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Publication date
1994

Published in
Netherlands Journal of Aquatic Ecology

[Link to publication](#)

Citation for published version (APA):

Coesel, P. F. M., & Kooijman-van Blokland, H. (1994). Distribution and seasonality of desmids in the Maarsseveen Lakes area. *Netherlands Journal of Aquatic Ecology*, 28, 19-24.

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DISTRIBUTION AND SEASONALITY OF DESMIDS IN THE MAARSSEVEEN LAKES AREA

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KEYWORDS: desmids; seasonality; alkaline lakes; broads.

ABSTRACT

The desmid flora of mesotrophic Lake Maarsseveen I, eutrophic Lake Maarsseveen II, as well as the interconnecting broads was studied during the period 1987-1991. Seasonal periodicity of euplanktonic *Staurastrum* and *Cosmarium* species in the two Maarsseveen lakes fitted the well-known general pattern of desmid abundance peaks in (late) summer time. The deviating seasonality of two euplanktonic *Closterium* species (*C. aciculare* and *C. acutum* var. *variabile*) could be related to special nutritional demands. The tychoplanktonic desmid flora encountered in the interconnecting system of peat pits and canals proved to be more diversified as the influence of nutrient-poor seepage on the habitat (appearing from conductivity, transparency and the occurrence of particular macrophyte species) was greater. The rare species *Euastrum germanicum* and *Heimansia pusilla* had been only incidentally recorded in The Netherlands.

INTRODUCTION

The Maarsseveen Lakes are located in the broads area along the Vecht river, in the Dutch province of Utrecht. The area in question, marked by a meshwork of peat-excavated pools and lakes, is situated at the border of the holocene lowland part of The Netherlands and receives nutrient-poor seepage water from the higher pleistocene sands nearby. If not locally eutrophied, the aquatic habitat in this area may be characterized as oligo-mesotrophic. It harbours a highly diversified flora and fauna, including many desmids. The rather unusual combination of low nutrient contents and alkaline pH is concomitant with the common occurrence of a number of taxa which are absent or rare in other Dutch aquatic biotopes. In the present paper we will discuss the tychoplanktonic desmid flora in relation to its distribution within the study area, as well as seasonality patterns of some euplanktonic species occurring in the Maarsseveen Lakes proper.

MATERIAL AND METHODS

Study area

The two Maarsseveen lakes, man-made on behalf of the excavation of sand, are dimictic, with a distinct stratification in summer. Interconnected by a maze of shallow peat pits, canals and ditches they can be classified as semi-closed ecosystems (Fig. 1). Whereas L. Maarsseveen II, as a consequence of its connection to the highly polluted Vecht river, is markedly eutrophic, L. Maarsseveen I, mainly fed by nutrient-poor seepage and precipitation, may be characterized as mesotrophic. The difference in trophic state between these two lakes is gradually levelled in the interconnecting broads area. The Maarsseveen lakes system is described extensively by SWAIN *et al.* (1987).

Sampling

From 1987 onward the desmid flora was studied in greater or less detail. Plankton from the

Hanny Kooyman-van Blokland untimely died at the age of forty, in March 1994.

Fig. 1. Location of main sampling stations in the Maarsseveen lakes area. Arrows indicate direction of groundwater flow (modified after SWAIN *et al.*, 1987).

surface layer (0–1 m) of the Maarsseveen lakes was collected twice a month by means of a Van Dorn sampler. Desmid cells were counted in sedimented 1-l samples, using the inverted-microscope method according to UTERMÖHL (1958). Sampling of tycho-planktonic desmid species from the shallow inter-connecting pools and canals was only qualitatively, in September, by means of a plankton net or by squeezing out submerged water plants. As a rule, collection of tycho-planktonic desmids was combined with measurement of the electric conductivity of the water sampled with a WTW-LF92 conductivity meter. Main sampling stations in the broads area are indicated in Fig. 1.

RESULTS

Seasonality of euplanktonic species

Fig. 2 shows seasonal variation in cell numbers of the four most abundant desmid taxa in each of the two Maarsseveen lakes over the period 1988–1992. Whereas the *Cosmarium* and *Staurastrum* species were confined to either me-

sotrophic Lake I or eutrophic Lake II, the two representatives of the genus *Closterium* obtained a dominant position in the desmid flora of both lakes. Roughly, two different seasonality patterns may be discerned. In the first one, shown by the *Cosmarium* and *Staurastrum* taxa, abundance peaks were consistently linked to the (late) summer period. The second one, shown by the two *Closterium* taxa, was more irregular but abundance peaks tended to occur in winter.

