ABSTRACT

A COMPARISON OF ALGAL FLORAS IN TWO LAKE TYPES,
BARRY COUNTY, MICHIGAN

by James Herbert Graffius

This study is concerned with an analysis of the local distribution of algal species in two southern Michigan lakes. Most similar studies of algal distribution have concentrated on an analysis of distributions over wide areas, and much of our knowledge of algal distribution is based, therefore, on results from broad regional, rather than local, investigations. The purpose of the present study was to analyze the algal components of an acid bog and a nearby hard-water marl lake during the same period of time so that a direct comparison of the two could be made. The study also was designed to analyze algal species distribution within each of the study areas, to ensure the investigation of diverse sites within the bounds of the larger study region which might represent different environmental situations.

This study has as its objectives the following: (1) to list and describe the total algal flora of each area in some detail, and to obtain extensive data on the occurrence and distribution of individual algal species in time and space; (2) to describe the seasonal periodicity of algal species or communities, especially those of the phytoplankton; (3) to investigate the temporal and spatial distribution of algal species within each study area; (4) to obtain fundamental chemical data on the

environmental conditions under which individual species occur; (5) to investigate the possible influence of various environmental factors on the distribution of algal species; (6) to determine the extent to which conclusions based on results of broad regional studies of algal distribution can be applied to distributions observed within narrow geographical limits.

Samples were collected from a variety of habitats in both study areas at approximately two-week intervals from September, 1958 to November, 1960, after which five supplementary collections were made, to verify previous results. The study is based, therefore, on an analysis of algal samples which were gathered on 42 collecting dates. A total of 495 species were observed during the study, of which 128 represent new records for Michigan. Of these, two are new records for the United States, and 35 are listed tentatively as new records for North America. All new records are illustrated and described fully in the text, and the temporal and spatial distribution of all species observed during the study is summarized and presented in tabular form.

The flora of each study area is described in respect to several separate aspects, among them the number of taxa present, floral composition, floral distribution, community structure and seasonal periodicity. The analysis of the distribution of algal species within each study area includes a discussion of the possible relationship between the observed distributions and various chemical factors of the environment, both in respect to data gathered during the present study, and in conjunction with data presented in other studies of algal distribution.

Analyses of the algal floras of these two ecologically-different biotopes indicate that only 39 of the 495 species observed were common

to both. The greatest difference between the floras of the two environments is shown by a comparison of the desmid and Euglenophyta components. The environmental factors which have been held to be influential in the distribution of these floras are discussed briefly.

A comparison of previous results with those of the present study suggests that generalizations derived from broad regional studies of algal distributions cannot be applied directly to studies of local distribution. This is especially true if emphasis is placed on an analysis of the distribution of individual species, and if a number of diverse habitats within the bounds of a particular study area are investigated.

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BARRY COUNTY, MICHIGAN

By

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CHAPTER I

INTRODUCTION

When the phycologist attempts to study or to analyze algal distribution, he faces a task more difficult than that of the terrestrial taxonomist or ecologist, because he cannot observe directly in the field the organisms with which he is working. Thus, to study the distribution of algal species or communities, he must sample a variety of apparently different habitats, and then methodically analyze and compare the inhabitants of each to determine whether, and to what extent, floristic differences occur in these various ecological situations. It is only in this manner that he finally may come to understand algal distribution, algal communities and algal ecology.

Another difficulty is that many species are cosmopolitan, inasmuch as they are found on almost every continent (Antarctica excepted), and yet they are not distributed uniformly within any one geographical region. Thus, the phycologist must explain why it is that, although many species show an almost world-wide distribution, they apparently are not well-adapted for life in a large variety of ecologically different habitats. To determine the range of environmental conditions under which a particular species can exist becomes, then, an important aspect of any study of algal distribution.

Our present knowledge concerning the dynamics of algal distribution is far from complete. But, as more and more studies are made, and

data begin to accumulate, it should be possible eventually to recognize the range of ecological conditions under which individual species can exist, and to discuss the distribution of algal species or species associations which apparently are adapted to the same kinds of environmental conditions. But, before one can discuss the tolerance range of individual species, he must first study particular kinds of habitats to determine the kinds of species which live there, and, if possible, the relative length of time during which they occur. It would be necessary also to determine as carefully as possible the particular range of physical and chemical conditions under which the species are living in each type of habitat. Such basic information must be compiled before one can discuss the range of habitats which a species may occupy, or the environmental factors which may influence its distribution.

Therefore, the study of algal distribution becomes primarily a study of the flora of selected habitats. The two kinds of habitats which have been investigated most intensively from this viewpoint, and about which a voluminous literature exists, are the acid bog (moor of European terminology) and the hard-water or basic lake. Because these represent different lake types, both from the standpoint of water chemistry and floristics, various studies have been made to determine the extent to which the algal floras of these individual lake types are similar (in different regions of the world), and to attempt to determine the factors responsible for the development of the unique algal flora which each of them supports.

Another approach to the problem has been to make direct comparative studies of the flora of an acid bog and an alkaline lake, not only for the purpose of studying algal distribution, but to determine

factors responsible for observed floristic differences. Yet, direct studies of this kind have been almost lacking in this country. If the broad objectives outlined above are ever to be achieved, our knowledge of the flora of these habitats must be expanded by more and more studies of a comparative nature. It is with these considerations in mind that the current study was designed.

Background and Purpose of Study

Although many studies have been made of the algal floras of acid bogs and alkaline or basic lakes, our knowledge of the flora of such biotopes is far from complete, especially from the standpoint of comparative information. For, although many studies of these lake types have been made in the United States, none has been a direct comparative one. Most of our information regarding the algae of these aquatic environments has been gained from a study of one or the other of these lake types, or from results of broad regional surveys, in which event no direct comparison is possible. It is thus difficult to evaluate, from such studies, the influence of environmental factors on the particular species which inhabit these biotopes if our knowledge is wholly of a general nature.

In addition, although much is known about the algal flora of acid bogs in general, few comprehensive studies have been made of individual bog areas in this country, and of these, none has extended throughout the year. Data on seasonal periodicity are almost wholly lacking, and winter conditions are practically unknown (Welch, 1952).

Therefore, from such data as exist in our own country, it would be difficult to explain the floristic differences noted in a "comparison"

of a basic lake and an acid bog, on the basis of differences in habitat alone. For, one would have to utilize data (especially for acid bogs) which had been obtained from the more complete studies made in other countries, and, thus, data obtained from widely-separated study areas. But, because of the longer distances involved, and the fact that the data might not have been gathered during the same period of time, it is possible that similar dissemules were never present in the two areas under consideration. This possibility must be recognized, even though many species have been shown to have an almost cosmopolitan distribution.

It is not reasonable, therefore, (especially if one wishes to utilize direct comparative data) to base a study of algal distribution on results obtained from widely-separated areas, or during different periods of time. This is especially true if one wishes to compare the floras of two so ecologically different environments as an acid bog and a basic lake. Such a direct comparison is possible only if the two study areas are in geographical proximity so that it is fairly certain there has been an equal opportunity for similar dissemules to enter either area. Such proximity also would have the obvious advantage of allowing for sampling both areas on the same day. If study areas are chosen with the above considerations in mind, any differences noted would have to be attributed to differences inherent in the habitats themselves.

Another problem in designing a study of this type arises from the fact that lakes change as suitable habitats for certain kinds of algae not only with various seasons of the year, but through extended periods of time as well (Pearsall, 1921; Gessner, 1929). Yet, many comparative studies are based on collection data which have not been

taken during the same period of time. That is, the results of samples taken one year in an acid bog have been compared with those taken from an alkaline lake at a much later date. The need for data based on samples collected at approximately the same time is evident.

In addition, much of our knowledge of the algal floras of these lake types is based on an analysis of the plankton alone, or on collections which have been taken only sporadically from other habitats, in many cases only once. Most of our records are based on a study of summer plankton alone.

Analysis of results from existing studies becomes difficult also if one wishes to utilize the data of various workers in the field, because emphasis of individual studies has been so varied. Many investigators place primary emphasis on limnological features, and either largely neglect the organisms themselves, or list only generic names. Some study only one group of algae and neglect the others, or study only one or a few chemical factors and neglect the remaining ones. Others include a long list of observed species, but include little or no chemical data concerning the habitat itself. Where extensive quantitative data are given, qualitative data are largely lacking, and vice versa.

Thus, although much is known regarding the ecology (*e.g.*, occurrence and distribution) of acid bog and hard-water lake floras, and although the algae "typical" or "characteristic" of these lake types are generally known, several questions remain to be investigated in this country, or remain unanswered, primarily because of a lack of direct comparative evidence. There appears to be a need, then, for a comprehensive comparative study of the algal flora of two such lakes in

this country, based on considerations noted above. Such an investigation should be designed so that data could be collected at approximately the same time in both study areas, should extend through all seasons of the year over an extended period of time, and should include information taken from a variety of habitats within the individual study areas, rather than from one type of habitat alone.

The purpose of the present study was to institute such an investigation, and had as its objectives the following: to list and describe the "total" algal flora of each area in some detail, and to obtain extensive data on the occurrence and distribution of individual species in time and space; to describe the seasonal periodicity of algal species or communities, especially those of the phytoplankton; to investigate the distribution of algal species within each area, and to describe habitat selectivity if noted; to obtain fundamental chemical data from each of the study areas; to investigate the possible influence of various environmental factors on the distribution of the algal species noted; finally, to determine the extent to which conclusions based on results of broad regional studies of algal distribution can be applied to distributions observed within narrow geographical limits.

Literature Review

Because the scope of the study as outlined above is of a rather broad nature, it is evident that reference must be made to a diverse literature to survey adequately important background material. Such a survey, of necessity, would have to include general considerations of algal ecology or distribution, as well as more pertinent references to acid bog and hard-water lake floras.

Fritsch (1931) has summarized our knowledge of algal ecology as of about 1930, and has given a broad classification of the algal communities of static water. G. M. Smith (1924b, 1950) has discussed the ecology, occurrence and geographical distribution of algae, and both Ruttner (1953) and Welch (1952) have included a discussion of algal ecology in their well-known texts. The latter two works also contain extensive discussions of the bog biotope as an environment for algae, including possible factors which may influence the structure of the bog community. Prescott (1951a) has included a discussion of lake types, especially as these are related to the ecology and distribution of algae, and has discussed some of the factors determining the character of lake floras. In addition, much information is given in respect to the particular kind of habitat in which individual algal species occur. A later work by the same author (1956) contains extensive references to the factors and relationships of algal ecology. The works of Dangeard (1933) and Messikommer (1942a) also include useful sections on algal ecology and distribution.

In respect to acid bogs, few comprehensive studies of individual areas have been made on this continent, with the exception of the excellent one by Irénée-Marie (1939) in Canada, although the works of Prescott (1936-1953) contain a wealth of information on the floras of a whole series of such habitats. In this country, Welch (1936a-1938b) has made comparative studies of the summer plankton from several bog lakes in Michigan, and has included a list of algal species from each of the lakes investigated. Another study (Welch, 1945) has made brief reference to algae found in the sphagnum mat of one of these bogs. More recently, Tucker (1957) has reported on phytoplankton periodicity in two

of the lakes studied earlier by Welch. The writer (1958) has investigated the algal flora of two bogs in Pennsylvania during a one-year period, and has delimited the communities typical of various habitats in the study areas. In Ohio, Chapman (1934) has published on an intermittent study of the algae of an alkaline raised bog over a three-year period, and has listed algal species typical of several different habitats in the bog.

Much more extensive work has been carried out in Europe on the various types of moors and moor associations. Harnisch (1929) has summarized much of the earlier work on bog biology and has included a discussion of the algal inhabitants typical of bogs. Magdeburg (1926) has made comparative studies on the algal flora of various habitats in two German bogs, and has listed the associations typical of each of the areas. The works of Gessner (1929-1953) also include much data on the algae of bog lakes in Germany.

In Holland, de Graaf (1957) has studied the community structure of micro-organisms in a quaking bog as related to various successional stages, and has discussed the ecological factors related to several of these biocoenoses. The algal associations of various successional stages of a swampy area in Prussia have been outlined also by Steinecke (1917). A. M. Smith (1942) studied the algal flora of a raised bog in England during approximately a four and one-half year period, and has categorized the species and associations typical of the area.

As noted earlier, many investigators have been interested primarily in studying one group of algae, and for acid bogs this usually has involved a study of the desmid flora of such situations. In fact, one could not refer to the bog biotope without mentioning the extensive work concerning this group of algae. But, because of the voluminous nature of the literature, only the most pertinent references will be cited here.

Perhaps the most intensive series of studies on desmids in North America are those by Prescott (1936-1953) and his co-workers (Prescott and Magnotta, 1935; Prescott and Scott, 1942-1952; Scott and Grönblad, 1957; Scott and Prescott, 1952) in this country, including data not only from bogs but from other habitats as well. In addition, Croasdale (1955-1962) has published an extended series of papers on the desmid flora of Alaska. Wade (1952, 1957a) has published on the distribution of desmids in Michigan, and has summarized information gathered by previous workers on the state's flora. These studies also include a discussion of various earlier notions concerning factors responsible for the distribution of desmids, so that it would be repetitious to include such ideas here. One survey which must be mentioned because of its completeness, however, is that by Prescott (1948). In addition to the study mentioned earlier (1939), Irénée-Marie (1949-1956) made an extended series of studies on the desmid flora of Canada, and has included much information of ecological value. In Europe, Laporte (1931) studied a series of habitats, especially bogs, and, in comparison with taxonomic lists from the literature, established and discussed the distribution of ten associations of desmids. This work also includes a good general discussion on the ecology and sociology of this group of algae. Niessen (1956), concentrating on desmid and diatom floras, studied the communities of various habitats in a German bog, and has discussed the distribution of these within the bog area as related to water chemistry. Wasylik (1957-1961b) discussed the distribution of

algae, especially desmids, in boggy areas of Poland and Finnish-Lappland, and van Oye (1941) wrote on the distribution of desmids in Belgium.

Because the literature on hard-water lakes likewise is so extensive, only general references can be cited here. In addition, many studies have been directed primarily toward a study of the productivity of such lakes, and as such go beyond the purpose of the present study.

Most of our general knowledge of hard-water-lake floras is summarized in the works of Prescott (1951a) or Smith (1920, 1924b, 1950), so that it would be repetitious to survey this literature in detail. Both workers include, as well, extensive references to species which are commonly found in hard-water lakes. Perhaps the only specific study which need be mentioned here is the pertiment one by Raymond (1937) on the plankton of a marl lake in Michigan. Even here, the primary emphasis of the study was limnological, and was primarily concerned with determining the cause of the lake's low productivity.

With the exception of the brief study by Reed and Klugh (1924), the writer is aware of no study on this continent in which a direct comparison has been made of the algal floras of acid versus alkaline waters, although Jewell and Brown (1929) have reported on the fauna of alkaline and acid bog lakes located within five miles of each other. Several comparative studies have been made in other regions of the world, however, and much useful information pertinent to such an investigation has been included in those of a broader scope designed to investigate various factors affecting algal distribution.

One of the most comprehensive series of comparative studies of algal distribution, covering almost all aspects mentioned previously, is that of Messikommer (1935a-1960) in Switzerland. His investigations

have dealt with both acid and alkaline waters of the region, and include much data on the relationship of algal distribution, especially of desmids, to water chemistry, altitude and temperature.

The ideas of many workers as to the factors responsible for the distribution of algal species or associations have been well summarized by Dangeard (loc. cit.). Krieger (1933-1937) has a section on the ecology and geographical distribution of desmids, in addition to listing the known pH ranges and habitat preferences of many species. Many of the factors which have been advanced as being causal or related to the distribution of algae in general, or of particular groups of algae, have been summarized or referred to by Prescott (1939; 1951a; 1956). Behre and Wehrle (1944) also have reviewed some of the factors possibly influencing algae distribution, and have cited the need for more critical chemical analyses of the investigated waters.

In England, Pearsall (1921) has discussed the factors responsible for the distribution of phytoplankton in various lakes as related to the developmental age of the lakes, and Wesenberg-Lund (1905) has made a comparative study of different lake types in Scotland and Denmark. Rawson (1956a, b), as a result of his studies of Canadian lakes, has listed the algal species indicative of various trophic levels.

Strøm (1921-1931) has made studies of the ecology, biology and distribution of algae in Norway, and Skuja's (1948, 1956) works in Sweden contain much data of ecological significance. Thunmark (1942, 1945a, b), working also in Sweden, has made comprehensive surveys of the biocoenoses of waters of several trophic levels and has directed his studies toward understanding the factors responsible for the distribution of different associations of micro-organisms. Much of his work is based on a study of geographically different habitats, many of them in boggy regions.

Budde (1944) studied the influence of hydrogen-ion concentration and alkalinity on the structure of algal associations in different habitats, and has summarized the known pH tolerance of many species. Bock (1953) studied the influence of changes in pH and temperature on the algal flora of a series of temporary ponds. Quantitative changes in the community composition of various habitats as related to pH have been discussed by Gistl (1931), and Wehrle (1927) has studied the colonization by algae of various habitats of different pH. The latter study also lists many species considered to be indicators of a definite pH range, and includes an extensive literature survey on the earlier physiological and ecological studies of algae.

Gessner (1929-1953) has studied a whole series of lakes in respect to pH, and has discussed the influence of this and other ecological factors on the distribution of algae. Behre (1956) likewise made an extended comparative study of a series of alkaline and acid lakes in Germany, and has discussed the influence of pH on the distribution of algae in these. More recently, Hirano (1960) made an extensive study of desmid distribution in Japan, and has included much data on water chemistry and the pH tolerance of individual species.

An analysis of the observations made in this country, as compared with those from other areas of the world, only emphasizes the need for further information of a similar nature in the United States.

CHAPTER II

MATERIALS AND METHODS

Sampling Methods

Samples of algae were collected from each of the study areas at two-week intervals during most of two years, but at approximately monthly intervals during the winter periods. Five collecting stations were established in each of the areas so that algae could be collected periodically from a variety of habitats for the study of algal distribution.

Sampling was begun in September, 1958 and continued through November, 1960, after which five supplementary collections were made to verify seasonal changes noted in earlier collections. Accordingly, samples of algae were gathered from a variety of habitats on 42 collecting dates.

Collections were taken in each study area on the same day, and at approximately the same times. Most samples were collected at 1:00 P.M. to minimize any daily variations inherent in the plankton or physical-chemical characteristics.

Sampling techniques varied with the habitat from which the samples were taken. All plankton samples were concentrated by means of a six-inch silk plankton net of number 20 mesh. Two labeled nets were used, one for each of the lakes studied, to avoid contamination. The net was drawn through the water at least 20 times to assure an adequate sampling;

in most instances two or three vials of plankton material were collected on each sampling date, all in the same manner. Caution was taken so that material from the bottom was not included in the plankton samples.

Because of the shallow nature of the lakes, however, and the fact that most samples were taken from shore, it was difficult to avoid stirring up some bottom materials. As a check on this possibility, and to make a proper evaluation, samples were also taken manually from the lake bottom in the sampling area by squeezing the bottom vegetation and sediments into a vial.

Samples from the sphagnum mat and pools in Purdy Bog were collected by making squeezings of the moss and other aquatic plants such as *Utricularia*, as well as partially-decayed plant material. Any evident growths of algal material, such as filamentous forms, were collected *en masse* by hand.

All samples were placed into labeled vials and were taken immediately, unpreserved, to the laboratory for study.

Methods for Examination and Identification

All samples were studied in the living condition on the date of collection, after which a portion of each was preserved in FAA for future examination. Remaining portions of the samples were placed in a refrigerator for periodic study as time allowed, after which they were preserved, also in FAA.

Mounts of living material were examined initially to determine the motile forms which were present, as these are most difficult or impossible to recognize when preserved. Following this, the specimen slides were surveyed to glean as many species as possible from each

sample.

During examination of the samples, cards were prepared which listed the organisms identified, the relative abundance of each (where possible), the particular habitat in which each was found, and its condition at the time of observation, i.e., pigmented or colorless. Also, camera-lucida drawings were made of each species which appeared in the two study areas, both as a record for its occurrence and as an aid to identification for those species which were not readily identifiable. Measurements and other descriptive material were recorded with the drawing and filed for future reference.

Following the identification of specimens on each mount, a few drops of dilute (5%) glycerine were added to the material. Most of these slides were retained as semi-permanent mounts so that the specimens could be re-examined, and identifications made or verified, at a later date.

Physical-Chemical Methods

Physical-chemical data were collected periodically, primarily from open-water habitats. Water temperature was determined by means of a standard laboratory-type mercury thermometer, and recorded in degrees Centigrade. Values for pH were determined colorimetrically by means of a La Motte Universal pH kit or, rarely, by using La Motte Utility Indicator.

Total alkalinity was measured at the collecting site. Initially, methyl orange was the indicator used, but because the end-point for this is difficult to ascertain accurately, M-Alka Ver was substituted. The procedure used was that recommended by Hach (Hach Chemical Company). Titrations were made in duplicate, and the results expressed as ppm of calcium carbonate.

Nine iced samples were also taken to the M.S.U. campus for analysis in a chemical laboratory, for more complete data. Total and dissolved organic matter were determined by the procedure outlined by Slater (1954), and the results expressed as mg./l. Samples to be analyzed for dissolved organic matter were first passed through a millipore filter, using type HA paper having a pore diameter of 0.45μ.

Sulfate was determined according to the turbidimetric method of Hach (Hach Chemical Company, p. 21). Phosphate, nitrate nitrogen and iron were determined colorimetrically using the Klett-Summerson photoelectric colorimeter and the Hach Model DR colorimeter. Stock solutions were prepared as directed in Standard Methods (A.P.H.A., 1955), and diluted to give values of from 5.0 to 0.05 mg./l., after which standard curves of concentration were plotted. In all cases, the methods of Hach (*loc. cit.*) were used to bring out the color of the water samples.

Calcium, magnesium and total hardness were determined by using the methods outlined in Hach (*loc. cit.*), and the results expressed as ppm of calcium carbonate.

CHAPTER III

DESCRIPTION OF STUDY AREAS

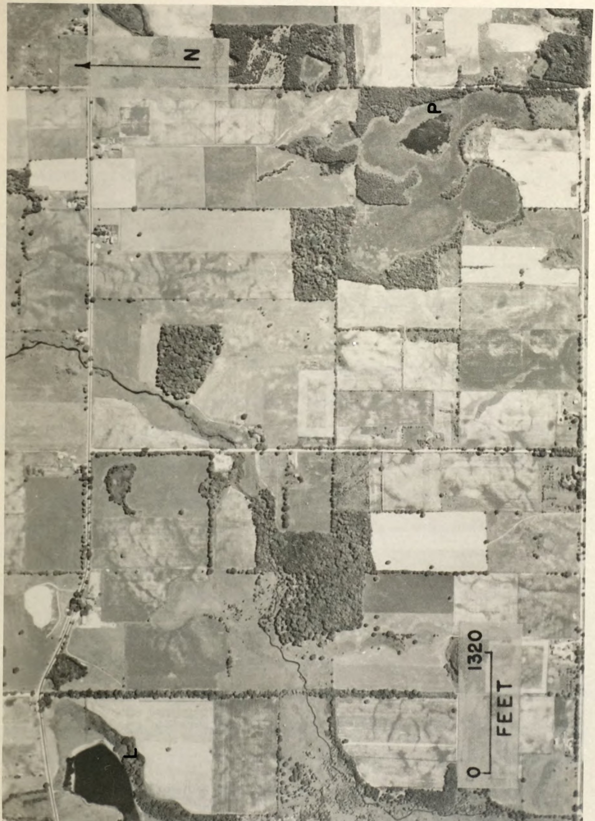
After some preliminary reconnoitering, two areas, Purdy Bog and Lawrence Lake, located in the southern portion of Barry County, Michigan, were selected for study. Their relative locations and surrounding terrain are shown in Figure 1.

These lakes were chosen for study for several reasons. First, they are separated from one another by a distance of only about 1.4 miles, yet represent highly diverse lake types. Second, they are located in the same general drainage basin, that of Augusta Creek. Third, their topographic location assures that they should have the same geologic history in respect to age and glaciation. Fourth, they are conveniently located to M.S.U. and the laboratory facilities of Gull Lake Biological Station, and thus permitted frequent investigation, especially during summer months. In addition, their approximation allowed for sampling both study areas on the same day. Finally, no previous comprehensive studies had been made of either lake.

The surface geology of the region surrounding the lakes has resulted from events which took place during recessions and readvances of glacial ice in the Wisconsin glacial period. Because of the importance of geologic structure and age on the development of lake basins and their flora (Pearsall, 1921; Gessner, 1929; Prescott, 1951a; Wade, 1952), a brief review of the geologic history of the region is pertinent. Most

Figure 1

Aerial view of Lawrence Lake (L) and Purdy Bog (P), showing their relative locations and the gently rolling terrain which surrounds them. Photo copied from U.S.D.A. Commodity Service Print.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of this information is contained in the works of Leverett (1917) and Leverett and Taylor (1915).

The lakes are located on a sandy, gravelly outwash plain in the interlobate tract formed by the junction of the Lake Michigan and Saginaw ice lobes, and thus lie in a region which has received outwash from two different ice sheets. In general, this interlobate tract is of knob and basin (knob and kettle) topography, and, as might be expected, small lakes and marshy depressions are common throughout its extent. Bedrock of the region is of Carboniferous age, largely of the Marshall formation. The soil is of diverse origin, but shows a medium to strong influence from limestone.

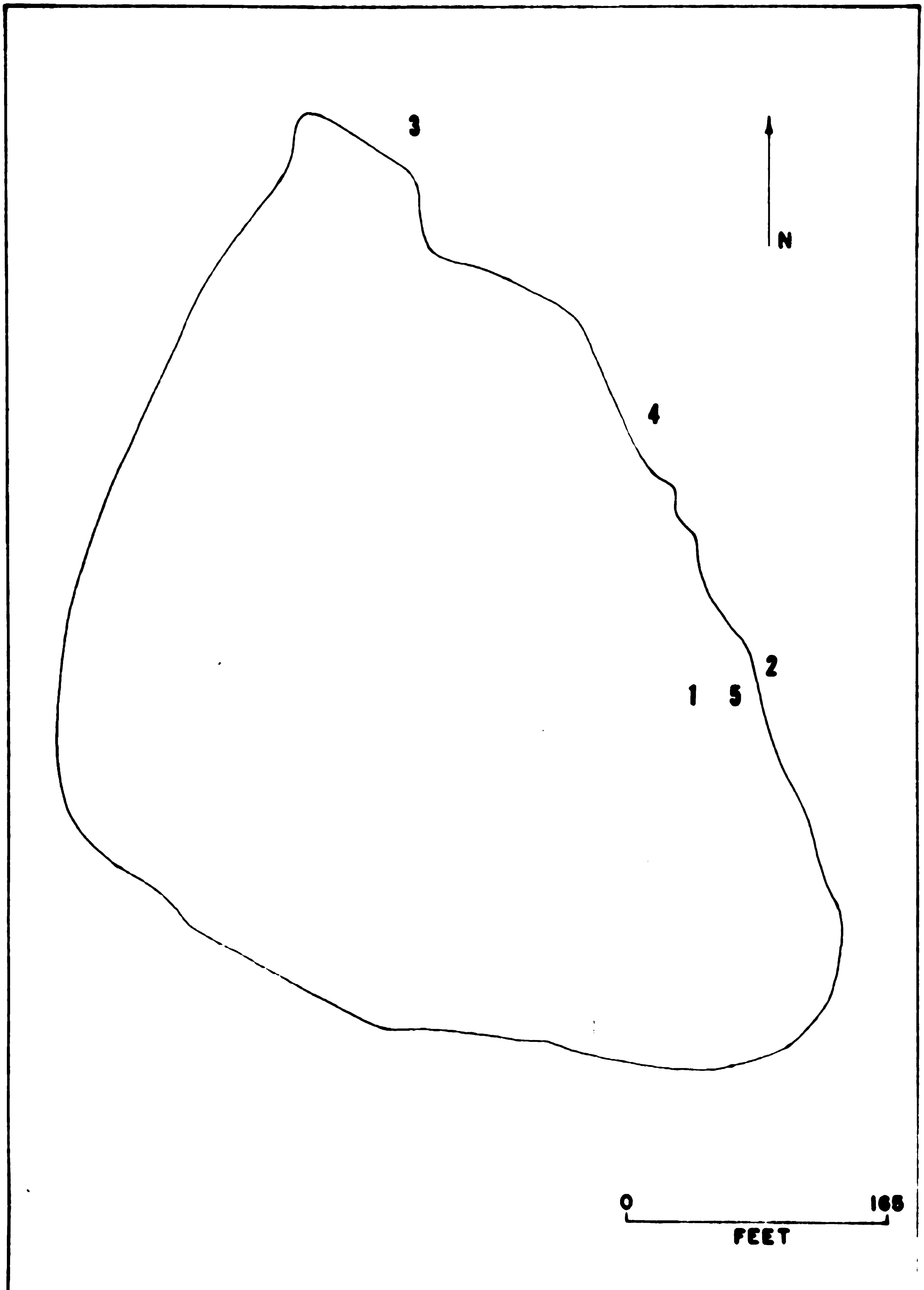
According to Veatch (1953), Lawrence Lake lies within the Fox-Oshtemo-Plainfield soil association, whereas Purdy Bog borders on this and the Bellefontaine-Hillsdale-Coloma association, being more under the influence of the former soil series. Deeter and Trull (1928) characterize the general soil surrounding both areas as Fox Sandy Loam: level or undulating soils with little run-off, acid in the upper layers, but neutral or alkaline below.

The soil immediately surrounding Purdy Bog is Greenwood Peat, while that of Lawrence Lake is Carlisle Muck. A further discussion of these soil types will be made in a later section.

The two lake areas were subdivided into a series of smaller habitat sampling stations for purposes of study (Figures 2, 3). These were not chosen arbitrarily, but with one purpose in mind: to allow a study of algal species distribution within each of the study areas, as well as a comparison of one with the other, and to ensure the investigation of diverse sites within the bounds of the larger study region which might

Figure 2

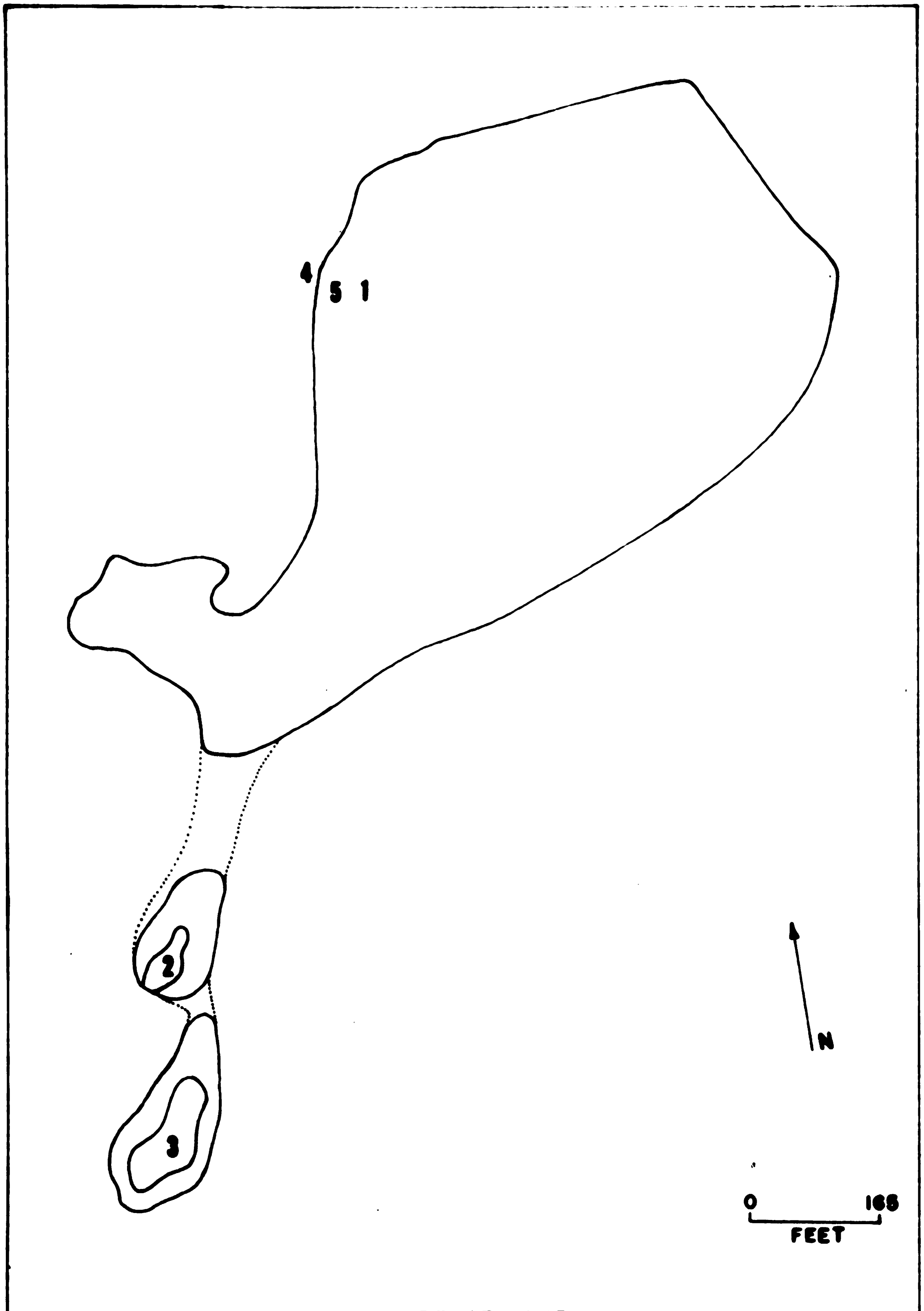
Outline map of Purdy Bog showing the relative locations of the sampling stations for habitats 1 to 5. (Re-drawn from enlargement of U.S.D.A. Commodity Service Print)



PURDY BOG

Figure 3

Outline map of Lawrence Lake showing the relative locations of the sampling stations for habitats 1 to 5; outlet portion of lake (3) at lower left. (Re-drawn from enlargement of U.S.D.A. Commodity Service Print)



LAWRENCE LAKE

represent different environmental situations.

A brief description of the study areas is presented below.

Purdy Bog

Location and Description

Purdy Bog is an acid bog located in T. 1N., R. 9W., northwest quarter of Section 36. This bog, typical of glacial bogs in the Great Lakes region, is referred to as a "sphagnum", "open water" or "quaking" bog (Figures 4, 5). It has developed from a body of water over which a semi-floating mat of vegetation and peat has partially encroached, leaving an area of open water in the center. The mat is thickest at the shoreward edge where peat deposits are greatest, and becomes thinner toward the lake.

The soil within the bog is Greenwood Peat (Deeter and Trull, 1928; Veatch, 1941). This is a highly acid, brown or yellow, coarse, fibrous peaty material, existing in deposits up to 40 or 50 feet thick, which contains relatively small proportions of inorganic matter, or ash.

Because the bog has not been described previously, it is appropriate to present its salient features. To do this, it will be necessary to describe in general the plant associations or communities which surround the lake, as well as to describe the lake itself. A more complete discussion of the latter will be given under Description of Habitats, below.

The center lake (Figures 2, 5) is approximately ovoid in outline, and is located in a small basin which is surrounded by low, wooded hills. It is quite shallow, having a maximum water depth of less than seven feet. This depth is reached only in one small depression in the lake,

Figure 4

View of Purdy Bog, showing a portion of the sphagnum mat (foreground), the center lake and the surrounding terrain.

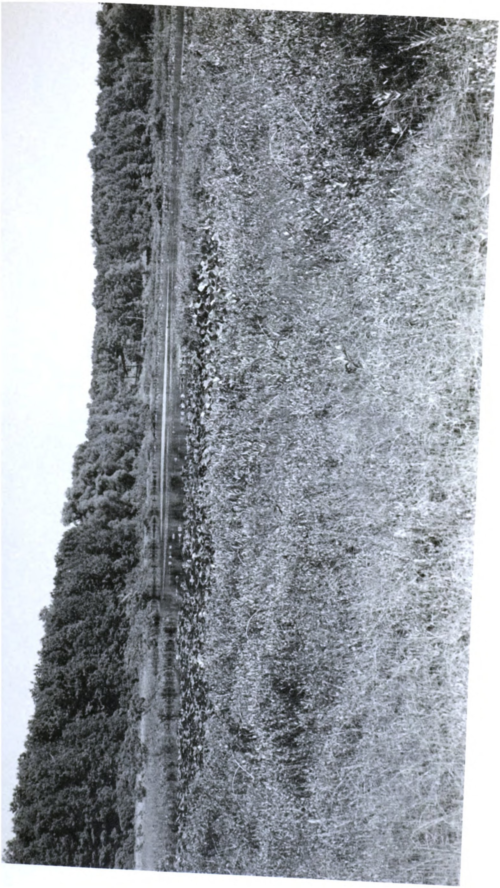
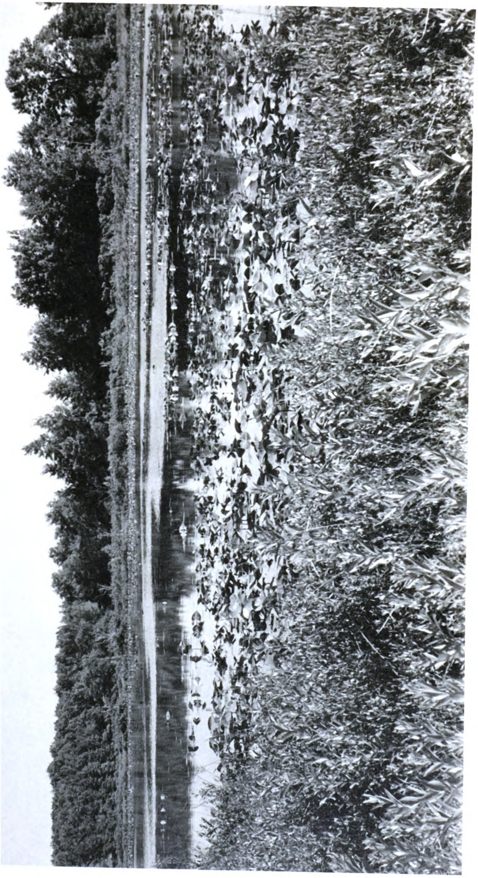


Figure 5

A portion of the center lake at Purdy Bog, showing the extensive growths of Nuphar advena and N. variegatum in the marginal regions. Taller vegetation in foreground is Decodon verticillatus.



much of it having a depth of only two to three feet of water (Depth to a solid bottom is somewhat greater, however, as noted below). The marginal region is particularly shallow, and is being invaded by extensive growths of Nuphar advena Ait., and N. variegatum Engelmann (Figure 5). Here are found also Utricularia purpurea Walt. and Eriocaulon septangulare With., along with some Potamogeton sp. and Nymphaea tuberosa Paine. The latter is fairly common in deeper portions of the lake as well.

The sphagnum mat which surrounds the lake is so extensive that only the portion close to the lake was studied in respect to macrophytic vegetation. As with most bogs of this type, the vegetation tends to be organized into concentric zones around the bog lake. No major emphasis was placed on delimiting the complete flora of each zone, although a brief description of the dominant vegetation seems pertinent here.

The primary mat invader in this area appears to be Decodon verticillatus (L.) Ell., because an association dominated by this species borders the lake at the shoreline. Immediately behind the Decodon is a region of low vegetation which could be termed the Bog Meadow Zone. It consists primarily of a substratum of Sphagnum spp., peat, Polytrichum spp. and the interwoven roots of vascular plants, such as Vaccinium macrocarpon Ait., Andromeda glaucophylla Link, Eriophorum virginicum L., Cladium mariscoides (Muhl.) Torr., Rhynchospora alba (L.) Vahl, Sarracenia purpurea L. and Drosera rotundifolia L., along with various species of Carex and Juncus.

This zone blends, through a dense growth of Woodwardia virginica (L.) Sm., into a Shrub Zone dominated by Chamaedaphne calyculata (L.) Moench. Along with this are, in addition to Woodwardia virginica, Vaccinium corymbosum L.,, Cephalanthus occidentalis L., Spiraea tomentosa L., and Rhus Vernix L. The latter species is scattered throughout other zones of the bog also, along with small trees of Acer rubrum L.

No description of the more shoreward portion of the mat will be given here, because algal collections were all obtained within the limits of the Bog Meadow and Bog Shrub zones, and the investigation of macrophytic vegetation was thus confined to these regions of the bog.

Description of Habitats

A series of collecting stations, designated subsequently as Habitats (i.e., Habitat 1, Habitat 2, etc.), were established as noted under Materials and Methods. It was believed that only in this manner could one arrive at an understanding of the bog's total flora and its distribution. In fact, any attempt to describe the algal flora of this bog without taking account of these various habitats would fail to characterize it adequately as an environment. Thus, the following habitats have been selected for study; their location is indicated in Figure 2.

(Note: In this and subsequent discussions, these habitats have been designated both numerically and by a descriptive phrase. This dual terminology is used because of the necessity of using symbols for tabulation and mapping purposes. But, because a symbol or number may not mean much to the reader, the descriptive phrases have been used wherever possible. These phrases are indicated in parentheses beside the symbol for each habitat below; a complete listing of these is shown at the top of each page in Table I.)

Habitat 1 (Center Lake). This region includes the open water of the center lake, although most samples were collected from shore by means of a plankton net. The point of collection is indicated in Figure 2. This particular location was chosen because the prevailing winds are toward shore at this point, and cause lake plankton to be concentrated near the margin.

The center lake is about 420 feet in diameter and 660 feet in length. Because of semi-solid sediments in the lake bottom, depth measurements must be separated into water depth, versus depth to a solid bottom. The water depth from shore out to 10 feet (the region from which most collections were taken) varies between 10 inches and 2 feet (Figures 6, 7); that to a solid bottom from 23 inches to 6 feet, 8 inches. The maximum water depth of the lake is slightly over 6 feet, 6 inches, whereas the maximum depth to a solid bottom is 19 feet, 6 inches.

The water is colored brown by suspended colloidal materials, largely of humic origin. The pH of the water varies between 5.2 and 6.5, classifying it as an intermediate or weakly acid lake.

The shallow nature of the water in the vicinity of this collecting station can be seen easily in Figures 6 and 7. As shown also, the bottom is at times covered by extensive growths of filamentous algae. The dominant bottom vegetation here is Eriocaulon septangulare With. Floating mats of Utricularia purpurea Walt. are common also, and become abundant during the summer months. Decodon verticillatus (L.) Ell. is abundant along the margins of the habitat, along with Nuphar advena Ait. and N. variegatum Engelm.

Habitat 2 (Sphagnum Mat). This habitat includes the water enclosed

Figure 6

View of the collecting station for the center lake (Habitat 1) and lake bottom (Habitat 5) habitats in Purdy Bog, showing the shallow depth of the water and the extensive filamentous growths on the bottom.

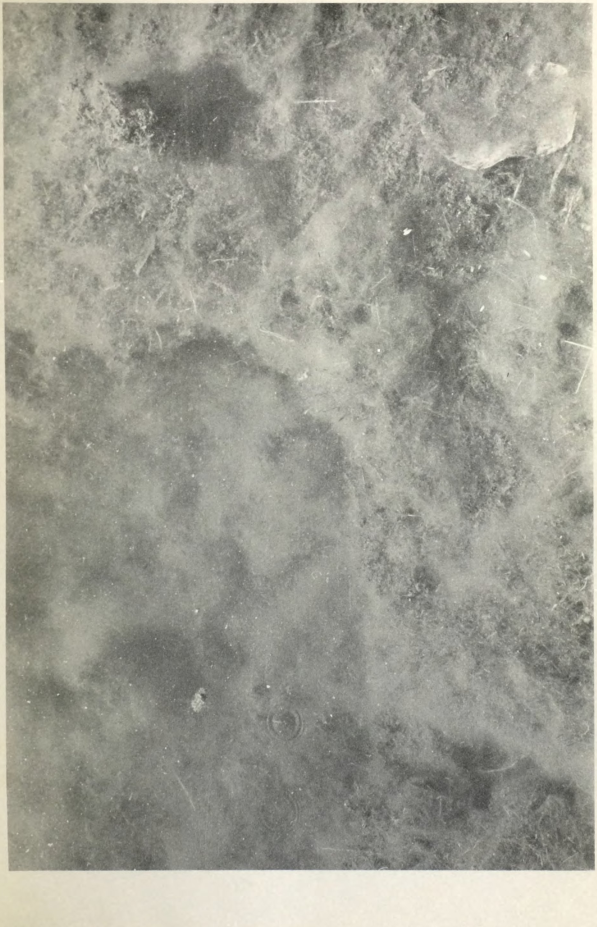
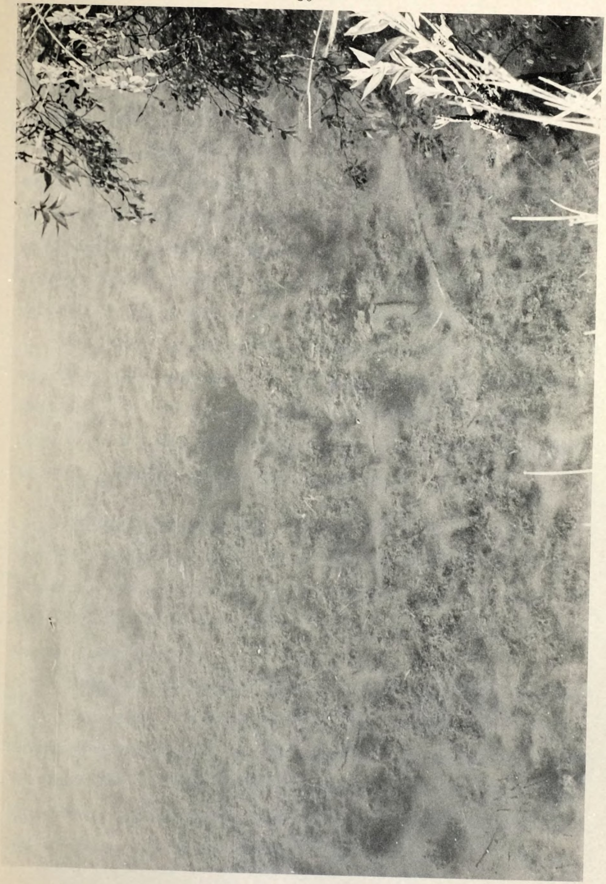


Figure 7

Another view showing the extensive filamentous growths and the shallow nature of the water in the vicinity of the collecting stations for the center lake and lake bottom in Purdy Bog. _Decodon verticillatus_ toward the right.



within the sphagnum or peat of the bog mat. In actual practice, most samples were collected from the mat near Habitat 1, as indicated in Figure 2. The distance from the lake margin to the collecting station is about 7 feet.

Because algae were never present in any abundance in the mat itself, a shallow hole 4 inches in depth and about 14 inches in diameter was dug into the vegetation (Figure 8), and the water in this was compared with that within the sphagnum mat. This depression is considered also as a portion of Habitat 2, and reports of algal collections from this habitat include samples from both the mat and depression.

As shown in Figure 8, various sedges and rushes, as well as cranberry and sundew, were common in this region of the bog, and surrounded the depression. The vegetation within the depression was largely sphagnum (with peat), and all collections from this habitat were taken by making squeezings of these latter materials.

Habitat 3 (Sphagnum Pool). A small, rather shallow (depth 1 to 1.5 feet) water-filled hole in the mat has been designated as Habitat 3 (Figure 9). This habitat is approximately 2 by 3 feet in diameter, and lies at a distance of about 26 feet from the lake margin, 470 feet from Habitat 2 (see Figure 2).

Figure 9 shows the dense growths of aquatic plants in and around this sphagnum pool. As indicated by the name, the pool contains an extensive bed of sphagnum, and dense growths of *Utricularia* spp. so fill the water that the medium is almost semi-solid. All collections from this habitat were taken by squeezing water from sphagnum and *Utricularia*. The marginal plants of this habitat are similar to those of Habitat 2,

Figure 8

A portion of the sphagnum mat (Habitat 2) in Purdy Bog, showing the shallow hole from which many samples were collected. Fifty-cent piece at upper left for size comparison.

Figure 9

The sphagnum pool (Habitat 3) in Purdy Bog, showing the dense growths of aquatic plants in and around this habitat. Fifty-cent piece on <u>Nuphar</u> leaf for size relationships.

although in addition *Nuphar advena* Ait. grows within the pool, and young growths of *Decodon verticillatus* (L.) Ell. surround it.

Habitat 4 (Marginal Pool). This habitat actually consists of three water-filled holes (pools) (Figures 10, 11, 12, 13) through the sphagnum mat, which lie close to, and in some cases interconnect with, the water of the center lake. They are about 165 feet from the collecting station for the center lake, and about 230 feet from the sphagnum pool (Habitat 3). Separate records were maintained of the algae from each of these pools, but the collection records were combined for the purpose of this report because the pools contained, with few exceptions, the same kinds of algal species.

The pool closest to the lake (Figure 13) is 12 feet long by 8 feet in diameter, has a maximum water depth of 10-12 inches, and is directly connected to the center lake by means of a Y-shaped channel. Ten feet away from this one, and about 8 feet from the lake edge, lies a second pool (Figure 11) 7 feet long by 3.5 feet in diameter, which has a solid bottom at a depth of about 10 feet. The third pool (Figure 12) is about 4 by 5 feet in diameter, lies about 11 feet from the lake edge, and has a depth of about 5 feet to a solid bottom. It is 16.5 feet away from the first pool, 6.5 feet from the second one; all three pools lie almost in a straight line (Figure 10).

Figures 11 to 13 show the dominant vegetation of these marginal pools, which is similar except for the greater dominance of *Decodon* surrounding the first-described pool (Figure 13). The water of this pool is fairly free from extensive aquatic growths, although *Nuphar* leaves almost cover the surface. The bottom is largely of peat deposits,

Figure 10

The series of marginal pools (Habitat 4) in Purdy Bog, showing their relative location to one another and to the center lake. The pool in the foreground (3) is about four feet in diameter, and lies at a distance of about 11 feet from the lake edge. The relative locations of the other two pools are indicated by the poles near the center and background of the figure. Enlarged views of these pools are shown in Figures 11, 12 and 13.


2
3

Figure 11

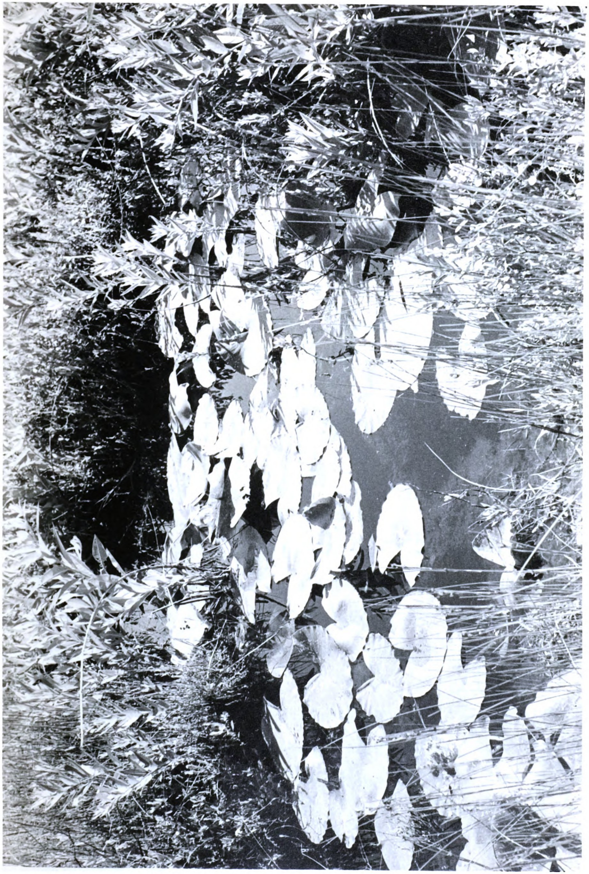
An enlarged view of the center pool (2) in Figure 10, showing the dense growths of aquatic vegetation within. _Decodon verticillatus_ at left of picture.

Figure 12

An enlarged view of the pool shown in the foreground (3) of Figure 10. Larger-leaved plants are Decodon.

Figure 13

View of the marginal pool in Purdy Bog which lies closest to the center lake. This pool is directly connected to the center lake by means of channels which extend through the *Decodon* (background). The water is fairly free of aquatic vegetation, although *Nuphar* leaves almost cover the surface.



decaying vegetation and sphagnum, and it was from squeezings of these that algal collections were obtained.

In contrast to this first pool, the water of the other two was usually densely filled with aquatic plants (Figures 11, 12), especially Utricularia and sphagnum, and algal collections were taken by making squeezings of these aquatic growths.

Habitat 5 (Lake Bottom). The organic debris and aquatic plants of the lake bottom at the collecting station for Habitat 1, as well as submerged portions of marginal plants which grow along shore, are included in this habitat (Figures 6, 7). Essentially, it consists of the lake bottom and associated plants in the vicinity from which plankton samples were obtained.

This habitat was selected as a check against the occurrence of algal species which might appear in the plankton samples due to agitation of bottom materials during sampling. It also serves as a comparative reference for the primarily non-planktonic collections taken from the marginal pools. The dominant vegetation of this habitat has been described previously under Habitat 1, above. Algal collections were obtained from the lake bottom by making squeezings of Eriocaulon septangulare and other aquatic plants, as well as of the decaying bottom organic debris and peat.

In respect to the plant zones mentioned earlier, all mat habitats with the exception of the sphagnum pool (Habitat 3) lie within the limits of the Bog Meadow; the latter borders the Shrub Zone.

Lawrence Lake

Location and Description

Lawrence Lake is a hard-water marl lake located in T. 1N., R. 9W. on the northern border of the southwest quarter of Section 27. In contrast to Purdy Bog, the soil surrounding the lake is Carlisle Muck, rather than peat. This is a dark-brown to black, loamy muck 3-5 inches deep, which is usually underlain by a layer of very finely divided material (black in color) that extends to a depth of 12-18 inches and then grades into undecomposed material (Deeter and Trull, 1928; Veatch, 1941). It is neutral or alkaline in reaction and contains high amounts of lime and nitrogen.

The lake itself is about 1500 feet in length, has a maximum diameter of 620 feet, and at present a maximum depth of about 15 feet (see paragraph below). Because of the encroachment of terrestrial vegetation into the lake in two regions, the lake is almost subdivided into three bodies of water (Figures 1, 3) which are described below.

The lake has been dredged recently for marl, hence its natural morphometry is difficult to describe. Also, neither the date of dredging nor the original shape of the basin are known, and because it is so difficult to judge the possible influence of dredging on the lake's flora and physical-chemical features, especially when the time factor is unknown, any attempt to state depths or describe contours could lead to misinterpretations. The lake is, however, a relatively shallow one, although certainly deeper than that of Purdy Bog.

Large deposits of marl are evident on the lake bottom, and much of the attached vegetation is similarly marl-encrusted, testifying to the hardness of the water in terms of carbonates. These encrustations also make difficult the identification of aquatic plants to species.

The lake water is so clear that extensive patches of aquatic plants can be sighted easily on the bottom. Large beds of *Chara*, especially *Ch. contraria* A. Br. and *Scirpus subterminalis* Torr. line the lake bottom in many areas, along with some *Najas flexilis* (Willd.) Tostk. and Schmidt. Plants typical of the deeper water in the lake include various species of *Potamogeton*, among them *P. praelongus* Wulf., *P. gramineus* L. (and varieties), and *P. amplifolius* Tuckerm., along with some *Myriophyllum* and *Utricularia* spp.

Scirpus validus Vahl and *S. acutus* Muhl. form large patches along the shoreline in many places, and extend out into the water. Other plants growing in the marginal areas of the lake include *Nymphaea tuberosa* Paine, *Nuphar advena* Ait., *N. variegatum* Engelm., *Asclepias incarnata* L. and several species of *Carex* which are listed below.

The dominant vegetation immediately surrounding the lake in most areas is *Potentilla fruticosa* L., although various grasses and sedges are common also. Among these are *Carex hystericina* Muhl., *C. aquatilis* Wahlenb., *C. Bebbii* Olney, *C. lasiocarpa* var. *americana* Fern., *C. rostrata* Stokes, *C. cryptolepis* (*flava*?) Mackenzie and *Sorghastrum nutans* (L.) Nash. Characteristic shrubs include *Rhus Vernix* L., *Salix candida* Flugge, *Salix* spp. and *Sambucus canadensis* L. In certain regions also *Typha latifolia* L. and various species of *Cornus*, especially *C. stolonifera* Michx., form extensive patches, usually at some distance back from the shoreline.

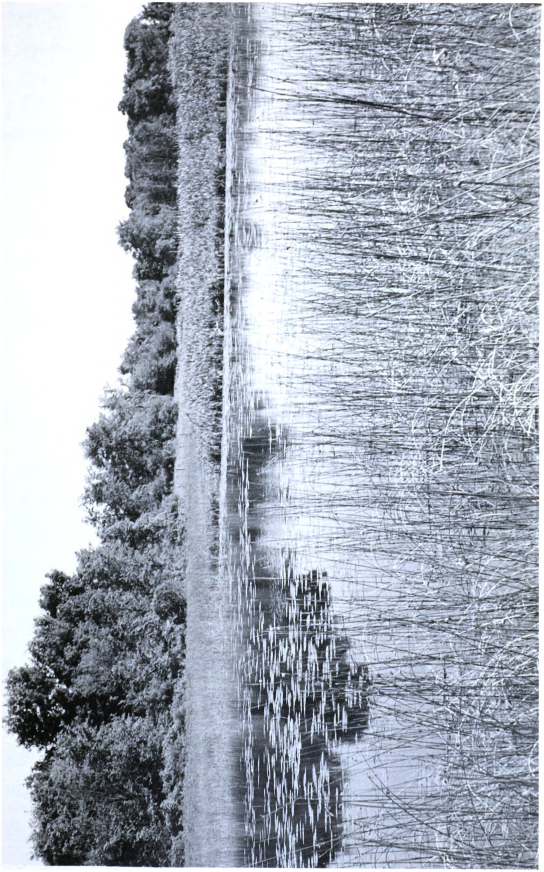
In two regions of the lake, extensions of macrophytic vegetation grow from opposite shores to form an almost continuous bridge, through which only a narrow channel of open water persists (Figures 1, 14, 15).

Figure 14

Intermediate portion of Lawrence Lake (Habitat 2), showing the vegetational bridge which partially separates this habitat from the main portion of the lake (background). Taller rush-like vegetation is *Scirpus acutus* and some *S. validus*.

Figure 15

Another view of the intermediate portion of Lawrence Lake, facing toward the outlet portion. The vegetational bridge which separates these two habitats can be seen just in front of the row of trees toward the background. The dominant vegetation toward the left of the bridge is *Scirpus*, that toward the right is *Typha latifolia*.



Even these are partially closed due to extensive growths of aquatic plants within the channels. These extensions are described further, below.

Description of Habitats

Due to the extension of aquatic plants into the lake basin in two regions (Figures 14, 15), Lawrence Lake is almost subdivided into three bodies of water. The largest of these (Figures 1, 3) was studied more intensively than the other two; investigations of the latter were included primarily to determine whether this partial subdivision of the lake proper had resulted in the formation of aquatic environments which might support an algal flora different from that of the main body of water. These lake regions are described below as Habitats 1, 2, and 3; their relative locations are indicated in Figure 3.

Habitat 1 (Main portion of Lake). This is the largest region of water in the lake (Figures 3, 16), designated subsequently as the main portion of Lawrence Lake. It has a maximum diameter of 620 feet, a length of 1050 feet, and is separated from other lake regions by a vegetational barrier consisting largely of sedges (Figure 14). The dominant plants in this barrier are various species of *Carex* and *Scirpus*, largely *S. acutus* and *S. validus*.

As in Purdy Bog, this habitat represents the open water of the main lake portion, although collections were taken primarily from shore by means of a plankton net, and always from the same station (Figure 3). This sampling station was chosen again to take advantage of the concentrating action of wind on the plankton in this vicinity of the lake. It was located also in an area of deeper water, so that there was less

Figure 16

General view of Lawrence Lake, showing the surrounding vegetation and terrain. The intermediate and outlet portions of the lake are located toward the background, but cannot be seen, in this view.

chance of including bottom materials in the plankton samples.

The bottom here is covered by extensive marl deposits, and beds of Chara. The pH of the water varies seasonally between 7.2 and 8.3. Readings for total alkalinity ranged from 148 to 236 ppm calcium carbonate.

The vegetation surrounding this portion of the lake is much as has been described above (Figure 16, 17); a mixture of sedges and grasses dominated by Potentilla fruticosa.

Habitat 2 (Intermediate Portion of Lake). This water area, located between habitats 1 and 3 (Figure 3), has a maximum diameter of about 125 feet, a length of about 165 feet, and is separated from the main portion of the lake by the sedge extensions mentioned above (Figure 14). Only a narrow water channel is maintained between these two bodies of water, and even this is partially closed by extensive growths of Nuphar advena Ait., N. variegatum Engelm., and various species of Myriophyllum.

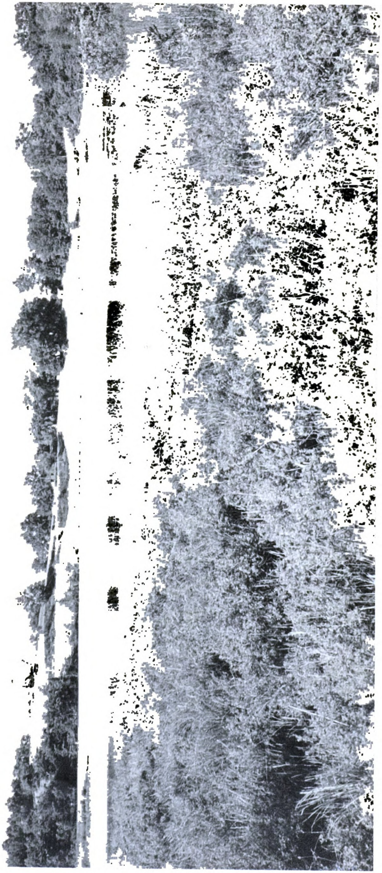
In and along this portion of the lake are found growing Nymphaea tuberosa Paine, Potamogeton amplifolius Tuckerm., Nuphar advena Ait., N. variegatum Engelm., Typha latifolia L., Decodon verticillatus var. laevigatus T. and G., Scirpus validus Vahl, and some S. acutus Muhl., along with several species of Utricularia and Myriophyllum.

Algal samples were collected from this habitat by means of a plankton net, but, because of its shallow nature, bottom materials and floating filamentous forms were included also.

Habitat 3 (Outlet Portion of Lake). This habitat represents the small portion of the lake near its outlet (Figure 3). It is of about

Figure 17

Another view of the main portion of Lawrence Lake, showing the dominant shoreline vegetation, *Potentilla fruticosa*.



the same size as Habitat 2, and has a maximum diameter of 125 feet, a length of 205 feet. It is separated from Habitat 2 by extensions of vegetation from the eastern and western margins of the lake (Figures 15, 18). Those from the western shore are composed largely of *Decodon verticillatus* var. *laevigatus* T. and G. and *Typha latifolia* L., whereas those from the eastern shore consist primarily of *Scirpus acutus* Muhl. and *S. validus* Vahl, along with other sedges, especially the genus *Carex*. Only a narrow water channel separates this region of the lake from Habitat 2, but even this is partially closed by extensive growths of *Myriophyllum* spp., *Nuphar advena* Ait., and *N. variegatum* Engelm.

This outlet portion of the lake is the one least resembling the other two habitats; in fact, it little resembles any other region of Lawrence Lake (Figure 18). For example, much of the water it contains is brownish in color, much like that of a bog, and quite different from the clear water of the main and intermediate portions. Further, it lies in a more "boggy" or swampy area surrounded by growths of various sedges and grasses as well as aquatic mosses and *Decodon*. Dense patches of *Nuphar advena* Ait., *N. variegatum* Engelm., and other aquatic plants are evident in the shallow water along shore. A small stream enters the lake here, and the lake outlet is through a smaller stream which flows through a nearby pasture.

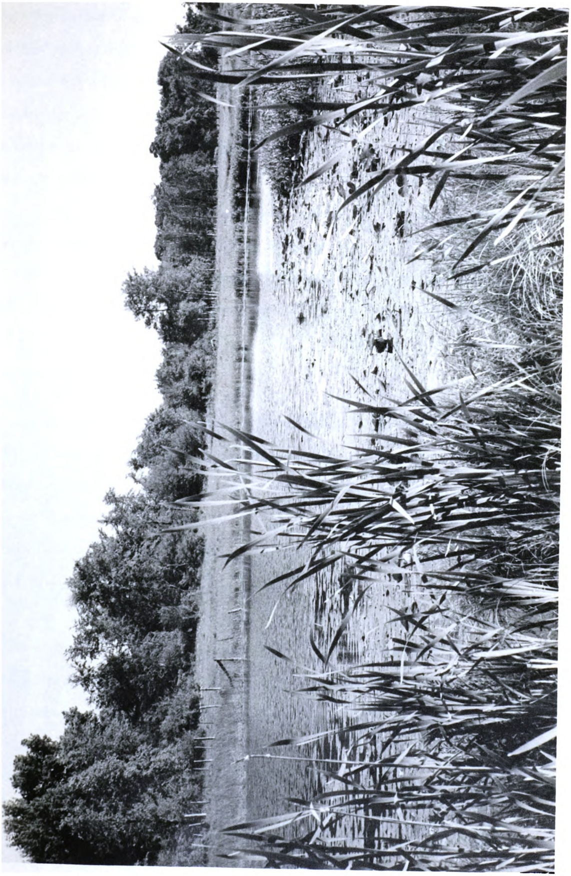
Although not studied extensively, this habitat was chosen to compare the algal flora here with that in the main portion of the lake.

