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Viking Age cereal cultivation in SW Finland – a study of charred grain from Pahamäki in Pahka, Lieto

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Charred cereal remains from the hill of Pahamäki in Pahka, Lieto, SW Finland, and dated to the early Viking Age (AD 700–900) have been investigated. The macrofossils came from the sooty infill of a ditch surrounding a stone cairn. A sub-sample analysis of the material shows that *Hordeum vulgare* var. *vulgare*, four-rowed barley, was the staple crop in the Pahka region during the period in question. *Secale cereale* was also important, whereas *Triticum aestivum* s.l., *Avena* sp. and *Pisum sativum* were poorly represented in the samples. Both charred and non-charred macrofossils of meadow plants, weeds and ruderals, wetland plants and trees and shrubs were present in modest numbers. The length distribution of the barley grains revealed a considerably larger grain size than that recorded in studies from other contemporary Finnish localities. Probable reasons for this and also the low number of rachis fragments and other cereal components found among the grain, are discussed with special emphasis on the origin of plant remains from crop processing and the possibilities of their carbonization. The remains are apparently of cleaned prime grain grown in the rich clayey soils around Pahamäki. The archaeological evidence indicates a possible origin in a cremation burial, but in the light of the macrofossil investigations, the grains may merely have been charred during a fire or in the course of some household activities such as drying or roasting and then deposited later as refuse.

Key words: carbonization, cereals, crop processing, cultivation, grain finds, macrofossils, palaeoethnobotany, SW Finland, Viking Age

INTRODUCTION

Over the last two decades, in southern Finland, many new grain finds have been made in the course of archaeological excavations, thus greatly increasing the macrofossil evidence of cereal cultivation in the region. Grain finds have come to light in connection with studies of dwelling sites such as at Salo (Aalto 1982), Karjaa (Matiskainen 1984), Turku (Lempiäinen & Vuorela 1988), Hämeenlinna (Lempiäinen 1992) and Paimio (Seppä-Heikka 1983), burial cairns as at Kokemäki and Nokia

Fig. 1. Hill of Pahamäki in Pahka, Lieto, SW Finland. Photo: J. Luoto.

(Lempiäinen 1987, 1991), cremation burials such as at Maaria (Seppä-Heikka M.Sc.-thesis unpubl.) and Paimio (Seppä-Heikka unpubl.) and, finally, in an ancient field at Rapola, Sääksmäki (Vikkula *et al.* 1994). These studies have complemented the current view of the history of cultivation and land use in SW Finland obtained by palynological investigations (eg. Tolonen *et al.* 1976, Tolonen 1985a, 1987, Vuorela & Lempiäinen 1988, Vuorela 1991, cf. also reviews by Donner 1984, Tolonen 1985b).

In the 1970s the Department of Archaeology of the University of Turku began a long-term research project on the Pahamäki hill, in the village of Pahka adjacent to the well-known hillfort of Vanhalinna. In addition to revealing information about the Iron Age culture in the valley of the River Aura, these excavations were also valuable from a palaeoethnobotanical point of view. In no other macrofossil study carried out so far in Finland have such large quantities of charred grain been encountered as in the excavations at Pahka.

The grain assemblage described here provides an opportunity for a more thorough insight into the qualitative aspects of cereal cultivation in SW Finland during the Viking Age. The state of preservation of the cereal grains also enables inferences to be made about the conditions under which the grains became carbonized.

THE STUDY AREA

The pine-clad rocky Pahamäki hill (Fig. 1) lies in Pahka, in the district of Lieto, SW Finland (22°20´E, 60°27´N) 8 km E of the outlet of River Aura in Turku (Åbo). It is located adjacent to the small river Vähäjoki (or Pikkujoki, Lausteenoja) which is a tributany of the River Aura (Fig. 2). The valley of the River Aura in the region surrounding the Pahka village is characterized by vast cultivated areas with a long history of human settlement.

Today the site lies c. 23 m a.s.l. For much of the Quaternary period it lay submerged below the sea. At the time of the Kiukainen culture (2 000–1 500 BC), when the first traces were left by the early occupants (Luoto 1988), it was a small island. Land uplift has subsequently exposed vast lowland areas covered with rich clayey sediments. Gradually settlement extended along the river valley, as shown by numerous prehistoric finds from the area (cf. Luoto 1988).

The ancient hillfort of Vanhalinna opposite Pahamäki was occupied during three distinct periods from the Bronze Age to the early Middle Ages (Luoto 1984b). The traces of human settlement at the hillfort, dated to 1 000–500 BC and AD 500–800, indicate its use by local inhabitants as a defensive stronghold under the threat of enemy attacks (Luoto 1984b, 1988). The later part of the last and most intensive occupation of the hillfort, from the 11th century up to the 14th century, was associated with a fortification held under Swedish power (Luoto 1988).

Indications of Iron Age culture on the hill of Pahamäki appeared during phosphate-mapping of the region in 1974 (Luoto 1984a, 1993). Excavations led by the Department of Archaeology at the University of Turku in 1975–1982 (Luoto 1988) (Fig. 3) revealed a mixed complex of earlier burial remains (AD 300–400; Luoto 1988) and younger settlement and burial finds. The area was dominated by cemetery finds from the late Iron Age ie. Younger Migration Period/Viking Age (AD 700–900) (Luoto 1989). The latest occupation covered approximately the period AD 1 250–1 600.

The context from which the palaeoethnobotanical samples were taken (Figs. 3 and 4) was first interpreted as a settlement layer because of the high phosphate content throughout the soil profile (cf. Luoto 1993). However, after the excavation maps from several years were compiled the context seemed to be a circular ditch filled with charcoal-rich soil. This ditch had been dug into the sub-soil surrounding a stone structure, possibly a burial cairn, situated on the SE corner of the excavation area. There were no finds to date the cairn.

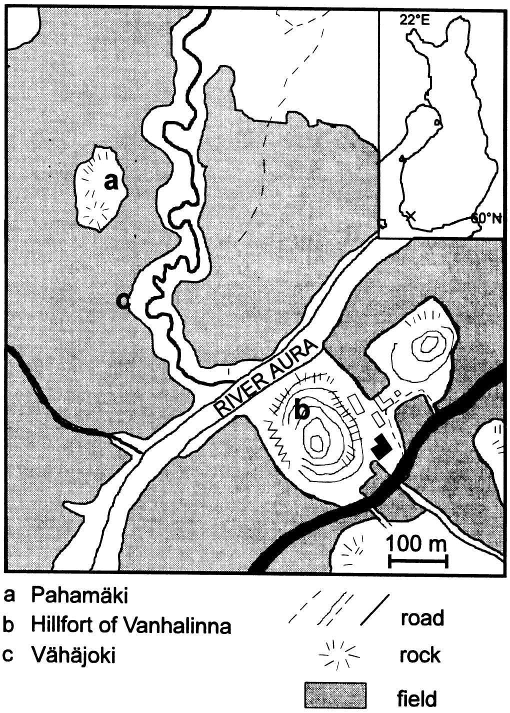

Fig. 2. Location of the study site.

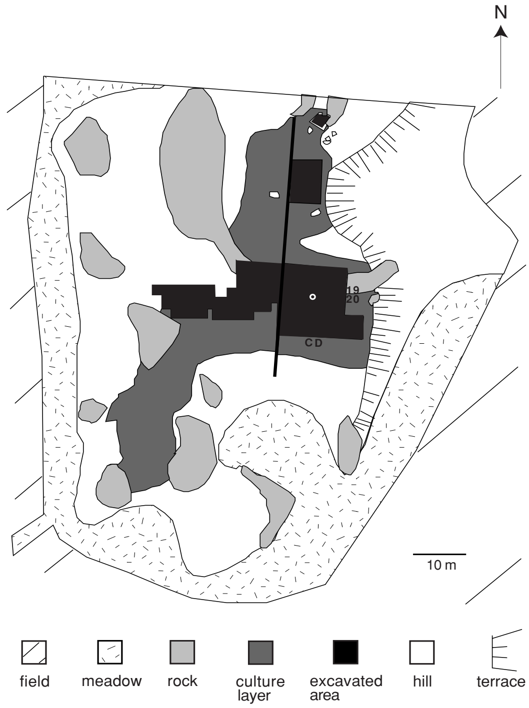

Fig. 3. Excavation area at Pahamäki in 1975–1982. Location of the sampling site is marked with a circle.

The distribution of potsherds showing a decoration characteristic of the Viking Age (cf. Aroalho 1978, Kivikoski 1939, 1963, Lehtosalo-Hilander 1982) covered both the ditch and the nearby flat cremation cemetery, indicating a date of around AD 800. In general, the archaeological finds indicate that ditch infill belongs to the period AD 700–900, probably to the later part of it. The possibility of a younger date cannot, however, be excluded.

