This PDF file of your paper in Diet and health in past animal populations belongs to the publishers Oxbow Books and it is their copyright.

As author you are licenced to make up to 50 offprints from it, but beyond that you may not publish it on the World Wide Web or in any other form.
Contents

Preface ............................................................................................................................................................................. vii
Umberto Albarella, Keith Dobney and Peter Rowley-Conwy

1. Introduction: animal diet and health – current perspectives and future directions ........................................... 1
Richard Thomas and Ingrid Mainland

2. Animal palaeopathology in prehistoric and historic Ireland: a review of the evidence ................................. 8
Eileen M. Murphy

3. Looking for human therapeutic intervention in the healing of fractures of domestic animals ...................... 24
Mircea Udrescu and Wim Van Neer

4. Rib and vertebral fractures in medieval dogs from Haithabu, Starigard and Schleswig .............................. 34
Wolf-Rüdiger Teegen

5. Palaeopathology and Neolithic cattle traction: methodological issues and archaeological perspectives .......... 39
Niels Nørkjær Johannsen

6. Palaeopathological evidence for draught cattle on a Roman site in the Netherlands ................................. 52
Maaike Groot

7. Pathological alteration of cattle skeletons – evidence for the draught exploitation of animals? ................. 58
Marian Fabiš

8. Can palaeopathology be used as evidence for draught animals? ................................................................. 63
Ylva Telldahl

9. Horse burials from Middle Lithuania: a palaeopathological investigation ................................................ 68
Linas Daugnora and Richard Thomas

10. Abnormal sheep metatarsals: a problem in aetiology and historical geography ........................................... 75
Don Brothwell, Keith Dobney and Deborah Jaques

11. Oral pathology, nutritional deficiencies and mineral depletion in domesticates – a literature review .......... 80
Jessica J. Davies

12. Linear enamel hypoplasia in medieval pigs from Germany ........................................................................... 89
Wolf-Rüdiger Teegen

13. Identifying livestock diet from charred plant remains: ................................................................................. 93
   a case study of a Neolithic settlement in Southern Turkmenistan
   Michael Charles and Amy Bogaard

14. The diet and management of domestic sheep and goats at Neolithic Makriyalos ..................................... 104
   Ingrid Mainland and Paul Halstead

15. Long distance movement of sheep and goats of Bakhtiari nomads tracked with intra-tooth variations of stable isotopes ($^{13}$C and $^{18}$O) ................................................................. 113
   Marjan Mashkour, Hervé Bocherens and Issam Moussa

16. Tuberculosis as a zoonotic disease in antiquity ...................................................................................... 125
   Simon A. Mays
6. Palaeopathological evidence for draught cattle on a Roman site in the Netherlands

Maaike Groot

The use of cattle as draught animals in the Roman period has been well documented historically. So far, however, few systematic attempts have been made to find the remains of draught cattle in archaeological deposits. This article will provide a short summary of the different methods of identifying draught cattle, and discuss the suitability of these methods for the archaeological material from Tiel-Passewaaij. This paper will focus on osteoarthritis since this condition was found in seven cattle acetabula, six femoral heads, two metapodials, a phalanx and a thoracic vertebra. In three cases the sex of the animal could be determined using the pelvis; all came from cows. Until now, it has always been assumed that only oxen were used for traction. It is time to rethink zooarchaeology’s sexist view of draught cattle.

Introduction

The site of Tiel-Passewaaij is located in the middle of the Netherlands, just inside the border of the Roman Empire. The site consists of two settlements and an associated cremation cemetery and can be dated from the Late Iron Age to the Late Roman period. In the early and middle Roman period, the Batavians, a local tribe, inhabited the settlement. During the Late Roman period, however, an ethnic change in inhabitants occurred as a result of the migration of people from across the Roman border.

The excavations at Tiel-Passewaaij (1996–2004) have uncovered a large number of well preserved animal bones. Most of these have come from the larger of the two settlement sites, the excavation of which is still ongoing. A problem associated with the unfinished state of the excavation is the lack of a completed analysis. Indeed most of the features have not yet been dated. Consequently, no attempt has been made to separate the animal bones into phases in this article.

The majority of the animal bones from this site represent the waste from butchery and consumption, however a number of animal burials have been found, both in the cremation cemetery and in the settlements. In the cemetery, the animal bones in graves were either burnt on the funeral pyre with the deceased, or were buried in the grave unburnt. These animal remains could be considered as a meal for the dead or the remains of a funeral feast. The remains of animals, which have probably been buried as part of a ritual, have been found both in the cemetery and the settlements. Apart from complete burials, these include skulls and articulated limbs.

