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Domestication as Enskilment: Harnessing Reindeer in Arctic Siberia

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Abstract:	<p>The study of reindeer domestication provides a unique opportunity to examine how domestication involves more than bodily changes in animals produced through selection. Domestication requires enskilment among humans and animals, and this process of pragmatic learning is dependent on specific forms of material culture. Particularly with the domestication of working animals, the use of such material culture may predate phenotypic and genetic changes produced through selective breeding. The lamal region of Arctic Siberia is generating an increasingly diverse set of archaeological evidence for reindeer domestication that evidences these processes. Three early sites, Ust'-Polui, Tiutei-Sale I, and Iarte VI, contain artifacts proposed to be parts of headgear worn by transport reindeer, the earliest dating to just over 2000 years ago. Contemporary Nenets reindeer herders scrutinized replicas of these archaeological objects, and comparisons with historic reindeer harness parts from Arctic Russia were also made. Nenets consistently interpreted barbed L-shaped antler pieces from lamal as headgear parts for training young reindeer in pulling sleds. Some types of swivels were also interpreted as transport reindeer headgear. Based on these consultations with Nenets and observations of their ongoing reindeer domestication practices, we argue that material things such as headgear, harnesses, and sleds are not merely technological means of using or controlling reindeer in transportation but</p>	

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Domestication as Enskilment: Harnessing Reindeer in Arctic Siberia

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Abstract

The study of reindeer domestication provides a unique opportunity to examine how domestication involves more than bodily changes in animals produced through selection. Domestication requires enskilment among humans and animals, and this process of pragmatic learning is dependent on specific forms of material culture. Particularly with the domestication of working animals, the use of such material culture may predate phenotypic and genetic changes produced through selective breeding. The Yamalo region of Arctic Siberia is generating an increasingly diverse set of archaeological evidence for reindeer domestication that evidences such processes. Three early sites, Ust'-Polui, Tiutei-Sale I, and Iarte VI, contain artifacts proposed to be parts of headgear worn by transport reindeer, the earliest dating to just over 2000 years ago. Contemporary Nenets reindeer herders scrutinized replicas of these archaeological objects, and comparisons with historic reindeer harness parts from Arctic Russia were also made. Nenets consistently interpreted barbed L-shaped antler pieces from Yamalo as parts of headgear for training young reindeer in pulling sleds. Some types of swivels were also interpreted as transport reindeer headgear. Based on these consultations with Nenets and observations of their ongoing reindeer domestication practices, we argue that material things such as headgear, harnesses, and sleds are not merely technological means of using or controlling reindeer in transportation but instead were part of the meshwork within which some reindeer became enskilled to being domestic. Domestication of reindeer and other animals involves ongoing efforts, landscapes, and made things, all of which form the environment within which domestic relationships emerge.

Keywords: domestication; reindeer; enskilment; Arctic; Siberia; material culture

Introduction

Animal domestication has been a major area of research in archaeology for over a century (Zeder et al. 2006a), and tracing out its origins and dispersal are considered critical topics for the discipline (Kintigh et al. 2014). Domestication is increasingly studied as a bodily phenomenon where changes in genomes and morphologies are produced by some level of human control over animal breeding. Advances in morphology and ancient DNA analytical techniques permit far higher resolution studies of evolutionary bodily change than possible just a decade ago, in effect directing domestication research to these particular areas. While such methodological advancements are both needed and welcome, they risk diverting attention away from the fact that domestication is a human-animal relationship involving practices, materials, socialization, and as we highlight here, mutual enskilment (Anderson et al. 2017a; Ingold 2000; Losey et al. 2018; Swanson et al. 2018). Genetic and morphological changes can and do result from human influence on animal breeding, but far more than breeding is necessary to sustain domestic relationships over the long-term. In turn, domestication is more than just bodily change (Losey et al. 2018).

Enskilment, or learning how to carry out a task by recurrently engaging in it (Pálsson 1994; Ingold 2000, 2013, 2018), is a critical element of the daily performances and long-term sustainment of domestication. For example, a person who does not know how to approach, handle, feed, or care for animals will have difficulty controlling their breeding, let alone successfully working with them in tasks such as hauling loads or plowing fields. Such skills also help to ensure that selective breeding is actualized—that offspring are produced and develop into reproductive adults. Animals too become enskilled in being domestic. They come to know our dispositions, feeding procedures, gestures and verbal communications, and even our smells and sounds. Mutual enskilment recruits broader contexts such landscapes, other living things, and made objects (Ingold 2013). Communication between horse and rider, for example, often involves bridles, saddles, and spurs, not just verbal and non-verbal acts, and these specific things have been continually refined for such purposes. One can breed animals to enhance their capacities to become enskilled, but without actually engaging in the activities and with these specific things, the needed skills to function with them will not emerge. Enskilment has evolutionary outcomes. Unskilled humans or animals might be killed or injured when interacting with each other. Animals known to be aggressive toward their handlers, poor at pulling sleds, or resistant to carrying riders might be culled or castrated, removing them from the reproductive pool. Those who become highly skilled in domestic relations with animals can displace people who fail at such relationships or who are reluctant to adopt them. In other words, mutual enskilment is developing understanding through practice (Lave 1990), and this is by no means a process restricted to humans.

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4 Reindeer present a particularly interesting case study, illustrating how issues of
5 control of breeding and bodily change continue to dominate domestication research,
6 while relationships and the enskilment involved are pushed to the periphery. First,
7 domestic reindeer are often described as incomplete, incipient, or semi-domestic
8 (Baskins 2000; Fitzhugh 2002; Takakura 2010). Fitzhugh (2002:119) states, “One of
9 the principal reasons that reindeer cannot be fully domesticated is because their
10 food sources—lichens and mosses—cannot be stored, so the animals cannot be
11 corralled and fed on fodder.” In the same paragraph, reindeer are described pulling
12 sleds, carrying packs and riders, and being kept in herds as large as 5000 animals.
13 Fully domestic here applies only to animals that are confined and foddered, but not
14 to those that are ridden or herded. Second, domestic reindeer continue to
15 interbreed with wild reindeer (Anderson et al. 2017b; Colson et al. 2014; Mager et
16 al. 2013; Røed et al. 2008, 2014), which can be taken to indicate that they are out of
17 control and thus not truly domestic. Ethnographic study of such reindeer
18 interbreeding, however, reveals much the opposite, with herders monitoring wild-
19 domestic pairings and culling offspring with unwanted behavioral characteristics
20 (Anderson et al. 2017b). Such domestication is on-going and involves attentiveness
21 and care, both of which must be learned and practiced. Third, modern domestic and
22 wild reindeer, let alone reindeer remains from archaeological contexts, have proven
23 difficult for scholars to differentiate osteologically (Puputti and Niskanen 2008;
24 Nieminen and Helle 1980). Unlike many other domestic mammals, their bodies are
25 not radically different from their wild counterparts, suggesting they are not truly
26 domestic, or only marginally so. Weaving through all three issues is the critical
27 matter of reindeer being domestic in ways unfamiliar to those who do not live with
28 these animals. We do not understand them as complete because they seemingly
29 have not reached their imagined destinies as selectively bred, physically altered, and
30 helpless barnyard animals. Those who live with and depend on reindeer have far
31 different understandings of these animals, which we draw upon in making our
32 arguments.
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41 These conceptual issues are not unique to reindeer but have forced archaeology to
42 search more widely for traces of human relationships with these animals. This
43 wider investigation includes research on reindeer habitual activity, site sediments,
44 settlement patterns, and potential reindeer gear, the latter being our focus
45 (Anderson 2011; Anderson et al. 2014, 2019; Aronsson 1991; Karlsson 2004;
46 Niinimäki and Salmi 2016; Salmi and Niinimäki 2016; Storli 1996). Conspicuously
47 absent in many studies of reindeer domestication, however, are the insights of
48 people whose lives are dependent upon reindeer. If reindeer are incompletely or
49 semi-domesticated, people herding and caring for these animals must be involved in
50 the project of domestication. Who can have more intimate knowledge of reindeer
51 domestication than the people engaged in it? Here we present a case study based in
52 the Iamal region of Northwest Siberia, a world center of reindeer pastoralism
53 (Klokov 2011; Figure 1). Many Indigenous Nenets people of this region migrate with
54 their reindeer, some traveling hundreds of kilometers each year from the forest
55 tundra in the south to the open tundra to the north (Golovnev et al. 2016; Stammler
56 2005). Historically, these mobile ways of being were enabled by reindeer sled
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4 transport, which allowed for efficient movement over long distances, often with
5 heavy gear in tow. Reindeer domestication continues to be enacted on a daily basis
6 in Iamal, and this goes far beyond just breeding control. Transport reindeer are not
7 just bred by Nenets to pull sleds—they become enskilled in this practice by
8 repeatedly engaging with specific forms of gear, other reindeer, and their Nenets
9 hosts. These practices have changed over time, and most importantly, material
10 evidence for reindeer enskilment in transport predates evidence of their
11 morphological or genetic change.
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15 The most widely cited models of reindeer domestication in Siberia posit that these
16 transport relationships first emerged in the south where the taiga (boreal forest)
17 meets the steppes of Central Asia (Laufer 1917; Pomishin 1990; Vainshtein 1980;
18 Vasilevich and Levin 1951). Forest or mountain groups in this region adopted
19 herding, milking, harnessing, and riding practices and equipment used by their
20 central Asian neighbors with cattle and horses for use with local reindeer. The
21 Saian-Altai mountains and the Trans-Baikal or Amur River regions are the proposed
22 areas where such ways of being first emerged. Groups then supposedly dispersed
23 from these origin places and adapted their reindeer practices and materials to more
24 northerly ecologies. For example, early Samoedic speakers and their newly domestic
25 reindeer in the Saian-Altai region, including the ancestors of Nenets we consulted
26 for this study, are thought to have moved north from this region, eventually settling
27 in the Arctic.
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33 These models are based on linguistic patterns and similarities in reindeer gear and
34 milking practices between Central Asian groups and taiga reindeer societies. They
35 have almost no archaeological or genetic data to support them. Current
36 archaeological evidence consists of a few rock art images that appear to show
37 reindeer being tethered or involved in transport (Adrianov 1888; Appelgren-Kivalo
38 1931; Devlet 1965, 1967; Kyzlasov 1952; Tallgren 1933), two sculptures potentially
39 representing reindeer wearing headgear (Kyzlasov 1952), and possible reindeer
40 headgear from a single site far to the west in Ukraine (Shramko 1988). In all three
41 cases, chronology is poorly established. Chinese written records provide the earliest
42 historical evidence for reindeer keeping in Siberia. Buddhist missionary Hui Shen
43 reported in 499 CE that reindeer were kept alongside horse and oxen and that the
44 reindeer were milked and used for pulling carts (Laufer 1917; Maksimov 1928).
45 Precisely where these observations were made is unknown. Clear genetic ties
46 between archaeological reindeer remains in southern Siberia with those kept in
47 modern domestic herds have yet to be established.
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53 A combination of old and recent research in Iamal provides a far more complex
54 history of living with reindeer than suggested by the earlier macro-level models. As
55 early as the 1940s, archaeologists argued that artifacts from the Ust'-Polui site were
56 potentially parts of reindeer headgear, probably to control tamed animals that
57 functioned as hunting decoys (Moszyńska 1974: 84-5). Historically, decoy reindeer
58 have always been trained domestic animals. If correct, domestic reindeer were
59 present in Iamal by at least 2000 years ago. Many of the same Ust'-Polui artifacts
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4 have more recently been used as evidence for extensive reindeer-led transport in
5 lamal (Figure 1; Fedorova 2000, 2006; Golovnev 1998; Gusev et al. 2016). Further,
6 some sculptures and incised images of reindeer at Ust'-Polui have been interpreted
7 as depicting sacrificed domestic reindeer that are being sacrificed, a practice seen
8 among today's regional herding societies (Fedorova 2000:57).
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11 Recent geoarchaeological research the Iarte VI site on the lamal peninsula tundra
12 suggests that small herds of reindeer were kept at this habitation site as early as
13 300 CE, but most convincingly several centuries later, when the site was intensively
14 occupied (Figure 1; Anderson et al. 2019). Previous research had argued that the
15 use of reindeer to pull sleds allowed for more widespread occupation of the lamal
16 tundra by the 10th century CE, including at Iarte VI itself (Fedorova 2000, 2006;
17 Golovnev 1998; Gusev et al. 2016). Seemingly in contrast, however, genetic analyses
18 of Holocene lamal reindeer appear to show that contemporary domestic reindeer
19 only arrived in the region sometime between the 15th and 18th centuries CE, long
20 after Ust'-Polui and Iarte VI were no longer in regular use (Røed et al. in press).
21 These new domestic reindeer seem to have mostly originated from a non-local
22 population. Finally, the earliest reliable historic records from the region, which are
23 from the 17th century CE, indicate domestic herds were small and used mostly for
24 pulling sleds and sacrifice, with subsistence based mainly on hunting wild reindeer
25 and fishing (Krupnik 1993; Stépanoff 2017). In the mid- to late-18th century CE,
26 herds significantly increased in size and large-scale reindeer pastoralism emerged,
27 which entails a heavy reliance on domestic reindeer for daily dietary needs and a
28 reordering of human society around the seasonal migrations of the domestic
29 animals. Small-scale semi-sedentary hunting and fishing reindeer-keeping societies
30 also persisted. These small family groupings relied on herds of ten to twenty head,
31 kept locally, to transport freight and people short distances (Haakanson 2000).
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39 This paper delves further into the long-term history of reindeer domestication in
40 new ways. We scrutinize the early artifact evidence for reindeer harnessing. These
41 objects were analyzed in comparison to modern harnesses to assess how their
42 shapes, sizes, and forms compared. Most critically, we consulted with Nenets
43 reindeer herders regarding these objects and participated in their daily routines of
44 caring for and training transport reindeer. In addition, replicas of the archaeological
45 objects were presented to these Nenets for their scrutiny. Nenets interpreted many
46 of the ~2000 year old archaeological objects in a completely novel way—for specific
47 reasons, they considered them parts of headgear made for training young reindeer
48 to pull sleds. Building on these insights, we provide a more nuanced account of
49 human-reindeer relations in lamal, and of domestication more broadly. We argue
50 that material things such as headgear, harnesses, and sleds were not merely means
51 of exploiting reindeer in transportation but instead were part of the meshwork or
52 infrastructure within which some animals became enskilled to being domestic.
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59 **Materials and Methods**

