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Diverse Economic Patterns in the North Baltic Sea Region in the Late Neolithic and Early Metal Periods

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Over 120 prehistoric pottery sherds from mainland Finland and the Åland Islands in the north Baltic region were studied for their organic residue content. Preserved fat residues found in these vessels indicated that the food procurement pattern was broad during the Neolithic and Early Metal periods. Based on previous research and these results, it appears that animal husbandry came to Finland with the Corded Ware culture. Groups using the succeeding Late Neolithic Kiukainen Ware did not, however, practice animal husbandry to any great extent, as there is an indication of dairy fats in only a single sherd. In general, even after dairy farming arrived in the area, prehistoric groups in southern and south-western Finland continued or returned to a hunter-gatherer lifestyle. During the Early Metal period, animal husbandry increased in importance among the groups living in the area, and the level of dairying then intensified.

Keywords: Finland, animal husbandry, archaeological pottery, dairying, lipids, compound-specific stable carbon isotope analyses

Introduction

The beginning of animal husbandry and cereal cultivation in Finland has been one of the most actively researched topics of recent Finnish archaeology. Evidence of early agriculture has been sought, e.g. from animal bone, pollen, starch, and organic residue analyses of pottery (Alenius et al., 2013; Bläuer & Kantanen, 2013; Lahtinen & Rowley-Conwy, 2013; Cramp et al., 2014; Juhola et al., 2014: 89; Lahtinen et al., 2017). Recent studies have dated the beginning of cereal cultivation in Finland to the Early Neolithic (*c.* 5300–4000 BC; Alenius et al., 2013) or the Early Iron Age (*c.* 500 BC; Lahtinen & Rowley-Conwy, 2013). Starch, interpreted as derived from cultivated cereals, has recently been reported from pottery dating back to the Bronze Age (Juhola et al., 2014: 89, 97) and cereal grains are known from Bronze Age sites (Pihlman & Seppä-Heikka, 1985; Vuorela & Lempiäinen, 1988; Asplund et al., 1989; Asplund, 2008: 292).

Even though the arrival of cereal cultivation is still debated, the earliest evidence of dairy farming thus far has been reported from two Corded Ware (3200–2250 cal BC)

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Table 1. *Pottery types mentioned in the text and their general dating according to Haggrén et al. (2015) and (for Swedish Pitted Ware in the Åland Islands) Halinen (2015: 58; see Stenbäck, 2003: 85; Brorsson et al., 2019: 98). The table also shows the number of studied sherds and number of sherds with lipid yield over 5 µg/g.*

	Dating	Number of studied sherds	Number of sherds with appreciable lipid (5 µg/g) yield
Corded Ware	2800/2700–2300 BC	30	21
Swedish Pitted Ware	3300–2300 BC	1	1
Kiukainen Ware	2500/2300–1800/1500 BC	56	39
Coastal Bronze Age Ware	1500–500 BC	2	2
Morby Ware	800 BC–300 AD	32	22

settlement sites in southern Finland (a general overview of the dates of pottery types is given in Table 1), where pottery fragments containing milk fats have been found (Cramp et al., 2014). Additionally, remains of goat hair have been recovered in a Corded Ware burial (Ahola et al., 2018). Domestic animal bones dating to the Corded Ware period, however, have so far not been found in Finland. The oldest radiocarbon-dated domesticated animal bone of sheep/goat (*Ovis aries*/*Capra hircus*) comes from the Kiukainen culture (2400–1900/1500 BC; Bläuer & Kantanen, 2013), while the oldest cattle (*Bos taurus*) and horse (*Equus caballus*) bones date to the Bronze Age (1700–500 BC; Bläuer & Kantanen, 2013). However, when dealing with single occurrences of animal bones, hair, or dairy residues, it should be noted it is possible that these materials were brought to Finland from surrounding areas, and thus might not be evidence of animal husbandry in the study area.

Soils in Finland are acidic, which creates difficult conditions for the survival of prehistoric bone (Kibblewhite et al., 2015). Unburnt bone typically decays over millennia, whereas burnt bone fragments are better preserved, even though they are highly fragmented (e.g. Siiriäinen, 1981: 11; Ukkonen, 1996: 66; Ukkonen, 2001: 13). This environment makes the study of food culture and food procurement practises a challenging task. Furthermore, settlement sites have been found to have been used by different cultural groups over the millennia, a circumstance that affects the interpretation of zooarchaeological materials. On the other hand, acidic soils create favourable conditions for the survival of absorbed organic residues in archaeological pottery.

In recent years, the study of absorbed organic residues in pottery has become increasingly common in the Baltic Sea area, allowing prehistoric food procurement practises to be traced (e.g. Cramp et al., 2014; Papakosta et al., 2015; Pääkkönen et al., 2016; Oras et al., 2017). The compound-specific stable carbon isotope ($\Delta^{13}C=\delta^{13}C_{18:0}-\delta^{13}C_{16:0}$) information on palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acid homologues can be used to distinguish the source of fats, in particular, non-ruminant and ruminant adipose, and dairy fats (Copley et al., 2003: 1526). In addition, specific biomarkers originating from aquatic organisms can be used to distinguish lipid residues of marine and freshwater organisms from those of terrestrial origin. The biomarkers of aquatic origin found in archaeological pottery are notably: ω-(*o*-alkylphenyl)alkanoic acids (APAAs) with 20 and 22 carbon atoms, isoprenoid fatty acids (IFAs, phytanic acid, pristanic acid, 4,8,12-trimethyltetradecanoic acid

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(4,8,12-TMTD)), and dihydroxy fatty acids (DHYAs) with 20 and 22 carbon atoms (Avigan, 1966; Ackman & Hooper, 1968; Hansel et al., 2004; Evershed et al., 2008; Hansel & Evershed, 2009; Hansel et al., 2011; Cramp & Evershed, 2014). In addition, dicarboxylic fatty acids are oxidation products of unsaturated fatty acids, and thus derive from processing of animal fats/oils (Regert et al., 1998). If branched chain fatty acids, especially C_{15} and C_{17}, are found from pottery, they can be considered as possible indicators of ruminant fat (Mottram et al., 1999).

