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PERIPHYTIC COMMUNITY ANALYSIS IN A SMALL OLIGOTROPHIC LAKE[1]

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ABSTRACT

Periphytic diatom communities on four aquatic macrophytes (*Brasenia schreberi, Orontium aquaticum, Sagittaria latifolia,* and *Pontedaria cordata*) were studied in Lake Lacawac (Lake Ariel, PA) during the 1981 and 1982 growing seasons. Four sites were chosen to represent sand, mud, and bog habitats. Throughout the study the most dominant taxon was *Tabellaria fenestrata. Achnanthes linearis, Gomphonema gracilis,* and *Fragilaria construens* were of secondary importance. Diatom communities on all macrophytes and habitats were found to be similar using the SIMI similarity index. In addition, diatom communities were very similar between the years. Few differences in community structure were also found and will be discussed. Attached diatom concentrations increased with progression of the growing season and were greatest at 15 to 45cm from the surface.

INTRODUCTION

Periphyton, organisms that grow attached to macrophytes, rocks or other submerged objects, are one of the most important groups of organisms in many aquatic systems. They are important in overall lake productivity (Wetzel, 1964), have been used in water quality studies (Collins and Weber, 1978; Cooper and Wilhm, 1975; Baker, 1974; Lowe, 1974; and Rasche and Weber, 1970), and are often primarily composed of Baillariophyceae (diatoms).

Studies examining the influence of aquatic vascular plant surfaces in determining the composition of periphytic algal communities have yielded mixed conclusions. Hutchinson (1975) found a general lack of specificity among macrophytes. Siver (1977) found similar diatom populations, in terms of both composition and concentration, on five macrophytes. Eminson and Moss (1980) found that the influence of host type was greatest in infertile lakes and less apparent in fertile lakes where environmental factors were more important.

The epiphytic diatom communities of four aquatic vascular plants were studied in Lake Lacawac (Lake Ariel, PA) during the 1981 and 1982 growing seasons. Based on nutrient analysis, phytoplankton composition, and phytoplankton concentrations, Lake Lacawac is an oligotrophic lake (Siver and Chock, personal communication). Because the lake is shallow and phytoplankton concentrations are low, it has been suggested that periphyton and aquatic vascular plants are very important in the overall productivity of the lake. The purpose of this study was to describe the epiphytic diatom communities in Lake Lacawac and examine the effect of habitat and host type on the communities.

MATERIALS AND METHODS

Monthly collections of aquatic vascular plants were made at four sites in the lake during the 1981 and 1982 growing seasons. The sites represented sandy, mud, and bog habitats. Four macrophytes, *Brasenia schreberi, Orontium aquaticum, Sagittaria latifollia,* and *Pontedaria cordata,* were chosen on the basis of their dominance and widespread distribution within the lake. Not all four macrophytes were present at each site (see results). For each of the four macrophytes present at a given site two plants were randomly chosen and harvested for diatom analysis. Starting from the water surface 15cm sections were carefully clipped from each macrophyte, placed into Whirl Pac bags containing 35ml of distilled water and returned to the laboratory.

The periphyton was scraped and washed from each plant segment into 100ml beakers. Sections were rinsed to insure complete removal of all epiphytes. Using mathematical formulas for certain geometric shapes, surface areas were calculated for each segment.

The epiphytic material was put through a cleaning process that oxidized all of the organic material, leaving behind the diatom frustules. Twenty ml of 50% H_2SO_4 and $K_2Cr_2O_7$ crystals were added to the samples and allowed to digest for 3-4 days. If the $K_2Cr_2O_7$ crystals were used up, more were added until the sample was completely oxidized. The sample was then centrifuged at 1600 R.P.M. for 10 minutes and washed several times until the supernatant was clean. After the final wash the pellet was placed into 10ml of distilled water and preserved with thymol to prevent fungal growth.

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A known volume of the oxidized sample was pipetted onto a cover slip and gently heated to insure an even distribution of frustules. Permanent slides were made by mounting the cover slip with a drop of Kleermount mounting medium (Carolina Biological Supply). At least two permanent slides were made of each sample and the slide with the most even distribution was used for quantification of the diatoms. The slides were scanned once or twice or until at least 100 organisms were counted. Taxa were identified at 1000X according to Hustedt (1930) and Patrick and Reimer (1966 and 1975).

