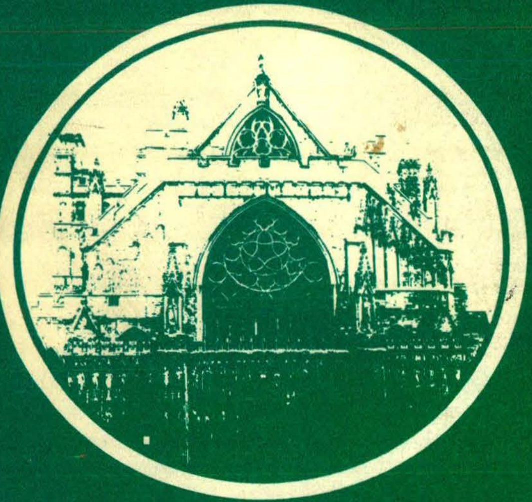
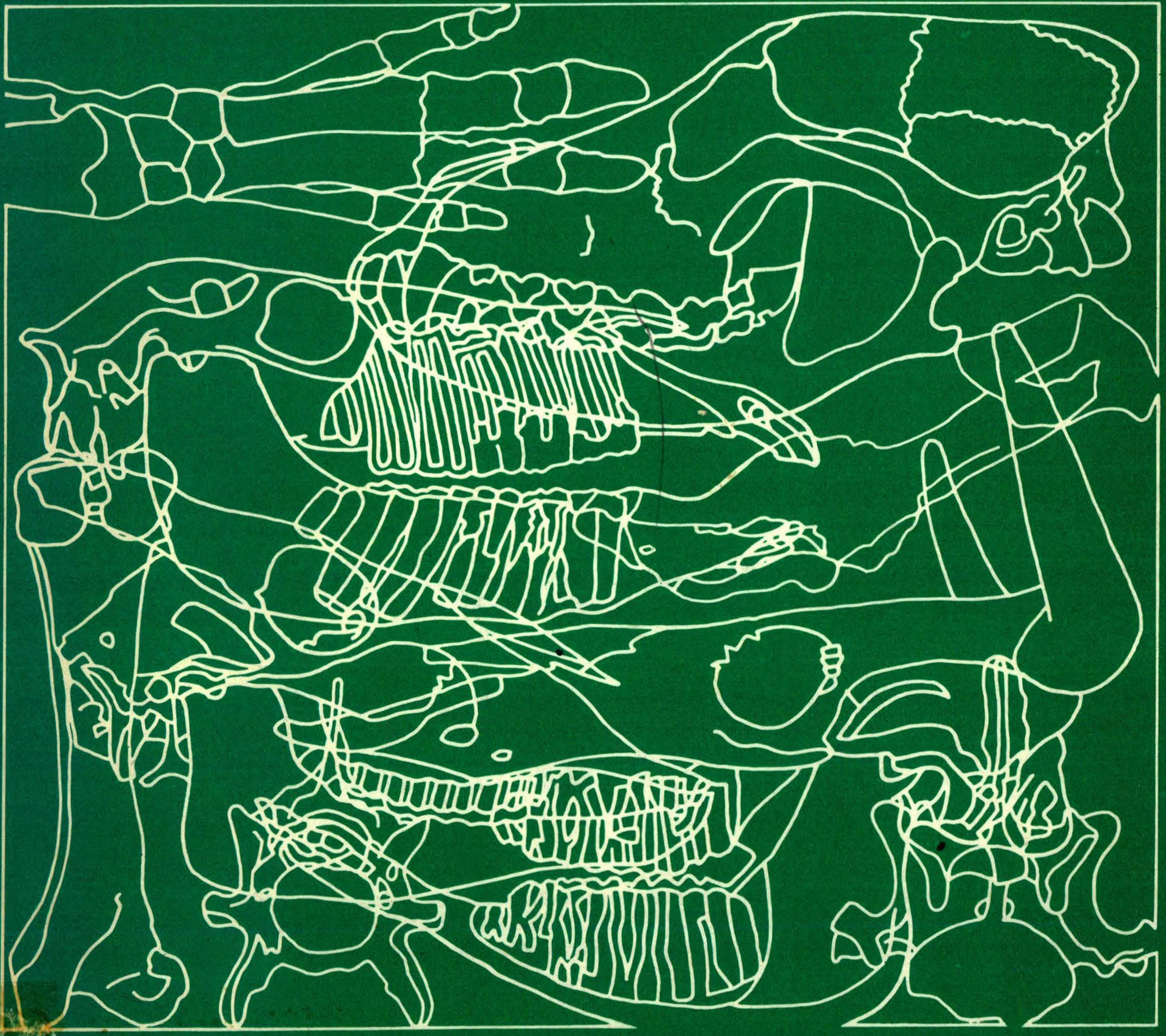
faunal studies on urban sites



the animal bones from EXETER 1971 – 1975

By Mark Maltby M.A.



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FAUNAL STUDIES ON URBAN SITES

THE ANIMAL BONES FROM EXETER

1971 - 1975

1979

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FOREWORD

The series of excavations which commenced in 1971 in Exeter in many ways epitomises the problems faced by urban archaeology in the last decade. Up to that time the initiative for archaeological research in the city, if not in Devon, lay with the University of Exeter, in the hands of Lady Aileen Fox, indeed for the two decades after the Second World War Aileen Fox *was* the archaeology of the southwest. When it was realised that major redevelopment was about to take place in central Exeter, it was again Aileen Fox who initiated discussion of financing excavations with the Department of the Environment, and also requested that I, as a newly appointed probationary lecturer in the Department of History, should direct the excavations. In addition the University agreed to give substantial financial aid to the excavations.

At the same time the more adventurous local councils were recognising their obligations to their archaeological heritage, among them Exeter City Council, who, under the initiative of their museum director Mr. Patrick Boylan, appointed a city archaeologist. In the event, Mr. Michael Griffiths did not take up his appointment until the summer of 1971 when excavations had already started. In theory I was to be the over-all director, but in practice two sites needed excavation, and we each took charge of one; myself on the Guildhall Site in Goldsmith Street (GS I, II, III), and he the St. Mary Major Site (MM) near the cathedral, though we were both under joint charge of our respective heads of department, Professor Frank Barlow and Patrick Boylan. On my departure to Sheffield in December 1972 Mike Griffiths took over total charge, including the final phases of GS III. From this time onwards the planning and execution of excavation in the city was in the hands of the City Council, as it should rightly be, for only in this way, within the planning department, can proper provision for archaeological excavation be arranged during redevelopment.

What then of the role of the universities? I hope in part this volume answers some of the questions, as we can provide both the facilities and the staff for the processing of archaeological finds and their publication. But we should not merely be considered as specialists on whom rubbish can be dumped for a 'specialist report' which will be assigned to an appendix and duly ignored, as long as the report is there for appearances sake. Sampling, indeed excavation strategy, can only be undertaken by close on-site cooperation between 'specialist' and excavator, as Mark Maltby's report makes abundantly clear. But there is also a danger that academics will drift out of rescue archaeology through lack of financial support; most funds now go directly to archaeological units, and I for one now use such university funds as I can muster to work abroad where I have more to contribute.

My special interest in the Exeter excavations lay in the socio-economic sphere, of which the animal bones are a major aspect, they were indeed the only group of finds I removed in their totality with me to Sheffield. I may be idealistic in believing that unless an archaeological director is himself capable of basic bone identification, he will be incapable of transmitting enthusiasm to the excavator in the trench, and the bones will end up so mangled as not to be worth the time of study; but I would suggest to many directors, throw them away unless you have some specific questions to ask. The Exeter bones were excavated with care, if sampling techniques are not what we would now demand, and this tradition of care has passed on to the present city archaeologist, Chris Henderson. The recognition of the importance of this bone collection, the most important by far from southwest England, has led the City Museum to accept the responsibility of storing them, though storage problems in Sheffield have caused some damage. As Mark Maltby himself admits, much more can be obtained from them, especially as our theoretical and technical skills develop. On the other hand poorly excavated bones (and pottery) are hardly worth the card-board boxes that contain them and should be discarded.

The first season in Exeter, based upon the model of Winchester, relied on a large influx of summer volunteers to whom a meagre subsistence was paid. Up to 80 workers were employed at one time, causing problems both of accommodation and control, but by the time GS III was started we were evolving towards the semi-professional small team of workers supplemented by a limited number of volunteers which is now the norm, raising standards of work and efficiency, especially in Exeter where we started with a lack of trained supervisors. But I still view advocates of a fully professional system with suspicion. Such a system, for instance, in Germany has led to a resistance to the introduction of new techniques (e.g. stratigraphy!), and has also divorced archaeology from its social context. A controlled use of local and seasonal volunteers will prevent archaeologists from becoming a brand of bureaucrat, and also allow interaction with local society, which is after all financing the project. Equally I hope the day of 'mass volunteers' are numbered with all the difficulty that implies in communication and control. If the aims and problems are not known, and questioned, by the workers at the trowel face and if volunteers are merely used as uninformed fodder, neither improvement of standards nor social relevance will be achieved.

The late 1960s saw a fundamental realignment of theoretical aims, and so of methodology in excavation techniques in urban archaeology. The expansion of aims from a narrow historical approach to one embracing a wide range of economic and social questions demanded a shift from the vertical section to the horizontal plan, from trench excavation to open area stripping, and from the start area excavation was employed in Exeter, with all its attendant problems - cost, difficulty of control, lack of rapid 'results' - and only now, in reports such as this on the animal bones, can our concern with late periods such as the seventeenth and eighteenth centuries, or with 'unspectacular' sites such as the Guildhall site at last be really vindicated. The site of visual impact, St. Mary Major, with its substantial remains of Roman masonry, while good for the archaeologists' public image, cannot be understood except in the total context of town houses and slums, cess pits and rubbish dumps. The city can only be viewed as a dynamic whole, both in spatial and chronological terms.

This volume is the second to be produced by the Department of Prehistory and Archaeology in the University of Sheffield, and as General Editor I would like to thank Miranda Barker, Gill Turner, Dorothy Cruse, Anne Hill and Cliff Samson for their help in preparing this volume, and of course to Mark Maltby for long hours of work both on the bones themselves, and on preparing the text for publication. The report has been generously supported by a grant from the Department of the Environment, and our thanks go especially to Sarnia Butcher for supporting what is a venture into an unpredictable area of publication.

Finally, as the publication of my excavations is now in the hands of the Exeter Unit, I would like to take this opportunity to thank my supervisors and assistants who worked for me on the excavation under often difficult and uncomfortable conditions. Eric Wayman, Dave Whipp and Chris Henderson were the main supervisors assisted by Sarah Campbell, Graham Black and John Reading. Stu May, Ann Gentry and Tim Shepherd were in charge of planning, and Sissel Collis assisted by Linda Hollingworth ran the finds shed.

John Collis
November 1979.

PREFACE

It is gratifying to find that many of the reasons I put forward to justify the detailed study of the Exeter animal bones over five years ago are still valid today. I wrote then that the material recently recovered from the excavations presented a rare opportunity to investigate a large and well excavated urban sample which could be used to monitor the exploitation of domestic animals in a major provincial centre throughout a substantial period of its history. It was intended that the analysis would examine possible changes in the meat diet, trends in the size and quality of the stock, various aspects of marketing practices and establish the importance of various species of wild mammals and birds in the diet. At the same time, I stress that the faunal material from Exeter would test the effectiveness of various methods of animal bone analysis when applied to a complex multiperiod site. Undoubtedly the original research proposal in parts reflected the naivety of someone embarking for the first time on a large faunal sample but the dual aims of reconstructing as much information from the Exeter animal bones as possible and, in conjunction with this, examining archaeozoological methodologies remain the major themes of this volume. I still believe that a great deal of information can be extracted from well sampled urban animal bone assemblages to supplement the knowledge about town life sometimes available to us in documentary records. Urban faunal samples, however, present many problems of interpretation and the work in Exeter has demonstrated some of these and has suggested ways of overcoming them I also hope others will benefit from my mistakes! As well as sheding some light on several aspects of Exeter's and Devon's agricultural history, I regard this work as a case study which I hope will be of value for current and future archaeozoological research on urban (and indeed rural) samples.

It is perhaps necessary to explain briefly how this volume came to take on its shape. The analysis of the Exeter animal bones began in October 1974 and formed the basis of a M.A. thesis in the Department of Prehistory and Archaeology at Sheffield University. The data presented in this volume rely heavily on that research (Maltby 1977), although some minor changes in phasing have since been taken into account. The layout of the book also remains substantially unaltered from that of the thesis, although Chapters 2-7 have all been revised and updated to a greater or lesser degree.
Mike Wilkinson has now investigated the fish bones from these excavations and his report has been incorporated in Chapter 7. The introduction (Chapter 1) and the conclusion (Chapter 8) have been completely rewritten and extended to cover several more general issues raised by this research. I make no apology for the large number of tables that appear at the end of this volume. The bones were not computer recoreded and these tables, besides being essential aids to the discussion in the text, should also be regarded as the archive for this material and thus easily accessible to archaeozoologists working on subsequent material from Exeter and also as comparative data for others interested in animal bone analysis in Britain and elsewhere. This is the first monograph published in this country concerned solely with British archaeozoological data. It is to be hoped that it will not be the last. At the same time, I hope that this work will not be regarded simply as a glorified specialist's report - a superbreed of the cursory appendix to the main site report, to which many faunal studies are still doomed If nothing else, I believe the work in Exeter has shown the potential such studies have in understanding many important aspects of complex societies.

The analysis was funded initially by a Department of Education and Science research studentship grant and then by a grant from the Department of the Environment. I also received generous financial assistance from my parents. I am grateful to Mike Griffiths, Chris Henderson, John Allan and Paul Bidwell for allowing me to study material from sites and for providing dating and other information about the bones. The chapter on bird and fish remains would not have been possible but for the detailed work on Mike Wilkinson on the fish bones and the kindness and patience of Don Bramwell, who guided me during my first faltering steps of bird bone identification and allowed me access to his comparative collection - my thanks to both. Robin Dennell kindly made available unpublished data from Plymouth. My thanks to Jennie Coy and Clive Gamble for their comments on earlier drafts of some of the Chapters. May I second the general editor's thanks to Miranda Barker, Dorothy Cruse, Gill Turner, Anne Hill and Cliff Samson for their work on the preparation of this volume for publication. Finally, special thanks to Graeme Barker, for his advice, encouragement and comments during the research and to John Collis, whose foresight in realising the value of the Exeter animal bones initiated this reasearch and who, as general editor, has guided this work through to final publication.

J.M.M.
December 1979.

1.

INTRODUCTION

The study of animal bones from archaeological sites is, to use a common economic cliche, very much a growth industry. During the last twenty years such studies have gradually become recognised as an essential aid towards the understanding of prehistoric and early historic populations. Much of the pioneering work was done in Germany and is epitomised by the production of detailed reports such as that for the iron age oppidum at Manching (Boessneck *et al.* 1971). In Britain, the value of economic and environmental data from archaeological sites was not realised until somewhat later. Previously, only a handful of such studies had been carried out and many of those consisted of short and cursory appendices to site reports. After years of such neglect the examination of animal bones has become much more common during the last decade. Ideally, the recovery of faunal remains should play an important part of the excavation of any site where they are preserved and an archaeozoologist should be consulted at the planning stage and during the course of an excavation to discuss recovery and sampling strategies. But, despite a growing acceptance by archaeologists that faunal studies are worthwhile, there are still those who remain sceptical about their value.

In addition, it is not surprising that faunal material from prehistoric sites has received much more attention than that from sites dated to Roman and more recent times. This situation has arisen because of the assumption that sufficient information about diet, livestock husbandry and other related topics can be found in documentary sources and that the collection and examination of animal bones are therefore of little consequence in these periods. This is a mistaken assumption. Such detailed documentary evidence is relatively rare and, where it does exist, it does not often relate directly to the specific questions being asked about an archaeological sample, which offer an insight into certain aspects of life that documentary sources are unlikely to provide. It is also interesting to compare the two types of evidence where they overlap and they should be used to complement each other where possible.

The scepticism of some archaeologists is perhaps to be expected when one considers the course of British archaeology during the last ten years. The growth of interest in faunal studies has coincided with the development of intensive rescue archaeology in both urban and rural settings. The recovery and examination of animal bones are expensive and time-consuming tasks for archaeologists with a limited budget and a minimal amount of time for excavation and they have the right to expect that their investments in this respect should provide dividends. Yet, although a number of site reports has been published on some relatively small samples and some specialised papers on particular aspects of faunal studies have appeared, very few major site studies have been produced in the last decade. Large faunal samples are essential, if we are to answer satisfactorily the detailed questions such analyses raise, or test sophisticated models concerning animal husbandry and marketing practices. However, extensive reports on animal bone assemblages of over 20,000 fragments have been limited to those from Portchester Castle (Grant 1975, 1976) and Melbourne Street, Southampton (Bourdillon and Coy *in press*). The situation will improve during the next few years as reports from extensive urban excavations at Winchester, London and elsewhere are published together with those from several important iron age, Roman and Saxon sites. At present, however, rescue archaeologists are faced with the problem of retrieving good faunal samples without a full appreciation of what they can achieve.

Bearing this in mind, the 75,000 animal bone fragments recovered from the excavations of the Exeter Archaeological Field Unit between 1971 and 1975 are important for two main reasons. In the first place, their study affords the opportunity to review the methodologies employed by archaeozoologists with particular regard to urban excavations. Secondly, they provide information about a fundamental aspect of life in the Roman and medieval periods. Exeter, the county town of Devon in southwest England, was first a Roman legionary base and then a *civitas* — a major provincial centre. Medieval Exeter was a thriving market town, which ranked as one of the largest in England. Later, it became the focus for an important cloth trade. In all, the faunal sample spanned a period of 1,800 years and provides an insight into the diet of the urban population and the agricultural economy of the surrounding area throughout that time.

What questions should be asked of the faunal samples from urban sites? Many of them relate to the everyday lives of their inhabitants. What was their diet? Did they supplement their meat supplies with the successes of hunting and fowling expeditions? Did a person's prosperity or status in society influence his diet? How were the domestic stock slaughtered, butchered and marketed? Were cattle most important for beef, their hides, dairy products or as working animals? Were sheep bred principally for meat or wool or milk or cheese? Identification of the fragments of animal bone can establish the relative importance of the different species. Recurring cut marks on bones provide information about butchery practices. Examination of the teeth and the epiphyseal fusion of the limb bones can reveal the age of the animals at death. Consequently, it is theoretically possible to reconstruct the mortality rates of the stock and understand their economic implications. Metrical analysis of bones and teeth can provide information about the size and quality of

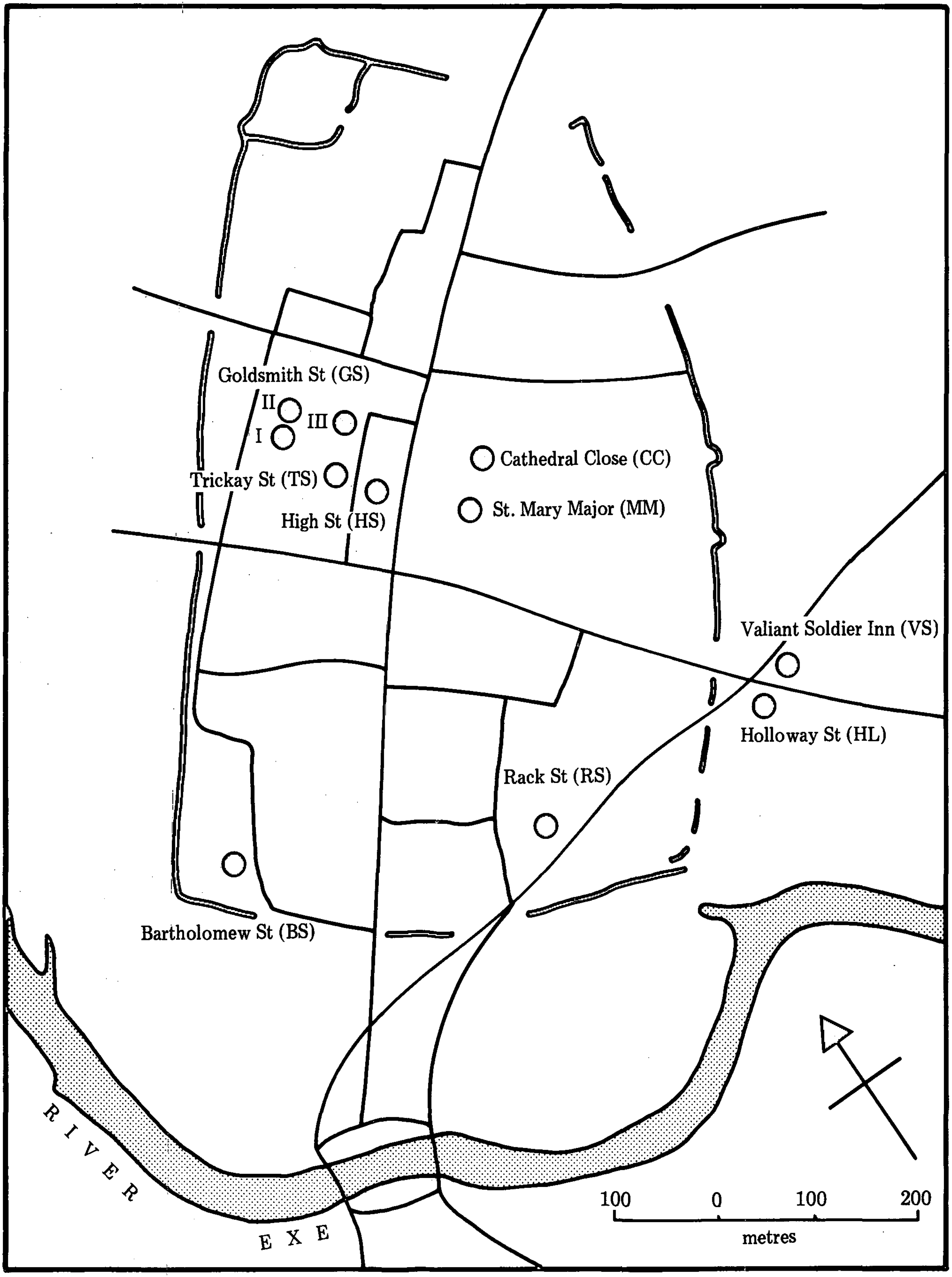

Figure 1 Map of sites under investigation at Exeter.

the stock, the ratios of female and male animals and even the different types of animal in existence at the time.

These are all important questions which faunal analysis should attempt to answer. Yet, as with other archaeological finds, the remains represent only a fragmentary proportion of the original data. The archaeologist is faced with the problem of interpreting postholes as meaningful structures and explaining their function. The expert in ceramics is expected to produce insights into the typology, provenance, dating, function and other aspects of pottery from the study of accumulations of very fragmentary sherds. Similarly, the archaeozoologist has to reconstruct all the aspects of faunal interpretation from inherently imperfect data. The rapid growth of intensive faunal studies has resulted in a number of methodologies to deal with the various aspects involved. Because the discipline is relatively new, there has been little attempt at standardisation. The approach has been one of trial and error and this trend will probably continue for some time. For there is no established way to investigate animal bones. Several detailed reviews of the methods and problems of faunal studies have been produced in the last few years (Chaplin 1971; Payne 1972b; Uerpmann 1973). These are all useful general surveys of archaeozoology but the study of urban assemblages produces additional dimensions that also have to be considered. It seems appropriate, therefore, to use the Exeter material as a case study and discuss at some length the methods of analysis employed. This gives the opportunity to review with the benefit of hindsight the methods originally used in the research, it is to be hoped in an objective way. Some of the methods are not now recommended for other urban sites, some could be modified or adapted in different ways, others are considered essential in the study of complex assemblages.

THE PROBLEMS OF QUANTITATIVE ANALYSIS

Quantification of animal bones involves their identification and recording and then the analysis of the material to assess the relative importance of each species on a site. It should also involve intra- and inter-site studies to assess how much variation there is in the animal bone assemblages.

The context of the sample

The archaeology of a town presents enormous sampling problems. Industrial areas, market places, public and ceremonial buildings, town defences and residential suburbs are just a few of the locations that may be excavated. These can be expected to produce a wide variety of material. The same applies to the faunal material found associated with them. The animal bones deposited from the slaughterhouse, the market, the butcher and the kitchens of rich or poor households may be completely different from each other. Accordingly the bone assemblage from one area of the town may not be typical of the rest and it is dangerous to read too much into such results. Conversely the existence of lateral variation is of interest and should be investigated thoroughly.

Exeter provided the opportunity to compare the faunal remains from the following nine sites:

1. Goldsmith St. Areas I-III (abbreviation: GS I-III)
2. Trickhay St. (TS)
3. High St. (HS)
4. St. Mary Major (MM)) Cathedral
5. Cathedral Close/Cathedral Yard (CC/CY)) Close
6. Rack St. (RS)
7. Holloway St. (HL)
8. Bartholomew St. (BS)
9. The Valiant Soldier site, Holloway St. (VS)

All these sites were excavated between 1971-1975 by Exeter University and the Exeter Archaeological Field Unit. They are situated in different parts of the city (Figure 1) and produced a wide variety of structures, pits and other features. The medieval and postmedieval bone samples investigated were collected mainly from the neighbouring GS and TS sites, both of which produced an abundance of material. The medieval deposits of the smaller HS site and the seventeenth century levels of the VS site were also studied in this analysis. The Roman sample consisted of material obtained from all areas except the VS site.

The excavated Roman deposits varied a good deal in their nature. The MM site produced the spectacular discovery of part of the Military Baths, which were converted into a Basilica and Forum in approximately 75 A. D. The GS and TS sites were residential areas until the fourth century when a cattleyard and associated gullies and ditches were constructed on the sites. The RS material was obtained mostly from the large defensive ditch, which incorporated part of the legionary defences and which was infilled from about 75 A.D. onwards. The remaining sites were predominantly residential areas.

The vast majority of the medieval and postmedieval material came from pits filled with cess or other domestic waste. Hardly any structural features survive because of postmedieval terracing. In the sixteenth century pottery kilns were constructed on the GS III site, while there is evidence that much of the GS I-II site was used for horticultural purposes. There is documentary evidence for stables on the TS site in the postmedieval period (Collis 1972; Henderson *pers. comm.*).

Investigation of the medieval pottery has not given any indication of major differences in social status before the sixteenth century on any of the sites investigated; imported vessels and fine jugs occurred in similar quantities in all areas. In the fourteenth century the TS site did possess large stone-lined pits, which did not occur on the GS III site until the sixteenth century. It is possible that the former area was more affluent than the latter in late medieval times. In the sixteenth century the GS III site produced many rich finds including Rhenish imports and the late seventeenth century levels of the TS site yielded objects of Chinese porcelain and glass. These wealthy finds were dated to a period of great prosperity in Exeter when there was a boom in the cloth trading industry in Devon. In contrast the pottery and other finds from the late seventeenth and eighteenth century contexts on the GS I-II site were conspicuously of a lesser quality. This appears to correlate with documentary evidence which describes the parish in which this site lies as being poorer and possibly subject to overcrowding at the time (Allan *pers. comm.*).

Preservation

The majority of animal bone originally deposited on any archaeological site does not survive. This stark reality has to be accepted by archaeozoologists. A whole series of physical, chemical and human agencies combine to destroy all but a fraction of the original number of bone fragments. The causes of destruction have been discussed in detail (Binford and Bertram 1977) and need not be elaborated here. Suffice it to say that the major agents of attrition are poor soil conditions, the erosion and weathering of unburied or shallowly buried bone, gnawing by carnivores and rodents, burning and fragmentation. Unfortunately these processes attack bone elements differentially. Some bones have a better chance of survival than others. Those most at risk are the small or more porous and less dense fragments. Bird, small mammal and fish bones are particularly vulnerable, as are the unfused limb bones of young animals of all species. In general, any fragment containing a high proportion of spongy cancellous bone (such as epiphyses, ribs and vertebrae) has a poorer chance of survival than those which consist mainly of cortical bone. All faunal samples are therefore biased towards the denser bones. The extent of this bias depends on the degree of attrition. Accurate methods of measuring these taphonomic processes have not yet been devised and research into the problem is only at an early stage. Until this has advanced, absolute reconstruction of the bone originally deposited is impossible using the methodology commonly practised on faunal data. Nonetheless, it is possible to observe the standard of preservation of the bone fragments and compare the evidence from different sites and periods in relative terms. Urban sites often offer a better chance of bone survival than others, since a lot of rubbish was buried deeply in pits and wells and other features where preservation conditions are good. Bone is soon destroyed if left lying open to the elements. The problem of extensive urban archaeology, however, is that the preservation conditions may vary significantly between widely separated areas and cause difficulties in inter-site comparisons.

The preservation of bone on all sites in Exeter was extremely good in general. Observed erosion on the bones investigated was confined to relatively few features, usually in association with slowly accumulated layers, in which the bones had probably lain on or near the ground surface for some time. The material of postmedieval date was generally in a better state of preservation than most of the Roman material; but the improvement was slight and usually only affected the results to a small degree. A few bones had evidence of gnawing on them, mostly by dogs. Most of the bone was unaffected by this, however, and this suggests that a lot of the material was buried soon after disposal. Dogs and rodents will have completely destroyed other fragments, however. There were a few cases of burnt charred bone in the deposits, the most numerous examples coming from the extremely rich GS III F.228 and TS F.316 pits, in which certain layers also produced many bones that had concretions adhering to them. These exceptions apart, the large majority of the bone was in a good but fragmentary state of preservation.

Recovery methods

The recovery methods can affect the nature of the faunal material studied. Payne (1972a, 1975) has shown that unsieved faunal samples tend to be biased towards the larger mammals because the bones of smaller mammals, birds and fish are more likely to be overlooked during excavation. The extent of such a bias also varies according to how well the bone is preserved. Sieving experiments at the early medieval settlement at Dorestad, in the Netherlands, revealed that the unsieved material was biased in favour of cattle and horse in comparison with pig, sheep and goat. Water-sieving produced an enormous amount of fish, bird and small mammal bones, of which very few were recovered from the initial excavation (Clason and Prummel 1977). Urban rescue archaeologists can rarely afford the time and labour to water-sieve all deposits. Such material also takes much longer to process and study and there is a limit to the amount of information that can be gained from its study. As Payne (1975: 16-17) points out, the answer must lie in sample-sieving and a flexible approach to such a strategy is needed.

Although the majority of the deposits in Exeter were not sieved, some sections of RS F.363 were both dry- and wet-sieved. The results obtained from these samples differed little from the unsieved material. However, this feature - a large defensive ditch that was deliberately infilled from about 75 A. D. onwards - is exceptional in that it was used as a depository for a vast amount of cattle mandible, skull and metapodia fragments and very little ordinary kitchen refuse was found in it. A limited amount of wet-sieving was carried out on GS I and GS II, but the return was so minimal that it was abandoned. Consequently, the sieving experiments must remain inconclusive with regard to the sample as a whole. It is fair to say that the standard of recovery and preservation at Exeter was very good; nevertheless it has to be assumed that a lesser proportion of the bones belonging to smaller animals, birds and fish was recovered, although the amount of bias is uncertain. Sample-sieving of some of the richest waterlogged pits probably would have increased the representation of the smallest animals and have provided additional information about the fauna in the deposits. However, assuming that the standard of excavation was similar in deposits of all periods, it is possible to make direct comparisons of the samples collected from them and to observe the relative changes in the assemblages. Detailed analysis of the Exeter deposits was able to test this assumption and in general found it to be true. Variations in the faunal assemblage in most cases could be explained by differential preservation and disposal practices rather than recovery bias.

The dating of the sample

The complexity of urban sites provides great problems of phasing and dating. It is very difficult to relate the phased stratigraphy of one site to another and the archaeozoologist has to rely heavily upon the dating evidence provided by the pottery and other artifacts. Often the dating of such objects is open to question and this causes further difficulties. Of even greater concern are the factors of redeposition and contamination of layers with material of other dates. To counter this, special care is needed to observe the fills of the deposits and the preservation of the bone, which can often indicate the likelihood of contamination.

The Exeter sample was divided into three major periods, Roman (about 55 A.D. to early fifth century), medieval (eleventh to fifteenth centuries) and postmedieval (sixteenth to late eighteenth centuries). Where possible these periods were divided into phases which spanned 50 years. This was not practicable in all cases since the pottery evidence, upon which the dating principally relied, was not always diagnostic to a particular 50 year period. When this occurred certain phases were extended to cover a longer time span. Details of these divisions will be given in the following chapter.

All deposits that were not securely dated were not considered in the analysis. Some of the Roman features examined may have had a little later medieval material in their make-up but the percentage of this would have been too small to bias the results significantly. Many of the early medieval features contained residual Roman pottery; indeed sometimes over 50% of the sherds were Roman in origin. However, many of the pits involved, especially those dated to the eleventh and early twelfth centuries, had black anaerobic fills which included much bone but very little pottery. The Roman residual sherds therefore tended to form a high percentage of the total potsherds but it is thought that the percentage of Roman bone in those early medieval features was of a much lower order, probably negligible in many cases. Prior to the twelfth century there was so little contemporary pottery in circulation that the presence of a few Roman sherds tended to overemphasise the amount of residual material present (Allan *pers. comm.*). Certainly, the amount of residual bone cannot be estimated on the percentage of pottery alone. In addition, the fills of these pits contrasted markedly with other features which did contain redeposited Roman material and which were not considered in the analysis. The medieval features which contained relatively high proportions of Roman pottery showed no significant variation from those with no residual material whatsoever, as far as the faunal remains were concerned. On the other hand, these medieval samples generally showed consistent variations from the Roman faunal material, thus supporting their independent and later origins.

THE METHODS OF QUANTITATIVE ANALYSIS

Any analysis of 75,000 items of data requires careful consideration of methodology. This has to be designed to take into account the complexity of the variations involved. Most of the published bone reports quantify the material by counting the number of fragments and recording the percentages of each species identified. Alternatively, various methods of estimating the minimum number of individuals of each species are employed. The percentage figures are then used to draw conclusions about the relative or absolute abundance of each species and their importance to the diet and economy. In the case of a multi-period site, the figures from each period are compared with each other. Such simplistic comparisons, however, are meaningless unless it can be shown that the samples are unaffected by variations in fragmentation, preservation, recovery methods, butchery practices and other possible biases. To do this the faunal analyst has to examine in more detail the type of bone fragments recovered. Many reports list the number of fragments of each bone element but such statistics are rarely analysed in any depth. It is only by such a study, however, that any real understanding of the sample can be obtained. This analysis formed a substantial part of the research on the animal bones from Exeter and the methods used warrant some discussion.

Identification

The identification of animal bones depends on an adequate comparative skeleton collection. Some fragments are more identifiable than others and often a time factor is involved in how long an archaeozoologist spends in attempting to identify each fragment to a particular species. Such considerations on the Exeter material meant that ribs and vertebrae (other than the atlas, axis and sacrum) were counted but not assigned to species. It is difficult in many cases to differentiate between certain species from the fragmentary remains of ribs in particular. The numbers of rib and vertebrae fragments are included in the number of unidentified fragments in the appropriate tables, of which they constituted between 60 to 90%. The decision to include vertebrae among the unidentified material was one enforced by pressures of time and by some inadequacies in the comparative reference collection originally used. This policy is not recommended for other sites, however, since vertebrae are good meat bones and provide important information about carcass disposal and butchery techniques and should therefore be identified to species where possible. The remainder of the unidentified material consisted mostly of small splinters of bone, which could not be assigned to species but which, like the ribs and vertebrae, could often be categorised as 'large mammal' (cattle, red deer, horse), 'medium mammal' (sheep, goat, fallow deer, roe deer, pig, dog), 'small mammal' (hare, cat, rabbit, rodent, etc.) and 'unidentified bird'.

Determination between sheep and goat is very difficult from bone evidence since differences between certain bones of the two species are very small and the fragmentary nature of an archaeological sample means that many specimens cannot be assigned with any confidence to one of the two species. Their bones will henceforth be referred to as 'sheep/goat'.

Analysis by fragment count

Each bone fragment examined was recorded and wherever possible assigned to species. Quantification by employing a simple count of fragments is still the most common method of analysis but it has recognised drawbacks. Estimating the percentage of each species from the number of identified fragments has been criticised because, since any bone can break up into several fragments, a large number of fragments may represent just one animal. A few animals may thus be represented by a disproportionately high number of identified fragments. The degree of variation may also vary between species. The following hypothetical example is given by Chaplin (1971:65-66): 'It may therefore be expected that if a usable joint is about the size of a leg of lamb, the femur, in the case of the sheep, will probably survive butchery and cooking, whereas that of the ox may be cut into a dozen or more pieces. In many cases the leg of beef may be boned out before the meat joints are cut and the bone chopped up to provide a meal in itself. Of these dozen pieces, perhaps five (to be conservative) will be identifiable compared to only one intact bone of the sheep. There is therefore a bias if the species ratio is based upon the number of fragments'.

Of course in actual practice the situation is not as clear cut as this. There is usually a good deal of variation in the size of fragments from any particular bone. Nevertheless it is true to say that the fragments method of counting does favour the largest mammals, in particular cattle, rather than pig and sheep/goat. This has to be borne in mind when considering the results.

Other problems concerning this method are easier to overcome. Certain species possess more bones in their skeletons than others. For example, a horse has twelve phalanges, cattle and other ungulates 24, a pig has 48 and a dog 52-58 (Payne 1972b:68). Smaller discrepancies occur also in the number of metapodials and teeth which each species possesses. Pigs, dogs and cats also have a fibula, whereas cattle, sheep/goat and deer only possess the vestigial remains of this bone which are very rarely recovered. Generally the bones involved did not occur in sufficient numbers to bias the sample significantly. Reference will be made to any feature or group of features that were exceptions to the rule.

A similar methodological problem relates to the occurrence of the burials of animals amongst other faunal remains. Several burials of animals were found in the deposits. For instance, from the Roman period there were three immature pig skeletons of late first century date (73 fragments), 42 fragments from one badger skeleton and 24 from two dogs, the badger and dogs being of third century date. From the fourth century levels another burial of a dog provided ten fragments and a partially preserved woodmouse skeleton contributed twenty. The pattern was similar in the medieval period, in which a dog burial of late thirteenth century date contributed thirteen fragments to the total. Two cat burials, the first of twelfth century date and the second of late twelfth-early thirteenth century date, contributed 35 and 21 fragments respectively. None of these animals bore evidence of butchery marks and it is clear that they were not part of the food supply, having in most cases been simply dumped on the rubbish heap. Obviously the presence of such skeletons inflates the total number of fragments of the species in question to a higher level than is truly representative and accordingly biases the results. The number of fragments from these burials was recorded but should be discounted from any overall assessment of the number of fragments. The presence of a burial or burials in a particular phase will be indicated in the relevant table by an asterisk against the species. Fortunately the five immature pig burials (three of Roman, one of medieval and one of postmedieval date) were the only examples of burials of the major stock animals, so the overall assessment of these was virtually unaffected. Most of the skeletons belonged to cats, dogs and other animals that are not considered to have been butchered for food. It is probable that many of the other bones of these species recovered from the excavations also belonged to burials but not enough of the skeleton has survived to establish this fact. This situation reached its greatest complexity in some of the large postmedieval deposits. For example, there was a big concentration of dog remains in TS F.316 (late seventeenth century), 265 fragments from a minimum number of 24 individuals were recovered. There seems no doubt that a large number of dogs was dumped in the pit but it is difficult to establish exactly how many since the skeletons were so mixed.The presence of such concentrations of burials undoubtedly biased the sample as a whole, especially when employing the fragments method of counting.

Analysis of the minimum number of individuals

Discussions of the methodology, interpretation and justification of this second method of quantification have appeared regularly during the last few years (Chaplin 1971; Payne 1972b; Grayson 1973; Uerpmann 1973; Casteel 1977). The aim of such calculations is self-explanatory and has the advantage of eliminating many of the problems of fragmentation from the analysis. It has to be emphasised that the method is merely a device to quantify the data in a formalised manner and the results should not be treated literally. The statement that a minimum number of 60 cattle and 30 pigs was represented on a site does not mean that cattle were twice as numerous as pigs. It merely states that the method of calculation used in the analysis produced these results. Given similar preservation, recovery practices, methodology and other factors, the results can be compared with those of another period or site. As with the simple count of fragments, it is the establishment of the homogeneity of the different samples that is the major problem.

The minimum number of individuals can be calculated in a variety of ways. Applied to the same material they may produce different results. Each method is subject to the vagaries of sample size and aggregation of the sampling units (Casteel 1977). Archaeozoologists should state clearly the particular methods they employ. The method adopted on the Exeter material was as follows.

The minimum number for each bone element (mandible, humerus, etc.) was established for each species for every individual feature. This was achieved by separating left-sided fragments from right, counting shaft fragments as well as those with articular surfaces still present. Fusion data and, in the case of jaws and teeth, evidence of tooth eruption were also taken into consideration.

The minimum number of animals belonging to a particular phase on a site was calculated for each bone type by adding together the numbers attained for each feature. This cumulative process assumed that there was no admixing of the same bone elements in different deposits of the same date. This is undoubtedly a false assumption. It can be argued justifiably that, for example, five fragments of the same cattle tibia may have been scattered in five different features and that theoretically the cumulative method of analysis may suggest that they came from five individuals. However, on a complex urban site often dealing with phases of 50 years or more, the sample of animal bones recovered is such a small proportion of the bones originally brought to the town that it is extremely unlikely that this factor would bias the results significantly. It should also be observed that had time allowed large numbers of measurements to be taken for each bone element, the minimum number of individuals would have been substantially increased in many features, since the discrepancy in size would not have permitted as many bones to be 'paired' with fragments from the opposite side of the body.

The percentages obtained for the various species for each phase by this method were taken from the most common bone element represented. The type of bone varied between species and between different phases and sites. Details of these for cattle, sheep/goat and pig will be found in Tables 7, 8, 9 and 10. In phases where material from more than one site was examined, the minimum number of individuals represented on each site was added together, irrespective of the bone element which produced this figure. This assumed that parts of the same animal were not scattered throughout the various sites. This again is probably a false assumption but the chances of this seriously biasing the results are small.

As is to be expected, there was a marked difference between the percentages obtained by a count of fragments and those calculated from the minimum number of individuals. The levels of cattle were much lower according to the latter method, with a fall of over 25% in some cases below the figure reached from the count of fragments. This discrepancy between the two methods has also been noted by Higham (1967: 85-86). It can be explained to a large extent by the fact that bovine bones, being relatively larger, have a greater chance of breaking into fragments that cannot be paired when calculating the minimum numbers. It was observed, for example, that whereas in certain features three fragments of sheep/goat or pig tibia belonging to the same side of the body would produce a minimum number of two or three individuals, three fragments of cattle tibia more often could only be given a minimum number of one, since they could have belonged to different parts of the same bone. This applied to all long bone, jaw and skull fragments. For every 100 fragments of a species identified, an average minimum number of 6.72 individuals was established for sheep/goat, 7.82 for pig but only 4.54 for cattle. A drawback in using this method of calculating the minimum numbers is that variability in context size may affect the results. The ratio of minimum numbers to fragments is higher in smaller features than in larger ones. Consequently, if the size of the bone assemblages in individual features varies significantly on different sites or in different periods, the results of the minimum number calculations may be influenced. More detailed studies of this ratio on the Exeter material did show a fairly consistent pattern between the different phases and sites and most of the variability could be explained by small sample size in some of the phases rather than by any dramatic changes in the fragmentation of the material.

One of the acknowledged problems of the minimum numbers method of analysis is that it overestimates the importance of the rarer species in the sample. Reference to Tables 1-6, 11, 14, 17, 20, 23, 26, 29, 30, 33, etc. will demonstrate this. Percentage figures obtained from small samples are thus unreliable. Bird bones present problems for the same reason. Because of the large number of species involved, the minimum numbers method tends to overstate their importance. Consequently it was decided to treat their remains separately.

The various minimum numbers methods of quantification have been claimed to be more reliable than a simple count of fragments and they do take into account more of the variables encountered in faunal assemblages. This advantage is, however, negated to a certain extent by the fact that, by reducing the figures for estimating the relative importance of each species by about 90% when compared to the fragment method of counting, only the larger samples carry any statistical importance.

Statistical tests

The two types of analysis described above were used as the basic quantitative methods for the faunal data from Exeter. However, to test their suitability to deal with complex urban samples, certain statistical techniques have to be applied. Two main considerations governed the type of test that was used. The first was that ideally the tests should be relatively straightforward to give a quick indication of inter-site variability and at the same time give a rough guide to the causes of this variability. Chi-square tests were found to be a useful means towards this aim. The second consideration was the size of the samples, which limited the range of tests that could be used, particularly with regard to the minimum numbers method. The statistical analysis was therefore restricted to the major stock animals — cattle, sheep/goat and pig. The samples of all the other identified species were too small to make similar analysis worthwhile.

In such tests, ideally each bone element should be considered separately. However, unless the samples are very large, the number involved would be too small for statistical tests on some of the less common elements to carry much weight. Consequently, the bone elements had to be amalgamated into categories and the following subdivisions of the skeletons were selected for study and comparison:

Category 1 — the mandible, loose teeth, maxilla and other skull fragments.
Category 2 — the scapula, humerus, pelvis and femur.
Category 3 — the radius, ulna and tibia.
Category 4 — the metapodials.
Category 5 — the carpals and tarsals.
Category 6 — the phalanges and sesamoids.
Category 7 — other bones (atlas, axis, sacrum, patella, fibula).

These categories were chosen in order to group together bones of similar uses and functions. Thus the parts of the carcass from which most meat can be obtained are included in Category 2 (although depending on butchery methods, both the scapula and pelvis can be treated as waste material). Category 3 consists of meat bones of a lesser quality. The other categories generally have little meat value, although both the skulls and feet can be boiled up for brawn and similar products. The phalanges were placed in a separate category from the metapodials since they may have served a different purpose. Cattle phalanges, for example, are often boiled up for glue, whereas the metapodia, especially of sheep/goat and cattle, offer good raw material for bone tool and ornament manufacture. These categories were used as the basis for testing both methods of quantitative analysis. They were designed to recognise the occurrence of lateral variation and suggest the principal causes. Subsequent multivariate analysis on faunal material from Exeter and other sites has suggested that these subdivisions are probably too crude (Maltby *in preparation*) and the bone categories should be divided still further. Some of the results of such tests are discussed in Chapter 2.

Ideally too, the bone assemblages of each feature should be considered separately. Once again, however, the logistics of sample size prevented this. Instead, for each phase the samples were subdivided by site and compared. Obviously, variations can occur at intra-site level as well and should be taken into consideration. Such phenomena were noted and will be discussed at the appropriate point.

The number of fragments for each of the seven categories was totalled in each of the principal stock species. To test for lateral variation within each phase or longer period, the proportions of the categories for each site were compared with the grand total for that phase or period. Chi-square calculations were employed to test whether the observed variations were significant. Exactly the same procedure was carried out on the minimum numbers method. The minimum numbers obtained for each bone element within each category were added together to obtain the sum of the minimum numbers (S. M.). The category proportions of these in each phase were then compared using chi-square calculations for each species in turn. The analysis was therefore designed to test the null hypothesis that, for each species, the proportions of the seven categories were similar on each site in the particular phase or period under consideration. In cases where the statistical tests confirmed this hypothesis, one was entitled to accept that the deposits contained a homogeneous sample of bones.

The results of these tests will be discussed in detail later but they revealed that there was often a significant degree of variation between features and sites dated to the same phase. This lateral variation is to be expected in a complex urban site. It emphasises the limitations of sampling only a restricted area on any large site, since the excavated area may not be representative of the whole settlement. It also calls for a cautious approach where two different sites are to be compared. In order for the comparison to have any validity, not only do the preservation conditions, excavation techniques and methods of analysis need to be similar, but the two samples should also show similarity in the proportions of the different bones represented in each of the major species. A simple comparison of the number of fragments or the minimum number of individuals is not in itself sufficient: in the Exeter sample it was found that even in phases where there was close agreement in the percentage of the animals represented on the different sites, it did not necessarily mean that the samples were similar in content.

The same considerations have to be taken into account when comparing material from different periods. Percentages obtained from simple counts of fragments or by analyses of minimum numbers of individuals cannot be compared directly, if the samples from which they are obtained differ significantly in their constituent parts.

The tests devised for the detection of variation in the samples were experimental. More sophisticated statistical methods can be developed to study these, provided the samples are of sufficient magnitude. The categories, for example, can be further subdivided in such analyses and correlations between the relative frequencies of individual bone elements can be compared. The tests were sufficient, however, to demonstrate the variations in the Exeter faunal assemblage and give some indication of the causes. They certainly demonstrated that, if large multi-period faunal samples are to be subject to quantitative analysis, or if assemblages from different sites are to be compared, the usual methods of such analyses have to be extended to deal with them in a meaningful manner.

THE STUDY OF THE INDIVIDUAL SPECIES

The problems and methods of the study of the individual species will be discussed in more detail in Chapters 3 to 7. This section will therefore be confined to a brief outline of the particular methods employed on the Exeter material.

Ageing methods

There are two ways of ageing animals from bone fragments currently employed by archaeozoologists: the first is to study tooth eruption and tooth wear, the second is to examine the evidence of epiphyseal fusion of the long bones. Both methods were employed on this sample.

Six stages of tooth eruption were selected for cattle and pig. Both mandibles and maxillae were examined in order to discover which of the stages had been reached. It was then possible to estimate the percentage of animals killed before each of the six stages had been attained. Jaws were often incomplete and this factor sometimes made it impossible to determine whether or not certain of the eruption stages had been reached. For instance many cattle jaws just had one or more of their permanent molars (M1-M3) intact and in wear. These jaws produced no direct evidence as to whether the fourth premolar (P4), which has a later development than the permanent molars in cattle, was also in wear or not. Consequently in the tables, where applicable, a minimum and maximum percentage of animals killed at each stage of tooth eruption is given.

It is apparent that when a large number of jaws gives insufficient evidence, any conclusions made on the ageing data will in consequence be rather vague. Accordingly, the wear patterns on selected samples of cattle and pig mandibles were studied using the method devised by Grant on the Portchester Castle bone sample (Grant 1975: 437-450). Using this method it was possible to estimate much more closely how many of the jaws would have reached the various stages and also, especially in the case of cattle, how long an animal lived after its tooth eruption sequence was complete.

Absolute ageing of domestic animals from archaeological sites is notoriously difficult. Variations in nutrition, breed and stock management all influence the rate of tooth eruption. To use modern figures from improved stock as absolute figures is known to be misleading. The use of nineteenth century data may be of more value (Silver 1969: 295-296) but it is nevertheless impossible to be certain of the true age of tooth eruption during any of the periods. This should be remembered when reference is made to the ages of cattle and pig in the later chapters.

Similar stages of tooth eruption and wear were established for the sheep/goat jaws. More detailed analyses have been attempted in recent years on these. For example, Ewbank *et al.* (1964) devised a detailed method, which divided the tooth eruption sequence into 26 stages with estimated ages for each stage. Carter (1975) adapted and modified this sequence and also measured the heights of the P4, M1, M2, M3 and p4 (fourth deciduous premolar) from the highest point of the crown to the division of the roots. By assuming that the wear on these teeth produced a fairly uniform decline in height, the method theoretically can calculate the age of a mandible or maxilla. Adopting a rather slower rate of tooth eruption than that allowed for by Ewbank *et al.*, Carter has claimed that a jaw with all three permanent molars intact can be aged to within a month with 80% confidence when applied to sheep jaws of iron age to medieval date in the Thames Valley region. This experimental method was tested on the material from Exeter with some interesting results.

Two other methods of studying sheep mandibles were taken into account. Both of these (Grant 1975; Payne 1973) rely on the study of the tooth eruption sequence and the wear patterns of the cheek teeth. It was possible to compare the results of Grant's and Carter's methods on some of the medieval material.

None of the methods established with any certainty the true age of the animals brought to the town. Research into the absolute ageing of teeth from archaeological sites is needed urgently. The various methods were able, however, to record the relative changes in mortality patterns and these were used to infer changes in the exploitation and marketing of the stock.

Epiphyseal fusion occurs on all mammalian long bones. A similar process occurs in bird bones as well. In mammals some epiphyses, for example the distal humerus and proximal radius, fuse at a much earlier age than others, such as the two epiphyses of the femur. It is possible, by grouping together epiphyses of approximately the same fusion age, to estimate the percentage of animals slaughtered before a particular fusion stage took place. Once again the ages given to these stages are adapted from data obtained from modern 'scrub' crossbred animals, which through improved breeding and better nutrition may have faster rates of development than animals of Roman and medieval date (Silver 1969: 285-288). Nevertheless, they can provide a general indication of the culling pattern. The percentages obtained for both ageing methods should be considered as the minimum figures, since in an unsieved sample the smaller and more fragile bones and jaws of the younger animals have less chance of recovery.

The study of epiphyseal fusion data is, however, less reliable than that of tooth eruption. Differential preservation of the long bones has a significant bearing on the results. Epiphyses with later fusion ages are more vulnerable to destruction than those which fuse at a comparatively early age. This causes discrepancies in the results, which will be discussed in the appropriate sections.

Metrical analysis

Measurements were carried out for two purposes. In the first place, specific measurements were used in an attempt to differentiate between species, type and sex. For example, metrical analysis of sheep/goat metapodia and calcanea was carried out to try to distinguish between the species. Specific measurements of sheep scapulae were taken to try to establish whether long- or short- tailed types were present on the site. Measurements of the metacarpi of cattle attempted to differentiate between cows and steers. Secondly, general measurements were taken in order to assess the size and quality of the stock animals and to note any improvements during the periods involved. The key to the measurements taken appears in Appendix 1. Tables were compiled of the sample size, range, mean, standard deviation and coefficient of variation for each measurement in all periods. Where possible measurements were compared to those from other contemporary sites in order to observe any variations between different regions. Many of the measurements correspond to those described by von den Driesch (1976) and can be compared directly with other European faunal assemblages.

Butchery practices

Any cut marks discovered on bones and any recurrent breaking points were noted. From these observations it was possible to draw some conclusions about butchery practices. It was possible, for instance, to discover in what way the carcass of a particular animal was divided up into joints and how certain bones, horns and antlers were used in the production of tools and ornaments. The study of the proportions of the various categories of bone represented in each species also provided information about butchery practice in the periods concerned.

Skeletal abnormalities

Note was taken about any bone that had suffered a trauma or had been affected by disease. Certain congenital factors were also observed and are discussed in the appropriate section.

The strands of evidence discussed above were drawn together in an attempt to obtain a clear idea of how each species was exploited and how this exploitation varied during the 1,800 years of occupation under consideration. The recent series of excavations in Exeter has recovered one of the largest and best preserved faunal samples from an urban site in Britain. The analysis that follows inevitably raises as many questions as it solves but these are questions that will be answered by further work on faunal samples from other contemporary urban or rural sites. It is still true to say, however, that the animal bones from Exeter present an invaluable opportunity to examine the animal exploitation of a regional centre in the Roman and succeeding periods. In the following chapters I will endeavour to make the most of this opportunity.

2.

THE QUANTITATIVE ANALYSIS

The purpose of this chapter is to study in detail the results of the quantitative analyses for the Roman, medieval and postmedieval periods in turn, in order to observe the changes and trends that were taking place.

In the consideration of the data from these periods, it is tempting simply to compare the relative percentages of the species present in the various phases without regard to any variations in the types of bone fragments encountered. However, such a method of analysis is too simplistic. It cannot be assumed that the faunal sample from Exeter, despite its large size, represents, in any phase, a cross-section of the animal bones deposited in the town at the time. Accordingly, it is hazardous to compare results from different phases without first considering the types of bone fragments present in the samples, since variations in these may influence the relative percentages obtained for each species. Therefore, in order to make valid comparisons between samples of different dates, it has first to be established that the samples under consideration are statistically similar in their constituent parts.

The following analysis therefore also endeavours to test whether the quantitative methods usually employed on archaeological faunal material are adequate for complex sites. As a result, the study of the samples from many of the phases is of a lengthy and detailed nature. Space precludes the publication of all the data on which the results are based but summaries of the number of fragments of each species and the minimum number of individuals represented are given for each phase. Where the samples are of sufficient size, the proportion of fragments and the proportion of the sum of the minimum numbers (S.M.) within each of the seven bone categories (as described on page 7) are given for cattle, sheep/goat and pig. The analysis is published in full to aid comparisons with other sites and to act as the basis for future work in Exeter itself. Some may not wish to study the results in their full detail and accordingly a discussion and summary of the conclusions are given for each major period at the end of the relevant section. The chapter ends with a discussion of the methodology of quantification in the light of this study and the general conclusions that can be made about the animals represented in Exeter.

THE ROMAN PERIOD

The subdivision of the sample

The total number of bone fragments examined from the eight sites with Roman material amounted to 18,317 of which 9,730 were identifiable. The sample was subdivided into the following nine groups:

R1) The period of military occupation (approximately 55 to 75 A. D.).
R2) The late first century (approximately 75 to 100).
R3) Features dated to 55 to 100.
R4) Features dated to the late first-early second centuries (approximately 75 to 150).
R5) The second century (100 to 200).
R6) The third century (200 to 300).
R7) Features dated to the second and third centuries (100 to 300)
R8) The fourth century until the end of the Roman occupation (300 and after).
R9) Undated Roman features.

It was possible to subdivide the sample into smaller units in the first place the dating evidence was not precise enough and some of the rubbish layers may have accumulated over a considerable period of time; secondly further subdivision would have made many more of the samples too small to be statistically significant. The number of fragments and the minimum number of individuals for phases R3, R4, R7 and R9 are included in Table 6 but the number of fragments found was insufficient for any assessment of a more detailed nature to be worthwhile. Tables 1 to 6 include all the fragments recovered from the various Roman deposits. The presence of any burial or burials is marked in the table by an asterisk and the number of fragments involved is given in the footnote to the table. The tables do not take into account variations observed in the Roman samples and it is these that need to be considered in depth.

The individual phases

R1 — Features dated to the period of military occupation (approximately 55 to 75 A. D.)

Material was recovered from the GS, TS, RS and Cathedral Close (MM/CC) sites (Figure 1). The GS and TS sites were partially occupied by barrack blocks during this phase and the Cathedral Close sited included material associated with the building of the legionary baths. Consequently, this gave an opportunity to compare the bone assemblages from sites of quite different natures during the period of occupation by the Roman forces.

2,717 animal bone fragments were examined, of which 1,321 were identifiable. 96% of the identified mammalian fragments from all the sites belonged to cattle, sheep/goat and pig (Table 1). The identified fragments of the principal stock animals were subdivided into seven bone categories and the results are shown in Table 7 for the GS, TS and MM/CC sites. The sample from the RS site was too small for detailed analysis. It can be seen that cattle fragments were more abundant on the GS site, in which they contributed 48.89% of the fragments of the principal stock animals. This figure, however, was inflated by concentrations of skull, jaw and loose teeth fragments (Category 1) in GS F.49 (cobbles), F60 (road level) and L.424 (floor makeup). Including these features the proportion of Category 1 fragments (0.44) was much higher than on other sites dated to this phase. Even when these features were excluded, the proportion of Category 1 fragments (0.39) was high compared to most other Roman samples (Table 8). The GS cattle sample therefore differed substantially from the smaller TS and MM/CC samples and this appears to have had a direct bearing on the proportions of fragments represented (Table 7).

The sheep/goat and pig assemblages also displayed lateral variation in their contents. The samples of sheep/goat from the GS and MM/CC sites were quite similar but the small and possibly unrepresentative TS sample had significantly higher proportions of tibia, radius and ulna fragments (Category 3 = 0.41, Table 7). Pig was better represented on the MM/CC site (30.88%) than on the others, a trend that continued in most subsequent Roman phases. It is interesting to note that the proportion of pig Category 1 fragments (0.58) in the GS sample was the highest of all the Roman samples. The same is true of the sheep/goat sample (0.32). These correlate with the higher concentration of cattle skull, jaw and teeth fragments in the same deposits. There is a possibility that these bones, which have relatively little food value, were dumped together during the disposal of carcass waste, perhaps in association with the provisioning of the troops living in the barrack blocks nearby.

R2 — Features dated to the late first century (approximately 75 to 100 A.D.)

Five sites (GS, TS, MM/CC, RS and HL) produced animal bone dated to this phase. The Cathedral Close site (MM/CC) included material associated with the modification of the Bath House after the departure of the legionary forces, and with dumps of furnace ash (Bidwell 1979). The RS material was all obtained from RS F. 363. This was the defensive ditch of the legionary fortress and was deliberately infilled during this phase with debris that included large amounts of animal bone. The other sites were residential areas within the Roman town.

3,697 animal bone fragments, of which 2,018 were identifiable, were examined. About half of these came from RS F. 363 and comparatively large samples were obtained from the GS and MM/CC sites. The TS and HL sites produced very small quantities of bone. Fragments from the principal stock animals contributed 93.68% of the identified mammalian fragments (Table 2).

A more detailed study of the material revealed the outstanding example of inter-site variation discovered in the Exeter animal bone assemblages. The sample from RS. F.363 included 1,036 identifiable mammalian fragments, 754 of these belonged to cattle, 157 to sheep/goat, 51 to pig, 57 to horse, eleven to dog, four to roe deer and two to red deer. A minimum number of 49 cattle was established from the mandible fragments. A minimum of fifteen sheep/goat (radius), five pig (teeth) and four horse (teeth) were also represented (Table 2). The concentration of cattle fragments in this ditch was such that they contributed 78.38% of the principal stock animal fragments — a much higher percentage than in the great majority of the Roman deposits (Table 7). The cattle sample was dominated by jaw, skull and loose teeth fragments, as the extremely high proportion of Category 1 fragments (0.72) demonstrates. In addition 86 metatarsi and 26 metacarpi fragments were recovered, giving a proportion of 0.15 for the Category 4 fragments (metapodia). Several of the metatarsi had knife cuts just beneath the proximal epiphysis where they had been detached from the rest of the carcass. In stark contrast, very few good cattle meat bones were recovered — a fact clearly demonstrated by the extremely low proportions of fragments belonging to Categories 2 and 3 (Table 7). Another interesting aspect of the sample was the almost complete absence of horn cores, despite the abundance of other skull fragments. There seems no doubt that this assemblage represents evidence of the primary butchery of cattle carcases, in which their heads and other unwanted portions of their bodies were discarded. The good meat bones were taken elsewhere for marketing and the horns were probably required for the manufacture of tools and ornaments. The proportion of cattle phalanges was relatively low (Category 6 = 0.02) and it seems likely that these were also taken elsewhere, either for food or in the manufacture of glue. However, the possibility that poor preservation conditions contributed to the low representation of these fragile bones cannot be ruled out. The concentration of this material suggests that either many cattle were being slaughtered nearby or, at least, that the material from the primary butchery process was brought to the ditch during the deliberate infilling that took place in the late first century.

The sheep/goat and pig assemblages did not display the same trends as the cattle remains in RS F. 363, perhaps indicating that their carcases were treated in a different manner. It should be noted, however, that over half of the 51 pig fragments recovered belonged to Category 1 and once again correlated with the concentration of cattle skull and jaw fragments. The sample was nevertheless heavily biased in favour of cattle and this made direct comparisons with the relative proportions of animals on other sites meaningless.

The number of pig fragments on the MM/CC site was swollen by the presence of three partially surviving burials of young animals, which contributed 70 fragments (Table 2). All three were very young and may have died of disease. They were certainly not butchered for food and were discarded from the subsequent analysis.

Excluding these burials, the proportions of the principal stock fragments were more typical of the rest of the Roman deposits on both the GS and MM/CC sites. Once again, however, their constituent parts were significantly different. The proportion of the carpals, tarsals and phalanges (Categories 5 and 6) was substantially greater on the MM/CC site for all the principal stock animals. The number of pig metapodial fragments was also much higher on that site (Table 7). These discrepancies (the causes of which will be discussed later) meant that, although the proportion of stock animals represented was similar, the samples from which the results were obtained were significantly different.

Of the remaining mammalian species, only horse contributed over 1% of the identified fragments. This was due entirely to the concentration of skull and jaw fragments in RS F. 363 dumped together with the more numerous cattle waste bones. Red deer, roe deer, hare and dog fragments were present in small numbers. Eight fragments from a skeleton of a fox were discovered on the GS site.

R3 — Features dated from approximately 55 to 100 A.D.
Only 69 fragments from the RS and HL sites were examined from this phase, which contained features not specifically datable to phases R1 and R2. Details of the

species represented are given in Table 6 but the numbers involved were too small for further analysis.

R4 — Features dated from approximately 75 to 150 A. D.

66 fragments from the TS site were dated to this phase which overlaps with phases R2 and R5. Details of the species identified are given in Table 6.

R5 — Features dated to the second century

Seven sites produced animal bone from this phase. All were basically residential areas during this time except for the MM/CC site, on which the town's Basilica was situated. Of these sites, four (RS, HS, HL and BS) contained too little bone for detailed analysis. The majority of material was recovered from the Guildhall sites (GS and TS) and a total of 3,680 fragments was recovered from all deposits dated to this phase. Of these 1,992 were identifiable (Table 3).

Table 7 again shows the inter-site variations encountered among the principal stock animal fragments. Employing a simple count of fragments, cattle varied between 28-49%, sheep/goat 32-40% and pig 19-34% on the GS, TS and MM/CC sites. The cattle assemblages on the GS and TS sites were very similar, although both contained higher proportions of Category 3 fragments than any of the other Roman deposits. This was in stark contrast with the MM/CC site, in which the fragments of radius, ulna and tibia made up only about 6% of the cattle sample. On that site also, as in the previous phases, the proportions of Categories 5 and 6 (0.09 and 0.16 respectively) were high. The sample also contained the lowest proportion of Category 1 (0.20) and the highest proportion of Category 2 (0.39) fragments in any of the Roman cattle assemblages.

The sheep/goat samples showed some similar traits. The GS and TS sites both had relatively high proportions of Category 3 fragments but the GS site produced an unusually low proportion (0.19) of Category 2 bones. The MM/CC sample differed from the other two in the high proportions of Categories 5 and 6 (0.07 and 0.07 respectively) and the highest proportion of Category 2 fragments (0.39) found in the Roman deposits.

The percentage of pig fragments was higher on the MM/CC site and this again correlates with the unusually large number of phalanges (0.11) and metapodials on this site.

The GS and TS deposits were both associated with residential areas. No heavy concentrations of cattle skull and jaw fragments were found in features associated with them and it is reasonable to assume that most of the bone was deposited as kitchen waste. The variations between these sites and those of the MM/CC site were marked and consistent for all the stock animals and probably reflect both differential preservation conditions and marketing practices.

None of the remaining mammalian species, which contributed only 3.12% of the identified fragments, were important in the diet.The species identified were horse, hare, red deer, roe deer, dog and cat (Table 3).

R6 — Features dated to the third century

Material was examined from the TS, MM/CC, RS, HL, BS and HS sites but only the sample from the MM/CC site was large enough for statistical analysis. 874 of the 1,293 fragments dated to this phase were found on that site (Table 40).

The number of cattle fragments on the Cathedral Close (MM/CC) site was inflated by the concentration of skull fragments in some of the features and also resulted in a high proportion of Category 1 fragments (0.47). Generally, however, the cattle sample displayed the same characteristics as others from the earlier phases of this site. Both the cattle and sheep/goat assemblages contained high proportions of Categories 5 and 6. The pig sample was heavily weighted by fragments of metapodials (Category 4 = 0.27) and phalanges (Category 6 = 0.19), as Table 7 demonstrates. This concentration of these bones was even more pronounced than in the other phases of the MM/CC site. In several cases the bones of individual trotters were found in close association and were obviously thrown away together. Their presence sets the MM/CC assemblage apart from the other Roman samples.

Red deer, roe deer, hare, dog, cat and badger provided 14.86% of the identifiable mammalian fragments. These included bones from three burials. 42 fragments of badger and 23 of dog survived from two burials in the MM/CC deposits. Fifteen of the hare fragments from the TS site belonged to one individual (Table 4).

R7 — Features dated 100 to 300 A.D.

Only 77 fragments from features on the RS site belonged to this phase. Only cattle, sheep/goat and pig were identified and the sample was too small for further study (Table 6).

R8 — Features dated to the fourth century and later (300 A.D. and after)

The largest sample of Roman animal bones was collected from deposits dated to the fourth and early fifth centuries. Four sites (GS, TS, MM/CC and RS) produced material from this phase. The nature of occupation on the Guildhall sites (GS and TS) had changed by this time. The building plots previously occupied by several houses were amalgamated and replaced by large stone town-houses. One of these was associated with a farmyard and stock enclosure, from which a lot of animal bone was recovered. The TS site was occupied by two yards. One was covered with a thick loamy deposit, which has been interpreted as mud and dung accumulated whilst cattle were kept there. Ditches found on the adjoining GS site are in turn interpreted as cattle enclosures or droveways. The fourth century MM animal bone material continued to show similarities with that of previous phases. A midden, possibly dating to the early fifth century (CC L.14) was of a different nature, however, and was treated separately in the following analysis.

5,794 fragments from all sites were examined. Over 3,500 of these were found in the GS deposits mostly in ditches. Over 1,400 were found in layers on the TS site and about 500 in deposits on the Cathedral Close site. Cattle, sheep/goat and pig provided 95.38% of the identifiable mammalian fragments (Table 5).

Examination of the principal stock fragments again revealed evidence of the concentrated disposal of cattle skull and jaw fragments on the GS site. Nearly half of the cattle fragments belonged to Category 1 (0.49). The high percentage of cattle fragments (54.85%) was a direct reflection of the concentration of this skull material on this site (Table 7). The sheep/goat and pig samples were more typical of other Roman deposits. The cattle skull and jaw material was not, however, evenly scattered throughout the GS deposits. Instead certain sections of the ditches (GS F.47, F.160, F. 618) contained concentrations of such material. When these sections were excluded from the analysis (Table 8), the proportion of cattle Category 1 fragments fell sharply to 0.26 and was more typical of other Roman deposits. The proportion of cattle fragments

(43.81%) also decreased. The nature of the sheep/goat and pig samples remained virtually unchanged. The slaughter and primary butchery of cattle possibly kept in the adjoining farmyard may well be associated with these concentrations of cattle waste bones among ordinary domestic refuse.

All the layers on the TS site produced consistent collections of animal bone Cattle dominated the assemblage contributing 71.48% of the principal stock fragments. Such a high percentage could not in this instance be attributed to concentrations of Category 1 fragments (0.36). The types of bone represented from all the principal stock animals were similar to others associated with domestic refuse deposits. The preservation and recovery of these bones was as good as most of the other Roman samples and the increase in the percentage of cattle fragments cannot be attributed to those factors. It is tempting to correlate the increase with the presence of the cattleyard on the site, although the causes of such an interaction are not obvious.

The sample from the fourth century MM deposits was small but it continued to show concentrations of pig metapodials and phalanges of all the principal stock animals and contained a much higher percentage of pig fragments than other samples dated to this phase (Table 7). The late Roman midden (CC L.14) produced over 70% cattle fragments in its sample of 135 identifiable principal stock fragments. The proportion of cattle fragments was similar to that of the TS site, although the sample was too small to be very reliable.

The fourth and fifth century deposits therefore continued to reveal the complexities of faunal material from urban sites. Lateral variations caused by differential disposal of bone elements and possibly by the change in function of a site were again recognisable and had a significant bearing on the proportion of the species represented.

Of the remaining mammalian material, small quantities of bone belonging to red deer, roe deer, hare, horse, dog, cat, fox, hedgehog and woodmouse were recovered. None of the species played an important role in the diet.

R9 — Undated Roman features

1,147 undated Roman fragments were examined from the GS site. Because of the lack of close dating no further analysis of the material was worthwhile. Details of the fragments recovered are given in Table 6.

Lateral variation in the Roman deposits

The Roman samples were taken from areas of different functions and should be expected to produce pronounced variations in their faunal remains. Some of these variations were found consistently on a particular site. The Cathedral Close site (MM/CC) provided the best example of this. Apart from the midden dated possibly to the fifth century, these deposits were characterised by the large number of phalanges of all species, a high proportion of pig metapodials, generally a low proportion of Category 1 fragments and a higher proportion of good meat bones of all species. The percentage of pig fragments recovered from this site was consistently higher than on any of the others (Table 7).

Several factors could lie behind these trends. The occurrence of the smaller bones in larger numbers — particularly the sheep/goat and pig phalanges — could be the result of more careful excavation of this site than others in Exeter, in which more may have been overlooked. This, however, appears unlikely since the standard of excavation on the Cathedral Close site differed little from the others.

A second possibility is that the preservation of the bone on the Cathedral Close site was substantially better than on the other sites and thus more bones of smaller volume and density survived. This again would favour the recovery of the phalanges in particular, which have very low densities and are very susceptible to destruction (Binford and Bertram 1977:109). It is certainly true to say that the preservation of bone on this site was excellent and significantly better than much of the material from the GS, TS and RS sites. A study of the survival patterns of the articular surfaces of the long bones of the principal stock animals supports this. The ends of the long bones contain a high proportion of spongy cancellous bone, which is more vulnerable to destruction than the cortical bone of the shafts. This applies particularly when the cancellous bone is directly exposed. Unfused or butchered epiphyses are therefore less likely to survive. The proportion of unfused and fused epiphyses of the same fusion age was fairly consistent for all the principal stock species throughout the Roman deposits. The ratio of articular surfaces to shaft fragments varied significantly however. Assuming that the fragmentation of the bone is constant, the ratio of shaft fragments should be higher in poorly preserved deposits, in which a greater proportion of articular ends have been destroyed. To take the tibia as an example, the ratios of the articular surfaces to shaft fragments in the Cathedral Close deposits (excluding the fifth century midden) were 1.63:1, 1:1.57 and 1.50:1 for sheep/goat, cattle and pig respectively. From the rest of the Roman deposits the equivalent ratios were 1:2.57, 1:2.89 and 1:1.38. Restricting this analysis to the later-fusing and more vulnerable proximal tibia, the ratios of articular surfaces to shaft fragments were 1:1.93, 1:5.50 and 1:2.50 for sheep/goat, cattle and pig respectively on the Cathedral Close site and 1:16.27, 1:8.53 and 1:3.38 elsewhere. Similar variations in these ratios were found in the humerus, radius and femur. In all cases the articular surfaces of these long bones were found more commonly on the Cathedral Close site than on the other Roman sites. Using such ratios as a rough guide and assuming that differential fragmentation did not play an important role, it seems clear that the more fragile bones had a better chance of survival on the Cathedral Close site. The higher proportions of Category 2 bones in the MM/CC deposits and the abundance of phalanges and other vulnerable bones can therefore be attributed to some degree to differential preservation.

This factor alone cannot, however, explain all the discrepancies in the Cathedral Close assemblages. In particular, the concentrations of pig metapodial fragments were not the result entirely of the excellent preservation of the bones on that site. Such high proportions of these bones are more likely to have been the result of differential disposal patterns on the Roman sites. Pigs' trotters are a recognised cut of meat in modern times but this may not have been the case in the Roman period. The concentration of pig metapodials and phalanges, sometimes from the same foot, and the lack of butchery marks on these (although they require little) suggest that these were often thrown away whole and not regarded as a source of meat. The same explanation may apply for the concentrations of cattle phalanges and sheep/goat tarsals and phalanges, although preservation conditions also aided their survival. The proximity of the Cathedral Close deposits to the Forum — the marketplace of the Roman *civitas* — cannot be overlooked. Some carcass trimming is to be expected at such a distribution centre and it is possible that the unwanted feet of the major food animals were cut off and dumped nearby. Good meat bones were discovered in the same deposits and there is no doubt that the Cathedral Close site contained a large amount of kitchen waste as well.

From the archaeozoological point of view, the animal bones from the ditch RS F. 363 represent the most important material discovered in any of the periods investigated at Exeter. They provide clear evidence of the slaughtering and marketing techniques practised on cattle in the early Roman period. The contents of the excavated sections of the ditch have already been discussed in detail (see section R2). The interpretation is of great interest. The cattle bones deposited represent the parts of the carcass considered to be of no further use. Consequently very few meat bones were found and mandibles, skull fragments and metapodia dominated the sample. Yet, virtually no horn cores were discovered. The recovery of sawn and chopped horn cores elsewhere in the Roman deposits strongly suggests that these were detached from the rest of the skull to utilise the horn sheath in the manufacture of artifacts or ornaments. Also, despite the large number of metapodia fragments, relatively few phalanges were recovered from the ditch (despite the sieving of some of the layers). The discovery of concentrations of these on the Cathedral Close site indicates that these were often taken elsewhere after the initial butchery of the carcass. The overall impression of the RS F. 363 material is one of a consistent and extensive exploitation of the cattle carcases for distribution in the town.

In comparison, the concentrations of skull and jaw fragments in the ditches of fourth century date on the GS site represent primary butchery on a much smaller scale. Certainly, the number of skulls and jaws in certain sections of the ditches witness a similar type of disposal of waste bones but these were interspersed by sections that contained material more typical of the domestic refuse deposits elsewhere in the Roman town. Whether these concentrations of skull material can be linked directly to the stock enclosures that appeared on the adjoining TS site or not, it is possible to postulate that the slaughter of cattle was carried out in a much more decentralised pattern in the later Roman period. Clearly the evidence is as yet far from conclusive but such an hypothesis would fit in with the archaeological evidence. The presence of a Roman garrison in Exeter between approximately 55 and 75 A.D. entailed the provisioning of about 6,000 men in addition to the needs of the civilian inhabitants. It is likely, therefore, that the organisation of the food supply was of paramount importance in the early years of the town. The animal bones from the Rack Street ditch are in levels that postdate the departure of the legionary forces but belong to a period when direct Roman influence was still important. The large-scale, organised and systematic slaughtering, butchery and distribution of cattle carcases, which these deposits evidence, are practices likely to have been inherited from the period of military occupation.

The social structure within the town had changed by the fourth century, as witnessed by the construction of large stone town-houses on the Guildhall sites on plots of land previously occupied by several houses (Bidwell *pers. comm.*). At least one of these, as we have seen, was associated with its own farmyard and stock enclosure. It seems likely too that the stock brought there was slaughtered for consumption in the town. If this was a pattern that was followed elsewhere in the town and its hinterland, it is possible to visualise a much more decentralised system of cattle slaughtering and marketing, mainly in the hands of large stockowners who managed their own animals independently. It has been shown at the Roman villa at Gatcombe that the slaughter and butchery of the estate's stock took place there and much of the meat was taken away for marketing elsewhere (Branigan 1977: 201). Such a system of distribution may have been typical of the economic and social organisation elsewhere in the later Romano-British period. The region around Exeter is unusual in its lack of villas but it is possible that a similar system was operating in the area. The evidence of stock enclosures associated with the slaughter of cattle in the Exeter deposits may therefore represent the urban counterparts of the marketing processes on the rural estates elsewhere in Roman Britain. Such changes need not have affected the sale of meat from the market place, as the continued evidence of carcass trimming from the Cathedral Close deposits may imply. Future research will no doubt shed further light on this topic.

Relative abundance of species in the Roman deposits

Most of the previous discussion has centred upon the lateral variations of bone within the Roman deposits. These provide important insights into aspects of the economy of Exeter but cause many problems in the interpretation of the relative importance of the various species in the meat diet. It has been shown that the various stages in the butchery process can affect the relative number of fragments of the principal stock animals recovered. It is also obvious that none of the samples in the Roman phases needs represent a cross-section of the animal bones deposited in the town. Comparisons between phases therefore should be limited to samples which contain similar types of bone.

Accordingly, samples biased by the concentration of cattle skull and jaw fragments dumped in the primary butchery process have to be excluded from an overall analysis. Most of the remaining animal bone assemblages have been interpreted as domestic waste and, in theory, can be directly compared. Table 8 is an amended version of Table 7, listing the number of fragments of each of the principal stock animals and their category proportions excluding the deposits most heavily biased by concentrations of primary butchery material. Chi-square tests were employed on each sample to establish whether the proportion of fragments in each of the seven categories was similar to that of the cumulative total of all the Roman deposits for cattle, sheep/goat and pig in turn. Table 8 shows that about half of the samples tested were significantly different from the overall totals. These tests, unsophisticated as they are, can be used in this way to act as a quick guide to the similarity of various samples. In this case it is apparent that the amount of inter-site variation was such that changes in the relative percentage of fragments of the principal stock animals may be a function of sample variation rather than changes in the relative importance of the stock in the meat diet. Any direct comparisons may therefore be misleading.

Similar statistical tests can be made on the minimum numbers represented by each bone. This drastically reduces the sample size for analysis. Accordingly, the minimum numbers of the various bones within the seven categories were added together to obtain the 'sum of minimum numbers' (S.M.). Most of the resulting samples were now of sufficient size for simple statistical tests. Table 9 lists the minimum numbers, the S.M. and the category proportions of each of the principal stock animals. The chi-square tests revealed that the samples bore a much greater degree of similarity using this method of analysis. All the cattle samples were statistically similar to the overall category proportions and only one of the pig and three of the sheep/goat samples were significantly different at the 1% level of chi-squared. The reasons for the decrease in variation in samples derived from exactly the same data lie in the methodology employed. The smaller sample sizes are less likely to produce conclusive evidence of variability. It is possible that, had the samples been larger, the same variations encountered in the count of fragments would have been monitored. On the other hand, the method does eliminate many of the discrepancies caused by differential fragmentation of the material (in particular that of skull fragments).

In samples that are statistically similar it is possible to make comparisons between the relative number of animals represented but, as can be seen in Tables 9 and 10, by this stage the samples that could be compared were often too small to enable any categorical statements about changes in the meat diet to be made. Even by adding together totals of assemblages from different sites, the samples in terms of the minimum number of individuals are woefully small and are subject to a high degree of statistical error. It can be seen that by meat weight cattle dominated in all deposits. Table 10 gives the estimated minimum meat weights based on the multiplication of the minimum number of individuals by the average meat content of the species. The weight of a Roman cow was based on the estimation of Cram (1967:79) and those of pig and sheep from modern figures. According to these figures, cattle provided between 64 to 85% of the meat in the statistically similar samples. Pig and sheep/goat generally contributed an equal amount of meat throughout. Whether these figures are a true reflection of the actual amount of meat consumed on these sites is questionable. It assumes that the estimations of meat weights are accurate (and does not take into account the presence of immature animals). It also assumes that the relative proportions of the minimum number of individuals obtained are an accurate estimate of the percentage of the stock animals slaughtered. Both excavation techniques and preservation conditions favoured the recovery of cattle, although this bias is counterbalanced to some extent by the method employed to obtain the minimum number of individuals, which favoured sheep/goat and pig. Despite all these complications it can be said with confidence that cattle provided the majority of the meat throughout. It is a sobering thought, however, that in a sample of over 18,000 bones (a sample much larger than many investigated, in which much more forthright statements have been made about the relative abundance of each species) the traditional methods of quantitative analysis were not able to give a more detailed picture of changes in the meat diet.

THE MEDIEVAL PERIOD

The subdivision of the sample

The medieval levels produced by far the greatest quantity of bone. 40,555 fragments were examined of which 22,031 were identifiable. Of the remaining fragments about 80% were accounted for by rib and vertebrae fragments. The sample was subdivided into ten phases as follows:

- Md1) Features dated to the eleventh and early twelfth centuries (1000 to 1150).
- Md2) Features dated to the twelfth century (1100 to 1200).
- Md3) Features dated to the eleventh and twelfth centuries (1000 to 1200).
- Md4) Features dated to the late twelfth to early thirteenth centuries (1150 to 1250).
- Md5) Features dated to the early thirteenth century (1200 to 1250).
- Md6) Features dated to the late thirteenth century (1250 to 1300).
- Md7) Features dated to the thirteenth century (1200 to 1300).
- Md8) Features dated to the late thirteenth to early fourteenth centuries (1250 to 1350).
- Md9) Features dated to the early fourteenth century (1300 to 1350).
- Md10) Features dated to the late fourteenth to fifteenth centuries (1350 to 1500).

The dating of these samples relies principally on the pottery evidence (Allan *pers. comm.*). Many of the phases overlap with others because it was not possible to date some features more accurately. For example, some features belonging to phases Md1 to Md3 could in fact have been contemporary. Separation of the eleventh and twelfth century pottery groups relies largely on the recognition of imports typical of the twelfth century. It is possible that some of these were reaching Exeter before the beginning of that century. This would give more overlap between phases Md1 and Md2.

The medieval bones analysed were recovered from the GS, TS and HS sites. The Goldsmith Street samples were further subdivided into those of the GS I-II and GS III sites. The analysis is therefore limited to only one area of the medieval town (Figure 1). The vast majority of the bone came from rubbish and cess pits. The pattern of disposal changed in the fourteenth century when open pits were no longer dug and town refuse disposal began. This resulted in much smaller animal bone assemblages in the later medieval phases. The largest samples were obtained from phases Md1, Md2 and Md6. Some of the other phases, in particular Md4, Md7 and Md8, had samples too small to be of much significance. The amount and complexity of the material required each phase to be examined in detail. The methods of analysis remained the same as those employed on the Roman samples.

The individual phases

Md1 — Features dated to the eleventh and early twelfth centuries

A total of 6,277 fragments was recovered from 35 features. 3,255 of the fragments were identified. The GS I-II, GS III and TS sites each accounted for over 1,900 fragments. The HS site, which included the earliest features of medieval date (early eleventh century) unfortunately did not produce much bone. Table 11 shows the number of fragments and the minimum number of individuals obtained for each species from each site. The major stock animals dominate the assemblage, accounting for 97.38% of the mammalian fragments present in the sample. None of the other species found in this phase requires much comment, other than to observe that these deposits produced the earliest evidence of rabbit and fallow deer from the excavations.

When the fragments of the principal stock animals only were considered, their proportions in the three largest samples were consistent. It was found that cattle provided the largest number of fragments (45 to 47%), followed by sheep/goat (35 to 38%) and pig (16 to 19%). However, this apparently uniform picture is misleading. The GS I-II cattle assemblage included a concentration of skull and jaw fragments in one pit (F.170). 58 of the 108 cattle fragments in this feature belonged to Category 1 (0.54). This biased the relative percentages of principal stock fragments in favour of cattle (about 67%). The assemblage was similar to the dumps of cattle skull and jaw fragments on the GS site in the late Roman period. F.170 contained a high percentage of residual Roman pottery and it is conceivable that much of the faunal material in this case was also of

Roman origin. Certainly it is safer to exclude this feature from the analysis. Omitting F. 170, the percentage of cattle fragments of the GS I-II site fell to about 39% of the principal stock fragments (Table 12). The content of the cattle sample also changed significantly. The proportion of Category 1 fragments decreased from 0.32 to 0.21, whereas Category 2 fragments increased from 0.24 to 0.30. The exclusion of F. 170 therefore increased the proportion of good meat-bearing long bone fragments of cattle.

Chi-square tests on the contents of the principal stock samples also revealed significant variation in the sheep/goat assemblages (Table 12). The TS site produced a markedly higher proportion of Category 2 fragments (0.41) and a substantially lower proportion of Category 1 fragments (0.15) than on the other sites in this phase. When the category proportions of the TS sheep/goat sample were compared against those obtained from all the sites dated to this phase, they were found to be significantly different at the 1% level of chi-squared. It should be noted that had this sample been directly compared with those of either the GS I-II or GS III sites individually, chi-square tests would have revealed even more pronounced variations. By including data from all sites in these and subsequent calculations, the monitoring of inter-site variations is to some extent impaired. The tests, however, were devised for a specific and limited purpose: namely to test the assumption (tacitly made in many bone analyses) that the total sample analysed from a particular period (upon which statements about the abundance of each species are made) does not differ significantly in content from any of the subsamples (features, sites, etc.) from which it is derived. The presence of significant variations in the subsamples as evidenced in this example, places doubt upon the validity of using such data in gross comparisons in the manner usually adopted by archaeozoologists.