Here, we address questions of food procurement practices and animal husbandry in Finland, presenting new results on absorbed organic residues obtained from pottery sherds recovered from Finnish archaeological contexts. Previously published research on absorbed organic residues from Finnish material has been scarce. However, the Middle Neolithic groups with Comb Ware have been shown to have had a hunter-gatherer lifestyle (Cramp et al., 2014; Pääkkönen et al., 2016). In this article, we present a substantially larger-scale study of organic residues absorbed into the walls of ceramic vessels from archaeological sites in southern and south-western Finland and the Åland Islands, dating back to the Late Neolithic and Early Metal period (Figure 1). In the world-wide context, the Neolithic is considered to begin with agriculture. However, in Finnish archaeology, it is a chronological term used to describe cultures that used ceramic containers. Hence, we have chosen to use the word ´Neolithic´ for both hunter-gatherer groups with a pottery tradition as well as for culture groups that were more dependent on agriculture. The pottery types were selected as representative of periods of potential change in subsistence patterns towards animal husbandry in southern and south-western Finland. The chronological span of the vessels ranges from Corded Ware and Kiukainen Ware to Morby Ware. Two sherds of pottery related to Swedish Pitted Ware, as well as two sherds of Bronze Age pottery, were also studied. The organic residue findings are compared with zooarchaeological records from the same sites.

Material and Methods

A total of 121 sherds from 23 sites in southern Finland and the Åland Islands from different periods were screened for their absorbed lipid content. Of the studied sherds, 85 were chosen for further biomarker and compound-specific stable isotope analysis using gas chromatography-mass spectroscopy (GC-MS) and gas chromatography combustion isotope ratio mass spectrometry (GC-C-IRMS) respectively. Two different methods were used to extract sub-samples (1–2 g) of surface-cleaned sherds: (1) direct methanolic acid extraction (Correa-Ascencio & Evershed, 2014) and (2) solvent extraction (Evershed et al., 1994) using $CHCl_3$/MeOH (2:1 *v/v*). Extraction and instrumental methods are described in more detail in the Supplementary Data.

Results

Corded Ware

Out of the 30 sherds studied, 21 yielded appreciable lipid residues (Table 2 – Supplementary Data). The biomarker and stable carbon isotope analyses showed that a variety of different products were processed or stored in the vessels. Residues of dairy fats were observed in five sherds, a mixture of ruminant and possible aquatic fats in one sherd. In addition, ruminant carcass fat residues were found in six sherds, and six sherds contained ancient

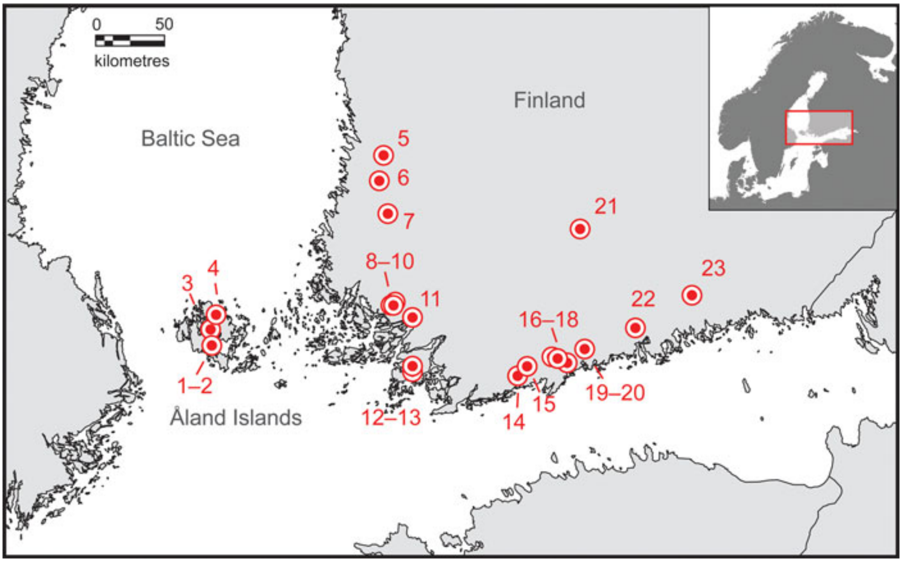

Figure 1. *Location of the archaeological sites studied in southern and south-western Finland and the Åland Islands. 1: Jomala Överby (M); 2: Jomala Dalkarby (M); 3: Finström Godby (M); 4: Saltvik Härdalen 21.11 (S); 5: Ulvila Suolisto Peltomäki (M); 6: Kiukainen Uotinmäki (K); 7: Eura Luistarintien alue (B); 8: Turku Jäkärlä (C); 9: Turku Räntämäki Orhinkarsina (M); 10: Turku Kotirinne (K); 11: Piikkiö Moisio Moision Alitalo (M); 12: Kemiönsaari Kåddböle (M); 13: Västanfjärd Galtarby II (C); 14: Inkoo Ragnvalds Tähtelä (C); 15: Siuntio Dalamalm (C); 16: Kirkkonummi Tengo Nyåker (C); 17: Espoo Näkinkylä (C); 18: Espoo Bolarskog I (M); 19: Helsinki Malminkartano (C); 20: Vantaa Jönsas (C); 21: Hämeenlinna Hauho Perkiö (C); 22: Porvoo Böle Munkby (C); 23: Lapinjärvi Malmbacken Norrby (C). B: Bronze Age Ware; C: Corded Ware; K: Kiukainen Ware; M: Morby Ware; S: Swedish Pitted Ware. No organic residues were found at the Corded Ware sites of Inkoo Ragnvalds Tähtelä and Siuntio Dalamalm.*