The cereal remains from Pahka had been studied before the present palaeoethnobotanical investigations were undertaken. Macrofossils sampled during the excavation in 1977 from quadrates adjacent to the present find context were reported by Seppä-Heikka (Seppä B.Sc.-thesis unpubl., Seppä-Heikka M.Sc.-thesis unpubl.), at a time when the excavations were still in progress. The quadrates included in her study were 17C I–V, 18B I–IV, 19B I–IV, 20A I–V and 20C I–V. Sample 17C IV and those from layer V were dated in the course of excavations to the late Iron Age, 900–1 150 AD, the other samples derive from the Middle Ages.

MATERIAL AND METHODS

The soil samples for macrofossil analysis were taken in 1976–1978 from the infill of the ditch described above (Figs. 3 and 4). The number and size of the soil samples taken from Pahka was considerable, totalling more than 100 litres of soil. The sample size was 5–8 litres, but only one sub-sample of 1 litre was examined in detail for each; the results are based on this sub-sample analysis. The nine samples studied are presented in Table 1. The quadrate 20C V was also sampled and examined by Seppä-Heikka (Seppä B.Sc.-thesis unpubl., Seppä-Heikka M.Sc.-thesis unpubl.).

The charred cereal remains were picked from the dry soil samples in the laboratory using a stereoscopic microscope (WILD 5, WILD M3B). The remainder of the macrofossil material was first put into a weak KOH solution (c.

Table 1. The samples taken from Pahamäki, Pahka. The volume of the sub-sample examined in each case is 1 litre.

Sample	Layer	Material
20C	V	Sooty, dark clayey soil with charcoal
	VI	
	VII	
	VIII	
20C–D	–	Sooty, dark clayey soil with charcoal
20D	IV	As above
	V	
	VII	
	X	

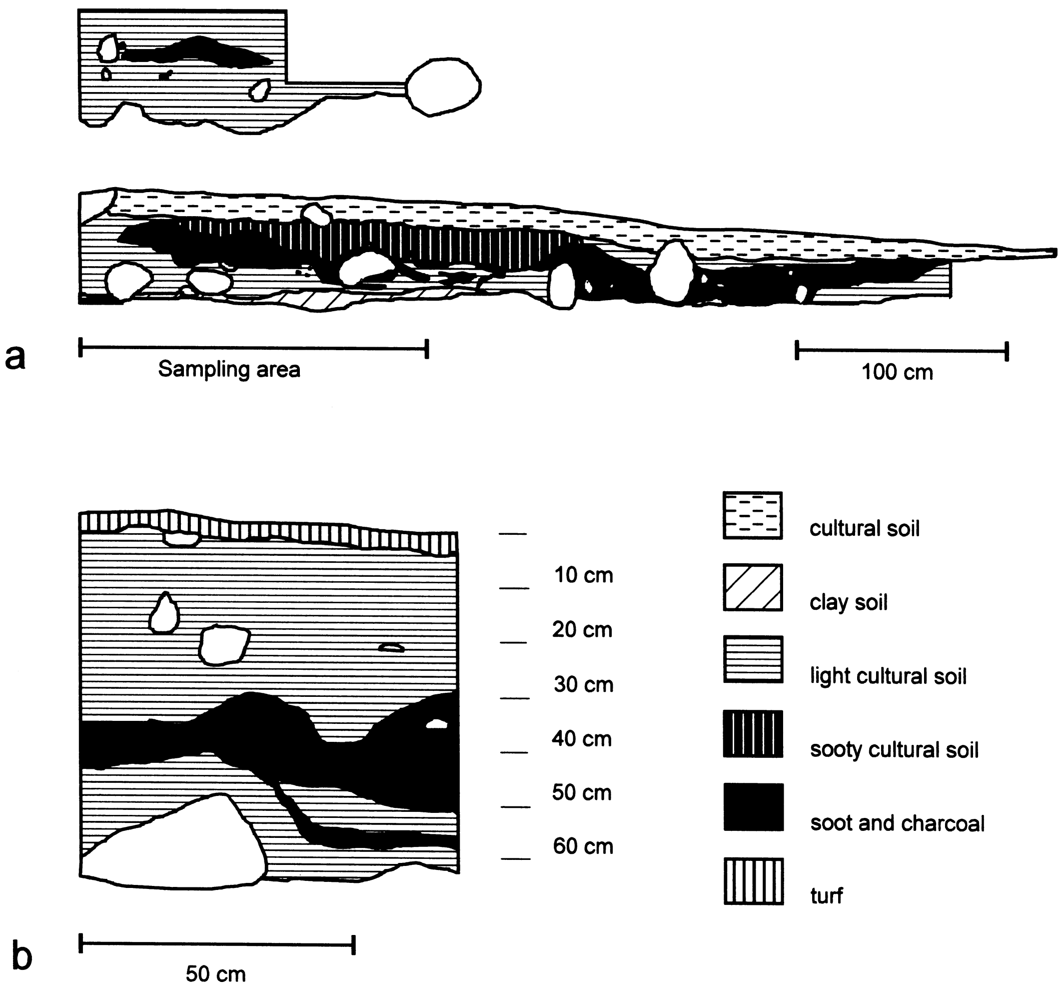

Fig. 4. a) Sections through the charcoal-rich infill of the ditch. b) Section through the trial pit made in the sampling area in 1976.

3–4%) for a while in order to break it down. Macrofossils were extracted from the samples by means of flotation in a saturated salt water solution (3 l water/1 kg NaCl) (cf. also Nunez & Vuorela 1976). The floating material was removed onto a sieve (mesh size of 0.25 mm) and washed with running water. The remains were separated from the floated samples as above and identified by means of identification literature (eg. Beijerinck 1947, Behre 1983), a reference collection and herbarium material at the University of Turku's Herbarium.

For fairly well preserved grains, with or without an embryo, the length, breadth and thickness was measured. In the case of *Hordeum vulgare* puffed grains were also included, because they were dominant in the material. Any extrusions on the grain surface were, however, ignored. The diameter of the specimens of *Pisum sativum* was measured with the hilum as the central point.

The nomenclature employed follows Hämet-Ahti *et al.* (1986) for wild plants and for cultivated plants, Palmen and Alanko (1993).

RESULTS

Cultivated plants

General

The total number of macrofossils examined from 9 samples was 9 161 (excluding charcoal) most of which were found in sample 20C–D (Table 2). Charred remains of cultivated plants constituted the majority of the finds; weeds, ruderals and meadow plants amounted to only 4% of the total material. In addition to cereals, pea, *Pisum sativum*, was also present among the crop plants. Over 8 000 cereal remains were counted. Nearly all were

Table 2. Charred macrofossil remains of cultivated plants from Pahamäki,Pahka, Lieto. Dating AD 700–900.

Sample	D IV	C V	D V	C VI	C VII	D VII	C VIII	D X	C–D	Total
Hordeum vulgare (without lemma)										
Whole grains	47	46	67	5	2	30	2	–	127	326
Grains without embryo	48	84	95	–	3	91	3	–	231	555
3/4 grain	129	326	330	8	16	379	3	–	753	1 944
Halves	85	166	126	4	13	137	6	–	373	910
Fragments	44	43	79	15	5	35	4	1	157	383
TOTAL	353	665	697	32	39	672	18	1	1 641	4 118
Rachis segments	–	–	–	–	–	–	–	–	1	1
Hordeum vulgare (with remains of lemma)										
Whole grains	11	19	46	–	2	31	–	–	50	159
Grains without embryo	7	24	27	1	1	15	–	–	25	100
3/4 grain	3	21	10	–	1	34	1	–	41	111
Halves	–	17	2	–	–	4	–	–	14	37
Fragments	–	1	–	–	–	1	–	–	3	5
TOTAL	21	82	85	1	4	85	1	–	133	412
cf. ***Hordeum vulgare***										
Grains without embryo	2	–	–	–	–	1	–	–	–	3
3/4 grain	5	–	2	–	–	–	–	–	52	59
Halves	–	–	–	–	–	–	–	–	13	13
Fragments	–	–	–	–	–	–	–	–	–	–
TOTAL	7	–	2	–	–	1	–	–	65	75
Secale cereale										
Whole grains	12	199	27	–	2	65	1	–	45	351
Grains without embryo	5	92	11	1	–	38	–	–	19	166
3/4 grain	12	141	26	1	5	99	2	–	98	384
Halves	12	107	14	–	5	43	3	–	68	252
Fragments	3	25	1	3	3	15	–	–	25	75
TOTAL	44	564	79	5	15	260	6	–	255	1 228
***Avena* sp.** (without lemma)										
Whole grains	–	–	–	–	–	–	–	–	1	1
Grains without embryo	–	1	–	–	1	–	–	–	–	2
3/4 grain	–	2	1	–	–	1	–	–	4	8
Halves	–	1	1	–	–	–	–	–	1	3
Fragments	–	–	–	–	–	–	–	–	–	–
Whole grains (with remains of lemma)	–	–	–	–	–	–	–	–	1	1
TOTAL	–	4	2	–	1	1	–	–	7	15
Triticum aestivum s.l.										
Whole grains	–	–	–	–	–	–	–	–	–	–
Grains without embryo	–	4	–	–	–	1	–	–	–	5
3/4 grain	–	3	–	–	–	4	–	–	5	12
Halves	–	–	–	–	–	–	–	–	–	–
Fragments	–	2	–	–	–	–	–	–	–	2
TOTAL	–	9	–	–	–	5	–	–	5	19
Rachis segments	–	–	–	–	–	–	–	–	1	1
cf. ***Triticum*** 3/4 of the grain	–	–	–	–	–	–	–	–	9	9
TOTAL	–	–	–	–	–	–	–	–	9	9
Pisum sativum										
Whole specimens	–	–	10	–	–	–	–	1	9	20
Halves	–	1	–	–	–	–	–	–	–	1
TOTAL	–	1	10	–	–	–	–	1	9	21
Fragments of cereals	127	487	368	12	13	210	–	1	1 101	2 319
cf. cereals	–	–	–	–	–	–	–	–	213	213
TOTAL	552	1 812	1 243	50	72	1 233	25	3	3 438	8 429