The variations encountered in the Md1 samples could not (except for F. 170) be ascribed to the presence of one or two atypical features, since the larger deposits showed relatively little intra-site variation.

The chi-square tests on the sum of the minimum numbers (S.M.) represented in the seven bone categories showed less variation between sites than the fragments method of counting. The small HS sample was biased by a disproportionately high number of pig mandibles. These came from a minimum number of seven animals, which accounted for half of the stock represented on that site (Table 13). This figure was more than double the percentages of pig obtained from the other three larger sites (20 to 25%) and much overstated its importance. The HS sample was small, however, and although it should be treated separately, it made little overall impression upon the percentage of the minimum number of pigs in the phase as a whole (25.19%). Pig still ranked third behind sheep/goat and cattle. The former produced percentages of between 40 to 50% on the three major sites. Cattle was relegated to second place using this method of counting, contributing 30 to 38% of the stock on the same sites. The minimum numbers method of counting nullified a lot of the variations met in the count of fragments. None of the calculations for chi-squared fell outside the 5% limit. The TS site still revealed a high proportion of Category 2 bones and a correspondingly lower proportion of Category 1 bones for all three species than the GS III site, but the samples were not large enough for the observed variations to be significant.

Md2 — Features dated to the twelfth century

The 40 features dated to this phase produced the largest faunal sample from medieval Exeter. 13,227 bone fragments were examined of which 7,435 were identifiable. Over 11,000 of these fragments were collected from the two GS sites, while the remainder were recovered from the TS and HS sites. The principal stock animals provided 95.62% of the identifiable mammalian fragments (Table 14).

Chi-square tests on the proportion of fragments represented in the seven bone categories of the principal stock once again revealed sample bias. All three stock species were affected to a greater or lesser extent.

The sheep/goat assemblages from both the GS I-II and GS III sites were found to be significantly biased. There was an unusually large proportion of Category 1 fragments in the sheep/goat sample in the phase as a whole (0.35) but the level of 0.39 on the GS I-II site was exceptionally high (Table 15). In nearly all its larger deposits Category 1, fragments outnumbered those of Category 2, a situation in contrast to the previous and most subsequent phases. GS F. 718 was exceptional in that 93 of the 181 sheep/goat fragments (0.51) in that pit belonged to Category 1, due principally to a concentration of horn cores belonging to both sheep and goat. Several of the deposits also had low representations of Category 3 fragments, particularly GS F. 718, F. 691 and F. 614, which accounts for the low representation of this category on the site in general (0.17).

The sheep/goat sample from the GS III site was more typical of the medieval samples in general. Except for GS F. 217, in which Category 1 bones accounted for 88 of its 218 fragments (0.40), fragments belonging to Categories 1 to 3 were found in roughly equal numbers in the larger deposits. The contrast between this sample and the assemblage from GS I-II was such, however, that when chi-square tests were applied, both samples were found to be significantly different from the overall sheep/goat sample in this phase. The TS deposits were dominated by one feature, TS F. 227, which contained a total of 991 fragments. 90 out of 233 sheep/goat fragments in this pit were skull, teeth or mandible fragments, with once again a noticeable concentration of horn cores. This accounts for the high proportion of Category 1 fragments (0.36) on the site. The HS sample had only 44 sheep/goat fragments and was too small to be of importance.

The cattle assemblage was also subject to a lot of lateral variation, although only the small HS sample of 66 fragments was significantly different from the rest, due principally to the site's high proportion of Category 2 fragments (0.45). If those deposits are excluded, the remaining sites reveal a more consistent picture. Fragments of Categories 1 and 2 were found in roughly equal proportions throughout (Table 15). Category 3 fragments obtained levels of 0.16 to 0.17 on all three sites, a rather lower proportion than in most of the other medieval samples. Variations between features in the contents of the cattle assemblage on the respective sites were relatively limited. One minor exception was GS II F. 614 which produced a large number of cattle phalanges (34 out of 208 fragments). Category 6, into which the phalanges are classified, contributed a proportion of 0.09 of all cattle fragments on the GS I-II site during this phase, a higher level than usual due partially to the concentration of phalanges in this feature.

The smaller pig assemblage was biased by the variable amounts of skull fragments found in the deposits. The variation between the three major sites cannot be ascribed to one or two atypical features. It is interesting to note that the two sites that produced the highest concentrations of Category 1 pig fragments (GS I-II, TS) were the same ones which produced the highest proportions of sheep/goat skull and jaw fragments, perhaps suggesting that similar processes were at work on both species on those sites.

The lateral variations encountered between sites in this phase made the calculations of the overall percentages of the number of fragments no more than an academic exercise, since the bias was such that none of the species represented was a homogeneous sample. On the three largest sites sheep/goat provided the most fragments (39 to 50%). The GS I–II site produced the largest percentage of these animals (49.63%). This directly reflects the unusual concentrations of horn cores and mandibles found on that site, which have inflated the number of caprine fragments. The percentage of cattle varied between 37 to 48% and pig between 13 to 17% of the total number of stock fragments.

The minimum numbers method again tended to nullify the observed variations encountered in a simple count of fragments. Only one of the chi-square calculations, that of cattle on the HS site, fell outside the limitations of the tests, principally because of a high ratio of Category 2 bones (0.41) in that small sample (Table 16). However, the percentage figures obtained for the stock animals on the three larger sites must still be treated with some caution.

A minimum number of 43 sheep/goat was obtained on the GS I-II site. This number, however, was obtained from the skull fragments in the various features. Since the large number of horn cores in some of the deposits was found to bias the total number of fragments in favour of sheep/goat, it is also probable that it has inflated the percentage of individuals (53.75%) obtained as well. The second most common bone represented was the tibia (39 individuals). Since this bone (together with the radius) was more commonly found to produce the highest figure for the number of sheep/goat individuals on the Exeter sites in all periods, it is probably better in this instance to take that figure to be the more representative of the proportion of sheep/goat on that site. Taking the minimum number of sheep/goat to be 39, the percentage of that species on the GS I-II site dropped to 51.32%. The percentages of cattle and pig both rose accordingly to 28.95% and 19.74% repectively. The level of sheep/goat was still therefore rather higher on this site than on either the GS III or TS sites (Table 16).

The results from the TS site must also be treated with suspicion. Both cattle and sheep/goat had a minimum number of fifteen individuals (39.47%) on this site. The minimum number of sheep/goat was obtained from three bones, the mandible, skull and radius. The comparatively high number of skulls and mandibles reflects the concentration of their fragments in TS F. 227. The radius, on the other hand, was generally a more reliable indicator of the minimum number of sheep/goat present and the figure of fifteen individuals is therefore thought to be a reasonable one. The cattle sample was unusual, however, since it was the calcaneum that produced the highest minimum number of individuals. There was indeed an unusual number of calcanea in TS F. 227, which accounted for the high proportion of Category 5 bones (0.18). The second highest number of cattle obtained from any bone was 11, a figure derived from the scapula. It is possible, therefore, that the concentration of cattle calcanea deposited in that pit may have biased the overall percentages for that site in favour of cattle — although it should be noted that on the GS III site in the same phase, the calcaneum along with the skull and the humerus also provided the highest minimum number of 31 cattle. When the figure obtained from the scapula (11 individuals) instead of the calcaneum was employed in the calculations of the minimum numbers of stock, the percentages obtained from the TS site more closely reflected the results of the other two sites (sheep/goat 44.12%, cattle 32.35%, pig 23.53%). The TS sample, however, is comparatively small and the unusual nature of its major deposit requires any conclusion to be tentative.

The GS III site produced fewer discrepancies in its deposits. The percentages obtained of 46.94% sheep/goat, 31.63% cattle and 21.42% pig from a sample of 98 individuals are probably the most reliable of any of the sites dated to this phase.

Lateral variation between sites was particularly noticeable in this late twelfth century phase. Both the GS I-II and TS sites revealed the dumping of sheep/goat mandibles and horn cores in some numbers. Isolated features also evidenced unusual concentrations of cattle phalanges and calcanea. The variations encountered meant that the percentage of fragments found on the sites could not directly be compared. Results from the analysis of the minimum number of individuals must also be treated with caution because of the differential butchery practices encountered. It is interesting to note that the sites that now appeared to have a greater proportion of waste bones were the GS I-II and TS sites, a complete contrast to the evidence of the previous phase. Possibly the disposal of unwanted portions of the carcass was not carried out on a large scale in any of the areas concerned during the twelfth century but dumping of such material on a small scale was liable to occur on all of them.

The rest of the mammalian assemblage in this phase consisted principally of cat, of which 126 fragments (2.32%) from 15 individuals (5.40%) were recovered. The number of fragments was inflated by the presence of several partial skeletons in the deposits. There is evidence here of the beginning of the phenomenon that accounted for a relatively large number of cats that were consistently recovered from most of the medieval and postmedieval phases. None of the other mammals provided over 1% of the identifiable fragments. The stoat fragments consisted of the metapodials and phalanges of one animal, the only occurrence of the species in the Exeter deposits. All three species of deer were again represented but only in small numbers. The scarcity of rabbit as a food resource is indicated by the discovery of only one bone belonging to that species. Hare continued to be the more popular game, although it too seemed only to be an occasional addition to the diet. The large number of fish bone fragments (1,213) in the GS I-II deposits was a direct consequence of the discovery of 1,007 fragments in GS II F. 614 (Table 14).

Md3 — Features dated to 1000 to 1200

The 28 features examined in this phase were contemporary with the deposits in the previous two phases but could not be dated specifically to either. 3,578 fragments were examined from the GS I-II, GS III and TS sites, of which 1,869 were identifiable. The largest samples once again originated from the two GS sites, each of which produced over 1,400 fragments (Table 17). 90.80% of the identifiable mammalian fragments belonged to cattle, sheep/goat and pig.

Chi-square tests on the relative number of fragments in the bone categories represented revealed little variation in the cattle and sheep/goat assemblages. The pig sample was significantly biased, however, by a very high concentration of Category 1 fragments (0.52) on the GS I-II site and a very low proportion of the same category on the GS III site (0.19) (Table 18).

Significance tests on the sum of the minimum number of individuals revealed that the sample was homogeneous: the variations encountered were not enough to bias the sample to any degree. The percentage of sheep/goat varied from 40 to 58% of the stock animals, with an average of 48.24% for the whole phase. Cattle ranked second with figures ranging between 25 to 40% (average 29.41%), with pig third (16 to 21%, average 18.82%) (Table 19). The average percentages obtained for this phase were similar to those obtained on the amended Md2 sample, although the variation between the individual sites in this phase was greater, perhaps due to the smaller samples and to the variations encountered in the sheep/goat sample in particular.

The representation of the rest of the mammalian sample in this phase has similarities with that of the previous one. Cat was the only mammal species discovered in any numbers: 103 fragments (7.07%) were found belonging to seven individuals (6.48%). 35 of these fragments came from one skeleton. The rare occurrence of fragments of the three deer species, dog, hare, rabbit, horse and two rodent species completed the mammalian assemblage (Table 17).

Md4 — Features dated to the late twelfth to early thirteenth centuries

Only twelve features from the three major sites were dated to this phase. Most of the features were small, which meant that the pottery evidence was not detailed enough to assign a more specific date to those features. The bone sample also was small, only 889 fragments were found and only 415 of these were identifiable. 90.55% of the fragments were assigned to the principal stock species (Table 20).

Most of the faunal material in this phase came from GS III F. 289, which contributed 460 of the 889 fragments found. This feature produced relatively large numbers of Category 2 fragments for all three species, and especially for cattle and sheep/goat, since such fragments contributed almost half of the total assemblage of each species. This accounts for the high ratio of Category 2 bones on the GS III site and in the deposits of the phase as a whole (Table 21). Overall in this phase, sheep/goat contributed 41.75% of the fragments, cattle 38.38% and pig 19.87%, but there was a good deal of variation in the percentages obtained from each site and the sample as a whole was too small for comparisons to be made with other phases.

The minimum numbers of individuals involved were too small to draw many conclusions. The overall percentage of 50% sheep/goat, 31.25% cattle and 18.75% pig was similar to the Md2 and Md3 phases; but from a total sample of just 32 individuals, these figures carry little weight (Table 22).

Of the remaining mammals, 23 fragments of cat from a minimum of two individuals provided 7.01% of the mammalian fragments. 21 of these fragments came from one burial in GS III F. 289. Red deer, horse, hare and rat were also represented in the sample (Table 20).

Md5 — Features dated to the early thirteenth century

Twelve features produced a total of 2,390 fragments of which 1,053 were identifiable. Most of the sample was derived from the GS III site, which produced over 1,600 fragments. 96.23% of the mammalian sample belonged to the principal stock animals (Table 23).

Chi-square tests on the principal stock fragments were only possible for sheep/goat and cattle on the two GS sites, the HS site having too few fragments for analysis to be made. No significant variation was found in the proportion of cattle fragments represented on the two GS sites, despite variations particularly in Categories 1 and 4 (Table 24). Variations in the sheep/goat samples, on the other hand, were found to be significant. Examination of Table 24 shows that there was a high proportion of Category 1 fragments (0.41) on the GS I-II site and a very low proportion of Category 2 fragments (0.12). On the GS III site, on the other hand, the proportions of the equivalent categories were 0.22 and 0.31 respectively. There were also large variations in Categories 3 and 4. 612 of the 652 fragments found on the GS I-II site belonged to one pit, F. 114. Of the 92 sheep/goat fragments in this feature, 37 (0.40) belonged to Category 1 and these included an unusually large number of 24 teeth. Only 11 fragments (0.12) belonged to Category 2. The percentage of sheep/goat fragments in this feature (55.42%) was also higher than usual. It seems that this was another case of an unusual concentration of specific types of bone of one species having a direct effect on the percentage of fragments of that species in the sample. Because of this atypical sheep/goat sample, the GS I-II site should be ignored in the overall assessment.

One is therefore left with the GS III sample, which produced the largest number of fragments in this phase. Of the stock animals, 43.25% of the fragments belonged to sheep/goat, 36.11% to cattle and 20.63% to pig. Once again these figures ought to be treated with reserve. The proportion of pig skull and jaw fragments (0.42) was found to be very high and the pig sample as a whole was not comparable with that of any of the earlier phases. In contrast, the proportion of caprine Category 1 fragments (0.22) was lower than that found in many of the medieval phases. Cattle too had a high incidence of fragments from Categories 2 and 3 during this phase. Although the relative percentages of fragments obtained were similar to the other twelfth and thirteenth century phases, the results from the GS III site alone cannot be compared with those of any of the preceding phases since the component parts of its samples were significantly different.

Once more the minimum numbers method tended to overcome most of the biases encountered by the fragments method of counting. Chi-square tests on the S.M. of the GS I-II and GS III sheep/goat assemblages indicated no significant difference between the samples, although the minimum number of five sheep/ goat on the GS I-II site was obtained from the mandible — a reflection of the concentration of Category 1 bones on that site which was the highest proportion of that category in any of the medieval phases. The overall size of the sheep/goat sample on the GS I-II site was such that the significance tests revealed that the variation involved could reasonably be assigned to chance. The HS site produced only a minimum number of nine animals shared equally between the three species and was therefore too small to be of importance. The GS III site, despite unusual proportions of cattle Category 2 bones (0.34) and pig Category 2 bones (0.15), was probably more representative. Once again sheep/goat provided the greatest number of individuals (48.65%) followed by cattle (29.73%) and pig (21.62%) (Table 25).

Cat was the only one of the rarer mammals represented in any numbers (21 fragments from four individuals). The high number of fish fragments (116) on the GS I-II site was principally the result of a concentration of these in GS F. 114 (Table 23).

Md6 — Features dated to the late thirteenth century

This phase produced the second largest sample of bones from the Exeter excavations. 10,313 fragments were recovered, of which 5,692 were identifiable. The GS III site itself provided 6,800 of these fragments, while the GS I-II site contributed over 2,000 and the TS site over 1,400. Some of the 39 deposits contained a large number of fragments; most contained over 100, and several produced over 500. Cattle, sheep/goat and pig, as usual, completely dominated the assemblage and accounted for 95.54% of the total number of identifiable mammalian fragments (Table 26).

Unfortunately, as was the case with the largest medieval sample (Md2), the deposits dated to this phase produced significant inter-site variations, making an overall comparison employing the fragments method of counting once again impossible. All three principal species were affected.

The cattle assemblage showed the least variation. Only the GS I-II sample was found to be significantly different at the 5% level of chi-squared. The GS III and TS sites produced very similar category proportions in their cattle samples (Table 27). Within both sites, however, there was a fair degree of variation between features, although no clear pattern was discernable. The cause of divergence in the GS I-II sample cannot be ascribed to a single deposit. The intra-site variations met on this site were generally no greater than those encountered on the other two. Overall, there was a higher proportion of Categories 1 and 3 cattle fragments on the GS I-II site than on either the GS II or TS sites, with a a correspondingly smaller proportion of Category 5 (carpals and tarsals) fragments.

The caprine assemblage too showed bias. The TS sample was found to be significantly different at the 1% level of chi-squared. The reasons for this were a low proportion of Category 1 fragments (0.15) and a high proportion of Category 3 fragments (0.35). Once again this trend was evidenced in most of the features on the TS site and not in just one or two isolated deposits, although a few features did emphasise the trend more than others.

Finally, the pig sample was biased by the high proportion of Category 1 fragments (0.54) on the GS I site and by the extremely variable amounts of Category 3 fragments found on the three sites in question (0.09 to 0.32). Both the smaller GS I-II and TS sample showed significant variation at the 1% level of chi-squared. Once more the observed variations were not the product of one or two atypical deposits.

Although the percentage obtained from a simple count of fragments varied by only 3 to 7% for the principal stock animals in this phase on the three sites in question, sample variability precluded any direct comparisons between them.

In this phase not even the minimum numbers method was able to nullify all the inter-site variability. The pig sample on the GS I-II site was still significantly different at the 5% level of chi-squared, due to the variations in the proportions of Categories 1,3 and 4 (Table 28). The minimum number of ten pigs on that site was obtained from the teeth. The second most represented bone was the femur (eight) and that bone is probably a better indicator of the proportion of pig on that site, since the high figure obtained for the teeth reflects the bias in the sample towards Category 1 bones (0.36). This would cause the percentages of stock animals on the GS I-II site to be amended as follows: sheep/goat 44.18%, cattle 37.20%. pig 18.60%, in a total sample of 43 individuals. The variations observed in the proportion of the seven bone categories in the other two species were still quite large but the smaller numbers involved in the S.M. method meant that none of the variations was significant. Sheep/goat continued to dominate the assemblage, contributing 44 to 53% of the stock animals on the three sites, with an amended average percentage of 48.30%. Cattle were second (average 31.40%) and pig last (average 20.29%). Once again these percentages have close similarities to the previous four phases, although this does not take into account sample variance between them. It is of interest to note that the lateral variations found in the assemblages of all three principal species during this phase were caused by similar phenomena. The GS I-II site had higher proportions of Category 1 fragments for all three species than the other two sites, although the trend was more marked with pig than cattle or sheep/goat. Both the pig and sheep/goat samples on the TS site were found to have much smaller quantities of Category 1 bones and unusually high concentrations of Category 3 fragments. These variations could again be explained simply in terms of differential butchery practice, in which the GS I-II site was subject to a higher proportion of waste fragments being dumped in its deposits. Certainly the variations cannot be explained in terms of differential preservation or recovery, since the proportions of the smallest and most fragile bones represented on the three sites were found to be consistent.

92 fragments of cat were recovered from the late thirteenth century phase (2.17%). These fragments belonged to at least sixteen individuals (6.40%). None of the other mammals present attained levels of over 1% of the fragments, although hare was a little more common than usual (0.87%). Rabbit still appeared extremely rarely and only six fragments of deer were identified. Horse as always appeared rarely in deposits derived mainly from food refuse. Thirteen of the twenty dog fragments came from one burial and in fact a minimum of only three dogs was present (Table 26).

Md7 — Features dated from 1200 to 1300

Only three features, all from GS III, were dated to this phase. In all 141 fragments were recovered and 61 identified. The sample was too small for detailed analysis to be worthwhile (Table 29).

Md8 — Features dated to the late thirteenth to early fourteenth centuries

1,038 bone fragments were recovered from five features on the GS I-II and GS III sites. 535 of these were identifiable. The percentage of cattle, sheep/goat and pig in the mammalian sample was 96.55% (Table 30).

The chi-square tests upon the cattle and sheep/goat samples revealed no significant bias in the deposits. The number of pig fragments was too small for such calculations to be made. The cattle sample showed a fair degree of variation, especially in the proportions of fragments in Categories 1 and 4, but relatively few fragments involved meant that the difference between the GS I-II and GS III sites could still be ascribed to chance. Both the sheep/goat samples had high proportions of Category 1 fragments (0.33 and 0.36) and low proportions of Category 2 fragments (0.18 and 0.20). Because of these unusual category proportions, the percentages of the major stock animals recorded in this phase (54.14% sheep/goat, 33.33% cattle, 12.53% pig) could not be directly compared with any of the other phases (Table 31).

A minimum number of only 24 individuals could be assigned to this phase, and the numbers involved precluded any significance tests being carried out on the category proportions of the principal species. Overall the percentages of 50% sheep/goat, 29.17% cattle and 20.83% pig were similar to those of the preceding phases, but the sample was small and the proportions of the sheep/goat assemblage were such that any conclusions must remain tentative (Table 32).

Of the other mammalian species only cat, dog, horse and hare were present in these deposits, all in small numbers (Table 30).

Md9 — Features dated to the early fourteenth century

Eleven features from the GS I-II, GS III and TS sites contributed 2,145 fragments, of which 1,237 were identifiable. All the 459 fragments from the GS III site were discovered in one deposit (F. 296). The five GS I-II features contributed about half the fragments dated to this phase. The principal domestic stock accounted for 95.22% of the 1,005 identifiable mammalian fragments (Table 33).

Chi-square tests were again carried out where possible on the principal stock assemblages and these showed no significant lateral variation in the fragments represented in the cattle and sheep/goat samples. The pig sample was again too small for such tests to be carried out. However, despite the homogeneity of the sample, the percentages obtained for the stock animals on the three sites varied a lot. The GS III sample in particular was unusual in that only 33 fragments of cattle (21.85%) were recovered. This was even less than those of pig (23.18%). In contrast, on the GS I-II site, cattle contributed 50.60% of the fragments. In the phase as a whole, cattle and sheep/goat contributed about 43% of the stock fragments (Table 34). The variations in the percentage of fragments on the sites are probably the result of the small sample sizes from a limited number of features dated to this phase.

The chi-square tests on the S.M. also showed no significant variation in the cattle and sheep/goat assemblages. The bones from which the minimum numbers of each species were calculated on the three sites in question were generally typical for the animals involved (Table 35). The minimum numbers method of counting also eradicated most of the lateral variations in stock percentage figures encountered in the count of fragments. In a sample of 65 animals, sheep/goat contributed 56.92% of the individuals, cattle 27.69% and pig 15.38%. The percentages on each site varied by about 6 to 7% for sheep/goat and cattle and about 2% for pig. The GS III site, which produced the highest percentage of sheep/goat should be treated with suspicion since the sample was taken from only one feature.

The representation of the remainder of the mammalian sample was typical of the medieval period. Cat was the most common of the rarer mammals, contributing 2.09% of the mammalian fragments (Table 33). Horse, hare, dog (whose seven fragments all came from one skeleton) red deer and rabbit were also occasionally represented.

Md10 — Features dated to the late fourteenth to fifteenth centuries

Features dated to the period immediately subsequent to the Black Death unfortunately did not contain enough faunal material to indicate what effect the plague had, if any, on the diet of the inhabitants of Exeter. Only 795 fragments from fourteen features were analysed, of which 479 were identifiable. The GS I-II and TS sites between them contributed all but five of the fragments dated to this phase. 93.69% of the fragments belonged to the principal stock animals (Table 36).

In this phase, chi-square tests were only feasible on the sheep/goat sample and these indicated no significant variation between the GS I-II and TS sites, although the variation in the number of fragments in the seven bone categories was quite high. The TS site contained a high proportion of sheep/goat Category 1 fragments (0.42). In addition 17 of the 37 pig fragments (0.47) dated to this phase also came from the skull or jaw. Consequently, the overall percentages of 47.16% sheep/goat, 39.72% cattle and 13.12% pig are best kept in isolation, since the assemblages are different in content to those of other phases (Table 37).

In a sample of only 33 individuals, any assessment of the relative percentages of stock obtained through the minimum numbers method in this phase is a hazardous procedure and the results given in Table 38 should not necessarily be considered representative.

Of the rarer mammals, cat, hare, horse, dog and rabbit were represented in small numbers. 108 of the 112 fish fragments recorded from the TS site were recovered from TS F. 169 and that concentration accounted for the large percentage of fish on that site (Table 36).

Lateral variation in the medieval deposits

The detailed examination of the medieval deposits again revealed the effects of lateral variation in animal bone assemblages even from neighbouring sites. The variability encountered was less dramatic than in the Roman deposits. No large scale dumps of material associated with the primary butchery process were discovered, for example. This is not surprising as the majority of the bone was derived from domestic rubbish and cess pits. If large scale dumping of particular parts of the carcases took place in this period, the evidence for it is unlikely to be contained in these deposits. Smaller concentrations of particular bone types were encountered, however. The abundance of sheep and goat horn cores in the GS I-II deposits of twelfth century date (Md2) may be associated with the manufacture of horn objects, for example. In several instances concentrations of skull and jaw fragments of one species coincided with those of one or more of the others. Similarly, unusually large numbers of good quality meat bones were found sometimes in the assemblages of all the principal stock animals in the same deposits. In addition, there was often a positive correlation between the proportions of carpals, tarsals (Category 5) and phalanges (Category 6) represented.

Several factors could account for the inter-site variations observed in these deposits. Differential preservation of bone is one, although there was no consistent evidence of this from the observations of the condition of the surviving fragments. Some waterlogged pits, which produced large concentrations of fish in some instances, did preserve more of the fragile bones but there was no consistent inter-site variability. Differential recovery is another factor that can influence the types of bone represented. The increase of Category 5 and Category 6 bones in some deposits is probably indicative of both good preservation and recovery. Again, however, these variations were not confined to one site and cannot explain other aspects of lateral variation. It is also possible that the inter-site variations reflect the different social status or wealth of the inhabitants of the various sites. Such a phenomenon was not reflected, however, in the pottery types (Allan *pers. comm.*) and the best cuts of meat (represented by Category 2 bones in particular) showed no consistent trend to be more common on a particular site. Indeed, there is no reason why variability in social status should be reflected in this way.

Despite the variability in the assemblages, there seems no doubt that all parts of the skeleton were liable to be deposited in domestic rubbish deposits. This could imply two things: the first is that the householders themselves did a lot of their own butchery of carcases; the second is that they procured from the market (or other source) all parts of the skeleton, even the portions that have little food value. Given adequate space and by salting the meat, there is no reason why individual households could not store complete carcases on occasions for domestic consumption. However, it is necessary to compare these assemblages with those of other sites in medieval Exeter before such distributions can be better understood.

Relative number of animals represented in the medieval deposits

Since the analysis was confined to a large sample of bone obtained from one area of the town, it is theoretically possible to obtain some idea of the relative abundance of the domestic species, whose meat was consumed by the inhabitants of that neighbourhood. Such a premise does not take into account several factors. The first is that the abundance of material was concentrated mostly in features dated to the twelfth and thirteenth centuries. Evidence from the late medieval period was extremely limited due to the change in disposal practices, which resulted in the digging of much fewer refuse pits in the areas in question. Secondly, it is possible that the evidence from these pits is not representative of all the disposal practices. Some bones may have been cast onto the ground surface where they are more likely to have been destroyed. There is no guarantee that these bones were the same types as those that were dumped in the pits. Thirdly, it has been shown that inter-site variability still played an important part in the relative abundance of the species represented. This meant that some of the methodologies usually employed in quantitative analysis of animal bones were inadequate for such a complex situation.

The complexity of the deposits and the variations encountered between individual features, sites and phases meant that the method of counting all the identifiable fragments could not be employed as an accurate means of comparing the relative number of stock animals in the medieval period. Because different concentrations of bone types can affect the relative number of fragments represented, direct comparison between two phases can only be made in cases where the samples of all species are of a similar nature, and in practice these were found to be comparatively rare.

Other faunal analysts have counted individual teeth and skull fragments separately from the rest of the sample, no doubt in recognition of the fact that these fragments in particular are subject to a great deal of variability in archaeological samples, since often a large concentration of loose teeth and skull fragments may represent the smashed remains of relatively few jaws and skulls. Certainly many of the biases observed in the medieval phases of Exeter resulted partly from the variations in Category 1 fragments. However, these were not the only cause of the sample bias. When all Category 1 fragments were excluded from the medieval sample and a constant proportion for each of the six remaining categories established for each species using data derived from the period as a whole, chi-square tests still revealed significant variations in the cattle and sheep/goat assemblages. Table 39 gives the results of these calculations. Pig was the only stock animal that was found to have an homogeneous sample in most of the phases. However, only the small Md10 sample showed no significant variation in the samples of all three species. The results of this analysis meant that it was not possible to compare the relative percentages of fragments found in the ten medieval phases, even after Category 1 fragments had been isolated from the rest of the samples.

The question must then be posed as to whether the minimum numbers method of counting is in fact a valid method of assessing the proportions of stock animals in this period, given the fact that the fragment samples were so heterogeneous in nature. As has been seen, the chi-square tests on the proportions of the sum of the minimum numbers in each bone category usually revealed less variation than that observed in the count of fragments. However, this in itself does not mean that the number of individuals calculated for a particular species was not biased by the inclusion of an atypical concentration of one type of bone. A case in point is the twelfth century (Md2) sample from the TS site. As was demonstrated above, although the significance tests on the cattle sample indicated that the contents of the various categories were similar to those from the other sites in that phase, the presence of an unusually large number of calcanea had raised the minimum number of cattle to a misleadingly high level. With this method, however, such discrepancies were easier to spot and overcome and although caution had still to be exercised the method was found to be much more reliable in a complex urban situation than the fragments method of counting. Its major drawback, however, was that except in the phases where an abundance of faunal material was recovered, the sample sizes of the minimum number of individuals obtained were small. As a result, although the general trends were apparent, any more subtle variations in the relative number of stock animals during the medieval period could not be recognised.

In order to test whether valid comparisons could be made between the various medieval phases using the minimum numbers method, an overall proportion for each of the seven categories was obtained for each species by adding together the sum of the minimum numbers obtained for the respective categories from all the deposits. Chi-square tests were then performed on each sample to test the null hypothesis that each sample was statistically similar to the medieval sample as a whole. In cases where the total sum of the minimum numbers was less than 40, the tests were not carried out, since the samples were too small for such tests to have much value.

The results of the analysis are given in Table 40. These showed that only three of the samples were biased at the 5% level of chi-squared: the cattle sample on the TS site in the Md1 phase; the sheep/goat sample on the GS I-II site during the Md2 phase; and the sheep/goat sample in the Md5 phase on the GS III site. None of the variations encountered in the other samples was found to be significant. The three biased samples did not unduly affect the relative percentages of the stock animals in their respective phases; but in order to obtain a statistically similar sample, the three sites involved were excluded from the calculations in those phases.

The resulting percentages of stock animals for all medieval phases are shown in Table 41. The figures for the Md2 and Md6 phases were based on the amended number of cattle and pig individuals respectively. Caution should be maintained over the interpretation of the results from Md4, Md8 and Md10 phases, since these samples were fairly small. In general, however, the results do show a fairly consistent pattern (Figure 2). Sheep/goat was the most common species with percentages ranging from 44 to 57%. Cattle was the second ranked species with between 27 to 34% of the minimum number of individuals. Pig was third with percentages that varied between 15 and 23%. The variations in the percentage figures can be explained simply as the variations one would expect in samples of a relatively small size, although the figures possibly do suggest that sheep/goat did become slightly more important numerically in the thirteenth and fourteenth centuries but according to these figures there was no dramatic change in the relative numbers of stock animals deposited in those areas throughout the Middle Ages.

Calculations of the minimum amount of meat weight represented by these figures were made on the largest samples. As will be seen later, there was no dramatic improvement in the size of the animals during this period and accordingly the Roman estimates of meat weight, as employed in Table 10, were used again. The criticisms and problems which were cited for the equivalent Roman calculations should be remembered in this instance as well.

As expected in a period in which the relative proportions of animals remained relatively constant, a fairly stable picture emerges in this analysis as well. Cattle provided 73 to 78% of the meat, sheep/goat 12 to 19% and pig 8 to 12% in the phases involved (Table 42). Even allowing for substantial errors in the estimations of the sizes of the animals and in the relationship between the percentages obtained for the minimum number of individuals and the actual proportion of livestock on the sites, beef in its various forms remained by far the most common meat during the Middle Ages in Exeter.

THE POSTMEDIEVAL PERIOD

The subdivision of the sample

The postmedieval sample was of similar size to the Roman assemblage. 17,928 fragments were studied, of which 10,865 were identifiable. Over 80% of the remaining fragments belonged to ribs and vertebrae of domestic animals. The bones were subdivided into the following four groups:

- Pm1) Features dated to the sixteenth century (1500 to 1600).
- Pm2) Features dated to the late sixteenth - early seventeenth centuries (1550 to 1650).
- Pm3) Features dated to the late seventeenth century (1660 to 1700).
- Pm4) Features dated to the late seventeenth eighteenth centuries (1660 to 1800).

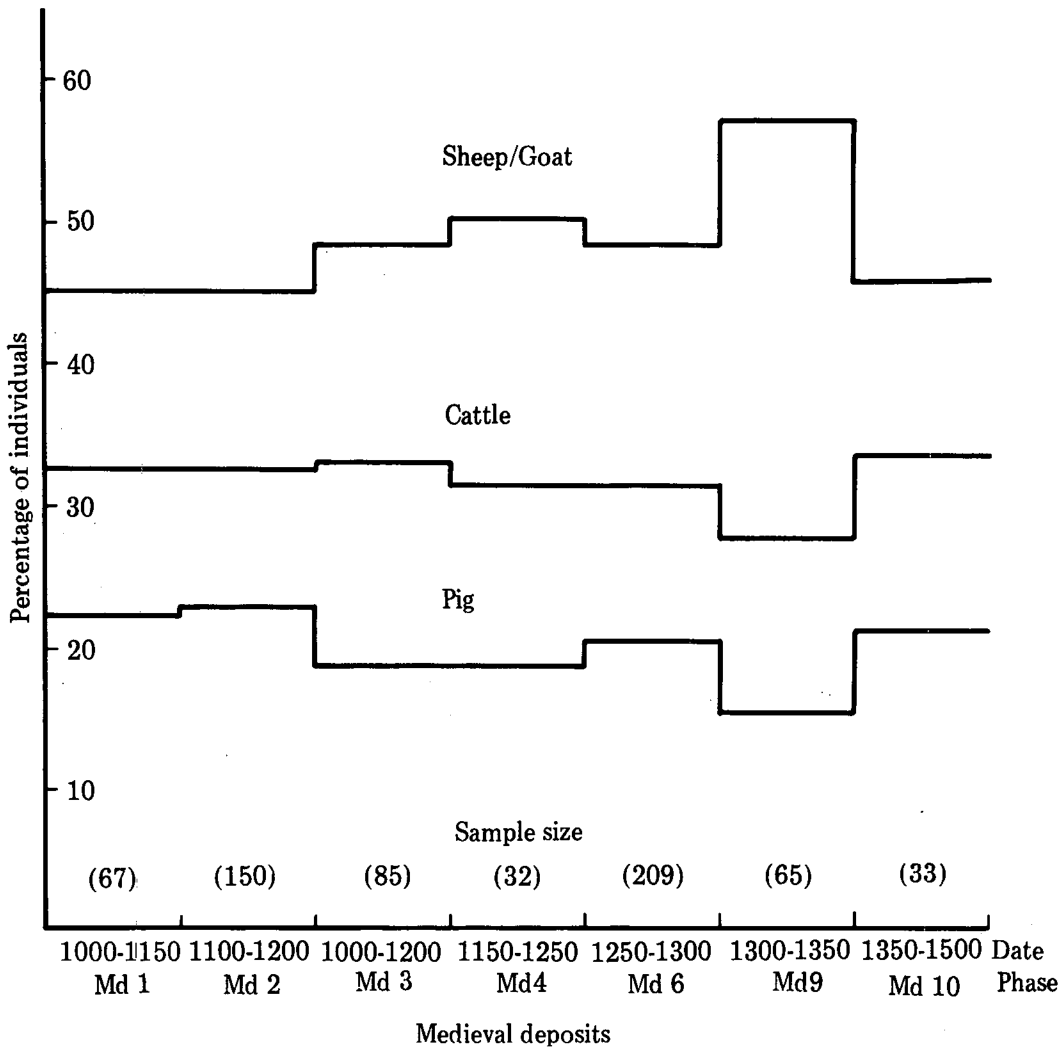

Figure 2 Minimum numbers of principal stock in the medieval period.

As was the case with the medieval animal bones, the assemblages from the GS site were divided into those from GS I-II and GS III for comparative purposes. The other sites studied were the TS and VS (phase Pm3 only) sites. The two most important samples belonged to phases Pm1 and Pm3. The former contained over 10,000 fragments and the latter over 3,500. Once again the deposits were of a complex nature, comprised mostly of material excavated from industrial pits, garderobes and garden deposits.

The individual phases

Pm1 — Features dated to the sixteenth century

The 29 features dated to this phase produced the most varied as well as the largest sample in the postmedieval deposits. 10,302 fragments were recorded, of which only 127 came from the TS site. 7,150 were examined from the GS III site and the remaining 3,025 were recovered from the GS I-II site. 3,934 fragments from all sites were unidentifiable. Only 79.76% of the identified mammalian fragments belonged to cattle, sheep/goat and pig. There were also very large quantities of bird and fish bones, especially from the GS III site (Table 43).

Table 44 shows the percentage of fragments and the relative category proportions of the principal stock animals. A feature of the assemblages of both the GS sites was the extremely large number of fragments belonging to Categories 2 and 3 — the major meat-bearing bones — and a correspondingly lower number of Category 1 fragments. This table excludes the pit GS III F. 264, which contained a large number of immature cattle skull fragments and was atypical of the other major deposits in this phase. Chi-square tests on the remaining features revealed that the observed variations in the contents of the GS I-II and GS III samples were not significant for any of the principal stock species. Using a simple count of fragments, cattle was found more commonly on the GS I-II site. Overall, however, sheep/goat contributed the most fragments (49.91%), followed by cattle (38.89%) and pig (11.20%).

Significance tests on the S.M. of the seven bone categories revealed little variation between the GS I-II and GS III samples. Once again the analysis revealed the high proportion of Category 2 and Category 3 bones for all species. Taking the figures for the minimum numbers at their face value, sheep/goat contributed 52.03%, cattle 30.40% and pig 17.57% of the 148 animals represented in the deposits dated to this phase (Table 45).

The GS III site in particular contained unusually large numbers of fragments belonging to species other than the principal stock animals. The outstanding example of this was GS III F. 228, a stone-lined pit which produced 318 cat, 125 rabbit and 42 dog fragments in a total of 1,206 identifiable mammalian fragments. This remarkable feature (the largest deposit investigated) also contained extremely large concentrations of fish (789 fragments) and bird (724 fragments) belonging to a wide variety of species. If the results from this feature are excluded, the remaining features on all sites in this phase produced a percentage of stock animals of 89.31% of the total mammalian fragments, a more typical figure. The concentrations of cat bones in the GS III site were accounted for by the remains of several burials, although the concentrations were so mixed that it was impossible to be certain of the actual number of skeletons involved. The number of fragments and minimum numbers of all species in this phase can be found in Table 43.

Pm2 — Features dated to the late sixteenth to early seventeenth centuries

Nine features from all three major sites were dated to this phase. The TS material consisted mainly of that excavated from the earliest levels of F. 316, a rich pit whose upper layers were dated solely to the late seventeenth century. From all the sites a total of only 770 fragments was recovered. 476 were identifiable and 89.90% of the mammalian fragments belonged to sheep/goat, cattle and pig (Table 46).

The total of 276 fragments was once again too small for chi-square tests to be carried out on the principal stock samples. As in the Pm1 phase, high proportions of Category 2 fragments were obtained for the sheep/goat assemblages (0.52), much higher than the equivalent figures in any of the medieval or Roman phases. In the phase as a whole, sheep/goat provided 52.54% of the fragments, cattle 40.58% and pig a meagre 6.88% (Table 47).

In a sample of 32 individuals, upon which no significance tests were possible, sheep/goat provided 59.38% of the animals present, cattle 28.13% and pig 12.58%. The high percentage of sheep/goat was to some extent inflated by the figures obtained from the GS I-II site, where an unusual abundance of humeri produced a minimum number of twelve individuals (70.59%) out of a total of seventeen stock animals on that site (Table 48).

Remains of seven other species of mammal were discovered in these features, mostly in TS F. 316. This rich deposit also had a comparatively large number of bird bones in its lowest layers, 129 fragments from 15 individuals (Table 46).

Pm3 — Features dated to the late seventeenth century

This phase produced the second largest faunal sample of postmedieval date. The sample of 3,502 fragments (2,224 identifiable) was collected from three sites. The TS site provided the largest number of fragments, which were nearly all obtained from the uppermost layers of F. 316. This deposit produced 1,826 fragments from these levels. The majority of the remainder of the bones dated to this phase belonged to much poorer GS I-II deposits. Finally a sample of 145 bones was obtained from the VS (Valiant Soldier) excavations. The principal stock animals provided only 68.31% of the total mammalian fragments in this phase (Table 49).

An examination of Table 50 reveals that the fragment assemblages of the individual species of stock animals obtained on the three sites were incompatible with each other. The degrees of variation witnessed in the sheep/goat and cattle assemblages were such that the chi-square calculations produced results that were well outside the 1% limit of the method in some cases. The sheep/goat remains were especially subject to a large amount of lateral variation. The VS assemblage produced a high percentage of this species (73.74%) but 29 of the 73 fragments recovered were metapodia producing a proportion of Category 4 fragments of 0.40, which, even though this was a small sample, was sufficient to produce significant variation from the other samples of sheep/goat in this phase. The results from the VS site highlight the problems of comparing the number of fragments excavated from different sites. This site is located in another part of the city from the GS and TS sites (Figure 1) and its faunal material from the seventeenth century levels was examined at random for comparative purposes. Its deposits illustrate the high levels of variation that can be encountered on a complex urban site such as Exeter.

Even when the VS site was omitted, there were still significant variations between the GS I-II and TS samples of sheep/goat and cattle. The TS site produced only 9 sheep/goat Category 1 fragments (0.04), an extremely low proportion, whereas the Category 2 and Category 3 fragments both produced levels of over 0.40 of the sheep/goat assemblage on the site (Table 50). The very low proportions of waste bones on this site caused the sheep/goat assemblage to differ significantly in content from that of the GS I-II site, which produced category proportions more typical of other postmedieval levels. The cattle assemblages had higher proportions of Category 2 fragments on the TS site than the GS I-II site, but the major variation in their assemblages was caused by the high ratio of Category 4 bones on the TS site. Most of the cattle metapodia came from very young animals and were deposited in TS F. 316. Accordingly the site samples contained in this phase have to remain separated, although the percentages of the stock animals in each case were similar. On the GS I-II site, sheep/goat contributed 53.58% of the fragments, cattle 38.92% and pig 7.50%. In the TS deposits, the equivalent percentages were 48.80%, 42.07% and 9.14% respectively.

The variations in the deposits were sufficiently great also to bias significantly the calculations of the minimum number of individuals. The samples of sheep/goat on the three sites again showed significant variation at the 1% level of chi-squared. The causes of this variation were the same as those cited for the fragments method of counting. The results from the three sites could therefore not be compared directly, although the percentages of stock animals obtained were similar. The percentage of sheep/goat ranged from 57 to 67%, that of cattle from 20 to 26% and that of pig from 11 to 15% (Table 51). The results from the VS samples were based only on nine individuals, however, and should probably be ignored. The GS I-II and TS samples consisted of 35 and 34 individuals respectively and may therefore be more reliable.

The comparatively low percentage of stock animal fragments in the total mammalian assemblage during this phase was caused by the presence of a large number of dog, cat and rabbit remains in TS F. 316. Like GS III F. 228 (Pm1), this feature that produced extremely rich artifacts also contained a much wider variety of mammalian, avian and fish remains. In this instance, the burial of a large number of dogs produced 265 fragments from a minimum of 24 individuals, with the result that the dog was the most commonly found species on the TS site (Table 49). Cat and rabbit also contributed a higher proportion of the total number of mammalian fragments than was normally the case. Bird bones were very numerous in this deposit, as indeed they were in GS F. 228, producing a total of 320 fragments from at least 37 individuals. In contrast, the percentage of the principal stock animals on the GS I-II site (91.97%) was similar to the results obtained from the majority of the phases in the Exeter deposits.

Pm4 — Features dated to the late seventeenth to eighteenth centuries

The final phase considered in this analysis consisted of 31 features dated to the late seventeenth or eighteenth centuries. 2,503 of the 3,354 fragments (1,797 identifiable) were found on the GS I-II site. Only 66 fragments came from the TS site and the remainder were recovered from the GS III site. The majority of the GS I-II features contained small amounts of bone, although F. 96 contributed 921 and the results from this stone-lined pit influenced the results from the phase as a whole. The majority of the material was associated with an area of low social status. The GS sites produced artifacts of low quality and the documentary evidence shows that the area was situated in a parish that had a low tax assessment (Allan *pers. comm.*). The bone therefore came from contexts far removed from some of the very rich deposits found in the other postmedieval phases. 81.61% of the identified mammalian fragments belonged to the principal stock animals (Table 52).

The figures for pig in Table 52 included ten fragments from one very young animal, which were discounted in the detailed analysis of the principal stock animals (Table 53). The only samples of any significance were those of cattle and sheep/goat on the GS I-II and GS III sites. The category proportions of the smaller GS III samples differed at the 5% level of chi-squared from those obtained from all sites in this phase. Divergences in the proportions of cattle Categories 3 and 6 and sheep/goat Category 4 fragments were the major reasons for the sample variation. Intra-site variation among the GS I-II assemblages was also high due principally to the small sample sizes and the differential preservation within the deposits. Despite these fluctuations the analysis of the category proportions revealed similar trends to most of the other postmedieval deposits. There were low proportions of Category 1 fragments and high proportions of Category 2 bones. Despite the significant variations between the GS I-II and GS III samples, the percentages of the species represented showed less fluctuation. In all deposits sheep/goat contributed 52.24% of the principal stock fragments, cattle 36.90% and pig 10.86%.

Significance tests on the S.M. of the bone categories were not practicable for cattle and pig because of the small samples obtained from the GS III and TS sites. No significant variation was found in the sheep/goat samples, although the comparatively large number of metapodia recovered from the GS I-II site (Category 4 = 0.15) was again reflected in the category proportions. In a sample of a minimum of 76 individuals from all sites, 50% were represented by sheep/goat, 28.95% by cattle and 21.05% by pig (Table 54).

The number of fragments belonging to the rarer mammals was inflated by the presence of a partially preserved dog skeleton in GS I F. 10 (56 fragments). GS III F. 214 produced a large number of rabbit (66 fragments) and hare (40 fragments) bones. The majority of these belonged to the metapodials and phalanges and were the remains of the unwanted feet of these animals which were dumped in this pit after the carcases had been skinned and butchered. These factors combined to produce the high percentage of non-stock fragments in the sample (Table 52).

Lateral variation in the postmedieval deposits

The postmedieval animal bone assemblages again demonstrated the difficulties of interpretation of such material. A feature of all of the phases was the low representation of skull and jaw fragments, especially of sheep/goat. This phenomenon is demonstrated in an extreme form in the rich late seventeenth century deposits of the TS site (Pm3). Sheep/goat Category 1 fragments formed very little part of an assemblage that was completely dominated by Category 2 and Category 3 meat bones. Despite excellent preservation conditions the metapodia and phalanges of sheep/goat were also rarely found. The predominance of good meat bones was also a feature of the cattle and pig assemblages in all phases. It will be shown later that the Category 1 fragments of cattle and sheep/goat that were recovered belonged mainly to the skulls and jaws of young animals. Those of the older stock now appeared only rarely on these sites. This is doubtless a reflection of postmedieval marketing practices. The carcases of the principal stock animals were treated in a systematic way by the town's butchers. Most of the skulls and feet of the animals were not sold to the townspeople. Accordingly they were not found amongst domestic rubbish in any numbers. On the other hand, these parts of the skeleton of young animals did appear more commonly and this suggests that all parts of their carcases more often reached the consumer.

Such trends were found generally in both rich and poor contexts and seem unaffected by any possible distinctions in social status. It may be more than coincidence, however, that it was the richest pits (in particular TS F. 316 and GS F. 228) that produced the largest proportions of good meat bones (Category 2) and also the widest range of species. Although by no means all the animals represented were eaten — for example the cats and dogs — the proportion of rabbit and the variety of bird species were much greater than usual. The abundance of fish in these deposits was also very high but this can be explained largely by the excellent preservation conditions that prevailed.

Relative number of animals represented in the postmedieval deposits

The lateral variations encountered in the deposits again presented difficulties in comparing the number of animals represented. In addition, the unusually rich and varied nature of some of the contexts was probably atypical of other areas of the town. Generally, the relative percentages of the major stock animals were consistent in all four phases. The inter-site variations do not seem to have affected these figures except in a few extreme cases. To take the results from the more reliable minimum numbers method, nearly all the samples produced percentages that ranged between 50 to 65% for sheep/goat, 20 to 35% for cattle and 12 to 25% for pig. Because of the size and nature of these samples, however, little can be said about the fluctuations in these percentages until a wider range of postmedieval material has been compared.

COMPARISONS OF THE ROMAN, MEDIEVAL AND POSTMEDIEVAL SAMPLES

Lateral variation and methodology

The methods of quantitative analysis employed on the Exeter material enabled the monitoring of lateral variations at both intra- and inter-site levels. Their interpretation is, however, more difficult. Differential preservation, excavation techniques and cultural activities, such as butchery and marketing practices, all played some part in the variations encountered, sometimes in a complex inter-relationship. For example, it is not possible to define from the Exeter animal bones what types of bone make up a typical domestic refuse assemblage. Differential destruction of bone fragments by attrition (Binford and Bertram 1977) and by butchery (Yellen 1977) has been demonstrated in ethnographic studies and can be applied to this and other urban material. In addition, although most of the animal bones examined were derived from domestic rubbish (if one accepts that most of the broken pottery and other artifacts, with which the bones were associated, were discarded as domestic waste), their contents displayed a great deal of variability between periods. Some of this was a direct consequence of changes in marketing practice, as the dramatic decrease in the occurrence of skull and jaw fragments in the postmedieval deposits showed. Other more subtle variations, such as those potentially resulting from dietary preference or social stratification were much harder to demonstrate, since factors of differential preservation and recovery could also have influenced the appearance of the assemblages. It should be possible to overcome these difficulties even on complex urban sites given a rigorous and consistent sampling policy and a detailed analysis of the types of fragments recovered. Unfortunately research on taphonomic processes of bones needs to be developed before a satisfactory solution can be reached. At Exeter it was possible to demonstrate that there was a strong correlation between the unusually high proportion of phalanges of the principal stock species and the survival of a large number of poorly surviving epiphyses on the Cathedral Close site in the Roman deposits. Subsequent multivariate analysis of some of the larger samples has revealed equally interesting correlations between different classes of bone. For example, poorly preserved material was often characterised by a high proportion of loose teeth– the densest and best-surviving parts of the skeleton (Maltby *in preparation*). Unfortunately most of the samples in the Exeter deposits were too small to allow a more detailed multivariate analysis of the material to be undertaken. It was because of the size of the samples that the bone fragments were subdivided into the seven categories used throughout the preceding analysis. It should be stressed, however, that each of these categories contains independent elements, which, given consistently larger samples, should be treated separately. Ideally the analysis of variability should be extended still further to take into account the different portions of each bone element and the butchery and ageing evidence. Nevertheless, even the more limited examination of the Exeter material was able to demonstrate the major variations in the assemblages. It was possible in some periods to distinguish primary butchery debris, specific carcass trimmings and waste from the manufacture of bone and horn implements from ordinary domestic refuse. This in turn enabled important information about the marketing of meat to be attained. There is no reason why similar analyses of animal bones from other urban sites should not provide equally interesting insights into the refuse disposal and marketing practices of a town.

The relative number of species represented

The difficulties of comparing the number of animals represented within the three major periods have already been discussed. The problems are compounded still further when attempts are made to compare the material from the three periods as a whole. Any attempt to do this using a simple count of fragments is doomed to failure, since the samples from the different periods produced large discrepancies in their contents. The minimum numbers method carries more hope, although it drastically decreases the size of the sample. It has also to be established that the samples that were similar from one period were also similar to those from another. Accordingly chi-square tests were carried out to test the null hypothesis that the samples of the principal stock animals of Roman date (Table 9) were similar to the statistically similar samples of medieval date (Table 40). To do this, all the relevant data from both periods were pooled, so that an overall proportion for the S.M. of each of the seven categories of bone could be established for cattle, sheep/goat and pig. The results (Table 55) revealed that, although the sheep/goat and pig assemblages were similar in both periods, the cattle samples changed significantly in the medieval deposits. The variation in the proportions of Categories 1 and 3 was the major cause of this dichotomy. Therefore, even though the large concentrations of cattle skull and jaw fragments in the Roman deposits were omitted from these calculations, the proportion of Category 1 bones (0.23) was still incompatibly high in comparison with the larger medieval assemblages (0.18). This variation was sufficient to have a bearing on the calculations of the minimum number of individuals as well. In nine of the fourteen Roman samples considered, the most represented bones (from which the minimum number of individuals was obtained) were the skull, teeth or mandible, either singly or together with a bone of another category. In the medieval deposits a similar situation occurred only in five of the 28 site samples in which cattle were represented. Consequently the percentages of the minimum numbers of stock animals cannot be compared in their entirety, since it seems likely that the changes in the cattle samples significantly affected the results. In addition, it has already been shown that some of the Roman samples still revealed significant variation in their contents, even using the less discriminating S.M. method of analysis. This again may have influenced the calculations of the minimum number of individuals.

Similarly, because of the notable changes in the assemblages of all the principal stock animals in the postmedieval deposits, these cannot be compared directly with the samples from the earlier periods. Significance tests on the medieval and postmedieval assemblages were made and showed that the contents of the sheep/goat samples in particular had changed so much that not one of the post-medieval samples was statistically similar to those of the medieval deposits.

It is interesting to note that, despite the heterogeneity of the samples in all periods, the variations in the percentage of the minimum numbers gave much more consistent results once the unreliable small samples had been disgarded. It is not claimed that the variations between any of the samples need necessarily have affected the relative representations of the animals in those samples; indeed, the general similarity between the percentages obtained in many cases would suggest that the opposite was true. However, unless one is certain that a totally representative cross-section of the faunal sample has been collected at any particular period, it is not justifiable to ignore the lateral variations encountered and accept the cumulative results from the different areas as being representative of the city as a whole. That situation may never be achieved on an urban site unless the excavations are of an enormous scale. It is possible to say, for example, that, employing the minimum numbers method, the percentage of sheep/goat on the sites so far investigated in Exeter ranged mainly between 35 to 50% in the Roman and earlier medieval deposits. In phases dated later than the thirteenth century, the same species provided 50 to 60% of the minimum number of individuals represented. This does not prove, however, that there was a significant increase in the amount of lamb or mutton eaten in the town in those later periods, since the contents of the samples themselves changed significantly. It is tempting to correlate the increase in the levels of sheep/goat with the well documented expansion and boom in the cloth trade in Devon from the late Middle Ages onwards. It is indeed possible that more sheep were kept and brought to Exeter in that period. It is equally likely, however, that the changes in the marketing of meat, as demonstrated by the archaeological evidence, contributed to the changes in the relative number of animals recovered from the deposits.

On the other hand, more limited conclusions can be drawn. The similarities in the contents of the sheep/goat and pig samples from the Roman and medieval deposits (Table 55) make it possible for these species to be compared. Ignoring the Cathedral Close Roman samples that contained unusually high proportions of pig phalanges and metapodials, sheep/goat was consistently slightly better represented in the medieval deposits. This is perhaps best demonstrated by comparing the minimum amount of meat represented in these periods (Tables 10 and 42). Most of the Roman samples are, however, too small for us to place much confidence in the results. Pigs were more poorly represented in the postmedieval deposits but once again this may have been due more to factors of sample variation than to an actual decrease in the importance of pork as a food resource. The statistically similar medieval samples derived from large accumulations of bone showed only small fluctuations in the proportions of the principal stock animals represented (Figure 2). It remains to be seen whether these were typical of deposits in other areas of the town, but the impression of the present evidence is one of consistency throughout the earlier medieval period at least.

Another consistent feature of all the periods was the total dominance of the domestic stock animals in the food deposits. Only in isolated cases did the percentages of the principal stock drop below 90% of the mammalian fragments. When this did occur, the reasons underlying it could be ascribed to unusual concentrations of dog or cat burials, or in one case, the disposal of the unwanted feet of hares and rabbits. None of these concentrations of bones was the result of ordinary domestic disposal of kitchen waste. It will be seen later that the avian sample was also dominated by domestic species, particularly domestic fowl. Game animals and birds played only a small role in the diet of an average city dweller in all periods.

It is also likely that the citizen of Exeter ate more beef than any other type of meat or poultry. Tables 10 and 42 showed the estimations of the minimum amount of meat weight of the major stock animals in the Roman and medieval periods respectively. Similar calculations could be carried out for the postmedieval period with similar results. Cattle provide so much more meat per individual than either pig or sheep/goat that, even allowing for all the possible errors in the assessment of meat weight and in the minimum numbers method of counting, cattle would still have supplied (at a conservative estimate) over half of the meat consumed in Exeter.

COMPARISONS BETWEEN ARCHAEOLOGICAL AND DOCUMENTARY EVIDENCE

Reference to animal husbandry in Devon in the documentary record are few and far between . There is no evidence at all from the Roman period and the medieval and postmedieval evidence consists mostly of passing references in contemporary texts. For example, John Hooker, writing in 1599, stated that although Devon farmers did not possess great flocks, every landowner had, along with his other stock, a few sheep, so that he thought that Devon might possess more sheep than any other county in England. Hooker, however, also noted that his county was a great producer of cattle as well as sheep (MacCaffrey 1958: 7-8, 162). More detailed surveys have been carried out on the records and accounts of Tavistock Abbey in West Devon (Finberg 1951). From these it can be elucidated that at the time of the Domesday survey the Abbey possessed 918 sheep on its various manors. By 1398 the number of sheep on these lands had increased to approximately 1,200. In 1497 the total had dropped to

1,074, but by that time one of the manors had been leased out and the number of animals on its lands was not recorded (Finberg 1951:145). Unfortunately, similar figures were not quoted by Finberg for other stock animals, other than those obtained from Domesday Book, so it was not possible to compare the numbers of pigs and cattle with those of sheep, in order to establish whether there was any change in the relative numbers of stock kept on the estates during the medieval period. Such results would have proved interesting, although the same trends need not have been reflected in eastern Devon, where Exeter is situated.

One is therefore left with the Domesday record as the only detailed documentary source of livestock numbers in the medieval period. The information about the Domesday survey of Devon is extant not only in the Exchequer Book but also in another volume known as the 'Exon Domesday' which gives details of the survey in the counties of Cornwall, Devon and parts of Wiltshire, Somerset and Dorset (Trow-Smith 1957:66). A translation of the text was published in the Victoria County History of Devonshire in 1906 (Vol. 1 403-549). The following is a typical entry of a manor held in demesne to the King, the Church and other landowners:

> 'Ruald has a manor called Wenforda (Wonford) which Edmer held T.R.E. (in the time of King Edward) and it paid geld for ½ virgate. This 2 ploughs can till. Walter de Osmundvil holds it for Ruald. Of this W(alter) has in demesne 1 ferding and 1 plough and the villeins 1 ferding and 1 plough. There W(alter) has 2 villeins, 2 serfs, 20 beasts, 8 swine, 30 sheep, 10 goats, coppice 1 furlong long by ½ furlong broad, 50 acres of meadow and 2 furlongs of pasture taking length and breadth. Worth 15 shillings a year; when R(uald) received it it was worth 5 shillings'. (Page 1906:510).

Such records therefore give quite detailed information about the amounts and types of land owned, the number of animals kept, and the number of villeins and serfs on each manor. The references to livestock concern the actual numbers of animals recorded and also the animals that pulled the ploughs. It is generally assumed that the plough-team consisted of eight cattle, although one or two discrepancies in the Domesday text may indicate a six-beast team. On one manor in the vicinity of Exeter, however, (Creedy Peyherin), it is recorded in the Exon Domesday that the villeins possessed one plough and had seven oxen towards another. In the Exchequer version the same manor is recorded as having two complete ploughs (Page 1906:482-3). Accordingly it seems that eight-beast teams were the usual complement. Therefore in the quoted example the two ploughs mentioned would indicate that sixteen cattle were kept for such purposes on those lands. Horses were not employed in ploughing in Devon until much later times.

The twenty beasts (*animalia*) also recorded on the Wonford estate are usually assumed to be non-ploughing cattle. This would bring the quota of cattle on that manor to 36. Occasionally cows (*vaccae*) were recorded but never on the same holding of land as *animalia*. The *animalia* may have consisted mainly of breeding stock, which would have been required to replace with new stock the oldest members of the plough team when their working days were over. However, it is doubtful that the number of *animalia* recorded for Devon as a whole (7,357) would have been sufficient to have provided all the replacements required for the 46,066 cattle in the 5,758¼ plough teams unless the average working life of plough animals was an extremely long one. It is possible that only adult animals were recorded. Alternatively some of the breeding herd may have been included in the numbers of the plough team. The question cannot be answered satisfactorily from historical records alone.

Another problem encountered with regard to the total number of cattle in Devon at the time is the fact that in the Domesday Book a total of 90 entries, which were recorded as possessing plough lands, did not mention the presence of any plough teams (Welldon Finn 1967:245). Most of those lands, however, consisted of fairly small tracts which may not have had much, if any, ploughing done on them.

Bearing these factors in mind, the total numbers of livestock on demesne lands in Devonshire in 1086 is recorded in Table 56. If the numbers of the principal stock animals are considered alone, the relative percentages read: sheep/goat 48.57%, cattle 45.28% and pig 6.16%. The numbers of pig are certainly under-represented since there are several instances of manors where swineherds were recorded as paying an annual rent to the landowner but no pigs were actually mentioned. In Devon as a whole 264 swineherds paid 1,343½ pigs in rent, while 110 others were not stated to pay any fixed sum (Trow-Smith 1957:80).

The animals listed for Devonshire, assuming that all were utilised for food upon their deaths, would have gone to other markets as well as Exeter and the picture for the county as a whole may not reflect the situation in the vicinity of the city itself. Accordingly, only the manors in the surrounding area of Exeter were considered (Figure 3). Livestock in the reduced area would still have found other markets, such as Crediton, but the results ought to give a better indication of the resources available to Exeter. Table 56 shows that on the demesne lands in the Hundreds around Exeter cattle and sheep/goat were recorded in almost equal numbers (48.69% and 49.22% repectively). The very low percentage of pig (2.09%) is misleading since in this area 49 swineherds are recorded as paying 253 swine yearly and another five swineherds paid 31s. 3d/ annum to their respective landowners .

Can such figures be used in a direct comparison with the animal bones recovered from Exeter? It is unfortunate that one cannot be certain that either source of evidence is an accurate reflection of the relative numbers of livestock kept in the area. Domesday Book only records animals held on demesne lands. It does not take into account the livestock owned by villeins and serfs on holdings that were not subject to the Domesday assessment. How large a proportion of the total stock this entailed is impossible to say but it cannot be assumed that the ratios of the stock animals on the demesne lands were the same as those on other holdings. The poorer peasant, if he had any livestock at all, would tend to keep pigs and sheep, which are less costly to maintain than cattle. If this was the case, the relative percentages of cattle and sheep/goat may in fact be somewhat biased in favour of cattle but to what extent is unknown. Nor do the records state whether all animals of a species were recorded Young animals are nowhere specifically mentioned and it is possible they were not included in the accounts. Nor indeed need the population of Exeter have consumed a true cross-section of the meat available to them in the surrounding countryside. As will be discussed in Chapters 3 and 4, it is possible to argue a case that many older cattle and sheep/goat did not find a market in the city. In addition the two methods of counting employed may not accurately reflect the true ratio of the species being brought into Exeter.

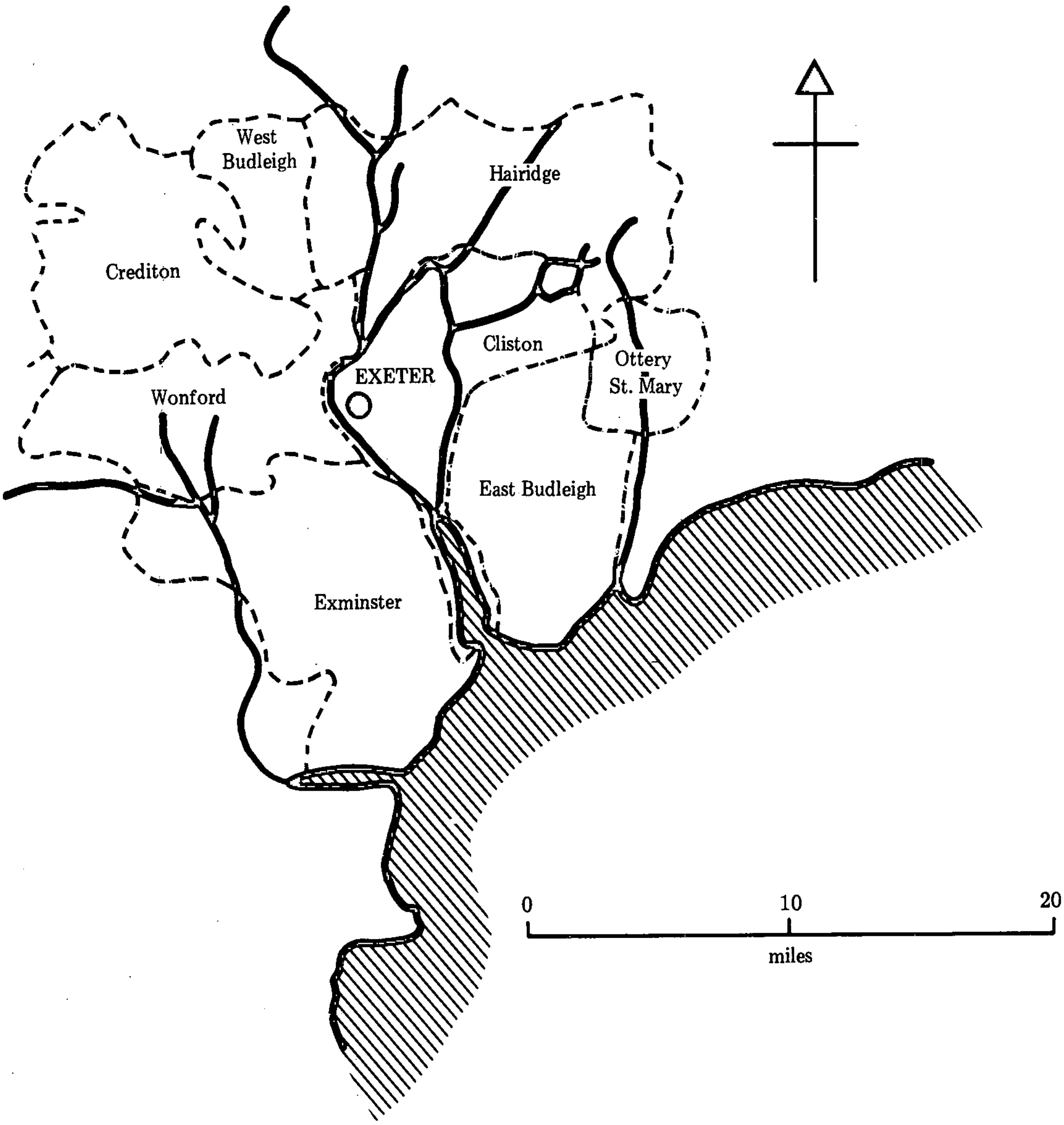

Figure 3 The Hundreds around Exeter.

An equally important point is that, whereas Domesday Book records living animals, the analysis of animal bones attempts to estimate the proportions of the animals slaughtered. They are therefore dealing with quite different phenomena. It will be shown later that many of the sheep/goat represented in the early medieval layers of Exeter were immature animals whereas the majority of the cattle were mature. Assuming for the moment that the animals represented in Exeter were a cross-section of the animals bred in the surrounding area, cattle in terms of absolute livestock numbers kept are probably underestimated in the archaeological samples because of their longer life expectancy.

Consequently, when the relative percentages of sheep/goat and cattle recorded in the demesne lands around the town are compared with the data obtained from the two methods of counting the bone fragments in the excavations, the results have to be treated with suspicion, since the results obtained from all three methods may not be indicative of the actual percentage of livestock numbers in the area. Figure 4 shows the relative percentages of cattle and sheep/goat obtained from the three sets of analysis. Pig was excluded from the comparisons because of its obvious under-representation in the historical records. The data of the minimum numbers were taken from the GS I-II and GS III sites in deposits dated to the eleventh and early twelfth centuries (the Md1 phase). The percentage of fragments was calculated from data obtained from the largest of the Md1 samples, that of the GS III site. The results revealed that the variations in the percentage of animals obtained by the three methods were in the order of about 14% and that the results from the Domesday survey (49.7% cattle) lay between the two extremes obtained from the fragments method of counting (about 56% cattle) and the minimum numbers method (about 42% cattle). The results therefore showed general similarities but it is not possible to draw direct comparisons because of the quality of the data involved.

The results of the quantitative analysis of the Exeter faunal material must in some ways remain largely inconclusive. It is apparent that the traditional methodologies used in such analyses have to be improved. Large samples from well excavated urban sites will be understood fully only by detailed statistical examination of the individual fragments. As the number of variables considered increases, the only practicable way to study the material is through the use of multivariate analysis. Such techniques are useful only in large samples, however, but more limited statistical techniques

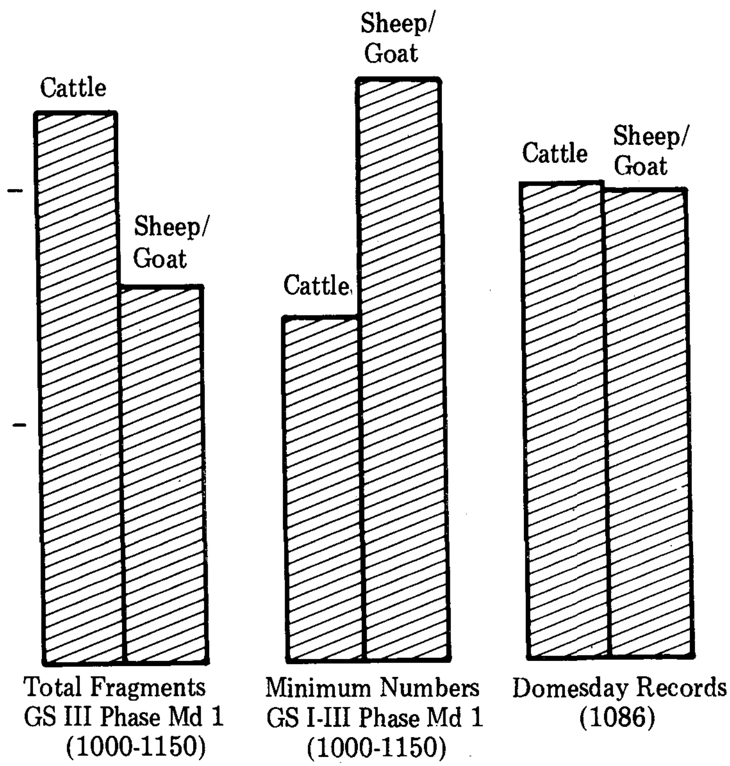

Figure 4 Cattle and sheep/goat percentages compared with Domesday Records.

can be used to provide a guide to the amount and sometimes the causes of intra- and inter-site variations, as it is hoped the previous discussion has demonstrated.

Despite the problems of lateral variation, it is possible to attain some idea of the relative changes in the meat diet in an urban situation over a long period of time but such quantitative analyses and the calculations of factors such as meat weights do not represent the total potential value of the animals represented. Dairy commodities, hides, skins and fertiliser are all additional important products of the animals involved. Cattle and horses can also be employed as beasts of burden. To obtain an idea of the real importance of these species in the economy other factors must be considered. These will be dealt with in the following chapters, in which the exploitation pattern of the major stock animals and the rarer mammals, birds and fish will be studied in turn.

3.

THE EXPLOITATION OF CATTLE

AGEING DATA

Both tooth eruption and epiphyseal fusion data were studied on samples of all periods. Six stages of development of the mandible and maxilla were chosen for comparison. These were as follows:

- Stage 1 The fourth deciduous premolar (p4) in wear.
- Stage 2 Both columns of the first molar (M1) in wear.
- Stage 3 Both columns of the second molar (M2) in wear.
- Stage 4 The first column of the third molar (M3) in wear.
- Stage 5 All columns of the M3 in wear.
- Stage 6 The fourth premolar (P4) in wear.

Wear pattern analysis was also carried out upon the teeth of the older mandibles dated to the first to third centuries and the eleventh to twelfth centuries, in order to obtain a more detailed picture of the mortality rates of the animals concerned in these two large samples.

The Roman period

A total of 179 jaws was examined. It became clear that the sample from the fourth century was different from that of the earlier period. All but four of the 132 jaws dated to the first three centuries had the second permanent molar in wear (Stage 3). The other four had the M1 already in wear, but since they were very fragmentary, the M2 was not present and so theoretically it may not have been in wear (Table 57). In the fourth century sample, however, the pattern changed. At least seven of the 47 jaws failed to reach Stage 3 of the tooth eruption sequence, whilst three more were too fragmentary for this fact to be determined. There was a marked increase in the number of jaws that were between Stages 3 and 4, especially in the fourth century sample, whilst in the fourth century, too, half the cattle jaws had not reached Stage 5 before the animals were killed. At the equivalent stage for the earlier period only 12.88% of the total sample of 132 jaws had failed to reach this stage of development. 62.12% had done so, while the remaining 25% did not provide sufficient evidence for this determination to be made. Not too great a reliance can be placed on the figures attained for Stage 6 of the eruption sequence in Table 57, because of the high percentage of jaws that provided insufficient evidence as to whether P4 was in wear. However, a study of the wear patterns on the permanent molars following the method employed by Grant (1975:437-450) was carried out on 25 mandibles of first to third century date. None of these jaws had the P4 extant and therefore did not initially provide information about whether Stage 6 of the eruption sequence had been obtained. Table 58 shows the wear stages of each tooth and the numerical value for each jaw, using Grant's system. In nearly all cases not all the molars have survived and so estimates of the value are given. It was found that twenty of the mandibles had values of over 40. Comparison with jaws that had the complete set of molars present, both at Exeter (Table 58 specimens 26 to 46) and at Portchester Castle (Grant 1975: 443-444) indicate that the P4 was invariably in wear in cases where the numerical values of the M1-M3 lay above 40. Therefore, the twenty jaws in question would have had their P4s in wear and would accordingly have reached Stage 6 of the tooth eruption sequence. Of the remaining five mandibles, two would certainly have not had their fourth premolar in wear, whilst three others still did not give conclusive evidence of this fact. Consequently it would seem that the minimum percentage figure given in Table 57 (13.64%) for jaws that failed to attain Stage 6 represents a much closer reflection of the number of animals killed before that age than the maximum figure (63.64%).

It seems, therefore, that more immature cattle were slaughtered (or died) in Exeter during the late Roman period. The nineteen jaws found in the ditch deposits of the GS site dated to the fourth century showed a particularly high proportion (a minimum of eleven) of animals killed prior to the completion of the tooth eruption sequence. A minimum of twelve of the 28 jaws found in other parts of late Roman Exeter were also not fully developed, perhaps indicating that the trend was not confined to a few isolated deposits in one area of the town.

Similar trends can be seen in the figures for epiphyseal fusion (Table 59). The bones were divided into three groups containing epiphyses that fuse at approximately the same age. The youngest group (distal humerus, etc.) contained virtually no unfused specimens throughout the Roman period, confirming the observations noted on Stages 1 and 2 of the tooth eruption sequence. The second group of bones (the distal tibia and distal metapodia) did, however, reveal a disparity in the figures. The number of unfused specimens ranged from 3.13% in the earlier Roman levels to as high as 30.61% from the fourth century TS deposits. Other fourth century sites did not produce such a high percentage of unfused bones. Indeed all of the fifteen examples found on the MM/CC and RS sites were fused, and only three (9.38%) from the GS site were unfused. The reason for this disparity is not clear. Perhaps there is a connection between the higher percentage of immature jaws discovered in the GS ditches and the younger distal metapodia and tibia found on the adjacent TS site, both being part of the same butchery process. This, however, still does not explain why these unfused metapodia were not as a rule deposited in the GS ditches as well as the jaws, nor why the metapodia and tibiae in the ditches were nearly all fused. Percentages obtained from the final group of bones, although they produced a consistent picture of between 26 to 36% unfused specimens overall, should be treated with caution because of the variations found within the group. For example, only four radii out of a total for the whole period of 34 possessed an unfused distal epiphysis whereas fifteen out of 36 proximal femora were unfused. The discrepancies in the fusion data are associated with the differential survival of the various epiphyses. Much fewer of the latest group of epiphyses to fuse were recovered because their low densities and physical structure made them more susceptible to decay by erosive processes. For this reason the results of the epiphyseal fusion analysis should not be treated literally in any interpretation of the mortality rates of the cattle to which they belonged.

Both sets of ageing data revealed that a large number of cattle reached maturity, particularly in the early Roman period. Absolute ageing of animals from archaeological material is difficult and it is not yet possible to correlate with confidence the dental development of the jaws with absolute age. At Portchester Castle, Grant equated numerical values of 45 to 48 as possibly belonging to animals of between four and a half and five years old (Grant 1975:395), adapting the tooth eruption data of Silver (1969:295-6). This should be regarded as very much the minimum age since nineteenth century sources on cattle ageing give slower rates of tooth eruption. Most of the mandibles examined in Exeter of Roman date had numerical values of 45 to 48 and were therefore at least four and a half years old. The fact that the majority of the animals found in the town was at least this old would suggest that cattle were not bred primarily as meat producers. Had this been the case one would have expected a much higher rate of juvenile slaughter, since it would have been bad economic practice to keep alive any longer than necessary fully-grown animals whose only value was their meat. This implies that cattle were required as draught animals and/or as producers of dairy commodities. In Italy, Roman authors considered steers and cows primarily as draught animals, the cattle only being slaughtered when their working lives were over (White 1970: 278). The situation in Exeter may have been similar. However, if the cattle there had been working animals, one would expect most of them to be older than five years of age, since draught oxen can work satisfactorily until the age of twelve. It seems that the methods of absolute ageing have underestimated the actual ages of the jaws. In the fourth century there may have been some intensification in the exploitation of cattle for their meat. Certainly in the areas investigated the number of immature jaws increased and most of them belonged to animals seemingly culled for meat as they approached full size. How typical this was in the late Roman town or in the surrounding rural area remains to be seen.

The medieval period

The medieval ageing data were divided into three samples dated to the eleventh to twelfth, thirteenth and fourteenth to fifteenth centuries respectively. Most of the tooth eruption evidence came from the first of these samples with 72 of the 95 jaws examined belonging to those centuries. The results of the analysis (Table 60) revealed similar trends to that encountered in the early Roman period. Once again there was very little evidence for the slaughter of young calves. The maximum percentage of animals killed before their second permanent molars were in wear (stage 3) was as low as 4.17% in the eleventh to twelfth century sample. The percentages obtained for this and the thirteenth century sample for Stages 4 to 6 were similar to the results from the early Roman period. A maximum of about 30% of the medieval jaws had not reached Stage 5. Again this method of ageing did not provide conclusive results about how many of the specimens attained Stage 6 of the eruption sequence. 30 of the 72 jaws of eleventh to twelfth century date, for example, were too fragmentary to establish whether the fourth premolar was in wear. However, closer examination of the wear pattern on the molars of 21 of these jaws revealed that they all would have possessed a fully erupted tooth row. This indicates that less than 20% of the cattle represented in the sample were immature. Table 61 gives details of the wear pattern analysis and once again it can be seen that most of the mandibles examined had numerical values of 44 to 50. No very old cattle were present. Assuming that the rates of tooth eruption and wear were similar, the peak of slaughter of cattle in Exeter in the early Roman period and in the eleventh and twelfth centuries was similar and most lived to a mature age.

The medieval epiphyseal fusion data confirm the low mortality rates of young animals (Table 62). In the period as a whole, only twelve of the 548 epiphyses belonging to the early fusing group (distal humerus, etc.) were unfused. The later fusion groups in most cases contained higher percentages of unfused specimens than their Roman counterparts, although the small size of some of the Roman samples may give a misleading picture. The excellent preservation conditions in some of the medieval pits also favoured the survival of more fragile unfused specimens than many of the Roman deposits.

There is possibly some evidence that the ratio of immature animals brought into the city increased a little during the medieval period. The percentage of unfused distal metapodia and tibiae rose from 12.95% in the eleventh to twelfth century sample to 25% in the smaller fourteenth to fifteenth century sample. Equivalent percentages for the late fusing epiphyses rose from 39.50% to 51.22% during the same period. The percentages of unfused calcanea, which fuse at an age intermediate to the groups of epiphyses mentioned above also increased accordingly.

The combined ageing evidence therefore indicated that the majority of the stock was allowed to mature. The value of the species as a beast of burden was probably the major factor in its exploitation. This would accord with the impression given by Domesday Book. This recorded the number of plough teams and the number of other livestock on demesne lands. The number of plough teams recorded in Devon amounted to 5,758¼ or 46,066 animals on the assumption that each plough team consisted of eight oxen. Other than these only 7,357 *animalia* and 23 cows were listed (Welldon Finn 1967:286). If, as is often assumed, the *animalia* consisted of cattle not in the plough team, their low numbers would indicate that the majority of cattle (probably including cows as well as steers) was required for the plough team. In the area surrounding Exeter itself, the ratio of recorded *animalia* to plough beasts was even smaller (1:10, Table 56) and the district also possessed the greatest concentration of plough teams per square mile in the county (Welldon Finn 1967:242).

If the majority of the cattle eaten in Exeter at that time had been working animals, it must be assumed that the age of peak slaughter using modern criteria (about 4½ to 5 years) has again underestimated the actual age of the animals in the deposits, possibly by several years. It should not be assumed, however, that all these cattle would have completed a full working life. The demands of the urban population and the attraction of the town's market will have encouraged cattle owners to sell their beasts for a good price at a younger age to obtain a better return for their investment than to allow them to reach their full age. The absence of extremely old cattle in the deposits would support this view.

The postmedieval period

Both sets of ageing evidence produced results in marked contrast with the earlier periods (Tables 63 and 64). Out of a sample of 30 jaws dated to the sixteenth century, thirteen (43.33%) did not even have their deciduous premolars in full wear (Stage 1) and 22 (73.33%) had not reached Stage 3 of the eruption sequence. Only one specimen had for certain its fourth premolar in wear, although three more may also have reached this final stage in the sequence. The situation appears to have been the same in the seventeenth and eighteenth centuries: 26 of the 33 jaws in the deposits of this date had not reached Stage 3 of the sequence.

The same phenomenon was encountered in the study of the epiphyseal fusion data. All the fusion groups possessed a much higher proportion of unfused specimens than in the earlier periods. The latest group of epiphyses to fuse (proximal humerus, etc.) contained 67.52% and 64.71% of unfused specimens in the sixteenth century and seventeenth to eighteenth century samples respectively. Some of the increase in the proportion of jaws and long bones of calves can be accounted for by concentrations of these bones in the two very rich pits, GS III F. 228 and TS F. 316. However, very young cattle were by no means restricted to these features and were found commonly in contexts associated both with poor preservation and a poorer material assemblage. Undoubtedly veal became an important item of the meat diet in postmedieval times.

Clearly such a high rate of immature slaughter as represented by the archaeological evidence would preclude any large-scale dairying or ploughing activities, if the age structure of the cattle represented in the deposits was typical of the cattle population as a whole. However, there is abundant documentary evidence that cattle continued to be important in Devon as plough beasts and became increasingly important as dairy animals in the postmedieval period. Ploughing in Devon continued to be carried out generally by cattle alone, although Colpresse, writing in the second half of the seventeenth century, did note that some hillside cultivation was ploughed by a team of four oxen and two horses (Trow-Smith 1957:176). Fraser, writing at the end of the eighteenth century, discussed the various uses of the cattle in the south of Devon:

> 'The best of the breed are excellent milkers and answer well for either work or fatting. The oxen are generally turned off for fat at five or six years old and run up to eight, ten, twelve cwt.' (Fraser 1794:32).

Marshall also noted the ploughing and dairying roles of Devonshire cattle as well as their meat potential. In west Devon at that time he observed that four aged oxen or six growing steers were the usual 'plow' of the district. He also stated that oxen were still worked to a full age, sometimes to ten or twelve years old (Marshall 1796:vol.I, 116-7).

If the archaeological sample is typical of the rest of Exeter, it does not reflect the true cattle population of its period. The animals used for dairying and the plough were under-represented in the deposits. It is possible that the meat from the older animals was now filleted from the bones and these were therefore absent from the domestic rubbish deposits. This would imply that the marketing of beef and veal was subject to different forces since the bones of young animals were found in abundance. Alternatively the demand for the meat of young cattle by the townspeople was such that it was principally the animals specifically raised for meat that found a market in the city, whereas the older plough, breeding and dairy cattle were less likely to be brought to such a market.

The rise in the importance of dairy farming in postmedieval times was associated closely with the production of veal for the markets of English towns. Marshall (1796:vol.I, 248) listed the rearing of calves amongst the produce of the Devonshire dairy and many of these together with pigs were fattened for slaughter on the surplus buttermilk. In the postmedieval period too, the demands of the urban markets for meat saw the emergence of the grazier as an important factor in the agricultural economy. London, whose population increased from about 50,000 - 60,000 in 1500 to 675,000 in 1750 (Clarkson 1971:47), put the greatest demands not only upon the surrounding countryside of the Home Counties but much further afield as well. For example, London butchers heavily exploited the grazing on the Thames marshes to fatten up the livestock driven in from other parts of the country (Holderness 1976:68). During the seventeenth century droving of cattle from the breeding areas of Scotland, Wales, parts of northern England and elsewhere to be fattened up for urban markets developed into an annual cycle (Thirsk 1967b:186). South-west England was included in this development. Even in the early seventeenth century Richard Carew observed:

> 'Devon and Somerset graziers feed yearly great droves of cattle in the north corner of Cornwall and utter (sell) them at home.' (Halliday 1953:107).

