

New cereal grain finds from southern Satakunta, Finland, dated from the Late Bronze Age to the Middle Ages

Terttu Lempiäinen¹, Maija Helamaa³, Heli Lehto^{2,3}, Ulla Moilanen^{1,3},
Markku Oinonen², Sanni Salomaa^{1,3}, Kari Uotila^{1,2,3}

Author addresses:

¹ University of Turku, ² University of Helsinki, ³ Muuritutkimus Oy

E-mail: terlem@utu.fi

Abstract

New cereal grains were discovered from three archaeological excavations conducted during the years 2012–2015 in southern Satakunta, south-western Finland. The oldest of these, identified as *Hordeum vulgare*, were found at the site of Eura Luistari, between the stones of a cooking pit. With a Late Bronze Age ¹⁴C date they are the oldest cereal grain finds from southern Satakunta to date. In total, nine cereal grains were dated from Luistari. These resulted in Late Bronze-Age, Pre-Roman Iron Age, Late Iron Age, and modern dates. Also, ard marks indicating ancient fields were noted at this site and at the site of Eura Kauttua. Cereal grains of *Hordeum vulgare*, *Secale cereale* and *Triticum aestivum* cf. *compactum* were found at the sites of Kauttua and Rauma Ellinniitty. Single grains of wheat and barley from Ellinniitty were ¹⁴C dated to the Pre-Roman Iron Age.

Study areas and site descriptions

The three studied sites: Eura Kauttua Old village, Eura Luistari Luistarintie and Rauma Ellinniitty are all situated in the southern part of Satakunta, a province of western Finland (Fig. 1). The known history of the village of Eura Kauttua extends back to the Middle Ages, at which time it was one of the largest villages in the municipality of Eura. Archaeologically, the history of the village stretches back in time to at least 900–1100 AD. Currently, parts of the settlement remains are under a 30–50 cm thick layer of field soil. Foundations of buildings as well as cultural layers from the village have survived for a millennium. From the area of Eura Luistari (municipality of Eura), cooking pits and other signs of a settlement from the Early Metal Age are known. In the same area are cairns that date to the Bronze Age, as well as the Luistari cemetery, which was in use from the 5th century AD. There was still a cemetery in the same area during the early Middle Ages. The cemetery area of Luistari and the village of Kauttua seem to form a single, larger entity. The Pre-Roman Iron Age site (500–0 BC) of Rauma Ellinniitty contains hundreds of low stone mounds. Two of them have been identified as burial cairns covered with red sandstone slabs. One of them contained two iron bracelets. There are also settlement structures at the Ellinniitty knoll (municipality of Rauma), but here no ard marks indicat-

ing ancient fields were found (Uotila and Helamaa 2015; Uotila and Lehto 2016).

The sites were studied archaeobotanically, concentrating on the cultivation history of southern Satakunta. A few radiocarbon-dated macrofossil cereal grain finds from the Eura Luistari cemetery area have already been published (Lehtosalo-Hilander 1999, 2000). A charred grain of barley (*Hordeum vulgare*) was dated to cal AD 780–562. Another barley grain was dated to the Viking age, cal AD 699–841, whereas a rye grain (*Secale cereale*) resulted in a much later dating, to the 18th century AD (Lehtosalo-Hilander 1999). The Viking age cereals were accompanied by weed seeds, namely, fat-hen (*Chenopodium album*), black-bindweed (*Fallopia convolvulus*), corn spurrey (*Spergula arvensis*), and even seeds of flax (*Linum usitatissimum*) and *Camelina linicola*. Lehtosalo-Hilander (1999) dated charcoal from some graves near the present study site within the Luistari cemetery area, and the oldest date was 1308–1078 cal BC. In this chapter, new ¹⁴C dates on cereal grains found from Eura Luistari and Rauma Ellinniitty will be presented.

Studied samples and archaeobotanical methods

Soil samples were collected by the field archaeologists from every studied site. The archaeobotanical studies comprised an analysis of soil samples, which



Figure 1. Map showing location of the municipalities of Rauma and Eura discussed in the text (map: Santeri Vanhanen).

