SHAPE VARIATION OF CATTLE METAPODIALS: AGE, SEX OR BREED? SOME EXAMPLES FROM MEDIAEVAL AND POSTMEDIAEVAL SITES

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Summary

Cattle metapodials are apparently among the bones which have been most investigated by zooarchaeologists. Nevertheless the effect of different variables on size and shape of these bones is still only poorly understood. Here the effect of age, sex, pathology and genetic change on the shape of mediaeval and postmediaeval cattle metapodials at Launceston Castle (England) is considered. It is suggested that a change is due to the presence in the later period of a genetically different type of cattle. This explanation is supported by the contemporary occurrence of a size change and by the different frequency of a non-metrical trait between the two periods. Comparison with other sites and with data from modern animals shows the very large extent to which the shape of metapodials may vary in different regional types, and how this can obscure the difference between sexes.

Résumé

Variation de la forme des métapodes de bœuf : âge, sexe ou variété ? Quelques exemples provenant de sites médiévaux et post-médiévaux.

Les métapodes de bœuf sont une des catégories d'os qui a été la plus étudiée par les archéozoologues. Pourtant l'effet de certaines variables sur la taille et la forme de ces os est encore mal compris. Nous avons examiné ici les effets des changements dus à l'âge, au sexe, à la pathologie et à la génétique sur la forme des métapodes de bœuf de Launceston Castle (Angleterre) au Moyen Âge et à l'époque suivante. Nous avons suggéré que l'un des changements est dû à la présence, à la période plus récente, d'un type de bovin génétiquement différent. Cette explication est soutenue par deux observations : on a noté d'une part à cette époque un changement de taille et, d'autre part, un caractère non métrique que l'on trouve aux deux époques dans des proportions différentes. Les comparaisons avec d'autres sites et avec les mesures prises sur des animaux de l'époque actuelle nous indiquent combien la forme des métapodes peut varier selon les régions, et combien ce fait peut masquer les différences entre les sexes.

Zusammenfassung

Morphologische Variation von Rindermetapodien: Alter, Geschlecht oder Zucht? Einige Beispiele von mittelalterlichen und nachmittelalterlichen Fundstellen.

Die Zooarchäologie hat schon immer großes Interesse an den Rindermetapodien gezeigt. Trotzdem bleibt die Auswirkung verschiedener Parameter wie Alter, Geschlecht, Pathologie und Mutation auf Maße und Morphologie dieser Knochen zum größten Teil noch unklar. In diesem Beitrag wird der Einfluß solcher Faktoren an mittelalterlichen und nachmittelalterlichen Knochen aus Launceston Castle (England) untersucht. Es wird die Hypothese aufgestellt, daß die zwischen zwei Perioden festgestellten morphologischen Veränderungen mit dem Aufkommen eines genetisch neuartigen Rindertyps zusammenhängen. Diese Annahme wird durch das gleichzeitige Auftreten metrischer und nichtmetrischer Merkmale gestützt. Vergleiche mit anderen Fundorten und rezenten Rindern zeigen, wie sehr die Morphologie der Metapodien in verschiedenen Regionaltypen variieren kann und wie diese die Geschlechtsunterschiede überlagern können.

Key Words

Cattle metapodials, Shape, Size, Age, Sex, Pathology, Breed.

Mots clés

Métapodes de bœuf, Forme, Taille, Âge, Sexe, Pathologie, "Race".

Schlüsselworte

Rindermetapodien, Form, Größe, Alter, Geschlecht, Pathologie, "Rasse".

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Introduction

The analysis of metric data in zooarchaeology is commonly used for comparing the size of animals belonging to different populations. However, metric data can also be used as a measure of shape. In a classic and seminal study on "growth and form", Thompson (1917) showed that the difference in form between different animals could be expressed as a difference in relative measurements, and ultimately it could be expressed in mathematical terms. The main problem when we want to apply allometric studies (i.e. study of shape change correlated with increase or decrease in size; Gould, 1977) to archaeological assemblages is that complete skeletons are rarely found on archaeological sites. Despite these limitations the study of the shape of animal bones, as expressed by the ratio between different measurements, can be extremely useful in zooarchaeology both for comparing different species and different populations. Moreover differences within one population are very valuable in order to detect the extent and the nature of the shape variability.

In this article relative measurements are used to detect patterns of shape variation of metapodials. After a brief introduction to the potential of the study of *cattle metapodials* a different method for considering the relative measurements of these bones is suggested. Data from the mediaeval/postmediaeval site of Launceston Castle will be presented in a way which considers separately the variables *size* and *shape*. These data will also be compared to data from other sites, in order to detect the extent of shape variability at a regional level. Zooarchaeological data, such as size, shape and non metrical traits of cattle bones, as well as historical sources will all be taken into account in this interpretation of shape variation. It is suggested that the sex as a factor influencing metapodial shape has been overemphasized. The main aim of this paper is not to try to resolve a historical problem, but rather to present a study of one particular case in the hope it will be useful in interpreting shape patterns of metapodials from other sites.

Cattle metapodials: most studied bones?