In the same period there are well-documented records of Irish imports of livestock into Britain, especially in the seventeenth century (Trow-Smith 1957:229), to meet the requirements of the rising urban population whose demands had produced a shortage of store cattle for breeding purposes. Previously an Act of Parliament in 1556 encouraged farmers to rear more cattle because, it was claimed, there had been too much emphasis on meat production and rearing had been neglected, resulting in a shortage of store cattle (Thirsk 1967b:225-6). It seems that the documentary and archaeological evidence in this case concur. From the sixteenth century veal and beef were in great demand, at least from urban centres — the same period as the number of immature cattle fragments increases significantly in the archaeological deposits at Exeter.

METRICAL ANALYSIS

Metacarpus

Several attempts have been made to differentiate between the sexes of cattle from metrical analysis of the metacarpus. Higham and Message (1969) claimed to have distinguished the male and female specimens at the Danish bronze age site of Trøldebjerg from the measurements of the maximum distal width and the maximum distal diaphyseal width. Higham (1969) demonstrated the sexual dimorphism of these measurements on modern material derived from specimens of the Aberdeen Angus and Red Danish breeds. The differentiation between the sexes relied upon the splaying of the distal metacarpus in male specimens. Fock (1966), however, found that this feature varied in different breeds and it has been suggested that the splaying was a pathological condition related to the ploughing activities of cattle. Uerpmann (1973:314) observed that the Trøldebjerg case was exceptional and suggested that the analysis was favoured by the small sample size, the uniformity of an isolated cattle population and the large size of the cattle studied. Howard (1963) used the indices of the maximum distal width and minimum diaphyseal width against the total length of the metacarpus to differentiate between cows, castrates and bulls. Grant (1975:401) also used these indices in her analysis of complete metacarpi from the Roman levels of Portchester Castle, Hampshire. Bulls generally have shorter and stockier metacarpi than cows, while castrates usually have indices that fall between the two. Castrates also tend to have longer bones than either cows or bulls. Care has to be taken in the interpretation of such indices. Fock (1966) has shown that these vary in different breeds, although they can sometimes be used to differentiate between the sexes, if the animals belong to the same population. Another problem concerns the fragmentation of archaeological material. Only about 10% of the metacarpi recovered from Exeter were complete and some of these belonged to young animals with unfused epiphyses that could not be measured. Consequently the sample size was much reduced.

The following measurements were used in the metrical analysis of the metacarpi found in Exeter.

1. The maximum length.
2. The maximum distal epiphyseal width (breadth).
3. The maximum width at the distal fusion point.
4. The minimum diaphyseal width.
5. The maximum thickness (depth) at the distal fusion point.

Figure 5 plots the index of the $\frac{\text{maximum distal width} \times 100}{\text{maximum length}}$ against the maximum length of complete metacarpi from Roman and medieval Exeter. The specimens fell into two main clusters. The majority of those which possess indices of 30 and below can be classified as cows, those of 31 and above as castrates and bulls. However, these measurements were only possible on 31 complete specimens — too small a sample for significant trends to be observed. The index of the $\frac{\text{minimum diaphyseal width}}{\text{maximum length}}$ x 100 plotted against the maximum length showed a similar clustering into main groups, although the sample size was again small. The same specimens, however, could be classified as 'male' or 'female' as in the previous analysis suggesting that in this instance

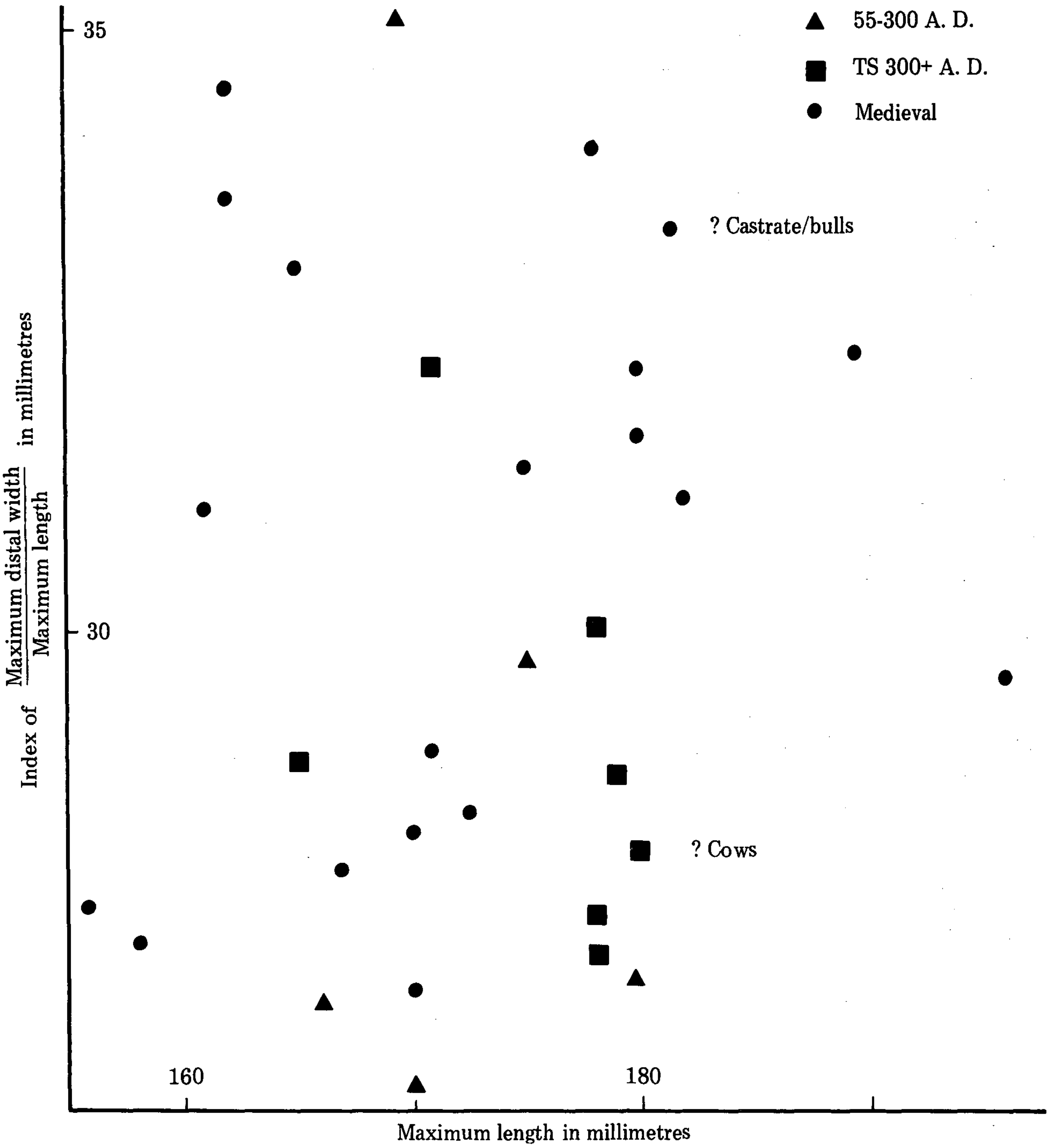

Figure 5 Metrical analysis of complete cattle metacarpi.

the maximum distal width could be used as an indicator of sexual dimorphism with some confidence.

Employing only the measurements of the distal part of the bone, the sample size was greatly increased. Plotting the measurements used by Higham (1969) of the maximum distal epiphyseal width against the width of the distal fusion point, the specimens from the Roman and medieval samples again fell into two main clusters (Maltby 1977:Figures 5 and 7). However, the differentiation between the two groups can be seen more clearly when plotting the maximum thickness at the distal fusion point against the maximum distal epiphyseal width (Figures 6 and 7). These figures also included all the complete specimens shown in Figure 5 and are regarded as being more reliable indicators of sexual dimorphism than the fragmented specimens. It can be seen from the Roman sample (Figure 6) that the specimens dated to the first three centuries again fall into two groups: the majority lies in the smaller size group, whereas six or seven others lie in a distinct cluster of larger specimens. Nearly all the fourth century metacarpi, obtained solely from the TS site, fell within the smaller size group, whereas, at most, only two or three can be ascribed to the other group.

One interpretation of the analysis is that the two clusters show sexual dimorphism, the smaller specimens belonging to cows and the larger to steers and bulls. In support of this, with one exception, all the complete metacarpi included in this analysis fell into the sex clusters predicted by the previous analyses of the indices of the maximum distal epiphyseal width and the minimum diaphyseal width against the maximum length. If this interpretation is correct, the reasons for the observed changes in the clustering pattern in the fourth century sample have to be explained. Reverting to the epiphyseal fusion evidence, we observed that about 30% of the distal metacarpi found in the fourth century TS deposits possessed unfused epiphyses, whereas only one of the 41 specimens dated to the earlier Roman phases was unfused (Table 59). Since the measurements used in this analysis were restricted to fused specimens, it means that only about 70% of the fourth century TS metacarpi are represented in Figure 6, whereas the sample from the earlier period represents virtually all the metacarpi recovered. There is therefore a possibility that the majority of the unfused specimens of fourth century date belonged to steers or bulls slaughtered when immature. Such an explanation would account for the clustering of a much higher proportion of the fourth century metacarpi in the smaller (female) size group. This explanation would also accord with sensible husbandry management, since cows can be kept as mature animals for breeding and possibly dairying purposes. Varro, referring to his herd in Italy, states that his cows were not allowed to conceive before two years of age and that preferably they should not bear a calf until they were at least four years old (White 1970: 286). The distal metacarpus fuses at an earlier age than this, even allowing for a much slower rate of epiphyseal fusion in Roman times. It is logical that most cattle deliberately culled before this age would be steers rather than cows required for breeding purposes.

Alternatively, if the splaying of the distal portion of the metacarpi is a direct result of ploughing activities, the significant decrease in the number of such specimens in the fourth century TS deposits may be taken to indicate that fewer plough animals were represented on that site. Taken in conjunction with the ageing evidence, it would suggest

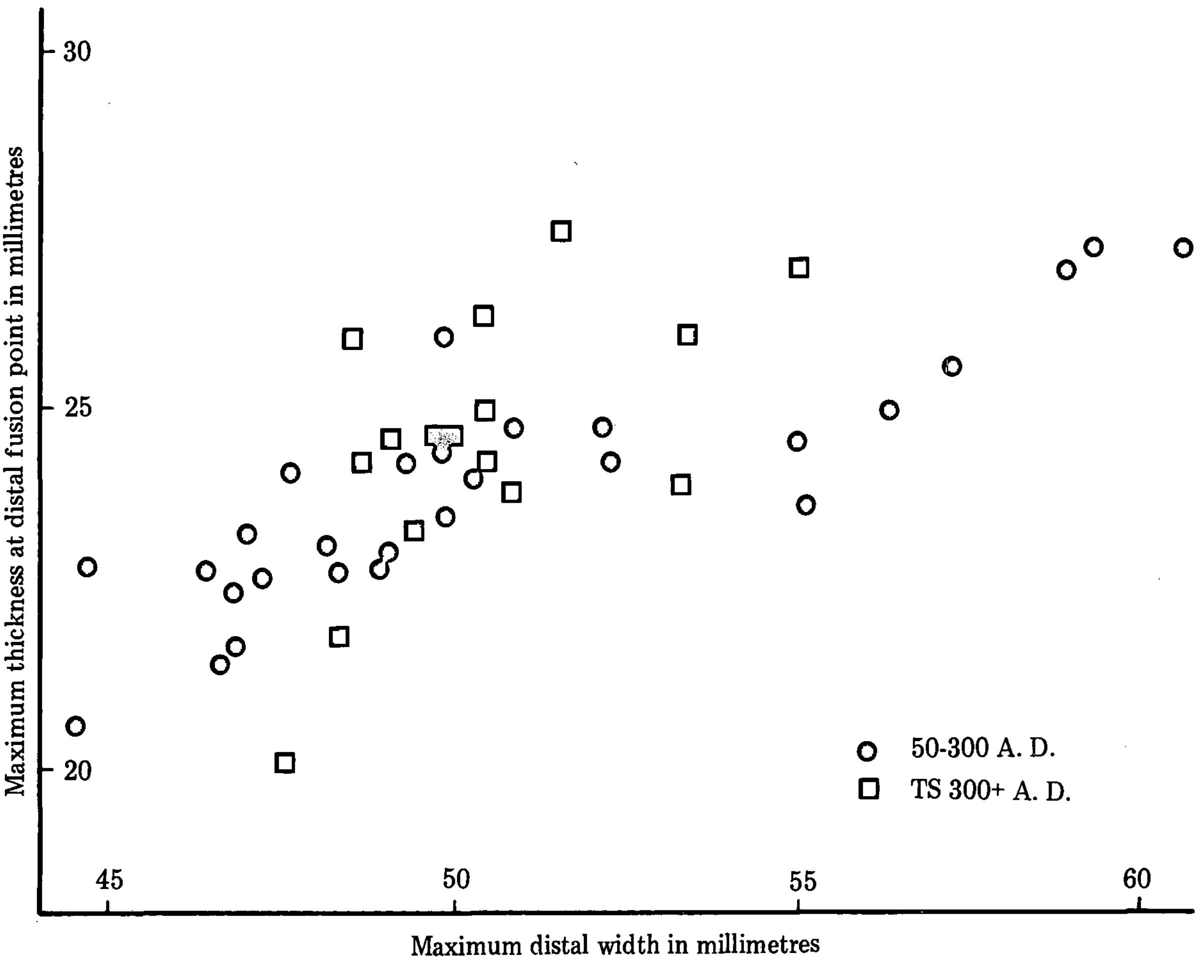

Figure 6 Scatter diagram of cattle distal metacarpi in the Roman period.

that there was a greater kill-off of potential plough animals.

The results from the metrical analysis of the Roman cattle metacarpi were similar to that carried out on complete and fused metacarpi of Roman date from Portchester Castle. There, out of a sample of 119 bones, 65 to 72% were sexed as female and 28 to 35% were classified as castrates or bulls (Grant 1975:401). This ratio is similar to that obtained from the smaller sample of Exeter specimens, if sexual dimorphism is the main cause of the clustering pattern. Such a high ratio of mature female specimens may imply that some cattle were kept principally as dairy animals, although it is by no means certain that the samples from either site represented the total population of cattle in their respective areas.

The medieval deposits provided far larger samples of fused distal metacarpi, which once again clustered into two groups (Figure 7). However, a notable change in this sample is that, although about 20% of the distal metacarpi were unfused, the proportion of specimens that fell into the 'male' grouping was much higher than in the Roman period. Only about 27 of the 46 specimens measured fell into the smaller size cluster. It can be argued that more of the medieval specimens were splayed due to their derivation from plough animals. On the other hand, the complete specimens included in this analysis showed no discrepancies from the sex groupings established in the analysis of the indices of the maximum distal width against total length (Figure 5) and the minimum diaphyseal width against total length. Although alternative explanations can be made for these clusterings, the conclusions derived from them need not be different. One explanation suggests that more plough animals were represented, the other indicates that more mature male specimens were present and the most logical explanation for their longevity would be their exploitation as working animals. It is interesting to compare this evidence with the impression conveyed by the Domesday records for Devon. The overwhelming concentration in the records on cattle in the plough teams led Trow-Smith (1957:73) to the conclusion that '...the cow played a very minor part as a milch animal'. Certainly in the Hundreds around Exeter there were very few cattle recorded on demesne lands apart from animals in the plough teams. Cows (*vaccae*) were mentioned specifically only in occasional entries. As in Roman times, there is no reason why cows, provided they were not in calf, could not be included in the plough team. How accurate a picture of cattle farming the Domesday records paint is uncertain and clearly the absolute figures given should be treated with caution, but there does seem to be a distinct probability that cattle were bred principally as working animals. The increase in the proportion of adult steers/plough animals in the Exeter medieval deposits could indicate a change in the emphasis of exploitation of cattle in the area from that of Roman times. This of course assumes that the cattle represented on the sites in both periods were a cross-section of the animals brought to the town as a whole and, more important, representative of the cattle kept in the surrounding countryside. Exeter's importance as a market centre may have exerted specific pressures on the types of animals brought to the town. Comparisons with urban and rural sites in both the Roman and medieval periods are essential before the full pattern of cattle exploitation can be understood.

Tibia

Metrical analysis of the maximum distal width of the tibia on 80 modern Aberdeen Angus specimens has shown that this bone displays much less sexual dimorphism than the metacarpus (Higham 1969:65). Figure 8 is a scatter diagram of the measurements of the maximum distal width plotted against the maximum distal thickness of tibiae from all periods in Exeter. By decreasing the variation caused by sexual dimorphism, it is possible to give a visual comparison of the size of stock in the various periods. It can be seen that there was no significant change in size of the specimens dated broadly to the Roman and medieval periods.

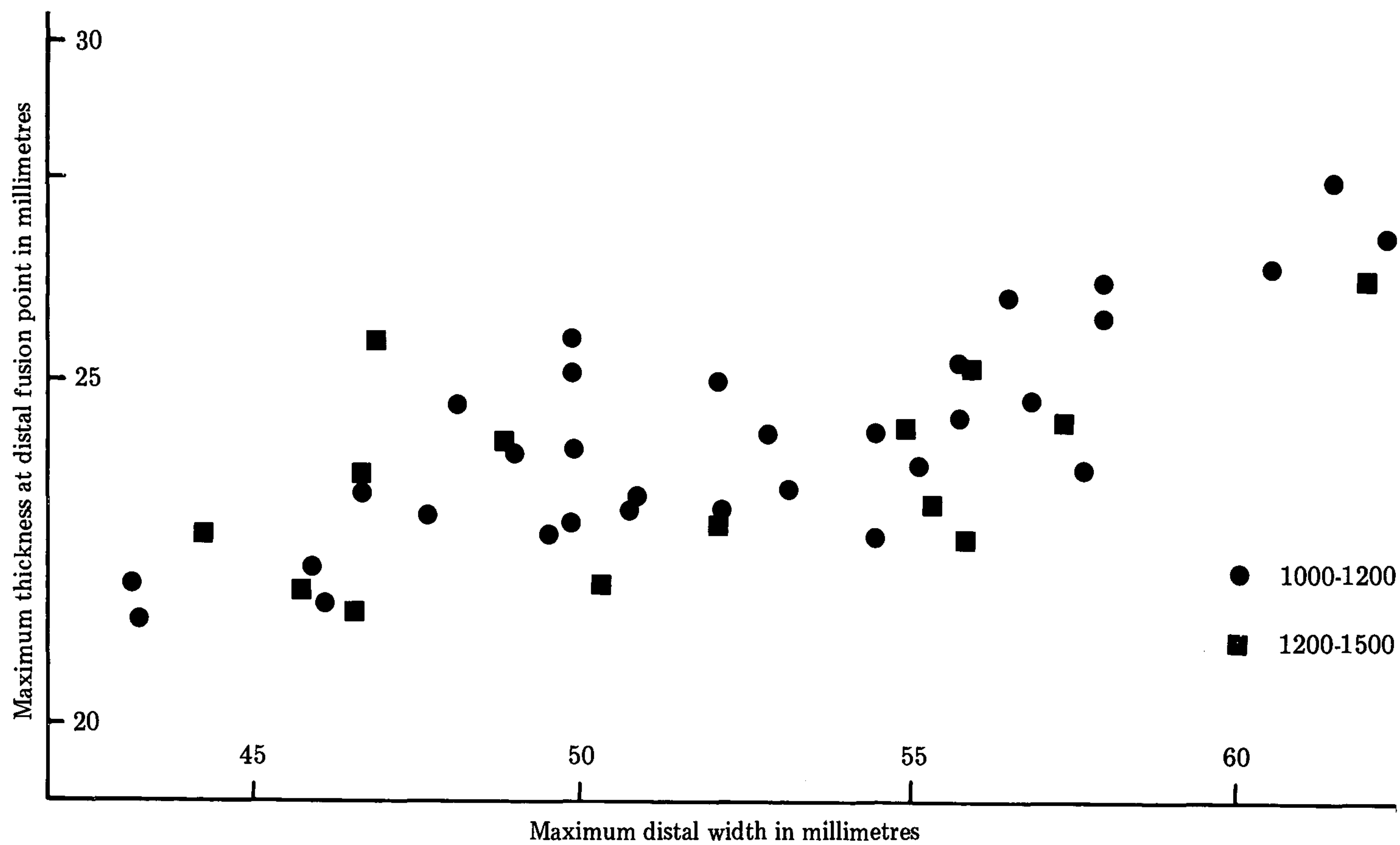

Figure 7 Scatter diagram of cattle distal metacarpi in the medieval period.

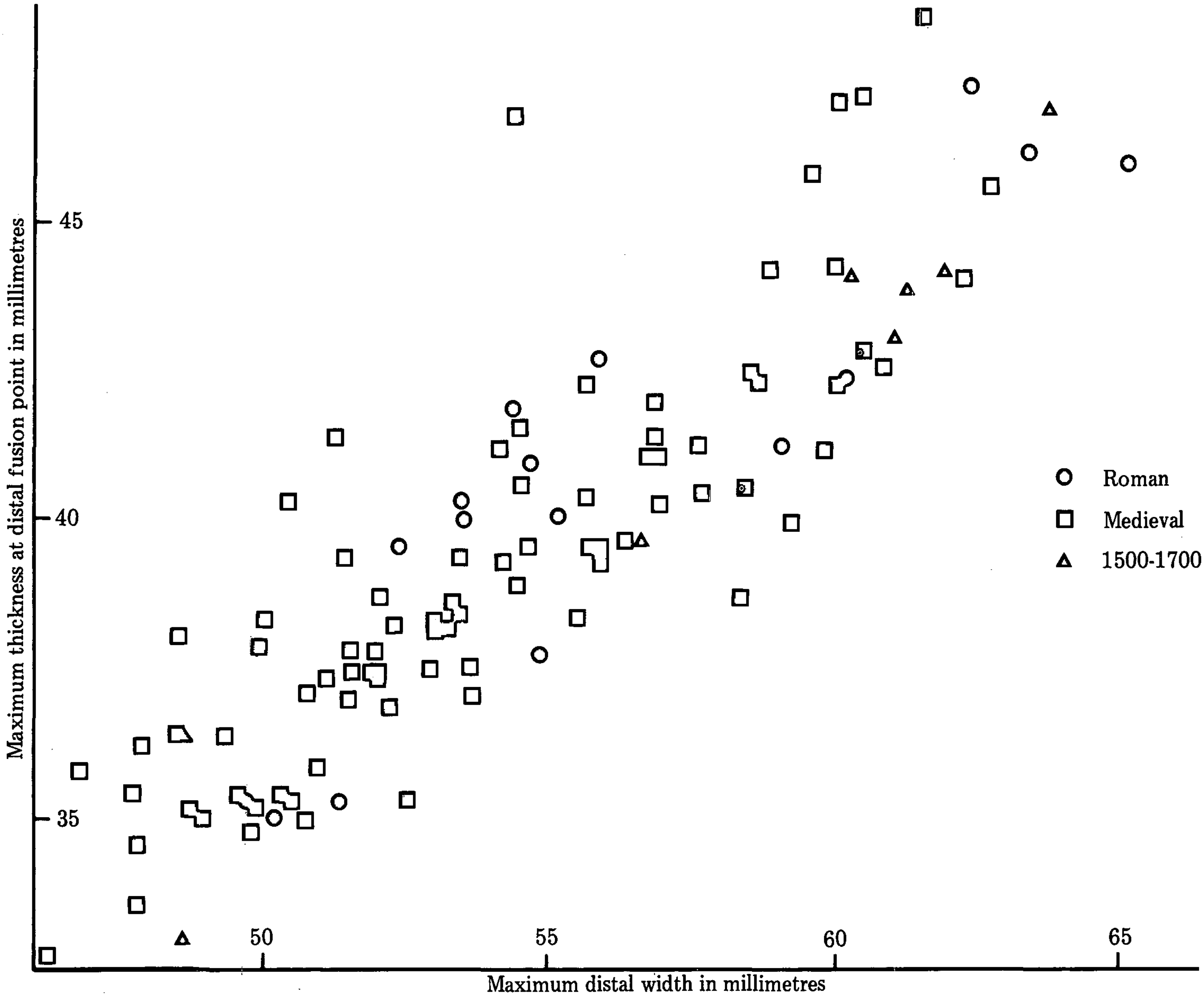

Figure 8 Scatter diagram of cattle tibiae measurements.

Although this may mask fluctuations in the size of stock within these periods (the sample size was too small for further subdivisions), there seems to have been little improvement in stock size until the postmedieval period, in which some specimens were significantly larger than earlier examples.

Metatarsus

Figure 9 plots the maximum distal width at the fusion point against the maximum distal thickness at the fusion point of the metatarsus. These measurements again display comparatively little sexual dimorphism in modern breeds. Exactly the same pattern can be observed as that displayed by the tibiae measurements. The Roman and medieval specimens displayed approximately the same range and variation in size and again suggest that there was little improvement in the size of the stock prior to the sixteenth century.

Other metrical analysis

Table 65 shows the range in measurements, the mean and (where the sample size merited such calculations) the standard deviation and coefficient of variation for each measurement taken in the various samples from the Roman, medieval and postmedieval periods. A comparison of these measurements shows little evidence of any improvement of stock during the Roman and medieval periods. The post-medieval specimens are too few in number to draw detailed conclusions but there is some indication that from the sixteenth century onwards the average size of cattle increased, although the smallest animals were of no better quality than their Roman and medieval predecessors and indeed many of the larger specimens were no larger than the largest Roman cattle.

The smallest animals represented at Exeter were no larger than many iron age cattle, whereas the largest almost attained the size of modern Shorthorns, although the average size of the stock was markedly smaller than modern breeds. Comparisons with some other sites of Roman date (Table 66) showed that, although the cattle represented in the Exeter sample were mostly of similar or slightly smaller stature than contemporary cattle in other parts of England, some larger cattle have been discovered at most other sites, for example at Corstopitum (Jewell 1963:81-84, 88; Hodgson 1969), Vindolanda (Hodgson 1977), Fishbourne (Grant 1971:387), Portchester Castle (Grant 1975:401), Hemel Hempstead (Harcourt 1974b:256-7), Shakenoak Farm, Oxfordshire (Cram 1978:149). The largest animals at all these sites did not have parallels in Exeter even in the medieval period. A detailed comparison has been made with a large Roman sample from Alcester, Warwickshire (Maltby *in preparation*). The results clearly indicate that the cattle represented in Exeter were smaller than those at Alcester.

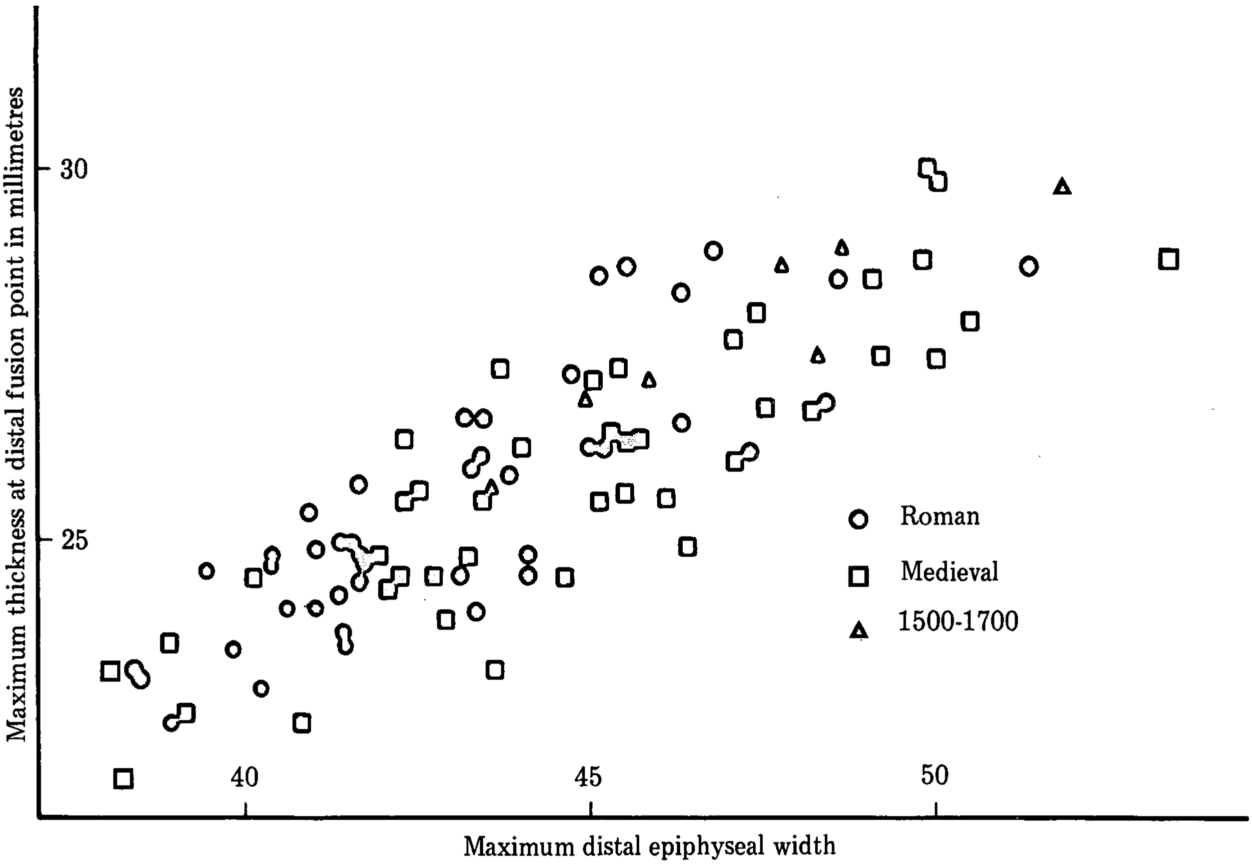

Figure 9 Scatter diagram of cattle metatarsi measurements.

Not only were there larger specimens at Alcester but also the average size of the specimens was consistently greater. A comparison of the absolute size of cattle can be made by multiplying the lengths of complete long bones by a constant factor to obtain an estimation of withers height. Using Fock's conversion factors for the metapodia (von den Driesch and Boessneck 1974:336), the mean of the various calculations made on the Roman metapodia from Exeter ranged between about 107 to 111 cm. In the late Roman levels at Alcester the same calculations ranged between about 114 and 115 cm. The estimation of withers height obtained from medieval specimens at Exeter showed no improvement in the size of the stock. The various estimates ranged between about 104 to 108 cm based again on relatively small samples. No detailed comparisons from contemporary medieval sites are available at the time of writing. A large sample of Saxon material from Southampton (Hamwih) has produced mean withers heights of about 115 to 117 cm from the complete metapodia (Bourdillon and Coy *in press*). It seems possible, therefore, that the overall size of the cattle brought to Exeter in the Roman and medieval periods was smaller than in other parts of the country. Assuming that the majority of the stock was reared in Devon, it may be possible to discern regional variations in stock size during these periods. Whether the variations were due to differences in the types of animals bred or in their planes of nutrition remains for future research to determine. By the postmedieval period, movements of cattle across the British Isles became widespread (Skeel 1926) and stock management improved. Both factors lie behind the improvement in the size of cattle brought to the Exeter market in that period.

THE TYPES OF CATTLE REPRESENTED

Several attempts have been made to analyse and interpret the morphological and metrical characteristics of horn cores from British archaeological sites. Two medieval horners' deposits at Coventry and at York have been studied in detail. Both sites produced several types of horn cores. At Coventry four types were distinguished from a sample of 37 horn cores, which the author implied may have been indicative of different types of cattle (Chaplin 1971:138-42). Four types were also recognised in a sample of 175 horn cores from Petergate, York but Ryder (1970) concluded that the animals were all of a similar type.

Recently a series of detailed articles concerning the craniology of cattle has been published (Grigson 1974; 1975; 1976; 1978). It has been demonstrated that the measurements of the circumference of the base of the horn core and its overall length show significant sexual dimorphism within a breed. It was also shown that the growth rate of horn cores is high during the first two years of the animal's life and thereafter diminishes rapidly to a new low growth rate which is maintained until the animal is about seven years old (Grigson 1974:366). There is therefore a problem in using such data on archaeological material, since it is usually impossible to age the horn cores that are recovered. It is likely, however, that the sample from Exeter derives mostly from adult animals, judging from the ageing data.

A detailed system for the classification of horn cores from archaeological sites has also been devised (Armitage and Clutton-Brock 1976). The criteria involved include size, curvature, torsion and the shape of the cross-section. By first dividing the horn cores by size into 'small horned', 'short horned', 'medium horned' and 'long horned', the sex of the core is designated by the study of its morphological characteristics. The terms 'short horned', etc. are descriptions merely of size and not of breed or type of cattle.

31 Roman and 107 medieval horn cores were examined from the Exeter excavations. Table 67 summarises the metrical analysis of the basal circumference and the length along the outer curvature of the cores. The great majority fell into the 'short horned' category. These possessed basically an ovoid cross-section, although there were variants in which the cross-section had a more flattened or more rounded appearance. This variability is caused to some extent by sexual dimorphism (Armitage and Clutton-Brock 1976:332). The anterior edge of the horn core base usually formed an angle of about 100 to 110^{o} with the frontal bone. Most cores then gradually arched forward and narrowed fairly uniformly but quite sharply towards the tip. At the same time many of the horn cores curved gently upwards from the frontal profile often forming an angle of 25 to 35^{o} with its junction with the skull. There was a lot of variation in the relationship between the length of the horn cores and their basal circumference. Generally, however, the latter measurement was a few millimetres longer than the former. Indeed many of the cores were similar to the 'short horned' group of Roman specimens from Angel Court, London, illustrated by Armitage and Clutton-Brock (1976:338).

Athough sexing of each individual core was not possible, few had the characteristics of bulls and the majority were similar to those of castrates and cows, although the distinction between these was not always clear cut.

The smallest cores fell into the 'small horned' category but were similar in many respects to those described above. These tended to curve upwards much more sharply, usually at an angle of over 50^{o}. It is possible that these belonged to younger animals whose horn cores were not fully developed. Certainly they do not resemble the small cores commonly found on iron age sites and their tendency to appear more porous than the majority of horn cores suggests that they are simply younger specimens of the same type. A few cores were substantially different from the majority. Two medieval specimens (belonging to the few that fell into the 'medium horned' range) had very round cross-sections and were very long in relation to their basal circumference. These morphological characteristics suggest that they belonged to cows, possibly of a larger type of cattle than was usual. One example of a naturally polled animal was discovered in a twelfth century deposit.

Animal bone remains can rarely be used to differentiate between breeds of cattle. Indeed breeds as we know them today were probably not differentiated until the later post-medieval period. The concept of breeds also relies on factors such as the colour of coat, which cannot be determined from osteological evidence. Broad classes of animal can be seen, however. Examination of the Exeter horn cores demonstrated that most animals were of the 'short horned' type. There was no evidence of 'long horned' cores in these periods. Such cores have been recovered from fifteenth century deposits at Baynard's Castle, London (Armitage and Clutton-Brock 1976:330). Documentary evidence on the types of medieval cattle is virtually non-existent. Traditionally the Red Devon breed is considered to have been prominent in the area in the later postmedieval period and has been thought to have had a long heritage in the area. They were considered as excellent draught animals (Thirsk 1967b:186). Scale models of this breed made by Garrard at the end of the eighteenth century showed oxen and cows which had shoulder heights of approximately 112 to 121 cm (Clutton-Brock 1976:21-22). Great play has been made of the recording of the acquisition of a 'red heriot' at Tavistock Abbey in 1366 (Finberg 1951:133). Trow-Smith has suggested that the heavy concentration of cattle in North Devon, as recorded in Domesday Book, could indicate the beginnings of a slow expansion of the Red Devon breed (Trow-Smith 1957:85). However, the documentary evidence on this point is somewhat equivocal. There is evidence that in the middle of the eighteenth century the majority of cattle in Devon were in fact black (Stanes 1969). Clearly the animal bones from Exeter do not shed much light on this problem. It can be said, however, that the cattle in the area during Roman and medieval times were probably of a similar type of animal of a size possibly smaller than in some other areas of England at that time. The postmedieval period saw an improvement in the size and a greater concentration in the selective breeding of cattle which culminated in the appearance of modern breeds.

BUTCHERY AND MARKETING OF CATTLE

Butchery marks, fragmentation and the distribution of the fragments of different parts of the body were all taken into consideration in this analysis. What follows is a general summary of this evidence.

The skull and jaws

The concentrations of cattle skull and jaw fragments have been discussed in the previous chapter (pages 11, 14). Organised dumping on a large scale was found in the late first century levels of the legionary ditch (RS F. 363). Skull and jaw fragments together with bones of the limb extremities were found almost to the exclusion of the major meat bearing bones. Similar concentrations of skull and jaw fragments were found in the fourth century ditches on the GS site. Both deposits demonstrate the primary butchery process of cattle, in which the unwanted portions of the body were thrown away while the remainder of the carcases were made available for distribution or sale within the Roman town. The RS ditch deposit shows that a systematic policy for the marketing of beef was taking place in the first century. This does not mean that all cattle were butchered in the same way, however, as the presence of skull and jaw fragments amongst major meat bearing bones throughout the other Roman deposits indicates.

Similar large scale dumps of skulls were not discovered in the the medieval deposits, although several pits did have unusually high proportions of these bones. Certain postmedieval pits contained a large number of jaw and skull fragments of young animals. The majority of these samples came from only one area of the town and the lack of such concentrations of waste bones need not preclude the continuation of the practice elsewhere in the town. The archaeological evidence supports this theory. The proportion of cattle skull and jaw fragments in the medieval deposits was consistently lower than in the majority of Roman deposits, indicating that much of this material may have been dumped elsewhere.

The presence of skull and jaw fragments amongst ordinary domestic refuse in the deposits of all periods shows that the majority of the carcass was utilised commonly for food. Indeed the fragmentary condition of much of the skull material probably indicates that the skulls were often smashed to remove the brain. Similarly, butchery marks were found on the mandibles, particularly around the dorsal condyle at the back of the jaw and probably made to detach the mandible from the skull and enable the tongue to be removed easily.

The virtual absence of horn cores from the major Roman dumps of cattle skulls implies that cattle horns were required elsewhere for some industrial practice. Three small cores discovered in other Roman deposits had been sawn off about 40 to 60 mm above the base, a process which would have damaged the horn sheath and a practice that suggests that in some cases only the tip of the horn was required for working. More commonly, however, the Roman horn cores had been detached from the skull just below their base so that the whole of the horn could be utilised. This too was the common practice in medieval times. One skull of early twelfth century date bore evidence of cutmarks on the nuchal eminence just below the junction with both horn cores. In this instance they had not been detached but most medieval horn cores were cut from the skull at this point. A recent discovery of debris from a horner's workshop in another part of the city (Henderson *pers. comm.*) demonstrates that the horns of cattle were required as industrial raw material. Similar workshops have been discovered in Coventry (Chaplin 1971:138-142) and York (Ryder 1970). The evidence from Exeter suggests that this type of industry was already in existence in Roman times.

The long bones

The long bones bore the greatest evidence of butchery. Throughout the deposits less than 1% of the humeri, radii, tibiae and femora fragments had both epiphyses present (Table 68). Even allowing for the fact that many of these breakages could have occurred during or after dumping, most of them must have resulted from butchery for meat and marrow. Cutmarks were discovered quite commonly on these bones. To consider the fore limb first, this was detached from the rest of the carcass usually at the distal end of the scapula. This bone was often found to be broken near the point where the spine of the bone begins. Few cutmarks were actually found on the glenoid itself, where the scapula articulates with the proximal epiphysis of the humerus. The most common portion of the humerus to survive was the distal epiphysis and the lower end of the shaft. The knife cuts on this part of the bone and especially on the distal articulation were the result of cutting the meat off the bone rather than of the severance of the limbs. The main severance points appear to have been higher up the bone on the shaft, although some chop marks were found on the distal epiphysis itself. The proximal epiphysis of the humerus has a poor survival on archaeological sites and an insufficient number of these was recovered for conclusions to be made about this area of the carcass. Knife cuts corresponding to those on the distal humerus were found on the proximal portions of the radius and ulna in all periods. These were made during the removal of meat from the elbow joint. The radius was commonly broken or severed transversely both across the middle of the shaft and especially a little above the distal epiphysis, probably for the removal of marrow.

A similar picture of intensive butchery was apparent on the major meat bones of the hind limb. The proximal articulation of the femur commonly revealed butchery marks. These would have been caused by the same process that resulted in the marks often found on, or near, the acetabulum of the pelvis, with which the proximal femur articulates, when the hind limb was severed from the hip. The distal epiphysis of the femur was also a common area for knife cuts and in some cases, severing. The tibiae were always in a very fragmentary condition — not one from any period was intact — and breakages and cut marks were liable to occur anywhere along the shaft, although the mid-shaft and distal parts of the bone were the commonest areas for these.

As is to be expected, the major meat bearing bones were intensively butchered. Usually they were severed in several places for the removal of marrow. The presence of so many of these bones amongst Roman and medieval domestic refuse suggests that meat was sold or distributed on the bone and that filleting of meat was not practised to a great extent. This may have become more fashionable in the postmedieval period, although there is little evidence of this from the present archaeological material.

The metapodia, tarsals and phalanges

The metapodia were comparatively more complete than the other long bones but still about 90% of them were found in a fragmented condition (Table 68). In the Roman deposits, several of the metatarsi in RS F. 363 had knife cuts on the posterior aspect of the proximal epiphysis made when the bone was detached from the tarsals. The majority of the metapodia were also severed midway down the shaft, probably for the removal of marrow. This section of ditch was unusual in that it contained many more proximal than distal epiphyses of cattle metapodia in its debris. 50 proximal epiphyses of metatarsi were discovered compared to only eight distal epiphyses. Usually the numbers of proximal and distal epiphyses of the metapodia were roughly equal in the deposits. The concentration of the proximal metapodia together with the discarded skull and jaw fragments suggests that these too were dumped during the primary butchery process of cattle. It also indicates that the distal half of the bones was required for some other purpose, possibly as raw material in the manufacture of tools or ornaments.

The metapodia of all periods were often severed laterally across the shaft, more often towards the distal epiphyses. Very few were split longitudinally. These bones have much less meat value than the other limb bones but contain a lot of marrow, which could be extracted by such butchery methods.

The tarsals also displayed evidence of knife cuts and chop marks on occasions. The calcaneum and astragalus often formed a severance point between the main meat bones and the extremities of the hind limb. Consquently they were sometimes chopped during the butchery process to facilitate this operation.

The phalanges have little meat value but can be boiled up in the manufacture of glue. Their low representation in many deposits can be explained both by their poor preservation and by their being overlooked during excavation. Their comparatively low representation in RS F. 363, however, included sieved deposits. Phalanges were not dumped necessarily during the primary butchery process in Roman times and their use in glue manufacture may have been the reason for this. Butchery marks on phalanges were rare in any period.

Ribs and vertebrae

Cutmarks were also present on cattle ribs and vertebrae. The practice of splitting the vertebrae down their dorso-ventral axis was uncommon before the postmedieval period when it became the established practice. Prior to that time, the vertebrae were more often found to be cut laterally. The change in this practice probably indicates that by the sixteenth century it was common policy to butcher the carcass into sides of beef. Before that date, the trunk of the body must have been cut laterally along the flanks of the animal.

The butchery and marketing of cattle carcases was obviously intensive. The overriding impression of the Roman and medieval cattle assemblages is that very little of the animal's skeleton was considered to be waste material. The parts of the animal of little or no food value were often utilised for other purposes such as tool manufacture, marrow extraction and possibly glue manufacture. The deposits produced evidence of large scale organised marketing of cattle in the early Roman period. Excavation of the areas of the city where the medieval and postmedieval butchers operated would no doubt produce a similar picture of organised butchery of carcases in those periods. Finds of leather from the medieval and postmedieval deposits have yet to be studied, but it must be remembered that the hides of cattle were an important part of the animals' market value.

SKELETAL ABNORMALITIES

The majority of the bone fragments produced no evidence of pathology. This may imply that the majority of animals were healthy when slaughtered, although many diseases do not affect the bone formation at all.

There were five instances where the second premolar of the mandible was absent. Three of these were of Roman date whilst the others were found in medieval deposits. A recent discussion of this condition has concluded that it was quite commonly found among both 'wild' and 'domestic' ruminants, and it has been put forward that such an absence is due to congenital factors (Andrews and Noddle 1975). Another phenomenon noted by Andrews and Noddle (1975: 140) was the absence of the fifth column of the third permanent molars on one of the cattle mandibles they investigated. Ten of the 76 mandibles with the M3 fully erupted from the Roman levels of Exeter had only, at most, the vestigial remains of the most posterior column present. Once again congenital factors are possibly the cause of this feature. It is interesting to note that this phenomenon did not occur in the large sample of medieval mandibles investigated at Exeter, nor has it occurred on any other sites of this date to my knowledge. Several Roman and Saxon sites, on the other hand, have produced mandibles with similar features. It seems as though this characteristic disappeared in England sometime after the Roman period. One Roman mandible had evidence for the overcrowding of teeth, the fourth premolar being set at an angle of 45° to the tooth row, a deformity that may have resulted from poor nutrition. Several less serious cases of malocclusion of the cheek tooth row were discovered in Roman and medieval samples.

One Roman and four medieval first phalanges had abnormal growths of bone around the proximal epiphysis. The proximal epiphysis of a seventeenth century metatarsus suffered from a condition which may have been caused by arthropathy or arthritis. Only one instance of a fractured bone was discovered: a 'cow-sized' rib of Roman origin had been broken at some stage of the animal's life and an irregular growth of bone formed over the fracture giving the bone a distorted appearance. It is unlikely that many casualty or diseased animals would have found a market in the city. Unless their carcases were transported to the town, which does not seem to have been a common practice in the Roman and medieval periods at least, the animals in question were probably not strong enough to be brought any distance on the hoof to the market, where in any case they may have been rejected or have fetched only a low price.

SUMMARY: THE EXPLOITATION OF CATTLE

Throughout the Roman and medieval periods the percentage of adult cattle eaten in Exeter was high and it seems that the majority of the stock was valued more for draught and dairy purposes. It is difficult to say whether cows were allowed to reach maturity principally for their milking, breeding or working qualities, or for a combination of these reasons. Documentary evidence would imply that, in the early medieval period at least, cattle were considered principally as draught animals. In the Roman period, however, there is some evidence to suggest that there was a greater emphasis on the keeping of mature cows rather than steers which may imply that dairy produce was a more important factor in cattle husbandry at that time.

In the medieval period the rates of immature slaughter continued at a low level, although there may have been some increase in the number of adolescent animals brought to the city in the later Middle Ages. It was not until the sixteenth century, however, that veal became an important food resource. The Exeter sample was biased by the inclusion of an unusually high number of very young jaws and bones in certain deposits, but the documentary and archaeological evidence both suggest that the raising of beef cattle had become an integral part of the rural economy. The production of veal was closely associated with dairy farming as documentary evidence makes clear.

There is no evidence before the postmedieval period of any attempt to improve the size of cattle in the area, which appears to have produced smaller animals than some other parts of the country. It was only when the raising and marketing of cattle became more commercialised and improved methods of grazing, fattening and eventually selective breeeding took place that any improvement was shown.

In the Roman and medieval periods it seems that most, if not all, of the cattle were brought to the city on the hoof for slaughter. Organised butchery of cattle carcases was a feature of the Roman deposits. No such centres for slaughter were found in the later deposits but such centres would have existed in other parts of the town where butchers slaughtered their animals. The postmedieval period brought a change in butchery practice in that the carcases were predominantly butchered into sides of beef and much fewer skull and jaw bones of adult animals were found amongst domestic rubbish indicating that many more of these were discarded at slaughter.

4.

THE EXPLOITATION OF SHEEP / GOAT

PROPORTION OF SHEEP TO GOAT

Horn cores

Although it is very difficult to differentiate between these species from osteological analysis, certain parts of the skeleton do display some diagnostic differences. Sheep horn cores, for example, can be differentiated from goat on the basis of shape. The former are roughly D-shaped in section and curved. Goat horn cores, on the other hand, are oval in cross-section and rise more vertically from the skull. Of the sixteen horn cores recovered in the Roman levels, ten could be assigned to sheep and the other six to goat. In the medieval deposits of the TS and HS sites, on which the most detailed analysis of horn core fragments took place, 63 specimens could be assigned to sheep and only 24 to goat. In addition, there were three sheep skulls which possessed no horns at all.

Metacarpi

Various attempts have been made to distinguish between sheep and goat by means of metrical analysis of the metapodia. One method is to measure the diameter of the medial and lateral articular surfaces of the condyles on the fused distal epiphyses of the bones and express the outer measurements as a percentage of the inner. The percentage is lower in goat than in sheep, the division being given at 62-63% (Boessneck *et al.* 1964:115-116). The indices of the maximum proximal width: maximum length, and the maximum distal width: maximum length were also calculated where possible. The metapodia of sheep are more slender than those of goat, although there is some degree of overlap (Boessneck 1969:354). Both methods were carried out on the metacarpi of all periods. In the Roman deposits measurements were only possible from five metacarpi. Four of the specimens produced distal condyle values ranging above 66%; the other produced a figure of 59%. It can be suggested that this bone belonged to a goat, whereas the others were from sheep.

In the medieval period, sheep metacarpi greatly outnumbered those of goat. In a sample of 45 distal epiphyses, upon which it was possible to take measurements of the condyles, only four could be ascribed to goat, whereas the remainder belonged to sheep. In addition, when the proximal and distal widths of six other metacarpi were compared to their greatest lengths, it was found that all six bones were slender enough to be classified as sheep. The two complete goat metacarpi possessed noticeably wider epiphyses in relation to their length than any of the complete sheep metacarpi.

In the postmedieval period none of the 41 fused metacarpi analysed could be assigned to goat. The ratio of the outer to inner condyle of sheep increased to over 70% in some cases. Many sheep metacarpi were much stouter in this period — a fact evidenced by the higher proportions attained by the indices of the proximal and distal widths: maximum length.

Metatarsi

An identical series of measurements was carried out for the metatarsi found in the deposits. In the Roman period, five of the eight specimens examined had distal condyle values of over 62% for both condyles, while the other three had values of 59 to 62%. When the proximal and distal width indices were calculated, however, they showed little difference between specimens with values of over 62% and those below it. This data combined with certain morphological criteria suggested that all the specimens belonged to one species, that of sheep.

Examination of 42 specimens of medieval date, using both methods of metrical analysis, indicated that only one bone certainly belonged to goat. This had condyle percentages of 57.6% and 57.8%, a proximal width: maximum length index of 0.17, and a distal width: maximum length index of 0.20. These indices confirm that the bone was stouter than the rest of the specimens, the majority of which had indices of 0.14 to 0.15 and 0.16 to 0.17 for the proximal and distal width indices respectively. The results therefore confirm the impression gained by the analysis of the metacarpi that the great majority of the caprine population brought to Exeter was sheep.

The results obtained from the postmedieval period are complicated by the fact that, like the metacarpi, the sheep metatarsi became relatively stouter. This makes the distinction between sheep and goat more difficult. One example had condyle percentages of over 63%, which would suggest that it belonged to a sheep, yet the proximal and distal width indices were 0.17 and 0.21 respectively, which meant that the bone was as stout as the goat identified in the medieval period. This was an extreme example, however, and most of the fourteen specimens, from which results were taken, could be assigned with confidence to sheep.

Calcanea

The maximum length of this bone is greater in goat than sheep in relation to its greatest width, although there are degrees of overlap (Boessneck 1969:352). Measurements on specimens from all periods in Exeter showed that the proportions between the two measurements were relatively consistent throughout and that most of the calcanea belonged to sheep. The dominance of sheep in the samples was also evident from the metrical analysis of the articular facet following the criteria of Boessneck *et al.* (1964:104).

Morphological observations

These observations supported the impression gained from the metrical analyses that the samples consisted principally of sheep. Certain diagnostic fragments (particularly the proximal femur, the radius and the third phalanx) occasionally possessed characteristics distinctive of goat but by far the majority could be positively identified as sheep.

Accordingly, the horn core evidence would suggest that a higher proportion of goat was exploited in Exeter than that of the long bones. The same discrepancy has been observed on other sites. At the iron age oppidum of Manching and on several Dutch sites of Roman date this was explained by the fact that, whereas all goats on the sites possessed horns, some sheep were hornless (Clason 1967:78). This probably accounts for some of the variation in the Exeter material, since polled sheep skulls were discovered, albeit in small numbers, in the medieval and postmedieval deposits. More important, however, was the use of horn for industrial manufacture. This may have favoured the recovery of goat horn cores, since their horns were larger in general than those of sheep and presumably were more in demand. Consequently, concentrations of horn cores found in some features on the Goldsmith Street site dated to the twelfth century may be misleading and biased in favour of goat. With regard to the metrical analysis, the results obtained from the metacarpus appear to be the most reliable, although it should be remembered that the results are limited to the fused specimens of animals over eighteen months old. The exploitation of sheep and goat may have been quite different and the proportions of sheep and goat amongst the unfused specimens may not have been the same. The results from the metacarpi indicate that in the medieval deposits less than 10% of the sample belonged to goat and that in the postmedieval period goat disappears almost entirely from the deposits. The other measurements and morphological criteria (employed on both young and old bones) support this view.

According to Domesday Book, there were on the demesne lands in the Hundreds around Exeter 1,613 goats compared to 9,689 sheep, a percentage of 14.27% of the total caprine stock (Table 56). This figure is similar to the results obtained from the twelfth century deposits in Exeter, in which three of the 30 fused metacarpi examined (10%) belonged to goat. The flimsy documentary evidence contains some evidence that goats became less common during the later Middle Ages: there is no mention of them in the account rolls of Tavistock Abbey in the fourteenth century and it seems that the Bishop of Exeter did not keep any goats on his estates either in 1328 (Finberg 1951:129). There is not as yet enough archaeological material dated to the fourteenth century in Exeter to confirm or deny this trend, although certainly by the sixteenth century, goats had become very scarce indeed inside the city. No goat bones were positively identified in the Plymouth sample of over 1,000 caprine fragments dated to the fifteenth century (Dennell *pers. comm.*).

AGEING DATA

The use of ageing data is limited by the fact that the jaws and long bones of sheep and goat are hard to differentiate in many cases. The tooth eruption data and fusion evidence of the two species cannot realistically be separated. It is possible that the exploitation pattern and mortality rates of sheep may have been radically different from those of goat. However, since sheep appear to have greatly outnumbered goat in the deposits of all periods, it is possible to obtain a good indication of the mortality rates of sheep in samples of sufficient magnitude.

The methods employed and the problems encountered in the ageing of sheep and goat jaws have been discussed in Chapter 1 (page 7). With the exception of 40 mandibles of medieval date employed in a comparison of Carter's (1975) and Grant's (1975) methods of ageing mandibles, individual results from the 450 jaws examined are not given. Instead Tables 69, 72 and 76 summarise the data by giving details of the number of jaws that reached or failed to reach various stages in the tooth eruption sequence. The stages employed were:

Stage 1 Both columns of the M1 in wear.
Stage 2 Both columns of the M2 in wear.
Stage 3 P4 in wear.
Stage 4 All columns of the M3 in wear.
Stage 5 M1 in heavy wear.
Stage 6 M2 in heavy wear.

'Heavy wear' is defined as the stage beyond the relatively long-lasting 'mature wear' stage defined by Payne (1973: 288). That stage is equivalent to Stage g of the permanent mandibular molars in the system of tooth wear analysis devised by Grant (1975:439). A similar process occurs on the maxillary molars. The sequence of tooth eruption and wear is well defined but the absolute ageing of this sequence in Roman and medieval times is very much a problem. As in the case of cattle, improvements in husbandry during the last 200 years have increased the rate of tooth eruption, as data derived from eighteenth century 'semi-wild' hill sheep indicate (Silver 1969: 297). Even these figures are not reliable, since the ages cited for the eruption of some of the teeth by the eighteenth century sources do not correlate with the eruption sequences evidenced on British archaeological sites (Ewbank *et al.* 1964:423). Several ageing scales for sheep jaws have been used on British material in recent years based on estimates of Ewbank *et al.* (1964), Silver (1969), Payne (1973) and Carter (1975), all of which differ in detail. Tables 70, 73 and 77 follow the ageing scales employed by Carter but it should be emphasised that these figures are only estimates derived from archaeological interpretation. It has not been established from modern specimens that the rate of decline in height of the permanent molars due to wear (upon which the method is based) is in fact uniform, nor similar to that envisaged by Carter. The rate of tooth eruption is slower than that proposed by Ewbank *et al.* but may significantly underestimate the true age of the animals and should be treated as a guide only.

The Roman period

118 jaws of sheep/goat bore evidence of dentition. The specimens were subdivided into samples dating to A. D. 55 to 100, 100 to 300, and over 300. The results of the analysis are shown in Table 69. Throughout the Roman period at least two-thirds of the jaws belonged to animals that died prior to the completion of the tooth eruption sequence (Stage 4). Correspondingly high figures were obtained for Stages 1 to 3. The situation appears to have been fairly consistent in all the phases studied, with minor variations probably explained by small sample sizes obtained from some of these. Tables 69 and 70 show that the main peak of slaughter lay between Stages 2 and 3 (approximately 15 to 26 months). In all phases, however, a few specimens belonged to animals probably over four years of age and at least four examples belonged to senile animals, probably well over six years old.

The study of fusion data produced a number of problems of interpretation (Table 71). Sometimes epiphyses of the same fusion age gave contradictory results. For example, there were noticeably less unfused calcanea than unfused proximal epiphyses of femora. Yet both fuse at about 30 to 36 months, according to figures provided by Silver (1969:285-6). The most likely explanation of this discrepancy is that the unfused calcanea had less chance of survival and recovery than the larger bones such as the femora because of their small size and more delicate state: consequently they produced higher percentages of fused specimens than expected. The distal metacarpus and distal tibia also show incompatible results, although both epiphyses fuse between 18 to 24 months, according to Silver. For example, in the sample taken from deposits dated to the second and third centuries, all fourteen of the distal metacarpi were unfused but only 25 of the 48 distal tibiae were in a similar condition. It is probable that some of the metacarpi with fused distal epiphyses were employed in tool-making and consequently were missing from ordinary refuse deposits, biasing the remaining sample in favour of the unfused specimens. It is possible that the metatarsus was used in a similar fashion and this bone was also treated separately in the analysis. The preservation of the epiphyses of sheep/goat bones is linked to their age of fusion and to their specific gravity (Brain 1967; Binford and Bertram 1977). Table 71 (and also Tables 75 and 78) show that many more of the early fusing epiphyses were recovered than those which fuse later in the animal's life. This helps to explain some of the discrepancies in the results. It also serves to emphasise that the percentages of unfused specimens obtained by this method should be treated as relative figures only, since the samples are biased to an unknown degree in favour of the denser, fused epiphyses.

Despite these problems, there was a broad correlation between the two sets of ageing evidence. For example, according to the pooled data from the proximal humerus and tibia and the distal radius and femur, a consistently high percentage of epiphyses were unfused (about 61 to 70%) and belonged to animals that died before 36 to 42 months of age. The results also confirmed that the kill-off of young animals was quite high.

It is unfortunate that the period when the evidence from the jaws suggests that the most intensive slaughter took place (15 to 26 months) is covered mainly by fusion data from bones that appear to give misleading results, notably the phalanges and metacarpus. The distal tibia (18 to 24 months) gave a consistently lower figure of animals killed (22 to 25%) than that indicated by the tooth eruption data for that age, and in some cases a lower percentage than those given by epiphyses of earlier fusion ages. For some reason it seems that a greater percentage of unfused distal tibiae failed to survive. Certainly the small dimensions of many of the shaft fragments would suggest that a far greater percentage than about 25% was unfused. It is also possible that the epiphyses fused a little before the main period of slaughter of the stock.

Because of the doubts about the absolute ages of the animals, one cannot state categorically that the main slaughter of stock took place in the autumn or winter of the animal's second year, although this would have been one of the best times for such culling, since the sheep would have provided at least one fleece at this age and the slaughter of non-breeding animals at that time of the year would allow more pasture for the remaining stock.

The medieval period

In this period it was possible to make comparisons between the two methods of classifying and ageing teeth employed by Grant (1975) and Carter (1975). Grant's method of classifying sheep mandibles was identical to that employed on cattle. Each stage of the surface wear pattern of the M1-M3 was noted and a numerical value for the whole tooth row was obtained by adding up the individual totals for each tooth. Teeth with less wear scored fewer points and therefore the younger jaws had a lower numerical value.

The results of the analysis are shown in Table 74. Apart from one or two anomalies, the two methods were in broad agreement. The jaws aged over 72 months by Carter's method all had numerical values of over 40 using Grant's classification system. Jaws with values of 35 to 39 were found to lie between the ages of 36 to 60 months, and those with values of 30 to 34 were aged between 24 to 36 months. However, some stages of tooth wear in Grant's system appear to have lasted for a very long time. For example, Stage g of the M2 was found to be present in jaws ranging from 24 to 54-60 months in age, a very long time span in the animal's life. Similarly Stage g of the M1 and of the M3 also appear to have lasted for a long time (Table 74). Consequently jaws which had only one or two of the permanent molars present in these particular stages of wear could not be closely aged. Although further research is needed, it should be possible to correlate the two methods of analysis. One thing that has not been taken into consideration, however, is the possible variability in the rates of wear due to differential feeding which may limit the application of these techniques.

The tooth eruption data for the medieval period were obtained from a total of 271 mandibles and maxillae. These were divided up into samples dated to the eleventh to twelfth, thirteenth and fourteenth to fifteenth centuries. The earliest sample was further subdivided into samples dated to the eleventh to early twelfth centuries (Phase Md1) and the twelfth century (Md2) (Tables 72 and 73). The results continued to show the presence of a high percentage of young animals, especially in the early medieval period. The results indicated that over two-thirds of the animals had been killed by Stage 3 of their tooth eruption sequence and that over three-quarters were dead before Stage 5 was reached. The later medieval samples witness some decrease in this high rate of immature slaughter and the percentage of jaws which failed to reach Stage 3 fell to below 50%. The figures for Stage 5 also dropped by over 20% in comparison to the earlier medieval samples. The main peak of slaughter, as in the Roman period, occurred between Stages 2 to 3 of the tooth eruption sequence (15 to 26 months). In the sample from the thirteenth century deposits there was for the first time a notable concentration of jaws that belonged to animals that died between Stages 5 to 6 (approximately 42 to 60 months on Carter's ageing scale).

The fusion data gave consistent results throughout the medieval period (Table 75). The percentage of unfused proximal humeri and tibiae, and distal radii and femora (fusion age: 36 to 42 months) ranged between 69 to 82% in the samples involved. Close similarities were also found in the percentages of unfused proximal femora and ulnae (69 to 75%) and distal metatarsi epiphyses (52 to 60%). The percentage of unfused distal tibiae dropped from about 43% to about 32% between the twelfth and thirteenth

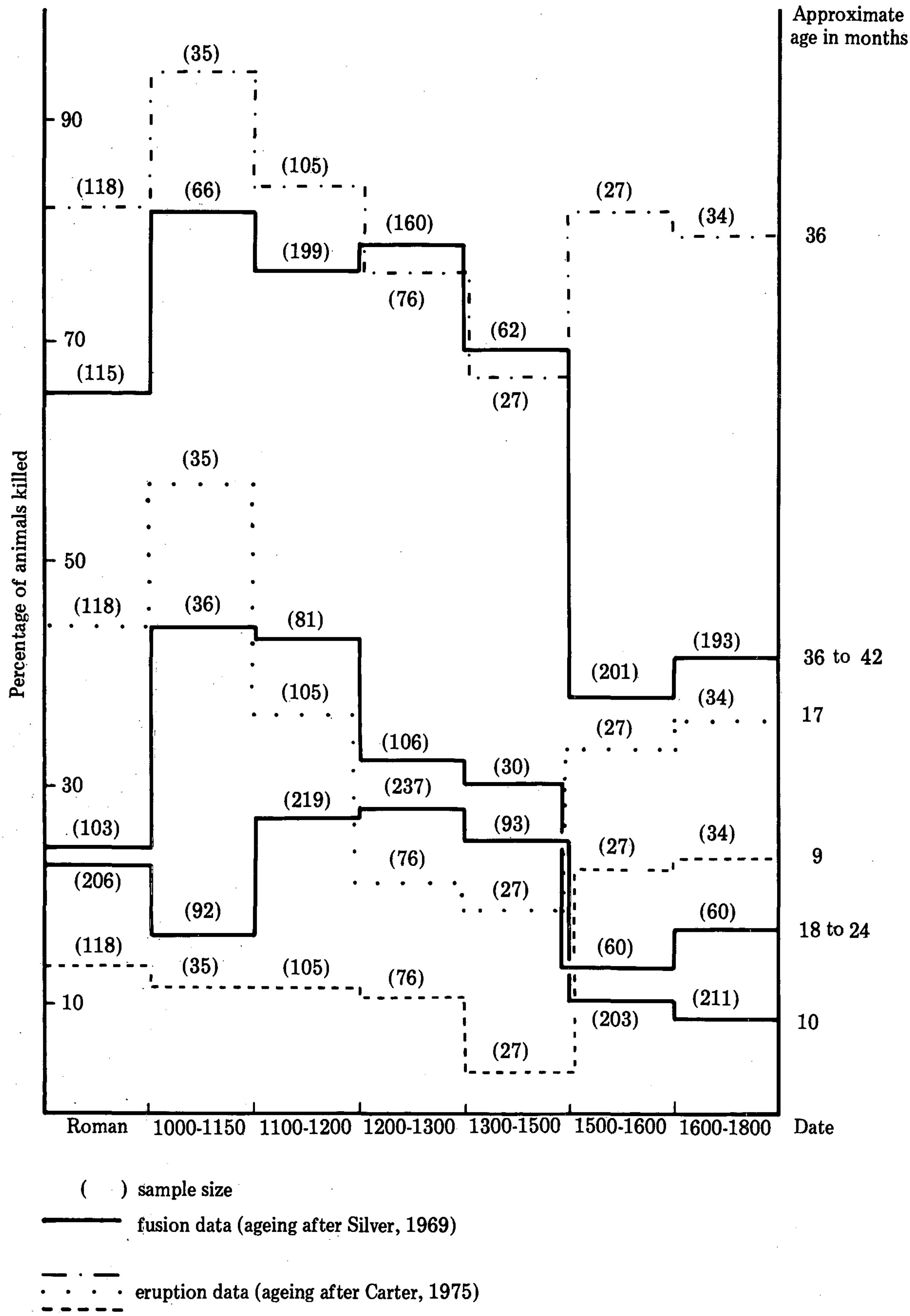

Figure 10 Sheep/goat ageing data.

century samples. This may reflect the fact that the period of peak slaughter began at a rather later age in the thirteenth century. The earliest epiphyseal fusion group (distal humerus, etc.) had percentages of unfused specimens that ranged from 16 to 28% of the samples, again suggesting that quite a high level of immature slaughter was taking place in the medieval town.

A comparison between the two sets of ageing evidence is made in Figure 10. This plots the cumulative percentages of sheep/goat killed against the age of the animals, using the estimates of Carter and Silver for the tooth eruption and fusion data respectively. In all the Roman and early medieval samples the fusion data produced slightly lower figures of animals killed by the age of 36 to 42 months than the maximum percentages obtained from the tooth eruption data for 36 months. Both sets of data do show a gradual trend throughout the medieval period towards a decrease in the slaughter of immature animals, although these continued to run at a very high rate. Both sets of evidence also indicate that a large proportion of animals brought to Exeter in this period were slaughtered between the ages of 18 and 36 months, if the ageing estimates are accurate and that a relatively large number of animals died during their first year.

The postmedieval period

A total of 61 jaws was studied; 27 were dated to the sixteenth century and 34 to the seventeenth and eighteenth centuries. The results from both these samples bore close resemblances to the results obtained from the thirteenth century sample (Tables 76-77), especially in the later stages of the eruption sequence. Once again, unfortunately, a significant number of the older jaws could not be aged with any accuracy, which accounts for the wide margins between the minimum and maximum percentage figures obtained in Table 76. The major change between these samples and that of the thirteenth century was the increased number of very young jaws. For the postmedieval period as a whole, 22.95% of the jaws had not reached Stage 1 of the tooth eruption sequence, compared to the figure of 10.53% attained from the thirteenth century sample. Other than these early mortalities, there were very few jaws that belonged to animals under two years of age. Certainly there was no peak of slaughter between Stages 2-3 as there had been in the earlier periods. It is interesting to note that as in the thirteenth century sample, a significant number of sheep was aged between 42 to 60 months, using Carter's ageing estimates (Table 77).

The fusion evidence (Table 78) was in direct contrast to the tooth eruption data. The results showed an appreciable drop in the number of unfused bones of all age groups. For the postmedieval period as a whole about 40% of the epiphyses with late fusion ages (the proximal humerus, etc.) belonged to immature animals, a decrease of over 35% in comparison with most of the medieval samples. The other fusion groups also revealed similar dramatic decreases in the number of unfused specimens. For example, only about 15% of the distal tibiae were unfused, compared with levels of 30 to 45% in the medieval samples. Similarly the youngest group of bones to fuse (the distal humerus, etc.) only had about 10% of the specimens in an unfused condition, a drop of over half compared with the equivalent medieval figures (Figure 10).

How, therefore, can two such conflicting sets of data be reconciled? To take the fusion data first, the samples from which the results were obtained were large ones, and, despite the variety in the richness of the postmedieval deposits, the sample of sheep/goat appears not to have been influenced significantly by this factor. The fusion data from rich deposits such as GS F. 228 and TS F. 316 were similar to those of the much poorer Goldsmith Street deposits of the seventeenth and eighteenth centuries. The decrease in the proportion of the more fragile unfused bones cannot be ascribed to poorer preservation or hurried excavation; indeed the preservation of bone in the post-medieval features was better than in the earlier deposits.

One cannot, on the other hand, be as confident with the results obtained from the tooth eruption data. As was observed in Chapter 2, the proportion of jaw and skull fragments of sheep/goat fell to very low levels in many of the postmedieval deposits, and the sample of 61 jaws was much smaller than one would have expected in a sample of over 2,900 sheep/goat fragments. Secondly, there is good evidence that, due to a change in marketing practice, very few jaws of older animals were found in the deposits in question. For example, the fused distal radii (fusion age about 36 months) outnumbered the jaws of Stage 4 and above by a ratio of over 3:1 in the postmedieval samples. This was in contrast both to the medieval period, when the number of jaws was greater than the number of fused radii (1.31:1) and to the Roman period, when the numbers were roughly equal. Similar results were obtained from other epiphyses with late fusion ages.

Consequently, there seems to have been a change of marketing practice in the postmedieval period which resulted in considerably fewer skull and jaw fragments of the older sheep/goat population being associated with their major limb bones in the deposits investigated. Many of the animals must have been decapitated at slaughter and their skulls deposited elsewhere within, or outside, the city. This practice does not seem to have been carried out on the younger lambs to the same extent. Possibly they may more often have been roasted whole. Certainly in the deposits in question their skulls and jaws were much more frequently found with their limb bones.

As a result of this change in butchery practice, the post-medieval tooth eruption data cannot be directly compared with the earlier periods, since it seems likely that the number of older animals was significantly under-represented. Accordingly, the fusion data probably provide a more accurate indication of the slaughter pattern in this instance. There would therefore seem to have been a marked change in the rate of sheep/goat slaughter at Exeter in the post-medieval period, in that a much greater number of mature animals was killed.

DISCUSSION OF AGEING DATA

The interpretation of the ageing evidence depends to a large extent upon whether the tooth eruption and fusion ages as estimated by Carter (1975) and Silver (1969) are accurate when applied to the Exeter material. If one accepts that those ages approximate to the true age of the animals, there is evidence that the animals slaughtered for consumption in Exeter were not representative of the sheep/goat population in the area. Both sets of ageing data indicate a high rate of immature slaughter in the Roman and medieval periods. According to the tooth eruption data, 46 to 78% of the animals eaten in Exeter were younger than 25 months old in all the Roman phases and in the eleventh to thirteenth centuries. Animals culled before this age must have been bred principally for their meat value since, at most, they would have provided one fleece of wool only, as sheep yield their first fleece at about 18 months of age. The peak period of slaughter varied a little in the phases involved but most deaths occurred at between 15 to 30 months. One can therefore visualise a policy of the culling of the animals not required for breeding or other purposes at this age for their meat, the animals having already provided one, or perhaps two, fleeces of wool. To ensure the continuance of the stock, however, a certain number of ewes and rams would have to be kept alive for breeding purposes. Even if the remaining animals represented were all breeding stock, it is unlikely that they would have produced enough lambs to maintain such a high rate of immature slaughter, especially since the fertility rates of sheep were low by modern standards. In seventeenth century Norfolk, for example, this rate was only 0.5 to 0.8 lambs per ewe (Allison 1958: 103). In addition, the rate of natural deaths among lambs was also high in medieval times and losses of over 30% of the stock through disease have been recorded in several documentary records (Miller and Hatcher 1978:217). The same probably applied to the Roman period as well. The number of neonatal deaths and lambs that died during their first winter was comparatively low in the Exeter deposits and they are almost certainly under-represented. It is therefore probable that the Exeter samples do not contain a cross-section of the sheep population and that a considerable number of the breeding stock and the infant mortalities did not find a market in the town. It is possible to visualise a marketing system in which the majority of the stock not required for breeding or wool-growing purposes was culled with the view to satisfying the demands of the urban population for meat. The older animals and infant mortalities did not find a similar market in the town. In this respect it is unfortunate that as yet no rural sites in Devon can be compared to test this hypothesis.

Alternatively, the estimated ages of tooth eruption and fusion may both substantially underestimate the true age of the animals involved. Eighteenth century data for tooth eruption of 'semi-wild' hill sheep do show a much slower rate of dental development. According to this data, the premolars did not erupt prior to 30 months, while the M3 only erupted between three to four years (Silver 1969: 297). However, doubts have been raised about the validity of this data, since it allows a period of two years between the eruption of the M2 and M3, whereas the specimens from Exeter and other contemporary sites suggest a much shorter time span between the eruption of these two teeth. Despite these discrepancies, however, it is not impossible that the development of the Devon sheep was significantly slower than that allowed for above. If so, it is possible that the animals present in the Exeter deposits included a more representative cross-section of the sheep population, although young fatalities are still under-represented. In that case the overriding value of sheep was for their meat production with both wool and milk production taking only secondary roles.

It is interesting to compare both documentary and other archaeological evidence for sheep mortalities and exploitation patterns in these periods. The growth of a flourishing wool trade is frequently cited for some areas of southern Britain during the Roman period. The existence of this trade has been implied from Roman sources: Dionysius Perigates, for example, writing about 300 A.D., remarked upon the quality of British wool (Ryder 1964: 5). However, the ageing data from Exeter suggest that the southwest peninsula of Britain lay outside the area of this postulated wool trade, since the high rate of mortalities of young animals for meat in the city would suggest that wool was only a secondary product. A similar situation was found in the Portchester Castle Roman deposits. In a sample of 134 proximal humeri and tibiae and distal femora, 103 (76.87%) were found to be unfused and therefore, using Silver's ageing data, belonged to animals under 42 months in age (Grant 1975:394). The peak of slaughter was estimated to lie late in the second year of the animals' lives and the tooth eruption data produced results that bear close similarities to those of the Roman levels in Exeter. If a flourishing wool trade did develop in some areas of Roman Britain, the new economic trends did not supersede the necessity to obtain an adequate meat supply for the two centres in question.

The number of mature sheep represented in medieval Exeter was less than almost any other contemporary site investigated in southern and central England. This could be explained by regional variations in the exploitation of sheep or in a dichotomy between the ages of sheep eaten on rural and urban sites. There are arguments in favour of both these explanations from the piecemeal archaeological evidence available. In support of the latter explanation are the high percentages of adult animals represented on some rural medieval sites. At the medieval village of Upton, Gloucestershire, only 18% of the jaws found on the site had not reached Stage 4 of the tooth eruption sequence (all columns of M3 in wear) (Yealland and Higgs 1966:140). On the seven medieval sites investigated by Noddle (1975), the percentage of immature sheep represented in the medieval levels at North Elmham, Norfolk, was also low. This contrasted with the assemblages from two urban sites in Bristol, which had percentages of immature animals approaching the high levels from Exeter. The hypothesis of a rural-urban dichotomy is supported by some documentary evidence. In fifteenth century Norfolk the production of wool and store lambs was the principal motive in sheep breeding and Norwich's demand for mutton was satisfied by the sale of crones (old ewes) and pucks (poor quality lambs) drawn almost entirely from the surrounding district (Allison 1958:108). This implies that many of the wethers kept for the production of wool seem not to have found a market in the city to the same extent.

The division is not always clear-cut, however. The medieval deposits in the towns of Southampton and Kings Lynn contained higher percentages of mature individuals (Noddle 1975:255). The number of specimens from the former was very small, however, and may be misleading (Noddle 1974a: 336). The sample from Kings Lynn is larger (Noddle 1977) but the ageing data are presented differently from those of Exeter and the two sites cannot be closely compared. There is nevertheless a likelihood that there was regional variation in sheep exploitation related to the importance of producing surpluses of wool. Documentary evidence can again be used in support of this theory. Although it is accepted that the rearing of sheep for wool was the major pastoral occupation in the Middle Ages (Power 1941:21) and that the export of wool was by far the most important commodity in England's foreign trade (Lloyd 1977), not all regions enjoyed the boom to the same extent. It was the fine wools that were most in demand and those of the southwest were too coarse for the foreign market and were not exported (Power 1941:23). It was certainly less profitable for sheep farmers in Devon and Cornwall to concentrate on wool production because of the poor quality of the fleeces of their stock. An evaluation of 1343, which fixed a minimum price for wool, shows that the least expensive wool was grown in Cornwall and the second cheapest in Devon. The quality of Cornish wool was scornfully referred to as 'Cornish hair' (Trow-Smith 1957: 162). If the records of Tavistock Abbey can be taken to indicate the situation in the rest of Devon, the amount of wool obtained from each fleece was also lower than the national average. At Leigh, one of the abbot's manors, 156 fleeces sold in 1398 weighed an average of 1.08 lb. In the midlands and southern England on the other hand, the average weight of a short-woolled fleece ranged from 1.2 to 1.7 lb (Trow-Smith 1957:167). Accordingly, the southwestern farmers not only obtained very low prices for their wool but also produced less wool per fleece than most of the rest of England.

Therefore there was less incentive in terms of profit for large surpluses of wool to be produced in Devon in the medieval period. It would not be surprising to find that there was indeed a higher kill-off rate of immature animals for sale in market centres such as Exeter, which would have been more attractive economically for local sheep farmers than similar urban markets in areas of more profitable wool production. Devon does not seem to have been an important producer of wool in the twelfth and thirteenth centuries and it is of interest to note that on the Tavistock estates mature ewes were kept for their milking and breeding qualities rather than for their wool. Wool sales did not become more important until the middle of the fourteenth century (Finberg 1951:150). The increasing importance of Devon wool production in the later medieval period is also indicated by the appearance of large numbers of fulling mills during the thirteenth century (Carus-Wilson 1954:51). It is significant too that Exeter became one of the staple towns in the 1320s, through which the export of wool had to be directed (Lloyd 1977:115). This in itself merely confirms Exeter's importance as a commercial and trading centre at this period but it must also imply that the merchants in the city were now dealing with substantial quantities of wool, much of which must have been produced in Devon. Such an increase in the importance of wool production may also explain the relative increase of mature sheep represented in the Exeter deposits of the later medieval period, although the percentage of immature animals culled for meat remained predominant.

It is not until the postmedieval period that a dramatic change in the exploitation of sheep is evidenced and there is a substantial increase in the number of adult animals represented. If it is accepted that the estimated ages of tooth eruption and fusion approximate to the true age of the animals, the increase in the number of older animals shown by the fusion data may indicate that more of the breeding stock was now brought to the city along with the animals specifically reared for meat. In other words, the apparent change in the mortality rate may simply have been the result of a change in the marketing of animals. On the other hand, although the tooth eruption data overemphasises the importance of the younger animals in the postmedieval period, both sets of ageing evidence do suggest that very few animals were killed now between 15 to 30 months of age. Apart from lambs slaughtered in their first year, comparatively few of the stock brought to the city were under three years of age. It would seem, therefore, that most sheep eaten in Exeter were no longer reared especially for that purpose and slaughtered between 15 to 30 months, but instead were usually allowed to live to at least three years of age and often longer.

Similarly, even if the estimated ages of fusion and tooth eruption do substantially underestimate the actual ages of the animals, the evidence still indicates that many more animals were allowed to reach maturity in postmedieval times than previously. Consequently, there does seem to have been a change in the exploitation of sheep/goat in the postmedieval period, which cannot solely be explained by a change in marketing techniques. The reasons for this change may have lain in the increased importance of wool or dairy produce, both of which require a relatively high number of adult animals to provide annual supplies of fleeces and milk. The documentary evidence indicates that it was the former which was the prime factor in the new husbandry policy.

It was not until the fifteenth century that the wool obtained from Devon sheep, which was turned into broadcloths of coarse material called 'kerseys', became popular. It was the boom in this production that was the prime factor that brought such prosperity to Exeter in the fifteenth to seventeenth centuries. The demand for Devon kerseys began to snowball in the fifteenth century. The expensive cloths obtained from finer wool grown in other parts of England during the medieval period were now less popular and cheaper, coarser cloths were now in demand in Britain and in Europe. Export of Devon kerseys became common. In the 1440s more than 2,000 cloths per year were sent overseas. Despite a slump in the 1450s and 1460s, the export figures rose rapidly so that, in the years 1481 to 1483, an average of 6,000 cloths was exported. Thereafter exports averaged over 3,000 cloths a year for the rest of that century. The boom continued in the sixteenth century: between 1500 to 1510, for example, trade in Devon cloths averaged 8,600 cloths per year and the main industrial activity in Devon during that century was clothmaking (Carus-Wilson 1963:7-9; Thirsk 1967a:73). By the seventeenth century the demand for wool had outstripped the local supplies and Spanish wool which was imported to Exeter from the late fifteenth century, increased in quantity (Hoskins 1935:35). Westcote noted in 1630 (by which time serge manufacture had begun to increase in importance), that the large local wool supply which had previously been sufficient for the kersey industry was being supplemented by fleeces obtained from other southwestern counties, Gloucester, Worcester, Norwich, Wales, Ireland and London. Later in the seventeenth century wool was shipped to the Devon ports from Rye and Folkstone and increasing amounts were imported from Spain and Ireland (Stephens 1958:49).

Such a boom in the cloth industry undoubtedly encouraged the local flock owners to supply more wool. The demand increased the price of wool and it is therefore likely that the farmers would have kept more adult sheep in order to obtain their yearly growth of wool. The dramatic drop in the number of immature animals in the sixteenth century levels at Exeter, as evidenced by the epiphyseal fusion data, can most easily be explained by this phenomenon. Documentary evidence from England in general reveals that wethers were often finished for the butcher at four to five years of age in the sixteenth century (Thirsk 1967b:188). The same practice appears still to have been common in Devon at the end of the eighteenth century (Fraser 1794: 53). This would correlate with the concentration of jaws aged, using Carter's estimates, at between 42 to 60 months. Except for lambs killed at a few months old, meat production had become of secondary importance to that of wool.

Unfortunately, the Exeter deposits produced virtually no faunal material dated to the fifteenth century. Consequently the rise in the number of adult animals may have been more gradual than the evidence suggests. A bone sample from Plymouth investigated some years ago may cast light on the intervening period. Excavations on part of the medieval harbour in Woolster Street produced a quantity of animal

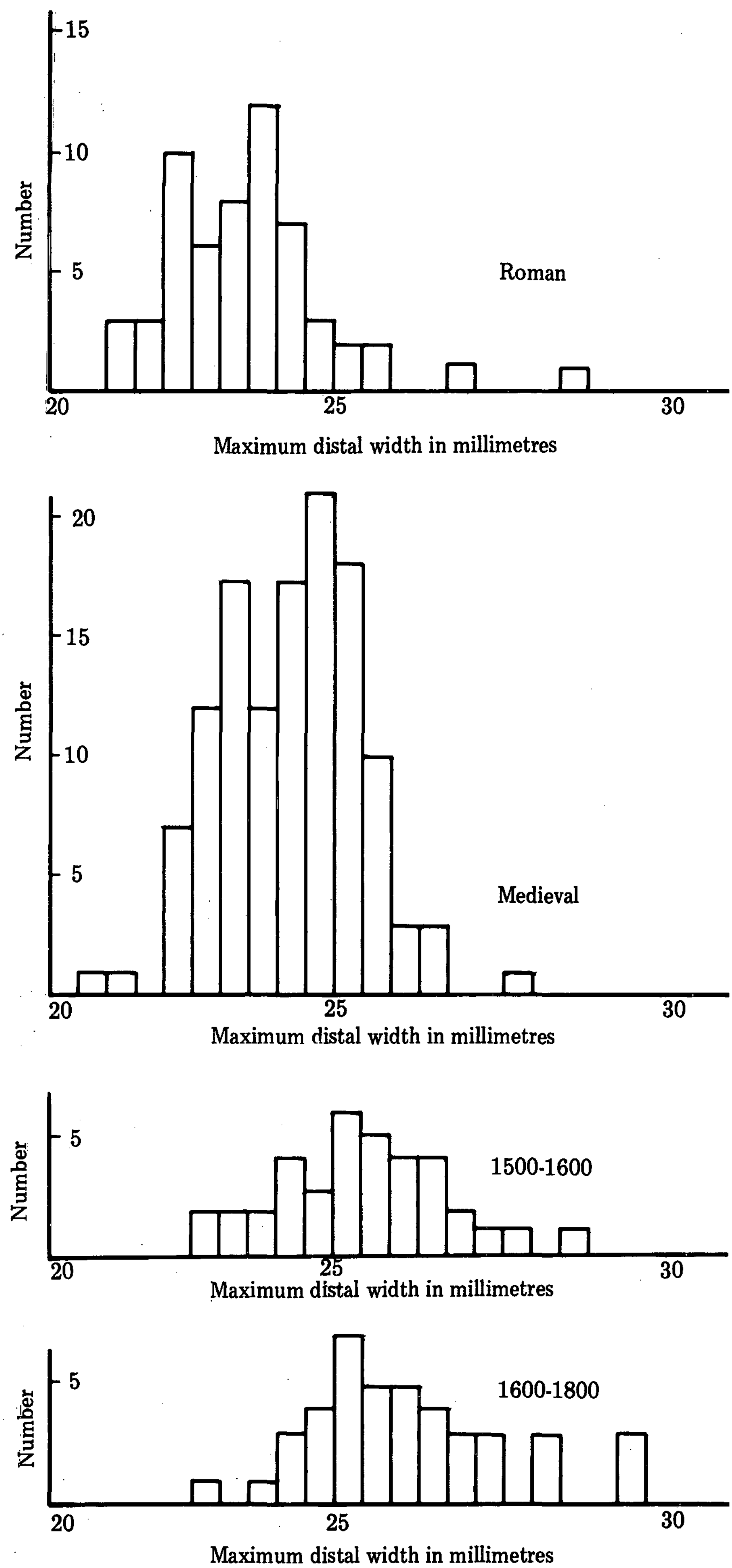

Figure 11 Histograms of sheep/goat tibiae measurements.

bones located on the old harbour bed outside a warehouse, associated with pottery dated to the fifteenth and early sixteenth centuries. 27 of the 62 mandibles had their third permanent molars in full wear (Stage 4) (Dennell *pers. comm.*) and therefore the remaining 35 (56%) were under 29 to 30 months of age, using Carter's ageing sequence; seven (11%) of the latter were under nine months old. There seems to have been a peak of slaughter between Stages 3 to 4 of the tooth eruption sequence (24 to 30 months), since seventeen (27%) of the mandibles had reached the stage where their third permanent molars were in partial, but not complete, wear. There appear to have been very few animals aged between 12 to 24 months. The tooth eruption evidence from fifteenth century Plymouth therefore shows some similarities to the thirteenth century sample from Exeter. The percentages of jaws failing to reach Stage 1 of the tooth eruption sequence are very similar as indeed are the percentages of jaws that failed to attain Stage 4. However, the Exeter sample had a much higher proportion of animals killed between Stages 2 and 3. Unfortunately the fusion data from the two sites could not be compared. Consequently, because the tooth eruption data from the postmedieval levels at Exeter are suspect, it is impossible to compare the two samples directly. The apparent change in marketing practice evidenced in Exeter in the sixteenth century may have been in existence in Plymouth in the fifteenth century, in which case the number of older jaws in the sample may be under-represented. On the other hand, the proportion of skull and jaw fragments in the Plymouth sample was larger than in the sample from postmedieval Exeter, which may indicate that the practice of butchery had as yet not changed and that the mortality rate, as evidenced by the tooth eruption data in Plymouth, was a relatively accurate reflection of the ages of the animals eaten in that part of the town. If so the drop in the number of immature animals in postmedieval Exeter, as witnessed by the fusion data, may have been basically a sixteenth century phenomenon — a period when the demand for wool reached new heights.

