Chapter 10 - Conclusions

This chapter will return to the aims, objectives and specific research questions outlined in chapter 1 (Introduction) and will demonstrate how these have been addressed by this project. First, the broader aims will be discussed, so that the significance of this project can be placed in its wider archaeological context. Next, each of the specific research questions outlined in section 1.2 will be answered in turn. Finally, an assessment of the project's results as a whole will be made, from which will emerge possible improvements on the methods used here as well as suggestions for further work.

10.1: Aims: The General Aims of the Project Addressed

Section 1.2 stated that the central aims of this project were to "expand on what is already known about bone density" and to "review ...the methods generally used in taphonomic interpretation". It was also stated that an aim of this project is to "to develop a measurement method that is accurate, reliable and accessible". These have all been achieved.

The measurement method set out in chapter 7 was shown to be capable of producing density data that are well suited to answering the specific research questions of this project. The method is also relatively cheap and more widely available than many previously used techniques.

The data regarding the variability of bone density according to the five main attributes presented in chapter 8 represent an increase in the existing body of knowledge in this area. The data presented in chapter 9, concerning the variability of bone density according to the fusion status of a bone, have also significantly added to the current understanding of bone density. By doing so, it has increased our understanding of how bone density varies with age in sheep. These data in particular are of considerable potential to future studies into the effects of destructive taphonomic processes on the age structure of an assemblage.

In applying these data to an archaeological assemblage it was possible to suggest improvements on existing analytical methodologies. The use of density ranges rather than specific values is a significant contribution here.

Chapter 2 outlined an analytical framework upon which this project could be based. It asserted that cultural information and archaeological data are separated by a series of “correlates”, “c-transforms” and “n-transforms”. The analytical framework stated that this project would endeavour to use “laws” to understand the effects of c- and n-transforms. This has certainly been possible in the case of n-transforms. However, the cultural aspect of c-transforms means that the use of density data to understand their effects is not entirely successful. To this end, this project has fulfilled the aim to apply the laws to an archaeological assemblage in order to “assess their suitability and to demonstrate any scope for their refinement”, stated in chapter 2 (section 2.3). The potential for refining the laws used in the project will be explored below.

It can therefore be concluded that the primary contribution of this project to the field of archaeology has been in the definition of laws for the understanding of n-transforms. It has also aided the definition of laws for understanding c-transforms, although the cultural aspect of these processes means that this is a lesser contribution. Since bone density data do not contribute to the definition of correlates, this project cannot be said to have influenced the understanding of these.

10.2: Objectives: The Specific Research Questions Answered

This project has enabled the six main research questions presented in the introduction to be addressed. Specific answers to each question in turn will be presented here.

10.2.1: To what extent is the destruction of animal bones by taphonomic processes mediated by bone density?

The available literature has suggested that bone density is probably amongst the primary factors that control bone destruction through taphonomic processes. However, factors other than bone density have some impact on the ability for any given bone to survive destructive taphonomic processes. These factors are too numerous to list fully here, but include the size, shape and economic value of a bone as well as the chemistry of the burial environment. The ways in which these factors interact remain unknown. The experimental work has supported this conclusion. Even though taphonomic processes had clearly affected one of the assemblages from Çatalhöyük, factors other than bone density seem to have contributed to its element frequencies. Much more research is required before the various impacts of each factor can be understood.

10.2.2: How does bone density change according to factors other than element or species (eg age, sex, breed etc.)?

This question was addressed in chapter 8 and the findings of this chapter are summarised in section 8.10. It is clear from this research that, although bone density can be seen to vary according to some of the specific factors, a considerable amount of bone density variation cannot be accounted for in this way and so was attributed to "background variation" (this term is explained in section 8.3.1). The significant degree of variation between very similar individuals means that it is impossible to predict the density of a particular scan-site with any degree of certainty. Previous studies have tended to ignore the high degree of variability of bone density for a given skeletal location. This means that, although these studies have produced interesting and meaningful results, their archaeological application is not as straightforward as has sometimes been proposed.

10.2.3: How might this information be used to improve the ability of zooarchaeologists to interpret archaeological assemblages?

