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ORIGINAL ARTICLE

New evidence of late Neolithic and early Metal Period agriculture in Turku, southwest Finland

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Abstract

A re-evaluation of late Neolithic cereal grains, combined with new archaeobotanical data, add to the evidence of late Neolithic and early Metal Period farming in southwest Finland. Earlier indications of late Neolithic cereals at the Niuskala Kotirinne site in Turku are confirmed by new radiocarbon dating results. An early occurrence of *Hordeum* has also found at a second site nearby, Räntämäki Riihivainio. The finds are discussed in relation to early dates of cereal finds and other indications of farming, as well as general interpretations of the earliest cereal growing in Finland and the northern Baltic region.

Keywords Archaeobotany · Archaeology · Barley · Cereal growing · Early Metal Period · Finland · Late Neolithic

Introduction

Early farming in Finland

The burning question of the date when the first signs of farming occur in different areas of northern Europe has been explored by researchers from a range of disciplines such as palynology, archaeobotany, archaeozoology and archaeology (Zvelebil and Dolukhanov 1991; Bonsall et al. 2002). It has been shown that the effects of human activities on soils are evident from the start of farming 6,000 years ago in Fennoscandia; the earliest cereals were planted on pristine soils and agriculture intensified by the late Neolithic (Alenius et al. 2021; Gron et al. 2021). Early agriculture in Finland has recently been studied from many perspectives and the data emphasize the importance of multidisciplinary studies for this. For example, animal and plant material, including seeds, pollen and starch, as well as analyses of organic residues on pottery have added greatly to our knowledge (Alenius et al. 2013, 2017; Bläuer and Kantanen 2013; Cramp et al. 2014; Juhola et al. 2014; Lahtinen et al. 2017; Ahola et al. 2018; Vanhanen 2019; Vanhanen et al. 2019; Pääkkönen et al. 2020). Despite all the information gathered, our knowledge is still somewhat fragmented.

In southwest Finland, the earliest evidence of agriculture seems to relate to the Kiukainen culture (Fig. 1), which dates back to 2500/2300–1800/1500 BC (all BC dates are calibrated) (Haggrén et al. 2015) and is often referred as the late (or final) Neolithic. Previous studies have found evidence of cereal grains and *Hordeum*-type pollen, bones of sheep or goats and residues of milk lipids in pottery residues, all dated to this culture (Vuorela and Lempiäinen 1988; Bläuer and Kantanen 2013; Pääkkönen et al. 2020).

Although there is only scattered evidence of the way of life at this period, the overall pattern seems to indicate that it was mainly hunting, fishing and gathering together with some farming until the Metal Period (Bläuer and Kantanen 2013; Lahtinen and Rowley-Conwy 2013; Vanhanen and Koivisto 2015; Pääkkönen et al. 2020; Heyd 2022). The Metal Period includes the Bronze Age and the pre-Roman Iron Age ca. 1700–1 BC. Additionally, the majority of the bone material as well as the data from lipid analyses indicate dependence upon marine resources,

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Fig. 1 Location of the study area around Turku in southwest Finland. The hatched area shows the distribution of the Kiukainen culture sites. Map by Henrik Asplund

fishing and sealing (Asplund et al. 1989; Bläuer and Kantanen 2013; Pääkkönen et al. 2020). These suggest that agriculture in southwest Finland was small-scale and supplemented by other resources. It was scattered over a small geographical area and the surviving botanical material is scarce.

This study aims to further understanding of the early farming in Finland; we publish new botanical and radiocarbon results here from two settlements dating to the Kiukainen culture in the late Neolithic, Niuskala at Kotirinne (60°28'42" N; 22°19'26" E) and Riihivainio at Räntämäki (60°28'35" N; 22°18'44" E), both located in Turku, southwest Finland. The discussion also includes an evaluation of bone material from the sites as well as results of lipid analysis of pottery from the Niuskala Kotirinne site. Finally, we discuss late Neolithic and early Metal Period farming in southwest Finland, in general.

Late Neolithic sites

Niuskala Kotirinne

In investigations into early agriculture in Finland or more generally the northeastern shores of the Baltic Sea, one specific site, Niuskala Kotirinne in Turku, is important. It dates to the late Neolithic or early Bronze Age, within the Kiukainen culture (2500/2300–1800/1500 BC) according to the chronology of southwest Finland (Pihlman and Seppä-Heikka 1985). At this time, Niuskala Kotirinne was on an island in an inland archipelago. Its location is typical of Neolithic sites in Finland, facing the sea on a southern slope by a sandy shore, with the open water in front of it. It is presently ca. 20–25 m above sea level (Fig. 2).

The site has been subject of several excavations and surveys from 1915 until recently (Tallgren 1915; Lehtosalo

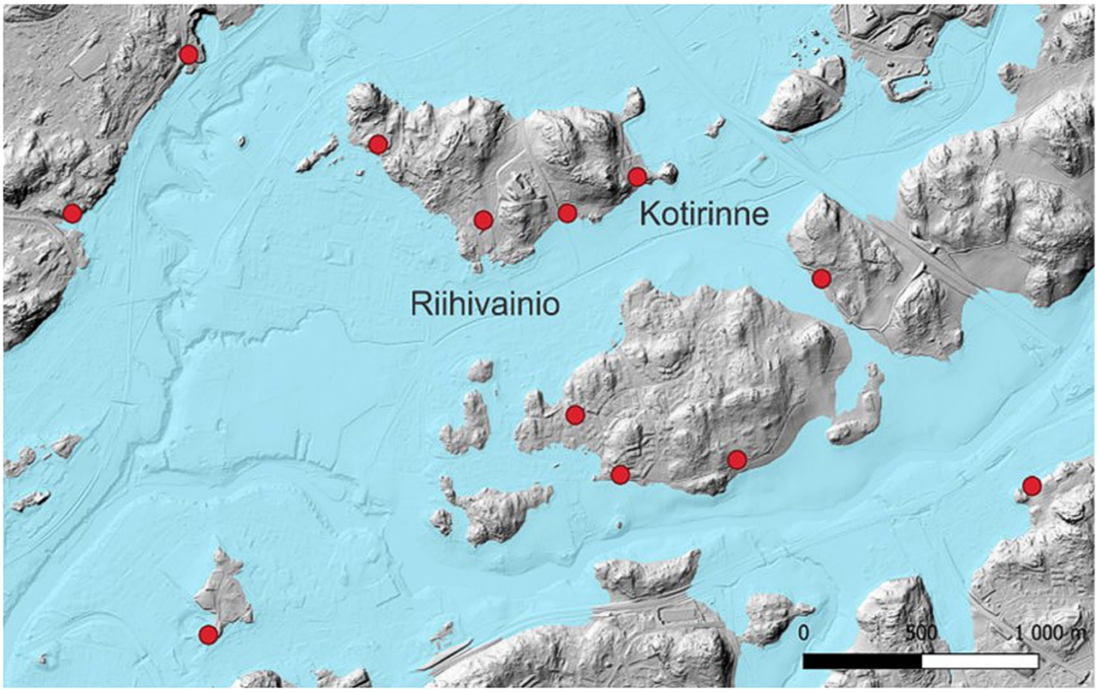

Fig. 2 Locations of Niuskala Kotirinne and Räntämäki Riihivainio as well as nearby Neolithic sites indicated in a modelled Late Neolithic landscape. The shoreline is shown at 22 m above present sea level. Map by Henrik Asplund, based on Elevation model 2 m and Hillshade 2 m of the National Land Survey of Finland

1961; Seppänen 1977; Pihlman 1983, 1984, 1985; Korkeakoski-Väisänen 1986, 1988, 1989, 1990, 1991). The most recent survey was done in 2012 (Pukkila 2012a). Within the main area of the site there are distinctively coloured partly sooty cultural layers containing an abundance of pottery fragments and stone material, mostly porphyrite and quartz, but also some flint. Except for a few postholes and hearths, no obvious structures like building remains have been found.

