EAST ANGLIAN ARCHAEOLOGY

dedicated to Judy Cartledge

Norwich Castle: Excavations and Historical Survey, 1987–98 Part III: A Zooarchaeological Study

by Umberto Albarella, Mark Beech, Julie Curl, Alison Locker, Marta Moreno García and Jacqui Mulville

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Cover illustrations
(top) Reconstruction of the Norman castle in the12th century. The new masonry keep lies on its enlarged motte, and the defences of the south bailey have been strengthened. The Castle Fee boundary may have been marked, and the Norman French Borough lies in the foreground. *Painted by Nick Arber*

(below) Reconstruction of Norwich Castle *c.*1650–1738, showing the decline of the defences and the encroachment of the city. *Painted by Nick Arber*

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Abbreviations

AML	Ancient Monuments Laboratory, English Heritage
BS	Bones deriving from the 0.5mm flotation residues of 'bulk samples'
HC	Hand-collected bones
NISP	Number of individual specimens present (number of fragments)
MNI	Minimum number of individuals
NAU	Norfolk Archaeological Unit
POSAC	Parts of skeleton always counted
SF	Small Find number
SRS	Bones deriving from 8.0mm sieving of 'site riddled samples'
Wt	Weight

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Summary

Norwich Castle, established soon after the Norman Conquest, was the only royal castle in Norfolk and Suffolk for nearly a century. Together with its surrounding Fee or Liberty, the fortification overlay a substantial part of the Late Saxon town. Redevelopment for a shopping centre complex — named Castle Mall — entailed the archaeological excavation of the castle's south bailey, its barbican and part of its north-east bailey (the Castle Meadow), along with the fringes of the adjacent urban settlement. This was the largest archaeological excavation ever undertaken in Norwich and remains one of the largest urban excavations in Europe. The investigation was carried out by the Norfolk Archaeological Unit (NAU) between 1987 and 1991,with supplementary work undertaken at Golden Ball Street in 1998.

This is Part III of the Norwich Castle report. A two-volume monograph (Shepherd Popescu 2009) presents a synthesis of all the results from the excavations and associated historical and documentary research. Part I spans the Anglo-Saxon period to *c.*1345 and includes the background to the project. Part II spans the period *c.*1345 to modern and includes chapters on finds analysis, the development of the castle and overall conclusions. Although Parts I and II both contain summary accounts of the faunal remains, setting them into their wider context and including additional information on craft activities, the scale of the data required the production of a separate and more specialised report on the faunal remains. This permits presentation of metrical and other data that could not be published in detail within the monograph, where the faunal assemblage is considered largely in chronolological terms: this occasional paper details the evidence more specifically by species.

Excavations at Castle Mall yielded the largest faunal assemblage ever recovered from Norwich with the greatest, most continuous chronological spread. The assemblages recovered demonstrate the breadth of information available from faunal remains, from the common farm animals providing milk, meat and eggs, to the trade in horns, antlers, hides and bones for crafts and industries. Evidence ranging from the occasional exotic species to the use of non-traditional food animals such as horse and dog has revealed a picture of the human-animal interaction within a medieval town. The analyses reveal details on the diet of the citizens of Norwich; how animals were procured and butchered, which foods people ate and how they disposed of their waste. It has also been possible to link archaeological and zooarchaeological evidence to trace the changing use of space within and around the castle site throughout its long history.

Amongst the various assemblages recovered from the site, the well-preserved late medieval group from the barbican well suggests that between the mid/late 15th and early 16th centuries at Norwich, cattle were raised for prime beef production and pigs for pork. Sheep seemed to be more important for other products than meat, such as wool and skin. Chicken and geese supplied meat and eggs, with geese also providing the raw material for the fletching of arrows and/or quills for writing.

The results presented here build upon previous work both within the city and further afield and contribute greatly to the debates on the changing use of animals, agricultural improvement, the fishing industry, the relationship between urban sites and their rural hinterland. Finally, and perhaps most importantly, this site has provided evidence for the most elusive of innovations, that of the 'agricultural revolution'. Analysis of these large assemblages has allowed linkage between a shift in animal use to a change in animal type. These changes, occurring between the 15th and 17th centuries, are the initial stages in a new economic system of animal husbandry. The creation of a large corpus of ageing and metrical data has provided an extensive and detailed body of evidence absent from many other sites, upon which future research into the development of animal use can build.

Résumé

Norwich Castle, qui fut construit peu après la conquête normande, demeura le seul château royal dans le Norfolk et Suffolk pendant près d'un siècle. Si l'on inclut le Fee ou Liberty environnant, les fortifications s'étendaient sur une part importante de la ville pendant la période saxonne tardive. L'extension d'un centre commercial, appelé Castle Mall permit d'entreprendre la fouille archéologique de la basse-cour situé au sud du château. Ces recherches portèrent également sur la barbacane et la partie du pont situé au nord-est (le Castle Meadow) ainsi que sur la périphérie de l'implantation urbaine voisine. Il s'agit du plus grand projet archéologique entrepris dans le Norwich, qui reste l'une des fouilles urbaines les plus importantes en Europe. Les fouilles furent conduites par la Norfolk Archaeological Unit (NAU) entre 1987 et 1991 auxquelles s'ajoutèrent des recherches supplémentaires sur le site de Golden Ball Street en 1998.

Il s'agit de la partie III du rapport sur le Norwich Castle. Une monographie en deux volumes (Shepherd Popescu 2009) présente une synthèse de tous les résultats tirés des fouilles ainsi que de la recherche documentaire et historique qui leur est associée. La partie I couvre la période anglo-saxonne jusqu'à environ 1345 et elle expose le contexte du projet. La partie II couvre la période allant d'environ 1345 à l'époque moderne et elle comprend des chapitres sur l'analyse des découvertes, le développement du château et les conclusions générales. Bien que les parties I et II contiennent chacune des résumés sur les restes de la faune, qui les placent dans un contexte plus large et apportent des informations supplémentaires sur les activités artisanales, la taille des données nécessite la production d'un rapport distinct et plus spécialisé sur les restes faunistiques. Cela permet de présenter des données métriques, parmi d'autres éléments, qui ne pourraient pas être publiées en détail dans les monographies. En effet, celles-ci considèrent dans une large mesure l'ensemble faunistique sur un plan chronologique. Le présent volume détaille plus précisément les preuves rassemblées en fonction des espèces.

Parmi les fouilles entreprises jusqu'à présent à Norwich, l'ensemble faunistique découvert à Castle Mall est le plus important sur le plan de la taille et de la continuité chronologique. Les ensembles découverts attestent de l'étendue des informations tirées des restes faunistiques, depuis les animaux familiers de la ferme qui fournissent le lait, la viande et les oeufs jusqu'au commerce des cornes, des bois, du cuir et des os dans le cadre d'activités artisanales et industrielles. Les traces découvertes vont des espèces exotiques occasionnelles jusqu'aux espèces proies inhabituelles telles que le cheval et le chien. Ces traces ont permis de révéler une image des interactions homme-animal au sein d'une ville médiévale. Les analyses ont permis de connaître de façon approfondie les habitudes alimentaires des habitants de Norwich et les moyens qu'ils utilisaient pour obtenir des animaux, pour les abattre, et se débarrasser de leurs restes. Il a également été possible de relier les preuves archéologiques et zooarchéologiques afin de découvrir les changements dans l'utilisation de l'espace à l'intérieur et autour du site du château au cours de sa longue histoire.

Parmi les différents ensembles découverts sur le site, la partie bien préservée de la barbacane datant de la fin du Moyen Âge suggère clairement que dans la ville de Norwich, les bovins et les porcs étaient essentiellement élevés comme viandes de boucherie entre le milieu/fin du quinzième siècle et le début du seizième siècle. Apparemment, les moutons étaient élevés pour leur laine et leur peau plutôt que pour leur viande. Les poulets étaient élevés pour la viande et les œufs, comme les oies qui en outre fournissaient la matière première pour l'empennage des flèches et/ou pour les plumes servant à écrire.

Les résultats présentés ici s'appuient sur les études antérieures qui traitaient à la fois de l'intérieur de la ville et des alentours. De plus, dans une large mesure, ils alimentent les débats concernant les changements d'utilisation des animaux, les améliorations de l'agriculture, l'industrie de la pêche et les relations entre les sites urbains et l'arrière-pays rural. Enfin, et il s'agit peut-être là du point le plus important, ce site a fourni des preuves concernant la « révolution de l'agriculture » qui représente l'innovation la plus difficile à défnir. L'analyse de ces grands ensembles a permis d'établir le lien entre les modifications dans l'utilisation des animaux et les changements de type d'animaux. Ces transformations, qui sont intervenues entre le quinzième et le dix-septième siècles, correspondent aux premières étapes d'un nouveau système économique de l'élevage. La création d'un grand corpus contenant des données métriques sur la taille des os et des informations sur l'âge des animaux a permis de constituer un grand ensemble de preuves précises qui sont absentes des autres sites. Ces données alimenteront les recherches futures sur le développement de l'utilisation des animaux.

(Traduction: Didier Don)

Zusammenfassung

Das kurz nach der normannischen Eroberung erbaute Norwich Castle war fast hundert Jahre lang die einzige Königsburg in Norfolk und Suffolk. Zusammen mit dem umliegenden Lehen überlagerte die Festungsanlage einen beträchtlichen Teil der spätangelsächsischen Stadt. Zu den Erschließungsarbeiten vor dem Bau eines Einkaufszentrums — der Castle Mall — zählte die Ausgrabung der südlichen Vorburg, des Vorwerks sowie von Teilen der Vorburg im Nordosten (der Castle Meadow) und von Rändern der angrenzenden Stadtsiedlung. Es war das größte archäologische Projekt, das je in Norwich unternommen wurde, und eine der

größten Stadtgrabungen in Europa. Die Untersuchung wurde zwischen 1987 und 1991 von der Norfolk Archaeological Unit (NAU) durchgeführt, 1998 fanden zusätzliche Arbeiten an der Golden Ball Street statt.

Dies ist Teil III des Berichts über Norwich Castle. In einer zweibändigen Monographie (Shepherd Popescu 2009) sind die Ergebnisse der Ausgrabungen sowie der zugehörigen historischen Forschungen und Quellenstudien dokumentiert. Teil I umfasst die angelsächsische Periode bis ca. 1345 und gibt einen Überblick über den Hintergrund des Projekts. Teil II, der mit der Zeit von ca. 1345 bis heute befasst ist, enthält neben Kapiteln zur Auswertung der Befunde und zur Entwicklung der Burg auch allgemeine Schlussfolgerungen. Obwohl Teil I und Teil II Übersichten über die gefundenen Tierreste enthalten und diese in den Gesamtkontext einbetten sowie mit Zusatzinformationen über die entsprechenden Handwerkstätigkeiten versehen, machte das Datenausmaß die Produktion eines separaten Detailberichts zum Thema Tierreste erforderlich. Er enthält metrische sowie sonstige Daten, die nicht im Detail in die Monographien Eingang finden konnten, in denen die Tierfunde vornehmlich unter chronologischen Gesichtspunkten aufgeführt sind. Der vorliegende Band enthält nach Tierarten unterteilte Einzelheiten zu den Befunden.

Die Ausgrabungen an der Castle Mall brachten die umfangreichsten Tierfunde ans Licht, die je in Norwich bekannt wurden, mit der längsten chronologisch durchgängigen Sequenz. Die Fundkomplexe demonstrieren die Breite an Informationen, die sich aus Tierresten gewinnen lassen, von normalen Bauernhoftieren, die Milch, Fleisch und Eier liefern, bis hin zum Handel mit Hörnern, Geweihen, Häuten und Knochen für handwerkliche und gewerbliche Zwecke. Die Befunde, sowohl zu vereinzelten exotischen Arten wie auch zur Nutzung unüblicher Nahrungstiere wie Pferd oder Hund, illustrieren die Beziehung zwischen Mensch und Tier in einer mittelalterlichen Stadt. Die Analysen förderten Details über die Nahrungsgewohnheiten der Bürger von Norwich zutage: wie Tiere beschafft und geschlachtet wurden, was die Menschen aßen und wie sie sich ihrer Abfälle entledigten. Die archäologischen Befunde ließen sich zudem mit den archäzoologischen Belegen verknüpfen, um zu verfolgen, welche Veränderungen bei der Raumnutzung innerhalb und außerhalb des Burggeländes in seiner langen Geschichte aufgetreten sind.

Unter den verschiedenen Fundkomplexen der Grabungsstätte lässt die gut erhaltene spätmittelalterliche Fundgruppe vom Brunnen im Vorwerk darauf schließen, dass zwischen der zweiten Hälfte des 15. und dem Beginn des 16. Jh. in Norwich Rinder und Schweine gehalten wurden, um hochwertiges Rind- und Schweinefleisch zu liefern. Schafe hatten als Fleischlieferanten offenbar weniger Bedeutung; sie sorgten vielmehr für Wolle und Häute. Hühner und Gänse lieferten Fleisch und Eier, Gänse zudem das Rohmaterial für die Befiederung von Pfeilen und für Schreibfedern.

Die hier vorgestellten Resultate, die auf vorherigen Arbeiten in und außerhalb der Stadt aufbauen, leisten einen wichtigen Beitrag zu den Debatten über den sich wandelnden Gebrauch von Tieren, über Agrarverbesserungen, die Fischwirtschaft sowie die Beziehungen zwischen Städten und ihrem Hinterland. Schließlich liefert der Grabungsort — und dies ist vielleicht der wichtigste Befund — auch Hinweise auf eine schwer zu erfassende Neuerung: die »Agrarrevolution«. Bei der Analyse der umfangreichen Fundkomplexe wurde eine Verbindung zwischen einem Wandel bei der Tiernutzung und Änderungen im Bereich der Tierarten festgestellt. Diese Änderungen, die zwischen dem 15. und dem 17. Jh. auftraten, bilden die Anfangsphase eines neuen landwirtschaftlichen Tierzuchtsystems. Durch die Schaffung eines umfangreichen Korpus aus Daten zur Alterung und metrischen Daten entstand eine ausgedehnte und detaillierte Befundsammlung, die zu anderen Stätten nicht existiert und auf die sich künftige Arbeiten über die Entwicklung der Tiernutzung stützen können.

(Übersetzung: Gerlinde Krug)

Chapter 1. General Introduction

by Elizabeth Shepherd Popescu

Norwich has long been one of the most important centres in East Anglia. Its distinctive plan form is dictated by local topography, dominated by the sinuous course of the River Wensum and two major areas of high ground (Fig.1). The city lies about 32km (20 miles) from the sea, at the lowest fording point of the Wensum, just above its confluence with the River Yare. Alluvial flats extend to its east and were extensively used for grazing by the time of Domesday. Lighter soils lie to the north, while to the west and north-west the heavier and more fertile soils were probably densely wooded in antiquity: until the 18th century, there was 'a contrast between the largely pastoral agriculture of this 'wood and pasture' area and the largely arable agriculture of the lighter soils of the 'corn and sheep' area to the north' (Campbell 1975, 1). The city developed on a series of gravel and chalk plateaux and ridges, surrounded by extensive areas of marsh along the river margins. The surface geology is of sand and gravel, forming well-drained terraces. The royal Norman castle, which continues to dominate the city centre, was placed at the end of a spur of high ground known locally as the Ber Street ridge. Despite the masking effects of modern buildings, steep natural slopes still exist around the site to the north-east and west, with much of the southern area forming a relatively level plateau.

Recognition of Norwich Castle's national importance had led to provision of Scheduled Ancient Monument status (*1979 Ancient Monuments and Archaeological Areas Act*; SAM5), subsequently extended in 1983 to include more of the surrounding earthworks. The Castle Mall site (Site 777N; TG 2320 0837 — centre) occupied the castle's south bailey, the barbican and part of the north-east bailey (the Castle Meadow), along with the fringes of the adjacent urban settlement (Fig.2). This was the largest archaeological excavation ever undertaken in Norwich and remains one of the largest urban excavations in Europe (see Part I, Chapter 1). The investigation was carried out by the Norfolk Archaeological Unit (NAU) between 1989 and 1991, following trial work in 1987–8, in advance of redevelopment for a massive underground shopping centre. Supplementary work took place at nearby Golden Ball Street in 1998 (Site 26496N; TG 2321 0828 - centre) in advance of redevelopment for a cinema complex. This revealed important additional evidence for the castle ditches, linking directly to observations made at Castle Mall.

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The Castle Mall site comprised four evaluation trenches, eighteen excavation areas and eighty-one watching briefs. The project generated nearly 14,000 contexts, well over ten thousand artefacts, nearly a ton of pottery and a similar quantity of mammal and avian bone. Over four hundred human burials were recovered from four cemeteries/burial groups ranging in date from Middle Saxon to post-medieval. Work at Golden Ball Street produced a further 480 contexts in two excavation areas. At Castle Mall, each area was phased separately using a grouping system, linking archaeological features and deposits into wider interpretative entities (sequentially numbered) such as buildings, cemeteries and open areas. Groups are identified by area and group number thus:

Period	*Site Context*	*Chronology*	*General Period*	*Monograph Part/Chapter*
Period 1	stray early finds; pre-Conquest settlement & cemeteries	*c.*5th to *c.*mid 9th centuries late 9th to 11th centuries	Early and Middle Saxon Late Saxon	Part I, Chapter 4
Period 2	Norman Conquest/timber castle & defences	*c.*1067–70 to *c.*1094	Norman ('early medieval')	Part I, Chapter 5
Period 3	masonry castle & revised defences	*c.*1094 to 12th century	Norman ('early medieval')	Part I, Chapter 6
Period 4	excavation of barbican ditch. Transfer of castle baileys to city in 1345	late 12th century to *c.*1345	medieval ('mid medieval')	Part I, Chapter 7
Period 5	castle decline & encroachment of tenements; use of baileys for craft/industry & grazing	*c.*1345 to mid/late 16th century	late medieval/transitional	Part II, Chapters 8 & 9
Period 6	tenement development; first Cattle Market 1738	late 16th to 18th centuries	post-medieval	Part II, Chapter 10
Period 7	tenement development; revised Cattle Market 1862	19th to 20th centuries	modern	Part II, Chapter 11

Table 1 Concordance of site periods and monograph chapters

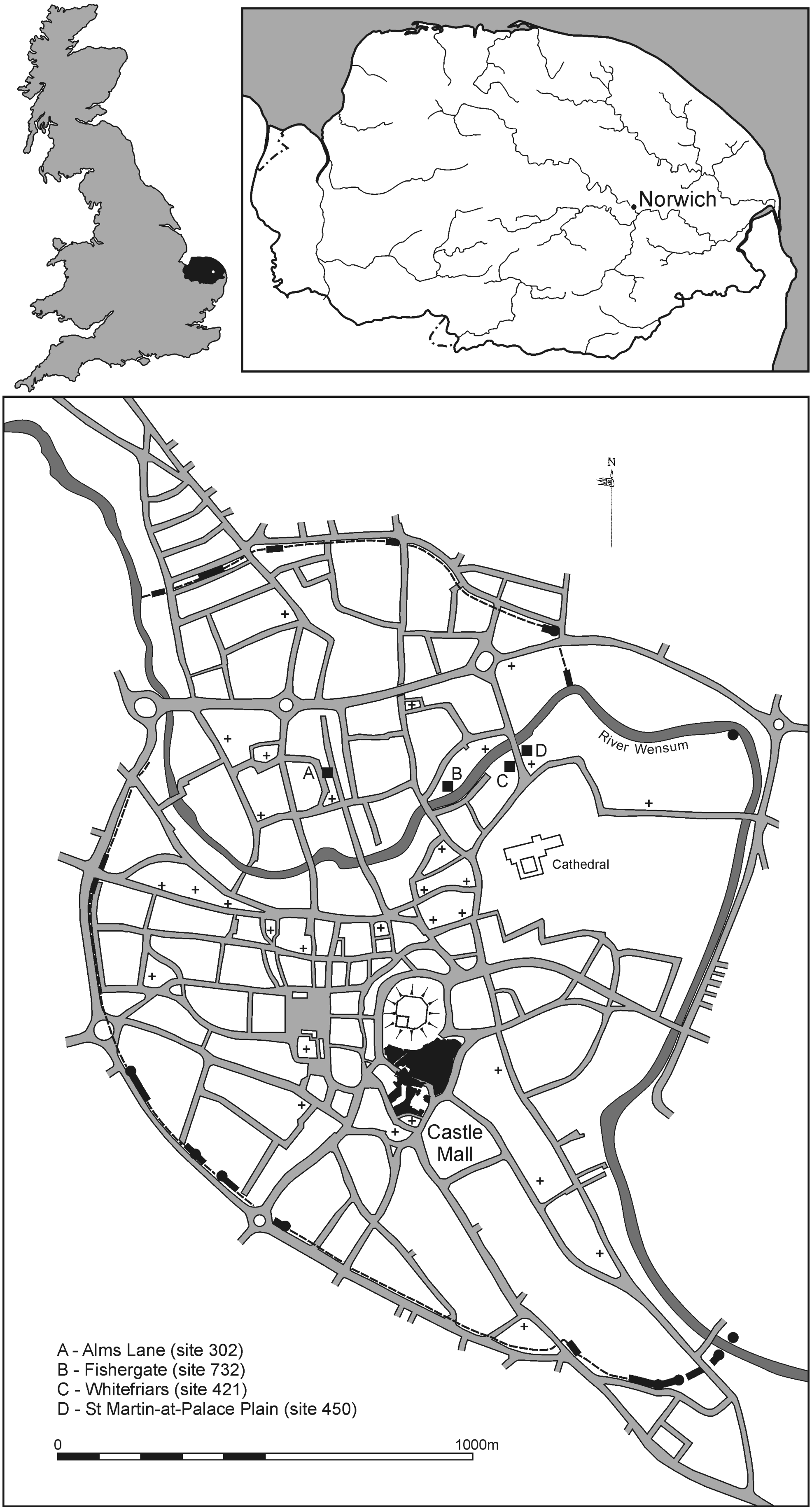


Figure 1 Map showing Late Saxon and medieval Norwich and its location. Not to scale

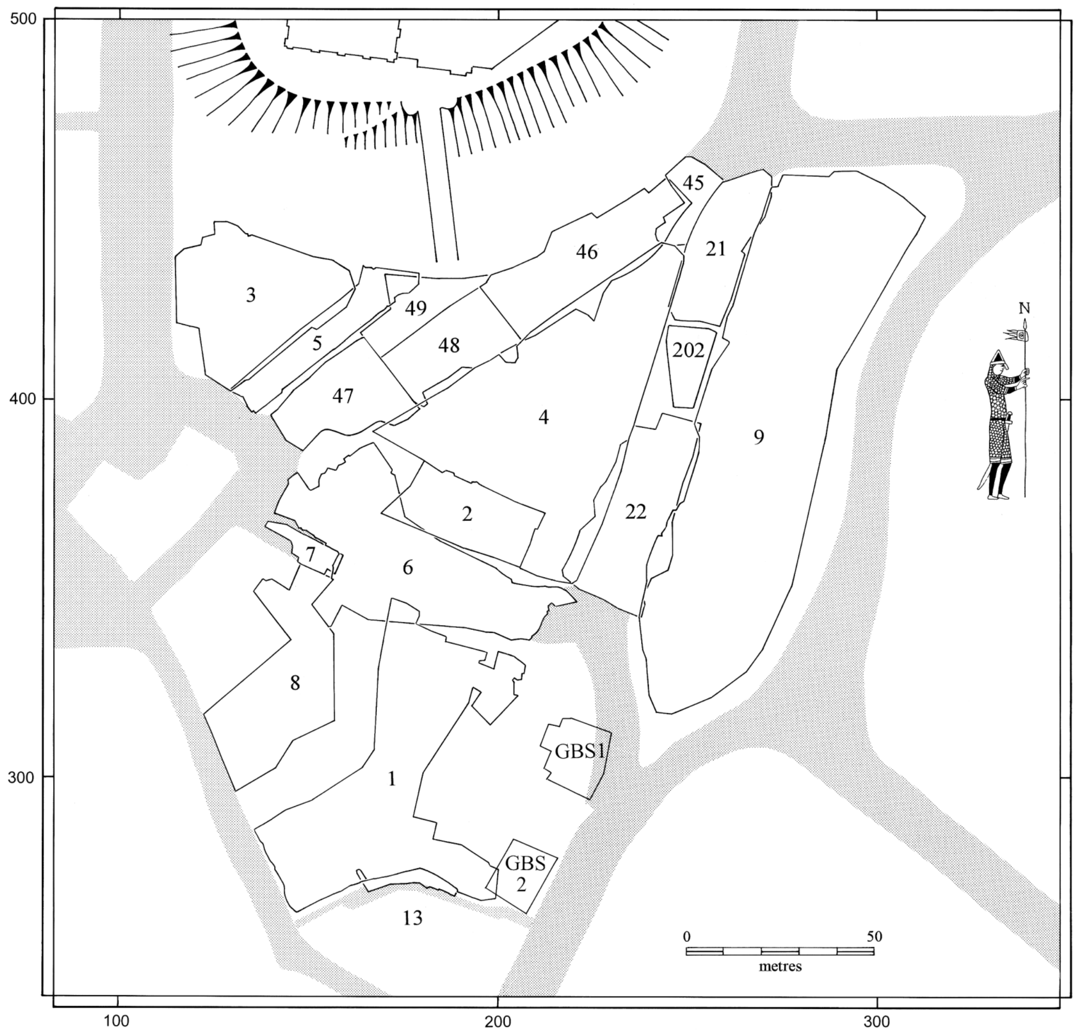


Figure 2 Location of the Castle Mall and Golden Ball Street excavations, showing excavation area numbers. Scale 1:2000

G1/61 = Area 1, Group 61. Watching briefs groups are shown as follows: T100/2 = Watching brief 100, Group 2. At Golden Ball Street, a single running sequence of group numbers was employed for the two areas excavated (groups relating to this site are annotated *e.g.* GBS Group 1). The groups from each site were then allocated to seven periods (Table 1) divided into sub-periods (Table 2). Table 1 links the periods to their relevant monograph chapter, where summary information on the faunal assemblages is given in its archaeological context. Although Period 1 spans the Anglo-Saxon period, zooarchaeological remains were only recovered from Late Saxon deposits. Modern material (Period 7) is not included in the study of animal and bird bones, although summary comments are given for the fish.

Excavations at Castle Mall yielded the largest faunal assemblage ever recovered from Norwich with the greatest, most continuous chronological spread. A total assemblage of 937kg of mammal and avian bone was collected, of which 131kg (14%) of mammal bones and 6kg (0.5%) of avian bones came from mid/late 15th to early 16th century fills of a major castle well sited within the barbican. Additional material was obtained from 1,898 samples (Site Riddled Samples (SRS) producing 764 measurable bones and Bulk Samples (BS) accounting for a further 561 measurable bones). Over 14,000 fish bones were identified, of which 2,882 (20%) came from fills of the well. An additional 54kg of mammal and avian

Period/sub-period	*Date Range*
1.1	5th to 9th century
1.2	late 9th to early 11th centuries
1.3	11th century
1.4	mid to late 11th century
2.1	*c.*1067–70 to *c.*1094/early 12th century
2.2	*c.*1067–70 to *c.*1094/early 12th century
3.1	*c.*1094 to 12th century
3.2	*c.*1094 to 12th century
4.1	late 12th to 13th centuries
4.2	13th century to *c.*1345
5.1	*c.*1345 to 15th century
5.2	mid/late 15th to mid/late 16th centuries
6.1	late 16th to mid 17th centuries
6.2	mid 17th century to *c.*1738
6.3	post-*c.*1738 to *c.*1800
7.1	19th century (to 1862)
7.2	1862 to 20th century

Table 2 Periods and sub-periods[1]

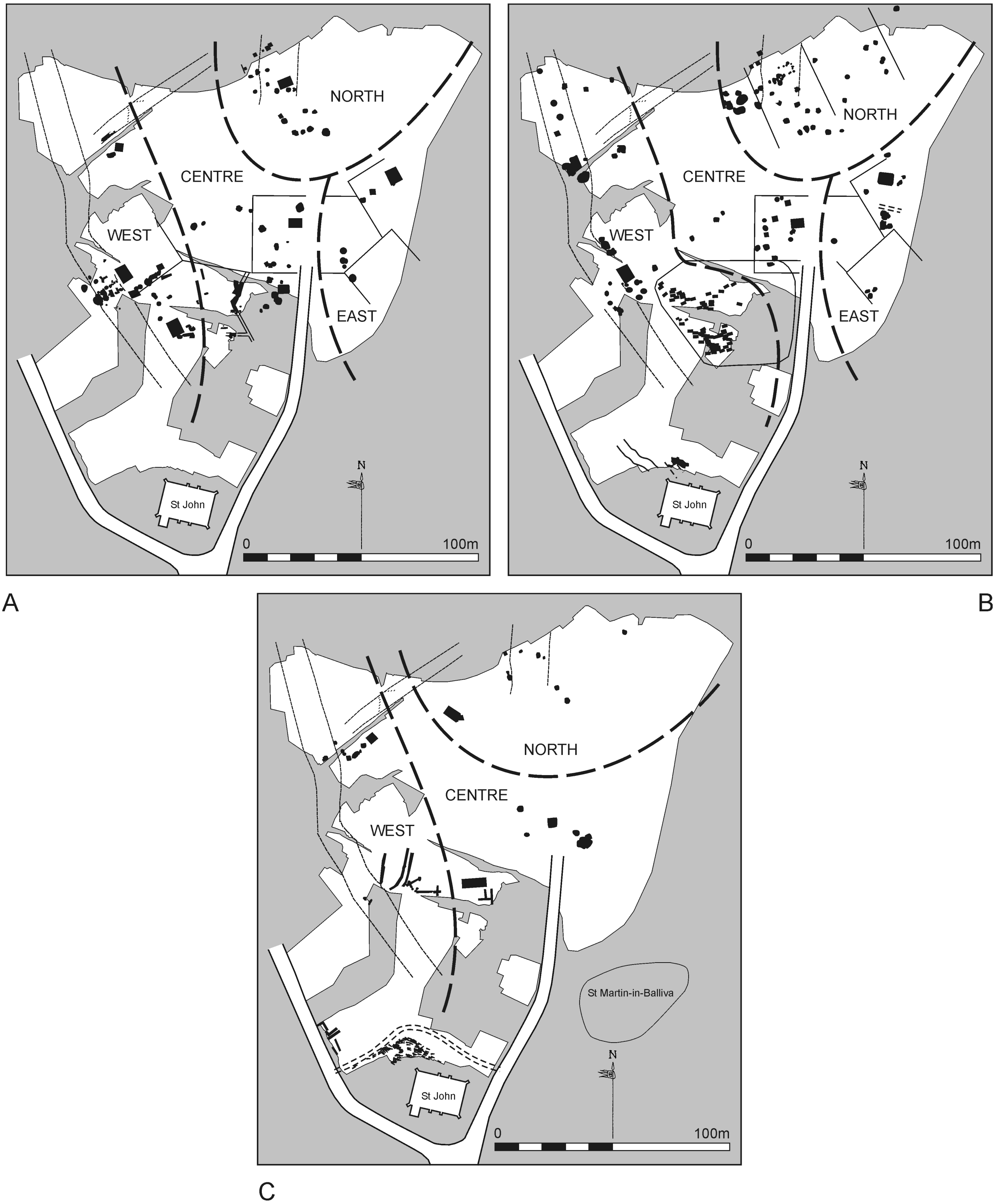


Figure 3 Spatial distributions used for analysis of animal bones in Period 1. A = 1.2 (10th to early 11th century); B = Period 1.3 (11th century); C. Period 1.4 (mid to late 11th century). Scale 1:2500

bone and 0.322kg of fish bone was retrieved from the excavations at Golden Ball Street.

Due to the complex nature of the project, the faunal remains were analysed in stages. Following assessment of the whole assemblage in 1994 by Rosemary Luff and Marta Moreno García (at the Cambridge Faunal Remains Unit, University of Cambridge), analysis of the substantial remains from the barbican well was completed in 1995 by Marta Moreno García and was updated in 2003. Fish bones from these deposits were analysed separately by Alison Locker. Subsequent work on the remainder of the assemblage began at Birmingham University in 1995 by Umberto Albarella, Mark Beech and Jacqui Mulville (AML72/97). The remaining fish bone was studied by Alison Locker (AML85/97) and integrated with the results of analysis of the well shaft assemblage: this analysis was updated in 2002. Material from the Golden Ball Street site was scanned by Julie Curl in 1998 and finalised in 2003.

Endnote

1. At the time that analysis of the faunal remains was undertaken, site phasing was not complete to sub-period level for Periods 4–6. Subsequent revisions to the phasing were necessary after the unexpectedly early radiocarbon dating of one cemetery (St John de Berstrete/Timberhill, G1/61), which necessitated the rephasing both of the cemetery and related stratigraphic sequences (the cemetery itself was rephased from Period 4.1 to Period 1.4). A number of other minor revisions took place in the light of refined dating by other specialists, most being confined within periods and many relating to contexts which did not contain faunal remains or from which the latter had not been studied. Period 2.3 was later combined with Period 2.2. Although it proved possible to include the revised structure in the final version of the fish bone report published here (Chapter 5), in agreement with EH the previous phasing structure employed for the animal and bird bone was not revised in the light of practical and financial considerations: the changes are not so extensive as to affect seriously the interpretations offered in Chapter 3. The alterations do not affect the barbican well assemblage (Chapter 4) nor Golden Ball Street site (Chapter 6). Further details are available in the project archive.

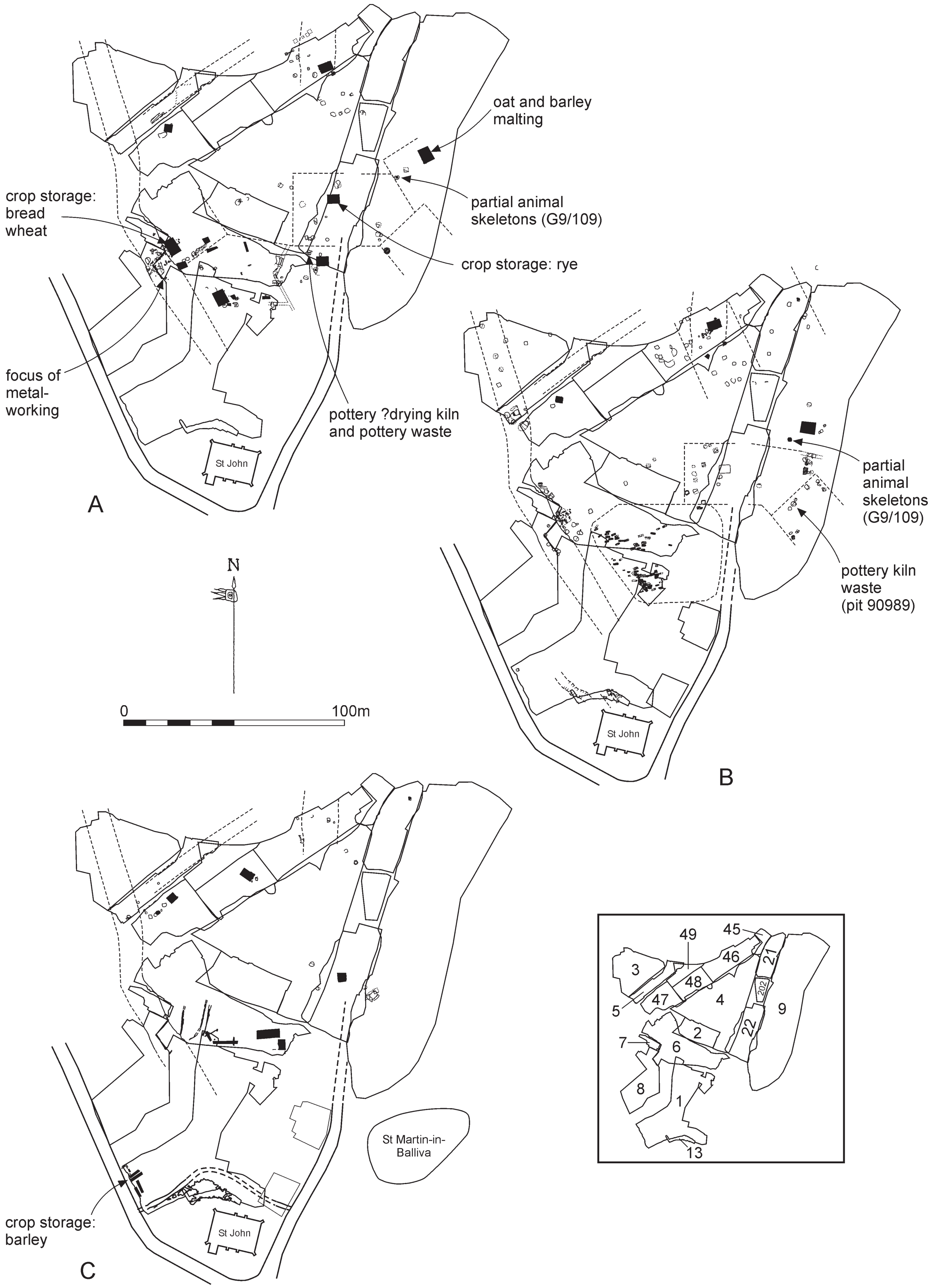


Figure 4 Location of Late Saxon craft activities and associated waste: A=Period 1.2 (late 9th to early 11th century); B=Period 1.3 (11th century); C=Period 1.4 (mid to late 11th century). Scale 1:2500

Chapter 2. Archaeological and Historical Summary

I. The Archaeological Evidence

by Elizabeth Shepherd Popescu

The six acre site of the Castle Mall development in central Norwich (Figs 1 and 2) was a unique archaeological opportunity: redevelopment involved excavation within and around the defences of the only 11th-century royal castle in Norfolk and Suffolk. This is one of only a handful of such fortifications in the country where excavation has not been restricted to the defences and/or to small areas of the bailey. The castle had been built on part of the Late Saxon town, where traces of Middle Saxon activity survived in the form of burials. This was not, as had been supposed, the site of the Middle Saxon settlement of *Needham*, but instead what appear to be the fringes of a more extensive Late Saxon settlement. There is evidence for domestic buildings or workshops, a multitude of pits of various types and functions, boundary or drainage ditches and cemeteries, all with the potential to provide a picture of life in a pre-Conquest town. One cemetery — that of St John de Berstrete/Timberhill — revealed (*inter alia*) evidence for a significant group of leper burials.

Construction of a timber castle followed soon after the Norman Conquest (probably between 1067/1068 and 1070), with the first documentary reference made in 1075 when its defences were substantial enough to withstand a siege. Evidence for the impact of castle building comes not only from documentary sources (*Domesday Book* of 1086 records 98 houses destroyed or enclosed; Brown (ed.)1984, 116b (1.61)) but also in excavated evidence for the abandonment, destruction or possibly even reuse of buildings within the subsequent south bailey. A large area of crown land — the Castle Fee or Liberty — was defined around the fortification at an early date, enclosing about 23 acres. This boundary may have been marked, at least partially, by a ditch which was observed at Castle Mall and Golden Ball Street, as well as other excavations further west. Other early ditchwork was set within the Fee and included defences for bridge landings.

Norwich Castle's surviving stone keep and bridge (*c.*1094–1122) replaced timber forerunners, with two baileys augmenting an enlarged motte. Evidence for both baileys has been excavated: the Castle Meadow or north-east bailey (at the Castle Mall and Anglian Television sites; for the latter see Ayers 1985) and the larger south bailey (at Castle Mall and Golden Ball Street). Masonry gatehouses were added and a deep well placed within a forework (later to become a barbican) at the foot of the new bridge.

The 13th century saw alterations to the defences with the creation of a massive barbican ditch and bank, replacing its smaller forerunner. The castle served mainly as an administrative centre and prison from about 1300 and the baileys were granted to the city in 1345 with the mound, keep and Shirehouse (lying within the south bailey) remaining Crown property. Throughout the later medieval and post-medieval periods the baileys were used for grazing, industrial activities and quarrying. Tenements encroached around the fringes of the former defences.

Landscaping took place in 1738, prior to the construction of a Cattle Market and again in 1862 when new roads were added. In 1939 air-raid shelters were built and in 1960 the area became a car park following the relocation of the Cattle Market. The south bailey was destined to become a massive underground shopping complex, but to this day retains the character of an open space: a park has been laid out on the roof.

II. The Norwich Context: Trade, Industry and Economy

by Umberto Albarella, Mark Beech, Jacqui Mulville and Elizabeth Shepherd Popescu
(Figs 4–9)

Although in the Late Saxon period eastern Norfolk was densely populated compared to the rest of England, few towns had developed (Campbell 1975, 6). Norwich — as one of the largest — had already acquired its dominant status. Trade was mainly local and regional although contacts were also established with the continent (Scandinavia, the Low Countries and the Rhineland). Craftsmen such as metalworkers, bone- and antler-workers were active within the town, their presence being attested at numerous archaeological sites.

With some forty churches by 1066, Norwich had become the fourth largest town in England at the time of the Norman Conquest, its population probably exceeding five thousand. The city grew in importance and its Jewry, which lay just to the west of the castle, was one of the most important in England (Lipman 1967). In the late 11th century the main market place, lying within the French Borough to the west of the castle, was used for the sale of poultry, sheep, cattle, wheat, cheese and other provisions. It also housed butchers, fishmongers and those working in the leather trades[1] (Priestley 1987). Fish, particularly herring, was an important resource, with fish houses and shops being mentioned in the period 1285–1311 (Kelly *et al.* 1983, 26). The tanning, skinning, fulling, dying and horn-working trades were also well established and were mainly situated along the banks of the river. By *c.*1300, the leatherworkers were the most numerous group and included shoemakers, tanners, skinners, tawyers, saddlers, parchmentmakers and whitawyers (Kelly *et al.* 1983, 22–24). Butchers were numerous in the Ber Street leet, just to the south of the castle.

Norwich's wealth during the medieval and post-medieval periods derived from the wool and textile trades, with resultant import and export links stretching across Europe and beyond. Norwich cloth seals have been found as far afield as colonial sites such as Jamestown in

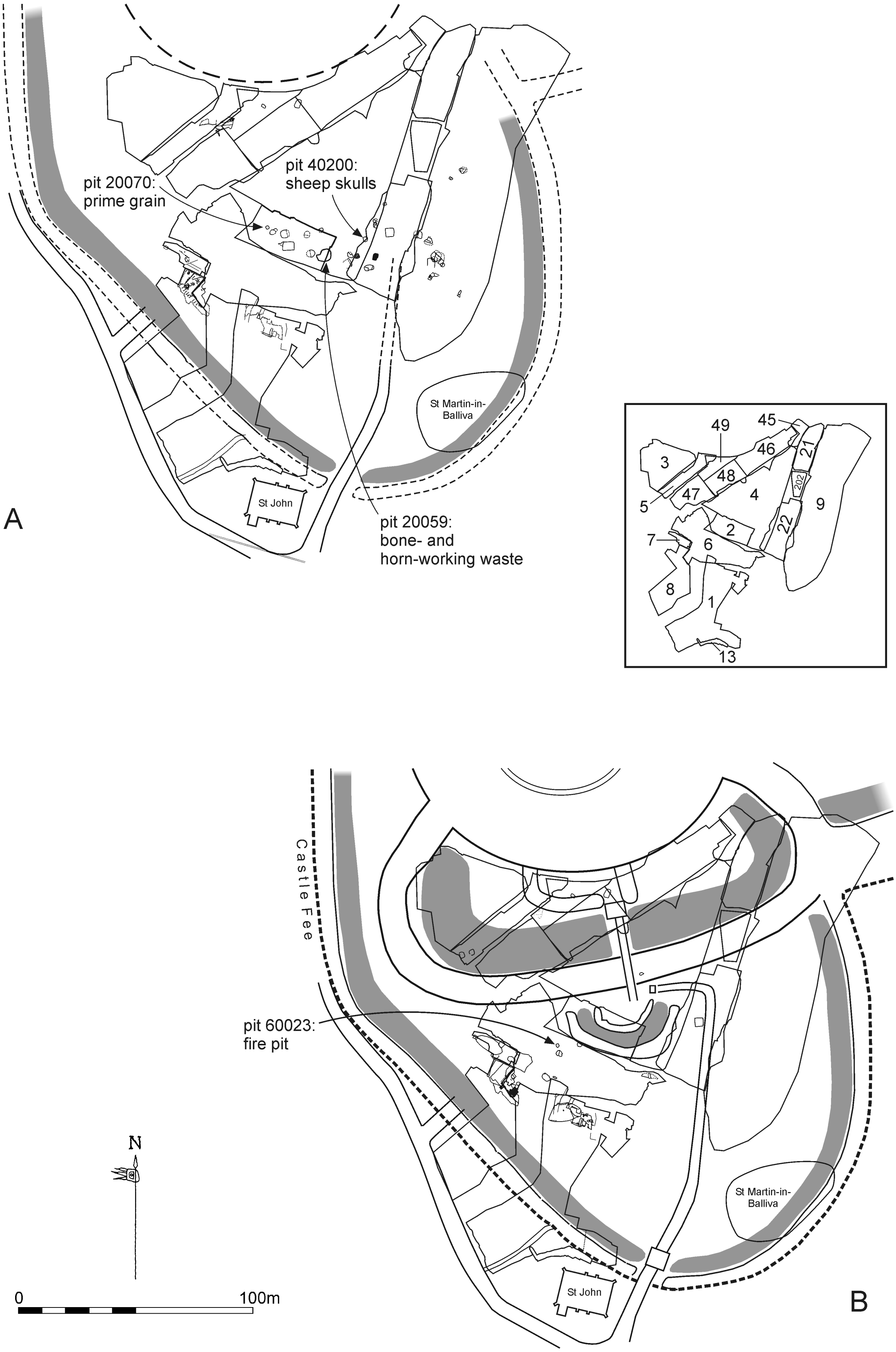


Figure 5 Location of early Norman craft activities and associated waste: A=Period 2.1 (late 11th to early 12th century); B=Period 2.2 (late 11th to early 12th century). Scale 1:2500

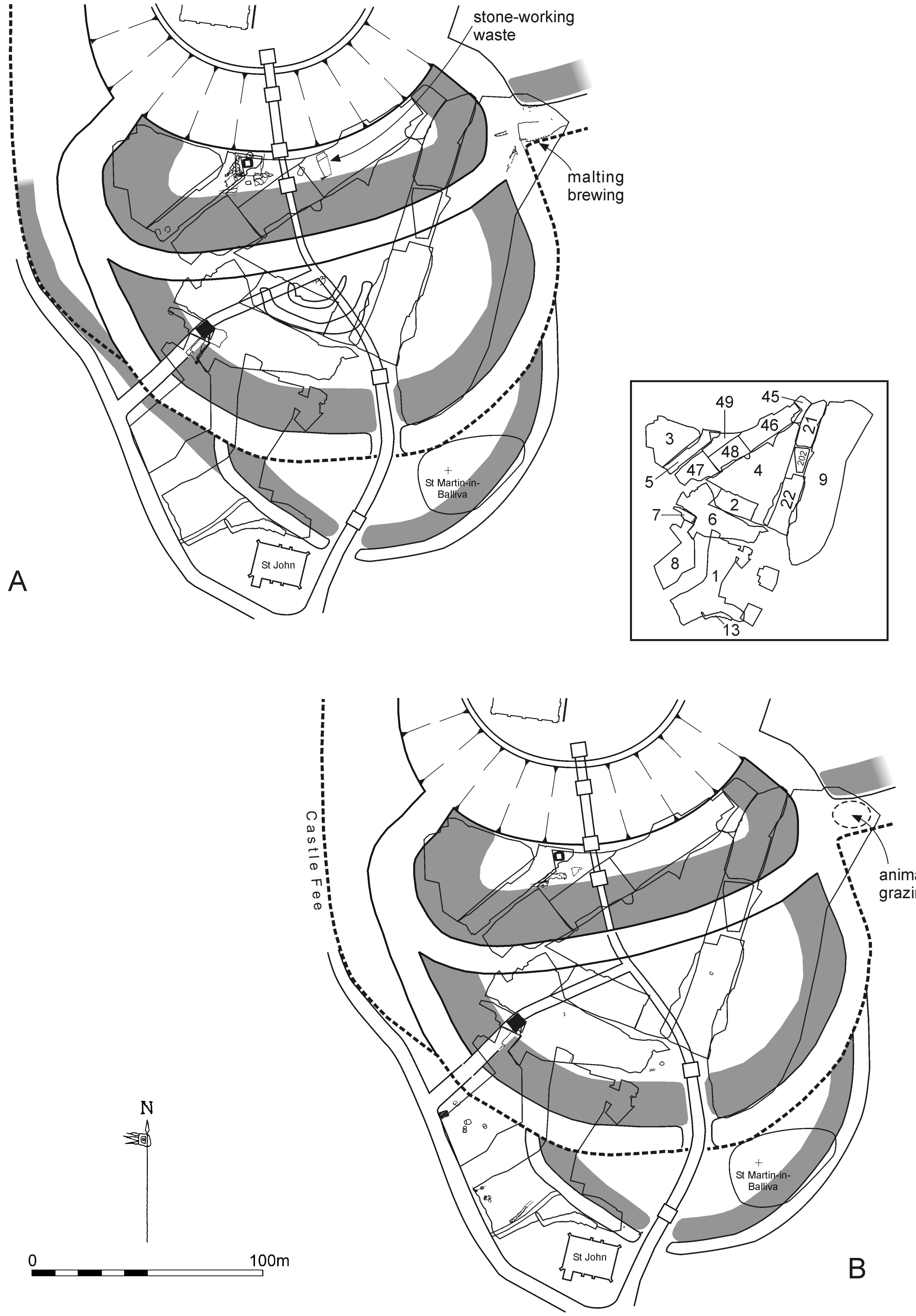


Figure 6 Location of Norman craft activities and associated waste: A=Period 3.1 (12th century); B=Period 3.2 (12th century). Scale 1:2500

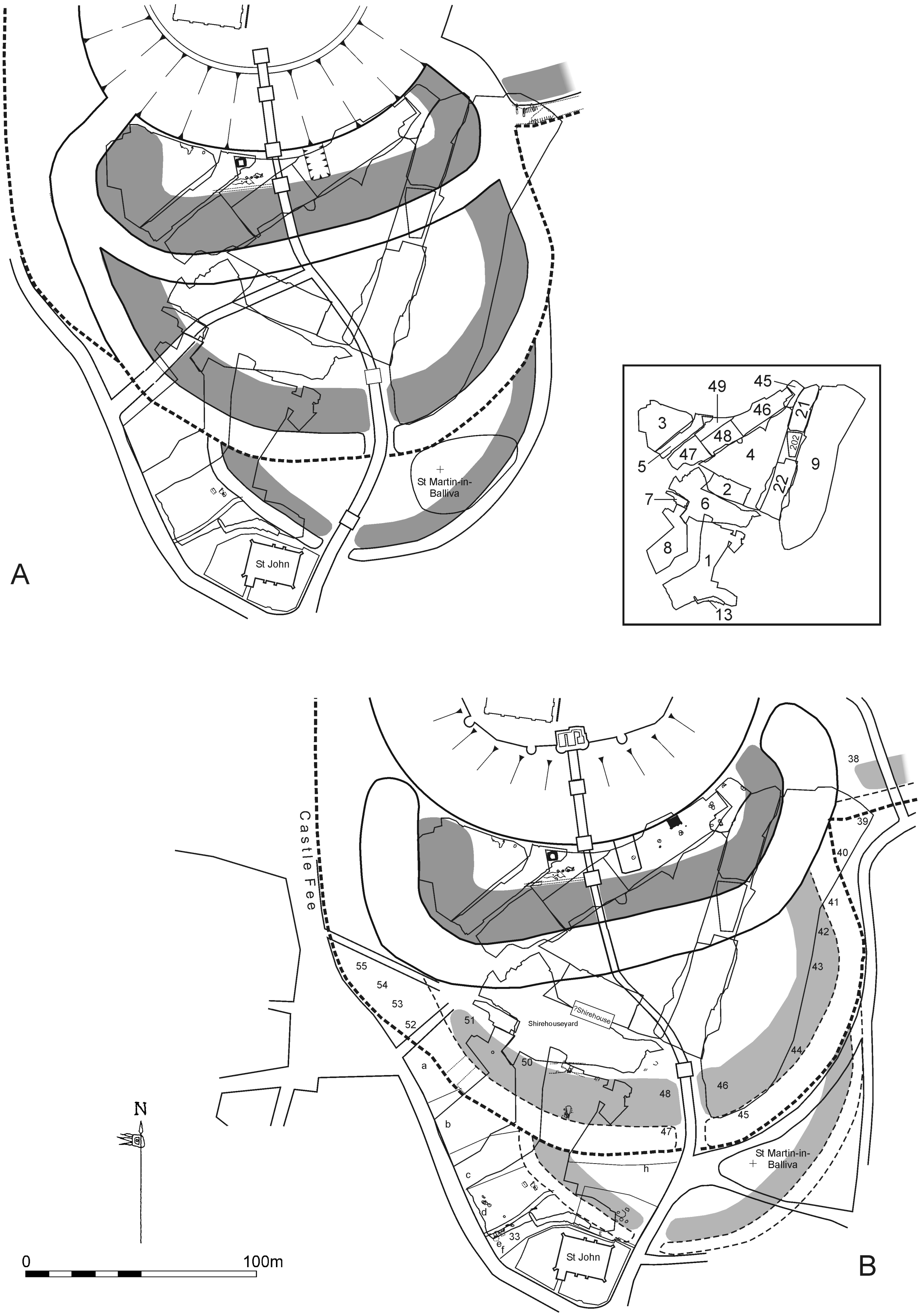


Figure 7 Location of medieval craft activities and associated waste: A=Period 4.1 (late 12th to 13th century); B=Period 4.2 (13th century to *c*.1345). Scale 1:2500

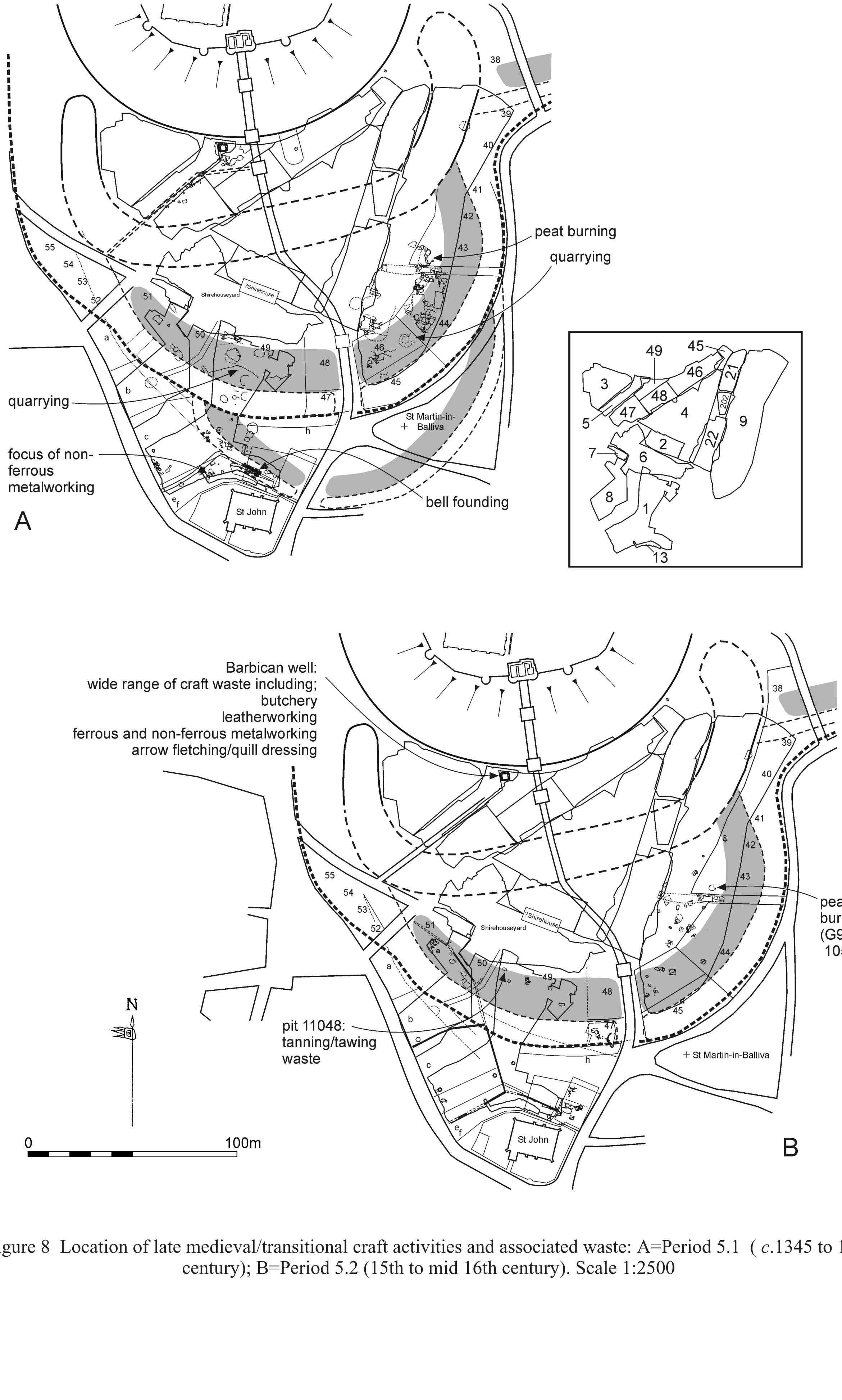


Figure 8 Location of late medieval/transitional craft activities and associated waste: A=Period 5.1 (*c*.1345 to 15th century); B=Period 5.2 (15th to mid 16th century). Scale 1:2500

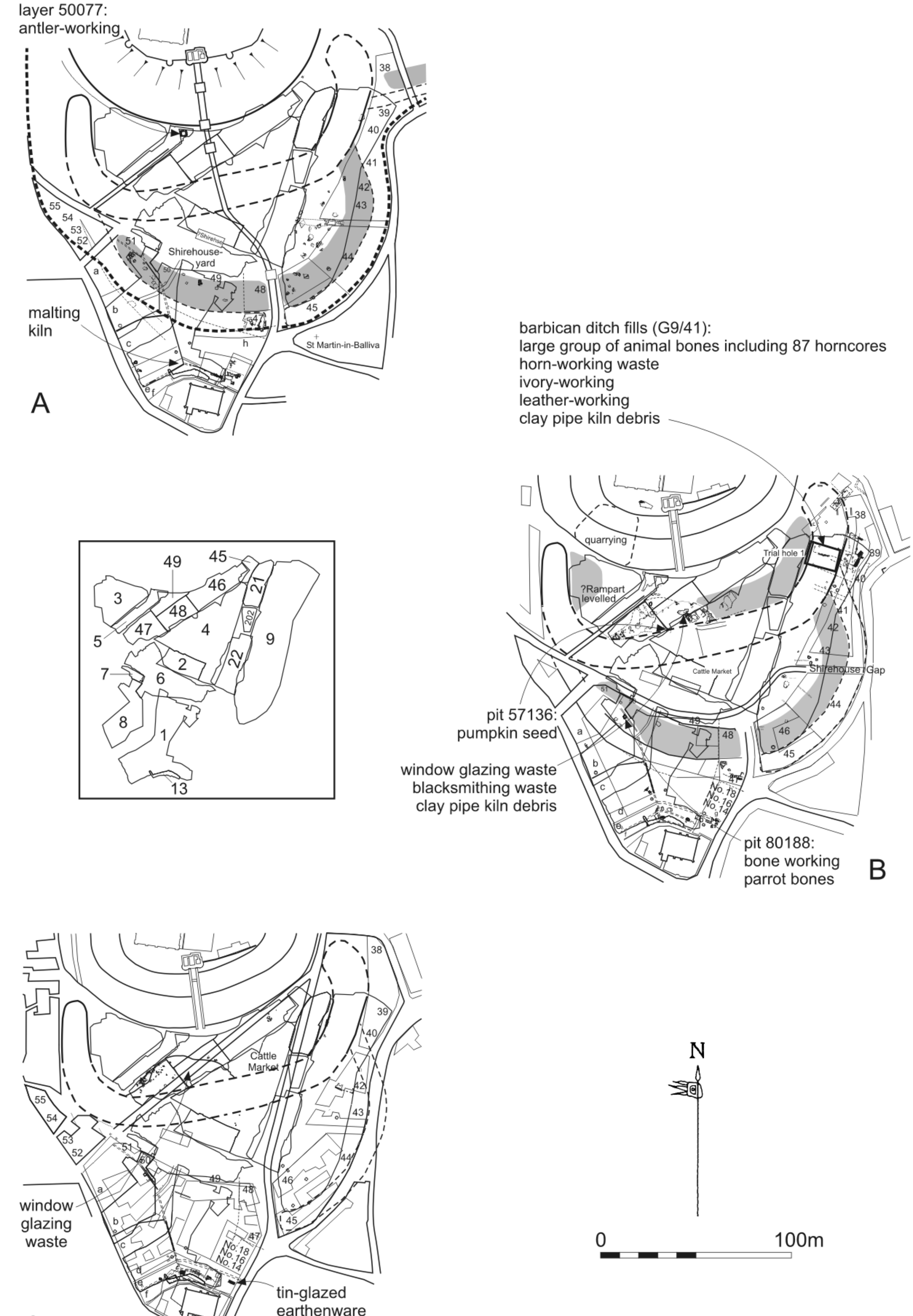


Figure 9 Location of post-medieval craft activities and associated waste: A=Period 6.1 (late 16th to mid 17th century); B=Period 6.2 (mid 17th century to *c*.1738); C=Period 6.3 (*c*.1738 to *c*.1800). Scale 1:3000

Virginia, America (Egan 1994). The city was particularly known for worsted. Other aspects of the clothing trade (such as drapers, tailors and woolmen) are well-attested.

By 1344 Norwich had become one of the largest walled towns in England, comparable in size to London (Campbell 1975, 11). The city's population may have increased to over 25,000 (Ayers 1991, 3). The burgeoning population began to create problems with rubbish disposal which were partly resolved by dumping material along the river bank as well as on a smaller scale in tenement yards. In 1349 Norwich was hit hard by the Black Death, which affected the city into the later part of the century. During the late 14th and 15th centuries the city authorities bought up shops and market stalls and controlled the sale of commodities such as meat, poultry and fish (Priestley 1987, 10–11). Industrial activities continued to flourish, although the fortunes of the textile trade fluctuated. Craftsmen continued to use the river frontage as in earlier periods and were also utilising other open spaces such as the castle baileys.

With the completion of the city walls and the transfer of the baileys to the city in 1345, the castle defences had lost their importance and were in a state of decay. A long-standing battle is evident between the authorities and people who used the castle ditches as rubbish dumps (detailed by Tillyard in Parts I and II). Documentary evidence attests to the prosecution of several individuals for illegal dumping of waste in the ditches. Cases of the illegal disposal of horse carcasses in a lane near the Shirehouse and in the castle ditches are recorded in 1391 and 1549. Evidence for sheep and horse pasturing in the castle ditches and meadows is suggested by a 1535 decree which prohibited such activities.

A great fire broke out in 1507, destroying around 40% of the city (Carter *et al.* 1985, 77). This disaster added to the economic problems that the city was already facing. Although some indications of wealth are still recognisable, a general economic malaise characterises this period. Despite economic and political problems, however, Norwich maintained its importance as a major urban centre in the region. Dutch and Walloon weavers were invited to the city in 1565 to produce draperies and textiles and the trade flourished (Ayers 1991, 6). The population continued to grow and by the 17th century Norwich was the second largest city in England. Its importance as a regional centre and as a market also increased. By the end of the 18th century the city was densely populated, although most of its population remained housed within the city walls.

Endnote

1. Documented trades within and around the Castle Fee (from the late 13th century to the modern period) are fully explored by Tillyard in the monograph (Parts I and II), with supplementary evidence in Part IV.

Chapter 3. Mammal and Bird Bone from Castle Mall (Site 777N), excluding the Barbican Well

by Umberto Albarella, Mark Beech and Jacqui Mulville

I. Summary and Objectives

The large assemblage of mammal and bird bone recovered from the Castle Mall site has been divided into six main periods that range in date from the 10th to the 18th century AD (Late Saxon to post-medieval; Table 1). The assemblage is dominated by the major domesticates, such as cattle, sheep, pig and domestic fowl. Beef was the main meat consumed in all periods, with pork making an important contribution to the diet in the early periods and mutton in the later periods. Meat supply derived from three main sources: animals bred on site; animals brought to site on the hoof and pieces of dressed carcass purchased from the market. The local breeding of cattle and sheep may have died out in post-medieval times, whereas pigs continued to be reared within the city. The practise of intramural stock rearing confirms that open areas remained available, Norwich providing a mixture of rural and urban environments.

While the majority of remains represent butchery and kitchen refuse, many are also associated with craft and industrial activities such as bone-, horn-, antler- and leather-working. Taken as a whole the bones indicate a variability in the quality of diet which is typical of urban sites. No evidence of high status could be found in Periods 2 and 3 when the castle was most active as a royal fortification. The bones do not, therefore, appear to represent the remains of royal banquets. The presence of two parrot bones in a 17th-century context points to the existence of trade with distant countries.

An increase in animal size and morphological changes are found in the post-medieval and, in some cases, the late medieval levels. These changes are related to the agricultural revolution and indicate the presence of improved breeds. A difference in the kill-off patterns in later periods attests to a change in use. Cattle, which had mainly been used for traction throughout the Middle Ages, became more important for meat production. Sheep remained extremely important for their wool, but their size increase after the 16th century suggests also an emphasis on mutton production. There is a particularly early increase in the size of domestic fowl which represents an original contribution that the Castle Mall assemblage can provide to the debate on the beginning of the agricultural revolution.

The main objectives of this report are:

1. to contribute to understanding of human activities in the area of Norwich Castle in different periods. In more general terms to see how animals contributed to the economy of Norwich, how they influenced (or were influenced by) the environment of the site, and how these relationships developed through time;
2. to contribute to understanding of more general issues, such as husbandry practices, economic development and use of the environment at a regional and national level.

A secondary but still important aim is to review how methodological approaches and problems can contribute to the improvement of zooarchaeological research in the future.

II. Methodology

Site Periods

Site periods have been outlined in Tables 1 and 2. Although Period 1 deals substantially with the Late Saxon occupation of the site, some of the contexts assigned to Period 1.4 (mid to late 11th century) may be attributable to the Norman Conquest. There is a considerable overlap in the ceramic dating of Periods 2 and 3 (late 11th/12th century), which were formulated on both historical and archaeological evidence for the two main phases of castle construction (*c.*1067–*c.*1094 and *c.*1094–*c.*1121/12th century). The constricted dating of these periods means that they were often combined in the analysis detailed below. Although further division of the periods into sub-periods was possible it was generally not adopted in this report, as the resulting bone assemblages would have been too small for meaningful analysis. The only exception is in Period 1 where a comparison between Periods 1.2–1.3 (10th to 11th centuries) and Period 1.4 (mid/late 11th century) was attempted. In addition a few specific bone deposits or individual finds could be more precisely dated than to period level.

Animal bones were found throughout all areas and periods of the site, but were more abundant in Periods 1 and 6 (see also the large assemblage of material from Period 5 detailed by Moreno García in Chapter 4). The distribution of bones across the site was very uneven and changed in different periods. Only stratified contexts which could be reliably phased have been considered. Contexts seriously affected by contamination or residuality have also been excluded.

Excavation, Sampling and Recovery

Much of the site was hand-excavated. The major earthwork features such as the castle ditches were, however, largely dug by machine, a technique which did not allow the recovery of many animal bones. The great majority of the bones from the barbican ditch derive from a trial excavation (Trial Trench 1, Fig.9.B), which was excavated by hand. Most animal bones were hand-collected, but many others derive from the large-scale sampling programme which was carried out on the site.

Samples for sieving and flotation were taken from all pre-modern 'sealed' and 'primary' deposits and from all features that could not be fully excavated due to time constraints (Shepherd 1994).

Two types of samples were taken: 'Site Riddled Samples' (SRS) and 'Bulk Samples' (BS). Site riddled samples were wet sieved through an 8.0mm mesh and provided supplementary finds to the hand retrieved material. Bulk samples were taken for flotation (0.5mm mesh) to recover smaller material, such as plant remains and snails. The sorting of the flotation residues allowed the recovery of a substantial amount of animal bones. The size of the samples was variable but normally 15–30 litres were taken for bulk samples and 150 litres for site riddled samples (Murphy and Huddle, Parts I and II, Appendix 3). More specific information is available in the project archive.

Both types of samples were a 'whole earth' sample, *i.e.* no material was extracted from the samples prior to sieving or flotation. This provided a true representation of all the species present and therefore could be confidently used for quantification purposes, and not only to supplement the list of species from the hand-collected assemblage (see Payne 1992 for a more detailed discussion of this problem). The method of recovery of the mammal and bird bones from Castle Mall is of particular relevance to the interpretation of results such as the frequency of different taxa and the representation of body parts.

Identification

Some closely related taxa were difficult to distinguish. In such cases, separation was only attempted for parts of the skeleton for which it was thought that reliable criteria were available. It was considered that this method would preserve all the quantitative aspects of analysis, would be more reliable and less time consuming.

Caprines: it was generally possible to identify the following parts of the skeleton as either sheep or goat: dP_3, dP_4, distal humerus, distal metapodial (both fused and unfused epiphyses), distal tibia, astragalus, and calcaneus using the criteria described in Boessneck (1969), Kratochvil (1969) and Payne (1969 and 1985b). Since horncores are not necessarily present in both sexes and can be subject to different patterns of preservation, they were distinguished but not used to calculate the sheep:goat ratio.

Equids: the shape of the enamel folds (Davis 1980; Eisenmann 1981) was used for identifying equid teeth to species. Only complete or sub-complete molar rows were considered. All post-cranial bones were identified simply as 'equid'.

Galliforms: the closely related galliforms — domestic fowl, guinea fowl (*Numida meleagris*) and pheasant (*Phasianus colchicus*) — are difficult to distinguish. The presence of a spur on tarsometatarsi was considered a diagnostic character of male domestic fowl/pheasant (being absent from guinea-fowl), whereas the lack of a continuous posterior keel on the tarsometatarsus was considered a diagnostic character for distinguishing between pheasant and domestic fowl/guinea fowl. Therefore a spurred tarsometatarsus lacking the posterior continuous keel was securely identified as 'domestic fowl'. The presence or absence of an air-sac foramen on the proximal end of the femur was used to distinguish between pheasant and domestic fowl/guinea fowl. MacDonald's (1992) criteria for the scapula and carpometacarpus were used to distinguish domestic fowl/pheasant from guinea fowl.

Amphibians: all amphibian bones were identified to class level; differences in the shape of the pelvis were used to distinguish frog from toad.

Counting and Quantification

For a full description of the methods used for mammal bones see Davis (1992a). In brief, all mandibular teeth and a restricted suite of 'parts of the skeleton always recorded' (*i.e.* a predetermined set of articular ends/epiphyses and diaphyses of girdle, limb and foot bones) were recorded and used in counts. These are: scapula (glenoid articulation), distal humerus, distal radius, carpal 2–3 (or 2 or 3 according to the taxon), distal metacarpus, ischial part of the acetabulum (pelvic girdle), distal femur, distal tibia, calcaneus, astragalus, distal metatarsus, proximal end of the first phalanx, and third phalanx. In order to avoid multiple counting of very fragmented bones, at least 50% of a given part had to be present for it to be counted. Single metapodial condyles of cattle, caprines and cervids were counted as halves, as were each of the two central pig metapodia. Metapodia of carnivores and lagomorphs were counted as quarters. One skull element (the zygomatic arch) was added to the list of countable elements suggested by Davis (1992a). The radiale was not recorded.

Horncores and antlers with a complete transverse section and 'non-countable' elements of particular interest (*e.g.* belonging to rarer species, of anomalous size or with interesting butchery marks or abnormalities) were recorded, but not included in the counts. Worked bones were recorded, but included in the counts only if they included a 'countable' zone (see above). Countable worked bones were few and are thus unlikely to affect the distribution of species and body parts.

For birds the following elements were always recorded: articular end of scapula, proximal coracoid, distal humerus, proximal carpometacarpus, distal femur, distal tibiotarsus and distal tarsometatarsus. For amphibians, the following were always recorded: humerus, radius, pelvis, femur and tibia. Long bones were recorded when at least one half was present, whereas pelvis was recorded when the acetabulum was present.

Total number of fragments (NISP) and minimum number of individuals (MNI) were both calculated for the most common taxa. As the side of each element was not recorded, the MNI was simply calculated by dividing each element by its number in the body. The MNI was calculated at the 'higher level of aggregation' (Grayson 1984), *i.e.* it was calculated considering each period as a single group, rather than calculating the MNI for smaller groups, such as units, and summing them to get the total for the period.

The weight of bird bones for each context was also recorded. This was then compared to the total weight of bones by context as provided by the NAU (these data were originally collected by Rosemary Luff during assessment). Unfortunately this comparison was only possible for the hand-collected material, as the total animal bone weight of the sieved samples was not recorded either by Rosemary Luff or by the current authors. It was not intended to use the 'weight method' to assess precisely the relative importance of different taxa, but rather to compare broad taxonomic groups in a similar way as done by Davis (1991a) for the site of Closegate and as recommended by Barrett (1993).

Ageing and Sexing

The wear stage was recorded for all P_4s, dP_4s and molars of cattle, caprines and pig, both isolated teeth and those in mandibles. Tooth wear stages follow Grant (1982) for cattle and pig and Payne (1973 and 1987) for sheep/goat. Mandibles with at least two teeth in the dP_4/P_4 –M_3 row, whose wear stage was recordable, were also assigned to the mandibular wear stages of O'Connor (1988) for cattle and pig and of Payne (1973) for caprines. A complete list of the mandibular wear stages of the three main domesticates is held in the site archive.

The fusion stage of post-cranial bones was recorded for all species. An epiphysis was described as 'fusing' once spicules of bone had formed across the epiphysial plate joining the diaphysis to the epiphysis but open areas were still visible between epiphysis and diaphysis. An epiphysis was described as 'fused' when this line of fusion was closed. Bird bones with 'spongy' (*i.e.* incompletely ossified or growing) ends were recorded as 'juvenile'.

It was only possible to separate the sexes using morphological characters in pig and domestic fowl. The size and shape of pig canines (and their alveoli) were used to distinguish boars from sows, whereas the presence or absence of a spur on the tarsometatarsus was the criterion used to distinguish cocks (and capons) from hens (exceptions can occur, so this method may not separate all male from female domestic fowl). For other taxa any attempt to detect the sexual composition of the population had to rely on metrical analysis.

Measurements

A complete list of the individual measurements taken at Castle Mall is held in the site archive, whereas a summary of the most common measurements of the main species can be found in Tables 20, 29, 38 and 43. Measurements in general follow von den Driesch (1976), but some specifications are necessary for a few cases. Cattle M_3 length and width (M_3L and M_3W) are the maximum length and width of the crown. In order to take the maximum measurement some mandibles had to be carefully prised apart in order to extract the tooth. This was also the case when taking the maximum crown widths of caprine teeth. Measurements taken on equid cheek teeth follow Davis (1987a). Pig tooth measurements follow Payne and Bull (1988) but in addition, the width of the central (*i.e.* second) pillar of M_3 was measured.

Humerus HTC and BT and Tibia Bd are, for all species, taken in the way described by Payne and Bull (1988) for pigs. Measurements on cattle and caprine metapodia follow Davis (1992a).

W_{max} and W_{min} are the largest and smallest diameters at the base of horncores and antlers. L is the dorsal distance between the base and the top of the horn-core.

Gnawing, Butchery and Burning

For all 'countable' post-cranial bones gnawing and butchery marks were recorded. They were also recorded when present on mandibles, but not used for quantitative purposes. Butchery marks were described crudely as 'chop', 'cut' and 'saw' marks. Their position was recorded only if considered particularly meaningful (*e.g.* cuts on the proximal or distal part of the metapodia), but this was not used for quantitative purposes. Gnawing marks made by carnivores and rodents were differentiated. Signs of partial digestion (see Payne and Munson 1985) were also recorded.

Burnt bones were recorded as 'singed' (only a relatively small area of the bone had been in contact with fire), 'burnt' (a substantial part of the bone was burnt and had acquired a brown/black colour), or 'calcined' (the bone had been subject to high temperature stress and had acquired a whitish colour and a 'chalky' consistency). Given the reduction in size which is generally consequent to contact with fire, 'burnt' and 'calcined' bones were not measured.

III. Preservation

(Pl. 1)

The majority of the Castle Mall bones were fragmented as a consequence of human activity, animal gnawing, trampling and combined mechanical/chemical action in the soil. However, a few complete or sub-complete articulated skeletons were found, as well as a substantial quantity of complete bones which were either untouched by fragmentation mechanisms or derived from redeposited skeletons.

The level of fragmentation varied between different periods, areas and contexts, but was difficult to assess. The level of fragmentation of a bone assemblage is generally assessed using the ratio between the number of teeth and bones or between the number of isolated teeth and mandibles. Unfortunately these ratios are particularly affected by problems such as recovery biases and disposal practices, and, especially in the case of urban excavations, can be of little use as an index of fragmentation. For instance, a very low number of isolated teeth was observed in all periods at Castle Mall. Although this is possibly connected with a relatively low rate of fragmentation, it is almost certainly a consequence of recovery bias which led to the preferential collection of larger and more visible mandible fragments.

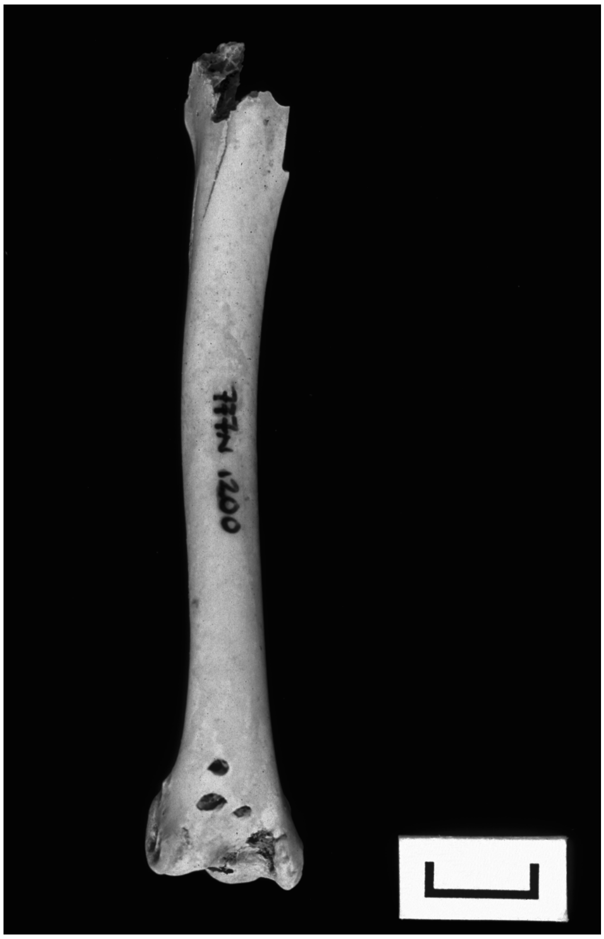


Plate 1 Duck humerus (Period 5): punctures probably caused by cat gnawing

The few articulated bones, indicating the presence of primary deposits, were found across the site in various periods (see Table 7 for a list of articulated skeletons). It is probable that most bones derive from contexts representing secondary deposits, *i.e.* they were not found at the original site of discard. This is typical of most archaeological sites and does not necessarily affect the quality of zooarchaeological information that can be obtained from the faunal assemblage. The presence of gnawing marks generally attests to the redeposition of the animal bones as a result of scavenger activity. A substantial amount of bone — ranging between 6% and 15% of the total in different periods — bore gnawing marks (Table 22). These were mainly caused by dogs, but in a few cases also by smaller carnivores (Plate 1). This total is somewhat lower than that generally found on most rural sites — see for instance Burystead and Langham Road (Davis 1992b) and West Cotton (Albarella and Davis 1994b). The lower incidence of scavenger marks on bones from urban sites may suggest more organised disposal practices in towns than in villages. In this respect it is interesting to notice that the percentage of gnawing marks at Castle Mall decreases by Period 4, possibly indicating a change of strategy in the organisation of disposal practices.

Only slight variations in the incidence of gnawing marks on different species were noted. This is somewhat surprising as it is expected that dogs would more commonly chew bones of a relatively small size, such as sheep or pig bones. However, smaller bones could also be more easily destroyed and therefore become 'invisible' in the archaeological assemblage (the recording system used only takes into account bones which still bear an articular end).

Very few bones were burnt: no more than 4% in any period. It is interesting to note that the lowest percentage of burnt bones (1%) was found in the post-medieval period, perhaps suggesting that a larger proportion of the material deriving from this phase was of non-domestic origin.

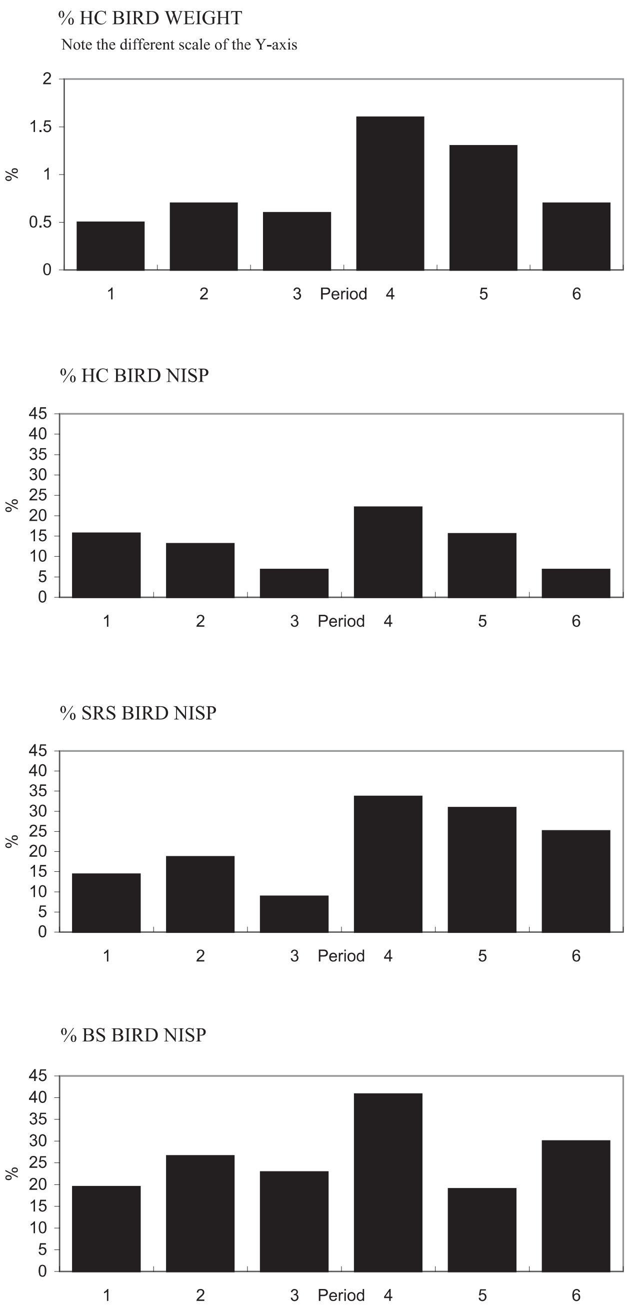


Figure 10 Comparison of relative % of bird weight and bird NISP for hand-collected (HC) and sieved (SRS + BS) bone by period. Percentages are calculated from total weight and NISP of all elements

IV. Occurrence and Relative Importance of Different Animals

(Figs 10–15, Tables 3–14)

The Castle Mall animal bone assemblage, like most other medieval sites in Britain, is dominated in all periods by the main domestic livestock — cattle, sheep, pig and domestic fowl. However, a variety of other mammals and birds was also found at the site (Tables 3–6). Some of these taxa may not have an anthropogenic origin, and certainly not all of them represent food animals. Nevertheless, it is obvious that most of the animals were associated with people and certainly the bulk of the bones originate from animals which were eaten.

Mammals Versus Birds

The relative percentage and importance of mammals and birds is strongly affected by differential recovery and taphonomic biases and is therefore difficult to assess. This comparison becomes easier to tackle when it is seen in relative terms by comparing different periods. Thus rather than trying to establish the exact proportion of mammals and birds in each period, variation over time will be investigated.

In Fig.10 the relative weight and number of bird fragments are compared. Due to their small size and low weight bird bones represent only a very small percentage of the total bone weight. The percentage of bird fragments (NISP) is much higher, especially for the material recovered from sieving where there was a better recovery rate of smaller material. Little difference was noted in the bird and mammal ratios between the SRS and BS sieving: for bird bones the sorting of the flotation residues (BS) did not result in a more efficient recovery than the coarse sieving (SRS).

All quantification systems indicate that there is no dramatic variation in the frequency of birds in different periods. The highest number of birds is found in Period 4 (medieval) and after this period the frequency of birds started to decline again. In general there are more birds present in the mid- to post-medieval periods than in the Saxo-Norman period.

Taxa	*Period*					
	1	*2*	*3*	*4*	*5*	*6*
Cattle (*Bos taurus*)	HSB	HSB	HSB	HSB	HSB	HSB
Sheep/goat (*Ovis/Capra*)	HSB	HSB	HSB	HSB	HSB	HSB
sheep (Ovis aries)	HSB	HSB	HSB	HSB	HSB	HSB
goat (Capra hircus)	H	HSB	H		H	H
Pig (*Sus domesticus*)	HSB	HSB	HSB	HSB	HSB	HSB
Equid (*Equus* sp.)	HS	HSB	HS	H	H	HS
Dog (*Canis familiaris*)	H B	HSB	HS	HS	HS	HS
Dog/fox (*Canis/Vulpes*)	B					
Cat (*Felis catus*)	HSB	HSB	HSB	HSB	HSB	HS
Red deer (*Cervus elaphus*)	H	H	H	HS	H	H
Fallow deer (*Dama dama*)	H		H			H
Roe deer (*Capreolus capreolus*)	H	H				
Badger (*Meles meles*)			B			
Hare (*Lepus* sp.)	SB	H		HS	HS	HS
Rabbit (*Oryctolagus cuniculus*)	H			H	HSB	HSB
Lagomorph				H		
Rat (*Rattus* sp.)		B	S	HS	S	
Rat/water vole (*Rattus/Arvicola*)	H					
House mouse (*Mus musculus*)			B			
House/wood mouse (*Apodemus/Mus*)	B	B		B	B	
Field vole (*Microtus arvalis*)	B					
Domestic fowl (*Gallus gallus*)	HSB	HSB	HSB	HSB	HSB	HSB
Goose (*Anser anser*)	HSB	H B	H	HSB	HSB	HSB
Duck (*Anas* sp.)	H B	HS	H	HSB	HSB	HS
Turkey (*Meleagris gallopavo*)					H	H
Little Grebe (*tachybaptus ruficollis*)					H	
Cormorant (*Phalacrocorax carbo*)						H
Grey heron? (*Ardea ?cinerea*)		H				
Swan (*Cygnus* sp.)		H			H	
Teal/Garganey (*Anas crecca/querquedula*)		S	B	H		
Pochard/Tufted duck (*Aythya ferina/fuligula*)					H	
Buzzard (*Buteo buteo*)	B					
Goshawk (*Accipiter gentilis*)	H					
Grey partridge (*Perdix perdix*)				H	B	H
Coot (*Fulica atra*)					HS	
Moorhen (*Gallinula chloropus*)						H
Woodcock (*Scolopax rusticola*)						S
Curlew (*Numenius arquata*)				S		
Snipe (*Gallinago gallinago*)						S
Crane? (*?Grus grus*)					H	
Small wader		B				
?Black headed gull (*Larus ?ridibundus*)						H
Pigeon (*Columba* sp.)	H	HS			S	H
Parrot (*Psitaccinae*)						H
Rook/Crow (*Corvus frugilegus/corone*)					H	H
Small corvid	H		S	H		H
Turdid		SB				
Passeriform			H			S
Bird	B				H	HS
Amphibian	HSB	H B			SB	HSB
Toad (Bufo bufo)	B					

Taxa present in hand collected material are denoted as ‘H’, that in SRS sieved material as ‘S’ and that in BS sieved material as ‘B’

Table 3 Presence of mammal, bird and amphibian taxa in all levels

Taxa	*Period*						
	1	*2*	*3*	*4*	*5*	*6*	***total***
Cattle (*Bos taurus)*	540.5	374	71.5	170.5	312.5	676.5	2145.5
Sheep/goat (*Ovis/Capra)*	236	165	42.5	133	477**	530.5	1584
(sheep)	(51)	(44)	(12)	(11)	(193)	(135)	446)
(sheep ?)	-	-	-	-	-	(2)	(2)
(goat)	*(9)	(2)	(+)	-	(1)	(1)	13)
(goat ?)	-	(1)	-	-	-	(2)	(3)
Pig (*Sus domesticus)*	*276.5	181	34.5	61.5	*121.5	*148.5	823.5
Equid (*Equus* sp.)	*43.5	27.5	6	5.5	1.5	161.5	245.5
Dog (*Canis familiaris*)	*51.5	*67	7.5	10.5	*10	*82.5	229
Cat (*Felis catus)*	*73	*40.5	3	*25.5	*35	84	261
Red deer (*Cervus elaphus)*	+	+	+	+	+	+	+
Fallow deer (*Dama dama*)	1	-	-	1	-	1	3
Roe deer (*Capreolus capreolus)*	1.5	3	-	-	-	-	4.5
Hare (*Lepus* sp.)	-	1.5	-	1.5	3	1	7
Rabbit (*Oryctolagus cuniculus)*	4.5	-	-	4.5	22.5	*16.5	48
Lagomorph ?	-	-	-	1	-	-	1
Rat (*Rattus* sp.)	-	-	-	1	-	-	1
Rat/water vole (*Rattus/Arvicola*)	1	-	-	-	-	-	1
Domestic fowl (*Gallus gallus*)	*191	93	6	*83	*119	*82	574
Goose (*Anser anser*)	22	26	4	18	48	25	143
Duck (*Anas* sp.)	9	8	1	3	9	9	39
Turkey (*Meleagris gallopavo*)	-	-	-	-	1	1	2
Little Grebe (*tachybaptus ruficollis*)	-	-	-	-	1	-	1
Cormorant (*Phalacrocorax carbo*)	-	-	-	-	-	1	1
Grey heron? (*Ardea ?cinerea*)	-	1	-	-	-	-	1
Swan (*Cygnus* sp.)	-	1	-	-	1	-	2
Teal/Garganey (*Anas crecca/querquedula)*	-	-	-	1	-	-	1
Pochard/Tufted duck (*Aythya ferina/fuligula*)	-	-	-	-	+	-	+
Goshawk (*Accipiter gentilis)*	4	-	-	-	-	-	4
Grey partridge (*Perdix perdix*)	-	-	-	1	-	+	1
Coot (*Fulica atra*)	-	-	-	-	1	-	1
Moorhen (*Gallinula chloropus*)	-	-	-	-	-	1	1
Crane? (*?Grus grus*)	-	-	-	-	+		+
?Black headed gull (*Larus ?ridibundus*)	-	-	-	-	-	+	+
Parrot *(Psitaccinae)*	-	-	-	-	-	2	2
Pigeon (*Columba* sp.)	2	1	-	-	-	1	4
Rook/Crow (*Corvus frugilegus/corone*)	-	-	-	-	1	1	2
Small corvid	1	-	-	*12	-	1	14
Passeriform	-	-	1	-	-	-	1
Bird	-	-	-	-	1	3	4
Amphibian	3	1	-	-	-	+	4
total	**1461**	**990.5**	**177**	**533.5**	**1165**	**1829**	**6156**

Sheep/Goat also includes the specimens identified to species. Cases where only 'non-countable' bones were present are denoted by a '+'. Pig metapodia and ruminant half distal metapodia have been divided by two, while carnivore and lagomorph metapodia have been divided by four. Due to the difficulty in distinguishing between upper and lower incisors in equids and upper and lower canines in carnivores, all have been recorded and then divided by two. All totals which include material from partial skeletons are denoted by '*'. This material is described in further detail in Table 7. ** = This figure includes a 'special' group of 169 sheep metapodia and phalanges.

