



An investigation of the periphyton in a riffle of the West Gallatin River, Montana  
by Ronald B Gumtow

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for a degree of  
Master of Science in Fish and Wildlife Management  
Montana State University  
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Abstract:

An investigation was made of the periphyton complex in a riffle area on the West Gallatin River, Montana, from August 1952 through February 1954. The riffle gradient in 1954 was 1.76 feet per 100 lineal feet and average riffle depth during the study period was 12 inches. One square centimeter samples were collected from formalin-treated stones placed in the riffle. Some random stones were sampled as controls and to supplement treated stones washed from the area. From August 1952 to March 1953 one periphyton sample was collected from each station while two samples were collected from each station from March 1953 through February 1954. Statistical analysis was made to determine the number of "count units" needed to give satisfactory precision in making estimates of organisms per ml sub-sample. Gross seasonal changes of the periphyton complex are described. Three divisions of algae representing 34 species and live phyla of animals representing 35 species were found in periphyton. Chrysophyta was the most abundant algae and Diptera was the most frequently represented animal. A sharp increase in number of organisms occurred in August-September and peaked in November. A decline occurred in December-January and a minor peak appeared in March. Another decline occurred in May. Organisms were found at a minimum in July. Diatoms were superseded in number by a green algae in February 1953 and in July 1953 by a blue-green algae. Two peaks occurred in Tendipedidae larvae in 1952 and one in 1953. One peak in Simulium larvae was found in January 1954. The abundance of organisms in relation to temperature, ice formation, discharge, turbidity and velocity are considered.

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RONALD B. GUMTOW

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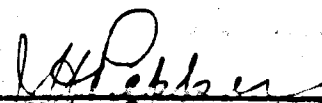
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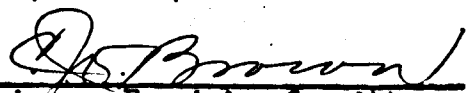
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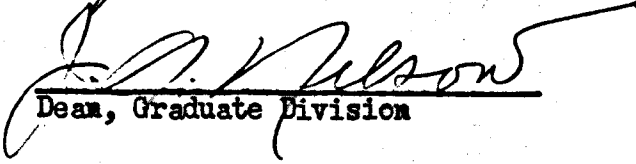
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ABSTRACT

An investigation was made of the periphyton complex in a riffle area on the West Gallatin River, Montana, from August 1952 through February 1954. The riffle gradient in 1954 was 1.76 feet per 100 lineal feet and average riffle depth during the study period was 12 inches. One square centimeter samples were collected from formalin-treated stones placed in the riffle. Some random stones were sampled as controls and to supplement treated stones washed from the area. From August 1952 to March 1953 one periphyton sample was collected from each station while two samples were collected from each station from March 1953 through February 1954. Statistical analysis was made to determine the number of "count units" needed to give satisfactory precision in making estimates of organisms per ml sub-sample. Gross seasonal changes of the periphyton complex are described. Three divisions of algae representing 34 species and five phyla of animals representing 35 species were found in periphyton. Chrysophyta was the most abundant algae and Diptera was the most frequently represented animal. A sharp increase in number of organisms occurred in August-September and peaked in November. A decline occurred in December-January and a minor peak appeared in March. Another decline occurred in May. Organisms were found at a minimum in July. Diatoms were superseded in number by a green algae in February 1953 and in July 1953 by a blue-green algae. Two peaks occurred in Tendipedidae larvae in 1952 and one in 1953. One peak in Simulium larvae was found in January 1954. The abundance of organisms in relation to temperature, ice formation, discharge, turbidity and velocity are considered.

## INTRODUCTION

Few quantitative investigations on the abundance and distribution of periphyton in streams and lakes have been made. Young (1945) completed a careful limnological study of periphyton in Douglas Lake, Michigan, and gave a comprehensive list of organisms found on three types of substrata. Butcher (1932) found seasonal variation in sessile algae growing on glass slides submerged for certain periods in the Rivers Lark and Tees. Neel (1953) listed the periphyton organisms scraped from stones and other submerged objects in the North Platte River in Wyoming and Nebraska during July, August and October.

The present investigation of periphyton was confined to a riffle area on the West Gallatin River, immediately upstream from Shedd's Bridge, Gallatin County, Montana. Thirty-four collections were made at intervals, from August 1952 through February 1954 (Table 1). A total of 491 samples was taken during this period. The objective was to determine kinds and seasonal abundance of periphyton organisms.

Variable definitions of periphyton occur in the literature. Young (1945) described periphyton as an "assemblage of organisms growing upon the free surfaces of submerged objects in water, and covering them with a slimy coating". He excludes benthos from the definition but does not separate benthic organisms from periphyton in his tabulations. Hunt (1952) defines this complex as an "assemblage of algae and minute animals covering submerged objects with a slimy coating". He includes both free-living and sessile organisms. Neel (1953) describes periphyton as "an assemblage of mainly microscopic organisms that form or live in coatings

Table 1. The number of sampling visits and samples taken at Shedd's Bridge, West Gallatin River, Montana, 1952-54.

| Month     | No. Visits |      |      | No. Samples |      |      | Total Samples |
|-----------|------------|------|------|-------------|------|------|---------------|
|           | 1952       | 1953 | 1954 | 1952        | 1953 | 1954 | 1952-54       |
| January   |            | 2    | 2    | 14          | 24   |      | 38            |
| February  |            | 1    | 2    | 22          | 30   |      | 52            |
| March     |            | 2    |      | 11          |      |      | 11            |
| April     |            | -    |      | --          |      |      | --            |
| May       |            | 4    |      | 44          |      |      | 44            |
| June      |            | -    |      | --          |      |      | --            |
| July      |            | 2    |      | 30          |      |      | 30            |
| August    | 2          | 4    |      | 19          | 70   |      | 89            |
| September | 3          | 1    |      | 25          | 36   |      | 61            |
| October   | 1          | 2    |      | 9           | 68   |      | 77            |
| November  | 1          | 2    |      | 9           | 49   |      | 58            |
| December  | 2          | 1    |      | 15          | 16   |      | 31            |
| Total     | 9          | 21   | 4    | 77          | 360  | 54   | 491           |

upon rocks and other submerged objects". His definition closely parallels Ruttner's (1953) "Aufwuchs". In the present study all organisms forming or living within the mat are considered part of the periphyton complex.

#### Description of Study Area and General Methods

In 1954 the riffle gradient was 1.76 feet per 100 lineal feet as compared with the average of 0.64 feet per 100 lineal feet, for the valley portion of the West Gallatin River (Purkett, 1950). In 1952 the riffle was located at the convergence of two channels; one was about 30 feet and the other 45 feet in width. Floods in 1953 widened the larger channel to about 80 feet and reduced the smaller to approximately 10 feet. This placed the riffle upstream 6 - 8 feet from the 1952 position. The approximate average riffle depth for both years was 12 inches. In 1952

the riffle proper was about 12 feet long and 60 feet wide while in 1953 it was approximately 20 feet long and 100 feet wide. Maximum and minimum recorded discharge for 1952 was 6,320 and 110 cubic second-feet respectively, and for 1953, 4,405 and 50 cubic second-feet (Bureau of Reclamation).

Bottom materials in the riffle did not noticeably change in type or size during the study period. Most stones were stream worn and irregularly rounded. In 1954, 2.8 percent of the area in two one-yard quadrats was coarse gravel (1/8 to 1 inch diameter), 3.3 percent pebbles (1 to 2 inch diameter), 38.5 percent cobbles (2 to 10 inches diameter), and 55.4 percent boulders (10 inches or more in diameter). Some stones were solid colors while others were mottled or streaked. The colors recognized were white, cream, pink, red, red-brown, brown, light gray, blue-gray, and black. The texture of stone surfaces ranged from semi-polished to a roughness equal to about number four grit sandpaper.

