The Application of Bone Histology for Species Identification in Archaeology; with a Photo Catalogue

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8 Synthesis

8.1 Research aims

This project was started in order to explore the potential of histology as a means of telling human and animal apart and to identify animal species when dealing with small bone fragments in archaeology. In general, species identification in physical anthropology and archeozoology is achieved through comparison with a reference series or through specific measurements. However, setting human bone fragments apart from animal bone fragments is not always easy or even possible. This is especially the case when dealing with burnt fragments. In addition to this problem, determination and information about the animal species involved is also difficult to obtain when dealing with small bone fragments. Thus, the development of an identification method for bone fragments would add to a more complete picture of the relationships between humans and animals in the past in general and with the burial ritual in particular. Moreover, such a method would also be valuable in the decision making process of archaeological heritage management. Ascertaining the presence or absence of human remains in a site leads to a correct assessment of its importance and might be a great help in choosing the measures that have to be taken to minimise further degradation of the site (Jans 2005).

Histology has been used for many purposes and in many sciences. In forensic science, as an example, histology has been used to prove the presence of human remains. Also in archaeology it has proven its use in, for instance, determining the age of fragmented human skeletons and cremated remains. So, the idea of using histology as an identification tool is by no means a new one.
Metric studies have been conducted to find quantitative differences. These methods have shown to be very suitable for complete bones, but are not devised for bone fragments and can not easily be applied to burnt bones. In earlier studies bone structures were also investigated qualitatively. Many species and different skeletal categories were compared to find distinguishing features. However, bone structure shows a lot of variability between species, within a species, within one skeleton and even within a bone, due to e.g., ontogeny, growth rate, bone formation, age and mechanical factors. Therefore, a novel approach was chosen for the thesis. It was felt that a descriptive approach, confined to the bone structure in a specific bone category and level, of a small group of species but relevant to northwestern European archaeology, would allow for a better assessment of its use in archaeology than the existing methodologies.

The research was confined to the diaphyseal part of long bones in five species: humans, horses, cattle, pigs, sheep and goats. Of each species, several individuals and long bones were studied. By describing and inventarising the histological structure within a species, insight into the variability is obtained, and common characteristics that would allow for differentiation between these species can be inferred. The diaphyseal part of long bones commonly occurs in archaeological bone remains, while small fragments can be difficult to determine macroscopically. However, if a diaphyseal fragment is not too small for histological analysis - less than 1 cm (length/width) as an average - it can in most cases be assigned to the bone category. Besides variability in the bone structure, the development of an identification method for archaeological bone fragments also has to take into account specific drawbacks: the identifying features have to be present even when dealing with bone that was affected by degradation or burning.

To describe and compare the diaphyseal bone structure adequately, the open system of de Ricqlès (Francillon-Vieillot *et al.* 1990) was adapted to facilitate its use for the purpose of this study. A number of bone structures and characteristics were added during the study in order to ascertain common and distinguishing features. To facilitate the use of the developed histological identification method the applied terminologies were compared with those in other relevant studies on species identification (Chapter 2). In addition, a photo catalogue, showing all observed bone structure types, bone characteristics and special features, is provided in Chapter 7.

8.2 Setting apart late juvenile-adult human bone from horses and cattle

In Chapter 3 late juvenile-adult human diaphyseal bone structure is compared to the bone structure of horses and cattle. Unidentified these bone fragments would be grouped together as "large-sized" mammals. Observed differences that set late juvenile and adult human primary bone structure apart from the main bone structure in horses and cattle are described and explained. The general primary bone structure in late-juvenile and adult humans consist of lamellar types, slow-growing bone structure. In contrast, horses and cattle diaphyses consist in general of fast-growing bone, fibro-lamellar bone types. Exceptions are distinctive growth layers that indicate a difference in growth rate and subsequently differ from the general primary bone structure. Although they can be set apart, this has to be kept in mind when dealing with degraded or partly remodelled bone. A difference in secondary bone structure is also postulated, namely the presence of several slanting connecting canals emanating from the centre of a secondary osteon, which gives the secondary bone a reticular aspect. This is seen only in one secondary osteon in human bone, but is a common feature in the secondary bone structure of horses and cattle. It is also shown that organisation of scattered osteons did set apart horses and cattle, because this is also only observed once and to a lesser degree in humans.
To check the validity of the observed differences and their applicability to archaeological bone fragments, a blind test was conducted on 15 bone fragments. A high degree of degradation (Oxford Histological Index 1) in four bone fragments made histological identification impossible. All other bone fragments were correctly attributed to either human or animal. The distinguishing features could also be observed in burnt bone. Primary bone structure types, lamellar and fibro-lamellar, can be set apart in cremated bones. In the secondary bone structure, organisation of osteons is visible and the reticular aspect of the Haversian canals can be distinguished from cracks due to burning.
In conclusion, the observed differences between human and horses/cattle enable us telling them apart and ascertain the presence or absence of humans when dealing with small bone fragments.