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4 We focus on two groups of objects interpreted as parts of early transport reindeer
5 gear, which have been found at three sites, namely Ust'-Polui, Iarte VI, and Tiutei-
6 Sale I (Figure 1). The objects consist of L-shaped antler pieces that are similar to
7 parts of modern transport reindeer headgear, and antler swivels, which now attach
8 directly to the headgear at one end and at the other to the rope used by the sled
9 driver to communicate with the lead reindeer (described below). Other artifacts
10 from these same three sites also have been implicated in discussions of reindeer
11 domestication, but are more ambiguous in terms of their potential roles and
12 functions. These include fragments of 'built-up' sleds and various toggles or buttons,
13 some of which we have previously argued are parts of dog-sledding gear (Losey et
14 al. 2018); they are not further discussed here.
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19 Ust'-Polui is an Iron Age site located in the city of Salekhard at the confluence of the
20 Polui and Ob' rivers near the northern margins of the forest-tundra (Figure 1). The
21 site has been repeatedly excavated, starting in the 1930s, with the final phases of
22 excavation being in 2015 (Adrianov, 1936a, 1936b, 1936c; Fedorova and Gusev,
23 2008; Gusev and Fedorova, 2012, 2017; Moshinskaia, 1953, 1965). This long history
24 of excavation has produced well-over 50,000 artifacts. Ust'-Polui has been
25 interpreted as a multi-community ritual site where groups gathered to conduct
26 sacrifices, feasting, and a variety of other practices, including metalworking.
27 Reindeer and dogs dominate its mammalian faunal remains (Bachura et al., 2017;
28 Losey et al. 2018). Modeled radiocarbon dates from the site span from ~260 BCE to
29 140 CE (Losey et al. 2017).
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34 Ust'-Polui has produced at least nine L-shaped antler objects thought to be reindeer
35 headgear elements (Figure 2) (Fedorova 2000, 2006; Golovnev 1998; Gusev 2014;
36 Gusev et al. 2016). Each has small barbs along its inner margin, and where the ends
37 of the object are intact, holes or grooves for the attachment of lines are present. Use-
38 wear analysis of these objects found that all show heavy wear on their barbed
39 surfaces from rubbing against soft material, very similar to that seen on modern
40 reindeer headgear (Aleksashenko 2006). All such objects were found scattered
41 amongst other artifacts and faunal remains at the site, but not in direct association
42 with other objects or features; they were not paired with other L-shaped or straight
43 objects. At least 266 antler swivel parts have been recovered from Ust'-Polui, and
44 these can be grouped into four general types. The first and most abundant, termed
45 type 1.0 (following Gusev and Fedorova 2017:80, 204-5), consists of a plate, round
46 to sub-rectangular in outline, with a central hole for a pin, and four additional holes
47 (one at each corner) for the attachment of lines (Figure 3a). In the later excavations
48 at Ust'-Polui, 53 such plates were found, but those from the earlier phases of
49 excavation have never been quantified (but multiple such objects are shown in
50 Chernetsov and Moszyńska (1974)). At least five type 1.0 swivels were found with
51 the pins in place. Five artifacts assigned to the second form of swivel (type 1.1) were
52 found at Ust'-Polui. These consist of barrel-shaped pieces each with a large central
53 hole for a pin and two parallel sets of holes at the opposite sides of the barrel pieces
54 (Figure 3b). Only one of these was found with the pin in place. The third swivel type
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(type 1.2) involves an elongated tab with a hole (or two in one case) at one end and a socket at the opposite end for the pin; none were found with pins in place (Figure 3c). At least two of these were found in the earlier excavations, and one in the later phase of work at the site. The final form of swivel (type 1.3), represented by four artifacts, consists of a bell-shaped piece with the narrow end bearing a hole transverse to the object's long axis, and a hole at its broad end that is parallel to its long axis; this latter hole is for the pin, which in one case was found in place (Figure 3d). All other swivel parts at the site are unclassifiable antler pins, all with rounded heads and holes at their distal ends for line attachment.

Iarte VI is an Iron Age habitation site on the tundra of the central portion of the Iamal Peninsula near the Iuribei River (Figure 1). This site was excavated in the 1990s and again in 2013 and 2015. Iarte VI consists of a series of seven house pits, a ditch of unclear function southeast of the houses, and a series of associated anthropic soils (Anderson et al. 2019; Brusnitsina and Oshchepkov 2000; Plekhanov 2014). The objects described here came from the house pit excavations in the 1990s. Modeling of radiocarbon dates from the houses and faunal remains in the site's ditch feature span from ~1016 to 1122 CE (Nomokonova et al. 2018). Iarte VI has also generated one of the largest reindeer assemblages in the Arctic, numbering just over 22,000 specimens (Nomokonova et al. 2018; Vizgalov et al. 2013:253-6). Iarte VI has been variously interpreted, including as a location inhabited by people largely reliant on relatively sizeable domestic reindeer herds (as many as 200 individuals) for transport and subsistence, to a central place from which wild reindeer were hunted, processed, and consumed, and transport involved some domestic reindeer (Anderson et al. in 2019; Fedorova 2006; Gusev et al. 2016; Nomokonova et al. 2018).

One L-shaped and three arched antler pieces from Iarte VI have been argued to be parts of reindeer headgear (Figure 4) (Anderson et al. 2019; Gusev et al. 2016; Plekhanov 2014: 111-112, 114). All have holes at their ends for the attachment of other materials. Note that one of these objects is a fragment (one end is missing) and is not further analyzed here. None of the four objects have barbs like those seen in the Ust'-Polui specimens—their inner margins are rounded or flat. Further, none were found paired with one another, and no swivels were found at Iarte VI. Use-wear analysis of three of the objects (no catalog numbers were provided) revealed that their inner surfaces showed signs of wear from contact with soft material such as reindeer fur, and that the holes at the ends were used for the attachment of straps (Aleksashenko 2004).

Tiutei-Sale I is an Iron Age habitation site on the northwestern shore of the Iamal Peninsula (Figure 1). Excavated were carried out at the site in the 1990s, revealing two periods of occupation, one at ~500-800 CE, the other at ~1100-1400 CE (Fedorova et al. 1998). The objects from the site discussed below are from the later occupation. Faunal remains from Tiutei-Sale I are dominated by arctic fox, birds, reindeer, pinnipeds, and polar bear. The site has been interpreted as a warm-season

