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The Origins of Viking Age Dogs in Luistari, Eura, Finland

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ABSTRACT

We used stable ($\delta^{18}O$) and radiogenic ($^{87}Sr/^{86}Sr$) isotopic proxies to investigate the origins of dogs (Canis familiaris) buried in Viking Age graves at Luistari, Finland. While all 13 dogs exhibited oxygen isotope values compatible with local surface waters, $^{87}Sr/^{86}Sr$ ratios for two of the four dogs analyzed (graves 289 and 480) were compatible with a likely origin in southern Scandinavia. The findings align with previous evidence of the mobility of Viking Age dogs. The results highlight the importance of dogs in trade, exchange and social networks between communities in southwestern Finland and the Baltic Sea coastline during the Viking Age.

1 | Introduction

Throughout history, dogs (*Canis familiaris*) have been invaluable animals for hunting, herding, guarding (Jennbert 2011, 65; Gräslund 2004, 168), and even warfare (Forster 1941; Gotfredsen et al. 2014, 158; Perri 2020). Dogs were also important in Northern Europe during the Iron Age. Dog collars and fittings associated with collars and leashes have been found in high-status 7th–8th-century boat burials at Vendel and Valsgärde in Sweden, as well as in Viking Age boat burials at Ladby, Denmark and Oseberg, Norway (Gräslund 2004, 168–169; Nichols 2021, 2023). Beyond their practical uses, dogs held significant symbolic and cultural importance. For example, they were often buried alongside their owners, suggesting a belief that dogs would continue to serve and follow their masters in the afterlife (Lehtosalo-Hilander 1982, 38; Prummel 1992; Morey and Jeger 2022).

The Luistari cemetery is a prominent archaeological site in Eura, southwestern Finland (Figure 1), dating to the Iron Age and Early Medieval Period (c. 600–1300 CE). With its ca. 1300 graves, of which around 300 are from the Viking Age (c. 800–1050 CE) (Lehtosalo-Hilander 2000, 158–162), it is one of the largest cemeteries in the Nordic countries. At least 13 of the Viking Age graves contained remains of dogs (Lehtosalo-Hilander 1982, 38), though due to preservation issues, it is possible that more originally included dog remains. The dog remains were in most graves found by the feet or legs of the deceased and inside the remains of a wooden coffin. In one grave, dog bones were found at the waist area, and in one they were found outside the coffin.

We studied the Viking Age dogs buried at Luistari using $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ isotope proxies to determine their origins. Strontium isotopes ($^{87}Sr/^{86}Sr$) are commonly used in archaeology to trace the geographical provenance of humans or animals based on the geological settings of their habitat, while oxygen isotopes ($\delta^{18}O$) are related to the climatic context, thus also being linked to their geographical location (e.g., Bentley 2006; Daux et al. 2008; Pederzani and Britton 2018; Lazzerini et al. 2021).

2 | Materials and Methods

Dog tooth enamel from 13 graves (Table 1) was analyzed for phosphate δ[18]O values (δ[18]Op). The material belongs to the collections of the Finnish Heritage Agency (museum numbers 18,000 and 22,346). Due to the poor preservation of the remains, only loose enamel fragments were used for sampling, thus leaving the specific tooth from which the samples were

FIGURE 1 | Location of the places mentioned in the text. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 | *Luistari dog tooth enamel $^{87}Sr/^{86}Sr$ and δ[18]Op values, and calculated δ[18]O of drinking water.*