The previous research on the Niuskala Kotirinne material includes published plant macrofossil data (Pihlman and Seppä-Heikka 1985) and a pollen study combined with radiocarbon dates (Vuorela and Lempiäinen 1988; Jungner and Sonninen 1996), as well as soil chemical analyses (Asplund et al. 1989). A discussion on settlement development and farming techniques with reference to the Niuskala Kotirinne material has also been published (Korkeakoski-Väisänen 2012). Additionally, osteological analyses by Bläuer and Kantanen (2013) include burnt bones identified as Phocidae (unspecified seals), *Esox lucius* (pike), Canidae (dog or wolf) and humans. The most recent study is an analysis of absorbed lipids from pottery, where even traces of milk fats were found (Pääkkönen et al. 2020).

Some of the plant macrofossil samples have been analysed and published (Pihlman and Seppä-Heikka 1985; Vuorela and Lempiäinen 1988), while some samples have remained unanalysed. The study by Pihlman and Seppä-Heikka (1985) included charred cereal grains, in addition to much pottery and stone material from an excavation. The macrofossil material was dated to the late Neolithic period based on archaeological artefact typology. Also, a radiocarbon date from a charred cereal grain, 3,200 ± 170 BP (Ua-338) (1885–1015 BC) (all the radiocarbon dates in this article are given with calibrated 2σ 95.4% probability ranges) seems to agree, indicating this as the earliest occurrence of cereals and probably their cultivation in mainland Finland (Vuorela and Lempiäinen 1988). This dated grain has often been referred to as *Hordeum vulgare* cf. var. *nudum*. This is probably due to a published picture of a naked barley grain from the site (Pihlman and Seppä-Heikka 1985; Fig. 3). This is, however, not the actual dated sample, which was from a fragment identified only to the level of Cerealia.

The date from the cereal grain fragment, however, has such broad margins of error that it could even date to the early Bronze Age. This, has added to the complexity of dating the activities at the site together with the fact that a few other radiocarbon dates from charcoal from the site, sampled from cultural layers or features without a specific context, have shown differing results ranging from the late Neolithic to the late Iron Age (Fig. 3; Table 1). In this study, some more soil samples were analysed and charred cereal grains dated to gain more information and certainty about the date of the farming at Niuskala Kotirinne.

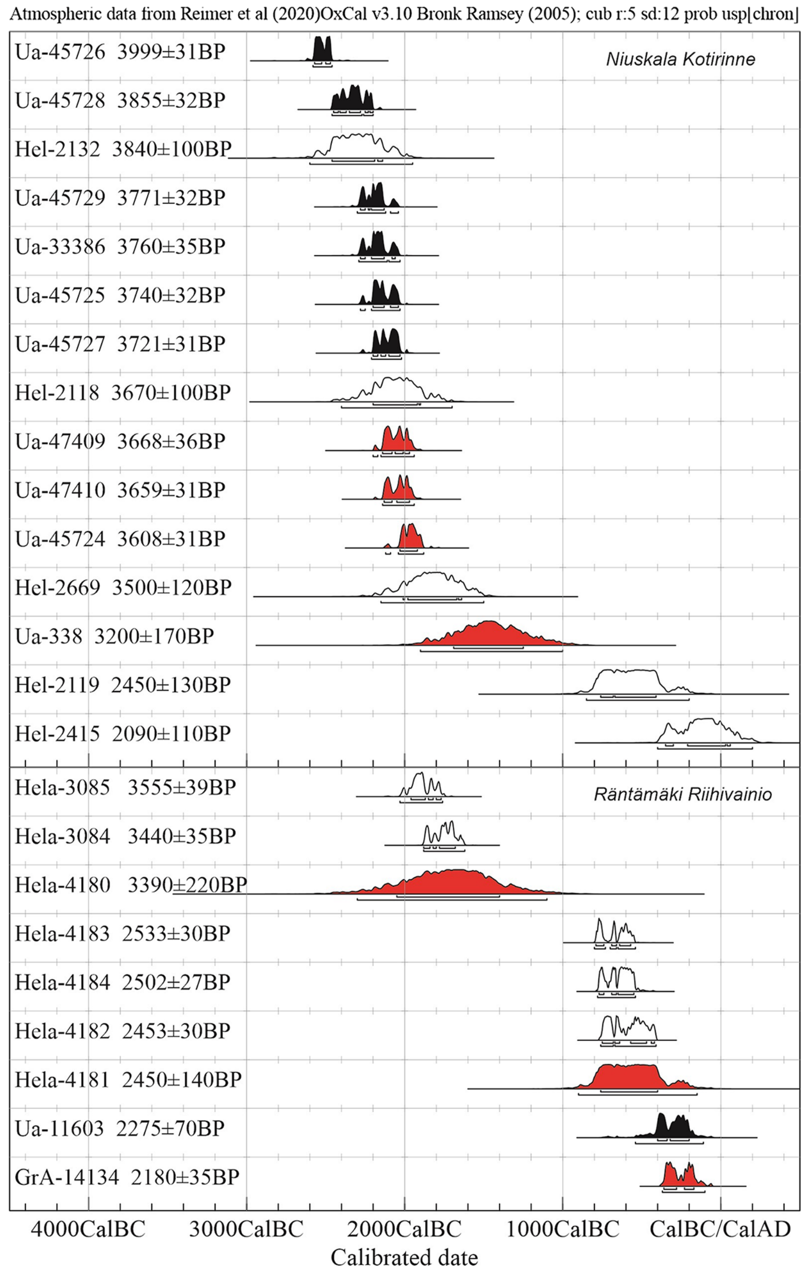

Fig. 3 Radiocarbon dating results from cereal grains (red), pottery crusts (black) and charcoal (white) from Niuskala Kotirinne and Räntämäki Riihivainio. The most recent charcoal date from Niuskala Kotirinne (Hel-2131) has been excluded

Räntämäki Riihivainio

The second site, Räntämäki Riihivainio, also dates to the Kiukainen culture (2500/2300–1800/1500 BC), however, later periods of settlement or other activities were indicated, such as a significant later occupation period during the pre-Roman Iron Age, verified by the occurrence of Morby Ware pottery, which dates from 800 BC to AD 300 (Haggrén et al. 2015; with regard to the characteristics and dating of Morby Ware, see also Asplund 2004, 2008, pp 210–230, with references). The location of the site is similar to that of Kotirinne on Niuskala, on the southern slope of the former island on a sandy beach (Fig. 2).

Since 1961 some archaeological finds have been reported and surveys or excavations have been done at the site (Lehtosalo 1961; Seppänen 1977; Pihlman 1986; Brusila and Laitinen 1989; Brusila 1990; Raike 1991; Asplund 1992; Korkeakoski-Väisänen 1996; Korkeakoski-Väisänen and Ratilainen 1997; Pellinen 2001; Pukkila 2012b, c). The latest excavations were carried out in 2017 (Pukkila 2018) and cultural layers, a hearth and marks from an ard plough related to an ancient field were studied (Fig. 4). The archaeological find material included Kiukainen culture and Morby-type pottery, stone tools and grinding stones. So far, there is only one publication on the Riihivainio excavations by Pukkila (2019), which mentions that single ard marks

Table 1 Radiocarbon dated material and results from Niuskala Kotirinne and Räntämäki Riihivainio. The cereal dates are all from grains

