ON THE OCCURRENCE OF SUBFOSSIL *PEDIASTRUM* ALGAE IN A FLANDRIAN CORE AT KIRKKONUMMI, SOUTHERN FINLAND

PENTTI ALHONEN and SINIKKA RISTILUOMA

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Subfossil green algae of *Pediastrum* were observed in a Flandrian core in south-west Finland. Their greatest relative abundance was slightly above the rational border for *Tilia* (T_o) in the pollen stratigraphy. The authors believe that the species indicate the presence of eutrophic chlorococcal plankton, thus reflecting a more or less productive environment of sedimentation. The proximity of the transgressive Litorina Sea and the contemporaneous moist Atlantic climate are also assumed to have made the physical and chemical conditions in the lake phase of the site favourable for their growth. These observations and the data from the literature show that *Pediastrum* provides a useful indication of environmental changes, and that its occurrences in sediments is thus deserving of attention.

Pentti Alhonen and Sinikka Ristiluoma, Department of Geology and Palaeontology, University of Helsinki, 00170 Helsinki 17, Finland.

Introduction

The purpose of this biostratigraphic study is to discuss the occurrence and significance of subfossil *Pediastrum* algae (Chlorophyta, Protococcales) in a bog profile in southern Finland. In the literature total counts of *Pediastrum* have been presented in connexion with pollen diagrams, but only a few attempts have been made to interpret their ecological significance. Green algae of the genus *Pediastrum* have previously been noted in the Pleistocene sediments of Finland by Salmi (1963) and Lappalainen (1970), and this study may serve as a further contribution on this subject.

Methods

The methods used were similar to those normally employed in sediment studies. The core was obtained with the Hiller sampler, and dated by pollen analysis. 10 % KOH was used in the preparations of pollen slides. Siliceous matter was removed by treatment with HF, and 200 tree pollen grains were counted. *Pediastrum* algae were counted on the pollen slides and identified by comparison with the illustrations in Brunnthaler (1915), Sebestyén (1968) and Whitford and Schumacher (1969).

Description of the site and the profile

The site is situated in the parish of Kirkkonummi, south Finland (60° 12′ N Lat. 24° 32′ E Long). It is a pine bog, which covers 1.5 ha. The altitude of the threshold is about 39 m. The profile is taken from the western part of the bog (Fig. 1). The stratigraphy is as follows:

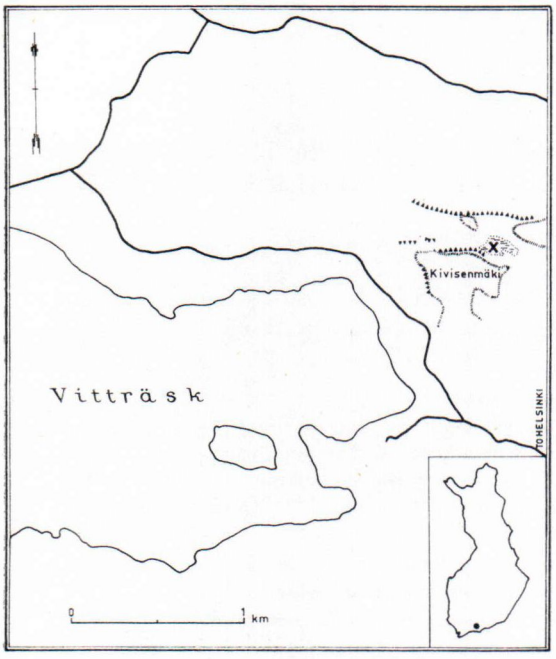

Fig. 1. Map showing the location of the site.