METRICAL ANALYSIS OF SHEEP/GOAT

The tibia

Histograms of the maximum distal width of the tibia reveal a gradual increase in overall size during the periods involved (Figure 11). In the sample taken from the Roman levels, only six out of 58 specimens (10.35%) measured over 25 mm. In the medieval period, within which there was little variation in the size of the specimens, 39 out of 125 (31.20%) distal tibiae had a width of 25 mm and above. The overall size of the stock increased significantly in the sixteenth century when 24 out of 36 specimens (66.67%) were larger than 25 mm in width. In the seventeenth to eighteenth centuries a total of 33 out of 42 specimens in the sample (78.57%) had attained this size and a few measured over 30 mm. Data from modern sheep indicated that the maximum distal width of the tibia of wethers (castrated males) is about 104% that of ewes (Noddle 1975:253). There would, however, be an overlap in size in populations drawn from different flocks. Although the bimodality evident in the histograms of the Roman and medieval samples may be related to sexual dimorphism, further research is needed before firm conclusions can be drawn.

The humerus

Histograms of the maximum width of the fused distal humerus were also constructed for all periods. This measurement is less reliable as a guide to the overall size of the stock than the distal tibia since it has an earlier fusion age (about 10 months). The epiphysis tends to increase a little in size after fusion and, as a result, many more of the specimens included in the histograms may have belonged to animals not fully grown. A significant change in the mortality rate may therefore affect the measurements and the histograms resulting from them, especially at the lower end of the scale. Accordingly, the small fluctuations found in the histograms for the Roman and medieval periods (Figure 12) may be due in part to variations of exploitation during the second year of the animal's life. However, the size of the stock seems to have improved only slightly during that time. All the histograms for the Roman and medieval periods have a unimodal distribution with a concentration of specimens measuring between 27 to 28 mm. In the postmedieval period this concentration disappears and there are noticeably more specimens over 29 mm (21 out of 57) than in the medieval period as a whole (22 out of 97). One or two of the eighteenth century specimens measured over 33 mm and in general the post-medieval samples witness an increase in the average size of the stock.

The radius

The distal epiphysis of the radius fuses at about 36 months in sheep. Consequently the possibility of fluctuations in the measurements caused by the slaughter of relatively young animals is eliminated, since the sample consists of mature animals. However, because the kill-off of sheep was so intensive in the town during the Roman and medieval periods, most of the animals eaten in Exeter had been slaughtered before their distal radius had fused and so the sample size was much smaller because only fused bones could be measured. Histograms were constructed of the number of specimens whose maximum distal width was measured (Figure 13). These revealed an increase in size between the Roman and medieval periods. In the Roman sample, thirteen out of 22 (59.09%) radii had a distal width of below 25 mm. In the medieval period, during which time there would appear to have been little improvement in overall size, fourteen out of 42 specimens (33.33%) were under 25 mm wide. The histogram of specimens dated to the sixteenth century shows that, although the peak of the measurements was similar to that of the medieval period, there were relatively more specimens over 25 mm wide; only nine (25%) were below that size. The most dramatic improvement in stock size, however, was again found to have taken place in the seventeenth and eighteenth centuries. Only three out of 25 radii (12%) were under 25 mm in width and the majority of the specimens measured between 26.5 and 29 mm. For the first time several specimens were over 30 mm wide.

The overall size of the stock

The three studies above have been concerned with epiphyses fusing at three different ages. They point to the same over-all conclusions and the trends are confirmed by other measurements from sheep/goat bones. Table 79 shows the range, mean, standard deviation and coefficient of variation of all the measurements taken from all periods. Most of those indicate a slight improvement in the average size of the animals between the Roman and medieval periods. The improvement in the overall size of the animals can be explained in terms of either better husbandry management or by the introduction of larger stock. During the Middle Ages there was very little improvement in the stock and it was not until the postmedieval period that advances took place. In this respect, the sixteenth century seems to have been a time of gradual transition, rather than one of

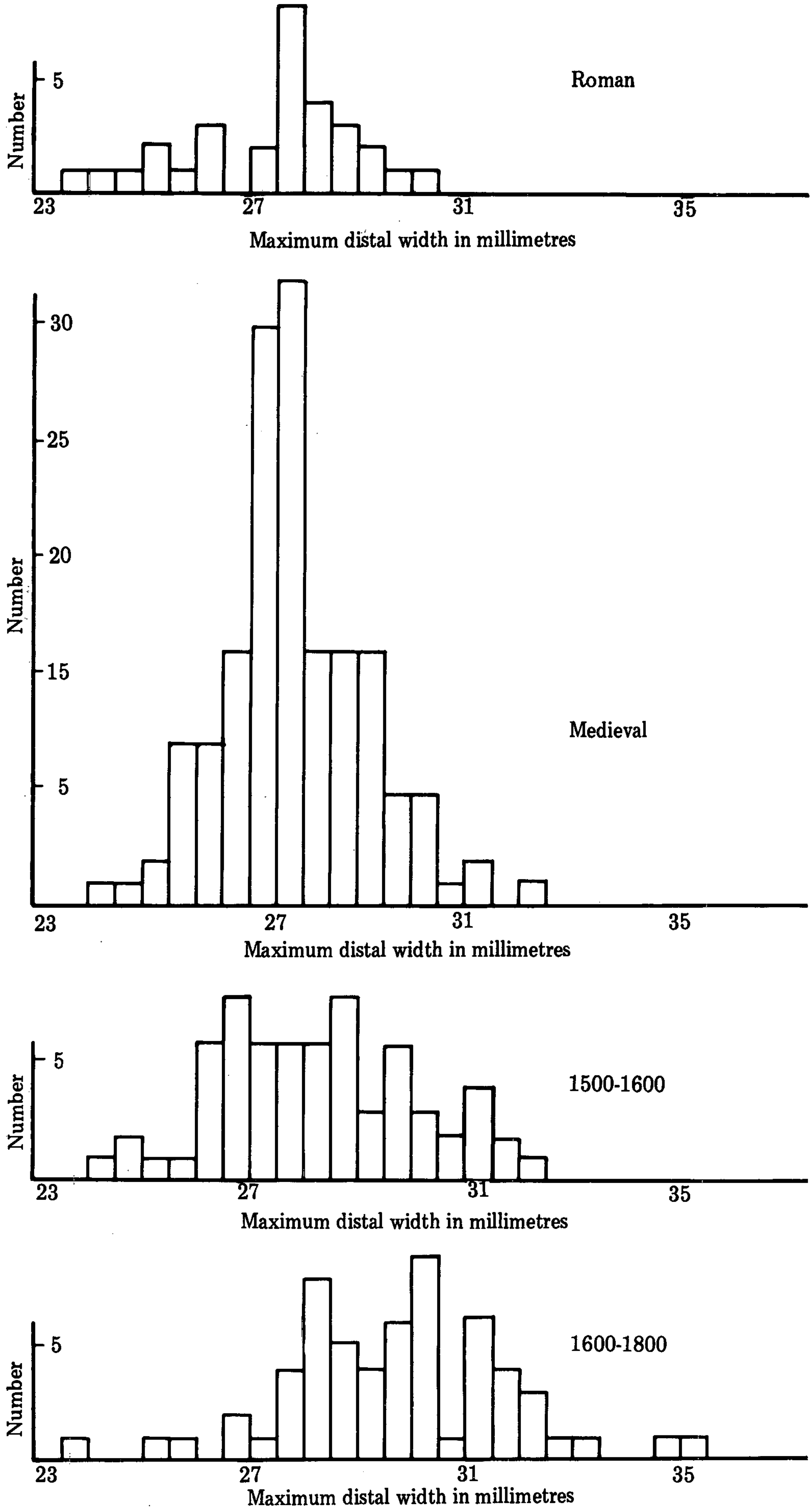

Figure 12 Histograms of sheep/goat humeri measurements.

dramatic change. Certainly most measurements showed some improvements in the overall size of the animals but, as the tibiae and radii measurements demonstrated, much of the stock was no larger than had been the case in the earlier periods. The appearance of larger animals in the sixteenth century once again can be explained either by the introduction of better stock or by the improvement in grazing and other husbandry methods. The seventeenth and eighteenth centuries saw a much larger improvement in the size of the stock. It would seem that for the first time some concerted attempts were being made to improve the quality of the animals and selective breeding was now being practised. Although a few animals were still no larger than Roman sheep, the size of some of the animals was beginning to approach modern standards.

For most of the period under consideration the sheep found in Exeter were smaller than stock represented in other parts of England. This impression is gained by the comparison of material from several other sites and further studies will no doubt enlarge the picture. To take the maximum distal width of the tibia as an example, the means of the specimens of the various Roman phases in Exeter (23.1 to 23.9 mm) were significantly less than that of 59 specimens from Alcester, Warwickshire (25.5 mm) (Maltby *in prep.*). The same measurements on sheep/goat tibiae from Shakenoak Farm, a villa site in Oxfordshire, were also found to be larger on average (Cram 1978:152). The medieval sheep represented in Exeter were smaller than those found on other contemporary sites. At Kings Lynn, Bristol Castle and North Elmham — the three largest medieval samples investigated by Noddle (1975:274) — well over half the tibiae had distal widths of over 25 mm compared to about 30% at Exeter. The sheep found in another Devon town — Plymouth — were also small; only about 20% of the 39 specimens measured in a sample dated to the fifteenth century had a distal width of over 25 mm (Dennell *pers. comm.*).

The conversion of the lengths of sheep radii, metacarpi and metatarsi into estimations of withers heights using Teichert's factors (von den Driesch and Boessneck 1974: 339) again demonstrate the small size of the stock. Pooling the data from all these bones, the sheep represented from Roman Exeter possessed a mean withers height of about 57 cm (from a sample of eighteen bones). Similar calculations on the medieval specimens produced mean figures that ranged mostly between 55 and 56 cm from relatively small samples of complete bones. The improvement in size of sheep in the postmedieval period was not reflected in the estimation of withers heights, which showed at most a small increase. Yet the other measurements of sheep consistently provided evidence of an increase in carcass size in the postmedieval period. It has already been observed that the sheep metapodia became significantly stouter in the later deposits but their overall lengths showed only small improvements in size. Increase in the size of the carcass is therefore not necessarily reflected by an increase in withers height and other methods have to be taken into consideration. By using these it can be shown that the sheep in Devon generally increased in carcass size during postmedieval times when concerted efforts were made to improve the stock.

ANALYSIS OF THE TYPES OF SHEEP REPRESENTED

Several discussions of the types of sheep found in medieval Britain have been published (Ryder 1964, 1976; Ryder and Stephenson 1968:21-23; Noddle 1974b; Armitage and Goodall 1977), although much more evidence is required from archaeological sources before the pattern can be seen clearly. This discussion will concentrate mainly upon the archaeological evidence for the types of sheep represented in Exeter using metrical and morphological data, although it is extremely difficult to distinguish between breeds or types of animals from this evidence alone.

Most of the Roman and medieval horn core specimens were small and, although there was quite a lot of variation, many were similar in several respects to those of the modern breeds of Soay sheep. Quite a high proportion of the more massive horn cores of rams was found, which probably reflects the importance of their horns for industrial purposes in the town. Horned ewes and wethers were also present in both periods, however. No polled skulls were found in the small Roman sample and the earliest occurrence of these was in the twelfth century deposits. They were found comparatively rarely in the medieval deposits, however. None of the cores possessed a longitudinal groove, which has been associated with black-faced varieties (Noddle 1975:253). This tentative evidence may support Ryder's hypothesis that the sheep of medieval Devon consisted mainly of a white-faced and horned type (Ryder 1964). Only one polycerate skull was discovered in a medieval context. Sheep with four horns were noted by Richard Carew in some parts of Cornwall in the sixteenth century (Halliday 1953:107).

Problems of the interpretation of medieval horn core evidence have been discussed by Armitage and Goodall (1977) employing both archaeological and iconographic evidence. The presence of both horned and polled skulls does not necessarily imply that more than one type of sheep was present. Both polled and horned ewes are found in modern Soay, for example (Doney *et al.* 1974:98). In short, there is no support from the present horn core evidence from Exeter to suggest that more than one type of sheep was present in the area. Unfortunately the material from the postmedieval deposits is very sparse due to the lack of skull fragments. Documentary evidence, however, at the end of the eighteenth century, after interest in specialised breeding had increased, points to a greater variety in the types of sheep and by then it is clear that there was a distinction between horned and polled (knott) types in Devon (Fraser 1794:33-37; Marshall 1796:vol.I 260-261). It will be interesting to see when a larger sample of postmedieval horn cores is available for study from sites in Devon whether there was a marked increase in polled sheep amongst archaeological material in this period.

Noddle has shown that the scapulae of modern short-tailed breeds such as the Soay have a comparatively longer neck than those of long-tailed breeds, whereas crossed breeds have scapulae of intermediate form. She has also applied this method to archaeological material (Noddle 1975: 256; 1976:281). Figure 14 plots the ratio of the distance between the glenoid cavity to the base of the spine against the minimum width of the neck of the scapula for specimens from Exeter. In all the samples the majority were found to lie in the intermediate range (0.90 to 1.10). The results from the analysis of the medieval scapulae were similar to those from Bristol Castle in the same period (Noddle 1975:256), possibly suggesting that the sheep from the two sites were of similar type.

Finally, the unimodal distribution of most of the measurements of sheep in the Roman and medieval samples may suggest that most of the population belonged to one type of animal. Differences in type or breed need not be reflected in metrical analysis, although it can act as a useful guide along with morphological criteria. Conversely size variation can be correlated with other factors such as sexual dimorphism and standards of nutrition. Nevertheless, it is clear that the postmedieval period witnessed a change from the earlier pattern and larger animals were present alongside stock of the previous unimproved size. Evidence was also found of the presence of sturdier animals. This suggests that either some of the existing stock was managed much more carefully or that there was the introduction of superior types of animal.

Armitage and Goodall (1977:82) list the morphological traits of a late medieval ewe based upon iconographic and archaeological evidence. The animal is depicted as polled with a white face, a long neck, narrow chest, small body and long and slender legs. The appearance of Roman and medieval sheep in Exeter may have been very similar. Certainly they had a small body and slender legs, as metrical analysis has shown, although it seems that the majority of the sheep brought to Exeter were horned at this time. From the sixteenth century onwards, an increasing number of sheep possessed larger bodies and stouter legs. Future research may show that the number of polled sheep increased significantly as well. Such features were characteristic of the improved breeds of sheep that appeared in the second half of the eighteenth century, such as the New Leicester (Armitage and Goodall 1977:81-82). The significant improvement in the size of sheep in the later postmedieval samples at Exeter correlates with the emerging interest in selective breeding. There is also evidence from well dated deposits that some of these improvements were already made in the sixteenth and seventeenth centuries. The observation of Fraser (1794: 53) in his description of sheep on Dartmoor that:

'Many of these are the small horned sheep, which neither in wool nor carcass are equal to the polled or knott.'

demonstrates the diversity in sheep types by that time. This heterogeneity may have been increasing for some considerable time.

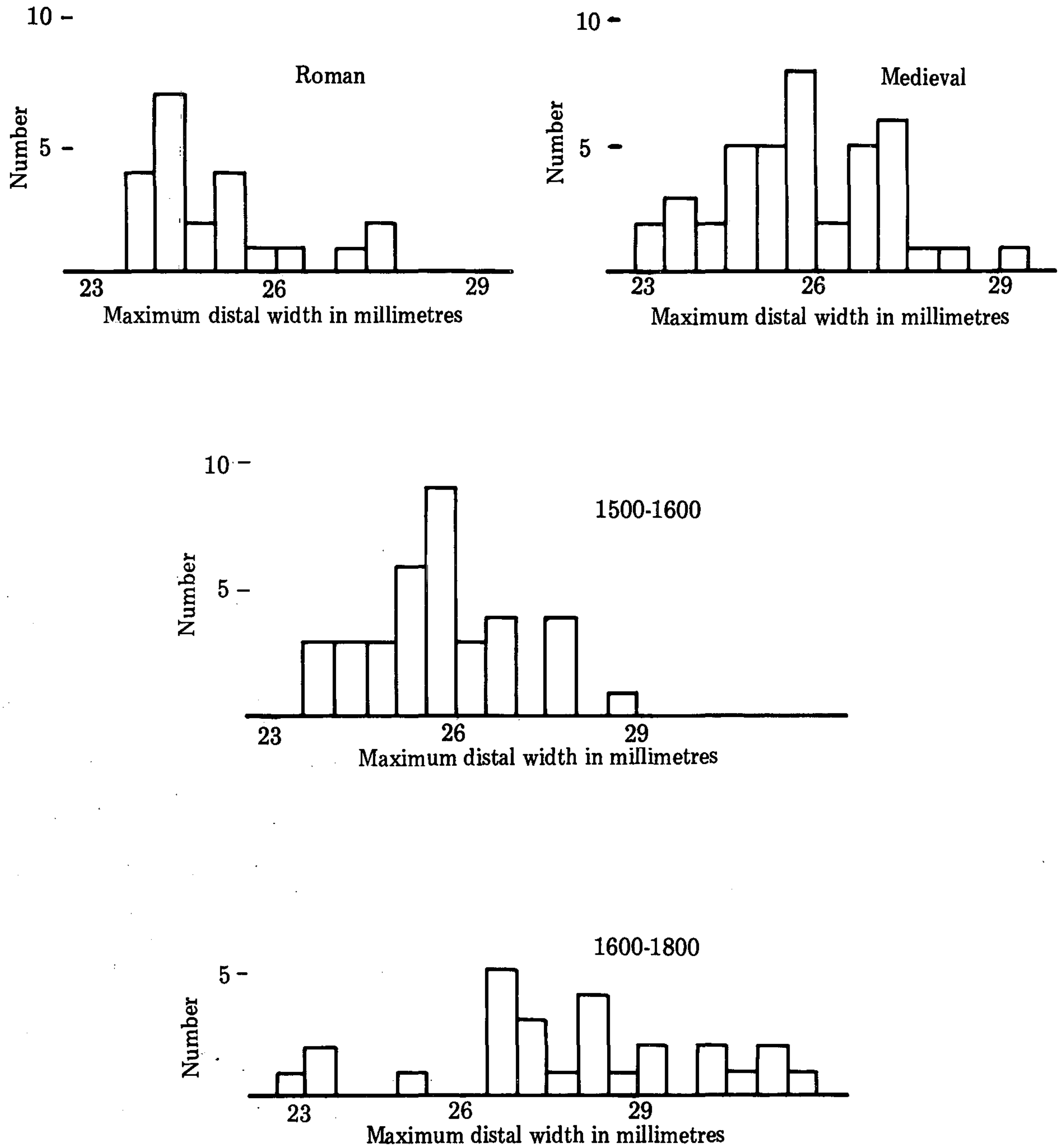

Figure 13 Histograms of sheep/goat radii measurements.

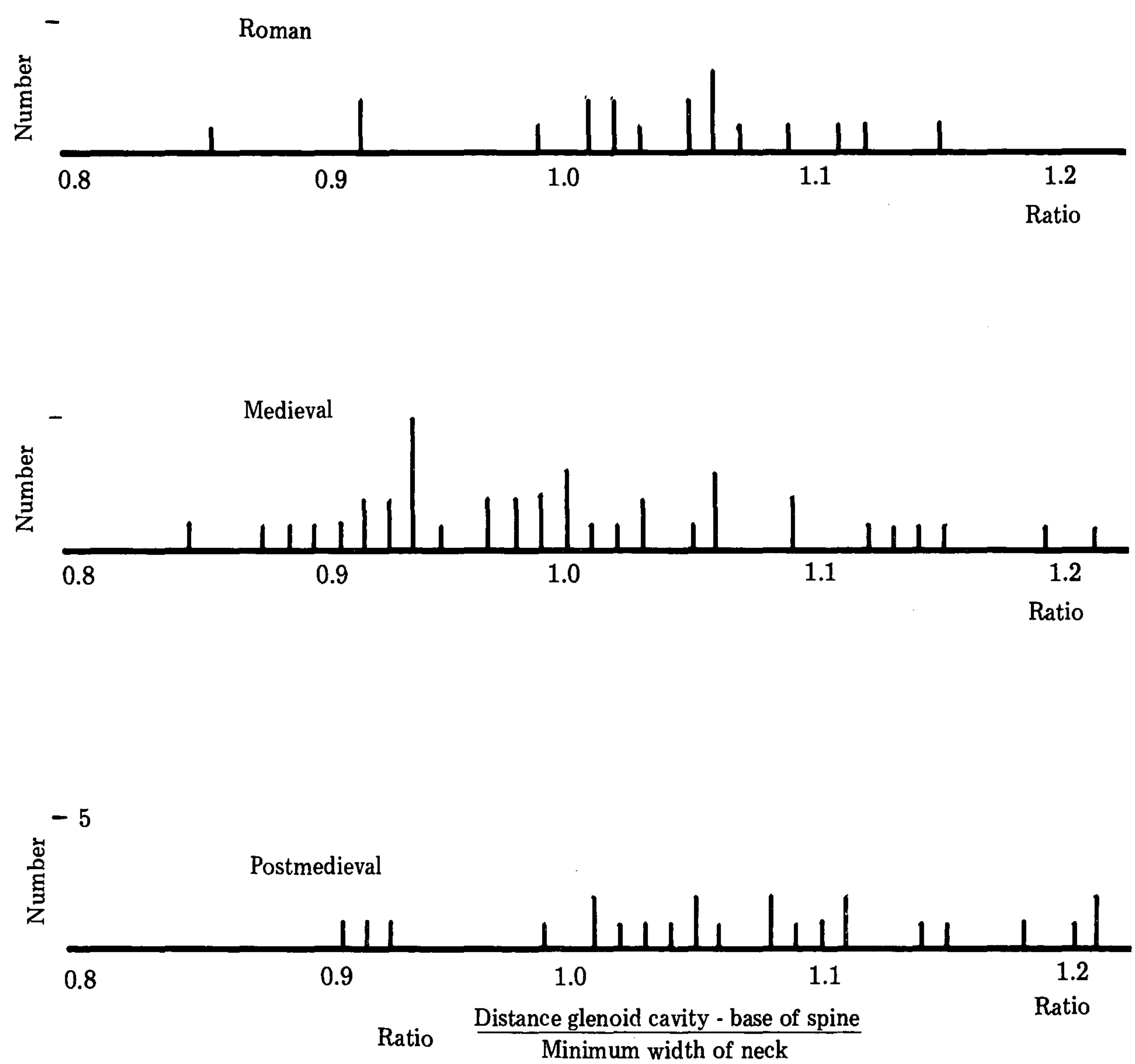

Figure 14 Metrical analysis of sheep/goat scapulae.

BUTCHERY PRACTICE

The skull and jaw

Skull and jaw fragments were found in the deposits commonly in the Roman and medieval periods. The brains of sheep/goat were probably a recognised food and therefore the skulls need not have been discarded at slaughter. Occasionally a deposit was found to contain a higher concentration of mandibles than average indicating the dumping of these waste bones, although this does not seem to have been done on a large scale in the deposits in question. In the postmedieval period the number of skulls and jaws found in the investigated deposits was much smaller, suggesting that many more of the skulls were discarded elsewhere and accordingly did not find themselves in domestic rubbish deposits. This practice does not seem to have applied to the younger animals for lamb skull and jaw fragments were still quite common. A fair proportion of the medieval and postmedieval skulls had been chopped in a cranial-caudal direction along the dorsal aspect of the skull to remove the brain.

The long bones

The vast majority of the major meat-bearing bones of sheep/goat were in a fragmentary condition. In the Roman period only 36 out of 1,105 (3.26%) fragments of humeri, radii, femora and tibiae were complete. In the medieval sample only 177 out of 2,670 (6.63%) of the bones were unbroken and finally in the postmedieval period 143 out of 1,307 (10.94%) long bones had both epiphyses intact. Of those bones the tibia was almost inevitably broken, as indeed were the humerus and femur, apart from a few isolated instances. The smaller radius tended to survive intact rather more frequently but was still predominantly fragmentary.

Many butchery marks were discovered on these bones. The most commonly found were those on the mid-shaft of the tibia. This was the case in all periods and nowadays, too, many leg joints of lamb are broken off at roughly the same point. Few proximal humeri have survived but the fairly common occurrence of severance near the distal articulation of these bones suggests that the scapula and most of the humerus were included in a single joint. The meat from the radius may have formed a separate joint, or more probably was used in stews. The distal shaft of the radius was another common butchery point where the feet of the animal were severed from the rest of the carcass. A greater concentration of complete femora and humeri was discovered in the postmedieval period, particularly in GS F.228 and TS F. 316. The lack of butchery on these bones, most of which belonged to mature animals is unusual. The phenomenon cannot be explained by the presence of several skeletons since very few of the skulls and metapodia were found associated with these bones.

Possibly the practice of boning out some of the limb joints was taking place at this time, or marrow extraction from these bones had become less important.

The metapodia

The smaller metapodia tended to show less fragmentation. In the Roman period 38 out of 292 specimens (13.01%) were complete. In the medieval period 157 out of 738 (21.27%) had both epiphyses present. The degree of fragmentation dropped noticeably in the postmedieval period in which 91 out of 260 specimens (35%) were unbroken. The metapodia have much less food value than the other long bones and may have been thrown away as waste, particularly in postmedieval times when, in certain cases, there was a scarcity of such bones in association with deposits that predominantly consisted of the major meat-bearing bones. In contrast, the seventeenth century deposits from the Valiant Soldier Inn site and several features on the GS I site, dated to the seventeenth and eighteenth centuries, had a marked concentration of such bones, indicating that they were treated differently from the other long bones.

The smaller metapodia would have required less butchery to be performed upon them and they may also have been boiled complete in many cases. The majority were in a fragmentary condition, however, and some butchery was undoubtedly practised upon them in all periods. These bones are ideal raw material for the manufacture of bone tools and ornaments. Indeed, the lack of fused distal metacarpi in the Roman period in particular may have resulted from the removal of the distal part of the bone for such manufacturing processes.

Vertebrae

As was the case with cattle, sheep/goat vertebrae were not sliced down their dorso-ventral axis before the postmedieval period, when the practice became widespread. Occasionally cutmarks were found on medieval specimens made when the vertebrae were cut laterally.

Conclusions

The butchery practised on sheep remained the same for a long period of time. It was only in the sixteenth century that a wholesale change in the methods of cutting up the carcass took place. No primary butchering area has as yet been found, although it seems clear that many fewer bones were discarded at slaughter compared with those of cattle. In the postmedieval period skull and jaw fragments were rarely found and to a lesser extent, metapodia fragments, suggesting that much more of the carcass was discarded at slaughter. The animals were cut into sides of mutton, a process which necessitated chopping the vertebrae dorso-ventrally, and their heads and feet were discarded. The butchery on the major limb bones seems to have changed little, however, although in some cases the leg bones may have been filleted out of these joints, perhaps by the butchers, or by individual cooks of rich households. This phenomenon was restricted mainly to the two richest deposits, which leads one to suspect that the practice may not have been widespread in the city.

SKELETAL ABNORMALITIES

The most common defect found in sheep/goat was that of periodontal disease. Many of the older jaws had teeth that were loose in their sockets and some also suffered from overcrowding. Both these deficiencies can be ascribed to poor planes of nutrition, a condition confirmed by the poor size of most of the stock. Six mandibles in the deposits had no P2 present in an otherwise fully developed tooth row. This condition was also found in cattle and is not uncommon among deer and other ruminants as well. Degenerative conditions were very rarely discovered in sheep/goat bones, probably because in the Roman and medieval periods at least, most of the animals consumed in the city had not attained any great age. One sheep horn core showed severe restrictions in its growth, a condition possibly caused by an injury early in life. No sheep/goat bones bore any signs of trauma.

SUMMARY: THE EXPLOITATION OF SHEEP/GOAT

The horn/core evidence, other morphological criteria and the metrical analysis of certain bones all indicate that sheep greatly outnumbered goat in the sample. The archaeological evidence thus confirms the impression gained from documentary sources, in particular Domesday Book.

The ageing evidence is beset with difficulties and the interpretation of the results obtained from this analysis depends to some extent on whether the estimated ages for tooth eruption and fusion are accurate. If they are, then during the Roman and medieval periods a sizeable proportion of the flocks was raised simply to supply the city with meat, a fact indicated by the high mortality rate of immature individuals. The age of peak slaughter lay between 15 to 30 months, with a tendency in the later medieval period for this peak to be rather later than before. This may reflect the fact that wool production was becoming increasingly more important in the late Middle Ages, the older animals providing rather more wool. However, to maintain such a level of immature slaughter would require a much larger breeding herd than that evidenced in the deposits. If the estimated ages for sheep are accurate much of the breeding stock was not brought to the city for slaughter.

It is conceivable that many of the sheep and goats brought to the Exeter market were animals considered surplus to the requirements of the stock such as barren ewes and young males not needed for breeding or wool production.

During the postmedieval period the boom in the cloth trade as attested by the documentary evidence had a profound effect on sheep husbandry. Many more animals were allowed to reach full maturity in order to obtain as much wool off the animals as possible. Apart from the slaughter of some lambs, the pressure to obtain sufficient wool for the growing clothmaking industry precluded the slaughter of both ewes and wethers until they had provided several fleeces of wool. Mutton therefore became a more common item in the diet, as a result of a change not so much in dietary preferences as in market requirements.

The size of the stock was small even by contemporary standards and it was only in the postmedieval period that concerted efforts were made to improve the stock (which previously had consisted mostly of one type of animal) by the introduction of new breeds and by improved grazing and stocking policies. All the animals were probably herded to the city on the hoof in both Roman and medieval periods, and possibly in the postmedieval period as well. The butchery methods did change, however, in the sixteenth century, when carcases were cut into sides of meat for the first time. Some of these carcases may have been dressed and brought into the city by butchers not resident in the city, although most, no doubt, still passed through the hands of the resident butchers.

5.

THE EXPLOITATION OF PIG

AGEING DATA

As in the case of cattle, the tooth eruption sequence was divided into six stages and the evidence of both mandibles and maxillae was pooled in order to obtain a percentage of animals slaughtered before they had reached a particular stage in their dental development. The six stages chosen were:

Stage 1 p4 in wear.
Stage 2 Both columns of M1 in wear.
Stage 3 Both columns of M2 in wear.
Stage 4 P4 in wear.
Stage 5 The first column of M3 in wear.
Stage 6 All columns of M3 in wear.

The estimated ages for these stages of tooth development, as shown in Tables 80 to 82, are adapted from data derived from modern pigs (Silver 1969:298-9). Once again these ages may underestimate the true age of the animal. Improvements in breed and nutrition during the last 200 years may have accelerated tooth growth by as much as 50%, judging from some eighteenth century figures.

362 jaws were examined: 161 of Roman origin, 163 of medieval date and 38 of postmedieval date. The Roman sample was subdivided into three phases (55 to 100 A. D., 100 to 300, 300+) for this purpose. The three late first century burials of immature animals were excluded from the calculations, as it was considered that these were not killed for food and therefore were not typical of the overall slaughter pattern. The medieval sample was subdivided into specimens dated to the eleventh to twelfth, thirteenth, and fourteenth to fifteenth centuries. Both the postmedieval samples, dating to the sixteenth and seventeenth to eighteenth centuries respectively, were small.

The results from all periods showed a good deal of similarity. In all eight samples for which percentages were estimated, a minimum of over 40% of the jaws had not reached Stage 6. The number of immature deaths was in reality probably much higher since about 30% of the jaws were too fragmentary for this age determination to be made. Examination of the wear pattern of 22 jaws of twelfth century date, using Grant's system of wear pattern analysis (Grant 1975), suggested that seventeen of these had not reached Stage 6, only three had done so and the other two may just have reached that stage of development. Therefore, it seems likely that the actual numbers of stock slaughtered before their tooth eruption sequence was complete would have approached the maximum percentage figures given for Stage 6 of the sequence in Tables 80 to 82. This would indicate that over 80% of the pigs eaten in Exeter in all periods were killed before Stage 6 of the tooth eruption sequence. The earlier stages in the sequence also reveal a high rate of immature mortalities. For example, the maximum percentage of animals killed before reaching Stage 4 ranged from 41 to 76% in the eight samples involved. The samples also showed some similarities for Stages 1 to 3 of the tooth eruption sequence.

The fusion data were divided into four groups of bones whose epiphyses fuse at approximately the same age. The sample was subdivided into the same groups as those employed for the tooth eruption evidence (Tables 83 to 85). In all periods, the latest group of epiphyses to fuse (proximal humerus, etc.), whose fusion ages in modern breeds range from 36 to 42 months (Silver 1969:285-6), revealed that over 85% of the epiphyses were unfused. In addition, the sample of epiphyses that fuse at about 24 months in modern breeds (the distal metacarpal and tibia and proximal first phalanx) contained large numbers of unfused specimens. Combining the data from each of these epiphyses, 58 to 64% of the Roman specimens were unfused and the equivalent percentages rose even higher in the subsequent periods ranging from 68 to 87% (Tables 83 to 85). These figures do not take into account the discrepancies between the various fusion points (for example, significantly more distal epiphyses of tibia were fused than distal metacarpals) but they do indicate the high rate of immature mortalities which took place throughout. The youngest group of epiphyses to fuse (the distal humerus, etc.) confirm this pattern. If these epiphyses fused within the first twelve months of the animal's life, as in more modern examples, the proportion of first year killings appears to have been higher in the Roman period (16 to 33% of the epiphyses were unfused) than in medieval times (9 to 18%). Nine of the 27 specimens (33.33%) of sixteenth century date were unfused. Once again differential preservation influenced the epiphyseal fusion data. Epiphyses with late fusion ages had less chance of survival than those with an earlier development. The figures, therefore, should not be taken literally, although the relative changes between periods can be monitored.

Both sets of ageing data therefore show that relatively few pigs reached maturity. Probably less than 10% of the pigs eaten were mature animals. This high rate of immature mortalities is to be expected, since, unlike cattle, sheep and goats, pigs have no economic importance other than their value for meat and skin. Accordingly, only a few breeding animals can be expected to reach maturity. The fecundity of the pig is great and the species can thus tolerate a very high rate of immature slaughter without endangering stock levels. The modern practice is to fatten up pigs for slaughter during their first year. Such an intensive exploitation was not matched in Roman and medieval

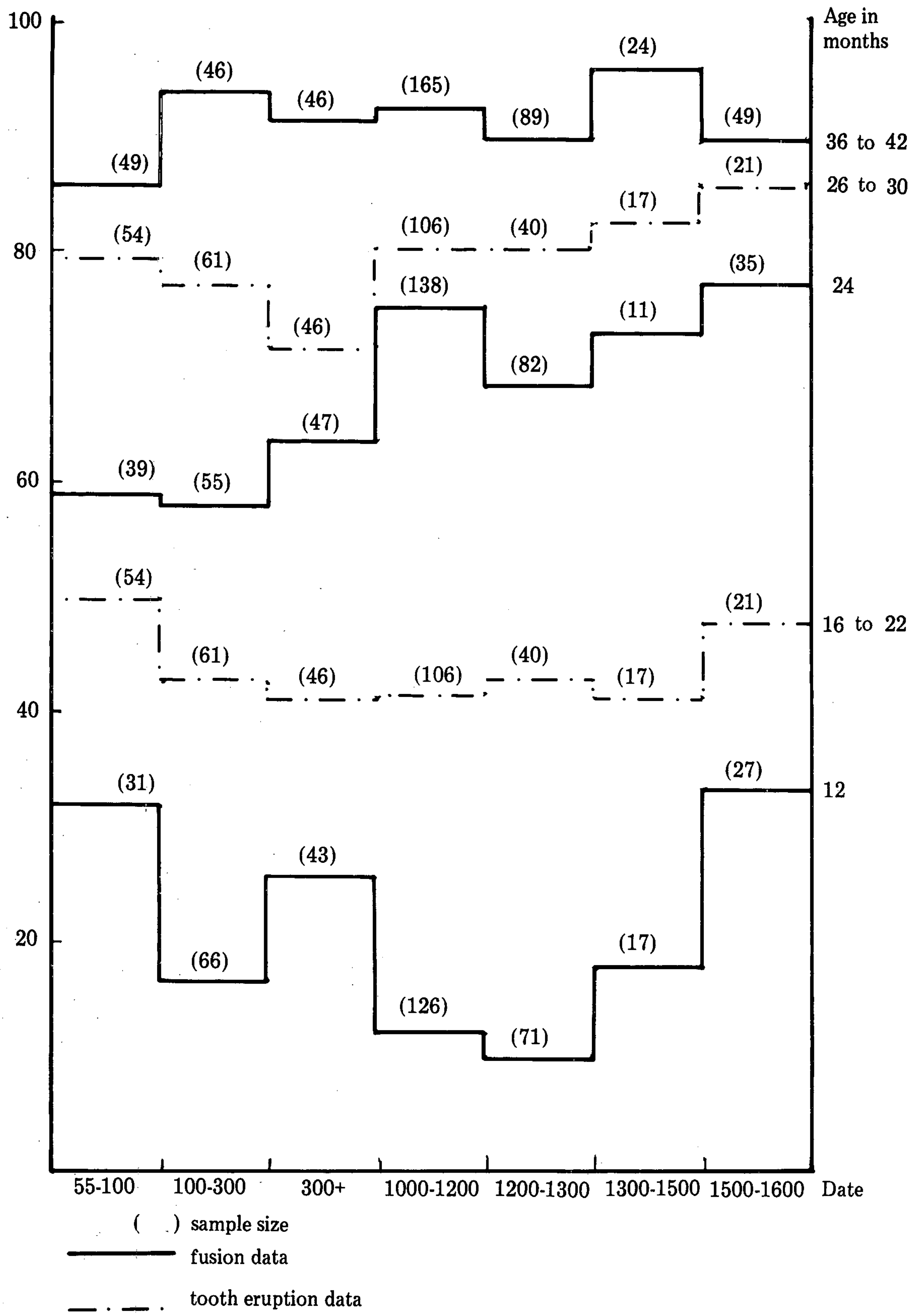

Figure 15 *Pig ageing data.*

Exeter, where a fair proportion of animals survived at least into their third year.

Despite the overall similarity between the mortality rates in the samples involved, there does seem to have been some variation in the peak killing periods of the pig. In the Roman period, to take the fusion evidence at its face value, there are indications that there was a fairly steady kill-off of pigs during the first three years. Taking the average percentage figures for the Roman period, about 25% of pigs were killed in their first year, about 35% in their second, and about 30% in their third. In the medieval period as a whole, however, the equivalent average percentage figures were about 13%, 59% and 20% respectively. There is therefore some evidence that the majority of the medieval stock was culled during their second year. This is confirmed by a closer analysis of the tooth eruption data. As can be seen from Figure 15, the permanent premolars (Stage 4) come into wear during the second year of the pig's life and Stage 5 is probably attained early in its third year (adapting Silver's estimates). In the medieval period, most of the animals seem to have been slaughtered between Stages 3 to 5 of the tooth eruption sequence. Of the 163 jaws examined, 28 (17.18%) were at a stage when the premolars were just coming into wear. Another 24 (14.72%) were killed between Stages 4 to 5. Using Grant's method of wear pattern analysis (Grant 1975), it was found that at least another fifteen mandibles (9.20%) belonged to animals killed between Stages 4 and 5. Consequently, at least 41.10% of the medieval pig jaws recovered belonged to animals slaughtered between the ages of about 16 and 26 months, mostly in the earlier part of that period.

There are only scant references to the breeding of pigs in the medieval period but it is interesting to note two examples Trow-Smith was able to cite. The first was gleaned from the accounts for the demesne farm at Stevenage, Hertfordshire, for 1273 to 1274. These revealed that pigs began to be fattened for the table at about eighteen months of age. At Wellingborough, Northamptonshire, it seems that pigs were slaughtered at almost any age in the fourteenth century but were not considered to make adult porkers or baconers until they were rising two years of age (Trow-Smith 1957:124-128). If a similar practice was carried out at Exeter, one would expect to see the peak of slaughter for animals aged between 18 to 24 months of age. The two sets of ageing data would seem to correlate broadly with this (Figure 15).

In the Roman period the majority of the stock was also killed between Stages 3 to 5 of the tooth eruption sequence, although the peak of slaughter was not so marked between Stages 4 and 5. There is some evidence that there was a greater number of animals killed in their first year, in particular demonstrated by the fusion evidence. This preference for younger animals may reflect the Roman liking for sucking-pig — a popular dish in Italy according to Roman authors (White 1970:318-320). It may be more than coincidence that the highest rate of immature deaths in the Roman period was in the first century, when the Roman influence in the garrisoned city was at its greatest. The level of young killings did not rise as high again until the sixteenth century (although this was a small sample and may not be reliable). It is interesting to note that the documentary evidence for the slaughter of pigs in the postmedieval period shows in certain areas of England that the age of slaughter generally decreased from that of the medieval period. In Leicestershire, for example, pigs were fattened in sties from the age of nine to twelve months (Thirsk 1967b :194). Similar advances in pig husbandry in Devon at the same time would explain the increase in the number of animals killed in their first eighteen months, shown by the (admittedly limited) ageing data. It should be noted, however, that William Marshall observed that some pigs were not fattened for slaughter until they were two or three years of age in some parts of Devon at the end of the eighteenth century. He also noted that the 'native breed of the county' did not fatten up well until they were 18 to 24 months of age (Marshall 1796:256).

METRICAL ANALYSIS OF PIG

Humerus

The maximum width of the fused distal epiphyses of the humerus was plotted against its maximum thickness for specimens dated to the Roman and medieval periods (Figure 16). There was a greater concentration of medieval specimens in the smaller size range, perhaps indicating a decrease in stock size in the later period.

Radius

The proximal epiphysis of the radius fuses at approximately the same age as the distal humerus. Histograms of the maximum width of this epiphysis show a decrease in the average size of the bone between the Roman and medieval samples (Figure 17). In the Roman sample of 25 specimens the measurements were spread fairly evenly between 25.5 to 29.5 mm. In the medieval sample 27 out of the 51 specimens measured 24.5 to 26.5 mm.

The mandibular third molar

Enough measurements were obtained from the Roman sample to make comparisons of the length of the M3 with those of other sites. The length varied between 27.0 to 34.9 mm. When these measurements were compared with those obtained from the Roman sample from Fishbourne (Grant 1971:386), it was found that the pigs on the two sites displayed a similar range in size, with over 44% of the specimens in both cases lying in the 30.0 to 32.9 mm size range (Table 86). Using the same criteria, the pigs from the Saxon site of North Elmham were rather larger on average (Noddle 1975:256) than the stock on the Roman sites. Unfortunately, too few measurements were possible from the Exeter medieval and postmedieval samples for analysis to be worthwhile.

The overall size of the stock

Table 87 shows the range, mean, standard deviation and coefficient of variation of all pig measurements taken. Direct comparison between the results from the Roman and medieval periods would suggest superficially that the Roman stock was slightly larger. For example, the mean of the maximum distal width of the humerus in the Roman period was 37.4 mm, but only 35.7 mm in the sample of eleventh to twelfth century date. The mean of the maximum proximal width of the radius decreased from 27.1 to 25.9 mm, and the measurements of the distal scapula decreased to a similar degree. Unfortunately, because of the high mortality rate of immature animals, too few epiphyses with later fusion ages provided measurements for comparative purposes. It is interesting to note, however, that the measurements taken on the distal tibia, which fuses at about two years, did not show any significant change in size between the limited Roman and medieval samples. Too few bones of postmedieval date provided measurements to make realistic comparisons with the previous periods. One or two certainly belonged to larger animals, for example an astragalus of sixteenth century date measured 49.1 mm along its lateral length and a

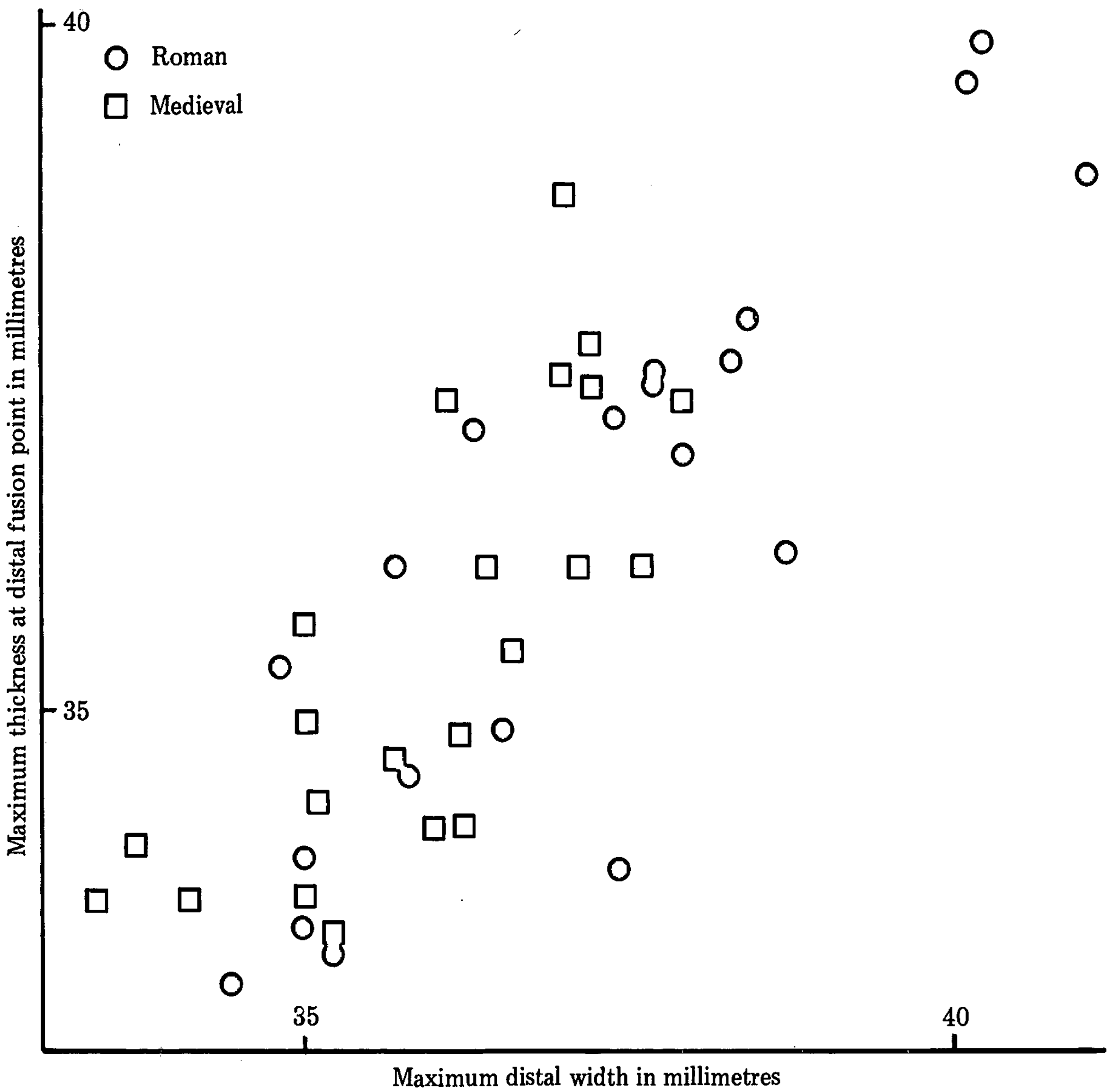

Figure 16 Scatter diagram of pig humeri measurements.

humerus of eighteenth century date possessed a maximum distal width of 47.1 mm. These were exceptional cases but it is certain that the postmedieval period saw great improvements in the size of the stock.

The results showed little evidence for the presence of wild boar, which is thought to have been a larger animal than domesticated pig. One Roman astragalus had a maximum length of 50.7 mm, which was over 10 mm larger than the second largest Roman example. The isolation of this specimen may indicate that it belonged to an animal of a different population, in which case the presence of wild boar could be postulated. Its rare occurrence would fit the pattern observed with regard to other game, which was also extremely rare in Exeter. On the other hand, of course, it is possible that the astragalus in question belonged to an exceptionally large domesticated pig.

BUTCHERY PRACTICE

The five burials uncovered all belonged to very young animals and showed no signs of butchering, being mostly too small to be of much food value. These were probably burials of diseased or casualty animals. Their presence may therefore indicate that some pigs were kept in the city itself. The pig is an ideal animal for even small households to keep, being inexpensive to feed and maintain. In Worcester pigs were kept within the city even in the sixteenth century (Dyer 1973:207) and the same may have been the case in Exeter.

Apart from these burials, the pig samples revealed abundant evidence of butchery. Only 23 (5.23%) of the remaining 440 fragments of humeri, radii, femora and tibiae dated to the Roman period survived with both epiphyses intact. The pattern was similar in the later periods; 60 (8.02%) out of 748 medieval long bones were complete, and only 26 out of 250 (10.40%) specimens of postmedieval date were found to be unbroken. Such a high degree of fragmentation cannot be explained simply by damage during or after disposal and many of the breaks must have occurred during butchery. Much of the butchery on the long bones was similar to that of sheep/goat, which is to be expected, since the animals are of similar size and would require similar treatment of the carcass. Cut marks occurred on all types of long bone, the most common being knife cuts on the shaft of the humerus, a little above the distal epiphysis. Butchery marks associated with the disarticulation of the hind limb were also found quite frequently on the pelvis

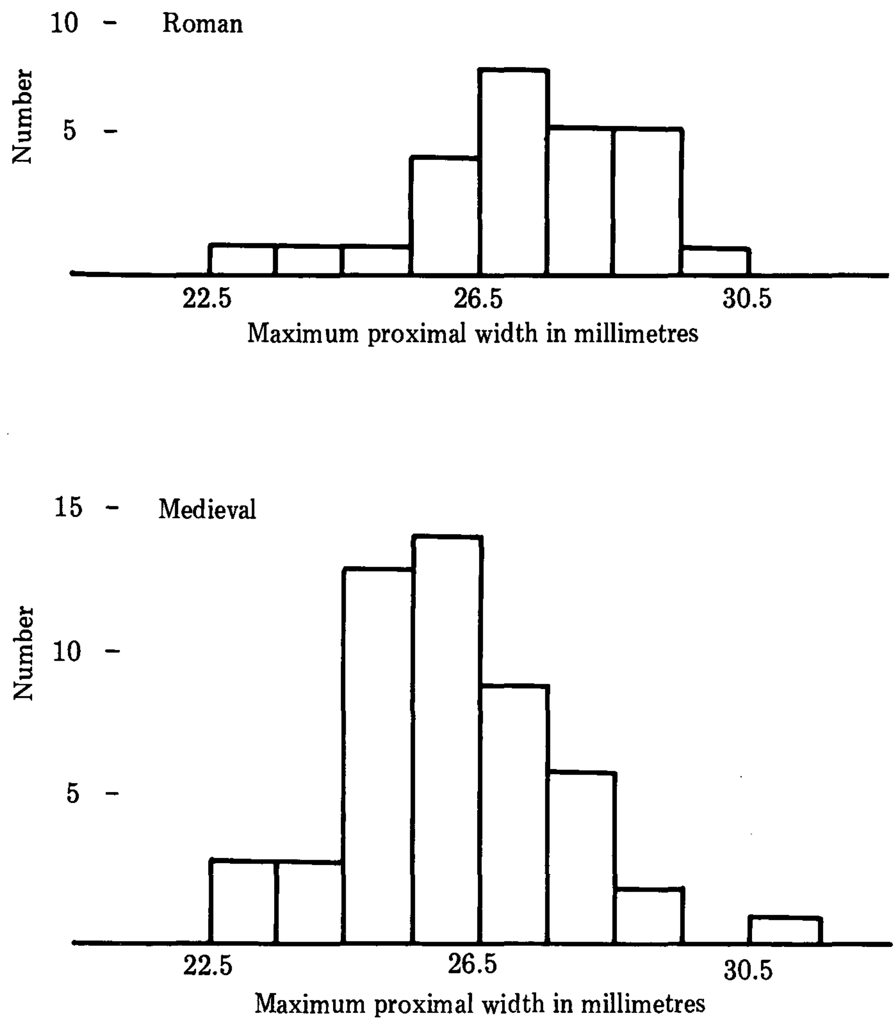

Figure 17 Histograms of pig radii measurements.

and proximal femur. Butchery on the smaller bones of young animals was less common and many more tended to be unfragmented because their smaller carcases required less butchery and marrow was not extracted from their bones.

In the Roman period, the MM/CC site produced a higher proportion of metapodials and phalanges (the bones from the trotters) than elsewhere. This was especially true in the third century deposits in which the numbers of these bones significantly biased the sample. Several features in particular had a marked concentration of the bones from pigs' trotters. None of the bones recovered bore evidence of butchery, although as pigs' feet are generally boiled after being cut off at the metapodials, there is no reason why these bones should bear cut marks. It cannot be said with certainty therefore whether these remains represent the refuse of a meal or the discarded trotters which were not considered as a source of food. The concentration of such bones in association with each other would suggest that the latter is the more likely alternative. Occasionally a similar concentration of such bones was found in later deposits, perhaps indicating a continuation in this butchery practice. The majority of the metapodials survived complete, being much smaller and less subject to butchery than cattle or sheep/goat metapodia.

As in the case of the other principal stock, the vertebrae of pig were rarely cut down the dorso-ventral axis to form chops until the sixteenth century, when it seems that the carcass was more often cut into sides of meat.

SKELETAL ABNORMALITIES

Apart from the young burials which may have belonged to diseased animals, although the cause of death was not manifest from the osteological evidence, most of the fragments showed no pathological conditions. Once again dental disease was the most common abnormality found, with some jaws displaying overcrowding and occasionally the crooked setting ot the cheek teeth. No signs of trauma were discovered on any of the bones.

SUMMARY: THE EXPLOITATION OF PIG

All, or virtually all, the pigs represented belonged to the domesticated variety. These were bred for their meat and lard, the only commodities for which they are economically important. This fact is reflected in the ageing data, which show a high number of immature deaths, a culling policy consistent with such a meat economy. The ageing evidence suggests that, apart from fluctuations in the number of first year deaths, the exploitation of pig gradually became more intensive during the periods of occupation at Exeter. The size of the stock showed no improvement until the post-medieval period. Like cattle and sheep/goat, many pigs would have been brought from outside the city for slaughter, although some pigs may have been kept by individual householders within the city itself.

6.

THE EXPLOITATION OF OTHER ANIMALS

A minimum of sixteen species provided the remainder of the mammalian sample. As was seen in Chapter 2, none of the animals discussed in this chapter was found in great numbers in the deposits. Only in a few isolated instances did they contribute more than 10% of the identifiable mammalian fragments in the phases involved. See page 65 for list of species discussed.

DEER

Red, fallow and roe deer contributed a total of 183 fragments in all the deposits. 78 of these, belonging to red and roe deer only, were discovered in the Roman levels (0.86% of the identifiable mammalian fragments). Red deer (43 fragments) was the slightly more common of the two, over half its fragments coming from the first century deposits. In the medieval period, deer became rarer still: just 42 fragments (0.25%) of the identifiable mammalian fragments belonged to the three cervid species present. Red deer (25 fragments) was still the most common; roe deer (nine fragments) continued to be recovered only in small numbers; fallow deer (eight fragments) was represented in the deposits for the first time in an early twelfth century context. No certain evidence of the latter species has been found among Roman or Saxon faunal remains and it may have been introduced by the Normans. No fallow deer fragments were found in the Roman levels at Exeter. Deer bones were also rarely found in the postmedieval deposits: only 62 deer fragments (0.85%) were discovered. 47 of these fragments were dated to Phase Pm1 (1500 to 1600), in which they contributed 1.22% of the identifiable mammalian fragments. The greater wealth indicated by the artifacts found in many features dated to this phase may also be reflected by the evidence of a more varied diet and a slight increase in the amount of venison eaten. Venison would presumably have been more expensive to buy than veal, mutton or pork which were available in much larger quantities at the time. Red deer (38 fragments) continued to be the species most frequently found in the postmedieval deposits. Fallow (fourteen fragments) and roe deer (ten fragments) completed the assemblage.

Other than the fact that few immature specimens were found, little can be said in detail of the intensity of exploitation of deer from the scanty ageing evidence. No red deer fragments from the Roman deposits belonged to young animals; a complete skull dated to the first century possessed fully erupted tooth rows and belonged to an adult animal. A fragment of a maxilla dated to the twelfth century did still have part of its deciduous tooth row present but this was the only example of an immature beast found in the medieval levels. A complete mandible of late eleventh century date belonged to a mature animal, and none of the handful of bones which bore fusion evidence possessed unfused epiphyses.

Two immature roe deer were discovered in the Roman deposits; one mandible of military date did not have its third molar in wear and a distal epiphysis of a radius from a second century context was unfused. On the other hand, both the other mandibles discovered in this period had their tooth rows fully erupted. In addition, the two proximal humeri and the distal epiphysis of another radius were all fused, indicating that they belonged to adult animals. In the medieval sample, one metacarpus with an unfused distal epiphysis was the only example of a bone that definitely belonged to an immature animal. The only other fusion evidence consisted of two fused proximal epiphyses, of a radius and a tibia respectively. One maxilla fragment had its premolars in a state of wear that suggested that the jaw had belonged to a very old animal.

There was no evidence of immature animals among the few fragments of fallow deer discovered in the deposits.

No cut marks were discovered on any of the deer long bones but their fragmentary condition suggests that butchery did take place to obtain meat and marrow. In the Roman period, there were two instances of cut marks on red deer antlers. The first example, of late first century date, had several of its tines sawn off; the second, of fourth century date, revealed a chop mark close to the burr of the antler. Similar marks have been discovered on antlers recovered from other Romano-British sites, including the villa at Hemel Hempstead (Harcourt 1974b:260) and the fort at Longthorpe (Marples 1974:124). It is possible that the species was appreciated as much for the tool and ornament producing qualities of its antlers as for its meat — a fact supported by the high proportion of antler fragments found among the red deer assemblage at Exeter. There is a little documentary evidence for the exploitation of deer in the Exeter area. To the north of Exeter, the manor of Duryard belonged to the city from at least 1086, when it was mentioned in Domesday Book. The name means 'Deer-Park' and before deforestation the area would have provided an ideal habitat for such animals (Hoskins 1969:14). Despite this, it seems that venison played little part in the diet. This pattern is consistent with other medieval sites investigated. At Bristol, Hereford, Kings Lynn, Southampton (Noddle 1975:251), Kirkstall Abbey, Pontefract Abbey, Petergate (York) and Wharram Percy (Ryder 1961:106) the percentage of deer bone fragments was small in every case. In fact, of the Saxon and medieval sites investigated by Noddle, only Loughor Castle in southwest Wales produced a large percentage of deer bones (19%), presumably a result of the hunting practised by the inhabitants of the castle (Noddle 1975:252-3). A similar situation has been discovered at Okehampton Castle, some 30 km to the west of Exeter. Here, in deposits dated mostly to the late medieval period, fallow and red deer bones were found in abundance (Maltby *in prep.*). In the Middle Ages hunting was a pastime enjoyed principally by the wealthier classes. The discovery of deer in association with their residences is of no surprise, especially as many were located near deer parks. On the other hand, an urban site such as Exeter can be expected to produce information about the diet of a much broader section of the community. Indeed the faunal evidence suggests that venison was of little importance for the majority of Exeter's inhabitants.

LAGOMORPHS

Hare was the only one of these species exploited in the Roman period; 68 fragments were recovered from a minimum number of eighteen individuals, although fifteen of the fragments came from one third century skeleton.

Rabbit did not appear in the deposits until the early twelfth century and only fifteen fragments of this species were discovered in the medieval deposits investigated. The earliest discovery of rabbit confirms the documentary evidence obtained concerning its introduction into this country (Veale 1957). The earliest reference is dated to 1176 when rabbits were recorded to be present in the Scilly Isles and they seem to have been found in some numbers farther north on Lundy Island at roughly the same date. It seems possible that the rabbit became established in the southwest peninsula at an early date. In 1221 there is a reference to 6,000 rabbit skins in a Devon plea, although these skins could have been imported from Spain (Veale 1957:85-87). From the thirteenth century onwards, there are a number of references to the establishment of warrens in southern Britain, but it seems that rabbits were considered something of a luxury, since they were expensive to purchase (Veale 1957:88-89). Several warrens may have been established in Devon during the Middle Ages but even so, it seems that rabbit was rarely eaten by the majority of the populace. In the medieval period, the hare was still the more regular source of food. Fragments of this species outnumbered those of rabbit in almost every medieval phase. A total of 92 fragments (0.57%) was recorded.

In the postmedieval period, the rabbit seems to have replaced the hare as the more popular food resource: 315 rabbit fragments (4.34%) were recovered compared to just 72 (0.99%) of hare. The percentages of both species in this period were inflated by their unusually high numbers in GS III F. 214, a feature dated to the late eighteenth century. In this feature alone, 66 fragments of rabbit (17.19%) and 40 of hare (10.42%) were recovered. There was also a larger concentration of rabbit in the sixteenth century phase. On the GS III site in this phase, 144 fragments were found, 6.11% of the identifiable mammalian fragments on that site (Table 43). It seems that by the sixteenth century rabbits had become much easier to obtain than hare, no doubt due to the construction of more and more warrens in the countryside.

Once again, the ageing evidence was limited by the small sample sizes involved. Only the medieval hare and post-medieval rabbit samples produced sufficient material for analysis to be worthwhile (Table 88). The fusion data for the hare suggested that very few leverets were eaten, a fact demonstrated by the low numbers of distal humeri and proximal radii that were unfused. However, several animals were killed immature, although the majority were fully grown before they were captured. Very young animals would have had too little food value to have been caught in any numbers.

Rabbits were quite heavily exploited in the postmedieval period. Table 88 shows that possibly as many as 40% of the animals in the deposits did not have all their bones completely fused prior to their deaths, although few were killed as very young animals. The high rate of adolescent slaughter may be indicative of the demand for the rabbit as a food resource. Certainly its encouragment to live and breed in man-made warrens would enable a more efficient exploitation of the species to take place. The fecundity of the rabbit allows intensive exploitation to take place without endangering the population levels.

There was no indication of butchery on the partially preserved skeleton of the hare dated to the third century. Julius Caesar remarked that the Britons considered that it was impious to eat hare (Matheson 1941:378). This taboo does not seem to have applied at Roman Exeter, however, since a late first century layer produced a fragment of pelvis which had three knife marks on the ilium made when the femur was detached presumably during butchery for meat.

The concentration of both hare and rabbit fragments in the F. 214 deposit dated to the late eighteenth century was interesting in that it gave an insight into the butchery practice performed on these animals at that time. Almost all the assemblage consisted of metapodials, phalanges and occasionally the distal portions of the radius and tibia. This was clear evidence for the cutting off of the feet of both species. These were of no value for meat or skins and were simply discarded. A minimum number of fourteen rabbits and seven hares was recovered from this pit. Nowadays rabbits are butchered in a similar fashion. A study of the fragmentation of the major meat-bearing bones (humerus, radius, femur, tibia) in the postmedieval sample revealed that only four of the 45 hare bones were complete, a fair indication of the butchery practised upon that species. The smaller rabbit needs less butchery and in the same period 76 of these bones were complete and only 43 were broken. Of these, 51 out of 60 humeri and femora were unbroken, but only 25 out of 59 radii and tibiae had both epiphyses present. The practice of cutting off the feet of the animal has resulted in this dichotomy. The upper limb bones required little or no butchery and consequently the humerus and femur have often survived intact. The radius and more especially the tibia, on the other hand, were quite often broken when the feet were removed from the rest of the body.

Rabbit and hare never played an important part in the diet of the ordinary people of Exeter. In terms of overall meat weight, the minimum number of individuals represented would have provided a minimal proportion of the total meat and poultry consumed. Despite the introduction of warrens in the Middle Ages, rabbits did not supersede hare in relative importance until the sixteenth century. Before, and possibly even at, that time, rabbit was probably regarded as a luxury item and only the wealthier classes would have been able to afford them with any regularity. Both animals would also have been valued for their fur and skins.

HORSE

Horse was only rarely represented in any of the periods. 126 fragments were recovered from the Roman levels (1.39% of the identifiable mammalian species). Over 40 of these fragments, almost entirely from the skull, were found in the late first century levels of the large ditch, RS F. 363. The horse continued to be represented only occasionally in the medieval deposits; 109 fragments (0.66%) were recorded and in no phase did they constitute over 1% of the total number of mammalian fragments. Documentary evidence suggests that horses were only used as pack animals and as a means of transport and not as plough animals in Devon during the Middle Ages. There is no suggestion in the Domesday records that horses were members of the plough teams and the number of horses recorded on the demesne lands at that time was small. For the whole of Devonshire, only 477 horses of various descriptions were mentioned (Telldon Finn 1967:286). In the Hundreds immediately around Exeter, only 48 rounceys (riding horses), five forest mares and one mare were documented. The scarcity of horse bones in the deposits may therefore reflect the fact that there were few horses in the county at the time. The same is probably true of the postmedieval period, in which only 15 fragments of horse (0.21%) were recovered. Although Colpresse, writing in the seventeenth century, did mention that some hillside tracts of arable farmland in Devon were ploughed by a mixed team of four oxen and two horses, most documentary evidence indicates that horses were only rarely employed in the plough team in that period (Trow-Smith 1957:176), in which case the number of horses would have been comparatively low in comparison with those of the other domesticated animals.

The ageing data support the view that the horse was kept as a working animal. Only three fragments certainly belonged to immature animals, all of medieval date; a mandible of early twelfth century date had its third permanent molar just coming into wear, and a femur and calcaneum, both of twelfth century date, had unfused proximal epiphyses. On the other hand, in the medieval period, there were nine examples of epiphyses with late fusion ages (e.g. the distal radius) which had already fused — evidence that the animals to which they belonged had reached maturity. Most horses probably attained old age. A third metatarsal of early fourteenth century date was so badly affected by arthritis that several of the tarsal bones had become fused to the proximal epiphysis. This condition is usually associated with old animals.

Most of the horse bones were in a fragmentary condition, although in all periods they were usually relatively more complete than those of cattle, and not broken into small pieces as was often the case with bovine long bones. In the medieval period, for example, only two out of 28 long bones had both epiphyses present, but these were generally much less fragmentary than their counterparts for cattle, even though the animals were of similar size. No butchery marks were positively identified on any of these horse fragments. On the other hand, no burial of a horse was discovered, and the isolation of the fragments would suggest that horses were dismembered for some purpose. There is no reason why the carcases of horse were not butchered for human consumption, although the extraction of marrow would also explain the fragmentation of the long bones. Documentary evidence sheds little light on this point, although it is known that the hides of dead horses were bleached and used in the mending of harness in some areas (Trow-Smith 1957:124) — an indication that the horse's carcass was not always simply buried or discarded. However, as Walter of Henley wrote in the late thirteenth century:

> 'And when the horse is olde (and worn out) then hathe he nothing but his skynne. But when the oxe is olde with xd. of grass he wilbe made fatte to kylle or to sell for as muche as he coste youe.' (Oschinsky 1971:319).

The presence of fragmented long bones may be indicative of the fact that the horse was used as an occasional food resource but there was obviously little incentive to make the species a regular part of the diet.

A third metatarsal of first century date was found to have been neatly sawn into three portions. Butchery for meat or the extraction of marrow do not require such a painstaking procedure. Cannon bones are known to have been fashioned into tools and ornaments and this example provides evidence of such a process on horse bones.

Too few measurements were obtained for a clear understanding of the size of the animals involved. The few Roman measurements suggest that the animals were of a similar or of a little smaller size than the horses found at Hemel Hempstead, which were described as animals of 13 to 14 hands (Harcourt 1974b:260). Some of the medieval horses were no larger than the ponies found in the Roman period, but others must have belonged to rather sturdier and larger animals. Trow-Smith suggests that the horses of Devon were bred for nimbleness to negotiate hillsides and for pack transport, rather than for the weight and strength required in pulling the plough (Trow-Smith 1957:176).

Throughout the Roman, medieval and postmedieval periods in Exeter, the principal employment for the horse, judging from the documentary evidence, was as a pack animal. Only towards the end of the postmedieval period did some horses plough the fields. The ageing data from the Exeter deposits confirm that most horses were allowed to reach old age and to live a full working life. The rare occurrence of horse in the Exeter deposits could be the result of two factors; the scarcity of the species in the area (as evidenced in particular by the Domesday records) and the fact that the horse was not considered as food. Certainly at Exeter it was rarely found in deposits derived principally from food waste. Although the remains of horse from Exeter are mostly fragmentary, there was no positive evidence from the faunal remains to suggest that horsemeat was consumed. The fragmentation of the major meat-bearing bones was not as great in cattle and could simply have been caused by the extraction of marrow. Even if horses were eaten, they must have provided only a rare supplement to the diet.

DOG

Dog fragments were only occasionally found in the Roman and medieval deposits. 22 of the 91 Roman fragments (1.01% of the identifiable mammalian fragments) recovered came from a partially complete skeleton. It is likely that many of the remaining fragments also belonged to animals whose bodies were thrown on to the rubbish heaps after they had died. The dog continued to be rarely represented in the medieval period. Only 69 fragments (0.42%) were recovered, three partially preserved burials accounted for 27 of these. Once again the remainder of the fragments probably also belonged to animals buried in, or simply cast upon, the rubbish heaps.

In the postmedieval period, the number of dog fragments increased greatly; 439 fragments (6.05%) were discovered in these deposits. However, a series of factors combined to overemphasise the dog's importance. 56 of the fragments came from the burial of an adult animal in GS I F. 10 (late eighteenth century). 22 fragments belonged to another burial in GS I F.107 (seventeenth century). These burials have inflated the percentage of dog fragments to a misleadingly high level, but the major reason for the increase in the number of dog bones was the concentration of dog burials in TS. F. 316, which in its late seventeenth century layers produced 265 fragments of dog from at least 24 individuals. A smaller concentration of dog fragments was found in GS F. 228, which contained 42 fragments from at least three individuals. That most of the dogs were deposited as complete skeletons is certain, since in many cases bones from the opposite sides of the body matched exactly. However, the contents of the deposits were too mixed to reconstruct the individual skeletons. The increase in the number of dogs in the postmedieval deposits may therefore not be typical of the city as a whole.

Not enough evidence was accumulated from the Roman and medieval deposits to study the mortality rates of dogs in any detail. A number of immature dogs was represented in the medieval period but there was nothing to indicate that the animals were not normally allowed to enjoy their full life span. More evidence was obtained from the postmedieval period (Table 89). Although it is evident that a number of puppies were present, most dogs reached maturity before they died judging by the fusion data. Depending on which epiphysis one considers, between 20% and 43% of the animals failed to reach an age of eighteen months, at which age the latest group of epiphyses fuse (Silver 1969:285-6).

No butchery marks were discovered on any dog bone in any period. A much higher proportion of long bones survived complete than those of the stock animals, which indicates that the dog served in some different role from these. In TS F. 316, 52 out of 53 humeri, radii, femora and tibiae were found intact. In the postmedieval period as a whole, 74 out of 92 of these bones were in an unbroken state of preservation. Such a high survival of complete bones shows that the carcases were not butchered for meat. The breakages that did occur could have been caused after disposal in the rubbish pits.

TS F. 316 produced enough material for detailed metrical analysis to be carried out. Sixteen skulls were complete enough for measurements to be undertaken. The eight measurements taken and the three indices calculated followed those devised by Harcourt (1974a:152-3). These were as follows:

Measurement I	The most posterior aspect of the occipital protuberance to the anterior margin of the medial alveoli between the central incisors (alveolare).
Measurement II	Occipital protuberance to the junction of the nasal and frontal bones (nasion).
Measurement III	Nasion to alveolare.
Measurement IV	The maximum zygomatic width.
Measurement IX	The palatal length.
Measurement X	The palatal width between P4 and M1.
Measurement XI	Maxillary cheek tooth row length.
Measurement XII	Snout width across outer margins of the alveoli of the canines.

Cranial Index (CI) Measurement IV x 100/I.
Snout Index (SI) Measurement III x 100/I.
Snout Width Index (SWI) Measurement XII x 100/III.

Table 90 gives the results of these measurements. In terms of overall size, there was a fairly wide degree of variation. The coefficient of variation for the measurements ranged from 7.43 (XII) to 11.67 (III). The amount of variation compares relatively closely to that encountered by Harcourt in his sample of skulls from eleven Anglo-Saxon sites but in that case nearly all the skulls belonged to larger animals. Indeed the largest skull in TS F. 316, which produced a figure for Measurement I of 192 mm, was still smaller than the mean figure of 202 mm obtained in the Anglo-Saxon sample (Harcourt 1974a:168). The sample from Exeter probably did not represent the full range in size of dogs in that period, since the degree of variability in skull measurements was much less than in the Roman specimens also examined by Harcourt. To take Measurement I as an example, 93 Roman skulls gave a coefficient of variation of 25.2, compared with one of only 10.86 from the twelve Exeter specimens on which this measurement could be taken. The average size of the Roman specimens was rather greater (168 mm) than the Exeter postmedieval sample (156.9 mm) but all the Exeter specimens fell comfortably into the observed range of Roman measurements (Harcourt 1974a:163).

The various cephalic indices also showed some reduction in variability in the Exeter sample. The cranial index (CI), for example, which gives an indication of the width of the skull in relation to its length, ranged from 51.79 to 59.69 compared to 47.0 to 65.5 in the Roman specimens examined by Harcourt. Once again the decrease in variation may simply reflect the small and probably unrepresentative sample in Exeter, rather than any overall change in the type of animals found in the two periods.

The metrical analysis on the lengths of the mandibular tooth rows of 27 individuals of postmedieval date gave similar results to those from the skull. These showed a noticeably smaller degree of variation and a mean (61.6 mm) rather less than the 180 Roman specimens examined by Harcourt (67 mm) (Table 90).

Metrical analysis was also undertaken on the lengths of fused long bones. It was only possible to take measurements from three of the skeletons found in Roman Exeter. The height of the animals at the shoulder was calculated following the formulae used by Harcourt (1974a:153). The two smallest (307 and 344 mm) come into the range of 'lap-dogs' which would have had to rely on human protection and shelter to survive. The largest measured 567 mm and could have been a working dog.

Measurements were also taken on 35 long bones of sixteenth and seventeenth century date, 32 of which were found in TS F. 316. The results are given in Table 91 and these revealed a greater degree of overall variation (16.16 to 18.65) than observed in the skulls. This was still rather less than the variation encountered in Harcourt's 679 Roman examples (18.4 to 25.8) but as great as that found in the 108 Anglo-Saxon specimens examined by the same authority (14.7 to 19.3) (Harcourt 1974a:163-168). The smallest dog in the Exeter deposits would have had a shoulder height of 265 mm, half the size of the largest example (528 mm). Some animals analysed by Harcourt would have been much larger with shoulder heights of 700 mm and above. No very large dogs were therefore discovered in Exeter. The mean measurements of the humeri, radii, femora and tibiae were between 9 to 15 mm less than Harcourt's Roman sample and as much as 32 to 48 mm less than the Anglo-Saxon specimens (Harcourt 1974a:163-168). Again the Exeter sample, which originated mainly from one exceptional deposit, cannot really shed a lot of light on any possible changes in the type of dogs present, since there is no way of proving that the Exeter sample is typical of its period from existing archaeological evidence.

Two bones showed degrees of skeletal abnormality; the first, of twelfth century date, was a femur belonging to a young animal that had an irregular growth of bone around its distal epiphysis. This was possibly the result of some relatively minor trauma. A more serious injury had been suffered by the owner of a tibia of sxteenth century date; this bone had been completely fractured and not reset. The result was that a new growth of bone had formed in an irregular manner. The tibia reformed at an angle of over 45° to its natural line. The animal obviously survived for some time after injury, although it would have hobbled on three legs for the rest of its life.

The lack of butchery marks, the relatively high number of complete bones and the presence of several partially preserved skeletons all argue against the possibility that the dog was a food resource in Exeter during any of the periods involved. What therefore were the uses of the dog? Harcourt (1974a:163) believes that the smallest dogs in his Roman sample would have been too small to have served any useful purpose. The smallest animals found at Exeter could also have been pets. The functions of the larger dogs may have been diverse. Some could have been employed in hunting or herding or as guard dogs. It is, however, impossible to tell from size alone what uses a dog may have had. As yet research is not so far advanced that the skull measurements can differentiate between breeds, although the variations encountered do show that several types of dog were in existence at the time. The pelt of the dog would no doubt have been of some value to the fur and skin traders of the city.

It seems possible, however, that many dogs in the city were little more than scavengers. In 1423, dogs were banned from being kept in the city because it was believed that they were a major health hazard. Watchmen finding stray dogs were empowered to kill them and anyone keeping a dog was fined a shilling. The regulation was modified in 1509, although a fine of fourpence was still payable by owners who allowed their dogs to roam the streets (Hoskins 1969: 58-59). Such strict observances and penalties can only have been considered necessary if there were severe problems caused by strays in the city. The concentration of dog burials in TS F. 316, at the rather later date, may also have been the result of a scourge on stray dogs.

CAT

Cat was rarely found in the Roman period; only sixteen fragments of this species were discovered. In the medieval period, however, it was the most commonly found of the mammals discussed in this chapter. In all, 435 fragments were recovered (2.62% of the identifiable mammalian fragments). Many of these fragments did derive from partially preserved skeletons, however, which has tended to overemphasise the species' importance. Several other bones could be 'matched' with bones from the opposite side of the body, which suggests that these bones also belonged to burials.

The majority of the 660 fragments dated to the postmedieval period were found in GS F.228 and TS F.316. As in the medieval period, many of these fragments belonged to semi-complete skeletons, although the concentration of bones in these deposits made it impossible to establish with certainty the exact number of skeletons involved.

Table 92 gives the fusion data for the medieval and post-medieval periods. The medieval sample revealed a high percentage of unfused epiphyses. 49 out of 76 (64.47%) proximal humeri and tibiae and distal femora and radii were unfused and therefore belonged to young animals, probably under eighteen months of age.

Much of the GS F. 228 assemblage belonged to very young animals. This accounts for the relatively high number of unfused distal humeri and proximal radii as shown in Table 92. Most of the feline fragments in TS F. 316, on the other hand, belonged to adult animals. Generally, however, the high mortality rates of immature cats continued in the postmedieval period.

The archaeological evidence supports the traditional view that cats were not butchered for food. The presence of several partial unbutchered burials supports this fact. The relative lack of fragmentation of the long bones also indicates that feline carcases were not normally cut up. In the medieval sample, 81 out of 160 humeri, radii, femora and tibiae were found in a complete state. An examination of the postmedieval sample showed an even greater tendency towards the intact survival of these bones, since 177 out of 211 had both epiphyses present. This evidence combined with the lack of cut marks on any of the bones undoubtedly seems to show that most of the skeletons of cats were left intact after death. It is interesting to compare the fragmentation evidence with that obtained from the hare, an animal of similar size. Much fewer hare long bones remained intact, since they were much more often broken in butchery. Most, if not all, of the fragmentary cat bones could have been broken during or after dumping in the rubbish heaps.

There is a large degree of variability in the size of domestic cats and some are as large as the wild cat. It is generally accepted, however, that from Roman times onwards most bones belong to the domesticated species. One mandible of Roman date had a length of 55.1 mm, which compares closely with a mandible from Hemel Hempstead measuring 56 mm (Harcourt 1974b:261). Both were therefore fairly large specimens, as indeed was the cat skeleton found at the Latimer Roman villa (Branigan and King 1965:462-3). None of the nine medieval mandibles from which measurements were possible was as large as the Roman example. The average length of the mandible, measured from the posterior condyle to the anterior edge of the canine alveolus, was 48.9 mm (Table 93). Examination of ten postmedieval mandibles revealed an increase in the average size (53.1 mm). However, most of these examples came from TS F. 316, and the increase in average size of the mandibles may not be typical of the period.

Too few Roman and medieval long bones survived for metrical analysis to be carried out. In the postmedieval sample, the various long bones measured produced coefficients of variation ranging from 4.67 to 9.43 (Table 93). Cats, like other domestic animals, therefore varied quite a lot in size. The reasons for the variations may have been due to sexual dimorphism, different planes of nutrition or to the presence of different types of cat. No doubt different breeds of cat were present in the medieval and postmedieval periods but it is not as yet possible to make distinctions between them from the archaeological material available.

The exploitation of cat seems to have changed little in the medieval and postmedieval periods. Their bodies were dumped in the rubbish pits alongside other domestic waste. It is evident that from medieval times cats were kept, or were present, in the city in appreciable numbers. They would certainly have helped to keep down the vermin which would have been attracted to the rubbish deposits, whether they were pets or stray animals. It may be that this was their only practical use. However, their comparatively frequent recovery and their relatively high early mortality rate may suggest a more intensive exploitation. One possible explanation is that their skins were of some value. Skinning an animal does not necessitate butchery of any of the bones and after the removal of the fur, the remaining carcass could simply have been dumped. A similar theory has been put forward to explain the presence of a similar type of cat assemblage in medieval Southampton (Noddle 1974a:333). On the other hand, surprisingly little appears to be known of the life expectancy of cats. The archaeological evidence may simply be representing the natural mortality rates of the species, perhaps enhanced by the deliberate putting down of young, unwanted and potentially stray animals.

FOX, OTTER, BADGER, HEDGEHOG, STOAT

A minimum number of three foxes, all of Roman date, was found. The fourteen fragments included eight fragments of an immature specimen of late first century date. The only otter bone discovered was the fused distal epiphysis of a femur of military date. Badger was represented by a relatively complete skeleton from the third century deposits consisting of 42 fragments (excluding ribs and vertebrae). Both finds were from adult animals. Fox and badger have been discovered on several Roman military sites in this country and otter has been discovered on a similar site in Germany (Davies 1971:128). The fox in particular could have been attracted to the rubbish tips as a scavenger. Alternatively all three species may have been hunted for their fur.

A humerus with an unfused proximal epiphysis, found in a fourth century dump, was the only evidence of hedgehog discovered. The only remains of the stoat were discovered in a late twelfth century deposit and consisted of ten fragments mostly derived from the foot of the animal. Both are best explained as stray finds.

RODENTS

Three species of rodent were positively identified. Water vole was discovered in a fourth century context. The black rat and woodmouse were recovered from deposits dated to the medieval and postmedieval periods together with fragments of rodents not identifiable to species. Their presence in deposits of rubbish and food waste is to be expected.

SUMMARY: THE EXPLOITATION OF OTHER ANIMALS

None of the species discussed above played a significant role in the diet of the inhabitants of Exeter; some indeed played no part at all. Probably only red, roe and fallow deer, hare, rabbit and possibly horse were eaten. The rest fulfilled different roles; some of the dogs and cats may have been valued for their fur; other dogs may have been employed in the hunt, or in herding or guard duties; cats may have been kept to keep down the number of vermin. Some of the cats and dogs would have been kept simply as pets or allowed to wander unattended around the streets where they scavenged for their food. The horse's main role was as a beast of burden and pack animal; hares and rabbits would also have been valued for their skins. All the remaining mammals in the deposits could have perished, or been deposited there, simply by accident or chance, although some might have provided their pelts for the furriers.

THE MAMMALIAN SPECIES PRESENT

Red deer (*Cervus elaphus*)
Fallow deer (*Dama dama*)
Roe deer (*Capreolus capreolus*)
Hare (*Lepus* sp.)
Rabbit (*Oryctolagus cuniculus*)
Horse domestic
Dog domestic
Cat domestic
Fox (*Vulpes vulpes*)
Otter (*Lutra lutra*)
Badger (*Meles meles*)
Hedgehog (*Erinaceus europaeus*)
Stoat (*Mustela erminea*)
Water vole (*Arvicola terrestris*)
Black rat (*Rattus rattus*)
Woodmouse (*Apodemus* sp.)

7.

THE BIRD AND FISH REMAINS

THE AMOUNT OF BIRD PRESENT

A total of 4,238 bird bone fragments belonging to a minimum of 41 species was recovered in all the deposits. Table 94 shows the number of bird fragments found in each phase, expressed as a percentage of the total number of identifiable fragments. During the Roman and medieval periods a fairly consistent percentage of bird fragments was found (4 to 12% in the larger samples). Certain features, particularly one or two of the large medieval pits, contained higher quantities of bird bones, but generally there was little variation in the relative numbers of bird remains on the different sites. During the sixteenth century and late seventeenth century phases the percentage of bird bone fragments rose to between 16% and 30%. The reason for this increase was due mainly to the high concentrations of bird bones in the two very rich pits, GS F. 228 and TS F. 316. Yet again, GS F. 228 produced the most striking results; a total of 724 bird fragments from no less than twenty species was discovered in this pit. The relative number of fragments may therefore have been overemphasised by these rich deposits, which may not be typical of the city as a whole. In Phase Pm4 (1660 to 1800) the proportion of bird fragments reverted to a level more typical of the Roman and medieval deposits (6.57%). The exceptional preservation in the earlier postmedieval deposits examined obviously favoured the recovery of birds. The same features, however, also produced a much wider range of species, perhaps indicating a more varied diet of the people associated with those deposits. This contrasts with the more restricted range of birds associated with the GS I-II deposits dated to the late seventeenth and eighteenth centuries, when both the documentary and archaeological evidence indicate that this area of the city had become much less prosperous.

To compare the percentage of bird bones found at Exeter with other Roman and medieval sites is extremely difficult since it is uncertain how much the preservation conditions and the methods of recovery differed between the sites involved. In addition, the methods of quantitative analysis vary. For example, 378 bird bones were discovered in the Roman levels at Portchester Castle but these made up only 0.13% of the 28,908 'identifiable fragments'; in this case, 'identifiable fragments' included ribs and vertebrae and these were not counted in the Exeter sample. If the number of ribs and vertebrae fragments of the major stock animals are omitted from the Portchester sample, a total of 18,680 fragments remain (Grant 1975:390). The percentage of bird fragments then equals 2.02%, still lower than the equivalent figures in the Roman phases at Exeter. Noddle (1975:251) has tabulated the relative proportion of fragments from eight Saxon and medieval sites in southern England. The percentage of bird fragments on these sites ranged from 1 to 20%, with an average of 7 to 8%. However, it is not stated whether the total number of fragments included ribs and vertebrae. Nor are the samples in some cases large enough for it to be certain that the final percentages obtained are in fact representative.

