THE AGRICULTURAL REVOLUTION IN ENGLAND: SOME ZOO-ARCHAEOLOGICAL EVIDENCE

Simon J. M. DAVIS*

Summary

Historians are not agreed as to when farmers began a series of advances in agriculture, often referred to as the Agricultural Revolution. These advances included the improvement of livestock. A traditional view links them with the 18th century Industrial Revolution, while another view suggests they began as early as the 15th century. This article considers measurements of sheep and cattle bones from English mediæval and post-mediæval archaeological sites. In mediæval times sheep and cattle appear to have been smaller in outlying regions, such as Cornwall and Northumberland, and larger in central regions. Sheep and cattle increased in size in the early post-mediæval period - one or even several hundred years before the traditionally accepted date of the onset of the Agricultural Revolution. This early onset of livestock "improvement" provides support for the view that the Agricultural Revolution began in the 15th and 16th centuries rather than the 18th century.

Résumé

La révolution agricole en Angleterre : données archéozoologiques.

Les historiens ne sont pas d'accord sur l'époque à laquelle les fermiers ont fait de réels progrès en agriculture, auxquels on se réfère souvent sous l'appellation de Révolution agricole. Ces progrès comprennent une amélioration du cheptel. On rattache traditionnellement ces progrès à la Révolution industrielle du 18e siècle, mais une autre approche suggère qu'ils ont commencé dès le 15e siècle. Cet article traite des mesures de restes osseux d'ovins et de bovins de sites archéologiques médiévaux et post-médiévaux d'Angleterre. Au Moyen Âge, les moutons et les bœufs semblent avoir été plus petits dans des régions périphériques, comme les Cornouailles et le Northumberland, et plus grands dans les régions centrales. Les ovins et les bovins augmentent en taille au début de la période post-médiévale -un siècle ou plusieurs centaines d'années avant la date traditionnellement acceptée d'emblée pour la Révolution agricole. Cette première "amélioration" du cheptel tend à prouver que la Révolution agricole a commencé aux 15e et 16e siècles plutôt qu'au 18e siècle.

Zusammenfassung

Die Agrarrevolution in England: einige zooarchäologische Ergebnisse.

Die Historiker sind sich nicht darüber einig, wann die Bauern mit der Folge von Verbesserungen in der Landwirtschaft - häufig als Agrarrevolution bezeichnet - begonnen haben. Dieser Fortschritt beinhaltete auch eine Optimierung des Viehbestandes. Aus traditionellem Blickwinkel wird die Agrarrevolution mit der Industriellen Revolution des 18. Jahrhunderts in Zusammenhang gebracht. Andere gehen davon aus, daß die Anfänge bereits im 15. Jahrhundert lagen. In diesem Beitrag werden die Maße von Rinder- uns Schafknochen aus archäologischen Fundstellen des Mittelalters und der frühen Neuzeit Englands betrachtet. Es scheint, daß die mittelalterlichen Rinder und Schafe in abgelegenen Gegenden (Cornwall, Northumberland) kleiner waren, als in den Kerngebieten. Die Größe der Tiere nahm in der frühen Neuzeit zu; also deutlich vor dem traditionell angenommenen Beginn der Agrarrevolution. Dieser frühe Ansatz läßt annehmen, daß die Agrarrevolution eher im 15./16. Jahrhundert, als erst im 18. Jahrhundert begann.

Key Words

Size, Agricultural Revolution, England, Mediæval, Post-mediæval.

Mots clés

Taille, Révolution agricole, Angleterre, Médiéval, Post-médiéval.

Schlüsselworte

Größe, Agrarrevolution, England, Mittelalter, Frühe Neuzeit.

Introduction

The Agricultural Revolution is often regarded as having played a formative role in England's economic development, especially in the growth of her industry and wealth. It comprised a number of technological and other changes in farming practises which effectively improved agriculture in post-mediæval England enabling farmers to feed some 3 million more people in 1700 than in 1540 and almost 20 million more in 1880 than in 1750 (Kerridge, 1967; Thirsk, 1987; Beckett, 1990). One of the technological changes which comprised this revolution, and the one addressed here, concerns the improvement of livestock.

* *Ancient Monuments Laboratory, English Heritage, 23 Savile Row, London W1X 1AB, United Kingdom.*

There has been some disagreement as to when the Agricultural Revolution occurred. Lord Ernle's (Prothero, 1912) influential book *English farming past and present* was largely responsible for assigning agricultural change to the period between 1760 and 1830, that is, largely coincident with the reign of George III (known also as "farmer George" because of his keen interest in farming matters) to the English throne. In his introduction to the 6th edition of Ernle's book, Fussell (1961) states that Ernle was not "over-critical" of his sources which were mainly the printed farming textbooks. Although Ernle also read some of the controversial pamphlets and other literature of Tudor and later times, he apparently neglected other material such as contemporary histories and an immense number of trivial but useful local histories. Fussell (1961) points out also that many early farming textbooks contain anachronisms, absurd theories and plagiarized material from earlier writers.

More recently some historians have begun to question the dates when agriculture improved, an event which, they suggest, may have begun two or even three centuries earlier and that it has been a long and complex process whose timing and impact varied across the country (Fussell, 1961; Kerridge, 1967; and see Thirsk, 1987, and Beckett, 1990, for an overview). This has resulted in the divorce of the Agricultural Revolution from the Industrial Revolution, and agricultural developments after 1820 are even viewed in terms of a second revolution (Thirsk, 1987; Beckett, 1990).

Fussell in 1961 pointed out that some of the agricultural improvements like turnip and clover cultivation which Ernle attributes to people like Townshend had been recognised much earlier. Fussell mentions that field cultivation of these two crops was learned by farmers near Norwich from Flemish refugees during the reign of Elizabeth I and that these crops became common early in the 17th century (Fussell, 1961: lxvii). Fussell (1961: lxix) also suggests it was "inexact" that Townshend was the initiator of the Norfolk four-course rotation of crops.

Professor Eric Kerridge in his book *The Agricultural Revolution* (Kerridge, 1967) is generally credited as being the first to suggest an early onset of the Agricultural Revolution (Thirsk, 1987; Beckett, 1990). Kerridge spreads the revolution over two and a half centuries, and suggests that agricultural innovations had achieved "all possible progress" by 1750. However, as we shall see below, several 19th century sources also suggested that improvements in the English countryside were under way long before the 18th century. Some have even regretted the term "revolution", though it is now generally agreed that significant changes were under way in the 16th and 17th centuries, and that agricultural production improved remarkably between 1500 and 1750. Thirsk also emphasizes regional contrasts and mentions the considerable delay in the onset of improvements in, for example, the four northern counties, where change hardly occurred before 1700 and most progress was made after 1750, while in East Anglia the spread of improvements was evident from the 1580s (see Thirsk, 1987: 59-61).

The last three decades have seen the development of the study of animal remains from archaeological sites, or zoo-archaeology. This article considers archaeological remains of sheep and cattle, particularly their size change deduced from such remains and presumes that a size increase denotes "improvement". This independent source of data may help provide an answer to the question when did sheep and cattle increase in size and hence when did the Agricultural Revolution begin? In brief, it is suggested here that improvements to livestock were under way as early as the 16th century, thus corroborating Kerridge's suggestion that the agricultural revolution was an Elizabethan rather than a Georgian phenomenon.

What the historians say

John Burke (1834: 20-22) dates the dawn of general agricultural improvement in England to the reign of Edward III (1326-1377), a period which marks the beginning of international intercourse. He suggests that subsequent civil strife may have further helped by emancipating bondsmen and dismembering large estates. The increase of population must have swelled the number of townspeople and stimulated the growth of markets which had not previously existed. He also suggests that the agitations of the 15th century gave rise to "that middle order of society to which much of its prosperity in the succeeding ages is to be attributed". But he warns, "The progress of agriculture during that period is ... rather to be inferred from circumstances than deduced from facts, for we are only imperfectly acquainted with the rural economy of our forefathers under the Plantagenets".

Another factor considered by Postan (1939) in the context of the 15th and 16th centuries was that this period followed the great plagues of the 14th century. These probably killed about one half (estimates vary) of the population, including of course the agricultural population, of England and led to a contraction of the area under cultivation. From the 1350s until the last quarter of the 15th century manorial accounts mention "vacant lands" which reverted to the lords (the 15th century was also the time of the last and most disastrous phase of the 100 years war).