Depth below surface (cm)	Layer No.	Description
0—325	6	Forest sedge peat including two ash layers at levels of 155 cm and 255 cm. The uppermost 1 m was not analysed because of the poor humification of the peat
325—380	5	*Sphagnum* peat
380—480	4	Coarse detritus gyttja with abundant *Carex* fragments, brown in colour. The lowermost part of this layer consists of some centrimetres of fine detritus gyttja
480—500	3	Clay-gyttja, which according to subfossil diatoms represents the isolation sediment from the Ancylus Lake stage of the Baltic Sea
500—545	2	Silty clay containing diatoms typical of the Ancylus Lake
545—	1	Sand and fine sand. This layer continues downwards

Pollen stratigraphy and the dating of the profile

The pollen diagram (Fig. 2) is zoned according to the principles used by Donner (1963; see also 1971). In addition to the Flandrian zone boundaries, the rational limit of *Tilia* (T_o) is used as the local pollen zone boundary VI/VII in dating the sediments of this site (see Alhonen 1967, p. 11). The upper part of zone V is visible in the sand and silty clay. The zone boundary V/VI lies in the clay-gyttja. T_o is in the coarse detritus gyttja, and pollen zone boundary VIII/IX occurs in the forest sedge peat.

The numerous radiocarbon datings from profiles in south-west Finland recently summarized and discussed by Donner (1971, Table 1, p. 285; see also Fig. 2) show that the zone boundary V/VI can be dated at c. 8 000 B. P. and the zone boundary VIII/IX at c. 2 500 B. P. (Donner 1971, p. 284). The age of T_o in this profile cannot be given with certainty, because C-14 dates for the rational limit of *Tilia* differ greatly in southern Finland. If some generalizations can be made, the T_o limit can be dated at c. 7 500 B. P. on the south coast of Finland (Aartolahti 1967, Fig. 6).

The occurrence of *Pediastrum* in the profile and its interpretation

Fig. 3 shows the stratigraphical distribution of *Pediastrum* in the profile. From the first column of the diagram it is evident that the main occurrence of these algae coincides with the coarse detritus gyttja, just above the rational border for *Tilia* (T_o). There are some findings of *Pediastrum* in the minerogenous sediments of pollen zone V, too.

Four kinds of *Pediastrum* were identified: *Pediastrum duplex* Meyen, *P. araneosum* (Racib.) G. M. Smith, *P. araneosum var. rugulosum* (G. S. West) G. M. Smith and *P. boryanum* (Turp.) Menghini. As is seen from Fig. 3, *P. duplex* is the predominant species in the succession. It