Chapter 7 increased our understanding of the variability of bone density and contributed to the ability to predict the bone density of an animal, given its age, sex, breed etc. However, it was noted that this ability is of limited direct archaeological use, because excavated faunal material is often of unknown age, sex and breed. Consequently, the density data used to interpret archaeological assemblages must reflect the level of information available from the excavated material. Specific density information for particular breeds would therefore be inappropriate, although knowledge of the different densities of bone at different stages of fusion is potentially very useful. This project has been the first to produce density data that relate specifically to scan-sites at different fusion stages. The potential for these data as an interpretative tool is considerable. The value of these density data was demonstrated through an analysis of the faunal remains from neolithic Çatalhöyük, Turkey. Reference to the density data enabled testable models to be built that predicted the nature of the Çatalhöyük material. Regardless of the accuracy of these predictions, the models contributed to both the understanding of the nature of the site itself and the role of bone density in site formation generally. This archaeological application showed clearly that appropriately used density data are capable of contributing significantly to an understanding of site formation processes.

10.2.4: What impact have taphonomic processes had on the animal remains recovered from Çatalhöyük, Turkey?

The archaeological application of the data revealed that taphonomic processes have not acted uniformly across the site of Çatalhöyük. In fact, the impact of taphonomic processes seems to have been governed partly by the artificial division of space by humans. Material from internal areas shows evidence of having been less subject to taphonomic destruction, while material derived from external areas appears to have been more thoroughly gnawed, burned, digested etc. An implication of this is that the internal assemblage more closely represents the material that was originally deposited by humans, while the external assemblage consists of the same culturally derived material, but has been distorted by taphonomic bias. It has been impossible to conclude if or how these two assemblages differed prior to the taphonomic distortion of the external material.

10.2.5: Which taphonomic processes are responsible?

An examination of the taphonomic signatures of the two assemblages revealed that a number of processes might have been responsible for the observed differences. These included carnivore gnawing, digestion, butchery and burning. Carnivore gnawing and digestion were implicated as being particularly important.

10.2.6: How are taphonomic processes capable of distorting archaeological age profiles (particularly those from Çatalhöyük)?

Drawing on the density data for fused and unfused material enabled a model to be created that predicted the differences in the age profiles of the two assemblages. This model successfully predicted that, overall, the external assemblage would contain relatively fewer unfused elements than the internal material. However, the prediction that the unfused group 2 and 4 elements would be particularly under-represented was incorrect. An exploration of the reasons for this failure of the model highlighted some shortcomings of bone density when used as a tool for predicting taphonomic destruction. This analysis went some way toward expelling the myth that taphonomically ravaged assemblages would display a considerable under-representation of early fusing (group 1 or 2) elements. No considered application of bone density data to age profiles has previously been attempted (largely because of a lack of appropriate data). This project has therefore been able to lay the foundation stone of what is potentially a considerable advance in our ability to predict and account for the biasing effects of taphonomic processes.

10.3: Project Limitations and Suggestions for Further Work

10.3.1: Project limitations

This project represents a small step towards a further understanding of archaeological site formation processes and has focussed on an important aspect of zooarchaeological research. Naturally, considerable further work in this area is required before the nature of taphonomic bias can fully be appreciated. Before suggestions of how the results of this project can be built upon, it would be useful to offer suggestions as to how it might have been improved.

Although this project examined a total of 95 individuals (several times more than has previously been examined), the sample size was occasionally too small to provide meaningful results. This was mainly a function of the large number of variables that were being addressed. It should be noted that the number of combinations of the different animal attributes (as defined by this project and assuming that 10 separate age categories are used) is 5,400. This means that in order to ensure that an animal representing every possible combination of age, sex, breed, month at death and preparation method was included in the experimental material, no less than 1,800 animals would have to be examined. Furthermore, so that statistically reliable results could be obtained, at least two animals displaying each combination would be required (raising the minimum sample number to 10,800). Such sample sizes, even if they were available, could not have been analysed in the timeframe available for this project. A realistic solution to this problem would have been to concentrate attention on a much smaller number of variables. If differences due to sex alone were to be addressed, a considerably smaller number of animals would have had to be examined, providing they were identical in terms of their breed, age, preparation method etc.

The experimental sample used by this project also lacked certain life history information that would have been useful. Although the material was outstanding in that it consisted of animals of known age, sex, month of death, preparation method and breed, other details about the animals' lives remained unknown. The diet and health of the animal, for example, was frequently unknown. Had factors such as these been known, their impact on bone density may have been addressed specifically. Consequently, the extent of the "background variation" would have undoubtedly been reduced considerably.

