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The Variability of Faunal Samples and their Effects upon Ageing Data

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Many analyses of ageing data from British archaeological sites still follow the same basic pattern. Tooth eruption and/or epiphyseal fusion evidence are recorded and used as the basis for the interpretati of exploitation patterns of the animals involved.(e.g. Hodgson 1977: 10-17). In some cases data obtained from several sites have been compared and used in a general survey of animal exploitation in a given period (Noddle 1975: 255; Bradley 1978: 37). The interpretation of the ageing data in this way makes several assumptions of the archaeological sample, which are not always taken into consideration. This paper will examine some of the assumptions and give some examples where such interpretations may be misleading. In the light of the observed variability in ageing samples, detailed examination of three Iron Age sites in Hampshire is in progress. The methods being used to analyse those samples will be described at the end of the paper.

Determinations of animal populations from archaeological ageing data often have made the following assumptions:

i) The sample (of jaws or fusion points) is representative of the site in terms of the bone originally deposited.

(ii) The sample is representative of the animal populations exploited by the inhabitants of the site.

The first assumption ignores the problems of differential preservation, biases created by the recovdry of bone and lateral variations in the location of disposal of different bones. The second assumption ignores the possibility of animal or carcase redistribution between different settlements.

Preservation

The problems of differential preservation on fusion data have been recognised by several authors (e.g. Payne 1972b: 76; Meadow 1975: 275). Binford & Bertram (1977) have shown that the pattern of bone survival may be extremely complicated and related to variations in bone density. It is clear in archaeological samples that younger fusing epiphyses of all species have a better chance of survival and accordingly are found in greater numbers than the more vulnerable late fusing epiphyses, confirming the observations of Brain (1976). What has not been established so clearly is to what extent differential preservation affects the survival of jaws of different ages. There is some encouragement in that these are bones most resiliant to destruction (particularly the teeth themselves) (Binford & Bertram 1977: 109; Brain 1976: 109) but some are destroyed and this may bias the sample recovered for ageing analysis. The problem may be heightened by the present ageing methods adopted by faunal specialists. Most reports disregard loose teeth and the ageing data studied are restricted to jaws with some of their teeth remaining. Yet the fact that loose teeth are present is itself evidence that the mandibles and maxillae to which they belonged have been destroyed. On the other hand, inclusion of loose teeth in assessments of ageing may be biased towards older animals because of recovery problems (Payne 1972a: 59). There is still an urgent need to establish what effects differential preservation conditions have on tooth eruption data, not only between sites but within sites as well.

Recovery of Bone

Payne (1975: 11-13) has shown that poor retrieval methods can bias the epiphyseal fusion data towards older animals. Loose teeth are also liable to be missed and the smaller deciduous teeth may be under-represented. Again, however, all too little is known of how far collections of ageable mandibles are biased in a similar manner and which species are most likely to be affected.

Lateral Variation of the Disposal of Bones

A combination of cultural activities combine to create lateral variation in the faunal remains recovered from a site. Primary and secondary disposal activities, as defined by Meadow (1976), create variations in the relative quantity of each bone type recovered. Detailed ethnoarchaeological studies of animal bone distributions have demonstrated the complexities of such disposal mechanisms in hunter-gatherer groups (e.g. Yellen 1977; Binford 1978). Similar mechanisms can be expected in farming settlements and indeed on urban sites. Detailed studies of refuse disposal patterns of British archaeological material are in progress and results that have relevance to ageing data have been obtained from a few sites already investigated. For example, Halstead et al. (1978: 130) observed that the proportions of young domestic animals varied in different part of the Roman villa at Wendens Ambo. Grant (1975: 397-8) noted that a higher proportion of young sheep were found in wells than in other types of feature of Roman date at Portchester Castle. The proportion of young cattle jaws represented in fourth century A.D. deposits at Exeter varied significantly on different sites within the Roman town (Maltby in press).

In addition, apparent changes in the age structure of animals represented on the same site in different periods must also be treated with caution. It is worthwhile to examine one example, again from Exeter, in detail. Table 1 summarises the tooth eruption data of sheep goat jaws from the Goldsmith St. and Trickhay St. sites in samples of late medieval and postmedieval date. The two small postmedieval samples show a consistent pattern with higher percentages of jaws belonging to animals killed before Stage 1 than in the medieval samples but significantly fewer killed between Stages 1-3. All four samples had quite high numbers of immature animals and over half belonged to animals killed before the completion of the tooth eruption sequence (Stage 4). The results of the epiphyseal fusion analysis, however, were contradictory (Table 2).