For comparing the diatom communities between each macrophyte, each site, and each date, the SIMI similarity index was used. In this index, percentages of organisms, not concentrations, are compared. The SIMI index is as follows:

$$\text{SIMI} = \frac{\sum_{i=1}^{s} P_{ij}P_{in}}{\sqrt{\sum_{i=1}^{s} P_{ij}^2}\ \sqrt{\sum_{i=1}^{s} P_{in}^2}}$$

where P_{ij} P_{in} are the relative percentages of each species on each macrophyte and s the total number of species in the two communities being compared (McIntire and Moore, 1977). Values range from 0-1, where a value of 1 represents identical communities and a value of 0 totally unrelated communities.

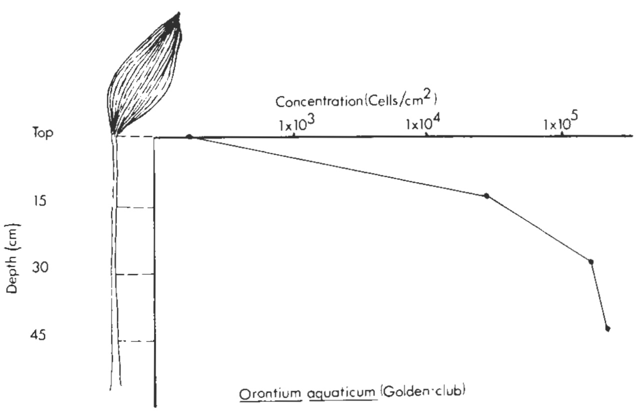

FIGURE 1. Concentration of epiphytic diatoms plotted as a function of depth on the aquatic vascular plant *Orontium aquaticum* in August, 1982. Concentration and depth ranged from 0 to 1.0 x 10^5 cells / cm^2 and 0 to 45 cm respectively.

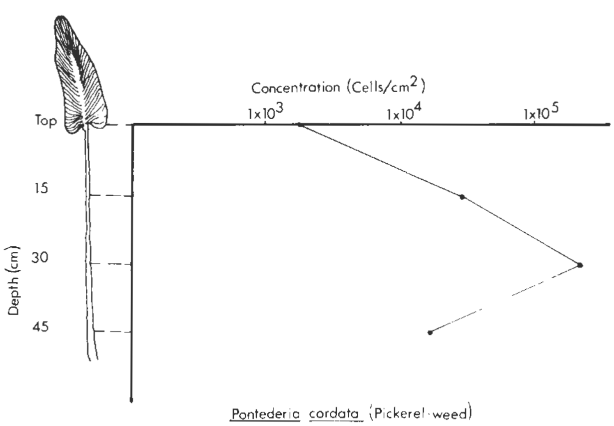

FIGURE 2. Concentration of epiphytic diatoms plotted as a function of depth on the aquatic vascular plant *Pontedaria cordata* in July, 1982. Concentration and depth ranged from 0 to 1.0 x 10^5 cells / cm^2 and 0 to 45 cm respectively.

RESULTS

During 1981 diatom concentrations ranged from 4.2 x 10^1 cells/cm^2 to 9.3 x 10^6 cells/cm^2. A range of 1.5 x 10^2 cells/cm^2 to 7.9 x 10^5 cells/cm^2 was found during the 1982 growing season. Diatom concentrations on the macrophytes were always lowest near the surface and greatest 15-45 cm below the surface. For example, cell density on *O. aquaticum* during August of 1982 increased from 1.5 x 10^2 cells/cm^2 at the surface to a maximum of 2.5 x 10^5 cells/cm^2 at 45 cm from the water surface (Figure 1). Similarily, cell concentrations on *P. cordata* during July of 1982 increased from 2.1 x 10^3 cells/cm^2 to 4.4 x 10^4 cells/cm^2 at the top and 15 cm segments respectively, reached a maximum density at 30 cm of 2.9 x 10^5 cells/cm^2 and decreased to 2.4 x 10^4 cells/cm^2 at 45 cm (Figure 2). In general, epiphyte concentrations were always lowest at the surface, maximal below 30 cm from the surface and often lowered from the maximum number in the deepest water.