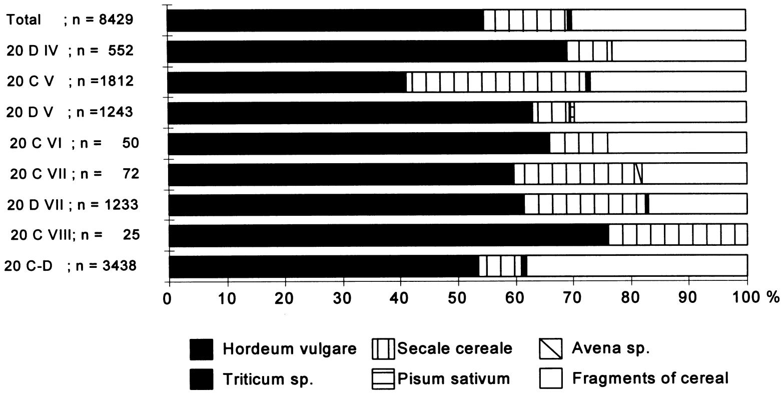

Fig. 5. Species composition of the cultivated plants in the samples from Pahka. Sample 20D X is not shown (*n* = 3).

grains — only four rachis segments, one of them identified as *Triticum aestivum* and one as *Hordeum vulgare,* were found. As both the archaeological context — a circular ditch filled with dark charcoal-rich soil around a burial cairn — and dating were the same for all the samples, it was decided for the purposes of interpretation and discussion to combine the results from the different quadrats and layers.

In general, barley was clearly dominant followed by *Secale cereale* with 54.5% and 14.6% of the remains of cultivated plants, respectively (Table 2, Fig. 5). Occurrences of *Avena* sp. and *Triticum* sp. were very rare. Besides bread wheat, *Triticum aestivum*, club wheat, *T.* cf. *compactum* was also found. Bread and club wheat will be considered collectively as *Triticum aestivum s.l.* in this study.

The grains from different layers varied greatly with regard to their state of preservation and distortion. Usually the state of preservation varied according to Hubbard and al Azm (1990) between class P3 — the epidermis was incomplete, and class P4 — fragments of epidermis remained; the latter being the more common. The state of distortion due to carbonization also varied (D1–5, cf. Hubbard & al Azm 1990). Carbonized tarry material had often been exuded from the edges of the grain as solid lumps and there were scar formations on the surface. Some of the barley grains were in quite a bad condition and were only identifiable on the basis of their gross morphology due both to weak preservation and great distortion; on the other hand some perfect specimens also occurred.

Rye grains were preserved in far better condition. Often even the outermost cell layer of a grain was left without damage. Differences in the state of preservation and distortion of the rye and barley grains may be due to differences in the way in which they are affected by carbonization. Charring experiments with rye are few (eg. Renfrew 1973) so little is known of the changes in the appearance of rye grains during carbonization. Alternatively the explanation could lie in the heterogenous nature of the study material.

Barley (*Hordeum vulgare* var. *vulgare*)

The macrofossil analysis revealed that barley was the staple crop in Pahka during the early Viking Age. Barley was dominant in all the samples with a proportion of 40–70% (Fig. 5). Altogether 412 whole grains or identifiable fragments out of a total of 4 606 still had the remains of lemma. Well preserved dehusked grains had the characters of hulled barley with an angular cross-section and longitudinal ridges on the surface (Van Zeist 1970). However, since the poorly preserved barley specimens could not be identified as hulled or naked type, the sporadic occurrence of var. *nudum* may still be possible. Only one identified rachis segment derived from barley.

The asymmetry and twisted ventral furrow of some of the grains indicated that the barley was *Hordeum vulgare* var. *vulgare*. Some grains appeared to have a horse-shoe shaped or bevelled lemma base indicating lax-eared barley instead of a nicked one with a sharp groove typical for dense-eared i.e. the six-rowed variety (Van Zeist 1970, Renfrew 1973) (Fig. 6). The L/B ratio was more than 1.8 in 79.5% of the grains, which has been designated as characteristic of the four-rowed

Fig. 6 (continues on the next page). Charred cereal remains from Pahka. — A: *Hordeum vulgare*, well preserved hulled grain. — B–C: *H. vulgare*. — D: *H. vulgare*, sprouted grains. — E: *H. vulgare*, sprouted grain. — F: *H. vulgare*, lemma bases view with a horseshoe-shaped depression. — G: *Secale cereale*, ventral view. — H: *S. cereale*, dorsal view. — Scale = 1 mm. Photos: J. Onnela.

variety (Knörzer 1970). Seppä-Heikka's studies (Seppä-Heikka M.Sc.-thesis unpubl.), in which the dimensions of the grains were compared with those of charred recent material, also reached the same conclusion.

The grains were quite long with respect to their

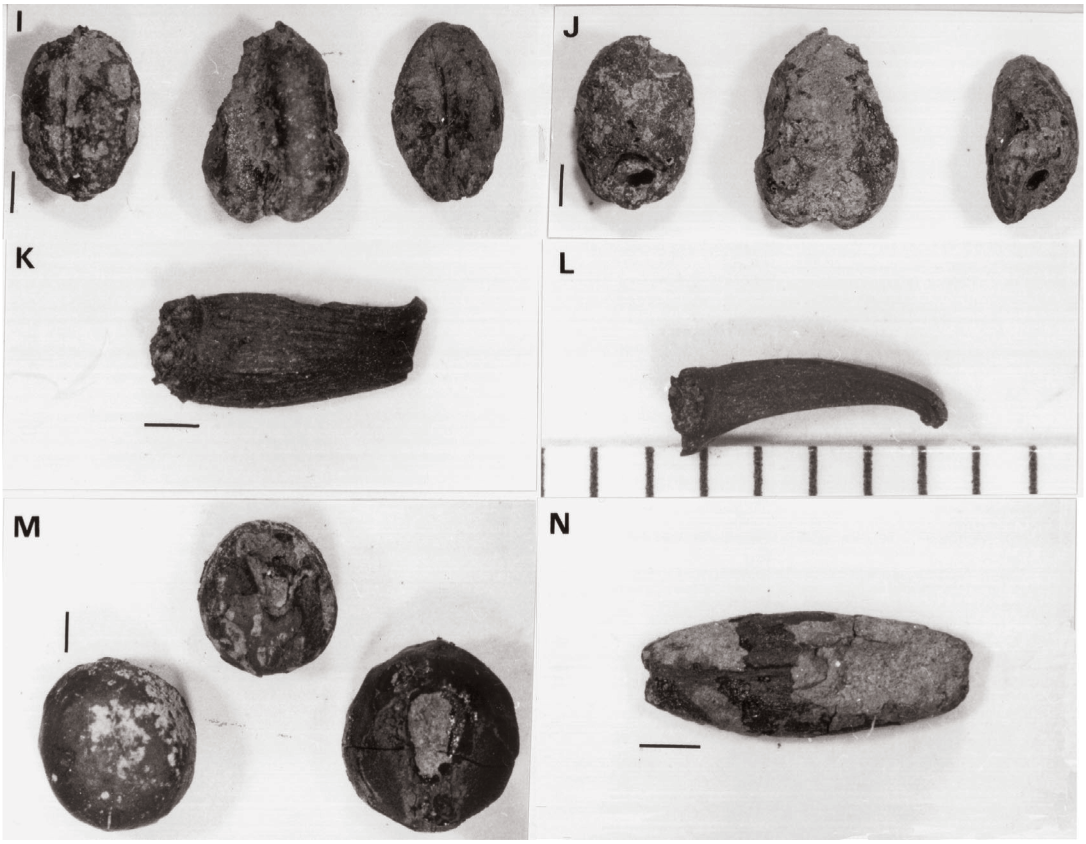

Fig. 6 (continued). Charred cereal and pea remains from Pahka. — I: *Triticum aestivum*, ventral view. — J: *T. aestivum*, dorsal view. — K: *T. aestivum*, rachis fragment from dorsal view. — L: *T: aestivum*, rachis fragment from lateral view. — M: *Pisum sativum*. — N: *Avena* sp. — Scale = 1 mm. Photos: J. Onnela.

breadth and thickness. The length distribution of barley was quite even and 70% of the measured grains fell within the range 5.8–7.0 mm (Fig. 7a). It must be noted, however, that it was the absolute length which was measured, rather than the length minus the embryo, as is the case in some investigations (e.g. Behre 1983, Seppä-Heikka M.Sc.-thesis unpubl.). In 45.6% of the measured grains the embryo remained intact. The possibility of comparing the length with those studies mentioned above was checked by measuring 81 grains without the embryo. The length of the embryo varied between 0.1–0.7 mm with an average of 0.4 mm.