The results showed a substantial drop in the number of unfused bones of all age groups in the postmedieval samples. The variations cannot b explained in terms of differential preservation, as much of the postmedieval material's preservation was superb and one would have expected that this would have favoured unfused epiphyses rather than fused ones. Nor was there any significant bias in the standard of excavation of the samples. Another explanation is required. First we have to test the assumption that the samples were derived from similar populations in each period. Table 3 shows the percentage of ageable jaws in each sample and it can be seen that the two postmedieval samples had comparatively fewer jaws.

Table 3

Percentages of Ageable Jaws in Exeter Sheep/Goat Samples

Period	No. Aged Jaws	Total Sheep/Goat Fragments	% Aged Jaws
1200-1300	76	2213	3.4
1300-1500	27	549	4.9
1500-1600	27	1542	1.8
1600-1800	34	1213	2.8

A χ^2 test between the two medieval and the two postmedieval samples showed that the differences in the proportion of ageable jaws were significant at the 1% confidence limit. Detailed comparisons of the samples also revealed significantly greater number of ageable long bones in the later samples and indeed the postmedieval sheep/goat samples from Exeter were characterised by a substantial increase in the proportions of good meat bones in comparison to earlier assemblages (Maltby in press). It seems probable therefore that a change in disposal practices in the later periods increased the ratio of ageable long bones in relation to jaws. The question remains, however, of whether these changes caused the discrepancies in the two types of ageing data.

Table 4

Ratios of Fusion Points:Ageable Jaws in the Medieval and Postmedieval Sheep/Goat Samples from Exeter

		1200-1300	1300-1500	1500-1600	1600-1800
Humerus	DNF/Jaws < Stage 2	2.2	1.2	1.3	0.9
Radius	PNF/Jaws < Stage 2	1.4	2.2	1.0	0.3
Humerus	DF/Jaws > Stage 2	1.2	1.0	4.2	4.0
Radius	PF/Jaws > Stage 2	1.4	1.6	5.8	4.0
Humerus	PF/Jaws > Stage 4 (min.)	0.0	0.1	3.7	2.8
Radius	DF/Jaws > Stage 4 (min.)	0.8	0.5	1.8	2.7
Femur	DF/Jaws > Stage 4 (min.)	0.3	0.5	3.2	2.1
Tibia	PF/Jaws > Stage 4 (min.)	0.3	0.4	1.8	1.8
Humerus	PF/Jaws > Stage 4 (max.)	0.0	0.1	3.4	2.3
Radius	DF/Jaws > Stage 4 (max.)	0.5	0.5	1.6	2.1
Femur	DF/Jaws > Stage 4 (max.)	0.2	0.4	2.9	1.7
Tibia	PF/Jaws > Stage 4 (max.)	0.2	0.3	1.7	1.5
Humerus	PF/Jaws > Stage 5 (min.)	0.1	0.1	8.8	4.9
Radius	DF/Jaws > Stage 5 (min.)	1.0	0.8	4.2	4.6
Femur	DF/Jaws > Stage 5 (min.)	0.4	0.7	7.6	3.6
Tibia	PF/Jaws > Stage 5 (min.)	0.4	0.6	4.4	3.1
Humerus	PF/Jaws > Stage 5 (max.)	0.0	0.1	4.0	2.3
Radius	DF/Jaws > Stage 5 (max.)	0.6	0.5	1.9	2.1
Femur	DF/Jaws > Stage 5 (max.)	0.3	0.4	3.5	1.7
Tibia	PF/Jaws > Stage 5 (max.)	0.2	0.3	2.0	1.5
Humerus	PNF/Jaws < Stage 4 (min.)	0.3	0.5	1.5	1.1
Radius	DNF/Jaws < Stage 4 (min.)	1.3	1.6	1.0	0.8
Femur	DNF/Jaws < Stage 4 (min.)	0.7	0.7	1.3	1.3
Tibia	PNF/Jaws < Stage 4 (min.)	0.7	0.8	1.6	1.1
Humerus	PNF/Jaws < Stage 4 (max.)	0.3	0.4	1.4	0.9
Radius	DNF/Jaws < Stage 4 (max.)	1.0	1.4	0.9	0.7
Femur	DNF/Jaws < Stage 4 (max.)	0.6	0.6	1.2	1.1
Tibia	PNF/Jaws < Stage 4 (max.)	0.5	0.7	1.5	0.9
Humerus	PNF/Jaws < Stage 5 (min.)	0.3	0.5	1.3	1.1
Radius	DNF/Jaws < Stage 5 (min.)	1.2	1.6	0.9	0.8
Femur	DNF/Jaws < Stage 5 (min.)	0.7	0.7	1.1	1.3
Tibia	PNF/Jaws < Stage 5 (min.)	0.6	0.8	1.4	1.1
Humerus	PNF/Jaws < Stage 5 (max.)	0.2	0.3	1.0	0.7
Radius	DNF/Jaws < Stage 5 (max.)	0.9	1.0	0.6	0.6
Femur	DNF/Jaws < Stage 5 (max.)	0.5	0.4	0.8	0.9
Tibia	PNF/Jaws < Stage 5 (max.)	0.5	0.5	1.1	0.7

