Rural History (1999) **10**, 1, 1–17. © *1999 Cambridge University Press*
Printed in the United Kingdom

Animal Husbandry and Agricultural Improvement: The Archaeological Evidence from Animal Bones and Teeth*

SIMON J. M. DAVIS and JOHN V. BECKETT

In the choice therefore of your sheepe, choose the biggest boned, with the best wooll; ... These sheep ... are alwaies the best butchers ware, and goe soonest away in the market': Gervase Markham, *Cheape and Good Husbandry for the Well-Ordering of All Beasts and Fowles, and for the Generall Cure of their Diseases* (London, John Harison, 1631), pp. 108–9.

Agricultural historians have long been aware that a major increase in productivity and output characterised the so-called 'agricultural revolution'. Usually, however, this has been measured by indirect means: the fact, for example, that English farmers were able to feed some 3 million more people in 1700 than in 1540, and almost 20 million more in 1880 than in 1750.[1] Since mouths were fed without recourse to massive imports – which would have had significant economic implications for the industrial revolution – and since these increases in output were achieved while the agricultural labour force was in steep relative decline, the obvious implication is that productivity was increasing. Measuring such changes has proved complex, partly because data were not collected in a systematic fashion prior to the 1870s, and partly because such evidence as we have relating to prices and rents hardly represents an adequate proxy for productivity. In general terms, the best material has been for the grain acreage, particularly for wheat and barley.[2]

Evidence relating to animals, despite their overall importance in the agricultural economy, has proved much more elusive. 'There is', as Mark Overton has recently written, 'no direct evidence of livestock weights or yields of livestock produce which could be used to measure output per animal before the nineteenth century'.[3] This is

particularly unfortunate given that he has argued elsewhere in relation to the agricultural revolution that 'the key development was the integration of grass and grain and the ability to support a higher density of livestock while simultaneously extending the arable area'.[4] With stocking densities much higher than in the Middle Ages, wheat and barley yields, which were at medieval levels until the early eighteenth century, began to improve rapidly from about 1710 as the mean yields of wheat, barley, rye and oats simultaneously bettered the earlier standards of productivity.[5] Campbell and Overton have gone even further to suggest that in Norfolk the technological innovations on the arable were known as early as the thirteenth century. The reason that they were not more widely used until the seventeenth and eighteenth centuries was all to do with developments in the livestock sector, especially the doubling of stocking densities. As a result, advances in livestock productivity far outweighed those for crops, so that the livestock sector emerges as the more dynamic over the whole period from the thirteenth century onwards.[6]

Overton has taken the view that evidence for livestock prices and for the prices of their products (meat and wool), and the ratio between the two, might be indicative of output per animal. The price of cattle divided by the price of beef per pound, for example, should give some indication of the number of pounds of beef per animal. Although he tried to correlate the available evidence, Overton concluded that 'unfortunately (and rather surprisingly) there are no livestock prices series for the century after 1760'. His conclusion was that 'for what they are worth, the price-ratios indicate no change in the productivity of cattle between the mid-sixteenth and the mid-eighteenth centuries, but an increase for both mutton and wool of some 78 per cent during the first half of the eighteenth century, in comparison with the preceding century'.[7]

Overton's approach is that of the standard economic/agrarian historian: he uses straightforward price evidence (where it is available) to act as a proxy for measuring animal product output. However, with animals there is a problem of what the data may indicate. An increase in the sale price of sheep, cattle and pigs may reflect not simply market conditions, but changes in the nature of the animals, changes in feeding practices, even changes in breeding. Agricultural historians have never been very confident about dealing with such matters. For most livestock farmers in the past the emphasis of their work was on fattening rather than breeding. Improvements in livestock required selective breeding, the creation of new breeds, or the improvement of native breeds by crossing with newer varieties. Crossing of animals, in an attempt to improve the quality of output, had taken place for centuries, as farmers sought – pragmatically – to improve the weight and quality of the beasts they took to market.

Agricultural historians have undertaken relatively little work on this aspect of animal husbandry. The pioneer was G.E. Fussell in the 1920s and 1930s. In 1929 he addressed the question of 'whether there was an improvement in the average size of cattle, as meat supply, in the course of the 18th century'. He sought to do this by collecting together contemporary evidence of dead weights for animals brought to Smithfield and other meat markets. Fussell adjudged the evidence 'confused and unreliable', and sought instead to find more about different breeds 'to discover how great an increment of meat was gained by better methods of breeding directed specifically towards that purpose'. As a result of his researches, Fussell concluded that there was an increase in the volume

of meat production not through any real increase in either the number or size of animals, but 'in the change from oxen to horses for ploughing, and the consequent release of stock for fatting at an earlier age'. Thus, the increase in size – such as it was – together with 'the earlier maturity of the beasts', was his explanation of change in the eighteenth century, which he thought rather more realistic than vague dead stock figures culled from contemporary guesstimates.[8] Yet in a number of later articles Fussell was able really only to describe the different animals to be found in eighteenth-century England, usually on the basis of contemporary comments, particularly the *General Views* produced for the Board of Agriculture and the work of William Marshall. Such sources seldom if ever offered the level of statistical accuracy which would enable us to quantify changes in the quality, as well as the size, of animals, and in any case – as is well known – many of the figures quoted in the *General Views* were often little more than impressionistic comments. Fussell was forced, in other words, to fall back on description rather than analysis.[9]

Fussell wrote before there were many statistics available and at a time when the agricultural revolution was still seen as the product of a handful of heroic figures. As a result, he thought it best not to go too far: 'it would be little less than absurd to belittle the achievements of the great stockbreeders of the eighteenth century'.[10] These achievements were such that 'the foundation of all the modern breeds had been laid by 1800, and they possessed characteristics and possibilities much more valuable than their ancestors'.[11] Robert Bakewell of Dishley, near Loughborough, was often regarded as a pioneer of the agricultural revolution for his work in stockbreeding, which began around 1745. Bakewell was not alone, but his reputation was forged by his methods. He selected more rigorously than many of his contemporaries, breeding only from the finest animals. His fame rested largely on the 'New Leicester', a breed of sheep which fattened rapidly and had a high proportion of saleable flesh to bone.[12] What he achieved was a profitable meat animal which grew quickly, permitted the farmer a higher turnover of stock, and ensured a more efficient use of grazing resources. Even so, his achievements need to be kept in perspective. The flesh of the 'New Leicester' was regarded as 'coal-heavers' mutton because of the high proportion of fat to meat, and not fit for genteel dinner parties. Others followed where Bakewell led, but the pioneers often worked with only a handful of followers, so that it was not until well into the nineteenth century, and in conjunction with High Farming, that the importance of quality in livestock spread from the progressive few to the general run of farmers.[13]