The amount of bird present in the Exeter sample may be under-represented, since many of the bones are small and therefore are more likely to have been overlooked during excavation than the bones of the larger mammals. However, as the evidence now stands, bird was not very important in comparison to the major stock animals in terms of total meat weight, although a comparatively large number was eaten.

THE BIRD SPECIES PRESENT

Land fowl

Domestic fowl
Turkey *(Meleagris gallopavo)*
Partridge (*Perdix perdix*)

Swans, geese and ducks

Mute swan *(Cygnus olor)*
Greylag goose (*Anser anser*)/domestic goose
Small goose species
Mallard (*Anas platyrhynchos*)/domestic duck
Teal (*Anas crecca*)
Wigeon (*Anas penelope*)

Waders

Common crane (*Grus grus*)
Grey heron (*Ardea cinerea*)
Oyster catcher (*Haematopus ostralegus*)
Golden plover (*Pluvialis apricaria*)
Ringed plover (*Charadrius hiaticula*)
Green sandpiper (*Tringa ochropus*)
Small wader species
Curlew (*Numenius arquata*)
Bar-tailed godwit (*Limosa lapponica*)
Woodcock *(Scolopax rusticola)*

Seabirds

Gannet (*Sula bassana*)
Lesser black-back gull(*Larus fuscus*)
Kittiwake (*Rissa tridactyla*)
Black-throated diver (*Gavia arctica*)
Auk species

Pigeons and doves

Rock dove/feral pigeon/domestic pigeon (*Columba livia*)

Stock dove (*Columba oenas*)
Woodpigeon (*Columba palumbus*)

The crow family

Chough (*Pyrrhocorax pyrrhocorax*)
Raven (*Corvus corax*)
Rook/crow (*Corvus frugilegus/Corvus corone corone*)
Jackdaw (*Corvus monedula)*

Birds of prey

Sparrowhawk (*Accipitor nisus*)
Buzzard (*Buteo buteo*)
Osprey (*Pandion haliaetus*)
Barn owl *(Tyto alba)*

Passerines and other species

Thrush/blackbird/fieldfare (*Turdus merula/Turdus philomelos/Turdus pilaris*)
Starling (*Sturnus vulgaris*)
Cuckoo *(Cuculus canorus)*
Skylark (*Alauda arvensis*)
Large finch/bunting

Tables 95-97 show the number of fragments and the minimum number of individuals for each of the above species for the Roman, medieval and postmedieval periods respectively. The following sections will discuss each group of birds listed above in turn.

LAND FOWL

Domestic fowl dominated the avian assemblage in all periods. A total of 3,121 (73.64%) of the bird fragments in all deposits belonged to this species. In no period did the percentage of fowl fragments fall below 50%, and in some of the postmedieval phases the percentage of fowl was over 80%.

The study of the minimum numbers of individual species of birds revealed a similar picture. Throughout, domestic fowl contributed 54.31% of the individuals. There was no significant variation in any of the larger samples, which produced percentages of fowl ranging from 51 to 62%. The minimum numbers method of counting again elevated the importance of the rarer birds, which accounts for the relatively lower percentages obtained for domestic fowl compared to the fragments method of counting. Some of the samples were small (consisting of only twelve individuals in some cases) but even these seem to reflect the pattern of the larger samples.

Domestic fowl has been found to be the most popular species of poultry on several Roman sites in Britain. At Portchester Castle 230 (60.85%) of the avian fragments belonged to fowl (Eastham 1975:409). It was also the dominant species at Fishbourne, where 604 (75.12%) of the bird bones belonged to fowl (Eastham 1971:391). Other Roman samples are too small to make valid comparisons, although at Longthorpe only 30 of the 115 bird fragments were fowl. However, 39 raven bones from four skeletons also discovered on this military site have underestimated the importance of fowl (Marples 1974:124). Domestic fowl was also the dominant species recovered in the late Saxon levels at Portchester Castle, where they provided 56.84% of the identified bird fragments (Eastham 1975). From sites I, IV, V, VI, and XX of the Melbourne Street excavations of Saxon Southampton (Hamwih), domestic fowl (and probable fowl) provided 597 (65.03%) of the identifiable bird bones (Coy 1977). In contrast, fowl was found to be the most common species by fragment count on only one of the medieval sites investigated by Noddle (1975:251) — the manor of North Elmham in Norfolk. On six other sites in southern England it was found in equal numbers to, or less commonly than goose. None of the four Yorkshire sites studied by Ryder produced sufficient avian material for comparisons to be made (Ryder 1961). Once again caution must be maintained in any direct comparisons of simple counts of fragments from different sites, but it is interesting to note the similarity in the proportions of domestic fowl represented in the Roman assemblages at Exeter, Portchester and Fishbourne. On present evidence the relative importance of fowl and goose in the Middle Ages was more variable. At Exeter fowl continued to be the dominant species; on other sites goose has been found in equal or greater numbers. There may have been regional variations in poultry keeping at this time.

There is evidence to suggest that domestic fowl became more intensively exploited in Exeter during the medieval and postmedieval periods. The percentage of immature limb bones in the Roman period, taken from a sample of 294 bones, was 10.88%. This was less than half the level of immature deaths encountered in the succeeding periods, when over 20% of the birds eaten in the city were killed under six months of age (the age by which the long bones have fused) (Table 98). On this point, however, it should be pointed out that the better preservation conditions in some of the medieval and postmedieval contexts may have favoured the recovery of more immature bones than the Roman levels. Unfortunately, although various authors mention the presence of immature fowl on Roman and medieval sites, there are no detailed figures published for comparison. The number of unbroken mature limb bones was sufficient for metrical analysis to be undertaken. Table 99 shows the range, mean, standard deviation and coefficient of variation of the lengths of the wing and leg bones in all periods involved. The table reveals the amount of variation encountered; in the Roman and medieval periods, the coefficient of variation usually lay between 5 and 10; in the postmedieval period, this figure increased in some cases to over 10, an indication of the greater range in size in that period. Table 99 also shows that there was no improvement in the average size of domestic fowl from Roman to medieval times. In fact, although the Roman sample was small, the mean of the various measurements was generally found to be rather greater than those of the early medieval period. There seems to have been little increase in overall size during the medieval period itself, except perhaps during the fourteenth century, although once again the sample obtained from that phase was too small to allow for firm conclusions. This relative stability was shattered in the postmedieval period — the size of domestic fowl was found to increase significantly during the sixteenth and seventeenth centuries. Although the smallest birds (particularly in the sixteenth century) were no larger than the smallest specimens in the preceding periods, the largest postmedieval bones were much larger than their Roman and medieval counterparts.

The large amount of variation encountered in the size of domestic fowl is indicative of the practice of poultry farming, and has been noted on several other sites. At Fishbourne, attempts to distinguish different breeds of domestic fowl from metrical analysis proved largely inconclusive, although certain broad groups were postulated for some bones (Eastham 1971:391-3). At Exeter, histograms were constructed of the lengths of various bones in the Roman, medieval, sixteenth century and seventeenth to eighteenth century samples. The results are shown in Figures 18 to 20. Too few measurements from specimens of Roman date were possible to show any significant

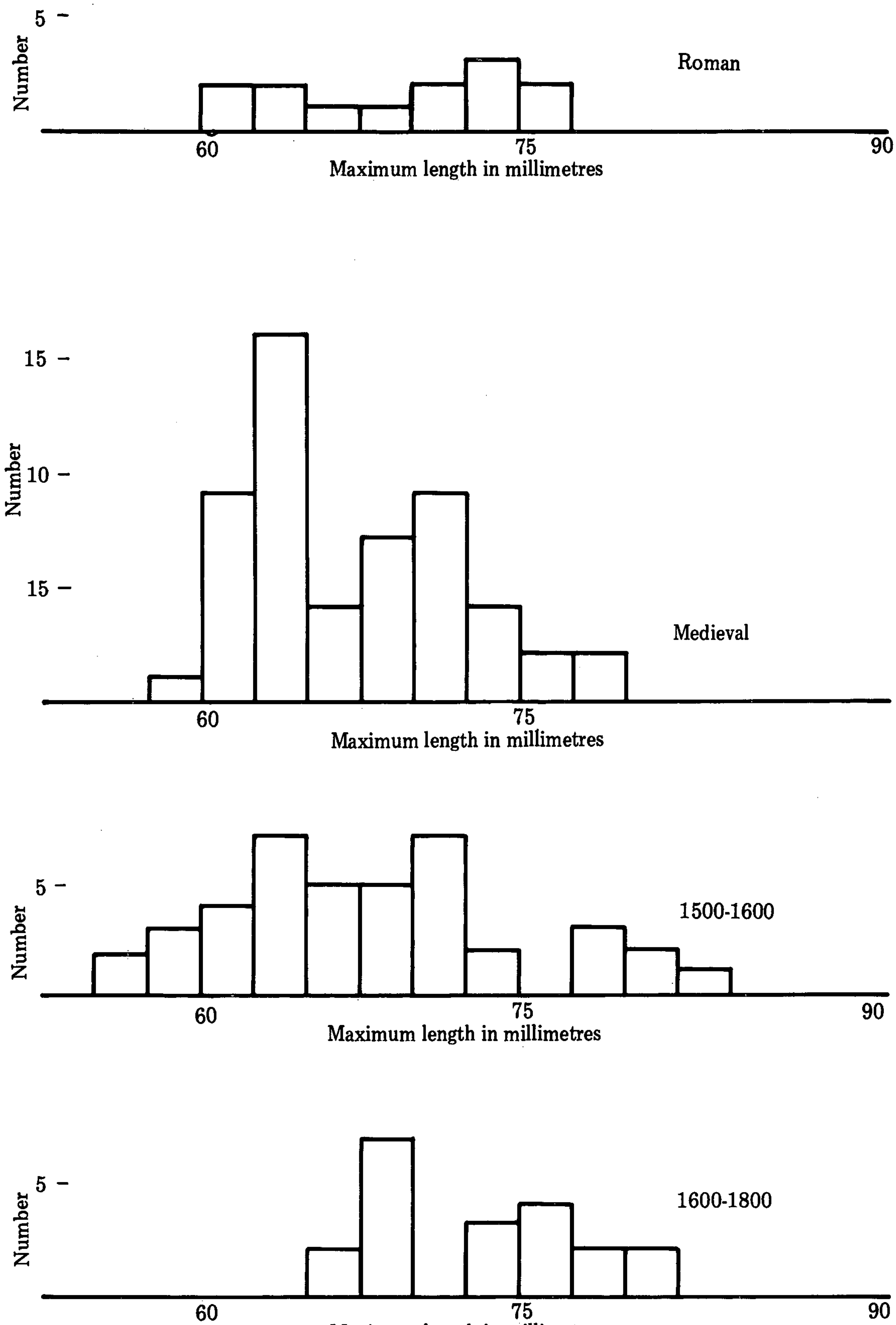

Figure 18 Histograms of domestic fowl humeri measurements.

trends. A much larger series of measurements taken on medieval specimens provided interesting results. Histograms of the humerus and femur (Figures 18 and 19) showed a bimodal distribution. In both cases the concentration of the smaller specimens was of rather greater magnitude than that of the larger examples. It could be argued that the two groupings represent more than one breed of fowl. This may be true in part, but the measurements of the tarsometatarsus suggest that much of the variation can be ascribed to sexual dimorphism. Cock birds possess a spur on the medial aspect of the tarsometatarsus, towards the distal end of the shaft; hen birds, on the other hand, only rarely possess this feature. It is therefore possible to distinguish between the sexes of these bones and compare the measurements taken on them (Figure 20). When both spurred and unspurred tarsometatarsi were placed in the same histogram, it was found that the spurred specimens, although fewer in number, were consistently larger than the unspurred

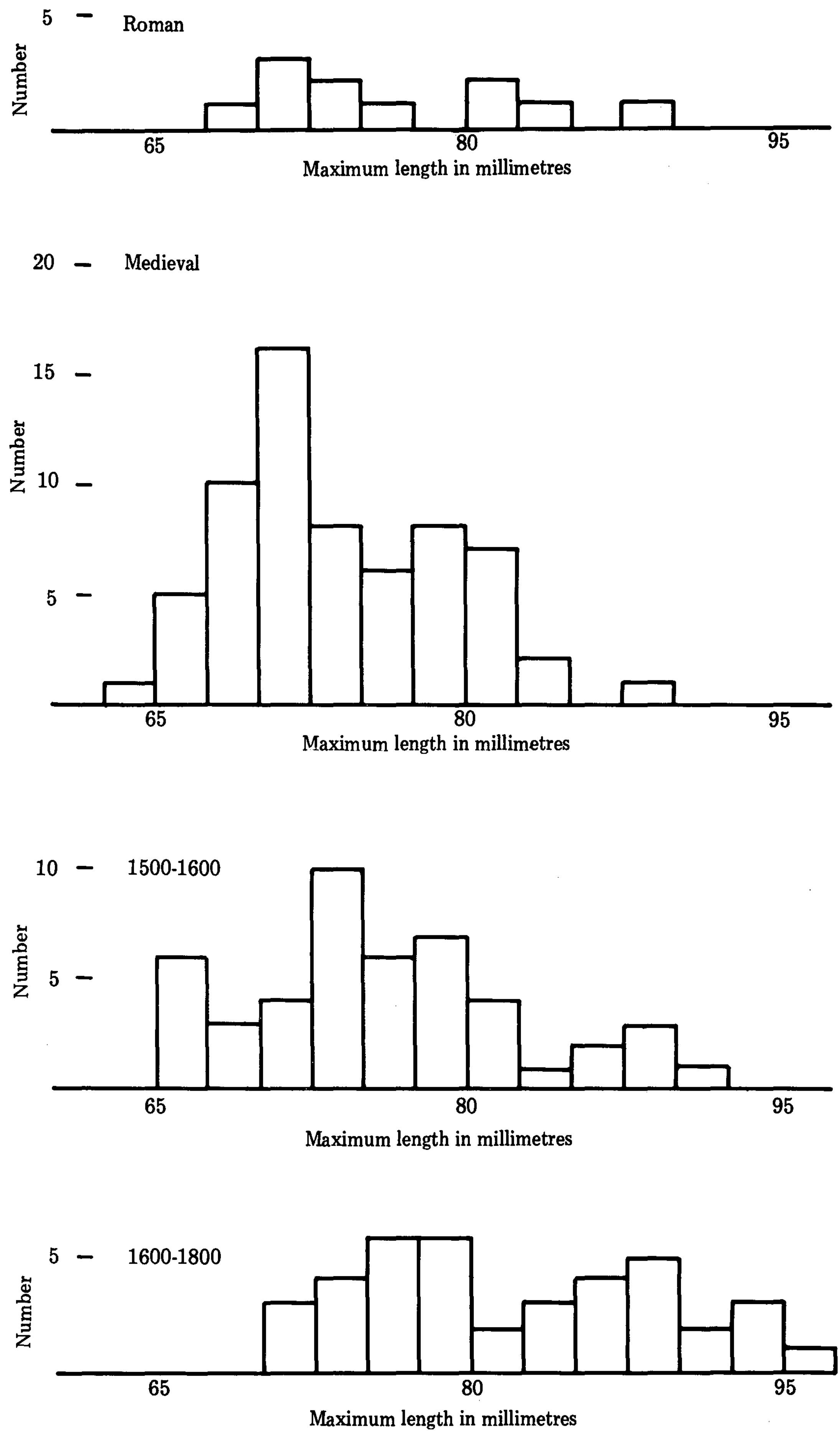

Figure 19 Histograms of domestic fowl femora measurements.

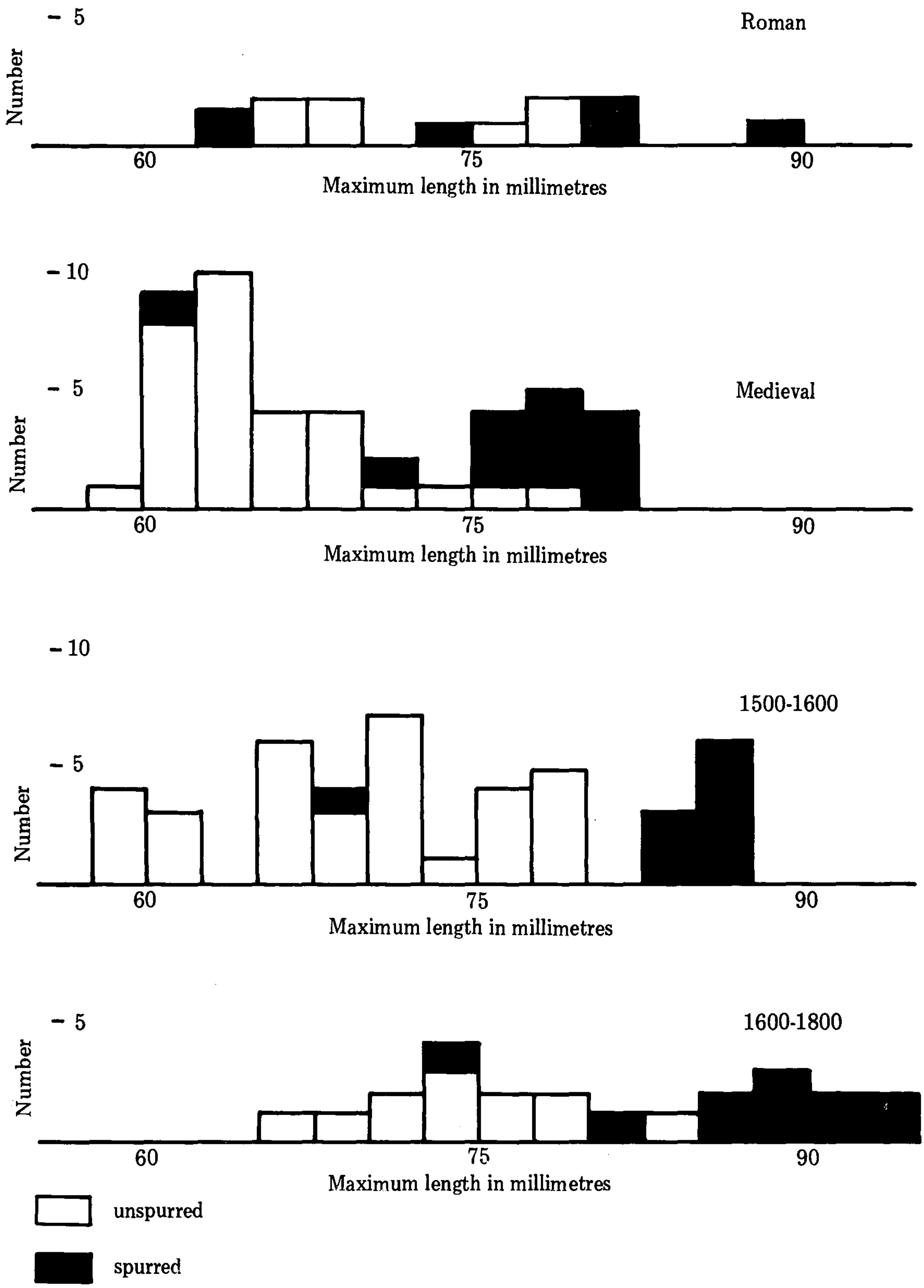

Figure 20 Histograms of domestic fowl tarsometatarsi measurements.

specimens, although there was some overlap. The resulting histogram therefore formed two peaks of measurements; a larger concentration of smaller female specimens and a distinct cluster of spurred specimens. The bimodal distribution bore reasonably close resemblances to the histograms of the other long bones, suggesting that their bimodality was also due to a large extent to sexual dimorphism. The degree of overlap between the lengths of male and female specimens may have been greater in these bones, which would account for the variations observed in the distributions. These results do not preclude the possibility that more than one type of fowl was represented in the sample but they would suggest that sexual dimorphism was a more important factor in size variance.

The situation became more complex in the postmedieval period. In the sixteenth century, the range in size of the unspurred tarsometatarsi increased greatly and the largest specimens were as big as many of the spurred medieval tarsometatarsi had been. The spurred tarsometatarsi also increased in size during this time. In the seventeenth century sample, the smallest specimens disappeared almost completely as the tarsometatarsi of both sexes became larger. The same phenomenon can be seen in the postmedieval histograms of the other bones analysed. The greater variability in size resulted in a much greater overlap between male and female specimens resulting in the disappearance of the bimodal appearance of these histograms.

As yet, the above study has not taken into consideration the possibility that some of the bones belonged to capons (castrated males). Several tarsometatarsi in all periods possessed incomplete spurs but it was difficult to tell whether or not these spurs had simply been broken off close to their root. Nor is it established whether this genetic factor was present in capons in the periods in question. There is documentary evidence that caponising was practised by the sixteenth century and that capons were sold in the markets at Exeter (MacCaffrey 1958:81) and elsewhere in Devon by that time (Hoskins and Finberg 1952:263). There is documentary evidence that this practice was carried out in the medieval period, although how common this was is uncertain. The increase in the size of some of the fowl in the postmedieval period may have been due to innovations in poultry farming, such as selective breeding and the caponising of males for fattening and sale to the poultry markets. The improvement in size could also be the result of the introduction of superior breeds of fowl into the area during the sixteenth century.

Butchery marks were occasionally found on domestic fowl bones. The majority of limb bones were complete. Because of its small size, the fowl does not require much butchery. The leg and wing of chickens can be eaten without the necessity of cutting through any of the limb bones.

One ulna and one tarsometatarsus, both of medieval date, had suffered traumas, which had healed before the bird was killed and were not the cause of death.

The exploitation of the domestic fowl seems, therefore to have been quite intensive throughout the deposits, judging by the various strands of evidence discussed above. Besides providing meat, hens would have contributed eggs to the diet, although it is impossible to say exactly how important a commodity this would have been. Nowadays chickens lay about 200 eggs in their first year. They go off lay at the end of their first year and are then often killed. Hens brought back into lay in their second year produce fewer eggs. Whether hens were treated in a similar manner in Exeter is uncertain. Like pigs, poultry could have been kept by house-holders in the city and by most of the rural farmers, being inexpensive to keep and at the same time providing a cheap source of food. Poultry farming on a large scale probably did not take place until late in the postmedieval period. Certainly in the medieval period and before, there seems to have been little attempt at selective breeding or stock improvement.

Only three fragments of turkey were discovered in these excavations. The earliest of these was recovered in a context dated to the middle of the sixteenth century. This species was only introduced into Britain in the 1520s (Thirsk 1967a:194) and so its absence from previous deposits is to be expected. Even in postmedieval times, it seems that turkey was only a rare addition to the table.

No bones of peafowl were specifically identified, although some of the postmedieval domestic fowl bones reached peafowl proportions. Its absence is a little surprising since during the late sixteenth century it was mentioned alongside other poultry in the mayor's annual proclamation upon taking office (MacCaffrey 1958:81). However, like the turkey, it may only have been eaten on rare festive occasions, which would explain its absence from most domestic rubbish deposits.

Thirteen fragments of partridge were found, one of Roman origin, two belonging to the later medieval period, seven (from a minimum of two individuals) in GS F. 228 and three from TS F. 316. Its scarcity even in the latter opulent deposits indicates that this gamebird was not extensively exploited.

SWANS, GEESE AND DUCKS

The swan, like the turkey and peafowl, was probably only eaten on festive occasions. Its absence save for four fragments (from a minimum of two individuals) found in late thirteenth century contexts is therefore not surprising.

Greylag goose/domestic goose was the second most popular species of bird eaten in the city of Exeter. A total of 509 (12.01%) fragments from a minimum number of 92 (12.40%) individuals was recovered from the deposits investigated. However, only fifteen of these fragments were discovered in the Roman levels (Table 95). Despite the fact that the Romans are generally believed to have domesticated the greylag goose, it can only have played a minimal part in the diet at the time. It was not until the medieval period that the species became more important. The percentage of goose fragments varied between 14% and 29% in the nine medieval phases in which percentages were estimated. In each case it was the second most commonly found species, although it does not seem to have been reared as commonly around Exeter as in other areas of medieval Britain. During the sixteenth and seventeenth centuries, the goose may have become less popular. The percentage of fragments dropped to between 2% and 7% in the first three postmedieval phases. The seventeenth and eighteenth century sample (Phase Pm4) included seven fragments from one gosling, which accounts for the goose's unusually high percentage of 22.03% in the sample of 118 fragments.

A study of the minimum number of geese in all the phases showed a similar pattern to that of a simple count of fragments. In the larger Roman samples figures of 2 to 9% were obtained. The minimum numbers method employed on rather small samples tended to overestimate the importance of goose in these phases, since it was in fact only represented by a few fragments in each phase. During the medieval period, the percentage of goose obtained by this method ranged from 15 to 19% in the two largest samples. This figure dropped to between 6 to 10% in the larger postmedieval samples, a decrease paralleled by the count of fragments.

Although the numbers of geese on medieval sites would indicate that they were reared as poultry, their exploitation at Exeter was in marked contrast to that of domestic fowl. Only two out of a total of 172 limb bones were found to be unfused in the medieval sample. In the postmedieval deposits, apart from the partial skeleton of a gosling already mentioned, only four out of 39 long bones belonged to immature birds. It appears that the goose was much less intensively exploited than the domestic fowl. The birds were allowed to attain full size before they were fattened up for slaughter. The variation in the size of goose was less than in fowl. Only the carpometacarpus and tarsometatarsus produced samples large enough for measurements to be analysed. These had a coefficient of variation of 4 to 6. There was no significant change in the mean size of these bones between the medieval and post-medieval periods (Table 100). A greater percentage of geese bones were broken than those of domestic fowl. This is to be expected, since the goose is a much larger bird and the wings and legs would have to be broken up to allow manageable servings to be provided.

The mallard or its domesticated form was the commonest duck species found at Exeter, although it played only a small part in the diet. 142 (3.35%) fragments from a minimum of 41 (5.53%) individuals were recovered. Only eighteen of these fragments were of Roman date. The duck's scarcity continued throughout the medieval period. With the exception of one small sample dated to the late thirteenth and early fourteenth centuries, none of the medieval phases produced percentages of duck of over 2.25% of the avian fragments. In most of them the figure was below 1%. The percentage obtained by the minimum numbers method were rather higher, although once again the presence of a few fragments in each phase overvalued the importance of this and other rare species in the sample. The mallard is known to have been domesticated in medieval times and it is possible that it was also reared as poultry during the Roman period (Eastham 1971:391). However, the paucity of its remains in Exeter indicated that it was either kept in captivity in small numbers, or simply hunted occasionally as game. In the Roman levels of Portchester and Fishbourne (Eastham 1971, 1975) bones of the mallard species ranked second only to domestic fowl and ahead of goose. In Exeter, eighteen fragments of duck were found in comparison to fifteen of goose, indicating that neither was an important component in the diet of the townsfolk.

The sixteenth century deposits accounted for over half the fragments of duck found in the deposits. Two pits accounted for all but five of the 86 bones recovered; 58 fragments were discovered in GS F. 228, while 23 came from GS F. 291. The latter deposit was interesting in that all the bones belonged to the wings. It is probable that these were the discarded refuse from meals or a feast since a lot of meat can be extracted from these bones. In GS F. 228 both the wing and leg bones of duck were represented in roughly equal numbers. The amount of duck in these two features was exceptional and produced a percentage of that species in the sixteenth century phase of 8.11% of the bird bone fragments and 10.53% of the minimum number of individuals represented. In the rest of the postmedieval phases, the number of duck bones was no higher than their previous low levels.

Only two bones in the whole of the deposits, one of Roman origin and one from GS F. 228, belonged to immature birds. Their mortality rate was therefore similar to goose, and indeed to most gamebirds in this respect. Too few measurements were taken for any conclusions to be made about the overall size of the ducks. Except in the rich deposits of the late sixteenth century, they appear to have been of very little importance in the economy.

Other goose and duck species were very rare indeed. One bone of a small goose species was discovered, possibly belonging to the white-fronted species (*Anser albifrons*). Of the smaller duck species, only teal (eleven fragments) and wigeon (three fragments) were identified. Seven of the teal bones came from the sixteenth century phase and indicate that this bird was a source of game in that period at least. The teal nowadays breeds quite commonly in the area, and the wigeon is a common winter visitor. Both birds are edible but wild duck and geese do not seem to have been caught in large numbers.

WADERS

A total of eleven wading species (other than swans, ducks and geese) was identified. By far the most common of these was the woodcock. A total of 169 (3.99%) fragments from a minimum of 52 (7.55%) individuals was found. In the deposits as a whole, therefore, the woodcock ranked third behind domestic fowl and goose. The species was found relatively more commonly in the Roman and early medieval levels than later. It was reasonably popular throughout the Roman phases, contributing approximately 10% of the avian fragments in the samples from the third and fourth centuries. In the earlier medieval phases, the species provided between 5 and 10% of the number of bird bone fragments. In the later medieval and postmedieval periods the level of woodcock declined usually to under 5% of the total avian sample. It was still, however, the most commonly found gamebird in the deposits.

This decline is not so marked in the results obtained from the minimum numbers method, although the same general trend can be observed (Tables 95-97). In modern times, the woodcock is found commonly as a non-breeding winter visitor in Devon and Cornwall, although it still breeds in Dorset and Wales (Heinzel *et al.* 1972:328). There is good documentary evidence to suggest that it was a winter visitor in the sixteenth century as well. Richard Carew, writing about the fauna of his native Cornwall, said:

> 'But amongst all the rest (wild birds) the inhabitants are most behoven to woodcock, who (when the seasons of the year affordeth)
> flock to them in great abundance.' (Halliday 1953:108).

Woodcock was constantly in demand between October and February in the sixteenth century at Tavistock Abbey. It was not recorded in the other months (Hoskins and Finberg 1952:263). The species was therefore regarded principally as a winter food resource, at the season when it was common in the region.

The woodcock's more common occurrence in the Roman and early medieval periods may be due in part to the fact that it was present in the area all the year round. There is some documentary evidence to show that prior to the early medieval period, when the land around Exeter was drained by the cutting of leats, the area around the river Exe below the city was marshland (Hoskins 1969:24). The decline in the number of woodcock around Exeter from this time could reflect a decrease in the amount of marshland in the area, which either compelled the species to stop breeding in the area, or attracted fewer winter migrants. Alternatively the decline in the relative number of woodcock may simply be a reflection of the fact that more domesticated poultry was kept and consumed by the inhabitants of Exeter.

The hypothesis that some degree of environmental change has taken place in the countryside in the vicinity of Exeter during the past 2,000 years would also help to explain the presence of the common crane in a late first century context. This species is not now found in the British Isles but is known to have bred on areas of extensive marsh such as the Fens in historic times. Its bones have been recorded on several sites including that of medieval Southampton (Bramwell 1975:340). The crane was the largest species of bird found at Exeter and of undoubted food value.

Of the remaining wading species, all except the two plover species and the green sandpiper attain a length of at least

30 cm when measured from beak to tail. All could have been considered as game in a wildfowling expedition, although their very rare occurrence indicates that they were little sought after. Nowadays both the heron and curlew are fairly common residents in the southwest peninsula, both on marshland and near the shore; the oyster catcher and ringed plover are resident as shore birds and probably would have been found on the marshland and mud flats near the city. The golden plover, green sandpiper and bar-tailed godwit are all winter migrants to the area, although the godwit is now only occasionally found in coastal habitats (Heinzel *et al.* 1972).

SEABIRDS

Five species of seabird contributed just seven fragments to the bird assemblage. All were dated to the fourteenth century or later. These may have been present as food resources, although Carew remarked that the gannet was unpalatable (Halliday 1953:121). The gannet, lesser black-back gull and kittiwake can still be found nesting on the rocky cliffs of the Devon coast. The black-throated diver, on the other hand, is not found in the area at all at present, although it is occasionally seen during the winter farther east along the coast (Heinzel *et al.* 1972).

PIGEONS AND DOVES

Only 29 fragments of domestic pigeon or its wild progenitor, *Columba livia*, were identified. A few fragments were found in all periods. Their sparse occurrence is rather surprising, since there are several references to dovecotes from at least the fourteenth century at Tavistock Abbey. The abbot's accounts occasionally refer to the sale of pigeons at a penny a pair. One of the manor's dovecotes is recorded as possessing 149 birds in 1356 (Finberg 1951:193). Pigeon was, however, only a rare addition to the diet in Exeter at this time and later. The relative of the pigeon, the stock dove, was represented by eighteen fragments. This gamebird is a relatively common resident in Devon nowadays, although Rodd, writing in the late nineteenth century, observed that the species was comparatively rare in the western counties, although large flocks were occasionally seen in winter (Rodd 1880:72). The stock dove is in fact still rather less common in Cornwall than in the rest of England. Six fragments of late thirteenth century date came from one immature individual. Finally the woodpigeon, which is now common, especially in areas of woodland, was represented by four fragments of bone, again indicating the unimportance of most gamebirds in the diet of the city dweller.

THE CROW FAMILY

The rarest of the four corvid species was the chough, which is now only resident in the British Isles in parts of Wales and Ireland. A skull dated to the fourteenth century was its only positive occurrence in the deposits. By the middle of the nineteenth century it seems that the numbers of this species were declining rapidly in Cornwall, where it was already considered to be rare. However, sixteenth century accounts refer to Cornwall as being the only county in England where the species was found. The evidence from Exeter would indicate that the species was also found in Devon in the Middle Ages. It appears that even in the early nineteenth century, several dozen choughs used to be shot in Cornwall and sent to Falmouth annually during the game season (Rodd 1880:62-3). The fact that a member of the crow family was considered as game even in the nineteenth century is interesting, since it may also explain the more common occurrence in Exeter of jackdaw (30 fragments) and rook/crow (fifteen fragments) in all periods of the deposits. Equally, however, these species could have been attracted to the city as scavengers, or simply killed as pests to the grain harvest. The most common member of the crow family found in the excavations was the raven, which contributed 91 fragments from a minimum of twenty individuals. 26 of those fragments came from one individual of Roman military date, a specimen which had suffered a trauma on its right tarsometatarsus that had partially healed before the bird eventually died. In the twelfth century phase, ten of the thirteen raven bones belonged to another partially preserved skeleton. All the nine fragments of late thirteenth century date, and all seven fragments of the late sixteenth and early seventeenth century phase also came from a single bird in each case. In all, over half the raven fragments recovered belonged to just four individuals. The presence of these skeletons would indicate that the raven was not normally regarded as a food resource. The rubbish dumps may have attracted it as a scavenger, but a more likely explanation is that ravens were often tamed as pets. The Romans are known to have taught some ravens to talk and indeed the species is found quite commonly on many Roman sites. At Portchester, 29 of the 378 bird fragments belonged to a minimum of eight ravens (Eastham 1975: 410). As already mentioned, the Roman fort at Longthorpe produced 39 raven fragments from four individuals in its sample of 115 bones. Fishbourne, however, only produced one raven bone out of a sample of 607 avian fragments (Eastham 1971:389). At Silchester it appears that raven was the second most commonly occurring bird species in the sample examined. It was suggested that the species was semi-domesticated on the site (Jones 1892:288). The evidence from Exeter would suggest that the practice of keeping tame ravens continued until the postmedieval period.

BIRDS OF PREY

Four species of bird of prey were recovered. Two partially surviving skeletons of sparrowhawk were found: one, a female, was found in a late twelfth century deposit, the other, a smaller male bird, was discovered in GS F. 228. Their presence is indicative of the practice of the sport of falconry. Richard Carew, in the late sixteenth century, was rather scathing about the sport; but it is clear from his comments that falconry was popular in Cornwall and Devon:

> 'As for the sparrowhawk, though she serve to fly a little above
> six weeks in the year, and that only at the partridge where the
> falconer and spaniels must also now and then spare her extraordinary
> assistance, yet both Cornish and Devonshire men employ so much
> travail in seeking, watching, taking, manning (taming), rizzling
> (rearing), dieting, curing, bathing, carrying and mewing (confining to mews while moulting) them as it must needs proceed from a greater
> folly that they cannot discern their folly therein.'
> (Halliday 1953:108).

The fragments of common buzzard and the barn owl could have been deposited as the remains of birds hunted and eaten as game, although they could have been chance finds. The discovery of an osprey's tibiotarsus in GS F. 228 was an interesting find; nowadays several pairs breed in northern Scotland but the species is not found elsewhere in Britain. Rodd, however, does record that the osprey was occasionally seen fishing in Cornish estuaries during its autumn migration during the nineteenth century (Rodd 1880:6). Carew, however, writing 300 years earlier, remarked that the meat of an osprey was not edible (Halliday 1953:121). Consequently, its presence in an Exeter pit is not easily explained.

PASSERINES AND OTHER SPECIES

All the species in this group appeared only occasionally in the deposits and in most cases, their presence is due to chance rather than any other factor. All the species except the cuckoo (summer visitor), fieldfare (winter visitor), and possibly starling, would have been resident the whole year round in the region. The thrush and the blackbird are known to have provided occasional sources of food but there is no evidence for or against this fact from the few remains in the Exeter deposits. The presence of skylark may reflect their exploitation for food. In 1536 or 1537, while negotiating the city's charter, Robert Tucker is said to have entertained certain gentlemen at a hostelry and the fare provided included two woodcock and a dozen larks (Youings 1974:23). Very few lark remains were discovered however and although their small size may preclude some recovery they seem never to have been a popular source of food.

SUMMARY: THE EXPLOITATION OF BIRDS

The avian remains revealed the total domination of the domestic fowl. It may have been the only poultry kept during the Roman period and was the only domestic species kept in large numbers throughout. The production of eggs would undoubtedly have been a factor in its exploitation, although it is uncertain how important this was. The feathers and fat of fowls (and geese) would also have had some value. There was no improvement in the size of domestic fowls in the Roman and medieval periods. Larger birds were reared in the postmedieval period, either as a result of the introduction of new breeds, or through innovations in poultry practice, or a combination of these two factors. Of the other domesticated species, the duck was only a rare addition to the table in most periods. If it was domesticated in the area, it must have been only in small numbers. The same applied to the goose in the Roman period, when it was rarely found in the deposits. It became a more common resource in the medieval period, reflecting the greater importance of domestic poultry at that time, although its numbers in the Exeter deposits are lower than on most other medieval sites. Despite the documentary evidence for the existence of dovecotes, the number of pigeons eaten was small in comparison to other domestic species.

The number of wild species of bird recovered indicates that a wide selection of game was available, but only the woodcock was consistently caught in any numbers. Sixteenth century documentary evidence suggests that the woodcock was a winter food resource and it is interesting to note that several other species of wildfowl found in the deposits are now only resident in the area during that time. The wildfowling season may have been restricted mainly to the winter months, when the game was most numerous and at a time possibly when less fresh meat was available from the more usual sources of cattle and sheep.

The richest deposits investigated, dated to the sixteenth and seventeenth centuries, produced the greatest variety of edible species of bird recovered. It is possible that increased wealth made a more varied diet possible. Normally, however, the proportion of wildfowl eaten was very small. The people relied on the stock species for their basic requirements and wildfowl rarely found their way to the table.

THE FISH REMAINS by M. Wilkinson

The material examined in this study is the same as in the main faunal report, with the addition of three samples from the Queen Street site which date to the latter part of the seventeenth century. Almost all of it was recovered by hand-sorting; the few sieved deposits contained little fish. While the importance of such techniques requires no further emphasis, the recovery rate appears to have been fairly high especially in the larger samples where material is naturally concentrated; this point is demonstrated by the presence of several species of smaller fishes (Table 102).

Identifications were based on comparative skeletal collections in Sheffield and at the British Museum (Natural History), and for this and other assistance I would like to thank Mr. Alwyne Wheeler. Generally such work has concentrated on the few elements most clearly diagnostic as to species but in this study an attempt has been made to recognise a larger range of bones. Some of these were only classifiable to genus or family level but using criteria such as size and colour of bone they could be assigned to the list of positively identified material. This less certain procedure has been adopted to look for evidence of the ways in which fish were processed and utilised.

Of course, a large proportion of the material remains unidentifiable. Many skeletal parts are spinous or plate-like which increases their likelihood of fragmentation and limits their range of diagnostic features. Species of fish differ greatly in the number of bones they possess but this is mostly due to variations in length of the backbone and fins, and so the number of bone types is reasonably constant. However, this list of elements is then distorted by varying preservation in the archaeological record and by their differing potential for identification. This makes it difficult to compare the representation of different parts of the skeleton both within and between species (see page 75), and to assess the importance of each species. For instance, the skeletons of the gurnards and the conger eel are sturdy, sufficiently distinctive that even small fragments can be recognised, and are the only species for which respectively fin spines and branchiostegals have been identified. Consequently, these fish could, in relative terms, be over-represented and this raises the problem of how the material can be quantified.

Bearing in mind these sorts of biases, measures of the quantity of bone, either by weight or number of pieces, seem inappropriate for anything except an order of magnitude of fish present (Table 101). It is perhaps worth making two further points about the quantity of bone. Firstly there is no correspondence between the amount of meat consumed and the amount of bone recovered, and this applies both to the parts of the body and to contrasts between species. The second point is to stress that this does not invalidate the collection of all material; for besides the problem of recognition of all identifiable pieces in the field, the unidentified part is a good reflection of the conditions of preservation and recovery. It is rather that simple bone counts do not convey these types of information.

A favoured approach in faunal studies generally is the calculation of minimum numbers of individuals. This seemed unsuitable here because of the small size of many of the units; this can produce an exaggeration of the role of minor species. Some calculations of numbers of individuals have been made, based primarily on the larger samples. Units could be combined of course, but this can only be based on a fuller understanding of their contexts and the processes of disposal; at present, it seems safer to treat each unit as an independent sample. The relative importance of the species has therefore been based on its presence in a sample; its position is thus a reflection of the number of the samples in which it occurs. All the available material was examined for this study; the results are based on those 179 units that have a firm date and contain fish remains that were positively identified.

ANALYSIS

The first stage of analysis is the identification of the elements and species present, and the quantification of this material. But the work can then be extended in a number of ways, four of which are considered below:

Reconstruction of fish size

The existence of a relationship between bone size and fish size is well known and has been discussed in detail by Casteel (1977). However, it is questionable whether such precision is necessary for many of the purposes to which the data will be put; rather, the need is for conversion tables based on easily replicable measurements on bones that can be positively identified and which survive well in the archaeological record. The measurements in this report are those used by Wheeler and Jones (1976:209-10), using dial calipers (and dividers for the smaller bones) accurate to 0.1 mm: dentary depth at the proximal edge of the foramen and the width at the base of the premaxillary processes. Their method meets the criteria outlined above and are the only measurements for which conversion tables have been published to date; by following them it is also hoped to standardise the results from British archaeological sites.

Measurements were made on the hake and all the gadoid species (cod, haddock, ling, pollack, whiting), but only the hake and whiting contain more than a few suitable bones. Histograms of hake premaxillae and dentaries (Figure 21) show similar unimodal distributions with the exception of one smaller premaxilla. Although no conversion table is yet available, these bones are estimated to come from large adult fish of between 50 and 100 cm and weighing several kg. The whiting measurements also form unimodal distributions (Figure 22), and on the basis of the Great Yarmouth material (Wheeler and Jones 1976:224), represent fish over a considerable size range averaging around 40 to 45 cm. Figures for the remaining species are given later in the report.

Age and season of death

The determination of the age of a fish is based for most temperate species on the reading of growth rings on bones and other hard parts of the body; the study of these annual rings has been the subject of extensive research, and is discussed and illustrated by Casteel (1977). In assessing the season of death the same technique is used, based on the amount of growth since the last annual ring. The method has considerable archaeological potential but was not applicable here because of the shortage of suitable material. The elements most commonly used are scales and otoliths, and very few of either were recovered during excavation. The scales were all incomplete and were not positively identified. Of the otoliths examined, two were from the conger eel, a species that has not been used in ageing studies; the other pieces — six complete and three fragments — were of the hake for which age determination is very difficult (Kennedy 1969:336). These were sectioned and examined but showed a complex pattern that could not be read.

Representation of skeletal elements

The numerous ways in which fish are processed are well-known but have attracted little detailed attention. One approach to this subject is to consider the proportions in which the various bones are represented and to interpret patterning as the result of different activities. It is clear that skeletal elements are rarely present in the ratios in which they occur in the body, but much of this can be explained by the processes affecting the material between deposition and the tabulation of results. These are both taphonomic and archaeological: preservation and fragmentation differentially affect the 'softer' bones while recovery and identification are biased toward the larger and more diagnostic pieces. A general pattern does emerge dominated by various sturdy and recognisable head bones like the jaws, much fewer elements of the cranium, and a tendency for the under-representation of the vertebral column particularly the caudal region. The exact pattern depends upon the species and there are notable exceptions such as the flat fishes, where the body elements (vertebrae, cleithra, pterygrophores, etc.) tend to exceed those of the head.

Its widespread occurrence suggests that this pattern is basically the result of post-depositional factors and only one species markedly diverges from it in the Exeter sample. In the case of the cod the most frequent elements, whether expressed as numbers of fragments or by numbers of individuals, are the postcranial cleithrum, supracleithrum and post-temporal which occur together in the region where the head and body join, and there are more caudal than precaudal vertebrae (Table 103). That this is a deliberate pattern is suggested by several lines of evidence. The cod skeleton is very similar to that of other gadoids which do follow the basic pattern here, as do the cod bones at other sites, e.g. medieval Lund (Ekman 1973:Table 3). Indeed this applies to the medieval cod at Exeter and only the postmedieval bones show this alternative pattern; and it is precisely these bones that display most signs of butchery marks, which further supports an explanation based on processing activities. These bones could well represent 'split fish' where the viscera, head and anterior part of the backbone have been removed to leave a solid body of meat.

Butchery marks

The prevalence of cut marks on the bones of cod has already been noted; they occur on two cleithra (ventral portions missing), a supracleithrum (dorsal extremity cut off) and at least 21 vertebrae. All these are precaudal and early caudal centra with the same pattern of cuts on their left side; the parapophyses and haemal arches are cut away together with part of the centrum in some instances. Similar marks occur on some other species; the cleithrum of a large pollack has several cuts on its dorsal part and eight precaudal centra of ling are identical to those of the cod. All these marks could be produced during the 'splitting' of a fish, an operation that was common for large roundfish that were to be preserved by salting and/or drying.

The remaining butchery marks fall into several groups and occur on various species. Cuts on the centra, which would be produced when chopping the body into lengths, have been found on single vertebrae of the salmon, hake, ling, haddock and sea bream. Those of the flat fishes have been treated in a different way and appear to show that such fish were not filleted as they are today. Two anterior caudal vertebrae of the turbot have part of the neural spine cut off while two other caudal centra of the same species together with one of a smaller species had been chopped into neural and haemal parts. A few head bones show possible cut-marks and there are two instances where the cranium appears to have been split open: the vomerine bloc of a conger has been split lengthways and the premaxilla of a gurnard has its first process cut off. These marks on the heads of various species might suggest that all parts of the fish were being utilised in some way.

FISH SPECIES REPRESENTED

In this section the species identified in the Exeter material are briefly discussed, together with a short account of their natural history which is based primarily on Wheeler (1969), with additional material from Kennedy (1969) the Plymouth Marina Fauna and the earlier naturalists. The species are listed in the order of their estimated importance.

The hake (Merluccius merluccius)

This species is closely related to the cod family (gadoid fishes) with a similar form and skeleton. It is a large elongated fish with a maximum length of 100 cm and weight of 4.5 kg. It occurs in most British waters but is most common off the south and west coasts where it was the object of a major fishery. There are records of large catches, including 1,000 taken on lines in one night by six men in Waterford Bay. It is a relatively deepwater fish, especially during the winter (over 150 m) but enters shallower waters in summer-autumn to feed. The fishery for this species is based on lines and trawls. Opinions vary as to the quality of its flesh but its suitability for salting and drying has made it popular. There are references to large quantities being preserved in the nineteenth century, with some of it exported to the Mediterranean.

The skeleton of the hake resembles that of the cod family but most elements can be readily distinguished including the vertebrae. The dentition is distinctive and the jaw bones are among the best preserved bones. All the fish represented are quite large and so the fishery was presumably based on the inshore migrations of the mature fish during the summer months. It is easily the most common species represented.

Conger eel (Conger conger)

A common fish on most British coasts including the south-west occupying rocky ground from the shore to considerable depths. It reaches a large size especially in deep water although fish of 122 cm have been taken from the shore. It is caught mainly on lines and its flesh is firm and good though not always esteemed; there are references to considerable quantities being dried and exported in the past.

Most of the skeleton is solid and easily identified, and so this species may be over-represented in relation to others. Based on the number of samples it is undoubtedly the second species although its importance is reduced in terms of numbers of individuals as no more than a couple are present in any sample. All sizes of fish are represented.

Whiting (Merlangius merlangus)

One of the smaller gadoids, averaging 35 to 45 cm (1.5 kg) though it can grow up to 70 cm (2.7 kg). It is an inshore species most common in 30 to 100 m of water, shoals are common in shallow waters over soft ground in winter, moving into slightly deeper water for spawning in the spring-summer months. It is caught on lines and in nets: the flesh is good but delicate although some was preserved.

This is numerically the most common gadoid. A wide size range is present, averaging 40 to 45 cm but reaching sizes well above this. The skeleton is quite similar to that of the cod, although some bones are quite distinct; the remainder were segregated by size.

Cod (Gadus morhua)

The most familiar of the gadoids, the cod is found in all British waters but is less common on the south coast; it is recorded as occasional at Plymouth. In British waters the larger fish enter relatively shallow water over winter then move offshore for spawning in spring. It is a large species, reaching 150 cm (40 kg) though more usually 5 to 15 kg, and is caught with nets and lines. The flesh is firm and good, and preserves well; the cod also provides liver oil, roes, etc.

All the fish represented are large although the few measured bones lie at the upper end of the size range present; the estimated sizes are based on Wheeler and Jones (1976:214). The only medieval measurement is from a fish of about 97 cm (premaxilla 15.8) while the postmedieval material covers the range 87 to 107 cm (prem. 14.9, 17.4 mm: dentary 9.8, 10.3, 10.8 mm).

Small flatfish

The only species of small flatfish positively identified is the plaice (*Pleuronectes platessa*), based on jawbones, although it is likely that others are present. The bones of flatfish are relatively common, especially those of the body region (vertebrae, first anal pterygrophores, cleithra). Most come from fish equivalent to small to medium plaice although a couple are somewhat larger.

The plaice is a very common fish in British waters, occupying shallow inshore waters on sandy grounds. It congregates for spawning in spring and then moves into shallow waters to feed over summer, working out into greater depths (to 120 m) for winter. The plaice dominates the flatfish fishery; it is common, reaches a suitable size (generally 50 cm; occasional specimens 90 cm) and its flesh is good. It is mostly taken by trawl and seine, though it will take a hook.

Sea Breams (Sparidae)

These are warmwater fishes only found in any numbers on southwest coasts. There has been much confusion between species, with dentition a major distinguishing feature (Kennedy 1969:95). The jaw bones are large and solid, and from them three species have been identified here.

Gilthead (Sparus aurata)

A large fish (up to 70 cm) but infrequent in British waters.

Red Sea Bream (Pagellus bogaraveo)

This is the commonest species and, is at times, quite frequent in the south and west. It inhabits moderately deep water, making an inshore migration over summer. It reaches 50 cm.

Pandora (Pagellus erythrinus)

A rare visitor, this is a shallow, inshore species that reaches 30 and occasionally 50 cm.

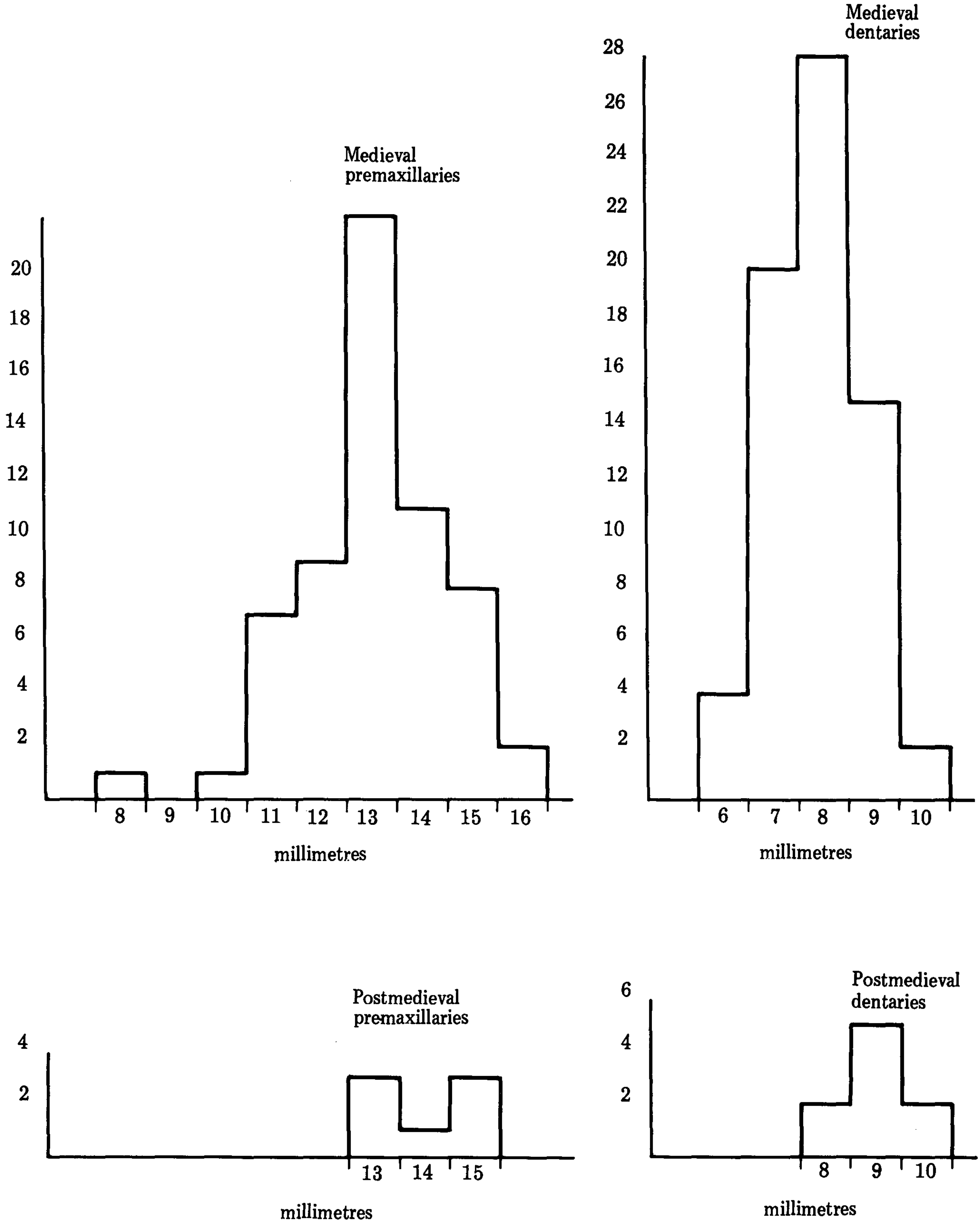

Figure 21 Size frequencies of premaxillary and dentary bones of hake.

Gurnards (Triglidae)

These are small distinctive fishes with a large head covered with sculptured bony plates; this sculpturing occurs on most bones so even tiny fragments are recognisable. They are common in British waters and the four main species have been identified.

Grey gurnard (Eutrigla gurnardus)

The most widespread species, it is found close inshore during summer months moving into somewhat deeper water for winter. Reaches 40 cm.

Red gurnard (Aspitrigla cuculus)

This is reported as the most common species at Plymouth, found on all types of ground but not so close inshore as *Eutrigla* (20 m and more). Grows to 30 cm.

Tub gurnard (Trigla lucerna)

The largest gurnard, (reaching 60 cm). It is fairly common and occurs in the same waters as *Eutrigla*.

Piper (Trigla lyra)

Seems uncommon, but this may be because it is a

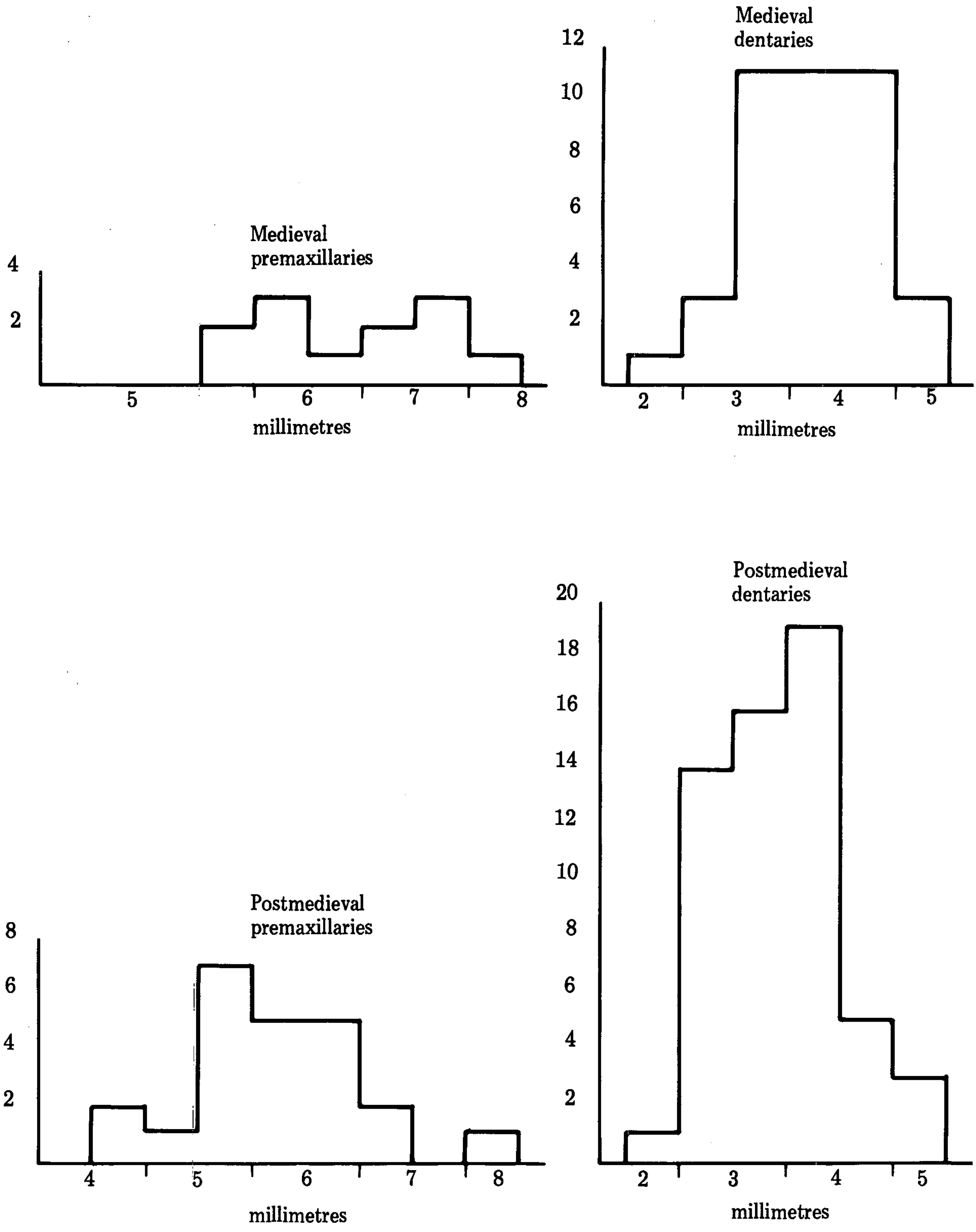

Figure 22 Size frequencies of premaxillary and dentary bones of whiting.

deepwater fish occupying depths of 300 m plus. In British waters it is mainly taken off the southwest coast. Grows to 46 cm.

Ling (Molva molva)

One of the largest gadoids, it reaches 200 cm (32 kg) though most are much smaller. It is found all around Britain but is most common in northern waters. A deep-water species, preferring 300 to 400 m, but occasionally in shallower waters; it lives on the bottom and does not shoal. It is caught on lines and in trawls. The flesh is good and preserves very well; there used to be an extensive trade in dried ling.

All of the ling are large; the measured bones (all post-medieval) include a premaxilla (12.8 mm) and two dentaries (12.5, 13.7 mm).

Bass (Dicentrarchus labrax)

A fairly common fish, particularly in the south and west. There is a marked inshore migration during summer with many fish attracted to estuaries. It can reach 100 cm (9 kg). Taken in nets and on lines.

Haddock (Melanogrammus aeglefinus)

A small gadoid, that can reach 80 cm (2.7 kg) and more. Enters inshore waters over winter then moves offshore for spawning and summer feeding. Caught by nets and lines, its flesh is good and preserves well.

Most easily recognised by the cleithrum, though most other bones are also identifiable. All the fish are small to medium (40 to 50 cm); the dentary measurements (postmedieval) all fall within the range 2.7 to 3.0 mm.

Pollack (Pollachius pollachius)

An inshore species found over rocky ground; young fish are found on the coast while the larger fish frequent inshore reefs during summer returning to deeper water over winter. Generally a solitary fish, it is caught by trawls and lines; it is most common to the south and west of Britain, where it also attains the greatest size. Size varies between localities but it does reach over 75 cm (10kg). The flesh is not generally regarded, but is suitable for salting and drying.

The skeleton is quite similar to the cod, with dentition providing the clearest distinction. All sizes of fish are represented; premaxilla (medieval) 14.4 mm, dentary (postmedieval) 3.1, (medieval) 3.8 mm.

Scad (Trachurus trachurus)

This resembles the mackerel but is slightly larger, reaching 40 cm (1.5 kg). It is only common in the southwest but even here it is not sufficiently regular to support a fishery. Shoals appear close inshore during summer, retiring to deeper water over winter.Generally regarded as a coarse fish; there are references to it being salted.

Wrasses (Labridae)

These are shore fishes, common on rocky ground especially during summer. Four species are included in the Plymouth fauna, of which the largest is the ballan wrasse *Labrus bergylta* (50 cm). The majority of bones could belong to this species but at least one other is also present. Their flesh is soft and little regarded, apart from a reference to large quantities preserved in the west of Ireland.

Salmon (Salmo salar)

This genus also includes the freshwater brown trout and migratory sea trout; the identification of salmon is based on the large size of some of the vertebrae. It is an anadromous fish,spending much of its life in the sea but entering freshwater to spawn. While it can be caught at all times, fishing effort is concentrated on this upstream migration using traps, nets, etc. The river Exe is a noted salmon river, with the other species also present (Beale 1969:91).

Turbot (Scophthalmus maximus)

One of the largest flatfish this can reach 100 cm. It is found in inshore waters, of less than 80 m, over sand-gravel bottoms. Most common on southwest coasts where it forms an important part of the trawl fishery; it is also taken on lines. As a food fish it ranks as a prime species.

Dory (Zeus faber)

Relatively frequent, especially in the southwest; it inhabits inshore waters to a depth of 200 m coming close to the coast in summer. It is a solitary fish, only taken in any numbers by trawls. It is a very highly regarded fish, reaching an average size of 66 cm (5 kg).

Herring (Clupea harengus)

Once common in all British waters appearing inshore at various times of the year. In the southwest they come close inshore in autumn, spawn in winter, then move away from the coast in summer. It occurs in large shoals near the surface and is mainly taken by surface nets. It is a very popular food fish and huge quantities are preserved (salted and smoked).

Mackerel (Scomber scombrus)

Second to the herring among pelagic species, this also forms huge shoals that approach the coast in summer retiring to deeper water over winter. It is taken mainly by nets, but also on lines. The flesh is good but deteriorates unless it is preserved.

Thornback Ray (Raja clavata)

Only one species of cartilaginous fish has been identified; this may be biased as the bucklers of the thornback are much larger than the denticles and teeth of other species. It is the commonest ray in shallow waters (2 to 60 m), and is fairly sedentary although in the English Channel a winter inshore migration occurs. It is also the best-flavoured of the rays and was frequently salted and dried. Commonly taken in trawls, and also on lines.

Eel (Anguilla anguilla)

Spends most of its life in freshwater, and estuaries and shallows, but returns to the sea to spawn. It is caught at all stages of its life, from the initial upstream migration of elvers in spring, in freshwater (yellow eel) and during the downstream migration (silver eel). Its flesh is fatty and well regarded; large quantities are smoked.

Tunny (Thunnus sp.)

Two very large maxillae may belong to this genus. The tunny is a large pelagic fish, that is a southern visitor to British waters; off southwestern coasts shoals of smaller fish are not uncommon.

INTERPRETATION

One of the most important features of the Exeter material is the timespan it covers and the opportunity this provides to compare periods. To ensure that samples are large enough the material has only been broken down into the three periods, although the evidence of the phases will be considered later. This is not, however, a prejudgement on whether the division is valid in terms of the development of fishing; but the separation of Roman and medieval can be justified by the gap of five centuries between them, and there are differences visible between the medieval and postmedieval material.

Roman

This is the least adequate sample, with identifiable fish present in only 18 units; all are small with one to five bones. This paucity in comparison with later periods suggests that fish were considerably less important at this time; differences in preservation could be involved although this is doubtful as the surviving material is in good condition and covers the range of size and type of bone. But the presence of at least ten species of fish indicates a diversity even if not a great quantity of fishing.

The species list does not differ markedly from later periods; hake is the most common, and there are bones of conger, whiting, and a large gadoid (cod or pollack). The 'middle order' species like the sea breams, gurnards and wrasses, are present as is one bone of the turbot. Two species do stand out as being more common at this time than generally (salmon and bass) and so it could be significant that they can both be caught in estuaries during the summer. This evidence agrees with that from other sites in suggesting that fishing at this time was based on the hook and line in inshore and deeper waters together with surface nets and inshore traps.

Medieval

With identifiable fish present in 113 units, this period possesses the most fish. The number of species present is double that of the Roman period which can be taken to indicate considerable developments in fishing during the intervening centuries. The new species include several gadoids (cod, ling, pollack, haddock), various gurnards and sea breams, plaice, scad, eel and the only traces of cartilaginous fish (thornback ray). However, the medieval fishery is clearly dominated by the hake; it occurs in 79 units, with up to nine individuals in a unit and there are often many bones of each fish present. The conger is also common (61 units) but there are never more than one or two fish per unit. Other common species include whiting, cod, sea bream, and plaice. The scad and pollack are more common in this period than in the postmedieval. So the medieval fishery appears to be similar in technique to that of the Roman period; the emphasis is on line fishing in shallow and deeper waters with surface nets and river/estuarine 'traps'.

Postmedieval

This period is marked by the appearance of three new species. The herring and mackerel are the most common pelagic fishes in British waters and are mostly fished for with surface nets although mackerel are also taken on lines. The other species is the dory which is fairly common but not caught in great quantities; its solitary life means that it is generally caught when trawling for other species. Upon closer examination there are other differences from the medieval period. Several of the gadoids are more common; haddock and ling occur in more postmedieval units while there are more individuals of cod and whiting. At the same time conger and hake decline in importance; the conger occurs in only one quarter of the units while the hake drops markedly in numbers of individuals. This is visible in the number of measured bones (Figure 21) and in the number of individuals per unit; from a maximum figure of nine it has fallen to two with one exception in the postmedieval, while the whiting shows the reverse going from three up to fifteen individuals. The appearance of the new species may not be very significant as all have been found at other sites in earlier periods including the medieval site of Okehampton Castle (Wilkinson *forthcoming*), but there is a clear change in the emphasis of the fishery.

A comparison between the sizes of fish caught in the medieval periods and postmedieval periods is hampered by the numbers of measured bones, and must be restricted to two species: whiting and hake. The size range of whiting appears to be the same for both periods, especially for the larger sample of premaxillae, but with a smaller average size in the postmedieval (Figure 22). It is interesting to note that histograms similar to that of the medieval premaxillae are given by the whiting from medieval Great Yarmouth (Wheeler and Jones 1976: Table 20) and from Okehampton Castle. The postmedieval sample of hake is too small for firm conclusions to be drawn from a comparison with the medieval sizes, but all the measurements on premaxillae and dentaries do lie in the upper half of the range. So for both species the overall size range remains the same but there is an apparent shift in the preferred sizes within it. If either of these patterns are real and not just the result of sampling bias, then there are several possible explanations; but until further data are available this point should not be pressed further.

The evidence from the archaeological material can be enhanced by looking at the historical records for the medieval and postmedieval periods. In general terms, fish was undoubtedly an important part of the diet and the great majority of it was consumed in a preserved form. Most species could be pickled, smoked or dried, and while cod and herring may have been the most important, a wide range of others was exploited. The fishing industry was very different from the centralised capital intensive industry of the nineteenth to twentieth centuries; most coastal villages supported fishing craft, often as a seasonal occupation, and while much was consumed locally there was considerable trade in fish inland, to large population centres and for export.

For the southwest of England there is a considerable amount known (Hoskins 1954) and its fishing industry can be described under three headings. The freshwater fishery was obviously dominated by salmon and references from the eleventh century onwards show that the river Exe was the most prolific river in south Devon; this is emphasised by the paucity of the remaining indigenous fish fauna (Beale 1969: 92). The coastal waters of the southwest have always been very rich in fish and the location for major fisheries. Their particular richness is derived from the addition of 'southern' species to the fauna, particularly several important pelagic fishes (herring, pilchard, mackerel, and so on). Though Exeter and its local villages were never as important as some other centres, like Brixham and Plymouth, fishing was still an important industry. Herring and pilchard formed the largest single-species fisheries, but a large number of fishes was exploited as a petition of 1578 makes clear: 'divers kinds of sea fishes, as congers, hakes, pilchards, skates, rays, thornebags, papillons and dogs being necessary victuals for the people of this realm.' (Cutting 1955:81). This petition complained that the export of these fish was against the interests of the local people, suggesting that the trade must have been considerable and there are references to the export of pilchards and hake from Exeter and Plymouth from at least the fifteenth century.

The third kind of fishery was that carried on in distant waters. The participation of Exeter and other southwestern ports in this really began in the seventeenth century as England assumed the dominant position in the cod fishery off Newfoundland (Innis 1940). The cod were salted and dried, then brought back to England originally for home consumption but soon developing into an export trade to Mediterranean countries and eventually the fish were taken directly to these markets. This trade was dominated by ports in the southwest, together with London and Bristol, and Exeter became its leading centre in the latter part of the seventeenth century (Stephens 1958).

Certain features of the archaeological material could be explained within this historical framework, particularly the changes in the representation of cod. The increase in numbers of cod together with the possibility of 'split fish' in the postmedieval period could be interpreted as coming from the distant water fisheries. The fall in hake at the same time could reflect its replacement by this cod, as was suggested by Couch (1878:101). One point that does emerge from the historical record is the great importance of the surface fisheries for herring and pilchard in Devon from medieval times, but this is not reflected in the archaeological material; herring only appears in the sixteenth century and there is no trace of pilchard. Part of the explanation could be that Exeter may not have been a major centre for this fishery although deficiencies in the archaeological record may also be involved. The bones of these species are both small and delicate so good recovery is necessary to find them. It is therefore not coincidental that the majority of herring bones come from the most recently excavated samples, both of which happen to be postmedieval.

On a broader level it is possible to consider the adequacy of the Exeter material in terms of two sampling strategies; large individual samples or a large number of samples. Almost all of the units containing more than a few bones are multi-species, which has interest for the way the fish were processed and disposed of, and suggests that the larger the sample the more species it will contain. This is likely to be exaggerated by hand-sorting for where material is most concentrated recovery, especially of the smaller elements, is likely to be enhanced. Large samples also have the advantage of containing several bones per fish making it possible to consider the different presence of parts of the body.

The evidence given by single large samples can be compared with that produced by the second strategy, of sampling a number of units. This produces a similar species list, with only the smaller fish not recorded; this would be avoided by finer recovery methods although a greater volume of matrix would need to be processed than for single concentrated samples. But as a measure of the frequency of species it can differ considerably from the other line of evidence. This is clearly visible in the case of the hake; it occurs in the same proportion of the postmedieval units as in the medieval period (30:48 and 79:113 respectively) (Table 104) which suggests an equivalent importance, but in the larger units the number of individuals present falls considerably, challenging its dominant position.

It is also possible to make some suggestions on the amount of material required for an adequate sample using the data in Table 104. If the number of species in a phase is plotted against the number of units there is a clear linear relationship at least up to ten units. Thereafter there is a much greater spread which means that there is not necessarily an adequate return on the time spent analysing additional units. It also suggests that ten or more units should be taken as the minimum number to make up an adequate phase sample. This would obviously exclude the majority of phases and could demonstrate that the medieval-postmedieval division is an illusory one. The overall differences between these two periods were considered earlier, but these revolve largely around the two largest phases in each period: Md2 (1100-1200) and Md6 (1250-1300), and Pm1 (1500-1600) and Pm4 (1660-1800). So the developments that do take place between them could lie anywhere within the fourteenth and fifteenth centuries.

SUMMARY: THE EXPLOITATION OF FISH

This report has tried to demonstrate that much can be understood from the detailed examination of large samples like the Exeter material. But it has also tried to show that it is a complex subject where several alternative explanations can be applied to any data. To emphasise this, one aspect that has not been considered can be mentioned: the problem of context. This can be used to study the location and nature of activities together with disposal patterns, but variations in context can also seriously distort results. For instance, the small quantity of fish in the Roman period has already been discussed and although it was described as a diverse fishery, the presence of ten species in eighteen samples is a much lower figure than for any later phases. However, this takes no account of context for while the medieval and postmedieval material comes mainly from pits, the Roman sample is spread between a variety of features some of which may be too small to contain much bone (post holes) or too large for detailed recovery (ditch). Therefore the Roman fishery should not be directly compared with the material for the two later periods.

Nevertheless, there is an increase in the importance of fish between Roman and medieval period, apparent both in the number of fragments (Table 101) and the range of species (Table 102). The fish bones never exceed 1.34% of the identifiable remains in the Roman phases, but this rises to 5.88% to 25.26% in the later periods. This large variation in the medieval and postmedieval phases is due to the presence of some very rich deposits in certain phases; for example GS II F. 614 contained 1,007 fish bones in its 1,725 identifiable fragments and GS III F. 228 contained 789 fish fragments in its total of 2,719. The increase in the consumption of fish can be related to changes in diet, including the Christian practice of eating fish on Fridays. and to the intensification of fishing effort, both in local waters and later on in more distant grounds. In terms of the overall diet, fish was never a major food source, but it was eaten in large quantities in these later periods and Exeter possessed a fish market from at least the sixteenth century.

8.

CONCLUSION : EXETER'S ROLE IN ANIMAL HUSBANDRY

The preceding chapters have considered in detail the relative numbers of the different species represented in Exeter and have closely examined the exploitation pattern of each of the species encountered. It remains in this concluding chapter to draw together the strands of evidence, in order to consider in more general terms the agricultural economy practised in the area around Exeter and the influence the urban population had upon farming policy. It also remains to summarise the information that the archaeological material has provided and to compare it with some of the published documentary evidence. It is not intended to present a detailed examination of the historical records but to give some idea of the present state of knowledge of both the archaeological and documentary data as an aid to future research. At the same time it is hoped that the present case study from Exeter can offer some help in tackling the problems faced by archaeozoologists on urban samples in general.

MEAT PRODUCTION

The vast majority of the bone fragments recovered from the Exeter excavations belonged to animals butchered for meat. Although at least two primary butchery areas were discovered in the Roman deposits, in which many waste bones of cattle were discarded, the faunal material in most deposits consisted principally of domestic refuse dumped with other rubbish into the features.

Chapter 2 dealt at length with the problems of assessing the relative importance of the animals discovered in the deposits. Statistical analysis demonstrated that the proportions of the types of bone represented were subject to much lateral variation. Although it is a fact that those variations did not necessarily alter the relative percentages obtained for the animals in the samples involved, on statistical grounds many of these samples should not be directly compared. As a result, conclusions about the trends and fluctuations in the amount of meat provided by each species are of a somewhat limited nature. Such a cautious approach is necessary because it is wrong simply to assume that the relative number of animals represented in the various samples are unaffected by the observed fluctuations in their constituent parts. Nevertheless, several conclusions can still be drawn. The most obvious of these is that the principal farmyard stock — cattle, sheep, goats, pigs and poultry — provided the vast majority of the meat eaten in the city. Deer, hare, rabbit and gamebirds were only rare additions to the diet. The relative importance of beef, mutton and pork is impossible to calculate in absolute terms, although it seems that cattle throughout provided well over half the meat eaten. Changes in the relative popularity of these meats undoubtedly took place, although the conclusions about the trends and fluctuations are complicated by the amounts of lateral variation encountered and by changes in marketing practice. Despite these problems there are indications that cattle may have become more important to Exeter's meat consumption in the late Roman period. Bones of this species were certainly found in greater abundance in several of the fourth century samples (Phase R8). These may be atypical, however, and several were too small for detailed analysis. A broader base of material from other parts of the Roman town is needed to confirm that such a change took place.

Unfortunately direct comparisons between the Roman and medieval samples proved impossible, employing the usual methods of quantitative analysis, since the contents of the cattle samples changed significantly. Consequently, although the relative percentages of animals represented were similar, it is not certain whether this is a true representation of long term stability in the meat diet. It was possible to compare some of the Roman and medieval sheep/goat and pig samples and these indicated that pig became less important in the latter period, although the change was not dramatic. The medieval deposits examined have the disadvantage of being located in just one area of the city. The animal bone refuse contained in them may not have been typical of the rest of Exeter. The large body of material of twelfth and thirteenth century date did, however, produce a relatively stable picture. There were no dramatic changes in the relative numbers of the principal stock represented in this period. The fourteenth century deposits showed an increase in sheep/goat and a corresponding decline in pig, although the sample from these deposits was too small to be reliable.

It is not until the sixteenth century that a larger sample is available for comparison and by then there had been a significant change in the marketing of meat within the town. This in turn resulted in changes in the proportions of the different types of bone represented in the samples. In general, good meat bones increased in quantity at the expense of skull and jaw fragments, which decreased markedly from their previous levels. In these samples sheep/goat fragments increased in abundance and pig declined to very low levels. The changes in the contents of the samples, however, made direct comparisons between the medieval and and postmedieval periods impossible. Indeed, the main conclusion of the quantitative analysis is that the relative importance of animals in the urban meat diet cannot be reliably estimated by employing a simple count of fragments or by using the minimum numbers method, unless it is certain that a representative sample has been taken. The same problems confound the estimations of the proportion of animals by weighing fragments. This method, like the others, does not take into account the variations between the types of bone represented in different phases and on different sites. Comparisons of individual bone elements of species may be more productive, although caution must again be applied. It is impossible, for example, to compare the representation of mandibles in the medieval and postmedieval samples, since it is clear that many of the jaws of older cattle and sheep/goat were not disposed of with domestic rubbish in the latter period, whereas this had been the case more often in the medieval period. A similar difficulty faces anyone making direct comparisons with the number of meat bone fragments represented. Pig humeri and femora fragments can be compared with those of sheep/goat in the medieval and postmedieval periods and it can be seen that they declined in quantity in the latter period. This may be a reflection of the increased importance of lamb and mutton in the diet but other factors are worth consideration. The age structure of sheep/goat changed in the postmedieval deposits and a much higher percentage of the long bones belonged to mature individuals. These had a better chance of survival than the more fragile immature specimens that comprised a large proportion of the medieval sheep/goat assemblages. The factors that influence the relative number of animals represented on an archaeological site are often complex and require a greater depth of study than simple quantitative analysis allows. The development of multivariate techniques on large samples of animal bones is essential before urban faunal assemblages can be fully understood. These must be designed to assess the contributions of differential preservation, recovery techniques, changes in exploitation and marketing of animals and butchery techniques. Only then will the fundamental question about the meat diets of the inhabitants of a town be answered satisfactorily.

Of the major stock animals, the pig was the most intensively exploited for its meat, judging by the high rate of juvenile mortalities that prevailed throughout. Since pigs have little value except for their skins and carcases, such a high exploitation of young animals is to be expected, especially as the reproduction rate of the pig is very high and the species can therefore tolerate high rates of slaughter. Sucking pig, a popular dish in Italy during Roman times according to Roman authors (White 1970:318-20), seems to have been fairly common in Roman Exeter. Perhaps there is an indication that the Roman presence had some bearing on the slaughter pattern. Certainly the percentage of animals killed under one year old did not rise as high again until the sixteenth century, when probably the more efficient system of sty husbandry had largely replaced the practice of allowing swine to find pannage in the woods and forests. Sty husbandry made it easier to fatten up animals quickly for early slaughter. The fattening of pigs on the surplus whey at the dairy also became common in the postmedieval period and enabled a more intensive exploitation to take place.

In the same way, lamb was quite popular in all periods of Exeter's history. In general, the proportion of young sheep was very high in both the Roman and medieval periods. If the ageing estimates of dental development are an accurate indication of the true age of the animals involved, over 50% of the sheep eaten in the city during the Roman and early medieval periods were under two years of age. According to the fusion data, generally over 70% of the animals represented were not fully mature, a figure not far short of the percentage of immature pigs discovered. For reasons stated in Chapter 4, the reproduction rate of sheep would be insufficient to maintain the levels of stock, given this high rate of immature mortalities. In that case it would appear that the demand for younger and more tender meat in the city had precluded much of the older breeding stock from finding a market in the town. Even allowing for a substantially slower rate of tooth development, the number of immature animals found in the city indicates that a large proportion of the stock was raised principally to supply meat to the urban population. The culling of barren ewes and other sheep considered unsuitable for wool production or breeding and milking purposes may well have had a considerable bearing on the town's meat supply. The emphasis changed in the postmedieval period when, apart from lambs slaughtered under one year of age, the fusion evidence indicates that mutton from older animals had become much more popular, due primarily to the importance of the cloth industry, which encouraged sheep farmers to concentrate principally on wool production and allow many more of their flocks to attain maturity.

Cattle, although providing the most meat, were not bred specifically for that purpose in the Roman and medieval periods. During the first two centuries of Roman occupation, well over half the animals eaten in Exeter had reached maturity, in order that they might provide dairy produce, breed and work as draught animals. In the fourth century there is perhaps evidence that more adolescent cattle were slaughtered in the town, suggesting that beef production had become more important. Even so, the percentage of mature individuals remained much higher than that of other stock. The medieval period saw a continuation in this policy. The number of immature animals did slowly increase during the Middle Ages, which again may evidence a growing demand for beef. However, although the tooth wear analysis indicated that very few of the animals eaten in the city were very old individuals, many would have been old enough to have worked in the plough teams before they were fattened up for slaughter.

Veal did not become popular until possibly as late as the sixteenth century. The demand for this commodity and for beef at this time seems to have resulted in a national shortage of store animals and the necessity to import cattle from Ireland. In Devon, cattle still provided the traction power for the ploughs but also had to provide meat for the rapidly increasing urban population of Exeter and other centres. The high percentage of immature animals recovered from the postmedieval Exeter deposits was not typical of the mortality rates of the whole cattle population. These animals had been bred only for the urban meat market. The breeding stock, dairy and working animals found much less of a market, if the excavated sample is typical of the rest of the city.

The domestic fowl was by far the most common poultry eaten in Exeter, but in terms of meat weight, it would have been of relatively little importance in comparison with the much larger stock animals although the possible importance of eggs as a food resource should not be overlooked. From the early medieval period, domestic goose also began to be a common food resource.

How great a part fish played in the overall diet is difficult to say, since the small size and fragility of their bones has given them less chance of survival and recovery. However, fish do appear to have become more important in the medieval and postmedieval periods than in Roman times, when they were rarely found. The reasons for their increased popularity could be twofold: the Christian custom of eating fish alone on a Friday would have increased the demand and secondly, the development of inland fisheries from at least the eleventh century and the advent of deep sea fishing in the later Middle Ages would have increased the supply. Nonetheless, compared with the principal stock animals, fish meat was only a relatively small supplement to the diet.

The analysis of the faunal material from Exeter has demonstrated that the assumption that the stock animals represented on an archaeological site are a cross-section of the total stock population of an area can be misleading. It seems likely, for example, that the sheep slaughtered in the city during the Roman and medieval periods did not include many of the animals kept for breeding and milking purposes. Moreover, the predominance of young cattle bones in the postmedieval period also suggests that the urban market favoured only one section of the cattle population. The lack of many very mature cattle in the earlier periods may indicate that the oldest working animals did not find a market in the city. It appears that throughout historic times farmers around Exeter raised a considerable proportion of their stock principally for consumption by the urban population. One can therefore formulate a hypothesis that the animals slaughtered in Exeter consisted of a higher proportion of those raised solely for meat than those slaughtered in rural areas. Older stock, whose meat was tougher, may not have fetched as high a price and therefore fewer were brought for sale in the city's markets. If so, the existence of selective markets for the urban population played a significant role in farming policy throughout that time. Unfortunately no rural sites in the surrounding area have as yet produced faunal material. Many of the sites are located on soils that preclude the survival of animal bones. Meanwhile it cannot be assumed that the faunal samples from urban and rural sites are a simple representation of stock-keeping in the area of the sites. It is abundantly clear from the Exeter sample that, at least in the case of complex urban sites, it is quite wrong to make such an assumption.

DAIRY PRODUCTION

Cows, ewes and goats can all provide milk for human consumption. It is logical to assume that, if milk production was an important factor in the exploitation of a particular species, a large number of females of that species would be allowed to reach a comparatively old age. In the Roman period, the ageing evidence and possibly the metrical analysis of the metacarpi suggest that a large number of cows were allowed to reach maturity and that steers were more likely to be culled at a young age. This system allowed the mature cows to breed and perpetuate the stock but whether the evidence also implies that they were kept for their dairy produce as well is uncertain.

It is difficult to assess the importance of dairy cattle in the medieval period too, for, although dairy farms are mentioned as present on many manors (Postan 1973:255) and many villagers in England kept one or two cows (Miller and Hatcher 1978:97, 153), there is some documentary evidence to indicate that cows were of relatively little importance as a dairy animal. Domesday Book records few *vaccae* in Devon and it has to be assumed that many cows were included in the numbers in the plough teams. Detailed analysis of the accounts of Tavistock Abbey suggests that many more ewes than cows were kept as milk producers on the estates in the fourteenth century. On the abbot's manor of Hurdwick, for example, the accounts of 1332 record the production of 48½ stones of cheese from 69 ewes but only seven cows. On the same manor in 1347, 58 stones of cheese were made from the milk of three cows and 80 ewes (Finberg 1951:138-143). If the Tavistock records are characteristic of the rest of Devon (and there is no evidence that they are), many adult ewes provided milk for cheese whereas only a few cows did so.

The situation regarding goats is problematical. Those referred to in Domesday were described as 'she-goats', perhaps implying that the species was most important for breeding and milking. On the other hand, what medieval documentary evidence there is suggests that goats were not kept in large numbers in Devon and the potential amount of dairy produce to be obtained from them would have been low in comparison with ewes and cows.

Large-scale dairy farming increased greatly in the postmedieval period, whereas the milking of ewes declined in importance (Bowden 1962:13). In the seventeenth century England had a profitable export trade in dairy produce to western Europe based on surplus cow milk (Thirsk 1976:75). By the beginning of the nineteenth century, a substantial area around London was given over to the pasturing of dairy cattle to provide the capital with milk (Bull 1956:28). Devon was no exception in this development as eighteenth century writers show (Marshall 1796:vol.I 248; Fraser 1794:32). The appearance of calf bones in large quantities in the Exeter deposits during this period is indirect evidence of the importance of the dairy industry. Many calves were fattened in the dairy to provide veal and rennet from the calves' stomachs was an essential ingredient in the manufacture of cheese. Veal, therefore, was a natural supplement of dairying.