Site*	Year	Sample ID	Material	Lab ID	^{14}C	Cal. age (95.4%)	Reference
NK	1983	TYA 239:1556	Charcoal	Hel-2119	2,450 ± 130	830–203 BC	Vuorela and Lempiäinen 1988; Jungner and Sonninen 1996
NK	1983	TYA 239:1664	Charcoal	Hel-2131	1,360 ± 100	AD 534–893	Vuorela and Lempiäinen 1988; Jungner and Sonninen 1996
NK	1983	TYA 239:1660	Charcoal	Hel-2132	3,840 ± 100	2571–2024 BC	Vuorela and Lempiäinen 1988; Jungner and Sonninen 1996
NK	1983	9/1983	Cerealia	Ua-338	3,200 ± 170	1885–1015 BC	Vuorela and Lempiäinen 1988
NK	1983	TYA 239:268	Crust from pottery	Ua-45,725	3,740 ± 32	2280–2031 BC	Pääkkönen et al. 2020
NK	1983	TYA 239:398, 401	Crust from pottery	Ua-45,726	3,999 ± 31	2580–2461 BC	Pääkkönen et al. 2020
NK	1984	TYA 245:2500	Charcoal	Hel-2118	3,670 ± 100	2343–1764 BC	Vuorela and Lempiäinen 1988; Jungner and Sonninen 1996
NK	1984	TYA 245:50, 76	Crust from pottery	Ua-45,727	3,721 ± 31	2204–2026 BC	Pääkkönen et al. 2020
NK	1984	TYA 245:426	Crust from pottery	Ua-45,728	3,855 ± 32	2457–2205 BC	Pääkkönen et al. 2020
NK	1985	TYA 287	Charcoal	Hel-2415	2,090 ± 110	389 BC–AD 130	Jungner and Sonninen 1996
NK	1986	TYA 331:1183	Crust from pottery	Ua-45,729	3,771 ± 32	2293–2042 BC	Pääkkönen et al. 2020
NK	1987	TYA 385:1171	Charcoal	Hel-2669	3,500 ± 120	2138–1518 BC	Jungner and Sonninen 1996
NK	1989	TYA 489:236	Crust from pottery	Ua-33,386	3,760 ± 35	2289–2037 BC	Pääkkönen et al. 2020
RR	1977	TYA 96:36	Crust from pottery	Ua-11,603	2,275 ± 70	520–148 BC	Asplund 2008
RR	1996	1/1996	*Hordeum*	GrA-14,134	2,180 ± 35	367–109 BC	Asplund 2008; Lempiäinen 2010
RR	2012	2/2012	Charcoal	Hela-3084	3,440 ± 35	1878–1629 BC	Pukkila 2019
RR	2012	26/2012	Charcoal	Hela-3085	3,555 ± 39	2023–1766 BC	Pukkila 2019
NK	1983	3/1983	*Hordeum*	Ua-47,409	3,668 ± 36	2191–1943 BC	This publication
NK	1983	5/1983	*Hordeum*	Ua-45,724	3,608 ± 31	2114–1884 BC	This publication
NK	1983	15/1983	*H. vulgare*	Ua-47,410	3,659 ± 31	2137–1945 BC	This publication
RR	2017	3/1/2017	*H. vulgare*	Hela-4180	3,390 ± 220	2291–1125 BC	This publication
RR	2017	9/1/2017	*H. v.* cf. var *nudum*	Hela-4181	2,450 ± 140	839–198 BC	This publication
RR	2017	8 A/1	Charcoal	Hela-4182	2,453 ± 30	753–413 BC	This publication
RR	2017	8B/1	Charcoal	Hela-4183	2,533 ± 30	794–544 BC	This publication
RR	2017	11/2	Charcoal	Hela-4184	2,502 ± 27	776–540 BC	This publication

* NK - NK, RR - Räntämäki Riihivainio

have been previously noticed at the site (Brusila 1990; Raike 1991; Asplund 1992), but the ancient field revealed during the 2012 and 2017 excavations covered a wider area, approximately 40 × 15 m, with several different types of ard marks. A common feature in these types of fields is that the ard marks cross each other, showing that the ploughing was done crosswise or in different directions. What seems important is that some ard marks seemed to form curving lines and had rounded, not V-shaped, cross sections maybe indicative of a blunted ard. This might fit one stone tool (TYA 385:385), found at Niuskala Kotirinne, later suggested as a potential ard share (Korkeakoski-Väisänen 2012). The interpretation of the tool is, however, not certain as the most obvious wear marks from its use were found on its end and not along the sides, as would have been expected if it had been used as an ard.

Soil samples were collected to obtain information on the dating of the field excavated in 2012 and to identify the crops that were grown, but only *Esox lucius* (pike) teeth, *Picea abies* (spruce) needle-like leaves and a few charcoal fragments were found in the samples. However, none of these were suitable for radiocarbon dating (Lempiäinen-Avci 2012a, b with osteological comments by Bläuer). Thus, an axe or chisel made from olivine diabase, typical of the Kiukainen culture and found at the bottom of one of the ard marks, gave an initial indication of the chronology from its typology. Moreover, sherds of pottery dating from the late Neolithic to the early Iron Age were found above the ancient field layer, in a layer disturbed by modern ploughing. During the excavations in 2017, soil samples were collected again to obtain more information about the structures and cultural layers of the site. These were collected from the ard marks and from a hearth, where remains of a broken pot identified as Morby Ware was found. No identifiable bone remains were found from the latest excavations of the site, however archaeobotanical material included charred cereal grains.