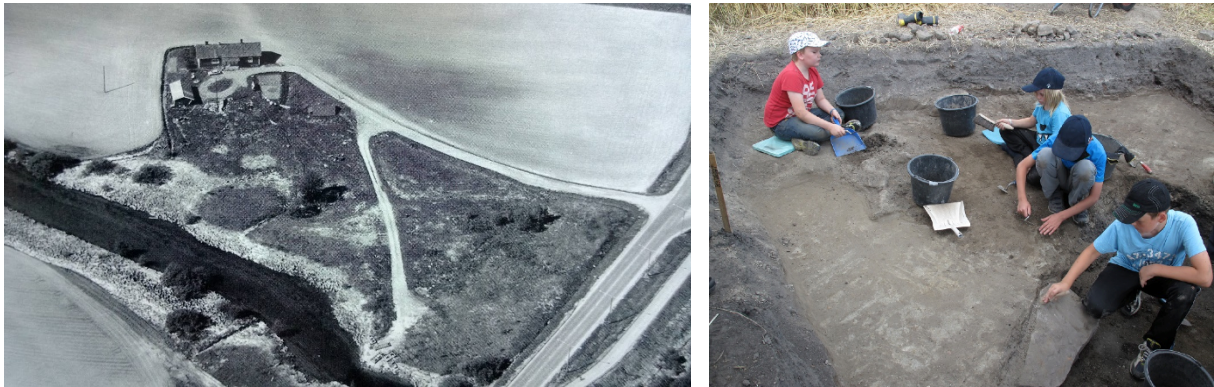


Figure 2. Aerial view of Eura Kauttua Old village site (left) (reproduced with permission from Antti Kylänpää 1977) and view of the archaeological excavation with ard marks (right) (reproduced with permission from Eeva Raike 2012).

varied in volume from 0.4 dl to 2 litres. A total of 107 samples from various contexts were collected, and 102 of these are included in the current chapter. Detailed results are described in archaeobotanical and archaeological reports (Lempiäinen 2012, 2013, 2014a, b, 2015; Uotila 2013; Uotila and Helamaa 2015; Uotila and Lehto 2016):

At Eura Kauttua (Fig. 2), a total of 36 samples were collected at a depth of 10–60 cm from the settlement layers, consisting of with dark and sooty to sandy soil with clay and charcoal, and a total of 8 samples were collected from the ancient plough layers/ard marks

of an ancient field, approximately 34.5 m above sea level.

At Eura Luistari Luistarintie (Fig. 3), a total of 45 soil samples were retrieved near and in connection to the large Luistari cemetery area (Lehtosalo-Hilander 1982, 2000). Samples were collected from cooking pits (10 samples, at a depth of c. 37 cm), graves (20 samples), the ancient plough layers/ard marks of an ancient field (4 samples), the settlement area (5 samples), and postholes within the settlement area (6 samples). Nine cereal grains from Luistarintie were ^{14}C dated.



Figure 3. View of Eura Luistari Luistarintie showing the area excavated in 2013 with a fireplace or a cooking pit on the lower left corner (photo: Terttu Lempiäinen).



Figure 4. Views of Rauma Ellinniitty showing a posthole area before (left) and after excavation, with dirty, sooty, sandy soil with small stones, pieces of plants and charcoal (right) (photos: Kari Uotila).

At Rauma Ellinniitty (Fig. 4), a total of 21 samples were collected from small postholes filled with dark, sooty and sandy soils, small stones, pieces of plants, wood and charcoal. Two cereal grains, one each of wheat and barley, were ^{14}C dated.

This chapter concentrates on those samples from which macrofossil cereal grains were identified. Soil samples were floated in tap water, after which plant remains were picked from the plant mass with the help of a microscope (Olympus SZX 9; at magnification of 40–100 \times). After drying, the charred cereal grains were stored in small bottles and housed in the macrofossil collection of the Botanical Museum, University of Turku, Finland. Plant names are according to Hämet-Ahti et al. (1998) and identifications are based on Cappers et al. (2006).

Radiocarbon dates

Nine samples collected from different layers and contexts in the Eura Luistari settlement area and the Luistarintie settlement/cemetery area were radiocarbon dated. These comprised eight charred cereal grains, of barley, bread wheat (*Triticum aestivum*) and rye, and one seed of the field weed fat-hen. Two cereal grains, one each of wheat and barley, were ^{14}C dated from Rauma Ellinniitty. All samples were analysed at the Laboratory of Chronology of the Finnish Museum of Natural History. The results are presented in Table 1, sorted by the sample laboratory number.