Table 4 Numbers of hand collected mammal, bird and amphibian bones and teeth (NISP) in all levels at Castle Mall (excluding the barbican well)

Taxa	*Period*						
	1	*2*	*3*	*4*	*5*	*6*	***total***
Cattle (*Bos taurus)*	37	28.5	4	20.5	41	36	167
Sheep/goat (*Ovis/Capra)*	29.5	21.5	6	45.5	41.5	25.5	169.5
(sheep)	(6)	(5)	(1)	(13)	(4)	(1)	30)
(goat)	-	+	-	-	-	-	(+)
Pig (*Sus domesticus)*	48	42.5	7	21	18	18.5	155
Equid (*Equus* sp.)	2	2	1	-	-	2	7
Dog (*Canis familiaris*)	-	3	1	7.5	4	2.5	18
Cat (*Felis catus)*	*6	2.5	0.5	*14	0.5	4.5	28
Red deer (*Cervus elaphus)*	-	-	-	+	-	-	+
Hare (*Lepus* sp.)	1	-	-	0.5	4.5	0.5	6.5
Rabbit (*Oryctolagus cuniculus)*	-	-	-	-	7	*11	18
Rat (*Rattus* sp.)	-	-	1	1	1	-	3
Domestic fowl (*Gallus gallus*)	20	19	1	44	38	21	143
Goose (*Anser anser*)	1	-	-	10	11	1	23
Duck (*Anas* sp.)	-	1	-	1	2	7	11
Teal/Garganey (*Anas crecca/querquedula)*	-	1	-	-	-	-	1
Coot (*Fulica atra*)	-	-	-	-	1	-	1
Woodcock *(Scolopax rusticola)*	-	-	-	-	-	1	1
Curlew *(Numenius arquata)*	-	-	-	1	-	-	1
Snipe *(Gallinago gallinago)*	-	-	-	-	-	1	1
Pigeon (*Columba* sp.)	-	1	-	-	1	-	2
Small corvid	-	-	1	-	-	-	1
Turdid	-	1	-	-	-	-	1
Passeriform	-	-	-	-	-	1	1
Bird	-	-	-	-	-	2	2
Amphibian	1	-	-	-	1	1	3
total	**145.5**	**123**	**22.5**	**166**	**171.5**	**135.5**	**764**

Table 5 Numbers of SRS (soil riddled samples) sieved mammal, bird and amphibian bones and teeth (NISP) in all levels at Castle Mall (excluding the barbican well)

Taxa	*Period*						
	1	*2*	*3*	*4*	*5*	*6*	***total***
Cattle (*Bos taurus)*	41.5	11	6	8	11.5	6	84
Sheep/goat (*Ovis/Capra)*	35.5	22	13.5	15	43	5.5	134.5
(sheep)	(4)	(5)	(4)	(3)	(5)	-	21)
(goat ?)	-	(1)	-	-	-	-	1)
Pig (*Sus domesticus)*	49.5	27.5	4.5	5	15	5.5	107
Equid (*Equus* sp.)	-	1	-	-	-	-	1
Dog (*Canis familiaris*)	3.5	6	-	-	-	-	9.5
Cat (*Felis catus)*	*23	2.5	1	1.5	*10.5	-	38.5
Badger *(Meles meles)*	-	-	1	-	-	-	1
Hare (*Lepus* sp.)	0.5	-	-	-	-	-	0.5
Rabbit (*Oryctolagus cuniculus)*	-	-	-	-	12	3	15
Rat (*Rattus* sp.)	-	5	-	-	-	-	5
House mouse *(Mus musculus)*	-	-	1	-	-	-	1
House/Wood mouse *(Apodemus/Mus)*	2	1	-	1	1	-	5
Field vole *(Microtus arvalis)*	2	-	-	-	-	-	2
Domestic fowl (*Gallus gallus*)	*34	25	7	19	19	8	112
Goose (*Anser anser*)	2	2	-	1	1	1	7
Duck (*Anas* sp.)	1	-	-	1	1	-	3
Teal/Garganey (*Anas crecca/querquedula)*	-	-	1	-	-	-	1
Buzzard *(Buteo buteo)*	4	-	-	-	-	-	4
Grey partridge (*Perdix perdix*)	-	-	-	-	1	-	1
Small wader	-	1	-	-	-	-	1
Tirdid	-	1	-	-	-	-	1
Bird	2	-	-	-	-	-	2
Amphibian	15	4	-	-	1	1	21
(toad)	(1)	-	-	-	-	-	1)
total	**219.5**	**109**	**35**	**51.5**	**116**	**30**	**561**

In Tables 5 and 6, all samples are 'whole earth' (see text for an explanation). Sheep/Goat also includes the specimens identified to species. Cases where only 'non- countable' bones were present are denoted by a '+'. Pig metapodia and ruminant half distal metapodia have been divided by two, while carnivore and lagomorph metapodia have been divided by four. Due to the difficulty in distinguishing between upper and lower incisors in equids and upper and lower canines in carnivores, all have been recorded and then divided by two. All totals which include material from partial skeletons are denoted by '*'. This material is described in further detail in Table 7

Table 6 Numbers of BS (bulk samples) sieved mammal, bird and amphibian bones and teeth (NISP) in all levels at Castle Mall (excluding the barbican well)

Period	*Area/Group*	*Context*	*Related feature*	*Collection method*	*Species*	*Notes*
1.2	9/109	90469	pit 90504	BS sieve	cat	16.5 bones
1.2	9/109	90398	pit 90504	hand	dom. fowl	12 bones
1.2	9/109	90366	pit 90389	hand	pig	3 bones
1.2	22/138	22023	pit 22015	hand	goat	10 bones + teeth
1.2	22/145	22110	pit 22111	hand	cat	13 bones + teeth
1.3	9/109	90354	pit 90516	hand	horse (juvenile)	10 bones
1.3	9/109	90354	pit 90516	SRS sieve	cat	4.5 bones
1.3	9/109	90491	pit 90516	hand	goshawk	4 bones
1.3	9/109	90501	pit 90516	hand	dog	13.5 bones
1.3	9/109	90506	pit 90516	hand	horse (juvenile)	6 bones
1.3	9/109	90506	pit 90516	hand	cat	18 bones + teeth
1.4 (1.3)	9/63	90227	pit 90292	hand	dog	5 bones
1.4	2/11	40002	pit 40003	BS sieve	dom. fowl	5 bones
1.4	2/11	40047	pit 40003	hand	pig	13 bones
2.1	2/5	20168	pit 20167	hand	cat	15 bones
2.1 (1.2)	2/7	40319	pit 40320	hand	dog	16.5 bones + teeth
2.1 (1.4)	5/47	49192	pit 49193	hand	cat	25 bones
2.2	2/2	20152	ditch 20129	hand	dog	14 bones
2.2	2/2	20163	ditch 20129	hand	dog	17.5 bones
2.2	2/4	40185	ditch 40285	hand	cat	5 bones
4.1	8/16	80268	ditch 80301	hand	cat	4.5 bones
4.2	2/28	40416	ditch 40928	SRS sieve	cat	8 bones
4.2	8/28	80112	pit 80113	hand	dom. fowl	7 bones
4.2	45/1	45183	pit 45196	hand	dom. fowl	13 bones
4.2	45/1	45183	pit 45196	hand	small corvid	11 bones
5.1	1/97	10976	pit 10899	hand	cat	20 bones
5.1	1/97	10976	pit 10899	BS sieve	cat	4.5 bones
5.1	9/61	90765	pit 90766	hand	dom. fowl	10 bones
5.2	9/73	90171	pit 90261	hand	pig	6 bones
5.2	9/94	92716	pit 92715	hand	dog	5 bones
6.1	1/87	10023	dog burial	hand	dog	10.5 bones + teeth
6.1	1/98	10521	pit 10766	hand	dog	3 bones
6.1	1/98	10850	dump	hand	dom. fowl	4 bones
6.2	1/103	10095	pit 10463	SRS sieve	rabbit	6 bones
6.2	9/41	91387	barbican ditch 91295	hand	pig	3 bones

The number of bones and teeth given in the notes are the number of countable specimens from each skeleton (see also Tables 2–4). Bracketed periods indicate contexts which have been rephased (bracketed nos indicating previous phasing)

Table 7 Catalogue of partial skeletons found within all periods

This difference is not a result of better recovery as it is also observed in the sieved material. There is no evidence that taphonomic factors lead to a better preservation in Period 4 or that the bird bones came from one or two specific deposits which could be the consequence of specialised activities. Thus it appears that a slight, but genuine, increase in the economic importance of birds occurred in Period 4.

Comparison Between Quantification and Recovery Systems

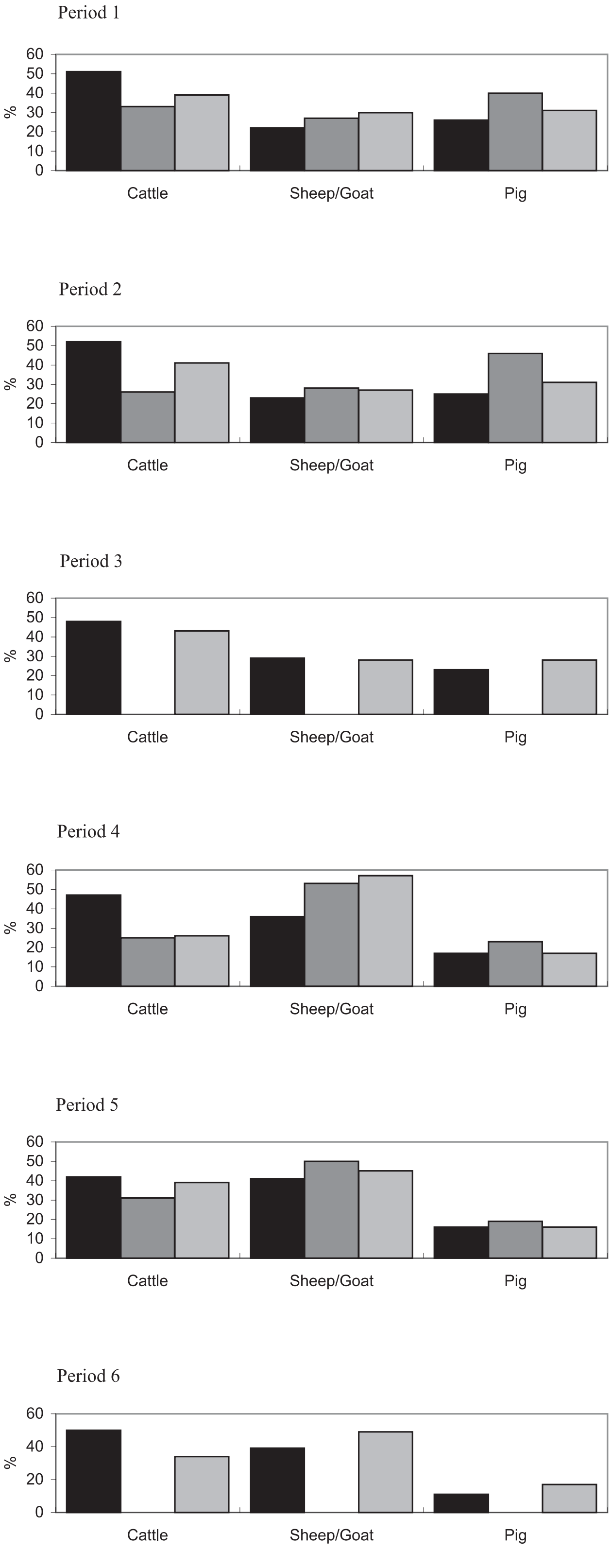
When the frequency of the main mammal taxa was compared, different quantification methods gave different results (Tables 8 and 9; Fig.11). Cattle were consistently better represented in the NISP count of hand-collected specimens, whereas sheep/goat and pig were more frequent when the NISP for sieved material or the MNI counts were applied. The only minor exception is represented by Period 3 and this is almost certainly a consequence of small sample bias. Among the birds, goose was slightly over-represented in the hand-collected material (Table 10).

MNI is less affected by taphonomic and recovery biases than NISP and therefore provides results which are similar to those obtained from the sieved assemblage. A good way to quantify the frequency of different taxa would be to calculate the MNI for the sieved material. Unfortunately MNI can be reliably applied only to large samples, and this is generally not the case for the sieved assemblages from Castle Mall.

The different biases that affect the three different quantification systems at Castle Mall can be summarised as:

1. *NISP hand collected*: severely affected by recovery and taphonomic biases
2. *NISP sieved*: still partly affected by taphonomic biases and less reliable due to smaller and selective samples
3. *MNI*: not applicable to small assemblages; it may count body portions rather than individuals.

One possible solution to these problems is to calculate correction factors from the NISP sieved material to apply



Percentages were only calculated if the combined total of the three main species exceeded 100 for NISP and 20 for MNI
black bars = NISP (HC)
grey bars = NISP (SRS+BS)
light grey bars = MNI

Figure 11 Comparison of hand collected, sieved NISP and MNI for major species (all periods)

to the NISP hand collected material, successfully accomplished by some authors (*e.g.* Watson 1983). However, to carry out such a correction it is important that there are no substantial lateral variations in the distribution of the main taxa. Due to differential sampling at Castle Mall, the sieved material does not have the same spatial distribution as the hand-collected material. Therefore, lateral variation in the distribution of the bones would imply that the hand-collected and the sieved assemblages are not entirely comparable. To check this, the distribution of the main taxa in Period 1 was investigated and statistically significant differences between areas were identified. Thus a correction factor from sieved material could not be applied (see below for a more detailed discussion of lateral variation). It can therefore only be concluded that, as is the case for almost all bone assemblages, none of these systems provide a precise estimate of the relative frequency of the three main taxa. However, a comparison between the different quantification systems suggests that by assuming the NISP hand collected count furnishes a figure for cattle which is about 10–20% too high (this should be equally distributed between sheep/goat and pig) a realistic estimate of abundance can be reached. For birds an over-representation of goose of about 5% is probable.

The Castle Mall excavation produced a sieved bone assemblage that is much larger than that recovered from most other archaeological sites in Britain. This has been invaluable for the recovery of smaller species and in highlighting problems of recovery bias. Nevertheless, this is still insufficient to produce the best possible result from such a time-consuming recovery process. A substantial percentage of the content of *all* contexts or group of contexts should be coarse sieved to allow for the calculation of correction factors to apply to the hand-collected material. Selective sampling necessarily leads to the creation of two, non-comparable, assemblages of hand collected and sieved animal bones.

Comparison Between Different Periods

Although there are problems in combining information from different areas and types of context an attempt to compare the frequency of the main mammals and birds between different periods was undertaken. Only a few contexts clearly contained bone deposits which were different from the normal mixture of butchery, food and work refuse found in most urban medieval sites. Only one of these 'special' assemblages — a pit full of sheep horncores, metapodia and phalanges from Period 5 — was large enough to severely bias the analysis of taxon frequency, and it was excluded from this comparison.

Another consideration was the possibility that variation in the recovery rate of hand collected bones had occurred between different periods. This could affect the relative frequency of species and thus create artificial differences between periods. The problem was tackled by calculating the relative number of small elements (incisors and astragali) within each period (Table 11). Although the small elements were heavily underrepresented no major changes could be noted between different periods. Thus it can be assumed that roughly the same recovery bias affects the hand collected assemblage in all periods and that no large differences in the frequency of the species due to differential recovery occur as a result. Although not the most numerically frequent species (Tables 8 and 9;

Period	*1*		*2*		*3*		*4*		*5*		*5**		*6*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Hand collected bones and teeth														
Cattle	541	**51**	374	**52**	71.5	**48**	171	**47**	313	**34**	313	**42**	676.5	**50**
Sheep/Goat	236	**22**	165	**23**	42.5	**29**	133	**36**	477	**52**	308	**41**	530.5	**39**
Pig	277	**26**	181	**25**	34.5	**23**	61.5	**17**	122	**13**	122	**16**	148.5	**11**
total	**1053**		**720**		**149**		**365**		**911**		**742**		**1356**	
SRS sieved bones and teeth														
Cattle	37	**32**	29		4		20.5		41	**41**			36	
Sheep/Goat	29.5	**26**	22		6		45.5		41.5	**41**			25.5	
Pig	48	**42**	43		7		21		18	**18**			18.5	
total	**115**		**93**		**17**		**87**		**101**				**80**	
BS sieved bones and teeth														
Cattle	41.5	**33**	11		6		8		11.5				6	
Sheep/Goat	35.5	**28**	22		13.5		15		43				5.5	
Pig	49.5	**39**	28		4.5		5		15				5.5	
total	**127**		**61**		**24**		**28**		**69.5**				**17**	
SRS + BS sieved bones and teeth														
Cattle	78.5	**33**	40	**26**	10		28.5	**25**	52.5	**31**			42	
Sheep/Goat	65	**27**	44	**28**	19.5		60.5	**53**	84.5	**50**			31	
Pig	97.5	**40**	70	**46**	11.5		26	**23**	33	**19**			24	
total	**241**		**153**		**41**		**115**		**170**				**97**	

* = in this count a 'special' group of sheep metapodia and phalanges (context 11030) has been excluded

Table 8 Numbers and percentages (NISP) of cattle, sheep/goat and pig within all periods. Percentages are only calculated where the total number of fragments is greater than 100 within a particular period

Period	*1*		*2*		*3*	*4*	*5*		*5**		*6*	
	MNI	*%*	*MNI*	*%*	*MNI*	*MNI*	*MNI*	*%*	*MNI*	*%*	*MNI*	*%*
Cattle	28 (TI)	**39**	21 (CA)	**41**	6 (M3)	6 (PM, M3, CR, MC)	17 (MT)	**24**	17 (MT)	**39**	35 (M1/2, HU)	**34**
Sheep/Goat	21 (M1/2)	**30**	14 (TI)	**27**	4 (TI)	13 (M1/2)	47 (MT)	**66**	20 (MT)	**45**	51 (SC)	**49**
Pig	22(MC)	**31**	16 (C)	**31**	4 (C, MC)	4 (M1/2, SC, MC)	7 (M1/2)	**10**	7 (M1/2)	**16**	18 (M1/2)	**17**
total	**71**		**51**		**14**	**23**	**71**		**44**		**104**	

Percentages are only calculated where the total MNI is greater than 30 within a particular period.
Those parts of the skeleton which indicated the highest MNI are given in parentheses: C=canine, PM=deciduous and permanent premolars, $M_{1/2}$=1st/2nd permanent molars, M_3=3rd permanent molar,
CR=cranium (zygomaticus), SC=scapula, HU=humerus, MC=metacarpus, TI=tibia, CA=calcaneus, MT=metatarsus.
* = in this count a 'special' group of sheep metapodia and phalanges (context 11030) has been excluded.

Table 9 Minimum numbers of individuals (MNI) of cattle, sheep/goat and pig within all periods (hand collected only)

Period	*1*		*2*		*3*		*4*		*5*		*6*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Hand collected bones and teeth												
Domestic fowl	191	**86**	93	**73**	6		83	**80**	19	**68**	82	**71**
Goose	22	**10**	26	**20**	4		18	**17**	48	**27**	25	**22**
Duck	9	**4**	8	**7**	1		3	**3**	9	**5**	9	**8**
total	**222**		**127**		**11**		**104**		**176**		**116**	
SRS + BS sieved bones and teeth												
Domestic fowl	54	**93**	44		8		63	**83**	57	**79**	29	
Goose	3	**5**	2				11	**15**	12	**17**	2	
Duck	1	**2**	1				2	**3**	3	**4**	7	
total	**58**		**47**		**8**		**76**		**72**		**38**	

Table 10 Number and percentages (NISP) of the main bird taxa within all periods. Percentages are only calculated where the total number of fragments is greater than 50 within a particular period

Fig.11), cattle, due to their large size, must have provided the bulk of meat in most periods at Castle Mall. Whilst the frequency of cattle remained stable throughout the Castle Mall chronological sequence, in the later periods sheep became more common at the expense of pig.

Although many varied factors are affecting these percentages, they still demonstrate an interesting trend. Despite possible differences in preservation, in the use of the archaeological features and in disposal practices between different periods, the change in the frequency of the main domestic mammals reflects the results of previous research. Several authors have noted a countrywide trend (*e.g.* Grant 1988, Albarella and Davis 1996) for a high frequency of pigs in early medieval periods and an increase in the importance of sheep, probably connected to the rise of the wool industry, in the late Middle Ages. A decline in the number of pigs in late medieval times has been identified in another area of Norwich, at Fishergate (Jones 1994).

The presence of a large number of pig bones has been linked to high status sites (Grant 1988, Albarella and Davis 1996). Pigs are typically 'meat animals' and are thus expected to be more common on sites with a higher meat consumption. Periods 2 and 3 at Castle Mall are those associated with the most active period of castle life, and thus it is possible to speculate that the higher frequency of pigs in these periods is an indication of status. However, as will be discussed below, no other evidence of high status, either from the animal or the plant assemblages (Murphy, Parts I and II *passim*), could be found for these periods. It therefore appears more likely that the decrease in the number of pig bones in later periods is a consequence of a genuine change in the animal economy noted at a countrywide level. This question is further discussed in the section 'Comparison with other sites'.

A substantial increase in the number of pigs was noted in the later part of Period 1 (Table 12), namely in the immediately pre-conquest or early post-conquest period. This again could be interpreted as a consequence of the high status that the site acquired with the erection of the castle, but it is more probably due to some change in animal exploitation or in the use of the site which was brought about by the arrival of the Normans.

Another expected trend is a decrease in cattle, relative to horse, in late medieval and post-medieval times (Albarella and Davis 1994a). In Norfolk in particular horses increased in importance very early, already during the Middle Ages (Langdon 1986). Equids are rare in any period at Castle Mall with the remarkable exception of the latest, post-medieval Period 6 (Table 4). However, it is doubtful that this is connected with changes in the economic system. The high number of horse bones in the late fills of the castle ditches (mainly the barbican ditch) is probably the consequence of the different disposal

	Period 1		*Period 1*			
	Sub-period 1–3		*Sub-period 4*		***total***	
	n	*%*	*n*	*%*	*n*	*%*
Hand collected bones and teeth						
Cattle	421	**57**	120	**37**	541	**51**
Sheep / Goat	150	**20**	86	**27**	236	**22**
Pig	162	**22**	115	**36**	277	**26**
total	**733**		**320**		**1053**	
SRS + BS bones and teeth						
Cattle	70.5	**35**	8		78.5	**33**
Sheep / Goat	48	**24**	17		65	**27**
Pig	83	**41**	14.5		97.5	**40**
total	**202**		**39.5**		**241**	

Table 12 Period 1: numbers and percentages (NISP) of the main taxa in pre-Conquest (Period 1.1 and 1.3) and pre/post-Conquest contexts (Period 1.4)

Period	*Element*	*Cattle % MNI*	*Sheep/Goat % MNI*	*Pig % MNI*
Period 1	incisors	4%	4%	8%
	astragalus	*20%*	*9%*	*8%*
Period 2+3	incisors	4%	7%	7%
	astragalus	*24%*	*3%*	*7%*
Period 4	incisors	6%	3%	15%
	astragalus	*25%*	*10%*	-*
Period 5	incisors	5%	2%	14%
	astragalus	*9%*	*7%***	*5%*
Period 6	incisors	3%	1%	5%
	astragalus	*14%*	*6%*	*6%*
Pits (all periods)	incisors	5%	2%	11%
	astragalus	*17%*	*6%***	*10%*
Ditches (all periods)	incisors	4%	1%	7%
	astragalus	*17%*	*11%*	-***

% MNI is calculated as follows:
incisors: [MNI of incisors/ (MNI incisors + MNI premolars + MNI 1st and 2nd molars + MNI 3rd molar)] x 100
astragalus: [MNI astragalus/ (MNI femur + MNI tibia + MNI astragalus + MNI calcaneus + MNI metatarsi)] x 100
* = not calculated due to small sample size
** = a 'special' group with many sheep metatarsi has been excluded from this count
*** = no pig astragali out of 37 hind-limb bones

Table 11 Percentages of small elements in different periods practises carried out in post-medieval times. Historical evidence of the illegal disposal of horse skeletons in the castle ditches is abundant (see above and Tillyard, Part II, Chapters 8.I and 10.I). Horses are typical farm animals and are generally not common in urban sites: they were used in towns, but they were generally bred or slaughtered elsewhere. Very low frequencies of horse bones have also been noted for the other Norwich sites at Alms Lane (Cartledge 1985), St Martin-at-Palace Plain (Cartledge 1987) and Fishergate (Jones 1994).

Among the main domestic birds, domestic fowl represents by far the most common species, with goose relatively common and duck only occasionally present. A slight increase in the importance of goose was noted after Saxon times: a possible consequence of minor cultural and economic changes. Slightly higher percentages of goose bones have been found in the 10th to 12th-century levels at Fishergate (Norwich) (Jones 1994) and Thetford (Jones 1993), although this may only reflect differences in the efficiency of recovery.

Spatial Analysis

Bone assemblages within each period have so far been considered as single units. However, the possibility must be considered that variation occurs between different areas of the site and types of context. This analysis is intended to identify variations in use of different parts of the site and to assess to what extent these affect the frequency of the species in different periods.

Due to the nature of the archaeological evidence the analyses of lateral variation in animal bone distribution in terms of a comparison between different 'activity areas' could only be undertaken for Period 1. For other periods the comparison was limited to the study of the contrast between the contents of pit and ditch fills.

Period 1 covers the Late Saxon occupation of the site and possibly the very early post-conquest phase (Period 1.4). The Castle Mall area was occupied by different 'properties' which probably had both domestic and craft/industrial functions. It was not possible to compare bone assemblages from each individual 'property' as this would have resulted in a division of the assemblage into very small samples. Thus, after discussion with the post-excavation team, it was decided to group the 'properties' into four different areas: centre, north, east and west (Fig.3). The frequency of the main domestic taxa was calculated for each of these areas (Fig.12).

This comparison identified substantial differences between the areas. 'Properties' on the east part of the settlement produced a much larger number of domestic fowl bones, whereas those in the north had a larger number of pig bones. The distribution of craft activities, such as horn-working, in different areas was also investigated. Horncore and antler finds were scattered throughout the site, but were less common in the northern area (Fig.13). Antler fragments were mainly concentrated in the eastern part which produced very few horncores.

The interpretation of these differences is far from easy and should be attempted in the light of all other archaeological evidence. One possibility is that they reflect differences in food taste between different families; another is that they indicate variation in the disposal of food refuse. Wilson (1994) has pointed out that greater amounts of large bone fragments are generally present on the periphery of a settlement. In view of this observation it is possible that the eastern area, with its high number of small chicken bones, might be closer to the real centre of the site. It seems reasonable to suggest that the central part of a settlement was kept clear of the largest food and butchery refuse.

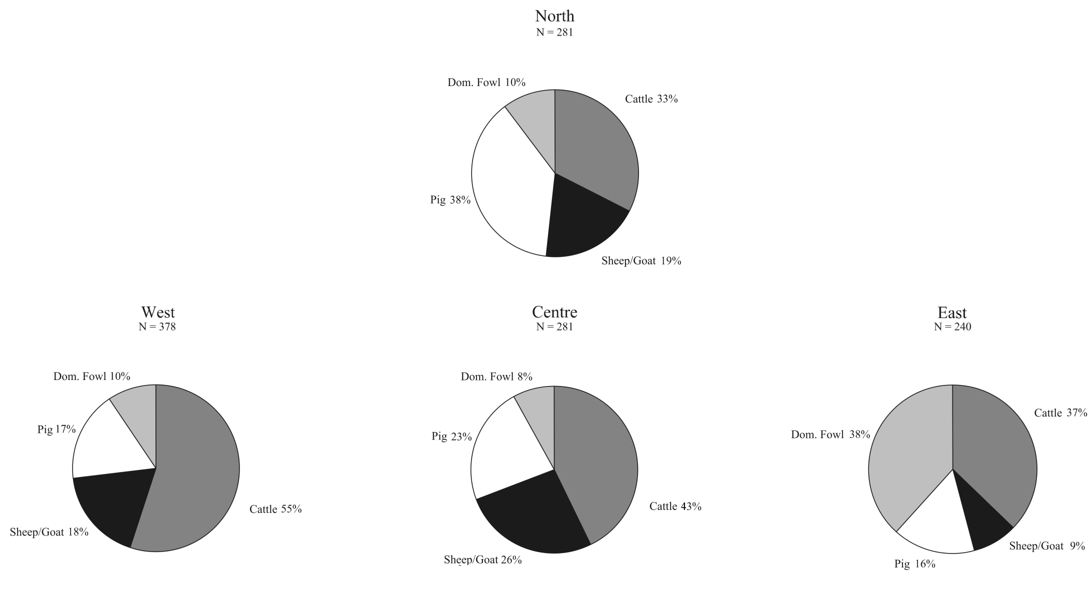


Figure 12 Relative proportion of the main species within different areas (see below) in Period 1

North: area 2 (group 19), area 4 (groups 11, 19 & 50–1, area 21 (groups 168 &170), area 45 (group 12), area 46 (groups 1, 7, 11 & 14–17), area 49 (groups 27–9, 35 & 47), area 202 (group 165), T20 (group 8), T95 (group 6)

Centre: area 2 (groups 5 & 8), area 4 (groups 5–10), area 22 (groups 130–2, 134–5, 137–8, 140, 145–8 & 154–5)

East: area 9 (groups 39, 48, 51–2, 63–4, 69, 79, 88–9, 100 & 117)

West: area 1 (groups 3, 7, 10, 41 & 141), area 5 (groups 1, 3, 10 & 64), area 6 (groups 3–4, 13–15, 17, 20 & 37), area 7 (group 4), area 8 (groups 3–6), area 47 (groups 7, 18, 21, 24 & 33)

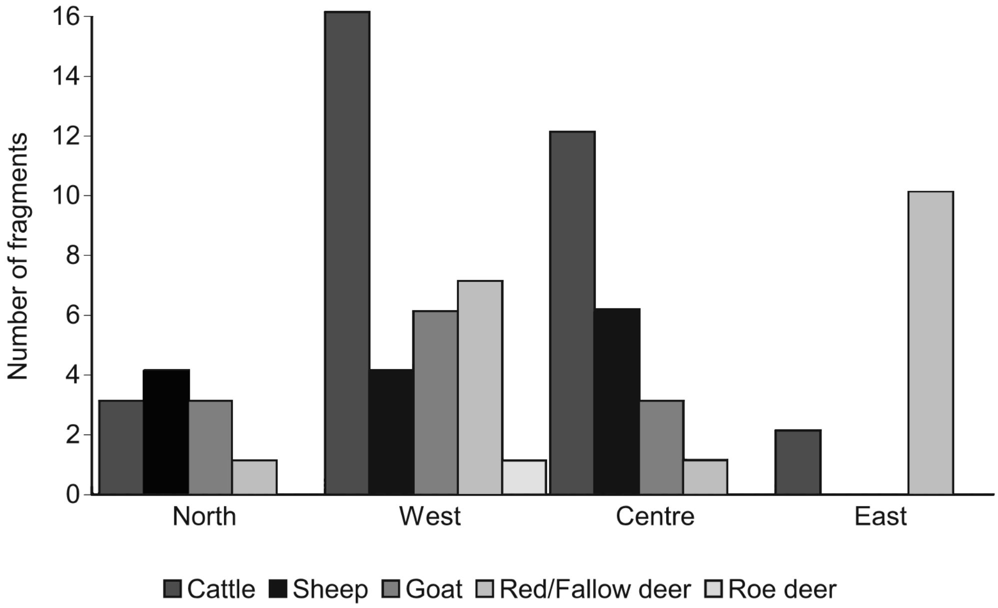


Figure 13 Distribution of horncores and antlers in Period 1 by area (see Fig. 12 for a definition of these areas)

In considering the distribution of horncores and antlers it must be emphasised that the data consists of small samples (Fig.13). However, it appears that horn and antler working was practised all over the site. The latter was mainly concentrated in the 'properties' in the east, whereas horn-working was primarily practised in the centre and northern 'properties'. It is also possible that this distribution reflects patterns of disposal rather than activity, but this appears to be a less likely explanation. In the area under analysis there is a rather high density of buildings and workers would probably dispose of their refuse either in the vicinity of their own workshop or much further afield.

Although bones were recovered from floors, external layers and other contexts, the majority of the Castle Mall animal bones derive from pit and ditch fills. The assemblages from Periods 2, 3, 4 and 6 are more or less evenly distributed between these two types of context, whereas bones from Periods 1 and 5 derive almost entirely from pits (Table 13). Differences between the distribution of bone in ditches and pits have been noted by several authors (Maltby 1985, Coy 1983, Wilson 1994). Wilson (1994) also suggested that ditches have a tendency to contain higher frequencies of the bones of larger animals (cattle and horses). If the small, and possibly misleading, assemblages are ignored this tendency is confirmed at Castle Mall (Table 13). Although the difference is not striking, cattle bones are regularly relatively scarcer in pit fills. The figure for Period 6 must be carefully considered as the percentages are affected by the high number of equid and carnivore bones presumably derived from complete bodies discarded in the barbican ditch.

The main difference between ditch and pit fills is the larger number of domestic fowl bones in the latter contexts. This is particularly evident for Period 6. The large number of chicken bones in pit fills can be associated with the possibly more 'domestic' nature of these features and with the fact that their small bones are more easily tolerated in the vicinity of domestic activities. No major differences in the recovery rate could be noted between ditch and pit fills (see Table 11).

Variation in the frequency of taxa between different types of context thus occurs but is not particularly striking and does not severely affect the interpretation of differences between periods. However a slight under-representation of cattle in Periods 1 and 5, when their bones are found mainly in pit contexts, must be taken into account. The hypothesis that the higher number of bird bones in Period 4 is due to a genuine change in diet/economy rather than the nature of the excavated deposits (see Table 13) is confirmed.

A high concentration of partial skeletons was found in a series of pits (Open Area 8, G9/109) in the eastern part of the settlement in Period 1.3 (Table 7; Fig.4.A and B) which suggests that in Late Saxon times these pits were used to dispose of carcasses. The contexts then remained undisturbed, as indicated by the presence of bones in articulation. More bones than indicated in Table 7 presumably derive from complete, rather than butchered and dismembered skeletons. This is probably the case for many of the bones found in the barbican ditch fills (Period 6, Fig.9). A substantial number of complete horse, dog and cat bones was found in these contexts. Whilst not found in articulation it is probable that these bones derive from complete skeletons discarded in the ditch and subsequently reworked. Thus the archaeological evidence suggests that the illegal disposal of animal corpses (mainly horses) continued to be practised in spite of all prohibitions.

A few contexts provided abundant evidence of craft activities. These are highlighted in Figs 5.A, 8.B and 9.A and B.

Comparison with the Barbican Well Assemblage

Although this report does not include the large assemblage from the barbican well (detailed by Moreno García below) a comparison with the material from the rest of the site is worth investigating. The barbican well was located within the castle precinct (Fig.6) and was probably built in the 12th century. Animal bones were recovered from infills dating from the mid/late15th to early 16th century (Period 5.2; Fig.8.B).

The percentage total weight of bird bones in the barbican well is substantially higher (4.3%: sieved *and* hand-collected) than the remainder of the Period 5 assemblage (1.3%: hand collected) (Fig.10). However, when the NISP count is considered the difference is not particularly evident. Bird bones represent 21% of the total number of mammal and bird fragments from the barbican well (this count includes both material hand-collected and from sieving) and between 15% and 30% (depending on which type of recovery is considered) (Fig.10) from the rest of the site in Period 5. The relatively higher weight of bird bones from the barbican well is partly the result of the inclusion of material from sieving (where a larger number of bird bones are expected) and partly due to the higher number of bones from the larger goose. The abundance of goose bones in the barbican well deposit can be attributed to the high numbers of carpometacarpi, which are probably the by-product of some industrial activity (see Moreno García below).

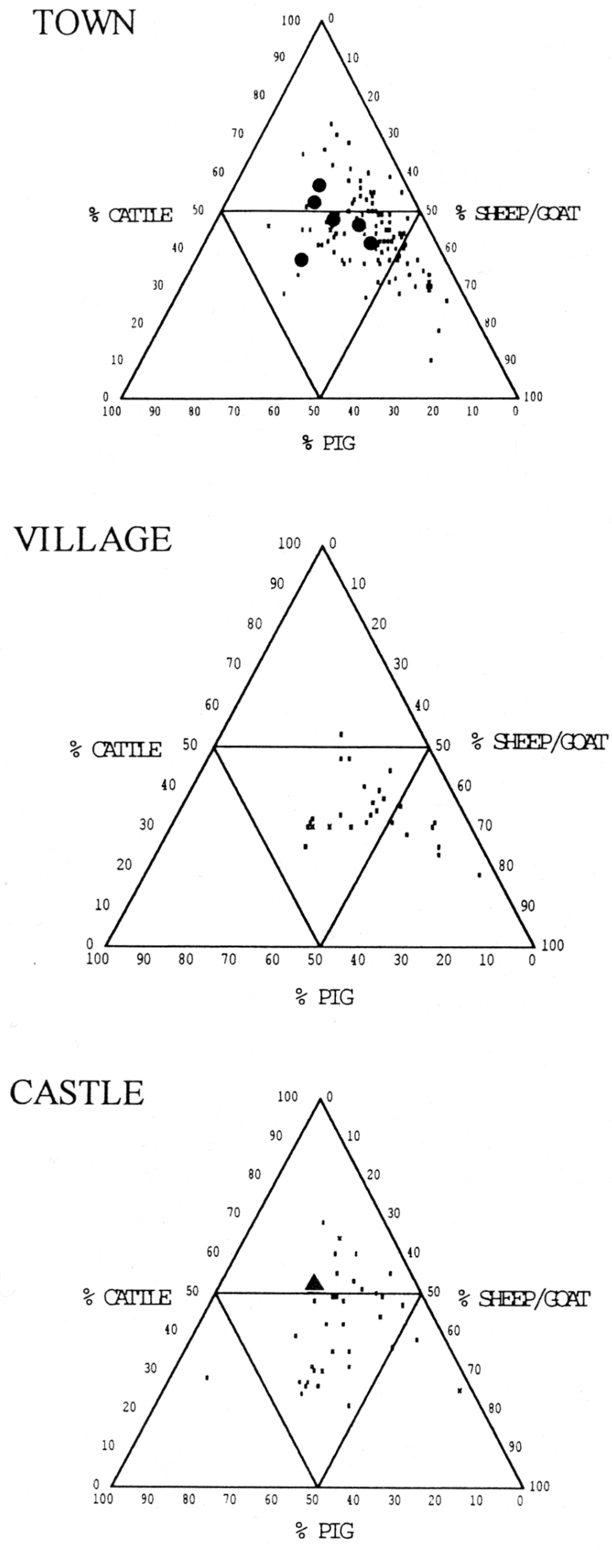
The MNI percentage of the main domestic mammals from the barbican well was compared to the rest of the site for Period 5. A larger proportion of pig bones (30% versus 16%) and a smaller proportion of cattle bones (20% versus 39%) were found in the barbican well. However, the counts were very similar when the frequency of taxa calculated through a ‘diagnostic zone’ system (hand collected + sieved material) adopted by Moreno García was compared to the current authors’ NISP (which is also a ‘diagnostic zone’ system). In general, more similarities than differences emerge from the comparison between the barbican well and the rest of the site. The minor differences can be attributed to factors such as variation in preservation, recovery or quantification methods which are of little archaeological interest. Wild species are poorly represented both in the barbican well and in the rest of the Castle Mall assemblage, however a moderate number of hare and rabbit bones were recorded from the barbican well. It is interesting to note that for the rest of the site the largest number of lagomorph bones were also found in Period 5 (see Tables 4–6).

Comparison with Other Sites

The comparison of the frequency of species between different sites is one of the most difficult tasks in zooarchaeology (King 1978; Payne 1985a; Albarella 1995b; Hambleton 1999). Differences in butchery patterns, waste disposal, preservation, excavation strategies (especially recovery) and quantification methods can severely affect the frequency of taxa and therefore the interpretation of variation between sites.

Two possible approaches can be adopted. One approach compares two assemblages, trying to take into consideration all possible biases which may have affected the frequency of species at the two sites. Once this ‘background noise’ has been eliminated, differences and similarities are interpreted on the basis of environmental and economic factors. This is the approach adopted in the comparison of the barbican well with the rest of the site (see above).

The other approach is to examine a large number of assemblages, without exploring in detail all the variables



Town: ● = Castle Mall, Periods 1.4, 1.1–3, 3, 4, 5 and 6 (left to right)
Castle: ▲ = Castle Mall, Period 2

The inner triangle assists the reading of percentages in the appropriate direction, e.g. the left outer triangle on the pig axis represents greater than 50% (as does the top triangle on the cattle axis and the bottom right triangle on the sheep/goat axis). Points located within the innermost triangle indicate sites where none of the three major species form more than 50% of the total

Figure 14 Comparison of town, village and castle zooarchaeological assemblages in England

	Period 1				Period 2				Period 3				Period 4				Period 5				Period 6			
	Ditch		Pit		Ditch		Pit		Ditch		Pit		Ditch		Pit		Ditch		Pit		Ditch		Pit	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	14	**45**	448	**37**	124	**38**	144	**35**	33	**39**	16	**53**	116	**37**	32	**27**	17	**49**	277	**28**	254	**36**	234	**37**
Sheep/Goat	10	**32**	185*	**15**	59	**18**	62	**15**	18	**21**	9	**30**	96	**31**	21	**18**	6	**17**	439	**45**	184	**26**	226	**35**
Pig	4	**13**	258*	**21**	35	**11**	88	**22**	21	**25**	3	**10**	29	**9**	19	**16**	4	**11**	105*	**11**	65*	**9**	66	**10**
Equid	2	**7**	35*	**3**	10	**3**	14	**3**	3	**4**	-	**0**	2	**1**	4	**3**	-	**0**	2	**<1**	111	**16**	13	**2**
Dog + Cat	1	**3**	129*	**11**	75*	**23**	52*	**13**	9	**11**	2	**7**	27*	**9**	8	**7**	3	**9**	53*	**5**	100	**14**	34*	**5**
Domestic fowl	-	**0**	166*	**14**	21	**7**	47	**12**	1	**1**	-	**0**	44	**14**	33*	**28**	5	**14**	98*	**10**	1	**<1**	64	**10**
total	**31**		**1221**		**324**		**407**		**85**		**30**		**314**		**117**		**35**		**974**		**715**		**637**	

Corrections for the number of metapodia (see Table 44) have not been carried out for this table. Only hand collected material is included
* These figures include bones from partial skeletons (see Table 7 for details)

Table 13 Frequencies of main taxa (NISP) in ditch and pit fills (all periods)

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
ABINGDON, STERT STREET	OX	U	MM	XIII-XIV	229	453	127	28	56	16	Wilson R. 1979
ABINGDON, STERT STREET	OX	U	LM	XV-XVI	21	48	14	25	58	16	Wilson R. 1979
ABINGDON, WEST ST.HELEN STREET	OX	U	EMMM	XII-XIII	38	41	7	44	48	8	Wilson R. 1975
ABINGDON, WEST ST.HELEN STREET	OX	U	MM	LATEXIII-EARLYXV	62	79	12	41	52	8	Wilson R. 1975
AYLESBURY	BU	U	MM	2-3 (XIII-XIV)	488	396	170	46	38	16	Jones G. 1983
BANBURY CASTLE	OX	C	EMMM	XIII-XIV	48	67	42	31	43	27	Wilson R. 1976
BANBURY CASTLE	OX	C	PM	XVII-XVIII	47	22	3	65	31	4	Wilson R. 1976
BARNARD CASTLE	DU	C	MM	5 (XIII)	959	302	2108	28	9	63	Jones R. *et al.* 1985a
BARNARD CASTLE	DU	C	LM	8 (XV-XVI)	130	150	93	35	40	25	Jones R. *et al.* 1985a
BARNARD CASTLE	DU	C	PM	10 (XVII+)	521	430	279	42	35	23	Jones R. *et al.* 1985a
BATH	AV	U	M	X-XIII	581	767	219	37	49	14	Grant 1979b
BEVERLEY, 33-35 EASTGATE	HU	U	EM	3-5 (XI-XII)	2706	3499	622	40	51	9	Scott 1992
BEVERLEY, 33-35 EASTGATE	HU	U	MM	6-12 (XIII-XIV)	3029	4558	808	36	54	10	Scott 1992
BEVERLEY, LURK LANE	HU	U	MM	7 (XIII-XIV)	1068	1339	500	37	46	17	Scott 1991
BEVERLEY, LURK LANE	HU	U	LM	8 (XV)	384	337	137	45	39	16	Scott 1991
BEVERLEY, LURK LANE	HU	U	PM	9 (XVI)	202	230	54	42	47	11	Scott 1991
BRAMBER CASTLE	WS	C	M	$	274	182	254	39	26	36	Westley 1977
BRISTOL, MARY-LE-PORT	AV	U	M	$	660	571	113	49	42	8	Noddle 1985
BURYSTEAD & LANGHAM ROAD	NN	V	M	XII-XV	181	199	79	39	43	17	Davis 1992b
CAISTER-ON-SEA	NF	U	S	MID-SAXON	305	108	77	62	22	16	Harman 1993

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
CARLISLE, BLACKFRIARS STREET	CU	U	M	XII-XVI	179	40	27	73	16	11	Rackham 1990
CARLISLE, BLACKFRIARS STREET	CU	U	PM	POSTMED.	142	86	45	52	32	16	Rackham 1990
CASTLE ACRE CASTLE	NF	C	EM	1 (LATE XI)	0	0	0	24	34	42	Lawrance 1982
CASTLE ACRE CASTLE	NF	C	EM	1cc (XI-XII)	0	0	0	49	29	22	Lawrance 1987
CASTLE ACRE CASTLE	NF	C	EM	2 (EARLY XII)	0	0	0	26	34	40	Lawrance 1982
CASTLE ACRE CASTLE	NF	C	EM	2/3 (MID XII)	0	0	0	27	34	39	Lawrance 1982
CASTLE ACRE CASTLE	NF	C	EM	3 (LATE XII)	0	0	0	27	32	41	Lawrance 1982
CASTLE LANE	NN	V	MM	XIII	455	904	123	31	61	8	Jones R. *et al.* 1985b
CHEDDAR PALACE	SO	P	EMMM	4-5 (XI-XII)	274	95	57	64	22	13	Higgs *et al.* 1979
CHEDDAR PALACE	SO	P	MMLM	6 (XIII- XVI)	118	141	34	30	36	34	Higgs *et al.* 1979
CHESTER, DOMINICAN FRIARY	CH	M	MM	XIII	331	217	182	45	30	25	Morris 1990
CHESTER, DOMINICAN FRIARY	CH	M	MMLM	XIV-XVI	210	67	184	46	15	40	Morris 1990
CHRISTCHURCH	DO	U	M	MEDIEV.	88	85	21	45	44	11	Coy 1983
CHRISTCHURCH	DO	U	PM	POSTMED.	73	75	25	42	43	14	Coy 1983
COLCHESTER, CULVER STREET 7	EX	U	EM	EARLY MEDIEV.	125	53	68	51	21	28	Luff 1993
COLCHESTER, CULVER STREET 8	EX	U	M	MEDIEV.	313	309	219	37	37	26	Luff 1993
COLCHESTER, LONG WYRE STREET	EX	U	EMMM	XI-XIV	62	38	20	52	32	16	Luff 1993
COLCHESTER, LONG WYRE STREET	EX	U	PM	XVI-XVII	34	45	13	37	49	14	Luff 1993
COLCHESTER, MIDDLEBOROUGH	EX	U	M	$	180	121	34	54	36	10	Luff 1993
COLCHESTER, MIDDLEBOROUGH	EX	U	PM	$	249	428	87	33	56	11	Luff 1993
COPT HAY	OX	V	EM	1-2	39	23	13	52	31	17	Pernetta 1974
COPT HAY	OX	V	EMMM	3-5	98	105	124	30	32	38	Pernetta 1974
DROITWICH, FRIAR STREET	HW	U	S	4ii (LATER SAXO-NORMAN)	140	103	93	42	31	27	Locker 1992
DROITWICH, FRIAR STREET	HW	U	EM	5i (XII)	257	159	110	49	30	21	Locker 1992
DROITWICH, FRIAR STREET	HW	U	MM	5ii (EARLY XIII)	90	64	48	44	32	24	Locker 1992
DROITWICH, FRIAR STREET	HW	U	MM	6 (XIII-XIV)	554	367	292	46	30	24	Locker 1992
DROITWICH, FRIAR STREET	HW	U	LM	7 (XV-XVI)	58	60	38	37	39	24	Locker 1992
DROITWICH, THE OLD BOWLING GREEN	HW	U	EMMM	XII-XIV	303	160	43	60	32	8	Locker 1992
DROITWICH, THE OLD BOWLING GREEN	HW	U	LMPM	XV-XVIII	55	53	88	28	27	45	Locker 1992
ECKWEEK	AV	V	MM	XIII-XIV	113	333	54	23	67	11	Davis 1991b
EXETER	DV	U	MM	Md5-Md9 (XIII-XIV)	2454	2871	913	39	46	15	Maltby 1979
EXETER	DV	U	LM	Md10 (XIV-XV)	112	133	37	40	47	13	Maltby 1979
EXETER	DV	U	PM	Pm1-Pm4 (XVI-XVIII)	2156	2900	608	38	51	11	Maltby 1979
FACCOMBE NETHERTON	HA	N	MM	XIII-XIV	105	127	114	30	37	33	Sadler 1990
FACCOMBE NETHERTON	HA	N	LM	XV AND LATER	616	682	754	30	33	37	Sadler 1990
GLOUCESTER, EAST GATE	GC	U	M	$	1219	942	283	50	39	12	Maltby 1983
GLOUCESTER, WEST GATE	GC	U	M	5-7	0	0	0	27	48	25	Maltby 1983
GORHAMBURY	HT	V	M	$	81	110	76	30	41	28	Locker 1990
GRENSTEIN	NF	V	M	XI-XV	130	214	78	31	51	18	Ambros 1980
ILCHESTER	SO	U	M	$	1483	1614	250	44	48	7	Levitan 1982
KING'S LYNN	NF	U	EM	1 (LATE XI-XII)	603	715	350	36	43	21	Noddle 1977
KING'S LYNN	NF	U	MM	2 (XIII-XIV)	2493	1861	764	49	36	15	Noddle 1977
KING'S LYNN	NF	U	LM	3 (XIV-XV)	674	411	209	52	32	16	Noddle 1977

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
KING'S LYNN	NF	U	PM	POSTMED. (XIV-XVIII)	895	513	195	56	32	12	Noddle 1977
KIRKSTALL ABBEY	WY	M	LM	XV-XVI	0	0	0	92	5	3	Ryder 1959
LAUNCESTON CASTLE	CO	C	MM	6 (LATE XIII)	397	427	463	31	33	36	Albarella and Davis 1996
LAUNCESTON CASTLE	CO	C	LM	8 (MID-LATE XV)	1185	854	764	42	30	27	Albarella and Davis 1996
LAUNCESTON CASTLE	CO	C	PM	9 (XVI-XVII)	577	409	156	51	36	14	Albarella and Davis 1996
LAUNCESTON CASTLE	CO	C	PM	10+11 (LATE XVII-EARLY XIX)	690.5	569	138	49	41	10	Albarella and Davis 1996
LINCOLN	LI	U	S	LATE XI	1037	449	203	61	27	12	Dobney *et al.* 1996
LINCOLN	LI	U	EM	XII-XIII	306	253	68	49	40	11	Dobney *et al.* 1996
LINCOLN	LI	U	MMLM	XIV-XV	206	133	36	55	35	10	Dobney *et al.* 1996
LINCOLN	LI	U	PM	MID XVII	1175	758	195	55	36	9	Dobney *et al.* 1996
LINCOLN, BISHOPS PALACE	LI	P	LM	XV	65	186	7	25	72	3	Ellison 1975
LINCOLN, FLAXENGATE	LI	U	S	PreT-T6 (IX-LATE XI)	11301	6106	2174	58	31	11	O'Connor 1982
LINCOLN, FLAXENGATE	LI	U	EM	T7-T13 (LATE XI-XII)	9543	8406	2268	47	42	11	O'Connor 1982
LINCOLN, FLAXENGATE	LI	U	MM	S1-S5 (XIII-XIV)	919	856	177	47	44	9	O'Connor 1982
LINCOLN, FLAXENGATE	LI	U	LM	S6-S10 (XV-XVI)	959	970	208	45	45	10	O'Connor 1982
LYVEDEN	GC	V	MMLM	$	253	254	126	40	40	20	Grant 1975
MIDDLETON STONEY	OX	C	MM	5	0	0	0	21	47	32	Levitan 1984a
MIDDLETON STONEY	OX	C	LM	6	0	0	0	26	38	37	Levitan 1984a
MIDDLETON STONEY	OX	C	PM	7	0	0	0	31	43	27	Levitan 1984a
NEWCASTLE, CLOSEGATE I & II	TW	U	MM	XIII-XIV	39	71	13	32	58	11	Davis 1991a
NEWCASTLE, CLOSEGATE I & II	TW	U	LM	XV-XVI	299	585	66	31	62	7	Davis 1991a
NEWCASTLE, CLOSEGATE I & II	TW	U	PM	XVII-XVIII	44	121	8	26	70	5	Davis 1991a
NEWCASTLE, QUEEN STREET	TW	U	MM	1-4ii (XIII)	475	227	111	58	28	14	Allison 1988
NEWCASTLE, QUEEN STREET	TW	U	MMLM	5-5i (MID XIV-XV)	920	557	217	54	33	13	Allison 1988
NEWCASTLE, QUEEN STREET	TW	U	PM	6-6i (LATEXVI-EARLYXVII)	144	121	31	49	41	10	Allison 1988
NORTH ELMHAM PARK	NF	V	S	1 (MIDDLE SAXON)	2424	2808	2182	33	38	29	Noddle 1980
NORTH ELMHAM PARK	NF	V	S	2 (LATE SAXON, X)	1046	1503	827	31	45	24	Noddle 1980
NORTH ELMHAM PARK	NF	V	EM	3-4 (LATE SAXON/EARLY MED.)	290	291	321	32	32	36	Noddle 1980
NORTH ELMHAM PARK	NF	V	M	5 (XIV-XV)	1025	1063	1225	31	32	37	Noddle 1980
NORTH ELMHAM PARK	NF	V	PM	6 (XVI-XVII)	1169	623	419	53	28	19	Noddle 1980
NORTH PETHERTON	SO	V	LM	3	46	34	10	51	38	11	Adcock 1976/77
NORTHAMPTON, ST PETER'S STREET	NN	U	EMMM	3 (XII-XIV)	1042	2006	377	30	59	11	Harman 1979
NORTHAMPTON, ST PETER'S STREET	NN	U	LM	4 (XV)	391	784	107	30	61	8	Harman 1979
NORTHAMPTON, ST PETER'S STREET	NN	U	PM	5 (XVI-XVII)	58	100	12	34	59	7	Harman 1979
NORWICH, ALMS LANE	NF	U	S	1 (EARLY XI)	30	17	12	51	29	20	Cartledge 1985
NORWICH, ALMS LANE	NF	U	EM	2 (LATE XI - EARLY XII)	33	20	11	52	31	17	Cartledge 1985

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
NORWICH, ALMS LANE	NF	U	EM	3 (EARLY XII - LATE XIII)	80	77	25	44	42	14	Cartledge 1985
NORWICH, ALMS LANE	NF	U	MM	4 (LATE XIII - XIV)	452	482	159	41	44	15	Cartledge 1985
NORWICH, ALMS LANE	NF	U	LM	5 (EARLY XV)	542	355	125	53	35	12	Cartledge 1985
NORWICH, ALMS LANE	NF	U	LM	6 (MID XV - LATE XV)	420	376	113	46	41	13	Cartledge 1985
NORWICH, ALMS LANE	NF	U	LM	7 (EARLY - MID XVI)	477	482	182	42	42	16	Cartledge 1985
NORWICH, ALMS LANE	NF	U	PM	8 (LATE XVI)	136	146	52	41	44	15	Cartledge 1985
NORWICH, ALMS LANE	NF	U	PM	9 (EARLY - MID XVII)	657	468	142	52	37	11	Cartledge 1985
NORWICH, ALMS LANE	NF	U	PM	10 (LATE VII - EARLY XVIII)	100	109	25	43	47	10	Cartledge 1985
NORWICH, ALMS LANE	NF	U	PM	11 (EARLY-MID XVIII)	350	409	108	40	47	13	Cartledge 1985
NORWICH, ALMS LANE	NF	U	PM	12 (MID-LATE XVIII)	222	166	58	50	37	13	Cartledge 1985
NORWICH, CASTLE MALL	NF	U	S	1.i-iii (LATE IX-XI)	421	150	162	57	20	22	
NORWICH, CASTLE MALL	NF	U	EM	1.iv (LATE XI)	119.5	86	114.5	37	27	36	
NORWICH, CASTLE MALL	NF	C	EM	2 (LATE XI-EARLY XII)	374	165	181	52	23	25	
NORWICH, CASTLE MALL	NF	U	EM	3 (LATE XI-XII)	72	43	35	48	29	23	
NORWICH, CASTLE MALL	NF	U	EMMM	4 (LATE XII-MID XIV)	171	133	62	47	36	17	
NORWICH, CASTLE MALL	NF	U	MMLM	5 (MID XIV-MID XVI)	313	308	122	42	42	16	
NORWICH, CASTLE MALL	NF	U	PM	6 (LATE XVI-XVIII)	677	531	149	50	39	11	
NORWICH, CASTLE MALL (BARBICAN WELL)	NF	U	LM	LATE XV - EARLY XVI	152	579	89	18	71	11	Moreno García forth.
NORWICH, FISHERGATE	NF	U	S	1 (X)	118	28	51	65	12	22	Jones G. 1994
NORWICH, FISHERGATE	NF	U	S	3i (EARLY XI)	117	70	61	47	28	25	Jones G. 1994
s43 NORWICH, FISHERGATE	NF	U	SEM	3ii (XI)	244	114	118	52	24	25	Jones G. 1994
NORWICH, FISHERGATE	NF	U	EM	4 (XII)	67	52	33	44	34	22	Jones G. 1994
NORWICH, FISHERGATE	NF	U	MMLM	6 (XIV+)	35	22	3	58	37	5	Jones G. 1994
NORWICH, ST.MARTIN-AT-PALACE PLAIN	NF	U	EM	1 (XI - EARLY XII)	1524	1102	1140	41	29	30	Cartledge 1987
NORWICH, ST.MARTIN-AT-PALACE PLAIN	NF	U	EMMM	1/2 (XI-XIII)	953	702	660	41	30	29	Cartledge 1987
NORWICH, ST.MARTIN-AT-PALACE PLAIN	NF	U	EMMM	2 (XII-XIII)	2040	1801	1433	39	34	27	Cartledge 1987
NORWICH, ST.MARTIN-AT-PALACE PLAIN	NF	U	MMLM	3 (XIV-XV)	686	310	312	52	24	24	Cartledge 1987
NORWICH, ST.MARTIN-AT-PALACE PLAIN	NF	U	PM	4 (XVI-IX)	14	15	10	36	38	26	Cartledge 1987
NORWICH, WHITEFRIARS	NF	U	EM	2-3 (lateX-XII)	504	374	294	43	32	25	Cartledge 1983
OKEHAMPTON CASTLE	DV	C	MM	XIV	264	271	214	35	36	29	Maltby 1982
OKEHAMPTON CASTLE	DV	C	LM	LATE MED.	489	674	185	36	50	14	Maltby 1982
OKEHAMPTON CASTLE	DV	C	PM	POSTMED.	631	667	54	55	41	5	Maltby 1982
OXFORD CASTLE	OX	C	MMLM	XIII-MIDXV	68	30	28	54	24	22	Marples 1976
OXFORD, QUEEN STREET	OX	U	MM	4a-4b (XIII)	63	69	26	40	44	16	Wilson R. *et al.* 1983
OXFORD, QUEEN STREET	OX	U	LM	5b (XV-XVI)	19	1136	32	10	73	17	Wilson R. *et al.* 1983
OXFORD, THE HAMEL	OX	U	EM	2-3 (XII)	257	435	141	31	52	17	Wilson R. and Bramwell 1980
OXFORD, THE HAMEL	OX	U	MM	4-5 (XIII-XIV)	370	577	232	31	49	20	Wilson R. and Bramwell 1980
OXFORD, THE HAMEL	OX	U	MMLM	7-8 (LATEXIII-XVI)	415	531	194	36	47	17	Wilson R. and Bramwell 1980

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
OXFORD, THE HAMEL	OX	U	PM	9-10 (XVI)	376	435	73	43	49	8	Wilson R. and Bramwell 1980
PORTCHESTER CASTLE	HA	C	S	EARLY-MIDDLE (V-VIII)	287	74	64	68	17	15	Grant 1986
PORTCHESTER CASTLE	HA	C	S	MIDDLE-LATE (VIII-X)	1935	1303	817	48	32	20	Grant 1986
PORTCHESTER CASTLE	HA	C	S	LATE (X-XI)	439	267	185	49	30	21	Grant 1986
PORTCHESTER CASTLE (INN.BAIL.)	HA	C	MM	A-B (XIII-XIV)	182	202	220	30	33	36	Grant 1985
PORTCHESTER CASTLE (INN.BAIL.)	HA	C	PM	C (XVI-XVII)	89	88	27	44	43	13	Grant 1985
PORTCHESTER CASTLE (OUT.BAIL.)	HA	C	MM	3-4 (XIII-XIV)	390	155	107	60	24	16	Grant 1977
PORTCHESTER CASTLE (OUT.BAIL.)	HA	C	LM	6 (XV-XVI)	70	99	13	38	54	7	Grant 1977
PRUDHOE CASTLE	ND	C	MM	4-5 (XIII-XIV)	249	129	141	48	25	27	Davis 1987b
PRUDHOE CASTLE	ND	C	LM	6-8 (XV-MIDXVI)	177	85	34	60	29	11	Davis 1987b
PRUDHOE CASTLE	ND	C	PM	9-11 (MIDXVI-XVIII)	351	352	45	47	47	6	Davis 1987b
SANDAL CASTLE	WY	C	MM	5-6 (XII-XIV)	99	49	33	55	27	18	Griffith *et al.* 1983
SANDAL CASTLE	WY	C	LM	2-4 (XV)	526	314	149	53	32	15	Griffith *et al.* 1983
SANDAL CASTLE	WY	C	PM	'+'-1 (XVI-XVIII)	684	521	154	50	38	11	Griffith *et al.* 1983
SOUTHAMPTON	HA	U	EMMM	A (XI-XIII)	145	73	104	45	23	32	Noddle 1975
SOUTHAMPTON	HA	U	MM	B (XIII-XIV)	73	62	88	33	28	39	Noddle 1975
SOUTHAMPTON	HA	U	PM	C (XVI-XVIII)	47	49	12	44	45	11	Noddle 1975
SOUTHAMPTON, MELBOURNE STREET	HA	U	S	MIDDLE SAXON	23896	14606	6953	53	32	15	Bourdillon and Coy 1980
SOUTHAMPTON, QUILTER'S VAULT	HA	U	EM	A	412	442	118	42	45	12	Bourdillon 1979b
SOUTHAMPTON, QUILTER'S VAULT	HA	U	MM	B	88	55	32	50	31	18	Bourdillon 1979b
SOUTHAMPTON, QUILTER'S VAULT	HA	U	PM	C	29	67	15	26	60	14	Bourdillon 1979b
yts43 TAUNTON, BENHAM'S GARAGE	SO	U	EMMM	3 (XII-XIII)	374	242	20	59	38	3	Levitan 1984b
TAUNTON, BENHAM'S GARAGE	SO	U	MM	4 (XIII-XIV)	1346	1316	125	48	47	4	Levitan 1984b
TAUNTON, BENHAM'S GARAGE	SO	U	PM	POSTMED.	154	120	6	55	43	2	Levitan 1984b
TAUNTON, PRIORY BARN	SO	U	EMMM	1 (XII-XIII)	199	367	35	33	61	6	Levitan 1984b
THETFORD, BRANDON ROAD	NF	U	EM	XI-XII	1757	1577	687	44	39	17	Jones G. 1993
THETFORD, BRANDON ROAD	NF	U	EMMM	XII-XIV	229	382	104	32	53	15	Jones G. 1993
THETFORD, BRANDON ROAD	NF	U	MMLM	XIV-XV	117	151	56	36	47	17	Jones G. 1993
THETFORD, BRANDON ROAD	NF	U	S	SAXON (X)	1427	1050	483	48	35	17	Jones G. 1993
THETFORD, BRANDON ROAD	NF	U	LM	XV-XVI	243	298	66	40	49	11	Jones G. 1993
THETFORD, REDCASTLE FURZE	NF	U	S	2 -EARLY SAXON (VI-VII)	203	159	67	47	37	16	Wilson T. 1995
THETFORD, REDCASTLE FURZE	NF	U	S	4ii -LATE SAXON (EARLY-MID XI)	92	97	29	42	45	13	Wilson T. 1995
THETFORD, REDCASTLE FURZE	NF	U	S	4iii -LATE SAXON/EM (LATE XI)	240	338	77	37	51	12	Wilson T. 1995
THETFORD, REDCASTLE FURZE	NF	U	MM	7 (XIII-XIV)	198	422	50	30	63	7	Wilson T. 1995
THETFORD, SITE 1092	NF	U	S	LATE SAXON	919	650	394	36	38	26	Jones G. 1984
THRISLINGTON	DU	V	MM	XIII-XIV	252	249	67	44	44	12	Rackham 1989
THUXTON	NF	V	M	XII-XV	140	188	224	25	34	41	Cartledge 1989
TOTNES	DV	U	PM	$	79	169	21	29	63	8	Bovey 1984

SITE	*COUNTY*	*TYPE*	*PERIOD*	*PUBPER*	*N.BOS*	*N.OVIS*	*N.SUS*	*%BOS*	*%OVIS*	*%SUS*	*REFERENCE*
UPTON	GC	V	EMMM	XII-XIII	106	452	23	18	78	4	Noddle *et al.* 1969
WALTON	BU	V	EM	SAXO-NORMAN	726	871	396	36	44	20	Noddle 1976
WALTON	BU	V	M	MEDIEV.	645	827	292	37	47	17	Noddle 1976
WEST COTTON	NN	V	EM	EARLY MED. (XII-XIII)	760	531	318	47	33	20	Albarella and Davis 1994
WEST COTTON	NN	V	MMLM	MID-LATE MED. (XIII-XV)	406	825	230	28	56	16	Albarella and Davis 1994
WEST STOW	SF	V	S	1 (V)	2539	3469	1683	33	45	22	Crabtree 1989
WEST STOW	SF	V	S	2 (VI)	4811	6944	1912	35	51	14	Crabtree 1989
WEST STOW	SF	V	S	3 (LATE VI-VII)	523	725	308	34	46	20	Crabtree 1989
WHARRAM PERCY	NY	V	MM	XIII-XIV	328	851	132	25	65	10	Ryder 1974
WHARRAM PERCY	NY	V	LM	XV-EARLY XVI	438	886	126	30	61	9	Ryder 1974
WINCHCOMBE	GC	U	M	XII ONWARDS	280	259	23	50	46	4	Levitan 1985
WINCHCOMBE	GC	U	PM	XVI-XVII	31	24	4	53	41	7	Levitan 1985
YORK, FISHERGATE	NY	U	EM	4 (XI-XII)	1025	660	237	53	34	12	O'Connor 1991
YORK, GENERAL ACCIDENT SITE	NY	U	EM	9 (XI-XII)	139	38	33	66	18	16	O'Connor 1988
YORK, GENERAL ACCIDENT SITE	NY	U	EMMM	10-11 (XII-XIV)	4059	1054	656	70	18	11	O'Connor 1988
YORK, GENERAL ACCIDENT SITE	NY	U	MM	12 (XIV)	581	200	76	68	23	9	O'Connor 1988
YORK, PETERGATE	NY	U	MM	XI-XIV	207	117	141	45	25	30	Ryder 1971
YORK, SKELDERGATE	NY	U	EM	SkK+SkN+SkZ (XI-XII)	1223	410	159	68	23	9	O'Connor 1984
YORK, SKELDERGATE	NY	U	LM	SkD-SkE (EARLY XV)	438	674	80	37	57	7	O'Connor 1984

Key
AV = Avon, BU = Buckinghamshire, CH = Cheshire, CO = Cornwall, DO = Dorset, DU = Durham, DV = Devon, EX = Essex, GC = Gloucestershire, HA = Hampshire, HT = Hertfordshire, HU = Humberside, HW = Hereford and Worcester, LI = Lincolnshire, NF = Norfolk, NN = Northamptonshire, ND = Northumberland, NY = North Yorkshire, OX = Oxfordshire, SF = Suffolk, SO = Somerset, TW = Tyne and Wear, WS = West Sussex, WY = West Yorkshire

C = castle, M = monastic, N = manor house, P = palace, U = urban, V = village

S = saxon, M = medieval, EM = early medieval (late XI-XII), MM = middle medieval (XIII-XIV), LM = late medieval (XV-early XVI), PM = post-medieval.

PUBPER is the code and date of each period in the original publication. In order to avoid confusion between period codes and dates, the periods are given in Arabic numbers, even if in the original publication they were numbered with Roman numbers.
The number of fragments (NISP) is calculated in different ways by different authors; when a 'diagnostic zones' method was used this has been preferred to the crude number of identified fragments. In most of the sites the figure for *Ovis* includes *Capra*

Table 14 List of Saxon, medieval and post-medieval sites whose faunal assemblages are plotted in the tripolar diagrams (Figs 22 and 23). Assemblages with less than 150 identified specimens have been excluded from the diagrams which can affect the frequency of species in each assemblage. It is then possible to observe whether, despite all biases, general trends can still be detected. This approach has successfully been undertaken by Hambleton (1999) and King (1978 and 1984) who analysed a large number of Iron Age and Roman sites respectively and succeeded in identifying patterns of regional variation. Albarella and Davis (1994b and 1996) applied a similar method to medieval and post-medieval England. By considering a large number of sites from across the country some of the trends initially suggested by Grant (1988), such as the higher number of pig bones in early medieval and high status sites, were confirmed. Naturally many exceptions to these general trends occur, so this method cannot be used to determine the status or the cultural context of an individual site.

The latter approach has been used to compare Castle Mall with other contemporary sites in England. The list of sites involved can be found in Table 14 and includes a larger number than those originally used by Albarella and Davis (1996). In particular Saxon sites and important sites in the same geographic area as Norwich and within the city itself have been added (see also Fig.1). The list is far from being complete, but the majority of the main Saxon to post-medieval sites have been incorporated. The sites have been divided on the basis of their type of settlement (Fig.14): towns, villages and castle. This division is very approximate, as the status of a site is not always clear, urban castles occur (Castle Mall is an example), monastic sites and manor houses are not easily assigned to one of these categories, *etc.* However, the aim, as stated above, is only the identifications of broad trends. Castle Mall has been considered as a 'town' in Periods 1, 3, 4, 5, and 6 and a 'castle' in Period 2, when the excavated features are more closely associated with the castle.

The Castle Mall assemblage is located within the main cluster of urban sites, which tend to be characterised by a high frequency of cattle (in most cases above 40%) and a relatively small number of pig bones. An exception is Period 1.4, which stands out as having a higher percentage of pig (Fig.14). In general there is a higher variability in castle sites, but even though many exceptions occur they tend to have a larger number of pigs. This is not evident at first sight, but if a line is drawn separating sites with more than 20% pig from the others, this group would contain 49% of the castles, 32% of the villages and only 16% of the towns. With its 25% pigs, Castle Mall Period 2 is within the >20% pig category. It is not until Period 4 that the pig frequency at Castle Mall drops below 20%. This suggests that the relatively high percentage of pigs in the early phases is not a consequence of status, but is a feature of the early medieval economy.

This can be better illustrated by dividing the assemblages by chronological period (Fig.15). The frequencies of sites with more than 20% pigs are distributed as follows: Saxon 38%, early medieval 38%, middle medieval 33%, late medieval 26% and post-medieval 8%. For sheep the frequency of sites with more than 40% of this species is: Saxon 29%, early medieval 28%, middle medieval 38%, late medieval 43% and post-medieval 62%. The steady decrease of pig and increase of sheep are countrywide phenomena and the Castle Mall assemblage — apart from the unusual Period 1.4 — lies well within the main distribution of sites for each period.

V. Cattle

(Pls 2–7, Figs 16–23, Tables 15–22)

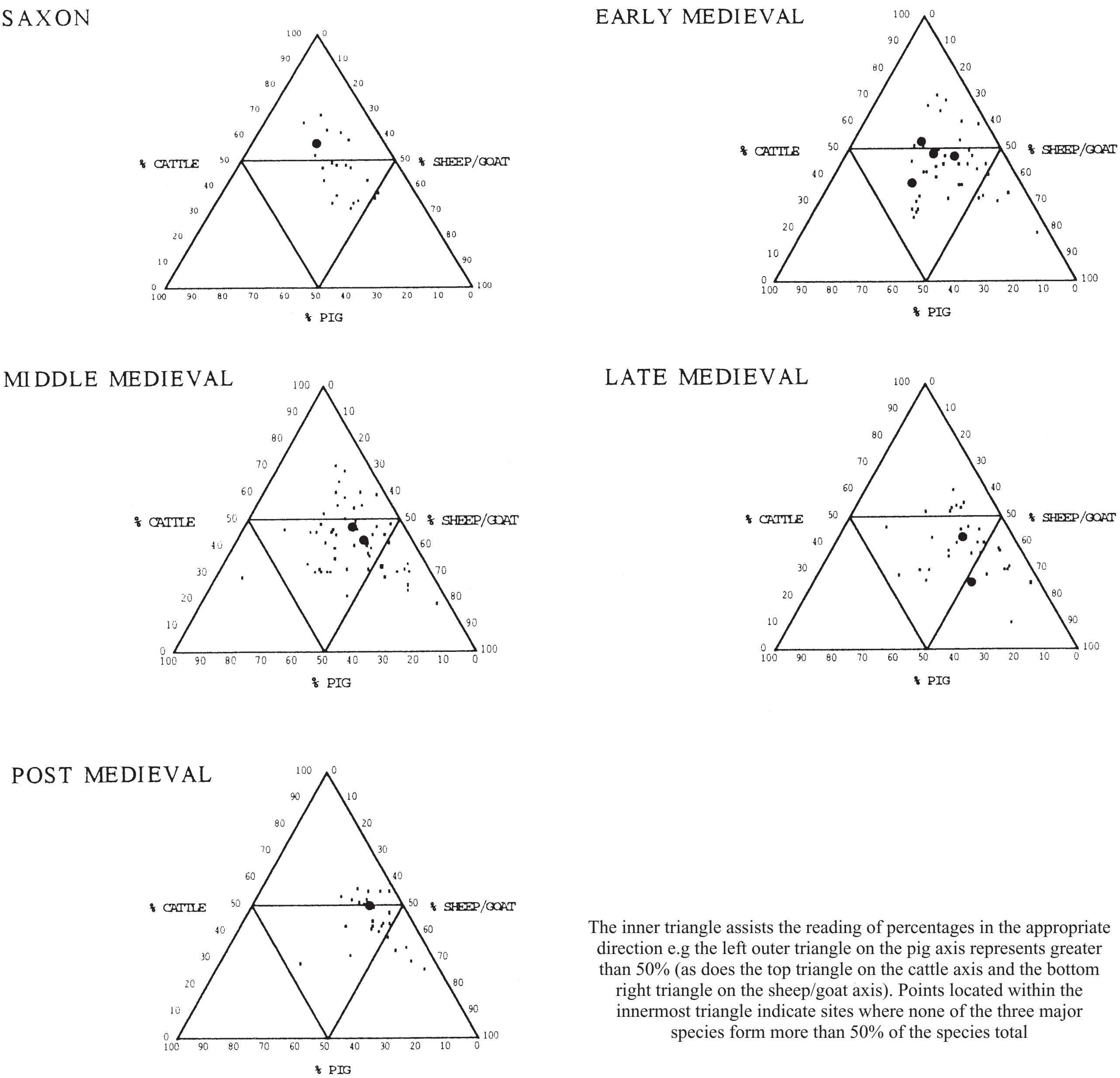
Anatomical Distribution

One of the main problems in the study of the distribution of body parts is the variation that may occur between different contexts or groups of contexts. Ideally the distribution of the anatomical elements should thus be analysed context by context or, at least, group by group. However, for Castle Mall this approach would reduce the size of each assemblage to such a degree that any variation between contexts — except for a few very large ones — would be of no statistical meaning. Therefore the whole assemblage for each period has to be studied, whilst bearing in mind the possibility of lateral variation affecting any interpretation.

The frequency of cattle body parts by period is shown in Table 15 and Fig.16. This only includes hand-collected material. As expected, the distribution of the anatomical elements is uneven. A general feature of all periods is the under-representation of some elements due to either differential recovery (incisors, carpals, phalanges) or preservation (cranium, femur). Further differences in distribution may be due to other factors and will be considered period by period.

In Periods 1 and 2, apart from the biases due to preservation and recovery, there is no significant variation in the frequency of different elements. Hind limb bones such as tibia, astragalus and calcaneus are particularly common perhaps because they survived slightly better than the humerus. This was not the case in the well known experiment undertaken by Brain (1967) in Africa where the distal humerus was the best preserved post-cranial bone. However, this experiment was carried out on a different species (goat) and in very different environmental and climatic conditions. In fact, archaeological cattle bone assemblages where hind-limb bones occur more frequently than fore-limb bones are very common. The roughly equal numbers of metacarpi and metatarsi (which tend to have similar patterns of preservation) in Periods 1 and 2 at Castle Mall support the hypothesis that the number of cattle fore and hind limbs on the site was originally the same.

The assemblages from Periods 3 and 4 are unfortunately rather small (Table 15 and Fig.16) and thus are not discussed. Period 5 is characterised by a surprisingly high number of metatarsi. Due to the comparatively small number of metacarpi present in this period it can be assumed that this is not due to a preservation bias. The metatarsi are scattered across the site more or less like the other elements and do not appear to derive from one specific event. It is likely that some of the industrial activities, such as tanning and bone working, that were being practised in this period, would have affected the distribution of the bones. It is possible that the extremities of hind limbs represent the by-products of such activities. Phalanges are under-represented relative to metatarsi but, when compared to other elements, are more common than in other periods. Once the metatarsi have been excluded the distribution of body parts is rather similar to that for Periods 1 and 2, but with a slightly higher number of cranial elements. Heads are the body parts most likely to be excluded from dressed carcasses and their abundance therefore further emphasises the presence of whole carcasses on site in Period 5.



The inner triangle assists the reading of percentages in the appropriate direction e.g the left outer triangle on the pig axis represents greater than 50% (as does the top triangle on the cattle axis and the bottom right triangle on the sheep/goat axis). Points located within the innermost triangle indicate sites where none of the three major species form more than 50% of the species total

Points marked by large circles indicate various phases belonging to Castle Mall.
Saxon: Period 1.1–3; early medieval: Periods 1.4, 2, 3 and 4 (from left to right); middle medieval: Periods 4 and 5 (from left to right); late medieval: Period 5 and barbican well (flint shaft) (from top to bottom); post-medieval: Period 6

Figure 15 Comparison of Late Saxon, medieval and post-medieval zooarchaeological assemblages in England

The distribution of elements in Period 6 is similar to Period 5, once the metatarsi have been excluded, but this time the fore limb elements slightly outnumber the hind-limb. As with other periods the teeth are still well represented.

It can thus be concluded that in each Castle Mall period all cattle body parts are present, although in different percentages. The majority of beef derived from complete carcasses present on site which suggests that a high percentage of the animals had been either locally reared or brought to town on the hoof. This pattern is also known for other Saxon and medieval sites in England, such as Southampton (Bourdillon 1994) and York (O'Connor 1994).

In early periods hind limbs are better represented than fore limbs and heads. In later periods, if the Period 5 metatarsi are excluded, the opposite is seen to be true. Thus it is possible that some dressed carcasses were also imported to the town. In the post-medieval period in particular it seems that some of the best cuts of meat are missing. They may have been consumed in specific areas of town and their refuse disposed of away from the Castle Mall area.

Ageing Data

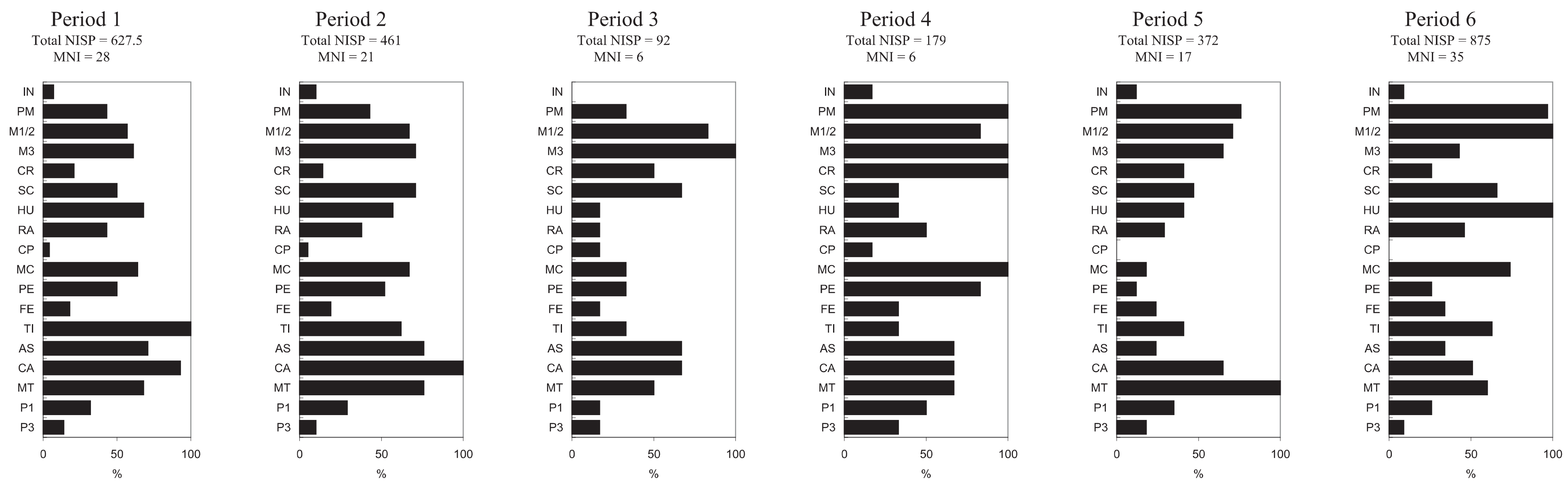
The ageing evidence for cattle suggests that the kill-off strategies for this species remained stable throughout Late Saxon and medieval times, whereas a major change occurred between the 15th and the 16th century.

Most cattle are adult or elderly in Periods 1 to 4, whereas a large number of milk premolars in early stages of wear have been found in Periods 5 and 6 (Table 16). Erupting first molars are also abundant during these periods but are totally absent in earlier periods. This

	Period																	
	1			*2*			*3*			*4*			*5*			*6*		
Element	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*
Deciduous + permanent incisors	13	2	**7**	10	2	**10**	-	-	**-**	3	1	**17**	14	2	**12**	21	3	**9**
Deciduous + permanent premolars	71	12	**43**	49	9	**43**	7	2	**33**	32	6	**100**	78	13	**76**	200	34	**97**
M1/2	64	16	**57**	54	14	**67**	17	5	**83**	20	5	**83**	46	12	**71**	139	35	**100**
M3	33	17	**61**	29	15	**71**	12	6	**100**	12	6	**100**	21	11	**65**	30	15	**43**
Cranium	11	6	**21**	6	3	**14**	5	3	**50**	11	6	**100**	13	7	**41**	18	9	**26**
Scapula	28	14	**50**	30	15	**71**	7	4	**67**	4	12	**33**	16	8	**47**	46	23	**66**
Humerus	37	19	**68**	23	12	**57**	1	1	**17**	4	2	**33**	14	7	**41**	69	35	**100**
Radius	23	12	**43**	16	8	**38**	2	1	**17**	6	3	**50**	10	5	**29**	32	16	**46**
Carpal	2	1	**4**	1	1	**5**	1	1	**17**	2	1	**17**	-	-	**-**	-	-	**-**
Metacarpus	35	18	**64**	26.5	14	**67**	3	2	**33**	12	6	**100**	5.5	3	**18**	51	26	**74**
Pelvis	27	14	**50**	22	11	**52**	4	2	**33**	9	5	**83**	4	2	**12**	18	9	**26**
Femur	10	5	**18**	7	4	**19**	1	1	**17**	4	2	**33**	7	4	**24**	24	12	**34**
Tibia	56	28	**100**	26	13	**62**	3	2	**33**	4	2	**33**	14	7	**41**	43	22	**63**
Astragalus	39	20	**71**	31	16	**76**	8	4	**67**	7	4	**67**	8	4	**24**	23	12	**34**
Calcaneus	51	26	**93**	42	21	**100**	7	4	**67**	8	4	**67**	21	11	**65**	35	18	**51**
Metatarsus	36.5	19	**68**	31.5	16	**76**	5	3	**50**	8	4	**67**	33.5	17	**100**	41	21	**60**
Phalanx 1	65	9	**32**	45	6	**29**	8	1	**17**	23	3	**50**	44	6	**35**	68	9	**26**
Phalanx 3	26	4	**14**	12	2	**10**	1	1	**17**	10	2	**33**	23	3	**18**	17	3	**9**
total	**627.5**			**461**			**92**			**179**			**372**			**875**		

Each individual tooth within mandibles has been counted, hence the total is greater than the total NISP in Table 4.
The MNI has been calculated as follows: Incisors and phalanges have been divided by 8, deciduous + permanent premolars by 6, $M_{1/2}$ by 4, all other elements, except metapodia, by 2.
Metacarpus = (MC1 + MC2/2 + MP1/2 + MP2/4) / 2
Metatarsus = (MT1 + MT2/2 + MP1/2 + MP2/4) / 2
Where: MC1 = complete distal metacarpus; MC2 = half distal metacarpus; MT1 = complete distal metatarsus; MT2 = half distal metatarsus; MP1 = complete distal metapodium; MP2 = half distal metapodium.
% = frequency of an element expressed in relation to the most common one (by MNI).

Table 15 Parts of the cattle skeleton by number of fragments (NISP) and minimum number of individuals (MNI) all periods. Unfused epiphyses are not counted. Only hand-collected material is included



Percentages are calculated on the basis of the frequency of an element in relation to the most common one (by MNI)

IN = deciduous and permanent incisors, PM = deciduous and permanent premolars, M1/2 = 1st and 2nd molars, M3 = 3rd molars, CR = cranium (zygomaticus), SC = scapula, HU = humerus, RA = radius, CP = carpal, MC = metacarpus, PE = pelvis, FE = femur, TI = tibia, AS = astragalus, CA = calcaneus, MT = metatarsus, P1 = 1st phalanx, P3 = 3rd phalanx

Figure 16 Cattle body parts at Castle Mall

		C	*V*	*E*	*H*	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*	*n*	*o*	*p*
DP4	Period 1								1		1			1	3	2				
	2													5	2	1				
	3		1												1					
	4						1								2					
	5						6	6	1						2	1				
	6						11	11	5					4	2	3				
P4	Period 1			3		1		3	1	3	7	4	3							
	2			1		1	1	1			1	8	4	1						
	3			1							1		2							
	4											1	2							
	5	1	1	2				3	1	2		3		1						
	6	1	2	2	5		5	6	5	5	10	3	6	1						
M1	Period 1				1	1					1	7	2		11	5	2	1	2	
	2											8		1	4	6	2	1	2	
	3											1		1	2	3		1		
	4											1			1	2			1	
	5		7	2								1	3	2	6	3				
	6		4	15							1	3	1	10	28	8	3	1		1
M2	Period 1	1			1	1					5	5		4	4	6	1			
	2						1	1	1		2	3		1	8	4	2			
	3										2	3			3				1	
	4											1		1	1		1			
	5						1					6		4	4	2				
	6		1								2	15	5	8	8	6	4			
M1/2	Period 1					1	1		1			1			1	2				
	2									1	1	3		1	1		2			
	3										1					3				
	4								1		1	3		2		2				
	5	1				2				1		1		1	3	1	1			
	6					3					5	2		2	6	1	1			
M3	Period 1		1	1	1	1	3	3			3	7		3	6	4	1			
	2	2	1	1					2	1	2	7		2	6	2	3			
	3			1		1	3					2			4		1			
	4									1		6		1	2	1	2			
	5	1					3	2	2	1		7		2	2					
	6					2	1		2	1	8	9	1		2	3	1			

Both teeth in mandibles and isolated teeth are included
Grant's stage 'U' is considered equivalent to stage 'a'
Unworn isolated teeth which could have been in one of the eruption stages (C, V, E, H) are coded as 'a'

Table 16 Cattle wear stages of individual teeth (following Grant 1982) all periods

Cattle	*Mandibular wear stage*										
	Juvenile		*Immature*		*Subadult*		*Adult*		*Elderly*		
Period	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
1	2	**6**	2	**6**	4	**12**	14	**41**	12	**35**	**34**
2 + 3	-	**0**	-	**0**	7	**19**	16.5	**45**	13.5	**36**	**37**
4	-		-		0.5		3		4.5		**8**
5	8	**29**	-	**0**	2	**7**	13.5	**48**	4.5	**16**	**28**
6	15	**21**	0.5	**1**	2.5	**3**	40.5	**55**	14.5	**20**	**73**

Percentages are only calculated where the sample is greater than 20 within a particular period
Only mandibles with two or more teeth (with recordable wear stage) in the $dP_4/P_4 – M_3$ row were considered

Table 17 Cattle mandibular wear stages (following O'Connor 1988) all periods

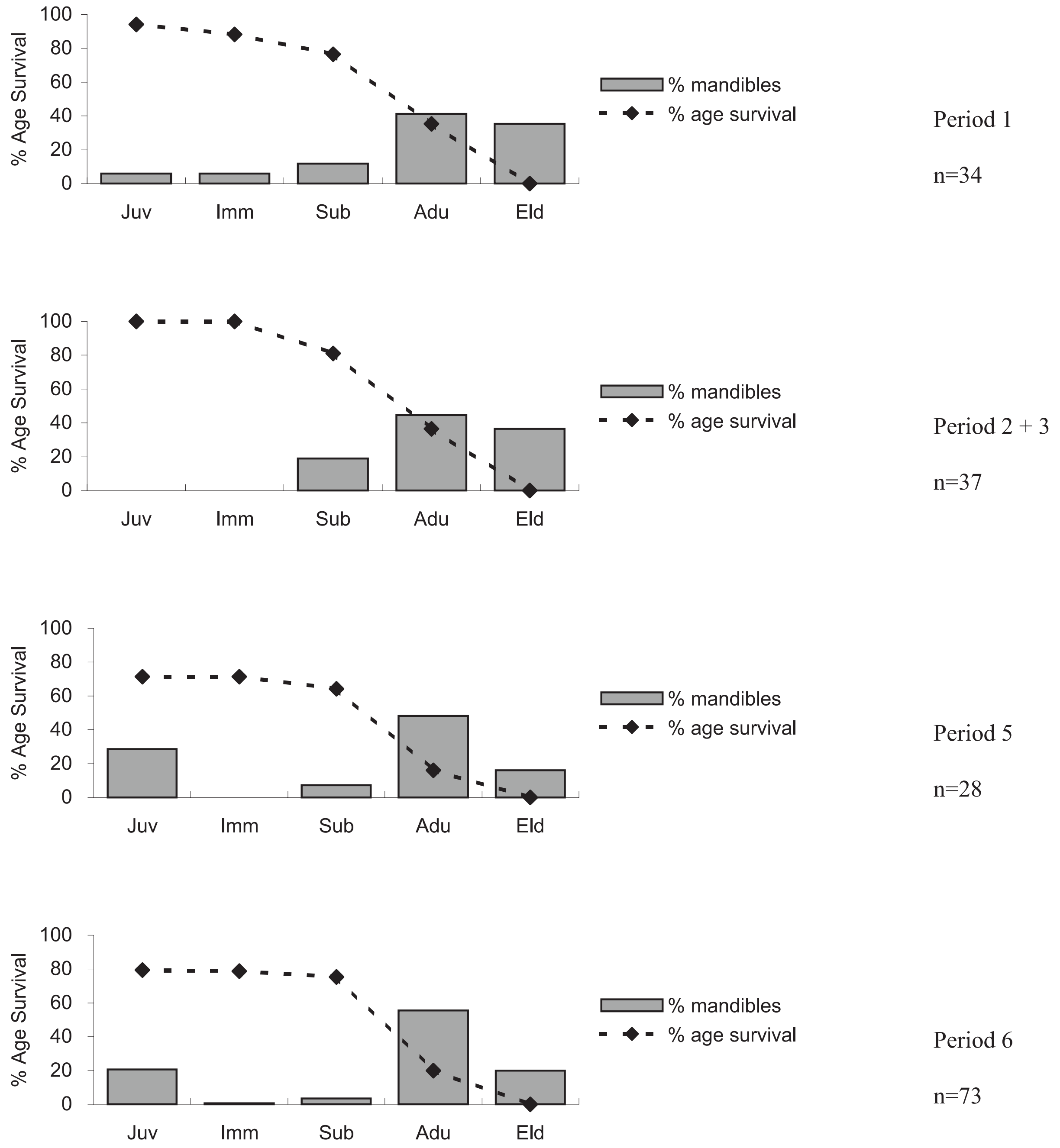


Figure 17 Relative percentages of cattle mandibles by age stage (all periods). Age stages are from O'Connor (1988). All mandibles with two or more teeth with recordable wear in the $dP_4/P_4 - M_3$ row were considered

finding is confirmed by the analysis of mandibular wear stages where juvenile mandibles become common only by Period 5 (Table 17; Fig.17). The difference in the mortality curve is highly statistically significant when Periods 2+3 and 5 are compared, whereas no changes is seen to occur between Periods 1 and 2+3 and between Periods 5 and 6 (Table 18).

