer in the late medieval period.

Table 26: Fallow deer, Number of bones identified and examined

	Castle pits	Dock basin			City debris
	c.1520 AD	c.1499-1500 AD			c. mid 14th cent. AD
	1 & 23	88	89	100	250
pedicle	-	-	-	1	-
antler	3	-	-	3	4
skull	-	-	-	-	-
mandible	-	-	-	-	-
scapula	6	-	-	1	-
humerus	6	-	-	-	-
radius	1	-	-	-	-
ulna	1	-	-	-	-
innominate	1	-	-	1	-
femur	4	2	-	1	1
tibia	14	2	-	4	2
calcaneum	6	2	1	1	-
talus	4	2	-	3	-
metapodia	18	1	-	5	5
phalanx 1	7	-	-	-	1
phalanx 2	2	-	-	2	-
hoof core	2	-	-	-	-
Total:	75	9	1	22	13

Other deposits:

Deposit 81	c. 15th century AD	antler 2
Deposit 5000	mostly c. 13th century AD	not examined

Evidence that the whole carcass of Fallow deer was brought into the city and not, as was usually the custom, dressed at the site of the kill, was provided by the relatively large number of metapodial bones and phalanges. These bones would normally be the first parts to be removed and discarded as they have very little flesh on them. Possibly the metapodial bones were used as a raw material for a bone-working industry; the long, straight shaft of this bone makes it ideal material for the manufacture of bone pins and bodkins.

The complete spike (specimen 76.6440) grown by a yearling buck was identified from the city debris (deposit 250, mid 14th century AD). Other specimens of antler, comprising sawn segments of palm, and beam with either the brow or trez tine attached came from older animals. Although there is progressive development in the size and form of the newly grown antlers of the male each year, which corresponds to the age of the individual (as illustrated in Taylor Page, 1963, p.5) there can occur considerable variation in the appearance of the palm even between animals of the same age and the same herd (see for example, Chapman & Chapman, 1975, p.111 & 113). It is not, therefore, possible to determine with any degree of certainty the age of the deer represented by antlers recovered from archaeological sites.

Two metacarpal bones and one metatarsal bone (reg.no. 76,6410, 3 specimens) from a full-term foetus were found in the city debris (deposit 250, mid 14th century AD). It is not possible to distinguish clearly between the foetal bones of Red deer and Fallow deer, and therefore the three specimens described here are only tentatively identified as those of Fallow deer. According to contemporary sources (referred to in Baille-Grohman, 1904, p.188), the season for hunting Fallow does and Red deer hinds, as laid down for the medieval huntsman, fell between Holyrood day (September 14th) and Candlemas (February 2nd). As Fallow fawns in England are generally born from mid May onwards (Chapman & Chapman, 1975, p.144), the presence of the fairly well-grown foetal bones at Baynard's Castle may therefore be interpreted as showing that in this particular instance, a pregnant doe had been killed outside the approved hunting season.

Using the criteria described by Lemppenau (1964) and by comparison with the pelves of known sex at the BM(NH), the innominate bones were found to be from a male (specimen 76.6529, deposit 23) and a female (specimen 76.6465, deposit 150).

(4) ROE DEER *Capreolus capreolus*

Only one Roe deer bone, a metacarpal bone (reg.no. 76, 6435) from deposit 5000 was identified. The lack of skeletal remains of Roe deer in the post thirteenth century deposits would seem to support the belief held by historians and zoologists (see Fitter, 1945, p.91) that this species had by the late middle ages been hunted to extinction in the forests around London. One reason for the decline of this species, as discussed by Whitehead (1964, p.210), was that in the fourteenth century the Roe deer was no longer fully protected by the forest law, and because it was thought (erroneously) to drive away the other deer and so spoil the hunting in an area, an attempt may have been made to eliminate this species from the royal hunting preserves.

The supply of venison to London

The discovery of cervid bones amongst the refuse at the site of Baynard's Castle provides an opportunity to consider the question of the sources of supply of venison to the city of London during the late medieval and Tudor periods, information on which has until now been lacking. A number of extant close rolls of Edward II (extracts of which are given in Baille-Grohman, 1904, p. 203) show that in the early fourteenth century, regular consignments of salted venison, packed in barrels were sent to the royal household in London from the counties of Essex, Hampshire, Northampton, Somerset and Wiltshire. Interestingly, there is a lack of references to either the sources of supply or the prices of venison for the late medieval period (Barron, 1977, pers. comm.), and therefore information has to be obtained from the archaeological record.

As mentioned above, the presence of relatively large numbers of metapodial bones and phalanges of Fallow deer indicates that the whole carcass of this animal was brought into the city, and this must mean that the deer had been hunted locally in one of the forests close to London.

The discovery that the bones of Fallow deer predominated over those of Red deer (see Tables 25 & 26) at Baynard's Castle was not unexpected as evidence from contemporary documents show that the Fallow was more numerous than the Red deer in the forests round London. Records of the swainmote (forest court) held in Epping Forest in 1495 AD (referred to in Whitehead, 1964, p. 24), for example, show that the number of Fallow deer killed in that year outnumbered that of Red deer (in the ratio of approx. 1 Red : 6 Fallow).

Even though the stringent forest laws instigated by the Norman kings no longer were applied in the late medieval period, the hunting of deer was still very much the prerogative of the monarch and the nobility, and venison would not normally have been an item in the diet of the commoner folk. This is borne out by the evidence from Baynard's Castle, where calculations of the proportions of deer bones (Fallow & Red) recovered from each of the two major dumps revealed that the refuse from the castle (deposits 1 & 23) contained almost four times the amount of cervid bone compared to the rubbish originating from the city (deposits 88, 89 & 100).

(5) HARE *Lepus sp.*

Compared with the large quantity of bone from the domestic rabbit (Tables 21 & 22, above) there are relatively very few bones of hare (Table 27). According to contemporary sources (see Baille-Grohman, 1904, p.199) the hare was highly esteemed as an animal for hunting, being classified as a beast of venery, of the forest, and of the warren. The popularity of the sport of hare coursing meant, however, that by the late medieval and Tudor periods the numbers of this species had declined (Wilson, 1976, p.77), and this may explain why the dumps of refuse at Baynard's Castle contained only a small quantity of bone.

Table 27: Hare. Number of bones identified and examined.

	Castle pits	Dock basin			City debris
	c.1520 AD	c.1499-1500 AD			c. mid 14th cent. AD
	1 & 23	88	89	100	250
humerus	1	-	-	-	3
radius	1	-	-	-	-
innominate	-	1	-	1	-
femur	1	1	-	-	-
tibia	3	-	-	1	2
calcaneum	-	-	-	-	1
Total:	6	2	0	2	6

Other deposits: Deposit 5000 mostly c.13th century AD not examined.

(6) BLACK RAT *Rattus rattus*

Table 28 shows the numbers of identified rat bones recovered from the site. As they came from well-defined, stratified dumps of refuse, the bones are unlikely to be intrusive in origin, and can therefore be regarded as being contemporary with the rest of the associated mammalian remains.

Table 28: Black rat. Number of bones identified and examined.

	Castle pits	Dock basin			City debris
	c. 1520 AD	c. 1499-1500 AD			c. mid 14th cent. AD
	1 & 23	88	89	100	250
skull	1	-	-	-	-
mandible	1	-	-	-	-
humerus	-	-	-	2	-
innominate	2	-	-	2	1
femur	6	1	1	10	3
tibia	-	5	-	7	3
rib	-	-	-	1	-
Total:	10	6	1	22	7

Other deposits:

Deposit 5000	mostly c. 13th century AD	not examined
Deposit 5067	c. 16th century AD	tibia 1

Using the criteria described by Lawrence & Brown (1973, p. 195 & Fig. 5: 26b, p. 196) and by comparison with specimens held at the BM(NH), the intact skull (specimen 76. 6003) from the castle pit (deposit 1) was identified as that of Black rat (see Figure 23). There is conclusive historical evidence (see Pennant, 1776, Vol. 1, p. 116) to show that the Brown rat (*Rattus norvegicus*) was not introduced to this country until the early eighteenth century AD, supposedly in Russian ships from the Baltic (Twigg, 1975, p. 22).

Therefore, although it is not possible to distinguish clearly between the limb bones of Black rat and Brown rat, all the postcranial elements from Baynard's Castle are also considered to be from Black rat.

The archaeological record at Baynard's Castle clearly shows that the Black rat was present in the city of London in the fourteenth century AD, at the time when many of London's citizens were succumbing to the bubonic plague (Black Death). The bacillus Pasteurella pestis responsible for bubonic plague is now known to be carried and transmitted to new human victims by the rat flea Xenopsylla cheopis, and it is therefore of interest to learn that the contemporary records for London which have been examined to date make no mention of rats (Thomson, Public Record Office, 1977, pers. comm.). This absence of any record of rats in the city in the fourteenth century AD can perhaps be explained by the fact that physicans in the middle ages attributed the spread of the plague to 'miasmas' or poison clouds, and it is only within the last century that the association between the plague and the Black rat has been established (Ziegler, 1975). The contemporary chroniclers who observed and recorded the terrifying effect that the plague was having on the human population therefore had no reason to mention the rat.

The two earliest references to rats known for London, date from the sixteenth century AD, and are to be found in the Bridge House Accounts, Vol. 8 (information supplied by Mr. J. Sewell, Records Office, Guildhall, 1977, pers. comm.); the two entries are reproduced here:-

Bridge House Accounts

Account 1563-64

f. 63v Paide the first[e] of Januarye to a Rat Taker for layeing bayte to kyll Rattes ijs.xd (2/10d)

f. 64 Paide the firste of Julye..........
and to a Rat Taker for layeing bayte
aboute the Garnettes (granaries) iijs. iiijd (3/4d)

The history of the Black rat in Britain

The Black rat (Rattus rattus) is a native of Asia, and it has, until recently, been a commonly held belief that this species was brought to this country, in the 12th century A.D. supposedly in the ships of the crusaders returning home from the Holy Land (Matheson, 1939; Fitter, 1959, p.107; Twigg, 1975, p.20). MacArthur (1957), however, advocates a much earlier date for the appearance of this species in Britain, and supports this assertion by reference to the illustrations of two rodent-like creatures nibbling a piece of Eucharistic bread that appear beneath the letters XPI (Christi) on the monogram page, St. Matthew i.18, Book of Kells (circa 850 AD) held by Trinity College, Dublin, which he interprets as being depictions of Black rats. After examining the copy of the monogram page which appears in the reprinted edition of the Book of Kells described by Sullivan (1914, Plate IX), I would question the identification made by MacArthur. Although the two animals nibbling the bread, plus the two shown sitting on the backs of cats, are certainly rodent-like, there is insufficient detail shown to enable them to be positively identified as Black rats. All the animals depicted are highly stylized, and there is the possibility that the cats and rodents may not have been drawn to the same scale, if the scales are different then the latter could represent mice rather than rats.

If the Black rat was introduced before the twelfth century AD then it is to be expected that evidence of this will be contained in the archaeological record. Recent excavation at York, of a dump of rubbish of the fourth century AD in a well which was partially sealed by the floor of an early Saxon building, brought to light the skeletal remains of two Black rats (Rackham, 1977, pers. comm.). The bones from York are the earliest remains of Black rat in Britain, found so far. Prior to their discovery, the earliest recorded find, that of a tibia from St. Aldates, Oxford, came from a level dated to between the late eleventh and early twelfth centuries AD (BM(NH) General letter file 1975-5, Professor Marples). It will be interesting to see if further bones of Black rat are found in Romano-British contexts, to substantiate the claim made by Rackham that 'the Black rat had penetrated as far as northern England by the fourth century AD'.

Enquiries made to the Public Record Office (PRO) London, revealed that the earliest known reference to the rat in Britain is to be found in Itinerarium Kamberiae (Vol. VI Rolls Series, 1868, Book II, p. 111) written by the monk Giraldus Cambrensis in circa 1191 AD (Thomson, 1977, pers. comm.). Among the other, early accounts of rats in Britain which have been catalogued at the Public Record Office are the following:-

	Document	Date	Description
(1)	PRO E101 19/3 m.1 King's Exchequer Account	1335 AD	contains a reference to rats on board a ship carrying corn, at Berwick.
(2)	PRO DL 242/3886 m. 3 Duchy of Lancaster, Ministers' Accounts	1336 AD	records a payment made to Thomas the rat catcher for catching and destroying rats
(4)	Surtees Soc. Vol. 99 (1898) Account Rolls of Durham Abbey, Vol. I, p. 42.	1347 AD	records the payment of 3d made for killing rats
(5)	Surtees Soc. Vol. 100 (1899) Account Rolls of Durham Abbey, Vol. II, p. 558	1356-57 AD	records payment of 9d made for catching rats inside the abbey.

To the historian, the Black rat is invariably linked with the second pandemic of bubonic plague (often referred to as the 'Black Death') which swept across Europe during the fourteenth century AD. As shown by the contemporary documents described above (1, 2 & 3), a population of Black rats was already established in England at this time, and the plague was therefore able to spread rapidly following the mingling of newly arrived individuals carrying infected fleas. In June 1348 the inhabitants of Melcombe Regis, Dorset were the first people in Britain to experience the terrible effects of bubonic plague, and by November 1348 it had reached London (Ziegler, 1975). Unlike the hardier Brown rat, which is found in hedgerow and barn, we well as house and sewer, the Black rat is not suited to the outdoor environment, and therefore seeks the warmth and shelter afforded by buildings occupied by man. Humans and Black rats thus lived in close proximity in the middle ages, and conditions were therefore at an optimum for the rapid transmission of the plague, especially in the cramped confines of the tenament buildings in the towns and cities. Langer (1964) has estimated that the population of England fell from about 3.8 million to 2.1 million in the period from 1348 to 1351 AD. The destruction wrought by the plague on the population had serious repercussions on the social and economic life of this country, and the Black Death is often cited as being the cause of the phenomenon of the 'deserted medieval village'.

Rattus rattus was the only species of rat to be found in Britain throughout the high and late middle ages, and early modern period. In the 1720's, the Brown rat (Rattus norvegicus) arrived, and because this animal is more aggressive and hardier than the Black rat (Fitter, 1959, p.113) it was able to drive out the latter from almost all localities. Today, the Black rat is found only in warehouses and derelict buildings situated close to docks. From the results of the two surveys on the distribution and status of the Black rat in

Britain, conducted in 1957 and 1961 by Bentley (1959, 1964), it is predicted that the numbers of this animal will continue to decline, and that the only places where it is expected to survive are in the commercial quarters adjacent to the docks in London, Bristol and Liverpool.

(7) HEDGEHOG *Erinaceus europaeus*

The hedgehog is represented by two bones from the dock basin dump, a mandible (specimen 76, 6014, deposit 88) and a humerus (specimen 76. 6015, deposit 89).

(8) HOUSE MOUSE *Mus musculus*

Parts of the articulated skeleton (listed below) of a House mouse (specimen 76. 6016) were recovered from the dock basin dump (deposit 88).

Parts of the skeleton found:-

maxilla	1
pelvic girdle	1
femur	2
vertebra	10

Using the criteria described by Lawrence & Brown (1973, p. 196-198) and by comparison with the pelves of known sex at the BM(NH), the pelvic girdle was identified as that of a female.

HUMAN:

Six bone elements of human were found, these being:-

BM(NH) Reg. No.	Deposit	Date	Description
76.6553	castle pits (1 & 23)	c.1520 AD	clavicle *
76.6551	cess pit (97)	14th cent. AD	humerus from a full-term foetus or neonate *
76.6552	dock basin (100)	c.1499-1500 AD	tooth
76.6567	" " "	" "	tooth
76.6554	secondary dump (5122)	mostly c.13th cent. AD	ulna from a young adult *
76.6573	" " (5040)	" "	mandible

*Identified by Miss R. Powers, Dept. Palaeontology, BM(NH).

Refuse from deposits numbered in the 5000 series represents material which has been dug up elsewhere in the city in the thirteenth century AD and dumped on the Baynard's Castle site, and it is therefore likely that the ulna and mandible found in two of these deposits (deposits 5122 & 5040) came originally from cemeteries in the city. The origin of the other specimens, from the castle pits, cess pit and dock basin is uncertain.

Figure 23: Rat skulls.

Rat skulls (dorsal view): Brown rat *Rattus norvegicus* (top); specimen 76.6003 from Baynard's Castle (centre); Black rat *Rattus rattus* (bottom)

The skull from Baynard's Castle exhibits the strongly, outward curving parietal ridges of the cranium which are diagnostic of the Black rat. In the Brown rat, the lateral edges of the brain-case are, by comparison, straight and parallel.

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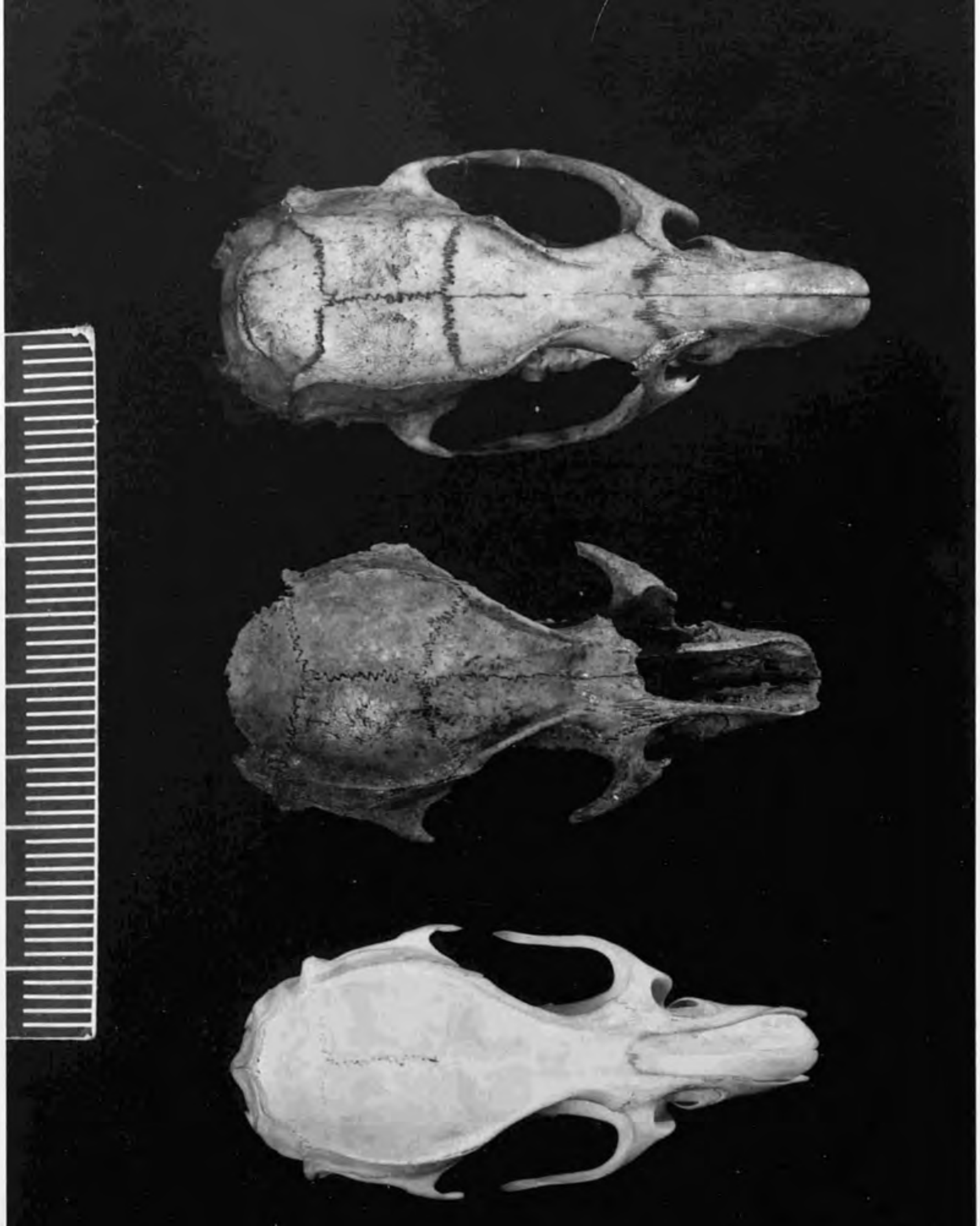


3.3 Butchery

Many of the bones examined had either chop or knife marks on them, showing evidence of butchery. Figures 24 and 25 show the positions of marks made by choppers and cleavers on the skull and limb bones of cattle, sheep, pig, rabbit, and Red and Fallow deer.

The evidence from the skeletal material indicates that the butcher in the late medieval period used only an axe, cleaver, chopper, and boning knife in his work, unlike the modern butcher who frequently employs a saw to cut up joints of meat (see Rixson, 1976a, 1976b); the only bones with evidence of sawing are the discarded waste from bone-working (section 3.4, below). The modern application of the saw in place of the chopper during the operation of disjointing, allows greater precision and cleaner cutting of the meat, without splintering the bone. The observation that the saw was not commonly used in butchery in the late fifteenth century AD is verified by the noticeable absence of this tool from the three contemporary engravings that are known from Nürnberg (reprinted in von Treue et al, 1965, Plates 96, 127 & 172) which depict butchers at work in their shops.

The presence of skull fragments, mandibles, metapodial bones, phalanges and hoof cores of cattle, sheep and pig (Tables 4, 7 & 15) in the dumps of rubbish on the site indicate that domestic livestock were slaughtered and butchered in the city. The head and extremities of the fore and hind limbs are removed during the dressing down of a carcass and would not have been present if the butchery had been carried out elsewhere. Cattle, sheep and pigs would have been brought 'on the hoof' into the city to either the meat market at Eastcheap (as depicted by a contemporary woodcut by Hugh Alley, see Hurstfield, 1964, Plate 9a) or St. Nicholas Shambles (in the centre of what is now Newgate Street), and in spite of an ordinance repeatedly issued by the King and Parliament which forbade the slaughtering of beasts within the city walls (see Sabine, 1933; Meyers, 1969, p.1102), the butchers of London carried out the business of killing and butchering animals either in yards situated behind their shops, or in the street itself, to the great annoyance of the other inhabitants (Pendrill, 1925, p.103-104; Jones, 1976, p.77).

The sequence of butchery in the late medieval and early Tudor periods has been reconstructed, and is described here:-

CATTLE:

1. Slaughter

   Pole-axing was the most common method of slaughter, as illustrated by two contemporary woodcuts from Nürnberg (reprinted in von Treue et al, 1965, Plates 225 & 239). From the way in which the butchers in the engravings appear to be holding their axes, it was the back of the axe head which was used to deliver the blow on the forehead. The stunned beast would then be finished off by being bled.

   Unfortunately all the skulls of cattle from Baynard's Castle are incomplete, and it is therefore not possible to determine the method of slaughter. I have, however, recently (1977) examined complete specimens of cattle skulls found elsewhere in the city (G. P. O. site, Newgate Street, excavation still in progress) with frontal bones that have been smashed by a pole-axe, and which provide conformation that butchers in London killed their animals in the manner described here.

2. Dressing down the carcass (primary butchery)

   After slaughter, the horns were removed, each of them being struck-off close to the skull by a blow delivered from a long handled, iron cleaver. Rixson (1977, pers. comm.) believes that this operation would have been carried out with the head laid on the ground but still attached to the body, this position allowing a massive, downward-directed blow delivered to the back of the skull. Even using this approach, it was occasionally necessary for the butcher to make two or more strikes before the core was severed from the head. The horns would be sent to the workshop of a horn-worker, where the sheaths were removed from the cores by soaking in boiling water and pulling (section 3.4, below).

Next the carcass was skinned, and eviscerated. The hide of cattle was highly valued, and was used in the manufacture of leather jerkins, shoes and sheaths for daggers, as well as in bookbinding.

Evidence of skinning on the bones of cattle from Baynard's Castle is provided by knife marks around the proximal epiphysis of metapodial bones from the castle pits (deposits 1 & 23);

Deposit	Bone	Size of sample	No. with knife marks
1	metacarpal bone	74	15
23	metacarpal bone	118	18
1	metatarsal bone	29	3
23	metatarsal bone	24	4

Following skinning, the head and extremities of the fore and hind limbs were removed. The carcass was then divided into two 'sides', as shown by the presence at Baynard's Castle of large numbers of vertebrae that have been chopped in half along the medial axis (i.e. in the sagittal plane). From the direction of the chop marks, it is seen that this division was made whilst the carcass was hoisted off the ground by flesh-hooks attached to the hind legs. To split the animal, the butcher would have first cut through the pubic symphysis and then continued downwards, chopping the vertebral column down the centre. Today, this operation has been made easier by application of the power-saw.

3. Disjointing (secondary butchery)

The majority of specimens of long bones from all deposits have several chop marks (with splintered ends) on them, and it would appear therefore that the joints of meat had been crudely 'hacked-off' the carcass. It is in this respect that medieval and modern techniques of butchery differ. For example, in separation of the humerus (clod bone) from the scapula, the medieval butcher apparently favoured 'hacking' through the head of the humerus with a heavy chopper (see Figure 24), whilst the butcher of today uses a knife to cut the ligaments joining these two bones, as described by Rixson (1976a, p. 7).

Only a very few of the bones with chop marks can be ascribed to known joints of meat. Included among those that can be identified are large numbers of the middle segments of rib bones chopped through at both ends, which resemble those of the modern cut of meat referred to as 'whole top ribs' (Rixson, 1976a, p. 11).

4. <u>Splitting and cracking open bones in order to extract the marrow (tertiary butchery)</u>

Large quantities of fragments from the shafts of long bones exhibit spiral fractures (see Bonnichsen, 1973) and straight-edged breaks. These are the debris from the smashing of 'marrow bones' (humeri, femora & tibiae etc.). In Tudor, as in later times, marrow was highly esteemed and was used to make broth and pottage, added to pies, or eaten alone (Wilson, 1976, p. 83-84).