Distribution of tycho-planktonic species

The gradient in trophic state of the water between L. Maarsseveen I and L. Maarsseveen II is reflected in the conductivity values at the sampling stations (Fig. 3). Conductivity was consistently lowest in the pools and canals adjacent to Lake I, viz. 350–450 $\mu\text{S cm}^{-1}$ (stations 2–5 in Fig. 1). From that area, conductivity increased in the direction to Lake II. This gradient was highly dependent on the suppletion of eutrophic water from the Vecht river needed to maintain the water table in the polder area. In dry, hot summers impending water shor-

Fig.2. Population dynamics of the four most abundant desmid species related to water temperature (dotted lines) in Lake Maarsseveen I (left) and Lake Maarsseveen II (right).

tage to agricultural activities in the neighbouring 'Bethune Polder' forces to an enhanced supply from Vecht river. The effect is illustrated in Fig. 3, showing the conductivity gradient in 1990, characterized by a very hot and dry summer (KNMI, 1990), as compared with that in 1987 when summer was wet and rather cool (KNMI, 1987).

Sampling station 9, highly influenced by the inflow of eutrophic, polluted water from the Vecht river, was characterized by a dense bloom of blue-green algae in late summer and a permanent absence of submerged macrophytes. Tycho-planktonic desmids were lacking.

From station 8 to 6, local stands of the

Fig. 3. Conductivity values (in $\mu\text{S cm}^{-1}$ at 25°C) at the main sampling stations on 28 September 1987 and 19 September 1990.

submerged aquatics *Elodea nutallii* and *Myriophyllum spicatum* were present, mingled with mats of the filamentous algal genus *Cladophora*. Water transparency in summer was low by blue-green algal bloom. Only a few trivial desmid species were encountered, such as *Closterium moniliferum* and *Cosmarium laeve*.

From station 6 to 4, water transparency markedly increased, along with the development of submerged macrophyte vegetation. Dense stands of the charophyte *Nitellopsis obtusa* present at station 5 were remarkably poor in desmids, but samples taken in vegetations of *Myriophyllum* and *Potamogeton lucens* around station 4 showed a fair number of taxa. Examples are *Closterium ehrenbergii*, *Cl. moniliferum*, *Cl. tumidulum*, *Cosmarium abbreviatum*, *C. formosulum*, *C. laeve*, *C. punctulatum*, *C. regnellii* and *C. turpinii*.

By far the most diversified desmid flora occurred near the stations 3 and 2, among luxurious stands of aquatic macrophytes, such as *Nymphaeoides peltata*, *Utricularia vulgaris*, *Myriophyllum spicatum*, *Ceratophyllum demersum* and *Potamogeton obtusifolius*, mingled with flocks of the filamentous zygnematalean genera *Mougeotia* and *Spirogyra*. Illustrative of the richness of the desmid flora in this area is Table 1, representing a list of taxa found in one single sample (a squeeze of *Utricularia*) taken at station 3, in September 1987.

DISCUSSION

With respect to the euplanktonic desmid taxa (Fig. 2), distinct differences appeared between mesotrophic Lake Maarsseveen I and eutrophic Lake Maarsseveen II. *Staurastrum cingulum* and *Cosmarium abbreviatum* var. *planctonicum*, exclu-

sively encountered in Lake I, are characteristic of oligo-mesotrophic habitats indeed, whereas *Staurastrum manfeldtii* s.l. (including of *S. pingue*, see COESEL, 1992) and *Cosmarium kjellmanii*, relevant species in Lake II, are particularly known of eutrophic waters. Remarkably, *Closterium acutum* var. *variabile* and *Cl. aciculare*, well-known of eutrophic water bodies too, were encountered in both Lake I and Lake II. Apart from qualitative differences in the euplanktonic desmid flora, attention may be paid to the higher absolute cell numbers marking population peaks of Lake II-taxa as against those in Lake I. The latter phenomenon could be related to the higher nutrient levels in Lake II, combined with the relatively high intrinsic growth rates of desmid taxa isolated from eutrophic environment (COESEL and WARDENAAR, 1990).

Regarding seasonality: the abundance peaks of *Staurastrum* and *Cosmarium* species in (late) summer (Fig. 2) fit the general pattern of planktonic desmids of temperate lakes, as shown by e.g. CANTER and LUND (1966). Most probably, water temperature is a decisive factor in this seasonality pattern, rather than total daily irradiance (COESEL and KOOIJMAN-VAN BLOKLAND, 1991). Notable are the deviating periodicity patterns of the two *Closterium* species (Fig. 2). The abundance peaks of *Closterium aciculare* in spring and autumn time may be related to the higher amounts of ammonium entrained from the bottom into the euphotic zone during bi-annual circulation of the water column, since this species appeared to be dependent on ammonium as exclusive nitrogen source (COESEL, 1991). The seasonality pattern of *Closterium acutum* var. *variabile* was less uniform. Whereas in mesotrophic Lake I this taxon consistently peaked in winter, in eutrophic Lake II highest cell numbers were reported for summer periods. As *Cl. acutum* var. *variabile* is particularly known of eutrophic waters where it even may cause a bloom (ROSÉN, 1981; HÖRNSTRÖM, 1981; BROOK, 1981) an explanation for its winter peaking in Lake I might be the higher nutrient levels present in that season. By its high growth rate (relative to that of other desmid species) at low temperature and light intensities, *Cl. acutum* var. *variabile* has a distinct potential of population increase in winter time (COESEL and KOOIJMAN-VAN BLOKLAND, 1991). In summer, when there is much more competition with other algal species, most of which might be better adapted to low nutrient contents (by higher affinities or storage capacities), the population will collapse.