The mean diatom density on the macrophytes in the lake during 1981 was 8.7 x 10^5 cells/cm^2 with a maximal peak in October. During July, August and October of 1981 mean diatom concentrations ranged from 4.0 x 10^3 to 9.6 x 10^5 cells/cm^2, 1.1 x 10^3 to 2.6 x 10^5 cells/cm^2, and 3.6 x 10^5 to 7.3 x 10^6 cells/cm^2 respectively. During 1982 the mean cell density was 7.9 x 10^4 cells/cm^2 with a peak during August (Figure 3). A decrease in epiphytic numbers was observed in June, 1982 (Figure 3). Concentration ranges for 1982 were 1.0 x 10^4 to 2.6 x 10^5 cells/cm^2 in May; 1.1 x 10^3 to 1.1 x 10^5 cells/cm^2 in June; 1.0 x 10^4 to 4.4 x 10^5 cells/cm^2 in July; 2.8 x 10^3 to 5.0 x 10^5 cells/cm^2 in August and 1.8 x 10^3 to 4.3 x 10^5 cells/cm^2 in September. In both years it was observed that periphyton colonized the aquatic vascular plants soon after they began growth in April/May (eg. Figure 4).

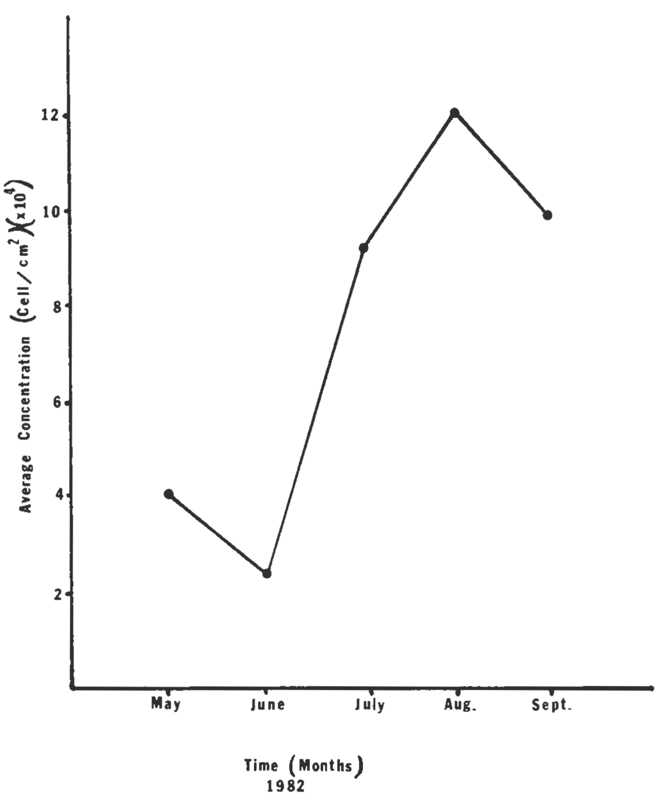

FIGURE 3. Mean cell density plotted as the average concentration of all species studied at all sites over the 5 month sampling period (May-September) in 1982. Concentration ranged from 2 to 12 x 10^4 cells/cm^2.