<u>SHEEP</u>:

The sequence of butchery of sheep follows that for cattle, but differs in the method employed in disjointing (stage 3, secondary butchery), where, instead of the joints of meat being crudely 'hacked-off' the carcass by repeated blows of a chopper, they were removed with greater precision (as shown by the presence on each bone of a single well-defined chop mark, Figure 24).

There is a striking similarity between the limb bones from Baynard's Castle and those from modern joints of meat (Figure 26); the cuts of meat sold in the medieval meat market would have resembled those commonly seen in butchers' shops today. From this it is seen that the style of cutting-up a sheep carcass is traditional, and can be traced back at least to the late middle ages.

Many of the skulls of sheep from Baynard's Castle (listed below) are split in half along the medial axis (i.e. in the sagittal plane). By chopping the skull in half, the cranial cavity was opened for extraction of the brain.

Sheep skulls:

Deposit	Date	No. specimens	No. split in median plane
castle pits 1 & 23	c.1520 AD	26	17
dock basin 100	c.1499-1500 AD	30	15
city debris 250	mid 14th cent. AD	4	4
secondary dumps 5000	mostly c.13th cent. AD	6	4

Evidence of skinning is provided by marks made by a knife on the anterior surface of the shaft of the radius. Although paper had, by the fifteenth century, become the standard material used for documents, parchment, prepared from the skins of sheep and goats, was still used for the more important records (see Hector, 1958, p.15).

PIG:

The sequence of butchery of pig follows that described for cattle, except that the head and extremities of the fore and hind limbs were occasionally removed during disjointing (stage 3), instead of during the dressing down of the carcass (stage 2). When this practice was adopted, the carcass, with the head still attached, was hoisted off the ground by flesh-hooks sunk into the hind legs, and using a chopper the butcher would chop down the centre of the vertebral column, continuing down through the head, as is done at the present day (Rixson, 1976b, p. 6-7). Two pig skulls from deposit 23 (specimens 75.10332 & 75.10333) have been cleaved in half in this way. Alternatively, the whole head was removed before dividing the carcass into two halves, as shown by a complete skull from deposit 100 (specimen 75.10611). This practice is illustrated by an engraving of the late fifteenth century AD from Nürnberg (see von Treue et al, 1965, Plate 127), in which a butcher is seen cutting off one of the hind legs of a complete carcass of a pig laid on a slab or cutting block, the head is still attached to the body.

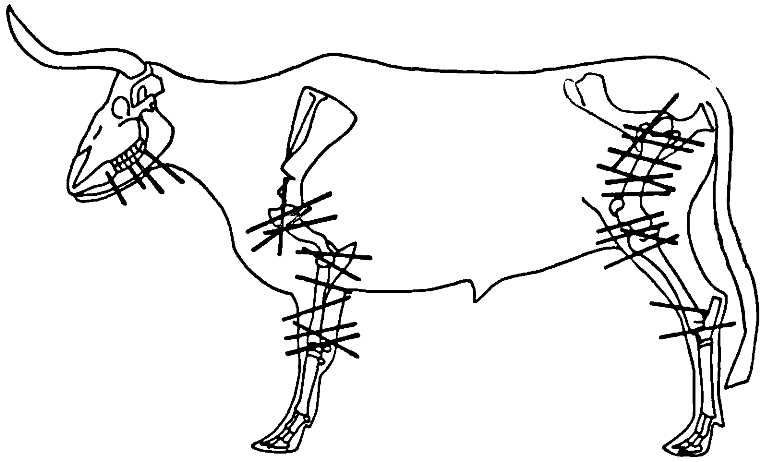
RABBIT and DEER:

There were insufficient numbers of rabbit and deer bones, with evidence of chop and knife marks, to enable the sequence of butchery to be reconstructed.

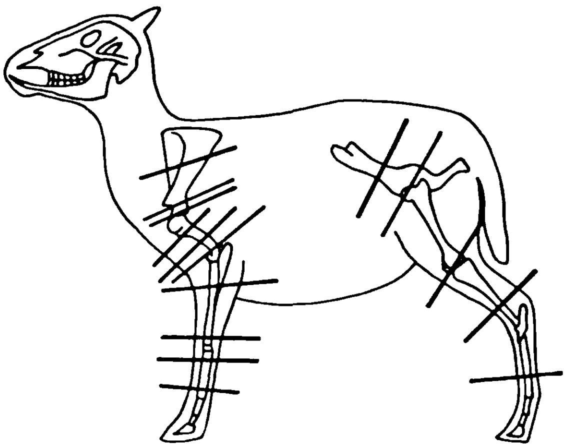
FIG.24

Butchery, position of chop marks on skull and limb bones.

(A) CATTLE



(B) SHEEP



(C) RED DEER & FALLOW DEER

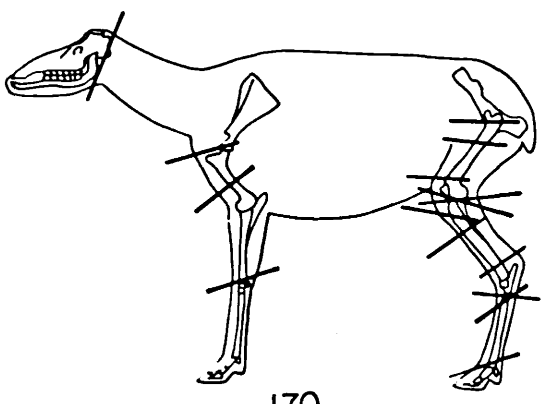
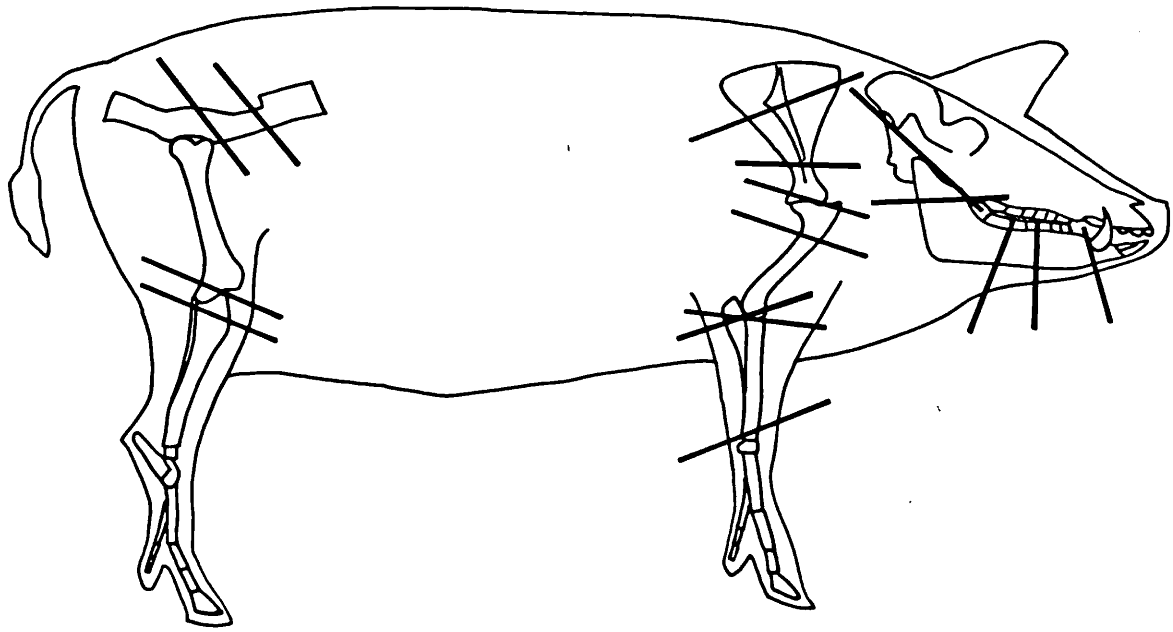


FIG. 25

Butchery, position of chop marks on skull and limb bones.

(A) PIG



(B) RABBIT

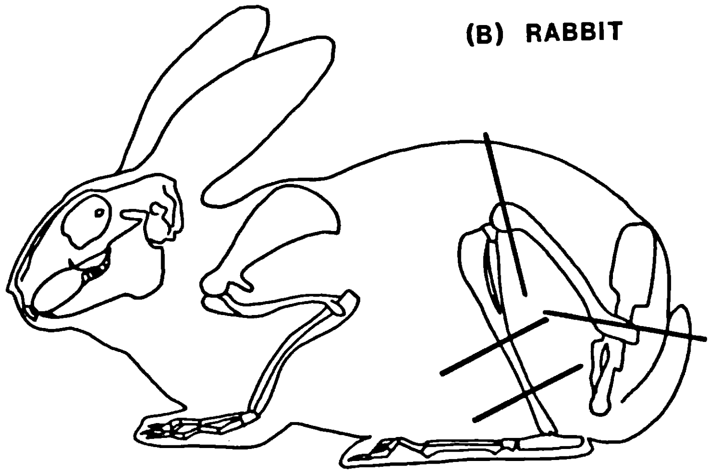


Figure 26: Sheep. Comparison of bones from medieval and modern cuts of meat.

Bones from modern joints of lamb (white bone on left of each pair) are compared with the bones of medieval and early Tudor joints (dark bone on the right).

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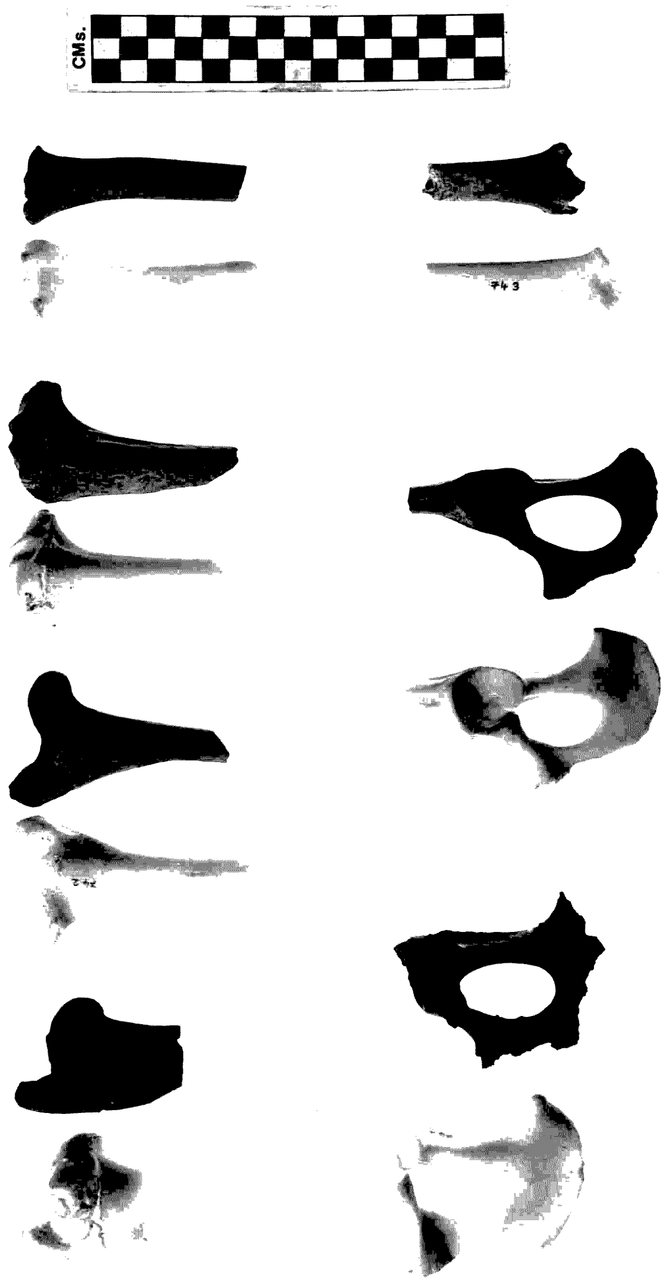
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3.4 Bone and horn working

There are, as far as I know, no written descriptions of bone-working until the eighteenth century AD, so information on this subject in the early Tudor period can only come from examination of material recovered by excavation. Objects made of bone were found in the refuse at Baynard's Castle, and include handles for knives, gaming counters, dice, combs and bodkins. Although these items are pleasing to examine, it is the pieces of bone and horn identified as the discarded waste from the workshops of bone-workers that provide nearly all the details relating to the techniques of horn and bone working, this evidence being discussed here.

Horn cores of cattle, sheep and goat

(1) Cattle

Marks left by choppers and saws on the horn cores indicate that horns were 'hacked off' the skull and then cut up into sections (rings) before removal of the horn sheath from the bony core by soaking and pulling. Further evidence of this practice is provided by seven rings of horn sheath (specimens 76.6199, 6200, 6201, 6202, 6204, 6205, 6491) recovered from the dock basin dump (deposits 88 and 100), the rings ranging in width from 17.5 to 68.5 mm. Rings of horn were used in the manufacture of many objects, including ink-wells (see Medieval Catalogue, Museum of London, 1940 reprinted 1975, p. 292) and drinking cups. To produce thin transparent sheets suitable for glazing lanterns, rings of horn were softened by heating, pulled open and then pressed flat, for a more detailed account of the process reference can be made to Fisher (1936, p. 2).

Three horn cores (specimens 75.8295, 8296, 8307) are sawn through at the base indicating that the horn had been removed whole, and had not been sawn up into segments. Complete horns were used to make such items as drenching horns for administrating draughts of medicine to livestock (Vince, 1974, p.18), powder horns and hunting horns etc.

(2) Sheep

The cores of sheep have been chopped half way through the base and then broken off the skull (Figure 27, top row). There is no evidence to show that the horn had been sawn up into sections, the whole sheath was pulled off the core.

(3) Goat

The horns were removed by a blow delivered by a chopper, and they were subsequently sawn into sections. A number of cores with evidence of this treatment are shown in Figure 27, bottom row.

Antlers of Red deer, Fallow deer and Elk

There are a number of sawn segments of antlers of Red deer and Fallow deer, as well as one piece (Figure 28, specimen 76.6436) identified as that of imported Elk (section 3.2, above). It is not possible to determine the nature of the finished product from these specimens, but sections of tines and beam of Red and Fallow deer antler are known to have been commonly carved into handles for knives.

Metapodial bones of cattle

Metapodia with evidence of bone-working were recovered from the dock basin dump (deposits 88, 89 and 100) and the castle pits (deposits 1 & 23). Two distinct types of working are recognised:-

Type 1 Removal of the shaft after sawing through the proximal and distal ends of the bone

Apart from six specimens (Reg. Nos. 75.8860 to 75.8865) from deposit 1, all the metapodia showing evidence of this type of working come from the dock basin dump, where over half of the metacarpal and metatarsal bones (196 out of 334) are represented by sawn proximal and distal ends. Measurement of the proximal and distal ends (see Table 29, below) reveals the precision taken in cutting through the bones. There is little variation in the distance between the articular end and the point of sawing, with the observed values falling close to the mean value of each group:-

Table 29: Bone working. Cattle metapodial bones. Length (mm) from articular surface to point of sawing.

Metacarpal bone

I. Proximal end and part of shaft

0-5		
6-10		
11-15		
16-20		
21-25	xx	2
26-30	xxxxxxxxxxxxxxxxxxxxxx	22
31-35	xxxxxxxxxxxxxxxxxxxx	20
36-40	xxxxx	5
41-45		
46-50		

No. specimens	49
Mean	30.8
Standard deviation	3.43
Standard error of the mean	0.49
Distribution	symmetrical

II. Distal end and part of shaft

0-5		
6-10		
11-15		
16-20		
21-25		
26-30		
31-35		
36-40		
41-45	xxxxxxx	7
46-50	xxxxxxxxxxxxxxxxxxxx	20
51-55	xxxxxxxxxxxxxxxxxxxx	20
56-60	xxxxxxxxx	9
61-65	xxxx	4
66-70		
71-75	x	1
76-80		

No. specimens	61
Mean	51.6
Standard deviation	6.13
Standard error of the mean	0.79
Distribution	symmetrical

Table 29 (continued)

Metatarsal bone

I. Proximal end and part of shaft

0-5		
6-10		
11-15		
16-20		
21-25	xxxx	4
26-30	xxxxxxxxxxxxxx	14
31-35	xxxxxxxxxxxxxx	14
36-40	xxxxxxxxxx	10
41-45	xxx	3
46-50		
51-55		
56-60		

No. specimens	45
Mean	32.3
Standard deviation	4.69
Standard error of the mean	0.69
Distribution	symmetrical

II. Distal end and part of shaft

0-5		
6-10		
11-15		
16-20		
21-25		
26-30		
31-35		
36-40		
41-45		
46-50	xx	2
51-55	xxxxxxxx	8
56-60	xxxxxxxxx	9
61-65	xxxxxxxxx	9
66-70	xxxxxx	6
71-75	x	1
76-80		
81-85		
86-90		

No. specimens	35
Mean	59.75
Standard deviation	6.45
Standard error of the mean	1.09
Distribution	symmetrical

Note: Six distal ends of immature animals (with the epiphysis unfused and detached) have been omitted from the table.

The position of a small protrusion of unsawn bone along the line of separation between the articular end and the shaft (where the sawing stopped and the end was 'snapped off'), allows the direction of sawing to be determined:-

Table 30: Bone-working. Cattle metapodial bones. Direction of sawing.

Metacarpal bone

I. Proximal end and part of shaft

43 out of 49 (88%)	sawn from anterior side
6 " " " (12%)	sawn from posterior side

II. Distal end and part of shaft

60 out of 61 (98%)	sawn from posterior side
1 " " " (2%)	sawn from anterior side

Metatarsal bone

I. Proximal end and part of shaft

17 out of 45 (38%)	sawn from medial side
9 " " " (20%)	sawn from posterior side
9 " " " (20%)	unknown (bone sawn completely through
8 " " " (18%)	sawn from lateral side
2 " " " (4%)	sawn from anterior side

II. Distal end and part of shaft

30 out of 35 (86%)	sawn from posterior side
4 " " " (11%)	unknown (bone sawn completely through)
1 " " " (3%)	sawn from medial side

From the observations summarised in Tables 29 and 30, it is seen that the bone-worker followed a set procedure when removing the unwanted ends of the bone from the shaft, with the lines of separation and direction of sawing nearly always the same for each of the metacarpal and metatarsal bones.

Metapodial bones, with their long, straight shafts and thick-sided walls are the ideal raw material for bone-working, and in Tudor times they were fashioned into handles for large knives and choppers. The flat sides of the shaft of metatarsal bones were also sawn up to make buttons and gaming counters. Examples of the waste from button manufacture, in the form of templates of bone with cicles cut out of them, were found in the dock basin dump (deposits 88 & 100).

Type 2 <u>Removal of the proximal epiphysis by sawing and reshaping of the end of the shaft.</u>

There are over three times as many complete metacarpal bones as complete metatarsal bones (192 to 53 elements respectively) from the castle pits (deposits 1 & 23). As there are almost equal numbers of splintered proximal and distal ends of metacarpal and metatarsal bones, this discrepancy in the numbers of complete bones cannot be explained by butchery practice. The presence of 11 metatarsal bones that have had the proximal epiphysis removed and the end of the shaft reshaped (cut into a square with a hole drilled down the centre) in the refuse from deposits 1 & 23, indicates that the missing bones had been selected for bone-working.

None of these carved metatarsal bones was found in the other deposits (88, 89 & 100; 250; 5000), but further examples are known from other Tudor sites in the city of London and are held by the Museum of London. Unfortunately it has not proved possible to determine the exact purpose of the modification made to the metatarsal bones, although it has been conjectured (Marsden & Rhodes, 1977, pers.comm.) that the reshaped bone functioned as a vice for holding sections of bone that were being cut into pins.

Other specimens with evidence of bone-working

The following bones show evidence of bone-working:-

BM(NH) Reg. No.	Deposit	Species	Bone	Description
75.9943	100 c. 1499-1500 AD	horse	metatarsal bone	Proximal end and part of shaft, sawn
75.6253	23 c. 1520 AD	sheep	humerus	Distal end and part of shaft. Three lines scored round shaft. Widths of bands 10.2 & 11.3 mm
75.6657	1 c. 1520 AD	sheep	humerus	Distal end and part of shaft. Three lines scored round shaft. Widths of bands 5.2 & 7.0 mm
75.6660	1 c. 1520 AD	sheep	humerus	Distal end and part of shaft. Two lines scored round shaft. Width of band 9.7 mm
75.10157	5168 13th cent. AD	pig	metacarpus IV	Complete bone. Hole bored through shaft.
75.10983	150 c. 1499-1500 AD	sheep	metatarsal bone	Complete bone. Centre of shaft 'constricted' (worn) with grooves cut into the surface. Bone highly polished.

The type of bone-working represented by each of the above specimens is uncertain.

Figure 27: Sheep and goat horn cores. Waste from a horn-working industry.

Top row: Horn cores of sheep, chopped through the base. BM(NH) Reg.Nos. 75.8277, 75.8161, 75.10883 & 75.8272.

Bottom row: Sawn segments of the horn cores of goats. BM(NH) Reg.Nos. 75.8156, 75.8155, 75. 8147, 75.8152, 75.8150, 75.8153 & 75.8157.

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Figure 28: Sawn sections of Elk, Red deer and Fallow deer antler. Waste from a bone-working industry.

Top row: Red deer. BM(NH) Reg. Nos. 76. 6450 & 76. 6449; Fallow deer. BM(NH) Reg. Nos. 76. 6447 & 76. 6437.

Bottom row: Elk. BM(NH) Reg. No. 76. 6436; Fallow deer. BM(NH) Reg. Nos. 76. 6445 & 76. 6444.

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3.5. Pathology

Bone elements with evidence of disease or deformity are described in systematic order under species:-

DOMESTIC:

I. Cattle

I.1 Congenital anomaly

A right mandible (Figure 29, specimen 75.9278)from the dock basin dump (deposit 150) is curved upwards in the region between the fourth premolar and first molar, there is a gap separating these teeth. A radiograph taken of this jaw does not show evidence of a healed fracture line, the condition is therefore believed to be a congenital anomaly (Appleby, 1976, pers. comm.).

I.2 Reshaping of bone as a result of repeated mechanical stress

Metapodial bone:

A number of metapodial bones from the castle pits (deposits 1 & 23) and dock basin dump (deposits 88 & 100) have distended (extra wide) medial or lateral condyles, which give the distal ends a splayed appearance:-

Deposit	No. bones examined	No. with extra wide distal ends
(1) Metacarpal bone		
castle pits (1 & 23)	192 (complete bones)	8 (4%)
dock basin (88 & 100)	79 (8 complete & 71 distal ends and part of shaft)	2 (3%)
(2) Metatarsal bone		
castle pits (1 & 23)	53 (complete bones)	0 (0%)
dock basin (88 & 100)	59 (8 complete & 51 distal ends and part of shaft)	6 (10%)

Only in a few of the specimens is this condition associated with exostoses on the distal epiphysis, and none of the bones shows eburnation or grooving of the articular surface, features which are diagnostic of osteoarthrosis (see below). It is widely held (see Jewell, 1963, p.89; Mennerich, 1968, p.132; Harcourt, 1975, pers. comm.) that cattle metapodial bones with abnormally broad distal ends are from plough oxen, the splayed epiphysis developing in response to repeated mechanical stress. For a description of the mechanism by which bone is able to remodel itself in response to stress, reference can be made to Halstead (1974, p.114). If this is a correct interpretation of the phenomenon, why is it that only a relatively small proportion (4%) of the metacarpal bones from deposits 1 & 23, Baynard's Castle exhibit this condition when the majority of these are assessed as being from plough oxen (section 3.2, above) ? There are, however, two possible explanations for this:-

(1) the deformed bones are from animals that were introduced to the plough at an age earlier than the usual three to five years

(2) the bones are from very old working beasts.

First phalanx:

Reshaping of the bone is also observed in several of the first phalanges (fore & hind):-

Deposit	No. bones examined	No. 'deformed'
castle pits (1 & 23)	117	7 (6%)
dock basin (88, 89 & 100)	82	5 (6%)

The presence of osteophytes (bony outgrowths) on the surface of the bone indicate that the periosteum had been inflamed, this often arises from traumatic injury, such as the pulling or tearing of muscular and tendinous insertions (Douglas & Williamson, 1975, p.122) events which are likely to afflict a working ox.

II. Sheep

II.1 Periodontal disease

A number of mandibles of sheep aged four years and over (listed below) show evidence of periodontal disease i.e. recession (erosion) of the bone below the line of the cheek teeth on the medial and/or lateral surfaces. None of the specimens of younger animals has been affected by the disease.

Deposit	No. jaws examined[1]	No. with periodontal disease
castle pits (1 & 23)	54	4 (7%)
dock basin (88 & 100)	30	1 (3%)

Key: 1. Sheep aged four years or more

II. 2 'Degenerative arthritis' (osteoarthrosis)

Tibia and talus:

A distal end of a tibia with its associated talus (Figure 29, specimen 76. 6574) from the dock basin dump (deposit 88) shows evidence of osteoarthrosis i. e. 'degenerative arthritis' arising from old age rather than infection of the joints as in osteoarthritis. The condition here is of a severe degree, with eburnation (polishing) and grooving of the articular surfaces of both bones. There is also fusion (ankylosis) of the bony outgrowths from the tibia and the talus (Note: In Figure 29, the bones have been separated in order to show the grooving on the articular surfaces).

Radius and ulna:

The proximal end of a radius with its associated ulna (specimen 76. 6565, deposit 89) shows evidence of osteoarthrosis. There is eburnation and grooving on the proximal articular surface of the radius, which has become fused to the ulna.

II. 3 Exostoses

Osteophytic outgrowths are present on the distal epiphysis of the humerus, nearly all of these are confined to the lateral surface of the trochlea condyle:-

Deposit	No. specimens with exostoses
castle pits (1 & 23)	8
dock basin (88 & 100)	17

III. Pig

III. I Infected traumatic wound

A tibia (specimen 75.11074), deposit 100) of an immature pig aged under two years has a crater-like lesion on the medial surface of the shaft (Figure 29). This has arisen from a deep penetrating wound to the lower part of the hind limb, leading to localised inflammation (osteomyelitis) and the creation of a suppurating abscess.

