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Working with reindeer: Methods for the identification of draft reindeer in the archaeological record

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Abstract

Draft and cargo reindeer were an efficient means of transportation for the Saami. The use of draft reindeer allowed the efficient movement of people and their belongings in the arctic landscape without roads. The use and training of draft reindeer led to a close working relationship between humans and animals. Working reindeer were companions to the Saami in their daily tasks and the training of an individual reindeer for several years created a companionship between the reindeer and the trainer. Recent developments in zooarchaeology offer the possibility to identify working reindeer in the archaeological record. New methods broaden the scope of interpretation of archaeological reindeer bone finds from Saami sites, especially the interpretations of the relationships between the Saami and the reindeer in the past. This paper presents some of the recent developments in zooarchaeological methodology, such as the development of muscle attachment site scoring for reindeer, as well as the identification of working-related pathological lesions on reindeer skeletons, and the use of bone cross-sections in the physical activity assessment of reindeer.

Keywords: physical activity reconstruction, palaeopathology, entheseal changes, biomechanics, reindeer

3.1 Introduction

Despite regional variations in reindeer herding traditions and the role of herding in the subsistence of the Saami from different parts of northern Fennoscandia, reindeer have been major players in the Saami world. Reindeer were domesticated probably from the Late Iron Age onwards (Bjørklund 2013; Hansen and Olsen 2014: 195–206; Mulk 2009; Sommerseth 2011). Archaeological and genetic evidence suggest that reindeer pastoralism became increasingly important in the Late Medieval and Early Modern periods, especially from the 16th century AD onwards (Bjørnstad et al. 2012; Bjørklund 2013; Hansen and Olsen 2014: 195–206; Mulk 2009; Sommerseth 2011; Røed et al. 2018; Wallerström 2000). However, the adoption of reindeer pastoralism varied in time and space. For instance, in Kemi Lapland in present day Finland, reindeer herding remained small-scale and was supported by other means of livelihood well into the 17th century AD and later (Tegengren 1952). On the other hand, it has been suggested that the transition to pastoralism already began in the Swedish mountain

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and forest areas from the 9th century AD onwards (Bergman et al. 2013; Hedman 2003). The Saami also used reindeer for pulling sledges and carrying loads. Working reindeer were usually castrated bulls (SaaN.: *heargit*) that were trained for working from the age of three to four years. These animals shared their lives with their human trainers and became working partners, forming a relationship where both the animals and people got to know each other, taught each other, and worked together.

This paper explores some of the analytical possibilities for archaeologists to identify working reindeer in the archaeological record (Figure 3.1). We will especially concentrate on palaeopathology, changes in muscle attachment sites (entheseal changes) and bone-cross-sections. The paleopathological analysis of working-related lesions has been conducted on other species such as cattle and horses (e.g. Bartosiewicz et al. 1997; Levine et al. 2005) and recently on reindeer (Salmi and Niinimäki 2016). Additionally, cross-sectional bone analyses have been applied to animals (e.g. Shackelford et al. 2013). The methodology for the analysis of entheseal changes has been developed for reindeer (Niinimäki and Salmi 2016) and work is currently being carried out to employ this method on other species, such as the horse (Binde et al. 2018; Niskanen 2018).

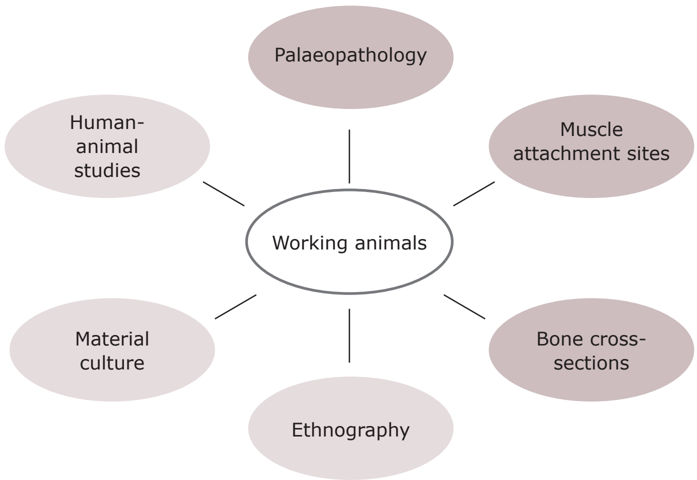

Figure 3.1: Methods and fields of study involved in the study of working animals of the past.