Bearing this in mind, the mean length of 6.35 mm (Table 3) exceeds that of all other measured barley finds from Finland (Table 4, Fig. 8). In general, a comparison between sites can be made only when an adequate number of remains of crop plants have been investigated. The absolute minimum required to give a reasonably representative picture of an individual site or context and to permit comparison with other sites or samples is 50 items (Robinson 1993). The number of cereal remains from one context or one sample revealed by macrofossil studies in Finland has generally been low (cf. Table 4). Commonly they represent single finds within the three categories presented by Robinson (1993); i.e. only one context or sample contains more than 50 crop plant remains. A lot of trace finds with less than 50 remains also occur (cf. Table 4), hence making it necessary to consider the measurements with caution.

The nearest settlement site dating to the Viking Age and early Middle Ages, from which numerous cereal grains have been found and meas-

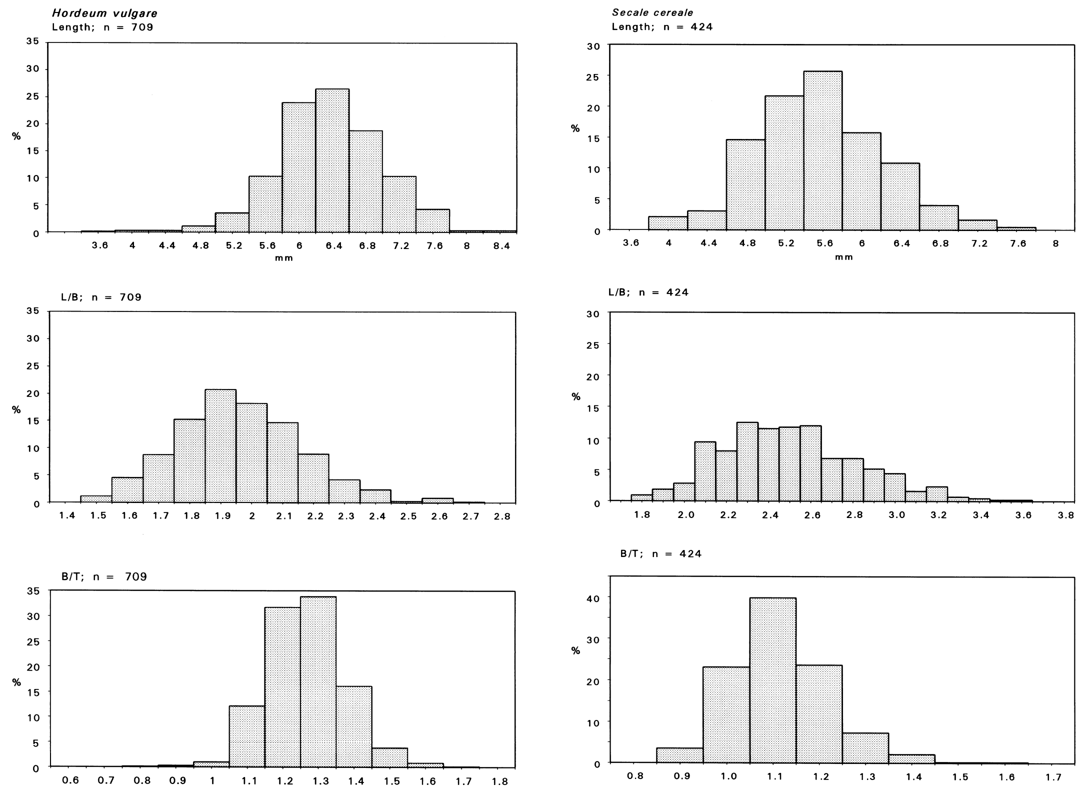

Fig. 7. Frequency distribution diagrams of *Hordeum vulgare* (A) and *Secale cereale* (B).

ured, is situated in Varikkoniemi, Hämeenlinna, 131 km N of Pahka. Here the average length of the barley grains was 5.42 mm. Grains found in a nearby cremation burial at Saramäki, Maaria dating to the later part of the same period, were relatively long, though still shorter than those from Pahka (Kivikoski 1939, Seppä-Heikka M.Sc.-thesis unpubl.). Some contemporary studies carried out in northern Germany also indicate smaller grain sizes than those at Pahka (Behre 1983, Behre & Kucan 1994).

Rye (*Secale cereale*)

Rye comprised 14.6% of the total cereal finds at Pahka with 1 228 specimens. The proportion of rye in the samples analysed ranged from 0–31.1% (Fig. 5). The sample richest in grain (20C–D) was actually quite poor in rye (7.4%). The general morphology of the grains was, as usual, very variable; a blunt and cut-like point and a sharp base with an embryo of varying size were characters typical of this material.

The dimensions of 424 grains could be measured, giving mean values as follows (Table 3): length 5.54 mm, breadth 2.25 mm and thickness 2.02 mm. The large variation of the L/B-index (Fig. 7b) shows great morphological diversity. When compared with values from other localities the method of measuring the absolute grain length must again be born in mind (Table 4). The size of the rye at Pahka was obviously greater than at Varikkoniemi, where growing conditions may have been poorer (Lempiäinen 1992). The grains at Pahka were shorter than those from the burial site at Maaria and in an ancient field at Rapola, Sääksmäki (Vikkula *et al.* 1994, Seppä-Heikka M.Sc.-thesis unpubl.). The finds dating to earlier periods seem to be slightly smaller in size (Matiskainen 1984, Seppä-Heikka unpubl.). Apart from Varikkoniemi, the other sites in Finland from which measurements have been carried out, have, only a poor representation of rye. Comparisons with some macrofossil studies in northern Germany in-

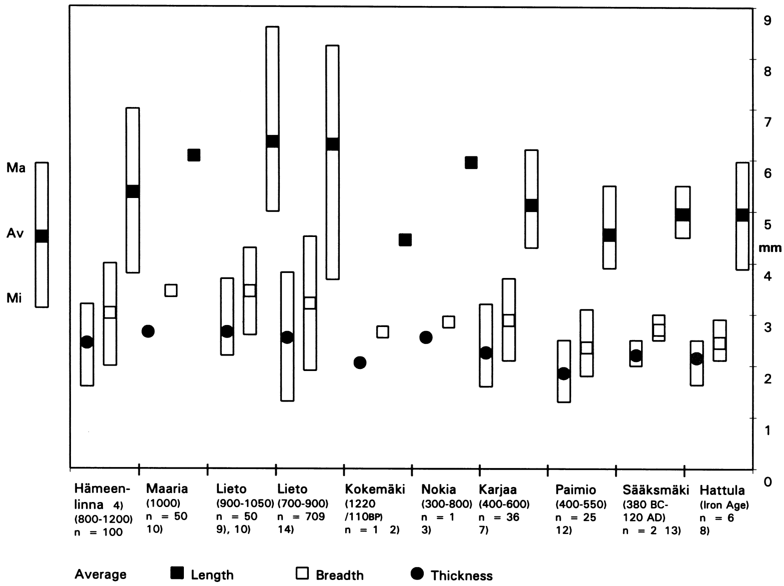

Fig. 8. The dimensions of barley grain from South Finland dated to the Viking Age and the early Middle Ages. The averages of the length, breadth and thickness are represented with symbols. The length of the boxes indicates the range of values obtained between minimum (Mi) and maximum (Ma). For numbers referring to the authors, see Table 4.

Table 3. Dimensions of measured grains from Pahka.