Burke (1834: 25) goes on to mention continuing developments in British agriculture after the 15th century. In the

mid 17th century many "gentlemen", who had been impoverished by the civil war, devoted themselves to farming and husbandry, an endeavour actively encouraged by Cromwell. The cultivation of the soil, hitherto almost exclusively confined to "unlettered men", began now to interest the educated classes.

Matters, it seems, could only have improved after these times, a change to which another well known 19th century source, John Green's *A short history of the English people*, (Green, 1888) alludes.

Green writes of the peace and prosperity of Elizabethan England - a new architecture abandoned defensive structures in favour of domestic comforts. Following the ruin of Antwerp, London developed into the general emporium of Europe. It was a period characterised by greater consumption of meat, the rise of the middle classes and tremendous improvements in agriculture. He writes (pp. 393-4): "Not only was a larger capital brought to bear upon the land, but the mere change in the system introduced a taste for new and better modes of agriculture; the breed of horses and of cattle was improved, and a far greater use made of manure and dressings ...woollen manufacture was fast becoming an important element in the national wealth. England no longer sent her fleeces to be woven in Flanders and to be dyed at Florence. The spinning of yarn, the weaving, fulling, and dying of cloth, was spreading rapidly from the towns over the countryside... it was under Elizabeth that commerce began the rapid career of development which has made us the carriers of the world... in the early part of the sixteenth century, ... the annual export of English wool and drapery ... was estimated at a sum of more than two millions in value." This 16th century increase of trade - especially wool - made farming a national rather than a purely local concern, with the development of *national* markets and international trade. Estate owners, in their quest for land for grazing sheep, cleared and enclosed (often with force) much wasteland (Drummond and Wilbraham, 1939: 24).

Rather than being a process of long duration beginning at the end of the mediæval period, Ernle and others (see for example Orwin, 1949, and Ritvo, 1987) in more recent times see agrarian innovations as being quite rapid, i.e. revolutionary and commencing in the mid 18th century and ending some 80-100 years later. These writers see the Agricultural Revolution as coinciding with the Industrial Revolution which commenced with the accession of George III. This was a period that supposedly saw improvement of the nation's breeds of cattle and sheep. Food was needed to feed the rapidly expanding population. Moreover, England was often at war with her neighbours and therefore vulnerable to blockade.

What then were the changes which are associated with the Agricultural Revolution? According to Kerridge (1967) they include:

1. Enclosure of common fields by Act of Parliament,

2. Replacement of bare fallows by root crops and artificial grasses,

3. Institution and spread of the Norfolk four-course system of crop rotation (turnips, barley, sown grass and wheat to maintain soil fertility),

4. Introduction of drills and other agricultural implements,

5. Drainage of farmland and

6. Breeding of *new and better sheep and cattle* and the replacement of draught oxen by horses.

The pioneers of this revolution were, it is often supposed, men like Jethro Tull (1674-1741), Charles "Turnip" Townshend (1674-1738), Thomas Coke (1752-1842) and Robert Bakewell (1725-1795).

Kerridge (1967) musters a wealth of data not only from farming textbooks and histories, but manuscripts from Public Records Offices (Courts such as the Star Chamber and the Exchequer), the British Museum, County archives, and Midland farms. His book is referred to by Wilson (1984: 391) as being a "very stimulating revision of the traditional view of the agricultural 'revolution' ..." which "has provoked alternating bouts of praise and exasperation from critics: both are warranted". Kerridge argues that there is little evidence to support the notion that agricultural changes between 1750 and 1850 were in any way revolutionary. Kerridge's arguments which counter the above six supposed innovations are as follows:

1. Most land in England was being exploited before the enclosures,

2. The extent to which bare fallows were replaced by fallow crops has been exaggerated,

3. No regular succession of crops was actually observable at that time (the 18th century), "the spread of the Norfolk four course system belongs to the realms of mythology",

4. Mechanization formed no part of the early modern agricultural revolution and farm implements changed only slowly and slightly. According to Kerridge, Tull was a

crank, his system of drilling corn in monoculture would have been unworkable, and his other ideas were not original. Until wages began to rise in the mid 19th century machinery hardly played a role in English agriculture. Many of the major agricultural engineering companies which flourished after 1850 depended for their success on exports (Beckett, 1990: 28),

5. Methods of draining fields were an old tradition,

6. Bakewell's Dishley breed of sheep for example did not improve on all the features of their antecedents. His sheep sacrificed quantity and quality of the wool and quality of the mutton to mere quantity of meat.

If the Agricultural Revolution did not occur in the 18th and 19th centuries, when did it begin? It is important to bear in mind that the population of England grew from about 2.8 million in 1540 to 5.2 million by 1650, though no further significant growth occurred until the 1720s (Beckett, 1990: 15). Kerridge (1967) writes that agricultural improvements of a revolutionary kind (see below) were taking place as early as the 16th and 17th centuries, and (Kerridge, 1988) that by the 16th century the whole of the English countryside was covered by a network of market towns. Livestock strains were widely interchanged. He gives examples of pedigree pasture sheep being sold to men wishing to improve their flocks. Around 1650 selected Midland rams were sold for about £10 a head. In 1615 Sir Robert Drury of the Chiltern country had a herd of 55 Hereford bulls and steers and was apparently running a stud or selling pedigree cattle (Kerridge, 1988: 19).

Dyer (1981) in his study of Warwickshire farming also concludes that the later Middle Ages saw radical changes in the agrarian economy such as a downward social distribution of access to land, the growth of larger farms of the modern type, a movement from arable to pasture and hence production of more manure. These changes were, Dyer suggests, as far reaching as those found in subsequent periods.

Kerridge's criteria for an agricultural revolution, hitherto ignored by historians, include the adoption of a grass-arable rotation otherwise known as "up-and-down husbandry" leading to soil improvement and increased yields of crops such as grass and corn, and the "floating of water meadows", a practise which commenced around 1560. This artificial flooding of meadows stimulated grass growth. The resulting crop of hay supported more sheep which in turn provided an increased amount of manure (Darby, 1973). Kerridge also points out that a fourfold increase in the production of grass nutrients "laid the foundation for a great expansion of animal husbandry" (Kerridge, 1967: 331). Other criteria which serve to date the onset of the Agricultural Revolution include the drainage of fens, most of which happened before 1660, and the increased application to fields of manure, soap ashes, marl and lime. Kerridge assigns these developments to the second half of the 16th century. Also by the turn of the 17th century new crops were being cultivated. Many of these had previously been grown in kitchen and market gardens, and their cultivation as field crops provided an important source of winter fodder for cattle, sheep and horses (winter fodder such as turnips solved the problem of keeping cattle in good condition during winter.) These new field crops include (with approximate date of introduction or establishment) carrots (1597), weld or dyer's weed (c. 1610), tobacco (1619), turnips (1670-1680), dwarf rape (1686), cabbage (c. 1660-1670), potato (c. 1650), sainfoin (by 1675), clover (shortly after 1645), spurrey and lucerne (later 17th/early 18th century). According to Hoskins (1968) yield ratios (the relationship between seed sown and grain harvested) roughly doubled between around 1500 and 1650 but hardly rose at all between 1650 and 1800.

Kerridge also writes that farmers were improving their stock as early as the turn of the 17th century. However, while various breeds of cattle only underwent "some improvement" the changes wrought in sheep breeds were far greater. For example the Cotswold was transformed by both improved feed and crossing with the Midland pasture sheep, "their legs shortened and their carcasses became larger and fleshier." Kerridge also cites mid-16th century examples of sheep farmers importing sheep from other parts of the country. The new pasture sheep was bred for fattening and had a quarter less wool than the old pasture sheep, and this of inferior quality. Improvements in the Midland pasture sheep occurred in the second half of the 17th century.

