Online Resource 1

Feeding of prehistoric and historic horses at the eastern Baltic Sea region and western Russia

Archaeological and Anthropological Sciences

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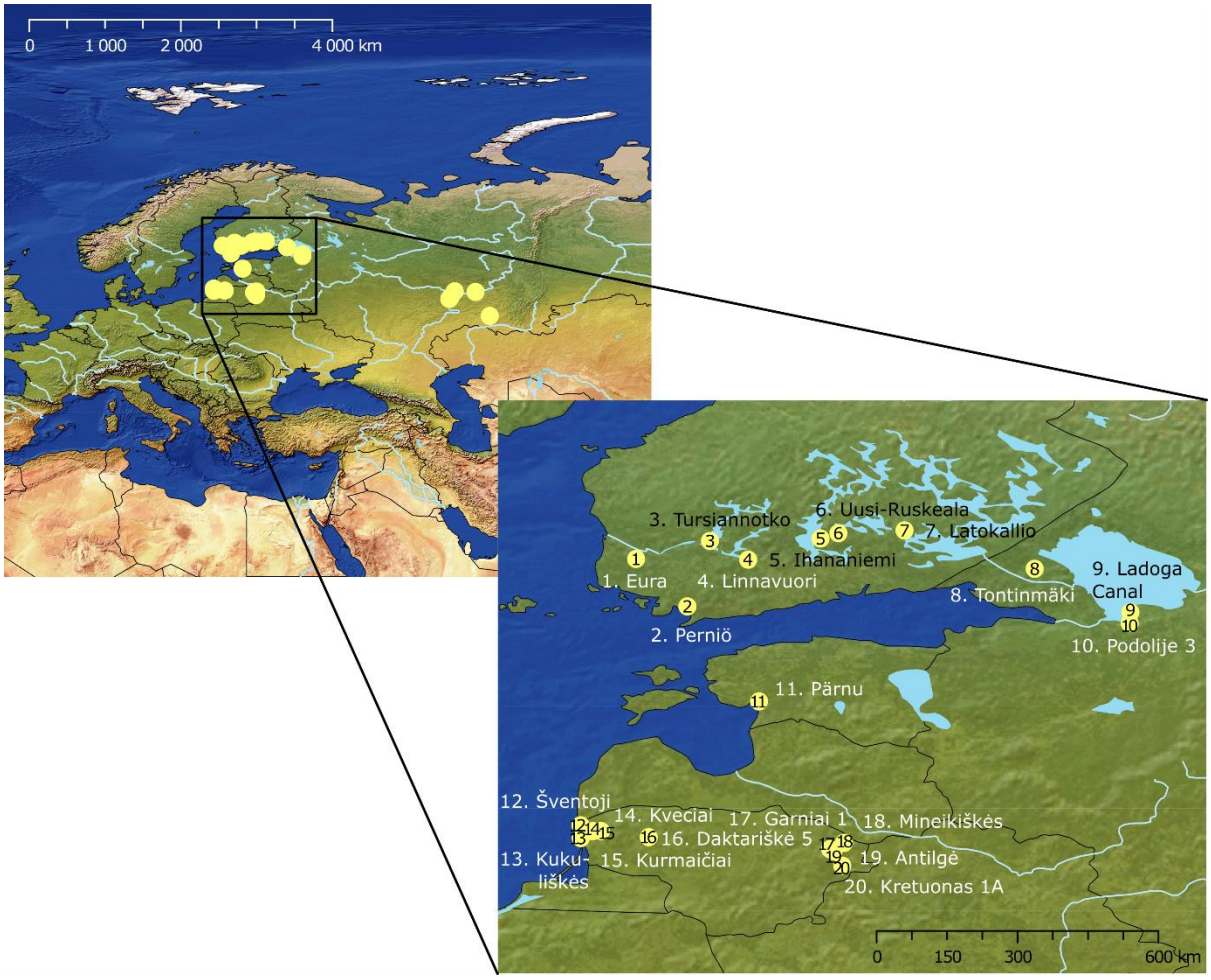
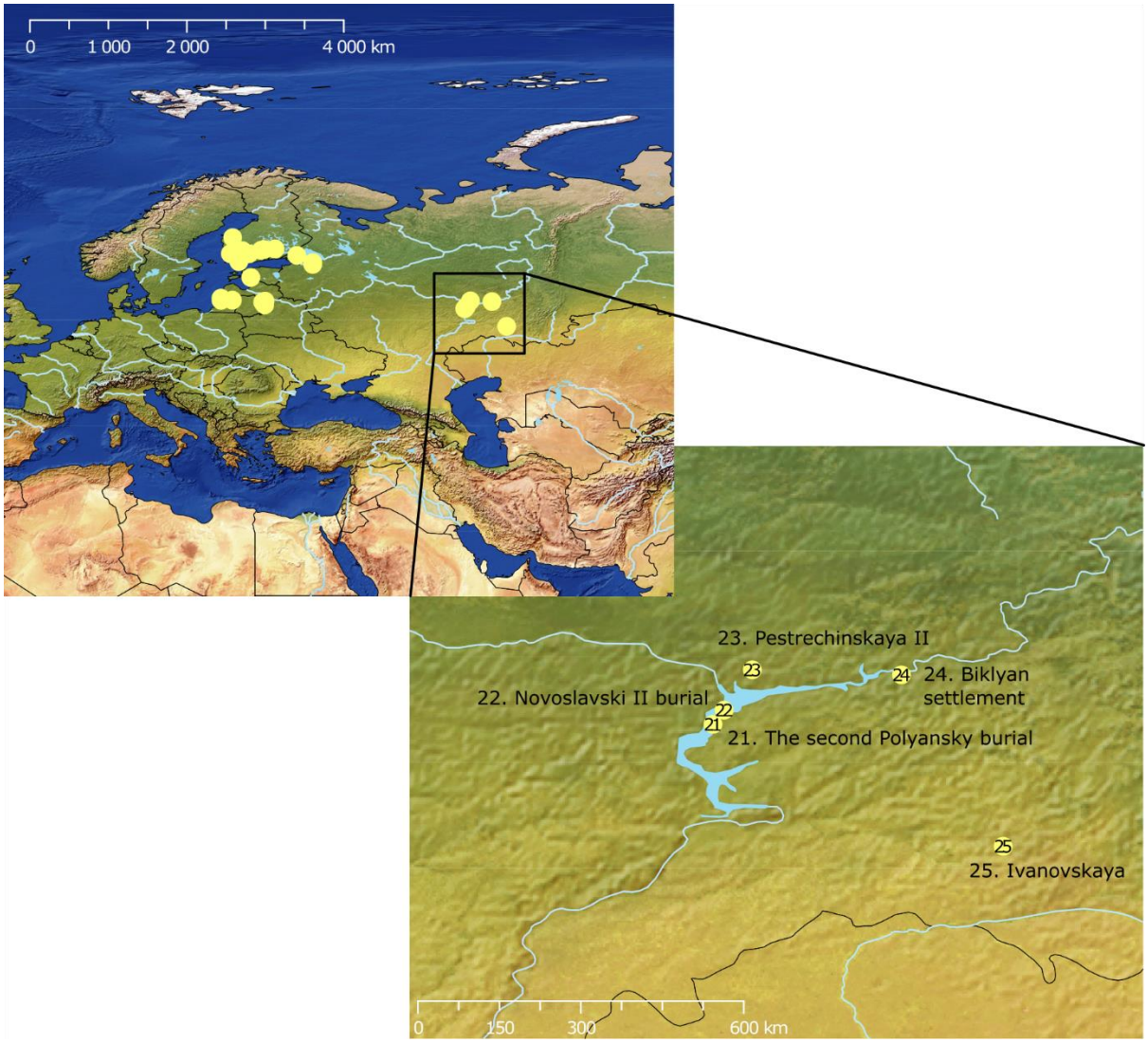


Supplementary Fig. 1 Archaeological sites or find sites selected for this study with the sampling sites within Finland, Estonia, Lithuania and Lake Ladoga area Russia shown in more detail. The numbering corresponds with Fig. 1 of the main article. As a background raster image, we used 1:50m Natural Earth II (public domain) which portrays the world in an idealized manner as it looked before the modern era with little anthropogenic influence.