Results of the archaeobotanical analysis and ^{14}C dating

Tables 2 and 3 present the results of the macrofossil analysis at the three studied sites, Eura Kauttua Old village, Eura Luistari Luistarintie and Rauma Ellinniitty, during the years 2012–2015.

Eura Kauttua

Only one charred cereal grain of *H. vulgare* was found in the 2012 samples, from a soil sample taken from an ard mark (Table 2). A total of eight charred cereal grains were found in the 2013 samples, from soil samples taken from cultural layers or settlement soils, namely, five *H. vulgare*, two *S. cereale* and one *T. aestivum*. The dating of the remains is based on archaeological observations, because the *H. vulgare* grain from the ard mark was too small for ^{14}C dating. Archaeologically, the history of the village stretches back to at least 900–1000 AD. The cereals were probably from early medieval layers, and at that period *Hordeum vulgare*, *Secale cereale* and *Triticum aestivum* were being cultivated in southern Finland and in the Eura Luistari area (Lehtosalo-Hilander 1999, 2000; Alenius et al. 2017; Grönlund and Simola 2011; Pukkila 2011). The find of rye brome (*Bromus secalinus*) from this site is interesting because it is a field weed associated with rye cultivation (Lempiäinen 2010). Other weeds accompanying the cereal grains, typical of cultivated fields and settlement sites, are *Chenopodium album*, common orache (*Atriplex patula*), common fumitory (*Fumaria officinalis*), bush vetch (*Vicia sepium*) and *Alchemilla* sp.

Eura Luistari Luistarintie

The cereal grains found in the different archaeological contexts are presented in Figure 5. Altogether, 19 macrofossil finds of charred cereal grains were found. The cereal species were *H. vulgare*, *S. cereale* and *T. cf. aestivum* (Fig. 6). One grain of *H. vulgare*, from the soil sample from the cooking pit, was ^{14}C dated to 894–786 cal BCE (Table 1), and barley grains were dated to 755–400 cal BCE, 471–195 cal BCE and cal AD 891–1026. *T. aestivum* was dated to cal AD 1461–1643 and *S. cereale* to cal AD 1680–1939. Five

Table 1. Radiocarbon dates on cereal grains and seeds of weeds from Eura Luistari and Rauma Ellinniitty.

Lab. ID	Site	Sample	Material dated	d13C (‰)	Radiocarbon date (BP)	±	Calibrated date (2σ range)
Hela-3328	Eura Luistari	cooking pit	barley grains (<i>Hordeum vulgare</i>)	-26,8	2641	31	900-780 cal BC
Hela-3402	Eura Luistarintie	Mn 10 or 52	barley grain (<i>Hordeum vulgare</i>)	-25	1065	40	cal AD 890-1030
Hela-3408	Eura Luistarintie	Mn 7	barley grain (<i>Hordeum vulgare</i>)	-25,7	2419	49	760-390 cal BC
Hela-3409	Eura Luistarintie	Mn 8	barley grain (<i>Hordeum vulgare</i>)	-26,6	>MODERN (101,35 pMC)		Modern
Hela-3410	Eura Luistarintie	Mn 17	wheat grain (<i>Triticum aestivum</i>)	-26,2	338	41	cal AD 1460-1650
Hela-3411	Eura Luistarintie	Mn 17	barley grain (<i>Hordeum vulgare</i>)	-26	>MODERN (100,34 pMC)		Modern
Hela-3413	Eura Luistarintie	Mn 19	barley grain (<i>Hordeum vulgare</i>)	-25,9	>MODERN (100,82 pMC)		Modern
Hela-3414	Eura Luistarintie	Mn 23	barley grain (<i>Hordeum vulgare</i>)	-24,4	2281	54	480-190 cal BC
Hela-3415	Eura Luistarintie	Mn 27	rye grain (<i>Secale cereale</i>)	-22,7	84 (98,96 pMC)	45	cal AD 1680-1940
Hela-3980	Rauma Ellinniitty	Mn 6	wheat grains (<i>Triticum aestivum</i>)		2341	37	540-250 cal BC
Hela-3981	Rauma Ellinniitty	Mn 7	barley grains (<i>Hordeum vulgare</i>)		2285	44	410-200 cal BC

Table 2. The number and contents of soil samples taken from Eura Kauttua Old village and Eura Luistari Luistarintie. * charred.

