THE ANNUAL DISTRIBUTION OF PHYTOPLANKTON COMMUNITIES IN A SOUTHEASTERN OHIO POND[1]

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ABSTRACT

The phytoplankton communities of a southeastern Ohio pond were monitored weekly from October 1964 to October 1965. Ninety taxa were identified: 56 Chlorophyta, 6 Chrysophyta, 14 Cyanophyta, 10 Euglenophyta, and 4 Pyrrhophyta. The pond was partially drained and the fish were removed during winter 1964; this had no marked effect on the phytoplankton community present at that time. Prominant pulses occurred during fall 1964, April 1965, and summer 1965; the fall and summer peaks were associated with pH values greater than 9.0. The fall pulse was comprised of *Anabaena planctonica*, *A. spiroides* var. *crassa*, *Botryococcus braunii*, and *Ceratium hirundinella*. Major components of the April pulse were *Dinobryon cylindricum*, *Oscillatoria limosa*, *O. amphibia*, *C. hirundinella*, and *Uroglena americana*. During the summer pulse a distinct succession of dominants was evident, with the community in July composed of *Staurastrum uniseriatum*, *Scenedesmus* spp., *Pediastrum duplex*, and *Euglena* spp., giving way to a community in August that included *Staurastrum tetracerum*, *Closterium* spp., and *Euastrum denticulatum;* the last community being displaced in September by a *Glenodinium quadridens*, *Scenedesmus* spp., *Anabaena* sp., *P. duplex* community.

Field research on freshwater phytoplankton generally has been done on monthly or summer sampling programs and concerns a wide variety of lake, stream, and pond habitats. For Ohio, many surveys have been conducted in Lake Erie (see Taft and Taft, 1971; Abrams and Taft, 1971), in numerous reservoirs and lakes throughout the state (*e.g.*, Kraatz, 1931, 1940, 1941; Walton, 1930; Roach, 1933; Wickliff and Roach, 1937; Marshall, 1965; Tressler *et al.*, 1940; Ward and Seibert, 1963), and in rivers (*e.g.*, Purdy, 1923; Brinley, 1942; Brinley and Katzin, 1942; Hirsch and Palmer, 1958; Roach, 1932); however, only a few of the many Ohio ponds have been studied (*e.g.*, Schultz, 1952; Cowell, 1960; Wickliff and Roach, 1937). With the exception of Lake Erie, little is known about phytoplankton community composition and distributional patterns in Ohio.

Pennak (1946) was among the first to point out that cause and effect relationships in regard to individual phytoplankton populations might be pursued more effectively by studying small bodies of water, which provide a wider variety of ecological conditions and species than the large and more nearly similar lakes. The present investigation was designed to provide base-line data on the phytoplankton communities of a southeastern Ohio pond for 12 months under an intensive sampling regime. Penrod Pond, the pond selected for study (fig. 1), is in the unglaciated portion of Ohio, within section 28 in the western part of Waterloo township, Athens County and is part of the 1,250 acre tract belonging to the Waterloo Wildlife Experiment Station, Division of Wildlife, Ohio Department of Natural Resources.

Penrod Pond's earthen dam was built in 1954 to receive runoff from a wooded watershed and contains about seven million gallons with a maximum depth of seven feet (Division of Wildlife, personal communication). The study was begun in October 1964, and in late November Department of Wildlife officials began draining the pond from the bottom with the water reaching a minimal surface area (2 acres) and depth (2 ft) on 4 December 1964. The pond was seined on 10 December 1964; removal of fish was completed by the addition of a rotenone mixture to the water. Refilling began on 21 March 1965 and by the end of the study (10 October 1965) the pond had regained slightly over half of its full volume.

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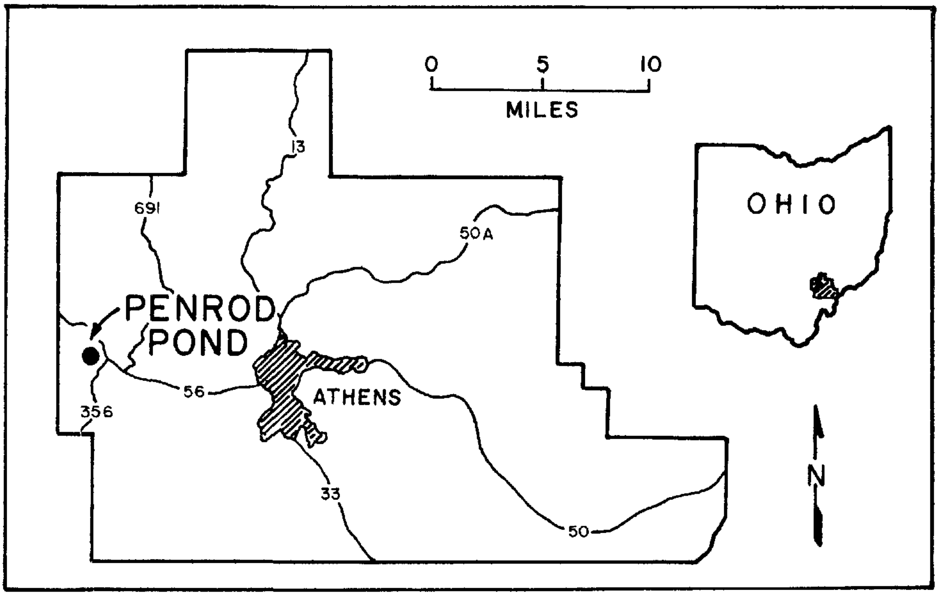

FIGURE 1. Outline map showing the location of Penrod Pond within Athens County, Ohio.