There are few bones which have stimulated the interest of the zooarchaeologists as much as cattle metapodials. What is probably the main advantage of these bones is that they display a strong sexual dimorphism (or rather, polymorphism, if castrates are included). The sexual polymorphism of these elements has been demonstrated, on the basis of the study of modern material, by several authors (e.g. Zalkin, 1962; Fock, 1966; Higham, 1969; Higham and Message, 1969), while a review of the literature on the topic can be found in Grigson (1982). There is general agreement that metacarpals are more sex-dimorphic than metatarsals and that both metapodials tend to be short and slender in cows, short and wide in bulls and long and slender in steers. This is confirmed by the fact that the proportional contribution to the body height of the metatarsal length is larger in females than in males (Bartosiewicz, 1985).

Nevertheless, archaeological interpretation of differences in relative size of cattle metapodials is far from easy. Many variables are clearly involved and too few modern populations have been investigated. We still do not have a precise idea to what extent metapodial shapes are sex-dependent, we do not know how variable is this phenomenon in different populations and overall it is still unknown what can be the influence of other variables such as age. A study carried out on gazelles (Davis, 1987a: 44) shows that the complete growth of distal metacarpals probably occurs very early (before fusion) in both females and males. Whether we can apply these results to cattle is uncertain, and we cannot rule out the possibility that cattle metapodials continue to grow substantially after fusion.

Also unknown is the effect of age of castration. We do not know to what extent the shape of steer metapodials is influenced by the age at which the animals are castrated.

Despite these problems, very often in the zooarchaeological literature cattle metapodials have been optimistically sexed (see for instance Howard, 1963). The influence of this early literature on the topic has been so strong that frequently different points in scatter diagrams of metapodial measurements have been taken as an indication of the presence of bull, cows, or steers even when no clusters were actually visible.

Some studies of modern specimens have demonstrated that a large amount of overlap can occur between sexes, especially when different populations are taken into account (Fock, 1966). The definition of a standard range of variation for metapodials of different sexes thus does not seem a sensible way to approach the problem.

In the rest of this paper one particular case will be discussed in which a simplistic interpretation of the shape variation of metapodials could result in a wrong interpretation. The importance of taking into account other variables will also be shown.

Chronological variation of shape: the case of Launceston Castle

Cattle bones were among the most common animal remains at Launceston Castle (Cornwall, south-western England; Albarella and Davis, 1994a). Four main periods, each with a large faunal assemblage, were considered:

- period 6 (mid mediaeval: late 13th cent. AD)
- period 8 (late mediaeval: 15th cent. AD)
- period 9 (early post mediaeval: 16th-17th cent. AD)
- period 10 + 11 (late post mediaeval: 17th-19th cent. AD).

A large increase in cattle size was noticed between the late mediaeval and postmediaeval periods. This increase was observed in both teeth (fig. 1) and bones (fig. 2) (in these as well as in the following figures, measurements, in tenths of millimetres, follow von den Driesch, 1976 and Davis, 1992). The width and length of the astragalus (fig. 2) are among the least sex-dependent bone measurements (Higham, 1969: tab. I). Molar widths are certainly non age-dependent and probably only very slightly sex-dependent (Degerbøl, 1963: 71). Furthermore, because of their fairly conservative nature teeth are probably less sensitive than

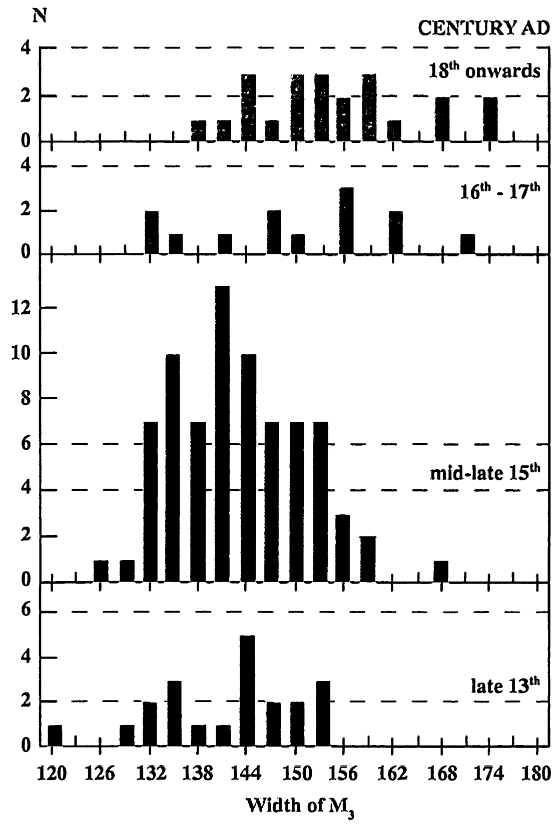

Fig. 1: Cattle M_3 from Launceston Castle.

Table 1: Significance of differences of metapodial shape between different periods and different sites as indicated by a t-test. LAU = Launceston Castle, PRU = Prudhoe Castle, WC = West Cotton, WES = Westminster, DOR = Dorchester. **= 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). Some caution is necessary in the interpretation of these data. Atchley *et al.* (1976) have suggested that the application of statistics tests (especially multivariate analysis) to ratios may be biased. The significance of the difference between the raw measurements is discussed in Albarella and Davis (1994a and 1994b).