Each sample consisted of one square centimeter. This was marked off by a brass ring and the material enclosed was scraped off with a scalpel and immediately preserved in four percent formalin. Velocities to the nearest 0.01 second-feet (Leupold & Stevens Midget Current Meter) and depths to the nearest 0.5 inch were measured for all stations on each sampling date. Turbidity was determined to the nearest 0.01 ppm with a Hellige Turbidimeter at irregular intervals, usually on collection dates. From August 1952 to July 1953 water temperatures were secured with a "checked" Taylor pocket thermometer and thereafter with a corrected maximum-minimum thermometer.

The writer wishes to acknowledge the assistance of Dr. C. J. D. Brown who suggested and directed the study and aided in preparation of the manuscript. Financial assistance was supplied by Montana State College Experiment Station. Sincere appreciation for the identification of periphyton organisms is extended to Mr. M. H. Hohn (algae and diatoms); Mr. D. W. Bergstrom (Hydracarina); Dr. H. H. Ross (Trichoptera); Dr. A. Stone (Simulidae); Dr. W. W. Wirth (Tendipedidae); and Dr. J. S. Rogers (Rhagionidae). Dr. Bernard Ostle generously assisted with the statistical analyses. Certain hydrological data were kindly supplied by Mr. T. R. Neuman, Bureau of Reclamation.

#### THE PERIPHYTON COMPLEX

##### Organisms

Most of the organisms found in the periphyton complex were identified to genus and some to species (Table 2), however, it was not possible to determine certain ones beyond the larger categories. The algae included 34 species representing three divisions while the animals included 35 species representing five phyla.

The Chlorophyta was represented by four genera and species; Tetraspora was the most frequently occurring and Cladophora and an undetermined green algae were common. Treubaria and Closterium were observed rarely.

The Chrysophyta contained 18 genera and 20 species (all diatoms). Neel (1953) found 21 genera of diatoms in the periphyton from the North Platte River and Young (1945) reported nine genera in the periphyton on stones in Douglas Lake.



Table 2. List of organisms.

CHLOROPHYTA

- Tetrasporales
  - Tetraspora (?)
- Cladophorales
  - Cladophora sp.
- Chlorococcales
  - Treubaria (?)
- Zygnematales
  - Closterium sp.

CHRYSOPHYTA

- Centrales
  - Melosira variens
- Pennales
  - Meridion sp.
  - Diatoma vulgare
  - Fragilaria sp.
  - Synedra ulna
  - S. ulna var. oxyrhynchus
  - S. ulna var. ramsei
  - Ceratoneis arcus
  - Rhoicosphenia curvata
  - Cocconeis placentula var. euglypta
  - Navicula cryptocephala
  - Navicula sp.
  - Pinnularia sp.
  - Gomphonema olivaceum
  - G. herculeanum var. robusta
  - Gomphoneis herculeanum var. robusta
  - G. herculeanum
  - Cymbella prostrata
  - C. turgidula
  - C. cistula
  - C. mexicana
  - C. affinis
  - C. sinuata
  - Epithemia sorex
  - E. zebra
  - Rhopalodia sp.
  - Nitzschia dissipata
  - Cymatopleura solea
  - Surirella ovata

CYANOPHYTA

- Oscillatoriales
  - Oscillatoria spp.
  - Lyngbya sp.
  - Nostoc sp.

PROTOZOA

- Ciliata
  - Vorticella sp.
  - Unknown sp.

ROTATORIA spp.

NEMATODA spp.

TARDIGRADA sp.

ARTHROPODA

- Hydracarina
  - Sperchon glandulosus
  - Megapus sp.
  - Aturus sp.
  - Feltria sp.
- Plecoptera sp.
- Ephemeroptera spp.
- Trichoptera
  - Limnephilidae spp.
  - Rhyacophilidae
  - Glossosoma sp.
  - Brachycentridae
  - Brachycentrus sp.
- Coleoptera sp.
- Diptera
  - Deuterophlebiidae sp.
  - Blepharoceridae sp.
- Simuliidae
  - Simulium arcticum
  - S. vittatum
- Tendipedidae
  - Hydrobaeninae spp.
  - Diamesa spp.
  - Syndiamesa sp.
  - Calopsectra sp.
  - Circotopus sp.
- Rhagionidae
  - Atherix sp.

The genera of diatoms which appeared most frequently were Navicula, Diatoma, Cymbella, Cocconeis, Synedra, and Ceratoneis. Undetermined representatives of the family Gomphonemataceae also occurred frequently. Rhoicosphenia, Surirella, Epithemia, Fragilaria, Melosira, and Pinnularia appeared commonly and Meridion, Rhopalodia, and Nitzschia were rare.

The Cyanophyta had three genera and four species. The most frequently occurring genus was Oscillatoria while Lyngbya was common and Nostoc was rare.

Protozoa, Rotatoria, and Nematoda occurred infrequently. A single specimen of Tardigrada was found.

The Arthropoda was represented by two classes and six orders. Diptera occurred most frequently with five families and 17 species; 12 of these were in the family Tendipedidae, two in Simuliidae, and single species of each in Blepharoceridae, Deuterophlebiidae, and Rhagionidae. Ephemeroptera were common and Trichoptera and Plecoptera were rare. A single Coleoptera was found. Only three Hydracarina were observed.

#### Seasonal Variation

Selection of Stations and Sampling: Cobblestones for stations were secured from the river bank. These were scraped clean and an identification number and reference point for velocity and depth measurements were painted on the top center of each stone. Stones were treated with full strength formalin for a few minutes and then immediately rinsed. This latter procedure was followed so that the order in which organisms appeared could be determined.

On August 9, 1952 ten treated stones were alternated at five foot intervals along a transect across the riffle width. One was lost August 23, 1952, another between February 22 and March 9, 1953; six more disappeared between March 9 and 20, 1953 and by March 30 all had been lost. On May 2, 1953, ten more treated stones (stations) were arranged in five groups of twos along one-half the length of the 1952 transect. Stations in each of the five groups were placed 2-6 inches apart. These were sampled from May 9 to 23; shortly after the latter date all were washed from the area. On August 3, 1953, 16 treated stones were placed in groups of fours along a transect one-half the width of the riffle and six inches or less apart. The distance between groups was 12 feet. Between November 14 and 29, 1953, eight stones (two groups) were lost and four others (one group) was believed pushed from the area by floating ice on January 21, 1954.

Random stones were selected in the riffle proper as controls for the treated stones. These also supplemented the treated stones which were washed away. Three were selected on March 9, 1953, nine on July 11, six on July 18, three on August 6; four on February 7, 1954 and three on February 23. No important difference in numbers and kinds of organisms was found on treated and random stones, except where samples were taken earlier than one week after treatment. In a single instance random sample stones showed greater quantities of periphyton than the treated ones.

One periphyton sample was taken from each station on each sampling visit from August 1952 to March 1953. After the stone (station) was re-

moved from the water, the sampler was placed at random (without looking) on its surface and the enclosed periphyton scraped off and preserved. From March 1953 through February 1954, two samples were secured from each station. A transect was established along the midline of the exposed surface from the upstream to downstream end of each stone. Samples were secured at random from each half of the transect without sampling any area twice.

