A quantitative study of the phytoplankton of the White River canal, Indianapolis, Indiana

Charleen Coffing
Butler University

Follow this and additional works at: https://digitalcommons.butler.edu/botanical

The Butler University Botanical Studies journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology.

Recommended Citation
Retrieved from: https://digitalcommons.butler.edu/botanical/vol4/iss1/3

This Article is brought to you for free and open access by Digital Commons @ Butler University. It has been accepted for inclusion in Butler University Botanical Studies by an authorized editor of Digital Commons @ Butler University. For more information, please contact digitalscholarship@butler.edu.
The Butler University Botanical Studies journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner, included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daubenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology textbooks, from the Butler University Botanical Studies continue to be granted. For more information, visit www.butler.edu/
A QUANTITATIVE STUDY OF THE PHYTOPLANKTON OF THE WHITE RIVER CANAL, INDIANAPOLIS, INDIANA

By Charlene Coffing

Numerous quantitative investigations of lake and river plankton are recorded for this country, but there seems to have been little work done on quantitative studies of canal phytoplankton. The present quantitative investigation of one year on the phytoplankton of the White river canal in Indianapolis, Indiana, follows a previous year of study of the taxonomy and periodicity of the plankton flora of that canal (3). There are apparently no published records of quantitative studies of plankton made in the vicinity of Indianapolis.

REVIEW OF LITERATURE

In 1913, Allen (1) reported results of a quantitative study of the plankton of the San Joaquin river and its tributaries in and near Stockton, California. One of the tributaries investigated was Smith canal, located about 400 yards from the San Joaquin river. Smith canal was a straight channel about 60 feet wide and two miles long, with a minimum depth of one meter. This work constitutes the only reference to quantitative studies of canal plankton that the writer has found in American literature. Allen's investigations show that the phytoplankton of the canal was dominated by diatoms. He concluded that temperature is the principal factor determining plankton periodicity. Similar conclusions have been reached by other workers in regard to river and lake plankton.

The methods of making quantitative studies of canal plankton are very similar to the technique used in the investigation of river and lake plankton.

One of the outstanding studies of river plankton was made by Kofoid (10) in a quantitative investigation of the plankton of the Illinois river. He concluded that the plankton of the river channel was subject to great seasonal and annual variations, minimum occurring during January and February, and maximum occurring during April and June. The average monthly production declined gradually during the remainder of the year.

*This paper is a portion of a thesis in partial fulfillment of the requirements for the degree of Master of Arts in Butler University.*
to the winter minimum in January and February. He found that the diatoms were more abundant than any other synthetic group of plankton organisms and exceeded the Chlorophyceae seven to one.

In the Illinois river only two main types or species groups of plankton were found, the summer and the winter types. The vernal and autumnal species were only transitions between summer and winter when organisms from both were present. The winter plankton of the river was composed of a small number of species peculiar to that season, and several perennial forms, while the summer plankton consisted of a large number of summer organisms with the perennial types.

Allen's (1) analysis of the plankton of the Smith canal confirmed, in part, some of the conclusions obtained by Kofoid for the Illinois river plankton. As in Kofoid's investigation, the phytoplankton was dominated by diatoms, while the Chlorophyceae were frequent but not abundant. Some of Allen's conclusions are as follows: temperature, within certain limits, determines the seasonal distribution of plankton; water currents above a very moderate rate of flow are inimical to the development of plankton; collections taken at intervals of one week or more do not give sufficient data for accurate determination of plankton distribution through the year, but daily collections would probably do so.

In an ecological study of the Hocking river in Ohio, Roach (18) found that phytoplankton varied in abundance in direct ratio with the temperature. Diatoms were the dominant plankton flora, with the Chlorophyceae second in abundance. Eddy (5), in an ecological study of fresh-water plankton communities, including some rivers, lakes and ponds in Illinois, found that the abundance of fresh-water plankton at different seasons in the same body of water varies directly with the temperature. Kraatz (12), in a quantitative net-plankton survey of East and West reservoirs, near Akron, Ohio, found that diatoms reach a distinct spring maximum in May. The autumn maximum, beginning in late summer, was not nearly so great as the spring maximum. In a limnological study of Lake Erie, Gottschall and Jennings (6) found diatoms to be the most abundant group of plankton, this group exhibiting the characteristic spring and fall peaks of abundance.