The ratio between deciduous and permanent premolars also indicates a lower frequency of juveniles in Period 1, though the proportion of milk teeth in Period 2+3 is almost as high as in later periods (Fig.18). However, most of the milk premolars from Period 2+3, unlike those from Periods 5 and 6, are heavily worn (Table 16).

Due to the differential preservation of unfused and fused bones the analysis of the epiphyseal fusion in the study of kill-off patterns is not as reliable as tooth eruption and wear. However, some broad trends can still be detected. The higher number of unfused bones in Period 5 and particularly Period 6, confirm the presence of younger animals in late periods. It is interesting to note that quite a few early fusing epiphyses, such as scapula, distal humerus, pelvis, are unfused in Periods 5 and 6. Indeed a remarkable 50% of scapulae are unfused in Period 6 (Table 19). Thus the presence of young calves in post-medieval times is confirmed. No consistent differences could be detected between Periods 1 and 2+3.

Taxon	*Periods compared*	*Value*	*Degrees of freedom*	*Probability*
Cattle	1 versus 2+3	5.06	4	25% < x < 50%
Cattle	2+3 versus 5	14.38	4	0.5% < x < 1% **
Cattle	5 versus 6	1.62	4	75% < x < 90%
Sheep/Goat	1 versus 2+3	3.85	8	75% < x < 90%
Sheep/Goat	2+3 versus 5	7.72	8	25% < x < 50%
Sheep/Goat	5 versus 6	5.62	8	50% < x < 75%
Sheep/Goat	1-4 versus 5-6	18.08	8	1% < x < 2.5% *
Pig	1 versus 2+3	2.83	4	50% < x < 75%
Pig	2+3 versus 6	9.32	4	5% < x < 10%

** = the difference is highly significant (with less than a 1% probability that it is due to chance)
* = the difference is significant (less than 5% probability that the difference is due to chance)
no asterisk = no significant difference (more than a 5% probability that it is due to chance)

Table 18 Significance of the differences between cattle, sheep/goat and pig kill-off patterns in different periods. The chi square (χ^2) test (Spiegel 1961) compares the age profiles as calculated by the mandibular wear stage distribution (Figs 17, 26 and 36)

To summarise, in Late Saxon and early medieval times most cattle were killed when adult or elderly, when older than approximately 3–5 years. A small number of animals were also killed when sub-adult, this is most noticeable in Periods 2+3. In late medieval, and to a greater extent in post-medieval times, a new culling strategy can be detected. Two mortality peaks can now be identified: cattle are mostly killed when juvenile (younger than 6 months) or adult (about 3–5 years old). However, the relatively low number of elderly cattle in these later times may simply be because they were not brought to the town market for sale.

The culling of a high number of calves in post-medieval times appears to be a countrywide phenomenon, well demonstrated from both archaeological and historical evidence. This same trend has been found in several other archaeological sites across the country, such as Exeter (Maltby 1979), Sandal Castle (Griffith *et al.* 1983), Leicester St Peter's Lane (Gidney 1991b and 1991c), St Andrew's Priory (O'Connor 1993a), Launceston Castle (Albarella and Davis 1996) and Lincoln (Dobney *et al.* 1996). This increase in the percentage of young animals at some sites is also highlighted by Grant (1988) in her summary of the animal economy in the British medieval countryside.

A large number of juvenile mandibles has also been found by Moreno García in her study of the bones from the Castle Mall barbican well (mid/late 15th to early 16th century; see Chapter 4) and by Curl from 15th- to 16th-century contexts at the Golden Ball Street site (Chapter 6). Together with the evidence from Period 5, this seems to suggest that the shift towards culling of juvenile cattle may have occurred earlier in Norwich than in other parts of the country. Other evidence to support this hypothesis comes from the site of St Martin-at-Palace Plain, Norwich (Cartledge 1987). Here a large number of calf mandibles were found in the 14th- to 15th-century levels, which is a remarkably early date for this occurrence. The site of Fishergate, Norwich, which is pre-15th-century in date, has produced almost only bones of mature cattle (Jones 1994), and is consistent with the findings from the medieval levels at Castle Mall.

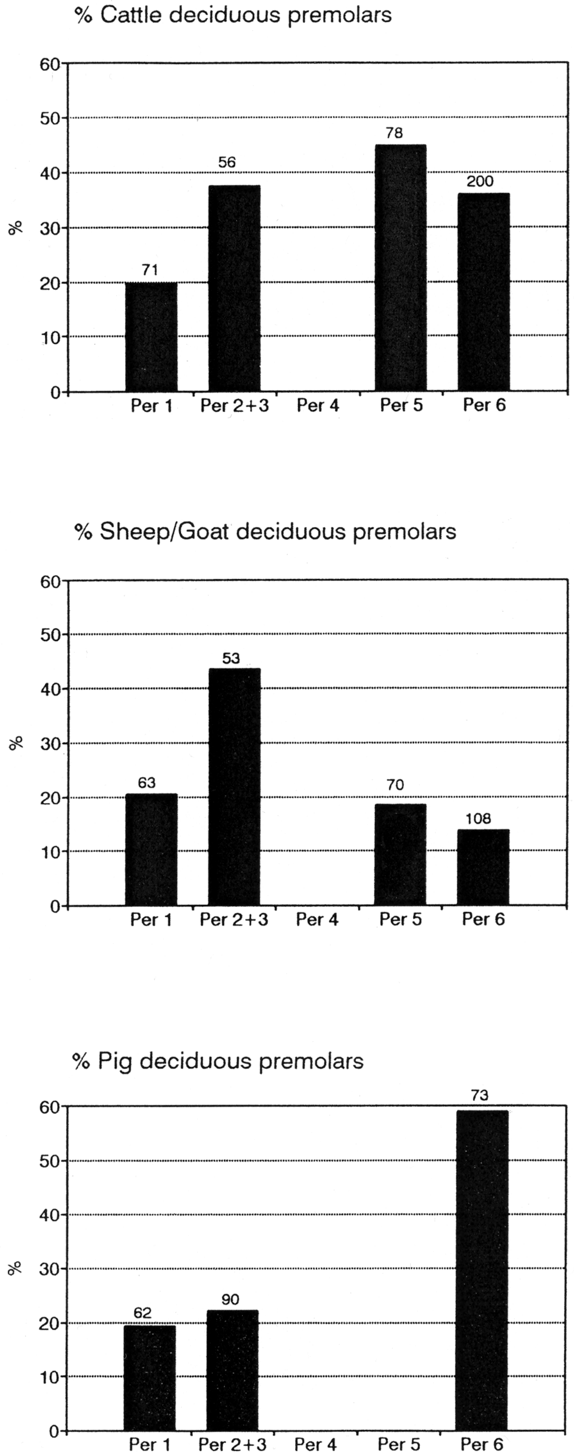
Historic documents demonstrate that throughout the Middle Ages cattle had mainly been used for traction, and particularly for ploughing. This must have been emphasised in areas such as Norfolk which were primarily

	Period 1		*Period 2+3*		*Period 4*		*Period 5*		*Period 6*	
Element	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Scapula d	32	**97**	39	**98**	5	**100**	16	**89**	22	**50**
Humerus d	39	**95**	25	**93**			12	**80**	51	**73**
Radius d	16	**67**	17	**89**			7	**50**	14	**42**
Metacarpus d	28	**78**	20	**67**	9	**64**	7	**64**	37	**71**
Pelvis a	30	**100**	29	**100**			5	**100**	16	**84**
Femur d	5	**50**	6	**60**					10	**42**
Tibia d	46	**77**	27	**84**			7	**47**	34	**77**
Calcaneus	15	**47**	20	**71**			4	**21**	10	**29**
Metatarsus d	20	**53**	33	**80**			17	**47**	24	**57**
Phalanx 1	66	**90**	54	**96**	29	**88**	45	**90**	68	**93**

n = total number of fused/ing epiphyses
% = percentage of fused/ing epiphyses out of the total number of fused/ing epiphyses and unfused diaphyses.
d = distal; a = acetabulum
Figures for total number of epiphyses smaller than 10 have been omitted

Table 19 Cattle, number and percentage of fused epiphyses. Fused and fusing epiphyses are amalgamated. Only unfused diaphyses, not epiphyses, are counted oriented towards arable farming (Dyer 1988). However, by the end of the Middle Ages many changes occurred in the agricultural economy of Britain (Kerridge 1967, Beckett 1990). These included a general shift from arable to pasture farming and the gradual replacement of oxen with horses for ploughing (Trow-Smith 1957). In fact horses had started replacing oxen as early as the 12th century (Langdon 1986, Overton and Campbell 1992), but in Norfolk it was only by the 17th century that oxen had virtually been eliminated as draught animals (Overton and Campbell 1992). By this time there was no need to keep large numbers of fully grown cattle, as the emphasis in their husbandry had shifted towards meat or dairy production. Norfolk in particular specialised in fattening young animals for meat production. The juvenile bones found at Castle Mall in Period 5 and 6 can thus be interpreted as the result of a demand for veal from the town. Meat husbandry can be complemented with the production of milk. The removal of the calf allows exploitation of the mothers' milk for human consumption. However, in Norfolk there was a general move away from dairying (Overton and Campbell 1992) and therefore although milk could have been a useful by-product, the emphasis probably lay upon meat production.

A few neonatal bones were found in all periods, except Period 4. This suggests that at least some animals were bred on site. This evidence is particularly sparse in Period 6, where only one neonatal bone has been identified. Since in this period there is an emphasis on juvenile calves it is possible that one animal was killed for sale when particularly young.



Calculations are made by [dP/(dP+P)] ×100
Numbers of (dP+P) for cattle, sheep and pig are given above the bars
Percentages were only calculated if the total (dP+P) >50
Only hand-collected material

Figure 18 Percentages of deciduous premolars of the three main taxa (all periods)

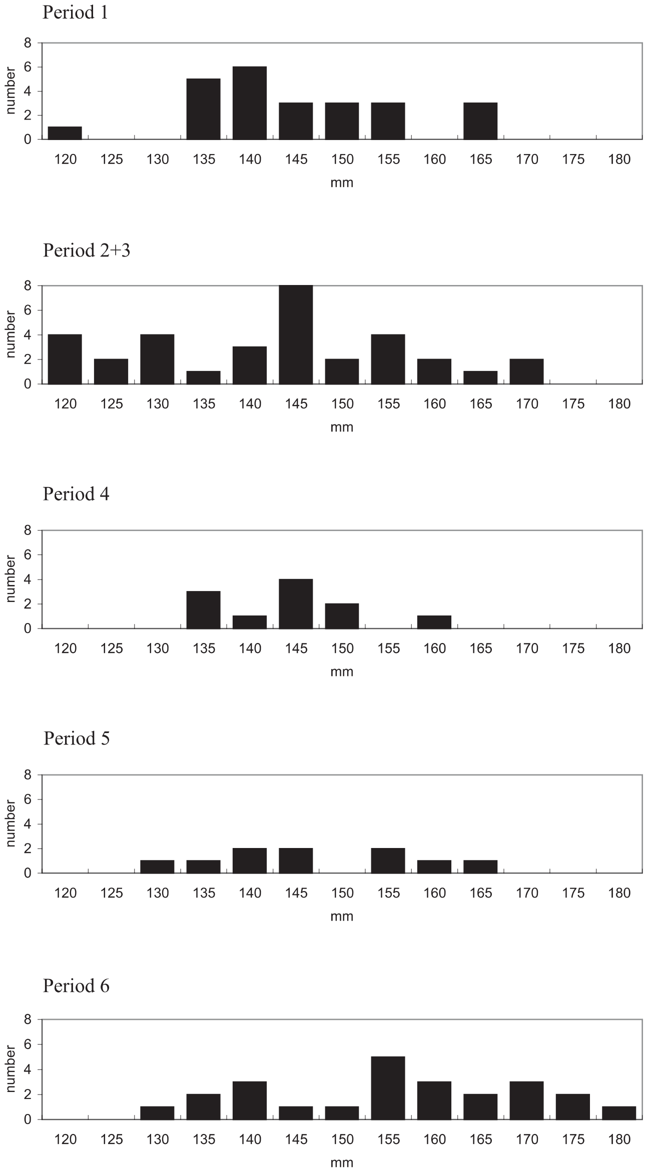
Size, Shape and Sex

Cattle from Late Saxon and medieval times at Castle Mall were of similar size. A noticeable, but not striking, size increase occurred in early post-medieval times, possibly as early as Period 5. Large differences in the size and shape of horncores attest to the presence of a new and different breed in Period 6.

The stable size of the cattle body in Saxon and medieval times can be appreciated in Fig.19, where the width of the lower third molar is plotted for all periods. Some apparent size increase may be seen in Period 6, but this is not statistically significant (Table 21), due to the small sample sizes in Periods 4 and 5. When the medieval and post-medieval periods are combined to increase the sample size, the difference between these two groups becomes highly significant (Table 21). Teeth are less susceptible to differences due to the age or sex of individuals (Degerbøl 1963) and are less affected by environmental factors such as different planes of nutrition. Therefore the increase in tooth size, although slight, attests to the genuine presence of larger cattle in post-medieval Norwich.

Size increase in later times is also attested by the post-cranial bones (Tables 20 and 21; Fig.20). However, the small sample for Period 5 does not permit an answer to the interesting question of when this size increase first occurred. A greater width of distal metatarsi from Period 5 (Table 20) suggests that larger animals were already present by at least the 16th century, but this measurement is very sex-dependent and thus this result must be interpreted with caution — it might merely reflect a shift towards a larger number of steers.

The larger size of cattle from Period 6 can also be seen from the analysis of the metapodia (Figs 21 and 22). Both dimensions of these elements increase in size in the 16th–18th century. Length is a less sex-dependent measurement as is demonstrated by its generally lower coefficient of variation (Table 20), thus the increase in metapodia length may indicate a genuine shift towards a different cattle



Measurements are in tenths of millimetres

Figure 19 Variation of cattle M_3 width (all periods)

type. The variation in cattle metapodia size also increases in post-medieval times (Figs 21 and 22). This phenomenon has been noted elsewhere (Albarella and Davis 1996) and is either due to a greater variation in cattle types in later times or by the presence of residual specimens in the upper layers of the site.

The metapodium shape is sexually dimorphic, with bulls having more robust bones than cows. Nevertheless, the analysis of the metapodia shape failed to reveal any identifiable clusters (Figs 21 and 22). This is hardly surprising as very few bulls were kept in medieval villages and towns (Grand and Delatouche 1950, Thornton 1992) and cows and steers are difficult to distinguish morphologically. Differences in the shape of metapodia in medieval sites are likely to reflect the presence of different cattle types rather than different sexes (Albarella 1997a). However, an extremely robust metatarsus from Period 1 (Fig.22) may actually represent a bull or an achondroplastic animal (many thanks to Sebastian Payne for the latter suggestion). The slightly more robust shafts of the cattle from Period 6 (Fig.21) may be a typical feature of the larger post-medieval animals.

A comparison between specimens from York (O'Connor 1986), Launceston Castle (Albarella and Davis 1996), West Cotton (Albarella and Davis 1994), Leicester (Gidney 1991a, 1991b) and Castle Mall
Measurements are in tenths of millimetres

Figure 20 Cattle astragalus distal breadth

The difference between medieval and post-medieval cattle becomes striking when the horncores are considered. Horncores from Period 6 are much larger than those from any other periods, whereas no change seems to occur between Saxon, early and mid medieval specimens (Fig.23A and 23B). Interestingly, the post-medieval horncores also have a very different shape, with a relatively much smaller base (Fig.23C). This is obviously the 'structural' consequence of having much longer horns, but it still seems that these horncores were more 'long' than 'massive'.

The evidence thus indicates short horned cattle in Late Saxon and medieval times and longer horned cattle in the late 16th–18th century (Period 6). This is consistent with the historical evidence that short horned cattle were widely distributed in the 12th and 13th century and could still be found until the 16th century (Armitage 1980). Long horned cattle first appeared in the late 14th–early 15th century (Armitage 1980) but became common only by the 16th century (Markham 1614, Trow-Smith 1957). On the basis of historical and archaeological evidence Armitage (1980) defines three main types of long horned cattle:

long-horned: late medieval–early Tudor; animals of large size; 'massive' horncores with large base.

longhorn: 17th–early 18th century; animals of small size; unimproved form of the modern 'Longhorn'

Longhorn: established in late 18th–early 19th century; improved breed; relatively small base.

On the basis of its rather large size, the shape of its horncores and its chronology it seems that the Period 6 cattle represent a form roughly intermediate between the *long-horned* and the *longhorn* types.

Late Saxon and medieval cattle from Castle Mall are similar in size to animals from other medieval sites in central England, but are larger than cattle from Cornwall (Fig.20). It has been suggested that the latter animals may be smaller due to their location in a marginal area (Albarella and Davis 1994a). The size of the post- medieval animals is also comparable to that found in other roughly contemporary sites in Britain, such as Exeter (Maltby 1979), Launceston Castle (Albarella and Davis 1996) and Lincoln (Dobney *et al.* 1996). These animals represent the product of the improvements in husbandry techniques which had been brought about by the 'agricultural revolution' which started before the beginning of Castle Mall Period 6 (Kerridge 1967, Davis 1997).

	Measurement	*Mean*	*V*	*Min*	*Max*	*N*
Period 1	Horncore L	1185	22.9	812	1700	13
	Horncore W_{max}	466	18.1	370	655	29
	Horncore W_{min}	357	17.3	260	563	25
	M_3L	342	7.2	263	377	22
	M_3WA	143	7.5	120	165	24
	Humerus BT	688	9.2	615	811	11
	Metacarpus GL	1811	4.4	1690	1940	15
	Metacarpus SD	292	11.3	241	347	16
	Metacarpus Bd	521	9.3	466	618	24
	Metacarpus 3	252	7.7	215	286	20
	Metacarpus BatF	471	8.6	411	578	22
	Metacarpus a	247	9.5	200	290	22
	Metacarpus b	237	9.7	191	284	23
	Tibia Bd	560	9.2	458	645	34
	Astragalus GLl	594	5.7	522	685	31
	Astragalus Bd	377	6.8	311	436	32
	Astragalus Dl	326	8.2	215	355	29
	Metatarsus Bd	478	5.6	441	557	19
	Metatarsus 3	248	4.1	227	264	19
	Metatarsus BatF	450	5.9	397	504	20
	Metatarsus a	228	7.2	206	279	18
	Metatarsus b	216	6.5	199	252	19
Period 2+3	Horncore L	1025	22.4	582	1446	21
	Horncore W_{max}	460	20.6	265	675	42
	Horncore W_{min}	346	17.7	212	496	41
	M_3L	339	5.7	309	388	33
	M_3WA	141	10.3	117	169	33
	Metacarpus GL	1803	6.9	1600	1960	15
	Metacarpus SD	275	11.7	223	321	13
	Metacarpus Bd	521	9.2	467	613	14
	Metacarpus 3	253	9.3	228	296	15
	Metacarpus BatF	478	9.7	428	586	14
	Metacarpus a	267	9.2	219	302	13
	Metacarpus b	244	10.1	215	288	13
	Pelvis LAR	616	6.6	561	695	10
	Tibia Bd	557	5.9	509	616	18
	Astragalus GLl	584	6.3	508	655	29
	Astragalus Bd	369	6.9	327	434	31
	Astragalus Dl	326	6.0	292	371	29
	Metatarsus GL	2026	6.9	1700	2270	15
	Metatarsus Bd	497	8.8	412	575	27
	Metatarsus 3	251	9.4	192	286	23
	Metatarsus BatF	461	8.2	394	529	26
	Metatarsus a	238	10.0	192	283	28
	Metatarsus b	225	9.5	181	262	24
Period 4	M_3WA	142	5.0	132	156	11
Period 5	M_3WA	145	7.0	129	161	10
	Metatarsus Bd	509	10.1	451	620	10
	Metatarsus 3	264	6.5	240	292	13
	Metatarsus BatF	454	11.2	377	548	12
	Metatarsus a	238	7.3	215	269	11
	Metatarsus b	230	10.1	202	275	11
Period 6	Horncore L	2339	25.7	1168	3190	15
	Horncore W_{max}	635	18.0	298	826	73
	Horncore W_{min}	540	19.6	237	747	70
	M_3L	359	6.7	314	407	18
	M_3WA	154	9.2	129	176	24
	Humerus BT	714	8.8	631	890	34
	Humerus HTC	323	9.8	247	393	42
	Metacarpus GL	1895	8.5	1550	2176	25
	Metacarpus SD	319	13.3	228	408	25
	Metacarpus Bd	555	10.9	426	701	28
	Metacarpus 3	270	8.8	229	324	30
	Metacarpus BatF	519	11.9	404	681	28
	Metacarpus a	268	11.6	222	348	26
	Metacarpus b	261	10.3	222	330	26
	Tibia Bd	609	9.5	519	725	27
	Metatarsus GL	2192	7.8	1912	2500	12
	Metatarsus SD	257	11.1	229	318	13
	Metatarsus Bd	525	9.2	460	638	17
	Metatarsus 3	271	7.6	238	318	17
	Metatarsus BatF	484	8.6	429	603	14
	Metatarsus a	255	10.3	225	313	13
	Metatarsus b	244	9.0	214	290	13

Fusing bones are included, unfused ones are not
A few measurements are approximated
All measurements are in tenths of millimetres
Only samples of at least 10 measurements are given

Table 20 Means, coefficients of variation (V), ranges and sample sizes for cattle measurements

Non-Metric Traits, Abnormalities and Pathologies

Two non-metric dental traits were regularly recorded for cattle: the absence of the lower second premolar (Andrews and Noddle 1975) and the absence of the third cusp, or hypoconulid, of the lower third molar.

The absence of the second premolar was a relatively common character, but unfortunately could only occasionally be recorded as the anterior part of the mandible was generally broken. In about 50% of the specimens the second premolar was absent (14 out of 30), but no variation in the occurrence of this trait could be noted between different periods.

In all periods the absence of the M_3 hypoconulid was rare. In only 4 out of 137 teeth (*c.*3%) the third cusp was missing or reduced. This condition is rather common in some Roman sites, such as Exeter (21% of cases; Maltby 1979), but remarkably unusual in late Roman Lincoln (Dobney *et al.* 1996). In Late Saxon Burystead and Langham Road (Davis 1992b) and in medieval West Cotton (Albarella and Davis 1994b) its occurrence was slightly greater than at Castle Mall. More than 10% of the late medieval cattle at Launceston Castle had a reduced or missing hypoconulid, but this condition almost completely disappeared in post-medieval times (Albarella and Davis 1996). The picture thus looks rather complicated: this trait can regularly be found in cattle populations from Roman to post-medieval times, but its frequency of occurrence was rather variable. If regularly recorded from other sites this character could represent a useful tool for identifying populations or perhaps regional types.

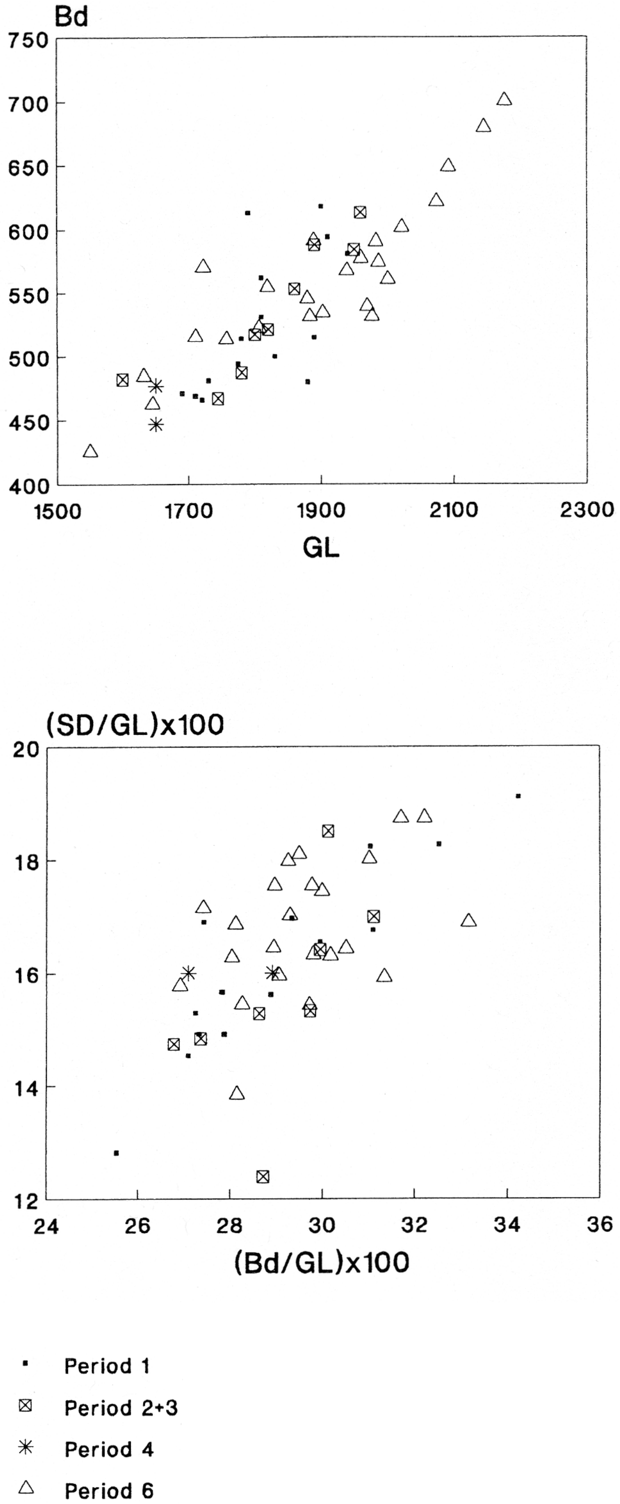
One of the most common abnormalities in cattle bones from archaeological sites is the asymmetry of distal metapodia caused by the abnormal development of the medial condyle. This condition, which has been claimed by many authors (*e.g.* Jewell 1963) to be due to traction stress, was virtually absent from Castle Mall. Only one metacarpus from Period 2 — the condition is generally more common in metatarsi — and one metatarsus from Period 5 had these arthropathic condyles. In addition to questioning the medieval use of cattle as draught animals this finding should cast some doubt upon the still undemonstrated association between metapodium asymmetry and traction stress.

Pathological bones were not particularly common, especially in later periods. Arthropathic conditions on metapodia and phalanges have been noted for Periods 1 and 2, whereas no evidence of spavin — namely the fusion of proximal metapodia to some of the carpal or tarsal bones — was found from any period. All these identified pathologies are traditionally associated with traction stress, but they may have alternative causes, for example they can be found in non-draught animals such as sheep. Two metatarsi from Periods 2 and 3 presented a swelling

Taxa	*Element*	*Measurement*	*Period compared*	*T - value*	*Probability*
Cattle	M3	WA	1 and 2+3	0.57	0.571
			2 +3 and 4	- 0.16	0.874
			4 and 5	- 0.84	0.414
			5 and 6	- 1.80	0.081
			1 and 2–4	0.58	0.561
			2–4 and 5–6	- 3.32	0.001**
	Tibia	Bd	1 and 2–4	0.52	0.604
			2–4 and 5–6	- 3.79	0.000**
Sheep / Goat	M3	WA	1 and 2+3	0.20	0.845
			2+3 and 4	- 0.04	0.969
			4 and 5	0.43	0.671
			5 and 6	- 3.22	0.002**
	Humerus	HTC	1 and 2+3	- 1.04	0.306
			2+3 and 4	2.33	0.026*
			4 and 5	- 1.06	0.296
			5 and 6	- 3.59	0.001**
Pig	M1	WP	1 and 2+3	0.75	0.458
			2+3 and 4	0.79	0.437
			4 and 5	- 1.29	0.215
			5 and 6	- 0.75	0.459
			1 and 2–4	0.97	0.338
			2–4 and 5–6	- 3.08	0.003**
Domestic Fowl	Tibiotarsus	Bd	1 and 2+3	1.50	0.141
			2+3 and 4	- 0.87	0.390
			4 and 5	- 1.63	0.113
			5 and 6	- 0.53	0.598
			1–4 and 5–6	- 3.55	0.001**
			1–4 and 5	- 2.42	0.018*
			1–4 and 6	- 3.07	0.003**
			1–5 and 6	- 2.65	0.009**

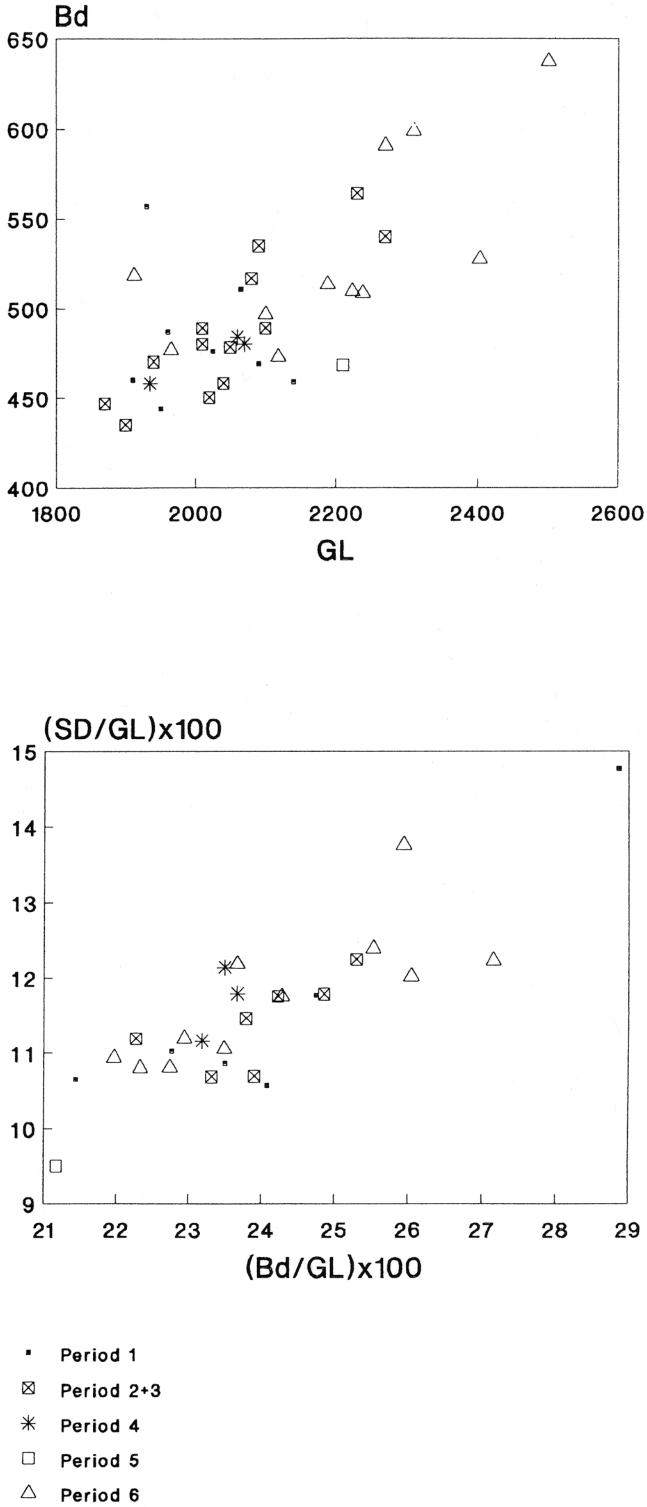
** = the difference is highly significant (with less than a 1% probability that it is due to chance)
* = the difference is significant (with less than a 5% probability that it is due to chance)
no asterisk = no significant difference (more than a 5% probability that it is due to chance)

Table 21 Significance of the size differences for cattle, sheep/goat and domestic fowl between different periods as indicated by a t-test.



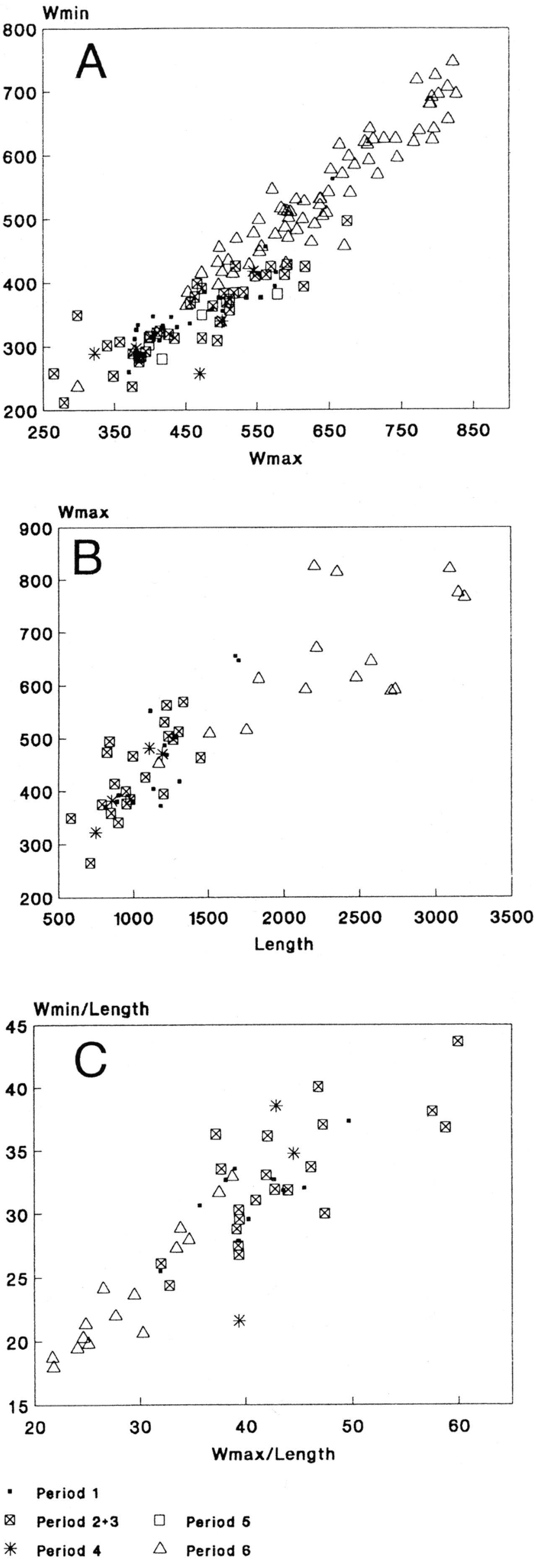
The bottom diagram is size independent: the higher the value the more robust the species

Figure 21 Size (top) and shape (bottom) variation of cattle metacarpus at Castle Mall



The bottom diagram is size independent: the higher the value the more robust the species

Figure 22 Size (top) and shape (bottom) variation of cattle metatarsus at Castle Mall



The bottom diagram is size independent

Figure 23 Size (A and B) and shape (C) variation of cattle horncores at Castle Mall

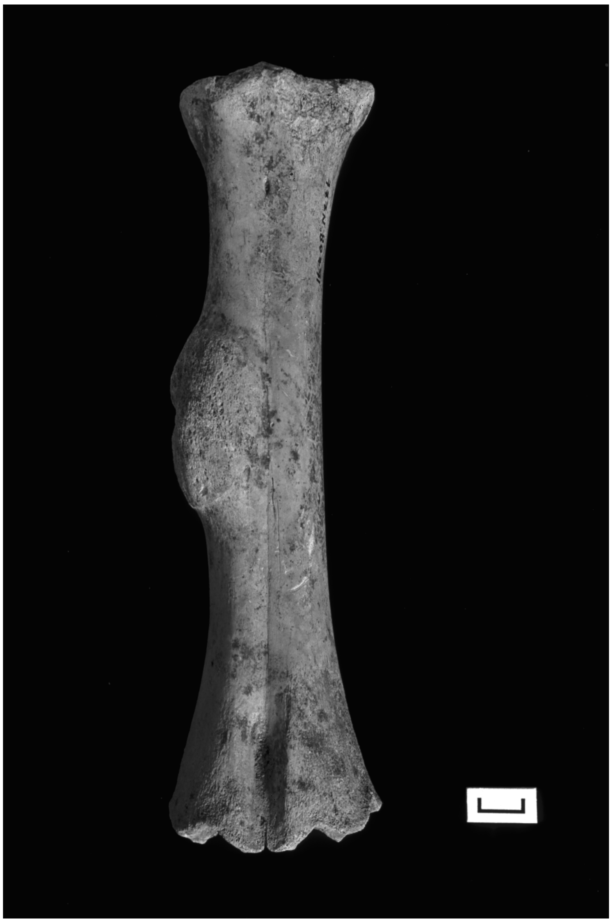


Plate 2 Cattle metatarsus (Period 2): ossified haematoma?

on the mid-shaft which looks like a haematoma caused by injury (see Baker and Brothwell 1980) (Plate 2). However, this does not seem to be associated with a fracture. Oral pathologies are mainly represented by the occasional occurrence of periodontal disease.

Butchery and Bone-Working

Butchery marks were recorded on about 20% of the cattle post-cranial bones. Chopping marks, in particular, were more common in Period 6 (Table 22). In all periods butchery marks were more common in cattle than in sheep and pig. This is presumably a consequence of the larger size of the cattle body which needs to be divided into a greater number of portions for processing.

Most of the chopping marks were produced by a cleaver or an axe. They are generally associated with the dismembering of the carcass — chops on articulations — or with the extraction of marrow — chops on long bone shafts. Cut marks were produced by a knife, and in most cases were to sever the tendons. However, when found on mandibles, metapodia and particularly phalanges, cut marks are more likely to be associated with skinning. In medieval times cattle hides were a secondary, but important, product of the cattle carcass (Grand and Delatouche 1950). Evidence for the use of ox hides has been found in all periods at Castle Mall and this is consistent with the historical evidence for a flourishing leather industry and market in Norwich (see above and Parts I and II).

	Period 1							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	79	**15**	30	**6**	102	**19**	84	**16**
Sheep / Goat	14	**7**	15	**7**	27	**13**	30	**14**
Pig	16	**5**	22	**7**	33	**11**	31	**10**
Equid	1	**3**	1	**3**	2	**5**	1	**3**
Dog	-	**0**	1	**2**	1	**2**	-	**0**
Cat	-	**0**	8	**6**	8	**6**	-	**0**
total	**110**	**9**	**77**	**6**	**173**	**14**	**146**	**11**
	Period 2							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	49	**13**	36	**10**	79	**22**	67	**18**
Sheep / Goat	11	**7**	20	**13**	28	**18**	23	**14**
Pig	3	**2**	6	**3**	9	**5**	29	**16**
Equid	1	**4**	1	**4**	2	**8**	8	**32**
Dog	1	**1**	2	**2**	2	**2**	-	**0**
Cat	1	**1**	3	**5**	4	**7**	-	**0**
total	**66**	**8**	**68**	**8**	**124**	**14**	**127**	**15**
	Period 3							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	5	**8**	11	**16**	16	**25**	8	**13**
Sheep / Goat	2	**4**	1	**3**	3	**6**	5	**10**
Pig	-	**0**	2	**2**	2	**6**	5	**14**
Equid	-	**0**	-	**0**	-	**0**	1	**25**
Dog	-	**0**	-	**0**	-	**0**	-	**0**
Cat	-	**0**	-	**0**	-	**0**	-	**0**
total	**7**	**4**	**14**	**9**	**21**	**13**	**19**	**12**
	Period 4							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	21	**15**	12	**9**	23	**16**	9	**6**
Sheep / Goat	9	**7**	11	**8**	30	**23**	14	**11**
Pig	3	**5**	5	**8**	7	**11**	7	**11**
Equid	0	**-**	1	**20**	1	**20**	-	**0**
Dog	0	**-**	-	**0**	-	**0**	-	**0**
Cat	0	**-**	-	**0**	-	**0**	-	**0**
total	**33**	**8**	**29**	**7**	**61**	**16**	**30**	**8**
	Period 5							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	53	**19**	13	**5**	61	**22**	18	**6**
Sheep / Goat	17	**4**	61	**13**	73	**15**	27	**6**
Pig	5	**5**	8	**7**	13	**12**	9	**8**
Equid	-	**0**	-	**0**	-	**0**	-	**0**
Dog	-	**0**	-	**0**	-	**0**	-	**0**
Cat	-	**0**	-	**0**	-	**0**	-	**0**
total	**75**	**8**	**82**	**9**	**147**	**15**	**54**	**6**
	Period 6							
	Chopping		*Cuts*		*Total butchery*		*Gnawing*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Cattle	164	**30**	36	**7**	189	**35**	40	**7**
Sheep / Goat	43	**9**	60	**13**	106	**23**	42	**9**
Pig	8	**7**	5	**5**	11	**10**	7	**6**
Equid	6	**5**	13	**10**	17	**13**	2	**2**
Dog	1	**1**	1	**1**	2	**3**	-	**0**
Cat	-	**0**	1	**1**	1	**1**	-	**0**
total	**222**	**16**	**116**	**8**	**326**	**23**	**91**	**6**

Total butchery includes chop and cut marks (its value is lower than the total of chopping and cuts because some bones were chopped *and* cut). Gnawing includes digested bones and bones gnawed by carnivores or rodents. The percentage is calculated from the total number of postcranial bones in that period

Table 22 Percentages of butchered and gnawed postcranial bones

One third phalanx with a chop mark on the plantar side may indicate an interest in the hoof as working material. However, the keratinous material the Norwich people were mainly after was horn. One hundred and eighty-five cattle horncores, 69 of which bear chop or cut marks, have been found at Castle Mall. They are distributed throughout all periods although major concentrations were found in Periods 2 and 6. Most chop and cut marks are located at the base of the horncore (Plate 3) and were presumably made to separate the horncores from the skull and to remove the horn sheath from its bony core. This was generally done after soaking the horncore in water for some weeks (MacGregor 1985), but it could also be done through desiccation (Keith Dobney pers. comm.). Strangely two of the Period 6 horncores had been sawn rather close to their tips (Plates 4 and 5), perhaps to help the separation of the horn sheath or because there was some specific interest in the horn tip or, more likely, in producing a flat sheet of horn (many thanks to Keith Dobney for this suggestion). Similar evidence was later found at Golden Ball Street (see Curl, Chapter 6).

Evidence of bone working was also abundant. This is discussed in more detail by Huddle (Parts I and II), and is therefore only briefly mentioned here. Sawn bones, mainly metapodia (Plate 6), were found in Periods 1 and 6 and illustrate the use of the robust metapodium shaft to make tools. Other chopping marks were also probably aimed at bone working. A group of cattle and sheep metapodia from Period 6 had been subject to some faceting (Plate 7) as a possible preliminary stage in bone tool production and this work was then abandoned (see Huddle, Part II, Chapter 10.III). Similar evidence has been found on another metatarsus and a series of metacarpi from Period 6. Femur heads were regularly used in Periods 1 and 2 to make spindle whorls, and testify to two of the common activities in Saxo-Norman Norwich: bone working and the weaving of wool.

VI. Sheep/Goat

(Pls 8–15, Figs 24–34, Tables 23–32)

Sheep or Goat?

The large majority of caprine specimens belong to sheep (Tables 4–6). The two species were separated on the basis of morphological criteria (see 'Methodology' for details). Metrical analysis was undertaken as a check on identifications (Fig.24). It must be noted that all unidentified specimens ('sheep/goat') plot together with the sheep clusters and thus almost certainly belong to this species. This suggests that the actual sheep/goat ratio is higher than that expressed in Table 4.

The scarcity of goats is not surprising as they are similarly scarce at most other British archaeological sites. Goats are, much more than sheep, adapted to a warmer climate and a rockier environment. Although regularly used in small numbers, they have never been very successful in northern Europe.

Although goats are uncommon in all periods at Castle Mall, this is particularly so in late medieval and post-medieval times. Even excluding the five 'identifiable' bones which belong to a partial skeleton from Period 1 (Tables 4 and 7), goats represent 7% of the sheep *and* goat total in Period 1+2, and less than 1% in Period 5+6. The decline of goats in Britain is historically attested and may be linked to the enclosure of land, as goats were

Plate 3 Cattle horncore (Period 6): cut marks near base

Plate 4 Cattle horncore (Period 6): sawn near the tip

Plate 5 Cattle horncore (Period 6): sawn near the tip

Plate 6 Cattle metatarsus (Period 6): sawn

Plate 7 Cattle and sheep metapodia (Period 6): bone-working

considered destroyers of hedgerows. Burke (1834 vol.2, 505) wrote that for goats: 'the enclosure of land has...banished them from the soil, as they nip the hedges, and bound over the highest common fences'.

Goats at Castle Mall are much better represented by their horncores (Plate 8), which, in earlier periods, are almost as common as sheep horncores (Table 23). These elements are not useful in calculating the frequencies of species, as they can be missing from the females of some breeds and are subject to a different pattern of preservation. As a result they are of no use in establishing sex ratios, because even in breeds where both sexes are horned, male horncores tend to be more robust and therefore to preserve better. The relatively high frequency of goat horncores compared to teeth and post-cranial bones has been noted elsewhere in Norwich (Cartledge 1987; Jones 1994) and also on other urban sites (*e.g.* King's Lynn: Noddle 1977; York: O'Connor 1988 and Keith Dobney pers. comm.). This suggests that horncores alone or hides with horncores still attached were imported to the town for handicraft purposes without the rest of the carcass. Goatskin was found in the Norwich barbican well, having been used to produce saddlery/upholstery (Mould, Chapter 9.III). Goats were probably bred in the countryside mainly for milk production. Goat meat has never been highly regarded in England (Markham 1614, Burke 1834), and thus was probably consumed by goat breeders themselves and only occasionally sold in the market, where its value would have been low.

Due to the overwhelming majority of sheep remains, the discussion in the rest of this section will almost entirely concern this animal.

Plate 8 Goat horncores (Period 1)

Period	*Sheep*	*Goat*	***total***
1	14	13	27
2	12	6	18
3	4	3	7
4	9	-	9
5	54 (33*)	3	57 (36*)
6	7	4	11
total	**100**	**29**	**129 (108*)**

* in these figures a 'special' context (11030) containing an accumulation of sheep horncores, metapodia and phalanges has been excluded

Table 23 Number of sheep and goat horncores by period

Anatomical Distribution

The recovery bias, discussed earlier with regard to cattle, is even more important in the interpretation of the body part distribution of the smaller species, such as sheep. Small elements are regularly under-represented in all periods (Tables 9 and 22; Fig.25). If the presence on site of whole carcasses is assumed, there is a loss of about 90% of incisors, astragali, calcanei and proximal phalanges, and almost 100% of carpals and distal phalanges. Unfortunately, as discussed above, the sieved assemblage is too small and not sufficiently comparable to the hand-collected material to allow the calculation of correction factors for the distribution of the anatomical elements. However, it is of some interest to note that 8% of sheep post-cranial elements from sieving are astragali and 27% are phalanges. These figures drop respectively to 1.5% and 10% when calculated from the hand-collected assemblage. Other elements such as cranium and femur are also rather uncommon, but this is more probably due to a preservation bias (see Brain 1967).

The distribution of body parts in Periods 1 and 2 can probably be explained entirely on the basis of differential recovery and preservation. The most common elements, such as tibia and mandibles, are those which preserve well and are large enough not to be overlooked on site. The remains from these early periods probably derive from the dismembering and butchery of complete carcasses. In Period 4 a higher number of cranial elements is found and this is interesting when considered in relation to the hind-limb bones which carry the best meat cuts. It is possible that by this period the castle ditches and pits were more commonly used for discarding primary butchery and industrial refuse — however, the sample from this period is not very large and the results must therefore be treated with caution.

In Period 5 teeth remain very common but the number of metapodia increases. Although the bones in this period clearly represent the consequence of a mixture of different activities, the contribution of industrial (bone-, horn- and leather working) and possibly primary butchery refuse may increase. Even excluding a large group from a possible 'tanning pit', metatarsi remain the most common elements for this period (Table 24).

In Period 6 a very different picture emerges: scapula becomes by far the most common body part. This is

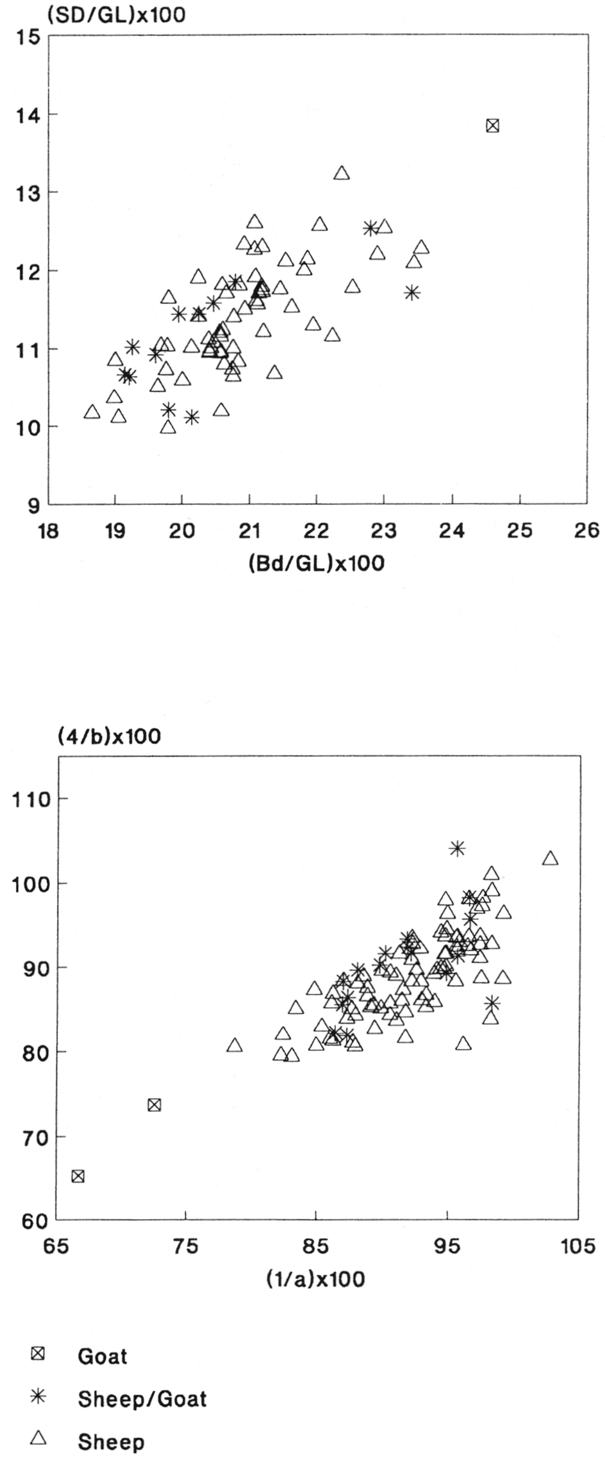


Figure 24 Shape of sheep and goat metacarpus at Castle Mall. This is expressed by the general robustness of the bone (top) and by the ratio between the trochlea depths and condyle widths (see Payne 1969) (bottom)

unusual as the scapula is not one of the elements which survive well (see Brain 1967). In the 'dog gnawing' experiment carried out by Payne and Munson (1985) the scapula was the element least likely to survive. This high number of scapulae must therefore be due to the manner in which the carcass was dressed and imported to the site. Sheep scapulae are particularly common in the barbican ditch fills (37% of the total number of bones, as opposed to the 15% from the rest of the site) and this may suggest that they represent the consequence of a specific pattern of distribution and disposal of meat cuts of sheep. However, they do not represent a single episode of accumulation, as they are dispersed through many different contexts of this very large ditch. Butchery evidence supports the suggestion that the barbican ditch scapulae derive from a different process and that the situation on the rest of the site reflects a more common, standard distribution. Only 1 scapula out of 62 (<1%) from the barbican ditch bore butchery marks as opposite to 16 out of 40 (40%) from the rest of the site. The percentage of sheep scapulae with butchery marks from other periods is about 30%. It can thus be hypothesised that some houses or tenements regularly received or produced specific cuts of meat which included the scapula and the proximal humerus (here not recorded, and generally poorly preserved on archaeological sites); food refuse from these meat cuts was subsequently discarded in the barbican ditch. On the rest of the site it is possible that the scapula was generally separated from the humerus which would explain the higher frequency of cut marks.

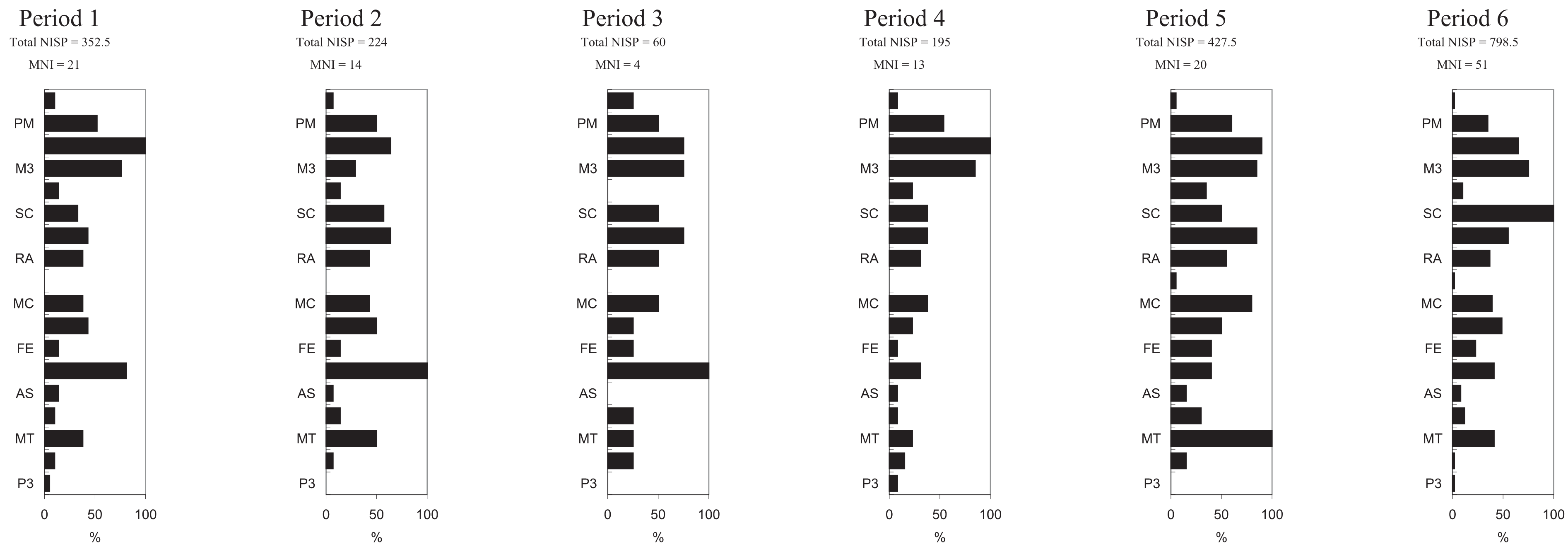
It is interesting to note that in early periods the best represented long bone is the tibia, whereas the humerus becomes more common by late medieval times. This has been observed on other sites such as Exeter (Maltby 1979) and Launceston Castle (Albarella and Davis 1996). It would be interesting to check whether the same pattern is found elsewhere as it might be connected to a general change in procurement and butchery practices.

Ageing Data

Throughout the Castle Mall sequence most sheep were killed between the second and the sixth year (mandibular wear stages D–G). This suggests a mixed economy aimed at the production of meat and wool. However, in Periods 1 to 3 the slaughter is concentrated on the lower part of the range (meat emphasis), whereas in Periods 5 and 6 more animals were slaughtered between the fourth and fifth year (wool emphasis). Unfortunately, only a small number when the wool industry was at its height.

Eruption and wear stages of individual teeth (Tables 25 and 27; Fig.18) and tooth rows (Table 26; Fig.26) have both been considered in the interpretation of the sheep kill-off pattern. The reconstruction of the mortality curve through mandibular wear stages has been carried out in two different ways (Table 26). In one system all mandibles with at least two teeth with recordable wear, in the dP_4/P_4 – M_3 row, were taken into account, whereas in the other system, following Payne's (1973) recommendations, only mandibles with a dP_4/P_4 in place have been considered. The two methods gave similar results (Table 26) and, since it produced a larger number of mandibles, the first one was chosen.

Data both from individual teeth and mandibles suggest a gradual increase in the age at which sheep were culled. Minor changes can be noted between different stages, but these may be due to chance, and probably the only significant trend is towards a higher number of mature animals in later periods. When Periods 1–4 and 5–6 are combined the difference in the mortality curve, as reconstructed through mandibular wear stages, is statistically significant (Table 18). Only a few data from Period 4 could be collected, but they suggest that a high number of mature animals were killed in this period.



Percentages are calculated on the basis of the frequency of an element in relation to the most common one (by MNI)
IN = deciduous and permanent incisors, PM = deciduous and permanent premolars, M1/2 = 1st and 2nd molars, M3 = 3rd molars, CR = cranium (zygomaticus), SC = scapula, HU = humerus, RA = radius, CP = carpal, MC = metacarpus, PE = pelvis, FE = femur, TI = tibia, AS = astragalus, CA = calcaneus, MT = metatarsus, P1 = 1st phalanx, P3 = 3rd phalanx
NB the special group of sheep bones from context 11030 has been excluded

Figure 25 Sheep/goat body parts

	Period																				
	1			*2*			*3*			*4*			*4*			*5*			*6*		
Element	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*
Deciduous + permanent incisors	12	2	**10**	3	1	**7**	1	1	**25**	6	1	**8**	8	1	**2**	8	1	**5**	6	1	**2**
Deciduous + permanent premolars	63	11	**52**	41	7	**50**	12	2	**50**	37	7	**54**	70	12	**26**	70	12	**60**	108	18	**35**
M1/2	82	21	**100**	33	9	**64**	10	3	**75**	50	13	**100**	69	18	**38**	69	18	**90**	132	33	**65**
M3	31	16	**76**	7	4	**29**	6	3	**75**	22	11	**85**	34	17	**36**	34	17	**85**	75	38	**75**
Cranium	6	3	**14**	3	2	**14**	-	-	**-**	5	3	**23**	14	7	**15**	14	7	**35**	9	5	**10**
Scapula	14	7	**33**	16	8	**57**	3	2	**50**	10	5	**38**	19	10	**21**	19	10	**50**	102	51	**100**
Humerus	18	9	**43**	17	9	**64**	5	3	**75**	10	5	**38**	33	17	**36**	33	17	**85**	56	28	**55**
Radius	16	8	**38**	12	6	**43**	4	2	**50**	7	4	**31**	22	11	**23**	22	11	**55**	37	19	**37**
Carpal	-	-	**-**	-	-	**-**	-	-	**-**	-	-	**-**	1	1	**2**	1	1	**5**	1	1	**2**
Metacarpus	16	8	**38**	10.5	6	**43**	3	2	**50**	10	5	**38**	84.5	43	**91**	30.5	16	**80**	38.5	20	**39**
Pelvis	18	9	**43**	14	7	**50**	2	1	**25**	5	3	**23**	20	10	**21**	20	10	**50**	50	25	**49**
Femur	6	3	**14**	4	2	**14**	1	1	**25**	2	1	**8**	16	8	**17**	16	8	**40**	24	12	**23**
Tibia	33	17	**81**	27	14	**100**	8	4	**100**	8	4	**31**	15	8	**17**	15	8	**40**	42	21	**41**
Astragalus	6	3	**14**	2	1	**7**	-	-	**-**	1	1	**8**	5	3	**6**	5	3	**15**	7	4	**8**
Calcaneus	4	2	**10**	3	2	**14**	2	1	**25**	2	1	**8**	12	6	**13**	12	6	**30**	11	6	**12**
Metatarsus	15.5	8	**38**	12.5	7	**50**	1	1	**25**	6	3	**23**	94	47	**100**	39	20	**100**	42	21	**41**
Phalanx 1	10	2	**10**	7	1	**7**	2	1	**25**	12	2	**15**	64	8	**17**	20	3	**15**	6	1	**2**
Phalanx 3	2	1	**5**	-	-	**-**	-	-	**-**	2	1	**8**	16	2	**4**	-	-	**-**	2	1	**2**
total	**352.5**			**212**			**60**			**195**			**596.5**			**427.5**			**748.5**		

Each individual tooth within mandibles has been counted, hence the total is greater than the total NISP in Table 4
The MNI has been calculated as follows:
Incisors and phalanges have been divided by 8, deciduous + permanent premolars and incisors by 6, $M_{1/2}$ by 4, all other elements, except metapodia, by 2
Metacarpus = (MC1 + MC2/2 + MP1/2 + MP2/4) / 2
Metatarsus = (MT1 + MT2/2 + MP1/2 + MP2/4) / 2
Where: MC1 = complete distal metacarpus; MC2 = half distal metacarpus; MT1 = complete distal metatarsus; MT2 = half distal metatarsus; MP1 = complete distal metapodium; MP2 = half distal metapodium
% = frequency of an element expressed in relation to the most common one (by MNI)
* = in this count a 'special' group of sheep metapodia and phalanges (context 11030) has been excluded

Table 24 Parts of the sheep/goat skeleton by number of fragments (NISP) and minimum number of individuals (MNI) . Unfused epiphyses are not counted. Only hand-collected material is included

		C	*V*	*E*	*H*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
DP4	Period 1							1			1							1	5			2						2	2
	2									1					2				1	2					1				
	3																												1
	4					1				1												1					1		1
	5														1				3										2
	6																		3	2			1						1
P4	Period 1				1		1			2		2	2	6	10			4		1									
	2							1					1	3	3			2						1					
	3								1					2				1											
	4			1	1					1	1		1	2	5		3	3		1									
	5					1							4	8	8		1	6			1								
	6					1	2	1			2		6	4	17		4	11		2	1								
M1	Period 1		3	1	1						1		1	1	26	6	1	3			2								
	2		2					2						1	6	4	1				2								
	3														4	1				2									
	4		1												10	2	1	4			3								
	5		1	1				1							15	2	4	2	1	3	4								
	6			2	1			3							29	10	6	9	1	4	4	1							
M2	Period 1							1		3		1	7	5	19		2												
	2	1									1		3	2	10														
	3												1		4														
	4									1		2	3		10			1		1									
	5	2											1	1	28	1	1	1		1	1								
	6	1								1		2	7	4	50				1		1								
M1/2	Period 1												3	2	2														
	2								1			1	1		1			1			1								
	3					1																							
	4											1	1	1	8		1				1								
	5											1	1	2	4														
	6											1		1	4			1		1									
M3	Period 1	3	2					3		6			1	5	2	1	11	1											
	2		2							1		1	2			1	3												
	3		1								1		1		1	1	1						1						
	4	1	3		1		1	1		2				1	1		10			1									
	5	1				1		1		2	2	3		4	5	5	12		1										
	6	3	1			1	3	3	1	4	3	3	1	6	11	5	33					1							

Both teeth in mandibles and isolated teeth are included
Unworn isolated teeth which could have been in one of the eruption stages (C, V, E, H) are coded as ‘0’

Table 25 Sheep/goat wear stages of individual teeth (following Payne 1973 and 1987)

Sheep/Goat 1

Period	*A*		*B*		*C*		*D*		*E*		*F*		*G*		*H*		*I*		*total*
	Mandibular wear stage																		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
1	-	**0**	5	**10**	2	**4**	9	**18**	17	**34**	6.5	**13**	8	**16**	2	**4**	-	**0**	49
2 + 3	-	**0**	2	**7**	2	**7**	5	**19**	7.8	**29**	3.3	**12**	5.8	**22**	-	**0**	1	**4**	26.9
4	1	**5**	-	**0**	-	**0**	5	**24**	3.5	**17**	1.5	**7**	6.3	**30**	2	**11**	1	**6**	20.9
5	-	**0**	2	**5**	1	**3**	2	**4**	11	**29**	8.8	**23**	10	**26**	3	**8**	1	**3**	38.9
6	-	**0**	2	**3**	3	**4**	5	**6**	20	**26**	14.8	**20**	29	**38**	1	**1**	2	**2**	74.9

Sheep/Goat 2

Period	*A*		*B*		*C*		*D*		*E*		*F*		*G*		*H*		*I*		*total*
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
1	-	**0**	5	**12**	1	**2**	6	**14**	16	**37**	6.5	**15**	7	**17**	1	**2**	-	**0**	42
2 + 3	-		2		2		1		4.8		1.8		4.3		-		1		16.9
4	1		-		-		4		2.5		1.5		6.3		2		1		18.9
5	-	**0**	2	**6**	1	**3**	2	**5**	9.8	**32**	6.3	**20**	8.3	**27**	2	**6**	-	**0**	30.9
6	-	**0**	2	**3**	3	**5**	2	**2**	19	**30**	13.8	**22**	23	**36**	0	**<1**	1	**2**	63.4

Sheep/Goat 1 = Only mandibles with two or more teeth (with recordable wear stage) in the dP_4/P_4 - M_3 row are considered
Sheep/Goat 2 = Only mandibles with two or more teeth (with recordable wear stage) in the dP_4/P_4 - M_3 row, one of the which is dP_4/P_4, are considered
Percentages are only calculated where the sample is greater than 20 within a particular period

Table 26 Sheep/Goat mandibular wear stages (following Payne 1973)

Period	*Age ranges*	*Tooth*	*Wear stage*	*% killed within age range*	*cumulative % killed*	*Age*
1	0–2 years	9 dP_4 (+5)		25% (33%)	25% (33%)	*c.*2 years
	> 2 years	27 P_4 (+2)		75% (67%)		
	2–3 years	8 M_3 (+1)	2–4	22% (20%)	47% (53%)	*c.*3 years
	3–5 years	8 M_3 (+1)	5–10	22% (20%)	69% (73%)	*c.*5 years
	6–10 years	11 M_3 (+0)	11G	29% (25%)	97% (98%)	*c.*10 years
	> 10 years	1 M_3 (+0)	>11G	3% (2%)	100% (100%)	
Period	*Age ranges*	*Tooth*	*Wear stage*	*% killed within age range*	*cumulative % killed*	*Age*
2+3	0–2 years	8 dP_4 (+3)		38% (42%)	38% (44%)	*c.*2 years
	> 2 years	13 P_4 (+2)		62% (58%)		
	2–3 years	- M_3 (+1)	2–4	0% (4%)	38% (46%)	*c.*3 years
	3–5 years	6 M_3 (+2)	5–10	37% (33%)	75% (79%)	*c.*5 years
	6–10 years	3 M_3 (+1)	11G	19% (17%)	94% (96%)	*c.*10 years
	> 10 years	1 M_3 (+0)	>11G	6% (4%)	100% (100%)	
Period	*Age ranges*	*Tooth*	*Wear stage*	*% killed within age range*	*cumulative % killed*	*Age*
4	0–2 years	3 dP_4 (+3)		14% (24%)	14% (24%)	*c.*2 years
	> 2 years	18 P_4 (+1)		86% (76%)		
	2–3 years	3 M_3 (+0)	2–4	16% (14%)	30% (38%)	*c.*3 years
	3–5 years	2 M_3 (+0)	5–10	11% (10%)	41% (48%)	*c.*5 years
	6–10 years	10 M_3 (+0)	11G	54% (48%)	95% (96%)	*c.*10 years
	> 10 years	1 M_3 (+0)	>11G	5% (5%)	100% (100%)	
Period	*Age ranges*	*Tooth*	*Wear stage*	*% killed within age range*	*cumulative % killed*	*Age*
5	0–2 years	5 dP_4 (+1)		16% (17%)	16% (17%)	*c.*2 years
	> 2 years	27 P_4 (+2)		84% (83%)		
	2–3 years	2 M_3 (+1)	2–4	5% (7%)	21% (24%)	*c.*3 years
	3–5 years	18 M_3 (+1)	5–10	49% (45%)	70% (69%)	*c.*5 years
	6–10 years	10 M_3 (+2)	11G	27% (28%)	97% (97%)	*c.*10 years
	> 10 years	1 M_3 (+0)	>11G	3% (2%)	100% (100%)	
Period	*Age ranges*	*Tooth*	*Wear stage*	*% killed within age range*	*cumulative % killed*	*Age*
6	0–2 years	7 dP_4 (+0)		13% (12%)	13% (12%)	*c.*2 years
	> 2 years	47 P_4 (+6)		87% (88%)		
	2–3 years	8 M_3 (+0)	2–4	11% (10%)	24% (22%)	*c.*3 years
	3–5 years	26 M_3 (+3)	5–10	35% (36%)	59% (58%)	*c.*5 years
	6–10 years	30 M_3 (+3)	11G	40% (41%)	99% (99%)	*c.*10 years
	> 10 years	1 M_3 (+0)	>11G	1% (1%)	100% (100%)	

Unworn P_4s are included and wear stages are as in Payne (1973). Teeth recovered from sieved samples are added in parenthesis.
Calculations including teeth recovered from sieved samples are also in parenthesis

Table 27 Sheep/goat, kill-off pattern at Castle Mall based upon single teeth (dP_4/P_4 and M_3) and teeth (dP_4/P_4 and M_3) in mandibles, using the system suggested by Payne (1988)

Data from post-cranial bones (Table 28) also indicate an older age for late and post-medieval animals. This evidence is not as convincing as the tooth wear data, particularly when metatarsi and phalanges are considered. It may be that industrial and craft activities have affected the distribution of the fusion data.

In early periods the age of slaughter suggests that most sheep had been bred for meat production. In later medieval times, probably already by the late 13th–early 14th century (Chris Dyer pers. comm.), the emphasis seems to shift towards wool production. This trend is further increased in post-medieval times. The presence of a considerable number of animals older than four years in later periods suggests either local breeding for wool or that poor quality meat was purchased by the Norwich inhabitants. Indeed Muffet (1655) suggests that the best mutton is not above four years old.

The mortality curve for the Late Saxon period resembles that found at the urban site of *Hamwic*, Southampton (Bourdillon and Coy 1980), but differs from the rural site of West Stow (Crabtree 1990). In the latter site a much higher number of animals were killed in their first year. However, West Stow, although geographically closer than Southampton, is much earlier than Castle Mall in date and its sheep husbandry strategies may have continued the Roman tradition.

The trend towards culling of older animals in late medieval and post-medieval periods has been consistently found on many sites in different areas of England, such as Leicester St Peter's Lane (Gidney 1991b and 1991c),

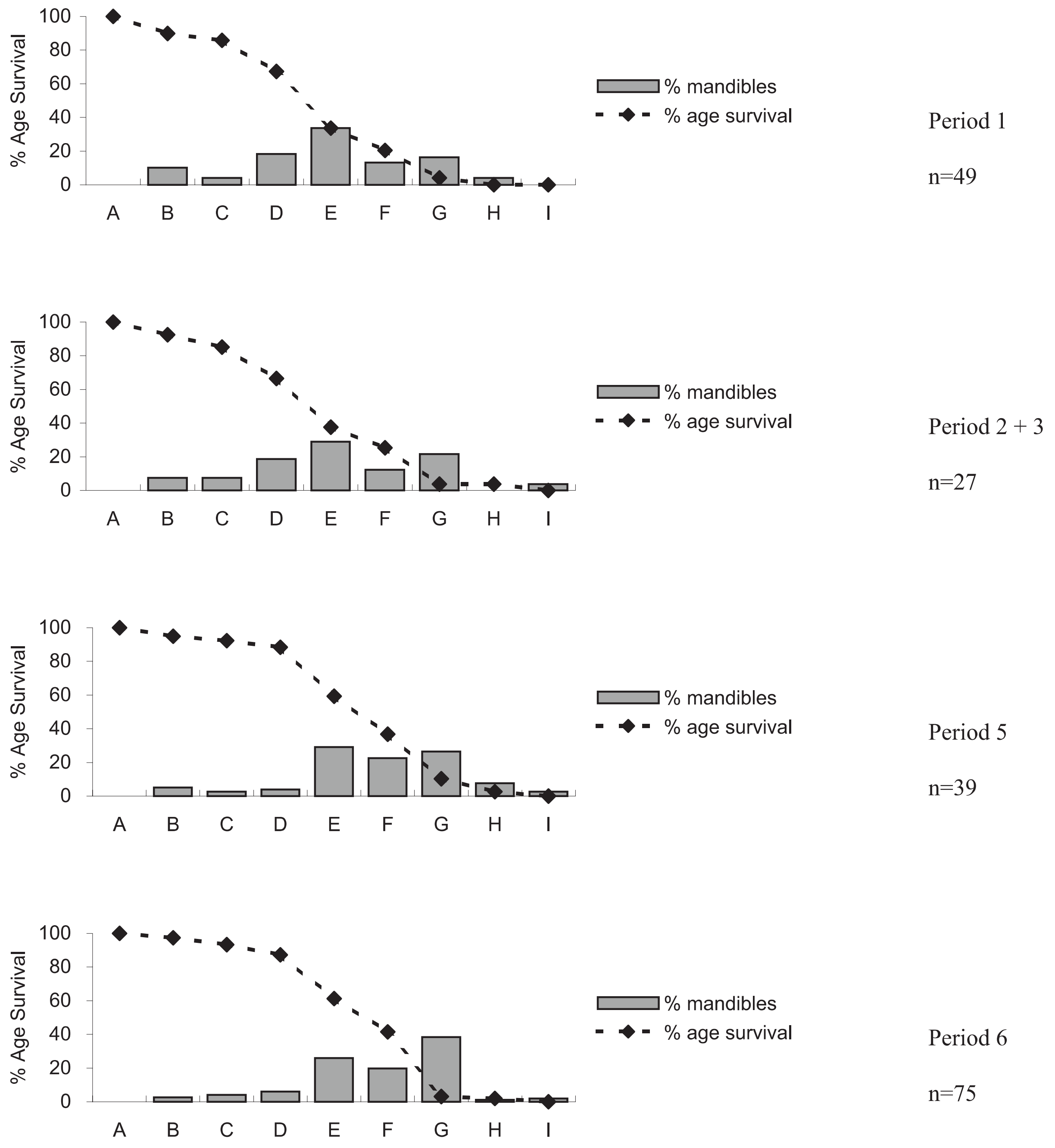
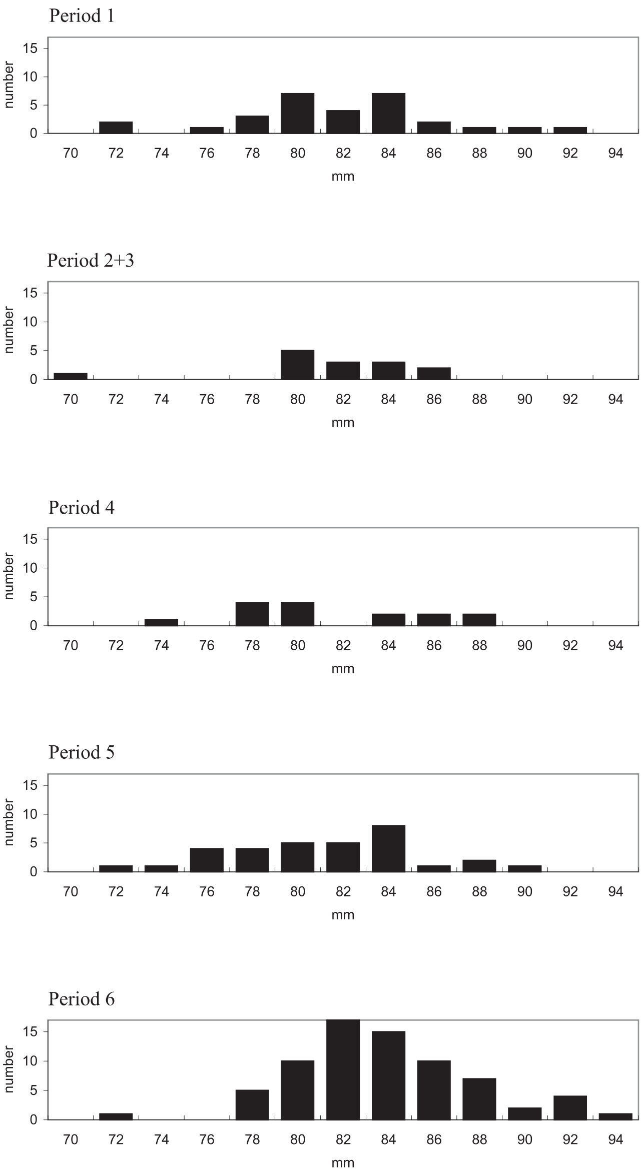


Figure 26 Relative percentages of sheep/goat mandibles by age stage (all periods). Age stages are from Payne (1973). All mandibles with two or more teeth with recordable wear in the $dP_4/P_4 – M_3$ row were considered

Element	Period 1 n	Period 1 %	Period 2+3 n	Period 2+3 %	Period 4 n	Period 4 %	Period 5 n	Period 5 %	Period 6 n	Period 6 %
Scapula d	16	**100**	18	**90**	8	**73**	19	**83**	97	**93**
Humerus d	19	**95**	28	**97**	**15**	94	33	**94**	56	**100**
Radius d	8	**47**	5	**26**			14	**64**	22	**56**
Metacarpus d	10	**63**	7	**47**	7	**58**	77	**86**	28	**70**
Pelvis a	20	**91**	16	**100**	**8**	80	21	**95**	50	**100**
Femur d							**13**	76	17	**68**
Tibia d	28	**76**	32	**86**	**6**	60	18	**100**	35	**81**
Calcaneus							12	**92**	9	**75**
Metatarsus d	15	**83**	6	**46**			92	**93**	27	**61**
Phalanx 1	11	**85**			13	**76**	80	**98**		

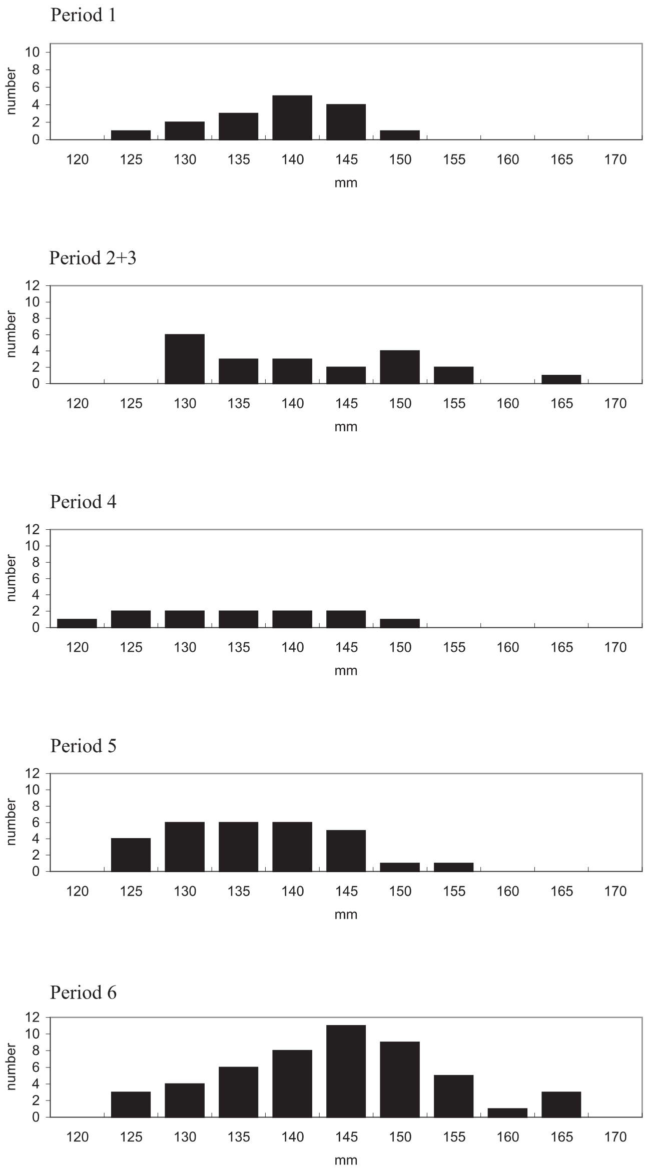
n = total number of fused/ing epiphyses
% = percentage of fused/ing epiphyses out of the total number of fused/ing epiphyses and unfused diaphyses
d = distal, a = acetabulum
Figures for total number of epiphyses smaller than 10 have been omitted

Table 28 Sheep/Goat, number and percentage of fused epiphyses . Fused and fusing epiphyses are amalgamated. Only unfused diaphyses, not epiphyses, are counted



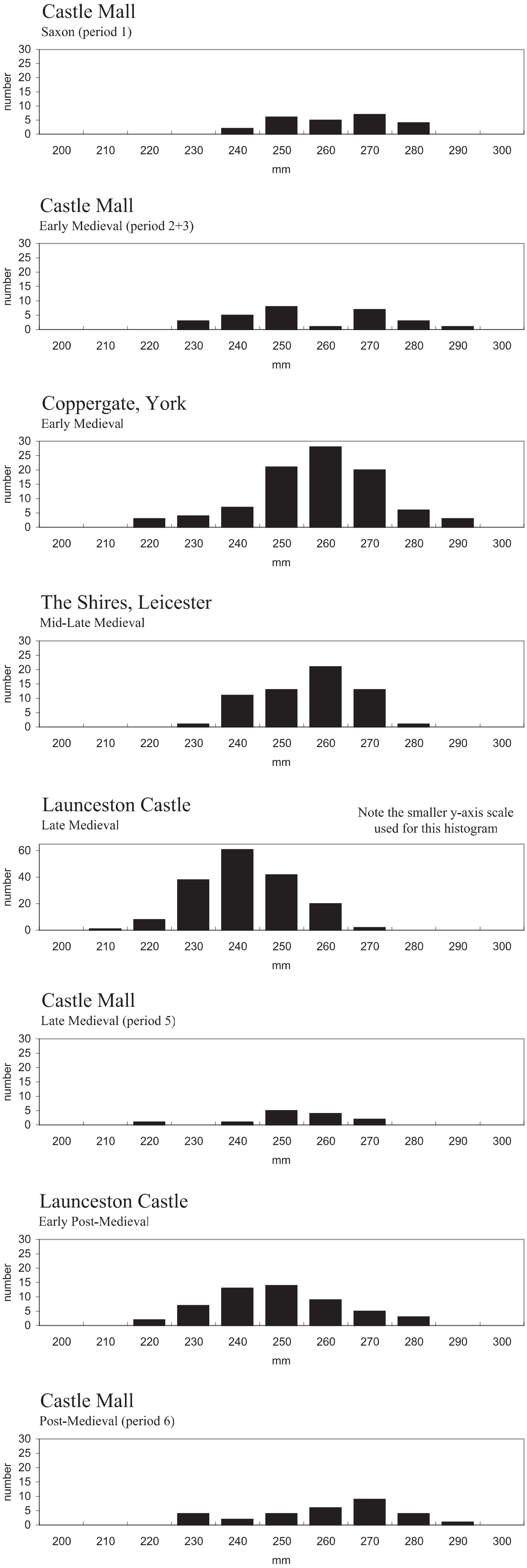
Measurements are in tenths of millimetres

Figure 27 Variation of sheep/goat M_3 width



Measurements are in tenths of millimetres

Figure 28 Variation of sheep/goat height of the humerus trochlea constriction (after Payne and Bull 1988)



A comparison between remains from York (O'Connor 1986), Launceston Castle (Albarella and Davis 1996), West Cotton (Albarella and Davis 1994), Leicester (Gidney 1991a, 1991b) and Castle Mall Measurements are in tenths of millimetres

Figure 29 Sheep/goat tibia distal breadth (Bd)

Leicester, Little Lane (Gidney 1991a and 1992), Colchester (Luff 1993), West Cotton (Albarella and Davis 1994b), Launceston Castle (Albarella and Davis 1996) and Lincoln (Dobney *et al.* 1996). Although a few exceptions can be found — for instance at Exeter a large number of lambs were found in the post-medieval levels (Maltby 1979) — these findings suggest that wool production continued to increase in importance as late as the 16th and 17th centuries.

The zooarchaeological evidence from Castle Mall and other sites confirms the historically well documented importance of the wool industry in medieval England. From the beginning of the 13th century British wool was considered the best in Europe (Grand and Delatouche 1950), and the wool trade reached its peak at the end of the 15th century (Trow-Smith 1957). In early modern times although the importance of mutton increased the importance of wool did not decrease (Trow-Smith 1957).

A few neonatal sheep/goat bones were found in all periods, although there is only one specimen from Period 6 recorded as 'neonatal/very juvenile'. Thus there is evidence that some sheep, from Late Saxon up to at least late medieval times, were bred on site. This agrees with the, somewhat tenuous, suggestions from the study of the skeletal parts and the kill-off pattern (see above).

Size and Shape

Until at least the 15th century the Castle Mall sheep were of the same, rather small type, found in many other British medieval sites. In Period 6 a substantial size increase occurred. The shape of the animals also varied over time and this suggests the presence of distinct types of sheep in different periods.

The increase in sheep size between medieval and post-medieval periods is attested by both tooth and bone measurements (Table 21; Figs 27–29). However, the increase is larger in bones than teeth. This is not surprising due to the more conservative nature of teeth (Degerbøl 1963). As in bovines, the combined increase in tooth and bone size suggests that a genuinely new type of sheep was present in Norwich in Period 6.

Davis (1996) has demonstrated that measurements taken on the same axis tend to be highly correlated. Thus all *lengths*, *widths* and *depths* have been combined, to allow the comparison of larger samples between different periods. Using the log ratio method (Simpson *et al.* 1960), these measurements have then been compared with 'standard' values calculated from a group of modern *female* unimproved Shetland sheep (Davis 1996). Lengths and depths confirm the previous findings: size stability between Periods 1 and 5 and an increase in Period 6 (Table 30; Figs 30 and 32). The depth increase is actually only very slight, but it is highly statistically significant due to the large sample obtained from the combination of different measurements. Somewhat surprisingly a different pattern was suggested by the variation of widths: a steady size decrease from Periods 1 to 4, and an increase from Periods 4 to 6 (Table 30; Fig.31). The different results obtained from measurements on different axes suggest some variation in the shape of sheep from different periods.

In Table 31 the significance of the difference for measurements on the three axes is shown. Sheep from Periods 1, 2+3 and 6, have more or less similar proportions as the female Shetland — although it is evident that those

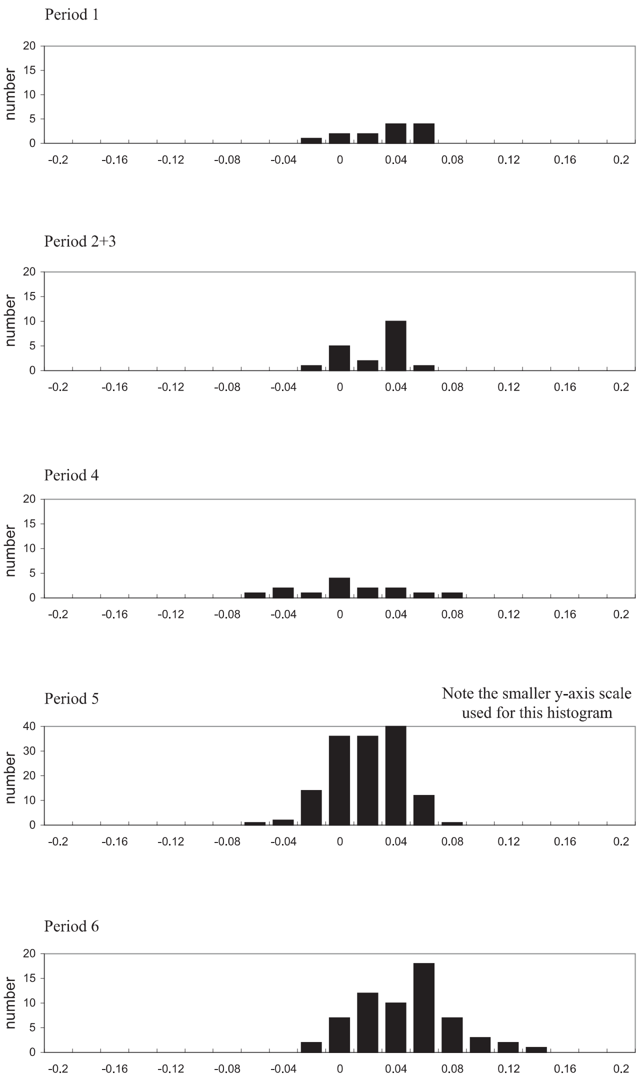


Figure 30 Variation in sheep/goat measurements (all periods). A comparison of the *length* of sheep/goat bones with a standard sample of unimproved Shetland ewes (Davis 1996), using the log ratio technique (Payne and Bull 1988)

from Period 6 are larger. In Period 4 and 5 *depth* measurements are relatively larger, suggesting some anatomical difference between these sheep and those from earlier and later periods.