Element	Index	Groups compared	Probability
Metacarpal	SD/GL	LAU Late Med. - LAU Postmed.	0.129
Metacarpal	Bd/GL	LAU Late Med. - LAU Postmed.	0.001 **
Metatarsal	SD/GL	LAU Late Med. - LAU Postmed.	0.606
Metatarsal	Bd/GL	LAU Late Med. - LAU Postmed.	0.000 **
Metatarsal	Bd/GL	LAU Late Med. - PRU Mid Med.	0.382
Metatarsal	Bd/GL	LAU Postmed. - PRU Mid Med.	0.000 **
Metatarsal	SD/GL	LAU Late Med. - WC Med.	0.069
Metatarsal	Bd/GL	LAU Late Med. - WC Med.	0.000 **
Metatarsal	SD/GL	LAU Postmed. - WC Med.	0.231
Metatarsal	Bd/GL	LAU Postmed. - WC Med.	0.337
Metatarsal	SD/GL	LAU Late Med. - WES Late Med./ Early Postmed.	0.000 **
Metatarsal	Bd/GL	LAU Late Med. - WES Late Med./ Early Postmed.	0.918
Metatarsal	SD/GL	LAU Postmed. - WES Late Med./ Early Postmed.	0.000 **
Metatarsal	Bd/GL	LAU Postmed. - WES Late Med./ Early Postmed.	0.000 **
Metatarsal	SD/GL	LAU Late Med. - DOR Postmed.	0.035 *
Metatarsal	Bd/GL	LAU Late Med. - DOR Postmed.	0.009 **
Metatarsal	SD/GL	LAU Postmed. - DOR Postmed.	0.015 *
Metatarsal	Bd/GL	LAU Postmed. - DOR Postmed.	0.075

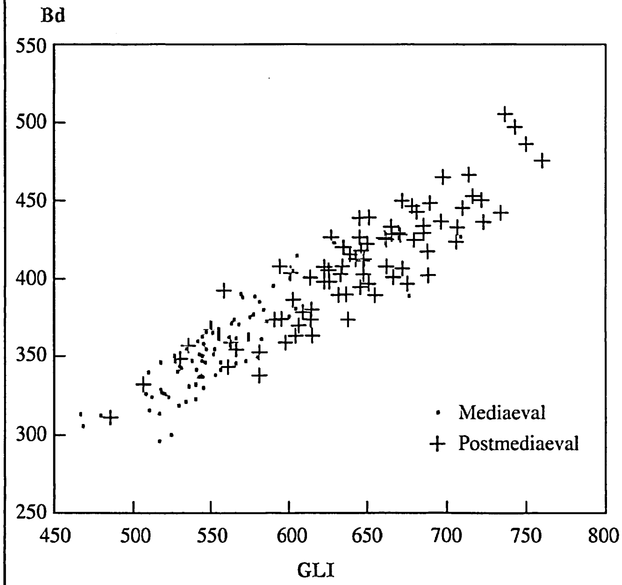

Fig. 2: Cattle astragalus from Launceston Castle.

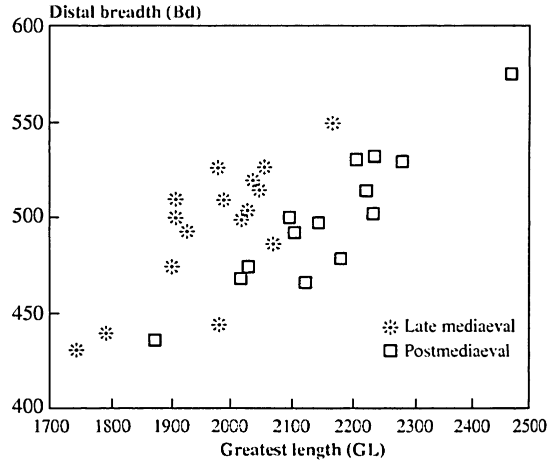

Fig. 3: Size of cattle metatarsal. Launceston Castle.

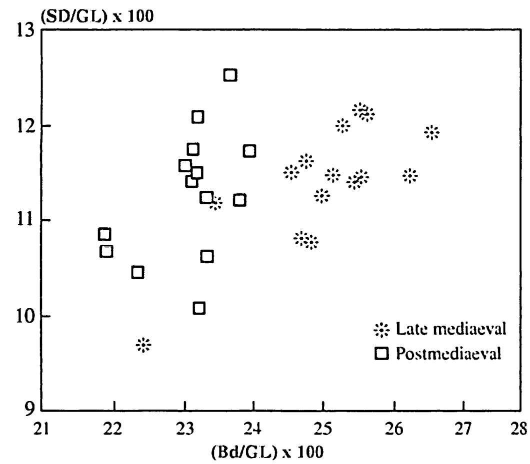

Fig. 4: Shape of cattle metatarsal. Launceston Castle.