As in Habitat 2, samples were collected by means of a plankton net, although many bottom and marginal forms were doubtless included.

Habitat 4 (Marginal Pool). A shallow pool in the muck shoreline,

Figure 18

View of the outlet portion of Lawrence Lake (Habitat 3), taken from the vegetational bridge which separates this habitat from the intermediate portion of the lake. Dominant plants of shallow water are largely *Nuphar advena* and *N. variegatum*. *Typha latifolia* in foreground.



near the collecting station for the main portion of the lake, was studied periodically and designated as Habitat 4 (Figures 3, 19). It is about 6 inches deep, 3 feet wide by 8 feet in length, and is surrounded by grasses and sedges, primarily Carex spp. Its inclusion in the study permits a comparison with the main lake flora, and with the marginal pools of Purdy Bog.

The surface water of this pool was frequently covered by extensive filamentous growths, as shown in Figure 19. Most samples taken from this habitat were squeezings of bottom materials and aquatic vegetation, along with the filamentous growths, when present. Because it contained a predominantly diatom flora, little emphasis was placed on a thorough study of this habitat.

Habitat 5 (Lake Bottom). This habitat includes the bottom sediments of the main portion of the lake at the collecting station for Habitat 1. Formed largely of marl depositions, it was almost continuously covered by thin wefts of Schizothrix lacustris. The dominant bottom vegetation here was Chara, especially Ch. contraria A. Br., along with some Najas flexilis.

Collections were taken from this habitat by loosening pieces of bottom material, especially those covered by evident filamentous growths, and by squeezing bottom vegetation. As with Habitat 4, few algae other than diatoms were present, and the habitat was not studied intensively for that reason.

Figure 19

View of the marginal pool (P) in Lawrence Lake (Habitat 4), showing the extensive patches of filamentous algae which occur in this habitat. The pool is surrounded by _Carex_ spp. The open water toward the right of the picture is near the collecting station for Habitat 1.


P

CHAPTER IV

RESULTS

The Algal Flora

Annotated list of Species

The following list of algal species is intended to be more than a mere taxonomic summary, in that brief descriptions are given of the majority of species which were observed during the study. It includes as well an analysis of the temporal and spatial distribution of each species, involving a topic which will be treated in greater detail in succeeding sections. Distribution records cited for each species refer to the collection stations or habitats which were described earlier.

The plate and figure citations located to the right of the names indicated as new records or new taxa refer to illustrations which are included in the current paper. The citations immediately below the names of species which represent new records refer to authoritative works wherein more complete descriptions or other illustrations are available, and in most instances indicate the description upon which the determination is based. Where a species has been recorded for Wisconsin, but not for Michigan, in Prescott (1951a) the appropriate description of Wisconsin material is cited.

No attempt has been made to illustrate or to describe completely the various species noted during the study, nor are their original descriptions cited in most instances. The writer has chosen, rather, to cite a more readily available source from which adequate and accurate descriptions and illustrations may be obtained. Illustrations and complete descriptions are given below only for those forms which are recorded rarely, which represent new records for Michigan, the United States or North America, or which represent apparently new taxa. Many of the species regarded as being new records for North America must be designated tentatively as such, pending further investigations. Several of these may have been reported previously, but because no descriptions or illustrations accompanied the report their occurrence cannot be substantiated. Valid records for the occurrence of taxa have been accepted only if accompanied by adequate verifying data.

The scheme of classification used below varies somewhat, depending upon which division or group of algae is being described. It is difficult to find one reference work which includes a complete and commonly-used system of classification which covers all groups of algae. In general, the following reference works have been used as guides for the classification of the various divisions noted:

I. Chlorophyta: Prescott, 1951a; Huber-Pestalozzi, 1961

II. Chrysophyta: Huber-Pestalozzi, 1941

III. Pyrrhophyta: Huber-Pestalozzi, 1950

IV. Euglenophyta: Huber-Pestalozzi, 1955; Pringsheim, 1956

V. Cyanophyta: Geitler, 1932; Prescott, 1951a

VI. Rhodophyta: Prescott, 1951a

The reference works most frequently used for the determination of these species include: Prescott, 1951a (all groups but desmids); Huber-Pestalozzi, 1938-1961 (planktonic forms in all groups); Geitler, 1932 (Cyanophyta); West and West, 1904-1912, West, West and Carter, 1923 (desmids); Tiffany, 1937 (Oedogoniales); Pringsheim, 1956 (Euglenophyta); Transeau, 1951 (Zygnematales); Skuja, 1948, 1956 (colorless forms, Chrysophyta and Euglenophyta); G. M. Smith, 1916-1924a (planktonic forms); Schiller, 1937 (Pyrrhophyta); Pascher, 1927, Pascher and Lemmermann, 1913, 1914 (flagellates); Irénée-Marie, 1939 (desmids); Krieger, 1933-1937, 1939 (desmids). In addition, the personal library and iconograph of Dr. G. W. Prescott have been extremely useful in the determination of species in all algal groups, especially the desmids.

It should not be assumed, however, that the following list is a complete one, even though every effort was made to identify all species possible with the literature available. The identification of diatoms requires in most instances that one be a specialist in this field; thus, only the more readily identifiable or common species are included in the study (Table I), although none are described below.

The flagellates also present a special problem, although much emphasis was placed on their study. Where they have not been identified it is because of a lack of sufficient specimens for study, the absence of "key" characters in the material, which are necessary for a definitive determination (e.g., number and arrangement of flagella), or the absence of adequate illustrations or descriptions in the literature.

The order of presentation of the following divisions is that of Prescott (1951a).

I DIVISION CHLOROPHYTA

Class: Chlorophyceae

Order: Volvocales

Family: Polyblepharidaceae

Hyaliella Pascher

Hyaliella polytomoides Pasch. Pl. 1, Fig. 12

Huber-Pestalozzi (1961) p. 41; Pl. VII, Fig. 30A

Cells colorless, free living, elliptical to ovate, weakly metabolic. Flagella 2, anterior. Cytoplasm densely filled with irregularly shaped starch bodies (usually rod-like to ellipsoid), and with tiny globular bodies of unknown composition, either oil droplets or volutin. Nucleus not clearly seen, but located in the anterior half of the cell. Cells 12-17μ long, 8-11μ wide.

Separated from *Polytoma* by the absence of a lorica. See Huber-Pestalozzi (1961) for a description and illustrations.

Distribution: Sphagnum mat of Purdy Bog. New record for Michigan, and probably for North America.

Occurrence: December through March; usually under an ice cover.

Family: Chlamydomonadaceae

Carteria Diesing

Carteria sp.

Cells motile by means of 4 long flagella. Chloroplast parietal, usually cup shaped. Stigma usually present, anterior.

Only a few cells of this genus were ever observed, and these were

insufficient to make a specific determination.

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Observed during May.

Chlamydomonas Ehrenberg

Chlamydomonas ambigua Gerloff Pl. 1, Fig. 4

Huber-Pestalozzi (1961) p. 332; Pl. LXVII, Fig. 404

Cells ellipsoidal, broadly rounded at both ends; papilla present at anterior end. Chloroplast dark green, reaching almost to the anterior apex, with several pyrenoids (usually 5 in ours); pyrenoids in an "x" pattern, or 2 opposite one another, the others in a different plane if less than 5 are present. Two contractile vacuoles, in the anterior portion of the cell. Flagella about body length, or slightly longer. Cells about 17-19μ in diameter.

Distribution: Center lake of Purdy Bog. New record for Michigan, and probably for North America.

Occurrence: Observed only in December.

C. Cienkowskii Schmidle Pl. 1, Fig. 6

Prescott (1951a) p. 70; Pl. 1, Fig. 4

Cells elongate-ellipsoid to cylindrical, with rounded ends and almost parallel sides; papilla present at anterior end. Chloroplast parietal, covering most of the cell wall. Several pyrenoids present, irregular in position. Stigma large, near the anterior end. Contractile vacuoles present in anterior portion. Flagella shorter than the body. Cells 28-31μ long, 11-14μ in diameter.

See Huber-Pestalozzi (1961) for an illustration and description.

Distribution: Center Lake and lake bottom in Purdy Bog. New record for Michigan.

Occurrence: November to April; observed sporadically.

C. elliptica Korsch. Pl. 1, Fig. 5

Huber-Pestalozzi (1961) p. 270; Pl. LIV, Fig. 317

Cells ellipsoidal, rounded at both ends; papilla present at anterior end. Chloroplast parietal, covering most of the wall, somewhat top-shaped; pyrenoid 1, lateral, about median in the longitudinal axis of the cell. Stigma small, anterior. Two anterior contractile vacuoles present. Flagella shorter than, to about body length (in ours). Cells 21μ long, 14μ in diameter.

For a description and illustration, see Huber-Pestalozzi (1961).

Distribution: Marginal pools of Purdy Bog. New record for North America.

Occurrence: Observed during November and December.

C. media Klebs (?) Pl. 1, Fig. 2

Huber-Pestalozzi (1961) p. 271; Pl. LIV, Fig. 321

Cells elliptical, with an anterior papilla. Chloroplast parietal, covering most of the cell wall, somewhat top-shaped. Stigma anterior. Pyrenoid lateral, about median in the longitudinal axis of the cell. Two anterior contractile vacuoles present. Flagella about body length. Cells 17μ long, 12μ in diameter.

Large numbers of this organism were observed, but only in one collection; along with the larger cells, many smaller forms resembling the gametes of this species were seen. Reproduction was never observed,

however.

See Huber-Pestalozzi (1961) for a complete description and illustrations.

Distribution: Sphagnum mat of Purdy Bog. Tentative new record for North America.

Occurrence: Observed during April.

C. subcompleta, new species. Pl. 1, Fig. 3

Cells elliptical to subcylindric, produced posteriorly into a short deflexed caudus, anteriorly into a conical papilla. Cell wall relatively thick, gelatinous in appearance. Flagella 2, about 1/2 body length. Chloroplast parietal, somewhat top-shaped, covering the cell wall; pyrenoid 1, lateral, in the anterior half of the cell. Stigma lateral, subspherical to elliptic, located slightly anterior to, and usually opposite, the pyrenoid. Two anterior vacuoles present. Nucleus difficult to observe, apparently located in the median portion of the cell below the vacuoles. Cytoplasm occasionally with rounded inclusions of unknown composition. Reproduction by division of contents to form daughter cells within old mother cell wall, the immature cells apparently at first lacking a caudus. Cells 16-23μ wide, 41-55μ in length; flagella about 20-25μ long.

This organism belongs to the subgenus _Chlamydella_, section _Monopleura_. See Huber-Pestalozzi (1961).

Distribution: Marginal pools and sphagnum mat in Purdy Bog.

Occurrence: Observed from November through May.

Chlamydomonas spp.

Several other forms of this genus were observed which could not

be identified to species, because only a few individuals of each were seen. Because the genus was of frequent occurrence, however, it is maintained here as an important floral element.

Distribution: In all habitats of Purdy Bog.

Occurrence: Observed during every month of the year. Common to abundant in April, July, November and January.

Gloeomonas Klebs

Gloeomonas ovalis Klebs, sensu Pascher Pl. 1, Fig. 9

Pascher (1927) p. 327; Fig. 296

Cells subspherical to broadly ellipsoidal, surrounded by a wide layer of mucilage. Chloroplasts numerous, discoid, variable in size, closely packed, parietal; pyrenoids absent. Stigma anterior and lateral, usually near base of one of the flagella. Flagella widely separated in origin, distinctly longer than the body, thicker and straight toward the proximal portion for about 1/3 their length, then flexible and whip-like in the distal two-thirds.

Resting stages Gloeocystis-like, the individual cells surrounded by a few (usually 2-3) layers of firm mucilage, the whole embedded in a wider layer of a more watery mucilage. Our cells (with sheath) 18-28.5μ wide, 23-24μ in length; flagella up to 46μ in length, usually about 1/3 longer than the body (including sheath).

The taxonomic status of this species remains in dispute. The illustration in Pascher (1927) does not show the full length of the flagella, and apparently other writers have shown only the flagella length as indicated in this figure. Because the present author can find no description of the flagella which agrees with those described

above, it appears that further observations are necessary before an exact description of the organism can be given. A rich collection of this material is at hand, and detailed studies will be made subsequently.

Distribution: Marginal pools, sphagnum pool and sphagnum mat in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence throughout the year; common in November.

Chlorogonium Ehrenberg

Chlorogonium spp.

Several evidently-different species of this genus were observed in our collections; however, these were always filled with opaque materials, probably by-products of metabolism, so that the cell contents could not be observed critically. Further study involving culture work is necessary for specific determinations.

Distribution: In all habitats of Purdy Bog.

Occurrence: From November through April. Common in March under an ice cover.

Phacotus Perty

Phacotus Lendneri Chod. (?) Pl. 1, Fig. 1

Cells elliptical in top view, elongate-ellipsoid in side view, calcareous. Protoplast small, near median portion of cell. Cells 12-14μ wide, 14-16μ long.

Questionably placed here because only 2 specimens were seen; both were intermediate between P. lenticularis (Ehrenb.) Stein and

P. Lendneri. The former is the commonly-reported form.

Distribution: Main portion of Lawrence Lake. Tentative new record for Michigan.

Occurrence: Noted during June.

Phacotus spp.

Several other forms of this genus were observed which could not be identified to species because of a lack of sufficient specimens for study.

Distribution: Center lake and spagnum pool in Purdy Bog; outlet portion of Lawrence Lake.

Occurrence: Observed during May, September and November.

Family: Volvocaceae

Gonium Mueller

Gonium pectorale Mueller

See Prescott (1951a) for a description and illustration.

Distribution: Main and intermediate portions of Lawrence Lake.

Occurrence: June through September.

Pandorina Bory

Pandorina morum (Muell.) Bory

Only 2 colonies of this species were observed. See Prescott (1951a) for a description and illustration.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed during August.

Order: Tetrasporales

Family: Palmellaceae

Sphaerocystis Chodat

Sphaerocystis Schroeteri Chod.

See Prescott (1951a) for a description and illustration.

Distribution: Center lake of Purdy Bog, and main portion of Lawrence Lake.

Occurrence: From May through November; abundant in Purdy Bog during May, in Lawrence Lake during June.

Gloeocystis Naegeli

Gloeocystis planctonica (West and West) Lemm.

For an illustration and description, see Prescott (1951a).

Distribution: Sphagnum and marginal pools, as well as lake bottom, in Purdy Bog.

Occurrence: Sporadic.

G. vesiculosa Naegeli

See Prescott (1951a) for a description and illustration.

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Noted in July.

Palmodictyon Kuetzing

Palmodictyon varium (Naeg.) Lemm.

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed only during October.

Astercoccus Scherffel

Asterococcus limneticus G. M. Smith

For a description see Smith (1920); Prescott (1951a)

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in October; probably of more frequent occurrence.

Family: Tetrasporaceae

Tetraspora Link

Tetraspora gelatinosa (Vauch.) Desvaux

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed only in May.

Family: Chlorangiaceae

Chlorangium Stein

Chlorangium spp.

Several forms of this genus were observed, but these were not identified because necessary culture studies were not undertaken.

Distribution: Center lake in Purdy Bog; main portion of Lawrence Lake. On microcrustacea.

Occurrence: From February through August.

Family: Coccomyxaceae

Elakatothrix Wille

Elakatothrix gelatinosa Wille

See Prescott (1951a) for a description and illustration.

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: September through December; also in May.

Order: Ulotrichales

Family: Ulotrichaceae

Geminella Turpin

Geminella mutabilis (Bréb.) Wille — Pl. 1, Fig. 8

Prescott (1951a) p. 101; Pl. 6, Fig. 16

Cells in uniseriate filaments, enclosed in a broad mucilaginous sheath. Chloroplast covering about 2/3 of the cell wall, parietal, laminate. Cells shorter than broad, up to longer than broad, usually somewhat cylindric or rectangular, 9-10μ in diameter, 5-11μ long.

The cells illustrated here are somewhat shorter than usual, but otherwise agree well with this species.

Distribution: Marginal pools and center lake in Purdy Bog. New record for Michigan.

Occurrence: May through July.

Binuclearia Wittrock

Binuclearia tatrana Wittr.

For a description, see Prescott (1951a).

Distribution: Marginal pools, lake bottom and center lake in Purdy Bog.

Occurrence: Observed from April through December.

Order: Microsporales

Family: Microsporaceae

Microspora Thuret

Microspora pachyderma (Wille) Lagerh.

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: April through June.

M. stagnorum (Kuetz.) Lagerh.

For a description, see Prescott (1951a).

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: Noted sporadically; May through July, also in November.

M. tumidula Hazen

For a description, see Prescott (1951a).

Distribution: In all habitats in Purdy Bog.

Occurrence: Found throughout the year.

Order: Chaetophorales

Family: Chaetophoraceae

Stigeoclonium Kuetzing

Stigeoclonium subsecundum Kuetz.

See Prescott (1951a) for a description and illustrations, or Islam (1960).

Distribution: Marginal pools, lake bottom and center lake in Purdy Bog.

Occurrence: Observed from September through April; abundant under the ice from November through January.

Chaetophora Schrank

Chaetophora elegans (Roth) C. A. Agardh

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during November and January.

Microthamnion Naegeli

Microthamnion Kuetzingianum Naeg.

For a description, see Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in January and April.

M. strictissimum Rabenh.

See Prescott (1951a) for a description and illustration.

Distribution: Marginal and sphagnum pools, as well as lake bottom, in Purdy Bog.

Occurrence: October to January, also April and May. Common in sphagnum pool during April.

M. strictissimum var. macrocystis Schmidle (?) Pl. 3, Fig. 5

Hazen (1902) p. 192; Pl. 27, Fig. 1

Separated from the typical by the long, tapering, colorless apices of the filaments. Cells about 2.3μ in diameter, usually 9μ and above in length.

See Hazen (1902) for a discussion of this variety.

Distribution: Marginal and sphagnum pools in Purdy Bog. Tentative new record for Michigan.

Occurrence: Observed in October and April.

Protoderma Kuetzing

Protoderma viride Kuetz.

Filaments short, creeping over other algae. See Prescott (1951a) for a description and illustration.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Observed only during January and February, under an ice cover.

Aphanochaete A. Braun

Aphanochaete polychaete (Hansg.) Fritsch   Pl. 5, Fig. 9

Prescott (1951a) p. 125; Pl. 17, Fig. 1

Filaments creeping over other algae; sparsely branched. Each cell bearing 2-4 setae, in ours usually 2 or 3. Cells rectangular to rounded in outline, 10-15μ in diameter, 11-15μ long. On *Mougeotia* spp.

Distribution: Sphagnum mat, marginal pools and lake bottom in Purdy Bog; outlet portion of Lawrence Lake. New record for Michigan.

Occurrence: September through December.

Family: Coleochaetaceae

Coleochaete de Brébisson

Coleochaete divergens Pringsheim

Our colonies were immature, and thus cell sizes were smaller than those usually given; otherwise, characteristics as for the species. See Prescott (1951a) for a description.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during October; probably of more frequent occurrence.

C. orbicularis Pringsh.

For a description and illustration, see Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in October, but probably of more frequent occurrence.

C. soluta (Bréb.) Pringsh.

See Prescott (1951a) for a description.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed from September through December.

Chaetosphaeridium Klebahn

Chaetosphaeridium globosum (Nordst.) Klebahn

See Prescott (1951a) for a description.

Distribution: Marginal pools, lake bottom and sphagnum mat in Purdy Bog.

Occurrence: Observed from September to June; probably of more frequent occurrence.

C. Pringsheimii Klebahn

For a description and illustration, see Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed only during December, but probably of more frequent occurrence.

Dicranochaete Hieronymus

Dicranochaete reniformis Hieronymus

A rarely-found species; see Prescott (1951a) for a description

and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Found from September to January.

Order: Cladophorales

Family: Cladophoraceae

Cladophora Kuetzing

Cladophora fracta var. *normalis* Rabenh.

For a description, see Prescott (1951a).

Distribution: Lake bottom in main portion of Lawrence Lake; at times, unattached and free-floating.

Occurrence: March through August.

Rhizoclonium Kuetzing; *emend*. Brand

Rhizoclonium hieroglyphicum (C.A.Ag.) Kuetz.

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed once, in April.

Order: Oedogoniales

Family: Oedogoniaceae

Bulbochaete C. A. Agardh

Bulbochaete minuta West and West

For a description, see Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Fertile specimens observed during September.

B. praereticulata Jao (?)

Only immature fertile specimens were ever observed. However, because the appearance of the plant, its size and cell wall ornamentation agree well with this species, it is listed here tentatively. See Tiffany (1937) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Found during December.

Bulbochaete spp.

Many species of Bulbochaete were noted which could not be identified because fertile specimens were never observed. Because the genus was of widespread occurrence and distribution, however, it is maintained here as an important element of the flora.

Distribution: In all three portions of the hard-water lake, but primarily found in the marginal pool, center lake and lake bottom in the acid bog.

Occurrence: Found during every month of the year.

Oedogonium Link

Oedogonium australe (G. S. West) Tiffany

For a description and illustration, see Tiffany (1937).

Distribution: Center lake of Purdy Bog.

Occurrence: Fertile specimens observed in May.

Oe. exocostatum Tiffany Pl. 2, Fig. 5

Prescott (1951a) p. 169; Pl. 30, Figs. 11, 12

Plants macrandrous, dioecious. Vegetative cells cylindric, 14-16μ wide, 102-143μ long. Oogonium solitary (in ours) 40-42μ in

diameter, 80μ long, opening by a superior pore. Oospores ellipsoid, nearly filling the oogonium, outer wall with heavy ridges; spores 36μ in diameter, 65μ long. Antheridia 14μ wide, about 10μ in length. Suffultory cell about 24μ wide.

The oospore is not as indented as shown by Tiffany (1937), otherwise the plant agrees well with the species description.

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: Fertile specimens observed in July.

Oe. macrandrium var. *propinquum* (Wittr.) Hirn

See Tiffany (1937) for a description and illustrations.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Fertile specimens observed in September.

Oe. spiripennatum Jao var. *inferior* new variety Pl. 2, Figs. 1-4

Pore of oogonium inferior, lower cell of dwarf male stipe shorter than described for the species; otherwise, characteristics as for the species.

Differs from *Oe. spiripennatum* by its inferior pore; that of the typical is median. Tiffany (personal communication) believes that pore position in this genus is a constant feature in any taxon, thus necessitating the establishment of this variety.

Plants dioecious, nannandrous, gynandrosporus (in ours; indicated questionably by Tiffany as idioandrosporus); oogonium subglobose, solitary, with an inferior pore. Oospore globose to subglobose, almost filling the oogonium; spore with 5-7 membranous ribs which unite at the poles, giving an echinate appearance in certain views. Suffultory cell swollen.

Dwarf male usually on suffultory cell or on cell above the oogonium. Vegetative cells 10-21.5μ by 77-112μ; oogonium 52-57μ wide, 51-56μ long; oospore diameter 46-51μ; dwarf male stipe (lower cell) 11-13 by 26-31μ; androsporangia 17μ wide, 8-12μ long. Complete dwarf male plants were never observed.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Fertile specimens observed from July to October, but rare.

Order: Chlorococcales

Family: Characiaceae

Characium A. Braun

Characium gracilipes Lambert

See Prescott (1951a) for a description and illustration.

Distribution: Center lake in Purdy Bog.

Occurrence: Noted only in June.

C. rostratum Reinhard

For a description and illustration, see Prescott (1951a).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Observed in October, January and May.

Family: Hydrodictyaceae

Pediastrum Meyen

Pediastrum araneosum (Racib.) G. M. Smith

See Prescott (1951a) for a description.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted in April and July.

P. araneosum var. rugulosum (G. S. West) G. M. Smith

For a description and illustration, see Prescott (1951a).

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Occurs sporadically throughout the year.

P. biradiatum Meyen

For a description, see Prescott (1951a).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found during almost all months of the year; presumably occurs throughout the year.

P. Boryanum (Turp.) Menegh.

A common, although variable, species; see Prescott (1951a) for a description and illustrations.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From May through November.

P. duplex Meyen

Some smooth-walled clathrate specimens are placed here pending further study; they may prove to be only forms of the variety below.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Noted in May, August, November and December.

P. duplex var. cohaerens Bohlin

In spite of the critical study of Pediastrum by Bigeard (1933), there is still some confusion in respect to interpretations of clathrate coenobia. These are in need of further study before any evaluation can

be made of the existing terminology. Because the observed material agrees well with that described for other Michigan lakes, the writer follows Prescott (1951a) and regards this expression as P. duplex var. cohaerens.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found during all months of the year; most abundant during July.

P. integrum Naegeli

A variable species, perhaps representing only a growth form of P. Boryanum. See Bigeard (1933) and Prescott (1951a) for a description and illustration.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: August through December.

P. muticum var. crenulatum Prescott Pl. 1, Fig. 13

Prescott (1951a) p. 226; Pl. 49, Fig. 9

Inner cells 5- 6-sided, walls of adjoining cells and other free surfaces wrinkled or crenulate; otherwise, characteristics as for the typical. Cells 28-29μ in diameter; illustrated colony 154μ in diameter.

Distribution: Marginal pools and lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Found in May, June and September; probably present throughout summer, but rare.

P. tetras (Ehrenb.) Ralfs

A characteristic, although somewhat variable, species; see

Prescott (1951a) for a description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog. More common in the marginal pools.

Occurrence: Of sporadic occurrence throughout the year.

Family: Coelastraceae

Coelastrum Naegeli

Coelastrum cambricum Archer

For a description and illustration, see Prescott (1951a).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

C. sphaericum Naegeli

See Prescott (1951a) for a description and illustration.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; intermediate and outlet portions of Lawrence Lake.

Occurrence: Not found from January to March, otherwise found throughout the year.

Family: Botryococcaceae

Botryococcus Kuetzing

Botryococcus Braunii Kuetz.

A species subject to much variation in the color of its mucilage, which usually is described as being yellowish or dark yellowish to brown in color. For a description and illustration, see Prescott (1951a).

The Purdy Bog material had a clear sheath so that the colonies appeared green; those found in Lawrence Lake had a yellowish to brownish sheath.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main and outlet portions of Lawrence Lake.

Occurrence: Found during every month of the year; more common in the bog lake. Abundant in July.

Family: Oocystaceae

Zoochlorella Brandt

Zoochlorella conductrix Brandt

Cells growing within the tissues of *Hydra*. For a description and illustration, see Prescott (1951a).

Distribution: Center lake of Purdy Bog; outlet portion of Lawrence Lake.

Occurrence: Observed in October and November, but probably of more frequent occurrence.

Z. parasitica Brandt

Cells inhabiting *Spongilla* and various ciliates such as *Stentor* and *Ophrydium*. See Prescott (1951a) for a description and illustration.

Distribution: In all habitats in both study areas.

Occurrence: Found throughout the year.

Trochiscia Kuetzing

Trochiscia reticularis (Reinsch) Hansg.

Care must be used in identifying this genus, because zygospores

of various Volvocales and of desmids may resemble this in general appearance. For a discussion of this genus, see Prescott (1951a).

Distribution: In all habitats of the acid bog except the sphagnum pool.

Occurrence: Observed from December through May.

Planktosphaeria G. M. Smith

Planktosphaeria gelatinosa G. M. Smith

Difficult to separate from Sphaerocystis unless many colonies in different stages of development are observed. For a discussion, see Prescott (1951a).

Distribution: Center lake of Purdy Bog.

Occurrence: Observed in only one collection, December.

Eremosphaera De Bary

Eremosphaera viridis De Bary

See Prescott (1951a) for a description and illustration.

Distribution: Purdy Bog; more common in the marginal pools, but found also on the lake bottom.

Occurrence: During all months of the year except January and February.

Oocystis Naegeli

Oocystis Borgei Snow

See Prescott (1951a) for an illustration and description.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed only in November.

<u>O</u>. <u>parva</u> West and West

For a description and illustration, see Prescott (1951a).

Distribution: Main portion of Lawrence Lake.

Occurrence: Observed only in September.

<u>Nephrocytium</u> Naegeli

<u>Nephrocytium</u> <u>ecdysiscepanum</u> W. West

Prescott (1951a) p. 248; Pl. 54, Fig. 17

Colony broadly ovate, 4-celled (in ours); cells ovoid, adjoined to one another by gelatinized cell wall fragments. Portions of old mother cell wall persisting as fragments in the outer portion of the colony. Cells 22-23μ wide, about 34μ long; colony 80 by 114μ.

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: Observed in June.

<u>N</u>. <u>limneticum</u> (G. M. Smith) G. M. Smith

See Prescott (1951a) for a description and illustration.

Distribution: Main portion of Lawrence Lake.

Occurrence: Observed in June and November.

<u>N</u>. <u>obesum</u> West and West

For a description and illustration see Prescott (1951a).

Distribution: Main portion of Lawrence Lake.

Occurrence: July and August

Ankistrodesmus Corda

Ankistrodesmus falcatus (Corda) Ralfs

For a description, see Prescott (1951a).

Distribution: Common in marginal pools of Purdy Bog; also found on the lake bottom.

Occurrence: Of sporadic occurrence through the year.

A. spiralis (Turn.) Lemm.

For a description and illustration, see Prescott (1951a).

Distribution: Main portion of Lawrence Lake.

Occurrence: Rare; observed once, in November.

Selenastrum Reinsch

Selenastrum Bibraianum Reinsch

Separated from Kirchneriella, below, by the lack of a gelatinous investment. See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

Kirchneriella Schmidle

Kirchneriella lunaris (Kirch.) Moebius

Cells crescent-shaped, strongly curved, ends somewhat pointed. For a description and illustration, see Prescott (1951a).

Distribution: Center lake of Purdy Bog.

Occurrence: Observed in only one collection, in September.

K. lunaris var. irregularis G. M. Smith Pl. 1, Fig. 11

Prescott (1951a) p. 258; Pl. 58, Fig. 4

Separated from the typical by the fact that the cell apices are

twisted away from one another, and point in different directions. Cells about 6μ in diameter, 14μ long.

Distribution: Center lake and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Sporadic; observed in May and October.

K. obesa var. major (Bernard) G. M. Smith

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in only one collection, in April.

Quadrigula Printz

Quadrigula Chodati (Tan.-Ful.) G. M. Smith (?)

Care must be exercized in separating this genus from Elakatothrix, which undergoes cell division. Our cells are in the genus Quadrigula and most resemble Q. Chodati, although the notch in the plastid was never observed positively. In cell shape and proportions, however, it agrees well with this species. Cells 5.7-6.8μ wide, about 40μ long; colony of 4 cells 23 by 74μ. Q. lacustris, which most resembles Q. Chodati, has a maximum length of about 25μ.

For a description and illustration, see Prescott (1951a).

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed only during October.

Family: Scenedesmaceae

Scenedesmus Meyen

Scenedesmus abundans var. asymmetrica (Schroed.) G. M. Smith
Pl. 3, Fig. 3

Prescott (1951a) p. 274; Pl. 61, Figs. 22, 23

A variety in which the outer cells have a spine at each pole, and the inner cells are provided with a median spine perpendicular to the lateral walls. Cells about 5μ wide, 15μ long.

Distribution: Lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Rare; observed only in April.

S. acutiformis Schroeder

See Prescott (1951a) for a description and illustration.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Probably present throughout the year; not observed in March or April.

S. armatus (Chod.) G. M. Smith

Cells up to 8μ in diameter and up to 16μ long. Terminal cells with 2 elongate curved spines at each pole; interior cells with an incomplete median longitudinal ridge.

See Smith (1920) and Prescott (1951a) for a description and illustration.

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: Sporadic; observed in July, August and December.

S. armatus var. major G. M. Smith Pl. 3, Fig. 1

Prescott (1951a) p. 276; Pl. 62, Fig. 15; Pl. 63, Fig. 23

Distinguished from the typical by its larger cells and stouter appearance. Cells 9μ in diameter, up to 27.5μ in length; colony without

spines 34.2μ long, 27.5μ wide; spines about 15μ long.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Throughout the year, although not seen in March.

S. bijuga (Turp.) Lagerh.

See Prescott (1951a) for an illustration and description.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; marginal pool in Lawrence Lake.

Occurrence: Sporadic; most common from September to November.

S. bijuga var. flexuosus (Lemm.) Collins Pl. 5, Fig. 7

Prescott (1951a) p. 277

Coenobia 8- or 16-celled (in ours), arranged in a single series in a loose spiral, or curving plane. Cells broader than in the typical. Illustrated cells 11.4 wide, 23μ long.

Separated from the preceding by the uniseriate series of broader cells which are arranged in a curving, rather than a flat, coenobium. See Smith (1916) and Prescott (1951a) for a description.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence throughout the year.

S. brasiliensis Bohlin

For a description, see Prescott (1951a).

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Of sporadic occurrence from October through December.

S. dimorphus (Turp.) Kuetz.

See Prescott (1951a) for an illustration and description.

Distribution: Common in marginal pools of Purdy Bog; also found in center lake and lake bottom habitats.

Occurrence: Present throughout most of the year.

S. longus Meyen

Distinguished from many species of Scenedesmus by the fact that the poles of all cells have 1-2 spines. Coenobia 2-4-8- (usually 4) celled.

For a description, see Prescott (1951a).

Distribution: Center lake of Purdy Bog.

Occurrence: Observed only in February, under an ice cover.

S. longus var. Naegelii (Bréb.) G. M. Smith

Separated from the typical by the fact that the coenobia are always 8-celled, and the interior cells have spines only on one, rarely on both, poles. For a description and illustrations, see Smith (1920) and Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed only in January, under an ice cover.

S. quadricauda (Turp.) Bréb.

See Prescott (1951a) for a description and illustrations of the typical species and its varieties.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Observed in only one collection, in November.

Crucigenia Morren

Crucigenia irregularis Wille

Separated from C. rectangularis, below, by the fact that the cells are irregularly arranged within the colony. See Smith (1920) and Prescott (1951a) for a description and illustrations.

Distribution: Main portion of Lawrence Lake.

Occurrence: Probably present from June through December; observed in June, July, November and December.

C. rectangularis (A. Braun) Gay

See Smith (1920) and Prescott (1951a) for illustrations and descriptions.

Distribution: Main and intermediate portions of Lawrence Lake.

Occurrence: Found only in November.

Order: Zygnematales

Family: Zygenemataceae

Mougeotia (C. A. Agardh) Wittrock

Mougeotia laetevirens (A. Braun) Wittr.

See Transeau (1951) for a description and illustrations.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Observed in June, July, August and November. Probably present at least from June through November.

M. recurva (Hass.) De Toni

See Transeau (1951) for a description and illustrations.

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Common to abundant during June.

M. scalaris Hass.

For a description and illustration, see Transeau (1951).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during June.

Zygogonium Kuetzing

Zygogonium ericetorum Kuetz. (?)

Because no reproductive structures were ever found, the species can only be assigned tentatively to Z. ericetorum. This is the commonest species of the genus, and the one which is found usually in a sphagnum bog. For a description, see Transeau (1951).

Distribution: In all habitats of Purdy Bog except the lake bottom.

Occurrence: Not noted during January and February, otherwise present throughout the year.

Pleurodiscus Lagerheim

Pleurodiscus sp. Pl. 4, Fig. 6

G. M. Smith (1950) p. 299; Fig. 211

Cells with two expanded disc- or plate-like chloroplasts, one on either side of a central nucleus. Chloroplasts oriented at various angles to one another in different cells. Cell sap purplish. Cells about 22μ wide, 24 to 26μ long. Sexual reproduction not observed. Distinguished from Zygogonium by the disc-like chloroplasts.

A controversial genus. Skuja (1932) has questioned the validity of the genus, although Transeau (1951) recognizes it as distinct from Zygogonium. The writer has found both Zygogonium and Pleurodiscus in this study, and agrees with Transeau that the latter is distinct from Zygogonium.

Distribution: In all habitats of Purdy Bog, except the sphagnum pool. New record for Michigan.

Occurrence: Throughout the year, although not observed in March. Common to abundant from June through December.

Family: Gonatozygaceae

Gonatozygon DeBary

Gonatozygon aculeatum Hastings

For a description and illustration, see Smith (1924a).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From July through September, although not noted in August.

G. Kinahanii (Arch.) Rabenh.

Care must be used to separate this species from certain expressions of Mougeotia. Easily separated from other species of Gonatozygon because of its smooth cell wall. For a description and illustration, see West and West (1904).

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: Common from September through December; observed once in April.

Family: Mesotaeniaceae

Spirotaenia Brébisson

Spirotaenia condensata Bréb.

For a description and illustration, see Krieger (1933).

Distribution: In all habitats of Purdy Bog, except the sphagnum pool; quite rare in the sphagnum mat.

Occurrence: Found during every month of the year. Abundant in July and August.

Cylindrocystis Meneghini

Cylindrocystis Brebissonii Menegh.

See Krieger (1933) for a description and illustration.

Distribution: In all habitats of Purdy Bog except the center lake.

Occurrence: Throughout the year, although not noted in September.

C. Brebissonii var. minor West and West

Separated from the typical by its smaller size. For a description, see Krieger (1933).

Distribution: Marginal pool in Purdy Bog.

Occurrence: Noted in November and April.

C. Brebissonii var. turgida Schmidle Pl. 4, Fig. 5

Krieger (1933) p. 210; Pl. 6, Fig. 10

Cells broadly cylindrical, 1 1/2 to 2 times longer than broad. Illustrated cell 36.5μ long, 19.5μ wide. Distinguished from the typical by its broader proportions.

Distribution: Marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: Noted from April to July.

Netrium (Naegeli) Itzigsohn and Rothe

Netrium digitus (Ehrenb.) Itzigs. and Rothe

See Krieger (1933) for a description and illustrations. Subject to quite a bit of variation; see below for those noted in our collections.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; observed in one collection in all three portions of Lawrence Lake.

Occurrence: Probably present during all months of the year in Purdy Bog, but not noted in March; common during summer.

N. digitus fa. elegans Kossinsk. Pl. 3, Fig. 8

Kossinskaja (1951) p. 85; Pl. 11, Figs. 1, 2

Cells more slender than in the typical, attenuated toward the rounded apices. Our cells about 5.5 times longer than broad, 40μ wide, 220μ long. Measurements according to Kossinskaja are: length, 192-242μ, width, 28-30μ.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for North America.

Occurrence: Of sporadic occurrence.

N. digitus var. lamellosum (Bréb.) Grönbl.

See Krieger (1933) for a description and illustration.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Found during every month of the year. Common to abundant from November to June.

N. digitus var. *Naegelii* (Bréb.) Krieger

For a description and illustrations, see Krieger (1933).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during April and May.

N. digitus var. *parvum* Borge   Pl. 3, Fig. 7

Krieger (1933) p. 216; Pl. 8, Fig. 2

Cells tapering from a broad midregion to the narrowed ends, about 2-3 times as long as broad. Our cells 26-29μ wide, 67-74μ in length.

Distribution: Marginal pools and lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Noted from May through July, also in January.

N. digitus var. *rhomboideum* Grönbl.   Pl. 3, Fig. 6

Krieger (1933) p. 218; Pl. 7, Fig. 5

Cells larger than the preceding variety, rhomboidal, tapering from the broad midregion to the much narrowed apices. Cells 57-92μ wide, 160-297μ long; apices 19.2-21.6μ wide. According to Krieger, 167μ long, 57μ wide, 19μ at the apex.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Sporadic; from September to January.

N. interruptum (Bréb.) Luetk.

See Krieger (1933) for a description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog; observed only once in the plankton.

Occurrence: Found during most of the year, although not noted in February or March; common in April.

N. oblongum (De Bary) Luetk.

See Krieger (1933) for a description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Noted from April to July.

Penium Brébisson

Penium cylindrus (Ehrenb.) Bréb.

For a description and illustrations, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout most of the year.

P. spirostriolatum Barker

See Krieger (1935) for a description and illustrations.

Distribution: Most common in the marginal pools in Purdy Bog; observed once in center lake and lake bottom at Purdy.

Occurrence: Found during most of the months from April to November.

Family: Desmidiaceae

Closterium Nitzsch

Closterium abruptum W. West

See Krieger (1935) for a description and illustrations.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Observed in June and July; probably of more frequent occurrence.

Cl. acerosum (Schrank) Ehrenb.

See Krieger (1935) for a description and illustration.

Distribution: Center lake and marginal pools in Purdy Bog; more common in the center lake.

Occurrence: April to November.

Cl. aciculare T. West

For a description and illustrations, see Krieger (1935).

Distribution: Main and intermediate portions of Lawrence Lake.

Occurrence: Rarely observed; noted in June and November.

Cl. acutum var. tenuis Nordst. Pl. 1, Fig. 10

Krieger (1935) p. 262; Pl. 13, Figs. 16, 17

Cells smaller than the typical, and only slightly curved. Illustrated cell 45.6μ long, 3.4μ wide. According to Krieger, the figures are: length 42-92μ, width 2-5.5μ.

Distribution: Marginal pools in Purdy Bog; observed once in the sphagnum pool. New record for Michigan.

Occurrence: Probably present from April through November, but easily overlooked because of its small size.

Cl. angustatum Kuetz.

For a description, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found sporadically from May to November.

Cl. Baillyanum Bréb.

Difficult to separate from Cl. didymotocum (which see). Ordinarily separated by the fact that the cells of Cl. Baillyanum are smooth-walled and lack a girdle, whereas those of Cl. didymotocum are usually striate, and with a girdle. Young or undivided cells of Cl. didymotocum thus may be called Cl. Baillyanum. Our cells were of mature size, were smooth-walled and lacked a girdle. See Krieger (1935) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From May to November; also noted in March. Common in September.

Cl. cornu Ehrenb., fa.

A form differing from the typical by its smaller length to width ratio, being only 21-26 times longer than broad.

For a description of Cl. cornu, see Krieger (1935).

Distribution: Lake bottom in Purdy Bog.

Occurrence: Observed in two collections; found in January and July.

Cl. costatum Corda var. angustum new variety Pl. 4, Fig. 1

Cells 14-16 times longer than wide, slender, gradually tapering to the apices. Cell wall costate; 5 (usually) to 6 costae visible in face view. Chloroplast ridged, with 10-15 pyrenoids in each chloroplast. A single large gypsum granule in each apex. Cell wall colorless to yellowish-brown, brownish near the apices and occasionally lightly punctate. Cells 24-25μ wide, 358-388μ in length; apex 8-9μ in width.

A variety differing from the typical and from var. Westii Cushman

by its much more slender appearance and proportions, and by the greater number of pyrenoids.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted in January, April and July.

_Cl_. _Cynthia_ De Not.

For a description and illustrations, see Krieger (1935).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only in July, but probably of more frequent occurrence.

_Cl_. _Cynthia_ var. _Jenneri_ (Ralfs) Krieg.

For a description and illustration, see Krieger (1935).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only in November.

_Cl_. _Dianae_ Ehrenb.

See Krieger (1935) for a description and illustrations.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed during October and November.

_Cl_. _Dianae_ var. _pseudodianae_ (Roy) Krieg.

See Krieger (1935) for a description and illustrations.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: From May through July; also observed in January.

Cl. didymotocum Corda

See note under *Cl. Baillyanum*, above. For a description and illustrations, see Krieger (1935).

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Of sporadic occurrence from May to November.

Cl. didymotocum var. *glabrum* Borge

See Krieger (1935) for a description and illustrations.

Distribution: Lake bottom in Purdy Bog.

Occurrence: From April through July; also observed in January.

Cl. Ehrenbergii Menegh.

See Krieger (1935) for a description and illustrations.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed only in October; probably of more frequent occurrence.

Cl. gracile Bréb.

For a description and illustrations, see Krieger (1935).

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence from April to December.

Cl. gracile var. *elongatum* West and West.

See Krieger (1935) for a description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Of sporadic occurrence from May to January.

<u>Cl</u>. <u>incurvum</u> fa. <u>latior</u> Irénée-Marie Pl. 1, Fig. 7

Irénée-Marie (1952) p. 10; Pl. 1, Figs. 9, 10

Cells small, curved. Chloroplasts 2; pyrenoids 3 or 4 in each chloroplast. A single gypsum granule in each apex. Separated from varieties of <u>Cl</u>. <u>Venus</u> by its greater degree of curvature, and from <u>Cl</u>. <u>intermedium</u> by its broader proportions. Our cells measured 13.7 by 52.4μ. Width at apex 5-6μ; degree of curvature 170-180.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for the United States.

Occurrence: Of sporadic occurrence throughout the year.

<u>Cl</u>. <u>intermedium</u> Ralfs

See Krieger (1935) for a description and illustrations.

Distribution: Marginal pools and center lake in Purdy Bog.

Occurrence: Noted from April to June, and in November.

<u>Cl</u>. <u>Kuetzingii</u> Bréb.

See Krieger (1935) for a description and illustrations.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Noted during October and November.

<u>Cl</u>. <u>Leibleinii</u> Kuetz.

For a description and illustrations, see Krieger (1935).

Distribution: Marginal pool in Lawrence Lake.

Occurrence: Noted during May and June.

Cl. Libellula Focke

See Krieger (1935) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Observed in almost every month of the year.

Cl. Libellula var. intermedium Roy and Biss.

See Krieger (1935) for illustrations and a description.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Noted throughout most of the year but February and March.

Cl. Libellula var. interruptum (West and West) Donat

For an illustration and description, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence from September through April.

Cl. lineatum Ehrenb.

For a description and illustrations, see Krieger (1935).

Distribution: Intermediate portion of Lawrence Lake.

Occurrence: Observed in November; probably of more frequent occurrence and distribution.

Cl. Lunula (Muell.) Nitzsch

For a description and illustration, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

Cl. Lunula var. intermedium Gutw.

For a description and illustration, see Krieger (1935).

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Noted from April to November.

Cl. Malmei Borge Pl. 4, Fig. 3

Krieger (1935) p. 372; Pl. 37, Fig. 8

Cells strongly curved, about 4.4-5.9 times longer than wide. Cell wall colorless, occasionally brownish toward the apices; wall costate, 9-11 costae visible across face of cell. Chloroplasts each with 10-12 pyrenoids (according to Krieger, 7-9); 1-2 gypsum granules in apex. Cells 54.7-75μ wide, 286-343μ long; width at apex, 12.5-15μ. Degree of curvature about 125.

Agrees well with the species description except for the number of pyrenoids and upper limits of cell width. Not distinct enough from the typical to warrant the creation of a new taxon without further study.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence throughout the year.

Cl. Navicula (Bréb.) Luetk.

See Krieger (1935) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found in all months of the year except February and March.

Cl. *parvulum* Naeg.

For a description and illustrations, see Krieger (1935).

Distribution: Of sporadic distribution; noted in marginal pools and lake bottom in Purdy Bog, as well as in the marginal pool, main and outlet portions of Lawrence Lake.

Occurrence: Of sporadic occurrence throughout the year.

Cl. *parvulum* var. *angustum* West and West.

See Krieger (1935) for a description and illustrations.

Distribution: Main portion of Lawrence Lake.

Occurrence: Observed once, in June.

Cl. *pronum* Bréb.

For a description and illustrations, see Krieger (1935).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Rare; noted in only one collection, in January.

Cl. *Ralfsii* var. *hybridum* Rabenh.

For a description and illustrations, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From May to August; also noted in November.

Cl. *Ralfsii* var. *hybridum* fa. *sigmoideum* Irénée-Marie Pl. 4, Fig. 2

Irénée-Marie (1939) p. 76; Pl. 2, Fig. 4

Semicells twisted on their axis at an angle of 180 degrees, otherwise as in the typical. Irénée-Marie found rich samples of this form and thus regards it as a separate taxon.

Distribution: Lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Observed only once, in July; with the typical plant.

Cl. setaceum Ehrenb.

For a description and illustrations, see Krieger (1935).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; noted once in sphagnum pool at Purdy.

Occurrence: Observed during almost every month of the year.

Cl. subfusiforme Messik. Pl. 3, Fig. 9

Messikommer (1951) p. 54; Pl. 1, Fig. 9

Cells subfusiform, tapering from the broader midregion to the narrowed, truncate apices. Cell wall smooth, girdle absent. Chloroplasts each with 2 longitudinal ridges; pyrenoids about 5 per semicell (in ours). Length of cells 210-231μ, width 22.8-23.5μ; width at apex 5-8μ.

Distribution: Marginal pools and lake bottom in Purdy Bog. New record for North America.

Occurrence: From September to January, also in May.

Cl. subulatum (Kuetz.) Bréb.

For a description and illustrations, see Krieger (1935).

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted only in January, under an ice cover.

Cl. tumidulum Gay Pl. 4, Fig. 4

Krieger (1935) p. 279; Pl. 14, Figs. 19-21

Cells strongly curved, about 6 times longer than broad; midregion of cells tumid, apices acute. Cell wall smooth, colorless; girdle bands absent. Chloroplast ridged, with (in ours) 4 pyrenoids. Illustrated cell 19.4μ wide, 128μ long; apices 3.6μ wide. Degree of curvature about 150.

Resembles Cl. parvulum, which never has a tumid midregion according to descriptions. Listed as a new record pending further studies.

Distribution: Main portion of Lawrence Lake. Tentative new record for Michigan.

Occurrence: Noted in only one collection, in May.

Cl. ulna Focke

For a description and illustrations, see Krieger (1935).

Distribution: Center lake in Purdy Bog.

Occurrence: Of infrequent occurrence; noted in June, October and December.

Cl. ulna Focke, fa.

A form differing from the typical by its narrower, more tapered, semicells. This form does not agree exactly with any published descriptions of Cl. ulna, but it has not been observed frequently enough to warrant the erection of a new taxon.

Distribution: Center lake in Purdy Bog.

Occurrence: Noted once, in June.

Docidium Brébisson

Docidium undulatum Bail., fa.

Our form is intermediate between the typical and the var. semi-undulatum Scott and Grönblad (1957). For a description and illustrations of the typical, see Krieger (1937).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted once, in December.

Pleurotaenium Naegeli

Pleurotaenium constrictum (Bail.) Wood

For a description and illustration, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Present throughout the year, although not noted in February.

P. Ehrenbergii (Bréb.) DeBary

See Krieger (1937) for a description and illustrations of this.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Found throughout the year, but not noted in March; common in May.

P. minutum (Ralfs) Delp.

See Krieger (1937) for a description and illustrations.

Distribution: Typically found in the sphagnum pool, but occurs also in the marginal pools, at Purdy Bog.

Occurrence: Found only from April to November, but probably present during winter also.

P. nodosum (Bail.) Lund

For a description and illustrations, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found during every month of the year.

P. nodosum var. Borgei Grönblad Pl. 3, Fig. 2

Krieger (1937) p. 437; Pl. 47, Fig. 4

Separated from the typical on the basis of the more prominent protuberances from the wall, and the flattened areas between them. Cells 47-51μ wide, 307-400μ long.

Some of our specimens were intermediate between this variety and the typical; the flat areas separating the protuberances, as well as the tapering of the semicells toward the apices, are regarded here as the distinguishing features of the variety. It appeared to be more common in our collections than the typical plant.

Distribution: Found with the typical species; center lake, lake bottom and marginal pools in Purdy Bog. New record for North America.

Occurrence: Found throughout the year.

P. subcoronulatum var. detum West and West

See Krieger (1937) for a description and illustrations.

Distribution: Never noted in the sphagnum pool; in all other habitats of Purdy Bog.

Occurrence: Found during every month of the year.

P. Trabecula (Ehrenb.) Naeg.

For a description and illustrations, see Kreiger (1937).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From June to November; probably of more frequent occurrence.

P. Trabecula var. maximum (Reinsch) Roll.

For a description and illustrations, see Krieger (1937).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From October through December.

P. Trabecula var. rectum (Delp.) W. West

See Krieger (1937) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted from August to October.

P. verrucosum (Bail.) Lund

For a description and illustration, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

Triploceras Bailey

Triploceras gracile Bailey

For a description and illustrations, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

T. verticillatum Bail.

See Krieger (1937) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; found rarely in the sphagnum mat also.

Occurrence: Throughout the year.

Tetmemorus Ralfs

Tetmemorus Brebissonii (Menegh.) Ralfs

For a description and illustrations, see Krieger (1937).

Distribution: Marginal pools, sphagnum mat and sphagnum pool in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

T. Brebissonii var. minor De Bary

See Krieger (1937) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted from April through December.

T. granulatus (Bréb.) Ralfs

See Krieger (1937) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: From April through November.

T. laevis (Kuetz.) Ralfs

For a description and illustrations, see Krieger (1937).

Distribution: Marginal pools and sphagnum pool in Purdy Bog.

Occurrence: Noted from April to October.

T. laevis var. minutus (De Bary) Krieg.

See Krieger (1937) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout most of the year.

Euastrum Ehrenberg

Euastrum affine Ralfs

See Krieger (1937) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

E. affine Ralfs, fa. Pl. 5, Fig. 8

Probably an immature form of E. affine; mentioned here because it resembles E. humerosum Ralfs, sensu Krieger (1937).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted in April.

E. Ciastonii Racib.

For a description and illustrations, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Not noted from February to April, otherwise common throughout the year.

E. crassum (Bréb.) Kuetz.

For a description and illustration, see Krieger (1937).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

E. denticulatum (Kirchn.) Gay Pl. 6, Fig. 2

See Krieger (1937) for a description and illustrations.

Distribution: In all five habitats in Purdy Bog.

Occurrence: Found during most of the year, but easily overlooked because of its small size.

E. denticulatum var. quadrifarium Krieg., fa. Pl. 6, Fig. 4

Krieger (1937) p. 585; Pl. 80, Figs. 20, 21

Separated from the typical on the basis of the 4 facial protuberances which form a square pattern. Our cells had the 4 protuberances in a slightly different arrangement than illustrated by Krieger, and lacked the 2 pores mentioned in his description. The plant illustrated here is 25μ wide, 31μ long; isthmus 5.5μ. Tentatively recorded as a new record for Michigan.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Rarely observed; noted in November, January and April.

E. humerosum Ralfs (?)

There is some confusion in the literature in respect to the proper delimitation of this species, although Ralfs (1848) seems to have described it accurately enough. The figures and description of Krieger (1937) do not agree with those of Ralfs, yet later workers have relied on Krieger's figures and this has led to confusion. Our specimens were somewhat intermediate between E. affine and E. humerosum, thus their questionable listing here.

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: Noted in February and July.

E. hypochondrum fa. decoratum Scott and Prescott   Pl. 6, Fig. 6

Scott and Prescott (1952) p. 386; Pl. 3, Fig. 10

Semicells broad-pyramidate, somewhat 3-lobed; apical lobe truncate. Basal lobes extended laterally, tapering to the rounded apices. Sinus narrow for most of its length, opening outwardly. Face of semicells with a median protuberance; this and the semicells decorated with large granules. Isthmial or supra-isthmial granules present in the midregion of the cell. Illustrated cell 65μ wide, 66μ long, 36.5μ thick; isthmus 13μ.

Separated from the typical by its larger size, and the more prominent semicell decorations. For a description of E. hypochondrum, see Krieger (1937).

Distribution: Main and intermediate portions of Lawrence Lake. New record for Michigan.

Occurrence: Common from June to October.

E. insigne fa. porifera new form   Pl. 7, Fig. 6

Semicells elongate-triangular, with an expanded polar lobe; 2 somewhat mamillate downward-projecting lobes present on the semicell face. Basal lobes acutely rounded. Each semicell with a median pore between the facial lobes, usually toward their base. Cell wall scrobiculate. Illustrated cell 94μ long, 55μ wide, 35μ thick; isthmus 13μ.

Separated from the typical on the basis of the semicell pore.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only in December.

E. insulare var. silesiacum Grönbl. Pl. 5, Fig. 4

Krieger (1937) p. 557; Pl. 76, Figs. 19-21

Cells somewhat shorter than the typical, thus appearing broader; apex slightly more rounded; margins of lateral lobe inclined toward the isthmus. Cells with a facial swelling discernible in side view. Illustrated cell 16μ wide, 22μ long; isthmus about 5μ.

For a description of E. insulare, see Krieger (1937).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Observed only in April and May, but easily overlooked because of its small size.

E. intermedium var. scrobiculatum Schmidle Pl. 6, Fig. 1

Krieger (1937) p. 533; Pl. 71, Fig. 13

Separated from the typical by the presence of 1 or 2 median pores on the face of the semicell between the basal swellings. Illustrated cell 32μ long, 36.5μ wide, 23μ thick; isthmus 11.5μ.

For a description of E. intermedium, see Krieger (1937).

Distribution: Lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Noted during January and April.

E. pinnatum Ralfs

For a description and illustrations, see Krieger (1937).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only from November through March.

E. validum var. glabrum Krieger

For a description and illustrations, see Krieger (1937).

Distribution: Marginal pools in Purdy Bog.

Occurrence: From October to December, also in May.

Micrasterias C. A. Agardh

Micrasterias arcuata Bail.

For a description and illustration, see Krieger (1939).

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted once, in May.

M. denticulata Bréb.

For a description and illustrations, see Krieger (1939).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Of sporadic occurrence; more common in July.

M. depauperata var. Kitchelii (Wolle) West and West   Pl. 7, Fig. 4

A variable species, grading somewhat into the form listed below. For a description and illustrations, see Krieger (1939).

Distribution: Most common in center lake, lake bottom and marginal pools in Purdy Bog; found once in sphagnum mat at Purdy.

Occurrence: Throughout the year.

M. depauperata var. Kitchelii fa. apiculata (Irénée-Marie) new comb.
Pl. 7, Fig. 5

Syn: M. depauperata var. Wollei Cush. fa. apiculata I.-M., 1952

Irénée-Marie (1952) p. 146; Pl. 14, Figs. 2, 3, 4, 5

A somewhat reduced form of the var. Kitchelii in which the polar lobe is reduced to a simple angular lobe, at the end of which one spine or tooth is present. Illustrated cell 116μ wide, 148μ long; isthmus 21μ.

Regarded as a distinct form by Irénée-Marie (1952).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Noted only once, in January.

M. floridensis var. spinosa Prescott and Scott Pl. 5, Fig. 3

Prescott and Scott (1943), p. 74; Pl. 3, Fig. 10.

Separated from the typical by the presence of spines on the margins of the lateral lobes, and along the margins of the polar lobe. Illustrated cell 180μ in diameter. Only one cell of this was ever observed, but there can be no doubt as to its identity. Our specimen had some spines on the face as well as along the margin, but this would appear to fall within the range of variation possible in a population.

For a description of M. floridensis, see Krieger (1939).

Distribution: Center lake in Purdy Bog. New record for Michigan.

Occurrence: Noted only in January, under an ice cover.

M. papillifera var. speciosa (Wolle) Krieg.

A variable form which needs further study to determine its true taxonomic position, especially in reference to other varieties of the species. For a description, see Krieger (1939).

Distribution: Most common in one marginal pool in Purdy Bog; also found in center lake and sphagnum mat at Purdy.

Occurrence: Common throughout most of the year, although not observed in February or March; common in January.

M. pinnatifida (Kuetz.) Ralfs

For a description and illustrations, see Krieger (1939).

Distribution: Most common in marginal pools at Purdy Bog; also found in center lake and lake bottom at Purdy.

Occurrence: Not observed in February or March, otherwise present throughout the year.

M. radiata var. gracillima G. M. Smith

For a description and illustration, see Krieger (1939).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Not observed in February or March, otherwise present throughout the year.

M. rotata (Grev.) Ralfs

For a description and illustration, see Krieger (1939).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From April through November.

M. rotata fa. nuda Irénée-Marie Pl. 5, Fig. 6

Irénée-Marie (1939) p. 230; Pl. 37, Fig. 1

Separated from the typical by its exerted polar lobe and by the laterally-extended basal lobe of each semicell, which has sharp, prominent (usually curved) teeth. Cells 233-272μ in width, 278-281μ long; isthmus about 28-30μ.

This form is almost as common as the typical in our collections.

Distribution: Center lake and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence from June to November.

M. Torreyi (Bail.) Ralfs

See Krieger (1939) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Present throughout the year, although not noted in February.

M. truncata (Corda) Bréb.

A variable species. For a description and illustrations of the typical and its variations, see Krieger (1939).

Distribution: In all habitats in Purdy Bog; most common in sphagnum mat and sphagnum pool.

Occurrence: Throughout the year.

M. truncata (Corda) Bréb., fa.

An undescribed form noted only once. Further study involving more cells will be needed to clarify its status, thus not illustrated or described here.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in January.

M. truncata var. crenata (Bréb.) Reinsch

See Krieger (1939) for a description and illustration.

Distribution: Sphagnum mat, sphagnum and marginal pools in Purdy Bog.

Occurrence: Not noted in February or March, otherwise present throughout the year.

M. truncata var. semiradiata (Naeg.) Cleve

For a description and illustration, see Krieger (1939).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From August to October.

Cosmarium Corda

C. abbreviatum var. planctonicum West and West.

For a description and illustration, see West and West (1908)

Distribution: Marginal pools in Purdy Bog.

Occurrence: Rarely observed; noted only in September.

_C_. _amoenum_ Bréb.

See West and West (1912) for a description and illustrations.

Distribution: In all habitats at Purdy Bog; most common in the marginal and sphagnum pools.

Occurrence: Found during most of the year.

_C_. _amoenum_ var. _mediolaeve_ Nordst.

See West and West (1912) for a description and illustration.

Distribution: Sphagnum mat in Purdy Bog.

Occurrence: Noted only in January, but probably of more frequent occurrence.

_C_. _bacillare_ Luetk. Pl. 8, Fig. 4

Syn: _Penium_ _inconspicuum_ West, in West and West (1904) p. 101; Pl. 10, Figs. 15-17

Cells minute, two (in ours) to three times as long as broad, subcylindrical; cell wall smooth, colorless. Cells slightly constricted in the middle, gradually narrowed to the apices. Illustrated cell 5.7μ wide, 12.5μ long. According to the Wests', the measurements are: length 15-19μ, breadth 4.8-5.8μ.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Noted only in December, but easily overlooked because of its extremely small size.

_C_. _Botrytis_ Menegh.

For a description and illustrations, see West and West (1912).

Distribution: Lawrence Lake; main portion of lake and marginal pool.

Occurrence: From April through July.

C. Cucurbita Bréb.

See West and West (1908) for a description of this.

Distribution: Never observed in lake plankton, but found in all other habitats in Purdy Bog. Most common in sphagnum habitats.

Occurrence: Found during every month of the year. Common in sphagnum pool from July to September.

C. Cucurbita Bréb., fa.

Cells broader in the apical region and with a more acute median constriction. Not regarded as a distinct taxon, but represents a form not noted in the Purdy Bog material.

Distribution: Marginal pool in Lawrence Lake.

Occurrence: Noted only in June.

C. Cucurbita var. attenuatum G. S. West Pl. 5, Fig. 1

West and West (1908) p. 108; Pl. 73, Figs. 34-36

Semicells tapering toward the rounded-truncate apices. Illustrated cell 14μ wide, 23μ long; isthmus 10.3μ. Somewhat smaller than described, and smaller in size than most of the C. Cucurbita observed. Tentatively listed as the var. attenuatum pending further study.

Distribution: Marginal pools in Purdy Bog. Tentative new record for Michigan.

Occurrence: Noted in December and May.

C. cucurbitinum fa. minor (West and West) Luetk.

For a description and illustrations, see West and West (1904).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted in July.

C. depressum (Naeg.) Lund., fa. Pl. 8, Fig. 1

West and West (1905) p. 176; Pl. 62, Figs. 2-5

Cells broader than long, deeply constricted; sinus narrow, opening outwardly. Semicells somewhat elliptical, depressed; sides of semicells rounded. Cell wall finely punctate. Cells elliptical in top view, semicells appearing circular in side view. Chloroplasts 2, each with a pyrenoid. Illustrated cell 34.2μ wide, 35μ long; isthmus 7μ.

Our cells are somewhat intermediate between the typical and var. achondrum (Boldt) West and West.

Distribution: Outlet portion of Lawrence Lake. New record for Michigan.

Occurrence: Observed in October.

C. difficile var. dilatatum Borge

For a description and illustration, see Irénée-Marie (1939).

Distribution: Lake bottom in Purdy Bog.

Occurrence: Rare; noted only in May.

C. exiguum var. pressum West and West Pl. 3, Fig. 4

West and West (1908) p. 64; Pl. 70, Figs. 23, 24

Separated from the typical on the basis of the smaller size and narrower proportions. Semicells narrowed from base to apex. Illustrated cell 6.8μ wide, 14μ in length; isthmus 3.5μ.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Found during November and December.

C. globosum Bulnh.

For a description and illustrations, see West and West (1908).

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Noted only during December.

C. ornatum Ralfs

For a description and illustrations, see West and West (1908).

Distribution: Marginal pools and lake bottom in Purdy Bog; noted once in center lake at Purdy.