METHODS AND MATERIALS

All sampling was done at a single surface station each week at 1200 hrs by means of a conical 6 in-diameter net (50 μm pore size) and one 8 l bottle. Two three-dram samples and one two-dram sample were concentrated by towing the net; one of the three-dram samples was preserved in Transeau's solution (Welch, 1948) and the other two samples were maintained alive for taxonomic examination.

Surface temperature, pH, and total alkalinity were measured at the time of collection, primarily in an attempt to elucidate some of the conditions under which the phytoplankters were living. An 8 l sample of sub-surface water was brought to the laboratory within 25 min after collection. Aliquots of this were prepared for counting by gently concentrating the organisms into 15–50 ml (depending upon the richness of phytoplankton) by the net method (Welch, 1948). Nannoplankton were not part of this study. Replicated counts were made by the Sedgewick-Rafter technique (Welch, 1948). Because the thrust of this study was to monitor patterns of community composition over an annual cycle, all counts were in terms of organisms per liter with all individuals receiving a numerical value of one whether they were colonial, multicellular, or unicellular. The taxonomy follows that of Prescott (1962) and the reader is referred to that work for the author citations of species. All of the collections have been deposited in the algal collection of the Department of Botany, Ohio University.

RESULTS

Physical-chemical data. Surface temperatures ranged from 1.0° to 29.0° C (fig. 2). The lowest temperature was reached on 26 February 1965 during total ice cover, the maximum on 16 August. The pH ranged from 6.2 to 9.2 (fig. 3), with the higher values recorded between October and December 1964, and between August and September 1965. Total alkalinity ranged from 14 ppm to 86 ppm (fig. 4), with low values in the periods October to December 1964, February to June 1965, and September to October 1965, and high values from December 1964 to February 1965.

Species Composition. Although a complete taxonomic analysis of the phytoplankton of the pond was not possible, 74 species (including all dominants) were identified (table 1), while other algae were determined only to genus or to class (some diatoms). For simplicity, these larger groups are treated as though they each represented one taxon, making a total of 90 taxa observed (table 1). Of the

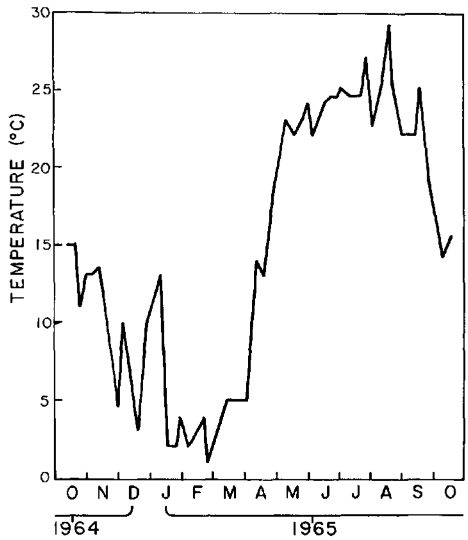

FIGURE 2

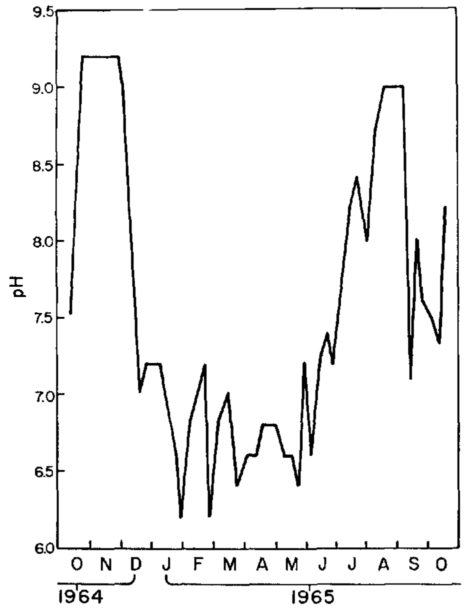

FIGURE 3

FIGURE 2. Seasonal variations in surface temperature.
FIGURE 3. Seasonal variations in pH.