Intensive mixed husbandry brought a substantial increase in sheep numbers, since folding or ranging sheep on turnips or clover leys brought advantages in dung and secondary commercial commodities. Improvements in feed, with the introduction of forage crops, increased both the number and weight of sheep in mixed farming systems. New breeds did not automatically bring carcass weight increases, but they did cut the age of slaughter which increased the supply of meat and in turn reduced the market price. The new breeds of sheep were ready for the butcher in two rather than four years. As animals were fed for less time before they went to market, and the quantity of saleable flesh from each animal increased, the price of meat fell. Contemporaries believed that this produced an increase in *output* independent of the work of the pioneer breeders,

and consequently selective breeding was only slowly adopted. Progress was further hampered by a combination of farmer conservatism, the relative backwardness of the biological sciences, and the lack of attention traditionally paid to grassland.[14]

To summarise, almost all the work done on animal husbandry has addressed qualitative issues because of the difficulty of assessing output other than by price evidence. Most of the statistical evidence used by Moore-Colyer in volume 6 of the *Agrarian History*,[15] together with the appendix to the same volume, was drawn from contemporary data. Those data have now been exhausted, and yet there remain considerable gaps in our knowledge. Changes in animal size might be important as a means of determining alternative or additional key factors. Is there, therefore, an alternative approach? The rest of this paper is primarily designed to look at likely changes in livestock as measured through size variations in cattle and sheep bones from medieval and post-medieval archaeological sites. An attempt will be made, albeit of a somewhat preliminary nature, to look at important questions about the age of slaughter, the relationship between bone size and animal size, and the more or less precise ageing of slaughter through teeth analysis, as well as questions relating to regional specialisation and environmental factors.

The use of archaeological bone measurements to help determine when sheep and cattle increased in size, and therefore to try to estimate when improvements in animal husbandry started, began with the work of Philip Armitage who looked at material recovered from excavations in the city of London.[16] Armitage's work was part of a research programme over the past half century in which important developments have taken place in the study of animal remains from archaeological sites. This science is known as zoo-archaeology, and one important aspect of it is the measurement of animal bones and teeth, generally mandibular teeth and limb-bones. Cattle and sheep are the obvious animals to test for increases in size. Armitage found bones of large cattle which came from levels dated between the thirteenth and sixteenth centuries, and the present article is a continuation of his work using finds from subsequent studies. It will be suggested that improvements to livestock were indeed under way at least by the sixteenth century.

The idea of using animal remains in this way as a means of developing our knowledge of changes in agriculture is quite new to historians of the subject. Zoo-archaeology is not mentioned in the pages of the *Cambridge Agrarian History of England and Wales*, or in most textbooks, and we are well aware that there are many problems involved with the interpretation of the data. It is easy enough to assume that an increase in size reflected an improvement in the animal, and that therefore animal bone size can be used to indicate periods of change. Such an assumption, however, pays no attention to the age of slaughter. It *may* tell us when sheep and cattle increased in size, from which we *may* assume that such increases measure improvements in husbandry. We shall, however, *not* make too many assumptions on the basis of the evidence we have gathered; rather, in this article we shall point to the potential of zoo-archaeological evidence for measuring changes in animal weights and sizes, and therefore as a potential means of analysing one other aspect of the agricultural revolution. By using evidence from English medieval and post-medieval sheep and cattle we hope to point agricultural historians in the direction of a source which has previously been neglected, but which may have significant implications for our understanding of agricultural change.

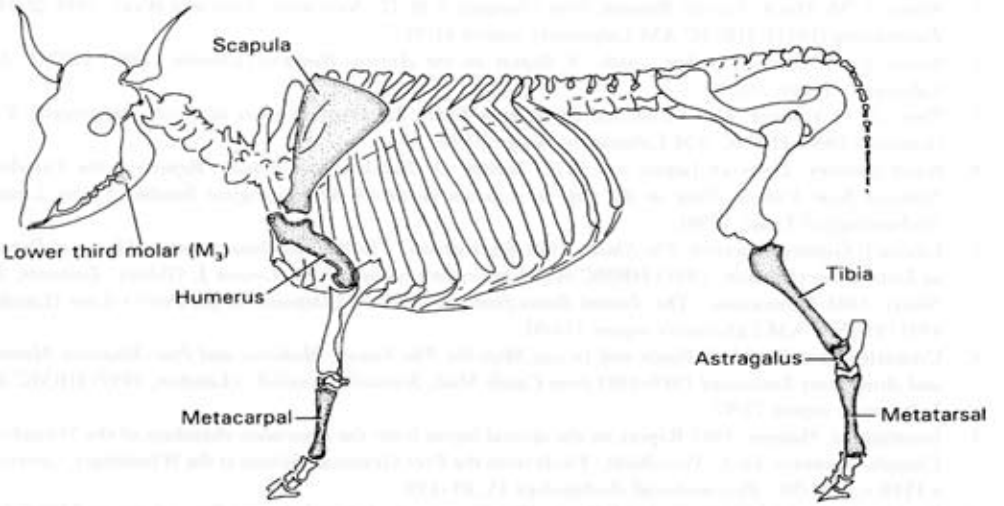

Figure 1. Sketch of a bovid skeleton to show the location of the bones whose measurements are discussed in this article.

What follows are two sets of comparisons of sheep and cattle measurements from archaeological sites (a) *synchronous* – within the medieval period across England and (b) *diachronous* – in various sites through time from medieval through to post-medieval (see table 1 which also gives the locations of the bones of the animals whose measurements are discussed below). Figure 1 shows which bones are considered here.