There is some evidence in the historical sources for both cross-breeding and even the import of foreign livestock in the 16th and 17th centuries. Traditionally cattle and sheep were sent on the hoof along countrywide droveways to London from Wales and Scotland along routes that were well established by the 17th century. The trade in Welsh cattle dates to the Middle Ages, and by the 17th century the Scottish trade was also substantial (Armitage, 1982; Beckett, 1990: 22). Perhaps better communication lead to cross-breeding and hence improvement through "hybrid vigour". In this respect Markham (1614: 42) recommended mixing Yorkshire with Staffordshire cattle, or Staffordshire with Lancashire, or Derbyshire with any of the "black races". In the 1720s Defoe observed and wrote that

Leicestershire and Lincolnshire sheep "are, without comparison, the largest, and bear not only the greatest weight of flesh on their bones but also the greatest fleeces of wool…".

Trow-Smith (1957: 202), citing various contemporary sources, mentions that in the 17th century and possibly earlier, a pied strain begins to be noted among English cattle. These were, according to some, of Dutch origin, and were described by Markham (1614: 42) as being for "… the most part, pyde with more white. … of bodies exceeding tall, long and large, … and are indeed fittest for labour and draught." (Note that turnips were first introduced into England from Holland as a garden vegetable in the 16th century; Beckett, 1990: 12). Mortimer (1707: 166) too writes about these cattle, stating that they are "the best sort of cows for the pail, … and need very good keeping, are long legged short horn'd cow of the Dutch breed in some places of Lincolnshire, but most used in Kent …". In Holland there is a persistent tradition of large exports of cattle to Lincolnshire in the 17th century (Trow-Smith, 1957). These Dutch cows, which were the basis of the late mediæval Dutch butter and cheese export trade, not only had a high milk yield, but had *considerable size*. Trow-Smith suggests that imports into England of large milky Dutch cattle began in the late 16th or early 17th century, a time when English improvers viewed Dutch agriculture as their principal model (Thirsk, 1985: 558).

In sum then, by the 1970s historians regarded the Agricultural Revolution as having covered most of the period from 1560 to 1880 (Beckett, 1990: 9) and Kerridge's view has been confirmed by the study of 16th and 17th century probate inventories (Beckett, 1990: 16). Let us now turn to a relatively new and alternative source of information about agricultural history, or at least that aspect which concerns livestock - *zoo-archaeology*.

Zoo-archaeology, an independent source of evidence

The last 20-30 years have seen an increasing interest in the study of animal remains from archaeological sites or zoo-archaeology.

One important aspect of zoo-archaeology is the measuring of animal bones and teeth. Measurements from several large assemblages have enabled this overview of the way in which the size of sheep and cattle - two of the most abundant species in English archaeological sites - has varied since mediæval times.

We are only just beginning to recognise the important role zoo-archaeology can play in understanding livestock improvement and the origin of modern breeds of farm animals. It is unfortunate that until recently many archaeologists have tended to ignore post-mediæval deposits. Many post-mediæval sites have probably suffered from 20th century "development". Despite the scarcity of animal remains from the post-mediæval, an attempt is made here to synthesise metrical data that are available for sheep and cattle.

What follows are two sets of comparisons of sheep and cattle measurements from archaeological sites a) within the mediæval period across England and b) in various sites through time from mediæval through to post-mediæval.

Measurements of sheep and cattle from twelve sites have been considered (tab. 1, fig. 1).

Geographical variation in the mediæval period

Within the mediæval period, did cattle and sheep vary in different parts of England? Figures 2 and 3 are

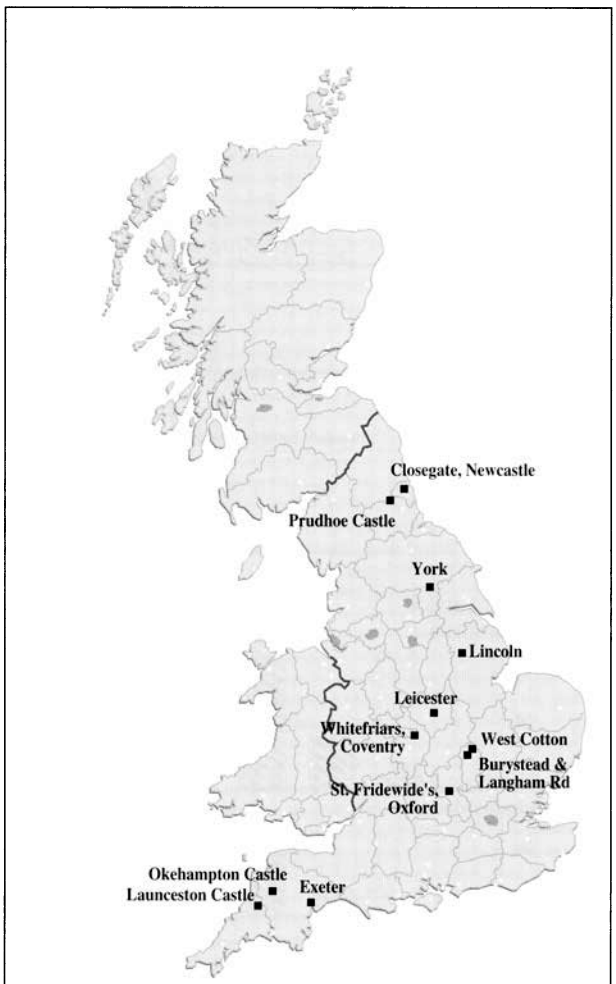

Fig. 1: Map of Britain to show the location of sites mentioned in the text.

Table 1: Sites and sources of data.

Site and location	dates (in centuries) of main assemblages of animal bone	source of data
Launceston Castle, Cornwall	late 13th-1840	Albarella and Davis, 1994a
Exeter, Devon	12th-19th	Maltby, 1979
Okehampton Castle, Devon	13th-18th	Maltby, 1982
St. Frideswides, Oxford	12th-17th	Stallibrass, 1988
Whitefriars, Coventry	mid 16th	Holmes, 1981
Closegate, Newcastle	13th-17th	Davis, 1991
Leicester the Shires	mid-late med	Gidney, 1991a and 1991b
Prudhoe Castle, Northumberland	11th-19th	Davis, 1987
York, Coppergate	early med	O'Connor, 1986
York, the Bedern	13th-19th	O'Connor, 1985
West Cotton, Northants	12th-15th	Albarella and Davis, 1994b
Burystead and Langham Road	7th-15th	Davis, 1992