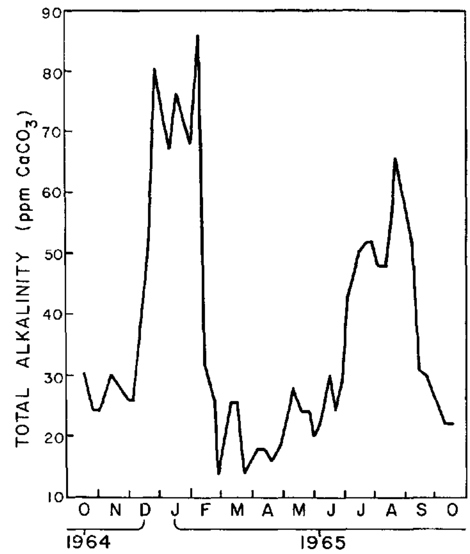

FIGURE 4

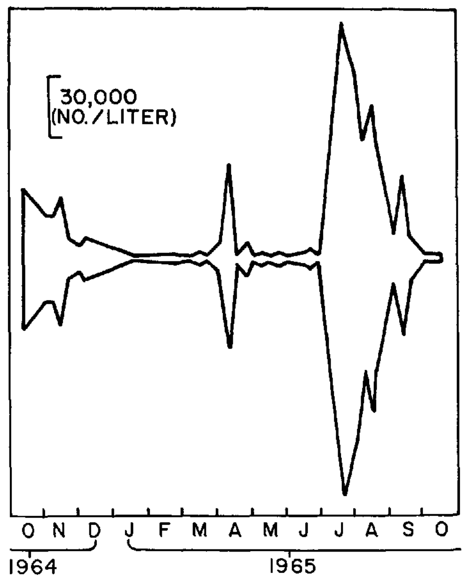

FIGURE 5

FIGURE 4. Seasonal variations in total alkalinity.
FIGURE 5. Seasonal variations in total phytoplankton abundance.

90, 56 were Chlorophyta, 6 Chrysophyta, 14 Cyanophyta, 10 Euglenophyta, and 4 Pyrrhophyta.

The total number of taxa (table 1) was lowest during December 1964 and January 1965 (7 taxa) and the highest during August 1965 (65 taxa). Chlorophyta contributed more taxa than any other division, except during October and November 1964 when taxa of Cyanophyta were most numerous.

TABLE 1

The monthly distribution of phytoplankton taxa (by division) from October 1964 through October 1965.

Those indicated by asterisks represent species that have been incompletely or only tentatively identified and are presently the subject of a further study.

Phytoplankton	O	N	D	J	F	M	A	M	J	J	A	S	O
Chlorophyta													
**Ankistrodesmus convolutus*	—	—	—	—	—	—	—	X	X	X	X	X	X
A. falcatus	—	—	—	—	—	—	—	X	X	X	X	X	X
Botryococcus braunii	X	X	X	X	X	X	X	X	X	X	X	X	X
Characium gracilipes	—	—	—	—	—	—	—	X	—	—	—	—	—
Chlamydomonas spp.	—	—	—	—	X	—	X	—	—	—	X	—	—
**Closterium* spp.	—	X	X	X	X	X	X	X	X	X	X	—	X
C. acerosum	—	—	—	—	X	X	X	—	—	—	X	—	—
C. incurvum	—	—	—	—	—	—	—	—	—	—	X	—	—
C. kuetzingii	—	—	—	—	—	—	X	X	—	—	—	—	—
C. venus	—	—	—	—	—	—	—	—	—	—	—	—	X
Coelastrum cambricum	—	—	—	—	—	—	—	—	—	—	X	—	—
**C. microporum*	—	—	—	—	—	—	—	X	X	X	X	X	—
**Cosmarium* spp.	—	—	—	—	—	—	X	X	X	X	X	X	X
C. margaritatum	—	—	—	—	—	—	—	X	X	X	X	X	—
C. subspeciosum	—	—	—	—	—	—	—	—	—	X	X	X	X
Dictyosphaerium pulchellum	—	—	—	—	—	—	—	—	—	—	X	X	—
**Euastrum* sp.	—	—	—	—	—	—	—	—	X	X	X	—	—
**E. denticulatum*	—	—	—	—	—	—	—	—	—	X	X	X	X
**Eudorina elegans*	—	—	—	—	—	—	—	X	—	—	—	—	—
Gloeocystis major	—	—	—	—	—	—	—	—	—	X	X	—	—
Kirchneriella lunaris	—	—	—	—	—	—	—	—	—	—	X	X	—
Micrasterias radiata	—	X	X	X	X	X	X	X	X	X	X	—	—
Nephrocytium limneticum	—	—	—	—	—	—	—	—	X	X	X	—	—
Oocystis parva	—	—	—	—	—	—	—	X	X	—	X	—	—
**Pandorina morum*	—	—	—	—	—	—	—	—	—	—	X	X	X
**Pediastrum duplex*	—	—	—	—	X	X	X	X	X	X	X	X	X
**P. duplex* var. *clathratum*	—	—	—	—	—	—	—	X	X	X	X	X	X
P. tetras	—	—	—	—	—	—	—	—	—	X	X	X	—
P. tetras var. *tetraodon*	—	—	—	—	—	—	—	—	—	X	X	X	—
Pleurotaenium trabecula	—	—	—	—	X	X	X	X	X	—	—	—	—
Polyedriopsis spinulosa	—	—	—	—	—	—	—	—	—	—	X	X	—
**Scenedesmus* sp.	—	—	—	—	—	—	—	X	X	X	X	X	—
S. abundans	—	—	—	—	—	—	—	—	—	—	X	—	—
S. antennatus	—	—	—	—	—	—	—	—	—	—	X	—	—
S. bijuga	—	—	—	—	—	—	—	X	X	X	X	X	X
S. brasiliensis	—	—	—	—	—	—	—	X	X	X	X	X	X
S. dimorphus	—	—	—	—	—	—	—	—	X	X	X	X	—
S. quadricauda var. *longispina*	—	—	—	—	—	—	—	—	X	X	X	X	X
**Sphaerocystis schroeteri*	—	—	—	—	—	—	—	X	X	X	X	X	X
**Staurastrum* spp.	—	—	—	—	X	X	—	X	X	X	X	X	X
S. johnsonii var. *depauperatum*	X	—	—	—	—	—	—	X	X	—	—	—	—
**S. polymorphum*	—	—	—	—	—	—	—	—	X	X	—	—	—
**S. setigerum*	X	—	—	—	—	—	—	X	X	X	X	X	—
S. tetracerum	—	—	—	—	—	—	—	X	X	X	X	X	X
S. uniseriatum	—	—	—	—	—	—	—	—	—	X	X	X	—
**Tetraedron* spp.	—	—	—	—	—	—	—	—	—	X	—	X	X
T. gracile	—	—	—	—	—	—	—	X	X	X	X	X	X
T. hastatum	—	—	—	—	—	—	—	—	X	X	X	X	—