Periphyton Analysis: The volumetric method and large counting cell used by Young (1945) and the differential plankton count method described by Welch (1948) were adapted for sample analysis. Samples were diluted or reduced to five ml and centrifuged for one minute at 360 rpm. Centrifuged volumes less than 0.05 ml were recorded as trace; greater than 0.05 ml and less than 1.0 ml were estimated to the nearest 0.05 ml; greater than 1.0 ml were estimated to the nearest 0.5 ml. Volume estimations over 1.0 ml could not be estimated closer than 0.5 ml because of the nature of the graduations on the centrifuge tube. A sample was placed on a counting cell (10 ml capacity) under a magnification of 27 X and all large organisms were counted. The average for each collection was based on total counts of all samples. This sample was diluted again and placed in a Waring Blendor (10,000-12,000 rpm) for 30 seconds. All rotifers and nematodes in a one ml sub-sample were counted using the same magnification. Diatoms, filamentous algae, and protozoa were counted at 100 X magnification using a Whipple ocular grid. Counts were made on fifteen 0.5618 cu mm "count units" obtained by random selection from each one ml sub-

sample. Using dilution and sample area, estimated averages were based on numbers calculated per one ml sub-sample. Fragments of diatoms, those less than 0.021 mm long, or those of doubtful identification were not counted. Fragments of filamentous algae smaller than 0.106 mm in length were also disregarded. Organisms of the same species attached to each other were considered one; only those wholly within a unit were included.

Calculations were performed in an attempt to find the number of counts needed to give satisfactory precision in estimating the population mean numbers of various organisms per one ml sub-sample. Each of two one-square centimeter samples were diluted to five ml and centrifuged. One (No. 1) of these was diluted to 15 ml (centrifuged volume 0.2 ml) and periphyton clumps were teased apart with needles. The other (No. 2) was diluted to 60 ml (centrifuged volume 0.5 ml) and placed in a Waring Blendor for 30 seconds.

A one ml sub-sample was taken from each. Fifteen units of a sub-sample from No. 1 were counted and 20 units of a sub-sample from No. 2. The averages were computed for the numbers of each kind of organism in the first sub-sample for 5, 10, and 15 units and for 5, 10, 15, and 20 units in the second. Ninety-five percent confidence limits for the true mean numbers of organisms per 0.5618 cu mm were found using the data from the 5, 10, 15, and 20 counts. All results were then multiplied by 1779 to secure estimates for a one ml sub-sample. In sub-sample one, only the confidence band for Cymbella narrowed as the number of "count units" was increased. In sub-sample two, the confidence band narrowed for Navicula,

Synedra, Diatoma, Cocconeis, Cymbella, Gomphonemataceae, and Oscillatoria as the number of count units was increased. A leveling off in the estimated mean values occurred when the number of counts (count units) approached 15. These results suggest that no fewer than 15 counts should be made per one ml sub-sample of the specified dilution if satisfactory estimates are to be realized. Therefore 15 counts per one ml sub-sample were made for all estimates of square centimeter samples and all samples were treated with a Waring Blendor.

Gross Seasonal Changes: This complex varied in numbers of organisms at different seasons of the year. Floods at time of run-off (May-June) caused extreme scouring by movement of sand, gravel, cobblestones, and even boulders. It was only possible at that time to observe riffle bottom materials near the bank. Those materials examined were without organisms. No coating of organisms was visible in late June although stones felt slick probably due to the presence of diatoms and blue-green algae. A thin brown film of diatoms and small scattered filaments of green algae appeared on stone surfaces in late July and this began to accumulate sand grains. By mid-September a relatively thick layer of diatoms, with obvious strands of filamentous green algae, completely covered riffle bottom material. By late November this growth became patchy, lighter brown in color, and the filamentous algae appeared in clumps. Scouring action of ice from late November to early March caused variations in the quantity of periphyton present. By late March the filamentous algae was less obvious and the entire periphyton complex was predominantly dark brown in color. From April to the May-June flood period no obvious changes occurred. No crusty

layer was found on stones in the riffle at Shedd's Bridge similar to that reported by Young (1945) for Douglas Lake or a calcareous growth as described by Percival and Whitehead (1930) in the River Wharfe.

Order of Appearance of Organisms: An attempt was made to determine the order of appearance of organisms on "cleaned" stones but samples were not taken soon enough after stones were placed to determine the earliest arrivals. Samples were taken August 16, 1952 and May 9, 1953, seven days after treated stones were placed in the riffle. On August 15, 1953, samples were taken on a third group of cleaned stones which were placed nine days before.

Diatoms occurred in all three collections; those present were Diatoma, Synedra, Cocconeis, Navicula, Cymbella and undetermined representatives of the Gomphonemataceae. Blue-green algae (Lyngbya) appeared in the August 16, 1952 collection and green algae (Tetraspora) was found in the May 9 and August 15, 1953 samples. Tendipedidae larvae were present in all three collections while Simulium larvae occurred August 15, 1952 and May 9, 1953 and Ephemeroptera on May 9, and August 15, 1953.

Quantitative Distribution (Fig. 1): A marked numerical increase in diatoms, blue-green, and green algae occurred from August through September in both years (1952-53) (Table 3) which resulted in a major peak in early November. In the 1952 peak, the estimated average number of diatoms per square centimeter of stone surface was 2,175,000; blue-green, 144,000; and green algae, 23,000, while in 1953 the diatoms numbered 2,525,000; blue-green, 561,000; and green algae, 46,000. A decisive general decline occurred during December and January in both years