An indication of the difference in periodicity between the plankton of rivers and lakes is seen when Kofoid's results on the Illinois river are compared with the Wests' work on some British lakes. The Wests (20) found that the greatest amount of phytoplankton, both quantitatively and qualitatively, occurred in late summer and autumn, during the autumnal
decline in temperature. They are convinced that the most important factor in both the quantitative and qualitative distribution of plankton is the amount of dissolved salts present in the water.

The predominant assumption in literature is that periodic changes in the plankton content of a body of water are due chiefly to temperature variations. It has been assumed that diatoms require lower temperatures for development, since they are usually most abundant during the cooler seasons. Pearsall (14) asserted that it is improbable that temperature alone is of any great importance in determining the periodicity of diatoms. He concluded that the real underlying causes are factors which normally operate during cold weather, namely, the fact that nitrates are washed from the soil most rapidly in cooler seasons when rainfall is in excess of evaporation, the fact that heavy rainfall causes a washing of dissolved silica from the soil, and the fact that rainfall increases the oxygen content of the water.

In a later study, Pearsall (16) emphasized the importance of dissolved substances in the water as a determining factor in the abundance and seasonal distribution of plankton. Diatoms occur in winter and spring when the waters are richest in nitrates, phosphates and silica, while the green algae occur in summer when nitrates and phosphates are low.

Whipple (21) emphasized the importance of the vertical circulation which occurs in a body of water in spring and autumn. This phenomenon brings to the surface any accumulation of organic matter, which is then oxidized. Some of the products of oxidation are favorable to the growth of diatoms. During the period of vertical circulation, the diatoms, or their spores, which have been lying dormant at the bottom, are carried to the surface by the vertical currents. The extent of the development of diatoms depends upon the amount of food material present and the temperature of the water. The periods of minimum development are during periods of stagnation.

FEATURES OF THE WHITE RIVER CANAL

Canals have certain features which distinguish them from rivers, namely a relatively slower rate of flow, a more uniform depth and a lower amount of aeration or oxidation. A possible difference in temperature may exist, due to the fact that the slower the rate of movement of water, the more likely it is to be affected by the temperature of the air.

White river is the source of the water of the White river canal. The
headwaters of White river and its tributaries rise in glacial drift which is high in lime and magnesia. About 40 per cent of the rainfall seeps through several feet of glacial drift. The ground water leaches out the lime and magnesia, making the water high in temporary and permanent hardness. About 25,000,000 gallons per day of ground water flow into White river in the 60 miles or more of its length above Indianapolis.

The canal is about 8.8 miles long, averaging 60 feet wide and 6 feet deep. Its rate of flow is rather slow, and is controlled by headgates in sluiceways at Broad Ripple. It is characterized by having water of rather low turbidity, a lack of benthon and marginal vegetation, and the presence of fish and mussels. It passes through the outskirts of the city and is relatively unpolluted.

PURPOSE OF THE INVESTIGATION

A qualitative study of the phytoplankton of the White river canal made by the writer in 1933-34 was introductory to the present quantitative investigation made in 1934-35. The present investigation was undertaken for the primary purpose of securing more definite information regarding the plankton flora of the canal as expressed in number of organisms per cubic centimeter, and of classifying the different genera into ecological groups according to their seasonal distribution and time of maximum. As a secondary purpose, an attempt was made to determine the correlation between temperature of water and the abundance and occurrence of the classes of phytoplankton and of the total phytoplankton.