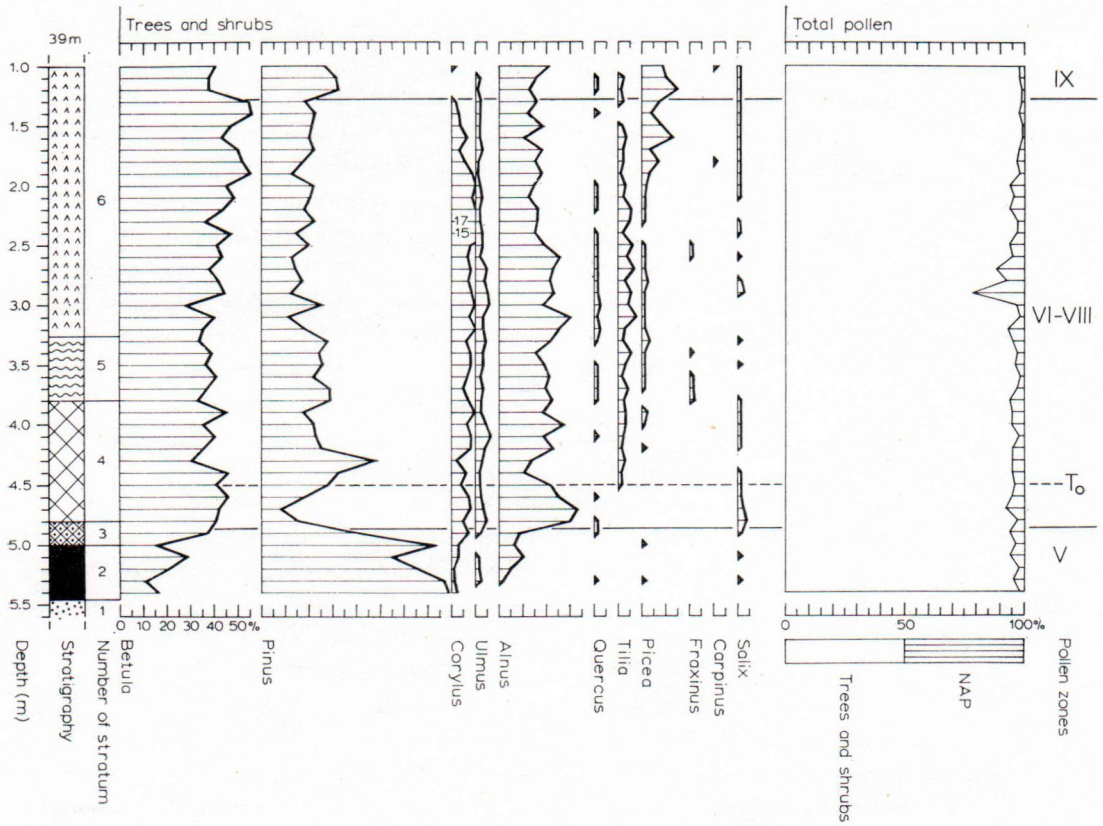

Fig. 2. Pollen diagram of the site.

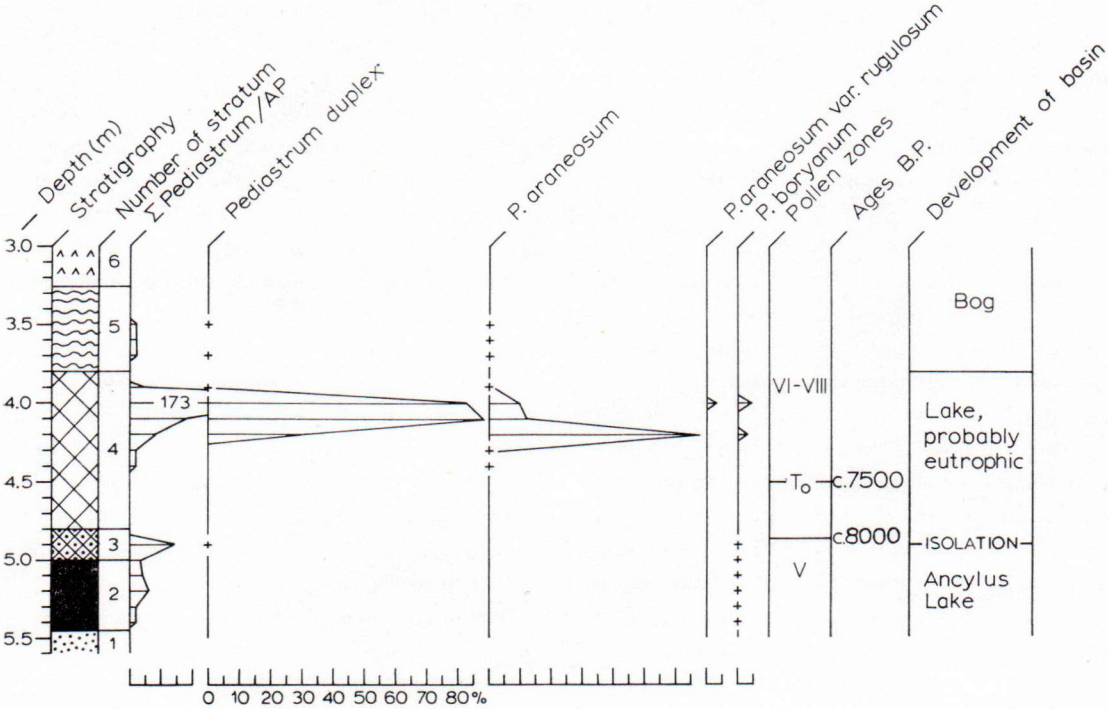

Fig. 3. The stratigraphical distribution of *Pediastrum* in the profile and its correlation to the pollen stratigraphy and the geological development of the site. The presence of *Pediastrum* is indicated by +.

has a frequency of 88 % at a depth of 410 cm in the profile. *Pediastrum araneosum* was found throughout the analysed levels, showing its greatest relative abundance (68 %) at a level of 420 cm. The occurrence of *P. araneosum var. rugulosum* and *P. boryanum* is only sporadic.

