



From wild to domestic reindeer – Genetic evidence of a non-native origin of reindeer pastoralism in northern Fennoscandia

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ABSTRACT

The question of how reindeer pastoralism came about has been the subject of recurrent scientific inquiry from many different disciplines. In order to investigate the genetic traces within a Fennoscandian transition from a predominantly hunting economy to reindeer pastoralism, we obtained sequences from the mitochondrial control region from 193 reindeer samples from several archaeological sites dated between 1000 and 1700 CE in Finnmark County, northern Norway. A comparison with similar data from more recent archaeological sites, including extant domestic reindeer, demonstrates that the mitochondrial genome in Finnmark reindeer has gone through massive genetic replacement since medieval times characterized by a significant loss of native mtDNA haplotypes, together with a significant introduction of new haplotypes. Out of a total number of 62 haplotypes identified in both the modern and archaeological samples, only 14 were detected among samples known to represent domestic reindeer, while nine of these haplotypes were completely absent from the more ancient sites. Our documentation of a major genetic shift during the 16th and 17th centuries suggests that non-native animals were introduced during this period, at the same time as the transition to reindeer pastoralism took place.

1. Introduction

Despite its great importance in understanding basic domestication processes, many key questions related to the origins, spread, and intensification of animal domestication remain largely unknown. Traditionally, the process has been viewed as involving reproductive isolation between wild and domestic herds, with successive spread of the domestic form through demographic diffusion away from a limited number of core zones (Clutton-Brock, 1999). As for pig and horse, phylogenetic affinities of domestic animals with multiple, geographically divergent wild populations has given support to alternative scenarios where the domestication process occurred independently multiple times among several geographical separate populations (Larson et al., 2005; Vilà et al., 2001). However, ancient DNA studies have given evidence that such a process could rather reflect extensive introgression from wild into the domesticate populations (Larson et al., 2005; Warmuth et al., 2012), a process which was probably more common than previously assumed. Related to this hypothesis is also the question whether the spread of domesticates actually involved the physical movement of domestic animal, or if it primarily involved the diffusion of husbandry techniques enabling different societies to

domesticate wild stocks locally (Vorren, 1973; Larson and Fuller, 2014). For most domesticated breeds, such processes of domestication has been difficult to study due to the extinction or rareness of the original wild populations.

Reindeer (*Rangifer tarandus*) is a species commonly considered to be in an early phase of domestication (Ingold, 1980; Reimers et al., 2009). Both wild and domestic types are often managed in close co-existence in many areas (Baskin, 2005). This makes reindeer an appropriate model species to approach key questions of when and where, how and why the early domestication took place. In Fennoscandia, the domestication of reindeer which is synonymous with reindeer husbandry and reindeer pastoralism, has been associated with the indigenous Sámi population, and debates surrounding the origins of Sámi reindeer pastoralism has been an area of recurrent scientific inquiry from many different disciplines (see Hansen and Olsen, 2014). Vorren (1973) argues that Sámi communities shifted from hunting to reindeer pastoralism in the Early Modern Period (1550–1750 CE) due to increased taxation, expanding trade relations and the introduction of firearms. This led to the depletion of the wild reindeer populations making the growth of domestic reindeer herds kept for transport and hunting a viable alternative. Others have emphasized how these very factors, together with

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increased state administrative interference, accentuated social tensions already inherent in Sámi hunting societies, and which favoured a pastoral system emphasizing individual ownership over a hunting economy based on sharing (Hansen and Olsen, 2014; Olsen, 1987). It has moreover been argued by Bjørklund (2013) that hunting wild reindeer and the development of domestic reindeer husbandry continued in tandem as parts of a multifaceted adaption that persisted up to the 19th century. He argues that pastoralism, defined as a dependency upon a herd of managed domesticated animals for subsistence, came into being among the Sámi as late as 1600–1700 CE due to expanding markets and dwindling numbers of wild reindeer. A number of archaeologists, on the other hand, have argued that the emergence of pastoralism can be dated to the Viking age and/or the Early Medieval Period, i.e. 800–1200 CE (e.g. Bergman et al., 2008; Storli, 1993), or even as early as the beginning of the contemporary era (Aronsson, 1991).

Current research on domestication has largely focused on identifying the impacts of domestication and using them as markers of the domestication process (Zeder, 2015). Recently, the analysis of ancient DNA has been particularly important in evaluating the genetic impacts of the domestication processes (e.g. Moray et al., 2014; Schubert et al., 2014). In reindeer, the mitochondrial DNA (mtDNA) diversity has been suggested to reflect maternal lineages with several different origins (Røed et al., 2008; Yannic et al., 2014). Bjørnstad et al.'s (2012) study of archaeological reindeer bones from Stone and Iron Age sites in Finnmark revealed a complete absence of mtDNA haplotype clusters that were typical to extant domestic herds in the region. They argued that this, together with a distinct haplotype shift in late Medieval, was evidence that the contemporary domestic population did not descend from the ancient native population in the region (Bjørnstad et al., 2012). However, the sample sizes taken from the Medieval sites cited in the study were small and spatially dispersed, making it difficult to argue a strong association between genetic and pastoral demographic change.

In this study, we present a much richer set of archaic *Rangifer* samples from archaeological sites across Finnmark over the period 1000–1700 CE, thus enabling a more accurate chronology of the earlier documented haplotype shift. This allows us to address the question of to what extent the pastoral transition in Fennoscandia is linked to the introduction of new domestic animals, or if it might be related to the indigenous selection and management of local reindeer stocks.