Understanding the relationship between people and the reindeer they were interacting with is another important goal of the paper. In this paper, we sketch out some of the reasons it is important to identify working animals in the archaeological record. Working animals are an indication of animal domestication. In addition, reindeer training and working together with reindeer are carried out according to cultural practices and they create special bonds between people and individual animals. The identification of draft reindeer in the archaeological record provides access to a vast set of cultural practices and ideas, as well as an interspecies network of social interaction.

3.2 History and ethnography of working with reindeer

It has been suggested, that the use of reindeer for the transportation of cargo was important for the Saami from the early stages of reindeer domestication onwards (e.g. Bjørklund 2013; Ingold 1986). Ingold (1986) has argued that castrated male reindeer were probably trained for draft use already in the early stages of domestication. It has also been argued that the earliest written documents mentioning domesticated reindeer, Ohthere's account to King Alfred the Great in England in 890

AD, testifies to the existence of draft reindeer. Ottar told the King that he had six hundred tame deer, among them six decoy reindeer (an animal used to attract others of its own species for hunting purposes) (Bately 2007: 46). This passage has usually been translated as evidence of the use of decoy reindeer for hunting, but Bately (2007: 56) suggests that according to the correct translation, they should be understood as tame male animals "kept at the homestead, not allowed to roam free". As pointed out by Bjørklund (2013), tame (and therefore supposedly castrated) male reindeer do not make very good decoy animals. Moreover, Bjørklund argues that hunting with decoy animals became important only after the pitfall systems and corrals fell out of use and hunting individual animals with firearms became more common (Bjørklund 2013: 177). Whichever way Ottar's story is interpreted, the role of working reindeer in the early historical documents of reindeer pastoralism is clear. For instance, Olaus Magnus writes about draft reindeer in his *Description of the Northern Peoples* (1996 [1555]: 215): "The natives make their way into these mountains in winter-time using reindeer like yoked stags to bear quite heavy burdens for a distance of almost two hundred Italian miles." To name another example, Johannes Schefferus' *Lapponia* (1963 [1673]) features a cover image of a couple walking with a reindeer carrying a child in a cradle on its back.

The Saami used reindeer for transportation and cargo in various ways. First, they were used to pull loads, for instance sledges of different types and travois made of the trunks of young birch trees (Itkonen 1948: 399–412). The Saami have traditionally used only one animal to pull a sled. Only the Skolt Saami used an arrangement of several reindeer, a custom adopted from the Komi people of the Kola Peninsula, from the late 19th century AD onwards (Itkonen 1948: 388–412). The traditional Saami harness was made of leather. It was placed around the neck of the reindeer, on the anterior side of the scapulae. It was attached to the sledge with a leather string that went under the reindeer's stomach and between its legs. When this type of harness is used, the reindeer mainly uses its neck muscles to pull the weight of the sledge. Later, the Saami used a wooden collar (SaaN.: *leaŋggat*), adapted from a horse collar, on draft reindeer (Figure 3.2). The collar was attached to a harness of which there were different types according to their function. When using a collar, the reindeer uses its shoulder and upper back muscles to pull the weight (Itkonen 1948: 414–416).

Figure 3.2: Different types of reindeer harnesses in the Skolt Sámi Heritage House in Sevettijärvi. (Photo: A. Salmi.)

In addition to pulling sledges, the Saami used reindeer for carrying loads. The load was attached to two crossing wooden beams, placed on the back of the reindeer so that the load was distributed evenly on both sides of the reindeer (Itkonen 1948: 388–391; Näkkäläjärvi and Pennanen 2000). A usual load weighed about 25–35 kg, and the reindeer walked with the load for two to three hours and then had a break (Itkonen 1948: 388–391). Sometimes small children of three to six years of age travelled by riding on top of the load on the back of the cargo reindeer (Itkonen 1948: 391).