LIMITATIONS OF THE INVESTIGATION

This survey includes only the phytoplankton, no attempt being made to include the unpigmented planktons. The organisms were listed by genus only, since the species of many small forms could not be determined by using only a 16 mm. objective. Because of the low magnification used, a number of forms could not be identified even to genus, and consequently had to be listed as unknown.

Results are given in terms of number of organisms per cubic centimeter of canal water. In this investigation the term "number of organisms" refers to the number of cells when dealing with isolated unicells, and to the colony or filament when counting colonial and filamentous forms. Genera such as Pediastrum and Tribonema, regardless of the
number of cells each possessed, were always counted as a unit. The methods of "standard units" in which the size of organisms is determined, and of "cubic standard units" in which the cubic centimeters of plankton per cubic meter of water is expressed (Whipple, 21) were not used. No attempt was made to determine the weight of plankton or of organic matter of the plankton (Birge and Juday, 2). In connection with this investigation, several major environmental factors were not studied, temperature of water being the only agent with sufficiently accurate data for presentation. Further limitations of this study include the time limit, the investigation being carried on over a period of only fifty weeks; the fact that samples were collected only once a week; the fact that samples were collected at only one depth; and the fact that sampling was done at only one location.

METHODS AND APPARATUS

COLLECTION

The procedure followed in the investigation consisted in, (1) collection of samples; (2) concentration by filtration and preservation of the residuum; (3) the examination of the concentrate and the enumeration of the phytoplankton; (4) the calculation of the number of organisms per cubic centimeter.

A collection was made every Monday during the middle of the day from June 4, 1934, to May 14, 1935, covering a period of fifty weeks. Samples were obtained from near the canal bridge on the Butler University campus. This sampling point is 2.6 miles from the place where the canal begins. The sampling apparatus consisted of two one-half gallon Mason fruit jars equipped with a rope. Collections were made in the center of the canal at a depth not exceeding six inches below the surface of the water, the jars being lowered by a rope from the edge of the bridge. A sufficient amount of water was secured to concentrate duplicate samples of 1000 cc. A thermometer was placed in one of the jars as soon as the water was drawn, and the temperature in degrees Centigrade was read through the jar. The sample was taken immediately to the laboratory and concentrated. The method of concentration used was the Sedgwick-Rafter method in which a measured quantity of the sample is filtered through sand.
EXAMINATION AND ENUMERATION

The equipment used in the microscopic examination of the concentrated samples of plankton consisted of a compound binocular microscope equipped with a mechanical stage and 20X oculars, a Whipple ocular micrometer and a Sedgwick-Rafter counting cell. It was almost impossible to recognize with certainty many of the genera when the microscope was calibrated in the usual manner so that the area on the stage covered by the Whipple ocular micrometer was one square millimeter. Consequently, a calibration was worked out whereby a portion of the micrometer would cover an area on the stage exactly .25 square millimeter. Since the counting cell was one millimeter deep, the volume within the outlines of the 49 squares was .25 cubic millimeter.

In the enumeration of the number and variety of organisms present, four fields in each of the duplicate samples were counted, making eight counts for each week's collection. Since the volume per field was .25 cubic millimeter, one cubic millimeter per sample or two cubic millimeters per weekly collection were examined. In the enumeration, cells of organisms touching the upper and left-hand boundaries of the field were not counted, while cells touching or overlying the lower and right-hand limits of the field were counted, as is recommended for blood corpuscle work (Kilduff, 9). From the counts obtained, the number of organisms per cubic centimeter of canal water was calculated.

The writer realizes that the method of counting only eight fields of .25 cubic millimeter each per collection does not give such representative results as would the customary method in which 10-20 fields of one cubic millimeter each are counted, yet the writer felt justified in using a method whereby greater magnification could be obtained so that recognition of genera would be easier and more accurate.