fat residues that are likely to be derived from the processing of non-ruminant terrestrial animal products, with three sherds containing mixtures of non-ruminant and aquatic or possibly aquatic fats (see Figure 2, Table 2). Since no aquatic biomarkers were detected in the Corded Ware sherds that were studied, aquatic fats identifications were based on the $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids and on the $\Delta^{13}C$ proxy.

Kiukainen Ware and Swedish Pitted Ware

Only one sherd out of 56 Kiukainen Ware sherds contained a possible dairy fat residue. Based on the $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids and the $\Delta^{13}C$ proxy, lipid residues of ruminant fats were found in nine sherds. Four of these contained, in addition to ruminant fats, possible traces of aquatic fats, detected by the presence of diagnostic C_{20} and C_{22} APAAs or DHYAs (Figure 3), or the $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids and the $\Delta^{13}C$ proxy. Of the studied sherds, 15 contained fat residues derived from or likely to derive from non-ruminant terrestrial animals, five of these sherds contained a possible mixture of aquatic fats (Figure 2). One Swedish Pitted Ware sherd contained aquatic fats, and one sherd from the same site with characteristic Kiukainen Ware features contained a ruminant fat residue.

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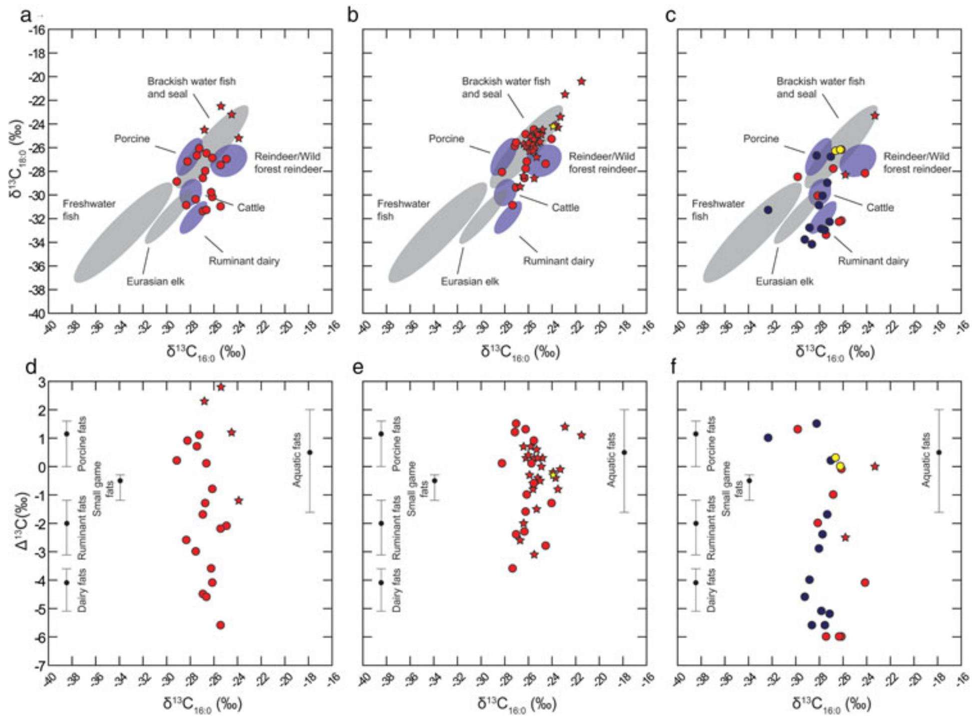

Figure 2. *Graphs showing the scatter plots of* $\delta^{13}C_{16:0}$ *values against* $\delta^{13}C_{18:0}$ *values from (a) Corded Ware; (b) Kiukainen Ware (red) and Swedish Pitted Ware (yellow); (c) Bronze Age Ware (yellow), Morby Ware from Mainland Finland (red), and Morby Ware from the Åland Islands (blue). Ellipses represent confidence of 68.27% derived from modern reference datasets. Graphs of the* $\Delta^{13}C$ *proxy plotted for the different pottery types: (d) Corded Ware; (e) Kiukainen Ware (red) and Swedish Pitted Ware (yellow); (f) Bronze Age Ware (yellow), Morby Ware from Mainland Finland (red), and Morby Ware from the Åland Islands (blue). The organic residues from sherds plotting to the right contained a greater marine component compared to those plotting more to the left. The stars represent lipid residues that contained biomarkers of marine/aquatic origin, and the circles represent the fats that originated from terrestrial resources. Modern reference data from Pääkkönen et al., in press. Modern terrestrial and freshwater fats have been corrected for contribution of post-industrial carbon by adding 1.3 ‰ (Friedli et al., 1986).*

