SUBFOSSIL CHIRONOMID STRATIGRAPHY OF A SMALL ACID LAKE IN SOUTHERN FINLAND

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Chironomid analysis was used to study ecological changes in shallow oligotrophic Lake Orajärvi in Espoo, southern Finland. A 53 cm long sediment core for chironomid analysis was obtained at 6 m depth.

Changes in chironomid composition of the Lake Orajärvi are related to temperature changes and anthropogenic acidification. Decline of *Microtendipes* and emergence of *Heterotrissocladius* at 30—35 cm depth are due to deteriorating climate after Holocene climatic optimum. Most recent changes in chironomid fauna can be related to strong human induced acidification of the lake, which has led to domination of *Dicrotendipes* and *Psectrocladius*.

Chironomid analysis, which mostly has been used in deep stratified lakes, seems to be a valid method also in shallow unstratified lakes.

Key words: paleolimnology, Chrionomidae, lake sediments, stratigraphy, palaeoclimatology, acidification, Holocene, Lake Orajärvi, Espoo, Finland.

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Introduction

Chironomid analysis (Chironomidae: Diptera) has been carried out for quite a long time. Nevertheless its value as a palaeolimnological research method has largely been underestimated, primarily because of an inadequate knowledge of the ecology and taxonomy of chironomid larvae. During the few last decades however the situation has improved because of many studies about chironomid ecology.

Chironomid larvae are suitable for palaeolimnological research in reconstructing the environmental conditions at the time of sedimentation because: 1) Chironomid communities in individual lakes are highly diverse, so that both species and individuals are numerous; 2) Different species are adapted to different kinds of ecological environments; 3) Chironomids are able to react to changing environmental conditions extremely rapidly when compared with plants for example; 4) Chironomid head capsules have a relatively high presevation potential in bottom sediments and may remain recognizable for a long time; 5) It is possible to identify chironomid remains even to species level.

In deep stratified lakes the oxygen condition of the hypolimnion correlates well with lake's trophic status and chironomid fauna (Hofmann 1986, Hofmann 1988). Thus changes in profundal chironomid faunas have been studied more than changes in littoral or sublittoral faunas. The ecology of profundal species is therefore better known, which makes it difficult to reconstruct past conditions in shallow unstratified lakes. The ecology of littoral chironomids is often more complex than that of profundal species. In shallow lakes other factors than trophic status may be more important, for example water temperature and sedimentation (Hofmann 1986).

Chironomid analysis has been used to study anthropogenic eutrophication (Alhonen and Haavisto 1969, Wiederholm and Eriksson 1979, Warwick 1980, Brodin 1982, Dévai and Moldován 1983,