Occurrence: Of sporadic occurrence throughout the year.

C. ovale Ralfs

See West and West (1908) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted from December to February.

C. ovale var. Prescottii Irénée-Marie

For a description and illustrations, see Irénée-Marie (1939).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

C. pachydermum Lund.

For a description and illustration, see West and West (1905).

Distribution: Main portion of Lawrence Lake.

Occurrence: Noted only in July.

C. pseudobroomei Wolle

Some specimens showed wide variation in the ornamentation of the semicell wall, but have been included here until more material can be observed. For a description and illustrations, see West and West (1912).

Distribution: Lake bottom and marginal pools in Purdy Bog.

Occurrence: During June and July; noted also in January, enclosed in a thick gelatinous sheath.

C. pseudoconnatum Nordst.

See West and West (1908) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main and outlet portions of Lawrence Lake.

Occurrence: Not noted from February to April, otherwise present throughout most of the year.

C. pseudopyramidatum Lund.

For a description and illustrations, see West and West (1905).

Distribution: In all habitats in Purdy Bog, except the sphagnum mat.

Occurrence: Of sporadic occurrence throughout the year; less frequent from January to April.

C. pyramidatum Bréb.

For a description and illustrations, see West and West (1905).

Distribution: Most common in sphagnum and marginal pools in Purdy Bog; also on lake bottom and in center lake at Purdy.

Occurrence: Not noted in February or March, otherwise present throughout the year. Common from July to September in sphagnum pool.

C. quinarium Lund.

For a description and illustrations, see West and West (1908).

Distribution: In all habitats of Purdy Bog except the sphagnum pool.

Occurrence: Of sporadic occurrence throughout the year, but apparently absent in February and March.

C. Regnellii var. minimum Eichl. and Gutw.

See Taft (1945) for a description and illustration.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: Noted sporadically from May to October.

C. reniforme (Ralfs) Arch.

See West and West (1908) for a description and illustrations.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Found during October and November.

C. retusiforme (Wille) Gutw.

See West and West (1905) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Of sporadic occurrence; noted in May and June, as well as from November to January.

C. scopulorum Borge

For a description and illustration, see Borge (1923).

Distribution: Marginal pool in Lawrence Lake.

Occurrence: Noted only in May.

C. subarctoum (Lagerh.) Racib.

For a description and illustrations, see West and West (1908).

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: Noted only in January.

C. subcrenatum Hantzsch.

See West and West (1908) for a description and illustrations.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted only during January.

C. subcrenatum Hantzsch., fa.

Several observed forms varied from the typical pattern of ornamentation and are included here pending further study.

Distribution: Marginal pools and lake bottom in Purdy Bog; marginal pool in Lawrence Lake.

Occurrence: Noted from April to July.

C. subcucumis Schmidle

For a description and illustrations, see West and West (1905).

Distribution: Marginal pools in Purdy Bog; marginal pool in Lawrence Lake.

Occurrence: Noted from April to May.

C. Turpinii Bréb.

See West and West (1908) for a description and illustrations.

Distribution: Intermediate and outlet portions of Lawrence Lake.

Occurrence: Noted in August and November.

C. Ungerianum (Naeg.) De Bary, fa.

A form somewhat intermediate between this species and C. triplicatum Wolle. More material would have to be studied before an accurate determination could be made. For a description and illustration of C. Ungerianum, see West and West (1908).

Distribution: Main portion of Lawrence Lake.

Occurrence: Noted during July.

C. venustum fa. minor Wille. Pl. 5, Fig. 2

West and West (1908) p. 10; Pl. 66, Fig. 4

Cells only about 2/3 the size of the typical plant. Our cells were about 15-16μ in width, 22-23μ long; isthmus 4-5μ.

The isthmus is somewhat narrower than described; otherwise the plants agree well with available descriptions.

Distribution: Marginal pools and lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence.

C. venustum fa. minor Wille, fa.

A form of the above with irregular thickenings on the semicell face; otherwise resembling the fa. minor.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted once, in July.

Xanthidium Ehrenberg

Xanthidium antilopaeum (Bréb.) Kuetz.

See West and West (1912) for a description and illustration.

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: From June to November.

X. antilopaeum var. minneapoliense Wolle

For a description and illustrations, see Wolle (1892).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

X. antilopaeum var. polymazum Nordst.

For an illustration and description, see West and West (1912).

Distribution: Most common in center lake, lake bottom and marginal pools in Purdy Bog; found once in the sphagnum pool at Purdy.

Occurrence: Found throughout the year.

Arthrodesmus Ehrenberg

Arthrodesmus octocornis Ehrenb.

For a description and illustrations, see West and West (1912).

This is the only representative of the genus noted in our collections. See under Staurodesmus Teiling, however, for species formerly included in this genus.

Distribution: Lake bottom in Purdy Bog.

Occurrence: From May through July.

Staurastrum Meyen

S. aciculiferum (West) Anders., fa. Pl. 7, Fig. 3

West, West and Carter (1923) p. 171; Pl. 134, Fig. 6

A somewhat reduced form of the typical, lacking, in the observed specimens, the "obscure series of minute granules round each margin." (West, West and Carter, 1923). The cells are difficult to illustrate accurately because of their shape, and the difficulty of keeping them in one position for any length of time. Illustrated cell 22μ wide, 27.4μ in length. Resembling some expressions of S. monticulosum, which see.

Distribution: Sphagnum pool in Purdy Bog. New record for Michigan.

Occurrence: Noted in October collections.

S. alternans Bréb.

For a description and illustrations, see West and West (1912).

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: From December to April.

S. anatinum Cooke and Wills

See West, West and Carter (1923) for a description and illustrations.

Distribution: Center lake of Purdy Bog.

Occurrence: From May to August.

S. Brebissonii Arch., fa.

A form in which the semicells are more angularly elliptic than described; otherwise similar to the typical. See West, West and Carter (1923) for an illustration and description of S. Brebissonii.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted once, in May.

S. brevispinum Bréb.

For a description and illustrations, see West and West (1912).

Distribution: Main and intermediate portions of Lawrence Lake.

Occurrence: Noted infrequently from June to November.

S. brevispinum var. retusum (West and West) Borge

For a description and illustration, see West and West (1912).

Distribution: Main portion of Lawrence Lake.

Occurrence: Noted in June, with the typical plant.

S. Cerastes Lund.

See West, West and Carter (1923) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

S. furcigerum Bréb.

For a description and illustrations, see West, West and Carter (1923).

Distribution: Main and intermediate portions of Lawrence Lake.

Occurrence: From June to August.

S. gladiosum Turner

See West, West and Carter (1923) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted once; in December.

S. inconspicuum var. crassum Gay Pl. 5, Fig. 5

West, West and Carter (1923) p. 87; Pl. 141, Fig. 8

Separated from the typical by its smaller size and stouter processes, which are jointed. Width of cells about 12μ, length 11-16μ.

For a description of S. inconspicuum, see West, West and Carter (1923).

Distribution: Sphagnum mat, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Sporadic; noted in December, January and May.

S. margaritaceum (Ehrenb.) Menegh.

For a description and illustrations, see West, West and Carter (1923).

Distribution: Most common in sphagnum mat at Purdy Bog; also found in sphagnum and marginal pools at Purdy.

Occurrence: Of sporadic occurrence throughout most of the year.

S. margaritaceum facies variabile Grönbl.

Grönblad (1956) p. 32; Pl. 12, Figs. 145-147, 152-159.

A variable form of the species, especially in respect to the number of processes; triangular forms resemble S. gracile, but with an increase in the number of angles, the cells approach S. margaritaceum. Because the cells are so variable, the reader is referred to Grönblad (1956) for a description and illustrations of this form. Our material is tentatively assigned here pending further study. Because the status of this taxon is subject to various interpretations, it is not listed

as a new record for the state.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Noted in January and July.

S. monticulosum Bréb. var. Irenee-Mariei new variety Pl. 7, Fig. 7

S. aciculiferum (West) Anders. in Irénée-Marie (1939)

Irénée-Marie (1939) p. 328; Pl. 58, Fig. 1

Cells longer than broad, deeply constricted, with an acute sinus opening outwardly. Semicells subtrapeziform, lower lateral margins convex, upper lateral margins slightly concave; apex truncate to slightly concave or convex. Lower lateral angles with a short, bifurcute (occasionally simple) process. Vertical view triangular; angles acute, terminated by a conical or sharp-pointed process. Apical portion somewhat elevated, showing two bifurcate or simple processes on either side of the angles, these appearing at the apical angles in face view. A series of small granules around cell angles and occasionally on the central portion of the apex. Our cells 23-25μ wide, 27-28.5μ long; isthmus 9-11μ.

Distribution: Sphagnum mat and sphagnum pool in Purdy Bog.

Occurrence: Found throughout the year, usually common.

S. muticum Bréb.

For a description and illustrations, see West and West (1912).

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Noted during July.

S. orbiculare var. depressum Roy and Biss.

For a description and illustrations, see West and West (1912).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only during March.

S. pentacerum (Wolle) Smith

See Smith (1924a) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout the year.

S. punctulatum Bréb., fa.

Our form approaches var. ellipticum Lewin, but more material would be needed to make a definite determination. For a description and illustrations of S. punctulatum, see West and West (1912).

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Noted only in October.

S. quebecense Irénée-Marie Pl. 7, Fig. 1

Irénée-Marie (1939) p. 306; Pl. 47, Fig. 6, Pl. 54, Fig. 5

Cells broader than long (with processes); bases of semicells swollen, with a row of supra-isthmial granules. Sinus acute, opening outwardly. Vertical view triangular; verrucae present at apex, in a circular pattern, 2 between each of the processes. Processes undulate, terminated by 3 or 4 spines at the apex. Illustrated cell: length, 43.3μ, width 19.5μ; width with processes 58μ. Isthmus about 9μ.

Distribution: Main, intermediate and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Noted from June to December.

S. rugosum Irénée-Marie

For a description and illustrations, see Irénée-Marie (1939).

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: Noted in June and October.

S. setigerum var. occidentale West and West

For a description and illustrations, see Smith (1924a).

Distribution: Main portion of Lawrence Lake.

Occurrence: Noted only from June through September.

S. Simonyi Heimerl

See West, West and Carter (1923) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted during July.

S. tetracerum Ralfs

For a description and illustrations, see West, West and Carter (1923).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted in January.

S. urinator G. M. Smith Pl. 6, Fig. 5

G. M. Smith (1924a) p. 107; Pl. 79, Figs. 16-18

Cells cup-shaped with elongated undulate processes; lateral margins of semicell bases semicircular, with an erect spine in the median portion. Cells 2-armed in vertical view, processes in a straight line; apex somewhat elliptic, bearing 3 verrucae along each lateral margin. Face of semicell in median portion showing 1, occasionally 2, truncate to rounded projections. Illustrated cell 56μ long with

processes, 32μ without processes; breadth with processes 64μ, without processes 18-20μ. Isthmus 11μ.

Resembles *S. bioculatum* Taylor (1935).

Distribution: Center lake and lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Rare; noted in January and May.

S. vestitum var. *subanatinum* West and West

For a description and illustrations, see West, West and Carter (1923).

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: Found throughout most of the year.

Staurodesmus Teiling 1948

The genus *Staurodesmus* was erected in 1948 to include bi- and tri-radiate monospinous desmids which formerly had been included in the genera *Arthrodesmus* and *Staurastrum*. Because the writer has utilized the ideas of Teiling in the present paper, some species of the latter two genera above will have been reported previously for Michigan under different names than those used here. To avoid confusion, the writer has indicated below each named taxon the name under which it has been reported previously.

Dr. Teiling (personal communications) has been most helpful to the writer in respect to the identification and terminology of the species, varieties and forms listed below.

<u>Staurodesmus</u> <u>controversus</u> (West and West) new comb. Pl. 6, Fig. 3

Syn: <u>Arthrodesmus</u> <u>controversus</u> W. and G. S. West

Cells small, about as broad as long; semicells subtriangular, provided with a small spine (which may be reduced) at each pole. Isthmus broad, sinus angular (not acute). Top view elliptic to lemon-shaped; semicells subcircular in side view. Our cells measuring about 11.4 to 12.5μ in length, by 11.4-12.5μ in width (including spines); thickness about 5.7 to 7μ; isthmus 7-8μ.

It is very difficult to separate <u>Std</u>. <u>controversus</u> from <u>Std</u>. <u>crassus</u> [see West and West (1912) as <u>Arthrodesmus</u> <u>crassus</u> W. and W.] based on the characteristics used by the Wests. Dr. Teiling, after comparing the writer's material with his own rich samples of <u>Std</u>. <u>crassus</u>, maintains them as separate species. Any further discussion of the differences between them should await the anticipated appearance of Teiling's monograph of this genus.

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Present during most of the period from May to December. Abundant during June and July.

<u>Std</u>. <u>dejectus</u> (Bréb.) Teiling

(<u>Staurastrum</u> <u>dejectum</u> Bréb. in Wade, 1952)

For a description and illustrations of this as <u>Staurastrum</u> <u>dejectum</u> Bréb., see West, West and Carter (1923).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Rarely observed; noted in June and December.

Std. extensus (Anderss.) Teiling

For a description and illustrations of this as Arthrodesmus incus var. extensus see Borge (1913).

Distribution: In all habitats at Purdy Bog except the sphagnum mat.

Occurrence: From April through June.

Std. extensus var. Joshuae (Gutw.) new comb. Pl. 7, Fig. 2

(Arthrodesmus incus var. extensus Andersson in Wade, 1952)

For a description and illustrations of this as Arthrodesmus incus var. extensus, see Smith (1924a)

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted only in January, under an ice cover.

Std. glabrus (Ehrenb.) Teiling

(Staurastrum glabrum (Ehr.) Ralfs in Wade, 1952)

For a description and illustrations of this as Staurastrum glabrum, see West, West and Carter (1923).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted only in June; rare. Probably of more frequent occurrence, but not observed because few individuals are present.

Std. megacanthus var. scoticus (W. and W.) Lillier. fa. minor new form
Pl. 8, Fig. 3

A form differing from the typical by its smaller size. Illustrated cell 17.1μ long, 19.4μ wide (without spines), 34μ wide (with spines). Isthmus 7.9μ.

Teiling (personal communications) has suggested the use of the new forma designation after observing a drawing of the writer's material. For a description of Staurastrum megacanthum var. scoticum, see West, West and Carter (1923).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed in June and September; probably present during the intervening months also.

Spondylosium Brébisson

Spondylosium pulchellum Arch.

For a description and illustration, see West, West and Carter (1923).

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Not observed during February and March, otherwise present throughout the year.

Hyalotheca Ehrenberg

Hyalotheca dissiliens (Smith) Bréb.

For a description and illustration, see West, West and Carter (1923).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Found throughout the year.

H. dissiliens var. tatrica Racib.

See West, West and Carter (1923) for a description and illustrations.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From March to October.

H. mucosa (Mert.) Ehrenb.

For a description and illustration, see West, West and Carter (1923).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Not noted in February or March, otherwise present throughout the year.

H. undulata Nordst.

For a description and illustration, see West, West and Carter (1923).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Rarely noted, thus sporadic.

Desmidium C. A. Agardh

Desmidium Aptogonum Bréb.

For a description and illustration, see West, West and Carter (1923).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Absent from February to April; otherwise present throughout the year.

D. Baileyi (Ralfs) Nordst.

See Smith (1924a) for a description and illustration.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: Not noted in December or January, otherwise present throughout the year.

D. Grevillii (Kuetz.) De Bary

For a description and illustration, see Smith (1924a).

Distribution: Marginal pool (not studied) in Purdy Bog.

Occurrence: Observed in only one collection. See remarks on this species, under Distribution of Selected Species.

D. Swartzii var. amblyodon (Itz.) Rabenh.

For a description and illustration, see West, West and Carter (1923).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From May to November.

Gymnozyga Ehrenberg

Gymnozyga moniliformis Ehrenb.

For a description and illustration, see West, West and Carter (1923).

Distribution: In all habitats at Purdy Bog, except the sphagnum mat.

Occurrence: Found throughout the year; common in July.

Class: Charophyceae

Order: Charales

Family: Characeae

Nitella (C. A. Agardh) Leonhardi

The taxonomy of this genus is rather complex, and is still undergoing revision (Wood, 1962). For this reason, no attempt will be made to describe or illustrate the observed species of Nitella. Herbarium specimens of these have been retained in the writer's collection for use as vouchers.

Nitella gracilis (Smith) Ag.

Identified by Fay K. Daily.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Observed in July.

N. oligospira A. Br.

Identified by Fay K. Daily.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Observed in September.

Chara Linnaeus

Chara contraria A. Br.

See Prescott (1951a) for a description.

Distribution: Lake bottom in Lawrence Lake.

Occurrence: Observed from May to October.

II DIVISION CHRYSOPHYTA

Class: Chrysophyceae

Order: Chromulinales

Family: Euchromulinaceae

Chromulina Cienkowski

Chromulina gigantea Naumann Pl. 8, Fig. 9

Huber-Pestalozzi (1941) p. 36; Pl. III, Fig. 29

Cells pyriform, only slightly metabolic; periplast thin, smooth. Chromatophore a curved parietal plate, toward the anterior end of the cell; stigma absent in observed cells. Cytoplasm hyaline, posterior portion filled with globular bodies of unknown composition. Flagellum approximately body length. Illustrated cell 34µ long, 23µ wide.

Our material is placed here tentatively. It resembles *C. pyriformis* Bachmann and *C. diachloris* Skuja. *C. pyriformis* Bachmann and *C. gigantea* are not fully described, and neither the figures nor the descriptions allow one to be certain of their true identity. However, one cannot from available descriptions say that our material differs in any significant way from *C. gigantea* except for the degree of metaboly. It is separated from *C. diachloris* by its larger size and lack of a stigma. The chromatophore in ours is closer to the wall than in Naumann's species, but this does not warrant the erection of a new taxon without further study.

Distribution: Sphagnum mat and marginal pools in Purdy Bog. New record for North America.

Occurrence: Common in November and December; also noted in April.

C. pyriformis Playfair Pl. 9, Fig. 4

Huber-Pestalozzi (1941) p. 30; Pl. II, Fig. 13

Cells elongate-obpyriform to elongate-obovate, anterior end broadly rounded, posterior acuminate. Chromatophore a curved parietal plate; stigma present near the anterior end. Illustrated cell 12μ long, 6μ wide.

This species is not fully described in the literature, but our material agrees well with the available descriptions and illustrations.

Unfortunately, two species of *Chromulina* bear the epithet *pyriformis*; *C. pyriformis* Playfair and *C. pyriformis* Bachmann. The former is broadly rounded anteriorly, the latter broadly rounded posteriorly. Pending further studies on this group, the writer follows the descriptions and nomenclature used in the available literature. For a description and illustrations of the above species, see Huber-Pestalozzi (1941).

Distribution: Marginal pools in Purdy Bog. New record for North America.

Occurrence: Noted during November.

C. suprema Skuja Pl. 9, Figs. 2, 3

Skuja (1956) p. 259; Pl. 46, Figs. 3-9

Cells ellipsoid to obovate, somewhat metabolic. Surface appearing "warty" due to subpellicular alveoli or vacuoles. Chromatophore 1, parietal, covering most of the cell wall; stigma anterior, present in mature cells, not observed in young cells (in ours). One flagellum, about body length. Rounded fat-like bodies present (or not) in cytoplasm, these occasionally almost covering the cell wall (not shown in our illustration for sake of clarity). Contractile vacuoles anterior, 2 or 3 in number (2-4 according to Skuja). Cell size variable; illustrated cell

18μ wide x 34μ long (18-25μ wide by 30-65μ long, Skuja). Cyst globose, about 32μ in diameter (25-50μ, Skuja).

As mentioned by Skuja (1956), this organism resembles Microglena very closely. Our material agrees well with Skuja's description and illustrations, except that the cysts were never as gelatinous as described. Large numbers of this species were observed, but they are of such a delicate nature that they burst soon after being placed on a slide, and so prolonged observation is quite difficult.

Separated from Microglena (here) on the basis of the difference in plastid structure, and the single stigma. Our material may prove to be a variety of Skuja's or even a different taxon, but without further study the writer cannot justify any separation.

Distribution: Sphagnum mat and pool in Purdy Bog. New record for North America.

Occurrence: Common to abundant in April and May. Cysts noted in December.

Chrysopyxis Stein

Chrysopyxis stenostoma Lauterb. Pl. 10, Fig. 1

Pascher and Lemmermann (1913) p. 29; Fig. 43, p. 28

Lorica subspherical to ovate in front view, tapering to long acuminate extensions which attach the cell to its substrate. Chromatophores 2. Protoplast with a delicate pseudopodium which extends through the opening of the lorica and branches at the distal end; lorica opening by a simple pore at the apex. Cells 10-13.7μ in diameter, 11-14μ long; total length with extensions 25-31μ.

See Pascher and Lemmermann (1913) for a description and illustrations of the common species of Chrysopyxis.

Distribution: Center lake and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: From July through November.

Family: Mallomonadaceae

Mallomonas Perty

Mallomonas elongata Reverdin Pl. 10, Figs. 6, 7

Huber-Pestalozzi (1941) p. 111; Pl. XXVII, Figs. 149, 150

Cells narrowly elongate-ellipsoid to cylindrical, narrower toward the anterior end. Chromatophores 2, parietal. Scales ellipsoidal, arranged in slightly spiralling rows; spines long, covering about 3/4 of the body (in some, covering almost the whole surface). Cells about 58μ long, 17μ wide; spines approximately 57μ long.

Distribution: Main and intermediate portions of Lawrence Lake. New record for Michigan.

Occurrence: From October to March.

Chrysosphaerella Lauterborn

Chrysosphaerella longispina Lauterb.

For a description and illustration, see Prescott (1951a).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From August through December.

Order: Isochrysidales

Family: Synuraceae

Synura Ehrenberg

Synura sphagnicola Korschik. Pl. 9, Fig. 1

Huber-Pestalozzi (1941) p. 137; Fig. 194, p. 138.

Cells spherical to subspherical, usually in few-celled colonies (up to 12 or so). Scales ring-like, with a spine-like protuberance toward the apex (shaped like a tennis racquet). Chromatophores 2, more band-like and parietal than described. Cytoplasm with small globular bodies, reddish in color, usually concentrated in anterior half of cell. Flagella of approximately equal length, body length or longer. Cells 11-14μ in diameter.

Skuja (1956) has figured some cells of this species which resemble ours almost exactly. He shows the chromatophores as being more parietal and band-like than in the original figures of Korschikow (See Huber-Pestalozzi, 1941).

Distribution: In all habitats of Purdy Bog; outlet portion of Lawrence Lake. New record for North America.

Occurrence: From November to June.

S. uvella Ehrenb.

See Huber-Pestalozzi (1941) for a description and illustrations.

Distribution: In all habitats of Purdy Bog; main and outlet portions of Lawrence Lake.

Occurrence: Found throughout the year.

S. uvella Ehrenb., fa.

A form differing by its more elongated cells, yet maintaining the scales of S. uvella. For a discussion of variability in S. uvella, see Huber-Pestalozzi (1941).

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: From September to February.

Order: Ochromonadales

Family: Ochromonadaceae

Ochromonas Wyssotzki

Ochromonas crenata Klebs Pl. 8, Fig. 6

Huber-Pestalozzi (1941) p. 170; Pl. XLI, Fig. 230

Cells spherical to subspherical. Chromatophore a curved, sometimes folded, parietal plate. Periphery of cell with globular refringent bodies beneath the membrane, these probably fat-like in composition. Flagella 2, of unequal length, the longer one about body length. Diameter of cells about 15μ.

See Huber-Pestalozzi (1941) for a complete description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog. New record for North America.

Occurrence: Observed in January.

Uroglena Ehrenberg

(incl. Uroglenopsis, Lemm.)

Uroglena americana Calkins

For a description and illustration, see Huber-Pestalozzi (1941).

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: From June through December.

U. botrys (Pascher) Conrad Pl. 8, Fig. 7

Huber-Pestalozzi (1941) p. 185; Pl. XLIX, Fig. 250

Cells obovate to obpyriform, located at the periphery of large spherical colonies. Flagella 2, of unequal length, the longer one exceeding body length. Chromatophore 1, parietal, usually along one side of the body; stigma large, at anterior apex of the cell, somewhat lens-shaped. Illustrated cells about 5.7μ in diameter, 9μ long; colonies up to 120μ in diameter (in ours).

Distinguished from U. americana by the larger, anterior stigma, the usually longer flagella and the shape of the cell. See Huber-Pestalozzi (1941) for a discussion and illustrations of the above two species.

Distribution: Center lake of Purdy Bog; main portion of Lawrence Lake. New record for North America.

Occurrence: Noted in July and December.

Synuropsis Schiller

Synuropsis danubiensis Schiller, fa. Pl. 8, Figs. 10-12

Huber-Pestalozii (1941) p. 191; Pl. LII, Fig. 255

Cells obpyriform to elongate-obovate, broadly rounded anteriorly, tapering sharply to the point of attachment at the center of a colony. Chromatophores 2, parietal, plate-like. Cell membrane smooth. Flagella 2, of about the same length, but differing in action; one active in motility, curling, the other almost straight, passive in this respect. Globular refingent body or bodies usually present, between the chromatophores. Cells about 7-11μ wide, 14-24μ long.

The flagella in our specimens are not of 2 greatly different lengths; thus, regarded as a forma until further studies can be made.

Distribution: Center lake and marginal pools of Purdy Bog; outlet portion of Lawrence Lake. New record for North America.

Occurrence: From September to March.

Pseudokephyrion Pascher

Pseudokephyrion undulatissimum Scherffel, fa. Pl. 8, Fig. 8

Huber-Pestalozzi (1941) p. 200; Pl. LV, Fig. 266

Test ovate, broadest in anterior portion, with ring-like thickenings. Protoplast small, with 1-2 chromatophores. Flagella 2, of unequal length. Cells free floating, about 10μ long, 8μ wide.

For a description and illustration, see Huber-Pestalozzi (1941).

Distribution: Outlet portion of Lawrence Lake. New record for North America.

Occurrence: Noted during December.

Dinobryon Ehrenberg

Section: Eudinobryon

Dinobryon bavaricum Imhof

See Prescott (1951a) for a description and illustration.

Distribution: Center lake and marginal pools of Purdy Bog.

Occurrence: From May to September.

D. cylindricum Imhof

See Huber-Pestalozzi (1941) for illustrations and descriptions.

Distribution: Center lake bottom and marginal pools in Purdy Bog; main and outlet portions of Lawrence Lake.

Occurrence: Throughout the year.

D. divergens Imhof

See Huber-Pestalozzi (1941) for a description and illustrations.

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: Found throughout most of the year.

D. divergens var. Schauinslandii (Lemm.) Brunnth. Pl. 9, Fig. 7

Huber-Pestalozzi (1941) p. 229; Pl. LXVII, Fig. 304.

Differing from D. divergens by its more undulate loricas and usually fewer-celled colonies. For a discussion of this variety, see Huber-Pestalozzi (1941).

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: From May to November.

<u>D</u>. <u>pediforme</u> (Lemm.) Steinecke Pl. 9, Figs. 8, 9

Huber-Pestalozzi (1941) p. 227; Pl. LXV, Fig. 301

Colonies with cells divergent. Basal part of loricas produced to form swellings, these characteristic of the species. Sides of lorica undulate. Cells about 7μ in diameter, 35μ long. Cyst spherical, about 11μ in diameter.

See Huber-Pestalozzi (1941) for a discussion and list of synonyms.

Distribution: Center lake, marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: From May to July.

<u>D</u>. <u>sertularia</u> Ehrenb.

For a description and illustrations, see Prescott (1951a).

Distribution: Center lake and marginal pools in Purdy Bog; outlet portion of Lawrence Lake.

Occurrence: From September to December; also in April and May.

<u>D</u>. <u>sertularia</u> var. <u>protuberans</u> (Lemm.) Krieger Pl. 9, Fig. 6

Huber-Pestalozzi (1941) p. 223; Pl. LIX, Fig. 291

Differing from the above by the swellings produced at the base of the lorica. Only a few cells were observed, but these are distinct enough that their inclusion seems warranted.

For a description, see Huber-Pestalozzi (1941).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Observed during March.

Hyalobryon Lauterborn

Hyalobryon ramosum Lauterborn Pl. 10, Figs. 8-10

Huber-Pestalozzi (1941) p. 239; Pl. LXXI, Fig. 327

Cells elongate-cylindric, straight to slightly curved, in thickly-branched colonies; apical portion of cells tapering slightly. Growth rings evident in extreme anterior portion of cell, these most easily seen at or near apex. Protoplasts not observed. Cells about 10 times as long as broad; illustrated cells 50-60μ long, 5.7-6.5 wide.

Our colonies contain many more cells than those shown by Lauterborn, but otherwise agree very well.

Distribution: Marginal pools in Purdy Bog; intermediate and outlet portions of Lawrence Lake. New record for North America.

Occurrence: From May to December.

Order: Rhizochrysidales

Family: Rhizochrysidaceae

Chrysostephanosphaera Scherffel

Chrysostephanosphaera globulifera Scherffel

See Prescott (1951a) for a description and illustrations.

Distribution: In all five habitats of Purdy Bog (more common in the marginal and sphagnum pools).

Occurrence: Found throughout the year; not noted in March or April.

Chrysarachnion Pascher

Chrysarachnion insidians Pasch. Pl. 8, Fig. 2

Huber-Pestalozzi (1941) p. 248; Pl. LXXV, Fig. 336

Cells polygonal in outline, attached to one another by rhizopodial strands to form a net-like colony. Chromatophore brownish in color, lying along the membrane. Cells about 2-3μ in diameter.

Agrees very well with the species as described in the literature, except that our material appears to have an eyespot in one corner of each cell. Because only one colony was observed, however, it is best to retain this for the present under the typical species. See Huber-Pestalozzi (1941) for a description and illustration.

Distribution: Marginal pools in Purdy Bog. New record for North America.

Occurrence: Observed in November; rare.

Class: Farblose Flagellaten

Order: Protomastiginae

Family: Craspedomonadaceae

Salpingoeca J. Clark

Salpingoeca gracilis Clark (?), fa. Pl. 9, Fig. 5

Skuja (1956) p. 310; Pl. LIV, Figs. 19, 20

Cells epiphytic on Pleurodiscus, elongate-vase shaped, widened to a flange anteriorly, acuminate posteriorly. Cells 6μ wide, 25-32μ long.

This species is placed here tentatively because only four cells were observed. Only one of these showed the collar typical of this genus. Because the protoplasts were retracted in our material, it is possible that the collar could not be readily observed. The one observed collar was misshapen.

Distribution: Lake bottom in Purdy Bog. A tentative new record for North America.

Occurrence: Observed during January.

Family: Amphimonadaceae

Spongomonas Stein

Spongomonas sp.

Several colonies of Spongomonas were noted in our collections, but never in enough abundance that a specific determination could be made. Because the occurrence of the genus may be of ecological significance, it is included here. The colonies resembled young stages of S. uvella Stein. For a description, see Pascher and Lemmermann (1914).

Distribution: Center lake and marginal pools in Purdy Bog.

Occurrence: From November through February.

Rhipidodendron Stein

Rhipidodendron splendidum Stein Pl. 10, Figs. 2, 3

Pascher and Lemmermann (1914) p. 113; Fig. 215, p. 115

Cells naked, located terminally in long mucilaginous tubes which are adjoined to form fan-like groups. Mucilage (in ours) yellowish to yellowish brown in color. Cells small, about 5-7μ in diameter. Illustrated colony 250μ long, tubes 6μ in diameter.

Our forms never reached the number of tubes usually described for R. splendidum. They appear to be intermediate between this and R. Huxleyi, because some colonies have many of the tubes in groups of four. For a description of Rhipidodendron, see Pascher and Lemmermann (1914).

Distribution: In all habitats of Purdy Bog except the sphagnum mat. New record for Michigan.

Occurrence: From December to July.

Heterochromonas Pascher

Heterochromonas sphaerophora Skuja (?) Pl. 8, Fig. 5

Skuja (1956) p. 313; Pl. LVI, Figs. 7-12

Cells obpyriform to elongate-obovate, broadly rounded anteriorly, tapering posteriorly to an acuminate caudal region. Cytoplasm granular, with vacuoles. Stigma anterior. Flagella 2, of unequal length. Cells 7-8μ wide by 17-20μ in length.

A questionable determination, due to the lack of sufficient specimens for a critical study.

Distribution: Lake bottom in Purdy Bog. New record for Michigan, and probably for North America.

Occurrence: Noted during January.

Class: Xanthophyceae

Order: Rhizochloridales

Family: Stipitococcaceae

Stipitococcus West and West

Stipitococcus urceolatus West and West

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during August.

Order: Heterococcales

Family: Gloeobotrydaceae

Chlorobotrys Bohlin

Chlorobotrys regularis (W. West) Bohlin

See Prescott (1951a) for a description.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during August.

Family: Botryochloridaceae

Chlorellidiopsis Pascher

Chlorellidiopsis separabilis Pasch.

See Prescott (1951a) for a description and illustration.

Distribution: Marginal pools and lake bottom in Purdy Bog.

Occurrence: Sporadic; noted from October to December, also in June.

Family: Mischococcaceae

Mischococcus Naegeli

Mischococcus confervicola Naeg.

Prescott (1951a) p. 347; Pl. 93, Fig. 30

Cells small, in gelatinous tubes which are usually dichotomously branched; colonies appearing dendroid. Cells at distal ends of the tubes, spherical, about 4μ in diameter.

Distribution: Sphagnum pool in Purdy Bog.

Occurrence: Observed during May.

Family: Characiopsidaceae

Peroniella Govi

Peroniella planctonica G. M. Smith Pl. 8, Fig. 13

Prescott (1951a) p. 359; Pl. 94, Figs. 7-9

Cells obpyriform, tapering posteriorly to a long acuminate stalk. Chromatophores laminate, parietal. Total length of illustrated cell 33μ; length 12.5μ, 10.2μ in diameter. Attached to filaments of Mougeotia.

Distribution: Lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Observed during September.

Family: Chlorotheciaceae

Ophiocytium Naegeli

Ophiocytium capitatum Wolle

See Prescott (1951a) for a description.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted during November.

Order: Heterotrichales

Family: Tribonemataceae

Tribonema Derbes and Solier

Tribonema minus (Wille) Hazen

For a description and illustration, see Prescott (1951a).

Distribution: Sphagnum mat in Purdy Bog.

Occurrence: Noted in October.

T. utriculosum (Kuetz.) Hazen

See Prescott (1951a) for a description and illustration.

Distribution: Main portion of Lawrence Lake.

Occurrence: Observed during June; rare.

III DIVISION PYRRHOPHYTA

Class: Cryptophyceae

Order: Cryptomonadales

Family: Cryptomonadaceae

Chroomonas Hansgirg

Chroomonas Nordstedtii Hansg., fa. Pl. 11, Fig. 5

Huber-Pestalozzi (1950) p. 28; Pl. III, Fig. 13

Cells ellipsoid to ovate or obovate, small. Chromatophore parietal, somewhat overlapping, yellowish-green to blue green. Anterior portion slightly indented, from which the two flagella (approximately body length) arise. A rounded assimilation body evident in the cytoplasm near the median portion of the cell. One anterior vacuole present. Cells averaging about 15μ in length, 9μ in width. Range of size from literature: length 8-20μ; width 4-10μ.

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: Noted during April.

Cryptomonas Ehrenberg

Cryptomonas erosa Ehrenb.

A characteristic species; subject to some variation in shape, but maintaining a readily recognizable form and internal organization.

For a description, see Huber-Pestalozzi (1950).

Distribution: In all habitats of Purdy Bog except the sphagnum pool; outlet portion of Lawrence Lake.

Occurrence: Common from November to April; also noted in July.

C. obovata Skuja Pl. 13, Fig. 4

Huber-Pestalozzi (1950) p. 51; Pl. V, Fig. 27

Cells obovate, with one lateral margin almost straight, the other convex. Pyrenoids absent. Anterior end broadly rounded, somewhat protruding; a relatively deep indentation on the ventral side where the flagella arise. Flagella 2, about body length. Gullet straight, reaching up to two-thirds of the body length, lined with trichocysts and appearing cylindrical in shape. Chromatophores 2, greenish-brown in color. Cytoplasm containing numerous starch(?) bodies. One contractile vacuole present, in the anterior portion near the gullet. Cells measuring 19-23μ long by 11-13μ wide; Skuja's measurements are: length, 24-46μ, width 13-24μ.

Distribution: In all habitats of Purdy Bog except the sphagnum mat. New record for North America.

Occurrence: From November to June.

C. ovata Ehrenb.

Cells measuring 28.5-52μ in length, 17-27μ in width.

The limits of this species have never been defined accurately, and many records of its occurrence undoubtedly refer to other species of the genus. For a good discussion of the species, see Huber-Pestalozzi (1950).

Distribution: In all habitats in Purdy Bog; outlet portion of Lawrence Lake.

Occurrence: Found during every month of the year.

C. rostratiformis Skuja. Pl. 13, Fig. 10

Syn.: C. rostrata Skuja

Huber-Pestalozzi (1950) p. 55; Pl. VI, Fig. 33

Cells relatively large, elongate-ellipsoid in outline, narrowed toward the anterior end, which ends in a rostrum on one side; posterior end narrowed, but not acute, in our specimens. Gullet broadly ellipsoid in shape, with many trichocysts, opening into a deep depression along one side of the rostrum and toward its base. Starch bodies present, in our specimens more densely packed than in Skuja's. Chromatophores 2, brownish. Nucleus large, in posterior half of the cell; difficult to see in the living cell. Cells 46-55μ long, 23-26μ wide (according to Skuja, 48-60μ long, 16-26μ wide).

No cells were observed which showed the curved caudus illustrated in one of Skuja's two drawings. Certain expressions of this species closely resemble C. ovata, but may be separated from it on the basis of the pronounced rostrum. Skuja mentions (1948) that it is difficult to distinguish this species from certain expressions of C. ovata and C. curvata Ehrenberg.

Distribution: In all habitats of Purdy Bog except the sphagnum mat. New record for North America.

Occurrence: From January through August.

Chilomonas Ehrenberg

Chilomonas sp.

Several cells were observed which were undoubtedly members of the genus Chilomonas; these resembled most closely C. Paramecium Ehrenb., but due to a lack of sufficient specimens no exact determination could

be made. The cells are rather difficult to slow down without entirely distorting their shape and internal features. To eliminate a premature determination, these forms have been listed only to genus.

Distribution: Marginal and sphagnum pools in Purdy Bog.

Occurrence: From November to January; also in July.

Class: Chloromonadinae

Family: Chloromonadaceae

Vacuolaria Cienkowski

Vacuolaria virescens Cienk. Pl. 13, Fig. 7

Huber-Pestalozzi (1950) p. 81; Fig. 64, p. 82

Cells, ovate-pyriform to ellipsoid, more or less actively metabolic. Numberous tiny mucilage bodies or alveoli in the peripheral region of the cell. Flagella 2, originating at the anterior end, quite thick, usually shorter than the length of the body. Chromatophores greenish, numerous, lentiform to somewhat elliptical. Several vacuoles usually apparent in anterior portion of the cell. Illustrated cell 34μ long, 23μ wide.

The cells usually round up soon after collection, so that motile forms may be observed only under favorable conditions. The measurements cited above are for a specimen which was just ceasing active motility. Most forms observed were at rest and were more rounded than shown in Figure 7, but there can be no doubt regarding the determination of the species.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; outlet portion of Lawrence Lake. New record for North America.

Occurrence: From November through April.

Trentonia Stokes

Trentonia flagellata Stokes Pl. 13, Fig. 8

Huber-Pestalozzi (1950) p. 83; Fig. 66, p. 84.

Motile cells elongate-obovate to obpyriform, broadly rounded at the anterior end. Chromatophores numerous. Cytoplasm alveolate (much as in Vacuolaria). Flagella 2, anterior, shorter than the body. Illustrated motile cell 51.3μ long by 25μ wide.

Non-motile cells rounded, chromatophores aggregated near the center of the cell; remainder of contents appearing as a grayish, gelatinous mass of cytoplasm in which vacuoles (alveoli) are readily discernible.

The cells of this species, as those of Vacuolaria, above, are usually rounded-up and not actively motile unless observed immediately after collection; even then, there seem to be times when the organisms are just not motile. These are illustrated well by Penard (see Huber-Pestalozzi (1950), p. 84); no forms were ever observed which resemble Stokes' illustration of the species. The chromatophores in motile cells are more scattered than when the organism is at rest, although these are less numerous than those shown by Stokes (see Huber-Pestalozzi (1950), p. 84).

Distribution: In all habitats of Purdy Bog except the sphagnum mat. New record for North America.

Occurrence: From November through March.

Gonyostomum Diesing

Gonyostomum semen Dies.

Cells elongate-obovate to almost rounded in shape, somewhat metabolic and flattened dorsiventrally. Flagella 2, approximately body-length of which 1 is directed anteriorly, the other trailing. Trichocysts present in the peripheral region, distributed over most of the cell surface. Color variable from grayish-green to dark green. Cylindrical (food reserve?) bodies occasionally present, usually 2, lateral in position. Cells 44-48μ long by 28-34μ wide.

This organism is very sensitive to external changes and bursts readily upon the slightest agitation, or under the heat of the microscope lamp.

Distribution: Sphagnum mat, marginal and sphagnum pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

Merotrichia Mereschkowski

Merotrichia capitata Skuja Pl. 13, Fig. 9

Huber-Pestalozzi (1950) p. 89; Fig. 71, p. 89

Cells elliptic to oblong-obovate, broadly rounded and somewhat capitate anteriorly, slightly metabolic. Flagella 2, approximately body length, inserted laterally in anterior portion of the cell, 1 directed anteriorly, 1 trailing. Trichocysts distinct, more numerous in the anterior, capitate portion of the cell. Chromatophores numerous, light green in color, almost spherical. Illustrated cell about 41μ long, 26μ in diameter.

This species was observed in only one sample, and, like Gonyostomum, becomes deformed or ruptures rapidly. Because of this, neither accurate

drawings nor measurements could be made, hence the possible inaccuracy of the included drawing.

Distribution: Marginal pools in Purdy Bog. New record for North America.

Occurrence: Observed once, in November.

Class: Peridineae

Order: Gymnodiniales

Gymnodinium Stein; emend. Kofoid and Swezy

Gymnodinium fuscum (Ehrenb.) Stein Pl. 13, Fig. 5

Prescott (1951a) p. 426; Pl. 89, Fig. 23

Cells elongate-ovoid to obpyriform or top-shaped, dorsiventrally but little flattened, with the epi- and hypocones of approximately the same size. Illustrated cell 80μ long, 50μ in diameter, the latter figure somewhat less than the lower limit of size which is usually given (55μ).

Separated from G. caudatum Prescott by the lack of an elongated, curved caudus.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: From May through November.

G. ordinatum Skuja (?) Pl. 11, Fig. 7

Huber-Pestalozzi (1950) p. 137; Pl. XIX, Fig. 119

Several minute Gymnodinium specimens were observed which, because of a lack of suitable numbers to work with, and due to their extremely small size, can be identified only tentatively. They resemble most closely G. ordinatum Skuja.

Cells broadly oval, somewhat flattened dorsiventrally, broadly

rounded at the poles, with the epicone and hypocone of almost equal size and shape. Length 12-13μ, width 11-13μ.

Distribution: Center lake, marginal and sphagnum pools in Purdy Bog. Tentative new record for North America.

Occurrence: Noted during November and March.

Order: Peridiniales

Family: Glenodiniopsidaceae

Hemidinium Stein

Hemidinium nasutum Stein Pl. 13, Fig. 6

Prescott (1951a) p. 421; Pl. 90, Figs. 4-6

Cells unsymmetrically ellipsoidal, dorsiventrally flattened; transverse furrow incomplete, curving down and to the right as seen from the ventral side. Longitudinal furrow reaching to, or nearly to, the posterior of the cell. Cells 23-25μ long, 15-16μ wide.

Distribution: Lake bottom in Purdy Bog. New record for Michigan.

Occurrence: Noted during January.

Family: Glenodiniaceae

Glenodinium (Ehrenb.) Stein

Glenodinium spp.

Several small forms of this genus were observed which could not be determined to species because of a lack of sufficient specimens for study. The genus was never very common in either of the study areas.

Distribution: Center lake, lake bottom and sphagnum pool in Purdy Bog.

Occurrence: Noted sporadically from June to November.

Family: Peridiniaceae

Peridinium Ehrenberg

Peridinium cinctum var. tuberosum (Meunier) Lindem. Pl. 11, Fig. 1

Prescott (1951a) p. 433; Pl. 91, Figs. 7-12

Cells spherical to ovoid in front view, little flattened, if at all, dorsiventrally. Epicone somewhat larger than the hypocone, with 7 precingular, 1 rhomboidal, 2 ventral apical, 2 median apical and 2 dorsal apical plates. Illustrated cell 64μ long, 68.5μ wide and 63μ thick.

Separated from the typical on the basis of the 3 posteriorly-produced protuberances which arise from the plates of the hypocone.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: From June to September; also in December.

P. gatunense Nyg. Pl. 13, Fig. 1

Prescott (1951a) p. 433; Pl. 90, Figs. 25, 26

Cells spherical to depressed-globose, with broadly-rounded poles. Epicone equaling, to slightly larger than, hypocone, consisting of 14 plates: 7 precingulars, 1 rhomboidal, 2 ventral apical, 2 median apical and 2 dorsal apical. Hypocone with 2 antapical and 5 postcingular plates. Illustrated cell 55μ long, 55μ in diameter.

Although subject to some variation, the species in general resembles P. cinctum, from which it can be distinguished by the fact that the longitudinal furrow extends only slightly into the epicone.

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: During July and August.

P. inconspicuum Lemm. Pl. 13, Fig. 2

Prescott (1951a) p. 433; Pl. 90, Figs. 22-24

Cells small and subject to rather extensive variation, but generally ovoid in shape and somewhat flattened dorsiventrally. Apical end somewhat pointed, posterior broadly rounded and usually possessing spines or other decorations. Epicone with 13 plates; apical opening present. Hypocone with 5 postcingular and 2 antapical plates. Observed cells 15-19μ long, 12.5 to 18μ in width.

Distribution: Marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: From May to August; also in January.

P. palustre (Lindem.) Lef. Pl. 12, Fig. 3

Huber-Pestalozzi (1950) p. 204; Pl. XXXVI, Fig. 194

Cells somewhat rounded, resembling in general those of P. cinctum, although more flattened dorsiventrally. Epicone slightly larger than the hypocone, with 7 precingular, 1 rhomboidal, 2 ventral apical, 2 median apical and 2 dorsal apical plates. Hypocone with 5 postcingular and 2 antapical plates. Cells 65-67μ long, 64-68μ in diameter.

As seen in dorsal view, the shape of the left dorsal apical plate is quite characteristic, being chiefly smaller and more nearly square than those of closely related species. Care must be taken, however, to separate some expressions of this species from P. cinctum.

Distribution: Sphagnum pool in Purdy Bog. New record for North America.

Occurrence: From July to September.

P. polonicum Wolosz. Pl. 11, Figs. 2-4

Huber-Pestalozzi (1950) p. 233; Pl. LI, Fig. 252

(?) Syn.: Glenodinium Gymnodinium Penard

Cells broadly oval in front view, strongly flattened dorsiventrally. Epicone with 7 precingular, 4 intercalary and 1 (or 2?) apical plates; hypocone with 5 postcingular and 2 antapical plates. An apical opening is present, and a short spine or tooth is almost always present on the hypocone near the opening of the longitudinal furrow. Cells 36-46μ wide, 41-63μ long, about 26μ thick.

Several monographers of this group, among them Schiller (1937), regard this species as being identical with Glenodinium Gymnodinium Penard. The writer follows Huber-Pestalozzi's views, however, and regards them as two distinct forms, because Penard's figures (see Huber-Pestalozzi (1950) Pl. XXVII, Fig. 155) show no plate structure and, according to Huber-Pestalozzi, no mention was made of them in the original diagnosis. See Huber-Pestalozzi (1950) for an extensive discussion of the taxonomic position of these two species.

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: From June through September.

P. umbonatum Stein Pl. 12, Fig. 4

Huber-Pestalozzi (1950) p. 220; Pl. XLIV, Fig. 218

A few cells belonging to the Umbonatum section of Peridinium were observed and illustrated, although complete thecae were never found. By a comparison of these with available illustrations they obviously agree with P. umbonatum, but because a few of the plates were never observed, the species is listed here questionably. Illustrated cell 24μ long,

22μ in diameter.

Distribution: Main portion of Lawrence Lake. Tentative new record for Michigan.

Occurrence: Noted during July.

P. Volzii Lemm. Pl. 13, Fig. 3

Huber-Pestalozzi (1950) p. 195; Pl. XXX, Fig. 177

Cells oval to spherical in front view, little flattened dorsiventrally, otherwise resembling P. Willei in general structure. Epicone and hypocone of about the same size, the epicone with 7 precingular, 1 rhomboidal, 2 ventral apical, 1 dorsal apical and 3 median apical plates, the hypocone with the usual 5 postcingular and 2 antapical plates. Illustrated cell 63μ in length, 63μ wide.

Easily separated from P. Willei by the smaller rhomboidal plate and the greater extension of the longitudinal furrow into the epicone.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Observed during December.

P. wierzejskii Wolosz. (?) Pl. 11, Fig. 6

Complete thecae of this organism were never observed, although it definitely belongs to the Lomnickii section of the genus. From available evidence, it resembles most P. wierzejskii, but because neither the complete dorsal view of the epicone nor the ventral view of the hypocone was seen, it must remain as a questionable determination. Illustrated cell 28μ wide, 30μ long.

Distribution: Marginal pools in Purdy Bog. Tentative new record for the United States.

Occurrence: Noted during December.

P. Willei Huitf.-Kaas Pl. 12, Fig. 2

Prescott (1951a) p. 434; Pl. 91, Figs. 22-25

Cells almost spherical, only slightly flattened dorsiventrally. Epicone slightly larger than hypocone, with 7 precingular, 1 rhomboidal, 2 ventral apical, 3 median apical and 1 dorsal apical plate. Cells about 50-60μ in diameter, 50-65μ in length.

The species is subject to some variation, of which the most common is listed below.

Distribution: Center lake and marginal pools in Purdy Bog; main and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Throughout the year.

P. Willei fa. lineatum Lindem. Pl. 11, Fig. 8; Pl. 12, Fig. 1

Huber-Pestalozzi (1950) p. 194; Pl. XXIX, Fig. 176B

Cells similar in appearance to the typical, but separated on the basis of the compressed apex and the narrower, more compressed shape of the apical plates in end view. Cells 53-60μ long, 51-60μ in diameter.

Probably the commonest expression of P. Willei found in both study areas. The only positive way to distinguish it from the typical is to manipulate the cell until the apex is clearly seen, therefore making it difficult to quantify data on relative abundance of the two. It, along with P. Willei, becomes abundant in the plankton from November to April.

Distribution: Center lake and marginal pools in Purdy Bog; main and outlet portions of Lawrence Lake. New record for North America.

Occurrence: From November to June.

P. Willei fa. *stagnale* Lindem. Pl. 12, Figs. 5-8

Huber-Pestalozzi (1950) p. 194; Pl. XXIX, Fig. 176C

Cells strongly flattened dorsiventrally, apical plates much compressed. Characters otherwise as for the typical. The form illustrated in Huber-Pestalozzi (after Lindemann) shows a less-compressed apex than those observed here, but the slight degree of difference does not warrant the erection of a new taxon. Illustrated cell 57μ long, 55μ wide and 27μ thick.

This forma resembles both *P. Willei* fa. *lineatum* and *P. Volzii* fa. *compressum*. It is distinguished from the former by the more pronounced dorsiventral flattening, and from the latter by the larger rhomboidal plate.

Distribution: Center lake of Purdy Bog. New record for North America.

Occurrence: Observed during November.

Family: Ceratiaceae

Ceratium Schrank

Ceratium cornutum (E.) Clap. and Lachm. (?)

Listed here questionably, because living material was never observed, and the observed material was fragmented to such an extent that no accurate drawing was ever made.

Distribution: Lake bottom in Purdy Bog.

Occurrence: Noted in April.

C. hirundinella (O. F. M.) Schrank

A common species subject to a wide range of morphological variations, many of which have been given forma names. Although many of the described variations have been observed, no attempt has been made here to distinguish among them. See Prescott (1951a) for a description.

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: From March through November.

Order: Dinococcales

Family: Cystodiniaceae

Cystodinium Klebs

Cystodinium bicorne (Wolosz.) Huber-Pestalozzi Pl. 10, Fig. 4

Syn: Raciborskia bicornis Wolosz.

Prescott (1951a) p. 440; Pl. 93, Figs. 4-7

Cells stalked, ellipsoid-triangular in front view, oval or ellipsoid in top view, the poles with a short curved spine. Illustrated cell 38μ long including the spines, 17μ in diameter. Attached to filaments of Mougeotia.

Reported for Wisconsin by Prescott (1951a) as Raciborskia bicornis Wolosz.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Noted during May.

C. Steinii Klebs

For a description and illustrations, see Huber-Pestalozzi (1950).

Distribution: Outlet portion of Lawrence Lake.

Occurrence: Observed in October.

Tetradinium Klebs

Tetradinium javanicum Klebs Pl. 10, Fig. 5

Huber-Pestalozzi (1950) p. 300; Pl. LXVIII, Fig. 295

Cells up to 48μ in diameter. Attached to filaments of Mougeotia by a short, stout holdfast.

The observed material was somewhat intermediate between T. javanicum and T. intermedium Geitler, which has a diameter from 33-48μ, lacks a stigma and is usually free-floating. Short holdfasts may be present in the latter also. The writer follows Thompson (1949) in including these expressions under T. javanicum Klebs.

Distribution: Marginal pools in Purdy Bog.

Occurrence: Noted in July.

IV DIVISION EUGLENOPHYTA

Class: Euglenophyceae

Order: Euglenales

Family: Euglenaceae

Euglena Ehrenberg

Euglena acus Ehrenb.

See Huber-Pestalozzi (1955) for a description and illustration.

Distribution: In all habitats of Purdy Bog except the sphagnum mat.

Occurrence: From December to August; more common in winter.

E. deses Ehrenb.

For a description and illustration, see Huber-Pestalozzi (1955).

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: From November through June.

E. fusca (Klebs) Lemm. Pl. 15, Fig. 7

Huber-Pestalozzi (1955) p. 64; Pl. VII, Fig. 41

Cells elongate-fusiform to cylindrical, metabolic and usually somewhat twisted. Periplast brownish, with rows of protuberances which are rounded to rectangular in face view, triangular or elongate when seen in side view. Flagellum shorter than described, only about 1/4 the body length. Two large cylindrical paramylon bodies present. Caudal region sharp pointed, usually twisted. Illustrated cell: length 150μ, width 35μ; paramylon 48-51μ long, 28μ wide and 11μ thick.

Distinguished from E. spirogyra by the larger size of the cells and browner color of the periplast. For a description of these two

7-

species, see Huber-Pestalozzi (1955) and Pringsheim (1956).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During December and January.

E. mutabilis Schmitz Pl. 15, Fig. 5

Huber-Pestalozzi (1955) p. 76; Pl. XI, Fig. 53

Cells small, vermiform, long-cylindric, metabolic, usually adhering to the substrate by the posterior tip. Chromatophores trough-shaped to almost cylindric, 2 to 8 in number. Flagellum apparently absent. Illustrated cell 51μ long, 6μ wide.

This species belongs to the group Serpentes of Pringsheim (1956). For a description, see Huber-Pestalozzi (1955).

Distribution: In all habitats of Purdy Bog; common in sphagnum mat and pools. New record for Michigan.

Occurrence: Throughout the year.

E. proxima Dang.

A variable species. Cells fusiform, broadly rounded anteriorly, generally conical toward the blunt posterior portion. Flagellum about 1 1/2 times body length. For a description, see Prescott (1951a).

Distribution: Marginal and sphagnum pools in Purdy Bog.

Occurrence: From November to January.

E. variabilis Klebs (?) Pl. 15, Fig. 8

Huber-Pestalozzi (1955) p. 73; Pl. X, Fig. 49

Cells metabolic, short-cylindric to obovate, with a short, acute to rounded caudal region. Chromatophores plate-like discs, few in number (according to Pringsheim (1956), numerous). Nucleus in posterior

half of cell, surrounded by a ring of small paramylon (?) grains. Flagellum longer than the body. Stigma large, located near the large anterior vacuole. Illustrated cell 33μ long, 16μ wide.

The writer did not observe the large paramylon grain said to be found in the anterior portion of the cells, but Skuja (1956, p. 232) mentions that he has found this to be absent in many cases, and questions its constant occurrence; Pringsheim (1956) lists it as a characteristic of the species. For a description, see Huber-Pestalozzi (1955) and Pringsheim (1956).

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: Noted only in April.

Lepocinclis Perty

Lepocinclis colligera Defl. Pl. 15, Fig. 10

Huber-Pestalozzi (1955) p. 142; Pl. XXVI, Fig. 124

Cells obpyriform to top-shaped, with a distinct short papilla at the apex, and a short caudus in the posterior end. Periplast strongly spirally striate. Paramylon bodies numerous, mostly cylindric in shape, obscuring the other cell contents. Flagellum not observed. Length, 47-71μ, width 28-34μ, papilla about 2.3μ wide by 4.6μ long.

The writer is not convinced that this is really a species of Lepocinclis, although it obviously is the same organism illustrated by Deflandre (see Huber-Pestalozzi). No contents were ever figured for the organism, and the flagellum has never been observed; no mention was made of the large doughnut-shaped paramylon bodies usually present in this genus. It is possible that the organism belongs to a group of colorless flagellates, because no chromatophores could be seen in the

specimens observed, but more material would be needed in order to establish this. Because apoplastidy is shown by some euglenoids, this species may be able to exist either as a colorless or a chromatophore-bearing form. Length, 47-71μ, width 28-34μ; papilla about 2.3 x 4.6μ high.

Distribution: Marginal pools in Purdy Bog. Tentative new record for North America.

Occurrence: Observed during March.

Phacus Dujardin

Phacus caudatus Hueb. Pl. 17, Fig. 6

Prescott (1951a) p. 398; Pl. 87, Fig. 13

Cells elongate-ovoid to ellipsoid, with a straight, short, acuminate caudus; periplast striate. Paramylon discoid, with 1 large and 1 or 2 smaller discs present. Keel acute to somewhat rounded, distinct, reaching the caudus. Flagellum approximately body length. Illustrated cell 45.6μ in total length, 19.4μ wide; caudus about 11μ long.

See Huber-Pestalozzi (1955) for a complete description.

Distribution: Center lake and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During January and February.

P. lismorensis Playf. Pl. 17, Fig. 12

Huber-Pestalozzi (1955) p. 219; Pl. XLVIII, Fig. 297

Cells long-ellipsoid, asymmetrical, tapering to the long caudus. Periplast striate longitudinally. Chromatophores numerous, rounded. Paramylon in the form of numerous discs. Cells 110-128μ in length by

32-40μ in diameter; caudus 45-48μ long.

Distinguished from P. longicauda by the definite two-lipped appearance at the anterior end, and the slimmer, more elliptic shape of the cell. See Huber-Pestalozzi (1955) for a complete description.

Distribution: Marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: From June to January.

P. longicauda (Ehrenb.) Duj.

Distinguished from P. lismorensis by its almost body-length caudus and more rounded to oval shape, which gives the plant an entirely different appearance. See Prescott (1951a) for a description.

Distribution: Center lake, marginal and sphagnum pools in Purdy Bog.

Occurrence: Of sporadic occurrence throughout the year.

P. orbicularis Hueb. Pl. 16, Fig. 7

Prescott (1951a) p. 401; Pl. 87, Fig. 10

Cells orbicular, with a short, curved caudus. Paramylon bodies 2 discs, 1 larger in diameter than the other. Flagellum about body length. Illustrated cell 50μ long, 39μ wide.

For a description, see Huber-Pestalozzi (1955).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During July.

P. pyrum (Ehrenb.) Stein

See Huber-Pestalozzi (1955) for a description and illustrations.

Distribution: Marginal pools in Purdy Bog.

Occurrence: During November.

P. suecicus Lemm. Pl. 16, Fig. 8

Prescott (1951a) p. 403; Pl. 88, Figs. 2, 3

Cells asymmetrically ellipsoid or ovate; periplast decorated with rows of rounded warts. Flagellum longer than the body. Illustrated cell 33μ long, 20.5μ wide.

See Huber-Pestalozzi (1955) for a description and illustration.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During July and August.

P. triqueter (Ehrenb.) Duj. Pl. 17, Fig. 2

Prescott (1951a) p. 404; Pl. 107, Figs. 4-6

Cells ovoid, broadest in the posterior portion, with a short, deflexed caudus. Keel a sharp, high ridge, giving the cell a triangular aspect in front view. Two or more discoid paramylon bodies present. Cells 28-32μ long by 23μ wide.

For a description, see Huber-Pestalozzi (1955).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During December and January.

Trachelomonas Ehrenberg; emend. Deflandre

Trachelomonas Dybowskii Drez. Pl. 16, Figs. 9, 10

Prescott (1951a) p. 412; Pl. 83, Fig. 21; Pl. 84, Fig. 6

Test ellipsoidal; wall smooth, yellowish-brown. Cells 25-26μ long, about 16μ wide.

Regarded by some authorities as a smooth-walled form of T. intermedia, below. For a description and illustrations, see Huber-Pestalozzi (1955).

Distribution: Lake bottom, marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: Common from November to February; of sporadic occurrence during other seasons of the year.

T. hispida (Perty) Stein *emend.* Defl.

A variable species; see Huber-Pestalozzi (1955) for a description and illustrations.

Distribution: Lake bottom and marginal pools in Purdy Bog.

Occurrence: Noted infrequently during the year.

T. intermedia Dangeard — Pl. 16, Fig. 6

Prescott (1951a) p. 415; Pl. 83, Fig. 10

Test ellipsoidal to subspherical; wall finely punctate, yellowish-brown. Illustrated cell 17μ long, 12.5μ wide.

Resembles *T. Dybowskii* except for the punctate wall and usually broader outline. For a description and illustrations, see Huber-Pestalozzi (1955).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During January.

T. Kelloggii Skv. *emend.* Defl. — Pl. 16, Fig. 11

Huber-Pestalozzi (1955) p. 300; Pl. LXIX, Fig. 543

Test broadly ellipsoid to subspherical, with blunt to sharp spines or tubercules at both ends of the cell. Wall thick, finely and densely punctate. Cells 34-36μ in length by 31-33μ in diameter.

The ornamentations of this species are described as being

tubercules, short spines or papillae. The species resembles T. Raciborskii, from which it may be distinguished by the punctate wall, more subspherical shape and shorter, blunter spines. See Huber-Pestalozzi (1955) for illustrations and descriptions of these two species.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: From July to December.

T. Klebsii Defl. Pl. 16, Fig. 12

Huber-Pestalozzi (1955) p. 298; Pl. LXIV, Fig. 534

Test cylindrical, thickly beset with short, sharp, conical spines. Cells 31-33μ long, 16μ wide.

Resembling T. hispida in some aspects, and regarded by some authorities as a variety of this. For a description and illustration, see Huber-Pestalozzi (1955).

Distribution: Lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: From November to June.

T. oblonga Lemm. Pl. 17, Fig. 4

Huber-Pestalozzi (1955) p. 278; Pl. LXI, Fig. 459

Test ellipsoidal, smooth walled; pore without a ring-like thickening. Flagellum (in ours) longer than the body.

Separated from T. Dybowskii by the lack of a thickened ring around the flagellar pore, and by a relatively thicker wall.

Distribution: Center lake in Purdy Bog. New record for Michigan.

Occurrence: During February.

T. Raciborskii var. nova Drez. Pl. 16, Fig. 13

Huber-Pestalozzi (1955) p. 299; Pl. LXIV, Fig. 541

Cells ellipsoidal to broadly ellipsoidal; wall thick, smooth, except for a series of short, sharp spines on the anterior end. Illustrated cell 34μ long, 31μ in diameter.

Resembles T. Kelloggii somewhat, but the wall is non-punctate, and spines are at the anterior pole only.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Observed during August.

T. triangularis Defl. Pl. 17, Fig. 5

Prescott (1951a) p. 418; Pl. 83, Fig. 6

Test subtriangular to ovate, broadest at the base and tapering to the truncate apex; wall smooth. Length, 18-18.2μ; width 12.5-14.3μ.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During January.

T. volvocina Ehrenb.

A common, although variable, species. For a description and illustration, see Prescott (1951a).

Distribution: In all habitats at Purdy Bog except the center lake; outlet portion of Lawrence Lake.

Occurrence: Not noted in February or March, otherwise present throughout the year.

Eutreptia Perty

Eutreptia viridis Perty

Huber-Pestalozzi (1955) p. 397; Pl. LXXXI, Fig. 863

Cells elongate-obovate to obpyriform, with a narrowed caudus-like posterior region. Chromatophores numerous, discoid. Flagella 2, anterior.

Easily separated from other chloroplast-containing euglenoids by its characteristic shape and the presence of two flagella of equal length. The writer was never able to obtain accurate figures or measurements of the organisms observed, because they could not be slowed without distorting the cell; thus, no illustrations or measurements are given here. For a description and illustration, see Huber-Pestalozzi (1955).