TABLE 1. *Continued.*

Phytoplankton	O	N	D	J	F	M	A	M	J	J	A	S	O
T. hastatum var. *palatinum*	—	—	—	—	—	—	—	—	—	—	X	X	—
T. limneticum	—	—	—	—	—	—	—	—	—	—	—	X	—
T. planctonicum	—	—	—	—	—	—	—	—	X	X	X	X	—
T. regulare	—	—	—	—	—	—	—	—	X	X	X	X	X
T. regulare var. *bifurcatum*	—	—	—	—	—	—	—	—	—	—	—	X	—
T. regulare var. *torsum*	—	—	—	—	—	—	—	—	—	—	X	—	—
T. trigonum var. *gracile*	—	—	—	—	—	—	—	—	X	X	X	—	—
T. victoriae var. *major*	—	—	—	—	—	—	—	X	X	X	X	X	—
Chrysophyta													
*Diatoms (unicells)	—	X	X	X	X	X	X	X	X	X	X	X	X
Dinobryon cylindricum	—	—	—	—	X	X	X	X	—	—	—	—	—
Fragilaria sp.	—	—	—	—	—	—	—	—	—	—	—	—	X
F. capucina var. *mesolepta*	X	X	X	X	X	X	X	X	X	X	X	X	—
**Synura uvella*	—	—	—	—	X	X	X	—	—	—	—	—	—
**Uroglena americana*	—	—	—	—	—	—	X	X	—	—	—	X	—
Cyanophyta													
Anabaena sp.	—	—	—	—	—	—	—	—	—	X	X	X	X
A. circinalis	X	—	—	—	—	—	—	—	—	—	—	—	—
**A. planctonica*	X	X	X	—	—	X	—	—	—	—	X	—	—
A. spiroides var. *crassa*	X	X	X	—	—	—	—	—	—	X	—	X	—
**Coelosphaerium kuetzingianum*	—	—	—	—	—	—	—	—	—	X	—	—	—
Gomphosphaeria lacustris	—	—	—	—	—	—	—	—	—	—	X	X	—
Merismopedia elegans	—	X	—	—	X	—	—	X	X	X	X	X	X
Microcystis aeruginosa	X	—	—	—	—	—	—	—	—	X	X	—	—
**Oscillatoria* spp.	—	—	—	—	—	—	—	—	—	X	X	X	—
O. amphibia	—	—	—	—	X	X	X	X	—	X	X	X	—
O. limosa	—	—	—	X	X	X	X	X	—	X	—	X	—
O. princeps	—	—	—	—	—	—	X	X	—	—	—	—	—
O. subbrevis	—	—	—	—	—	—	—	—	—	—	X	—	—
O. tenuis	—	—	—	—	—	—	—	—	—	—	X	X	—
Euglenophyta													
**Euglena* spp.	—	—	—	—	—	—	X	X	X	X	X	X	X
E. acus	—	—	—	—	—	—	—	—	—	X	X	—	—
E. ehrenbergii	—	—	—	—	—	—	—	—	—	X	—	—	—
E. oxyuris	—	—	—	—	—	—	—	—	—	—	—	X	—
**Phacus* spp.	—	—	—	—	—	—	—	—	—	—	—	X	—
P. acuminatus	—	—	—	—	—	—	—	—	—	—	X	—	—
P. longicauda	—	—	—	—	—	X	X	X	X	X	X	X	X
P. nordstedtii	—	—	—	—	—	—	—	—	—	X	—	—	—
P. tortus	—	—	—	—	—	—	—	—	—	—	—	X	—
**Trachelomonas* spp.	—	—	—	—	—	X	X	—	X	X	X	X	X
Pyrrhophyta													
Ceratium hirundinella	X	—	—	—	—	X	X	X	X	X	X	X	X
Glenodinium quadridens	—	—	—	—	—	—	—	—	—	X	—	X	X
Gymnodinium sp.	—	—	—	—	—	—	—	—	—	—	X	X	—
**Peridinium* spp.	—	—	—	X	X	X	X	X	X	X	X	X	X

Total Abundance. The total number of organisms (fig. 5) remained relatively low during the periods January to early March, May through June, and October 1965. Three distinct pulses occurred as follows: 1) fall 1964, 60,000 per liter; 2) April 1965, 88,000 per liter; and 3) summer 1965, 200,000 per liter.

Cyanophyta were most abundant during fall 1964 (fig. 6) at which time they constituted 81% of the phytoplankton stock. Chrysophyceae were most abundant in April 1965 (figs. 6 and 7) in association with a smaller Cyanophyta pulse. Early in July, members of all divisions began to increase and by the middle of the month Chlorophyta were dominant (86%). A second Chrysophyta pulse, comprised mostly of diatoms (fig. 7), occurred with the increase in Chlorophyta, and the secondary maxima of both groups coincided during the summer and early-fall of 1965. Euglenophyta and Pyrrhophyta appeared sporadically in low abundance.