Studied site	Soil samples	Sample size and contents	Number of macrofossil remains	Number of cereal grains	Cereal species	Weeds
Kauttua Old village 2012	29	0.1-1.5 l clayey sandy settlement soil	39	1	<i>Hordeum vulgare</i> /barley*	<i>Chenopodium album</i> *, 38 <i>Atriplex patula</i> *, 1 <i>Fumaria officinalis</i> *, 1 <i>Alchemilla sp.</i> *, 1
Kauttua Old village 2013	7	0.1-1.5 l clayey sandy settlement soil	17	8	<i>Hordeum vulgare</i> /barley* <i>Secale cereale</i> /rye* <i>Triticum aestivum</i> /bread wheat*	<i>Bromus secalinus</i> *, 1 <i>Chenopodium album</i> *, 8 <i>Vicia sepium</i> *, 1 <i>Picea abies</i> /needles*,
Eura Luistarintie 2013	45	0.1-1.2 l sooty sandy soil with charcoal	159	19	<i>Hordeum vulgare</i> /barley* <i>Secale cereale</i> /rye* <i>Triticum cf. aestivum</i> /bread wheat*	<i>Bromus secalinus</i> *, 1 <i>Chenopodium album</i> *, 138 <i>Scleranthus annuus</i> *, 1 <i>Picea abies</i> /needles*, +

of the nine dated cereals and the single dated fat-hen *Chenopodium album* seed were found to be of modern date (not included in Table 1).

The ¹⁴C dates indicate that the soil was very mixed, containing also modern material. The oldest cereal date, on *H. vulgare*, is 894–786 cal BCE, which makes it the oldest cereal grain find thus far from southern Satakunta. The nearest location subjected to pollen analyses is the Eura Hyväsuo bog, about 1 km south-east of the centre of Eura. The first and earliest signs of cereal cultivation in the pollen core date from the 4th century BCE (Vuorela 2003; Grönlund and Simola 2011), and the more or less permanent field cultivation dates from as late as the beginning of the Middle Ages. However, according to pollen assemblages from the same time as the earliest cereal grain finds (i.e. of the 9th century BCE), spruce (*Picea abies*) and some deciduous trees (*Tilia cordata*, *Ulmus glabra* and *Corylus avellana*) were drastically diminished in relation to other pollen types. Two of the dated cereal grains of *H. vulgare* come from the Late Bronze Age and Early Iron Age, respectively. The grains of *T. aestivum* and *S. cereale* were both dated to the end of the Middle Ages to Modern times (Table 1). The weeds with the cereal finds were

Chenopodium album, annual knawel (*Scleranthus annuus*), *Bromus secalinus* and *Fallopia convolvulus*.

Rauma Ellinniitty

Archaeologically, the site was dated to the Pre-Roman Iron Age. Total of 155 macrofossil remains were found, but only 14 of these were charred (Table 3), including 12 charred cereal grains, all from six sooty and sandy soil samples taken from a small pit of dark soil full of burnt bones. The cereals comprised 11 grains of *H. vulgare* and 1 grain of *T. aestivum* cf. *compactum*, all in very poor condition (Fig. 7). The ¹⁴C date of one *H. vulgare* grain was 409–206 cal BCE, and that of one *T. aestivum* cf. *compactum* grain was 540–259 cal BCE. The *Triticum* grain is one of the oldest wheat finds in Finland. There are some finds from the Roman period and the Late Iron Age (e.g. Alenius et al. 2017; Matiskainen 1984; Vikkula et al. 1994). Other *Triticum* finds date archaeologically to the Early Iron Age, for instance those of Salo Katajamäki (Aalto 1982), Salo Ketohaka (Aalto 1997), Vanutehtaanmäki (Aalto 1997) and Paimio Spurila (Seppä-Heikka 1985). The dating of the