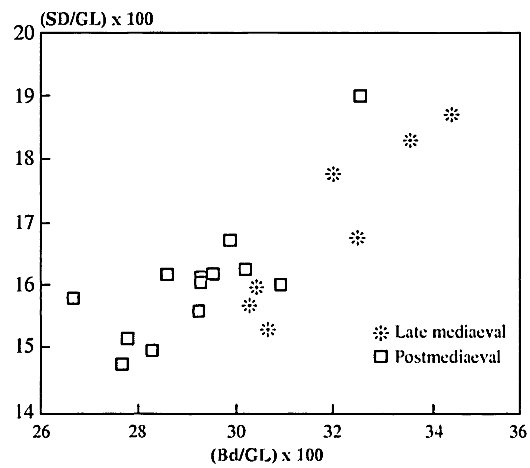

Fig. 5: Shape of cattle metacarpals. Launceston Castle.

bones to environmental conditions. On this basis we have suggested that the size change at Launceston probably represents a real genotypic change, due to the presence of a different "breed" of cattle in the postmediaeval period - although certainly not a "pedigree breed" in the modern sense, but rather a regional type (Trow-Smith, 1957).

When we compared the size of the metatarsal between the late mediaeval and postmediaeval periods (fig. 3) we noticed that the length increased as well as other dimensions, but the distal width only increased slightly. In other words postmediaeval cattle metatarsals appear to have a relatively more slender distal end.

In order to concentrate attention on the shape modification I have plotted the maximum width of the distal end (Bd *sensu* von den Driesch, 1976) expressed as a percentage of the length versus the minimum width of the shaft (SD *sensu* von den Driesch, 1976) also expressed as a percentage of the length (fig. 4). This diagram is therefore entirely *size independent*. When different populations are compared this system avoids indeed the possibly misleading effect of size in the study of shape modification and, at the same time, allows comparisons between the two indexes.

Two groups can easily be distinguished on the basis of the different Bd/GL ratio, while in contrast the SD/GL ratio does not seem to change much. These observations are confirmed by a t-test (tab.1): the difference in the Bd/GL ratio is (highly) statistically significant, whereas the one in the SD/GL ratio is not.

Similar results were obtained from a study of the metacarpal shape (tab. 1, fig. 5), although the difference between the two periods is not as evident as for the metatarsals, partly because of the smaller size of the sample of metacarpals.

A variation of both size and morphology was thus noticed in cattle between late mediaeval and postmediaeval times at Launceston Castle. If we assume then that the *size* change reflects a real genetic change in the population, what we want now to investigate is how different variables may have affected the *shape* change.

Geographic variation of shape: examples from mediaeval and postmediaeval Britain

Before trying to answer this question it will be useful to compare the cattle metapodials from Launceston with samples from other sites. The main purpose of this comparison is to observe the extent of the variability of metapodial shape and also to check whether an interpretation of the shape modification at Launceston can help us to understand differences between sites.

The sites considered are: West Cotton, central England (12th-15th centuries AD; Albarella and Davis, 1994b),

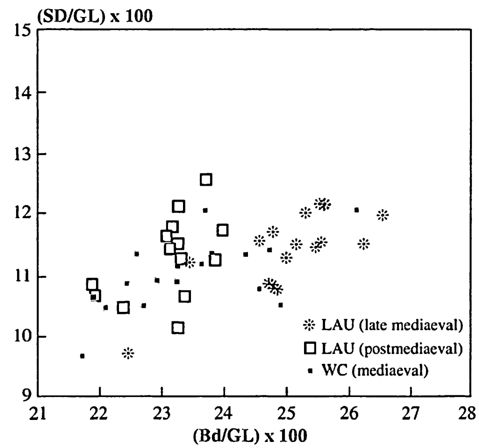

Fig. 6: Shape of cattle metatarsals. Launceston (LAU) and West Cotton (WC).

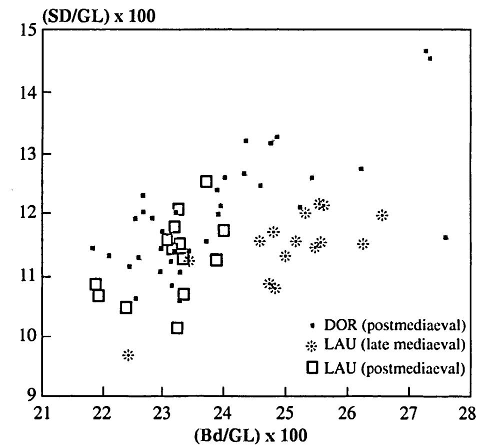

Fig. 7: Shape of cattle metatarsals. Launceston (LAU) and Dorchester (DOR).

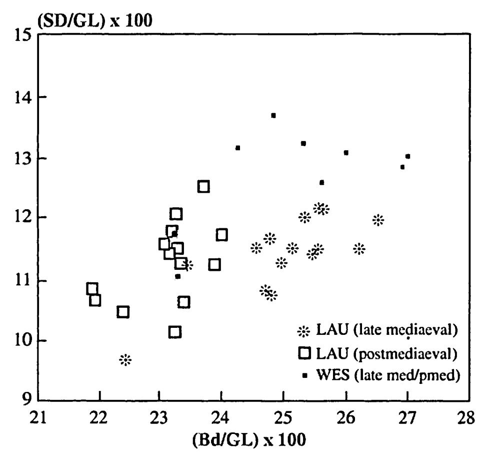

Fig. 8: Shape of cattle metatarsals. Launceston (LAU) and Westminster (WES).