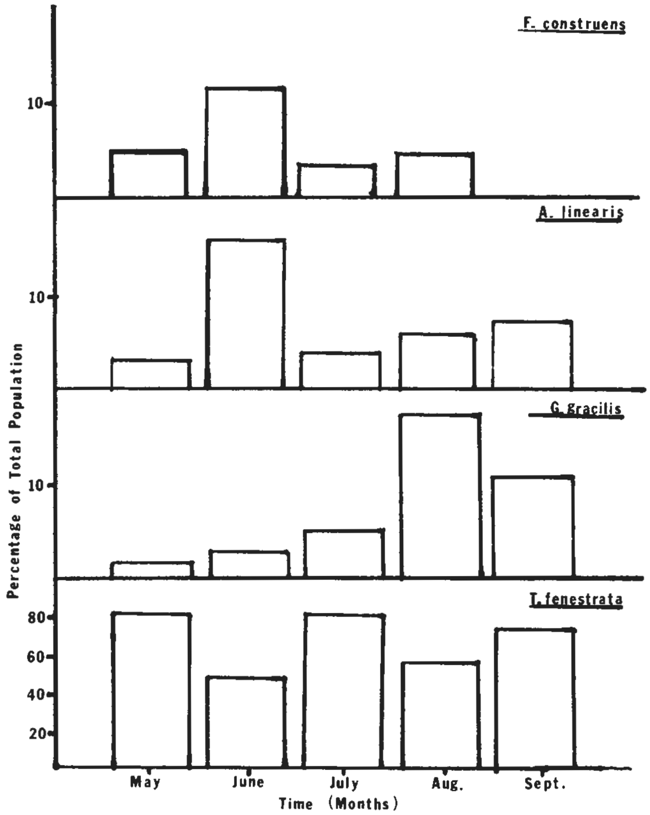

FIGURE 4. Populations of four epiphytes, *Fragilaria construens, Achnanthes linearis, Gomphonema gracilis,* and *Tabellaria fenestrata,* plotted as a percentage of the total population for each month of the 5 month (May-September) sampling period in 1982.

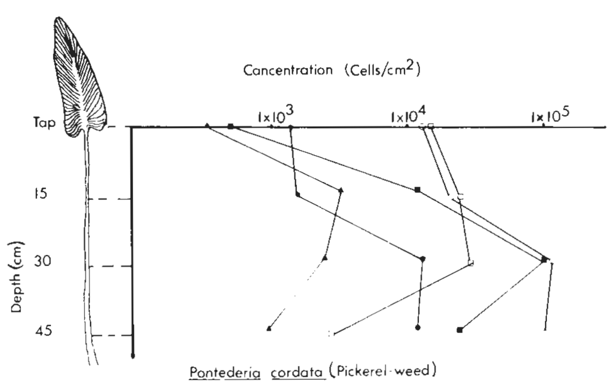

FIGURE 5. Concentrations of epiphytic diatoms plotted as function of depth on the aquatic vascular plant *Pontedaria cordata* during 5 months of 1982. □-May, ▲-June, ■-July, •-August, ○-September. Concentration and depth ranged from 0 to 1.0 x 10^5 cells/cm² and 0 to 45 cm respectively.

Tabellaria fenestrata was the most dominant epiphyte on the aquatic vascular plants accounting for 77% of all the epiphytic diatoms in 1981 and 68% in 1982 (Table 1). *T. fenestrata, Tabellaria flocculosa, Eunotia incisa, Achnanthes linearis, Gomphonema gracilis,* and *Fragilaria construens* constituted 87% of the diatom community in 1981 and 83% in 1982. With few exceptions, *T. fenestrata* was the most dominant taxon at each depth on all plants for all dates. *Frustulia rhomboides* was an important species on *Brasenia schreberi* where it dominated during June of 1982.

During 1982 *Tabellaria fenestrata* accounted for over 70% of all peiphyton during each month of the study except June and August. In June, two other diatoms, *Achnanthes linearis* and *Fragilaria construens,* accounted for 16 and 11% of the populations respectively (Figure 4). *Gomphonema gracilis* composed 17% of the epiphytic diatoms in August, 1982 (Figure 4).

TABLE 1

Percentages of Tabellaria fenestrata *in each of the four sites over the 8 month sampling period starting July, 1981 and ending September, 1982.*

	SITE 1	2	3	4
7/81	59	51	63	45
8/81	55	74	63	73
10/81	79	78	71	—
5/82	87	91	77	49
6/82	55	51	48	45
7/82	91	71	78	84
8/82	56	56	60	63
9/82	69	76	70	81

The SIMI values comparing diatom communities within a site, between sites, and/or between sampling dates were almost always above 0.94. SIMI values between any site within a growing season were all greater than 0.97 (Figure 6 and 7). In addition, SIMI values comparing communities from different years, but from the same site, were all greater than 0.97. (Table 2).