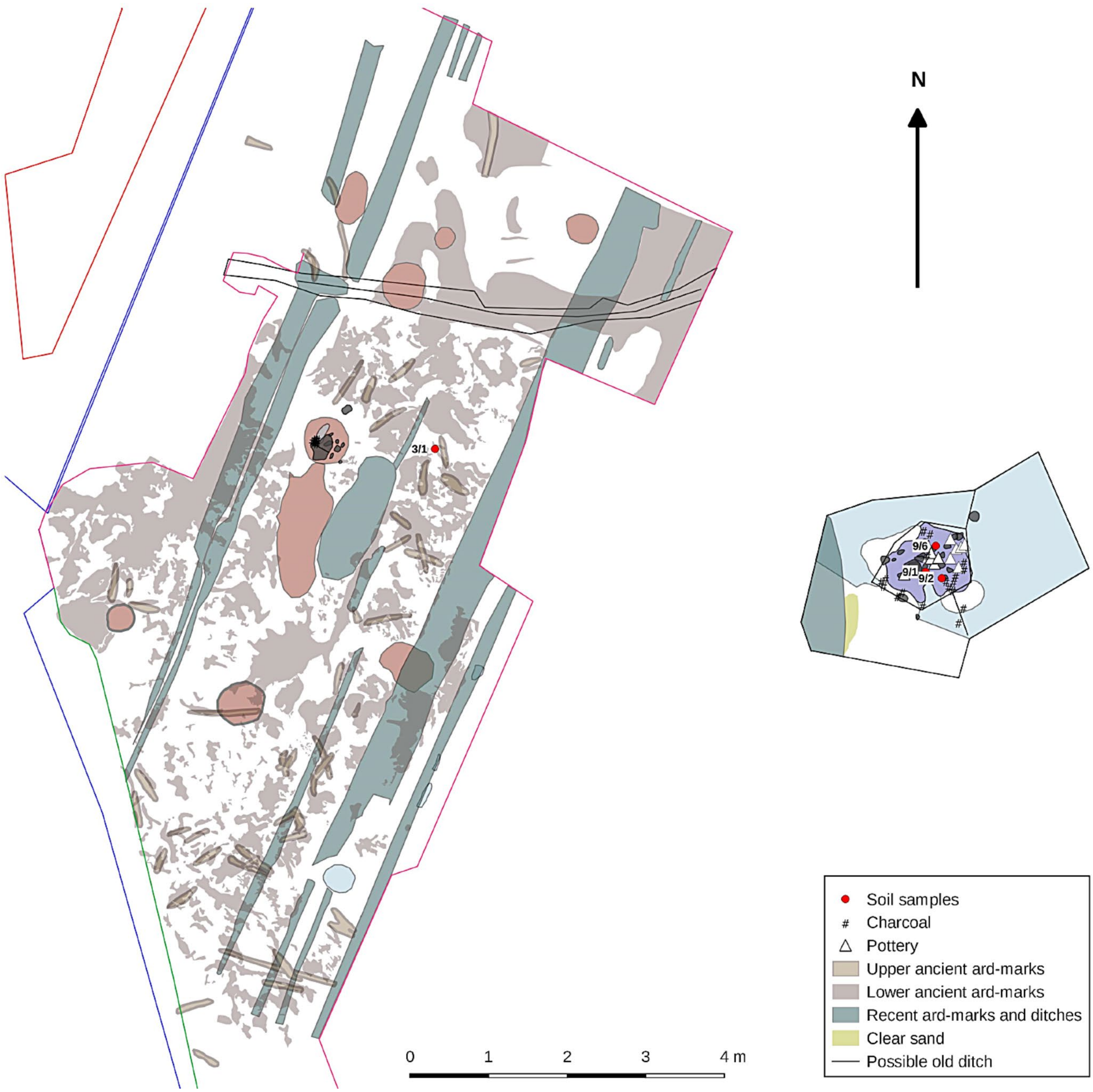

Fig. 4 Plan of the 2017 excavations at Räntämäki Riihivainio showing the excavated structures and locations of soil samples that contained cereal grains. Drawing by Jouko Pukkila

Materials and methods

The sample material and archaeobotanical soil samples analysed

The research process started with a list of the sample material previously excavated from the site. The list in 2016 by Asplund and Haapala aimed at gathering all the information then available on the macrofossil and related soil samples, including analyses completed, reports and publications in reports. The intention of this new listing was also to locate any samples that had not already been analysed or published and evaluate the possibility of using them in further studies. We also searched for the samples, which had already been analysed for plant macrofossils including cereal grains and other sieved plant remains (Asplund and Haapala 2016).

Based on the list of the Niuskala Kotirinne material (Asplund and Haapala 2016), 12 soil samples were chosen for

Table 2 Archaeobotanical results from Niuskala Kotirinne

Excavation year	1985			1987					1989				
Context*	Cl	Cl	Ss	Ss	Ss	Ss	Ss	Ph	Ss	Ss	Ss	Ss	Sum
Sample no.	1	2	3	2	3	4	5	7	1	2	3	5	
Sample volume (L)	1.4	1.4	1.8	0.4	0.6	0.5	0.5	0.3	2.4	2.4	1.3	2.3	15.3
Cereals													
Hordeum vulgare cf. var. *nudum,* caryopsis		1	2						1				4
Cerealia, caryopsis			1						1				2
Arable weeds													
Fallopia convolvulus, nutlet			1				2						3
Poaceae, caryopsis			1										1
Ranunculus sp., nutlet			1										1
Vicia sp. seed										1			1
Woodland and shrubs													
Picea abies, needle		16	148										164
Picea abies, seed			1										1
Pinus sylvestris, seed			1										1
Rubus idaeus, fruitstone	1		1										2
Indeterminate, seed			2	2					4		5	1	14
Sum	1	17	159	2			2		6	1	5	1	194

* Cl - cultural layer, Ss - sooty soil, Ph - post hole

Table 3 Archaeobotanical results from Räntämäki Riihivainio, 2012 excavation

Context*	Cl	Cl	Cl	Cl	Cl	Cl	Am	Am	Am	Cl	Cl	Am	Am	Am	Am	Sum
Sample no.	2	5	7	12	13	14	16	18	19	21	22	25	26	27	29	
Sample volume (L)	3.8	2.5	3.4	3.2	2.8	3.1	3	2.8	4.1	3.2	2.8	4.2	2.3	4	0.5	45.7
Arable weeds																
Galium verum, seed					1											1
Poaceae, caryopsis	1															1
Ranunculus sp., nutlet	1															1
Woodland and shrubs																
Picea abies, needle			1										1			2
Indeterminate, seed	2	1	5										2			10
Sum	4	1	6		1								3			15

* Cl - cultural layer, Am - ard marks

archaeobotanical investigation. The samples came from excavations carried out in 1985, 1987 and 1989, and the contexts of the samples were described as cultural layers, sooty soils and a posthole (Korkeakoski-Väisänen 1986, 1988, 1990). The sample volumes varied from 0.3 to 2.4 l and totalled 15 l (Lempiäinen-Avci 2012a; Haapala and Lempiäinen-Avci 2016).

With regard to the archaeobotanical material from Räntämäki Riihivainio, 15 soil samples were analysed from the 2012 excavations and 21 from 2017 (Pukkila 2012b, c, 2018). The contexts of the samples were cultural layers, ard marks, an ancient field, a posthole, a hearth and a pot (Pukkila 2012b, c, 2018). The sample volumes varied from 0.5 to 4.2 l, in all 77 l (Lempiäinen-Avci 2012b, 2017).

To extract the plant remains, the soil samples were floated in water and the flot was sieved using a series of mesh sizes between 2 and 0.25 mm. The floated material was mainly charred and the various fractions were sorted and identified under a stereomicroscope. Charred cereal grains or their fragments were identified to species or genus level by using the reference collections at the University of Turku Herbarium (TUR). Relevant literature for identifications was also used (Beijerinck 1947; Jacomet 2006). Tables 2, 3 and 4 show the volumes and details of the sample contexts of the studied sites.

Table 4 Archaeobotanical results from Räntämäki Riihivainio, 2017 excavation

Context*	Am	Cl	Cl	Af	Sip	Up	Bp	Sum
Sample no.**	3/1	8/1	8/2	9/1	9/2	9/6	R11/3	
Sample volume (L)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	31.6
Cereals								
Avena sp. caryopsis				1		5		6
Hordeum vulgare, caryopsis	1							*1*
H. vulgare var. *vulgare*, caryopsis				4	1	23		*28*
H. vulgare cf. var. *nudum*, caryopsis				1				1
Cerealia, caryopsis					1	15		16
Arable weeds								
Galium spurium, seed				13	13	32		58
Galium sp.	1							1
Polygonum aviculare, nutlet						2		2
Rhinanthus minor agg., seed	1		1				1	3
Rumex acetosella agg., nutlet				1		3		4
Vicia hirsuta, seed						6		6
Indeterminate, seed	2	1	1	1		4		9
Sum	5	1	2	21	15	90	1	135

* Am - ard marks, Cl - cultural layer, Af - ancient field, Sip - soil inside a pot, Up - under pot, Bp - bottom of post hole

** unproductive samples not shown: Am - ard 4/1 (1.5 l), 5/1 (1.5 l), 8B/1 (1.5 l), 12/2 (1.5 l), ard 1 (1.2 l), ard 2 (1.5 l); Cl – 2/1 (1.5 l), 4/1 (1.5 l), 8/3 (1.5 l); Af – 8 A/1 (1.5 l), 9/5 (1.5 l); hearth – 9/7 (1.5 l), 12/1 (1.6 l); post hole R11/1 (1.8 l)

Radiocarbon samples

The radiocarbon dating material from the excavations at Niuskala Kotirinne in 1983 (Pihlman 1984) was selected based on the list (Asplund and Haapala 2016). From this, charred fragments of *Hordeum* from samples 3/1983, 5/1983 and 15/1983 (Pihlman and Seppä-Heikka 1985) were sent to the Tandem laboratory, University of Uppsala, Sweden, for dating.

The material from the Räntämäki Riihivainio excavations of 2017 (Pukkila 2018) was sent for radiocarbon dating to the Laboratory of Chronology at the Finnish Institute of Natural History, University of Helsinki in Finland. The dated samples included carbonised *Hordeum* grains from samples M3/1 and M9/1 (Lempiäinen-Avci 2017), as well as charcoal from samples M8A/1, MB/1 and R11/2.