It is hard to estimate the importance of dairying in the economy. The difficulties of transport would have hindered milk being brought from the farm to the town, although pedlars hawked it in towns by the seventeenth century (Thirsk 1976:75). Cheese and butter, on the other hand, would have been commodities that were easier to transport and sell. It does seem from medieval documentary evidence, however, that the yields of milk from cows and ewes were low. On the Tavistock manors in the fourteenth century, a cow was expected to yield only 32 lb of cheese with butter in proportion (Finberg 1951:243). This would have been a very low figure, if it was obtained from a cow exploited for the whole milking season. Low milk yields appear to have been a feature of medieval agriculture (Miller and Hatcher 1978:217). The advent of specialisation in dairy production in postmedieval times saw an increase in production. By the early nineteenth century cows in Devon were expected to produce enough milk to make 140 lb of cheese and 206 lb of butter (Finberg 1951:243).

The exploitation of animals for their milk is therefore well documented in the medieval and postmedieval periods. It was, however, essentially a rural practice throughout and its importance is not reflected in the animals brought to Exeter. Indeed ageing evidence has shown that there is a likelihood that many older ewes did not find a market in the town in medieval times and the dairy cattle of postmedieval times are under-represented in the assemblages examined to date. This is again a warning that urban centres did not stand in isolation. Their influence on the agricultural economy cannot be evaluated without comparison with the evidence of rural sites.

WOOL PRODUCTION

Aspects of wool production have been discussed in detail in Chapter 4 (pages 43-48). To summarise the conclusions drawn there, it is clear from the documentary evidence that the exploitation of sheep for wool was of great importance in Devon from the late medieval period onwards and the mortality data from Exeter broadly support this. The earlier flimsy documentary evidence and the more abundant archaeological evidence indicate that wool production was of much less significance. Several points arise out of the analysis, however, that merit further discussion.

The first is again to emphasise that the evidence of sheep exploitation is biased in urban deposits towards animals reared specifically for meat or towards inferior animals culled to supply the town's markets. Exeter was always a centre for a substantial non-self-sufficient population and therefore always attracted surplus stock or sheep raised specifically for urban consumption. The mortality data need not give a complete picture of sheep exploitation nor reflect the full importance of wool production.

Another factor that emerged from the analysis of the post-medieval material was that, although wool production was extremely important, it was not to the exclusion of the interests of the urban meat market. Historical studies have shown how fundamental the broadcloth and later the serge industries were to the status of Exeter as a commercial centre between the fifteenth and seventeenth centuries. Cloth, wool and yarn markets were set up in Exeter in 1538 and exports of cloth at times attained very high levels. All this put great demands on the local wool supply, which was heavily supported by wool imports from Ireland and the continent (Hoskins 1935:25, 30-36). It can be shown that this had a great influence on the exploitation of sheep in the county. The dominance of second and third year mortalities, which were such a feature of the Roman and most of the medieval ageing evidence in Exeter, disappeared in the postmedieval deposits and the epiphyseal fusion evidence in particular showed that many more adult sheep were brought to the city for slaughter. Nevertheless the mortality data from Exeter were not similar to those of the theoretical model of wool production suggested by Payne (1973:284). If wool production alone had been the motive behind the exploitation of sheep, we would expect few animals to be slaughtered until old age. Apart from infant mortalities most of the stock could have expected a long life. Males would have been castrated and run as a wether flock, which in turn favoured wool production since wethers generally produce a heavier fleece than ewes. This is a logical pattern, yet at the period when wool production seems to have had its greatest emphasis, the Exeter material produced relatively few senile animals. This may be due in part to the problems of the absolute ageing of sheep jaws but this does not account for all the anomalies. It is clear from both local sources (Fraser 1794:43) and from other reviews of this aspect of postmedieval agriculture (Bowden 1962:10; Thirsk 1967b:188) that wethers were often fattened for slaughter between four and five years of age to provide prime mutton. The increase in the number of jaws aged to between three and five years in the Exeter deposits from the late medieval period onwards is testimony to the dual role of sheep exploitation in those periods. This is also reflected in the prices of commodities in the seventeenth century, for although wool prices were low nationally throughout this century (Thirsk 1976:73), mutton prices tended to rise (Bowden 1962:9).

Finally, there is the question of why wool production became important when it did and why circumstances were not favourable beforehand. It should be said that sheep were exploited for their wool in all periods under consideration but the development of an international trade in broadcloths from the fifteenth century was in stark contrast to the previous periods when, at most, wool was traded only on a regional basis. Yet, during the medieval period some areas of England enjoyed a profitable export trade of wool especially to Flanders. Two major factors were at work. The first is clear from historical research; the Flanders wool trade was based upon the production of fine wools whereas the sheep from Devon produced only coarse wool. There was no incentive in terms of demand or profit for southwestern stockowners to concentrate on wool-growing. This contrasted with the wide markets and high prices for 'kerseys' made from coarser wool in the fifteenth and sixteenth centuries, for example. Secondly, large-scale wool production is dependent upon the quality and good husbandry of the stock. A flock run for wool is far more expensive to maintain than one kept merely for meat or for milk. To provide a good fleece, the stock has to be fed throughout the year and this entails the provision of a large amount of winter pasture or fodder for a lot of animals kept alive to provide several annual growths of wool. Rearing sheep for meat is cheaper because most of the flock can be culled at a young age and less fodder is required for the surviving breeding stock. Poor nutrition decreases the fineness of the wool and its length. It is clear that the sheep in Roman and medieval Exeter were of small size and provided substandard fleeces in both quality and quantity of wool. Devon simply did not have the quality of stock to enable the region to gain much benefit from the medieval wool trade. This was not the case by the sixteenth century. The size of some of the sheep brought to Exeter had increased, either by the introduction of new stock or by better management of the existing flocks or a combination of the two. Much of Devon had enclosed fields from the late medieval period and this development improved the quality of grazing available for sheep and also allowed more sheep to be kept. The fleeces of the sheep of southwest England had also improved and even the 'Cornish hair' was viewed with more approval by the late sixteenth century (Bowden 1956:48). These improvements made the Devon sheep farmer better equipped to take advantage of the large demands and high prices for wool at this period. This in turn radically altered the exploitation and marketing of sheep in the area.

THE MARKETING OF HIDES AND FURS

Furs and skins are rarely recovered from archaeological sites and it is only in certain types of waterlogged conditions that leather objects can be discovered. There is no doubt, however, that animal hides were of significant economic importance in the periods under consideration. Most documentary information as usual comes from the post-medieval period. In towns the leather industry provided work for many craftsmen, such as tanners, shoemakers, skinners and glovers. At Chester such workers formed 22% of the freedmen of the city between 1558 and 1625 (Woodward 1967:66). In urban centres in general it appears that a substantial number of the working population consisted of various craftsmen in leather (Clarkson 1966: 38). At Exeter leatherworkers formed 8% of the new freedmen of the city between 1620 and 1640 (MacCaffrey 1958:163).

How much the existence of this important industry influenced the exploitation of the stock is less clear. Hoskins (1956:15) suggested that the hide and skin market was sometimes more important than the meat market. Noddle (1975:257) also emphasised the influence of the leather industry and suggested that the importance of skins would have encouraged medieval farmers to keep larger numbers of smaller animals and that the lack of improvement in the small stature of the animals was partially the result of a deliberate policy by farmers. This hypothesis is very difficult to test. A more valid explanation for the small size of the stock in the Roman and medieval periods may be the fact that economic pressures to produce larger stock were not sufficient to make improvements worthwhile. Clarkson (1966:26) maintains that leather production was less important than either meat or wool production in the sixteenth and seventeenth centuries and that the supply of hides was a by-product of meat production. Certainly the value of the hides was less than that of the carcass and many of the changes in the post-medieval exploitation of domestic animals can be best explained by an increased demand for meat in that period. The situation in earlier periods is uncertain but leather-working should not be overlooked in any consideration of animal husbandry in those periods.

Little is known about the fur trade in Roman or medieval times. Rabbit skins were certainly sought after in Devon in the thirteenth century (Veale 1957:87). It is probable that both rabbits and hares, besides being an additional source of food, were valued equally for their fur. In the late Middle Ages, Exeter and other provincial centres obtained expensive furs from the Arctic via London skinners such as sable, fox and ermine (Carus-Wilson 1963:26). On a local level, the presence of a large number of immature cats in the deposits in medieval times may indicate that the cat was exploited as a relatively young animal for its fur. The presence of badger, fox, otter and stoat may also be due to the fact that they were killed for their pelts. The marketing of leather and fur are topics which would repay further documentary study.

WORKING ANIMALS

There is no documentary evidence to say that cattle were the main plough animals in Roman Britain but it is widely assumed that this was the case (Trow-Smith 1957:55-56). The high percentage of mature cattle from the Roman deposits in Exeter would imply that a substantial part of the herd was kept for working purposes. Some of the cows may have been dairy animals but it is probable that most of them would have been submitted to the yoke alongside steers. This certainly seems to have been the case in the medieval period, when Domesday Book, the Tavistock accounts and the archaeological evidence from Exeter all suggest that many cattle were principally kept as working animals and only slaughtered when they had completed their working lives. Documentary evidence suggests that cattle continued to be the main plough animals in the postmedieval period, although the Exeter sample revealed that more stock was then being raised solely for meat and slaughtered at a young age.

The principal employment of the horse in Devon was as a working animal. It does not appear to have been used in the plough team prior to postmedieval times, and even then seems to have been thus employed only occasionally (Trow-Smith 1957:176). It is extremely unlikely, therefore, that it would have been yoked to the plough in the Roman period. Its main employment throughout would have been as a pack animal and as a means of transport.

The only other working animals in Exeter would have been the dogs employed in driving stock and occasionally in hunting and in falconry.

TOOLS AND ORNAMENTS

Much of the evidence for bone tool manufacture is indirect. For instance, it is possible that the fused distal epiphyses of sheep/goat metacarpi were employed in some sort of industrial activity in both the Roman and medieval periods. This statement is based on the fact that a comparatively low number of distal epiphyses of this bone was found in relation to the number of proximal epiphyses. In addition, the percentage of unfused distal epiphyses in the deposits was much higher than expected, when compared with other fusion data. This suggests that many fused distal epiphyses were removed for some purpose, probably in tool manufacture, for which their shape, hardness and other working qualities makes them well suited. In this connection, it is of interest to note a nineteenth century deposit from the GS I site (not considered in any previous analysis), which produced a concentration of over 200 proximal metapodia belonging to sheep. Virtually all the specimens had been cut about 20 to 40 mm from the proximal epiphysis on their posterior surface and then snapped off. Most of the specimens were of a size that suggested that the distal epiphysis would have reached the stage of fusion. These were not found in this deposit, however, since they were taken away for manufacture into tools or ornaments. There is no reason why such a bone-working industry should not have existed in Roman and medieval times.

Similarly, a horn industry can be postulated. In the second century levels of the RS defensive ditch, only one cattle horn core was discovered out of a total of 87 skull fragments, indicating that this part of the anatomy was not discarded along with other non-edible parts of the carcass but kept for some other purpose. The same phenomenon was noted in the sections of the fourth century ditches on the GS sites that produced a large quantity of cattle cranial fragments. Several horn cores of both Roman and medieval date had cut marks just below the base of the *cornea processus*, indicating that the horn sheath had been deliberately detached from the core. Similarly, sheep and goat cores were removed from the rest of the skull for manufacturing processes. Recent excavations in the city have revealed the remains of a horner's workshop (Henderson:*pers. comm.*). Similar workshops have been discovered in other centres in medieval England.

Red deer antlers, judging by the frequency of cut marks found on the few examples recovered, were also employed in a similar manufacturing process.

BUTCHERY AND MARKETING OF MEAT

Dealing with samples taken from limited areas of a conurbation makes it difficult to be certain whether a representative view of how meat was butchered, distributed and sold has been obtained. There is little documentary evidence about this topic from Exeter. Hooker's map, published in 1587, showed a street marked 'The Shambles' where the butchers did their slaughtering and sold their meat. On one side of the Shambles (which was situated in the present day Market Street) was Butcher Row, which was a row of nineteen butchers' shops built as a piece of municipal enterprise at the beginning of the sixteenth century (Hoskins 1969:66). The Shambles probably existed in medieval times, for the concentration of butchers in one area of a town was a common feature of the time — Leicester (Simmons 1974:37), Worcester (Dyer 1973:141) and York (Raine 1955:186) are examples of other provincial centres where this occurred. The Market Street area of Exeter has not as yet been excavated and it has to be assumed that the individual butchers did their slaughtering there. It should perhaps be noted that in London in 1371, butchers were forbidden to slaughter animals in the market of St. Nicholas Shambles because of the health hazard involved and they were ordered to a place outside the city for this purpose (Pendrill 1925:103-4). On the other hand, Exeter may have suffered less from overcrowding than the capital and the unpleasant aspects of slaughtering may have been tolerated. Even at the end of the seventeenth century butchers were permitted to slaughter their animals in the open street (Hoskins 1935:25) and this unhygienic practice had probably existed for centuries.

There is evidence from the early Roman period that there was at least one area of concentrated slaughter and butchery of cattle, as the waste bones in the late first century Rack Street ditch deposits show. Whether these continued in the late Roman period is less certain. The appearance of stockyards associated with large town-houses and the discovery of more limited concentrations of waste from cattle primary butchery processes may represent a more fragmented policy in the slaughtering of stock. The lack of very large deposits of primary butchery waste from the Guildhall sites in the early medieval period possibly only implies that the slaughter areas were situated in another part of the city.

In all periods it would seem that many animals were driven to Exeter on the hoof and then slaughtered. By the varied nature of the faunal material in these household deposits, it seems clear that most parts of the animals' skeletons were distributed along with the meat. Some caution must be applied here, however, since some animals would have been kept by townsfolk and slaughtered by them. The presence of unusual quantities of waste bones in some pits in the medieval Guildhall deposits may support this. Pigs and poultry may often have been kept in this way. Several skeletons of very young pigs were thrown into the deposits in all periods. Documentary evidence can be cited in support of the presence of farm animals in towns in the medieval period. Indeed in Worcester, pigs were kept by the city-dwellers as late as the sixteenth century (Dyer 1973:207). If the same practice was common in Exeter, many pigs may have been slaughtered for private consumption rather than sold to butchers or sent to market. The same may be true to a lesser extent for sheep and cattle, although these would need access to more grazing than pigs. Stables testify to the presence of horses in towns. There is no reason why townspeople should not own farm animals, if they had sufficient land, and this should be borne in mind when examining urban faunal remains. Indeed the present butchery evidence from Exeter may be misleading since it is derived from just one area of the city from the medieval period onwards. The effects of social stratification on the distribution of meat has not been tested. The provisioning of rich and poor households was probably very different in the medieval period and this may be reflected in the types of bone represented in their respective rubbish deposits. Indeed, the very poor in towns may have eaten very little meat at all (Drummond and Wilbraham 1957:55).

The most notable change in butchery practices appeared in the sixteenth century deposits (although its origin may have been earlier). This was the practice of dividing carcases of all the major domestic animals into sides of meat and removing their heads and feet. Butchery evidence on vertebrae clearly demonstrates this development. The marked decrease in the number of skull fragments of adult sheep and cattle was also a feature of the postmedieval deposits. The annual proclamation of Exeter's mayor in the late sixteenth century is interesting in this light:

> 'Butchers should have no more gain than one penny in every shilling besides the hedd, the feete and the inwards.' (MacCaffrey 1958:81).

These parts of the body were therefore treated differently from the rest of the carcass. What the butchers did with the skulls, limb extremities and offal is uncertain. Much of it may just have been dumped (as in the Roman period). In London and Worcester the rivers Thames and Severn respectively were common depositories of such material (Pendrill 1925:39; Dyer 1973:207). The river Exe may have had a similar function. The head and feet may also have had some industrial uses. Butchers no doubt would have had close co-operation with other dealers in animal products, particularly the leather craftsmen, although it is impossible from present evidence to say how much this influenced the marketing of animals. Calves' head and feet, however, were more popular food items and consequently these were found more often alongside good meat bones in the postmedieval deposits, as indeed were the skull and jaws of lambs.

What were the reasons for the change in butchery techniques? It is possible that the stimulus came from outside traders. In 1571 standings in the yarn market were given to 'Foreign' butchers, who were allowed to sell their meat there on Wednesdays and Saturdays (MacCaffrey 1958:83). These men may have slaughtered their animals in the town but their hours of sale were limited. It is possible that they may only have brought in dressed carcases to their stalls on marketdays and slaughtered many of their animals outside the city, butchering them into convenient sides of meat for transport. This, however, is pure speculation and much more needs to be done to understand the processes of slaughtering, marketing and butchery from both documentary and archaeological sources before the mechanisms of this important aspect of urban life can be fully understood.

URBAN POPULATION AND ANIMAL HUSBANDRY

The previous sections have summarised the present state of knowledge of many facets of animal exploitation in Exeter and its hinterland. There are many gaps to fill but it has been shown that changes took place and that animal bones can be used to demonstrate them. The question remains, why did such changes take place when they did? There is also a need for a structured approach towards the study of such processes. What follows is one possible line of study.

The framework of a testable model

As Postan (1973:12) points out it is difficult to separate the closely allied aspects of population, prices and agricultural production when seeking the principal causes of economic change. Nor should these trends be isolated from considerations of social change. However, the very existence of urban centres exerts pressure on the agricultural base of the economy. A town contains a high proportion of people not directly involved in food production but employed in specialist activities, for example, craftsmen, administrators, merchants, etc. The number of people thus employed will vary according to a variety of social and economic factors but we can expect that the amount of surplus required from agricultural production increases in proportion to the size of the non-food-producing population. It is also true that the efficiency of agricultural production at certain stages has to be improved to produce the surpluses to support an increasing number of these people. This simple model follows Boserup's thesis that an agricultural system will tend to remain at a particular level of intensity for as long as possible but that in time an increasing population will make the system uneconomic until eventually the community is forced to intensify the system (Boserup

1965). The only modification made here is to propose that it is the increase in the number of people not directly involved in food production, especially in urban centres, that may act as a major stimulus to agricultural change.

Urban growth in industrialising societies is usually linked with increasing agricultural efficiency, which releases labour for non-farm activities, provides surpluses to feed those people and enlarges markets for their manufactures and services (John 1976:45). In underdeveloped economies urban growth may also be the result of migration from the rural areas, reflecting a lack of development there rather than economic improvements in the towns (Corfield 1976: 215). In both cases, however, the rise of the urban population requires an increased supply of food from a decreasing number of producers and therefore in certain circumstances demands an improvement in productivity. Any improvement in stock management to supply more food necessitates greater input in terms of labour on behalf of the agricultural workforce. This will only take place if the pressures for improvement are of sufficient magnitude. These may be stimulated by the profit motive and other incentives or through greater control of farming surpluses by regional authorities or central government. In some cases, however, social or economic factors may prevent any intensification and population growth may be checked.

Can such changes be observed in the archaeological record? Not necessarily from archaeozoological data alone, since it is conceivable that certain improvements in the agricultural system may have left animal husbandry completely unaffected. One reaction to population pressures, for example, may be to increase cereal production at the expense of pastoral farming. In terms of yields/acre, an agricultural system based on cereals is often more productive than one based on the exploitation of domestic stock. Any intensification of farming practices may thus be limited to arable production. Nevertheless, substantial changes in the mode of agricultural production usually affect animal husbandry in some way. Even in the example cited above, we might expect an increased proportion of cattle to be employed to plough the fields, which may in turn be monitored by the cattle bones on sites in a particular region. It is suggested that changes in animal husbandry related to urban population pressures may be monitored by examining the following aspects of the archaeological record:

1. Evidence for redistribution of animal products.
2. Organisation of agricultural surpluses.
3. The quality of the stock.
4. The intensity of exploitation of the stock.

These require some explanation.

1. Evidence for redistribution of animal products

Any urban society requires redistribution of commodities. At its simplest level this enables people not producing food to be supplied by those who are, while the food producers receive either payment or services in return. Obviously the exchange systems can become much more complex than this but the basic principle remains the same. When such a system operates on a regional scale, there is a likelihood that redistribution of agricultural produce will depend to some extent on urban pressures. In a town or city the demand for food usually dominates over other animal products and the consumers are not concerned directly with the maintenance of stock levels for breeding purposes, or with wool production or with working animals, although these aspects affect them indirectly and may be more important to the agricultural economy of the region. It is probable, therefore, that the animals that provide the urban centre with their meat supply do not represent a cross-section of the animals kept but are drawn from stock either raised specifically for meat or from inferior stock not required for other agricultural purposes. Conversely, neonatal mortalities and older breeding, wool-producing or working animals may be under-represented on urban sites, since they may not be included in the mainstream of the urban marketing system. The greater the demands for agricultural commodities in towns, the greater the selectivity of stock is likely to be and we can therefore expect a trend towards a greater 'bias' from the overall population of a species as the non-food-producing population increases. Obviously this hypothesis may be influenced by other factors, such as dietary preference in different elements of the social hierarchy, and to be tested fully requires comparisons between the urban site and settlements in its rural hinterland. Nevertheless examination of the age structure of the animals represented in urban centres should provide some information to test this element of the model.

2. Organisation of agricultural surpluses

As urban populations increase more control is needed to manage the incoming surpluses of food. This control may be centralised in the form of regional or national administration or military coercion, or decentralised in the hands of middlemen or retailers controlling the marketing and perhaps the prices of the produce. Animal bones can provide evidence for the systematic marketing of animals, the presence or absence of large scale slaughtering centres and the consistency of butchery practices by a statistical study of the individual bone elements and of the lateral variation in the bone assemblages within urban sites. The discovery of waste bones from slaughtering or marketing centres depends to some extent on chance and this may bias results in different periods, although their existence can sometimes be inferred from the evidence of domestic rubbish deposits.

3. The quality of the stock

Obviously, the better the quality of the stock, the more meat, wool, milk and other animal products can be obtained. One way to meet demands from increasing urban populations, therefore, is to improve the nutrition of domestic animals or to introduce better stock, both of which will be beneficial to stock quality, although this improvement costs more in terms of fodder or cash outlay. Increases in population do not necessarily entail the emergence of better quality animals, nor do they necessarily preclude the introduction of new stock in periods of no growth in the economy. It is, however, more likely that such improvements will take place in circumstances of increased demand. The hypothesis can easily be tested by metrical analysis of animal bones, which can monitor changes in carcass size in the periods under consideration.

4. The intensity of exploitation of the stock

Again this is an obvious avenue of investigation and is closely allied to the other three factors. As the non-farming population grows and demands for food increase, we can expect increased incentives to kill off more young animals for meat. This can be achieved by simply keeping more stock and maintaining the same exploitation patterns or by decreasing other aspects of animal husbandry, such as the exploitation of sheep for wool or cattle for ploughing. If this is not possible, the intensity of exploitation of domestic stock has to increase. This may entail the use of new methods of husbandry that are more costly to maintain but enable farmers to fatten up their animals more quickly for slaughter. It may also encourage better nutrition for the stock, to improve the quality of the breeding stock, increase fertility rates, decrease neo-natal mortalities, etc. A study of the exploitation patterns as represented by ageing data should again be able to show any changes that occurred.

These four lines of investigation can be incorporated into the framework of a predictive model. The model suggests that the processes discussed will tend to increase in conjunction with a parallel increase in the proportion of non-food producing inhabitants in the population, particularly in urban centres. Similarly a decrease in the urban population may result in a decline or collapse of some of these processes, or at least in no intensification of them. No significant improvements are expected in periods of slow or no population growth. This does not preclude improvements in the four factors discussed above as the result of other causes and it is not suggested that the greater intensity of exploitation of a particular species, for example, can be attributed merely to population pressures. The hypothesis, however, predicts that most or all of these factors will increase concurrently in periods of significant urban population growth. Obviously other factors could be incorporated into such a model but these have the advantage that theoretically they can be studied from faunal evidence alone. For certain periods in Exeter's history these archaeological monitors can be studied in conjunction with known or estimated population changes and can be combined with relevant documentary evidence of animal husbandry. The model can therefore be tested, at least partially, against the available archaeological and historical data.

The Roman period

The earliest period under consideration (approximately 55 to 75 A.D.) was one when Exeter was under military occupation and garrisoned by a legionary force of up to 6,000 men (Bidwell 1979). Consequently at the outset of Exeter's importance it contained a population larger than it was ever to become until the late medieval period. Although the legion probably did not rely entirely upon local resources, there is no doubt that its presence placed a great burden on the farmers of the area. The difficulty is that there is no iron age material from this area of Devon to compare with this early Roman data to measure the full impact of the change. The quality of all the Roman domestic species was better, however, than most iron age material examined to date in southern England, probably as the result of the introduction of new stock. Similarly the early Roman deposits showed particularly high levels of first year killings of sheep/goat and pig in comparison to later Roman and medieval assemblages, possibly showing the intensity of exploitation required to feed the large population. There is limited ageing evidence, however, and this needs to be supplemented from other sites in the city. There is certainly evidence of the redistribution of animal products, which reflects itself particularly in the number of second year animals represented in the sheep/goat sample at the expense of neo-natal mortalities and those of older stock. The legionary forces departed at about 75 A.D. but the organisation of food surpluses can be seen in the evidence from the Rack Street deposits of late first century date. These showed that the marketing of cattle carcases was organised systematically on a large scale and it is likely that this developed in the earlier period when military control ensured the food supply to the legionary forces.

The situation in the late Roman period requires some clarification by study of material from other sites. There are no indications from the archaeological record that the population increased. Indeed, despite its status as a provincial centre, the population of Exeter was probably quite small after the departure of the military forces. In the later Roman period very large stone town-houses have been found on the Guildhall sites replacing building-plots previously occupied by several houses. If this was the typical pattern within the town, it would suggest a fall in urban population. Against this, there is some evidence for the spread of settlement from the late third century to peripheral sites in the town but these are countered by the vacation of some other areas that had been occupied in the early Roman period. The absence of villas in this part of Devon may also indicate that the population in the area was relatively low. Of particular interest to the model of urban popluation pressure is the evidence that farmyards and stock enclosures were associated with at least some of the late Roman town-houses. This shows that some of the inhabitants of Exeter were directly involved with animal husbandry and emphasises the point that urban populations are never derived entirely from non-food producers.

As the evidence now stands, therefore, it seems that there was no rise in population in late Roman Exeter and possibly the number of non-food producers decreased. We would accordingly expect no intensification in the animal husbandry and marketing systems and, if anything, a decline. In support of this there appears to have been no significant improvement in the size of domestic stock during the Roman period, although the samples are too small to be conclusive. Nor do there seem to have been any improvements in the organisation of agricultural surpluses. Indeed the evidence of the primary butchery of cattle in association with the stock enclosures of the town-house on the Guildhall site, if typical, suggests that there could have been a more decentralised system of cattle marketing controlled by numbers of independent stockowners. If such a change did take place, it may reflect a decline in the demand for food from a smaller non-food-producing sector of the community, although this development in economic organisation must also be linked with possible social changes.

One development that seems to have taken place in the late Roman period was the increase in the slaughter of immature cattle. Again the small samples investigated may not be typical of the town as a whole, but if they are, the change has to be explained. It is possible to argue that an increase in the intensity of cattle exploitation was the result of the demands of a growing urban population. This may have increased the demand for meat and one solution could have been to slaughter more immature animals. As both pig and sheep/goat already had high levels of immature mortalities in Exeter, the existing systems of pig and sheep/goat management may not have been able to tolerate much higher culling rates without substantial improvements in husbandry practice. Cattle breeding could, on the other hand, be intensified and an increase in the number of young beef cattle could augment the supply of older breeding or working animals, which provided the majority of meat in Exeter throughout the Roman period. This would provide a greater supply of meat but only at a greater cost of labour on behalf of the agricultural workforce, if all the other elements of cattle exploitation, such as ploughing, were maintained alongside the greater emphasis on beef production. However, as we have seen, the there is no archaeological evidence for a population increase in Exeter in the late Roman period and none of the other factors of agricultural intensification appears to have been made. An alternative explanation for the increase in immature cattle is thus required. It may even be conceivable that the change resulted from a decrease in the demand for food. If less grain was required by a dwindling population in Exeter, this may have decreased the amount of arable land under cultivation. Fewer plough animals would be required to work on the fields. This would perhaps result in the release of more potential draught cattle for slaughter while still young. It is interesting that the metrical analysis of the cattle metacarpi suggests that the number of immature cattle increased at the expense of potential plough animals. Therefore, although cattle may have been more intensively exploited for their meat, it may have been due to a decline in arable farming and a result of a decrease in demand for grain. In addition, if the evidence of the stockyards and enclosures on the Guildhall site in the fourth century is interpreted as the presence of cattle husbandry within the city walls, it can be argued that the redistribution of food surpluses was on a more limited scale and that the urban and rural dichotomy in animal products may not have been as significant in this period. It is unlikely, however, that there was a complete collapse of the redistribution and marketing systems at that time. Nevertheless the late Roman period may have been a time of agricultural decline in the area.

The early medieval period

This covers a period from the eleventh century until the outbreak of the plague in the middle of the fourteenth century and is represented best from twelfth and thirteenth century deposits from the Guildhall sites. These include several large, well-dated samples but their typicality to the rest of the city has still to be tested. This should be borne in mind during the following discussion.

Estimations of medieval populations from historical sources are always hazardous and sometimes little more than guesswork but can at least establish the general pattern. Hoskins, adapting data recorded in Domesday, has estimated that the population of Exeter lay between 1,500 (Hoskins 1954:57) and 2,500 (Hoskins 1969:20) in 1086. By 1377, an estimated 2,400 people lived in the city (Hoskins 1954: 107). Between these two dates, there is no record of population levels. The similarity between the two sets of population estimates does not imply that the population remained static during the intervening centuries. In fact there was probably a gradual rise in the town's population until the disastrous consequences of the plague in the middle of the fourteenth century. The Black Death appears to have hit Exeter and Devon in general very hard, judging by the recorded number of deaths in the city. Hoskins (1954:107) estimated that the population in Exeter prior to the plague may have been as high as 4,000, although there are no figures to support this statement. Therefore, there was probably a significant rise in Exeter's population in the twelfth and thirteenth centuries. Other urban centres in England developed and many new towns were founded in the same period. However, there was also a large expansion of the rural population and it is possible that England's population tripled between 1086 and the middle of the fourteenth century (Miller and Hatcher 1978:33). Whether the number of urban inhabitants increased in proportion to the rural population is less clear. Colonisation of new lands for agricultural purposes took place nationally and was still taking place in parts of southwest England in the early fourteenth century (Miller and Hatcher 1978:53). If the growth was roughly equal, there would be no necessity to alter the agricultural systems radically, although obviously more produce would be obtained. In many parts of England the system of demesne farming, upon which agricultural production was largely based, became inadequate for the needs of the population by the middle of the thirteenth century and especially in the early fourteenth century, when famines became commonplace. It was the failure of this system to adapt to the problems of increasing population when all the agricultural lands had been occupied that prevented agricultural improvement. The population was accordingly unable to cope with the harvest failures and animal epidemics that occurred in the second decade of the fourteenth century and high mortality rates resulted even before the outbreak of the Black Death.

We should therefore expect little evidence from the animal bones of intensification of husbandry practices within the twelfth and thirteenth centuries, except perhaps in the organisation of the food surpluses, the volume of which would have increased significantly as the population grew and more land was exploited.

Indeed the single most impressive feature of the twelfth and thirteenth century animal bone assemblages is the apparent stability.The relative numbers of the principal species remained fairly constant in this period and if changes did occur they appear to have been only gradual. In addition the exploitation patterns of the major stock animals were consistent throughout the period. There was no evidence for the intensification of the redistribution system or for the control of marketing, although this may be the mistaken impression created by a limited sample.

In the medieval period documentary evidence indicates that most of the farms in Devon were small and a high percentage of them were freehold. Ownership at a landlord level too was fragmented. Manors in the southwestern peninsula of England were mostly small (Youings 1969: 166) and consequently flocks and herds never attained high numbers. The result was a relatively poor small-scale farming enterprise, which rose little above subsistence agriculture. There were no great incentives for improvement; prices were low and the quality of wool was such that it commanded the lowest prices in England. Even in the later Middle Ages, when the woollen industry became more commercialised, the manufacture of cloth was still largely the part-time occupation of small-holders, farm labourers and their families (Youings 1969:169).

As a result, there was little effort to improve the quality of stock. The average size of sheep did increase a little between Roman and medieval times but even in the latter period the size of stock was below that of some other areas of England. The grazing of animals on open moorland and commons would have precluded most attempts at selective breeding. The milking of ewes, as evidenced at the Tavistock manors, would have meant lambs being weaned at a younger age resulting in diminished growth and probably a coarse fleece as well. Nor did pig show any improvement in size during the period. Documentary evidence indicates that at that time pigs were allowed to forage for food in woods, a less intensive and efficient exploitation than the practice of keeping them in sties for fattening before slaughter. The tenants of the abbot's manors of Tavistock, for example, paid twopence for each pig allowed pannage in the lord's woods (Finberg 1951: 132). There is no evidence that sty husbandry had been introduced on a large scale in the medieval period. Again it seems that selective breeding and improvements in nutrition were of little concern to the swineherds of the day. Cattle were often only fattened up after they had served their working lives, although the demand for meat from Exeter did tempt some farmers to slaughter a few of their animals, particularly steers, in their adolescence. Once again the lack of improvement in the size of cattle in the medieval period indicates that neither selective breeding nor improved grazing were introduced. Even domestic poultry were of a standard small size in these periods.

This is not to say that the system was uninfluenced by the demands of the urban population. On the contrary, there are good reasons to argue that an intensive marketing system was in operation from the outset of this period. The urban demands for meat are shown in the redistribution of animal products, in particular the extremely high levels of second year killings of sheep/goat in the early medieval deposits must have been to the exclusion of many of the breeding stock from the urban market, if the ageing estimates are accurate. Similar redistribution of the cattle population may have been taking place.

Whether these urban pressures made any greater demands on animal husbandry in this period than in the early Roman period is doubtful, however, and this is again reflected in the animal bone assemblages. The quality of medieval stock showed little or no improvement over that of the Roman period. There is as yet no evidence that the control and marketing of animal produce within Exeter was any more efficient, or indeed as intensive in the medieval period. The number of first year killings of both pig and sheep decreased in the later deposits, perhaps indicating a greater intensity of meat production in the early Roman period. This pattern is perhaps to be expected if we accept the sketchy knowledge we have of Exeter's population in these periods. The military forces present at the beginning of the Roman period meant that the urban population was much higher in relation to the number of food producers than in any part of the Middle Ages. It is therefore unlikely that the later period required any greater productivity of animal husbandry, despite the rise in population in that period, so long as there were sufficient new lands to be cultivated by the expanding rural population. The effects of the traumatic period in the early fourteenth century on animal husbandry cannot be fully tested as yet because of the inadequate sample of that date.

The late medieval period

Between the late fourteenth century and the early sixteenth century there is as yet little faunal material available to assess the possible consequences population changes had upon stock husbandry. From the historical standpoint, Youings (1969:167) has seen the period as one of agricultural stagnation in Devon. Colonisation of the marginal farming lands came to a halt; land rents dropped steadily until 1450; prices in the markets were slow to recover from the disruptions of the Black Death. Wool had become more important, however, and an export market for broadcloths had begun to flourish by the middle of the fifteenth century (Carus-Wilson 1963:7-9). It seems that the population of Exeter recovered and the number of inhabitants is thought to have risen to 7 to 8,000 by the early sixteenth century (Hoskins 1969:51; MacCaffrey 1958:11-12). Exeter's population therefore trebled in this period and it will be interesting to see whether this increase is reflected in the animal bones when it is possible to examine a larger sample from this period.

The postmedieval period

The discussion of agricultural change in this period has long occupied many historians. The Agricultural Revolution of the second half of the eighteenth century is well known (Kerridge 1967) but possible developments prior to that time are open to question. Traditionally the sixteenth century has been seen by economic historians as a time of greater activity and commercialisation and a period in which farmers had many opportunities for agricultural improvements. This view has been challenged by several authorities. Bridbury (1974) argued that the decline in living standards in the sixteenth century was such that it would have precluded innovations in agricultural technology, since markets were limited and there was no incentive for any reforming farmers to invest in expensive new methods. This view is supported amongst others by Jones (1968), who does not see any acceleration in farming improvements until the latter half of the seventeenth century. At that time prices for agricultural produce were comparatively low and farmers were forced to increase their profit margins by greater specialisation and increased efficiency. Holderness (1976:75) sums up the problems facing historians on this important period of agricultural innovation as follows:

> 'But even if we assume a very long process of evolution, the level of activity from 1660-1760, in a period of low prices and very slow population growth, is still remarkable. Was it the turning-point? Until we can date the improvement in the yields (and yield ratios) of grain or the increase in carcass weight of average animals — until we can actually measure changes in agricultural productivity in the pre-industrial world — the question must remain open.'

The following discussion attempts to demonstrate some of the changes in agricultural productivity that can be seen in Exeter during this period.

On the question of population increase, the growth of towns was a national phenomenon in the sixteenth and first half of the seventeenth centuries. Exeter was no exception. The late sixteenth and early seventeenth centuries saw a dramatic increase in the city's population. MacCaffrey (1958:11-12), adapting figures based on the number of able-bodied men resident in the city, has computed that the total number of inhabitants increased from about 7,700 in the 1570s to about 10,200 in 1638. In other words, Exeter's population increased by almost one third within a space of just 70 years. The expansion continued throughout the seventeenth century, and by its end, the population had risen to about 15,000 (Youings 1969:173). The increase in population at this time was closely linked with the equally dramatic expansion of the cloth industry from the late fifteenth century onwards. Many more people were attracted to the city to work, not only in the cloth making industry, but also in other professions that prospered in a flourishing provincial centre. In the second half of the seventeenth century Exeter was among the cities whose population increased at a greater rate than the national average, which was much slower in this period. This was the time indeed of its greatest prosperity and economic importance (Corfield 1976:227). Thus there was a rapidly increasing non-food-producing community in the city that greatly increased the demand for food. It is a period, therefore, in which we should expect changes in the intensity of agricultural production and there is good evidence for this from both archaeological and historical sources.

Redistribution of animal products

The most remarkable change in the postmedieval deposits in Exeter is the appearance for the first time of large quantities of calf bones. These had been almost non-existent in the earlier periods but were very common in features dated to the sixteenth century onwards. In the deposits investigated so far such bones were over-represented in relation to those of the dairy and plough cattle, which were also very important in the economy. This may be a misleading picture created by the excavation of a limited area of the city and marketing practices within Exeter may have had some effect upon the distribution of cattle bones, but the importance of veal in urban centres is attested by documentary evidence as well and it seems likely that it arose as a response to the rise in urban populations generally in England. The significant increase in the number of lambs and pigs fattened for slaughter in their first year in postmedieval Exeter may also be a reflection of urban demands for meat.

Another fundamental development of the postmedieval period was the national redistribution of stock. By the seventeenth century England can be divided broadly into rearing or fattening regions for stock (Thirsk 1967b:186). This development was necessary to accommodate the great demands of London, for which there is good documentary evidence of the system of market supply (Fisher 1954). How long a tradition this regional specialisation had is less certain. Cattle were driven from Wales to be fattened for the London market from at least the fifteenth century and possibly earlier (Skeel 1926) and some movements of flocks and herds around the country took place in the medieval period but not on anything like the scale of later. London still relied mainly upon its neighbouring shires for its food at the end of the sixteenth century (Fisher 1954:136), as indeed no doubt did Exeter throughout the postmedieval period. Nevertheless, certainly by the early seventeenth century increasing numbers of stock were reared in areas a long distance away from the provincial markets where they ended their lives. It was one element in the increasing internal trade that took place at that time. The large scale Irish imports of livestock in the seventeenth century can be seen as an extension of the same process. So at this time, therefore, not only are the animal bones from an urban centre unlikely to be representative of the livestock kept in the surrounding area, but may also include an increasing percentage of animals bred possibly hundreds of miles away.

Organisation of agricultural surpluses

The postmedieval period saw greater control of animal products in Exeter than previously. To take the archaeological evidence first, it is clear that a standard method of butchery and marketing of meat was established by the sixteenth century. The chopping off of the heads and feet and the splitting of the carcases into sides of meat became standard practice in Exeter and contrasted with the early medieval butchery evidence, which gives no such impression of consistency. The increasing importance of the butchers in Exeter can perhaps be seen in the establishment of nineteen shops in Butchers Row in the early sixteenth century (Hoskins 1969:66). The presence of 'Foreign' butchers in Exeter from at least the late sixteenth century indicates that the resident butchers could not supply enough meat for the rising population. The importance of the butchers was also accompanied by the emergence of graziers and other middlemen, who were able to take advantage of the greater demand for food particularly from urban centres. As agriculture became more commercialised, greater organisation of surpluses was needed and these types of tradesmen appeared. Once again London was the most organised centre, in which large and increasing amounts of the food passed through the control of free retailers (Fisher 1954:146) but Exeter saw the same developments on a smaller scale in the sixteenth and seventeenth centuries.

The quality of the stock

The average size of cattle, sheep, pig and domestic fowl brought to Exeter increased in the postmedieval period. More metrical analysis on some of these species is required but it seems that the greatest advances in the size of the stock occurred in the late seventeenth and eighteenth centuries after some improvements during the sixteenth century as well. Exeter's cattle and sheep may have been smaller than average in the medieval period and the earlier improvements may be of only regional significance as the size of the southwestern stock caught up in other parts of England. Increases in carcass weight were useful in the sixteenth century, however, because of the sharp rise in Exeter's population. Many of Devon's common fields had already been enclosed prior to the sixteenth century and this had resulted in better grazing for much of the stock. Carew, writing of Cornish husbandry at the end of the century, observed that by enclosure, pasture improvement and selective breeding, the quality of stock was beginning to improve (Trow-Smith 1957:175). Enclosure, as we have seen, also helped to improve the quality and quantity of wool obtained from Devon and Cornwall sheep during the time when cloth production became extremely important in those counties. The influence of graziers in the sixteenth century, who fattened up stock mainly for the urban markets must also have assisted in improving the quality of beef cattle in particular. The creation of water meadows in western England, for example in Dorset (Bettey 1973), was an innovation of the late sixteenth and early seventeenth centuries. This system provided valuable fodder in the early spring for the increasing numbers of stock. Its impact in lowland Devon is unclear but the development would improve the quality of stock where it did occur. The use of convertible husbandry has also been cited to have begun in lowland Britain in the late sixteenth and seventeenth centuries (Clarkson 1971:58) but this has been challenged by Bridbury (1974:553-554), who suggests that the system was too expensive to establish in a period when low prices and high rents would have stifled agricultural experiments. Indeed the evidence from Exeter does support the view that much of the improvements in stock size did not take place until after the middle of the seventeenth century. Nevertheless it can be shown that there was some improvement from at least the sixteenth century (and possibly earlier) due in part to the impact of changes in animal husbandry and possibly encouraged by the increasing problem of providing food for a much larger urban community.

The intensity of exploitation of the stock

The intensity of exploitation of all the major domestic stock increased from the sixteenth century onwards. Exeter's demands for meat are reflected in the large number of calf bones in the deposits investigated to date. Many of these animals were the products of the dairies and were fattened for early slaughter. The emergence of dairying as a more important aspect of cattle rearing also reflects the increased demands for milk products. It seems that a greater percentage of pigs were also culled in their first year. Again many were now fattened up on the surplus whey of the dairies and it is possible that more sty husbandry was introduced to speed fattening. The increased proportion of bones belonging to sheep killed under a year old again reflects an improvement in the fattening of some lambs for the urban market. Sheep were more important for wool, however, and did not share in the increased intensity of meat production to the same extent as cattle and pigs. Nevertheless many wethers were fattened for market at between four to five years of age, rather than being allowed to produce annual fleeces until senility. Their value for mutton was not therefore totally ignored. The number of animals kept must have increased enormously. Cattle still provided virtually all the traction power for ploughing in Devon but now also had to provide an increasing amount of dairy and meat produce. This in turn put extra demands on cattle breeders. Similarly enough sheep had to be bred to provide wool for an expanding export market in broadcloths as well as providing meat for a far larger non-food producing element in the population. This naturally led to increasing specialisation in pastoral farming and market specialisation in animal products was well established nationally by the end of the seventeenth century (Holderness 1976:71).

Consequently the model of urban population pressure as a prime mover in changes in animal husbandry can be applied to the postmedieval data in Exeter. The evidence presented here should not be taken as typical of the rest of England in this period, although several of the points apply to other regions as well. The fact that the quality of the stock did not show its greatest improvements until after the middle of the seventeenth century, at a time when population growth did decelerate nationally, may be used to challenge the validity of the model. The major spur may indeed have been low prices for agricultural products which forced enterprising farmers to specialise in and to intensify their husbandry techniques to increase their profits. However, the quality of stock should not be considered alone. There is good evidence that there were major changes in the agricultural and marketing systems in the earlier postmedieval period. We have seen that the redistribution of animal products, the organisation of food surpluses and the exploitation of stock had become much more intensive by the sixteenth century. There was also some improvement in the quality of the stock. It was in the sixteenth and early seventeenth centuries that the increasing urban population created their initial pressure on the existing agricultural system. Even the increased acreage under production in the sixteenth century (Youings 1969:172) was insufficient to satisfy these demands. The need to import store cattle and wool from abroad in this period indicated that the demands nationally outstripped advances by breeders in home production. Westcote wrote in the 1630s that 'no longer can Devon export corn, beeves and mutton, now it can barely feed itself' (MacCaffrey 1958:162). The changes and improvements in agriculture in the late seventeenth and eighteenth centuries, although better documented and in due course more far-reaching, may only have been extensions of processes that had their origins at a substantially earlier date.

It has been possible to examine three types of urban population change: a possible decrease in the non-farm element in the late Roman period; a rise in conjunction with rural expansion in the early Middle Ages; and a steep rise in urban population in the sixteenth and seventeenth centuries. It can be shown how the pastoral economy adapted to each of these situations. Obviously, there are gaps to fill in the archaeological and documentary data, which hinder the application of this model. There are also other important factors such as profits, prices and wages which need to be incorporated fully into the model along with a consideration of social organisation. The conclusions reached here may in time appear to be facile or misconceived when more evidence is available. Nevertheless this type of approach to archaeozoological studies should be of some value in the study of the development of urban societies and economies generally. The application of formal economic models making use of the limited data available has much potential both in purely historical studies (for example, Baack 1978) and in archaeozoological problems. This kind of systematic approach must be adopted, if we are to understand fully the processes that shaped pastoral agriculture throughout prehistoric and historic times.

EXETER, URBAN SITES AND RESEARCH PRIORITIES

The analysis of this large faunal sample from Exeter has enabled the role of a provincial centre in the pastoral economy to be studied in some detail from Roman times onwards. It is hoped that the results have justified such a study. The analysis has certainly helped to clarify and expand the flimsy documentary evidence of husbandry practices during the periods involved. Of course, many questions remain to be answered by further research, which should also be able to test some of the hypotheses put forward in this case study. The following aspects require urgent review.

The examination of historical records

This has been essentially an archaeological study, incorporating only easily accessible documentary evidence. There are many records as yet untapped, which have direct relevance to the marketing of food in Exeter. On several subjects only inferences can be made from the evidence of animal bones that could be clarified from the study of documentary data. This applies to all urban sites in historical periods. To develop cost-effective research strategies, we need to know what gaps there are in the historical evidence and develop the archaeozoological studies accordingly. Comparisons between historical and archaeological data are also valuable at this stage of research, since they provide an opportunity to test the accuracy of animal bone data against well documented aspects of agricultural history. So far the signs are favourable and in the few cases in this study where the two lines of approach overlapped, there was broad agreement on the conclusions gained. In other cases the archaeological data have been able to expand sketchy documentary evidence. This is encouraging for future faunal studies of prehistoric material, in which the archaeological evidence is the only source of evidence.

Examination of material from other areas of Exeter

Lateral variation has been established to be a fundamental influence on the types of animal bones represented on an urban site. There is no doubt that the full range of variation has not been met, particularly in the later samples, which were derived from only one part of Exeter. This places doubts on whether the data are representative of the city as a whole and makes any broader interpretations merely tentative. It has been shown that lateral variation can affect the relative number of animals represented, the ageing data and the types of bone represented. Similar intra-urban variations have been found in the metrical analyses of cattle represented on contemporary sites in London (Armitage 1977). On complex urban sites the goal must be to examine a representative cross-section of the animal bones deposited. Research strategies should be designed to deal with the different types of variation, whether caused by cultural or natural agencies. Evidence of lateral variation itself is important because it is the key to the understanding of the redistribution and organisation of the meat supply from faunal remains. In the case of Exeter, a more detailed study is also required of intra-site variations. The terracing of much of the medieval deposits prevented a detailed comparison being made between the contents of pits, floor and street deposits, for example. This can be remedied on other sites.

Similarly, there are many gaps in the picture in a purely chronological framework. Indeed there is no period that is adequately represented. A lot of the evidence is still woefully limited, particularly the late medieval material and various phases within the other periods as well. Again sensible research programmes are essential if a balanced view from any urban site is to be obtained. Sampling strategies for faunal remains are required to make most use of the limited resources available in archaeology (Gamble 1978).

Butchery data

The evidence of chopmarks, knife cuts and other butchery practices has been treated so far in only a superficial and generalised manner. There is a need for a systematic and detailed study of such data, looking especially at the aspects of consistency of butchery and its relation to the levels of organisation of the distribution and disposal of the carcases. The relationship between butchery, fragmentation and preservation of bone is not understood on any archaeological site as clearly as it should be. A concentrated programme of research on a sample of the animal bones should demonstrate the potential of such studies on urban sites.

Examination of rural sites

It will be obvious to anyone who has read the previous discussions that the study of animal bones from urban sites in a vacuum is of limited value. We cannot appreciate the impact or the role of an urban centre in the pastoral economy without reference to its catchment area for its agricultural products. Rural sites in general have been neglected in animal bone studies but it is as important to investigate these, in order to obtain a representative cross-section of the regional situation, as it is to ensure that the inter-site variations within an urban complex are taken into account. The opportunities for this in the area around Exeter are unfortunately limited by soil conditions adverse to the preservation of bone. In other regions, however, there is no reason why a cross-section of settlement types should not be investigated as part of a single research programme.

Development of improved methodologies

It is clear that several of the methods usually employed on faunal data are not satisfactory for the study of complex sites. The usual methods of quantitative analysis fail to monitor satisfactorily the variations in the assemblages. The methods of ageing still cannot provide an absolute age to the animals involved. There is a lack of consistency in the analysis of fragmentation, butchery, preservation and measurements. These need to be recorded in detail, if efficient use of the data is to be made. As the samples become larger, improved methodologies will be required. Especially important is the establishment of more standardised methods of recording, to enable realistic comparisons between sites to be made. Many of the conclusions from faunal studies are derived from statistical analysis. It is necessary that the data from different sites are presented in ways that are comparable. The advent of computer recording of faunal material will certainly help with standardisation. Interpretation of larger samples will have to rely more and more on multivariate analysis and advanced statistical procedures. This is the only way that the amount and variety of data can be handled efficiently.

Archaeozoology and archaeology

It is hoped that this study will act as a framework for future faunal work in Exeter and the rest of Devon and as a case study for workers facing similar problems on other urban sites. It is also hoped that the analysis has shown that work on animal bones from historic sites is not irrelevant. There is great potential for a lot of useful research into aspects of pastoral farming and food marketing. Of course there are methodological problems that have to be faced as the questions asked become more complex but these can be overcome.

It may appear ironic to conclude a volume that has been entirely devoted to the study of animal bones by emphasising that we should not be dealing with faunal data in isolation from other aspects of archaeological evidence. The evidence of animal bones has been discussed here in relation to preservation conditions, context types, redistribtution, regional and overseas trade, marketing practices, social hierarchy, population — to name just a few topics. These are all aspects about which other branches of archaeology such as the study of settlement patterns, pottery, seeds and other environmental evidence can also be expected to provide information. This is therefore a plea for a more integrated approach to archaeology. Faunal remains have their place in the interpretation of past human activities. To ensure this, animal bone studies should not be treated simply as appendices to site reports but must be included as an intrinsic tool to aid the understanding and reconstruction of prehistoric and historic societies.

TABLES

Species		GS No	GS %	TS No	MM/CC No	MM/CC %	RS No	TOTAL R1 No	TOTAL R1 %
Cattle	F	307	47.97	61	119	32.08	10	497	41.35
	M	17	40.48	4	5	20.00	3	29	31.52
Sheep/Goat	F	194	30.31	66	125	33.69	3	388	32.28
	M	12	28.57	10	7	28.00	1	30	32.60
Pig	F	127	19.84	40	109	29.38	-	276	22.96
	M	8	19.05	4	8	32.00	-	20	21.74
Red Deer	F	2	0.31	9	1	0.27	1	13	1.08
	M	1	2.38	1	1	4.00	1	4	4.35
Roe Deer	F	-	-	1	9	2.43	-	10	0.83
	M	-	-	1	1	4.00	-	2	2.17
Hare	F	2	0.31	-	-	-	-	2	0.17
	M	1	2.38	-	-	-	-	1	1.09
Horse	F	4	0.63	-	-	-	-	4	0.33
	M	1	2.38	-	-	-	-	1	1.09
Dog	F	2	0.31	-	6	1.62	-	8	0.67
	M	1	2.38	-	1	4.00	-	2	2.17
Cat	F	2	0.31	-	1	0.27	-	3	0.25
	M	1	2.38	-	1	4.00	-	2	2.17
Otter	F	-	-	-	1	0.27	-	1	0.08
	M	-	-	-	1	4.00	-	1	1.09
TOTAL MAMMAL	F	640	100	177	371	100	14	1202	100
	M	42	100	20	25	100	5	92	100
Bird	F	47	6.73	9	50	11.82	-	106	8.02
	M	9		1	6		-	16	
Fish	F	11	1.58	-	2	0.47	-	13	0.98
TOTAL FRAGMENTS		698	100	186	423	100	14	1321	100
TOTAL UNIDENTIFIED		836		187	371		2	1396	

TABLE 1

Number of fragments and minimum number of individuals represented in phase R1 (c.A.D.55 - c.A.D.75)

F = number of fragments identified.
M = minimum number of individuals represented.

Species		GS No	GS %	TS No	MM/CC No	MM/CC %	RS No	RS %	HL No	TOTAL R2 No	TOTAL R2 %
Cattle	F	76	29.57	33	143	26.63	754	72.78	2	1008	51.85
	M	6	18.18	3	6	18.75	49	62.03	1	65	41.67
Sheep/Goat	F	89	34.63	37	172	32.03	157	15.15	-	455	23.41
	M	11	33.33	3	10	31.25	15	18.99	-	39	25.00
Pig	F	75	29.18	37	194*	36.13	51	4.92	1	358	18.42
	M	10	30.30	3	9	28.13	6	7.60	1	29	18.59
Red Deer	F	1	0.39	-	11	2.05	2	0.19	-	14	0.72
	M	1	3.03	-	1	3.13	2	2.53	-	4	2.56
Roe Deer	F	1	0.39	4	3	0.56	4	0.39	-	12	0.62
	M	1	3.03	1	1	3.13	1	1.27	-	4	2.56
Hare	F	3	1.17	-	4	0.75	-	-	-	7	0.36
	M	1	3.03	-	1	3.13	-	-	-	2	1.28
Horse	F	3	1.17	-	-	-	57	5.50	-	60	3.09
	M	1	3.03	-	-	-	4	5.06	-	5	3.21
Dog	F	1	0.39	-	7	1.30	11	1.06	-	19	0.98
	M	1	3.03	-	2	6.25	2	2.53	-	5	3.21
Fox	F	8*	3.11	-	2	0.37	-	-	-	10	0.51
	M	1	3.03	-	1	3.13	-	-	-	2	1.28
Water Vole	F	-	-	-	1	0.19	-	-	-	1	0.05
	M	-	-	-	1	3.13	-	-	-	1	0.64
TOTAL	F	257	100	111	537	100	1036	100	3	1944	100
MAMMAL	M	33	100	10	32	100	79	100	2	156	100
Bird	F	34	11.68	8	23	4.10	3	0.29	-	68	3.37
	M	6		3	5		1		-	15	
Fish	F	-	-	1	1	0.18	4	0.38	-	6	0.30
TOTAL FRAGMENTS		291	100	120	561	100	1043	100	3	2018	100
TOTAL UNIDENTIFIED		313		172	361		830		3	1679	

TABLE 2

Number of fragments and minimum number of individuals represented in phase R2 (c.A.D.75 - c.A.D.100)

F = number of fragments identified.
M = minimum number of individuals represented

** Pig includes 70 fragments from three burials.*
Fox includes 8 fragments from one burial.

Species		GS No	GS %	TS No	TS %	MM/CC No	MM/CC %
Cattle	F	245	29.91	102	47.01	126	27.16
	M	12	16.67	11	35.48	13	27.08
Sheep/Goat	F	311	37.97	68	31.34	169	36.42
	M	33	45.83	11	35.48	13	27.08
Pig	F	236	28.82	41	18.89	148	31.90
	M	21	29.17	5	16.13	12	25.00
Red Deer	F	-	-	4	1.84	1	0.22
	M	-	-	2	6.45	1	2.08
Roe Deer	F	1	0.12	1	0.46	1	0.22
	M	1	1.39	1	3.23	1	2.08
Hare	F	13	1.59	-	-	3	0.65
	M	2	2.78	-	-	1	2.08
Horse	F	5	0.61	-	-	14	3.02
	M	1	1.39	-	-	5	10.42
Dog	F	7	0.86	1	0.46	2	0.43
	M	1	1.39	1	3.23	2	4.17
Cat	F	1	0.12	-	-	-	-
	M	1	1.39	-	-	-	-
TOTAL MAMMAL	F	819	100	217	100	464	100
	M	72	100	31	100	48	100
Bird	F	57	6.47	11	4.83	18	3.73
	M	19		4		8	
Fish	F	5	0.57	-	-	1	0.21
TOTAL FRAGMENTS		881	100	228	100	483	100
TOTAL UNIDENTIFIED		1039		130		214	

TABLE 3 (i)

Number of fragments and minimum number of individuals represented in phase R5 (A.D.100 - A.D.200)

F = number of fragments identified.
M = minimum number of individuals represented.

Species		RS No	HS No	HL No	BS No	TOTAL R5 No	TOTAL R5 %
Cattle	F	31	55	57	89	705	38.63
	M	7	4	3	7	57	28.79
Sheep/Goat	F	24	20	9	14	615	33.70
	M	4	4	3	4	72	36.36
Pig	F	5	11	3	4	448	24.55
	M	2	3	2	1	46	23.23
Red Deer	F	-	-	-	-	5	0.27
	M	-	-	-	-	3	1.52
Roe Deer	F	1	-	-	-	4	0.22
	M	1	-	-	-	4	2.02
Hare	F	-	-	-	-	16	0.88
	M	-	-	-	-	3	1.52
Horse	F	-	-	-	1	20	1.10
	M	-	-	-	1	7	3.54
Dog	F	-	1	-	-	11	0.60
	M	-	1	-	-	5	2.53
Cat	F	-	-	-	-	1	0.05
	M	-	-	-	-	1	0.51
TOTAL MAMMAL	F	61	87	69	108	1825	100
	M	14	12	8	13	198	100
Bird	F	2	2	-	1	91	4.74
	M	1	1	-	1	34	
Fish	F	-	-	-	-	6	0.31
TOTAL FRAGMENTS		63	89	69	109	1922	100
TOTAL UNIDENTIFIED		45	70	79	111	1688	

TABLE 3 (ii)

Number of fragments and minimum number of individuals represented in phase R5 (A.D.100 - A.D.200)

F = number of fragments identified.
M = minimum number of individuals represented.

Species		TS No	MM/CC No	MM/CC %	RS No	HL No	BS No	HS No	TOTAL R6 No	TOTAL R6 %
Cattle	F	35	163	33.20	25	3	5	4	235	35.29
	M	5	12	29.27	2	1	1	1	22	31.88
Sheep/Goat	F	37	107	21.79	8	-	-	-	152	22.82
	M	6	8	19.51	2	-	-	-	16	23.19
Pig	F	33	143	29.12	3	1	-	-	180	27.03
	M	4	13	31.70	1	1	-	-	19	27.54
Red Deer	F	1	2	0.41	-	-	-	-	3	0.45
	M	1	1	2.44	-	-	-	-	2	2.90
Roe Deer	F	-	3	0.61	-	-	-	-	3	0.45
	M	-	1	2.44	-	-	-	-	1	1.45
Hare	F	19*	7	1.43	-	-	-	-	26	3.90
	M	2	2	4.88	-	-	-	-	4	5.80
Dog	F	-	23*	4.68	1	-	-	-	24	3.60
	M	-	2	4.88	1	-	-	-	3	4.35
Cat	F	-	1	0.20	-	-	-	-	1	0.15
	M	-	1	2.44	-	-	-	-	1	1.45
Badger	F	-	42*	8.55	-	-	-	-	42	6.31
	M	-	1	2.44	-	-	-	-	1	1.45
TOTAL MAMMAL	F	125	491	100	37	4	5	4	666	100
	M	18	41	100	6	2	1	1	69	100
Bird	F	28	32	6.08	2	1	-	-	63	8.55
	M	11	13		1	1	-	-	26	
Fish	F	5	3	0.57	-	-	-	-	8	1.09
TOTAL FRAGMENTS		158	526	100	39	5	5	4	737	100
TOTAL UNIDENTIFIED		151	348		52	3	2	-	556	

TABLE 4

Number of fragments and minimum number of individuals represented in phase R6 (A.D.200 - A.D.300)

F = number of fragments identified.
M = minimum number of individuals represented.

** Badger includes 42 fragments from one burial.*
Dog includes 22 fragments from one burial.
Hare includes 15 fragments from one burial.

Species		GS No	GS %	TS No	TS %	MM/CC No	MM/CC %	RS No	TOTAL R8 No	TOTAL R8 %
Cattle	F	808	52.00	589	69.54	140	47.78	66	1603	56.94
	M	17	24.29	22	40.74	7	25.00	4	50	30.68
Sheep/Goat	F	375	24.13	97	11.45	43	14.68	33	548	19.47
	M	22	31.43	14	25.93	7	25.00	4	47	28.83
Pig	F	290	18.66	138	16.29	85	29.01	21	534	18.97
	M	15	21.43	11	20.37	6	21.42	2	34	20.86
Red Deer	F	7	0.45	-	-	1	0.34	-	8	0.28
	M	3	4.29	-	-	1	3.57	-	4	2.45
Roe Deer	F	6	0.39	-	-	-	-	-	6	0.21
	M	1	1.43	-	-	-	-	-	1	0.61
Hare	F	7	0.45	1	0.12	3	1.02	1	12	0.43
	M	3	4.29	1	1.85	1	3.57	1	6	3.68
Horse	F	14	0.90	17	2.01	8	2.73	-	39	1.39
	M	3	4.29	3	5.56	2	7.14	-	8	4.91
Dog	F	13	0.84	4	0.47	12	4.10	-	29	1.03
	M	2	2.86	2	3.70	3	10.71	-	7	4.29
Cat	F	10	0.64	1	0.12	-	-	-	11	0.39
	M	2	2.86	1	1.85	-	-	-	3	1.84
Fox	F	4	0.26	-	-	-	-	-	4	0.14
	M	1	1.43	-	-	-	-	-	1	0.61
Hedgehog	F	-	-	-	-	1	0.34	-	1	0.04
	M	-	-	-	-	1	3.57	-	1	0.61
Woodmouse	F	20*	1.29	-	-	-	-	-	20	0.71
	M	1	1.43	-	-	-	-	-	1	0.61
TOTAL MAMMAL	F	1554	100	847	100	293	100	121	2815	100
	M	70	100	54	100	28	100	11	163	100
Bird	F	141	8.16	45	5.04	23	7.26	6	215	7.00
	M	26		11		8		2	47	
Fish	F	33	1.91	1	0.11	1	0.32	6	41	1.34
TOTAL FRAGMENTS		1728	100	893	100	317	100	133	3071	100
TOTAL UNIDENTIFIED		1812		556		188		167	2723	

TABLE 5

Number of fragments and minimum number of individuals represented in phase R8 (A.D.300+)

F = number of fragments identified.
M = minimum number of individuals represented.

** Woodmouse includes 20 fragments from one burial.*

Species		RS-R3 No	HL-R3 No	TS-R4 No	RS-R7 No	GS-R9 No
Cattle	F	8	6	11	44	249
	M	1	1	2	4	14
Sheep/Goat	F	2	5	6	13	157
	M	2	2	2	2	14
Pig	F	4	5	14	7	67
	M	1	1	3	2	6
Hare	F	-	-	-	-	5
	M	-	-	-	-	2
Horse	F	-	-	-	-	3
	M	-	-	-	-	1
TOTAL MAMMAL	F	14	16	31	64	481
	M	4	4	7	8	37
Bird	F	-	-	2	-	38
	M	-	-	1	-	9
Fish	F	-	-	-	-	15
TOTAL FRAGMENTS		14	16	33	64	534
TOTAL UNIDENTIFIED		20	19	22	13	613

TABLE 6

Number of fragments and minimum number of individuals represented in phases R3, R4, R7 and R9 (c.A.D.55 - A.D.100, c.A.D.75 - A.D.150, A.D.100 - A.D.300, undated Roman)

F = number of fragments identified.
M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7
GS-R1	307	48.89	0.44	0.26	0.11	0.09	0.03	0.04	0.03
TS-R1	61	36.52	0.25	0.31	0.10	0.13	0.05	0.15	0.02
MM/CC-R1	119	33.71	0.24	0.35	0.14	0.05	0.08	0.09	0.03
GS-R2	76	31.67	0.40	0.32	0.16	0.08	0.05	0.00	0.00
MM/CC-R2	143	32.57	0.23	0.34	0.10	0.11	0.11	0.11	0.01
RS-R2	754	78.38	0.72	0.07	0.02	0.15	0.00	0.02	0.02
GS-R5	245	30.93	0.27	0.30	0.25	0.11	0.03	0.04	0.01
TS-R5	102	48.34	0.29	0.32	0.20	0.10	0.03	0.04	0.02
MM/CC-R5	126	28.44	0.20	0.39	0.06	0.09	0.09	0.16	0.02
MM/CC-R6	163	39.47	0.47	0.20	0.08	0.07	0.05	0.13	0.00
GS-R8	808	54.85	0.49	0.22	0.11	0.08	0.04	0.06	0.01
TS-R8	589	71.48	0.36	0.22	0.12	0.14	0.06	0.08	0.02
MM-R8	46	34.07	0.22	0.28	0.07	0.07	0.07	0.26	0.02
CC-R8	94	70.68	0.39	0.27	0.13	0.09	0.07	0.05	0.00
RS-R8	66	55.00	0.38	0.29	0.17	0.08	0.08	0.00	0.02
TOTAL	3699	50.44	0.45	0.22	0.11	0.11	0.04	0.06	0.02

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7
GS-R1	194	30.89	0.32	0.25	0.25	0.14	0.02	0.02	0.01
TS-R1	66	39.52	0.15	0.29	0.41	0.14	0.02	0.00	0.00
MM/CC-R1	125	35.41	0.26	0.23	0.25	0.10	0.04	0.06	0.06
GS-R2	89	37.08	0.18	0.32	0.28	0.21	0.01	0.00	0.00
MM/CC-R2	172	39.18	0.18	0.34	0.20	0.11	0.09	0.06	0.02
RS-R2	157	16.32	0.24	0.20	0.41	0.13	0.02	0.00	0.01
GS-R5	311	39.27	0.26	0.19	0.35	0.17	0.01	0.01	0.00
TS-R5	68	32.23	0.21	0.32	0.34	0.09	0.00	0.02	0.03
MM/CC-R5	169	38.15	0.17	0.39	0.22	0.07	0.07	0.07	0.01
MM/CC-R6	107	25.91	0.18	0.26	0.23	0.06	0.16	0.09	0.02
GS-R8	375	25.45	0.25	0.28	0.32	0.13	0.01	0.01	0.01
TS-R8	97	11.77	0.29	0.27	0.31	0.11	0.00	0.00	0.01
MM-R8	32	23.70	-	-	-	-	-	-	-
CC-R8	11	8.27	-	-	-	-	-	-	-
RS-R8	33	27.50	-	-	-	-	-	-	-
TOTAL	2006	27.36	0.24	0.27	0.30	0.13	0.03	0.03	0.01

TABLE 7 (i)

Number of fragments and category proportions of the principal stock animals - Roman phases

F = number of fragments identified.

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7
GS-R1	127	20.22	0.58	0.16	0.08	0.12	0.03	0.03	0.00
TS-R1	40	23.95	0.35	0.30	0.08	0.05	0.10	0.05	0.08
MM/CC-R1	109	30.88	0.45	0.28	0.06	0.07	0.06	0.05	0.04
GS-R2	75	31.25	0.35	0.40	0.15	0.04	0.01	0.00	0.05
MM/CC-R2	124	28.25	0.34	0.21	0.15	0.12	0.06	0.08	0.04
RS-R2	51	5.30	0.51	0.31	0.14	0.02	0.02	0.00	0.00
GS-R5	236	29.80	0.44	0.28	0.11	0.09	0.03	0.01	0.04
TS-R5	41	19.43	0.37	0.34	0.12	0.17	0.00	0.00	0.00
MM/CC-R5	148	33.41	0.28	0.26	0.14	0.15	0.03	0.11	0.02
MM/CC-R6	143	34.62	0.19	0.19	0.11	0.27	0.05	0.19	0.00
GS-R8	290	19.69	0.43	0.22	0.14	0.09	0.04	0.04	0.03
TS-R8	138	16.75	0.32	0.25	0.21	0.15	0.02	0.03	0.02
MM-R8	57	42.22	0.37	0.14	0.12	0.21	0.02	0.14	0.00
CC-R8	28	21.05	-	-	-	-	-	-	-
RS-R8	21	17.50	-	-	-	-	-	-	-
TOTAL	1628	22.20	0.39	0.25	0.13	0.12	0.04	0.06	0.02

TABLE 7 (ii)

Number of fragments and category proportions of the principal stock animals - Roman phases

F = number of fragments identified.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	145	34.61	0.39	0.32	0.10	0.08	0.04	0.06	0.02	A
TS-R1	61	36.52	0.25	0.31	0.10	0.13	0.05	0.15	0.02	A
MM/CC-R1	119	33.71	0.24	0.35	0.14	0.05	0.08	0.09	0.03	A
GS-R2	76	31.67	0.40	0.32	0.16	0.08	0.05	0.00	0.00	A
MM/CC-R2	143	32.57	0.23	0.34	0.10	0.11	0.11	0.11	0.01	*
GS-R5	245	30.93	0.27	0.30	0.25	0.11	0.03	0.04	0.01	**
TS-R5	102	48.34	0.29	0.32	0.20	0.10	0.03	0.04	0.02	A
MM/CC-R5	126	28.44	0.20	0.39	0.06	0.09	0.09	0.16	0.02	**
MM/CC-R6	163	39.47	0.47	0.20	0.08	0.07	0.05	0.13	0.00	**
GS-R8	368	43.81	0.26	0.32	0.17	0.11	0.05	0.07	0.02	A
TS-R8	589	71.48	0.36	0.22	0.12	0.14	0.06	0.08	0.02	**
MM-R8	46	34.07	0.22	0.28	0.07	0.07	0.07	0.26	0.02	**
CC-R8	94	70.68	0.39	0.27	0.13	0.09	0.07	0.05	0.00	A
RS-R8	66	55.00	0.38	0.29	0.17	0.08	0.08	0.00	0.02	A
TOTAL	2343	42.38	0.32	0.28	0.14	0.11	0.06	0.08	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	162	38.67	0.31	0.24	0.26	0.14	0.02	0.02	0.01	A
TS-R1	66	39.52	0.15	0.29	0.41	0.14	0.02	0.00	0.00	A
MM/CC-R1	125	35.41	0.26	0.23	0.25	0.10	0.04	0.06	0.06	A
GS-R2	89	37.08	0.18	0.32	0.28	0.21	0.01	0.00	0.00	**
MM/CC-R2	172	39.18	0.18	0.34	0.20	0.11	0.09	0.06	0.02	**
GS-R5	311	39.27	0.26	0.19	0.35	0.17	0.01	0.01	0.00	**
TS-R5	68	32.23	0.21	0.32	0.34	0.09	0.00	0.02	0.03	A
MM/CC-R5	169	38.15	0.17	0.39	0.22	0.07	0.07	0.07	0.01	**
MM/CC-R6	107	25.91	0.18	0.26	0.23	0.06	0.16	0.09	0.02	**
GS-R8	257	30.60	0.29	0.28	0.31	0.10	0.01	0.01	0.00	A
TS-R8	97	11.77	0.29	0.27	0.31	0.11	0.00	0.00	0.01	A
MM-R8	32	23.70	-	-	-	-	-	-	-	-
CC-R8	11	8.27	-	-	-	-	-	-	-	-
RS-R8	33	27.50	-	-	-	-	-	-	-	-
TOTAL	1699	30.73	0.24	0.27	0.29	0.12	0.04	0.03	0.01	

TABLE 8 (i)

Amended version of Table 7 excluding RS F.363, GS F.49, F60, L.424, F.47, F160, F.618

F = number of fragments identified.
** = sample significantly different at the 5% level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	112	26.73	0.58	0.16	0.08	0.12	0.03	0.04	0.00	**
TS-R1	40	23.95	0.35	0.30	0.08	0.05	0.10	0.05	0.08	A
MM/CC-R1	109	30.88	0.45	0.28	0.06	0.07	0.06	0.05	0.04	A
GS-R2	75	31.25	0.35	0.40	0.15	0.04	0.01	0.00	0.05	**
MM/CC-R2	124	28.25	0.34	0.21	0.15	0.12	0.06	0.08	0.04	A
GS-R5	236	29.80	0.44	0.28	0.11	0.09	0.03	0.01	0.04	**
TS-R5	41	19.43	0.37	0.34	0.12	0.17	0.00	0.00	0.00	A
MM/CC-R5	148	33.41	0.28	0.26	0.14	0.15	0.03	0.11	0.02	**
MM/CC-R6	143	34.62	0.19	0.19	0.11	0.27	0.05	0.19	0.00	**
GS-R8	215	25.60	0.44	0.22	0.14	0.09	0.05	0.02	0.03	A
TS-R8	138	16.75	0.32	0.25	0.21	0.15	0.02	0.03	0.02	*
MM-R8	57	42.22	0.37	0.14	0.12	0.21	0.02	0.14	0.00	**
CC-R8	28	21.05	-	-	-	-	-	-	-	-
RS-R8	21	17.50	-	-	-	-	-	-	-	-
TOTAL	1487	26.89	0.38	0.25	0.13	0.13	0.04	0.06	0.03	

TABLE 8 (ii)

Amended version of Table 7 excluding RS F.363, GS F.49, F.60, L.424, F.47, F.160, F618

F = number of fragments identified
** = sample significantly different at the 5% level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	10	35.71	te.	89	0.28	0.31	0.12	0.10	0.08	0.07	0.03	A
TS-R1	4	22.22	mc.p1.	39	-	-	-	-	-	-	-	-
MM/CC-R1	5	25.00	sk.	47	0.21	0.34	0.15	0.06	0.06	0.09	0.09	A
GS-R2	6	22.22	m.sc.	44	0.25	0.43	0.16	0.09	0.07	0.00	0.00	A
MM/CC-R2	6	25.00	sk.te.	67	0.25	0.24	0.13	0.10	0.15	0.09	0.03	A
GS-R5	12	18.18	sk.t.	127	0.24	0.31	0.19	0.13	0.06	0.06	0.02	A
TS-R5	11	40.74	sc.	79	0.27	0.27	0.23	0.13	0.04	0.05	0.03	A
MM/CC-R5	13	34.21	sc.	87	0.20	0.36	0.09	0.09	0.12	0.13	0.02	A
MM/CC-R6	12	36.36	m.	94	0.32	0.22	0.14	0.09	0.08	0.15	0.00	A
GS-R8	10	29.41	h.	124	0.13	0.27	0.19	0.15	0.13	0.10	0.04	A
TS-R8	22	46.81	m.	246	0.22	0.22	0.16	0.15	0.11	0.08	0.05	A
MM-R8	3	27.27	sc.p2.	30	-	-	-	-	-	-	-	-
CC-R8	4	44.44	m.sk.	37	-	-	-	-	-	-	-	-
RS-R8	4	40.00	m.te.	39	-	-	-	-	-	-	-	-
TOTAL	122	31.12	-	1149	0.23	0.27	0.16	0.12	0.10	0.09	0.03	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	11	39.29	r.	84	0.29	0.21	0.27	0.14	0.04	0.04	0.01	A
TS-R1	10	55.55	t.	43	0.19	0.23	0.39	0.16	0.02	0.00	0.00	A
MM/CC-R1	7	35.00	t.r.h.	69	0.20	0.28	0.22	0.10	0.06	0.04	0.10	A
GS-R2	11	40.74	t.	50	0.20	0.28	0.28	0.22	0.02	0.00	0.00	A
MM/CC-R2	10	41.67	t.	97	0.16	0.28	0.20	0.13	0.15	0.04	0.03	**
GS-R5	33	50.00	t.	179	0.24	0.21	0.34	0.18	0.02	0.01	0.01	**
TS-R5	11	40.74	t.	59	0.20	0.34	0.31	0.10	0.00	0.02	0.03	A
MM/CC-R5	13	34.21	r.	121	0.17	0.38	0.23	0.08	0.08	0.04	0.02	*
MM/CC-R6	8	24.24	t.	75	0.16	0.24	0.20	0.08	0.18	0.11	0.03	**
GS-R8	15	44.12	r.	106	0.25	0.25	0.30	0.13	0.03	0.02	0.02	A
TS-R8	14	29.79	t.	73	0.29	0.23	0.34	0.11	0.00	0.00	0.03	A
MM-R8	4	36.36	f.	25	-	-	-	-	-	-	-	-
CC-R8	3	33.33	m.	10	-	-	-	-	-	-	-	-
RS-R8	4	40.00	t.	15	-	-	-	-	-	-	-	-
TOTAL	154	39.29	-	1006	0.22	0.26	0.28	0.13	0.06	0.03	0.02	

TABLE 9 (i)

Minimum number of individuals and category proportions of the principal stock animals - Roman phases (excluding RS F.363, GS F.49, F.60, L.424, F.47, F.160, F618)

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
*** = sample significantly different at 1% level of chi-squared.*
A = sample within 5% level of chi-squared.
m = mandible; te = teeth; sk = skull; mx = maxilla; sc = scapula;
h = humerus; f = femur; r = radius; u = ulna; t = tibia;
mc = metacarpus; p1 = first phalanx; p2 = second phalanx;
ca = calcaneum.

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS-R1	7	25.00	m.	57	0.39	0.25	0.14	0.11	0.05	0.07	0.00	A
TS-R1	4	22.22	ca.	29	-	-	-	-	-	-	-	-
MM/CC-R1	8	40.00	mx.	49	0.37	0.29	0.08	0.06	0.08	0.06	0.06	A
GS-R2	10	37.04	sc.	50	0.28	0.38	0.18	0.06	0.02	0.00	0.08	A
MM/CC-R2	8	33.33	m.	65	0.28	0.20	0.17	0.11	0.08	0.09	0.08	A
GS-R5	21	31.82	m.	150	0.37	0.29	0.13	0.09	0.05	0.01	0.05	A
TS-R5	5	18.52	m.	36	-	-	-	-	-	-	-	-
MM/CC-R5	12	31.58	h.	100	0.22	0.29	0.20	0.12	0.05	0.09	0.03	A
MM/CC-R6	13	39.39	pl.	108	0.20	0.22	0.14	0.21	0.06	0.16	0.00	**
GS-R8	9	26.47	t.te.	98	0.29	0.26	0.20	0.10	0.08	0.03	0.04	A
TS-R8	11	23.40	m.	101	0.26	0.27	0.24	0.15	0.03	0.03	0.03	A
MM-R8	4	36.36	u.pl.	39	-	-	-	-	-	-	-	-
CC-R8	2	22.22	h.r.f.	15	-	-	-	-	-	-	-	-
RS-R8	2	20.00	te.	12	-	-	-	-	-	-	-	-
TOTAL	116	29.59	-	909	0.29	0.27	0.17	0.12	0.05	0.06	0.04	

TABLE 9 (ii)
Minimum number of individuals and category proportions of the principal stock animals - Roman phases (excluding RS F.363, GS F.49, F.60, L.424, F.47, F.160, F.618)

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
*** = sample significantly different at 1% level of chi-squared.*
A = sample within 5% level of chi-squared.
m = mandible; te = teeth; sk = skull; mx = maxilla; sc = scapula;
h = humerus; f= femur; r = radius; u = ulna; t = tibia;
mc = metacarpus; pl = first phalanx; p2 = second phalanx;
ca = calcaneum.

Species	GS, TS, MM/CC - R1 M	Min.Wt.	% meat	GS - R2 M	Min.Wt.	% meat
Cattle	19	9,500 lb.	72.63	6	3,000 lb.	64.38
Sheep/Goat	28	1,680 lb.	12.84	11	660 lb.	14.16
Pig	19	1,900 lb.	14.53	10	1,000 lb.	21.46

Species	TS - R5 M	Min.Wt.	% meat	GS - R8 M	Min.Wt.	% meat
Cattle	11	5,500 lb.	82.58	10	5,000 lb.	73.53
Sheep/Goat	11	660 lb.	9.91	15	900 lb.	13.24
Pig	5	500 lb.	7.51	9	900 lb.	13.24

Species	TS - R8 M	Min.Wt.	% meat	MM/CC, RS - R8 M	Min.Wt.	% meat
Cattle	22	11,000 lb.	85.01	11	5,500 lb.	79.02
Sheep/Goat	14	840 lb.	6.49	11	660 lb.	9.48
Pig	11	1,100 lb.	8.50	8	800 lb.	11.49

TABLE 10

Estimations of minimum meat weights of the principal stock animals in statistically similar Roman deposits

M = minimum number of individuals represented.
Min.Wt. = minimum amount of meat represented.
Meat weight of a cow estimated tobe 500 lb.
Meat weight of a sheep estimated to be 60 lb.
Meat weight of a pig estimated to be 100 lb.

		GS I-II		GS III		TS		HS	TOTAL Md1	
Species		No	%	No	%	No	%	No	No	%
Cattle	F	320	45.20	415	44.82	379	44.80	39	1153	45.07
	M	12	28.57	13	28.89	19	33.93	4	48	29.81
Sheep/Goat	F	265	37.43	326	35.21	289	34.16	13	893	34.91
	M	17	40.48	15	33.33	20	35.71	3	55	34.16
Pig	F	113	15.96	161	17.39	153	18.09	18	445	17.40
	M	8	19.05	9	20.00	11	19.64	7	35	21.74
Red Deer	F	-	-	2	0.22	-	-	1	3	0.12
	M	-	-	1	2.22	-	-	1	2	1.24
Fallow Deer	F	-	-	1	0.11	-	-	1	2	0.08
	M	-	-	1	2.22	-	-	1	2	1.24
Roe Deer	F	-	-	-	-	-	-	2	2	0.08
	M	-	-	-	-	-	-	1	1	0.62
Hare	F	-	-	3	0.32	2	0.24	-	5	0.20
	M	-	-	1	2.22	1	1.79	-	2	1.24
Rabbit	F	-	-	1	0.11	-	-	-	1	0.04
	M	-	-	1	2.22	-	-	-	1	0.62
Horse	F	2	0.28	8	0.86	2	0.24	4	16	0.63
	M	2	4.76	1	2.22	1	1.79	1	5	3.11
Dog	F	2	0.28	2	0.22	10	1.18	-	14	0.55
	M	1	2.38	1	2.22	3	5.36	-	5	3.11
Cat	F	5	0.71	7	0.76	11	1.30	-	23	0.90
	M	1	2.38	2	4.44	1	1.79	-	4	2.49
Rodent sp.	F	1	0.14	-	-	-	-	-	1	0.04
	M	1	2.38	-	-	-	-	-	1	0.62
TOTAL	F	708	100	926	100	846	100	78	2558	100
MAMMAL	M	42	100	45	100	56	100	18	161	100
Bird	F	60	6.17	83	7.32	135	12.66	5	283	8.69
	M	12		16		22		3	53	
Fish	F	204	20.99	125	11.02	85	7.97	-	414	12.72
TOTAL FRAGMENTS		972	100	1134	100	1066	100	83	3255	100
TOTAL UNIDENTIFIED		957		1066		970		29	3022	

TABLE 11

Number of fragments and minimum number of individuals represented in phase Md1 (A.D.1000 - A.D.1150)

F = number of fragments identified
M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	212	39.48	0.21	0.30	0.24	0.09	0.06	0.08	0.01	A
GS III	415	46.01	0.30	0.32	0.19	0.07	0.06	0.05	0.02	A
TS	379	46.16	0.18	0.35	0.25	0.04	0.07	0.06	0.04	A
HS	39	55.71	-	-	-	-	-	-	-	-
TOTAL	1045	44.85	0.24	0.33	0.22	0.06	0.06	0.06	0.03	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	228	42.46	0.29	0.31	0.23	0.12	0.03	0.02	0.01	A
GS III	326	36.14	0.30	0.30	0.26	0.08	0.02	0.03	0.01	A
TS	289	35.20	0.15	0.41	0.29	0.11	0.00	0.02	0.01	**
HS	13	18.57	-	-	-	-	-	-	-	-
TOTAL	856	36.74	0.24	0.34	0.26	0.10	0.02	0.02	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	97	18.06	0.30	0.24	0.16	0.18	0.05	0.06	0.01	A
GS III	161	17.85	0.32	0.24	0.19	0.15	0.04	0.03	0.04	A
TS	153	18.64	0.31	0.33	0.22	0.11	0.02	0.00	0.01	A
HS	18	25.71	-	-	-	-	-	-	-	-
TOTAL	429	18.41	0.32	0.27	0.19	0.14	0.04	0.03	0.02	

TABLE 12

Number of fragments and category proportions of the principal stock animals - phase Md1 (excluding GS I F.170)

F = number of fragments identified.
*** = sample significantly different at 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	9	30.00	r.t.p.	95	0.17	0.34	0.23	0.10	0.07	0.07	0.02	A
GS III	13	35.14	f.	149	0.22	0.27	0.16	0.09	0.12	0.07	0.06	A
TS	19	38.00	r.	171	0.12	0.29	0.25	0.05	0.13	0.07	0.09	A
HS	4	28.57	r.t.f.	35	-	-	-	-	-	-	-	-
TOTAL	45	34.35	-	450	0.17	0.30	0.22	0.10	0.10	0.07	0.06	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	15	50.00	t.	109	0.22	0.30	0.24	0.15	0.05	0.03	0.02	A
GS III	15	40.54	t.	148	0.26	0.30	0.24	0.12	0.03	0.02	0.03	A
TS	20	40.00	t.	150	0.16	0.36	0.28	0.13	0.01	0.03	0.03	A
HS	3	21.42	r.	12	-	-	-	-	-	-	-	-
TOTAL	53	40.46	-	419	0.22	0.32	0.27	0.13	0.03	0.03	0.02	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	6	20.00	h.m.	62	0.23	0.26	0.19	0.18	0.08	0.05	0.02	A
GS III	9	24.32	p.	90	0.26	0.27	0.19	0.12	0.06	0.06	0.06	A
TS	11	22.00	s.t.	98	0.26	0.35	0.23	0.10	0.05	0.00	0.01	A
HS	7	50.00	m.	18	-	-	-	-	-	-	-	A
TOTAL	33	25.19	-	268	0.26	0.28	0.22	0.12	0.06	0.03	0.03	

TABLE 13

Minimum number of individuals and category proportions of the principal stock animals - phase Md1 (excluding GS I F.170)

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
s = scapula; h = humerus; r = radius; m = mandible; p = pelvis;
f = femur; t = tibia.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TS %	HS No	TOTAL Md2 No	TOTAL Md2 %
Cattle	F	753	35.42	940	39.09	349	45.86	66	2108	38.83
	M	22	22.45	31	27.19	15	33.33	7	75	26.98
Sheep/Goat	F	1005	47.27	979	40.71	292	38.37	44	2320	42.73
	M	43	43.88	46	40.35	15	33.33	6	110	39.57
Pig	F	267	12.56	371	15.43	101	13.27	24	763	14.05
	M	15	15.31	21	18.42	8	17.78	5	49	17.63
Red Deer	F	1	0.05	7	0.29	-	-	1	9	0.17
	M	1	1.02	2	1.75	-	-	1	4	1.44
Fallow Deer	F	2	0.09	3	0.13	-	-	-	5	0.09
	M	1	1.02	1	0.88	-	-	-	2	0.72
Roe Deer	F	1	0.05	-	-	2	0.26	-	3	0.06
	M	1	1.02	-	-	1	2.22	-	2	0.72
Hare	F	21	0.99	3	0.13	6	0.79	-	30	0.55
	M	3	3.06	1	0.88	2	4.44	-	6	2.16
Rabbit	F	-	-	-	-	-	-	1	1	0.02
	M	-	-	-	-	-	-	1	1	0.36
Horse	F	7	0.33	27	1.12	5	0.66	-	39	0.72
	M	3	3.06	5	4.39	1	2.22	-	9	3.24
Dog	F	3	0.14	8	0.33	3	0.39	-	14	0.26
	M	1	1.02	1	0.88	1	2.22	-	3	1.08
Cat	F	55*	2.59	67*	2.79	3	0.39	1	126	2.32
	M	6	6.12	6	5.26	2	4.44	1	15	5.40
Stoat	F	10*	0.47	-	-	-	-	-	10	0.18
	M	1	1.02	-	-	-	-	-	1	0.36
Rat	F	1	0.05	-	-	-	-	-	1	0.02
	M	1	1.02	-	-	-	-	-	1	0.36
TOTAL MAMMAL	F	2126	100	2405	100	761	100	137	5429	100
	M	98	100	114	100	45	100	21	278	100
Bird	F	251	6.99	205	7.24	75	8.66	9	540	7.26
	M	30		32		18		3	83	
Fish	F	1213	33.79	221	7.81	30	3.46	2	1466	19.72
TOTAL FRAGMENTS		3590	100	2831	100	866	100	148	7435	100
TOTAL UNIDENTIFIED		2705		2471		526		90	5792	

TABLE 14

Number of fragments and minimum number of individuals represented in phase Md2 (A.D.110 - A.D.1200)

F = number of fragments identified.
M = minimum number of individuals represented.