IV. Dog

IV.I Diseases and disorders associated with old age and traumatic injury

Bone elements from a partially complete skeleton (specimen 76.6107, deposit 100) of an old animal show the following pathological conditions:-

(a) Decalcification (generalised osteoporosis)

Removal of calcium from nearly all the elements of the skeleton has left them lighter than normal, healthy bones, with their surfaces soft and chalky (powdery) in texture.

(b) 'Degenerative arthritis' (ossifying spondylosis)

Evidence of this disease is provided by bony outgrowths on the anterior and posterior sides of the bodies of the lumbar vertebrae, similar outgrowths are also seen on the ventral surface of the sacrum. The animal died before fusion (ankylosis) of adjacent lumbar vertebrae had occurred, and before the thoracic vertebrae had become affected (these elements show only localised lesions and roughening of the ventral surface of the centrum). As is common to this condition (see Douglas & Williamson,,1975, p. 86), the cervical vertebrae are unaffected.

(c) Dislocation of the head of the femur from the acetabulum

The right innominate bone has a second acetabulum above the original socket (Figure 30). This condition has arisen from dislocation of the femur head (possibly dislodged as a result of a fall, or from a congenital defect - hip dysplasia) which, remaining untreated, resulted in remodelling of the structure of the innominate bone, giving rise to a 'false' (replica) acetabulum. The head of the right femur exhibits areas of erosion and exostoses, which bear testimony to the mechanical stresses experienced by the proximal end of the bone while the new socket was being 'moulded'. Immediately after dislocation of the femur, the right leg was incapacitated, the full weight of the body being thrown onto the left hindlimb which was then subjected to repeated mechanical stress, as shown by the presence of osteophytes on the distal epiphysis of the left femur (Figure 30).

V. Cat

V.I Healed traumatic fracture

A right femur (specimen 76. 6354, deposit 88) from an adult cat shows a fracture in the proximal third of the shaft. Although successfully healed, the bone is deformed due to vertical and lateral displacement of the broken halves of the shaft (Figure 31), the hindlimb would have been foreshortened in consequence, making the animal walk with a limp.

This type of injury is of common occurrence in cats. For information on the different forms of fracture that arise in this bone, reference can be made to Douglas & Williamson (1975, p. 114).

WILD:

I. Fallow deer

I. 1 Septic abscess

A first phalanx fused to the grotesquely deformed second phalanx of a Fallow deer (Figure 29, specimen 76. 6575) was found in one of the castle pits (deposit 1). Radiographs of this specimen show that there is complete disorganisation of bone structure in what was once the second phalanx, and that at time of death of the animal the distal end of the first phalanx was undergoing a similar breakdown. This condition may have arisen from chronic infection (septic abscess) of the hoof following a traumatic injury, with the infection spreading 'up the foot'.

The incidence of disease in late medieval and early Tudor livestock

There are relatively very few bones of cattle, sheep and pig from Baynard's Castle with evidence of disease or deformity (Table 31). This apparent low incidence of disease belies the true situation in domestic livestock in the late medieval and early Tudor periods; it must be remembered that many diseases while causing severe damage and disruption to the soft body tissues (including the heart, lungs and other internal organs), leave no trace on the skeleton, and that evidence taken from the archaeological record must be viewed in this light. A more accurate picture is obtained from study of contemporary documents, which reveal that even on large, well managed farms, losses to animals were, in some years, extraordinarily high. Losses seem to have been particularly high in sheep flocks, an entry in the record for Ebblesburn, Wiltshire (referred to in Trow-Smith, 1957, p.154), for instance, mentions that in 1357 AD the 'red death' (an unspecified disease) struck the estate causing the death of nearly a quarter of the animals in the flock of 1,232. Infestation by mange mite, giving rise to the condition called 'scab', was probably the most common disease in sheep in the late medieval period, and was the scourge of every flockmaster, for although 'scab' very rarely kills an animal it ruins the wool and causes premature shedding of the fleece, and to the medieval flockmaster the fleece was all-important. As he did not possess the means to successfully combat such a disease there was no other option for him but to cull out any infected beast, and where 'scab' became well established and reached epidemic proportions, the large scale culling of afflicted sheep led to very great losses in revenue.

There appear to have been no significant advances in veterinary practice during the early Tudor period, the treatment of livestock continued to be extremely primitive, it was, for example, standard practice to bleed a sick animal in order to 'purify' and purge it of 'ill humours'.

A much more sensible approach was, however, adopted when attempting to cure an animal with 'scab', here sulphur powder or tar was daubed onto infected areas of the skin. But even this form of treatment was not always effective, and as a general policy, livestock in the Tudor period were slaughtered at the first sign of illness. Interestingly, this practice is still thought, today, to be the best means of eradicating contagious abortion in cattle, a blood test is used to screen the herd for infected cows, which are isolated and sent off for slaughter as soon as possible.

Table 31: Number of bones of domestic livestock with evidence of disease and deformity. Castle pits (deposits 1 & 23) and dock basin dump (deposits 88, 89 & 100).

	cattle	sheep	pig
skull	-	-	-
mandible	1	5	-
scapula	-	-	-
humerus	-	25	-
radius	-	1	-
ulna	-	1	-
innominate	-	-	-
femur	-	-	-
tibia	-	1	1
calcaneum	-	-	-
talus	-	1	-
metapodia	16	-	-
phalanx 1	12	-	-
phalanx 2	-	-	-
hoof core	-	-	-
Total no. bones with evidence of disease	29	34	1
Total no. bones identified	2549	3457	1219
Proportion of bone with pathology (% total)	1%	1%	< 0.1%

Figure 29: Specimens with evidence of disease and deformity.

From top to bottom:-

1. Mandible of ox with a congenital defect. BM(NH) 75.9278, deposit 150.

2. Tibia of pig with an infected traumatic wound. BM(NH) 75.11074, deposit 100.

3. Tibia and talus of sheep showing evidence of osteoarthrosis. BM(NH) 76.6574, deposit 88.

4. First and second phalanx of Fallow deer. Disorganisation of bone structure following chronic infection (septic abscess ?). BM(NH) 76.6575, deposit 1.

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cm

Figure 30: Dog. Pelvis with right and left femora.

Bone elements of a partially complete skeleton BM(NH) Reg. No. 76.6107, deposit 100. Right innominate bone has a 'false' (replica) acetabulum.

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Figure 31: Radiograph of a cat femur showing a healed traumatic fracture.

Specimen BM(NH) Reg. No. 76. 6354, deposit 88, c. 1499 - 1500 AD.

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3.6 Discussion

The study of urban refuse of the late medieval and early Tudor periods has formed the basis of this work. From the exceptionally well preserved rubbish, it has been possible to gain insight into the history of everyday life in the city of London, and to reconstruct some of the ways in which the society exploited its animal resources, both wild and domestic.

According to Sabine (1937), machinery for the collection and disposal of refuse from the city of London was set up as early as the thirteenth century AD. Each ward was supplied with two carts and two horses for use in collecting the rubbish and transporting it to quays on the bank of the River Thames, from where it was loaded onto barges and carried out of the city along the river, or, when the opportunity presented itself, dumped as 'backfill' for the construction of dock basins and other waterfront structures (see below). In spite of the work undertaken by teams of street cleaners and refuse collectors, the city, at least by present-day standards, was still very insanitary. Conditions were made worse by the continuation of the practice of illegally dumping obnoxious material in the streets and lanes, contemporary records showing that the worst offenders were the butchers in the three main meat markets of St. Nicholas Shambles, Stocks market and East Cheap (Pendrill, 1925; Sabine, 1933; Jones, 1976). By the fourteenth century, greater efforts were being made by the authorities to clean up the city, and this included tighter control exercised over the activities of the butchers, who were obliged to cut up offal from carcasses on a special pier known as 'Bochersbrigge' situated near Baynard's Castle. Accumulated piles of entrails and other offal were then taken out periodically into midstream by boat and thrown into the water. This operation was usually performed during ebb tides to ensure dispersal of the waste away from the city. A similar provision was undoubtedly provided for butchers in other

European cities, information on which is unfortunately scant, except for Linz in Upper Austria, where contemporary engravings show a specially constructed building set on wooden piles at the edge of the river from which the butchers could dispose of offal into the ebb tide (Knecht, 1966). It is against this background that the presence of very large quantities of animal bone at the site of Baynard's Castle should be viewed.

Further development and expansion of the existing waterfront along the northern bank of the River Thames took place in the late medieval period, and instead of transporting unwanted refuse and debris to dumping grounds outside the city walls, this material was usefully employed as 'backfill' in the open areas behind the newly built revetments, quays and dock basins. Analysis of the material forming the 'backfill' to the waterfront structures reveals that a large proportion is comprised of animal bone, representing the discarded waste from slaughter yard, household and workshop (see sections 3.3, 3.2 & 3.4, above). Very large amounts of mammalian bone were, for instance, present in the three major dumps (deposits 1 & 23; 88, 89 & 100; 250) on the site of Baynard's Castle. This is illustrated below by values of the weight and number of bones per cubic metre of matrix excavated, calculated for each of the sieved deposits (1 & 23; 89):-

Deposit[1]	Density of mammalian bone:[2]	
	I. (by weight)	II. (by number)
castle pits (1 & 23)	26,723 gm per cubic metre	298 bones per cubic metre
dock basin (89)	14,423 gm per cubic metre	197 bones per cubic metre

Key: 1. Sieved deposit only

2. Density of bone: I. Value calculated from total weight of bone/volume of matrix excavated

II. Value calculated from number of identified bones/volume of matrix excavated.

Relatively very few bones from the castle pits and dock basin show signs of weathering and abrasion, and they must, therefore, have been rapidly buried. This is in contrast to bones from the thirteenth century pits (deposits numbered in the 5000 series) many of which show evidence of weathering and abrasion, indicating that they had been left unburied, possibly on open rubbish heaps, for a considerable period of time before being removed to a refuse pit. Although the citizens of London in the late fifteenth and early sixteenth centuries were apparently indifferent to all but the most obnoxious filth in the streets, and tolerated conditions that today would be regarded as highly insanitary and a hazard to health, it is unlikely that the inhabitants of Baynard's Castle would have allowed waste from the kitchen and other refuse to accumulate and remain exposed for any length of time within the grounds attached to the building. The three 'robber pits' (deposits 1 & 23, also referred to as the 'castle pits' in this thesis) must therefore have been filled and covered in a very short period. Information supplied by Marsden (1974, pers. comm.) verifies this interpretation; the sides of the pits formed when part of the masonry lining the side of the dock basin was removed ("robbed out') did not show evidence of long exposure (i. e. they retained their vertical profile), indicating that each pit had been filled with rubbish within a very short time period, possibly less than one month. Dumping in the dock basin would also seem to have been completed within a very short period, probably inside a year.

The material recovered from the three main dumps of refuse (deposits 1 & 23; 88, 89 & 100; 250) comprises a total of 10,301 identified bone elements, only 206 (2%) are from wild species, compared with 10,095 (98%) from domestic animals. The following mammalian species have been identified:-

Domestic:	Wild:
Equus (domestic horse)	Alces alces, Elk[1]
Bos (domestic ox)	Cervus elaphus, Red deer

Domestic (continued)	Wild (continued)
Ovis (domestic sheep)	Dama dama, Fallow deer
Capra (domestic goat)	Capreolus capreolus, Roe deer[2]
Sus (domestic pig)	Lepus sp., hare
Canis (domstic dog)	Rattus rattus, Black rat
Felis (domestic cat)	Erinaceus europaeus, hedgehog
Oryctolagus cuniculus (domestic rabbit)	Mus musculus House mose

Key: 1. Imported antler
2. Thirteenth century AD deposit only

There were also six human bone elements.

For each of the domestic species, an attempt was made to establish the stature of the animals, as well as the age at which they were slaughtered, or died. For example, by applying the method of Kiesewalter (1888) to two complete bones (humerus & metacarpus) of horse, the height at the withers is estimated from the lateral length at 139 cm (approx. 13.7 hands) and 144 cm (approx. 14.2 hands). Comparison of the horseshoes found in association with the skeletal material with shoes from modern horses of known stature reveals that they came from small and medium sized animals.

There was an increase in the stature of cattle during the late medieval and early Tudor period, and it is at this time that long horned cattle (i.e. with horns over 200 mm in length of outer curve) first make their appearance. Calculated values of the height at the withers, based on the length of the metacarpal bone (after the method of Fock), range from just over 100 cm (deposit 5000, thirteenth century AD) to 151 cm (deposit 23, c.1520 AD). Half of the cattle had been killed at less than nine months of age, the rest at five years and over.

Unlike the cattle, the sheep show no increase in size between the middle ages and early Tudor period, and they were similar in stature and build to the primitive Soay sheep kept on the mainland today.

Two peaks of slaughtering are discerned, one at age 2 to 6 months (sucking and very young lambs) and another at 4 to 6 years. This kill-off pattern, together with the presence of many castrated (wether) sheep reflects a mainly wool-producing economy with some fattening of lambs for the table.

As the majority of the leg bones of pig come from immature animals (with unfused epiphyses) it has not been possible to determine their stature. A complete skull does, however, show that the pig in the late middle ages had a long, sharp snout, being similar in appearance to the wild pig, although much smaller. The pig in Britain remained in its largely unimproved state through the Tudor period and into the eighteenth century AD, when a change in conformation occurred following the crossing of indigenous animals with imported Chinese, Siamese and Neapolitan stock (Trow-Smith, 1959, p. 41). There were two peaks of slaughtering, one at age 2 to 3 years, the other at less than one year (sucking pigs). Very few animals were kept alive after 3 years of age.

No bones of very large dogs were found, as have been recovered from other Tudor sites in the city of London. Values for height at the shoulder for the adult dogs from Baynard's Castle range from 25 cm to 48 cm.

Three partially complete, articulated skeletons of kittens, and two of adult cats were recovered. The fully grown animals are, by comparison with modern cats, very small, and they were probably feral, semi-wild scavengers.

Kubasiewicz (1956 , referred to in Uerpmann, 1973, p. 310) has demonstrated that the weight of bone can be used directly to assess the relative contribution of meat that each species makes to the diet. His method has been applied to the mammalian remains from Baynard's Castle, and the results are given in Table 32.

Table 32: Proportion of meat contributed by each species to the late medieval diet. Values based on weight of bone[1]. Sieved deposits only.

Deposit	Domestic:				Wild:		
	cattle	sheep	pig	rabbit	Red deer	Fallow deer	hare
castle pits (1 & 23)	73%	20%	4%	< 1%	< 0.5%	2%	< 0.1%
dock basin (89)	70%	19%	9%	1%	0%	1%	0%

Key: 1. For each species, the value is calculated from (weight of bone/total weight) x 100

From Table 32, it is seen that the bulk of the meat in the diet in the late medieval and early Tudor periods came from cattle and sheep. Interestingly, only a relatively small amount of pig-meat was apparently eaten. This is an unexpected result as contemporary recipes indicate that the flesh of this animal was highly regarded (see Wilson, 1976, p.74, 78, 80 & 82). Compared to the contribution made by the domestic species, meat from deer and hare was not an important feature in the diet, but only supplemented it.

The values presented in Table 32, however, must only be considered as providing an approximate guide to the contribution that each species made to the medieval diet. They are based on the weight of bone and so have not taken into account supplies of boned meat e.g. salted pork and venison, items which leave no trace in the archaeological record. Apart from records of regular consignments of barrels of salted venison sent from Essex, Hampshire, Northampton, Somerset and Wiltshire to the Royal household in London in the fourteenth century (see Baille-Grohman, 1904, p.203; section 3.2, above), there are no known contemporary inventories showing that this traffic continued into the Tudor period. It is not, therefore, possible to estimate the quantities of salted, dried and smoked meat, if any, imported into the city during the fifteenth and sixteenth centuries AD.

One of the lines of enquiry pursued during the study was a comparison of the faunal remains collected from the 'robber pits' (deposits 1 & 23) inside the castle walls with the animal bones from the dump of city rubbish (deposit 100) outside, in order to investigate possible differences between the diet of the nobility and that of the commoners. One striking difference between the castle and city dumps of refuse is seen in the size of their cattle; the bones of cattle from the castle are all from large sized, long horned animals, whilst those from the city come from small, medium, as well as large sized cattle. There are two reasons for believing that the bone elements of the large sized cattle in deposits 1 & 23 were dumped altogether at one time, and that they originated from only one or two herds. Firstly, the castle pits were only open for a very limited period of time, perhaps less than a month, and secondly, the supply of livestock to the Royal household in the Tudor period was often met by contract with individual farmers (Everitt, 1967, p. 516). If the cattle from the castle pits are from a single herd then the assessment that most of these animals are castrates (see section 3.2, above) may be taken to indicate that they had been raised specifically for the table and not culled after a full working life as plough oxen, as was general for cattle supplied to the butchers in the city. The group from deposits 1 & 23 represents over 80 castrates, and no arable farm at that time would have maintained such a large number of oxen. In addition to the difference in size of cattle from the two dumps, there was a higher proportion of young rabbits and a greater quantity of bone of deer found in the refuse from the castle. On the other hand, the overall analyses on the other mammalian remains showed no difference in the quality of diet of the nobility, compared to that of the commoners. The values for pig in Table 32 may show a discrepancy, but this was not borne out by the other samples (deposits 88 & 100) of mammalian bone taken from the dock basin dump where the proportion of pig bone was estimated at just under 4%, the same as for the pig from the castle. This discrepancy between samples from different areas of the same dump exemplifies the danger of arriving at an incorrect interpretation through use of data drawn from a sample taken from a much larger deposit.

The kill-off patterns established for cattle, sheep and pig, reveal that both the inhabitants of the castle and the citizens of London ate both young and old animals i. e. veal, lamb and sucking pig, as well as the meat of older beasts.

The refuse in the castle pits which included skull fragments and metapodial bones of cattle, sheep and pig, may indicate that domestic livestock were being slaughtered within the walls of the castle, and this presupposes the existence of a slaughter yard attached to the kitchens at Baynard's Castle. Unfortunately, this observation can not be verified or refuted as there are, as yet, no known extant plans showing the interior layout of the castle. This and other aspects associated with the history of the site remain unresolved, and work on the collection of mammalian bone is continuing.

The collection of mammalian bone from Baynard's Castle provides a good basis for the elucidation of the problems relating to the exploitation of domestic and wild species of animals by the late medieval and early Tudor society of London. This bone material should not be viewed, however, in isolation but as part of a much larger body of evidence on the supply of food to the city in the late fifteenth and early sixteenth centuries AD, information on which remains to be collated and published. To promote this, the primary data on the faunal remains from Baynard's Castle are available at the BM(NH), as are the specimens, for anyone who may wish to make use of them.

4. SUMMARY OF THE DATA

INDEX

KEY

1. With the exception of values for the height at the withers (in cm), all measurements are given in mm.
2. Unless stated otherwise, all measurements for long bones are maximum dimensions taken from elements with fused epiphysis.
3. Abbreviations used:-

   Prox. width - Medio-lateral width across proximal epiphysis

   Prox. depth - Anterio-posterior depth of proximal epiphysis

   Min. shaft width - Minimum medio-lateral width across the shaft

Dist. width - Medio-lateral width across distal epiphysis

N = Number of specimens

M = Mean (estimated by average value of the observations on the variate)

Range = Observed size range (lowest and highest values of variate)

SD = Standard deviation

SE = Standard error of the mean

4. Letters in parenthesis e.g. (BT) refer to points of measurement described by von den Driesch (1976)

5. Registration numbers are those entered into the BM(NH) computer-based catalogue.

HORSE

Order: Perissodactyla
Family: Equidae
Taxon: Equus (domestic)

Height at the withers, calculated after the method of Kiesewalter (1888).

Factors:-	humerus	4.87	femur	3.51
	radius	4.34	tibia	4.36
	metacarpus	6.41	metatarsus	5.33

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c.1520 AD)

Table I.1 Tibia

Reg. No. 75.9939 (deposit 1)

Dist. width (Bd)	85.5
Dist. depth (Td)	54.7

Table I.2 Phalanx 2

Reg. No. 75.9936 (deposit 1)

Length (GL)	45.6
Prox. width (Bp)	50.5
Prox. depth (Tp)	32.2
Mid shaft width (KD)	44.6
Dist. width (Bd)	48.6

II. Baynard's Castle, deposit 80 (dock basin dump c.1500 AD)

Table II.1 Mandible

Reg. No. 75.9945. Left mandible of male or castrate. Aged 6 to 7 years

1.	Length of mandible	400.0
6.	Length of tooth row, P_2 - M_3	174.8
15.	Length of the diastema, anterior edge of P_2 alveolus to posterior edge of I_3 alveolus	93.1
19.	Height of mandible, condyle to angle of mandible	219.9
22b	Height of mandible in region of M_1	73.4
22c	Height of mandible in region of P_2	51.2

Numbers as in Driesch (1976, Fig.19a, p.51)

III Baynard's Castle, deposit 88 (dock basin dump c.1500 AD)

Table III.1 Phalanx 2

Reg. No. 75.9935

Length (GL)	49.3
Prox. width (Bp)	54.5
Prox. depth (Tp)	31.9
Mid shaft width (KD)	45.1
Dist. width (Bd)	52.1

IV. Baynard's Castle, deposit 100 (dock basin dump. c.1500 AD)

Table IV.1 Humerus

Reg. No. 75.9941. Proximal epiphysis gnawed by dog.

Lateral length (GLl)	284.9
Mid shaft width	34.1
Dist. width	69.7
Height at the withers	138.8 cm

Table IV.2 Innominate

Reg. No. 75.9947. Male

Length of acetabulum (LA) 65.9

Table IV.3 Talus

Reg. No. 75.10879

Dist. width (GB)	61.0
Length of medial rim of the trochlea (LmT)	55.9

Table IV.4 Metacarpal bone

Reg. No. 75.9942

Length (GL)	236.3
Lateral length (GLl)	225.0
Prox. width (Bp)	53.6
Prox. depth (Tp)	35.5
Mid shaft width (KD)	35.0
Dist. width (Bd)	51.8
Height at the withers	144.2 cm

Table IV.5 Metatarsal bone

Reg. No. 75.9943. Proximal epiphysis & part of shaft, sawn.

Prox. width (Bp)	44.8
Prox. depth	37.4

Table IV.6 Phalanx 1

Reg. Nos. 75.9927 to 75.9929

	Reg. No.		
	9927	9928	9929
Length (GL)	85.7	79.3	83.8
Prox. width (Bp)	58.1	50.1	55.0
Mid shaft width (KD)	35.4	33.0	35.6
Dist. width (Bd)	48.2	44.5	47.3

Table IV.7 Phalanx 2.

Reg. No. 75.9934

Length (GL)	43.1
Prox. width (Bp)	46.9
Prox. depth (Tp)	29.1
Mid shaft width (DK)	40.0
Dist. width (Bd)	44.1

Table IV. 8 Hoof core

Reg. No. 75.9937 Hind limb

Length (GL)	68.1
Width (GB)	76.0

V. Baynard's Castle, deposits 5000 (secondary rubbish pits, mostly c. 13th century AD.)

Table V.1 Tibia

Reg. No. 75.9940 (deposit 5041, 1 specimen)

Dist. width (Bd)	69.0
Dist. depth (Td)	41.2

Table V2. Phalanx 2

Reg. Nos. 75.9930 to 75.9933
Deposits 5212, 5154, 5017 & 5078, 4 specimens)

Reg. No.	Length (GL)	Prox. width(Bp)	Dist. width(Bp)	Mid shaft width (KD)
9930	81.5	53.5	43.7	31.5
9931	80.0	55.7	46.3	36.4
9932	83.4	52.5	45.3	34.6
9933	73.4	49.1	42.7	31.6

Table V.3 Hoof core

Reg. No. 75.9938 (deposit 5045). Fore limb

Length (GL)	66.3
Width (GB)	77.5
Length of dorsal surface (Ld)	50.0
Height in region of pyramidal process (HP)	38.0

VI. Modern specimens of horses held in the BM(NH)

Table VI.1 New Forest pony

Reg. No. H37

Bone	Lateral length (mm)	Height at the withers (cm)
Humerus	253	123.2
Radius	280	121.5
Metacarpal bone	184	117.9
Femur	354	124.3
Tibia	286	124.7
Metatarsal bone	223	118.9
	Mean height at the withers	121.8 cm

Table VI.2 Modern racehorse, St. Frusquin

Reg. No. H42. Male

Bone	Lateral length (mm)	Height at the withers (cm)
Humerus	342	166.6
Radius	375	162.8
Metacarpal bone	257	164.7
Femur	475	166.7
Tibia	379	165.2
Metatarsal bone	299	159.4
	Mean height at the withers	164.2 cm

Table VI.3 Modern racehorse, Brown Jack

Not reg., mounted specimen. Castrate

Bone	Lateral length (mm)	Height at the withers (cm)
Humerus	338	164.6
Radius	392	170.1
Metacarpal bone	263	168.6
Femur	490	172.0
Tibia	385	167.9
Metatarsal bone	314	167.4
	Mean height at the withers	168.4 cm

Table VI. 4 Modern racehorse (Arab), Dwarka

Reg. No. 1924. 5. 4. 1 Male

Bone	Lateral length (mm)	Height at the withers (cm)
Humerus	320	155.8
Radius	359	155.8
Metacarpal bone	237	151.9
Femur	422	148.1
Tibia	349	152.2
Metatarsal bone	283	150.8
	Mean height at the withers	152.4 cm

Table VI. 5 Modern Shire horse, Blaisdon Conqueror

Reg. No. H14. Male. Foaled in 1894 and died in 1904

Bone	Lateral length (mm)	Height at the withers (cm)
Humerus	370	180.2
Radius	380	164.9
Metacarpal bone	269	172.4
Femur	520	182.5
Tibia	395	172.2
Metatarsal bone	315	167.9
	Mean height at the withers	173.4

CATTLE

Order: Artiodactyla
Family: Bovidae
Taxon: Bos (domestic)

Height at the withers, calculated after the methods of Boessneck and Fock (see von den Driesch & Boessneck, 1974, p. 336).