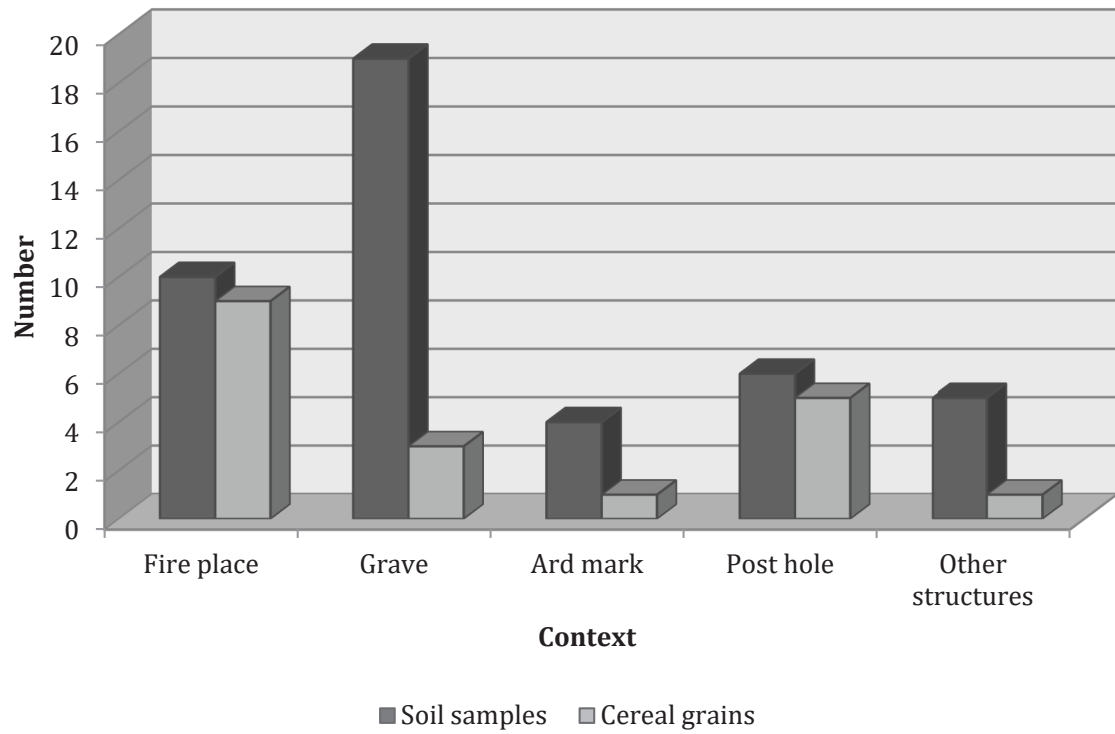


Figure 5. The distribution of soil samples and charred cereal grain finds among different contexts in the Eura Luistari Luistarintie 2013 material.



Figure 6. Charred cereal grains of barley (*Hordeum vulgare*) from an oven at Eura Luistari Luistarintie (photos: Mikael Kukkonen).

Table 3. Macro-remains identified from samples taken from five different excavation areas and from and from 21 soil samples at Rauma Ellinniitty in 2015. * charred; +++ plenty of charcoal in soil samples.

Layer	Area A2, cairns with sooty sandy soil	Area B1 with sooty sandy soil	Area F1 with sooty sandy soil	Area G1 with sooty sandy soil	Area D1 /M 416 with sooty sandy soil	Sum
Number of samples	12	1	4	2	2	21
Plant species						
Cereals						
<i>Hordeum vulgare</i>	11*					11
<i>Triticum aestivum</i> cf. <i>compactum</i>	1*					1
Weeds						
<i>Fallopia convolvulus</i>	1*					1
Trees and shrubs						
<i>Rubus idaeus</i>	1*					1
Other remains						
Charcoal	+++	+++	+++	+++	+++	
Sum	14	-	-	-	-	14

Figure 7. Charred cereal grains of barley (*Hordeum vulgare*) (left) and club wheat (*Triticum aestivum* cf. *compactum*) (right) from a posthole at Rauma Ellinniitty (photos: Mikael Kukkonen).

Triticum at Ketohaka was confirmed by radiocarbon dating (Vanhanen, this volume). *Fallopia convolvulus* represented settlement weeds. The cereal grain finds relate to some kind of cultivation at the site or near the area during the Pre-Roman Iron Age, although barley and wheat were already being cultivated in southern Satakunta some centuries earlier (see above).

Discussion

According to written documents, the history of the village of Kauttua extends back to the Middle Ages, at which time it was one of the largest villages in the municipality of Eura. Archaeologically, the history of the village stretches back to at least 900–1100 AD. The macrofossil cereal grain found at Kauttua consist

of barley, rye and wheat. They were dated archaeologically to the 10th–12th century AD. All three cereals were cultivated in southern Finland at that time, but *Hordeum vulgare* was the most commonly cultivated (Salo 1981; Lempiäinen and Häkkinen 1995; Häkkinen and Lempiäinen 1996; Vuorela 2003; Grönlund and Simola 2011).