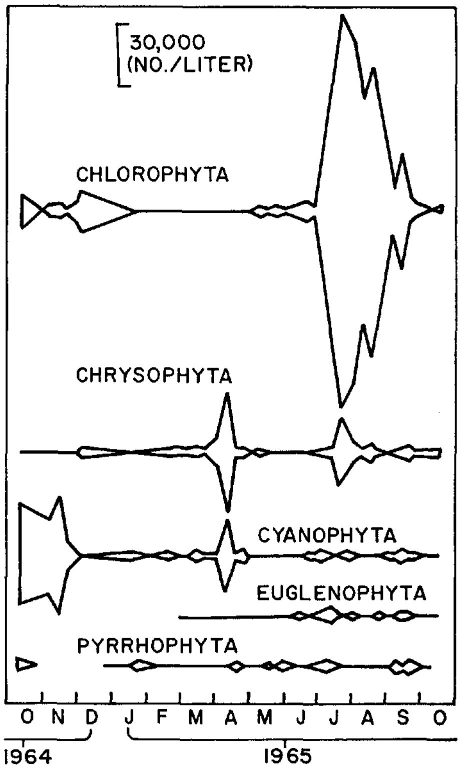

FIGURE 6

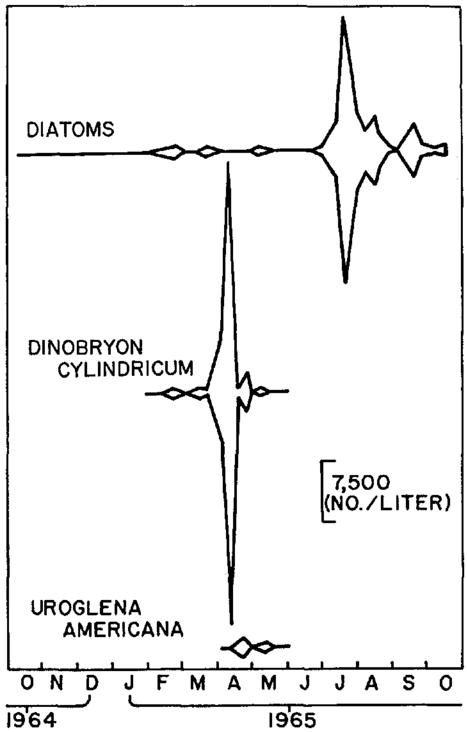

FIGURE 7

FIGURE 6. Seasonal variations in abundance of the major phytoplankton divisions.
FIGURE 7. Seasonal variations in abundance of major Chrysophyta.

Community Structure. A dynamic series of complex interplays and changes is implicated when the individual species in Penrod Pond are considered. The populations commonly were observed to replace one another rapidly (figs. 8–11), with little apparent regular or predictable periodicity. Species that appeared in relatively large numbers during any specified period were designated as community dominants for that period. The term community, as used here, refers to those aggregations of phytoplankton populations that consistently occurred together in relatively high concentrations during a specified period. Because of their seasonal patterns, some species are components of more than one community.

The community during fall 1964 was dominated by *Anabaena planctonica* and *A. spiroides* var. *crassa* (fig. 8), along with *Botryococcus braunii* (fig. 10). The large dinoflagellate *Ceratium hirundinella* was a major component of the community during October 1964 (fig. 9) but declined rapidly and was absent from November 1964 through February 1965. The two dominants, *A. planctonica* and *A. spiroides* var. *crassa*, decreased rapidly in late November 1964 and were absent thereafter. As the two *Anabaena* declined, *Botryococcus braunii* increased rapidly to a peak in December 1964 (fig. 10), whereupon it decreased steadily but remained dominant until early January 1965.

The community from January through the first week in March 1965 was primarily *Oscillatoria limosa* and *O. amphibia* (fig. 8), with very low numbers of