The inability for the project to assess the impact of the month of death on an animal's bone density was unfortunate. It is unlikely that any experimental material that is well suited to tackle this question will be readily available. It is possible, however, to hypothesise that if both seasonal and longer term variations in bone density exist, the pattern produced would be one of seasonal undulations superimposed on the longer term increase and decrease in bone density. If this is to be noted experimentally, a complete and very closely controlled experimental sample is needed, so that "background variation" is kept to a minimum. If this is not achieved, then the background variation will almost certainly obscure the more subtle patterns of interest.

Certainly, therefore, this project would have benefited from a larger sample of individuals deriving from more closely monitored animals. Such a reference collection is currently being reared by the English Heritage Ancient Monuments Laboratory (Poly Baker, pers. com.). Should this material become available for density measurement, it is bound to have a significant positive impact on the state of this area of taphonomic research.

A further drawback of this project was the archaeological application of the density data. The small number of suitable bone fragments excavated so far from Çatalhöyük (even though a total of nearly 400,000 bone fragments have so far been excavated and recorded) means that conclusions derived from the material must be treated with some caution. This is especially true of the internal assemblage and in this case is probably a function of the tendency of the ancient inhabitants of the site to clean their dwellings, thereby removing bone material from the internal areas. This problem is caused by the use of DZs as a basis for quantification by this project, since bones with DZs make up a very small portion of the total excavated assemblage. It is a problem, however, that can easily be solved, since excavation at the site is ongoing and future seasons will eventually yield the large numbers of fragments required for this analysis. Since newly recovered faunal material is simply added to the same database used by this project, incorporation of any new data into the analyses would be a relatively simple task.

10.3.2: Suggestions for further work

This project forms a small step towards the greater goal of a full understanding of site formation processes. As such, it has also increased the interpretative power of the zooarchaeologist. So that this advance can be built upon, further work is certainly required. Practical advances, such as the measurement of a wider range of species would certainly be valuable. Similarly, the examination of a greater number of scan-sites would serve to increase the definition (in terms of skeletal location) of subsequent archaeological interpretations. This latter point would be especially useful if a faunal recording protocol could be developed that reliably defines the presence or absence of these scan-sites.

On a more general level, it is imperative that further work addresses the question of exactly which factors mediate the destruction of bone in archaeological contexts. This project has suggested that, although it is probably the primary factor, bone density is certainly not the only variable to control the impact of taphonomic processes. Any work intending to assess the importance of other variables (and their interaction) will need to draw heavily on the literature on mechanical processes (see chapter 4).

A considerable task that must be completed before a full understanding of taphonomic processes can be achieved relates to Schiffer's c-transforms. It has already been noted that density is a comparatively poor predictor of these processes. What is required is a model by which these processes can be more accurately predicted. Consequently, while research into the effects of n-transforms will draw on the mechanical literature (as suggested above), similar research into c-transforms will need to draw on anthropological, ethnographic and other literature.

This project has made a number of observations that resources did not enable to be explored fully. The nature of the marked fluctuation in the bone density of very young animals does not yet seem to have been generally appreciated by archaeologists. This feature of bone development needs to be confirmed and its archaeological implications explored. Similarly, the slight increase of the bone density of the epiphyses at the time of their fusion requires confirmation and exploration.

The model that was intended to predict the differences between the age profiles of the internal and external assemblages was a partial failure. The reasons for this failure were discussed and explored and possible reasons for the failure of the model were presented. It was, however, not possible to test adequately the validity of the revised model. A future project to undertake this task would be most useful.

This thesis set out with a number of general aims and specific objectives. As far as the limitations of the data have allowed, these have been achieved. The contribution of this project to the study of archaeology, and specifically taphonomy, is small, but significant. It has asserted the concept that bone density is not necessarily completely stable, as is often assumed. It has also developed an accessible technique for measuring bone density, so that the factors that influence this variable can be explored. Finally, it has demonstrated that the impact of destructive taphonomic processes will vary according to the fusion stage of a bone. If these foundations are built upon, the result will be an improved ability of archaeologists to understand taphonomic biases and, ultimately, past societies.