Sample	*n*	Mean length (min., max.) (mm)	Mean breadth (min., max.) (mm)	Mean thickness (min., max.) (mm)	Mean L/B (min., max.)	Mean L/T (min., max.)	Mean B/T (min., max.)
Hordeum vulgare							
20D IV	84	6.49 (4.52, 7.74)	3.30 (2.11, 4.52)	2.69 (1.31, 3.82)	1.98 (1.56, 2.42)	2.45 (1.74, 3.46)	1.24 (0.83, 1.62)
20D V	174	6.47 (4.92, 8.24)	3.27 (1.91, 4.02)	2.57 (1.41, 3.42)	1.99 (1.55, 2.61)	2.55 (1.90, 3.84)	1.28 (0.87, 1.65)
20D VII	81	6.31 (5.03, 8.24)	3.29 (2.31, 4.32)	2.64 (2.01, 3.32)	1.93 (1.46, 2.65)	2.41(1.91, 3.25)	1.25(1.03, 1.59)
20C–D	248	6.28 (3.62, 7.74)	3.21 (2.11, 4.22)	2.54 (1.51, 3.52)	1.97 (1.49, 2.54)	2.49 (1.86, 3.35)	1.27 (1.00, 1.70)
20C V	105	6.21 (4.12, 7.64)	3.24 (2.11, 4.22)	2.57 (1.71, 3.52)	1.94 (1.46, 2.57)	2.44 (1.90, 3.11)	1.27 (1.07, 1.60)
20C VI	6	6.67 (5.93, 7.44)	3.63 (3.32, 4.12)	2.80 (2.41, 3.22)	1.85 (1.56, 2.06)	2.41 (2.00, 2.88)	1.31 (1.19, 1.42)
20C VII	6	6.10 (5.43, 6.73)	3.48 (3.02, 4.02)	2.75 (2.31, 3.32)	1.76 (1.55, 1.89)	2.23 (2.03, 2.35)	1.27 (1.21, 1.43)
20C VIII	5	6.77 (5.83, 7.84)	3.64 (3.12, 4.32)	2.81 (2.21, 3.42)	1.88 (1.61, 2.30)	2.43 (2.13, 2.81)	1.30 (1.22, 1.41)
Total	709	6.35 (3.62, 8.24)	3.26 (1.91, 4.52)	2.59 (1.31, 3.82)	1.96 (1.46, 2.65)	2.48 (1.74, 3.84)	1.27 (0.83, 1.70)
Secale cereale							
20D IV	15	5.73 (4.82, 6.83)	2.30 (2.11, 2.81)	2.03 (1.71, 2.41)	2.51 (2.01, 2.83)	2.87 (2.35, 3.43)	1.14 (0.96, 1.41)
20D V	38	5.80 (4.32, 7.14)	2.43 (1.71, 3.32)	2.14 (1.41, 3.02)	2.43 (1.84, 3.11)	2.76 (2..11, 3.66)	1.14 (0.93, 1.40)
20C V	218	5.49 (3.82, 7.24)	2.22 (1.31, 3.02)	2.01 (1.21, 2.71)	2.52 (1.86, 3.63)	2.78 (1.93, 4.08)	1.11 (0.90, 1.59)
20C VI	1	6.43	3.12	2.61	2.07	2.47	1.19
20C VII	1	5.63	2.11	2.01	2.68	2.81	1.05
20D VII	97	5.58 (3.82, 7.54)	2.22 (1.31, 2.91)	1.98 (1.11, 2.71)	2.56 (1.97, 3.33)	2.87 (2.05, 3.71)	1.12 (0.90, 1.41)
20C VIII		5.73	2.21	2.01	2.60	2.86	1.10
20C–D	53	5.42 (3.82, 7.34)	2.32 (1.61, 3.02)	2.06 (1.41, 2.91)	2.38 (1.79, 3.02)	2.67 (2.14, 3.52)	1.13 (0.90, 1.50)
Total	424	5.54 (3.82, 7.54)	2.25 (1.31, 3.32)	2.02 (1.11, 3.02)	2.50 (1.79, 3.63)	2.79 (1.93, 4.08)	1.12 (0.90, 1.59)
***Avena* sp.**							
20C V	1	4.32	1.71	1.51	2.54	2.88	1.13
20C VII	1	5.63	2.21	1.61	2.56	3.52	1.38
20D VII	1	5.23	1.91	1.91	2.75	3.16	1.29
20C–D	3	5.06 (4.22, 5.63)	1.98 (1.51, 2.31)	1.71 (1.31, 1.91)	2.60 (2.32, 2.81)	3.00 (2.80, 3.25)	1.16 (1.11, 1.21)
Total	6	5.06 (4.22, 5.63)	1.96 (1.51, 2.31)	1.69 (1.31, 1.91)	2.61 (2.32, 2.81)	3.03 (2.80, 3.52)	1.16(1.11, 1.38)
Triticum aestivum							
20 C V	4	4.65 (4.32, 4.92)	3.27 (2.81, 3.62)	2.56 (2.31, 2.91)	1.44 (1.34, 1.62)	1.83 (1.70, 1.97)	1.27 (1.20, 1.44)
20 C–D	1	5.23	2.81	2.31	1.87	2.27	1.22
Total	5	4.76 (4.32, 5.23)	3.18 (2.81, 3.62)	2.51 (2.31, 2.91)	1.53 (1.34, 1.87)	1.92 (1.70, 2.27)	1.26 (1.20, 1.44)
Pisum sativum							
	n	Diameter (mm) (min., max.)					
20D V	9	3.50 (3.02, 4.12)					
20C–D	9	3.89 (2.81, 4.92)					
Total	18	3.69 (2.81, 4.92)					

Table 4. Macrofossil finds of cereals in South Finland dated to the Viking Age and the early Middle Ages. Total numbers, percentages of total sum of grain remains and dimensions when measured. Numbers 1)–13) refer to the author as follows: 1) Aalto (1982), 2) Lempiäinen (1987), 3) Lempiäinen (1991), 4) Lempiäinen (1992), 5) Lempiäinen (1994), 6) Lempiäinen (1995), 7) Matiskainen (1984), 8) Nunez and Vuorela (1976), 9) Seppä B.Sc.-thesis unpubl., 10) Seppä-Heikka M.Sc.-thesis unpubl., 11) Seppä-Heikka (1983), 12) Seppä-Heikka unpubl., 13) Vikkula *et al.* (1994), 14) the present study. Abbreviations: s.l. = sensu lato; cf. = uncertain identification; sp. = identified to genus level; L = length; B = breadth; T = thickness. Site types: b = burial site; bc = burial cairn; c = castle; cbc = concentration of burnt clay; ds = dwelling site; fcc = flat cremation cemetery; mp = market place; af = ancient field.

Site	Site type	Dating AD	n	% of grains	L	B	T	L/B	L/T	B/T	*n*
Hordeum vulgare											
Salo, Katajamäki 1)	ds	300	202	40.8							
Paimio, Spurila 12)	b	100–400	28	3.1							
Paimio, Spurila 12)	b	400–550	91	12.6	4.6	2.4	1.9	1.3		1.9	25
Karjaa, Domargård 7)	ds	400–600	119	39.9	5.17	2.93	2.3	1.88	2.35	1.27	36
Hattula, Retulansaari 8)	ds	Iron Age	6	54.5	5.0	2.5	2.2	1.98	2.28	1.16	6
Kokemäki, Ylistaro 2)	bc	1220 ±110 BP	3	100	4.5	2.7	2.1	1.67	2.14	1.29	1
Nokia, Viik 3)	bc	300–800	7	36.8	6.0	2.9	2.6	2.07	2.31	1.12	1
Hämeenlinna, Varikkoniemi 4)	ds	800–1200	2 240	68.8	5.42	3.07	2.49	1.78	2.21	1.25	100
Sääksmäki Rapola 13)	cbc	380 BC–120 AD	9	60.0	5.0	2.75	2.25	1.82	2.23	1.23	2
	af	780–1217	9	21.4							
Maaria, Saramäki 10)	cc	1000	106	90.6	6.13	3.5	2.7	1.75	2.27	1.3	50
Lieto, Pahka 9) 10)	ds	900–1050	214	62.8	6.4	3.5	2.7	1.83	2.37	1.3	50
Lieto, Pahka 14)	ds	700–900	4 605	56.1	6.35	3.26	2.59	1.96	2.48	1.27	709
Paimio, Sievola 11)	ds	1050–1200	38	26.2							
Turku, Old Market Place 6)	mp	1250–1450	91	21.8	5.7						
Kaarina, Kuusisto 5)	c	1300–1500	82	32.3							
Secale cereale											
Paimio, Spurila 12)	b	100–400	10	1.1	5.2	2.3	2.0	2.3		1.2	3
Paimio, Spurila 12)	b	400–550	2	0.3							
Karjaa, Domargård 7)	ds	400–600	3	1.0	5.2	2.2	2.1	2.36	2.47	1.04	1
Nokia, Viik 3)	bc	300–800	1	5.3							
Hämeenlinna Varikkoniemi 4)	ds	800–1200	150	4.6	5.08	2.29	2.12	2.21	2.41	1.08	50
Sääksmäki Rapola 13)	af	780–1217	1	2.4	7.0	2.9	2.9	2.41	2.41	1.0	1
Maaria, Saramäki 10)	fcc	1000	7	6.0	6.15	2.72	2.6	2.26	2.37	1.05	6
Lieto, Pahka 9) 10)	ds	900–1050	103	30.2	5.6	2.5	2.2	2.24	2.55	1.14	50
Lieto, Pahka 14)	ds	700–900	1 228	15.0	5.54	2.25	2.02	2.50	2.79	1.12	424
Paimio, Sievola 11)	ds	1050–1200	83	57.2							
Turku, Old Market Place 6)	mp	1250–1450	10	2.4							
Kaarina, Kuusisto 5)	c	1300–1500	74	29.1							
Avena sativa											
Salo, Katajamäki 1)	ds	300	15	3.0							
Hämeenlinna Varikkoniemi 4)	ds	800–1200	34	1.0	5.60	2.01	1.83	2.78	3.06	1.10	7
Sääksmäki Rapola 13)	af	780–1217	1	2.4							
Turku, Old Market Place 6)	mp	1250–1450	4	1.0							
Kaarina, Kuusisto 5)	c	1300–1500	8	3.1							
***Avena* sp.**											
Paimio, Spurila 12)	b	100–400	3	0.3							
Paimo, Spurila 12)	b	400–550	6	0.8	4.5	2.0	1.6	2.2		1.2	4
Karjaa, Domargård 7)	ds	400–600	2	0.7	5.7	1.9	1.5	3.0	3.8	1.26	1
Lieto, Pahka 14)	ds	700–900	15	0.2	5.06	1.96	1.69	2.61	3.03	1.16	6
Maaria,	fcc	1000	2	1.7	7.3	3.0	2,5	2.43	2.92	1.2	2
Saramäki 10) cf.					5.5	2.5	–	2.20	–	–	
Paimio, Sievola 11) cf.	ds	1050–1200	3	2.1							
Triticum aestivum											
Salo, Katajamäki 1)	ds	300	3	0.6							
Paimio, Spurila 12) s.l.	b	100–400	13	1.4	4.5	2.9	2.2	1.4		1.3	6
Paimio, Spurila 12) s.l.	b	400–550	1	0.1							
Hämeenlinna, Varikkoniemi 4) cf.	ds	800–1200	10	0.3							
Sääksmäki, Rapola 13) cf.	af	1020–1220	1	2.4							
Lieto, Pahka 14) s.l.	ds	700–900	28	0.3	4.76	3.18	2.51	1.53	1.92	1.26	5
Lieto, Pahka 10)	ds	1300–1500	?	?	5.5	4.0	3.5	1.38	1.6	1.14	1
Hattula, Retulansaari 8) sp.	ds	Iron Age	5	45.5	4.3	3.0	2.2	1.42	1.98	1.40	5
Maaria, Saramäki 10)	fcc	1000	2	1.7	7.0	4.0	3.5	1.75	2.0	1.14	1
Paimio, Sievola 11) coll.	ds	1050–1200	7	4.8							
Kaarina, Kuusisto 5)	c	1300–1500	1	0.4							
Triticum compactum											
Sääksmäki, Rapola 13)	cbc	380 BC–120 AD	2	13.3	3.8	3.0	2.7	1.26	1.41	1.12	2
Karjaa, Domargård 7)	ds	400–600	48	16.1	3.94	2.97	2.47	1.34	1.60	1.20	17
Turku, Old Market Place 6)	mp	1250–1450	312	74.8	4.35	2.92	2.63	1.48	1.66	1.10	23
*)Pahka Lieto 9)	ds	1300–1500	2	0.6	4.2	3.1	2.2	1.35	1.91	1.41	1