Early Metal Period Vessels: Bronze Age Ware and Morby Ware

Only two Bronze Age sherds were included in this study. During the Bronze Age, the quantity of pottery per site seems to have been low (Asplund, 2008: 88), which makes sampling difficult. The number of samples is insufficient for a generalized interpretation, but serves as an example, comparable to the results from two vessels analysed earlier by Cramp et al. (2014). The sherds analysed in the present study contained fat residues from non-ruminant terrestrial animals, i.e. the vessels they came from were likely to have been used to process commodities from either small game animals or pigs. The 32 Morby Ware sherds sampled for this study came from settlement sites or burial cairns. The 18 sherds from mainland Finland were collected from settlement sites, one of which

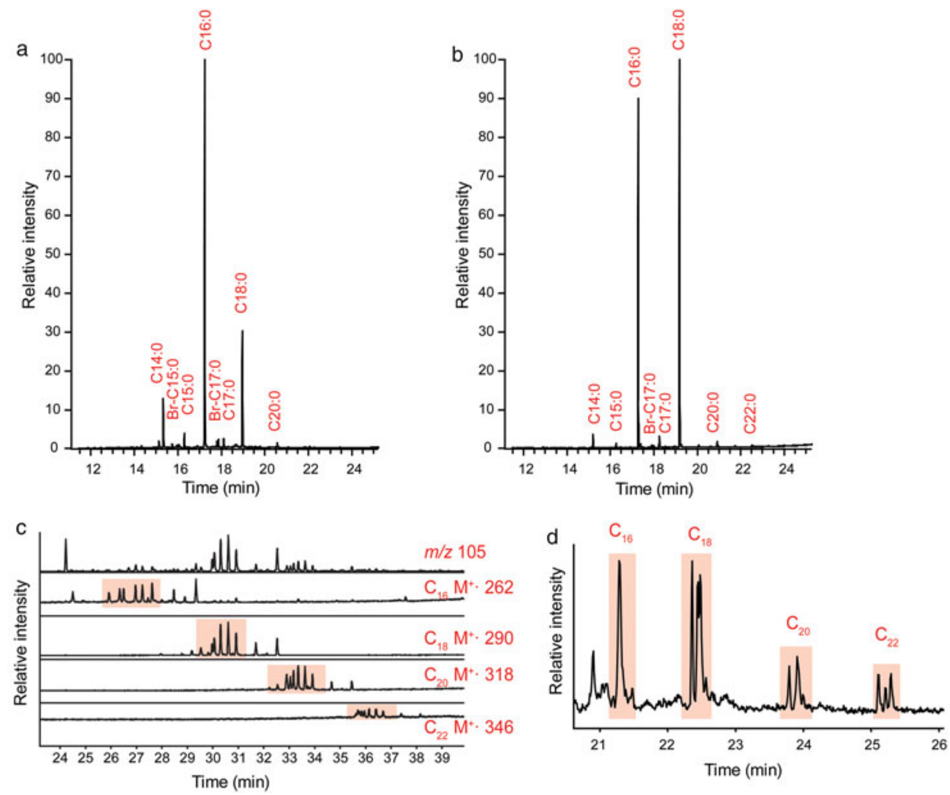

Figure 3. *Partial gas chromatograms of lipid extracts of two sherds : (a) Kiukainen Ware vessel TYA 489:104, 120; (b) Morby Ware vessel ÅM 652:284. In (c) APAAs and (d) DHYAs indicate that aquatic organisms were processed in TYA 489:104, 120.*

was related to a burial cairn. However, most of the 14 sherds from the Åland Islands were collected from burial cairns, and only one came from a settlement site. Four sherds from mainland Finland contained residues of dairy fats. One contained ruminant fats, and one, based on $\delta^{13}C$ values of the $C_{16:0}$ and $C_{18:0}$ fatty acids and on $\Delta^{13}C$ proxy, a mixture of ruminant and non-ruminant terrestrial fats. Three sherds contained residues of non-ruminant terrestrial fats, of which one also contained mixture of aquatic fats. One contained a possible mixture of ruminant and aquatic fats. Six of the Morby sherds from the Åland Islands contained dairy fat residues, three contained ruminant carcass fats, and three contained terrestrial non-ruminant fats (Table 2).

Discussion

Corded Ware

The results presented here demonstrate that the Corded Ware vessels were used for processing various commodities, including those from ruminant (adipose and dairy) and non-ruminant animals. These results are similar to those obtained by Cramp et al. (2014), where dairy, ruminant, and possible aquatic fats were detected. In the present study, only four sherds showed evidence of fats deriving from the processing of commodities of aquatic origin. The low number of sherds with signs of processing aquatic organisms may suggest that groups using Corded

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Ware preferred terrestrial over aquatic resources. Even though four sherds showed evidence of processing of aquatic fats based on $\delta^{13}C$ values, the lack of aquatic biomarkers could, on the other hand, also be explained by different cooking habits. The absence of food crusts and soot in Corded Ware vessels implies that they were not held over an open fire in the same way as the vessels from some of the other periods. Only one of the Corded Ware vessels sampled for this study contained traces of a food crust. Unfortunately, it contained modern contamination introduced during storage and was therefore not analysed further for aquatic biomarkers. As the APAAs are formed by heating at 260–270° C (Matikainen et al., 2003; Hansel et al., 2004; Evershed et al., 2008), differing cooking habits could, in principle, explain the absence of such aquatic biomarkers in these vessels.