When the Castle Mall sheep are compared to sheep from other sites, the situation is similar to that for cattle. The Norwich Late Saxon and medieval sheep are similar in size to animals from other areas of the country, apart from the Cornish sheep (from Launceston Castle), which are definitely smaller. A large group of sheep metapodia from an early–mid 15th-century context (Period 5) at Castle Mall has been compared with metapodia from another discrete group from early 16th-century Lincoln (Dobney *et al.* 1996) (Table 32; Figs 33 and 34). The Castle Mall sheep are far smaller than the Lincoln ones which suggests that they belong to a still unimproved type. A relatively larger width of the Castle Mall metapodia is noted in Figs 33 and 34, but the difference is not statistically significant (Table 32). Finally, it is important to point out that the data from the barbican well (Moreno

	Measurement	*Mean*	*V*	*Min*	*Max*	*N*
Period 1	M_1W	72	6.7	59	83	39
	M_2W	79	5.7	70	91	37
	M_3W	81	5.3	72	92	29
	Humerus BT	275	7.1	247	318	12
	Humerus HTC	136	4.4	125	146	16
	Tibia Bd	257	4.7	234	279	24
	Metatarsus Bd	239	5.0	213	255	14
	Metatarsus 3	134	4.3	124	143	12
Period 2+3	M_1W	71	5.5	63	79	20
	M_2W	79	4.8	72	86	18
	M_3W	81	5.1	69	86	14
	Humerus BT	281	6.1	257	313	16
	Humerus HTC	139	7.3	127	162	20
	Tibia Bd	251	6.6	222	284	27
Period 4	M_1W	73	7.1	62	84	18
	M_2W	81	5.1	74	86	16
	M_3W	81	5.2	73	88	15
	Humerus BT	263	5.5	243	285	11
	Humerus HTC	132	6.6	118	146	14
Period 5	Horncore W_{max}	320	11.0	237	378	37
	Horncore W_{min}	225	12.5	180	295	31
	M_1W	68	7.3	59	80	26
	M_2W	78	5.8	67	85	32
	M_3W	81	5.3	71	89	32
	Humerus BT	270	6.1	217	292	26
	Humerus HTC	134	5.9	121	151	29
	Metacarpus GL	1158	5.3	940	1298	56
	Metacarpus SD	134	5.6	110	149	53
	Metacarpus Bd	244	3.6	220	265	63
	Metacarpus 3	131	5.1	110	144	67
	Metacarpus a	114	4.1	102	130	68
	Metacarpus b	111	4.9	96	123	67
	Metacarpus 1	105	5.2	89	115	68
	Metacarpus 4	99	6.1	83	112	65
	Pelvis LAR	268	5.9	251	305	10
	Tibia Bd	248	5.3	219	267	13
	Metatarsus GL	1236	5.4	1105	1360	69
	Metatarsus SD	116	6.3	95	133	67
	Metatarsus Bd	230	5.0	206	257	85
	Metatarsus 3	127	5.2	113	142	83
Period 6	M_1W	72	6.3	63	84	63
	M_2W	81	5.9	68	94	61
	M_3W	83	4.7	72	93	72
	Humerus BT	284	5.9	252	322	47
	Humerus HTC	142	6.9	122	163	50
	Radius GL	1404	4.8	1290	1510	10
	Radius Bd	150	8.1	124	168	10
	Metacarpus GL	1281	8.1	1080	1507	19
	Metacarpus SD	143	10.1	116	172	18
	Metacarpus Bd	256	7.3	224	305	24
	Metacarpus 3	135	7.5	118	166	23
	Metacarpus a	120	8.0	106	142	23
	Metacarpus b	116	8.0	104	139	23
	Metacarpus 1	107	8.3	95	134	22
	Metacarpus 4	102	8.8	89	131	23
	Pelvis LAR	282	11.2	216	379	30
	Tibia Bd	257	7.4	223	303	31
	Metatarsus GL	1350	5.4	1141	1425	14
	Metatarsus SD	115	9.6	97	135	13
	Metatarsus Bd	234	5.4	214	266	22
	Metatarsus 3	129	3.9	120	140	21

Fusing bones are included, unfused ones are not
A few measurements are approximated
All measurements are in tenths of millimetres
Only samples of at least 10 measurements are given

Table 29 Means, coefficients of variation (V), ranges and sample sizes for sheep/goat measurements

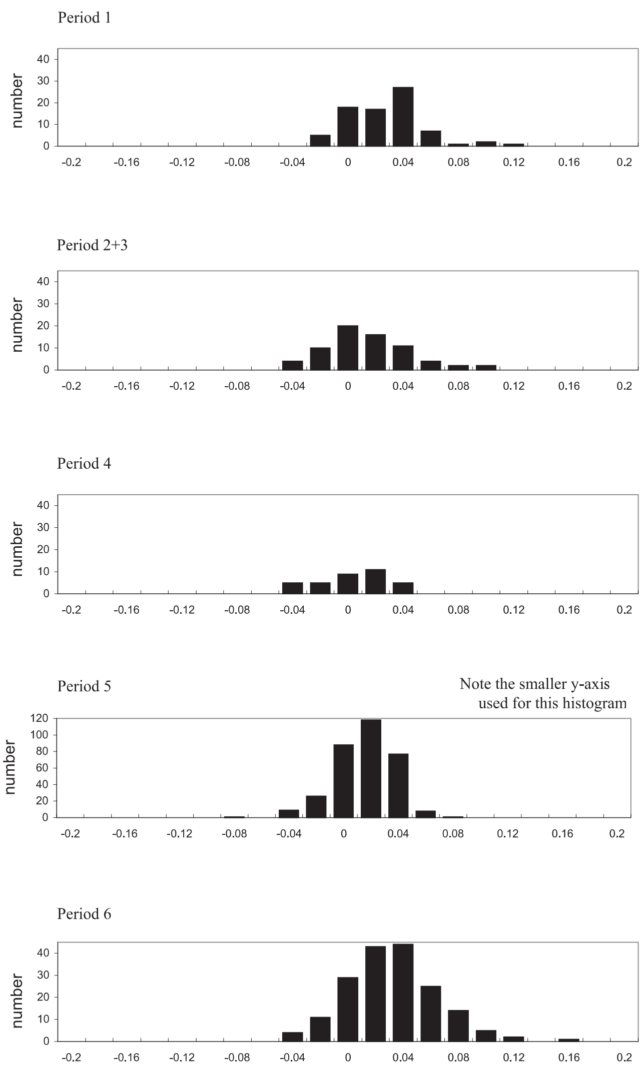


Figure 31 Variation in sheep/goat measurements (all periods). A comparison of the *width* of sheep/goat bones with a standard sample of unimproved Shetland ewes (Davis 1996), using the log ratio technique (Payne and Bull 1988)

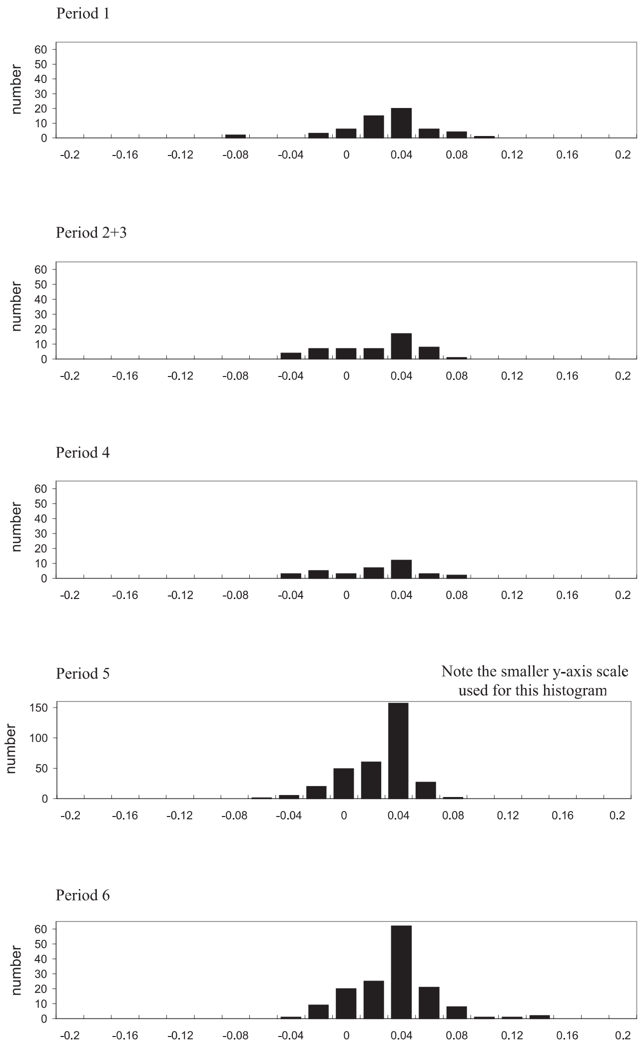


Figure 32 Variation in sheep/goat measurements (all periods). A comparison of the *depth* of sheep/goat bones with a standard sample of unimproved Shetland ewes (Davis 1996), using the log ratio technique (Payne and Bull 1988)

García, Chapter 4) support the hypothesis that the sheep in Period 5 are relatively small.

How can this rather puzzling collection of data be interpreted? The lack of any substantial size variation between the 10th and the 15th century is not surprising in view of the rather homogeneous size of medieval sheep attested by historical (Trow-Smith 1957) and archaeological sources (Grant 1988). The sheep in medieval times was essentially a wool animal and the importance of a larger body mass was emphasised only in post-medieval times, when mutton production also became important. Although Period 5 is rather broadly dated to the mid/late 14th–mid 16th century, most of the bones come from pre-16th-century contexts, thus the lack of any size increase in this period is probably still an entirely medieval phenomenon. Unfortunately there is no tightly dated information on the size of the 16th-century Castle Mall sheep. It can be seen that in Period 6 sheep were still mainly bred for wool although by this time mutton production had become of countrywide importance which may explain the larger size of the animals from this period. Very few Period 6 contexts are as late as the mid 18th century and it can thus be suggested that sheep improvement was well under way by the beginning of the 18th century. Even earlier evidence of sheep size increase has been found on other sites — *e.g.* Exeter (Maltby 1979) and Lincoln (Dobney *et al.* 1996) — this indicates that in some areas sheep improvement began earlier than was suggested by O'Connor (1995).

It is more difficult to interpret the differences in shape. First of all it is interesting to note that when the relatively new approach suggested by Davis (1996) is adopted the assumed general homogeneity of the English medieval sheep is no longer confirmed. This is hardly surprising, if the main driving force in sheep husbandry was the production of wool, some variation occurred and this would have had an effect on the type of animal required. Moreover, although the general small size of the medieval sheep is attested by historical documents, sheep throughout the country would not have been identical. Indeed Trow-Smith (1957) mentions the presence of several regional types. Differences between sheep from

Taxa	Element	Period compared	T - value	Probability
Sheep / Goat	Length	1 and 2+3	1.07	0.294
		2 +3 and 4	0.12	0.907
		4 and 5	-1.40	0.164
		5 and 6	-3.99	0.000*
	Width	1 and 2+3	2.65	0.009**
		2 +3 and 4	2.04	0.044*
		4 and 5	-3.50	0.001**
		5 and 6	-6.97	0.000**
	Depth	1 and 2+3	1.29	0.201
		2+3 and 4	0.17	0.868
		4 and 5	-1.63	0.104
		5 and 6	-3.00	0.003**
Pig	All bone measurement	1 and 2+3	-1.94	0.057
		2+3 and 4	1.05	0.304
		4 and 5	-0.35	0.730
		5 and 6	-1.59	0.124
		1 and 2–5	-1.31	0.196
		1–5 and 6	-2.87	0.005**
		2–5 and 6	-1.84	0.071
	All teeth measurements	1 and 2+3	0.45	0.650
		2+3 and 4	-0.36	0.722
		4 and 5	-0.86	0.390
		5 and 6	-1.32	0.187
		1 and 2-5	-0.32	0.749
		1–5 and 6	-3.99	0.000**
		2–5 and 6	-.3.43	0.001**

for key and details of the sheep/goat measurements used, see Table 31

Table 30 Significance of the size differences for sheep/goat and pig between different periods as indicated by a t-test. The test is carried out on the log values of the ratio between the actual measurements and the standard values proposed by Davis (1996) for sheep/goat and by Albarella and Payne (2005) for pig

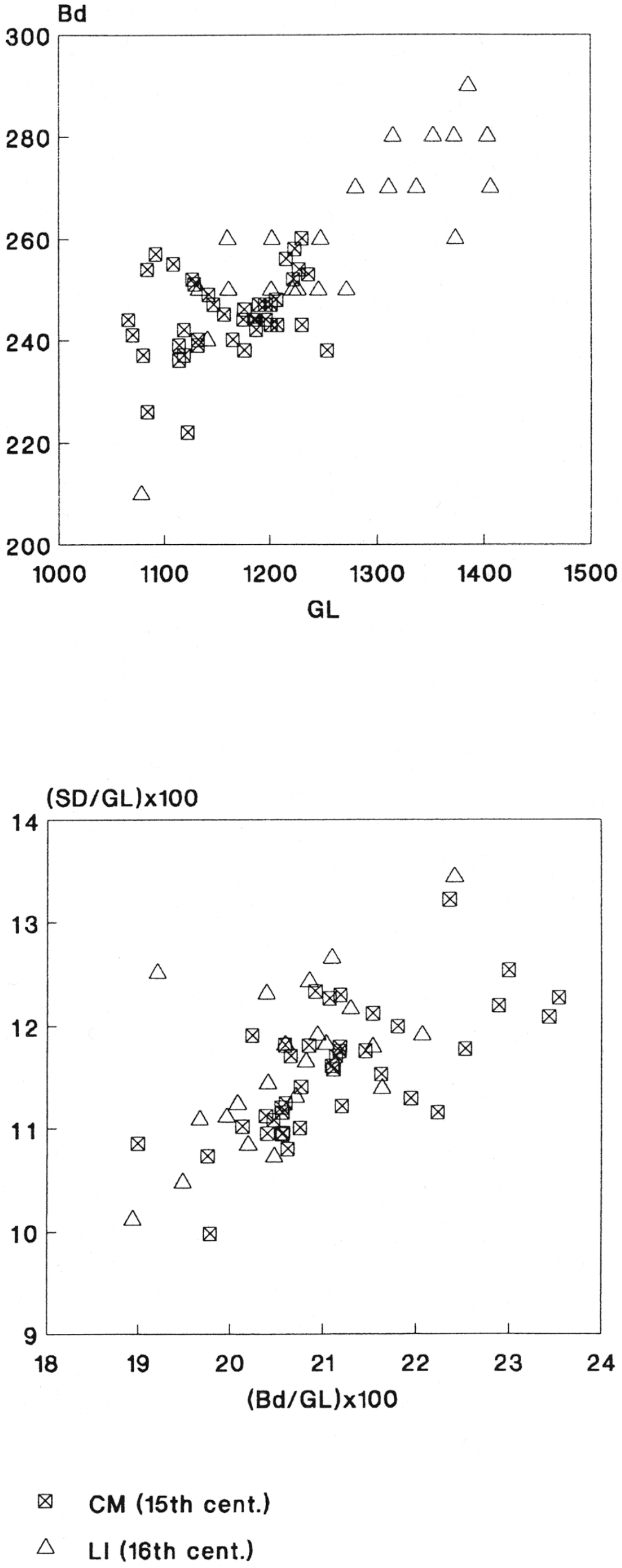
Taxa	Period	Measurement	T - value	Probability
Sheep / Goat	1	Length / Width	0.45	0.652
		Length / Depth	0.17	0.867
		Width / Depth	-0.42	0.674
	2+3	Length / Width	-0.44	0.662
		Length / Depth	-1.00	0.322
		Width / Depth	-1.25	0.214
	4	Length / Width	0.56	0.579
		Length / Depth	-1.17	0.246
		Width / Depth	-2.59	0.012*
	5	Length / Width	0.84	0.400
		Length / Depth	-4.18	0.000**
		Width / Depth	-6.80	0.000**
	6	Length / Width	1.35	0.179
		Length / Depth	0.81	0.420
		Width / Depth	-0.88	0.379
Pig	1	Teeth / Bones	1.82	0.070
	2+3	Teeth / Bones	-1.60	0.111
	4	Teeth / Bones	1.13	0.267
	5	Teeth / Bones	0.64	0.527
	6	Teeth / Bones	-2.45	0.016

** = the difference is highly significant (with less than a 1% probability that it is due to chance)
* = the difference is significant (with less than a 5% probability that it is due to chance)
no asterisk = no significant difference (more than a 5% probability that it is due to chance)

The following measurements have been used:
Sheep/Goat lengths: humerus GLC; radius GL; metacarpus GL; pelvis LA; femur GL; tibia GL; astragalus GLl; calcaneus GL; metatarsus GL
Sheep/Goat widths: humerus BT; metacarpus Bd,a,b; tibia Bd; astragalus Bd; metatarsus Bd
Sheep/Goat depths: humerus HTC; metacarpus 1,3,4; astragalus Dl; metatarsus 3

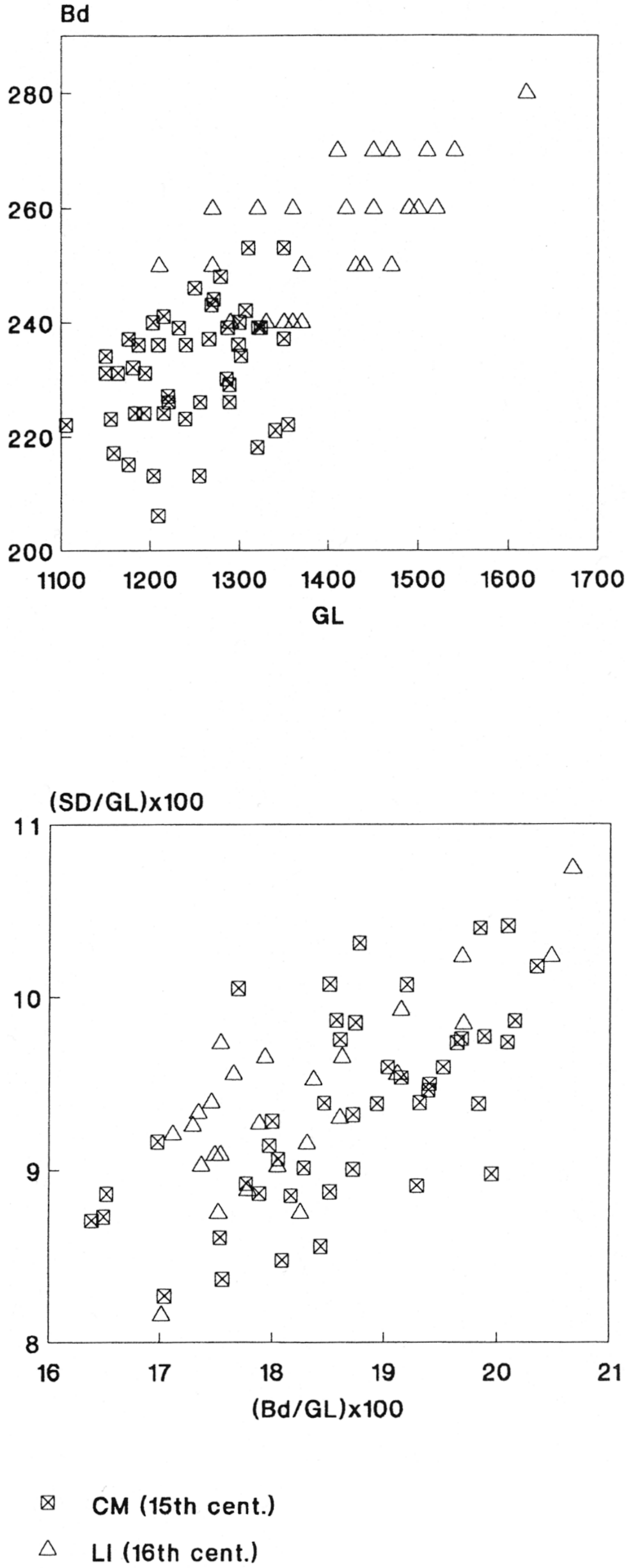
Pig teeth: dP4 L,WA; M1 WA,WB; M2 WA,WB; M3 L,WA,WC
Pig bones: humerus BT,HTC; pelvis LAR; tibia Bd; astragalus GLl; calcaneus GL

Table 31 Significance of the difference between measurements on different axes (sheep/goat) and between teeth and bone measurements (pig) as indicated by a t-test



The bottom diagram is size independent: the higher the value the more robust the species

Figure 33 Size (top) and shape (bottom) variation of sheep metacarpus from an early to mid 15th-century group at Castle Mall (context 11030) and an early 16th-century group at Lincoln (Dobney *et al.* 1996)



The bottom diagram is size independent: the higher the value the more robust the species

Figure 34 Size (top) and shape (bottom) variation of sheep metatarsus from an early to mid 15th-century group at Castle Mall (context 11030) and an early 16th-century group at Lincoln (Dobney *et al.* 1996)

Groups compared	Bones compared	Measurements compared	t-value	Probability
Castle Mall early mid 15th century/ Lincoln early 16th century	Sheep metacarpus	GL	*-6.04*	0.000**
		Bd	*-6.11*	0.000**
		SD	*-6.39*	0.000**
		Bd/GL	*1.94*	0.057
		SD/GL	*-0.90*	0.372
	Sheep metatarsus	GL	*-9.39*	0.000**
		Bd	*-8.68*	0.000**
		SD	*-10.23*	0.000**
		Bd/GL	*1.59*	0.116
		SD/GL	*-0.29*	0.772

** = the difference is highly significant (with less than 1% probability that it is due to chance)
no asterisk = no significant difference (more than 5% probability that it is due to chance)

Table 32 Significance of size and shape measurements between two groups of sheep metapodia from Castle Mall and Lincoln as indicated by a t-test. Note the much larger size of the Lincoln specimens

different periods at Castle Mall are therefore not surprising. It is possible that in Periods 4 and 5 a different, rather sturdy, type of sheep was present. This is the period in which the wool industry was probably most important and this sheep type might be associated with wool production. An alternative explanation is that this difference in shape reflects a change in the sex distribution. By Period 4 it is possible that more wethers, the typical wool animals, were used. It is evident that, compared to other sexes, wethers' limb bones tend to mainly increase in length (Hatting 1983; Davis pers. comm.) but this is dependant on the age of castration. It is possible that in mid and late medieval times rams were castrated at a later age than in post-medieval times, acquiring in this manner a different, more male-like shape. At present only hypotheses can be presented, but hopefully future experimental and archaeological work will reveal more about the only apparently monotonous shape of the medieval sheep.

Insufficient horncores were found to allow comparison between periods. In Period 5 (Table 29) a group of 21 horncores from a possible tanning pit are remarkable for their general small, female-like, size (although they may represent early castrated wethers). The presence of a hornless sheep type is attested by a skull from Period 5. Another specimen from Period 6 has a nubbin, possibly indicating the presence of a lateral horncore; this would not be improbable as there is historical evidence for four-horned sheep (Trow-Smith 1957).

Abnormalities and Pathologies

The most common abnormalities were periodontal disease and unusual tooth wear. More interesting is the relatively common occurrence of depressions on sheep horncores. These are more like 'thumb prints' than indentations (see Albarella 1995a). These depressions were found in specimens from Periods 1, 2 and 5. In particular 9 out of 21 horncores found in the possible tanning pit from Period 5 have clear thumb prints. This condition is commonly found in archaeological sites and has been associated with environmental stresses such as malnutrition or breeding in elderly animals, which may cause calcium resorption (Hatting 1983; Albarella 1995a). Its occurrence in about 25% of the horncores from Period 5 suggests that the condition of these sheep may have been poor. Their rather small size may also be associated with a low plane of nutrition (see Davis 1996). A similar occurrence of depressions (23%) was found by Moreno García (Chapter 4) in her study of the late 15th– early 16th-century fills of the barbican well and in one Period 3 example by Curl at Golden Ball Street (Chapter 6).

Of particular interest amongst the post-cranial pathologies are the so called 'penning elbow' and 'spavin'. The former condition is characterised by exostoses around the elbow joint possibly due to trauma when the animals are put through pens (Baker and Brothwell 1980). This condition has been found on two humeri from Periods 1 (Plate 9) and 6. Evidence of 'spavin' comes from one metatarsus from Period 1 (Plate 10). This condition has been considered typical of draught animals such as horse, cattle and camel (Baker and

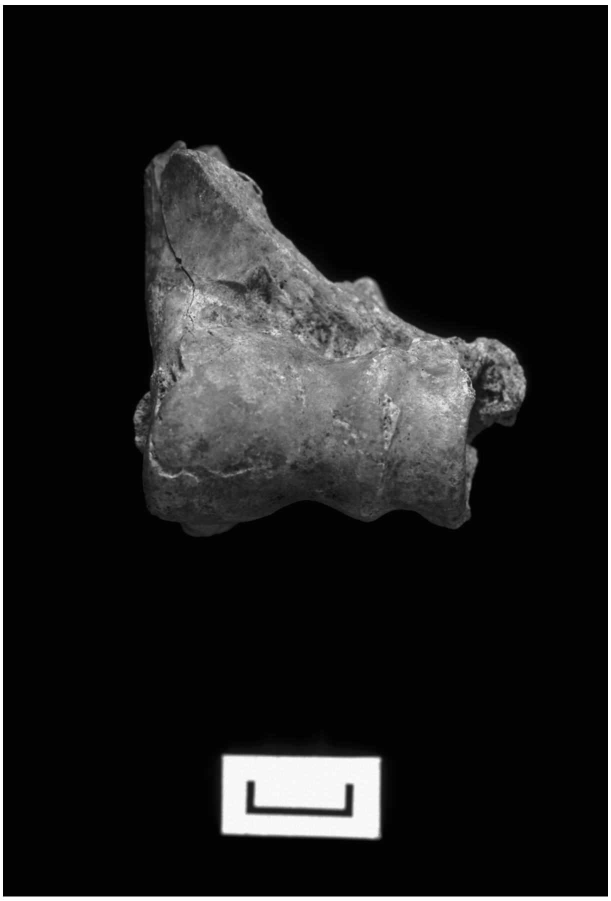


Plate 9 Sheep humerus (Period 1): 'penning elbow'

Plate 10 Sheep metatarsus (Period 1): 'spavin'

Plate 12 Sheep skull (Period 1): chopped horncores

Plate 11 Sheep horncores, metapodia and phalanges (Period 5): possible tanning pit

Brothwell 1980) and its presence in sheep is therefore of some interest. This proves that other factors, apart from traction stress, can be involved.

Butchery and Bone-Working

Butchery marks were found on about 15% of the sheep post-cranial bones. Unlike cattle, cut marks are more frequent than chopping marks (Table 22). This is due to the smaller size of the sheep carcass which does not require the extensive use of heavy tools. Moreover only a small quantity of marrow can be extracted from sheep bones, and therefore chops aimed at breaking long bones are less common in this species.

Most butchery marks are associated with division of the carcass, but evidence of skinning — in the form of cut marks on metapodia and phalanges — has also been found in Periods 1, 2, 3 and 5. A sawn pelvis from a barbican ditch fill in Period 6 (G9/41: mid 17th to early 18th century) suggests that saws were being used as butchery tools by this period, and not just for bone-working.

Of particular interest are the contents of a Period 5 pit (context *11030*, pit *11048*, Open Area 38, Castle Fee Property 49; see Part II: Chapter 8.II, Period 5.2) which produced a collection of 21 horncores, 109 metapodia and 60 phalanges, all belonging to sheep (Fig.8.B; Plate 11). This context was dated to the early–mid 15th century, a period at which a number of those associated with the leather trades were working in the castle area. *All* horncores had been chopped off the skull, 22% of the metapodia bore cut marks, presumably from skinning, whereas no butchery marks could be found on any

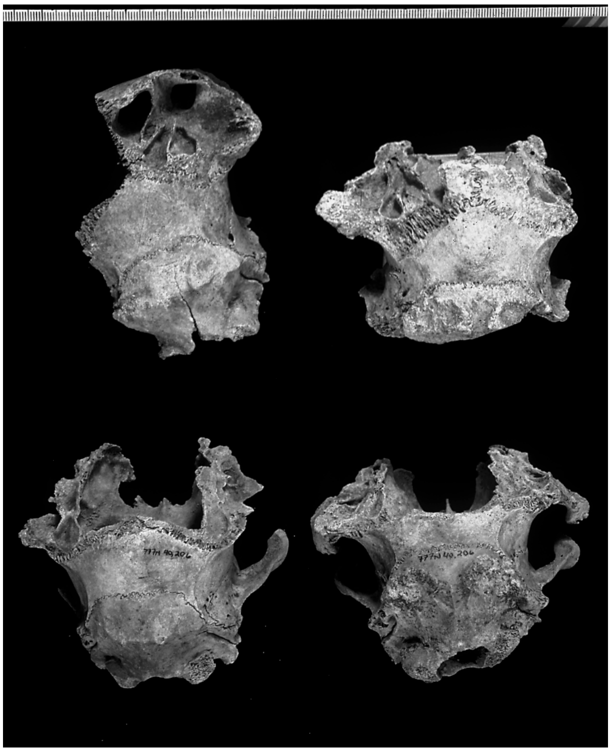


Plate 13 Sheep skulls (Period 2): chopped horncores

phalanges. Cut marks on both metacarpi and metatarsi were all located very close to the proximal end. This deposit can be interpreted as the result of a primary butchery activity, that is when body parts which carry little or no meat are discarded. However, due to the total absence of any other sheep anatomical elements, the contemporary presence of foot bones *and* horncores and the historically well attested importance of leather working in the town, it seems more probable that it represents tanning or tawing waste. Indeed it is known that in the past foot bones and horncores were left on the skin when this was brought to the tanner or the tawyer (Serjeantson 1989). The lower number of horncores compared to metapodia can be explained either by the fact that some skins were brought to the tannery with feet but no horncores, or that some skins derived from polled sheep. A better preservation of metapodia would also account for this discrepancy.

Deposits with a high concentration of foot bones or horncores have been found in several other sites, and have generally also been interpreted as tanning waste. For instance, sheep metapodia and phalanges interpreted as refuse of leather working have been found at Walmgate, York (O'Connor 1984), Hungate, Lincoln (Dobney *et al.* 1996) and St Peters Street, Northampton (Harman 1979). The last case had originally been interpreted as slaughtering waste, but Serjeantson (1989) suggests that it could be another case of tanning or tawing refuse. Association between horncore deposits and leather working activities has also been suggested by Prummel (1978; quoted by Serjeantson 1989) for the site of Hertogenbosch, Netherlands. Castle Mall provides the only case known to the current authors of the close association of foot bones and horncores. This is interesting because it represents the first archaeological confirmation of the historically known phenomenon of

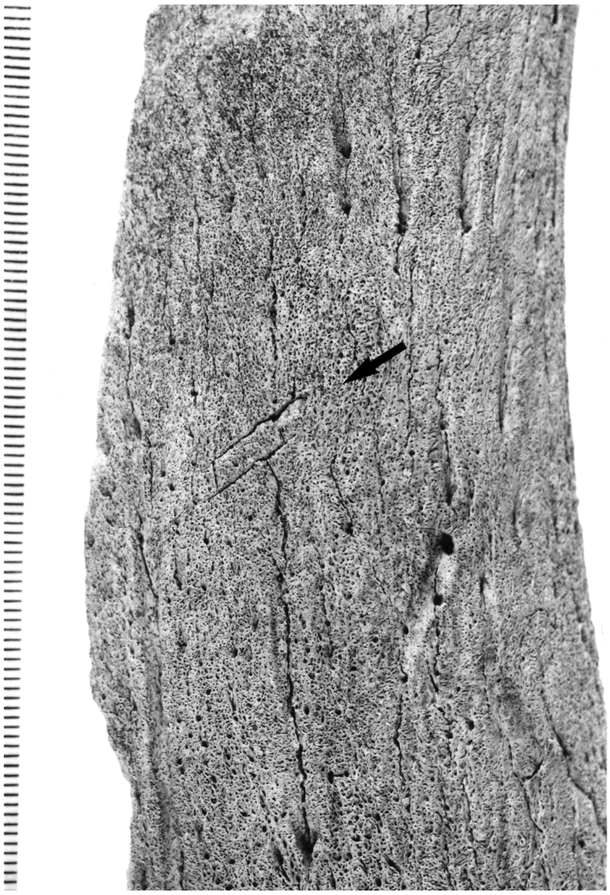


Plate 14 Goat horncore (Period 2): cut marks

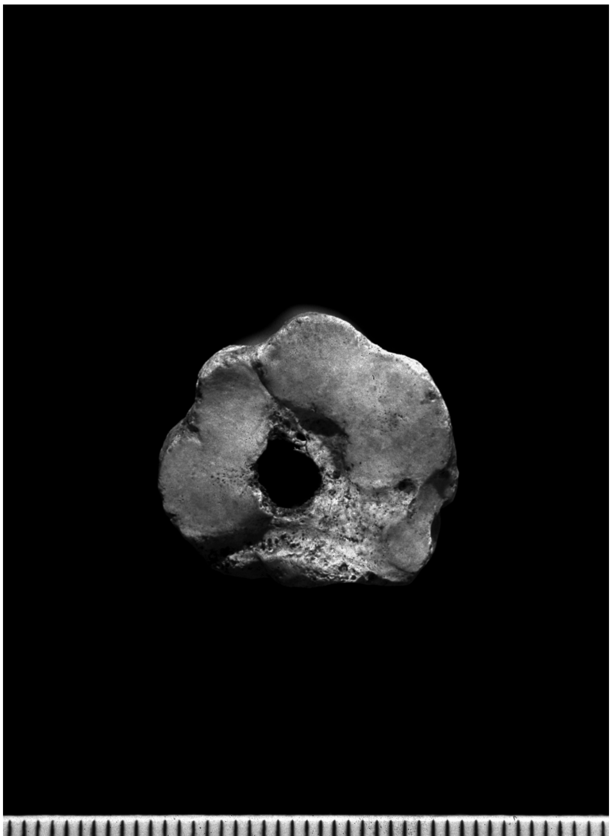


Plate 15 Sheep metatarsus (Period 6): hole in the proximal end, used as a handle?

leaving the cranial and foot bones attached to the skin, and also because it suggests that different practices may have been carried out in different towns.

Sheep and goat horncores are fairly common, but not as common as cattle horncores. Many horncores — from all periods — bear chop marks at their base, aimed at separating them from the skull. In addition several skulls had their horncores chopped off (Plate 12). A remarkable group of four such skulls was found in Period 2 within the same context (pit *40200,* Plate 13; Fig.5.A) and suggests that this activity may have been concentrated in specific areas. (For discussion of this evidence in relation to the Norman castle, see Shepherd Popescu, Part I, Chapter 5.V, 'Antler, Bone and Horn Working' and Chapter 12.VIII, 'Castle Life' and Albarella *et al.* Chapter 13, 'Bone and Horn Working'.) Cut marks — also related to the removal of the horn sheath from the horncore — are rarer, but they have been noted on a few horncores (Plate 14).

Evidence of bone working was less common than for cattle. This is hardly surprising due to the smaller size of this animal and the less robust nature of its bones. However, a few cases were noted; the faceting of sheep metapodia from Period 6 has already been mentioned in the 'Cattle' section and is discussed further by Huddle *et al.*in Chapter 10.III, 'Bone Working'. The presence of a hole in the proximal end of another metatarsus from Period 6 (Plate 15) is also worth mentioning. It is possible that this bone had been used as a handle.

VII. Pig

(Figs 35–39, Tables 33–38)

Anatomical Distribution

The pattern of representation of pig body parts can almost entirely be explained by differences in recovery and preservation. As for sheep, the smaller elements such as incisors, tarsals and phalanges are poorly represented as well as the most fragile elements such as skull and femur (Tables 1 and 33; Fig.35). On average about 90% of phalanges and 80% of astragali have been lost, with some fluctuations in different periods. This loss is mainly due to recovery bias, as is demonstrated by the phalanges representing 36% of the sieved assemblage and only 11% of the hand-collected material.

The proportion of teeth is higher than in cattle and sheep and is probably due to the destruction by scavengers of the more porous and greasy pig epiphyses (Albarella 1995b) as well as other taphonomic factors. It is improbable that the high frequency of teeth is due to a genuine over-representation of heads, since skull fragments are not very numerous. This pattern of body part distribution has been found at most archaeological sites and can be even more emphasised, especially in rural sites (see Albarella and Davis 1994b).

No major differences in the representation of pig body parts between periods have been noted. However, the further under-representation of post-cranial bones in Period 6 is of some interest (Fig.35). This is probably due to the younger age of pigs in this period (see below) which has made the taphonomic bias between teeth and bones even more pronounced.

Age and Sex

Pigs were generally killed at a younger age than cattle and sheep. This is typical of animals which are exploited almost entirely for meat, and indeed this pattern is found on almost all archaeological sites. However, a change in the kill-off pattern occurred by Period 6 when pigs were killed even earlier.

Data on tooth eruption and wear are summarised in Tables 34 and 35 and Figs 18 and 36. Fusion data can be found in Table 36. Unfortunately insufficient ageable specimens were available for Periods 4 and 5, thus the related analysis is limited to a comparison between Late Saxon, early medieval and post-medieval times. No significant changes could be noted between Periods 1 and 2+3. In Period 6 a much higher number of deciduous premolars were present (Fig.18). Furthermore a different mortality curve can be detected for this period when mandibular wear stages are considered. The culling peak in the early periods is at the 'subadult' stage, whereas in post-medieval times it shifts towards the younger 'immature' stage (Fig.36). In approximate terms this means a shift from about two year old to one year old animals. The analysis of wear on individual teeth is also of some interest, as it can be noted that a higher percentage of first and second molars are in early stages of wear in Period 6. Although not many post-cranial bones were available, they confirm the trend suggested by the tooth analysis, with a higher number of unfused epiphyses in the latest period (Table 36). A high frequency of less than one year old pigs has been found in the barbican well (Moreno García, Chapter 4), which can compensate for the scarcity of data from Period 5. This suggests that the change in culling strategies may have begun before the 17th century.

Due to the relatively small number of mandibles, the difference in the kill-off pattern is not statistically significant, although it is only marginally beyond significance levels (Table 18). However, due to the consistency of the data from individual teeth, mandibles and bones it can be confidently suggested that a real change in the culling strategies occurred by post-medieval times.

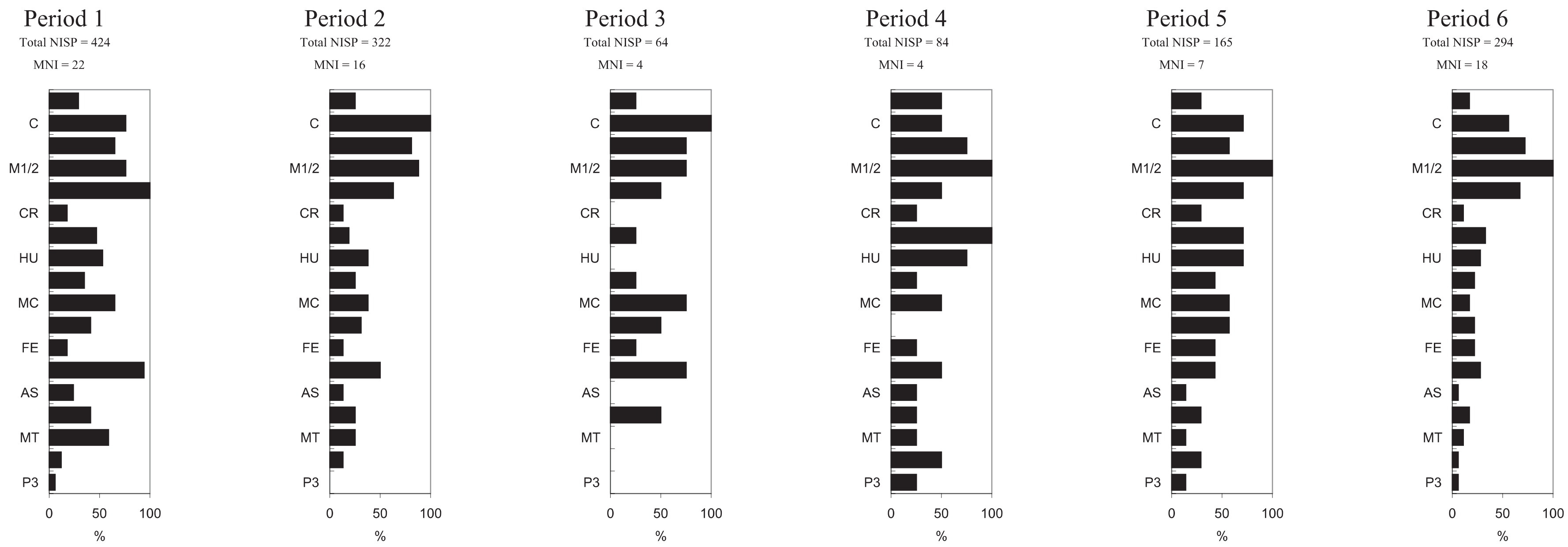
The trend towards the slaughter of younger animals is not as well documented for pigs as it is for cattle. A similar trend has been found in other towns such as Exeter (Maltby 1979) and Lincoln (Dobney *et al*. 1996), although in both cases the post-medieval samples are rather small. No such change was detected at Launceston Castle (Albarella and Davis 1996). The very young age of the post-medieval pigs is consistent with what the authorities of the period suggested. Markham (1614) for instance recommended the slaughter of pigs of 9–12 months, whereas Mortimer (1707) claimed that pigs of 12–18 months are good for bacon. However, some regional variation occurred, Marshall (1796; quoted by Maltby 1979) observed that in some parts of Devon pigs were not slaughtered until they were two or three years old. This might explain the variation in the archaeological evidence — the location of Launceston Castle near the Devon border is interesting in this respect.

Unlike cattle, the decrease in pig slaughter age does not indicate a change in their use. Pigs have been reared for meat since they were first domesticated and this kind of exploitation has never changed. The culling of very young animals, which is also typical of modern husbandry, can rather be associated with the selection of improved, faster growing breeds. The presence of a different type of animal in Period 6 is also attested by the biometric analysis and will be discussed in the next section.

	Period																	
	1			*2*			*3*			*4*			*5*			*6*		
Element	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*	*NISP*	*MNI*	*%*
Deciduous + permanent incisors	31	5	**29**	24	4	**25**	6	1	**25**	7	2	**50**	11	2	**29**	18	3	**17**
Deciduous + permanent premolars	25	13	**76**	31	16	**100**	7	4	**100**	4	2	**50**	9	5	**71**	20	10	**56**
M1/2	62	11	**65**	77	13	**81**	13	3	**75**	13	3	**75**	23	4	**57**	73	13	**72**
M3	51	13	**76**	56	14	**88**	10	3	**75**	13	4	**100**	26	7	**100**	71	18	**100**
Cranium	34	17	**100**	19	10	**63**	3	2	**50**	4	2	**50**	10	5	**71**	23	12	**67**
Scapula	6	3	**18**	3	2	**13**	-	-	**-**	2	1	**25**	4	2	**29**	3	2	**11**
Humerus	15	8	**47**	6	3	**19**	1	1	**25**	7	4	**100**	9	5	**71**	12	6	**33**
Radius	18	9	**53**	11	6	**38**	-	-	**-**	5	3	**75**	10	5	**71**	9	5	**28**
Carpal	11	6	**35**	8	4	**25**	1	1	**25**	2	1	**25**	6	3	**43**	7	4	**22**
Metacarpus	44	11	**65**	20	6	**38**	8	3	**75**	8	2	**50**	13	4	**57**	11	3	**17**
Pelvis	13	7	**41**	9	5	**31**	4	2	**50**	-	-	**-**	8	4	**57**	7	4	**22**
Femur	6	3	**18**	4	2	**13**	2	1	**25**	2	1	**25**	6	3	**43**	8	4	**22**
Tibia	31	16	**94**	16	8	**50**	6	3	**75**	3	2	**50**	6	3	**43**	9	5	**28**
Astragalus	7	4	**24**	3	2	**13**	-	-	**-**	1	1	**25**	1	1	**14**	1	1	**6**
Calcaneus	14	7	**41**	8	4	**25**	3	2	**50**	2	1	**25**	4	2	**29**	6	3	**17**
Metatarsus	37	10	**59**	12	4	**25**	-	-	**-**	1	1	**25**	3	1	**14**	8	2	**11**
Phalanx 1	16	2	**12**	10	2	**13**	-	-	**-**	9	2	**50**	14	2	**29**	7	1	**6**
Phalanx 3	3	1	**6**	-	-	**-**	-	-	**-**	1	1	**25**	2	1	**14**	1	1	**6**
total	**424**			**317**			**64**			**84**			**165**			**294**		

Each individual tooth within mandibles has been counted, hence the total is greater than the total NISP in Table 4
The MNI has been calculated as follows:
Phalanges have been divided by 8, deciduous + permanent premolars and incisors by 6, M1/2 by 4, all other elements, except metapodia, by 2
Metacarpus = (MC/2 + MP/4) / 2
Metatarsus = (MT/2 + MP/4) / 2
Where: MC = metacarpus: MT = metatarsus; MP = metapodium
% = frequency of an element expressed in relation to the most common one (by MNI)

Table 33 Parts of the pig skeleton by number of fragments (NISP) and minimum number of individuals (MNI). Unfused epiphyses are not counted. Only hand-collected material is included



Percentages are calculated on the basis of the frequency of an element in relation to the most common one (by MNI)

IN = deciduous and permanent incisors, PM = deciduous and permanent premolars, M1/2 = 1st and 2nd molars, M3 = 3rd molars, CR = cranium (zygomaticus), SC = scapula, HU = humerus, RA = radius, CP = carpal, MC = metacarpus, PE = pelvis, FE = femur, TI = tibia, AS = astragalus, CA = calcaneus, MT = metatarsus, P1 = 1st phalanx, P3 = 3rd phalanx

Figure 35 Pig body parts

		C	*V*	*E*	*H*	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*
DP4	Period 1									1	1				1	2	1
	2									2		1	2	1		2	3
	3																1
	4					1			1	1		1		1			
	5					3				2	2				1	1	
	6					3			1	2	2		1	1	2	3	3
P4	Period 1			1		5	10	1	2	2	1						1
	2		1			6	8	1	2		1	1	1				
	3				1	2	2				1						
	4						1				1						
	5			1		1		1	1								1
	6			2	1	7	5	1	1								
M1	Period 1					2	1		3	8	3	5	2	1			1
	2					3	1	2	2	8	2	5	5	1		1	2
	3	1								3			1		1		
	4	1			1	1		1	1	1	1			1			1
	5		1				1	2	1	4	1		2			1	
	6	1				4	3	3	4	13	3	2		1	1		
M2	Period 1	1	1		2	7	4	4	3	8		1		1			1
	2	1	2	1	1	4	2	5	1	6	2			1			
	3					2			1		2						
	4	1		1		1		1		2							
	5	1	1			5	1	2			2	1		1			
	6	4	2	4		15	4	1	3	2		1					
M3	Period 1	7	9	1		11	3	2	3		1		2				
	2	4	5	1	2	4	1	1	1								
	3		1		1		1	1									
	4	1	1			2											
	5	1	5	1		3	3										
	6	7	6	5	1	2				2	1	1					

Both teeth in mandibles and isolated teeth are included
Grant's stage 'U' is considered equivalent to stage 'a'
Unworn isolated teeth which could have been in one of the eruption stages (C, V, E, H) are coded as 'a'

Table 34 Pig wear stages of individual teeth (following Grant 1982)

Pig	*Mandibular wear stages*										
Period	*Juvenile*		*Immature*		*Subadult*		*Adult*		*Elderly*		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	
1	3	**8**	9.8	**27**	16	**44**	5.8	**16**	2	**5**	37
2 + 3	4	**9**	13	**31**	21	**48**	4.8	**11**	-	**0**	43
4	2		2		4		0.5		0.5		9
5	1		7.5		4.5		2		-		15
6	6	**15**	23	**58**	9.5	**24**	1	**3**	-	**0**	39

Percentages are only calculated where the sample is greater than 20 within a particular period
Only mandibles with two or more teeth (with recordable wear stage) in the dP_4/P_4 - M_3 row are considered

Table 35 Pig mandibular wear stages (following O'Connor 1988)

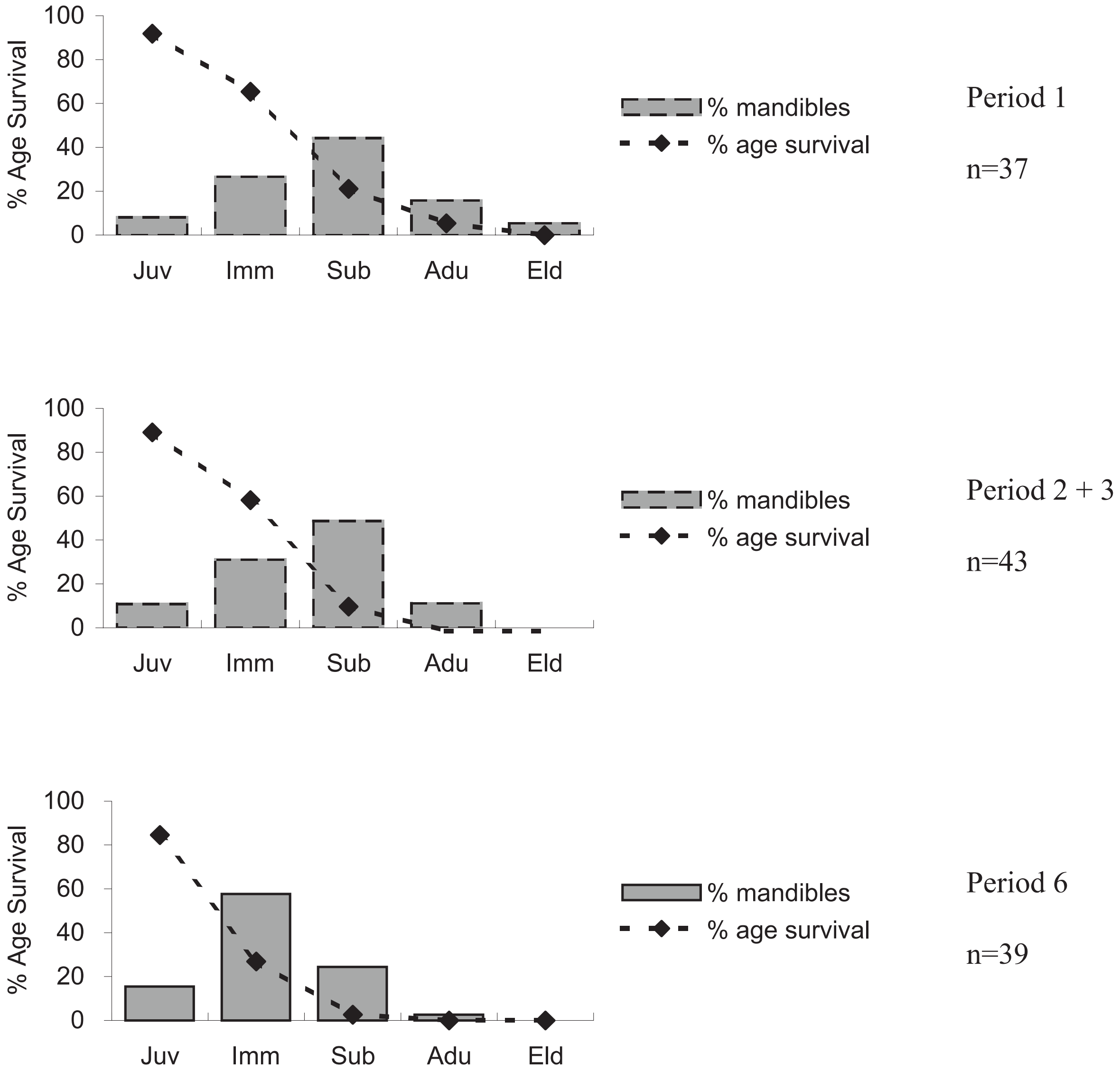


Figure 36 Relative percentages of pig mandibles by age stage (all periods). Age stages are from O'Connor (1988). All mandibles with two or more teeth with recordable wear in the $dP_4/P_4 – M_3$ row were considered

	Period 1		*Period 2+3*		*Period 4*		*Period 5*		*Period 6*	
Element	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Scapula d	12	**60**					5	**50**	6	**43**
Humerus d	12	**48**	9	**60**			5	**42**		
Radius d										
Metacarpus d	2	**4**	4	**13**			3	**21**	1	**8**
Pelvis a	16	**100**	12	**86**			4	**40**		
Femur d									1	**13**
Tibia d	12	**32**	9	**33**					2	**18**
Calcaneus	2	**14**	2	**13**						
Metatarsus d	1	**2**	1	**7**						
Phalanx 1	8	**32**	9	**43**			8	**40**		

n = total number of fused/ing epiphyses
% = percentage of fused/ing epiphyses out of the total number of fused/ing epiphyses and unfused diaphyses
d = distal; a = acetabulum
Figures for total number of epiphyses smaller than 10 have been omitted

Table 36 Pig, number and percentage of fused epiphyses. Fused and fusing epiphyses are amalgamated. Only unfused diaphyses, not epiphyses, are counted

Period	Females		Males	
1	8	(5)	17	(11)
2+3	12	(9)	26	(12)
4	-		4	(1)
5	2	(2)	6	(2)
6	5	(3)	13	(7)
total	**27**	**(19)**	**66**	**(33)**

Table 37 Pig sex ratio. Both isolated canines and mandibles with canines are included. The numbers of canines in mandibles are given in parenthesis. Only hand-collected specimens are included

Neonatal bones are present in Periods 1, 2, 3, 5 and 6, but they are more common in late periods (13 neonatal bones from Period 5 and 11 from Period 6). Their presence suggests that, even more convincingly than for cattle and sheep, some animals were bred on site. This practice may have become more common in late medieval and post-medieval times. The presence of pigs within the walls of the town is also implied by the documentary evidence, and in particular by the Records of the City of Norwich (Hudson and Tingey 1910, 205–206; quoted by Moreno García, Chapter 4) in the 14th century: 'It is ordained and established that each man or woman...who has boar, sow or other pig within the said city, that they keep them within their enclosure...'.

Due to the presence of the sexually diagnostic canines it is possible to ascertain the sex distribution of the pig population (Table 37). Both females and males are present at Castle Mall. When all canines are considered the male:female ratio is about 2.5:1. However, it is possible that female canines might have been more commonly overlooked than the larger male tusks. The ratio was therefore recalculated excluding isolated teeth. Males were still predominant, but this time in a ratio of about 1.7:1, which is probably closer to reality. Unfortunately, only 14 canines were collected from the sieved samples, and they were equally distributed between the two sexes. The relative number of females and males appears to have remained constant in all periods.

The higher number of males is not surprising as males (possibly castrated) were more frequently killed at a younger age for meat consumption. More females than males were kept for breeding. It is probable that many of the very young animals, which could not be sexed due to the non diagnostic shape of the milk canine, were also males. However, there is still a remarkably high number of females which could be consistent with the assumption that some on-site breeding was carried out. In other words, the evidence suggests that Castle Mall was not only a 'consumer' site but also a 'producer'.

Size and Shape

Biometrical analysis shows that, like cattle and to some extent sheep, no major changes in the size of pigs occurred between Late Saxon and medieval times (Table 38,). Larger and dimensionally different animals were present in Period 6.

A size increase in the width of the first molar can be definitely detected in Period 6 and possibly in Period 5 (Table 21; Fig.37). To increase the sample size all teeth measurements were combined. Using the 'log ratio technique' (Simpson *et al.* 1960) they were then compared with 'standard' measurements obtained from a population of English Neolithic pigs from Durrington Walls, Wiltshire (Albarella and Payne in prep.) (Table 30; Fig.38). The small, but statistically significant, size increase in Period 6 is confirmed. Due to the smaller number of bone measurements, it was necessary to combine measurements to carry out a comparison between different periods. Unfortunately, even after combining all bone measurements, samples from Period 4 and 5 are still rather small. Nevertheless, the larger size of the post-medieval animals is clearer for bones than it is for teeth (Fig.39). The statistical significance of the difference is not as striking as for teeth (Table 30), but this is a result of the smaller sample size, as the bone increase is actually larger than the tooth one. This is confirmed by the comparison between tooth and bone measurements. Whereas in Periods 1 to 5 the relative proportion of teeth and bones is not significantly different from the Durrington Walls pigs, in Period 6 bones become relatively larger than teeth (Table 31).

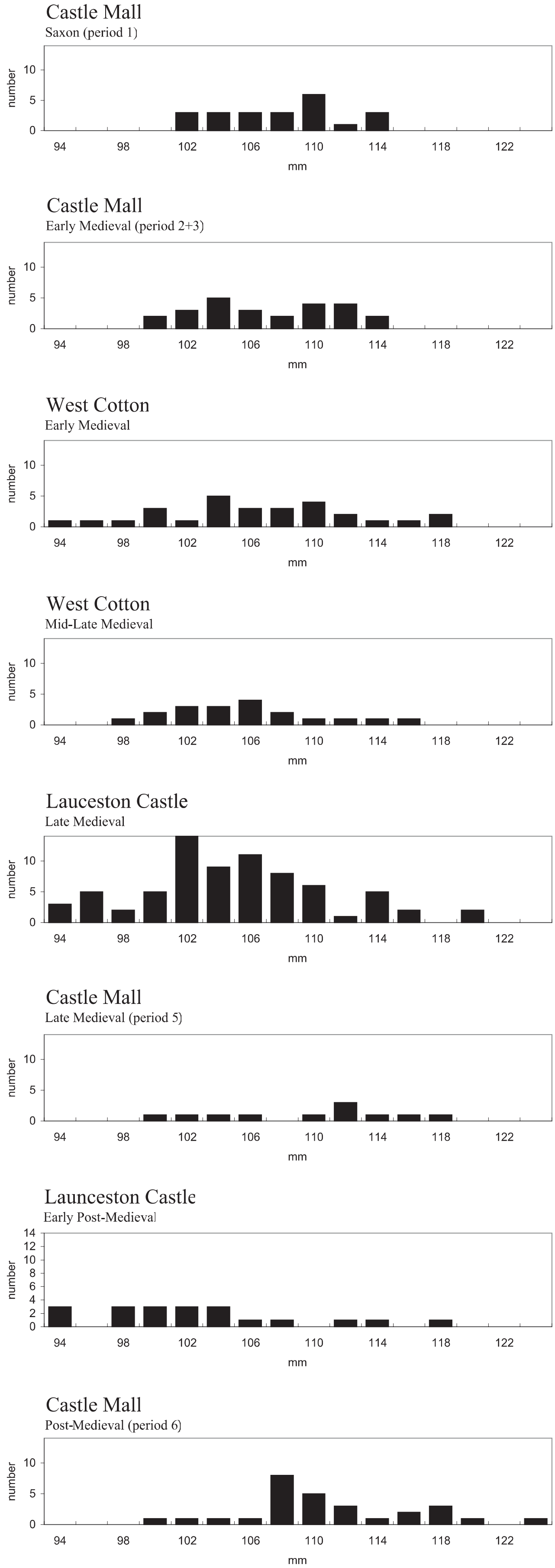
Unlike cattle and sheep, the wild ancestor of the domestic pig, namely the wild boar, was still present in Britain until the 17th century (Corbet and Harris 1991) and its presence at Castle Mall cannot therefore be excluded. However, in all periods the distribution of measurements tend to plot out as a rather unimodal curve, suggesting the presence of a single population. Due to the general historical and archaeological context and to the rather small size of these animals there seems little doubt that the *status* of this population is *domestic*. One very large outlier from Period 2 (Fig.39) may represent an odd wild specimen in an assemblage mainly composed of domestic animals.

The comparison between Castle Mall and other sites is somewhat handicapped by the fact that only a few zooarchaeologists measure pig teeth. Thus the data presented here could only be compared with

	Measurement	Mean	V	Min	Max	N
Period 1	M_1WA	101	4.4	93	108	20
	M_1WP	107	3.7	101	114	22
	M_2WA	128	6.1	113	140	23
	M_2WP	130	6.2	119	144	22
	M_3L	313	8.1	271	362	14
	M_3WA	151	7.6	138	180	14
	M_3WC	144	5.3	132	161	13
Period 2+3	M_1WA	100	4.3	91	109	28
	M_1WP	106	4.1	99	113	25
	M_2WA	126	6.6	111	143	18
	M_2WP	128	4.6	117	139	15
Period 5	M_1WA	103	3.7	96	108	11
	M_1WP	109	5.4	99	117	11
Period 6	M_1WA	103	4.9	95	115	28
	M_1WP	111	5.0	99	123	28
	M_2WA	133	5.6	122	152	23
	M_2WP	136	5.5	119	149	21

A few measurements are approximated
All measurements are in tenths of millimetres
Only samples of at least 10 measurements are given

Table 38 Means, coefficients of variation (V), ranges and sample sizes for pig measurements



Measurements are in tenths of mm
A comparison between specimens from Launceston Castle (Albarella and Davis 1996), West Cotton (Albarella and Davis 1994) and Castle Mall

Figure 37 Pig first molar: posterior width

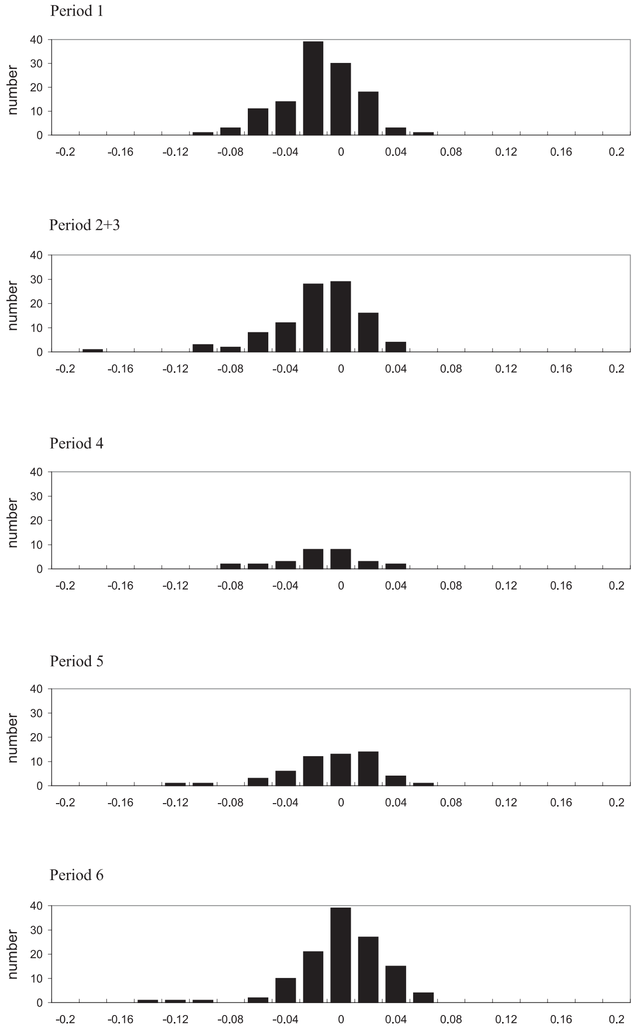


Figure 38 Variation in pig tooth measurements. A comparison of pig teeth with a standard Neolithic pig sample from Durrington Walls (Albarella and Payne, in prep.), using the log ratio technique (Payne and Bull 1988)

measurements from West Cotton (Albarella and Davis 1994b) and Launceston Castle (Albarella and Davis 1996). The Norwich medieval pigs are similar in size to the roughly contemporary animals from West Cotton, whereas the late medieval pigs from Launceston are probably smaller. The post-medieval pigs from Castle Mall (Period 6: late 16th–18th century) are much larger than the early post-medieval (16th century) animals from Launceston Castle, which, once again, emphasises the small size of the Cornish animals.

As discussed above, the increase in tooth size can be taken as good evidence for the presence of a larger and different type (breed?) of pig in post-medieval Norwich. The relatively larger dimension of the bones from Period 6 confirms the presence of rather different animals in these later times. This has been observed at other sites, such as Launceston Castle (Albarella and Davis 1996) and Lincoln (Dobney *et al.* 1996) where, in post-medieval times, pigs could be described as having small teeth and large bones. This has also been noted on some modern breeds (Payne pers. comm.) and it is probably

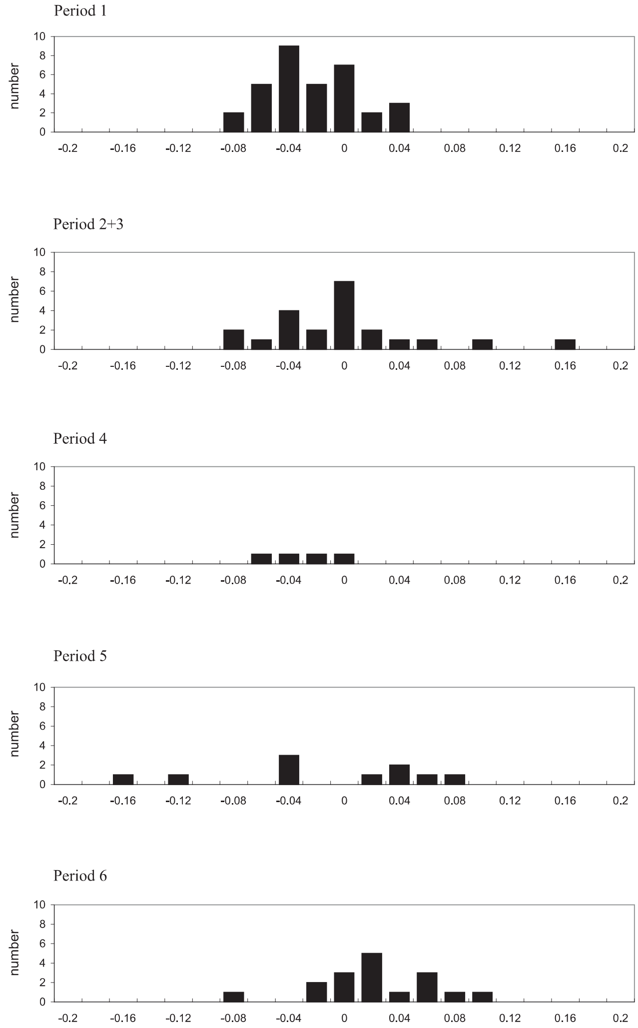


Figure 39 Variation in pig bone measurements. A comparison of pig bone with a standard Neolithic pig sample from Durrington Walls (Albarella and Payne, in prep.), using the log ratio technique (Payne and Bull 1988)

characteristic of improved, fast maturing breeds, possibly subject to a high plane of nutrition. The ratio between tooth and bone measurements is the best criterion evident at the moment to detect the first arrival or selection of modern pig breeds.

Abnormalities and Pathologies

Periodontal disease, tooth rotation, irregular tooth wear, exostoses and fractures have all been occasionally noted on the Castle Mall pig bones. These conditions do not have any particular archaeological interest and are thus not described here in detail.

Butchery and Bone-Working

Around 10% of the pig post-cranial bones bear butchery marks (Table 22). Unlike cattle and sheep this percentage does not increase in the late periods. Cut marks and chop marks are more or less equally represented, indicating a situation intermediate between cattle, which has more chops, and sheep, which has more cuts. This is probably determined by the size of the pig body, which is smaller than cattle but larger than a sheep. Chop and cut marks were also observed on several mandibles.

Cut marks on metapodia and phalanges, which may be associated with skinning, have been found in Periods 1, 5 and 6. These are less common than for cattle, sheep and horse, and may indicate the minor value of the pigskin. Pig bones were not commonly used for making tools, this is not surprising due to their rather fragile and porous consistency. However, two metatarsi from Period 1 (SF6586 and 6669) and two from Period 2 (SF5507 and 5517) have holes in their shafts, which suggests their use as toggles or 'buzz-bones' (see Huddle, Part I, Chapter 4.III and Fig.5.54).

VIII. Other Mammals

(Pls 16–41, Figs 40–43, Tables 39–41)

Equids

Equid bones have been found in all periods, but are very common only in Period 6. Whilst in Period 1 they are partly represented by sub-complete skeletons (Table 7) in the later post-medieval contexts they were only found as disarticulated bones. As discussed above this may partly be due to the reworking of specimens originally discarded as complete skeletons. All the mandible tooth rows recovered had horse-like teeth, and there was no evidence for the presence of donkeys (*Equus asinus*). Hence all equid bones are considered to be horse, although the presence of the occasional donkey bone cannot entirely be excluded.

Two partial skeletons were found in the same Period 1.3 pit (pit *90516*, G9/109, Open Area 8, Chapter 4.II; see Fig.4, Table 7 and Plates 16 and 17). Both belong to very young animals, possibly neonatal, with all epiphyses, including the scapula, unfused. This suggests that not only the main food animals but also horses were, at least occasionally, reared on site.

A possible increase in the horse withers height occurred in Period 6 (Fig.40), but this is only slight and the comparison is made difficult by the small samples from Late Saxon and medieval contexts. All horses from Saxon and medieval periods are shorter than 140cm (*i.e.* 14 hands), and can thus be defined as 'ponies'. The majority of post-medieval animals also fall within this category, but some larger animals ('horses') are present. The Castle Mall medieval horses are similar in size to the contemporary specimens from West Cotton (Albarella and Davis 1994b) and the earlier specimens from West Stow (Crabtree 1990), whereas the larger Period 6 animals are comparable to the post-medieval horses from Lincoln (Dobney *et al.* 1996). It is possible that the use of horses for ploughing, which gradually increased in importance, encouraged the selection of larger and stronger animals.

Apart from occasional exostoses, the only horse pathology of some interest was a 'spavin' in a metatarsus from Period 6. Most interesting was the presence of a peculiar pattern of wear on the anterior part of a second premolar in a post-medieval mandible from the barbican ditch (Plates 18–20). This condition has been noted in other specimens from Buhen, Egypt (Clutton-Brock 1974) and Towcester, England (Payne 1983). Anthony and Brown (1991) have investigated this condition in detail and suggest that it can confidently be associated with *bit wear*, when the following three characters are present:

Plate 16 Horse partial skeleton, juvenile (Period 1)

Plate 18 Horse mandible, bit wear (Period 6)

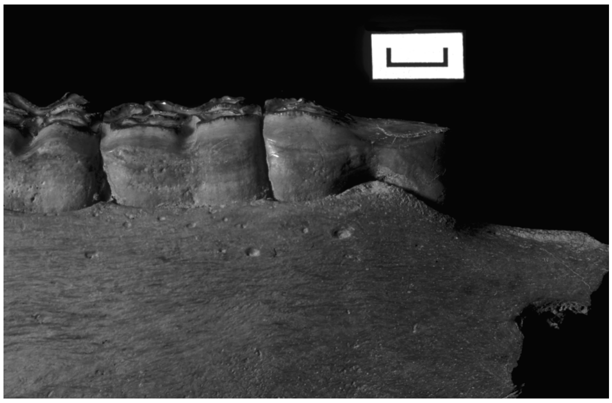


Plate 19 Horse mandible, bit wear (Period 6)

1. bevelling of the anterior part of the tooth of at least 2mm at the front;
2. diagnostic pattern of breakage on the occlusal enamel;
3. localisation of the wear over the entire paraconid cusp (*i.e.* the anterior cusp), so that enamel and dentine are worn to the same level.

The amount of bevel (measured as suggested by Anthony and Brown 1991) was about 5mm. The tooth was not analysed by SEM (scanning electronic microscope), but observation under an optical microscope was enough to detect the presence of a peculiar breakage pattern restricted to the enamel of the bevelled area of the tooth. No such pattern was present on the other enamel ridges either on the posterior part of the P_2 or on the other teeth. Finally the wear was definitely extended across the whole paraconid area and indeed also on the anterior part of the metaconid. On the basis of Anthony and Brown's (1991) suggestions, it can be assumed that this wear pattern was caused by a bit and that this horse had thus been used for riding or, more probably, as a draught animal. The animal

Plate 17 Horse partial skeleton, juvenile (Period 1)

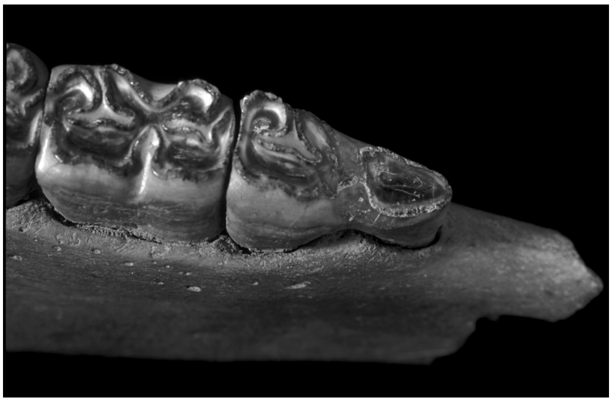


Plate 20 Horse mandible, bit wear (Period 6)

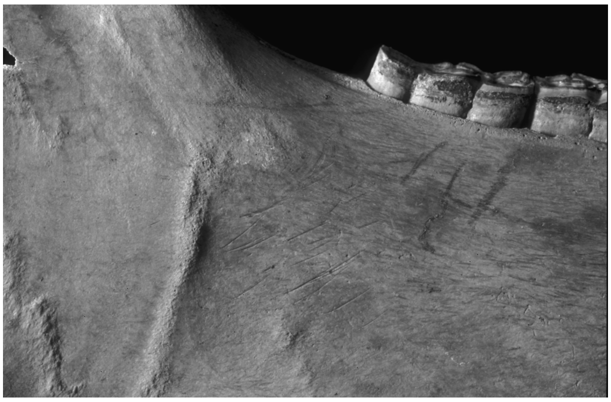


Plate 21 Horse mandible, bit wear (Period 6)

Plate 22 Horse limb (Period 2): extremity of hind limb in anatomical connection

was used in this way until its death — which occurred at an advanced age — as is demonstrated by its heavily worn teeth. Indeed the bit wear is obliterated by subsequent wear if a bit is not used any more. Cut marks on the posterior part of the mandible (Plate 21) indicate that, after its death, the animal was skinned.

Butchery marks on horse bones were less frequent than for cattle (Table 22), but not uncommon. Chop and cut marks were both noted. Some of the cut marks are concentrated on metapodia and phalanges (Table 39) and were probably caused by skinning. The use of horse hides is well attested in medieval times (Grand and Delatouche 1950; Langdon 1989). However, butchery marks were also found on typical meat bearing bones such as scapula, humerus, pelvis and femur (Table 39). This indicates that horse flesh was also used, possibly for feeding dogs, as Markham (1633) suggests that horse meat is '...the strongest and the lustiest meat you can give' to hunting hounds. However, there is evidence that, despite the proscription by Pope Gregory III (AD 732), in periods of poor harvests and livestock diseases, horse meat was also consumed by people (Hollis 1946). Evidence for the dismembering of horse carcasses is also provided by the extremity of a hind limb found in articulation in a Period 2 pit (pit *91954*; Plate 22). The calcaneus of this specimen is gnawed and the absence of the rest of the skeleton suggests that this limb was separated and given to the dogs. (See futher comments in Part I, Chapter 5.V.)

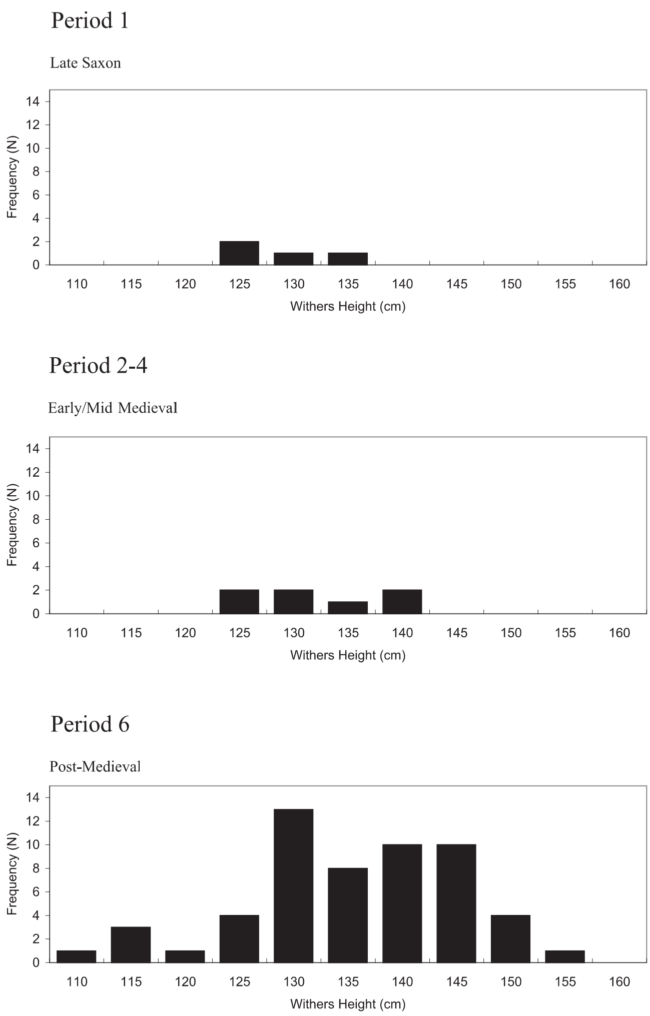
Butchered horse bones are regularly found in medieval and post-medieval sites, both urban and rural (see

Plate 23 Horse metatarsus, sawn (Period 6)

	Period 1			*Period 2+3*			*Period 4*			*Period 6*		
	Tot	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*
Cranium	-	-	-	-	-	-	-	-	-	10	-	-
Mandible	7	-	-	9	-	-	1	-	-	42	-	1
Scapula	3	-	-	1	1	-	1	-	-	13	-	1
Humerus	3	-	-	7	-	1	-	-	-	15	-	-
Radius	6	-	-	-	-	-	-	-	-	17	-	2
Pelvis	2	-	-	-	-	-	-	-	-	20	4	4
Femur	2	-	-	2	-	-	-	-	-	18	1	1
Tibia	4	-	-	2	-	-	-	-	-	12	-	1
Astragalus	1	-	-	1	-	-	-	-	-	1	-	-
Calcaneus	2	-	-	2	-	-	-	-	-	-	-	-
Metapodia	8	1	-	6	1	-	2	-	1	17	1	4
1st Phalanx	6	-	1	6	-	-	1	-	-	3	-	-
total	**44**	**1**	**1**	**36**	**2**	**1**	**5**	**-**	**1**	**168**	**6**	**14**

'Tot' = the total number of each element within a particular period

Table 39 Number of butchery marks on equid bones



All withers height calculations are based on the formulae provided by Vitt (1952), using the greatest length (GL) measurements of the following elements: humerus, radius, metacarpus, femur, tibia and metatarsus

Figure 40 Equid withers heights in centimetres

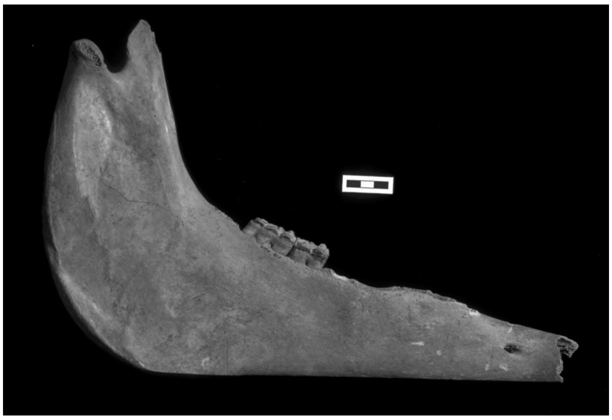


Plate 24 Horse mandible, sledge (Period 6, SF421)

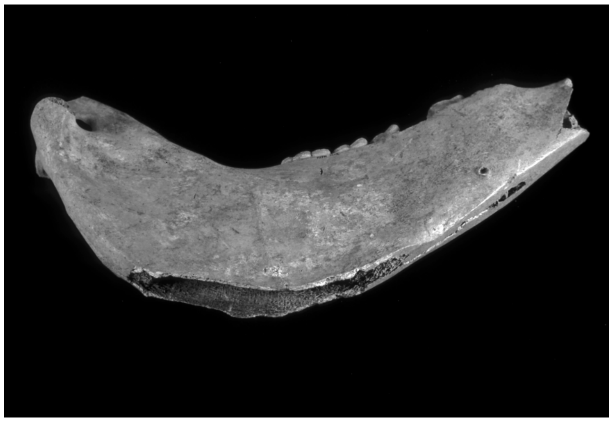


Plate 25 Horse mandible, sledge (Period 6, SF421)

Albarella and Davis 1996 for a summary). Even in Norwich a horse pelvis with a similar pattern of butchery to the Castle Mall specimens had already been found at Fishergate (Jones 1994). There is a remarkably large aggregation of butchered horse bones at Witney Palace, Oxfordshire (Wilson and Edwards 1993). These remains are concentrated in an 18th-century occupation phase and have been interpreted as the waste from dog food. So whether for people or dogs, there is evidence that throughout the country horse flesh was, if not regularly, commonly used.

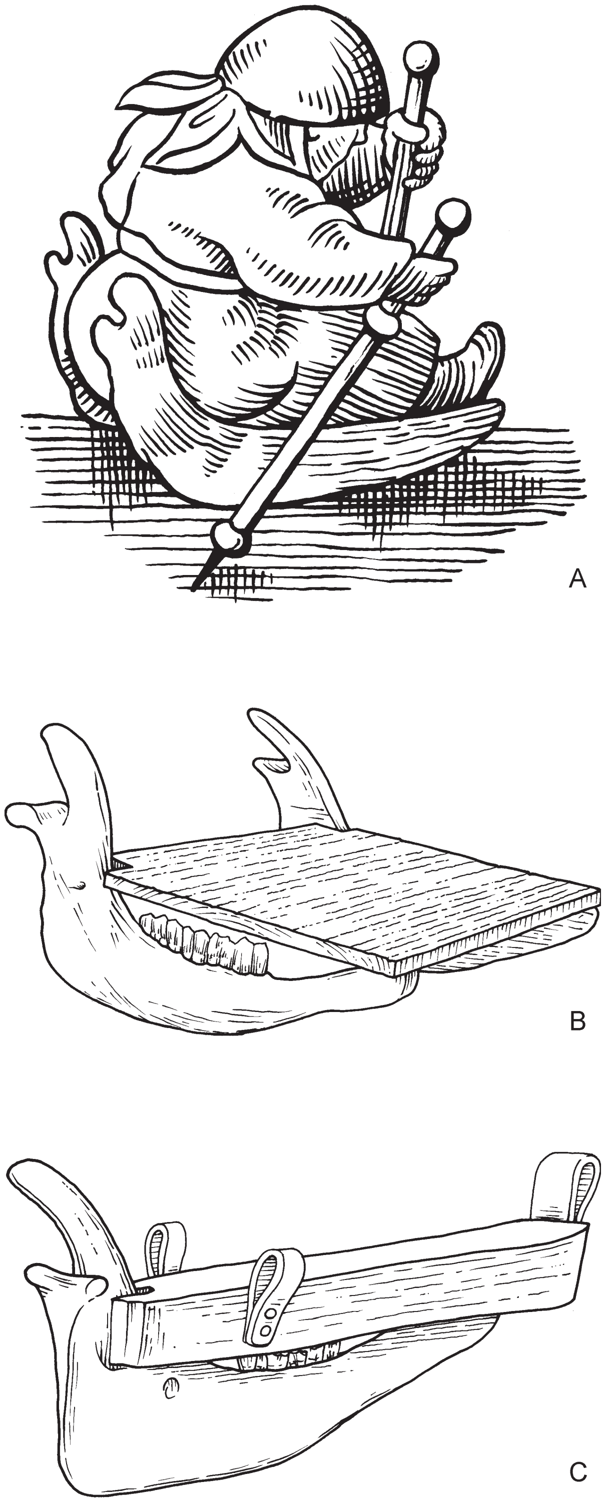
A few horse bones from Period 6 had been worked or sawn (Plate 23). Horse bones are very robust and, like cattle bones, make very good tools. Amongst the worked specimens were two quite remarkable right mandibles found together in one of the barbican ditch contexts (Period 6, SF421, Fig. 41). Both mandibles are polished at the bottom (Plates 24 and 25) as a consequence of severe and continuous wear. Their use as a sledge is discussed by Huddle (see Part II, Chapter 10.III). There is substantial pictorial evidence from the 16th and 17th century, in the work of Dutch artists such as P. Brueghel the younger, E. Van de Velde and A. Van der Neer, for the use of bone sledges and skates.

Dog

Dog bones were represented in the form of partial skeletons as well as isolated bones (Tables 4 and 7). Two of the partial skeletons from Period 1 and a few loose bones from Period 6 belong to neonatal specimens. The other animals were of variable age and included some old dogs with very worn teeth.

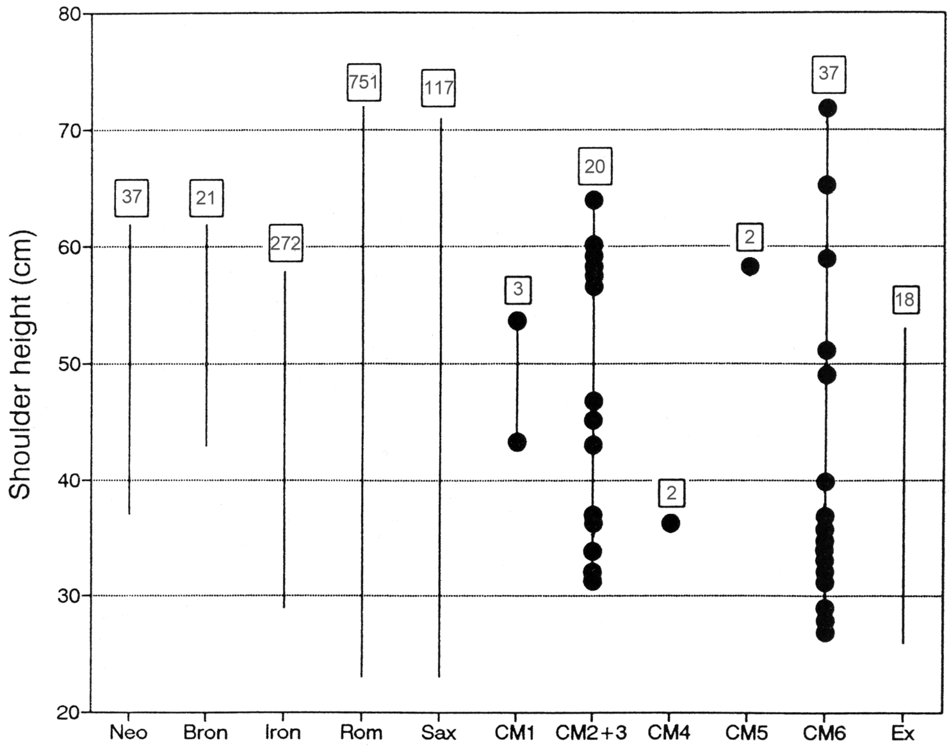
Calculation of the shoulder heights reveals a wide range of sizes (Fig.42). Almost the full size range of British Saxon and Roman dogs (Harcourt 1974) is present at Castle Mall. The dogs from Period 2+3 are more or less equally distributed between the small-medium and a medium-large size groups. In Period 6 the situation is quite different and most dog bones belong to very small animals, although there are a few medium, large and very large specimens also present (Fig.42). The shape of the complete skulls found in Period 6 also confirms the wide variety of dog types. Comparison of these skulls with those in the reference collection of the Ancient Monuments Laboratory (London) indicates that one small rounded skull (Plate 26) was very similar to a poodle, whereas another small skull was similar to a beagle. A small-medium size skull was remarkably similar to a terrier (Plate 27) whilst a larger specimen resembled a robust version of a Labrador.

Butchery marks (Table 22) were not particularly common, but are nonetheless noteworthy. Unlike those found on other non-food species, such as horse and cat, they do not appear to be associated with skinning activities. A couple of bones were chopped (Plate 28) whilst cut marks were not located in areas normally associated with skinning, such as the acetabulum (Plate 29) and the distal femur (Table 40; Plate 30). Butchery marks on dog bones are found more rarely than on horse bones, but they have been noted on several sites such as medieval West Cotton (Albarella and Davis 1994b), Roman Eastbourne (Serjeantson 1989), medieval Lincoln (Dobney *et al.* 1996), Roman Lincoln (Dobney *et al.* 1996), post-medieval Witney Palace (Wilson and Edwards 1993) and post-medieval Newcastle upon Tyne (Gidney 1996). In the first three sites cut marks on dog bones were probably associated with skinning. At medieval Lincoln and Witney Palace the bones were chopped rather than cut and this has been interpreted either as dismembering of the carcass for human consumption (Dobney *et al.* 1996) or as use of the dog flesh for feeding other dogs (Wilson and Edwards 1993). An alternative explanation has been provided for the



a) Child on a jaw-bone sledge, taken from a Dutch engraving representing sports on the ice in the town ditch at Antwerp, 1594 (Chambers 1869 vol II, 787)
b) Jaw-bone sledge from Pomerania (Virchow, 1887, 362)
c) Jaw-bone skate from Pomerania (Virchow, 1887, 362)

Figure 41 Jaw-bone sledges and skates (reproduced from Balfour 1898, figs 8–10)



The lines represent the range of measurements for each of the periods. Points on the Castle Mall lines represent the actual position of calculated shoulder height measurements. The numbers enclosed in boxes above the lines represent the sample size

All shoulder heights are calculated using the formulas given in Harcourt (1974)

Neo = Neolithic; Bron = Bronze Age; Iron = Iron Age; Rom = Roman; Sax = Anglo-Saxon; CM1 = Castle Mall Period 1; CM 2 + 3 = Castle Mall Periods 2 + 3; CM4 = Castle Mall Period 4; CM5 = Castle Mall Period 5; CM6 = Castle Mall Period 6, Ex = Exeter (post-medieval)

Neolithic/Anglo-Saxon data from Harcourt (1974). Exeter post-medieval data from Maltby (1979)

Figure 42 Dog shoulder heights from Castle Mall

Plate 26 Dog skull, poodle-like (Period 6)

Plate 27 Dog skull, terrier-like (Period 6)

Plate 28 Dog tibia, chopping marks (Period 6)

Plate 29 Dog pelvis, cut marks (Period 1)

Plate 30 Dog femur, cut mark (Period 2)

	Period 1			*Period 2+3*			*Period 4*			*Period 5*			*Period 6*		
	Tot	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*
Cranium	2	-	-	3	-	-	-	-	-	-	-	-	6	-	-
Mandible	7	-	-	15	-	-	7	-	-	3	-	-	14	-	-
Scapula	7	-	1	4	-	-	1	-	-	2	-	-	7	-	-
Humerus	6	-	-	8	-	-	1	-	-	2	-	-	16	-	-
Radius	3	-	-	6	-	-	-	-	-	1	-	-	12	-	-
Pelvis	6	-	-	4	-	1	2	-	-	1	-	-	5	-	1
Femur	7	-	-	14	1	1	2	-	-	4	-	-	13	-	-
Tibia	6	-	-	12	-	-	3	-	-	-	-	-	12	1	-
Astragalus	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-
Calcaneus	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Metapodia	18	-	-	27	-	-	4	-	-	5	-	-	6	-	-
1st Phalanx	2	-	-	7	-	-	1	-	-	-	-	-	-	-	-
total	**65**	**-**	**1**	**105**	**1**	**2**	**22**	**-**	**-**	**18**	**-**	**-**	**91**	**1**	**1**

'Tot' = the total number of each element within a particular period

Table 40 Number of butchery marks on dog bones

chopped dog bone from Newcastle. Gidney (1996) suggests that dogs may have been butchered for their fat rather than their flesh and supports this hypothesis with historical evidence for the use of dog fat for cosmetic and medical reasons. It is unclear which of these the correct explanation for the Castle Mall specimens is. The preferred interpretation is that occasionally dog meat was eaten, either by other dogs or by people in periods of food shortage.