Table 1
Sites with animal bone measurements discussed herein

Site and location (arranged geographically)	dates (in centuries) of main assemblages of animal bone	source of data
Closegate, Newcastle	13th– 17th	Davis, 1991 [1]
Prudhoe Castle, Northumberland	11th–19th	Davis, 1987 [2]
Coppergate, York	early med	O'Connor, 1986 [3]
Lincoln	4th–post-med	Dobney *et al* . (1996) [4]
Leicester The Shires	mid–late med	Gidney, 1991a and 1991b [5]
Castle Mall, Norwich	9th–18th	Albarella, *et al* . (1997) [6]
Whitefriars, Coventry	mid 16th	Holmes, 1981 [7]
West Cotton, Northants	12th–15th	Albarella and Davis, 1994 [8]
Burystead and Langham Road, Northants	7th–15th	Davis, 1992 [9]
St. Frideswides, Oxford	12th–17th	Stallibrass, 1988 [10]
Okehampton Castle, Devon	13th–18th	Maltby, 1982 [11]
Exeter, Devon	12th–19th	Maltby, 1979 [12]
Launceston Castle, Cornwall	late 13th–1840	Albarella and Davis, 1996 [13]
Camber Castle, Sussex	c.1540–1640	Connell, Davis and Locker 1997 [14]

References for this table:

1. Simon J. M. Davis, *Faunal Remains from Closegate I & II, Newcastle, Tyne and Wear, 1988 & 1990 Excavations* (1991). HBMC AM Laboratory report 81/91.
2. Simon J. M. Davis, *Prudhoe Castle, A Report on the Animal Remains* (London, 1987) HBMC AM Laboratory report 162/87.
3. Terry P. O.'Connor, *Hand-Collected Bones from Seven Medieval Deposits at 16–22 Coppergate, York* (London, 1986) HBMC AM Laboratory report 20/86.
4. Keith Dobney, Deborah Jaques and Brian Irving, *Of Butchers and Breeds: Report on the Vertebrate Remains from Various Sites in the City of Lincoln* (Lincoln Archaeological Studies 5, the Lincoln Archaeological Trust, 1996).
5. Louisa J. Gidney, *Leicester, The Shires, 1988 Excavations: The Animal Bones from the Medieval Deposits at Little Lane* (London, 1991) HBMC AM Laboratory report 57/91. Louisa J. Gidney, *Leicester, The Shires, 1988 Excavations: The Animal Bones from the Medieval Deposits at St. Peter's Lane* (London, 1991) HBMC AM Laboratory report 116/91.
6. Umberto Albarella, Mark Beech and Jacqui Mulville *The Saxon, Medieval and Post-Medieval Mammal and Bird Bones Excavated 1989–1991 from Castle Mall, Norwich (Norfolk)* (London, 1997) HBMC AM Laboratory report 72/97.
7. Jonathan M. Holmes, 1981 Report on the animal bones from the resonance chambers of the Whitefriars Church, Coventry. In: C. Woodfield, 'Finds from the Free Grammar School at the Whitefriars, Coventry, c.1545–c.1557/58', *Post-medieval Archaeology* 15, 81–159.
8. Umberto Albarella and Simon J. M. Davis, *The Saxon and Medieval Animal Bones Excavated 1985–1989 from West Cotton, Northamptonshire.* (London, 1994) HBMC AM Laboratory report 17/94.
9. Simon J. M. Davis, *Saxon and Medieval Animal Bones from Burystead and Langham Road, Northants; 1984–1987 Excavations* (1992) HBMC AM Laboratory report 71/92.
10. Sue Stallibrass, 'The Animal Bones'. In: C. Scull, 'Excavations in the cloister of St. Frideswide's Priory, 1985' *Oxoniensia* (1988) 53, 21–75, pp. 56–60.
11. Mark Maltby, 'Animal and Bird Bones' In: R. A. Higham, 'Excavations at Okehampton Castle, Devon. Part 2–The Bailey', *Devon Archaeological Society* 40 (1982) 114–135.
12. Mark Maltby, *The Animal Bones from Exeter 1971–1975*, Exeter Archaeological reports (2) (Sheffield University, Department of Prehistory and Archaeology, 1979).
13. Umberto Albarella and Simon J. M. Davis, 'Mammals and Birds from Launceston Castle, Cornwall: Decline in Status and the Rise of Agriculture', *Circaea*, 12 (1996), 1–56.
14. Brian Connell, Simon Davis and Alison Locker, *The Post-Medieval Animal Bones from Camber Castle, East Sussex, Excavated 1963-1983* (1997) HBMC AM Laboratory report 107/97.

Large faunal assemblages whose dates span the medieval–post-medieval periods are not common, and post-medieval assemblages are especially rare. There are all sorts of reasons why this is the case. Post-medieval man probably used the whole animal more efficiently, and disposed of his garbage in a more effective way, than his predecessors, while the vast range of buildings erected in England since the nineteenth century may have destroyed many such deposits. In addition, archaeologists have shown rather less interest in biological remains from 'late' levels than from earlier ones. However, as table 1 shows, in recent years several medieval and post-medieval bone assemblages have been studied. These are mostly from castles and towns. Although the numbers of bones from post-medieval levels are often small, the site of Launceston Castle in Cornwall, with its large deposits both medieval and post-medieval is a notable exception.[17]

The zoo-archaeological evidence suggests that the sizes of animals varied across the country. This is hardly surprising. Indeed, agricultural historians are well aware of the regional diversity in English agriculture.[18] Although the zoo-archaeological evidence is not strong on the point because data have not been collected from every region, it seems likely that cattle and sheep were smaller in the more outlying regions such as Cornwall and Northumberland than in central England. In the medieval period there seems to