Grave	Museum ID	$^{87}Sr/^{86}Sr$	2SE	δ[18]Op (‰, VSMOW)	δ[18]O (‰, VSMOW) water
280	18,000:3143	0.728387	0.000006	14.7	−8.1
281	18,000:3191	0.726662	0.000006	14.1[a]	−8.5
289	18,000:3306	0.721288	0.000005	14.4[a]	−8.3
480	22,346:387	0.713837	0.000007	12.7[a]	−9.5
35	18,000:1448	N/A	N/A	13.1	−9.2
51	18,000:1571	N/A	N/A	13.4	−9.0
76	18,000:1999	N/A	N/A	13.9	−8.6
145	18,000:2485	N/A	N/A	14.0	−8.5
195	18,000:2785	N/A	N/A	13.1	−9.2
208	18,000:2865	N/A	N/A	15.0	−7.8
318	18,000:3600.5	N/A	N/A	13.8[a]	−8.7
345	18,000:3854	N/A	N/A	14.4[a]	−8.3
359	18,000:4117	N/A	N/A	14.4[a]	−8.3

[a]Mean value of duplicate extraction and IRMS analysis (SD; ‰): grave (281 = 0.00, 289 = 0.01, 480 = 0.06, 318 = 0.03, 345 = 0.01, 359 = 0.24).

taken unknown. The analytical protocol included acetic acid leaching, microprecipitation of Ag_3PO_4, pyrolysis at 1400°C on a Thermo Scientific Delta V Plus isotope ratio mass spectrometer and data normalization to Nbs120c (21.7‰), AGPO-SCRI (14.58‰) and SJ-1 (in-house; 5.56‰). R^2 between expected and measured values > 0.99, and analytical reproducibility within ± 0.4‰. For details, see Danielisová et al. (2025). To estimate the drinking water $\delta^{18}O$ values, calibration equations for humans (Equation 6 of Daux et al. 2008) and foxes as the nearest canid analogue (Iacumin and Longinelli 2002) were used.

Strontium isotopes were determined only in four cases where enough material was left after the other analyses and enamel had retained its characteristic hardness and translucence according to a visual and tactile inspection. The samples were pre-treated following Dudás et al. (2016). $^{87}Sr/^{86}Sr$ ratios were measured using a Thermo Triton Plus thermal ionization mass spectrometer at the Institute of Geology of the Czech Academy of Sciences using W filaments in the presence of Ta activator. During this study, the periodical analyses of NIST 987 reference solution yielded $^{87}Sr/^{86}Sr$ of 0.710252 ± 0.000007 (2σ, $n = 18$); (details in Danielisová et al. 2025).

3 | Results

Dog $\delta^{18}Op$ values show a constrained range without outliers (Table 1) with the mean at 13.9‰ ± 0.7‰ ($n = 13$), ca. 2‰ lower than that of humans buried at Luistari (15.8 ± 1.0‰, $n = 78$; Danielisová et al. 2025). The offset is possibly associated with differences in physiology and metabolism affecting fractionation. Applying the taxon-specific calibration equations (Daux et al. 2008; Iacumin and Longinelli 2002) on the mean $\delta^{18}Op$ values yielded drinking water $\delta^{18}O$ estimates for dogs and humans at −8.6‰ and −9.4‰, respectively. Factoring in measurement uncertainty and variance around the mean (SD), the drinking water $\delta^{18}O$ estimates are similar, suggesting also that the use of the fox-based equation for dogs is justified.

The $^{87}Sr/^{86}Sr$ provenance analysis of dogs from Luistari builds on a strontium baseline based on plants, surface waters and archaeological bones covering an area of ca. 40 × 45 km around the burial ground (Danielisová et al. 2025). The bioavailable range estimated using the high-density interval method yielded ranges of 0.7262–0.7353 at 90% and 0.7246–0.7390 at 99% of the highest-density intervals.

Of the four specimens analyzed for $^{87}Sr/^{86}Sr$ (Table 1), two returned surprisingly low values. At only 0.7138 (grave 480) and 0.7212 (grave 289), both are outside the 99% range of the bioavailable Sr for Luistari. The $^{87}Sr/^{86}Sr$ values place the origins of both these dogs outside the Eura region and, for grave 480 most likely also outside of Finland (see Discussion). The remaining two dogs have very similar $^{87}Sr/^{86}Sr$ values of 0.7283 and 0.7266 at the lower fringe of the $^{87}Sr/^{86}Sr$ distribution of the Luistari population (Figure 2, cf. Danielisová et al. 2025), and it is quite probable that they were, therefore, likely local.