*) measurements from Fig. 8.

dicate more accordance with them than with the contemporary Finnish material (Behre 1983, Behre & Kucan 1994).

Oats and wheat (*Avena* sp. and *Triticum* sp.)

Oats and wheat were very rare in the samples (Table 2, Fig. 5). Their remains constituted 0.2% and 0.4% of the total number of remains of cultivated plants respectively. In the case of oats, identification was only possible to genus level. Dimensions could be measured on 6 specimens (mean values: L: 5.06 mm; B: 1.96 mm; T: 1.69 mm) each of which differed considerably in size. In general, the meagre macrofossil evidence of cultivated oats dates to the late Iron Age and early Medieval times with one exception from a Roman Iron Age dwelling site at Salo (Aalto 1982). In most studies the remains of oats have been identified only to genus level and therefore the occurrence of wild oat species, like *Avena fatua* and *A. strigosa*, is also possible. So far, no identified macrofossil record of these species is known from Finland. The few measurements of *Avena* sp. (cf. Table 4) vary in size and, some of them even exceed the dimensions of the remains of cultivated oats found in Hämeenlinna (Lempiäinen 1992). In any case, the overall low incidence of oats grains in Pahka indicates its occurrence as a weed irrespective of whether the grains are derived from a cultivated or wild form of oats.

One identified rachis segment clearly belonged to wheat (Fig. 6) (L: 5.0 mm and B: 2.2 mm). Grains of *Triticum* spp. were quite badly preserved and only five grains of *Triticum aestivum s.l.* were measured.

Pea (*Pisum sativum*)

Twenty-one specimens identified as *Pisum sativum* were quite well preserved (Fig. 6). The hilum was typical of pea, even though the overall size was exceptionally small (Table 3). The fragments without clear remains of hilum were counted as Fabaceae indiff., which thus consisted of mainly uncertain identifications of *Pisum* sp. and probably also *Lathyrus* sp. Pea was also represented in Seppä-Heikka's studies at Pahka (Seppä B.Sc.-thesis unpubl.).

Wild plants

The material studied was quite poor in remains of wild plants, weeds and ruderals which comprised just 4% of the total number of macrofossils. The identified remains were mainly seeds and fruits, both charred and non-charred, but some needles, buds and scales were also detected. In addition to plant and moss finds, the remains of insects, cocoons of *Lumbricus terrestris* and sclerotia of fungi were also found. Charcoal fragments were most numerous in sample 20C–D. A recent origin for the non-charred remains is possible, as the presence of earth worms also suggests. The vegetation analysis carried out by Seppä-Heikka (Seppä-Heikka M.Sc.-thesis unpubl.) in the vicinity of the quadrats indicates that the species found as macrofossils also belong to the present local flora. Hence an interpretation based on the charred macrofossils (20% of the identified remains) gives a more reliable insight into the environment of the site. The charred remains belonged mainly to the groups of meadow plants and weeds and ruderals.

The majority of diaspores identified represent species which grow in open habitats under human influence, such as meadows, pastures and road edges (Table 5). These remains were mainly uncharred, only 29.2% were carbonized. The latter group included *Galium* sp., *Lathyrus pratensis*, *Ranunculus* sp., *Cerastium* sp., *Poa* sp. and unidentified seeds of the Poaceae family. Ecologically these plants are not demanding, but can spread and thrive in a great variety of places provided the site is kept open. Neither do they avoid nutrient-rich soils. These species probably grew around the settlement in meadows and pastures from where the remains were either transported by cattle or brought in with animal fodder.

About 23% of the remains of weeds and ruderals were carbonized. *Chenopodium album*, *Polygonum aviculare* and *Stellaria media* as typical weeds favour highly nutrient-rich habitats. They may have occurred in close proximity to the settlement or as impurities in the grain crop. One uncharred drupe of *Rubus idaeus* represents a wild species utilized by man.

The few finds of wetland plants include *Ranunculus flammula* and species such as *Eleocharis palustris*, *Juncus bufonius* and *Carex* spp. Only

Table 5. Macrofossil remains of wild plants at Pahamäki, Pahka. Unless otherwise mentioned the remains are seeds or fruits. Abbreviations: * and c = charred; n-c = non-charred, fl = flower; flt = floret; le = leaf; ne = needle; sc = scale; st = stem; c = egg cocoon. Charcoal: * = < 50 pieces; ** = 50–100 pieces; *** = > 100 pieces.