Supplementary Fig. 2 Archaeological sites selected for this study with the sampling sites within the Middle Volga region in Russia shown in more detail. The numbering corresponds with Fig. 1 of the main article. As a background raster image, we used 1:50m Natural Earth II (public domain) which portrays the world in an idealized manner as it looked before the modern era with little anthropogenic influence.

Supplementary text 1

Characteristics of archaeological sites with investigated bone remains of horses

Archaeological sites in Russia

Geographical locations of the archaeological sites of the Lake Ladoga region samples are presented in Supplementary Fig. 1 and the Middle Volga region in Supplementary Fig. 2.

Bones of horses used for DNA analysis and isotope analysis with data on horse individuals: sex, age and size

The determination of the height at the withers of Russian horses was carried out from the greatest length of the bones (according to Vitt 1952) using corrected factors (according to Johnstone 2004), except for the Ivanovskaya site for which the size estimations are delineated in Supplementary text 2. Determination of the limb-robusticity category of horses was carried out according to Brauner 1916. The age determination of horses was determined on the basis of the dental development (eruption time, degree of wear and size of the teeth) according to Silver 1969, Levine 1982, Petrenko 1984 and Weber 1991.

Archaeological sites

Novoslavski II burial ground

The Novoslavski II burial ground (5^{th}–6^{th} centuries CE) belongs to the bearers of the Imenkovskaya archaeological culture with infiltration of the Turbaslin culture. The burial ground is located at the western tip of Spassky Island (or “Stary Gorod” Island) in the water area of the Kuibyshev Reservoir (Spassky District, Republic of Tatarstan). In 2015 and 2018–2019, 16 burials were investigated. A striking feature of the burial rite is the presence of the leg bones and the skull of a horse placed at the legs of the buried human, near the southern wall of the grave pit. Of the 16 burials, this was found in ten (burials 1, 2, 4, 5, 8, 9, 10, 12, 13 and 16). Some burials contained leg bones and skulls from several horses: two individuals in burials 8 and 9, and three in burial 13. Comparison of the sexes of the horses buried and those of humans buried with them showed that out of five female burials with the remains of horses, mares are represented in all, and stallions are represented in four male burials. This is also true for burials containing the remains of several other animals: domestic pigs, cattle and sheep. In burial 13 with the bones of a man and a woman, containing the skulls of three horses, two belong to stallions, the third is not identified. Burial 12, of unclear gender, contained the bones of a stallion's legs (the skull was most likely washed away by the water from Kuibyshev Reservoir). The buried humans were also accompanied by sacrificial food, as evidenced by the finds of animal bones located at the feet of the deceased and moulded pots placed to the south, west, north and southeast of the feet of the buried. The archaeological and archaeozoological

description of the burial ground was made by R.R. Valiev and G.Sh. Asylgaraeva (Valiev & Asylgaraeva 2020).

Novoslavski II burial was in a forest-steppe (a northern variant of the Trans-Volga herb steppes with areas of pine-deciduous forests) with almost no C_4-plants.

The following samples of horse bones were taken for DNA analysis and isotope analysis:

5A - Digging 1, 2019, burial 13, center, no. XXV – incisor from a stallion aged 10-11 years, height at the withers 130 cm (small size), thin-legged.

5B - Digging 1, 2018, burial 2, no. XXVI - splint bone from a stallion aged 8–9 years, height at withers 140 cm (medium size), semi-thin-legged.

5C - Digging 1, 2019, burial 9, eastern, no. XIX - incisor from a stallion aged 11–12 years, height at the withers 128-136 cm (small size), semi-thin-legged.

5D - Digging 1, 2019, burial 9, no. XXIII - incisor and petrous bone from a mare aged 9–10 years, height at withers 144-136 cm (medium size), thin-legged.

5E - Digging 1, 2018, burial 8, no. XXVII - petrous bone from a stallion aged 7–8 years, height at the withers 137 cm (medium size), semi thin-legged.

5F - Digging 1, 2019, burial 9, no. XXIII - molar, from a horse of unknown sex over two years old.

5G - Digging 1, 2018, burial 5, eastern, no. XXI - molar (M3) from a mare aged 10-11 years, height at withers 130 cm (small size), thin-legged.

5H - Digging 1, 2019, burial 12, no. XVIII – splint bone, gender unknown, height at withers 128-136 cm (small size), semi-thin-legged.

5I - Digging 1, 2018, burial 4, no. XXIV - molar from a stallion aged 6.5–7 years, height at the withers 136 cm (small size), thin-legged.

Podolije 3 (Lake Ladoga, Karelia)

Podolije 3 is located on the left bank of the Lava River, 4 km from the southern coast of Lake Ladoga, 0.5 km north of the village of Podolije, Kirovsky District, Leningrad Region, excavated in 2015–2019 over an area of more than 60 m^2 (Gusentsova 2017). The archaeological site was inhabited repeatedly during the Neolithic and Early Metal Ages, until the Late Middle Ages. The sequence of settlement is confirmed by a series of radiocarbon dates within 3900–1800 cal BCE and 1493–1780 cal CE (Gusentsova & Kulkova 2020). Archaeozoological studies were carried out by I.V. Askeyev. The main game animals of the inhabitants of the site in the Neolithic and Early Metal Ages were moose (*Alces alces*), beaver (*Castor fiber*), Ladoga ringed seal (*Pusa hispida ladogensis*), pine marten (*Martes martes*), wild boar (*Sus scrofa*) and mountain hare (*Lepus timidus*); he also draws attention to the presence of bone remains of a horse in the layers of the late Middle Ages: 2 teeth and 1 femur (Gusentsova et al. 2020).

The following samples of horse bones were taken for DNA analysis and isotope analysis:

6 - Deciduous upper premolar PM^3 (upper crown of the tooth) from the late Middle Ages layer.

Pestrechinskaya II site (Pestretsy II)

Pestrechinskaya II site is located on the territory of the Republic of Tatarstan, 25 km east of Kazan in the Pestrechinskiy district on the right bank of the river Mesha (right tributary of the Kama River) at the confluence of the Sula River. The archaeological site was discovered in 1977, and excavations were carried out in 2013. As a result of the excavations, cultural strata were investigated, containing in the bulk the remains of settlements of the Late Bronze Age (Zaimishchensky cultural type) and the early Iron Age (Ananyino cultural and historical unity). The archaeozoological description of this archaeological site showed the presence of bone remains from 17 species of mammals, 12 species of birds and 3 species of fish. The basis of the population's economic activity was farming and hunting for wild ungulates (reindeer *Rangifer tarandus*, moose *Alces alces*, Siberian roe deer *Capreolus pygargus*) and beaver *Castor fiber* (Askeyev et al. 2019). According to the studied bone remains, reindeer (19.5% of the total number of bones) and beaver (8.8%) were the main prey. Percentages of bone remains of domestic animals are: horse (5.1%), cattle (5.6%), pig (7.6%) and sheep (0.1%). The age and size composition of horses, as well as the presence of characteristic pathologies on the bones, indicate a diverse use of horses by the inhabitants of this settlement: horseback riding and draft use, and horses were also used for meat.

The Pestrechinskaya II site was in a coniferous-deciduous forest with almost no C_4-plants.

The following samples of horse bones were taken for DNA analysis and isotope analysis:

7 - Phalanx II of the left hind leg of an adult horse "medium-sized" from layer 8.