Distribution: Marginal pools and lake bottom in Purdy Bog. Unverified new record for Michigan (because of no published illustration).

Occurrence: Noted sporadically; more common from September to December.

Family: Cyclidiopsidaceae

Cyclidiopsis Korschikow

Cyclidiopsis acus Korschik. Pl. 14, Figs. 1-4

Huber-Pestalozzi (1955) p. 405; Pl. LXXXIII, Fig. 869

Cells elongate-spindle shaped, slightly metabolic; posterior portion elongate-acuminate, anterior end truncate. Flagellum 1, relatively short. Oral canal funnel shaped; reservoir in the middle, or to one side, of the cell, near the anterior end. Stigma conspicuous, beside the reservoir, or cytopharynx. Nucleus cylindrical, clearly evident only when stained; nucleoli present. Paramylon bodies needle-like to rod-shaped, variable in shape, size and position. Cells 174-179μ long, 6.8-9μ wide. Paramylon bodies from about 1 to 2.5μ in width, 11-26μ long. Nucleus about 3.4μ wide, 25μ long.

This organism is subject to some metaboly, which is mostly of a twisting or bending nature because the periplast is relatively firm. The species has numerous synonyms and, as regarded here, includes both Cycl. pseudomermis (Penard) H-P. and Cycl. crescentia (Packard) H.-P. For a discussion on the taxonomy of this group, see Huber-Pestalozzi (1955) and Pringsheim (1956).

Distribution: Sphagnum mat, marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: From May to November.

Family: Astasiaceae

Astasia Dujardin

Astasia praecompleta Skuja Pl. 14, Fig. 8

Huber-Pestalozzi (1955) p. 434; Pl. LXXXVII, Fig. 896

Cells elongate-obovate to cylindrical, slightly metabolic; periplast faintly spirally striate. Anterior end broadly rounded, posterior narrowing to the blunt terminus. Anterior half of cell densely packed with cylindric or rounded paramylon bodies, posterior portion of cell mostly hyaline. Nucleus in posterior half of the cell. Flagellum 1/2 to 2/3 the body length. Cells 40-44μ long, 10-11μ in width, agreeing well with Skuja's measurements of 46-53μ by 9-11μ.

For a description, see Huber-Pestalozzi (1955).

Distribution: Sphagnum mat in Purdy Bog. New record for North America.

Occurrence: From April through June.

A. Skadowskii Korschik. Pl. 14, Figs. 6, 7

Huber-Pestalozzi (1955) p. 427; Pl. LXXXVI, Fig. 883

Cells actively metabolic when at rest, elongate obovate; anterior end broadly rounded, posterior narrowed to the short, stout tail region. Periplast spirally striate. Paramylon bodies densely packed in the cell, discoid to cylindrical, numerous. Nucleus near the center of the cell. Flagellum 1/2 to about 2/3 body length. Cells about 15μ wide by 55-68μ long.

See Huber-Pestalozzi (1955) for a description and illustration.

Distribution: Lake bottom, marginal pools and sphagnum mat in Purdy Bog. New record for North America.

Occurrence: Commonly found from April to August; also in October.

Menoidium Perty

Menoidium pellucidum Perty Pl. 15, Fig. 1

Huber-Pestalozzi (1955) p. 443; Pl. XC, Fig. 912

Cells colorless, curved when seen from the side, thin in top view. Upper margin convex, lower margin concave to almost straight. Periplast firm, appearing smooth. Cells tapering to an acute anterior apex which is somewhat two-lipped; posterior broadly rounded. Two large cylindrical paramylon bodies usually present in the cell, along with numerous smaller food bodies and granules. Flagellum short (in ours), less than, to almost 1/2 the body length. Cells 7-11μ wide by 40-46μ long.

An apparently variable species according to our observations; more careful analyses might enable one to separate this into several taxa. For a description of M. Pellucidum, see Huber-Pestalozzi (1955).

Distribution: Lake bottom, marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: Noted sporadically throughout the year.

Rhabdomonas Fresenius

Rhabdomonas incurva Fresenius Pl. 15, Fig. 6

Huber-Pestalozzi (1955) p. 451; Pl. XCII, Fig. 931

Cells somewhat flattened dorsiventrally, slightly curved, cylindrical, rounded at both ends and somewhat bean-shaped. Periplast striate. Paramylon bodies numerous to few, cylindric or discoid in shape. Flagellum about body length. Nucleus not observed. Illustrated cell 15μ long, 7μ wide, within the range given for the species.

See Huber-Pestalozzi (1955) for a description and illustration.

Distribution: Sphagnum mat in Purdy Bog. New record for Michigan.

Occurrence: Observed during May.

Distigma Ehrenberg

Distigma curvatum E. G. Pringsh. Pl. 14, Fig. 5

Huber-Pestalozzi (1955) p. 463; Pl. XCIV, Fig. 952

Cells small, obovate to elongate-obpyriform, somewhat metabolic; periplast finely spirally striate. Anterior half of the cell densely filled with paramylon bodies, these mostly cylindrical. Nucleus toward the posterior half of the cell. Primary flagellum approximately body length, secondary flagellum quite short. Cells 18-26μ long, 6.5-11μ wide.

Pringsheim (cited in Huber-Pestalozzi, 1955) separates the species into 2 forms based on size; the forma major 18-25μ, and the fa. minor 15-18μ, in length. According to this, most of our specimens agree with

the fa. major and may be designated as D. Curvatum fa. major E. G. Pringsh.

For a description, see Huber-Pestalozzi (1955).

Distribution: Sphagnum mat, marginal and sphagnum pools in Purdy Bog. New record for North America.

Occurrence: From December to April.

Gyropaigne Skuja

Gyropaigne kosmos Skuja Pl. 15, Fig. 9

Huber-Pestalozzi (1955) p. 464; Pl. XCV, Fig. 954

Cells rounded-cylindric to ellipsoidal, with a short, pointed caudus; periplast firm, with a series (8 in our specimens) of 8-10 longitudinal, somewhat curving ridges which are separated by grooves, the grooves meeting, or nearly so, at each end of the cell. Flagellum body length (or shorter). Paramylon bodies present, these mostly localized in the anterior half of the cell. Nucleus not observed. Illustrated cell 28.5μ long by 17μ wide, as compared with Skuja's measurements of 30-46μ by 16-23μ.

The ridges are not as spiral in arrangement as those illustrated by Skuja, but otherwise our material agrees well with G. kosmos. For a description, see Huber-Pestalozzi (1955).

Distribution: Marginal pools in Purdy Bog. New record for North America.

Occurrence: During November.

Family: Peranemaceae

Peranema Dujardin

Peranema trichophorum (Ehrenb.) Stein Pl. 15, Fig. 2

Huber-Pestalozzi (1955) p. 473; Pl. XCV, Fig. 959

Cells ovate to somewhat cylindrical, occasionally long-triangular in shape, metabolic. Apex narrowed and somewhat acute, posterior broadly rounded to truncate. Periplast striate. Pharyngeal rods present near the large anterior vacuole and gullet. Paramylon bodies present, these small and numerous, present in most of the cell behind the vacuole. Only one flagellum seen, this quite thick and directed anteriorly. Illustrated cell 52μ long by 12μ wide; flagellum 63μ long.

For a description and illustration, see Huber-Pestalozzi (1955).

Distribution: In all habitats at Purdy Bog except the center lake. New record for Michigan.

Occurrence: Noted in all months except February and March.

Petalomonas Stein

Petalomonas praegnans Skuja Pl. 17, Figs. 7-11

Huber-Pestalozzi (1955) p. 500; Pl. CI, Fig. 1023

Cells relatively large, oval to ellipsoidal; anterior end broadly rounded, usually protruded slightly, posterior and tapering to a short, acute caudus. Ventral margin almost straight, dorsal margin convex, keeled. Cells somewhat triangular in cross section, the lateral margins appearing flanged; dorsal side convex, showing 2-3 longitudinal keels or ridges, of which the central is usually the highest. Flagellum 3/4 to about as long as the body. Periplast smooth (in ours). Cytoplasm with many globose granules. Nucleus spherical. Length 66-68μ, width about 34μ, thickness 20-34μ; flagellum length 40-56μ.

The genus Petalomonas is difficult taxonomically, because the organisms must be observed from many angles and their configuration, especially ridges, must be noted exactly. For a description, see Huber-Pestalozzi (1955).

Distribution: Center lake and lake bottom in Purdy Bog. New record for North America.

Occurrence: May to July; also in January.

P. Steinii Klebs — Pl. 15, Fig. 3

Huber-Pestalozzi (1955) p. 497; Pl. C, Fig. 1010

Cells elliptical to subcylindric; anterior end obliquely truncate to rounded. Triangular in cross section, keeled, the keel somewhat deflexed toward one of the lateral margins. Flagellum (in ours) 1/2 to body length. Nucleus barely discernible, in the middle portion of the cell. Illustrated cell 38μ long, 19μ in diameter.

A variable species. See Huber-Pestalozzi (1955) for a description and illustrations.

Distribution: Lake bottom and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: During January and February.

Heteronema Dujardin; emend. Stein

Heteronema acus (Ehrenb.) Stein, fa. Pl. 15, Fig. 4

Huber-Pestalozzi (1955) p. 510; Pl. CIV, Fig. 1041

Cells metabolic, spindle-shaped to fusiform; anterior end tapering to the somewhat acute apex, caudal region acuminate. Periplast smooth. Pharyngeal apparatus sometimes apparent. One anterior gullet; vacuoles present posterior to this. Nucleus rounded, in the posterior half of the cell. Flagella 2, one usually longer than the other, but many times of almost the same length. Illustrated cell 83µ long, 11.4µ wide; shorter flagellum 58µ in length.

Our specimens agree well with a form illustrated by Skuja (see Huber-Pestalozzi, 1955, Fig. 1041).

Distribution: Sphagnum pool in Purdy Bog. New record for Michigan.

Occurrence: From September to November.

Anisonema Dujardin

Anisonema pseudoprosgeobium new species Pl. 16, Figs. 1-5

Cells ovoid to subelliptic, only slightly metabolic. Anterior end tapering to the subacute, to rounded, apex which may be slightly produced. Periplast more or less firm, longitudinally striate; striae thick, sometimes appearing as low ridges, observable clearly only under oil-immersion. Nucleus oval to elliptic, on the right side of the organism. Vacuoles present in the anterior portion (opposite the nucleus), toward the organism's left side, usually one large one which may have several smaller ones within it, or several smaller ones alone. Various rounded inclusions present, these larger and more densely packed in the posterior half, some of them, at least, yellowish-brown in color. Flagella 2; swimming flagellum about 1/2 body length, trailing flagellum much thicker, 1 1/2-3 times the body length. Ventral side straight to concave, with a longitudinal groove, hooked toward the anterior end; dorsal margin convex. Length, 38-51μ, width 17-28μ, thickness 13-16μ. Swimming flagellum 24-26μ long, trailing flagellum 74-122μ in length. Nucleus averaging 7-10μ by 12-14μ, rarely larger.

A variable species, most closely resembling A. prosgeobium Skuja, from which it may be distinguished by its striate periplast, slightly larger size, and habitat; Skuja's species is a brackish-water form.

Distribution: Sphagnum mat, marginal pools and lake bottom in Purdy Bog.

Occurrence: From January to April.

Entosiphon Stein

Entosiphon sulcatum (Duj.) Stein. Pl. 17, Fig. 1

Huber-Pestalozzi (1955) p. 533; Pl. CIX, Fig. 1099

Cells oval to ellipsoidal, rounded at both ends, 32-36μ long by about 15μ wide. Siphon reaching almost to the posterior of the cell. Ridges variable in number, from 8-12. Flagella shorter than described, the swimming flagellum less than body length, the trailing flagellum about body length.

The cell size is somewhat longer than given in the literature (20-25μ), but because the organism has not been observed frequently, it is assumed that this falls within the range of the species. The number of ridges present varies between that given for E. sulcatum (4-8) and E. ovatum (10-12). Because E. sulcatum is the older name,

the writer includes E. ovatum with E. sulcatum; any changes in nomenclature will have to await a monographic treatment of the genus. Our forms approach the var. major erected by Seckt (see Huber-Pestalozzi, 1955) for larger forms of E. ovatum. For a description, see Huber-Pestalozzi (1955).

Distribution: Marginal and sphagnum pools in Purdy Bog. New record for Michigan.

Occurrence: From May to November; infrequent.

V DIVISION CYANOPHYTA

Class: Myxophyceae

Order: Chroococcales

Family: Chroococcaceae

Chroococcus Naegeli

Chroococcus dispersus (Keissl.) Lemm.

Care must be used to separate this from *C. limneticus*, below. For a description and illustration, see Prescott (1951a).

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: Observed from September through December.

C. limneticus Lemm. (incl. varieties)

For a description and illustration, see Prescott (1951a).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Found from June through November; absent during the winter months.

C. minutus (Kuetz.) Naeg.

See Prescott (1951a) for a description and illustration.

Distribution: Sphagnum mat and marginal pools in Purdy Bog.

Occurrence: During April, November and December; apparently absent during warmer months of the year.

C. Prescottii Drouet and Daily

For a description and illustration, see Prescott (1951a).

Distribution: Center lake, sphagnum mat and marginal pools in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Common from June to October; of sporadic occurrence otherwise.

C. turgidus (Kuetz.) Naeg.

One of the most easily recognized species of the genus. See Prescott (1951a) for a description and illustration.

Distribution: In all habitats of Purdy Bog except the lake bottom; main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Found throughout the year.

C. turgidus var. maximum Nyg. Pl. 18, Fig. 5

Huber-Pestalozzi (1938) p. 147; Pl. 10, Fig. 26

Cells arranged in colonies of 2, 4 or 8 individuals, yellowish to olive-green or light blue-green in color. Sheath colorless. Cell diameter 34 to 45.6μ, exclusive of sheath; with sheath, up to 60μ.

Distinguished from the typical by the larger cell size and somewhat thicker sheath. In our specimens, the cells were yellowish to olive-green in color, rather than bright blue-green as in the typical, and were more vacuolate. According to Huber-Pestalozzi (1938), the cell size varies from 22-45μ, exclusive of the sheath; C. turgidus has a maximum cell diameter of 32μ.

The variety is separated from C. giganteus by its smaller size and different cell coloration, those of the latter being of a purplish or dark blue-green color.

Distribution: Main, intermediate and outlet portions of Lawrence Lake. New record for Michigan, and probably for North America.

Occurrence: From May through December.

Microcystis Kuetzing

Microcystis aeruginosa Kuetz.; emend. Elenkin

For a description and illustration, see Prescott (1951a).

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: From May through November.

Merismopedia Meyen

Merismopedia elegans A. Braun

Questionably recorded here because of the coarsely-granular appearance and darker color of the cells; possibly only a variation of M. glauca, below. For a description and illustration, see Prescott (1951a).

Distribution: Sphagnum mat in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Observed in July and November only.

M. glauca (Ehrenb.) Naeg.

Cells often more coarsely granular than described, otherwise typical of the species. See Prescott (1951a) for a description.

Distribution: In all habitats of Purdy Bog except the sphagnum pool; main portion of Lawrence Lake.

Occurrence: Found throughout the year.

M. punctata Meyen

Occasionally resembling M. Trolleri below, because of the occasional presence of gas vacuoles. The contents are usually homogeneous, however, and when vacuolate do not show the brownish color of the latter species. For a description and illustration, see Prescott (1951a).

Distribution: Of wide distribution; found in all habitats in both study areas, but more common in Purdy Bog in non-planktonic habitats.

Occurrence: Probably occurs throughout the year; not observed during March.

M. Trolleri Bachmann — Pl. 18, Fig. 4

Prescott (1951a) p. 460; Pl. 101, Fig. 5

Cells minute, about 2-4μ in diameter; with pseudovacuoles.

Difficult to separate from certain expressions of M. punctata, unless many colonies are observed and compared.

Distribution: Center lake and sphagnum mat in Purdy Bog; main portion and marginal pool in Lawrence Lake. New record for Michigan.

Occurrence: Of sporadic occurrence.

Synechococcus Naegeli

Synechococcus aeruginosus Naeg.

For a description and illustration, see Prescott (1951a).

Distribution: Lake bottom and marginal pools in Purdy Bog.

Occurrence: Found throughout most of the year.

Rhabdoderma Schmidle and Lauterborn

Rhabdoderma lineare Schmidle and Lauterborn — Pl. 18, Fig. 3

Prescott (1951a) p. 463; Pl. 103, Figs. 11, 12

Cells rod-shaped, about 2μ in diameter, up to 10μ long; in gelatinous colonies.

On the basis of limited samples, it is difficult to separate with

accuracy certain expressions of bacteria from smaller blue-greens, because of their extremely small size and the occurrence of color interference in microscopy. Some of our material is placed here tentatively, however, until further examination can be carried out on more numerous specimens.

Distribution: Center lake in Purdy Bog. New record for Michigan.

Occurrence: During February; questionably of more frequent occurrence.

Aphanothece Naegeli

Aphanothece microscopica Naeg.

Easily distinguished from other species of Aphanothece by the microscopic size of the mature colony, which reaches a maximum diameter of only 2mm. See Geitler (1932) for a description and illustration.

Distribution: Primarily euplanktonic in center lake of Purdy Bog, but also found on lake bottom; observed once in outlet portion of Lawrence Lake.

Occurrence: Found during every month of the year.

A. Naegelii Wartm. Pl. 18, Figs. 8, 9

Geitler (1932) p. 172

Cells oval to cylindrical, 4.6-5.2μ wide, 8-9μ long, blue-green; in yellowish-brown to olive-green mucilage. Colonies macroscopic, on soil.

This is regarded as a questionable form by Geitler (1932), but our material agrees well with the species description.

Distribution: On soil near marginal pool in Lawrence Lake. Tentative new record for Michigan.

Occurrence: Noted during October, but probably of more frequent occurrence.

A. stagnina (Spreng.) A. Braun

For a description, see Geitler (1932).

Distribution: In plankton of main and outlet portions of Lawrence Lake.

Occurrence: Irregularly from May to November; probably present during all of these months.

Coelosphaerium Naegeli

Coelosphaerium Naegelianum Unger

A species easily separated from other members of the genus by its cell size and shape. Cells 2-3 times longer than broad, 3.5-5μ in diameter by 5-7μ in length.

One of the key characteristics of this species is its pseudo-vacuolate contents; the writer has found colonies under the ice, however, which are definitely not vacuolate, and which are embedded in quite firm mucilage. It would appear that further winter collections from other areas might prove this to be of more common occurrence. See Huber-Pestalozzi (1938) for a description.

Distribution: Main and outlet portions of Lawrence Lake.

Occurrence: Found during all months of the year.

C. pallidum Lemm. Pl. 17, Fig. 3

Prescott (1951a) p. 471; Pl. 106, Fig. 3

Colonies spherical to ovate; cells contents pale blue-green, homogeneous. Cells 1.5-2μ in diameter, 2-3μ in length; colonies 28-38μ in diameter, up to 51μ long.

Distinguished from Gomphosphaeria lacustris var. compacta by the absence of radiating gelatinous strands in the colony; otherwise the

two are somewhat similar and may be confused. See Prescott (1951a) for a description.

Distribution: Main, intermediate and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Sporadic; from August to December.

<u>Gomphosphaeria</u> Kuetzing

<u>Gomphosphaeria</u> <u>aponina</u> Kuetz.

See Prescott (1951a) for a description.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Probably present during all months of the year, but more abundant in summer.

<u>G</u>. <u>aponina</u> var. <u>cordiformis</u> Wolle.

Distinguished from <u>G</u>. <u>aponina</u> by the larger size and compact arrangement of the cells; for a description, see Prescott (1951a).

Distribution: Main, intermediate and outlet portions of Lawrence Lake; occurs with the typical species.

Occurrence: Observed from April through January.

<u>G</u>. <u>lacustris</u> var. <u>compacta</u> Lemm. Pl. 18, Fig. 2

Prescott (1951a) p. 473; Pl. 106, Fig. 8

Cells attached to mucilaginous strands which radiate and branch from the center of the colony; cells compactly arranged at the periphery of a wide gelatinous envelope. Illustrated colony: cells 2.3μ wide, 4.6μ long; colony 34μ in diameter. (See note under Coelosphaerium pallidum, above).

Distribution: Main, intermediate and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Observed during all months but March; probably present all year.

Order: Hormogonales

Suborder: Homocystineae

Family: Oscillatoriaceae

Spirulina Turpin

(Incl. Arthrospira Stizenberger)

Section: Arthrospira

Spirulina Jenneri (Stiz.) Geitl.

For a description, see Huber-Pestalozzi (1938).

Distribution: Main portion of Lawrence Lake.

Occurrence: During November and December.

S. platensis (Nordst.) Geitl., fa. Pl. 19, Figs. 1, 2

Huber-Pestalozzi (1938) p. 225; Pl. XLVII, Figs. 146, 159.

Cells 4.5-6.8μ long; trichomes up to 11.4μ wide; width of spirals 32-34μ, length of spirals up to 91μ.

Some trichomes found in Lawrence Lake must be placed under this species, because they agree with almost all characteristics except cell width. Rich (cited in Geitler, 1932) found trichomes up to 11μ wide in this species, but Geitler thinks that Rich observed a mixture of species;

for this reason it is included here tentatively. For a description of S. platensis, see Geitler (1932).

Distribution: Main portion of Lawrence Lake. New record for Michigan.

Occurrence: Observed during July.

Section: Euspirulina

S. laxa G. M. Smith (?) Pl. 18, Fig. 1

Prescott (1951a) p. 479; Pl. 108, Fig. 10

Trichomes with loose spirals; cells 2.3-3μ wide, about 5μ long when observable. Windings up to 11μ wide, and up to 28μ long.

Questionably listed here because Smith's species was described as not having cross walls. Both conditions were observed in our materials. This, along with its somewhat larger windings, necessitates the questionable determination. For a description, see Geitler (1932).

Distribution: Center lake in Purdy Bog. Tentative new record for Michigan.

Occurrence: During February and March.

Oscillatoria Vaucher

Oscillatoria amphibia C. A. Agardh

Distinguished by its narrow width, and paired granules along the cross walls. See Prescott (1951a) for a description.

Distribution: In all habitats in Purdy Bog except the center Lake; main portion of Lawrence Lake. (More common in the bog).

Occurrence: Sporadic; noted from March through November.

O. Bornetii Zukal Pl. 19, Fig. 6

Geitler (1932) p. 956; Fig. 609, p. 957

Cell contents pale, with large quadrangular vacuoles; apical cell without a calyptra, non-capitate, broadly rounded. Trichomes not tapering, cells about 12μ wide, 1/3-2/3 as long as broad.

The large vacuoles easily separate this from other species of Oscillatoria. For a description, see Huber-Pestalozzi (1938).

Distribution: Main, intermediate and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Common from October through January.

O. curviceps C. A. Agardh

Rather closely related to O. limosa, but separated from it by the curving or hooked apical region. See Prescott (1951a) for a description.

Distribution: Center lake and lake bottom in Purdy Bog.

Occurrence: During February and March.

O. limosa (Roth) C. A. Agardh

As noted above, resembling O. curviceps; distinguished from it by the straight trichomes and more granular cross walls. See Prescott (1951a) for a description.

Distribution: Center lake and lake bottom in Purdy Bog; main and outlet portions of Lawrence Lake.

Occurrence: Observed in October.

O. princeps Vaucher

Readily distinguished from other Oscillatoria species because of the large diameter of its trichomes. See Prescott (1951a) for a description.

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog; main portion of Lawrence Lake.

Occurrence: Absent from January to March, otherwise found throughout the year.

O. rubescens DeCandolle

Trichomes straight, somewhat constricted near the apex; apical cell capitate, with a calyptra. Cells not constricted at the cross walls, vacuolate or granular.

Not forming bundles of trichomes or coloring the water, otherwise as described for the species. For a description, see Geitler (1932).

Distribution: Center lake, lake bottom and marginal pools in Purdy Bog.

Occurrence: From May through September.

O. splendida Greville (incl. varieties)

Trichomes 1.8-2μ in width, constricted toward the apex; end cell capitate, almost spherical. For a description, see Geitler (1932).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Observed during September.

O. tenuis C. A. Agardh

Trichomes straight or slightly curved, not tapering at the anterior end. Apical cell convex, not capitate. Cells 5 to 8μ in width, 4 to 6μ long, constricted at the cross walls, which are granular.

Represented in our collections by the two varieties below.

O. tenuis var. natans (Kuetz.) Gom. Pl. 18, Fig. 7

Prescott (1951a) p. 491; Pl. 110, Figs. 10, 11

Cell diameter greater than 6μ (6 to 9μ); contents granular to vacuolate. Otherwise, as in the typical.

Characterized by its stouter appearance and broader trichomes. See Geitler (1932) for a description.

Distribution: In all habitats of Purdy Bog except the sphagnum mat; main and outlet portions of Lawrence Lake. New record for Michigan.

Occurrence: Not noted in summer, otherwise present throughout the year.

O. tenuis var. tergestina (Kuetz.) Rabenh. Pl. 18, Fig. 6

Prescott (1951a) p. 492; Pl. 110, Figs. 12, 13

Trichomes thinner than in var. natans, mostly 5 to 6μ in width; apical cell (in ours) more conical in shape; otherwise, as described for the species.

For complete description, see Geitler (1932).

Distribution: Center lake in Purdy Bog. New record for Michigan.

Occurrence: During March.

Lyngbya Agardh

Lyngbya Birgei G. M. Smith

Trichomes somewhat narrower than described, otherwise with characteristics of the typical species.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Absent from February to April, otherwise present throughout the year.

Suborder: Heterocystineae

Family: Nostocaceae

Anabaena Bory

Anabaena augstumalis var. marchica Lemm.

Characteristics as described, except for the size of the akinetes. The length of akinetes is usually given as 40-63(-70)μ. Geitler (cited in Huber-Pestalozzi, 1938) found specimens with akinetes up to 100μ in length, and the writer has found akinetes which were up to 120μ long. For a description, see Huber-Pestalozzi (1938).

Distribution: Sphagnum mat in Purdy Bog; observed once in marginal pools of this bog.

Occurrence: Vegetative during June, July and August; akinetes found throughout the year.

A. flos-aquae (Lyngb.) Bréb. (incl. varieties).

A characteristic species which is readily identified by its clustered, somewhat sausage-shaped akinetes. See Prescott (1951a) for a description.

Distribution: Main, intermediate and outlet portions of Lawrence Lake.

Occurrence: Observed from June through November; clumps of akinetes common in December.

Anabaena sp.

A species in which neither mature heterocysts nor akinetes were ever observed, thus incapable of identification. Cells varying in size and shape from those of the preceding species, thus maintained as a separate category.

Distribution: Center lake, marginal and sphagnum pools in Purdy Bog.

Occurrence: From June to October.

Nostoc sp.

Several quite small, immature colonies of Nostoc were observed, but because these contained no heterocysts or akinetes, an exact determination could not be made. The colonies most resembled N. paludosum Kuetz.

Distribution: Main portion of Lawrence Lake.

Occurrence: Found during March.

Cylindrospermum Kuetzing

Cylindrospermum minutissimum Collins Pl. 19, Fig. 5

Prescott (1951a) p. 531; Pl. 131, Fig. 13

Trichomes quite narrow, 2.6 (-3.4)μ wide. Cells longer than broad, cylindrical. Heterocysts elongate, (2-) 4 (-6)μ wide, (3-) 6-8 (-10)μ long. Akinetes cylindric to ellipsoid, 7-9μ wide, 12-25μ long; wall smooth.

Distribution: Sphagnum mat and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Of sporadic occurrence throughout the year.

Family: Scytonemataceae

Scytonema C. A. Agardh

Scytonema Arcangelii Born. and Flah. Pl. 19, Figs. 8, 9

Prescott (1951a) p. 534; Pl. 123, Figs. 6, 7

Filaments light blue-green in younger portions, yellowish-brown when mature. Cells quadrate or up to twice as long as broad, (7-9) 10-14μ wide, enclosed in a clear or yellowish non-lamellate sheath; filaments 11.5-15μ wide. Branches arising in pairs (usually) or singly. Heterocysts almost quadrate to longer than broad.

The diameter of the cells is somewhat less than the range given in Geitler (1932), but does not reach the narrow width of fa. minus (width 5-6μ); for a description, see Geitler (1932).

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Noted in February.

Scytonema sp.

Several fragments of one other Scytonema were observed, but amounts sufficient for a specific determination were never gathered.

Distribution: Intermediate portion of Lawrence Lake.

Occurrence: Observed during August.

Tolypothrix Kuetzing

Tolypothrix distorta Kuetz.

See Geitler (1932) for a description and illustration.

Distribution: Outlet portion of Lawrence Lake.

Occurrence: October through December; probably of more frequent occurrence.

Plectonema Thuret

Plectonema nostocorum Bornet (?)

Several fragments of this plant were found in decaying colonies of an Aphanothece colony, and both the habitat and cell size agreed well with P. nostocorum. But, because of the condition of the material no definite determination could be made.

For a description of P. nostocorum, see Geitler (1932).

Distribution: In mucilage of colonial forms; main portion of Lawrence Lake.

Occurrence: Observed during September.

P. notatum Schmidle Pl. 19, Fig. 7

Prescott (1951a) p. 540; Pl. 126, Figs. 6, 7

Filaments quite narrow, 1.7-2 (-2.6)μ in diameter, sparsely branched. Cells quadrate to cylindric, 1-2 times as long as broad, containing 1 or 2 large granules near the cross walls. Filaments light to dark blue-green in color, forming thin wefts over the substrate.

See Geitler (1932) for a complete description.

Distribution: Center lake in Purdy Bog. New record for Michigan.

Occurrence: Observed during January.

Family: Stigonemataceae

Hapalosiphon Naegeli

Hapalosiphon confervaceous Borzi Pl. 19, Figs. 3, 4

Prescott (1951a) p. 545; Pl. 128, Fig. 4

Branches arising from all sides of the main axis; cells quadrate to cylindrical, about 9-10μ in diameter. Sheath close and firm, thin, colorless. Heterocysts cylindrical, of about the same diameter as the vegetative cells.

See Prescott (1951a) for a complete description and illustration.

Distribution: Sphagnum mat and marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Observed during April, October and November. Probably present at other times, but immature.

H. fontinalis (Ag.) Born.

Syn: H. pumilus (Kuetz.) Kirchner in Prescott (1951a).

This species varies somewhat in size and morphology, necessitating the examination of mature material. For a discussion, see Prescott (1951a).

Distribution: Marginal pools in Purdy Bog.

Occurrence: Mature in December; perhaps present at other times also.

H. hibernicus West and West Pl. 18, Fig. 10

Prescott (1951a) p. 545; Pl. 128, Figs. 7, 8

Branches elongate, arising primarily from one side of the main axis; cells cylindric to quadrate, or shorter than broad, 5.7-6.5μ in diameter. Sheath thin, colorless. Heterocysts cylindrical, 4.5-5.7μ broad, 1 1/2-5 times as long as broad.

Separated from H. confervaceous by the one-sided branching, and the more elongate, cylindrical heterocysts.

Distribution: Marginal pools in Purdy Bog. New record for Michigan.

Occurrence: Mature during June; probably present during other months.

VI DIVISION RHODOPHYTA

Class: Rhodophyceae

Subclass: Florideae

Order: Nemalionales

Family: Batrachospermaceae

Batrachospermum Roth

Batrachospermum vagum (Roth) C. A. Agardh (?)

Prescott (1951a) p. 568; Pl. 135, Figs. 7-11

Reproductive organs were never observed in this material, although all other characters agree with those of *B. vagum*; thus, only a tentative identification can be made. However, both the color (gray-green) and the habitat in which the plants occur lend credence to the determination. Fott (1959, p. 189) thus states that, of all the species of *Batrachospermum*, "*Nur B. vagum* (Roth) Ag. *bevorzugt stilles, schattiges Wasser*."

Distribution: Center lake, marginal pools and lake bottom in Purdy Bog.

Occurrence: Probably occurs throughout the year, but not observed in February, March or May.

Plate I

Fig. 1. Top and side views of Phacotus Lendneri Chod., X 1100.

Fig. 2. Chlamydomonas media Klebs, X 1100.

Fig. 3. Chl. subcompleta new species, X 1100.

Fig. 4. Chl. ambigua Gerl., X 1100.

Fig. 5. Chl. elliptica Korsch., X 1100.

Fig. 6. Chl. Cienkowskii Schmidle, X 1100.

Fig. 7. Closterium incurvum fa. latior Irénée-Marie, X 1100.

Fig. 8. Geminella mutabilis (Bréb.) Wille, X 550.

Fig. 9. Gloeomonas ovalis Klebs, sensu Pascher, X 1100.

Fig. 10. Closterium acutum var. tenuis Nordst., X 1100.

Fig. 11. Kirchneriella lunaris var. irregularis G. M. Smith; portion of colony, X 1100.

Fig. 12. Hyaliella polytomoides Pascher, X 1100.

Fig. 13. Pediastrum muticum var. crenulatum Prescott; portion of coenobium, X 550.

Plate I

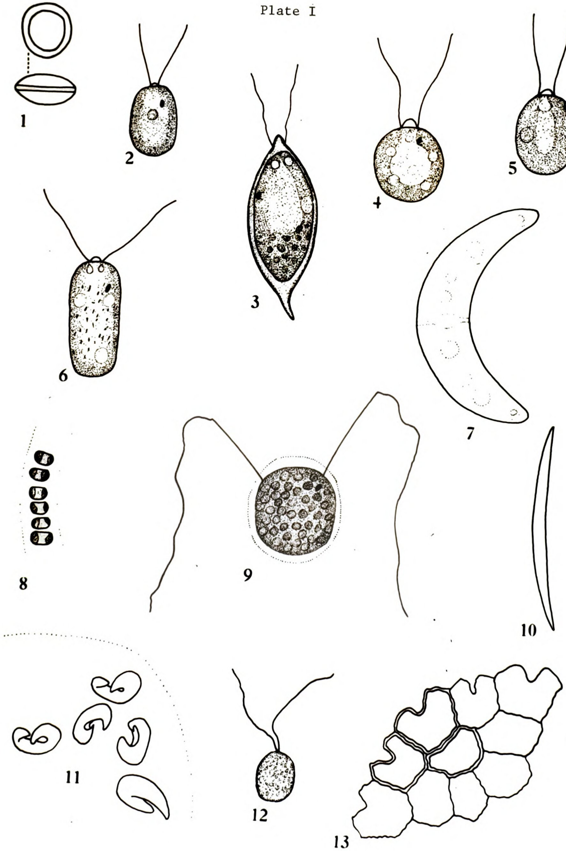


Plate II

Figs. 1-4 Oedogonium spiripennatum var. inferior new variety; 1, portion of filament showing oogonium, mature oospore and portion of dwarf male, X 1100; 2, another view of oospore, X 1100; 3, portion of filament showing oospore and androsporangia, X 245; 4, enlarged view of androsporangia, X 1100.

Fig. 5. Oedogonium exocostatum Tiffany, X 1100.

Plate II

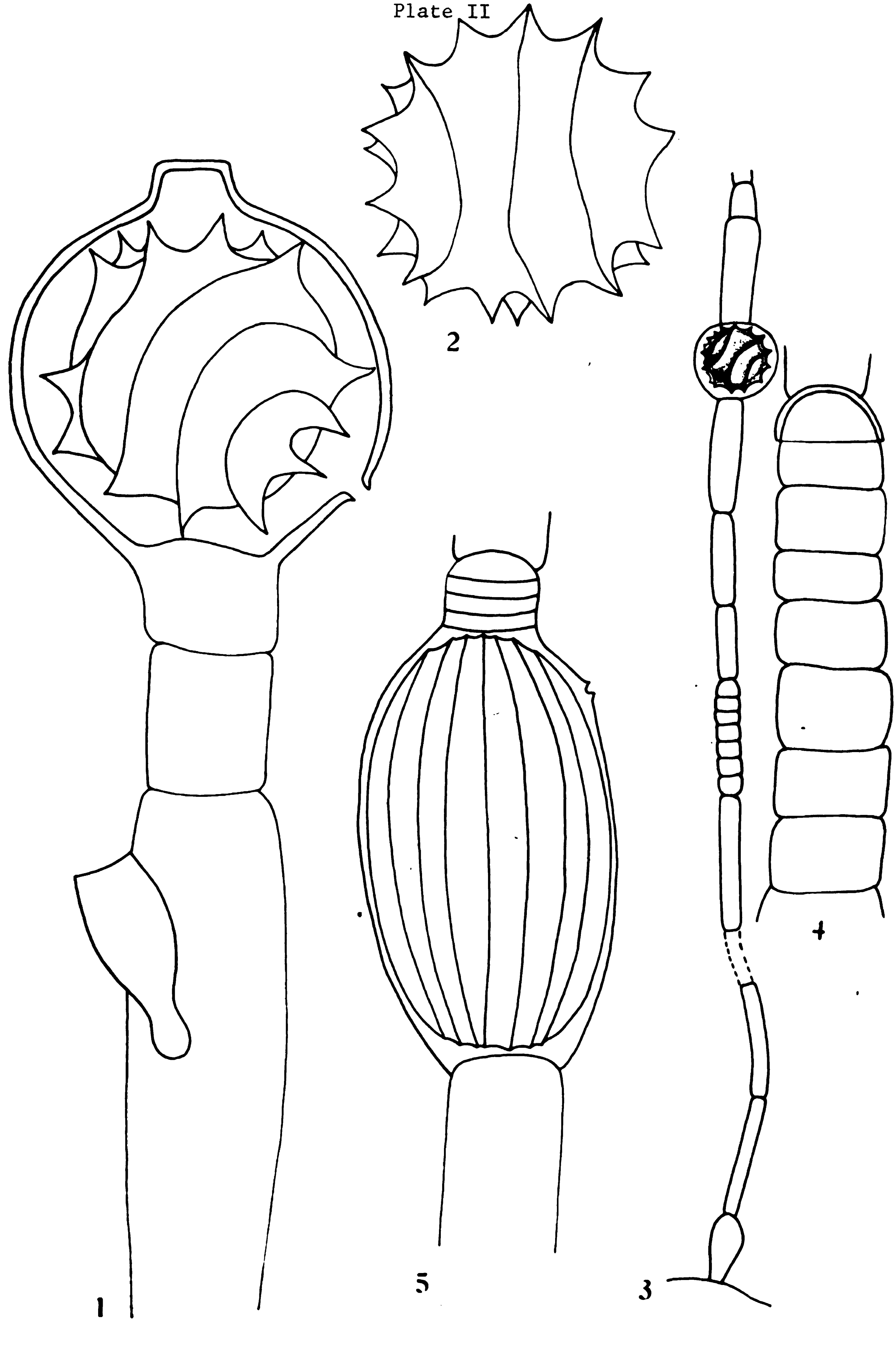


Plate III

Fig. 1. *Scenedesmus armatus* var. *major* G. M. Smith, X 1100.

Fig. 2. *Pleurotaenium nodosum* var. *Borgei* Grönblad, X 550.

Fig. 3. Face and end views of *Scenedesmus abundans* var. *asymmetrica* (Schroed.) G. M. Smith, X 1100.

Fig. 4. *Cosmarium exiguum* var. *pressum* West and West, X 1100.

Fig. 5. *Microthamnion strictissimum* var. *macrocystis* Schmidle, X 550.

Fig. 6. *Netrium digitus* var. *rhomboideum* Grönblad, X 550.

Fig. 7. *N. digitus* var. *parvum* Borge, X 1100.

Fig. 8. *N. digitus* fa. *elegans* Kossinsk., X 550.

Fig. 9. *Closterium subfusiforme* Messik., X 550.

Plate III

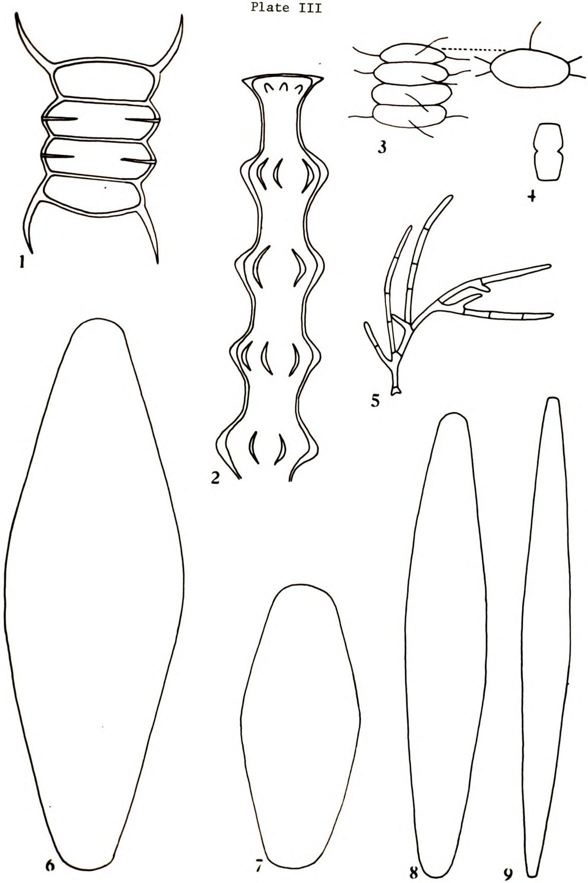


Plate IV

Fig. 1. Closterium costatum var. angustum new variety, X 550; apex and central portion of cell showing costae, X 1100.

Fig. 2. Cl. Ralfsii var. hybridum fa. sigmoideum Irénée-Marie, X 550; apex, X 1100.

Fig. 3. Cl. Malmei Borge, X 550; apex, X 1100.

Fig. 4. Cl. tumidulum Gay, X 550; apex, X 1100.

Fig. 5. Cylindrocystis Brebissonii var. turgida Schmidle, X 1100.

Fig. 6. Pleurodiscus sp.; portion of filament, X 1100.

Plate IV

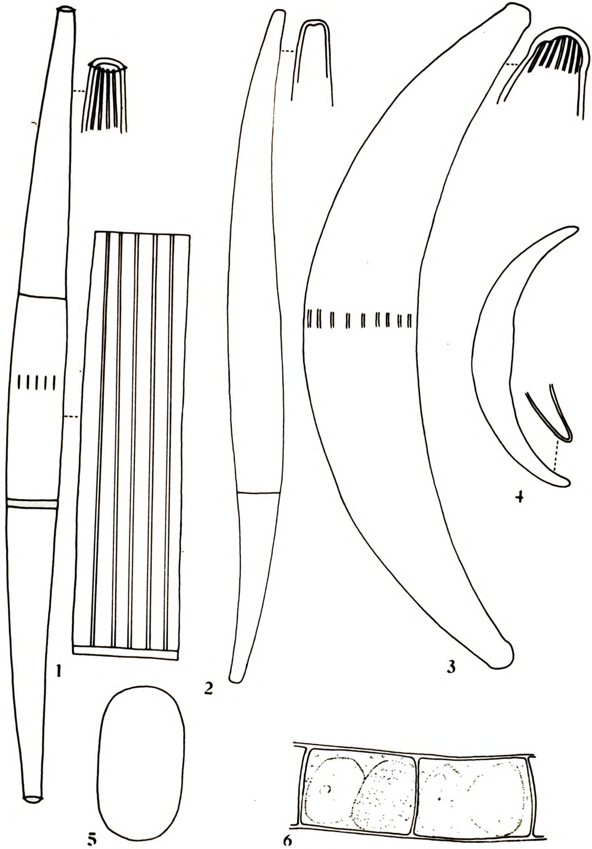


Plate V

Fig. 1. Cosmarium cucurbita var. attenuatum G. S. West, X 1100.

Fig. 2. C. venustum fa. minor Wille, X 1100.

Fig. 3. Micrasterias floridensis var. spinosa Prescott and Scott, X 550.

Fig. 4. Euastrum insulare var. silesiacum Grönbl., X 1100.

Fig. 5. Staurastrum inconspicuum var. crassum Gay, X 1100.

Fig. 6. Micrasterias rotata fa. nuda Irénée-Marie, X 550.

Fig. 7. Scenedesmus bijuga var. flexuosus (Lemm.) Collins, X 1100.

Fig. 8. Euastrum affine Ralfs, fa., X 1100.

Fig. 9. Aphanochaete polychaete (Hansg.) Fritsch, X 1100.

Plate V

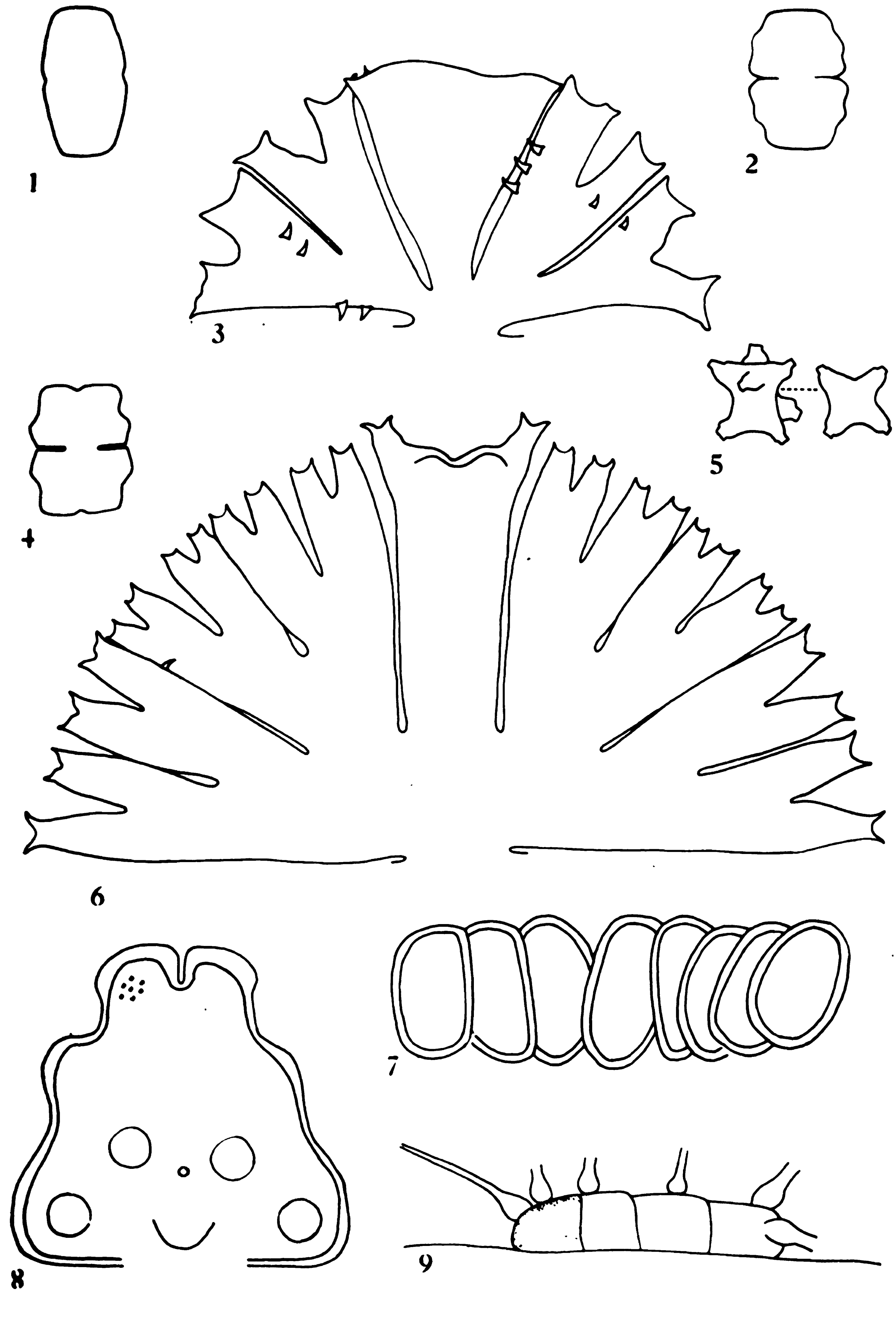


Plate VI

Fig. 1. Euastrum intermedium var. scrobiculatum Schmidle, X 1100.

Fig. 2. Euastrum denticulatum (Kirchn.) Gay, X 1100.

Fig. 3. Staurodesmus controversus (West and West) new combination; face and top views of a series of cells, X 1100. Two developing cells at upper right.

Fig. 4. Euastrum denticulatum var. quadrifarium Krieger, X 1100.

Fig. 5. Staurastrum urinator G. M. Smith, X 1100, showing variation of verrucae at right.

Fig. 6. Euastrum hypochondrum fa. decoratum Scott and Prescott, X 1100.

Plate VI

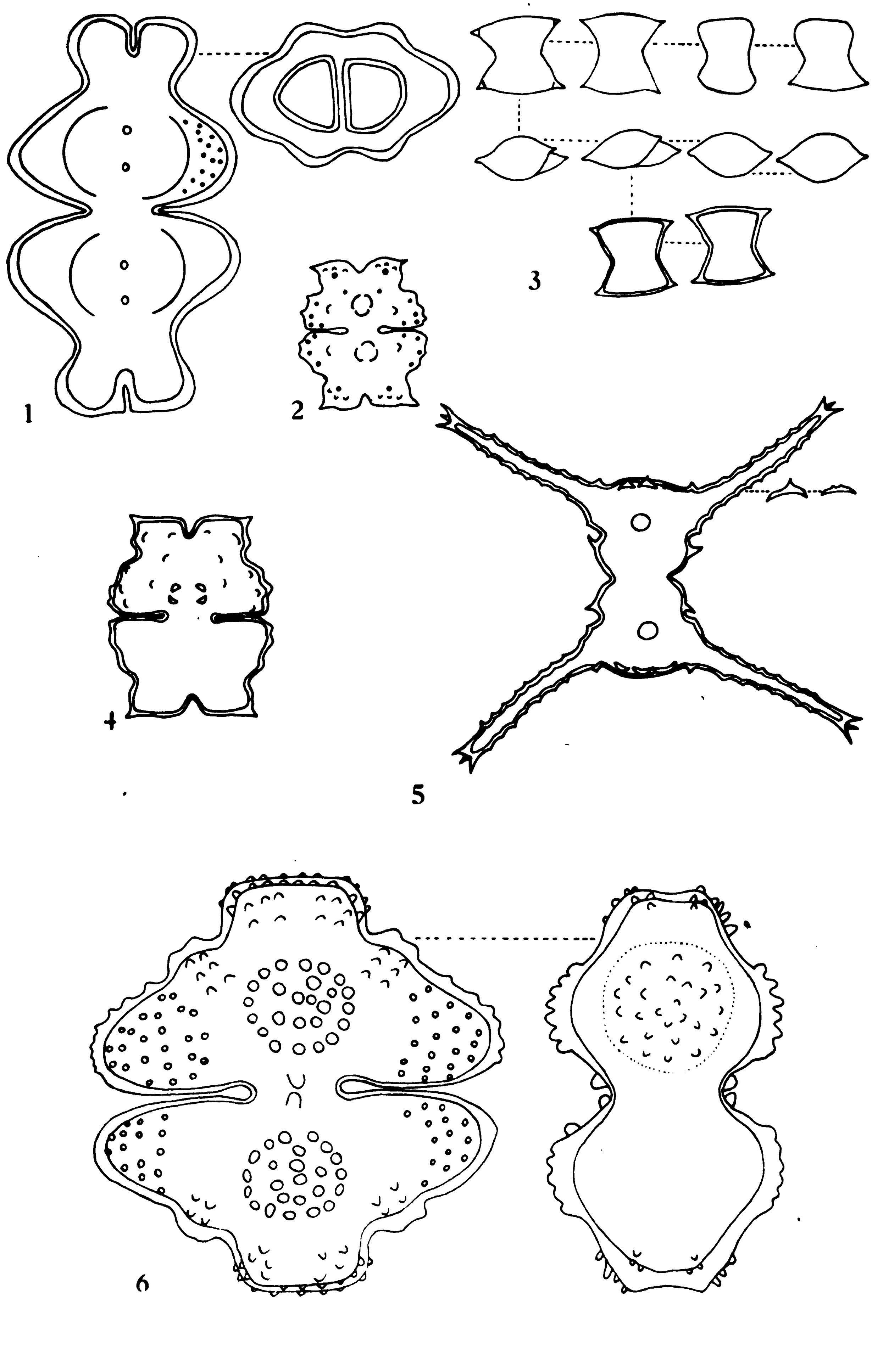


Plate VII

Fig. 1. *Staurastrum quebecense* Irénée-Marie, X 1100.

Fig. 2. *Staurodesmus extensus* var. *Joshuae* (Gutw.) new combination, X 1100.

Fig. 3. *Staurastrum aciculiferum* (West) Anders., fa., X 1100.

Fig. 4. *Micrasterias depauperata* var. *Kitchelii* (Wolle) West and West, X 550.

Fig. 5. *M. depauperata* var. *Kitchelii* fa. *apiculata* (Irénée-Marie) new combination, X 550.

Fig. 6. *Euastrum insigne* fa. *porifera* new form, X 1100.

Fig. 7. *Staurastrum monticulosum* var. *Irenee-Mariei* new variety, X 1100.

Plate VII

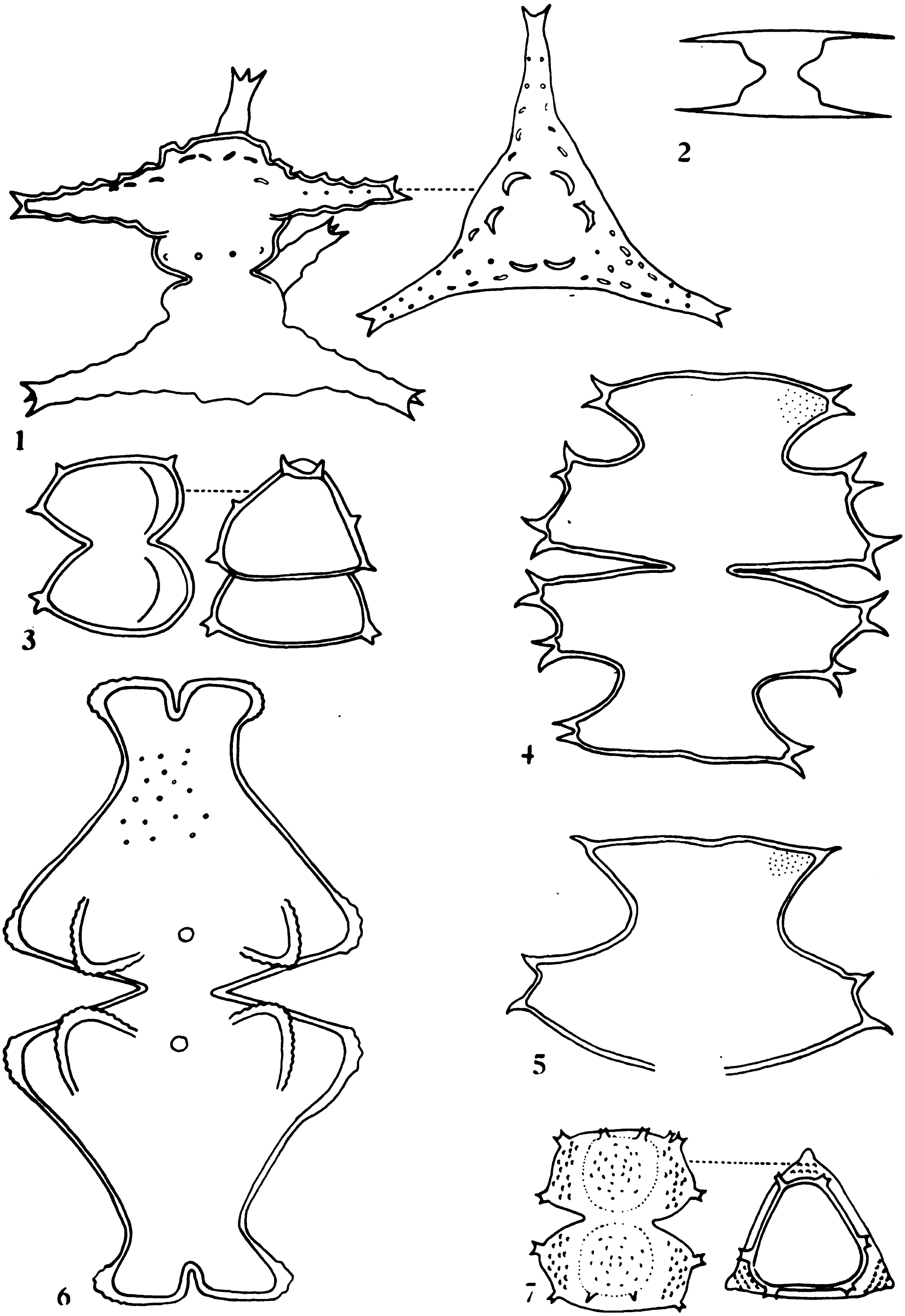


Plate VIII

Fig. 1. *Cosmarium depressum* (Naeg.) Lund., fa., X 1100.

Fig. 2. *Chrysarachnion insidians* Pasch., X 2200.

Fig. 3. *Staurodesmus megacanthus* var. *scoticus* (West and West) Lillier. fa. *minor* new form, X 1100.

Fig. 4. *Cosmarium bacillare* Luetk., X 1100.

Fig. 5. *Heterochromonas sphaerophora* Skuja, X 1100.

Fig. 6. *Ochromonas crenata* Klebs, X 1100.

Fig. 7. *Uroglena botrys* (Pascher) Conrad; portion of colony, X 1100.

Fig. 8. *Pseudokephyrion undulatissimum* Scherffel, X 1100.

Fig. 9. *Chromulina gigantea* Naumann, X 1100.

Figs. 10-12. *Synuropsis danubiensis* Schiller, fa.: 10, colony, X 1100; 11, enlarged view of cells from dissociating colony, X 2200; 12, end view of cell, X 2200.

Fig. 13. *Peroniella planctonica* G. M. Smith, X 1100.

Plate VIII

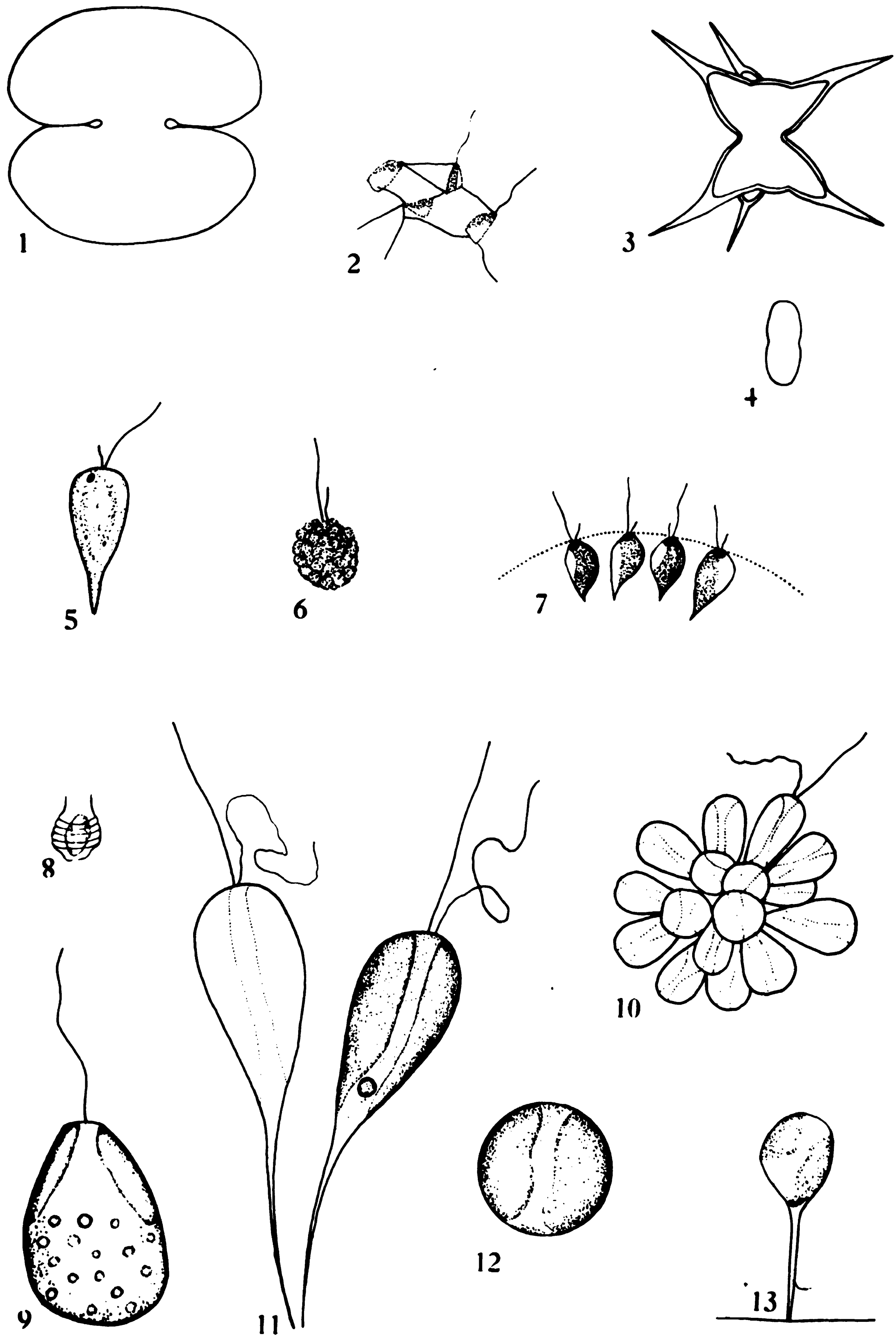


Plate IX

Fig. 1. Synura sphagnicola Korschik., X 1100.

Figs. 2, 3. Chromulina suprema Skuja: 2, cell, X 1100; 3, cyst, X 1100.

Fig. 4. Chromulina pyriformis Playfair, X 1100.

Fig. 5. Salpingoeca gracilis Clark, fa., X 1100.

Fig. 6. Dinobryon sertularia var. protuberans (Lemm.) Krieger, enlarged view of cell, X 1100.

Fig. 7. D. divergens var. Schauinslandii (Lemm.) Brunnth., X 1100.

Figs. 8, 9. D. pediforme (Lemm.) Steinecke: 8, cyst, X 1100; 9, colony, X 550 and enlarged cell, X 1100.

Plate IX

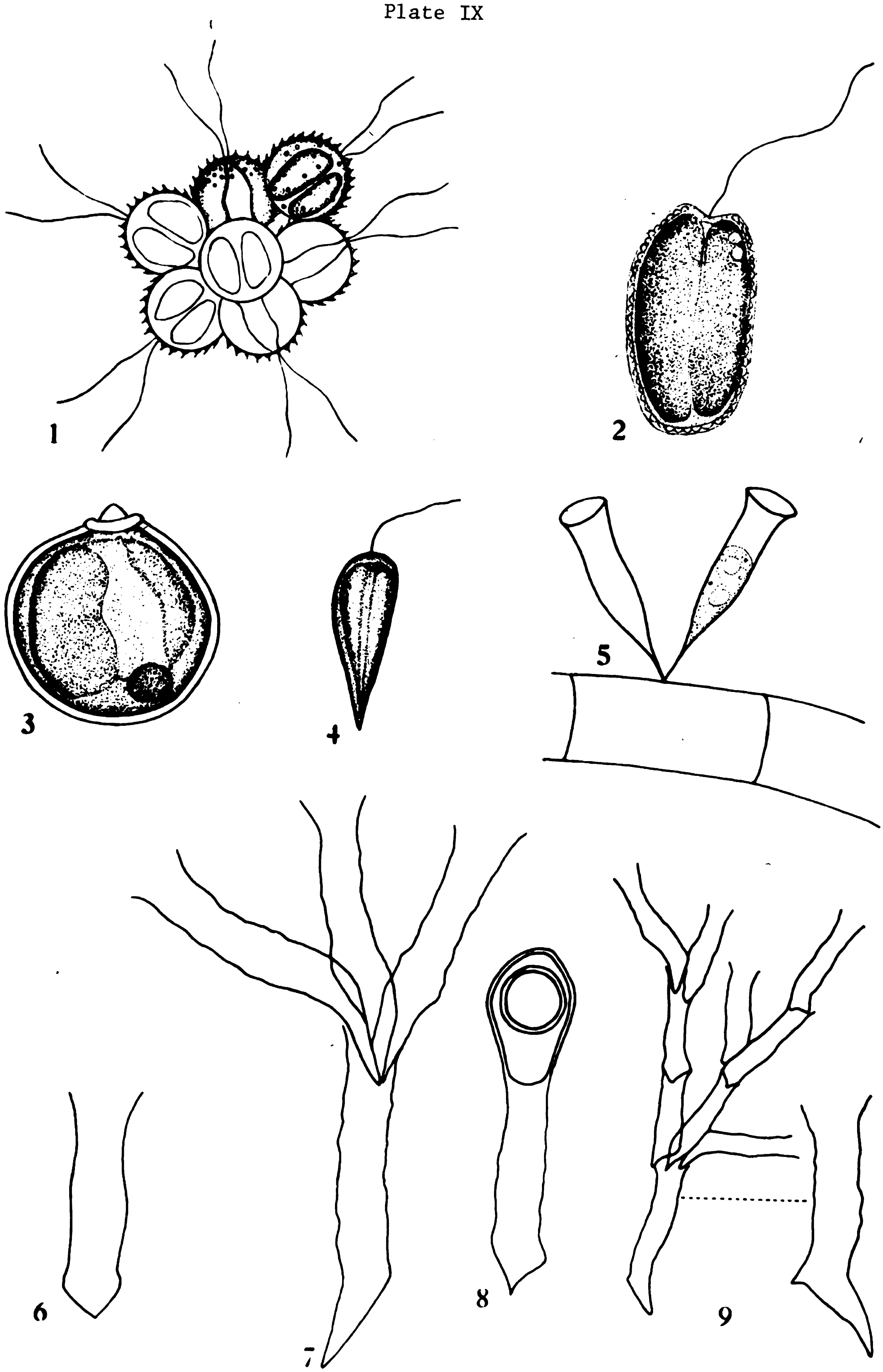


Plate X

Fig. 1. *Chrysopyxis stenostoma* Lauterb., X 1100.