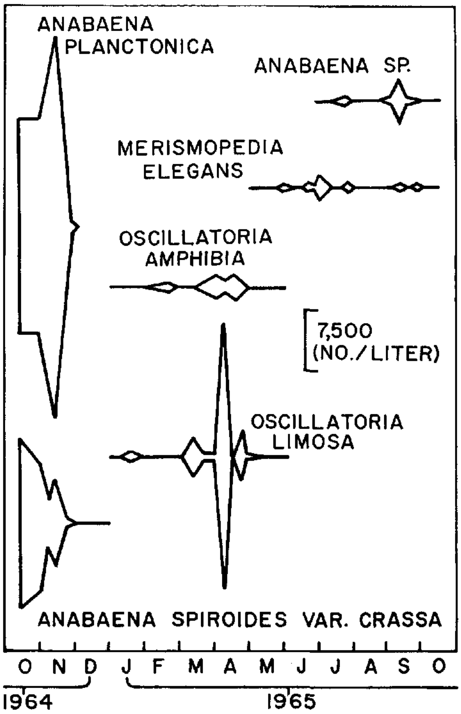

FIGURE 8

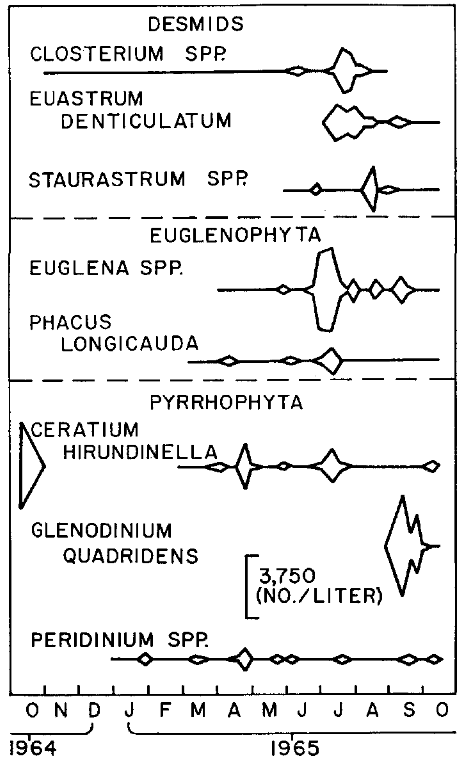

FIGURE 9

FIGURE 8. Seasonal variations in abundance of major Cyanophyta.
FIGURE 9. Seasonal variations in abundance of desmids, Euglenophyta and Pyrrhophyta.

Closterium sp., *Fragilaria capucina* var. *mesolepta*, *Botryococcus braunii* (fig. 10), and *Peridinium* sp. (fig. 9). The chrysophyte *Dinobryon cylindricum* pulsed and dominated the community from March through April (fig. 7). During early May, the phytoplankton community began to shift and by June, many additional species had appeared.

July through September 1965 was characterized by many species that reached maxima. *Staurastrum uniseriatum* produced a single pulse from July through August which represented the highest numerical concentration (160,000 per liter) of any species during the survey (fig. 11). As *S. uniseriatum* decreased (fig. 11), *S. tetracerum* increased to a density of 113,000 per liter in the middle of August and then it too declined sharply.

Diatoms ranked third in abundance from July through August and their pulse (fig. 7) coincided with that of *Staurastrum uniseriatum*. Although *Staurastrum tetracerum* had decreased by early September 1965 (fig. 11), it continued to dominate the phytoplankton and reached a second smaller peak on 18 September. Diatoms were sub-dominant and attained a third peak at this time (fig. 7).

October 1965 exhibited decreases in nearly all of the species comprising the previous community. This last month was characterized by low numbers of diatoms (fig. 7), *Scenedesmus* spp. (fig. 10), *Glenodinium quadridens* (fig. 9), *Pediastrum duplex*, *Botryococcus braunii* (fig. 10), and *Ceratium hirundinella* (fig. 9).

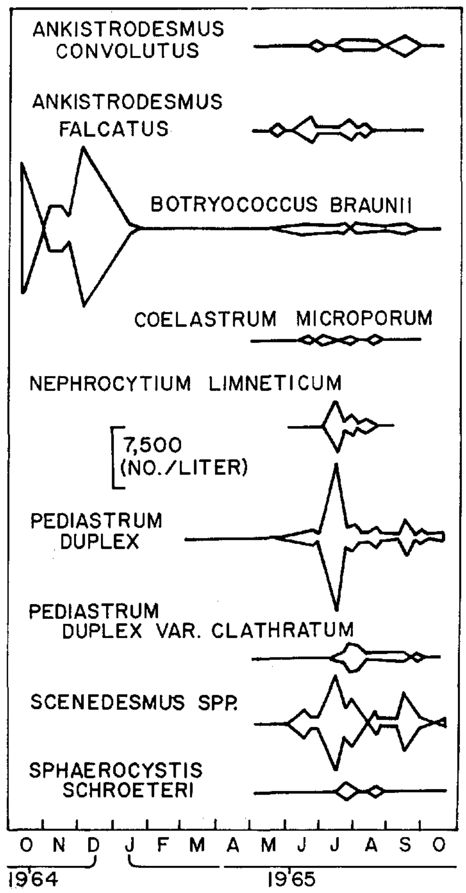

FIGURE 10

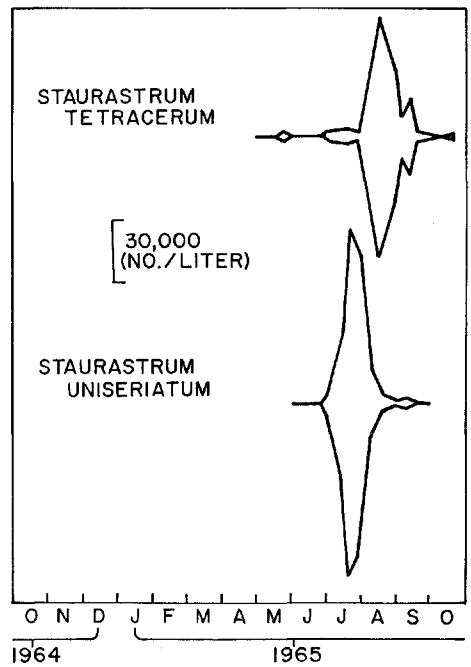

FIGURE 11

FIGURE 10. Seasonal variations in abundance of major Chlorophyta.
FIGURE 11. Seasonal variations in abundance of *Staurastrum tetracerum* and *S. uniseriatum*.