The Second Polyansky burial ground

The burial ground is located 350 meters from the village of Polyanka, Spassky district of the Republic of Tatarstan, on the edge of the third terrace on the left bank of the Volga River. This archaeological site was discovered and excavated in 1962, an area of 468 m^2 was excavated and 30 burials of the transitional period from the Late Bronze Age to the Early Iron Age were studied (Khalikova 1967), belonging to the period of the Post-Maklashevo archaeological culture (1100-900 BCE). The upper layer, in which there are no burials, contains the remains of the cultural layer of the settlement and dates to the period of the Volga Bulgaria (1000 - 1200 CE). Archaeozoological studies were carried out by V.A. Popov and T.M. Kulaeva, the collection of bone remains contains remains of molars from four species of domestic animals: horses, cattle, sheep and pig (Archive of Biomonitoring Laboratory, Institute of Problems in Ecology and Mineral Wealth, Tatarstan Academy of Sciences). Animal bones found in the burials (28 bones) are the remains of sacrificial food, objects of worship, bone products and ritual actions. It should be noted that some animal remains were found in the upper layer (medieval) that did not contain a burial, including 2 horse molars.

The second Polyansky burial was in a forest-steppe (a northern variant of the Trans-Volga herb steppes with areas of pine-deciduous forests) with almost no C_4-plants.

The following samples of horse bones were taken for DNA analysis and isotope analysis:

8 - Lower molar (M^1) (permanent) from a 6–10-year-old individual from the medieval layer.

Biklyan settlement

Biklyan settlement is located to the north-west of the village Biklyan (Tukaevsky district, Republic of Tatarstan). It occupies a cape and the territory adjacent to it, above the floodplain terrace of the left bank of the river Malaya Kamyshka (left tributary of the Kama River). The archaeological site was discovered in 2016, and in 2018, excavations were carried out on it in an area of 100 m^2. The complex of artefacts from the Biklyan settlement finds the closest analogies with the materials of the sites from the beginning of the era of the Great Migration of Peoples in the Middle Volga region (3^{rd} –4^{th} centuries CE) (Lyganov et al. 2021). The analysis of fried grains, carried out in the Laboratory of A.E. Lalonda of the University of Ottawa (Canada) showed that the last stage of its functioning dates back to 302±58 cal CE (UOC-10747) - 303±54 cal CE (UOC-10748) (Lyganov et al. 2021). The archaeozoological description of this archaeological site was carried out by G.Sh. Asylgaraeva and I.V. Askeyev. Domestic animals dominated in the collection of bone remains; cattle (38.5%), pigs (22.2%), sheep (11.1%), while horses are represented by 48 bone remains (28%). Only single wild animals are represented in the collection: beaver (*Castor fiber*), fish (2 species) and birds (4 species).

The Biklyan settlement was in a forest-steppe (a northern variant of the Trans-Volga herb steppes with areas of pine-deciduous forests) with almost no C_4-plants.

The following samples of horse bones were taken for DNA analysis and isotope analysis:

9 - Mandibular molar M_2 (permanent) from a 4–6-year-old individual.

Ivanovskaya site (Ivanovka)

The Ivanovskaya site is located 5 km south of the village of Ivanovka, Krasnogvardeisky district, Orenburg region, on the banks of the oxbow river Tok. The archaeological site was excavated in 1977 - 1982, the explored area was more than 2000 m^2, subdivided into three layers: Neolithic, Eneolithic and Late Bronze Age (Morgunova 1995). The Neolithic cultural layers were successively formed by the bearers of the Elshan and Middle Volga archaeological cultures (7900–5800 BP) (Vybornov & Kulkova, 2021), the Eneolithic layers contain cultural remains belonging to the bearers of the Samara and Khvalyn archaeological cultures (Morgunova 1995, 2011), and the layers of the Late Bronze Age are characterized by finds of archaeological materials belonging to the Abashevskaya and Srubnaya archaeological cultures. Archaeozoological studies of this archaeological site were carried out by A.G. Petrenko (2007). Studies have shown that the main activity of the inhabitants of this settlement in the Neolithic and Eneolithic was hunting for large ungulates (wild horse *Equus ferus/E. ferus ferus* and moose

Alces alces) and beaver (*Castor fiber*), and starting from the Eneolithic and, especially during the Bronze Age, animal husbandry. The horse, both the wild and domestic forms, played a very important role in the economic and spiritual life of the inhabitants throughout the entire existence of this site. This is clearly demonstrated by quantitative data on the diagnosed horse bone remains in different time layers: Neolithic - 584 bone remains (41.7% of all bone remains), Eneolithic - 2442 bone remains (40%) and Late Bronze Age - 608 bone remains (30.3%).

The Ivanovskaya site (Ivanovka) was in the steppe (Zavolzhsko - North Kazakhstan variant cereals [feather grass-fescue] with elements of forb areas) with very few C_4-plants and transitional C_3/C_4-plants.

The following horse bones were taken for DNA analysis and isotope analysis:

10 - Lower molar (M_2) (permanent) from a 5–6-year-old individual from the Neolithic layer.

Ladoga Canal, (Lake Ladoga, Karelia)

Ladoga Canal is a multi-chronological and multi-layered archaeological assemblage, excavated during the canal construction in the 18th century in the southern coast of Lake Ladoga, Karelia, Russia. The osteological assemblage, consisting of mammals (including human remains), birds and fish has originally been analysed by several osteologists in the 19th century and published in 1882 (Inostrantsev 1882). A new project aiming to study the chronology of the assemblage was launched in 2019 between the University of Helsinki, the Museum of Staraya Ladoga (Staraya Ladoga) and the Peter the Great Museum of Anthropology and Ethnography (St. Petersburg). Two horse samples included in this study derive from humerus and a mandibular tooth and both date to early modern or modern period. The materials from Ladoga Canal are stored at the Museum of Staraya Ladoga.

Hovinsaari Tontinmäki in Räisälä in Karelia, Russia (former Finland)

See below from the chapter “Archaeological sites in Finland”.

Archaeological sites in Lithuania

Geographical locations of the Lithuanian archaeological sites are presented in Supplementary Fig. 1. The zooarchaeological material from all the below-mentioned sites is stored in the repository of the Vilnius University, Faculty of History.

Antilgė

Antilgė fortified settlement site is located in north-eastern Lithuania on the hill near Sylis Lake. It was investigated in 2016 and 2017. A total area of 71.5 m^2 was excavated, and the remains of buildings and fortifications were found on the hillfort. An abundant find collection was discovered during the investigation: 9,685 pottery sherds, and about 300 artefacts - casting forms

for pins, the first iron needles in eastern Lithuania, crook-shaped iron pins, bone and stone artefacts, and about 4,000 fragments of zooarchaeological material. The majority of the artefacts were dated to the Early Roman Period, with fewer finds to the Late Bronze Age. According to the six AMS ^{14}C dates, the site was inhabited in two episodes: 8th-5th century BCE (Late Bronze Age) and 1st–3rd c. CE (Roman Iron Age) (Poškienė et al. 2018, Podėnas 2022). Four horse samples (aEca1, aEca2, aEca3, aEca4) from Antilgė were analysed in this study, and two teeth (MIS 2) were AMS ^{14}C dated to 15–201 cal CE and 18–201 cal CE (this study).

Daktariškė 5

Daktariškė 5 settlement site was excavated in 1987–1990 (648 m^2) and 2016 (48.6 m^2). In this stratified site, a total of 437 flint flakes and artefacts, 11,600 pottery sherds, 143 amber flakes and artefacts, hundreds of bone and antler artefacts, wooden piles, floats, as well as an artefact fragment, presumably made from bronze, were discovered. The finds date back to the Sub-Neolithic–Early Bronze Age, 4500–1700 cal BCE. In 2016, 244 animal bone fragments were found, including two horse bone fragments (Piličiauskas 2018, Piličiauskas et al. 2017). One horse bone (talus, aEca10) was sampled, included in this study, and AMS 14C dated to 4540-4369 cal BCE (this study). So far, it is the earliest directly dated horse bone in Lithuania.