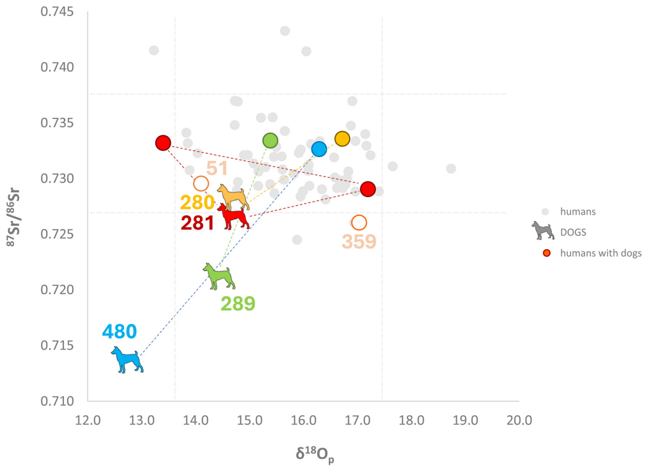

FIGURE 2 | $^{87}Sr/^{86}Sr$ and $\delta^{18}O_p$ values of the four dogs from the Luistari cemetery compared to humans (Danielisová et al. 2025). Dashed colored lines connect the dogs to humans from the same graves (in the case of grave 281, human isotope values are shown for both second and third molars). The notable differences in the Sr ratios between the dogs and humans indicate that two of the dogs came from different geographical regions than the humans they were buried with. Horizontal dashed gray lines show the local Sr range according to 90% highest density interval (Danielisová et al. 2025). [Colour figure can be viewed at wileyonlinelibrary.com]

4 | Discussion

Archaeological dog remains offer direct evidence of past canine populations. (e.g., Fortelius 1982, 311; Nichols 2021, 2023). It has been suggested that the morphology of the Luistari dogs resembled that of modern spitzes, and that they mainly came from one interbreeding population based on their similar morphology and intermediate size (Fortelius 1982: 310–311). Our Sr and O isotope results are not, however, consistent with this theory.

In comparison to $\delta^{18}O$ values of mean annual precipitation and groundwaters in the Eura region today (ca. −12‰; Rautio and Korkka-Niemi 2011), the $\delta^{18}O$ of drinking water for both dogs and humans is distinctly higher, at first glance indicating non-local origins for the whole human population and their dogs. However, we argue that the cause for this apparent discrepancy is the prevalent use of evaporated surface waters as the main water supply. The extensive Pyhäjärvi lake close to the cemetery, featuring prominently in the diets of the Luistari people (Etu-Sihvola et al. 2022), has $\delta^{18}O$ values at ca. −8‰ (Rautio and Korkka-Niemi 2011). Thus, variable mixtures of lake Pyhäjärvi and other surface waters with groundwater sources would be compatible with the indicated drinking water $\delta^{18}O$ levels. In this region, precipitation $\delta^{18}O$ values were not significantly higher during the Medieval Warm Period (ca. 900–1300 CE): reconstructed warm (Ljungqvist 2010) and cold season (Edwards et al. 2017) temperatures for Fennoscandia show anomalies mostly < 0.5°C, corresponding to even smaller‰-shifts in precipitation $\delta^{18}O$ values according to $\delta^{18}O/T$ correlation slopes in Finland (Kortelainen 2007).

Bioavailable $^{87}Sr/^{86}Sr$ in Finland are commonly > 0.73, but lower values around 0.72 have been observed in certain parts (Åberg and Wickman 1987; Sikora et al. 2018; Lahtinen et al. 2020, Price et al. 2021; Armaroli et al. 2024; Danielisová et al. 2025): the $^{87}Sr/^{86}Sr$ value of the dog in grave 289 could thus be associated to origins in South Savo and the coastal areas of the Bothnian Bay north of Oulu. However, similar ratios can also be found outside Finland, particularly in southern Sweden (Blank et al. 2018; Sjögren et al. 2009; Eriksson et al. 2018) and sparsely on the island of Bornholm in Denmark (Frei and Frei 2013; Price et al. 2012). Given that the material culture of Luistari shows strong evidence of connections with Gotland and mainland Sweden (Lehtosalo-Hilander 1982, 2000), and isotopic evidence suggests that some humans buried at Luistari may have originated from Scandinavia (Danielisová et al. 2025), it is possible that the dog in grave 289 also came from there, rather than more distant areas within Finland.