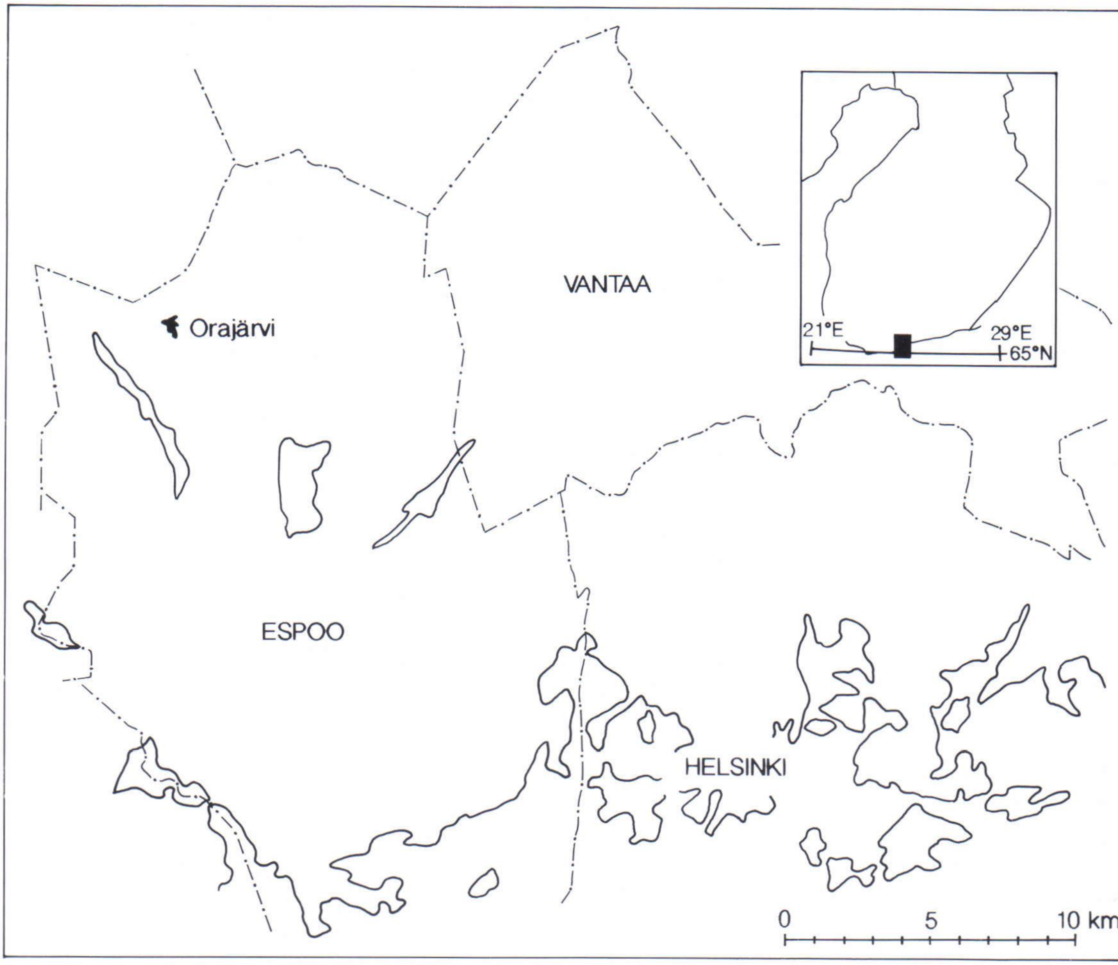

Fig. 1. Location of Lake Orajärvi.

Meriläinen 1987, Räsänen *et al.* 1992), acidification (Henrikson *et al.* 1982, Charles *et al.* 1990, Brodin 1990, Johnson *et al.* 1990), salinity (Paterson and Walker 1974) and climatic changes (Walker and Mathewes 1987, Walker *et al.* 1991a, Walker *et al.* 1991b). Many lake classifications based on chironomids have been presented, but they are valid only in deep stratified lakes.

The aim of this study was to adapt and apply chironomid analysis to a shallow unstratified lake and examine anthropogenic acidification and climatic changes.

Study site

Lake Orajärvi is situated in the city of Espoo, in the forested area of Nuuksio, about 25 km NW of Helsinki. It is a small, unstratified, oligotrophic lake with a maximum depth of 6,0 m, an area of 0,22 km^2 and an elevation of 87 m above sea level. The catchment area is neither inhabited nor cultivated. The sedimentation rate in Orajärvi is only about 0,1—0,2 mm/a. Orajärvi has become heavily acidified during the last decades because of acid rain. At the sediment surface there is a 5 cm thick black gyttja layer, black colour being derived from airborne coal dust (Tolonen and Jaakkola 1983). At the end of the 1970's Lake Orajärvi was known for its large perch but the fish population has subsequently disappeared (Tolonen and Jaakkola 1983).

Sampling

Sediment core was taken from Orajärvi in October 1990 using a crust-freeze corer (Saarnisto 1975). Water depth at the sampling site was 6 m. The length of the continuous sample was 53 cm and in addition to it one separate sample from 69—72 cm depth was obtained. Visible structures were described at the sampling site. A subsample for radiocarbon dating was taken from 27—30 cm depth and another subsample from 69—72 cm depth. Subsamples for chironomid, water content and loss-on-ignition analyses were taken from 0—1 and 1—2 cm depths and then 3 cm thick sections continuously down to 53 cm depth. Sample sizes for chironomid analysis varied between 2—20 g. Radiocarbon age determinations were made at the Radiocarbon laboratory of the Geological Survey of Finland.