Figs. 2, 3. *Rhipidodendron splendidum* Stein: 2, colony, X 245; 3, cell, X 1100.

Fig. 4. *Cystodinium bicorne* (Wolosz.) Huber-Pestalozzi, X 1100.

Fig. 5. *Tetradinium javanicum* Klebs, X 1100.

Figs. 6, 7. *Mallomonas elongata* Reverdin: 6, cell, X 550; 7, enlarged view of scales and spine, X 2200.

Figs. 8-10. *Hyalobryon ramosum* Lauterb.: 8, portion of colony, X 550; 9, 10, enlarged views of two cells, X 1650.

Plate X

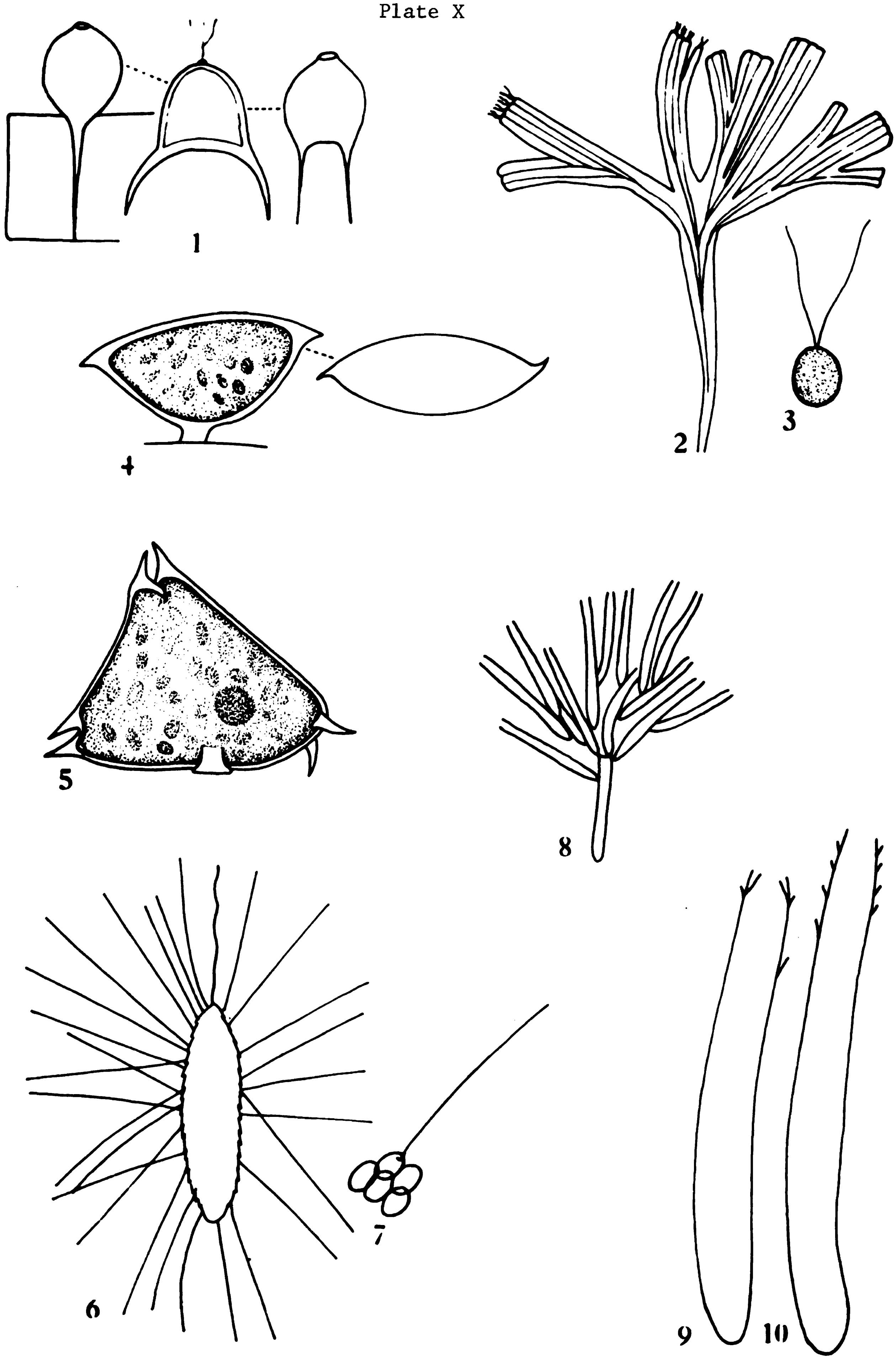


Plate XI

Fig. 1. Peridinium cinctum var. tuberosum (Meunier) Lindem.; ventral, dorsal and apical views, X 550.

Figs. 2-4. P. polonicum Wolosz.: 2, 4, dorsal views showing variation in dorsal apical plates, X 1100; 3, ventral view of another cell, X 1100.

Fig. 5. Chroomonas Nordstedtii Hansg., fa., X 1100.

Fig. 6. Peridinium Wierzejskii Wolosz., dorsal and apical views, X 1100.

Fig. 7. Gymnodinium ordinatum Skuja, X 1100.

Fig. 8. Peridinuim Willei fa. lineatum Lindem., ventral and dorsal views, X 1100.

Plate XII

Fig. 1. Peridinium Willei fa. lineatum Lindem., side and apical views, X 550.

Fig. 2. P. Willei Huitf.-Kaas, apical view, X 1100.

Fig. 3. P. palustre (lindem.) Lef., ventral and dorsal views, X 550.

Fig. 4. P. umbonatum Stein, X 1100.

Figs. 5-8. P. Willei fa. stagnale Lindem.: 5, ventral and dorsal views, X 1100; 6, 7 end views of epicone and hypocone, X 1100; 8, side view, X 1100.

Plate XIII

Fig. 1. Peridinium gatunense Nyg.; ventral and dorsal views, X 550.

Fig. 2. P. inconspicuum Lemm.; ventral and dorsal views, X 1100.

Fig. 3. P. Volzii Lemm.; ventral and dorsal views, X 550.

Fig. 4. Cryptomonas obovata Skuja, X 1100.

Fig. 5. Gymnodinium fuscum (Ehr.) Stein, X 1100.

Fig. 6. Hemidinium nasutum Stein, X 1100.

Fig. 7. Vacuolaria virescens Cienk.; two views of a recently-immobilized cell, X 1100.

Fig. 8. Trentonia flagellata Stokes, swimming and resting stages, X 1100.

Fig. 9. Merotrichia capitata Skuja, X 2200.

Fig. 10. Cryptomonas rostratiformis Skuja, X 1100.

Plate XIII

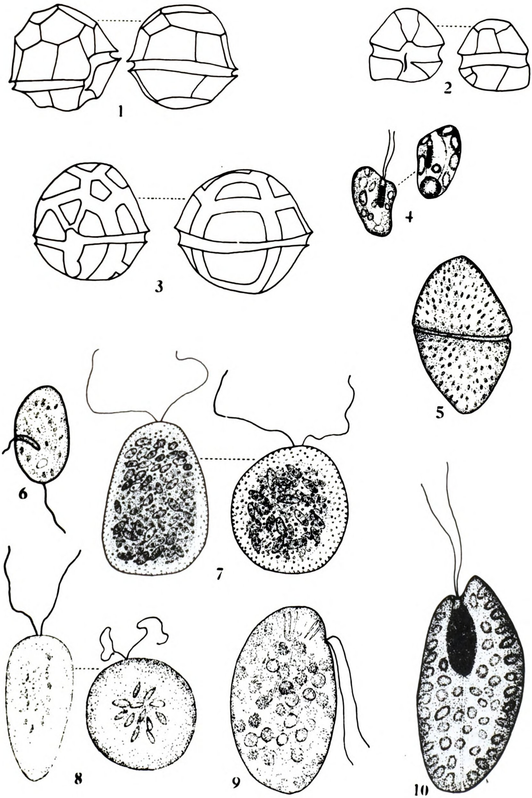


Plate XIV

Figs.
1-4. <u>Cyclidiopsis</u> <u>acus</u> Korschik., showing variations in cell shape and paramylon rods: 1, view of slightly curved cell, X 550; 2, apex and caudus of same, X 1100; 3, non-metabolic cell showing nucleus near mid-region, X 1100; 4, curved form, X 550 and apex, X 1100.

Fig. 5. <u>Distigma</u> <u>curvatum</u> E. G. Pringsh., X 550.

Figs.
6, 7. <u>Astasia</u> <u>Skadowskii</u> Korschik.: 6, swimming cell, X 1100; 7, metabolic stage of same, X 1100.

Fig. 8. <u>Astasia</u> <u>praecompleta</u> Skuja, X 1100.

Plate XIV

Plate XV

Fig. 1. *Menoidium pellucidum* Perty, X 1100.

Fig. 2. *Peranema trichophorum* (Ehrenb.) Stein, X 1100.

Fig. 3. *Petalomonas Steinii* Klebs, dorsal and cross sectional views, X 550.

Fig. 4. *Heteronema acus* (Ehrenb.) Stein, fa., X 1100.

Fig. 5. *Euglena mutabilis* Schmitz, X 1100.

Fig. 6. *Rhabdomonas incurva* Fresenius, X 1100.

Fig. 7. *Euglena fusca* (Klebs) Lemm., X 550.

Fig. 8. *E. variabilis* Klebs, X 1100.

Fig. 9. *Gyropaigne kosmos* Skuja, face and end views, X 1100.

Fig. 10. *Lepocinclis colligera* Defl., X 1100.

Plate XV

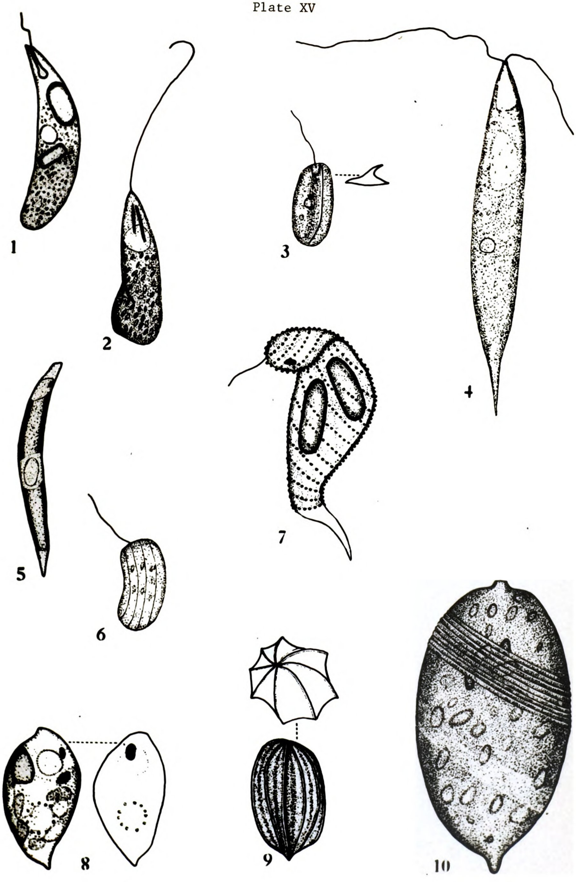


Plate XVI

Figs.
1-5. Anisonema pseudoprosgeobium new species: 1, 2, dorsal and ventral views of two cells showing variation in cell shape, X 1100; 3, ventral view of another cell, X 1125; 4, nucleus, X 1125; 5, side view, X 1125.

Fig. 6. Trachelomonas intermedia Dang., X 1100.

Fig. 7. Phacus orbicularis Hueb., X 1100.

Fig. 8. P. suecicus Lemm., X 1100.

Figs.
9-10. Trachelomonas Dybowskii Drez., X 1100.

Fig. 11. T. Kelloggii Skv. emend. Defl., X 1100.

Fig. 12. T. Klebsii Defl., X 1100.

Fig. 13. T. Raciborskii var. nova Drez., X 1100.

Plate XVI

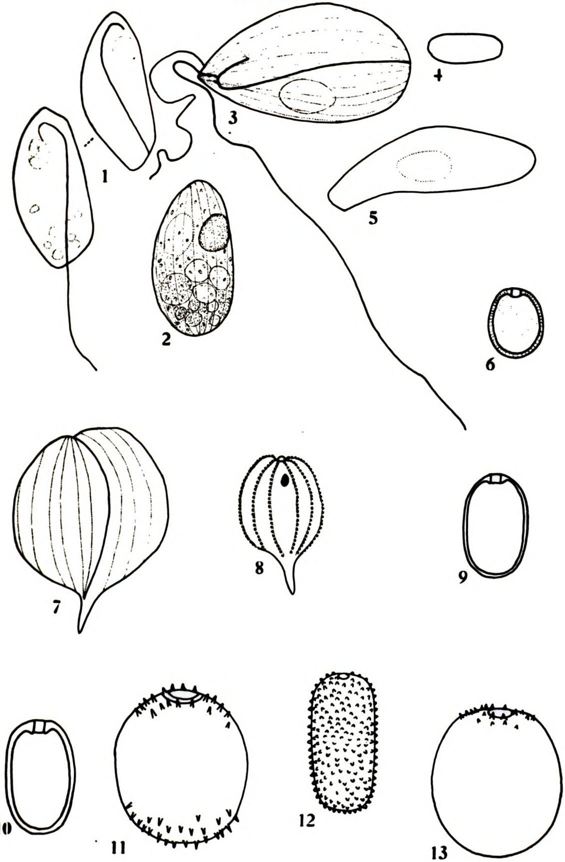


Plate XVII

Fig. 1. Entosiphon sulcatum (Duj.) Stein, X 1100.

Fig. 2. Phacus triqueter (Ehrenb.) Duj., X 1100.

Fig. 3. Coelosphaerium pallidum Lemm., portion of colony, X 1100.

Fig. 4. Trachelomonas oblonga Lemm., X 1100.

Fig. 5. T. Triangularis Defl., X 1100.

Fig. 6. Phacus caudatus Hueb., X 1100.

Figs. 7-11. Petalomonas praegnans Skuja: 7, dorsal view, X 1100; 8, view of tilted cell from the rear, X 1100; 9, front view of tilted cell, X 1100; 10, side view, X 550; 11, cross section, X 1100.

Fig. 12. Phacus lismorensis Playf., X 1100.

Plate XVII

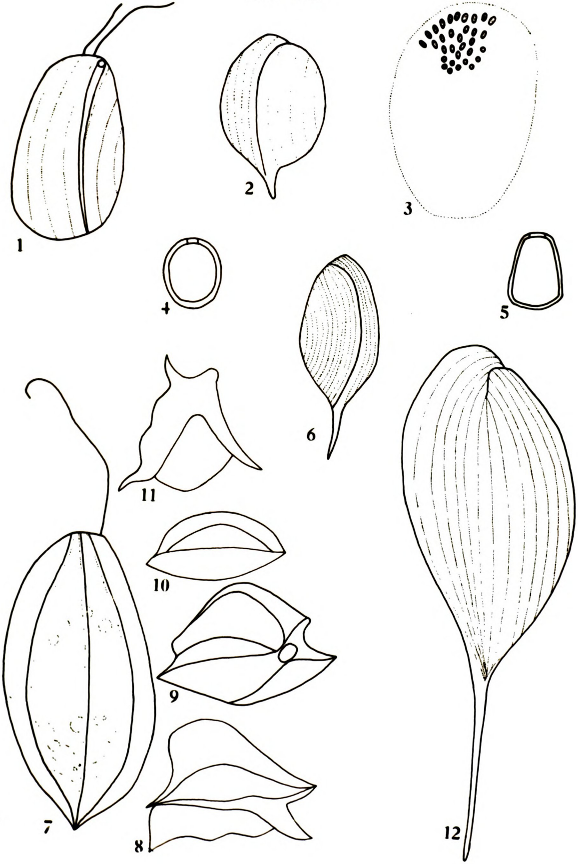


Plate XVIII

Fig. 1. Spirulina laxa G. M. Smith, X 1100.

Fig. 2. Gomphosphaeria lacustris var. compacta Lemm.; portion of colony, X 1100.

Fig. 3. Rhabdoderma lineare Schmidle and Lauterb.; colony, X 1100.

Fig. 4. Merismopedia Trolleri Bachmann; colony, X 1100.

Fig. 5. Chroococcus turgidus var. maximus Nyg., X 1100.

Fig. 6. Oscillatoria tenuis var. tergestina (Kuetz.) Rabenh.; portion of trichome, X 1100.

Fig. 7. O. tenuis var. natans Gom.; portion of trichome, X 1100.

Figs. 8, 9. Aphanothece Naegelii Wartm.: 8, portion of colony, X 1100; 9, habit sketch, X 1.

Fig. 10. Hapalosiphon hibernicus West and West; portion of filament, X 1100.

Plate XVIII

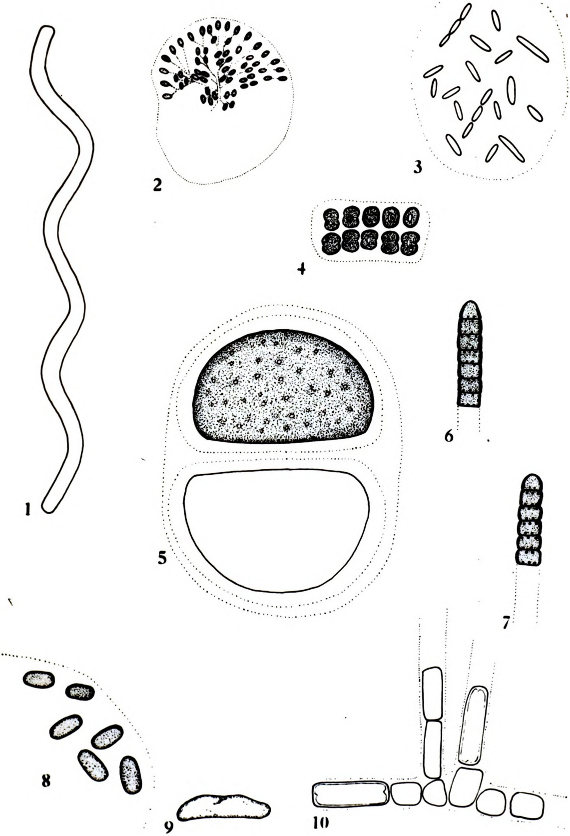


Plate XIX

Figs.
1, 2. <u>Spirulina platensis</u> (Nordst.) Geitl., fa.: 1, trichome, X 245; 2, enlarged portion of trichome, X 1100.

Figs.
3, 4. <u>Hapalosiphon confervaceous</u> Borzi: 3, portion of filament, X 550; 4, enlarged view of main filament showing heterocyst, X 1100.

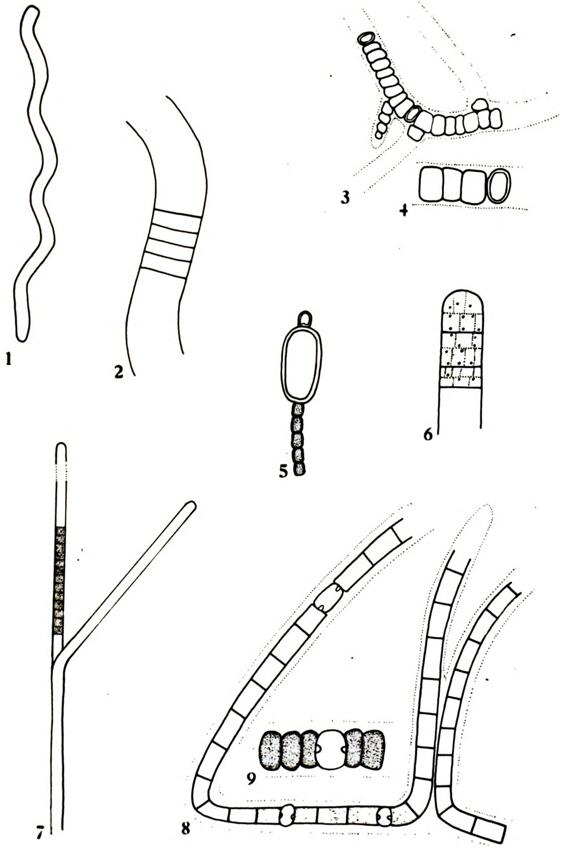
Fig. 5. Apical portion of <u>Cylindrospermum minutissimum</u> Collins, X 1100.

Fig. 6. <u>Oscillatoria Bornetii</u> Zukal; apical portion of trichome, X 1100.

Fig. 7. <u>Plectonema notatum</u> Schmidle; portion of trichome, X 1100.

Figs.
8, 9. <u>Scytonema Arcangelii</u> Born. and Flah.: 8, portion of filament, X 550; 9, enlarged view of cells and heterocyst, X 1100.

Plate XIX



Description of Flora

It is difficult to describe the algal flora of the study areas in general terms, because several specific lines of investigation were pursued. Thus, it will be necessary to discuss the flora in respect to several separate aspects, among them the number of taxa (i.e., species, varieties and forms) present, percentage composition, distribution within the study area, community structure and seasonal periodicity.

Before describing the floras of the individual study areas, it is appropriate to note some general features (Tables I, II). (Note: Because frequent reference will be made to Tables I - XXII both here and in the following discussion portions, these tables are grouped together at the end of this section.)

Table I contains a complete list of identified taxa, and shows their temporal and spatial distribution. Data in Table II show the number of taxa which were identified from each algal division.

A total of 495 taxa, comprising representatives of six major divisions, were found. Of these, 293, or about 59 per cent, are Chlorophyta. The Chrysophyta and Cyanophyta are represented respectively by about 16 and ten per cent of the flora, whereas the Euglenophyta and Pyrrhophyta are represented by slightly smaller numbers. The Rhodophyta are represented by only one species, Batrachospermum vagum.

Table III presents data concerned with the relative numbers of taxa in each area. Of the 495 species identified, 385, or about 78 per cent, were found in Purdy Bog, whereas less than half as many (170 taxa or about 44 per cent) were found in Lawrence Lake. An analysis of the flora of each study area is presented in greater detail below.

Purdy Bog

Floral Composition and Distribution

It is evident from an analysis of Table II that this bog supported a large proportion of the total number of taxa which were recorded during the study, and that this relationship holds true for all divisions. It supported from about 59 per cent of the taxa in one division (Cyanophyta) to as much as 98 per cent of those in another (Euglenophyta).

In respect to floral composition, data in Table III indicate also that the Chlorophyta are the dominant component, at least qualitatively. Thus, 243 out of a total of 385 species, or about 63 per cent of the flora, are green algae. The Euglenophyta and Chrysophyta compose respectively about 11 and 12 per cent of the flora, while the Cyanophyta and Pyrrhophyta together compose only about 14 per cent.

To analyze the distribution of this flora within the bog, it will be necessary to examine the flora of individual habitats. These analyses are shown in Tables IV to VIII, and XI.

In Table XI, the number of taxa in individual habitats is compared with the total number in the bog. It is evident that the greatest number of taxa was found in the marginal pools. In fact, almost four-fifths of the bog's total flora was found in this habitat. The center lake and lake bottom habitats supported the next largest number of species, representing from 47 to 50 per cent of the total bog flora. The smallest numbers were found in the sphagnum mat and sphagnum pool habitats, each of which supported only about one-fifth of the taxa in this bog.

An analysis of the percentage composition of the algal flora in

these habitats is presented in Tables IV to VIII.

As might be expected, because of the shallow nature of the lake, the floras of the center lake and lake bottom are similar, as shown in Tables IV and VIII. Aside from the fact that the center lake contains a larger percentage of Cyanophyta than does the lake bottom, and that the reverse holds true in respect to the Euglenophyta, the floras are qualitatively very similar.

The total number of species in the sphagnum mat and sphagnum pool was relatively low, as noted earlier. Tables V and VI show that the floral compositions of these two habitats are very similar, with the exception of the Cyanophyta and Pyrrhophyta. In respect to the number of taxa, the sphagnum pool supported only slightly more species than did the sphagnum mat.

As noted earlier, the richest habitat qualitatively was the series of marginal pools, from which some 300 taxa, or over 78 per cent of the total bog flora, were collected. A comparison of Table VII with the data for other habitats indicates that the largest number of taxa in every algal division was found in this habitat. The percentage composition of this flora compares well with that of the center lake and, especially, the lake bottom.

The largest number of taxa in each habitat were Chlorophyta, and, of these, the most numerous were the desmids. An analysis of their distribution is presented in Tables XII to XIV.

Table XII shows a comparison of the number of desmid forms with the total number of taxa in the bog. Of this total, about 39 per cent were desmids. The greatest number was found in the marginal pools, with slightly fewer in the center lake and lake bottom. About one-fifth of the taxa in these latter two habitats were desmids. The sphagnum mat and sphagnum pool supported the smallest number and percentage of desmids in any area of the bog, representing less than six per cent of the total.

In respect to the floral composition of individual habitats, data in Table XIII indicate that the center lake, lake bottom and marginal pools supported similar percentages of desmid taxa, whereas those of the sphagnum mat and pool were again much lower.

Somewhat similar relationships are shown in Table XIV, which compares the number of desmid forms with the total number of Chlorophyta in each habitat. From this it is evident that the greatest proportion of Chlorophyta taxa in all habitats of the bog were desmids.

It should be emphasized that the above data are qualitative only, in the sense that they deal with the number of species present without regard to the relative abundance of these. It is almost impossible in a study of this kind to quantify data for individual species, although data on relative abundance will be presented for some in a later section. It is evident, however, that green algae, especially desmids, formed the dominant portion of the flora of the center lake, lake bottom and marginal pools during most of the year, whereas the Euglenophyta and Cyanophyta were dominant quantitatively in the sphagnum mat and sphagnum pool, along with a few species of desmids. These floras will be discussed in greater detail below, under the descriptions of the communities typical of each habitat.

Community Structure

Because the above data are only numerical, it is necessary to

examine the taxonomic composition of the flora of individual habitats to gain a better understanding of community structure, as well as to see similarities or differences in the abundance of individual species or groups of species. The algal communities typical of individual habitats in the bog are listed in Table XVII.

(Note: The term "community" as used here refers to the aggregation of species which was deemed to be characteristic of a particular habitat.)

The center lake or plankton community contains a large proportion of desmids, of which only the more typical are listed. Two of the most typical species are Triploceras gracile and T. verticillatum. Among the other green algae, Botryococcus Braunii is characteristic, along with various species of Scenedesmus and Pediastrum, especially P. duplex var. cohaerens. The most typical and abundant Pyrrhophyta are Peridinium Willei and the fa. lineatum, along with Trentonia flagellata, Gymnodinium fuscum and Peridinium cinctum var. tuberosum. Various members of the Chrysophyta form a conspicuous portion of this flora also, at least during certain periods of the year (see Seasonal Periodicity, below). Among these are various species of Dinobryon, especially D. bavaricum and D. pediforme, along with Synura uvella and Synuropsis danubiensis. The most typical blue-green alga is Aphanothece microscopica. Euglenophyta are not well-represented, although Petalomonas praegnans is a characteristic member of this community.

In contrast with the center lake community, those of the sphagnum mat and sphagnum pool contain only a few desmids. Of these, Cosmarium cucurbita, Micrasterias truncata, Cylindrocystis Brebissonii, Staurastrum margaritaceum and St. monticulosum var. Irenee-Mariei are characteristic of the sphagnum mat community, the latter two being present usually in large numbers. The dominant portion of this sphagnum mat community, so far as the number of individuals is concerned, are Euglenophyta. Thus, various species of *Anisonema*, *Petalomonas*, *Euglena*, *Astasia* (especially *A. praecompleta* and *A. Skadowskii*) and *Distigma* (especially *D. curvatum*) are commonly found in this habitat in large numbers. *Chroococcus turgidus* and *C. minutus* are most common among the blue-greens, along with *Anabaena augstumalis* var. *marchica*. Flagellated Chrysophyta such as *Chromulina suprema* and other smaller species form a conspicuous part of the flora during certain periods of the year (see Seasonal Periodicity).

The community of the sphagnum pool shows many similarities with that of the sphagnum mat, so far as species composition is concerned. Although only a few desmid species form a conspicuous part of the flora, these are present usually in large numbers. Especially common are *Cosmarium cucurbita*, *C. pseudopyramidatum*, *C. pyramidatum*, *Staurodesmus controversus*, *Staurastrum margaritaceum* and *St. monticulosum* var. *Irenee-Mariei*, along with *Pleurotaenium minutum*. As for other Chlorophyta, *Microspora tumidula* is characteristic, along with some *Gloeocystis* spp. and *Gloeomonas ovalis*.

Chroococcus turgidus was the most abundant blue-green alga in the habitat, many times forming dense gelatinous clusters over submerged vegetation. Various Euglenophyta are typical of the habitat also, especially during certain seasons of the year. Among these are *Cyclidiopsis acus* and *Heteronema acus*, along with *Euglena mutabilis* and *Menoidium* spp., especially *M. pellucidum*. The characteristic Pyrrhophyta are *Gonyostomum semen* and *Peridinium palustre*, the former becoming quite abundant during certain periods of the year. Various flagellated Chrysophyta such as Synura sphagnicola and Chromulina suprema are characteristic also, along with Rhipidodendron splendidum.

As can be seen from the length of the list for the marginal pools (Table XVII), a large and diversified community inhabited this region of the bog. Only a few conspicuous or characteristic members need be mentioned here. In general, it can be characterized as a desmid community, of which those listed are quite typical. Many of these, such as Euastrum pinnatum, E. insulare var. silesiacum and E. validum var. glabrum, were never found in any other habitat. Other characteristic desmids include Cosmarium ornatum, Euastrum Ciastonii, Hyalotheca undulata, Micrasterias papillifera var. speciosa, Penium spirostriolatum and Tetmemorus spp. Several other Chlorophyta were likewise either very characteristically found in this habitat, or were never found in any other. Among these are Asterococcus limneticus, Binuclearia tatrana, Chaetosphaeridium globosum, Dimorphococcus lunatus, Eremosphaera virdis, Geminella mutabilis, Microthamnion strictissimum, M. Kuetzingianum, Pediastrum tetras, Selenastrum Bibraianum, Stigeoclonium subsecundum and Pleurodiscus sp. Of the above, Dimorphococcus lunatus and Selenastrum Bibraianum are particularly characteristic of the habitat, and were never observed outside of it.

Among the Cyanophyta, Chroococcus Prescottii, Cylindrospermum minutissimum, Merismopedia glauca, M. punctata and several species of Hapalosiphon were typical members of the community. The Euglenophyta was usually well represented in this habitat, and various species of Euglena, Phacus and Trachelomonas were common, along with Peranema trichophorum. Pyrrhophyta present were, in general, similar to those found in the center lake, although Cryptomonas obovata was more typical

of the marginal pools.

A large number of Chrysophyta are typical of this habitat, and several become quite common. Chrysopyxis stenostoma was very common at times, and almost covered certain filamentous growths, especially those of Pleurodiscus sp. Among other common or characteristic species should be mentioned Chrysostephanosphaera globulifera, Synura sphagnicola, S. uvella, Dinobryon cylindricum, Chromulina gigantea and Spongomonas sp., along with Rhipidodendron splendidum.

The community of the lake bottom was similar in many ways to that of the center lake, although several genera or species were more prevalent in the former habitat, whereas others were much more abundant on the bottom. Thus, Synechococcus aeruginosus, Arthrodesmus octocornis and Hemidinium nasutum were found only on the lake bottom and never in the plankton community, although at least the latter should be expected there. Several species of Scenedesmus and Pediastrum were common also, along with many desmids which were typical of the plankton. Extensive growths of Oedogonium and Mougeotia were common during certain periods of the year (see Seasonal Periodicity below, and Figures 6, 7), along with Nitella, especially N. oligospira. The diatoms Tabellaria fenestrata, T. flocculosa and Stauroneis phoenicentron also were typical members of the lake bottom community. Resting stages of Trentonia flagellata and Vacuolaria virescens, especially those of the former, were common during the winter months.

Seasonal Periodicity

The community compositions as outlined above are not constant, but, as might be expected, show seasonal variations. These fluctuations

take the form of changes in both the quality and quantity of the flora. Data relative to changes in the number of taxa are shown in Table XV, although this gives no idea of the changes in relative abundance of individual species.

The total number of species was fairly constant in the bog as a whole, with the largest number of taxa appearing during fall and winter. A slightly lesser number was found during spring, and the lowest number was found during summer. The species number of Chlorophyta showed but little fluctuation during the year and, because these formed the majority of species in the bog, their abundance helped to keep the total number of taxa relatively constant. There were within this group, however, changes in floral composition which are not evident in the numerical listing in Table XV. Fluctuations in the number of taxa present occurred in all other divisions also, with the exception of the lone member of the Rhodophyta.

Major emphasis in this study was placed on determining seasonal changes in the composition of the center lake community, and only these changes will be described here in detail. Although observations were made during a two-year period, the general seasonal fluctuations will be described as though observed for only twelve months, unless significant differences were noted in the seasonal changes in one year as compared with the other. Only major changes will be noted or discussed in the seasonal structure of communities from other bog habitats. The descriptions as given below begin with the spring communities.

Center lake community.--Before describing the seasonal fluctuations of this community, it should be pointed out that certain species are present during all or most all of the year, and so will not be

mentioned further except with reference to quantitative changes. Among these are: the desmids in general, species of Scenedesmus and Pediastrum (especially P. duplex var. cohaerens), Tabellaria fenestrata, Aphanothece microscopica and Botryococcus Braunii. Seasonal changes for organisms not noted below are given in Table I.

The center lake is ice-covered from late November or early December through March. In April, after the ice has melted, the plankton is dominated by large numbers of microcrustaceans. Netrium digitus var. lamellosum is dominant among the phytoplankton, along with Dinobryon cylindricum. This is a time of transition for the community, and some remnants of the winter community remain during April. Among these are Peridinium Willei and the fa. lineatum, Synura uvella, Cryptomonas ovata and resting stages of Trentonia flagellata.

The microcrustaceans remain dominant through May, along with the rotifer Keratella cochlearis. Phytoplankton in general is sparse, although large numbers of the green alga Sphaerocystis Schroeteri are present, and many of the desmids are beginning to divide actively. During this time, most of the members of the winter community disappear, although some Dinobryon cylindricum and Trentonia flagellata remain.

Later in May the zooplankton decreases in quantity, and toward the end of the month the lake bottom becomes covered by a dense growth of Mougeotia, the filaments of which fragment into one- or several-celled pieces and become dominant in the plankton near shore. Desmids, and other Chlorophyta typical of the habitat, become more abundant, and the quantity of phytoplankton increases as the zooplankton declines. By this time the epiphyte Chlorangium spp. is fairly common on the remaining microcrustacea, and remains so into early June.

The community is still dominated by Mougeotia throughout June, although during this month desmids and other Chlorophyta, especially species of Scenedesmus and Pediastrum, increase in quantity. Keratella cochlearis remains abundant in the zooplankton during the early part of the month, although a new community of microcrustaceans, which are different from those noted during early spring, begins to take form and to increase in abundance. The cladoceran Polyphemus pediculus is a characteristic member of this community, and furnishes a new substrate for species of Chlorangium.

Later in June a bloom of Dinobryon bavaricum and D. pediforme occurs, and this is augmented by a bloom of Synura uvella, which becomes quite abundant by the end of the month. Dinobryon cylindricum declines during this period.

The phytoplankton again decreases in quantity during July, and the plankton is dominated by large numbers of copepods, cladocerans and Keratella, especially K. cochlearis. Mougeotia still remains the dominant alga, although Botryococcus Braunii increases during this time and becomes almost a co-dominant species. Peridinum cinctum var. tuberosum first appears in July, and by late in the month Netrium digitus var. lamellosum is again common, along with smaller numbers of the usual desmids and other Chlorophyta.

Although no really dominant organisms are present in the phytoplankton during August, Mougeotia is still abundant, along with other Chlorophyta, especially desmids. The latter increased in quantity during the month, although the numbers of Netrium digitus var. lamellosum decreased toward the end. The flagellates Gymnodinium fuscum and Peranema trichophorum first appear during this latter part of the month.

By September, the number of desmid species has increased, and these become dominant in the plankton along with Peridinium cinctum var. tuberosum and Synura uvella. Although the number of yellowish or brown-pigmented algae increases somewhat, Botryococcus Braunii is still common, along with Mougeotia spp. The protozoan Stentor is fairly abundant during this month, and several new taxa emerge, the most notable being Synuropsis danubiensis, along with Kirchneriella lunaris and Elakatothrix gelatinosa.

During October, more members of the brown-pigmented Chrysophyta and Pyrrhophyta appear in the community. Peridinium Willei and, especially, the fa. lineatum, succeed P. cinctum var. tuberosum and increase in abundance, along with the Synuropsis and Synura uvella. Although desmids are still common during this time, many have become, or are becoming, colorless.

Not much change in community structure is evident during early November, although Dinobryon cylindricum appears and increases in abundance, as do various microcrustaceans. Synura uvella becomes abundant to dominant in the plankton, and by late November the numbers of Peridinium Willei and fa. lineatum increase also. Oscillatoria, especially O. limosa, appears in the plankton during this time, and the resting stages of Trentonia flagellata and Vacuolaria virescens appear and remain until late spring.

In late November or early December the lake becomes ice-covered, and remains so until early April. The changes in community structure which occur as this cover forms and becomes continuous are outlined below.

During December, Peridinium Willei and the fa. lineatum remain abundant, along with some Synura uvella, and S. sphagnicola first appears along with these. Uroglena botrys and Cryptomonas ovata are added also to the community during this time.

By early January, the plankton is dominated by large numbers of Synura uvella, Synuropsis danubiensis and Dinobryon cylindricum, along with Peridinium Willei (especially the fa. lineatum), Synura sphagnicola and some Dinobryon sertularia. During the latter part of the month Keratella cochlearis, various microcrustaceans and nauplius larvae again become dominant in the plankton, along with the flagellates mentioned above.

Synuropsis danubiensis decreases in quantity during February, but the above-named species of Peridinium, Synura and Dinobryon remain common throughout the month. Several species of Oscillatoria arise during this time also, among them O. curviceps, O. limosa, O. tenuis var. natans and O. tenuis var. tergestina. The desmids, along with other Chlorophyta, especially Scenedesmus spp. and Pediastrum spp., remain under the ice, although many of the first-named are embedded in a heavy gelatinous matrix. Euglena acus and Cryptomonas erosa become fairly common under this extensive ice cover, along with Cryptomonas ovata.

By March, the microcrustaceans are again dominant, along with Keratella cochlearis. The most abundant organism in the phytoplankton during this time is Peridinium Willei fa. lineatum, and many of the other flagellates remain along with it. Among these are Dinobryon cylindricum and D. sertularia, Cryptomonas ovata and C. obovata, Synuropsis danubiensis and the resting stage of Trentonia flagellata.

With the melting of the ice in April, the microcrustaceans remain dominant, and a cycle similar to that described above begins again.

Sphagnum mat community.--During most seasons of the year, this community is dominated by various protozoa, especially the testaceous rhizopods, along with Euglenophyta and a few characteristic desmids. Euglenophyta are abundant in April, especially the genus Astasia, of which A. Skadowskii is the most abundant species. During May, Mougeotia spp. becomes abundant, along with large numbers of Euglena deses, Astasia Skadowskii, Synura sphagnicola and Petalomonas spp. Staurastrum monticulosum var. Irenee-Mariei becomes abundant in June, along with dense wefts of Anabaena augstumalis var. marchica, the latter of which remains abundant until August. During July, Trachelomonas volvocina becomes quite abundant, along with several species of Chlamydomonas, and many of these remain through August.

Trachelomonas volvocina and Anabaena augstumalis var. marchica remain dominant during August, but by September large numbers of Astasia spp., especially A. Skadowskii, largely replace these. Mougeotia spp. becomes common again in October, and by November Staurastrum monticulosum var. Irenee-Mariei is again common, along with Chroococcus turgidus. Staurastrum monticulosum var. Irenee-Mariei remains abundant during the winter, from November through January. During January, Anisonema spp. becomes abundant and remains common until spring.

Sphagnum pool community.--Chroococcus turgidus is abundant to dominant almost throughout the year in this habitat, becoming especially common during April and May. Microthamnion strictissimum becomes abundant with the melting of ice in April, and is replaced during May by extensive growths of Mougeotia spp., especially M. recurva. During May also, Gonyostomum semen and Chromulina suprema occur in large numbers. Gonyostomum semen remains common to abundant during June and

July, and Cosmarium pyramidatum, Cosmarium cucurbita, Gymnozyga moniliformis and Staurodesmus controversus appear and become abundant during the latter month.

From July through September Gonyostomum semen, Cosmarium pyramidatum and C. cucurbita remain abundant, and these are augmented by a brief pulse of Heteronema acus in September. The most abundant form during winter is Chroococcus turgidus.

Marginal pool community.--Because of the large number of species which are typical of this habitat, and the attendant fluctuations of these, it is almost impossible to do justice to seasonal changes in this community by anything less than a lengthy discussion, which does not seem to be pertinent here. Suffice it to state desmids, Euglenophyta and Batrachospermum vagum were abundant throughout the year, and that only major fluctuations will be noted below.

As the ice begins to melt during late March Chlorogonium spp. becomes abundant, and remains so until early April. Euglenophyta as a group are common during April, along with Cryptomonas ovata, C. erosa, Netrium interruptum and Chlamydomonas spp.

Gymnodinium fuscum becomes abundant during June, and by July Pediastrum duplex var. cohaerens, Spirotaenia condensata and Pleurodiscus sp. increase greatly. Spirotaenia condensata remains abundant through August, and mats of Pleurodiscus sp. become common and remain so until December. During November, the number of flagellated species increases as Gloeomonas ovalis, Mallomonas spp. and Chlamydomonas spp. appear and become abundant. Stigeoclonium subsecundum becomes abundant under the ice also, and remains common until January.

By January, Chlamydomonas spp. is still abundant, along with various flagellated organisms and some desmids, and most common of which is Micrasterias papillifera var. speciosa.

Lake bottom community.--Desmids are, in general, abundant throughout the year. Oscillatoria curviceps becomes abundant during March, and this, along with Netrium digitus and N. digitus var. lamellosum, remains common in early spring. By late May, extensive growths of Mougeotia spp. cover the bottom, along with some Oedogonium spp., and these remain abundant during June, July and August. Pleurodiscus sp. becomes common during June, and by July Netrium digitus, N. digitus var. lamellosum and Euglena mutabilis become fairly abundant.

During September, Closterium Baillyanum and Cl. didymotocum increase in numbers, along with Synura uvella, but by November these are largely replaced by abundant growths of Tabellaria fenestrata. Chlorogonium becomes common under the ice in January, along with Netrium digitus var. lamellosum, the latter of which remains abundant during spring and early summer.

Lawrence Lake

Floral Composition and Distribution

As is evident from a study of Table II, this lake supported a proportionally smaller number and relative percentage of the taxa found in this study. With the exception of the Chrysophyta and Cyanophyta, less than 50 per cent of the total number of taxa in each division are found in the Lawrence Lake flora. Thus, by comparison at least, few of the algal divisions are well represented.

An analysis of the floral composition within the study area (Table III) indicates that the majority of species are Chlorophyta. Thus, 74 out of 170 species, or about 43 per cent of the floral are green algae. The Chrysophyta and Cyanophyta represent respectively about 30 and 18 per cent of the total number of species, whereas the Pyrrhophyta and Euglenophyta together comprise less than ten per cent of the flora. The Euglenophyta represent an almost insignificant floral component, making up less than two per cent of the total.

To analyze floral distribution in the lake, it is necessary to refer to the individual habitats mentioned earlier. Of these, only two major habitats, the main and outlet portions of the lake, will be considered in detail. The other three habitats contained such an abundance of diatom species that a critical analysis was not attempted.

Data relative to flora distribution in the main and outlet portions are shown in Tables IX to XI. It is evident from Table XI that about the same number of species was found in both habitats. A comparison of Tables IX and X indicates also that the floral composition was very similar. Although the main portion of the lake contained slightly more species of Chlorophyta, in general the number of taxa from each division is similar in both habitats, and their percentage compositions compare very favorably. Thus, no great contrast is evident in the floral compositions of these habitats on a qualitative basis, although, as will be shown later (under Community Structure), floristic differences do occur.

The desmids were never abundant in Lawrence Lake, either qualitatively or quantitatively, with the exception of a few species. Data in Tables XII to XIV indicate few differences in the desmid flora of the two major habitats so far as composition is concerned, although, as demonstrated below, taxonomic differences do exist.

Community Structure

The above data are again only numerical. To gain some understanding of the kinds and relative abundance of taxa, it is necessary to describe briefly the algal communities which inhabit various regions of the lake. An outline of these communities is presented in Table XVIII, although many diatom taxa have been omitted, as noted above.

The community typical of the main portion of the lake is one composed primarily of Chrysophyta (largely diatoms) and Cyanophyta. The diatoms Fragilaria crotonensis, Stephanodiscus niagarae, Melosira ambigua and Asterionella formosa are typical members of this community, and frequently become dominant (see below). Synedra spp. and Cyclotella spp. are characteristic also. Chrysosphaerella longispina, Dinobryon divergens, D. divergens var. Schauinslandii, D. cylindricum and Uroglena americana form important components of the flora at certain seasons of the year also, as does Mallomonas elongata.

The Cyanophyta form a major component of the community structure also and among the most abundant of these are Microcystis aeruginosa, Lyngbya Birgei, Anabaena flos-aquae, Chroococcus limneticus and C. turgidus var. maximus, along with Gomphosphaeria aponina, G. aponina var. cordiformis and G. lacustris var. compacta.

Among the Pyrrhophyta, Ceratium hirundinella and various species of Peridinium are typical members of this open-water community. The most common of the latter are P. Willei and the fa. lineatum, P. polonicum and P. gatunense. Characteristic Chlorophyta include Pediastrum Boryanum, P. integrum, Crucigenia irregularis, C. rectangularis and Nephrocytium spp.

Although desmids as a group are not abundant, Xanthidium antilopaeum, Cosmarium Botrytis, Euastrum hypochondrum fa. decoratum, Staurastrum brevispinum, St. setigerum var. occidentale, St. quebecense and St. furcigerum are characteristic, and many times abundant, members of the community.

No typical community is recorded for the intermediate portion of the lake because, as might be expected, its flora is composed primarily of a mixture of members from both the main and outlet portions of the lake, along with many undetermined diatoms.

The community typical of the outlet portion is smaller than that of the main portion, but includes several species which are quite characteristic of the habitat. Coelosphaerium pallidum, Tolypothrix distorta and, especially, Oscillatoria Bornetii are typical members, along with the three species of Gomphosphaeria mentioned above. Although many of the diatoms and other Chrysophyta of the main portion community are present also, several additional ones characterize the present community. Two of the most important of these are Synura sphagnicola and Synuropsis danubiensis, fa.

The Pyrrhophyta are not as well represented in this community, except for the occurrence of Peridinium Willei and P. Willei fa. lineatum. Characteristic desmids include Pleurotaenium Trabecula and the var. maximum, Cosmarium Turpinii, Closterium Dianae and Cl. Ehrenbergii.

The marginal pool community is another one which is difficult to describe, because of the large numbers of diatom species present. Closterium Leibleinii is a characteristic desmid member of the community, along with various species of Spirogyra and Mougeotia.

In the lake bottom community, Chara spp. (especially Ch. contraria A. Br.), Cladophora fracta var. normalis and Schizothrix lacustris are dominant, along with various diatoms and Mougeotia spp.

Seasonal Periodicity

In contrast with Purdy Bog, seasonal fluctuations in the number of taxa are evident. Data in Table XVI show that almost twice as many species were present during the fall and summer months as were present during the winter and spring. These fluctuations were even greater than is shown here, because there was not merely a decline in the number of species which were present during fall and summer, but a general replacement of many of these by other taxa during winter and spring. Thus, floristic variation was even more pronounced than is indicated by these numerical data.

In contrast with Purdy Bog also, the plankton of the main portion of Lawrence Lake is composed primarily of diatoms and various blue-green algae (Cyanophyta). The diatoms are present throughout the year, as are many of the Cyanophyta, although both of these exhibit periods of maxima and declines. Only major changes in community structure will be discussed below, and it should be realized that many of the taxa listed in Table XVIII are present, even though not discussed here. Individual reference will be made to the occurrence of some of these in a later section (Distribution of Selected Species). Reference may be made to Table I to find the occurrence and seasonal periodicity of algae not mentioned below.

Main portion of lake.--As in Purdy Bog, the lake is ice-covered from early December through March. After the ice has melted in April, the plankton still retains many components of the winter community, and is largely a mixture of diatoms and Pyrrhophyta. Peridinium Willei, especially the fa. lineatum, is abundant, along with Synura uvella, Ceratium hirundinella and the diatoms Melosira ambigua, Asterionella

formosa and Stephanodiscus niagarae.

Little change in composition is evident during the month, although Asterionella formosa increases slightly in abundance.

Melosira ambigua and Ceratium hirundinella replace Peridium Willei and the fa. lineatum, becoming abundant by early May. Although almost all of the species present in April remain during May, the community structure begins to change as the quantity and numbers of species of Cyanophyta and Chlorophyta increase during the month. Among the Cyanophyta, Lyngbya Birgei, Microcystis aeruginosa and Chroococcus turgidus var. maximus begin to appear and to increase in number. Mougeotia spp. and Botryococcus Braunii arise during this time also, and remain fairly common until fall.

Several desmids are found in this late spring community, among them Hyalotheca dissiliens, Desmidium Swartzii var. amblyodon and Euastrum hypochondrum fa. decoratum, the latter of which persists until October.

Chlorophyta become more common during June as new species appear and increase in quantity. The Chrysophyta and Pyrrhophyta decline in general, although Ceratium hirundinella, Uroglena americana and Dinobryon divergens remain fairly abundant. Sphaerocystis Schroeteri becomes the dominant alga during the month, along with Chroococcus limneticus. The number of desmid taxa increases during this time also, and three species of Cosmarium, as well as three of Staurastrum, appear, along with Xanthidium antilopaeum and various species of Euastrum. E. hypochondrum fa. decoratum is common by this time. By now also, Cyanophyta such as Microcystis aeruginosa, Gomphosphaeria aponina and the var. cordiformis, Coelosphaerium Naegelianum and Anabaena flos-aquae, occur in large numbers.

During July, although the Cyanophyta remain common, a small pulse of Fragilaria crotonensis and Dinobryon divergens occurs, and Peridinium polonicum and P. gatunense first appear and begin to increase in quantity. Microcystis aeruginosa increases in numbers and becomes abundant to dominant by the end of the month. By this time Cyanophyta in general are common, along with Peridinium polonicum. Desmids such as Staurastrum furcigerum, St. quebecense, St. setigerum var. occidentale and Cosmarium pseudoconnatum are typical of this community, along with Xanthidium antilopaeum and Euastrum hypochondrum fa. decoratum.

The community is dominated by Cyanophyta throughout August. A few Chrysophyta and Chlorophyta occur here also, but the abundant forms during this time are the blue-greens Microcystis aeruginosa, Anabaena flos-aquae and Gomphosphaeria lacustris var. compacta, along with Chroococcus limneticus. Among the Chlorophyta, Micrasterias truncata var. semiradiata appears first during this time and remains through October. The dinoflagellates Peridinium polonicum and P. gatunense occur in increasingly smaller numbers as a small pulse of Fragilaria crotonensis occurs again.

Species of Chrysophyta and Pyrrhophyta increase somewhat during September, as both Fragilaria crotonensis and Ceratium hirundinella become abundant, along with Uroglena americana. Microcystis aeruginosa and Coelosphaerium Naegelianum are common also, along with Lyngbya Birgei and Gomphosphaeria lacustris var. compacta.

The Cyanophyta as a group are dominant during October, and the plankton includes a mixture of Microcystis aeruginosa, Lyngbya Birgei, Coelosphaerium Naegelianum, Gomphosphaeria aponina and the var. cordiformis, as well as G. lacustris var. compacta.

The community structure begins to change by early November, as

the number of blue-green algae decreases, leading to an increase in the number and quantity of brown-pigmented species of the divisions Chrysophyta and Pyrrhophyta. Fragilaria crotonensis and Chrysosphaerella longispina dominate the plankton early in the month, and other Chrysophyta such as Melosira ambigua, Uroglena americana and Mallomonas elongata become more common. Peridinium Willei and the fa. lineatum appear here also; the latter is more typically found during winter.

Toward the middle of November, Chrysosphaerella longispina declines, and Stephanodiscus niagarae, Fragilaria crotonensis and Melosira ambigua become co-dominants. Of the Cyanophyta, only a few akinetes of Anabaena flos-aquae remain, along with some Coelosphaerium Naegelianum.

Stephanodiscus niagarae, Melosira ambigua and Fragilaria crotonensis remain abundant and dominant throughout December. Other typical community members at this time include Mallomonas elongata and Mallomonas spp., Chrysosphaerella longispina, Uroglena americana and Peridinium Willei, mostly the fa. lineatum. Asterionella formosa and Dinobryon cylindricum appear about the middle of the month. A few Cyanophyta occur here also, but these are quite rare during winter. The community structure remains fairly constant throughout early January, although Melosira ambigua declines, leaving Fragilaria crotonensis and Stephanodiscus niagarae dominant; of these two, the former is more common. Toward the end of January, the diatoms decrease in quantity as Mallomonas spp. and Dinobryon cylindricum increase in numbers.

Few organisms are present in the plankton community during February, and the water contains mostly detritus. A few diatoms are present at this time, although the flagellates are quite rare. Fragilaria crotonensis is fairly common, along with Stephanodiscus niagarae, Asterionella formosa

and Melosira ambigua.

By March, however, Peridinium Willei and the fa. lineatum are again abundant, and the diatoms have decreased in quantity, although still present. Some Cyanophyta, such as Coelosphaerium Naegelianum and Gomphosphaeria lacustris var. compacta, are still present at this time of the year, although rare in numbers.

As the ice melts in late March, the Pyrrhophyta and diatoms remain in the water to initiate the beginning of the spring community noted in early April.

Other habitats.--Because diatoms formed such a conspicuous part of the flora of the other habitats in Lawrence Lake, no attempt has been made to describe seasonal periodicity in these. Such attempts would lead only to misinterpretations of data.

Physical-Chemical Data

Seasonal variations in water temperature and pH are shown in Figures 20 and 21. In Purdy Bog, the maximum water temperature reached was 32.5°C, in August. The maximum reading for Lawrence Lake was 27.5°C, also in August. A comparison of water temperatures for these two lakes (Figure 20) shows no great differences during any season of the year, although those of the bog center lake were usually slightly higher during any one time period.

The pH of the two study areas was quite different, however (Figures 21-23), the range in Purdy Bog being from 4.0 - 6.5, that of Lawrence Lake from 7.2 - 8.3. These figures represent over-all ranges for all investigated habitats. Ranges for individual habitats are given below.

Figure 20

Seasonal variations of water temperature in the center lake of Purdy Bog and the main portion of Lawrence Lake, from December, 1958 to August, 1960.

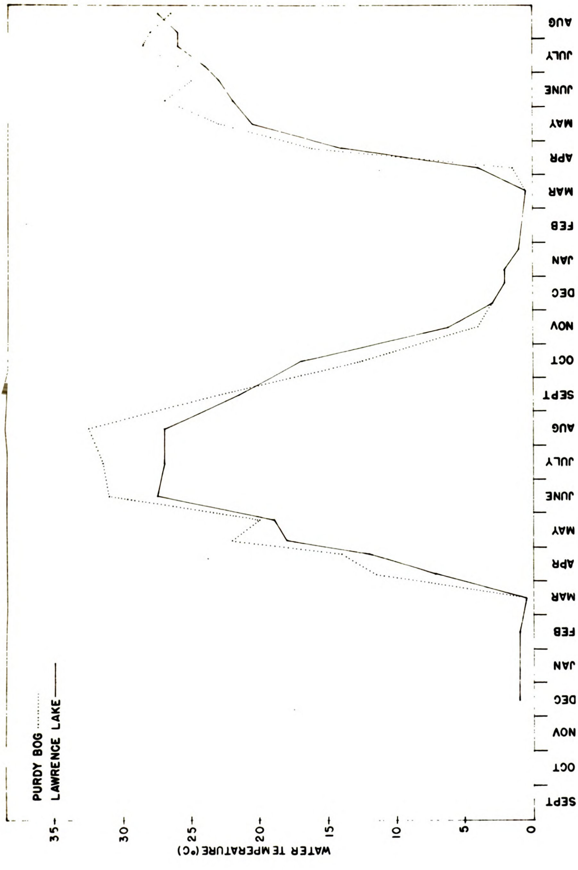

PURDY BOG
LAWRENCE LAKE
WATER TEMPERATURE (°C)
0
5
10
15
20
25
30
35
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG

Figure 21

Seasonal variations of pH in the center lake of Purdy Bog and the main portion of Lawrence Lake, from September, 1958 to August, 1960. (Data not available for December, 1958 or January, 1959).

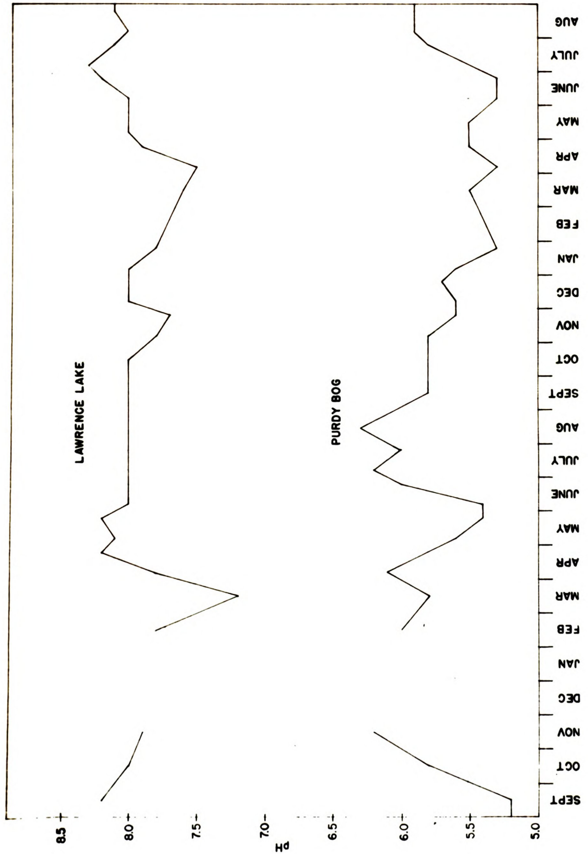

LAWRENCE LAKE
PURDY BOG
pH
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG

Figure 22

A comparison between the pH, total alkalinity and floral compositions of Lawrence Lake (all habitats), Purdy Bog (all habitats) and the marginal pools habitat in Purdy Bog. (pH read along right ordinate).

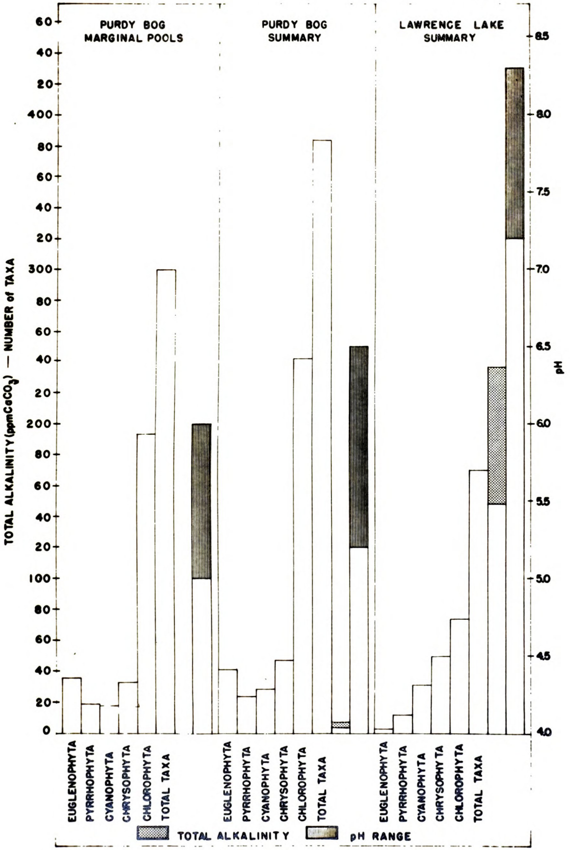
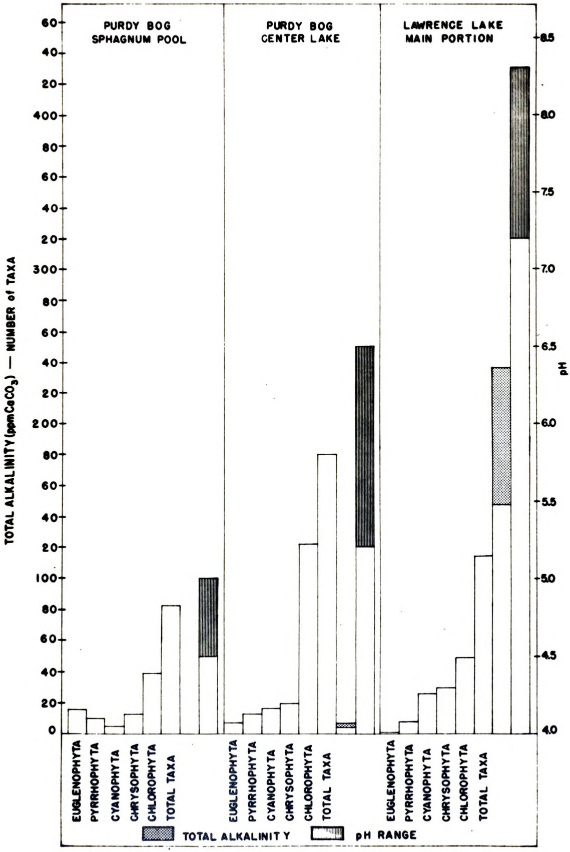

PURDY BOG
MARGINAL POOLS
PURDY BOG
SUMMARY
LAWRENCE LAKE
SUMMARY
TOTAL ALKALINITY (ppmCaCO3) — NUMBER of TAXA
pH
60
40
20
400
80
60
40
20
300
80
60
40
20
200
80
60
40
20
100
80
60
40
20
0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
EUGLENOPHYTA
PYRRHOPHYTA
CYANOPHYTA
CHRYSOPHYTA
CHLOROPHYTA
TOTAL TAXA
TOTAL ALKALINITY
pH RANGE

Figure 23

A comparison between the pH, total alkalinity and floral compositions of the main portion of Lawrence Lake and the center lake and sphagnum pool habitats in Purdy Bog. (pH read along right ordinate).



PURDY BOG SPHAGNUM POOL
PURDY BOG CENTER LAKE
LAWRENCE LAKE MAIN PORTION
TOTAL ALKALINITY (ppm CaCO3) — NUMBER of TAXA
pH
EUGLENOPHYTA
PYRRHOPHYTA
CYANOPHYTA
CHRYSOPHYTA
CHLOROPHYTA
TOTAL TAXA
TOTAL ALKALINITY
pH RANGE

The pH of the center lake and marginal pools in Purdy Bog was very similar. The center lake pH varied between 5.2 and 6.5, whereas that of the marginal pools showed a variation between 5.0 and 6.0. Lower readings were obtained in the sphagnum mat and sphagnum pool habitats. The pH of the mat varied seasonally from 4.0 - 5.5, whereas that of the sphagnum pool showed a range of from 4.5 - 5.0.

Readings of pH in Lawrence Lake were largely confined to the center lake, although such readings as were obtained elsewhere all fell within the range of 7.2 - 8.3. At no time did any of the values for either study area reach neutrality.

Values for total alkalinity in Purdy Bog ranged from 4.0 to 7.0 ppm calcium carbonate in the center lake. Accurate readings could not be determined for other bog habitats. Much higher values were recorded for the main portion of Lawrence Lake (Figure 23), where total alkalinity varied between 148 and 236 ppm calcium carbonate.

More extensive chemical analyses are given in Table XXII for three of the above habitats; the center lake and sphagnum pool in Purdy Bog, and the main portion of Lawrence Lake. Several additional distinctions among these habitats become evident from an analysis of this table. First, the total organic content of both the center lake at Purdy and the main portion of Lawrence Lake is similar, although the dissolved organic matter in the former is somewhat higher. Both the total and dissolved organic matter of the sphagnum pool are much higher than those of either lake habitat. Secondly, the Lawrence Lake habitat has a much higher proportion of sulfates and nitrate nigrogen in its water than does either of the bog habitats, and the total hardness of the water, as might be expected, is much higher. Next, the sphagnum

pool contains a higher proportion of iron than does either of the lake habitats. Finally, both bog habitats are relatively low in calcium, whereas the main portion of Lawrence Lake is high in calcium.