** Cat includes 20 fragments fron one burial in GS I-II and 33 fragments from one burial in GS III.*
Stoat includes 10 fragments from one burial.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	753	37.19	0.26	0.27	0.17	0.11	0.05	0.09	0.04	A
GS III	940	41.05	0.30	0.32	0.16	0.09	0.06	0.06	0.03	A
TS	349	47.04	0.26	0.27	0.17	0.12	0.09	0.06	0.04	A
HS	66	49.25	0.24	0.45	0.16	0.08	0.06	0.00	0.00	*
TOTAL	2108	40.61	0.27	0.30	0.16	0.10	0.06	0.07	0.04	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	1005	49.63	0.39	0.27	0.17	0.11	0.03	0.03	0.00	**
GS III	979	42.75	0.31	0.27	0.26	0.11	0.02	0.02	0.01	*
TS	292	39.35	0.36	0.25	0.23	0.13	0.02	0.00	0.01	A
HS	44	32.84	0.20	0.27	0.27	0.18	0.05	0.00	0.02	A
TOTAL	2320	44.69	0.35	0.27	0.22	0.11	0.02	0.02	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	267	13.19	0.40	0.21	0.14	0.16	0.01	0.05	0.03	*
GS III	371	16.20	0.29	0.25	0.22	0.14	0.04	0.03	0.03	A
TS	101	13.61	0.38	0.31	0.16	0.11	0.02	0.00	0.03	A
HS	24	17.91	-	-	-	-	-	-	-	-
TOTAL	763	14.70	0.34	0.25	0.18	0.14	0.03	0.03	0.03	

TABLE 15

Number of fragments and category proportions of the principal stock animals - phase Md2

F = number of fragments identified.
** = sample significantly different at the 5% level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	22	27.50	h.mc.	275	0.16	0.24	0.19	0.13	0.12	0.08	0.08	A
GS III	31	31.63	h.ca.	359	0.21	0.25	0.16	0.14	0.12	0.07	0.06	A
TS	15	39.47	ca.	134	0.14	0.22	0.19	0.12	0.18	0.05	0.10	A
HS	7	38.89	f.	46	0.22	0.41	0.17	0.11	0.09	0.00	0.00	*
TOTAL	75	32.05	-	814	0.18	0.25	0.18	0.13	0.13	0.07	0.07	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	43	53.75	sk.	359	0.26	0.26	0.24	0.13	0.06	0.04	0.01	A
GS III	46	46.94	r.	419	0.24	0.26	0.27	0.14	0.04	0.03	0.02	A
TS	15	39.47	m.sk.r.	133	0.29	0.27	0.24	0.14	0.03	0.01	0.02	A
HS	6	33.33	r.	41	0.17	0.27	0.29	0.20	0.05	0.00	0.02	A
TOTAL	110	47.01	-	952	0.25	0.26	0.26	0.14	0.05	0.03	0.01	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	15	18.75	t.	134	0.28	0.24	0.21	0.11	0.03	0.08	0.05	A
GS III	21	21.42	t.	212	0.23	0.25	0.23	0.14	0.07	0.03	0.05	A
TS	8	21.05	h.	60	0.27	0.35	0.16	0.13	0.03	0.00	0.06	A
HS	5	27.78	t.	22	-	-	-	-	-	-	-	-
TOTAL	49	20.94	-	428	0.25	0.28	0.21	0.12	0.05	0.04	0.05	

TABLE 16

Minimum number of individuals and category proportions of the principal stock animals - phase Md2

M = minimum number of individuals.
M R B = most represented bone(s).
S M = sum of minimum numbers.
** = sample significantly different at the 5% level of chi-squared.*
A = sample within 5% level of chi-squared.
h = humerus; r = radius; m = mandible; sk = skull; mc = metacarpus;
f = femur; t = tibia; ca = calcaneum.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TS %	TOTAL Md3 No	TOTAL Md3 %
Cattle	F	160	30.89	180	27.15	93	33.70	433	29.72
	M	8	20.51	12	27.27	8	32.00	28	25.93
Sheep/Goat	F	279	53.86	300	45.25	102	36.96	681	46.74
	M	18	46.15	15	34.09	8	32.00	41	37.96
Pig	F	63	12.16	105	15.84	41	14.86	209	14.34
	M	5	12.82	7	15.91	4	16.00	16	14.81
Red Deer	F	4	0.77	-	-	1	0.36	5	0.34
	M	2	5.13	-	-	1	4.00	3	2.78
Fallow Deer	F	-	-	1	0.15	-	-	1	0.07
	M	-	-	1	2.27	-	-	1	0.93
Roe Deer	F	1	0.19	-	-	-	-	1	0.07
	M	1	2.56	-	-	-	-	1	0.93
Hare	F	1	0.19	2	0.30	1	0.36	4	0.28
	M	1	2.56	2	4.55	1	4.00	4	3.70
Rabbit	F	-	-	5	0.75	-	-	5	0.34
	M	-	-	1	2.27	-	-	1	0.93
Horse	F	3	0.58	1	0.15	2	0.72	6	0.41
	M	1	2.56	1	2.27	1	4.00	3	2.78
Dog	F	-	-	7*	1.06	-	-	7	0.48
	M	-	-	1	2.27	-	-	1	0.93
Cat	F	6	1.16	61	9.20	36*	13.04	103	7.07
	M	2	5.13	3	6.82	2	8.00	7	6.48
Rat	F	1	0.19	-	-	-	-	1	0.07
	M	1	2.56	-	-	-	-	1	0.93
Rodent sp.	F	-	-	1	0.15	-	-	1	0.07
	M	-	-	1	2.27	-	-	1	0.93
TOTAL MAMMAL	F	518	100	663	100	276	100	1457	100
	M	39	100	44	100	25	100	108	100
Bird	F	53	8.37	75	8.58	20	5.53	148	7.92
	M	10		9		8		27	
Fish	F	62	9.79	136	15.56	66	18.23	264	14.13
TOTAL FRAGMENTS		633	100	874	100	362	100	1869	100
TOTAL UNIDENTIFIED		793		663		253		1709	

TABLE 17

Number of fragments and minimum number of individuals represented in phase Md3 (A.D.1000 - A.D.1200)

F = number of fragments identified.
M = minimum number of individuals represented.

** Dog includes 7 fragments from one burial.*
Cat includes 35 fragments from one burial.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	160	31.87	0.26	0.30	0.25	0.11	0.03	0.02	0.04	A
GS III	180	30.77	0.31	0.28	0.20	0.07	0.07	0.07	0.01	A
TS	93	39.41	0.22	0.28	0.27	0.10	0.10	0.01	0.03	A
TOTAL	433	32.73	0.27	0.29	0.23	0.09	0.06	0.03	0.03	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	279	55.58	0.27	0.29	0.28	0.12	0.03	0.01	0.00	A
GS III	300	51.28	0.25	0.34	0.24	0.12	0.01	0.04	0.01	A
TS	102	43.22	0.25	0.35	0.23	0.11	0.01	0.02	0.02	A
TOTAL	681	51.47	0.26	0.32	0.25	0.12	0.02	0.03	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	63	12.55	0.52	0.17	0.13	0.11	0.03	0.03	0.00	**
GS III	105	17.95	0.19	0.21	0.21	0.28	0.03	0.06	0.02	A
TS	41	17.37	0.29	0.27	0.27	0.12	0.02	0.00	0.03	A
TOTAL	209	15.80	0.31	0.21	0.20	0.20	0.03	0.04	0.01	

TABLE 18

Number of fragments and category proportions of the principal stock animals - phase Md3

F = number of fragments identified.
*** = sample significantly different at the level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	8	25.81	te.	77	0.22	0.29	0.18	0.14	0.05	0.04	0.08	A
GS III	12	35.29	sk.	90	0.27	0.26	0.19	0.08	0.11	0.07	0.02	A
TS	8	40.00	r.	63	0.17	0.29	0.25	0.08	0.14	0.02	0.05	A
TOTAL	28	29.41	-	230	0.23	0.27	0.20	0.10	0.10	0.05	0.05	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	18	58.07	t.	145	0.22	0.32	0.29	0.10	0.04	0.02	0.01	A
GS III	15	44.12	r.	138	0.21	0.31	0.22	0.15	0.02	0.06	0.03	A
TS	8	40.00	sk.f.t.	71	0.23	0.31	0.27	0.13	0.01	0.03	0.02	A
TOTAL	41	48.24	-	354	0.22	0.31	0.26	0.13	0.03	0.04	0.02	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	5	16.13	m.	42	0.36	0.24	0.17	0.14	0.05	0.05	0.00	A
GS III	7	20.59	t.	68	0.22	0.19	0.21	0.25	0.04	0.06	0.03	A
TS	4	20.00	r.t.	33	-	-	-	-	-	-	-	-
TOTAL	16	18.82	-	143	0.27	0.23	0.21	0.17	0.04	0.04	0.02	

TABLE 19

Minimum number of individuals and category proportions of the principal stock animals - phase Md3

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
te = teeth; sk = skull; m = mandible; r = radius;
f = femur; t = tibia.

Species		GS I-II No	GS III No	GS III %	TS No	TOTAL Md4 No	TOTAL Md4 %
Cattle	F	24	83	36.40	7	114	34.76
	M	3	5	26.32	2	10	25.00
Sheep/Goat	F	37	71	31.14	16	124	37.80
	M	5	6	31.58	5	16	40.00
Pig	F	8	46	20.18	5	59	17.99
	M	2	3	15.79	1	6	15.00
Red Deer	F	-	2	0.88	-	2	0.61
	M	-	1	5.26	-	1	2.50
Hare	F	1	-	-	-	1	0.3
	M	1	-	-	-	1	2.50
Horse	F	2	2	0.88	-	4	1.22
	M	2	1	5.26	-	3	7.50
Cat	F	-	23*	10.09	-	23	7.01
	M	-	2	10.53	-	2	5.00
Rat	F	-	1	0.44	-	1	0.30
	M	-	1	5.26	-	1	2.50
TOTAL MAMMAL	F	72	228	100	28	328	100
	M	13	19	100	8	40	100
Bird	F	9	39	13.22	3	51	12.29
	M	3	9		2	14	
Fish	F	6	28	9.49	2	36	8.6
TOTAL FRAGMENTS		87	295	100	33	415	100
TOTAL UNIDENTIFIED		82	349		43	474	

TABLE 20

Number of fragments and minimum number of individuals represented in phase Md4 (A.D.1150 - A.D.1250)

F = number of fragments identified

M = minimum number of individuals represented.

** Cat includes 21 fragments from one burial.*

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	24	34.78	-	-	-	-	-	-	-	-
GS III	83	41.50	0.31	0.37	0.08	0.06	0.12	0.04	0.02	A
TS	7	25.00	-	-	-	-	-	-	-	-
TOTAL	114	38.38	0.28	0.38	0.11	0.07	0.11	0.04	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	37	53.62	-	-	-	-	-	-	-	-
GS III	71	35.50	0.17	0.42	0.32	0.03	0.03	0.01	0.01	A
TS	16	57.14	-	-	-	-	-	-	-	-
TOTAL	124	41.75	0.25	0.38	0.23	0.10	0.02	0.02	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	8	11.59	-	-	-	-	-	-	-	-
GS III	46	23.00	0.26	0.28	0.17	0.19	0.02	0.07	0.01	A
TS	5	17.86	-	-	-	-	-	-	-	-
TOTAL	59	19.87	0.31	0.24	0.17	0.19	0.03	0.05	0.02	

TABLE 21

Number of fragments and category proportions of the principal stock animals - phase Md4

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	3	30.00	r.f.	17	-	-	-	-	-	-	-	-
GS III	5	35.71	f.	45	0.20	0.29	0.11	0.11	0.20	0.07	0.02	A
TS	2	-	h.	7	-	-	-	-	-	-	-	-
TOTAL	10	31.25	-	69	0.19	0.30	0.13	0.12	0.17	0.06	0.03	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	5	50.00	m.	24	-	-	-	-	-	-	-	-
GS III	6	42.86	r.t.	41	0.17	0.34	0.34	0.05	0.05	0.02	0.03	A
TS	5	-	sk.	15	-	-	-	-	-	-	-	-
TOTAL	16	50.00	-	80	0.20	0.30	0.24	0.10	0.03	0.03	0.01	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	2	20.00	sk.	6	-	-	-	-	-	-	-	-
GS III	3	21.43	u.t.h.	29	-	-	-	-	-	-	-	-
TS	1	-	-	4	-	-	-	-	-	-	-	-
TOTAL	6	18.75	-	39	0.28	0.23	0.21	0.15	0.05	0.05	0.03	

TABLE 22

Minimum number of individuals and category proportions of the principal stock animals - phase Md4

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
sk = skull; m= mandible; h = humerus; r = radius;
u = ulna; f = femur; t = tibia.

Species		GS I-II No	GS I-II %	GS III No	GS III %	HS No	TOTAL Md5 No	TOTAL Md5 %
Cattle	F	57	28.93	182	35.07	18	257	33.38
	M	4	26.67	11	26.83	3	18	27.27
Sheep/Goat	F	105	53.30	218	42.00	26	349	45.32
	M	5	33.33	18	43.90	3	26	39.39
Pig	F	23	11.68	104	20.04	8	135	17.53
	M	2	12.33	8	19.51	3	13	19.70
Hare	F	2	1.02	2	0.39	-	4	0.52
	M	1	6.67	1	2.44	-	2	3.03
Rabbit	F	-	-	1	0.19	-	1	0.13
	M	-	-	1	2.44	-	1	1.52
Horse	F	-	-	-	-	2	2	0.26
	M	-	-	-	-	1	1	1.52
Cat	F	9	4.57	12	2.31	-	21	2.73
	M	2	13.33	2	4.88	-	4	6.06
Rat	F	1	0.51	-	-	-	1	0.13
	M	1	6.67	-	-	-	1	1.52
TOTAL MAMMAL	F	197	100	519	100	54	770	100
	M	15	100	41	100	10	66	100
Bird	F	21	6.29	76	11.57	7	104	9.88
	M	4		14		4	22	
Fish	F	116	34.73	62	9.44	1	179	17.00
TOTAL FRAGMENTS		334	100	657	100	62	1053	100
TOTAL UNIDENTIFIED		318		975		44	1337	

TABLE 23

Number of fragments and minimum number of individuals represented in phase Md5 (A.D.1200 - A.D.1250)

F = number of fragments identified.

M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	57	30.81	0.32	0.32	0.21	0.04	0.04	0.07	0.02	A
GS III	182	36.11	0.24	0.33	0.22	0.10	0.03	0.05	0.03	A
HS	18	34.62	-	-	-	-	-	-	-	-
TOTAL	257	34.68	0.25	0.33	0.20	0.09	0.03	0.06	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	105	56.76	0.41	0.12	0.21	0.21	0.02	0.02	0.01	**
GS III	218	43.25	0.22	0.31	0.27	0.12	0.04	0.03	0.02	A
HS	26	50.00	-	-	-	-	-	-	-	-
TOTAL	349	47.10	0.28	0.26	0.25	0.15	0.03	0.02	0.02	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	23	12.43	-	-	-	-	-	-	-	-
GS III	104	20.63	0.42	0.14	0.15	0.16	0.05	0.06	0.01	-
HS	8	15.39	-	-	-	-	-	-	-	-
TOTAL	135	18.22	0.43	0.15	0.16	0.16	0.04	0.05	0.01	

TABLE 24

Number of fragments and category proportions of the principal stock animals - phase Md5

F = number of fragments identified.
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	4	36.36	f.	24	-	-	-	-	-	-	-	-
GS III	11	29.73	t.	86	0.19	0.34	0.23	0.10	0.05	0.06	0.03	A
HS	3	33.33	f.	17	-	-	-	-	-	-	-	-
TOTAL	18	31.58	-	127	0.18	0.35	0.20	0.11	0.06	0.07	0.03	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	5	45.46	m.	36	-	-	-	-	-	-	-	-
GS III	18	48.65	t.	121	0.19	0.26	0.26	0.14	0.07	0.05	0.03	A
HS	3	33.33	sk.t.	19	-	-	-	-	-	-	-	-
TOTAL	26	45.61	-	176	0.23	0.25	0.25	0.14	0.06	0.05	0.03	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	2	18.18	t.	13	-	-	-	-	-	-	-	-
GS III	8	21.62	t.	65	0.31	0.15	0.20	0.17	0.08	0.08	0.02	A
HS	3	33.33	te.	7	-	-	-	-	-	-	-	-
TOTAL	13	22.81	-	85	0.31	0.16	0.20	0.16	0.07	0.07	0.02	

TABLE 25

Minimum number of individuals and category proportions of the principal stock animals - phase Md5

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
m = mandible; te = teeth; sk = skull; f = femur; t = tibia.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TS %	TOTAL Md6 No	TOTAL Md6 %
Cattle	F	368	41.07	966	36.93	283	39.14	1617	38.18
	M	16	29.63	35	25.36	14	24.14	65	26.00
Sheep/Goat	F	405	45.20	1115	42.62	325	44.95	1845	43.57
	M	19	35.19	54	39.13	27	46.55	100	40.00
Pig	F	88*	9.82	408	15.60	88	12.17	584	13.79
	M	10	18.52	24	17.39	10	17.24	44	17.60
Red Deer	F	1	0.11	1	0.04	1	0.14	3	0.07
	M	1	1.85	1	0.72	1	0.72	3	1.20
Roe Deer	F	1	0.11	2	0.08	-	-	3	0.07
	M	1	1.85	1	0.72	-	-	2	0.80
Hare	F	5	0.56	27	1.03	5	0.69	37	0.87
	M	1	1.85	5	3.62	1	1.72	7	2.80
Rabbit	F	-	-	4	0.15	-	-	4	0.09
	M	-	-	1	0.72	-	-	1	0.40
Horse	F	5	0.56	17	0.65	4	0.55	26	0.61
	M	2	3.70	3	2.17	1	1.72	6	2.40
Dog	F	15*	1.67	3	0.11	2	0.28	20	0.47
	M	1	1.85	1	0.72	1	1.72	3	1.20
Cat	F	5	0.56	72	2.75	15	2.08	92	2.17
	M	1	1.85	12	8.70	3	5.17	16	6.40
Rat	F	2	0.22	1	0.04	-	-	3	0.07
	M	1	1.85	1	0.72	-	-	2	0.80
Rodent sp.	F	1	0.11	-	-	-	-	1	0.02
	M	1	1.85	-	-	-	-	1	0.40
TOTAL MAMMAL	F	896	100	2616	100	723	100	4235	100
	M	54	100	138	100	58	100	250	100
Bird	F	125	11.49	351	9.49	102	11.27	578	10.16
	M	25		58		21		104	
Fish	F	67	6.16	732	19.79	80	8.84	879	15.44
TOTAL FRAGMENTS		1088	100	3699	100	905	100	5692	100
TOTAL UNIDENTIFIED		957		3126		538		4621	

TABLE 26

Number of fragments and minimum number of individuals represented in phase Md6 (A.D.1250 - A.D.1300)

F = number of fragments identified.
M = minimum number of individuals represented.

*** Pig includes 8 fragments from one burial.***
Dog includes 13 fragments from one burial.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	368	43.14	0.27	0.28	0.26	0.10	0.03	0.05	0.01	*
GS III	966	38.81	0.23	0.30	0.20	0.10	0.06	0.05	0.05	A
TS	283	40.66	0.22	0.32	0.22	0.10	0.08	0.04	0.02	A
TOTAL	1617	40.04	0.24	0.30	0.22	0.10	0.06	0.05	0.03	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	405	47.48	0.29	0.25	0.25	0.17	0.01	0.02	0.01	A
GS III	1115	44.80	0.27	0.32	0.25	0.13	0.01	0.01	0.01	A
TS	325	46.70	0.15	0.30	0.35	0.17	0.01	0.01	0.01	**
TOTAL	1845	45.69	0.25	0.30	0.27	0.15	0.01	0.01	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	80	9.38	0.54	0.21	0.09	0.05	0.04	0.06	0.01	**
GS III	408	16.39	0.24	0.26	0.21	0.18	0.03	0.05	0.03	A
TS	88	12.64	0.22	0.25	0.32	0.15	0.01	0.00	0.05	**
TOTAL	576	14.26	0.28	0.26	0.21	0.16	0.03	0.04	0.03	

TABLE 27

Number of fragments and category proportions of the principal stock animals - phase Md6

F = number of fragments identified.
** = sample significantly different at the level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

F = number of fragments identified.
** = sample significantly different at the 5% level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	16	35.56	t.	167	0.20	0.28	0.22	0.14	0.06	0.08	0.02	A
GS III	35	30.97	t.	391	0.18	0.24	0.19	0.12	0.13	0.07	0.07	A
TS	14	27.45	t.	153	0.16	0.28	0.22	0.11	0.14	0.06	0.03	A
TOTAL	65	31.10	-	711	0.18	0.26	0.20	0.12	0.11	0.07	0.06	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	19	42.22	h.	182	0.24	0.29	0.23	0.16	0.03	0.03	0.02	A
GS III	54	47.79	t.	455	0.20	0.31	0.27	0.16	0.02	0.02	0.02	A
TS	27	52.94	t.	183	0.16	0.31	0.33	0.15	0.02	0.01	0.02	A
TOTAL	100	47.85	-	820	0.20	0.31	0.27	0.16	0.02	0.02	0.02	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	10	22.22	te.	64	0.36	0.27	0.13	0.09	0.05	0.08	0.02	*
GS III	24	21.24	r.	236	0.19	0.24	0.23	0.18	0.06	0.06	0.04	A
TS	10	19.61	t.	67	0.21	0.24	0.30	0.16	0.01	0.00	0.08	A
TOTAL	44	21.05	-	367	0.22	0.24	0.23	0.16	0.05	0.05	0.05	

TABLE 28

Minimum number of individuals and category proportions of the principal stock animals - phase Md6

M = minimum number of individuals.
M.R.B. = most representd bone(s).
S.M. = sum of minimum numbers.
** = sample significantly different at 5% level of chi-squared.*
A = sample within 5% level of chi-squared..
h = humerus; r = radius; t = tibia; te = teeth.

Species		GS III No
Cattle	F	14
	M	3
Sheep/Goat	F	19
	M	3
Pig	F	14
	M	2
Dog	F	1
	M	1
Cat	F	10
	M	1
TOTAL MAMMAL	F	58
	M	10
Bird	F	1
	M	1
Fish	F	2
TOTAL FRAGMENTS		61
TOTAL UNIDENTIFIED		80

TABLE 29

Number of fragments and minimum number of individuals represented in phase Md7 (A.D.1200 - A.D.1300)

F = number of fragments identified.

M = minimum number of individuals represented.

		GS I-II		GS III	TOTAL Md8	
Species		No	%	No	No	%
Cattle	F	106	30.81	43	149	32.18
	M	4	22.22	3	7	22.58
Sheep/Goat	F	191	55.52	51	242	52.27
	M	7	38.89	5	12	38.71
Pig	F	35	10.17	21	56	12.10
	M	3	16.67	2	5	16.13
Hare	F	1	0.29	-	1	0.22
	M	1	5.56	-	1	3.23
Horse	F	2	0.58	1	3	0.65
	M	1	5.56	1	2	6.45
Dog	F	4	1.16	-	4	0.86
	M	1	5.56	-	1	3.23
Cat	F	5	1.45	3	8	1.73
	M	1	5.56	2	3	9.68
TOTAL	F	344	100	119	463	100
MAMMAL	M	18	100	13	31	100
Bird	F	28	7.05	11	39	7.29
	M	9		5	14	
Fish	F	25	6.30	8	33	6.17
TOTAL FRAGMENTS		397	100	138	535	100
TOTAL UNIDENTIFIED		403		100	503	

TABLE 30

Number of fragments and minimum number of individuals represented in phase Md8 (A.D.1250 - A.D.1350)

F = number of fragments identified.
M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	106	31.93	0.19	0.29	0.23	0.16	0.04	0.05	0.04	A
GS III	43	37.39	0.35	0.28	0.19	0.02	0.12	0.04	0.00	A
TOTAL	149	33.33	0.23	0.29	0.21	0.12	0.06	0.05	0.04	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	191	57.53	0.36	0.18	0.26	0.13	0.02	0.03	0.02	A
GS III	51	44.35	0.33	0.20	0.27	0.20	0.00	0.00	0.00	A
TOTAL	242	54.14	0.36	0.19	0.26	0.14	0.02	0.02	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	35	10.54	-	-	-	-	-	-	-	-
GS III	21	18.26	-	-	-	-	-	-	-	-
TOTAL	56	12.53	0.29	0.32	0.21	0.07	0.05	0.04	0.02	

TABLE 31

Number of fragments and category proportions of the principal stock animals - phase Md8

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	4	28.57	f.t.	44	0.18	0.25	0.20	0.20	0.07	0.07	0.03	A
GS III	3	30.00	sk.	23	-	-	-	-	-	-	-	-
TOTAL	7	29.17	-	67	0.22	0.25	0.18	0.15	0.10	0.07	0.03	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	7	50.00	r.t.	68	0.29	0.18	0.25	0.15	0.06	0.04	0.03	A
GS III	5	50.00	t.	26	-	-	-	-	-	-	-	-
TOTAL	12	50.00	-	94	0.30	0.18	0.28	0.15	0.04	0.03	0.04	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	3	21.43	u.t.	23	-	-	-	-	-	-	-	-
GS III	2	20.00	te.	15	-	-	-	-	-	-	-	-
TOTAL	5	20.83	-	38	0.24	0.26	0.26	0.08	0.08	0.05	0.03	

TABLE 32

Minimum number of individuals and category proportions of the principal stock animals - phase Md8

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
te = teeth; sk = skull; r = radius; u = ulna; f = femur; t = tibia.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TS %	TOTAL Md9 No	TOTAL Md9 %
Cattle	F	253	47.83	33	21.15	131	40.94	417	41.49
	M	9	22.50	3	20.00	6	20.69	18	21.43
Sheep/Goat	F	196	37.05	83	53.21	137	42.81	416	41.39
	M	17	42.50	8	53.33	12	41.38	37	44.05
Pig	F	51	9.64	35	22.44	38	11.88	124	12.34
	M	5	12.50	2	13.33	3	10.35	10	11.90
Red Deer	F	2	0.38	-	-	1	0.31	3	0.30
	M	1	2.50	-	-	1	3.45	2	2.38
Hare	F	3	0.57	-	-	3	0.94	6	0.60
	M	1	2.50	-	-	2	6.90	3	3.57
Rabbit	F	-	-	-	-	1	0.31	1	0.10
	M	-	-	-	-	1	3.45	1	1.19
Horse	F	7	1.32	1	0.64	2	0.63	10	1.00
	M	4	10.00	1	6.67	1	3.45	6	7.14
Dog	F	7*	1.32	-	-	-	-	7	0.70
	M	1	2.50	-	-	-	-	1	1.19
Cat	F	10	1.89	4	2.56	7	2.19	21	2.09
	M	2	5.00	1	6.67	3	10.35	6	7.14
TOTAL	F	529	100	156	100	320	100	1005	100
MAMMAL	M	40	100	15	100	29	100	84	100
Bird	F	45	7.37	26	12.44	82	19.66	153	12.37
	M	11		4		13		28	
Fish	F	37	6.06	27	12.92	15	3.60	79	6.39
TOTAL FRAGMENTS		611	100	209	100	417	100	1237	100
TOTAL UNIDENTIFIED		470		250		188		908	

TABLE 33

Number of fragments and minimum number of individuals represented in phase Md9 (A.D.1300 - A.D.1350)

F = number of fragments identified.
M = minimum number of individuals represented.

** Dog includes 7 fragments from one burial.*

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	253	50.60	0.30	0.29	0.17	0.11	0.07	0.05	0.02	A
GS III	33	21.85	-	-	-	-	-	-	-	-
TS	131	42.81	0.26	0.31	0.21	0.13	0.08	0.02	0.01	A
TOTAL	417	43.57	0.28	0.30	0.19	0.11	0.08	0.03	0.01	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	196	39.20	0.22	0.23	0.34	0.18	0.01	0.01	0.01	A
GS III	83	54.97	0.19	0.35	0.32	0.07	0.02	0.02	0.02	A
TS	137	44.77	0.27	0.26	0.28	0.17	0.01	0.00	0.00	A
TOTAL	416	43.47	0.23	0.26	0.32	0.16	0.01	0.01	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	51	10.20	0.37	0.18	0.24	0.14	0.04	0.00	0.03	A
GS III	35	23.18	-	-	-	-	-	-	-	-
TS	38	12.42	-	-	-	-	-	-	-	-
TOTAL	124	12.96	0.38	0.18	0.23	0.15	0.02	0.01	0.03	

TABLE 34

Number of fragments and category proportions of the principal stock animals - phase Md9

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	9	29.03	t.	101	0.20	0.23	0.21	0.12	0.14	0.06	0.05	A
GS III	3	23.08	ca.	17	-	-	-	-	-	-	-	-
TS	6	28.57	r.mc.t.	59	0.15	0.29	0.25	0.15	0.12	0.02	0.02	A
TOTAL	18	27.69	-	177	0.19	0.25	0.22	0.12	0.14	0.04	0.03	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	17	54.84	t.	101	0.21	0.29	0.29	0.16	0.02	0.02	0.01	A
GS III	8	61.54	r.	35	-	-	-	-	-	-	-	-
TS	12	57.14	r.	75	0.17	0.32	0.27	0.19	0.01	0.01	0.03	A
TOTAL	37	56.92	-	211	0.19	0.29	0.31	0.16	0.02	0.02	0.01	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	5	16.13	t.	33	-	-	-	-	-	-	-	-
GS III	2	15.39	m.h.t.	17	-	-	-	-	-	-	-	-
TS	3	14.29	r.u.	25	-	-	-	-	-	-	-	-
TOTAL	10	15.38	-	75	0.27	0.20	0.27	0.16	0.04	0.01	0.05	

TABLE 35

Minimum number of individuals and category proportions of the principal stock animals - phase Md9

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
m = mandible; h = humerus; r = radius; u = ulna;
mc = metacarpus; t = tibia; ca = calcaneum.

Species		GS I-II No	GS I-II %	GS III No	TS No	TS %	TOTAL Md10 No	TOTAL Md10 %
Cattle	F	77	40.10	-	35	32.71	112	37.21
	M	7	29.17	-	4	26.67	11	26.83
Sheep/Goat	F	87	45.31	1	45	42.06	133	44.19
	M	8	33.33	1	6	40.00	15	36.59
Pig	F	19	9.90	1	17	15.89	37	12.29
	M	4	16.67	1	2	13.33	7	17.07
Hare	F	2	1.04	-	2	1.87	4	1.33
	M	1	4.17	-	1	6.67	2	4.88
Rabbit	F	2	1.04	-	-	-	2	0.66
	M	1	4.17	-	-	-	1	2.44
Horse	F	1	0.52	-	2	1.87	3	1.00
	M	1	4.17	-	1	6.67	2	4.88
Dog	F	2	1.04	-	-	-	2	0.66
	M	1	4.17	-	-	-	1	2.44
Cat	F	2	1.04	-	6	5.61	8	2.66
	M	1	4.17	-	1	6.67	2	4.88
TOTAL MAMMAL	F	192	100	2	107	100	301	100
	M	24	100	2	15	100	41	100
Bird	F	19	8.68	-	38	14.79	57	11.90
	M	8		-	10		18	
Fish	F	8	3.65	1	112	43.58	121	25.26
TOTAL FRAGMENTS		219	100	3	257	100	479	100
TOTAL UNIDENTIFIED		249		2	65		316	

TABLE 36

Number of fragments and minimum number of individuals represented in phase Md10 (A.D.1350 - A.D.1500)

F = number of fragments identified.
M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	77	42.08	0.19	0.31	0.26	0.10	0.04	0.07	0.03	A
GS III	0	-	-	-	-	-	-	-	-	-
TS	35	36.08	-	-	-	-	-	-	-	-
TOTAL	112	39.72	0.20	0.36	0.23	0.09	0.04	0.06	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	87	47.54	0.23	0.28	0.32	0.14	0.00	0.01	0.02	A
GS III	1	-	-	-	-	-	-	-	-	-
TS	45	46.39	0.42	0.20	0.31	0.07	0.00	0.00	0.00	A
TOTAL	133	47.16	0.30	0.25	0.32	0.11	0.00	0.01	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	19	10.38	-	-	-	-	-	-	-	-
GS III	1	-	-	-	-	-	-	-	-	-
TS	17	17.53	-	-	-	-	-	-	-	-
TOTAL	37	13.12	0.47	0.19	0.11	0.14	0.06	0.03	0.00	

TABLE 37

Number of fragments and category proportions of the principal stock animals - phase Md10

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	7	36.84	h.	51	0.16	0.33	0.22	0.14	0.06	0.08	0.01	A
GS III	0	-	-	-	-	-	-	-	-	-	-	-
TS	4	33.33	h.f.	26	-	-	-	-	-	-	-	-
TOTAL	11	33.33	-	77	0.17	0.36	0.19	0.12	0.06	0.08	0.00	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	8	42.11	te.	55	0.22	0.31	0.28	0.15	0.00	0.02	0.02	A
GS III	1	-	-	1	-	-	-	-	-	-	-	-
TS	6	50.00	r.	34	-	-	-	-	-	-	-	-
TOTAL	15	45.46	-	90	0.28	0.29	0.28	0.11	0.00	0.01	0.03	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	4	21.05	te.	15	-	-	-	-	-	-	-	-
GS III	1	-	-	1	-	-	-	-	-	-	-	-
TS	2	16.67	te.t.	14	-	-	-	-	-	-	-	-
TOTAL	7	21.21	-	30	0.44	0.21	0.10	0.14	0.07	0.03	0.01	

TABLE 38

Minimum number of individuals and category proportions of the principal stock animals - phase Md10

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
te = teeth; h = humerus; r = radius; f = femur;
t = tibia.

Phase	Cattle			Sheep/Goat			Pig		
(all sites)	No	%	Chi^2	No	%	Chi^2	No	%	Chi^2
Md1	848	46.44	*	676	37.02	A	302	16.54	A
Md2	1529	43.10	**	1510	42.57	**	508	14.32	A
Md3	317	32.81	A	505	52.28	A	144	14.91	*
Md4	82	37.96	**	93	43.06	A	41	18.98	A
Md5	192	36.78	A	253	48.47	**	77	14.75	A
Md6	1227	40.50	A	1378	45.48	*	425	14.03	A
Md8	114	36.77	A	156	50.32	*	40	12.90	A
Md9	301	43.12	*	320	45.85	*	77	11.03	A
Md10	90	44.12	A	94	46.08	A	20	9.80	-

Category proportions - using data from all medieval deposits

Species	Cat. 2	Cat. 3	Cat. 4	Cat. 5	Cat. 6	Cat. 7
Cattle	0.41	0.27	0.13	0.08	0.07	0.04
Sheep/Goat	0.41	0.35	0.18	0.02	0.03	0.01
Pig	0.36	0.28	0.22	0.05	0.05	0.04

TABLE 39

Number of fragments of the principal stock animals in the medieval phases discounting category 1 fragments; and the results of chi-squared tests on the proportions of categories 2 - 7.

N = number of fragments.
A = sample within the 5% level of chi-squared.
** = sample significantly different at the 5% level of chi-squared,*
*** = sample significantly different at the 1% level of chi-squared.*

Site/Phase		Sheep/Goat	Cattle	Pig
GS I-II	Md1	0.42 (4 d.f.)	2.62 (6 d.f.)	0.43 (4 d.f.)
GS III	Md1	1.40 (4 d.f.)	3.26 (6 d.f.)	1.49 (4 d.f.)
TS	Md1	6.62 (4 d.f.)	16.16 (6 d.f.)*	8.25 (4 d.f.)
TOTAL Md1 (excluding HS & TS)		2.32 (6 d.f.)	2.84 (6 d.f.)	1.45 (6 d.f.)
GS I-II	Md2	15.98 (6 d.f.)*	6.50 (6 d.f.)	6.41 (5 d.f.)
GS III	Md2	2.24 (6 d.f.)	5.18 (6 d.f.)	3.03 (6 d.f.)
TS	Md2	3.87 (4 d.f.)	12.59 (6 d.f.)	4.05 (4 d.f.)
HS	Md2	1.09 (3 d.f.)	9.65 (5 d.f.)	-
TOTAL Md2 (excluding GS I-II)		3.03 (6 d.f.)	6.13 (6 d.f.)	6.43 (6 d.f.)
GS I-II	Md3	2.57 (4 d.f.)	3.15 (5 d.f.)	2.57 (4 d.f.)
GS III	Md3	2.21 (4 d.f.)	5.09 (5 d.f.)	7.20 (4 d.f.)
TS	Md3	0.36 (4 d.f.)	4.28 (5 d.f.)	-
TOTAL	Md3	3.30 (6 d.f.)	4.60 (6 d.f.)	2.66 (6 d.f.)
TOTAL	Md4	3.56 (4 d.f.)	4.32 (5 d.f.)	-
TOTAL	Md5	9.77 (4 d.f.)*	5.91 (5 d.f.)	4.34 (4 d.f.)
GS I-II	Md6	2.29 (5 d.f.)	8.34 (6 d.f.)	6.18 (4 d.f.)
GS III	Md6	5.92 (6 d.f.)	7.44 (6 d.f.)	9.43 (6 d.f.)
TS	Md6	9.56 (5 d.f.)	4.03 6 d.f.)	3.82 (4 d.f.)
TOTAL	Md6	10.84 (6 d.f.)	0.88 (6 d.f.)	4.60 (6 d.f.)
TOTAL	Md8	4.51 (4 d.f.)	1.80 (6 d.f.)	-
GS I-II	Md9	1.09 (4 d.f.)	1.68 (6 d.f.)	-
GS III	Md9	5.18 (4 d.f.)	5.65 (5 d.f.)	-
TOTAL	Md9	5.04 (5 d.f.)	5.42 (6 d.f.)	2.70 (4 d.f.)
TOTAL	Md10	4.26 (4 d.f.)	4.56 (5 d.f.)	-

TABLE 40

Chi-square calculations on the sum of minimum numbers for the seven bone categories - medieval phases

d.f. = number of degrees of freedom in chi-square calculations.
** = sample significantly different at 5% level of chi-squared.*
All other samples were within 5% level of chi-squared.
See Table 55 for the overall category proportions for the medieval period used as the basis for these calculations.

Phase	T.M.	% Cattle	% Sheep/Goat	% Pig
Md1	67	32.84	44.78	22.39
Md2	150	32.67	44.67	22.67
Md3	85	32.94	48.24	18.82
Md4	32	31.25	50.00	18.75
Md6	209	31.40	48.30	20.29
Md8	24	29.17	50.00	20.83
Md9	65	27.69	56.92	15.38
Md10	33	33.33	45.45	21.21

TABLE 41

Minimum number of individuals - relative percentage of the principal stock animals in statistically similar medieval samples

T.M. = total minimum number of individuals.

Species	Md1 M	Md1 Min.Wt.	Md1 % meat	Md2 M	Md2 Min.Wt.	Md2 % meat
Cattle	22	11,000 lb.	76.92	49	24,500 lb.	76.75
Sheep/Goat	30	1,800 lb.	12.59	67	4,020 lb.	12.59
Pig	15	1,500 lb.	10.49	34	3,400 lb.	10.65

Species	Md3 M	Md3 Min.Wt.	Md3 % meat	Md6 M	Md6 Min.Wt.	Md6 % meat
Cattle	25	12,500 lb.	74.14	65	32,500 lb.	75.76
Sheep/Goat	41	2,460 lb.	14.59	100	6,000 lb.	13.99
Pig	19	1,900 lb.	11.27	44	4,400 lb.	10.26

Md9

Species	M	Min.Wt.	% meat
Cattle	18	9,000 lb.	73.65
Sheep/Goat	37	2,220 lb.	18.17
Pig	10	1,000 lb.	8.18

TABLE 42

Estimations of minimum meat weights of the principal stock animals in the major medieval phases.

M = minimum number of individuals represented.
Min.Wt. = minimum amount of meat represented.
Meat weight of a cow estimated to be 500 lb.
Meat weight of a sheep estimated to be 60 lb.
Meat weight of a pig estimated to be 100 lb.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TOTAL Pml No	TOTAL Pml %
Cattle	F	610	41.44	552	23.41	17	1179	30.49
	M	27	27.84	20	16.13	1	48	21.15
Sheep/Goat	F	662	44.97	867	36.77	13	1542	39.88
	M	43	44.33	38	30.65	2	83	36.56
Pig	F	121	8.22	237	10.05	5	363	9.39
	M	10	10.31	17	13.71	1	28	12.33
Red Deer	F	10	0.68	22	0.93	-	32	0.83
	M	2	2.06	3	2.42	-	5	2.20
Fallow Deer	F	1	0.07	6	0.25	-	7	0.18
	M	1	1.03	1	0.81	-	2	0.88
Roe Deer	F	5	0.34	3	0.13	-	8	0.21
	M	1	1.03	2	1.61	-	3	1.32
Hare	F	6	0.41	-	-	-	6	0.16
	M	2	2.06	-	-	-	2	0.88
Rabbit	F	15	1.02	144	6.11	1	160	4.14
	M	4	4.12	9	7.26	1	14	6.17
Horse	F	8	0.54	1	0.04	-	9	0.23
	M	2	2.06	1	0.81	-	3	1.32
Dog	F	20	1.36	52	2.21	-	72	1.86
	M	2	2.06	4	3.23	-	6	2.64
Cat	F	14	0.95	447	18.96	1	462	11.95
	M	3	3.09	23	18.55	1	27	11.89
Rat	F	-	-	23	0.98	-	23	0.60
	M	-	-	5	4.03	-	5	2.20
Woodmouse	F	-	-	4	0.17	-	4	0.10
	M	-	-	1	0.81	-	1	0.44
TOTAL MAMMAL	F	1472	100	2358	100	37	3867	100
	M	97	100	124	100	6	227	100
Bird	F	120	7.22	927	20.09	14	1061	16.67
	M	20		108		5	133	
Fish	F	70	4.21	1330	28.82	40	1440	22.61
TOTAL FRAGMENTS		1662	100	4615	100	91	6368	100
TOTAL UNIDENTIFIED		1363		2535		36	3934	

TABLE 43

Number of fragments and minimum number of individuals represented in phase Pml (A.D.1500 - A.D.1600)

F = number of fragments identified.

M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	610	43.79	0.20	0.33	0.20	0.12	0.05	0.06	0.03	A
GS III	449	33.53	0.20	0.39	0.14	0.12	0.06	0.06	0.04	A
TS	17	-	-	-	-	-	-	-	-	-
TOTAL	1076	38.89	0.20	0.35	0.17	0.12	0.05	0.06	0.03	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	662	47.52	0.22	0.33	0.28	0.10	0.04	0.02	0.02	A
GS III	706	52.73	0.17	0.41	0.26	0.06	0.02	0.02	0.04	A
TS	13	-	-	-	-	-	-	-	-	-
TOTAL	1381	49.91	0.19	0.37	0.27	0.08	0.03	0.02	0.03	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	121	8.69	0.29	0.30	0.26	0.04	0.07	0.03	0.01	A
GS III	184	13.74	0.24	0.35	0.19	0.12	0.04	0.06	0.00	A
TS	5	-	-	-	-	-	-	-	-	-
TOTAL	310	11.20	0.26	0.33	0.22	0.09	0.05	0.05	0.00	

TABLE 44

Number of fragments and category proportions of the principal stock animals - phase Pml (excluding GS III F.264)

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	27	33.75	h.	254	0.15	0.26	0.20	0.14	0.11	0.07	0.07	A
GS III	17	26.56	t.	190	0.20	0.29	0.16	0.11	0.10	0.08	0.07	A
TS	1	-	-	13	-	-	-	-	-	-	-	-
TOTAL	45	30.40	-	457	0.17	0.28	0.18	0.13	0.11	0.08	0.07	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	43	53.75	r.	307	0.15	0.33	0.28	0.11	0.06	0.03	0.05	A
GS III	32	50.00	r.	287	0.11	0.36	0.29	0.09	0.03	0.02	0.10	A
TS	2	-	r.h.	11	-	-	-	-	-	-	-	-
TOTAL	77	52.03	-	605	0.13	0.35	0.28	0.10	0.05	0.02	0.07	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	10	12.50	t.	71	0.21	0.27	0.28	0.06	0.13	0.06	0.00	A
GS III	15	23.44	f.	99	0.24	0.36	0.15	0.11	0.07	0.06	0.00	A
TS	1	-	-	5	-	-	-	-	-	-	-	-
TOTAL	26	17.57	-	175	0.23	0.32	0.21	0.09	0.09	0.06	0.00	

TABLE 45

Minimum number of individuals and category proportions of the principal stock animals - phase Pml (excluding GS II F.264)

M = minimum number of individuals
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
h = humerus; f = femur; r = radius; t = tibia.

Species		GS I-II No	GS I-II %	GS III No	TS No	TS %	TOTAL Pm2 No	TOTAL Pm2 %
Cattle	F	67	39.88	6	39	32.50	112	36.48
	M	4	21.05	1	4	21.05	9	21.43
Sheep/Goat	F	90	53.57	10	45	37.50	145	47.23
	M	12	63.16	2	5	26.32	19	45.24
Pig	F	8	4.76	3	8	6.67	19	6.19
	M	1	5.26	1	2	10.53	4	9.52
Red Deer	F	-	-	-	1	0.83	1	0.33
	M	-	-	-	1	5.26	1	2.38
Fallow Deer	F	-	-	-	2	1.67	2	0.65
	M	-	-	-	1	5.26	1	2.38
Hare	F	-	-	-	4	3.33	4	1.30
	M	-	-	-	1	5.26	1	2.38
Rabbit	F	-	-	-	4	3.33	4	1.30
	M	-	-	-	1	5.26	1	2.38
Horse	F	1	0.60	-	-	-	1	0.33
	M	1	5.26	-	-	-	1	2.38
Dog	F	-	-	-	10	8.33	10	3.26
	M	-	-	-	2	10.53	2	4.76
Cat	F	2	1.19	-	7	5.83	9	2.93
	M	1	5.26	-	2	10.53	3	7.14
TOTAL MAMMAL	F	168	100	19	120	100	307	100
	M	19	100	4	19	100	42	100
Bird	F	6	3.30	6	129	48.13	141	29.62
	M	4		2	15		21	
Fish	F	8	4.40	1	19	7.09	28	5.88
TOTAL FRAGMENTS		182	100	26	268	100	476	100
TOTAL UNIDENTIFIED		120		62	112		294	

TABLE 46

Number of fragments and minimum number of individuals represented in phase Pm2 (A.D.1550 - A.D.1650)

F = number of fragments identified.
M = minimum number of individuals represented.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	67	40.61	0.19	0.27	0.21	0.18	0.03	0.10	0.01	A
GS III	6	-	-	-	-	-	-	-	-	-
TS	39	42.39	-	-	-	-	-	-	-	-
TOTAL	112	40.58	0.18	0.29	0.21	0.13	0.07	0.09	0.03	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	90	54.55	0.14	0.54	0.24	0.01	0.03	0.01	0.01	A
GS III	10	-	-	-	-	-	-	-	-	-
TS	45	48.91	0.04	0.53	0.38	0.04	0.00	0.00	0.00	
TOTAL	145	52.54	0.11	0.52	0.29	0.04	0.01	0.01	0.01	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	8	4.85	-	-	-	-	-	-	-	-
GS III	3	-	-	-	-	-	-	-	-	-
TS	8	8.70	-	-	-	-	-	-	-	-
TOTAL	19	6.88	-	-	-	-	-	-	-	-

TABLE 47

Number of fragments and category proportions of the principal stock animals

F = number of fragments identified.
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	4	23.53	t.mt.	43	0.16	0.28	0.21	0.19	0.02	0.12	0.02	A
GS III	1	-	-	6	-	-	-	-	-	-	-	-
TS	4	36.36	s.h.c.	32	-	-	-	-	-	-	-	-
TOTAL	9	28.13	-	81	0.16	0.31	0.19	0.14	0.09	0.09	0.04	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	12	70.59	h.	50	0.16	0.54	0.18	0.02	0.06	0.02	0.02	A
GS III	2	-	r.	9	-	-	-	-	-	-	-	-
TS	5	45.46	u.	29	-	-	-	-	-	-	-	-
TOTAL	19	59.38	-	88	0.13	0.48	0.28	0.05	0.03	0.02	0.01	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	1	5.88	-	7	-	-	-	-	-	-	-	-
GS III	1	-	-	3	-	-	-	-	-	-	-	-
TS	2	18.18	sk.t.	7	-	-	-	-	-	-	-	-
TOTAL	4	12.50	-	17	-	-	-	-	-	-	-	

TABLE 48

Minimum number of individuals and category proportions of the principal stock animals - phase Pm2

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
sk = skull; h = humerus; r = radius; u = ulna; t = tibia;
c = calcaneum; s = scapula; mt = metatarsus.

		GS I-II		TS		VS	TOTAL Pm3	
Species		No	%	No	%	No	No	%
Cattle	F	223	35.79	175	20.19	22	420	26.37
	M	10	22.73	7	8.75	2	19	13.97
Sheep/Goat	F	307	49.28	203	23.41	73	583	36.60
	M	20	45.46	22	27.50	6	48	35.29
Pig	F	43	6.90	38	4.38	4	85	5.34
	M	5	11.36	5	6.25	1	11	8.09
Red Deer	F	-	-	2	0.23	-	2	0.13
	M	-	-	1	1.25	-	1	0.74
Fallow Deer	F	1	0.16	1	0.12	-	2	0.13
	M	1	2.27	1	1.25	-	2	1.47
Roe Deer	F	-	-	-	-	2	2	0.13
	M	-	-	-	-	1	1	0.74
Hare	F	7	1.12	6	0.69	-	13	0.82
	M	2	4.55	1	1.25	-	3	2.21
Rabbit	F	11	1.77	54	6.23	-	65	4.08
	M	2	4.55	7	8.75	-	9	6.62
Horse	F	2	0.32	1	0.12	1	4	0.25
	M	1	2.27	1	1.25	1	3	2.21
Dog	F	24*	3.85	265	30.57	1	290	18.20
	M	2	4.55	24	30.00	1	27	19.85
Cat	F	5	0.80	120	13.84	-	125	7.85
	M	1	2.27	10	12.50	-	11	8.09
Rat	F	-	-	2	0.23	-	2	0.13
	M	-	-	1	1.25	-	1	0.74
TOTAL MAMMAL	F	623	100	867	100	103	1593	100
	M	44	100	80	100	12	136	100
Bird	F	44	5.08	320	25.87	17	381	17.13
	M	11		37		5	53	
Fish	F	200	23.07	50	4.04	-	250	11.24
TOTAL FRAGMENTS		867	100	1237	100	120	2224	100
TOTAL UNIDENTIFIED		648		605		25	1278	

TABLE 49

Number of fragments and minimum number of individuals represented in phase Pm3 (A.D.1660 - A.D.1700)

F = number of fragments identified.
M = minimum number of individuals represented.

** Dog includes 22 fragments from one burial.*

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	223	38.92	0.30	0.29	0.19	0.07	0.07	0.06	0.02	A
TS	175	42.07	0.30	0.35	0.10	0.18	0.02	0.02	0.02	*
VS	22	22.22	-	-	-	-	-	-	-	-
TOTAL	420	38.60	0.30	0.30	0.16	0.12	0.05	0.05	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	307	53.58	0.20	0.28	0.32	0.09	0.07	0.01	0.04	A
TS	203	48.80	0.04	0.44	0.42	0.04	0.03	0.00	0.03	**
VS	73	73.74	0.15	0.23	0.18	0.40	0.04	0.00	0.00	**
TOTAL	583	53.59	0.14	0.33	0.34	0.11	0.05	0.01	0.03	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	43	7.50	0.33	0.26	0.28	0.00	0.09	0.05	0.00	A
TS	38	9.14	-	-	-	-	-	-	-	-
VS	4	4.04	-	-	-	-	-	-	-	-
TOTAL	85	7.81	0.31	0.31	0.21	0.08	0.07	0.02	0.00	

TABLE 50

Number of fragments and category proportions of the principal stock animals - phase Pm3

F = number of fragments identified.
** = sample significantly different at the 5% level of chi-squared.*
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	10	25.57	t.	100	0.19	0.25	0.21	0.09	0.13	0.10	0.03	A
TS	7	20.59	m.h.p.	70	0.29	0.30	0.14	0.14	0.04	0.03	0.06	A
VS	2	22.22	t.	14	-	-	-	-	-	-	-	-
TOTAL	19	24.36	-	184	0.23	0.26	0.18	0.11	0.09	0.08	0.04	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	20	57.14	t.	154	0.14	0.25	0.29	0.12	0.10	0.03	0.07	A
TS	22	64.71	r.	113	0.06	0.40	0.42	0.04	0.04	0.00	0.04	**
VS	6	66.67	h.t.mc.	38	0.16	0.24	0.24	0.32	0.05	0.00	0.00	**
TOTAL	48	61.54	-	305	0.11	0.30	0.33	0.12	0.07	0.01	0.05	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	5	14.29	te.t.	34	-	-	-	-	-	-	-	-
TS	5	14.71	f.	26	-	-	-	-	-	-	-	-
VS	1	11.11	-	3	-	-	-	-	-	-	-	-
TOTAL	11	14.10	-	63	0.30	0.32	0.21	0.05	0.10	0.03	0.00	

TABLE 51

Minimum number of individuals and category proportions of the principal stock animals - phase Pm3

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
*** = sample significantly different at the 1% level of chi-squared.*
A = sample within 5% level of chi-squared.
m = mandible; te = teeth; h = humerus; r = radius; p = pelvis;
f = femur; t = tibia; mc = metacarpus.

Species		GS I-II No	GS I-II %	GS III No	GS III %	TS No	TOTAL Pm4 No	TOTAL Pm4 %
Cattle	F	350	32.53	85	22.14	10	445	29.87
	M	17	23.94	3	7.50	2	22	18.80
Sheep/Goat	F	502	46.65	119	30.99	9	630	42.28
	M	28	39.44	8	20.00	2	38	32.48
Pig	F	104*	9.67	32	8.33	5	141	9.46
	M	12	16.90	3	7.50	1	16	13.68
Red Deer	F	3	0.28	-	-	-	3	0.20
	M	1	1.41	-	-	-	1	0.86
Fallow Deer	F	3	0.28	-	-	-	3	0.20
	M	1	1.41	-	-	-	1	0.86
Hare	F	9	0.84	40	10.42	-	49	3.29
	M	2	2.82	7	17.50	-	9	7.69
Rabbit	F	20	1.86	66	17.19	-	86	5.77
	M	4	5.63	14	35.00	-	18	15.38
Horse	F	1	0.09	-	-	-	1	0.07
	M	1	1.41	-	-	-	1	0.85
Dog	F	66*	6.13	1	0.26	-	67	4.50
	M	2	2.82	1	2.50	-	3	2.56
Cat	F	18	1.67	40*	10.42	6	64	4.30
	M	3	4.23	3	7.50	1	7	5.98
Rat	F	-	-	1	0.26	-	1	0.07
	M	-	-	1	2.50	-	1	0.86
TOTAL	F	1076	100	384	100	30	1490	100
MAMMAL	M	71	100	40	100	6	117	100
Bird	F	81	6.05	34	7.98	3	118	6.57
	M	16		5		2	23	
Fish	F	181	13.53	8	1.88	-	189	10.52
TOTAL FRAGMENTS		1338	100	426	100	33	1797	100
TOTAL UNIDENTIFIED		1165		359		33	1557	

TABLE 52

Number of fragments and minimum number of individuals represented in phase Pm4 (A.D.1660 - A.D.1800)

F = number of fragments identified.
M = minimum number of individuals represented.

* *Pig includes 10 fragments from one burial.*
Dog includes 56 fragments from one burial.
Cat includes 10 fragments from one burial.

Cattle	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	350	37.00	0.27	0.30	0.18	0.09	0.03	0.11	0.02	A
GS III	85	36.02	0.31	0.27	0.09	0.05	0.05	0.22	0.01	*
TS	10	-	-	-	-	-	-	-	-	-
TOTAL	445	36.90	0.27	0.30	0.17	0.09	0.03	0.13	0.02	

Sheep/Goat	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	502	53.07	0.20	0.35	0.22	0.13	0.04	0.02	0.04	A
GS III	119	50.42	0.25	0.39	0.24	0.02	0.02	0.03	0.03	*
TS	9	-	-	-	-	-	-	-	-	-
TOTAL	630	52.24	0.21	0.36	0.23	0.11	0.03	0.02	0.04	

Pig	F	% Stock	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	94	9.94	0.35	0.39	0.14	0.09	0.02	0.00	0.01	A
GS III	32	13.56	-	-	-	-	-	-	-	-
TS	5	-	-	-	-	-	-	-	-	-
TOTAL	131	10.86	0.31	0.46	0.15	0.06	0.02	0.00	0.01	

TABLE 53

Number of fragments and category proportions of the principal stock animals - phase Pm4

F = number of fragments identified.
** = sample significantly different at 5% level of chi-squared.*
A = sample within 5% level of chi-squared.

Cattle	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	17	29.82	f.	175	0.19	0.31	0.21	0.09	0.05	0.10	0.04	A
GS III	3	21.43	h.r.t.	32	-	-	-	-	-	-	-	-
TS	2	-	t.	8	-	-	-	-	-	-	-	-
TOTAL	22	28.95	-	215	0.19	0.31	0.20	0.10	0.06	0.11	0.04	

Sheep/Goat	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	28	49.12	h.	265	0.15	0.34	0.21	0.15	0.06	0.02	0.08	A
GS III	8	57.14	h.	53	0.17	0.38	0.21	0.04	0.04	0.06	0.11	A
TS	2	-	p.t.	8	-	-	-	-	-	-	-	-
TOTAL	38	50.00	-	326	0.15	0.35	0.21	0.13	0.05	0.02	0.08	

Pig	M	% Stock	M.R.B.	S.M.	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.6	Cat.7	Chi^2
GS I-II	12	21.05	m.	82	0.33	0.35	0.17	0.09	0.04	0.00	0.02	A
GS III	3	21.43	f.	14	-	-	-	-	-	-	-	-
TS	1	-	-	5	-	-	-	-	-	-	-	-
TOTAL	16	21.05	-	101	0.30	0.38	0.20	0.07	0.02	0.00	0.02	

TABLE 54

Minimum number of individuals and category proportions of the principal stock animals - phase Pm4

M = minimum number of individuals.
M.R.B. = most represented bone(s).
S.M. = sum of minimum numbers.
A = sample within 5% level of chi-squared.
m = mandible; h = humerus; f = femur; p = pelvis;
r = radius; t = tibia.

	Cattle		Sheep/Goat		Pig	
Roman	S.M.	Proportion	S.M.	Proportion	S.M.	Proportion
Category 1	268	(0.23)	221	(0.22)	265	(0.29)
2	315	(0.27)	265	(0.26)	243	(0.27)
3	181	(0.16)	280	(0.28)	151	(0.17)
4	139	(0.12)	131	(0.13)	113	(0.12)
5	110	(0.10)	57	(0.06)	48	(0.05)
6	100	(0.09)	30	(0.03)	55	(0.06)
7	36	(0.03)	22	(0.02)	34	(0.04)
TOTAL/Chi^2	1149 /	**	1006 /	A	909 /	A
Medieval						
Category 1	498	(0.18)	722	(0.23)	376	(0.26)
2	741	(0.27)	914	(0.29)	371	(0.25)
3	533	(0.20)	850	(0.27)	319	(0.22)
4	326	(0.12)	453	(0.14)	207	(0.14)
5	302	(0.11)	108	(0.03)	76	(0.05)
6	177	(0.07)	87	(0.03)	65	(0.04)
7	149	(0.06)	63	(0.02)	51	(0.04)
TOTAL/Chi^2	2726 /	A	3197 /	A	1465 /	A
Combined Roman and Medieval						
Category 1	766	(0.20)	943	(0.22)	641	(0.27)
2	1056	(0.27)	1179	(0.28)	614	(0.26)
3	714	(0.18)	1130	(0.27)	470	(0.20)
4	465	(0.12)	584	(0.14)	320	(0.13)
5	412	(0.11)	165	(0.04)	124	(0.05)
6	277	(0.07)	117	(0.03)	120	(0.05)
7	185	(0.05)	85	(0.02)	85	(0.04)
TOTAL	3875		4203		2374	

TABLE 55

Comparison of overall Roman and medieval category proportions of the principal stock animals (sum of minimum numbers)

S.M. = sum of minimum numbers.
*** = sample significantly different at 1% level of chi-squared from the combined Roman and medieval data.*
A = sample within 5% level of chi-squared.

Cattle	A	% Stock	B	% Stock
Plough Animals*	46,066	-	10,124	-
"Animalia"	7,357	-	1,055	-
TOTAL	53,423	45.28	11,179	48.69

Sheep/Goat	A	% Stock	B	% Stock
Sheep	50,039	-	9,689	-
Goat	7,263	-	1,613	-
TOTAL	57,302	48.57	11,302	49.22

Pig	A	% Stock	B	% Stock
TOTAL	7,263	6.16	480	2.09

TABLE 56

Domesday records of livestock on the demesne lands of Devon and in the hundreds around Exeter.

A = animals recorded on demesne lands in the whole of Devon.
B = animals recorded on demesne lands in the hundreds of Crediton, Exminster, Cliston, Hairidge, Wonford, Ottery, St. Mary, East Budleigh and West Budleigh.
** = Estimate based on eight animals/plough team.*

Stage	55 - 300			GS 300+			TS 300+			Rest 300+		
	A	B	C	A	B	C	A	B	C	A	B	C
Stage 1	0	0	132	0	0	19	1	0	13	1	0	13
Stage 2	0	0	132	0	0	19	1	1	12	1	0	13
Stage 3	0	4	128	3	1	15	3	1	10	1	1	12
Stage 4	10	21	101	11	0	8	6	0	8	3	0	11
Stage 5	17	33	82	11	1	7	6	0	8	6	0	8
Stage 6	18	66	48	11	4	4	6	2	6	6	2	6

Percentage of animals killed

Stage		55 - 300	GS 300+	TS 300+	Rest 300+
Stage 1		0.00%	0.00%	7.14%	7.14%
Stage 2	min.	0.00%	0.00%	7.14%	7.14%
	max.	0.00%	0.00%	14.29%	7.14%
Stage 3	min.	0.00%	15.79%	21.43%	7.14%
	max.	3.03%	21.05%	28.57%	14.29%
Stage 4	min.	7.58%	57.89%	42.86%	21.43%
	max.	23.48%	57.89%	42.86%	21.43%
Stage 5	min.	12.88%	57.89%	42.86%	42.86%
	max.	37.88%	63.16%	42.86%	42.86%
Stage 6	min.	13.64%	57.89%	42.86%	42.86%
	max.	63.64%	78.95%	57.14%	57.14%

TABLE 57

Cattle: tooth eruptions data - Roman period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Specimen	P4	M1	M2	M3	n.v.	St.6
1	-	-	n	m	54e	A
2	-	-	n	-	50+e	A
3	-	m	l	k	48	A
4	-	-	-	k	48e	A
5	-	-	l	-	47e	A
6	-	-	l	j	47e	A
7	-	-	k	j	45e	A
8	-	-	-	j	45e	A
9	-	-	-	j	45e	A
10	-	-	-	j	45e	A
11	-	-	-	j	45e	A
12	-	-	k	j	45e	A
13	-	k	k	-	44e	A
14	-	-	-	j	44e	A
15	-	-	k	-	44e	A
16	-	-	-	j	44e	A
17	-	-	-	j	44e	A
18	-	-	k	-	42+e	A
19	-	-	-	g	40+e	A
20	-	-	-	g	40+e	A
21	-	-	-	f	37-40e	B
22	-	-	-	f	37-40e	B
23	-	-	g	-	37-40e	B
24	-	h	g	-	c.37e	C
25	-	-	f	-	c.30e	C

TABLE 58 (i)

Study of wear patterns on cattle mandibles dated to A.D.55 - A.D.300 (phases R1-R7)

n.v. = numerial value of mandible (after Grant 1975).
St.6 = stage 6 of tooth eruption sequence.
A =P4 certainly in wear.
B = P4 possibly in wear.
C = P4 not in wear.
e = estimated value of mandible.
- = tooth absent from mandible.

Specimen	P4	M1	M2	M3	n.v.	St.6
26	g	m	l	-	49e	A
27	h	m	-	-	49e	A
28	g	l	k	j	45	A
29	g	l	k	j	45	A
30	g	l	-	-	45e	A
31	f	l	-	-	45e	A
32	f	k	k	j	44	A
33	f	k	-	-	44e	A
34	f	k	-	-	44e	A
35	g	k	-	-	44e	A
36	g	k	k	-	44e	A
37	f	j	-	-	c.40e	A
38	c	h	g	-	c.37e	A
39	g	-	-	-	-	A
40	f	-	-	-	-	A
41	f	-	-	-	-	A
42	f	-	-	-	-	A
43	e	-	-	-	-	A
44	e	-	-	-	-	A
45	e	-	-	-	-	A
46	c	-	-	-	-	A

TABLE 58 (ii)

Study of wear patterns on cattle mandibles dated to A.D.55 - A.D.300 (phases R1-R7)

n.v. = numerical value of mandible (after Grant 1975).
St.6 = stage 6 of tooth eruption sequence.
A = P4 certainly in wear.
e = estimated value of mandible.
- = tooth absent from mandible.

Fusion Age		55 - 300		GS 300+		TS 300+		Rest 300+	
7-18 months		NF	F	NF	F	NF	F	NF	F
Scapula	DF	0	45	0	15	0	11	0	5
Humerus	DF	1	35	2	8	0	10	0	5
Radius	PF	2	38	0	10	0	9	0	6
Phal.1	PF	0	62	0	20	0	27	0	8
Phal.2	PF	0	45	0	19	0	8	0	7
% unfused		1.32%		2.70%		0.00%		0.00%	
24-36 months		NF	F	NF	F	NF	F	NF	F
Metacarpus	DF	1	41	2	8	5	17	0	3
Tibia	DF	2	20	0	6	4	7	0	6
Metatarsus	DF	0	32	1	15	6	10	0	3
% unfused		3.13%		9.38%		30.61%		0.00%	
36-42 months		NF	F	NF	F	NF	F	NF	F
Calcaneum	PF	3	8	3	4	1	4	1	1
42-48 months		NF	F	NF	F	NF	F	NF	F
Humerus	PF	1	5	0	0	0	0	1	2
Radius	DF	2	19	1	3	0	3	1	5
Ulna	PF	0	2	1	0	0	0	0	0
Femur	PF	8	14	3	1	3	5	1	1
Femur	DF	6	4	0	1	1	1	1	0
Tibia	PF	5	5	0	4	1	3	0	3
% unfused		30.99%		35.71%		29.41%		26.67%	

TABLE 59

Cattle: epiphyseal fusion data - Roman period

NF = not fused.
F= fused.
PF = proximal fusion point.
DF = distal fusion point.

Ageing data after Silver (1969; 285-6).

Stage	1000 - 1200			1200 - 1300			1300 - 1500		
	A	B	C	A	B	C	A	B	C
Stage 1	0	0	72	0	0	20	1	0	2
Stage 2	1	0	71	0	1	19	1	0	2
Stage 3	2	1	69	0	2	18	1	0	2
Stage 4	9	9	54	1	2	17	1	1	1
Stage 5	12	10	50	1	5	14	1	1	1
Stage 6	12	30	30	3	4	13	1	2	0

Percentage of animals killed

Stage		1000 - 1200	1200 - 1300
Stage 1		0.00%	0.00%
Stage 2	min.	1.39%	0.00%
	max.	1.39%	5.00%
Stage 3	min.	2.78%	0.00%
	max.	4.17%	10.00%
Stage 4	min.	12.50%	5.00%
	max.	25.00%	15.00%
Stage 5	min.	16.67%	5.00%
	max.	30.56%	30.00%
Stage 6	min.	16.67%	15.00%
	max.	58.33%	35.00%

TABLE 60

Cattle: tooth eruption data - medieval period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Specimen	P4	M1	M2	M3	n.v.	St.6
1	-	-	-	m	50e+	A
2	-	-	n	-	50e+	A
3	-	n	l	l	50	A
4	-	m	l	k	48	A
5	-	-	-	k	48e	A
6	-	-	-	k	48e	A
7	-	-	-	k	48e	A
8	-	n	k	j	47	A
9	-	-	l	j	47e	A
10	-	l	k	k	46	A
11	-	-	-	j	45e	A
12	-	l	k	-	45e	A
13	-	-	-	j	45e	A
14	-	-	-	j	45e	A
15	-	k	k	j	44	A
16	-	k	-	-	44e	A
17	-	-	k	j	44e	A
18	-	k	-	-	40e	A
19	-	-	h	g	40e	A
20	-	-	h	g	40e	A
21	-	k	g	g	39	A
22	h	m	-	-	47e	A
23	g	l	l	j	46	A
24	g	l	j	j	44	A
25	g	k	k	-	44e	A
26	g	k	j	j	43	A
27	f	k	-	-	42e	A
28	f	j	j	g	40	A
29	c	k	g	g	39	A
30	c	h	g	g	37	A

TABLE 61

Study of wear pattern on cattle mandibles dated to the eleventh-twelfth centuries (phases Md1-Md3)

n.v. = numerical value (after Grant 1975).
St.6 = Stage 6 of tooth eruption sequence.
A = P4 certainly in wear.
e = estimated value.
- = tooth absent from mandible.

Fusion Age		1000 - 1200		1200 - 1300		1300 - 1500	
7-18 months		NF	F	NF	F	NF	F
Scapula	DF	0	48	0	22	0	13
Humerus	DF	3	114	4	27	1	12
Radius	PF	0	87	0	51	1	16
Phal.1	PF	2	52	0	25	1	9
Phal.2	PF	0	35	0	22	0	3
% unfused		1.47%		2.65%		5.36%	

24-36 months		NF	F	NF	F	NF	F
Metacarpus	DF	9	47	7	24	2	5
Tibia	DF	12	77	16	50	1	7
Metatarsus	DF	4	44	4	21	3	6
% unfused		12.95%		22.13%		25.00%	

36-42 months		NF	F	NF	F	NF	F
Calcaneum	PF	25	51	11	18	8	7

42-48 months		NF	F	NF	F	NF	F
Humerus	PF	15	27	5	10	2	0
Radius	DF	26	41	12	18	3	4
Ulna	PF	4	12	5	2	2	0
Femur	PF	25	40	12	21	4	4
Femur	DF	16	25	13	9	3	7
Tibia	PF	25	25	8	13	7	5
% unfused		39.50%		42.97%		51.22%	

TABLE 62

Cattle: epiphyseal fusion data - medieval period

NF = not fused.
F= fused.
Pf = proximal fusion point.
DF = distal fusion point.

Ageing data after Silver (1969: 285-6).

Stage	1500 - 1600 A	B	C	1600 - 1800 A	B	C
Stage 1	13	0	17	13	1	19
Stage 2	18	4	8	24	0	9
Stage 3	22	0	8	26	1	6
Stage 4	24	2	4	27	1	5
Stage 5	25	2	3	27	1	5
Stage 6	26	3	1	27	2	4

Percentage of animals killed

Stage		1500 - 1600	1600 - 1800
Stage 1	min.	43.33%	39.39%
	max.	43.33%	42.42%
Stage 2	min.	60.00%	72.73%
	max.	73.33%	72.73%
Stage 3	min.	73.33%	78.79%
	max.	73.33%	81.82%
Stage 4	min.	80.00%	81.82%
	max.	86.67%	84.85%
Stage 5	min.	83.33%	81.82%
	max.	90.00%	84.85%
Stage 6	min.	86.67%	81.82%
	max.	96.67%	87.88%

TABLE 63

Cattle: tooth eruption data - postmedieval period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Fusion Age		1500 - 1600		1600 - 1800	
7-18 months		NF	F	NF	F
Scapula	DF	-	-	-	-
Humerus	DF	15	30	10	21
Radius	PF	5	15	7	16
Phal.1	PF	2	41	3	30
Phal.2	PF	1	21	0	18
% unfused		17.69%		19.05%	

24-36 months		NF	F	NF	F
Metacarpus	DF	15	13	10	1
Tibia	DF	9	16	9	11
Metatarsus	DF	11	13	15	1
% unfused		45.45%		72.34%	

36-42 months		NF	F	NF	F
Calcaneum	PF	11	7	9	7

42-48 months		NF	F	NF	F
Humerus	PF	19	3	16	3
Radius	DF	15	9	10	5
Ulna	PF	7	0	8	1
Femur	PF	7	7	12	9
Femur	DF	14	11	10	8
Tibia	PF	17	8	10	10
% unfused		67.52%		64.71%	

TABLE 64

Cattle: epiphyseal fusion data - postmedieval period

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Ageing data after Silver (1969: 285-6).

Measurement		Date	N	Range	Mean	S	V
Mandible	(1)	55-300	33	29.0-36.9	32.1	2.19	6.82
	(1)	300+	8	30.6-36.6	33.1	2.27	6.86
	(1)	1000-1200	22	30.1-37.8	33.4	2.06	6.17
	(1)	1200-1300	2	31.2-36.2	33.7	-	-
Mandible	(2)	55-300	14	72.5-84.5	78.8	3.10	3.93
	(2)	300+	4	75.1-86.0	79.8	-	-
	(2)	1000-1200	11	74.3-84.3	78.3	3.27	4.18
Mandible	(3)	55-300	13	42.0-48.9	44.8	1.89	4.22
	(3)	300+	3	42.3-43.9	43.0	-	-
	(3)	1000-1200	4	39.4-46.5	43.0	-	-
Mandible	(4)	55-300	4	116-125	121.3	-	-
Maxilla	(1)	55-300	9	23.8-28.1	25.6	1.31	5.12
	(1)	300+	5	24.0-27.4	26.1	-	-
	(1)	1000-1200	12	22.0-26.3	25.0	1.30	5.20
Maxilla	(2)	Roman	5	67.0-72.0	69.3	-	-
	(2)	1000-1200	6	62.3-71.9	70.4	1.73	2.46
Scapula	(1)	55-300	11	54.0-72.0	62.4	6.80	10.90
	(1)	300+	9	54.5-69.5	62.7	4.84	7.72
	(1)	1000-1150	5	47.9-64.2	54.5	-	-
	(1)	1100-1200	4	55.5-55.9	55.6	-	-
	(1)	1200-1300	9	56.2-71.1	59.9	5.39	9.00
	(1)	1500-1700	8	47.6-81.9	67.5	11.20	16.59
	(1)	1700-1800	6	49.1-76.8	66.0	11.24	17.03
Scapula	(2)	55-300	14	44.9-61.0	52.6	4.54	8.63
	(2)	300+	7	43.7-58.2	51.3	4.62	9.01
	(2)	1000-1150	5	39.4-51.7	45.4	-	-
	(2)	1100-1200	4	45.5-50.8	48.0	-	-
	(2)	1200-1300	10	45.8-55.8	50.0	3.11	6.22
	(2)	1500-1700	8	42.9-66.6	55.8	8.06	14.44
	(2)	1700-1800	6	41.9-67.4	55.2	9.22	16.70
Humerus	(1)	Roman	6	63.1-74.3	69.1	-	-
	(1)	1000-1150	4	65.1-68.1	67.1	-	-
	(1)	1100-1200	13	63.6-89.9	71.2	7.76	10.90
	(1)	1200-1300	3	68.0-72.2	70.3	-	-
	(1)	1500-1700	13	68.9-98.3	79.6	7.93	9.96
	(1)	1700-1800	4	66.1-68.9	71.7	-	-
Humerus	(2)	Roman	4	57.9-64.6	60.8	-	-
	(2)	1000-1150	4	58.7-63.7	61.7	-	-
	(2)	1100-1200	8	57.6-68.3	62.9	4.18	6.65
	(2)	1200-1300	3	58.0-61.8	60.5	-	-
	(2)	1500-1700	9	61.7-86.3	74.2	7.60	10.24
	(2)	1700-1800	2	58.1-61.7	59.9	-	-
Humerus	(3)	Roman	6	36.0-42.9	39.7	-	-
	(3)	1000-1150	7	34.7-40.8	38.1	2.20	5.77
	(3)	1100-1200	14	35.2-48.7	39.0	3.66	9.39
	(3)	1200-1300	3	37.6-41.6	39.0	-	-
	(3)	1500-1700	13	36.0-51.4	44.6	4.31	9.66
	(3)	1700-1800	4	35.5-43.5	39.2	-	-
Humerus	(4)	Roman	4	59.8-65.0	62.5	-	-
	(4)	1000-1150	6	57.7-71.2	63.3	5.98	9.45
	(4)	1100-1200	14	56.6-74.7	64.4	5.62	8.73
	(4)	1200-1300	4	60.1-65.3	62.8	-	-
	(4)	1500-1700	15	61.8-85.3	72.7	6.49	8.93
	(4)	1700-1800	6	58.3-84.7	70.2	-	-

TABLE 65 (i)

Metrical analysis of cattle

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Radius	(1)	55-300	10	65.5-78.8	71.7	4.14	5.77
	(1)	300+	5	61.2-71.0	67.0	-	-
	(1)	1000-1150	16	60.3-85.4	68.8	6.02	8.75
	(1)	1100-1200	25	56.7-79.1	68.2	5.56	8.15
	(1)	1200-1300	16	55.1-79.3	68.5	7.91	11.55
	(1)	1300-1500	6	62.3-80.5	71.0	7.33	10.32
	(1)	1500-1700	3	66.0-80.6	73.4	-	-
Radius	(2)	55-300	3	58.0-60.5	59.3	-	-
	(2)	300+	6	59.2-76.7	68.8	6.69	9.72
	(2)	1000-1150	11	58.1-71.9	63.4	4.84	7.63
	(2)	1100-1200	13	54.7-69.5	60.1	5.74	9.55
	(2)	1000-1200	6	49.3-67.6	59.1	7.38	12.48
	(2)	1200-1300	11	54.0-72.1	61.4	6.51	10.60
	(2)	Postmed.	5	49.6-85.0	70.7	-	-
Radius	(L)	Roman	5	243-274	261.6	-	-
	(L)	Medieval	3	240-254	245.7	-	-
Metacarpus	(1)	55-300	30	44.8-57.3	48.8	3.70	7.58
	(1)	300+	31	43.7-54.0	47.9	2.14	4.47
	(1)	1000-1150	12	45.0-54.9	49.2	3.45	7.01
	(1)	1100-1200	35	42.3-57.8	49.6	4.66	9.40
	(1)	1200-1300	17	42.5-58.7	49.7	4.72	9.50
	(1)	1300-1500	7	45.1-52.9	49.6	2.91	5.87
	(1)	1500-1700	16	36.5-62.3	49.8	6.36	12.77
	(1)	1700-1800	4	39.5-51.0	46.7	-	-
Metacarpus	(2)	55-300	26	27.9-34.0	30.5	1.94	6.36
	(2)	300+	30	27.1-34.1	29.5	1.79	6.07
	(2)	1000-1150	12	27.9-34.2	30.4	2.15	7.07
	(2)	1100-1200	34	26.4-38.9	31.3	3.25	10.38
	(2)	1200-1300	15	25.2-38.6	32.3	3.84	11.89
	(2)	1300-1500	6	27.4-33.6	31.7	1.11	3.50
	(2)	1500-1700	15	21.2-38.2	31.1	4.46	14.34
	(2)	1700-1800	4	23.2-33.8	29.5	-	-
Metacarpus	(3)	55-300	36	40.9-52.9	45.3	3.55	7.84
	(3)	300+	26	38.5-50.5	44.8	2.73	6.09
	(3)	1000-1150	11	42.2-50.5	46.1	2.90	6.29
	(3)	1100-1200	26	39.9-55.4	47.0	4.54	9.66
	(3)	1200-1300	20	40.3-58.4	46.8	4.65	9.94
	(3)	1300-1500	4	41.4-53.2	46.1	-	-
	(3)	1500-1700	13	40.9-61.4	50.6	7.57	14.96
Metacarpus	(4)	55-300	35	20.6-27.2	24.2	1.48	6.12
	(4)	300+	23	20.0-27.5	24.1	1.83	7.59
	(4)	1000-1150	10	23.6-25.4	24.2	0.61	2.52
	(4)	1100-1200	26	21.6-28.1	24.3	1.95	8.02
	(4)	1200-1300	20	20.3-28.0	23.9	1.82	7.62
	(4)	1300-1500	4	22.0-26.0	24.5	-	-
	(4)	1500-1700	13	22.0-31.6	25.7	3.39	13.19
Metacarpus	(5)	55-300	30	44.5-60.6	48.6	4.69	9.65
	(5)	300+	19	44.3-55.0	50.0	2.41	4.82
	(5)	1000-1150	9	46.7-55.8	51.2	3.11	6.07
	(5)	1100-1200	22	43.2-62.5	52.8	5.68	10.76
	(5)	1200-1300	12	44.3-62.0	52.5	5.27	10.04
	(5)	1300-1500	3	45.9-58.0	50.2	-	-
Metacarpus	(L)	55-300	5	166-194	174.8	10.03	5.74
	(L)	300+	13	159-183	174.3	6.65	3.82
	(L)	1000-1150	4	167-174	170.0	-	-
	(L)	1100-1200	15	156-196	174.7	11.36	6.50

TABLE 65 (ii)

Metrical analysis of cattle

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Metacarpus	(L)	1200-1300	6	159-192	173.6	12.51	7.21
	(L)	1500-1700	5	153-213	183.8	-	-
Tibia	(1)	55-300	9	49.7-63.3	55.4	4.51	8.14
	(1)	300+	11	50.1-65.1	55.7	4.16	7.47
	(1)	1000-1150	21	48.7-62.2	54.0	4.11	7.61
	(1)	1100-1200	28	47.7-62.7	53.2	3.85	7.24
	(1)	1200-1300	29	46.8-60.4	54.4	4.09	7.52
	(1)	1300-1500	5	49.9-58.8	54.6	-	-
	(1)	1500-1700	9	48.6-69.0	59.0	6.73	11.41
Tibia	(2)	55-300	11	35.3-47.3	41.3	3.44	8.33
	(2)	300+	11	35.0-46.0	39.5	3.29	8.33
	(2)	1000-1150	21	35.0-47.1	39.6	3.55	8.96
	(2)	1100-1200	27	34.8-45.8	38.7	2.91	7.52
	(2)	1200-1300	29	33.6-47.0	39.0	2.98	7.64
	(2)	1300-1500	5	37.9-44.2	40.8	-	-
	(2)	1500-1700	8	32.5-46.9	41.5	-	-
Tibia	(L)	300+	3	284-311	293.7	-	-
Astragalus	(1)	55-300	14	50.7-59.6	55.2	2.59	4.69
	(1)	300+	18	54.3-62.0	58.3	2.48	4.25
	(1)	1000-1150	14	50.5-63.1	57.6	3.26	5.66
	(1)	1100-1200	17	52.2-64.3	57.6	3.96	6.88
	(1)	1200-1300	13	50.5-59.9	55.2	2.87	5.20
	(1)	1300-1500	3	54.5-58.0	56.0	-	-
	(1)	1500-1700	15	53.3-68.9	59.6	4.75	7.97
Astragalus	(2)	55-300	14	28.9-35.3	31.6	1.58	5.00
	(2)	300+	18	29.1-38.0	33.3	2.28	6.85
	(2)	1000-1150	14	29.5-36.3	31.8	1.97	6.20
	(2)	1100-1200	16	29.7-37.4	32.6	3.07	9.42
	(2)	1200-1300	13	28.0-34.9	31.8	2.10	6.60
	(2)	1300-1500	3	30.3-33.0	31.4	-	-
	(2)	1500-1700	17	29.5-42.4	33.9	3.44	10.15
Astragalus	(3)	55-300	13	47.1-54.6	50.5	1.94	3.84
	(3)	300+	18	48.8-61.6	53.6	2.93	5.47
	(3)	1000-1150	15	45.6-56.4	52.2	3.20	6.13
	(3)	1100-1200	17	48.4-59.3	53.1	3.35	6.31
	(3)	1200-1300	15	45.5-56.6	50.8	3.32	6.54
	(3)	1300-1500	3	50.1-51.9	51.1	-	-
	(3)	1500-1700	11	48.6-62.5	54.3	4.70	8.66
Calcaneum	(1)	Roman	5	37.3-46.3	42.3	-	-
	(1)	1000-1150	6	39.4-46.6	42.3	2.48	5.86
	(1)	1100-1200	19	38.0-46.5	42.9	2.31	5.38
	(1)	1200-1300	8	40.5-49.6	44.1	3.01	6.83
	(1)	1300-1500	4	36.5-45.2	40.0	-	-
	(1)	1500-1700	5	37.1-55.1	47.1	-	-
Calcaneum	(2)	Roman	3	21.1-25.3	23.7	-	-
	(2)	1000-1150	6	21.9-26.6	23.5	1.79	7.62
	(2)	1100-1200	20	20.7-27.0	23.3	1.67	7.17
	(2)	1200-1300	9	21.2-29.3	24.3	2.58	10.62
	(2)	1300-1500	3	20.6-27.3	23.6	-	-
	(2)	1500-1700	6	22.5-29.6	25.7	2.62	10.19
Calcaneum	(3)	Roman	5	40.3-50.3	45.2	-	-
	(3)	1000-1150	5	43.7-48.3	45.5	-	-
	(3)	1100-1200	13	43.6-51.1	46.3	2.35	5.08
	(3)	1200-1300	7	41.6-47.5	44.7	2.33	5.21
	(3)	1300-1500	3	40.6-46.8	43.7	-	-
	(3)	1500-1700	3	43.8-49.0	46.1	-	-

TABLE 65 (iii)

Metrical analysis of cattle

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Calcaneum	(L)	Roman	6	99.1-129	115.9	-	-
	(L)	1000-1150	6	111-131	121.3	-	-
	(L)	1100-1200	20	101-136	120.0	9.41	7.84
	(L)	1200-1300	8	108-136	118.4	10.51	8.88
	(L)	1300-1500	4	100-116	105.3	-	-
	(L)	1500-1700	5	101-156	129.2	-	-
Metatarsus	(1)	55-300	38	37.3-45.4	40.8	2.11	5.17
	(1)	300+	24	36.0-48.2	41.7	2.84	6.81
	(1)	1000-1150	5	38.3-46.4	43.0	-	-
	(1)	1100-1200	31	36.8-49.1	42.1	3.46	8.22
	(1)	1200-1300	26	34.4-45.8	41.5	3.18	7.66
	(1)	1300-1500	4	38.3-46.5	41.7	-	-
	(1)	1500-1700	10	31.2-49.3	43.3	5.34	12.33
Metatarsus	(2)	55-300	33	36.0-44.8	38.7	2.25	5.81
	(2)	300+	21	35.4-44.9	39.4	2.82	7.16
	(2)	1000-1150	5	35.3-46.1	41.5	-	-
	(2)	1100-1200	29	32.8-46.8	39.3	3.83	9.75
	(2)	1200-1300	27	33.0-44.8	39.7	3.05	7.68
	(2)	1300-1500	4	36.4-42.5	39.0	-	-
	(2)	1500-1700	8	27.6-46.4	41.2	6.68	16.21
Metatarsus	(3)	55-300	24	38.3-49.5	42.3	2.63	6.22
	(3)	300+	25	36.9-51.1	44.0	3.60	8.18
	(3)	1000-1150	5	41.9-50.0	46.0	-	-
	(3)	1100-1200	23	36.8-49.1	44.8	3.48	7.77
	(3)	1200-1300	13	38.0-53.6	45.6	3.59	7.87
	(3)	1300-1500	3	40.0-49.1	43.3	-	-
	(3)	1500-1700	7	43.6-51.9	47.3	2.75	5.81
Metatarsus	(4)	55-300	22	22.8-28.5	25.2	1.69	6.71
	(4)	300+	22	22.3-28.8	25.4	1.97	7.76
	(4)	1000-1150	5	24.3-29.9	27.0	-	-
	(4)	1100-1200	20	22.4-28.7	25.9	1.61	6.22
	(4)	1200-1300	10	23.0-28.7	25.6	1.92	7.50
	(4)	1300-1500	2	22.3-28.4	25.4	-	-
	(4)	1500-1700	8	25.5-30.7	28.0	1.69	6.04
Metatarsus	(L)	55-300	5	190-205	199.0	5.51	2.77
	(L)	300+	10	191-219	204.4	9.24	4.52
	(L)	1000-1150	2	198-200	199.0	-	-
	(L)	1100-1200	10	182-223	196.5	14.40	7.33
	(L)	1200-1300	5	182-205	193.0	-	-
	(L)	1500-1700	3	199-222	208.0	-	-

TABLE 65 (iv)

Metrical analysis of cattle

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Site	Date	N	Range
Exeter	Roman	20	49.7-65.1
Exeter	Medieval	83	46.8-62.7
Exeter	Postmed.	9	48.6-69.0
Portchester	Roman	143	50-69
Corstopitum	Roman	78	45-68
Gadebridge Park	Roman	13	44-60

a) Maximum distal width of tibia

Site	Date	N	Range
Exeter	Roman	15	190-219
Exeter	Medieval	17	182-223
Exeter	Postmed.	3	199-222
Portchester	Roman	108	183-240
Corstopitum	Roman	67	181-244
Gadebridge Park	Roman	3	208-254

TABLE 66

Comparison of the range in size of Exeter cattle with cattle from some other Roman-British sites

All measurements in millimetres.
N = number of specimens.
Data from Portchester and Corstopitum after Grant (1975: 401).
Data from Gadebridge Park after Harcourt (1974b: 256-7).