8.3 Distinguishing between horses and cattle

In Chapter 4 the diaphyseal bone structure in horses and cattle is evaluated. A difference was observed in the composition of fibro-lamellar complex subtypes. A predominance of the fibrous component within a lamina was exclusively observed in cattle. Horses showed a predominance of the lamellar component. In the first blind test, consisting of 10 bone fragments, three bone fragments could not be identified; two showed severe degradation (Oxford Histological Index 1) and one bone fragment did not show primary bone structure. With one exception, the others were correctly attributed to either horse or cattle. The incorrectly attributed bone fragment showed a predominance of the lamellar component in most of the bone structure and a predominance of the fibrous component in a small area of the structure. Therefore, it was attributed to horse. However, it turned out that cattle can display a predominance of lamellar bone, although in combination with fibro-lamellar bone showing a predominance of the fibrous component. To study this further, another blind test was conducted on 15 archaeological bone fragments. Only four fragments could not be identified either because of the degree of degradation or because of secondary remodelling, both of which obscure the (primary) bone structure. All other 11 bone fragments were identified correctly using predominance of either the fibrous or lamellar component as a distinguishing feature. None of the cattle bones showed a predominance of the lamellar component.

More research is needed to use the presence of a predominant lamellar component as a discerning characteristic for horses. However, the presence of a pre-dominant fibrous component is seen as a distinguishing feature of cattle.
The applicability of this feature was also checked on burnt bones. The composition of the fibro-lamellar primary bone structure can be assessed, despite burning at high temperatures.
The distinguishing histological feature observed in the primary bone structure of horses and cattle will be very useful when trying to gain insight into their respective use for food, making of artefacts and use as grave gifts.

8.4 Identifying metapodia of castrated cattle (oxen)

The aim of the study in Chapter 5 was to find out whether the primary bone structure in oxen metapodia differs from other cattle metapodia and if this could be caused by castration. All oxen metapodia showed the presence of a thick growth layer at the periost, throughout the cross-section. This growth layer consists of primary lamellar bone types and constitutes a high percentage of the radial cross section at that point. In general oxen metapodia are slender, as they are longer but not thicker than the metapodia of bulls. Thus, it can be deduced that in addition to a prolongation of the longitudinal growth time, the radial growth is delayed. Such a reduction of the growth rate influences the primary bone types (Amprino's rule). One would expect slow-growing bone types instead of the common fibro-lamellar bone structure types in cattle long bones. Therefore, growth layers of lamellar bone types can be linked to a delay in radial growth caused by castration.
Thick growth layers were not observed in the metapodia of a bull and a cow. Furthermore, only one of the metrically sexed metapodia in this study showed a growth layer whose thickness and percentage fell in the minimum thickness range of the oxen metapodia. However, this archeological bone may have been wrongly determined as a female, since measurements do overlap between the sexes and can differ between samples. In addition, none of the diaphyseal bones of modern and archaeological horses and cattle of different sexes and ages previously studied showed such an extensive growth layer of primary lamellar bone at the periost. Therefore, it was proposed that an extensive layer of lamellar bone (extensive relative to the thickness of the cortex at that point) could be indicative of castration, due to an increased growing period and a subsequently decreased radial growth rate. This would make the identification of oxen possible in archaeological material and, as such, indicating the use of cattle for traction.