Boessneck:	Length x 6.40
Fock:	Length x 6.13

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c.1520 AD)

Table I.1 Horn core

Reg. Nos. 75.8299 to 75.8302 (deposit 23); 75.8303 (deposit 1)

Reg. No.	Measurements[a]			Description & classification[b]			
	1	2	3	curvature	shape of tip	group	sex
8299	355	207	84	twisted	pointed	LH	C/F?
8300	-	201	78	twisted	-	LH	M ?
8301	-	255	94	twisted	-	LH	C
8302	-	238	86	twisted	-	LH	C
8303	-	219	91	twisted	pointed	LH	C/F ?

Key:

a. Measurements:
1. Length of posterior-dorsal (outer)curve
2. Basal circumference
3. Index of (minimum diameter at base/maximum diameter at base) x 100

b. Description & classification, after the system proposed by Armitage & Clutton-Brock (1976)

Group:	LH	Long horned
	MH	Medium horned
	SH	Short horned
	SmH	Small horned
Sex:	M	Male (bull)
	F	Female (cow)
	C	Castrate (ox)

Table I.2 Radius

Reg. Nos. 75.9651 to 75.9666 (deposits 1 & 23)

Measurement	N .	M	Range
Prox. width	8	76.12	73.1 - 80.4
Dist. width	5	72.76	65.6 - 77.5

Table I. 3 Metacarpal bone

Reg. Nos. 75. 8556 to 75. 8673 (deposit 23); 75. 8674 to 75. 8747 (deposit 1)

	N	M	Range	SD
Deposit 1				
Length	74	196.80	178.9 - 216.0	8.49
Prox. width (Bp)	74	60.80	48.8 - 69.4	3.53
Prox. depth	74	34.50	29.1 - 39.0	2.10
Mid. shaft width	74	35.60	27.6 - 40.3	2.44
Dist. shaft width	74	57.95	48.6 - 63.5	2.90
Dist. epiphysial width	74	64.89	51.5 - 76.1	3.83
Deposit 23				
Length	118	201.12	177.5 - 247.0	10.22
Prox. width (Bp)	118	61.74	53.7 - 73.0	2.86
Prox. depth	118	34.95	30.1 - 39.3	1.55
Mid shaft width	118	35.95	30.1 - 42.6	2.31
Dist. shaft width	118	59.82	52.4 - 71.8	3.08
Dist. epiphysial width	118	66.36	55.2 - 77.3	3.66

Height at the withers (cm):

Deposit 1.

Method	N	M	Range
Boessneck	74	126.0	114.5 - 138.2
Fock	74	120.4	109.5 - 132.2

Deposit 23

Method	N	M	Range
Boessneck	118	128.7	113.6 - 158.1
Fock	118	123.1	108.6 - 151.1

Table 1. 4 Phalanx 1

Reg. Nos. 75. 9676 (deposit 1); 75. 9677 (deposit 23); 75. 9693 (deposit 23)

Deposit 1 & 23	N	M	Range	SD	SE
(1) Fore					
Length (lateral)	39	58.75	54.1 - 65.4	2.74	0.44
Length (medial)	39	58.08	53.8 - 64.2	2.70	0.43
Prox. width	39	31.27	28.4 - 34.7	1.28	0.20
Prox. depth	39	32.24	29.5 - 34.9	1.45	0.23
Dist. width	39	30.65	26.4 - 36.2	1.89	0.30

(2) Hind

	N	M	Range	SD	SE
Length (lateral)	34	61.61	56.4 - 68.2	2.69	0.46
Length (medial)	34	61.88	55.2 - 67.6	2.76	0.47
Prox. width	34	29.33	26.2 - 32.0	1.40	0.24
Prox. depth	34	32.90	28.5 - 36.0	1.86	0.32
Dist. width	34	28.96	25.1 - 32.3	1.64	0.28

see von den Driesch (1976, p. 86)

II. Baynard's Castle, deposits 88, 89, 100 & 150 (dock basin dump c. 1500 AD)

Table II.1 Horn core

Reg. Nos. 75.8278 to 75.8309 (deposit 100); 75.8749 (deposit 150)

Reg. No.	Measurements[a]			Description and Classification[b]			
	1	2	3	curvature	shape of tip	group	sex
8278	400e	250	87	twisted	pointed	LH	C
8279	325	186	88	twisted	pointed	LH	F
8280	-	195	85	twisted	-	LH	F
8284	220	182	75	twisted	pointed	MH	C
8285	170e	153	76	twisted	pointed	MH	F
8286	-	120	83	-	-	SH	F
8291	258	200	76	twisted	pointed	LH	M
8292	240	215	74	twisted	pointed	LH	M
8293	65	90	78	straight	pointed/ round ended	SmH	C
8309	-	125	85	-	-	SH	F
8749	200	167	85	twisted	pointed	MH	C

a. & b. as in Table I.1

Table II.2 Radius

Reg. Nos. 75.9548 to 75.9565 (deposit 100)

Measurement	N	M	Range	SD	SE
Length	1	-	275.8	-	-
Prox. width	33	76.60	64.5 - 86.1	5.58	0.97
Dist. width	13	69.70	55.8 - 90.1d	8.99	2.49

d. Specimen with dist. width of 90.1 was deformed.

Table II. 3 Metacarpal bone

Reg. Nos. 75. 8377 to 75. 8415 (deposits 88 & 100); 75. 8453 to 75. 8460 (deposit 100); 75. 8462 to 75. 8493 (deposit 88); 75. 8525 to 75. 8538 (deposit 88); 75. 8970 to 75. 9009 (deposit 150)

Deposits 88, 100 & 150	N	M	Range	SD	SE
Length	8	180.20	164.5 - 199.2	-	-
Prox. width (Bp)	13	56.79	43.3 - 69.9	6.34	1.76
Prox. depth	13	32.30	26.8 - 36.4	2.86	0.79
Mid shaft width	8	30.44	26.4 - 34.1	-	-
Dist. shaft width	79	51.31	39.9 - 61.5	4.40	0.49
Dist. epiphysial width	79	56.68	46.6 - 66.5	4.88	0.55

Height at the withers (cm):

Deposits 88, 100 & 150

Method	N	M	Range
Boessneck	8	115.3	105.3 - 127.5
Fock	8	110.8	100.8 - 122.1

Table II. 4 Phalanx 1

Reg. Nos. 75. 9678 (deposit 100); 75. 9679 (deposit 150); 75. 9682 (deposit 89); 75. 9683 (deposit 88)

Deposit 88, 89, 100 & 150 *

	N	M	Range	SD	SE
(1) Fore					
Length (lateral)	29	55.11	45.7 - 62.3	3.42	0.64
Length (medial)	29	54.47	46.0 - 61.5	3.28	0.61
Prox. width	29	29.94	25.5 - 32.6	2.10	0.39
Prox. depth	29	30.98	25.1 - 35.9	2.62	0.49
Dist. width	29	29.06	23.0 - 33.0	2.50	0.47
(2) Hind					
Length (lateral)	31	58.61	49.8 - 62.9	3.20	0.58
Length (medial)	31	59.10	49.3 - 63.2	3.43	0.62
Prox. width	31	27.63	23.0 - 31.8	2.31	0.42
Prox. depth	31	31.22	25.6 - 38.4	2.67	0.48
Dist. width	31	26.97	22.4 - 30.4	2.12	0.38

* Excluding deformed specimens and any with exostosis

III. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table III.1 Horn core

Reg. No. 75. 9233

Reg. No.	Measurements[a] 1	2	3	Description & classification[b] curvature	shape of tip	group	sex
9233	104	128	83	curved	round ended	SH	M/C ?

a. & b. as in Table I.1

Table III. 2 Radius

Reg. Nos. 75. 9629 to 75. 9650

Measurement	N	M	Range
Prox. width	9	70. 68	65. 1 - 76. 5
Dist. width	7	59. 91	54. 6 - 68. 5

Table III. 3 Metacarpal bone

Reg. Nos. 75. 8825 to 75. 8849

	N	M	Range	SD	SE
Length	1	-	175. 3	-	-
Prox. width (Bp)	12	53. 90	46. 7 - 61. 7	5. 66	1. 64
Prox. depth	12	30. 95	26. 7 - 34. 9	2. 54	0. 73
Mid shaft width	1	-	29. 5	-	-
Dist. shaft width	11	47. 55	41. 6 - 53. 8	3. 69	1. 11
Dist. epiphysial width	11	52. 98	47. 4 - 58. 9	3. 90	1. 18

Height at the withers (cm):

Method	N	M	Range
Boessneck	1	-	112. 2
Fock	1	-	107. 5

IV. Baynard's Castle, deposits 5000 (secondary rubbish pits, mostly c. 13th Century AD)

Table IV. 1 Horn core

Reg. Nos. 75. 9230 & 75. 9232

Reg. No.	Measurements[a] 1	2	3	Description & classification[b] curvature	shape of tip	group	sex
9230	120	109	77	twisted	pointed	SH	F
9232	130e	144	73	curved	-	SH	C

a. & b. as in Table I.1

Table IV.2 Metacarpal bone

Reg. Nos. 75.9093 to 75.9117; 75.9256 to 75.9257

	N	M	Range	SD	SE
Length	4	176.80	170.2 - 185.9	-	-
Prox. width (Bp)	4	51.80	46.2 - 55.6	-	-
Prox. depth	4	29.88	26.1 - 32.2	-	-
Mid shaft width	4	28.48	25.0 - 32.0	-	-
Dist. shaft width	22	47.67	39.4 - 54.7	4.39	0.94
Dist. epiphysial width	21	53.51	46.0 - 63.7	5.57	1.22

Height at the withers (cm):

Method	N	M	Range
Boessneck	4	113.2	108.9 - 119.0
Fock	4	108.4	104.3 - 114.0

Table IV.3 Phalanx 1

Reg. No. 75.9680

	N	M	Range	SD	SE
(1) Fore					
Length (lateral)	22	50.83	44.1 - 55.3	2.72	0.58
Length (medial)	22	49.93	43.4 - 54.7	2.68	0.57
Prox. width	22	26.80	22.8 - 31.0	2.31	0.49
Prox. depth	22	27.57	23.3 - 33.5	2.59	0.55
Dist. width	22	25.90	21.8 - 29.5	2.21	0.47
(2) Hind					
Length (lateral)	24	53.24	47.7 - 61.7	3.62	0.74
Length (medial)	24	53.07	48.2 - 61.9	3.44	0.70
Prox. width	24	23.93	20.3 - 27.8	2.25	0.46
Prox. depth	24	26.61	23.0 - 31.1	2.28	0.47
Dist. width	24	23.43	20.2 - 27.9	2.29	0.47

V. Modern specimens of cattle

Table V.1 Metacarpal bone

(1) Red Danish cows

Measurements supplied by Professor C. Higham, Dept. Anthropology, University of Otago, New Zealand

	N	M	Range	SD
Length	32	215.03	197.2 - 228.3	7.08
Prox. width (Bp)	32	68.83	63.5 - 73.8	2.20
Mid shaft width	32	35.75	32.0 - 39.0	1.65
Dist. epiphysial width	32	64.66	60.0 - 70.3	2.26

Height at the withers (cm):

Method	N	M	Range
Boessneck	32	137.6	126.2 - 146.1
Fock	32	131.6	120.7 - 139.7

(2) Chartley bulls

BM(NH) Reg. Nos. 1924.4.28 & 1975.303

	1 (24.4.28)	2 (75.303)
Length	208.3	212.4
Prox. width (Bp)	77.2	80.9
Prox. depth	48.3	49.8
Mid shaft width	46.8	47.4
Dist. shaft width	71.0	70.6
Dist. epiphysial width	74.8	76.7

Height at the withers (cm)

Method	Specimen number 1	2
Boessneck	133.3	135.9
Fock	127.7	130.2

(3) Chillingham cattle

Specimens held in the BM (NH), Reg. No. 1953.4.22.9

	N	M	Range
Length	7	179.80	174.2 - 183.8
Prox. width (Bp)	7	53.79	50.5 - 58.9
Prox. depth	7	32.96	31.0 - 34.7
Mid shaft width	7	30.70	28.0 - 35.5
Dist. shaft width	7	48.73	46.3 - 53.5
Dist. epiphysial width	7	55.39	52.5 - 61.3

Height at the withers (cm):

Method	N	M	Range
Boessneck	7	115.1	111.5 - 117.6
Fock	7	110.2	106.8 - 112.7

SHEEP

Order: Artiodactyla
Family: Bovidae
Taxon: Ovis (domestic)

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c. 1520 AD)

Table I.1 Horn core

Reg. Nos. 75. 8271 (deposit 23); 75. 8274 & 75. 8275 (deposit 1): 75. 10881 & 75. 10882 (deposit 23)

Reg. No.	Length of outer curve[1]	Basal circ.[2]	Max. diam.[3]	Min. diam.[4]
8271	122	86	31.6	22.9
8274	125	93	37.8	23.6
8275	77	80	26.4	23.7
10881	45	55	17.6	15.3
10882	88	-	31.7	-

Key to measurements:

1. Length of outer curve: Length of the posterior-dorsal (outer) curve of the core
2. Basal circ.: Basal circumference
3. Max. diam.: Maximum diameter at base of the core
4. Min. diam.: Minimum diameter at base of the core

Table I. 2 Mandible

Reg. Nos. 75. 6000 to 75. 6090 (deposit 23); 75. 6597 to 75. 6621 (deposit 1): 75. 6748 to 75. 6802 (deposit 1)

Age class[a] (years)	Measurements[b]	N	M	Range	SD	SE
E 2-3	2	6	49.92	45.1 - 51.7	-	-
	3	13	40.02	35.8 - 43.5	2.51	0.69
	4	17	23.41	19.5 - 26.8	2.03	0.49
	5	9	15.40	13.6 - 18.9	-	-
	6	14	70.59	65.5 - 76.4	3.12	0.83
	7	6	13.23	12.1 - 14.9	-	-
F 3-4	2	10	51.16	46.6 - 57.8	3.22	1.02
	3	28	39.66	36.4 - 45.1	2.54	0.48
	4	32	23.24	20.6 - 25.3	1.06	0.19
	5	23	16.41	14.2 - 19.9	1.57	0.33
	6	29	69.72	64.9 - 75.1	2.70	0.50
	7	12	13.32	12.1 - 16.0	1.07	0.31
G 4-6	2	13	53.32	44.6 - 68.2	7.17	1.99
	3	26	37.94	34.1 - 42.5	2.40	0.47
	4	31	22.48	18.5 - 25.4	1.80	0.32
	5	21	15.94	14.3 - 18.9	1.25	0.27
	6	28	68.29	63.5 - 74.9	3.15	0.60
	7	18	13.32	12.2 - 16.6	1.29	0.30
H 6-8	2	2	-	52.7 - 57.7	-	-
	3	6	35.87	33.4 - 38.1	-	-
	4	6	23.05	21.7 - 24.5	-	-
	5	6	16.63	15.0 - 18.9	-	-
	6	6	64.27	60.0 - 67.2	--	-
	7	5	13.02	12.0 - 14.0	-	-
I 8-10	2	1	-	58.4	-	-
	3	5	34.00	30.9 - 37.0	-	-
	4	5	21.44	19.7 - 22.9	-	-
	5	4	15.40	14.3 - 16.6	-	-
	6	5	63.10	60.6 - 67.7	-	-
	7	3	13.13	13.0 - 13.2	-	-

a. Age class: Based on sequence of tooth eruption and wear, after the method of Payne (1973, p. 299)

b. Key to measurements:

2. Length: Posterior edge of M_3 alveolus - angle of the mandible

3. Height of mandible in region of M_3
4. Height of mandible in region of M_1
5. Height of mandible in region of P_2
6. Length of tooth row, P_2 - M_3
7. Height of mandible in region of the mental foramen

Numbers as in Duerst (1926, p. 334)

Table I. 3 Scapula

Reg. Nos. 75. 6969 to 75. 7044 (deposit 1)

Measurement[a]	N	M	Range	SD	SE
Length of articular surface (GLP)	51	32.88	27.7 - 36.0	1.68	0.24
Width of glenoid cavity (BG)	69	20.76	16.7 - 23.7	1.32	0.16
Height of neck	55	21.01	17.4 - 23.4	1.55	0.21
Min. neck length (KLC)	69	20.21	16.3 - 22.3	1.23	0.15

a. Measurements: See Driesch (1976, p. 68 - 69); Height of neck: Point of attachment of spine to neck below acromion - Mid-point on rim of glenoid cavity.

Table 1. 4 Humerus

Deposit I

Reg. Nos. 75. 6641 to 75. 6697; 75. 6944 to 75. 6962

Measurement	N	M	Range	SD	SE
Length	-	-	-	-	-
Prox. width	2	-	35.2 - 39.7	-	-
Prox. depth	8	41.30	36.8 - 45.4	-	-
Min. shaft width	48	15.05	12.3 - 17.5	1.16	0.17
Dist. width (BT)[1]	67	29.30	24.9 - 32.4	1.73	0.21

Deposit 23

Reg. Nos. 75. 6205 to 75. 6270

Measurement	N	M	Range	SD	SE
Length	2	-	135.0 - 140.8	-	-
Prox. width	4	38.62	36.7 - 40.8	-	-
Prox. depth	5	42.08	40.6 - 43.3	-	-
Min. shaft width	27	15.08	12.9 - 18.3	1.09	0.20
Dist. width (BT)[1]	62	29.33	25.9 - 32.8	1.43	0.18

Key to measurement: 1. Dist. width (BT): Maximum distal width taken across the trochlea condyle, see Driesch (1976, p. 71, Bos humerus)

Table I.5 Radius

Deposit 1

Reg. Nos. 75.6698 to 75.6747; 75.6926 to 75.6943

Measurement	N	M	Range	SD	SE
Length	6	146.27	140.2 - 151.7	-	-
Prox. width	58	31.24	26.1 - 35.5	2.03	0.27
Min. shaft width	45	16.10	10.0 - 19.0	1.89	0.28
Dist. width	5	28.66	27.1 - 29.6	-	-

Deposit 23

Reg. Nos. 75.10199 to 75.10268

Measurement	N	M	Range	SD	SE
Length	11	150.49	136.3 - 162.0	8.21	2.48
Prox. width	60	31.18	25.8 - 34.4	1.79	0.23
Min. shaft width	52	16.79	13.1 - 19.9	1.39	0.19
Dist. width	16	28.52	27.2 - 29.9	0.77	0.19

Table I.6 Metacarpal bone

Deposit 1

Reg. Nos. 75.7057 to 75.7066

Measurement	N	M	Range
Prox. width	6	22.51	20.8 - 25.2
Prox. depth	6	16.50	14.6 - 18.4
Mid. shaft width	5	13.40	12.2 - 14.8
Dist. shaft width	4	24.33	22.7 - 25.5

Deposit 23

Reg. Nos. 75.6188 to 75.6200

Measurement	N	M	Range	SD	SE
Prox. width	12	23.22	20.6 - 24.7	1.17	0.33
Prox. depth	12	17.20	14.9 - 19.1	1.12	0.32
Mid shaft width	3	13.36	12.9 - 13.8	-	-
Dist. shaft width	1	-	24.7	-	-

Table I.7 Innominate

Deposit 1

Reg. Nos. 75.7114 to 75.7138 & 75.10902 (7 specimens)

Measurement	N	M	Range	SD	SE
Length of acetabulum	28	24.85	23.2 - 27.6	1.07	0.20
Thickness (depth) of medial rim of acetabulum	27	4.87	2.1 - 7.7	1.42	0.27

Deposit 23

Reg. No. 75. 6307 to 75. 6328; 75. 7355 to 75. 7365

Measurement	N	M	Range	SD	SE
Length of acetabulum	32	24. 55	21.7 - 27.0	1. 22	0. 22
Thickness (depth) of medial rim of acetabulum	32	6. 20	2. 4 - 8. 8	1. 34	0. 24

Table I. 8 Femur

Reg. Nos. 75. 6271 to 75. 6293 (deposit 23); 75. 7101 to 75. 7113 (deposit 1)

Measurement	N	M	Range	SD	SE
Dist. width (Bd)	12	36. 10	33. 7 - 37. 6	0. 98	0. 28

Table I. 9 Tibia

Measurements for dimensions of the proximal epiphysis refer to sub-adults (with unfused epiphysis) and adults.

Deposit 1.

Reg. Nos. 75. 6857 to 75. 6925

Measurements	N	M	Range	SD	SE
Length	1	-	188. 9	-	-
Prox. width	7	39. 72	34. 9 - 43. 2	-	-
Prox. depth	7	39. 62	37. 3 - 41. 8	-	-
Min. shaft width	25	14. 33	10. 7 - 16. 8	1. 34	0. 28
Dist. width	38	24. 41	20. 2 - 27. 0	1. 44	0. 23

Deposit 23

Reg. Nos. 75. 6110 to 75. 6174

Measurement	N	M	Range	SD	SE
Length	1	-	190. 2	-	-
Prox. width	19	41. 20	37. 6 - 46. 8	2. 26	0. 52
Prox. depth	17	40. 18	34. 4 - 45. 3	2. 34	0. 57
Min. shaft width	31	14. 92	13. 6 - 16. 8	0. 75	0. 14
Dist. width	44	24. 92	20. 0 - 27. 5	1. 27	0. 19

Table I. 10 Metatarsal bone

Deposit 1.

Reg. Nos. 75. 7046 to 75. 7056; 75. 7067 to 75. 7083

Measurement	N	M	Range	SD	SE
Prox. width	16	20. 18	19. 1 - 21. 4	0. 67	0. 17
Prox. depth	15	19. 63	18. 4 - 20. 3	0. 49	0. 13
Mid. shaft width	12	11. 61	9. 5 - 12. 5	0. 91	0. 26
Dist. shaft width	8	22. 92	20. 9 - 24. 6	-	-

Deposit 23

Reg. Nos. 75. 6175 to 75. 6187

Measurement	N	M	Range	SD	SE
Prox. width	12	20. 25	18. 5 - 22. 4	1. 23	0. 36
Prox. depth	11	19. 98	18. 4 - 21. 6	1. 14	0. 34
Mid. shaft width	2	-	9. 4 - 10. 4	-	-
Dist. shaft width	2	-	21. 2 - 22. 4	-	-

Table I. 11 Phalanx 1

Reg. Nos. 75. 6467 to 75. 6469 (deposit 1); 75. 7155 to 75. 7157 (deposit 23)

Measurement	N	M	Range
Length (medial)	6	33. 35	31. 2 - 36. 0
Prox. width	6	11. 87	10. 4 - 12. 8
Dist. width	6	10. 95	9. 6 - 11. 5

II. Baynard's Castle, deposits 88, 89, 100 & 150 (dock basin dump c. 1500 AD)

Table II. 1 Horn core

Reg. Nos. 75. 8277 (deposit 100); 75. 8168 & 75. 10884 (deposit 150)

Reg. No.	Length of outer curve [1]	Basal circ. [2]	Max. diam. [3]	Min. diam. [4]
8277	-	121	43. 0	34. 1
8168	97	77	29. 3	19. 1
10884	111	88	31. 0	23. 8

Key to measurements as in Table I. 1

Table II. 2 Mandible

Reg. Nos. 75. 7366 to 75. 7460 (deposit 100); 75. 7461 to 75. 7468 (deposit 88)

Age class[a] (years)	Measurements[b]	N	M	Range	SD	SE
E 2 - 3	2	6	47. 46	43. 3 - 50. 9	-	-
	3	9	38. 45	36. 1 - 40. 9	-	-
	4	10	22. 68	20. 8 - 26. 6	-	-
	5	8	15. 25	13. 0 - 18. 1	-	-
	6	8	71. 55	68. 6 - 74. 4	-	-
	7	7	13. 40	11. 6 - 14. 7	-	-

Age class[a] (years)	Measurements[b]	N	M	Range	SD	SE
F 3 - 4	2	3	45.76	43.0 - 47.7	-	-
	3	7	37.67	34.1 - 40.6	-	-
	4	9	21.80	17.8 - 24.5	-	-
	5	6	15.35	13.7 - 16.2	-	-
	6	7	70.30	67.4 - 76.4	-	-
	7	6	13.40	12.5 - 14.1	-	-
G 4 - 6	2	9	47.43	40.3 - 55.7	-	-
	3	23	37.20	34.1 - 48.1	3.05	0.64
	4	30	22.06	18.1 - 25.9	1.77	0.32
	5	25	15.50	13.9 - 18.4	1.10	0.22
	6	25	66.44	61.8 - 74.1	3.30	0.66
	7	25	12.93	10.8 - 15.4	0.89	0.18
H 6 - 8	2	-	-	-	-	-
	3	1	-	35.0	-	-
	4	1	-	20.7	-	-
	5	1	-	13.3	-	-
	6	1	-	62.3	-	-
	7	1	-	12.2	-	-
I 8 - 10	2	-	-	-	-	-
	3	1	-	35.0	-	-
	4	1	-	20.2	-	-
	5	-	-	-	-	-
	6	-	-	-	-	-
	7	-	-	-	-	-

a. & b. Age class and key to measurements as in Table I.2

Table II.3 Scapula

Reg. Nos. 75.7561 to 75.7635 (deposit 100)

Measurement[a]	N	M	Range	SD	SE
Length of articular surface (GLP)	59	31.26	27.8 - 35.3	1.44	0.19
Width of glenoid cavity (BG)	68	19.96	17.4 - 23.4	1.35	0.16
Height of neck	68	20.73	16.6 - 23.9	1.48	0.18
Min. neck length (KLC)	68	19.21	16.7 - 22.6	1.16	0.14

a. Measurements as in Table I.3

Table II. 4 Humerus

Reg. Nos. 75. 7636 to 75. 7755 (deposit 100)

