The most notable feature of figures 8.7 - 8.12 is that between different individuals there is significant variation that does not seem to follow any clear pattern. This variation can be seen between animals that are of very similar ages. For example, the trabecular skeletons of animals number 16 and 13 (801 and 813 days old respectively (see figure 8.9)) show some marked differences, even though there is less than two weeks between the ages at death of these two animals.

Despite these occasionally dramatic variations between individuals, some more general trends may be noted. Figure 8.10 on the whole shows a very slight increase in cortical bone density between 447 and 1198 days of age (about 15 months and 3 years). This pattern is not repeated in the trabecular bones (figure 8.9). A slightly more marked increase of cortical bone density between 230 and 1309 days of age (about 7.5 months and 3.5 years) is apparent in figure 8.8. Again, this increase is not observed in the trabecular bones (figure 8.7).

An examination of the figures that include the older individuals reveals a different pattern. Figures 8.11 and 8.12 show the general trend being one of density reduction in both the trabecular and the cortical skeleton between the ages of 1258 and 4175 days (about 3.5 years and 11.5 years).

Even though general trends in the data can be noted, these trends are slight and open to argument. They are also based on relatively few observations and so lack statistical robustness. Perhaps the most important feature of all of these graphs is that the variation between individuals invariably exceeds the variation that produces the more general trends. The following discussion will assess the implications of this and will offer an interpretation of both the inter-individual and the more general variation as described here.

8.9.3: Discussion

The inter-individual variation described above strongly resembles background variation. It consists of both uni- and multi-directional variation and affects all the scan-sites apparently at random. In this analysis it can be observed between individuals that are matched in all of their five main attributes (in individuals with very similar ages). This variation must be the result of either age or background variation. It is inconceivable that such dramatic changes in density as the ones observed here could be the result of age differences between the animals (occasionally of only a few days). The conclusion that background factors are at the root of this variation is therefore the most reasonable one.

The more general trends in the data that were described above also require discussion. Both figures that relate to immature animals (figures 8.7 and 8.9) show a slight increase in cortical bone density as the animals mature. This is in agreement with the findings of the authors cited in section 5.2.2, all of whom noted an increase in skeletal density as an individual approached maturity. Some authors have associated developmental density increases with higher levels of mineral in more mature animals (Burns and Henderson 1936 p1213, Dickerson 1962b p57, Weidmann and Rogers 1958 pp339 - 340). However, none of these authors attempted to measure changes in the bulk density of the bone. The work undertaken by Trotter and Hixon (1974) addressed changes in both mineral content (ash weight) and bulk density. They concluded (pp12-13) that changes in bulk density rather than the mineral content of the bone were primarily responsible for increases in density of developing humans. It is most probable that the observed changes in bone density throughout early life are the result of some combination of both of these factors. Whatever the reasons for these changes, it is almost certain that their implication for taphonomic analysis are almost negligible, since the changes themselves are so small, when compared to the background variation.

The tendency for both cortical and trabecular bone to lose density with older age has also been noted previously (see section 5.2.2 and references therein). This change has been attributed to a reduction in bulk density rather than mineral content (Currey 1979 p462, McCalden 1993 p1200, Trotter and Hixon 1974 p12) and is usually associated with the onset of osteoporosis in old age. Again, the impact of the changes observed here are likely to be negligible, since they are so minor, in comparison to the background variation.

Another feature of bone density changes that has been noted in the literature takes the form of a sudden drop in density immediately following birth, rapidly followed by an equally sharp increase (see section 5.2.2 and references therein). This feature has not been identified in this particular part of the analysis, because no matched groups that contained sufficiently young animals could be formed and examined. However, such a feature was identified and discussed in section 8.2.3.

8.9.4: Summary

This analysis has demonstrated that there is possibly some variation in bone density according to age. The pattern that has been identified is one of a gradual density increase as immature animals approach adulthood, followed by a gradual decrease as the animals enter old age and experience the effects of osteoporosis. The analysis in section 8.2.3 has also suggested that bone density falls rapidly around the time of birth and then recovers shortly afterwards. All of these features have been predicted and explained in the literature.

These observations were based on small numbers of individuals and so must be treated with caution, but form a basis for extensive further study. Until these observations have been substantiated, it might be unwise to incorporate them into taphonomic analysis. However, even if they are substantiated, their ability to produce significant age-mediated differences in the archaeological record is likely to be minimal.

Perhaps the most important conclusion of this analysis is that, even though age related differences in bone density might exist, these are inconsequential when compared with background variation.

8.10: Summary of Results

This chapter has demonstrated that a broad number of interacting factors are responsible for the density of a bone. This interaction produces significant variability in the skeletal density of an individual, although its precise nature is complex and poorly understood. By examining each of a series of predefined factors individually it has been possible to gain an insight into how each of a number of individual factors can affect bone density.

This chapter has therefore been able to draw a number of conclusions regarding the factors that influence the bone density if the experimental material. These can be summarised as follows:

- Different methods of defleshing the experimental material did not appear to result in differences in its bone density.
- Distinct breeds apparently had different skeletal densities, although this is more likely to be a reflection on the flock management regime under which each breed was raised, rather than the breed itself.
- Castrated sheep tend to have lower skeletal density than male sheep.
- Fetal sheep have a comparatively high bone density which drops sharply around birth and then rapidly recovers, before beginning a gradual increase in cortical density until they reach maturity. In later life, bone density drops gradually.

- All of these observations are against a background of variation that cannot always be explained by the available data. This "background variation" is probably caused by factors such as nutrition, parity or health, which cannot always be measured in the experimental material. It is capable of obscuring, altering or even enhancing other patterns in bone density.

These conclusions were occasionally based on limited samples, but have been presented above as generalisations that are applicable to the material as a whole. Further investigations on a more representative collection of material will confirm whether such generalisations are valid. For example, the conclusion that castrates have less dense skeletons than males was based on observations of Shetland sheep only. Further work is required to ascertain whether the same is true for other breeds. Also, a more closely controlled assemblage would enable the reduction of background variation to a minimum. Conclusions drawn from such an assemblage would be based on higher definition data, since bone density variation would be due solely to controlled factors.

This chapter has presented the results obtained by this project. Presentation data from all of the animals together (ie not from matched groups) demonstrated that control over the material being examined is required, so that the cause of any variation can be determined. By asserting such control, it has been possible to explore some of the factors that have been suggested to affect bone density. Considerable potential for variation in bone density has been identified. This may cast some doubt on the validity of using bone density data to assess impact of destructive taphonomic processes on archaeological assemblages. However, in the next chapter, it will become apparent that despite this variation some patterns are discernible. Not only can these patterns be used to aid the interpretation of archaeological assemblages, but they also have the potential to provide an understanding of taphonomic processes that has so far been impossible.