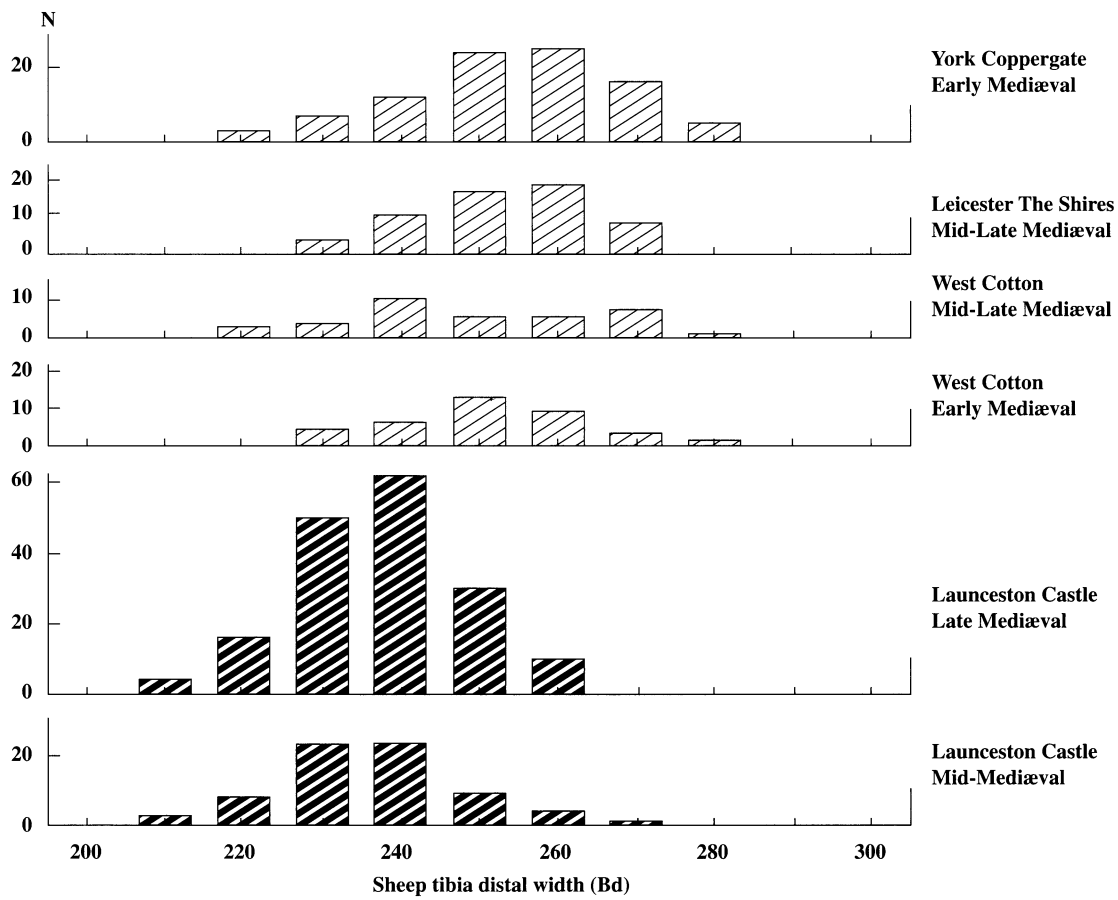

Fig. 2: Mediæval sheep-size variation in different parts of England. Distal widths (Bd) of sheep tibiae. Scale in tenths of a millimetre.

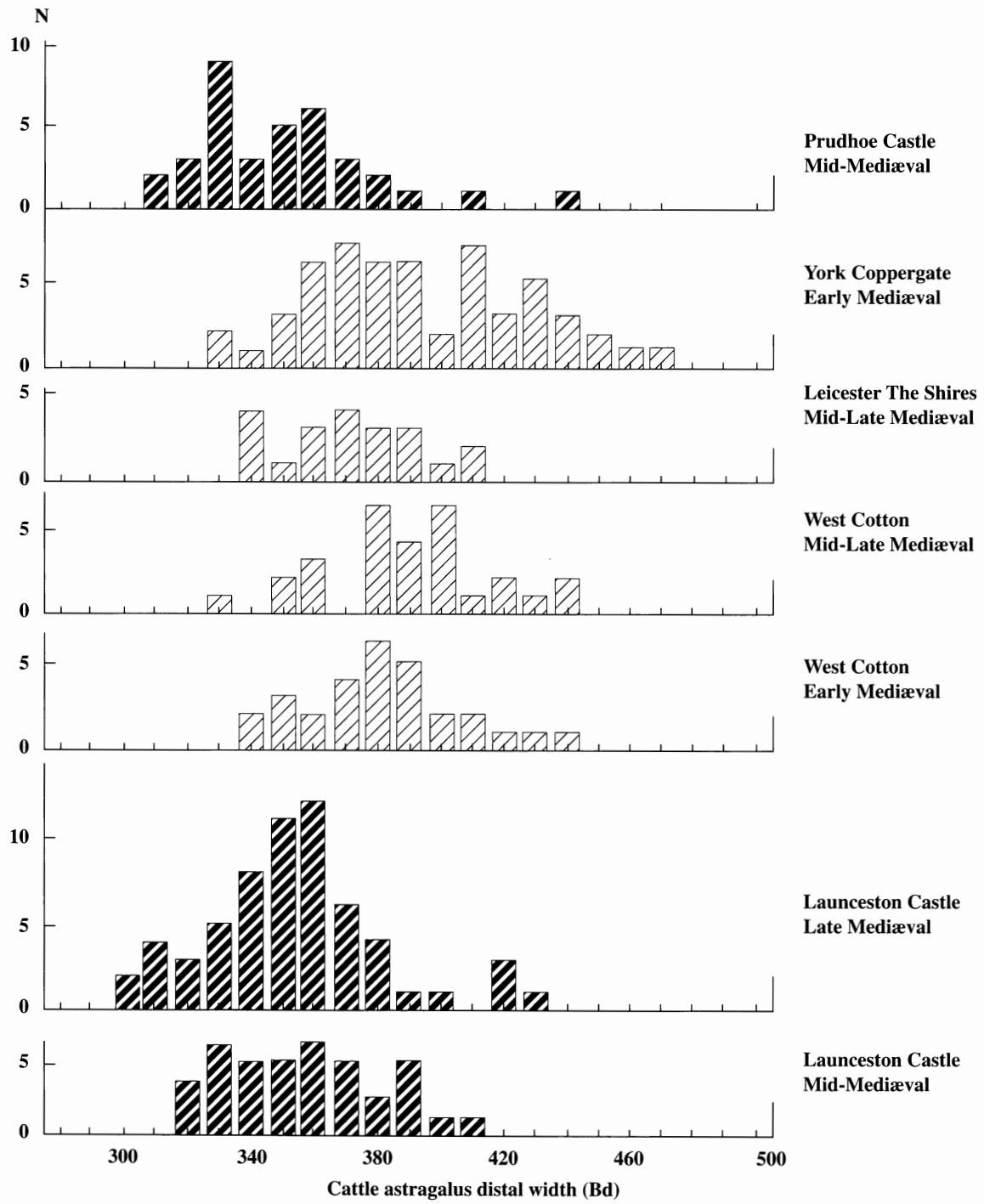

Fig. 3: Mediæval cattle-size variation in different parts of England. Distal widths (Bd) of cattle astragali. Scale in tenths of a millimetre.

plots of some measurements of cattle and sheep bones (cattle astragalus width and sheep distal tibia width; both measurements are frequently taken by zooarchaeologists). The results for the few assemblages so far available suggest that during mediæval times there was considerable variation in the size of these two animals across England.

It appears that sheep and cattle were larger in central parts of the country (shown hatched) than in peripheral regions such as Cornwall and Northumberland (shown in black). The sheep at Launceston in Cornwall, similar to sheep at Exeter and Okehampton (Devon), were smaller than their contemporaries in Northants, Leicester and York. Similarly, cattle from Launceston, Exeter and Prudhoe, Northumberland were smaller than cattle from Northants, Leicester and York. In Northamptonshire at least, cattle were equally large in earlier times: the cattle from Saxon levels at Burystead and Langham Road (two miles from West Cotton; Davis, 1992) are similar to the mediæval West Cotton cattle.

The hypothesis offered here is that in mediæval times, cattle and sheep in central England were larger than in outlying parts of the country. This needs to be tested when more measurements from mediæval sites are available.

Chronological variation

Despite the scarcity of large faunal assemblages spanning the mediæval - post-mediæval, there are some noteworthy exceptions (tab. 1), most are from castles and towns, although in many the numbers of bones from post-mediæval strata are small. For example there were fewer than 30 post-mediæval sheep-bone measurements at Closegate, and at St. Frideswide Stallibrass had no measurable bones from the later levels. The size-difference she found was based merely on the appearance of the broken fragments. Launceston Castle is a notable exception, and it was a recent study of its large assemblage of bones (Albarella and Davis, 1994a) which stimulated our concern with the evolution of post-mediæval farm animals.

The graphics used in the figures to portray size change vary according to the way authors have published their measurements. Thus Maltby (1979) provides statistical summaries (mean and standard deviation) of his data from Exeter. Some are shown here. Several other sites provided enough individual measurements to allow portrayal of individual bone measurements. This can, for example, provide information on the sexual composition of a sample of bones, since in most mammals males are larger than females.