Data adapted from Tables 1 and 2. DNF = distal not fused; PNF = proxima not fused; DF = distal fused; PF = proximal fused.

Comparisons between tooth eruption and epiphyseal fusion data are fraught with problems. The difficulties of differential preservation and of absolute ageing are well known. Table 4 is, however, an attempt to compare the two types of data. In all four samples the number of unfused sheep/goat distal humeri and proximal radii were each compared with the number of jaws that had not reached Stage 2 of the tooth eruption sequence. It is not claimed that the fusion ages of the distal humerus and proximal radius occur at the same time as this tooth eruption stage but they can both be used as indicators of the number of young animals represented on the site. By dividing the number of unfused humeri and radii by the number of jaws, we can obtain a ratio that is comparable between samples. Similarly, by comparing the number of fused proximal humeri and tibiae and distal radii and femora with the number of older jaws , we can establish the ratio of adult animals represented by each ageing method. Both Stages 4 and 5 of the tooth wear sequence were used in this analysis and the minimum and maximum figures for each stage (cf. Table 1) were also used. Assuming that preservation conditiond and excavation techniques were constant, we would expect the ratios between different samples to be similar, unless other factors were at work. In the two medieval samples the ratio of fused proximal humeri and tibiae and distal radii and femora was always less than 1.0 when compared to the number of jaws that had reached Stages 4 and 5, irrespective of whether minimum or maximum figures were used. The postmedieval samples, however, had significantly higher ratios of fused epiphyses. These ranged from 1.5 to as high as 8.8 and most had ratios of 2.0 and over (Table 4). This could be interpreted either as a substantial improvement in the preservation of the postmedieval epiphyses or as an increase in the proportion of these bones deposited in the postmedieval layers. As a control, the number of unfused proximal humeri and tibiae and distal radii and femora were compared to the number of jaws that failed to reach Stages 4 or 5 respectively. If preservation factors alone were the cause of the variation, we would expect the postmedieval sample show similar increases in the ratio of unfused epiphyses. This, howe was not the case. Most of the postmedieval ratios increased slightly but nowhere near as dramatically as the increase in the ratio of the fused epiphyses: older jaws. The ratios of young bones: young jaws showed a different picture. The ratios of unfused distal humeri and proximal radii were generally slighly lower in the postmedieval samples than in their medieval counterparts. The ratios of fused distal humeri a proximal radii: jaws of Stage 2 and older again showed that the postmedieval samples had substantially higher numbers of fused bones in comparison with the medieval samples.