Animal bones (and one possible human bone) were recovered from most of the Corded Ware sites included in this study (see Table 3 – Supplementary Data). The majority of the sites were, however, multi-period settlement sites with several phases of occupation. Because of thin and mixed cultural layers, it is difficult to connect any individual bone with a given occupation phase without undertaking radiocarbon dating. The recovered bones are mostly burnt with a few unburnt fragments, which are most likely to date to later periods of use (see Bläuer & Kantanen, 2013). No burnt domestic animal bones were recovered from these sites. The sites of Tengo Nyåker, Hämeenlinna Perkiö, Salo Märy Halikko, and Inkoo Ragnvalds included predominantly Corded Ware finds. Burnt bone from these sites was scarce, with only a few identifiable fragments of animals and one possible human bone.

A comparative geochemical analysis (scanning electron microscope-energy dispersive spectroscopy, SEM-EDS, and particle-induced X-ray emission, PIXE) of Corded Ware pottery recovered in Finland, Sweden, and Estonia indicated that *c.* 8 per cent of Corded Ware vessels recovered in archaeological contexts potentially derive from inter-regional material transport, i.e. assemblages include pots that were made and probably used in a geographic context that was separate from their archaeological find location (Holmqvist et al., 2018). Hence, the issue of material transfer should be acknowledged when using ceramic-related data to interpret regional subsistence strategies. Accordingly, lipid interpretations should also be carried out hand-in-hand with pottery source determination. The geochemical and mineralogical fingerprint of 12 Corded Ware pots included in this study was investigated, and 11 were confirmed as being products of the region they were found in, based on the SEM-EDS and PIXE data (see Figure 1). One pot from Jönsas in Vantaa (KM 19914:594) appears to be a geochemical outlier, and its source is yet to be determined (Holmqvist et al., 2018).

Corded Ware Culture potters also used pots produced in previous generations, sometimes imported, for temper (Holmqvist et al., 2018). Two of the pots geochemically associated with the Finnish region origin (KM 16288:59 and KM 21501:107, both with non-ruminant terrestrial fat residues) were tempered with grog originating from pottery probably made in Sweden, and another pot (KM 17281:149, with ruminant fat residues) displayed grog linked to Estonian pottery manufacture. A recent study shows that the firing of a pot, even at relatively low temperatures, removes lipids present in unfired clay matrices (Reber et al., 2018). Grog-tempered fabrics were not analysed by Reber et al. (2018) but the results indicate that grog-introduced lipid contamination (i.e. lipids unrelated to the use of the analysed pot itself, being remnants from the previous generation of pot used as temper) will not occur.

Kiukainen Ware and Swedish Pitted Ware

In previous research by Cramp et al. (2014), Kiukainen Ware vessels were found to contain both marine and ruminant carcass fats. We have been able to show that possibly dairy and non-ruminant terrestrial animals, likely to be game, were also part of the food procurement cycle. Evidence of processing aquatic fats were detected in 24 of the lipid residues extracted from Kiukainen Ware vessels. This finding agrees with the zooarchaeological data, as the animal bone from the Kiukainen culture sites consists predominantly of seal and fish bones (Bläuer & Kantanen, 2013). Although only a few fragments of identifiable bone were recovered from the sites on which this study is focused, they consisted predominantly of seal and fish bones. This is entirely consistent with the organic residues and animal bone finds from contemporary sites (Table 4 – Supplementary Data).

In addition to seal and fish bones, there are possible indications of animal husbandry and cereal cultivation during the Kiukainen period. A sheep or goat bone from a Kiukainen settlement site at Pietarsaari has been radiocarbon-dated to this period (2200–1950 cal BC; Bläuer & Kantanen, 2013). Two cattle (*Bos taurus*) bones, a sheep bone, and a pig (*Sus scrofa*) bone recovered from the Åland Islands have been radiocarbon-dated to the Late Neolithic, which was contemporaneous with the Kiukainen culture (Storå, 2000). Furthermore, some pollen evidence indicates that cereals were cultivated in this period (Vuorela, 1999: 146–47; Asplund, 2008: 190). Cereal grains have been found at the Turku Niuskala site. One grain, radiocarbon-dated during earlier research, dates to the very end of the Neolithic or the Early Bronze Age (1900–1000 cal BC; see Figure 4; Pihlman & Seppä-Heikka, 1985; Vuorela & Lempiäinen, 1988; Asplund et al., 1989; Asplund, 2008: 292). The fact that organic residues of dairy fats were also found at the Turku Niuskala site provides further evidence that agriculture was carried out in south-western Finland to some degree during the Late Stone Age. It is, however, likely that cultivation of crops and possible dairy farming were only of local or minor importance for the dietary subsistence practices of the groups who were using Kiukainen pottery. This finding, i.e. that cultivation and farming seemingly played a minor role, agrees with previous views that Baltic Sea resources complemented early agrarian practices (e.g. Asplund et al., 1989: 126).

In the Ålandic Swedish Pitted Ware culture too, seals dominate the animal bone assemblages (Storå, 2000: 69). Bones of mountain hare (*Lepus timidus*) and European beaver (*Castor fiber*), Eurasian elk (*Alces alces*), and red deer (*Cervus elephus*) have also been identified; however, it is likely that both Eurasian elk and red deer were transported to the islands as raw material for bone tool production, and were not part of the local diet (Storå, 2000: 73–74). Radiocarbon dates of the first domestic animals (cattle and sheep) fall between 2400 and 760 cal BC (Storå, 2000: 70). Thus, the residues of ruminant carcass fats recovered from a sherd from Saltvik Härdalen (ÅM 642:1), which is somewhat reminiscent of Kiukainen Ware, might just as easily derive from domesticated stock as from game animals.