Measurement	N	M	Range	SD	SE
Length	11	135.5	125.7 - 145.9	5.90	1.78
Prox. width	18	37.11	31.1 - 40.0	2.70	0.64
Prox. depth	19	41.15	36.7 - 44.7	2.54	0.58
Min. shaft width	76	14.54	10.6 - 17.1	1.15	0.13
Dist. width (BT) [1]	103	27.98	23.5 - 32.4	1.65	0.16

1. Dist. width (BT) as in Table I. 4

Table II. 5 Radius

Deposit 100

Reg. Nos. 75. 8234 to 75. 8265

Measurement	N	M	Range	SD	SE
Length	8	144.48	137.2 - 149.3	-	-
Prox. width	19	30.50	29.1 - 32.8	1.03	0.24
Min. shaft width	8	16.07	14.1 - 17.1	-	-
Dist. width	13	27.17	24.6 - 30.0	1.42	0.39

Deposit 150

Reg. No. 76. 6063 (81 specimens)
Data for complete specimens only

Measurement	N	M	Range	SD	SE
Length	16	140.69	126.1 - 154.0	9.19	2.30
Prox. width	16	29.98	27.6 - 32.4	1.66	0.41
Min. shaft width	16	15.58	14.0 - 17.1	1.02	0.26
Dist. width	16	27.03	24.7 - 29.2	1.20	0.30

Table II. 6 Metacarpal bone

Deposit 100

Reg. Nos. 75. 7203 to 75. 7276; 75. 7325 to 75. 7354

Measurement	N	M	Range	SD	SE
Length	6	116.4	104.4 - 125.3	8.57	3.50
Prox. width	25	20.9	16.8 - 23.4	1.28	0.26
Prox. depth	29	15.52	10.7 - 19.4	1.40	0.26
Mid shaft width	24	13.22	8.5 - 15.1	1.45	0.30
Dist. shaft width	81	23.55	20.8 - 26.4	1.17	0.13

Table II. 7 Innominate

Reg. Nos. 75. 7469 to 75. 7545 (deposit 100)

Measurement	N	M	Range	SD	SE
Length of acetabulum	77	23.44	21.5 - 25.4	1.04	0.12
Thickness (depth) of medial rim of acetabulum	76	5.94	2.3 - 9.5	1.45	0.17

Table II. 8 Femur

Reg. No. 75. 8270 (deposit 100, 20 specimens)

Measurement	N	M	Range
Dist. width (Bd)	6	35.97	34.2 - 38.2

Table II. 9 Tibia

Deposit 100

Reg. Nos. 75. 8096 to 75. 8143; 75. 8266 (20 specimens)

Measurement	N	M	Range	SD	SE
Length	1	-	190.1	-	-
Prox. width	8	38.01	36.2 - 39.9	-	-
Prox. depth	5	37.86	35.8 - 39.3	-	-
Min. shaft width	-	-	-	-	-
Dist. width	51	22.78	20.2 - 24.7	1.14	0.16

Table II. 10 Metatarsal bone

Deposit 100

Reg. Nos. 75. 7199 to 75. 7202; 75. 7277 to 75. 7324

Measurement	N	M	Range	SD	SE
Length	3	121.80	115.5 - 126.8	-	-
Prox. width	21	19.28	17.5 - 22.5	1.23	0.27
Prox. depth	20	18.59	16.8 - 20.7	1.00	0.22
Mid. shaft width	42	11.37	9.8 - 13.6	0.84	0.13
Dist. shaft width	47	22.43	20.4 - 24.3	1.03	0.15

Table II. 11 Phalanx 1

Reg. No. 75. 8168 (deposit 100, 25 specimens)

Measurement	N	M	Range	SD	SE
Length (medial)	23	32.61	29.9 - 34.5	1.29	0.27
Prox. width	23	11.46	10.2 - 12.6	0.67	0.14
Dist. width	23	10.38	9.1 - 11.8	0.76	0.16

III. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table III. 1 Horn core

Reg. No. 75. 8161

Reg. No.	Length of outer curve[1]	Basal circ.[2]	Max. diam.[3]	Min. diam.[4]
8161	190e	135	52.0	31.7

Key to measurements as in Table I.1

Table III. 2 Mandible

Reg. Nos. 75. 7804 to 75. 7823

Age class[a] (years)	Measurements[b]	N	M	Range
E 2-3	2	1	-	45.7
	3	4	35.10	32.6 - 37.5
	4	4	22.30	21.2 - 23.4
	5	4	15.08	14.7 - 15.5
	6	4	65.28	61.8 - 69.5
	7	4	12.05	10.8 - 13.0
F 3 - 4	2	-	-	-
	3	-	-	-
	4	1	-	20.3
	5	1	-	14.5
	6	1	-	68.0
	7	1	-	11.0
G 4 - 6	2	1	-	45.7
	3	1	-	36.0
	4	3	21.13	20.8 - 21.5
	5	3	15.47	15.3 - 15.8
	6	2	-	65.3 - 65.6
	7	2	-	12.9 - 12.9

a. & b. Age class and key to measurements as in Table I. 2

Table III. 3 Scapula

Reg. Nos. 75. 8008 to 75. 8041

Measurements[a]	N	M	Range	SD	SE
Length of articular surface (GLP)	12	29.53	27.1 - 31.4	1.10	0.32
Width of glenoid cavity (BG)	16	19.56	17.8 - 23.7	1.49	0.37
Height of neck	18	19.52	17.0 - 22.8	1.54	0.36
Min. neck length(KLC)	18	18.22	16.4 - 20.3	1.20	0.28

a. Measurements as in Table I. 3

Table III. 4 Humerus

Reg. Nos. 75. 7762 to 75. 7794

Measurement	N	M	Range	SD	SE
Length	1	-	134.1	-	-
Prox. width	4	33.37	31.5 - 35.9	-	-
Prox. depth	6	39.41	36.5 - 41.6	-	-
Min. shaft width	9	14.03	13.2 - 14.9	-	-
Dist. width (BT)[1]	28	26.91	23.8 - 31.4	1.46	0.28

1. Dist. width (BT) as in Table I. 4

Table III. 5 Radius

Reg. Nos. 75. 8176 to 75. 8233

Measurement	N	M	Range	SD	SE
Length	7	132.44	122.9 - 140.9	-	-
Prox. width	28	29.18	25.9 - 31.9	1.62	0.31
Dist. width	28	26.15	23.5 - 28.5	1.22	0.23

Table III. 6 Metacarpal bone

Reg. Nos. 75. 7824 to 75. 7838

Measurement	N	M	Range
Length	1	-	105.0
Prox. width	7	20.33	18.6 - 21.6
Prox. depth	7	14.75	12.4 - 15.9
Mid. shaft width	7	12.40	11.6 - 12.9
Dist. shaft width	8	22.25	20.5 - 23.1

Table III. 7 Innominate

Reg. Nos. 75.7991 to 75.8007

Measurement	N	M	Range	SD	SE
Length of acetabulum	17	23.28	21.9 - 25.2	0.93	0.23
Thickness (depth) of medial rim of acetabulum	17	5.65	2.1 - 8.3	1.55	0.38

Table III. 8 Femur

Reg. No. 75.8175 (18 specimens)

Measurement	N	M	Range
Dist. width (Bd)	4	33.67	31.7 - 35.4

Table III. 9 Tibia

Reg. Nos. 75.8042 to 75.8095

Measurement	N	M	Range	SD	SE
Length	-	-	-	-	-
Prox. width	8	37.01	32.9 - 40.2	-	-
Prox. depth	8	36.65	31.9 - 39.4	-	-
Min. shaft width	-	-	-	-	-
Dist. width	35	21.85	20.3 - 24.3	1.09	0.18

Table III. 10 Metatarsal bone

Reg. Nos. 75.7839 to 75.7867

Measurement	N	M	Range	SD	SE
Length	2	-	128.9 - 137.6	-	-
Prox. width	8	19.33	18.1 - 20.8	-	-
Prox. depth	8	18.73	17.6 - 20.2	-	-
Mid shaft width	11	11.15	10.2 - 12.7	0.69	0.21
Dist. shaft width	17	21.94	20.2 - 23.3	0.99	0.24

Table III. 11 Phalanx 1

Reg. Nos. 75.8169 (6 specimens); 76.6467 (5 specimens)

Measurement	N	M	Range	SD	SE
Length (medial)	11	32.36	30.6 - 34.6	1.48	0.45
Prox. width	11	11.14	9.7 - 12.1	0.81	0.24
Dist. width	11	10.29	8.6 - 11.3	0.95	0.29

IV. Modern specimens of sheep

Table IV. 1 Clun Forest sheep

Collection of Miss B. A. Noddle, University College, Cardiff.

(1) Humerus

Measurement	N	M	Range	SD	SE
Length	12	155.90	138.6 - 170.7	10.80	3.12
Prox. width	12	46.25	43.3 - 52.6	3.43	0.99
Min. shaft width[1]	12	19.43	16.2 - 23.9	2.27	0.66
Dist. width (BT)	12	35.09	32.0 - 37.9	1.84	0.53

(2) Radius

Measurement	N	M	Range	SD	SE
Length	12	162.52	140.7 - 182.6	12.71	3.67
Prox. width	12	36.33	31.4 - 40.8	2.65	0.76
Min. shaft width	12	20.95	18.7 - 26.4	2.28	0.66
Dist. width	12	35.13	30.9 - 39.9	2.72	0.78

(3) Metacarpal bone

Measurement	N	M	Range
Length	9	129.56	116.3 - 142.2
Prox. width	9	27.22	24.4 - 29.6
Prox. depth	9	19.86	17.1 - 21.6
Mid. shaft width	9	18.27	15.4 - 20.5
Dist. shaft width	9	30.27	26.1 - 33.8

(4) Metatarsal bone

Measurement	N	M	Range	SD	SE
Length	11	133.93	121.9 - 148.3	9.71	2.93
Prox. width	11	24.23	20.6 - 26.8	1.85	0.56
Prox. depth	11	23.65	19.8 - 25.8	1.71	0.51
Mid. shaft width	11	16.15	13.7 - 18.6	1.45	0.44
Dist. shaft width	11	27.86	24.6 - 29.7	1.87	0.57

Table IV. 2 Soay sheep

Collection of Professor P. Jewell (with exception of specimen marked *)

(1) Horn core

Sex	Age (years)	Length of outer curve[1]	Basal circ.[2]	Max. diam.[3]	Min. diam.[4]
Male	yrling	75	86	30.1	23.5
Female	yrling	62	70	24.0	16.0
Female	2 +	51	71	24.9	15.8
Male	3 +	235	143	46.5	40.0
Female	5 +	77	77	25.2	16.6
* Castrate	6 +	135	116	42.8	25.9

Key to measurements as in Table I.1

*Specimen presented to BM(NH) by Mr. J. Clark, ARC. Institute of Animal Physiology, Babraham, Cambridge.

(2) Humerus

Measurement	N	M	Range	SD	SE
Length	70	128.40	120.4 - 144.4	6.24	0.75
Dist. width (BT)[1]	70	25.35	23.3 - 28.0	1.31	0.16

1. Dist. width (BT) as in Table I. 4

(3) Radius

Measurement	N	M	Range	SD	SE
Length	36	134.40	122.2 - 149.5	7.21	1.20
Prox. width	36	26.88	25.0 - 29.8	1.15	0.19
Min. shaft width	36	14.09	12.9 - 16.9	1.07	0.18
Dist. width	36	24.58	22.3 - 27.6	1.38	0.23

(4) Metacarpal bone

Measurement	N	M	Range	SD	SE
Length	18	114.45	106.5 - 124.7	5.44	1.28
Prox. width	18	19.67	18.2 - 22.0	1.02	0.24
Prox. depth	18	14.50	13.4 - 15.8	0.76	0.18
Mid shaft width	18	13.03	10.9 - 15.0	1.24	0.29
Dist. shaft width	18	22.75	20.3 - 28.2	1.75	0.41

(5) Innominate

Measurement	N	M	Range	SD	SE
Length of acetabulum	57	23.01	20.1 - 25.8	1.32	0.18
Thickness (depth) of medial rim of acetabulum	57	4.70	1.1 - 9.9	2.33	0.31

Thickness (depth) of medial rim of acetabulum analysed according to sex:

Sex	N	M	Range	SD	SE
Male	27	6.86	4.3 - 9.9	1.22	0.23
Female	30	2.75	1.1 - 5.2	0.93	0.17
*Castrate	1	-	5.9	-	-

(6) Metatarsal bone

Measurement	N	M	Range	SD	SE
Length	18	122.31	114.1 - 133.7	5.97	1.41
Prox. width	18	17.78	16.4 - 19.5	0.79	0.19
Prox. depth	18	17.95	16.3 - 20.0	0.91	0.22
Mid. shaft width	18	11.22	9.5 - 13.8	1.14	0.27
Dist. shaft width	18	21.56	20.2 - 25.0	1.21	0.28

DOMESTIC PIG

Order: Artiodactyla
Family: Suidae
Taxon: Sus (domestic)

Almost all the pig bones from Baynard's Castle were from immature individuals (with unfused epiphyses), therefore no comparison has been made with modern specimens.

Only the measurements for the metapodial bones shown below refer to complete specimens with both the distal and proximal epiphysis fused.

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c.1520 AD)

Table I.1 Skull

Reg.No. 75.10332 & 75.10333 (deposit 23)

Reg.No.	Measurements[a]								
	8	11	24	34	37	38	40	41	45
75.10332	107.9	114.2	40.0	-	29.3	83.6	23.2	103.8e	110.5
10333	106.0	115.7	-	-	28.9	67.4	28.0	103.6e	102.5

a. Key to measurements:

8. Length of cranium: Basion - nasion
11. Length of cranium: Mid point of nuchal crest - supraorbital foramen
24. Maximum inner length of the orbital part of the frontal bone
34. Width across the occipital condyles
37. Height of the foramen magnum
38. Maximum width of nuchal crest.
40. Least width across fused parietal and interparietal bones
41. Maximum width across the frontal bone in region of supraorbital processes.
45. Maximum occipital height: Basion - mid point of nuchal crest.

Numbers as in Driesch (1976, Figs.12a & c, p.36 and 12e, p.37)

Table I.2 Mandible

Reg.Nos.75.10275 to 75.10280 (deposit 23); 75.10286 to 75.10293 (deposit 1)

Reg.No.	Age[a] (years)	Measurements[b] 6	7a	8	9	11	12	16a	16b	16c	21	M_3 L	M_3 W
10275	2 - 3	115.2	94.5	-	50.8	41.4	60.5	42.1	35.0	38.6	7.8	-	-
10276	1 - 1½	-	-	-	-	-	-	-	29.1	31.3	-	-	-
10277	1 - 1½	-	-	-	-	-	-	-	32.7	36.0	-	-	-
10278	2 - 3	107.5	89.6	-	-	-	-	40.7	35.0	38.1	-	-	-
10279	over 3	-	-	-	-	-	-	53.9	-	-	-	32.0	15.1
10280	2 - 3	122.0	98.2	-	-	39.0	-	40.6	35.8	40.8	7.7	-	-
10286	over 3	117.7	100.9	-	-	-	67.9	45.7	40.6	45.6	9.6	31.1	13.8
10289	3	-	-	-	-	-	-	44.5	-	-	-	25.0	13.2
10293	over 3	-	109.1	-	-	-	-	55.7	48.4	-	-	32.0	12.7

a. Age: Based on sequence of tooth eruption for late 18th century pigs, Silver (1971, Table G, p. 298).

b. Key to measurements:

6. Length: Posterior edge of canine alveolus - posterior edge of M_3 alveolus.

7a. Length of tooth row, P_2 - M_3

8. Length of molar tooth row, M_1 - M_3

9. Length of premolar tooth row, P_1 - P_4

11. Length: Posterior edge of I_3 alveolus - anterior edge of P_2 alveolus

12. Length of symphysis

16a. Height of mandible in region of M_3

16b. Height of mandible in region of M_1

16c. Height of mandible in region of P_2

21. Maximum diameter at base of canine (tusk)

M_3 Lower third molar: (L) Length, (W) Width.

Numbers as in Driesch (1976, Fig. 22b, p. 55)

Table I. 3 Humerus

Reg. Nos. 75.10297 to 75.10302 (deposit 1); 75.10303 & 75.10304 (deposit 23)

Measurement	N	M	Range
Mid shaft width	3	17.60	14.6 - 19.7
Dist. width	8	39.91	34.4 - 45.2
Dist. depth	7	40.94	37.8 - 44.7

Table I. 4 Radius

Reg. Nos. 75.10305 to 75.10309 (deposit 1)

Measurement	N	M	Range
Prox. width	5	28.00	27.3 - 29.2
Prox. depth	5	19.96	18.5 - 21.6
Mid shaft width	1	-	15.6

Table I. 5 Ulna

Reg. No. 75.11041 (deposit 23, 2 specimens)

	1	2
Width across articular surface	20.7	22.5

Table I. 6 Metacarpal bone III

Reg. No. 75.11028 (deposit 23, 1 specimen)

Length	71.9
Prox. width (Bp)	17.4
Mid shaft width	13.5
Dist. width (Bd)	15.6

Table I.7 Innominate

Reg. No. 75.10323 (deposit 1) & 75.10321 (deposit 23)

Reg. No.	Thickness of medial rim of acetabulum	Length of acetabulum
75.10323	14.1	33.2
10321	19.2	34.0

Table I.8 Femur

Reg. Nos. 75.10312 to 75.10315 (deposit 1)

Reg. No.	Mid shaft width	Dist. width	Dist. Depth
10312	17.9	41.0	49.1
10313	24.3	50.0	65.1
10314	-	48.0	-
10315	-	51.2	-

Table I.9 Tibia

Reg. Nos. 75.10310 & 75.10311 (deposit 1)

Reg. No.	Mid shaft width	Dist. width	Dist. depth
10310	19.4	31.1	27.9
10311	16.7	30.4	23.6

Table I.10 Metatarsal bone III

Reg. No. 75.11025 (deposit 23, 1 specimen)

Length	99.5
Prox. width (Bp)	19.2
Mid shaft width	16.3
Dist, width (Bd)	19.0

Table I.11 Metatarsal bone IV

Reg. No. 75.11020 (deposit 23, 1 specimen)

Length (GL)	102.9
Prox. width (Bp)	19.9
Mid shaft width (BB)	14.8
Dist. width (Bd)	18.9

II. Baynard's Castle, deposit 88 (dock basin dump c.1500 AD)

Table II.1 Mandible

Reg. Nos. 75.10616 to 75.10618; 75.11106 to 75.11108

Reg. No.	Age[a] (years)	6	7a	8	9	11	12	16a	16b	16c	21	M_3 L	M_3 W
10616	2 - 3	-	-	-	-	-	-	-	33.0	38.3	-	-	-
10617	2 - 3	-	-	-	-	-	-	-	35.3	-	-	-	-
10618	1 - 2	-	-	-	-	-	48.3	-	-	38.2	-	-	-
11106	3	-	108.6	-	-	-	-	52.5	40.3	41.6	-	33.6	14.0
11107	2 - 3	-	-	-	-	-	53.5	-	30.7	39.0	-	-	-
11108	1 - 2	-	-	-	-	-	43.8	-	-	-	-	-	-

a & b as in Table I.2

Table II.2 Humerus

Reg. Nos. 75.11055 to 75.11060

Measurement	N	M	Range
Mid. shaft width	5	15.24	13.0 - 18.3
Dist. width	5	38.98	36.8 - 43.0
Dist. depth	3	39.33	36.2 - 42.1

Table II.3 Radius

Reg. Nos. 75.11123 to 75.11131

Measurement	N	M	Range
Prox. width	6	28.57	27.0 - 30.5
Prox. depth	6	20.48	20.1 - 21.2
Mid. shaft width	7	16.71	14.5 - 19.0

Table II. 4 Ulna

Reg. No. 75.11154

	N	M	Range	SD	SE
Width across articular surface	15	21.13	19.3 - 23.5	1.12	0.29

Table II. 5 Innominate

Reg. No. 75.11159 (3 specimens)	1	2	3
Thickness of medial rim of acetabulum	17.1	15.1	-
Length of acetabulum	35.2	36.7	30.6

III. Baynard's Castle, deposit 89 (dock basin dump c.1500 AD)

Table III. 1 Humerus

Reg. No. 75.11161 (1 specimen)

Mid shaft width	14.5
Dist. width	38.6

Table III. 2 Ulna

Reg. No. 75.11192 (3 specimens)

	1	2	3
Width across articular surface	22.4	21.0	24.1

Table III. 3 Metacarpal bone IV

Reg. No. 75.11168 (1 specimen)

Length	76.9
Prox. width (Bp)	17.1
Mid shaft width	14.2
Dist. width (Bd)	17.9

Table III. 4 Femur

Reg. Nos. 75.11164 & 75.11165

Reg. No.	Mid shaft width	Dist. width	Dist depth.
11164	16.9	41.6	51.6
11165	-	42.9	48.9

Table III. 5 Tibia

Reg. Nos. 75. 11148 to 75. 11152

Reg. No.	Prox. width	Mid shaft width	Dist. width
11148	-	-	28. 8
11149	48. 6	-	-
11151	-	17. 6	-
11152	-	15. 4	-

IV. Baynard's Castle, deposits 100 & 150 (dock basin dump c. 1500 AD)

Table IV. 1 Skull

Reg. No. 75. 10610 & 75. 10611 (deposit 100)

Reg. No.	Measurements[a]									upper M_3	
	8	11	24	34	37	38	40	41	45	Length	Width
10610	-	129. 6	-	-	-	74. 4	38. 9	114. 4	-	-	-
10611	-	102. 6	-	58. 2	24. 0	60. 1e	28. 2	95. 9	71. 4	28. 0	17. 6

a. Key to measurements as in Table I. 1

Table IV. 2 Mandible

Reg. Nos. 75. 10578 to 75. 10598 (deposit 100); 75. 10735 to 75. 10755 (deposit 150)

Reg. No.	Age[a]	Measurements[b]									M_3	
	(years)	6	7a	8	9	11	12	16a	16b	16c	21	L	W
10578	over 3	-	105. 6	69. 7	-	-	-	49. 6	-	-	-	34. 3	15. 0
10579	2 - 3	-	-	-	-	-	62. 1	-	36. 3	40. 1	8. 5	-	-
10580	2 - 3	-	-	-	-	-	60. 5	-	40. 9	45. 1	7. 9	-	-
10582	over 3	-	-	-	-	-	-	-	-	-	-	30. 9	14. 7
10585	2 - 3	-	-	-	-	-	-	-	33. 4	-	-	-	-
10586	2 - 3	-	-	-	-	-	-	-	32. 4	-	-	-	-
10587	1 - 2	-	-	-	-	-	-	-	27. 1	-	-	-	-
10588	2 - 3	-	-	-	-	-	-	-	34. 9	38. 9	-	-	-
10590	1 - 2	-	-	-	-	-	-	-	36. 3	39. 5	-	-	-
10591	1 - 2	-	-	-	-	-	-	-	28. 5	-	-	-	-
10592	2 - 3	-	-	-	-	-	51. 7	-	35. 7	39. 8	-	-	-
10593	3	-	-	-	-	-	-	42. 4	38. 5	40. 9	-	31. 2	13. 6
10594	2 - 3	-	-	-	-	-	62. 2	-	33. 6	40. 4	-	-	-
10596	over 3	-	-	-	-	-	-	46. 1	-	-	-	33. 7	15. 5
10597	2 - 3	-	-	-	-	-	-	-	38. 7	43. 6	-	-	-
10598	over 3	-	-	-	-	-	66. 8	-	-	-	-	33. 3	14. 2
10735	0 - 1	-	-	-	-	-	22. 1	-	14. 8	16. 9	-	-	-
10743	2 - 3	-	-	-	-	-	-	-	35. 6	37. 2	-	-	-
10744	2 - 3	-	-	-	-	-	-	-	-	-	8. 5	-	-
10747	2 - 3	-	-	-	-	-	-	-	33. 1	-	6. 7	-	-
10750	2 - 3	-	-	-	-	-	-	-	-	-	7. 8	-	-
10751	3	-	-	-	-	-	-	-	39. 0	-	-	28. 6	14. 1
10753	1 - 2	-	-	-	-	-	-	-	31. 1	35. 1	-	-	-
10755	2 - 3	-	-	-	-	-	-	-	34. 5	39. 6	6. 5	-	-

a & b as in Table I. 2

Table IV. 3 Humerus

Reg. Nos. 75. 10623 to 75. 10646 (deposit 100); 75. 10996 to 75. 11019 (deposit 150); 75. 11043 to 75. 11054 (deposit 100)

Measurement	N	M	Range	SD	SE
Prox. width	1	-	38.3	-	-
Mid shaft width	30	14.87	11.3 - 21.1	1.97	0.36
Dist. width	41	38.18	33.2 - 48.4	2.90	0.45
Dist. depth	37	39.42	34.7 - 48.7	2.82	0.46

Note: Specimen 75. 11043 with a distal width of 48.4mm is either a very large male or a wild pig (value falls within range of Sus scrofa proposed by Clason, 1967, p. 63)

Table IV. 4 Radius

Reg. Nos. 75. 10654 to 75. 10676 (deposit 100); 75. 10843 to 75. 10851 (deposit 150); 75. 11113 to 75. 11122 (deposit 100)

Measurement	N	M	Range	SD	SE
Prox. width	39	28.22	23.2 - 34.3	2.20	0.35
Prox. depth	40	20.29	15.4 - 26.5	1.82	0.29
Mid shaft width	38	16.42	13.2 - 21.5	1.41	0.23

Table IV. 5 Ulna

Reg. Nos. 75. 10859 (deposit 150); 75. 11153 (deposit 100)

Measurement	N	M	Range	SD	SE
Width across articular surface	49	21.74	18.2 - 27.4	2.02	0.29

Note: The three specimens with articular widths of 26.6, 27.3 and 27.4mm are either from very large males or from wild pigs (values fall within range of Sus scrofa proposed by Clason, 1967, p. 63).