All the calibrated dates are given with a 95.4% probability, calculated with OxCal v. 3.10 (Bronk Ramsey 1995, 2001), using the IntCal20 calibration dataset (Reimer et al. 2020). Table 1 shows the materials sent for dating from the studied sites.

Results

Archaeobotanical analyses

Niuskala Kotirinne

Three grains of *Hordeum vulgare* cf. var. *nudum* (possible naked barley) and one unidentified Cerealia fragment were recovered from the samples from sooty soils and cultural layers of the 1985 excavations. Charred weeds from these samples include *Fallopia convolvulus* (L.) A. Löve (black bindweed), Poaceae (grasses) and *Ranunculus* sp. (buttercups). In addition, abundant numbers ($n=148$) of charred *Picea abies* L. (spruce) needles together with a *Pinus sylvestris* L. (Scots pine) seed and *Rubus idaeus* L. (raspberry) fruit stones were also found. The samples from the 1987 excavations did not yield any cereal grains, but two charred nutlets of *Fallopia convolvulus*, a weed of cultivated land, were found. The archaeobotanical material from the 1989 excavations included one naked barley, one Cerealia fragment and one charred seed of *Vicia* sp. (vetch).

Räntämäki Riihivainio

The macrofossil analyses of the samples from the excavations at Räntämäki Riihivainio in 2012 did not produce any cereal grains. The only finds were charred remains of *Galium verum* L. (lady's bedstraw), grasses, buttercups, spruce needles and some seeds, which could not be identified due to their fragmentary state. Nevertheless, the analyses of the 2017 samples produced 36 identified grains; one *Hordeum vulgare* cf. var *nudum* (possible naked barley), 29 *Hordeum vulgare* var. *vulgare* (hulled barley) and six *Avena* sp. (oat) grains, as well as 16 unidentified Cerealia fragments. Weeds, such as *Galium spurium* L. (false cleavers), *Rhinanthus minor* L. agg. (yellow rattle) and *Vicia hirsuta* L. Gray (hairy vetch) were also identified. Interestingly, only five barley and one oat grain were found in the samples from the ard marks and the ancient field, while the rest of the grains, five oats, one naked barley and 24 hulled barley, came from a pot in a hearth.

The archaeobotanical results from Niuskala Kotirinne and Räntämäki Riihivainio are presented in Tables 2, 3 and 4.

Radiocarbon dating results

Three new radiocarbon dates are available from Niuskala Kotirinne. The *Hordeum* from sample 3/1983 is dated to 3,668 ± 36 BP (Ua-47409), equivalent to 2191–1943 BC. Another *Hordeum* grain from sample 5/1983 has a radiocarbon result of 3,608 ± 31 BP (Ua-45724), (2114–1884 BC). Finally, the *Hordeum* from sample 15/1983 was dated to 3,659 ± 31 BP (Ua-47410) corresponding to 2137–1945 BC.

Five new radiocarbon dates are available from Räntämäki Riihivainio. The *H. vulgare* var. *vulgare* (barley) grain from the ard mark in the ancient field (sample 3/1/2017; Fig. 5a) was dated to 3,390 ± 220 BP (Hela-4180) (2291–1125 BC). The possible *H. vulgare* var. cf. *nudum* (possible naked barley) grain from the ancient field (sample 9/1/2017; Fig. 5b) dated to 2,450 ± 140 BP (Hela-4181), (839–198 BC). The barley grains were mineralized by the natural iron oxide in the soil. Due to their low organic content, they were measured directly from their carbon dioxide (CO_2), thus avoiding the conversion to graphite required for high precision measurements. This method, unfortunately, gives much wider error margins. However, the results indicate that the *Hordeum vulgare* var. *vulgare* from the ard mark is from the end of the Neolithic or the early Bronze Age, while the *Hordeum vulgare* var. *nudum* is from the late Bronze Age or the pre-Roman Iron Age.

Two earlier published charcoal dates from samples 26/2012 and 2/2012 (Pukkila 2019) could possibly be contemporary with the earlier of the dated grains. The later dated charcoal fragments, samples 8 A/1, 8B/1 and 11/2, all have rather similar dates: 2,453 ± 30 BP (Hela-4182), (753–413 cal BC), 2,533 ± 30 BP (Hela-4183) (794–544 cal BC) and 2,502 ± 27 BP (Hela-4184) (776–540 BC). These dates may relate to activities during the same period as the occurrence of the naked barley.

The new dates from the sites are given together with the earlier ones in Table 1; Fig. 3.

Discussion

In addition to Niuskala Kotirinne and Räntämäki Riihivainio, there are several other late Neolithic or early Metal Period sites in the vicinity, distributed in a landscape which formed an inner archipelago of islands during the late Neolithic, but which is now located inland, about 4 km both from the sea and the centre of the nearby city of Turku (Fig. 2). The topographical map shows that the ancient islands were in a large estuary during the late Neolithic, and several settlement sites form an occupation cluster on these islands and the nearby mainland, providing finds from the Neolithic to the Bronze and early Iron Age. Perhaps the criteria for

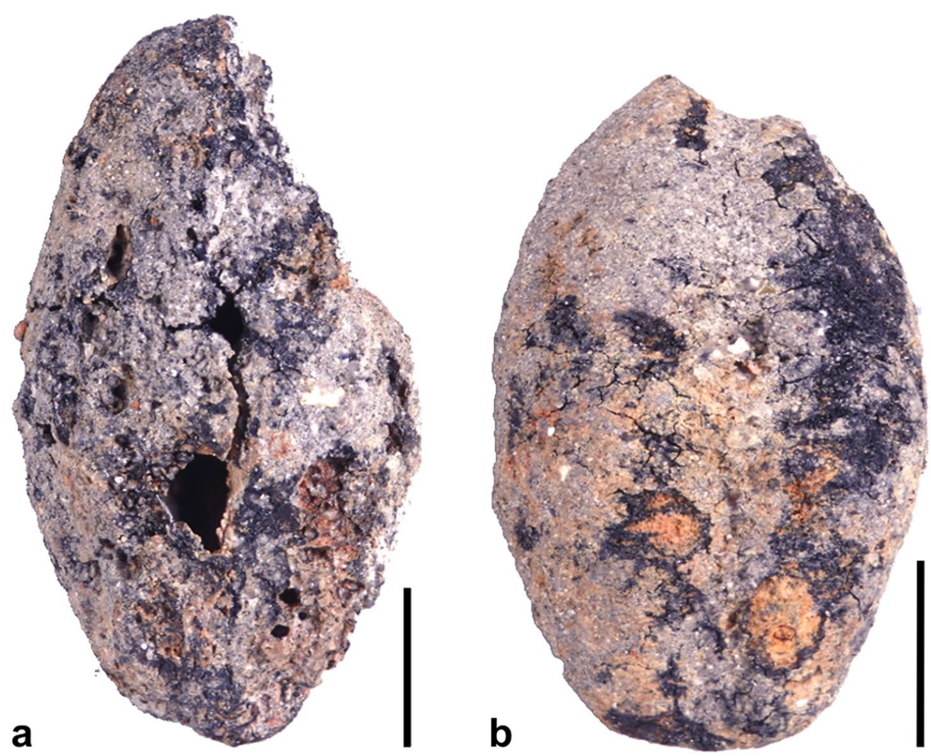

Fig. 5 **a** Charred *Hordeum* (barley) grain from an ard mark at Räntämäki Riihivainio (sample 3/1) dated to 2291–1125 BC. **b** Charred grain of *Hordeum vulgare* cf. var. *nudum* (possible naked barley) from an ancient field at Räntämäki Riihivainio (sample 9/1) dated to 839–198 cal BC. Photos by Mia Lempiäinen-Avci

selecting the area for occupation remained unchanged from the time of the Kiukainen culture until the early Iron Age. One of these could have been good fishing and hunting on the sea, another being arable farming, both possibly being practised at Niuskala Kotirinne and Räntämäki Riihivainio during this time.