Garniai 1 and Mineikiškės

Garniai 1 and Mineikiškės are fortified settlement sites, located in north-eastern Lithuania, on isolated hills near two rivers Kriauklė and Nikajus. The distance between sites is 21 km. Both rivers mentioned are parts of different river basins - Neris-Nemunas running southwest, and Daugava, running northwest. Therefore, the area among these sites could have been an important land route between Daugava and Nemunas river basins. The region bordering these river basins was important for the development of early fortified settlements as at least 1/3 of all Late Bronze Age fortified settlements in the Eastern Baltic region are located in this area. The sites were inhabited by farmers who might have been engaged in the bronze trade. The archaeological artefacts and AMS ^{14}C dating for both sites fall to the Late Bronze Age (1800-500 BCE), with no finds indicating later periods (Podėnas 2020, Podėnas 2022).

In **Garniai 1,** an area of 107 m^2 was excavated in 2016–2017, and 2021. Several features attributed to postholes of houses were identified. Eighty-seven artefacts made of antler, bone, bronze, ceramics, flint, stone, 1,140 fragments of pottery and 2,432 animal bones were also collected. A tooth of sheep/goat, a tibia of large ungulate, and a horncore of a large bovid found in Garniai 1 were AMS-dated to 786–541 cal BCE. Seven horse bone fragments and teeth (MNI 2) contained 1.3 % of all identified faunal remains of the site (Podėnas 2020, Podėnas 2022, Minkevičius et al. 2024). Two horses' teeth (samples aEca11, 799-570 cal BCE, and aEca12, 770-541 cal BCE, this study) from Garniai 1 were included in this study.

In **Mineikiškės**, 40 m^2 was investigated in the southern part of the settlement during 2017 and 2020. The assemblage consists of 99 artefacts fragments made of antler, bone, ceramics,

bronze, flint, and stone, supplemented by 5,889 pottery sherds and 7,948 specimens of animal skeletal remains. Bones of horse and large bovid, charred organic residues in pottery, and grains and wood charcoal (altogether 19 finds) were AMS-dated to the period from 983 to 388 cal BCE. One-hundred-four horse bone fragments and teeth (MNI 8) were found during the excavations, which contained 5.3 % of all identified faunal remains (Podėnas 2020, Podėnas 2022, Minkevičius et al. 2024). Two samples from Mineikiškės were included in this paper (aEca5, 807–776 cal BCE (this study), and aEca6).

Kukuliškiai

Kukuliškiai hilltop settlement site is located on the edge of the Littorina Sea terrace, around 300 m from the Baltic Sea shore. The site was first discovered in 2016. Archaeological excavations have taken place in 2017, 2018, 2020 and 2022. During the four seasons of the field survey, 68 m2 were excavated, and 1346 artefacts were collected. Fifteen AMS 14C dates revealed that the site dates to 883–400 cal BCE and consists of one occupational layer (Urbonaitė-Ubė & Brorsson 2024). A total of 950 animal bones were found in Kukuliškiai. Horses remains (n = 47) accounted for 10% of the identified mammals, and most of the horse bones had butchering marks (Minkevičius et al., in preparation)

Kurmaičiai

Kurmaičiai barrow cemetery, located in western Lithuania, contains 15 barrows and dates to the Late Bronze–Roman Period. The site was excavated in 1940, 1948, 1950-1951 and in 2010, twenty-eight cremated and four inhumated human burials were found. Two horse teeth were found in barrow 8 and two more were found in barrow 11 (Kulikauskas, 1968; Merkevičius, Murdian 2016) The horse teeth from barrow 8 were associated with the Late Bronze Age, as cremated human bones from the same barrow were AMS 14C dated to 766–425 cal BCE (Muradian 2022). However, the direct date of a horse tooth from barrow 8 was later (1900±30 BP, this study), and related horse remains to the Roman Period.

Kveciai

Kveciai barrow cemetery, located in western Lithuania, was excavated in 1963. The burial site included two partially damaged barrows. They were 1 to 1.65 m high and 6 to 13 m wide, surrounded by stone circles. Barrow 1 contained twelve cremated human burials and the skeleton of a horse, while three cremated human graves were found in a barrow 2. Based on the archaeological context, the barrows were dated to the Late Bronze Age – the pre-Roman Iron Age (Merkevičius 1963). Later, grave no. 11 in a barrow 1 has been dated to 771–423 BCE and based on this date, the horse remains from the same barrow were assumed to be the earliest horse grave in Lithuania (Merkevičius & Muradian 2016). However, the horse bones were incredibly well preserved, so their direct 14C date of 221±30 BP (this study) was not surprising.

Šventoji

Šventoji archaeological complex was discovered in 1966 during irrigation works carried out in the region. At the time, more than 60 sites as well as many stray finds dated to the period between 6000 and 500 cal BCE were identified. Šventoji sites are located on a swampy

Littorina sea terrace, 16 km long and up to 2.5 km wide, stretching between the City of Palanga and the Lithuanian Latvian state border. The sites were interpreted as habitation sites, refuse layers, fishing stations and possibly pile dwelling sites. A number are wetland sites with well-preserved organic materials were found in waterlogged lake deposits. The subsistence of the Šventoji site's inhabitants was based on freshwater fishing and hunting, and the seal bones comprise 30-40% of all mammal bones (Rimantienė 2005, Piličiauskas 2016, Luik & Piličiauskienė 2016).

Šventoji 23 settlement site was located on the eastern bank of the ancient lagoon. The site was investigated in 1970–1971. An area of 1500 m^2 was uncovered during the archaeological investigations. 16,070 pottery sherds, 1,330 flint artefacts, 5,170 amber debris, flakes and artefacts, dozens of bone tools and other finds, dated to 3200-2500 cal BCE were found during the excavations (Rimantienė 2005, Piličiauskas 2016). Approximately 10 horse bones were found in the zooarchaeological collection of the Šventoji 23 site. These were better preserved than the rest of the zooarchaeological material from this site. One horse bone (humerus, aEca13) was included in this study. AMS 14C dating (1528-1795 cal CE, this study) confirmed that the horse is younger and not related to the Subneolithic-Neolithic settlement site

Šventoji 41B site was excavated in 2012. The site is represented by a find spot at the Bronze Age riverbed. Fifty-two finds - remains of wooden fishing structures and fishing traps, stone weights, as well as an antler hoe and two horse teeth dating to 3200-2500 cal BCE and 1200–600 cal BCE were discovered (Piličiauskas et al. 2013). Horse premolar/molar tooth (aEca14), dated to 1107-925 cal BCE (this study) was included.

Šventoji 43 was discovered and investigated in 2013 and 2014. It revealed a homogenous Comb Ware pottery assemblage and was AMS ^{14}C dated to 3900–3650 cal BCE. A total area of 67 m^2 was excavated, and 25,826 highly fragile pottery fragments, 2,198 pieces of processed amber, 1,939 of flint debitage and tools, about 2,000 pieces of non-siliceous rocks and approximately 26,000 pieces of zooarchaeological material were collected in the site. Seven hundred eighty-six fish bone fragments and 661 specimens of mammal remains were identified to the species level. Fourteen horse bone fragments contained 2.1 % of all identified mammal bones (Piličiauskas et al. 2019). Horse tibia (aEca15, 3958–3798 cal BCE, this study) and talus (aEca16) were sampled for this study.

Archaeological sites in Estonia

Geographical location of the Estonian bone find is presented in Supplementary Fig. 1.