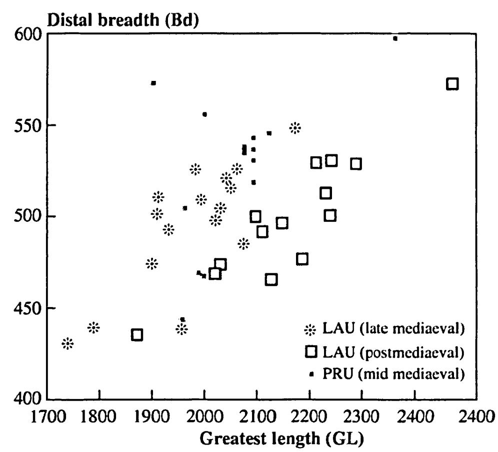

Fig. 9: Size of cattle metatarsals. Launceston (LAU) and Prudhoe (PRU).

Prudhoe Castle, northern England (13th-14th centuries AD; Davis, 1987b), Westminster, London (15th-16th centuries AD; Locker, 1980) and Dorchester, southern England (17th-18th centuries AD; Davis, 1987c). The attention will be concentrated on metatarsals, which, as we have seen, are generally present in larger numbers and provide a clearer pattern of distinction between the two periods at Launceston.

The West Cotton mediaeval metatarsals are closer in shape to those from the postmediaeval period at Launceston rather than to those from the mediaeval period (tab. 1, fig. 6). Their size is approximately intermediate between the two groups from Launceston (Albarella and Davis, 1994b).

The shape of the Dorchester postmediaeval metatarsals is also quite slender. Although the shaft is more robust than in the Launceston specimens, the main discriminant is again the ratio of Bd to GL, which is similar to the Launceston postmediaeval group (tab. 1, fig. 7). The presence of two extremely robust specimens (males?) from Dorchester must be noticed. The Dorchester specimens are even larger than the Launceston postmediaeval ones.

A completely different situation is found for late mediaeval-early postmediaeval Westminster. Despite the small sample, the relative size of the distal width of these specimens is significantly larger than at postmediaeval Launceston (tab. 1, fig. 8). The relative size of the shaft width is also strongly different for Westminster: it is significantly larger than at both periods at Launceston. On balance the Westminster specimens appear to be extremely robust.

Finally the Prudhoe Castle specimens (here "SD" is not available) look quite similar to the specimens from late mediaeval Launceston (tab. 1, fig. 9). The general size of cattle from Prudhoe is also similar to mediaeval Launceston (Albarella and Davis, 1994a), and therefore smaller than at postmediaeval Launceston and at mediaeval West Cotton.

An attempt to summarize this evidence is given in table 2. A large variety of shapes has thus been observed between different sites in mediaeval and postmediaeval Britain. I will try to explain this variability through a more detailed analysis of the Launceston data.

Age, pathology, sex or breed?

It has been seen that a large shape change occurred in cattle metapodials at Launceston Castle between late mediaeval and postmediaeval times. As mentioned above metapodial shape can depend on several variables. It is highly probable that they all play some role in this change, but we want to analyze the data more carefully in order to see if we can detect which was the main cause of this shape difference between the two periods.

Age

As stated above it is not clear how metapodial shape changes during the growth of the animal. The possibility that a major change occurs must therefore be considered. The study of the cattle kill-off pattern at Launceston Castle has shown that different culling strategies were adopted in mediaeval and postmediaeval times (Albarella and Davis, 1994a). However this difference cannot have affected the relative size of measurable metapodials, because it mainly consists in the killing of a higher number of very juvenile animals in postmediaeval times: these animals were slaughtered before the fusion of distal metapodials and, therefore, they do not appear in the diagrams in figures 3-5. Apart from this difference, in the mediaeval period there are slightly more "elderly" animals (*sensu* O'Connor, 1988) than in the following period. However, even if we assumed that postfusion growth generated a relative increase of the distal end of metapodials, this would be hardly enough to explain the dramatic change observed in figure 4. Yet it is possible that the difference in age played a role in the shape modification, although probably a minor one.

Pathology

Many archaeological sites have produced cattle metapodials (especially metatarsals) whose distal ends are asymmetric, the medial condyle being generally wider

Table 2: Robustness and size of cattle metatarsals from several British sites. For more details about the size of animals and their significance of its difference between sites see Albarella and Davis (1994a and 1994b). * Small sample.