All the animal bones from the first settlement and the burial site have been identified where possible and analysed. Nearly 4,500 fragments could be identified to species. Work on the material from the second settlement has not yet finished. So far, the species has been established for just over 6,000 fragments of animal bone. Most of the bones belong to domesticated animals: cattle, sheep or goat, pig, horse and dog. Cattle were the most numerous animal. Some chicken and a few wild mammals and birds are also present.

Cattle were the most important animal for the local economy at this rural settlement. Not only would their meat have been consumed, but other products such as hides and manure would also have been utilised. Another important product cattle provide is power; they can be harnessed and made to pull carts or ploughs, enabling larger fields to be cultivated more efficiently. Whether cattle were used for traction at this particular settlement is an important question. The answer will help us to establish how agriculture was practised in this community. Another question we can ask is which cattle were used for labour? Was it oxen, as is usually assumed, or did cows contribute as well?
This article will describe pathological changes in cattle bones and ask whether they are the result of traction. Previous research into the identification of draught cattle will be discussed, and new information that the present study can add to this field will be considered.

Methodology
To find out whether the cattle at Tiel-Passewaaij were used for traction, the pathologies present in the cattle bones will be examined. This method is a relatively straightforward way of investigating traction, since it does not require the use of complicated calculations or expensive methods. In this research, macro-morphological inspection of the bones formed the basis for the identification of pathology. Traction can leave its marks in different places on the skeleton, but a study of the lower legs is likely to provide more data since they will have borne most of the stress when pulling heavy weights. The hip joint should also be examined because this will endure extra stress as a result of traction. Although some other cattle bones from Tiel-Passewaaij had pathological changes that could have resulted from traction, this article will focus on the hip joint and the lower legs.

One problem with using macro-morphological inspection is that the progress of pathological change is gradual. Visual inspection can only identify the severest cases and draught cattle would have been worked for some time before they developed any pathological lesions on their bones. The first signs of degenerative disease would have occurred in the cartilage, which is missing in the archaeological record. It also has to be considered that the number of cattle found on an archaeological site, probably only represent a small proportion of those that were originally present.

Previous research into draught cattle pathology
The study of the pathology of draught cattle has received a great deal of interest during the last twenty years. What follows is a summary of that research and a discussion of the advantages and disadvantages of the different methods and their relevance to the present study.

In 1981 Higham et al. published a paper, in which the insertions of the tendons on the third phalanx were examined on the premise that the development of exostoses at these points was related to age, sex, weight and stress caused by regular activities. The authors developed a method involving multivariate statistics. A modern comparative sample was collected and the exostoses analysed and compared with prehistoric material from Thailand; both cattle and water buffalo were included in this study. Only the third phalanx of the right forelimb was studied, because it was believed that the forequarters carry most weight in traction. The study concluded that exostoses around the extensor process were mostly influenced by weight, whereas those around the flexor process were mostly affected by traction. Based on this evidence it was possible to suggest that only water buffalo were used for traction in prehistoric Thailand.

There are three problems associated with this study. Firstly, the third phalanx is less robust than the first and second, and therefore not as commonly found in archaeological material. Secondly, the third phalanges from the fore- and hind limb are so similar that distinguishing between them is nearly impossible. Finally, multivariate statistics are complicated and not easily carried out.

In 1993 Bartosiewicz et al. published a study based on investigation of metapodials from a modern sample of cattle. The sample contained a large number of bulls, steers and cows, and included 14 draught oxen. Six different measurements were taken in total, for both the metacarpal and the metatarsal in an attempt to quantify asymmetry in relation to sex, body size, and traction. Metapodial asymmetry was found to be dependent on body weight. Since traction acts as a weight increase it can consequently increase asymmetry and because the medial half of metapodials carries more weight, it becomes more developed than the lateral half. This is reflected in breadth measurements of the trochlea.

Metapodial asymmetry seems to be a promising way of identifying draught cattle (Bartosiewicz et al. 1993). However, the boundary between draught and non-draught cattle is arbitrary. Furthermore, as asymmetry can be caused by weight alone, or in combination with traction, we cannot exclude the possibility that asymmetry will occur in fattened cattle. Finally, asymmetry is a non-pathological adaptation to the stresses placed on the joint. Our study, on the other hand, is mainly concerned with the pathological changes caused by traction.