Pärnu

A complete left femur of a horse was found on the sandy beach of Pärnu in 2017 by Kristiina Mannermaa. Several straight marks, potential cut marks were visible on the bone shaft. The origin of the bone is unknown, but it has potentially been revealed from the Pärnu River bank by erosion and then exposed and transported with the help of the wave forces. The bone is stored at the Archaeology laboratory of the University of Helsinki.

Archaeological sites in Finland

Geographical locations of the Finnish (and former Finnish, now Russian) archaeological sites are presented in Supplementary Fig. 1.

Ihananiemi in Sysmä

The late Iron Age (1000–1500 CE) complex in Ihananiemi was excavated in 2000 by Hannu Poutiainen. The area has several ancient activity areas, for example, occupation areas and burial cairns. Some of them may be from the historical period. We analysed eight horse bones or teeth samples from Ihananiemi: KM32291: 212 (maxillary M1 sin), 274 (mandibular M1 sin), 377 (maxillary M1 sin), 521 (maxillary M1 sin and humerus sin), 526 (tibia dex), 640 (mandibular M1 sin) and 736 (mandibular M1 sin). They derive from different excavation squares in the settlement area but unfortunately, more precise find contexts are not available. The material from this site was very rich, containing unburnt animal bones (ca 27 kg), bone and metal artefacts, silver coins, stone settings and iron slag (Poutiainen 2000). Three horse samples were radiocarbon dated to the first millennium CE (KM32291:274) and to the 3rd or 4th millennium CE (KM32291:377 and 521). The material is stored in the collection of the Finnish Heritage Agency.

KM32291:212 square 106/484

KM32291:274 square 98/478

KM32291:377 square 98/478

KM32291:521 square 105/490

KM32291:526 square 105/492

KM32291:640 square 104/482

KM32291:736 square 104/482

Tursiannotko in Pirkkala

KM39258:726

A Late Iron Age farm/village site Tursiannotko (c. 700–1300 CE) is located in Pirkkala, Southern Finland. Iron Age and medieval settlement layers have been found mixed together in the area. Investigated on several occasions between 1987-2022, Tursiannotko is one of the most investigated Iron Age settlements in Finland. Preservation of the organic material is exceptionally good in the Finnish context. We sampled one horse bone from the rescue excavations conducted in 2012, led by Sami Raninen. The bone was found in the fourth layer in the area 2/Y1 which is a blackish grey undisturbed cultural layer (Raninen 2012). The horse dates to c. 1000

CE. Bone assemblages from Tursiannotko are stored in the archives of the Finnish Heritage Agency.

Luistari in Eura

The Iron Age cemetery of Luistari (c. 650–1050 CE) is situated in Eura, western Finland. For this study, we selected one fragmented horse premolar or molar from the test pit which was found close to the surface. It is catalogued with the find number KM20552:219. Our radiocarbon date dates it to the 17th century, meaning that it does not belong to prehistoric activities. The test pit was excavated by Pirkko-Liisa Lehtosalo Hilander in 1979. The Luistari bone collections are stored by the Finnish Heritage Agency.

Knaapila in Perniö

Unburnt foal bones were found during Aarne Europeus´ inspection of a Bronze Age (c. 1700–500 BCE) stone cairn area in Knaapila, Perniö in 1925. In the summer of 1924, the archaeologist Dr. A. Europaeus inspected the cairns/stone mounds of the lower ruin group of Knaapila Varemäki. Professor A.M. Tallgren surveyed the stone cist in 1924, and Helmer Salonen in 1929 studied the associated stone mound/cairn. Ella Kivikoski conducted an archaeological excavation of one of the other cairns of Varemäki in 1937.

Twenty years before Europeus´ inspection, local people had found a 3-meter-long cist made of large stones from the same place. Inside the cist they had picked up two skulls. Europeus was able to find unburnt animal bones and teeth, and remains of the destroyed stone cist. Human skulls have not been dated but according to our radiocarbon dating, the horse is from the 17th century. We analysed one bone (metatarsus or metacarpus) and a tooth. The bones belong to the collection of the Finnish Heritage Agency and have a number KM8612:1.

Hovinsaari Tontinmäki in Räisälä in Karelia, Russia (former Finland)

KM2553:23

The first excavations of Hovinsaari Tontinmäki in the Municipality of Räisälä (Räisälä 28 Särkisalo Hovinsaari Tontinmäki) were made by archaeologist Reinholm in 1846, and several researchers have investigated the site after that. The horse tooth investigated in this study derives from 1887 excavation by Theodor Schvindt and is stored at the archives of the Finnish Heritage Agency (Schvindt 1893; Nordqvist et al. 2008). Settlement activities (for example, hearths) and mostly destroyed inhumation burials have been detected in the area. The occupation activities contain finds from Iron Age Age and Middle Ages. The layers are heavily mixed after construction work (Nordqvist et al. 2008). The precise context of the studied horse bone is not known, but it was found in the context associated with a stone setting (size approximately 7x15 metres) together with human skull fragments, cattle, sheep, pig teeth, and skull fragments

and fish and bird bones. Also, a mussel shell fragment and charred wood fragments were found in the same context (Schvindt 1893).

Uusi Ruskeala C in Hartola

Uusi Ruskeala C is an Iron Age and historical period (c. 1000–1500 CE) settlement site in Hartola, Southern Finland. It was excavated by Petro Pesonen in 2009 (Pesonen 2009). The excavation material consists of animal bones (mostly domestic species), pottery, glass, pipes and Iron artefacts. Occasional copper and bronze artefacts were found, as well as glass pearls. The horse bones chosen for our study are a radius from structure 11 (KM37985:63) and from a right radius from structure 31 (KM37985:125, radiocarbon-dated to the 17th century). Structure 11 is a potential stove pit (finds are glass, burnt clay and animal bones) and the function of the structure 31 is unknown (finds are burnt clay, quartz flakes, clay pipe fragments, glass, and animal bones). The bones belong to the collections of the Finnish Heritage Agency.

Tenholan linnavuori in Hattula

The Tenhola ancient hill fortification in Hattula, Southern Finland was excavated by Jouko Voionmaa in 1948. It was in use in the Iron Age and Middle Ages, and probably also in the 15th and 16th centuries. No report has been delivered from Voionmaa´s excavation in 1948, and the contextual details of the horse premolar fragment chosen for this analysis are not known. The tooth dates from the 8th–10th century according to our radiocarbon dating. The tooth is part of the collection number KM11968:21 and it is archived by the Finnish Heritage Agency.

Moisio Latokallio in Mikkeli

Excavation in the Late Iron Age (ca 800–1200 CE) settlement site in Moisio Latokallio in Mikkeli was led by Eeva-Liisa Schultz in 1993. Fragments of an unburnt horse mandible were found in structure 17, a potential stove pit. Also, other bones, burnt clay, an iron knife and a small silver ring were found (Schultz 1993). The horse tooth analysed here was radiocarbon-dated to the 12th-13th century and has museum number KM 28014:49. It is part of the collections of the Finnish Heritage Agency.