The lowest observed $^{87}Sr/^{86}Sr$ value of the dog in grave 480 is anomalously low for the Precambrian bedrock of Finland (Nironen 2017; Supporting information Figure S1). Recent Sr isoscape modeling (Supporting information Figure S2; Armaroli et al. 2024) predicts ratios below 0.715 for regions in e.g., central Finland and the Kainuu province in modern-day Finland, but these areas were not permanently settled in the Viking Age (Raninen and Wessman 2014, 331), making them improbable source regions for the animals. The most probable origin could be sought from further south, for example, the Baltic countries (Piličiauskas et al. 2022; Price et al. 2020; Pētersone-Gordina et al. 2022), the islands of Bornholm, Gotland, or Öland (Magnell et al. 2024; Wilhelmson and Ahlström 2015), or southern Sweden, specifically regions of Scania and Falbygden (, Ladegaard-Pedersen et al. 2021; Blank et al. 2018; Sjögren et al. 2009).

The $\delta^{18}O_p$ values of dogs in graves 289 and 480 match the values of the other Luistari dogs (Table 1), and they could be considered locally raised. However, the values are also consistent with the more southerly source regions mentioned above, with precipitation and surface waters showing $\delta^{18}O$ values of ca. −10‰ to −8‰ (Supporting information Figure S2; Burgman et al. 1987; IAEA/GNIP, n.d.; Stansell et al. 2017; Kalvāns et al. 2020).

Mobility of Viking Age dogs has also been noted in previous $^{87}Sr/^{86}Sr$ studies (Wilhelmson and Ahlström 2015; Löffelmann et al. 2023), and it has been suggested that dogs could have accompanied their owners on long voyages (Löffelmann et al. 2023). Dogs were considered valuable animals, and there are indications they could have been the subject of trade and exchange, and also given as gifts (Magnell et al. 2024). Magnell et al. (2024) propose that the exchange of dogs, particularly puppies, may have played a role in forming and maintaining social bonds and relationships between kinship groups. The fact that Luistari dogs were buried in rich graves with international goods suggests that these animals might have been acquired through trade or diplomatic exchanges. This, again, reinforces the idea that the high status of human individuals may have resulted from contacts beyond the individuals' immediate region. Similarly, it is possible that dogs associated with these humans were not only companions but also served as status symbols, diplomatic tokens, or participants in gift-giving practices that strengthened social and political alliances.

5 | Conclusions

The isotopic analyses of Viking Age dogs from the Luistari cemetery provide insights into the mobility and cultural significance of these animals. The $\delta^{18}O_p$ and $^{87}Sr/^{86}Sr$ values suggest that while some dogs could have been locally bred, others, particularly those in graves 289 and 480, likely originated from more southern regions around the Baltic Sea. The results support the idea that dogs in Viking Age Finland were part of extensive networks of trade, exchange, and social interaction that bound regions across the sea together.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

References

Åberg, F., and F. E. Wickman. 1987. "Variations of $^{87}Sr/^{86}Sr$ in Water From Streams Discharging Into the Bothnian Bay, Baltic Sea." *Nordic Hydrology* 18: 33–42.

Armaroli, E., F. Lugli, A. Cipriani, and T. Tütken. 2024. "Spatial Ecology of Moose in Sweden: Combined Sr-O-C Isotope Analyses of Bone and Antler." *PLoS ONE* 19, no. 4: e0300867.

