THE OCCURRENCE OF *PERIDINIUM INCONSPICUUM* LEMMERMANN (DINOPHYCEAE) IN MINERALLY ACID WATERS OF THE UPPER OHIO RIVER BASIN

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ABSTRACT.—*Peridinium inconspicuum* Lemmermann (Dinophyceae) is a member of the algal association of several lakes affected by mineral acids. Sustained dominance of phytoplankton communities by this pyrrhophyte was observed in at least two large acid impoundments. [Phytoplankton, mine drainage, pollution, diversity, Dinophyceae]

INTRODUCTION

From 1972 to 1977 phytoplankton samples were collected in fifteen federal reservoirs in the upper Ohio River drainage basin (Pennsylvania, West Virginia, New York, Ohio, and Maryland). This paper deals principally with the occurrence of one phytoplankton species, *Peridinium inconspicuum* Lemmermann. Some of the physical, chemical, and biological characteristics of the waters in which this species was found are also noted.

The chemistry and biology of surface and subsurface waters in many portions of the Appalachian region are affected by sulfuric acid. The source of this H_2SO_4 is primarily from the oxidations of pyrite and marcasite (both having the composition FeS_2). These pyritic sulfur forms occur in coal, and in rock and clay found above and below coal seams. The sulfides are uncovered in the process of coal mining, and exposed to the oxidizing action of air, water, and sulfur-oxidizing bacteria. The end products are water soluble and the basic reaction is:

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$

Acid drainage from bituminous coal mining activities is nearly a basin wide problem in the upper Ohio River drainage. Nine of the fifteen reservoirs studied received acid mine drainage. One reservoir is very seriously degraded (pH < 4.5) and four others are moderately affected (pH 4.5 to 6.5). In addition, two large non-federal impoundments in the area, Lake Lynn and Piney Reservoir, are extremely acid.

The locations of the impoundments considered in the study are shown in Fig. 1. The dimensions of the reservoirs in Fig. 1 represent approximate sizes at maximum pool elevations.

MATERIALS AND METHODS

All reservoir sampling stations were located in the deepest section of specifically designated reservoir transects. At each project the stations were placed at roughly 1.5 kilometer intervals from the dam to the inflow, and in all major arms and embayments. There were nine established reservoir sampling stations at each of the two impoundments of major interest in this study, Tygart River Lake and East Branch of the Clarion River Lake.

At each station vertical measurements of dissolved oxygen, water temperature, and specific conductance were taken with cabled probes at the surface, one meter below the surface, and then at 1.5 meter depth