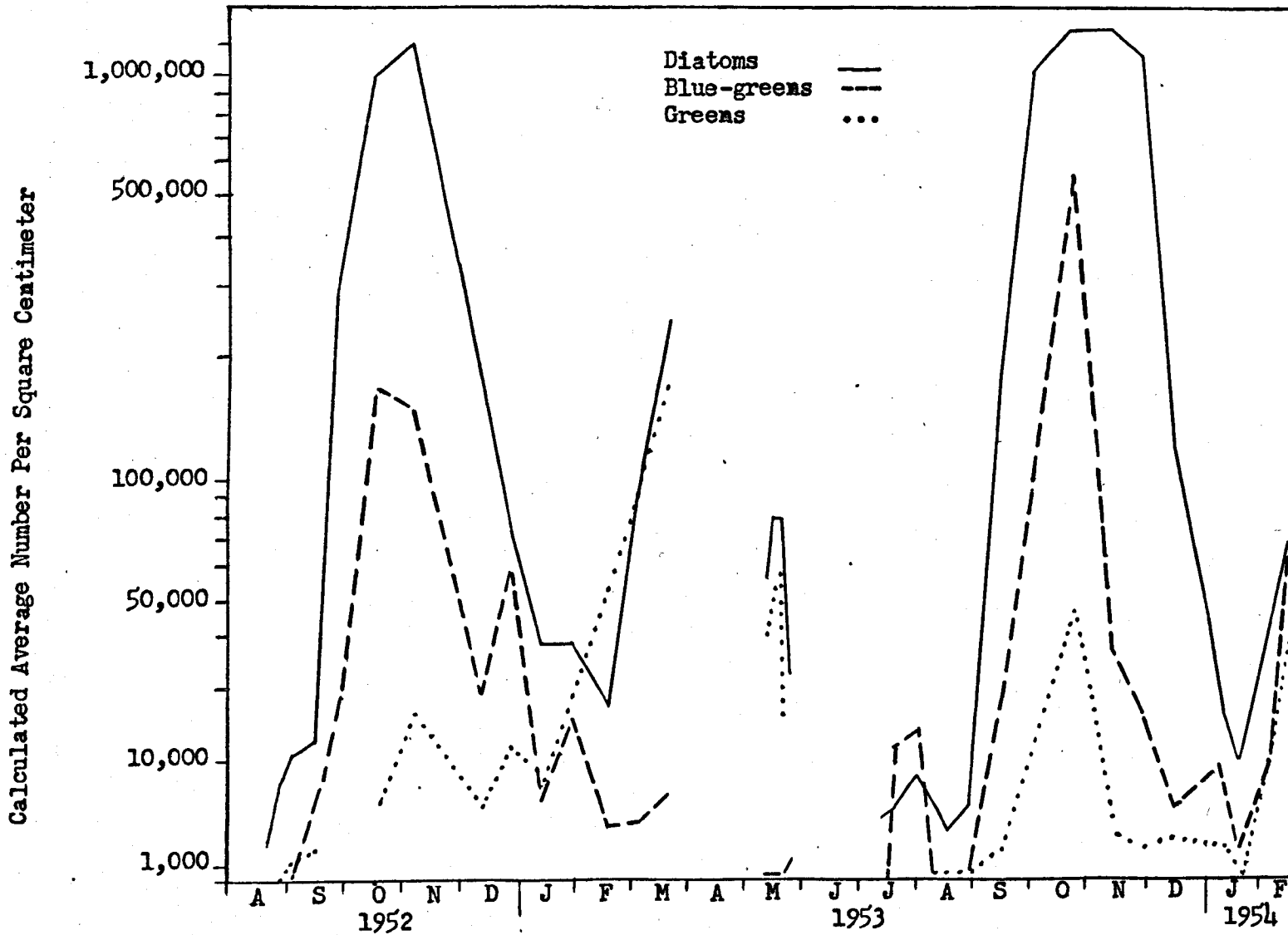


Fig. 1. Quantitative distribution of diatoms, blue-green, and green algae, West Gallatin River, Montana, 1952-54.



Table 3. The calculated total average numbers and total average volumes per square centimeter for all collections made at Shedd's Bridge, West Gallatin River, Montana, 1952-54. (L)=Larvae (P)=Pupae.

| Date                      | 8/16/52 | 8/23/52 | 9/3/52 | 9/15/52 | 9/28/52 |
|---------------------------|---------|---------|--------|---------|---------|
| Av. Volume - ml           | Tr.     | Tr.     | Tr.    | Tr.     | 0.074   |
| <u>Tetraspora</u> sp. (?) |         |         | 839    | 1790    |         |
| <u>Cladophora</u> sp.     |         | 36      |        |         |         |
| <u>Treubaria</u> sp. (?)  |         |         |        |         |         |
| <u>Closterium</u> sp.     |         |         |        |         |         |
| Undet. Green sp.          |         |         |        |         |         |
| <u>Melosira</u> sp.       |         |         |        |         |         |
| <u>Meridion</u> sp.       |         |         |        |         |         |
| <u>Diatoma</u> sp.        | 569     | 1712    | 2826   | 1804    | 72868   |
| <u>Fragilaria</u> sp.     |         |         |        |         |         |
| <u>Synedra</u> spp.       | 167     | 72      | 99     | 151     | 20879   |
| <u>Ceratoneis</u> sp.     | 40      |         | 98     |         | 2334    |
| <u>Rhoicosphenia</u> sp.  |         | 275     | 343    |         | 1263    |
| <u>Cocconeis</u> sp.      | 79      | 772     | 2220   | 760     | 5600    |
| <u>Navicula</u> spp.      | 1044    | 2800    | 3352   | 9043    | 167985  |
| <u>Pinnularia</u> sp.     |         |         |        |         |         |
| Gomphonemataceae spp.     | 59      | 178     | 293    | 811     | 20145   |
| <u>Cymbella</u> spp.      | 364     | 1564    | 1529   | 1650    | 17442   |
| <u>Epithemia</u> spp.     | 40      |         | 296    | 381     |         |
| <u>Rhopalodia</u> sp.     |         |         |        |         |         |
| <u>Nitzschia</u> sp.      |         |         |        |         |         |
| <u>Surirella</u> sp.      |         |         |        | 151     | 398     |
| <u>Oscillatoria</u> spp.  |         | 186     |        | 5347    | 28360   |
| <u>Lyngbya</u> sp.        | 640     | 497     | 49     |         |         |
| <u>Nostoc</u> sp.         |         |         |        |         |         |
| Protozoa                  |         |         |        |         |         |
| Rotatoria                 |         |         |        |         |         |
| Nematoda                  |         |         |        |         |         |
| Hydracarina               |         |         |        |         |         |
| Plecoptera                |         | 0.10    |        |         |         |
| Ephemeroptera             |         |         | 0.10   | 0.14    |         |
| Trichoptera               |         |         |        |         |         |
| Coleoptera sp.            |         |         |        |         |         |
| Deuterophlebiidae sp. (P) |         |         |        |         |         |
| Blepharoceridae sp. (L)   |         |         |        | 0.14    |         |
| <u>Simulium</u> spp. (L)  | 4.33    | 5.40    | 5.10   |         | 0.33    |
| <u>Simulium</u> sp. (P)   |         | 0.30    |        |         | 0.11    |
| Tendipedidae spp. (L)     | 0.22    | 0.60    | 0.20   | 0.70    | 2.88    |
| Tendipedidae spp. (P)     |         |         |        |         |         |

Table 3, continued.

| Date                      | 10/15/52 | 11/8/52 | 12/13/52 | 12/27/52 | 1/13/53 |
|---------------------------|----------|---------|----------|----------|---------|
| Av. Volume - ml           | 0.139    | 0.201   | 0.117    | 0.098    | 0.222   |
| <u>Tetraspora</u> sp. (?) | 4800     | 17808   | 4937     | 13778    | 7869    |
| <u>Cladophora</u> sp.     | 398      | 795     |          |          |         |
| <u>Treubaria</u> sp. (?)  |          |         |          |          |         |
| <u>Closterium</u> sp.     |          |         |          |          |         |
| Undet. Green sp.          | 398      | 4061    |          |          |         |
| <u>Melosira</u> sp.       |          |         | 244      | 693      |         |
| <u>Meridion</u> sp.       |          |         |          |          |         |
| <u>Diatoma</u> sp.        | 293670   | 1104759 | 90103    | 17481    | 4502    |
| <u>Fragilaria</u> sp.     | 398      | 3578    |          |          |         |
| <u>Synedra</u> spp.       | 38430    | 52468   | 1672     | 1256     | 257     |
| <u>Ceratoneis</u> sp.     | 4658     | 9458    |          | 907      | 824     |
| <u>Rhoicosphenia</u> sp.  | 5126     | 4316    | 636      | 159      | 749     |
| <u>Cocconeis</u> sp.      | 21143    | 48295   |          | 418      | 631     |
| <u>Navicula</u> spp.      | 438799   | 591225  | 63236    | 42092    | 20149   |
| <u>Pinnularia</u> sp.     |          |         |          |          |         |
| Gomphonemataceae spp.     | 101261   | 122990  | 10971    | 2969     | 4450    |
| <u>Cymbella</u> spp.      | 101805   | 280426  | 15202    | 7520     | 6712    |
| <u>Epithemia</u> spp.     | 2130     | 1590    | 286      |          |         |
| <u>Rhopalodia</u> sp.     |          |         |          |          |         |
| <u>Nitzschia</u> sp.      |          |         |          |          |         |
| <u>Surirella</u> sp.      | 795      | 5198    | 1601     |          |         |
| <u>Oscillatoria</u> spp.  | 163198   | 138988  | 27896    | 58897    | 4581    |
| <u>Lyngbya</u> sp.        | 3323     | 4856    |          |          | 1129    |
| <u>Nostoc</u> sp.         |          |         |          |          |         |
| Protozoa                  | 398      | 9997    |          |          |         |
| Rotatoria                 |          |         |          |          |         |
| Nematoda                  |          |         |          |          |         |
| Hydracarina               |          |         |          |          |         |
| Plecoptera                |          | 2.11    |          |          | 0.20    |
| Ephemeroptera             | 0.33     |         |          |          |         |
| Trichoptera               |          |         |          |          |         |
| Coleoptera sp.            |          |         |          |          |         |
| Deuterophlebiidae sp. (P) |          |         |          |          |         |
| Elepharoceridae sp. (L)   |          |         |          |          |         |
| <u>Simulium</u> spp. (L)  | 0.11     | 0.66    | 3.66     | 1.75     | 2.40    |
| <u>Simulium</u> sp. (P)   | 0.66     | 0.33    |          |          |         |
| Tendipedidae spp. (L)     | 3.55     | 12.55   | 1.66     | 2.37     | 3.20    |
| Tendipedidae spp. (P)     |          |         | 0.16     |          |         |