Table IV. 6 Metacarpal bone III

Reg. Nos. 75. 10790 & 75. 11167;

Reg. No.	Deposit	Length	Prox. width (Bp)	Dist. width (Bd)	Mid shaft width
10790	150	76.0	18.4	16.5	13.7
11167	100	90.7	21.2	19.5	17.6

Table IV. 7 Femur

Reg. Nos. 75. 10678 to 75. 10683 (deposit 100); 75. 11193 to 75. 11195 (deposit 100); 76. 6547 (deposit 150), distal epiphysis unfused.

Measurement	N	M	Range	SD	SE
Dist. width	11	44.78	40.4 - 48.7	3.03	0.91
Dist. depth	10	54.96	51.4 - 57.6	2.58	0.82

Table IV. 8 Tibia

Reg. No. 75.10860 (Deposit 150, 1 specimen)

Mid shaft width	24.2
Dist. width	33.9
Dist. depth	31.5

Table IV. 9 Metatarsal bone III

Reg. No. 75. 10708 (Deposit 100, 1 specimen)

Length	89.0
Prox. width (Bp)	17.5
Mid shaft width	12.7
Dist. width (Bd)	16.3

Table IV. 10 Metatarsal bone IV

Reg. Nos. 75. 10718 & 75. 10809

Reg. No.	Deposit	Length (GL)	Prox. width (Bp)	Mid shaft width (BB)	Dist. width (Bd)
10718	100	93.3	16.0	12.9	17.4
10809	150	96.0	17.6	14.5	18.5

V. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table V. 1 Mandible

Reg. Nos. 75. 10348 to 75. 10373

Reg. No.	Age[a] (years)	Measurements[b] 6	7a	11	12	16a	16b	16c	21	M_3 L	W
10348	over 3	-	-	34.7	49.1	-	34.5	37.2	8.3	-	-
10349	2 - 3	120.5	98.5	40.6	59.3	-	36.9	39.7	7.9	-	-
10364	1 - 2	-	-	-	-	-	28.5	31.2	-	-	-
10369	1 - 2	-	-	-	-	-	30.9	33.9	-	-	-
10372	1 - 2	-	-	-	-	-	28.4	30.7	-	-	-
10373	3	-	-	-	58.8		-	44.8	-	-	-

a and b as in Table I. 2

Table V. 2 Humerus

Reg. Nos. 75. 10421 to 75. 10437

Measurement	N	M	Range	SD	SE
Mid shaft width	11	14.04	12.1 - 17.7	1.53	0.46
Dist. width	10	37.00	34.7 - 44.9	2.98	0.94
Dist. depth	6	39.60	35.8 - 48.8	-	-

Table V. 3 Radius

Reg. Nos. 75. 10384 to 75. 10410

Measurement	N	M	Range	SD	SE
Prox. width	21	26.04	23.2 - 29.1	1.75	0.38
Prox. depth	21	18.61	16.4 - 21.1	1.14	0.25
Mid. shaft width	16	15.28	13.0 - 17.5	1.33	0.33

Table V.4 Ulna

Reg. No. 75. 10568

Measurement	N	M	Range	SD	SE
Width across articular surface	31	19.82	16.9 - 24.2	1.69	0.30

Table V.5 Metacarpal bone III

Reg. No. 75. 10442 (1 specimen)

Length	82.1
Prox. width (Bp)	19.3
Mid shaft width	16.1
Dist. width (Bd)	20.3

Table V.6 Metacarpal bone IV

Reg. No. 75. 10456 (1 specimen)

Length	79.4
Prox. width (Bp)	15.1
Mid shaft width	12.8
Dist. width (Bd)	17.5

Table V.7 Innominate

Reg. Nos. 75.10535 to 75.10540

Measurement	N	M	Range
Thickness of medial rim of acetabulum	6	16.45	14.1 - 19.9
Length of acetabulum	6	31.03	26.5 - 38.0

Note: Specimen 75.10538 with length of acetabulum of 38.0 mm is either from a very large male or from a wild pig (value falls within range of Sus scrofa proposed by Clason, 1967, p. 63).

Table V.8 Femur

Reg. Nos. 75.10413 to 75.10416

Reg. No.	Dist. Width	Mid. shaft width	Dist. depth
10413	-	19.8	-
10414	44.7	-	55.6
10415	40.2	-	48.6
10416	-	18.0	-

Table V. 9 Tibia

Reg. Nos. 75.10545 to 75.10564

Measurement	N	M	Range	SD	SE
Mid shaft width	14	16.31	13.9 - 21.0	1.82	0.49
Dist. width	2	-	27.0 - 30.5	-	-
Dist. depth	2	-	24.0 - 27.4	-	-

Table V.10 Metatarsal bone III

Reg. No. 75. 10471 (1 specimen)

Length	79.1
Prox. width (Bp)	15.4
Mid shaft width	12.5
Dist. width (Bd)	14.9

Table V.11 Metatarsal bone IV

Reg. Nos. 75.10484 to 75.10487

Reg. No.	Length(G L)	Prox. width (Bp)	Mid shaft width (BB)	Dist. width(Bd)
10484	78.8	13.3	12.5	15.0
10485	82.1	14.4	12.2	15.0
10486	77.5	13.7	12.6	13.5
10487	78.0	14.6	12.8	18.1

DOMESTIC DOG

Order: Carnivora
Family: Canidae
Taxon: *Canis* (domestic)

The values for the height at the withers shown below were calculated after the method of Harcourt (1974, p. 154) and are in cm, all other measurements are given in mm

I. Baynard's Castle

Table I.1 Skull

Reg. Nos. 76.6081 to 76.6085

Reg. No.	Deposit	Measurements[a] I	II	III	IV	IX	X	XI	XII	Indices[b] 1	2	3
6081	100	119.4	68.9	55.5	80.6e	59.7	44.0	39.0	23.1	67.5	46.5	41.6
6082	100	-	-	-	88.0e	-	-	-	-	-	-	-
6083	23	143.0	71.5	58.0	81.6e	54.5e	45.0	48.9	23.7	68.2	48.5	40.9
6084	23	-	-	88.0	90.9	83.0	54.5	58.2	31.8	-	-	36.1
6085	1	151.5	89.0	77.6	88.4	74.1	50.4	57.7	29.7	58.3	51.2	38.3

a. Key to measurements:

I. The most posterior aspect of the occipital protuberance to the anterior margin of the medial incisor alveoli between the central incisors (alveolare)
II. Occipital protuberance to junction of nasal and frontal bones (nasion)
III. Nasion to alveolare
IV. Zygomatic width (maximum)
IX. Palatal length
X. Palatal width between PM4 and M1
XI. Maxillary cheek tooth row length
XII. Snout width across the outer margins of the alveoli of the canines

Numbers and key as in Harcourt (1974, p. 152)

b. Key to indices:
1. Cephalic index (IV x 100/I)
2. Snout index (III x 100/I)
3. Snout width index (XII x 100/III)

Numbers as in Harcourt (1974, p. 153 & 154)

Table I.2 Humerus

Reg. Nos. 76.6094 (deposit 250); 76.6095 to 76.6099 (deposit 1); 76.6100 to 76.6102 (deposit 23); 76.6106 & 76.6107 (deposit 100); 76.6196 (deposit 100)

(1)

Measurement	N	M	Range	SD	SE
Length[1]	11	126.77	99.6 - 148.6	15.64	4.72
Dist. width	12	25.53	19.0 - 33.1	4.62	1.33

Key to measurement: 1. Length of humerus: Lateral tuberosity to the most distal point on the trochlea

(2) Height at the withers: Largest dog 48cm
Smallest dog 32cm

Table I. 3 Radius

Reg. Nos. 76.6107 (deposit 100); 76.6120 (deposit 1, 4 specimens); 76.6121 (deposit 23, 4 specimens); 76.6197 (deposit 100)

(1)

Measurement	N	M	Range	SD	SE
Length (GL)	10	109.80	85.8 - 142.3	23.22	7.34
Prox. width (Bp)	10	12.47	9.9 - 15.9	2.18	0.69
Min. shaft width (KD)	10	8.54	6.0 - 11.1	1.67	0.53
Dist. width (Bd)	10	16.36	11.9 - 20.8	3.02	0.96

(2) Height at the withers: Largest dog 47 cm
Smallest dog 29 cm

Table I. 4 Femur

Reg. Nos. 76.6107 (deposit 100, 2 specimens); 76.6109 (deposit 1, 3 specimens); 76.6110 to 76.6115 (deposit 23)

(1)

Measurement	N	M	Range	SD	SE
Length	11	127.46	99.1 - 154.6	19.16	5.78

(2) Height at the withers: Largest dog 47 cm
Smallest dog 30 cm

Table I. 5 Tibia

Reg. Nos. 76.6194 & 76.6195 (deposit 100); 76.6118 (deposit 23, 5 specimens); 76.6119 (deposit 1, 4 specimens)

(1)

Measurement	N	M	Range	SD	SE
Length	11	119.83	83.0 - 159.0	26.40	7.96

(2) Height at the withers: Largest dog 47 cm
Smallest dog 25 cm

II. Specimens of dog skulls and limb bones from other late medieval and early Tudor sites in Britain held in the BM(NH)

Table II. 1 Walbrook, London

Reg. Nos. 1954.12.19.1 & 1954.12.19.2. Large skulls from greyhound-like dogs. Pit dated to c. 1500 AD

Measurements[a]

Reg. No.	I	II	III	IV	IX	X	XI	XII
54.12.19.1	219.5	117.7	116.1	106.3	106.5	63.6	75.9	42.7
54.12.19.2	237.8	129.2	128.0	128.6	112.3	73.7	79.1	47.7

Indices[b]

Reg. No.	1	2	3
54.12.19.1	48.4	52.9	36.8
54.12.19.2	54.1	53.8	37.3

a & b Key to measurements and indices as in Table I. 1

Table II. 2 Lion Tower, Tower of London

Reg. No. 1969. 396 (20 specimens). Large skulls from mastiff-like dogs. Deposit dated c. 14th to 17th century AD

No.	Measurements[a]							
	I	II	III	IV	IX	X	XI	XII
1	232.5	128.5	117.0	-	111.8	-	70.0	52.0
3	228.5	128.6	112.0	125.0e	112.6	79.0	70.7	48.7
4	216.5	119.5	113.6	125.8	105.9	81.3	68.2	47.2
5	214.4	120.9	105.7	130.0	104.1	79.5	68.5	47.2
7	214.5	116.2	110.8	121.9	104.0	74.3	67.9	44.5
9	234.1	135.1	120.0	138.2	115.2	83.2	69.6	50.0

No.	Indices[b]		
	1	2	3
1	-	50.3	44.4
3	54.7	49.0	43.5
4	58.1	52.5	41.5
5	60.6	49.3	44.7
7	56.8	51.7	40.2
9	59.0	51.3	41.7

a & b Key to measurements and indices as in Table I. 1

Table II. 3 Brixworth, Northants.

Reg. No. 1974. 5080 (3 specimens). Level dated to c. 12th - 15th century AD

Bone	Length (mm)	Height at the withers (cm)
Humerus	201.1	66
Femur*	203.0	62
Tibia*	210.5	62

* Possibly from same dog

III. Modern specimens of dogs held in the BM(NH)

Table III. 1 Skull

Breed[c]	Measurements[a]								Indices[b]		
	I	II	III	IV	IX	X	XI	XII	1	2	3
OEM	242.0	127.9	123.0	136.8	116.8	83.4	76.2	54.2	56.5	50.8	44.1
M	214.8	123.2	101.5	127.1	107.3	75.9	70.4	46.9	59.2	47.3	46.2
G	201.5	107.1	105.6	101.0	105.1	60.4	68.4	34.0	50.1	52.4	32.2
FT	143.0	80.5	68.9	84.3	70.2	51.2	49.4	25.8	59.0	48.2	37.5
Mt	94.6	58.6	42.2	62.1	48.5	40.9	33.2	20.1	65.7	44.6	47.6

a & b Key to measurements and indices as in Table I. 1

c Key to breeds:

OEM	Old English mastiff	BM(NH)	88.1.30
M	Mastiff	" "	58.5.4
G	Greyhound	" "	D53
FT	Fox Terrier	" "	D74
Mt	Maltese	" "	D38

Table III. 2 Brindled mastiff

Reg. No. D29 Female

Bone	Length (mm)	Ht. at withers (cm)
Humerus	248.4	83
Radius	244.3	80
Femur	268.0	83
Tibia	284.5	84

Table III. 3 Fox terrier

Reg. No. D74 Sex ?

Bone	Length (mm)	Ht. at withers (cm)
Humerus	130.4	42
Radius	128.7	43
Femur	131.9	40
Tibia	139.8	42

Table III. 4 King Charles spaniel

Reg. No. 52.4.7.11. Male

Bone	Length (mm)	Ht. at withers (cm)
Humerus	104.1	33
Radius	97.5	33
Femur	108.3	33
Tibia	109.6	33

Table III. 5 Maltese

Reg. No. D38 Female

Bone	Length (mm)	Ht. at withers (cm)
Humerus	73.5	22
Radius	71.5	25
Femur	79.1	24
Tibia	80.6	25

DOMESTIC CAT

Order: Carnivora
Family: Felidae
Taxon: Felis (domestic)

I. Baynard's Castle, deposit 23 ('robber pit' c.1520 AD)

Table I.1 Skull

Reg. No. 76.6303 (1 specimen)

Measurements[a]								
6	12	18	19	22	23	25	30	32
61.3e	-	37.7	20.3	40.5	57.6	17.0e	24.4	23.0

a. Key to measurements:

6. Length of cranium: Basion - nasion
12. Length of tooth row, P_2 - M_1
18 Maximum width at base of cranium in region of mastoid process
19. Width across occipital condyles
22. Maximum width across cranium
23. Maximum zygomatic width
25. Minimum width of frontal bone between orbits
30. Maximum inner length of the orbital part of the frontal bone
32. Maximum occipital height: Basion - mid point of lambdoidal ridge.

Numbers as in Driesch (1976, Fig.17a, b & c, p.46-47).

Table I.2 Humerus

Reg. Nos. 76.6313 & 76.6315

Reg. No.	Length
6313	91.7
6315	90.8

Table I.3 Femur

Reg. No. 76.6307 (1 specimen)

Length	99.2

Table I.4 Tibia

Reg. Nos. 76.6310 & 76.6311

Reg. No.	Length
6310	105.8
6311	104.2

II. Baynard's Castle, deposits 88, 100 & 150 (dock basin dump c.1500 AD)

Table II. 1 Parts of articulated skeleton

Reg. No. 76.6343 (deposit 88)

(1) Skull

Measurements[a]

6	12	18	19	22	23	25	30	32
67.0	20.1	37.5	19.7	40.0	59.8	17.5	21.8	23.9

a. Key to measurements as in Table I.1

(2) Mandible

Measurements[b]

1	5	8	9	10
58.3	17.5	24.0	9.8	8.8

b. Key to measurements :

1. Length of mandible: Condyle - anterior edge of I_1 alveolus
5. Length of tooth row, P_3 - M_1
8. Height of mandible: Angle of mandible - coronoid process
9. Height of mandible in region of M_1
10. Height of mandible in region of P_3

Numbers as in Driesch (1976, Fig. 24, p. 59)

(3) Humerus

Length	91.1
Mid shaft width	6.0
Dist. width	16.9

(4) Radius

Length	86.2
Prox. width	7.8
Mid shaft width	5.4
Dist. width	11.9

(5) Tibia

Length	102.1
Prox. width	17.6
Mid shaft width	6.1
Dist. width	13.7

Table II. 2 Parts of articulated skeleton

Reg. No. 76.6342 (deposit 88)

(1) Humerus

Length	90.0
Mid shaft width	6.7
Dist. width	17.9

(2) Radius

Length	83.9
Prox. width	7.5
Mid shaft width	5.0
Dist. width	12.4

(3) Femur

Length	97.6
Mid shaft width	7.6
Dist. width	18.0

(4) Tibia

Length	102.6
Prox. width	18.0
Mid shaft width	6.2
Dist. width	14.3

Table II. 3 Humerus

Reg. Nos. 76. 6217 to 76. 6359

Reg. No.	Deposit	Length
6217	100	93.4
6218	100	85.8
6219	100	84.3
6253	150	95.3
6359	88	89.5

Table II. 4 Radius

Reg. Nos. 76. 6209 (2 specimens)
76. 6361 (1 specimen)

Reg. No.	Deposit	Length
6209.1	100	81.2
6209.2	100	84.2
6361	88	85.1

Table II. 5 Tibia

Reg. No. 76. 6210 & 76. 6211 (deposit 100)

Reg. No.	Length
6210	108.3
6211	97.3

III. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table III. 1 Femur

Reg. No. 76. 6267 (1 specimen)
Length 91.9

IV. Skulls of medieval cats from other archaeological sites held in the BM(NH)

Reg. Nos. 1954. 12. 19. 3 & 1954. 12. 19. 4. Pit dated to 1500 AD on Walbrook, London. Excavated by N. Cook, Guildhall Museum.

Reg. No.	Measurements[a]								
	6	12	18	19	22	23	25	30	32
54.12.19.3	63.6	21.6	39.4	20.9	43.5	59.5	16.5	24.7	24.6
54.12.19.4	64.8	21.8	39.2	20.8	40.5	62.2	16.7	24.2	24.0

a. Key to measurements as in Table I.1

V. Modern specimens of British wild and domestic cats held in the BM(NH)

Table V.1 Wild cat

Newton collection. Female

(1) Skull

Measurements[a]								
6	12	18	19	22	23	25	30	32
73.1	22.4	42.2	23.4	43.5	70.5	19.3	28.5	27.3

a. Key to measurements as in Table I.1

(2) Mandible

Measurements[b]

1	5	8	9	10
65.1	23.0	29.0	11.5	9.9

b. Key to measurements as in Table II. 1 (2)

(3) Humerus

Length	109.1
Mid shaft width	6.7
Dist. width	19.7

(4) Radius

Length	106.5
Prox. width	9.1
Mid. shaft width	5.5
Dist. width	13.3

(5) Femur

Length	121.0
Mid shaft width	8.3
Dist. width	20.3

Table V. 2 Domestic cat

Reg. No. C6. Black domestic cat. Male

(1) Skull

Measurements[a]

6	12	18	19	22	23	25	30	32
76.4	22.0	41.7	25.0	43.6	69.1	18.8	25.2	29.5

a. Key to measurements as in Table I.1

(2) Mandible

Measurements[b]

1	5	8	9	10
66.3	23.6	27.6	13.2	11.6

b. Key to measurements as in Table II.1 (2)

(3) Humerus

Length	113.3
Mid shaft width	8.4
Dist. width	22.5

(4) Radius

Length	109.7
Prox. width	10.6
Mid shaft width	7.1
Dist. width	15.7

(5) Femur

Length	127.2
Mid shaft width	9.5
Dist. width	23.4

(6) Tibia

Length	134.9
Prox. width	24.5
Mid shaft width	8.8
Dist. width	17.3

Table V. 3 Domestic cat

Newton collection

(1) Skull

Measurements[a]

6	12	18	19	22	23	25	30	32
71.5	21.3	42.4	22.2	41.9	67.8	17.5	26.1	26.7

a. Key to measurements as in Table I.1

(2) Mandible

		Measurements[b]		
1	5	8	9	10
63.5	21.1	27.4	12.2	11.1

b. Key to measurements as in Table II. 1 (2)

(3) Humerus

Length	98.1
Mid shaft width	7.3
Dist. width	17.8

(4) Radius

Length	96.0
Prox. width	8.4
Mid shaft width	6.8
Dist. width	12.1

(5) Femur

Length	108.3
Mid shaft width	8.7
Dist. width	18.5

(6) Tibia

Length	115.0
Prox. width	19.4
Mid shaft width	7.4
Dist. width	14.1

DOMESTIC RABBIT

Order: Lagomorpha
Family: Leporidae
Taxon: *Oryctolagus cuniculus* (domestic rabbit)

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c. 1520 AD)

Table I. 1 Humerus

Reg. Nos. 76. 6019 (deposit 23); 76. 6027 (deposit 1)

Measurement	N	M	Range	SD	SE
Length	36	61.62	57.3 - 65.5	1.86	0.31
Prox. width	36	10.54	9.8 - 11.5	0.38	0.06
Mid shaft width	36	4.18	3.5 - 4.7	0.24	0.04
Dist. width	36	8.84	8.1 - 9.3	0.27	0.05

Table I. 2 Femur

Reg. Nos. 76. 6017 (deposit 23); 76. 6018 (deposit 1)

Measurement	N	M	Range	SD	SE
Length[1]	27	78.91	75.4 - 83.5	2.17	0.42
Prox. width[2]	28	15.28	13.9 - 16.2	0.55	0.10
Trochanter width[3]	30	14.51	13.1 - 15.9	0.62	0.11
Mid shaft width	31	6.78	6.3 - 7.3	0.28	0.05
Dist. width	30	13.09	12.4 - 13.9	0.35	0.06

Key to measurements:
1. Length: Pars caudalis - distal epiphysis
2. Prox. width: Gross proximal breadth (Bp)
3. Trochanter width: Gross breadth in region of the trochanter tertius (BTr)

see Driesch (1976, p. 77)

Table I. 3 Tibia

Reg. Nos. 76. 6020 (deposit 23); 76. 6029 (deposit 1)

Measurement	N	M	Range
Length	5	90.92	86.0 - 95.0
Prox. width	5	14.22	13.3 - 14.9
Mid shaft width	5	6.30	6.0 - 6.6
Dist. width	4	11.75	11.3 - 12.3

II. Baynard's Castle, deposit 88 (dock basin dump c.1500 AD)

Table II. 2 Humerus

Reg. No. 76. 6025

Measurement	N	M	Range
Length	8	63.58	61.0 - 65.7
Prox. width	8	10.85	10.1 - 11.4
Mid shaft width	8	4.21	4.1 - 4.3
Dist. width	8	9.01	8.6 - 9.3

Table II. 2 Femur

Reg. No. 76. 6024

Measurement	N	M	Range
Length[1]	6	79.72	77.0 - 82.4
Prox. width[2]	5	15.42	14.6 - 16.0
Trochanter width[3]	6	15.15	14.0 - 16.2
Mid shaft width	6	6.88	6.5 - 7.4
Dist. width	6	13.48	12.9 - 14.0

Key to measurements as in Table I. 2

Table II. 3 Tibia

Reg. No. 76. 6026. Specimens with broken shafts

Measurement	N	M	Range
Prox. width	8	14.03	13.2 - 15.1
Dist. width	3	11.87	11.6 - 12.0

III. Baynard's Castle, deposit 100 (dock basin dump c.1500. AD)

Table III. 1 Humerus

Reg. No. 76. 6040

Measurement	N	M	Range	SD	SE
Length	23	62.10	58.5 - 65.6	1.90	0.40
Prox. width	23	10.69	10.2 - 11.4	0.33	0.07
Mid shaft width	23	4.15	3.8 - 4.7	0.24	0.05
Dist. width	23	8.57	8.0 - 8.9	0.27	0.06

Table III. 2 Femur

Reg. No. 76. 6039

Measurement	N	M	Range	SD	SE
Length[1]	15	79.14	75.7 - 83.3	1.97	0.51
Prox. width[2]	15	15.68	14.9 - 16.5	0.42	0.11
Trochanter width[3]	14	14.77	13.4 - 15.6	0.66	0.18
Mid shaft width	15	6.80	6.1 - 7.3	0.32	0.08
Dist. width	15	12.91	12.3 - 13.5	0.39	0.10

Key to measurements as in Table I. 2

Table III.3 Tibia

Reg. No. 76.6042 (2 specimens)

	1	2
Length	86.0	87.9
Prox. width	13.7	13.5
Dist. width	11.8	11.2

IV. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table IV.1 Humerus

Reg. No. 76.6178 (2 specimens)

	1	2
Length	64.8	61.0
Prox. width	10.1	10.0
Dist. width	8.5	8.6

Table IV.2 Femur

Reg. No. 76.6177 (1 specimen)

Length[1]	82.5
Prox. width[2]	16.4
Trochanter width[3]	16.0

Key to measurements as in Table I.2

V. Modern specimens of British wild and domestic rabbits held in the BM(NH)

Specimens collected by Darwin (1905, p. 141)

Table V.1 Humerus

Reg. No.	Description	Length	Prox. width	Mid. shaft width	Dist. width
1868.2.19.98	British wild, Kent	60.9	10.8	4.0	8.9
1869.8.19.100	British wild, Kent	66.1	11.0	4.1	8.3
1868.2.19.94	Angora (domestic)	69.5	12.4	4.8	10.2
1868.2.19.101	Silver-grey (domestic)	75.0	12.0	5.0	10.6
1868.2.19.99	Lopeared (domestic)	77.0	-	-	12.8

Table V.2 Femur

Reg. No.	Description	Length[1]	Prox. width	Troch. width[3]	Mid. shaft	Dist. width
1868.2.19.98	British wild, Kent	78.1	15.5	15.5	7.0	13.3
1869.8.19.100	British wild, Kent	85.9	16.6	16.6	7.5	13.3
1868.2.19.94	Angora (domestic)	90.4	16.5	17.1	7.6	14.2
1868.2.19.101	Silver-grey (domestic)	97.9	17.8	18.9	8.5	16.6
1868.2.19.99	Lop-eared (domestic)	102.8	20.5	22.0	7.8	17.9

Key to measurements as in Table I.2

RED DEER

Order: Artiodactyla
Family: Cervidae
Taxon: *Cervus elaphus*

I. Baynard's Castle, deposit 250 (city debris c. mid 14th century AD)

Table I.1 Metatarsal bone.