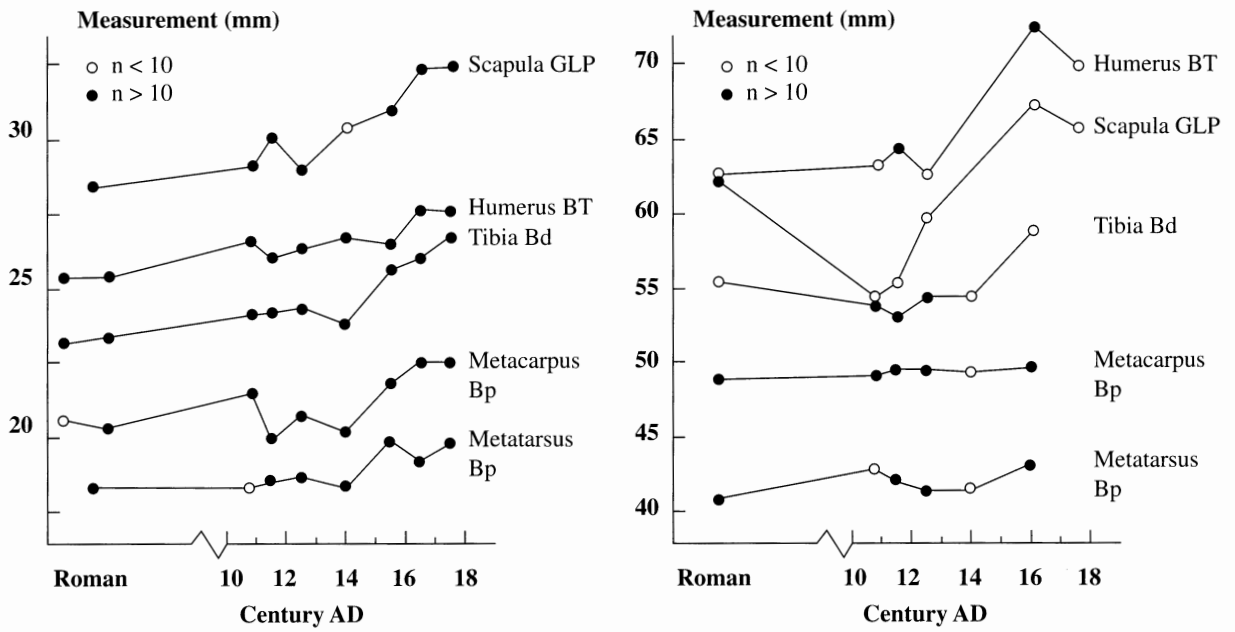

Fig. 4: Sheep (left) and cattle (right) size variation at Exeter. Plots of the means of several bone-measurements taken from Maltby (1979). Samples greater than 10 are depicted as black circles, samples less than 10 are depicted as open circles.

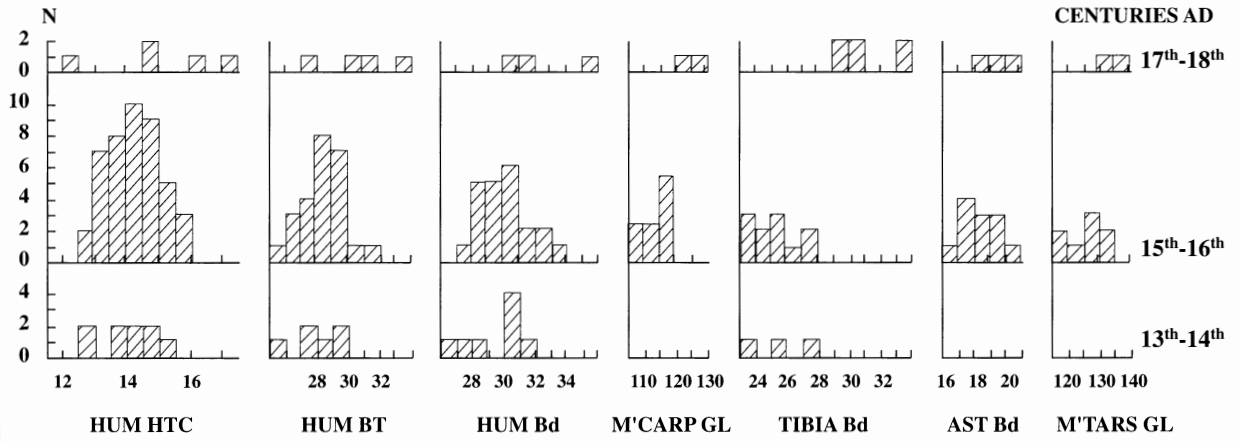

Fig. 5: Sheep size variation at Closegate, Newcastle. Plots of measurements in millimetres of humerus, metacarpal, tibia, astragalus and metatarsal.

Exeter. Excavations in various parts of this city uncovered animal bones from Roman, mediæval and post-mediæval periods. Maltby's (1979) measurements of the cattle and sheep (summarised in figure 4) show that they, especially the cattle, increased in size after the 15th century.

Whitefriars, Coventry. The mid-16th century sheep bones from Whitefriars, Coventry, were, according to Holmes (1981) somewhat larger than mediæval ones but much smaller than modern sheep. Although the sample was rather small, Holmes suggests that this post-mediæval size increase reflects "... slight evidence of the Tudor improvement of sheep".

Closegate, on the north bank of the river Tyne, in Newcastle, was excavated in 1988 and 1990. The sample of bones retrieved at Closegate was rather small, and the majority derived from 13th-16th century contexts (Davis, 1991). However, there were some bones from 17th and 18th century contexts, many of which could be accurately dated. The 13th-16th century sheep bones are rather small in size, (similar to the modern "primitive" breed, the Soay). While there is little evidence for any size difference between the 13th-14th centuries and the 15th-16th centuries, sheep bones from the 17th-18th centuries are generally larger (fig. 5). A size increase is most noticeable for four complete metapodials (all come from different contexts, and so are less likely to be from the same animal) which are considerably longer than metapodials from the earlier periods. The measurements of distal tibia breadth also show a marked size increase. The evidence, however, for other bones such as distal humerus and astragalus is little better than suggestive. Some of the large 17th-18th century sheep bones can be dated more precisely[1]. For example a large metacarpal is "mid - late 17th century", another large metacarpal is "late 17th - early 18th century". And five of the six large sheep tibiae can be dated with some precision on the basis of documentary and archaeological information to the period 1683-1692. It appears then, that by the end of the 17th century, sheep in the Newcastle region were considerably larger than their 13th-16th century antecedents.

St. Frideswide's priory, Oxford. The cloister of St. Frideswide's Priory was excavated in 1985. Besides Anglo-Saxon burials some contexts dated to the second quarter of the 16th century and later were also uncovered. Unfortunately, there were too few animal bones from these later contexts to provide useful measurements, but Stallibrass (1988) was able to observe (qualitatively) large sheep bones in 17th century contexts and "massive cattle bones" even in 16th as well as 17th century contexts.

[1] I am grateful to Richard Fraser, the archaeologist who excavated Closegate, for this information.

The Bedern complex in York was first occupied in the 13th century and continued in use until the 18th and 19th centuries. It was excavated mostly during the 1970s. A biometric study of the sheep bones was undertaken by O'Connor (1985) on material retrieved between 1977 and 1980. His study showed that the sheep increased in size between phases 3-9 and phase 10. Most of the bone in phase 10 is dated to the 16th century, with "some much later material".

Prudhoe Castle, Northumberland, was first constructed by the Normans and has been in more or less continuous use since then. It was excavated between 1972 and 1981 and 12 occupation phases dating from the mid 11th to 19th centuries were recognised. The animal bones were studied by Davis (1987) who found that the cattle bones at this site show a size increase (figure 6) between the 14th and 17th centuries, possibly (there were not many post-mediæval bones) during the 15th-16th centuries.

Launceston Castle in Cornwall was excavated between 1961 and 1982 and has produced a large number of measurements of mediæval - post-mediæval bones (Albarella and Davis, 1994a). The majority derive from four periods as follows: period 6 (late 13th century), period 8 (mid-late 15th century), period 9 (16th-17th centuries), and periods 10 + 11 (18th century - 1840).

Figures 7 and 8 show size variation of the cattle, and sheep at Launceston. Some discussion of this variation at Launceston now follows.

Cattle. With such large numbers of measurable cattle bones at this site, many of which are well preserved, we were able not only to study their size, but also shape variation of the metatarsals and astragali, and the frequency of a non-metric dental trait (see also Albarella, 1997).

Between periods 8 and 9, (and to a smaller extent between periods 9 and 10) we found a substantial size increase in all the cattle measurements (see table 1 for the statistical significance of differences of means). The size increase is noticeable also in the plots of the widths of the lower third molar teeth (fig. 8). Figure 9 compares the percentage difference in mean measurements of all bones measured with those of period 8 (represented by the vertical "0" line) being a "standard". Note that the greatest average size increase appears to have occurred between periods 8 (mid-late 15th century) and 9 (16th-17th centuries).