Usually the Saami employed castrated males to carry and pull loads, but there are sporadic mentions of females being used for these purposes as well. It was said that the females were faster than males, but they had less stamina. Usually, however, young castrated males (ca. three to four years of age) were selected for training to be transport reindeer. The training commenced in the autumn when the reindeer were first tied to a tree for a few days, after which the trainer started to walk them around on a leash (Itkonen 1948: 418–419). The training for pulling loads commenced in the winter when there was permanent snow cover on the ground. At that point, the trainer harnessed the young trainee reindeer in front of a sled, first together with more experienced animals. The weight of the load was gradually increased, and the trainer started to teach steering and turning. Some reindeer were faster to learn than others. The personality and teaching style of the trainer also affected how the reindeer learned and how good a transport reindeer it became (Itkonen 1948: 421–422).

3.3 What does it mean to work with a reindeer: The human-animal relationship perspective

Draft use is a close working relationship between humans and animals. Gala Argent (2016) describes the process of learning to ride a horse as an interspecies apprenticeship, where both humans and horses pass along social knowledge. Horses are social animals, which means that they have a range of social relationships within their herds. The relationships may vary as the herd composition changes over the year and are therefore contextual and negotiable. Horses, therefore, learn to form social relationships with a variety of individuals in different roles (Argent 2016).

Like horses, reindeer are social animals. Therefore, much of this applies to the relationship with a reindeer and its trainer and/or human companion in draft activities (Figure 3.3). Terhi Vuojala-Magga (2010) writes about the relationship between a draft reindeer and the trainer. According to her, the training process involves learning and cooperation between human and animal individuals, and both parties, the human and the animal, learn in the course of training. The trainer gets to know the reindeer and the right way to deal with that reindeer. In this sense, the reindeer teaches the human. The trainer and the reindeer get to know each other on a very personal level, and they become attuned to each other's feelings (Vuojala-Magga 2010). In this process of learning and getting to know each other, communication takes place through nonverbal means, such as body movement, gestures, touch, and physical closeness (Argent 2012; Vuojala-Magga 2010). Therefore, working with animals is not a one-way relationship where humans master the animals and take advantage of their work. It is a relationship between human and animal persons (Argent 2012).

Learning also happens between people and between generations. Knowledge of reindeer herding is often transmitted nonverbally and involves learning by doing with the more experienced herders. Furthermore, reindeer pass information between generations as the reindeer also learn behavior from older generations – for instance being around people and dogs. Therefore, knowledge of herding practices is transmitted from older reindeer to the young (Vuojala-Magga 2010).

The human-animal relationship perspective on working reindeer clearly shows that the identification of working reindeer in the archeological record is topical not only because it can inform us about

Figure 3.3: A boy about to take a ride in a reindeer sledge. Korvanen, Sodankylä 1938. (Photo: Samuli Paulaharju/Finnish Heritage Agency. KK3490:7605.)

the beginnings of reindeer domestication, but also because it has implications on how we understand the relationships between people and reindeer. Working animals were clearly companions for people. They had personhood and there would have been a significant deal of non-verbal communication with people. In the Saami worldview, animals were persons in their own, non-human ways and they could be incorporated into the web of social interaction (Helander-Renvall 2010). Working reindeer were surely among those animals included in the sphere of social interaction. Therefore, their identification in the archaeological record provides information about a certain way of relating to an animal individual, although ideas of animal personhood certainly must have varied from time to time and from place to place.