Reg. No. 76.6386 (1 specimen)

Length	Prox. width	Mid shaft width	Dist. shaft width.	Dist width.
255.0	31.4	17.7	35.8	36.0

II. Modern specimens of Red deer held in the BM(NH)

Table II.1 Metatarsal bone

Reg. No.	Sex	Length	Prox. width	Mid shaft width	Dist shaft width	Dist width
1962.11.22.1	male	276.4	35.5	21.8	38.5	39.8
Newton collection	female	264.3	32.5	20.7	35.2	36.0

FALLOW DEER

Order: Artiodactyla
Family: Cervidae
Taxon: *Dama dama*

I. Baynard's Castle, deposits 1 & 23 ('robber pits' c. 1520 AD)

Table I.1 Humerus

Reg. No.	Dist. width
76.6457	40.0
6461	43.2
6462	37.4
6463	35.6
6464	36.2

Table I.2 Radius

Reg. No. 76.6455 (1 specimen)

Length	207.8
Prox. width	40.8
Mid shaft width	25.0
Dist. Width	36.7

Table I.3 Tibia

Reg. No.	Prox. width	Dist. width
76.6421	55.5	-
6422	50.5	-
6423	53.2	-
6425	-	35.2
6426	-	30.0
6427	-	30.7
6428	-	30.6
6429	55.7	-
6430	47.5	-
6432	-	31.9
6433	-	33.9
6434	-	31.0

Table I.4 Metacarpal bone

Reg. No. 76.6412 (1 specimen)

Length	194.6
Prox. width	30.5
Mid shaft width	18.0
Dist. shaft width	29.6
Dist. width	29.8

Table I. 5 Metatarsal bone

Reg. No.	Length	Prox. width	Mid shaft width	Dist shaft. width	Dist width
76. 6387	218. 6	26. 0	16. 3	29. 6	30. 3
6388	217. 9	26. 4	15. 8	29. 1	29. 4
6389	210. 7	25. 3	15. 5	28. 9	29. 4
6390	201. 8	25. 2	15. 4	27. 4	28. 9
6391	201. 2	24. 0	14. 5	26. 3	27. 0
6392	189. 6	23. 4	13. 9	26. 2	27. 5
6393	188. 3	23. 5	13. 7	26. 5	26. 9
6394	191. 2	23. 0	13. 1	25. 3	26. 1

II. Baynard's Castle, deposits 88, 100 & 150 (dock basin dump. c. 1500 A. D.)

Table II. 1 Tibia

Reg. No.	Length	Prox. width	Dist. width
76. 6416	275. 4	50. 8	34. 3
6418	-	56. 3	-
6419	-	55. 4	-
6420	-	53. 5	-

Table II. 2 Metatarsal bone

Reg. No.	Length	Prox. width	Mid shaft width	Dist shaft width.	Dist. width
76. 6395	201. 4	23. 9	15. 3	26. 8	27. 1
6396	197. 0	23. 2	14. 4	26. 0	26. 6

III. Baynard's Castle, deposit 250 (city debris. c. mid 14th century AD)

Table III. 1 Femur

Reg. No. 76. 6456 (1 specimen)	
Length	211. 0 e
Prox. width	55. 9
Mid shaft width	18. 2

Table III. 2 Tibia

Reg. No. 76. 6414 (1 specimen)	
Dist. width	35. 7

IV. Modern specimens of Fallow deer held in the BM(NH)

Table IV. 1

Reg. No. 1937. 3. 10. 1 Male

	Radius	Humerus	Femur	Tibia
Length	208. 5	211. 0	251. 4	281. 2
Prox. width	41. 6	52. 9	65. 6	58. 6
Mid shaft width	25. 0	23. 2	23. 4	23. 9
Dist. width	38. 2	44. 6	52. 7	36. 9

Table IV. 2 Metatarsal bone

Reg. No.	Sex	Length	Prox. width	Mid shaft width	Dist. shaft width	Dist. width
1937. 3. 10. 1	male	224. 0	28. 6	17. 6	31. 2	31. 3
1936. 11. 3. 1	male	208. 5	25. 9	16. 0	29. 7	29. 3
1937. 6. 9. 1	female	196. 5	25. 1	13. 6	36. 9	27. 5
1937. 3. 10. 2	female	198. 9	23. 8	14. 2	25. 9	26. 4

ROE DEER

Order: Artiodactyla
Family: Cervidae
Taxon: *Capreolus capreolus*

I. Baynard's Castle, deposit 5104 (secondary dump c.13th century AD)

Table I. 1 Metacarpal bone

Reg. No. 76. 6435 (1 specimen)

Length	Prox. width	Mid shaft width	Dist width.
141. 1	18. 0	11. 5	19. 3

HARE

Order: Lagomorpha
Family: Leporidae
Taxon: *Lepus* sp.

I. Baynard's Castle

Table I.1 Humerus

Reg. No. 76.6173 (deposit 250, 1 specimen). Proximal epiphysis unfused.

Length	Mid shaft width	Dist. width
99.0	5.8	11.6

Table I.2 Femur

Reg. No.	Deposit	Prox. width[1]	Trochanter width[2]
76.6173	250	25.1	-
76.6346	88	27.5	24.8

Key to measurements:
1. Prox. width: Gross proximal breadth (Bp)
2. Trochanter width: Gross breadth in region of the trochanter tertius (BTr)

see Driesch (1976, p. 77)

Table I.3 Tibia

Reg. No.	Deposit	Prox. width	Dist. width
76.6041	100	-	15.3
76.6174	23	20.1	-
76.6175	23	19.1	-

II. Modern specimens of hares held in the BM(NH)

Table II.1 Humerus

Description	Length	Mid shaft width	Dist. width
Common hare *	102.6	5.9	11.2
Scottish hare **	93.6	4.8	10.4

Proximal epiphysis unfused (*) and fused (**)

Table II.2 Femur

Description	Prox. width[1]	Trochanter width[2]
Common hare	25.0	21.8
Scottish hare	22.4	22.1

1 & 2 measurements as in Table I.2

Table II.3 Tibia

Description	Prox. width	Dist width
Common hare	18.6	14.9
Scottish hare	17.4	14.1

BLACK RAT

Order: Rodentia
Family: Muridae
Taxon: Rattus rattus

Table 1 Skull

Reg. No. 76.6003 (deposit 1 c.1520 AD, 1 specimen)

Maximum breadth across the cranium	15.1
Length of upper tooth row	7.1

Table 2 Femur

Reg. No.	Deposit	Date	Length
76.6005	1	c. 1520 AD	35.9
6010	23	"	36.4
6275	23	"	34.9
6146	100	c. 1500 AD	37.7
6152	100	"	36.8
6160	250	mid 14th cent. AD	39.8
6161	250	"	37.8

Table 3 Tibia

Reg. No.	Deposit	Date	Length
76.6022	5067	16th cent. AD	40.9
6153	100	c.1500 AD	42.2) same
6154	100	"	42.2) individual
6155	100	"	40.5

HEDGEHOG

Order: Insectivora
Family: Erinaceidae
Taxon: Erinaceus europaeus

Table 1 Humerus

Reg. No. 76.6015 (deposit 89 c.1500 AD, 1 specimen). Proximal epiphysis not fused, distal epiphysis fused.

Dist. width 10.6

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5. REFERENCES

A. D. A. S. (1971).

A System for Lowland Sheep. Ministry of Agriculture, Fisheries and Food.

Armitage, P. L. (1977, in prep.).

The history of long horned cattle in Britain from the late middle ages to the modern period.

Armitage, P. L. & Clutton-Brock, J. (1976).

A system for classification and description of the horn cores of cattle from archaeological sites. Journal of Archaeological Science, 3, 329-348.

Armitage, P. L. & Goodall, J. A. (1977, in press).

Medieval horned and polled sheep: The archaeological and inconographic evidence. The Antiquaries Journal, 57 (Part 1), 73 - 89.

Ash, E. C. (1927).

Dogs: Their History and Development (2 vols). London: Ernest Benn Ltd.

Baille-Grohman, W. A. (1904).
The Master of Game by Edward, Second Duke of York.
London: Ballantyne, Hanson & Co.

Barone, R. et al. (1973).

Atlas D'Anatomie Du Lapin. Paris: Masson & Cie.

van Bath, B. H. S. (1966).

The Agrarian History of Western Europe. A. D. 500-1850. London: Edward Arnold.

Bentley, E. W. (1959).

The distribution and status of Rattus rattus L. in the United Kingdom in 1951 and 1956. Journal of Animal Ecology, 28, 299-308.

Bentley, E. W. (1964).

A further loss of ground by Rattus rattus. L. in the United Kingdom during 1956-61. Journal of Animal Ecology, 33 (No. 2), 371-373.

Bergquist, H. & Lepiksaar, J. (1957).

Animal skeletal remains from Medieval Lund. Archaeology of Lund, I.

Bewick, T. (1790 reprinted 1970).

A General History of Quadrupeds. London: Ward Lock Reprints.

Biddle, M., Hudson, D. & Heighway, C. (1973).

The Future of London's Past: A Survey of the Archaeological Implications of Planning and Development in the Nation's Capital. Worcester: Rescue publication number 4.

Bloice, B. (1974).

Excavation round-up 1973. The London Archaeologist, 2(No. 6), 133-135.

Boessneck, J. (1956).

see von den Driesch, A. & Boessneck, J. (1974).

Boessneck, J. (1971).

Osteological differences between sheep (Ovis aries L.) and goat (Capra hircus L.) In (D. Brothwell & E. Higgs, Eds.) Science in Archaeology. London : Thames & Hudson, 331-358.

Boessneck, J. et al (1964).

Osteologische Unterscheidungsmerkmale zwischen Schaf (Ovis aries L.) und Ziege (Capra hircus L.). Kuhn Archiv, 78, 1-129.

Bökönyi, S. (1974).

History of Domestic Mammals in Central and Eastern Europe. Budapest: Akadémiai Kiddó.

Bonnichsen, R. (1973).

Some operational aspects of human and animal bone alteration. In (B. M. Gilbert, Ed.) Mammalian Osteo-Archaeology: North America. Columbia: Missouri Archaeological Society, 9-24.

Bowden, P. (1967).

Agricultural prices, farm profits and rents. In (J. Thirsk, Ed.) The Agrarian History of England and Wales, IV 1500-1640. Cambridge: Cambridge University Press, 593-694.

Bramwell, D. (1975).

Bird remains from medieval London. The London Naturalist, 54, 15-20.

Chaplin, R. E. (1971).

The study of animal bones from Archaeological sites. London: Seminar Press.

Chapman, D. & Chapman, N. (1975).

Fallow Deer. Lavenham: Terence Dalton Ltd.

Clason, A. T. (1967).

Animal and Man in Holland's Past, vol. A. Groningen: J. B. Wolters.

Clutton-Brock, J. (1962).

An Analysis of Mammalian Faunas from Prehistoric Sites in India and Western Asia. Ph.D. thesis, University of London.

Clutton-Brock, J. (1976a).

The animal resources. In (D. M. Wilson, Ed.) The Archaeology of Anglo-Saxon England. London: Methuen & Co. Ltd., 373-392.

Clutton-Brock, J. (1976b).

George Garrard's livestock models. The Agricultural History Review, 24 (Part 1), 18-29.

Clutton-Brock, J. & Armitage, P. L. (1977, in press).

Animal remains from the Roman and Medieval levels of Angel Court, Walbrook, London. Transactions of the London & Middlesex Archaeological Society.

Corbet, G. B. (1974).

The distribution of mammals in historic times. In (D. L. Hawksworth, Ed.) The Changing Flora and Fauna of Britain. London: Academic Press, 179-202.

Cornwall, J. (1954).

Farming in Sussex, 1560-1640. Sussex Archaeological Collections, 92, 48-92.

Creasey, J.S. (1974).

The Draught Ox. Reading: Institute of Agricultural History and Museum of English Rural Life.

Darwin, C. (1905).

The Variation of Animals and Plants under Domestication, 2 vols. London: John Murray.

Dent, A. (1974).

Lost Beasts of Britain. London: George G. Harrap & Co. Ltd.

Dent, A. (1976).

Cleveland Bay horses. The Ark, III (No. 9, 254-255.

Dent, A. & Goodall, D.M. (1962).

The Foals of Epona. London: Galley Press.

Dergerbøl M. (1963).

Prehistoric cattle in Denmark and adjacent areas. In (A.E. Mourant & F.E. Zeuner, Eds.) Man and Cattle. London: Royal Anthropological Institute, 69-79.

Douglas, S.W. & Williamson, H.D. (1975).

Veterinary Radiological Interpretation. Philadelphia: Lea & Febiger.

von den Driesch, A. (1976).

Das Vermessen von Tierknochen aus vor-und frühgeschichichtlichen Siedlungen. München: Aus dem Institut für Paläoanatomie, Domestikations forschung un Geschichte der Tiermedizin der Universität München.

von den Driesch, A. & Boessneck, J. (1974).

Kritische Anmerkungen zur Widerristhöhenberechnung aus Längenmassen vor-und fruhge-schichtlicher Tierknochen. Säugetierkundliche Mitteilungen, 22, 325-348.

Duerst, J.U. (1926).

Handbuch der biologischen Arbeitsmethoden. Berlin & Wien.

Ekman, J. (1973).

Early Medieval Lund-the fauna and the landscape. *Archaeologica Lundensia*, *V*.

Everitt, A. (1967).

The marketing of agricultural produce. In (J. Thirsk, Ed.) *The Agrarian History of England and Wales, IV 1500-1640.* Cambridge: Cambridge University Press, 466-589.

Fisher, F. J. (1935).

The development of the London food market, 1540-1640. *Economic History Review*, *V*, 47.

Fisher, F. J. (1936).

The Worshipful Company of Horners: A Short History. London: ?

Fitter, R. S. R. (1945).

London's Natural History. London: Collins.

Fitter, R. S. R. (1959).

The Ark in our Midst. London: Collins.

Fitzherbert, A. (1523).

The Book of Husbandry. Southwark: Peter Treverys.

Fock (1966).

see von den Driesch, A. & Boessneck, J. (1974).

Fraser, A. (1947).

Sheep Production. London: Thomas Nelson & Sons Ltd.

Fraser, A. S. (1955).

Growth of horns in sheep. *Australian Journal of Agricultural Research*, *6*, 770-775.

Fraser, A. (1972).

The Bull. Reading: Osprey Publishing Ltd.

Fussell, G. E. (1952).

Four centuries of farming systems in Sussex, 1500-1900. *Sussex Archaeological Collections*, *90*, 60-101.

Grigson, C. (1974). The craniology and relationships of four species of Bos. 1. Basic craniology: Bos taurus L. and its absolute size. Journal of Archaeological Science, 1, 353-379.

Groves, C. P. (1971). Request for a declaration modifying Article I so as to exclude names proposed for domestic animals from zoological nomenclature. Bulletin of Zoological Nomenclature, 27, 269-272.

Guilday, J. E. (1970). Animal remains from archaeological excavations at Fort Ligonier. Annals of Carnegie Museum, 42, 177-186.

Halstead, L. B. (1974). Vertebrate Hard Tissues. London: Wykeham Publications Ltd.

Hammond, J. (1948). Farm Animals. London: Edward Arnold & Co.

Harcourt, R. A. (1974). The dog in prehistoric and early historic Britain. Journal of Archaeological Science, 1, 151-175.

Harding, J. P. (1949). The use of probability paper for the graphical analysis of polymodal frequency distributions. Journal of the Marine Biological Association of the United Kingdom, 28, 141-155.

Hatting, T. (1975). The influence of castration on sheep horns. In (A. T. Clason, Ed.) Archaeozoological Studies. Amsterdam: North-Holland Publishing Company, 345-351.

Hector, L. C. (1958). The Handwriting of English Documents. London: Edward Arnold Ltd.

Higham, C. F. W. (1969).

The metrical attributes of two samples of bovine limb bones.
Journal of Zoology, London, 157, 63-74.

Higham, C.& Message, M. (1971).

An assessment of a prehistoric technique of bovine husbandry. In (D. Brothwell & E. Higgs, Eds) Science in Archaeology.
London Thames and Hudson, 315-30.

HMSO (1908).

Animal Management. London: His Majesty's Stationery Office.

Holmes, M. (1969).

Elizabethan London.
London: Cassell & Company Ltd.

Howard, M. M. (1963).

The metrical determination of the metapodials and skulls of cattle. In (A. E. Mourant & F. E. Zeuner, Eds.) Man and Cattle.
London: Royal Anthropological Institute, 91-100.

Hughes, H. V. & Dransfield, J. W. (1953).

McFadyean's Osteology & Arthrology of the Domesticated Animals.
London: Baillière, Tindall and Cox.

Hughes, T. Mckenny (1896).

On the more important breeds of cattle which have been recognised in the British Isles in successive periods. Archaeologia, LV, 125-158.

Hurstfield, J. (1964).

Tudor Times.
London: The Historical Association.

Ibsen, H. L. (1944).

Horn and scur inheritance in certain breeds of Sheep.
American Naturalist, 78, 506-516.

Jewell, P. A. (1963).

Cattle from British archaeological sites. In (A. E. Mourant & F. E. Zeuner, Eds.)
Man and Cattle.
London : Royal Anthropological Institute, 80-91.

Jewell, P. A. (1975).
The case for the preservation of rare breeds of domestic livestock.
The Ark, II (No. 4), 84-88.

Jewell, P. A. *et al* (1974).
Island Survivors: The Ecology of the Soay Sheep of St. Kilda.
London: The Athlone Press.

Jones, P. E. (1976).
The Butchers of London.
London: Secker & Warburg.

Kendall, P. M. (1973).
Richard III, London: Sphere Books Ltd.

Kiesewalter (1888).
see von den Driesch, A. & Boessneck, J. (1974)

Knecht, G. (1966).
Mittelalterlich-frühneuzeitliche Tierknochenfunde aus Oberösterreich (Linz und Enns).
München: dissertation.

Kubasiewicz, M. (1956).
see Uerpmann, H. P. (1973), 310.

Kühnhold, B. (1971).
Die Tiernocherfunde aus Unterregenbach, einer mitterlatterlichen Siedlung Würtembergs.
München: dissertation.

Langer, W. L. (1964).
The Black Death. *Scientific American*, 210 (No. 2), 114-121.

Lawrence, M. J. & Brown, R. W. (1973).
Mammals of Britain: Their Tracks, Trails and Signs.
London: Blandford Press.

Lemppenau, U. (1964).
Geschlechts-und Gattungsunterschiede am Becken mitteleuropäischer Wiederkäuer.
Dissertation, München Universitat.

Lydekker, R. (1912).

The Sheep and its Cousins.
London: George Allen & Co. Ltd.

MacArthur, W.P. (1957).

The occurrence of the rat in early Europe. Transactions of the Royal Society of Tropical Medicine and Hygiene, 51 (No. 1), 91-92.

Marks, S.P. (1964).

The Map of Mid Sixteenth Century London.
London: London Topographical Society.

Marsden, P. (1972a).

Baynard's Castle. Archaeological excavations 1972.
London: Her Majesty's Stationery Office, 95.

Marsden, P. (1972b).

Baynard's Castle. The London Archaeologist, 1. (No. 14), 315-316.

Marsden, P. (1973).

Baynard's Castle. Unpublished account of the historical background to the building.

Marsden, P. (1977 in prep.).

Excavations at the site of Baynard's Castle, London 1972-73.

Matheson, C. (1939).

A survey of the status of Rattus rattus and its subspecies in the seaport of Gt. Britain and Ireland. Journal of Animal Ecology, 8 (no. 1), 76-93.

Mennerich, G. (1968).

Römerzeitliche Tierknochen aus drei Fundorten des Niederrheingebietes.
München: dissertation.

Miles, W.J. (1890).

Modern Practical Farriery.
London: William Mackenzie.

More, T. (1516 reprinted 1971).

Utopia.
Harmondsworth: Penguin Books Ltd.

Museum of London (1940 reprinted 1975).
Medieval Catalogue.
London: Her Majesty's Stationery Office.

Myers, A. R. (1969).
English Historical Documents, IV. 1327-1485.
London: Eyre & Spottiswoode.

Naus, J. I. (1975).
Data Quality Control and Editing.
Statistics: textbooks and monographs vol. 10.
New York: Marcel Dekker Inc.

Payne, S. (1972a).
Partial recovery and sample bias: The results of some sieving experiments. In (E. S. Higgs, Ed.)
Papers in Economic Prehistory.
Cambridge: University Press, 49-64.

Payne, S. (1972b).
On the interpretation of bone samples from archaeological sites. In (E. S. Higgs, Ed.)
Papers in Economic Prehistory.
Cambridge: University Press, 65-81.

Payne, S. (1973).
Kill-off patterns in sheep and goats:
The mandibles from Aşvan Kale.
Anatolian Studies XXIII, 281-303.

Payne, S. (1975).
Partial recovery and sample bias. In
(A. T. Clason, Ed.) Archaeozoological Studies.
Amsterdam: North-Holland Publishing Company, 7-17.

Pendrill, C. (1925).
London Life in the Fourteenth Century.
London: George Allen & Unwin Ltd.

Pennant, T. (1776).
The British Zoology. London: Benjamin White.

Pollock, K. (1976).
Untersuchungen an Schädeln von Schafen und Ziegen aus der frühmittelalterlichen Siedlung Haithabu. Kiel: dissertation.

Power, E. (1941 reprinted 1969).
The Wool Trade in English Medieval History.
Oxford: University Press.

Rixson, D. (1976a).
Beef Cutting: A Step by Step Guide.
London: Meat Trades Journal.

Rixson, D. (1976b).
Pig and Lamb Cutting: A Step by Step Guide.
London: Meat Trades Journal.

Russell, J. F. (1972).
Witchcraft in the Middle Ages.
London: Cornell University Press.

Ryder, M. L. (1964).
The history of sheep breeds in Britain.
Agricultural History Review, 12, (Parts 1 & 2) 1-2 & 65-82.

Ryder, M. L. (1971).
Changes in the fleece of sheep following domestication (with a note on the coat of cattle).
In (P. J. Ucko & G. W. Dimbleby)
The Domestication and Exploitation of Plants and Animals.
London: Gerald Duckworth & Co. Ltd., 495-521.

Sabine, E. L. (1933).
Butchering in mediaeval London.
Speculum, 8, 335-353.

Sabine, E. L. (1937).
City cleaning in medieval London.
Speculum, 12, 19-43.

Savage, H. L. (1933).
Hunting in the Middle Ages.
Speculum, 8, 30-41.

Schmid, E. (1972).
Atlas of Animal Bones.
Amsterdam: Elsevier Publishing Company.

Shapiro, S. S. & Wilk, M. B. (1965).
An analysis of variance test for normality (complete samples).
Biometrika, 52. (Parts 3 & 4), 591-611.

Sillar, F. C. & Meyler, R. M. (1961).
The Symbolic Pig.
London: Oliver and Boyd.

Silver, I.A. (1971).
The ageing of domestic animals. In (D. Brothwell & E. Higgs, Eds.) Science in Archaeology.
London: Thames and Hudson, 283-302.

Simpson, F. (1903).
The Book of the Cat.
London: Cassell & Company Ltd.

Sisson, S. (1964).
The Anatomy of the Domestic Animals.
London: W.B. Saunders Company.

Snedecor, G.W. & Cochran, W.G. (1967).
Statistical Methods. Iowa: The Iowa State University Press.

Stow, J. (1603. reprinted 1970).
The Survey of London.
London: Dent & Sons Ltd.

Sullivan, E. (1914).
The Book of Kells.
London: 'The Studio' Ltd.

Taylor Page, F.J. (1963).
Fallow Deer.
Animals of Britain 11. Sunday Times Publications

Thirsk, J. (1967).
Farming techniques. In (J. Thirsk, Ed.) The Agrarian History of England and Wales. IV 1500-1640.
Cambridge: Cambridge University Press, 161-197.

Thompson, H.V. & Worden, A.N. (1956).
The Rabbit. London: Collins.

Thompson, M.W. (1977).
General Pitt-Rivers.
Bradford-on-Avon: Moonraker Press.

Topsell, E. (1607 reprinted 1967).
The History of Four footed Beasts and Serpents and Insects. Vol. 1.
The History of Four-footed Beasts.
London: Frank Cass & Co.

von Treue, W. et al (1965).
Das Hausbuch der Mendelschen Zwölfbrüderstiftung zu Nürnberg.
München: Bruckmann.

Trow-Smith, R. (1957).
A History of British Livestock Husbandry to 1700.
London: Routledge and Kegan Paul.

Trow-Smith, R. (1959).
A History of British Livestock Husbandry 1700-1900.
London: Routledge and Kegan Paul.

Twigg, G. (1975).
The Brown Rat. London: David & Charles.

Uerpmann, H. P. (1973).
Animal bone finds and economic archaeology: a critical study of osteo-archaeological method.
World Archaeology, 4 (No. 3), 307-322.

Veale, E. M. (1957).
The rabbit in England
The Agricultural History Review, V. (Part 2), 85-90.

Vesey-Fitzgerald, B. (1957).
The Domestic Dog.
London : Routeledge and Kegan Paul Ltd.

Vince, J. (1974).
Old Farm Tools. Aylesbury: Shire Publications Ltd.

Watson, J. P. N. (1972).
Fragmentation analysis of animal bone samples from archaeological sites.
Archaeometry, 14 (No. 2), 221-228.

White, L. (1971).
Medieval Technology and Social Change.
Oxford: Oxford University Press.

Whitehead, G. K. (1964).
The Deer of Great Britain and Ireland.
London: Routledge & Kegan Paul.

Wildman, A. D. (1954).
The Microscopy of Animal Textile Fibres. Leeds: Wool Industries Research Association.

Wilson, C. A. (1976).
Food and Drink in Britain from the Stone Age to Recent Times. Harmondsworth: Penguin Books.

Youatt, W. (1847).
The Pig: A Treatise on the Breeds, Management, Feeding and Medical Treatment of Swine. London: Cradock & Co.

Youatt, W. (1855).
The Horse. London: Longman, Brown, Green and Longmans.

Zeuner, F. E. (1963).
A History of Domesticated Animals. London: Hutchinson.

Ziegler, P. (1975).
The Black Death. Harmondsworth: Penguin Books Ltd.