These differences will be examined further, under the Discussion portion of this paper.

Table I.--Monthly distribution of algal taxa in various habitats of the study areas

Symbols Used:

	1	2	3	4	5
P(Purdy):	Center Lake	Sphagnum Mat	Sphagnum Pool	Marginal Pool	Lake Bottom
L(Lawrence):	Lake, Main Portion	Lake, Intermediate Portion	Lake, Outlet Portion	Marginal Pool	Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Chlorophyta												
Ankistrodesmus												
falcatus		P4		P4	P45				P45	P4		P4
spiralis			L1									
Aphanochaete												
polychaete	P5	P4	L3	P2								
Arthrodesmus												
octocornis									P5	P5	P5	
Asterococcus												
limneticus		P4										
Binuclearia												
tatrana	P4		P45	P14				P4	P145	P14	P4	
Botryococcus												
Braunii	P145	P14:L3	P145:L1	P1:L1	P15	P1	P1	P14:L1	P145:L1	P14	P145:L1	P14:L1
Bulbochaete spp.	P145:L1	P4	P145:L3	P14	P45	P14	P1	P4	P4	P4:L1	P14:L1	P15:L12
minuta	P4											
praereticulata				P4								
Carteria sp.										P3		
Chaetophora												
elegans			P4		P4							

Table I.--Continued

Symbols Used:	P(Purdy):	1 Center Lake	2 Sphagnum Mat	3 Sphagnum Pool	4 Marginal Pool	5 Lake Bottom
	L(Lawrence):	1 Lake, Main Portion	2 Lake, Intermediate Portion	3 Lake, Outlet Portion	4 Marginal Pool	5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Chaetosphaeridium												
globosum	P4	P4	P4	P4	P5	P4	P2			P2		
Pringsheimii				P4								
Chara												
contraria	L5	L5							L5	L5	L5	L5
Characium sp.		P4										
gracilipes										P1		
rostratum		P4			P5				P1			
Chlamydomonas spp.	P14	P4	P1245	P124	P45	P14	P4	P12345	P134	P2	P2	P24
ambigua				P1								
Cienkowskii			P1		P5			P5				
elliptica			P4	P4								
media								P2				
subcompleta			P4	P4	P4		P4	P24				
Chlorangium spp.						P1		P1	P1:L1	P1	P1	P1
Chlorogonium spp.			P24		P45	P24	P12345	P234				
Cladophora												
fracta var. normalis							L5		L5	L5	L5	L5

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Closterium spp.		L2									P2	L3
abruptum										P1	P5	
acerosum	P1		P4					P1	P1		P1	P1
aciculare			L2							L1		
acutum var. tenuis	P34	P4	P4					P4	P4	P4		
angustatum	P4		P1						P5	P1	P1	
Baillyanum	P145	P1	P14			P1			P5	P145	P145	P14
cornu, fa.					P5						P5	
costatum var. angustum					P4			P4			P4	
Cynthia											P4	
Cynthia var. Jenneri			P4									
Dianae		L3	L3									
Dianae var. pseudodianae					P5				P5	P1	P5	
didymotocum			P1		P5	P1			P1			
didymotocum var. glabrum					P5			P5	P5	P5	P5	
Ehrenbergii		L3										
gracile		P1	P4	P4				P4			P1	

Table I.--Continued

Symbols Used:	P(Purdy):	1 Center Lake	2 Sphagnum Mat	3 Sphagnum Pool	4 Marginal Pool	5 Lake Bottom
	L(Lawrence):	1 Lake, Main Portion	2 Lake, Intermediate Portion	3 Lake, Outlet Portion	4 Marginal Pool	5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Closterium, Cont.												
gracile var. elongatum	P4				P5				P5	P4		
incurvum fa. latior	P45		P45	P4	P5	P4		P4		P14	P145	P4
intermedium			P1					P4	P4	P1		
Kuetzingii		L3	L3									
Leibleinii									L4	L4		
Libellula		P1	P145	P4	P5	P14	P1	P14	P145	P4		P1
Libellula var. intermedium		P4	P4		P45			P1	P5	P14	P45	P1
Libellula var. interruptum	P1		P4		P5		P1	P1				
lineatum			L2									
Lunula		P1	P145		P5		P1	P15	P15		P14	
Lunula var. intermedium	P1		P1					P15	P5	P5	P5	
Malmei	P15	P1	P14		P5	P1	P1		P1		P15	P1
Navicula	P145	P4	P14	P4	P45			P45	P15	P14	P45	P4
parvulum	L14		L3		P5			P4	P5:L4	P4		
parvulum var. angustum										L1		
pronum					P4							

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Closterium, Cont.												
Ralfsii var. hybridum			P4						P1		P15	P1
Ralfsii var. hybridum fa. sigmoideum											P5	
setaceum	P145	P14	P145	P4	P45		P1	P15	P1345	P14	P1	
subfusiforme	P5	P4	P4		P5				P45			
subulatum					P5							
tumidulum									L1			
Ulna		P1		P1						P1		
Ulna, fa.										P1		
Coelastrum												
cambricum	P1	P5			P45	P4			P45	P1	P45	P1
sphaericum	P145	P4	P4	P14				P5	P5	P4	P45	P4:L23
Coleochaete sp.					P4							
divergens		P4										
orbicularis		P4										
soluta	P4	P4		P4								
Cosmarium spp.	P125:L1	L3	L1			L1	P4	P123	P345	P2:L15	P2	P2:L15
abbreviatum var. planctonicum	P4											

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Cosmarium, Cont.												
amoenum		P4	P34	P24	P4	P1	P4		P2345	P34		P1
amoenum var. mediolaeve					P2							
bacillare				P4								
Botrytis								L1	L4	L1	L1	
Cucurbita	P3	P3	P234	P234	P24	P23	P4	P2345	P345	P234	P34	P34
Cucurbita, fa.										L4		
Cucurbita var. attenuatum				P4					P4			
cucurbitinum fa. minor											P4	
depressum		L3										
difficile var. dilatatum									P5			
exiguum var. pressum			P4	P4								
globosum				L3								
ornatum	P4		P5		P45			P4	P4	P14	P45	
ovale				P4		P4						
ovale var. Prescottii	P15	P1	P14	P4	P45		P5	P1	P15	P1	P145	P14
pachydermum											L1	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Cosmarium, Cont.												
pseudobroomei					P5					P4	P5	
pseudoconnatum	P5:L1		P5:L3		P5				P145	P1:L1	P145:L1	
pseudopyramidatum	P13			P3		P3			P35	P34	P5	P4
pyramidatum	P3	P34	P34	P34	P4			P35	P3	P3	P13	P3
quinarium	P145		P5		P5			P2	P5	P4	P145	
Regnellii var. minimum		P1							P5	P1		
reniforme		L3	L3									
retusiforme			P15		P5				P45	P1		
scopulorum									L4			
subarctoum					P24							
subcrenatum					P5							
subcrenatum, fa.								P4	P5:L4		P4	
subcucumis								P4	L4			
Turpinii			L3									L23
Ungerianum, fa.											L1	
venustum fa. minor	P4				P4				P5			
Crucigenia												
irregularis			L1	L1						L1	L1	
rectangularis			L12									

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Cylindrocystis												
Brebissonii		P3	P34	P2	P245	P4	P24	P24	P2345	P234	P23	P4
Brebissonii var. minor			P4					P4				
Brebissonii var. turgida								P4	P34		P3	
Desmidium												
Aptogonum	P15	P1	P14	P5	P5				P15	P14	P145	P4
Baileyi	P15	P1	P14			P1	P1	P1	P145	P14	P145	P1
Grevillii		P4										
Swartzii var. amblyodon		L23	L123						L1		L1	L12
Dicranochaete												
reniformis	P5	P4			P5							
Dimorphococcus												
lunatus		P4	P4		P4		P4				P4	P4
Docidium												
undulatum, fa.				P4								
Elakatothrix												
gelatinosa	P1		P1	P4					P1			
Eremosphaera												
viridis	P4	P4	P4	P4			P4	P45	P4	P4	P45	P4

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Euastrum spp.	P4		P4	P14	P5					P4		
affine	P145		P14	P4	P45	P14	P1	P145	P145	P4	P14	P14
affine, fa.								P4				
Ciastonii		P14	P4	P4	P45				P145		P4	P4
crassum	P1	P5	P14	P4	P45	P1	P15		P1	P1	P15	
denticulatum		P4	P14	P4	P45			P2		P3		
denticulatum var. quadrifarium			P4		P5			P1				
humerosum					P4						P1	
hypochondrum fa. decoratum	L1	L2								L1	L1	L12
insigne fa. porifera				P4								
insulare var. silesiacum								P4	P4			
intermedium var. scrobiculatum					P4		P5					
pinnatum			P4	P4	P4	P4	P4					
validum var. glabrum		P4	P4	P4					P4			
Geminella												
mutabilis									P14		P4	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Gloeocystis												
planctonica			P3					P5	P4			
vesiculosa											P3	
Gloeomonas												
ovalis	P3		P34		P4	P4	P4	P2	P4			P4
Gonatozygon												
aculeatum	P15										P145	
Kinahanii	P1	P4	P14	P14				P1				
Gonium												
pectorale	L1									L1		L12
Gymnozyga												
moniliformis	P134		P3	P13	P145	P13	P4	P134	P1345	P134	P1345	P134
Hyaliella												
polytomoides				P2	P2		P2					
Hyalotheca												
dissiliens	P15	P1:L3	P14:L123		P5	P4:L1	P1	P1	P145:L1	P14:L1	P4:L1	L23
dissiliens var. tatrica		P4					P1			P14	P45	
mucosa	P15	P1	P145	P1	P4			P1	P15	P1	P14:L1	P4
undulata	P4				P4						P4	
Kirchneriella sp.							P4		P4			

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Kirchneriella, Cont.												
lunaris	P1											
lunaris var. irregularis		P4							P1			
obesa var. major								P4				
Micrasterias												
arcuata, fa.									P5			
denticulata			P4		P5			L1			P14	
depauperata var. Kitchelii	P14	P14	P4	P145	P45	P14		P145	P145	P14	P14	P24
depauperata var. Kitchelii fa. apiculata					P4							
floridensis var. spinosa					P1							
papillifera var. speciosa	P4	P4	P4	P4	P4			P124	P4	P4	P14	P24
pinnatifida	P45	P4	P4		P4			P1		P4	P14	P4
radiata var. gracillima	P15	P4	P14	P4	P45			P15	P1	P1	P1	P14
rotata	P1		P14					P15	P5	P1	P145	
rotata fa. nuda			P14							P1		P4
Torreyi	P145	P1	P1	P14	P5		P1	P1	P14	P14	P15	P1

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Micrasterias, Cont.												
truncata	P23	P23	P234	P24	P24	P23		P12	P2345	P23	P3	P134
truncata var. crenata	P34	P4	P234	P3	P24			P4		P3		P2
truncata var. semiradiata		L3										L12
Microspora												
pachyderma								P4		P4		
stagnorum			P3						P3		P4	
tumidula	P3		P1234	P24	P4	P12	P4	P2345	P234	P3	P4	P24
Microthamnium												
Kuetzingianum					P4			P4				
strictissimum		P4	P4	P4	P4			P34	P35			
strictissimum var. macrocystis		P4						P34				
Mougeotia spp.	P1-5:L1	P124:L123	P1-5:L123	P1-5:L3	P1245:L13	P123	P14	P1-5:L1	P1-5:L1	P1-5:L1	P1-5:L1	P1234:L13
laetevirens			L3							L1	L1	L2
recurva										P3		
scalaris										P4		
Nephrocytium												
ecdysiscepanum										L1		
limneticum			L1							L1		

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Nephrocytium, Cont.												
obesum											L1	L1
Netrium												
digitus	P145	P14	P145	P14	P45	P14		P14	P145	P14	P45	P124:L123
digitus fa. elegans			P4		P5			P4		P1		
digitus var. lamellosum	P145	P14	P14	P14	P45	P14	P15	P14	P145:L1	P14	P145:L1	P14
digitus var. Naegelii								P4	P4			
digitus var. parvum					P4				P5	P4	P5	
digitus var. rhomboideum	P4		P1		P5							
interruptum		P4	P4	P4	P45			P45	P5	P4	P4	P14
oblongum								P4		P4	P45	
Nitella												
gracilis											P5	
oligospira	P5											
Oedogonium spp.	P1-5	P124:L2	P1245:L23	P1245	P45	P134		P1245:L1	P1245	P145:L1	P145:L1	P124:L1
australe									P1			
exocostatum											L1	
macrandrium var. propinquum	P5											

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Oedogonium, Cont.												
spiripennatum var. inferior	P15	P1									P5	P1
Oocystis spp.											P3:L1	
Borgei			L3									
parva	L1											
Palmodictyon												
varium		P4										
Pandorina												
morum												L3
Pediastrum												
araneosum								P5			P5	
araneosum var. rugulosum	P1	P1	P1		P5		P1	P1			P5	P1
biradiatum	P5	P4		P14	P145	P1		P1	P4	P1	P4	P1
Boryanum	L1	L13	L3						L1	L1	L1	L123
duplex			P14	P4					P5			P1
duplex var. cohaerans	P145	P14	P145	P14	P45	P14	P15	P145	P145	P145	P145	P14
integrum		L3	L3	L1								L2
muticum var. crenulatum	P4								P5	P5		
tetras	P4		P4		P4			P4	P5	P4	P4	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake, 2 Sphagnum Mat, 3 Sphagnum Pool, 4 Marginal Pool, 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion, 2 Lake, Intermediate Portion, 3 Lake, Outlet Portion, 4 Marginal Pool, 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Penium												
cylindrus	P15	P14	P4	P4	P45	P4		P4	P45	P4	P4	
spirostriolatum	P4		P4					P4	P4	P14	P5	
Phacotus spp.	P1		L3						P3			
Lendneri										L1		
Planktosphaeria												
gelatinosa				P1								
Pleurodiscus sp.	P145	P14	P145	P24	P245	P4		P24	P45	P145	P145	P14
Pleurotaenium												
constrictum	P15	P1	P1	P1	P45		P1	P145	P1	P145	P1	P14
Ehrenbergii	P145	P4:L2	P145	P14	P45	P1		P14	P145	P145	P145:L1	P1:L3
minutum	P3	P3	P34					P34	P3	P3	P34	P3
nodosum	P145	P1	P145	P14	P45	P1	P1	P14	P15	P14	P145	P1
nodosum var. Borgei	P145	P1	P145	P14	P45	P1	P1	P14	P15	P14	P145	P1
subcoronulatum var. detum	P145	P1	P14	P14	P245	P1	P1	P145	P15	P14	P1245	P1
Trabecula		L3	L23							L1		L3
Trabecula var. maximum		L3	L12	L3								
Trabecula var. rectum		P4										P4
verrucosum	P15	P1	P145	P4	P5	P1	P1	P1	P15	P145	P145	P1

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Protoderma												
viride					P5	P1						
Quadrigula												
Chodatii		L3										
Rhizoclonium												
hieroglyphicum								P4				
Scenedesmus spp.		P5					P15					
abundans var. asymmetrica								P5				
acutiformis	P145	P4	P4	P4	P45	P1			P45	P4	P45	P1
armatus				P4							P4	P1
armatus var. major	P15	P14	P145	P14	P45	P1		P45	P5	P14	P145	P1
bijuga	P5	P4	P4			P14				L4		
bijuga var. flexuosus	P5		P45			P1			P5			
brasiliensis	P5			P4							P4	P4
dimorphus	P4	P14	P4	P4	P45			P4	P4	P4	P4	
longus						P1						
longus var. Naegelii					P4							
quadricauda		P4	P4	P4	P5	P4		P1	P5		P15	P1
quadricauda var. maximus			P4									

Table I.--Continued

Symbols Used:

P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom

L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Selenastrum												
Bibraianum	P4		P4		P4		P4	P4	P4	P4	P4	
Sirogonium sp.		L3										
Sphaerocystis												
Schroeteri	P1		P1						P1	L1	L1	
Spirogyra spp.	P145:L1	P4:L2	P4:L13	P14	P45	P4		P4:L4	P145:L4	P145:L14	P145:L1	P4:L12
Weberi											P4	
Spirotaenia												
condensata	P145	P14	P145	P124	P145	P14	P1	P14	P145	P145	P145	P14
Spondylosium												
pulchellum	P5		P45	P4	P5			P4	P45		P4	
Staurastrum spp.	P235	P3	P1234	P45	P45			P1	P1-5	L1	P2	P234:L3
aciculiferum, fa.		P3										
alternans				P24	P2		P2	P2				
anatinum									P1		P1	P1
Brebissonii, fa.									P5			
brevispinum	L1		L2							L1		
brevispinum var. retusum										L1		
Cerastes	P14	P1	P14	P4	P45	P1		P1	P14	P4	P145	P14
furcigerum										L1	L1	L12

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Staurastrum, Cont.												
gladiosum								P4	P4			
gracile var. nanum				P4								
inconspicuum var. crassum				P2	P45				P24			
margaritaceum		P2	P24		P2			P23	P2	P2	P23	P2
margaritaceum facies variabile					P5							
monticulosum var. Irenee-Mariei	P23	P2	P2	P2	P2	P23		P23	P23	P23		P23
muticum											P3	
orbiculare var. depressum							P4					
pentacerum	P1	P1	P1		P5	P14	P1	P1	P5	P1	P1	P1
punctulatum, fa.		L3										
quebecense			L3	L1						L1	L1	L2
rugosum		L3								L1		
setigerum var. occidentale	L1									L1	L1	L1
Simonyi											P4	
tetracerum					P4							
urinator					P5				P1			

Table I.--Continued

Symbols Used:

	1	2	3	4	5
P(Purdy):	Center Lake	Sphagnum Mat	Sphagnum Pool	Marginal Pool	Lake Bottom
L(Lawrence):	Lake, Main Portion	Lake, Intermediate Portion	Lake, Outlet Portion	Marginal Pool	Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Staurastrum, Cont.												
vestitum var. subanatinum	P1		P4	P4	P4			P1	P14	P1	P14	
Staurodesmus												
controversus			P3	P3					P3	P3	P3	P3
dejectus				P4						P4		
extensus								P4	P345	P1		
extensus var. Joshuae					P5							
glabrus										P4		
megacanthus var. scoticus fa. minor	P4									P4		
Stigeoclonium												
subsecundum	P4	P4	P45	P14	P4		P4	P4				
Tetmemorus spp.	P4	P4	P5		P5				P5	P3	P4	P4
Brebissonii	P4		P34	P4	P4			P4	P4	P2		
Brebissonii var. minor			P4	P4				P4	P4	P4		
granulatus			P4					P4	P4	P4		P4
laevis		P3						P4	P4	P4	P4	
laevis var. minutus			P4	P4		P4	P4	P4			P4	P4

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Tetraspora												
gelatinosa									P4			
Triploceras												
gracile	P145	P1	P14	P14	P5	P14	P1	P4	P15	P14	P145	P1
verticillatum	P14	P1	P14	P14	P25	P1	P12	P124	P15	P14	P145	P1
Trochiscia												
reticularis				P14		P1		P145	P245			
Xanthidium												
antilopaeum		L13	L1							L1	L1	L1
antilopaeum var. minneapoliense	P145		P14	P1	P5	P1		P1	P14		P14	P1
antilopaeum var. polymazum	P15	P1	P14	P1	P45	P1		P1	P1345	P14	P1	P1
Zygnema sp.		L2						L1		L14	L1	L12
Zoochlorella												
conductrix		L3	P1:L3									
parasitica	P1345	P15:L12	P1345	P14:L1	P45	P1		P45:L1	P345	P23	P1	P4:L3
Zygogonium												
ericetorum	P12	P2	P2	P24			P4	P1234	P123	P234	P4	P2

Table I.--Continued

Symbols Used:	P(Purdy):	1 Center Lake	2 Sphagnum Mat	3 Sphagnum Pool	4 Marginal Pool	5 Lake Bottom
	L(Lawrence):	1 Lake, Main Portion	2 Lake, Intermediate Portion	3 Lake, Outlet Portion	4 Marginal Pool	5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
II Chrysophyta												
Achnanthes spp.			P5:L3									
Amphipleura spp.			L23									
rutilens			L3									
Amphora spp.			L3									
obesa			L3									
ovalis			L3									
Anomoeoneis spp.			P5								P5	
Asterionella												
formosa			L1	L1	L13	L1		L1	L1	L1	L1	
Chlorellidiopsis												
separabilis		P4	P45	P4						P4		
Chlorobotrys												
regularis												P4
Chromulina spp.					P45							
gigantea			P4	P4				P2				
pyriformis			P4									
suprema								P2	P3			
Chrysarachnion												
insidians			P4									

Table I.--Continued

Symbols Used:	P(Purdy):	1 Center Lake	2 Sphagnum Mat	3 Sphagnum Pool	4 Marginal Pool	5 Lake Bottom
	L(Lawrence):	1 Lake, Main Portion	2 Lake, Intermediate Portion	3 Lake, Outlet Portion	4 Marginal Pool	5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Chrysopyxis												
stenostoma	P14		P4								P4	P14
Chrysosphaerella												
longispina	L1	L13	L123	L13								L3
Chrysostephanosphaera												
globulifera	P3	P4	P4	P4	P4	P4			P2345	P1234	P3	P34
Cocconeis												
placentula			L3						L1			
Cyclotella spp.			P3:L23			L1			L1	L1	L1	
bodanica			L1									
Cymatopleura spp.				L1				L1	L1			L1
Cymbella spp.			L123			L1		L1	L1			
Diatoma spp.			L3									
Diploneis spp.			L2									
Dinobryon												
bavaricum	P4								P1	P1	P14	
cylindricum	P4	P4	P14	P145:L3	P145:L3	L1	P14	P145	P4	P1		P4
divergens			L13	L1	L1	L1			L1	L1	L1	L3
divergens var. Schauinslandii	L1		L1						L1	L1	L1	
pediforme									P34	P1	P14	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Dinobryon, Cont.												
sertularia	P4	P1	L3	P4:L3				P4	P4			
sertularia var. protuberans							P4					
Epithemia												
sorex			L23									
Eucocconeis spp.			L2									
Eunotia spp.			P345:L23			L1						
lunaris			P5					P3				
pectinalis			L3									
tenella			P5									
Fragilaria												
crotonensis	L1	L13	L123	L13	L13		L1	L1	L1	L1	L1	L1
Frustulia spp.			P345:L13					P3				
Gomphonema spp.		L3	L123	L1		L1	L1	L1		L1	L1	L2
acuminatum					L3				L1		L1	
Gyrosigma spp.							L1					
Heterochromonas												
sphaerophora					P5							
Hyalobryon												
ramosum	P4		P4:L3	P4:L3					P4		P4	L2

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Lagynion spp.	P1										P4	P4
Mallomonas spp.		L1	P4:L12	L1	L1	P1	L1	L1	P2	P2	P4	P1
elongata		L1	L1	L1	L12		L1					
Melosira												
ambigua		L1	L123	L13	L1	L1	L1	L1	L1	L1	L1	L1
Mischococcus												
confervicola									P3			
Navicula spp.			P345:L23						L1		L1	
pupula var. capitata			L2									
radiosa			L3									
Neidium sp.			P5									
Nitzchia spp.			P5:L23									
Ochromonas												
crenata					P45							
Ophiocytium												
capitatum			P4									
Peroniella												
planctonica	P5											
Pinnularia spp.	P3		P1345:L13	P34	P45	P3	P1	P1235:L1	P35:L1	P13:L1	P35	
Pseudokephyrion												
undulatissimum, fa.				L3								

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake, 2 Sphagnum Mat, 3 Sphagnum Pool, 4 Marginal Pool, 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion, 2 Lake, Intermediate Portion, 3 Lake, Outlet Portion, 4 Marginal Pool, 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Rhipidodendron												
splendidum				P13	P5	P4		P5	P4	P4	P3	
Rhopalodia spp.			L23									
Salpingoeca												
gracilis, fa.					P5							
Spongomonas sp.			P4		P4	P14						P1
Stauroneis												
phoenicentron	P1		P45	P4	P4	P14	P1	P45	P15		P145	P1
Stephanodiscus												
niagarae		L1	L123	L13	L1	L1	L1	L1	L1	L1		
Stipitococcus												
urceolatus												P4
Surirella												
elegans			L1									
Synedra spp.			L23	P4:L1	L13	L1		P1:L1	P1	P4	L1	L1
capitata	L1		L123		L1		L1	L1	L1		L1	L1
Synura												
sphagnicola			P34:L3	P14:L3	P45:L3		P4	P4	P24	P3		
uvella	P1	P14:L3	P134:L13	P14:L3	P145	P1		P134:L1	P34:L1	P1	P24	P4
uvella, fa.	P1	P1	P1	P14	P14	P1						

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake, 2 Sphagnum Mat, 3 Sphagnum Pool, 4 Marginal Pool, 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion, 2 Lake, Intermediate Portion, 3 Lake, Outlet Portion, 4 Marginal Pool, 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Synuropsis												
danubiensis, fa.	P1		P1:L3		P14		P1					
Tabellaria												
fenestrata	P15	P1	P15:L13	P14:L1	P145:L1	P14:L1	P15:L1	P145:L1	P145:L1	L1	P45:L1	P1:L1
flocculosa			P245	P1	P45			P145	P5		P4	
Tribonema												
minus		P2										
utriculosum										L1		
Uroglena												
americana	L1	L13	L13	L1						L1	L1	
botrys				P1							L1	
III Pyrrhophyta												
Ceratium												
cornutum								P5				
hirundinella	L1	L13	L1				L1	L1	L1	L1	L1	L13
Chilomonas sp.			P4		P4						P3	
Chroomonas												
Nordstedtii								L1				
Cryptomonas spp.	P5		P3			P4	P4			P2		
erosa			P4:L3	P24:L3	P24	P145		P24			P4	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Cryptomonas, <u>Cont</u>.												
obovata			P4		P45		P1	P4	P4	P3		
ovata	P45	P4	P45:L3	P134:L3	P45	P1	P1	P14	P12345	P13	P4	P14
rostratiformis					P45	P1		P45	P4	P3		P34
Cystodinium												
bicorne									P4			
Steinii		L3										
Glenodinium spp.	P35	P1	L1							P3L1	L1	P13
Gonyostomum												
semen	P3	P3	P34		P4			P3	P3	P23	P3	P3
Gymnodinium												
fuscum	P14	P14	P14						P5	P45	P45	P1
ordinatum			P4			P13						
Hemidinium												
nasutum					P5							
Merotrichia												
capitata			P4									
Peridinium spp.		P14:L2	P4:L2			P4			P4	P14	P5	L2
cinctum var. tuberosum	P15			P4						P5	P14 L1	P1 L1
gatunense												

Table I.--Continued

Symbols Used:
P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Peridinium, Cont.												
inconspicuum					P4				P4		P34	P34
palustre	P3										P3	
polonicum	L1									L1	L1	L1
umbonatum											L1	
Volzii				P4								
wierzejskii				P4								
Willei	P1	P1	P1:L13	P14:L13	P14:L1	P1:L1	P1:L1	P14:L1	P1:L1	L1	L1	L1
Willei fa. lineatum		P1	P1:L13	P14:L13	P1	P1:L1	P1:L1	P1:L1	L1	L1		
Willei fa. stagnale			P1									
Tetradinium												
javanicum											P4	
Trentonia												
flagellata			P134		P45	P1	P1	P1				
Vacuolaria												
virescens			P1:L3		P145	P1	P5	P14				
IV Euglenophyta												
Anisonema spp.		L3	P4	P2:L3	P1					P134	P245	P4
pseudoprosgeobium					P245			P24				

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Astasia spp.	P2					P3		P2		P24	P2	
praecompleta								P2	P2	P2		
Skadowskii		P4						P24	P2	P245	P5	P45
Cyclidiopsis												
acus	P3		P34						P34	P2	P3	P2
Distigma spp.					P2			P24		P2		
curvatum				P2	P2	P34	P4	P24				
Entosiphon												
sulcatum	P3		P4						P4		P4	
Euglena												
acus				P4	P45	P1		P4	P35			P4
deses			P4		P24			P2	P4	P24		
fusca				P4	P4							
mutabilis	P234	P2	P2	P24	P245		P14	P2345	P235	P1245	P245	P25
proxima			P34		P4							
variabilis								L1				
Eutreptia												
viridis	P5		P4	P4					P5			
Gyropaigne												
kosmos			P4									

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake, 2 Sphagnum Mat, 3 Sphagnum Pool, 4 Marginal Pool, 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion, 2 Lake, Intermediate Portion, 3 Lake, Outlet Portion, 4 Marginal Pool, 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Heteronema												
acus, fa.	P3		P3									
Lepocinclis												
colligera							P4					
Menoidium spp.	P3				P4				P5	P4		
pellucidum	P3		P3			P3		P4			P5	P4
Peranema												
trichophorum		P4	P4	P234	P5			P4	P5	P4		P134
Petalomonas spp.	P2	P2	P2	P24		P4		P2	P25	P2	P24	P24
praegnans					P5				P1	P1	P1	
Steinii				P4	P5							
Phacus												
caudatus					P4	P1						
lismorensis	P3			P4	P4					P4	P3	P3
longicauda	P3	P1	P4		P4			P4	P3		P3	P14
orbicularis											P4	
pyrum			P4									
suecicus											P4	P4
triqueter				P4	P4							
Rhabdomonas												
incurva			•						P2			

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Trachelomonas spp.		P4	P4	P4	P45	P1		P234				P23
Dybowskii	P4		P4	P34	P4	P4			P5			P4
hispida		P4			P5					P4		
intermedia					P4							
Kelloggii		P4	P4	P4							P4	
Klebsii			P4	P4	P4		P45		P5	P4		
oblonga						P1						
Raciborskii var. nova												P4
triangularis					P4							
volvocina	P234	P24:L3	P23	P34	P24			P24	P25	P234	P234	P24
V Cyanophyta												
Anabaena sp.	P3	P1								P3	P3	P34
augstumalis var. marchica	P2	P2	P2	P2	P2	P2		P2	P2	P2	P24	P2
flos-aquae	L1	L13	L123	L13						L1	L1	L1
Aphanothece												
microscopica	P15	P1	P15:L3	P1	P15	P1	P15	P15	P15	P1	P1	P1
Naegelii		L4										
stagnina			L3						L1		L1	

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Chroococcus												
dispersus	P4		P2	P4								
limneticus	L1	L13	L3							L1	L1	L1
minutus			P2	P4				P4				
Prescottii		L1			P4	P1				P24	P4:L1	L1
turgidus	P234	P24:L23	P234	P234:L3	P4:L1	P123	P4	P234	P234	P234:L1	P3:L1	P234:L12
turgidus var. maximus		L23	L3	L3					L1	L1	L1	L12
Coelosphaerium												
Naegelianum	L1	L13	L13	L13	L1	L1	L1	L1	L1	L1	L1	L3
pallidum		L3	L23	L3								L13
Cylindrospermum												
minutissimum	P24	P24	P4	P24	P4			P24	P4			P4
Gomphosphaeria												
aponina	L1	L123	L13	L3		L1		L1		L1	L1	L12
aponina var. cordiformis	L1	L123	L123	L3	L13			L1		L1	L1	L12
lacustris var. compacta	L1	L13	L1	L1	L1		L1	L1	L1	L1	L1	L12
Hapalosiphon spp.	P25		P24	P4	P45	P4		P4				P4
confervaceous		P2	P4				P4					
fontinalis				P4								

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Hapalosiphon, Cont.												
hibernicus										P4		
Lyngbya												
Birgei	L1	L123	L12	L1	L1							
Merismopedia												
elegans			P2								L1	
glauca	P4		P24	P24	P45	P2		P24	P124	P124:L1	L1	P4:L1
punctata	P14	P24	P24	P24	P2	P2		P24	P25:L1	P245:L1	P34:L1	P2:L23
Trolleri	L4					P1		P2		L1		
Microcystis												
aeruginosa	L1	L13	L13						L1	L1	L1	L123
Nostoc sp.							L1					
Oscillatoria												
amphibia	P3:L1		P245				P45	P24	P5			
Bornetii		L23	L123	L3	L3							
curviceps						P1	P5					
limosa		L3	P1	P1:L3	P15	P1		P1		L1	L1	
nigra		P5										
princeps	P14:L1	P14	P1	P4				P4	P1	P14:L1	P145:L1	P14
rubescens	P4								P5		P1	P1
splendida	P4											

Table I.--Continued

Symbols Used:
P(Purdy): 1 Center Lake; 2 Sphagnum Mat; 3 Sphagnum Pool; 4 Marginal Pool; 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion; 2 Lake, Intermediate Portion; 3 Lake, Outlet Portion; 4 Marginal Pool; 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Oscillatoria, Cont.												
tenuis var. natans	P4	P1:L3	P3	P1	P5	P1	L1		P145	L1		
tenuis var. tergestina						P1						
Plectonema												
nostocorum	L5											
notatum					P1							
Rhabdoderma												
lineare						P1						
Schizothrix												
lacustris	L5	L5							L5	L5	L5	L5
Scytonema sp.												L2
Arcangelii					P4							
Spirulina												
Jenneri			L1	L1								
laxa						P1	P1					
platensis											L1	
Synechococcus												
aeruginosus	P5		P5	P5	P5			P4	P5		P4	
Tolypothrix												
distorta		L3	L3	L3								

Table I.--Continued

Symbols Used: P(Purdy): 1 Center Lake 2 Sphagnum Mat 3 Sphagnum Pool 4 Marginal Pool 5 Lake Bottom
L(Lawrence): 1 Lake, Main Portion 2 Lake, Intermediate Portion 3 Lake, Outlet Portion 4 Marginal Pool 5 Lake Bottom

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
VI Rhodophyta												
Batrachospermum												
vagum	P145	P4	P45	P4	P4			P14		P14	P145	P4

Table II.--Number of taxa found in Purdy Bog and Lawrence Lake, compared with the total number of taxa observed (by Division)

Division	Total Number of Taxa	Purdy Bog: Number of Taxa	Purdy Bog: Per cent of Total	Lawrence Lake: Number of Taxa	Lawrence Lake: Per cent of Total
Chlorophyta	293	243	82.8	74	25.3
Chrysophyta	80	47	58.8	50	62.5
Pyrrhophyta	30	24	80.0	12	40.0
Euglenophyta	42	41	97.6	3	7.1
Cyanophyta	49	29	59.2	31	63.3
Rhodophyta	1	1	100.0	0	0.0
Total number	495	385		170	

Table III.--Comparison of the number of taxa (by Division) identified in the two study areas

Division	Purdy Bog		Lawrence Lake	
	Number of Taxa Identified	Per cent of Total Which are Members of This Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	243	63.0	74	43.5
Chrysophyta	47	12.2	50	29.4
Pyrrhophyta	24	6.3	12	7.1
Euglenophyta	41	10.7	3	1.8
Cyanophyta	29	7.5	31	18.2
Rhodophyta	1	0.3	0	0.0
Total number	385		170	

Table IV.--Total number of taxa (by Division) identified in the center lake of Purdy Bog

Division	Number of Taxa Identified	Per cent of Total Which are Members of this Division
Chlorophyta	122	67.8
Chrysophyta	20	11.1
Pyrrhophyta	13	7.2
Euglenophyta	7	3.9
Cyanophyta	17	9.4
Rhodophyta	1	0.6
Total number	180	

Table V.--Total number of taxa (by Division) identified in the sphagnum mat of Purdy Bog

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	35	48.0
Chrysophyta	9	12.3
Pyrrhophyta	3	4.1
Euglenophyta	14	19.2
Cyanophyta	12	16.4
Rhodophyta	0	0.0
Total number	73	

Table VI.--Total number of taxa (by Division) identified in the sphagnum pool of Purdy Bog

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	39	47.0
Chrysophyta	13	15.7
Pyrrhophyta	10	12.0
Euglenophyta	16	19.3
Cyanophyta	5	6.0
Rhodophyta	0	0.0
Total number	83	

Table VII.--Total number of taxa (by Division) identified in the marginal pools of Purdy Bog

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	193	64.3
Chrysophyta	33	11.0
Pyrrhophyta	19	6.3
Euglenophyta	36	12.0
Cyanophyta	18	6.0
Rhodophyta	1	0.3
Total number	300	

Table VIII.--Total number of taxa (by Division) identified in the lake bottom of Purdy Bog

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	133	68.0
Chrysophyta	24	12.4
Pyrrhophyta	11	5.7
Euglenophyta	15	7.7
Cyanophyta	11	5.7
Rhodophyta	1	0.5
Total number	195	

Table IX.--Total number of taxa (by Division) identified in the main portion of Lawrence Lake

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	49	43.0
Chrysophyta	30	26.3
Pyrrhophyta	8	7.0
Euglenophyta	1	0.9
Cyanophyta	26	22.8
Rhodophyta	0	0.0
Total number	114	

Table X.--Total number of taxa (by Division) identified in the outlet portion of Lawrence Lake

Division	Number of Taxa Identified	Per cent of Total Which are Members of This Division
Chlorophyta	36	35.6
Chrysophyta	38	37.6
Pyrrhophyta	7	6.9
Euglenophyta	2	1.9
Cyanophyta	18	17.8
Rhodophyta	0	0.0
Total number	101	

Table XI.--Number of taxa in individual habitats of the study areas, compared with the total number of taxa in each area

Habitat	Number of Taxa in This Habitat	Per cent of Total Which Occurred in This Habitat
Purdy Bog	385	100.0
Center Lake	180	46.9
Sphagnum Mat	73	19.0
Sphagnum Pool	83	21.6
Marginal Pools	300	78.1
Lake Bottom	195	50.5
Lawrence Lake	170	100.0
Main Portion	114	67.0
Outlet Portion	101	59.4

Table XII.--Number of desmid taxa in individual habitats of the study areas, compared with the total number of taxa in each area

Habitat	Total Number of Taxa	Number of Desmid Taxa	Per cent of Total Which are Desmids
Purdy Bog	385	151	39.2
Center Lake		78	20.3
Sphagnum Mat		20	5.2
Sphagnum Pool		22	5.7
Marginal Pools		125	32.6
Lake Bottom		89	23.2
Lawrence Lake	170	40	23.5
Main Portion		26	15.3
Outlet Portion		20	11.8

Table XIII.--Number of desmid taxa in individual habitats of the study areas, compared with the total number of taxa in the habitat

Habitat	Total Number of Taxa	Number of Desmid Taxa	Per cent of Total Which are Desmids
Purdy Bog	385	151	39.2
Center Lake	180	78	43.3
Sphagnum Mat	73	20	27.4
Sphagnum Pool	83	22	26.5
Marginal Pools	300	125	41.7
Lake Bottom	195	89	45.9
Lawrence Lake	170	40	23.5
Main Portion	114	26	22.8
Outlet Portion	101	20	19.8

Table XIV.--Number and percentage of the Chlorophyta in individual habitats which are desmids

Habitat	Total Number of Chlorophyta	Number of Desmid Taxa	Per cent of Total Which are Desmids
Purdy Bog	243	151	62.1
Center Lake	122	78	63.9
Sphagnum Mat	35	20	57.1
Sphagnum Pool	39	22	56.4
Marginal Pools	193	125	64.8
Lake Bottom	133	89	67.4
Lawrence Lake	74	40	54.1
Main Portion	49	26	53.1
Outlet Portion	36	20	55.6

Table XV.--Seasonal changes in the number of taxa in Purdy Bog, compared with the total number of taxa (by Division)

Division	Total Number of Taxa	Number of Taxa			
		Fall	Winter	Spring	Summer
Chlorophyta	243	159	160	167	152
Chrysophyta	47	32	23	22	21
Pyrrhophyta	24	18	16	13	12
Euglenophyta	41	23	29	24	25
Cyanophyta	29	20	21	17	12
Rhodophyta	1	1	1	1	1
Total number	385	254	250	244	223

Table XVI.--Seasonal changes in the number of taxa in Lawrence Lake, compared with the total number of taxa (by Division)

Division	Total Number of Taxa	Number of Taxa			
		Fall	Winter	Spring	Summer
Chlorophyta	74	46	9	21	48
Chrysophyta	50	22	24	21	20
Pyrrhophyta	12	10	4	4	7
Euglenophyta	3	2	1	1	0
Cyanophyta	31	25	13	12	23
Rhodophyta	0	0	0	0	0
Total number	170	105	51	59	98

Table XVII.--Algal communities typical of individual habitats in Purdy Bog

Center Lake Community*

Aphanothece microscopica
Botryococcus Braunii
Cosmarium ovale var. Prescottii
Dinobryon bavaricum
D. cylindricum
D. pediforme
Euastrum affine
Gymnodinium fuscum
Gymnozyga moniliformis
Micrasterias spp.
Netrium digitus
N. digitus var. lamellosum
Oscillatoria princeps
Pediastrum spp.
Peridinium cinctum var. tuberosum
P. Willei
P. Willei fa. lineatum
Petalomonas praegnans
Pleurotaenium spp.
Scenedesmus spp.
Staurastrum anatinum
Synura uvella
Synuropsis danubiensis., fa.
Tabellaria fenestrata
T. flocculosa
Triploceras gracile
T. verticillatum
Trentonia flagellata
Vacuolaria virescens

Sphagnum Mat Community

Anabaena augstumalis var. marchica
Anisonema pseudoprosgeobium
Astasia spp.
A. praecompleta
A. Skadowskii

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*The communities of the center lake, marginal pools and lake bottom habitats are dominated by desmids, although only a few of the more characteristic species are included in this table.

Table XVII.--continued

Sphagnum Mat Community, continued

Chlorogonium spp.
Chromulina suprema
Chroococcus minutus
C. turgidus
Cosmarium amoenum var. mediolaeve
C. cucurbita
Cryptomonas erosa
Cyclidiopsis acus
Cylindrocystis Brebissonii
Cylindrospermum minutissimum
Distigma spp.
D. curvatum
Euglena deses
E. mutabilis
Gonyostomum semen
Hapalosiphon spp.
Hyaliella polytomoides
Micrasterias truncata
Microspora tumidula
Petalomonas spp.
Rhabdomonas incurva
Staurastrum alternans
St. margaritaceum
St. monticulosum var. Irenee-Mariei
Trachelomonas volvocina
Zygogonium ericetorum

Sphagnum Pool Community

Chromulina suprema
Chroococcus turgidus
Cosmarium amoenum
C. cucurbita
C. pseudopyramidatum
C. pyramidatum
Cyclidiopsis acus
Cylindrocystis Brebissonii
Euglena mutabilis
Gloeocystis vesiculosa
Gloeomonas ovalis
Gonyostomum semen
Gymnozyga moniliformis
Heteronema acus
Menoidium pellucidum
Micrasterias truncata
Microspora tumidula

Table XVII.--continued

Sphagnum Pool Community, continued

Peridinium palustre
Phacus lismorensis
Ph. longicauda
Pleurotaenium minutum
Rhipidodendron splendidum
Staurastrum margaritaceum
St. monticulosum var. Irenee-Mariei
Staurodesmus controversus
Synura sphagnicola
Trachelomonas volvocina
Zygogonium ericetorum

Marginal Pools Community*

Anisonema pseudoprosgeobium
Astasia Skadowskii
Asterococcus limneticus
Batrachospermum vagum
Binuclearia tatrana
Botryococcus Braunii
Bulbochaete spp.
Chaetosphaeridium globosum
Chlamydomonas subcompleta
Chlorobotrys regularis
Chromulina gigantea
C. pyriformis
Chroococcus Prescottii
C. turgidus
Chrysopyxis stenostoma
Chrysostephanosphaera globulifera
Closterium spp.
Coleochaete spp.
Cosmarium ornatum
C. ovale
C. ovale var. Prescottii
Cryptomonas erosa
C. obovata
C. ovata
Cylindrocystis Brebissonii
Cylindrospermum minutissimum
Dimorphococcus lunatus
Dinobryon cylindricum
Distigma curvatum
Entosiphon sulcatum
Eremosphaera viridis
Euastrum affine
E. Ciastonii

Table XVII.--continued

Marginal Pools Community, continued

E. insulare var. silesiacum
E. pinnatum
E. validum var. glabrum
Euglena acus
E. deses
E. fusca
E. mutabilis
Geminella mutabilis
Gloeomonas ovalis
Gymnodinium fuscum
Gymnozyga moniliformis
Hapalosiphon spp.
Hyalotheca undulata
Kirchneriella spp.
Menoidium pellucidum
Merismopedia glauca
M. punctata
Micrasterias spp.
M. papillifera var. speciosa
Microspora tumidula
Microthamnium Kuetzingianum
M. strictissimum
Netrium digitus
N. digitus var. lamellosum
Oscillatoria princeps
Pediastrum spp.
P. tetras
Penium spirostriolatum
Peridinium Willei
P. Willei fa. lineatum
Peranema trichophorum
Phacus spp.
Pleurodiscus sp.
Pleurotaenium spp.
Rhipidodendron splendidum
Scenedesmus spp.
Selenastrum Bibraianum
Spondylosium pulchellum
Spongomonas sp.
Stigeoclonium subsecundum
Synura sphagnicola
S. uvella
Tetmemorus spp.
Trachelomonas spp.
Trentonia flagellata
Triploceras gracile
T. verticillatum
Vacuolaria virescens

Table XVII.--continued

Lake Bottom Community*

Arthrodesmus octocornis
Batrachospermum vagum
Bulbochaete spp.
Closterium spp.
C. Dianae var. pseudodianae
Cosmarium ornatum
C. ovale var. Prescottii
Euastrum affine
Euglena mutabilis
Gymnodinium fuscum
Hemidinium nasutum
Micrasterias spp.
Mougeotia spp.
Netrium digitus
N. digitus var. lamellosum
Nitella gracilis
N. oligospira
Oedogonium spp.
Pediastrum spp.
P. araneosum
Peridinium cinctum var. tuberosum
Rhipidodendron splendidum
Scenedesmus spp.
Spondylosium pulchellum
Stauroneis phoenicentron
Synechococcus aeruginosus
Tabellaria fenestrata
T. flocculosa
Trentonia flagellata
Triploceras gracile
T. verticillatum
Vacuolaria virescens

Table XVIII.--Algal communities typical of individual habitats in Lawrence Lake*

Main Portion Community

Anabaena flos-aquae
Aphanothece stagnina
Asterionella formosa
Ceratium hirundinella
Chroococcus limneticus
C. turgidus var. maximus
Chrysosphaerella longispina
Closterium aciculare
Coelosphaerium Naegelianum
Cosmarium Botrytis
Crucigenia irregularis
C. rectangularis
Cyclotella spp.
Cymatopleura spp.
Desmidium Swartzii var. amblyodon
Dinobryon clindricum
D. divergens
D. divergens var. Schauinslandii
Euastrum hypochondrum fa. decoratum
Fragilaria crotonensis
Gomphonema spp.
Gomphosphaeria aponina
G. aponina var. cordiformis
G. lacustris var. compacta
Lyngbya Birgei
Mallomonas elongata
Melosira ambigua
Microcystis aeruginosa
Nephrocytium spp.
Pediastrum Boryanum
P. integrum
Peridinium gatunense
P. polonicum
P. Willei
P. Willei fa. lineatum
Pleurotaenium Trabecula
P. Trabecula var. maximum
Spirulina Jenneri
Staurastrum brevispinum

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*No attempt has been made to describe the community of the intermediate portion of the lake. It consists primarily of a mixture of the species which are found in both the main and outlet portions of the lake.

Table XVIII.--continued

Main Portion Community, continued

St. furcigerum
St. quebecense
St. setigerum var. occidentale
Stephanodiscus niagarae
Synedra spp.
Synura uvella
Uroglena americana
Xanthidium antilopaeum

Outlet Portion Community

Chroococcus turgidus var. maximus
Chrysosphaerella longispina
Closterium Dianae
Cl. Ehrenbergii
Coelosphaerium pallidum
Cosmarium Turpinii
Dinobryon divergens
Fragilaria crotonensis
Gomphosphaeria aponina
G. aponina var. cordiformis
G. lacustris var. compacta
Mougeotia laetevirens
Oscillatoria Bornetii
Pediastrum Boryanum
P. integrum
Peridinium Willei
P. Willei fa. lineatum
Pleurotaenium Trabecula
P. Trabecula var. maximum
Synura sphagnicola
S. uvella
Synuropsis danubiensis, fa.
Tolypothrix distorta

Marginal Pool Community

Closterium Leibleinii
Diatoms
Mougeotia spp.
Spirogyra spp.

Table XVIII.--continued

Lake Bottom Community

Chara contraria
Cladophora fracta var. normalis
Diatoms
Mougeotia spp.
Schizothrix lacustris

Table XIX.--Organisms apparently restricted to the center lake in Purdy Bog*

Chlorophyta

Arthrodesmus octocornis
Chlamydomonas Cienkowskii
Closterium abruptum
Cl. cornu
Cl. Dianae var. pseudodianae
Cl. didymotocum
Cl. didymotocum var. glabrum
Cl. Lunula var. intermedium
Cl. Ulna, fa.
Cosmarium Regnellii var. minimum
Nitella gracilis
N. oligospira
Pediastrum araneosum
P. araneosum var. rugulosum
Staurastrum anatinum
St. urinator

Chrysophyta

None

Pyrrhophyta

None

Euglenophyta

Petalomonas praegnans

Cyanophyta

Aphanothece microscopica
Oscillatoria curviceps
O. limosa
Spirulina laxa

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*Does not include those species which were observed in only one collection, or which otherwise are considered to be rare.

Table XX.--Organisms apparently restricted to the mat habitats in Purdy Bog*

Chlorophyta

Chaetophora elegans
Chlamydomonas elliptica
C. subcompleta
Closterium acutum var. tenuis
Cl. costatum var. angustum
Coleochaete soluta
Cosmarium cucurbita var. attenuatum
C. exiguum var. pressum
C. subarctoum
Cylindrocystis Brebissonii
C. Brebissonii var. turgida
C. Brebissonii var. minor
Dimorphococcus lunatus
Euastrum insulare var. silesiacum
E. pinnatum
E. validum var. glabrum
Gloeomonas ovalis
Hyaliella polytomoides
Hyalotheca undulata
Micrasterias truncata var. crenata
Microspora pachyderma
M. stagnorum
Microthamnium Kuetzingianum
M. strictissimum var. macrocystis
Netrium digitus var. Naegelii
Pleurotaenium minutum
P. Trabecula var. rectum
Selenastrum Bibraianum
Staurastrum alternans
St. gladiosum
St. margaritaceum
St. monticulosum var. Irenee-Mariei
Staurodesmus controversus
Std. dejectus
Tetmemorus Brebissonii
T. granulatus
T. laevis
T. laevis var. minutus

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*Does not include those species which were observed in only one collection, or which otherwise are considered to be rare.

Table XX--continued

Chrysophyta

Chromulina gigantea
Ch. suprema

Pyrrhophyta

Chilomonas sp.
Gonyostomum semen
Peridinium inconspicuum
P. palustre

Euglenophyta

Astasia spp.
A. praecompleta
Cyclidiopsis acus
Distigma spp.
D. curvatum
Entosiphon sulcatum
Euglena deses
E. fusca
E. proxima
Heteronema acus
Phacus lismorensis
Ph. suecicus
Ph. triqueter
Trachelomonas Kelloggii

Cyanophyta

Anabaena augstumalis var. marchica
Chroococcus dispersus
C. minutus
Cylindrospermum minutissimum
Hapalosiphon confervaceous

Table XXI.--Species which occur both in the acid bog and hard-water lake

Chlorophyta

Aphanochaete polychaete
Botryococcus Braunii
Closterium parvulum
*Coelastrum sphaericum
Cosmarium pseudoconnatum
C. subcrenatum, fa.
C. subcucumis
Hyalotheca dissiliens
*H. mucosa
Micrasterias denticulata
*Netrium digitus
*N. digitus var. lamellosum
*Pleurotaenium Ehrenbergii
*Scenedesmus bijuga
Sphaerocystis Schroeteri

Chrysophyta

*Dinobryon cylindricum
*D. sertularia
*Synura sphagnicola
S. uvella
*Synuropsis danubiensis, fa.
Tabellaria fenestrata
Uroglena botrys

Pyrrhophyta

*Cryptomonas erosa
*C. ovata
Peridinium Willei
P. Willei fa. lineatum
*Vacuolaria virescens

Euglenophyta

Trachelomonas volvocina

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*Indicates species whose distribution requires more critical analysis--see text, "Comparison of Study Areas."

Table XXI.--continued

Cyanophyta

*Aphanothece microscopica
Chroococcus Prescottii
*C. turgidus
*Merismopedia elegans
*M. glauca
*M. punctata
*M. Trolleri
*Oscillatoria amphibia
O. limosa
O. princeps
O. tenuis var. natans

Table XXII.--Chemical analyses of water samples collected in July, August and September from the center lake (P1) and sphagnum pool (P3) of Purdy Bog and the main portion of Lawrence Lake (L1)

	July 17, 1960			August 14, 1960			September 11, 1960		
	P1	P3	L1	P1	P3	L1	P1	P3	L1
Total Organic Matter (mg./l.)	50.7	135.2	39.4	34.2	125.4	34.2	44.9	134.7	44.9
Dissolved Organic Matter (mg./l.)	34.9	78.8	28.2	22.8	94.1	17.1	33.6	101.0	22.4
Sulfate (ppm)	6.0	11.0	25.1	5.0	11.0	24.0	7.0	12.5	22.5
Iron (ppm)	0.12	0.45	0.08	0.09	0.60	0.04	0.08	0.82	0.05
Phosphate (ppm)	2.0	3.0	1.7	0.25	0.59	0.43	0.05	0.22	0.13
Nitrate (ppm)	0.70	0.20	1.75	0.03	0.27	1.95	0.03	0.29	1.20
Calcium (ppm $CaCO_3$)	8.5	6.5	139.0	5.4	7.0	130.0	1.5	3.3	63.3
Total Hardness (ppm $CaCO_3$)	17.5	32.5	217.0	14.0	27.2	205.0	10.0	19.2	110.0
Magnesium (ppm $CaCO_3$)	9.0	26.0	78.0	8.6	20.2	75.0	8.5	15.9	46.7

CHAPTER V

DISCUSSION

In the following discussion of the respective algal floras of Purdy Bog and Lawrence Lake, it should be noted that major emphasis in the study has been directed toward gaining data of comparative value. Also, major stress was placed on an analysis of floral characteristics, rather than the characteristics of the abiotic environment. To have analyzed thoroughly the floral composition or physical-chemical features of either area would have been a problem in itself.

The Algal Flora of Purdy Bog

The following general features have been described for the algal flora of Purdy Bog: (1) the bog contains a large number of species, of which the majority are Chlorophyta, with desmids predominating; (2) in respect to floral composition, the Euglenophyta and Chrysophyta are second in abundance to the Chlorophyta, followed by smaller numbers of Cyanophyta and Pyrrhophyta; (3) the individual taxa of these phyla are not distributed in a general manner within the bog, but show some habitat selectivity; (4) each investigated habitat is occupied by a community which is more or less typical of that particular habitat; (5) although the floral composition changes seasonally, little change is evident in the total number of species found during different seasons of the year.

Although many of the observations presented above are similar to

those reported for other bogs, a direct comparison with previous studies of all aspects which were investigated is complicated by the fact that so few comprehensive seasonal analyses have been made of individual study areas; and also by the fact that so many different kinds of bogs are known. It is difficult to compare adequately the algal flora of a quaking bog with that of a raised bog, for example, because of inherent physical and chemical differences in the two kinds of environments. It can be stated in general, however, that the present results agree well with available data in demonstrating the occurrence of a large number of species, the dominance of Chlorophyta, and a preponderance of desmids (Wasylik, 1961a; Steinecke, 1917; de Graaf, 1957; Prescott, 1939, 1951a; Welch, 1952; Ruttner, 1953).

Prescott (loc. cit.) has emphasized the fact that soft-water, acid bogs typically contain a large number of algal species, especially desmids. In the present study, a total of 385 species, including 151 desmids, were found in Purdy Bog (Tables XII, XIII; Figure 22). The richness of this flora is evident from a comparison of these results with those from similar studies. Thus, Wasylik (1961a) reported a total of 247 species, including 191 desmids, in an investigation which included results from 11 different habitats in each of nine peat bogs. De Graaf (1957) has listed from 60 to 249 species which are typical of various zones in a quaking bog in the Netherlands. Steinecke (1917) found 320 species in an extensive "swampy" area of the "Hochmoor" formation in Prussia. Messikommer (1943a) noted 309 species, of which the majority were desmids, in a boggy area of Switzerland, and the writer (1958) determined 124 species, including 31 desmids, in a quaking bog in Pennsylvania. In respect to other bog floras, A. M. Smith (1942) found

only 59 species, including 13 desmids, in various habitats of a raised bog in England, and the writer (1958) found only 26 species, of which only three were desmids, in a "glade" bog in Pennsylvania. Thus, in comparison with other bogs, the algal flora of Purdy is relatively rich in species.

Many studies of acid bog lakes have concentrated on an analysis of their plankton flora. Welch (1936a; 1936b; 1938a; 1938b), for example, has made a series of studies on the phytoplankton of certain Michigan bog lakes. As a result of such studies, he has shown the following general features: (1) the lakes contain a relatively large number of planktonic species, varying from about 55 to 78 in different lakes; (2) the Chlorophyta are represented by the largest number of species, with the Cyanophyta second in number; (3) a large proportion of these species are desmids.

The center lake at Purdy Bog contained a total of 180 species, of which 78 were desmids (Table IV, XII). A majority of the species in this lake are Chlorophyta, with Chrysophyta second, and Cyanophyta third, in abundance.

Although these results agree in general with those of Welch, several differences are evident, and should be discussed further. First, in comparison with Welch's results, Purdy Bog lake has a larger number of species than has been reported previously from an extended study (180 as compared with 78); second, although the Chlorophyta are dominant in all of these lakes, more Chrysophyta and Pyrrhophyta species are present in Purdy than in any lake studied by Welch; finally, the number of desmids in the bog lake at Purdy (78) is the same as the largest number of species reported by Welch for all phyla.

The noted differences might be related to the fact that Welch's studies are based largely on an analysis of summer plankton alone, whereas the present results are based on an analysis of samples collected during all seasons of the year. The difference noted in respect to relative abundance of Chrysophyta and Pyrrhophyta may be explained, at least partially, on this basis. Also, many algae, especially desmids, were determined only to genus in Welch's studies, and it is possible that a much larger number of species is present than the published results indicate. Nevertheless, the above results do show the relative richness of the Purdy lake flora as compared with that of other Michigan bog lakes for which extensive published data are available. Other comparisons of this kind could be made also, but it is evident that the results presented for Purdy lake agree in general with those published for other, similar, bog lakes, in demonstrating the dominance of Chlorophyta, especially desmids, in the plankton. The results are certainly different from those reported by the writer (1958) for a bog lake in Pennsylvania, however, where the plankton community was dominated by Chrysophyta and Pyrrhophyta species. In all, only 37 species were ever collected in this lake. Of these, only four were desmids.

Although other comparisons of a general nature could be made in respect to the algal flora of this bog, one of the most intriguing aspects of the present study is an analysis of floral distribution within the study area itself, a subject which has received some previous attention (Messikommer, 1943a; de Graff, 1957; Steinecke, 1917; A. M. Smith, 1942; Magdeburg, 1926; Wasylik, 1957, 1961a; Irénée-Marie, 1939; Graffius, 1958). As was noted earlier, each bog habitat supported a flora which was more or less characteristic of that particular habitat.

In respect to species number alone, the following differences have been shown:

Center Lake	180
Sphagnum Mat. . . .	73
Sphagnum Pool . . .	83
Marginal Pools. . .	300
Lake Bottom	195

Not only was the number of species different, however, but in most instances the floral composition and community structure was different also (Table XVII; Figures 22, 23). That the two center lake habitats supported a flora different from that of the three habitats located in the sphagnum mat, for example, is evident from a comparison of Tables XIX and XX. In addition, it is important to note that the large number of species found in the marginal pools does not represent merely a combination of species from other bog habitats, but includes many species which were not found in any other habitat. Each of these habitats thus supported a flora which is more or less distinct from that of each of the others.

It is therefore appropriate to examine the floras of individual habitats in more detail. Major emphasis will be directed toward an analysis of the sphagnum pool, center lake and marginal pools in respect to the floral composition and number of species in each. These data are summarized graphically in Figures 22 and 23.

Differences have been noted in the floral composition of the sphagnum mat and sphagnum pool in respect to the numbers of Pyrrhophyta and Cyanophyta species which are present (Tables V, VI), and to the distribution of certain species (Table I). The sphagnum mat supported a much larger number of Cyanophyta species than did the sphagnum pool, and the reverse is true in respect to the Pyrrhophyta. The flora of

the sphagnum mat also contained fewer individuals of most species than did the sphagnum pool, and thus, in comparison, its flora was extremely sparse. In respect to non-algal components, the sphagnum mat also supported a much larger variety and quantity of testaceous rhizopods than did the spahgnum pool.

Nevertheless, the floras of these two habitats are similar enough both numerically and floristically (Table XVII) that it is convenient to discuss them together. In comparison with the other bog habitats, they respectively supported a much smaller number of species (73 and 83), numbers which represent less than one-fifth of the total number of species found in the bog. Also, both contained a very small number of desmid species (20 and 22) in an environmental area where much larger numbers were observed, and could be expected. In addition, both contained a relatively large number of individuals of Euglenophyta and Cyanophyta.

These observations tend to confirm the statement that similar kinds of habitats are colonized by similar algal floras, (Magdeburg, 1926; Gistl, 1931; Wehrle, 1937; Niessen, 1956; Messikommer, 1954a) even in widely-separated areas. The similarity of the two sphagnum habitats, in terms of physical features at least, has been mentioned previously. Also, the algal flora of these habitats is similar in composition to those which have been reported for comparable habitats in other regions of the world. Several species are characteristic of almost all such habitats which have been investigated. Among these are *Chroococcus turgidus*, *C. minutus*, *Anabaena augstumalis* var. *marchica*, *Cylindrospermum* spp., *Euglena mutabilis*, *E. deses*, *Cylindrocystis Brebissonii*, *Zygogonium ericetorum*, *Netrium digitus*, *N. oblongum*, *Penium cylindrus*, *P. polymorphum*, *Cosmarium cucurbita*, *Staurastrum margaritaceum*, *Micrasterias truncata*

and various species of Tetmemorus.

Another of the outstanding characteristics of the mat and pool habitats is the relatively low number of species which they support, a phenomenon which has been reported by many investigators (Welch, 1945; Wade, 1952; de Graaf, 1957; Graffius, 1958, among others). Yet, an adequate explanation for this is lacking, even though several lines of investigation have been pursued.

The question which arises here is, are such habitats really characterized by the kinds of species which they support, and if so, to what can such a floral composition be attributed? To attempt to understand or to categorize such habitats, however, one would have to rely on comparative data from other habitats in the present study area, as well as on data from other studies.

An analysis of Table I discloses that relatively few of the 180 to 300 species which were found in the center lake and marginal pools occurred also in the sphagnum habitats. Yet, almost all of the species which occurred in the sphagnum habitats occurred in other habitats of the bog as well. Eliminating as extremely rare those species which were observed only once, just seven species were restricted to the sphagnum mat or sphagnum pool. Among these are Peridinium palustre, Astasia praecompleta, Heteronema acus, Chromulina suprema, Hyaliella polytomoides, Staurastrum monticulosum var. Irenee-Mariei and Staurodesmus controversus.

Thus, the uniqueness of the sphagnum flora is related not so much to the presence of a rather small number of characteristic species, but, rather, to the absence of a large number of species which can exist in other habitats of the bog. This suggests, therefore, that the sphagnum habitats may represent a limiting or unfavorable environment for the

majority of bog species. The greatest difficulty of such an assumption arises when one attempts to explain or to analyze such a distribution on the basis of the physical and chemical features of the habitat.

Although a multitude of aspects would have to be considered in such an analysis, one of the environmental factors which has been most investigated is the relationship between the pH or hydrogen ion concentration of the medium and the distribution of algal species or algal floras. Because this subject will be re-examined throughout this paper, it is appropriate to discuss it in some detail here.

Granting the argument that pH itself may not be a causal factor in distribution, but may serve merely as an index of ecological conditions which are favorable or unfavorable for the growth of algae, it nevertheless has been made the subject of so many studies of algal distribution that it cannot be disregarded in any study such as the present one. In addition, pH has been shown to influence or to alter certain physiological or metabolic processes of algae, and thus may serve as more than an index in certain cases. Among other effects, it may alter the permeability of the cell membrane (Ruttner, 1953; Stadelmann, 1962; Mevius, 1924), alter the rate of phosphate uptake (Kuhl, 1962), influence the solubility and availability of trace metals (Provasoli and Pintner, 1960), and influence both respiration (Gibbs, 1962) and photosynthesis (Holm-Hansen, 1962).