The pattern that emerges from this analysis seems clear. Much fewer of the jaws belonging to adult animals were found to be associated with their long bones in the postmedieval samples. On the other hand, the jaws of young animals were more often associated with their long bones. The most plausible explanation is that we are observing a change in the marketing of sheep carcases in these deposits. The jaws (and skulls) of the adult animals are under-represented because they were removed during the primary butchery process. The increase in the proportion of the major meat-bearing bones in the postmedieval deposits is a consequence of this, since the majority of the material in these deposits seems to have been derived from domestic or kitchen waste and therefore included the major meat-bearing bones and not the previously discarded jaw bones. On the other hand, the jaws of young animals were much better represented, perhaps signifying that lamb carcases were treated differently. The roasting of complete carcases including the skull and jaws is one possibility that would account for the presence of the jaws, although this does not rule out other explanations. No such bias was found in the medieval samples where jaws of all ages were found in the deposits consistently with long bones of the same age. Primary butchery and the removal of the jaws elsewhere did not take place to the same extent and consequently the ratio of epiphyses : jaws remained more consistent, and the smaller variations can be ascribed to differential preservation, relatively small sample sizes and variations in the ages of fusion and tooth eruption stages used in the formulation of the ratios. If these interpretations are correct, the study of this evidence has shown that differential disposal practices and changes in the marketing of meat can be monitored successfully from faunal material. However, for determining changes in the age structure of the sheep populations in these periods, such variety causes problems. The apparent stability in the proportion of older jaws in the postmedieval period (Table 1) is misleading because it appears that many older jaws were not deposited on the site any more. The analysis of epiphyseal fusion data is rightly usually regarded as a much more hazardous ageing procedure but in this case it may be more reliable. Of course, we do not know whether the age patterns represented on these sites are typical of the rest of Exeter or indeed typical of the surrounding rural area. Documentary evidence, however, clearly shows that cloth production became extremely important in Devon at this time and a change to the keeping of more adult sheep for their wool may be reflected here in the fusion data (Maltby in press). Whether this interpretation is correct depends on further studies on medieval and postmedieval animal bones from other parts of Exeter and from other sites in Devon. What concerns us here, however, and why I have elaborated on this example at length, is that a change in marketing practice brought a change in the apparent age structure of a species as represented in an archaeological sample. Such an occurrence need not be restricted to a market economy. It is possible to visualize similar changes occurring in prehistoric situations, particularly where sites cannot be totally excavated. Comparisons between tooth eruption data or epiphyseal fusion evidence must take these problems into consideration.

Inter-Site Variability

Determinations of age structures of a species on the basis of samples derived from one site to interpret regional farming trends are problematic. Redistribution of carcases between sites may influence the ageing data, as has been pointed out by several authors (e.g. Uerpmann 1973: 315; Grant 1975: 395; Noddle 1977: 385; Wilson 1978: 134). The postmedieval deposits at Exeter contained a very high proportion of young jaws and bones of veal calves, which probably had been fattened in the dairy and brought to such urban centres. In the deposits investigated the bones of adult dairy or plough animals were grossly under-represented (Maltby in press). It is probable that urban demands of this sort played an important part in the redistribution of domestic stock. The rarity of neonatal animal mortalities on urban sites, such as Exeter, is itself significant and contrasts with (for example) some Iron Age sites where such deaths are better represented. Obviously the possibility of animal exchange may occur in any period and its nature cannot be fully understood until sampling on on a systematic regional scale is undertaken. Inter-site comparisons are therefore essential, despite the methodological problems of such studies. Differential preservation conditions, excavation techniques, diverse archaeozoological methodologies have all hindered detailed analyses of faunal samples from different sites. These problems are compounded by possible intra-site variations, as discussed in the previous sections.

Conclusions

Recent work on British faunal material has demonstrated that the samples from excavated sites used for ageing analysis need not represent an accurate reflection of the population structure of the herds kept by the inhabitants of the settlements. There are several questions that require detailed study.

1) A much greater awareness is needed of the effects of differential

preservation and particularly its influence on archaeological ageing data.

2) Much more work is needed on intra-site variations of animal bones. Of course, the greater the proportion of the site excavated, the more likely a representative cross-section of the bone originally deposited (or at least the proportion that has preserved) is to be obtained, even though intra-site variations may be observed. Total excavation of sites, however, is rarely practicable. Sampling for animal bones on excavations on the other hand, must be designed to test whether intra-site variation exists and, if so, must be developed in such a way that it is possible to quantify the results. To take a simple example from a hypothetical Iron Age site: suppose the settlement's surrounding ditch produced a consistent age pattern of sheep jaws irrespective of which sections of the ditch were excavated and a sample of contemporary pits also produced a consistent, but different, age pattern, how could the overall assessment of the age structure of the sheep be estimated? Assuming that it could be established that differential preservation conditions in the pits and ditch sections had no significant effect on the age patterns of the sheep jaws represented and that an estimated x% of the total volume of the ditch and y% of the volume of the pits had been excavated, the overall age pattern for the whole site could be estimated using the formula $T = \frac{N.ditch \times 100}{x} + \frac{N.pits \times 100}{y}$ where T is the overall age pattern, N.ditch and N.pits are the age patterns observed from the excavated ditch sections and pits and x and y are the proportions of the ditch and pits excavated respectively. Of course, the variables may well be more complicated than this and other biasing factors such as differential densities of bone disposal may be encountered.