Bentley, R. A. 2006. "Strontium Isotopes From the Earth to the Archaeological Skeleton: A Review." *Journal of Archaeological Method and Theory* 13, no. 3: 135–187. https://doi.org/10.1007/s10816-006-9009-x.

Blank, M., K.-G. Sjögren, C. Knipper, K. M. Frei, and J. Storå. 2018. "Isotope Values of the Bioavailable Strontium in Inland Southwestern Sweden—A Baseline for Mobility Studies." *PLoS ONE* 13: e0204649.

Burgman, J. O., B. Calles, and F. Westman. 1987. "Conclusions From a Ten Year Study of Oxygen-18 in Precipitation and Runoff in Sweden." In: Isotope Techniques in Water Resources Development. IAEA-SM-299/107, 579–590.

Danielisová, A., U. Nordfors, S. Kertes, et al. 2025. "Multi-Isotopic Evidence Reveals the Emergence of a Cosmopolitan Community at the Luistari Cemetery in Eura, Finland, During the Early Medieval Period (600–1130 CE)." *Archaeological and Anthropological Sciences* 17: 58.

Daux, V., C. Lécuyer, M.-A. Héran, et al. 2008. "Oxygen Isotope Fractionation Between Human Phosphate and Water Revisited." *Journal of Human Evolution* 55: 1138–1147.

Dudás, F. Ö., S. A. LeBlanc, S. W. Carter, and S. A. Bowring. 2016. "Pb and Sr Concentrations and Isotopic Compositions in Prehistoric North American Teeth: A Methodological Study." *Chemical Geology* 429: 21–32.

Edwards, T. W. D., D. Hammarlund, B. Newton, et al. 2017. "Seasonal Variability in Northern Hemisphere Atmospheric Circulation During the Medieval Climate Anomaly and the Little Ice Age." *Quaternary Science Reviews* 165: 102–110. https://doi.org/10.1016/j.quascirev.2017.04.018.

Eriksson, G., K. M. Frei, R. Howcroft, et al. 2018. "Diet and Mobility Among Mesolithic Hunter-Gatherers in Motala (Sweden) - The Isotope Perspective." *Journal of Archaeological Science: Reports* 17: 904–918.

Etu-Sihvola, H., K. Salo, Y. I. Naito, et al. 2022. "Isotopic Insights Into the Early Medieval (600–1100 CE) Diet in the Luistari Cemetery at Eura, Finland." *Archaeological and Anthropological Sciences* 14: 143.

Forster, E. S. 1941. "Dogs in Ancient Warfare." *Greece & Rome* 10: 114–117.

Fortelius, M. 1982. "Dogs in Eura." Appendix in Lehtosalo-Hilander 1982: 310–312.

Frei, R., and K. M. Frei. 2013. "The Geographic Distribution of Sr Isotopes From Surface Waters and Soil Extracts Over the Island of Bornholm (Denmark) – A Base for Provenance Studies in Archaeology and Agriculture." *Applied Geochemistry* 38: 147–160.

Gotfredsen, A. B., C. Primeau, K. M. Frei, and L. Jørgensen. 2014. "A Ritual Site With Sacrificial Wells From the Viking Age at Trelleborg, Denmark." *Danish Journal of Archaeology* 3, no. 2: 145–163. https://doi.org/10.1080/21662282.2015.1084730.

Gräslund, A.-S. 2004. "Dogs in Graves- a Question of Symbolism?" In *Pecus. Man and Animal in Antiquity: Proceedings of the Conference at the Swedish Institute in Rome, September 9-12, 2002*, edited by B. Santillo, 171–180. Swedish Institute in Rome.

Iacumin, P., and A. Longinelli. 2002. "Relationship Between $\delta^{18}O$ Values for Skeletal Apatite From Reindeer and Foxes and Yearly Mean $\delta^{18}O$ Values of Environmental Water." *Earth and Planetary Science Letters* 201: 213–219.