Among others, Budde (1944), Wehrle (1927), Irénée-Marie (1939), de Graaf (1957), Wasylik (1961a; 1961b), Whitford (1960), Gistl (1931), Messikommer (1946), Thunmark (1942), Niessen (1956), van Oye (1941), Grönblad, Prowse and Scott (1958), Behre (1956), Prescott and Scott (1943) and Ruttner (1953) have investigated and commented on the importance or the role of pH as a factor in algal distribution.

As a result of studies such as the above, lists have been prepared which indicate the known range of pH over which individual species have been found to occur. From such lists, algal species have been classified according to their tolerance limits or "preference" for a particular range of pH. Thus, terms such as "acidophilous" or "alkaliphilous" have been used to describe the response of individual species to hydrogen ion concentration. Much of this has been summarized by de Graaf (1957). Others have indicated that certain species are so characteristic of a definite pH range that their occurrence can be used to predict the pH of the habitat from which they were collected (Thunmark, 1942; Prescott, 1951a; Prescott and Scott, 1943).

Many of the above studies have demonstrated that, as the pH of the medium decreases, especially below 5.0, the number of algal species which it supports decreases also. Thus Budde (1944) found 108 desmid species within a pH range of 6.0 to 7.0 and 100 species at 5.0 to 6.0, but only 62 species at a pH range of 4.0 to 5.0. Of those species which occurred below 5.0, only 18 showed an optimum development. De Graaf (1957) found only 60 algal species in one zone of a bog at pH 3.3 to 5.2, as compared with 138 species at pH 4.9 to 6.0, and 249 species at pH 6.0 to 7.2. Ruttner (1953) also cites evidence to indicate that the number of species in a bog biotope decreases as the pH decreases. Thus, in one study area with a pH of 4.5 to 5.5, 180 desmid species were determined, as compared with only 40 in an adjacent area which had a pH of 4.0 or less. The writer (1958) noted similar results in an earlier study of two bogs, in which only 26 species were determined in one area having a pH range from 3.8 to 4.8, whereas over 124 species were found in another bog where the pH ranged from 6.0 to 6.4.

The pH of the two sphagnum habitats in the present study varied between 4.0 and 5.5, within a range which has been shown to be limiting in respect to the number of algal species which occur. Figures 22 and 23 depict graphically the pH and species number which occurred in the sphagnum pool as compared with similar data for the center lake and marginal pools habitats. It is evident from an analysis of these graphs that the lowest number of species occurred in the lowest range of pH. Thus, the sphagnum habitats may represent an environment which is unfavorable for the growth of a large number of algal species which were found in other bog habitats, because of the low pH or strongly acid nature of the medium. The bog species found in the center lake and marginal pools thus may not be able to tolerate such an acid environment, and therefore may be unable to invade the sphagnum habitats.

As for the few species which do occur, these may exist in the habitat due to a greater tolerance to the strongly acid conditions, and many of these may actually require such conditions for optimum development. Budde (1944) and others have demonstrated that certain species show an optimum development only within a certain pH range; and, as noted earlier, many of the species which occur in the sphagnum habitats do occur in relatively large numbers of individuals. Teiling (personal communication), for example, has commented on the richness of Staurodesmus controversus and Cosmarium (Actinotaenium) cucurbita in the sphagnum pool. Yet these two species were never abundant in any other bog habitat; and, the same is true for many of the other species which occurred in the sphagnum habitats.

Whether this is due to the presence of optimum conditions in these habitats, or to a lack of competition from other bog species is

not apparent, however. For, even though many of the individual species are abundant, this does not mean necessarily that they are growing under optimum conditions (Gessner, 1929; Wehrle, 1927). Such phenomena may be noted also in the colonization of new habitats (Smith, 1950), or under environmental conditions which are too extreme for all but the most tolerant of species. Thus, such species may develop and thrive in the sphagnum habitats not only because of a favorable response to the environment, but also because of a lack of competition from other, less tolerant species. The fact that most of the sphagnum species could exist in other habitats at pH values up to 6.5 also indicates that their distribution is not explained entirely on the basis of a favorable response to the low pH. That pH alone does not explain adequately the distribution of many algal species or floras will be noted later (Distribution of Selected Species).

In respect to the other bog habitats, the floras of the center lake, lake bottom and marginal pools contained many more species than did the sphagnum habitats. The pH of these habitats varied from 5.0 to 6.5, within a range shown to be favorable for the growth of a majority of algal species, especially desmids (Budde, 1944; Messikommer, 1946; Gistl, 1931). Nevertheless, just because a larger number of species occurs under weakly acid conditions, this does not mean that they are making a positive response to pH. It may merely indicate that, under these conditions, the pH is not too extreme for development to occur. Before discussing this aspect of the problem further, however, it is appropriate to consider the center lake flora in more detail.

As is evident from a comparison of Tables IV and VIII, the floras of the center lake and lake bottom habitats are similar. Not only is

the total number of species approximately the same in each, but the number of species in each algal division represented is similar also, with the exception of the Euglenophyta and Cyanophyta. The lake bottom habitat supported a larger number of Euglenophyta, whereas the center lake contained a greater number of Cyanophyta. Nevertheless, as shown in Tables I and XVII, the species composition of the two lake habitats is very similar. That this should be true is probably related to the shallow nature of the lake water, and to the sinking tendency of planktonic species. Because rooted aquatics extend almost across the whole width of the lake, both of these habitats are located within what would have to be termed the littoral zone. Given a deeper lake with a clearer demarcation of pelagic and profundal zones, greater floral differences would probably be evident in a comparison of these two habitats.

Because the flora of these two habitats is so similar, however, it is expedient to place major emphasis on a discussion of the center lake flora alone, because much more comparative data is available for plankton floras than is available for the bottom flora of bogs. Many of the salient features of this flora have been described in the early paragraphs of this section, and these need not be repeated here.

In comparison with the sphagnum habitats, a much larger number of species occurred in the center lake (Tables IV, V, VI, XI; Figure 23). The greatest difference which is evident in a comparison of the floras of these two habitats is the much larger number of Chlorophyta, especially desmids, which occurred in the center lake. Although conditions here thus are favorable for the development of a large number of species, and, although the water is weakly acid, this does not necessarily explain the presence of a large number of Chlorophyta or desmids, nor does a weakly

acid environment necessarily explain the richer number of algal species in bog lakes in general. Ruttner (1953), for example, has shown that similar conditions of acidity occur in other habitats, such as rain pools, but that one does not find floras in them which resemble those of bogs. Nor are large numbers of desmid species present in such habitats.

It would appear to be logical to assume that, if a weakly acid environment were the major factor to which Chlorophyta, especially desmids, respond favorably, such species would be expected to occur almost wherever these conditions obtained, and especially if such conditions were found in a bog lake. Yet, the writer (1958) found only eight Chlorophyta, of which only four were desmids, in a bog lake in Pennsylvania, where the pH varied from 6.0 to 6.4, well within the range noted in the center lake at Purdy Bog. Also, pH can fluctuate so widely during the day or during such short periods of time that individual species actually may be responding to a wider range of pH than would be evident from results of a few isolated samplings. Welch (1938a), for example, noted that the pH in another Michigan bog lake varied from 5.8 to 7.5 within a period of only a few weeks, and showed a total fluctuation of from 4.2 to 7.8. As noted by Ruttner (1953) and Behre and Wehrle (1944) also, one cannot refer to the influence of pH without reference to the total concentration of salts which are present in the water. Thus, the pH of an aquatic medium alone probably does not explain the distribution of individual species or floras, except perhaps near the extremes.

The above discussion has dealt primarily with the relationship between pH and species number in the various habitats of the bog. Yet, it is true that the factors which are influential in algal distribution probably do not have significance at the family or even genus level

(Prescott and Scott, 1943), even though certain investigators have used genera as indices of response to environmental conditions (Messikommer, 1935a-1960). Any study of algal distribution thus must be based on an analysis of species response. Although it is not expedient to examine each of the species in the present study individually, some further analysis of the kinds of species which occurred in the various habitats of the bog is necessary before making any further evaluation of other possible environmental influences.

One of the greatest differences between the floras of the center lake and the sphagnum pool is that the former contained a much larger number of Chlorophyta species (122), of which 78 were desmids. The sphagnum pool supported only 39 Chlorophyta, of which only 22 were desmids. Yet, the sphagnum pool supported a much larger number of Euglenophyta (16 as compared with 7; Figure 23) than did the center lake. Thus, even though conditions in the center lake were suitable for the growth of a large number of algae, they evidently were not suitable for the growth of all kinds of algae, and especially not for the Euglenophyta. Some further analysis of comparative chemical data for the sphagnum pool and center lake habitats may be pertinent in this instance.

In respect to the water analyses shown in Table XXII, it is evident that the sphagnum pool contained higher amounts of total and dissolved organic matter, sulfate, iron and magnesium, as well as total hardness, than did the center lake. The fact that both habitats contained about the same concentrations of calcium (expressed as ppm $CaCO_3$) is particularly interesting in relation to the observed difference in the number of desmid species which occurred in the two habitats.

It is well known (Prescott, 1948) that the largest numbers of

desmid species are found in habitats where the concentration of calcium is low. Hirano (1960), for example, states that, where the waters of Japan are rich in desmids, they are poor in calcium, regardless of what other nutrients might be present. On this basis, one would expect to find a greater number of desmid species in the sphagnum pool, because the calcium concentration is so low (Table XXII). In fact, the concentration of calcium in the sphagnum pool is even lower than that in the center lake itself.

From such observations, it is difficult to assess the role of calcium in the distribution of desmid species. Nor is the present observation an isolated example. Hirano (loc. cit.) has also stated that, although one does find large numbers of desmid species where the calcium concentration is low, one can find many habitats which are poor in calcium, but which support a poor desmid flora.

Perhaps the concentration of calcium itself is not as important an index to the distribution of desmid species as is the ratio of calcium to other ions which are present in the water. It has been shown (Pearsall, 1921; Prescott, 1939, 1948) that waters which have a low ratio of monovalent to divalent cations (Na-K/Ca-Mg.) usually contain a small number of desmid species, and that the reverse is true where such a ratio is higher. Unfortunately, in the present instance, no data are available for either sodium or potassium concentration in either the sphagnum pool or center lake habitats, and thus little can be said in respect to the relationship between the Na-K/Ca-Mg ratio and the number of desmids in these habitats. The amount of magnesium in the sphagnum pool was higher than that in the center lake, however, and it may be that the ratio of monovalent to divalent ions would be lower in this habitat because of

the higher total concentration of calcium and magnesium. But, this cannot be demonstrated positively on the basis of the results of the present study.

The water chemistry of these two habitats does show other differences which should be examined further, however, especially in respect to differences in the concentration of certain materials. As noted above, several substances were present in greater concentrations in the sphagnum pool than in the center lake. Of these, the one which may be of greatest importance in the present analysis is dissolved organic matter. A comparison of data for concentrations of the other materials listed above, with results published from analyses of similar habitats, yields such conflicting information that little can be said in respect to their role in the present situation. Also, a more extended series of analyses would be needed for these to be of any great value in the present discussion.

Our knowledge of the role of dissolved organic matter in the natural environment is far from complete, but as information accumulates from various studies, it is becoming increasingly evident that such materials may be among the most important in determining the nature of algal floras. Earlier work on organic matter in natural waters has been carried out by Birge and Juday (1934) on Wisconsin lakes, and excellent reviews of the possible role of such materials in the natural environment have been given by Saunders (1957), Droop (1962), and Provasoli (1958). Also, in respect to bog floras in particular, numerous investigators have commented on the probable importance of humic colloids or humic acids in determining the composition of such floras (see Ruttner, 1953).

It is known that the relative abundance or concentration of

dissolved organic matter may have an influence on the number or kinds of algal species which can inhabit a particular location (Saunders, 1957; Hirano, 1960). Saunders (loc. cit.) thus states that organic materials must be present in an environment in amounts which allow living organisms to grow and to reproduce; if such materials are at either extreme, the organisms will be affected adversely. This may be true particularly of desmid species.

Hirano (loc. cit.), for example, has noted the influence of the concentration of dissolved organic matter on the distribution of desmids in Japan. His data indicate that organic matter (expressed as mg./l. of $KMnO_4$) in bogs usually varies between 15 and 50 mg./l., but may run as high as 80 mg./l. This value in swamps varies only between 14 and 35 mg./l., and swamp waters were consistently richer in desmid species than were bogs. In those Japanese swamps where over 100 desmid species were found, the waters were low in dissolved organic matter, usually averaging around 15 mg./l. Bog waters which contained over 60 mg./l. supported a much lower number of species, averaging about 30. Thus, waters which were high in dissolved organic matter were poorer in desmid species than were those in which a lower concentration was noted.

In the present study, the concentration of dissolved organic matter in the sphagnum pool varied between 78.8 and 101 mg./l.; only 22 desmids were found under these conditions. The concentration of such materials in the center lake varied only between 22.8 and 34.9 mg./l.; 78 desmid species occurred under these conditions.

One cannot overlook the possibility that, in this particular instance, the presence of toxic or inhibitory amounts of dissolved organic matter, as well as the low pH, may prohibit many desmids from invading

the sphagnum habitat, even though other conditions, such as the concentration of calcium, may be favorable for their growth. Such observations may thus help to explain the variations which have been noted in the number of desmid species which occur in a habitat and the amount of calcium which is present. Therefore, one would have to consider local variations and more complete chemical analyses of the medium before assessing the importance of calcium alone, or of any other one factor, in the distribution of desmid species.

Thus, differences in the concentration of dissolved organic materials in the sphagnum pool as compared with the center lake may help to explain at least a part of the floral differences which were noted in a comparison of these two habitats. The full extent to which such materials may be influential cannot be demonstrated positively on the basis of the available chemical data, however. Nor can it be done on the basis of known analytical procedures. For, it would be necessary in most instances to know the kinds as well as the relative amounts of such materials which are present in these two habitats.

It is known from culture studies, for example, that many algae require certain particular organic compounds; if these are lacking in the medium, such organisms apparently cannot exist (Droop, 1962; Storm and Hutner, 1953; Provasoli, 1958). Dissolved organic materials also may have such a wide variety of functions in the natural environment, or may be present in such small concentrations, that one cannot hope to be able to analyze their influence on the basis of ordinary water analyses. Certain of these materials may be used directly in the nutrition of algal species, whereas others may supply accessory growth factors, may form organic complexes with trace metals, may exist in the form of

toxic compounds, or may be present in the form of growth-stimulating or growth-inhibiting compounds (Saunders, loc. cit.; Droop, loc. cit.). Many of these substances are present in the natural environment, and are effective, in such extremely small concentrations that they escape ordinary analyses. One group which is especially effective in micro-quantities are the vitamins (Provasoli, loc. cit.; Droop, loc. cit.). In addition, certain algae cannot be grown in the absence of certain, as yet unidentified, organic materials which are extractable from soil. Such materials thus may be among the most influential in determining the occurrence of algal species in the natural environment, and yet this cannot be demonstrated positively. For, if we do not know the identity of such compounds, it is impossible to detect them chemically in nature.

Lacking definitive analyses, then, one can only speculate as to the role of dissolved organic materials in the present circumstance.

It is possible, for example, that, even though large amounts of organic matter are present in the sphagnum pool, the right kinds are not present, or are not present in high enough concentrations, to allow for the growth of certain species. Shapiro (1957) has shown that certain yellow organic acids have a differential effect on the growth of individual species, and that the observed results depend upon the concentration of the particular compounds in question. Also, certain organic compounds influence the availability of trace metals by helping to solubilize them (Provasoli and Pintner, 1960). Others may influence the occurrence of algal species by forming organic complexes with trace metals, the effects of which may be either beneficial or harmful (Saunders, loc. cit.).

In addition, one would have to investigate the role of other

organic micro-nutrients such as growth-promoting or growth-inhibiting compounds, many of which may be produced by other micro-organisms, before being able to assess the complete role of dissolved organic matter in the sphagnum pool or center lake habitats. The role of vitamins will be discussed in a later paragraph.

Yet, one would have to investigate not only the possible role of organic compounds in the natural environment, but the influence of trace metals as well. Their influence in algal metabolism is manifold. In addition to the fact that most species cannot grow in their absence, trace metals are important because they may be toxic at certain concentrations (Provasoli, 1958), or may interact with one another, producing deleterious effects (Eyster, 1958a). Also, the availability of trace metals varies both with temperature and pH, so that these aspects would have to be investigated as well (Provasoli and Pintner, loc. cit.). Yet, the writer knows of no study in which such aspects have been studied in relation to the distribution of algal species in adjacent habitats.

One would thus have to have available a more extensive series of chemical analyses before being able to discuss adequately the noted floral distributions in these two habitats alone. The obvious difficulty with such an approach is that, in many cases, the chemical identity of compounds which may be influential in such distributions is unknown. In addition, many nutritional studies of algae have demonstrated the need for, or the effect of, unsuspected metabolites which cannot be detected chemically in nature (Provasoli, 1958).

It appears to be evident, then, that ordinary chemical analyses are insufficient to adequately characterize these environments. Another possible approach, suggested by Saunders (loc. cit.) and Provasoli (loc.

cit.) would be to combine observations in the natural environment with those known from physiological or nutritional studies of algae. Provasoli (*loc*. *cit*.) has stated, for example, that if an organism requires some growth factor *in vitro*, this factor should, and does, occur in the natural environment of the organism. Therefore, one should be able to extrapolate results from carefully refined nutritional studies to the present situation.

It is important to recall here that not all kinds of species occurred in low numbers in the sphagnum pool. Rather, a much larger number of Euglenophyta occurred here than occurred in the center lake (16 species as compared with 7). In addition, it is important to note that these differences may be even greater than available data would indicate, because the lake bottom consistently supported a higher number of Euglenophyta, many of which could have been included in the plankton samples inadvertently, due to the shallow nature of the lake and to the stirring action of the plankton net. Only two euglenoids were ever noted which occurred in the water of the center lake, but not on the lake bottom; each of these was observed only once. An analysis of the nutritional requirements of euglenoids therefore may be appropriate to the present discussion.

It is well known that most numbers of the Euglenophyta require certain organic compounds for growth to occur, and this is especially true of the colorless forms (Provasoli, *loc*. *cit*.; Provasoli and Pintner, *loc*. *cit*.). In addition, several species have been shown to require certain specific vitamins (Fogg, 1953; Provasoli, *loc*. *cit*.); in fact, all euglenoid species thus far studied show a vitamin requirement. Many euglenoids also prefer waters rich in available ferrous compounds and

ammonium salts (Pringsheim, 1956), and cannot utilize nitrate as a source of nitrogen (Provasoli, loc. cit.). The presence of decaying plant material also increases the number and variety of forms which occur in a given habitat. If all of these factors have been demonstrated to be necessary nutritional requirements for euglenoids, then most should be present in the sphagnum pool in amounts sufficient to allow growth and reproduction to occur. Apparently, many of these must be lacking in the waters of the center lake, or a larger variety of Euglenophyta would be expected.

Thus, even though the center lake habitat is favorable for the growth of a large number of species, it is relatively unfavorable for the growth of certain other algal species, especially euglenoids. Conversely, although the sphagnum pool is unfavorable for the growth of a large number of algal species, it is relatively favorable for the growth of euglenoids in particular.

Based on the above observations, it would be possible to make several hypotheses concerning the nature of the center lake and sphagnum pool environments. Almost any of these, however, would have to be modified or re-evaluated on the basis of an analysis of the flora of the marginal pools, and any summary statement will be withheld pending such analysis.

The marginal pools habitat represents the most interesting and distinct habitat of all those investigated in the present study, and supported the largest number of species noted in any bog habitat. In fact, it supported 300 of the 385 species found in the bog, a number which represents almost four-fifths of the total flora (Tables VII, XI; Figure 22).

One interesting aspect of this observation is that, although major emphasis in most studies is placed on an analysis of bog center lakes, these may not support the majority of bog species, and thus may not characterize the environment. That such marginal pools typically may support much larger numbers of species than the center lake is evident also from the writer's earlier study (1958) in which only 37 species were found in a bog center lake, as compared with over 98 in a series of shallow marginal pools a few feet away.

It is evident from Table I that many of the species found in the marginal pools occurred also in the center lake and lake bottom. This indicates that these habitats must have something in common which allows them to be populated by the same species. Conversely, the larger number of species found in the marginal pools does not represent merely a recombination of organisms from the other bog habitats, because over 100 species were found only in the marginal pools. Therefore, the marginal pools must contain some additional combination of environmental factors which is not present in the other bog habitats. The obvious question is, what are these factors? In seeking possible answers to this question, several considerations must be evaluated or explored.

First, the observed results probably are connected intimately with environmental differences which result from developmental changes in the bog itself. In a quaking bog, the mat is encroaching continuously over the water of the center lake, so that the eventual outcome is enclosure of the lake water. In this development, certain open areas may be left in the mat as it advances. The resultant pool of water would still be connected with, and would be under the influence of, the main body of water for a certain period of time. As the mat advances farther

over the lake, however, and becomes thicker in the shoreward portions due to accumulated vegetation, there must be a period of transition during which such pools are influenced to a greater and greater extent by the materials of the sphagnum mat as well as by the lake water. Finally, as the mat continues to advance over the water, these pools would be located progressively farther and farther from the lake edge, and would evolve gradually into habitats whose ecological features would be determined more by the character of the mat itself than by the lake water.

In respect to the transitional aspect of this habitat, de Graaf (1957) has investigated the various stages of a quaking bog in Holland as related to the development of the microflora and microfauna. His results indicate findings which are similar to those observed in the present study, in demonstrating a larger number of algal species in the mat near the lake edge, and a consistent decrease in species with increasing distance shoreward.

In the present study, 300 species, including 125 desmids, were found in the marginal pools, whereas only 83 species, including 22 desmids, were found in the sphagnum pool. This agrees well with de Graaf's (loc. cit.) results of 249 species, including 50 desmids, as compared with only 60 species, including 16 desmids, in corresponding regions of the bog.

De Graaf also noted the restriction of certain of these species to particular successional zones, much as in the present study. Similar results have been recorded by Wade (1952), Welch (1945), Gessner (1929), and the writer (1958), among others, but to date no satisfactory explanation is evident. Both Wade and de Graaf have made comparative

chemical analyses of such adjacent habitats, but the results do not demonstrate any major or consistent differences which might account for the noted floral differences.

The marginal pools in the present study thus may represent transitional stages which are intermediate between lake and sphagnum habitats. If this were true, they might be expected to contain representative species of both kinds of habitats, and apparently they do (Table I). This still would not explain adequately the much larger number of species which occurs in the marginal pools, however. For, if the marginal pools habitat was merely intermediate in its characteristics between those of the center lake and sphagnum pool, one would expect it to contain an intermediate number of species. Yet, it contains far more species than any other bog habitat, or of any combination of habitats. Similar results have been noted in other studies of bog floras, as noted previously.

Lacking extensive chemical data, it can only be assumed that the larger number of species found in the marginal pools is related to water chemistry. Non-dispersal can be eliminated particularly as a factor in this instance, because the waters of the marginal pools and center lake are interconnected by narrow channels of water. If favorable conditions for growth were present, either in the lake water or on the lake bottom, one would expect to find more of the pool species occurring in these habitats. In addition, both frogs and turtles were observed to move from marginal areas into the center lake. Based on the observations of Irénée-Marie (1939), there is no adequate reason to doubt that such organisms are efficient in dispersing algae from one habitat to another.

The most interesting feature of these marginal pools, in comparison

with the other bog habitats, is that they contained the largest numbers of algal species of all divisions, including 36 Euglenophyta out of the total of 41, and 125 desmids out of the total of 151, which were found in the bog. Thus, they must contain a large variety of organic compounds, including vitamins (because of the occurrence of euglenoids) and must contain at the same time concentrations of these which are not toxic or inhibitory to a large number of algal species.

It is difficult, on the basis of comparative chemical and floral data for the sphagnum pool and center lake, to conceive the particular combination of materials which must be present in these marginal pools, however. The sphagnum pool has a low pH, a high concentration of organic matter, a low number of desmids and a relatively high number of Euglenophyta. The center lake has a higher pH, a lower concentration of dissolved organic matter, a larger number of desmids and a lower number of Euglenophyta than does the sphagnum pool. Yet, the marginal pools have almost the same pH as the center lake (5.0-6.0 as compared with 5.2-6.5), the largest number of Euglenophyta and the largest number of desmids which was noted in the bog. One can only hypothesize that a large variety of organic compounds are present, that these do not reach toxic concentrations due to the diluent effect of a large water volume, and that inorganic materials such as ammonium salts, ferrous compounds, potassium, sodium, calcium and magnesium are present in quantities which are conducive to the growth of a large number of species. It may be, then, that the particular location of the marginal pools habitat aids in explaining its richer algal flora, for it lies at the border of two dissimilar habitats, and thus probably contains a particular combination of nutritive materials which is not available in either habitat alone.

Much useful information in respect algal distribution or to conditions which are particularly favorable for the growth of a large and diversified flora could be gained by a further study of these three habitats alone. Yet, the writer is not convinced that even extended and more complete analyses of the water would yield information of a definitive nature, due to the large number of species which are present, the variability of individual species, and to the kinetic nature of interactions which may occur either within the abiotic environment or the biotic environment, or between various components of the abiotic and biotic environments.

A more plausible approach may be that suggested by Saunders (1957) or Provasoli (1958), involving the cooperation of taxonomists and ecologists with physiologists, biochemists and ecologically-minded nutritionists in any attempt to explain algal occurrence or distribution in the natural environment. It is apparent from the above discussion that micro-quantities of several kinds of materials are influential in algal occurrence, and yet these cannot be determined by ordinary chemical analyses.

The need for more refined data is evident from a discussion of just one species noted in the bog. Peranema trichophorum was noted frequently in the sphagnum mat, sphagnum pool, marginal pools, and lake bottom, but was collected only once, probably incidentally, in the center lake. One could measure all environmental facets of these habitats and perhaps still not be able to state why it occurs there. For, in addition to requiring vitamin B-12 and thiamine, it also requires steroids, nucleic acid constituents, several amino acids, and growth factors which are present in liver digest and cream (Storm and Hutner, 1953). Even with refined laboratory data, it is not possible to identify the principal

substrate of this one species, and thus we cannot understand its distribution in the natural environment. In addition, it is known that other algal species cannot be grown in the absence of certain, as yet unidentified, organic materials apparently extracted from soil (Pringsheim, 1956).

The problem of ascribing distributions, such as those noted above, to a particular set of environmental conditions is of great complexity, and is further complicated by the fact that much of the significant data are either scanty or lacking. Dissolved organic matter has not been determined in many studies, or, where it has been measured, the results are subject to error (Slater, 1954). Also, few studies of bog habitats have included representatives of all algal phyla, so that it is difficult to compare results, or to theorize concerning the nature of the environment. Studies which list only the desmids which were observed, for example, give no indication as to whether such an ecologically-important group as the Euglenophyta was well represented. Yet, a knowledge of which Euglenophyta are present may be of more value in characterizing the habitat than would a knowledge of the desmids.

In addition, one must recognize that it is the individual species which are responding to the environmental conditions of a particular habitat, not the aggregation. Thus, any evaluation of such habitats must be based on a study of the occurrence of individual species, and all comparisons must be made on this basis. Because of the extremely large number of desmid species known, however, it is difficult to study their distribution adequately. One may find several hundred desmid species in one habitat under certain ecological conditions, and a similarly large number of species in a different habitat. Yet, the

species composition of the two habitats may be vastly different, and the individual species may occur in the two habitats in response to two different sets of environmental factors. Perhaps this would help to explain many of the conflicting results which have been obtained from chemical analyses of different habitats, each of which could be described as a "rich" desmid habitat. One would therefore have to consider local variations and species variations in any analysis of algal distribution before being able to propose broad generalizations concerning such distributions.

One can survey the literature on algal distribution in bogs and be able to state only that the evidence from individual studies is so contradictory, and the results so conflicting, that few major generalizations can be made. Perhaps this is due, in part at least, to the fact that we have not yet learned to recognize the environmental factors which are most significant in such distributions. So long as these studies continue to neglect the role of dissolved organic materials, or are directed toward delimiting the distribution of a group of organisms rather than that of the individual species, it does not appear that much progress will be made.

A more equitable approach would be that of the search for "indicator" species, as advocated by Provasoli (1958). Knowing the exact nutritional needs of a species for example, one could use the occurrence of the species as a guide to the peculiar set of environmental conditions which must be present in order for that species to exist in a particular habitat. Given a whole series of such species, one could use these as a refined analytical tool, and perhaps be able to characterize better a natural environment than could ever be done by chemical analyses of the medium.

Noting other species which occur under these same conditions, or in association with the indicator species, one would be better prepared to discuss the range of ecological conditions under which certain other species could occur. From a long series of such observations, coupled with nutritional experiments in the laboratory and other observations and chemical analyses in the natural environment, much impetus could be given to our understanding of the factors which may be influential in the distribution of algae.

In respect to the above observations that dissimilar algal floras may exist in adjacent habitats within the bounds of a relatively uniform environment, similar results have been reported by Prescott (1953), Prescott and Scott, (1942), Gessner (1929), Welch (1945), Wade (1952), Magdeburg (1926), de Graaf (1957) and the writer (1958), among others, but an adequate explanation is thus far lacking. Such observations merely serve to emphasize one of the major unsolved problems of algal distribution: if we cannot explain adequately the factors which influence algal distribution over such small distances within regions of a relatively uniform environment, how can we ever attempt to explain, or to understand completely, the reasons underlying algal distributions which occur over larger distances and among diverse habitats? The problem is certainly one of great complexity, and requires further, more critical, investigation.

In respect to seasonal periodicity of the flora, it was noted that little change in species numbers occurred during different seasons of the year. The total variation in species number during the year was only from 223 to 253 species (Table XV). This does not mean, however, that the flora is constant in composition, because some species disappear

during different seasons of the year and are replaced by others. The fact that the total species number remains so constant is related also to the large number of desmids which are present during almost all seasons of the year. Because these show no great decline during any season, and because they are so numerous, they help to keep the total number fairly constant. Similar results have been noted by Wasylik (1961a).

The interesting aspect of this seasonal cycle is, however, why is the total flora greater in fall than at other seasons, and why are lesser numbers noted during summer? Answers to these questions are not clearly evident, but are related to several factors. First the season "fall" as used here includes the months of September, October and November. During late October and November, especially, there is an increase in the number of brown-pigmented forms much as the Chrysophyta and Pyrrhophyta, and an increase in the number of filamentous Cyanophyta of the genera *Oscillatoria*, *Spirulina*, *Scytonema* and *Hapalosiphon*. Chlorophyta increase during this time also, due largely to an increase in the number of flagellated species and Chaetophorales. At least the latter group may be present during other seasons as well, but because these are epiphytic they would not be noted as readily until the macrophytic vegetation begins to decay in late fall. The number of Euglenophyta, especially species of *Phacus* and *Trachelomonas*, increases at this time also.

The lower number of species noted during the summer may be related to the occurrence of extensive wefts of *Oedogonium* and *Mougeotia* spp. which cover the lake bottom beginning in early May. These may withdraw large amounts of nutrients from the water, and cause a decrease in the number of planktonic forms. Also, zooplankton is extremely abundant

during the summer months, and these may reduce the numbers of phytoplankters by grazing.

The Algal Flora of Lawrence Lake

The algal flora of Lawrence Lake is characterized by the following general features: (1) a relatively large number of species is present, of which the Chlorophyta are qualitatively dominant, followed by smaller numbers of Chrysophyta and Cyanophyta; (2) quantitatively, the Chrysophyta and Cyanophyta are more abundant than the Chlorophyta; (3) the number of desmid species and Euglenophyta is low; (4) although floral differences are evident in a comparison of certain habitats, analyses of such differences are complicated by the dominance of diatom species; (5) seasonal changes are evident in both the floral composition and species number; (6) extensive algal blooms, especially of Cyanophyta, are lacking.

The results presented for this lake agree in general with those which have been reported for other hard-water lakes (Prescott, 1951a; Smith, 1924b), but a direct comparison is complicated by several factors. First, Lawrence Lake is a marl lake, and few comprehensive and intensive studies have been made of such lakes, especially in this country. Second, many studies of basic or hard-water lakes are primarily limnological in emphasis, and, accordingly, little, if any, extensive taxonomic data are given, especially for algae. Thirdly, if taxonomic lists are reported, generic names only are used; and, finally, such studies are concerned usually with quantitative, rather than qualitative, aspects of the flora. It should be re-emphasized here that the primary objective of the present study was to gain qualitiative data on the taxonomic composition of this flora.

In respect to floral composition, Prescott's (loc. cit.) summary analyses indicate that hard-water lakes, especially hard-water drainage lakes, typically contain a predominately cyanophyte-diatom flora, even though the number of Chlorophyta in such lakes may be equal to, or greater than, the numbers of Chrysophyta or Cyanophyta on a qualitative basis. The results of the present study agree well with these analyses (Table III). Thus, although 74 Chlorophyta species were found in Lawrence Lake as compared with 50 Chrysophyta and only 31 Cyanophyta, the bulk of the flora was composed of representatives of the latter two phyla. As noted in the earlier discussion of community composition, species of Chrysophyta and Cyanophyta were quantitatively dominant during almost all seasons of the year, even though more species of Chlorophyta were usually present (Table XVI).

Similar results of floral composition are reported by Tressler, Tiffany and Spencer (1940) for Buckeye Lake, Ohio, a lake having a pH range (7.3 to 8.9) and conditions of total alkalinity which approximate those of Lawrence Lake. They found 48 species of Chlorophyta, as compared with 23 diatoms and only 20 Cyanophyta, during a study period of four months.

Raymond (1937) studied a marl lake in Michigan and reported a relatively low number of species (32), including seven Cyanophyta and six Chrysophyta, although both the pH (7.5-8.3) and total alkalinity (154-196 ppm $CaCO_3$) were similar to those of Lawrence Lake. In comparison, then, the Lawrence Lake flora is much richer in number of algal species, even though basic chemical data for the two lakes are similar. Of the seven Cyanophyta found by Raymond, four occurred in Lawrence Lake; of the six Chrysophyta, three were also in Lawrence.

The results of the present study also agree in general with those reported by Wehrle (1927), Messikommer (1935a), Pearsall (1921), Nygaard (1949) and Chapman (1934) for other alkaline lake floras.

Other comparisons of this kind could be made to indicate clearly that the general features of the Lawrence Lake flora agree well with those which have been reported for similar study areas. An analysis of the species composition of this flora (Table I) demonstrates corresponding similarities. Thus, the blue-greens *Anabaena flos-aquae*, *Coelosphaerium Naegelianum*, *Gomphosphaeria aponina*, *Lyngbya Birgei* and *Microcystis aeruginosa* are typical of hard-water lake floras (Prescott, 1951a), and all were present in the Lawrence Lake flora. The diatoms *Asterionella formosa*, *Fragilaria crotonensis*, *Stephanodiscus niagarae* and *Melosira* spp., along with the dinoflagellates *Ceratium hirundinella* and *Peridinium Willei* likewise all are commonly reported from alkaline lakes. Species of *Chara*, as well as *Cladophora fracta*, also are characteristic of such lakes, and both *Chara* and *Schizothrix* are typical of marl lakes in particular.

The algal flora of marl lakes thus apparently is not a unique one, but, according to Raymond (1937), resembles that of other hard-water lakes which have been studied. Because certain general features of floral composition have been noted almost wherever hard-water lakes have been studied, therefore, numerous attempts have been made to relate the occurrence of such floras to features of the environment which are common to this type of lake. Much of this information has been summarized by Prescott (*loc. cit.*), so that only the major features need to be presented here.

It has been observed that, where lake waters are warm, rich in

fixed and half-bound carbon dioxide, and high in nitrogen, an abundant cyanophyte-diatom flora develops. Thus, in lakes of the Fox River and Green Bay areas of Wisconsin, whose waters are characterized by such features, the phytoplankton is dominated by Lyngbya Birgei, Microcystis aeruginosa, Aphanizomenon flos-aquae, Stephanodiscus niagarae and Melosira spp. In Lake Geneva, for example, the plankton is dominated by many of the same species noted in Lawrence Lake, such as Microcystis aeruginosa, Coelosphaerium Naegelianum and Lyngbya Birgei. Chemical data for Lake Geneva obtained when these species were abundant indicated that its waters were high in bicarbonates and carbonates, and relatively high in nitrate nitrogen (0.8 ppm). These results compare well with those for Lawrence Lake, both in respect to species composition and to available data for water chemistry (Table XXII, Figure 23).

Another characteristic feature of hard-water lake floras is the low number of desmid species which they contain (Prescott, 1951a). Messikommer (1935a to 1960), for example, has made an extended series of comparative studies on the desmid flora of hard-water versus soft-water lakes, and has demonstrated an almost consistently lower number of species in hard-water lakes. Similar results have been noted in the present study. Thus, of the total algal flora of Lawrence Lake, less than 25 per cent are desmids (Table IX), and the same is true in respect to the floral composition of individual habitats (Table XIII). In all, only 40 desmid species were ever found in Lawrence Lake; the majority of these are species typically recorded for hard-water or basic lake floras (Messikommer, loc. cit.; Wehrle, 1927). A fuller discussion of the desmid flora of this lake will be given in the following section.

In respect to floral composition, then, most phyla or groups of

algae appear to be represented in proportions which have been typically reported. Some further analysis of one other group, the Euglenophyta, appears to be pertinent at this point, however. This phylum was represented by only three species, each of which was extremely rare (Table I). Data in Table III indicate that less than two per cent of the Lawrence Lake taxa were euglenoids.

De Graaf (1957) states that only a very few euglenoids occur on the acid side of neutral, and this implies that the majority are found under alkaline conditions. Also, Tressler, et. al. (1940) mention the dominance of Euglena among the euglenoids in Buckeye Lake. Yet, the genus Euglena was almost wholly absent from Lawrence Lake, both qualitatively and quantitatively. A more complete discussion of this aspect will be made in the following section.

Because diatom species were so abundant in most habitats of the study area, less emphasis was placed on an analysis of the floral composition of individual habitats than was true in the case of Purdy Bog. In many of these habitats, for example, algae other than diatoms were largely lacking, and any attempt to describe the algal floras of such habitats without including the diatoms would be just meaningless as would be a discussion of the algal species in a desmid habitat without including the desmids. Because the list of algal species is so incomplete in so many habitats, it is thus difficult to make an adequate comparison of the floras in these habitats. Therefore, major emphasis in the study was directed toward making an analysis of the floral composition of planktonic habitats, which contained a large number of other algal species in addition to diatoms.

The small communities recorded for the marginal pool and lake

bottom habitats in this lake (Table XVIII) thus are misleading unless one realizes that such descriptions do not include an analysis of diatom populations. There is thus a sharp distinction between the floras of the marginal pool and lake bottom as compared with the open-water portions of the lake (Tables I, XVIII). The marginal pool contained a much lower number of species than did the plankton habitats, but the reasons for this are not apparent because adequate chemical data are not available for this habitat. It is possible that the place of the Cyanophyta and Chlorophyta is taken over by the large number of diatoms, or that the extensive mats of Spirogyra and Mougeotia exert a controlling influence over community composition either through a withdrawal of the available nutrients, or through shading effects (Talling, 1962).

In respect to the bottom flora, the community as recorded in Table XVIII is similar to that reported for other hard-water, especially marl, lakes. Extensive beds of Chara are a characteristic feature of such lakes, and Raymond (1937) has noted the extensive growths of Schizothrix in another Michigan marl lake. Both of these genera are intimately connected with the depositions of marl which occur in such lakes (Lewin, 1962). Cladophora fracta var. normalis is also a typical member of the bottom floras of alkaline or hard-water lakes (Prescott, 1951a).

The floras of the various open water portions of the lake are very similar to one another, and seem to represent almost a continuum. The flora of the intermediate portion of the lake is thus difficult to outline because it contains members of both the main and outlet portions of the lake (Table XVIII). Evidently, this lake is in a transitional stage of development, and it could be assumed that, as the three lake

segments become more isolated from one another through the continued growth of the vegetational bridges, greater differences in floral composition would be evident.

That this is true in part at least is shown by a comparison of the floras of the main and outlet portions of the lake, which are more isolated from one another, and which are under the influence of, or are surrounded by, different kinds of macrophytic vegetation. Although the relative number of species (Table XI) and the floral composition (Tables IX, X) is similar in these two habitats, certain species apparently are restricted to one or the other of these two habitats (Tables I, XVIII). Chief among these are certain desmids and characteristic Pyrrhophyta, along with a few species of other algal groups. Of the total number of desmids which occurred in Lawrence Lake (40), the majority were recorded from the main and outlet portions. That the desmid flora of these two habitats is different even numerically is thus evident from the fact that only 26 of the 40 occurred in the main portion of the lake, and only 20 occurred in the outlet portion (Tables XII, XIII).

In respect to species distribution, Cosmarium Botrytis, Euastrum hypochondrum fa. decoratum, Staurastrum brevispinum, St. furcigerum, St. setigerum var. occidentale, Peridinium polonicum and P. gatunense all were common in the main portion of the lake, but apparently never occurred in the outlet portion. The same is true also of Oscillatoria princeps, Dinobryon divergens var. Schauinslandii, Crucigenia irregularis, C. rectangularis and Nephrocytium spp. Conversely, Closterium Dianae, Cosmarium reniforme, C. Turpinii, Dinobryon sertularia, Cystodinium Steinii, Cryptomonas ovata, Trachelomonas volvocina and Vacuolaria virescens, among others, all were found in the outlet portion, but were

never observed in the main portion of the lake. In addition, Oscillatoria Bornetii, Pleurotaenium Trabecula and P. Trabecula var. maximum all were common and usually abundant in the outlet portion, but were observed only once in the main portion of the lake.

Possible reasons for such floral dissimilarities are again not apparent, because, as previously mentioned, no comparative chemical data are available for these two habitats. Nevertheless, an analysis of dissolved organic matter in the two habitats might afford an explanation. The flora of the outlet portion contains several species which are more typical of a swamp habitat than does that of the main portion. The "swampy" nature of the surrounding vegetation and the brownish color of the water in the outlet portion have been mentioned previously also, and it may be that organic substances such as humic colloids or organic growth factors are present in a variety or at a concentration not found in other portions of the lake.

One would have to make a more extensive series of collections from a wider variety of habitats and include more data on water chemistry before any definitive analyses of the Lawrence Lake flora could be made. Thus, it should be realized that results such as those reported above are of a preliminary nature only. Many phases of this aspect of the study thus await a more critical analysis.

The observations presented for seasonal changes in floral composition in the main portion of the lake agree well with those found in similar lakes, in showing an early spring community dominated by diatoms and dinoflagellates, a late spring and early summer community dominated by Chlorophyta and Cyanophyta, a summer and early fall community dominated by Cyanophyta along with a few Chlorophyta, and a fall and winter

community dominated by diatoms, along with other Chrysophyta and Pyrrhophyta. Although such changes have been observed in many studies, and, although many investigators have attempted to determine the factors influential in promoting such changes, an adequate explanation for such phenomena apparently is lacking (Talling, 1962; Provasoli, 1958).

No dense blooms of Cyanophyta, such as have been reported for many hard-water lakes, were ever observed in any habitat of Lawrence Lake. The absence of such blooms is probably related to the usually-low productivity of marl lakes (Raymond, 1937), and to the scarcity of essential nutrients (Eyster, 1958b).

Comparison of Study Areas

General Comparison

It is evident from the previous discussion that the algal floras of Purdy Bog and Lawrence Lake differed from one another in respect to almost all of the aspects which were investigated; namely, the number of taxa supported, percentage composition, community composition, species composition, occurrence and distribution of individual species and seasonal periodicity.

Of the 495 taxa which were found, 385, or about 78 per cent, occurred in Purdy Bog, whereas only 170, or less than half as many, were found in Lawrence Lake (Table II; Figure 22). Of the 385 bog species, 243, or about 63 per cent, were Chlorophyta (Table III). But, analysis of data in Table II indicates also that the bog supported a large proportion of the total number of taxa in all divisions, so that the difference in species number in one area as compared with the other is not related only to the larger number of Chlorophyta which occurred in the

bog. Approximately 59 per cent of the Cyanophyta, over 80 per cent of the Chlorophyta, 80 per cent of the Pyrrhophyta, and almost 98 per cent of the Euglenophyta species which were observed in the study thus were found in Purdy Bog.

Although the Chlorophyta are dominant in both study areas (Table III), the floral compositions of the two are different. The flora of Purdy Bog is predominately chlorophycean, both qualitatively and quantitatively, whereas that of Lawrence Lake is dominated by a cyanophyte-diatom complex. That floral differences exist even qualitatively is evident from an analysis of Table III. Whereas the Cyanophyta and Chrysophyta together represent about 50 per cent of the Lawrence Lake flora, as compared with about 44 per cent Chlorophyta, the Purdy Bog flora is composed of about 63 per cent Chlorophyta, as compared with only about 20 per cent Cyanophyta and Chrysophyta. The representation of Euglenophyta also is different in the two study areas. Whereas euglenoids compose about 11 per cent of the bog flora, members of this division formed only a negligible component of the hard-water lake flora, a proportion which represents less than two per cent of the total number of taxa which occur.

But, even though the above purely numerical data do indicate floral differences, a more adequate comparison of the study areas must be based on an analysis of the individual species and species aggregations which occur in the two lakes.

Related somewhat to the differences in percentage composition is a corresponding difference in the community composition of the two study areas. No similarity can be shown between the community of any habitat in Purdy Bog as compared with that of any habitat in Lawrence Lake

(Tables XVII, XVIII). Although it is not pertinent to discuss here all such noted community differences, some further comparison of the planktonic communities of the two lakes may be appropriate, especially as this relates to the results of previous investigations.

On the basis of species composition or community structure, plankton floras may be divided into two types, the Caledonian and the Baltic (Smith, 1950). A Caledonian flora is one which is composed primarily of desmids, along with relatively fewer numbers of Chroococcales and Hormogonales. A Baltic flora, conversely, contains a predominance of Cyanophyta and Chlorococcales, but has a corresponding poverty of desmids.

The plankton flora of Purdy Bog thus is of the Caledonian type, whereas that of Lawrence Lake is Baltic. These observations are in agreement with those of other investigators (Smith, 1924b; 1950; Prescott, 1951a) whose results indicate that hard-water lakes usually support a Baltic (cyanophyte-diatom) flora, whereas that of soft-water lakes, especially acid bogs, is of the Caledonian (chlorophycean) type.

Granted such differences in community composition can be shown, the most critical comparison of the study areas is based on an analysis of the distribution and occurrence of individual species. Of the 495 taxa which were observed during the study, only 39, or less than eight per cent of the total number, are common to both Purdy Bog and Lawrence Lake (Table XXI), even though a number of diverse habitats were studied in each. The largest number of these are Chlorophyta (15) and Cyanophyta (11). But, even this similarity is not as great as might seem evident from numerical data above. Mere occurrence of the same species in both study areas indicates only that there has been an opportunity for the dispersion of similar dissemules into each. To make a more significant

comparison, or, before stating that such species are typical of both study areas, one would have to consider also the relative abundance and duration of the species in each of the study areas.

A further analysis of the distribution and occurrence of certain species marked by an asterisk in Table XXI may serve to emphasize this point. Among the Chlorophyta, for example, all species so marked were extremely rare in Lawrence Lake, many of them occurring in only one collection during the two-year study period, although almost all were common in a variety of habitats in Purdy Bog, and occurred throughout most of the year. Thus, Coelastrum sphaericum was found during nine months of the year in Purdy Bog, but occurred only during August in Lawrence Lake; Hyalotheca mucosa occurred during 10 months of the year in the bog, but only during July in the hard-water lake; Netrium digitus was noted in Purdy Bog during every month but March, yet it was found in Lawrence Lake, and in all three open-water habitats, only in one collection; N. digitus var. lamellosum occurred only in May and July in the hard-water lake, and only in the main portion, whereas it was present during every month of the year in Purdy Bog, and in a variety of habitats.

Similar distinctions were noted in the occurrence of many other Chlorophyta listed in Table XXI, as well as for certain Chrysophyta and Cyanophyta. Dinobryon cylindricum, for example, was found only during the winter months in Lawrence Lake, but was present almost throughout the year in Purdy Bog. Similarly, Aphanothece microscopica, Merismopedia glauca and M. punctata, as well as Chroococcus turgidus and Oscillatoria amphibia, all were rare in Lawrence Lake, yet showed a far more general occurrence in the bog.

Whether observations such as the above indicate a greater rarity

of the species in one area as compared with the other, an inadequacy of sampling technique, or a response to growth conditions which are favorable for a much shorter period of time in Lawrence Lake, is not evident. But it is evident from such observations that more frequent sampling and more critical analyses of the occurrence and distribution of certain species are necessary before a more refined comparison of the algal floras of the two study areas can be made. It is possible, for example, that such observations in Lawrence Lake are a part of what might be termed "short-cycle" periodicity, in which species appear in a particular area only for a very short time, and then suddenly disappear, many times never to be observed again. Such a phenomenon has been observed and discussed previously by A. M. Smith (1942) and the writer (1958). It is possible, also, that certain of these species were introduced only recently into the study area and were able to develop there only for a short period of time, after which they could no longer adjust to the environmental conditions. In the latter event, such species could not be considered as being typical inhabitants of such a biotope.

In addition, several of the species in Table XXI were restricted to the outlet portion of Lawrence Lake. Included among these are Dinobryon sertularia, Synura sphagnicola, Synuropsis danubiensis fa., Cryptomonas ovata, C. erosa, Vacuolaria virescens and Trachelomonas volvocina. If such species were really adapted to conditions in the hard-water lake, one would expect them to show a wider distribution in the study area, or at least to occur in the main portion of the lake. Because they do not, however, caution is necessary in listing these as species which are typical of the hard-water lake, or of the chemical conditions which are found in the main lake portion. Such species may

be responding to the more "swampy" nature of the surrounding vegetation of the outlet portion, or to the presence of certain dissolved organic materials which occur in this, but not in the main, portion of the lake.

Among the Cyanophyta also, the similarities in species composition may be exaggerated on the basis of occurrence alone. In addition, this group presents problems which require a more thorough analysis before an adequate assessment of their distribution can be made. Many of these problems are taxonomic. For example, only one or two colonies of *Aphanothece microscopica* were ever observed in Lawrence Lake (and these only in one collection), whereas the species was quite common in Purdy Bog, and was found during every month of the year. It is difficult, however, to separate (taxonomically) young colonies of *A. stagnina* from those of *A. microscopica*, and only an extended series of observations would allow a final determination to be made. Nevertheless, the colonies which were observed in Lawrence Lake did have all the characteristics of *A. microscopica*, although an extended study of the species was impossible because these were observed in only one collection.

In addition, *Chroococcus turgidus* and the species of *Merismopedia* listed in Table XXI are so variable in their characteristics that an accurate determination is difficult to make, especially on the basis of a limited number of specimens. As noted under the descriptions of these species, it is difficult to separate certain expressions of *Merismopedia elegans* from *M. glauca*, or of *M. punctata* from *M. Trolleri*, unless many specimens are available for study. Even so, many colonies were observed in which the cellular morphology exhibited characteristics which were intermediate between those of two different species. Such differences may be due to differences in age or physiological condition, or they may

be due to a response to a different set of environmental conditions. One of the characteristics which is used in distinguishing many blue-green species, and thus one which is of taxonomic significance, is the presence or absence of pseudovacuoles. Yet, this may vary within any one species depending upon environmental conditions (Smith, 1950). A "key" characteristic of Coelosphaerium Naegelianum, for example, is the presence of pseudovacuoles; yet, the writer has observed many colonies in the present study which were definitely those of C. Naegelianum, but in which pseudovacuoles were entirely absent, the cell contents being homogeneous.

It is possible, therefore, that a more critical study of certain species listed as being common to both areas would reveal differences either of a morphological or physiological nature which might have ecological or taxonomic implications, and thus implications in respect to the distribution of these species. Such species generally are referred to as being "ubiquitous" or "indifferent", yet a more critical analysis of these, based on culture studies, may reveal physiological differences which would demonstrate that identical species were not present under the two different sets of environmental conditions.

Of the 39 species which were "common" to both areas, then, at least one-half show patterns of distribution or occurrence which are vastly different in the two study regions, and hence present problems of a taxonomic or physiological nature requiring more critical analyses. It should be evident, however, that the greatest difference between the floras of the two study areas is not manifested in the rare or isolated occurrence of a few species which are common to both, but by the overwhelming dissimilarity in the majority of species which were recorded.

As was noted in the introduction to this paper, one of the

objectives of the present study was to describe the general range of chemical conditions under which the floras of these two major types of habitats (hard-water lake and acid bog) were found to occur. Having demonstrated distinct floral differences between the two, it is appropriate, therefore, to compare the major chemical features of these two habitats.

Physical-chemical data for the two study areas are presented in Figures 20-23 and Table XXII. It is obvious from an analysis of these that the general chemical conditions of Purdy Bog are different from those of Lawrence Lake. Thus, whereas the pH in the acid bog never approached neutral, that of Lawrence Lake was always above neutral (Figures 21-23). The total alkalinity in Lawrence Lake ranged from 148 to 236 ppm $CaCO_3$, whereas that of the bog was much lower, varying from 4 to 7 ppm.

These data have been compared graphically with floral composition in the study areas (Figures 22, 23). In respect to the total floras of the two study areas (Figure 22), it is evident that the largest number of algal species, especially Chlorophyta, occurred where the pH was below neutral, and at a correspondingly low bicarbonate alkalinity. Conversely, where both the pH and total alkalinity are high, a correspondingly lower number of species, especially of Chlorophyta, was recorded. Similar results are shown in an analysis of the floral composition of the main portion of Lawrence Lake as compared with that of the center lake in Purdy Bog (Figure 23). In respect to the flora of individual habitats, it is evident that the largest number of species occurred in the marginal pools of Purdy Bog under weakly acid conditions (Figure 22); the smallest number occurred in the sphagnum mat and

sphagnum pool (Figure 23) at a low pH.

The more complete data given in Table XXII for the center lake and sphagnum pool in Purdy Bog and the main portion of Lawrence Lake indicate also that the water chemistries of the two study areas are different in respect to almost all of the analyses which are shown. The hard-water lake is higher in sulfate, nitrate, calcium, magnesium and total hardness than is the bog lake, whereas the latter contains a slightly higher amount of dissolved organic matter. Iron concentrations are similar in both lakes, but the phosphate concentration is so variable that little comparison can be made in respect to this factor. In addition, phosphate concentration, as reported here, is higher than that reported for other lakes, so that more critical analyses of this constituent may be indicated. The sphagnum pool in Purdy Bog contains greater concentrations of dissolved organic matter and iron, and has a lower pH, than does either of the lake habitats, although other conditions in this habitat are similar to those in the center lake of the bog, and are different from conditions found in the hard-water lake.

Thus, the dissimilarity of the study areas in respect to floral composition is matched by a corresponding difference in the chemical conditions of the two environments. The question which arises here, however, is: granted such differences do exist, is there any definite relationship between the two? That is, can these floral differences be explained in terms of the observed environmental differences?

Such questions probably cannot be answered directly on the basis of results from the present study. Because so much emphasis has been placed on gaining data of comparative value in the current study, however, it is appropriate to investigate these questions in more detail. Such

an investigation becomes meaningful only when the results of the present study are compared with those from other investigations.

Similar floral and chemical differences have been noted in other analyses of acid bogs or hard-water lakes, and numerous investigators have attempted to demonstrate a relationship between the two in respective lake types. In respect to the total floras of such habitats, suffice it to state here that such attempts have not met with much success, because few generalizations can be formulated from the results of such investigations. Nor can a definite relationship be shown between floral composition and any particular set of chemical factors. As was noted in the discussion of Purdy Bog, one must approach all such analyses with caution, since if one cannot explain adequately the floral dissimilarities noted within the bounds of a relatively uniform environment, it should be much more difficult to explain floral differences which are noted among diverse habitats. Such a statement becomes obvious if one recognizes that, because the chemical conditions of the two environments in the present study are so different, almost any factor or combination of factors could be held to have some influence in determining the observed floral differences.

Talling (1962, p. 744) also states that "Differences in the algal floras of separate water bodies can rarely be used to identify the response to a single factor, as many significant factors are likely to vary simultaneously, and their separation by an analysis of multiple correlations (Deevey, 1940) must be far from complete." In addition, floral differences can be much greater than is suggested by an analysis of all major inorganic nutrients (Talling, 1962). Also, it must be remembered that some metabolites which are influential in determining the occurrence

of many algal species cannot be detected chemically in nature by ordinary analyses.

It would be necessary also to have more complete chemical data for many of the parameters cited above. To characterize these study areas adequately, one would need to know at least the following criteria: concentration of total solids, prevailing major ions, main trace metals, ratios of monovalent to divalent ions, and of calcium to magnesium, as well as the content of dissolved organic matter. In many instances also, one would have to know the particular form in which an element was present; this is especially true of iron, phosphorus, nitrogen and carbon. Many of these can be detected chemically in the environment, yet may be present in a form which is unavailable to many organisms (Provasoli, 1958). Finally, one would have to have more closely-spaced observations and analyses of chemical parameters for these to be of any great value, because of the great fluctuations which may occur within the space of a year. Provosoli (loc. cit.) refers to the work of Bamforth, where complete measurements were made every other day. From such observations it was possible to make several correlations between the occurrence of organisms and the chemical features of the environment; yet, even "monthly samplings would have missed them completely."

Also, it must be emphasized again that it is the individual species which are responding to the chemical nature of the environment, and not the aggregation. Yet, individual species may vary greatly in their tolerance to certain environmental factors, or in their nutritional requirements. Various species, for example, may grow in the same environment in response to different nutritional needs (Provasoli and Pintner, 1960), and it is dangerous to extrapolate data from one species to another, even

in the same genus (Provosoli, 1958). Also, some species which occur under a particular set of environmental conditions may be merely withstanding them; others actually may require them. But, such distinctions cannot be made on the basis of a single study, and a comparison of results derived here with those from other studies yields such conflicting information that little can be stated in respect to the relationship between the occurrence of individual species and the observed chemical conditions of the environment. Such an analysis is complicated also by the large number of species which were observed in the present study, and by the fact that so little comparative or definitive data are available for these individual species.

Therefore, on the basis of a general comparison of floral composition and chemical conditions of the environment, it is difficult to demonstrate any positive relationship between the two. Such chemical data as are presented in the present study are not regarded as being definitive, nor were they gathered with this objective in mind. Rather, they serve merely to indicate the particular range of environmental conditions which were tolerated by the individual species in each study area. In this sense, then, they become meaningful only when added to, or when compared with, data recorded for these species from other habitats. It is believed that definitive information on algal distribution may become available only when the results of many studies such as the present one have been analyzed and compared with one another; it is only by such a summary process that we may finally come to understand the range of environmental conditions under which a particular species can exist. The present study thus represents a contribution to such knowledge, but by no means the culmination of such knowledge.

Nor does it appear to be possible to make a comparison of the study areas at the species level, because of conflicting data (see Distribution of Selected Species), the large number of analyses which would be required, and the fact that the chemical data which are available for such an analysis are not extensive enough to allow for such a comparison to be made. In addition, few studies of the total algal flora of individual study areas have been made, and thus it is difficult to compare directly the results from the present investigation with those of other studies, in any attempt to analyze species associations or community composition.

Realizing the limitations of such an approach, and with the above precautions in mind, it is possible, however, to discuss the occurrence of certain groups of algae in one study area as compared with the other. Such a comparison is possible because the representation of these groups is so different in the two study areas, and because such a large quantity of experimental data from related studies is available. Thus, data from other studies as well as the present one can be utilized, and a more meaningful comparison can be made.

The Desmid Flora

One of the greatest differences in the floras of the two study areas is that the acid bog contains a much larger number of desmid species than does the hard-water lake, the actual figures being 151 as compared with only 40 (Tables XII, XIII). But, not only was the number of species different, the kinds of species which were present in the two study areas were different also. Thus, only 10 desmids were "common" to both (Table XXI) out of the total of 181 species identified. This

appears to represent a valid difference between the floras of the two areas and necessitates a further discussion of the occurrence and distribution of desmid floras, and of the environmental factors which may be influential in determining their distribution or occurrence.

Because many of the earlier ideas concerning influential factors in the distribution of desmid floras, especially planktonic species, have been discussed fully in the works of Smith (1924b, 1950), Prescott (1948) and Wade (1952, 1957), only brief mention need be made of them here. This is especially true because many of these discussions are concerned with broad regional, rather than local, patterns of distribution.

It has been noted that desmid-rich lakes usually occur in geological formations older than the Mississippian, and for this reason it was assumed that the antiquity of the region was a primary factor which determined the floral composition of such lakes. West and West (W. and G. S. West, 1906, 1909), for example, emphasize the fact that an abundant desmid flora is found only where lakes occur over ancient rock formations such as the Precambrian. They suggest that the two factors which are necessary for an abundant desmid flora are waters which are located over a geological formation older than the Carboniferous, and an abundant rainfall. They also point out that an abundance of individuals is dependent upon a lack of lime and the presence of humic acids in the water, and suggest that chemical analyses of the water might help to shed some light on the problem of desmid distribution. Wesenberg-Lund (1905) pointed out that desmids require peaty water rich in humic acids, but did not regard the antiquity of the region as being of any great consequence. Strøm (1921, 1926) re-emphasized the need for

chemical analyses of the water, suggesting that rainfall is not so important a factor as was believed by West and West.

Later workers all seem to agree that mere antiquity of the region is probably not a primary factor in desmid distribution, because good desmid habitats have been found in more recent rock strata (Smith, 1950) and glaciation has modified or covered much of the older underlying rock strata. In fairness to West and West, however, it should be noted that the chemistry of a body of water is largely determined by the characteristics of the underlying rock layers (Prescott, 1948), and thus the Wests' ideas are at least partially correct. Most modern investigators now assume that the distribution of desmids is governed by water chemistry.

Smith (1924b) thus states that it is water chemistry and not the antiquity of the region which governs desmid distribution or occurrence. The important question which as yet is still unanswered, however, is, which factors of water chemistry govern such a distribution? The answers to this question are almost as numerous as are the investigators who have sought to analyze the problem.

"Primary" Chemical Factors and Species Number

Because the number of desmid species is usually lower in a hard-water lake than in a soft-water lake or acid bog, aspects such as the carbonate content or carbonate hardness of the water, the attendant alkaline reaction, or the relative abundance of calcium and magnesium have been studied in relation to the number of desmid species which occur in hard-water lakes. Although it is difficult to ascribe floral composition to only one or even a few factors of the environment

(Talling, 1962), it is generally believed that the calcium or lime content of a hard-water lake influences the composition of its flora. Smith, for example, states (1950, p. 21): "The factor determining the nature of the plankton flora is the hardness of the water, and a Caledonian flora is found only in waters poor in calcium." Hirano (1960) has stated also that, where the waters of Japan are rich in desmids, they are poor in calcium; similar ideas are stated by Prescott (1948). From such ideas, it is held that desmids as a group are calciphobic, whereas those species which do occur typically in hard-water lakes are either calciphilic, "lime-loving" or indifferent.

Pearsall (1921), although emphasizing also the importance of the age or evolutionary stage of a lake in determining the character of its plankton flora, states that a predominant desmid flora exists only where the waters contain a high ratio of $Na_2O + K_2O$ to $CaO + MgO$. Prescott (1939, 1948) has emphasized this latter factor in many of his writings, and states that where such a ratio is low (about 1.1) the number of desmid species is also low, whereas where a high ratio (3.2) exists, a much larger number of desmid species is found. Such a ratio, at least indirectly, emphasizes water hardness again, because hard-water lakes usually contain large amounts of calcium and magnesium, and thus might be expected to have a lower ratio of monovalent to divalent cations.

Messikommer (1935a - 1960) also agrees that certain aspects of water hardness are influential in the distribution of algal species, especially desmids, and his researches indicate that floral differences are related either to the lime content, total alkalinity or carbonate hardness of the water. In general, his results indicate that, the greater the carbonate content of the water, the fewer the number of

Chlorophyta, especially desmid, species which occur. On the basis of the carbonate content of the water, Messikommer discusses whether certain genera or groups of genera are "normally," "over-" or "under-represented" in a particular study. Also, not all desmids are regarded by him as being calciphobic. Rather, many species of certain genera may be well represented in hard waters; such forms have been termed "lime-loving," "indifferent" or "ubiquists" by Messikommer. He shows also that regions having waters with similar carbonate contents have similar algal floras, in some cases showing a correspondence of over 90 per cent (1954a).

Ruttner (1953, p. 193), in discussing the selectivity and individuality of the bog community, states that, even though all bog waters are poor in lime, it is not the presence of calcium which prohibits bog species from invading a lime-containing habitat, but, rather, the "alkaline reaction constantly associated with a lime content in natural waters." Thus, according to Ruttner, bog species are not calciphobic, they are in reality "acidophilic" or "alkaliphobic." The acid or alkaline reaction of the water as expressed by the hydrogen ion concentration thus must be considered also in any analysis of desmid distribution.

As was noted in a previous section, many investigators regard pH or hydrogen ion concentration as being either one of the most important, or the most important, factor influencing or determining the occurrence or distribution of algal species, especially desmids. Among those who have noted or discussed the importance of pH are: Gistl (1931); Wehrle (1927); Irénée-Marie (1939); Niessen (1956); de Graaf (1957); Wasylik (1961a,b); van Oye (1941); Budde (1944); Ruttner (1953); Behre (1956); Kreiger (1933-1937); Gessner (1929); Hirano (1960); Grönblad, Prowse

and Scott (1958) and Prescott and Scott (1943).