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4 occupation occupied by hunters and their families who mostly focused on taking
5 terrestrial fauna, but occasionally procured marine resources.
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8 Two objects found directly in association have been interpreted as reindeer
9 headgear elements at Tiutei-Sale I, both from floor deposits of a dwelling (Fedorova
10 et al. 1998; Gusev et al. 2016). These L-shaped objects are near identical, each
11 having attachment holes at both ends and small barbs along their inner margins
12 (Figure 5). A smaller arched antler object of unknown function was found together
13 with these two items and perhaps was part of the same bundle of gear. No swivels
14 were found at this site. Note that on the floor of this same dwelling, two strips of
15 baleen were found tied to leather straps, which were also interpreted as reindeer
16 headgear. These objects are not pictured in the original published site report
17 (Fedorova et al. 1998) and were unavailable to us for analysis.
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22 Historic collections of reindeer headgear and harnesses from the Nenets region and
23 adjacent sections of the Russian North were examined at the Iamal-Nenets Region
24 Museum Complex of I.S. Shemanovskii in Salekhard, Peter the Great Museum of
25 Anthropology and Ethnography in St. Petersburg, and British Museum in London
26 (Supplementary Table 1). Our efforts were focused on L-shaped and arched pieces
27 that form parts of transport reindeer headgear, any barbed pieces that formed parts
28 of reindeer (or dog) harnessing equipment, and swivels attached to any of this gear.
29 The collection dates for these objects span from 1882 to 1981. Also included in our
30 analyses were reindeer headgear given to D. Anderson in 1996, and a few sets of
31 gear observed in use during our ethnographic work in Iamal in 2018.
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36 The L-shaped and arched objects were photographed and measured with digital
37 calipers, and their sizes and shapes were compared with those of historic reindeer
38 headgear (Supplementary Tables 1-3). The angles formed by the 'arms' of the L-
39 shaped pieces (both archaeological and modern) were measured using a protractor,
40 and the lengths of the 'arms' were measured for length, rounded to the nearest half
41 centimeter. For the arched specimens, the height of the arch was measured and then
42 divided by the object length to calculate a height-to-length ratio for each specimen.
43 The diameters of any holes in these objects were measured and their orientation
44 was noted. The lengths of any barbs found on objects were measured to the nearest
45 millimeter. Independent-sample T-tests were performed to compare means using
46 SPSS. Metrically comparing archaeological and modern swivels was not attempted
47 due to issues of direct comparability. Only one of the swivels we observed on the
48 tundra or in the museums was fashioned from antler, the remainder all being made
49 from metal, meaning that we would have been comparing two very different
50 material types, which surely affects both implement form and size.
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56 In 2017, Losey and Nomokonova consulted with seven Nenets reindeer herders
57 living in or visiting Salekhard and Aksarka. These individuals were all males and
58 ranged in age from 30 to 64 years. These men herded reindeer for most of their
59 lives, and were parts of communities that migrate annually from the forest tundra of
60 southern Iamal to the open tundra to the north – and thus represent one of the most
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4 widely documented human-reindeer adaptations on the peninsula. In 2018, Losey,
5 Nomokonova, and Arzyutov spent nearly one month living with Nenets herders in
6 the Tambei tundra region at the northern end of the Iamal Peninsula (Figure 1).
7 During these consultations, which were unstructured, ~50 individuals ranging in
8 age from 18 to 60 years were interviewed. These individuals were predominantly
9 male, and all were lifetime herders living mobile lifestyles on the tundra with
10 reindeer herds of 200-300 animals. Tambei herders confine their migrations within
11 a small distance of their home pastures and do not effect long-distance migrations
12 as do the Nenets interviewed in Salekhard (Stammler 2005: 79, 109, 117 and
13 others). The Tambei group arguably live an autonomous existence, far removed
14 from industrial supply lines at Russian ports or railway stations. They are, however,
15 affected by the movements of ice-breakers in the Ob Gulf preventing the regular
16 migrations of wild reindeer between the Belyi island to the North, Taimyr to the
17 east, and Iamal. In 2018 Anderson spent a few weeks living with forest Nenets
18 herders around Khanimei in the Verkhniy Pur river valley. He led unstructured
19 interviews with seven Nenets men.
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25 There are a variety of human-reindeer adaptations in the region, and we have
26 attempted to cover all types. We did not consult the hunter-fisher Nenets reindeer
27 herders, who also maintain a semi-sedentary herding strategy. Nevertheless we feel
28 our ethnographic work covers a wide range of adaptations in the region by
29 consulting with Indigenous experts deeply experienced with reindeer, including
30 those closely involved with: 1) the management of large herds of 500 or more
31 animals who migrate long distances, 2) the keeping of small herds on the high
32 tundra but also the hunting of wild reindeer, and 3) the management of smaller
33 herds in forest settings by semi-sedentary groups.
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38 All Nenets consulted migrate using a combination of snowmobiles and reindeer
39 sleds. During the consultations, replicas and photographs of the artifacts from Ust'-
40 Polui, Iarte VI, and Tiutei-Sale I were shown to individuals for their interpretation
41 and discussion. The replicas consisted of 3D printed PLA filament copies of the
42 objects made from laser-scans of the artifacts, or antler versions of the artifacts
43 created by the authors using the 3D prints as models. During our time on the
44 Tambei tundra, we also observed, participated in, and enquired about reindeer
45 sledding, including the training of deer for these tasks.
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50 **Nenets Reindeer Headgear**

51 Headgear used with transport reindeer in Iamal shares a number of overall
52 characteristics, particularly in terms of its antler components and their
53 arrangements. In one of its most basic forms, two or three reindeer are harnessed
54 side-by-side in front of the sled (Figure 6). The left deer in this setup we call the lead
55 reindeer (Figure 7d), and those to its right are secondary (Figure 7e and f). The lead
56 deer's headgear consists of two major antler elements. The first is a relatively large
57 L-shaped piece that is positioned on the right forehead between the top of the eye
58 and base of the antler pedicle (Figure 7a). These pieces never have barbs on their
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4 inner margins. On the left side of the forehead is a straight or slightly arched antler
5 piece, which rests in the same position as the L-shaped piece. A short strap across
6 the forehead joins these pieces together. Additional straps extend from their
7 opposite ends backward behind the ears, and a second set joins the pieces under the
8 jaw. The straight or left antler piece, and the strap(s) behind the ear are both
9 attached to another strap, the latter tied to a swivel (Figure 7d). The opposite end of
10 this swivel is attached to a rope held by the sled driver. In Nenets, this is called the
11 *nenzamindya'sa*, or head-rope (Figure 7g). In Nenets practice the head-rope runs to
12 the left (on the outside) of the reindeer group. The swivel prevents twisting of the
13 rope from tightening the straps of the headgear, which can cause discomfort for the
14 deer, and render communication via the rope difficult (Figure 8).
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19 The secondary reindeer have different headgear, particularly in terms of the antler
20 components. For these animals, somewhat smaller L-shaped pieces (or arched
21 pieces) are used (Figure 7b and c). These are always paired—one on the left side of
22 the forehead and one on the right. They are often symmetrical in size and shape,
23 unlike those on the lead reindeer. These objects also never have barbs on them. The
24 strapping for these pieces is organized similarly to that on the lead deer, except that
25 no swivel is present. A single strap extends from the left side of this headgear to the
26 posterior belt on the torso of the deer to the left (Figure 7e and f) such that the
27 secondary reindeer would be compelled to turn in the direction of movement of the
28 lead reindeer. This wide belt joins with another belt that arches over the shoulder
29 (in the area of the first thoracic vertebra spinous process), which transfers the body
30 movements of the deer to the sled via long straps.
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35 The headgear for the lead reindeer is employed in communicating to the deer to
36 turn or stop. To turn the lead reindeer to the left, the driver pulls the *nenzamindya'sa*
37 down and toward his or her body, which directs the lead deer's head in the
38 desired direction. To direct it to the right, the *nenzamindya'sa* is lifted or flicked
39 upward slightly, communicating the driver's intent to the deer—this does not pull
40 or turn the deer's head to the right. The secondary deer read the body movements of
41 the lead reindeer in this process, but its head and gaze also can be physically
42 redirected to the left by the force exerted on their headgear by the belts of the deer
43 adjacent to them.
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48 More complex and ornate versions of the headgear (and harnesses) are also used by
49 Nenets and neighboring groups, many of which involve different ways of organizing
50 the headgear and other strapping, but also decorative straps that attach to
51 additional holes in the L-shaped antler pieces (Lukina 1985; Popov 1948; Siazia
52 2005: 60-61; Sukhanovskii 2009: 207-208). One set of additional antler or
53 mammoth ivory elements used in some headgear are 'cheek pieces,' which are most
54 often rectangular or nearly oval in outline. They typically have at least three holes
55 for attachment, one for a strap to the L-shaped pieces, one for the strap behind the
56 ears, and the final for the jaw strap. Note that many of strap connections in the
57 headgear and belts involve either knots or sub-square to rectangular buttons of
58 antler or bone (3-5 cm wide) that fit through slots in the straps. Today, polyethylene
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4 from barrels and pipes is often substituted for some or all antler, ivory, or bone
5 components just described.
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7 **Comparisons with Historic Headgear**

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9 Several general patterns emerge in comparisons of historic reindeer headgear with
10 the archaeological L-shaped and arched pieces. First, none of the historic transport
11 reindeer antler headgear we observed had barbs on them, and we are unaware of
12 any literature indicating that barbed headgear was used for daily transport
13 purposes with reindeer. The only barbed pieces we identified as employed with
14 reindeer in the Eurasian Arctic seem to have been placed on various parts of the
15 neck, and all of these functioned in training transport reindeer, directing decoy
16 animals, or intermittently pulling transport reindeer. Second, we see no evidence
17 that any such barbed items were used with swivels. In all cases, barbed reindeer
18 gear appears to be attached directly to leather strapping. Third, swivels are nearly
19 always present in lead transport reindeer gear used in the tundra of much of
20 northern Europe (east of the Sámi) through the Taimyr region. These are placed
21 where the headgear meets the rope held by the sled driver; they are otherwise
22 absent from the rest of the sledding gear. All but one swivel we observed was
23 fashioned from metal, the remaining case being crafted from antler and collected in
24 2002.
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30 Barbed antler pieces are used with reindeer among several groups in the Eurasian
31 Arctic. Chukchi (and other groups to the east of Iamal), for example, utilize a single
32 straight, slightly arched, or even blocky antler piece with relatively long and sharp
33 barbs (8-33 mm long in the objects we observed first-hand) that are placed on one
34 side of the neck of transport deer (Figure 9). These objects are attached to hide
35 straps that encircle the neck, which is connected to a braided lead or rope; they are
36 employed for correcting or training deer to turn in the desired direction (Bogoraz
37 1901:39; Levin and Potapov 1961:22). The barbs are designed to cause the animal
38 pain when it behaves in an undesired way, eventually dissuading it from such
39 actions when the gear is no longer in place. Dolgany utilize barbed V-shaped pieces,
40 which are employed with surplus transport reindeer tethered behind sleds
41 (D'iachenko 2005: 213; Popov 1935: 187, 189). These pieces too appear to have had
42 relatively long barbs and were positioned on the top of the neck just behind the
43 head to prevent the animal from pulling backward while the sled was in motion.
44 Very similar antler pieces, perhaps the same types of items just described, were
45 used by Nganasany with decoy reindeer, and these are reported to be around 29 cm
46 long (Popov 1948: 30-1), or nearly double the length of even the largest
47 archaeological L-shaped archaeological piece from Iamal (Table 1; Supplementary
48 Tables 1-3). Dolgany also utilized paired nearly straight antler pieces for decoy deer,
49 again with relatively large and sharply pointed barbs; these too were placed on each
50 side of the neck (D'iachenko 2005: 152-3). Such decoy animals were positioned
51 away from hunters on the tundra, where they would be approached by wild
52 reindeer. The hunters would direct the decoy deer toward them using the neck gear
53 connected to a thin rope, hopefully bringing the wild deer within striking distance of
54 their rifles. Unfortunately, we were unable to locate any such decoy reindeer gear in
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4 museum collections. No such implements have been documented for the Iamal
5 region at any point in the historic period. Note however that Nenets in the Timan
6 tundra near Archangelsk in Northern Europe did employ this technology and
7 method (Kuruptev 1927:34). Decoy hunting was common in Iamal in the 18th
8 through the beginning of the 20th centuries CE, but this technique involved no
9 headgear, only straps placed in the antlers designed to entangled the antlers of wild
10 deer when fighting (Khomich 1966:63; Zen'ko-Nemchinova 2006:117). Perhaps
11 most important to our arguments, the barbs found in the Iamal archaeological
12 specimens range in length from 2 to 4 mm, and some are blunt (Figures 2 and 4),
13 making them quite distinct from the decoy and correctional objects described above.
14 The longer and sharper barbs in the historic pieces seem to be necessary because
15 these objects were worn on the neck, which has far longer hair and far thicker
16 muscle than the reindeer forehead. Short and stubby barbs probably would have
17 little effect if used on the neck.
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23 Some shaped-based comparisons among the L-shaped archaeological and modern
24 headgear objects are informative. The angles of the arms of the historic pieces from
25 the lead and secondary transport reindeer are all over 90 degrees (Table 1). All but
26 one of the archaeological specimens also have angles greater than 90 degrees, the
27 single exception being one Iarte VI specimen. In our consultations, Nenets identified
28 this same object as atypical (see below). Excluding this specimen, the average angles
29 of the archaeological objects were not significant different than those of the historic
30 lead ($t(24) = -0.348, p = 0.731$) or secondary reindeer ($t(77) = 1.237, p = 0.220$)
31 pieces. Differential lengths of the arms of the L-shaped pieces were most
32 pronounced in the historic lead reindeer specimens, where the mean length of the
33 downward extending arm was nearly twice as long as the arm over the eye (Table
34 1). This difference was less pronounced in the historic secondary reindeer pieces,
35 where the downward arm was only 1.33 times longer on average, and the range in
36 proportions was from 1.00 to 1.71. The arms of the archaeological specimens are
37 nearly equal in length at a ratio of 1.10, meaning these objects are on average
38 significantly differently proportioned than the historic second reindeer pieces ($t(69)$
39 $= 2.850, p = 0.006$). However, the range present in the archaeological objects is from
40 1.0 to 1.75, quite similar to that of the historic secondary reindeer pieces. Finally, in
41 terms of cross-sections, 18.75% of the historic lead reindeer pieces were D-shaped,
42 the remainder being concave-convex. For the historic secondary pieces, 28.57%
43 have D-shaped cross-sections, the resting being concave-convex. In both sets, the
44 convex faces were those that (presumably) rested on the deer's heads, and concave
45 faces were formed on the opposing surface by the removal of the spongy interior
46 antler. In the archaeological specimens, 25.00% had subrectangular cross-sections,
47 the remainder being concave-convex, just as in the historic pieces.
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55 Several size-based patterns are also evident in the L-shaped pieces. First, the L-
56 shaped pieces in the historic lead reindeer headgear are on average longer and
57 wider than those of the secondary reindeer ($t(7.4) = 10.24, p = <0.000$; $t(77) = 5.17,$
58 $p = <0.000$) (Table 1). They are also longer and wider than the archaeological L-
59 shaped pieces, but the length results are not statistically significant (length $t(8.7) = -$
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0.668, $p = 0.521$; width $t(25) = 5.225$, $p = <0.000$). Second, the historic secondary reindeer L-shaped pieces were not significantly longer than the measurable archaeological specimens ($t(68) = 0.515$, $p = 0.616$) but are somewhat wider ($t(72) = 4.688$, $p = <0.000$). This also holds when the problematic Iarte VI specimen is removed from consideration (length $t(67) = 1.701$; $p = 0.094$; width $t(71) = 5.229$, $p = <0.000$). Third, the attachment holes in the historic reindeer L-shaped pieces are larger than those in the historic secondary L-shaped pieces ($t(48.1) = 2.83$, $p = 0.007$), and both of these groups have larger holes than the archaeological specimens ($t(54) = 4.386$, $p = <0.000$; $t(138) = 6.097$, $p = <0.000$). Note that five of the archaeological specimens have notches for line attachment, or at least have only notches at one of their ends. These are all less than 5 mm wide, or smaller than the average sizes of the attachment holes in the historic L-shaped items.