In a previous study of organic residues from Neolithic pottery from the Åland

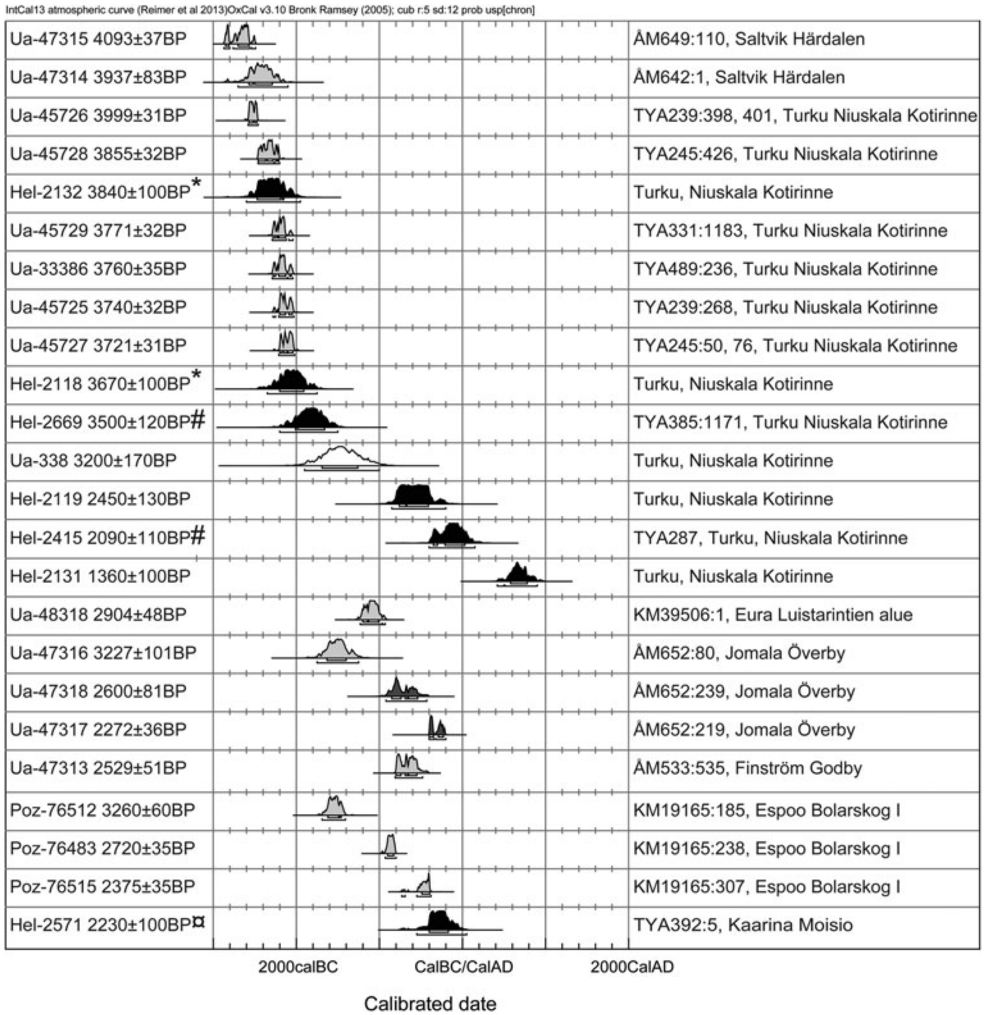

Figure 4. *Radiocarbon dates from the studied sites. Saltvik Härdalen (ÅM 642:1) is regarded as a Stone Age/Bronze Age site (Nunez, 1990). These dates are later than an earlier interpretation of the Stone Age settlement in the area (Stenbäck, 2003: 93) but consistent with the interpretation of ÅM 642:1 as being reminiscent of Kiukainen Ware. The Jomala Överby (ÅM 652:80) and Espoo Bolarskog I (KM 19165:185 and 238) results from Morby Ware are earlier than expected when compared with the general views of the chronology of this ceramic type (e.g. Edgren, 1999; Asplund, 2004). The Early Bronze Age dates are especially surprising. The characteristics of these sherds, as well as other dates from the same sites, indicate a Late Bronze Age or Early Iron Age date although the radiocarbon results have turned out differently. In principle, such divergences might relate to marine reservoir effects (for a definition and recent discussion, see Alves et al., 2018) or even to some freshwater reservoir effect (for a discussion on the dating of food crust, see Phillippsen, 2015). In this case, no clear explanation can be given. The lipid contents of these sherds do not imply a marine origin of the dated crusts; the results were ruminant fat, dairy, and no lipid content, respectively (Table 2). Key: black: charcoal; light grey: food crust from vessel surface; white: cereal grain; dark grey: burnt bone. * from Vuorela & Lempiäinen, 1988; # from Jungner & Sonninen, 1996; ¤ from Havia & Luoto, 1989 and Asplund, 2008. The calibration used the OxCal v3.10 program (Bronk Ramsey, 1995; 2001) and the IntCal13 calibration data (Reimer et al., 2013).*

Islands, traces of aquatic organism processing have been found (Papmehl-Dufay, 2005). In general, Swedish Pitted Ware groups along the Baltic Sea coastline did not include terrestrial animals in their diet to any significant extent (Eriksson et al., 2008; Fornander et al., 2008: 293). The faunal remains from the Åland Islands also indicate a dependence on marine resources (Storå, 2000: 73).