Table 3, continued.

| Date                      | 1/30/53 | 2/21/53 | 3/9/53 | 3/20/53 | 5/9/53 |
|---------------------------|---------|---------|--------|---------|--------|
| Av. Volume - ml           | 0.860   | 0.370   | 0.588  | 1.000   | 0.250  |
| <u>Tetraspora</u> sp. (?) | 28067   | 51763   | 101357 | 168820  | 40916  |
| <u>Cladophora</u> sp.     |         |         | 3391   |         |        |
| <u>Treubaria</u> sp. (?)  |         |         |        |         |        |
| <u>Closterium</u> sp.     |         |         |        |         |        |
| Undet. Green sp.          |         |         |        |         |        |
| <u>Melosira</u> sp.       | 353     |         |        |         |        |
| <u>Meridion</u> sp.       |         | 241     | 1540   | 12460   |        |
| <u>Diatoma</u> sp.        | 1893    | 2573    | 3895   | 6890    | 14135  |
| <u>Fragilaria</u> sp.     |         | 217     | 707    | 3710    |        |
| <u>Synedra</u> spp.       |         | 525     | 129    |         | 1955   |
| <u>Ceratoneis</u> sp.     | 353     | 457     | 7818   | 53550   | 15856  |
| <u>Rhoicosphenia</u> sp.  | 1187    | 919     | 5498   |         | 355    |
| <u>Cocconeis</u> sp.      | 2727    | 1575    | 13476  | 15015   | 933    |
| <u>Navicula</u> spp.      | 26600   | 8882    | 41080  | 126470  | 13830  |
| <u>Pinnularia</u> sp.     |         |         |        |         |        |
| Gomphonemataceae spp.     | 4448    | 5373    | 7132   | 3710    | 1373   |
| <u>Cymbella</u> spp.      | 1227    | 2408    | 31060  | 30560   | 6928   |
| <u>Epithemia</u> spp.     |         |         | 707    |         |        |
| <u>Rhopalodia</u> sp.     |         |         |        |         |        |
| <u>Nitzschia</u> sp.      |         |         |        |         |        |
| <u>Surirella</u> sp.      |         |         | 707    |         |        |
| <u>Oscillatoria</u> spp.  | 21227   | 2621    | 989    | 2180    |        |
| <u>Lyngbya</u> sp.        |         | 886     | 3391   | 2180    |        |
| <u>Nostoc</u> sp.         |         |         |        |         |        |
| Protozoa                  |         |         | 707    | 2180    |        |
| Rotatoria                 |         |         |        |         |        |
| Nematoda                  |         |         |        |         |        |
| Hydracarina               |         |         |        |         |        |
| Plecoptera                |         | 0.01    | 0.11   | 0.50    |        |
| Ephemeroptera             |         | 0.14    | 0.66   | 2.00    | 1.25   |
| Trichoptera               |         |         |        |         | 0.25   |
| Coleoptera sp.            |         |         |        |         |        |
| Deuterophlebiidae sp. (P) |         |         |        |         |        |
| Elepharoceridae sp. (L)   |         |         |        |         |        |
| <u>Simulium</u> spp. (L)  | 7.80    | 2.68    | 6.30   | 3.00    | 0.25   |
| <u>Simulium</u> sp. (P)   |         |         |        |         |        |
| Tendipedidae spp. (L)     | 16.30   | 3.95    | 4.88   | 45.00   | 5.00   |
| Tendipedidae spp. (P)     |         |         | 0.11   |         |        |

Table 3, continued

| Date                         | 5/13/53 | 5/17/53 | 5/23/53 | 7/11/53 | 7/18/53 |
|------------------------------|---------|---------|---------|---------|---------|
| Av. Volume - ml              | 0.344   | 0.467   | 0.158   | Tr.     | 0.004   |
| <u>Tetraspora</u> sp. (?)    | 38102   | 58158   | 18633   | 59      |         |
| <u>Cladophora</u> sp.        |         |         |         |         |         |
| <u>Treubaria</u> sp. (?)     |         |         |         |         |         |
| <u>Closterium</u> sp.        |         | 88      |         |         |         |
| Undet. Green sp.             |         |         |         |         |         |
| <u>Melosira</u> sp.          |         |         |         |         |         |
| <u>Meridion</u> sp.          |         |         | 177     |         |         |
| <u>Diatoma</u> sp.           | 14134   | 20805   | 3694    | 477     |         |
| <u>Fragilaria</u> sp.        | 298     | 866     | 770     | 59      | 88      |
| <u>Synedra</u> spp.          | 499     | 88      | 673     | 436     | 374     |
| <u>Ceratoneis</u> sp.        | 24023   | 19098   | 8442    | 412     | 1670    |
| <u>Rhoicosphenia</u> sp.     | 762     | 1341    | 265     | 176     |         |
| <u>Cocconeis</u> sp.         | 2389    | 3833    | 2325    | 370     | 555     |
| <u>Navicula</u> spp.         | 17923   | 17398   | 10391   | 876     | 555     |
| <u>Pinnularia</u> sp.        |         |         |         |         |         |
| Gomphonemataceae spp.        | 4643    | 1880    | 1259    | 59      | 177     |
| <u>Cymbella</u> spp.         | 14706   | 10385   | 5999    | 945     | 1220    |
| <u>Epithemia</u> spp.        |         | 750     | 91      |         |         |
| <u>Rhopalodia</u> sp.        |         | 442     |         |         |         |
| <u>Nitzschia</u> sp.         |         |         |         |         |         |
| <u>Surirella</u> sp.         | 160     | 1192    |         | 572     | 446     |
| <u>Oscillatoria</u> spp.     | 66      |         | 972     | 303     | 13608   |
| <u>Lyngbya</u> sp.           | 165     | 88      | 177     |         |         |
| <u>Nostoc</u> sp.            |         |         |         |         |         |
| Protozoa                     |         | 750     |         |         |         |
| Rotatoria                    |         |         |         |         |         |
| Nematoda                     | 1.25    | 1.67    |         |         |         |
| Hydracarina                  |         |         | 0.17    | 0.06    |         |
| Plecoptera                   |         |         |         |         |         |
| Ephemeroptera                |         | 0.25    | 0.17    |         | 0.17    |
| Trichoptera                  |         |         | 0.08    |         |         |
| Coleoptera sp.               |         |         |         |         |         |
| Deuterophlebiidae sp. (P)    |         |         |         |         |         |
| Blepharoceridae sp. (L)      |         |         |         |         |         |
| <u>Simulium</u> spp. (L)     |         |         |         |         | 1.33    |
| <u>Simulium</u> sp. (P)      |         |         |         |         |         |
| <u>Tendipedidae</u> spp. (L) | 2.00    | 1.92    | 4.92    | 1.17    | 0.92    |
| <u>Tendipedidae</u> spp. (P) |         |         | 0.26    | 0.11    | 0.08    |

Table 3, continued.

