# POLLEN AND CHARCOAL ANALYSES FROM LAKE ETU-MUSTAJÄRVI, SOUTHERNFINLAND, WITH SPECIAL REFERENCE TO AN EARLY HOLOCENE URTICA POLLEN MAXIMUM

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SARMAJA-KORJONEN, KAARINA 1995:Pollen and charcoal analyses from Lake Etu-Mustajärvi, Southern Finland, with special reference to an early Holocene *Urtica* pollen maximum. *Bull. Geol. Soc. Finland* 67, *Part* 1, 37-46.

Sediments of a small lake, Etu-Mustajärvi, in southern Finland, were studied with respect to their fossil pollen and charcoal content. Pollen analysis showed a typical development of vegetation from the earliest Holocene onwards, since the isolation of the lake from the Baltic Ice Lake. The emerged land was first colonised by herbs and bushes, and for the first time in Finland an *Urtica* maximum of 4 % is reported for this period. It is considered possible that *Urtica* may have been a commoner part of the pollen flora of newly emerged land in south Finland than has been previously thought. Charcoal analysis was undertaken to examine the Holocene history of forest fires in the area. At least in the Lammi area, charcoal seems to have been most abundant about 8000-6000 BP, a result which is in apparent disagreement with the general concept that the period was moist and thus forest fire frequency could not have been high.

Key words: paleoecology, lake sediments, paleobotany, pollen analysis, *Urtica*, charcoal, fires, Holocene, Lammi, Finland

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### **INTRODUCTION**

Although the development of vegetation from the early Holocene onwards has been widely studied in Finland (e.g. Donner 1966, Hyvärinen 1972, Alhonen & Vuorela 1974, Korhola & Tikkanen 1992), pollen analysis has generally not been combined with charcoal analysis, with one exception (Tolonen 1980). Charcoal analysis has been mainly limited to studies of human impact and clearence with fire (e.g. Tolonen 1978, 1985a, Huttunen 1980, Grönlund & Asikainen 1992, Sarmaja-Korjonen 1992). Thus the history of fire during the earlier Holocene is not well known.

A lake, Etu-Mustajärvi, from Lammi, southern Finland was selected for pollen and charcoal analyses. Its sediment covers the entire Holocene. The aim of the study was to examine in parallel with the development of vegetation, whether there are any noticeable trends in the amounts of microscopic charcoal during the different stages of the Holocene. Thus a general background for further forest fire frequency studies can be achieved.

#### THE SITE

Etu-Mustajärvi is situated between the First and Second Salpausselkä end-moraines, in the parish of Lammi, southern Finland (Fig. 1). It is a small basin (ca 4.5 ha) surrounded by a mire, Mustajärvensuo. A sediment core from the shore of another basin in the same mire, Lake Taka-Mustajärvi, was studied by Okko (1957).

The elevation of the site is 158.1 m above the sea level and the water depth was 9 m at the coring point. The level of the Baltic Ice Lake was about 160 m a.s.l. in the area (Okko 1957). The lake became isolated during the drainage of the Baltic Ice Lake about 10 300 BP. The change is also seen in the diatom composition (analysed by Heikki Haila) where the species common in a large lake drastically changed into small lake forms.

## SAMPLING AND LABORATORY TREATMENT

Coring was undertaken in March 1989 with a Livingstone corer near the center of the lake. The water depth was 9 m. The stratigraphy was as follows:

0-170 cm dark brown gyttja

170-200 cm a gradual change from gyttja to claygyttja

200 cm a layer of moss remains (Drepanocladus)

200-220 cm silty clay

220-240 cm sand

240-255 cm silty sand

Pollen was analysed only from 195 cm upwards since the lower sediment was non-polleniferous. Samples of 0.5 cm3 were taken for pollen analysis and treated with the KOH, HF and acetolycis methods (Fægri & Iversen 1989), HF and acetolycis only for the lowermost samples with high minerogenic content. 1000 or more pollen grains were counted from each sample except the lowest samples which were poor in pollen. Lycopodium tablets were added for estimates of the pollen concentration (Stockmarr 1971). The basic sum for land pollen percentages is AP + NAP (Total Pollen), for aquatic pollen AquP + Total Pollen and for spores the spore sum + Total Pollen.

Microscopic charcoal particles were counted according to the method described by Sarmaja-Korjonen (1992) but only in four size groups, 65, 225, 450 and 450-3200  $\mu$ m<sup>2</sup>. Charcoal particles were counted only from 170 cm upwards because in the lowermost samples there was a high proportion of black suphide which made the identification uncertain. The nomenclature of the vascular plants is according to Hämet-Ahti et al. (1986).



Fig. 1. Location of the study site, Etu-Mustajärvi, in the parish of Lammi, southern Finland. The sampling point is marked with a cross.