APPENDIX A: Computer programs

Program one	-	Format reading program
Program two	-	Gross error locating program
Program three	-	Main sorting program
Program four	-	Summary program for numerical data
Program five	-	Summary program for complete cattle metapodial bones

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C       PROGRAM   ONE
C       PROGRAM   WRITTEN BY K.M.SHAW,DEPT.CENTRAL SERVICES,B.M.(N.H.)
C       PROGRAM   READS THE DATA FROM THE PUNCHED TAPE AND STORES
C       THE INFORMATION ON DISC(DISC W1,FILE W1 PTAPES)
C       ANY ASTERISK,DENOTING A MISSING NUMBER,IS REPLACED BY -99.9
C
        DIMENSION W(3),X(7),Y(53),Z(9),NUMBER(12),MWA(13)
        INTEGER Y
        DATA NUMBER/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,
       11H8,1H9,1H.,1H*/
        DATA IBLANK,BELL/1H ,1H#/
        DATA MWA(8),MWA(9),MWA(10)/2HPT,2HAP,2HES/
        CALL VSOPEN(21,21,MWA,0)
      4 READ(4,100)W(1),X(1),W(2),X(2),(Y(I),I=1,9),
       1X(3),(Y(I),I=10,46),(X(I),I=4,7),(Y(I),I=47,53),
       2W(3)
    100 FORMAT(f5.0,a3,f4.0,a2,47a1,2(a2,a3),7a1,f2.0)
C        SEARCH FOR END OF DATA
        IF(X(3).EQ.BELL) GO TO 99
C        SEARCH FOR NUMERICAL DATA
        M=0
        I=1
        NV=1
      6 DO 2 J=1,14
        IF(Y(I).EQ.NUMBER(J)) GO TO 3
      2 CONTINUE
        I=I+1
        GO TO 6
C        TEST FOR NUMBER,*, .
      3 L=1
        IF(J.GT.10)L=J-9
        GO TO (7,10,11), L
C        READ WHOLE NUMBER
     39 Z(NV)=FLOAT(M)
     13 M=0
        NV=NV+1
        IF(NV.EQ.10)GO TO 98
        I=I+1
        GO TO 6
      7 M=M*10+J-1
        I=I+1
        IF(Y(I).EQ.IBLANK) GO TO 39
        GO TO 6
```

```
C        READ DECIMAL PART OF NUMBER
   10 N=0
      PC=0
   16 I=I+1
      IF(Y(I).EQ.IBLANK) GO TO 17
      DO81 J=1,10
      IF(Y(I).EQ.NUMBER(J)) GO TO 52
   81 CONTINUE
   52 N=N*10+J-1
      PC=PC+1.0
      GO TO 16
C        BLANK ENCOUNTERED,END OF NUMBER
   17 Z(NV)=FLOAT(M)+FLOAT(N)/(10.0**PC)
      GO TO 13
C        ASTERISK ENCOUNTERED
   11 Z(NV)=-99.9
      GO TO 13
C        10 NUMERICAL DATA ENTRIES READ,WRITE ALL ENTRIES FOR SPECIMEN
C        TO DISC AND TO LINE PRINTER
   98 WRITE(5,101)W(1),X(1),W(2),X(2),Z(1),Z(2),
     1X(3),(Z(I),I=3,8),(X(I),I=4,7),Z(9),W(3)
      WRITE(21,101)W(1),X(1),W(2),X(2),Z(1),Z(2),
     1X(3),(Z(I),I=3,8),(X(I),I=4,7),Z(9),W(3)
  101 FORMAT(' ',f6.0,a3,f4.0,a2,2f7.1,a3,6f6.1,
     11x,2(a2,a3),f6.1,f4.0)
      GO TO 4
   99 CALL VSCLOS(21,1)
      STOP
      END
C
C
C
```

```
C       PROGRAM   TWO
C       DATA EDITING PROGRAM  -- GROSS ERROR CONTROL
C       PROGRAM   WRITTEN BY P.L.ARMITAGE
C       BASED ON METHOD DESCRIBED IN NAUS(1975) PAGE 41
C       PROGRAM FOR COMPLETE DATA ONLY
C
        DIMENSION X(3,9)
        DIMENSION XMAX(9),XMIN(9),XMID(9),
       1DIFLS(9),DIFMS(9),DIFLM(9),
       2XLMRLS(9),XMSRLS(9)
C
  100   FORMAT(1X,f6.0,16x,f7.1,3x,6f6.1,11x,f6.1,4x)
  101   FORMAT(4x,f6.0,1x,f7.1,1x,6f6.1,1x,f6.1)
  201   FORMAT('****************************************')
  202   FORMAT('AVARIATE',I2,'+VE OUTLIER=',F6.2)
  203   FORMAT('YVARIATE',I2,'-VE OUTLIER=',F6.2)
  204   FORMAT(1H0,'****  DATA  EDITING  COMPLETED  ***')
C
C       WRITE TITLE
        WRITE(5,98)
   98   FORMAT(1H0,7X,'BAYNARDS CASTLE GROSS ERROR LOCATING PROGRAM')
        WRITE(5,99)
   99   FORMAT(1H0)
C
    2   WRITE(5,201)
C
C       INITIALISATION
        DO3 J=2,9
        XMIN(J)=999.0
        XMAX(J)=0.0
        XMID(J)=0.0
        DIFLS(J)=0.0
        DIFMS(J)=0.0
        DIFLM(J)=0.0
        XLMRLS(J)=0.0
    3   XMSRLS(J)=0.0
C
C       READ DATA - THREE ROWS AT A TIME - LIST DATA
        DO6 I=1,3
        READ(4,100) (X(I,J),J=1,9)
        IF(X(I,1).EQ.9999.0) GO TO 30
    6   WRITE(5,101) (X(I,J),J=1,9)
C
C       RANK OBSERVATIONS BY SIZE FROM SMALLEST TO LARGEST
C       IN EACH OF THE NINE VARIATES
        DO10 J=2,9
        DO9 I=1,3
        IF(X(I,J).GT.XMAX(J)) XMAX(J)=X(I,J)
        IF(X(I,J).LT.XMIN(J)) XMIN(J)=X(I,J)
    9   CONTINUE
   10   CONTINUE
```

```
C
      DO12 J=2,9
      DO11 I=1,3
      IF(X(I,J).EQ.XMAX(J)) GO TO 11
      IF(X(I,J).EQ.XMIN(J)) GO TO 11
      XMID(J)=X(I,J)
   11 CONTINUE
   12 CONTINUE
C
C     COMPUTE THE DIFFERENCES:
C     A LARGEST MINUS SMALLEST
C     B LARGEST MINUS MIDDLE
C     C MIDDLE MINUS SMALLEST
      DO20 J=2,9
      DIFLS(J)=XMAX(J)-XMIN(J)
      DIFLM(J)=XMAX(J)-XMID(J)
      DIFMS(J)=XMID(J)-XMIN(J)
C
C     COMPUTE THE RATIOS:
C     B/A
C     C/A
      XLMRLS(J)=DIFLM(J)/DIFLS(J)
      XMSRLS(J)=DIFMS(J)/DIFLS(J)
C
C     CHECK WHETHER THE RATIO B/A EXCEEDS 0.97
C     IF YES,THE LARGEST VALUE OF THE THREE NUMBERS IN THAT VARIATE
C     IS AN OUTLIER
      IF(XLMRLS(J).LT.0.97) GO TO 16
      WRITE(5,201)
      WRITE(5,202) J,XMAX(J)
      WRITE(5,201)
   16 CONTINUE
C
C     CHECK WHETHER THE RATIO C/A EXCEEDS 0.97
C     IF YES,THE SMALLEST VALUE OF THE THREE NUMBERS IN THAT VARIATE
C     IS AN OUTLIER
      IF(XMSRLS(J).LT.0.97) GO TO 20
      WRITE(5,201)
      WRITE(5,203) J,XMIN(J)
      WRITE(5,201)
C
   20 CONTINUE
C
C     SELECT THE NEXT THREE VALUES OBSERVED FOR EACH OF THE
C     NINE VARIATES AND PROCEED AS ABOVE
      GO TO 2
C
C     END OF DATA ENCOUNTERED
   30 WRITE(5,204)
      STOP
      END
C
C
C
```

```
C       PROGRAM   THREE
C       BAYNARDS CASTLE      MAIN SORTING PROGRAM
C       THIS PROGRAM   PROVIDES A SUMMARY OF THE QUALITATIVE INFORMATION
C       RELATING TO COMPLETENESS OF BONE SPECIMENS,EVIDENCE OF BUTCHERY
C       AND BONE ALTERATION(BURNING AND GNAWING ETC.)
C       PROGRAM   WRITTEN BY P.L.ARMITAGE
C
        DIMENSION J(5),IBC(19),FRQ(19),ITOT(19)
        DIMENSION ICOM(25),CFR(25),ICOT(25)
        DIMENSION JADD(25),ADFR(25),JTDD(25)
C
        INTEGER P
        DATA IBC/2INN,2HKK,2HCT,2HCD,2HCO,2HCK,
       12HCN,2HPP,2HEE,2HLL,2HSS,2HWN,
       22HCP,2HCS,2HCC,2HKP,2HKN,2HNK,2HCL/
        DATA ICOM/1HA,1HB,1HC,1HD,1HE,1HF,
       11HG,1HH,1HI,1HJ,1HK,1HL,1HM,1IN,
       21HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,
       31HW,1HZ,1HX/
        DATA JADD/1HA,1HR,1HM,1HG,1HT,1HB,
       11HC,1HD,1HY,1HN,1HO,1HS,1HK,1HP,
       21HW,1HU,1HX,1HF,1HH,1HI,1HJ,
       31HL,1HE,1HV,1HZ/
        DATA ISTAR/2H */
C
C       INITIALISATION
        M=0
        N=0
        P=0
        LTOT=0
        KTOT=0
        JTOT=0
        DO 2 I=1,19
    2   ITOT(I)=0
        DO 3 I=1,25
        ICOT(I)=0
    3   JTDD(I)=0
C
C       WRITE TITLE
        WRITE(5,98)
   98   FORMAT('        BAYNARDS CASTLE   BIOMETRIC   ANALYSIS,
       1  SORTING PROGRAMME#ONE')
C
C       READ REQUIRED DATA,ONE LINE AT A TIME,FROM TAPE AND PRINT
    4   READ(4,100)LI,J,LII
  100   FORMAT(10x,I4,1x,a1,14x,a3,37x,a2,a3,1x,a1,9x,I4)
        IF (LI.EQ.+99) GO TO 7
        IF (LII.NE.1) GO TO 4
        IF (LI.NE.47) GO TO 4
        WRITE(5,100) LI,J,LII
```

```
C
      LTOT=LTOT+1
      KTOT=KTOT+1
      JTOT=JTOT+1
      IF(J(4).EQ.ISTAR) M=M+1
      IF(J(1).EQ.ISTAR) N=N+1
      IF(J(5).EQ.ISTAR) P=P+1
C
C     SUM OBSERVATIONS
      DO 5 I=1,25
      IF(J(1).EQ.ICOM(I)) ICOT(I)=ICOT(I)+1
      IF(J(5).EQ.JADD(I)) JTDD(I)=JTDD(I)+1
    5 CONTINUE
      DO 6 I=1,19
      IF(J(4).EQ.IBC(I)) ITOT(I)=ITOT(I)+1
    6 CONTINUE
C
C     READ NEXT LINE AND PROCEED AS ABOVE
      GO TO 4
C
C     END OF DATA ENCOUNTERED
    7 LTOT=LTOT-M
      KTOT=KTOT-N
      JTOT=JTOT-P
C
C     COMPUTE PERCENTAGE FREQUENCIES
      DO 8 I=1,19
    8 FRQ(I)=FLOAT(ITOT(I))*(100.0/FLOAT(LTOT))
      DO 9 I=1,25
      CFR(I)=FLOAT(ICOT(I))*(100.0/FLOAT(KTOT))
    9 ADFR(I)=FLOAT(JTDD(I))*(100.0/FLOAT(JTOT))
C
C     TABULATE RESULTS
      WRITE(5,200)
  200 FORMAT('        BUTCHERY   SUMMARY SHEET')
      WRITE(5,201) LTOT
  201 FORMAT(8HOTOTAL=,I4)
      WRITE(5,202)
  202 FORMAT('  TYPE     N     FREQUENCY')
      DO 10 I=1,19
   10 WRITE(5,203)IBC(I),ITOT(I),FRQ(I)
  203 FORMAT(4x,a2,4x,I3,3x,f6.2)
      WRITE(5,204)
  204 FORMAT('        COMPLETENESS                    ADDITIONAL DATA')
      WRITE(5,205) KTOT,JTOT
  205 FORMAT(' TOTAL=',I4,'                          TOTAL=',I4)
      WRITE(5,206)
  206 FORMAT('  TYPE    N     FREQUENCY      TYPE     N     FREQUENCY')
      DO 11 I=1,25
   11 WRITE(5,207) ICOM(I),ICOT(I),CFR(I),JADD(I),JTDD(I),ADFR(I)
  207 FORMAT(5x,a1,4x,I3,3x,f6.2,10x,a1,4x,I3,3x,f6.2)
      STOP
      END
C
C
C
C
```

Program four

```
C     PROGRAM   FOUR
C     BAYNARDS CASTLE    SUMMARY PROGRAM   FOR NUMERICAL DATA
C     THIS PROGRAM   COMPUTES THE MEAN,RANGE AND STANDARD DEVIATION
C      FOR EACH VARIATE
C     PROGRAM   WRITTEN BY P.L.ARMITAGE
      DIMENSION X(9),SX(9),SD(9),XMAX(9),XMIN(9),M(9),N(9)
C
C     INITIALISATION
      DO1 I=1,9
      SX(I)=0.0
      SD(I)=0.0
      XMAX(I)=0.0
      XMIN(I)=999.0
    1 M(I)=0
      E=0.0
C
C     READ REQUIRED DATA,ONE LINE AT A TIME,AND PRINT
    4 READ(4,100)X
  100 FORMAT(10x,f4.0,19x,6f6.1,11x,f6.1,f4.0)
      IF(X(2).EQ.+99.9) GO TO 5
      IF(X(9).NE.1.0) GO TO 4
      IF(X(1).NE.47.0) GO TO 4
      WRITE(5,100)X
C
      E=E+1.0
C
C     SEARCH FOR HIGHEST AND LOWEST VALUES
      DO2 I=2,8
      IF(X(I).EQ.-99.9) GO TO 3
      IF(X(I).GT.XMAX(I)) XMAX(I)=X(I)
      IF(X(I).LT.XMIN(I)) XMIN(I)=X(I)
C
C     COMPUTE MEAN AND STANDARD ERROR
      SD(I)=SD(I)+(X(I)-SX(I))*(X(I)-SX(I))*(1.0-1.0/(E-FLOAT(M(I))))
      SX(I)=SX(I)+(X(I)-SX(I))/(E-FLOAT(M(I)))
      GO TO 2
    3 M(I)=M(I)+1
    2 CONTINUE
C
      GO TO 4
C
C     END OF DATA ENCOUNTERED
C     COMPUTE STANDARD DEVIATION
    5 DO 6 I=2,8
    6 SD(I)=SQRT(SD(I)/(E-1.0-FLOAT(M(I))))
C
C     TABULATE RESULTS
      WRITE(5,101)
  101 FORMAT(14x,'N     MAX    MIN    MEAN    S.D.    M')
      DO7 I=2,8
      N(I)=INT(E)-M(I)
      WRITE(5,102)I,N(I),XMAX(I),XMIN(I),SX(I),SD(I),M(I)
  102 FORMAT(' VARIATE',I3,I4,4F7.2,I4)
    7 CONTINUE
      STOP
      END

C
C
C
```

```
C       PROGRAM   FIVE
C       BAYNARDS CASTLE   SUMMARY PROGRAM
C       FOR COMPLETE CATTLE METAPODIAL BONES
C       THIS PROGRAM   COMPUTES THE MEAN,RANGE AND STANDARD
C        DEVIATION FOR EACH VARIATE
C       PRINTING OUT THESE VALUES IN THE FORM OF A TABLE
C       THE WITHERS HEIGHT IS ALSO CALCULATED USING
C       THE METHODS OF FOCK AND BOESSNECK
C
        DIMENSION X(10),SX(10),SD(10),XMAX(10),XMIN(10),M(10),N(10)
C
C       INITIALISATION
        DO 1 I=1,10
        SX(I)=0.0
        SD(I)=0.0
        XMAX(I)=0.0
        XMIN(I)=999.0
     1  M(I)=0
        E=0.0
        FOCK=0.0
        BOES=0.0
        SFK=0.0
        SBS=0.0
        XIND=0.0
        YIND=0.0
C
C       WRITE MAIN TITLE AND THEN SUB-TITLES
        WRITE(5,66)
    66  FORMAT(1H0,'*********************************************')
        WRITE(5,97)
    97  FORMAT('            BAYNARDS  CASTLE          SUMMARY  PROGRAM  ')
        WRITE(5,98)
    98  FORMAT(1H0,'                              RAW  DATA  MATRIX,
       1               WITHERS HEIGHT    SEX INDEX')
        WRITE(5,99)
    99  FORMAT('                              CATTLE  METACARPALS,
       1               FOCK    BOESS.   PW/L   MS/L')
C
C       READ REQUIRED DATA,ONE LINE AT A TIME,AND PRINT
     4  READ(4,190)X
   190  FORMAT(10x,f4.0,9x,f7.1,3x,6f6.1,11x,f6.1,f4.0)
        IF(X(5).EQ.+99.9) GO TO 5
        IF(X(10).NE.7.0) GO TO 4
C
C       COMPUTE WITHER'S HEIGHT FOR EACH SPECIMEN AND PRINT RESULT
        FOCK=X(3)*6.12
        BOES=X(3)*6.40
        XIND=(X(4)/X(3))*100.0
        YIND=(X(8)/X(3))*100.0
        WRITE(5,100)X,FOCK,BOES,XIND,YIND
   100  FORMAT(3x,f4.0,2x,f7.1,2x,7f6.1,2x,f4.0,5x,
       1f7.2,2x,f7.2,2x,f5.1,2x,f5.1)
C
```

```
      E=E+1.0
      DO2 I=2,9
      IF(X(I).EQ.-99.9) GO TO 3
C
C     SEARCH FOR HIGHEST AND LOWEST VALUES
      IF(X(I).GT.XMAX(I)) XMAX(I)=X(I)
      IF(X(I).LT.XMIN(I)) XMIN(I)=X(I)
C
C     COMPUTE MEAN AND STANDARD ERROR
      SD(I)=SD(I)+(X(I)-SX(I))*(X(I)-SX(I))*(1.0-1.0/(E-FLOAT(M(I))))
      SX(I)=SX(I)+(X(I)-SX(I))/(E-FLOAT(M(I)))
      GO TO 2
    3 M(I)=M(I)+1
    2 CONTINUE
C
      SFK=SFK+FOCK
      SBS=SBS+BOES
C
C     READ NEXT LINE DOWN AND PROCEED AS ABOVE
      GO TO 4
C
C     END OF DATA ENCOUNTERED
C     COMPUTE STANDARD DEVIATION
    5 DO 6 I=2,9
    6 SD(I)=SQRT(SD(I)/(E-1.0-FLOAT(M(I))))
C
C     TABULATE RESULTS
      WRITE(5,101)
  101 FORMAT(14X,'N     MAX     MIN     MEAN  S.D.     M')
      DO7 I=2,9
      N(I)=INT(E)-M(I)
      WRITE(5,102)I,N(I),XMAX(I),XMIN(I),SX(I),SD(I),M(I)
  102 FORMAT('VVARIATE',I3,I4,4F7.2,I4)
    7 CONTINUE
C
C     COMPUTE AVERAGE HEIGHT AT THE WITHERS AND PRINT RESULT
      SFK=SFK/FLOAT(N(3))
      SBS=SBS/FLOAT(N(3))
      WRITE (5,103) SFK,SBS
  103 FORMAT(1HO,'MEAN VALUES FOR WITHERS HEIGHTS=',5x,F7.2,10X,F7.2)
      STOP
      END

C
C
C
```

APPENDIX B : Statistical formulae

(I) Chi-square.

(II) Calculation of major and minor axes of the 95% percentile ellipse.

(I) CHI - SQUARE TEST

Formula for chi-square:- $$\chi^2 = \sum \frac{(O - E)^2}{E} \qquad (1)$$

where χ^2 = Value of chi-square
O = Observed number
E = Expected number

In this thesis, chi-square is used to test the Null hypothesis that a deposit contains equal numbers of adult and juvenile cattle (section 3.2, Table 6,p.58) and rabbits (section 3.2, Table 23,p.113).

Let a , b stand for the two values (i.e. observed number of adult and juvenile animals respectively) and E (expected number) = $\frac{a + b}{2}$

Substituting in formula (1) we get:-

$$\chi^2 = \frac{\left(a - \frac{a + b}{2}\right)^2}{\frac{a + b}{2}} + \frac{\left(b - \frac{a + b}{2}\right)^2}{\frac{a + b}{2}}$$

which reduces to:- $$\frac{(a - b)^2}{a + b} \qquad (2)$$

As we are dealing with whole numbers of animals, a correction for continuity has to be made (Shaw,1976, pers.comm.):-

$$\chi^2 = \frac{\left((a - b) - 1\right)^2}{a + b} \qquad (3)$$

on 1 degree of freedom

(II) CALCULATION OF MAJOR AND MINOR AXES OF 95% PERCENTILE ELLIPSE

The 95% percentile ellipse is used in this thesis on scatter diagrams of cattle metacarpal bones to delineate the 95% confidence limits of discrete groups of animals (section 3.2, Fig.7,p.44 & Fig.11,p.54).

Stages in calculation:-

Stage 1

As the X and Y values plotted on the scatter diagram are positively correlated, new axes, X' and Y', have to be drawn (see Figure A).

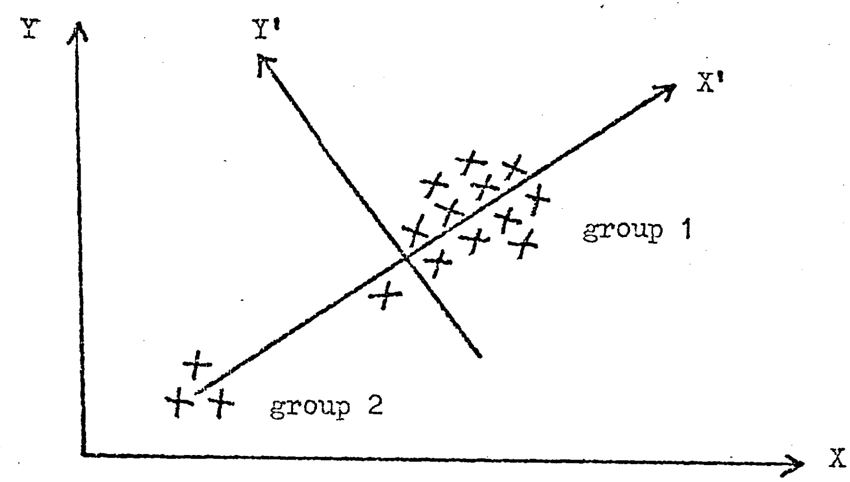


Figure A

Stage 2

Taking the largest group (group 1, Figure A) the new co-ordinates of all the points in the cluster are found by measuring the distance to the X' and Y' axes.

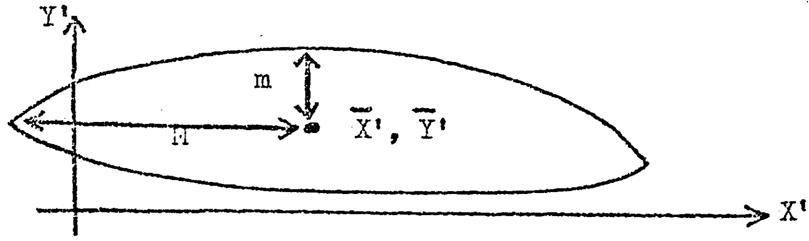
Stage 3

Calculate the mean and standard deviation of all the X' co-ordinates, likewise for all the Y' co-ordinates.

Note: Both the X' and Y' co-ordinates are assumed to be normally distributed with their means estimated by $\overline{X'}$ and $\overline{Y'}$ respectively, and standard deviations by SX' and SY'. The whole configuration is referred to as a 'bivariate normal distribution'.

Stage 4

The major and minor axes of the 95% percentile ellipse for group 1 are calculated from:-



M ($\frac{1}{2}$ distance along major axis) = $SX'\sqrt{\chi^2_{2,95}}$

m ($\frac{1}{2}$ distance along minor axis) = $SY'\sqrt{\chi^2_{2,95}}$

Stage 5

The ellipse can then be drawn on the scatter diagram, as in Figure B.

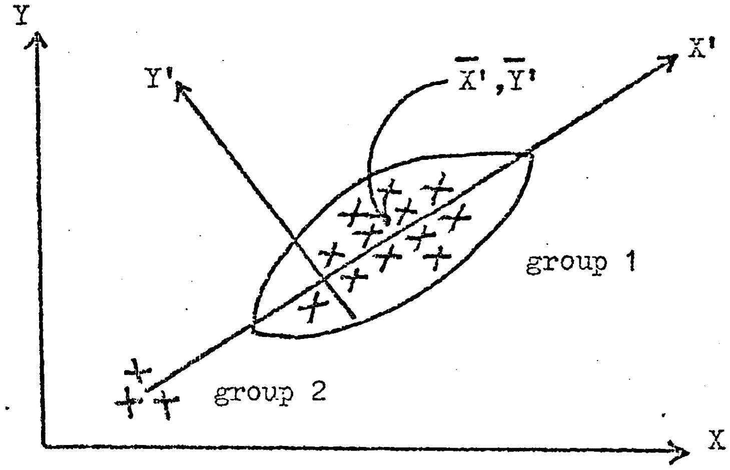


Figure B

In this example, the three points comprising group 2 are seen to lie well outside the ellipse round group 1 and the existence of two distinct clusters is therefore confirmed.