Bronze Age Ware and Morby Ware

During the Bronze Age, evidence of agriculture is more abundant in the Finnish archaeological record than during the preceding Late Neolithic Kiukainen culture. Cereal grains dating to the Bronze Age have been found at several settlement sites (e.g. from Turku Niuskala, Laihia Alatalo, and Palomäki, as well as from Eura Luistari and Luistarintie; Pihlman & Seppä-Heikka, 1985; Vuorela & Lempiäinen, 1988; Asplund et al., 1989; Asplund, 2008: 292; Holmblad, 2010: 135; Uotila, 2014; Vanhanen & Koivisto, 2015). Domestic animal bones (cattle, sheep, and horse) have been radiocarbon-dated to the Bronze Age (Bläuer & Kantanen, 2013). The results from organic residue analysis of pottery do not, however, indicate dairying during the Bronze Age; the sample size is however still too small to reach any firm conclusions.

Regarding the Morby sites included in this study, identifiable animal bones have been found at five sites. Only fish, ruminant, and seal (Phocidae) bones were identified at four sites (Table 5 – Supplementary Data), whereas at the Piikkiö Moisio settlement site domestic species, i.e. sheep or goat, dog (*Canis familiaris*), and possibly cattle, as well as wild mammals (European beaver and possibly elk) have been identified.

Even if agriculture seems to have spread geographically and its economic importance is likely to have increased during the Early Metal period and especially during the Early Iron Age, hunting, fishing, and gathering continued. This aspect is evident in both the zooarchaeological material and organic residues in pottery. Some sites of the Early Metal period have bone assemblages dominated by domestic animals with few and sometimes no seal bones. There are, however, also sites where seal bones are dominant and domestic animal bones are absent (Bläuer & Kantanen, 2013). This could be interpreted as either one population using separate sites for sealing and animal husbandry, or as the presence of separate groups of people with different subsistence strategies—some continuing the Kiukainen culture tradition of sealing and others relying increasingly on agriculture. Such a dual configuration could have involved new influences, possibly also immigration, from neighbouring areas. Finnish inland bone assemblages consist, however, only of fish bones, wild mammals, and birds; significantly, no domestic animal bones have been identified (Deckwirth, 2008; Bläuer & Kantanen, 2013).

The results of organic residue analyses presented here suggest that the pattern of use of cooking vessels by groups using Morby Ware was similar on mainland Finland and the archipelago. Sherds found at the Espoo Bolarskog I site and sherds from the Åland Islands contained residues of dairy fats, indicating the exploitation of domestic stock. Surprisingly, only two sherds contained aquatic or possibly aquatic residues. It seems that terrestrial resources were favoured over marine. Based on the organic residues, these groups did not use the Baltic Sea as a major food source, even though fish bones, albeit in only small quantities, have been found in zooarchaeological assemblages. However, it should be noted that there are ways of preparing food other than cooking it in pots. Foodstuffs can be, for example, smoked or dried, which would not leave organic residues on archaeological vessels, unless such commodities were subsequently processed in them, e.g. rehydration of dried fish.

The Changing Patterns of Resource Exploitation

Based on the modelling of summed probability distributions of radiocarbon dates, the population in Finland started to slowly grow after the end of the Stone Age, at around 1700 cal BC. That growth probably accelerated during the Late Bronze Age and Early Iron Age. In southern Finland, the lowest population levels are indicated for the period around 2900–2400 cal BC, the Corded Ware period (Tallavaara et al., 2010: 255; see Oinonen et al., 2010). The idea of using radiocarbon distributions as a proxy has been critically discussed as cultural factors could have had a big impact on the dating material available and collected by archaeologists (Mökkönen, 2011: 65; 2014; see Tallavaara et al., 2014). This problem is, in principle, comparable to the one addressed above concerning the possibility of differing cooking habits affecting the detection of biomarkers in the pottery of the Corded Ware culture. Recently, however, an idea has emerged, which might fit the scenario of a low population rate: it envisages a possible reduction in the Late Neolithic culture groups in Estonia and Finland, followed by new waves of development, and probably also people, during the Early Metal period (Lang, 2015; 2018). Thus, it may be that animal husbandry and dairying practised during the Corded Ware period did not have any significant effect on population size. Based on this finding, in Finland, the transition to agriculture was not a coercive force created by increasing population, nor did the first adaptation to keeping domestic animals result in significant population growth.

In Finland, settlement sites used by the Corded Ware groups were not usually reoccupied in the Late Neolithic or Bronze Age (Larsson, 2009: 63). Thus, it has been suggested that settlement patterns would have changed in north-eastern Europe after the Corded Ware period (Nordqvist & Häkälä, 2014: 19). With these changing settlement patterns, food procurement patterns also changed. While the organic residues from the Corded Ware period revealed an origin from dairy and terrestrial animals, the organic residues from the Kiukainen period have been shown to derive from aquatic sources in addition to ruminant and non-ruminant terrestrial fats, and possibly also dairy fat, although the latter is only indicated by a single vessel.

A previous investigation of pottery from the region revealed three lipid residues from Late Bronze Age and Morby Ware pottery, all of which corresponded to dairy fat (Cramp et al., 2014). Here we have analysed a larger number of sherds and begun to demonstrate a more diverse procurement pattern consisting of both ruminant and non-ruminant terrestrial carcasses and dairy products, and possibly aquatic products and some variability within and between sites. However, the zooarchaeological evidence from some of the sites of the Early Metal period is dominated by seal bones (Bläuer & Kantanen, 2013). These findings could indicate differing subsistence patterns among the Morby settlement sites. At some sites, the main focus was on animal husbandry and terrestrial resources, whereas at others sealing was important. It has been suggested that during this period in Sweden a more intensive form of agriculture using indoor winter feeding of animals and manuring of fields made it possible to keep animals and cultivate crops more efficiently in Norrland, an area that corresponds to the latitudes of the Finnish sites studied here (Viklund et al., 1998: 17; Welinder et al., 1998: 255–56). Similar changes may have taken place in Finland too (see Bläuer & Kantanen, 2013; Vanhanen & Koivisto, 2015). However, any direct evidence of stalling animals during this period is still missing.