Sample	D IV	D V	C V	C VI	C VII	C VIII	D X	C–D	Sum c	n-c	Total
Meadow plants											
Agrostis sp.	–	–	–	–	–	–	–	3	–	3	3
Anthoxanthum odoratum	–	–	–	7	–	1	–	1	–	9	9
Alchemilla sp.	–	–	–	15	–	2	–	–	–	17	17
Cerastium sp.	–	2	1	17	10	2	–	17*6	*6	49	55
Galium boreale/verum	–	–	–	1	–	–	–	–	–	1	1
Galium sp.	*1	*2	*1	–	–	–	–	*2	*6	–	6
Lathyrus pratensis	–	*1	cf*1	–	–	–	–	–	*2	–	2
Lychnis viscaria	–	–	–	–	–	–	–	*1	*1	–	1
Poa sp.	–	–	1	1	–	–	–	1*5	*5	3	8
Poaceae	*1	*11	*5	2	–	–	–	*17	*34	2	36
Potentilla erecta	–	–	–	2	–	–	–	1	–	3	3
Ranunculus acris	–	–	–	8	–	–	–	1	–	9	9
Ranunculus sp.	–	*2	–	–	–	–	–	–	*2	–	2
Rumex acetosa	–	–	–	sc 1	–	–	–	2	–	3	3
Trifolium pratense	–	–	–	–	–	1	–	–	–	1	1
Trifolium repens	2	–	–	–	–	1	–	1	–	4	4
Veronica sp.	–	1	–	1	–	–	–	1	–	3	3
Weeds and ruderals											
Chenopodium album	*1	*1	*2	–	–	*1	–	3	*5	3	8
Cirsium sp.	–	–	–	3	–	–	–	–	–	3	3
Epilobium sp.	–	–	–	–	–	–	–	1	–	1	1
Lapsana communis	–	–	–	–	–	–	–	1	–	1	1
Polygonum aviculare	–	–	–	–	–	–	–	*1	*1	–	1
Rumex acetosella	–	–	–	1	–	–	–	–	–	1	1
Stellaria media	–	–	–	–	*1	–	–	–	*1	–	1
Taraxacum sp.	–	–	–	3	–	1	–	11	–	15	15
Wetland plants											
Carex sp.	–	–	*1	3	–	1	–	3*1	*2	7	9
Eleocharis palustris	–	–	–	–	–	–	–	1	–	1	1
Juncus bufonius	1	–	–	1	–	–	–	–	–	2	2
Juncus sp.	–	1	–	13	18	4	1	3	–	40	40
Ranunculus flammula	–	–	–	7	–	–	–	–	–	7	7
Trees and shrubs											
Betula sp.	–	–	–	4	–	–	–	–	–	4	4
Juniperus communis, ne	–	–	–	–	–	1	1	–	–	2	2
Picea abies	–	–	–	1	–	1	–	–	–	2	2
Picea abies, ne	–	–	–	–	–	*1	–	*6	*7	–	7
Pinus silvestris, ne	–	1	–	2	–	–	1	3	–	7	7
Picea/Pinus	1	–	1	–	–	–	–	1	–	3	3
Picea/Pinus, sc	–	2	–	13	–	–	–	6	–	21	21
Picea/Pinus, fl	1	1	–	1flt, 3fl	–	–	–	1	–	7	7
Others											
Alchemilla/Viola sp.	–	–	–	3	–	–	–	–	–	3	3
Cruciferae	–	1	–	–	–	–	–	–	–	1	1
Fabaceae	*3	*19	*6	–	–	–	–	*13	*41	–	41
Rubus idaeus	–	–	–	1	–	–	–	–	–	1	1
Rumex sp.	–	–	*1	1	–	–	–	–	*1	1	2
Viola sp.	–	–	–	1	1	–	–	12	–	14	14
Other remains											
Bryophyta	–	1	–	le2, st9	st3	–	–	st 1	–	16	16
Fungi/sclerotia	1	1	14	3	13	3	–	1	–	36	36
Lumbricus terrestris/c	–	–	–	3	–	–	–	9	–	12	12
Insecta	1	5	1	43	40	12	2	24	–	128	128
Bones	–	1	–	–	–	–	–	1	–	2	2
Wood	–	–	1	–	–	–	–	–	–	1	1
Charcoal	*	*	**	*	*	*	*	***	***		***
Indetermined	16	21	–	33	9	4	3	83			169
Total (no charcoal)	29	74	36	209	95	36	8	245	114	449	732

fruits of *Carex* spp. were found charred. If not recent, the uncharred remains represent species which may have been cut for cattle fodder or other purposes from the meadows of the adjacent river banks. The remains of trees consisted mainly of uncarbonized scales, flowers and needles of *Picea abies* and *Pinus silvestris*. A few non-charred seeds were also found. In addition to the common conifers, *Juniperus communis* was also among the woody species at the site. Probably the open meadow-like landscape of Pahamäki also contained groups of conifers and juniper in prehistoric times.

DISCUSSION

The cultivation of cereals

Barley was doubtless the most important cereal in SW Finland during the Iron Age as shown by this and many previous studies. Since the earliest find of *Hordeum vulgare* var. *nudum* in Niuskala, Turku, which is dated to the Kiukainen period (3 620–3 260 cal BP) (Vuorela & Lempiäinen 1988) it has dominated all the macrofossil finds of cereals. Naked barley decreased gradually during the first millennia BC probably due to a deterioration in climate (Hjelmqvist 1992) or the beginning of more intensive cereal production with thorough soil preparation and heavy manuring (Engelmark 1992). It occurred occasionally along with the hulled type during the Iron Age, when four-rowed hulled barley is known to have been the staple crop in northern Europe (Behre 1983). No evidence for the deliberate cultivation of naked barley was detected at Pahka where the barley seemed to be exclusively of the hulled four-rowed variety.

The macrofossil studies at Pahka show a marked abundance of rye relative to other sites of the Viking Age so far investigated in S Finland. Intensive rye cultivation is known to have been practised in SW Finland in the 15th century (Vuorela 1975). The first occurrence of rye in pollen diagrams from SW Finland is dated to the early Iron Age (Vuorela & Lempiäinen 1988), the time when the growing of rye as a crop in its own right started in Central Europe (cf. Behre 1992). Sporadic evidence for the introduction of rye as a cultivated cereal varies considerably (AD 100–1 000) in SW Finland depending on the site, generally it is c. 500–800 AD (Tolonen *et al.* 1976, Tolonen 1985, Vuorela & Lempiäinen 1988, reviews by Donner 1984, Tolonen 1985b).

In general the occurrence of rye has been low in macrofossil finds from excavations dated to the earlier part of the first millennium AD (Aalto 1982, Matiskainen 1984, Seppä-Heikka unpubl.). The macrofossil evidence at Pahka clearly indicates the increasing importance of rye from the Viking Age onwards. Numerous pollen diagrams and macrofossil finds (Behre 1992) demonstrate a great increase in rye cultivation in Germany, the Netherlands and southern Scandinavia during the 8th–10th centuries. It is interesting to see, that in Varikkoniemi (Lempiäinen 1992) and Rapola in Tavastland (Vikkula *et al.* 1994) this expansion cannot be so clearly detected, although near the coast the proportion of rye does reach up to 15%. Later, in the Crusade Period (AD 1 050–1 200), rye was already dominant in grain from the settlement site at Paimio, Sievola (Seppä-Heikka 1983). Macrofossil evidence from the bishop's castle at Kuusisto, dating from AD 1 200–1 500, shows the equal abundance of rye and barley at that time (Lempiäinen 1994).

Both bread and club wheat were known in the region during Viking times, but they may have been of only minor importance in terms of cultivation. Wheat comprised just 0.4% of the cereal remains at Pahka. In Seppä-Heikka's studies (Seppä B.Sc.-thesis unpubl.) wheat occurred only in the medieval layers where it was represented by club wheat.

Club wheat has been cultivated in S Finland since the early Iron Age and it was probably more widely used than has previously been supposed (Vikkula *et al.* 1994). The earliest find from an ancient field at Rapola in Tavastland has been dated to the Pre-Roman Iron Age (Vikkula *et al.* 1994). At Domargård, Karjaa, club wheat was the second most important cereal after hulled barley, reaching c. 30% during the Merovingian period (Matiskainen 1984). Scant remains of bread wheat were also encountered. A great number of grains of club wheat were found at the old market place in Turku, dating from AD 1 250–1 450 (Lempiäinen 1995). Wheat production was, however, still low from the Middle Ages onwards and its cultivation was concentrated in SW Finland (Vuorela 1975).

There was no evidence of the cultivation of emmer wheat, *Triticum dicoccum*, at Pahka. This hulled wheat species was known in SW Finland just 150–500 years earlier, as shown by numerous finds from Salo and Paimio (Aalto 1982, Seppä-Heikka unpubl.). In the light of current macrofossil evidence the decline of emmer seems to have taken place in the Merovingian Period.

The first traces of the cultivation of oats in pollen diagrams from S Finland have been dated differently depending on the interpretation (Vuorela 1972, Tolonen *et al.* 1976). The first macrofossil evidence for the occurrence of *Avena sativa* comes from Salo, Katajamäki (Aalto 1982) and is dated to AD 300. The appearance of *Avena sativa* in subsequent macrofossil finds is generally low. The occurrence of oats at Pahka cannot confirm it as a cultivated plant, especially as in Seppä-Heikka's studies (Seppä B.Sc.-thesis unpubl.) oats were not found at all. Dehusked grains of the wild species resemble those of cultivated oats in morphology and the number of available measurements is too small to permit any conclusions on the basis of the size differences. Oats are mentioned for the first time in written sources in 1387 (Vuorela 1975). They were grown mainly for animal fodder and played only a minor role in agriculture. However, there are early prehistoric finds of cultivated oats from several European sites, which show that there are longer cultivation traditions elsewhere (Hjelmqvist 1955, 1979, Körber-Grohne 1987, Robinson 1993).

Pisum sativum was probably the only pulse cultivated in Pahka. It was also found by Seppä-Heikka in 1979. The sum of all the fragments accounted for 0.2% of the remains of cultivated plants. Their small size suggests that the seeds are of the grey pea commonly used by peasants in Finland up until the 18th century in Finland (Gadd 1751, Soininen 1974). The first macrofossil evidence from Finland is in the form of impressions of pea and lentil from a grave mound in Vammala dated to AD 400–500 (Luoto *et al.* 1981). Pea also occurred in low numbers at Varikkoniemi (Lempiäinen 1992), with one specimen within a building (AD 600–1 000) in Sievola (Seppä-Heikka 1983) and it was among the plant remains found in Viking Age house remains at Finström, Åland (Kivikoski 1946). Peas are known to be cultivated from Neolithic times: the plant came to Europe with the earliest farmers (Körber-Grohne 1987).