Cat

Cat bones were as common as those of dog, and occurred in all periods (Table 4). Most of them came from complete or sub-complete skeletons (Table 7), but isolated bones

Plate 31 Cat skull, cut marks (Period 1)

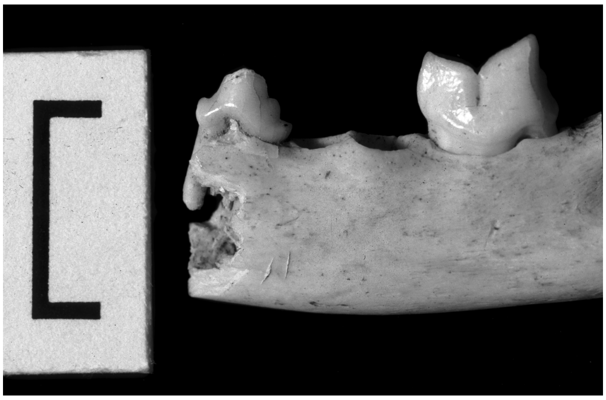


Plate 32 Cat mandible, cut marks (Period 4)

were also recovered, especially from Period 6. Periods 1, 5 and 6 all have evidence for the presence of neonatal or very juvenile animals.

The most remarkable feature of the cat bones was the presence of cut marks on skulls, mandibles, metapodia and phalanges (Table 41; Plates 31–33). These marks were almost exclusively found on Late Saxon and early medieval bones, although a single radius with deep cut marks was found in Period 6 (Plate 34). These cut marks are probably linked to skinning activities as they are located at the body extremities. There was no interest in cat flesh, this is clearly demonstrated on the complete skeletons where although skinning marks testify to the removal of the pelt (Plate 35) there is no evidence of any further dismemberment of the skeleton. Cut marks on a cat sacrum were reported from the barbican well (Moreno García, Chapter 4).

The interpretation of knife cuts as skinning marks is supported by the age distribution of the cat assemblage (Fig.43). A high percentage of cat bones from Late Saxon and medieval times (Periods 1–5) were unfused. However, the percentage of immature animals decreases in Period 6, when the number of cut marks becomes lower. The association between the young age of cats and exploitation of their pelts has been suggested by McCormick (1988) and Serjeantson (1989). In particular McCormick found a difference in the age of the Irish cat populations between Early Christian and medieval levels. In the latter period McCormick considers the higher numbers of younger cats to reflect the use of their pelts. A relationship between the young age of cat populations and pelt production has also been suggested for the sites of West Cotton (Albarella and Davis 1994b) and Cambridge (Luff and Moreno García 1995). On both these sites abundant cut marks were recorded on cat bones. In particular, the Cambridge assemblage consists of 79 cat skeletons all of which were

	Period 1			*Period 2+3*			*Period 4*			*Period 5*			*Period 6*		
	Tot	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*	*Tot*	*Chop*	*Cut*
Cranium	4	-	2	3	-	1	-	-	-	2	-	-	-	-	-
Mandible	10	-	-	4	-	-	6	-	1	5	-	-	4	-	-
Scapula	8	-	-	3	-	-	2	-	-	3	-	-	2	-	-
Humerus	11	-	-	11	-	1	4	-	-	6	-	-	21	-	-
Radius	9	-	-	5	-	-	2	-	-	4	-	-	14	-	1
Pelvis	6	-	-	3	-	-	3	-	-	3	-	-	4	-	-
Femur	13	-	-	6	-	-	8	-	-	6	-	-	16	-	-
Tibia	10	-	-	8	-	-	8	-	-	4	-	-	22	-	-
Astragalus	2	-	-	-	-	-	1	-	-	1	-	-	1	-	-
Calcaneus	3	-	-	1	-	-	4	-	-	2	-	-	-	-	-
Metapodia	45	-	3	18	-	2	6	-	-	29	-	-	12	-	-
1st Phalanx	12	-	3	1	-	-	1	-	-	3	-	-	-	-	-
total	**133**	**-**	**8**	**63**	**-**	**4**	**45**	**-**	**1**	**68**	**-**	**-**	**96**	**-**	**1**

'Tot' = the total number of each element within a particular period

Table 41 Number of butchery marks on cat bones

Plate 33 Cat first phalanx, cut marks (Period 1)

Plate 34 Cat radius, cut marks (Period 6)

skinned and then dumped in a well (Luff and Moreno García 1995). This assemblage is even younger than that at Castle Mall (Fig.43) which had a more mixed origin. The percentage of unfused epiphyses at medieval Castle Mall is more like that found at medieval West Cotton (Fig.43). Unlike the Cambridge well, at both these sites the cat populations were not entirely selected for their skins. Although young cats were preferred, adult cats were occasionally also skinned: there is a cat skeleton from Castle Mall with cut marks and all epiphyses fused.

An anatomical curiosity is represented by a cat mandible from Period 1 with an extra premolar. This phenomenon of tooth duplication has occasionally been found at other archaeological sites (Albarella 1993) and is described in Miles and Grigson (1990).

Deer

Deer bones are rare at Castle Mall and in particular no post-cranial bones of red deer were found in any period (Table 4). This is typical of medieval and post-medieval towns and rural sites, and contrasts with the high percentage of deer bones found in many castles (Grant 1988; Albarella and Davis 1996). Venison consumption was associated with high status, and deer hunting was a well known privilege of the aristocracy. The presence of deer bones on low status sites can be explained either as occasional poaching or a gift from an aristocrat. The donation of valuable goods such as venison was common practice in medieval times (Dyer 1988).

Even in Periods 2 and 3, which contain contexts most closely associated with the active life of the castle, deer

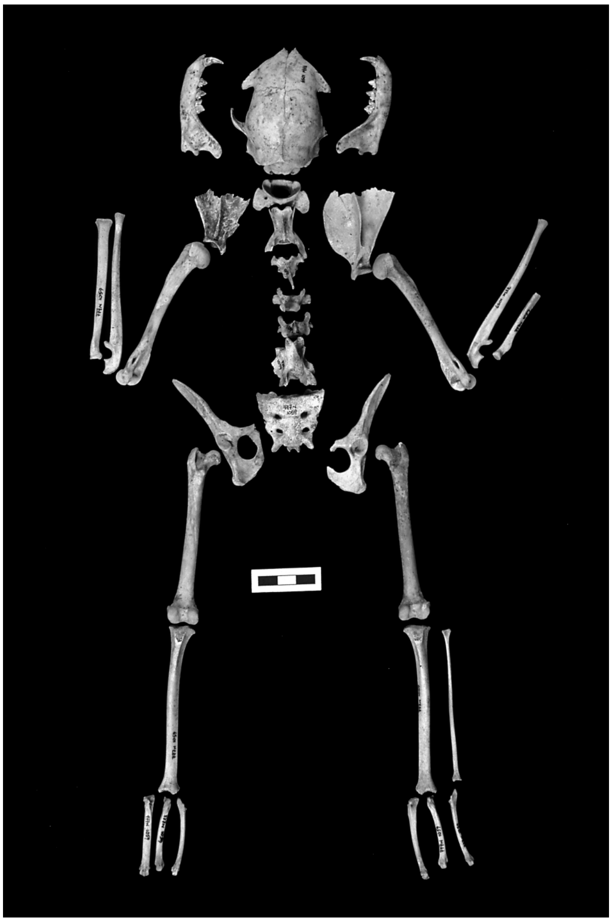


Plate 35 Cat skeleton, with cut marks on the skull (Period 2)

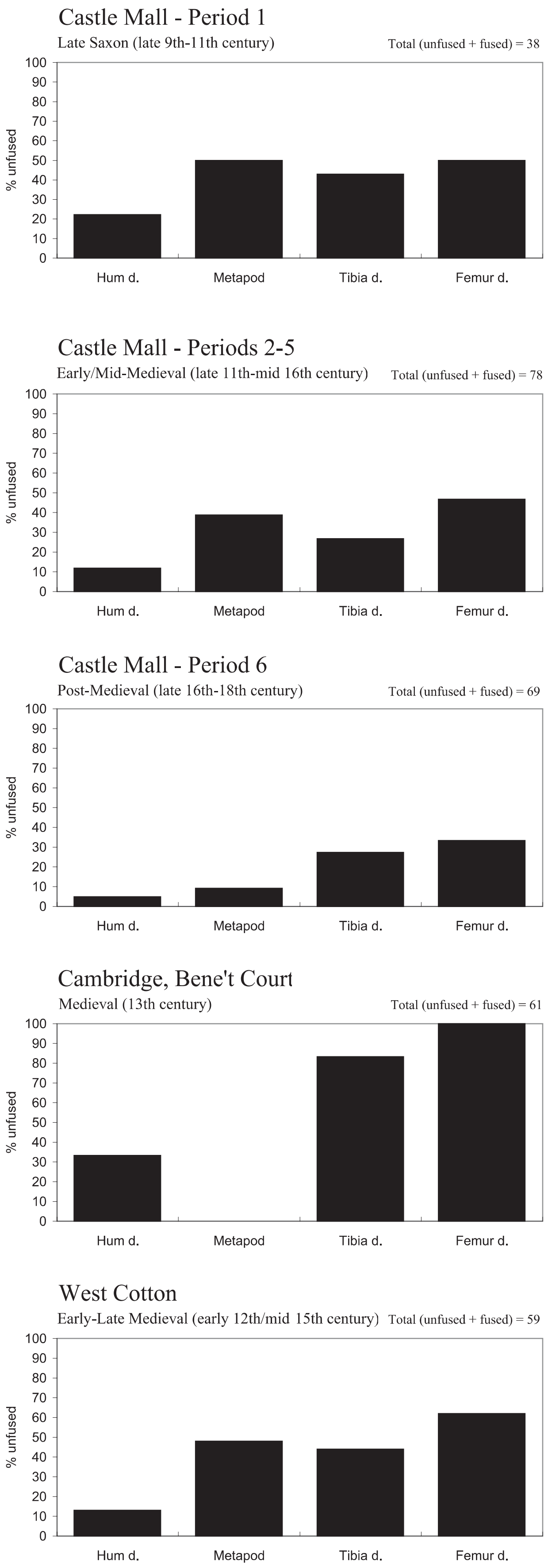


Figure 43 Percentage of unfused cat bones at Castle Mall, Cambridge Bene't Court (Luff and Moreno García 1995) and West Cotton (Albarella and Davis 1994)

Plate 36 Roe deer antlers (Period 1)

bones are scarce. This is not surprising as the castle refuse was not necessarily derived from high status meals. Visits by royalty were only very occasional (see above and Parts I and II), and the castle was mostly inhabited by tenants of lower social rank. No other evidence of particular wealth was found in the Period 2+3 assemblage.

Deer are much better represented by their antlers. The majority of identifiable antler is red deer, although in many cases it was not possible to separate red and fallow deer fragments. No positive evidence of fallow deer antler was found although this species is represented by a few post-cranial bones. A roe deer trophy — including antlers and the frontal part of the skull — was found in the Late Saxon period (pit *47831*, Period 1.3, Plate 36); this probably represented a hunting souvenir, rather than a specimen of any practical use. Antler was regarded as a good working material and many pieces are chopped or sawn (Plate 37). It was probably imported to the site as part of a general antler trade. In many cases the antlers were shed (Plate 38) which suggests they may have been collected in the woods around the town or further afield, hence no correlation is necessary between the number of antlers and cervid post-cranial bones.

Key to Figure 43 (left)
Numbers of unfused bones indicated above each bar
Hum = humerus, Metapod = metacarpus+metatarsus, d = distal
Where skeletons occurred at Castle Mall, only metacarpus+metatarsus was counted from each individual. No metapodial data were available from Bene't Court

Plate 37 Red/fallow deer antler, sawn tine (Period 6)

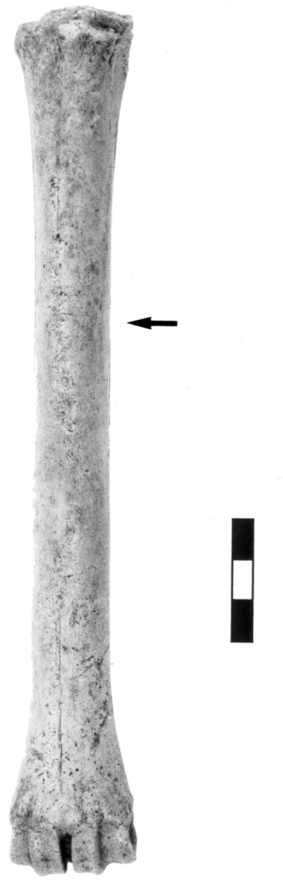


Plate 39 Fallow deer metatarsus, cut marks on shaft (Period 1)

One fallow deer metatarsus (Plate 39) was found in a context attributed to Period 1.4 (pit *90292,* Open Area 6), adjacent to sunken-featured Building 25 which apparently went out of use in the post-Conquest period. Fills of the pit yielded a large quantity (*c.*10kg) of 11th-century pottery, and it is possible that some post-Conquest material was included. This rather early occurrence is noteworthy. Fallow deer disappeared from England after the last glaciation and may have been reintroduced by the Romans. Rather than a full reintroduction to the wild the Romans probably brought with them some animals to be kept in semi-captivity. In fact, fallow deer bones are rare if not absent from Saxon sites, and become common only with the Norman conquest (see Lister 1984 for a review). Castle Mall is one of the earliest sites to provide evidence for the reintroduction of the fallow deer by the Normans, and the early occurrence of this species in Norwich is confirmed by another find from an 11th/early 12th-century context at St Martin-at-Palace Plain (Cartledge 1987). Fallow deer bones from Norman contexts have also been found at Castle Acre (Norfolk) (Lawrance 1982).

The Castle Mall specimen has been identified as a fallow deer on the basis of its size and of the morphological characteristics suggested by Lister (1996). This bone also displays knife cuts on the mid shaft (Plate 39) which attest to the skinning of the animal.

Minor Species

A few other wild mammals were found at Castle Mall. One badger mandible from Period 3 (Plate 40) testifies to the occasional exploitation of this animal, probably for its fur. Rabbit and hare bones are more common. In particular

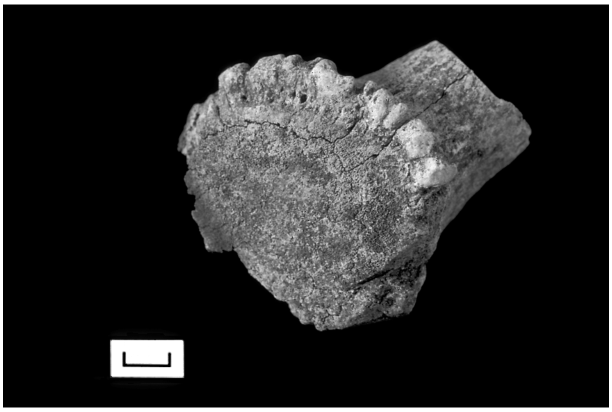


Plate 38 Red deer antler (Period 4)

Plate 40 Badger mandible (Period 3)

Plate 41 Hare tibia, chopping marks (Period 5)

quite a few rabbit bones were recovered from the late periods. These species were certainly exploited for their meat, as is also proved by the presence of clear chop marks on a hare tibia from Period 5 (Plate 41).

There is surprising evidence for the presence of rabbit bones in Period 1 (Table 4). This came from the fill of a post-hole (*11790*) associated with Building 8 (Period 1.2). This species, like the fallow deer, was introduced to England by the Normans (Corbet and Harris 1991), but probably not before the 12th century (Veale 1957). It is thus possible that the Castle Mall bones attest to an earlier introduction of the rabbit in this country. However, due to the burrowing habits of this species, it is more likely that the bones are contaminants from an upper level.

Other small mammals such as rats and mice are commensal species which are commonly found in medieval and post-medieval urban environments. Voles are typical inhabitants of grassland habitats (Corbet and Harris 1991) and their presence is probably connected to some open, not completely urbanised, areas of the town.

IX. Birds

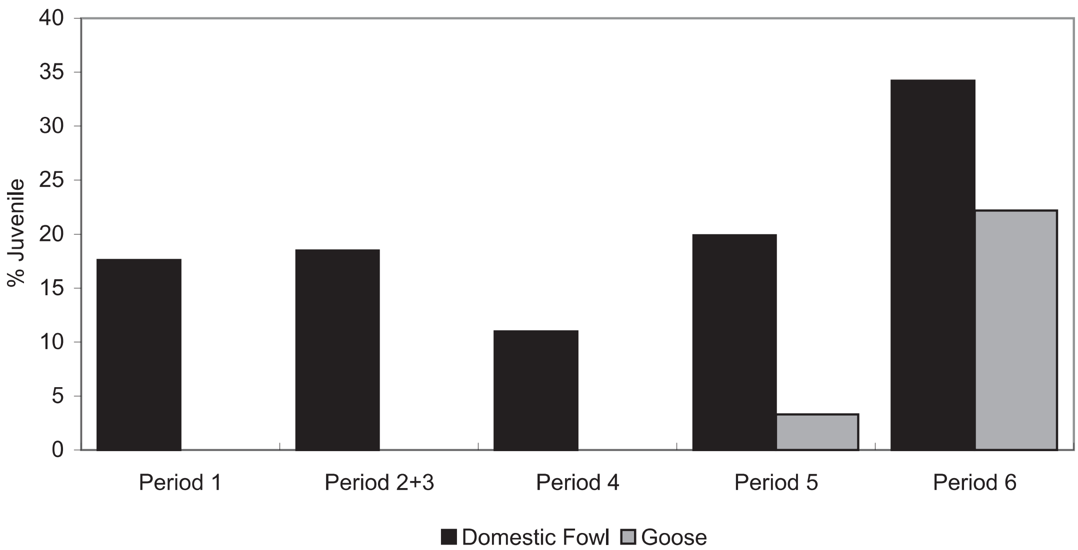
(Pls 42–47, Figs 44–46, Tables 42–43)

Domestic Fowl

No evidence of any other medium sized galliforms, such as pheasant (*Phasianus colchicus*) or guinea fowl (*Numida meleagris*), has been found at Castle Mall (although pheasant was recorded at the Golden Ball Street site, see Curl, Chapter 6). Hence, although only a few specimens could be identified to species (*Gallus gallus*), it is assumed that the overwhelming majority of the bones belong to the domestic fowl, and will be considered as such in the rest of this report.

Domestic fowl bones were common throughout all periods (Table 4), with their relative frequency even higher in the sieved assemblage (Tables 5 and 6). Most bones were isolated finds, although a few burials were present (Table 7). One of these skeletons from Period 1 belongs to a neonatal individual and indicates the local breeding of this species. The possibility that chickens were bred in towns has also been raised by Grant (1988), who suggests that they could easily have been fed with household scraps.

The majority of the domestic fowl bones have non-porous, adult-like, bone ends. This is typical of many



Sample sizes (total NISP) domestic fowl: 245 (Period 1), 151 (Period 2+3), 146 (Period 4), 176 (Period 5), 111 (Period 6)
goose: 25 (Period 1), 32 (Period 2+3), 29 (Period 4), 60 (Period 5), 27 (Period 6)

Figure 44 Percentage of juvenile domestic fowl and goose by period

Period	*Unspurred tarsometatarsi*	*Spurred tarsometatarsi*	*% females*
1	22	6	79
2+3	13	4	76
4	9	0	100
5	8	7	53
6	4	3	57
total	**56**	**20**	**74**

Table 42 Number of unspurred (females) and spurred (males) tarsometatarsi of domestic fowl. 'Spurred' also includes specimens which only have a 'spur scar' or a 'reduced spur'

archaeological sites and it is probably mainly due to preservation, recovery and identification problems which cause an underestimation of the number of young birds. However, about 15–20% of specimens had porous extremities, typical of juvenile animals. This percentage increases to *c.*35% in Period 6 (Fig.44). This change may be associated with a shift in importance away from egg production in the Middle Ages to meat production in the later periods. The same trend has been noted on other British sites (Grant 1988). The use of chicken meat and eggs is well documented for medieval times (Grand and Delatouche 1950). However, considering the relatively small body mass of a domestic fowl, chicken meat would have been a welcome, but not substantial, contribution to the diet.

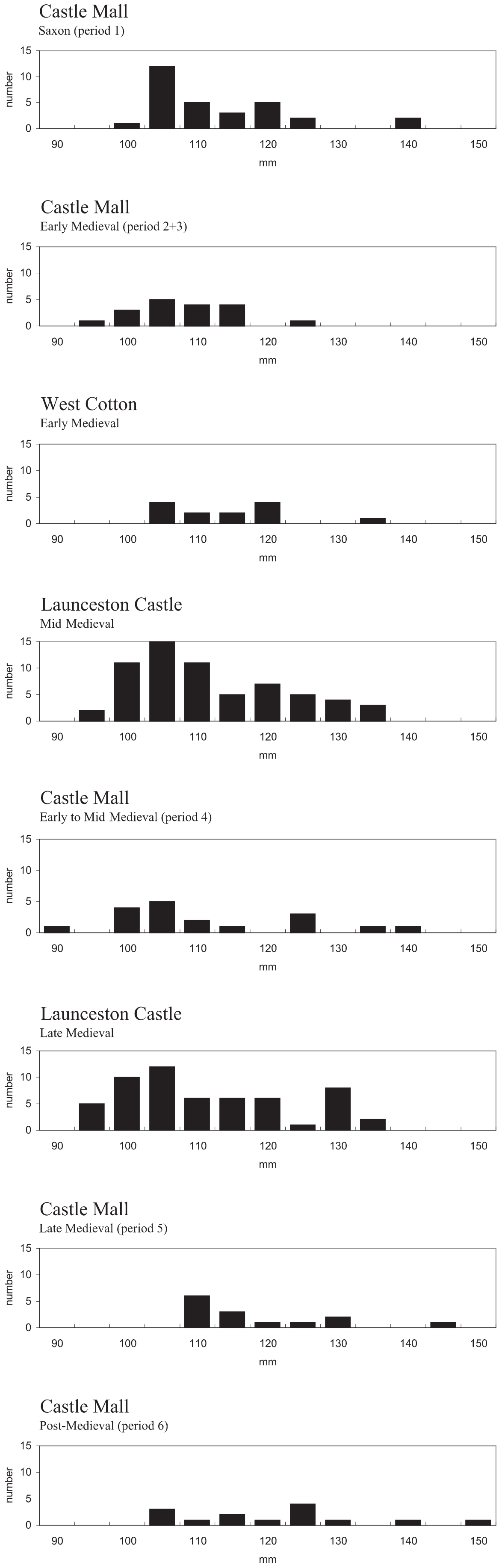
There is a difference in the sex ratio between Periods 1–4 and 5–6 (Table 42; Fig.45). In the Middle Ages a mixed economy aimed at the production of meat and eggs would have an expected sex ratio of about five hens for one cock (Grand and Delatouche 1950). In Roman times, Columella (VIII.2.13) suggested an identical ratio. The lower number of males is a result of the killing of males (generally caponized) at a young age, before they develop a tarsometatarsal spur (Sadler 1991). Approximately the same ratio is found in the medieval levels at Castle Mall. However, in later periods a roughly equal number of hens and cocks are found. This variation in the proportion of sexes probably has a similar cause to the age decrease in the population. In an economy mainly aimed at meat production many females as well as males would have been killed at early stages of growth. The data from the barbican well (mid/late 15th to early 16th century) confirms this with similar numbers of unspurred and spurred tarsometatarsi found (Moreno García, Chapter 4).

The analysis of the metric variation of this species has produced some very interesting results. A substantial size increase occurs in Periods 5 and 6 (Tables 21 and 43; Figs 45 and 46). This is highly statistically significant when Periods 1 to 4 are combined for comparison (Table 21). This can partly be explained by the higher number of males in later periods. However, when fowl of the same sex are compared the size increase is still evident. For instance, note in Fig.46C the larger size of the females from Periods 5 and 6. This size increase is again probably a consequence of the different use of the animals, as larger birds would have been selected for meat production. What is particularly interesting is the early occurrence of this improvement, which seems to have been initiated in the 15th century. Due to the general scarcity of metric data

	Measurement	*Mean*	*V*	*Min*	*Max*	*N*
Period 1	Humerus GL	665	7.8	611	815	16
	Humerus SC	67	9.5	58	83	16
	Humerus Bd	143	9.0	129	175	18
	Femur GL	732	9.4	638	854	21
	Femur Lm	690	9.2	590	799	20
	Femur SC	66	11.8	55	83	22
	Femur Bd	145	10.4	125	179	27
	Femur Dd	124	9.8	108	148	25
	Tibiotarsus GL	986	6.3	901	1155	16
	Tibiotarsus La	954	6.6	867	1120	17
	Tibiotarsus SC	57	9.3	49	69	19
	Tibiotarsus Bd	110	9.4	100	140	30
	Tibiotarsus Dd	114	9.3	98	146	28
	Tarsometatarsus GL	670	10.7	575	849	30
	Tarsometatarsus SC	59	8.8	52	72	33
	Tarsometatarsus Bd	122	9.1	108	148	32
Period 2+3	Humerus Bd	146	7.9	121	164	14
	Femur Lm	675	13.1	507	805	10
	Femur SC	63	11.3	55	77	12
	Femur Bd	142	10.4	122	163	14
	Femur Dd	123	7.7	109	141	13
	Tibiotarsus GL	1025	8.2	931	1175	10
	Tibiotarsus La	986	8.1	893	1134	10
	Tibiotarsus SC	59	9.1	51	68	11
	Tibiotarsus Bd	106	6.6	94	121	18
	Tibiotarsus Dd	111	8.6	95	127	16
	Tarsometatarsus GL	687	7.5	605	798	18
	Tarsometatarsus SC	59	8.1	53	68	18
	Tarsometatarsus Bd	122	6.9	113	142	20
Period 4	Humerus Bd	145	6.1	136	163	13
	Femur GL	670	3.9	656	747	10
	Femur Lm	647	4.0	603	692	12
	Femur SC	62	5.0	59	69	10
	Femur Bd	137	5.2	121	149	17
	Femur Dd	117	5.7	100	128	17
	Tibiotarsus Bd	109	12.3	90	138	18
	Tibiotarsus Dd	111	8.6	98	131	18
	Tarsometatarsus GL	660	7.1	581	757	12
	Tarsometatarsus SC	56	5.1	52	62	11
	Tarsometatarsus Bd	120	6.4	113	142	13
Period 5	Humerus SC	68	11.5	57	81	12
	Humerus Bd	149	8.6	129	172	20
	Femur GL	785	8.2	681	881	17
	Femur Lm	728	8.0	635	824	17
	Femur SC	71	11.4	60	84	16
	Femur Bd	186	11.7	124	204	20
	Femur Dd	133	10.6	109	156	20
	Tibiotarsus Bd	117	9.2	107	145	14
	Tibiotarsus Dd	119	11.5	102	147	13
	Tarsometatarsus GL	789	13.1	640	973	11
	Tarsometatarsus SC	70	17.9	52	94	12
	Tarsometatarsus Bd	135	12.4	115	166	10
Period 6	Humerus GL	747	10.8	629	871	10
	Humerus SC	73	11.1	58	86	10
	Humerus Bd	158	11.3	131	191	10
	Femur SC	72	10.9	63	86	10
	Femur Bd	158	10.2	139	186	11
	Femur Dd	135	11.4	115	163	10
	Tibiotarsus Bd	119	11.1	104	148	14
	Tibiotarsus Dd	121	9.9	103	141	14

Juvenile ('J') bones are not included
A few measurements are approximated
All measurements are in tenths of millimetres
Only samples of at least 10 measurements are given

Table 43 Means, coefficients of variation (V), ranges and sample sizes for domestic fowl measurements



Measurements are in tenths of mm
A comparison between specimens from Launceston Castle (Albarella and Davis 1996), West Cotton (Albarella and Davis 1994) and Castle Mall

Figure 45 Domestic fowl tibiotarsus distal breadth (Bd)

Plate 42 Domestic fowl tibiotarsus, large exostoses (Period 4)

available for domestic fowl from post-medieval sites, little is known about size variation in chicken populations. The Castle Mall data suggest that the agricultural revolution brought about improvements and changes not only in the mammalian stock but also in poultry. Moreover, Castle Mall provides evidence that these changes began at a remarkably early date, as historians and archaeologists have more recently been suggesting (Kerridge 1967; Davis 1997).

No significant size differences were noted between the medieval birds at Castle Mall, West Cotton (Albarella and Davis 1994b) and Launceston Castle (Albarella and Davis 1996). This might suggest that during the Middle Ages these birds were bred for similar purposes throughout England.

Pathologies such as exostoses and abnormal bone growth (Plate 42) were noted on some domestic fowl bones, but none were abundant and therefore are of little archaeological interest.

Butchery marks were present on about 6% of the bones, and were evenly distributed between the different periods. They are direct evidence for the consumption of chicken flesh. The majority of butchery marks are knife cuts, and they confirm the direct relationship between body size and the chops/cuts ratio suggested above. One tarsometatarsus from Period 1 had a series of parallel cuts on the spur which eventually led to the removal of the spur tip (Plate 43). A sensible explanation for this operation has not yet been found and any suggestions would be gratefully received. If the reason was the removal of the spur why were so many cuts produced and why was the whole spur not removed?

Other Domestic Birds

Goose was the second most common bird at Castle Mall, although it was much rarer than domestic fowl. On the basis of the large size of the bones it is assumed that most belong to domestic animals, although two smaller specimens from Period 6 might derive from a wild species.

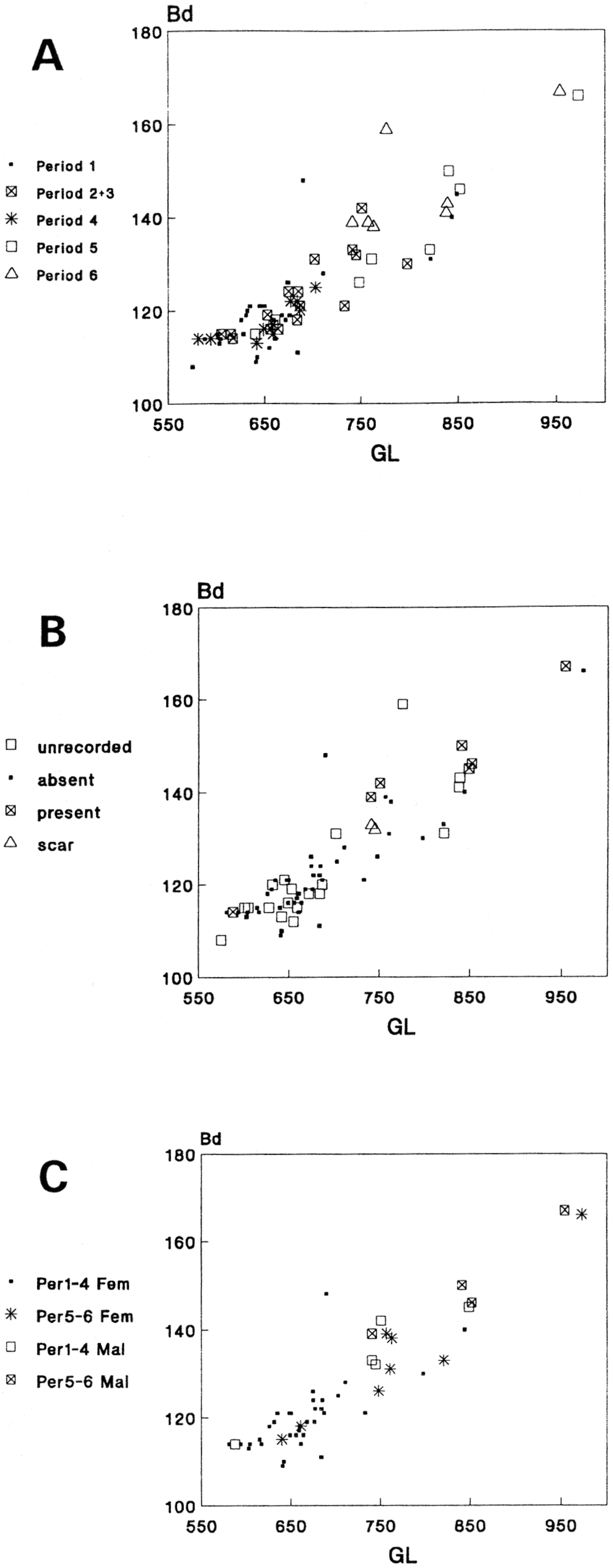
Geese were popular birds in medieval times when they were kept for their meat, eggs and particularly for their valuable feathers (Grand and Delatouche 1950). Fewer juvenile geese than juvenile domestic fowl were found at Castle Mall (Fig.44). This same pattern has been noted at other sites such as Exeter (Maltby 1979), Launceston Castle (Albarella and Davis 1996), West Cotton (Albarella and Davis 1994b) and also in the fills of the barbican well at

Plate 43 Domestic fowl tarsometatarsus, cut marks on spur (Period 1)

Castle Mall (Moreno García, Chapter 4). Bones from Periods 1 to 4 all belong to adult animals, but in Periods 5 and particularly Period 6 there are also a number of juvenile bones. As for domestic fowl, it appears that a change in the use of geese occurred by post-medieval and possibly late medieval times. The importance of eggs and feathers may have declined at the expense of more intensive breeding for meat production. Indeed during the Middle Ages geese were not killed for their feathers, but they were regularly plucked live twice a year, in spring and autumn (Grand and Delatouche 1950).

More goose than chicken bones bore visible cut marks (*c.*23%). This is not surprising in view of the larger size of this bird. Almost all marks were cuts rather than chops. The large numbers of carpometacarpi and of worked radii and ulnae which characterise the barbican well fills (Moreno García, Chapter 4; Huddle, Part II, Chapter 9.III) have only occasionally been found in the rest of the site (Julia Huddle, pers. comm.). Only two goose ulnae (from Periods 1 and 4) were worked to make bone cylinders, possibly serving as needle cases (Huddle, Part I, Chapter 4.III).

Ducks were rarer than geese and this is consistent with the situation on most medieval sites in Britain (Grant 1988). Unlike geese, ducks were not valued in the Middle Ages, and their meat was considered unhealthy due to their 'dirty' feeding habits (Grand and Delatouche 1950). It is therefore possible that duck meat was mainly eaten by lower class people. Cut marks are present on 9% of the bones, a similar percentage to that found on domestic fowl, which is of similar size. This suggests that ducks, along with the other domestic species, were kept for their meat.



In diagram C specimens without a spur are considered female and specimens with a reduced or complete spur are considered male

Figure 46 Size variation of domestic fowl tarsometatarsus at Castle Mall by period (A), according to the presence/absence of a spur (B), and the two variables together with Periods 1–4 and 5–6 combined (C)

Two turkey bones were found from Periods 5 and 6. The former specimen derives from a mid to late 16th-century pit fill (pit *90715*, Period 5.2). The first record of the presence of this American bird in England is from 1541 (Crawford 1984) and it evidently reached Norwich soon after its introduction.

A bone of a peacock — a bird normally associated with high status — was also identified, but unfortunately it belongs to a context of uncertain date.[1]

Wild Birds

Only a few bones of wild birds were found at Castle Mall, but some were of great interest. They are distributed in all periods (Tables 3–6), without any particular concentration in a specific phase or area.

Some of the duck bones were very small and could be confidently attributed to either of the two tiny wild species — the common and widespread teal or, less likely, the rarer garganey. Another duck bone from Period 5 was, on morphological grounds, identified as a diving duck (*Aythya* sp.). Other water birds include the swan, cormorant, coot and moorhen. A grebe humerus from Period 5 was identified as a little grebe (*Tachybaptus ruficollis*) on the basis of its size and proportions (see Bochènski 1994). This specimen displays clear cut marks (Plate 44) which suggests its use for meat.

Waders include curlew, snipe and an unidentified small wader the size of a dunlin. However, there is evidence that more waders were occasionally hunted, as plover and godwit bones were found in contexts of uncertain date.

Among the terrestrial birds woodcock and grey partridge bones were found. A partridge coracoid from Period 4 bore cut marks (Plate 45). Both these species were highly prized in medieval times (Simon 1944) and their bones are found in great abundance at some high status sites (Maltby 1982; Albarella and Davis 1996).

Birds of prey were only found in a single pit (Period 1.3). They are represented by four buzzard bones possibly belonging to the same individual and by the partial skeleton of a goshawk (Plate 46), both from the same 11th century pit (*90516*; G9/109, Fig.4) in Open Area 6, adjacent to a sunken-featured building. This pit and those surrounding it contained a notable concentration of partial skeletons (Table 7).

If the buzzard was just a scavenger (see O'Connor 1993b) then the presence of the goshawk is of more interest. This bird is one of the four species most commonly used in falconry (the others being the peregrine, the merlin and the sparrowhawk). This type of hunting was particularly common in the Middle Ages and the occurrence of falconry at Castle Mall seems the most plausible explanation for the presence of the goshawk. A few birds of prey have been found buried in human graves in European sites, but generally when a trained hawk died it was just thrown on the waste tip (Prummel 1995). Whereas falcons were strictly associated with the highest aristocracy, sparrowhawks and goshawks were also used by the lower nobility and rich commoners (Prummel 1995). In particular the goshawk was the typical bird of the yeoman (Grant 1988). Although it is tempting to connect the hawking practice with the arrival of the Norman nobility, it is also possible that the goshawk had a Late Saxon origin. The Domesday Book mentions that Norwich made a pre-Conquest payment (annually?) of a goshawk to the Earl (Brown 1984, (61) 117b).[2]

Plate 44 Little grebe humerus, cut marks (Period 5)

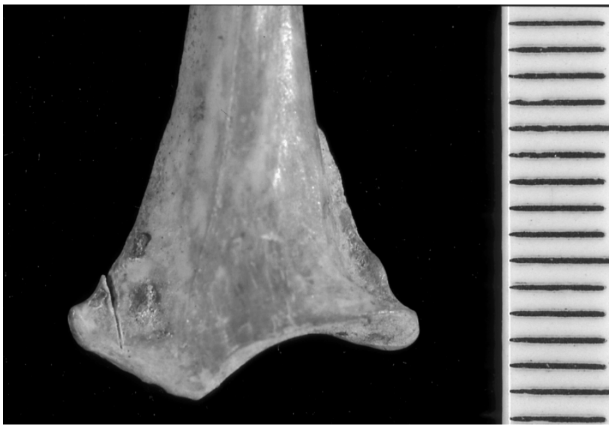


Plate 45 Grey partridge coracoid, cut marks (Period 4)

The most unusual finds from the Castle Mall assemblage were two parrot bones (Plate 47), which probably belong to the same individual. They derive from the fills of a pit dated to the mid–late 17th century (pit *80188*, Period 6.2, Fig.9.B). No other exotic finds came from this pit, although seeds of pumpkin, a fruit of American origin, were found in a nearby pit of the same date (Murphy, Part II, Chapter 10.IV). It is unfortunate that, despite careful analysis of the bird bone collection of the Natural History Museum in Tring, it was not possible

Plate 46 Goshawk partial skeleton (Period 1)

to identify these bones to species or even genus level. These bones belong to a middle-large sized parrot, of about the same dimensions as an African grey parrot (*Psittacus*). Parrots are tropical and sub-tropical birds with some 200 species found on four continents. They are a very homogeneous order (*Psittaciformes*), all grouped in the same family (*Psittacidae*) and subdivided in three subfamilies: Cacatuinae, Lorinae and Psittacinae (Forshaw 1989). On metric and morphological basis the first two subfamilies could be excluded, but this was not of much help as the *Psittacinae* are as widely distributed as the whole order. Despite an extensive survey of the parrot reference collection of the Natural History Museum in Tring undertaken by Umberto Albarella and John Stewart, identification of these bones at species or even genus level proved to be impossible. It must therefore be assumed that this bird could have come from virtually any place in the southern hemisphere.

Plate 47 Parrot coracoid and carpometacarpus (Period 6)

Parrot bones have never been found before on an archaeological site in England, and the current authors would be interested to hear of any such remains from the European continent. However, parrot illustrations are well known in medieval manuscripts. The earliest use of parrot pictures as decoration known in England is from the mid-13th century books associated with William of Devon. Another parrot, probably a ring-necked parakeet (*Psittacula* sp.), also appears in the Luttrell Psalter (13th century) (Yapp 1981). However, the Castle Mall bones belong to a larger parrot than the parakeet.

Although the place of its origin remains unknown, the parrot is interesting because it demonstrates a connection between Norwich and exotic countries. The 17th century was certainly a period of intense travelling and trade and the fact that valuable exotic goods arrived in Norwich suggests that the city had not lost its importance as a centre of exchange and market. Further discussion of the local context of this discovery is given by Shepherd Popescu in Part II, Chapter 10.VI, ‘Foreign Contacts’ and ‘Public Houses and Inns’, where a possible link with a local hostelry is noted.

X. Environment and Economy at Castle Mall: the evidence of the animal bones

Food Provision

One of the most interesting findings from the Castle Mall animal bones was the evidence of on-site breeding. The main evidence for this is the presence of neonatal bones of the main domestic animals: cattle, sheep, pig, horse and domestic fowl. These bones are not very abundant, but this is likely to be a result of their small size and fragility which cause poor preservation and recovery. Neonatal cattle and sheep bones are more common in early periods, whereas newborn pig bones were more commonly found in Periods 5 and 6.

Stock breeding within the town may be unexpected, as towns are primarily considered to be consumer sites. In fact animals were reared in the area of Castle Mall which suggests that the town was not fully urbanised until at least post-medieval times. Rural areas within the castle walls were probably used as pasture rather than cultivated land, as the evidence from the plant remains suggests that 'most grains were imported to the site as semi-cleaned prime product at all periods' (Murphy, Part II, Chapter 13). The absence of local agriculture is also suggested by the presence of large numbers of latrine pit assemblages, these indicate that there was no need to use human sewage as manure ('night soil') (Murphy, Parts I and II).

The scarcity of cattle and sheep neonatal bones in post-medieval times implies that breeding of these animals in the town gradually died out, or became much reduced. This is consistent with the growth of the Norwich population and the increasing urbanisation of the castle surroundings. However, pig breeding continued. This is not surprising as pigs need much less space and could be raised in house courtyards and fed with household food scraps (see also Hudson and Tingey 1910, 205–206 and Moreno García, Chapter 4).

The evidence from Castle Mall contrasts with that found in other Late Saxon and early medieval towns, such as Southampton (Bourdillon 1994) and York (O'Connor 1994). In these sites the presence of all skeletal parts of the livestock body, combined with the absence of neonatal bones, was taken as evidence that animals were imported to the site on the hoof. In other words, the breeding of animals took place elsewhere but the slaughtering and the primary butchery occurred in town. Can it therefore be suggested that Norwich had more open areas and was less urbanised than Southampton and York? This does not seem probable. It is more likely that these differences are due to assemblages coming from different areas of the town. There probably were areas in Southampton and York where stock-rearing occurred. It is also possible that Norwich in Late Saxon times still had a rather rural aspect. In the subsequent Norman and medieval periods the presence of the castle and its earthworks contributed to the fact that much of the area was not developed and retained its 'open land' characteristics suitable for animal pasturing (see Parts I and II). The castle's north-east bailey in particular (the Castle Meadow) continued in use as rough pasture. Full details of the use of the castle baileys for animal grazing (*e.g.* the trampling of herbivores attested by micormorphology; see MacPhail, Part I) and the various phases of Cattle Market are given in Parts I and II of this report.

The town and the castle were probably only partly supplied with products derived from local breeding. Norwich had an important market and, as already noted, the arrival of livestock on the hoof is historically well attested. Moreover the evidence from the distribution of body parts indicates that, although complete carcasses were present, selected cuts of meat were also sometimes imported or just distributed. For example, the presence of a high number of sheep scapulae in the post-medieval fills of the barbican ditch can be interpreted as the acquisition of selected parts of the carcass, not necessarily from the countryside but perhaps from butchers elsewhere in the town.

Diet

Isotopic analysis of the human remains from the Late Saxon cemeteries at Castle Mall is detailed by Bayliss *et al.*in Part I, Chapter 4.IV, allowing broad consideration of the contribution that animal products make to the diet compared to cereals (see also Bayliss *et al.*2004). The direct evidence for dairy products is poor. The kill-off patterns of cattle and sheep within Norwich do not suggest a particular emphasis on milk production, but the situation might have been different in the countryside, and milk and dairy products could regularly have been sold in urban markets. It is however possible to find historical sources describing the difference in the patterns of animal protein consumed by urban and rural populations, and the rich and the poor. Those in towns ate more meat than those living in villages, although for both cereals would have made a significant contribution to the diet, and by the early 15th century cereal foods accounted for 63% of the diet. Fish (Locker this volume; Locker 2001) and dairy products were also an important food source, and the latter formed the major source of animal protein for peasants and artisans (Dyer 1989).

Even taking into account the obvious over-representation of cattle bones, it is quite clear that beef was the most consumed meat during all periods. Pork was particularly important in Late Saxon and early medieval times. Mutton was also consumed but was of secondary importance to the main use of the sheep, which was the production of wool. Horse and dog meat may occasionally have been eaten, perhaps in periods of crisis, but the flesh of these animals was more likely to have been used to feed dogs.

Chicken and goose meat provided a secondary but constant contribution to the diet. This probably increased in post-medieval times when these birds began to be bred specifically for their meat, rather than for eggs or feathers. The contribution of wild game to the diet was negligible. Venison and wildfowl were only very occasionally eaten, perhaps in special circumstances and only by the more wealthy townsfolk.

Craft

The known intensity of craft and industrial activities in Norwich and the Castle Mall area (detailed in Parts I, II and IV) finds wide confirmation in the zooarchaeological evidence. Although only one large group of bones — from Period 5 — could be associated with a specific area of craft activity (Fig.8; Plate 11), scattered but plentiful evidence of bone-, horn- , antler- and leather-working was found throughout the site in all periods. A few small groups of bones associated with craft activities were found (Figs 5, 8 and 9; Plates 7, 11 and 13), but in most cases they were mixed with common food refuse.

Bone tools were generally made from cattle and horse bones, although bones of other animals were occasionally utilised. Due to their robust shaft, cattle and horse metapodia were the bones most commonly used; evidence of sawing and faceting has been found on these bones. However, many other objects, such as spindle whorls, handles, skates and sledges were also found (see Huddle, Parts I and II). Spectacular evidence for the use of goose feathers for making quills or fletching arrows and goose bones for making tools has been found in the barbican well (Moreno García, Chapter 4; Huddle, Part II, Chapter 9.III).

Antler and horn were also used for making tools. Horn generally does not survive on archaeological sites, but its bony core — the horncore — is commonly recovered. Analysis of certain artefacts from the site by scanning electron microscope has, however, confirmed the use of horn for the manufacture of handles (see Watson and Paynter, Part II, Chapter 9.III). Abundant evidence for the use of cattle, sheep and goat horns has been found in all periods, although this is more common in Periods 2 and 6 for cattle and Period 5 for sheep. The presence of a number of goat horncores, in contrast to the rare occurrence of post-cranial bones, attests to the existence of an independent horn trade and thus to a specific interest in this material. The same was true for antlers, which were found in large numbers, despite the rare occurrence of deer bones.

It is possible that the horn-worker was closely associated with the tanner — or tawyer — as horncores and foot bones were generally still on the skin when it arrived at the tannery (Serjeantson 1989). A large group of sheep horncores, metapodia and phalanges from the 15th century can indeed be explained as the dump of a tannery workshop. Evidence of skinning has also been found for cattle, pig, horse, fallow deer and cat. The use of cat pelts is almost entirely limited to the early phases of the site.

Status

The presence of a royal castle in Periods 2 and 3 might lead to the expectation that evidence of high status would be found in these periods. In fact this was not the case and the typical high status animals, such as deer and wild birds, are as rare during the castle phases as they are in earlier and later times. Continuity, rather than change, could be observed in the transition from Period 1 to 2. Thus it appears that the excavated features, even if belonging to the castle, did not contain refuse of royal banquets. This is not surprising as visits of the king were only very occasional and may have left traces in other areas of the castle, untouched by this excavation. The findings from the plant remains are consistent with the animal bone results: no exotic species or any other indication of high status was observed (Murphy, Part I, *passim*.).

Some findings, such as the evidence for falconry in the 11th century, or a rather high proportion of pig bones in Late Saxon to early medieval periods — roast pork was ‘the most consistent source of more delicate meat’ (Dyer 1989 quoted by Serjeantson in press) — or even the presence of exotic species, such as a parrot in a 17th-century pit fill, may hint at some evidence of high status. However, this is not necessarily related to the castle, but is more probably a consequence of the variation and inequality of the distribution of wealth within towns (Dyer 1989). For instance, the parrot might have belonged to a rich merchant and, as discussed above, the goshawk was not necessarily a bird associated with the highest aristocracy.

Use of Space and Disposal Practices

The topography of the site changed enormously in different periods, and when comparisons are made between periods they are also made between different types of sites. In all periods the animal bones mainly derived from pits and ditches filled with a mixture of food and industrial refuse, with no regard to the type of building present or the organisation of the space.

In Period 1 the site was organised as a settlement with several ‘properties’ (Figs 3–4). Although no obvious division between domestic and industrial areas could be detected, lateral variation occurred in the distribution of the animal bones. Not only did the frequency of different species vary in different areas, but also the type of handicraft — in particular horn- and antler-working. The significance of this variation is not completely understood, but it might be related to the disposal of food refuse on site and to the spatial distribution of different workshops.

From Period 2 onwards the features excavated are mainly represented by the outer and inner ditches of the castle, and by a series of minor structures also located within the castle perimeter (Figs 5–9). Some differences in the contents of ditches and pits have been noted, and this is probably due to the different use of these two types of features. Ditches may have been used mainly for large scale dumping of the town refuse, whereas pits were associated with small scale domestic activities. In particular, the disposal of the carcasses of dead animals in the barbican ditch (Fig.9) seems to have been common practice during late medieval and post-medieval times. Many complete horse bones were found in the ditch, but they were not in articulation, which suggests that these are not primary deposits and that reworking of the barbican ditch fills occurred at some stage.

A lower frequency of gnawing marks in later periods probably indicates a prompter burial of bone refuse and thus a more organised system of waste disposal. This would have become necessary as the density of population increased and is consistent with the increasing urbanisation of the town in late and post-medieval times as suggested above.

XI. Animal Economy and the Agricultural Revolution: the Castle Mall Contribution

(Tables 44 and 45)

The type of animals and the husbandry techniques found in the Late Saxon and medieval periods at Castle Mall are both consistent with other archaeological sites in England and with information from historical sources. It has also become apparent that the age, sex and size of the animals are inter-related factors which must all be considered in any study of the evolution of husbandry techniques.

From the 10th century (Period 1) to at least the mid 14th century (Period 4) the principal uses of the main domestic stock at Castle Mall and throughout the country were probably as follows: cattle were mainly exploited for

		Period 1–2+3	Period 2+3–4	Period 4–5	Period 5–6
Cattle	Age	stable	stable	*decrease*	stable
	Size	stable	stable	increase??	*increase*
	Shape	stable	stable	?	*change*
Sheep	Age	stable	stable?	*increase*	stable
	Size	stable	stable	stable	*increase*
	Shape	stable	*change*	stable	*change*
Pig	Age	stable	?	?	*decrease*
	Sex	stable	stable	stable	stable
	Size	stable	stable	stable?	*increase*
	Shape	stable	stable	stable	*change*
Domestic fowl	Age	stable	stable	stable	*decrease*
	Sex	stable	stable	*change*	stable
	Size	stable	stable	*increase*	stable
Goose	Age	stable	stable	stable?	*decrease*

Table 44 The main domesicates: changes in age, shape and size over time

traction, sheep were a precious source of wool, pigs provided almost exclusively meat (and fat) and domestic birds produced eggs and feathers. All animals were at some point eaten, but in some cases their flesh may have represented only a secondary product. This is obviously an over-simplification, because variation across the country occurred and in some periods other products may have become predominant, but in very broad terms these were the main uses of the animals.

In medieval times, partly due to the primitive techniques then available and partly due to the type of animal use, the livestock was of a relatively small size. This is well attested by historical sources and has been confirmed by the study of the Castle Mall animal bones. However, this does not mean that the animals were all identical across the country. Variation occurred and even if one cannot yet talk of genetic breeds in the modern sense, regional types were present (Trow-Smith 1957). The high homogeneity of the medieval sheep, in particular, has hitherto been emphasised in the zooarchaeological literature. However, using a technique which allows the comparison of different measurements on the same axis (Davis 1996), it is evident that the medieval sheep at Castle Mall, although of roughly the same size, show some shape variation between periods. This suggests that the homogeneity of the medieval sheep might have been overemphasised due to the way the measurements have been examined to date.

After a period of relative stability which lasted for several centuries, some major changes in the type of use and in the size and shape of the animals occurred towards the end of the Middle Ages and the beginning of the modern age. When exactly did these changes occur? The evidence from other sites suggests that many had already begun during the 16th century (Davis 1997). This is consistent with the view of some historians who suggest that the 'agricultural revolution' was an earlier and more gradual phenomenon than is often claimed (see for instance Kerridge 1967). Unfortunately the 16th century at Castle Mall is either poorly represented or not securely dated, therefore this animal bone assemblage cannot provide a major contribution to the question of when livestock improvement began. However, interesting data have been found concerning the changes in husbandry techniques and the consequent modifications in size and shape of the animals that the agricultural revolution brought about.

Before entering into a detailed discussion of the exploitation of the main species at Castle Mall, it is useful to summarise the data for age, sex, size and morphology (see Table 44). Details of how these results were obtained and their interpretation are presented above and will not be repeated here. In this concluding section more general comments will be made. In both cattle and sheep, variation in the kill-off patterns precedes size and morphological changes. In the case of cattle it is plausible to assume that a new type of animal use, more specifically aimed at the production of meat, was associated with a different kill-off pattern and led to the selection of larger beasts. The situation for sheep is more complex, as changes in size and mortality do not go in the same direction. The shift towards older animals is evidence that wool production was further increasing in importance, whilst the size increase suggests that large animals capable of producing more mutton were also being selected. In fact the two changes do not go together, but they are perfectly compatible, because large sheep can also produce good quality wool. Many of the best 'wool' breeds, such as the Lincoln Longwool, are actually very large (Keith Dobney, pers. comm.).

The situation is different for pig where both the main changes are concentrated in the latest period. The use of pig for meat and lard production continued and the only reason for these changes was to increase productivity. It is probable that this increase in productivity was realised with the importation of new stock, which was larger, faster growing and thus could be killed at an earlier age.

The role of the domestic fowl has been neglected in the study of changes connected to the agricultural revolution. However, the Castle Mall evidence suggests that already in Period 5 (*i.e.* almost certainly during the course of 15th century) this bird had been subject to a size increase: possibly the consequence of selective pressure towards higher meat production. This improvement was successfully completed in the later period, where an age decrease implies the increasing importance of meat. The evidence from Castle Mall alone is not enough to suggest that this increase in size of domestic fowl represents one of the first results of the agricultural revolution, but it

	medieval	*late medieval – post-medieval*
Cattle	TRACTION, meat, milk	MEAT, milk (traction in limited areas)
Sheep	WOOL, meat, milk	WOOL, MEAT, milk
Pig	MEAT, fat	MEAT, fat
Goat	milk, meat	-
Horse	traction	TRACTION
Domestic fowl	EGGS, meat	MEAT, eggs
Goose	FEATHERS, meat	MEAT, feathers

Table 45 The main domesticates: changes in use over time

certainly provides a stimulus for further investigation of this question on other sites.

Now that changes to the Castle Mall animals have been considered, innovations in their type of use can be summarised. Table 45 illustrates this by taking into account both the Castle Mall data, and what is known from the rest of the country, from both historical and archaeological sources. The animal products or uses of greater importance have been indicated in capital letters.

Certainly these changes did not all occur contemporaneously and in some areas they did not happen at all. In addition some of the data presented above are still under debate. Nevertheless, it is only by trying to generalise that the Castle Mall data can be put in a wider context and contribute to the history of animal husbandry in Britain. One general consequence, which is clear from the Table 45 and concerns most animals, is that the agricultural revolution gave rise to a much greater emphasis on meat production. This was probably caused by the growth of the urban population which required an increasingly larger meat supply.

Norwich was one of the largest medieval towns in Britain and a very important market place. Any study of the economic history of England must consider this town which had the advantage of being situated in a convenient position for contacts with the continent. The Low Countries, from where so many technological and economic innovations originated, have always had close contacts with the Norfolk area. If improvements in either the animals or husbandry techniques occurred, it is to be expected that they began earlier in Norfolk than in many other parts of the country. Potentially the Castle Mall data can contribute to the understanding of the economic development of the town and of the country as a whole. At the same time there may be more animal bones recovered from secure 15th- to 17th-century contexts in the city. Information from such contexts may provide answers to the important question of when improvement started which could not be concluded in this report.

Endnotes

1. The peacock bone came from a makeup dump on top of the castle mound and may relate to clearance of the contents of display cases from the Norwich Castle Museum Natural History Department in the 1950s, rather than to an earlier archaeological event (Barbara Green, pers. comm.). Alternatively, it may have been disturbed from elsewhere on the site during the modern period.

2. Many thanks to Elizabeth Shepherd Popescu for providing this reference.

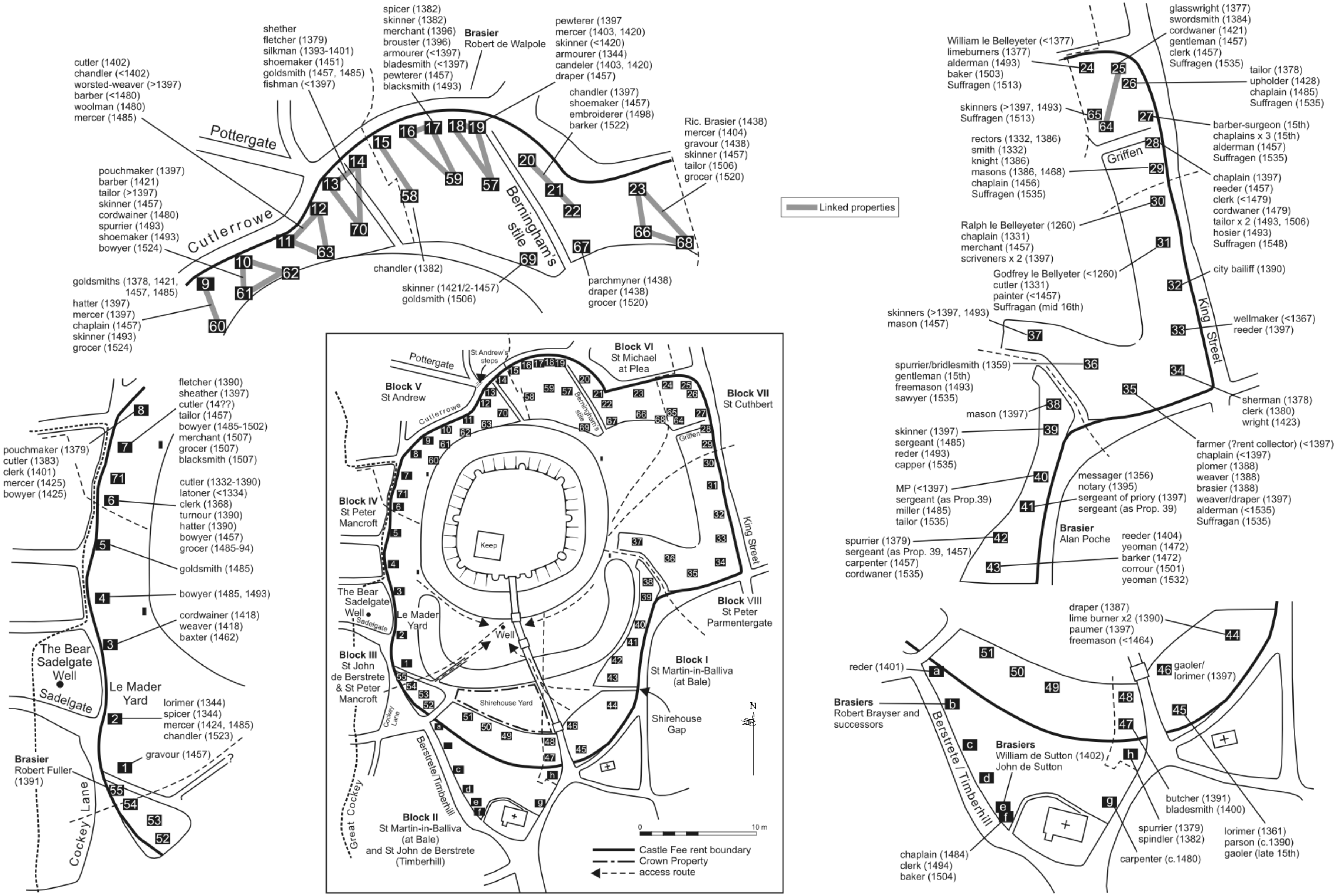


Figure 47 Documented trades around the Castle Fee from the late 14th century to *c.*1530

Chapter 4. Mammal and Bird Bone from the Barbican Well (mid/late 15th to early 16th century) (Site 777N)

by Marta Moreno García

I. Summary and Introduction

(Figs 47–49)

A well shaft within the castle barbican lay at the southern end of the surviving castle bridge (Figs 8.B and 47), originally forming a defended water supply within the Norman castle precinct. The well appears to have been constructed during the 12th century, at broadly the same time as other major alterations were undertaken to the defences including the construction of the great Keep or donjon (*c.*1094–1121). The upper part of the well consisted of a flint and mortar shaft approximately 4m square which shored back layers of natural sand and gravel. Lower down, at the level of the natural chalk, the previously square shaft became a circular well. The upper part of the structure was set within a large construction cut. Two sets of putlog holes survived within the shaft fabric which was itself supported on a timber frame. The putlogs may have held constructional scaffolding and an access ladder. The whole feature was at least 29m deep. Further details of the construction of the well are given in Part I, Chapter 6 (Period 3.1), with details of its infilling given in Part II, Chapter 9.

The large animal bone assemblage detailed here was excavated from ten sequential fills of the well (*50284, 50285, 50295, 50296, 50300, 50301, 50317, 50318, 50320* and *50321*; see Figs 48 and 49), the largest quantity (by weight) coming from fill *50300*. Although pottery attributable to the 12th to 14th centuries was present in earlier fills, the associated pottery from these ten deposits dates the material between the mid/late 15th and early 16th centuries, most appearing to have been deposited before *c.*1500. The uppermost fill in the sequence (*50285*) has a ceramic date of mid/late 15th to early 16th century.

At the period of deposition into the well, the castle had long served as a prison and administrative centre. After 1345 the baileys were under Borough jurisdiction, being used for industry, craft and domestic refuse disposal and grazing (see Part II, Chapters 8 and 9). Much of the waste from the immediate surroundings, generated by artisans ranged around the castle, also found its way into the well (see Fig.47 and Part II, Chapter 9). This material provides the major artefactual and ecofactual assemblage from the site. Included amongst it is important evidence for leatherworking (relating to the manufacture of objects such as shoes and spur leathers), while antler- and horn-working are also evident (see Mould; Huddle Part II, Chapter 9.III). Further comments on the nature and dating of the faunal assemblage are given throughout Part II, Chapter 9, alongside consideration of the faunal assemblage by context in relation to the other finds assemblages.

II. Methodology

Methods of Recovery

The bulk of the animal bone was retrieved by hand. In addition, site riddled samples (SRS) were wet-sieved on an 8.0mm mesh and bulk samples (BS) were processed in a wet-sieving/flotation tank, using 0.5mm meshes. SRS and BS samples were taken from ten contexts that constitute the upper fills of the shaft. An SRS sample constituted one/two barrow loads of sediment and a BS sample consisted of one 15 litre bucket.

Recording and Quantification

Bone fragments were identified to taxa wherever possible, but this was not always feasible with some skeletal elements such as long-bone shaft, rib, vertebrae and skull fragments. These were recorded under additional categories, for example 'oxo' (fragments of large artiodactyl and perissodactyl size, *e.g.* horse, red deer and cattle); 'lar' (large artiodactyles such as red deer, fallow deer and cattle); 'sma' (small artiodactyles, such as sheep, goat, roe deer, and possibly pigs); 'rum' (sheep/goat and roe deer); and 'tim' (bones of the smallest mammals).

Sheep bones were separated from those of goat, wherever possible, using the criteria described by Boessneck *et al.* (1964).

Bird remains were identified with the aid of the reference collection of recent bird skeletons at the CFRU and Tring (British Museum). With the identification of skeletal remains of galliformes, Erbersdobler (1968) was used in order to distinguish *Gallus gallus* from *Phasianus colchicus*. In the case of goose, Bacher (1967) was used in order to distinguish the domestic (*Anser* dom.) from the wild (*Anser anser*).

The material was recorded bone by bone, at the context level, and the data were fed into a database using DE and SPSSPC+. The following types of data were recorded for each bone fragment:

Archaeological context and sieved sample number, where necessary

Taxa

Skeletal element

Part of the bone present (whole, proximal, shaft, distal)

Side (right or left)

State of epiphysial fusion

Diagnostic zones present (see Appendix 1)

Indicator (presence or absence)

NISP (number of identified specimens). Although most of the bones were recorded individually, fragments such as ribs were grouped and recorded as a total for each taxa per context

Weight

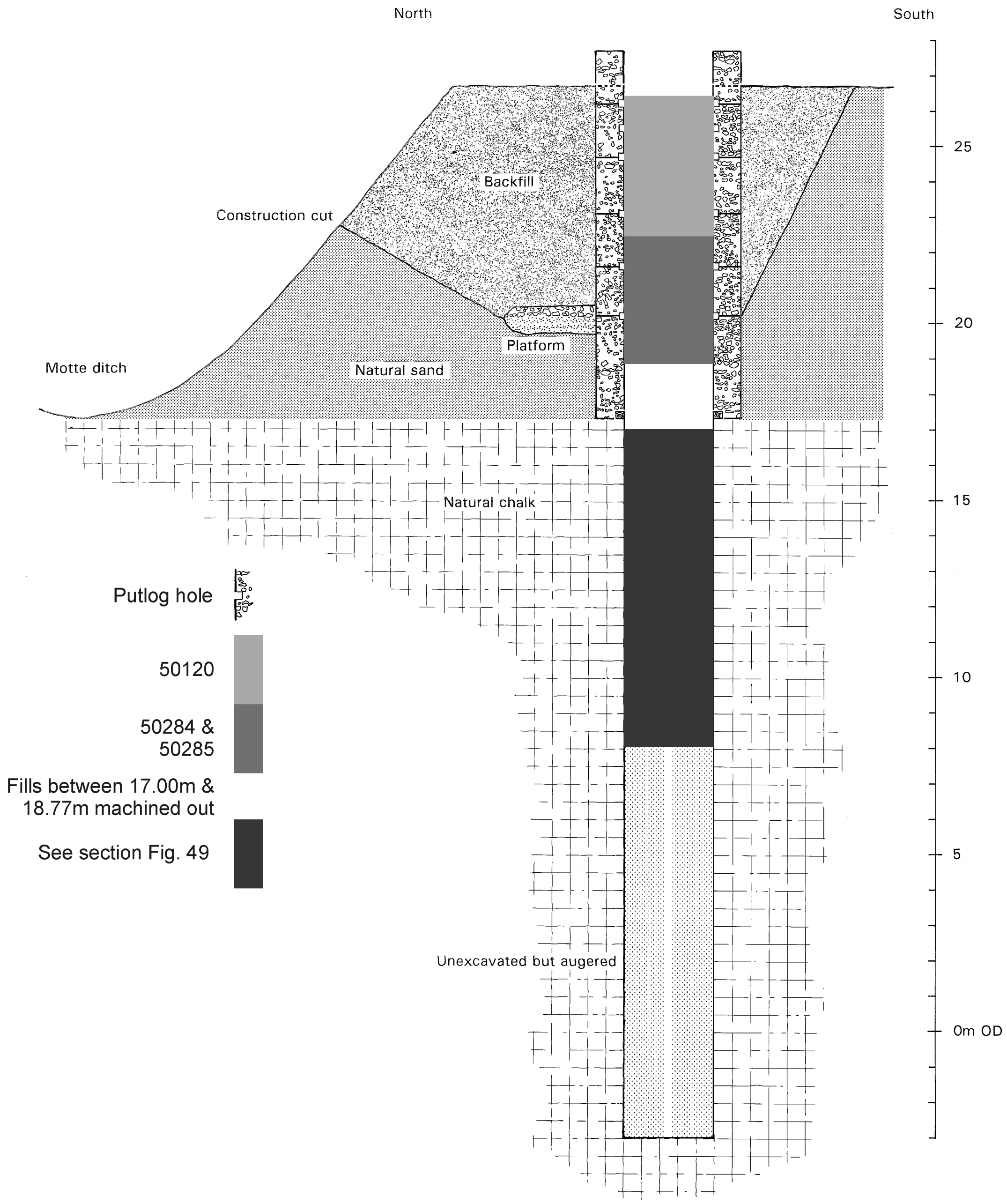


Figure 48 Schematic cross-section of well, showing position of excavated fills. Scale 1:200

State of preservation, including information on gnawed and butchered bones

Non-metrical traits and pathological conditions

Measurements were recorded for all mature bone elements after von den Driesch (1976) and the data were fed into another database, for each taxa and skeletal element, using SPSSPC+.

Three methods of quantification were used to estimate the relative proportions of the different taxa in the assemblage. The first was to count the number of identified bone fragments attributed to each taxa (NISP) and to compare the totals (Grayson 1984). The second was to estimate the minimum number of individuals (MNI) present in the assemblage for each taxa. Both methods have major drawbacks which have been examined at length in the literature (Grayson 1973, 1978; Fieller and Turner 1982; Rackham 1983; Ringrose 1990) and on which no further comments are needed. As an alternative to these two traditional quantitative methods, a third approach based on Watson's concept of 'diagnostic' anatomical zones (Watson 1979) and designed by Rackham (1986) is presented here. Results from each method are compared and the advantages of the last one are put forward. Diagnostic zones used in this report are summarised in Appendix 1.

In addition, in order to have an overview on the general state of preservation among the different taxa, indicators were counted (Luff 1993). Indicators are bones that preserve well and they comprise the following skeletal parts where more than 50% is present: horn core, mandible tooth row, scapula glenoid cavity, distal epiphyses of humerus, radius and metacarpal, pelvic acetabulum, distal epiphyses of femur, tibia, metatarsal and the proximal epiphysis of first phalanx.

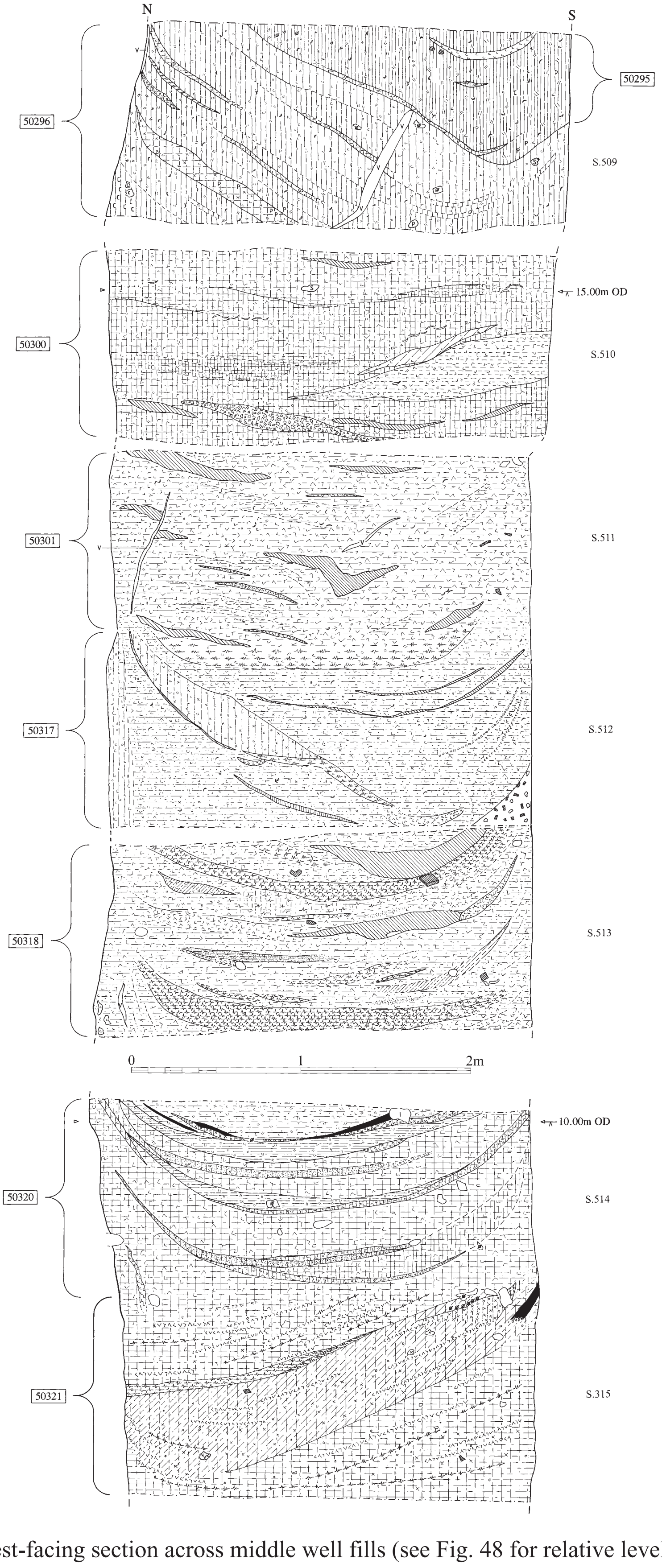


Figure 49 West-facing section across middle well fills (see Fig. 48 for relative level). Scale 1:40

Ageing, Sexing and Metrical Data
The age estimates for both epiphysial fusion and stages of tooth eruption are based on figures provided by Silver's (1969) modern data. Stages of tooth wear have been recorded using Grant's (1982) method. For sheep/goat Payne's (1973) method has also been used, so that results from both are compared.

The measurements used in this report are based on von den Driesch (1976). An attempt to distinguish the sex of cattle (Higham and Message 1969) and sheep/goat (Armitage 1977) bones was made metrically. Withers heights were estimated for cattle (Fock 1966), sheep/goat (Teichert, in von den Driesch and Boessneck 1974) and dog (Harcourt 1974).

III. Results

Recovery
(Tables 46–48)
Comparison of the hand-recovered material (10,522 fragments) with that of the sieved samples (4,083 fragments) shows that hand-recovery was very efficient (Table 46). Firstly, it is evident that a high proportion of unidentified mammal bone (65%) was retrieved from the sieved samples. This is mainly in the form of very small fragments of bone which account for only 1% of the total assemblage by weight (see Table 51). Secondly, it is notable that the sieved samples contain a considerable number of rabbit bones; in this sense, sieving was useful in correcting the bias in hand-collected bone towards the larger stock animals. Thirdly, as expected, the sieved samples picked up the smaller large ('lar') and medium-sized ('sma' and 'rum') mammal bone fragments, which consisted mainly of long-bone shaft fragments and vertebrae. Among the three main domesticates, sheep/goat shows the highest proportion (25%) of fragments recovered by sieving, followed by pig (16%) and then cattle (10%). Small bones such as phalanges and vertebrae fragments comprise most of the sheep/goat sieved material. For pig, metapodials as well as phalanges were the most abundant skeletal elements present. In contrast, skull and mandible fragments predominated for cattle (see Table 47). It is worth noting the high proportion of loose cattle teeth recorded in the sieved samples (34%) in contrast to those of the smaller species, so that their presence may be related to the abundance of skull and mandible fragments recorded for this taxon.

Standards of hand-recovery were also very good for the avian remains (Table 48). A total of 2,575 bird fragments were retrieved by hand as opposed to 1,313 fragments by sieving. Small unidentified fragments (mainly ribs,

	Recovered in trench		*Recovered by sieving*	
Taxa	*NISP*	*%*	*NISP*	*%*
Domestic mammals				
Cattle (*Bos taurus)*	1254 (66)	90 (66)	145 (34)	10 (34)
Sheep (*Ovis aries*)	449	93	32	7
Sheep/goat (*Ovis/Capra*)	801 (29)	75 (85)	264 (5)	25 (15)
Pig (*Sus* dom.)	892 (104)	84 (74)	166 (37)	16 (26)
Horse (*Equus caballus*)	8	100	-	-
Dog (*Canis familiaris*)	1114 (64)	94 (90)	67 (7)	6 (10)
Cat (*Felis catus*)	427 (5)	96	18	4
Total domestic mammals	**4945 (268)**	**88 (76)**	**692 (83)**	**12 (24)**
Wild Mammals				
Red deer (*Cervus elaphus*)	1	100	-	-
Deer (*Cervus* sp.)	5	83	1	17
Fallow deer (*Dama dama*)	6	100	-	-
Hare (*Lepus* sp.)	46	85	8	15
Rabbit (*Oryctolagus cuniculus*)	84	51	80	49
Badger (*Meles meles*)	1	100	-	-
Rat (*Rattus rattus*)	4	100	-	-
Dolphin (*Delphinus* sp.)	2	100	-	-
Total wild mammals	**149**	**62**	**89**	**38**
Unidentified mammal				
Oxo	1563	94	94	6
Lar	824	66	426	34
Sma	2004	63	1183	37
Rum	178	56	139	44
Tim	73	87	11	13
Total Unidentified mammal	**788**	**35**	**1449**	**65**
Total mammal bones	**10524**	**72**	**4083**	**28**

NISP: number of identified specimens
OXO: large artiodactyle and perissodactyl size (horse, red deer and cattle)
LAR: large artiodactyles (red deer, fallow deer and cattle)
SMA: sheep, goats, roe deer and possibly pigs
RUM: small artiodactyles (sheep, goats and roe deer)
TIM: bones of the smallest mammals

Table 46 Barbican well: a comparison of hand recovered as opposed to sieved recovered material — mammal bone. Teeth in brackets sternum and pelvic girdle fragments) comprise 58% of the sieved material. The only occurrence of *Corvidae* sp. was recorded from the sieved samples. It is clear that the larger taxa, such as swan and goose were well recovered (96% and 84%, respectively). As with mammals, phalanges, vertebra and rib fragments, which could not be identified to species level, were recorded according to their size, under the general categories goose-size and chicken-size. It is very likely that most of the bones included in these two categories belong to goose and chicken, since they are the dominant species. However, one cannot exclude the possibility that some mallard fragments (*i.e.* ribs and phalanges) have been recorded as chicken-size.

The well produced a considerable quantity of fish remains. They were extracted both from hand-recovered and sieved samples. They have been studied by Alison Locker and are detailed in the following chapter (see also her additional comments in Part II, Chapter 9.IV).

Finally, it is worth noting the scarcity of small mammals, such as rats, mice and voles present in both the sieved and hand-recovered samples.

Preservation of the Assemblage
(Pl. 48, Fig. 50, Tables 49–50)
The animal bone from the well is in a very well-preserved condition. Table 49 presents the percentage number of recently broken, eroded, burnt and gnawed fragments for cattle, sheep/goat, sheep, pig and the general categories of 'oxo', 'lar', 'sma' and 'rum'. As can be seen, there is little evidence of recent fragmentation and the proportion of eroded bone is very low for all taxa. Cattle, at 6%, show the highest value for surface wear. There is a slightly larger proportion of gnawed bones (8% for sheep and pig) and in particular, pig metapodials seem to have been especially preferred by dogs. In addition, cat gnawing marks were observed on neonatal pig bones from context *50320*. To conclude, such good preservation of the bones can only be explained as result of the immediate disposal of most of the remains in the shaft. Thus, this material can be described as a good 'primary deposit' (Armitage 1982), a situation confirmed by much of the artefactual assemblage.

		Cattle NISP	*Sheep/Goat NISP*	*Pig NISP*
Head	Skull	18	10	15
	Horncore	4	1	
	Maxilla	2	3	3
	Mandible	14	4	13
	Hyoid	2	9	
Fore Limb	Scapula	6	7	2
	Humerus	1	3	5
	Radius	7	6	6
	Ulna	4	3	5
	Radius+ulna			
	Carpal	9	2	3
	Metacarpal	5	15	
Hind Limb	Pelvis	7	9	4
	Femur	5	4	1
	Patella			
	Tibia	6	10	6
	Fibula			6
	Astragalus	3	5	1
	Calcaneum	4	4	4
	Tarsal	4	7	3
	Metatarsal	4	13	
	Metapodia	3	6	39
	Vertebrae	26	92	4
	Phalanges	11	83	46
total		**145**	**296**	**166**

NISP: number of identified specimens

Table 47 Barbican well: number of skeletal elements of the main domesticates recovered by sieving

Taxa	*Recovered in trench*		*Recovered by sieving*	
	NISP	*%*	*NISP*	*%*
Domestic fowl (*Gallus* sp.)	562	79	152	21
Domestic goose (*Anser anser* dom.)	1013	84	197	16
Domestic duck/mallard (*Anas* dom./ *Anas platyrhynchos*)	56	69	25	31
Chicken size	213	54	180	46
Goose size	193	73	72	27
Swan (*Cygnus* sp.)	27	96	1	4
Pheasant (*Phasianus colchicus*)	7	-	-	-
Partridge (*Perdix perdix*)	6	-	-	-
Corvid sp.	-	-	1	100
Domestic pigeon (*Columba livia*)	1	50	1	50
Wood pigeon (*Columba palumbus*)	8	73	3	27
Total Identified Birds	**2086**	**77**	**632**	**23**
Unidentified Birds	489	42	681	58
Total Bird Bones	**2575**	**66**	**1313**	**34**

NISP: number of identified specimens

Table 48 Barbican well: a comparison of hand recovered as opposed to sieved recovered material — bird bone

	Taxa							
	Cattle	*S/G*	*Sheep*	*Pig*	*OXO*	*LAR*	*SMA*	*RUM*
NISP	*1399*	*1065*	*481*	*1058*	*1657*	*1250*	*3187*	*317*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Condition								
Recently broken	1	2	3	1	<1	<1	<1	1
Eroded	6	3	4	4	3	4	2	2
Burnt	1	<1	2	1	1	2	1	5
Gnawed	6	7	8	8	2	2	2	2
Knife cuts	10	7	16	7	6	2	2	-
Chop marks	35	30	16	5	35	15	11	1

NISP: number of identified specimens
OXO: large artiodactyle and perissodactyl size (horse, red deer and cattle)
LAR: large artiodactyles (red deer, fallow deer and cattle)
SMA: sheep, goats, roe deer and possibly pigs
RUM: small artiodactyles (sheep, goats and roe deer)

Table 49 Barbican well: state of bone preservation — main domesticates

Good preservation of the surface does not mean that the bones were not altered in any way before being dumped in the shaft. Butchery contributed largely to bone fragmentation. In Table 49, it is evident that there is a high proportion of chopped cattle bones (35%) compared with knife-cut ones (10%). A very similar situation is observed for sheep/goat with 30% of fragments yielding chop marks against 7% with knife cuts. There is a decline in the number of chopped (5%) bones for pigs, with slightly more bones demonstrating knife-cuts (7%).

In order to assess the degree of bone fragmentation for the main domesticates, diagnostic zones were used to calculate what fraction of each bone for each taxa was present. As mentioned in 'Recording and Quantification', the bones were recorded using a system in which each bone was divided into a variable number of zones (see Appendix 1) and the presence (50% or more) or absence of each zone was noted. For example, if a fragment of mandible presented only two zones, it was recorded as a quarter (25%) of a complete mandible (eight zones). Thus, this system provides greater detail of which parts of the bone are present.

The proportion of fragments with a quarter or less (<25%), more than a quarter but less or equal to half (>25%–<50%), and more than half (>50%) of the zones present are set out in Fig.50. Cattle bones are most fragmented. This result may be related to the high proportion of chopped bones recorded for this species, shown in Table 49. A detailed study of the butchery marks affecting cattle bones is described below. Despite the similarity with cattle in the proportion of butchery marks, sheep/goat shows nearly half (47%) of the fragments with more than 50% of the zones present. The study of the skeletal elements, the age profile, and where the butchery marks are located will explain why this taxon is the least fragmented. Finally, pig bones appear less fragmented than cattle but most of the fragments have a quarter or less of the zones present. Reasons other than butchery processes may account for this fragmentation, since chop marks and knife cuts do not seem to be of particular importance for this taxa. The estimated kill-off pattern for pigs is presented in pig 'Ageing Data'. It is evident that the majority of pig remains in the well belong to young individuals whose bones are not fused, and are therefore more fragile and easily destroyed in the ground than the more robust adult animal bones.

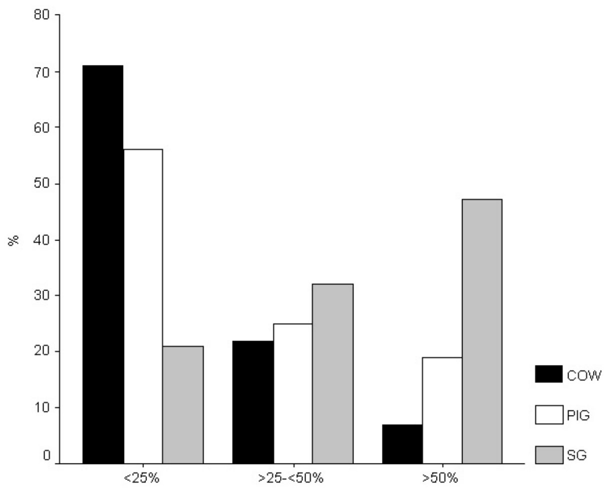


Figure 50 Barbican well. Bar-chart: frequency (%) of cattle (COW), sheep/goat (SG) and pig (PIG) bones with <25%, >25% - <50% and > 50% of zones present

The preservation of the avian remains is excellent as well. Table 50 shows the percentage number of recently broken, eroded, burnt and gnawed fragments for the main taxa identified. In comparison with mammal remains, bird bones are more affected by gnaw marks. However, if dog gnawing was prevalent among mammal bones, cat gnawing appears to have caused most of the damage to the avian remains. Paired punctures, such as those described by Moran and O'Connor (1992), with clearly defined margins and narrow in proportion to their depth, were observed on proximal and distal epiphyses of bird long bones (Plate 48). According to Moran and O'Connor these punctures may reflect the form of the feline first molar. Dogs gnawing upon these small bones would have probably destroyed them.

With respect to butchery marks, knife cuts are more abundant than chop marks for all taxa. Twenty-four per cent of the knife cuts occur on goose bones, mainly on the

	Taxa				
	Chicken	*Goose*	*Mallard*	*Chicken size*	*Goose size*
NISP	*714*	*1210*	*81*	*393*	*265*
	%	*%*	*%*	*%*	*%*
Condition					
Recently broken	<1	5	-	<1	-
Eroded	1	1	-	2	6
Burnt	1	<1	-	1	1
Gnawed	7	9	12	6	6
Knife cuts	5	24	7	<1	5
Chop marks	1	5	-	<1	3

NISP: number of identified specimens

Table 50 Barbican well: state of bone preservation — birds

Plate 48 Barbican well: domestic fowl humerus and femur, cat gnawed (Period 5.2)

proximal epiphysis of the carpometacarpus, and are associated with dismemberment of the wings.

General Quantification
(Tables 51–52)
On the basis of the NISP method, the number of fragments of each taxon has been totalled and is expressed as a percentage of the total number of fragments for either mammals or birds (Tables 51 and 52).

The total number of hand-recovered and sieved mammal fragments is 14,607 and these weigh 131 kg. Nearly 40% of the sample is comprised of domestic taxa. An additional 40% includes the general categories 'oxo', 'lar', 'sma' and 'rum'. Given the low number of wild animals (2%), *i.e.* red deer, roe deer and fallow deer, and since the identifiable fraction of the assemblage is dominated by the three main domesticates: cattle (*Bos taurus*), sheep (*Ovis aries*), sheep/goat (*Ovis/ Capra*) and pig (*Sus* dom.), it can be assumed that the general categories mainly represent cattle and sheep/goat. Pig bones, because of their more characteristic shape, are more difficult to misidentify. Dog bones constitute a high proportion of the domestic mammal assemblage, however it should be noted that these belong to at least fifteen partial burials.

Table 52 shows that the total number of bird bone fragments is 3,888, of weight approximately 6 kg. There is a high proportion of goose bones (over 31%) followed by domestic fowl (18%). As mentioned in Section II, 'Methodology', two additional categories (chicken-size and goose-size) were created to record fragments of long bone, rib, vertebrae and phalanges which could not be assigned confidently to one species, but which very likely belong to domestic fowl and goose. The unidentified bird category includes mainly fragments of skull, pelvic girdle and sternum. The avian assemblage is dominated by domestic taxa.

The Composition of the Assemblage
(Table 53)
Excluding the fifteen dog partial skeletons and cat remains, most of the identifiable fragments are of cattle, sheep/goat, sheep and pig. Since sheep bones, but none of goat, were identified, it is likely that most of the indeterminate sheep/goat remains represent sheep rather than goat. An attempt to separate sheep metrically from goat metacarpals was made, following Payne's (1969) method. Figure 51 shows the plot with a unique cluster indicating the absence of goat in the sample. To enable analysis of the assemblage, sheep and sheep/goat fragments are considered together.

In order to assess the relative frequency of the three main domesticates present in the well, Table 53 includes the proportions based on fragment counts (NISP), diagnostic zones, minimum number of individuals (MNI) and indicators (IND).

On the basis of NISP, sheep/goat are the most numerous of the main domestic species (39%), followed very closely by cattle (35%), and then pig (26%). In brackets, is shown the number of bones that could be identified as sheep (481 out of 1,546), totalling over 31% of those included under sheep/goat and 12% of the whole sample.