| Date                      | 8/6/53 | 8/9/53 | 8/15/53 | 8/28/53 | 9/18/53 |
|---------------------------|--------|--------|---------|---------|---------|
| Av. Volume - ml           | Tr.    | Tr.    | Tr.     | 0.002   | 0.390   |
| <u>Tetraspora</u> sp. (?) |        | 66     | 71      | 103     | 843     |
| <u>Cladophora</u> sp.     |        |        |         |         |         |
| <u>Treubaria</u> sp. (?)  |        |        |         |         |         |
| <u>Closterium</u> sp.     |        |        |         |         |         |
| Undet. Green sp.          |        |        |         |         | 1125    |
| <u>Melosira</u> sp.       |        |        |         | 34      |         |
| <u>Meridion</u> sp.       |        |        |         |         |         |
| <u>Diatoma</u> sp.        | 710    | 1576   | 449     | 320     | 8657    |
| <u>Fragilaria</u> sp.     |        | 66     |         |         | 66      |
| <u>Synedra</u> spp.       | 591    | 1065   | 141     | 332     | 3257    |
| <u>Ceratoneis</u> sp.     | 1524   | 409    |         | 34      | 277     |
| <u>Rhoicosphenia</u> sp.  |        | 265    | 71      | 34      | 521     |
| <u>Cocconeis</u> sp.      | 1669   | 331    | 366     | 607     | 8035    |
| <u>Navicula</u> spp.      | 1023   | 909    | 295     | 2483    | 144752  |
| <u>Pinnularia</u> sp.     |        | 133    | 141     | 34      | 199     |
| Gomphonemataceae spp.     |        |        | 141     | 68      | 5954    |
| <u>Cymbella</u> spp.      | 2201   | 1354   | 1502    | 1261    | 18123   |
| <u>Epithemia</u> spp.     |        |        | 71      |         | 629     |
| <u>Rhopalodia</u> sp.     |        |        |         |         |         |
| <u>Nitzschia</u> sp.      |        |        |         |         |         |
| <u>Surirella</u> sp.      | 734    |        | 71      | 109     | 1361    |
| <u>Oscillatoria</u> spp.  | 17338  | 199    |         | 177     | 24198   |
| <u>Lyngbya</u> sp.        | 133    |        |         |         |         |
| <u>Nostoc</u> sp.         |        |        |         |         |         |
| Protozoa                  |        |        |         |         |         |
| Rotatoria                 |        |        |         |         |         |
| Nematoda                  |        |        |         |         |         |
| Hydracarina               |        |        |         |         |         |
| Plecoptera                |        |        |         |         |         |
| Ephemeroptera             | 0.25   | 0.06   | 0.13    | 0.16    | 0.28    |
| Trichoptera               |        |        |         |         |         |
| Coleoptera sp.            |        |        |         |         |         |
| Deuterophlebiidae sp. (P) |        |        | 0.07    |         |         |
| Blepharoceridae sp. (L)   |        |        |         |         |         |
| <u>Simulium</u> spp. (L)  | 160    | 0.37   |         | 0.12    | 0.03    |
| <u>Simulium</u> sp. (P)   |        |        |         |         |         |
| Tendipedidae spp. (L)     | 0.25   | 0.56   | 0.93    | 2.03    | 2.72    |
| Tendipedidae spp. (P)     |        |        |         | 0.10    | 0.03    |

Table 3, continued.

| Date                         | 10/3/53 | 10/24/53 | 11/14/53 | 11/29/53 | 12/19/53 |
|------------------------------|---------|----------|----------|----------|----------|
| Av. Volume - ml              | 0.177   | 0.309    | 0.274    | 0.156    | 0.015    |
| <u>Tetraspora</u> sp. (?)    | 5620    | 360      | 612      | 883      | 2349     |
| <u>Cladophora</u> sp.        | 1248    | 2821     | 667      |          |          |
| <u>Treubaria</u> sp. (?)     |         |          | 906      | 989      | 66       |
| <u>Closterium</u> sp.        |         |          | 427      |          |          |
| Undet. Green sp.             | 2663    | 889      | 359      |          |          |
| <u>Melosira</u> sp.          | 3127    | 2804     | 4913     | 2942     | 364      |
| <u>Meridion</u> sp.          |         |          | 250      |          |          |
| <u>Diatoma</u> sp.           | 262236  | 1636041  | 1845831  | 962171   | 21748    |
| <u>Fragilaria</u> sp.        | 359     | 530      | 1279     | 1684     | 133      |
| <u>Synedra</u> spp.          | 13052   | 18733    | 17795    | 10276    | 343      |
| <u>Ceratoneis</u> sp.        | 7180    | 1590     | 1932     | 1675     | 232      |
| <u>Rhoicosphenia</u> sp.     | 3316    | 6862     | 11078    | 4678     | 575      |
| <u>Cocconeis</u> sp.         | 45716   | 64349    | 59848    | 65022    | 3098     |
| <u>Navicula</u> spp.         | 444706  | 495907   | 402951   | 465866   | 82078    |
| <u>Pinnularia</u> sp.        | 102     | 940      | 975      | 495      |          |
| <u>Gomphonemataceae</u> spp. | 127800  | 149648   | 72257    | 37351    | 3354     |
| <u>Cymbella</u> spp.         | 95644   | 135491   | 67650    | 40018    | 3443     |
| <u>Epithemia</u> spp.        | 1532    | 4524     | 11184    | 6326     | 575      |
| <u>Rhopalodia</u> sp.        |         |          |          |          |          |
| <u>Nitzschia</u> sp.         |         |          | 427      |          |          |
| <u>Surirella</u> sp.         | 11610   | 7372     | 3719     | 3711     | 232      |
| <u>Oscillatoria</u> spp.     | 947631  | 54713    | 34427    | 17582    | 4671     |
| <u>Lyngbya</u> sp.           |         | 1419     | 1343     | 1886     | 66       |
| <u>Nostoc</u> sp.            |         |          | 239      |          |          |
| Protozoa                     | 1626    | 1487     | 3211     | 883      |          |
| Rotatoria                    | 2.50    | 36.50    | 39.20    | 1.87     |          |
| Nematoda                     | 2.19    | 3.75     | 8.39     | 12.50    |          |
| Hydracarina                  |         |          |          |          |          |
| Plecoptera                   |         | 0.06     |          | 0.06     |          |
| Ephemeroptera                | 1.35    | 2.32     | 1.00     | 1.31     |          |
| Trichoptera                  | 0.10    | 0.71     | 0.03     |          | 0.06     |
| Coleoptera sp.               |         |          | 0.03     |          |          |
| Deuterophlebiidae sp. (P)    |         |          |          |          |          |
| Blepharoceridae sp. (L)      |         |          |          |          |          |
| <u>Simulium</u> spp. (L)     | 0.16    | 0.94     | 0.48     | 2.19     | 3.00     |
| <u>Simulium</u> sp. (P)      |         |          |          |          |          |
| <u>Tendipedidae</u> spp. (L) | 2.06    | 8.48     | 8.52     | 17.94    | 2.19     |
| <u>Tendipedidae</u> spp. (P) | 0.10    | 0.16     |          |          |          |

Table 3, continued.