Background factors affecting the presence and size distribution of grains

The considerable length of the barley grains from Pahka is a matter of interest. The phenomenon is difficult to explain in terms of the charring process alone, because carbonization tends to shorten and thicken the grain (Hopf 1955, Seppä-Heikka M.Sc.-thesis unpubl.). The grains must therefore have been long even before carbonization.

In Finland, climate and soil conditions are most advantageous for cereal cultivation in the southwestern part of the country. Evidently the fertile clayey soils surrounding the hill Pahamäki favoured arable agriculture and the large grain size of the macrofossil material from Pahka may simply reflect the higher productivity of the local agriculture. However, several other factors may also influence the qualitative and quantitative aspects of charred grain assemblages. These will be discussed below.

There are several possible ways in which grain can become charred. The usual explanation for the charring of massive macrofossil grain finds is accidental fires having burnt down different drying structures, granaries and other storage facilities. In principle, carbonization can take place before, during or after processing, and within that, either before or after threshing and cleaning, depending on the traditions and methods of drying, processing and storing employed. The stage at which accidental charring happens greatly influences the composition and appearance of the macrofossil assemblage under study (cf. Hillman 1981, 1984). Drying was a necessary stage in crop processing in regions with a wet climate. In Finland, unthreshed crops were traditionally pre-dried in the fields as sheaves which were then transported to a special drying barn called a *riihi* in Finnish in which the sheaves were first dried in considerable heat and smoke and then threshed (cf. Vuorela 1975). The *riihi* is thought to be of prehistoric origin (Vuorela 1975). Little ethnographic data is available pertaining to the various methods of drying threshed grain (cf. Talve 1960). In prehistoric times, primitive structures such as drying pits, four-sided drying structures, stone kilns, open fires and even hot stones were presumably used in northern Europe for the purpose of drying grain (Talve 1960).

Rowley-Conwy (1988) has proposed charring of the different fractions i.e. products and by-products produced in crop processing, as being one reason for the differences in the sizes of grain derived from Danish localities; i.e. the grain size may be smaller at one site than at another, because the first represents a by-product of the processing chain, tail grain, and the latter is the cleaned and most valuable quality class. Robinson (1991) has compared plant assemblages from various structures at Gammel Lejre in Denmark from the point of view of the average size of grain and the presence of non-grain cereal remains and weeds. He found both processed and unprocessed grain within the samples.

Discussions on the nature of prime grain and tail grain are based on Hillman's (1984) models of crop processing built up from ethnographic data. The models describe the effects of the different steps of crop husbandry and grain processing on the composition of crop products and by-products. The models help to infer ancient farming practices through an interpretation of the composition of individual samples of crop remains.

The grain size distribution depends on the method and the mesh size used in cleaning. The crucial processing stage in Hillman's model, which separates light grains and impurities from heavy grains, is fine-sieving. Prime grains are retained on the sieve which allows the tail grains and small weed seeds to pass through. The latter are either burnt or end up as cattle fodder or emergency human food during years of famine.

In Finland the traditional cleaning methods mainly followed the traditional crop processing chain presented by Engelmark (1989). The method, which was used until quite late in historical times was called casting or flinging (in Finnish *viskaus*) (cf. also Vuorela 1975) which was the indoor counterpart to the winnowing used in the Orient (Engelmark 1989). This method, however, gives a more distinct separation of grain than outdoor winnowing does (Engelmark 1989). When threshed grain is thrown towards the wall of a drying barn the grains become separated according to their weight. The heaviest prime grains travel the greatest distance and drop beside the wall. Smaller grains, rachis fragments, glumes, weed seeds and other lighter remains fall sooner. The prime grain was the most important quality class and was normally stored without further processing. It was mainly consumed as food or sown as the following years' seed-corn. Medium and tail fraction grains were usually treated to remove chaff and small weed seeds before storing. In Finland, both a winnowing tray and sieves are known to be used for this purpose, depending on the geographical area (Vuorela 1975). The poorest quality class i.e. the tail grain fraction was consumed only when the total yield was low (Engelmark 1989).

As discussed above, differences between sites in the dimensions of charred grains and in the composition of all the cereal remains and impurities could therefore indicate differences both in local growth conditions and in the stage of the crop processing chain at which charring took place. The macrofossil material from Pahka contained extremely low numbers of non-grain cereal parts i.e. rachis segments. This could be interpreted either in terms of human influence or through the composition of the charred cereal remains having been affected by differences in the survivability of cereal components during carbonization (Boardman & Jones 1990). Rachis fragments and straw nodes are much more sensitive to high temperatures than grains; at low temperatures non-grain components take a longer time to carbonize than grains (Boardman & Jones 1990). The absence of rachis segments in the samples from Pahka might just be due to their rapid combustion at high temperatures. However, the few undamaged rachis fragments indicate that conditions were not unduly unfavourable for the preservation of these types of remains. On balance it would appear that crop processing was responsible for the lack of non-grain cereal remains at Pahka. Cleaning may simultaneously have removed the majority of the weed seeds, thus explaining their scarcity.

In addition to fires, cleaned prime grain may be exposed to charring within grain roasting, which dates back to early prehistoric times. This is a more severe activity than corn-drying, and improves preservation during storaging due to a total loss of moisture in the grains which, in turn, also makes the grinding of the grain easier. In addition, it changes the chemical composition of the grains; starch turns to dextrine which gives the food a better flavour and makes it more easily digestible (Gall 1975).

Roasting may have been used in the course of preparing quick snacks and special dishes like 'burstin' in the Northern Isles of Orkney and Shetland (Fenton 1978). A traditional Finnish dish called *talkkuna* in Finnish is prepared by drying in the sauna or roasting cooked grains of oats, barley, rye and peas or mixtures of these, depending on the region, grinding them and mixing the resulting brownish flour with buttermilk or curdled milk or cooking it in water to make a thick porridge (Vuorela 1975, Talve 1990). The tradition of this eastern dish may have spread here from the Slavonian region about one thousand years ago (Vahter 1938) or later in the Middle Ages (cf. Talve 1990). However, such a primitive way of mixing grinded roasted grains with some liquid may well date back much further in time and may have been quite widespread. If so, the possibilities for charring may have existed when the heat in the oven rose too high during the roasting process.

The moisture content of both the fresh grain and the cooked swollen grains is high which may have some influence on the structure and morphology of the grains when charred. The effect of different moisture contents on carbonization processes and on the dimensions of charred grains has not yet been studied thoroughly; and hence it is difficult to say whether the large grain size depends as much on carbonization as on moisture content or not. In any case, the grains at Pahka were moist when charred, because some of them had sprouted. It seems unlikely that they were waste material from some special malting processes. Presumably the crop had been harvested under wet conditions, which would have promoted the sprouting of grains in the ear or the crop may have become wet later during storage.

In addition, either moist grain or cleaned prime grain may well have been offered as grave-goods for the deceased. In the light of the present archaeological evidence the association of the grain finds with a burial event is also possible. A few grain finds previously investigated from burial cairns suggest, however, that only a handful of grains were given as grave-goods (Kivikoski 1939, Lempiäinen 1991). If all the grains from Pahka represent grave-goods, the amount of grains offered to the deceased would appear to have been quite excessive. On the other hand, if whole sheaves had been offered, one would expect many more rachises and other cereal components to be present. Hence the linkage of all the charred grains to a single burial event cannot be directly confirmed.

The morphological appearance of the barley grains from Pahka cannot help directly in explaining the find context and their possible origin by revealing the way in which they became charred. Scars and glazed erupted clumps of starch and amorphous inner structure, which Gall (1975) regarded as an indication of charring in an open fire can be commonly seen. According to Boardman and Jones's (1990) experiments, barley tends to become carbonized after 1.5 hours at 250°C and to become a conglomerated mass from 350°C onwards. Numerous grains fromPahka, however, showed no damage from rapid charring at high temperatures. Similarly, the better preservation of the rye grains suggests milder charring conditions than those to which the majority of the barley grains were apparently exposed, thus indicating various sources for the grains studied. For this reason too, the linkage of all the charred grains with a single burial event cannot be directly confirmed.

CONCLUSION

In the light of the botanical material so far investigated from Pahka, barley was the most important crop followed by rye. The cultivation of oats could not be confirmed. Wheat seems to have played only a minor role in plant husbandry. The large grain size of barley and the low presence of non-grain cereal parts and charred weed seeds may indicate the accidental charring of cleaned prime grain grown on the fertile soils around Pahka. Since Finland belongs to an area with long traditions of drying crops as sheaves, it is possible that the material studied could have become carbonized accidentally in fires or in deliberate activities carried out after crop processing. Accidents during daily household activites, e.g. roasting, followed by dumping in a waste pit could explain their origin, but the possibility of a cremation burial also remains. Future studies aimed at investigating the dependence of the morphological characters of charred grains on different heating processes, variations in temperature and the moisture content of the grains during carbonization may help to clarify the interpretation of the origin of macrofossil grains.

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