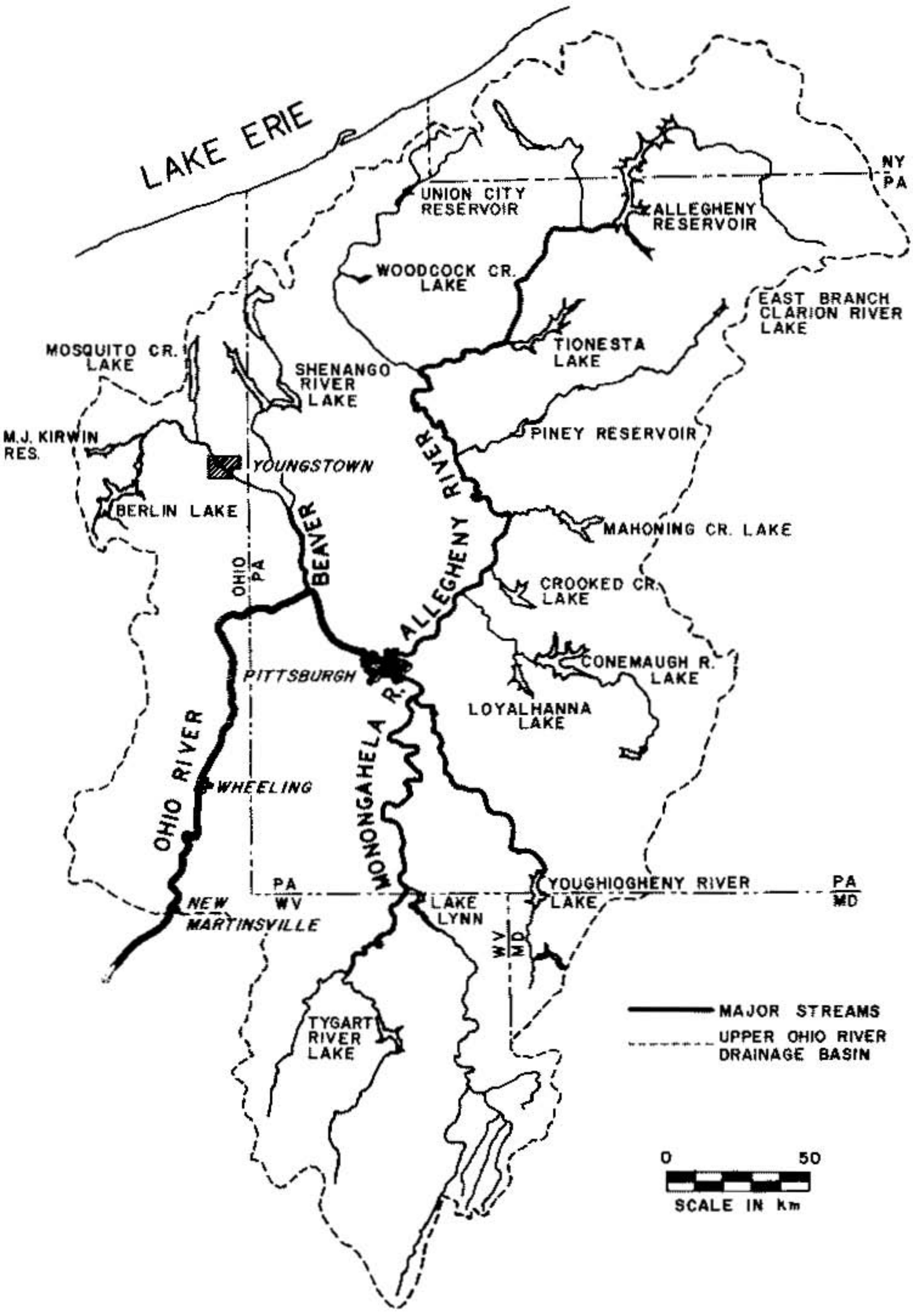

FIG. 1.—Large impoundments of the upper Ohio River basin.

increments to the bottom. Samples for acidity, field pH, and other pertinent parameters were collected with a Kemmerer bottle from a one meter depth, at mid-depth, one meter from the bottom, and wherever discontinuities were noted in the vertical profiles of water temperature, dissolved oxygen, and conductance.

The phytoplankton sampling procedure was more variable; vertical profiles were collected only at selected stations. One meter depth phytoplankton samples were routinely collected, however.

Two liter volume phytoplankton samples were collected with a Kemmerer bottle. The samples were stained and preserved with Lugol's solution and gravity concentrated. Cells were enumerated in a 0.1 milliliter subsample, using a Sedgewick-Rafter cell and strip method analysis.

Taxonomic Observations

Several taxonomic problems are likely to be encountered in the identification of *Peridinium inconspicuum*. As with most Dinophyceae, plate characteristics are presented in the keys as an important means of identification. However, the plate characteristics of *P. inconspicuum*, as shown in Fig. 2 with exaggerated clarity, are not conspicuous.

Even in empty cells the configuration of plates is difficult to determine. The absence of plate definition is one of the most distinctive taxonomic features of the organism. While Lemmermann may have been attempting to highlight this point when he chose the specific epithet *inconspicuum*, it is not adequately presented in any key that this author has used.

A secondary area of confusion involves the scattered antapical spines that are occasionally present on *P. inconspicuum*. Prescott (1962) describes only short, sharp, horn-like projections, but illustrates them as being plate projections. Tiffany and Britton (1971), on the other hand, describe them as spines occurring in the intercalary spaces between the antapical plates, and do not include them in their illustrations. Observations on the upper Ohio River basin variety are consistant with the latter description. A spine-bearing individual is shown in Fig. 2B.

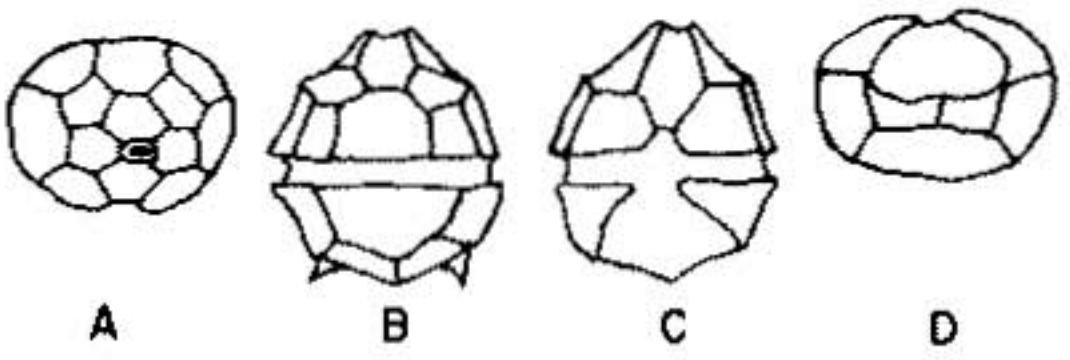

FIG. 2.—*Peridinium inconspicuum* Lemmermann; A. apical, B. dorsal, C. ventral, and D. antapical (modified from Tiffany and Britton, 1971).