| Date                      | 1/11/54 | 1/21/54 | 2/7/54 | 2/23/54 |
|---------------------------|---------|---------|--------|---------|
| Av. Volume - ml           | 0.023   | 0.015   | 0.049  | 0.332   |
| <u>Tetraspora</u> sp. (?) | 1967    | 133     | 11229  | 38542   |
| <u>Cladophora</u> sp.     |         |         | 66     |         |
| <u>Treubaria</u> sp. (?)  |         |         |        |         |
| <u>Closterium</u> sp.     |         |         |        |         |
| Undet. Green sp.          |         |         |        |         |
| <u>Melosira</u> sp.       | 66      |         |        |         |
| <u>Meridion</u> sp.       |         |         |        |         |
| <u>Diatoma</u> sp.        | 5085    | 975     | 11575  | 14771   |
| <u>Fragilaria</u> sp.     |         |         |        |         |
| <u>Synedra</u> spp.       | 66      |         | 66     | 1022    |
| <u>Ceratoneis</u> sp.     | 66      |         | 885    | 3181    |
| <u>Rhoicosphenia</u> sp.  | 66      |         | 144    | 265     |
| <u>Cocconeis</u> sp.      | 2658    | 133     | 1249   | 1111    |
| <u>Navicula</u> spp.      | 14326   | 6557    | 19528  | 41912   |
| <u>Pinnularia</u> sp.     |         |         |        |         |
| Gomphonemataceae spp.     | 364     |         | 363    | 76      |
| <u>Cymbella</u> spp.      | 1381    | 1143    | 5198   | 5928    |
| <u>Epithemia</u> spp.     | 298     |         |        |         |
| <u>Rhopalodia</u> sp.     |         |         |        |         |
| <u>Nitzschia</u> sp.      |         |         |        |         |
| <u>Surirella</u> sp.      |         |         |        |         |
| <u>Oscillatoria</u> spp.  | 9968    | 1456    | 12678  | 67460   |
| <u>Lyngbya</u> sp.        |         |         | 298    | 454     |
| Nostoc sp.                |         |         |        |         |
| Protozoa                  |         |         |        |         |
| Rotatoria                 |         |         |        |         |
| Nematoda                  |         |         |        |         |
| Hydracarina               |         |         |        |         |
| Plecoptera                |         |         |        |         |
| Ephemeroptera             |         |         | 0.06   | 1.00    |
| Trichoptera               |         |         | 0.06   |         |
| Coleoptera sp.            |         |         |        |         |
| Deuterophlebiidae sp. (P) |         |         |        |         |
| Blepharoceridae sp. (L)   |         |         |        |         |
| <u>Simulium</u> spp. (L)  | 10.50   | 3.13    | 4.60   | 4.78    |
| <u>Simulium</u> sp. (P)   |         |         |        |         |
| Tendipedidae spp. (L)     | 0.50    | 0.13    | 1.70   | 5.14    |
| Tendipedidae spp. (P)     |         |         |        |         |

(1952-53 and 1953-54) and was followed by another increase of lesser proportions in March (1953). A sharp decline in diatoms and green algae appeared in May and this probably continued to July although lack of samples in June makes this somewhat obscure. The number of blue-green algae was low in May and remained about the same in early July. During July, diatoms were scarce (4,300-5,000). Blue-green algae made a decided increase (300-13,600), and green algae (60) appeared in only one collection.

The most abundant diatom which contributed to the August-September increase in both years was Navicula, while Diatoma, Cymbella, and Gomphonemataceae were numerous. Oscillatoria was the only blue-green and Tetraspora the only green algae which occurred in large numbers. Diatoms were by far the most abundant organisms during this period.

During the early November peak (1952-53) Diatoma was the most numerous diatom and superseded Navicula. Navicula became predominant again in early December during the December-January decline (1952-53 and 1953-54) and remained in this position through March. Ceratoneis superseded Navicula as the most abundant diatom in May. Other diatoms which contributed large numbers during the peak period were Cymbella, Cocconeis, and Gomphonemataceae. In 1952 Ceratoneis probably peaked in early November but was relatively scarce in December. It reached maximum numbers in early October 1953 and declined sharply later that month. Tetraspora was the most numerous green algae present in 1952 and 1953 Cladophora was also found in moderate numbers. Tetraspora was the most abundant organ-



ism in late January 1953 and held this position through March and May, while in 1953-54 it was exceeded in numbers by Navicula, Diatoma, Cymbella and Oscillatoria.

Synedra occurred frequently but only in moderate numbers. Small numbers of Surirella, Epithemia, and Fragilaria occurred commonly in 1952. Fragilaria was somewhat more abundant in 1953. Pinnularia was scarce and found only during the early November peak. Meridion was common only during February and March 1953 although it occurred once in May and November. Nitzschia was rare, being found only once. Closterium appeared only once in May and once in November 1953. Treubaria was present only during the December-January decline in early December 1953. Lyngbya was found infrequently while Nostoc was observed only once.

The numerical abundance of Tendipedidae and Simulium for each month of the sampling period is shown in Figure 2. A gradual numerical increase in Tendipedidae larvae was observed from August through October resulting in a peak during November of each year (1952-53). The average number of larvae per square centimeter of stone surface was 12.55 during the first year and 17.94 the second year. A sharp decline occurred in December of both years. In late January (1953) there was a pronounced increase resulting in a peak (16.30). This was not found in 1954. A sharp decline occurred in February 1953, but an increase was found during the same month in 1954. The greatest number (45.00) was found in late March 1953.

Simulium larvae abundance was somewhat similar to that in Tendipedidae larvae. In December there was a definite increase in numbers which resulted in a peak during January in both years (1953-54). The

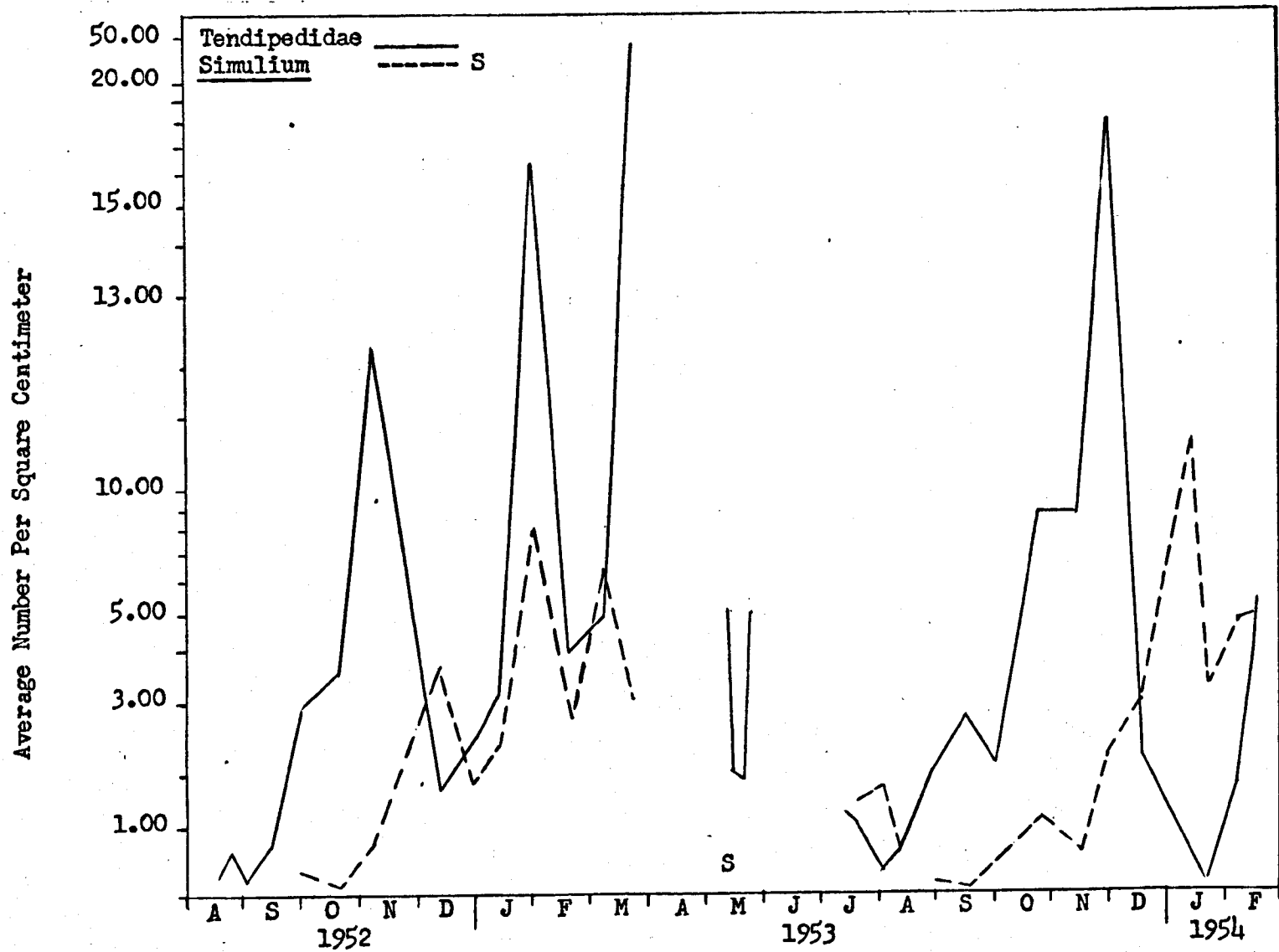


Fig. 2. Quantitative distribution of Tendipedidae and Simulium larvae, West Gallatin River, Montana, 1952-54.

greatest number (10.50) was reached in January 1954.