RESULTS

In the 50 collections taken from the White river canal, 39 genera of algae, representing 7 classes, were recorded. The classes recorded individually were the Myxophycæa, Chlorophycæa, and Bacillariæa, since they are usually the classes of algae found most abundantly. The other four classes were the Chrysophycæa, Desmidiæa, Euglenophycæa, and Heterokontæa. There were some members of the Bacillariæa and Chlorophycæa which could not be identified to genus and were listed as
"unknown" under their respective groups. In addition, there were a few other algae whose identity could not be determined and which were placed in the Miscellaneous Group as "unknown." The genera identified are given in an ecological classification following these results.

The average number of organisms per cc. per week was 3,338, with a range from a maximum of 27,750 per week on June 4, 1934, to a minimum of 45 per week on February 4, 1935. The average number of genera of algae per week was eight, with a range from 18 on June 4, 1934, to two on December 31, 1934, January 28, and February 11, 1935.

The total amount of plankton occurring in the weekly collections from June 4, 1934, to May 13, 1935, showed definite seasonal variations and also conspicuous weekly variations, especially from June to October. Two periods of maximum occurrence were evident, the higher peak occurring on June 4 and the lower peak on September 24. When considering the monthly averages, June and October were the months of greatest amplitude (Figure 2). The maximum in June was due to an abundance of Chlorophyceae (Figure 4) and diatoms (Figure 3), but the October maximum was due mainly to the appearance of Tribonema in large numbers. In October the Chlorophyceae were declining (Figure 4) and diatoms showed only a slight increase (Figure 3). Both maxima showed no definite correlation with temperature. In June, the average temperature was lower than in July (Figure 2), yet the plankton was much more abundant in June, especially during the first part of the month, than in July. In October, the peak in total plankton was preceded and accompanied by a fairly rapid and steady decline in temperature. Except for these two maxima of plankton, the plankton production and temperature were, in general, fairly well correlated (Figure 2). The best correlation came between November and April, when temperature seemed to be the controlling factor, but from June to October, 1934, and beginning in May, 1935, there were apparently other undetermined factors which played a part in influencing plankton production.

Only the Chlorophyceae and Bacillariaceae were considered in detail as to time of occurrence and relative abundance, since they comprise most of the plankton of the canal. The very prominent weekly fluctuations in amounts of Chlorophyceae during summer and early autumn are shown in Figure 4. Those of the Bacillariaceae during summer, early autumn and spring are shown in Figure 5. The results of Kofoid (11), West (20) and Whipple (21) show maxima varying from spring to autumn.
In general, the curve for Chlorophyceae parallels the temperature curve (Figure 3). Scenedesmus was the most conspicuous genus of the Chlorophyceae. At times during the early summer months it comprised from one-third to one-fourth the total phytoplankton, and outnumbered the other members of the class several times. Kofoid (11) likewise found that Scenedesmus was the leading green alga numerically.

Diatom frequency is shown in Figure 3. It will be noted that the curve is highest in June and lowest from November to February, with a spring maximum in March. In general, the diatom curve paralleled the temperature curve, which is contrary to the results of other workers (Whipple, pp. 228, 232). In previous work, the writer (3) found a diatom maximum in May, with a fairly uniform and abundant distribution through the rest of the year. Two of the most important genera were Synedra and Nitzschia. Whipple lists Synedra as a truly planktic genus which exhibits spring and autumn maxima. In this investigation, Synedra-Nitzschia were most abundant in the first collection on June 4, 1934, and reached another peak in July. In general, they were most abundant in the summer, declining to a winter minimum in November and December, exhibiting a rather feeble increase in January and an early spring maximum in March, after which they declined (Figure 6). Just how much of the deviation of this curve from the usual spring and fall maxima of Synedra alone was due to the presence of Nitzschia could not be determined.

Another genus probably as abundant as Synedra-Nitzschia was Cyclotella, which was very abundant during the summer months, but increased to a definite autumn maximum in October. It practically disappeared during the winter, but reached a spring maximum of less amplitude in March and April (Figure 7). The curve for Cyclotella is only partially in agreement with Whipple's statement that it is one of the truly planktic diatoms exhibiting spring and fall maxima, for although there is a definite increase in the spring, it is much more abundant during the summer months than in the spring.