Osteological material from the studied sites is scarce, indicated only by *Esox lucius* (pike) bones. Also, a seal bone was found in 1996 during an excavation of the nearby Räntämäki Orhinkarsina area, equivalent to the Riihivainio site (Korkeakoski-Väisänen 1996). Beside bone analyses, lipid analyses have also been done on finds from Niuskala Kotirinne. The dating results from six samples of organic material from crusts on pottery gave a late Neolithic date (Pääkkönen et al. 2020). What is interesting is that the pottery crust seems to be earlier than the cereal grains. There is not a big gap, but still one could theoretically think of a time span covering a generation or two. In that case, the growing of cereals may have taken place after the activity at the actual dwelling site had ceased. This is, however, a problematic issue as the crust is likely to contain material from sea fish and animals, which could cause a dating bias from the marine reservoir effect (for a definition and discussion, see Alves et al. 2018).

Early farming on site

As noted before, early signs of farming in Finland were found at Niuskala Kotirinne, including a Cerealia fragment dated to 1885–1015 BC (Ua-338). Now the early date is confirmed and pushed even further back in time by three additional dates, ranging from ca. 2200 to 1880 BC (Ua-47409, Ua-47410, Ua-45724). The Räntämäki Riihivainio site which is close to Niuskala Kotirinne, adds to the discussion and evidence of early agriculture by having a *Hordeum vulgare* var. *vulgare* (hulled barley) grain dated to 2291–1125 BC (Hela-4180). Interestingly, the possible *Hordeum vulgare* var. *nudum* (naked barley) grain from Räntämäki Riihivainio has been dated to 839–198 BC (Hela-4181). This is so far the earliest radiocarbon dated naked barley found in Finland.

Adding together both the old and new data, there are altogether 128 cereal grain remains known from both of the sites (Table 5). The archaeobotanical material from Niuskala Kotirinne includes three grains identified as *Hordeum*, five naked barley grains while hulled barley grains are absent, and 68 grains identified only as Cerealia. From Räntämäki Riihivainio there is only one possible naked barley grain, together with 29 hulled barley, six oats and 16 grains identified as Cerealia.

The Räntämäki Riihivainio site has two distinct periods of use, first in the late Neolithic and again in the pre-Roman Iron Age. The cereal grains from the site were found in connection with a potential late Neolithic ancient field with ard marks, but also in early Metal Period contexts (ca. 1700–1 BC). The pre-Roman Iron Age and possibly also the late Bronze Age are indicated by pottery typical of the period. A pre-Roman date of 2,180 ± 35 BP (GrA-14134) (367–109 BC) has also been obtained from a grain of *Hordeum vulgare* var. *nudum* identified by T. Lempiäinen and retrieved by flotation of a soil sample from excavations at the nearby Räntämäki Orhinkarsina site (Asplund 2008, p 297; Lempiäinen 2010, p 97).

The *Avena* (oat) grains from Riihivainio are interesting, as they seem strange in the context of the late Neolithic or the early Metal Period. They are fragmentary and the floret bases are missing or not visible due to charring. Therefore, the distinction between *Avena fatua* (wild) and *A. sativa* (cultivated oats) cannot be done from the grains. Both species grow in Finland, but the significance of oats during these early periods is unclear. It is noteworthy that the first reliable evidence of oats being grown in Finland date back to the first centuries AD (Aalto 1982; Häkkinen and Lempiäinen 1996). However, there is some evidence of other early oats in Finland, at the late Bronze Age site of Peltola Alatalo in Laihela, Ostrobothnia, where 41 barley grains and one oat have been found (Holmblad 2007, p 153).

The ard marks at Räntämäki Riihivainio are particularly interesting, as they do not seem to contain material dating to later periods of the Iron Age. The relationship between the stratigraphic layers of this multi-period settlement site and other contexts is not easy to interpret, but some environmental conditions and features are important to point out. At Riihivainio, both the settlement site and the field were located on the southern shore of the former island. The relationships between the features of the settlement site and the ard marks are not conclusive, but unmixed Neolithic layers were found to the north of the ancient field. The late Neolithic layer seemed to occur also partly above the field, although this could be due to the mixing of Neolithic material into the tilled soil. As the ancient field faces south and the soil is sandy over a layer of clay, the temperature and hydrology were probably favourable for growing cereals and the soil easy to till. Additionally, the location on an island (or later promontory) may have been good for protecting the field from large animals such as *Alces alces* (Eurasian elk), *Rangifer tarandus fennicus* (wild forest reindeer) or even *Ursus arctos* (brown bear).

The large number and wide distribution of cereal grains do not explicitly prove local growing or continuous use of cereals at the sites, but they do add some probability that the data do not come from a single event. Although difficult to date, the ancient field with its ard marks at Riihivainio

Table 5 Total grain data for the sites of Kotirinne in Niuskala and Riihivainio in Räntämäki

Site*	Year	Sample no.	Hordeum	cf. nudum	var. vulgare	Avena	Cerealia	Reference
Previous publications								
NK	1983	3/1983					3	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	5/1983					2	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	7/1983					1	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	8/1983					3	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	9/1983					2	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	10/1983					4	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	11/1983					2	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	14/1983		1				Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1983	15/1983					3	Pihlman 1984; Pihlman and Seppä-Heikka 1985
NK	1984	2/1984					2	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	3/1984					1	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	4/1984					2	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	5/1984					4	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	6/1984					3	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	7/1984	1					Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	8/1984					1	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	10/1984	1				4	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	11/1984					16	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	12/1984					6	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1984	13/1984					3	Pihlman 1985; Vuorela and Lempiäinen 1988
NK	1985	1/1985					2	Korkeakoski-Väisänen 1986; Vuorela and Lempiäinen 1988
NK	1985	2/1985	1				2	Korkeakoski-Väisänen 1986; Vuorela and Lempiäinen 1988
This publication								
NK	1985	2/1985		1				Korkeakoski-Väisänen 1986; Haapala and Lempiäinen-Avci 2016
NK	1985	3/1985		2			1	Korkeakoski-Väisänen 1986; Haapala and Lempiäinen-Avci 2016
NK	1989	1/1989		1			1	Korkeakoski-Väisänen 1990; Haapala and Lempiäinen-Avci 2016
RR	2017	3/1/2017	1					Lempiäinen-Avci 2017
RR	2017	9/1/2017			4	1		Lempiäinen-Avci 2017
RR	2017	9/2/2017		1	1		1	Lempiäinen-Avci 2017
RR	2017	9/6/2017			23	5	15	Lempiäinen-Avci 2017
Sum			4	6	28	6	84	128

* NK - NK, RR - RR

suggests that land at the site was cultivated. Interestingly, the earliest radiocarbon dates are from charcoal samples taken from the ard marks, as is the older of the dated grains. Due to the wide error margins of the *Hordeum* grain, the chronological correlation is not certain, but plausible. These dates could actually represent the first stages of cultivation, with land clearance by fire followed by the sowing of crops at the site.

The later dates from Riihivainio are from a hearth next to the ancient field as well as from samples from within the field that seem to be connected with some later anomalies that do not have a direct relationship to the ard marks. If earlier cultivation continued or it started at this later date, or started again after a break, this would have happened in a slightly different environment, when the island was already becoming part of the mainland and the nearby seawater was turning more brackish.