3.4 Methods for the identification of draft use in reindeer

3.4.1 Palaeopathology

Paleopathological analysis means the study of ancient diseases, usually using the marks they leave on the skeleton as source material. The skeletal effects of working have been studied especially in draft cattle and horses (Bartosiewicz et al. 1997; De Cupere et al. 2000; Levine et al. 2005; Telldahl 2012). It is often difficult to decipher the etiology of pathological lesions in archaeological bone finds due to the multifactorial origins of many types of lesions (e.g. De Cupere et al. 2000; Flensborg and Kaufmann 2012; Telldahl 2012; Thomas 2008). Most likely, pathological changes at joints and ligament attachment sites are due to over-use, or over-loading of the joint: with extra weight the joints and ligaments are under greater stress than they are structurally designed to carry. Research has shown that draft use typically causes lipping and new bone growth in the form of exostoses in the phalanges of draft cattle. The forelimb phalanges are especially affected (Bartosiewicz et al. 1997; De Cupere et al. 2000; Telldahl 2012). Riding, on the other hand, especially causes vertebral pathological lesions in horses (Levine et al. 2005). Bone growth in the form of exostoses occur near joints and develops as calcifying cartilage at ligament and/or muscle attachment sites of over-stressed joints. In addition, some specific trauma patterns could indicate human influence.

According to our preliminary study with a small sample of modern draft reindeer skeletons from Siberia, the patterns caused by draft use and riding seem to be quite similar in reindeer. The Siberian individuals used as draft reindeer exhibited new bone growth as a result from extra stress in their forelimb, and to a degree, in hindlimb phalanges (Figure 3.4). There was also vertebral spinous process warping, possibly related to draft use, in one individual. The warping was potentially related to uneven stress caused by the harness (Salmi and Niinimäki 2016). The Evenki use multiple reindeer to pull a sled, and the harness is asymmetrical (Vasilevich and Levin 1951: 69). However, as they also change the harnessing side from time to time in order to not to exhaust the animals (pers. comm. V. Davydov 2014), and such warping happens in other species in the wild (Flensborg and Kauffman 2012), the relationship between spinous process warping and the draft use of reindeer remains unclear. Moreover, because the ethnographic records suggest the Saami usually used only one reindeer to pull a sled and the harness was symmetrical, it is not likely that vertebral warping related to uneven strain would be observed in the archaeological material from Saami sites.

Figure 3.4: New bone growth in the form of exostoses on the proximal forelimb phalanges of a cargo reindeer from Taimyr, Siberia (Photo: A. Salmi).

Siberian reindeer herders also use domesticated reindeer for riding, and we observed probable riding-related new vertebral bone growth and fusion in one individual that was known to have been ridden by an unusually heavy rider (ca. 90 kg; whereas the suggested upper limit for reindeer riders is 70 kg) (Salmi and Niinimäki 2016). Based on current data, it is difficult to estimate the effects of carrying loads on vertebral pathologies in reindeer. The weight of the cargo loaded on a reindeer (ca. 25–35 kg according to the ethnographic data collected from the Saami) was considerably less than the weight of an adult rider, but it is still possible that habitual load-carrying caused extra stress on the backs of draft animals. The warping of the vertebral spinous process in one of the individuals in the sample (Salmi and Niinimäki 2016) was the only other vertebral pathology observed in the sample despite the fact that the animals were also used as draft reindeer.

We are currently expanding this preliminary small sample with more working reindeer. In addition to Siberian draft reindeer, we are collecting skeletons of reindeer working in the tourism industry and competing in reindeer racing in Finland. The increased sample size will allow a more detailed examination of the relationship between pathological lesions in reindeer and working. Moreover, it is important to include Fennoscandian reindeer in the sample, because of the genetic and phenotypic variation in reindeer (Banfield 1961; Røed et al. 2008) and the cultural differences in the use of draft reindeer between the Saami and the Siberian reindeer-herding peoples.

3.4.2 Entheseal changes

Patterns of physical activity can be analyzed by examining entheseal changes (EC). Entheses are sites where a muscle attaches to the bone either directly, via a periosteum, or a tendon (Benjamin et al. 1986, Benjamin et al. 2002; Villotte 2006). Muscle attachments close to joints usually attach via a tendon and are thus called fibrocartilaginous, as the entire or most of the soft-tissue part is comprised of the tendon. Muscles attaching to the bone diaphysis occur either directly to the bone or via the periosteum, where most or all of the soft-tissue is fibrous and are thus called 'fibrous attachments' (Benjamin et al. 1986; Benjamin et al. 2002; Jurmain and Villotte 2010; Santos et al. 2011; Villotte 2006; Villotte et al. 2016). An enthesis can be a muscle's origin or insertion site, although insertion sites are more likely to exhibit variation compared to the muscle origin (Niinimäki and Salmi 2014). EC observation methods were originally developed for humans (Hawkey and Merbs 1995; Henderson et al. 2017; Mariotti et al. 2004; Robb 1998; Villotte 2006), but recently observation methods suitable for other mammal species have been developed (for reindeer Niinimäki and Salmi 2014; 2016; for horse Binde et al. 2018).