	NISP	*%*	*Weight*	*%*
Domestic mammals				
Cattle (*Bos taurus*)	*1399 (100)*	*9*	*50319*	*38*
Sheep (*Ovis aries*)	*481*	*3*	*8089*	*6*
Sheep/goat (*Ovis/Capra*)	1065 (34)	7	7282	5
Pig (*Sus* dom.)	1058 (141)	7	12667	10
Horse (*Equus caballus*)	8	<1	1840	1
Dog (*Canis familiaris*)	1181(71)	8	6843	5
Cat (*Felis catus*)	445 (5)	3	743	<1
Total domestic mammals	**5637 (351)**	**39**	**87783**	**66**
Wild Mammals				
Red deer (*Cervus elaphus*)	1	<1	10	<1
Deer (*Cervus* sp.)	6	<1	14	<1
Fallow deer (*Dama dama*)	6	<1	277	<1
Hare (*Lepus* sp.)	54	<1	100	<1
Rabbit (*Oryctolagus cuniculus*)	164	1	194	<1
Badger (*Meles meles*)	1	<1	1	<1
Rat (*Rattus rattus*)	4	<1	2	<1
Dolphin (*Delphinus* sp.)	2	<1	5	<1
Total wild mammals	**238**	**2**	**603**	**1**
Oxo	1657	11	22387	17
Lar	1250	8	10533	8
Sma	3187	22	7916	6
Rum	317	2	376	<1
Tim	84	1	41	<1
Unidentified mammal	2237	15	1396	1
Total mammal bones	**14607 (351)**	**100**	**131035**	**100**

NISP: number of identified specimens
OXO: large artiodactyle and perissodactyl size (horse, red deer and cattle)
LAR: large artiodactyles (red deer, fallow deer and cattle)
SMA: sheep, goats, roe deer and possibly pigs
RUM: small artiodactyles (sheep, goats and roe deer)
TIM: bones of the smallest mammals

Table 51 Barbican well: total number (NISP), percentage number, weight and percentage weight of mammalian bones per taxa in the assemblage. Teeth in brackets

Taxa	*NISP*	*%*	*Weight*	*%*
Domestic fowl (*Gallus* sp.)	714	18.3	1248	21.3
Domestic goose (*Anser anser* dom.)	1210	31.1	3528	60.4
Domestic duck/mallard (*Anas* dom./ *Anas platyrhynchos*)	81	2.0	93	1.5
Chicken size	393	10.1	205	3.5
Goose size	265	6.8	53	4.3
Swan (*Cygnus* sp.)	28	<1	139	2.3
Pheasant (*Phasianus colchicus*)	7	<1	8	<1
Partridge (*Perdix perdix*)	6	<1	4	<1
Corvid sp.	1	<1	<1	<1
Domestic pigeon (*Columba livia*)	2	<1	1	<1
Wood pigeon (*Columba palumbus*)	11	<1	2	<1
Total Identified Birds	**2718**	**69.9**	**5481**	**93.8**
Unidentified Birds	1170	30.0	357	6.1
Total Bird Bones	**3888**	**100**	**5838**	**100**

NISP: number of identified specimens

Table 52 Barbican well: total number (NISP), percentage number, weight and percentage weight of bird bone fragments per taxa in the assemblage

Taxa	NISP	%
Cattle (*Bos taurus*)	1399	35
Sheep/goat (*Ovis/Capra*)	1546	39
Pig (*Sus* dom.)	1058	26
total	**4003**	

a) Numbers and percentage numbers of the main domesticates based on fragment counts (NISP)

Taxa	%
Cattle (*Bos taurus*)	27
Sheep/goat (*Ovis/Capra*)	53
Pig (*Sus* dom.)	20

b) Mean relative percentage contribution of the main domesticates to the assemblage based on diagnostic zones (after Rackham 1986)

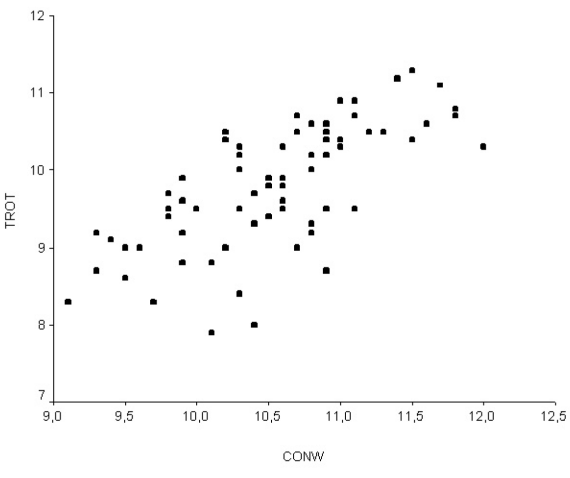
Taxa	MNI	%
Cattle (*Bos taurus*)	19	19.5
Sheep/goat (*Ovis/Capra*)	49	50.5
Pig (*Sus* dom.)	29	30.0
total	**97**	

c) Minimum number of individuals (MNI) and relative frequency of the main domesticates determined by the most common zone for each taxa

Taxa	IND	%
Cattle (*Bos taurus*)	152	18
Sheep/goat (*Ovis/Capra*)	579	71
Pig (*Sus* dom.)	89	11
total	**820**	

d) Numbers and percentage numbers of the main domesticates based on the indicators method (IND)

Table 53 Barbican well: assemblage composition



TROT=width trochlea; CONW=width condyle

Measurements in mm

Figure 51 Barbican well: sheep and goat metacarpal distinction (after Payne 1969)

One of the major drawbacks of the NISP method is that, since the total number of fragments is counted, it tends to over-represent the taxa that are more fragmented. Usually large species produce many more fragments than small species. The highly fragmentary condition of cattle bones has been noted above, in contrast to sheep/goat. Consequently, the relative frequency of species based on NISP is biased towards cattle in this assemblage. Any interpretation derived from such proportions must be treated with caution.

An alternative approach is to quantify relative proportions of species by the diagnostic zones method (Rackham 1986). The aim of this method is to calculate the proportion of each taxon as a percentage of the total number of occurrences of a particular bone. It has already been said that the animal bone assemblage from the well was recorded bone by bone. In addition, a number of diagnostic zones, common to all the taxa under analysis, of each skeletal element (except carpals, tarsals, vertebra and ribs) were also recorded (see Section II). Rackham (1986, 189) describes the FORTRAN programme written to analyse the 'zone' field in a database which for the sake of clarity is briefly summarised here.

This programme reads the taxa code, bone code, number of occurrences and diagnostic zones present for each fragment. An array is then generated with the number of times a zone of a particular element of a particular taxon occurs, and the counts for the same zone analysed for the other taxa. These are summed and the percentage contribution to the sum of that zone is calculated for each taxon and placed in a file. This is repeated for the entire database and all the zones until the file contains the percentages of each taxon for each zone. A frequency histogram programme is then run on this file to produce a frequency plot for each taxon, in which the mean of the distribution is also presented. The mean of each distribution shows the relative contribution of each taxon in the analysed assemblage.

The results are presented in Table 53. The relative frequencies obtained differ greatly from those of the NISP method. Sheep/goat is now overwhelmingly dominant. The mean contribution of this taxon to the assemblage is 53%. This means that given a collection of 100 fragments of a particular zone of a particular bone, it is expected that 53 will be sheep/goat, the prediction from the distribution being that this was the proportion of sheep/goat in the carcass population that generated the sample (Rackham 1986, 191). Cattle have a mean contribution of 27% and are followed by pig with a mean of 20%.

Because biases, such as the greater fragmentation of particular taxa, *i.e.* cattle, are minimised by the zone recording method, it is considered to give a more realistic indication of the relative abundance of taxa in the assemblage. Since each skeletal element is divided into zones, and by definition, a zone occurs only once on each bone, it is very unlikely that the same zone of a single bone is counted twice. In addition, a bar chart can be produced to show the abundance of each skeletal element per taxa (Figs 53, 58 and 65) so that those elements of a particular taxa affected by pre- and/or post-depositional factors can be recognised. Finally, the presence of whole or partial skeletons introduces a minimal bias since only one or two bones will appear in each record.

To conclude, the major drawback of this method, as Rackham (1983, 265) has pointed out, is that 'it gives a range for the proportion of species to species rather than a figure, but this may in fact be a more realistic result than the specific ratio obtained from fragment counts or the MNI index'.

In addition, the minimum number of individuals was estimated. Totalling the frequencies of each zone for each element per taxa, a MNI estimation was made from the zone most frequently recorded in each taxon (zones are listed in Appendix 1). In the case of cattle, it was zone 6 (the angle) of the mandible. Zone 5 of the metacarpal (anterior distal groove and foramen on the shaft) gives the highest frequency for sheep/goat. The MNI for pig resulted from zone 1 of the mandible (symphyseal surface). The final results are shown in Table 53. It is worth noting that the relative proportions for each taxon are much closer to the results obtained by Rackham's method of counting diagnostic zones than by counting identified fragments (NISP). Therefore, these results support the predominance of sheep/goat in the assemblage followed by cattle and pig in similar proportions.

Finally, in Table 53 the number and percentages of the main domesticates based on indicators are considered. It is evident that there is very good preservation and scarce fragmentation of the sheep/goat bones. Seventy-one per cent of the sample of indicators belongs to this taxa. In contrast, cattle are represented by only 18% and pig by a poor 11%. The fragmentary condition of the last two taxa has already been discussed (Section III), so that these results confirm the valuable use of indicators in providing an overview of the general state of preservation among the different taxa.

IV. Cattle

(Pl. 49, Figs 52–54, Tables 54–58)

Ageing Data

The age at death of the cattle remains was estimated by assessing the state of epiphysial fusion for post-cranial bones and the state of eruption and wear of mandibular teeth. Table 54 presents the data from the epiphysial fusion method. The bones have been split into four fusion stages. The first stage comprises the proximal epiphysis of the metapodials and the distal epiphyses of the proximal and middle phalanges which fuse before birth. The early fusion group contains those skeletal elements which fuse by 1.5 years: distal scapula, distal humerus, proximal radius and the proximal joint on proximal and middle phalanges. The middle fusion group includes the distal tibia and the distal metapodials which fused by 3 years, and the late fusion group consists of those bones which fuse by 4 years, that is the proximal calcaneus, femur and humerus, distal radius, proximal and distal ulna, distal femur and proximal tibia.

The epiphysial fusion data suggests that 24% of the bones in the first group belong to foetal and/or neonatal calves. Scarcely any slaughter of cattle occurred during the first year of life and it is between 1.5 and 3 years of age when approximately 54% are slaughtered. Twenty-six per cent survived for more than 3 years, and 29% survived 4.5 years. Thus, the pattern derived from epiphysial fusion data reflects a population of calves and young adult animals.

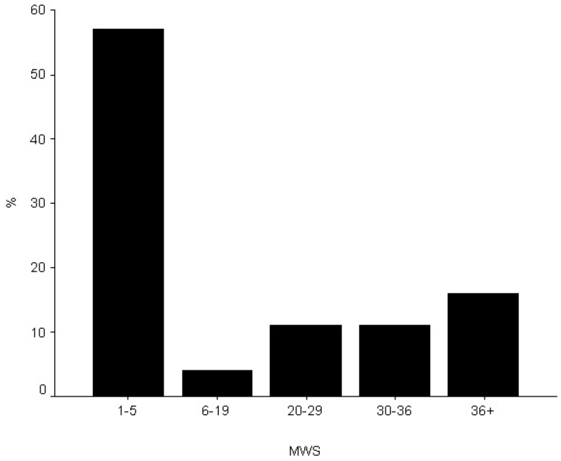
Twenty-five mandibles were examined in total. Figure 52 indicates that a significant number of them belong to neonates and/or young calves (MWS= 1–5; Grant 1982) which died before the age of six months. There is a marked decline in the number of adult mandibles; MWS= 30–36 and 36+ are coincident to a fully erupted permanent dentition and therefore to adult/mature animals.

	Fusion		
Bone	*Unfused NISP*	*Fused NISP*	*Fused %*
Fusion Before Birth			
Metacacarpus proximal	13	4	24
First phalanx distal	-	50	100
Second phalanx distal	-	13	100
Metatarsus proximal	9	3	25
total	**22**	**70**	**76**
Early Fusion (Birth–1.5 yrs)			
Scapula distal	8	23	74
Humerus distal	5	15	75
Radius proximal	5	19	79
First phalanx proximal	6	44	88
Second phalanx proximal	-	13	100
total	**24**	**114**	**83**
Middle Fusion (1.5–3 yrs)			
Metacarpus distal	18	9	33
Tibia distal	21	9	30
Metatarsus distal	13	4	24
Metapodium distal	14	1	7
total	**66**	**23**	**26**
Late Fusion (3–4.5 yrs)			
Calcaneus tuber	23	4	15
Femur proximal	16	6	27
Humerus proximal	17	4	19
Radius distal	13	12	48
Ulna proximal	14	5	26
Ulna distal	2	-	-
Femur distal	19	14	42
Tibia proximal	15	3	17
total	**119**	**48**	**29**

NISP: number of identified specimens

Table 54 Barbican well: epiphysial fusion data for cattle (after Silver 1969)

Although both methods highlight the abundance of young animals as opposed to mature beasts, there are slight differences worth mentioning. According to the epiphysial fusion data the peak of slaughter occurs between 1.5 and 3 years of age. The mandibular wear stages show a remarkable scarcity of mandibles for these ages but an abundance of much younger ones. It is likely that taphonomical factors have biased the sample towards the more robust limb bones of young adult and/or adult individuals. However, one must take into account the possibility that immature and adult carcasses may have undergone different butchery processes. Whereas heads (including mandibles) and feet of adults could have been discarded as primary butchery waste and their carcasses



MWS=mandibular wear stage
1–5 =neonates (n:14); 6–19 =young calves (n:1)
20–29 = young adults (n:3); 30–36 = adults (n:3)
36+ = mature (n:4)

Figure 52 Barbican well: cattle, frequency of mandibles by wear stage (after Grant 1982)

dismembered and distributed in joints, immature individuals could have been sold and/or consumed as whole carcasses. In short, the age of slaughter suggests that these animals were bred for their meat, when rapid growth has ceased at the transition from the juvenile to the sub-adult stage and the meat output no longer increases relative to the food input.

The occurrence of juvenile and young cattle in Norwich at this time (mid/late 15th–early 16th centuries) follows the trend that has been observed in other late medieval urban deposits, such as Exeter (Maltby 1979) and King's Lynn (Noddle 1977). Grant (1988, 156) suggested that ' ... while cattle were required primarily as working beasts and breeding animals in the early medieval period, their importance as suppliers of meat increased in the later centuries'. It seems therefore that the demand for meat in late medieval towns imposed a change in cattle husbandry practices.

Butchery

In general, two types of butchery mark are visible. The first are chop marks that appear to have been made with a heavy chopper or cleaver, and the second are fine cuts made probably with a sharp knife.

One of the commonest butchery marks, as with most medieval samples (O'Connor 1982), is the splitting of vertebrae in the sagittal plane, *i.e.* dorso-ventrally down the length of the body (Plate 49). Sixty-one per cent of the cervical vertebrae, 46% of the thoracic vertebrae and 65% of the lumbar vertebrae were split sagittally. This process indicates that the carcass of the animal was cut lengthways to produce two sides of beef. In addition, 44% of the rib fragments recorded under 'oxo' and 'lar' yielded chop marks.

It was observed that chopped ribs seemed to be of a particular length. In order to test if there was a pattern in the way they were butchered, the lengths of those present in one of the contexts were measured. Thus, from 169 chopped rib fragments there was a mean length of 95.7mm, with a standard deviation of 24.6; a minimum value of 34mm and a maximum value of 168mm. The coefficient of variation was quite high: 25% which suggests the butchery was fairly random.

In order to be chopped down the mid-line from tail to head, the carcass was probably suspended by the hind hocks. The feet could still have been in place, or have been removed. Very fine knife cuts were observed on the proximal epiphysis of the metatarsal bones and on the lateral and posterior side of the naviculo-cuboid. Although these marks could be related to the skinning of the carcass, they could have been produced when cutting the ligaments to detach the feet. Subsequent butchery generally involved chopping through the astragalus and naviculo-cuboid medio-laterally, and transversally through the calcaneum, to remove the hock from the tibia. In this process the distal end of the tibia was also chopped through. Occasionally, the shaft of the tibia demonstrated transverse chop marks.

The proximal end of the tibia together with the distal femur was one of the areas most heavily butchered. The hind leg was detached from the pelvis by chopping through the neck of the femur, close to or even through the head.

The pelvis was consistently butchered through the rim of the acetabulum, the pubic bone and the cranial end of the ilium. Chop marks on the lateral processes of the sacrum were commonly observed.

In the fore-limb, the same type of fine knife cuts observed on the metatarsals occurred on the metacarpals. Some carpal bones and most of the distal end of the radii were chopped through, probably when removing the feet. Although some of the radius shafts show chop marks, knife cuts were more commonly spotted, especially on the anterior part and near the proximal epiphysis. They could have been produced if meat was filleted off the bone.

The elbow joint was heavily butchered. The distal epiphysis of the humerus was chopped through transversely, either by a blow from in front of the joint or by an oblique blow from behind, which severed the main extensor muscles and the olecranon process of the ulna. In addition, the medial and lateral condyles of the distal epiphysis of the humerus were chopped off by blows parallel to the humerus shaft.

Fragments of the proximal epiphysis of humerus could have resulted from the process of detaching the humerus from the distal end of the scapula. The latter was chopped

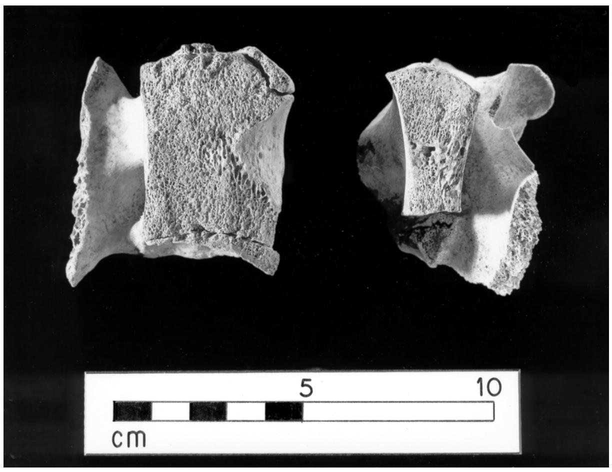


Plate 49 Barbican well: cattle thoracic vertebra and sacrum, sagitally split (Period 5.2)

transversely through the neck. Knife cuts on this part of the scapula as well as on its lateral side occur occasionally.

Chop marks are also common on the articular process of the mandible which could have been damaged in the process of detaching the tongue. Chop marks and knife cuts were observed on some skull fragments, especially in the occipital region and they could be related to the extraction of the brains.

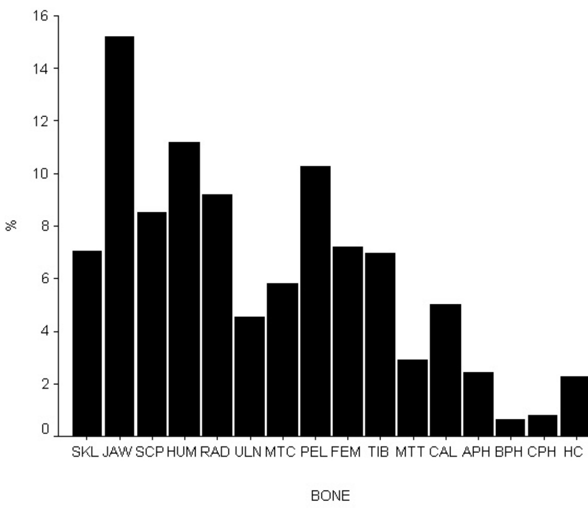
Overall, cattle carcasses were heavily butchered so that no joints were left complete.

Anatomical Distribution

One way to examine the distribution of skeletal elements is by counting the number of fragments of a particular bone and comparing the result in percentage terms with the other parts of the skeleton. An objection to this method is that highly fragmented elements will be over-represented. This drawback is minimised when using diagnostic zones. By counting the total number of zones recorded for all skeletal elements for one taxa, it is possible to estimate the contribution in percentage terms of each skeletal element for a taxa. The total number of cattle phalanges zones has been divided by four so that they are not over-represented in relation to the other bones.

Skeletal elements are arranged in three categories according to the relative quality of meat yield. Thus, the high quality meat bones are scapula, humerus, pelvis and femur. Meat of lesser quality is provided by tibia, radius, ulna, skull (cheek meat and brain) and mandible (tongue). Finally, horncores, metapodials, calcaneum and phalanges are included in the low quality meat or waste bones. Vertebrae and ribs have not been included since no zones were defined for them and they were mainly recorded under 'oxo' and 'lar'.

The results are listed in Table 55 and Fig.53. It is evident that there is a high abundance of mandible, humerus and pelvic fragments, and a low abundance of metapodials and phalanges. The total contribution of



SKL=skull; JAW=mandible; SCP=scapula; HUM=humerus; RAD=radius; ULN=ulna; MTC=metacarpus; PEL=pelvis; FEM=femur; TIB=tibia; MTT=metatarsus; CAL=calcaneus; APH=first phalanx; BPH=second phalanx; CPH=third phalanx; HC=horncore

Figure 53 Barbican well: cattle, mean relative percentage contribution of anatomical elements based on diagnostic zones (after Rackham 1986)

	Bone	*%*
	Scapula	8.5
HIGH QUALITY	Humerus	11.2
	Pelvis	10.3
	Femur	7.2
	Total	**37.2**
	Tibia	7.0
LESSER QUALITY	Radius	9.2
	Ulna	4.5
	Skull	7.1
	Mandible	15.2
	Total	**43.0**
total meat-bearing bones		**80.2**
	Horn core	2.3
	Metacarpus	5.8
	Calcaneum	5.0
LOW QUALITY	Metatarsus	2.9
	First phalanx	2.4
	Second phalanx	.6
	Third phalanx	.8
total waste bones		**19.8**

Table 55 Barbican well: mean relative percentage contribution of cattle anatomical elements based on diagnostic zones (after Rackham 1986)

meat-bearing bones to the cattle assemblage is over 80% as opposed to nearly 20% of the waste bones. In addition, the high number of vertebrae and ribs recorded under the general categories 'oxo' and 'lar' (a skeletal element distribution for these two categories, based on fragment counts, is shown in Table 56) indicates the consumption of meat from the flanks of the animal. It can be concluded that these remains would be consistent with the debris from secondary butchery of carcasses, and consumption. Although horncores, metapodials and phalanges were also recovered, it is clear that they were not dumped in the same proportion as the meatiest parts of the carcasses. If one can argue from negative evidence, it could be assumed that they were removed during the first butchery process and left attached to the skin. Horn working and tanning would have taken place somewhere else, as indicated on other sites by deposits comprising only these skeletal elements (Serjeantson *et al.* 1986). Evidence for such activity elsewhere on this site is detailed in Part II, Chapter 8 and by Albarella *et al.*above.

Metrical Data

A summary of the measurements taken on the cattle bones is included in Table 57. Sample numbers are small and pairs of measurements (useful for assessing shape) are scarcer. Standard deviations and the coefficients of variation have been calculated for all sample sizes greater than or equal to five.

Withers height could not be estimated due to the lack of complete adult long bones. There was only one whole adult metacarpal that gave a withers height of 100.3 cm by way of Fock's conversion factors (von den Driesch and Boessneck 1974, 336).

	Bone	OXO (nisp 1657) %	LAR (nisp 1250) %
	Scapula	2	6
	Humerus	1	2
	Pelvis	4	7
	Femur	<1	1
	Cervical vx.	<1	1
HIGH	Thoracic vx.	3	2
QUALITY	Lumbar vx.	2	3
	Sacrum	2	2
	Vertebra frag.	7	12
	Caudal vx.	<1	<1
	Sternum	1	1
	Ribs	61	20
	total	84	58
	Long bone frag.	13	19
	Tibia	1	1
LESSER	Radius	<1	2
QUALITY	Ulna	<1	1
	Skull	<1	12
	Mandible	<1	4
	total	**2**	**20**
Total meat bearing bones		**99**	97
	Horn core	-	-
	Hyoid	-	<1
	Atlas	<1	<1
	Axis	-	<1
	Carpal	-	<1
	Metacarpal	-	-
LOW	Patella	-	-
QUALITY	Astragalus	<1	<1
	Calcaneus	-	<1
	Tarsal	-	-
	Metatarsal	-	-
	Metapodial	<1	<1
	First phalanx	-	-
	Second phalanx	-	-
	Third phalanx	-	-
total waste bones		**1**	3

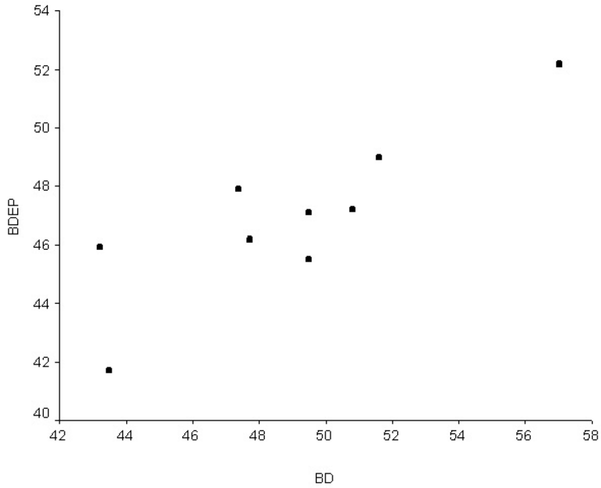
Table 56 Barbican well: percentage numbers of oxo and lar skeletal elements based on NISP

Measurements on complete distal ends of adult metacarpi have been used to infer the sex. Following Higham and Message (1969), the maximum distal breadth (Bd) of the metacarpal epiphysis plotted against the maximum distal breadth of the diaphysis (Bdep), suggests a sexual separation. Figure 54 shows the results from the nine metacarpals that were distally fused in the Castle Mall assemblage. It is evident that the specimens fall into three clusters. That at the lower left of the graph could include the females whilst the cluster in the centre it is likely to represent the castrates and the only specimen to the top right would be a male. Since these specimens are at least of three years of age, it seems that it was mainly castrates that reached this age and that a good proportion of the young calves killed for meat must have been males.

	Mean	*Min*	*Max*	*s*	*CV*	*N*
SCAPULA						
SLC	32.7	18.6	49.2	12.6	38.5	20
GLP	60.6	56.5	65.2	3.1	5.1	11
LG	51.6	47.3	55.3	2.3	4.4	12
BG	43.9	41.1	53.8	3.2	7.2	15
HUMERUS						
Bp	93.0	77.0	109.0			2
SD	30.8	24.6	37.0			2
Bd	74.7	65.0	90.0	8.3	11.1	7
RADIUS						
Bp	70.1	63.5	84.1	5.7	8.1	14
Bfp	64.8	59.5	75.3	4.6	7.0	14
SD	34.0	33.6	34.7			3
SDTH	22.1	18.8	25.9			3
BD	57.0	53.1	60.9			2
Bfd	51.7					1
METACARPUS						
GL	164.0					1
Bp	39.2	31.4	53.6	7.3	18.6	8
SD	25.5	17.3	34.6	6.4	25.0	13
SDAP	16.5	13.0	21.4	3.2	19.3	12
Bd	48.9	43.2	57.0	4.2	8.5	9
DD	26.8	24.9	30.4	1.9	7.0	9
Bdep	46.9	41.7	52.2	2.8	5.9	9
PELVIS						
LA	60.4	59.2	62.1	1.0	1.6	5
LAR	45.6	42.7	49.8	3.2	7.0	5
PB	26.6	23.2	31.4	2.7	10.1	6
PL	61.4	53.2	73.8	7.1	11.5	6
FEMUR						
DC	40.3	39.8	40.9			4
SD	27.7	18.6	32.2			4
SDTH	29.4	17.6	37.1			4
Bd	81.0	78.0	84.0			2
TIBIA						
SD	33.9	19.9	42.9	5.6	16.5	13
SDTH	22.8	15.8	27.4	3.0	13.1	12
Bd	56.0	53.1	59.2	2.9	5.1	5
METATARSUS						
Bp	34.8	30.8	40.6	3.1	8.9	9
SD	18.7	13.8	28.0	4.8	25.6	17
SDAP	16.3	12.2	23.5	3.9	23.9	17
Bd	46.3	43.7	48.3			4
DD	26.1	24.4	27.9			4
Bdep	45.5	44.0	46.9			4
1st PHALANX						
GL	56.0	50.0	63.0	3.3	5.8	41
Bp	25.8	21.3	32.6	2.5	9.6	43

s: standard deviation
CV: coefficient of variation
N: number

Table 57 Barbican well: cattle bone measurements, in mm (after von den Driesch 1976)



Measurements in mm

Figure 54 Barbican well: scattergram of cattle metacarpal maximum distal width (BD) against distal epiphysial width (BDEP); after von den Driesch 1976

The sample, however, is very small and any conclusions must be treated with caution.

No cattle pelves were complete enough to measure them for sexual characteristics.

The size, shape and measurements of cattle horncores were recorded using the criteria set by Armitage and Clutton-Brock (1976). Only twenty-five partially complete horncores were recovered from the well. Five were from juvenile animals, six were from sub-adult individuals, a further nine belonged to young-adults and only two were from adult animals. The remaining three could not be aged. Measurements of young-adults and adults are shown in Table 58.

Context	*OCL*	*BC*	*MINBD*	*MAXBD*	*Age*
50296	129	137	37.4	49.6	Adult
	78	90	27.2	29.8	Adult
	89	90	23.9	32.7	Young-adult
	98	112	32.1	38.8	Young-adult
	82	104	27.5	39.9	Young adult
50295		117	32.2	41.4	Young-adult
50317	117	98	28.0	33.3	Young adult
	115	104	31.3	36.4	Young-adult
50300	122	108	29.3	36.7	Young adult
50284		108	29.8	39.8	Young-adult
	152	131	42.1	45.3	Young-adult

OCL: outer curvature length
BC: basal circumference
MINBD: minimum basal diameter
MAXBD: maximum basal diameter

Table 58 Barbican well: measurements of complete cattle horncores, in mm (after Armitage and Clutton-Brock 1976)

Following Armitage and Clutton-Brock (1976) young-adult and adult horncores were sexed as possible males. This result supports the assumption that males were slaughtered for their meat mainly at a young age.

Pathology

Pathological conditions are very scarce among the cattle bones, which is not surprising given that most were juveniles and/or young adults.

The most frequent oral pathology was dental calculus (a black deposit with a metallic sheen). It occurs in six out of the twenty-five mandibles, on both the lingual and labial aspects and only for the oldest mandibles. Levitan (1985, 47) defines dental calculus as a composite mass of bacteria, fungi, food particles, desquamated epithelium and leucocytes. If Dobney and Brothwell's (1987) evaluation method on the severity of this condition is followed, the cattle mandibles from the well yielded the lowest values.

Lateral attrition was observed in a juvenile mandible, between the deciduous fourth premolar and the first molar.

The absence of the second premolar, a discontinuous genetic trait (Andrews and Noddle 1975), was observed in only one mandible.

A healed breakage was observed on the processus transversus of a lumbar vertebra and a lesion was noted on the lateral articulatory facet of a thoracic vertebra.

Three proximal phalanges exhibited a small pit cavity on the distal articular surface and the same condition was noted on the proximal articular surface of a third phalanx. No satisfactory explanations have been found to account for this anomaly.

V. Sheep/goat

(Pls 50–51, Figs 55–63, Tables 59–64)

Ageing data

As with cattle bones, four fusion stages are distinguished (see Table 59). The first comprises the proximal epiphysis of the metapodials and the distal epiphysis of the proximal and middle phalanges which fuse before birth. The early fusion group includes those epiphyses that fuse by 18 months (distal scapula and humerus, proximal radius, first and second phalanx). The third stage comprises the distal tibia and metapodial which fuse by 2.5 years of age while the fourth stage includes those elements that fuse by 3.5 years (proximal and distal ulna, proximal femur, calcaneus tuber, distal radius, proximal humerus, distal femur and proximal tibia).

According to the kill-off pattern based on epiphysial fusion only 1% of the sheep were foetal animals. They are represented by unfused metapodial shafts. Eighty-four per cent were older than 18 months. From these only 5% appear to have been slaughtered before they reached 2.5 years of age, and in fact 63% survived beyond 3.5 years. Evidently sheep were killed after reaching maturity.

Mandibular wear stages were estimated for thirty-one mandibles following the methods of Grant (1975, 1982) and Payne (1973) and the results were compared (see Table 60 and 61; Figs 55–57). Both methods showed a clearly unimodal distribution skewed to old animals. Following Grant (1975), the peak of slaughter was between 4 and 8 years of age (54.5%), whereas when assigning sheep mandibles to the wear stages of Payne (1973), the culling was concentrated (27.2%) between 4 and 6 years (MWS= G).

Bone	Fusion Unfused NISP	Fused NISP	Fused %
Fusion Before Birth			
Metacarpus proximal	3	74	96
First phalanx distal	-	144	100
Second phalanx distal	-	23	100
Metatarsal proximal	1	65	98
total	**4**	**306**	**99**
Early Fusion (Birth–1.5 yrs)			
Scapula distal	6	39	87
Humerus distal	1	35	97
Radius proximal	1	15	94
First phalanx proximal	29	115	80
Second phalanx proximal	6	17	74
total	**43**	**221**	**84**
Middle Fusion (1.5–2.5 yrs)			
Tibia distal	2	58	97
Metacarpus distal	18	82	82
Metatarsus distal	23	67	74
Metapodium distal	11	2	18
total	**54**	**209**	**79**
Late Fusion (2.5–3.5 yrs)			
Ulna proximal	3	6	67
Ulna distal	2	-	-
Femur proximal	5	18	78
Calcaneus tuber	4	21	84
Radius distal	5	31	86
Humerus proximal	15	2	12
Femur distal	11	12	52
Tibia proximal	12	6	33
total	**57**	**96**	**63**

NISP: number of identified specimens

Table 59 Barbican well: epiphysial fusion data for sheep and sheep/goat (after Silver 1969)

MWS	*Age*	*Number*	*%*
1–6	0–6 mths	2	6.0
7–18	6mths–1 yr	2	6.0
19–28	1–2 yrs	-	-
29–35	2–4 yrs	11	33.3
36–46	4–8 yrs	18	54.5
47+	8–10 yrs	-	-
total		**33**	

Table 60 Barbican well: age estimates for sheep/goat mandibles, after Grant (1982)

Stage	*Age*	*Number*	*%*
A	0–2 mths	2	6.0
B	2–6 mths	2	6.0
C	6 mths–1 yr	-	-
D	1–2 yrs	4	12.1
E	2–3 yrs	4	12.1
F	3–4 yrs	6	18.1
G	4–6 yrs	9	27.2
H	6–8 yrs	6	18.1
I	8–10 yrs	-	-
total		**33**	

Table 61 Barbican well: age estimates for sheep/goat mandibles, after Payne (1973)

These results support the evidence shown by the epiphysial fusion data. The presence of juvenile and young adults, unlike with cattle, is rather scarce. A similar tendency towards mature sheep is also seen in other medieval English towns such as Lincoln (O'Connor 1982), Southampton (Noddle 1975) and King's Lynn (Noddle 1977). There is no doubt that mature sheep were kept mainly for their wool, milk and breeding purposes before they were eventually slaughtered. Trow-Smith (1957, 247; 1951) mentions that wethers were kept for several seasons to give wool before being fattened for the butcher and that old and weak ewes were fattened for the winter market.

Butchery

The same type of butchery marks observed for cattle were present on the sheep/goat bones, although there is a decline in the abundance of chop marks in relation to cattle. Twenty-six per cent of sheep/goat bones display chop marks as opposed to 35% of cattle bones. The relative abundance of knife cuts was very similar for both taxa, 9% and 10% respectively.

Knife cuts usually occurred on the cranial and ventral sides of the atlas. These were probably caused when removing the head by inserting a knife between the occipital condyles and the atlas.

The splitting of the carcass into sides was undertaken in a similar fashion as that for cattle. Sagittally split vertebrae are very common (Plate 50). Seventy-eight per cent of cervical vertebrae, 61% of thoracic and 66% of lumbar vertebrae were cut through the sagittal plane. Even two out of seven caudal vertebrae were split. As mentioned previously, this process implies the carcass being hung from the hind legs. The abundance of knife cuts on the anterior and posterior sides of the shaft, near the proximal articulation of metatarsals and metacarpals, is very likely related to the skinning of the carcasses and dismemberment of the lower legs, since cuts in this region sever the flexor tendons (O'Connor 1984). In addition, knife cuts were also frequent on the shaft of metapodials and it is worth mentioning that nearly two thirds of them were broken across the midshaft, although no butchery marks were noted. A possible explanation is discussed in 'Anatomical Distribution'.

Four tarsals out of eleven and one carpal out of four sports very fine knife cuts. Thus, if the lower legs were severed when the animal was skinned, the carcass must have been hung from the hock joint. The type of butchery marks seen on calcanei were exactly in the same places as they occurred with cattle, although astragali were less damaged. Distal epiphyses of tibiae displayed chop marks, but in general, the shafts were the part most damaged.

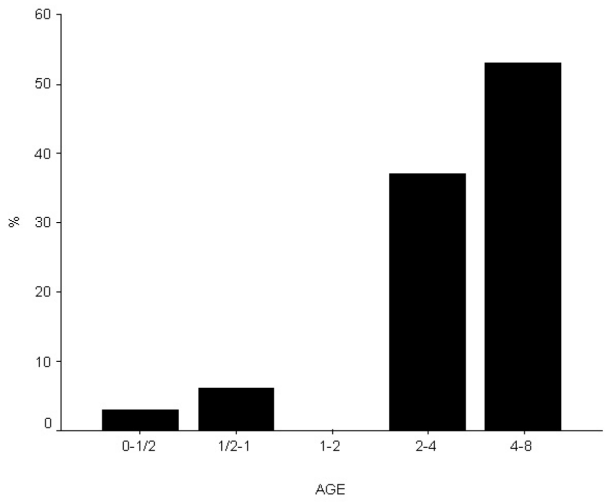


Figure 55 Barbican well: sheep/goat, frequency of mandibles by age (in years); after Grant 1982

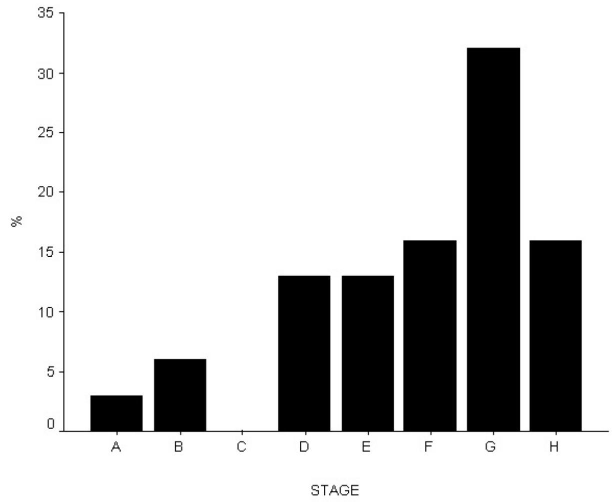


Figure 57 Barbican well: sheep/goat, frequency of mandibles (%) by wear stage; after Payne 1973

Femora were butchered following the same pattern described for cattle. The head was sliced off in order to detach the femur from the acetabulum; in this process the medial rim of the acetabulum was consistently chopped (Plate 51). However, pelves were not as fragmented as those of cattle.

The fore limb seemed to be more affected by knife cuts on the shafts of radius and humerus than by chopping through the epiphyses. No chop marks were observed on any ulna fragments. Occasionally, the proximal epiphysis of the humerus was sliced off in the process of detaching this bone from the distal end of the scapula. As a result, some scapulae were cleaved transversely through the glenoid cavity but in general, knife cuts on the ventral and lateral sides of the neck were more common.

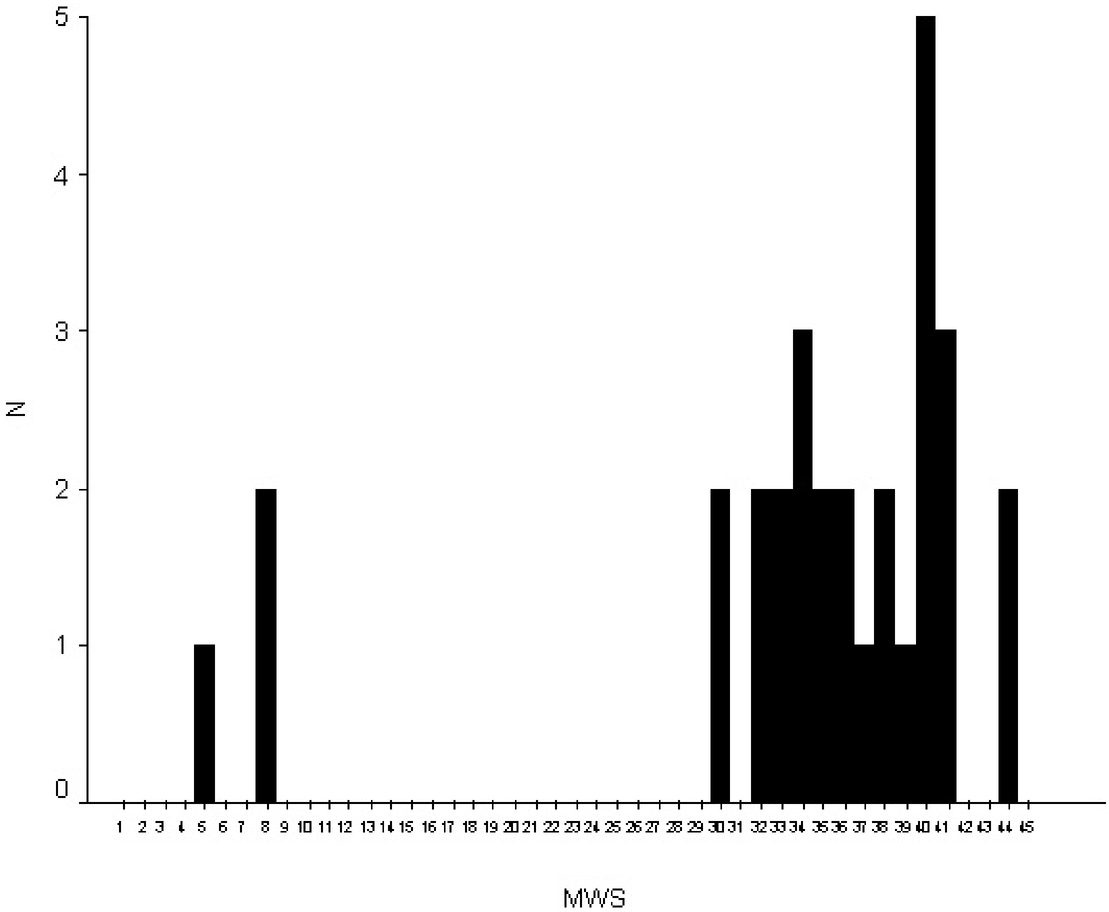


Figure 56 Barbican well: sheep/goat, number of mandibles (N) by wear stage (MWS); after Grant 1982

Butchery marks recorded on skull fragments are related to the extraction of the brain and chopping off the horns. Thirty-eight out of seventy almost complete sheep horncores exhibited chop marks near the base so that their basal circumference could not be measured. In addition, twenty-one more were sawn near the base and a few more near the tip. The latter can be clearly interpreted as the waste of a horn worker.

It can be concluded that, although sheep carcasses were split into sides, their limb bones were not cleaved through like those of cattle. The meat-bearing bones of the front and back leg were not disarticulated to be consumed.

Anatomical Distribution

In order to understand the distribution of skeletal elements, the same approach used for cattle, based on counting diagnostic zones, is followed for sheep/goat. The total number of phalanges was divided by four so that they are not over-represented in relation to the other bones.

The same three categories, according to the relative quality of meat yield, are maintained. The results are listed in Table 62 and Fig.58. Firstly, the contribution of meat-bearing bones (nearly 60%) is slightly higher than that of waste bones (just over 40%). However, a closer look at the data reveals that metacarpals and metatarsals are the most abundant skeletal elements. The rest of the limb bones, except for the femur (which is more fragmented by butchery, and is also a more fragile bone) are present in very similar proportions. The metapodials appear to be concentrated in certain contexts (such as fill *50300*, where 102 fragments were found). It would seem as if they were dumped together, at the same time, independently of the rest of the sheep bones. Therefore, it could be argued that the sheep/goat sample comes from two different sources. On the one hand, the butchered limb bones would be consistent with the debris from food consumption (that is to say domestic refuse) and on the other hand, the abundance of metacarpals and metatarsals could be interpreted as residue from some kind of 'industrial' activity.

The abundance of horncores, metapodials and phalanges in archaeological deposits could indicate the presence of tanning or leather working activities (Serjeantson 1989). The feet left attached to the skin could facilitate handling whereas the horncores would help in sexing and ageing the skins (Shaw 1987). An example is provided by the sheep metapodials and phalanges found at Skeldergate and Walmgate, York (O'Connor 1984) which were interpreted as the residue from the processing of sheepskins. However, in the well the proportion of sheep horncores and phalanges is much lower than that of metapodials. It could be argued that poor recovery is responsible for the low contribution of phalanges to the sample. This does not seem to be the case, for there is no bias towards cattle phalanges, which presumably are easier to recover. In fact, the relative contribution of phalanges to the sheep/goat sample is exactly the same as that of cattle, so it would appear that most of the hooves were not articulated with the metapodials when they were dumped in the shaft.

Plate 50 Barbican well: sheep/goat axis and cervical vertebra, sagittally split (Period 5.2)

Plate 51 Barbican well: chopped sheep/goat pelvis (Period 5.2)

	Bone	*%*
	Scapula	8.3
HIGH	Humerus	9.0
QUALITY	Pelvis	9.4
	Femur	5.2
	total	**31.9**
	Tibia	9.7
	Radius	6.7
LESSER	Ulna	1.2
QUALITY	Skull	1.4
	Mandible	8.6
	total	**27.6**
total meat-bearing bones		**59.5**
	Horn core	2.7
	Metacarpus	16.5
	Calcaneum	4.0
LOW	Metatarsus	13.9
QUALITY	First phalanx	2.6
	Second phalanx	.4
	Third phalanx	.4
total waste bones		**40.5**

Table 62 Barbican well: mean relative percentage contribution of sheep/goat anatomical elements based on diagnostic zones (after Rackham 1986)

Serjeantson *et al.* (1986), in discussing the calves' feet from Kingston Upon Thames, suggest that metapodials would not remain articulated with the phalanges if they had been rendered for oil. It is known that an alternative to tanning was 'chamoising', the treatment of skins with oils. Neatsfoot oil is the thinnest animal oil obtained from the feet of cloven-footed oxen, sheep and goats. Brunner (1923, 42–43) describes the process of neatsfoot oil collection. ' It is produced ... as a by-product in the boiling of cow heels and sheep trotters for food purposes. These are cleansed from blood and dirt by washing them in water, and after the hoofs have been removed they are boiled with water in a pan for a quarter of an hour, the temperature being then reduced so that the liquid is no longer in a state of ebullition. The fat collecting as an oily layer on the surface of the hot water is constantly skimmed off with a ladle and transferred to a tall, narrow vessel. The residue in the boiling pan — the hoofs deprived of their fat — may, if fresh, be used as food or otherwise sold to the glue manufacturer'.

As described above, a high number of the sheep/goat metapodials were broken at the midshaft. No butchery marks were apparent at that point so the fragmentation could have taken place after the bones were deposited in the shaft. Experimental work (Pearson and Luff 1994) on the resistance of cooked bones to breakage has shown that there is a reasonable correlation between the load at which bones break and the length of time they have boiled. As a hypothesis, it could be suggested that the group of sheep metapodials dumped in the well may have undergone some kind of processing, *i.e.* boiling, which, if it did not affect their appearance, could well have made them more fragile than other bones that were not treated in the same way. At the same time, such a process could account for the disarticulation of the phalanges from the rest of the foot, which could have been taken somewhere else for further processing or just got lost in the way from the tanner's to the well. It is understood that this is just a hypothesis and that more experimental work is needed on this subject.

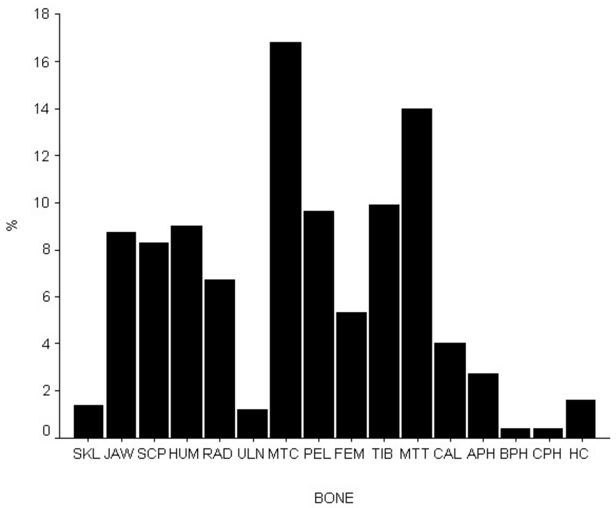
To conclude, it could be said that the sheep metapodials were very likely, in one form or other, related to leather working activities. The fact that right and left metacarpals and metatarsals occur in similar numbers supports this conclusion. There is a MNI of 49 left and 39 right metacarpals, and 39 left and 44 right metatarsals, indicating that they probably derive from the processing of the same sheepskins.

Metrical Data

A summary of the measurements taken on the sheep/goat bones is included in Table 63. Sample numbers are reasonable and pairs of measurements, useful to assess shape, were not as scarce as for cattle. Standard deviations and the coefficients of variation have been calculated for all sample sizes greater than or equal to five.

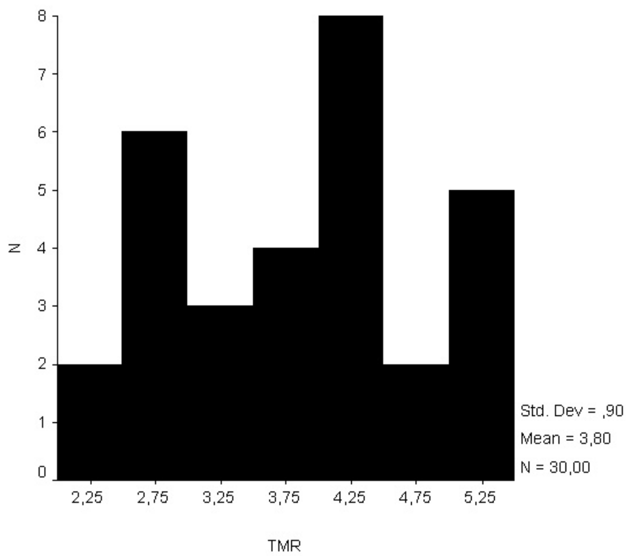
The metrical data permit estimations to be made of the withers heights and there are based on the regression factors described by von den Driesch and Boessneck (1974). A pooled reconstructed withers height based on 30 metacarpi, 20 metatarsi, 4 radii, 3 humeri and 1 tibia gave a result of 54.0 cm (s.d 4.37) and a range from 43.13 cm to 63.11 cm. A comparison of this result with the estimated withers height from other medieval sheep assemblages in Britain is shown in Table 64. The sheep from the well appear to be at the lowest end of the range.

The archaeological record shows that medieval sheep were considerably smaller than those of the Roman and Saxon periods (Bourdillon 1979a, 519; Grant 1977, 228). Grant (1988, 177) points to two reasons that could have contributed to the size reduction. Firstly, there is the possibility that castration to improve wool quality ' may have had a detrimental effect on the genetic constitution of the animals' and secondly, the location of grazing land in marginal areas could have caused a decline in the nutritional standards. In addition O'Connor (1982, 25) has suggested that in the medieval period 'the production of wool presupposed nothing about the body size of the sheep, and if sheep were regarded as valuable for wool rather than meat there would have been no impetus towards increased body size'.



SKL=skull; JAW=mandible; SCP=scapula; HUM=humerus; RAD=radius; ULN=ulna; MTC=metacarpus; PEL=pelvis; FEM=femur; TIB=tibia; MTT=metatarsus; CAL=calcaneus; APH=first phalanx; BPH=second phalanx; CPH=third phalanx; HC=horncore

Figure 58 Barbican well: sheep/goat, mean relative percentage contribution of anatomical elements based on diagnostic zones, after Rackham 1986



Measurements in mm

Figure 59 Barbican well: sheep/goat, distribution of measurements of the acetabular wall of the pelvis (TMR), after Armitage 1977

	Mean	*Min.*	*Max.*	*s*	*CV*	*N*
SCAPULA						
SLC	18.2	9.1	21.5	2.4	13.1	44
GLP	29.7	24.6	31.9	1.9	6.3	28
LG	22.9	19.3	24.8	1.3	5.6	31
BG	19.2	17.0	22.0	1.2	6.2	34
ASG	18.4	15.0	23.3	2.0	10.8	34
HUMERUS						
GLC	115.3	111.0	121.0			3
Bp	33.2	30.4	37.9			3
SD	14.2	11.9	15.9	1.0	7.0	23
SDTH	15.4	13.3	17.5	1.0	6.4	21
Bd	27.7	23.9	30.8	1.6	5.7	32
RADIUS						
GL	132.2	114.0	143.0			4
Bp	27.4	21.9	31.0	2.7	9.8	12
SD	15.0	11.3	17.4	1.2	8.0	38
SDTH	8.7	5.5	10.9	1.0	11.4	38
Bd	26.0	22.9	28.4	1.5	5.7	34
METACARPUS						
GL	110.2	98.0	126.0	8.1	7.3	30
Bp	20.6	17.9	23.5	1.3	6.3	68
SD	12.9	8.0	16.4	1.6	12.4	92
SDAP	8.7	6.1	10.5	.8	9.1	91
Bd	22.9	19.7	26.0	1.3	5.6	75
DD	14.0	10.7	16.1	1.3	9.2	74
Bdep	22.9	19.6	25.6	1.3	5.6	75
FEMUR						
Bp	42.1	38.0	45.3	2.4	5.7	6
DC	18.5	16.6	19.4	1.0	5.4	7
SD	15.0	11.7	17.4	1.7	11.3	8
SDTH	15.1	11.1	17.8	2.2	14.5	6
Bd	34.0	30.7	37.0	1.6	4.7	13
TIBIA						
GL	179.0					1
Bp	36.5	33.4	38.3	1.7	4.6	9
SD	13.6	9.8	15.9	1.0	7.3	44
SDTH	10.5	7.9	12.9	.9	8.5	41
Bd	24.3	21.8	26.8	1.1	4.5	51
METATARSUS						
GL	121.4	95.0	139.0	10.6	8.7	20
Bp	18.6	16.2	21.0	1.2	6.4	57
SD	11.0	6.7	14.1	1.2	10.9	91
SDAP	9.4	6.6	12.4	.9	9.5	91
Bd	22.2	19.4	24.7	1.1	4.9	69
DD	14.1	10.5	16.8	1.4	9.9	66
Bdep	21.9	18.7	24.6	1.1	5.0	68

Key as for Table 57

Table 63 Barbican well: sheep/goat bone measurements, in mm (after von den Driesch 1976)

More research is needed on the quality of grazing land to evaluate precisely the nutritional effects it could have had on late medieval livestock. However, there is written evidence on the importance of the wool trade in the city of Norwich. As mentioned in 'Ageing Data', the age profile supports the hypothesis that the sheep were bred for their wool and meat was a secondary product. Determination of sex for the sheep from the well could help as well in verifying this idea since it is known that the best fleeces come from wethers.

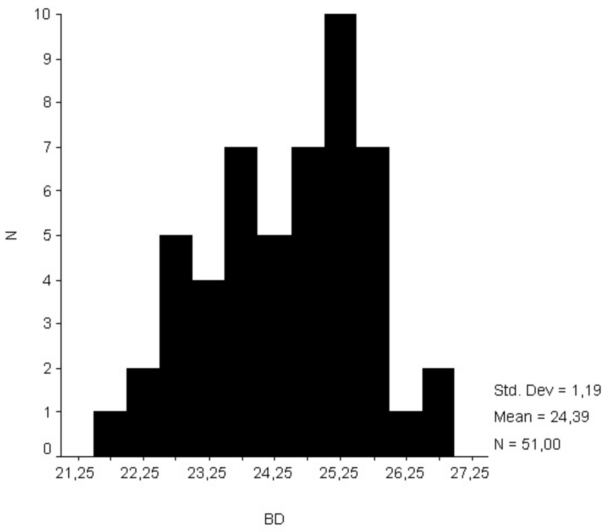


Figure 60 Barbican well: histogram of sheep/goat tibia distal breadth (BD) in mm (after von den Driesch 1976)

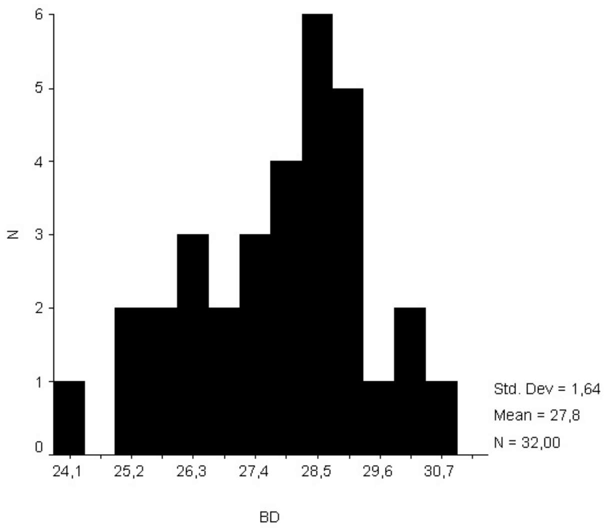


Figure 61 (right) Barbican well: histogram of sheep/goat humerus distal breadth (BD) in mm (after von den Driesch 1976)

Morphological differences in the pelvis between sexes have been pointed out by Boessneck *et al*. (1964) and Armitage (1977) concluded that measurements of the thickness of the acetabular wall, on the ventral (medial) border where the iliac and pubic portions of the acetabulum join, would show distinctions between males and females. A histogram with this measurement is plotted in Fig.59. Although the sample is not large, there is a clear trimodality in the distribution. It is worth noting that those pelves under 3.5 mm had always been sexed as ewes, according to morphological characteristics. Thus, it is assumed the majority of the rest, with bigger values, must be wethers and rams.

In addition, histograms of single variables were made in order to see if there was any more evidence on the sexes represented in the sample. Noddle (1980, 396) has

	Mean	s	N
Castle Mall (Barbican well), Norwich			
late 15th-early 16th-century	54.0	4.3	58
Greyfriars, Norwich (Moreno García 2007)			
<1100	60.0	1.2	4
1226–1538	56.2	2.8	22
Alms Lane, Norwich (Cartledge 1985)			
early 15th–late 16th-century	54.0	3.5	5
late 16th–late 18th-century	58.2	4.7	10
North Elham Park (Noddle 1980)			
(period 5, medieval)	57.6		6
Southampton (Noddle 1975)			
Period B, 1250–1350	54.0		4
Quilter's Vault, Southampton (Bourdillon 1979b)			
Period B, 13th–16th-century	56.0		
Wharram Percy (Ryder 1974)			
15th-century	55.4		6
St Mary of Ospringe, Kent (Wall 1980)			
1470–1550	60.7		25
Whitefriars Church, Coventry (Holmes 1981)			
mid 16th-century	57.7	33.1	37
King's Lynn (Noddle 1977)			
1250–1350	55.5		4
1350–1500	56.2		12
Greyfriars, London (Armitage & West 1985)			
c. 1480–*c*. 1500	60.5		
Flaxengate, Lincoln (O'Connor 1982)			
c. 870–1500	59.5	36.0	170
Skeldergate, York (O'Connor 1984)			
context 1094	58.8		50
context 1097	59.5		38
Exeter (Maltby 1979)			
c. 1100–*c*. 1300	55.1	7.0	17
Launceston Castle, Cornwall (Albarella & Davis 1994)			
Period 8	56.3		10
Frideswide's Priory, Oxford (Stallibrass 1988)			
medieval	59.3		5

s: standard deviation; N: number

Table 64 Barbican well: comparison of the withers height estimates (in cm) for Castle Mall (Barbican well) sheep/goat with those from other medieval sites in Britain

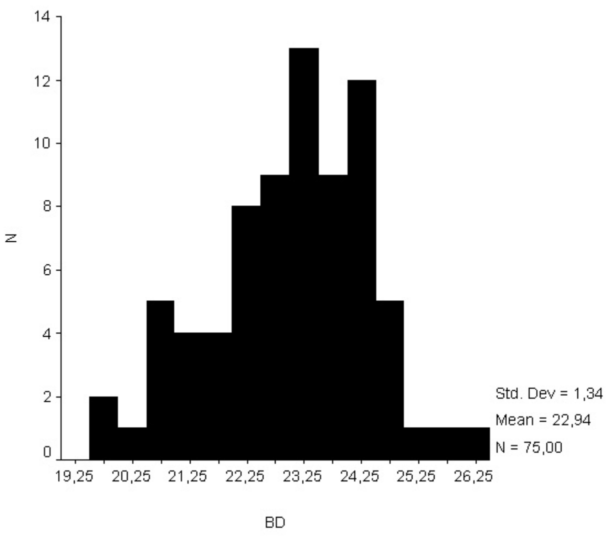


Figure 62 Barbican well: histogram of sheep/goat metacarpal distal breadth (BD) in mm (after von den Driesch 1976)

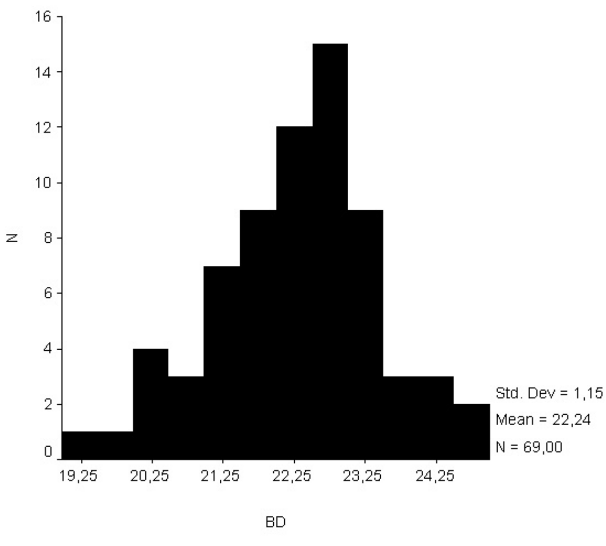


Figure 63 Barbican well: histogram of sheep/goat metatarsal distal breadth (BD) in mm (after von den Driesch 1976)

suggested that the sheep distal tibial breadth (Bd) has a trimodal distribution within a single breed. The distribution of this measurement in Fig.60 does not show a clear discrimination between the sexes, although it is skewed to larger values.

More evident differences were noted when plotting the distal breadth of the humerus (Fig.61). In this case there is a clear bimodality, with the female mode centred at about 26.1mm and the male mode centred at about 28.5mm. The probable male group is larger and it shows some bimodality which may be due to the presence of wethers and rams, the latter probably represented by the biggest values.

Similar profiles were observed when the distal breadth of metacarpals and metatarsals were plotted (Figs 62 and 63). The distributions are always skewed to the biggest values indicating a bias towards males, among which the number of castrates probably predominates.

Pathology

Pathological symptoms were noted mainly on sheep mandibles. Periodontal disease occurred around the alveoli of the first and second molars in four mandibles. In one case, there was indication of abscessing as well. The condition appeared to involve the alveolar bone surrounding the teeth and the periodontal membrane of each socket, leading to the partial loosening of both teeth. The age of these mandibles ranged from 2–3 years up to 6–8 years. These particular specimens also exhibited malocclusion and overcrowding of the teeth. In fact, lateral attrition was displayed by thirteen mandibles out of thirty-two and was especially common between the fourth premolar and the first molar (6 cases), followed by lateral attrition between the first and second molars (5 cases) and finally between the second and third molars (2 cases). Dental attrition was not restricted to old individuals but it was observed in animals of young age (1–2 years old).

Another pathological symptom linked with the health and functioning of the teeth are calculus deposits. Fifteen of the thirty-two mandibles in the Castle Mall sample were affected by this condition. Following the Dobney and Brothwell (1987) scoring system, the severity of the calculus deposits was assessed. Ten mandibles were scored as grade 1 in their 5 point-scale. This means that there was only a thin deposit on the lingual and labial aspect of the teeth. Grade 2, indicating the filling of the infoldings of the crown was recorded for four mandibles. Only one exhibited a severe condition on the labial aspect of all molar teeth, reaching grade 3 in the scale. In general, the occurrence of deposits was more frequent on molar than premolar teeth, and there was no bias towards old individuals. Mandibles aged to 1–2 years of age already exhibited calculus. It is worth mentioning as well that none of these mandibles with calculus developed periodontal disease.

The rates of pathology in animals coming to market may have been smaller than in the original population.

Two non-metrical traits on sheep mandibles were recorded. The first of these was the congenital absence of the second premolar. This characteristic may be linked to the effects of malnutrition at an early foetal stage (Andrews and Noddle 1975). Note was also made of the frequency of the occurrence and position of an extra nutrient foramen on the lateral anterior aspect of the mandible. It occurred in 14 out of 32 of the mandibles. In half of the cases, the foramen was positioned under the third premolar and in the other half under the second premolar. Unfortunately, the significance of the position of this foramen is not clear and is rarely mentioned in faunal analyses. It is possible that its presence or absence could be explained in terms of genetic heterogeneity, as seems to be the case with the different positions of the major nutrient foramen in sheep femora (O'Connor 1982). This variable was also recorded in the barbican well sheep assemblage for eleven specimens. It always occurred proximally on the anterior aspect. No evidence of its presence around midshaft on the posterior aspect or towards the distal epiphysis was noticed.

Apart from oral pathology the only other bone with pathological symptoms was the femur. Two femora were extremely light and had a very thin cortex, suggesting an osteoporotic condition. Osteoporosis may be dependent on a number of factors such as dietary insufficiencies of phosphorus and nitrogen, poor pastures, close herding and/or overstocking (Baker and Brothwell 1980).

Finally, seventeen out of seventy partially complete horncores bore shallow and irregular depressions, known as 'thumbprints'. Hatting (1975) suggested that these marks are probably formed during periods in which the animals suffered from malnutrition, and that castrates may be more susceptible since the walls of their horncores are weaker than normal cores.

VI. Pig

(Pls 52–53, Figs 64–65, Tables 65–67)

Ageing Data

Post-cranial pig bones were placed into age groups, according to their epiphysial fusion state, as for the cattle and sheep. Table 65 presents the epiphysial fusion data. Proximal metapodials, distal proximal and middle phalanges are fused before birth. The early fusion group includes those skeletal elements which fuse by 1 year of age, that is, distal scapula and humerus, proximal radius and proximal epiphysis of second phalanx. Distal tibia and metapodials, proximal first phalanx, distal fibula and calcaneus tuber fuse by 2.5 years and they confirm the second group. The elements that fuse by 3.5 years are included in the last group. They are proximal and distal ulna, proximal humerus, distal radius, proximal and distal femur, proximal tibia and fibula.

No foetal animals occurred. The majority of pigs (64%) were slaughtered at less than one year of age. That means 36% survived this age to be killed during the second year with just one per cent surviving to three and a half years of age.

The evidence for dental eruption and wear would be a better reflection of the kill-off pattern for this taxa given the high number of immature animals, the degree of fragmentation affecting pig bones and the good preservation of the mandibles. Since some of them were incomplete, Grant's mandibular wear stages were estimated within class intervals of five. Thus, MWS = 1–5 and 6–10 classes correspond to mandibles younger than 6 months of age. MWS = 11–15 and 16–20 classes correspond to mandibles between 6 months and 1 year. Mandibles aged 1 to 2 years are included in MWS = 21–25 and 26–30 classes. The next two classes, 31–35 and 36–40 comprise those mandibles between 2 and 3 years of age. Finally, those with a MWS higher than 40 correspond to

Bone	Unfused NISP	Fused NISP	Fused %
	FUSION		
Fusion Before Birth			
Metapodium proximal	-	180	100
First phalanx distal	-	-	100
Second phalanx distal	-	-	100
total	**-**	**308**	**100**
Early Fusion (Birth–1 yr)			
Scapula distal	2	5	71
Humerus distal	15	8	35
Radius proximal	23	10	30
Second phalanx proximal	35	19	35
total	**75**	**42**	**36**
Middle Fusion (1–2.5 yrs)			
Metapodium distal	177	14	7
First phalanx proximal	64	12	16
Tibia distal	28	2	7
Fibula distal	11	2	15
Calcaneus tuber	17	2	10
total	**297**	**32**	**10**
Late Fusion (2.5–3.5 yrs)			
Ulna proximal	9	-	-
Ulna distal	5	-	-
Humerus proximal	20	-	-
Radius distal	27	-	-
Femur proximal	14	-	-
Femur distal	29	1	3
Tibia proximal	27	-	-
Fibula proximal	4	1	20
total	**135**	**2**	**1**

Table 65 Barbican well: epiphysial fusion data for pig (after Silver 1969)

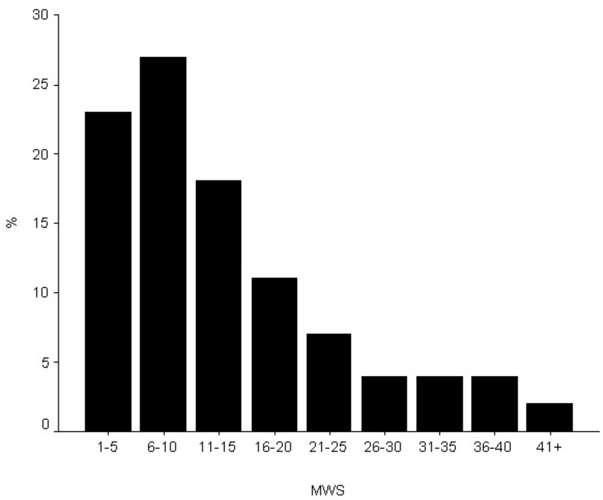


Figure 64 Barbican well: pig, frequency of mandibles (%) by wear stage (after Grant 1982)

	Bone	%
	Scapula	3.5
HIGH QUALITY	Humerus	11.7
	Pelvis	4.7
	Femur	8.3
	total	**28.2**
	Tibia	9.1
LESSER QUALITY	Radius	9.8
	Ulna	3.0
	Skull	6.4
	Mandible	19.3
	total	**47.6**
total meat-bearing bones		**75.8**
	Metacarpus	8.8
	Calcaneum	3.8
LOW QUALITY	Metatarsus	8.8
	First phalanx	1.3
	Second phalanx	1.1
	Third phalanx	.4
total waste bones		**24.2**

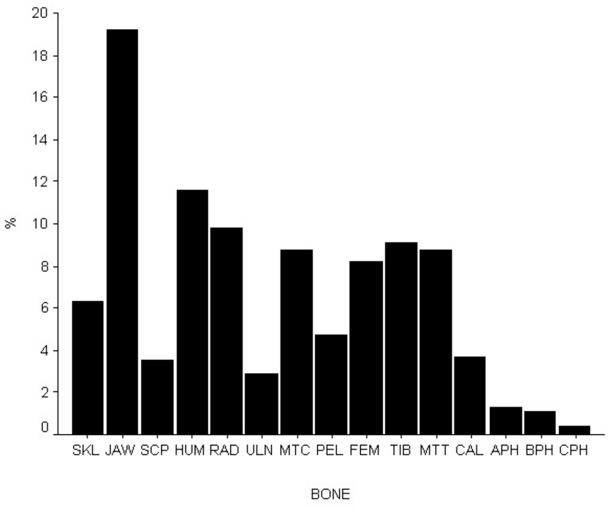
Table 66 Barbican well: mean relative percentage contribution of pig anatomical elements based on diagnostic zones (after Rackham 1986)

animals older than 3 years. Figure 64 presents the kill-off pattern obtained from the mandibular data. It shows that the mortality rate during the first year (79%), and especially in the first six months (MWS=1–5/6–10; 49%) is higher than that reflected in the epiphysial fusion data. The main product of this animal is meat. Therefore, this pattern of killing attests to the consumption of piglets.

Although these pigs could have been bought at market, the presence of the bones of one year old pigs may be seen as possible evidence for pig rearing within the town boundaries. Raising pigs in an urban area such as Norwich would not have been a problem since they can be fed on spare or waste food. In the *Records of the City of Norwich*, various entries refer to swine kept in the city. For example, the following order was issued on 19th November 1354: '…. It is ordained and established that each man or woman of whatsoever estate or condition he may be, who has boar, sow or other pig within the said city, that they keep them within their enclosure as well by day as by night, so that if any kind of pig be found going about at large without a keeper that he be heavily amerced by the bailiffs of the city, and also that anyone who may find them thus going about at large without a keeper by day or night that the said pigs may be killed by anyone who shall be willing to kill them without being interfered with, troubled or injured for the killing of such pigs going about contrary to this ordinance' (Hudson and Tingey 1910, 205–206).

Butchery

As can be seen in Table 49, the butchery of pig carcasses was less intense than for cattle and sheep/goat. In general, chop marks are very scarce. They occur on the occipital region of the skull and are very likely related to the decapitation of the animal. Some chop marks were observed on the atlas as well. Sagittally cloven vertebrae



Key as for Fig. 58

Figure 65 Barbican Well: pig, mean relative percentage contribution of anatomical elements based on diagnostic zones (after Rackham 1986)

occurred as with the other domestic stock, so it can be said that the splitting of the carcasses into sides was a regularly established tradition by the late 15th century. Calcanei and astragali were slightly affected by butchery.

Fine knife cuts are particularly abundant on the lateral side of the mandible, and sometimes occur on the medial side. These marks suggest the extraction of the tongue and the cheek meat.

Knife cuts are more common than chop marks on the limb bones. The former are abundant on the neck region of scapulae, only on the dorsal side; along the diaphyses of humerus, radius, femur and tibia. The proximal end of the humerus was chopped transversally, probably in order to dismember the whole leg. The same process was observed for the femur, the head of which was sliced from the rest of the bone, and in this process the acetabulum of the pelvis was also chopped. Radius, ulna and tibia sported knife cuts which indicate that whole joints were consumed.

Anatomical Distribution

The same approach used for cattle and sheep/goat, based on counting diagnostic zones, is followed for pig. The total number of phalanges and metapodials was divided by eight, so that they are not over-represented in relation to the other bones. The results are summarised in Table 66 and Figure 65.

As with the other domestic stock, meat-bearing bones are much more abundant in the sample, and among these, the dominance of mandibles is evident, followed by bones of the fore and hind leg. As described in the previous section, there was a low incidence of chop marks on these bones and it was very likely that whole joints were consumed. The pattern shown in Fig.65 supports this hypothesis as well. In addition, the contribution of metapodials is very similar to that of the long bones so it appears they were left attached to the rest of the limb bones and only the phalanges were thrown away. They are less common than for cattle and sheep/goat. One explanation that could account for this is the fact that since they were very young animals, they were consumed without cutting the carcass into smaller portions. Thus the only waste at the butcher's would be the phalanges.

	Mean	*Min*	*Max*	*s*	*CV*	*N*
SCAPULA						
SLC	19.6	9.5	24.1	5.4	27.5	6
GLP	33.8	33.2	34.5			2
LG	29.8	24.5	36.7			4
BG	26.6	23.3	30.0			4
HUMERUS						
SD	12.2	6.4	15.6	3.0	24.5	17
SDTH	17.9	8.0	23.3	5.2	29.0	17
Bd	37.8	35.9	40.0	1.5	3.9	6
RADIUS						
Bp	27.2	25.3	28.8	1.2	4.4	11
SD	14.8	7.1	19.0	4.3	29.0	20
SDTH	10.2	5.0	13.4	2.7	26.4	14
PELVIS						
LA	32.6	29.9	35.2			3
LADM	32.9					1
SH	21.3	18.5	22.9			3
SB	10.6	10.3	10.9			3
FEMUR						
SD	17.3	14.4	20.8	2.1	12.1	11
SDTH	20.2	17.6	24.3	2.0	9.9	11
Bd	42.0	33.4	47.0	4.8	11.4	7
TIBIA						
SD	17.0	7.9	21.0	2.7	15.8	17
SDTH	13.0	6.4	14.7	1.9	14.6	17
Bd	30.2	29.8	30.7			2

Key as for Table 57

Table 67 Barbican well: pig bone measurements in mm (after von den Driesch 1976)

Metrical Data

The majority of pig bones were of immature individuals and therefore very few measurements were available. A summary of them is included in Table 67. Standard deviations and the coefficients of variation have been calculated for all sample sizes greater than or equal to five.

The mean of the distal breadth of six humeri was 37.8mm. This value is very close to that of 37.7mm obtained from two medieval humeri from Greyfriars, Norwich (Moreno García 2007). The distal breadth of one tibia from the well (30.2mm) is very similar to one from Greyfriars (28.2mm) as well. However, the sample number is so small that it is not worth comparing these specimens with any other sites.

Metrically there is no evidence of wild boar in the sample.

Pathology

Six instances of oral pathology were noted in the pig mandibles. In the first case, inflammation was apparent around the alveoli of M1 and M2 as a consequence of a small abscess in this area. More severe abscessing and inflammation was associated with the fracture of the corpus mandibularis shown by another mandible (Plate 52). The development of spongy bone around the breakage was probably a reaction to infection and it demonstrates that the fracture failed to reunite. Only one half of the corpus mandibularis, from the fourth premolar to the symphiseal region, was recovered.

Plate 52 Barbican well: pathological pig mandible showing unhealed fracture (Period 5.2)

Plate 53 Barbican well: pathological pig mandible showing severe malocclusion (Period 5.2)

One very old specimen exhibited severe malocclusion and attrition on the lingual aspect of the first and second molars (Plate 53). Even the roots of both teeth were worn out.

Periodontal disease caused the ante mortem loss of the deciduous fourth premolar in two juvenile mandibles. The sockets of this tooth started to fill in during the healing process.

One left maxilla displayed overcrowding of the teeth and as a result the second premolar impacted on the third premolar.

Factors such as malnutrition and/or overstocking could have caused the pathologies described. The low incidence of pathologies does not allow any further conclusions to be drawn on the health of the original population.

VII. Dog

(Pl.54, Tables 68–69)

Fifteen dog partial skeletons were recovered from the shaft. All the bones examined were typical of domestic dog and there was no evidence of wolf. The occurrence of these partial skeletons in the shaft suggests deliberate burial and that there was some concern about the disposal of their carcasses. The *Records of the City of Norwich* (Hudson and Tingey 1910, 207) mention the problems caused by vagrant dogs as well as the high esteem in which some breeds were held: '... great injury and contentions have often happened in the said city for dogs which go at large, it is thus ordained by assent of the commonalty of the city, [that those] who have dogs in the city that they keep them tied up or in other way within their enclosures so that they do not go vagrant at large outside in the streets neither by day nor by night. And if any dogs be found vagrant in the streets contrary to this ordinance let them be killed by anyone who may find them thus going about outside in the streets. But this ordinance shall not extend to greyhounds, spaniels or little kennets [small dogs used in hunting, perhaps beagles], or to dogs which are for sport, nor to dogs which come with their masters in the city and go back the same day outside with their masters who are strangers and come not from the city'.

Metrical data show a wide range of size, suggesting different breeds were present. Shoulder heights were estimated according to Harcourt's (1974) equations and the results are summarised in Table 68. Most of the dogs were of medium size, except for one that could be compared with a modern Alsatian (height at the withers= 63.8 cm).

O'Connor (1982) has commented on the trend in modern dogs to a proportional reduction in the length of the snout. Table 69 summarises the skull measurements of nine of the fifteen skeletons recovered. The snout index proposed by Harcourt (1974; the ratio nasion to alveolare : alveolare to opisthocranion) could be calculated for five skulls. They range from 46.6% to 52.4% which indicates no short-snouted type dogs were present in the sample.

The fifteen skeletons belonged to adult individuals since the epiphyses were nearly always fused. Only one femur, one ulna and a mandible of a foetal puppy were recovered (context *50321*).

The sexual identification of the dogs was determined by the presence of the *os penis* and four males were counted. Three of them correspond to individuals with the following withers height: 36.5cm, 46.8cm and 56.3cm.

1	26.8
2	28.8
3	32.5
4	33.0
5	36.5
6	36.6
7	38.5
8	39.8
9	42.7
10	44.8
11	46.1
12	46.8
13	56.3
14	57.1
15	63.8

Table 68 Barbican well: withers height estimates for dog skeletons in cm (after Harcourt 1974)

Plate 54 Barbican well: dog calcaneus exhibiting knife cuts (Period 5.2)

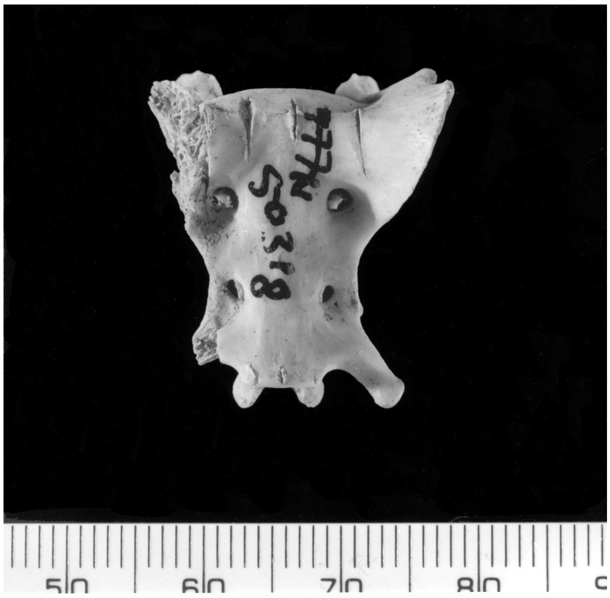


Plate 55 Barbican well: cat sacrum exhibiting knife cuts (Period 5.2)

As far as pathology is concerned, the distal articulation of four humeri (belonging to three individuals) had severe eburnation with associated exostoses, indicating an arthritic condition. Two of these individuals had developed the same condition on the proximal radius and ulna so that the whole joint was affected. In addition, the cervical, thoracic and lumbar vertebrae showed a severe exostoses of the centra. The advanced degree of arthritis indicates that these were quite old animals.

Healed fractures were observed on ribs from at least two individuals and the scapula from another displayed a small pit on the glenoid cavity, which may have been due to some kind of infection.

The skull of the biggest individual presented fractures on the left and right frontal bones. It has been suggested that this dog could have been alive after its arrival within the shaft. Possible claw marks were found in the vertical chalk wall of the shaft near to the skeleton together with large limestone blocks (see Part II, Chapter 9.II). Whether any of these blocks were thrown on top of the dog and caused the fractures in the skull and subsequent death, or whether the fractures happened after death is open to speculation.

None of the bones, except for a right calcaneum (Plate 54) bore butchery marks. Two very fine knife cuts were observed behind the sustentaculum tali and two more near the calcaneal tuber. These marks could have only originated when the dog was skinned. A few cut marks were found on both cat and dog bones from Bedford (St John's Street site) and Grant has suggested that these animals may have provided an occasional meal (Grant 1979, 107). There is no evidence that this could be the case for the dogs of the well. The occurrence of knife cuts in only one bone implies that either they were very skilled in skinning the animals or that it was a rare practice.

VIII. Cat

(Pl.55, Fig.66, Tables 70–71)

According to the number of fragments, cats were scarcer than dogs but an MNI based on the most common zone in a skeletal element (zone 4 of the femur, in this case), results in the presence of at least 16 individuals. Five cats, some retaining their fur, were found within putlog holes and appear to have been thrown or fallen into the well alive (Part II, Chapter 9.II).

The eleven mandibles present in the well assemblage sport permanent dentition (older than 6 months). Long-bone epiphysial fusion data were used to get a more accurate idea of the age of the cats. Smith's (1969) sequence was followed and the results are shown in Table 70. By comparing the percentage of fused bones in each of the groups (Table 70) it can be seen that the majority of the cats were older than one year but that only 38% of them would have lived for more than two years. For example,

Skull	*I*	*II*	*III*	*IV*	*IX*	*X*	*XI*	*XII*	*Snout index (III.100/I)*	*Snout width index (XII.100/III)*
1	-	-	122.0	-	116.1	69.0	70.8	49.6	-	40.6
2	191.5	103.4	100.5	-	96.4	56.4	64.4	37.9	52.4	37.7
3	187.0	99.0	93.1	-	-	58.3	63.6	36.9	49.7	39.6
4	154.0	84.3	77.1	-	75.2	44.7	53.8	31.7	50.0	41.1
5	142.2	75.8	71.8	79.1	51.5	41.8	52.0	28.6	50.4	39.8
6	-	-	89.1	-	84.3	48.4	60.8	33.3	-	37.3
7	136.2	74.8	63.6	-	-	-	49.6	-	46.6	-
8	-	86.3	-	-	-	-	-	-	-	-
9	-	74.1	-	-	-	-	-	-	-	-

Table 69 Barbican well: dog skull measurements in mm (after Harcourt 1974)

the ratio of unfused to fused proximal tibia is 15:5; most of these cats would have died aged less than 18 months (Smith 1969, 526), which also was noted by O'Connor for medieval Lincoln (O'Connor 1982).

Measurements taken indicate a small range of size (Table 71), the coefficient of variation being around or below 7% for most of the measurements. An attempt to sex the cats was made by a histogram of the length of the tooth row (Fig.66). Only one individual appears to separate from the rest, and because of its larger size may be a male. No clear distinctions appeared when other metrical data were plotted.

Bone	*FUSION*		
	Unfused	*Fused*	*Fused*
	NISP	*NISP*	*%*
Early Fusion (up to 7 mths)			
Humerus distal	-	15	100
Radius proximal	-	14	100
total	**-**	**29**	**100**
Middle Fusion (8–14 mths)			
Femur proximal	13	8	38
Ulna proximal	4	16	80
Tibia distal	2	20	91
total	**19**	**44**	**70**
Late Fusion (14–20mths +)			
Tibia proximal	15	5	25
Femur distal	13	9	41
Radius distal	4	10	71
Ulna distal	7	10	59
Humerus proximal	16	-	-
total	**55**	**34**	**38**

NISP: number of identified fragments

Table 70 Barbican well: epiphysial fusion data for cat (after Smith 1969)

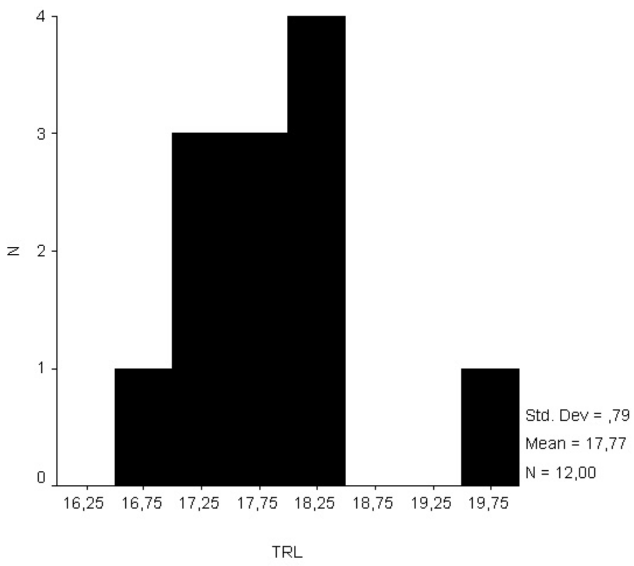


Figure 66 Barbican well: histogram of cat tooth row length (TRL) in mm (after von den Driesch 1976)

Knife cuts were observed on only one bone, a sacrum (Plate 55). This could be evidence of skinning the carcasses. These marks occur in areas where there is little flesh, thus it is relatively easy to nick the bone as the skin is being removed. It cannot be said with certainty if the cat skeletons were skinned or not. Neither was there a bias towards a particular group of bones that could indicate they were eaten.

	Mean	*Min*	*Max*	*s*	*CV*	*N*
SCAPULA						
HS	57.3	54.7	63.9	3.3	5.7	7
SLC	10.9	10.0	12.4	.8	7.3	8
GLP	12.1	11.1	13.3	.7	5.7	9
LG	10.4	9.9	11.9	.6	5.7	9
BG	7.9	7.5	8.9	.5	6.3	9
HUMERUS						
GL	85.9	76.0	93.8	6.4	7.4	11
GLC	84.3	75.0	91.0	6.1	7.2	11
Bp	15.0	13.3	16.5	1.1	7.3	12
DP	18.4	17.0	19.9	1.0	5.4	13
SD	5.8	4.8	6.5	.5	8.6	15
SDTH	6.6	6.0	7.3	.4	6.0	15
Bd	16.5	15.0	18.2	.8	4.8	15
RADIUS						
GL	82.0	73.7	97.0	8.3	10.1	9
Bp	7.3	6.6	7.9	.4	5.4	14
SD	5.3	5.0	6.1	.3	5.6	14
SDTH	3.2	2.9	3.8	.2	6.2	14
Bd	11.0	10.2	12.5	.7	6.3	10
ULNA						
GL	95.3	87.0	114.0	9.2	9.6	9
SDO	9.9	8.1	14.6	1.4	14.1	18
BPC	8.1	6.9	10.3	.7	8.6	18
PELVIS						
GL	70.0	64.3	80.5	4.6	6.5	10
LA	10.0	8.9	12.3	.9	9.0	14
SH	9.5	8.6	11.0	.7	7.3	16
SB	4.2	3.5	5.6	.6	14.2	16
LFO	17.2	16.3	18.4	.6	3.4	10
FEMUR						
GL	95.7	84.0	107	8.6	8.9	11
Bp	18.6	17.1	20.5	1.3	6.9	13
DC	8.7	7.8	9.6	.6	6.8	13
SD	7.5	6.3	8.7	.6	8.0	21
CD	6.6	5.4	7.2	.4	6.0	21
Bd	16.7	14.9	18.3	1.3	7.7	21
TIBIA						
GL	103.7	91.0	115	8.6	8.2	14
Bp	17.6	15.6	19.0	1.3	7.3	15
SD	6.4	5.4	7.6	.5	7.8	19
CD	6.0	5.0	6.9	.6	10.0	19
Bd	13.7	10.8	15.3	1.4	10.2	18

s: standard deviation
CV: coefficient of variation
N: number

Table 71 Barbican well: cat bone measurements in mm (after von den Driesch 1976)

IX. Other Mammals

Eight other mammal taxa were identified, the most common being the rabbit which, according to the archaeological evidence, seemed to have replaced the hare as a popular food resource by the late medieval period (Maltby 1979). As mentioned above (Section III), half of the rabbit remains were recovered from the sieved samples so that the importance of this taxa would have been totally biased if only the hand-collected material was considered. The rabbit assemblage consists mainly of the meatiest parts. Thus, from the tibia fragments there is a minimum number of twelve individuals. Metapodials and phalanges were found in lower numbers compared to the limb bones, suggesting that feet, without meat value, were likely cut off or left attached to the skin (Veale 1966). Knife cuts were observed on one rabbit calcaneum, femur, tibia, humerus and four pelves. Their occurrence suggests that rabbits were cut in small portions to be consumed. These remains are clearly food debris, an idea supported by the ageing evidence. The majority of the rabbits were killed when fully grown. Juveniles would not have much food value.

The presence of hare is limited to 54 remains. Metapodials, jaw and limb bone fragments comprise the assemblage with a minimum number of three individuals. Brown hare, *Lepus europaeus* was not distinguished from blue hare, *Lepus timidus* so that Lepus bones are recorded as hare.

Horse is very scarcely represented. One humerus, one femur, one metacarpal, two pelvic fragments and one cervical vertebra were retrieved from context *50321*. A fragment of a worked tibia was recovered from context *50320* and one first phalanx from context *50300*. It is not possible to know if the remains from context *50321* belonged to the same individual. The lack of horse in the well is related to the nature of this deposit, which was used only for the dumping of domestic and craft waste. Horses would have been disposed of as whole or partial burials in other parts of the city.

Cervid remains, except for antler fragments (see Huddle, Part II, Chapter 9.III) are present in low numbers. One pelvic fragment could be identified as red deer and one astragalus and metacarpal as fallow deer. No butchery marks were present on any of them.

Two vertebrae were identified as dolphin (*Delphinus* sp.) and one of them bore butchery marks, being chopped through. Though their remains are rare in the archaeological record, it is likely that dolphins were occasionally eaten as it is mentioned by Muffet (1655, 173) that: '... Dolphins smell like violets, taste most pleasantly being salted, and give competent nourishment...'.