Besides a simple size-increase, we have found a change of bone shape between periods 8 and 9 (i.e.

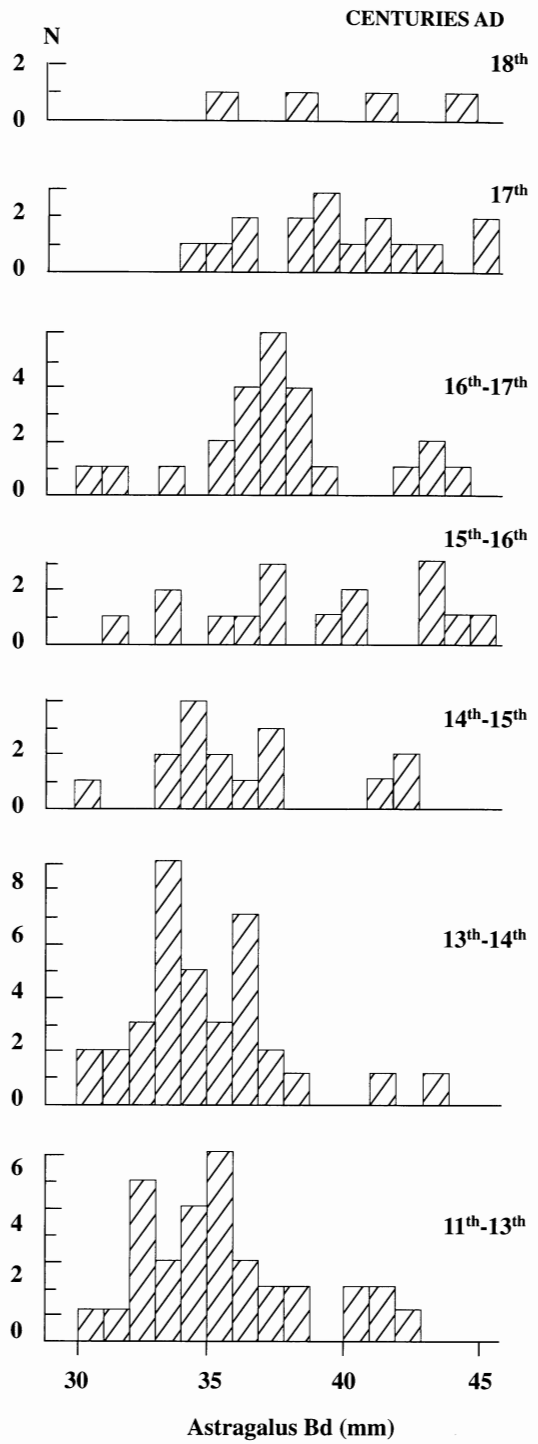

Fig. 6: Cattle size variation at Prudhoe Castle.

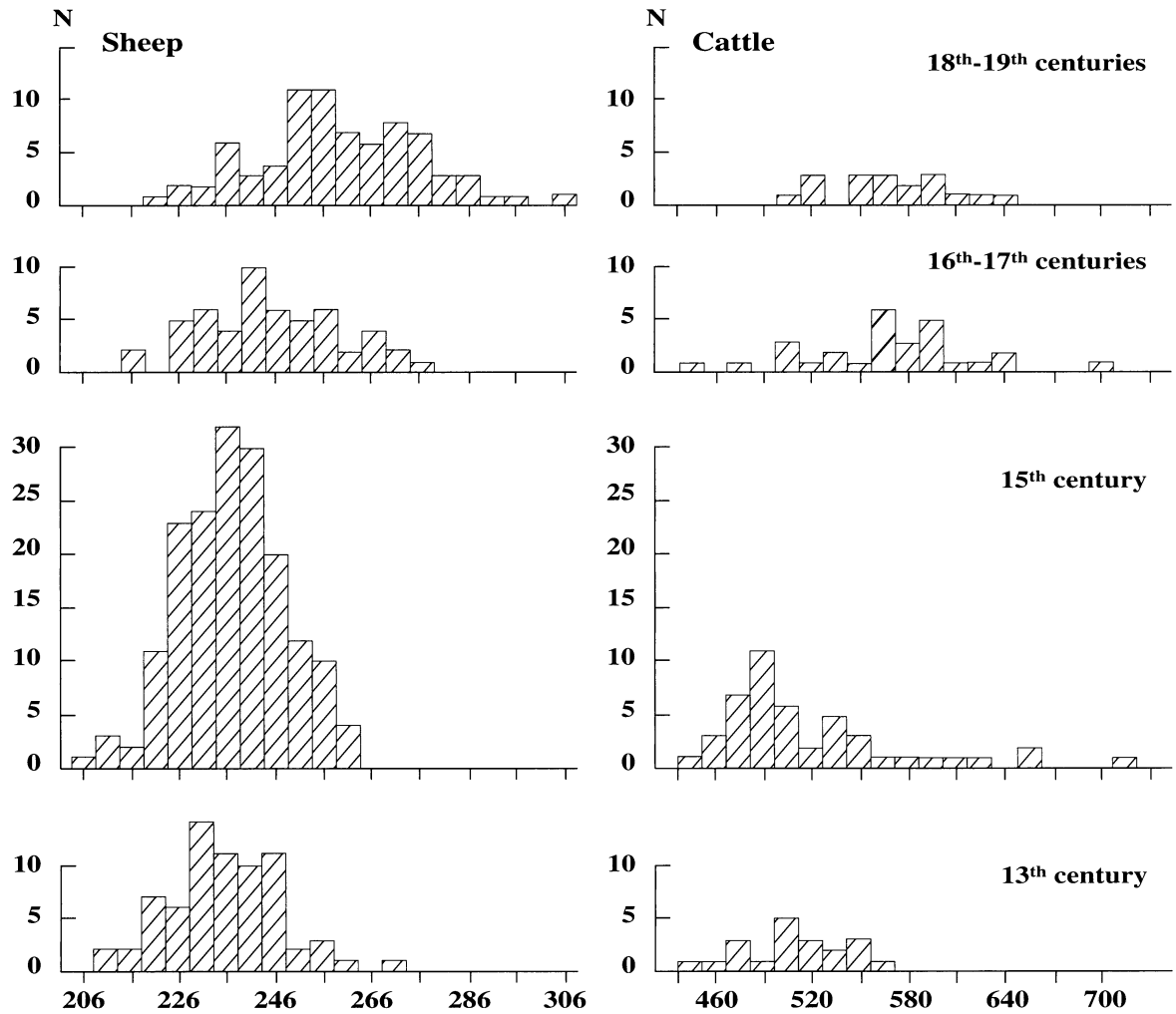

Fig. 7: Cattle and sheep size variation at Launceston Castle. Distal widths (Bd) of tibiae are given in tenths of a millimetre from the four main phases at this site. Only fused specimens are included.

Date	late 13th cent.	mid-late 15th cent.	16th-17th cent.	18th cent.-1840
Period	6	8	9	10+11
Cattle w.M3	n.s	*	n.s.	
Cattle Tibia Bd	n.s	**	n.s	
Cattle Astragalus GLI	n.s	**	n.s	
Sheep Humerus HTC	n.s	**	**	
Sheep Tibia Bd	n.s	**	**	
Period (pooled)	6-8		9-11	
Cattle w. M3		**		

Table 2: Launceston Castle. The significance of the size difference between periods as indicated by a t-test. ** = 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). "n.s." = no significant difference (more than a 5% probability that it is due to chance). w = bucco-lingual width, Bd = distal width, GLl = greatest length, HTC = diameter of the distal trochlea at its narrowest point. For details of how measurements are taken see Driesch, 1976, and Davis, 1992.