DISCUSSION

Maximal epiphytic diatom concentrations ranging from 10^4 to 10^6 cells/cm² have been observed by previous workers (Siver, 1977; Siver, 1978; Tuchman and Blinn, 1979 and Hoagland, 1983). In the present study, within 30 days after the initial development of the macrophytes, epiphytic diatom communities had reached concentrations of at least 10^4 cells/cm^2 and in many instances remained close to this concentration as the growing season progressed (Table 3). Thus, initial colonization and subsequent growth rates were very rapid. Tuchman and Blinn (1979) found similar results where initial colonization of diatoms on substrates occurred within 7-14 days, generally followed by rapid proliferation (Hoagland et. al., 1982).

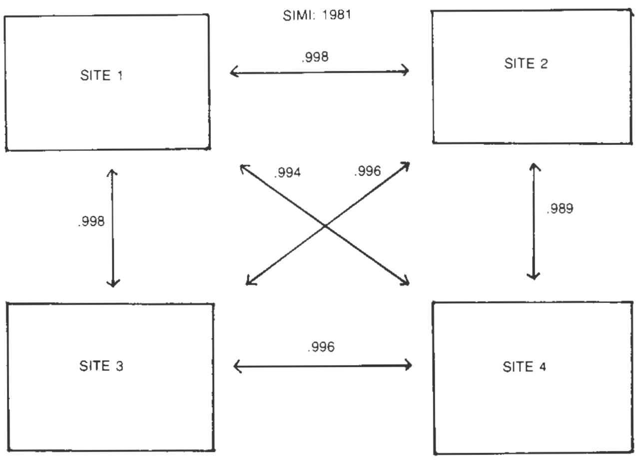

FIGURE 6. SIMI indices cross comparing each of the four sites for which epiphytic diatoms on aquatic vascular plants were studied in Lake Lacawac in 1981.

TABLE 2

SIMI indices between 1981 and 1982 giving the total SIMI for the years and for each individual site during those years.

1981	.996	1982
SITE 1	.978	SITE 1
SITE 2	.982	SITE 2
SITE 3	.995	SITE 3
SITE 4	.994	SITE 4

Increases in diatom concentrations on the macrophytes were never as great as they were between the months April and May. Concentrations remained relatively stable from June to the end of the growing season indicating either increases in the number of diatoms were miniml or as fast as the diatoms divided they were sloughed off. We feel growth rates lowered as the growing season progressed and that "sloughing off" of diatoms played a significant role in controlling the maximal concentrations. This agrees with previous work where diatoms have been shown to grow best during the spring and fall but slower in the summer (Patrick and Reimer, 1966; Siver, 1978; and Stockner and Evans, 1972).

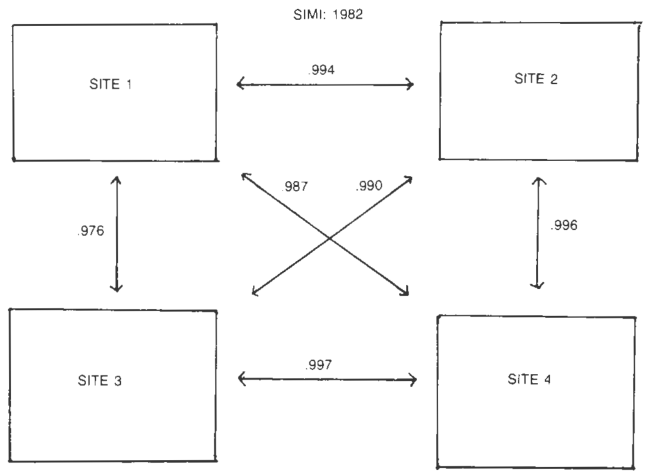

FIGURE 7. SIMI indices cross comparing each of the four sites for which epiphytic diatoms on aquatic vascular plants were studied in Lake Lacawac in 1982.