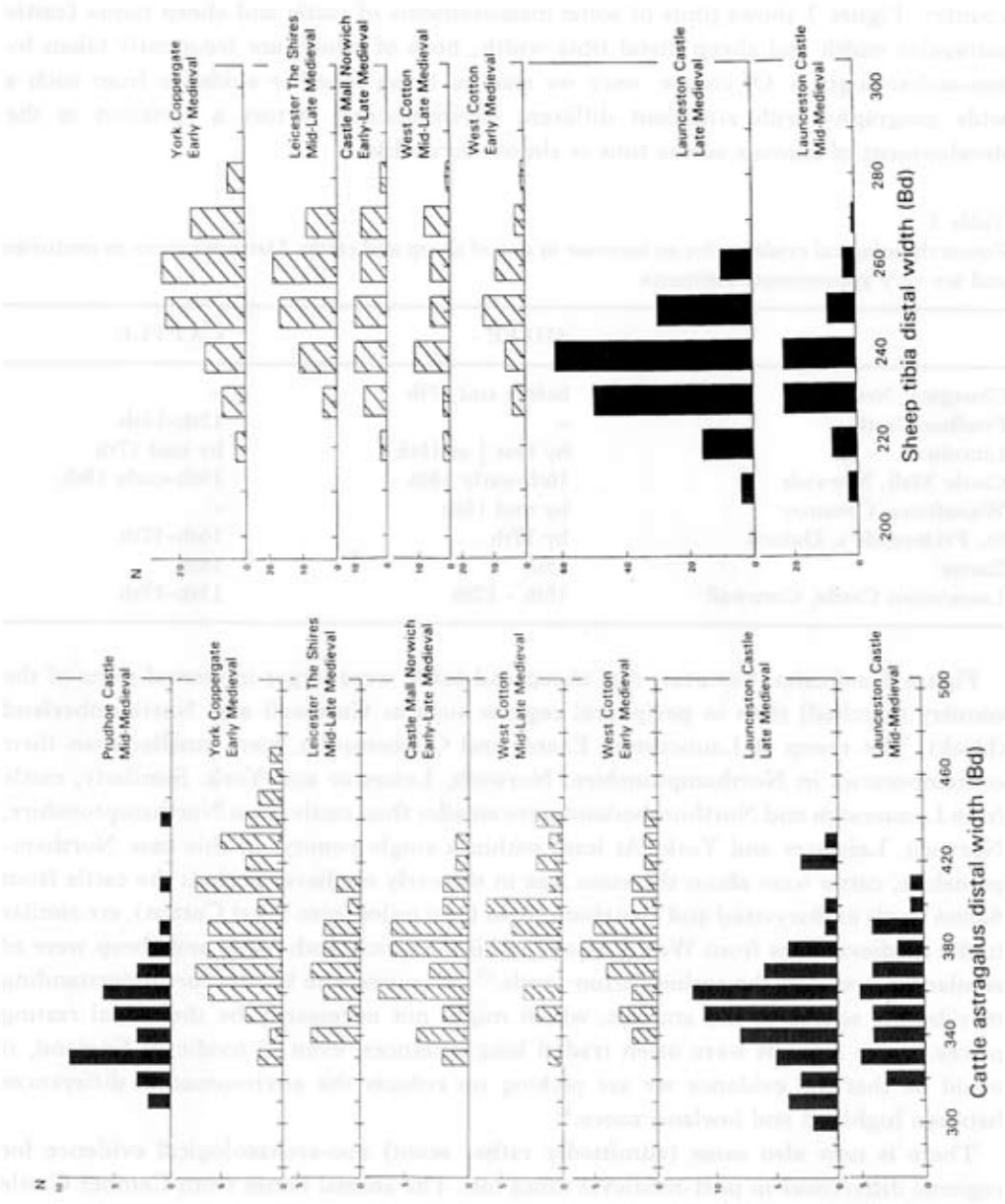

Figure 2. Synchronous variation in the size of sheep and cattle in medieval England. Distal widths (Bd) of medieval sheep tibiae and distal widths (Bd) of medieval cattle astragali in different parts of England. Vertical scales represent the numbers of specimens, horizontal scales are in tenths of a millimetre. Hatched plots are from sites in central England, solid plots are from sites (Launceston, Cornwall and Prudhoe, Northumberland) in peripheral regions.

have been considerable variation in the size of cattle and sheep in different parts of the country. Figure 2 shows plots of some measurements of cattle and sheep bones (cattle astragalus width and sheep distal tibia width; both of which are frequently taken by zoo-archaeologists). Of course, once we start to bring together evidence from such a wide geography with attendant different environmental factors a variation in the development of animals across time is almost inevitable.

Table 2
Zoo-archaeological evidence for an increase in size of sheep and cattle. Dates are given in centuries and are very approximate estimates.

	SHEEP	CATTLE
Closegate, Newcastle	before end 17th	–
Prudhoe Castle	–	15th–16th
Lincoln	by first $\frac{1}{2}$ of 16th	by mid 17th
Castle Mall, Norwich	16th–early 18th	16th–early 18th
Whitefriars, Coventry	by mid 16th	–
St. Frideswide's, Oxford	by 17th	16th–17th
Exeter	15th	16th
Launceston Castle, Cornwall	15th - 17th	15th–17th

Figure 2 indicates, however, that sheep and cattle were larger in central parts of the country (hatched) than in peripheral regions such as Cornwall and Northumberland (black). The sheep at Launceston, Exeter and Okehampton, were smaller than their contemporaries in Northamptonshire, Norwich, Leicester and York. Similarly, cattle from Launceston and Northumberland were smaller than cattle from Northamptonshire, Norwich, Leicester and York. At least within a single county, in this case Northamptonshire, cattle were about the same size in the early medieval period: the cattle from Saxon levels at Burystead and Langham Road (two miles from West Cotton), are similar to the medieval ones from West Cotton, and in Norwich both cattle and sheep were of similar large size in the earlier Saxon levels.[19] Of course, the key to our understanding may be the source of the animals, which might not necessarily be their final resting places. Since animals were often traded long distances, even in medieval England, it could be that the evidence we are picking up reflects the environmental differences between highland and lowland zones.[20]

There is now also some (admittedly rather scant) zoo-archaeological evidence for regional differences in post-medieval times too. The animal bones from Camber Castle in East Sussex, occupied between c.1540 and 1640, indicate that the sheep in early post-medieval Sussex were larger than their contemporaries in Cornwall and Norfolk.[21] Certainly the Cornish historian Richard Carew believed his local sheep were comparatively small. Writing in 1602 he noted that:

> What time the shire, through want of good manurance, lay waste and open, the sheep had generally little bodies and coarse fleeces, so . . . But since the grounds began to receive enclosure and dressing for tillage, the nature of the soyle hath altered to a better graine, and yeeldeth nourishment in