Cooking pits and other signs of a settlement from the Early Metal Age are known from the area of Eura Luistari (Lehtosalo-Hilander 1982, 2000). In the same area, there are cairns that date to the Bronze Age and a cemetery that was in use from the 5th century AD. There was a cemetery in the same area during the Middle Ages (Lehtosalo-Hilander 1982, 2000; Pukkila 2011; Uotila 2011). The cemetery area of Luistari and the village of Kauttua seem to form one larger entity. The oldest cereal grains, identified as *H. vulgare*, come from Eura Luistari Luistarintie, between the stones of a cooking pit, and were directly ¹⁴C dated to 894–786 cal BCE and 755–400 cal BCE. They are the oldest cereal grain finds from southern Satakunta to date. In total, nine dates were obtained on cereal grains from Luistari; one *H. vulgare* was dated to the Early Iron Age and another to the Late Iron Age. The grains of *T. compactum*-type, and *S. cereale*, were found to be much younger, dating to the late Middle Ages and to Modern times, respectively.

At the Pre-Roman Iron Age site of Rauma Ellinniitti, there are hundreds of low stone mounds. Two of them have been identified as cairns covered with red sandstone slabs. In total, 12 cereal grains come from six sooty and sandy soil samples from the area, which was interpreted as a settlement site. The cereals consisted of 11 *H. vulgare* grains and 1 *T. aestivum* cf. *compactum* grain. The barley grain was ¹⁴C dated to 409–206 cal BCE. The wheat grain was dated to 540–259 cal BCE. It is one of the oldest wheat finds in Finland. The cereal finds relate to some kind of cultivation at the site or near the area during the Pre-Roman Iron Age. Both barley and wheat cultivation were carried out in southern Satakunta (cf. Alenius et al. 2017; Salo 1981; Lehtosalo-Hilander 2000; Vuorela 2003; Grönlund and Simola 2011). There are very few macrofossil finds of cereals from the studied area. The nearest cereal finds that date to the same age come from Laihia in southern Ostrobothnia—far away from the present studied sites. At Laihia, the dates for *H. vulgare* range between 1000–830 cal BCE and 380–190 cal BCE, and the date for *Avena* sp. is 770–400 cal BCE (Holmblad 2010). Engelmark and Viklund (2002) published grain finds of *H. vulgare* from Vöyri in southern Ostrobothnia dated to the Early Roman Iron Age and some younger finds dating from the Late Roman Age to the Viking age. Previously published dates from Eura Luistari cemetery on barley grains show that they date to the Pre-Roman Iron Age and the Viking age, whereas a rye grain dates to the 18th century (Lehtosalo-Hilander 1999, 2000, pp. 265–266).

Acknowledgements

The authors would like to thank the editors and reviewers, especially Santeri Vanhanen, for useful comments on the manuscript. Marja Vieno revised the English text.