8.5 Setting apart young humans from pigs, sheep and goats

In Chapter 6 the bone structure in the long bones of young humans is compared with that in pigs, sheep and goats in order to test if human bone can be set apart from the animals. All the animals display fibro-lamellar complex bone as the general primary diaphyseal bone structure type, with the fibrous component predominant. Lamellar (primary) bone was only found in distinctive growth layers. In children two patterns are observed. Children from one year onwards display lamellar bone types as the general primary bone structure, in contrast to the medium-sized mammal species. However, children younger than one year old also show fibro-lamellar bone types, resembling animal bone structure. However, the composition of the fibro-lamellar bone is different; the lamellar component is predominant. Children can therefore be set apart from pigs, sheep and goats on the basis of their primary bone structure types or composition. The secondary bone structure also shows differences. Alignment of secondary osteons was not observed in children, but was seen in some of the animal bones. Also the reticular aspect of Haversian canals was only seen in animal long bones. No differences were found between the three animal species.
In a blind test the findings were applied to bone fragments from archaeological sites. All 14 bone fragments could be correctly identified. The distinguishing features are also seen in burnt bones. The observed histological differences enable us to set apart small bone fragments of young humans from those of pigs, sheep and goats. Thus, the presence or absence of human and/or animal remains can be established.

8.6 Conclusions and further research

In this thesis the opportunities of a histological identification method for archaeological bone fragments were investigated. This interdisciplinary approach has contributed to at least two fields of knowledge: archaeology and histology, but will also be useful in forensic sciences. In physical anthropology, the developed histological identification method enables human diaphyseal bone fragments to be distinguished from horses, cattle, pigs, sheep and goats. More archaeozoological information can also be gained from bone fragments belonging either to horses or cattle, adding to our knowledge of subsistence economy, the provenance of artefacts and insight into burial practices. In introducing a distinguishing characteristic of oxen metapodia, the study provides the possibility of identifying castrated cattle and their specific use for draught in the past, adding to our knowledge of past economies. The method can be applied even when degradation is up to Histological Index 1 and also burnt bones can be identified. This makes the method more applicable when dealing with degraded or burnt bones than biomolecular methods based on a DNA and protein extraction.

In the field of histology a lot is added to our knowledge of the diaphyseal bone structure in several species and in animals of different age, sex and height. Amprino's rule, which states that the primary bone types correspond with growth rate, was demonstrated for humans, horses, cattle pigs, sheep and goats. Also knowledge about the general primary bone structure and the occurrence of growth layers has been provided in these species. In addition, the thesis provides a much needed visual presentation of histological structures. In the extensive photo catalogue all observed histological bone structure types, bone characteristics and specific features are included. This will add to the applicability of the devised histological identification method and its use in archaeology.

Earlier studies on many species and different skeletal categories did not provide a means of identification for bone fragments. The variability of the bone structure shown by these studies was the reason to start a study that concentrated on one bone category in five species. Further research to broaden the applicability of histology as an identification tool could be very fruitful and should include other species, depending on the archaeological questions and periods under consideration. It would, for instance, be useful to establish histological reference series of the long bones from bear, deer and dog. The microstructure in bear is very interesting to study because hibernation may cause a slower growth rate, resulting in lamellar bone types in growth layers. Telling adult bear bone fragments apart from humans would then pose a challenge, because of the presence of primary lamellar bone between the secondary bone in both species. Studying deer long bone structure will give more information on the composition of fibro-lamellar bone and its use as a distinguishing feature within the ungulates. Knowledge about the microstructure in the long bones of dogs would be useful in a burial context, since grave gifts of dog bones are known to occur. Also an extension of the reference series with Pleistocene fauna would be useful. In Palaeolithic and Mesolithic contexts the question of whether human remains are present or not also has risen and an identification method would be very helpful in establishing the presence of human remains.

Further research should also include other bone categories. Identification problems can occur when dealing with rib and skull fragments. It would be very useful to know whether these skeletal categories also contain bone structure that displays species differences.

It is recommended to further investigate the composition of fibro-lamellar bone within cattle to determine if a predominance of the lamellar component can be used as a unique characteristic of horses. It is also recommended to establish more firmly the proposed difference in oxen metapodia. A larger series of cattle metapodia of known sex and age at castration, in the case of oxen, is needed to ascertain whether the proposed distinguishing feature can be used to indicate the presence of castrated cattle and as such establish the use of cattle as draught animals.

Finally, it is concluded that the fields of physical anthropology and archeozoology would benefit from an incorporation of histological analysis in relevant project outlines performed by commercial archaeological agencies. When dealing with otherwise unidentifiable bone fragments, whose provenance would yield more insight into the past, histological analysis on a carefully selected number of samples should be included into the standard requirements for the analysis of bones from archaeological sites.

References

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