No rotifers or nematodes were included in the counts for 1952 because the methods used were inadequate to detect them. In 1953, the greatest abundance of rotifers, protozoans, nematodes and Ephemeroptera occurred in October and November. Their abundance coincided with that of the diatoms, blue-green and green algae already described.

Rare organisms which occurred included Deuterophlebiidae, Blepharoceridae and Hydracarina.

#### Abundance of Organisms in Relation to Physical Characteristics (Fig. 3)

Diatoms, blue-green, and green algae increased in number during the period of high temperatures (late summer) in both years (1952-53) and peak periods were attained after temperatures began to decline (October-November). Minimum numbers were reached during the period of minimum temperatures in December-January. The first depression following maximum abundance occurred immediately after anchor ice and floating ice were observed. It is believed that this December-January decline in periphyton may have resulted from the effects of ice.

During the August-September increase in periphyton and through the peak periods in both years, recorded discharge and turbidity were low. A small increase in turbidity was observed on several occasions when floating ice was abundant. The decline in numbers of periphyton organisms in May was associated with a distinct increase in discharge and turbidity. The highest recorded discharge and turbidity. The highest recorded discharge and turbidity were found in June and the minimum number of organ-

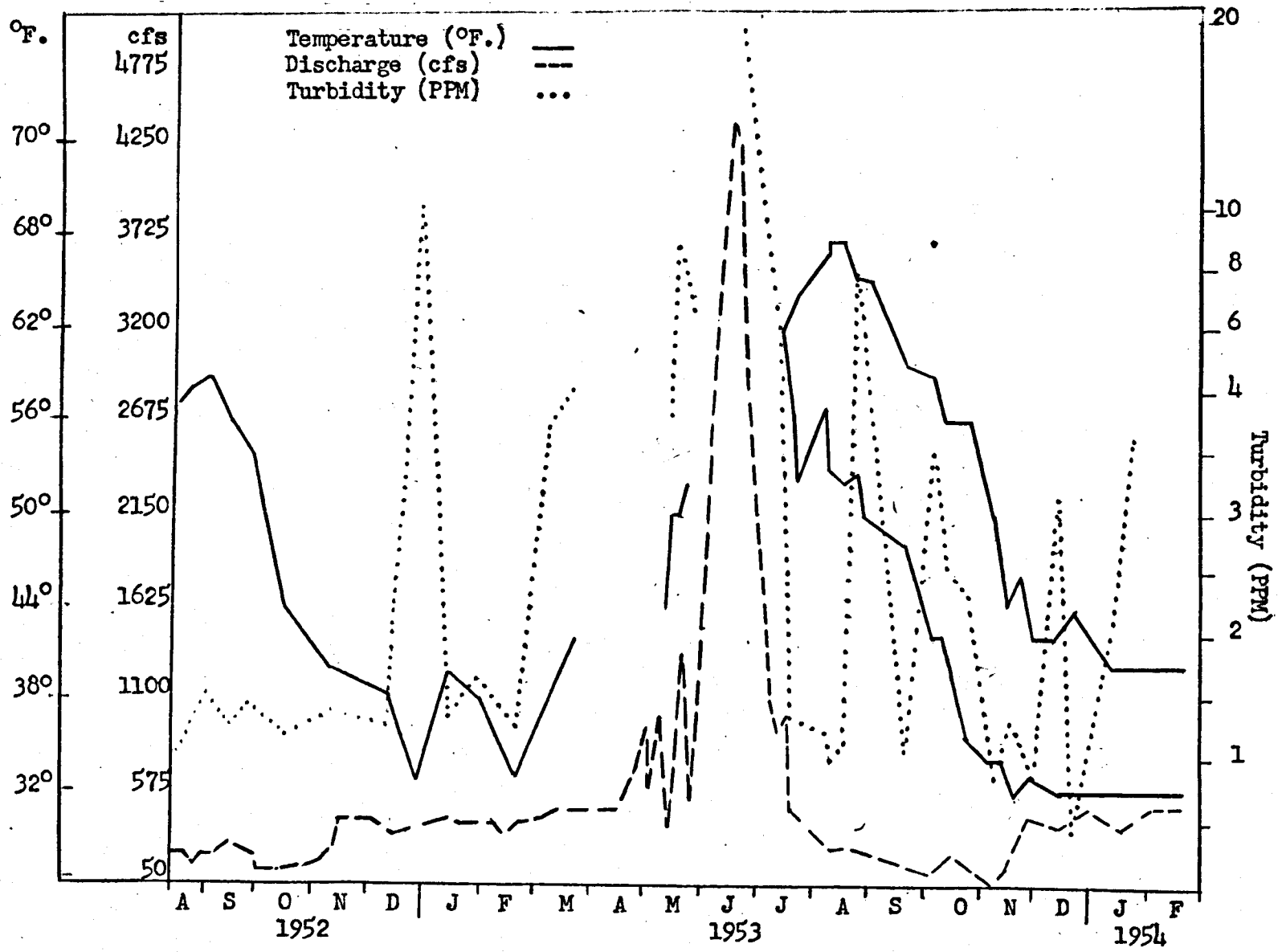


Fig. 3. Discharge, turbidity and temperature in the West Gallatin River, 1952-54.

isms was found in July. The low numbers very probably resulted from the molar action associated with high water and turbidity.

A preliminary effort was made to determine the effect of velocity on the distribution and abundance of organisms in the periphyton complex. Water velocities were measured in various places on the exposed surfaces of five stones at various depths (2-9 inches). These were found to increase from the upstream to downstream end of the stones. The average for the upstream half was 0.67 f/s while the downstream half was 1.76 f/s.

The numbers of diatoms, blue-green, and green algae were about the same on both halves of the stone during August and September (1953). During November the number of diatoms, blue-green, and green algae was higher on the downstream half. The numbers were as follows: diatoms: upstream 2,340,000; downstream 2,841,000; blue-green: upstream 33,200; downstream 38,900, and green algae: upstream 2,400; downstream 3,400. In November and early December the numbers were similar on both parts of the stones. In January 1954, the numbers were as follows; diatoms: upstream 4,000; downstream 14,500; blue-green: upstream 890; downstream 2,000; and green algae: upstream 260; downstream none.

During the increase in August-September (1953) Tendipedidae and Simulium larvae were found in about the same numbers on both portions of the stones. In the November peak the numbers of Tendipedidae were somewhat higher on the downstream (9.73) than on the upstream side (6.94). There was little difference in the number of Tendipedidae on each half of the stones in December, January, and February (1952-53). More Simulium


larvae were observed in early January on the downstream (18.88) than on the upstream (1.75) side of the stones while in December and February it was about equal on both sides.

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