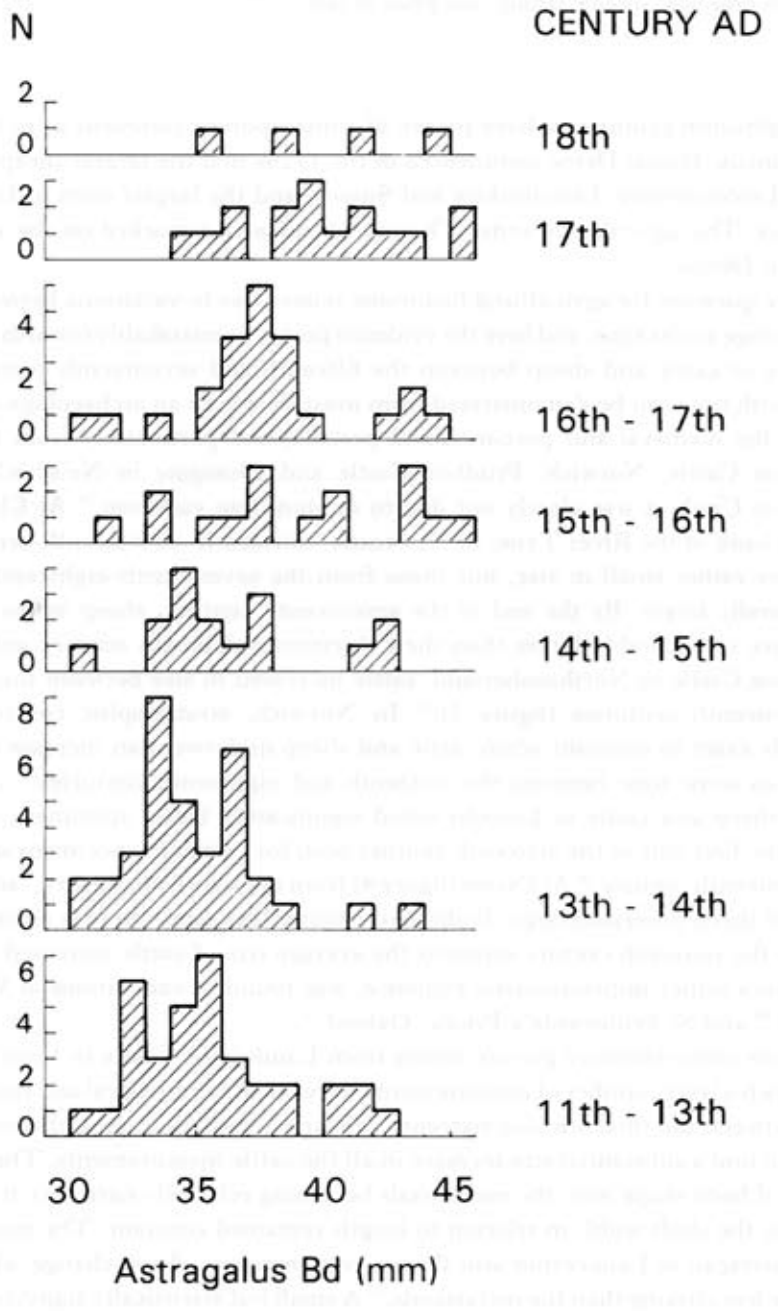

Figure 3. Cattle size variation at Prudhoe Castle, Northumberland. Measurements in millimetres of astragalus distal width (Bd). Vertical scale represents numbers of specimens (From Simon J. M. Davis, *Prudhoe Castle, A Report on the Animal Remains*, HBMC AM Laboratory report 162/87, 1987.

greater aboundance, and goodnesse to the beastes that pasture thereupon: so as by this meanes ... Cornish sheepe come but little behind the easterne flockes for bignes of mould, finenesse of wooll, often breeding, speedie fatting, and price of sale. ...[22]

By the eighteenth century we have plenty of contemporary comment as to the varying size of animals. Daniel Defoe commented in the 1720s that the largest sheep were to be found in Leicestershire, Lincolnshire and Sussex, and the largest oxen in Lincolnshire and Sussex. The agricultural writer Thomas Davis later remarked on the small breed of cattle in Devon.[23]

The key question for agricultural historians relates less to variations between regions than to change across time, and here the evidence points unmistakably towards an increase in the size of cattle and sheep between the fifteenth and seventeenth centuries. This increase with time can be demonstrated from most sites with an archaeological sequence spanning the medieval and post-medieval periods, and particularly from the Exeter, Launceston Castle, Norwich, Prudhoe Castle and Closegate in Newcastle sites. At Launceston Castle it was clearly not due to random size variation.[24] At Closegate, on the north bank of the River Tyne, in Newcastle, thirteenth- to sixteenth-century sheep bones were rather small in size, but those from the seventeenth–eighteenth centuries were generally larger. By the end of the seventeenth century, sheep in the Newcastle region were considerably larger than their thirteenth–sixteenth century antecedents.[25] At Prudhoe Castle in Northumberland, cattle increased in size between the fourteenth and seventeenth centuries (figure 3).[26] In Norwich, stratigraphic control was not sufficiently exact to pinpoint when cattle and sheep underwent an increase of size, but they did so some time between the sixteenth and eighteenth centuries.[27] A long-run study of sheep and cattle in Lincoln noted significantly larger specimens in contexts dated to the first half of the sixteenth century and, for cattle, in specimens dated to the mid-seventeenth century.[28] At Exeter (figure 4) from the sixteenth century, 'an increasing number of sheep possessed larger bodies and stouter legs' and 'there is some indication that from the sixteenth century onwards the average size of cattle increased'.[29] Similar, if sometimes rather impressionistic evidence, was found at excavations at Whitefriars, Coventry,[30] and St Frideswide's Priory, Oxford.[31]

The most comprehensive picture comes from Launceston Castle in Cornwall (figure 5), for which a large number of measurements were taken for medieval and post-medieval bones. Between the fifteenth and sixteenth centuries, and continuing thereafter, it was possible to find a substantial size increase in all the cattle measurements. There was also a change of bone shape with the metatarsals becoming 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 the metatarsals.[32] A small but statistically significant increase in size was also found in sheep, although somewhat later, primarily between the sixteenth and early nineteenth centuries. Sheep at Launceston underwent their 'major' size increase one or even two centuries after cattle. The size increase of the sheep seems to have been rather more gradual than that of the cattle.