DISCUSSION

Aspects of Species Composition. The number of species (a rough index of diversity) can be useful for comparing habitats. However, considerable caution must be used when parallels are drawn between different studies, because of variable emphasis on taxonomy. With this in mind, the number of taxa found during the present study (90) lies within the upper range of values reported (see Welch, 1952) for 53 other ponds.

Climatic factors such as temperature and rainfall were characteristic of the region during the study; however, the pond was partly drained and the aquatic macro-fauna was largely destroyed. It should be noted that no abrupt or extreme fluctuations in either pH, alkalinity, or phytoplankton composition took place that could be correlated with these alterations. This is somewhat contrary to the findings of Dineen (1953) and Ball and Hayne (1952) who noted an increase in planktonic prey organisms following the removal of fish.

It is of interest to compare the seasonal changes in temperature (fig. 2), pH (fig. 3), and the total alkalinity (fig. 4) with variations in phytoplankton composition. Temperature and species numbers showed similar trends, with Chlorophyta responsible for the larger fluctuations. On the other hand, the highest numbers of Chrysophyta species were correlated with the lowest values of temperature, pH, and total alkalinity.

The seasonal distributions of the major groups of phytoplankton (table 1) are similar to trends noted in other surveys of ponds and lakes. Chlorophyta constituted 62% of the total species found and predominated during the summer in accordance with the reports of Chandler (1940), Marshall (1965), Kraatz (1941), and Tressler *et al.* (1940) in their studies of Ohio lakes. Chrysophyta contributed only 7% of the species, and most were present as late-winter and early-spring forms in agreement with statements by Patrick and Reimer (1966). Species of Cyanophyta were most frequent in the late-summer and early-fall (table 1), corresponding with other studies (Chandler, 1940; Tressler *et al.* 1940) where high species numbers of blue-greens were reported during summer through autumn. Pyrrhophyta usually reach their greatest species numbers in the summer according to Rhode (1948), but in the present study they showed no seasonal trend (table 1).

Aspects of Abundance. Seasonal variations in abundance (fig. 5) did not follow the bimodal pattern classically described in limnological textbooks (*e.g.*, Welch, 1952; Hutchinson, 1967). Three distinct pulses were evident in Penrod Pond (fig. 5): 1) fall, 2) April, and 3) summer. The fall and summer pulses showed a strong association with pH values above 9.0 (fig. 3). Owing to its shallow depth (7 ft), the pond was frequently mixed by wind except during periods of winter ice cover when the depth was only two feet; therefore, it seems unlikely that either macro-or micro-nutrients were limiting. Although other chemical and biological factors probably were involved, the peak abundance of phytoplankton seems most closely correlated with the light energy and temperature maxima of the summer months.

In a pond, which is in relatively greater circulation all year, one would expect a more constant phytoplankton community with smaller and more frequent pulses than in a lake, because nutrients should remain in more continuous supply. Tucker (1957) also indicated that in shallow unprotected lakes there is usually an adequate supply of nutrients available; consequently, other factors must control the pulses. In summary, small bodies of water do not seem to show any consistent plankton cycles and it appears at present that generalizations cannot be made which successfully predict periodicity in a typical pond or small lake.

Aspects of Community Structure. The fall pulse (fig. 5) was predominantly the blue-greens *Anabaena planctonica* and *A. spiroides* var. *crassa* as co-dominants (fig. 8). The period from January until the second week in March 1965 was characterized by a peak of *Oscillatoria limosa* (fig. 8). In his work on five ponds, Brown (1908) also found that *O. limosa* pulsed from December through April, and similarly, *Oscillatoria* fluctuated in large numbers (Eddy, 1927) from January to April at Oxbow Pond, Illinois.

During the April pulse (fig. 5), *Dinobryon cylindricum* (fig. 7), *Oscillatoria limosa, O. amphibia* (fig. 8), *Ceratium hirundinella* (fig. 9), and *Uroglena americana* (fig. 7) were majoı components of the community. At Turkeyfoot Lake (near Akron, Ohio), *Dinobryon* also reached a peak in April (Kraatz, 1941) and, in a small Ohio pond, Schultz (1952) found it to be prominent in the spring plankton. *Synura* sp. and *Dinobryon* sp. were abundant throughout March in six ponds (Rao, 1955), where a maximum of *Synura* took place in April. *Synura uvella* developed its maximum in Penrod Pond in the same month (table 1), corresponding further to the findings of Rodhe (1948), who found that *S. uvella* developed best at low temperatures under the ice or shortly after the ice breakup.

Many chlorococcalean forms began to appear from May to June, becoming relatively abundant shortly thereafter (fig. 10). *Pediastrum duplex* and *Sphaerocystis schroeteri* were particularly common as early summer forms. Brown (1908) also found that *Pediastrum* sp., *Coelastrum* sp., and *Scenedesmus* sp. appeared during June and July in one pool; in Penrod Pond, these genera were all present during the summer months but appeared slightly earlier (table 1 and fig. 10). Correspondingly, Rao (1955) reported that chlorococcalean algae usually were present in his samples during April to October.