### RESULTS

### EMJ 1a (195-180 cm) Betula-NAP local paz

The zone (Fig. 2) is characterized by growing Betula values and high (40 % of the total pollen sum) NAP values. At the beginning of the zone some *Alnus*, *Corylus*, *Ulmus* and *Quercus* pollen are found, most certainly representing redeposited pollen. The main NAP components are *Salix*, *Juniperus*, Cyperaceae, Poaceae, Chenopodiaceae, Rumex acetosa/acetosella type, Artemisia, Thalictrum and Urtica which is present with a maximum of 4 % at 190 cm. Also Lycopodium is abundant. Towards the upper part of the zone Empetrum, Ericaceae and Ranunculaceae rise. Concentration (Fig. 3) of Betula is very low.

Because the *Urtica* values were exceptionally high at 195 cm, 8 extra 1cm thick samples were analysed around the maximum. The *Urtica* values varied from 1.5 % to 5.4 % in these samples. ETU-MUSTAJÄRVI



Fig. 2. Relative pollen diagram of Lake Etu-Mustajärvi, southern Finland.

## EMJ 1b (180-160 cm) Betula local paz

The zone boundary at 180 cm is defined by a further rise in *Betula* values and decrease in NAP to about 15 %. *Thalictrum, Myriophyllum alterniflorum, Potamogeton, Equisetum* and Polypodiaceae characterize the zone. *Urtica* does not reach values over 1 %, while *Humulus* pollen begins to be reported continuously. At the upper part of the zone *Populus, Corylus* and *Fraxinus* appear. Concentrations of *Betula* and *Pinus* are still low.

### EMJ 2 (160-135 cm) Pinus local paz

The lower zone boundary is defined by the decline of *Betula* and a rapid rise of *Pinus*. *Populus*, *Corylus* and *Ulmus* are present. In terms of NAP *Salix, Juniperus*, Cyperaceae and Poaceae occur throughout the zone at steady values (2-4 %). The zone is also characterized by high values of *Isoktes.* Charcoal particle area remains relatively low in the lower part of the zone but rises rapidly towards the top. Concentration of *Pinus* strarts to rise.

## *EMJ 3 (135-65 cm)* Betula-Alnus-Corylus-Ulmus *local paz*

The zone boundary at 135 cm is defined by a rapid decrease in *Pinus* and rise in *Alnus. Quercus, Tilia* and *Fraxinus* rise slightly. Just above the lower zone boundary the total NAP values decline below 5 % and remain low for the rest of the zone. *Salix, Juniperus,* Cyperaceae and Poaceae are steadily present but with values of about 1 %. *Urtica, Humulus, Artemisia* and *Filipendula* are continously present. The zone is also characterized by the presence *Pteridium.* Charcoal is abundant in the lower part of the zone and declines in the upper one. Concentrations are at their highest in this zone.



#### EMJ 4 (65-0 cm) Picea-Pinus local paz

The zone boundary is defined mainly by the rise in *Picea. Betula* starts to decrease as *Pinus* increases. The decline of *Populus, Corylus, Ulmus, Quercus, Tilia* and *Fraxinus* is gradual. NAP values rise towards the top. Concentrations follow the same pattern as the percentage curves of the trees.

#### DISCUSSION

The pollen stratigraphy (Fig. 2) shows the development of vegetation in Holocene well-known from earlier studies from southern Finland (e.g. Donner 1972, Tolonen & Ruuhijärvi 1976,

Donner et al. 1978). After the basin was isolated from the Baltic Ice Lake its surroundings were rapidly colonized by bushes, herbs and pteridophytes, such as *Salix, Juniperus,* Cyperaceae, *Artemisia,* Chenopodiaceae, *Rumex, Urtica* and *Lycopodium.* The basin is situated on an large elevated area which emerged early and offered habitats for the early vegetation.

The birch forest that followed (EMJ 1b) was relatively open and light as indicated by the still rather high NAP values. Also *Equisetum* and Polypodiaceae were present. *Salix*, Cyperaceae and Poaceae did not decrease markedly in the pine forest phase (EMJ 2), not until after the more closed broad-leaved forest was established (zone EMJ 2/EMJ 3 transition). *Pteridium* appears to have been a typical element in the broad-leaved forests as it is commonly abundant in this phase in pollen diagrams from southern Finland (e.g. Vuorela 1978, 1981, 1983, Tolonen 1985b).



Fig. 3. Lake Etu-Mustajärvi, southern Finland. Pollen concentrations of trees.

After the spread of spruce (zone EMJ 3/EMJ 4 transition) the broad leaved trees declined gradually. The rise of NAP near the top of the diagram can be connected to human activities (the first cereal pollen grain was found at 35 cm). Various studies from the Lammi area and neighboring areas have shown that intensive clearance and cultivation was practised from the Iron Age onwards (e.g. Tolonen 1978, 1980, Huttunen 1980).

The local pollen assemblage zones of Etu-Mustajärvi correspond well with the regional pollen assemblage zones suggested by Donner (1971). There are numerous radiocarbon dates from Lammi and the neighbouring areas for different events of forest history (listed in Tolonen & Ruuhijärvi 1976, Donner et al. 1978). According to them the transition of the Birch and Pine zones (EMJ Ib/EMJ2) is about 9000 radiocarbon years and the limit between the Pine zone and the Birch-alder-hazel-elm zone (EMJ2/ EMJ3) about 8000 radiocarbon years. *Picea* spread to the Lammi area about 4500 BP (Tolonen & Ruuhijärvi 1976, see also Tolonen 1980). The local pollen assemlage zones, age estimations and chronozones (*sensu* Mangerud et al. 1974) are shown in Fig. 4.