Cell size in the upper Ohio River basin samples varied from 12 to 25 μ in diameter and from 15 to 30 μ in length.

Results

The significance of *Peridinium inconspicuum* in lotic habitats influenced by mineral acids became apparent when sustained dominance of this organism was noted in two moderately acidic reservoirs, East Branch of the Clarion River Lake and Tygart River Lake.

East Branch Reservoir is located in northwestern Pennsylvania. In recent years the pH of East Branch Reservoir has ranged from 4.5 to 6.5. The mean pH for most stations has been approximately 5.5. Total acidity generally ranges from 2 to 20 mg/l as $CaCO_3$. The phytoplankton community was not diverse and was overwhelmingly dominated by the single species *P. inconspicuum*. At times *P. inconspicuum* was more than 95% of the total phytoplankton cell counts at individual stations and depths. Averaging all stations and depths for each survey, this species ranged from 14 to 88% of the total cell counts (Table 1).

A less extreme example of *Peridinium*

TABLE 1.—Percentage composition of *Peridinium inconspicuum* in the phytoplankton of East Branch Clarion River Lake during nine surveys.

Year	Month	Mean Total Cell Count cells/ml (all stations and depths)	Percent *P. inconspicuum*
1973	June	690	78
	August	176	45
1975	June	586	48
	August	196	27
1976	May	37	14
	June	303	26
	July	144	88
	August	160	59
	September	154	17

domination was observed at Tygart River Lake in northern West Virginia during 1973 and 1974. Usually Tygart River Lake is only mildly affected by acid mine drainage. Periodically, however, acidic slugs of mine drainage enter this impoundment. The mean pH for Tygart Lake waters in 1973 was 6.1 (394 measurements), with maximums of 7.6 and a minimum of 4.5. Total acidity varied from 6 to 1 mg/l and averaged 5 mg/l as $CaCO_3$ (333 measurements).

Eighty-two taxa of algae from 54 different genera were identified from Tygart River Lake in 1973 and 1974. The composition of the phytoplankton community was dominated by Chlorophyta and Pyrrhophyta. Forty-six taxa of Chlorophyta were present. *Crucigenia, Dictyosphaerium pulchellum, Scenedesmus, Tetraedron,* and *Schroederia sitigera* were numerically most important. Five taxa of pyrrophytes were identified from the impoundment. The single species *Peridinium inconspicuum,* however, was at times 70% of total cell counts. At one station, *P. inconspicuum* was 24% of the seasonal total in 1973 and 34% in 1974. Also, the percent abundance of this organism was observed to increase at stations near the inflow, when slugs of acid water entered the reservoir.

Peridinium inconspicuum was present, at least occasionally, at three other impoundments in the area that are affected by mine drainage (Conemaugh, Loyalhanna and Crooked Creek reservoirs). Moore (1974) reported that East Branch Clarion River Lake was dominated in 1974 by a species of *Peridinium*. He tentatively identified the organism as *P. inconspicuum* and has observed that the same species has been common in acid Piney Reservoir for a number of years (personal communication).

DISCUSSION

Decreased species diversity accompanying increased acidity has been reported by several investigators (Lackey 1939; Johnson; and Lind and Campbell 1970 *cited in* Diehl 1972). They also reported that while species diversity decreased, the populations of surviving species in acid polluted water are often quite high. This author has frequently observed very dense mats of *Ulothrix tenerrima* Kuetzing in acid springs and coal mine effluents (Koryak, Shapiro, and Sykora, 1972), and also exceptionally high numbers of Euglenophyta in small acid ponds. However, primary productivity was depressed in all of the large acid impoundments examined. Diehl (1972) demonstrated that mineral acid pollution limited productivity in Lake Lynn.

In Wisconsin *Peridinium inconspicuum* was found in soft water lakes and in desmid habitats (Prescott 1962). In the upper Ohio River basin, desmids, which are so frequently associated with organically acidic waters, were never found to be abundant in the large impoundments influenced by mineral acids. Cyanophytes, with a few exceptions, were rare or absent. *Dinobryon, Ankistrodesmus, Navicula,* some coccoid chlorophytes and various flagellates were usually present in the minerally acidic reservoirs along with *Peridinium*. In addition, *Cyclotella, Melosira, Pediastrum, Scenedesmus, Crucigenia, Dictyosphaerium,*

Schroederia, and some other genera were occasionally well represented.

The chemistry of acid mine drainage is complex and variable, and mine drainage can influence every type of aquatic habitat. *Peridinium inconspicuum* appears to be most typical of large, moderately affected impoundments.

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