The antler objects in the headgear of the historic secondary reindeer are predominantly composed of L-shaped pieces, but 8 of the 71 (11.27%) objects we examined were paired arched pieces. Among the archaeological specimens, 3 of the 14 (21.43%) potential headgear pieces are arched objects, all of which were recovered from Iarte VI. The historic arched pieces ranged in length from 106 to 165 mm (mean = 132.5 mm, st. dev. = 22.5 mm), and the arch height to length ratios ranged from 0.07 to 0.18 (mean = 0.13, st. dev. = 0.04) (Table 2). The line attachment holes ranged in size from 5.2 to 9.2 mm (mean = 7.57, st. dev. 1.41). The two complete arched specimens from Iarte VI had lengths of 151 and 126 mm, both within the range of the historic objects, and height to length ratios of 0.17 and 0.20, the latter falling outside the range of the historic objects. The third object was broken at one end and is 192 mm long; its fragmented state makes the height to length ratio impossible to calculate. The line attachment holes in all three ranged from 4 to 7 mm, with a mean of 5.5 mm (st. dev. 1.38), meaning that they are significantly smaller than those in the historic arched pieces ($t(20) = -3.077$, $p = 0.006$).

Finally, the straight or left antler pieces in the headgear of historic lead reindeer have no archaeological analogs in the three site assemblages we analyzed. Those in the historic gear ranged in length from 108-172 mm (mean = 130.7, st. dev. = 17.6), and their cross-sections were all sub-rectangular (Supplementary table 1). The holes for strap attachment in these items ranged in size from 5-13.6 mm (mean = 8.13, st. dev. = 2.27).

In sum, the L-shaped and arched archaeological specimens were most similar in size and shape to the L-shaped and arched antler pieces used with modern secondary reindeer. However, none of the modern pieces have barbs, which are present in the L-shaped archaeological pieces, and both the L-shaped and arched archaeological objects tend to have line attachment holes smaller than those in modern headgear pieces.

Nenets Interpretations, Practices, and Enskilment

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4 Nenets provided several general interpretations regarding the archaeological
5 replicas from Iamal. First, the type 1.0 swivels found at Ust'-Polui (the most
6 abundant type of swivels at that site) were unfamiliar to all individuals interviewed
7 (Figure 3A). Some seemed to doubt they functioned as swivels, and no one identified
8 these objects as reindeer gear. Note that we have previously discussed these objects
9 as being very similar to swivels found in historic dog sledding harnesses used
10 elsewhere in the Arctic (Losey et al. 2018). Second, the other Ust'-Polui swivel types,
11 particularly type 1.3, were consistently identified as transport reindeer headgear
12 parts (Figure 3b, c, and d). Several Nenets stated, "these are ours," and a few
13 individuals described making or seeing similar antler swivels in childhood. Nenets
14 also stated that swivels were otherwise absent in their other gear—they are only
15 used on the headgear of lead transport reindeer. Third, Nenets identified the arched
16 specimens from Iarte VI (Figure 4b and c) as virtually identical to the antler pieces
17 in their transport reindeer headgear, again stating, "these are ours." When asked
18 why arched pieces might be used instead of L-shaped pieces, the reply was that
19 there was no functional difference and that the shape was dependent on what antler
20 was available when the headgear was being made. The L-shaped pieces are
21 fashioned from appropriately angled sections of antler beams, which allows one to
22 obtain the desired shape without working too far into the beam's spongy interior. If
23 no angled pieces were readily available, an arching piece of dense antler would be
24 used in its place. Finally, one unbarbed L-shaped antler object from Iarte VI (Figure
25 4a), the only specimen with an angle below 90 degrees, was never identified as
26 reindeer gear. People thought perhaps it was a container handle or joked that it
27 might be a boomerang.