IAEA/GNIP. n.d. "Global Network of Isotopes in Precipitation Database." Accessed Through Water Isotope System for Electronic Retrieval (WISER); https://nucleus.iaea.org/wiser; Datasets Downloaded 24.10.2024.

Jennbert, K. 2011. *Animals and Humans: Recurrent Symbiosis in Archaeology and Old Norse Religion*. Nordic Academic Press.

Kalvāns, A., A. Dēliņa, A. Babre, and K. Popovs. 2020. "An Insight Into Water Stable Isotope Signatures in Temperate Catchment." *Journal of Hydrology* 582: 124442.

Kortelainen, N. M. 2007. *Isotopic Fingerprints in Surficial Waters: Stable Isotope Methods Applied in Hydrogeological Studies*, 39. Geological Survey of Finland.

Ladegaard-Pedersen, P., S. Sabatini, R. Frei, K. Kristiansen, and K. M. Frei. 2021. "Testing Late Bronze Age Mobility in Southern Sweden in the Light of a New Multi-Proxy Strontium Isotope Baseline of Scania." *PLoS ONE* 16: e0250279.

Lahtinen, M., L. Arppe, and G. Nowell. 2020. "Source of Strontium in Archaeological Mobility Studies—Marine Diet Contribution to the Isotopic Composition." *Archaeological and Anthropological Sciences* 13, no. 1: 1. https://doi.org/10.1007/s12520-020-01240-w.

Lazzerini, N., V. Balter, A. Coulon, et al. 2021. "Monthly Mobility Inferred From Isoscapes and Laser Ablation Strontium Isotope Ratios in Caprine Tooth Enamel." *Scientific Reports* 11, no. 1: 2277. https://doi.org/10.1038/s41598-021-81923-z.

Lehtosalo-Hilander, P.-L. 1982. "Luistari I – The Graves." *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 82, no. 1. Finnish Antiquarian Society.

Lehtosalo-Hilander, P.-L. 2000. "Luistari - A History of Weapons and Ornaments." Luistari IV. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 107. Finnish Antiquarian Society.

Ljungqvist, F. 2010. "A Regional Approach to the Medieval Warm Period and the Little Ice Age." In *Climate Change and Variability*, edited by S. Simard, 1–24. InTech. Available From:. http://www.intechopen.com/books/climate-change-and-variability/a-regional-approach-to-the-medieval-warm-period-and-the-little-ice-age.

Löffelmann, T., C. Snoeck, J. D. Richards, L. J. Johnson, P. Claeys, and J. Montgomery. 2023. "Sr Analyses From Only Known Scandinavian Cremation Cemetery in Britain Illuminate Early Viking Journey With Horse and Dog Across the North Sea." *PLoS ONE* 18, no. 2: e0280589. https://doi.org/10.1371/journal.pone.0280589.

Magnell, O., E. Iregren, and K. Jennbert. 2024. "Breeding, Feeding and Mobility Among Dogs in the Elite in the Merovingian Period – Analysis of Dogs in the Boat Grave Nabberör, Öland, Sweden." *Journal of Archaeological Science: Reports* 56: 104558. https://doi.org/10.1016/j.jasrep.2024.104558.

Morey, D. F., and R. Jeger. 2022. "When Dogs and People Were Buried Together." *Journal of Anthropological Archaeology* 67: 101434. https://doi.org/10.1016/j.jaa.2022.101434.

Nichols, C. 2021. "Domestic Dog Skeletons at Valsgärde Cemetery, Uppland, Sweden: Quantification and Morphological Reconstruction." *Journal of Archaeological Science: Reports* 36, no. 1–9: 775–776. https://doi.org/10.1016/j.jasrep.2021.102875.

Nichols, C. 2023. "Three Dogs From the Late Iron Age Boat Grave Cemetery at Gamla Uppsala Prästgården, Sweden." *European Journal of Archaeology* 27, no. 1: 67–84. https://doi.org/10.1017/eaa.2023.40.

Nironen, M. 2017. "Guide to the Geological Map of Finland - Bedrock 1:1000000." Geological Survey of Finland, Special Paper 60, 41–76. Geological Survey of Finland, Espoo.