The observation of bony changes at the entheses is based on the theory that habitual physical activity affects, or stresses, muscle attachments via muscle loading, or 'pulling' (Hawkey and Merbs 1995; for information on terminology, see Jurmain and Villotte 2010; Villotte et al. 2016). The markers were previously known as 'musculoskeletal stress markers'. More specifically, muscle-bone and muscle-tendon junctions are sites that experience mechanical loading, or stress, when a muscle contracts, and the frequency and possibly the magnitude of muscle use may be reflected in these junctions and exhibit as bone changes at the entheses. These changes are broadly considered as bone formation and bone resorption (Henderson et al. 2013, 2017; Villotte 2006). However, the etiology of EC is not well understood, and changes can be considered as over-use (mainly in case of fibrocartilaginous entheses and bone resorption), which would be pathological, or 'wear-and-tear' due to normal function. Activity reconstructions are then observed as variations between individuals in manifesting this 'wear-and-tear' as EC. More actively used joints and muscles tend to exhibit more pronounced bone formation, and sometimes bone resorption presents as fine porosity or larger porosity which is considered to be due to vascularization. The etiology of EC remains debatable and is most likely multifactorial (Jurmain and Roberts 2008; Villotte and Knüsel 2013). EC vary according to age, sex, hormones, body size (Chen et al. 2007; Jurmain and Roberts 2008; Mariotti et al. 2004; Niinimäki 2012; Villotte et al. 2010; Weiss et al. 2010; Wilczak 1998) and activity (for humans, e.g. Havelcová et al. 2012; Molnar 2006; Weiss 2007; for reindeer Niinimäki and Salmi 2014; Salmi and Niinimäki 2016).

Therefore, these factors should be considered when interpreting observed EC. Furthermore, due to large inter-individual variation in the manifestations of activity via EC, this method works best when making comparisons between groups rather than comparing individuals.

A preliminary analysis comparing the EC in modern non-working reindeer and four working reindeer suggests that working especially affects the entheses in the upper forelimbs, although the sample size was too small for a statistical analysis (Salmi and Niinimäki 2016). We observed difference between working and non-working reindeer in the deltoid and lateral digital extensor muscles attaching to the humerus. The deltoid muscle flexes the shoulder joint and the lateral digital extensor extends it. Extensor muscles work against greater weights when an animal is carrying loads, as do the muscles stabilizing the joint. Flexors and especially muscles that act to extend the joint to take on the animal's weight and/or push the animal forward work against the extra weight placed on the animal via a harness when pulling loads. Although the sample size of working reindeer in this analysis is small and the results will need to be confirmed with a larger sample, the preliminary results suggest that the shoulder extensors and flexors need to work more when a reindeer is pulling a load. This makes sense also considering that the draft-related paleopathological lesions are often the most pronounced in the forelimbs that carry most of the animal's weight and pulls the animal forward (Bartosiewicz et al. 1997; De Cupere et al. 2000; Telldahl 2012).

EC can also be indicative of feeding behavior in reindeer. Comparing the entheseal scores in free-ranging and zoo reindeer (reindeer kept in commercial or research station zoos), we observed that free-ranging reindeer had statistically significantly higher entheseal scores in the attachment site of the *flexor profundus* ulnar head, *flexor profundus digiti* and *biceps brachii* muscles. We hypothesized that this difference is due to feeding behaviour and feeding practices of the zoo reindeer. The winter diet of free-ranging reindeer consists mainly of lichen (Nieminen and Heiskari 1989; Nieminen 1994: 94–97) and the animals spend a considerable time digging for lichen from under the snow using their antlers and forelimbs (Helle 1982: 47–59; Itkonen 1948: 82; Nieminen and Pietilä 1999: 20–21; Korhonen 2008: 40). We believe that the repetitive movement of the elbow joint in that activity affects the attachment sites of the muscles (Niinimäki and Salmi 2016).