Conclusions

This study has revealed a considerable variability in subsistence in southern Finland and the Åland Islands in the Late Neolithic and Early Metal period. We have shown that combining organic residue analysis with zooarchaeological data is an efficient method for studying past economies, as the two methods together can lead to more comprehensive interpretations of animal exploitation.

The first evidence of dairy fats, and thus possibly evidence of animal husbandry, comes from the Corded Ware period. Thereafter, the intensity of animal husbandry seems to have decreased and groups transitioned towards hunting and gathering. Traditionally, it has been assumed that the groups using Kiukainen Ware were mainly hunter-gatherers but our results indicate that animal domestication, at least to some extent, was also practised during the Kiukainen Ware period in southern Finland. It is however also possible that residues of dairy fats are indications of contacts with agrarian groups in neighbouring regions. Dairy or other domesticated animal products could have been transported to Finland, and therefore we cannot definitively conclude that animal husbandry was practised in the region during the Late Neolithic. Be that as it may, dairy product use was not as intensive during the Kiukainen Ware period as it was during the preceding Corded Ware period, even though the agrarian way of life appears not to have been fully discarded: at least some sites, such as Turku Niuskala, show that it was of local importance. It is possible that improvements in winter feeding and field manuring practices enabled the rise of animal husbandry during the Early Metal period. Based on the results presented here, it also seems, as expected, that animal husbandry or at least dairying became important again in the Early Metal period for groups using Morby Ware.

It is often assumed that environmental factors, for example climatic deterioration, are solely responsible for the slow start of farming in northern latitudes. However, it cannot be excluded that cultural reasons, such as contacts with non-agrarian communities in neighbouring areas, could also have caused such a delay. Even if the organic residues from Corded Ware do provide the first evidence of animal husbandry, this period in Finland is dualistic in terms of the subsistence economy. Contemporary groups, especially inland, continued with a hunter-gatherer lifestyle. In the process of assimilation, the fisher/hunter system, perhaps surprisingly, became stronger, and that aspect can be seen in the Kiukainen culture. Assimilation, in this case, meant the integration of a new culture, probably from immigrating people and a new subsistence strategy into a pre-existing lifestyle rather than the other way around.

Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/eaa.2019.39.

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Une diversité de modèles économiques dans les régions de la Baltique du Nord à la fin du Néolithique et au début des âges des métaux

Cet article présente les résultats d'un e analyse des résidus organiques conservés dans plus de 120 tessons de céramique préhistorique provenant de la Finlande continentale et des îles d'Åland en Baltique du nord. Les résidus de matières grasses qui ont survécu dans ces récipients indiquent que l'approvisionnement en *nourriture se faisait sur un large éventail pendant le Néolithique et au début des âges des métaux. Notre analyse ainsi que des études plus anciennes révèlent que l'élevage d'animaux domestiques gagna la Finlande avec la culture de la céramique cordée. Les communautés utilisant un type de céramique néolithique plus récente nommée céramique de Kiukainen n'ont cependant pas pratiqué l'élevage du bétail à grande échelle ; un seul tesson dans notre échantillon indique la présence de matières grasses provenant de produits laitiers. En gros, même après l'arrivée de l'élevage laitier dans la région, les groupes préhistoriques du sud et du sud-ouest de la Finlande ont continué à suivre (ou ont repris) un mode de vie de chasseurs-cueilleurs. L'élevage prit plus d'importance parmi les communautés de la région au début des âges des métaux et le niveau de la production laitière s'intensifia.* Translation by Madeleine Hummler

Mots-clés: Finlande, élevage d'animaux domestiques, céramique archéologique, production laitière, lipides, analyse des isotopes stables du carbone

Ein unterschiedliches wirtschaftliches Modell im nördlichen Ostseeraum im Spätneolithikum und am Anfang der Metallzeit

Die Ergebnisse einer Analyse von organischen Reststoffen, die in über 120 urgeschichtlichen Keramikscherben aus dem finnischen Festland und den Åland Inseln im nördlichen Ostseeraum erhalten blieben, werden in diesem Artikel besprochen. Die Fettreste in diesen Gefäßen weisen darauf hin, dass die Nahrungsbeschaffung im Neolithikum und am Anfang der Metallzeit auf einer breiten Basis beruhte. Unsere Untersuchungen und frühere Studien zeigen, dass die Viehwirtschaft zusammen mit der Schnurkeramikkultur Finnland erreichte. Die Gemeinschaften, welche die nachfolgende spätneolithische Kiukainen Keramik benutzten, haben die Tierhaltung aber nicht maßgeblich betrieben: Ein einziges Fragment unter den untersuchten Scherben enthielt Milchfett. Im Allgemeinen behielten die Gemeinschaften in Süd- und Südwestfinnland eine Jäger-und-Sammler-Wirtschaft oder nahmen sie wieder auf, auch nach der Einführung der Milchwirtschaft in der Region. Während der frühen Metallzeit gewann die Tierhaltung in den Gemeinschaften der Gegend an Bedeutung und das Ausmaß der Milchwirtschaft verstärkte sich in diesem Zeitabschnitt. Translation by Madeleine Hummler

Stichworte: Finnland, Tierhaltung, archäologische Keramik, Milchwirtschaft, Lipide, Analyse der stabilen Kohlenstoffisotopen