	Prudhoe Mid Mediaeval	West Cotton Mediaeval	Launceston Late mediaeval	Westminster Late Med./Early Postmed.	Launceston Postmediaeval	Dorchester Postmediaeval
Shaft	?	slender	slender	robust	slender	fairly slender
Distal end	robust	slender	robust	robust	slender	slender
Size	small	fairly large	small	very large *	large	very large

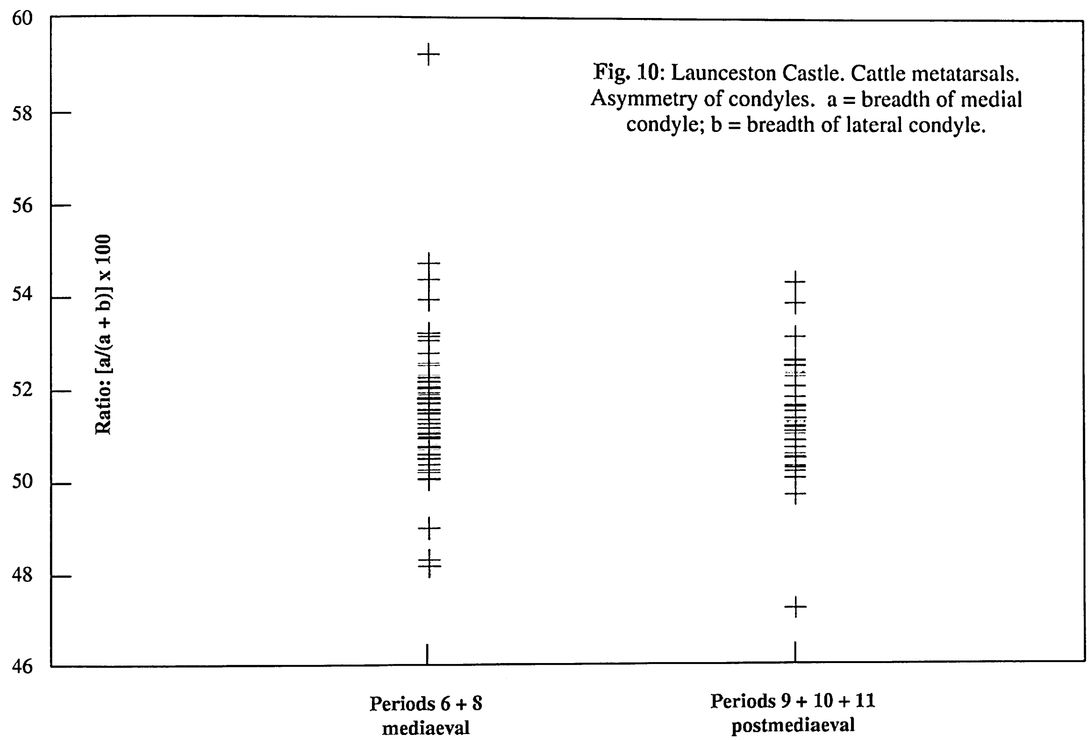

Fig. 10: Launceston Castle. Cattle metatarsals. Asymmetry of condyles. a = breadth of medial condyle; b = breadth of lateral condyle.

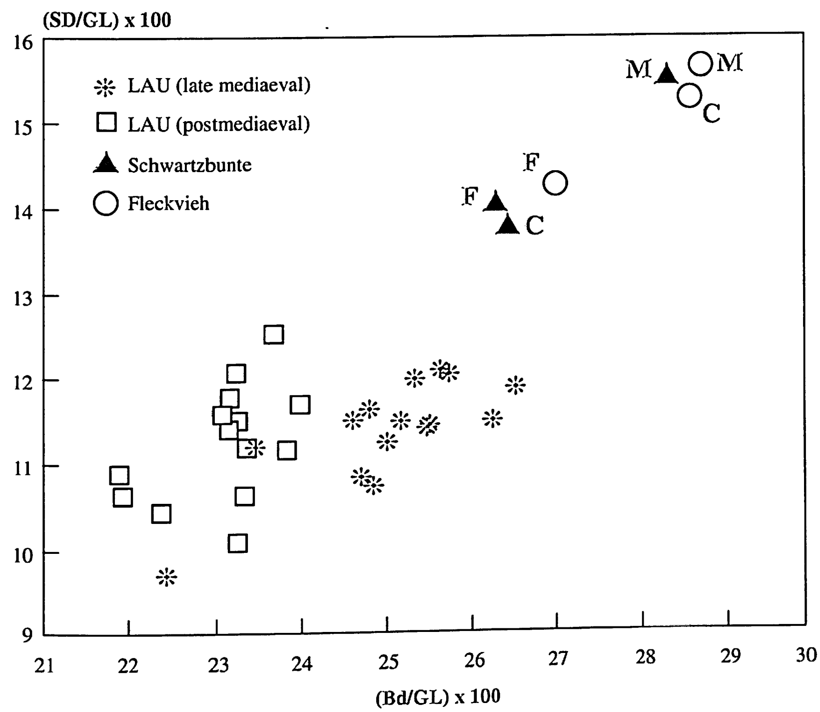

Fig. 11: Shape of cattle metatarsals. Launceston (LAU) and modern German breeds (after Fock, 1966). Values for modern breeds represent means. The sizes of samples from which they are calculated are as follows: Schwartzbunte: F (females) = 33, M (males) = 11, C (castrates) = 18. Fleckvieh: F (females) = 100, M (males) = 16, C (castrates) = 5.

than the lateral one. The consequence of this abnormality is a general splaying out of the distal end. The origin of this condition is unknown and it is not even clear whether it can be really considered pathological. It has been claimed that it may be connected to traction stress (Jewell, 1963), but there is no direct experimental evidence which supports this hypothesis. Bartosiewicz *et al.* (1993: 73) have suggested that the asymmetry increases with size and therefore that draft exploitation may increase metapodial asymmetry, as "it represents an exaggerated weight surplus".