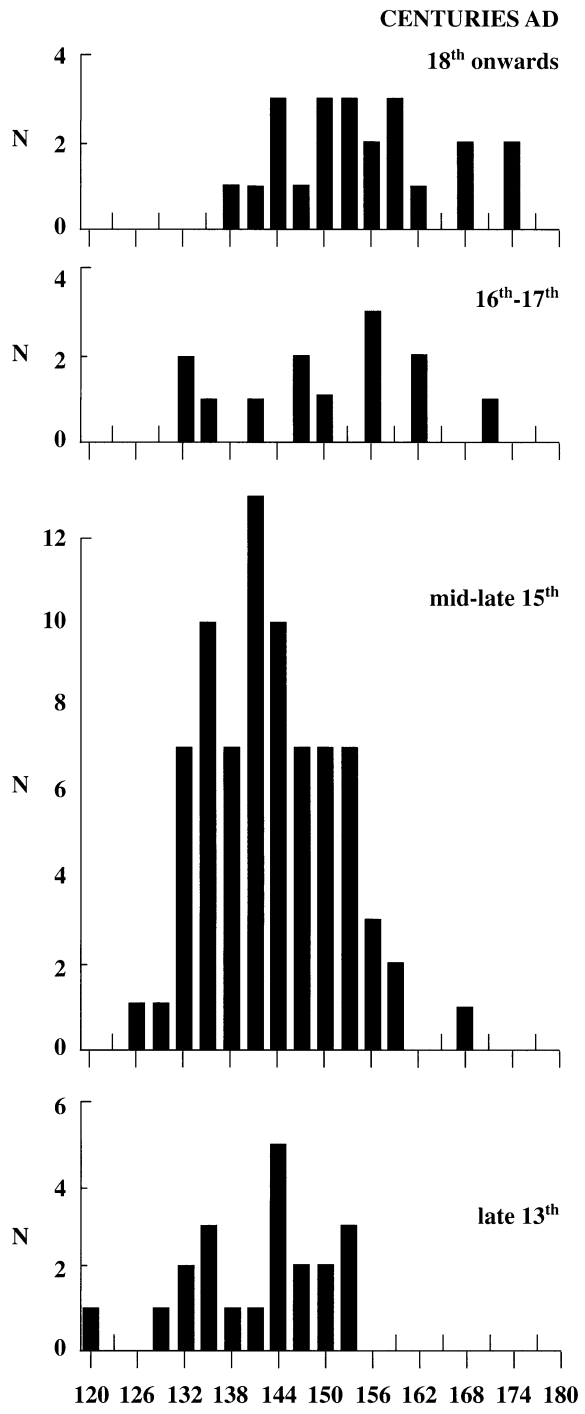

Fig. 8: Cattle lower third molar widths plotted in tenths of a millimetre from the four main phases at Launceston Castle.

Table 3: Zooarchaeological evidence for sheep and cattle size increase. Dates are given in centuries and are very approximate estimates.

	SHEEP	CATTLE
Prudhoe Castle		15th - 16th
Closegate, Newcastle	before end 17th	
Whitefriars, Coventry	by mid 16th	
Bedern, York	? by 16th	
St. Frideswide's, Oxford	by 17th	16th-17th
Exeter	15th	16th
Launceston Castle, Cornwall	15th-17th	15th-17th

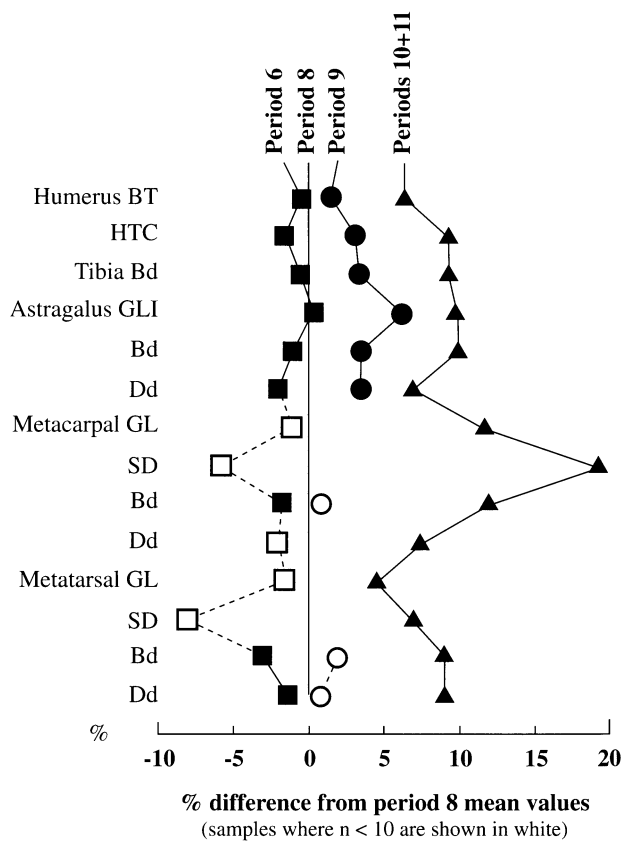

Fig. 9: Summary of all measurements of sheep at Launceston Castle. Diagram to show the percentage differences of means taking the measurements from period 8 (mid-late 15th century) as a baseline. Samples where n < 10 are shown in white.

between the 15th century and the 16th-17th centuries) the metatarsals became relatively narrower at their distal ends while the shaft width in relation to length remained constant. The measurements of cattle astragali at Launceston also show a contemporary shape-change, although the results are less striking than for the metatarsal.

In artiodactyls the lower third molar tooth is characterised by having three pillars. The third, or hypoconulid, is somewhat smaller, and occasionally fails to develop. At Launceston the number of cattle M_3s with reduced or missing hypoconulids was recorded (see fig. 10). It appears then that this condition became less common after period 8. Comparing the frequencies of M_3s with missing hypoconulids in periods 6 and 8 with periods 9, 10 and 11 indicates that the probability the change was a chance occurrence lies between 2.5% and 5% ($\chi^2 = 4.4$).

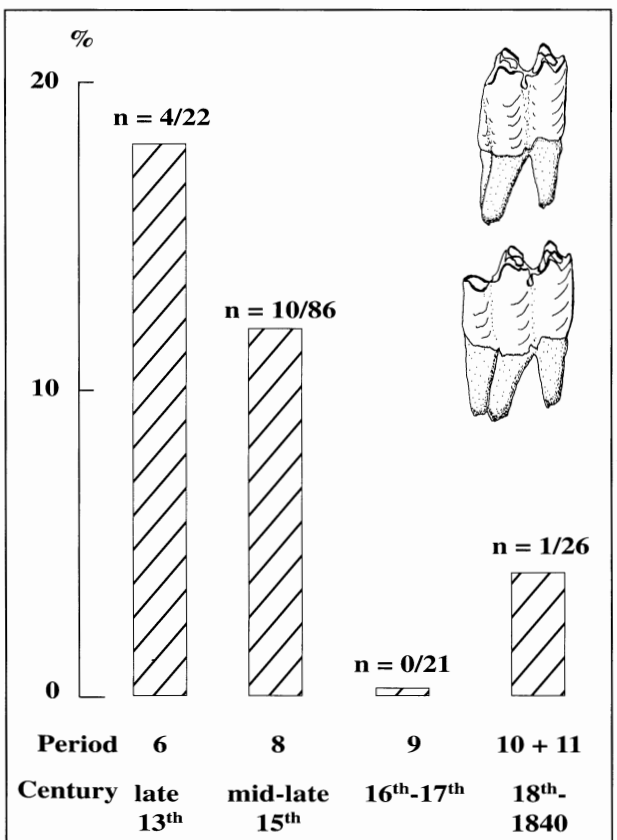

Fig. 10: Percentages of cattle lower third molars in the four main periods at Launceston Castle with missing hypoconulids (the drawing in the top right-hand corner shows an M_3 with missing hypoconulid on the left and a normal M_3 on the right). Numbers of cases are also expressed as a fraction of the total number of lower third molars.

Sheep. A small but statistically significant (see tab.2 and fig. 7 and 9), increase in size occurred between periods 8 and 9. However, a greater size increase occurred between periods 9 and 10 (i.e. between the 16th century-1650 and 1660-1840). Sheep at Launceston therefore underwent their "major" size increase one or two centuries after cattle. Moreover, the size increase of the sheep appears to have been gradual while that of the cattle was relatively sudden.

General discussion of the zoo-archaeological data

Two interesting phenomena now seem apparent from this survey of mediæval and post-mediæval sheep and cattle in England.