Another study aimed at identifying draught cattle in the archaeological record compared the metapodials and phalanges from a number of Romanian draught cattle of known age with the same bones of non-draught animals (Bartosiewicz et al. 1997). This study was based on the same data as that used by Bartosiewicz et al. (1993) and was limited to the lower limb bones. The main changes noted in the draught cattle were the formation of exostoses and the widening of articular surfaces (‘lipping’). The authors recognised several different stages in the pathologies identified and illustrated these with photographs and descriptions. Unfortunately, only five first and two second phalanges have been found amongst the material from Tiel-Passewaaij on which lipping or exostoses can be observed. We need to examine more phalanges before we can use this method on the material from this site.

Yet another study applies the method developed in Bartosiewicz et al. (1997) to zooarchaeological data from four Roman sites and a late medieval one (De Cupere et al. 2000). Only first phalanges are discussed in the article, because they were the most numerous at all five sites, however this method seems to work well for identifying
draught cattle in the archaeological record. The inclusion of the medieval site, for which it was known that horses and not cattle were used as draught animals, provides a reference of non-draught cattle of an older age. These valuable data were missing in Bartosiewicz et al. (1997).

Although the studies mentioned above provide important data, their use for the material from Tiel-Passewaaij is limited. Bartosiewicz et al. (1997) provide a very useful method for identifying draught cattle in archaeology, especially when combined with the additional data from De Cupere et al. (2000). However, none of the studies takes the sex of draught cattle into account, although De Cupere et al. (2000) mentions the possibility that cows were used for traction as well as oxen.

**Palaeopathology at Tiel-Passewaaij**

Overall, pathological lesions were recorded on nearly 3% of the identified bones from the larger settlement at Tiel-Passewaaij. These included congenital abnormalities such as oligodonty and developmental anomalies such as clefts in articular surfaces. The most frequently recorded lesions were dental anomalies, fractures, oral pathology, and osteoarthritis. Some pathologies are clearly species-related, being more prevalent or only occurring in one species. For example, oral pathology was mostly found in sheep and trauma was frequently recorded for dogs. Unfortunately, however, because most of the animal bones were found as refuse and consisted of isolated fragments, it is not possible to study the distribution of pathology through the skeleton.

Among the cattle bones from Tiel-Passewaaij, some pathological changes were seen a number of times and occurred in several places in the skeleton. Firstly, pathological changes were identified in the phalanges, as described by Bartosiewicz et al. (1997). Lipping was found on four first phalanges and four second phalanges, and distal exostoses on one first phalanx. The total number of first phalanges was 90 and the total number of second phalanges was 55, although this did include smaller fragments. One very clear case of broadening of the medial trochlea of a metatarsal was also seen; this specimen will be described in more detail below. Finally, eburnation was found in several locations: most commonly in the hip joint, but also on metapodials, a first phalanx and a vertebra. Because the pathological changes in phalanges and the broadening of the medial trochlea in metapodials have been covered elsewhere (Bartosiewicz et al. 1993; 1997), this study will focus on the occurrence of osteoarthritis.

Pathological changes were frequently found in the acetabulum and on the femoral head at Tiel-Passewaaij. These largely consisted of eburnation, although two of the femoral heads also showed a slight porosity of the bone surface. Eburnation is caused by bone-on-bone contact where the cartilage in the joint has been degraded. The lesions found in the acetabula from Tiel-Passewaaij were generally small, varying from 2×10 to 5×20 mm (Fig. 1). In all cases, eburnation was found on the part of the acetabulum belonging to the pubic bone. The lesions on the femoral heads were somewhat larger, varying from 5×18mm to 14×40 mm in size. At least two of the lesions were located on the posterior part of the head, close to the edge of the articular surface. One lesion extended onto the superior part of the neck of the femur. For the other three cases, the fragments were too fragmented to allow the location of the eburnation to be pinpointed exactly.

Eburnation was observed on six femora and seven acetabula unfortunately, however, prevalence rates could only be calculated for the largest settlement. Overall 11.4% of proximal femora and 6.7% of acetabula displayed evidence of eburnation. These are minimum prevalence rates, based on the total numbers of fragments from femora and pelves from the settlement, instead of just the number of femoral heads and acetabula. It also has to be remembered that these samples are small.