Asymmetric metatarsals were quite common at Launceston Castle and, therefore, the possibility that this condition may have increased the width of the distal end, to affect shape change, had to be considered.

In fact, metatarsals from mediaeval times tend to be a bit more asymmetric (fig. 10), but the difference is slight and, when the coefficients of correlation of the two condyles were compared, the difference between the two periods was not statistically significant (Albarella and Davis, 1994a). The possibility that this (perhaps arthropathic) condition is the main cause of the shape modification can therefore be excluded.

Sex

In figures 3-5 it is possible to see that, within each period, there are no separate groups, which could represent different sexes. In order to investigate whether the shape changes observed are the result of the presence of different proportions of males, females and castrates, the distal measurements of both metacarpals and metatarsals have been plotted, since according to Higham (1969) and Thomas (1988) these measurements discriminate between sexes. This also has the advantage of allowing larger sample size to be used than in figures 3-5. No distinct clusters were observed. Was thus each population represented by only one sex? And were the sexes different in the two populations?

In order to try to answer this question, the Launceston metatarsals have been compared to data from modern German breeds of known sex (Fock, 1966) (fig. 11). This diagram shows that in modern animals the main change between different sexes occurs along the same regression line - the two indexes both change indicating that males are simply more robust than females in both distal and minimum shaft widths. This is different from Launceston Castle where only one index (Bd/GL) changes, indicating only a distal narrowing of metatarsals in the postmediaeval period.

The fact that the pattern of modification was much clearer for metatarsals than metacarpals also does not support the hypothesis that the change is the result of sex differences: indeed it has been seen that metacarpals are more sex-dimorphic than metatarsals.

There is one final consideration which does not rely on biometric data but only on "deductive" considerations and it is probably the most important for ruling out the possibility that the change is due to a difference in the sex composition of the two populations. We have seen that metapodials from the mediaeval period appear to be stocky, as they are generally in males, whereas the postmediaeval ones are more slender, as they are generally in females or castrates. If sex was the main cause of the change we have therefore to assume that most of the mediaeval population is represented by entire males: from a management point of view this appears to be extremely improbable. From historical sources we know that in mediaeval times, cattle were exploited for traction, dairy products and meat. Whatever was the main aim of the cattle husbandry the tendency was to use mainly females and steers: males were castrated or slaughtered at young age (certainly before the fusion of the distal metapodials), apart from a few specimens kept for reproduction. In most mediaeval villages bulls were rare (Grand and Delatouche, 1950; Trow-Smith, 1957), if present at all (Thornton, 1992). Since Launceston Castle was probably mainly a "consumer" site, it would not be surprising if adult bulls were entirely absent from the archaeological assemblage (this would also explain the lack of distinct clusters).

Table 3: Launceston Castle: Cattle M_3s with missing hypoconulids.

	Period 6 late 13th	Period 8 mid-late 15th	Period 9 16th-17th	Periods 10 + 11 17th-19th
n missing hypoconulids	4	10	0	1
total n	22	86	21	26
%	18	12	0	4

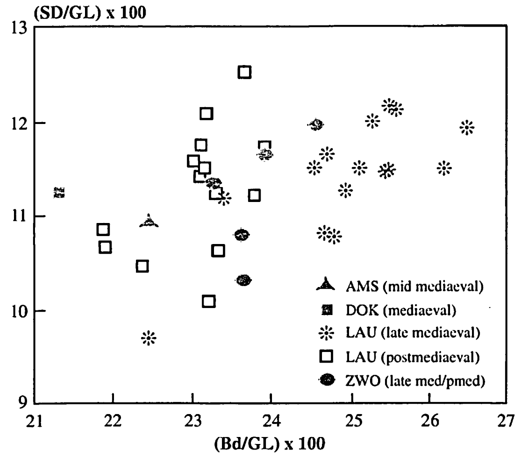

Fig. 12: Shape of cattle metatarsals. Launceston (LAU) compared to Dutch sites: Amsterdam (AMS) (Clason, 1967), Dokkum (DOK) (von Gelder-Ottway, 1979), Zwolle (ZWO) (van Mensch, 1980). The Dokkum value is calculated from the mean of 5 GL, 9 Bd and 5 SD, the others are all individual specimens.