Multidisciplinary data

The environmental evidence from Niuskala Kotirinne and Räntämäki Riihivainio emphasize the importance of studying subsistence by using several sources of evidence. Osteological and lipid data indicate the use of marine resources at Niuskala Kotirinne and in the Kiukainen culture in general (Asplund et al. 1989; Bläuer and Kantanen 2013; Pääkkönen et al. 2020). Residues of dairy products such as milk on pottery indicate the possibility of animal husbandry as well (Pääkkönen et al. 2020). Additionally, the data from plant remains show that there was some level of knowledge about crop growing in the Niuskala and Räntämäki area during the time of the Kiukainen culture and in the early Metal Period.

Partly due to the fragmentary evidence, there has been limited discussion about the type of the earliest farming, such as shifting or slash and burn cultivation, intensive garden cultivation or extensive field cultivation. It has been suggested that in the Baltic area, prehistoric animal husbandry and cereal growing began at some time before the early Metal Period as two separate activities, not necessarily dependent on each other. The two only formed an integrated system after permanent field cultivation began with animal manure being used as the main fertilizer (Myrdal 1984; Gustafsson 1998; Widgren and Pedersen 2011; cf. Vanhanen 2019; Vanhanen et al. 2019). In the general context of the Kiukainen culture, where fishing and sealing provided a significant part of the subsistence needs, the charred barley finds from Niuskala Kotirinne and Räntämäki Riihivainio could be interpreted to represent a form of farming in which land was cleared with fire and then cereals were grown, without any significant keeping of animal livestock. This cultivation may have been intensive small-scale farming, and the soil would have been tilled by hand (Bogaard 2004; Baum et al. 2016). In this case, the ard marks found at Riihivainio, if they are actually representative of this period, might have been made by some form of traction ard pulled by humans (Coles 1979; Kreuz and Schäfer 2011; Kreuz 2012).

There are several assumed reasons for the slow adoption of animal husbandry in Finland, among which the most important are the long winter and therefore the need for animal fodder, which also limited mobility for people. Also, the low population density would have made it hard to keep herds large enough for a stable population close enough to each other for easy animal exchange (Bogucki 1988, pp 85–92; Bläuer and Kantanen 2013). Sheep or goats, of which bone has been recovered from one of the Kiukainen sites, would also be more likely to have suited this hunting and fishing way of life as a source of milk, rather than cattle (Ebersbach 2010; Bläuer and Kantanen 2013).

On the other hand, the ard marks are not straight but curved at their ends. This occurs when animals pulling an ard or plough start to turn as they approach the end of a furrow (Hansen 1969; Coles 1979). In such a case, Niuskala Kotirinne and Räntämäki Riihivainio could represent sites where the old subsistence strategy of marine hunting and fishing was combined with the new idea of using animals to pull ard ploughs for tilling the soil. As both the Niuskala Kotirinne and Räntämäki Riihivainio sites were well situated for fishing and sealing from the island, animal livestock may have been kept on the mainland, with better access to coastal woods and meadows. Only milk products, but not the animals themselves may have been transported to the islands, or perhaps even only vessels used for cooking milk. This could explain the lack of bones from domesticates in the faunal samples and the milk lipids found from the pottery (cf. Hallgren 2008; Bläuer and Kantanen 2013). The keeping of livestock could have made possible a more intensive type of crop growing possibly also using manure (cf. Bogaard 2004; Bogaard et al. 2013; Baum et al. 2016).

The big question is whether there was farming in the inner archipelago area in the late Neolithic. The pollen evidence from a mineral soil profile at Niuskala Kotirinne supports this interpretation (Vuorela and Lempiäinen 1988). The pollen samples were obtained from near excavation area B (1983) and trench D (1985). Charred cereals were found in both areas; one grain from trench D, was identified as *Hordeum vulgare* cf. var. *nudum* in the original analysis (Pihlman and Seppä-Heikka 1985; cf. Vuorela and Lempiäinen 1988). In the present study, three more *Hordeum vulgare* cf. var. *nudum* grains were identified from two soil samples from trench D that had not previously been analysed (Haapala and Lempiäinen-Avci 2016).

When interpreting pollen from mineral soils, attention must be given to the possibility of mixing of the sediment. The pollen grains may not have stabilized at a certain level in the soil, but may have moved through the layers due to various cultural and non-cultural formation processes such as leaching and tillage, so the pollen results are not conclusive. In the pollen assemblage it is, however, interesting to note that one *Hordeum* type pollen grain was found in the lowermost subsample from a depth of 46 cm below the present ground level; another Cerealia pollen grain was found at 37 cm (Vuorela and Lempiäinen 1988, pp 39–40). Higher up in the soil sequence the amount of Cerealia (including *Secale*) increased, indicating farming activity usually seen in pollen spectra from the Iron Age and later.

Chronology and cultural influences

The first radiocarbon dated cereal grain from Räntämäki Riihivainio, which provided one of the earliest AMS dates from Finland, has unfortunately broad margins of error. The date 3,200 ± 170 BP (Ua-338) (1885–1015 BC), places this at the very end of the Neolithic or more probably in the early Bronze Age (Asplund 2008, p 292). The new evidence from Niuskala Kotirinne provides a late Neolithic date for the activities there and the Räntämäki Riihivainio result also supports an early date of *Hordeum*. Such early dates are rare in Finland. In addition to the Kotirinne and Riihivainio dates there is only one more early *Hordeum vulgare* date, from Bäljars 2 in Karjaa, 3,090 ± 35 BP (Poz-66757) (1434–1260 BC), corresponding to the early Bronze Age (Period II or early Period III) (Vanhanen et al. 2019).

In the Åland Islands the first evidence of cereal cultivation is related to the Pitted Ware culture (Gropkeramik kultur), which preceded the Kiukainen culture (Vanhanen et al. 2019; Fig. 5). Within the Pitted Ware culture on the eastern coast of Sweden as well as on the Åland Islands, the first evidence of cereal growing is linked with ritual meals, including the consumption of pigs; the hunter-gatherers adopted some farming practices without becoming full-time farmers (Vanhanen 2019; Vanhanen et al. 2019). In southwestern Finland there is no specific evidence to suggest that the earliest signs of farming might be related to ritual feasting and there is no evidence of pigs from the late Neolithic. The earliest radiocarbon dated bone of *Sus scrofa* (domesticated pig) from mainland Finland is dated to 1,404 ± 32 BP (Ua-57269) (AD 596–668) (Asplund et al. 2019). Several options remain when interpreting the data. What is interesting, however, is that pottery related to the Kiukainen culture is also found on the Åland Islands. This might be one route by which cereal cultivation spread further to the east.

Another explanation could be that this is some kind of echo from the preceding Corded Ware culture (Schnurkeramik), in which animal husbandry is known, however there is no evidence so far of growing cereals (Vanhanen et al. 2019, p 7), which makes this link less likely. Evidently, this use of animals did not manage to develop into a lasting subsistence economy (Pääkkönen et al. 2020). The early animal husbandry of the Corded Ware culture may have led either to its continuation, or a return to a way of life more based on hunting and fishing, in the following Kiukainen culture period (Heyd 2022, p 20). Adding to the complexity of the Kiukainen culture is the fact that more exact dating of this period has proved to be difficult and the date when this period ended is still under discussion, as also for the late Neolithic generally in the East Baltic area (Lang 2007, 2015, 2018, pp 127–128; Sperling 2014; Asplund 2008, pp 206–208).

The late Neolithic crisis

In fact, the late Neolithic indications of early crop growing and animal keeping do not necessarily explain or directly precede the early Metal Period subsistence strategies. Some data suggest that other factors apart from the knowledge of farming techniques probably have influenced the change from one culture to another. Two such factors are human migrations and climate change (Heyd 2022, p 17).

Migration

For migration, progress during the last two decades within the fields of linguistics and genetics has led to a new theory on the origins of the Finno-Ugric language and people. This indicates a relatively late date for the great changes in population which took place during the final Neolithic and the early Metal Period and it has also had strong implications for the interpretation of the archaeological data.