Pederzani, S., and K. Britton. 2018. "Oxygen Isotopes in Bioarchaeology: Principles and Applications, Challenges and Opportunities." *Earth-Science Reviews* 188: 77–107. https://doi.org/10.1016/j.earscirev.2018.11.005.

Perri, A. R. 2020. "Prehistoric Dogs as Hunting Weapons: The Advent of Animal Biotechnology." In *Dogs: Archaeology of the Human-Canine Connection Beyond Domestication*, edited by B. Bethke and A. Burtt, 7–44. University Press of Florida.

Pētersone-Gordina, E., J. Montgomery, A. R. Millard, et al. 2022. "Strontium Isotope Identification of Possible Rural Immigrants in 17th Century Mass Graves at St. Gertrude Church Cemetery in Riga, Latvia." *Archaeometry* 64, no. 4: 1028–1043.

Piličiauskas, G., E. Simčenka, K. Lidén, et al. 2022. "Strontium Isotope Analysis Reveals Prehistoric Mobility Patterns in the Southeastern Baltic Area." *Archaeological and Anthropological Sciences* 14, no. 4: 74. https://doi.org/10.1007/s12520-022-01539-w.

Price, D., A. Bläuer, E. Oras, and J. Ruohonen. 2021. "Baseline $^{87}Sr/^{86}Sr$ Values in Southern Finland and Isotopic Proveniencing of the Cemetery at Ravattula Ristimäki." *Fennoscandia Archaeologica* 38: 135–152.

Price, T. D., M. Naum, P. Bennike, et al. 2012. "Isotopic Investigation of Human Provenience at the Eleventh Century Cemetery of Ndr. Grødbygård, Bornholm, Denmark." *Danish Journal of Archaeology* 1, no. 2: 93–112. https://doi.org/10.1080/21662282.2013.798903.

Price, T. D., J. Peets, R. Allmäe, L. Maldre, and N. Price. 2020. "Human Remains, Context, and Place of Origin for the Salme, Estonia, Boat Burials." *Journal of Anthropological Archaeology* 58: 101149. https://doi.org/10.1016/j.jaa.2020.101149.

Prummel, W. 1992. "Early Medieval Dog Burials Among the Germanic Tribes." *Helinium 1992* 32, no. 1–2: 132–194.

Raninen, S., and A. Wessman. 2014. "Finland as a Part of the "Viking World"." In *Fibula, Fabula, Fact — The Viking Age in Finland*, edited by J. Ahola and C. Frog With Tolley, 327–346. Finnish Literature Society.

Rautio, A., and K. Korkka-Niemi. 2011. "Characterization of Groundwater-Lake Water Interactions at Pyhäjärvi, a Lake in SW Finland." *Boreal Environment Research* 16: 363–380.

Sikora, M., V. Pitulko, V. Sousa, et al. 2018. "The Population History of Northeastern Siberia Since the Pleistocene." *Nature* 570: 182–188.

Sjögren, K.-G., T. D. Price, and T. Ahlström. 2009. "Megaliths and Mobility in South-Western Sweden. Investigating Relationships Between a Local Society and Its Neighbours Using Strontium Isotopes." *Journal of Anthropological Archaeology* 28, no. 1: 85–101. https://doi.org/10.1016/j.jaa.2008.10.001.

Stansell, N., E. Klein, M. Finkenbinder, et al. 2017. "A Stable Isotope Record of Holocene Precipitation Dynamics in the Baltic Region From

Lake Nuudsaku, Estonia." *Quaternary Science Reviews* 175: 73–84. https://doi.org/10.1016/j.quascirev.2017.09.013.

Wilhelmson, H., and T. Ahlström. 2015. "Iron Age Migration on the Island of Öland: Apportionment of Strontium by Means of Bayesian Mixing Analysis." *Journal of Archaeological Science* 64: 30–45. https://doi.org/10.1016/j.jas.2015.09.007.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.