Date	N	Range	Mean	S	V
Roman	24	90-175	118.7	21.6	18.2
Medieval	76	88-189	131.7	26.9	20.4

a) Basal Circumference of Horn Core

Date	N	Range	Mean	S	V
Roman	7	85-130	111.9	18.2	16.3
Medieval	38	70-178	119.8	32.0	26.7

TABLE 67

Metrical analysis of cattle horn cores

All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

a) Humeri, femora, radii tibiae

Date	Complete Bones	Total Fragments	Percentage Complete Bones
Roman	10	843	1.18%
1000-1200	10	1216	0.82%
1200-1300	3	724	0.41%
1300-1500	0	243	0.00%
Postmed.	4	700	0.57%
TOTAL	27	3726	0.72%

b) Metacarpi, metatarsi

Date	Complete Bones	Total Fragments	Percentage Complete Bones
Roman	45	440	9.28%
1000-1200	46	313	12.81%
1200-1300	23	186	11.01%
1300-1500	4	72	5.26%
Postmed.	23	229	9.13%
TOTAL	141	1240	10.21%

TABLE 68

Cattle fragmentation data

Stage	55 - 100			100 - 300			300+		
	A	B	C	A	B	C	A	B	C
Stage 1	9	0	38	2	0	44	5	0	20
Stage 2	27	0	20	13	0	33	12	0	13
Stage 3	32	3	12	27	1	18	16	0	9
Stage 4	32	4	11	29	1	16	16	2	7
Stage 5	35	6	6	34	2	10	17	3	5
Stage 6	40	6	1	41	2	3	22	3	0

Percentage of animals killed

Stage	55 - 100	100 - 300	300+
Stage 1	19.15%	4.35%	20.00%
Stage 2	57.45%	28.26%	48.00%
Stage 3 min.	68.09%	58.70%	64.00%
max.	74.47%	60.87%	64.00%
Stage 4 min.	68.09%	63.04%	64.00%
max.	76.60%	65.22%	72.00%
Stage 5 min.	74.47%	73.91%	68.00%
max.	87.23%	78.26%	80.00%
Stage 6 min.	85.11%	89.13%	88.00%
max.	97.87%	93.48%	100.00%

TABLE 69

Sheep/goat: tooth eruption data - Roman period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Estimated Age (Months)	55 - 100	100 - 300	300+
1-2	6	0	1
2-5	2	1	3
6-8	1	1	1
9-11	1	1	0
9-17	8	1	2
13-14	2	1	1
15-16	4	5	2
17-18	3	3	2
17+	3	1	0
19-20	3	2	0
21-22	1	1	0
23-24	1	7	2
25-26	0	4	2
25+	1	0	2
27-28	0	2	0
29+	2	1	1
31-33	0	2	0
33-36	3	3	1
36-42	1	0	0
42-51	2	4	4
51-60	1	0	0
60-72	1	3	1
72+	1	3	0
TOTAL	47	46	25

TABLE 70

Sheep/goat: tooth eruption data employing Carter's method of analysis - Roman period

Method of ageing from Carter (1975).

Fusion Age		55 - 100		100 - 300		300+	
6-10 months		NF	F	NF	F	NF	F
Scapula	DF	5	15	2	21	3	5
Humerus	DF	4	13	8	26	6	12
Radius	PF	2	12	7	38	10	17
% unfused		21.57%		16.67%		35.85%	
13-24 months		NF	F	NF	F	NF	F
Phal.1	PF	0	14	3	20	0	6
Phal.2	PF	0	6	0	1	0	1
Metacarpus	DF	5	3	14	0	6	3
18-24 months		NF	F	NF	F	NF	F
Tibia	DF	8	25	12	36	5	17
% unfused		24.24%		25.00%		22.73%	
20-28 months		NF	F	NF	F	NF	F
Metatarsus	DF	9	7	8	4	3	3
30-36 months		NF	F	NF	F	NF	F
Ulna	PF	1	3	3	3	1	1
Femur	PF	7	4	10	3	9	3
% unfused		53.33%		68.42%		71.43%	
30-36 months		NF	F	NF	F	NF	F
Calcaneum	PF	5	9	6	14	1	4
36-42 months		NF	F	NF	F	NF	F
Radius	DF	7	5	20	14	8	6
Humerus	PF	2	1	5	0	2	0
Femur	DF	4	4	5	2	1	0
Tibia	PF	9	4	9	4	3	0
% unfused		61.11%		66.10%		70.00%	

TABLE 71

Sheep/goat: epiphyseal fusion data - Roman period

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Ageing data after Silver (1969: 285-6).

Stage	(Md1) 1000 - 1150 A	B	C	(Md2) 1100 - 1200 A	B	C	(Md1-3) 1000 - 1200 A	B	C	1200 - 1300 A	B	C	1300 - 1500 A	B	C
Stage 1	4	0	31	12	0	93	16	0	152	8	0	68	1	0	26
Stage 2	20	0	15	38	0	67	66	0	102	16	0	60	5	0	22
Stage 3	27	0	8	71	0	34	118	1	49	35	1	40	10	0	17
Stage 4	29	3	3	74	7	24	123	15	30	42	10	24	12	2	13
Stage 5	29	4	2	80	8	17	130	17	21	45	13	18	12	6	9
Stage 6	31	4	0	93	8	4	146	17	5	62	13	1	17	6	4

Percentage of animals killed

Stage		1000 - 1150	1100 - 1200	1000 - 1200	1200 - 1300	1300 - 1500
Stage 1		11.43%	11.43%	9.52%	10.53%	3.70%
Stage 2		57.14%	36.19%	39.29%	21.05%	18.52%
Stage 3	min.	77.14%	67.62%	70.24%	46.05%	37.04%
	max.	77.14%	67.62%	70.83%	47.37%	37.04%
Stage 4	min.	82.86%	70.48%	73.21%	55.26%	44.44%
	max.	91.43%	77.14%	82.14%	68.42%	51.85%
Stage 5	min.	82.86%	76.19%	77.38%	59.21%	44.44%
	max.	94.29%	83.81%	87.50%	76.32%	66.67%
Stage 6	min.	88.57%	88.57%	86.90%	81.58%	62.96%
	max.	100.00%	96.19%	97.02%	98.68%	85.19%

TABLE 72

Sheep/goat: tooth eruption data - medieval period

A = number of jaws failing to reach stage of tooth eruption.

B = number of jaws with inconclusive evidence.

C = number of jaws reaching stage of tooth eruption.

Estimated Age (Months)	(Md1) 1000 - 1150	(Md2) 1100 - 1200	(Md1-3) 1000 - 1200	1200 - 1300	1300 - 1500
1-2	1	6	7	6	1
2-5	3	4	7	2	0
6-8	0	2	2	0	0
9-17	4	9	15	2	1
11-12	1	0	1	0	0
13-14	4	2	7	0	0
15-16	3	8	13	2	1
17-18	4	7	14	4	2
17+	0	0	1	1	0
19-20	3	2	6	4	2
21-22	0	6	7	5	3
23-24	2	15	22	6	0
25-26	2	10	17	4	0
25+	3	7	14	9	2
26-30	0	0	0	5	0
27-28	1	1	2	1	1
29-30	1	2	3	1	1
29+	1	1	2	3	4
30-36	0	1	2	0	0
31-33	0	3	3	2	0
33-36	0	2	2	1	0
36-42	1	3	4	3	0
42-51	0	4	4	6	2
51-60	0	3	3	7	2
60-72	1	3	5	1	1
72+	0	4	5	1	4
TOTAL	35	105	168	76	27

TABLE 73

Sheep/goat: tooth eruption data employing Carter's method of analysis - medieval period

Method of ageing adapted from Carter (1975).

Specimen	P4	M1	M2	M3	n.v.	Estimate based on Carter's method
1	-	g	f	b	30	23-24 months
2	f	g	f	b	30	23-26 months
3	-	g	f	-	30e	24-26 months
4	f	g	g	b	31	23-24 months
5	-	g	f	c	31	24-26 months
6	-	g	f	c	31	25-26 months
7	e	g	g	c	32	25-26 months
8	g	g	g	d	33	25-26 months
9	g	g	g	e	34	45-51 months
10	h	-	g	e	34e	30-32 months
11	g	g	g	f	35	30-36 months
12	j	h	g	e	35	36-42 months
13	-	g	g	f	35	36-42 months
14	g	g	g	-	35e	36-40 months
15	-	-	g	f	35e	42-45 months
16	-	h	g	f	36	28-30 months
17	g	h	g	f	36	43-51 months
18	h	h	-	f	36e	42-51 months
19	-	k	g	f	38	51-60 months
20	h	k	g	g	39	36-42 months
21	g	k	g	g	39	45-60 months
22	-	-	g	g	39e	45-51 months
23	h	-	g	g	39e	51-60 months
24	j	l	g	g	40	60-70 months
25	j	l	h	g	41	63-72 months
26	j	l	h	g	41	72 + months
27	-	m	h	g	42	72 + months
28	l	m	k	-	44e	78 + months
29	-	n	m	m	53	78 + months

TABLE 74

Comparison of Grant's and Carter's methods of ageing sheep mandibles on specimens from medieval Exeter

n.v. = numerical value of mandible (after Grant 1975).
Estimates of age of mandible based on method of Carter (1975).
e = estimated value of mandible.
- = tooth absent from mandible.

Fusion Age		(Md1) 1000 - 1150		(Md2) 1100 - 1200		(Md1-3) 1000 - 1200		1200 - 1300		1300 - 1500	
6-10 months		NF	F	NF	F	NF	F	NF	F	NF	F
Scapula	DF	5	13	6	30	18	48	9	18	6	14
Humerus	DF	4	32	24	55	40	103	35	72	6	21
Radius	PF	6	32	29	75	43	130	22	81	11	35
% unfused		16.30%		26.94%		26.44%		27.85%		24.73%	
13-24 months		NF	F	NF	F	NF	F	NF	F	NF	F
Phal.1	PF	0	10	1	19	2	38	2	19	0	6
Phal.2	PF	0	1	0	4	0	6	0	1	0	1
Metacarpus	DF	8	10	35	22	53	37	42	22	9	4
18-24 months		NF	F	NF	F	NF	F	NF	F	NF	F
Tibia	DF	16	20	35	46	62	80	34	72	9	21
% unfused		44.44%		43.21%		43.66%		32.08%		30.00%	
20-28 months		NF	F	NF	F	NF	F	NF	F	NF	F
Metatarsus	DF	11	10	31	25	44	39	26	18	8	7
30-36 months		NF	F	NF	F	NF	F	NF	F	NF	F
Ulna	PF	9	5	26	12	42	20	21	7	10	3
Femur	PF	9	3	26	11	43	18	27	9	7	3
% unfused		69.23%		69.33%		69.11%		75.00%		73.91%	
30-36 months		NF	F	NF	F	NF	F	NF	F	NF	F
Calcaneum	PF	3	6	12	13	18	22	4	11	3	3
36-42 months		NF	F	NF	F	NF	F	NF	F	NF	F
Radius	DF	20	5	63	14	94	26	53	18	19	7
Humerus	PF	10	2	14	9	29	14	14	1	6	1
Femur	DF	8	1	30	8	42	11	31	8	8	6
Tibia	PF	16	4	45	16	68	24	28	7	10	5
% unfused		81.82%		76.38%		75.65%		78.75%		69.35%	

TABLE 75

Sheep/goat: epiphyseal fusion data - medieval period

NF = not fused. Pf = proximal fusion point.
F = fused. DF = distal fusion point.

Ageing data after Silver (1969: 285-6).

Stage	1500 - 1600 A	B	C	1600 - 1800 A	B	C
Stage 1	6	0	21	8	0	26
Stage 2	9	0	18	12	0	22
Stage 3	13	0	14	13	0	21
Stage 4	14	1	12	19	3	12
Stage 5	16	6	5	19	8	7
Stage 6	21	6	0	26	8	0

Percentage of animals killed

Stage		1500 - 1600	1600 - 1800
Stage 1		22.22%	23.53%
Stage 2		33.33%	35.29%
Stage 3		48.15%	38.24%
Stage 4	min.	51.85%	55.88%
	max.	55.56%	64.71%
Stage 5	min.	59.26%	55.88%
	max.	81.48%	79.41%
Stage 6	min.	77.78%	76.47%
	max.	100.00%	100.00%

TABLE 76

Sheep/goat: tooth eruption data - postmedieval period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Estimated Age (months)	1500 - 1600	1600 - 1800
1-2	2	0
2-5	4	5
6-8	0	3
9-17	2	2
15-16	0	1
17-18	1	1
19-20	1	0
23-24	1	0
25-26	2	1
25+	1	3
26-30	0	1
27-28	1	1
29-30	0	4
29+	5	5
33-36	2	0
36-42	1	0
42-51	2	3
51-60	1	3
60-72	1	1
TOTAL	27	34

TABLE 77

Sheep/goat: tooth eruption data
employing Carter's method of analysis - postmedieval period

Method of ageing adapted from Carter (1975).

Fusion Age		1500 - 1600		1600 - 1800	
6-10 months		NF	F	NF	F
Scapula	DF	-	-	3	19
Humerus	DF	12	77	11	87
Radius	PF	9	105	4	87
% unfused		10.34%		8.53%	
13-24 months		NF	F	NF	F
Phal.1	PF	4	15	2	13
Phal.2	PF	0	3	0	1
Metacarpus	DF	11	14	16	37
18-24 months		NF	F	NF	F
Tibia	DF	8	52	10	50
% unfused		13.33%		16.67%	
20-28 months		NF	F	NF	F
Metatarsus	DF	1	9	4	18
30-36 months		NF	F	NF	F
Ulna	PF	13	20	14	36
Femur	PF	3	16	10	17
% unfused		30.77%		31.17%	
30-36 months		NF	F	NF	F
Calcaneum	PF	14	14	7	19
36-42 months		NF	F	NF	F
Radius	DF	14	21	15	32
Humerus	PF	21	44	20	34
Femur	DF	18	38	25	25
Tibia	PF	23	22	20	22
% unfused		37.81%		41.45%	

TABLE 78

Sheep/goat: epiphyseal fusion data - postmedieval period

NF = not fused. PF = proximal fusion point.
F = fused. DF = distal fusion point.

Ageing data after Silver (1969: 285-6).

Measurement		Date	N	Range	Mean	S	V
Mandible	(1)	Roman	20	17.0-21.3	19.7	1.45	7.37
	(1)	1000-1200	11	18.5-21.4	20.1	0.75	3.73
	(1)	1200-1300	16	17.2-23.0	20.0	1.42	7.10
	(1)	1300-1500	7	18.2-22.7	19.7	1.55	7.87
	(1)	1500-1600	6	18.5-22.6	20.4	1.42	6.96
	(1)	1700-1800	9	19.4-22.8	21.3	1.21	5.68
Mandible	(2)	Roman	15	37.9-46.7	42.8	2.27	5.30
	(2)	1000-1200	9	35.3-46.3	43.3	3.17	7.32
	(2)	1200-1300	14	40.0-48.2	43.3	2.30	5.31
	(2)	1300-1500	6	38.0-45.2	40.7	2.54	6.24
	(2)	1500-1600	4	44.2-45.0	44.0	-	-
	(2)	1700-1800	6	41.1-49.0	44.5	2.94	6.61
Mandible	(3)	Roman	21	16.8-24.4	20.9	1.79	8.57
	(3)	1000-1200	25	17.8-25.5	21.4	1.78	8.31
	(3)	1200-1300	18	16.7-24.0	20.5	1.71	8.34
	(3)	1700-1800	4	19.1-23.3	21.1	-	-
Mandible	(4)	Roman	10	58.1-67.8	63.5	3.06	4.82
	(4)	1000-1200	5	63.3-68.9	65.3	-	-
	(4)	1200-1300	6	62.1-66.3	63.6	1.46	2.30
	(4)	1700-1800	4	55.6-63.8	60.2	-	-
Maxilla	(1)	Roman	4	17.4-22.8	20.1	-	-
	(1)	1000-1200	17	14.5-18.4	16.3	1.20	7.36
Maxilla	(2)	Roman	4	38.2-46.6	43.3	-	-
	(2)	1000-1200	13	38.1-42.9	40.7	2.04	5.01
Maxilla	(3)	Roman	6	20.0-26.6	22.5	2.55	11.33
	(3)	1000-1200	13	17.9-23.8	21.3	1.65	7.75
Scapula	(1)	Roman	23	25.9-32.1	28.4	1.68	5.92
	(1)	1000-1150	13	27.3-30.5	29.1	0.99	3.40
	(1)	1100-1200	29	27.3-32.9	30.0	1.34	4.47
	(1)	1200-1300	17	27.0-31.8	29.0	1.33	4.59
	(1)	1300-1500	9	28.8-33.1	30.4	1.33	4.38
	(1)	1500-1600	38	27.3-35.3	31.0	1.98	6.39
	(1)	1600-1700	28	28.7-36.6	32.4	1.92	5.93
	(1)	1700-1800	19	29.1-36.6	32.4	2.26	6.98
Scapula	(2)	Roman	19	19.0-24.9	21.7	1.36	6.27
	(2)	1000-1150	14	21.2-24.2	22.6	1.02	4.51
	(2)	1100-1200	28	21.0-26.5	22.7	1.24	5.46
	(2)	1200-1300	16	22.0-24.4	22.6	0.61	2.70
	(2)	1300-1500	8	22.3-24.9	23.6	0.83	3.52
	(2)	1500-1600	39	19.9-27.2	23.8	1.82	7.65
	(2)	1600-1700	28	21.0-28.2	24.8	1.61	6.49
	(2)	1700-1800	19	21.4-29.5	24.9	2.18	8.76
Scapula	(3)	Roman	19	15.9-18.9	17.5	0.90	5.14
	(3)	1000-1150	6	16.1-19.2	17.6	1.15	6.53
	(3)	1100-1200	16	16.3-20.1	18.2	1.10	6.04
	(3)	1200-1300	6	16.9-18.1	17.6	0.46	2.61
	(3)	1300-1500	8	17.5-20.0	18.9	0.78	4.12
Scapula	(4)	Roman	19	15.6-20.2	18.2	1.41	7.74
	(4)	1000-1150	6	15.8-19.1	17.5	1.60	9.14
	(4)	1100-1200	16	14.7-21.6	18.4	2.09	11.35
	(4)	1200-1300	6	16.6-20.3	18.2	1.38	7.58
	(4)	1300-1500	8	16.9-20.3	18.7	1.06	5.67

TABLE 79 (i)

Metrical analysis of sheep/goat

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Humerus	(1)	55-100	9	24.1-28.0	27.1	1.42	5.24
	(1)	100-300	14	23.9-30.1	27.0	1.70	6.30
	(1)	300+	8	26.8-29.5	28.0	0.61	2.18
	(1)	1000-1150	22	25.8-32.3	28.2	1.71	6.06
	(1)	1100-1200	39	24.1-32.1	27.6	1.48	5.36
	(1)	1000-1200	13	25.8-29.7	27.8	1.12	4.02
	(1)	1200-1300	41	25.4-30.6	27.8	1.28	4.60
	(1)	1300-1500	10	26.0-29.7	28.0	1.27	4.54
	(1)	1500-1600	54	24.3-32.2	28.1	1.92	6.83
	(1)	1600-1700	42	25.2-32.0	29.5	1.66	5.63
	(1)	1700-1800	31	23.9-35.3	29.5	2.54	8.61
Humerus	(2)	55-100	8	21.0-26.4	22.6	1.67	7.39
	(2)	100-300	8	19.9-25.3	22.4	1.82	8.13
	(2)	300+	6	22.9-24.8	23.9	0.63	2.63
	(2)	1000-1150	21	20.6-29.1	23.6	1.85	7.84
	(2)	1100-1200	35	20.9-25.8	22.9	1.20	5.24
	(2)	1000-1200	13	21.0-24.6	23.2	1.11	4.78
	(2)	1200-1300	37	21.2-26.0	23.0	1.22	5.30
	(2)	1300-1500	10	20.6-24.8	23.3	1.28	5.49
	(2)	1500-1600	53	20.7-27.3	23.6	1.48	6.27
	(2)	1600-1700	40	20.1-27.8	24.4	1.69	6.92
	(2)	1700-1800	27	21.5-29.7	24.9	2.05	8.23
Humerus	(3)	55-100	10	14.6-18.0	16.6	1.08	6.51
	(3)	100-300	15	14.8-18.4	16.7	1.40	8.38
	(3)	300+	10	16.4-18.7	17.3	0.74	4.28
	(3)	1000-1150	23	14.6-20.2	17.3	1.28	7.40
	(3)	1100-1200	44	14.9-19.5	17.0	0.98	5.77
	(3)	1000-1200	14	15.7-19.0	17.2	0.88	5.12
	(3)	1200-1300	44	15.1-18.6	17.0	0.76	4.47
	(3)	1300-1500	10	16.1-18.9	17.7	0.85	4.80
	(3)	1500-1600	59	14.4-20.9	17.4	1.39	7.98
	(3)	1600-1700	45	15.6-21.0	18.2	1.18	6.48
	(3)	1700-1800	35	13.3-21.9	18.4	1.61	8.75
Humerus	(4)	55-100	10	23.0-27.2	25.3	1.44	5.68
	(4)	100-300	16	23.3-28.8	25.3	1.38	5.44
	(4)	300+	9	25.8-27.5	26.7	0.63	2.36
	(4)	1000-1150	23	23.3-31.1	26.6	1.69	6.35
	(4)	1100-1200	43	22.9-29.9	26.0	1.38	5.31
	(4)	1000-1200	14	25.1-27.3	26.3	0.74	2.81
	(4)	1200-1300	44	23.9-30.2	26.3	1.29	4.90
	(4)	1300-1500	10	25.0-28.1	26.7	0.96	3.60
	(4)	1500-1600	62	24.0-30.2	26.5	1.51	5.70
	(4)	1600-1700	45	23.0-30.2	27.6	1.47	5.33
	(4)	1700-1800	35	23.1-32.3	27.6	2.08	7.53
Radius	(1)	55-100	11	25.4-28.4	27.0	0.95	3.51
	(1)	100-300	26	23.5-31.3	27.1	1.72	6.35
	(1)	300+	10	26.2-30.4	27.9	1.69	6.06
	(1)	1000-1150	20	24.4-31.0	28.7	1.98	6.90
	(1)	1100-1200	57	26.1-31.6	28.5	1.34	4.70
	(1)	1000-1200	19	26.4-30.3	28.5	1.41	4.95
	(1)	1200-1300	45	25.4-33.4	28.9	1.46	5.05
	(1)	1300-1500	22	26.2-31.0	28.5	1.36	4.77
	(1)	1500-1600	83	24.6-32.7	29.0	1.72	5.93
	(1)	1600-1700	53	24.9-35.7	30.1	2.27	7.54
	(1)	1700-1800	22	28.1-34.5	31.7	2.21	6.97

TABLE 79 (ii)

Metrical analysis of sheep/goat

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Radius	(2)	55-100	5	23.9-25.2	24.3	-	-
	(2)	100-300	11	24.0-27.9	24.9	1.19	4.76
	(2)	300+	6	24.2-27.7	25.7	1.40	5.47
	(2)	1000-1150	5	23.0-29.0	25.4	-	-
	(2)	1100-1200	10	23.9-28.4	25.9	1.23	4.75
	(2)	1000-1200	5	24.6-27.6	26.6	-	-
	(2)	1200-1300	13	23.4-27.4	25.4	1.19	4.69
	(2)	1300-1500	7	23.5-27.4	25.7	1.23	4.79
	(2)	1500-1600	34	20.5-28.5	25.5	1.50	5.88
	(2)	1600-1700	21	22.8-31.8	27.3	2.26	8.27
	(2)	1700-1800	9	25.4-31.0	28.5	1.87	6.56
Radius	(L)	Roman	6	131-151	139.3	6.05	4.34
	(L)	1100-1200	6	128-141	138.3	1.97	1.42
	(L)	1200-1300	4	128-143	135.8	-	-
	(L)	1500-1600	25	119-154	134.9	8.66	6.42
	(L)	1600-1700	15	125-155	139.1	8.91	6.41
Metacarpus	(1)	55-100	8	18.0-24.5	20.5	1.87	9.12
	(1)	100-300	16	17.8-27.0	20.3	2.14	10.54
	(1)	1000-1150	17	18.5-25.5	21.4	2.13	9.95
	(1)	1100-1200	38	15.9-22.8	19.9	1.69	8.49
	(1)	1000-1200	12	20.2-23.6	21.4	1.06	4.96
	(1)	1200-1300	34	16.9-22.5	20.7	1.37	6.62
	(1)	1300-1500	14	17.2-22.3	20.2	1.37	6.78
	(1)	1500-1600	29	19.5-24.2	21.8	1.46	6.69
	(1)	1600-1700	22	20.0-24.9	22.5	1.16	5.16
	(1)	1700-1800	26	19.4-26.7	22.5	1.90	8.44
Metacarpus	(2)	55-100	9	11.5-18.3	15.0	1.75	11.66
	(2)	100-300	17	13.0-18.4	14.4	1.39	9.65
	(2)	1000-1150	17	13.2-18.0	15.5	1.44	9.29
	(2)	1100-1200	38	11.3-16.4	14.4	1.47	10.20
	(2)	1000-1200	12	14.1-16.5	15.4	0.79	5.13
	(2)	1200-1300	34	11.0-16.7	14.8	1.26	8.51
	(2)	1300-1500	13	11.5-16.5	14.7	1.25	8.50
	(2)	1500-1600	28	14.0-18.1	16.0	1.18	7.38
	(2)	1600-1700	22	14.6-18.8	16.5	1.12	6.79
	(2)	1700-1800	26	14.7-19.1	16.7	1.21	7.25
Metacarpus	(3)	Roman	6	20.7-27.8	23.0	2.61	11.36
	(3)	1000-1150	9	21.3-30.5	24.8	2.49	10.04
	(3)	1100-1200	20	20.5-24.5	23.1	1.15	4.98
	(3)	1200-1300	16	20.9-26.4	22.7	1.46	6.43
	(3)	1300-1500	5	20.7-24.1	22.9	-	-
	(3)	1500-1600	11	21.7-27.6	24.5	1.66	6.78
	(3)	1600-1700	13	22.6-26.8	24.9	1.26	5.06
	(3)	1700-1800	21	20.6-28.5	25.1	2.01	8.00
Metacarpus	(4)	Roman	5	10.8-13.9	12.3	1.18	9.59
	(4)	1000-1150	9	11.5-15.9	13.0	1.24	9.54
	(4)	1100-1200	20	10.7-13.8	12.6	1.05	8.33
	(4)	1200-1300	15	11.1-13.4	12.2	0.64	5.25
	(4)	1300-1500	5	11.4-12.2	12.0	0.36	3.00
	(4)	1500-1600	9	10.7-13.3	12.2	0.76	6.23
	(4)	1600-1700	14	11.8-14.3	13.0	0.54	4.15
	(4)	1700-1800	21	11.0-13.9	12.9	0.80	6.20
Metacarpus	(L)	Roman	3	112-127	119.0	-	-
	(L)	1100-1200	10	105-123	114.0	4.99	4.38
	(L)	1200-1300	7	99-124	114.0	9.17	8.04
	(L)	1500-1600	10	96-124	113.4	7.52	6.63
	(L)	1600-1700	11	110-128	118.7	6.65	5.60
	(L)	1700-1800	19	102-128	118.7	7.54	6.35

TABLE 79 (iii)

Metrical analysis of sheep/goat

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Tibia	(1)	55-100	21	21.3-29.2	23.1	1.54	6.68
	(1)	100-300	30	21.4-25.9	23.3	1.21	5.21
	(1)	300+	15	22.3-27.0	23.9	1.25	5.22
	(1)	1000-1150	13	20.6-26.8	24.1	1.69	7.01
	(1)	1100-1200	29	21.0-28.0	24.2	1.41	5.83
	(1)	1000-1200	8	22.2-25.9	24.0	1.21	5.04
	(1)	1200-1300	61	22.0-26.9	24.3	1.12	4.61
	(1)	1300-1500	16	22.0-25.7	23.8	1.20	5.04
	(1)	1500-1600	39	23.5-31.5	25.6	1.78	6.95
	(1)	1600-1700	24	22.5-28.9	26.0	1.42	5.46
	(1)	1700-1800	17	22.9-30.4	26.7	2.22	8.31
Tibia	(2)	55-100	21	16.0-20.0	17.7	0.84	4.72
	(2)	100-300	30	16.2-19.4	17.8	0.85	4.75
	(2)	300+	14	16.8-19.9	18.5	0.79	4.26
	(2)	1000-1150	14	16.4-20.4	18.3	1.20	6.56
	(2)	1100-1200	29	15.7-20.5	18.7	1.04	5.56
	(2)	1000-1200	7	18.0-18.8	18.5	0.28	1.51
	(2)	1200-1300	61	16.9-20.1	18.7	0.79	4.24
	(2)	1300-1500	16	16.9-19.2	18.2	0.70	3.86
	(2)	1500-1600	39	16.7-25.0	19.3	1.45	7.51
	(2)	1600-1700	26	17.4-22.2	19.7	1.26	6.40
	(2)	1700-1800	18	18.1-23.7	20.5	1.54	7.51
Astragalus	(1)	Roman	13	23.6-32.9	26.2	2.64	10.10
	(1)	1000-1150	4	24.7-27.4	26.4	-	-
	(1)	1100-1200	14	23.5-27.7	25.8	1.51	5.85
	(1)	1200-1300	11	25.0-29.0	26.9	1.48	5.50
	(1)	1500-1600	14	22.1-29.0	26.6	1.93	7.26
	(1)	1600-1700	6	27.5-29.1	28.2	0.75	2.66
	(1)	1700-1800	7	24.5-31.3	28.2	2.47	8.76
Astragalus	(2)	Roman	14	12.8-17.0	14.3	1.11	7.76
	(2)	1000-1150	4	14.1-15.8	14.8	-	-
	(2)	1100-1200	14	13.1-15.9	14.6	0.82	5.60
	(2)	1200-1300	11	14.0-16.6	14.9	0.77	5.17
	(2)	1500-1600	14	12.2-16.4	14.9	1.14	7.65
	(2)	1600-1700	6	14.1-16.2	15.3	0.71	4.64
	(2)	1700-1800	7	13.7-17.0	15.2	1.42	9.34
Astragalus	(3)	Roman	13	22.3-30.2	24.9	2.33	9.37
	(3)	1000-1150	4	23.8-26.4	25.0	-	-
	(3)	1100-1200	13	22.8-27.1	24.9	1.23	4.94
	(3)	1200-1300	11	22.8-27.5	25.5	1.45	5.69
	(3)	1500-1600	14	21.4-28.0	25.5	1.70	6.67
	(3)	1600-1700	6	26.0-27.4	26.7	0.62	2.32
	(3)	1700-1800	6	23.6-29.6	27.2	2.39	8.78
Calcaneum	(1)	Roman	17	18.7-23.0	19.9	1.00	5.03
	(1)	1000-1150	6	19.2-23.3	20.8	1.56	7.50
	(1)	1100-1200	13	19.0-22.0	20.5	0.95	4.65
	(1)	1200-1300	7	18.0-22.1	20.3	1.44	7.09
	(1)	1500-1600	13	18.2-23.9	21.8	1.36	6.24
	(1)	1600-1700	11	20.6-24.6	22.6	1.30	5.75
	(1)	1700-1800	5	21.9-25.0	23.1	-	-
Calcaneum	(2)	Roman	17	10.2-13.0	11.5	0.65	5.65
	(2)	1000-1150	6	11.0-12.8	11.8	0.78	6.61
	(2)	1100-1200	12	10.5-12.8	11.8	0.85	7.20
	(2)	1200-1300	7	10.7-12.4	11.8	0.71	6.02
	(2)	1500-1600	12	11.4-14.3	12.4	0.89	7.18
	(2)	1600-1700	12	10.7-14.6	12.6	0.99	7.86
	(2)	1700-1800	5	12.0-14.4	13.0	0.98	7.53

TABLE 79 (iv)

Metrical analysis of sheep/goat

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Calcaneum	(3)	Roman	11	18.9-23.5	20.8	1.10	5.31
	(3)	1000-1150	6	19.2-23.4	21.1	1.52	7.20
	(3)	1100-1200	12	18.4-22.1	20.9	1.01	4.83
	(3)	1200-1300	6	19.4-22.5	20.9	1.16	5.55
	(3)	1500-1600	11	21.0-23.9	22.2	0.87	3.91
	(3)	1600-1700	10	21.2-24.8	22.7	1.12	4.93
	(3)	1700-1800	5	22.3-24.7	23.3	0.90	3.86
Calcaneum	(L)	Roman	17	46.6-55.7	50.5	3.16	6.26
	(L)	1000-1150	6	48.1-55.3	52.7	3.30	6.26
	(L)	1100-1200	13	45.3-55.6	50.3	2.82	5.61
	(L)	1200-1300	7	45.8-54.9	50.8	3.14	6.18
	(L)	1500-1600	13	49.0-59.6	55.0	3.03	5.51
	(L)	1600-1700	11	53.0-59.3	56.2	2.31	4.11
	(L)	1700-1800	5	55.5-62.3	58.8	3.11	5.29
Metatarsus	(1)	Roman	25	16.0-20.0	18.2	1.05	5.75
	(1)	1000-1150	8	16.3-19.5	18.3	1.01	5.52
	(1)	1100-1200	33	16.8-19.5	18.4	0.78	4.24
	(1)	1000-1200	7	17.3-20.7	19.0	1.32	6.95
	(1)	1200-1300	32	16.2-20.4	18.6	0.95	5.10
	(1)	1300-1500	10	17.3-21.0	18.3	1.16	6.34
	(1)	1500-1600	15	17.8-21.4	19.8	1.22	6.16
	(1)	1600-1700	14	17.5-20.8	19.2	1.13	5.89
	(1)	1700-1800	12	18.9-21.0	19.8	0.65	3.28
Metatarsus	(2)	Roman	23	15.2-20.0	17.4	1.02	5.87
	(2)	1000-1150	9	16.4-19.5	18.1	0.87	4.81
	(2)	1100-1200	31	15.8-19.5	18.1	0.90	4.97
	(2)	1000-1200	7	16.8-20.2	18.2	1.47	8.08
	(2)	1200-1300	30	15.4-19.4	17.9	0.91	5.08
	(2)	1300-1500	10	16.8-19.6	18.0	0.93	5.17
	(2)	1500-1600	16	16.6-21.6	19.2	1.50	7.81
	(2)	1600-1700	14	15.2-20.0	18.6	1.27	6.83
	(2)	1700-1800	12	18.3-20.1	18.9	0.69	3.65
Metatarsus	(3)	Roman	12	18.9-21.3	19.8	0.64	3.25
	(3)	1000-1150	9	19.3-22.2	21.1	0.90	4.27
	(3)	1100-1200	18	19.6-23.7	21.6	1.10	5.09
	(3)	1200-1300	13	19.9-23.7	21.6	0.97	4.49
	(3)	1300-1500	7	20.0-23.1	21.1	1.09	5.17
	(3)	1500-1600	8	19.9-25.7	22.3	1.85	8.29
	(3)	1600-1700	10	21.1-24.6	22.5	1.17	5.20
	(3)	1700-1800	7	22.0-24.7	23.1	0.93	4.02
Metatarsus	(4)	Roman	11	10.9-12.3	11.5	0.41	3.57
	(4)	1000-1150	9	11.5-13.2	12.6	0.57	4.52
	(4)	1100-1200	19	10.7-14.3	12.5	1.00	8.00
	(4)	1200-1300	13	11.5-13.0	12.3	0.49	3.98
	(4)	1300-1500	6	12.3-13.6	12.9	0.51	3.95
	(4)	1500-1600	8	11.5-13.2	12.4	0.65	5.24
	(4)	1600-1700	9	11.1-13.5	12.2	0.77	6.31
	(4)	1700-1800	7	11.9-14.5	13.2	0.86	6.52
Metatarsus	(L)	Roman	9	120-143	126.2	6.64	5.27
	(L)	1000-1150	4	117-130	123.5	-	-
	(L)	1100-1200	8	111-134	125.8	8.46	6.72
	(L)	1200-1300	5	111-123	115.8	5.72	4.94
	(L)	1500-1600	5	118-128	123.6	-	-
	(L)	1600-1700	8	116-129	122.4	4.37	3.57
	(L)	1700-1800	7	109-129	120.4	7.09	5.89

TABLE 79 (v)

Metrical analysis of sheep/goat

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Stage	Age	55 - 100 A	B	C	100 - 300 A	B	C	300+ A	B	C
Stage 1	c. 2-6 months	1	6	47	3	0	58	2	0	44
Stage 2	c. 7-9 months	5	3	46	5	0	56	2	1	43
Stage 3	c. 10-16 months	8	7	39	7	5	49	2	6	38
Stage 4	c. 16-22 months	22	5	27	22	4	35	14	5	27
Stage 5	c. 24-27 months	27	16	11	27	20	14	15	18	13
Stage 6	c. 27-30 months	30	16	8	28	22	11	21	19	6

Percentage of animals killed

Stage	55 - 100	100 - 300	300+
Stage 1 min.	1.85%	4.92%	4.35%
max.	12.96%	4.92%	4.35%
Stage 2 min.	9.26%	8.20%	4.35%
max.	14.81%	8.20%	6.52%
Stage 3 min.	14.81%	11.48%	4.35%
max.	27.78%	19.67%	17.39%
Stage 4 min.	40.74%	36.07%	30.43%
max.	50.00%	42.62%	41.30%
Stage 5 min.	50.00%	44.26%	32.61%
max.	79.63%	77.05%	71.74%
Stage 6 min.	55.56%	45.90%	45.65%
max.	85.19%	81.97%	86.96%

TABLE 80

Pig: tooth eruption data - Roman period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Ageing data adapted from Silver (1969: 298-9).

Stage	Age	1000 - 1200 A	B	C	1200 - 1300 A	B	C	1300 - 1500 A	B	C
Stage 1	c. 2-6 months	3	0	103	0	0	40	0	0	17
Stage 2	c. 7-9 months	5	3	98	2	3	35	0	1	16
Stage 3	c. 10-16 months	11	7	88	7	3	30	2	2	13
Stage 4	c. 16-22 months	35	9	62	17	0	23	4	3	10
Stage 5	c. 24-27 months	49	36	21	24	8	8	7	7	3
Stage 6	c. 27-30 months	62	36	8	27	8	5	9	7	1

Percentage of animals killed

Stage		1000 - 1200	1200 - 1300	1300 - 1500
Stage 1		2.83%	0.00%	0.00%
Stage 2	min.	4.72%	5.00%	0.00%
	max.	7.55%	12.50%	5.88%
Stage 3	min.	10.38%	17.50%	11.76%
	max.	16.98%	25.00%	23.53%
Stage 4	min.	33.02%	42.50%	23.53%
	max.	41.51%	42.50%	41.18%
Stage 5	min.	46.23%	60.00%	41.18%
	max.	80.19%	80.00%	82.35%
Stage 6	min.	58.49%	67.50%	52.94%
	max.	92.45%	87.50%	94.12%

TABLE 81

Pig: tooth eruption data - medieval period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Ageing data adapted from Silver (1969: 298-9).

Stage	Age	1500 - 1600 A	1500 - 1600 B	1500 - 1600 C	1600 - 1800 A	1600 - 1800 B	1600 - 1800 C
Stage 1	c. 2-6 months	0	0	21	2	0	15
Stage 2	c. 7-9 months	0	1	20	4	3	10
Stage 3	c. 10-16 months	0	1	20	4	4	9
Stage 4	c. 16-22 months	5	5	11	11	2	4
Stage 5	c. 24-27 months	7	11	3	14	2	1
Stage 6	c. 27-30 months	9	11	1	14	2	1

Percentage of animals killed

Stage		1500 - 1600	1600 - 1800
Stage 1		0.00%	11.77%
Stage 2	min.	0.00%	23.53%
	max.	4.76%	41.18%
Stage 3	min.	0.00%	23.53%
	max.	4.76%	47.06%
Stage 4	min.	23.81%	64.71%
	max.	47.62%	76.47%
Stage 5	min.	33.33%	82.35%
	max.	85.71%	94.12%
Stage 6	min.	42.86%	82.35%
	max.	95.24%	94.12%

TABLE 82

Pig: tooth eruption data - postmedieval period

A = number of jaws failing to reach stage of tooth eruption.
B = number of jaws with inconclusive evidence.
C = number of jaws reaching stage of tooth eruption.

Ageing data adapted from Silver (1969: 298-9).

Fusion Age		55 - 100		100 - 300		300+	
12 months		NF	F	NF	F	NF	F
Scapula	DF	2	9	2	17	3	7
Humerus	DF	3	7	4	18	4	11
Radius	PF	2	4	5	13	4	12
Phal.2	PF	3	1	0	7	0	2
% unfused		32.26%		16.67%		25.58%	

24 months		NF	F	NF	F	NF	F
Metacarpal	DF	10	1	16	6	10	8
Tibia	DF	4	5	11	8	7	2
Phal.1	PF	9	10	5	9	13	7
% unfused		58.97%		58.18%		63.83%	

24-30 months		NF	F	NF	F	NF	F
Metatarsal	DF	3	3	15	9	10	3
Calcaneum	PF	15	0	10	1	5	1
Fibula	DF	3	2	3	0	1	2
% unfused		80.77%		73.68%		72.73%	

36-42 months		NF	F	NF	F	NF	F
Ulna	PF	6	0	8	0	4	1
Humerus	PF	4	1	4	1	5	0
Radius	DF	6	0	6	0	10	1
Femur	PF	10	3	8	0	8	1
Femur	DF	11	3	9	0	4	1
Tibia	PF	4	0	7	2	8	0
Fibula	PF	1	0	1	0	3	0
% unfused		85.71%		93.48%		91.30%	

TABLE 83

Pig: epiphyseal fusion data - Roman period

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Fusion ages after Silver (1969: 285-6)

Fusion Age		1000 - 1200		1200 - 1300		1300 - 1500	
12 months		NF	F	NF	F	NF	F
Scapula	DF	2	25	0	4	2	1
Humerus	DF	4	39	4	25	0	4
Radius	PF	6	37	2	30	1	9
Phal.2	PF	3	10	1	5	0	0
% unfused		11.90%		9.86%		17.65%	

24 months		NF	F	NF	F	NF	F
Metacarpal	DF	54	6	26	3	1	0
Tibia	DF	38	20	17	14	6	2
Phal.1	PF	12	8	13	9	1	1
% unfused		75.36%		68.29%		72.73%	

24-30 months		NF	F	NF	F	NF	F
Metatarsal	DF	29	6	27	9	7	2
Calcaneum	PF	21	1	16	0	3	0
Fibula	DF	0	3	0	2	0	0
% unfused		83.33%		79.63%		83.33%	

36-42 months		NF	F	NF	F	NF	F
Ulna	PF	33	1	18	2	9	1
Humerus	PF	13	2	6	0	3	0
Radius	DF	24	0	13	0	2	0
Femur	PF	26	4	11	3	2	0
Femur	DF	21	4	14	1	4	0
Tibia	PF	28	2	16	3	3	0
Fibula	PF	7	0	2	0	0	0
% unfused		92.12%		89.89%		95.83%	

TABLE 84

Pig: epiphyseal fusion data - medieval period

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Fusion ages after Silver (1969: 285-6).

Fusion Age		1500 - 1600		1600 - 1800	
12 months		NF	F	NF	F
Scapula	DF	0	0	0	0
Humerus	DF	5	10	6	3
Radius	PF	2	7	2	3
Phal.2	PF	2	1	0	0
% unfused		33.33%		57.14%	

24 months		NF	F	NF	F
Metacarpal	DF	9	3	5	0
Tibia	DF	9	2	6	2
Phal.1	PF	9	3	2	0
% unfused		77.14%		86.67%	

24-30 months		NF	F	NF	F
Metatarsal	DF	4	0	2	0
Calcaneum	PF	10	0	4	1
Fibula	DF	0	0	1	0
% unfused		100.00%		87.50%	

36-42 months		NF	F	NF	F
Ulna	PF	3	0	4	1
Humerus	PF	6	1	7	0
Radius	DF	3	1	4	0
Femur	PF	1	1	8	0
Femur	DF	14	2	9	1
Tibia	PF	16	1	9	1
Fibula	PF	0	0	0	0
% unfused		87.76%		93.18%	

TABLE 85

Pig: epiphyseal fusion data - postmedieval period

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Fusion ages after Silver (1969: 285-6)

Site	Date	N	Size Range (mm.) 27.0-29.9	30.0-32.9	33.0-35.9	36.0+
Exeter	Roman	17	17.65%	52.94%	29.41%	0.00%
Fishbourne	Roman	52	13.46%	44.23%	30.77%	11.54%
North Elmham	Saxon	96	2.08%	26.04%	52.08%	19.79%

TABLE 86

Pig: length lower third molar - comparison with other sites

N = number of third molars measured.
Fishbourne data adapted from Grant (1971: 386).
North Elmham data adapted from Noddle (1975: 256).

Measurement		Date	N	Range	Mean	S	V
Mandible	(1)	Roman	17	27.0-34.9	31.7	2.18	6.87
	(1)	1000-1200	4	30.0-31.8	30.9	-	-
	(1)	1200-1300	3	27.6-31.4	29.6	-	-
	(1)	1300-1500	1	28.5	-	-	-
Mandible	(2)	Roman	1	62.1	-	-	-
	(2)	1000-1200	3	59.6-64.6	62.7	-	-
	(2)	1200-1300	1	63.2	-	-	-
Maxilla	(1)	Roman	6	26.9-31.1	29.3	1.79	6.11
	(1)	1000-1200	3	28.4-29.9	29.3	-	-
	(1)	1200-1300	1	32.8	-	-	-
	(1)	1300-1500	1	29.9	-	-	-
Maxilla	(2)	Roman	3	55.1-65.9	60.2	-	-
	(2)	1000-1200	2	56.2-59.1	57.7	-	-
Scapula	(1)	Roman	13	31.2-38.8	33.7	2.46	7.29
	(1)	1000-1200	13	27.7-37.0	32.5	2.40	7.38
	(1)	1200-1300	2	32.6-41.0	36.8	-	-
Humerus	(1)	Roman	29	34.4-41.3	37.4	1.97	5.28
	(1)	1000-1200	20	33.4-37.9	35.7	1.47	4.12
	(1)	1200-1300	7	35.3-37.2	36.4	0.71	1.97
	(1)	1300-1500	3	33.0-35.3	33.8	-	-
	(1)	Postmed.	4	34.1-47.1	40.0	-	-
Humerus	(2)	Roman	23	33.2-39.5	36.3	1.94	5.34
	(2)	1000-1200	16	33.4-37.2	35.1	1.40	3.99
	(2)	1200-1300	6	34.1-38.7	36.1	1.99	5.51
	(2)	1300-1500	2	33.2-33.3	33.3	-	-
	(2)	Postmed.	4	33.2-49.5	38.6	-	-
Humerus	(3)	Roman	25	24.2-29.9	26.3	1.64	6.26
	(3)	1000-1200	19	24.1-27.1	25.4	0.97	3.82
	(3)	1200-1300	8	23.6-27.6	25.8	1.58	6.12
	(3)	1300-1500	3	23.5-24.3	23.9	0.98	4.09
	(3)	Postmed.	5	23.6-32.9	26.5	-	-
Humerus	(4)	Roman	32	28.0-34.2	31.7	1.97	6.22
	(4)	1000-1200	20	28.5-33.1	30.9	2.21	7.15
	(4)	1200-1300	8	27.3-33.2	31.1	1.91	6.14
	(4)	1300-1500	3	27.9-30.3	29.2	-	-
	(4)	Postmed.	4	26.0-37.6	31.3	-	-
Radius	(1)	Roman	25	22.9-30.1	27.1	1.64	6.05
	(1)	1000-1200	25	22.7-28.5	25.9	1.41	5.44
	(1)	1200-1300	19	24.0-30.5	26.4	1.69	6.40
	(1)	1300-1500	7	22.9-27.5	25.7	1.67	6.50
	(1)	Postmed.	8	24.6-36.4	30.0	-	-

TABLE 87 (i)

Metrical analysis of pig

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Tibia	(1)	Roman	12	24.8-30.0	27.7	1.53	5.53
	(1)	1000-1200	14	24.7-28.9	27.3	1.46	5.35
	(1)	1200-1300	8	26.0-34.4	28.5	2.79	9.79
	(1)	1300-1500	3	24.5-27.8	27.3	-	-
	(1)	Postmed.	2	29.4-32.6	31.0	-	-
Tibia	(2)	Roman	12	21.4-27.3	24.4	1.42	5.82
	(2)	1000-1200	15	22.1-26.3	24.3	1.25	5.14
	(2)	1200-1300	8	24.1-29.9	25.4	2.05	8.07
	(2)	1300-1500	3	16.9-24.8	21.5	-	-
	(2)	Postmed.	2	24.5-30.0	27.3	-	-
Astragalus	(1)	Roman	14	31.0-50.7	37.7	4.05	10.74
	(1)	1000-1200	3	35.5-37.0	36.2	-	-
	(1)	1200-1300	4	38.4-41.5	39.9	-	-
	(1)	1300-1500	2	39.3-40.2	39.8	-	-
	(1)	Postmed.	3	35.9-49.1	41.7	-	-
Astragalus	(2)	Roman	13	18.3-28.9	20.7	2.67	12.90
	(2)	1000-1200	3	18.7-20.7	19.5	-	-
	(2)	1200-1300	4	19.5-22.6	21.1	-	-
	(2)	1300-1500	2	20.0-21.9	21.0	-	-
	(2)	Postmed.	2	18.5-20.4	19.5	-	-
Astragalus	(3)	Roman	13	30.4-47.9	36.0	4.04	11.22
	(3)	1000-1200	3	34.0-35.7	34.9	-	-
	(3)	1200-1300	4	36.1-40.4	38.3	-	-
	(3)	1300-1500	2	37.8-38.3	38.1	-	-
	(3)	Postmed.	3	34.1-47.3	39.9	-	-

TABLE 87 (ii)

Metrical analysis of pig

Key to measurements in Appendix I.
All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

		Hare				Rabbit			
		Medieval		Postmed.		Medieval		Postmed.	
		NF	F	NF	F	NF	F	NF	F
Humerus	DF	0	9	0	1	0	0	3	27
Radius	PF	1	4	0	1	0	1	0	13
Phal.1	PF	1	4	0	0	0	0	0	2
Phal.2	PF	1	0	0	0	0	0	0	1
Metacarpal	DF	0	2	0	0	0	0	3	1
Tibia	DF	0	4	0	1	0	1	6	19
Metatarsal	DF	1	7	0	0	0	0	0	19
Calcaneum	PF	0	1	0	0	0	0	0	0
Ulna	PF	2	1	0	0	0	0	3	12
Humerus	PF	1	2	0	0	0	0	13	15
Radius	DF	0	0	0	3	1	0	5	7
Femur	PF	1	1	0	1	0	1	7	20
Femur	DF	1	1	0	1	0	2	7	20
Tibia	PF	1	4	2	0	1	1	12	14

TABLE 88

Lagomorphs: epiphyseal fusion data - medieval and postmedieval periods

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

		Medieval		Postmed.	
		NF	F	NF	F
Humerus	DF	0	2	2	12
Radius	PF	1	1	1	9
Phal.1	PF	0	2	2	8
Metacarpal	DF	0	3	0	7
Tibia	DF	0	0	3	13
Metatarsal	DF	0	3	0	5
Calcaneum	PF	1	0	0	2
Ulna	PF	0	2	1	13
Humerus	PF	0	1	5	8
Radius	DF	0	2	2	8
Femur	PF	1	1	7	11
Femur	DF	0	3	6	8
Tibia	PF	1	1	3	9

TABLE 89

Dog: epiphyseal fusion data

NF = not fused.
F= fused.
PF = proximal fusion point.
DF = distal fusion point.

Measurement		N	Range	Mean	S	V
Measurement	I	12	128-192	156.9	17.04	10.86
	II	12	71.1-96.4	83.7	6.73	8.04
	III	14	61.1-90.5	75.0	8.75	11.67
	IV	11	76.4-93.2	85.4	6.70	7.85
	IX	14	66.1-92.8	78.1	8.79	11.25
	X	16	46.0-60.8	53.0	4.53	8.55
	XI	16	44.8-62.5	53.5	5.61	10.49
	XII	14	25.6-34.9	30.3	2.25	7.43
CI		9	51.79-59.69	56.52	2.70	4.78
SI		11	45.95-51.92	49.05	2.25	4.59
SWI		14	37.43-45.88	40.56	2.67	6.58
Mandible	(1)	27	52.1-70.9	61.6	5.62	9.12

TABLE 90

Metrical analysis of dog skulls found in TS F.316 (late seventeenth century)

All measurements in millimetres.
N = number of specimens
S = standard deviation.
V = coefficient of variation.
CI = cranial index.
SI = snout index.
SWI = snout width index.
Mandible (l) = length of mandibular cheek tooth row.

cranial measurements after Harcourt (1974a: 152-3).

Measurement		Date	N	Range	Mean	S	V	Shoulder Height
Humerus	(L)	Roman	1	107	-	-	-	344
	(L)	Postmed.	8	84.9-151	121.9	22.74	18.65	265-491
Radius	(L)	Roman	1	172	-	-	-	567
	(L)	Postmed.	10	83.6-160	125.6	22.86	18.20	285-528
Femur	(L)	Roman	1	102	-	-	-	307
	(L)	Postmed.	8	105-168	140.3	21.84	15.57	317-515
Tibia	(L)	Postmed.	9	112-176	136.5	22.05	16.16	336-523

TABLE 91

Dog: long bone measurements

All measurements in millimetres.
(L) = maximum length.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Estimations of shoulder heights after Harcourt (1974a: 153).

		Medieval		Postmed.	
		NF	F	NF	F
Humerus	DF	1	24	11	29
Radius	PF	0	15	9	18
Phal.1	PF	1	3	1	3
Phal.2	PF	0	1	0	1
Metacarpal	DF	11	12	3	15
Tibia	DF	10	9	15	12
Metatarsal	DF	19	21	1	14
Ulna	PF	7	12	16	11
Calcaneum	PF	1	2	2	1
Femur	PF	16	11	15	18
Humerus	PF	16	7	26	14
Radius	DF	8	5	15	14
Femur	DF	11	6	13	20
Tibia	PF	14	9	17	15

TABLE 92

Cat: epiphyseal fusion data

NF = not fused.
F = fused.
PF = proximal fusion point.
DF = distal fusion point.

Measurement		Date	N	Range	Mean	S	V
Mandible	(1)	Medieval	9	17.0-19.4	18.3	0.88	4.81
	(1)	Postmed.	10	16.5-19.3	18.3	0.85	4.64
Mandible	(2)	Medieval	9	25.8-29.2	26.9	1.38	5.13
	(2)	Postmed.	10	27.9-29.3	28.5	0.43	1.51
Mandible	(3)	Medieval	9	47.0-51.9	48.9	2.19	4.48
	(3)	Postmed.	10	52.0-54.5	53.1	0.78	1.47
Humerus	(1)	Medieval	5	14.4-17.3	15.2	-	-
	(1)	Postmed.	15	14.9-18.8	17.0	1.23	7.24
Humerus	(L)	Medieval	5	80.6-93.4	83.8	-	-
	(L)	Postmed.	15	79.8-93.8	88.1	5.41	6.14
Ulna	(L)	Medieval	3	90.2-95.6	93.6	-	-
	(L)	Postmed.	7	96.4-106.9	101.9	4.76	4.67
Femur	(L)	Medieval	3	94.5-102.8	98.3	-	-
	(L)	Postmed.	12	86.9-117.6	98.9	9.33	9.43
Tibia	(1)	Postmed.	9	12.4-15.4	14.0	0.98	7.00
Tibia	(L)	Medieval	3	96.7-100.9	98.5	-	-
	(L)	Postmed.	12	90.3-111.6	101.9	6.69	6.57

TABLE 93

Metrical analysis of cat

All measurements in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.
(L) = maximum length.
Mandible (l) = length of cheek tooth row.
(2) = length canine - M1.
(3) = length canine - posterior condyle.
Humerus (1) = maximum distal width.
Tibia (1) = maximum distal width.

Phase/Date	Total Bird Fragments	% Identifiable Fragments
Rl 55-75	106	8.02
R2 75-100	68	3.37
R3 55-100	0	0.00
R4 75-150	2	6.06
R5 100-200	91	4.74
R6 200-300	63	8.55
R7 100-300	0	0.00
R8 300+	215	7.00
R9 Undated Roman	38	7.12
Mdl 1000-1150	283	8.69
Md2 1100-1200	540	7.26
Md3 1000-1200	148	7.92
Md4 1150-1250	51	12.29
Md5 1200-1250	104	9.88
Md6 1250-1300	578	10.16
Md7 1200-1300	1	1.64
Md8 1250-1350	39	7.29
Md9 1300-1350	153	12.37
Md10 1350-1500	57	11.90
Pml 1500-1600	1061	16.67
Pm2 1550-1650	141	29.62
Pm3 1660-1700	381	17.13
Pm4 1660-1800	118	6.57

TABLE 94

Number of bird fragments and percentage of total identifiable fragments

		55-75		75-100		75-150	100-200	
Species		No	%	No	%	No	No	%
Domestic Fowl	F	61	57.55	58	85.29	2	65	71.43
	M	10		8		1	19	54.29
Grey Lag Goose/	F	2	1.89	-	-	-	1	1.10
Domestic Goose	M	1		-		-	1	2.86
Mallard/	F	2	1.89	1	1.47	-	3	3.30
Domestic Duck	M	1		1		-	2	5.71
Woodcock	F	2	1.89	3	4.41	-	6	6.59
	M	1		2		-	3	8.57
Common Crane	F	-	-	2	2.94	-	-	-
	M	-		1		-	-	
Curlew	F	-	-	-	-	-	1	1.10
	M	-		-		-	1	2.86
Pigeon	F	-	-	-	-	-	2	2.20
	M	-		-		-	2	5.71
Raven	F	39*	36.79	3	4.41	-	10	10.99
	M	3		1		-	5	14.29
Jackdaw	F	-	-	1	1.47	-	1	1.10
	M	-		1		-	1	2.86
Thrush/	F	-	-	-	-	-	2	2.20
Blackbird	M	-		-		-	1	2.86
TOTAL	F	106	100	68	100	2	91	100
BIRD	M	16		14		1	35	100

TABLE 95 (i)

Bird: number of fragments and minimum number of individuals - Roman period.

F = number of fragments identified.
M = minimum number of individuals represented.

** Raven includes 26 fragments from one skeleton.*

Species		200-300 No	200-300 %	300+ No	300+ %	Undated Roman No	Undated Roman %
Domestic Fowl	F	45	71.43	162	75.35	24	63.16
	M	13		24	51.06	3	
Grey Lag Goose/	F	1	1.59	7	3.26	4	10.53
Domestic Goose	M	1		4	8.51	2	
Mallard/	F	-	-	9	4.19	3	7.89
Domestic Duck	M	-		4	8.51	1	
Woodcock	F	7	11.11	23	10.70	3	7.89
	M	3		8	17.02	1	
Teal	F	-	-	2	0.93	-	-
	M	-		1	2.13	-	
Partridge	F	1	1.59	-	-	-	-
	M	1		-	-	-	
Pigeon	F	1	1.59	3	1.40	-	-
	M	1		2	4.26	-	
Stock Dove	F	-	-	1	0.47	-	-
	M	-		1	2.13	-	
Raven	F	-	-	2	0.93	-	-
	M	-		1	2.13	-	
Rook/Crow	F	1	1.59	1	0.47	-	-
	M	1		1	2.13	-	
Jackdaw	F	-	-	5	2.33	-	-
	M	-		1	2.13	-	
Thrush/Blackbird	F	4	6.35	-	-	-	-
	M	3		-	-	-	
Oyster Catcher	F	-	-	-	-	3	7.89
	M	-		-	-	1	
Cuckoo	F	1	1.59	-	-	-	-
	M	1		-	-	-	
Smaller Wader	F	-	-	-	-	1	2.63
	M	-		-	-	1	
Large Bunting	F	2	3.17	-	-	-	-
	M	2		-	-	-	
TOTAL	F	63	100	215	100	38	100
BIRD	M	26		47	100	9	

TABLE 95 (ii)

Bird: number of fragments and minimum number of individuals - Roman period

F = number of fragments identified.
M = minimum number of individuals.

Species		1000-1150 No	1000-1150 %	1100-1200 No	1100-1200 %	1000-1200 No	1000-1200 %	1150-1250 No	1150-1250 %
Domestic Fowl	F	204	72.08	352	65.19	108	72.97	33	64.71
	M	31	58.49	50	60.24	15		8	
Grey Lag Goose/ Domestic Goose	F	42	14.84	135	25.00	22	14.86	15	29.41
	M	8	15.09	15	18.07	5		4	
Mallard/ Domestic Duck	F	1	0.35	3	0.56	2	1.35	-	-
	M	1	1.89	3	3.61	2		-	
Teal	F	-	-	2	0.37	-	-	-	-
	M	-	-	1	1.20	-		-	
Wigeon	F	-	-	-	-	-	-	1	1.96
	M	-	-	-	-	-		1	
Woodcock	F	16	5.65	29	5.37	15	10.14	2	3.92
	M	4	7.55	5	6.02	4		1	
Oyster Catcher	F	-	-	1	0.19	-	-	-	-
	M	-	-	1	1.20	-		-	
Curlew	F	3	1.06	-	-	-	-	-	-
	M	1	1.89	-	-	-		-	
Smaller Wader	F	1	0.35	-	-	-	-	-	-
	M	1	1.89	-	-	-		-	
Pigeon	F	2	0.71	1	0.19	1	0.68	-	-
	M	2	3.77	1	1.20	1		-	
Stock Dove	F	1	0.35	1	0.19	-	-	-	-
	M	1	1.89	1	1.20	-		-	
Woodpigeon	F	-	-	1	0.19	-	-	-	-
	M	-	-	1	1.20	-		-	
Raven	F	2	0.71	13*	2.41	-	-	-	-
	M	2	3.77	3	3.61	-		-	
Rook/Crow	F	1	0.35	-	-	-	-	-	-
	M	1	1.89	-	-	-		-	
Sparrowhawk	F	10*	3.53	-	-	-	-	-	-
	M	1	1.89	-	-	-		-	
Thrush/Blackbird	F	-	-	2	0.37	-	-	-	-
	M	-	-	2	2.41	-		-	
TOTAL BIRD	F	283	100	540	100	148	100	51	100
	M	53	100	83	100	27		14	

TABLE 96 (i)

Bird: number of fragments and minimum number of individuals - medieval period

F = number of fragments identified.
M = minimum number of indivduals represented.

** Sparrowhawk includes 10 fragments from one skeleton.*
Raven includes 10 fragments from one skeleton.

Species		1200-1250 No	1200-1250 %	1250-1300 No	1250-1300 %	1200-1300 No	1250-1350 No	1250-1350 %
Domestic Fowl	F	79	75.96	420	72.66	-	27	69.23
	M	15		63	60.58	-	6	
Grey Lag Goose/ Domestic Goose	F	22	21.15	92	15.92	-	7	17.95
	M	5		16	15.38	-	3	
Mallard / Domestic Duck	F	-	-	13	2.25	1	2	5.13
	M	-		3	2.88	1	2	
Wigeon	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Partridge	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Small Goose Species	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Mute Swan	F	-	-	4	0.69	-	-	-
	M	-		2	1.92	-	-	
Woodcock	F	2	1.92	22	3.81	-	1	2.56
	M	1		7	6.73	-	1	
Golden Plover	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Green Sandpiper	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Pigeon	F	1	0.96	-	-	-	-	-
	M	1		-	-	-	-	
Stock Dove	F	-	-	7*	1.21	-	-	-
	M	-		2	1.92	-	-	
Raven	F	-	-	9*	1.56	-	1	2.56
	M	-		1	0.96	-	1	
Rook/Crow	F	-	-	1	0.17	-	1	2.56
	M	-		1	0.96	-	1	
Jackdaw	F	-	-	2	0.35	-	-	-
	M	-		1	0.96	-	-	
Buzzard	F	-	-	1	0.17	-	-	-
	M	-		1	0.96	-	-	
Skylark	F	-	-	2	0.35	-	-	-
	M	-		2	1.92	-	-	
TOTAL BIRD	F	104	100	578	100	1	39	100
	M	22		104	100	1	14	

TABLE 96 (ii)

Bird: number of fragments and minimum number of individuals - medieval period

F = number of fragments identified.
M = minimum number of individuals represented.

** Stock dove includes 6 fragments from one skeleton.*

Raven includes 9 fragments from one skeleton.

Species		1300-1350 No	1300-1350 %	1350-1500 No	1350-1500 %
Domestic Fowl	F	119	77.78	40	70.18
	M	18		9	
Grey Lag Goose/ Domestic Goose	F	25	16.34	8	14.04
	M	4		2	
Mallard/ Domestic Duck	F	1	0.65	-	-
	M	1		-	
Partridge	F	-	-	1	1.75
	M	-		1	
Woodcock	F	1	0.65	1	1.75
	M	1		1	
Gannet	F	-	-	1	1.75
	M	-		1	
Bl.-Throated Diver	F	1	0.65	-	-
	M	1		-	
Pigeon	F	1	0.65	1	1.75
	M	1		1	
Chough	F	-	-	1	1.75
	M	-		1	
Raven	F	5	3.27	-	-
	M	2		-	
Rook/Crow	F	-	-	3	5.26
	M	-		1	
Jackdaw	F	-	-	1	1.75
	M	-		1	
TOTAL BIRD	F	153	100	57	100
	M	28		18	

TABLE 96 (iii)

Bird: number of fragments and minimum number of individuals - medieval period

F = number of fragments identified.
M = minimum number of individuals represented.

Species		1500-1600 No	1500-1600 %
Domestic Fowl	F	788	74.27
	M	71	53.38
Grey Lag Goose/ Domestic Goose	F	76	7.16
	M	8	6.02
Mallard/ Domestic Duck	F	86	8.11
	M	14	10.53
Turkey	F	1	0.09
	M	1	0.75
Partridge	F	7	0.66
	M	2	1.50
Teal	F	7	0.66
	M	3	2.26
Small Duck cf. Widgeon	F	1	0.09
	M	1	0.75
Woodcock	F	24	2.26
	M	6	4.51
Oyster Catcher	F	1	0.09
	M	1	0.75
Golden Plover	F	1	0.09
	M	1	0.75
Ringed Plover	F	1	0.09
	M	1	0.75
Green Sandpiper	F	1	0.09
	M	1	0.75
Curlew	F	1	0.09
	M	1	0.75
Bar-Tailed Godwit	F	1	0.09
	M	1	0.75
Lesser Black-Back Gull	F	1	0.09
	M	1	0.75

Species		1500-1600 No	1500-1600 %
Auk species	F	1	0.09
	M	1	0.75
Pigeon	F	13	1.23
	M	3	2.26
Stock Dove	F	7	0.66
	M	2	1.50
Woodpigeon	F	2	0.19
	M	1	0.75
Rook/Crow	F	4	0.38
	M	1	0.75
Jackdaw	F	16	1.51
	M	3	2.26
Sparrowhawk	F	7*	0.66
	M	1	0.75
Buzzard	F	1	0.09
	M	1	0.75
Osprey	F	1	0.09
	M	1	0.75
Barn Owl	F	2	0.19
	M	1	0.75
Thrush/ Blackbird	F	8	0.75
	M	3	2.26
Starling	F	1	0.09
	M	1	0.75
Skylark	F	1	0.09
	M	1	0.75
TOTAL BIRD	F	1061	100
	M	133	100

TABLE 97 (i)

Bird: Number of fragments and minimum number of individuals - postmedieval period

F = number of fragments identified.

M = minimum number of individuals represented.

** Sparrowhawk includes 7 fragments from one burial.*

Species		1550-1650 No	1550-1650 %	1660-1700 No	1660-1700 %	1660-1800 No	1660-1800 %
Domestic Fowl	F	122	86.52	333	87.40	80	67.80
	M	15		34	64.15	12	
Grey Lag Goose/ Domestic Goose	F	4	2.84	20	5.25	26*	22.03
	M	2		5	9.43	6	
Mallard/ Domestic Duck	F	6	4.26	3	0.79	6	5.08
	M	2		1	1.89	2	
Turkey	F	-	-	1	0.26	1	0.85
	M	-		1	1.89	1	
Partridge	F	-	-	3	0.79	-	-
	M	-		1	1.89	-	
Woodcock	F	2	1.42	5	1.31	5	4.24
	M	1		4	7.55	2	
Grey Heron	F	-	-	1	0.26	-	-
	M	-		1	1.89	-	
Kittiwake	F	-	-	3	0.79	-	-
	M	-		1	1.89	-	
Pigeon	F	-	-	3	0.79	-	-
	M	-		1	1.89	-	
Stock Dove	F	-	-	1	0.26	-	-
	M	-		1	1.89	-	
Woodpigeon	F	-	-	1	0.26	-	-
	M	-		1	1.89	-	
Raven	F	7*	4.96	-	-	-	-
	M	1		-	-	-	
Rook/Crow	F	-	-	3	0.79	-	-
	M	-		1	1.89	-	
Jackdaw	F	-	-	4	1.05	-	-
	M	-		1	1.89	-	
TOTAL BIRD	F	141	100	381	100	118	100
	M	21		53	100	23	

TABLE 97 (ii)

Bird: number of fragments and minimum number of individuals - postmedieval period

F = number of fragments identified.
M = minimum number of individuals represented.

** Grey lag goose/domestic goose includes 7 fragments from one burial.*
Raven includes 7 fragments from one burial.

Date	NF	F	% NF
Roman	32	262	10.88
All 1000-1200	127	366	25.76
1200-1300	79	307	20.47
1300-1500	38	99	27.74
1500-1600	128	453	22.03
1600-1800	52	261	16.61

TABLE 98

Domestic fowl: fusion data

NF = number of unfused longbones.
F = number of fused longbones.

Fusion of longbones of domestic fowl occurs by c.6 months of age (Silver 1969: 300).

Measurement		Date	N	Range	Mean	S	V
Coracoid	(L)	Roman	11	46.4-59.3	52.5	4.39	8.36
	(L)	1000-1200	18	44.9-55.0	48.2	2.49	5.17
	(L)	1200-1300	19	46.0-57.5	50.6	2.93	5.79
	(L)	1300-1500	2	47.8-57.7	52.8	-	-
	(L)	1500-1600	48	43.2-64.7	53.0	5.97	11.26
	(L)	1600-1800	17	45.5-67.8	56.4	7.27	12.89
Humerus	(L)	Roman	14	60.5-75.3	69.0	4.99	7.23
	(L)	1000-1200	28	60.2-78.1	66.4	4.70	7.08
	(L)	1200-1300	14	59.5-78.1	68.5	5.41	7.90
	(L)	1300-1500	12	61.1-75.7	66.8	5.42	8.11
	(L)	1500-1600	41	57.3-83.3	67.9	6.82	10.04
	(L)	1600-1800	25	65.7-88.6	75.0	7.15	9.53
Ulna	(L)	Roman	8	59.9-76.7	67.2	5.51	8.20
	(L)	1000-1200	13	59.9-79.4	65.7	7.16	10.50
	(L)	1200-1300	16	57.4-77.1	66.0	5.62	8.52
	(L)	1300-1500	11	59.1-74.8	68.2	6.13	8.99
	(L)	1500-1600	43	56.2-85.5	67.2	7.43	11.06
	(L)	1600-1800	32	60.7-89.3	74.9	7.19	9.60
Carpo-metacarpus	(L)	Roman	7	36.3-43.2	40.0	2.29	5.73
	(L)	1000-1200	9	34.3-40.9	37.9	2.31	6.09
	(L)	1200-1300	9	34.6-39.2	35.7	2.13	5.97
	(L)	1500-1600	6	37.4-44.3	41.7	3.38	8.11
	(L)	1600-1800	10	33.1-57.0	42.0	6.43	15.31
Femur	(L)	Roman	11	67.9-88.0	76.8	6.32	8.23
	(L)	1000-1200	23	64.8-80.9	73.0	4.84	6.63
	(L)	1200-1300	33	65.4-84.0	73.4	5.19	7.07
	(L)	1300-1500	9	66.7-88.1	75.1	6.48	8.63
	(L)	1500-1600	47	65.5-90.7	77.7	11.99	15.43
	(L)	1600-1800	39	70.0-94.9	81.9	7.23	8.83
Tibiotarsus	(L)	Roman	1	119.1	-	-	-
	(L)	1000-1200	20	92.5-117	104.3	9.60	9.20
	(L)	1200-1300	22	90.3-117	103.0	8.18	7.94
	(L)	1300-1500	9	96.0-115	103.9	7.75	7.46
	(L)	1500-1600	43	89.8-137	108.4	13.05	12.04
	(L)	1600-1800	50	96.2-150	118.4	13.29	11.22
Tarso-metatarsus (spurred)	(L)	Roman	5	63.8-89.2	77.6	-	-
	(L)	1000-1200	7	61.0-81.4	75.3	7.29	9.68
	(L)	1200-1300	5	75.0-81.1	78.5	-	-
	(L)	1300-1500	1	77.4	-	-	-
	(L)	1500-1600	11	83.9-95.7	84.8	6.16	7.26
	(L)	1600-1800	13	73.1-102	88.8	6.64	7.48
Tarso-metatarsus (unspurred)	(L)	Roman	8	66.2-79.1	72.0	5.29	7.35
	(L)	1000-1200	16	60.2-75.5	65.4	4.62	7.06
	(L)	1200-1300	14	57.0-78.9	64.8	5.48	8.46
	(L)	1300-1500	3	60.6-65.5	63.8	-	-
	(L)	1500-1600	33	58.1-79.0	69.3	6.38	9.21
	(L)	1600-1800	12	65.1-83.1	73.9	4.84	6.55

TABLE 99

Metrical analysis of domestic duck

(L) = length in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Measurement		Date	N	Range	Mean	S	V
Coracoid	(L)	Medieval	4	67.0-79.8	73.7	-	-
	(L)	Postmed.	2	75.0-83.0	79.0	-	-
Humerus	(L)	Medieval	3	149-172	166.3	-	-
	(L)	Postmed.	3	168-185	174.0	-	-
Ulna	(L)	Medieval	1	167	-	-	-
Carpo-	(L)	Medieval	15	84.6-100.9	92.5	5.03	5.44
metacarpus	(L)	Postmed.	9	86.2-97.1	91.0	3.75	4.12
Femur	(L)	Medieval	8	78.9-85.1	81.5	2.70	3.31
Tibiotarsus	(L)	Medieval	4	141-151	145.5	-	-
	(L)	Postmed.	1	149	-	-	-
Tarso-	(L)	Medieval	18	80.0-93.5	85.8	3.82	4.45
metatarsus	(L)	Postmed.	3	81.9-89.6	85.8	-	-

TABLE 100

Metrical analysis of greylag goose/domestic goose

(L) = length in millimetres.
N = number of specimens.
S = standard deviation.
V = coefficient of variation.

Phase/Date	Total Fish Fragments	% Identifiable Fragments
R1 55-75	13	0.98
R2 75-100	6	0.30
R3 55-100	0	0.00
R4 75-150	0	0.00
R5 100-200	6	0.31
R6 200-300	8	1.09
R7 100-300	0	0.00
R8 300+	41	1.34
R9 Undated Roman	15	2.81
Md1 1000-1150	414	12.72
Md2 1100-1200	1466	19.72
Md3 1000-1200	264	14.13
Md4 1150-1250	36	8.67
Md5 1200-1250	179	17.00
Md6 1250-1300	879	15.44
Md7 1200-1300	2	3.28
Md8 1250-1350	33	6.17
Md9 1300-1350	79	6.39
Md10 1350-1500	121	25.26
Pm1 1500-1600	1440	22.61
Pm2 1550-1650	28	5.88
Pm3 1660-1700	250	11.24
Pm4 1660-1800	189	10.52

TABLE 101

Number of fish fragments and percentage of total identifiable fragments

	Roman	Medieval	Postmedieval
Thornback Ray		*	
Shark/Ray Sp.		*	
Herring			*
Salmon	*	*	*
Eel		*	*
Conger Eel	*	*	*
Hake	*	*	*
Whiting	*	*	*
Pollack		*	*
Ling		*	*
Gadoid Sp.	*	*	*
Dory			*
Bass	*	*	*
Scad		*	*
Pandora		*	*
Red Sea Bream		*	
Gilthead	*	*	
Sea Bream Sp.	*	*	*
Wrasse Sp.	*	*	*
Mackerel			*
Tunny ?		*	
Grey Gurnard		*	*
Red Gurnard		*	*
Tub Gurnard		*	*
Piper		*	
Gurnard Sp.	*	*	*
Turbot	*	*	*
Plaice		*	*
Flatfish Sp.		*	*

TABLE 102

Species of fish represented,
Roman, medieval and postmedieval periods

Body Region	Bones	Medieval	Postmedieval
Jaws:	Premaxillaries (2)	3	5
	Maxillaries (2)	2	3
	Dentaries (2)	2	4
Roof of Mouth:	Vomer (1)	-	2
	Parasphenoid (1)	4	2
	Palatines (2)	-	2
Support for Lower Jaw:	Articulars (2)	1	2
	Quadrates (2)	1	1
	Ectopterygoids (2)	-	4
	Hyomandibulars (2)	1	3
Gill Covers:	Preoperculars (2)	2	2
	Operculars (2)	2	2
Gill Supports:	Ceratohyals (2)	3	3
	Epibranchials (6)	1	1
	Hypobranchials (8)	-	2
Post-Cranial:	Cleithra (2)	4	44
	Supracleithra (2)	1	19
	Posttemporals (2)	1	9
Base of Cranium:	Basioccipital (1)	1	2
Backbone:	Centra-Precaudal (c.17)	32	22
	Centra-Caudal (c.34)	5	80

TABLE 103

Cod: frequency of parts of the skeleton

( ) = number of bones per individual.

	Roman	Md1	Md2	Md4	Md5	Md6	Md7	Md8	Md9	Md10	Pm1	Pm2	Pm3	Pm4
Elasmobranch			4											
Herring											3	2		
Salmon	4		2		1						1			
Eel			1									1		
Conger Eel	1	8	22	5	4	16		1	4	1	5	2	3	1
Hake	5	5	21	5	6	27	2	4	8	3	11	5	4	10
Whiting	3	6	18	1	4	10	1	1	1		5	3	1	5
Pollack		2	4	1		5								1
Cod		1	9	2	2	7		1	2	1	7	3	7	2
Haddock			3		1	1					6	2	1	
Ling			1	1		3					9		4	1
Gadoid	1	1	3	2		2	1	1		1	3		2	
Dory											2		1	2
Bass	4	2	7			2					3		1	
Scad		1	5			4								2
Sea Bream	2	1	9	2	3	7			2	1	4	1		
Wrasse	1	3	2								2		1	1
Mackerel											1	2		
Tunny ?									1					
Gurnard	1	1	8		1	6	1		2		5	2	2	
Turbot	1		1								2			2
Flatfish		3	10	1	3	8			2	2	8	4	4	1
No. of units	18	9	37	9	9	28	2	4	9	6	17	8	10	13

TABLE 104

Species of fish represented by phases

APPENDIX

KEY TO MAMMAL MEASUREMENTS

The following measurements were taken on cattle, sheep/goat and pig bones and are summarised in Tables 65, 79 and 87 respectively. The measurements corresponding to those illustrated by von den Driesch (1976) are indicated.

Mandible and *maxilla*: (1) maximum length M3; (2) maximum length M1-M3; (3) maximum length P2-P4; (L) maximum length P2-M3.

Scapula: (1) greatest length of the glenoid process (vdD-GLP); (2) length glenoid cavity (vdD-LG); (3) minimum width neck (vdD-SLC); (4) distance glenoid cavity-base of spine.

Humerus: (1) maximum width (breadth) distal end (vdD-Bd); (2) maximum thickness (depth) distal end; (3) maximum height trochlea; (4) maximum width of trochlea (vdD-DT); (L) maximum length (vdD-GL).

Radius: (1) maximum width proximal end (vdD-Bp); (2) maximum width distal end (vdD-Bd); (L) maximum length (vdD-GL).

Metacarpus: (1) maximum width proximal end (vdD-Bp); maximum thickness proximal end; (3) maximum width distal fusion point; (4) maximum thickness distal fusion point; (5) maximum width distal end (vdD-Bd); (L) maximum length (vdD-GL).

Tibia: (1) maximum width distal end (vdD-Bd); (2) maximum thickness distal end (vdD-Dd); (L) maximum length (vdD-GL).

Astragalus: (1) greatest length lateral half (vdD-GLl) ; (2) greatest thickness lateral half (vdD-Dl); (3) maximum length medial half (vdD-GLm).

Calcaneum: (1) length from most posterior point of bone to most anterior point of articular surface; (2) length of articular surface at the lateral process (after Boessneck 1969: figure 70c): (3) length of the lateral process from the most proximal part of the articular surface to the most distal point of the bone (after Boessneck 1969: figure 70c+d).

Metatarsus: (1) maximum width proximal end (vdD-Bp); (2) maximum thickness proximal end; (3) maximum width distal fusion point; (L) maximum length (vdD-GL).

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One of the biggest revolutions in modern archaeology has been the development of techniques to study ordinary food refuse such as scraps of animal bone and tiny carbonised seeds which often provide a most vivid picture of life in the past. They tell us not just about diet, but also about the history of animal and plant breeds, and, most important, about the kind of agricultural systems that originally provided the refuse found in an excavation.

Mark Maltby's study of the animal bones from the Exeter excavations makes this abundantly clear. His analysis is the first detailed report on a large faunal collection — about 100,000 fragments of bone — to be published from one of our major cities. Exeter, from a Roman fort, rose to become an important Roman provincial town and a centre of the wool trade in medieval England. The animal bones document changes in the economic life of the city over the past two thousand years. One of the most crucial problems Mark Maltby had to face was the enormous variation in contemporary samples from different parts of the city: from administrative, industrial and residential quarters. The methodology he develops provides an essential model for archaeological projects dealing with similarly complex material in many other historic towns and cities in Britain. In addition, he presents a full analysis of the documentary evidence for the Exeter economy, and his rigorous comparisons of the strengths and weaknesses of the different kinds of data result in a major contribution to the economic history of this important English town.

The book will be of interest not simply to specialists working in this branch of archaeology ('archaeozoology'), but also to archaeologists and historians interested in the economic and social reconstruction of the past.