The occurrence of these species may be assumed to indicate the presence of eutrophic chlorococcal plankton, the most usual dominant of which appears to be *Pediastrum* (see Hutchinson 1967, p. 388). Thus it seems likely that the most abundant occurrence of *Pediastrum* may here reflect a more less productive environment of sedimentation. The increase in the relative frequency of these algae may also be considered to be related to a rising water level, which interpretation is supported by the observations of *e.g.*, Jørgensen (1954).

Discussion

When the occurrence of *Pediastrum* algae is examined from the palaeocological point of view, it may be noted that the site lies close to the coast of the Litorina Sea, the altitude of which (L I) is about 35 m in this area (Ristiluoma, unpublished), and accordingly it did not reach the site, since the altitude of the threshold of the bog is about 39 m. In view of the pollen-analytical dating of the main occurrence of *Pediastrum* in the stratigraphy, it may, however, be presumed that the proximity of the transgressive Litorina Sea and the moist Atlantic climate prevailing at that time made the physical and chemical conditions in the lake phase of the site favourable for these algae. Thus *Pediastrum* algae may have general significance as indicators of water level changes caused by the climate *(cf.* Nilsson 1964, Fig. 5).

As *Pediastrum* algae have been found in various sedimentary series, we will now briefly discuss their ecological significance in the light of some examples given in the literature. Salmi (1963) investigated *Pediastrum* in the sediments of two sites, Sompiojärvi and Kalkkarovuoma, in Finnish Lapland. He identified seven species, *viz. P. boryanum*, *P. duplex*, *P. integrum*, *P. kawraiskyi*, *P. muticum*, *P. simplex* and *P. tetras* (Salmi, *op. cit.*, p. 113). Their occurrence in the stratigraphy of these sites is probably causally connected with the climatic conditions and the calcareous sedimentation environment (Kalkkarovuoma).

Lappalainen (1970) also found abundant *Pediastrum* algae in his studies of peat deposits in central Finnish Lapland. *Pediastrum boryanum*, *P. integrum* and *P. kawraiskyi* were typical species and were concentrated mainly in the transition between »lateglacial» and »postglacial» (see Lappalainen 1970, p. 54).

As the representatives of the genus *Pediastrum* are mostly planktonic, Sebestyén (1968, 1969) attempted to relate the chydoric Cladocera/*Pediastrum* (C/P) ratio with fluctuations in the water level during the development of Lake Balaton, Hungary. *Pediastrum simplex var. clathratum*, which is characteristic of large lakes, dominated the pelagic phases of the lake.

Goulden (1970) identified three distinct forms of *Pediastrum*, *viz. P. boryanum*, *P. duplex* and *P. simplex*, in the bottom deposits of Lago di Monterosi, Italy. The abundance of *P. boryanum* during the early history of the lake may be related to the colder climate which probably occurred then. *Pediastrum duplex* and *P. simplex* were commoner during the warmer and relatively eutrophic conditions of the recent history of Lago di Monterosi (see Goulden 1970, Fig. VIII—3 A, p. 104; also pp. 107—111).

Livingstone *et al.* (1958) found a number of *Pediastrum boryanum* colonies in the sediments of four Alaskan lakes (Fig. 9), showing an increase from the lower to the upper strata. The greatest abundance of *P. boryanum* was found in the shallowest lakes, and is probably the result of the special conditions obtaining there. It has been suggested (Livingstone *et al.* 1958, p. 207) that the progressive increase of *P. boryanum* may reflect shoaling as the lake filled in.

The occurrence of *Pediastrum* in lake sediments of the South-western United States shows that

the frequency of this algal genus is highest in sediments referred to the pluvial period. Whiteside (1965) found four species of *Pediastrum* in a core from Potato Lake, Coconino County, Arizona, *viz*. *P. boryanum*, *P. araneosum*, *P. sculptatum* and *P. integrum*. He suggested that oligotrophic conditions existed in Potato Lake during the pluvial, and that eutrophication began in post-pluvial times (Whiteside 1965, Fig. 1). *Pediastrum boryanum* was the predominant species during the pluvial period, while *P. araneosum* and *P. sculptatum* show their greatest relative abundance during the eutrophic phase of the history of the lake.

From our own observations and the cases quoted above, it is apparent that *Pediastrum* algae indicate environment changes. Their occurrence in sediments thus deserves attention, since they may profitably be used as palaeoecological and palaeolimnological tools.

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