Finally, one badger (*Meles meles*) metapodial was identified from context *50317* and the remains of one rat (two femora and two pelvic halves) were recovered from context *50301*. Apart from this rat, no other small mammal remains were retrieved from the assemblage despite the fact that an extensive sieving programme had been undertaken.

X. Birds

(Pls 56–57, Figs 67–80, Tables 72–79)

Avian remains account for 21% of the total number of faunal remains from the well. As has been mentioned domestic goose (*Anser dom)* followed by domestic fowl (*Gallus gallus* dom) and domestic duck/mallard (*Anas* dom/*Anas platyrhyncos*) dominate the barbican well bird-bone assemblage (Table 52).

The goose sample is dominated by one skeletal element: the carpometacarpus (see 'Goose Carpometacarpi'). If this bone is excluded, the proportions of domestic fowl and goose, based on NISP, are practically the same. Further, on the basis of MNI, chicken is the most frequently occurring bird species with 46 individuals; goose is represented by a MNI of 21 (NB: carpometacarpi not counted). Nevertheless, the amount of meat provided by these number of geese may have been similar to that provided by fowl.

As with the mammal bones, it is clear that the avian material found in the well derives from two sources. The large number (392 complete + 71 fragments) of goose carpometacarpi comprise what is evidently the waste from a specialised craft, such as the production of quills. The rest of the bird bones seem to be merely food waste. The presence of butchery and gnawing marks together with the distribution of skeletal elements argue in favour of this hypothesis.

The recovery standards and preservation of the avian remains have already been described in Section III, so that no further discussion on these topics is presented here.

Domestic fowl

Anatomical Distribution

Figure 67 shows the proportional representation of domestic fowl skeletal elements. This was calculated by isolating the element with the highest minimum number (MNI), and then expressing the remaining elements as a percentage of that particular element. Overall the leg bones are strongly represented, followed by sterna and the wing bones. Skull and mandibles are present in very low numbers which suggests primary butchery of the birds,

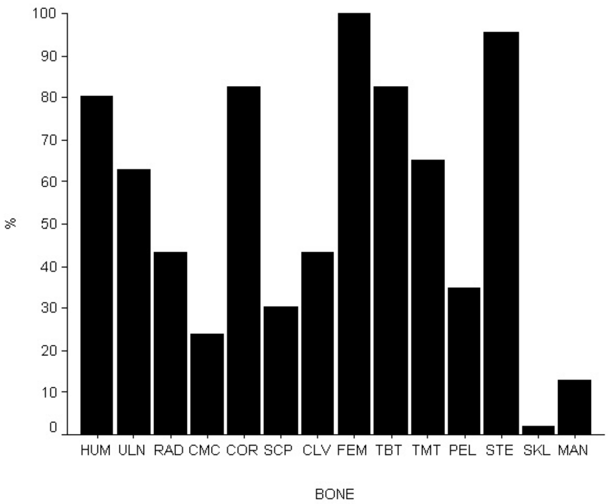


Figure 67 Barbican well: histogram of distribution of domestic fowl anatomical elements

with the removal of the heads. This would seem to confirm the domestic nature of the fowl remains.

The scarcity of skulls might suggest a preservational bias in favour of the more robust long bones, as opposed to the more fragile skeletal elements. However, the high proportion of sterna indicate that this was not the case. The fragments of sternum counted were only those with a complete front (manubrium sterni, labia ventrale and dorsale, and apex cristae sterni). They are as numerous as the robust femur.

Butchery

Butchery marks were occasionally found on domestic fowl bones, but the majority of limb bones were complete. One coracoid was chopped at its proximal end and very fine knife cuts were common on the cranial aspect of the proximal end. These are most likely related to the dismemberment of the wing. Some knife cuts were also present on the proximal end of the humerus and along its shaft.

The dismemberment of the leg was accomplished in the same way, although chop marks are more frequent on the distal end of the femur and distal epiphysis of the tibiotarsus, the latter being very common and always present on the anterior side of the epiphysis. The tarsometatarsus showed knife cuts on the proximal end and some had cuts on the spur.

Overall chickens were consumed as whole carcasses. Only heads and feet were discarded as butchery waste. The knife cuts observed could have been produced to facilitate the cooking or once the animal was on the table. During the meal, cats seem to have had a quick forage as is evident from the gnawing marks they left on them.

Ageing Data

Immature bones (under five or six months of age) were counted for each of the long bones and their percentage of the total was then estimated. The results are shown in Table 72. At Castle Mall bones from juvenile birds made up 20% approximately of the fowl assemblage. This compares with 19% juvenile fowl from castle refuse dated to 1520 from Baynard's Castle (Carey 1982, 266) and with 28% juvenile fowl from 1300–1500 Exeter (Maltby 1979). The low frequency of juvenile bones suggests that domestic fowl was not intensively exploited for meat and highlights the importance of egg-production. Little is known of the laying potential of medieval hens but eggs were consumed in large quantities (Labarge 1965, 81–82). Cockerels may also have been used in cock-fighting, before they ended up in the pot.

Bone	*Unfused NISP*	*Fused NISP*	*Unfused %*
CORACOID	14	61	19
HUMERUS	10	60	14
RADIUS	10	40	20
ULNA	15	46	26
CARPOMETACARPUS	-	17	-
FEMUR	20	73	21
TIBIOTARSUS	30	67	31
TARSOMETATARSUS	10	63	14
total	**109**	**427**	**20**

NISP: Number of identified fragments

Table 72 Barbican well: domestic fowl long-bone epiphysial fusion data

Sexing and Metrical Data

Birds can be sexed by detecting the presence/absence of medullary bone. Medullary bone is deposited as a store of minerals required for eggshell production, and is formed only in females. Deposition of the bone begins before the eggs are laid and while they are being formed, the medullary bone is depleted (Driver 1982, 251). Thus, medullary bone is a positive indicator that a bone is from a female, but its absence does not necessarily imply a male bird. Bones were not drilled to look at medullary bone deposits but in nineteen cases where the bone was already broken, medullary bone was observed to be present (nine femora and ten tibiotarsi).

Sexual dimorphism is better reflected in the size of the bones so that metrical data may provide some information. Histograms of the greatest length of coracoid, humerus, ulna, femur, tibiotarsus and tarsometatarsus showed a slight trimodality that becomes obvious in the case of ulna (Fig.68), femur, tibiotarsus and tarsometatarsus. A clear bimodality is apparent when plotting the greatest length (GL) against the width at midshaft (SC) of each of the leg long bones (Figs 69–71) and the humerus (Fig.72). There is one clear cluster at the bottom left and a more spread group going to the top right. The smaller size specimens, both in the histograms and scatterplots, could represent the females. Those specimens of larger size probably include males, and it is possible that among these, the biggest values are those of capons. Goodale (1918) attributed the capon's increased body size to a prolonged juvenile growth period. However, one cannot exclude the possibility of the presence of different breeds.

Another method used in sexing domestic fowl from archaeological samples is to score for the presence or absence of the spur in the tarsometarsus. The tarsometarsus of the domestic fowl has a spur on the medial aspect of the distal part of the shaft in adult males, but this spur is generally absent in females (West 1982). In addition, Sadler (1991), on the basis of Juhn's (1952) work

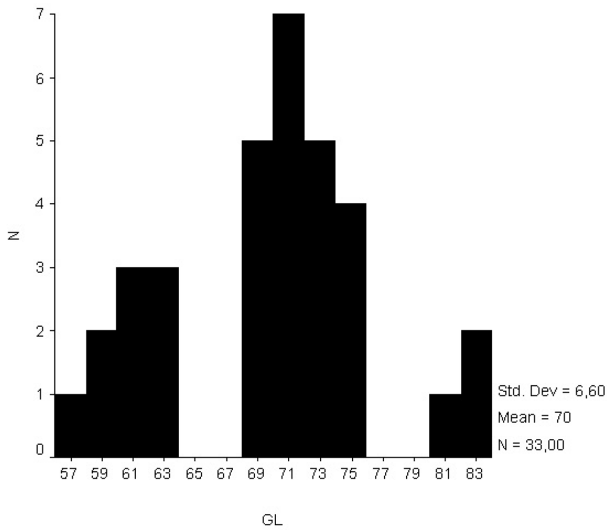


Figure 68 Barbican well: histogram of domestic fowl ulna greatest length (GL) in mm (after von den Driesch 1976)

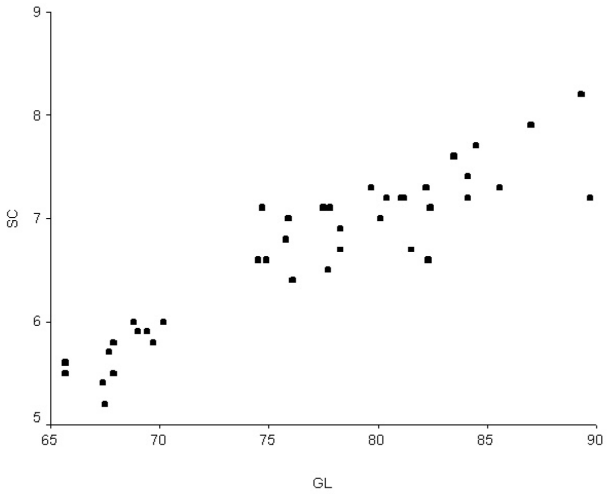


Figure 69 Barbican well: scattergram of domestic fowl femur greatest length (GL) against smallest breadth of the corpus (SC) in mm (after von den Driesch 1976)

on spur growth, has noted that fusion between the spur core and the tarsometatarsus takes place later than it was previously thought. This means that male tarsometatarsi in the archaeological record may not show any sign of a spur, even when mature. Four types of tarsometatarsus were found in the well: those without a spur (*), those with a spur (+), those with a spur scar (o) and those with incomplete spurs (see Fig.71). For the latter case it was difficult to tell whether or not the spurs had simply broken off to their root.

Figure 73 shows a scatterplot of proximal width (BP) against greatest length (GL) of *Gallus gallus* dom. tarsometatarsus; the presence or absence of the spur is indicated by the symbols described above. It is evident that there is a separation into three clusters. The tarsometatarsi without a spur form a group at the bottom left hand corner of the plot, being shorter and narrower than those with a spur. Following West (1982) the former are assumed to be hens. There are two cases of unspurred tarsometarsi that fall in the group in the centre which could be interpreted as hens of a larger type or as Sadler (1991,

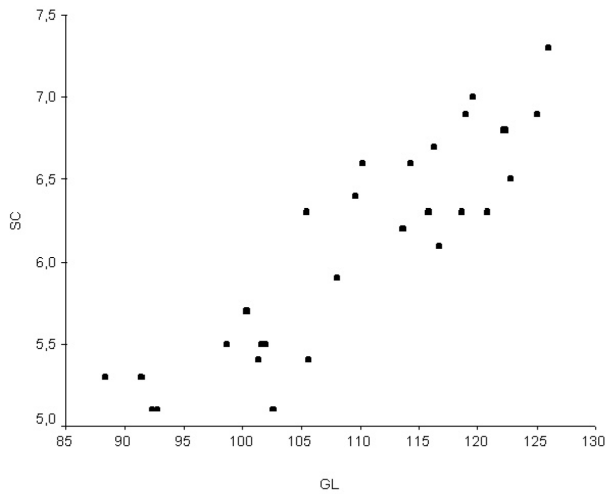


Figure 70 Barbican well: scattergram of domestic fowl tibiotarsus greatest length (GL) against smallest breadth of the corpus (SC) in mm (after von den Driesch 1976)

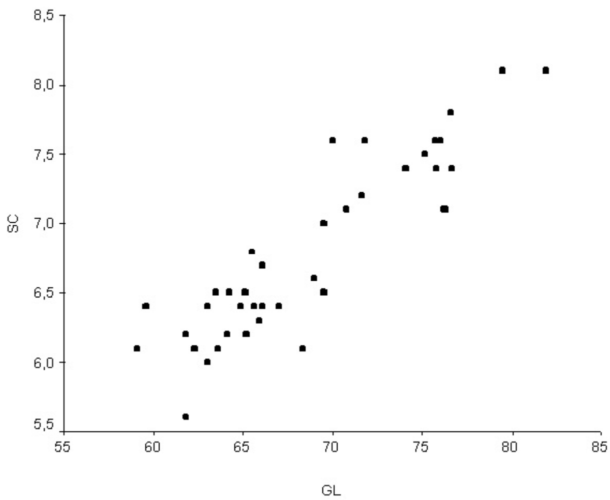
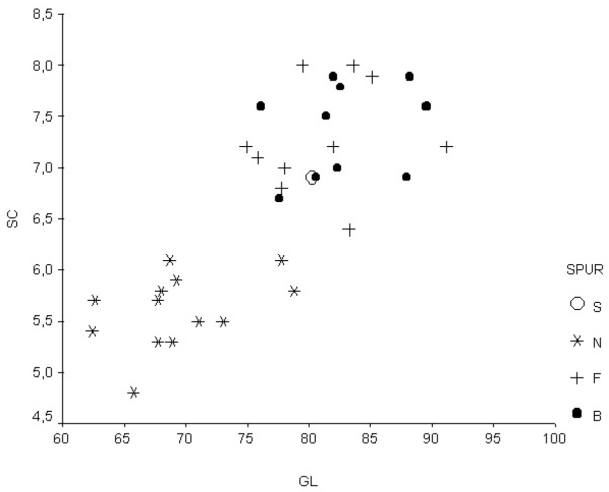
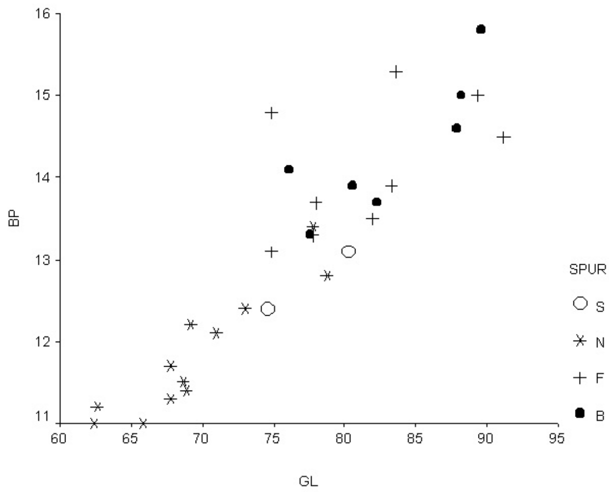


Figure 72 Barbican well: scattergram of domestic fowl humerus greatest length (GL) against smallest breadth of the corpus (SC) in mm (after von den Driesch 1976)



B=broken spur; F=fully developed spur; N=absent spur; S=scar in place of spur

Figure 71 Barbican well: scattergram of domestic fowl tarsometatarsus greatest length (GL) against smallest breadth of the corpus (SC) in mm (after von den Driesch 1976) by spur condition



Key as for Fig. 71

Figure 73 Barbican well: scattergram of domestic fowl tarsometatarsus greatest length (GL) against breadth of the proximal end (BP) in mm (after von den Driesch 1976) by spur condition

42–43) pointed out they could be sub-adult cocks. One of the bones with a scar spur is associated with the hen group while another falls in the centre group. According to West (1982, 259) these may be assumed to represent females. The rest of the cases in the cluster in the centre belong to specimens with broken/eroded spurs and/or complete spurs. Therefore, it seems likely they are cockerels.

Finally, at the top right there is a third cluster with the biggest tarsometatarsi. On the basis of what has been said above (Goodale 1918) this group may comprise the capons in the sample under consideration.

The difference between the male (spurred) and female (unspurred) tarsometatarsi greatest length is highly significant (p being less than 0.001% in the Student's t Test).

Quigley and Juhn (1951) described the spur of the capon as being longer and more pointed than that of the cock and gave the mean values for the length of the spur core in cocks, slips and capons, which they obtained from New Hampshire fowl (Quigley and Juhn 1951, 901). They are as follows: cock spur core 22.8 mm; slip spur core 24.2 mm and capon spur core 26.1 mm.

The lengths of the spurs of the fowl tarsometatarsi from the well are measured, whenever possible. Figure 74 shows a histogram of this measurement. Three specimens on the left of the distribution are separated from the rest of the sample. Assuming that there is only one fowl breed present in the assemblage under discussion, these three specimens may be capons.

A summary of fowl measurements is shown in Table 73. When comparing the greatest length (GL) mean of the individual skeletal elements with the same measurements calculated by Maltby (1979) from medieval (*c.*1300–1500) Exeter, the means of the fowl from the well were slightly higher. Further, the lower limit of Exeter for this measurement (GL) always exceeded the values of the Castle Mall range and the opposite is true for the upper limit; Castle Mall maximum values are always larger. Overall, the Castle Mall fowl sample has a wider range of size and a greater proportion of larger individuals than medieval Exeter. This may suggest that the fowl was reared more intensively in Norwich (O'Connor 1982, 41).

Comparable measurements to those of the well assemblage are given by Carey (1982) for Baynard's Castle (London). On the basis of the greatest length of the tarsometatarsus, a mean length of 83.1 mm is reported for the spurred specimens and a mean length of 70.0 mm for the unspurred individuals.

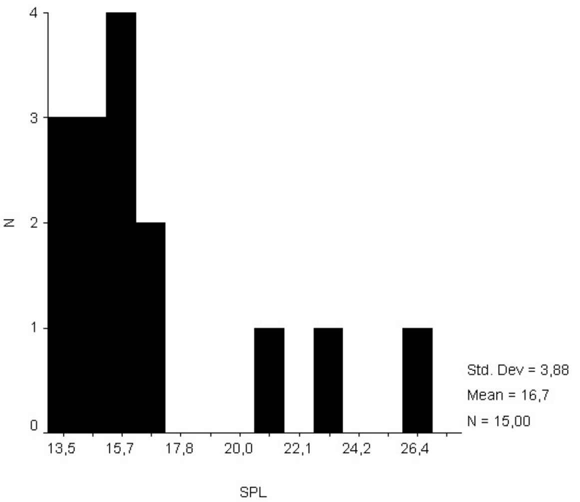


Figure 74 Barbican well: histogram of domestic fowl tarsometatarsus spur length (SPL) in mm

Pathology

Seventeen pathological specimens were recorded from the fowl sample. They are grouped under the following categories:

a) Trauma

A healed fracture was observed in the proximal part of a radius shaft with displacement of the articular surface. Two coracoids show inflammation on the shaft. One case seems to be an ossified haematoma and another an old healed fracture. The head of a femur was totally destroyed, displaying eburnation round joint base, possibly through trauma. A healed fracture of the proximal end is shown by

	Mean	*Min*	*Max*	*s*	*CV*	*N*
CORACOID						
GL	54.3	45.0	66.6	4.7	8.6	44
BB	14.4	11.5	17.6	1.6	11.1	35
HUMERUS						
GL	68.7	59.1	81.9	5.9	8.5	39
Bp	18.6	16.1	21.8	1.6	8.6	40
SC	6.9	5.6	8.4	.6	8.6	59
BD	14.7	12.4	18.1	1.4	9.5	62
ULNA						
GL	69.6	56.6	82.8	6.6	9.4	33
Bp	8.4	6.6	9.7	.7	8.3	36
SC	4.0	3.1	4.9	.4	10.0	40
CARPOMETACARPUS						
GL	37.5	31.4	42.1	2.9	7.7	16
Bp	11.3	9.9	12.7	.9	7.9	16
FEMUR						
GL	76.9	65.7	89.7	6.9	8.9	40
Bp	14.8	12.2	18.1	1.5	10.1	57
SC	6.5	5.2	8.2	.7	10.7	60
Bd	14.6	11.2	17.8	1.6	10.9	65
TIBIOTARSUS						
GL	109.3	88.3	126.0	10.9	9.9	28
SC	5.9	4.8	7.3	.6	10.1	68
Bd	10.9	9.1	13.5	1.0	9.1	52
TARSOMETATARSUS						
(SPURRED)						
GL	81.6	74.6	91.2	5.0	6.1	24
Bp	14.0	11.8	17.0	1.1	7.8	23
SC	7.2	5.7	8.0	.5	6.9	34
Bd	13.9	12.1	15.0	.6	4.3	29
Spur length	16.6	13.1	26.8	3.8	22.8	15
(UNSPURRED)						
GL	69.3	62.4	78.8	4.9	7.0	13
Bp	11.8	10.6	13.6	.8	6.7	17
SC	5.6	4.8	6.7	.4	7.1	23
Bd	12.2	10.6	13.5	.8	6.5	17

s: standard deviation
CV: coefficient of variation
N: number

Table 73 Barbican well: domestic fowl bone metrical data in mm (after von den Driesch 1976) another femur. One tarsometatarsus shows a noticeable deformed shaft with callus formation as a result of a healed fracture. The distal articular end is abnormally angled to the axis of the shaft, and could have resulted from the fowl's leg being trodden on (Luff and Brothwell 1993, 112).

b) 'Old age' related pathologies
Bony outgrowths are displayed around the acetabulum in one pelvis, the sternal facet of one coracoid, on the distal internal condyle of three tibiotarsi and on the external aspect of the shaft of a fourth. In addition, five tarsometatarsi exhibited these bony outgrowths on the proximal medial condyle. Outgrowths of bone were observed around the spur on the tarsometatarsi on several occasions.

c) Neoplasia
A sacrum exhibits spongy outgrowths of new bone, suggestive of a myeloma. Myeloma is a tumour of bone marrow and related cells. It produces multiple spongy growths of new bone simultaneously in a number of sites (Baker and Brothwell 1980, 103–104).

d) Osteodystrophies
One tibiotarsus displays a bowed shaft which may be indicative of rickets (Brothwell 1993, 35). Another specimen displays changes of density and of surface appearance with bone swelling. It involves much of the shaft. This could represent an early lesion of osteopetrosis. The disease has a viral aetiology, and generally starts at the tibiotarsus of a young bird to extend with age and affect the whole skeleton (Baker and Brothwell 1980, 61).

Goose
(Pls 56–57, Figs 75–80, Tables 74–79)

Anatomical Distribution
Figure 75 shows the proportional representation of goose skeletal elements. As with domestic fowl, this is expressed

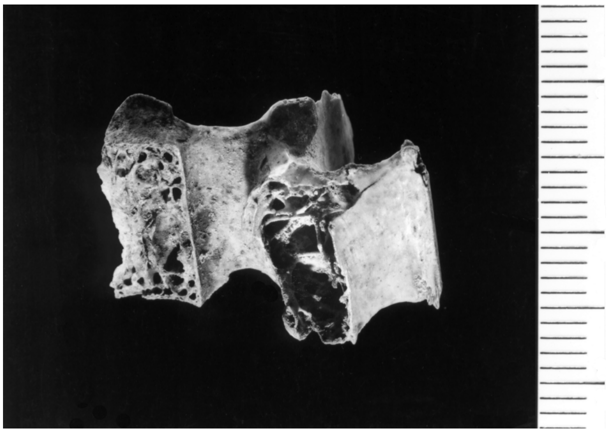
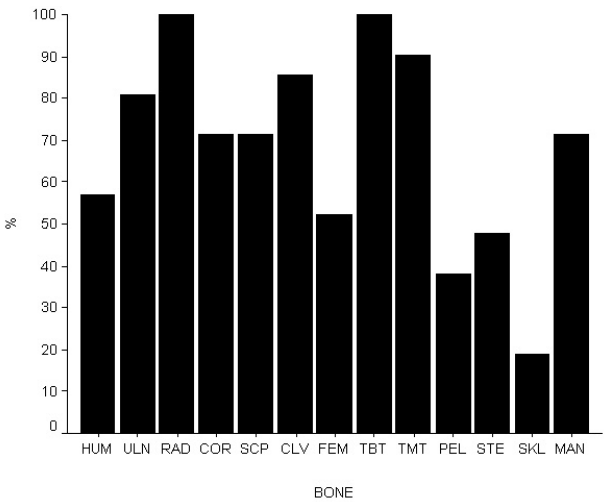


Plate 56 Barbican well: domestic goose vertebra, sagittally split (Period 5.2)

as a percentage of the expected number of bones based on MNI. Carpometacarpi were excluded due to their overwhelming preponderance, suggesting some craft/industrial activity (see 'Goose Carpometacarpi' below). This is also the case for five worked radius shafts. No proximal or distal epiphyses were present so that one end of the shaft was cut and polished. They could have been used as pins or may be stilae for writing (see Huddle, Part II, Chapter 9.III).

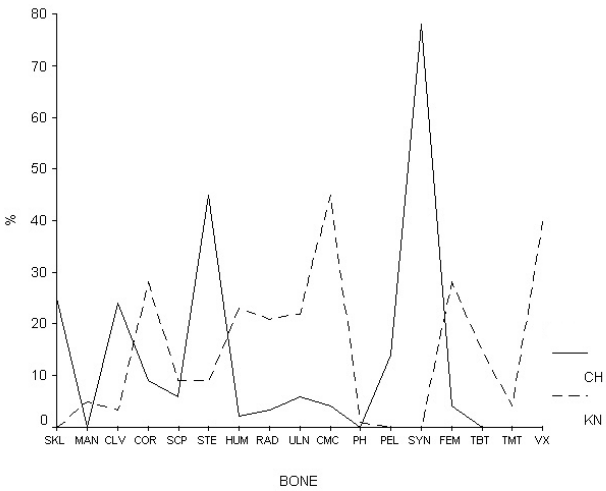
In general, all the wing and leg bones are very well represented with the lowest proportions being those of humerus and femur. Sternum, pelvis and skull elements are less frequently observed. Thus, it could be said there is a bias towards the more robust limb bones. The high frequency of clavicles and mandibles is surprising.

Butchery
Butchery marks were more frequent on goose than on chicken bones. Of special interest is one skull which had been split sagittally. The reason for this practice is unclear, although Gidney (1993) reported the same practice in



HUM=humerus; ULN=ulna; RAD=radius; COR=coracoid; SCP=scapula; CLV=clavicle; FEM=femur; TBT=tibiotarsus; TMT=tarsometatarsus; PEL=pelvis; STE=sternum; SKL=skull; MAN=mandible

Figure 75 Barbican well: bar-chart showing distribution of domestic goose anatomical elements



SKL=skull; MAN=mandible; CLV=clavicle; COR=coracoid; SCP=scapula; STE=sternum; HUM=humerus; RAD=radius; ULN=ulna; CTC=carpometacarpus; PH=phalanx; PEL=pelvis; SYN=os lumbosacral; FEM=femur; TBT=tibiotarsus; TMT=tarsometatarsus; VX=vertebrae

Figure 76 Barbican well: domestic goose, frequency (%) of knife-cuts (KN) and chop marks (CH) by skeletal element

Plate 57 Barbican well: domestic goose carpometacarpi exhibiting knife cuts on the proximal end (Period 5.2)

medieval (*c.* 1400–1550) Leicester. Among the possible reasons for this operation she suggests: 'extraction of the brain; a subtlety whereby the head was opened to reveal, for example, a jewel or a sweetmeat in the brain case; the attachment of an ornament to the head for serving the bird whole in its plumage in the manner of a peacock; a special method of carving to serve the heads as individual portions containing the comb, brain and tongue' (Gidney 1993, 7).

By plotting the relative percentage of chop marks and knife cuts by bone (see Fig.76), the axial bones (clavicle, sternum and pelvis) favour chopping which indicates that geese were split longitudinally into two halves. Some vertebrae were split sagittally as with the main domesticates (Plate 56). On the contrary, the limb bones are biased to knife cuts, probably to facilitate dismemberment of the carcass into smaller portions. The sternal facet of the coracoid was often chopped but knife cuts were more common on the proximal epiphysis and along the shaft. Only two scapulae were chopped proximally. Fine knife cuts were noted on the distal humerus, proximal and distal radius and distal ulna, consistent with the dismemberment of the wing. In addition, 45% of the carpometacarpi (209 out of 463) yielded knife cuts on the internal and external aspects of the proximal end (Plate 57) and 4% were chopped. This would seem to indicate severance of the meatless parts of the wing (carpometacarpus and phalanges) in the initial butchery process. As already mentioned, the high concentration of these bones in the barbican well assemblage derives from sources other than domestic refuse, indicating that wing tips were valued for their primary feathers (see 'Goose Carpometacarpi'). On the leg bones, knife cuts were observed on the proximal and distal femur, distal tibiotarsus and proximal tarsometatarsus.

The same type of butchery was noted in the goose assemblage recovered from medieval Dublin (Hutton-MacDonald *et al*. 1993).

Ageing Data

Immature bones, with unfused epiphyses, were counted for each of the long bones and their percentage of the total number of fused and unfused bones calculated. The results are shown in Table 74. Just 1% of the bones belong to immature individuals. The absolute dominance of adults may be related to the fact that unlike fowl, goose was mainly raised in rural areas and driven to the urban market to be sold. Therefore, it seems unlikely that very young individuals made the journey.

The presence of adults may also be related to the importance of these animals as egg-producers.

Metrical Data

The distinction between the wild (*Anser anser*) and/or domestic goose (*Anser* dom) was made metrically. A summary of the measurements taken on the goose bones from the well is included in Table 75.

Bramwell (1977, 401) noted that the tarsometatarsus was probably the most reliable bone for making the distinction between the domestic and the grey-lag goose. He suggested that the greater weight of the domestic bird would lead to an increase in mid-shaft width and that also, as a result of flightlessness, the distal end of this bone would be more robust. Bramwell's conclusions have been supported by Reichstein and Pieper's (1986) work on the German goose assemblage from medieval Haithabu. The leg bones (femur, tibiotarsus, tarsometatarsus) of the Haithabu geese were wide in comparison with those of the wild grey-lag geese of identical length. In contrast, the wing bones (humerus, radius, ulna and carpometacarpus) of the Haithabu geese were narrow in comparison with those of wild grey-lag geese of equal length. Reichstein and Pieper (1986) proposed that the Haithabu geese were

Bone	*Unfused NISP*	*Fused NISP*	*Unfused %*
CORACOID	-	32	-
HUMERUS	-	30	-
RADIUS	-	49	-
ULNA	-	36	-
CARPOMETACARPUS	-	438	-
FEMUR	2	20	9
TIBIOTARSUS	4	44	8
TARSOMETATARSUS	2	35	5
total	**8**	**684**	**1**

NISP: Number of identified fragments

Table 74 Barbican well: goose bone fusion data

	Mean	Min	Max	s	CV	N
CORACOID						
GL	72.2	68.0	76.0	2.9	4.0	8
BB	31.3	29.7	33.3	1.3	4.1	5
HUMERUS						
GL	166.0	158.0	176.0	6.1	3.6	9
Bp	34.3	32.2	37.2	1.4	4.0	13
SC	11.5	10.7	12.6	.5	4.3	25
BD	23.9	22.6	25.2	.9	3.7	16
ULNA						
GL	150.3	147.0	154.0	3.5		3
Bp						
SC	8.1	7.2	9.1	.5	6.1	24
CARPOMETACARPUS						
GL	90.5	77.1	102.1	4.1	4.5	328
Bp	21.3	18.3	23.5	.9	4.2	365
FEMUR						
GL	79.5	72.0	86.0	3.9	4.9	14
Bp	20.8	18.8	22.5	1.0	4.8	19
SC	8.4	7.6	9.2	.3	3.5	19
Bd	20.7	19.1	22.0	.8	3.8	14
TIBIOTARSUS						
GL	139.1	131.0	154.0	8.3	5.9	6
SC	8.5	7.5	9.6	.5	5.8	46
Bd	17.1	15.2	18.9	.8	4.6	33
TARSOMETATARSUS						
GL	84.6	78.0	92.0	3.7	4.3	20
Bp	18.6	17.1	20.0	.6	3.2	22
SC	8.1	7.7	8.9	.2	2.4	30
Bd	18.9	17.4	20.3	.8	4.2	25

s: standard deviation
CV: coefficient of variation
N: number

Table 75 Barbican well: domestic goose bone metrical data in mm (after von den Driesch 1976)

	Mean	Min	Max	N
Norwich, Barbican well	**84.6**	**78.0**	**92.0**	**20**
King's Lynn (Bramwell 1977)	81.1	75.0	86.0	10
Medieval York (Allison 1985)	83.6	78.5	89.2	12
Medieval Wood Quay, Ireland (Hutton-MacDonald *et al*. 1993)	83.9	77.1	90.8	69
Haithabu (Reichstein & Pieper 1987)	86.1	78.0	96.8	37
Modern domestic goose (Bacher 1967)	**92.2**	**81.8**	**103.0**	**17**
Modern wild goose (Bacher 1967)				
Male	**85.1**	**79.5**	**91.3**	**10**
Female	**79.3**	**74.4**	**83.7**	**11**

Table 76 Barbican well: comparison of greatest length (GL) of archaeological domestic goose tarsometatarsi, with modern reference specimens. Measurements in mm

	Mean	Min	Max	N
Norwich, Barbican well	**8.1**	**7.7**	**8.9**	**30**
King's Lynn (Bramwell 1977)	7.6	7.3	8.3	10
Haithabu (Reichstein & Pieper 1987)	7.8	6.7	8.7	46
Modern domestic goose (Bacher 1967)	**8.4**	**7.4**	**9.7**	**17**
Modern wild goose (Bacher 1967)				
Male	**7.5**	**7.0**	**8.9**	**10**
Female	**6.9**	**6.6**	**7.3**	**11**

Table 77 Barbican well: comparison of minimum shaft breadth (SC) of archaeological domestic goose tarsometatarsi, with modern reference specimens. Measurements in mm

less used to flying than the wild geese and were therefore domestic geese.

The greatest length (GL) and mid-shaft width (SC) of the goose tarsometarsi from British, Irish and German medieval deposits are compared with modern reference specimens in Tables 76 and 77. The mean mid-shaft width of the Castle Mall specimens was very similar to that of domestic geese. On the other hand, the mean greatest length was closer to those of males of wild geese. Exactly the same situation was noted by Allison (1985) in the medieval goose assemblages from York. These results also agree with those from Haithabu (Reichstein and Pieper 1986). The goose tarsometatarsi from the well are wide in comparison with those of the modern wild goose of similar length. Therefore, it is assumed that the Castle Mall assemblage belongs to the domestic species.

A scatterplot of the greatest length (GL) against width at mid-shaft (SC) of goose tarsometarsi from the well, King's Lynn (Bramwell 1977) and Haithabu (Reichstein and Pieper 1986) is shown in Fig.77. Comparing the Norwich and King's Lynn goose samples, the former are clearly larger. O'Connor (1982, 43) has already pointed out the unexpected smaller size of the King's Lynn assemblage in comparison with the Flaxengate geese,

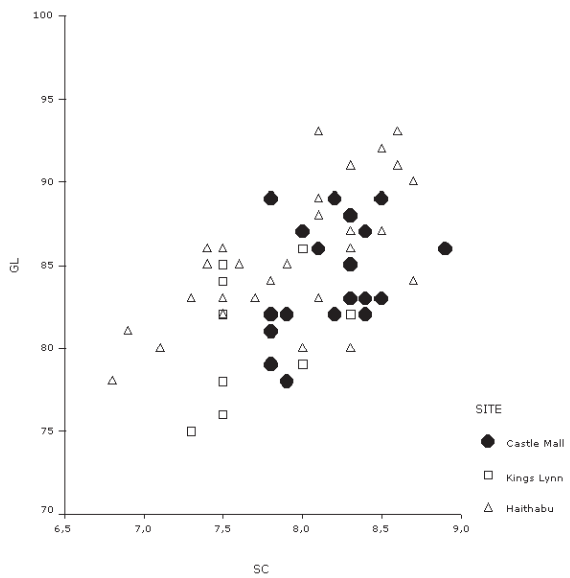


Figure 77 Barbican well: scattergram of domestic goose tarsometatarsus greatest length (GL) against smallest breadth of the corpus (SC) in mm (after von den Driesch 1976) by site

	Mean	Min.	Max.	N
Norwich, Barbican well	**90.5**	**77.1**	**102.1**	**328**
Medieval Wood Quay, Ireland (MacDonald et al. 1993)	89.5	78.9	99.2	132
Haithabu (Reichstein & Pieper 1987)	92.0	85.3	98.8	32
Modern domestic goose (Bacher 1967)	**95.9**	**87.7**	**103.9**	**16**
Modern wild goose (Bacher 1967)				
Male	**95.1**	**90.8**	**103.3**	**9**
Female	**90.9**	**86.7**	**95.9**	**9**

Table 78 Barbican well: comparison of greatest length (GL) of archaeological domestic goose carpometacarpi, with modern reference specimens. Measurements in mm

	Mean	Min	Max	N
Norwich, Barbican well	**21.3**	**18.3**	**23.5**	**365**
Medieval Wood Quay, Ireland (Hutton-MacDonald *et al*. 1993)	21.5	19.3	23.6	134
Haithabu (Reichstein & Pieper 1987)	20.8	18.3	23.7	41
Modern domestic goose (Bacher 1967)	**23.2**	**21.0**	**26.4**	**16**
Modern wild goose (Bacher 1967)				
Male	**21.7**	**20.0**	**22.9**	**9**
Female	**21.0**	**20.1**	**23.4**	**9**

Table 79 Barbican well: comparison of proximal breadth (Bp) of archaeological domestic goose carpometacarpi, with modern reference specimens. Measurements in mm

although the latter are earlier in time (*c.* 870 to 1200). In relation to Haithabu, the well group does not show any significant differences.

Pathology

Only seven specimens displayed any pathological conditions: one ulna, one tibiotarsus and one tarsometatarsus exhibit swelling and inflammation of the shaft; one carpometacarpus shows a rough and lumpy shaft and three more displayed bony outgrowth on the proximal articulatory surface.

Goose Carpometacarpi

A total of 463 fragments of goose carpometacarpi were recovered from the well. Seventy-five per cent of them were retrieved from three consecutive contexts (*50300, 50301* and *50317*; Fig.49) out of the ten that are analysed in this report. It is likely that they were dumped all together during a short period of time.

They are very well preserved and it was possible to measure the greatest length in 328 cases. The remains indicate a minimum discard of 270 left and 122 right goose wing tips. Associated with them, although present in lower numbers, were the first and second digits: 71 left and 76 right first digits and 92 second digits (no attempt to determine the side of these was made).

Knife cuts on the proximal end (especially on the internal aspect) were seen on 45% of the carpometacarpi. Chop marks were rarely present, only in 4% of the specimens. These butchery marks indicate the severance of the tip from the edible portion of the wing. Walters and Parker (1976) state that with old ducks and geese one does not need to pluck the flight feathers (which are attached to the carpometacarpi) because during the final dressing process, the last joint of the wing is cut off.

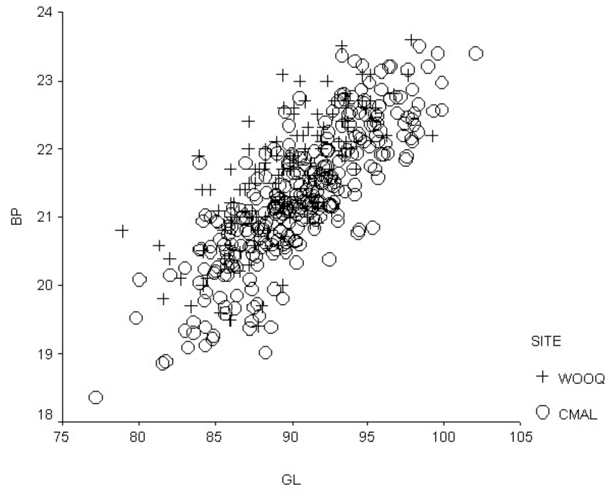
The primary flight feathers were one of the most valued commodities obtainable from geese. As Heath (1971, 9) says: 'Apart from the obvious benefits of an excellent dinner and, in the sixteenth century at any rate, a down-filled mattress and a ready supply of quills for writing, possibly the most important commodity supplied by this bird was its strong and supple wing-feathers, which were used in vast quantities for fletching arrows'.

Swanson (1989, 101) suggests that the adoption of the longbow as standard equipment for infantry in the late medieval period resulted in the birth of crafts such as bower, stringmaker and fletcher in medieval towns. Such crafts were evident in the vicinity of Norwich Castle and are discussed in local context by Shepherd Popescu and Tillyard in Part II, Chapters 9.I and 9.VI. Figure 47 shows the documented occupations of Castle Fee property owners contemporary with the infilling of the barbican well (based on Tillyard's work in Part II, Chapter 9.I and Part IV). The most suitable feathers for vanes were goose pinion feathers and these were needed in enormous numbers: in 1436 the sheriffs of Yorkshire and of York were ordered to provide 100,000 goose wing feathers for arrows; 'the inventory of James Halle (d.1538) contained 6000 feathers valued at 4s; the Winchester fletcher who contracted with a poulterer for 5000 goose feathers in 1403 had to pay 10s for this purchase' (Swanson 1989, 104).

The bias towards the left side in the well goose carpometacarpi suggests another possible use of the feathers. Finlay (1990, 3) comments on the good qualities of the first five goose feathers from each wing, which were regarded as useful for pens because of their 'elasticity, hardness and durability'. Also he refers to the fens of Lincolnshire and Norfolk as being the main suppliers of quills.

A quill is composed of the central barrel and the barbs, that are the little feathers attached to it. The barbs on each side of the barrel and the barrel itself are different for each of the first five goose feathers. Thus, 'the first quill in the wing, called a Pinion, (...) is distinguished by the extreme narrowness of the barbs on that side of the feather which in flight is the leading edge and is exposed to the wind' (Finlay 1990, 4). In the process of preparing the quills to be used as pens, the quill-dresser trimmed the barbs. Right and left feathers curve in different directions so that a right-handed person would prefer to write with a left feather since its curvature bent away from the eyes (Riddle 1943, 154). This may be an explanation for the abundance of left carpometacarpi in the assemblage. It seems possible they are the refuse from a quill-dresser workshop. (Further discussion on both the fletcher and quill dresser interpretations is given by Shepherd Popescu in Chapter 9.VI.)

Gidney (Gidney 1993) reports on a smaller concentration of goose wing tips found in medieval deposits at Leicester. There was a minimum of 36 left and 38 right carpometacarpals. The same author suggests that the use of the goose wings may have been related to the horn and antler found in the same deposit but no exact use for them is offered.



WOOQ=medieval Wood Quay, Ireland (Hutton-MacDonald *et al* 1993)
CMAL=barbican well, Castle Mall

Figure 78 Barbican well: scattergram of domestic goose carpometacarpus greatest length (GL) against breadth of the proximal end (BP) in mm (after von den Driesch 1976) by site

The lack of parallels for the barbican well goose assemblage makes it something unique in the archaeological record. As mentioned above, the good preservation allowed measurement of most of the bones recovered. Tables 78 and 79 compare the greatest length (GL) and proximal breadth (Bp) of the well sample with other archaeological domestic goose carpometacarpi and modern reference specimens of wild and domestic geese. The difference in sample numbers prevents drawing any final conclusions apart from pointing out the similarities of the well geese with those of medieval Wood Quay, Ireland (Hutton-MacDonald *et al*. 1993). A scattergram of the greatest length (GL) against proximal width (BP) for both sites supports the similarity (see Fig.78).

Dudley Stamp (1969, 161) comments on the fenlands of East Anglia as an important goose-breeding area where very large flocks were kept. The fact that the geese from the well came from a single population is supported by the normal distributions obtained when greatest length (GL) and proximal width (Bp) are plotted (Figs 79 and 80, respectively) in a histogram.

Domestic Duck/Mallard

Domestic duck/mallard was the third most abundant avian species after fowl and goose. Only 56 fragments were identified. Two nearly whole skulls were retrieved from the assemblage. Occasional knife cuts were observed in the same places as described for fowl.

The *Records of the City of Norwich* include the following remark on ducks: ' It is granted that all sows (*porce*) and ducks wandering in the streets of the said city to the nuisance of the neighbours shall be expelled out of the city within 14 days next following after the first proclamation then made for them, under the penalty of forfeiting both the said pigs (*porcorum*) and ducks' [5 Nov. 1437] (Hudson and Tingey 1910, 88).

XI. Synthesis

The preceding sections have considered in detail the relative numbers of the different species represented in the barbican well and have examined the exploitation pattern of each of them. It remains to draw together the results, in order to consider possible interpretations of the data. In brief, what do the animal remains from the barbican well indicate about Norwich in the mid/late 15th to early 16th centuries?

The problems attached to the interpretation of faunal remains from urban sites have been greatly discussed in the literature (Serjeantson 1989; O'Connor 1989). It is a difficult task to evaluate how much information on the diet and social composition of the urban population, and on the economic system, can be obtained from such remains. The archaeological assemblage from the barbican well stems from two main sources: food preparation and consumption, with a further component derived from specialised crafts and/or industries.

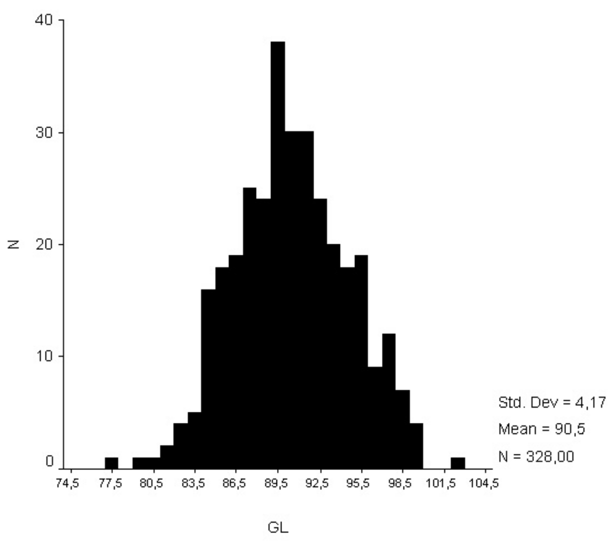


Figure 79 Barbican well: histogram of domestic goose carpometacarpus greatest length (GL) in mm (after von den Driesch 1976)

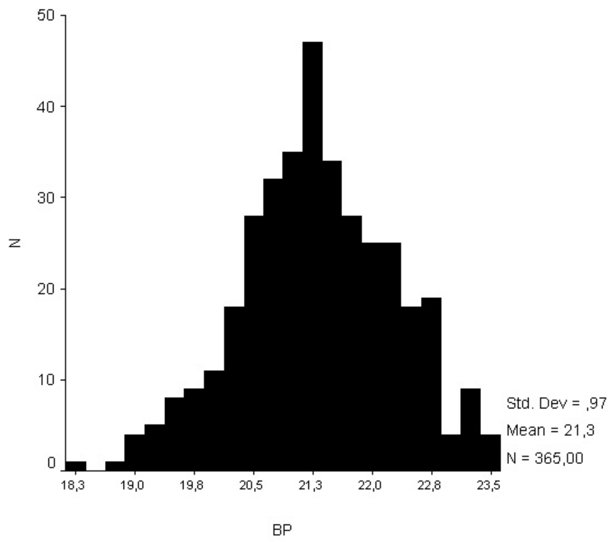


Figure 80 Barbican well: histogram of domestic goose carpometacarpus breadth of the proximal end (BP) in mm (after von den Driesch 1976)

Evidence for the domestic nature of the refuse is provided firstly by the presence of the skeletal elements of those taxa that were butchered for meat. The abundance of high quality meat bones is in clear contrast to the low quality meat parts of the carcass. Secondly, the estimation of the relative contribution of the three main domesticate taxa, by the 'diagnostic zones' approach, made it possible to compare more accurately the cattle, sheep/goat and pig samples. This indicated the importance of sheep remains in relation to the other two taxa, which were less common. Thirdly, an examination of the kill-off pattern suggested that whereas cattle were primarily bred for meat, sheep/goat were probably the surplus stock from a different production system, that of wool.

Norfolk's importance as the long-established home of England's worsted industry is well-documented (Munro 1978). The rise in the importance of wool appears to have conditioned, to some extent, the urban food supply in England during the medieval period (O'Connor 1989, 15). There is a general increase with time in the relative frequency of sheep bones to those of cattle, as evidenced from other archaeological urban deposits such as Lincoln (O'Connor 1982), York (O'Connor 1984), Exeter (Maltby 1979) and London (Armitage 1983). The fact that sheep were bred mainly for wool implies that the production of sheep/lamb for the urban market may have been in decline. There is evidence for a change in the exploitation pattern of cattle at this moment, when veal and prime beef appear to increase in the urban meat supply. Norwich, as is shown by the faunal remains from the barbican well, follows this general trend. Thus, an attempt to reconstruct the diet of the population of Norwich, from the remains analysed, would point to the high consumption of mutton but with prime beef and veal providing most of the meat supply. Pig would come in third place together with poultry and game.

It would be most interesting to know how early or how late in the medieval period, the population of Norwich started to take part in this new economic system that seems to have been a countrywide phenomenon.

The 11th-century animal bone assemblage from excavations at St Martin-at-Palace Plain, Norwich (Cartledge 1987) comprises 40% cattle and around 30% sheep and pig. By the 12th to 13th centuries, sheep increased at the expense of cattle and pig, whereas there is once more a decline in sheep and pig in favour of cattle by the 14th to 15th centuries. All these percentages are based on NISP and it is right to question how well they reflect the relative proportions of these species, after having discussed the biases of this quantitative method in Section III. The same situation applies to Alms Lane, Norwich (Cartledge 1985) animal bone assemblage. However, the apparent increase in sheep remains as early as the 12th to 13th centuries could be reflecting, at a local level, the first stages of the new economic system that would develop in the following centuries.

Particular emphasis was made in describing the butchery marks yielded by the main domesticates. A regularity in the way carcasses were butchered was apparent in most cases. Apart from the sectioning in halves that was common for cattle, sheep/goat and pig, the skeletons of these three species underwent different processes according to their size. Cattle, with the exception of the very young calves, were heavily chopped at all articulation points. Sheep/goat limb bones seem to have remained articulated as whole joints after being detached from the body. Pigs appear to have been consumed as whole carcasses in most instances. The consistency in the occurrence of the butchery marks on the same parts of the carcass points to the work of professional butchers. Thus, the domestic refuse from the barbican well provides evidence for one of the most prosperous crafts in the urban economy, that of the butcher (Swanson 1989).

By the late medieval period rubbish disposal was well organised and butchers were assigned places to dump their waste (Dyer 1989, 191). The barbican well may have been one of these places, as shown for instance by the presence of cattle skull fragments. The abundance of other skeletal elements such as sheep metapodials could also be related to butchers' refuse. However, it is known that butchers sold cattle and sheep skins to the leather industry (tanners, glovers, parchment makers, *etc.*) so the occurrence of these bones is likely to be associated with these other industrial activities (see further discussion in Part II, Chapter 9).

Clarkson (1966) considers leather workers the second most important component of the industrial population of Norwich from the mid 16th century, after the weavers.

The occurrence of sheep horncores sawn and chopped at the base implies the presence of horn-working activities as well. Nevertheless, the most conclusive evidence of refuse from a particular craft was provided by the goose carpometacarpi. No published parallels of the same importance have been found for these remains elsewhere in Britain.

The results from other specialists working on the antler fragments, leather and worked bone (detailed in Part II, Chapter 9.III) complement the findings presented here, and increase the knowledge of craft activities developed in a late medieval town, based on animal by-products.

XII. Conclusions

The excellent preservation and recovery of the barbican well animal bone has allowed a detailed study of the relative occurrence of the main domestic taxa. Rackham's method (1986) proved to be a much more accurate analytical tool in comparison with the other methods of quantification, generally used in animal bone reports (NISP and MNI).

The barbican well assemblage suggests that between the mid/late 15th and early 16th centuries at Norwich, cattle were raised for prime beef production and pigs for pork. Sheep seemed to be more important for other products than meat, such as wool and skin. Chicken and geese supplied meat and eggs, with geese also providing the raw material for the fletching of arrows and/or quills for writing.

In conclusion, analysis of this important assemblage has gone some way to fulfil the vital need for well preserved and well recovered late medieval faunal samples from urban and rural sites in East Anglia.

Chapter 5. Fish Bone from Castle Mall (Site 777N)

by Alison Locker

I. Summary

The assemblage was dominated by marine species, specifically herring and cod, while other gadids and small flatfishes were also important. The elasmobranchs, which include rays and sharks, may have been eaten much more widely than the poor survival of their cartilaginous skeletons suggest and have been mainly identified from denticles and teeth. Seasonal fisheries for mackerel and other locally available marine fish including sea breams and gurnards provided variety to the major food fishes. Consumption of migratory species, such as eel, was of some importance but true freshwater fish were few. The incidence of herring and cod reflects the importance of these species as food, with herring dominant by bone numbers but as a quantity of food, cod appears to have been more important. Fish processing, mainly for herring, was a significant part of commerce and trade in the developing city which was closely connected to the rich fisheries of the East Anglian coastline and North Sea, as well as the fish trade both domestically and from foreign ports.

This report is updated from an Ancient Monuments report (Locker 1997) and incorporates those data, but looks in greater detail at the differences in the fish assemblages between periods. Some lateral variations within periods were observed in the distribution of animal bones (detailed in earlier chapters), but this was not discernible for the fish. Over 14,000 fish bones were identified from seven periods of occupation at Castle Mall, largely from bulk sieved samples. A consideration of the marine molluscs recovered from the site is given by Murphy in Part II, Chapter 13.II.

II. Methodology

(Table 80)

Fish bones were recovered from seven periods of occupation from Late Saxon to modern times, though fish from the most recent period are only included here and not in the monograph summary reports. Site periods are indicated in Table 1, with sub-periods shown in Table 2. The fish bones were recovered by three methods; hand collection, site riddling through an 8.0mm mesh and bulk sieving of whole earth samples through a 0.5mm mesh. The total number of identified fish bones by all methods in each sub-period is shown in Table 80. Only 7% of the identified fish were recovered by hand collection, 15% from site riddling and 78% from bulk sieving, where the fine mesh employed ensured the recovery of the smallest fish bones. Consequently the assemblage from bulk sieving is most representative of the range of surviving fish, including both small bones from large fish and all bones from small fish. Only the fish identified to species and family level have been included in the tables, though all potentially identifiable material was included in the bone record. The bones were recorded to the smallest archaeological unit, though some have subsequently been amalgamated for the published report.

Tables summarising the fish by sub-period only indicate the total number of bones. In tables showing individual context groups the fish are listed both by species and general anatomy, *i.e.* skull elements or vertebrae, and all methods of retrieval have been added together. Any association of bones, indicating part of a single individual or cut and knife marks, was also recorded.

III. The Species Identified

The following species/families were identified: Elasmobranch indet., spurdog (*Squalus acanthias*), Rajidae, roker (*Raja clavata*), eel (*Anguilla anguilla*), conger eel (*Conger conger*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*), pilchard (*Sardina pilchardus*), Salmonidae, smelt (*Osmerus eperlanus*), pike (*Esox lucius*), chub/dace (*Leuciscus* sp.), tench (*Tinca tinca*), roach (*Rutilus rutilus*), Cyprinidae, cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), pollack (*Pollachius pollachius*), saithe (*Pollachius virens*), ling (*Molva molva*), Gadidae, Triglidae, sea scorpion/bullrout (*Taurulus bubalis/ Myoxocephalus scorpius*), perch (*Perca fluviatilis*), ruffe (*Gymnocephalus cernuus*), bass (*Dicentrarchus labrax*), scad (*Trachurus trachurus*), black sea bream (*Spondyliosoma cantharus*), pandora (*Pagellus erythrinus*), Sparidae, red mullet (*Mullus surmuletus*), thin-lipped grey mullet (*Liza ramada*), ballan wrasse (*Labrus bergylta*), catfish (*Anarhichas lupus*), *c.f.* dragonet (*Callionymus lyra*), mackerel (*Scomber scombrus*), Scombridae, turbot/brill (*Scophthalmus maximus/ Scophthalmus rhombus*), plaice (*Pleuronectes Platessa*), flounder (*Platichthys flesus*), halibut (*Hippoglossus hippoglossus*), sole (*Solea solea*) and flatfish indet.

IV. The Distribution of Species Through Time; the relationship with sample size and recovery method

(Tables 81–85)

The proportion of different species between periods by bone numbers suggests general continuity dominated by the same species. Table 80, which summarises all fish from each period, shows that by bone number or 'NISP' herring is by far the most numerous species, followed by cod. The 'large gadid' category might also be included here as cod was the most numerous large gadid, therefore bones that could not be specifically attributed probably

Period	*1*	*2*	*3*	*4*	*5*	*6*	*7*	***total***
Elasmobranch	31	9	6	10	21	9	0	**86**
Spurdog	0	0	0	0	1	0	0	**1**
Ray	10	2	2	11	7	0	0	**32**
Roker	25	13	6	18	13	15	2	**92**
Eel	741	73	60	33	394	46	3	**1350**
Conger eel	0	0	1	1	5	0	0	**7**
Herring	2548	765	949	566	2281	238	73	**7420**
Sprat	3	0	0	62	202	2	1	**270**
Pilchard	0	0	0	0	1	0	0	**1**
Salmonidae	1	2	3	3	3	4	0	**16**
Smelt	5	6	2	3	6	2	0	**24**
Pike	13	7	35	1	29	0	0	**85**
Tench	72	0	0	0	0	1	0	**73**
Chub/Dace	0	0	0	0	1	0	0	**1**
Roach	3	0	4	0	12	0	0	**19**
Cyprinidae	6	2	12	7	115	6	2	**150**
Cod	467	258	220	309	505	206	21	**1986**
Large Gadid	448	72	118	253	322	56	4	**1273**
Small Gadid	1	2	13	3	10	0	1	**30**
Haddock	10	7	22	12	100	9	2	**162**
Whiting	82	50	39	65	301	23	2	**563**
Pollack	1	0	0	0	7	0	0	**8**
Saithe	2	0	0	2	2	0	0	**6**
Ling	1	0	4	6	16	5	1	**33**
Gurnard indet.	2	1	7	1	0	0	0	**11**
Sea scorpion/Bullrout	0	0	0	0	2	0	0	**2**
Perch	0	0	0	0	4	0	0	**4**
Ruffe	0	0	0	0	1	0	0	**1**
Bass	0	1	0	0	1	0	0	**2**
Scad	1	2	2	1	0	0	1	**7**
Black sea bream	1	0	0	0	0	0	0	**1**
Pandora	0	0	0	0	1	0	0	**1**
Sea bream indet.	3	1	1	1	1	0	0	**7**
Red mullet	3	0	0	0	0	0	0	**3**
Thin lipped-grey mullet	1	0	2	1	0	0	0	**4**
Ballan wrasse	0	0	0	0	6	0	0	**6**
Catfish	0	0	0	0	1	0	0	**1**
?Dragonet	0	0	0	0	1	0	0	**1**
Mackerel	68	22	14	10	25	9	0	**148**
Scombridae	0	1	0	0	1	0	0	**2**
Turbot/Brill	2	0	2	0	2	4	0	**10**
Plaice	1	2	6	7	19	9	0	**44**
Plaice/Flounder	25	21	75	25	201	41	5	**393**
Halibut	2	0	0	0	6	2	0	**10**
Sole	1	0	0	4	23	3	0	**31**
Flatfish indet.	9	6	3	12	17	14	1	**62**
total	**4589**	**1325**	**1608**	**1427**	**4666**	**704**	**120**	**14439**

Table 80 Summary of the total number of identified fish for all periods from Castle Mall

belong to cod. Other gadids were also important, particularly the smaller whiting and haddock, but pollack, saithe and ling were few. Eel was also numerous, though subject to over representation since this fish has at least double the number of vertebrae per fish compared to the other bony fish present, other than conger eel. The small flatfishes, particularly plaice and flounder, were also a significant group of food fishes. The elasmobranchs, owing to poor preservation of their cartilaginous skeletons, are likely to be seriously under represented, as are the salmonids owing to seasonal reduction of calcium levels in the skeleton.

Sub-period	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*3.1*	*3.2*	*4.1*	*4.2*	*5.1*	*5.2*	*6.1*	*6.2*	*6.3*	*7.1*	*7.2*	***total***
Elasmobranch	1	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	**4**
Eel	0	0	0	0	0	0	0	0	0	1	18	0	1	0	0	0	**20**
Herring	0	0	0	0	0	0	0	0	0	3	233	0	12	0	0	0	**248**
Salmonid	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	**3**
Pike	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	**7**
Cyprinid	0	2	0	0	0	0	0	0	0	0	8	0	0	0	0	0	**10**
Cod	21	44	5	3	64	2	20	19	4	16	117	76	6	3	2	0	**402**
Large Gadid	4	47	0	2	15	4	12	4	7	24	64	0	0	3	2	1	**189**
Small Gadid	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	**6**
Haddock	2	0	0	0	0	0	1	0	0	1	12	1	0	0	0	0	**17**
Whiting	0	0	0	0	0	0	0	2	0	8	26	3	0	0	0	0	**39**
Ling	0	0	1	0	0	0	4	0	0	2	12	0	0	0	0	0	**19**
Mackerel	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Turbot	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**2**
Plaice	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	**4**
Plaice/Flound	0	1	0	0	0	0	0	0	0	1	15	0	0	0	0	0	**17**
Halibut	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	**3**
Sole	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Flatfish	0	0	1	0	0	0	0	0	2	0	2	0	0	0	0	1	**6**
total	**28**	**94**	**7**	**6**	**79**	**7**	**37**	**26**	**14**	**65**	**520**	**84**	**19**	**6**	**4**	**2**	**998**
Period total			**129**		**85**		**44**		**40**		**575**			**109**		**6**	

Table 81 The hand collected fish bone by sub-period from Castle Mall

Sub-period	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*3.1*	*3.2*	*4.1*	*4.2*	*5.1*	*5.2*	*6.1*	*6.2*	*6.3*	*7.1*	***total***
Elasmobranch	0	0	0	0	0	0	0	0	1	0	4	2	0	0	0	**7**
Spurdog	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Roker	0	2	6	0	0	0	0	3	2	2	4	0	0	0	0	**19**
Eel	0	0	0	0	0	0	0	0	0	1	56	0	1	0	0	**58**
Conger eel	0	0	0	0	0	0	1	0	1	3	1	0	0	0	0	**6**
Herring	0	7	18	0	0	1	4	0	3	12	431	4	0	0	1	**481**
Sprat	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	**7**
Salmonid	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	**3**
Pike	0	0	1	0	0	0	3	0	1	2	8	0	0	0	0	**15**
Tench	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Chub/Dace	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
Roach	0	0	0	0	0	0	1	0	0	0	9	0	0	0	0	**10**
Cyprinid	0	0	0	0	0	0	1	0	4	0	23	0	0	0	0	**28**
Cod	2	82	52	31	24	0	102	25	127	54	201	24	12	29	9	**774**
Large Gadid	3	151	23	15	18	0	11	1	40	16	99	6	8	6	0	**397**
Small Gadid	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	**2**
Haddock	0	2	0	0	1	2	8	3	5	21	18	4	1	0	1	**66**
Whiting	0	5	0	4	2	1	6	0	4	9	67	3	1	1	0	**103**
Pollack	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	**3**
Saithe	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	**3**
Ling	0	0	0	0	0	0	0	0	2	1	0	0	2	0	0	**5**
Perch	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
Ruffe	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
Pandora	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Sea bream	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**2**
Thin l g mullet	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Ballan wrasse	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	**5**
Catfish	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
Mackerel	0	1	0	1	1	1	2	1	1	1	2	1	1	0	0	**13**
Scombrid	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Plaice	0	0	0	0	0	0	2	0	2	7	0	1	0	1	0	**13**
Plaice/Flound.	0	0	4	10	0	1	15	2	3	18	53	3	1	0	0	**110**
Halibut	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Sole	0	0	0	0	0	0	0	0	0	2	11	0	0	0	0	**13**
Flatfish	0	0	0	0	5	0	0	0	5	1	5	1	5	2	0	**24**
total	**5**	**251**	**105**	**63**	**51**	**6**	**159**	**35**	**202**	**156**	**1012**	**49**	**32**	**40**	**11**	**2177**
Period total			**361**		**114**		**165**		**237**		**1168**			**121**	**11**	

Table 82 The fish bones from site riddled samples by sub-period from Castle Mall

Sub-period	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*3.1*	*3.2*	*4.1*	*4.2*	*5.1*	*5.2*	*6.1*	*6.2*	*6.3*	*7.1*	*7.2*	***total***
Elasmobranch	15	5	10	6	3	3	3	0	9	8	6	5	2	0	0	0	**75**
Ray	4	5	1	2	0	0	2	0	11	4	3	0	0	0	0	0	**32**
Roker	7	5	5	7	6	2	4	2	11	4	3	2	12	1	0	2	**73**
Eel	161	366	214	35	38	5	55	6	27	149	169	38	5	1	3	0	**1272**
Conger eel	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
Herring	939	716	868	547	218	225	719	100	463	618	984	165	34	23	56	16	**6691**
Sprat	0	2	1	0	0	0	0	0	62	50	145	0	2	0	1	0	**263**
Pilchard	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Salmonid	0	1	0	1	1	0	2	1	1	1	0	1	1	0	0	0	**10**
Smelt	1	1	3	6	0	0	2	0	3	5	1	2	0	0	0	0	**24**
Pike	0	0	12	5	2	26	6	0	0	5	7	0	0	0	0	0	**63**
Tench	0	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**72**
Roach	0	1	2	0	0	1	2	0	0	1	2	0	0	0	0	0	**9**
Cyprinid	0	2	2	2	0	7	4	0	3	22	62	6	0	0	2	0	**112**
Cod	116	76	69	85	51	14	82	24	110	42	75	38	7	11	6	4	**810**
Large Gadid	109	82	29	8	14	14	77	77	124	46	73	23	2	8	0	1	**687**
Small Gadid	0	0	0	0	0	2	11	0	3	4	1	0	0	0	1	0	**22**
Haddock	0	5	1	2	4	3	8	1	3	36	12	3	0	0	0	1	**79**
Whiting	26	16	35	39	5	7	25	10	49	96	95	7	8	0	0	3	**421**
Pollack	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	**5**
Saithe	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**3**
Ling	0	0	0	0	0	0	0	0	4	0	1	2	0	1	1	0	**9**
Gurnard	1	1	0	1	0	0	7	0	1	0	0	0	0	0	0	0	**11**
S scorp/Bullr.	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	**2**
Ruffe	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	**3**
Bass	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	**2**
Scad	1	0	0	1	1	0	2	0	1	0	0	0	0	0	0	1	**7**
Black sea bream	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Sea bream ind	0	0	2	1	0	0	0	0	1	0	1	0	0	0	0	0	**5**
Red mullet	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
Th l g mullet	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	**3**
Ballan wrasse	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
?Dragonet	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Mackerel	27	13	27	16	4	0	11	2	5	15	7	5	1	1	0	0	**134**
Scombrid	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Turbot	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	**6**
Turbot/Brill	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Plaice	0	1	0	2	0	0	3	1	4	10	0	6	0	0	0	0	**27**
Plaice/flounder	3	6	11	6	5	13	46	4	16	45	69	24	1	12	3	2	**266**
Halibut	1	1	0	0	0	0	0	0	0	0	3	0	0	1	0	0	**6**
Sole	0	1	0	0	0	0	0	0	4	8	1	2	1	0	0	0	**17**
Flatfish	6	2	0	0	1	1	2	2	3	2	7	2	0	4	0	0	**32**
total	**1420**	**1384**	**1295**	**773**	**353**	**325**	**1074**	**231**	**919**	**1177**	**1736**	**330**	**77**	**67**	**73**	**30**	**11264**
Period total			**4099**		**1126**		**1399**		**1150**		**2913**			**474**		**103**	

Table 83 The fish bones from bulk sieved samples by sub-period from Castle Mall

The fish assemblage centres around herring and the gadids (mainly cod) as the prime food fishes both feeding the developing city of Norwich and providing employment and trade processing herring caught in local fishing grounds. Some evidence for the importance of fish processing is indicated by the mention of two fishing houses in the late 13th century (see Chapter 2.II above): a fishman was present at Castle Fee Property 14 before 1397 (see Fig.47). Tables 81–83 show the fish identified by hand collection, site riddling and bulk sieving, divided by sub-period. Hand collection obviously favours the larger fish with larger bones, such as cod, while small fish such as herring are likely to be missed unless observed as articulated remains. Site riddling, employing an 8.0mm mesh recovered a greater range including some smaller fish, but the smallest species still passed through the mesh. The major part of the fish identified from each period are from the whole earth samples which were bulk sieved through a 0.5mm mesh from which all surviving fish remains were recovered. How representative this

Period	*1*	*2*	*3*	*4*	*5*	*6*	*portion*	*1*	*2*	*3*	*4*	*5*	*6*	*NISP*
herring	44	5	23	21	33	19	%	91	85	89	82	85	85	%
cod	52	94	71	68	48	77	%	7	11	7	8	4.5	10	%
haddock	0.5	0.2	4	2	8	1	%	0.07	0.4	1	0.4	2.5	0.3	%
whiting	3	0.6	2	6	7	3	%	2	0.4	3	10	8.5	5	%
pollack/saithe	0.5	0	0	0	3	0	%	0.07	4	0	0	0.1	0	%
ling	0	0	0	3	1	0	%	0	0	0	0.1	0.02	0	%

Table 84 Herring and the Gadidae compared by 'portion' and 'NISP' percentage

	sample wt		*NISP % of sample*			*Total NISP*	*% NISP*		
	*wt**	*wt**	*HC*	*SRS*	*BS*		*HC*	*SRS*	*BS*
Sub-period 1.2	482		1.9	0.3	97.7	1453	28	5	1420
Sub-period 1.3	388		5.4	14.5	80	1729	94	251	1384
Sub-period 1.4	213		0.4	7.4	92	1407	7	105	1295
Period 1		**1083**				**4589**			
Sub-period 2.1	375		0.7	7.4	91.8	842	6	63	773
Sub-period 2.2	211		16.3	10.5	73	483	79	51	353
Period 2		**586**				**1325**			
Sub-period 3.1	94		2	1.7	96.1	338	7	6	325
Sub-period 3.2	291		2.9	12.5	84.5	1270	37	159	1074
Period 3		**385**				**1608**			
Sub-period 4.1	119		8.9	11.9	79.1	292	26	35	231
Sub-period 4.2	283		1.2	17.7	80.9	1135	14	202	919
Period 4		**402**				**1427**			
Sub-period 5.1	323		4.6	11.1	84.1	1398	65	156	1177
Sub-period 5.2	430		15.9	30.9	53.1	3268	520	1012	1736
Period 5		**753**				**4666**			
Sub-period 6.1	139		18.1	10.5	71.2	463	84	49	330
Sub-period 6.2	55		14.8	25	60.1	128	19	32	77
Sub-period 6.3	38		5.3	35.3	59.2	113	6	40	67
Period 6		**232**				**704**			
Sub-period 7.1	42		4.5	12.5	60.8	88	4	11	73
Sub-period 7.2	10		6.2	0	93.7	32	2	0	30
Period 7		**52**				**120**			

Wt* = weight in gms of whole earth sample for bulk sieving

Table 85 The weight of bulk sieved samples, percentage and total numbers of bones recovered by the three methods

assemblage is of the fish originally disposed of in these deposits is unknown, but a number of factors adversely affect bone survival. These include; boiling, burning *etc*. prior to disposal (Nicholson 1995), pH of the surrounding matrix (Nicholson 1996), the differential survival between species (as described for the elasmobranchs above) and the recovery method. The fish from Castle Mall can be described as in good condition, with no clear evidence for cess material, such as distortion of the bone. All interpretation of the bone assemblage is qualified by the understanding that different factors of bone survival may have resulted in a selective sample of the original material.

There are considerable differences between the numbers of fish bones from each period and each sub-period and within those, varying proportions of the identified fish recovered by different methods. In Table 85 the weight in grams of the whole earth samples for bulk sieving from each sub-period is shown against the percentage of hand collected to site riddled to bulk sieved bone and the total number of identified fish bones (NISP). It appears, without taking the time span or number and type of contexts sampled in each sub-period into account, that there is a broad correlation between the weight of the whole earth sample and the number of identified bones. Generally, as might be expected, the larger the sample the greater the number of bones, although there are some variations. The largest samples (by weight) are from Period 1, following the priority given to contexts of early date and Period 1.2 has the single largest whole earth sample. From Period 1.2 a total of 1420 bones were identified and from Period 5.2 (50 g lighter than 1.2) 1736 bones, of which 1506 were from the barbican well, a particularly rich feature (see Moreno García above). The indeterminate bones, though not quantified here, do not redress the disparity and there is evidently a difference in the fish bone density between the samples. The hand collected material shows a fairly random distribution as a percentage of the assemblage from each sub-period and does not reflect a higher incidence of cod or other large

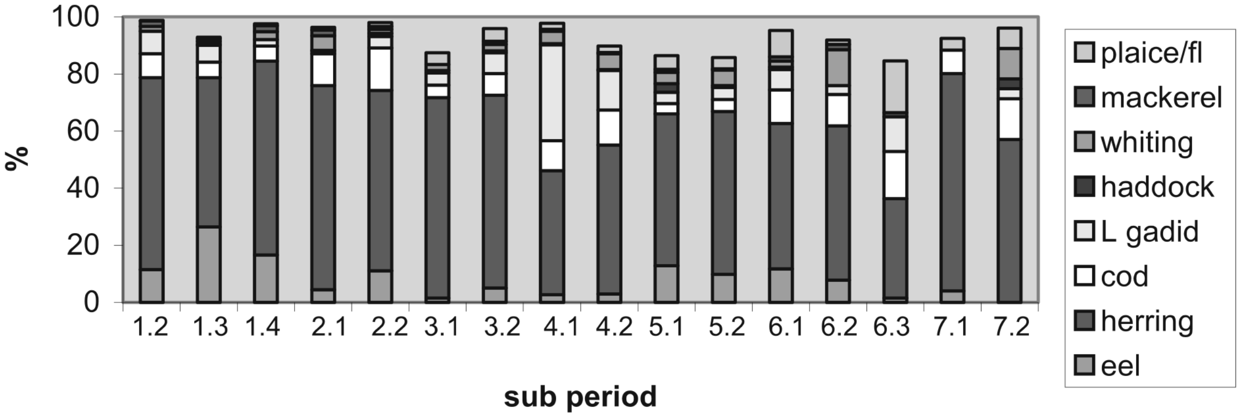


Figure 81 The relative percentage of the main food fishes in each sub-period as a % of the 'NISP' total minus the elasmobranchs (excluded on the basis of their differential preservation)

fish in a sample where larger fish are better represented. In fact, herring has a higher incidence in Period 5.2 than 5.1, but in the former the hand collected bone has a relatively high percentage at 15.9%. The percentage of site riddled bone is also variable and may reflect the difficult circumstances of excavation which prevented a systematic sampling of features for site riddling or bulk sieving treatment. Priority was given to early features and those to which particular questions were directed as described in Part I, Chapter 1.

Consequently the differences between the distributions of species through time are best compared across bulk sieved samples as a statistical comparison for changes between periods and contexts.

V. Representation of the Major Food Fishes and Their Relative Importance

(Figs 81–82, Tables 86–98)

In Table 83, the bulk sieved material, the most commonly occurring species by bone number can be seen to comprise eight species/families; eel, herring, cod, large gadid, haddock, whiting, mackerel and plaice and/or flounder, all important food fishes and dominated by herring. Cod is clearly the most common large gadid and those bones designated to the latter category are most likely to be cod over any other large gadid species. In Fig. 81 the percentage of these species in each sub-period is shown, based on the total number of identified fish, but minus the elasmobranchs (the latter being disproportionately represented by dermal denticles and few skeletal elements). It is evident that the sum of these eight species is over 90% in most of the sub-periods except 3.1, 5.1 and 5.2. Herring outnumbers all other by 'NISP' count, the lowest being 34% from Period 6.3 and 43% from Period 4.1 (where large gadid is 33.6%), otherwise herring is always over 50%. The higher the total percentage of the common food fishes, the lower the diversity of other fish. By that measure the greatest diversity of other species is in Periods 3.1, 5.1 and 5.2. where these fish are between 85–87%.

These percentages are based on 'NISP' totals which, in terms of fish as food, overestimate the contribution of small fish remaining skeletally whole whether eaten fresh or stored. Herring was an important food fish, particularly in Norwich so close to the East Anglian fishing grounds, and meets the criteria for small size and completeness. Consequently in all the tables showing the assemblage from bulk sieved samples herring predominates. In hand collected (in particular) and site riddled samples herring does not fare so well. Larger fish like cod, ling and haddock are more likely to be seen by eye, or caught in the 8.0mm sieve.

In order to make some comparison between herring and the gadids (the primary food fishes of much of the historic pre-industrial period) as a quantity of food, the author used historically recorded 'portion' sizes for herring and the main gadid species. These were based on a study of the fish eaten by the monks of Westminster Abbey by Harvey (1996) and from accounts of army and particularly naval rations, where precise quantities of stored fish were required to feed soldiers and men at sea.

The quantities of these fish were broadly compatible over a number of documentary sources; five herring = two whiting = quarter of cod = sixth of ling. To these were added pollack, saithe and hake at the same value as cod and one haddock on the basis of size. Hake was absent at Castle Mall and pollack, saithe and ling occurred rarely, while haddock was regularly identified but in low numbers.

The fish used at Westminster Abbey were in large part stored; pickled, salted and dried. Fish in forces rations were all stored, other than those from opportunistic fishing by crews during a voyage. While herring are of a relatively uniform size (though of varying fat and weight levels at different seasons), large fish like cod may vary greatly in size with mature specimens reaching 120cm in length. The inclusion of fish of varying size when applying a standard measure to a species is problematic. However, successful storage, particularly as 'stockfish' (a method where cod is desiccated by drying out of doors in parts of Norway) depends on a certain size range of cod being used. This appears to have been most commonly fish between 80–90cm, though fish between 60–110cm can be airdried (Perdikaris 1999, 390). Other methods, particularly a combination of salting and drying, were more successful in the British climate and relied on a similar size range to ensure evenly cured fish. The range of fish sizes suggested by the metrical data in Fig. 83 shows a number of fish around this size as well as smaller and larger individuals. However the bones from which these

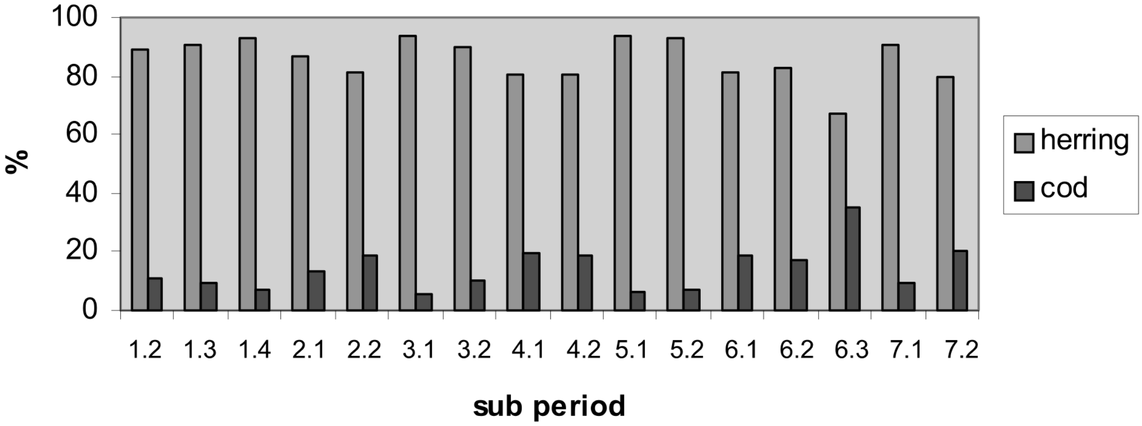


Figure 82 The % of cod versus herring based on the 'NISP' totals for both species

measurements were taken are from the head and therefore whole, probably fresh fish, since cod are usually headed for storage. There is no evidence of fish processing in these deposits, which might be detected from an excessive proportion of skull elements and precaudal vertebrae.

In order to calculate the number of fish and from this extrapolate the 'portions' as represented by the 'NISP' data, a 'suite' of identifiable bones was established. Thirty-two skull bones were selected as consistently recognisable (though not the entire skull) and an average of 55 vertebrae per whole fish. For a stored cod and related fish (haddock, saithe, pollack, ling and hake) 6 bones of the appendicular or 'shoulder' area plus 22 caudal vertebrae were retained in the stored product, the head and upper vertebral column being discarded during processing. Herring and whiting, both small fish, were always considered whole, whether stored or fresh, with 87 bones per fish. The remaining large gadids were either whole or stored, the latter having a reduced skeleton of 28 bones, depending on the particular bones identified. To avoid any overestimation for the large gadids by considering all fish stored, or the reverse by considering all fish whole, an adjustment to the data takes account of both forms of fish (Locker 2001, 157). Both stored and whole (?fresh) fish were evidently present at Castle Mall from the distribution of body parts of the large gadids.

The comparison of 'NISP' and 'portion' percentages of the Castle Mall data by period was included as part of a large sample of many sites and phases while researching the role and evidence for stored fish (Locker 2001). The results have already been described in the summaries for each period (see Parts I and II, Section IV of Chapters 4–10) and also in Part II, Chapter 13. It was evident when the data was shown as a 'portion' that cod was the most important food fish in all periods in contrast to the 'NISP' percentage, which showed a high level of herring (Table 84). Large gadid was not included in these calculations as more than one species may be represented. However since cod was the most common large gadid their numbers add support to cod as the main food fish. Cod is particularly high in Periods 2, 4 and 6 and lowest in Period 5, which also has a higher level of diversity of minor species than other periods as shown in Fig. 81. By 'portion' Table 84 shows haddock is low in Periods 1 and 2, rising in Period 3, dipping in Period 4 and peaking in Period 5 with a subsequent decline. Whiting is very low in Period 2, otherwise ranging from 3–8% and peaks in Periods 4 and 5. Pollack and saithe were rare, found in Periods 1 and 5, the highest percentage being found in the latter. Ling was only found in Periods 4 and 5. Caught in the northern part of the North Sea, ling seems only to have been eaten after the 12th century as represented by this sample.

The 'portion' data described above also included fish from hand collected and site riddled samples therefore the results will show some bias towards the larger fish. As herring and cod are the two main food fishes at Castle Mall, the numbers of bones of these fish from bulk sieved samples were compared by sub-period. On the premise that the ratio of herring to cod is 20:1 (20 herring are equal to one cod by portion) if all fish are whole, with 87 bones in the skeleton, to be of equal food quantity herring should be 95.3% and cod 4.7%. If the fish are stored and cod skeletally reduced then equal volume places herring at 98.5% and cod 1.5%. As there is evidence for both whole and stored cod then only occurrences of over 4.7% for cod have been considered to be of greater quantity than herring.

Figure 82 shows that in all sub-periods cod is greater than 4.7%, the minimum is 5.8% in Period 4.1. Cod shows particular peaks in Periods 2, 4 and 6. Notably Periods 1 and 5, with the largest samples, are more favourable to herring. On the evidence from both sets of data cod is established as the main food fish at Castle Mall, though possibly more favoured in the smaller samples.

Looking at the periods in more detail; Period 1, the Late Saxon fish sample, is the largest from all periods, fairly evenly divided between Periods 1.2, 1.3 and 1.4 and shown in Table 83. The incidence of the main food fishes herring and cod has already been described; cod is the most eaten fish by 'portion', though herring is at its highest percentage by this method, shown in Table 84. Of the other gadids whiting is 3% by 'portion' and haddock low at 0.5%. Between the three sub-periods the earliest (Period 1.2; 10th to early 11th century) shows the least diversity with only 18 of 42 possible species/families identified from all periods occurring. The main food fish groups eel, herring, cod, large gadid, haddock, whiting and plaice/flounder comprise 98.8% of all fish (excluding the elasmobranchs because of their poor preservation), as shown in Table 86. The remaining 1.2% of fish were of marine or migratory origin, and included single bones of saithe and pollack, large gadids similar to cod. The

Sub-period	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*3.1*	*3.2*	*4.1*	*4.2*	*5.1*	*5.2*	*6.1*	*6.2*	*6.3*	*7.1*	*7.2*
total NISP	1394	1369	1279	764	344	320	1065	229	888	1161	1724	323	63	66	73	28
eel %	11.5	26.7	16.7	4.5	11	1.5	5.1	2.6	3	12.8	9.8	11.7	7.9	1.5	4.1	0
herring %	67.3	52.3	67.8	71.5	63.3	70.3	67.5	43.6	52.1	53.2	57	51	53.9	34.8	76.7	57.1
cod %	8.3	5.5	5.3	11.1	14.8	4.3	7.6	10.4	12.3	3.6	4.3	11.7	11.1	16.6	8.2	14.2
large gadid %	7.8	5.9	2.2	1	4	4.3	7.2	33.6	13.9	3.9	4.2	7.1	3.1	12.1	4.1	3.5
haddock %	0	0.3	0.07	0.2	1.1	0.9	0.7	0.4	0.3	3.1	0.6	0.9	0	0	0	3.5
whiting %	1.8	1.1	2.7	5.1	1.4	2.1	2.3	4.3	5.5	3.9	5.5	2.1	12.6	0	0	10.7
mackerel %	1.9	0.9	2.1	2	1.1	0	1	0.8	0.5	1.2	0.4	1.5	1.8	1.5	0	0
pl/flound %	0.2	0.5	0.8	1	1.4	4	4.6	2.1	2.2	4.7	4	9.2	1.5	18.1	4.1	7.1
% of sample	98.8	93.2	97.6	96.4	98.1	87.4	96	97.8	89.8	86.4	85.8	95.2	91.9	84.6	97.2	96.1
no of species	18	25	20	20	14	15	21	13	23	27	27	17	12	11	8	8

Table 86 The 'NISP' percentage of the most commonly occurring food fishes

Species	*denticle*	*skull*	*vert*	***total***
elasmobranch	0	0	6	**6**
roker	2	0	0	**2**
eel	0	0	8	**8**
herring	0	13	180	**193**
cod	0	2	6	**8**
large gadid	0	0	1	**1**
haddock	0	0	1	**1**
whiting	0	2	2	**4**
saithe	0	0	1	**1**
mackerel	0	0	1	**1**
plaice/flounder	0	1	1	**2**
halibut	0	0	1	**1**
flatfish	0	1	2	**3**
total	**2**	**19**	**210**	**231**

Table 87 Fish bone from Building 1 (G6/4, Period 1.2)

Species	*skull*	*vert*	*frag*	***total***
elasmobranch	0	2	0	**2**
eel	1	2	0	**3**
herring	56	46	1	**103***
cod	2	5	0	**7**
whiting	1	0	0	**1**
scad	0	0	1	**1**
mackerel	1	1	0	**2**
total	**61**	**56**	**2**	**119**

* 39 from one fish

Table 88 Fish bone from Building 12 (G9/48, Period 1.2)

Species	*denticle*	*tooth*	*skull*	*vert*	*frag*	***total***
ray	2	1	0	0	0	**3**
roker	5	0	0	0	0	**5**
eel	0	0	3	178	0	**181**
herring	0	0	26	228	0	**254**
roach	0	1	0	0	0	**1**
cod	0	0	22	38	0	**60**
large gadid	0	0	21	3	90	**114**
haddock	0	0	2	1	0	**3**
whiting	0	0	1	4	0	**5**
red mullet	0	0	0	1	0	**1**
mackerel	0	0	0	2	0	**2**
plaice flounder	0	0	3	1	0	**4**
total	**7**	**2**	**78**	**456**	**90**	**633**

Table 89 Fish bone from pits in Open Area 8 (G9/109, Period 1.2)

presence of halibut could suggest some offshore line fishing for this mid water predator, though they migrate across different water depths and conditions. In Period 1.3 (11th century) the greatest diversity of the period is found. The main food fishes drop to 93% of the assemblage and the number of species increased to 25, including some true freshwater fishes with parts of two individual tench and some roach. Pike only appears in Period 1.4 (mid to late 11th century), and is found through Periods 2 and 3 (late 11th to 12th century) though it declines thereafter.

Three specific context groups are shown in Tables 87 to 89. In Table 87 the assemblage from Building 1 (G6/4), is dominated by herring (83% by 'NISP') with other species represented by few bones. If herring is compared with cod by 'NISP' cod is only 3.9%, below the 4.7% marker where cod is considered to be greater than herring in terms of food. Therefore in this building herring was the main food fish, then cod. Other fish include gadids: haddock, whiting and saithe, also mackerel, rays and flatfishes. The latter includes a single halibut vertebra. This species has been cited as a possible status symbol because of its potentially large size (over 2m) as much as for the quality of its flesh which coarsens with size. In another sunken structure (Building 12) most of the assemblage was herring, though 39 bones were from a single fish (Table 88). Cod was the second most commonly occurring species and at 6.3% slightly greater in terms of quantity than herring, while other species, including eel, scad and mackerel were poorly represented. Unusually no flatfishes were present in these deposits. From the refuse pits shown in Table 89 (G9/109; see comments on animal bone from these features in Chapter 3) cod is particularly well represented against herring at 19.1%, with a greater number of bones attributed to large gadid. These are most likely to be cod as the most common large gadid, haddock, were few and whiting too small to

Species	1.2 vert	1.3 skull	vert	total	1.4 skull	vert	frag	total
elasmobranch	2	0	1	**1**	0	3	0	**3**
eel	10	0	0	**0**	0	44	0	**44**
herring	22	0	23	**23**	9	201	0	**210**
tench	0	11	60	**71**	0	0	0	**0**
cod	0	2	1	**3**	0	3	0	**3**
large gadid	0	2	1	**3**	0	0	4	**4**
whiting	0	0	1	**1**	0	0	0	**0**
saithe	0	0	0	**0**	0	1	0	**1**
black s bream	0	0	1	**1**	0	0	0	**0**
mackerel	0	0	0	**0**	0	8	0	**8**
plaice/flounder	0	0	0	**0**	0	1	0	**1**
total	**34**	**15**	**88**	**103**	**9**	**261**	**4**	**274**

Table 90 Fish bone from pits in Open Area 10 (G2/11, Periods 1.2–1.4)

	Period 1.2					*Period 1.3*			
Species	*dent*	*skull*	*vert*	*frag*	***total***	*skull*	*vert*	*frag*	***total***
ray	1	0	0	0	**1**	0	0	0	**0**
herring	0	0	23	0	**23**	4	137	0	**141**
cod	0	3	4	0	**7**	1	7	0	**8**
large gadid	0	2	1	2	**5**	2	0	6	**8**
gurnard	0	0	0	0	**0**	0	1	0	**1**
mackerel	0	0	2	0	**2**	0	7	0	**7**
total	**1**	**5**	**30**	**2**	**38**	**7**	**152**	**6**	**165**

Table 91 Fish bone from pits in Hollow 1, phase 5 (G8/6, Periods 1.2 & 1.3)

have been included in this category. Other fish include the ubiquitous roker, together with eel, mackerel and plaice/flounder. Red mullet was also present and from freshwater, roach. The higher proportion of large fish, *i.e.* cod and large gadid, may reflect the nature of these deposits (pit fills) compared to those recovered from structures which may have been kept comparatively clear of larger bone debris. However this is not the case in Table 90 where herring dominates the pit deposits (in Period 1.4 the remains of two tench give an exaggerated impression of the importance of freshwater fish) or the pit assemblages of Table 91. The fills of an early boundary ditch (Ditch 1, G1/43, Table 92) do show a high proportion of cod, 26.4% against herring, by far the most important food fish in this group, with only a small assemblage from later fills (G1/44). Although mackerel is only 1.6% by 'NISP' of all bulk sieved fish in Period 1 it was present in all the context groups represented in Tables 87 to 92, a common, if not numerous, seasonal fish from the earliest period at Castle Mall.