A striking ratio between the Chlorophyceae and Bacillariaceae of the canal was discovered. The total Chlorophyceae for the year outnumbered the diatoms 2.5 to 1. In direct contrast are Kofoid's results (11), in which the green algae were outnumbered 6 to 1 by diatoms. Even greater difference was reported by Allen (1): the Chlorophyceae being outnumbered by the diatoms 14 to 1. In Lake Erie and Presque Isle
bay (6), diatoms were also the most abundant group. A few possible explanations for these striking divergences are given. (1) Green phytoplankton (Chlorophyceae) are more abundant at a higher level than are diatoms (19). Since the samples from the canal were taken within six inches of the surface, they would contain larger quantities of Chlorophyceae in proportion to the amount of diatoms than the results of workers who have sampled at greater depths show. (2) Welch (19) refers to the work of Cilleuis (1928), in which the plankton of rivers and large streams possessing slow currents is characterized, in part, by having a lower diatom content than the plankton of rivers with a rapid current. The canal has a fairly slow current and therefore would tend to have fewer diatoms in proportion to the number of Chlorophyceae. (3) Streams with high turbidity, which indicates the presence of silt with silicon, have more diatoms than a less turbid body of water (15, 19). Since the water of the canal exhibits relatively low turbidity, it would tend to have fewer diatoms than a more turbid stream. (4) According to Whipple (21), filtration through sand will retain the nannoplankton better than straining through bolting cloth. In case the smaller plankton were composed of more green algae than diatoms, the use of sand would obviously increase the amount of Chlorophyceae.

Myxophyceae were found in only two samples, June 25, 1934, and January 21, 1935. In studies of lake plankton, the Wests (20), Whipple (21) and Gottschall and Jennings (6) reported maxima of blue-green algae in autumn, usually after a period of hot weather. Kraatz (12), however, found a maximum in June, soon after the beginning of hot weather. In 1933, the writer (3) found that the blue-greens appeared the last of June, were fairly abundant during August and the first part of September, and disappeared by October. The maximum did not show the relation to temperature that the above workers reported. It is possible that temperature of water is a minor factor influencing the occurrence and abundance of the Myxophyceae. A factor which some workers emphasize is the amount of organic matter in the water. The Wests (20) reported the blue-greens to be largely absent from lakes with very pure water, while White (22) stated that their abundance was probably dependent upon the amount of nitrogenous matter in the water. If the amount of organic matter in the water is the more important factor, the fact that the writer found so few blue-greens indicates that the canal is relatively free from organic matter, or that the slow current of the canal allows much of the organic matter to sink to the bottom.
Tribonema was found in 41 of the 50 collections, at times in large numbers. Two periods of maximum occurrence were evident. The first peak occurred on July 30 and August 6 (Figure 8). The filaments ranged from fragments of two or three cells to many cells. The number declined to a low level until September 24, when the maximum for the year of almost 11,000 filaments and fragments of filaments per cc. were recorded. The number remained fairly high during October and decreased to a low level during the winter and spring.

From the observations made by the writer and by other workers, Tribonema seems to be primarily an autumn form. White (22) found Tribonema to be the dominant alga in November and December, while Delf (4) reported a definite maximum in February and March, with a lesser maximum in October and November. The writer in 1933 found Tribonema most abundant from August 21 to September 25, with the temperature of the water ranging from 21.5° to 24.5° C. In the present study, Tribonema appeared in greatest numbers when the temperature ranged from 15° to 22° C.

ECOLOGICAL CLASSIFICATION

In making an ecological classification of each genus found in the canal during the two-year investigation, two factors were considered: the distribution of the organism through the year, and the numerical variation of the organisms during the portion of the year that it occurred, with special emphasis on the time of greatest amplitude. The classification of most of the genera was based upon results obtained during 1933-35 and upon data secured from an unpublished study of the plankton of White river in and near Indianapolis from August, 1930, to September, 1931 (13).