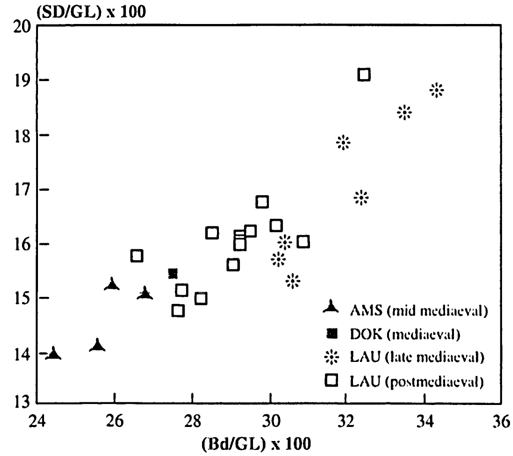

Fig. 13: Shape of cattle metacarpals. Launceston (LAU) compared to Dutch sites: Amsterdam (AMS) (Clason, 1967), Dokkum (DOK) (von Gelder-Ottway, 1979). The Dokkum value is calculated from the mean of 6 GL, 12 Bd and 7 SD, the others are all individual specimens.

"Type" or "breed"

Looking again at figure 11 it can be easily noticed that the difference in metapodial shape between different breeds can be even larger than between sexes. On the basis of this and other considerations presented above it is suggested that the explanation for the shape change of cattle relies mostly on the presence of a new, morphologically different, type of cattle in postmediaeval times at Launceston. We have seen that a size change, interpreted as genotypic (see above) also occurred, but a further piece of evidence would suggest that a different type of cattle was present in the later period. The phenomenon of the absence of the third pillar (hypoconulid) of the lower 3rd molar was much more common in mediaeval cattle (tab. 3), the difference between the two periods being statistically significant ($Chi^2 = 4.4$, i.e. there is only a 2.5-5% probability that the difference is due to chance). It is probable that this condition occurs with different frequency in different breeds.

It is worth noticing that Cornwall, as well as many other areas in Britain, was a producer area for cattle (Trow-Smith, 1957), and, because of the absence of very large urban centres, was not one which received many animals from elsewhere as part of the meat trade (Serjeantson, pers. comm.). The Launceston animals are therefore very probably the product of local husbandry.

Although not often taken into account in the interpretation of morphological variability of cattle metapodials the "breed" explanation is probably the most obvious. It makes sense from a historic, a management and a morphometric point of view. The presence of different cattle types on the basis of different metapodial shapes was also suggested by Reichstein (1973) when he compared cattle from the sites of Feddersen-Wierde (1st-4th cent. AD) and Haithabu (9th-11th cent. AD) in north Germany.

Whether these new cattle at Launceston were derived from imported stock or emerged as a product of local selective breeding is uncertain. Cattle were commonly imported from the Netherlands in the 17th century (Trow-Smith, 1957) and these animals of Dutch origin were described by Markham (1614: 42) as "exceeding tall, long and large" and by Mortimer (1707: 166) as "long legged". It is worth remembering in this respect that postmediaeval cattle at Launceston were longer and more slender than in the previous period.

Unfortunately I have not been able to collect many data from Dutch mediaeval and postmediaeval sites. The few available data are plotted in figures 12-13 together with the Launceston data. It is clear that all Dutch measurements plot in the same group as postmediaeval Launceston. This shows that the data are not inconsistent with the hypothesis that the postmediaeval cattle at Launceston represent a Dutch introduction, as the documentary evidence might suggest. In fact it has been seen that also cattle from mediaeval West Cotton were long and slender. Therefore, if we believe in the "imported stock" hypothesis, central England and Netherlands both represent possible regions from which a new (more improved?) livestock may have come.

In view of these considerations the regional variability that we have noticed above is interpreted as a consequence of the presence of several different types of cattle in mediaeval and postmediaeval England. This heterogeneity of cattle type is not at all surprising and is confirmed in historical sources (Trow-Smith, 1957; Armitage, 1980, 1982).

Conclusions

The analysis of cattle metapodial shape, combined with other sorts of evidence, shows us that a new type of cattle, larger but more gracile, was present in south-western England (Cornwall) after the 15th century. We have also seen that there is evidence that different types of cattle could be found in different parts of the country in the same period. Hopefully these conclusions can be of more general use in the interpretation of metric data of metapodials, particularly when different periods or sites are compared.

In fact, despite the relationship between shape of cattle metapodials and sex has been strongly emphasised, other variables are also involved. We have seen that, comparing different populations, the morphological difference between breeds can obscure differences between sexes, as Fock (1966) had also pointed out.

When we try to detect the sexual composition of a population through the study of metapodial shape, we must also consider that, at least in mediaeval and postmediaeval sites but probably also in earlier times, bulls are uncommon and populations are mainly represented by cows and steers, which are not at all easy to distinguish morphologically.

To recognize the presence of different types of cattle, whether or not these are breeds in the modern sense, is certainly of great archaeological importance, at least as well as to recognize different sexes, and the potential of the analyses of metapodials for this kind of study should therefore be further explored. However, as well as with many other archaeological problems, it is vital that the study of morphological variation is combined with other sort of investigations, such as the study of size variation and the analysis of non metrical traits.

Despite a number of works on the subject, mainly published in the sixties, the interpretation of shape variability in cattle metapodials is still rather hypothetical. Not much experimental work has been done and it is hoped that further study of modern animals of known sex, age and breeding history, will help to improve our understanding of the grade and type of influence which different variables exert on the shape of metapodials.

Biometric studies can help to answer many important archaeological questions, but in order to do that it is necessary to try to understand the biological phenomena which cause variability in size and shape of animal bones from archaeological sites.

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