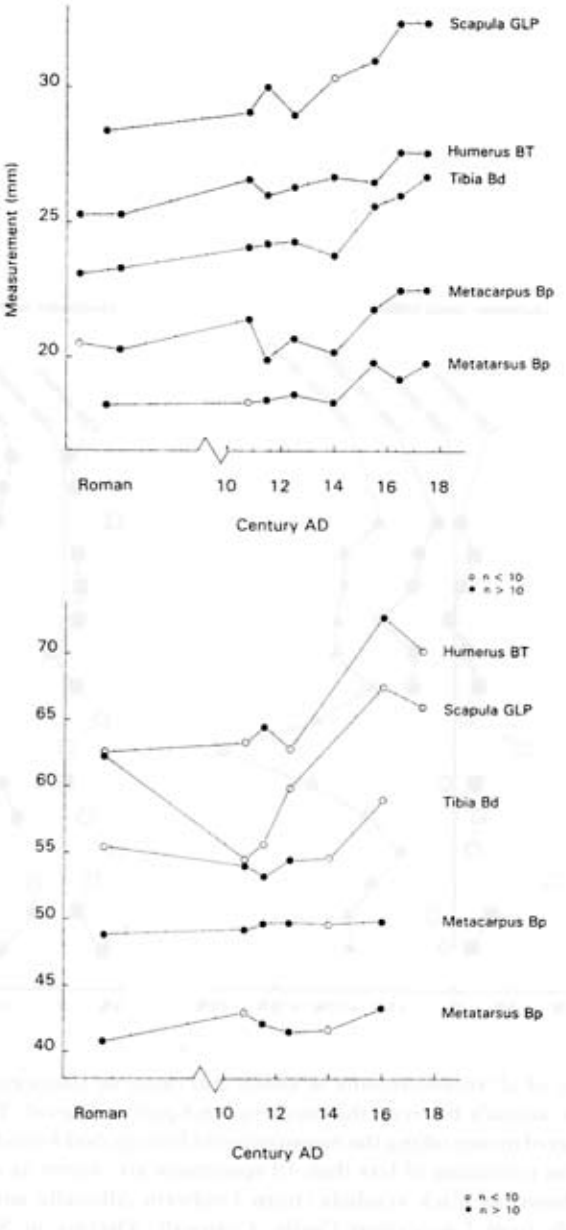

Figure 4. Sheep and cattle size variation at Exeter. Plots of the mean values of measurements of several bones (from Mark Maltby, *The Animal Bones from Exeter 1971-1975*, Exeter Archaeological reports, 1979, Sheffield University, Department of Prehistory and Archaeology. Samples consisting of less than 10 specimens are shown as open symbols, samples more than 10 are shown as black symbols. GLP: length of the articular end, BT: medio-lateral width of the trochlea, parallel to the axis of rotation of the joint, Bd: distal width, Bp: proximal width. For details of how measurements were taken see Angela von den Driesch, *A Guide to the Measurement of Animal Bones from Archaeological Sites*, Peabody Museum Bulletin 1, Cambridge Mass., Harvard University, 1976.

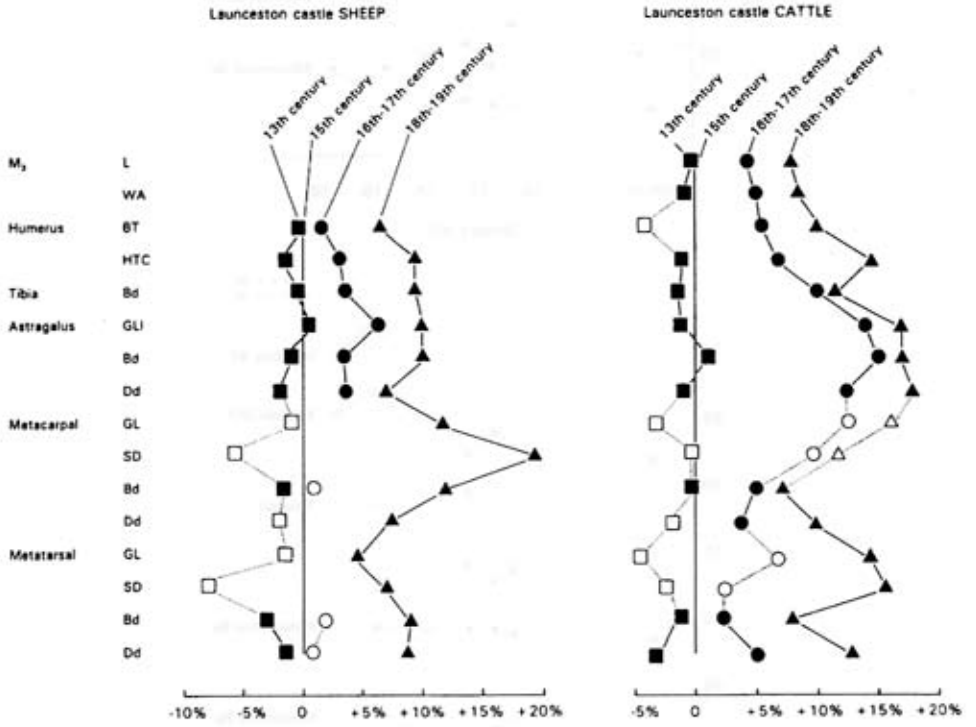

Figure 5. Summary of all measurements of sheep and cattle at Launceston Castle to show the size increase of these animals between the medieval and post-medieval. The diagrams show the percentage differences of means taking the measurements from period 8 (mid–late fifteenth century) as a baseline. Samples consisting of less than 10 specimens are shown as open symbols, samples more than 10 are shown as black symbols (from Umberto Albarella and Simon J. M. Davis, 'Mammals and Birds from Launceston Castle, Cornwall: Decline in Status and the Rise of Agriculture' *Circaea*, 12 (1996), 1-156.

Why should these changes have occurred? The most obvious point to make is that the variations in bone/tooth size discussed here are not simply an illusion reflecting differences in the age of slaughter of the animals. Many of the measurements are for widths and depths of the articular ends of long-bones whose epiphyses or growing ends are fused, i.e. they are fully adult. Once fusion of epiphyses occurs, little or no further increase in bone growth can take place. Moreover, teeth such as cattle third molars, once erupted, cannot increase in size. Unlike fish and many reptiles, measurements of mammalian bones with fused epiphyses are therefore age-independent. Size may change as a result of the effects of many different factors. Owing to sex-linked size characteristics, a sudden change in the sex ratio would produce a change in the mean size of a sample of bones. However, at least in the case of Launceston, there is no evidence for a change in the sex ratio of cattle to one with a greater proportion of adult males to females. Moreover, artiodactyl molar teeth show little if any sexual dimorphism.[33] Certainly at Launceston the increase in size of the animal 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 is probably safe to rule out a variation of the sex-ratio as a factor here (see figure 5 at the top right hand side the plot showing the increase in length and width of cattle third molar teeth). Another possibility is that the post-medieval size increase reflects the adoption of the practice of castration. Castration is known to delay epiphysial closure which permits continued growth of long-bones.[34] However, results from work in progress indicate that castration does not alter the widths of the articulations of long-bones and most of the measurements considered here are widths.[35] (Animal bones from archaeological sites are generally broken and so length measurements cannot be taken.) We conclude therefore that a real (perhaps even a genotypic) size increase must have occurred in these animals. It is fitting to quote Markham: 'Touching the bignesse of bone, the larger that every cow is, the better she is; for when either age, or mischance shall disable her for the paile, being of large bone, shee may bee fed, and made fit for the shambles, and so no losse, but profit, and any other to the paile as good and sufficient as her self'.[36]