Even if it is possible to ascertain the age pattern of a species for the whole site, we are still left with the problem of to what extent the jaws recovered are representative of the jaws deposited and what percentage of each age class has survived the processes of erosion gnawing etc. The approach is also limited if the full extent of the site is unknown or the proportion of pits or ditch excavated cannot be estimated. It would also be extremely difficult to apply this technique on urban samples or indeed on any extensive multiperiod site. It should however, be possible to apply it on many smaller prehistoric sites and such work is necessary if we are to reconstruct successfully prehistoric animal populations.

3) Regional assessments of ageing data are required and these will have to take into consideration settlements of different sizes, function, location and status. This again faces us with severe sampling problems. Given that intra-regional variations in carcase distribution can be established and that the extent and the nature of the redistributuon is important to our understanding of both economic and social organisation, how do we quantifiy this? It is one thing to say that, for example, urban centres attracted the marketing and slaughter of a lot of young animals and that contemporary rural settlements had a higher proportion of adult animals but to attempt to quantify the proportion of sheep raised for consumption by the urban population and the proportion of sheep kept for breeding purposes or wool production that did not find a market in the town is another matter. To do this we would have to incorporate data on estimates of the proportion of meat eaten in different types of settlement within a region (assuming that there was no import of animals from outside that region) and this would involve detailed knowledge of settlement distribution and population. The problem may not be so severe prior to the development of market economies, although we must not assume that no redistribution of meat took place in the prehistoric period. Indded, we should be striving to develop means of establishing whether we can monitor redistribution of animal carcases on prehistoric sites.

4) The methods used to assess ageing data have to be developed to take

into account the different types of biases recent research has led us to expect. It is not sufficient to treat the tooth eruption or the epiphyseal fusion evidence at its face value. Current work on three Iron Age sites in Hampshire - the hillfort of Balksbury and the settlements of Old Down Farm, Andover, and Winnal Down, near Winchester, is investigating the problem. The study has made use of computer recording that has involved a very detailed description of the animal bones and also has the advantage that each site has been recorded in an identical manner, which greatly facilitates comparisons between them. In addition, the samples are reasonably large ones. The sites have other similarities for comparison: all three are multiperiod and have comparable Iron Age occupations; Balksbury and Old Down Farm are situated close together in the Andover area; Old Down Farm and Winnal Down are sites of similar type and size with sub-rectangular ditches dug in the Early Iron Age; the largest samples from all three sites have been obtained from pits of Middle Iron Age date; both Winnal Down and Balksbury have Romano-British enclosure systems consisting of a series of gullies. As a pilot study, the jaws of sheep/goat and cattle from Balksbury and Winnal Down have been recorded and are being subjected to computer analysis employing the following variables:-

a) Wear stage
b) Date/period
c) Type of deposit
d) Depth of jaw within deposit
e) Soil type
f) Observable preservation of jaw (eroded, gnawed etc.)
g) Observable preservation of bones associated in the same layer
h) Area of site where feature is located

By employing a series of contingency tests to these variables, it will be possible to establish whether there are significant intra-site variations in the samples of jaws and their nature. It will also be possible c[illegible]se com[illegible] other variables. For example, it may be established that more you jaws were found in pits than ditches but this in turn may also be a factor of better survival of jaws in the pits and so one of the preservation criteria used in the analysis can be employed as a control variable. Of course, much depends on how useful the classifications of the variables are but experimental work can be used to test these. Other variables may have to be introduced, such as comparisons with the fusion data, density of deposition, speed of excavation, the number of associated loose teeth etc. Similarly, inter-site comparisons can be made using the same control variables on observed variations in the age structures of the jaws represented.

Such studies may seem overelaborate but our knowledge of variabili in faunal samples and the causes of it is extremely limited and detailed work like this is essential. Even if no significnat variations can be demonstrated in such studies and the disposal of jaws of all ages is found to be random, this at least gives us a sound basis to proceed to the next step of interpretation of the observed age patterns.

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