2. Material and methods

2.1. Archaeological sites and material

The archaeological reindeer samples used in the present study was taken from bone assemblages from twelve excavated settlements sites in Finnmark County (Table 1 and Fig. 1). Based on conducted osteological

determinations, suitable reindeer teeth, bones or antlers were carefully selected, also representing, if possible, different individuals identified and classified according to morphology, size, and age groups.

The majority of the chosen sites and bone assemblages were radiocarbon dated prior to this work (Table 1). In addition, fourteen samples were radiocarbon dated for this study, partly to verify the time horizon of the particular bone assemblages and partly to confirm the dates associated with samples featuring particular haplotypes. The sites Brodtkorbneset, Steintjørna and Kjerringneset are all situated in the interior boreal forest zone in the Pasvik river valley in eastern Finnmark. The former two are so-called hearth row sites dated to 1050–1300 CE, with bone assemblages dominated by reindeer, but also include fish, birds and sheep. Reindeer is also the dominant species at the slightly younger Kjerringneset site (1300–1500 CE), and the archaeological material from all three sites indicate an economy based on hunting and fishing, possibly in combination with small-scale reindeer and sheep husbandry (Halinen et al., 2013; Hedman et al., 2015). Gollevárri (1200–1600 CE) is interpreted as a hunting site with very large deposits of reindeer bones and antlers. It is located on the isthmus ridge between the Tana River and Varanger Fjord and nearby a huge trapping system blocking the wild reindeer's migration to and from the Varanger Peninsula (Hansen and Olsen, 2014; Munch and Munch, 1998). Ássebákke (1400–1700 CE) is a late Sámi dwelling site, located in the boreal forest region in interior western Finnmark (Simonsen, 1979). The Kjøøya site (1600–1800 CE) is located on the tiny Kjøøya Island on the southeast coast of the Varangerfjord. This site was used until the 20th century as a fishing site for the local Sámi and the bone samples are from the thick middens accumulated here (Olsen, 1987). Oardujavri (1600–1800 CE) is yet another late Sámi site located in the interior northern part of the Varanger Peninsula. The archaeological material suggests a site used for lake fishing, hunting and reindeer herding, most likely by Sámi living at the Varangerfjord (Hedman, 2008). While all the previous sites represent seasonal Sámi settlements, the samples from the remaining assemblages come from the ethnically more heterogeneous and sedentary sites Kongshavn, Skonsvika (both 1200–1450 CE), and Vadsøya (1400–1600 CE). Situated at the northern and southern coast of the Varanger Peninsula respectively, these sites are characterized by complex multi-room dwellings. The sites probably represent trade and administrative interests in the region involving the presence of representatives of distant Norse and Russian powers as well as native middlemen. The bone assemblages at these sites are mixed, containing both domesticates (sheep, cattle, pig), fish, and wild animals including reindeer (Olsen et al., 2011). The Late Stone Age dwelling site Karlebotn in Varanger (c. 3000 BCE) (Hood and Helama, 2010) was included to obtain samples which we assumed would be sufficient distant in time from contemporary domestic haplotypes.

In order to compare and complement our samples we have also included previously published genetic sequences from recent

Table 1

Levels of genetic variation in the CR in prehistoric and historic reindeer from Finnmark County in northern Norway. N = number of individuals, Nh = number of haplotypes. Estimates of variation are given with \pm standard deviation (SD).

Site	Site code	Time period	N	Nh	Nucleotide diversity	Haplotype diversity	Haplotype pairwise difference
Karlebotn	1	3400–2700 BCE	25	11	0.0173 (0.0103)	0.803 (0.077)	3.287 (1.749)
Brodtkorbneset	2	1000–1300 CE	26	13	0.0248 (0.0140)	0.883 (0.047)	4.720 (2.387)
Steintjørna	3	1000–1300 CE	18	12	0.0258 (0.0147)	0.948 (0.033)	4.908 (2.508)
Kongshavn/Skonsvika	4	1200–1450 CE	14	8	0.0219 (0.0130)	0.901 (0.058)	4.165 (2.203)
Gollevárre	5	1200–1600 CE	28	18	0.0256 (0.0143)	0.952 (0.024)	4.857 (2.442)
Kjerringneset	6	1300–1500 CE	20	13	0.0318 (0.0176)	0.953 (0.028)	6.032 (2.999)
Ássebákke	7	1400–1700 CE	15	9	0.0148 (0.0093)	0.905 (0.054)	2.819 (1.574)
Kjøøya	8	1600–1800 CE	15	9	0.0264 (0.0152)	0.914 (0.052)	5.010 (2.579)
Vadsøy	9	1400–1600 CE	16	9	0.0342 (0.0191)	0.908 (0.048)	6.492 (3.242)
Ordujavri	10	1600–1800 CE	27	7	0.0349 (0.0190)	0.732 (0.058)	6.627 (3.229)
Måsøy	11	1600–1800 CE	19	9	0.0316 (0.0176)	0.813 (0.081)	6.000 (2.992)
Finnmark-1900	12	1900 CE	21	6	0.0328 (0.0180)	0.805 (0.059)	6.229 (3.081)
Finnmark-extant	13	Present	34	10	0.0298 (0.0163)	0.720 (0.064)	5.663 (2.784)

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