The 70 genera found during 1933-35 were grouped into four ecological classes with fairly definite periods of occurrence and times of maximum. A fifth group was made, consisting of forms which were quite variable in time of occurrence and time of maximum in the studies made, and of forms which appeared rarely. Some of the genera were not found in the collections of both years, and some were not reported in the year’s investigation of White river plankton (13). Consequently the classification of some of the genera was based on only one year’s observation. Such genera were listed as probably belonging in the various groups in

28
which they were placed. The five ecological groups and the genera comprising them are given below:

**Group I. June-October group, with maximum in June or July:**
- Actinastrum Kirchneriella
- Ankistrodesmus Lagerheimia
- Celastrum Micractinillum
- Crucigenia Pediastrum
- Dictyospherium Trachelomonas
- Golenkinia Treubaria
- Additional genera probably belonging in this group are:
  - Eunotia Schroederia
  - Hemidinium Staurastrum
  - Phacotus Westella

Closterium, Lepocinclis and Phacus have been placed in Group V, although their distribution approximates that of Group I.

**Group II. July-November to all-seasons (continuous) group, with maximum June-October:**
- Cyclotella Synedra-Nitzschia
- Scenedesmus Tribonema

**Group III. October-May group, with maximum in March or April:**
- Diatoma Navicula
- Gomphonema

**Group IV. March-May group, with maximum in March or April:**
- Asterionella Cymbella
- Cymatopleura Gyrosigma
- An additional genus probably belonging in this group is:
  - Meridion

**Group V. Variable in time of occurrence and time of maximum. Includes rare forms. Abbreviation following each genus indicates month of maximum occurrence:**
- Lepocinclis, July. Selenastrum, July
- Lyngbya, Aug. Staurosoros, April
Additional genera probably belonging to this group are:

Achnanthes, Dec.
Anabena, Aug.
Botrydiopsis, Feb.
Carteria, July, Aug.
Cladophora, Feb.
Colosphaerium, Oct.
Cosmarium, July
Cryptomonas, Oct.
Elaktothrix, July
Eudorina, Aug., Sept.
Fragilaria, March
Frustulia, April
Groecystis, Aug.
Gonium, Sept.

It seems that the classification of Cymatopleura solea into Group IV should be somewhat tentative. Although it may appear to be primarily a spring form as found by Allen (1) at Station II, and by the writer, yet Kofoid's results on the Illinois river and Allen's results on Stations I and III, indicate that it might be considered as a variable form and hence placed in Group V.

The results of Kofoid, Whipple and Palmer differ considerably concerning the occurrence of Diatoma. The writer's results are more similar to Whipple's than to Kofoid's and Palmer's. Since the appearance of Diatoma was very similar during the two years' study, the writer felt justified in placing it in Group III.

The seasonal distribution of Actinastrum in the Illinois river (11) and in the San Joaquin river (1) indicates that the genus unquestionably belongs in Group I, but when the time of maximum occurrence is considered, the writer's classification does not apply to the Actinastrum of other localities. Difference in temperature in different localities during the same month may cause the variation in time of maximum, for the writer found the optimum temperature for Actinastrum to be practically the same as Kofoid (11) reported. Another reason for the variation may lie in the difference in species. Allen and Kofoid reported A. hantzschii, while the species in the canal was A. gracillimum.

Cosmarium, another member of Group I, showed a much earlier maximum in the canal than it did in the Illinois river and San Joaquin river, although the period over which it was present is much the same. Again,
difference in temperature in different regions during the same month may account for the difference in time of maximum occurrence. In agreement with Kofoid (11), its maximum development was during the period of highest temperature.

The information secured on Pediastrum indicates that its classification into Group I would not hold true in other localities. However, the similarity in seasonal distribution of the organism during 1930-31 (13) and 1933-35, places it in Group I in this region. Kofoid (11) found Pediastrum every month, and the optimum temperature was 15°-20° C, while in the canal it occurred less than half the year and seemed to prefer temperatures of 20°-26° C.