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35 For the barbed L-shaped objects from Ust'-Polui and Tiutei-Sale I, Nenets shared a
36 suite of new interpretations. First, these objects were said to be "not ours" due to
37 the presence of the barbs. Everyone shown these objects, starting with our first
38 interview in 2017, stated that these barbs would cause the reindeer pain if worn on
39 their heads, potentially even injuring them. As such, they were definitively not daily
40 use reindeer gear. Second, repeatedly and consistently, people interpreted these
41 objects as headgear employed in training young reindeer for use in transport. One
42 forest Nenets elder at Khanimei recalled carving a similar barbed piece in order to
43 train a particularly unruly young bull. He said the barbed piece was only used for a
44 few days before a smooth piece was traded in. Many Nenets added that the pieces
45 would help to prevent the deer from pulling or otherwise resisting being fitted with
46 headgear and harnesses. We return more to this critical point below. Third, when
47 we inquired about the somewhat larger sizes of the modern shaped L-shaped pieces
48 in comparison to our archaeological L-shaped objects, two individuals on separate
49 occasions responded, "some people are rich now." Following up on this point, it
50 became apparent that the sizes of the antler pieces were not wholly determined by
51 function or antler size, but that issues of prestige and wealth were in play. Putting
52 significant effort into one's gear, making things a bit over-sized, of bright colors
53 (particularly the strapping) and rare materials such as moose (*Alces alces*) antler or
54 mammoth ivory, was a way of showing your importance, connections, standing, and
55 level of care. Fourth and perhaps most surprisingly, our host family, the Okotettos,
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4 explained that the L-shaped antler pieces were not required for directing transport
5 deer. Wearing today's gear (which is not barbed) agitates the heads of the deer to
6 some extent, and this is particularly true in mid-winter when very low temperatures
7 render the antler pieces extremely hard, and the deer particularly sensitive and
8 vulnerable. In such cases, they would sometimes forgo using the headgear with the
9 antler pieces, instead employing gear constructed of strapping and a few antler or
10 plastic connector buttons. While not as effective as the headgear with the antler
11 elements, particularly that used with the lead reindeer, it was nonetheless
12 functional in communicating with the animals during sled pulling. Further, even
13 when the 'normal' headgear is utilized, it is often ill-fitting, and the L-shaped pieces
14 commonly fall out of place and rest just below the eyes (Figure 10). For transport
15 reindeer, particularly those that are already skilled in this practice, the L-shaped
16 pieces are not necessary for sledding to be carried out—the deer could still be
17 communicated with in its absence or misplacement. Note that many Eurasian Arctic
18 people successfully employ reindeer headgear lacking such L-shaped antler
19 elements (Levin and Potapov 1961).
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25 Enskilment is the process of becoming skillful at something by pragmatically
26 engaging with it in its contexts (Pálsson 1994; Ingold 2000, 2013). In other words,
27 learning how to perform a set of tasks, particularly those that are complex and
28 critical, entails being immersed in them, not just acquiring a set of mental
29 instructions for carrying them out. One can read about techniques and processes for
30 constructing a house, but this alone does not make one a skilled carpenter.
31 Repeatedly building houses, doing the work, and responding to challenges that
32 inevitably arise, causes these skills to emerge (Ingold 2013). The enskilment
33 literature in anthropology typically aims to describe the process by which human
34 craftspeople come to embody their craft intuitively and organically. In this article
35 we extend the argument to a human-animal relation. For example, reindeer are not
36 good at avoiding predators at birth but become skilled at this through experience
37 and physical development. They become better recognizers and assessors of these
38 threats and learn to change their movements and interactions with their fellow herd
39 members, landscapes, and humans to escape or avoid them. One such practice,
40 described to us by one of our Nenets hosts, is that when reindeer are frightened by
41 such threats, they will run to their people for protection. The deer have learned to
42 whom to turn for help, and know where to find them. The potential or capacity for
43 both reindeer to adeptly avoid predators and humans to be skilled carpenters is due
44 to the evolution of our particular genomes, but genomes alone do not accomplish
45 this.
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52 Reindeer (as well as human and dog) enskilment was evident throughout our time
53 with tundra Nenets at Tambei, which fell during the calving season. Training of
54 reindeer occurred every few days during our stay. By that time, our hosts had
55 separated the male and female deer into two herds. The male half, foraging through
56 the snow some distance away from the home, was rounded up using a reindeer sled
57 or snowmobile and one or two herding dogs. The deer were pushed slowly toward
58 the home, pausing calmly about 100 m or so outside of a small C-shaped corral
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4 constructed of reindeer sleds, rope, and netting (Figure 11). The female head of the
5 household stood ~15 m outside of the corral holding a rope at waist height
6 connected to the corral opening. The rope acted as a half-funnel directing the deer
7 to the corral. Using a gentle voice command the deer had come to know, she would
8 invite them to enter, which some would do with little other guidance. Others had to
9 be pushed forward with the dogs and sled, while others tried to escape around the
10 opposite side of the corral, where the household males intercepted some of them
11 through their remarkably adept use of lassos. Once the needed deer were inside, the
12 mouth of the corral was quickly closed with netting. As unskilled novices, we
13 functioned as mobile corral posts, helping to keep the few particularly rowdy and
14 frightened deer in the corral. Our hosts explained that repeatedly corralling calmed
15 the deer and gave them a sense of home and of their herd, which together
16 encouraged them to stay in this relationship.
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22 To even our unskilled eyes, this daily process of corralling the deer revealed that
23 some of the deer, particularly the larger males (some of which were castrated), were
24 more docile and cooperative than others. Such differences occur in part because
25 recurrent corralling of the deer is a process of skill-building or learning through
26 practice (Lave 1990). Through this process, the deer learn to move into the
27 enclosure where they are subject to harnessing, health assessment, antler and velvet
28 harvesting, and selection for slaughter. In turn, people learn some of the deer's
29 dispositions and refine their skills, including lasso use and veterinary care (see
30 Anderson 2006; Stammler 2005; Vuojala-Maga 2010). The older, larger deer were
31 more easily approached and handled in these processes, with many of the younger
32 individuals aggressively pulling when grabbed, lassoed, or fitted with headgear.
33 Some would dart under the corral fence, or attempt to run past the lassos being
34 directed at them. Nenets we consulted repeatedly said the barbs on the L-shaped
35 pieces would help curtail some of this behavior. The barbs would cause the deer
36 discomfort when they pulled against them, and soon after experiencing this, they
37 would stop pulling when fitted with headgear, regardless of the presence of the
38 barbs. They would come to know that it was easier to accept being harnessed rather
39 than resisting it. Well-established reindeer enskilment was also evident when
40 watching older male lead reindeer being collected for harnessing. Older skilled deer
41 could be 'caught' by having the end of the lasso tossed over their shoulders (if the
42 lasso was to miss its target, for example). Not physically constrained, such deer
43 would often calmly stop, recognizing what was to happen next, and then allow
44 themselves to be fitted with the gear with little resistance.
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52 Enskilment in sled pulling also drew upon generational differences in domestic skill
53 and experience. Once corralled, the men and boys carefully moved through the
54 jumble of tightly packed and enclosed deer, selecting experienced older individuals
55 and those younger and far newer to the harness by grabbing them around the neck.
56 A specific older and skilled individual was fitted with lead reindeer headgear, and
57 one or two inexperienced reindeer were placed in secondary headgear. All three
58 were then harnessed side-by-side to a sled, with the older lead deer to the far left.
59 The inexperienced reindeer are first engaged in this practice when two or three
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4 years of age, with castration potentially happening around the same age, the latter
5 also helping in making the deer more docile and easier to work with in transport.
6 Female deer are sometimes also trained to pull sleds, but usually only if they are not
7 able to calve. Regardless, the younger deer are expected to learn much of the
8 process from the older, lead animal, who has long been immersed in that particular
9 task. The training process may last as long as one year for the secondary animals
10 and even two or more years for lead reindeer. Not all transport deer can become
11 lead animals, as only a select few become skilled enough to function in such roles.
12 Given the extent of skill and time invested in lead reindeer, they are considered
13 particularly precious individuals. Historically in Iamal, transport reindeer might
14 work until they are ten years of age (Khomich 1966: 91).
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19 Once the reindeer are in place, the driver directed the group across the tundra,
20 which during our visit often entailed trips to check on the adult females and their
21 calves (Figure 6). Simply put, driving the sled entailed directing the deer via the
22 *nenzamindya'sa* of the lead animal (described earlier), vocal commands to spur
23 them forward, and taps or pokes to the backsides of the deer with the *khorei*, a long
24 pole held by the driver. The inexperienced reindeer can and do resist this process,
25 turning in the opposite direction of the lead deer, or repeatedly slowing down or
26 abruptly stopping. These acts of resistance and unskilled behavior make sledding
27 difficult for the other deer and the driver, and abruptly stopping, in particular, can
28 result in injury—the sled can run into or over the stationary animals. During the
29 repeated process of being corralled, harnessed, and pulling the sled, the younger
30 deer learn the pragmatics of that material and social environment—by engaging in
31 it with more experienced deer, people, dogs, the tundra, and the gear itself.
32 Becoming a transport animal involves enskilment within a meshwork of people,
33 sounds, made things, landscapes, and other generations of one's species.
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39 But is enskilment a part of domestication, or something outside of it? Domestication
40 has been defined in numerous ways (see Russell (2011:207-258) for a review), but
41 we highlight the recent description of this process given by Zeder (2015: 3191):
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43 “Domestication is a sustained multigenerational, mutualistic relationship
44 in which one organism assumes a significant degree of influence over the
45 reproduction and care of another organism in order to secure a more
46 predictable supply of a resource of interest, and through which the
47 partner organism gains advantage over individuals that remain outside
48 this relationship, thereby benefitting and often increasing the fitness of
49 both the domesticator and the target domesticate.”
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51 The multigenerational influence on reproduction and securing of resources are
52 parts of many domestication definitions and narratives (e.g., Bökönyi 1969; Clutton-
53 Brock 1989; Russell 2011; Vigne 2011), but here we also see the terms sustained,
54 relationship, and care. This definition recognizes that the genotypic and phenotypic
55 changes brought about through processes such as isolation, paired breeding, culling,
56 and castration can only be realized if the relationships are carried forth.
57 Domestication is not enacted by moments of breeding or genomes alone. It requires
58 interaction, maintenance, and mobility (often for the needs of animals), as well as
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4 landscapes, food, and made things—but also human and animal skill in enacting
5 these practices. With changes to or elimination of the practices and things that
6 sustain domestication, such relationships and their multi-directional benefits will
7 alter or cease. As such, domestication clearly must be an ongoing relationship
8 (Larson and Burger 2013), not an absolute threshold, phenotype, or genotype that is
9 achieved, but rather something emergent, material, and practiced (Anderson et al.
10 2017a; Lien 2015).
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14 Most importantly here, domestic animals in such ongoing relationships do not
15 merely relate to or interact with one another, made things, people, and landscapes,
16 but rather emerge in concert with them (Appadurai 1986; Hodder 2012; Olsen
17 2010; Ingold 2013). In fact, domestication practices have been shown to alter the
18 physical development of individuals (Salmi and Niinimäki 2016; Shackelford et al.
19 2013; Taylor et al. 2015) and transform ecosystems (McClure 2015; Smith 2006),
20 and the specific forms of such changes are closely tied to the types of material
21 culture, practices, and places that are involved (Anderson et al. 2017a; Boivin 2008;
22 Hodder 2012; Lien 2015; Losey et al. 2018; Swanson et al. 2018; Verhoeven 2014).
23 Little discussed in this literature, however, is that animals and people in domestic
24 relationships become mutually enskilled within these meshworks of practice and
25 things. This is perhaps most obvious with working animals, where years of daily
26 engagement with specific individuals and items such as yokes, plows, bridles,
27 harnesses, and saddles are required to develop and maintain pragmatic working
28 relationships (Allentuck 2015; Looovers 2015). A reindeer is not just bred by Nenets
29 to pull sleds. They learn to do this by recurrently engaging in the task, as just
30 described. Further, enskilment in particular material and social contexts, or the lack
31 thereof, also potentially affects longevity and in turn reproductive opportunities,
32 meaning it is also part of the selective processes at work in domestication as an
33 evolutionary process. Animals that are poorly skilled at their social roles, or that are
34 expected to be poorly skilled based on their behavior while young, might be selected
35 for slaughter, culled, or injured in accidents, rendering them non-reproductive.
36 Conversely, animals that are particularly adept in their roles might be so valued that
37 they are cared for long past their prime, potentially extending their reproductive
38 opportunities, if they are not castrated. Even if castrated, long-living working
39 animals have more chances to pass on elements of their skill through extended
40 opportunities to work with younger animals, people, and gear.
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49 **Synthesis of Reindeer Domestication in Iamal**