References

- Aalto M (1982) Archaeobotanical studies at Katajamäki, Isokylä, Salo, south-west Finland. In: Hackens T (ed) ПАСТ 7/1. Council of Europe, Strasbourg, pp 137–147
- Aalto M (1997) The cultivated plants of Finnish Iron Age. In: Кирпичников АН, Рябинин ЕА, Сакс АИ (eds) Славяне и финно-угры: археология, история, культура. С.-Петербург, pp 47–61
- Alenius T, Haggren G, Koivisto S, Vanhanen S, Sugita S (2017) Landscape dynamics in southern Finland during the Iron Age and the Early Modern Era: Pollen-based landscape reconstruction (LRA), macrofossil and historical data from western Uusimaa. *J Archaeol Sci Reports* 12:12–24
- Engelmark R, Viklund K (2002) Korn i rägens rike! Pörnnullbackens jordbruk och kulturlandskap. In: Viklund K, Gullberg K (eds) Från romartid till vikingatid. Scriptum, Vasa, pp 13–24
- Grönlund E, Simola H (2011) Suoturvetta ja järvenpohjaa: Euran Hyväsuon ja Köyliönjärven paleoekologiset tutkimukset. In: Uotila K (ed) Avauksia Ala-Satakunnan esihistoriaan. Eura Print, Eura, pp 81–110
- Cappers RTJ, Bekker RM, Jans JEA (2006) Digitale Zadenatlas van Nederland. Barkhuis Publishing & Groningen University Library, Groningen
- Häkkinen K, Lempiäinen T (1996) Die älteste finnische Getreide und ihre Namen. *Finno-Ugrische Forschung* 53(1–3):115–182
- Hämet-Ahti L, Suominen J, Ulvinen T, Uotila P (1998) Retkeilykasvio. Luonnontieteellinen keskusmuseo, Helsinki
- Holmblad P (2010) Coastal communities on the move: House and polity interaction in southern Ostrobothnia 1500 BC–AD 1. Dissertation, University of Umeå
- Lehtosalo-Hilander P-L (1982) Luistari III. Vammalan Kirjapaino, Vammala
- Lehtosalo-Hilander P-L (1999) Dates. In: Huurre M (ed) Dig it all: Papers dedicated to Ari Siiriäinen. Archaeological Society of Finland, Helsinki, pp 39–43
- Lehtosalo-Hilander PL (2000) Kalastajista kauppanaisiin: Euran esihistoria. Euran kunta, Vammala
- Lempiäinen T (2010) Muinaisten peltojen rikkaruohot makrofossiilaineistoissa. In: Hirvilammi, J (ed) Varhainen viljely Suomessa. Suomen Maatalousmuseo Sarka, Loimaa, pp 3–19
- Lempiäinen T (2012) Eura Kauttua, vanhan kylän paikka (Arkeologinen kaivaus, makrofossiilitutkimusraportti). Unpublished archaeobotanical report, Biodiversiteettiysikkö, Turun yliopisto
- Lempiäinen T (2013) Eura Luistari Luistarintie (Arkeologinen kaivaus 2013, makrofossiilitutkimusraportti). Unpublished archaeobotanical report, Biodiversiteettiysikkö, Turun yliopisto
- Lempiäinen T (2014a) Euran Kauttua vanhan kylän paikan kaivaukset 2013. Unpublished archaeobotanical report, Biodiversiteettiysikkö, Turun yliopisto

- Lempiäinen T (2014b) Rauma Ellinniitty: Arkeologinen kaivaus 2014. Unpublished archaeobotanical report, Turun yliopisto
- Lempiäinen T (2015) Rauma Ellinniitty: Arkeologinen kaivaus 2015. Unpublished archaeobotanical report, Biodiversiteettiyksikkö, Turun yliopisto
- Lempiäinen T, Häkkinen K (1995) Koska Suomessa on alettu viljellä maata? *Hiidenkivi* 6:11–14
- Matiskainen H (1984) Getreidekörner aus der spätzeitlichen Siedlungsmmer Domargård I in Karjaa, Südfinnland. *Fennoscandia Archaeologica* I:43–50
- Pukkila J (2011) Euran viikinkiaika. In: Uotila K (ed) *Avauksia Ala-Satakunnan esihistoriaan*. Eura Print, Eura, pp 111–132
- Salo U (1981) Satakunnan historia, osa 1, 2: Satakunnan pronssikausi. Satakunnan maakuntaliitto, Rauma.
- Seppä-Heikka M (1985) Grains and seeds from younger Roman Iron Age excavations in Spurila. *Iskos* 5:460–461
- Uotila K (2011) *Avauksia Ala-Satakunnan esihistoriaan*. Eura Print, Eura
- Uotila K (2013) Eura Luistarintie, arkeologinen kaivaus 2013. Unpublished excavation report, Muuritutkimus ry.
- Uotila K, Helamaa M (2015) Rauma, Ellinniitty 2014: Varhaisrautakautinen röykkiökaivaus. Unpublished excavation report, Muuritutkimus ky.
- Uotila K, Lehto H (2016) Rauma, Ellinniitty 2015: Unpublished excavation report, Muuritutkimus ky.
- Vikkula A, Seppälä S-L, Lempiäinen T (1994) The ancient field of Rapola. *Fennoscandia Archaeologica* 11:42–57, Archaeological Society of Finland.
- Vuorela I (2003) Satakunnan kasvillisuuden historia ja siitepölyanalyysit. In: *Sarka 2001–2002, Satakunnan Museon vuosikirja*. Satakunnan Museo, pp 68–76. Pori