First, the sizes of these animals varied across the country. This is hardly surprising given the regional diversity of English agriculture in the past (Kerridge, 1967). Earlier writers appear to corroborate this regional variation: Defoe (1724) wrote that the largest sheep in 18th century England were the Lincolnshire and Leicestershire longwools and Davis (1794) remarked upon the small breed of cattle in Devon. It appears (though with so few sites this must remain a very tenuous suggestion) that cattle and sheep were smaller in the more outlying districts such as Cornwall and Northumberland than in central England.

Second, and of relevance to the history of agriculture, in many areas cattle and sheep increased in size some time between the 15th and 17th centuries. This size increase with time is apparent in most sites with an archaeological sequence spanning the mediæval - post-mediæval and is most clearly demonstrable at Exeter, Launceston Castle, Prudhoe Castle and Closegate. At Launceston Castle for example it is clearly not due to random size-variation (tab. 2). The possible dates when cattle and sheep became larger are given in table 3.

It is important to try and understand what caused sheep and cattle to increase in size after mediæval times. Size may change as a result of the effects of many different factors. Generally, in mammals, males are larger than females. A sudden change in the sex ratio would produce a change in the mean size of a sample of bones. Although experimental evidence is not available, artiodactyl teeth tend to show less sexual dimorphism than post-cranial bones (Degerbøl, 1963). Therefore, at least in the case of Launceston, the cattle size increase is unlikely to have been due to a shift in the sexual composition of the samples (i.e. from samples with fewer males to samples with more males) and it seems safe to rule out sex-ratio variation as a factor here. Another possibility is that the post-mediæval size increase reflects the adoption of the prac-

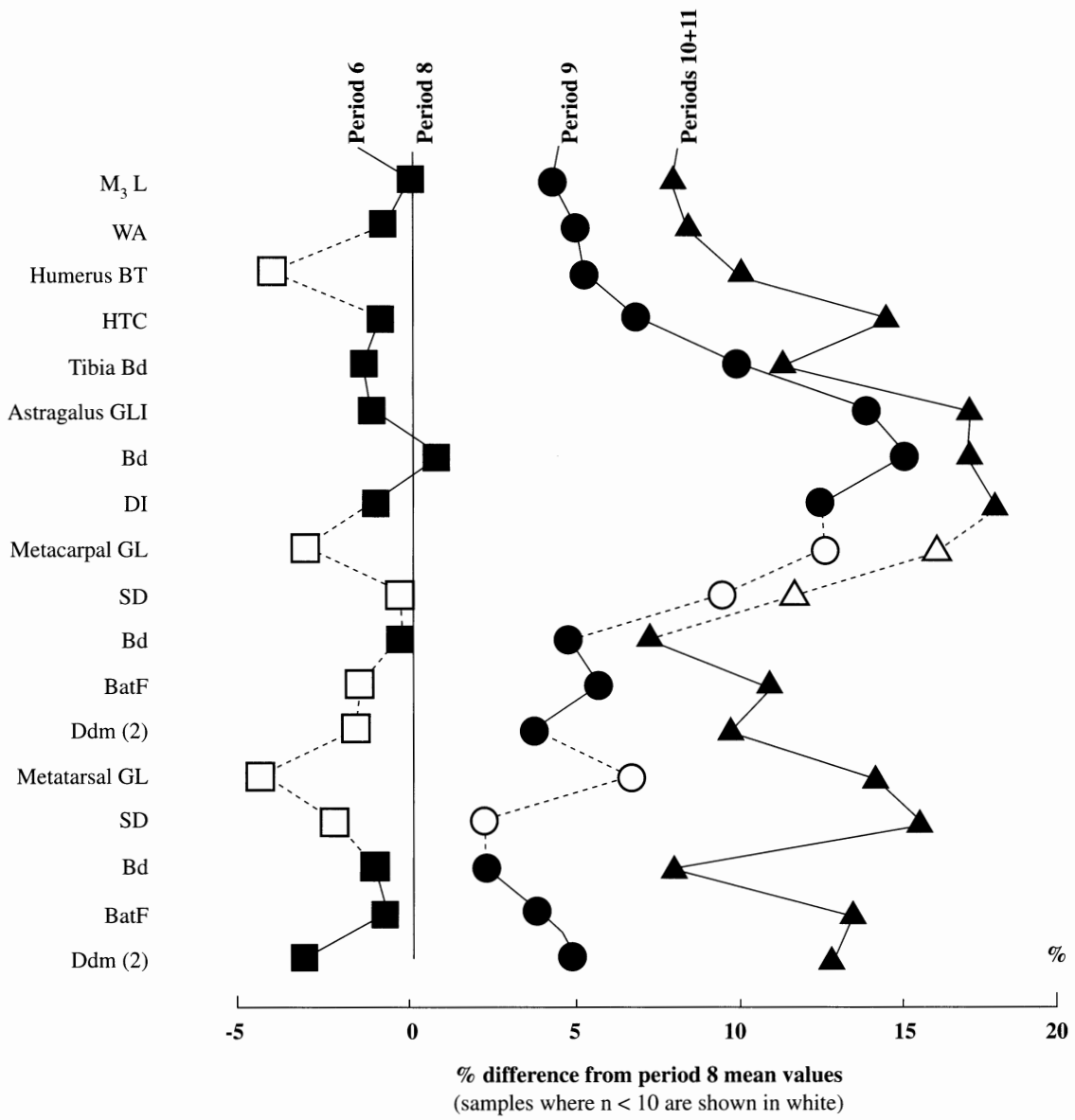

Fig. 11: Summary of all measurements of cattle at Launceston Castle. Diagram to show the percentage differences of means taking the measurements from period 8 (mid-late 15th century) as a baseline. Samples where n < 10 are shown in white.

tise of castration. Castration is known to result in delayed epiphysial closure (Hatting, 1983) which permits continued growth of long-bones. However, preliminary results from work in progress (Davis, in prep.) suggest castration does not alter long-bone width and most of the measurements considered here are widths. Moreover castration does not influence tooth-size. Therefore, castration too seems an unlikely explanation of size variation and a real (i.e. genotypic) size increase must have occurred in these animals.

Further support for the case that cattle underwent a real change comes from the simultaneous alteration of a) bone-shape and b) the reduced frequency of a dental anomaly at Launceston between periods 8 and 9 (i.e. between the mid-late 15th century and 16th-17th centuries; Albarella and Davis, 1994a).

Conclusion

It is suggested here that in post-mediæval England the size increase in both cattle and sheep was due to artificial selection and/or the import of new breeding stock (perhaps from as far away as Holland). Moreover this size increase reflects increased sophistication of animal husbandry in the 16th and 17th centuries.

If these zoo-archaeological findings are correct, then it follows that Professor Kerridge was correct when he suggested that agricultural improvement in England was already happening as early as the 15th-16th centuries and that the Agricultural Revolution should be viewed more as a long-term and *gradual* development originating in the 15th century, rather than a *revolutionary* one which commenced with the rule of George III. It is worth noting that historians are not in agreement as to the time of the onset of the Industrial Revolution: since some suggest that it too may have commenced much earlier with 1660, rather than 1760, being the turning point (Darby, 1973: 353).

While not wishing to belittle the efforts of the well-known gentlemen farmers like Robert Bakewell and the Collings brothers, they may have been given a little more than their fair share of credit for the development of English livestock. As Beckett (1990: 29) suggests - "the true credit for agricultural innovation ought perhaps to rest with the lesser landowners, with estate stewards and with tenant farmers", and as Kerridge (1967: 324) writes: "the new pasture sheep were only perfected by Bakewell. Their creation was the work of Joseph Allom, Major Hartopp, Captain Tate, Mr Stone and successive generations of improvers."

Tusser's *Hundred* (later *Five*) *hundred points of good husbandry*, first published in 1557, went through 23 editions in 81 years. It was one of the 15 most popular books in Elizabethan England but was not recorded in the published catalogues of major private libraries of the time, and was written for a readership "lower down the social scale" (Hey, 1993). The reign of Elizabeth I is often referred to as the age of enlightenment, it would seem that many farmers too were adopting a more enlightened attitude to their animals and were instrumental in improving England's livestock.

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