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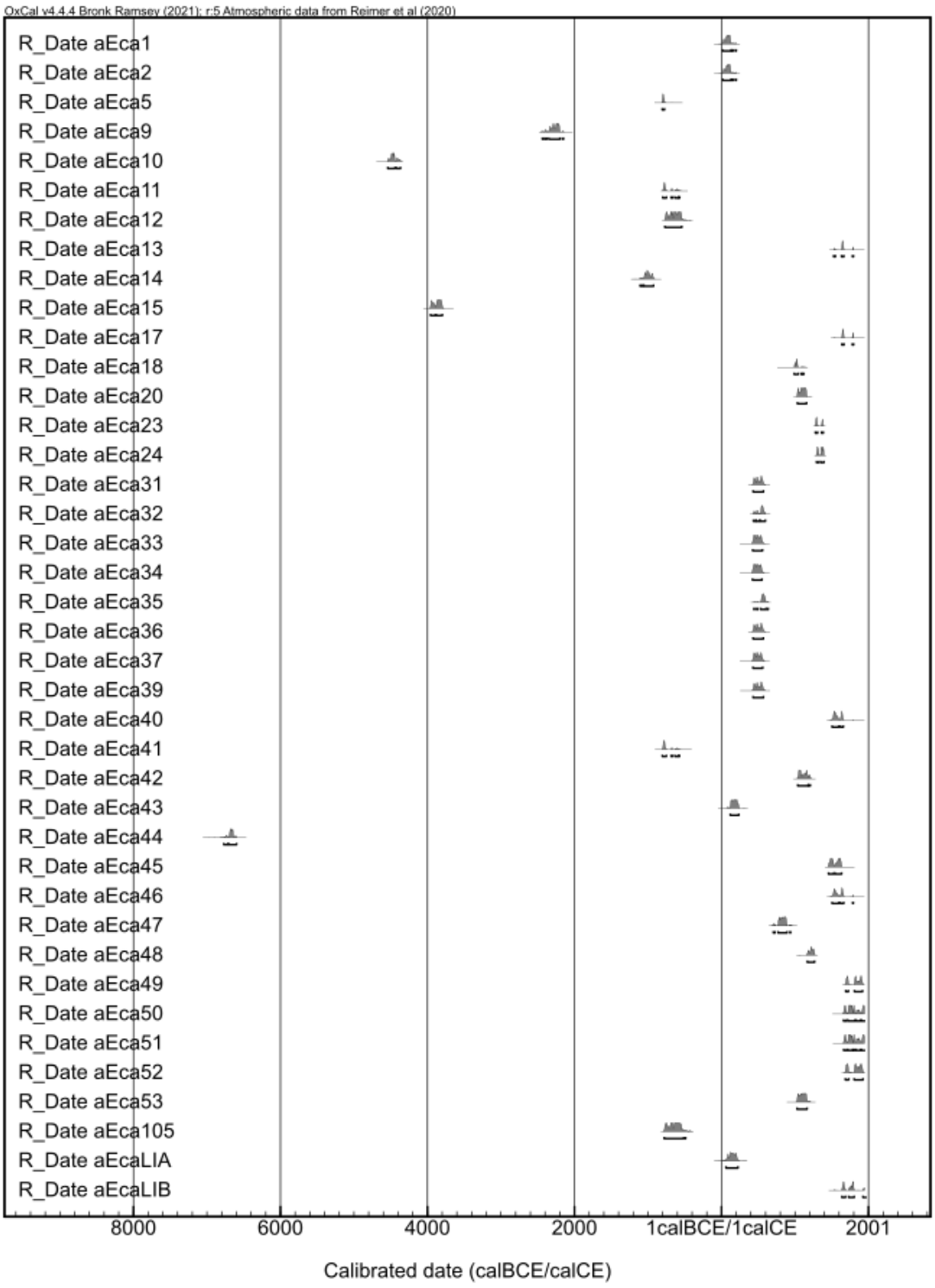

Supplementary Fig. 3 Calibrated ^{14}C dates and Bayesian modelling of 38 bone collagen or tooth dentine samples with the OxCal 4.4 program (Ramsey 2009) with IntCal20 (Reimer et al. 2020) for Russian, Finnish, Estonian and Lithuanian horses. Thirty-seven of the samples were radiocarbon dated in this study and for five samples the ^{14}C dating was published previously.