Gistl (loc. cit.), for example, shows that the number of desmid species in a habitat increases from a pH of 4.7 up to 7.0 then drops off rapidly so that at pH 7.4 there is only one-tenth of the number which occur at pH 7.0. This indicates, as others have stated (Ruttner, 1953) that the neutral point is a "scarcely-surmountable barrier" for many species of algae. (On the basis of his investigations, however, de Graaf (loc. cit.) states that the dividing line between acidophilic and alkaliphilic organisms is not pH 7.0, but 6.0). Hirano (loc. cit.) found that the largest number of desmid species occurred in the larger lakes of Japan at a pH of 7.2, where the pH of such lakes varied between 6.4 and 8.8. Krieger (1933-1937) discusses the distribution of many desmids in respect to pH, and notes that many apparently are limited to either acid or to alkaline waters.

Irénée-Marie (loc. cit.) claims to have definitely established a relationship between pH and the occurrence of desmids, and describes a series of experiments in support of such an idea. In one experiment, for example, during a two-month period he placed samples of all desmid collections which were obtained from the region of Montreal into an aquarium which was maintained between pH 7.0 and 8.0. Of all the thousands of desmids added to the aquarium, he found only 3 species of Closterium, a few Mictasterias truncata and two species of Euastrum at the end of the study period. In another vessel, he added stream water having a pH of 8.2 to some algae which were collected from a bog. The culture lived for only eight days. Yet, when he added the same bog cultures to similar vessels which contained bog water and sphagnum moss, at a pH between 5.5 and 6.3, he found 13 genera after a two-month period

had passed (the presence of sphagnum moss in the vessel is particularly interesting in this respect). All of these experiments were supplemented by a large number of verifying field studies. From such investigations, Irénée-Marie concludes that the optimum development of desmids occurs between pH 5.5 and 6.5.

Budde (1944) states that the largest number of desmid species show an optimum development in weakly acid water at a pH of from 6.7-6.8, and that there is an equal tendency for the number to decrease on both sides of this range. In studies of waters having a pH interval of 3.0-4.0, 4.0-5.0, 5.0-6.0, 6.0-7.0, 7.0-8.0, and 8.0-9.0, he found respectively 12, 62, 100, 108, 75, and 14 desmid species. Using the same pH intervals, and determining the number of species having an optimum development at each range, he found the relationship to be 3, 18, 42, 64 and 27 species (data for pH 8.0-9.0 not included).

Niessen (loc. cit.), after an extensive study of desmid and diatom distribution in bog habitats, states that pH (literally, hydrogen ion concentration) is either one of the most important, or the most important, factor for the development of "Algenwelt," without regard to whether it is considered to be a "bedingter oder bedingender" factor.

In addition, Prescott and Scott (loc. cit.), Prescott (1951a) and Thunmark (1942) state that one can use the occurrence of certain species to predict the pH of the habitat from which they were collected.

Although no data are available for the Na-K/Ca-Mg ratio, the observations of the present study agree in general with those expressed above. Thus, the hard-water lake supported only 40 desmid species, as compared with the 151 species which were found in the acid bog. These results indicate also that the majority of species which occurred in

Purdy Bog apparently could not exist under the chemical conditions which are found in Lawrence Lake; nor, could the hard-water species exist in the acid bog, because only ten species were "common" to both areas.

Having noted such distinctions, it is appropriate to investigate any possible relationships between this observed difference in species number and the primary environmental factors which are listed above. The highest calcium concentration (expressed as ppm $CaCO_3$) which was noted in any bog habitat was 8.5 mg./l., whereas the lowest concentration in Lawrence Lake was 63.3 mg./l. Because a much lower number of desmid species occurred under the latter conditions, these observations agree well with those of many investigators whose results indicate that, where the calcium content of the water is high, the number of desmid species which occurs in low, and vice versa. Based on the present results, this may indicate also that, not only can several desmid species actually tolerate large quantities of calcium, but many actually may require it (the "lime-loving" forms of Messikommer, loc. cit.)

Similar analyses could be made in respect to the factors of pH and carbonate content as related to the distribution of desmid species; the larger number occurred in Purdy Bog within a pH range of from 4.0 to 6.5 and at a bicarbonate alkalinity of 4.0 to 7.0 ppm $CaCO_3$, whereas a smaller number occurred in Lawrence Lake at a pH above 7.0, and where the total alkalinity was much higher, varying between 148 and 236 ppm $CaCO_3$.

Some further analysis of individual habitats is necessary, however, to make a more adequate analysis of these factors, and to allow for a more adequate comparison of the study areas. The center lake in Purdy Bog supported 78 desmid species. Chemical data for this habitat

(Figures 21-23, Table XXII) indicate that the pH, calcium content and bicarbonate alkalinity of the water all fall within a range which has been shown to be favorable for the growth of a large number of desmid species. Only 26 desmids were found in the main portion of Lawrence Lake, where the pH, calcium content and carbonate content of the water all were much higher than were those of Purdy Bog.

Yet, one cannot select any one of these factors and say that it is more important than any of the others in influencing the occurrence of desmid species in these study areas. To state otherwise would be to disregard conflicting information not only from the present study, but from other studies as well.

One of the greatest difficulties in any attempt to relate algal distribution or occurrence to one particular factor of the environment is to show a positive relationship; that is, a relationship which holds true whether one investigates it from the standpoint of the biotic or the abiotic component. If one assumes, for example, that there is a definite relationship between the calcium content of a habitat and the number of desmids which occurs in the habitat, the relationship should be expected to hold true whether one investigates the calcium concentration in relation to the number of desmids which occur, or vice versa. Thus, if one states that waters which are poor in calcium are favorable for the growth of a large number of desmid species, or, that the largest number of desmid species occurs only where the calcium concentration is low, or that desmids as a group are calciphobic, one should expect such statements to hold true almost wherever and whenever they are tested, if a positive relationship exists. Conversely, if it is stated that waters which are high in calcium contain a low number of desmid species,

or that such waters are unfavorable for the growth of a large number of desmids, one would expect this relationship to hold true almost wherever it is investigated.

Yet, if one makes any one of these hypotheses and then subjects it to careful scrutiny, it becomes evident that the hypothesis does not hold true in all instances. In the present study, for example, although it is true that 78 desmid species occurred in the center lake of Purdy Bog, where the calcium concentration was low (1.5-8.5 ppm $CaCO_3$), only 22 desmid species were found in the sphagnum pool at Purdy Bog, where the calcium concentration varied only from 3.3 to 7.0 ppm $CaCO_3$. By comparison, 40 desmid species occurred in the hard-water lake, where the lowest calcium concentration recorded was 63.3 ppm $CaCO_3$. Hirano (1960) also has noted that, although a large number of desmid species occurs where the calcium concentration is low, one can find many habitats which have a low content of calcium, and which support a very poor desmid flora. Thus, large numbers of desmid species do not always occur where the calcium concentration is low. One therefore would have to state that, perhaps other factors, such as a low pH or a high concentration of dissolved organic matter in such habitats, prevent the occurrence of desmids, even though the calcium concentration is favorable. Nevertheless, it cannot be stated that calcium concentration alone influences the distribution of desmid species in all instances, or that a low concentration of this element is always beneficial to the growth of desmids.

Nor can it be stated that the number of desmid species which occurs in a particular habitat is related directly either to the pH or to the carbonate content of the water. For, even though large numbers of desmids do occur under weakly acid conditions, or where the bicarbonate

alkalinity is low, not all such habitats contain large numbers of desmids. Wade (1952), for example, compared the pH and bicarbonate alkalinity of the water in nine different study areas with the number of desmid species which occurred in each. He found that, although desmids do occur in soft-water habitats which have similar pH and alkalinity values, the number of species in some is greater than in others. Thus, at a pH range of from 5.5 to 6.0 and a bicarbonate alkalinity of from 9.0 to 25 ppm, he found from 4 to 94 species of desmids. The writer (1958) also found only 4 desmids in a bog lake at a pH of from 6.0 to 6.4, yet over 30 occurred in an adjacent habitat having the same pH range.

In respect to carbonate content of the water, Messikommer (1949a) states that water hardness influences the desmid flora of individual study areas qualitatively and, perhaps, quantitatively as well. He states also (*loc. cit.*) that waters with a high carbonate content are always desmid-poor, and many of his other studies apparently support this statement. Thus (1942a), he shows that only 9 desmids were found at a carbonate hardness of 360 ppm $CaCO_3$, whereas 37 were found at an "*Alkalinität*" of 25 ppm $CaCO_3$. Yet, in a later study (1943b) he found 163 desmids at a carbonate content of 25 to 50 ppm $CaCO_3$ (as compared with only 37 in 1942a) and 128 at the much higher value of 100 to 245 ppm $CaCO_3$. The interesting aspect of this latter record is that, although the water hardness or carbonate content was equal to, or was greater than, that of Lawrence Lake, the number of desmid species which occurred was not only greater than that which occurred in Lawrence Lake, but was greater than the number which occurred in the richest habitat of Purdy Bog (125 species, in the marginal pools).

One cannot state, therefore that either pH, carbonate hardness or calcium content of the water influences directly the number of desmid species which occurs in a particular habitat. Such factors may be influential in determining the over-all desmid flora of a particular region or study area, however, or at least may serve as an index of the general range of conditions which are favorable or unfavorable for the growth of a large number of desmid species. Thus, it is true that the majority of desmid species which were recorded in the present study occurred under weakly acid conditions where the bicarbonate alkalinity and calcium concentration were low, and that a much smaller number of species occurred under alkaline conditions where the calcium and carbonate content of the water was much higher.

Influence of Other Chemical Factors

To attempt to equate these "primary" factors to any analysis of individual habitats, however, one would have to consider local variations and the probable influence of other physical and chemical factors in each of the particular habitats under investigation. Yet, so many other factor's have been held to be influential in the distribution of desmid floras, or to modify the influence of the above-mentioned "primary" factors, that one faces only confusion in attempting either to relate these to general patterns of distribution, or to form any generalization which would aid in explaining the distribution patterns of desmid species as noted in investigations of individual habitats or individual study areas. In addition to water hardness, for example, Messikommer cites the following factors as being important in determining the occurrence or distribution of certain algal species or floras, especially desmids:

an alkaline medium, humic acid and the presence of moss-rich habitats (1953); water depth, water motion, electrolyte content of the water and the presence of macrophytes (1944); pH, quantity of dissolved bicarbonates, presence of humic substances, amounts of dissolved oxygen and the phosphorus and nitrogen content of the water (1954b); humic acids and soft water (1945). Also, he shows that desmids thrive best in waters colonized by "cliff-mosses", where the pH is neutral to weakly acid (1943a). In addition, he has mentioned the modifying influence of altitude several times (1935b; 1953), and states that, with increased height, differences in algal floras which are due to the presence of lime-rich versus soft-water habitats are not so "strong" (1949b).

Thunmark mentions the influence of mineral salts, iron content of the water, pH and the presence of "sphagnous" water (1942), and states that desmids are found in "nutrient-stuff"--poor, humus-rich waters, rather than in nutrient-rich waters (1945). Griffiths (1923) relates plankton composition to the presence of submerged macrophytes, and A. M. Smith (1942) believes that algal distribution and occurrence is influenced primarily by the nitrate content of the water. Wasylik (1961a) mentions that the largest number of desmid species was found in places changed by "human management."

Scott and Grönblad (1957) show the influence of temperature on algal distribution, and Prescott and Scott (1943) state that temperature, light and water chemistry are the most important factors influencing desmid distribution. Prescott (1948) mentions that low calcium and a pH below neutral are very favorable for the occurrence of desmids, and lists also organic acids and a high carbon dioxide content (1951b), humic acids (1953) and the possible occurrence of growth-promoting or

growth-inhibiting compounds (loc. cit.) as being influential in determining the character of algal floras. Hirano (1960), after an extended study of the waters of Japan, shows the importance of pH, humic acids and other dissolved organic matter, the presence of swamp water on (geologically) old formations and the concentration of the chloride ion on the occurrence and distribution of desmid floras.

The above represent only a precursory sampling of factors which have been held to have some influence in determining the nature of hard-water versus soft-water floras, especially in respect to the desmid component of such floras. Yet, an analysis of data from many of the studies cited above indicates that much of it does not agree with hypotheses of distribution which are expressed in the same study. As one example of this, Hirano (loc. cit.) indicates that: desmids are more numerous where the $KMnO_4$ consumption is from 10-25 mg./l., with an optimum probably around 15 mg./l.; the chloride ion has a great influence on the number of desmid species which occur in a habitat, and the largest number of such species occurs where the concentration of the chloride ion is low; the greatest number of species also occurs where the silica and sulfate contents of the water are low; finally, waters which are rich in desmids usually are poor in calcium. On these bases, how does one explain the observed difference in species number in the two study areas below, as recorded in Hirano's data?

	pH	$KMnO_4$	Ca	SO_4	Number of desmids
1	6.5	12.6 mg./l.	4.8 ppm	5.8 ppm	7
2	5.4	28.7 mg./l.	8.4 ppm	11.5 ppm	98

The concentrations of silica, chloride and iron were almost identical in the two study areas. Granted that chloride, calcium, sulfate, silica

and $KMnO_4$ consumption are similar and low in concentration in both areas, and that a large number of desmid species occurs under such conditions, why were only seven desmid species found in the first study area? The second study area showed actually higher concentrations of these, as well as a pH value at which a lower number of species might be expected. Yet, it contained far more species than did the first, and a significantly greater number, because the largest number of desmid species which was found in any one body of water during the entire study was only 128. The writer can only agree with Hirano in stating that it is "difficult" indeed to explain the observed distributions on the basis of the chemical composition of the water.

Similar examples could be cited from the results of many other studies of desmid distribution. But, it is clear that, if few evident generalizations can be made from an analysis of the data from a series of studies which have been made on a wider variety of habitats than was investigated in the present study, and where in many instances more chemical data are available for individual habitats, then little can be said in respect to the relative importance of the environmental factors which were studied in the present investigation. Such data as are included in the present study may become meaningful only when a large volume of comparative data from other studies becomes available and is subjected to a critical analysis and re-evaluation.

Also, there is a definite need for obtaining new kinds of data in addition to the ordinary physical-chemical data which have been gathered in the past. As is evident from the preceding portions of this paper, most studies of the relationship between desmid distribution and certain factors of the environment have dealt with inorganic, rather than organic,

constituents of the aquatic medium. Yet, it seems almost inconceivable that organic materials in the environment do not play some role in influencing the occurrence and distribution of desmids. This cannot be demonstrated positively on the basis of available evidence either from the present study, or from other studies; yet, if analyses of inorganic nutrients alone yield little information of general value, this may indicate that we are not measuring those factors of the environment to which desmids actually are responding. It would indicate also, perhaps, that our knowledge of the factors which are influential in the distribution of desmids will not expand or become meaningful until more emphasis is placed on an analysis of the role of dissolved organic matter in such distributions.

Some preliminary analyses or suggestions have been made in the literature in respect to the relationship between desmid floras and organic materials in the medium. Many investigators mention, for example, the presence and probable importance of "humic acids" or "sphagnous" water in habitats where desmids are abundant (Thunmark, 1942, 1945; Wesenberg-Lund, 1905; Messikommer, 1945, 1953; 1954b; and Prescott, 1948, 1951b, 1953, among others), and both Ruttner (1953) and Smith (1950) have commented on the probable importance of organic materials in influencing the selective nature of the bog biotope, or the composition of its flora. Hirano (1960) also has shown that optimum concentrations of such materials may be necessary for the growth of many desmids.

The possible role of dissolved organic matter in determining the floral composition in Purdy Bog has been indicated previously, especially in reference to the distribution of Euglenophyta. It is also true, however, that the marginal pools habitat in Purdy Bog, which contained the

largest number of euglenoids, and presumably, therefore, a rich variety of organic materials, also contained the largest number of desmid species. Although this may indicate a relationship between the occurrence of desmid species and the presence of dissolved organic matter in the water, none can be demonstrated positively. For, again, it would be necessary perhaps to know the kinds of materials which are present, rather than the mere fact that such materials are present, or are present in a certain concentration.

Thus, in the present study, little difference is evident in the concentration of dissolved organic matter in Lawrence Lake as compared with that of the center lake in Purdy Bog (Table XXII); yet, the desmid floras of the two are almost entirely different. The concentration of dissolved organic material in the main portion of Lawrence Lake varied from 17.1 to 28.2 mg./l., whereas that of the bog lake varied only between 22.4 and 34.9 mg./l. The former habitat supported only 26 desmids, whereas the latter supported 78 desmid species; of these, only 7 were common to both habitats. If such materials are influential in desmid distribution, then, it is probably through a qualitative, rather than a quantitative effect, because the range of concentration in both study areas is well within that which was found by Hirano (loc. cit.) to be favorable for the growth of desmids.

Other examples could be cited from the literature to demonstrate the difficulty of relating desmid distribution or the occurrence of desmid floras to particular factors of the environment. It is clear, however, that one can state but little in respect to the positive (or negative) influence of any of the "primary" environmental factors on the distribution of desmid species so far as numerical data alone are

concerned. Thus, one can make few, if any, generalizations in respect to environmental factors which may influence the relative number of desmid species which is found in a particular study area.

Chemical Factors and Species Composition

Yet, it is true, however, that many of the environmental factors which have been cited above may have some influence in determining the kinds of species which occur in a particular study area, especially when one eliminates from consideration those species which probably are ubiquitous. It is true generally, for example, that the desmid species which occur in acid bogs are different from those which occur in hard-water lakes. Certainly this is true in the present study, because the desmid species which occurred in Lawrence Lake were almost entirely different from those which were found in Purdy Bog. Also, most of the species which occurred in Lawrence Lake are similar to those which have been reported by other writers, especially Messikommer (1935a, 1960), Wehrle (1927) and Krieger (1933-1937), as being typical of hard-water lakes; only a few of these species ever occur in acid bogs. The same is true of the desmid flora of Purdy Bog; most of the species which were found in the bog occur typically in acid bogs, but rarely, if ever, in hard-water lakes.

Granting the truth of such observations, it is still not possible to state why such floral differences occur, even at the species level. It cannot be demonstrated, for example, why the bog species cannot invade the hard-water habitat, or why the species which were found in the hard-water lakes cannot exist in the acid bog. Certain of the species which were found in one area may not be able to exist in the other study area because of a lack of essential nutrients in the medium, or because

some necessary growth factors are absent; others may be restricted due to some toxic or inhibitory factor in the medium. Yet, usually only the latter factor is considered in any evaluation of floral differences which are noted in a comparison of two unlike habitats. Because of the large number of species involved, and the almost infinite combination of factors which might be influential in such situations, one would have to know more about the nutritional needs of individual species, or about their tolerance range to a wide variety of ecological factors, before demonstrating possible reasons for such restricted distributions.

One could not expect the results of the present study alone to yield conclusive evidence for the observed differences in species composition. Yet, a comparison of results from this study with those of related studies yields only little information of much significance. In many instances, for example, species which occurred together in other studies were separated in the present one. But, the data from many such studies are so meager that no reasons for these differences in association, or occurrence, can be postulated. In addition, many studies present data only for the pH or carbonate content of the water, but give little information as to the other chemical conditions in the habitat which was investigated. Also, much of the data given in distribution studies are concerned with an analysis of the number of species which occurred under a particular set of environmental conditions, rather than an analysis of the occurrence of individual species. Or, a listing of the species which were observed in a particular lake is published, but is accompanied only by the range of chemical conditions which were found in the lake over a period of time. From such information, one has no idea of whether the species occurred over the whole range of chemical conditions, or whether

they were present only within a more restricted range, because data are not given for individual collections. In other instances, data are based on an analysis of only one collection from a study area and include little chemical or floral information of comparative value; many such studies list only the pH of the habitat at the time the collection was made.

In certain reports also, it is difficult to determine accurately the chemical conditions under which certain desmids were living, because chemical data which are presented in the study are either misleading or are incomplete. Collections may be made from a variety of habitats in a study area, including littoral and bottom regions as well as planktonic habitats, yet chemical data may be given only for the open water. Many times, the desmid species which occur in these marginal or bottom areas are different from those which occur in the plankton, and such species probably are not responding to the same set of environmental conditions as are those which occur in the pelagic zone. Yet, either the species from non-planktonic habitats are listed as occurring under the environmental conditions which were found in the open water, or no chemical data whatever are given for the particular habitat from which they were collected. How, then, can one utilize such data in any comparative study?

That littoral or bottom floras can be quite different from that of the plankton is evident from the results of much of Messikommer's work. In 1945, for example, his data indicate that only one desmid occurred in the plankton of a lake which had a pH of 7.3, and an "Alkalinität" of 80 ppm $CaCO_3$. From squeezings which were made in the littoral zone of the same lake, however, he found 28 desmid species, a figure which represents the highest number which was found in any of

the 22 collections which were made in this particular study region. One cannot determine accurately, from the data cited in this study, the chemical conditions under which these 28 species actually were living, and yet such information would have been useful in an analysis of the distribution of certain species which were observed in the current investigation.

As one example of this, the squeezings from the littoral zone (which contained 28 desmids) included Cylindrocystis brebissonii, Closterium Leibleinii, Cosmarium cucurbitinum fa. minor and Penium species in the same sample. In the present study, Closterium Leibleinii was found only in the marginal pool of the hard-water lake, whereas all of the other species listed above occurred in Purdy Bog, many of them in the most acid habitats of the bog. Cylindrocystis Brebissonii is usually listed as a characteristic member of the community or association of algae which inhabits one of the most acid regions of a bog, the sphagnum mat: Wehrle (1927) lists it as a characteristic member of the society of algae which lives at pH 3.2 to 4.5; de Graaf (1957) states that it is an acidophilous or acidobiontic species; Harnisch (1929) lists it as a characteristic "Torfmoor" form which is found from pH 3.8-5.2. Such a series could be continued, for this species has been listed as being a characteristic species of sphagnum habitats almost wherever such habitats have been investigated (see Wasylik, 1961a), including the present study. Yet, it occurs also in the littoral regions of basic lakes: why, or under what conditions? If one states that this may be a ubiquitous species, then why doesn't it occur in the hard-water lake in the present study?

Answers to questions such as these (and to those which will be

presented in the following paragraphs) cannot be given on the basis of simple chemical data, such as the pH of the habitat; yet it is just such questions which must be answered before our knowledge of the factors which may be influential in the distribution of individual desmid species can be expanded or can become meaningful.

The Need for Critical Data

The dilemma which one faces in attempting to analyze the distribution of individual desmid species is that, although presently such knowledge can be gained only by making a painstaking analysis of the data from a series of isolated studies, such an analysis yields so much conflicting, or incomplete, information, that few positive statements or generalizations can be made. As was noted previously, much of the environmental data which are presented are so meager, or are of such questionable value, that they add little to our knowledge of the distribution of individual species. Yet, such data continue to be taken, in deference to more refined data.

Even from an analysis of more extensive chemical data, however, it is difficult to formulate any generalization which would explain the occurrence or distribution of individual species. Perhaps this is due, in part at least, to the fact that most studies of desmid distribution are broadly regional in their emphasis, and are concerned more with describing the general range of environmental conditions which are found in a series of habitats, than with describing the environmental conditions which may be peculiar to an individual habitat or study area.

More meaningful information on desmid distribution probably could be gained best only from a series of studies which were based on an

analysis of the distribution of individual species in relation to the micro-habitats which they occupy. Such studies would involve not only a thorough analysis of the chemical nature of these micro-habitats, but the utilization also of data from supplementary laboratory studies of the nutrition of "indicator" species. These studies would involve not only the isolation and culture of individual species from the particular habitat under study, but the concurrent investigation of the occurrence of these species in the natural environment, and of the environmental conditions under which they occur (see Provasoli, 1958). The need for such studies has been outlined earlier (see The Algal Flora of Purdy Bog), and need not be fully described again here.

This kind of approach to the problem would of necessity lead to a long and involved study which probably could not be undertaken by one person. It would involve, and would necessitate, the cooperation of taxonomists and ecologists with biochemists, physiologists, ecologically-minded nutritionists and other specialists, such as analytical chemists. The need for such an approach is evident not only from an analysis of the results which have been presented in the present study, but from a survey of the range of environmental factors which one would have to investigate in any attempt to analyze the distribution of individual species (see Provasoli, *loc. cit.*, for example), or to characterize a particular habitat.

Initially at least, one would not have to isolate or to study all species which are found in a particular habitat in order to attempt to characterize the habitat. Rather, an attempt should be made to determine the nutritional requirements of the ecologically-important or "indicator" species (Provasoli, *loc. cit.*). It is obvious, for example, that one

could not attempt to investigate all of the desmid species which were observed in the present study, nor is it possible to obtain complete chemical analyses of individual habitats, especially in respect to the quantitative aspects of dissolved organic matter. But, much useful preliminary information on the chemical nature of desmid habitats could be gained, perhaps, from a critical investigation of one particular species; Eremosphaera viridis.

This species has been found so frequently in association with desmids, or in "rich" desmid habitats, that it is regarded by many phycologists as an indicator of a "good" desmid habitat. In the present study, this species was almost restricted to the marginal pools in Purdy Bog; the same habitat which contained the largest number of desmids of any habitat which was investigated. The only other habitat in which it occurred was the lake bottom in Purdy Bog, a habitat which contained the second highest number of desmids. E. viridis was absent from the sphagnum habitats, where only 20 to 22 desmid species occurred, and it was never found in Lawrence Lake. Thus, it occurred only in habitats which contained a large variety of desmids.

The writer knows of no critical study of the metabolism of this species, and thus there is no direct evidence that it may prove to be an indicator species. But, if one could discern the particular set of environmental conditions under which this species can exist, or any nutritional requirements which may be peculiar to this species, such information might prove to be of significant value in any attempt to describe the general range of chemical conditions which are favorable for the growth of a large number of desmids, or to determine the particular set of environmental factors which may characterize a desmid

habitat. At least, such information probably could be used to characterize the desmid habitats which were observed in the present study.

Using this information as a basis, then, one could make a more critical analysis of individual habitats than might be possible by using conventional methods. If, as has been stated by Provasoli (1958),.one can extrapolate data from carefully refined nutritional studies to the natural environment, this search for, and utilization of, indicator species may prove to be one of the most useful analytical tools for determining finally the peculiar set of environmental conditions to which individual species may respond, or under which they can occur in the natural environment. At least, it might demonstrate what knowledge must be gained before one can discuss or attempt to understand the distribution of desmid species.

Such an approach becomes necessary because, on the basis of our present knowledge, one faces only confusion in any attempt to relate the occurrence or distribution of individual algal species to the abiotic or biotic factors of their environment. Much of this confusion probably arises because we have not yet learned to recognize those factors to which the individual species are responding, or those factors which characterize a particular kind of habitat. Lackey (1938) recognized this when he stated that, although in general we tend to correlate definite habitat types with particular protozoa or groups of protozoa, we fail to recognize the specific factors which are favorable or restrictive to such habitats. The same probably can be said in reference to desmid species and to desmid habitats.

In addition, it must be emphasized again that many of the environmental factors which may be influential in the distribution of algal

species cannot be detected chemically in nature (Provasoli, *loc. cit.*). This is especially true of organic micro-nutrients.

Distribution of Euglenophyta

Ordinary chemical analyses also may be insufficient to explain the differences which were noted in respect to the distribution of other algae, especially Euglenophyta, in the two study areas. As was noted earlier, one of the greatest differences in the algal floras of Purdy Bog and Lawrence Lake is the representation of Euglenophyta species. Only three species of this phylum were ever noted in Lawrence Lake, as compared with 41 in the bog. In all, only 42 species were observed during the study. Therefore, this represents a valid difference between the two floras, and necessitates some further discussion of this group.

Two of the three species which occurred in Lawrence Lake were found only in the outlet portion, for which no extensive chemical data are available. These are *Trachelomonas volvocina* (probably a ubiquitous species; see Graffius, 1958) and a species of *Anisonema* which could not be determined because only two cells were observed. The third species, *Euglena variabilis* Klebs (?) has been described by Pringsheim (1956, p. 63) as a species which occurs in quiet waters which are rich in organic residues, and often in association with Volvocales. Yet, Volvocales were almost entirely absent in Lawrence Lake, and the waters are not rich in organic matter.

A more critical study of this latter species is needed before any generalizations can be made concerning its distribution, however. First, because only two or three specimens ever were observed during the course of the present study, only a tentative determination of this species

can be made. Our specimens agree well with available descriptions of the species, especially those of Skuja (1956) and Huber-Pestalozzi (1955), but, because it has been observed so rarely, little can be said in respect to a definitive determination. In addition, Skuja (loc. cit.) and Pringsheim (loc. cit.) disagree as to certain features of its internal morphology, so that more critical taxonomic work is needed before one can be certain that all authors are discussing the same species. These taxonomic problems may lead to confusion in any attempt to describe the distribution of the species, or the chemical conditions under which it occurs. Thus, although Pringsheim (loc. cit.) states that *E. variabilis* occurs only in waters which are rich in organic matter, Skuja (1948, p. 191) found it "*in Wasseransammlungen auf der Zenitflache des Felsens unweit des Laboratoriums, 1 m. uber dem Niveau.*"

Therefore, one can say but little about the occurrence of euglenoid species in Lawrence Lake, or about possible reasons why such species occur, because of a lack of critical data of comparative value from the literature, and the fact that available chemical data are not complete enough to allow for any definitive discussion of the nutrition of these species.

It is evident again, however, that the algal flora of Lawrence Lake is characterized not by the presence of the few euglenoids which do occur, but by the almost complete absence of members of this phylum. Based on the preceding discussion of euglenoid ecology (in The Algal Flora of Purdy Bog), almost any number of hypotheses could be erected to explain the absence of these species; yet no positive reasons can be given. Because it is true that most members of the Euglenophyta require certain organic compounds or organic micro-nutrients for growth to occur, this may indicate that the waters of Lawrence Lake are deficient in certain

necessary organic compounds such as vitamins or amino acids. But, many species also prefer waters which are rich in available ferrous compounds and ammonium salts, and cannot utilize nitrate as a source of nitrogen (Pringsheim, loc. cit., Provasoli, 1958). Therefore, one would have to analyze critically the range of inorganic compounds which occurred in the water, and determine the particular form in which they were present. Such analyses appear to go beyond the realm of the present study; in addition, as was noted earlier, many of these influential factors cannot be detected chemically in nature.

The need for a more critical study of the chemistry of hard-water lakes in relation to the occurrence of euglenoids is evident also from the results of previous studies. It has been shown that other lakes having chemistries similar to that of Lawrence Lake (so far as available data indicate) can support a significant euglenoid population (Tressler, et. al., 1940), and de Graaf (1957) has stated that the majority of euglenoid species occur on the alkaline side of neutral. If this is true, why are euglenoids almost entirely absent from Lawrence Lake? It may be that such species can occur in alkaline lakes, if suitable organic materials are present in the water; but, these aspects must be investigated before any generalizations can be formulated.

Thus, a wide variety of factors would have to be analyzed before one could discuss adequately either the distribution of euglenoids as noted in the present study, or the distribution of euglenoids in general. On the basis of existing data, it does not seem to be possible to explain adequately the noted difference in the occurrence of euglenoids in the two study areas.

Other Algal Groups

Such a statement hold true not only in respect to the distribution of Euglenophyta or desmids, but to that of other algal groups as well. This is especially true because we probably know even less about the environmental factors to which these species may respond than we do about those to which euglenoids or desmids respond. The one exception to this is the Cyanophyta, a group which has been discussed previously in the description of the algal flora of Lawrence Lake.

When one surveys the multiplicity of factors which may influence the distribution of algal species, as well as the heterogeneity of algae as a group, and the interactions which may occur among or between these abiotic or biotic components, the difficulty of assessing the relative importance of any one individual factor, or of deriving any generalization from the study of algal distribution, becomes apparent. Much of this is due to the fact that we need to know more about the occurrence of individual species and the range of environmental conditions under which they can exist. All such studies should be based on an analysis of the total flora of a habitat in relation to the total spectrum of the physical-chemical features of the habitat.

Because many algal groups are studied so rarely, one can say but little about their distribution. This is especially true of the Pyrrhophyta, motile Chrysophyta and Euglenophyta. Few studies either of acid bogs or of hard-water lakes have included analyses of the occurrence of members of all algal phyla, and it is difficult, therefore, to compare the results of individual studies, or to theorize concerning the nature of such environments.

Studies which list only the diatoms which occurred in a hard-water

lake, or the desmids which occurred in an acid bog, for example, give no indication as to whether other ecologically-important groups of algae were present in the same habitat. Thus, nothing can be said of the possible relationships or associations of algal species which might aid in characterizing individual habitats. It is interesting to note in the present study, for example, that the largest number of euglenoid species occurred in the same habitat which supported the largest number of desmids and other algae (the marginal pools in Purdy Bog), whereas a much smaller number of desmids was found in Lawrence Lake, where euglenoids were almost non-existent. This may indicate that a richer desmid flora develops in habitats which contain the same kinds of materials which are necessary for the growth of euglenoids in general, and that many of these materials may be of an organic nature. Yet, to what extent such a relationship holds true in other situations is not evident, because in most instances Euglenophyta are not studied.

The Need for Further Study

Thus, even though many generalizations have been made in respect to algal distribution on the basis of broad regional studies, few, if any, generalizations can be made as a result of the current one. This may indicate that broad generalizations cannot be applied to the investigation of phenomena in individual study areas, and that some re-appraisal or re-evaluation of these generalizations is needed. Such results also may indicate that major emphasis in studies of algal distribution has been directed toward an approach from which few evident generalizations can be made. A more equitable approach would be to study critically floral distributions and environmental factors within selected habitats,

and then to apply the results of such researches to distributional phenomena which are noted in broad regional studies. It is only from such analyses and syntheses of data from individual study areas that meaningful generalizations can be formulated ultimately.

The writer thus is not prepared to state that the results of the current study can either substantiate or invalidate present ideas concerning the reasons for the floral differences which are noted in a comparison of hard-water versus acid bog habitats. Only further research on the floras of individual habitats, involving an analysis of the occurrence and distribution of individual species, ultimately will enable one to understand the selectivity of these aquatic biotopes.

Distribution of Selected Species

The need for a more critical analysis of algal species distribution has been stressed throughout this paper, along with the need for a more critical analysis of the environmental factors to which such species may be responding. Based on our current knowledge, the occurrence and distribution of many species which were observed in the present study cannot be explained. Although it is not pertinent to discuss each of these species individually, some further analysis of the distribution of several may serve to emphasize the need for further research on the ecology of individual algal species.

The distribution of several species which apparently are limited to one type of habitat, or to one region of the Purdy Bog study area has been described previously; these species are listed in Tables XIX and XX. Several of these might be expected to show a wider distribution throughout the various habitats of the study area, at least on the basis

of results from other studies.

Because of the similarity which was noted between the floras of the center lake and marginal pools in Purdy Bog, and because the marginal pools support a greater number and variety of species than does the center lake, one would expect to find few species which are restricted to the center lake. That this is true is evident from a comparison of Table XIX and XX.

Because so few species were restricted to the center lake (Table XIX), this may indicate that many organisms which are found typically in the plankton can exist in other habitats as well. The question which cannot be answered, however, is, what is the origin of those species which can exist either in the plankton or in mat habitats? Have these species evolved in planktonic habitats and then invaded the terrestrial habitats, or have many of the shore forms been washed into limnetic habitats? These questions will be examined again in a later paragraph.

Of the species which apparently are restricted to the bog center lake, many should be expected to occur in the marginal pools as well, because the waters of these two habitats are interconnected, and available chemical data indicate that the water chemistry of both is similar. In addition, several species which occurred only in the center lake at Purdy Bog were found in the waters of Lawrence Lake under an entirely different set of chemical conditions; one of these is *Oscillatoria limosa*. If this species can be dispersed a distance of one and one-half miles from one lake to the other, why can't it exist in pools located a few feet away from the center lake? Such observations may indicate the need for more critical taxonomic and physiological studies of algal species which show such aberrant distributions.

Other examples such as this could be cited, but the investigation of the reasons for such distributions, or the extent of noted restrictions would be a problem in itself, and could not be investigated further in the present study.

Also, a large number of species were restricted to the mat habitats, never being observed in the center lake. This raises again the question of the origin of lake plankton, a question which is still largely unresolved. Wesenberg-Lund (1905) believes that moss-covered hillsides and terrestrial pools are the "home of plankton desmids," and that a plankton flora is derived, then, from pools or similar habitats in the immediate vicinity of a lake. Other investigators (see G. M. Smith, 1925b) hold that the plankton flora of a lake is derived not from the immediate area, but from other planktonic habitats lying some distance away. This would indicate that there has been an evolution of planktonic species entirely within limnetic habitats.

In the present study, where such short distances are involved, and where there is a direct interconnection of the waters of the center lake and marginal pools, one would expect to find many more pool species in the center lake than apparently are present, assuming that the plankton is derived from surrounding regions of the bog. Yet, this apparently does not hold true.

These observations also may indicate the need for a more critical analysis of the water chemistries of these two habitats, especially in respect to dissolved organic matter. Such analyses would be necessary to explain the difference in the euglenoid flora of the two habitats, and might help to explain differences in the occurrence of other species as well.

Even more interesting is the question, from where are these marginal pool species derived? Certainly not from the sphagnum mat, but neither do they all originate from the center lake, because over 100 species occurred only in the marginal pools. On the basis of the present data this question cannot be answered; yet, it has implications which go beyond the realm of the present study.

In addition, many organisms which were noted only in the mat habitats have been found more typically in the plankton in other studies (e.g., Asterococcus limmeticus). The reasons for, and the extent of, such differences are unknown, but further observations from a variety of environmental situations would appear to be necessary before one could make any broad generalizations about the occurrence or distribution of such species.

As was noted earlier also, many species which occurred only in one or the other of the two study areas in the present investigation have been found together in other studies. The report of Tressler, et. al. (1940) is particularly interesting in this respect. An analysis of the data from their study indicates that 25 Chlorophyta and Cyanophyta which occurred in Buckeye Lake, Ohio, also were observed during the present study. Of these species, eight (Chroococcus turgidus, Merismopedia elegans, M. glauca, Oscillatoria limosa, O. princeps, O. tenuis, Coelastrum sphaericum and Scenedesmus bijuga) occurred in both Lawrence Lake and Purdy Bog. Seven species, including Pleurotaenium Trabecula, Closterium Ehrenbergii, Cl. Kuetzingii, Crucigenia rectangularis, Anabaena flos-aquae, Microcystis aeruginosa and Pediastrum Boryanum, occurred only in Lawrence Lake. Such results might be expected, because the available chemistry for Lawrence Lake and Buckeye Lake indicates

that both are hard-water, basic lakes (the pH of Lawrence Lake varied between 7.2 and 8.2; that of Buckeye Lake from 7.3 to 8.9). Yet, 10 species which occurred in Buckeye Lake were found only in Purdy Bog in the present study. Among these are Ankistrodesmus falcatus, Closterium acerosum, Cl. acutum, Cl. pronum, Pediastrum tetras, P. duplex, Scenedesmus armatus, S. dimorphus, S. quadricauda, and Selenastrum Bibraianum; all are species which are reported commonly. If these 25 species occurred together in Buckeye Lake, why were 17 of them separated in the present study? Almost all could be expected to occur in Lawrence Lake, yet only 15 of them did.

Even more interesting is the occurrence of Selenastrum Bibraianum in Buckeye Lake. In the current study, this species was found in the marginal pools of Purdy Bog, but in no other bog habitat; nor did it occur in Lawrence Lake. To what factors of the environment is this species responding?

Related somewhat to the above problem, and to the need for further observations and more critical analyses of the occurrence of individual algal species, is the distribution of certain taxa which are discussed in greater detail below. These species show, in the current study, either an interesting habitat selectivity, a narrow range of tolerance to certain environmental factors, or a distribution which is not explainable on the basis of results which have been published by other investigators. Most of the data below relate to pH tolerance alone, a factor which has been discussed critically in earlier sections. Many of these observations merely reiterate the questionable role of pH as a factor in algal distribution. But, because it has been used so widely as an index to distribution, a few specific examples have been chosen

which raise some rather interesting questions.

Ceratium hirundinella (O.F.M.) Schrank

This species apparently does not occur at a pH value much below 6.5. Its range of tolerance to pH is listed usually in the literature as being from 6.7 to 7.3. It can exist above 7.3, however, because it occurred frequently in Lawrence Lake, and always at a pH which was above 7.5. It was absent from Purdy Bog, where the highest pH value recorded was 6.5. The writer (1958), however, noted it in a different bog lake which had a pH range (seasonally) of 6.0 to 6.4; it occurred only at a pH of 6.4, and never at a lower value. Nevertheless, it can exist in bogs, but not in Purdy.

This species probably finds optimum conditions for growth in an alkaline medium, because blooms usually are reported only from hard-water lakes. Because this is such a biologically-important species, it would be interesting to determine the factors other than pH which may influence its growth or development.

Cosmarium pseudoconnatum Nordst.

This species occurred in both study areas; at a pH of from 5.4 to 6.0 in Purdy Bog, yet never below pH 8.0 in Lawrence Lake. According to Budde (1944), it finds optimum development from pH 5.0 to 5.5. Yet, it was common to abundant in both lakes when it occurred. If this species can exist at pH 5.4 to 6.0 in the acid bog, why doesn't it occur at a value below pH 8.0 in Lawrence Lake?

Cosmarium Botrytis Menegh.

Observed in the present study only in Lawrence Lake, at a pH value

always above 7.2. In agreement with this, the species is reported commonly from basic lakes, both in Europe and North America.

Yet, Irénée-Marie (1954) reports it from pH 5.4 to 8.0; Wehrle (1927) records its range as pH 5.5 to 7.8; Wasylik found it at pH 4.4 to 5.6 and Strøm (1926) reported it at pH 5.0, all within the pH range of the habitats in Purdy Bog. If the species occurs at Lawrence Lake, and can exist within the pH range of the Purdy Bog habitats, why doesn't it occur there?

Such observations probably indicate again that we have not yet learned to recognize the environmental factors to which this species actually is responding. The same may be true of many of the other species which were observed during the current study.

Closterium _Leibleinii_ Kuetz. and _Closterium_ _parvulum_ Naeg.

Wehrle (1927) lists the pH of _Cl_. _Leibleinii_ at 4.5 to 8.2, and that of _Cl_. _parvulum_ at 5.0 to 8.2. Yet, although _Cl_. _parvulum_ was found in both study areas, and within the entire pH range listed by Wehrle, _Cl_. _Leibleinii_ was found only in Lawrence Lake, at a pH above 7.2. Irénée-Marie (1954) records the latter species at pH 5.5; why, then, doesn't it occur in any of the habitats in Purdy Bog?

Closterium _Ehrenbergii_ Menegh.

Hirano (1960) found this species only between pH 5.0 and 6.0, well within the range of the Purdy Bog habitats. Yet, in the present study, it occurred only in Lawrence Lake at a pH above 7.2. The need for further observations on the distribution of this species is evident.

Closterium acerosum (Schrank) Ehrenb.

According to the observations of Irénée-Marie (1954), this species occurs over a pH range of from 7.5 to 8.0, within the range of Lawrence Lake. Tressler, et. al. (1940) reported it from a lake having a pH of 7.3 to 8.9. In the current study, it was found only in Purdy Bog, over a pH range of from 5.2 to 6.5.

Closterietum commune Association

Laporte (1931) has listed a Closterietum commune association which includes many supposedly ubiquitous and calcareous-tolerant desmids. Yet, many of the species which comprise this association, and which therefore have been found growing together in other studies, were found only in one or the other of the two study areas here, and never together. Among these species are: Closterium acerosum, Cl. aciculare, Cl. cornu, Cl. Dianae, Cl. Ehrenbergii, Cl. Leibleinii, Cl. lunula, Cosmarium Botrytis and Staurastrum tetracerum.

Laporte's association was not erected without due thought, and was based on an extensive survey of the results of other investigators as well as his own. But, if such species really are ubiquitous, or grow typically in association with one another, why were they not found in association during the present study, or in both study areas?

Desmidium Grevillii (Kuetz.) DeBary

This species was collected from a marginal pool in the vicinity of the writer's other habitats by Dr. G. W. Prescott, and during the course of the present study. Although it was abundant in that particular sample, it has never been observed since, in any sample which has been collected from any other habitat in the bog.

Dimorphococcus lunatus A. Br. and Selenastrum Bibraianum Reinsch

These species were collected from only one of the three marginal pools in Purdy Bog; under acid conditions, and throughout the year. Yet, they never occurred in any other bog pool, even those which were only a few feet away. The water of adjacent pools intermixed during the spring with the water which contained these species, in addition to which it was almost impossible not to cause some mixing to take place during sampling. What factors could be responsible for the restricted occurrence of species such as these and Desmidium Grevillii, cited above? As noted earlier, S. Bibraianum has been found at a pH as high as 7.3 to 8.9, and in other hard-water lakes; Welch (1936a) records Dimorphococcus lunatus at pH 7.2 to 9.4. Why, then, did these species not occur in Lawrence Lake? Even more important is the question, why didn't they occur in other habitats of the bog?

Staurastrum furcigerum Bréb.

Wasylik (1961a) found this species at a pH range of 4.6 to 5.6, and Strøm (1926) reports it at pH 6.5 and 7.8. In the present study, it occurred only at pH 8.0 in Lawrence Lake. If it can occur over a pH range of from 4.6 to 8.0 why doesn't it occur in Purdy Bog?

Microcystis aeruginosa Kuetz.; emend. Elenkin

This species is well known as a typical inhabitant of basic or hard-water lakes. In the present study, it occurred only in Lawrence Lake, at a pH above 7.2. Wasylik (1961a) reports it as a pH range of 3.7 to 5.6. One can only wonder whether all authors have observed the same species. If so, why isn't it reported more frequently from acid habitats?

Micrasterias floridensis var. spinosa Prescott and Scott

This species was described by Prescott and Scott (1943) from Florida, and apparently has never been reported again until now. The writer has observed only one (damaged and apparently non-living) cell of this species, which was collected beneath an ice cover. Its discovery is interesting for several reasons. First, it shows the difficulty of plotting the distribution of such rare (or rarely-found?) species; if it has been observed in Michigan and in Florida, why not in the states in between? Second, because no living cells were ever observed, does this mean that the observed cell is a relict of an earlier period when it might have been more common, or that it is a remnant of a population which found favorable conditions for growth only during a short period of time? Or, does it represent the chance discovery of cells deposited by wind or waterfowl from another region? It would be interesting to note whether this species is ever found again, either in this bog, or in other Michigan lakes, at a later date.

Euastrum hypochondrum fa. decoratum Scott and Prescott

Also described by Scott and Prescott (1952) from Florida, this species poses an interesting problem in desmid distribution. In addition to the fact that it was known only from the original location in Florida prior to the present study, its occurrence as observed here was erratic. Although it was common in Lawrence Lake from June to October of 1959, it had never been observed previous to this (i.e., during 1958), and was noted only rarely subsequently, a few cells occurring in September, 1960. How can one even attempt to explain, or to understand, the occurrence of distribution of such species?

Hyalotheca mucosa (Mert.) Ehrenb.

Strøm (1926) found this species at a pH of from 3.8 to 8.0, and it was found in the present study over a pH range of 5.0 to 8.0, so evidently it has a broad range of tolerance to pH. The interesting aspect of its occurrence, however, is that, although it was found during 10 months out of the year in Purdy Bog, it was observed in only one collection from Lawrence Lake during a time span of two years of study.

Other examples similar to those cited above could be given here also. Differences which were noted in the occurrence or periodicity of several species which were "common" to both study areas have been discussed in the preceding section, however, and need not be repeated here.

In addition, many species were observed which could exist in the center lake, lake bottom and marginal pools habitats of Purdy Bog, as well as in the hard-water lake; yet these species apparently could not exist in either the sphagnum mat or sphagnum pool in Purdy Bog. Among these species are: Botryococcus Braunii, Closterium parvulum, Cosmarium pseudoconnatum, Hyalotheca dissiliens, H. mucosa, Micrasterias denticulata, Netrium digitus, N. digitus var. lamellosum, Pleurotaenium Ehrenbergii, Scendesmus bijuga, Sphaerocystis Schroeteri, Oscillatoria princeps, Peridinum Willei, P. Willei fa. lineatum, Dinobryon cylindricum, D. sertularia, Synuropsis danubiensis, Tabellaria fenestrata and Uroglena botrys.

Other species could withstand not only the most acid environments of the bog, (the sphagnum mat and pool), but could occur also in the outlet portion of Lawrence Lake, at a much higher pH. Among these are Cryptomonas ovata, C. erosa, Vacuolaria virescens, Synura sphagnicola,

S. uvella and Trachelomonas volvocina. Yet, to state that all such species are ubiquitous does not necessarily explain these observations. Vacuolaria virescens, for example, is not even included by G. M. Smith (1950), and therefore apparently has not been observed previously anywhere in the United States.

Some further evaluation of many so-called ubiquitous species may be indicated by the above observations. Are such species really ubiquitous, or have we just been unable to recognize the critical environmental factors to which such species are responding, or which may be influential in their distribution?

Many other examples such as the above could be cited, but suffice it to state that, if we cannot explain adequately the distribution of these individual species, as observed in adjacent habitats, how can we even attempt to make any generalizations concerning the distribution of algal floras in general, or of the algal species which are characteristic of a particular type of habitat? As was noted earlier also, the species occupants of many of the habitats in Purdy Bog were so different from one another that almost no similarity could be seen in a comparison of these. If one thus cannot characterize the flora of Purdy Bog as a whole, and notes many floral differences in a comparison of the various habitats in Lawrence Lake, plus differences in the occurrence of these species as noted from the results of other studies, how can one discuss the algal flora which is typical or characteristic of a bog or an alkaline lake? Yet, one continues to see in the literature, and even in respected texts, statements such as: "The microscopic world of life of these aquatic bog biotopes, often filling the shallow bog puddles in particular with a grey-green soup, is if possible even more characteristic than the

surrounding macrophytic vegetation. Its features on the whole are so uniform wherever bogs occur, both in the arctic and temperate regions as well as in the mountainous regions of the tropics, that a quick look into a microscope is sufficient for recognition that a given sample belongs ecologically to these biotopes" (Ruttner, 1953, p. 192). Or, "With samples of algae, a fleeting glance in the microscope is often sufficient to establish whether they came from acid or alkaline water" (Ruttner, loc. cit., p. 61).

The problem of studying the distribution of individual species is complicated also by the fact that algal species are just as variable in their characteristics as are other taxonomic entities. But, one cannot be certain many times from taxonomic lists alone whether a particular author observed the same expression of the species as did a different author, because in many instances only the species itself is named; yet, the author may have observed a variety of the species and failed to differentiate this from the typical. That such distinctions may be important in studies of algal distribution should be evident from only a few examples which are cited below. In addition, observations on the occurrence of several of these taxonomic expressions in the present study differ from those which are reported in the literature, but the reasons for this are not obvious.

Xanthidium antilopaeum (Bréb.) Kuetz. and varieties

X. antilopaeum occurred in the present study only in Lawrence Lake, at a pH of from 7.8 to 8.0. Yet, Wasylik (1961a) reports it at pH 4.2 to 5.6, and states that it is characteristic of all Weiss and Braunmoores; Strøm (1926) found it over a pH range of from 5.0 to 7.8, Wehrle (1927)

lists it over a pH range of 4.2 to 7.0, and Hirano (1960) found it a pH of 4.9 to 6.8. If the typical species can occur over such a broad range of pH, why doesn't it occur in Purdy Bog?

This question becomes even more meaningful when it is emphasized that, although the typical species itself never occurred in the bog, two varieties did. Both X. antilopaeum var. polymazum Nordst. and X. antilopaeum var. minneapoliense Wolle occurred in Purdy Bog, yet neither ever occurred in Lawrence Lake. Do these observations indicate that the varieties are adapted to different habitats than is the typical (Yet, the typical is reported from acid habitats more frequently), or that certain morphological expressions of a species may change in response to different environmental conditions? Or, do they indicate that more critical observations, both taxonomically and ecologically, must be made on these species expressions?

One report by Messikommer (1935b) is particularly interesting in respect to the distribution of Xanthidium species. He states that it is noteworthy that not one Xanthidium was found in the alpine region he was investigating, and that this can be ascribed to the carbonate (lime) richness of the water. Messikommer cites an earlier work of Huber-Pestalozzi in support of this, which indicates that X. antilopaeum avoids lime areas in the Alps; but Messikommer states further that this holds true in the Alps only, because Xanthidium is found in low altitude areas where the water has a significant lime content. Why should a genus or species avoid lime-rich areas in mountains, yet tolerate lime-rich waters at lower elevations?

Pleurotaenium Trabecula (Ehrenb.) Naeg. and varieties.

In the present study, Pleurotaenium Trabecula and P. Trabecula

var. maximum (Reinsch) Roll. occurred only in Lawrence Lake, at a pH between 7.8 and 8.0, whereas P. Trabecula var. rectum (Delp.) W. West occurred only one habitat, at a pH below 6.5.

In agreement with these results, Wehrle (1927) found P. Trabecula at 7.8 in a marly lake, and Tressler, et. al. (1940) report it at pH 7.3 to 8.9. But, Wasylik (1961a) states that P. Trabecula was more common than the var. rectum in all bog habitats which he investigated; both occurred within the same pH range, P. Trabecula from 4.2 to 5.6, and the var. rectum at pH 4.6 to 5.6. Strøm reports that P. Trabecula occurs at pH 6.5, but not at pH 5.0, 7.5, or 7.8. If P. Trabecula and the var. rectum can occur together, why were they separated in the present study? Thus, why didn't P. Trabecula occur in the acid bog?

Netrium digitus (Ehrenb.) Itzigs. and Rothe and N. digitus var. lamellosum (Bréb.) Grönblad

Netrium digitus showed a broad distribution and occurrence in the acid bog, being found during 11 months of the year, and in four different habitats. Wehrle (1927) states that this species is wholly absent under alkaline conditions; yet it occurred also in Lawrence Lake, at a pH between 8.0 and 8.2. The interesting aspect of this latter observation is that it occurred in only one collection; but, in this one sample, it was present in all three open-water habitats of the lake.

Netrium digitus var. lamellosum was found during all months of the year in Purdy Bog, and in a variety of habitats, yet was noted only in two collections from the hard-water lake.

If such forms can exist over a much longer time span in the bog, why were they observed so rarely in the hard-water lake? To what factors of the environment are they responding?

Closterium Dianae Ehrenb. and C. Dianae var. pseudodianae (Roy) Krieg.

In the present study, Cl. Dianae occurred only in Lawrence Lake, at a pH above neutral. Yet, Hirano (1960) reports it from pH 4.8 to 7.2, and Wehrle (1927) records it from pH 5.0 to 7.8. Cl. Dianae var. pseudodianae occurred only at a pH below neutral, in Purdy Bog. If the typical species occurs at least from pH 4.8 to 7.8, why didn't it occur in Purdy Bog?

Many authors regard the variety as a separate species, Cl. Pseudodianae. The writer knows of no study in which both expressions have been reported from the same habitat.

Micrasterias truncata (Corda) Bréb. and varieties

Micrasterias truncata and the var. crenata were found only in Purdy Bog, and throughout the year. M. truncata var. semiradiata (Naeg.) Cleve occurred only in Lawrence Lake, from August to October.

Desmidium Swartzii C. A. Agardh and D. Swartzii var. amblyodon (Itz.) Rabenh.

Typical D. Swartzii never occurred in the present study, but the var. amblyodon occurred only in Lawrence Lake, and at a pH above neutral. D. Swartzii is reported commonly from acid waters.

Chroococcus turgidus (Kuetz.) Naeg. and C. turgidus var. maximus Nyg.

Chroococcus turgidus was found in both study areas, but the variety maximus occurred only in Lawrence Lake. The latter taxon probably is of more frequent occurrence than records in the literature would indicate, because it is very similar to C. giganteus W. West. Only C. giganteus is reported from this country, however.

These last few examples emphasize again the need for a careful determination of varietal expressions of a species, since in many cases these may be adapted to different ecological conditions. An inaccurate determination of these could lead, therefore, to misleading interpretations of data on the occurrence or distribution of these taxa.

It should be evident from this brief discussion that more critical data are needed before one can even begin to understand the distribution of many of the species which were observed in the current study. Such data can be gained best only from an analysis of individual species in relation to the whole range of external factors, both biotic and abiotic, which constitute their environment.

Implications of the Study

It is evident from an analysis of the preceding sections that our knowledge of the temporal and spatial distribution of algae is far from complete. More information is needed both in respect to the distribution of algal species *per se*, especially their local distribution, and in respect to the relationship between observed distribution patterns and the environmental conditions under which individual species may occur. The need for further study of this problem has been stressed throughout this paper, and several suggestions for future studies have been made in various sections. It is appropriate, therefore, to outline briefly some of the major implications of the present study which might be useful in any future investigation of algal distribution, and to describe briefly the major gaps which exist in our present knowledge of this subject.

1. A more critical analysis of individual algal species is needed, both in respect to their temporal and spatial distribution, and to

variations in their morphology and physiology. Because of the variation which is inherent in algal species as well as in other biological entities, it is apparent that one must investigate, and subsequently must be cognizant of, morphological or physiological variations within a species which might have taxonomic or ecological implications, and thus implications in respect to an analysis of the distribution or occurrence of these taxa.

2. It is evident that more critical floral and chemical analyses must be made of individual habitats within a study area if our knowledge of the factors which are influential in algal distribution ever are to be understood. Most studies of algal distribution still are broadly regional in emphasis, yet the major conclusions from such studies probably do not aid in explaining distributions which may be observed within the bounds of a relatively uniform environment. Yet, it is in just such a situation, where dispersal can be almost eliminated as a factor, and where much of the water chemistry shows similarities, that critical factors could be evaluated more readily than in a comparison of two unlike habitats which may be separated by great distances. It is apparent also that, the greater the difference between the environmental conditions of two habitats, the easier it is to attribute any floral differences noted in a comparison of the two to corresponding differences in the environment. It is much more difficult to explain floral dissimilarities noted within the bounds of a relatively uniform environment, however, because of the general similarity of environmental conditions. Nevertheless, it is probably only under such conditions that one finds in the natural environment a suitable arena for a study of the critical factors to which individual species are responding. That floral differences may be extreme within any one study area is evident from the fact that, in the present study,

differences equal to, or in some cases greater than, those shown in a comparison of the algal flora of the acid bog and the hard-water lake have been demonstrated within the bounds of the acid bog itself.

3. Related somewhat to the above is the need for more frequent collections within a study area, and the necessity of extending observations over a longer period of time. Lacking such critical studies, one cannot explain, or even detect, phenomena such as "short-cycle" periodicity, or the rare occurrence of certain species. Several specific examples of these phenomena have been mentioned earlier, and an analysis of Table I should serve to emphasize the fact that many species were observed so rarely that little can be said in respect to the extent of their distribution spatially or temporally. If this is true, it is even more difficult to attempt to evaluate the environmental factors or changes to which such species may be responding. Only more frequent and sustained observations of individual habitats may eventually enable one to unravel the complexities of such distributional phenomena.

4. Investigations of individual study areas or habitats should include an analysis of their "total" algal flora if our understanding of the relationships or interactions between algal species is to expand, or if we are ever to understand why certain associations of algae occur in a particular habitat. It is difficult also to compare results of one study with those of another unless complete data are given for all floral components.

5. Studies of the natural environment of an organism should be supplemented by critical laboratory studies of the physiology and nutrition of algal species which have been isolated from the same environment. Because ordinary chemical analyses may not detect the presence of certain

potentially ecologically-important constituents in the natural environment, and, because of the complex nature of the aquatic medium, resort must be made to refined laboratory studies, where components may be varied systematically under controlled conditions. Both types of study should be made, however, as it is believed that neither one alone would serve adequately to delimit the ecologically-important parameters which may influence the distribution of algal species.

6. Along with the above aspect should be included the inference that more complete analyses of the chemical constituents of the natural environment must be made. Many investigators study only one, or at best a few, factors of the environment, assuming apparently that these are the determinative factors operable in algal distribution. Yet, from the results of such studies, one has no criteria to judge the overall features of the environment, or to make comparisons of the results from different studies.

Our knowledge of the factors which are influential in algal distribution has not progressed to the stage where we can state definitely that individual species respond only to certain constituents of the aquatic medium. The writer knows of no direct cause and effect relationship which has been shown between the distribution of algal species and any one factor of the environment. What is needed are more extensive chemical analyses of the water, so that data from an extended series of studies can be analyzed and compared in an attempt to determine relationships. We must first determine the complete range of ecological conditions to which a species may respond, or under which it may occur, before attempting to understand or to postulate why it grows where it does.

Such information still is lacking, despite all previous studies of the dynamics of algal distribution.

CHAPTER VI

SUMMARY

A comprehensive study was made of the algal floras of an acid bog and a nearby hard-water marl lake during a two year period. Major emphasis in the study was directed toward making an analysis of the temporal and spatial distribution of algal species within each study area, and of one study area as compared with the other. Samples were collected from a variety of habitats in both study areas during all seasons of the year, at approximately two-week intervals, and on the same day.

Several specific lines of investigation were pursued in both study areas. An analysis was made of the number of species which occurred, their distribution within the study area, the community structure of the flora of individual habitats, and seasonal periodicity of the flora. The bog supported a richer and more diverse algal flora than did the hard-water lake. Of the 495 species observed during the study, 385 occurred in the acid bog, whereas only 170 occurred in the various habitats of the hard-water lake. An analysis of the distribution of these species within each of the study areas indicates that they are not distributed in a general manner.

The largest number of species in the bog occurred in a series of marginal pools located in the sphagnum mat a few feet away from the center lake, whereas the smallest number occurred in the sphagnum mat itself. Floral differentiations are evident also in a comparison of the other bog

habitats. Although the floras of the center lake, lake bottom and marginal pools are rather similar to one another in a general manner, distinctions can be shown among these on the basis of the number and kinds of species which occur. The most restricted algal floras occur in the sphagnum mat and sphagnum pool habitats; almost no similarity exists between the floras of these habitats and those of other stations in the bog.

The greatest difference in floral composition within the bog is shown by a comparison of the flora of the marginal pools with those of the sphagnum mat and sphagnum pool. The latter two habitats supported only 73 and 83 species respectively, as compared with 300 in the marginal pools. It is suggested that the lower number of species in the two sphagnum habitats may be related to the low pH and high concentration of organic matter in these habitats.

Floral analyses of the hard-water lake are complicated by the large number of diatom species which occur, but differences are evident in the species compositions of the main and outlet portions of the lake. It is suggested that these differences may be related, in part at least, to differences in the amount or kinds of organic materials which occur in these habitats.

The algal floras of the acid bog and hard-water lake differed from one another in respect to almost all of the aspects which were investigated. No similarity can be shown between the number of taxa supported, species composition, community composition, distribution and occurrence of individual species or seasonal periodicity in one study area as compared with the other. Of the 495 species observed during the study, only 39 are "common" to both areas. The algal flora of the acid

bog is dominated by a chlorophycean, especially desmid, association, whereas that of the hard-water lake is composed of a cyanophyte-diatom complex. The greatest difference between the algal floras of the study areas is shown by the representation of desmids and Euglenophyta in the two. Only 40 desmids were found in the hard-water lake, as compared with 151 in the bog; of these, only ten were "common" to both. Only three euglenoid species were observed in the hard-water lake, as compared with 42 in the bog; of these, only one species was "common" to both. In addition to the above differences, a distinct change in community structure was observed to occur in the flora of the hard-water lake during different seasons of the year, whereas the total number of algal species in the bog remained fairly constant throughout the year.

Although this floral dissimilarity in the two study areas is matched by a corresponding difference in water chemistry, a direct relationship cannot definitely be proved on the basis of available data. It is difficult to explain the difference in general floral composition, or in the number of species which occur, due to conflicting results obtained in previous studies, and because of a lack of critical information on the distribution of individual species. The results of the present study do indicate, however, that a lower number of algal species, especially desmids, occurs where the pH is above neutral, and where the calcium and carbonate content of the water is high. The lower number of euglenoid species in the hard-water lake may be related to the absence of necessary organic materials in the water.

The difficulty of applying generalizations derived from broad, regional studies of algal distribution to the present situation is discussed, along with the need for a more critical approach to the study of

algal distribution. It is suggested that our knowledge of the dynamics of algal distribution will expand only when emphasis is placed on an analysis of a series of studies on the total algal flora of a habitat in relation to the total spectrum of the physical-chemical features of the habitat, and that emphasis in such studies should be directed toward analyzing the distribution of individual species over a long period of time. The need for a more critical analysis of the nutritional requirements of individual species is stressed, along with the desirability of utilizing "indicator" species in any attempt to characterize the natural environment.

It is suggested that neither field nor laboratory studies in themselves will yield definitive information on the relationship between the distribution of algal species and the environmental complex to which such species may respond. The need for a cooperative effort among specialists such as taxonomists, ecologists, biochemists and ecologically-minded nutritionists is indicated, and the complexity of attempting to analyze the distribution of individual species is discussed.

Further research, involving more frequent periods of collection extending over a longer period of time, and a more comprehensive analysis of the distribution of individual species, would appear to be necessary before any generalizations can be made in respect to the factors which may be influential in the distribution of the algal species observed during this study.

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