50 Our analyses and other recently published archaeological data allow for a new
51 understanding of the history of reindeer domestication in Iamal. The earliest and
52 most convincing artifact evidence for reindeer domestication comes from Ust'-Polui
53 at ~260 BCE to 140 CE (Figure 1; Losey et al. 2017). This consists of nine L-shaped
54 barbed antler objects interpreted by our Nenets colleagues as headgear used in
55 training juvenile transport reindeer, and seven swivels thought to be parts of gear
56 used with lead transport reindeer. A single barbed L-shaped piece has also been
57 found at the Niaksimvol' site about 500 km to the southwest of Ust'-Polui in the
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4 Khanty-Mansiisk region (Figure 1; Iakovlev 2014:31). This site is not radiocarbon
5 dated, but it stylistically appears to be equivalent in age to Ust'-Polui. Additional
6 support for a relatively deep history of reindeer domestication in Iamal, potentially
7 as early as 300 CE, is the sedimentary evidence for the small-scale holding of
8 reindeer at Iarte VI (Figure 1; Anderson et al. 2019). Note however that no artifacts
9 or faunal remains from this period have been identified at Iarte VI—all such
10 evidence, including the potential headgear there, dates to the 11th century CE
11 (Anderson et al. 2019; Nomokonova et al. 2018; Shiiatov and Khantemirov 2000).
12 Overall, by as early as 260 BCE, reindeer were involved in transport along the
13 northern fringes of the forest tundra of Northwest Siberia, and perhaps also in areas
14 of the taiga and nearby tundra just a few centuries later. Reindeer transport was
15 practiced there alongside dog sledding and boating, both well evidenced at Ust'-
16 Polui (Gusev and Fedorova 2012; Losey et al. 2018). There is little evidence for a
17 significant shift in subsistence practices at this time, and at least at Ust'-Polui diets
18 were relatively broad (Bachura et al. 2017). Reindeer were certainly critical, but
19 substantial amounts of freshwater fish and waterfowl also were present in the diet
20 (Losey et al. 2017).
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27 The causes of the emergence of reindeer domestication and transport in the Iamal
28 region are unknown. Episodes of migration or climate change may be related to
29 these developments, but such links have yet to be firmly established. Historic and
30 linguistic research indicates there were multiple complex movements of Samoedic
31 and Ugric speakers (which include Nenets and their northern Khanty and Mansi
32 neighbors just to the south) into and within the Iamal region (Abondolo 1997;
33 Chernetsov 1935; Golovnev 2004; Honkola et al. 2013; Sokolova 1987; Vasil'ev
34 1979, 1988). The proposed timings of many of these movements remain speculative
35 and require additional supporting evidence before they can be correlated with
36 archaeological data. Further, there is no evidence the headgear objects described
37 here appeared earlier in the proposed origin areas for these linguistic groups to the
38 south of Iamal. We also see no similarities in the Ust'-Polui headgear with that
39 employed with early transport horses in the south of Siberia and Central Asia (c.f.,
40 Taylor et al. 2016; Tkačenko 2010). Horses of course are far different animals than
41 reindeer, so perhaps such similarities should not be expected. The inhabitants of
42 Ust'-Polui were nonetheless likely aware of horse riding given that a bronze
43 medallion depicting a person on horseback was found at the site itself
44 (Aleksashenko 2003: 17). Regardless, all current evidence suggests that the
45 reindeer harnessing practices evidenced at Ust'-Polui emerged in Iamal—they were
46 not introduced from outside the region.
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53 Climate-driven explanations face additional challenges. The most detailed Late
54 Holocene climate history available for Iamal is a ~2000 year dendrochronology
55 record for the central portion of the peninsula (Briffa et al. 2013). Tying any
56 variability in this climate model to the region's human-animal history is difficult
57 because many of the sites, including Ust'-Polui, have periods of occupation that span
58 centuries, meaning they were in use through periods of both warming and cooling.
59 In other words, we are left trying to link high-resolution climate data with broad
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4 and sometimes imprecise archaeological chronologies, a problem seemingly
5 widespread in the Arctic (c.f., Friesen and Mason 2016). Data directly on how
6 climate changes affected Iamal ecosystems is entirely lacking. Included in this is the
7 Little Ice Age, which has been claimed to have had transformative consequences for
8 the region's domestic and wild reindeer populations (Krupnik 1993; Stépanoff
9 2017). Further, reindeer and caribou numbers vary dramatically and often in
10 unclear relationship to climate change (Bergerud 1996), so additional support
11 linking reindeer numbers to climate shifts is required. Until such issues are
12 resolved, invoking climate change as a primary factor in changes in human-reindeer
13 relations in Iamal will remain unconvincing.
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18 What is clear is that the L-shaped barbed objects from Ust'-Polui and later-dating
19 Tiutei-Sale I are on average somewhat smaller than modern regional reindeer
20 headgear pieces, as are their attachment points for straps. This pattern suggests
21 they were used in training of smaller-bodied reindeer, likely individuals younger
22 than those now trained in Iamal for transport, which begins with 2-3 year-old
23 animals (described above). Nearly all modern Iamal male and female reindeer are
24 biologically mature by 1.5 years age and reach near-maximum body masses as early
25 as 2 years of age (Podkorytov 1995: 19, 42-3). We suggest that the barbed headgear
26 was first used with juvenile deer near the end of their first year of life when they
27 would have been roughly three-fourths of their adult body size. One possible reason
28 training began earlier in life is that these animals were more skittish or resistant to
29 these processes than their modern counterparts, who are largely genetically distinct
30 from the reindeer represented at Ust'-Polui, Tiutei-Sale I, and Iarte VI (Røed et al. in
31 press). Presumably, intensively engaging with reindeer when they are developing
32 would increase the likelihood of them socially bonding with humans (and humans
33 with them) and provide an extended period over which enskilment in engaging with
34 humans and their things could develop. Innate (genetic) differences in enskilment
35 and other social abilities might also help to explain why these early domestic
36 animals were mostly replaced in Iamal between the 15th and 18th centuries CE by
37 what was likely a newly arrived reindeer population (Røed et al. in press). These
38 new reindeer potentially learned more quickly and offered less resistance.
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45 Once young reindeer were skilled in working and being with humans, their barbed
46 headgear was likely replaced with leather strap gear, or as evidenced at Iarte VI,
47 with headgear bearing unbarbed arched antler pieces. Lead reindeer at this time
48 were probably communicated with using something similar to a *nenzamindya'sa*
49 which was employed in combination with an antler swivel, as seen in modern lead
50 reindeer equipment. These relatively rare but well-trained transport animals,
51 recurrently interacted with from a young age, were likely highly valued both
52 economically and emotionally. For example, even in the late 18th century, before the
53 emergence of large-scale reindeer herding in the Eurasian Arctic, transport reindeer
54 had very high standings across a range of Indigenous societies (Stépanoff 2017).
55 Perhaps close human-reindeer bonds with transport animals are related to the
56 numerous images of reindeer found at Ust'-Polui—people were making images of
57 those animals most important to them, including on their everyday things such as
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knives and spoons (Fedorova 2000). Such transport reindeer allowed people to travel in new ways and to inhabit hitherto little-used landscapes. Dog sledding was practiced here at least as early as reindeer sledding (Losey et al. 2018), but the former was most effective along the Ob and its tributaries, where productive fisheries provided economical food for these working animals (Davydov and Klokov 2018; Losey et al. 2017). Reindeer were most economical in transport on the tundra where fishing was less productive. Unlike dogs, reindeer can feed themselves in this environment, eliminating the time and effort involved in procuring and transporting the dog food. The extent to which reindeer transport facilitated occupation of the tundra was in part depended upon the scale of these practices. Small-scale reindeer herds have relatively low mobility requirements compared with more massive herds, which necessitate frequent and sometimes long-distance moves to cope with the grazing pressure the latter place on vegetation (Stépanoff 2017). Small-scale herding perhaps facilitated mobility patterns on the tundra involving seasonal patterns of sedentism, as seemingly evidenced at Iarte VI, where multiple pit houses were found associated with a midden of thousands of reindeer remains (Nomokonova et al. 2018; Plekhanov 2014). Such sedentary ways of being on the tundra are undocumented in this region within the historic period, perhaps because larger-scale herding was common among most Indigenous groups by that period.

Estimating the number of transport deer at any place and point in the prehistory of Iamal is challenging due to the inability to osteologically differentiate transport animals from other domestic reindeer. Potential transport equipment—sleds, headgear, and swivels—is rare in all periods in Iamal, not just in the early sites discussed here. Further, even as late as the 17th century CE, subsistence in Iamal was mainly based on hunting wild reindeer and fishing, not slaughtering domestic herds, even though these were sometimes relatively large (Krupnik 1993). These reindeer, however, were used predominately for transport. It follows that domestic reindeer, particularly transport animals, would form small constituents of archaeological faunal assemblages dating before the transition to large scale reindeer herding, which seemingly emerged here in the mid- to late-18th century CE (Krupnik 1993). The reindeer genetic data for Iamal predating the 18th century shows a pattern consistent with this—persistent diversity in mtDNA haplotypes throughout the Holocene before this period followed by the near-complete dominance of just a few haplotypes (Røed et al. in press). This too suggests the number of domestic deer remained quite small. Notably, the current genetic data lacks samples dating between the 15th and 18th centuries CE, meaning that precisely when the new domestic reindeer population entered the region is unknown, nor is it clear how rapidly this population replaced the domestic animals already in place.

As has been previously argued, recurrent occupation of the Iamal tundra may have begun in the 11th century CE, which was largely seasonal, focusing on the warmer portions of the year (Fedorova 2000, 2006; Golovnev 1998; Gusev et al. 2016). Earlier occupations of the tundra are clearly evidenced (Anderson et al. 2019; Fedorova et al. 1998; Korolev and Khlobystin 1969; Nomokonova et al. 2018), but not until the 11th century did Iarte VI experience its peak period of occupation

(Nomokonova et al. 2018; Plekhanov 2014), and starting in the 12th century, significant occupations at Tiutei-Sale I and Bukhta Hakhodka also are evidenced (Figure 1; Fedorova et al. 1998; Kardash 2011). Further, the peninsula's earliest well-dated human burials, located ~5 km to the west of Iarte VI at Iur'-Iakha III, date to the 11th century CE (Figure 1; A. Plekhanov, personal communication, 2019). Subsistence on the tundra by this period was based on reindeer, but faunal assemblages from Tiutei-Sale I and Bukhta Hakhodka also contain some pinnipeds, indicating some use of coastal ecosystems (Nomokonova et al. 2018; Vizgalov et al. 2013). Fishing was also likely important in some places, but very few of the region's sites were sieved during excavation, meaning that remains of fish are underrepresented.

The development of modern transport reindeer equipment occurred slowly over the last millennium. The latest-dating barbed L-shaped pieces are found at Tiutei-Sale I on the west coast of the peninsula at ~1100-1400 CE (Figure 1; Fedorova 1998), after which these objects are wholly absent in the Northwest Siberian archaeological record. Swivels are rare everywhere except for Ust'-Polui. A single type 1.2 swivel was also found at Mutnaia V in northern Yamal and is thought to date to the 8th or 9th century CE (Figure 1; A. Gusev, personal communication 2019). Further, one type 1.2 swivel has been found at Komatyvis I and one type 1.3 swivel at Mys Vkhodnoi, both on the tundra just west of the Ural Mountains (Figure 1; Khlobystin and Pitul'ko 1996; Murygin 1992). Neither is well-dated, but both appear to be from the last millennium. The unbarbed arched pieces from Iarte VI date to the 11th century, and a single unbarbed piece was also found at Zelenaia Gorka, which may be of similar age (Figure 1; Chernetsov 1957). Neither of these sites has the unbarbed L-shaped pieces that today dominate modern headgear, nor did they produce swivels. Built-up wood sleds—those with ski-like runners and a raised bed supported by stanchions—first appear at Ust'-Polui (Gusev 2014). These are from relatively small and lightly built sleds, with even the largest being more gracile than those used by Nenets with reindeer, suggesting they were employed with dogs or even hand-pulled (Losey et al. 2018). Sled fragments from other early sites are too fragmentary to determine their uses (Kardash 2011; Plekhanov 2014).

Modern forms of reindeer headgear and sleds appear in the archaeology of Northwest Siberia quite recently, perhaps co-occurring with the emergence of the modern domestic reindeer population. By the 16th to 17th centuries CE, harnessing gear in modern form, ranging from multiple unbarbed L-shaped antler pieces to wood blocks (used in some modern gear to connect harness straps to the sled itself), can be found at Gorodok Monkys' Ureevskii in the Khanty-Mansiisk region to the south of Yamal (Figure 1; Kardash and Vizgalov 2015). At Nadymskii Gorodok in southern Yamal, many similar items were found, along with portions of a built-up sled with reclined stanchions and up-curved runners, traits seen in almost all modern Nenets reindeer sleds (Figure 1; Golovnev et al. 2016); these date from the end of the 16th century through the latter portion of the 18th century (Kardash 2013a). Finally, Poluiskii Gorodok, a large settlement dating from the late 16th century through the early 18th century CE, also has produced modern-looking headgear along with

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4 fragmented sled parts (Figure 1; Kardash 2013b). Likely, the L-shaped antler pieces
5 in these three sites are historically related to the earlier barbed L-shaped pieces
6 from the region rather than a new development. They first appear just a few
7 centuries following the latest known L-shaped barbed items and otherwise have no
8 precedents in local material culture, including in Southwest Siberia. Now working
9 with deer that were perhaps more docile and quicker to learn, the barbs were left
10 off the gear and training began later in life when the deer were closer to adult body
11 size. Some of L-shaped pieces were also made over-sized and retained for use on
12 fully-enslaved transport animals. Both practices may be related to status making, as
13 seen on the Iamal tundra today, and have roots that began just over 2000 years ago
14 in this region.
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19 **Implications and Conclusions**