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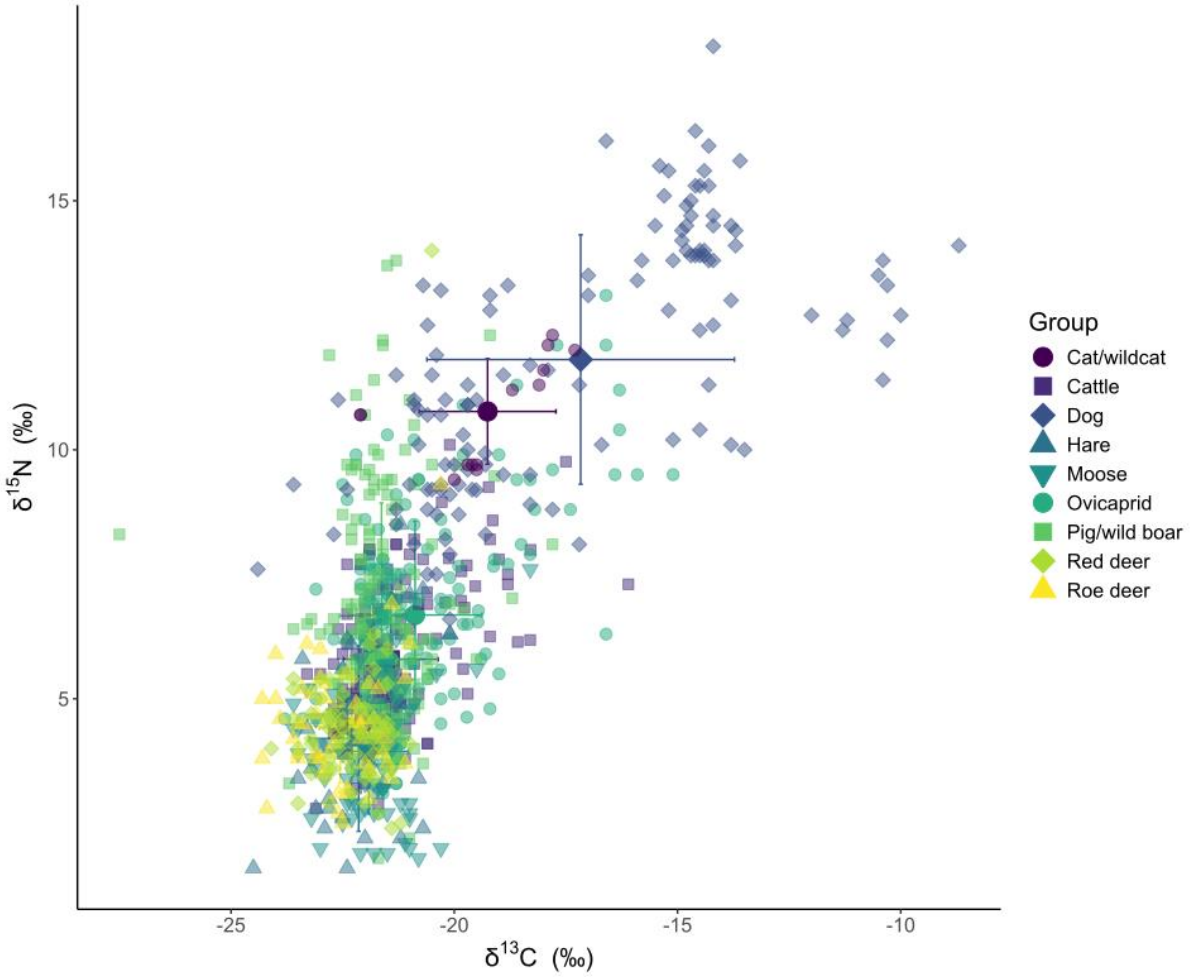
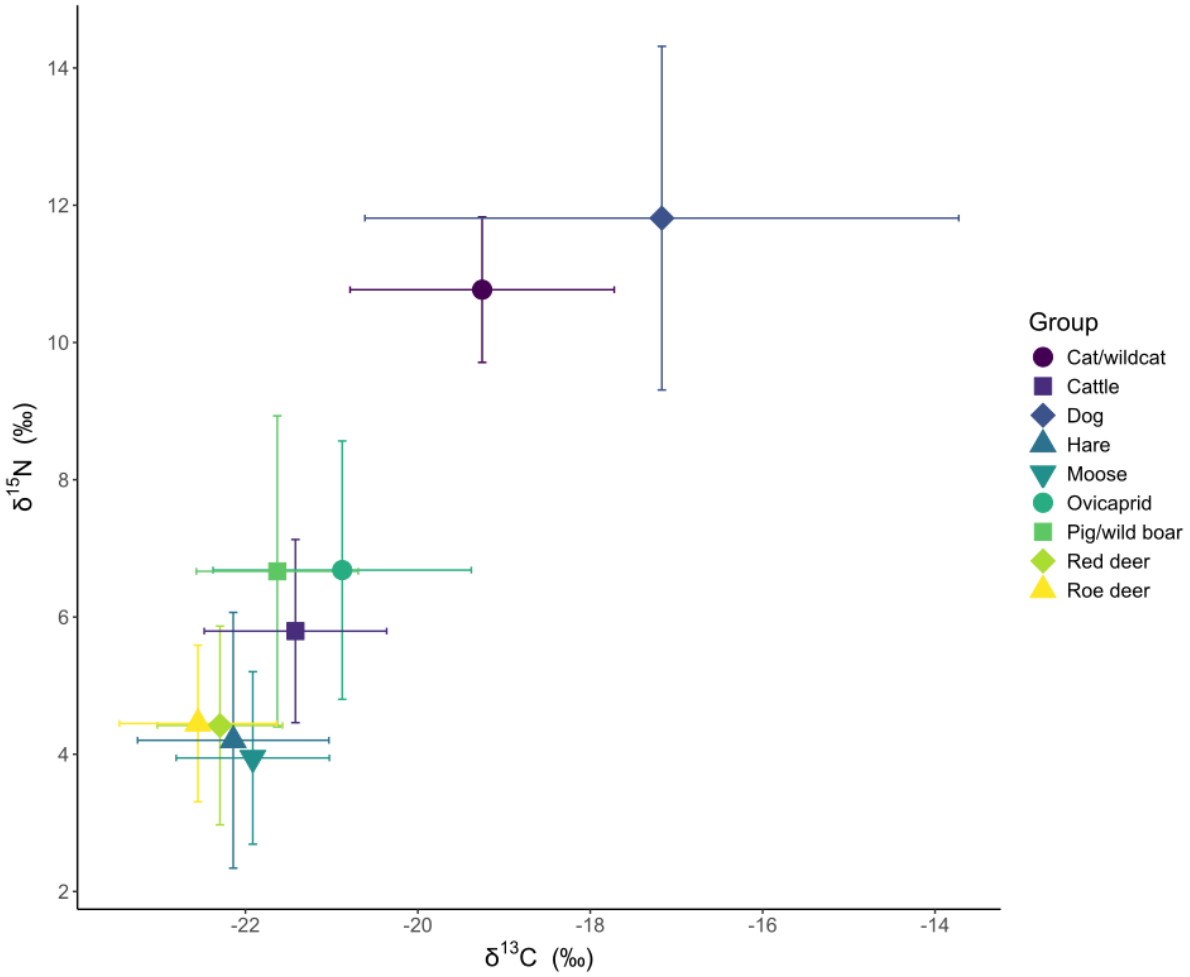
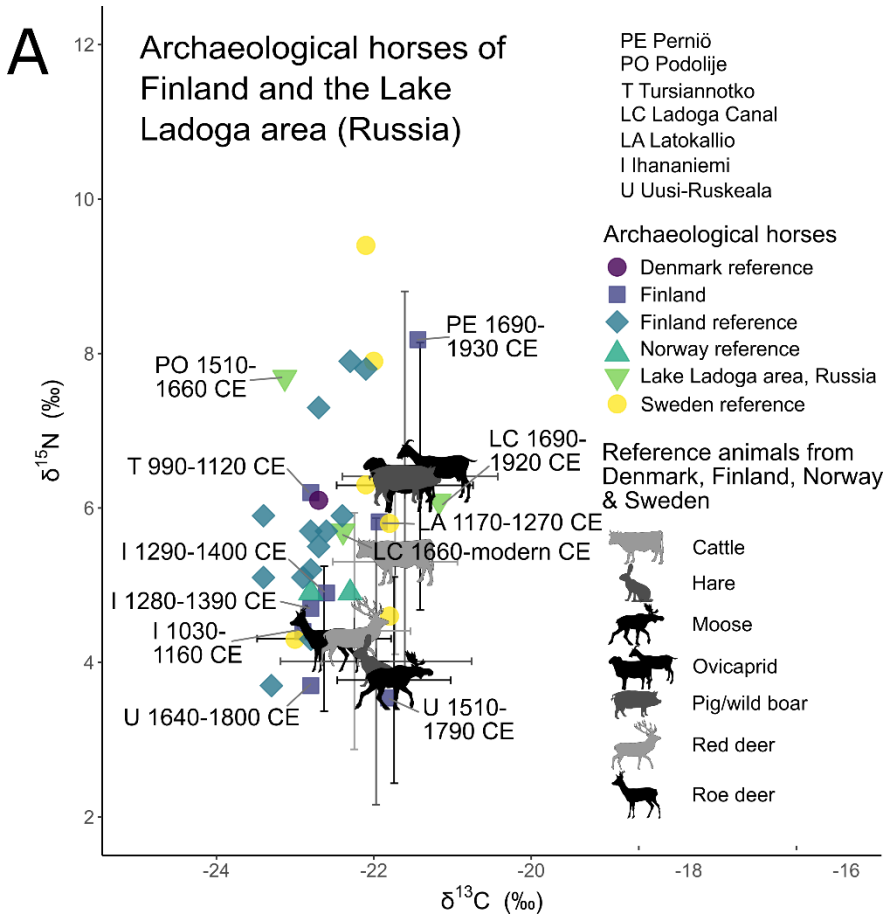
A)