Further evidence to support the argument that cattle underwent a real change in size comes from the simultaneous alteration of (a) bone-shape, (as at Launceston Castle, mentioned above) and (b) the reduced frequency of a dental anomaly at Launceston between the mid to late fifteenth century and the sixteenth and seventeenth centuries. In artiodactyls the lower third molar tooth is characterised by having three pillars. The third pillar, the hypoconulid, is somewhat smaller, and occasionally fails to develop. At Launceston we recorded 14 out of 108 in the medieval layers and only 1 out of 47 in the post-medieval layers of cattle M_3s with reduced or missing hypoconulids. The probability that such a change is due to chance is less than 5%.[37]

However, there is a further issue which needs to be addressed, the *age* of slaughter. If there was change across time, this could skew the analysis, and it is clear from the Launceston evidence that there was such change between the medieval and post-medieval periods. Analysis of dental eruption and wear stages indicates that in the thirteenth to fifteenth centuries less than 20 per cent of the cattle were under 3 years old at slaughter, reflecting perhaps beeves derived mainly from retired dairy/breeding and work animals.

The situation later changed with approximately 60 per cent of the cattle aged under three years, suggesting a shift towards greater emphasis on the production of beef and dairy products and a countrywide increase in specialisation. Grant mentions an 'increase in the percentage of young animals in later deposits at some sites', a change which she attributes to the increasing importance of cattle as meat suppliers.[38] Trow-Smith suggests that during the sixteenth and seventeenth centuries the cow shifted in importance from a beast of traction to become a breeder of meat and supplier of milk.[39] Maltby notes an increase of young cattle in the sixteenth century and onwards at Exeter,[40] and Griffith *et al* ., note many more young cattle jaws in the seventeenth century at Sandal castle.[41]. In his summary of animal remains from monastic sites, O'Connor notes that at St Andrew's priory 'the fifteenth and sixteenth centuries seem to have seen an increase in . . . the exploitation of newly-weaned cattle for veal', and similar results are now reported at Lincoln, Norwich, Camber Castle and Launceston.[42]

These zoo-archaeological indications of an early onset of agricultural improvement in England support the findings of agricultural historians working from a more traditional viewpoint. In the medieval period animals were slaughtered relatively old and relatively small, while in later centuries they were relatively young, but larger animals. Greater care and selective breeding of ruminants in the sixteenth and seventeenth centuries was made possible by general improvements to livestock nutrition – the introduction and spread of new fodder crops, innovations such as water meadows, and the increased use of horses for cultivation.[43] Moreover, this size increase reflects increased sophistication of animal husbandry.

It follows from the argument presented in this paper that agricultural improvement in England was already under way in the fifteenth and sixteenth centuries, and that improvement in animal husbandry should be viewed more as a long-term and *gradual* development originating in the fifteenth century, rather than a *revolutionary* one which commenced sometime after 1760. Nor is such a conclusion out of line with current thinking. Overton, one of the few historians in recent years to quote zoo-archaeological evidence, has commented that 'the absence of improvement in the size of cattle is confirmed by archaeo-zoological evidence which suggests that the increase in the size of cattle took place between the middle ages and the sixteenth century, rather than later'.[44] No particular sources are cited for this argument, but this paper suggests there is relevant evidence to argue for an improvement from the medieval into the post-medieval period.

Zoo-archaeological work can never stand on its own as an indicator of agricultural improvement, but in view of the relatively poor quality of animal husbandry data from which agricultural historians usually work, it offers an alternative means of viewing a question which is widely recognised as important for our understanding of agricultural change. It may be that there are other ways of measuring productivity which have yet to be fully exploited,[45] but this evidence, drawn from an alternative approach, must point us in a helpful direction for future research. We wonder whether historical sources tend to emphasise theory rather than practice and to present an idealised picture of the achievements of great men, whereas bones have the potential to record practice rather than theory and to measure the activity of the population at large.

Acknowledgements

We are grateful to Sebastian Payne for his encouragement, and to him and Umberto Albarella, Matt Canti, Paul Halstead and Michael Turner for reading earlier versions of this article. Umberto Albarella, Mark Beech and Jacqui Mulville kindly allowed us to quote from their unpublished report on the animal bones from Castle Mall, Norwich. Simon Davis is grateful to the late Barbara Noddle who, several years ago, drew his attention to the debate concerning the beginnings of the Agricultural Revolution.

Notes

1. Eric Kerridge, *The Agricultural Revolution* (London, 1967; Joan Thirsk, *England's Agricultural Regions and Agrarian History, 1500–1750* (London, 1987); J. V. Beckett, *The Agricultural Revolution* (Oxford, 1990).
2. J. Thirsk (ed), *The Agrarian History of England and Wales, Volume IV, 1500–1640* (Cambridge, 1967); *Volume V* (Cambridge, 1984–5; G. E. Mingay (ed), *The Agrarian History of England and Wales, Volume VI, 1750–1850* (Cambridge, 1989).
3. M. Overton, *Agricultural Revolution in England: The Transformation of the Agrarian Economy 1500-1850* (Cambridge, 1996), p. 115.
4. B. M. S. Campbell and M. Overton, 'A New Perspective on Medieval and Early Modern Agriculture: Six Centuries of Norfolk Farming, c.1250–c.1850', *Past and Present*, 141 (1993).
5. Campbell and Overton, 'New Perspective', pp. 74, 83, 88. However, R. C. Allen has argued that late early-modern yields were a good deal higher than medieval levels.
6. Campbell and Overton, 'New Perspective'.
7. Overton, *Agricultural Revolution*, p. 115.
8. G. E. Fussell, 'The Size of English Cattle in the Eighteenth Century', *Agricultural History*, 3, 1929, 160–81.
9. G. E. Fussell, 'Animal Husbandry in Eighteenth Century England, Part 1', *Agricultural History*, (April 1937), 96–116; 'Part 2', *ibid*, (July 1937), 189–214.
10. Fussell, 'Animal Husbandry Part 1', p. 96.
11. *Ibid*, p. 97
12. N. Russell, *Like Engend'ring Like: Heredity and Animal Breeding in Early Modern England* (Cambridge, 1986).
13. R. Trow Smith, *A History of British Livestock Husbandry to 1700* (London, 1957); *A History of British Livestock Husbandry, 1700–1900* (London, 1959); E. L. Jones, *The Development of English Agriculture 1815–1873* (London, 1968).
14. Mingay, *Agrarian History*, pp. 313–51.
15. *Ibid*, pp. 313–51, 973 passim.
16. Philip L. Armitage, 'A Preliminary Description of British Cattle from the Late Twelfth to the Early Sixteenth Century', *The Ark*, 7 (1980), 405–13.
17. Umberto Albarella and Simon J. M. Davis, 'Mammals and Birds from Launceston Castle, Cornwall: Decline in Status and the Rise of Agriculture', *Circaea* , 12, 1996, 1–156.
18. Kerridge, *The Agricultural Revolution*; Thirsk, *England's Agricultural Regions and Agrarian History, 1500–1750*.
19. Simon J. M. Davis, *Saxon and Medieval Animal Bones from Burystead and Langham Road, Northants; 1984–1987 Excavations*, HBMC AM Laboratory report 71/92, 1992; Umberto Albarella, Mark Beech and Jacqui Mulville, *The Saxon, Medieval and Post-Medieval Mammal and Bird Bones Excavated 1989–1991 from Castle Mall, Norwich (Norfolk)*, (1997 HBMC AM Laboratory report 72/97).
20. H. E. Hallam (ed.), *The Agrarian History of England and Wales*, volume II, 1042–1350 (Cambridge, 1986); E. Miller (ed.), *The Agrarian History of England and Wales*, volume III, 1348–1500 (Cambridge, 1991).