One line of this investigation is linguistics, suggesting a relatively late date for the dissolution of Proto-Uralic languages at around 2000 BC and the formation of Proto-Finnic, which would have happened during the late Bronze Age or even the early Iron Age (Kallio 2006; Häkkinen 2009). The ancestors of the Finno-Ugric people would therefore have been relatively late arrivals in Estonia and Finland, where they would have met the descendants of the earlier Neolithic population and Scandinavian migrants. It has also been suggested that, instead of having an eastern origin, the Proto-Finnic language could have developed within the present areas of Estonia, Latvia and Finland as the end result of extensive intercultural contacts between the various populations there (Lang 2015, 2018, 2020, 2022).

A further factor which may have contributed to the success of immigration is the probable crisis or setback in late Neolithic development in Finland, as convincingly shown by the summed distributions of radiocarbon dates (Oinonen et al. 2010; Tallavaara et al. 2010). These indicate that the lowest population levels may have been reached at slightly different dates in the various geographical regions. In the south, the low point of population seems to have happened earlier, at around 2900–2400 BC, than in central Finland, where it dates to around 1900–1600 BC (Tallavaara et al. 2010, p 255, Fig. 1). When compared with the archaeological data from the number of sites representing different periods, there seems to be some correlation of the population maximum followed by its decline, as indicated by the numbers of radiocarbon dates and therefore settlements (Tallavaara et al. 2010; Table 2). With regard to the late Neolithic data from the Kiukainen culture in southwest Finland discussed here, the later date (1900–1600 BC) actually at present seems more probable. The date of the end of the preceding Corded Ware culture as well as the final phases of the Comb Ceramic culture (Pit Comb Ware culture) are not particularly well known in southwest Finland. The ending of these cultural periods could also have been the result of a crisis or setback, but there is more and more evidence that the end of the Kiukainen culture is also marked by the end of archaeological evidence for continuity of settlement.

The potential population decrease in southwest Finland also seems to correlate roughly in time with a suggested population reduction at around 3,900 BP in eastern Fennoscandia in general (Tallavaara et al. 2010, pp 251, 256; cf. Sajantila et al. 1996; Sundell et al. 2014). This was first proposed from genetic evidence from Y chromosome mitochondria and it is supported by archaeological data indicating a decrease in the number of settlement sites in inland areas of Finland between 4,000 and 3,700 BP (Lavento 2001). This corresponds to the general reduction in the number of radiocarbon dates, as there are few sites to provide dating material.

The population maximum, around or after 6000 BP indicated by the chronological distribution of radiocarbon dates has been interpreted as being related to an increase in environmental productivity providing better availability of resources to hunter-gatherers (Tallavaara et al. 2010, p 256). The reduction after this is more complex to interpret, but the start of farming seems to be linked with a later new increase in population during the late Bronze and early Iron Age (Tallavaara et al. 2010, pp 257–258). An interesting thought is that "something paved the way for farming economies and populations to come" (Tallavaara et al. 2010, p 258).

If this trend towards increased farming included major changes of population, it is quite interesting that some sites in the Turku area show a degree of geographical continuity from the late Neolithic to the early Metal Period (Asplund 1997, 2008, p 13). Abandoned late Neolithic sites still seem to have attracted later settlers. One could imagine several reasons for this, ranging from cultural ones, such as existing knowledge of earlier settlements, to environmental ones such as having the same preferences or requirements for suitable sites as earlier. The latter could perhaps be related to land suitable for farming.

The theory of a population setback seems plausible from the chronology of the Kiukainen culture. To date there are about 20 radiocarbon dates from organic crusts on Kiukainen Ware, the latest roughly from the period 2000–1800 BC (without taking into account a probable marine reservoir effect). It is hard to find reliably dated pottery from later than that in this part of Finland, from before the late Bronze Age and the pre-Roman Iron Age. The later pottery types, previously regarded as having developed locally, are now seen as having been heavily influenced or brought in from elsewhere, mainly Estonia. Any other scientific dates from this period, like those from charred archaeobotanical remains and burned bones, are of great interest, but at the moment it is uncertain whether these could fill the gap in dated archaeological evidence.

One possibility is that farming in our study area intensified due to western influences from Sweden probably including immigration after the Kiukainen culture period. However, the major elements of the Scandinavian Bronze Age in southwest Finland are difficult to trace archaeologically before Period II (1500 BC) (Asplund 2011; Soikkeli-Jalonen 2021). Thus, Bronze Age dates do not close the gap in evidence from after the Kiukainen culture, but early Bronze Age activity is important, as the case of the date from *Hordeum* from Karjaa Bäljars 2. Another early Bronze Age date is from Kitulansuo in Ristiina, situated inland, within the area of the eastern Bronze Age culture (Lavento 2001, p 139).

Climate

One factor which has been suggested as an explanation for the late Neolithic population decline is climate deterioration. Climate change has been regarded as having had a large impact on farming, specifically after 2190 BC (Heyd 2022; Helama and Oinonen 2019). On the other hand, one would expect variations in climate to have affected subsistence not only locally, but on a wider geographical scale. In southern Norway, for example, signs of a Neolithic population maximum and decline have been found, as in Finland (Nielsen et al. 2019). In Norway, however, a new population expansion began already during the late Neolithic, regardless of the potentially worsening global climate then. For Finland, the idea of climate change as a reason for the "Final Neolithic crises" has been criticized by Saipio, who has especially discussed the crisis with reference to the potential effect of a *Yersinia pestis* (plague) epidemic, of which there are late Neolithic indications from the eastern Baltic region (Saipio 2022, pp 60–61).

In addition, it could be pointed out that poor climatic conditions have also been interpreted from environmental proxy data for periods of the Bronze Age and the early Iron Age, which is the time when farming seems to have spread in southwest Finland, according to increasing amounts of pollen and macrofossil data (Asplund 2008, pp 275–281). The correlation of climatic and archaeological data, including finds related to crops and domestic animals, is not straightforward.

Conclusions

This paper reviews the evidence of late Neolithic finds of cereal grains and their radiocarbon dates and the probable growing of naked and hulled barley in the area of Turku, southwest Finland, which is also supported by published pollen results. Some isolated indications of animal husbandry add to the evidence of at least some farming at the time of the Kiukainen culture.

Interpretation of the continuation of farming practices in this area after the late Neolithic is complicated by data showing a probable reduction in settlement density and population numbers. Thus, the later increase of evidence of crop growing and domestic animals during the late Bronze Age and especially the pre-Roman Iron Age may not be directly connected with the first stages of these in the late Neolithic. Still, there seems to have been some kind of long-term geographical site continuity in the Turku region as shown by

Räntämäki Riihivainio, where early Metal Period archaeological material is sometimes found at the same locations as the late Neolithic sites. In the Turku area, this might indicate a similar preference for a particular type of landscape, such as having easily tillable soils.

Some kind of a pattern seems to be evolving in which late Neolithic sites in southwest Finland provide dispersed and isolated archaeobotanical, osteological and lipid data indicating crop growing and domestic animals. The scattered archaeological remains with fragments of this evidence may actually show what was really happening, in a period when ways of farming were known in principle, but still had a minor role in the overall subsistence strategy, which remained based on hunting and fishing. Not before the early Metal Period and especially the early Iron Age, can a breakthrough be seen in the sense that farming was by then no longer restricted to isolated sites or geographical areas.

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Author contributions ML-A performed the archaeobotanical analysis; JP conducted the archaeological fieldwork at the Räntämäki Riihivainio site and collected the soil samples, AB was responsible of the animal bone identifications; MP conducted the lipid residue analysis; HA designed this study. All authors discussed the results, wrote and edited the manuscript.

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Data availability All data presented in this study are available with open access at the botanical collections at the Herbarium, and at the archaeological collection at the Department of Archaeology, both at the University of Turku.

Declarations

Competing interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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