The luxurious and diverse tychoplanktonic desmid flora encountered in the seepage-fed part of

Fig. 4. Two rare desmid taxa, *Euastrum germanicum* (a) and *Heimansia pusilla* (b) from the Maarsseveen broads area. Scale bar = 25 μ m.

the interconnecting canal system between Lakes I and II highly resembles that in comparable habitats elsewhere in the Vecht broads area (HEIMANS and MEIJER, 1955; ZWART, 1969) as well as the Overijssel broads area (COESEL, 1981). It has been established earlier (COESEL, 1984) that the alkaline seepage areas at the boundaries of pleistocene and holocene deposits in the provinces of Utrecht and Overijssel harbour the richest desmid sites in The Netherlands. This holds the more since almost all of the formerly weakly acidic, mesotrophic moorland

pools on pleistocene soils – also reputedly rich in desmids – have been biologically impoverished by acid precipitation (e.g. COESEL *et al.*, 1978). As, in recent times, also water quality in the Vecht and Overijssel broads areas is decreasing due to a decline in seepage, the Maarsseveen site may be considered one of the last unspoiled examples of this desmid habitat type.

Among the many taxa listed in Table 1, some are of special interest. The species *Cosmarium furcatospermum*, *C. insigne*, *C. klebsii*, *C. vexatum*, *Staurodesmus gladius* and *Staurodesmus mamillatus* are characteristic of the above discussed alkaline seepage areas. Often occurring abundantly in this kind of environment, they are rare or even totally absent in other water types. *Euastrum germanicum* (Fig. 4a) is a rare species, also in the rest of Europe, and has only incidentally been recorded in The Netherlands (COESEL, 1978). *Heimansia pusilla* (Fig. 4b) – formerly named *Cosmocladium pusillum* (see COESEL, 1993) – was not recorded in this country since the thirties (HEIMANS, 1935).

The striking poverty in desmids in dense charophyte stands is in agreement with the findings of ANTHONI *et al.* (1980), viz. the production of sulphur compounds by *Chara* that inhibit growth of epiphytic and planktonic algae.

Table 1. Desmid species composition of a tycho plankton sample from station no. 3 (30 September 1987).

<i>Closterium aciculare</i> T. West	<i>C. reniforme</i> (Ralfs) Arch.
<i>Cl. acutum</i> var. <i>variabile</i> (Lemm.) Krieg.	<i>C. subgranatum</i> (Nordst.) Lütkem.
<i>Cl. parvulum</i> Näg.	<i>C. tetraophthalmum</i> Bréb.
<i>Cl. pritchardianum</i> Arch.	<i>C. turpinii</i> Bréb.
<i>Cl. pronum</i> Bréb.	<i>C. vexatum</i> W. West
<i>Cl. venus</i> Ralfs	<i>Desmidium aptogonum</i> Kütz.
<i>Cosmarium abbreviatum</i> Racib.	<i>Euastrum bidentatum</i> Näg.
<i>C. boeckii</i> Wille	<i>Gonatozygon monotaenium</i> De Bary
<i>C. botrytis</i> Ralfs	<i>Heimansia pusilla</i> (Hilse) Coes.
<i>C. crenulatum</i> Ralfs	<i>Hyalotheca dissiliens</i> (Smith) Bréb.
<i>C. depressum</i> (Näg.) Lund.	<i>Micrasterias crux-melitensis</i> Ralfs
<i>C. formosulum</i> Hoff	<i>Pleurotaenium trabecula</i> Näg.
<i>C. furcatospermum</i> W. & G.S. West	<i>Staurodesmus avicula</i> Bréb.
<i>C. granatum</i> Bréb.	<i>S. dispar</i> Bréb.
<i>C. humile</i> (Gay) Nordst.	<i>S. gladius</i> Turn.
<i>C. impressulum</i> Efv.	<i>S. gracile</i> Ralfs
<i>C. insigne</i> Schmidle	<i>S. inflexum</i> Bréb.
<i>C. klebsii</i> Gutw.	<i>S. manfeldtii</i> Delp.
<i>C. laeve</i> Rabenh.	<i>S. orbiculare</i> var. <i>depressum</i> Roy & Biss.
<i>C. moniliforme</i> Ralfs	<i>S. polymorphum</i> Bréb.
<i>C. phaseolus</i> Ralfs	<i>S. tetraerum</i> Ralfs
<i>C. polygonum</i> var. <i>acutius</i> Messik.	<i>Staurodesmus dejectus</i> (Ralfs) Teil.
<i>C. portianum</i> Arch.	<i>Std. mamillatus</i> (Nordst.) Teil.
<i>C. punctulatum</i> Bréb.	<i>Teilingia granulata</i> (Roy & Biss.) Bourr.
<i>C. regnellii</i> Wille	<i>Xanthidium cristatum</i> Bréb.

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