Despite the fact that not all the classic symptoms of osteoarthritis (as described in Baker and Brothwell 1980) were found at Tiel-Passewaaij, eburnation on a joint surface was present, and this is considered to be pathognomonic for osteoarthritis (Waldron 1992). If eburnation is absent, two of the following should be present before a diagnosis can be made: marginal osteophytes, deformation of the normal joint contour, pitting of the joint surface or the formation of new bone on the joint surface (Waldron 1992). In human palaeopathology, diagnosis is usually made on the presence of eburnation (Waldron...
Palaeopathological evidence for draught cattle on a Roman site in the Netherlands

Eburnation and grooving on the proximal articular surface of the vertebra and on a thoracic vertebra. On the vertebra, eburnation was found on the posterior surface of the vertebral body, indicating that the intervertebral disc had degenerated. Marginal osteophytes were also found on the same vertebra. The first phalanx exhibited both eburnation and grooving on the proximal articular surface, together with exostoses on the proximal metaphysis (Fig. 3).

Draught cows

Although the fragments from the pelvis were small, it was apparent that some of them definitely came from female cattle (Figs. 4–6). The pelvis was sexed morphologically, using a combination of a thin ridge on the pubis and a shallow groove on the dorsal side of the ridge as indicative of the female sex. Three pubic bones (out of the seven fragments for which eburnation was recorded) could definitely be assigned to cows, whereas the other fragments were missing the essential part of the pubic bone necessary for identification. However, the thickness of the bone and the presence of exostoses suggest that they were from female cattle.

Figure 2. Distal metatarsal with signs of osteoarthritis: grooving and eburnation. Asymmetry of the condyles is clearly visible.

Figure 3. First phalanx with proximal exostoses (right) compared with normal first phalanx (left).
of one of the fragments of pubis seems to indicate that male cattle were used for traction as well as females.

Despite the fact that we are generally accustomed to the idea that oxen were used for traction, the concept that cows were used for this purpose is not as strange as it might seem. It is perhaps logical to assume that draught cattle were only used at certain times of the year, at least in front of a plough, and that fields were ploughed before the crops were sown. In a small community, it might make sense not to keep specialised animals throughout the year for these short periods of work but rather to use the animals that were around. Cows have the advantage that they can provide calves and milk as well as labour. Alternatively, it is possible that the cows used for traction were those that had failed to reproduce during the year.

This interpretation is indeed supported by other zoo-archaeological and historical data. Bones from female draught cattle have been found before. In Bronze and Iron Age sites in Turkey, for example, metapodials from both male and female cattle were found that had broadened medial trochlea (De Cupere et al. 2000). De Cupere et al. (2000) also suggest that cows might have been used for traction at the Roman site of Sagalassos, Turkey.

Roman sources such as Columella mention the use of sterile cows as draught animals (Columella, De re rustica, 6.22.1). Additionally, an illustration in Bartosiewicz et al. (1997) shows a cow pulling a cart together with her calf. The photograph was taken in Romania in 1991 and, interestingly, this cow is clearly not sterile. Fig. 7 also shows cows being used as draught animals in Spain.

**Conclusions**

Osteoarthritis was found in seven cattle acetabula, six femoral heads, two metapodials, a phalanx and a thoracic vertebra. Based on the literature mentioned above, it seems reasonable to conclude that osteoarthritis, at least in the hip joint and the lower leg, is a result of the cattle being used as draught animals.

Although it is no surprise that cattle were used for
traction in a native Roman settlement, it is interesting that cows were used for this work. We do not know whether sterile cows were used, or whether pulling power was just another product they provided apart from calves, manure and possibly milk.

More systematic research is needed to answer the question of the importance of draught cattle to the rural economy, covering more sites from the same period and region. Systematic recording of measurements and use of the method described in Bartosiewicz et al. (1993) will probably identify even more draught cattle. Only those specimens that are clearly pathological have been identified to date.

Acknowledgements
I would like to thank L.H. van Wijngaarden-Bakker for providing the illustration of the cows in Spain, C.H. Maliepaard for information and advice, Linda Kamp for commenting on an earlier draft of this paper, Anneke Dekker (Amsterdam Archaeological Centre) for her excellent photographs (Figs 1–6), and of course the editors for the opportunity to present this paper.

Bibliography

Maaike Groot
Archeologisch Instituut Vrije Universiteit
Faculteit der Letteren
De Boelelaan 1105
1081HV Amsterdam
The Netherlands
E-mail: m.groot@let.vu.nl