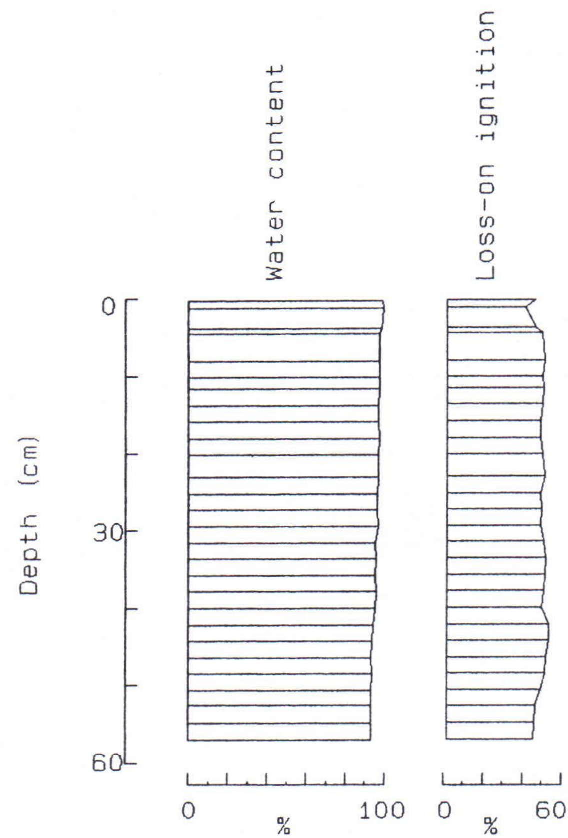

Fig. 2. Lake Orajärvi sediment water content and loss-on- ignition diagrams.

Preparation

Preparation was done using methods described by Wiederholm and Eriksson (1979), Hofmann (1986), Walker and Paterson (1985) and Walker (1987). Every subsample was boiled in hot (60°C) 10 % KOH- solution for one hour to remove organic material. A magnetic stirrer was used when necessary to deflocculate sediment. Samples were then sieved through 210 and 125 μm:n sieves to reduce sample size. Remaining material was examined under a Wild stereo microscope using 10—50 fold magnification. All head capsules were handpicked and placed on microscope slides using small forceps and mounted in Euparal.

Chironomid identification, to species level when possible, was made using Hofmann (1971), Saether (1975) and Wiederholm (1983). Head capsules of the subfamily Orthocladiinae split easily into two equal parts, a fact which was taken into account during identification.

Results

Sediment

A layer about 5 cm thick at the surface of the sediment consisted of black striped fine detritus gyttja and underneath that was a homogeneous dark green fine detritus gyttja. Water content in sediment was rather stable throughout the whole

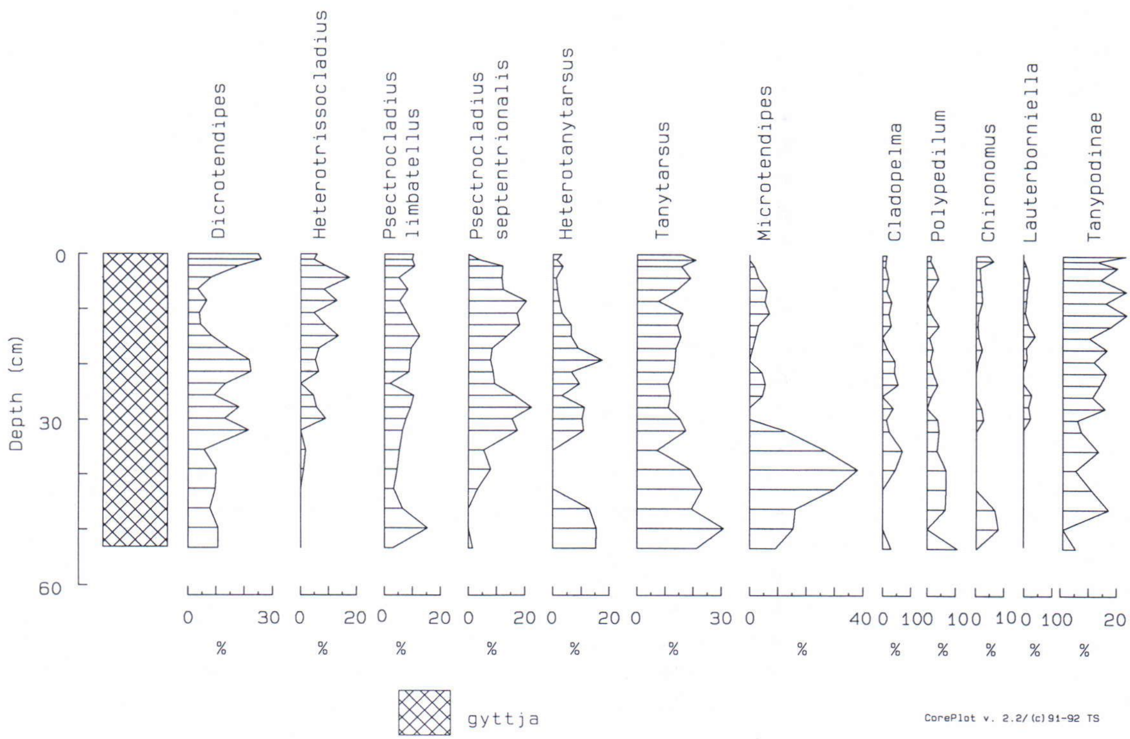

Fig. 3. Lake Orajärvi chironomid diagram.

sample variying between 90—95 %, with a tendency to steadily increase towards the surface (Fig. 2). Organic contents also increase slightly towards the surface varying between 40—53 %. the organic content of the surface samples is however lower than elsewhere in the profile. The radiocarbon age at 27—30 cm depth was 2180±100 years (Su-1988) and at 69—72 cm depth 6560±70 years (Su-1989).