Following the summer pulse (fig. 5) a distinct succession of dominants was evident. The community in July, comprised of *Staurastrum uniseriatum* (fig. 11), *Scenedesmus* spp., *Pediastrum duplex* (fig. 10), and *Euglena* spp. (fig. 9), gave way to a community in August that included *Staurastrum tetracerum* (fig. 11), *Closterium* spp., and *Euastrum denticulatum* (fig. 9) as major components, which finally was displaced in September by a *Glenodinium quadridens* (fig. 9), *Scenedesmus* spp. (fig. 10), *Anabaena* sp. (fig. 8), *P. duplex* (fig. 10) community.

Staurastrum uniseriatum (fig. 11) produced a pulse on 19 July which was the highest by any single species. Some *Staurastrum* and other desmids have been indicated to form blooms (Palmer and Maloney, 1955) or to occur in abundance (Peckham and Dineen, 1953). In a small shallow lake, *Staurastrum* likewise dominated the summer plankton (Tucker, 1957); this lake was also relatively low in diatoms and Chrysophyceae. In further agreement, Rao (1955) noted that desmids dominated two ponds and reached greatest development during July associated with high temperature and light intensity. On the basis of his four-year study of a pond, Hodgetts (1921, 1922) concluded that temperature and the concentration of nutrients were strongly correlated with the abundance of desmids. Fritsch and Rich (1909) also noted a domination by desmids from June to August correlated with high light intensity.

Diatoms were another group (fig. 7) important during July to August. In harmony with this finding, Tressler *et al.* (1940), Eddy (1927), Pennak (1946), and Rodhe (1948) all observed midsummer peaks in diatom populations, but spring and autumn peaks were more common.

Many workers (*e.g.*, Rhode, 1948; Rao, 1955; Fritsch and Rich, 1909; Transeau, 1916; Tressler *et al.*, 1940) have noted a chlorococcalean maximum from June to August, and most attributed this to high temperatures. *Pediastrum duplex* (fig. 10) had its maximum development in July; a finding similar to that of Rao (1955) who considered it to be favored by a combination of both warm temperatures and high light intensity. *Ankistrodesmus falcatus* (fig. 10) and *Pediastrum tetras* (table 1) were other summer forms in Penrod Pond. According to Hodgetts (1921, 1922), Rhode (1948), and Rao (1955), *A. falcatus* and *P. tetras* characteristically develop better in brighter and warmer summer months; Hodgetts (1922) further reported that temperature appeared to be critical in determining the development of *Pediastrum*, and felt that *Ankistrodesmus* grew better at lower temperatures than did *Pediastrum*. During the present study, both achieved highest numbers during the brightest and warmest months, but no separation of *Ankistrodesmus* and *Pediastrum* on the basis of temperature or on any other basis was noted. *Coelastrum microporum* (fig. 10) showed maximum development in the summer as it had in numerous other ponds and lakes (*e.g.*, Rao, 1955; Chandler, 1940; Nygaard, 1949).

Staurastrum tetracerum descreased in early September (fig. 11), but continued to dominate the phytoplankton community. Although Frohne (1939) indicated that it is exceptional among desmids for one species to become numerous, he also found exceedingly abundant numbers of a small *Staurastrum* in a pond from September through October. It should not noted that the two autumn communities were different both qualitatively and quantitatively, a condition that is apparently not unusual (see Chandler, 1940).

SUMMARY AND CONCLUSIONS

Phytoplankton were identified and enumerated weekly, and physical/chemical data were collected to assess the conditions under which the phytoplankton were

living. The pond was partially drained and refilled during the study; this did not result in observable pH or alkalinity changes, and apparently had little or no impact on phytoplankton periodicity. Ninety taxa were identified; 56 Chlorophyta, 6 Chrysophyta, 14 Cyanophyta, 10 Euglenophyta, and 4 Pyrrhophyta. The numbers of species, surface temperature, pH, and total alkalinity were observed to fluctuate seasonally; generally, the highest values being recorded during the summer and the lowest during the winter.

Three prominant pulses occurred as follows: 1) fall, 2) April—an abrupt one, and 3) summer—by far the greatest. The fall and summer peaks were associated with pH values above 9.0. The fall pulse was comprised of *Anabaena planctonica*, *A. spiroides* var. *crassa*, *Botryococcus braunii*, and *Ceratium hirundinella*. Major components of the April pulse were *Dinobryon cylindricum*, *Oscillatoria limosa*, *O. amphibia*, *C. hirundinella*, and *Uroglena americana*. During the summer pulse a distinct succession of dominants was evident, with the community in July composed of *Staurastrum uniserialum*, *Scenedesmus* spp., *Pediastrum duplex*, and *Euglena* spp., giving way to a community in August including *Staurastrum tetracerum*, *Closterium* spp., and *Euastrum denticulatum*, which then was displaced in September by a *Glenodinium guadridens*, *Scenedesmus* spp., *Anabaena* sp., *P. duplex* community. Because of the pond's shallowness, nutrients probably were abundant throughout the year in the photic zone; therefore a summer maximum would be expected and did occur, when light energy and temperature were at their greatest.

Species comprising the various divisions were observed to reach maxima at a specific season, during more than one season, or several times within a single season, thus emphasizing the complexities encountered when dealing with phytoplankton cycles or community patterns in a small pond. Phytoplankton communities are composed typically of many species that are in constant change under the influence of many causal factors. No two ponds are identical in detail, and chance appears to play an important role in these small habitats. Random variables (such as a cloudy day or rainfall) may modify the species composition, and this has profound effects on subsequent developments in the pond.

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