21. Brian Connell, Simon Davis and Alison Locker, *The Post-Medieval Animal Bones from Camber Castle, East Sussex, excavated 1963–1983* (HBMC AM Laboratory report 107/97, 1997)
22. R. Carew, *The Survey of Cornwall*, 1602, pp. 23–4.
23. D. Defoe, *A Tour Through the Whole Island of Great Britain* [1724] (London, 1962); Thomas Davis, *General View of the Agriculture of the County of Wiltshire* (London, 1794).
24. Albarella and Davis, 'Launceston Castle' measured over three and a half thousand bones and teeth. Statistical tests revealed a significant difference in the average size of cattle teeth and bones and sheep bones between the mid-late fifteenth century and the sixteenth-seventeenth century at Launceston.
25. Simon J. M. Davis, *Faunal Remains from Closegate I & II, Newcastle, Tyne and Wear, 1988 & 1990 excavations* HBMC AM Laboratory report 81/91, 1991; Richard Fraser, Caroline Jamfrey and John Vaughan, 'Excavation on the site of the Mansion House, Newcastle, 1990', *Archaeologia Aeliana*, fifth series, 23, 1995.
26. Simon J. M. Davis, *Prudhoe Castle, A Report on the Animal Remains*, HBMC AM Laboratory report 162/87, 1987.
27. Umberto Albarella, Mark Beech and Jacqui Mulville, *Norwich* (1997).
28. Keith Dobney, Deborah Jaques and Brian Irving, *Of Butchers and Breeds: The Vertebrate Remains from Excavations in the City of Lincoln (1972–1989)* (Lincoln, 1996) Lincoln Archaeological Trust.
29. Mark Maltby, *The Animal Bones from Exeter 1971–1975*, Exeter Archaeological reports, 2 (Sheffield University, Department of Prehistory and Archaeology, 1979).
30. Jonathan M. Holmes, 'Report on the Animal Bones from the Resonance Chambers of the Whitefriars Church, Coventry', in C. Woodfield, 'Finds from the Free Grammar School at the Whitefriars, Coventry, c.1545– c.1557/58', *Post-Medieval Archaeology* 15 (1981), 81–159.
31. Sue Stallibrass, 'The Animal Bones', in C. Scull, 'Excavations in the Cloister of St. Frideswide's Priory, 1985', *Oxoniensia* 53 (1988), 56–60.
32. Albarella and Davis, 'Launceston Castle'. See also Umberto Albarella, 'Shape Variation of Cattle Metapodials: Age, Sex or Breed? Some Examples from Medieval and Post-Medieval Sites'. *Anthropozoologica* 25–26 (1997) 37–47.
33. Magnus Degerbøl, 'Prehistoric Cattle in Denmark and Adjacent Areas', in A. E. Mourant and F. E. Zeuner (eds), *Man and Cattle: Proceedings of a Symposium on Domestication at the Royal Anthropological Institute 24–26 May 1960* (1963), 69–79 (Occasional Paper no. 18 of the Royal Anthropological Institute, London).
34. Tøve Hatting, 'Osteological Investigations on *Ovis aries* L', *Dansk Naturhistorisk Førening* 144 (1983), 115–35.
35. Simon J. M. Davis, 'The Effect of Castration on the Development of the Shetland Sheep Skeleton and a Biometric Comparison Between Males, Females and Castrates' (in preparation).
36. Gervase Markham, *The English Howse-Wife, containing the inward and outward vertues which ought to be in a compleate woman* (1637), p. 190.
37. Albarella and Davis, 'Launceston Castle'.
38. Annie Grant, 'Animal Resources', in G. Astill and A. Grant (eds), *The Countryside of Medieval England* (Oxford, 1988) pp. 149–261, especially p. 156.
39. Trow-Smith, *History of British Livestock Husbandry to 1700.*
40. Maltby, *Exeter*
41. N. J. L. Griffith, P. L. J. Halstead, A. MacLean and P. A. Rowley-Conwy, 'Faunal Remains and Economy' in P. Mayes and L. A. S. Butler, *Sandal Castle Excavations 1964–1973* (Wakefield, 1983), pp. 341–8.
42. Terry P. O'Connor, 'Bone Assemblages from Monastic Sites: Many Questions but few Data', in R. Gilchrist and H. Mytum (eds), *Advances in Monastic Archaeology*, (Oxford,

1993) BAR British series 227, p. 109; Dobney, et al, *Lincoln* ; Albarella et al. *Norwich* ; Connell, Davis and Locker, 'Camber'; Albarella and Davis, 'Launceston Castle'.

43. Kerridge, *Agricultural Revolution*; Christopher Dyer, *Warwickshire Farming 1349– c.1520 : Preparations for the Agricultural Revolution* (Oxford, 1981) Dugdale Society Occasional papers no. 27; Bruce M. S. Campbell and Mark Overton, 'Norfolk Livestock Farming 1250–1740: A Comparative Study of Manorial Accounts and Probate Inventories', *Journal of Historical Geography*, 18 (1992), 377–96.
44. Overton, *Agricultural Revolution*, p. 115.
45. M. E. Turner, J. V. Beckett and B. Afton, 'Taking Stock: Farmers, Farm Records and Agricultural Output in England, 1700–1850', *Agricultural History Review*, 44 (1996), 21–34.