Chironomids

Altogether 2216 chironomid head capsules were counted. The most common genera were *Psectrocladius*, *Heterotrissocladius*, *Dicrotendipes*, *Microtendipes* and *Tanytarsus*. Members of the Tanypodinae-subfamily were also common. *Heterotrissocladius* is absent below 45 cm depth and its relative abundance increases towards the sediment surface (Fig. 3). *Dicrotendipes* is the most common genus in the uppermost samples and is also common at 30—20 cm depth, but between 20—10 cm its proportion decreases strongly. Increasing relative proportions of *Psectrocladius limbatellus*, *P. septentrionalis* and *Tanytarsus* sp. towards the surface are distinctive features of the profiles. *Microtendipes* is the most common genus at 45—35 cm depth, but at 35 cm depth its proportion decreases rapidly. The Tanypodinae-subfamily is common in the whole sediment section with an increase towards the surface.

Discussion

Changes in water and organic content are most likely due to compaction and diagenesis of the sediment. These minor changes also clearly indicate that sedimentation has been rather stable throughout the portion of the lake's history studied here. According to Tolonen and Jaakkola (1983) the pH-value in the sediment decreases from 6,1 at 15 cm depth to 5,0 at 0 cm depth. It is probable that a similar change has occurred in lake water too.

In shallow lakes climate is an important factor influencing chironomid faunas (Hofmann 1986, Walker and Mathewes 1987a, Walker and Mathewes 1987b, Hofmann 1988). The studied core extends back, according to the radiocarbon age determinations, the warm Atlantic period, so that climatic changes have certainly had an effect on the chironomids of Lake Orajärvi. The age determinations are however scarce, which may render the results questionable.

Dicrotendipes and *Psectrocladius*, which are the most common genera at the sediment surface and also in the recent chironomid population of the Lake Orajärvi (Jarmo Meriläinen, pers. comm.), have possibly benefited by the disappearance of fish population; their larvae are rather large and therefore natural prey for perch. Because of their size they can also tolerate low pH-values. Another reason for the dominance of *Dicrotendipes* may be that it emerges in June—July (Henrikson et al. 1982) and not in early spring when pH values are at their lowest. Increasing proportions of *Dicrotendipes* and *Psectrocladius* are typical features in acidified lakes.

Heterotrissocladius is totally absent from the samples below 45 cm, which may be related to a warm period at the Holocene climatic optimum. The warmest adapted species of *Heterotrissocladius* is still restricted to relatively cold waters (Walker and Mathewes 1987a). The marked decrease in the proportion of *Microtendipes* at 30—35 cm depth is possibly related to a deteriorating climate following climatic optimum. According to Walker et al. (1991a) *Microtendipes* is classified as a temperate genus. *Tanytarsus* were impossible to identify to species level and were not used in making interpretations. The head capsules of the subfamily Tanypodinae are fragile, which greatly reduces their value as indicators. In this study they were therefore left unstudied.

Decreasing diversity of zoobenthos is a typical feature of acidic lakes (Henrikson et al. 1982, Brodin 1990). In Lake Orajärvi however, this kind of trend is not apparent, probably because of the very slow sedimentation rate compared with the sample intervals. Decreasing total number/g dry matter in the lowermost samples is possibly due to mechanical or chemical dissolution of the head capsules.

Through the acidification of the lake man has destroyed the fish population in Lake Orajärvi and this change in natural predation relationships has had effect on the composition of chironomid populations. Lowered ph-values in the lake may also have had direct effect on at least some chironomid genera. However the most striking changes in chironomid composition are caused by long-term climatic changes.

The chironomid fauna of Lake Orajärvi consists of littoral and sublittoral taxa. It is thus evident that chironomid analysis is a valid palaeolimnological method in shallow as well as in deep stratified lakes. Interpretation of results obtained by chironomid analysis should however be compared with results obtained by other methods.

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