In the assemblage associated with the early timber castle (Period 2, *c.*1067–*c.*1094), the fish assemblage is much smaller than that of Period 1. The greater part is from Period 2.1 in which the eight common food fishes are 96.4% by 'NISP' of the assemblage and 20 of the 42 species/families identified from the whole site are present. In Period 2.2 this percentage rises to 98.1% with a corresponding decrease in the number of species to 14

	Group 1/43					*Group 1/44*				
Species	*dent*	*skull*	*vert*	*frag*	***total***	*dent*	*skull*	*vert*	*frag*	***total***
ray	0	0	0	0	**0**	1	0	0	0	**1**
roker	2	0	0	0	**2**	0	0	0	0	**0**
eel	0	0	2	0	**2**	0	0	0	0	**0**
herring	0	9	175	0	**184**	0	1	1	10	**12**
cyprinid	0	0	1	0	**1**	0	0	0	0	**0**
cod	0	23	43	0	**66**	0	2	1	0	**3**
large gadid	0	3	3	10	**16**	0	0	0	2	**2**
whiting	0	5	9	0	**14**	0	0	0	0	**0**
mackerel	0	0	3	0	**3**	0	0	0	0	**0**
plaice/flounder	0	6	3	0	**9**	0	0	0	0	**0**
total	**2**	**46**	**239**	**10**	**297**	**1**	**3**	**2**	**12**	**18**

Table 92 Fish bone from boundary marker, Ditch 1 (G1/43 & 1/44, Period 1.4)

Species	*tooth*	*skull*	*vert*	***total***
elasmobranch	0	0	2	**2**
ray	1	0	0	**1**
eel	0	1	5	**6**
herring	0	3	129	**132**
smelt	0	0	6	**6**
pike	0	0	4	**4**
cod	0	3	6	**9**
large gadid	0	2	0	**2**
whiting	0	0	6	**6**
mackerel	0	0	3	**3**
scombrid	0	0	1	**1**
total	**1**	**9**	**162**	**172**

Table 93 Fish bone from pits in the early bailey, Open Area 19 (G2/9, Period 2.1)

Species	*tooth*	*skull*	*vert*	***total***
elasmobranch	0	0	2	**2**
ray	1	0	0	**1**
eel	0	1	5	**6**
herring	0	3	129	**132**
smelt	0	0	6	**6**
pike	0	0	4	**4**
cod	0	3	6	**9**
large gadid	0	2	0	**2**
whiting	0	0	6	**6**
mackerel	0	0	3	**3**
scombrid	0	0	1	**1**
total	**1**	**9**	**162**	**172**

Table 94 Fish bone from Castle Fee ditch fills, Ditch 3 (G1/57, Period 3.2)

from an assemblage around half the number of bones of 2.1. The percentage of cod against herring is 13.4% in Period 2.1 and 18.9% in Period 2.2, a reflection of the high 'portion' of cod over the period seen in Table 84, with evidence of a relative increase in cod in the less diverse later sub-period. The pit group within the early castle bailey (Table 93) shows a relatively low level of cod, 2.9%, indicating that in this particular group herring was the more important food fish, few large gadid bones were present and no flatfishes. Rays, eel and mackerel were present and from freshwater, pike.

During Period 3, which saw the growth of the Norman city and the new stone castle (*c*.1094 to 12th century), a greater proportion of the fish assemblage came from the later Period 3.2 as shown in Table 83. The eight most common food fishes were 96% of the sample with 25 species/families identified. The earlier smaller sample shows a lower percentage of the common food fish at 87.4% because of the presence of pike, and has a low number of species (15). Cod is only 1.7% against herring in Period 3.1, but rises to 10.1% in Period 3.2, so cod is the most important food fish in the later phase of Period 3. Using the data from fills of the ?Castle Fee ditch in Period 3.2 (Table 94), cod is 26.1% against herring, a particularly high percentage. Other gadids were also present: haddock, whiting and ling. Some 22 of a possible 42 species/families from the whole site were identified from this ditch including; ray, eel, pike, roach, gurnard, sea bream, grey mullet and flatfish.

In Period 4, most bone comes from Period 4.2, spanning the period 13th century to *c*.1345. The earlier sample (Period 4.1) is high in the most common food fishes, 97.8% with only 13 species from the whole sample. By contrast in Period 4.2 the common fish are 89.8% and the number of species increases to 23. However in both sub-periods cod is 19% against herring, clearly the most important food fish by quantity. In Period 4.1 (late 12th to 13th century) there is a relatively larger quantity of large gadid than in 4.2, further supporting the status of cod in this earlier phase. Two groups of fish are shown in Table 95, both from the south bailey ditch (Ditch 10) and both show a high quantity of cod and large gadid with some haddock and whiting. Other identifications of ray, eel, mackerel and flatfish are typical of this site. In a group of

	Group 8/16					*Group 8/17*			
Species	*dent*	*Skull*	*vert*	*frag*	***total***	*dent*	*skull*	*vert*	***total***
elasmobranch	0	0	1	0	**1**	0	0	0	**0**
roker	2	0	0	0	**2**	3	0	0	**3**
eel	0	0	8	0	**8**	0	0	0	**0**
herring	0	0	48	0	**48**	0	0	4	**4**
salmonid	0	0	1	0	**1**	0	0	0	**0**
cod	0	5	41	0	**46**	0	6	71	**77**
large gadid	0	6	16	1	**23**	0	1	0	**1**
small gadid	0	1	0	0	**1**	0	0	0	**0**
haddock	0	0	1	0	**1**	0	0	4	**4**
whiting	0	4	20	0	**24**	0	0	0	**0**
gurnard	0	0	0	0	**0**	0	0	1	**1**
mackerel	0	0	0	0	**0**	0	0	1	**1**
turbot/brill	0	0	0	0	**0**	0	1	0	**1**
plaice	0	1	0	0	**1**	0	0	0	**0**
plaice/flounder	0	1	9	0	**10**	0	1	2	**3**
flatfish	0	0	3	0	**3**	0	2	0	**2**
total	**2**	**18**	**148**	**1**	**169**	**3**	**11**	**83**	**97**

Table 95 Fish bone from south bailey ditch fills, Ditch 10 (G8/16 (Period 4.1) and G8/17 (Period 4.2)

Species	*skull*	*vert*	*frag*	***total***
elasmobranch	0	3	0	**3**
eel	1	2	0	**3**
herring	1	48	0	**49**
smelt	0	1	0	**1**
cod	8	13	0	**21**
large gadid	9	0	22	**31**
whiting	1	8	0	**9**
mackerel	0	3	0	**3**
plaice	0	1	0	**1**
plaice/flounder	0	5	0	**5**
sole	0	1	0	**1**
total	**20**	**85**	**22**	**127**

Table 96 Fish bone from pits within the barbican, Open Area 29 (G45/1, Period 4.2)

medieval pits within the barbican (Period 4.2, Table 96), a high proportion of cod and large gadid relative to herring is evident, while other species are represented by few bones.

The second largest sample was recovered from Period 5, the decline of the castle after *c*.1345 until the mid 16th century, a particularly large group coming from the barbican well in Period 5.2 (see Moreno García above). Table 84 shows a drop in cod by 'portion' from earlier periods and comparing cod with herring by 'NISP' percentage reflects this, showing cod at 6.3% in Period 5.1 and 7% in Period 5.2. This suggests cod is narrowly the major food fish. Although the sample from Period 5.1 is around 70% of that from Period 5.2 the percentage of common food fishes and number of species is similar between the two at 86.4% with 27 species and 85.8% also with 27 species. The similarity may reflect the sufficiency of the sample size, passing the point where new species are likely to be added.

Table 97 shows the fish bone recovered from a group of pits associated with Castle Fee Property 43 (Open Area 36, G9/104 and 9/105), which produced a wide species range including the single bone of ?dragonet recovered from the excavations.

The 'NISP' percentage of cod compared to herring in the barbican well (Table 98) is proportionately lower than the rest of Period 5.2 at 3%, indicating a lower disposal of cod in this feature (see further comments in Part II, Chapter 9.IV). From the bulk sieved material (see Table 83) there appears to be less haddock in Period 5.2 but whiting remains the same numerically though proportionately reduced. Pollack and ling are only present (poorly) in Period 5.2. Sprat was most common from Periods 4.2 to 5.2, and suggests an increase of consumption in the numbers of these tiny fish linked with the site over this period. This is not a feature of identification to species rather than genera as the contexts were identified randomly.

Period 6 (the development of the second city in the late 16th to 18th centuries) produced a comparatively small sample, mostly from Period 6.1 (late 16th to early 17th century). Here the 'NISP' percentage of cod against herring rises to 18.7%, re-establishing cod as the major primary food fish on the site at this time. This assemblage is reduced in species range, only 17 of the 42 from bulk

	Group 9/104				*Group 9/105*		
Species	*skull*	*vert*	*frag*	***total***	*skull*	*vert*	***total***
elasmobranch	0	2	0	**2**	0	0	**0**
eel	2	32	0	**34**	0	3	**3**
conger eel	1	0	0	**1**	0	0	**0**
herring	4	119	0	**123**	0	2	**2**
pilchard	1	0	0	**1**	0	0	**0**
pike	2	0	0	**2**	0	0	**0**
perch	1	0	0	**1**	0	0	**0**
roach	1	0	0	**1**	0	0	**0**
cyprinid	0	13	0	**13**	0	0	**0**
cod	12	26	0	**38**	2	4	**6**
large gadid	6	8	25	**39**	0	0	**0**
small gadid	3	4	4	**11**	0	0	**0**
haddock	9	39	0	**48**	0	0	**0**
whiting	21	33	0	**54**	1	1	**2**
pollack	1	0	0	**1**	0	0	**0**
saithe	0	2	0	**2**	0	0	**0**
pandora	0	1	0	**1**	0	0	**0**
ballan wrasse	0	1	0	**1**	0	0	**0**
?dragonet	0	1	0	**1**	0	0	**0**
mackerel	1	8	0	**9**	0	0	**0**
plaice	2	1	0	**3**	0	0	**0**
plaice/flounder	8	26	0	**34**	0	0	**0**
halibut	0	1	0	**1**	0	0	**0**
sole	0	6	0	**6**	0	0	**0**
flatfish	0	1	0	**1**	0	0	**0**
total	**75**	**324**	**29**	**428**	**3**	**10**	**13**

Table 97 Fish bone from pits in Open Area 36 (G9/104 and G9/105, Period 5.2)

sieved samples, lacking the sea breams, gurnard, grey mullets found in earlier periods. Of the flatfishes only plaice/flounder and sole were present. Periods 6.2 and 6.3, including the construction of the first Cattle Market in 1738, had small assemblages shown in Table 83. These were mainly herring and the gadids with low percentages of major food fishes and low numbers species, a feature of the small sample size.

The final period (Period 7, 19th and 20th centuries) includes the 19th-century Cattle Market and the assemblage again was mainly herring, gadids and a few plaice and flounder bones, an impoverished reflection of earlier periods.

The overall trend is one of fish consumption based on herring and cod with a gradual increase favouring cod until Period 5 where it shows a slight reduction though still equal/greater than herring. Other species of importance include the rays, eel, other gadids, especially haddock and whiting and, to a lesser degree, pollack, saithe and ling. Flatfishes particularly plaice/flounder, as well as sole, halibut and turbot were also found throughout. The contribution of these fish is summarised in Table 86. Some of the changes through sub-periods may be temporal or spatial, linked to changing usage which also affected the quantities of fish bones recovered, and the data suggests that the size of the sample also relates to the diversity of the sample.

VI. The Fisheries and Fish Trade as Represented by Castle Mall: the Marine Fishery

(Fig. 83)

The main commercial fisheries supplying Norwich as represented at Castle Mall were for herring and cod. The establishment of the East Anglian herring fishery is well documented from the 5th century (Hodgson 1957, 26), and there is said to have been a church — St Benet — on the Greenhill in Yarmouth where prayers were made for the success of the herring fishery from the 7th century (Cushing 1988, 79). Herring not only provided an important source of protein from the Late Saxon period but also provided employment and trade in Norwich linked by river to the port at Great Yarmouth. The herring fishery was seasonal, in the autumn off the East Anglian coast, and large numbers of fish were caught and consumed over the many compulsory fish days imposed by the church up to the Reformation. After that time non-religious fish days were reintroduced in the 17th century to relieve pressure on meat supplies and boost the fishing industry which fostered manpower for the navy. This failed, however, as did later efforts to make the industry sufficiently strong to provide all the fish needed for home consumption.

	Bulk sieved			*Site riddled*			*Hand collected*			*Sub-total*			***total***
Species	*dent*	*skull*	*vert*	*dent*	*skull*	*vert*	*dent*	*skull*	*vert*	*dent*	*skull*	*vert*	
elasmobranch	0	0	5	0	0	5	0	0	2	0	0	11	**11**
ray	1	0	0	0	0	0	0	0	0	1	0	0	**1**
roker	1	0	0	4	0	0	0	0	0	0	0	0	**5**
eel	0	10	145	0	4	51	0	3	15	0	17	211	**228**
conger eel	0	0	1	0	0	1	0	0	0	0	0	2	**2**
herring	0	104	881	0	113	317	0	17	216	0	234	1414	**1648**
sprat	0	0	56	0	0	7	0	0	0	0	0	63	**63**
salmonid	0	0	0	0	0	1	0	0	0	0	0	1	**1**
smelt	0	0	1	0	0	0	0	0	0	0	0	1	**1**
pike	0	2	9	0	1	6	0	6	1	0	9	16	**25**
chub/dace	0	0	0	0	1	0	0	0	0	0	1	0	**1**
roach	0	2	0	0	4	5	0	0	0	0	6	5	**11**
cyprinid	0	3	42	0	0	22	0	0	8	0	3	72	**75**
cod	0	4	27	0	29	152	0	15	57	0	48	236	**284**
large gadid	0	16	37	0	9	55	0	8	25	0	33	117	**150**
haddock	0	2	8	0	9	8	0	7	5	0	18	21	**39**
pollack	0	0	4	0	0	0	0	0	0	0	0	0	**4**
whiting	0	3	71	0	23	41	0	1	25	0	27	137	**164**
ling	0	0	1	0	0	0	0	2	4	0	2	5	**7**
bass	0	1	0	0	0	0	0	0	0	0	1	0	**1**
perch	0	1	1	0	1	0	0	0	0	0	2	1	**3**
ruffe	0	0	0	0	1	0	0	0	0	0	1	0	**1**
sea bream	0	0	1	0	0	0	0	0	0	0	0	1	**1**
wrasse	0	0	0	0	0	5	0	0	0	0	0	5	**5**
mackerel	0	0	6	0	0	1	0	0	0	0	0	7	**7**
turbot/halibut	0	0	0	0	0	0	0	0	2	0	0	2	**2**
sole	0	0	3	0	0	9	0	0	0	0	0	12	**12**
plaice/flounder	0	5	44	0	16	36	0	4	11	0	25	91	**116**
flatfish	0	0	9	0	1	2	0	0	2	0	1	13	**14**
total	**2**	**153**	**1352**	**4**	**212**	**723**	**0**	**63**	**373**	**6**	**428**	**2448**	**2882**

Table 98 Fish bone from the barbican well (G5/24, Period 5.2)

The annual migration of distinct populations of herring in the North Sea from the north of Scotland to the English Channel supplied a number of seasonal fisheries, prosecuted increasingly later in the year the more southerly their location. The Yarmouth fishery was focussed on autumn spawning fish and a Free Fair was established for the sale of fish. In the 14th century (and therefore prior to this) Saul (1981, 34) considered that only coastal waters were fished, with more distant waters exploited in the 15th century. The fish were caught in drift nets and in the 14th century Saul describes boats of under 30 tonnes with sails and oars crewed by four to ten men who fished for one or two nights. The Statute of the Herrings (1357) ruled that no fresh herring were to be sold to merchants between September 29th and November 11th (Cushing 1988, 81) and prices were set for fresh herring and red herring. Three types of stored herring were produced; white (gutted, salted and barrelled), dried (salted, sun dried and lightly smoked) and red (salted and heavily smoked). Yarmouth was famous for the latter. The high oil content of herring rendered them unsuitable for long term storage by drying alone and was usually combined with salting. The 'reds' were only made from herring between 10–15% of oil, the fatter fish being unsuitable for this method (Cutting 1955, 79). Not only were herrings a symbol of lenten fast in Norwich, they were also used in medieval rents. Twenty-four herring pies were made from the first fresh herrings of the season with five herrings in each pie, flavoured with spices and rendered annually to the king by the City of Norwich (Wilson 1973, 42).

The East Anglian herring fishery continued through into modern times with various innovations including large Dutch 'busses' in the mid 18th century together with French boats of 80 and 100 tonnes each. Some years the herring were not so plentiful, and there seems to have been a decline from the 15th century through economics and war which reduced the number of fishermen exploiting the herring and disrupted European herring trade (Childs in Starkey (ed.) 2000, 23). In an attempt to standardise a high quality of herring a crown branding system on the barrels was introduced, but ultimately Yarmouth and associated herring ports lost out to superior cured herrings produced by Dutch methods.

In the North Sea cod were caught on a long line fishery, although only a single fish hook was found in unstratified medieval/post medieval levels at Castle Mall (see Goodall, Part I, Chapter 7.III). The fishery was prosecuted in deep water and also in shallower water during winter when mature fish move inshore. The smaller immature fish inhabit shallower waters all year, so cod and other gadids such as haddock and whiting could be caught all year round in local waters. Other cod fishing grounds in Iceland were exploited in the 15th century by English east coast fishermen who also traded there (Childs in Starkey (ed.) 2000, 22). Cured fish, including stockfish and saltfish, were brought from Iceland and Norway to East Anglian ports throughout the 15th and 16th centuries (Williams, 1988, 87). The Newfoundland cod fishing grounds, first extensively fished by English fishermen in the 16th century, were more accessible from ports on the west coast such as Bristol. However in the 17th century, Yarmouth fishermen could be found off the west coast of Ireland fishing for cod and ling from March to September and returning to Yarmouth for the autumn herring fishery (Elder 1912, 30).

Cod, in contrast to herring, are low in oil content but high in water and therefore of lower calorific value than herring and other oily fish found at Castle Mall, such as eel and mackerel. For example 100g of fresh cod has 70 calories compared to 180 calories in fresh winter herring and 125 calories in fresh spring mackerel (Cutting 1962, 164–7). At other seasons herring and mackerel are fattier with a commensurate higher calorie content. However drying reduced the water content of cod, in the most extreme method, as stockfish, down to around 16% allied with a large reduction in weight (Davidson, 1979, 54). Stockfish, produced in the Lofoten Islands under ideal climatic conditions, could be stored in dry conditions and without refrigeration for over two years (Perdikaris 1999, 390). Cut marks on eight cleithra (retained in stockfish) from Periods 1, 3, 5 and 6 may be evidence for the removal of the skull in curing stockfish or saltfish, and supportive evidence for the consumption of stored cod at Castle Mall. Salted and dried cod was produced along the east coast in England. It had a higher water content and weight than stockfish and a shorter shelf life.

Figure 83 shows the size of cod caught in each period based on measurements of the skull using the data for the premaxilla and dentary (the main upper and lower jaw bones) given by Wheeler and Jones (1976). As stated earlier, the presence of skull bones indicates whole fish, therefore not stockfish or saltfish, and these bones are most likely to be from fresh cod. Period 1 had the largest measured sample and shows a range of immature cod starting at 45cm total length with a spread of sizes between 60 and 100cm with only three over 100cm. This suggests exploitation of both mature and immature cod in the North Sea. A similar distribution of sizes is seen in the smaller samples from Periods 2 and 4, while Period 5 shows only small cod.

Amongst the other gadids, haddock were caught on lines: they migrate to shallow water in this area, the southern end of their range. Whiting were netted and are small fish averaging 35cm, abundant in shallow water. Pollack and saithe were few, but both species can be found in the southern North Sea, while ling is not found as far south and is most likely to have been brought to Norwich as a stored fish from more northerly fishing grounds. In terms of food quality cod was considered the best of the gadids, haddock was often regarded as an offal fish, though more popular in Scotland. Ling was also considered a prime gadid and some considered it better than cod as a salted fish, though there is some confusion where 'lynge' is also used as a term for salt cod.

Of the remaining marine species the elasmobranchs includes the sharks, though none have been positively identified here except for spurdog (identified by a single distinctive spine found at the front of the dorsal fin) in Period 5. Found near the seabed up to 200m it feeds on schooling fish such as herring and may have been caught on lines. Only roker has been positively identified among rays, from the dermal denticles known as 'bucklers', though other species are likely to be present but could not be specifically identified. Roker (also known as thornback ray) is found in shallow water and would have been caught on lines. Now marketed as 'skate' this species has been eaten throughout history and was also dried.

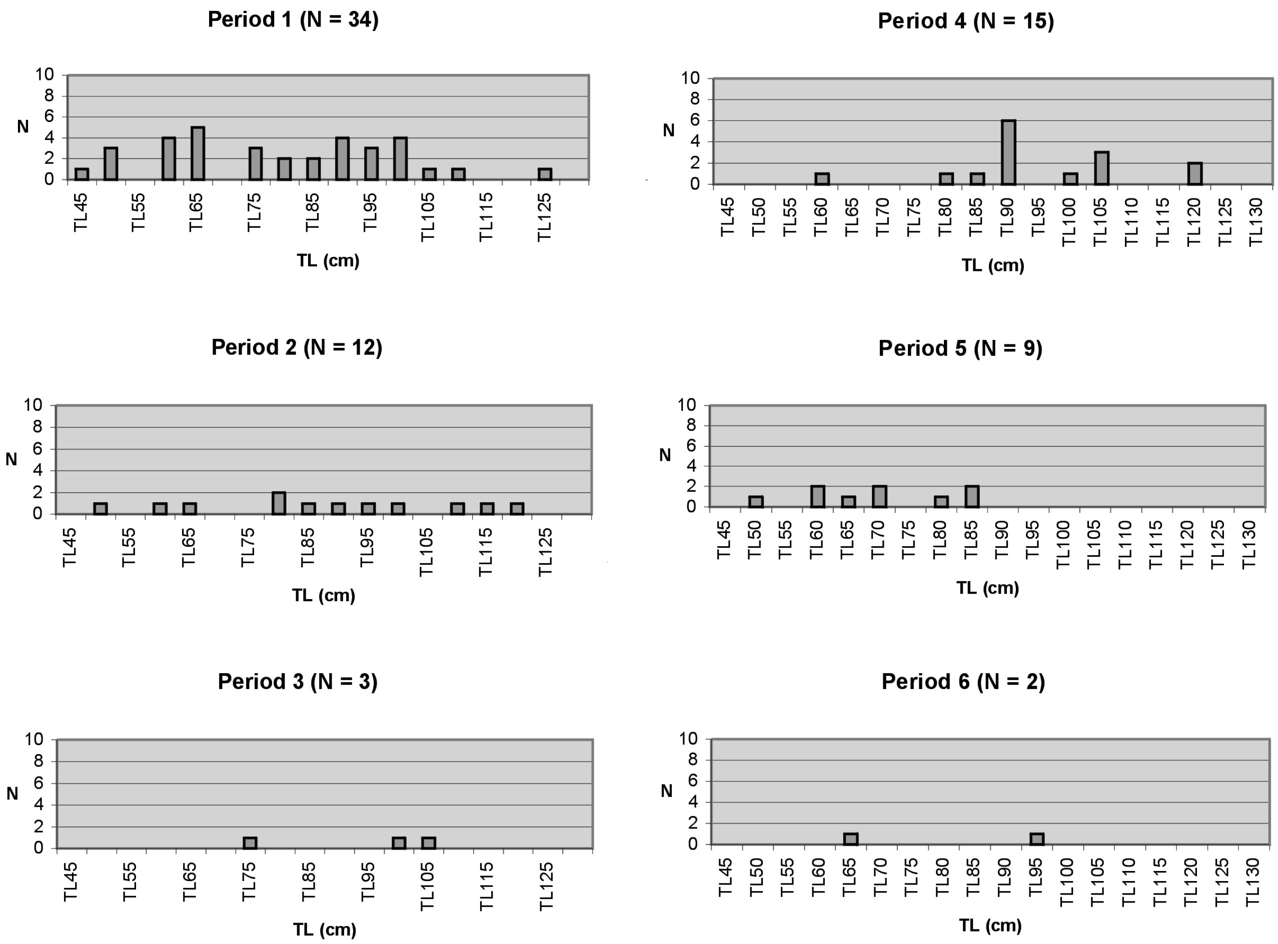


Figure 83 The total length of cod using the measurements of the premaxilla and dentary (after Wheeler and Jones 1976)

Conger eel occurred in small numbers in Periods 3, 4 and 5. Inhabiting rocky shores it can be trapped or caught on lines. Commonly eaten in areas where it is more prolific such as the southwest, conger eel was eaten both fresh and pickled in barrels.

A close relative of the herring, the sprat is also an oily fish. The juvenile herring and sprat enter estuaries in mixed shoals where they are caught as 'whitebait'. Periods 4 and 5 had the largest numbers of these small fish. Smaller than herring, adult sprats are a maximum 16cm and their abundance in inshore shallow waters in summer leads to large nettings. Sprats were eaten fresh, also salted and smoked. Another member of the Clupeidae, the pilchard (or sardine at a smaller size) was a traditional fishery, netted in large shoals, off the Cornish coast. Salted and barreled pilchards sustained many poor people through the winter months. Most easily distinguished from herring by a ridged opercular, the pilchard mirrors its spawning distribution with herring, depending on the water temperature. The pilchard moves northwards as waters warm and is within its natural distribution off the East Anglian coast, though not commonly identified from sites in this area.

The following fishes are all common in the southern North Sea and were identified in small numbers from a number of contexts. Gurnards include a number of species that were and are regularly eaten. They were found in Periods 1 to 4, but no later. The tub gurnard (*Trigla lucerna*) is most commonly eaten and, with the red gurnard (*Aspitrigla cuculus*), could have been caught locally in shallow water, while the grey gurnard (*Eutrigla gurnardus*) is more common offshore. Most of the identifications were made from the fragments of the characteristic 'armoured' skull bones which unless complete are difficult to assign to species, as are the vertebrae and have been described here as 'gurnard'.

Sea scorpion (or the closely related bullrout) was only identified from two bones in Period 5. It is not a food fish of note, and may be an incidental catch. Found in shallow water it may have been caught amongst other fish.

Sea bass is a renowned food fish, particularly in the Mediterranean, however it is relatively common in the southern North Sea in summer, schooling in inshore waters and sometimes entering estuaries (Wheeler, 1979, 232). Only identified from two bones in Periods 2 and 5 bass were evidently not commonly eaten at Castle Mall. The scad (or horse mackerel) is found in large schools, more typically offshore, the young small fish being found inshore. It is identified fairly regularly in assemblages, but in small numbers and often from the distinctive' scutes' along the lateral line. The sea breams were represented by two species, black sea bream and pandora and a number of indeterminate 'sea bream' fragments. Though not regarded as highly as gilthead (*Sparus aurata*) commonly caught in the south west (the ubiquitous 'daurade' of the Mediterranean) these are both good food fish and likely to have been summer migrants locally in the southern North Sea, caught in shallow waters. Similarly the red mullet is highly regarded in the Mediterranean where it is found in large numbers. However it is comparatively scarce in more northerly waters and was only identified in Period 1.

The thin lipped grey mullet (a separate family to the red mullets) is one of three species of grey mullet found in Northern Europe where it is a summer migrant when water temperatures are higher. This species stays close to the shore, entering lagoons and estuaries and likely to have been caught on a line. The ballan wrasse is the largest European wrasse and its range does not normally extend into the northern North Sea so this may have reached Castle Mall as a stored fish or a rare catch. It was only identified from Period 5. The catfish (a single bone from Period 5) is common in more northerly waters and is good to eat and would have been caught on a line. Dragonet is not an important food fish, but can be very common in certain areas. Identified from a single bone in Period 5, it is therefore rare in the Castle Mall assemblage.

Mackerel was commonly identified in small numbers in all phases except Period 7. This was an important seasonal catch in May off the East Anglian coast (Williams, 1988, 166). Schooling in large numbers they could be netted or caught on lines. A high oil content (20% in autumn fish) meant mackerel deteriorated quickly leading to some exceptions to the ban on Sunday fresh fish sales for this fish. Mackerel were also suitable for salting and smoking, in much the same way as herring.

The remaining marine species are all flatfishes, the most common being plaice and/or flounder, often indistinguishable from the bones. These were caught on lines and in traps along the shoreline and in estuaries. Turbot (or brill) is also found in shallow water and is highly regarded as a food fish. Halibut is a deep water predator that can grow extremely large (over 2m), although at this size the flesh is said to coarsen and may be of more interest as a spectacle than as high quality flesh. Sole was also identified from four periods: a good food fish it is found at a variety of depths and would have been caught on lines.

VII. Migratory Species

The eel is the most numerous of this group. Eels could have been caught locally in rivers during their migration to the sea, when traps were laid across streams and rivers. They were also caught using special large flat edged fork-like spears which have been recovered from some sites, though not Castle Mall. Another fish with a high oil content, eels were eaten fresh and also salted and smoked. Customs records for eels imported to London give them many different names, possibly denoting different sizes and types of curing, such as 'dole, pimper and shaft' (Dietz (ed.) 1972).

Salmon also migrate, but upriver to spawn. Whether any of the few vertebrae recovered (salmon bones survive poorly) were from local fish, or from the renowned cures of 'Newcastle salmon' (actually from Berwick) cannot be ascertained. The smelt is a tiny relative of the salmon and is eaten seasonally, caught when it enters rivers to spawn. This fish has been considered quite a delicacy and smells of cucumber.

VIII. Freshwater Species

The remaining fish are all freshwater. Pike is a predatory fish, considered a good food fish in the past, and large pike were a status fish featuring at festive meals. Together with the cyprinids; tench, chub (or dace) and roach, these could all have been caught in local rivers. The remains of two tench boost the number of this fish in Period 1. The chub/dace and roach were all fairly small specimens.

IX. Conclusions

The large fish assemblage from Castle Mall, the largest to date from Norwich, reflects the proximity to the sea. The route to the coast was initially directly navigable and the sea was later reached using shallow craft via Great Yarmouth after the river silted by the 12th century. The two main species are herring and cod, both major fisheries from Yarmouth and other local ports as well as imported cured cod from Iceland and Norway and perhaps imported Dutch herring as the local fishery suffered periods of failure. Williams (1988, 167) records that most of the cod and ling landed at Yarmouth in the second half of the 16th century went to feed Norwich.

Looking at the quantities of fish by numbers of bones it would seem that herring was the most important food fish. However, by looking at the data as a quantity of food or 'portion' or directly comparing percentage of herring versus cod based on a comparative quantity of food, cod appears more important than herring. Although it was not possible to compare other species in the same way, apart from other gadids by 'portion', cod is among the largest fish species and the bone numbers of other fish of comparable size were far fewer than cod.

Although the use of the area excavated at Castle Mall did change through time the essential balance of species in the surviving fish assemblages did not, either broadly through periods or between context groups as shown in the tables. This suggests a great continuity of fish supply and consumption over a long time span.

Of three other sites from Norwich examined by the author, a very small assemblage (150 identified bones) from Wensum Street (Locker 2002) included the same main marine species. These were; rays, herring, sprat, cod, whiting, scad, mackerel, plaice/flounder plus the ubiquitous eel from six contexts of Saxo/Norman to 12th-century date. A large sample of some 2,800 identified bones from St Martin-at-Palace Plain (Locker 1987, 115), of Saxo/Norman to Medieval date, also showed a similar species range to Castle Mall. It was dominated by herring and cod in which 'portion' suggested cod was the prime food fish, marginally in the Saxo/Norman period and increasing through time (Locker 2001, 243). Similarly a smaller sample from Fishergate (Locker 1994b, 44) of 10th- to 13th-century date also reflected a similar species range though here cod was overall less well represented, perhaps reflecting particular consumption on a site known to have been associated with the fishing industry (Ayers 1994, 81). However, comparison of herring and the gadids by 'portion' from one 11th-century pit showed cod to be the dominant species in this feature. Both St Martin-at-Palace Plain (Ayers 1987, 169) and Fishergate may have been areas for off-loading fish brought up river and though these buildings are not domestic in usage they do contain domestic debris. The large assemblage from Fullers Hill, Great Yarmouth (Wheeler and Jones 1976) is 11th- to 12th-century in date and showed a similar species range. This is a different type of site, directly coastal, rural and associated with fishing and not really comparable with Castle Mall, which was associated with the castle and within the developing city of Norwich, though they share the same sources for fish. The other Norwich assemblages tie in well with those from Castle Mall where the debris of the castle was later replaced by the deposition of waste representing people working and living in the area, though not usually directly attributable to any specific domestic buildings.

Chapter 6. Mammal, Bird and Fish Bone from Golden Ball Street (Site 26496N)

by Julie Curl

I. Summary and Introduction

This section of the report summarises the faunal assemblage collected both by hand and by 'Site Riddled samples' (SRS) during excavations at Golden Ball Street in 1998. Excavations at the site revealed evidence for a continuation of the previously recorded boundary ditch around the northern part of the cemetery of St John de Berstrete/Timberhill and evidence for the termini of both the Castle Fee and south bailey ditches, adjacent to the castle approach road. Later activity consisted of pit groups and infilling of the castle ditches.

In consideration of the detailed analysis of the large Castle Mall assemblage presented above, the Golden Ball Street remains were subjected to study at a lower analytical level (*i.e.* a thorough scan) as a supplement to the previous work. Metrical data was not recorded and fish bone was not identified to species except in a single instance.

The phasing structure adopted was identical to that used at Castle Mall (Tables 1 and 2), although no deposits of Late Saxon date (Period 1) were encountered. Bone was recovered from contexts dating between the Norman Conquest and the post-medieval period (Periods 2–6; detailed in Parts I and II, Chapters 4–8 and 10), with small quantities either being modern or unstratified. The majority of the assemblage dated to the 15th to 16th centuries (Period 5.2, Part II, Chapter 8), with a substantial part of the remainder being post-medieval.

A total of 54.060kg (3,844 fragments) of bone was recovered from pit and ditch fills. The majority was animal and bird bone (51.273kg hand-collected; 2.465kg from SRS), with a lesser quantity of fish bone (0.322kg hand collected and from SRS). A single fragment of human bone was found. Both the hand collected bone and material retrieved from samples produced greater quantities of cattle and sheep from all periods than any other species, as is typical of urban sites at this date. Pig was the next most common mammal, while other mammals included dog, rabbit, hare and mole. The smaller species are probably under-represented in this assemblage as no fine-mesh samples were taken. Horse and deer were only represented by worked bone and antler. The majority of the bird bone was domestic fowl, the second most common being goose. Wild species include duck, pheasant and partridge. Herpetofauna was represented by two bones from the Common Toad. Some of the smaller bones (*i.e.* the mole, rabbit and toad) may have been contaminants from later periods as a result of burrowing.

The majority of the bone derives from butchery and food waste and the assemblage provides additional evidence of the countrywide changes in butchery practices that occurred in the later medieval period, particularly the culling of younger cattle. Several pathologies were recorded, notably a probable unhealed and infected fracture on a pig mandible, an ossified haematomata on a sheep/goat metapodial and two clear 'thumbprint' depressions (indications of calcium resorbtion) on a sheep horncore.

Limited evidence for bone-, antler- and horn-working was present. Horncores of cattle, sheep and goat all displayed cutting, chopping and saw marks indicating their use in the hornworking industry.

II. Methodology

Identification and Recording

All of the bone was examined using standard NAU methods for scanning smaller assemblages, in accordance with *POSAC* guidelines (Davis 1992a). Mandibles, complete or minimum of 50% complete limb bones, teeth, calcaneus, scapulae, complete/50% complete pelvic bones, metacarpals, metatarsals, hooves, horns and phalanges were always identified to species. Other fragments of bone were identified to species whenever possible. Skull fragments were recorded and identified only where a sufficient amount of the skull was present to make identification certain.

Wherever possible sheep were separated from goats using previously accepted methods of identification such as differences in the distal metapodials, teeth, cranial sutures and horncores (Davis 1987c). Males and females are difficult to determine in most cases during a scan. The presence of a spur was, however, noted on a domestic fowl and is only present in the male.

Estimation of age was recorded for any partially fused or unfused bones, all unfused bones being recorded as juvenile. Wear on teeth was also noted. All bones were examined for pathological conditions and any visible signs were recorded. Each bone was examined for clear signs of butchering or other modification such as traces of working or other utilisation of the bone. Evidence of gnawing of the bones was also recorded, noting the bone gnawed, the location of the gnawing and determining species responsible where possible. The overall condition of the bone was also noted. Fish bone was not generally identified to species, a simple quantification by context/group being conducted.

Counting and Quantification

As noted above, measurements and counts of individuals were not undertaken for this assemblage. A broad quantification by collection category is given in Table 99.

Excavation, Sampling and Recovery

The majority of the bone was hand collected. In addition, forty site riddled samples were processed through an 8.0mm mesh. No fine sieved samples were taken. Recovery for the hand collected bone was very good, producing a reasonable number of bird and fish bone to

	Qty (no. fragments)	*Wt (kg)*
Mammal & bird bone (HC)	2,600	51.273kg
Mammal & bird bone (SRS)	993	2.465kg
Fish bone (HC)	183	0.266kg
Fish bone (SRS)	68	0.056kg
		54.06**0kg**

HC = hand collected; SRS = site riddled through 8mm mesh

Table 99 Quantification of bone by collection method at Golden Ball Street

supplement material from sieved samples. As a result of the fragmentary nature of the bone recovered from samples, much of it could not be identified. The samples produced relatively little bone, with only six of the forty contexts sampled producing between 0.100 to 0.370kg of bone. Most of the bone from samples belonged to the five main species recovered from this excavation; cattle, sheep, pig, domestic fowl and goose. Very few samples produced anything of real significance, although evidence for sheep butchery was noted.

Gnawing and Burning

The occurrence of gnawing marks (canid and cat) may indicate that some of the bone was redeposited after scavenger activity, such marks being recorded on cattle bones and in lesser amounts on sheep, pig and goose. Very few burnt bones were recovered.

III. Preservation

The majority of the bone was fragmentary, although it remained in reasonable to good condition. Fragmentation had generally resulted from human activity (such as butchering) but was also due to animal gnawing, post-depositional trampling and the chemical action of the soil. No complete skeletons were found. The most complete group of bones belonged to a mole found in a 12th-century fill of the Castle Fee ditch.

IV. Occurrence and Comparison Between Periods

(Table 100)

The frequency of species between different periods is indicated in Table 100.

Cattle bones are the most represented species in all periods but, as with the other species, most come from late medieval and post-medieval deposits. A particularly large group was recovered from a very large late 15th- to 16th-century pit (*411/530*, GBS Group 44, Open Area 51, Period 5.2) which cut through the terminus of the south bailey ditch. The majority of the juvenile cattle remains came from 15th- to 16th-century deposits.

Sheep/goat are again common in all periods, but are generally secondary to cattle despite the fact that they predominate above them in a number of individual features. Again, large quantities derive from 15th- to 16th-century contexts, particularly pit *411/530* noted above. The only definitive goat remains consist of a worked

Taxa	*Period (NISP)*					
	1	*2*	*3*	*4*	*5*	*6*
Cattle (*Bos taurus*)		23	8	10	69	63
Sheep/goat (*Ovis/Capra*)		2	8	4	81	67
sheep (*Ovis aries*)						
goat (*Capra hircus*)				*1*	*1*	
Pig (*Sus domesticus*)				1	8	7
Equid (*Equus* sp.)		1			1	
Dog (*Canis familiaris*)			1			3
Cat (*Felis catus*)						
Red deer (*Cervus elaphus*)						Antler only
Fallow deer (*Dama dama*)		Antler only				
Hare (*Lepus* sp.)						
Rabbit (*Oryctolagus cuniculus*)					4	1
Lagomorph						
Mole (*Talpa europaeea*)		11*				
Domestic fowl (*Gallus gallus*)			1	2	25	30
Goose (*Anser anser*)				2	16	11
Duck/Mallard (*Anas* sp./ *Anas platyrhyncos*)				1		
Teal (*Anas crecca*)						1
Grey partridge (*Perdix perdix*)					3	1
Pheasant (*Phasianus colchicus*)					9	
Amphibian						
Toad (*Bufo bufo*)					1*	1
total	**0**	**37**	**18**	**21**	**218**	**185**

* = Material from SRS is only included when it forms the only representation of a species from the excavation
Teeth in *italics*

Table 100 Golden Ball Street: Quantification of hand collected mammal and bird bone by period (NISP) horncore from another 15th- to 16th-century pit (GBS Group 23, Period 5.2).

There are far fewer pigs — approximately 75% less in each period than cattle and sheep/goats.

Horse remains, consisting of a few worked bones, were only found in the larger features: fills of the cemetery boundary ditch (GBS Group 25, Period 2.1) and the south bailey ditch (GBS Group 49, Period 5.2). Dog bones were found in 12th-century fills of the Castle Fee ditch (GBS Group 20, Period 3.2) and in post-medieval pits (GBS Group 46, Period 6.2). Deer is represented by worked antler, while hares are apparent in late medieval/transitional and post-medieval pits (GBS Group 45, Period 5.2; GBS Group 8, Period 6.2). Rabbit remains generally come from post-medieval contexts with a few bones from late medieval/transitional deposits.

Domestic fowl are evident at the site from the Conquest onwards. As with other species, they are particularly common in late medieval and post-medieval contexts, but continue to occur in pit fills until the 18th century. Juvenile bird bones were collected from medieval pits (GBS Group 21, Period 4.2) and a 17th-century pit (pit *146,* GBS Group 9, Period 6.1).

Goose is the second most common bird, recovered from contexts ranging in date from the 13th to the 17th centuries. Duck and partridge were also evident between the medieval and post-medieval periods. Partridge came from 15/16th- and 17th-century pit fills (GBS Groups 45 and 46, Period 5.2 and 6.2) while duck was evident in medieval pits (GBS Group 21, Period 4.2) and the large 17th-century pit noted above (pit *146*). A group of seven pheasant bones came from late 15th- to 16th-century pits (GBS Group 23, Period 5.2) and a beak, tarso-metatarus and coracoid from late 15th- to 16th-century pit *411/530*.

Two bones of herpetofauna are both from the Common Toad. One was hand collected bone from a post-medieval pit (GBS Group 14, Period 6.2), the other from a sample from late 15th- to 16th-century fills of the south bailey ditch (GBS Group 48, Period 5.2). Mole remains came from a sample of the upper fills of the Castle Fee ditch (GBS Group 20, Period 3.2), dating to the 12th century.

V. Cattle

Age

Cattle remains indicate the presence of both adults and juveniles. No particularly old animals were noted, although some animals were mature enough to show early signs of arthritic conditions. The majority of the remains of juveniles are attributable to the 15th and 16th centuries, a period which saw great changes in the use of a variety of domestic animals. Although the cow had originally been used for traction, meat and milk, during the medieval period the horse began to dominate as the main traction animal and there was a move to the culling of younger cattle for veal. This change in the culling practice was recorded at Castle Mall as well as at later medieval sites all over the country: its early occurrence in Norfolk is discussed by Albarella *et al.*in Chapter 3.

Butchery

Butchered cattle bones were recovered from all periods. Although few elements were left complete, butchering evidence was noted on metapodials, calcaeneus, ribs, vertebrae, mandibles, tibia, talus, phalanges, scapulae, pelvis, humerus and horncores. It took two basic forms: chop marks (made with a cleaver or heavy chopper) and fine cut marks (probably made with a knife). Saw marks were visible on one cattle horncore, indicating use of the horn for working (see 'Craft' below).

The butchering of elements such as the metapodials, calcaeneus, phalanges and talus indicate the splitting up of the carcass and either the processing of lower quality meat or simply the resultant waste. Some of the metapodials may have been butchered to remove the marrow. Splitting of, or cuts on, the vertebrae were also recorded. Splitting was in the sagittal plane which probably indicates the reduction of the carcass to produce two sides of beef. The split vertebrae may also indicate marrow extraction.

Chopping was noted on the proximal ends of the humerus and tibia, as a result of detachment of the hind leg from the rest of the carcass to produce high quality meat. Chopping and cut marks were apparent on a large number of ribs, although the location of these butchering marks was quite variable and suggests a rather random method for dismembering this part of the carcass. Both chop and cut marks were evident on some mandibles, possibly the result of detaching the tongue or in the process of removing the brain.

Chopping or sawing indicative of horn-working was evident on cattle horncores from ditch and pit fills (Periods 3.2 and 5.2), while medieval and late medieval fills of the south bailey ditch (Periods 4.2 and 5.2) yielded evidence for bone-working in the form of six probable strip or box mount fragments made from cattle ribs.

Anatomical Distribution

The frequency of body parts was only examined for the hand collected material. The assemblage is dominated by limb bones and ribs in roughly equal proportions, with lesser quantities of mandibles/loose teeth, foot bones and vertebrae. Seven horncores were found. Other body parts (scapulae, pelvis and skull) were present in only a few contexts. The frequency of body parts recovered remained much the same throughout all periods, tending to represent the lesser quality meat bones such as the mandibles, tibia, and radius/ulna and the low quality/waste bones such as the metapodials, phalanges and calcaeneus. The metapodials bear very little actual meat although they are a very good source of marrow. Deposits of 15th- to 16th-century date demonstrate the disposal of some of the higher quality meat bones: the scapula, humerus, pelvis and femur.

Pathology

The low number of pathologies recorded in this group is due, at least in part, to the relatively high number of juvenile cattle present. Dental calculus (a dark deposit with a metallic appearance) was observed on several mandibles, although it had not resulted in any noticeable periodontal disease. Probable arthritis was noticed on an adult tibia from a late medieval/transitional pit (GBS Group 45, Period 5.2). The proximal end of a metapodial from Conquest period fills of the cemetery boundary ditch (GBS Group 25, Period 2.1) showed signs of lipping and moving of the facet, probably due to an arthritic condition. Another metapodial from early fills of the Castle Fee ditch (GBS Group 27, Period 2.2) exhibited extra growth at the proximal end pushing the two smaller facets over to face the back of the bone, again, probably due to arthritis. The

Plate 58 Golden Ball Street: red deer antler burr

Plate 59 Golden Ball Street: horse radius ?handle

two pre-15th-century individuals displaying arthritic conditions may have been used for traction, resulting in greater physical and environmental stresses.

VI. Sheep/Goat

(Plates 60–61)

Sheep or Goat?

Although sheep was well represented, a single goat horncore attests to the presence of this species.

Age

Adult and juvenile remains were discovered, juveniles being more common in the 15th to 16th centuries, indicating a greater interest in lamb at this time. The juveniles included unfused and part-fused individuals, while the adults included individuals with a reasonable degree of tooth wear, although no very old animals were present.

Butchery

Butchery marks attest to chopping and cutting, although chopping marks are less common than for cattle. This probably results from the much smaller size of sheep with less requirement for force in dismembering the carcass. Chopping and/or cut marks were noted on mandibles, radius/ulna, metapodials, ribs, skulls, humerus, horncore, tibia, vertebrae, upper jaw fragments, scapulae, calcaeneus and pelvis. Many of the butchering marks relate to the splitting of the carcass for various cuts of meat, using similar means as for cattle. Fine transverse knife cuts were found on the proximal end of a sheep metacarpal from a late 15th- to 16th-century pit (GBS Group 44, Period 5.2) and may result from skinning or the process of severing tendons to dismember the carcass. Several vertebrae had been split in the sagittal plane, either during the production of cuts of meat or for the removal of marrow.

At least two sheep skulls had been sagittally split, presumably to allow for the removal of the brain (GBS Group 13, Period 5.2 and Group 45, Period 5.2). Upper jaw fragments and mandibles also bore several chops and many fine knife cuts, possibly indicating brain removal or extraction of the tongue. Sixteenth-century backfills of the south bailey ditch (GBS Group 48, Period 5.2) produced two examples of saggittally chopped sheep vertebrae, presumably for marrow extraction, along with another sheep skull with a transverse chop that could again indicate removal of the brain. This group contained a further fragment of upper jaw with fine, transverse cuts above the teeth on the outer area of the skull.

Most of the sheep horncores showed chop marks where they had been cut off the skull. Some also displayed further cut marks as a result of the removal of the horn sheath for horn-working, with some also having the tip of the core missing.

Anatomical Distribution

As a result of the smaller size of sheep, there is a tendency for the smaller elements to be under-represented in hand collected groups. This is evident in this assemblage, with the limb bones, mandibles, scapulae and other larger elements being present in all periods. In hand collected material the smaller elements are under-represented in all periods. A greater proportion of body parts are present in the 15th to 16th centuries, although this mainly results from the greater quantity of material. Many of the remains are of the main meat-bearing bones such as the tibia, humerus and scapulae producing a higher quality meat. The lower quality meat bones were also present, such as the metapodials, jaws and skull fragments.

Pathology

A greater number of pathologies were noted for sheep than for cattle. The most common are the accumulation of dental calculus and the occurrence of periodontal disease which occurs on several individuals from different

Plate 60 Golden Ball Street: sheep horncore with 'thumbprint' depressions (Period 3.2)

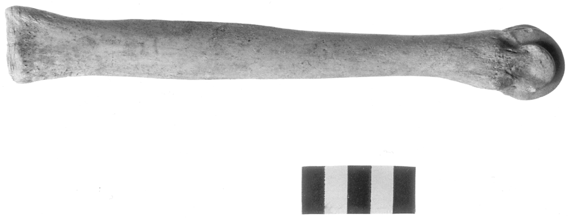


Plate 61 Golden Ball Street: sheep metapodial ossified haematoma? (Period 5.2)

periods. One metapodial from a late 15th- to 16th-century pit (GBS Group 44, Period 5.2) has a possible ossified haematoma (see Plate 61) on the anterior surface of the proximal half of the shaft. This is probably the result of injury and suggests bruising as a result of continuous pressure in one place, the pressure leading to sub-periosteal bleeding and the formation of new bone. This condition has been observed on other archaeological sites, notably at Walmgate, York (O'Connor 1984). A similar pathology was noted on a cattle bone at Castle Mall (Albarella *et al.* Chapter 3).

A horncore recovered from a Castle Fee ditch fill (GBS Group 20, Period 3.2), showed at least two 'thumbprint' depressions caused by calcium resorption (see Plate 60). The condition is commonly found in archaeological sites and has been associated with environmental stresses such as breeding in elderly animals or malnutrition (Hatting 1983). Similar evidence was also found across the Castle Mall excavation (see Chapters 3 and 4).

VII. Pig

(Plate 62)

Age

It appears that most of the Golden Ball Street pigs were killed as juveniles or young adults (many unfused elements were recovered). This kill-off pattern is common on other archaeological sites, reflecting the fact that pigs are kept almost entirely for meat. Apart from breeding, there was no reason to keep pigs to full maturity. Adult animals (with fully fused bones and all molars present) were killed before attaining reasonable age and there is very little wear apparent on most of the teeth.

Plate 62 Golden Ball Street: pathological pig mandible showing unhealed fracture (Period 5.2)

Butchery

Knife cuts were visible on one radius, indicating the removal of meat from a joint. Several knife cuts found on the lateral side of a mandible may suggest the removal of the tongue or cheek meat.

Anatomical Distribution

As with the cattle and sheep, smaller elements of the skeleton, such as tarsals and phalanges, were under-represented in the hand collected material. A slightly higher proportion of these smaller elements were recovered from the sample collected material as a result of sieving. Generally, body parts present were the limb bones, mandibles and isolated tusks. The group was too small to permit comparison between periods.

Pathology

One pathology was found on a pig mandible (Plate 62) from a late medieval/transitional pit (GBS Group 44, Period 5.2). Under the area of M2 there is a considerable amount of spongy bone growth all around the body of the mandible. This growth appears to be as a result of the fracture of the mandible and an infection in the area, causing swelling and abscessing. The development of the growth shows that the fracture failed to heal and only the mandibular condyle, M3 and the growth around the area of M2 is present. It is possible that overstocking and/or malnutrition could have contributed to the extent of the infection and the lack of healing in this specimen. A pig mandible with a similar injury and infection was also recovered from the barbican well at the Castle Mall site (see Moreno García above). It is not certain what could have caused such an injury, but quite a hefty blow would have been required.

VIII. Other Mammals

(Plates 58–59)

Equids

Only two horse bones were identified, both in the form of worked radii, the proximal ends of which had been utilised to serve as handles (*cf.* Margeson 1993, fig.143; see Plate 59). The lack of other horse remains is not surprising, given that they are a traction animal and not normally used for food.

Dog

The few isolated elements attributable to dog included limb bones, jaw fragments/isolated teeth and metacarpals from small to medium sized animals. Further evidence for the presence of canids came from gnawing on bones from late medieval and post-medieval pits and ditch fills. Tooth marks were recorded on cattle metapodials and rib fragments, a pig radius and possibly a goose radius (this gnawing was either by a small dog or cat). Evidence of canids eating sheep remains came from 16th-century fills of the south bailey ditch with canid gnawing evident on a sheep metapodial. One sheep phalange shows acid erosion which may indicate that it had passed through the digestive system of a dog. Dogs may therefore have been fed butchery or household waste, or animal waste may have been dumped into the ditches and left uncovered long enough to allow scavenging by dogs and other animals.

Cat

Although there were no skeletal remains of cats from the Golden Ball Street excavation, possible evidence for their presence took the form of tooth marks on a goose coracoid bone from a 17th-century pit. Similar gnawing was found on domestic fowl bones from the barbican well at Castle Mall (Moreno García above).

Deer

A red deer antler burr, sawn on two sides, was unstratifed (see Plate 58), while a sawn/cut fragment from the palm of a fallow deer came from Conquest period fills of the boundary ditch of St John's cemetery (Group 25, Period 2.1). The latter had been sawn/cut on three sides, possibly in the process of making a tool or decorative item. The red deer antler was naturally shed (in the springtime) and would probably have been collected from nearby woodland.

Minor Species

The majority of rabbit remains were humerii and phalanges, although two mandibles were also retrieved. All specimens found were full adults. The rabbit was a popular meat animal, although no clear butchering marks were seen on the bones from this excavation. The rabbit was introduced into this country by the Normans and were originally kept in fenced enclosures. They extended their range quickly and became well established by the medieval period.

Elements of hare consisted of phalanges and a humerii. Although no butchery marks were present, these animals may have been eaten.

Eleven mole bones were found in a 12th-century ditch fill and consisted of a vertebrae, a pelvis and nine limb bones. This animal may have been the prey of a dog or cat, or it may have burrowed down from an upper level.

IX. Birds

Domestic fowl

Domestic fowl are represented by various elements including the humerus, tibiotarsus, coracoid, tarsometatarsus and skulls. The majority of bones are of adults, with juvenile definitely identified in medieval and post-medieval pits. The younger birds may indicate breeding on or close to the site. The remains from this excavation included at least one male, identified by the spur on the tarsometatarsus. Butchering, in the form of knife cuts, was only noted on one ishium. No pathologies were present.

Goose

Elements of goose include the tarsometatarsus, coracoid, tibiotarsus, humerus, fercula, distal phalanx and the carpometacarpus. Juvenile elements came from a 17th-century pit and again may indicate local breeding. Although the goose was less common than the domestic fowl more of the birds had been butchered, replicating the situation noted at the Castle Mall site. Knife cuts were found on the coracoid, fercula and carpometacarpus. The higher frequency of butchery marks on goose bones reflects the larger size of the bird which made it a popular choice for meat.

Wild Birds

Ducks are much less common than geese, something that is found on most medieval sites in Britain (Grant 1988) and — as noted elsewhere in this volume — it is possible that they only provided food for a lower class of people. Most of the remains found on the Golden Ball Street excavation belonged to mallard and included a pair of juvenile tarsometatarsus. The duck remains also included a coracoid from a very small species; probably the widely common teal.

Both partridge and pheasant were evident in small numbers from the 15th to 16th centuries onwards. Pheasant was introduced in the Roman period and would have been widespread by the medieval period, providing a popular meat. The partridge was a highly prized food bird in medieval times (Albarella and Davis 1996) and may indicate the inclusion of higher status food waste amongst the assemblage.

X. Herpetofauna

Two limb bones (radio-ulna) both came from the common toad (GBS Group 14, Period 6.2). This species was probably common in the area of this excavation during the post-medieval period as there was marshland relatively nearby and the common toad travels some distance from water outside the springtime breeding period. It is often found around human habitation. The low number of herpetofauna remains is due, at least in part, to the lack of fine mesh samples taken.

XI. Fish

Although the fish bone was not identified to species, a single example of roker (also known as thornback ray) was instantly recognisable from the presence of several dermal denticles (65g). This came from pit *411/530* (GBS Group 44, Period 5.2). As noted by Locker above, this marine food species would have been line-caught in shallow water.

XII. Human Skeletal Remains

Part of an upper jaw, from the area of the right incisor teeth, was recovered from a late medieval post-hole where it had been used as post-packing (GBS Group 43, Period 5.2). Presumably, it was disturbed from one of the local cemeteries (detailed in Part I), the closest being those of St John de Berstrete/Timberhill (the most likely candidate), St Martin-in-Balliva and another beneath modern Farmer's Avenue.

XIII. Discussion and Conclusions

As is evident at the Castle Mall site, waste from all levels of society is present at Golden Ball Street. The assemblage demonstrates that cattle were the most popular source of meat throughout all periods with both beef and veal consumed in later times. Sheep and pigs were also consumed regularly, with younger animals being preferred. Mutton was eaten, but consumption would have taken secondary place to the use of sheep for their wool. A variety of birds was also consumed, most commonly chicken and goose. The goose was an obvious choice for food given its large size. Both of these birds would have provided a ready supply of eggs, the goose also providing feathers. In medieval times, however, the emphasis changed from egg to meat consumption and this may have contributed to their greater numbers at the site between the 15th and 17th centuries. Wild birds such as partridge and pheasant had some place in the diet but neither they nor fish feature much compared to other remains. Notably, no pheasant remains were identified from the Castle Mall excavation.

Although small compared to that from Castle Mall, the Golden Ball Street assemblage provides supporting evidence in relation to changes in agricultural practice noted there, specifically a reduction in the culling age of cattle during the late medieval/post-medieval period linked to the consumption of veal. The lack of detailed metrical analysis, however, hampers comment on changes in other species.

Evidence for craft activity at Golden Ball Street is limited, although antler-, bone- and horn-working were apparent. Bone-working was evident only in early fills of the castle ditches. Evidence for horn-working indicated the utilisation of cattle, sheep and goat horns. As is commonly the case, none of the actual horn was preserved and the bony horncore is all that was recovered. The tips of some of the Golden Ball Street horncores had been removed as part of the process of removing the horn sheath.

The animal bones derived from two main types of context: domestic-type pit fills and ditch fills. The pit fills probably represent small scale general domestic/craft residue and the disposal of butchery waste. The ditch fills are likely to represent larger scale disposal of rubbish, probably including complete or near complete animal carcasses. As noted above, documentary evidence indicates that the disposal of animals in the ditches was common practice and the lack of any articulated material from Golden Ball Street may suggest a considerable amount of re-working of the soil at various stages. The evidence of canid gnawing indicates that rubbish may have been left uncovered for periods of time, allowing scavenging by dogs and cats. Scavenging activity could also account for at least some of the re-distribution of the animal remains.

Chapter 7. General Discussion and Conclusions

by Jacqui Mulville

I. Introduction

This chapter considers the four separate faunal reports above as a single entity in order to discuss the changes in animal use around Norwich Castle. All four reports have detailed discussions on which this chapter relies. This chapter is by necessity brief and interested readers are directed to the individual reports for additional information. As noted in the introduction (Chapter 1), these reports represent the analysis of a large collection of bone and provide a picture of animal usage from the Late Saxon through to the post-medieval period; that is from the 10th to the 18th century AD. The excavations in advance of the Castle Mall development (Chapter 3, Albarella *et al.*) produced the majority of material and spanned the longest date range. A well lay within the castle barbican (Chapter 4, Moreno García), and although constructed in the 12th century, the deposits analysed dated to between the mid/late 15th and early 16th centuries. For both these assemblages the significant quantities of fish were extracted and are the subject of Chapter 5 (Locker). These three reports describe full analyses. The Golden Ball Street assemblage was significantly smaller and derived from a wide date range, from the Norman Conquest to post-medieval contexts. It was the subject of a 'scan' (Chapter 6, Curl); fish bone from this site was not identified and no metrical information was recorded.

II. Comparison of Methodologies

The methodology for each of the four groupings varies in detail and has resulted in four different recording and analytical strategies being employed. This was not a problem for the fish remains; since the only identified fish derive from the Castle Mall and barbican well contexts (with the exception of a thornbacked ray noted from Golden Ball Street) they were analysed as a single assemblage. For the mammal and bird bone the predominance of the large Castle Mall assemblage overall has resulted in the majority of conclusions being drawn from this area with the other sites providing ancillary information.

It is possible to compare briefly the results generated by these different methodologies; from the rapid scan at Golden Ball Street to the detailed analysis of the barbican well. Each of these methods provides a different degree of information, and the balance between speed, economy and detail can be considered. The 'scan' at Golden Ball Street allowed this small assemblage to be compared with the other larger assemblages, but not to contribute to the more detailed discussions on shape and size. As a stand-alone report it contributes little new information on the zooarchaeology of Norwich but as part of a wider study it can be usefully compared with the larger assemblages. The barbican well assemblage was recorded in the greatest detail and allowed a careful analysis of the body part distributions and butchery which is missing from the Castle Mall site. The briefer recording method at the latter facilitated the effective recording of this substantial assemblage, with the collection of an extensive data set of metrical and ageing information in a short period of time. The larger size of the Castle Mall assemblage is its major advantage and it is hard to judge how much information was lost in the exclusion of many elements and parts of elements. For example the abundance of sheep scapula in the post-medieval period could not be related to, or excluded from, the articulating proximal humerus as this bone was not recorded. In terms of the quality of information the full analysis produced the best results, but in terms of economy the more rapid recording method at Castle Mall, with a loss of some information, provided a good compromise. The rapid scan at Golden Ball Street provides useful basic information but also serves to demonstrate the need for more detailed work.

III. Use of Space

The groups detailed in this volume represent differing activities around Norwich Castle. The earliest animal bone evidence is from the Late Anglo-Saxon deposits at Castle Mall when this area was organised as a settlement with several 'properties'. There are differences in species frequency and the type of handicraft present across the area but no obvious divisions between industrial and domestic spaces could be identified. From Period 2 onwards the animal bone derived from the outer and inner ditches of the castle and structures and other features located within the castle perimeter including the barbican well. Differences in the contents of ditches and pits have been noted by Albarella *et al.*(Chapter 3) for Castle Mall, but could not be identified within the smaller Golden Ball Street assemblage. Ditches appear to have been used for large scale dumping of the town refuse, whereas pits were associated with small scale domestic activities, although some contained substantial evidence for industrial processes (*e.g.* Castle Mall, pit *11048*). In particular, the disposal of the carcasses of dead animals in the barbican ditch (Fig.9.B) seems to have been common practice during late medieval and post-medieval times. The mid/late 15th- and early 16th-century fills of the barbican well are derived from a range of activities and include both food and industrial waste as well as a number of smaller animals.

The decline in the frequency of canid gnawing marks in later periods at Castle Mall suggests that dogs had less access to the bone waste, and is probably related to a more organised system of rubbish disposal. This would have become necessary as the density of population increased and is consistent with the increasing urbanisation of the town in late and post-medieval times. By the late medieval period rubbish disposal was well organised and butchers were assigned places to dump their waste (Dyer 1989, 191)

IV. Species Represented

Turning to the detailed results, the analyses revealed the evidence for seven domestic mammals: cattle, sheep, goat, pig, horse, dog and cat. A wide range of other species was also noted, including fourteen wild mammals, four domestic bird species and about twenty wild bird species. The large fish assemblage produced evidence for some thirty-seven species/families.

For the domestic species, the Norwich Castle assemblages reflect the situation found across England; the main food mammals are cattle, sheep, pig and domestic fowl and up until the 14th century their respective roles were as providers of traction, meat and wool, meat and feathers/eggs. All these animals were eventually killed and eaten, but in general their role as providers of secondary products was of greatest value. This changed from the 14th century onwards when firstly wool and then later mutton and beef become of greater import. A comparison of the relative abundance of the main food animals — cattle, sheep and pig — for a number of medieval sites has identified that the largest assemblage, Castle Mall, has more in common with other urban sites rather than with high status castle sites (Albarella *et al.* Chapter 3). This is reflected in the general absence of evidence for high status, either from the animal or the plant assemblages, for these periods.

Norwich, like many towns, had large markets and it is likely that the majority of stock was imported on the hoof into Norwich and slaughtered by butchers, with joints of meat sold on. The presence of very young, neonatal, bones of the main domestic species suggests that a small amount of on-site breeding occurred. This demonstrates either the presence of open areas within the city providing grazing (for example the Castle Meadow; see McPhail Part I, Chapter 3.IV) or the keeping of house cows and pigs within smaller enclosures and yards. Other urban Late Saxon and early medieval sites in England have less evidence of neonates (*e.g.* Southampton, Bourdillon 1994 and York, O'Connor 1994) although problems with spatial variation and the preservation of fragile neonatal bone may be biasing this evidence.

In Late Saxon and early medieval times the majority of cattle were killed when adult or elderly (over 3–5 years). A second peak in slaughter at the prime meat age (sub-adult) in the latter period suggests an increasing interest in beef. From the late medieval period onwards all the assemblages (Castle Mall, the barbican well and Golden Ball Street), indicate that cattle were slaughtered mostly as juveniles and adults. This change over time reflects a change in emphasis from the use of cattle as traction animals, with a small beef trade, to one where surplus calves were slaughtered to provide veal and to liberate milk for human consumption.

Sheep were generally slaughtered between their second and sixth year. In the earlier periods there is an emphasis on meat production with animals killed toward the younger end of this range. From the late 12th century onwards there is a change, with the majority of animals killed at an older age demonstrating a switch in emphasis to wool production. This switch reflects the development of the wool trade which started in about 1200 AD and rose to a peak in the late 13th to early 14th century (Dyer pers. comm.). The best wool is taken from wethers and the variation seen in sheep size during the medieval and late medieval periods may reflect a change in the sex composition of the herd or the appearance of a new type of sheep associated with wool production. Sheep in the post-medieval period are larger than in previous periods suggesting that improvements in stock were beginning, possibly driven by an increased demand for mutton. There is also evidence that pasture and fodder provision for sheep was problematic, with some evidence of osteoporosis seen in the presence of small depressions on horncores and the smaller size of the sheep within the well. Feeding stock — particularly in winter — caused problems, and there is historical evidence for quarrels over grazing, most notably in the later Middle Ages (Dyer comm.).

The evidence for goats is rather sparse. They represent a small and declining part of the assemblage at Castle Mall and are virtually absent at the other two sites. Goats were frequently mentioned in the Domesday book, but their number declined in the 12th and 13th century because they were hard to contain within enclosures and a threat to hedges as well as destroyers of woodland (Burke 1834 II, 505). They are generally much less common on archaeological sites than historical records suggest they should be (Albarella 1999, 2002a) and the evidence from Castle Mall has been used to argue for a trade in goat horncores.

Pigs were only exploited for meat, and as they provide only death products their age of slaughter depends on the balance between feed provision and carcass size. In the earlier periods the majority of pigs are killed as two year olds, but from the late 12th century onwards both the barbican well and Castle Mall assemblages demonstrate a shift in emphasis towards younger animals; many die at around one year of age. This shift to a younger age of slaughter is demonstrated at other urban sites such as Exeter (Maltby 1979) and Lincoln (Dobney *et al.* 1996), and generally reflects husbandry advice at that time, for example Markham (1614) and Mortimer (1707). A younger age of slaughter suggests a desire to increase productivity which could come about through the selection of improved, faster growing breeds. There is an increase in the number of pigs kept within the town over time, and the presence of pigs is noted in documentary sources that ordain town folk to keep their pigs within their enclosures (see Moreno García, Chapter 4).

Domestic fowl are common throughout all periods; the majority of birds were killed as adults although over time there was an increase in the number of juveniles in the assemblage. This trend is apparent at other British sites (Grant 1988) and is probably associated with a shift away from egg production in the Middle Ages to meat production in the later periods. There is a corresponding change in the sex ratio; hens predominate in the earlier periods when egg laying is important, whilst there is an equal number of hens and cocks in the later periods at Castle Mall and the barbican well when both sexes were killed young to provide meat. Butchery marks on domestic fowl limb bones were cut marks associated with chicken consumption.

The body part evidence for the major food mammals indicated a general spread of all elements for all species; thus entire animals were bought on the hoof to Norwich. There is some evidence for differing abundance of elements across the site and throughout time. There are, however, no general observable trends; the deposits found in the areas around Norwich Castle vary in their content, demonstrating local changes in fortune or rubbish dispersal strategies over the periods represented.

By examining which parts of individual species are found at the sites the changing fortunes of the individual areas can be examined in detail. At the Castle Mall site there seems to be an emphasis on cattle hind limbs in the early phases and on forelimbs in the later phases. In the post-medieval period in particular the best cuts of meat are absent from the Castle Mall contexts and these deposits contain more waste bone, the prime meat associated with these carcasses being consumed elsewhere in the town. This differs from the material contained within the late medieval/transitional well contexts which demonstrated an abundance of meat-bearing bones. At Golden Ball Street the change over time is the opposite to the Castle Mall assemblage: there is a predominance of lower quality meat and waste bones in the earlier periods with more prime meat bones appearing in the 15th and 16th century. There is little evidence of any specialised industrial activities involving cattle bone, horn or hides; the majority of bones are related to food production.

Sheep usage has a different trajectory, in the early phases at Castle Mall all elements of the skeleton are present, but in the later periods (from the late 12th century) waste bone became increasingly common, with deposits of horn and tanning waste present (horncores, metapodia and phalanges). Within the barbican well meat-bearing bones are slightly more abundant than waste bones, suggesting that, as for cattle, the well received mostly food waste although a few contexts also have evidence for the processing of sheep hides. The smaller samples from Golden Ball Street show a slight predominance of meat bones in the 15th to 16th century compared to the earlier deposits, with a small amount of horn/hide/bone-working noted.

Despite careful morphological and metrical analyses of all elements for evidence of goat remains, goat horncores are far more common than other parts of the skeleton. This pattern has been noted at a number of sites in Norwich and other urban areas (Albarella 1999, 2002a) and suggests that horncores were imported to the town for handicraft purposes. Although they may have arrived attached to hides, as is described for sheep, the absence of goat metapodia indicates that this is unlikely and instead the data provides evidence of a trade in goat horncores alone. These elements, or rather their associated horn, must have had a value beyond that of any other parts of the goat carcass. Goats were probably used mainly for milk production. Their meat was not highly regarded in England (Markham 1614, Burke 1834) and the lack of goat bones suggests their carcasses were not bought to Norwich for sale. Instead they were kept in the countryside, milked, and once past their useful life consumed locally with only their hides/horncores imported to the city.

There are no differences in body part distribution for pig over time. A range of elements is always present at Castle Mall and Golden Ball Street, whilst in the barbican well a high proportion of meat bones is again evident.

Thus variation in body parts at the sites reflects the range of contexts this material was derived from. The ditches and pits of Castle Mall appear to contain more waste material than the comparable well assemblage, although some discrete dumps of industrial waste and stray dogs and cats were disposed of within the well. The pits and ditches of Golden Ball Street contain both food and slaughter waste, with some evidence for horn- and bone-working present. This suggests that material placed in the well generally derived from consumption, with the occasional episode of more specialist waste disposal, whilst in other areas the contexts were more mixed.

V. Butchery and Craft Waste

Butchery evidence is available throughout the history of the site; however the most detailed analysis was undertaken on the late/post-medieval fills of the barbican well. In general, the proportion of butchered cattle and sheep bone increased over time, and the frequency and method of butchery used for the major food animals reflects their carcass size. In all periods butchery marks were more commonly reported on cattle bones than on those of sheep and pig. The larger cattle were more often butchered with a large bladed tool, bearing chop rather than cut marks as their substantial carcasses require more division for dispersal, cooking and marrow extraction. Smaller carcasses could be divided into manageable units through disarticulation and hence demonstrate more disarticulating knife cuts. The first evidence for the use of saws comes from the post-medieval period.

Areas of intensive butchery in the cattle skeleton included *all* the major joint articulations; demonstrating division of the limbs into the individual longbones. Skulls showed evidence of tongue and brain removal, and the removal of the horncore. Little evidence of subsequent shaft butchery was observed, suggesting that either careful pre-cooking occurred or that bones were cooked as complete joints with only less damaging post-cooking butchery occurring. Sheep and pig joints were less extensively butchered demonstrating the use of larger portions of individual animals within households. For all three species the lower limbs showed marks associated with skinning and ligament severing with the removal of the metapodials and phalanges. In pigs, cut marks relating to skinning were less common, and it has been suggested that in pigs only the phalanges were removed, the metapodials remaining with the carcass.

Vertebral butchery at both the barbican well and Golden Ball Street demonstrated the splitting of the carcass. This evidence is absent from the Castle Mall assemblage, as vertebrae were not recorded. Cattle, sheep and pig were all divided by splitting down the length of the body to produce two sides of meat. To do this the carcass would have been suspended by the hind hocks, and there is evidence for the subsequent removal of the hock in cattle and sheep. The practise of splitting carcasses becomes more common in the later phases at these sites.

If the body part data and butchery data are combined with historical records indicating the presence of numerous butchers (see Tillyard and Shepherd Popescu, Parts I and II), it is apparent that the majority of meat was being provided by animals bought in to market, slaughtered and divided into joints by the butchers and then sold on to individual households.

There is abundant evidence for horn- and bone-working from finished artefacts, unfinished artefacts and waste. The most commonly worked material is horn, with cattle and sheep horncores showing evidence of removal from the skull, subsequent collection and in some cases cut and chop marks associated with the removal of the sheath or the tip of the core. The major concentration of cattle horncores comes from the Norman and post-medieval periods. There are fewer sheep horncores scattered throughout the time at Castle Mall, although four sheep skulls with horncores removed were found in Period 2 and one pit in Period 5 produced twenty-one horncores all of which had been removed from the skull by chopping. In the barbican well a large number of sheep horncores were recovered, the majority of which were either chopped or sawn near the base. For other comments on bone-working see Huddle *et al.*(Parts I and II).

Leather-working is also common on the sites, a number of leather artefacts and offcuts were recovered, with associated evidence coming from skinning marks, and for sheep, from a number of metapodia groups. At Castle Mall, pit *11048* contained 109 metapodia and 60 sheep phalanges, in addition to the 21 horncores mentioned above. High concentrations of foot bones are associated with tanning waste and the presence of metapodials, phalanges and horncores in this pit demonstrate that the head and feet were left attached to the skin when it was removed. In the barbican well sheep metapodia — but not the associated foot bones — were the most abundant element and these were concentrated in certain contexts. There were almost equal quantities of metacarpals and metatarsals and a similar number of lefts to rights present which suggested that this material could have derived from the skins of forty or so individual sheep. The absence of phalanges, unrelated to recovery methods, suggests separation of the metapodia and foot bones before deposition in the well. This could be linked to some further processing of the metapodia, perhaps by boiling to extract fats and oils.

Other crafts represented in the faunal assemblage include the notable evidence for quill dressing or arrow fletching from the barbican well, detailed by Moreno García above.

VI. Minor Domesticates

Minor domestic species make up a smaller but important part of the assemblage. The horse bone mainly derives from the Castle Mall site; Golden Ball Street and the well produced few bones. At Castle Mall there is a change from articulated groups of bones in the earliest phases to disarticulated bones in the post-medieval period when horse remains become more common. The majority of equids were pony-size although in the post-medieval period some horses were present suggesting an increase in size. Careful analysis of equid teeth at Castle Mall produced no evidence of donkeys; although it is possible that other donkey elements may have been present.

Cut marks at the limb extremities demonstrate the use of horse hides, however some of the butchery was concentrated on the meat bones and suggested that some of the horse carcasses were divided up for consumption. However horse bones were less frequently butchered and generally more complete than the comparatively sized cattle, suggesting their carcasses were not as intensively utilised. Despite the proscription against hippophagy by Pope Gregory III (AD 732), in periods of poor harvests and livestock disease horsemeat was consumed by people (Hollis 1946), alternatively horsemeat was a recommended dog food, and seems to have been particularly favoured for hounds. The more robust horse bones were often worked; two elements at Golden Ball Street had been worked into handles, whilst an unusual horse mandible sledge was recovered from the ditch contexts at Castle Mall along with other sawn bones (see Huddle Part II, Chapter 10.III).

At Castle Mall, horses are more common in the early and post-medieval periods, although the abundance in the former is probably due to the disposal of these large animals in the castle ditches. Overall, horses make up only a small part of the assemblages, which seems at odds with historical data indicating the predominance of arable farming in Norfolk and the widespread use — from the 12th century onwards — of horses to pull ploughs, carts and to act as pack animals in the course of trade (Dyer 1988; Dyer pers comm.). Indeed, historical records demonstrate that Norwich, from medieval times, had some of the highest proportions of working horses found in England (Langdon 1986), although oxen remained in use until the 17th century (Overton and Campbell 1992); the latter is confirmed by the discovery of ox-shoes in Period 5 and 6 deposits at Castle Mall (Mould, Part II, Chapters 8.III and 10.III). However very low frequencies of horse bones have also been noted for the other Norwich sites of Alms Lane (Cartledge 1985), StMartin-at-Palace Plain (Cartledge 1987) and Fishergate (Jones 1994), which suggests that few horse carcasses made their way into urban deposits.

There are only a few isolated dog bones recovered from Golden Ball Street, but at Castle Mall and in the barbican well they are more common. A number of skeletons were recovered from the barbican ditch and the barbican well, as well as isolated dog burials (see Part II, Chapter 10.IV). Analysis revealed dogs of a variety of heights, with an increase in the size range over time. In the early phases small-medium and medium-large dogs were present but by the latest phase mostly small dogs were recovered from the Castle Mall contexts and medium-sized animals in the well, with occasional very large individuals noted. The majority of dogs were adult, although puppies and some very old individuals were also identified.

The presence of butchery marks on a number of dog bones is of note and suggests that dog carcasses were of value. The bodies of animals at the Castle Mall site were divided with chop marks at joints and knife marks on the main bones, whilst there are skinning marks on a single individual in the well. There is little documentary evidence for dog consumption, however Grant (1979) and Dobney *et al.*(1996) have suggested that on some sites dogs flesh provided the occasional meal. Another use of dog carcasses is to provide food for other dogs (Wilson and Edwards 1993), or they could be rendered producing dog fat for cosmetic and medical reasons (Gidney 1996). The death and disposal of this species is of interest, there is evidence to suggest that dogs, as well as cats, were considered a nuisance and some animals appear to have been eliminated by being thrown live into the well (see wider discussion by Shepherd Popescu in Chapter 9.VI).

Cats were as common as dogs and present in all periods. As for dogs, both young and old individuals were identified, and there were many articulated groups of bones present. The cats also bore evidence for the use of their skins with cut marks on their skulls, mandibles, metapodia and phalanges but no butchery evidence for the use of their flesh. On the main site many immature animals were skinned in the Late Saxon and early medieval periods. Over time animals died at an older age and demonstrated less exploitation of their skins in the post-medieval period. There is ample evidence on medieval sites elsewhere for the exploitation of young cats for their pelts (McCormick 1988; Serjeantson 1989; Albarella and Davis 1994b; Luff and Moreno García 1995).

Disused wells often seem to have presented an ideal opportunity for the disposal of unwanted felines, and the occasional dog. In addition to the numerous cats found in the barbican well, a well in Cambridge contained the remains of 79 skinned cats (Luff and Moreno García 1995). The Norwich animals were not necessarily dead upon disposal; at least five cats were thrown into the barbican well alive; their skeletons were found lying within putlog holes into which they had presumably crawled.

Minor domestic birds are represented by goose and duck. The geese derive from a mainly adult population in the earlier phases, with more immature animals present in the post- and late medieval phases. As for domestic fowl this suggests a change in emphasis from egg production to one where the animals were bred to be consumed. Geese were also prized for their feathers and the large collection of carpometacarpi dumped within three contexts in the well may relate to this. The butchery evidence indicates severance of the primary flight feather bearing wing tips, including the first and second digits, from the edible lower portion of the wing. There were twice as many left wing elements as right elements present. Primary feathers had an important use in fletching arrows and in the making of quills. It has been suggested that right handed people may prefer the quills from left hand wings as these would curve away from users, which could explain the abundance of left hand wing elements in the assemblage: a similar bias may relate to fletching which requires feathers from the same side of the bird. For a further discussion of both this issue and the wider context, see Shepherd Popescu, Part II Chapter 9.VI.

VII. Wild Species

Wild foods seem to have played only a minor role in the evolving urban environment. The most common wild species is red deer, and for all three deer species present the most common element is antler; often shed and/or worked. Few post-cranial elements are found demonstrating that venison was rarely eaten by town inhabitants. Instead there is evidence for a trade in antler and material associated with all the stages of production of antler artefacts. Where this traded antler comes from is unknown, is it collected from wooded areas around Norwich or further afield? The presence of red deer has often been identified as a high status marker, hunting particularly after the Norman Conquest was a strictly controlled pursuit and the preserve of the aristocracy. The lack of venison consumption during all periods of the site suggests that even when the Castle was in its heyday those living around its precincts rarely had access to rich foods.

There is occasional evidence for fallow deer, this species is rare if not absent from Saxon sites and only became common with the Norman Conquest (Lister 1984). Norwich provides some of the earliest records of the reintroduction of fallow deer with two 11th- to early 12th-century records from Castle Mall, and St Martin-at-Palace Plain (Cartledge 1987). The presence of worked fallow antler in the Conquest period fills of the boundary ditch of St John's cemetery (GBS Group 25, Period 2.1) at Golden Ball Street supports this evidence, although as noted above the traded antler may not derive from a local population. The smaller roe deer was rarely recovered; the only find was a roe deer trophy consisting of the antlers and frontal part of the skull lying within a Late Saxon pit on the main site.

Other wild food species include the lagomorphs; rabbit and hare. Over time rabbit becomes more abundant than hare though both animals are present in most periods. There is evidence for the use of adults as food with mainly meat rather than waste bones present. The increasing importance of rabbits has been reported elsewhere (Maltby 1979); they were introduced by the Normans and originally kept within enclosures, gradually replacing hare as a food source by the late medieval period. The hunting of hare continued however, and hare bones are present in small quantities throughout the history of the site.

There is also the occasional record of other wild species. A badger mandible from Norman contexts and a metapodia from a late medieval/post-medieval fill of the barbican well context suggest that these animals were occasionally hunted. These bones of the head and feet could be associated with the importation of the pelt of this animal. There was also a partial mole skeleton from 12th-century contexts at Golden Ball Street. There is evidence for a range of wild birds, many water birds, some game birds and a few birds of prey. The latter included both species regarded as scavengers, the buzzard, and those associated with falconry, the goshawk. The most unusual bird bones recovered were two parrot bones from a medium sized bird, found in a post-medieval pit (see Part II, Chapter 10). It has proved impossible to pinpoint these bones to species and the bird could be evidence of trade with anywhere in the Southern Hemisphere.

The most unusual food species recovered was the dolphin (*Delphinous* sp). Two vertebrae,one of them butchered, came from barbican well fills dated mid/late 15th- to early 16th-century. Cetacean remains are common on coastal sites from prehistory onwards and were a sought-after food in the medieval period (Gardiner 1997). Their procurement is probably linked to the marine fish trade, indeed they were often an incidental inclusion in the main catch of herrings and sprats. They were treated as fish and could be eaten on Fridays and during Lent and their presence could relate to the increased use of fish in later medieval periods (Gardiner 1997). Alternatively they were considered a suitable dish for feasts at any time of the year and their presence in the well, amongst the deposits richer in food waste, suggests that some higher status food was consumed during this time.

VIII. Fish

It is only with the fish trade itself that any significant contribution that wild foods make to the diet can be traced. Herring and cod are the predominant species recovered; cod were the most important food species in terms of flesh weight, although herring were more numerous. Over time there is an increase in the amount of cod up until the late medieval period (Period 5) where its abundance declines to a level similar in importance to herring. Other important species included both freshwater and marine species: eels, rays, other gadids (haddock, whiting and pollack, saithe and ling) and flatfish (plaice/flounder and sole, halibut and turbot). There were small changes in the overall diversity and relative proportions of species, although the essential balance of species remained the same through all periods and context groups. This suggests a great continuity of fish supply and consumption over time.

The large fish assemblage reflects the proximity of Norwich to the coast (Locker, above). There were major cod and herring fisheries from Yarmouth and local ports, and when these local fisheries failed, cured cod from Iceland and Norway and possibly Dutch herrings were supplied to the town. The records indicate that most of the cod and ling at Yarmouth in the second half of the 16th century went to feed Norwich.

IX. Stock Size

The size of food animals at Norwich can be compared to those at other sites (Albarella *et al.*; Moreno García this volume; Albarella 1997b). The animals are generally similar in size to those of contemporary assemblages; the only exception is the smaller size of the early/mid 15th-century sheep, demonstrated both at the main site and the barbican well, when compared to other sites. This evidence suggests that the increase in sheep size at Norwich came later than at other sites such as Exeter and Lincoln (Maltby 1979; Dobney *et al.* 1996).

The large assemblage at the Castle Mall main site has allowed a comparison to be made between changes in management and changes in animal size from the Late Saxon period through to the agricultural revolution. Over time cattle, sheep, and to some extent pig, domestic fowl and possibly horse all increased in size. The analysis of age data has demonstrated a shift in focus towards meat production in Period 5, *c.* 1345 to mid 16th century; whilst the metrical data indicates that an increase in stock size is not visible until the late 16th- to 18th-century deposits. The only exception is domestic fowl; with a particularly early increase in size during Period 5. The evidence from Norwich suggests that the beginning of the increase in stock size can already be found within the 16th century and may occur earlier, as suggested by Davis (1997); unfortunately for most of the sites the evidence for the 16th century is sparse.

The increase in stock size in Norwich did not occur at the same rate for all species, for cattle it was rather sudden, whereas in sheep it was more gradual and for pig and domestic fowl a size change occurred at a later stage. The general increase in size cannot be attributed merely to improvements in feeding, there is an increase in both bone and tooth size suggesting a genetic change. In general the morphological changes were preceded by a changing emphasis in production; there is now wide evidence for a switch to milk and veal for cattle, towards wool and mutton for sheep, and an increasing emphasis on meat for pigs (Albarella *et al.*this volume; Albarella 1997b). The forces driving these changes have been linked to the effects of pestilence in the 14th century, a new demographic increase in the 16th century as well as the switch from arable to pastoral economy in the later Middle Ages (Albarella 1997b). Stocking densities increased and consumption patterns changed with an increasing demand for meat, and at some point population growth and higher farming productivity would have started to reinforce each other.

X. Conclusion

The assemblages around Norwich Castle have demonstrated the breadth of information available from faunal remains, from the common farm animals providing milk, meat and eggs, to the trade in horns, antlers, hides and bones for crafts and industries. Evidence ranging from the occasional exotic species to the use of non-traditional food animals such as horse and dog has revealed a picture of the human-animal interaction within a medieval town from food to sport to industry. The analyses have revealed details on the diet of the citizens of Norwich; how animals were procured and butchered, which foods people ate and how they disposed of their waste. It has also been possible to link archaeological and zooarchaeological evidence to trace the changing use of space within and around the castle.

The complexity of urban life has been documented in the changing relationships between people and their animals over time, from the cattle used for traction to the focus on meat, particularly veal and mutton, in the post-medieval period. The relationship between the town and its hinterlands, terrestrial, freshwater and marine, has been illustrated through the resources bought to the town. The trade in food animals, in horncores, in antler, in fish and even in exotic birds paints a picture of a city with an extensive network of contacts and complex social organisation. Although the excavations concentrated on the area around the castle it appears that these contexts provide only scant evidence for the diet of high status inhabitants, and instead provides a view of the more mundane aspects of urban life; the intermingling of food and industrial waste allows us to picture the people who lived and worked within these areas, revealing how the butchers, the tanners and the ordinary people lived their lives. The value of hides, bone and horn and the intimate relationship between the various trades and crafts has been demonstrated.

These results have built upon previous work both within the city and further afield and have contributed greatly to the debates on the changing use of animals, agricultural improvement, the fishing industry, the relationship between urban sites and their rural hinterland (*e.g.* Albarella 1997b; Albarella 1999; Albarella 2002a; Albarella 2002b; Barrett *et al.*2004; Locker 2001). Finally, and perhaps most importantly, this site has provided evidence for the most elusive of innovations, that of the 'agricultural revolution'. Analysis of these large assemblages has allowed linkage between a shift in animal use to a change in animal type. These changes, occurring between the 15th and 17th centuries, are the initial stages in a new economic system of animal husbandry. The creation of a large corpus of ageing and metrical data has provided an extensive and detailed body of evidence absent from many other sites, upon which future research into the development of animal use can build.

Appendix 1: Diagnostic Zones (Barbican Well)

SKULL
1. Paraoccipital process
2. Occipital condyle
3. Intercornual protuberance or position of such
4. External acoustic meatus
5. Frontal sinus
6. Ectorbitale
7. Entorbitale
8. Temporal articular facet
9. Facial tuber
10. Infraorbital foramen

MANDIBLE
1. Symphyseal surface
2. Diastema
3. Lateral diastemal foramen
4. Coronoid process
5. Condylar process
6. Angle
7. Anterior dorsal ascending ramus
8. Mandibular foramen

SCAPULA
1. Supraglenoid tubercle
2. Glenoid cavity
3. Origin of the distal spine
4. Tuber of spine
5. Posterior of neck with foramen
6. Cranial angle
7. Caudal angle

HUMERUS
1. Head
2. Greater tubercle
3. Lesser tubercle
4. Intertuberal groove
5. Deltoid tuberosity
6. Dorsal angle of olecranon fossa
7. Capitulum
8. Trochlea
9. Radial fossa
10. Teres major tubercle

RADIUS
1. Medial half of proximal epiphysis
2. Lateral half of proximal epiphysis
3. Posterior proximal ulna scar and foramen
4. Medial half of distal epiphysis
5. Distal shaft

ULNA
1. Olecranon tuberosity
2. Trochlear notch-semilunaris
3. Lateral coronoid process
4. Distal epiphysis

METACARPUS
1. Medial facet of proximal articulation
2. Lateral facet of proximal articulation
3. Medial distal condyle
4. Lateral distal condyle
5. Anterior distal groove and foramen

PELVIS
1. Tuber coxae
2. Tuber sacrale and scar
3. Body of ilium with dorso-medial foramen
4. Iliopubic eminence
5. Acetabular fossa
6. Symphyseal branch of pubis
7. Body of ischium
8. Ischial tuberosity
9. Depression for medial tendon of rectus femoris

FEMUR
1. Head
2. Trochanter major
3. Trochanter minor
4. Supracondyloid fossa
5. Distal medial condyle
6. Lateral distal condyle
7. Distal trochlea
8. Trochanter tertius

TIBIA
1. Proximal medial condyle
2. Proximal lateral condyle
3. Intercondylar eminence
4. Proximal posterior nutrient foramen
5. Medial malleolus
6. Lateral aspect of distal articulation
7. Distal pre-epiphyseal portion of the diaphysis

CALCANEUS
1. Calcaneal tuber
2. Sustentaculum tali
3. Processus anterior

METATARSUS
As for metacarpus

FIRST PHALANX
1. Proximal epiphyseal junction
2. Distal articular facet

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