Therefore, an analysis of EC is suitable for analyzing a range of physical activity patterns, including working and feeding behavior. The additional working reindeer skeletons we are currently collecting will also be analyzed for EC scoring in order the better understand the working-related changes in the muscle attachment sites.

3.4.3 Bone cross-sectional properties

Long bone cross-sectional properties, such as bone robusticity in the cortical area (CA), and the bending and torsional rigidity (J), as well as the bone shape and ratio of second moment of inertia planes are considered to reflect loading patterns of humans and animals (Figure 3.5). Thus, these properties have been used in reconstructing physical activity from the skeletons of humans and other mammals (e.g. Shackelford et al. 2013; Shaw and Stock 2009).

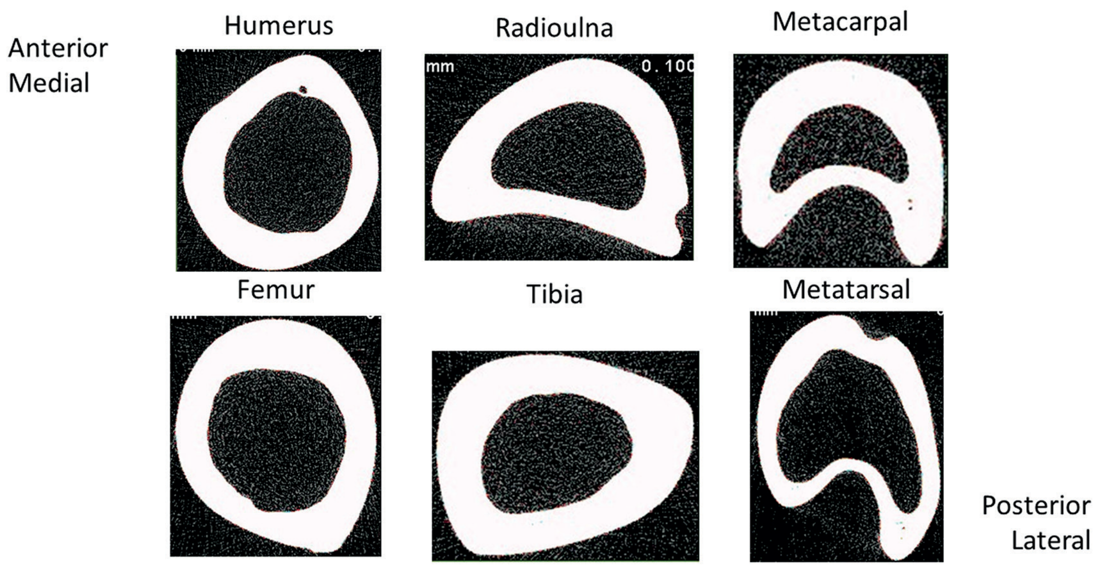

Figure 3.5: Examples of cross-sections of reindeer humerus, radioulna, metacarpal, femur, tibia and metatarsal. The cross-sections are from different individuals and do not represent any particular activity group (Figure: S. Niinimäki).

The underlying assumption for making activity inferences from cross-sectional properties of bones is that mechanically strong and appropriate bone structures are achieved by exercise-induced skeletal adaptation at the loaded regions (Nikander et al. 2006). Increased loading increases both the bone mass and the cross-sectional bone area (Daly et al. 2004; Haapasalo et al. 2000; Kontulainen et al. 2002), thus affecting bone robusticity indicators. The loading direction seems to associate more with cortical bone distribution (Narra et al. 2013; Niinimäki et al. 2013; Niinimäki et al. 2017) and the cross-sectional bone shape (Lieberman et al. 2004; Narra et al. 2013; Nikander et al. 2005, 2009; Ruff et al. 1994; Ruff 2000), thus affecting bone shape indicators.