## Urtica

Among the typical herb pollen flora of newly emerged land in early Holocene (*Artemisia*, Chenopodiaceae, *Rumex*) the maximum of 4 % of *Urtica* pollen is a feature never before reported in Finnish pollen diagrams before, although some sporadic finds have been reported (e.g. Alhonen & Vuorela 1974, Tolonen 1980, Bondestam et al. 1994). In northwestern Europe and Scandinavia seeds and pollen of *Urtica* have been found also in Late Glacial and preboreal sediments (Bohncke *et al.* 1987, Paus 1988, 1989, Oeggl & Eicher 1989). According to Godwin (1975) *Urtica* was present in the 'tall-herb' communities in the Weichselian lowland landscape in Britain.

When a peak in a pollen taxon in just one sample is found, the possibility of flower or insect contamination in the sediment cannot be ruled out. In the present case, however, the high amounts of Urtica pollen in the extra samples suggest that this is not a case of contamination. Two explanations are plausible. First, that Etu-Mustajärvi was a special site around which Urtica was present in early Holocene unlike lakes in previous studies. Secondly, that Urtica pollen may not have been noticed earlier in early Holocene samples. The sediments of this period are usually rich in minerogenic matter and need HF treatment which seems to shrink pollen grains. The pores are then hardly visible on the very small pollen grain, even at magnification of 400 in microscope.



Fig. 4. The main tree pollen curves and the running mean for charcoal area (3 samples) obtained from Lake Etu-Mustajärvi, S Finland. The time scale is approximate and adapted from other studies (see text).

### 44 Kaarina Sarmaja-Korjonen

Since the identification of Urtica pollen grains has become more common in Finland, it has appeared an inseparable component of the seashore pollen flora (M. Tolonen 1983, Sarmaja-Korjonen et al. 1991, Sarmaja-Korjonen 1992), as well as the damp groves around lakes (Sarmaja-Korjonen 1992) during the Holocene. The latter case is also shown in Etu-Mustajärvi by the continuous occurrences of Urtica along with Humulus above the early maximum. It is also possible that Urtica was a commoner component of the southern Finnish flora of newly emerged land in Early Holocene than has been considered earlier. This possibility is also suggested by studies from Vihti, southern Finland (Sarmaja-Korjonen, in prep.). Further studies are needed to clarify this problem.

### Charcoal record and forest fires

Charcoal was analysed to derive a general forest fire history and to see if there are any clear trends during the different forest phases of the Holocene. Sample thickness was 5 cm and therefore not adequate to find individual forest fires as can be done with more detailed analysis methods (e.g. Sarmaja-Korjonen 1992). Therefore the charcoal area is also shown by a running mean curve (Fig. 4).

The charcoal area is not very large during the end of the Preboreal and rises sharply towards the end of the Boreal. It stays high during the first half of the Atlantic period, up to about 6000 BP, after which it decreases and stays low till the end of the Subboreal. Then it rises again, after the spread of spruce, and according to many studies (Tolonen 1978, Huttunen 1980, K. Tolonen 1983) this is due to two facts. First, the new forests where spruce was very common burned easily and secondly, the practice of clearance increased in the Lammi area from the Iron Age onwards.

According to the present results fires were more common during the first half of the Atlantic period than the second. By comparison, lake levels in southern Sweden were at their highest around 7000 BP and the time between 8000-6000 has been considered moist (Digerfeldt 1988, Harrison & Digerfeldt 1993). In Finland lake levels rose towards the beginning of the Atlantic period (Alhonen 1972, Donner et al. 1978, Korhola & Tikkanen 1991). A drier period followed from about 6000-3000 (Digerfeldt 1988, Harrison & Digerfeldt 1993). At least in the Lammi area, fires seem to have been more common during the moist period than the following drier one. This is supported by the results of Tolonen (1980) from Lake Lamminjärvi where she got almost identical behaviour of the charcoal curve. These two charcoal analyses are the only ones covering the whole Holocene done so far in Finland and the controversy can be explained only by further and more detailed studies.

ACKNOWLEDGEMENTS: The fieldwork was done by Prof. Joakim Donner, Mr. Peter Voss, and Mr. Heikki Haila. Heikki Haila also analysed the diatoms and did the loss-on-ignition determinations. Dr. Marjatta Aalto kindly identified the moss sample. I wish to express my sincere thanks to all of them. I am also most grateful to Dr. Mirjami Tolonen and Dr. Keith Bennett for critical comments on the manuscript and to Dr. Chronis Tzedakis who made helpful suggestions and checked the English. I greatly appreciate the financial support given me by the Ella and Georg Ehrnrooth Foundation.

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#### 46 Kaarina Sarmaja-Korjonen

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