The seasonal distribution of Scenedesmus in the canal coincides fairly well with information secured by other workers, and consequently it was placed in Group II. Although it was a perennial plankton, it was predominant only during the warmer part of the year, at temperatures ranging from 15°-30° C.

Euglena is an exception in Group V in being rather common. However, its range and time of maximum were so different during the two years that it could not be placed in any of the other groups. In 1933 it was present and fairly abundant from July to the latter part of September, but in 1934-35 it appeared only four times during the summer and eight times during early spring. Whipple (21) reported Euglena to be most abundant from June to September. Palmer (13), in samples taken from White river below a sewage disposal plant, found Euglena more or less abundant throughout the year. White (22) emphasized the presence of nitrates as a factor influencing the abundance of Euglena. A similar view was stated by Purdy (17), who named Euglena and its relatives as positive indicators of contamination. From results obtained on Euglena in the investigation of the plankton of the canal, the writer cannot list temperature of water as a determining factor.

SUMMARY

1. A quantitative study of the phytoplankton of the White river canal from June 4, 1934, to May 13, 1935, was made by filtering weekly samples through sand and observing measured units of the concentrate at a magnification of 200.

2. The study revealed a marked periodicity of the total plankton and of the classes and genera of algae.
3. The total plankton showed considerable weekly variation, but when seasonal distribution is considered, it exhibited a summer and early autumn maximum which extended from June through October, and a winter minimum which lasted from November through February. During the winter minimum the plankton curve was uniformly low, but the maximum showed two peaks of abundance, the larger occurring in June and the smaller in October. The October peak was caused by a sudden and large increase in the amount of Tribonema. The total plankton showed a small increase in March, due mostly to diatoms, however.

4. The maximum average monthly production of total plankton, Chlorophyceae and Bacillariaceae occurred in June.

5. The Chlorophyceae showed considerable weekly fluctuation. When monthly averages were considered, the green algae were abundant from June through October and dropped suddenly in November to a winter minimum which lasted until May.

6. The green algae followed the temperature curve fairly closely except during March, April and May, when they failed to increase with the temperature.

7. Of the Chlorophyceae, Scenedesmus was by far the most abundant, at times during early summer comprising from one-third to one-fourth the total phytoplankton.

8. The Bacillariaceae showed a summer and early autumn maximum, a winter minimum, and an increase in March when the temperature increased.

9. The diatom curve fluctuated more from week to week than the Chlorophyceae curve, but the diatoms showed almost as close correlation to the temperature curve as did the green algae.

10. Of the Bacillariaceae, Synedra-Nitzschia was conspicuously abundant during early summer, and less abundant in early spring, while Cyclotella was dominant in late summer and early autumn.

11. The Chlorophyceae were the dominant class of algae in the canal, outnumbering the diatoms 2.5 to 1.

12. The Myxophyceae of the canal were almost entirely absent, occurring in only two of the 30 collections.

13. Tribonema, although present and at times abundant during late summer, reached a maximum in October during the autumnal decline in temperature. It exhibited tolerance of low temperatures, being present, although in small numbers, during most of the winter.

14. In general, temperature seemed to be a primary factor influencing
plankton production. At times, however, there were apparently other undetermined factors which played an important part in phytoplankton periodicity.

15. From records of three years, the algae of the canal were placed in five ecological groups, which are as follows:

Group I. June-October group, with maximum in June or July.
Group II. June-November to all-seasons (continuous) group, with maximum June-October.
Group III. October-May group, with maximum in March or April.
Group IV. March-May group, with maximum in March or April.
Group V. Variable in time of occurrence and time of maximum. Includes rare forms.
ACKNOWLEDGMENTS

The writer expresses her sincere thanks to Professor C. M. Palmer, under whose supervision this research was carried out, for his suggestion of the problem and for his helpful criticisms and suggestions throughout the investigation and the preparation of the manuscript.

The writer is also very grateful to Dr. R. C. Friesner for his aid in preparing the copy.