20 Reliance on ethnographic information in archaeological interpretation has been
21 critiqued for decades (c.f., Wobst 1978; Gosselain 2016). Such critiques often focus
22 on the ahistorical and decontextualized use of ethnographic data, which are of
23 course warranted. Conversely, the use of ethnographic information in archaeology is
24 pervasive, in large part because interpretation without such inferences is difficult,
25 and at times even impossible. Caution is warranted, particularly when drawing
26 analogies from highly different environments or from groups wholly unrelated to
27 the archaeological material in question. We have carefully tried to control for these
28 issues by consulting broadly amongst Nenets groups who work with reindeer in
29 several different types of environment and on different scales. The broad range of
30 our consultations from the tundra tip of Iamal to the forested interior helps to
31 control for changes in the landscape overtime due to different climate regimes.
32 What is key in this study is that the Indigenous experts consulted have worked with
33 reindeer their entire lives, and are familiar with how the animals' behavior changes
34 during different life stages and in different seasons. This intimate knowledge –
35 which we called enskilled – can be read into the artefacts placed before them. The
36 insights provided by Nenets find some support in our comparative research on
37 reindeer harness parts, which demonstrated at least some similarities between the
38 historic and archaeological objects, particularly in terms of the shapes and forms of
39 the L-shaped objects. Just as important, Indigenous communities in many regions
40 now often require direct involvement in interpreting their archaeological heritage.
41 These efforts are helping to decolonize archaeological practice (McNiven 2016;
42 Hennessy et al. 2013), which are trying to support through this project. These
43 transformations in archaeological practice create novel opportunities for
44 collaboration, and here profound new insights on the past.
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53 The study of enskilment as a critical element of domestication has the potential to
54 deepen and enlighten the histories of many long-term human-animal relations. Past
55 relations of domestication, particularly those of limited scale or early in their
56 history, all will not necessarily be marked by detectable morphological or genetic
57 change (Russell 2011; Vigne et al. 2004; Zeder 2006, 2015; Zeder and Hesse 2000).
58 They are not the sole signs of past domestication. In this study, various lines of
59 artifactual evidence indicate reindeer were being repeatedly trained for transport in
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4 lamal beginning at least 2000 years ago—they were becoming enskilled first in
5 interacting with humans, then in pulling single loads, and finally in pulling sleds as
6 part of a team. Each of these processes implies a type of mutual enskilment of
7 animal to animal, animal(s) to human, and human and animals to material objects.
8 These domestication practices were probably small-scale, judging by the relatively
9 small numbers of barbed items and swivels currently known from the region, and
10 the present dearth of genetic and morphological evidence for this relationship.
11 However, morphological changes in reindeer due to domestication have not been
12 thoroughly studied in lamal (or elsewhere) with advanced methods such as
13 geometric morphometrics, so this current lack of evidence may be misleading.
14 Regardless, genetic and morphological changes in reindeer likely were not the
15 immediate goals in these relationships. In fact, we suspect such goals were also not
16 pursued in the early domestication history of most animals. Instead, in lamal new
17 ways of being with reindeer were being sought which required animals that could
18 be traveled with and handled. The goal was to have individuals with the ability to
19 learn and cooperate beyond the boundaries of their species. Similar goals also were
20 important in the early domestication history of many other working animals. These
21 early histories might also show material traces of enskilment, if we are willing to
22 search for them.
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29 Clearly, the study of animal domestication in archaeology is increasingly relying on
30 taxonomic and cladistic methods, where early-dating skeletal specimens are
31 scrutinized as to which category (domestic, wild, hybrid) they belong and how they
32 relate to one another. Origin places and dispersals are the highlights of these
33 approaches, and the stories they help create are built on reconstructed genomes and
34 comparative analyses of skeletal element shape. Importantly, other archaeological
35 theoretical approaches are also revisiting this narrow focus, foremost of which is
36 niche construction theory, which highlights the emergent nature of domestication
37 and its multidirectional effects and diverse selective agents (Smith 2006; McClure
38 2015). This approach argues that not just human control over animal mating creates
39 domestication, but rather entire ecosystems, which are in turn shaped by particular
40 forms of ongoing human-animal-environment relationships. In this body of theory,
41 domestication seems to be understood as reciprocal and relational, allowing a wider
42 array of data to come into play and other questions to be pursued.
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48 Our focus on enskilment in domestication expands upon this critique, but from a
49 different point of emphasis by calling attention to how animals (and humans) accrue
50 pragmatic skill at being domestic in distinct material and social environments.
51 Domestic relationships emerge in the environmental entanglements highlighted by
52 niche construction theory, but also are clearly interdependent on engagement with
53 technologies built for these particular relationships and ecologies. These made
54 things do not merely help control or dominate animals but rather are part of the
55 total field within which they become domestic (Anderson et al. 2017a). A focus on
56 enskilment helps ensure that archaeology plays a prominent role in domestication
57 research by reinforcing a disciplinary emphasis on social relations and material
58 culture and their key roles in history and evolution. Archaeology clearly can
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contribute more to current domestication research than providing materials for specialists to analyze.

Finally, Iamal has remarkable potential for continued archaeological research. The region is home to vibrant Indigenous people with keen interests in the animals that have made life in the Arctic possible, many of whom still work daily with reindeer. In our experience, they also have much interest in their long-term history and can provide remarkable insights into it. Their goals for domestication are to not radically alter reindeer beyond what they already are—reindeer are very well suited for the shared landscape they inhabit with Nenets and others. Rather they seek to continue building lives with these animals, albeit in a rapidly changing environment (Forbes et al. 2009), which requires ongoing refinement of skills. Continued collaborative research in Iamal should provide many further unique insights on these compelling domestication process.

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Conflict of Interest Statement

The authors declare that they have not conflict of interest.

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Figure Captions

Figure 1. Map of the study area in the Russian North with locations of archaeological sites mentioned in the text indicated. 1. Komatyvis I; 2. Mys Vkhodnoi; 3. Tiutei-Sale I; 4. Mutnaia V; 5. Iur'-Iakha III; 6. Iarte VI; 7. Bhukhta Nakhodka; 8. Nadymskii Gorodok; 9. Ust'-Polui; 10. Poluiskii Gorodok; 11. Zelenaia Gorka; 12. Mokys Urii; 13. Niaksimvol'.

Figure 2. Barbed L-shaped antler objects from Ust'-Polui.

Figure 3. Example of antler swivel types at Ust'-Polui. a. type 1.0; b. type 1.1; c. type 1.2; d. type 1.3. The pins shown in a, b, and d were found *in situ* with the parts shown.

Figure 4. Unfragmented L-shaped and arched antler objects from Iarte VI. Item a. was considered unusual by all Nenets collaborators, while b. and c. were considered to be wholly consistent with antler parts in their current reindeer headgear.

Figure 5. Barbed L-shaped antler objects from Tiutei-Sale I. The objects were found together *in situ* at the site.

Figure 6. A Nenets man traveling on a sled pulled by three reindeer, Tambei region of the Iamal peninsula, June, 2018. In his left hand he holds the *khorei* (a wood pole) and in his right the *nenzamindya'sa* (head rope), both of which are used to communicate with the reindeer during sledding.

Figure 7. A simplified overhead schematic of the headgear and harnesses used with a sled pulled by three reindeer in Iamal. The antler pieces employed with the lead reindeer are shown in a. Those used with most secondary reindeer are shown in b. Alternatively, arched pieces are used in place of the L-shaped items with secondary reindeer, as shown in c. The lead reindeer (d.) is always positioned on the left, and the secondary reindeer (b. and c.) are to its right. The headgear of the lead reindeer is attached to the *nenzamindya'sa* (head rope) via a swivel. The dashed lines extending behind the deer represent the strapping that extends from the body straps to the sled.

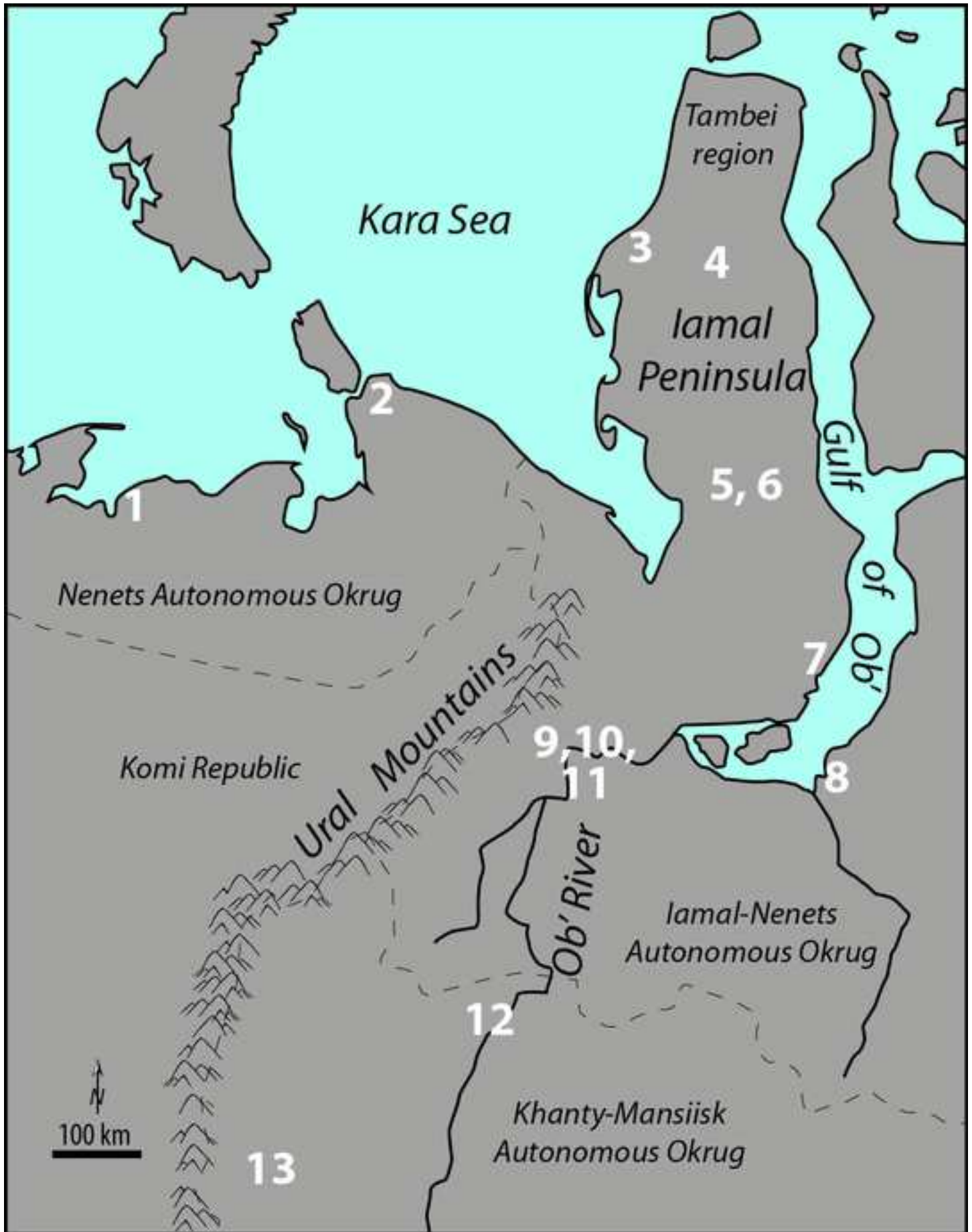
Figure 8. A lead reindeer wearing headgear in the Tambei region, Iamal peninsula, May, 2018. The straight antler piece is positioned just above its left eye (it is twisted to the right somewhat out of ideal position). The greenish *nenzamindya'sa* (head rope) is visible at the lower right and meets the strapping of the headgear at the metal swivel.

Figure 9. A barbed corrective device used by Chukchi in training transport reindeer collected in 1903. The object (# As-1903-12) is curated at the British Museum.