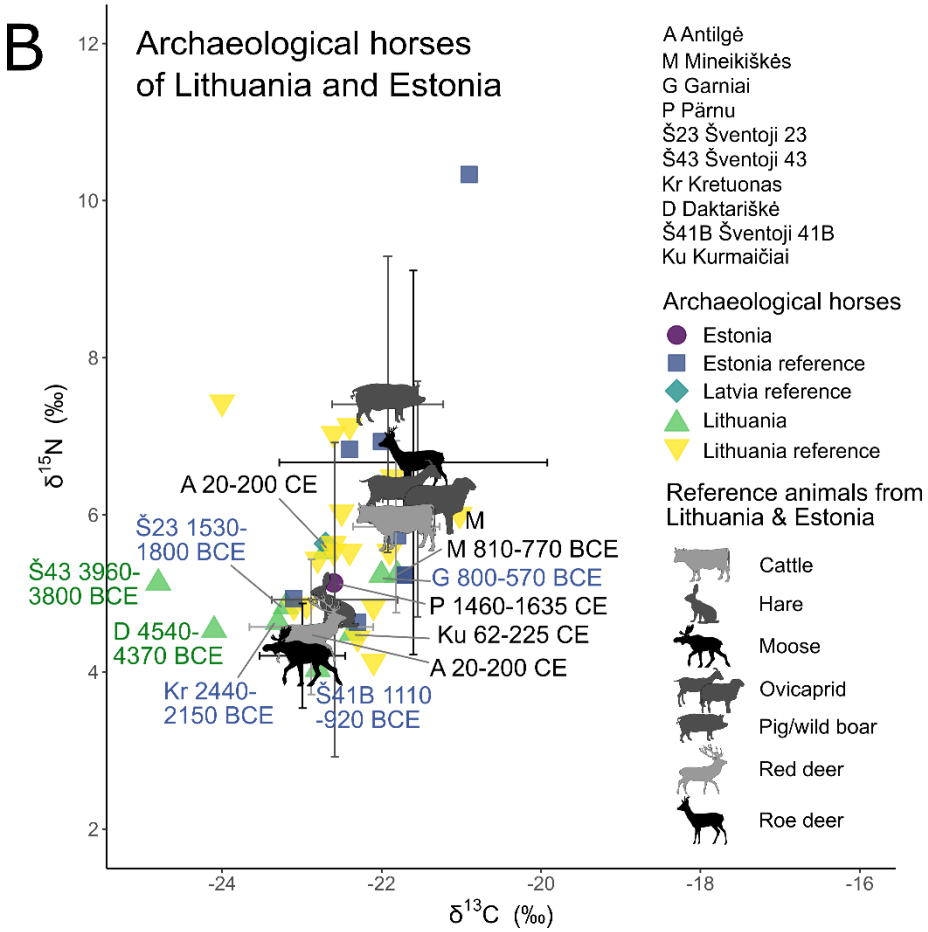


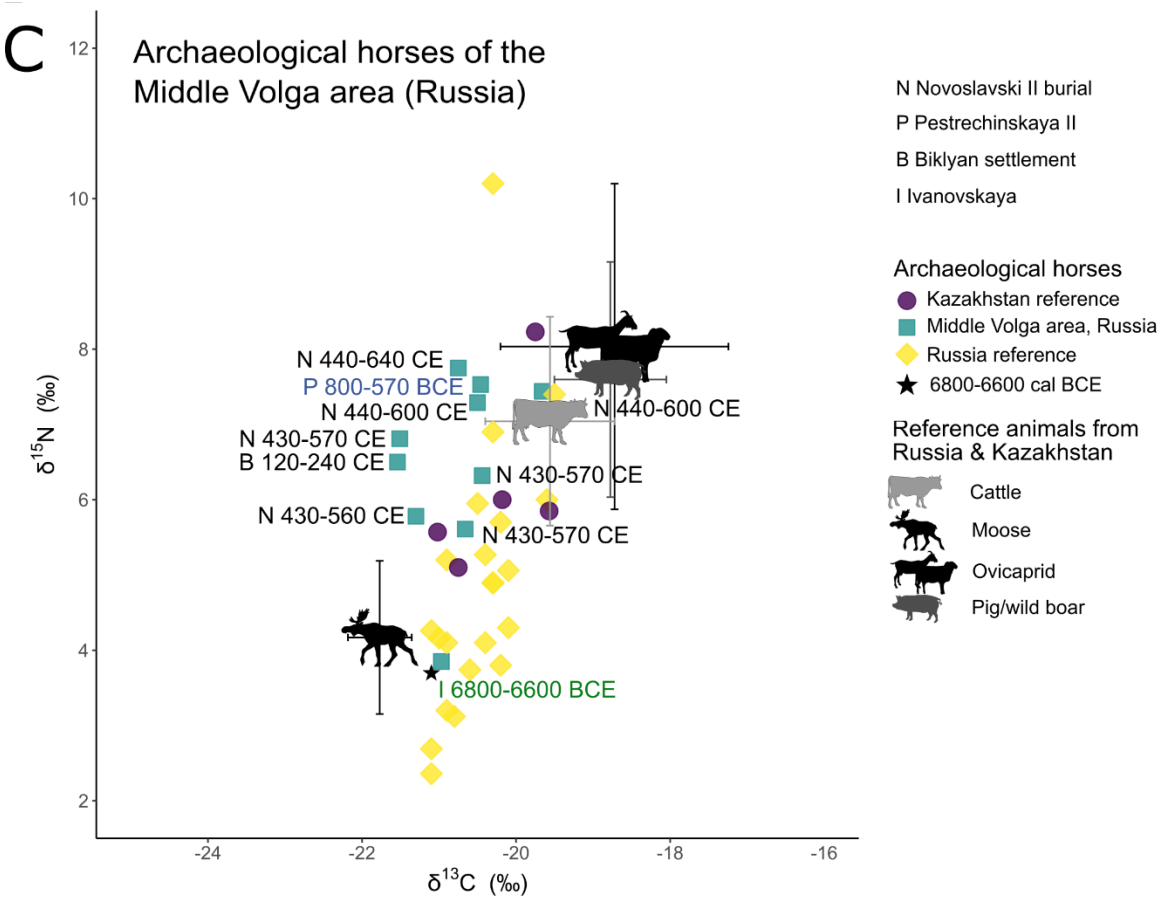
B)



Supplementary Fig. 4 Scatter plot of the stable isotope ratios for carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) from bone collagen or dentine (grouped together) of archaeological reference domestic animals and wild herbivores in coloured symbols from Russia, Estonia, Lithuania, Latvia, Sweden, Finland, Denmark, Norway, Germany, Poland and westernmost Kazakhstan. **A)** All individual samples and means and standard deviations of these samples. **B)** Only the means and standard deviations of the samples. Note that the scales of the axes are different in A) and B).


A
Archaeological horses of Finland and the Lake Ladoga area (Russia)
PE Perniö
PO Podolije
T Tursiannotko
LC Ladoga Canal
LA Latokallio
I Ihananiemi
U Uusi-Ruskeala
Archaeological horses
Denmark reference
Finland
Finland reference
Norway reference
Lake Ladoga area, Russia
Sweden reference
Reference animals from Denmark, Finland, Norway & Sweden
Cattle
Hare
Moose
Ovicaprid
Pig/wild boar
Red deer
Roe deer
PE 1690-1930 CE
PO 1510-1660 CE
LC 1690-1920 CE
T 990-1120 CE
A 1170-1270 CE
LC 1660-modern CE
I 1290-1400 CE
I 1280-1390 CE
I 1030-1160 CE
U 1640-1800 CE
U 1510-1790 CE
δ15N (‰)
δ13C (‰)
12
10
8
6
4
2
-24
-22
-20
-18
-16


B
Archaeological horses of Lithuania and Estonia
A Antilgė
M Mineikiškės
G Garniai
P Pärnu
Š23 Šventoji 23
Š43 Šventoji 43
Kr Kretuonas
D Daktariškė
Š41B Šventoji 41B
Ku Kurmaičiai
Archaeological horses
Estonia
Estonia reference
Latvia reference
Lithuania
Lithuania reference
Reference animals from Lithuania & Estonia
Cattle
Hare
Moose
Ovicaprid
Pig/wild boar
Red deer
Roe deer
A 20-200 CE
Š23 1530-1800 BCE
M
M 810-770 BCE
Š43 3960-3800 BCE
G 800-570 BCE
P 1460-1635 CE
D 4540-4370 BCE
Ku 62-225 CE
A 20-200 CE
Kr 2440-2150 BCE
Š41B 1110-920 BCE
δ15N (‰)
δ13C (‰)
12
10
8
6
4
2
-24
-22
-20
-18
-16



Supplementary Fig. 5 Scatter plots of the stable isotope ratios for carbon (δ13C) and nitrogen (δ15N) from bone collagen and dentine of archaeological horses with the archaeological site (marked with letter codes in the scatter plots) and the calibrated radiocarbon age (green font: > 3800 cal BCE, blue font: 2500 - 500 BCE and black font: 20 CE - modern) indicated for each sample. For clarity, the sites and ages were not shown for the horses used as reference with the exception of indication origin of horses deriving from the same archaeological context as our data. BCE stands for Before Common Era and CE for Common Era. A) A scatter plot for Finnish and Russian Lake Ladoga area archaeological horses analysed in this study, reference horses from Finland, Sweden, Norway and Denmark and reference archaeological domestic and wild herbivores from the same countries. B) A scatter plot for Lithuanian and Estonian archaeological horses analysed in this study, reference horses from Lithuania, Latvia and Estonia and reference archaeological domestic and wild herbivores from the same countries. C) A scatter plot for Russian Middle Volga area archaeological horses analysed in this study, reference horses from Russia, Mongolia and Kazakhstan and reference archaeological domestic and wild herbivores from the same countries, in addition to Turkmenistani, Omani and Spanish donkeys and Bulgarian wild asses.