The importance of sloughing off of diatom communities by water turbulence has been previously recorded (Fox et. al., 1969; Siver, 1978; and Hoagland, 1983). In the present study turbulence, caused by adverse weather conditions, had its greatest effect on epiphytic diatom communities during June of 1982 (Figure 3) when concentrations were significantly decreased. However, community structure, according to the SIMI index was not effected. Similar results were reported by Hoagland (1983), who found that changes in biomass, but not diversity, of diatom communities were reflected by bad weather.

Concentrations in the 0 to 15cm section of each macrophyte were always very low (Figures 1,2, and 4), probably due to wave action and slight fluctuations in the lake's water level. With increasing depth the epiphytic concentrations also increased as a result of decreased wave action and increased amounts of mucilage. Community structure, however, was usually the same in the 0 to 15cm portion as in the lower portions. Siver (1978 and 1980) found distinct "pioneer" and successional species of diatoms on *Potamogeton robbinsii* Oakes. Other workers, (Dillard, 1969 and Stockner and Evans, 1972) have also recorded successional patterns where certain diatoms are colonizers and other species become dominant during later stages of community development. In the present study we found no change in community structure representing a shift from pioneer to successional, and then to climax species.

Tabellaria fenestrata was the most dominant taxon present on all macrophytes during both years accounting for over 70% of all attached diatoms. Normally this taxon is a member of the phytoplankton, not the periphyton. Because of the overwhelming

TABLE 3

Mean cell concentration of epiphytic diatoms on aquatic vascular plants at four sites in Lake Lacawac during the 1982 growing season. Pi = Pontedaria cordata, *Gc* = Orontium auaticum, *Ar* = Sagittaria latifolia, *and Br* = Brasenia schreberi. (x10^4 cells/cm^2)

	SITE 1				SITE 2				SITE 3				SITE 4		
	Pi	Pi	Gc	Gc	Pi	Pi	Gc	Gc	Pi	Pi	Ar	Ar	Pi	Gc	Br
May	2.0	2.9	1.4	3.3	1.4	2.0	5.1	1.5	8.7	2.6	5.4	5.5	1.0	—	1.5
June	.23	1.2	.79	2.6	1.9	.11	.22	.14	7.5	3.6	.46	.33	1.0	11	1.1
July	4.2	5.2	2.0	—	8.7	1.4	3.0	1.0	—	44	—	16	21	11	1.4
August	50	.93	1.9	6.1	—	17	2.0	—	30	.75	1.6	—	6.9	17	.28
September	15	9.4	9.6	—	—	43	1.8	1.1	2.5	—	—	6.6	—	2.4	.18

importance of *T. fenestrata* an SIMI comparing any two samples taken during the study is always greater than 0.9, indicating extremely similar communities. Community structure (SIMI = 0.99) was very stable between 1981 and 1982. Thus, we found no differences in diatom communities between macrophytes, sites, or years in Lake Lacawac. This finding is in contrast to Eminson and Moss (1980) who found that differences in host type are expressed to a greater degree in infertile lakes. However, this is in direct agreement with Siver (1977) who found a similar community composition of periphytic diatoms on five aquatic vascular plants. This is also in agreement with Hutchinson (1975) who also found a general lack of specificity among macrophytes.

Despite the importance of *T. fenestrata* in periphytic communities around the lake it was never a major component of the phytoplankton communities (Siver and Chock, unpublished results). Diatom species in the periphyton common with the phytoplankton never accounted for more than 1% of the total indicating completely separate communities. *Mougeotia* sp. was the most important non-diatom taxon in the epiphytic communities and it also was not present in the phytoplankton.

The largest variation in structure occurred on *Brasenia schreberi,* in June of 1982, which, in addition to *T. fenestrata,* also supported a substantial population of *Frustulia rhombodies* (8%). Although *F. rhomboides* was consistently important on *B. schreberi* it was insignificant on other macrophytes. This difference in community structure may be due to the thick mucous coating surrounding the stem in *Brasenia.*

In summary, the epiphytic diatom communities that are very extensive in Lake Lacawac, are very similar between macrophytes and habitat types. In addition, communities were very stable over the two year period.

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