The loading of the bones occurs through mechanical stimuli experienced by the skeleton, and in activity reconstructions the result concerning the bone robusticity and shape is used to back-track the animals' loading environment and loading history. The sources of mechanical stimuli are due to weight-bearing loads, ground impacts and muscle activity (Kohrt et al. 2009; Niinimäki et al. 2017). Loading occurs in terms of magnitude and rate, where a high strain rate is considered more important than the strain magnitude (Lanyon and Rubin 1984) because the number and frequency of repetitions influence the skeletal response (Lanyon 1987, 1996; Umemura et al. 2002). Furthermore, the strain distribution is important, where unusual loading directions are more osteogenic (Lanyon 1987). A recent study by Niinimäki et al. (n.d.) indicates that the effects of activity on geometrical bone properties are not only due to activity-induced increases in muscle size and strength (i.e., muscle loading), but that activity has a more direct effect on geometrical bone properties. This is likely to be attributable to ground impact loading, and the magnitude and frequency at which this takes place (Niinimäki et al. n.d.).

Weight-bearing affects bone robusticity, where the cross-sectional bone properties scale with the body mass, body proportions, and muscle moment arms (Davies and Stock 2014; Ruff et al. 1994; Ruff 2000; Weaver 2003). With a greater body size, the bone tissue is distributed proportionally further from the cross-sectional centroid (Brianza et al. 2007). Weight-bearing can be considered intrinsic loading because the body weight determines the baseline for all gravitationally-induced mechanical stimuli from ground impacts. Therefore, it is essential to consider the body size and limb proportions when reconstructing activity from skeletons, especially regarding carrying and/or pulling loads. This is especially important considering reindeer, where the body size and limb proportions differ not only between males and females of the species, but there are also size difference between subspecies (Nieminen and Helle 1980). Hormonal influence (Daly 2007), such as the presence or absence of testosterone which affects muscle development should be considered to be a pathway which affects bone loading during activity. In reindeer, draft and racing reindeer are traditionally castrated, which affects the muscle development and therefore cross-sectional bone properties. However, this more likely affects the robusticity than the shape.

3.5 Conclusion

The Saami have probably used draft reindeer ever since reindeer were domesticated (e.g. Bjørklund 2013; Ingold 1986). The identification of draft reindeer in the archaeological record therefore provides important answers to the when, where, and how questions related to reindeer domestication. In addition to being useful in the identification of the origins of reindeer domestication, the archaeological markers of draft use provide information on cultural practices and human-reindeer relationships.

The ways of using reindeer to pull and carry loads have varied over time and at different locations. For instance, the Saami usually used only one reindeer to pull a sledge. Only the Skolt Saami used an arrangement of multiple reindeer to pull a sledge, which is a common practice among the Siberian reindeer herding peoples. Furthermore, the harness design has varied. The traditional leather harness was placed around the neck of the reindeer and the animal used its neck muscles to pull the weight. When using a wooden collar, adapted from a horse collar, the reindeer used the muscles attached to the scapula and proximal humerus. In principle, different workloads should manifest in different patterns of skeletal changes.

Working together also creates bonds between the individual animals and people. Draft reindeer were usually castrated bulls, trained for working from the age of three to four years. In such a relationship, the trainer and the reindeer get to know each other closely. They learned how to respond to each other and learned to communicate with each other through body movement, gestures, touch, and physical closeness. Although the relationships between a reindeer and its trainer are always individual, both people and reindeer also pass knowledge or reindeer herding practices from one generation to the next. In effect, the identification of working reindeer in the archaeological record means an identification of past interspecies companionship and communication.

One of the methods presented in this paper is the paleopathological analysis of work-related lesions in animals. This method is fairly well established and is regularly used to identify draft cattle and working horses especially. Through a preliminary study with a small sample size, our research group has established that the method is also suitable for identification of working reindeer, and we are currently collecting more data to increase the sample size and include Fennoscandian working reindeer. Other methods discussed in this paper, i.e., analysis of entheseal changes and bone cross-sections are regularly used for human physical activity assessment but have seldom been applied to animals. Our pioneering results on the entheseal changes in reindeer which were engaged in different types of activity, as well as our work to establish a methodology to infer physical activity from reindeer bone cross-sections, open new possibilities for understanding human-animal interactions in the past. In particular, they will help to understand the various relationships, interactions, and companionships between the Saami and their reindeer.

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