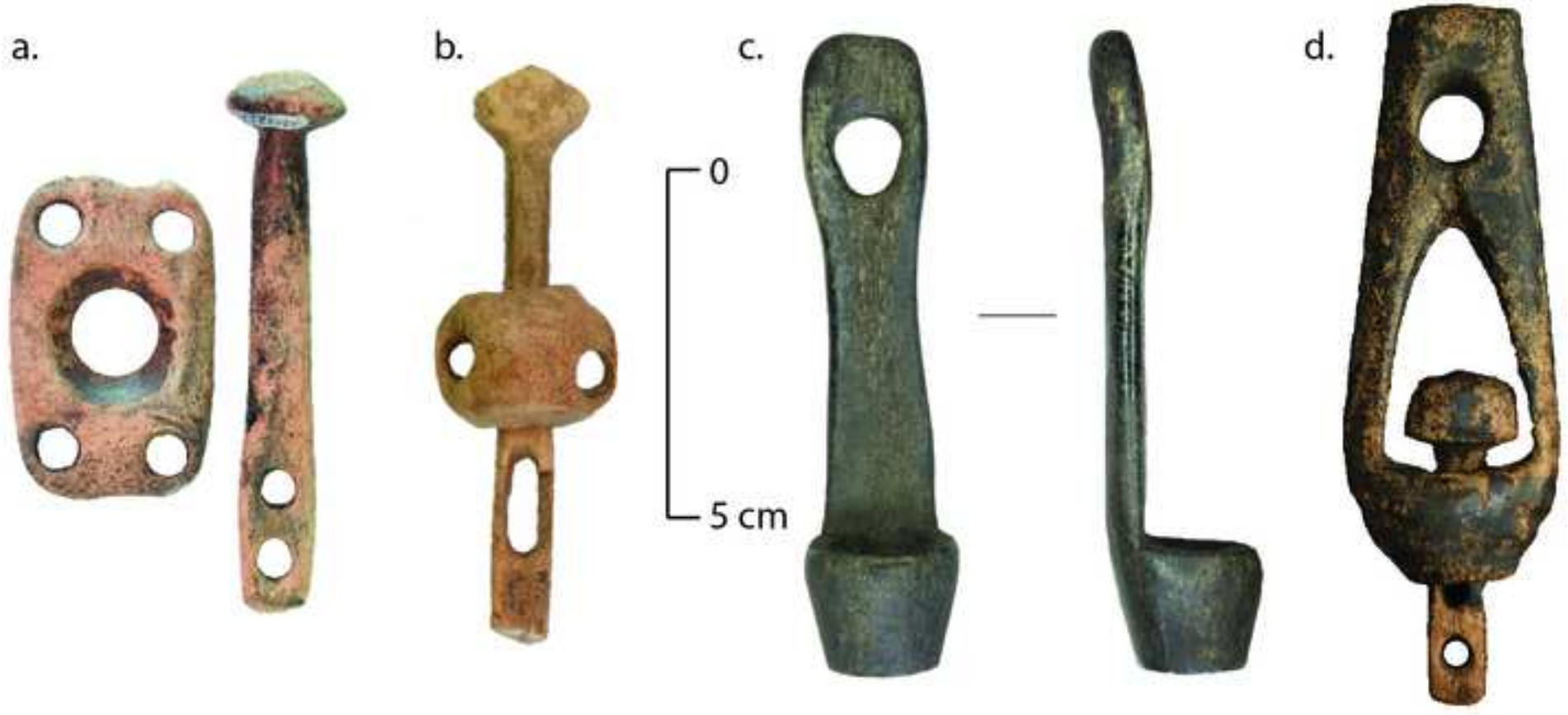
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4 Figure 10. Two secondary transport reindeer in the corral following training,
5 Tambei region, Iamal peninsula, May, 2018. The L-shaped antler pieces on both deer
6 have fallen out of position.
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9 Figure 11. Reindeer approaching the corral, Tambei region, Iamal peninsula, May,
10 2018. T. Nomokonova stands at left holding the line that forms the half-funnel
11 directing the deer toward the corral opening.
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Figure 1



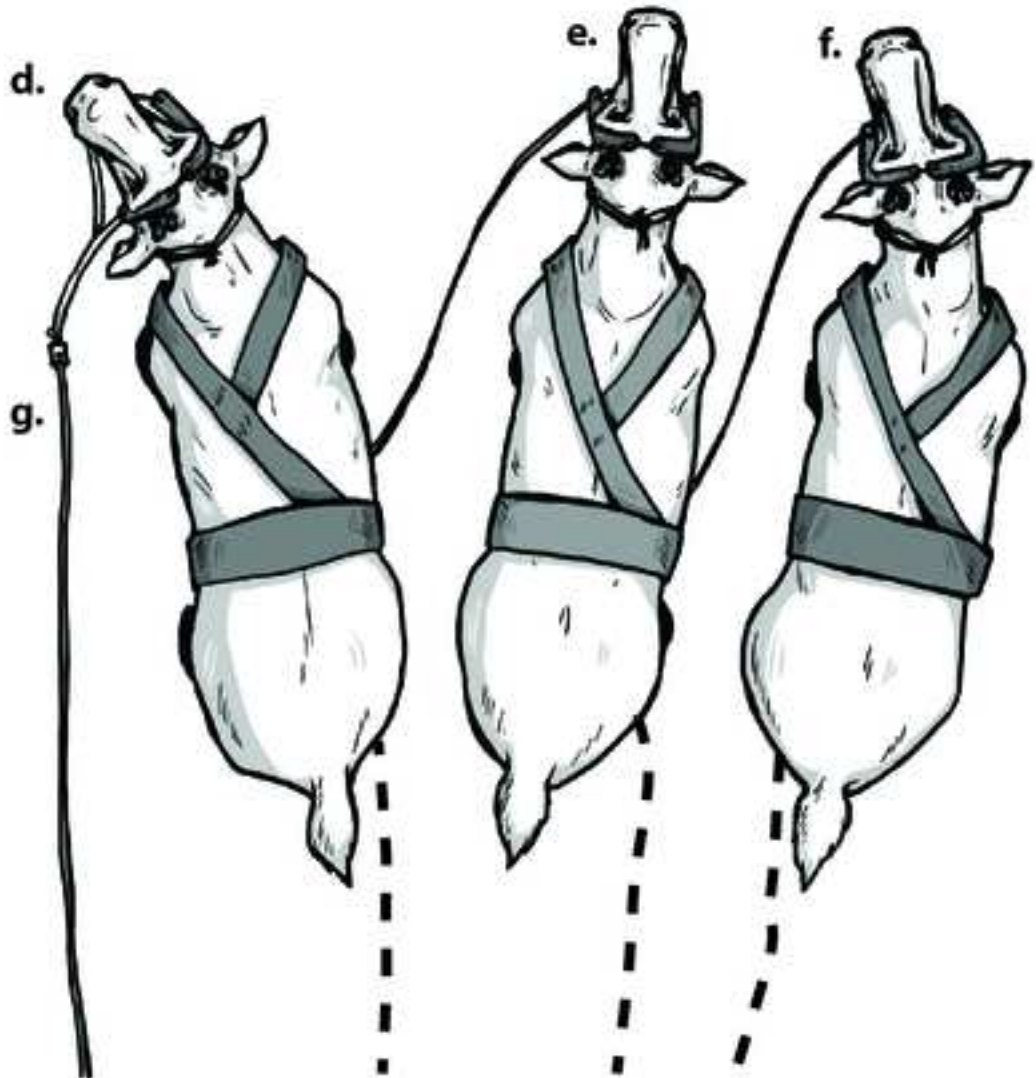
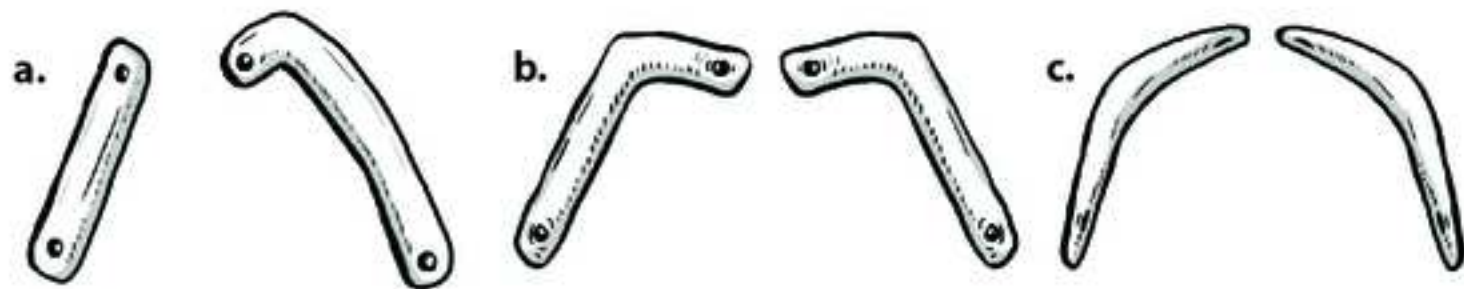




















	Mean	Length (mm) St. Dev.
Historic lead reindeer L-shaped pieces (n = 16)	174.5	24.7
Historic secondary reindeer L-shaped pieces (n = 63)	126.6	14.1
Archaeological L-shaped pieces (n = 11)	123.4	26.0
Archaeological L-shaped pieces, larte specimen removed (n = 10)	116.0	18.7

Range	Mean	Width at angle (mm)			Hole diameter (mm)		
		St. Dev.	Range	Mean	St. Dev.	Range	
115-212	22.7	5.5	13.0-30.3	8.4	2.9	4.6-19.8	
85-155	17.4	3.0	11.2-24.2	7.15	1.31	4.5-10.4	
93-168	12.6	3.9	8.0-20.0	4.80	1.60	3.0-7.0	
93-149	12.0	1.4	8.0-20.0	4.64	1.69	3.0-7.0	

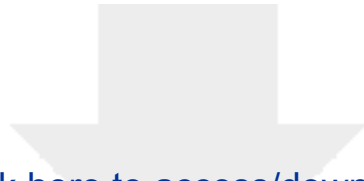
Mean	Angle (deg.)		Mean	Arm length ratio	
	St. Dev.	Range		St. Dev.	Range
109.9	8.1	94-127	1.99	0.51	1.27-3.45
107.2	7.9	93-124	1.33	0.21	1.00-1.73
108.7	11.3	85-120	1.10	0.26	1.00-1.80
111.1	8.5	94-120	1.12	0.28	1.00-1.80

	Mean	Length (mm)	
		St. Dev.	Range
Historic secondary reindeer arched pieces (n = 8)	132.5	22.5	106-165
Archaeological arched pieces (n = 2)	138.5	17.7	126-151

Mean	Height/length ratio			Width at angle (mm)			Mean
	St. Dev.	Range	Mean	St. Dev.	Range	Mean	
0.13	0.04	0.07-0.18	20.6	3.4	16.9-25.3	7.8	
0.18	0.02	0.17-0.20	15	0.0	--	5.5	

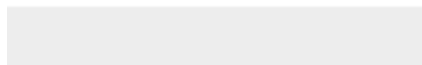
Hole diameter (mm)

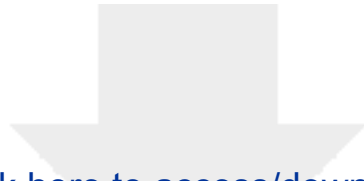
St. Dev.	Range
3.2	4.7-13.4
1.4	4.0-7.0



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